IBM Db2 11.5

Database Security Guide

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About this book

The *Database Security Guide* describes how to use Db2® security features to implement and manage the level of security you require for your database installation.

The *Database Security Guide* provides detailed information about:

- Managing the authentication of users who can access Db2 databases
- Setting up authorization to control user access to database objects and data

Contents

Chapter 1. Db2 security model

Two modes of security control access to the Db2 database system data and functions. Access to the Db2 database system is managed by facilities that reside outside the Db2 database system (authentication), whereas access within the Db2 database system is managed by the database manager (authorization).

Authentication

Authentication is the process by which a system verifies a user's identity. User authentication is completed by a security facility outside the Db2 database system, through an authentication security plug-in module. A default authentication security plug-in module that relies on operating-system-based authentication is included when you install the Db2 database system. For your convenience, the Db2 database manager also ships with authentication plug-in modules for Kerberos and lightweight directory access protocol (LDAP). To provide even greater flexibility in accommodating your specific authentication needs, you can build your own authentication security plug-in module.

The authentication process produces a Db2 authorization ID. Group membership information for the user is also acquired during authentication. Default acquisition of group information relies on an operating-system based group-membership plug-in module that is included when you install the Db2 database system. If you prefer, you can acquire group membership information by using a specific group-membership plug-in module, such as LDAP.

Authorization

After a user is authenticated, the database manager determines if that user is allowed to access Db2 data or resources. Authorization is the process whereby the Db2 database manager obtains information about the authenticated user, indicating which database operations that user can perform, and which data objects that user can access.

The different sources of permissions available to an authorization ID are as follows:

1. Primary permissions: those granted to the authorization ID directly.
2. Secondary permissions: those granted to the groups and roles in which the authorization ID is a member.
3. Public permissions: those granted to PUBLIC.
4. Context-sensitive permissions: those granted to a trusted context role.

Authorization can be given to users in the following categories:

- System-level authorization

  The system administrator (SYSADM), system control (SYSCTRL), system maintenance (SYSMAINT), and system monitor (SYSMON) authorities provide varying degrees of control over instance-level functions. Authorities provide a way both to group privileges and to control maintenance and utility operations for instances, databases, and database objects.
- Database-level authorization

  The security administrator (SECADM), database administrator (DBADM), database access control (ACCESSCTRL), database data access (DATAACCESS), SQL administrator (SQLADM), workload management administrator (WLMADM), and explain (EXPLAIN) authorities provide control within the database. Other database authorities include LOAD (ability to load data into a table), and CONNECT (ability to connect to a database).
- Schema-level authorization

  The schema-level authorities have been designed on the same principle as the database authorities and provide control over the objects defined in a schema. The schema administrator (SCHEMAADM), schema access control administrator (ACCESSCTRL), and schema data access administrator (DATAACCESS) have the privileges to create and manage objects in a schema, grant and revoke

privileges on objects defined in the schema and the schema itself, and access as well as manage data in the schema respectively. The schema LOAD authority allows users to load data in to the tables defined in the schema.

- Object-level authorization

  Object level authorization involves checking privileges when an operation is performed on an object. For example, to select from a table a user must have SELECT privilege on a table (as a minimum).

- Content-based authorization

  Views provide a way to control which columns or rows of a table specific users can read. Label-based access control (LBAC) determines which users have read and write access to individual rows and individual columns.

You can use these features, in conjunction with the Db2 audit facility for monitoring access, to define and manage the level of security your database installation requires.

Related information

Best practices: IBM Data Server Security

Authentication

Authentication of a user is completed using a security facility outside of the Db2 database system. The security facility can be part of the operating system or a separate product.

The security facility requires two items to authenticate a user: a user ID and a password. The user ID identifies the user to the security facility. By supplying the correct password, information known only to the user and the security facility, the user's identity (corresponding to the user ID) is verified.

Note: In non-root installations, operating system-based authentication must be enabled by running the **db2rfe** command.

After being authenticated:

- The user must be identified to Db2 using an SQL authorization name or *authid*. This name can be the same as the user ID, or a mapped value. For example, on UNIX operating systems, when you are using the default security plug-in module, a Db2 *authid* is derived by transforming to uppercase letters a UNIX user ID that follows Db2 naming conventions.
- A list of groups to which the user belongs is obtained. Group membership may be used when authorizing the user. Groups are security facility entities that must also map to Db2 authorization names. This mapping is done in a method similar to that used for user IDs.

The Db2 database manager uses the security facility to authenticate users in one of two ways:

- A successful security system login is used as evidence of identity, and allows:
  - Use of local commands to access local data
  - Use of remote connections when the server trusts the client authentication.
- Successful validation of a user ID and password by the security facility is used as evidence of identity and allows:
  - Use of remote connections where the server requires proof of authentication
  - Use of operations where the user wants to run a command under an identity other than the identity used for login.

Note: On some UNIX systems, the Db2database manager can log failed password attempts with the operating system, and detect when a client has exceeded the number of allowable login tries, as specified by the LOGINRETRIES parameter.

Authorization

Authorization is performed using Db2 facilities. Db2 tables and configuration files are used to record the permissions associated with each authorization name.

When an authenticated user tries to access data, these recorded permissions are compared with the permissions of:

- The authorization name of the user
- The groups to which the user belongs
- The roles granted to the user directly or indirectly through a group or a role
- The permissions acquired through a trusted context

Based on this comparison, the Db2 server determines whether to allow the requested access.

The types of permissions recorded are privileges, authority levels, and LBAC credentials.

A *privilege* defines a single permission for an authorization name, enabling a user to create or access database resources. Privileges are stored in the database catalogs.

Authority levels provide a method of grouping privileges and control over database or schema operations. Database and schema authorities are stored in the database catalogs; system authorities are associated with group membership, and the group names that are associated with the authority levels are stored in the database manager configuration file for a given instance.

LBAC credentials are LBAC security labels and LBAC rule exemptions that allow access to data protected by label-based access control (LBAC). LBAC credentials are stored in the database catalogs.

Groups provide a convenient means of performing authorization for a collection of users without having to grant or revoke privileges for each user individually. Unless otherwise specified, group authorization names can be used anywhere that authorization names are used for authorization purposes. In general, group membership is considered for dynamic SQL and non-database object authorizations (such as instance level commands and utilities), but is not considered for static SQL. The exception to this general case occurs when privileges are granted to PUBLIC: these are considered when static SQL is processed. Specific cases where group membership does not apply are noted throughout the Db2 documentation, where applicable.

A role is a database object that groups together one or more privileges and can be assigned to users, groups, PUBLIC, or other roles by using a GRANT statement or to a trusted context by using a CREATE TRUSTED CONTEXT or ALTER TRUSTED CONTEXT statement. A role can be specified for the SESSION_USER ROLE connection attribute in a workload definition. When you use roles, you associate access permissions on database objects with the roles. Users that are members of those roles then have the privileges defined for the role with which to access database objects.

Roles provide similar functionality as groups; they perform authorization for a collection of users without having to grant or revoke privileges for each user individually. One advantage of roles is that they are managed by the Db2 database system. The permissions granted to roles are taken into consideration during the authorization process for views, triggers, materialized query tables (MQTs), packages and SQL routines, unlike the permissions granted to groups. Permissions granted to groups are not considered during the authorization process for views, triggers, MQTs, packages and SQL routines, because the Db2 database system cannot discover when membership in a group changes, and so it cannot invalidate the objects mentioned previously, if appropriate.

Note: Permissions granted to roles that are granted to groups are not considered during the authorization process for views, triggers, MQTs, packages and SQL routines.

During an SQL statement processing, the permissions that the Db2 authorization model considers are the union of the following permissions:

1. The permissions granted to the primary authorization ID associated with the SQL statement
2. The permissions granted to the secondary authorization IDs (groups or roles) associated with the SQL statement

3. The permissions granted to PUBLIC, including roles that are granted to PUBLIC, directly or indirectly through other roles.
4. The permissions granted to the trusted context role, if applicable.

Security considerations when installing and using the Db2 database manager

Security considerations are important to the Db2 administrator from the moment the product is installed.

To complete the installation of the Db2 database manager, a user ID, a group name, and a password are required. The GUI-based Db2 database manager install program creates default values for different user IDs and the group. Different defaults are created, depending on whether you are installing on Linux® and UNIX or Windows operating systems:

- On UNIX and Linux operating systems, if you choose to create a Db2 instance in the instance setup window, the Db2 database install program creates, by default, different users for the DAS (`dasusr`), the instance owner (`db2inst`), and the fenced user (`db2fenc`). Optionally, you can specify different user names

  The Db2 database install program appends a number from 1-99 to the default user name, until a user ID that does not already exist can be created. For example, if the users `db2inst1` and `db2inst2` already exist, the Db2 database install program creates the user `db2inst3`. If a number greater than 10 is used, the character portion of the name is truncated in the default user ID. For example, if the user ID `db2fenc9` already exists, the Db2 database install program truncates the `c` in the user ID, then appends the `10` (`db2fen10`). Truncation does not occur when the numeric value is appended to the default DAS user (for example, `dasusr24`).
- On Windows operating systems, the Db2 database install program creates, by default, the user `db2admin` for the DAS user, the instance owner, and fenced users (you can specify a different user name during setup, if you want). Unlike Linux and UNIX operating systems, no numeric value is appended to the user ID.

To minimize the risk of a user other than the administrator from learning of the defaults and using them in an improper fashion within databases and instances, change the defaults during the install to a new or existing user ID of your choice.

Note: Response file installations do not use default values for user IDs or group names. These values must be specified in the response file.

Passwords are very important when authenticating users. If no authentication requirements are set at the operating system level and the database is using the operating system to authenticate users, users will be allowed to connect. For example on Linux and UNIX operating systems, undefined passwords are treated as NULL. In this situation, any user without a defined password will be considered to have a NULL password. From the operating system's perspective, this is a match and the user is validated and able to connect to the database. Use passwords at the operating system level if you want the operating system to do the authentication of users for your database.

When working with partitioned database environments on Linux and UNIX operating systems in releases of Db2 prior to version 11.5.6, the Db2 database manager by default uses the rsh utility to run some commands on remote members. The rsh utility transmits passwords in clear text over the network, which can be a security exposure if the Db2 server is not on a secure network. You can use the **DB2RSHCMD** registry variable to set the remote shell program to a more secure alternative that avoids this exposure. SSH is a more secure alternative, and is used by default starting from version 11.5.6. See the **DB2RSHCMD** registry variable documentation for restrictions on remote shell configurations.

After installing the Db2 database manager, also review, and change (if required), the default privileges that have been granted to users. By default, the installation process grants system administration (SYSADM) privileges to the following users on each operating system:

Linux and UNIX operating systems
To a valid Db2 database user name that belongs to the primary group of the instance owner.

Windows environments

- To members of the local Administrators group.
- If the Db2 database manager is configured to enumerate groups for users at the location where the users are defined, to members of the Administrators group at the Domain Controller. You use the **DB2_GRP_LOOKUP** environment variable to configure group enumeration on Windows operating systems.
- If Windows extended security is enabled, to members of the DB2ADMNS group. The location of the DB2ADMNS group is decided during installation.
- To the LocalSystem account

By updating the database manager configuration parameter **sysadm_group**, the administrator can control which group of users possesses SYSADM privileges. You must use the following guidelines to complete the security requirements for both the Db2 database installation and the subsequent instance and database creation.

Any group defined as the system administration group (by updating **sysadm_group**) must exist. The name of this group should allow for easy identification as the group created for instance owners. User IDs and groups that belong to this group have system administrator authority for their corresponding instances.

The administrator should consider creating an instance owner user ID that is easily recognized as being associated with a particular instance. This user ID should have as one of its groups, the name of the SYSADM group created previously. Another recommendation is to use this instance-owner user ID only as a member of the instance owner group and not to use it in any other group. This should control the proliferation of user IDs and groups that can modify the instance.

The created user ID must be associated with a password to provide authentication before being permitted entry into the data and databases within the instance. The recommendation when creating a password is to follow your organization's password naming guidelines.

Note: To avoid accidentally deleting or overwriting instance configuration or other files, administrators should consider using another user account, which does not belong to the same primary group as the instance owner, for day-to-day administration tasks that are performed on the server directly.

File permission requirements for the instance and database directories

The Db2 database system requires that your instance and database directories have a minimum level of permissions.

Note: When the instance and database directories are created by the Db2 database manager, the permissions are accurate and should not be changed.

The minimum permissions of the instance directory and the `NODE000`x`/sqldbdir` directory on UNIX and Linux machines must be: `u=rwx` and `go=rx`. The meaning of the letters is explained in the following table:

Character	Represents:
u	User (owner)
g	Group
o	Other users
r	Read
w	Write
x	Execute

For example, the permissions for the instance, `db2inst1`, in `/home` are:

```
drwxr-xr-x  36 db2inst1  db2grp1         4096 Jun 15 11:13 db2inst1
```

For the directories containing the databases, each and every directory level up to and including NODE000*x* needs the following permissions:

```
drwxrwxr-x  11 db2inst1  db2grp1         4096 Jun 14 15:53 NODE0000/
```

For example, if a database is located in /db2/data/db2inst1/db2inst1/NODE0000 then the directories: /db2, /db2/data, /db2/data/db2inst1, /db2/data/db2inst1/db2inst1 and /db2/data/db2inst1/db2inst1/NODE0000 need drwxrwxr-x.

Within the NODE000x directory, the sqldbdir directory requires the permissions drwxrwxr-x, for example:

```
drwx------   5 db2inst1  db2grp1          256 Jun 14 14:17 SAMPLE/
drwxr-x---   7 db2inst1  db2grp1         4096 Jun 14 13:26 SQL00001/
drwxrwxr-x   2 db2inst1  db2grp1          256 Jun 14 13:02 sqldbdir/
```

CAUTION: To maintain the security of your files, do not change the permissions on the *DBNAME* directories (such as SAMPLE) and the SQL*xxxx* directories from the permissions they are assigned when the Db2 database manager creates them.

Authentication details

Authentication methods for your server

Access to an instance or a database first requires that the user be *authenticated*. The *authentication type* for each instance determines how and where a user will be verified.

Important: The DATA_ENCRYPT authentication type is deprecated and might be removed in a future release. To encrypt data in-transit between clients and Db2 databases, we recommend that you use the Db2 database system support of Transport Layer Security (TLS). For more information, see *Configuring TLS support in a Db2 instance* in the *Data encryption* section of the Db2 Security Guide.

The authentication type is stored in the configuration file at the server. It is initially set when the instance is created. There is one authentication type per instance, which covers access to that database server and all the databases under its control.

If you intend to access data sources from a federated database, you must consider data source authentication processing and definitions for federated authentication types.

Switching User on an Explicit Trusted Connection

For CLI/ODBC and XA CLI/ODBC applications, the authentication mechanism used when processing a switch user request that requires authentication is the same as the mechanism used to originally establish the trusted connection itself. Therefore, any other negotiated security attributes (for example, encryption algorithm, encryption keys, and plug-in names) used during the establishment of the explicit trusted connection are assumed to be the same for any authentication required for a switch user request on that trusted connection. Java™ applications allow the authentication method to be changed on a switch user request (by use of a datasource property).

Because a trusted context object can be defined such that switching user on a trusted connection does *not* require authentication, in order to take full advantage of the switch user on an explicit trusted connection feature, user-written security plug-ins must be able to:

- Accept a user ID-only token
- Return a valid Db2 authorization ID for that user ID

Note: An explicit trusted connection cannot be established if the CLIENT type of authentication is in effect.

Authentication types provided

The following authentication types are provided:

SERVER
Specifies that authentication occurs on the server through the security mechanism in effect for that configuration, for example, through a security plug-in module. The default security mechanism is that if a user ID and password are specified during the connection or attachment attempt, they are sent to the server and compared to the valid user ID and password combinations at the server to determine if the user is permitted to access the instance.

Note: The server code detects whether a connection is local or remote. For local connections, when authentication is SERVER, a user ID and password are not required for authentication to be successful.

SERVER_ENCRYPT
Specifies that the server accepts encrypted SERVER authentication schemes. If the client authentication is not specified, the client is authenticated using the method selected at the server. The user ID and password are encrypted when they are sent over the network from the client to the server.

When the resulting authentication method negotiated between the client and server is SERVER_ENCRYPT, you can choose to encrypt the user ID and password using an AES (Advanced Encryption Standard) 256-bit algorithm. To do this, set the **alternate_auth_enc** database manager configuration parameter. This configuration parameter has three settings:

- NOT_SPECIFIED (default) means that the server accepts the encryption algorithm that the client proposes, including an AES 256-bit algorithm.
- AES_CMP means that if the connecting client proposes DES but supports AES encryption, the server renegotiates for AES encryption.
- AES_ONLY means that the server accepts only AES encryption. If the client does not support AES encryption, the connection is rejected.

AES encryption can be used only when the authentication method negotiated between the client and server is SERVER_ENCRYPT.

SERVER_ENCRYPT_TOKEN
Specifies the server accepts token authentication, or encrypted SERVER authentication schemes.

If the client authentication is TOKEN, the client is authenticated using token authentication.

If the client authentication is SERVER_ENCRYPT, the client is authenticated using a user ID and encrypted password.

If the client authentication is not specified, then the client will use an authentication type dependent on the type of credentials provided.

For other authentication types, an authentication error is returned.

This value is only valid for **SRVCON_AUTH** and can not be specified for AUTHENTICATION. The authentication type of the client cannot be specified as **SERVER_ENCRYPT_TOKEN**.

CLIENT
Specifies that authentication occurs on the database partition where the application is invoked using operating system security. The user ID and password specified during a connection or attachment attempt are compared with the valid user ID and password combinations on the client node to determine whether the user ID is permitted access to the instance. No further authentication will take place on the database server. This is sometimes called single signon.

If the user performs a local or client login, the user is known only to that local client workstation.

If the remote instance has CLIENT authentication, two other parameters determine the final authentication type: **trust_allclnts** and **trust_clntauth**.

CLIENT level security for TRUSTED clients only:

Trusted clients are clients that have a reliable, local security system.

When the authentication type of CLIENT has been selected, an additional option might be selected to protect against clients whose operating environment has no inherent security.

To protect against unsecured clients, the administrator can select Trusted Client Authentication by setting the **trust_allclnts** parameter to NO. This implies that all trusted platforms can authenticate the user on behalf of the server. Untrusted clients are authenticated on the Server and must provide a user ID and password. You use the **trust_allclnts** configuration parameter to indicate whether you are trusting clients. The default for this parameter is YES.

Note: It is possible to trust all clients (**trust_allclnts** is YES) yet have some of those clients as those who do not have a native safe security system for authentication.

You might also want to complete authentication at the server even for trusted clients. To indicate where to validate trusted clients, you use the **trust_clntauth** configuration parameter. The default for this parameter is CLIENT.

Note: For trusted clients only, if no user ID or password is explicitly provided when attempting to CONNECT or **ATTACH**, then validation of the user takes place at the client. The **trust_clntauth** parameter is only used to determine where to validate the information provided on the USER or USING clauses.

To protect against all clients, including JCC type 4 clients on z/OS® and System i® but excluding native Db2 clients on z/OS, OS/390®, VM, VSE, and System i, set the **trust_allclnts** parameter to DRDAONLY. Only these clients can be trusted to perform client-side authentication. All other clients must provide a user ID and password to be authenticated by the server.

The **trust_clntauth** parameter is used to determine where the clients mentioned previously are authenticated: if **trust_clntauth** is CLIENT, authentication takes place at the client. If **trust_clntauth** is SERVER, authentication takes place at the client when no user ID and password are provided and at the server when a user ID and password are provided.

Table 1. Authentication Modes using TRUST_ALLCLNTS and TRUST_CLNTAUTH Parameter Combinations.

trust_ allclnts	trust_ clntauth	Untrusted non- DRDA Client Authen- tication (no user ID & password)	Untrusted non- DRDA Client Authen- tication (with user ID & password)	Trusted non- DRDA Client Authen- tication (no user ID & password)	Trusted non- DRDA Client Authen- tication (with user ID & password)	DRDA Client Authen- tication (no user ID & password)	DRDA Client Authen- tication (with user ID & password)
YES	CLIENT	CLIENT	CLIENT	CLIENT	CLIENT	CLIENT	CLIENT
YES	SERVER	CLIENT	SERVER	CLIENT	SERVER	CLIENT	SERVER
NO	CLIENT	SERVER	SERVER	CLIENT	CLIENT	CLIENT	CLIENT
NO	SERVER	SERVER	SERVER	CLIENT	SERVER	CLIENT	SERVER
DRDAONLY	CLIENT	SERVER	SERVER	SERVER	SERVER	CLIENT	CLIENT
DRDAONLY	SERVER	SERVER	SERVER	SERVER	SERVER	CLIENT	SERVER

DATA_ENCRYPT

The server accepts encrypted SERVER authentication schemes and the encryption of user data. The authentication works the same way as that shown with SERVER_ENCRYPT. The user ID and password are encrypted when they are sent over the network from the client to the server.

The following user data are encrypted when using this authentication type:

- SQL and XQuery statements.
- SQL program variable data.

- Output data from the server processing of an SQL or XQuery statement and including a description of the data.
- Some or all of the answer set data resulting from a query.
- Large object (LOB) data streaming.
- SQLDA descriptors.

DATA_ENCRYPT_CMP
The server accepts encrypted SERVER authentication schemes and the encryption of user data. In addition, this authentication type allows compatibility with down level products not supporting DATA_ENCRYPT authentication type. These products are permitted to connect with the SERVER_ENCRYPT authentication type and without encrypting user data. Products supporting the new authentication type must use it. This authentication type is only valid in the server's database manager configuration file and is not valid when used on the **CATALOG DATABASE** command.

KERBEROS
Used when both the Db2 client and server are on operating systems that support the Kerberos security protocol. The Kerberos security protocol performs authentication as a third party authentication service by using conventional cryptography to create a shared secret key. This key becomes a user's credential and is used to verify the identity of users during all occasions when local or network services are requested. The key eliminates the need to pass the user name and password across the network as clear text. Using the Kerberos security protocol enables the use of a single sign-on to a remote Db2 database server. The KERBEROS authentication type is supported on various operating systems, see the related information section for more information.

Kerberos authentication works as follows:

1. A user logging on to the client machine using a domain account authenticates to the Kerberos key distribution center (KDC) at the domain controller. The key distribution center issues a ticket-granting ticket (TGT) to the client.
2. During the first phase of the connection the server sends the target principal name, which is the service account name for the Db2 database server service, to the client. Using the server's target principal name and the target-granting ticket, the client requests a service ticket from the ticket-granting service (TGS) which also resides at the domain controller. If both the client's ticket-granting ticket and the server's target principal name are valid, the TGS issues a service ticket to the client. The principal name recorded in the database directory can be specified as name/instance@REALM. (This is in addition to DOMAIN\userID and userID@xxx.xxx.xxx.com formats accepted on Windows.)
3. The client sends this service ticket to the server using the communication channel (which can be, as an example, TCP/IP).
4. The server validates the client's server ticket. If the client's service ticket is valid, then the authentication is completed.

It is possible to catalog the databases on the client machine and explicitly specify the Kerberos authentication type with the server's target principal name. In this way, the first phase of the connection can be bypassed.

If a user ID and a password are specified, the client will request the ticket-granting ticket for that user account and use it for authentication.

KERBEROS_TOKEN
Specifies the server accepts token authentication, or Kerberos authentication.

If the client authentication is TOKEN, the client is authenticated using token authentication.

If the client authentication is Kerberos, the client is authenticated using the Kerberos security system.

If the client authentication is not specified, then the client will use an authentication type dependent on the type of credentials provided. X

If the client authentication is not specified, then the client will use an authentication type dependent on the type of credentials provided.

For other authentication types, an authentication error is returned.

This value is only valid for SRVCON_AUTH and can not be specified for AUTHENTICATION. The authentication type of the client cannot be specified as KERBEROS_TOKEN.

KRB_SERVER_ENCRYPT
Specifies that the server accepts KERBEROS authentication or encrypted SERVER authentication schemes. If the client authentication is KERBEROS, the client is authenticated using the Kerberos security system. If the client authentication is SERVER_ENCRYPT, the client is authenticated using a user ID and encryption password. If the client authentication is not specified, then the client will use Kerberos if available, otherwise it will use password encryption. For other client authentication types, an authentication error is returned. The authentication type of the client cannot be specified as KRB_SERVER_ENCRYPT

Note: The Kerberos authentication types are supported on clients and servers running on specific operating systems, see the related information section for more information. For Windows operating systems, both client and server machines must either belong to the same Windows domain or belong to trusted domains. This authentication type should be used when the server supports Kerberos and some, but not all, of the client machines support Kerberos authentication.

KRB_SVR_ENC_TOKEN
Specifies the server accepts token authentication, Kerberos authentication or encrypted SERVER authentication schemes. See the description of KRB_SERVER_ENCRYPT for more information regarding the Kerberos and SERVER_ENCRYPT behaviour. This value is only valid for SRVCON_AUTH and can not be specified for AUTHENTICATION. The authentication type of the client cannot be specified as KRB_SVR_ENC_TOKEN.

GSSPLUGIN
Specifies the server accepts token authentication, Kerberos authentication or encrypted SERVER authentication schemes. See the description of **KRB_SERVER_ENCRYPT** for more information regarding the Kerberos and **SERVER_ENCRYPT** behavior. This value is only valid for **SRVCON_AUTH** and can not be specified for AUTHENTICATION. The authentication type of the client cannot be specified as **KRB_SVR_ENC_TOKEN**.

GSSPLUGIN_TOKEN
Specifies the server accepts token authentication, or plug-in authentication.

If the client authentication is TOKEN, the client is authenticated using token authentication.

If the client authentication is GSSPLUGIN, the client is authenticated using the first client-supported plug-in in the list of server-supported plug-ins.

If the client authentication is not specified, then the client will use an authentication type dependent on the type of credentials provided.

For other authentication types, an authentication error is returned.

This value is only valid for **SRVCON_AUTH** and can not be specified for AUTHENTICATION. The authentication type of the client cannot be specified as **GSSPLUGIN_TOKEN**.

GSS_SERVER_ENCRYPT
Specifies that the server accepts plug-in authentication or encrypted server authentication schemes. If client authentication occurs through a plug-in, the client is authenticated using the first client-supported plug-in in the list of server-supported plug-ins.

If the client authentication is not specified and an implicit connect is being performed (that is, the client does not supply a user ID and password when making the connection), the server returns a list of server-supported plug-ins, the Kerberos authentication scheme (if one of the plug-ins in the list is Kerberos-based), and the encrypted server authentication scheme. The client is authenticated using the first supported plug-in found in the client plug-in directory. If the client does not support any of the plug-ins that are in the list, the client is authenticated using the Kerberos authentication scheme. If the client does not support the Kerberos authentication scheme, the client is authenticated using the encrypted server authentication scheme, and the connection will fail because of a missing password. A client supports the Kerberos authentication scheme if a Db2

supplied Kerberos plug-in exists for the operating system, or a Kerberos-based plug-in is specified for the **srvcon_gssplugin_list** database manager configuration parameter.

If the client authentication is not specified and an explicit connection is being performed (that is, both the user ID and password are supplied), the authentication type is equivalent to SERVER_ENCRYPT. In this case, the choice of the encryption algorithm used to encrypt the user ID and password depends on the setting of the **alternate_auth_enc** database manager configuration parameter.

GSS_SVR_ENC_TOKEN
Specifies the server accepts token authentication, GSSPLUGIN authentication or encrypted SERVER authentication schemes. See the description of **GSS_SERVER_ENCRYPT** for more information regarding the GSSPLUGIN and SERVER_ENCRYPT behaviour.

This value is only valid for SRVCON_AUTH and can not be specified for AUTHENTICATION. The authentication type of the client cannot be specified as **GSS_SVR_ENC_TOKEN**.

Token Authentication
When SRVCON_AUTH database manager configuration parameter has been configured with one of **SERVER_ENCRYPT_TOKEN**, **KERBEROS_TOKEN**, **KRB_SVR_ENC_TOKEN**, **GSSPLUGIN_TOKEN**, **GSS_SVR_ENC_TOKEN**, then the server can accept various tokens for authentication. The server must be configured with a valid token configuration file. The supported tokens types in the token configuration file must be the types specified by the client during the connection in the **ACCESSTOKENTYPE** parameter. For more details, see Token authentication.

Authentication considerations for remote clients

When you catalog a database for remote access, you can specify the authentication type in the database directory entry.

Important: The DATA_ENCRYPT authentication type is deprecated and might be removed in a future release. To encrypt data in-transit between clients and Db2 databases, we recommend that you use the Db2 database system support of Transport Layer Security (TLS). For more information, see *Configuring TLS support in a Db2 instance* in the *Data encryption* section of the Db2 Security Guide.

The authentication type is not required. If it is not specified the client will try to connect using the SERVER_ENCRYPT authentication type first. If the server does not support SERVER_ENCRYPT, the server returns a list of the authentication types that it supports. The client will use the first authentication type listed to connect to the server. While unspecified, the database catalog listed using the LIST DATABASE DIRECTORY command will not show an authentication type. If the authentication type is not specified in the database directory entry then the client may take longer to connect. If an authentication type is specified, authentication can begin immediately provided that value specified matches that at the server. If a mismatch is detected, Db2 database attempts to recover. Recovery may result in more flows to reconcile the difference, or in an error if the Db2 database cannot recover. In the case of a mismatch, the value at the server is assumed to be correct.

The authentication type DATA_ENCRYPT_CMP is designed to allow clients from a previous release that does not support data encryption to connect to a server using SERVER_ENCRYPT authentication instead of DATA_ENCRYPT. This authentication does not work when the following statements are true:

- The client level is Version 7.2.
- The gateway level is Version 8 FixPak 7 or later.
- The server is Version 8 FixPak 7 or later.

When these are all true, the client cannot connect to the server. To allow the connection, you must either upgrade your client to Version 8 or later, or have your gateway level at Version 8 FixPak 6 or earlier.

The determination of the authentication type used when connecting is made by specifying the appropriate authentication type as a database catalog entry at the gateway. This is true for both Db2 Connect scenarios and for clients and servers in a partitioned database environment where the client has set the **DB2NODE** registry variable. You will catalog the authentication type at the catalog partition with the intent to "hop" to the appropriate partition. In this scenario, the authentication type cataloged at the gateway is not used because the negotiation is solely between the client and the server.

You may have a need to catalog multiple database aliases at the gateway using different authentication types if they need to have clients that use differing authentication types. When deciding which authentication type to catalog at a gateway, you can keep the authentication type the same as that used at the client and server; or, you can use the NOTSPEC authentication type with the understanding that NOTSPEC defaults to SERVER.

Partitioned database authentication considerations

In a partitioned database, each partition of the database must have the same set of users and groups defined. If the definitions are not the same, the user may be authorized to do different things on different partitions.

Consistency across all partitions is recommended.

Kerberos authentication

Kerberos is a third-party network authentication protocol that employs a system of shared secret keys to securely authenticate a user in an unsecured network environment. The Db2 database system provides support for the Kerberos authentication protocol on AIX®, Linux IA32 and AMD64, and Windows operating systems.

Introduction

Kerberos authentication is managed by a three-tiered system in which encrypted service tickets, rather than a plain-text user ID and password pair, are exchanged between the application server and client. These encrypted service tickets, called *credentials*, are provided by a separate server called the Kerberos Key Distribution Center (KDC). Credentials have a finite lifetime and are understood only by the client and the server. These features reduce the risk of a security exposure, even if the ticket is intercepted from the network. Each user, or *principal* in Kerberos terms, possesses a private encryption key that is shared with the KDC. Collectively, the principals and computers that are registered with a KDC are known as a *realm*.

One key feature of Kerberos is that it provides a single sign-on environment: a user must verify identity only once to access the resources within the Kerberos realm. This single sign-on environment means that a user can connect or attach to a Db2 database server without providing a user ID or password. Another advantage is that the administration of user identification is simplified because Kerberos uses a central repository for principals. Finally, Kerberos supports mutual authentication, which enables the client to validate the identity of the server.

Setup

Before you can use Kerberos with a Db2 database system, you must install and configure the Kerberos layer on all computers. For a typical configuration, you must meet the following requirements:

- Create the appropriate principals.
- Ensure that the client and server computers and principals belong to the same realm or to trusted realms. Trusted realms are known as trusted domains in Windows terminology.
- Where appropriate, create server keytab files.
- Synchronize the time clocks on all computers. Kerberos typically permits a 5-minute time skew; if there is more than a 5-minute time skew, a preauthentication error occurs during an attempt to obtain credentials.

Setting up Kerberos for a Db2 server

Before you can use Kerberos authentication with a Db2 database system, you must install and configure the Kerberos layer on all computers. For a typical configuration, you must follow the instructions on this page.

Before you begin

If you are using a Linux operating system, ensure that no Kerberos libraries other than the `krb5` library are installed on your system. Otherwise, Kerberos authentication fails, and a message is logged in the `db2diag` log files.

If you are using a Linux operating system, uninstall any instances of the IBM® Network Authentication Service (NAS) Toolkit, and remove any reference to the NAS installation path locations from the system **PATH** variable.

About this task

The use of Kerberos authentication by a Db2 database depends on whether the security authentication was successfully created using the credentials provided by the connecting application. Furthermore, whenever available, Kerberos mutual authentication is supported, where the client and server must both prove their identities to use Kerberos. However, other Kerberos features, such as the signing or encryption of messages, are unavailable.

For additional details on installing and configuring Kerberos products on your systems, refer to the documentation provided with your Kerberos product.

Kerberos support for a Db2 database system is provided through the IBMkrb5 GSS-API security plug-in. This plug-in is used for both server and client authentication. The plug-in library is installed during Db2 installation in the following locations:

- On UNIX and Linux 32-bit operating systems: the `sqllib/security32/plugin/IBM/client` and `sqllib/security32/plugin/IBM/server` directories
- On UNIX and Linux 64-bit operating systems: the `sqllib/security64/plugin/IBM/client` and `sqllib/security64/plugin/IBM/server` directories
- On Windows operating systems: the `sqllib\security\plugin\IBM\client` and `sqllib\security\plugin\IBM\server` directories

The source code for the UNIX and Linux plug-in, `IBMkrb5.C`, is available in the `sqllib/samples/security/plugins` directory. For 64-bit Windows operating systems, the plug-in library is called `IBMkrb564.dll`.

Kerberos and groups

Kerberos does not possess the concept of groups. As a result, the Db2 database instance relies upon the local operating system to obtain a group list for a Kerberos principal. For UNIX and Linux operating systems, this reliance requires an equivalent system account for each principal. For example, for the principal *name*@*REALM*, the Db2 database product collects group information by querying the local operating system for all group names to which the operating system user *name* belongs. If an operating system user *name* does not exist, the AUTHID belongs only to the PUBLIC group.

On Windows operating systems, a domain account is automatically associated with a Kerberos principal. The additional step of creating a separate operating system account is not required.

Kerberos keytab files

To accept security context requests, every Kerberos service on a UNIX or Linux operating system must place its credentials in a *keytab* file. This requirement applies to those principals that the Db2 database instance uses as server principals. Only the default keytab file is searched for the server key. For instructions on adding a key to the keytab file, see the documentation provided with the Kerberos product.

There is no concept of a keytab file on Windows operating systems; the system automatically handles storing and acquiring the credentials for a principal.

You can specify the default keytab file name by using the **KRB5_KTNAME** environment variable. However, because the server plug-in runs within a Db2 database engine process, this environment variable might not be accessible. To avoid this situation, add the **KRB5_KTNAME** environment variable to the **DB2ENVLIST** registry variable using the **db2set** command:

```
db2set DB2ENVLIST=KRB5_KTNAME
```

As keytab files are not used by Kerberos for Windows, this option is only available for a Linux or UNIX server.

Procedure

To set up Kerberos for a Db2 server:

1. Install Kerberos by performing one of the following steps:
   - For AIX operating systems, install the NAS (Network Authentication Services) Toolkit for Db2 on AIX, Version 1.4 or later. You can download the NAS package from https://www.ibm.com/services/forms/preLogin.do?source=dm-nas.
   - For Linux operating systems, install the Kerberos package, `krb5`, that is included on your operating system installation media.
   - For Windows operating systems, enable the Active Directory on your domain controller.
2. Configure the Db2 product to use the Kerberos plug-in. See "Deploying a Kerberos plug-in" on page 254.
3. Restart the Db2 server.

Naming and mapping for Kerberos

Before you can use Kerberos with a Db2 database system, you must ensure that the client and server computers and principals belong to the same realm or to trusted realms.

Client principals

Any unique identity that can receive Kerberos tickets for authentication is known as a *principal*. A Kerberos principal identity is defined by either a two-part or multipart format, either *name*@*REALM* or *name*/*instance*@*REALM*. Because the *name* component is used in the authorization ID (AUTHID) mapping, the *name* must adhere to the Db2 database naming rules. Those rules limit a name to 128 characters and restrict the choice of characters.

Note: Windows operating systems directly associate a Kerberos principal identity with a domain user. An implication is that Kerberos authentication is unavailable to Windows operating systems that are not associated with a domain or realm. Furthermore, Windows operating systems support only the two-part format for defining principal identities, that is, *name*@*domain*.

Authorization ID mapping

Unlike operating system user IDs, whose scope of existence is usually restricted to a single computer, Kerberos principals can be authenticated in realms other than their own. You can avoid the potential problem of duplicate principal names by using the realm name to fully qualify the principal name. In Kerberos, a fully qualified principal name takes the following form:

name/*instance*@*REALM*

where *instance* can be multiple instance names separated by a forward slash (/), for example, *name*/*instance1*/*instance2*@*REALM*. Alternatively, you can omit the *instance* field.

The realm name must be unique within all the realms that are defined within a network. A one-to-one mapping is needed between the authorization ID and the principal name, that is, the *name* field in the

fully qualified principal. This simple mapping is needed because the authorization ID is used as the default schema by the Db2 database manager and should be easily and logically derived. Be aware of the potential issues caused by the following mappings:

- Principals with the same name but from different realms are mapped to the same authorization ID. For example, the following two principal names both map to an authorization ID of gregor1x:
  - gregor1x@EXAMPLE.COM
  - gregor1x@WWW.COM
- Principals with the same name but on different instances are mapped to the same authorization ID. For example, the following two principal names both map to an authorization ID of gregor1x:
  - gregor1x/bigmachine@EXAMPLE.COM
  - gregor1x/littlemachine@EXAMPLE.COM

Therefore, follow these guidelines:

- Maintain a unique namespace for a name in all the trusted realms that access the Db2 database server.
- Make all principals with the same *name* field, regardless of the instance, belong to the same user.

Server principals

On UNIX and Linux operating systems, the server principal name for the Db2 database instance is assumed to be *instance name*/*fully qualified hostname*@*REALM*. This principal must be able to accept Kerberos security contexts, and it must exist before you start the Db2 database instance, because the server name is reported to the Db2 database instance by the plug-in at initialization time.

On Windows operating systems, the server principal is usually identified by the domain account that is used to start the Db2 database service. An exception to this situation is when the instance is started by the LocalSystem account. In this case, the server principal name is reported as host/*hostname*. This identity is valid only if both the client and server belong to Windows domains.

Windows operating systems do not support names that have more than two parts. For example: *component*/*component*@*REALM*. This creates an issue when a Windows client attempts to connect to a UNIX server. As a result, if you require interoperability with UNIX Kerberos, you must create a mapping between the Kerberos principal and a Windows account in the Windows domain. For instructions, see the appropriate Windows documentation.

You can override the Kerberos server principal name that is used by the Db2 server on UNIX and Linux operating systems by setting the **DB2_KRB5_PRINCIPAL** environment variable to the fully qualified server principal name. The replacement server principal name is recognized by the Db2 database system only after you restart the instance by issuing the **db2start** command.

Kerberos authentication enablement

Before you can use Kerberos with a Db2 database system, you must enable Kerberos authentication.

Enabling Kerberos authentication on the client

To enable Kerberos authentication on the client, set the **clnt_krb_plugin** database manager configuration parameter to the name of the Kerberos plug-in that you are using.

For local authorizations, the client will use Kerberos if the **authentication** configuration parameter is set to KERBEROS or KRB_SERVER_ENCRYPT. Otherwise, no client-side Kerberos support is assumed.

Important: No checks are performed to validate that Kerberos support is available.

To enable Kerberos authentication on outbound connections to a Db2 server, you instead specify Kerberos as the authentication type when you catalog the database, as shown in the following example:

```
CATALOG DATABASE testdb AT NODE testnode
   AUTHENTICATION KERBEROS TARGET PRINCIPAL
   service/host@REALM
```

However, if you do not provide authentication information, the server sends the name of the server principal to the client.

Enabling Kerberos authentication on the server

To enable Kerberos authentication on the server, include the specific Kerberos plug-in name in the list of plug-ins that you specify for the **srvcon_gssplugin_list** database manager configuration parameter on the server. Having the Kerberos plug-in name in this list enables the client to scan the server and select the Kerberos authentication method when making a connection.

If this configuration parameter is left empty and you set the **authentication** configuration parameter to KERBEROS or KRB_SERVER_ENCRYPT, the default Kerberos plug-in, IBMkrb5, is used instead. You can specify only one Kerberos plug-in.

Finally, to use Kerberos for authorization of incoming connections only, set the**svrcon_auth** parameter to one of the following two options:

- KERBEROS to use only Kerberos authentication; or
- KRB_SERVER_ENCRYPT to use Kerberos and SERVER_ENCRYPT authorization.

If you want to use Kerberos for incoming connections and local authorizations, leave the **svrcon_auth** configuration parameter empty and set the value of the **authentication** configuration parameter to one of the Kerberos options.

Kerberos plug-in creation

To customize the behavior of Kerberos authentication on a Db2 database system, you can develop your own Kerberos authentication plug-ins.

Consider the following points when creating a Kerberos plug-in:

- Write the Kerberos plug-in as a GSS-API plug-in, but in the initialization function, set the *plugintype* variable to DB2SEC_PLUGIN_TYPE_KERBEROS for the function pointer array that is returned to the Db2 database instance.
- Under certain conditions, the server reports the server principal name to the client. The Kerberos plug-in must specify principals in the GSS_C_NT_USER_NAME format (that is, *server*/*host*@*REALM*). The GSS_C_NT_HOSTBASED_SERVICE format (that is, *service*@*host*) is not supported.

Kerberos compatibility

Db2 Kerberos authentication is compatible with IBM System z®, IBM i, and Windows systems.

IBM System z and IBM i compatibility

To connect to a database on an IBM System z or IBM i system, you must catalog the database by using the **AUTHENTICATION** and **KERBEROS TARGET PRINCIPAL** parameters of the **CATALOG DATABASE** command.

Neither IBM System z nor IBM i operating systems support the mutual authentication security feature of Kerberos.

Windows issues

When you are using Kerberos on Windows operating systems, be aware of the following issues:

- Due to the manner in which Windows operating systems detect and report some errors, the following conditions result in a client security plug-in error.
  - Expired account
  - Invalid password
  - Expired password
  - Password change forced by administrator
  - Disabled account

  Furthermore, in all cases, the Db2 administration log or the **db2diag** log files contain `Logon failed` or `Logon denied` messages.
- If a domain account name is also defined locally, connections explicitly specifying the domain name and password fail with the following error: `The Local Security Authority cannot be contacted`. The error is a result of the Windows operating system locating the local user first. The solution is to fully qualify the user in the connection string, for example `name@DOMAIN.IBM.COM`.
- Windows accounts cannot include the at sign (@) character in their names because the Db2 Kerberos plug-in assumes that the character is the domain name separator.
- If the client and server are both on the Windows operating system, you can start the Db2 service using the `LocalSystem` account. However, if the client and server are in different domains, the connection can fail with an invalid target principal name error. To avoid this error, explicitly catalog the target principal on the client with the **CATALOG DATABASE** command, using the fully qualified server host name and the fully qualified domain name. Use the following format: *host/server hostname@server domain name*. For example, host248/server34.toronto.ibm.com@TORONTO.IBM.COM. An alternative to using the `LocalSystem` account is to use a valid domain account.

Maintaining passwords on servers

You might be required to perform password maintenance tasks. Because such tasks are typically required at the server, and many users are not able or comfortable working with the server environment, performing these tasks can pose a significant challenge. The Db2 database system provides a way to update and verify passwords without having to be at the server.

You can assign new passwords when you connect to databases on the following servers for the indicated (and later) releases: Db2 Universal Database Version 8 on AIX and Windows operating systems, Db2 Version 9.1 Fix Pack 3 or later on Linux operating systems, Db2 for z/OS Version 7, Db2 for IBM i V6R1.

For example, if an error message SQL1404N "Password expired" or SQL30082N "Security processing failed with reason 1 (PASSWORD EXPIRED)" is received, use the CONNECT statement to change the password as follows:

```
CONNECT TO database USER userid USING
    password NEW new_password CONFIRM new_password
```

Authentication and group cache

A new cache for both User ID and Password based authentication, and group plug-ins has been introduced to relieve pressure on backend authentication mechanisms.

Attention: This feature is available in Db2 Version 11.5 Mod Pack 3 and later versions.

The authentication portion of the cache will store information about successful authentications and compare the information from new, incoming authentication requests against the cached entries to see if a valid match is found. If the match is found, the new authentication request is considered successful and subsequent Db2 post-authentication processing begins.

This cache will only be applied to authentication requests associated with CONNECT requests that provide passwords for authentication. The cache exists at each database member that receives CONNECT

requests, and the cache contents are independent of the contents of the cache at any other database member.

The group portion of the cache will store a list of any external groups associated with a given User ID. This list is normally returned as part of the authentication process. If a match for a User ID is found in the group cache, the cached list of groups is returned and external group lookup is skipped.

Cache benefits

Enabling the cache is most beneficial when the authentication service for a Db2 instance is on a remote host and there is no caching locally on the server. Overhead of the network communication and overloading the authentication service can lead to significant delays when authenticating with the Db2 server, which results in slower connects. Using the ldap security plugin falls into this category.

Configuration

Both database configuration parameters for the authentication cache can be configured online and do not require the database to be deactivated and reactivated.

The number of entries to be cached is determined by the user and indicated by a new database configuration parameter. When the number of cached entries reaches the configured maximum value, any new entry to be cached will force the eviction of an existing cache entry.

See the parameter AUTHN_CACHE_USERS for more information.

The duration of time when a cached entry is considered valid for comparison is determined by the user and indicated by a new database configuration parameter. This duration begins when the cached entry is first entered into the cache; once the duration is exceeded, the entry is no longer considered valid for comparison against new requests and can be evicted.

See the parameter AUTHN_CACHE_DURATION for more information.

Cache monitoring and performance

The MON_GET_CONNECTION table function contains several metrics associated with the active connections for a given database. One of these metrics, `total_connect_authentication_time`, measures how long authentication took for a given connection. If the value for `total_connect_authentication_time` goes down once the cache is enabled, then the cache is working.

The MON_GET_DATABASE table function contains several metrics associated with the authentication cache itself.

AUTHN_CACHE_LOOKUPS measures how many times the cache is searched for an entry. AUTHN_CACHE_HITS, alternatively, measures how many times the Db2 server was able to find a valid entry corresponding to a given user. The efficiency of the cache can be defined by how often the server finds valid authentication information in the cache every time the server accesses it during authentication. The cache efficiency or hit ratio can be calculated by (AUTHN_CACHE_HITS / AUTHN_CACHE_LOOKUPS).

If the hit ratio of the cache is low, there could be two reasons:

1. If the cache size is too small, this leads to constant eviction of valid entries. This lowers the probability of finding cached authentication information for a given user.
2. The period for which an entry is valid in the cache before that user must be reauthenticated is too short. This means entries are expiring too fast. In this case, if matching authentication information is found for a connecting user, it cannot be used because it is expired.

The AUTHN_CACHE_EXPIRED_EVICTIONS monitoring metric counts how many times the system evicted an expired entry from the cache. The AUTHN_CACHE_VALID_EVICTIONS metric counts the number of evictions of entries that were still valid at the time of eviction. If the value of AUTHN_CACHE_EXPIRED_EVICTIONS is growing faster than that of AUTHN_CACHE_VALID_EVICTIONS,

it implies that the maximum duration an entry is valid in the cache is too short and should be increased. If it is the opposite, then the cache is too small and increasing its size could improve the cache efficiency.

Password and group membership changes

Db2 is unaware when the password or group membership of a given user changes, therefore, any entries in the cache containing stale information are still considered valid until they expire. In such a situation, a stale group list may be returned, or authentication with an old password may be returned.

If a user's password is changed and authentication is attempted with the new password, a stale entry present in the cache will be updated and any future authentications with that new password will be handled by the cache.

If a user's group membership changes, the entry must expire, be evicted, or be flushed before the cache can store updated group information.

To immediately invalidate all entries and flush the cache, the FLUSH AUTHENTICATION CACHE statement can be run. See FLUSH AUTHENTICATION CACHE for more information.

Token authentication

Token authentication is a mechanism for generalizing tokens such that they can be used for authentication to the Db2 server in a unified method. The token, represented as a string and a token type are sent by the client to the server. The token is opaque to the client, but is understood and can be validated by the server.

Note: This feature is available starting from Db2 version 11.5.4.

Currently, Db2 supports JSON Web Tokens (JWT).

Tokens are used in place of user IDs and passwords. They encapsulate both the identity of the user and proof of that identity into a single entity. Tokens are generated outside of Db2 and passed as input on the **connect** statement. If generated by an application or Identity Provider that uses the token for multiple services, it can provide a form of single sign-on (SSO).

Not all interfaces that establish connections to the database server accept tokens instead of user ID and passwords, only explicitly **CONNECT** statements do. For tools that establish local implicit connections (specifying neither user ID nor password), token authentication must always be configured along with an additional authentication mechanism such as SERVER_ENCRYPT, because there is no mechanism to obtain a default token from the environment.

At the Db2 server, token authentication is configured by first creating a token configuration file with details on how to validate the tokens, and then setting the **SRVCON_AUTH** database manager configuration parameter to one of the *_TOKEN values.

At the client, token authentication is first configured for use by setting TOKEN as the desired authentication mechanism, and then passing the token and type as input to the connect statement.

The tokens are not used for group membership, the configured group plug-in is used to lookup the users group.

Token authentication refers to the ability for the Db2 server to directly validate the token contents and authenticate the user. In addition, GSSAPI based security plug-ins can also take a token as input. That is not considered token authentication, it is still plug-in authentication but with a token input. How the client is configured will determine which security mechanism is used.

Token configuration file

In order to support token authentication, several configuration values are required to describe what types of tokens are supported, and how they are to be validated.

Before you begin

Note: This feature is available starting from Db2 version 11.5.4.

A file, db2token.cfg must be created in the instance directory, which defaults to the following:

- Linux and UNIX (for serial or DPF) $INSTHOME/sqllib/cfg
- Linux and UNIX for pureScale (for serial or DPF): $INSTHOME/sqllib_shared/cfg
- Windows: C:\ProgramData\IBM\DB2\db2copy1\DB2\cfg

The configuration file must be owned by the instance owner with read/write permissions.

Procedure

On the Db2 server, create the token configuration file in a text editor.

Keywords

Consider a JWT to be validated as follows:

```
{
   "alg": "RS256",
   "typ": "JWT"
}
.
{
   "username": "admin",
   "sub": "admin",
   "iss": "KNOXSSO",
   "iat": 1579286619,
   "exp": 1579329819
 }
 .
 signature
```

and this example token configuration file:

```
VERSION=1
TOKEN_TYPES_SUPPORTED=JWT
JWT_KEYDB=/home/db2inst1/jwtkeys.p12

JWT_IDP_ISSUER=KNOXSSO
JWT_IDP_AUTHID_CLAIM=username
JWT_IDP_RSA_CERTIFICATE_LABEL=mylabel
JWT_IDP_ISSUER=A_SECOND_ISSUER
JWT_IDP_AUTHID_CLAIM=userid
JWT_IDP_RSA_CERTIFICATE_LABEL=aDifferentLabel
```

Common parameters:

VERSION
The version of the configuration file. (Mandatory)

TOKEN_TYPES_SUPPORTED
The types of tokens supported as a comma-separated list. Currently, JWT is the only supported token type. (Mandatory)

JWT Parameters:

JWT_KEYDB
The path to local keystore file. (Mandatory)

Private keys, and public keys as certificates, are stored in a local keystore file with a corresponding stash file (*.sth extension). This keystore is used to store keys for all IDP and key labels must be unique across IDPs.

JWT IDP Group parameters:

The following parameters are grouped together and apply to a single IDP. The group starts with **JWT_IDP_ISSUER** and succeeding keywords apply to that IDP until the next **JWT_IDP_ISSUER** is parsed.

JWT_IDP_ISSUER
The name of the issuer of the token. Corresponds to iss claim in the JWT and must match exactly. Must appear first in a group of parameters particular to one IDP. (Mandatory)

JWT_IDP_AUTHID_CLAIM
The claim within the JWT that specifies the key holding the authorization ID of the user connecting to Db2. Must appear after **JWT_IDP_ISSUER** parameter. The value will depend on the contents specified by IDP. It may be a value such as "username", "userid", "uid" or "sub". This is not the value of the authid, but the key which identifies the authid in the token (see example above).

- Nested JSON is not supported for the claim

Rules for authid value in the token, which is looked up on the basis of this config parameter:

- The authorization ID in the token will be converted to uppercase.
- Additional parsing of the claim, such as separating a username portion of an email address, is not supported, the claim is taken as-is.

JWT_IDP_SECRETKEY_LABEL
The label for the secret (symmetric) key used to verify the signature of the token using the HMAC-SHA algorithm. Must appear after **JWT_IDP_ISSUER** parameter. (Optional)

JWT_IDP_RSA_CERTIFICATE_LABEL
The label for the certificate containing the public key used to verify the signature of the token using the RSA algorithm. Must appear after **JWT_IDP_ISSUER** parameter. (Optional)

JWT_IDP_ECDSA_CERTIFICATE_LABEL
The label for the certificate containing the ECDSA public key, used to verify the signature of the token using the ECDSA algorithm. Must appear after **JWT_IDP_ISSUER** parameter. (Optional)

JWT_IDP_PSS_CERTIFICATE_LABEL
The label for the certificate containing the RSA public key used to verify the signature of the token using the PSS-RSA algorithm. Must appear after **JWT_IDP_ISSUER** parameter. (Optional)

Notes

- Unless otherwise indicated, do not use quotes around values
- With the exception of **TOKEN_TYPES_SUPPORTED**, the value for all other parameters is case-sensitive. For example, the value for **JWT_IDP_ISSUER** must match exactly the `iss` value in the JWT.
- At least one IDP group must be specified.
- Starting from Db2 version 11.5.5, multiple labels are supported for JSON Web Tokens. Up to 10 issuers can be specified. Each issuer can have a maximum of 5 labels for each label type. Each of the labels are extracted and verified against token signature for verification.
- The maximum number of IDP groups is 6 for Db2 version 11.5.4, and 10 starting from version 11.5.5.
- For each IDP group, at least one of **JWT_IDP_SECRETKEY_LABEL**, **JWT_IDP_RSA_CERTIFICATE_LABEL**, **JWT_IDP_ECDSA_CERTIFICATE_LABEL**, **JWT_IDP_PSS_CERTIFICATE_LABEL** must be specified.
- Up to 5 labels can be specified for each label type per IDP group. Labels should be specified on separate lines. For example:

```
JWT_IDP_SECRETKEY_LABEL=secretkeyLabel1
JWT_IDP_SECRETKEY_LABEL=secretkeyLabel2
JWT_IDP_SECRETKEY_LABEL=secretkeyLabel3
JWT_IDP_SECRETKEY_LABEL=secretkeyLabel4
JWT_IDP_SECRETKEY_LABEL=secretkeyLabel5
```

  When multiple labels are used, each of the labels is extracted and an attempt is made to verify the token signature with the label until verification is successful or all labels have been attempted.
- Take caution when deciding to use the HMAC-SHA signature algorithm for signing tokens, because the key used to sign the token is the same as the one used to validate the signature. Therefore, anyone that can check signatures can also generate them. This should only be used in scenarios where there is strong trust between the issuer/signer (the IDP) and the verifier (Db2 instance owner).

Dynamic updates to the token configuration file

Dynamic updates allow you to update certificates that are close to their expiry dates without the need for a temporary outage.

The token configuration will be automatically refreshed during TOKEN authentication when the following conditions are met:

- The token configuration file on disk has an updated timestamp compared to the in-memory token configuration currently used by Db2.
- Db2 was unable to authenticate the presented **TOKEN**. This can occur when a new token type or verification certificate was added to the token configuration file.

Db2 will then read the updated token configuration from disk and attempt to authenticate presented token. If the token was successfully authenticated using the on-disk configuration, the in-memory token configuration will be updated and the connection will continue. If the token could not be verified using the on-disk configuration, the in memory configuration will not be updated and an error will be returned.

This behavior can be turned off by setting the Db2 registry variable **DB2_REFRESH_TOKEN_CONFIG_ON_FAILURE** to false. This registry variable is dynamic and can be updated online.

```
db2set DB2_REFRESH_TOKEN_CONFIG_ON_FAILURE=false
```

The **ADMIN_REFRESH_CONFIG** stored procedure can be used to manually refresh the Db2 token configuration file:

```
db2 call sysproc.admin_refresh_config('token')
```

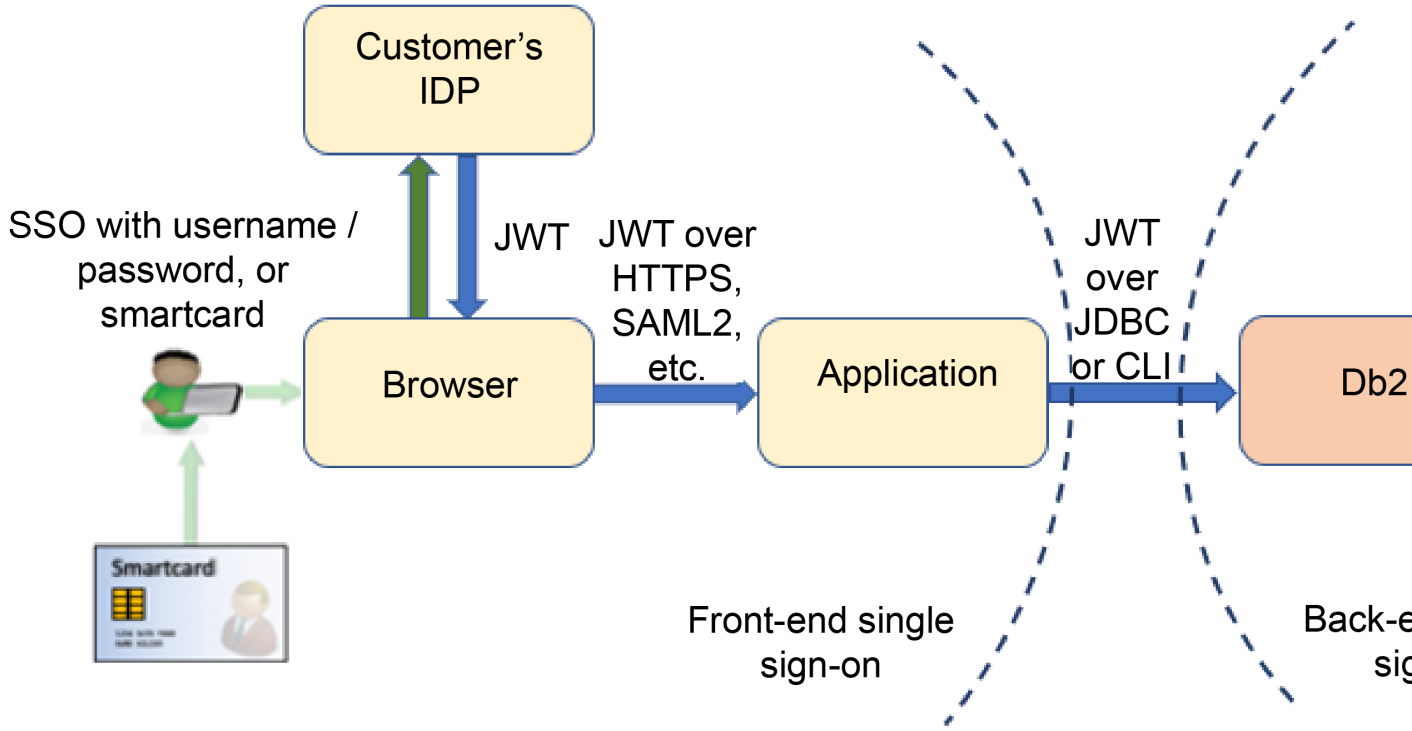
JSON Web Tokens (JWT)

JSON Web Tokens (JWT) are used to securely transmit authentication information formatted as a JSON object.

As JWT are digitally signed by the issuer, they can be used for authentication purposes by validating the signature, without having to expose a password to Db2. A claim within the JWT identifies the user's identity Db2.

Typically, it is an Identity Provider (IDP) product that will generate the JWT when a user logs in through an application, although it is possible for an individual application to create a JWT itself. Db2 can validate JWT but does not provide a method for generating them.

A diagram of the JWT workflow



The issuer of the JWT must be identified in the token under the 'iss' claim. An exact match for the issuer must be found in the token configuration file (`db2token.cfg`) in the **`JWT_IDP_ISSUER`** parameter in order to locate keys for validating the JWT signature. A local keystore file of type PKCS#12 (*.p12) is used to hold the keys and its location must be configured in the token configuration file.

The signature algorithm is declared as part of the JWT header. Db2 supports the following signature algorithms:

- HMAC using SHA2 (HS256, HS384, HS512)
- RSASSA-PKCS1-v1 using SHA2 (RS256, RS384, RS512)
- ECDSA P-256 with SHA256 (ES256)
- ECDSA P-384 with SHA384 (ES384)
- ECDSA P-512 with SHA512 (ES512)
- Available starting from Db2 version 11.5.5:
  - RSASSA-PSS using SHA-256 and MGF1 with SHA-256 (PS256)
  - RSASSA-PSS using SHA-384 and MGF1 with SHA-384 (PS384)
  - RSASSA-PSS using SHA-512 and MGF1 with SHA-512 (PS512)

Db2 does not support encrypted JWT. TLS/SSL is strongly recommended to protect the JWT while sent over the network.

For Db2 to validate tokens signed with the indicated algorithm, you must configure the appropriate key. A secret key that was used to sign the JWT must be configured if HS256, HS384 or HS512 is used. A certificate with appropriate public key must be configured for each of RSA signature algorithms. The label for these keys are specified in the `db2token.cfg` file.

To determine the identity of the token holder, Db2 examines the contents of the token itself. The token configuration file, under the **`JWT_IDP_AUTHID_CLAIM`** parameter determines which claim within the token holds the users identity. This claim will be taken as the authorization ID of the user within Db2. While not required to be named so, the claim is often called "sub" (for subject) or "username". Individual IDPs often include the ability to customize the JWT they produce, and it may even be possible to generate a claim such as "db2authid".

No processing is performed on the value identified by the authid claim. For example if a claim identifies an email address, it is not broken apart into username and domain portions, but kept as a whole.

The JWT must include an expiry time in the 'exp' claim, as Db2 does not support revoking methods. Careful thought must be given to appropriate values for the expiry time. If the JWT were exposed to a malicious user, a value that is too large increases the window during which it may be used. A value that is too small may interfere with Db2 operations. Once a connection is established, the token can expire without consequence. However, there are certain scenarios in which the token may be re-used, and if it had expired prevent the operation from succeeding. Specifically:

- Automatic Client Reroute: re-establishing a new connection would reuse the existing token and fail if it had expired.
- Federation connections to remote data source: When configured for single-sign on (SSO), outbound connections to remote data sources will use the JWT that was used to connect to the Federation server. If the token has expired, this connection will fail.

Often, when a JWT is generated, it is accompanied by a refresh token. Db2 does not support using a refresh token to obtain a new, non-expired JWT.

Db2 does not obtain group information or other authorization details from the JWT. The standard group plug-in is used to obtain groups for the user.

For the JWT to be validated by Db2, it must have the following properties:

- If a 'typ' claim is in the token header, it must have the value JWT. The claim is optional and does not need to be present.
- An 'alg' claim of a supported algorithm, and appropriately configured key in the `db2token.cfg` file
- An 'iss' claim that matches an issuer in the `db2token.cfg` file.
- A JWT_IDP_AUTHID_CLAIM claim identifying the authorization ID of the user.
- An 'exp' claim with a value that has not expired

The JWT may contain any other claims, but they are ignored by Db2.

The following is a sample JWT header and claims.

Example HEADER:

```
{
   "alg": "RS256",
   "typ": "JWT"
}
```

Example PAYLOAD:

```
{
   "username": "admin",
   "sub": "admin",
   "iss": "KNOXSSO",
   "aud": "DSX",
   "role": "Admin",
   "permissions": [
     "administrator",
     "can_provision"
   ],
   "uid": "1000330999",
   "authenticator": "default",
   "display_name": "admin",
   "iat": 1579286619,
   "exp": 1579329819
 }
```

In this case

- The issuer is KNOXSSO.
- The JWT signing algorithm uses RS256 - (RSA signature with SHA256).
- The expiration time for JWT is set at 12 hours.

- The "username" claim identifies the Db2 authorization ID.

Authorization, privileges, and object ownership

Users (identified by an authorization ID) can successfully execute operations only if they have the authority to perform the specified function. To create a table, a user must be authorized to create tables; to alter a table, a user must be authorized to alter the table; and so forth.

The database manager requires that each user be specifically authorized to use each database function needed to perform a specific task. A user can acquire the necessary authorization through a grant of that authorization to their user ID or through membership in a role or a group that holds that authorization.

There are three forms of authorization, *administrative authority*, *privileges*, and *LBAC credentials*. In addition, ownership of objects brings with it a degree of authorization on the objects created. These forms of authorization are discussed in the following section.

Administrative authority

The person or persons holding administrative authority are charged with the task of controlling the database manager and are responsible for the safety and integrity of the data.

System-level authorization

The system-level authorities provide varying degrees of control over instance-level functions:

- SYSADM (system administrator) authority

  The SYSADM (system administrator) authority provides control over all the resources created and maintained by the database manager. The system administrator possesses all the authorities of SYSCTRL, SYSMAINT, and SYSMON authority. The user who has SYSADM authority is responsible both for controlling the database manager, and for ensuring the safety and integrity of the data.

- SYSCTRL authority

  The SYSCTRL authority provides control over operations that affect system resources. For example, a user with SYSCTRL authority can create, update, start, stop, or drop a database. This user can also start or stop an instance, but cannot access table data. Users with SYSCTRL authority also have the SYSMAINT and SYSMON authorities.

- SYSMAINT authority

  The SYSMAINT authority provides the authority required to perform maintenance operations on all databases associated with an instance. A user with SYSMAINT authority can update the database configuration, backup a database or table space, restore an existing database, and monitor a database. Like SYSCTRL, SYSMAINT does not provide access to table data. Users with SYSMAINT authority also have SYSMON authority.

- SYSMON (system monitor) authority

  The SYSMON (system monitor) authority provides the authority required to use the database system monitor.

Database-level authorization

The database level authorities provide control within the database:

- DBADM (database administrator)

  The DBADM authority level provides administrative authority over a single database. This database administrator possesses the privileges required to create objects and issue database commands.

  The DBADM authority can be granted only by a user with SECADM authority. The DBADM authority cannot be granted to PUBLIC.

- SECADM (security administrator)

  The SECADM authority level provides administrative authority for security over a single database. The security administrator authority possesses the ability to manage database security objects

(database roles, audit policies, trusted contexts, security label components, and security labels) and grant and revoke all database privileges and authorities. A user with SECADM authority can transfer the ownership of objects that they do not own. They can also use the AUDIT statement to associate an audit policy with a particular database or database object at the server.

The SECADM authority has no inherent privilege to access data stored in tables. It can only be granted by a user with SECADM authority. The SECADM authority cannot be granted to PUBLIC.

- SQLADM (SQL administrator)

  The SQLADM authority level provides administrative authority to monitor and tune SQL statements within a single database. It can be granted by a user with ACCESSCTRL or SECADM authority.

- WLMADM (workload management administrator)

  The WLMADM authority provides administrative authority to manage workload management objects, such as service classes, work action sets, work class sets, and workloads. It can be granted by a user with ACCESSCTRL or SECADM authority.

- EXPLAIN (explain authority)

  The EXPLAIN authority level provides administrative authority to explain query plans without gaining access to data. It can only be granted by a user with ACCESSCTRL or SECADM authority.

- ACCESSCTRL (database access control authority)

  The ACCESSCTRL authority level provides administrative authority to issue the following GRANT (and REVOKE) statements.

  – GRANT (Database Authorities)

    ACCESSCTRL authority does not give the holder the ability to grant ACCESSCTRL, DATAACCESS, DBADM, or SECADM authority. Only a user who has SECADM authority can grant these authorities.
  – GRANT (Global Variable Privileges)
  – GRANT (Index Privileges)
  – GRANT (Module Privileges)
  – GRANT (Package Privileges)
  – GRANT (Routine Privileges)
  – GRANT (Schema Privileges)
  – GRANT (Sequence Privileges)
  – GRANT (Server Privileges)
  – GRANT (Table, View, or Nickname Privileges)
  – GRANT (Table Space Privileges)
  – GRANT (Workload Privileges)
  – GRANT (XSR Object Privileges)

  ACCESSCTRL authority can only be granted by a user with SECADM authority. The ACCESSCTRL authority cannot be granted to PUBLIC.

- DATAACCESS (database data access authority)

  The DATAACCESS authority level provides the following privileges and authorities.

  – LOAD authority
  – SELECT, INSERT, UPDATE, DELETE privilege on tables, views, nicknames, and materialized query tables
  – EXECUTE privilege on packages
  – EXECUTE privilege on modules
  – EXECUTE privilege on routines

    Except on the audit routines: AUDIT_ARCHIVE, AUDIT_LIST_LOGS, AUDIT_DELIM_EXTRACT.

  - READ privilege on all global variables and WRITE privilege on all global variables except variables which are read-only
  - USAGE privilege on all XSR objects
  - USAGE privilege on all sequences

  It can be granted only by a user who holds SECADM authority. The DATAACCESS authority cannot be granted to PUBLIC.
- Database authorities (non-administrative)

  To perform activities such as creating a table or a routine, or for loading data into a table, specific database authorities are required. For example, the LOAD database authority is required for use of the **1oad** utility to load data into tables (a user must also have the privilege to insert data into the table).

Schema-level authorization

The schema-level authorities provide control over a schema. They cannot be granted to PUBLIC or be granted with the WITH GRANT OPTION.

- SCHEMAADM (Schema administrator)

  The SCHEMADM authority provides administrative authority over a single schema. The schema administrator has the privilege to create and manage objects in the schema. It implicitly has the schema LOAD authority.
- ACCESSCTRL (Schema access control authority)

  The schema ACCESSCTRL authority provides the ability to grant and revoke all privileges on objects defined in the schema. The schema ACCESSCTRL authority can also grant and revoke all schema-level authorities and privileges on the schema except schema ACCESSCTRL itself.
- DATAACCESS (Schema data access authority)

  The schema DATAACCESS authority allows users to read and write data on all objects existing in the schema. The authority also gives users the permission to reference sequences and xsrobjects, execute routines, modules, and packages defined the schema, and implicit schema LOAD authority.
- LOAD (Schema load authority)

  The schema LOAD authority allows users to use the load utility to load data into tables defined in the schema (the user must also have the privilege to insert data into the table).

Privileges

A privilege is a permission to perform an action or a task. Authorized users can create objects, have access to objects they own, and can pass on privileges on their own objects to other users by using the GRANT statement.

Privileges may be granted to individual users, to groups, or to PUBLIC. PUBLIC is a special group that consists of all users, including future users. Users that are members of a group will indirectly take advantage of the privileges granted to the group, where groups are supported.

The CONTROL privilege: Possessing the CONTROL privilege on an object allows a user to access that database object, and to grant and revoke privileges to or from other users on that object.

Note: The CONTROL privilege only applies to tables, views, nicknames, indexes, and packages.

If a different user requires the CONTROL privilege to that object, a user with SECADM or ACCESSCTRL authority could grant the CONTROL privilege to that object. The CONTROL privilege cannot be revoked from the object owner, however, the object owner can be changed by using the TRANSFER OWNERSHIP statement.

Individual privileges: Individual privileges can be granted to allow a user to carry out specific tasks on specific objects. Users with the administrative authorities ACCESSCTRL or SECADM, or with the CONTROL privilege, can grant and revoke privileges to and from users.

Individual privileges and database authorities allow a specific function, but do not include the right to grant the same privileges or authorities to other users. The right to grant table, view, schema, package, routine, and sequence privileges to others can be extended to other users through the WITH GRANT OPTION on the GRANT statement. However, the WITH GRANT OPTION does not allow the person granting the privilege to revoke the privilege once granted. You must have SECADM authority, ACCESSCTRL authority, or the CONTROL privilege to revoke the privilege.

Privileges on objects in a package or routine: When a user has the privilege to execute a package or routine, they do not necessarily require specific privileges on the objects used in the package or routine. If the package or routine contains static SQL or XQuery statements, the privileges of the owner of the package are used for those statements. If the package or routine contains dynamic SQL or XQuery statements, the authorization ID used for privilege checking depends on the setting of the **DYNAMICRULES BIND** option of the package issuing the dynamic query statements, and whether those statements are issued when the package is being used in the context of a routine (except on the audit routines: AUDIT_ARCHIVE, AUDIT_LIST_LOGS, AUDIT_DELIM_EXTRACT).

A user or group can be authorized for any combination of individual privileges or authorities. When a privilege is associated with an object, that object must exist. For example, a user cannot be given the SELECT privilege on a table unless that table has previously been created.

Note: Care must be taken when an authorization name representing a user or a group is granted authorities and privileges and there is no user, or group created with that name. At some later time, a user or a group can be created with that name and automatically receive all of the authorities and privileges associated with that authorization name.

The REVOKE statement is used to revoke previously granted privileges. The revoking of a privilege from an authorization name revokes the privilege granted by all authorization names.

Revoking a privilege from an authorization name does not revoke that same privilege from any other authorization names that were granted the privilege by that authorization name. For example, assume that CLAIRE grants SELECT WITH GRANT OPTION to RICK, then RICK grants SELECT to BOBBY and CHRIS. If CLAIRE revokes the SELECT privilege from RICK, BOBBY and CHRIS still retain the SELECT privilege.

LBAC credentials

Label-based access control (LBAC) lets the security administrator decide exactly who has write access and who has read access to individual rows and individual columns. The security administrator configures the LBAC system by creating security policies. A security policy describes the criteria used to decide who has access to what data. Only one security policy can be used to protect any one table but different tables can be protected by different security policies.

After creating a security policy, the security administrator creates database objects, called security labels and exemptions that are part of that policy. A security label describes a certain set of security criteria. An exemption allows a rule for comparing security labels not to be enforced for the user who holds the exemption, when they access data protected by that security policy.

Once created, a security label can be associated with individual columns and rows in a table to protect the data held there. Data that is protected by a security label is called protected data. A security administrator allows users access to protected data by granting them security labels. When a user tries to access protected data, that user's security label is compared to the security label protecting the data. The protecting label blocks some security labels and does not block others.

Object ownership

When an object is created, one authorization ID is assigned *ownership* of the object. Ownership means the user is authorized to reference the object in any applicable SQL or XQuery statement.

When an object is created within a schema, the authorization ID of the statement must have the required privilege to create objects in the implicitly or explicitly specified schema. That is, the authorization name must either be the owner of the schema, or possess the CREATEIN privilege on the schema.

Note: This requirement is not applicable when creating table spaces, buffer pools or database partition groups. These objects are not created in schemas.

When an object is created, the authorization ID of the statement is the definer of that object and by default becomes the owner of the object after it is created.

Note: One exception exists. If the AUTHORIZATION option is specified for the CREATE SCHEMA statement, any other object that is created as part of the CREATE SCHEMA operation is owned by the authorization ID specified by the AUTHORIZATION option. Any objects that are created in the schema after the initial CREATE SCHEMA operation, however, are owned by the authorization ID associated with the specific CREATE statement.

For example, the statement `CREATE SCHEMA SCOTTSTUFF AUTHORIZATION SCOTT CREATE TABLE T1 (C1 INT)` creates the schema SCOTTSTUFF and the table `SCOTTSTUFF.T1`, which are both owned by SCOTT. Assume that the user BOBBY is granted the CREATEIN privilege on the SCOTTSTUFF schema and creates an index on the `SCOTTSTUFF.T1` table. Because the index is created after the schema, BOBBY owns the index on `SCOTTSTUFF.T1`.

Privileges are assigned to the object owner based on the type of object being created:

- The CONTROL privilege is implicitly granted on newly created tables, indexes, and packages. This privilege allows the object creator to access the database object, and to grant and revoke privileges to or from other users on that object. If a different user requires the CONTROL privilege to that object, a user with ACCESSCTRL or SECADM authority must grant the CONTROL privilege to that object. The CONTROL privilege cannot be revoked by the object owner.
- The CONTROL privilege is implicitly granted on newly created views if the object owner has the CONTROL privilege on all the tables, views, and nicknames referenced by the view definition.
- Other objects like triggers, routines, sequences, table spaces, and buffer pools do not have a CONTROL privilege associated with them. The object owner does, however, automatically receive each of the privileges associated with the object and those privileges are with the WITH GRANT OPTION, where supported. Therefore the object owner can provide these privileges to other users by using the GRANT statement. For example, if USER1 creates a table space, USER1 automatically has the USEAUTH privilege with the WITH GRANT OPTION on this table space and can grant the USEAUTH privilege to other users. In addition, the object owner can alter, add a comment on, or drop the object. These authorizations are implicit for the object owner and cannot be revoked.

Certain privileges on the object, such as altering a table, can be granted by the owner, and can be revoked from the owner by a user who has ACCESSCTRL or SECADM authority. Certain privileges on the object, such as commenting on a table, cannot be granted by the owner and cannot be revoked from the owner. Use the TRANSFER OWNERSHIP statement to move these privileges to another user. When an object is created, the authorization ID of the statement is the definer of that object and by default becomes the owner of the object after it is created. However, when you use the **BIND** command to create a package and you specify the **OWNER** *authorization id* option, the owner of objects created by the static SQL statements in the package is the value of *authorization id*. In addition, if the AUTHORIZATION clause is specified on a CREATE SCHEMA statement, the authorization name specified after the AUTHORIZATION keyword is the owner of the schema.

A security administrator or the object owner can use the TRANSFER OWNERSHIP statement to change the ownership of a database object. An administrator can therefore create an object on behalf of an authorization ID, by creating the object using the authorization ID as the qualifier, and then using the TRANSFER OWNERSHIP statement to transfer the ownership that the administrator has on the object to the authorization ID.

Authorities overview

Various administrative authorities exist at the instance level, at the database level, and at the schema level. These administrative authorities group together certain privileges and authorities so that you can grant them to the users who are responsible for these tasks in your database installation.

Instance level authorities

Instance level authorities enable you to perform instance-wide functions, such as creating and upgrading databases, managing table spaces, and monitoring activity and performance on your instance. No instance-level authority provides access to data in database tables. The following diagram summarizes the abilities given by each of the instance level administrative authorities:

- SYSADM -for users managing the instance as a whole
- SYSCTRL -for users administering a database manager instance
- SYSMAINT -for users maintaining databases within an instance
- SYSMON -for users monitoring the instance and its databases

A user with a higher-level authority also has the abilities given by the lower level authorities. For example, a user with SYSCTRL authority can perform the functions of users with SYSMAINT and SYSMON authority as well.

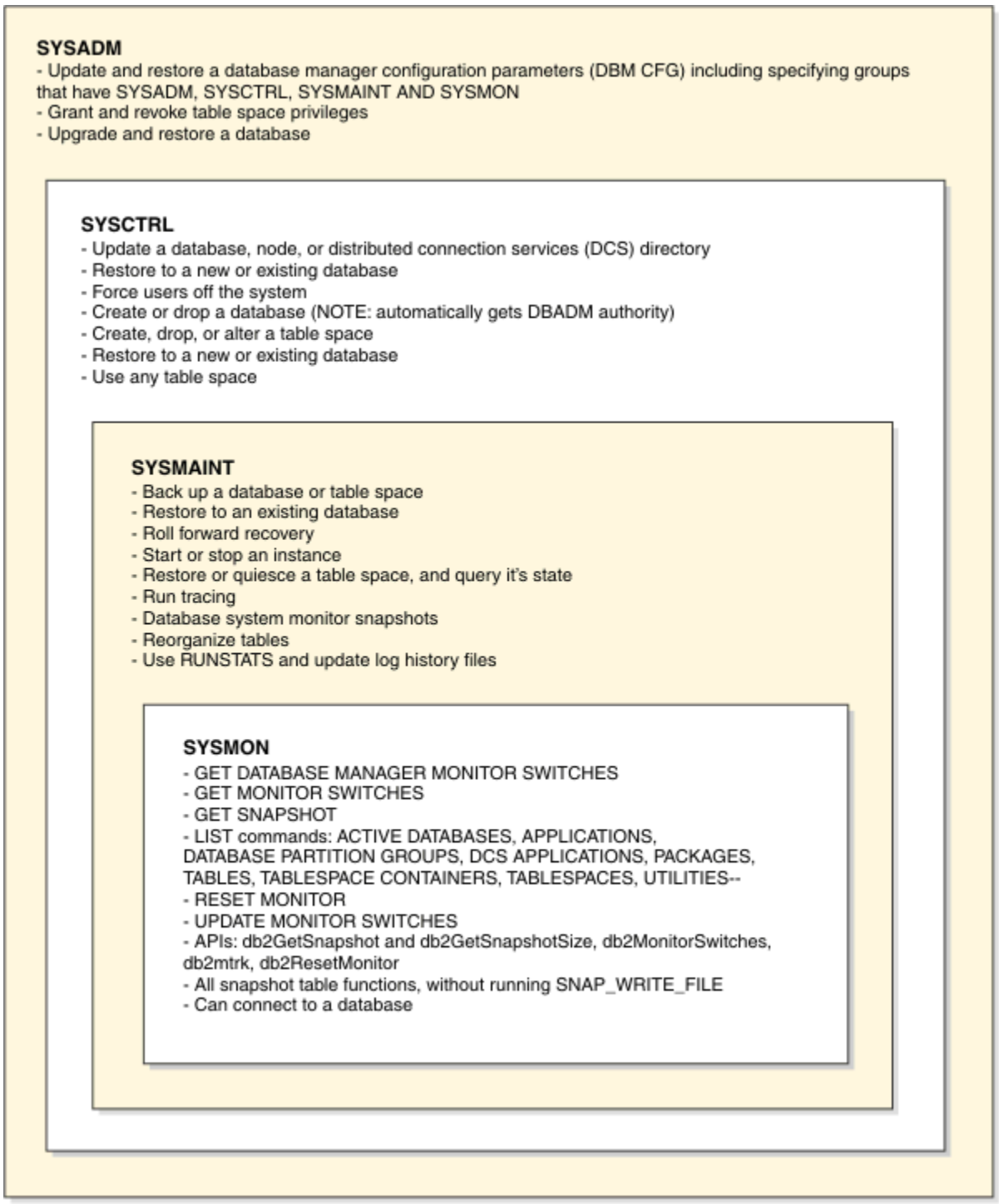


Figure 1. Instance-level authorities

Database level authorities

Database level authorities enable you to perform functions within a specific database, such as granting and revoking privileges, inserting, selecting, deleting and updating data, and managing workloads. The following diagram summarizes the abilities given by each of the database level authorities. The administrative database authorities are:

- SECADM - for users managing security within a database
- DBADM - for users administering a database

- ACCESSCTRL - for users who need to grant and revoke authorities and privileges (except for SECADM, DBADM, ACCESSCTRL, and DATAACCESS authority, SECADM authority is required to grant and revoke these authorities)
- DATAACCESS - for users who need to access data
- SQLADM - for users who monitor and tune SQL queries
- WLMADM - for users who manage workloads
- EXPLAIN - for users who need to explain query plans (EXPLAIN authority does not give access to the data itself)

The following diagram shows, where appropriate, which higher level authorities include the abilities given by a lower level authority. For example, a user with DBADM authority can perform the functions of users with SQLADM and EXPLAIN authority, and all functions except granting USAGE privilege on workloads, of users with WLMADM authority.

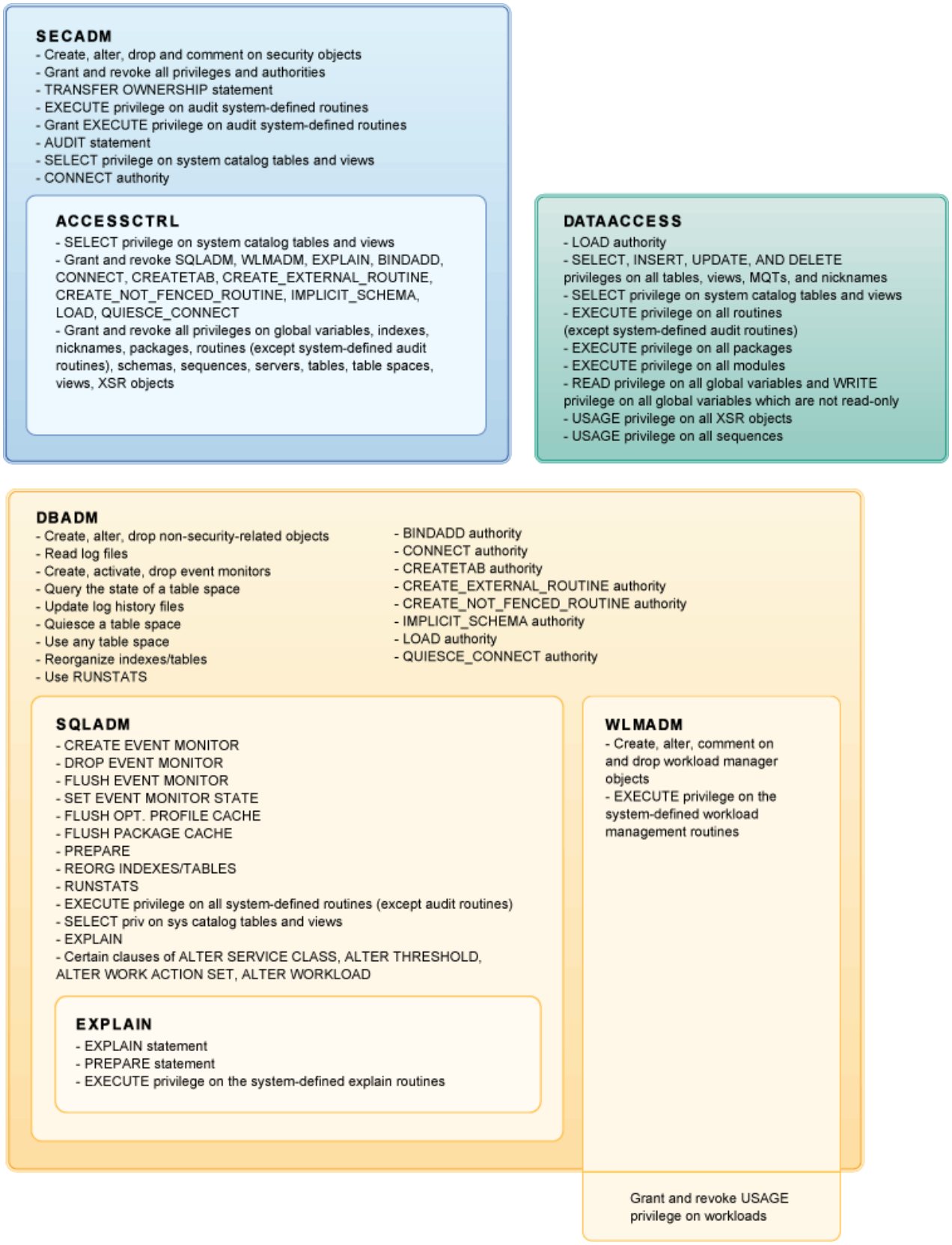


Figure 2. Database-level authorities

Schema level authorities

Schema level authorities enable you to perform functions within a specific schema, such as granting and revoking privileges, inserting, selecting, deleting and updating data, and executing routines, modules, and packages. The following diagram summarizes the abilities given by each of the schema level authorities. The schema authorities are:

- SCHEMAADM - for users administering a schema.
- ACCESSCTRL - for users who need to grant authorities and privileges on a schema (except Schema ACCESSCTRL) or on objects defined a schema.
- DATAACCESS - for users who need to read and write data on objects defined in a schema.
- LOAD - for users who need to use the load utility to insert data in tables defined in a schema.

The following diagram shows, where appropriate, which higher level authorities include the abilities given by a lower level authority. For example, a user with DBADM authority can perform the functions of users with SQLADM and EXPLAIN authority, and all functions except granting USAGE privilege on workloads, of users with WLMADM authority.

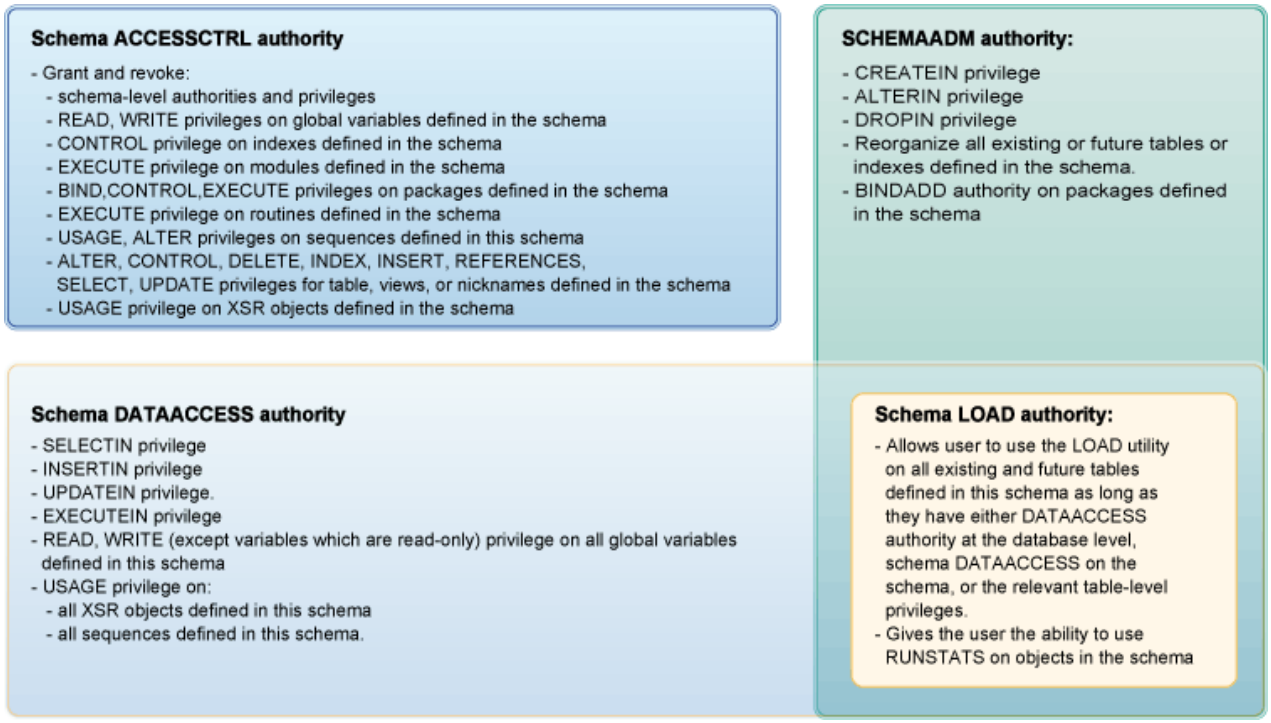


Figure 3. Schema-level authorities

Internal system-defined routine

When Security Administrator (SECADM) users GRANT privileges to individual routines for users, SECADM users might come across certain internal routines. When users do not have the required privileges for these internal routines, operations that require the privilege of these internal routines might fail.

This table can be useful when deploying a restrictive database. Users can encounter missing privilege errors on certain internal routines. SECADM must consult this table and the routine description to decide whether they need to grant EXECUTE privilege on the specific internal routine that is failing with an authorization error.

This table can also be useful when the SECADM is trying to harden/secure a non-restrictive database. After you receive the report of privileges on internal routines that are granted to the special group PUBLIC, a SECADM user can consult this table to decide which internal routines still need EXECUTE privilege granted to specific users, roles, or groups.

These internal routines, their respective description, and the appropriate criteria to use them in a GRANT statement are as follows:

Table 2. Internal system-defined routine needed by non-SECADM users	
Routine Name	**Description**

Instance level authorities

System administration authority (SYSADM)

The SYSADM authority level is the highest level of administrative authority at the instance level. Users with SYSADM authority can run some utilities and issue some database and database manager commands within the instance.

SYSADM authority is assigned to the group specified by the **sysadm_group** configuration parameter. Membership in that group is controlled outside the database manager through the security facility used on your platform.

Only a user with SYSADM authority can perform the following functions:

- Upgrade a database
- Restore a database
- Change the database manager configuration file (including specifying the groups having SYSADM, SYSCTRL, SYSMAINT, or SYSMON authority)

Note: In Db2 11.5.7 and later, use the SYSADM authority to perform the following actions:

- Grant and revoke table space privileges and can also use any table space.
- Grant and revoke CREATE_EXTERNAL_ROUTINE and CREATE_NOT_FENCED_ROUTINE privileges on the database.
- Grant and revoke the EXECUTE privilege on the UTL_DIR module.
- Execute the UTL_DIR module dynamically.

Note: When a user with SYSADM authority creates a database, that user is automatically granted ACCESSCTRL, DATAACCESS, DBADM and SECADM authority on the database. If you want to prevent that user from accessing that database as a database administrator or a security administrator, you must explicitly revoke these database authorities from the user.

In releases before Version 9.7, SYSADM authority included implicit DBADM authority and also provided the ability to grant and revoke all authorities and privileges. In Version 9.7, the Db2 authorization model has been updated to clearly separate the duties of the system administrator, the database administrator, and the security administrator. As part of this enhancement, the abilities given by the SYSADM authority have been reduced.

In Version 9.7, only SECADM authority provides the ability to grant and revoke all authorities and privileges.

For a user holding SYSADM authority to obtain the same capabilities as in Version 9.5 (other than the ability to grant SECADM authority), the security administrator must explicitly grant the user DBADM authority and grant the user the new DATAACCESS and ACCESSCTRL authorities. These new authorities can be granted by using the GRANT DBADM ON DATABASE statement with the WITH DATAACCESS and WITH ACCESSCTRL options of that statement, which are default options. The DATAACCESS authority is the authority that allows access to data within a specific database, and the ACCESSCTRL authority is the authority that allows a user to grant and revoke privileges and non-administrative authorities within a specific database.

Considerations for the Windows LocalSystem account

On Windows systems, when the **sysadm_group** database manager configuration parameter is not specified, the LocalSystem account is considered a system administrator (holding SYSADM authority). Any Db2 application that is run by LocalSystem is affected by the change in scope of SYSADM authority in Version 9.7. These applications are typically written in the form of Windows services and run under the LocalSystem account as the service logon account. If there is a need for these applications to perform database actions that are no longer within the scope of SYSADM, you must grant the LocalSystem account the required database privileges or authorities. For example, if an application requires database administrator capabilities, grant the LocalSystem account DBADM authority using the GRANT (Database Authorities) statement. Note that the authorization ID for the LocalSystem account is SYSTEM.

System control authority (SYSCTRL)

SYSCTRL authority is the highest level of system control authority. This authority provides the ability to perform maintenance and utility operations against the database manager instance and its databases. These operations can affect system resources, but they do not allow direct access to data in the databases.

System control authority is designed for users administering a database manager instance containing sensitive data.

SYSCTRL authority is assigned to the group specified by the **sysctrl_group** configuration parameter. If a group is specified, membership in that group is controlled outside the database manager through the security facility used on your platform.

Only a user with SYSCTRL authority or higher can perform the following actions:

- Update a database, node, or distributed connection services (DCS) directory
- Create or drop a database
- Drop, create, or alter a table space
- Use any table space
- Restore to a new or an existing database.

In addition, a user with SYSCTRL authority can perform the functions of users with system maintenance authority (SYSMAINT) and system monitor authority (SYSMON).

Users with SYSCTRL authority also have the implicit privilege to connect to a database.

Note: When users with SYSCTRL authority create databases, they are automatically granted explicit ACCESSCTRL, DATAACCESS, DBADM, and SECADM authorities on the database. If the database creator is removed from the SYSCTRL group, and if you want to also prevent them from accessing that database as an administrator, you must explicitly revoke the four administrative authorities mentioned previously.

System maintenance authority (SYSMAINT)

SYSMAINT authority is the second level of system control authority. This authority provides the ability to perform maintenance and utility operations against the database manager instance and its databases. These operations can affect system resources, but they do not allow direct access to data in the databases.

System maintenance authority is designed for users maintaining databases within a database manager instance that contains sensitive data.

SYSMAINT authority is assigned to the group specified by the **sysmaint_group** configuration parameter. If a group is specified, membership in that group is controlled outside the database manager through the security facility used on your platform.

Only a user with SYSMAINT or higher system authority can perform the following actions:

- Back up a database or table space
- Restore to an existing database

- Perform roll forward recovery
- Force users off the system
- Start or stop an instance
- Restore a table space
- Run a trace, using the **db2trc** command
- Take database system monitor snapshots of a database manager instance or its databases.

A user with SYSMAINT authority can perform the following actions:

- Query the state of a table space
- Update log history files
- Quiesce a table space
- Reorganize a table
- Collect catalog statistics using the **RUNSTATS** utility.

Users with SYSMAINT authority also have the implicit privilege to connect to a database, and can perform the functions of users with system monitor authority (SYSMON).

System monitor authority (SYSMON)

SYSMON authority provides the ability to take database system monitor snapshots of a database manager instance or its databases.

SYSMON authority is assigned to the group specified by the **sysmon_group** configuration parameter. If a group is specified, membership in that group is controlled outside the database manager through the security facility used on your platform.

SYSMON authority enables the user to run the following commands:

- **GET DATABASE MANAGER MONITOR SWITCHES**
- **GET MONITOR SWITCHES**
- **GET SNAPSHOT**
- LIST (some commands):
  - **LIST ACTIVE DATABASES**
  - **LIST APPLICATIONS**
  - **LIST DATABASE PARTITION GROUPS**
  - **LIST DCS APPLICATIONS**
  - **LIST PACKAGES**
  - **LIST TABLES**
  - **LIST TABLESPACE CONTAINERS**
  - **LIST TABLESPACES**
  - **LIST UTILITIES**
- **RESET MONITOR**
- **UPDATE MONITOR SWITCHES**

SYSMON authority enables the user to use the following APIs:

- `db2GetSnapshot` - Get Snapshot
- `db2GetSnapshotSize` - Estimate Size Required for db2GetSnapshot() Output Buffer
- `db2MonitorSwitches` - Get/Update Monitor Switches
- `db2mtrk` - Memory tracker
- `db2ResetMonitor` - Reset Monitor

SYSMON authority enables the user use the following SQL table functions:

- All snapshot table functions without previously running SYSPROC.SNAP_WRITE_FILE

  SYSPROC.SNAP_WRITE_FILE takes a snapshot and saves its content into a file. If any snapshot table functions are called with null input parameters, the file content is returned instead of a real-time system snapshot.

  Important: The SYSPROC.SNAP_WRITE_FILE procedure is deprecated and might be removed in a future release. For more information, see "SNAP_WRITE_FILE procedure" in *Administrative Routines and Views*.

Database authorities

Each database authority allows the authorization ID holding it to perform some particular type of action on the database as a whole. Database authorities are different from privileges, which allow a certain action to be taken on a particular database object, such as a table or an index.

These are the database authorities.

ACCESSCTRL
Allows the holder to grant and revoke all object privileges and database authorities except for privileges on the audit routines, and ACCESSCTRL, DATAACCESS, DBADM, and SECADM authority.

BINDADD
Allows the holder to create new packages in the database.

CONNECT
Allows the holder to connect to the database.

CREATETAB
Allows the holder to create new tables in the database.

CREATE_EXTERNAL_ROUTINE
Allows the holder to create a procedure for use by applications and other users of the database.

CREATE_NOT_FENCED_ROUTINE
Allows the holder to create a user-defined function (UDF) or procedure that is *not fenced*. CREATE_EXTERNAL_ROUTINE is automatically granted to any user who is granted CREATE_NOT_FENCED_ROUTINE.

Attention: The database manager does not protect its storage or control blocks from UDFs or procedures that are not fenced. A user with this authority must, therefore, be very careful to test their UDF extremely well before registering it as not fenced.

DATAACCESS
Allows the holder to access data stored in database tables.

DBADM
Allows the holder to act as the database administrator. In particular it gives the holder all of the other database authorities except for ACCESSCTRL, DATAACCESS, and SECADM.

EXPLAIN
Allows the holder to explain query plans without requiring them to hold the privileges to access data in the tables referenced by those query plans.

IMPLICIT_SCHEMA
Allows any user to create a schema implicitly by creating an object using a CREATE statement with a schema name that does not already exist. SYSIBM becomes the owner of the implicitly created schema and PUBLIC is given the privilege to create objects in this schema.

LOAD
Allows the holder to load data into a table

QUIESCE_CONNECT
Allows the holder to access the database while it is quiesced.

SECADM
Allows the holder to act as a security administrator for the database.

SQLADM
Allows the holder to monitor and tune SQL statements.

WLMADM
Allows the holder to act as a workload administrator. In particular, the holder of WLMADM authority can create and drop workload manager objects, grant and revoke workload manager privileges, and execute workload manager routines.

Only authorization IDs with the SECADM authority can grant the ACCESSCTRL, DATAACCESS, DBADM, and SECADM authorities. All other authorities can be granted by authorization IDs that hold ACCESSCTRL or SECADM authorities.

To remove any database authority from PUBLIC, an authorization ID with ACCESSCTRL or SECADM authority must explicitly revoke it.

Security administration authority (SECADM)

SECADM authority is the security administration authority for a specific database. This authority allows you to create and manage security-related database objects and to grant and revoke all database authorities and privileges. Additionally, the security administrator can execute, and manage who else can execute, the audit system routines.

SECADM authority has the ability to SELECT from the catalog tables and catalog views, but cannot access data stored in user tables.

SECADM authority can be granted only by the security administrator (who holds SECADM authority) and can be granted to a user, a group, or a role. PUBLIC cannot obtain the SECADM authority directly or indirectly.

The database must have at least one authorization ID of type USER with the SECADM authority. The SECADM authority cannot be revoked from every authorization ID of type USER.

SECADM authority gives a user the ability to perform the following operations:

- Create, alter, comment on, and drop:
  - Audit policies
  - Security label components
  - Security policies
  - Trusted contexts
- Create, comment on, and drop:
  - Roles
  - Security labels
- Grant and revoke database privileges and authorities
- Execute the following audit routines to perform the specified tasks:
  - The SYSPROC.AUDIT_ARCHIVE stored procedure and table function archive audit logs.
  - The SYSPROC.AUDIT_LIST_LOGS table function allows you to locate logs of interest.
  - The SYSPROC.AUDIT_DELIM_EXTRACT stored procedure extracts data into delimited files for analysis.

  Also, the security administrator can grant and revoke EXECUTE privilege on these routines, therefore enabling the security administrator to delegate these tasks, if required. Only the security administrator can grant EXECUTE privilege on these routines. EXECUTE privilege WITH GRANT OPTION cannot be granted for these routines (SQLSTATE 42501).
- Change the settings of the **encrlib** and **encropts** database configuration parameters.
- Execute the following security routines to perform the specified tasks:
  - The SYSPROC.ADMIN_ROTATE_MASTER_KEY stored procedure to rotate the master key for an encrypted database.

  - The SYSPROC.ADMIN_GET_ENCRYPTION_INFO table function to return the encryption information about the database.
- Use of the AUDIT statement to associate an audit policy with a particular database or database object at the server
- Use of the TRANSFER OWNERSHIP statement to transfer objects not owned by the authorization ID of the statement

No other authority gives these abilities.

Only the security administrator has the ability to grant other users, groups, or roles the ACCESSCTRL, DATAACCESS, DBADM, and SECADM authorities.

In Version 9.7, the Db2 authorization model has been updated to clearly separate the duties of the system administrator, the database administrator, and the security administrator. As part of this enhancement, the abilities given by the SECADM authority have been extended. In releases before Version 9.7, SECADM authority did not provide the ability to grant and revoke all privileges and authorities. Also, SECADM authority could be granted only to a user, not to a role or a group. Additionally, SECADM authority did not provide the ability to grant EXECUTE privilege to other users on the audit built-in procedures and table function.

Database administration authority (DBADM)

DBADM authority is an administrative authority for a specific database. The database administrator possesses the privileges that are required to create objects and issue database commands. DBADM authority has SELECT privileges on system catalog tables and views, and can run all built-in Db2 routines, except audit routines and the SET_MAINT_MODE_RECORD_NO_TEMPORALHISTORY procedure.

DBADM authority can only be granted or revoked by the security administrator (who holds SECADM authority) and can be granted to a user, a group, or a role. PUBLIC cannot obtain the DBADM authority either directly or indirectly.

Holding the DBADM authority for a database allows a user to perform these actions on that database:

- Create, alter, and drop non-security related database objects
- Read log files
- Create, activate, and drop event monitors
- Query the state of a table space
- Update log history files
- Quiesce a table space
- Use any table space
- Reorganize a table
- Collect catalog statistics using the **RUNSTATS** utility

SQLADM authority and WLMADM authority are subsets of the DBADM authority. WLMADM authority has the additional ability to grant the USAGE privilege on workloads.

Granting DATAACCESS authority with DBADM authority

The security administrator can specify whether a database administrator can access data within the database. DATAACCESS authority is the authority that allows access to data within a specific database. The security administrator can use the WITH DATAACCESS option of the GRANT DBADM ON DATABASE statement to provide a database administrator with this ability. If neither the WITH DATAACCESS or WITHOUT DATAACCESS options are specified, by default DATAACCESS authority is granted.

To grant database administrator authority without DATAACCESS authority, use GRANT DBADM WITHOUT DATAACCESS in your SQL statement.

Granting ACCESSCTRL authority with DBADM authority

The security administrator can specify whether a database administrator can grant and revoke privileges within the database. ACCESSCTRL authority is the authority that allows a user to grant and revoke privileges and non-administrative authorities within a specific database. The security administrator can use the WITH ACCESSCTRL option of the GRANT DBADM ON DATABASE statement to provide a database administrator with this ability. If neither the WITH ACCESSCTRL or WITHOUT ACCESSCTRL options are specified, by default ACCESSCTRL authority is granted.

To grant database administrator authority without ACCESSCTRL authority, use GRANT DBADM WITHOUT ACCESSCTRL in your SQL statement.

Revoking DBADM authority

If a security administrator has granted DBADM authority that includes DATAACCESS or ACCESSCTRL authority, to revoke these authorities, the security administrator must explicitly revoke DATAACCESS or ACCESSCTRL authority. For example, if the security administrator grants DBADM authority to a user:

```
GRANT DBADM ON DATABASE TO user1
```

By default, DATAACCESS and ACCESSCTRL authority are also granted to user1.

Later, the security administrator revokes DBADM authority from user1:

```
REVOKE DBADM ON DATABASE FROM user1
```

Now user1 no longer holds DBADM authority, but still has both DATAACCESS and ACCESSCTRL authority.

To revoke these remaining authorities, the security administrator needs to revoke them explicitly:

```
REVOKE ACCESSCTRL, DATAACCESS ON DATABASE FROM user1
```

Differences for DBADM authority in prior releases

In Version 9.7, the Db2 authorization model has been updated to clearly separate the duties of the system administrator, the database administrator, and the security administrator. As part of this enhancement, the abilities given by the DBADM authority have changed. In releases before Version 9.7, DBADM authority automatically included the ability to access data and to grant and revoke privileges for a database. In Version 9.7, these abilities are given by the new authorities, DATAACCESS and ACCESSCTRL as explained earlier.

Also, in releases before Version 9.7, granting DBADM authority automatically granted the following authorities too:

- BINDADD
- CONNECT
- CREATETAB
- CREATE_EXTERNAL_ROUTINE
- CREATE_NOT_FENCED_ROUTINE
- IMPLICIT_SCHEMA
- QUIESCE_CONNECT
- LOAD

Before Version 9.7, when DBADM authority was revoked these authorities were not revoked.

In Version 9.7, these authorities are now part of DBADM authority. When DBADM authority is revoked in Version 9.7, these authorities are lost.

However, if a user held DBADM authority when you upgraded to Version 9.7, these authorities are not lost if DBADM authority is revoked. Revoking DBADM authority in Version 9.7 causes a user to lose these authorities only if they acquired them through holding DBADM authority that was granted in Version 9.7.

Access control administration authority (ACCESSCTRL)

ACCESSCTRL authority is the authority required to grant and revoke privileges on objects within a specific database. ACCESSCTRL authority has no inherent privilege to access data stored in tables, except the catalog tables and views.

ACCESSCTRL authority can only be granted by the security administrator (who holds SECADM authority). It can be granted to a user, a group, or a role. PUBLIC cannot obtain the ACCESSCTRL authority either directly or indirectly. ACCESSCTRL authority gives a user the ability to perform the following operations:

- Grant and revoke the following administrative authorities:
  - EXPLAIN
  - SQLADM
  - WLMADM
- Grant and revoke the following database authorities:
  - BINDADD
  - CONNECT
  - CREATETAB
  - CREATE_EXTERNAL_ROUTINE
  - CREATE_NOT_FENCED_ROUTINE
  - IMPLICIT_SCHEMA
  - LOAD
  - QUIESCE_CONNECT
- Grant and revoke all privileges on the following objects, regardless who granted the privilege:
  - Global Variable
  - Index
  - Nickname
  - Package
  - Routine (except audit routines)
  - Schema
  - Sequence
  - Server
  - Table
  - Table Space
  - View
  - XSR Objects
- SELECT privilege on the system catalog tables and views

This authority is a subset of security administrator (SECADM) authority.

Data access administration authority (DATAACCESS)

DATAACCESS is the authority that allows access to data within a specific database.

DATAACCESS authority can be granted only by the security administrator (who holds SECADM authority). It can be granted to a user, a group, or a role. PUBLIC cannot obtain the DATAACCESS authority either directly or indirectly.

For all tables, views, materialized query tables, and nicknames it gives these authorities and privileges:

- LOAD authority on the database
- SELECT privilege (including system catalog tables and views)
- INSERT privilege
- UPDATE privilege
- DELETE privilege

In addition, DATAACCESS authority provides the following privileges:

- EXECUTE on all packages
- EXECUTE on all routines (except audit routines, the SET_MAINT_MODE_RECORD_NO_TEMPORALHISTORY procedure, and the encryption related routines ADMIN_ROTATE_MASTER_KEY and ADMIN_GET_ENCRYPTION_INFO)
- EXECUTE on all modules
- READ on all global variables and WRITE on all global variables except variables which are read-only
- USAGE on all XSR objects
- USAGE on all sequences

SQL administration authority (SQLADM)

SQLADM authority is the authority required to monitor and tune SQL statements.

SQLADM authority can be granted by the security administrator (who holds SECADM authority) or a user who possesses ACCESSCTRL authority. SQLADM authority can be granted to a user, a group, a role, or to PUBLIC. SQLADM authority gives a user the ability to perform the following functions:

- Execution of the following SQL statements:
  - CREATE EVENT MONITOR
  - DROP EVENT MONITOR
  - EXPLAIN
  - FLUSH EVENT MONITOR
  - FLUSH OPTIMIZATION PROFILE CACHE
  - FLUSH PACKAGE CACHE
  - PREPARE
  - REORG INDEXES/TABLE
  - RUNSTATS
  - SET EVENT MONITOR STATE

  Note: If the **DB2AUTH** registry variable is set to SQLADM_NO_RUNSTATS_REORG, users with SQLADM authority will not be able to perform reorg or runstats operations.
- Execution of certain clauses of the following workload manager SQL statements:
  - The following clauses of the ALTER SERVICE CLASS statement:
    - COLLECT AGGREGATE ACTIVITY DATA
    - COLLECT AGGREGATE REQUEST DATA
    - COLLECT REQUEST METRICS
  - The following clause of the ALTER THRESHOLD statement
    - WHEN EXCEEDED COLLECT ACTIVITY DATA

    .
  - The following clauses of the ALTER WORK ACTION SET statement that allow you to alter a work action:

    - ALTER WORK ACTION ... COLLECT ACTIVITY DATA
    - ALTER WORK ACTION ... COLLECT AGGREGATE ACTIVITY DATA
    - ALTER WORK ACTION ... WHEN EXCEEDED COLLECT ACTIVITY DATA
  - The following clauses of the ALTER WORKLOAD statement:
    - COLLECT ACTIVITY METRICS
    - COLLECT AGGREGATE ACTIVITY DATA
    - COLLECT LOCK TIMEOUT DATA
    - COLLECT LOCK WAIT DATA
    - COLLECT UNIT OF WORK DATA
- SELECT privilege on the system catalog tables and views
- EXECUTE privilege on all built-in Db2 routines (except audit routines and the SET_MAINT_MODE_RECORD_NO_TEMPORALHISTORY procedure)

SQLADM authority is a subset of the database administrator (DBADM) authority.

EXPLAIN authority is a subset of the SQLADM authority.

Workload administration authority (WLMADM)

WLMADM authority is the authority required to manage workload objects for a specific database. This authority allows you to create, alter, drop, comment on, and grant and revoke access to workload manager objects.

WLMADM authority can be granted by the security administrator (who holds SECADM authority) or a user who possesses ACCESSCTRL authority. WLMADM authority can be granted to a user, a group, a role, or to PUBLIC. WLMADM authority gives a user the ability to perform the following operations:

- Create, alter, comment on, and drop the following workload manager objects:
  - Histogram templates
  - Service classes
  - Thresholds
  - Work action sets
  - Work class sets
  - Workloads
- Grant and revoke workload privileges
- Execute the built-in workload management routines.

WLMADM authority is a subset of the database administrator authority, DBADM.

Explain administration authority (EXPLAIN)

EXPLAIN authority is the authority required to explain query plans without gaining access to data for a specific database. This authority is a subset of the database administrator authority and has no inherent privilege to access data stored in tables.

EXPLAIN authority can be granted by the security administrator (who holds SECADM authority) or by a user who possesses ACCESSCTRL authority. The EXPLAIN authority can be granted to a user, a group, a role, or to PUBLIC. It gives the ability to execute the following SQL statements:

- EXPLAIN
- PREPARE
- DESCRIBE on output of a SELECT statement or of an XQuery statement

EXPLAIN authority also provides EXECUTE privilege on the built-in explain routines.

EXPLAIN authority is a subset of the SQLADM authority.

LOAD authority

Users having LOAD authority at the database level, as well as INSERT privilege on a table, can use the **LOAD** command to load data into a table.

Note: Having DATAACCESS authority gives a user full access to the LOAD command.

Users having LOAD authority at the database level, as well as INSERT privilege on a table, can **LOAD RESTART** or **LOAD TERMINATE** if the previous load operation is a load to insert data.

Users having LOAD authority at the database level, as well as the INSERT and DELETE privileges on a table, can use the **LOAD REPLACE** command.

If the previous load operation was a load replace, the DELETE privilege must also have been granted to that user before the user can **LOAD RESTART** or **LOAD TERMINATE**.

If the exception tables are used as part of a load operation, the user must have INSERT privilege on the exception tables.

The user with this authority can perform **QUIESCE TABLESPACES FOR TABLE**, **RUNSTATS**, and **LIST TABLESPACES** commands.

Implicit schema authority (IMPLICIT_SCHEMA) considerations

When a new database is created, PUBLIC is given IMPLICIT_SCHEMA database authority, unless the **RESTRICTIVE** option is specified on the **CREATE DATABASE** command.

With the IMPLICIT_SCHEMA authority, a user can create a schema by creating an object and specifying a schema name that does not exist. SYSIBM becomes the owner of the implicitly created schema and PUBLIC is given the privilege to create objects in this schema. When the database is restrictive, PUBLIC does not have the CREATEIN privilege on the schema. The user who implicitly creates the schema has CREATEIN privilege on the schema.

If control of who can implicitly create schema objects is required for the database, the database must be created with the RESTRICTIVE option specified. If the database is not restrictive, IMPLICIT_SCHEMA database authority must be revoked from PUBLIC. In this scenario, there are only three ways that a schema object is created:

- Any user can create a schema with their own authorization name on a CREATE SCHEMA statement.
- Any user with DBADM authority can explicitly create any schema which does not exist, and can optionally specify another user as the owner of the schema.
- Any user with DBADM authority has IMPLICIT_SCHEMA database authority, so that they can implicitly create a schema with any name at the time they are creating other database objects.

Related information

Best practices: A practical guide to restrictive databases

Schema authorities

Schema authorities are designed to allow an authorization ID to perform certain duties on a schema, i.e., schema administrator, schema access control manager, and schema data administrator. Schema authorities have been designed on the same principle as the database authorities but are different from them as their scope is limited only to the schema on which they are granted. Schema authorities are also different from privileges, which allow a certain action to be taken on a particular schema or schema object, such as a table or an index.

These are four schema authorities:

SCHEMAADM
Allows the authorization ID to act as the schema administrator.

Schema ACCESSCTRL
Allows the authorization ID to grant and revoke all privileges on objects defined in the schema. It also allows the authorization ID to grant and revoke all schema authorities and privileges except for schema ACCESSCTRL itself.

Schema DATAACCESS
Allows the authorization ID to access and manage data in a schema.

Schema LOAD
Allows the authorization ID to load data in to tables defined in the schema.

No schema authority can be granted to the special group PUBLIC directly or indirectly or be granted with grant option.

Schema administration authority (SCHEMAADM)

SCHEMAADM authority is the administrative authority for a specific schema. The schema administrator has the required privilege to create and manage objects in a schema.

SCHEMADM authority can only be granted or revoked by a user holding database SECADM or database ACCESSCTRL authority or schema ACCESSCTRL authority. It can be granted to a user, a group, or a role. However, it cannot be granted with grant option or be granted on any schema whose name begins with the "SYS". Additionally, PUBLIC cannot obtain the SCHEMAADM authority directly or indirectly through a role.

Having the SCHEMAADM authority on a schema gives a user the following privileges on that schema:

- Create, alter, and drop non-security related schema objects
- Reorganize indexes/tables in the schema
- Use RUNSTATS utility on tables defined in the schema
- Bind privilege on packages defined in the schema
- Schema LOAD authority

The authority is the subset of the database DBADM authority with its scope limited only to the schema on which it is granted.

Schema access control authority (ACCESSCTRL)

Schema ACCESSCTRL authority allows users to grant and revoke privileges on objects within a specific schema and on the schema itself. Schema ACCESSCTRL authority has no inherent privilege to access data stored in any tables or views.

Schema ACCESSCTRL authority can only be granted or revoked by a user holding database SECADM or database ACCESSCTRL authority. A user with schema ACCESSCTRL authority cannot grant or revoke the authority from other users. It can be granted to a user, a group, or a role. However, it cannot be granted with grant option or be granted on any schema whose name begins with the "SYS". Additionally, PUBLIC cannot obtain the schema ACCESSCTRL authority directly or indirectly through a role.

ACCESSCTRL authority gives a user the ability to perform the following operations:

- Grant and revoke the following schema authorities and privileges:
  - SCHEMAADM
  - Schema DATAACCESS
  - Schema LOAD
  - CREATEIN
  - ALTERIN
  - DROPIN
  - UPDATEIN
  - SELECTIN

  - INSERTIN
  - UPDATEIN
  - DELETEIN
  - EXECUTEIN
- Grant and revoke all privileges on the following objects defined in a schema:
  - Global Variable
  - Index
  - Nickname
  - Package
  - Routine (except audit routines)
  - Sequence
  - Table
  - View
  - XSR Objects

The authority is the subset of the database ACCESSCTRL authority with its scope limited only to the schema on which it is granted.

Schema data access authority (DATAACCESS)

Schema DATAACCESS authority allows users access to data within a specific schema on which it is granted.

Schema DATAACCESS authority can only be granted or revoked by a user holding database SECADM or database ACCESSCTRL authority or schema ACCESSCTRL authority. It can be granted to a user, a group, or a role. However, it cannot be granted with grant option or be granted on any schema whose name begins with the "SYS". Additionally, PUBLIC cannot obtain the Schema DATAACCESS authority directly or indirectly through a role.

For all tables, views, materialized query tables, and nicknames defined in a schema it gives the following authority and privileges:

- Schema LOAD authority
- SELECT privilege
- INSERT privilege
- UPDATE privilege
- DELETE privilege

In addition, schema DATAACCESS authority provides the following privileges:

- EXECUTE privilege on routines and packages defined in the schema
- READ, WRITE (except variables which are read-only) privilege on all global variables defined in the schema
- USAGE privilege on all XSR objects defined in the schema
- USAGE privilege on all sequences defined in the schema

The authority is the subset of the database DATAACCESS authority with its scope limited only to the schema on which it is granted.

Schema load authority (LOAD)

The schema LOAD authority allows users to use the LOAD utility on all tables defined in a schema as long as they have DATAACCESS authority either at the database or the schema level for this schema, or the

relevant table-level privileges. It also gives the user the ability to run the RUNSTATS utility on the tables defined in the schema.

The relevant table-level privileges are:

- Privilege to insert into a table for LOAD with mode INSERT, TERMINATE (to terminate a previous LOAD INSERT), or RESTART (to restart a previous LOAD INSERT)
- Privilege to insert into and delete from a table for LOAD with mode REPLACE, TERMINATE (to terminate a previous LOAD REPLACE), or RESTART (to restart a previous LOAD REPLACE)
- Privilege to insert into an exception table, if the exception table is used as part of LOAD operation

Schema LOAD authority can only be granted or revoked by a user holding database SECADM or database ACCESSCTRL authority or schema ACCESSCTRL authority. It can be granted to a user, a group, or a role. However, it cannot be granted with grant option or be granted on any schema whose name begins with the "SYS". Additionally, PUBLIC cannot obtain the Schema LOAD authority directly or indirectly through a role.

The authority is the subset of the database LOAD authority with its scope limited only to the schema on which it is granted.

Privileges

Authorization ID privileges: SETSESSIONUSER

Authorization ID privileges involve actions on authorization IDs. There is currently only one such privilege: the SETSESSIONUSER privilege.

The SETSESSIONUSER privilege can be granted to a user or to a group and allows the holder to switch identities to any of the authorization IDs on which the privilege was granted. The identity switch is made by using the SQL statement SET SESSION AUTHORIZATION. The SETSESSIONUSER privilege can only be granted by a user holding SECADM authority.

Note: When you upgrade a Version 8 database to Version 9.1, or later, authorization IDs with explicit DBADM authority on that database are automatically granted SETSESSIONUSER privilege on PUBLIC. This prevents breaking applications that rely on authorization IDs with DBADM authority being able to set the session authorization ID to any authorization ID. This does not happen when the authorization ID has SYSADM authority but has not been explicitly granted DBADM.

Schema privileges and authorities

Schema privileges are in the object privilege category.

Object privileges are shown in Figure 4 on page 49.

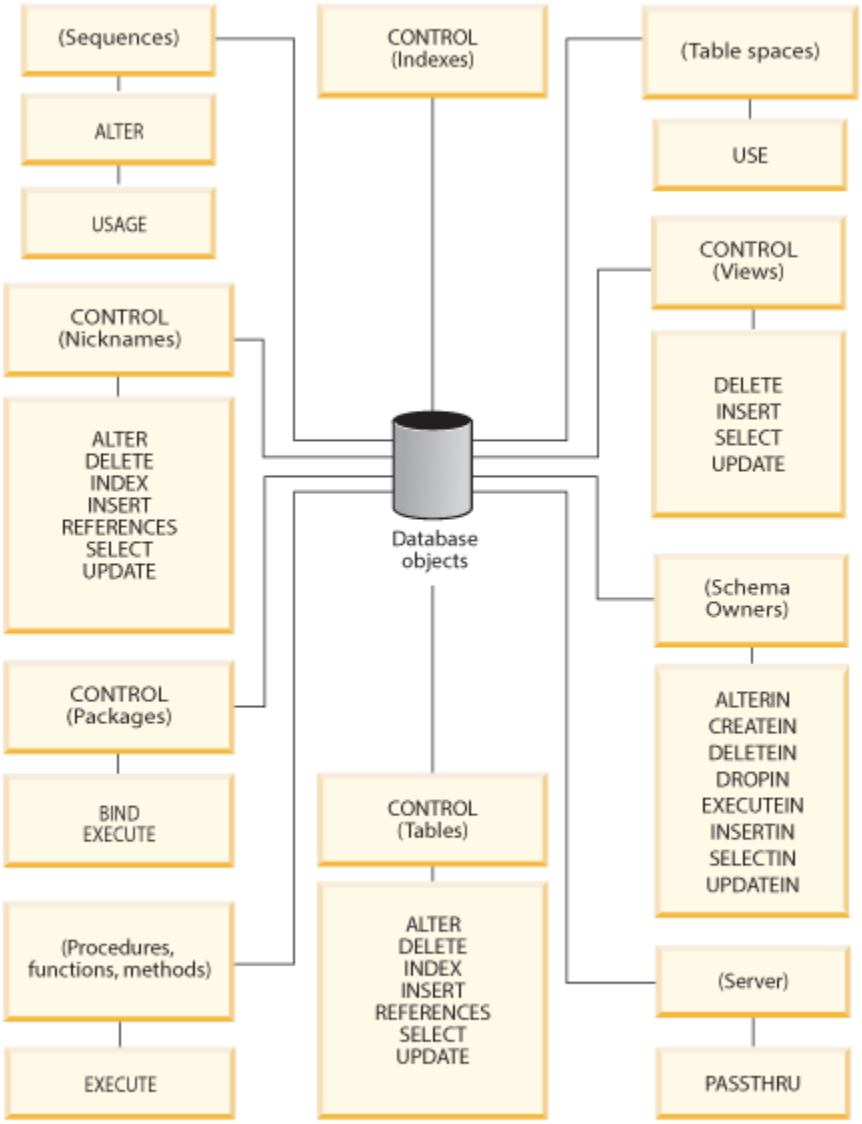


Figure 4. Object Privileges

Schema privileges and authorities involve actions on schemas in a database. A user, group, role, or PUBLIC can be granted any of the following privileges:

- CREATEIN allows the user to create objects within the schema.
- ALTERIN allows the user to alter objects within the schema.
- DROPIN allows the user to drop objects from within the schema.
- SELECTIN allows the user to execute select query on tables within the schema
- UPDATEIN allows the user to update a table within the schema
- INSERTIN allows the user to insert data into a table within the schema
- DELETEIN allows the user to delete rows from tables within the schema
- EXECUTEIN allows the user to execute user-defined functions, methods, procedures, packages, or modules defined in the schema.

Schema authorities

Schema LOAD authority:

The schema LOAD authority gives a user the right to use the LOAD utility on all existing and future tables defined in this schema as long as they have either DATAACCESS on the database, DATAACCESS on this schema, or the relevant table-level privileges. It also gives the user the ability to use RUNSTATS on objects in this schema.

The relevant table-level privileges are:

- INSERT privilege on the table for LOAD with mode INSERT, TERMINATE (to terminate a previous LOAD INSERT), or RESTART (to restart a previous LOAD INSERT)
- INSERT and DELETE privilege on the table for LOAD with mode REPLACE, TERMINATE (to terminate a previous LOAD REPLACE), or RESTART (to restart a previous LOAD REPLACE)
- INSERT privilege on the exception table, if such a table is used as part of LOAD

SCHEMAADM authority:

The SCHEMAADM authority provides administrative authority over a single schema.

This schema administrator implicitly possesses the following for this schema:

- CREATEIN privilege
- ALTERIN privilege
- DROPIN privilege
- schema LOAD authority
- The ability to reorganize indexes/tables in this schema
- The ability to use RUNSTATS on objects in this schema
- The BINDADD authority for packages whose names are qualified by this schema

The SCHEMAADM authority can be granted only by a user with schema ACCESSCTRL, ACCESSCTRL, or SECADM authority. The SCHEMAADM authority cannot be granted to PUBLIC.

Schema ACCESSCTRL authority:

The schema ACCESSCTRL authority provides administrative authority to issue the following statements for this schema:

- GRANT (and REVOKE) SCHEMAADM authority
- GRANT (and REVOKE) schema DATACCESS authority
- GRANT (and REVOKE) schema LOAD authority
- GRANT (and REVOKE) CREATEIN privilege
- GRANT (and REVOKE) ALTERIN privilege
- GRANT (and REVOKE) DROPIN privilege
- GRANT (and REVOKE) SELECTIN privilege
- GRANT (and REVOKE) INSERTIN privilege
- GRANT (and REVOKE) UPDATEIN privilege
- GRANT (and REVOKE) DELETEIN privilege
- GRANT (and REVOKE) EXECUTEIN privilege
- GRANT (and REVOKE) READ, WRITE privileges on global variables defined in this schema
- GRANT (and REVOKE) CONTROL privilege on indexes defined in this schema
- GRANT (and REVOKE) EXECUTE privilege on modules defined in this schema
- GRANT (and REVOKE) BIND,CONTROL,EXECUTE privileges on packages defined in this schema
- GRANT (and REVOKE) EXECUTE privilege on routines defined in this schema

- GRANT (and REVOKE) USAGE, ALTER privileges on sequences defined in this schema
- GRANT (and REVOKE) ALTER, CONTROL, DELETE, INDEX, INSERT, REFERENCES, SELECT, UPDATE privileges for table, views, or nicknames defined in this schema
- GRANT (and REVOKE) USAGE privilege on XSR objects defined in this schema

Schema ACCESSCTRL authority can only be granted by a user with ACCESSCTRL or SECADM authority. The schema ACCESSCTRL authority cannot be granted to PUBLIC.

Schema DATAACCESS authority:

The schema DATAACCESS authority level provides the following privileges and authorities within the schema:

- LOAD authority
- SELECTIN privilege
- INSERTIN privilege
- UPDATEIN privilege
- DELETEIN privilege
- EXECUTE privilege on packages defined in this schema
- EXECUTE privilege on modules defined in this schema
- EXECUTE privilege on routines defined in this schema
- READ, WRITE (except variables which are read-only) privilege on all global variables defined in this schema
- USAGE privilege on all XSR objects defined in this schema
- USAGE privilege on all sequences defined in this schema

Schema DATAACCESS can be granted only by a user who holds schema ACCESSCTRL, ACCESSCTRL, or SECADM authority. The schema DATAACCESS authority cannot be granted to PUBLIC.

The owner of the schema has CREATEIN, ALTERIN, DROPIN, and SCHEMADM privileges. The owner also gets the privilege to grant CREATEIN, ALTERIN, and DROPIN to others. The objects that are manipulated within the schema object include: tables, views, indexes, packages, data types, functions, triggers, procedures, and aliases.

Table space privileges

The table space privileges involve actions on the table spaces in a database. A user can be granted the USE privilege for a table space, which then allows them to create tables within the table space.

The owner of the table space is granted USE privilege with the WITH GRANT OPTION on the table space when it is created. Also, users who hold SECADM or ACCESSCTRL authority have the ability to grant USE privilege on the table space.

Users who hold SYSADM or SYSCTRL authority are able to use any table space.

Upon creating a non-restrictive database, by default, the USE privilege for the table space USERSPACE1 is granted to PUBLIC. This privilege can be later revoked.

You cannot GRANT the USE privilege to SYSCATSPACE and any other system temporary table spaces.

Table and view privileges

Table and view privileges involve actions on tables or views in a database.

A user must have CONNECT authority on the database to use any of the following privileges:

- CONTROL provides the user with all privileges for a table or view including the ability to drop it, and to grant and revoke individual table privileges. You must have ACCESSCTRL or SECADM authority to grant CONTROL. The creator of a table automatically receives CONTROL privilege on the table. The creator

of a view automatically receives CONTROL privilege only if they have CONTROL privilege on all tables, views, and nicknames referenced in the view definition.

- ALTER allows the user to modify on a table, for example, to add columns or a unique constraint to the table. A user with ALTER privilege can also COMMENT ON a table, or on columns of the table. For information about the possible modifications that can be performed on a table, see the ALTER TABLE and COMMENT statements.
- DELETE allows the user to delete rows from a table or view.
- INDEX allows the user to create an index on a table. Creators of indexes automatically have CONTROL privilege on the index.
- INSERT allows the user to insert a row into a table or view, and to run the **IMPORT** utility.
- REFERENCES allows the user to create and drop a foreign key, specifying the table as the parent in a relationship. The user might have this privilege only on specific columns.
- SELECT allows the user to retrieve rows from a table or view, to create a view on a table, and to run the **EXPORT** utility.
- UPDATE allows the user to change an entry in a table, a view, or for one or more specific columns in a table or view. The user may have this privilege only on specific columns.

The privilege to grant these privileges to others may also be granted using the WITH GRANT OPTION on the GRANT statement.

Note: When a user or group is granted CONTROL privilege on a table, all other privileges on that table are automatically granted WITH GRANT OPTION. If you subsequently revoke the CONTROL privilege on the table from a user, that user will still retain the other privileges that were automatically granted. To revoke all the privileges that are granted with the CONTROL privilege, you must either explicitly revoke each individual privilege or specify the ALL keyword on the REVOKE statement, for example:

```
REVOKE ALL
  ON EMPLOYEE FROM USER HERON
```

When working with typed tables, there are implications regarding table and view privileges.

Note: Privileges may be granted independently at every level of a table hierarchy. As a result, a user granted a privilege on a supertable within a hierarchy of typed tables may also indirectly affect any subtables. However, a user can only operate directly on a subtable if the necessary privilege is held on that subtable.

The supertable/subtable relationships among the tables in a table hierarchy mean that operations such as SELECT, UPDATE, and DELETE will affect the rows of the operation's target table and all its subtables (if any). This behavior can be called *substitutability*. For example, suppose that you have created an Employee table of type Employee_t with a subtable Manager of type Manager_t. A manager is a (specialized) kind of employee, as indicated by the type/subtype relationship between the structured types Employee_t and Manager_t and the corresponding table/subtable relationship between the tables Employee and Manager. As a result of this relationship, the SQL query:

```
SELECT * FROM Employee
```

will return the object identifier and Employee_t attributes for both employees and managers. Similarly, the update operation:

```
UPDATE Employee SET Salary = Salary + 1000
```

will give a thousand dollar raise to managers as well as regular employees.

A user with SELECT privilege on Employee will be able to perform this SELECT operation even if they do not have an explicit SELECT privilege on Manager. However, such a user will not be permitted to perform a SELECT operation directly on the Manager subtable, and will therefore not be able to access any of the non-inherited columns of the Manager table.

Similarly, a user with UPDATE privilege on Employee will be able to perform an UPDATE operation on Manager, thereby affecting both regular employees and managers, even without having the explicit

UPDATE privilege on the Manager table. However, such a user will not be permitted to perform UPDATE operations directly on the Manager subtable, and will therefore not be able to update non-inherited columns of the Manager table.

Package privileges

A package is a database object that contains the information needed by the database manager to access data in the most efficient way for a particular application program. Package privileges enable a user to create and manipulate packages.

The user must have CONNECT authority on the database to use any of the following privileges:

- CONTROL provides the user with the ability to rebind, drop, or execute a package as well as the ability to extend those privileges to others. The creator of a package automatically receives this privilege. A user with CONTROL privilege is granted the BIND and EXECUTE privileges, and can also grant these privileges to other users by using the GRANT statement. (If a privilege is granted using WITH GRANT OPTION, a user who receives the BIND or EXECUTE privilege can, in turn, grant this privilege to other users.) To grant CONTROL privilege, the user must have ACCESSCTRL or SECADM authority.
- BIND privilege on a package allows the user to rebind or bind that package and to add new package versions of the same package name and creator.
- EXECUTE allows the user to execute or run a package.

Note: All package privileges apply to all VERSIONs that share the same package name and creator.

In addition to these package privileges, the BINDADD database authority allows users to create new packages or rebind an existing package in the database.

Objects referenced by nicknames need to pass authentication checks at the data sources containing the objects. In addition, package users must have the appropriate privileges or authority levels for data source objects at the data source.

It is possible that packages containing nicknames might require additional authorization steps because Db2 database uses dynamic queries when communicating with Db2 Family data sources. The authorization ID running the package at the data source must have the appropriate authority to execute the package dynamically at that data source.

Index privileges

The creator of an index or an index specification automatically receives CONTROL privilege on the index. CONTROL privilege on an index is really the ability to drop the index. To grant CONTROL privilege on an index, a user must have ACCESSCTRL or SECADM authority.

The table-level INDEX privilege allows a user to create an index on that table.

The nickname-level INDEX privilege allows a user to create an index specification on that nickname.

Privileges on expression-based indexes

Special consideration must be given to privileges when you use expression-based indexes.

The authorization that is required to create an index with an expression-based key is the same authorization that is required for a regular index. For details, refer to the "Authorization" section of the CREATE INDEX topic in SQL Reference Volume 2.

When you create an expression-based index, two more database objects are system-generated and associated with the index. The first is a statistical view, and the second is a package. These additional objects are not system-generated when you create a regular index. A restricted set of privileges is granted on these additional objects.

Statistical view privileges

Normally, the authorization ID must hold either SELECT or DATAACCESS privilege on the table to create a statistical view. The same privilege is required to ALTER the same table to enable query optimization for the view.

For a system-generated statistical view that is associated with an index, these privileges are not required. The statistical view is automatically created if the authorization ID has the required authority to create an index on the table. However, the set of privileges that is granted on the statistical view that is associated with an index differ from a set of privileges on a normal statistical view. Namely, no privileges are granted to any authorization ID on the statistical view, including the owner of the index. The owner of the index is also the owner of the statistical view. No one, including authorization IDs with the SECADM or DBADM authority can modify privileges on a statistical view. An attempt to GRANT or REVOKE a privilege on the statistical view results in an error (SQLSTATE 42501).

The ability to issue RUNSTATS on the statistical view or manually update its statistics is governed by the authorities and privileges on the underlying table.

The TRANSFER OWNERSHIP operation on the statistical view is not allowed and results in SQL20344N, reason code 7. However, TRANSFER OWNERSHIP of an index with an expression-based key implicitly transfers the ownership of the associated statistical view.

Package privileges

No extra privileges are required to run any statement or command in the system-generated package. When an index is created with an expression-based key, any user with privileges on the table can use the package. That is, any user with INSERT, UPDATE, DELETE, or SELECT on the table has EXECUTE privilege on that package. This authorization is implicit as part of the statement or command that is run.

The TRANSFER OWNERSHIP operation on the package is not allowed and results in SQL20344N, reason code 5. However, TRANSFER OWNERSHIP of an index with an expression-based key implicitly transfers the ownership of the associated the package.

Sequence privileges

The creator of a sequence automatically receives the USAGE and ALTER privileges on the sequence. The USAGE privilege is needed to use NEXT VALUE and PREVIOUS VALUE expressions for the sequence.

To allow other users to use the NEXT VALUE and PREVIOUS VALUE expressions, sequence privileges must be granted to PUBLIC. This allows all users to use the expressions with the specified sequence.

ALTER privilege on the sequence allows the user to perform tasks such as restarting the sequence or changing the increment for future sequence values. The creator of the sequence can grant the ALTER privilege to other users, and if WITH GRANT OPTION is used, these users can, in turn, grant these privileges to other users.

Routine privileges

Execute privileges involve actions on all types of routines such as functions, procedures, and methods within a database. Once having EXECUTE privilege, a user can then invoke that routine, create a function that is sourced from that routine (applies to functions only), and reference the routine in any DDL statement such as CREATE VIEW or CREATE TRIGGER.

The user who defines the externally stored procedure, function, or method receives EXECUTE WITH GRANT privilege. If the EXECUTE privilege is granted to another user via WITH GRANT OPTION, that user can, in turn, grant the EXECUTE privilege to another user.

Usage privilege on workloads

To enable use of a workload, a user who holds ACCESSCTRL, SECADM, or WLMADM authority can grant USAGE privilege on that workload to a user, a group, or a role using the GRANT USAGE ON WORKLOAD statement.

When the Db2 database system finds a matching workload, it checks whether the session user has USAGE privilege on that workload. If the session user does not have USAGE privilege on that workload, then the Db2 database system searches for the next matching workload in the ordered list. In other words, the workloads that the session user does not have USAGE privilege on are treated as if they do not exist.

The USAGE privilege information is stored in the catalogs and can be viewed through the SYSCAT.WORKLOADAUTH view.

The USAGE privilege can be revoked using the REVOKE USAGE ON WORKLOAD statement.

Users with the ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM authority implicitly have the USAGE privilege on all workloads.

The SYSDEFAULTUSERWORKLOAD workload and the USAGE privilege

USAGE privilege on SYSDEFAULTUSERWORKLOAD is granted to PUBLIC at database creation time, if the database is created without the RESTRICT option. Otherwise, the USAGE privilege must be explicitly granted by a user with ACCESSCTRL, WLMADM, or SECADM authority.

If the session user does not have USAGE privilege on any of the workloads, including SYSDEFAULTUSERWORKLOAD, an SQL error is returned.

The SYSDEFAULTADMWORKLOAD workload and the USAGE privilege

USAGE privilege on SYSDEFAULTADMWORKLOAD cannot be explicitly granted to any user. Only users who issue the **SET WORKLOAD TO SYSDEFAULTADMWORKLOAD** command and whose session authorization ID has ACCESSCTRL, DATAACCESS, DBADM, WLMADM or SECADM authority are allowed to use this workload.

The GRANT USAGE ON WORKLOAD and REVOKE USAGE ON WORKLOAD statements do not have any effect on SYSDEFAULTADMWORKLOAD.

Authorization IDs in different contexts

An authorization ID is used for two purposes: identification and authorization checking. For example, the session authorization ID is used for initial authorization checking.

When referring to the use of an authorization ID in a specific context, the reference to the authorization is qualified to identify the context, as shown in the following section.

Contextual reference to authorization ID
Definition

System authorization ID
The authorization ID used to do any initial authorization checking, such as checking for CONNECT privilege during CONNECT processing. As part of the authentication process during CONNECT processing, an authorization ID compatible with Db2 naming requirements is produced that represents the external user ID within the Db2 database system. The system authorization ID represents the user that created the connection. Use the SYSTEM_USER special register to see the current value of the system authorization ID. The system authorization ID cannot be changed for a connection.

Session authorization ID
The authorization ID used for any session authorization checking subsequent to the initial checks performed during CONNECT processing. The default value of the session authorization ID is the value of the system authorization ID. Use the SESSION_USER special register to see the current value of the session authorization ID. The USER special register is a synonym for the SESSION_USER special

register. The session authorization ID can be changed by using the SET SESSION AUTHORIZATION statement.

Package authorization ID
The authorization ID used to bind a package to the database. This authorization ID is obtained from the value of the **OWNER** *authorization id* option of the **BIND** command. The package authorization ID is sometimes referred to as the package binder or package owner.

Routine owner authorization ID
The authorization ID listed in the system catalogs as the owner of the SQL routine that has been invoked.

Routine invoker authorization ID
The authorization ID that is the statement authorization ID for the statement that invoked an SQL routine.

Statement authorization ID
The authorization ID associated with a specific SQL statement that is to be used for any authorization requirements as well as for determining object ownership (where appropriate). It takes its value from the appropriate source authorization ID, depending on the type of SQL statement:

- Static SQL

  The package authorization ID is used.

- Dynamic SQL (from non-routine context)

  The table shows which authorization ID is used in each case:

Value of DYNAMICRULES option for issuing the package	Authorization ID used
RUN	Session authorization ID
BIND	Package authorization ID
DEFINERUN, INVOKERUN	Session authorization ID
DEFINEBIND, INVOKEBIND	Package authorization ID

- Dynamic SQL (from routine context)

  The table shows which authorization ID is used in each case:

Value of DYNAMICRULES option for issuing the package	Authorization ID used
DEFINERUN, DEFINEBIND	Routine owner authorization ID
INVOKERUN, INVOKEBIND	Routine invoker authorization ID

Use the CURRENT_USER special register to see the current value of the statement authorization ID. The statement authorization ID cannot be changed directly; it is changed automatically by the Db2 database system to reflect the nature of each SQL statement.

Default privileges granted on creating a database

When you create a database, default database level authorities and default object level privileges are granted to you within that database.

The authorities and privileges that you are granted are listed according to the system catalog views where they are recorded:

1. SYSCAT.DBAUTH
   - The database creator is granted the following authorities:
     - ACCESSCTRL

- DATAACCESS
- DBADM
- SECADM

- In a non-restrictive database, the special group PUBLIC is granted the following authorities:
  - CREATETAB
  - BINDADD
  - CONNECT
  - IMPLICIT_SCHEMA

2. SYSCAT.TABAUTH

   In a non-restrictive database, the special group PUBLIC is granted the following privileges:

   - SELECT on all SYSCAT and SYSIBM tables
   - SELECT and UPDATE on all SYSSTAT tables
   - SELECT on the following views in schema SYSIBMADM:
     - ALL_*
     - USER_*
     - ROLE_*
     - SESSION_*
     - DICTIONARY
     - TAB

3. SYSCAT.ROUTINEAUTH

   In a non-restrictive database, the special group PUBLIC is granted the following privileges:

   - EXECUTE with GRANT on all procedures in schema SQLJ
   - EXECUTE with GRANT on all functions and procedures in schema SYSFUN
   - EXECUTE with GRANT on most functions and procedures in schema SYSPROC, for a list of exceptions see "Default PUBLIC privilege for built-in routines" on page 58
   - EXECUTE on all table functions in schema SYSIBM
   - EXECUTE on all other procedures in schema SYSIBM

4. SYSCAT.MODULEAUTH

   In a non-restrictive database, the special group PUBLIC is granted the following privileges:

   - EXECUTE on the following modules in schema SYSIBMADM:
     - DBMS_DDL
     - DBMS_JOB
     - DBMS_LOB
     - DBMS_OUTPUT
     - DBMS_SQL
     - DBMS_STANDARD
     - DBMS_UTILITY

5. SYSCAT.PACKAGEAUTH

   - The database creator is granted the following privileges:
     - CONTROL on all packages created in the NULLID schema
     - BIND with GRANT on all packages created in the NULLID schema
     - EXECUTE with GRANT on all packages created in the NULLID schema

- In a non-restrictive database, the special group PUBLIC is granted the following privileges:
  - BIND on all packages created in the NULLID schema
  - EXECUTE on all packages created in the NULLID schema

6. SYSCAT.SCHEMAAUTH

   In a non-restrictive database, the special group PUBLIC is granted the following privileges:

   - CREATEIN on schema SQLJ
   - CREATEIN on schema NULLID

7. SYSCAT.TBSPACEAUTH

   In a non-restrictive database, the special group PUBLIC is granted the USE privilege on table space USERSPACE1.

8. SYSCAT.WORKLOADAUTH

   In a non-restrictive database, the special group PUBLIC is granted the USAGE privilege on SYSDEFAULTUSERWORKLOAD.

9. SYSCAT.VARIABLEAUTH

   In a non-restrictive database, the special group PUBLIC is granted the READ privilege on schema global variables in the SYSIBM schema, execpt for the following variables:

   - SYSIBM.CLIENT_ORIGUSERID
   - SYSIBM.CLIENT_USRSECTOKEN

A non-restrictive database is a database created without the RESTRICTIVE option on the CREATE DATABASE command.

Related information

Best practices: A practical guide to restrictive databases

Default PUBLIC privilege for built-in routines

When a non-restrictive database is created, the special group PUBLIC is granted EXECUTE with GRANT to the majority of built-in routines.

The exceptions are listed in Table 1. All the listed routines are in the schema SYSPROC.

Table 3. Built-in routines with no default PUBLIC privilege

Routine Name	Routine Type
ADMIN_GET_INTRA_PARALLEL	Function
ADMIN_GET_MEM_USAGE	Function
ADMIN_GET_STORAGE_PATHS	Function
ADMIN_GET_TAB_COMPRESS_INFO	Function
ADMIN_GET_TAB_COMPRESS_INFO_V97	Function
ADMIN_GET_TAB_DICTIONARY_INFO	Function
ADMIN_SET_INTRA_PARALLEL	Procedure
AUDIT_ARCHIVE	Function
AUDIT_ARCHIVE	Procedure
AUDIT_DELIM_EXTRACT	Procedure
AUDIT_LIST_LOGS	Function
AUTOMAINT_GET_POLICYFILE	Procedure

Table 3. Built-in routines with no default PUBLIC privilege (continued)	
Routine Name	**Routine Type**
AUTOMAINT_GET_POLICY	Procedure
AUTOMAINT_SET_POLICYFILE	Procedure
AUTOMAINT_SET_POLICY	Procedure
DB2_GET_CLUSTER_HOST_STATE	Function
DB2_GET_INSTANCE_INFO	Function
ENV_GET_DB2_EDU_SYSTEM_RESOURCES	Function
ENV_GET_DB2_SYSTEM_RESOURCES	Function
ENV_GET_NETWORK_RESOURCES	Function
ENV_GET_REG_VARIABLES	Function
ENV_GET_SYS_RESOURCES	Function
ENV_GET_SYSTEM_RESOURCES	Function
EVMON_UPGRADE_TABLES	Procedure
EXPLAIN_FROM_ACTIVITY	Procedure
EXPLAIN_FROM_CATALOG	Procedure
EXPLAIN_FROM_DATA	Procedure
EXPLAIN_FROM_SECTION	Procedure
MON_CAPTURE_ACTIVITY_IN_PROGRESS	Procedure
MON_COLLECT_STATS	Procedure
MON_FORMAT_LOCK_NAME	Function
MON_FORMAT_XML_COMPONENT_TIMES_BY_ROW	Function
MON_FORMAT_XML_METRICS_BY_ROW	Function
MON_FORMAT_XML_WAIT_TIMES_BY_ROW	Function
MON_GET_ACTIVITY_DETAILS	Function
MON_GET_ACTIVITY	Function
MON_GET_AGENT	Function
MON_GET_APPL_LOCKWAIT	Function
MON_GET_AUTO_MAINT_QUEUE	Function
MON_GET_AUTO_RUNSTATS_QUEUE	Function
MON_GET_BUFFERPOOL	Function
MON_GET_CF_CMD	Function
MON_GET_CF	Function
MON_GET_CF_WAIT_TIME	Function
MON_GET_CONNECTION_DETAILS	Function
MON_GET_CONNECTION	Function

Table 3. Built-in routines with no default PUBLIC privilege (continued)	
Routine Name	**Routine Type**
MON_GET_CONTAINER	Function
MON_GET_DATABASE_DETAILS	Function
MON_GET_DATABASE	Function
MON_GET_EXTENDED_LATCH_WAIT	Function
MON_GET_EXTENT_MOVEMENT_STATUS	Function
MON_GET_FCM_CONNECTION_LIST	Function
MON_GET_FCM	Function
MON_GET_GROUP_BUFFERPOOL	Function
MON_GET_HADR	Function
MON_GET_INDEX	Function
MON_GET_INDEX_USAGE_LIST	Function
MON_GET_INSTANCE	Function
MON_GET_LOCKS	Function
MON_GET_MEMORY_POOL	Function
MON_GET_MEMORY_SET	Function
MON_GET_PAGE_ACCESS_INFO	Function
MON_GET_PKG_CACHE_STMT_DETAILS	Function
MON_GET_PKG_CACHE_STMT	Function
MON_GET_QUEUE_STATS	Function
MON_GET_REBALANCE_STATUS	Function
MON_GET_ROUTINE_DETAILS	Function
MON_GET_ROUTINE_EXEC_LIST	Function
MON_GET_ROUTINE	Function
MON_GET_RTS_RQST	Function
MON_GET_SECTION	Function
MON_GET_SECTION_OBJECT	Function
MON_GET_SECTION_ROUTINE	Function
MON_GET_SERVERLIST	Function
MON_GET_SERVICE_SUBCLASS_DETAILS	Function
MON_GET_SERVICE_SUBCLASS	Function
MON_GET_SERVICE_SUBCLASS_STATS	Function
MON_GET_SERVICE_SUPERCLASS_STATS	Function
MON_GET_TABLE	Function
MON_GET_TABLESPACE	Function

Table 3. Built-in routines with no default PUBLIC privilege (continued)	
Routine Name	**Routine Type**
MON_GET_TABLESPACE_QUIESCER	Function
MON_GET_TABLESPACE_RANGE	Function
MON_GET_TABLE_USAGE_LIST	Function
MON_GET_TRANSACTION_LOG	Function
MON_GET_UNIT_OF_WORK_DETAILS	Function
MON_GET_UNIT_OF_WORK	Function
MON_GET_USAGE_LIST_STATUS	Function
MON_GET_UTILITY	Function
MON_GET_WORK_ACTION_SET_STATS	Function
MON_GET_WORKLOAD_DETAILS	Function
MON_GET_WORKLOAD	Function
MON_GET_WORKLOAD_STATS	Function
MON_INCREMENT_INTERVAL_ID	Procedure
MON_SAMPLE_SERVICE_CLASS_METRICS	Function
MON_SAMPLE_WORKLOAD_METRICS	Function
SET_MAINT_MODE_RECORD_NO_TEMPORALHISTORY	Procedure
SYSTS_ALTER	Procedure
SYSTS_CLEANUP	Procedure
SYSTS_CLEAR_COMMANDLOCKS	Procedure
SYSTS_CLEAR_EVENTS	Procedure
SYSTS_CONFIGURE	Procedure
SYSTS_CREATE	Procedure
SYSTS_DISABLE	Procedure
SYSTS_DROP	Procedure
SYSTS_ENABLE	Procedure
SYSTS_UPDATE	Procedure
SYSTS_UPGRADE_CATALOG	Procedure
SYSTS_UPGRADE_INDEX	Procedure
WLM_ALTER_MEMBER_SUBSET	Procedure
WLM_CANCEL_ACTIVITY	Procedure
WLM_CAPTURE_ACTIVITY_IN_PROGRESS	Procedure
WLM_COLLECT_STATS	Procedure
WLM_CREATE_MEMBER_SUBSET	Procedure
WLM_DROP_MEMBER_SUBSET	Procedure

Table 3. Built-in routines with no default PUBLIC privilege (continued)	
Routine Name	**Routine Type**
WLM_GET_ACTIVITY_DETAILS	Function
WLM_GET_CONN_ENV	Function
WLM_GET_QUEUE_STATS	Function
WLM_GET_SERVICE_CLASS_AGENTS	Function
WLM_GET_SERVICE_CLASS_AGENTS_V97	Function
WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES	Function
WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES_V97	Function
WLM_GET_SERVICE_SUBCLASS_STATS	Function
WLM_GET_SERVICE_SUBCLASS_STATS_V97	Function
WLM_GET_SERVICE_SUPERCLASS_STATS	Function
WLM_GET_WORK_ACTION_SET_STATS	Function
WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES	Function
WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES_V97	Function
WLM_GET_WORKLOAD_STATS	Function
WLM_GET_WORKLOAD_STATS_V97	Function
WLM_SET_CLIENT_INFO	Procedure
WLM_SET_CONN_ENV	Procedure

Granting and revoking access

Granting privileges

To grant privileges on most database objects, you must have ACCESSCTRL authority, SECADM authority, or CONTROL privilege on that object; or, you must hold the privilege WITH GRANT OPTION. Additionally, users with SYSADM or SYSCTRL authority can grant table space privileges. You can grant privileges only on existing objects.

About this task

To grant CONTROL privilege to someone else, you must have ACCESSCTRL or SECADM authority. To grant ACCESSCTRL, DATAACCESS, DBADM or SECADM authority, you must have SECADM authority.

The GRANT statement allows an authorized user to grant privileges. A privilege can be granted to one or more authorization names in one statement; or to PUBLIC, which makes the privileges available to all users. Note that an authorization name can be either an individual user or a group.

On operating systems where users and groups exist with the same name, you should specify whether you are granting the privilege to the user or group. Both the GRANT and REVOKE statements support the keywords USER, GROUP, and ROLE. If these optional keywords are not used, the database manager checks the operating system security facility to determine whether the authorization name identifies a user or a group; it also checks whether an authorization ID of type role with the same name exists. If the database manager cannot determine whether the authorization name refers to a user, a group, or a role,

an error is returned. The following example grants SELECT privileges on the EMPLOYEE table to the user HERON:

```
GRANT SELECT
 ON EMPLOYEE TO USER HERON
```

The following example grants SELECT privileges on the EMPLOYEE table to the group HERON:

```
GRANT SELECT
   ON EMPLOYEE TO GROUP HERON
```

Note:

WITH GRANT OPTION is ignored when granting database authorities, index privileges, schema authorities (SCHEMAADM, ACCESSCTRL, DATAACCESS, LOAD) and CONTROL privilege on tables or views.

Revoking privileges

The REVOKE statement allows authorized users to revoke privileges previously granted to other users.

About this task

To revoke privileges on database objects, you must have ACCESSCTRL authority, SECADM authority, or CONTROL privilege on that object. Table space privileges can also be revoked by users with SYSADM and SYSCTRL authority. Note that holding a privilege WITH GRANT OPTION is not sufficient to revoke that privilege. To revoke CONTROL privilege from another user, you must have ACCESSCTRL, or SECADM authority. To revoke ACCESSCTRL, DATAACCESS, DBADM or SECADM authority, you must have SECADM authority. Table space privileges can be revoked only by a user who holds SYSADM, or SYSCTRL authority. Privileges can only be revoked on existing objects.

Note: A user without ACCESSCTRL authority, SECADM authority, or CONTROL privilege is not able to revoke a privilege that they granted through their use of the WITH GRANT OPTION. Also, there is no cascade on the revoke to those who have received privileges granted by the person being revoked.

If an explicitly granted table (or view) privilege is revoked from a user with DATAACCESS authority, privileges will not be revoked from other views defined on that table. This is because the view privileges are available through the DATAACCESS authority and are not dependent on explicit privileges on the underlying tables.

If a privilege has been granted to a user, a group, or a role with the same name, you must specify the GROUP, USER, or ROLE keyword when revoking the privilege. The following example revokes the SELECT privilege on the EMPLOYEE table from the user HERON:

```
REVOKE SELECT
   ON EMPLOYEE FROM USER HERON
```

The following example revokes the SELECT privilege on the EMPLOYEE table from the group HERON:

```
REVOKE SELECT
   ON EMPLOYEE FROM GROUP HERON
```

Note that revoking a privilege from a group may not revoke it from all members of that group. If an individual name has been directly granted a privilege, it will keep it until that privilege is directly revoked.

If a table privilege is revoked from a user, privileges are also revoked on any view created by that user which depends on the revoked table privilege. However, only the privileges implicitly granted by the system are revoked. If a privilege on the view was granted directly by another user, the privilege is still held.

You may have a situation where you want to GRANT a privilege to a group and then REVOKE the privilege from just one member of the group. There are only a couple of ways to do that without receiving the error message SQL0556N:

- You can remove the member from the group; or, create a new group with fewer members and GRANT the privilege to the new group.
- You can REVOKE the privilege from the group and then GRANT it to individual users (authorization IDs).

Note: When CONTROL privilege is revoked from a user on a table or a view, the user continues to have the ability to grant privileges to others. When given CONTROL privilege, the user also receives all other privileges WITH GRANT OPTION. Once CONTROL is revoked, all of the other privileges remain WITH GRANT OPTION until they are explicitly revoked.

All packages that are dependent on revoked privileges are marked invalid, but can be validated if rebound by a user with appropriate authority. Packages can also be rebuilt if the privileges are subsequently granted again to the binder of the application; running the application will trigger a successful implicit rebind. If privileges are revoked from PUBLIC, all packages bound by users having only been able to bind based on PUBLIC privileges are invalidated. If DBADM authority is revoked from a user, all packages bound by that user are invalidated including those associated with database utilities. Attempting to use a package that has been marked invalid causes the system to attempt to rebind the package. If this rebind attempt fails, an error occurs (SQLCODE -727). In this case, the packages must be explicitly rebound by a user with:

- Authority to rebind the packages
- Appropriate authority for the objects used within the packages

These packages should be rebound at the time the privileges are revoked.

If you define a trigger or SQL function based on one or more privileges and you lose one or more of these privileges, the trigger or SQL function cannot be used.

Managing implicit authorizations by creating and dropping objects

The database manager implicitly grants certain privileges to a user that creates a database object such as a table or a package. Privileges are also granted when objects are created by users with DBADM authority. Similarly, privileges are removed when an object is dropped.

About this task

When the created object is a table, nickname, index, or package, the user receives CONTROL privilege on the object. When the object is a view, the CONTROL privilege for the view is granted implicitly only if the user has CONTROL privilege for all tables, views, and nicknames referenced in the view definition.

When the object explicitly created is a schema, the schema owner is given ALTERIN, CREATEIN, and DROPIN privileges WITH GRANT OPTION. An implicitly created schema has CREATEIN granted to PUBLIC.

Establishing ownership of a package

The **BIND** and **PRECOMPILE** commands create or change an application package. On either one, use the **OWNER** option to name the owner of the resulting package.

About this task

There are simple rules for naming the owner of a package:

- Any user can name themselves as the owner. This is the default if the **OWNER** option is not specified.
- A user ID with DBADM authority can name any authorization ID as the owner using the **OWNER** option.

Not all operating systems that can bind a package using Db2 database products support the **OWNER** option.

Implicit privileges through a package

Access to data within a database can be requested by application programs, as well as by persons engaged in an interactive workstation session. A package contains statements that allow users to perform a variety of actions on many database objects. Each of these actions requires one or more privileges.

Privileges granted to individuals binding the package and to PUBLIC, as well as to the roles granted to the individuals and to PUBLIC, are used for authorization checking when static SQL and XQuery statements are bound. Privileges granted through groups, and the roles granted to groups, are not used for authorization checking when static SQL and XQuery statements are bound.

Unless VALIDATE RUN is specified when binding the package, the user with a valid authorization ID who binds a package must either:

- Have been granted all the privileges required to execute the static SQL or XQuery statements in the package.
- Have acquired the necessary privileges through membership in one or more of:
  - PUBLIC
  - The roles granted to PUBLIC
  - The roles granted to the user

If VALIDATE RUN is specified at BIND time, all authorization failures for any static SQL or XQuery statements within this package will not cause the BIND to fail, and those SQL or XQuery statements are revalidated at run time. PUBLIC, group, role, and user privileges are all used when checking to ensure the user has the appropriate authorization (BIND or BINDADD privilege) to bind the package.

Packages may include both static and dynamic SQL and XQuery statements. To process a package with static queries, a user need only have EXECUTE privilege on the package. This user can then implicitly obtain the privileges of the package binder for any static queries in the package but only within the restrictions imposed by the package.

If the package includes dynamic SQL or XQuery statements, the required privileges depend on the value that was specified for **DYNAMICRULES** when the package was precompiled or bound. For more information, see the topic that describes the effect of **DYNAMICRULES** on dynamic queries.

Indirect privileges through a package containing nicknames

When a package contains references to nicknames, authorization processing for package creators and package users is slightly more complex.

When a package creator successfully binds packages that contain nicknames, the package creator does not have to pass authentication checking or privilege checking for the tables and views that the nicknames reference at the data source. However, the package executor must pass authentication and authorization checking at data sources.

For example, assume that a package creator's .SQC file contains several SQL or XQuery statements. One static statement references a local table. Another dynamic statement references a nickname. When the package is bound, the package creator's authid is used to verify privileges for the local table and the nickname, but no checking is done for the data source objects that the nickname identifies. When another user executes the package, assuming they have the EXECUTE privilege for that package, that user does not have to pass any additional privilege checking for the statement referencing the table. However, for the statement referencing the nickname, the user executing the package must pass authentication checking and privilege checking at the data source.

When the .SQC file contains only dynamic SQL and XQuery statements and a mixture of table and nickname references, Db2 database authorization checking for local objects and nicknames is similar. Package users must pass privilege checking for any local objects (tables, views) within the statements and also pass privilege checking for nickname objects (package users must pass authentication and privilege checking at the data source containing the objects that the nicknames identify). In both cases, users of the package must have the EXECUTE privilege.

The authorization ID and password of the package executor is used for all data source authentication and privilege processing. This information can be changed by creating a user mapping.

Note: Nicknames cannot be specified in static SQL and XQuery statements. Do not use the **DYNAMICRULES** option (set to BIND) with packages containing nicknames.

It is possible that packages containing nicknames might require additional authorization steps because Db2 database uses dynamic SQL when communicating with Db2 Family data sources. The authorization ID running the package at the data source must have the appropriate authority to execute the package dynamically at that data source.

Controlling access to data with views

A view provides a means of controlling access or extending privileges to a table.

Using a view allows the following kinds of control over access to a table:

- Access only to designated columns of the table.

  For users and application programs that require access only to specific columns of a table, an authorized user can create a view to limit the columns addressed only to those required.
- Access only to a subset of the rows of the table.

  By specifying a WHERE clause in the subquery of a view definition, an authorized user can limit the rows addressed through a view.
- Access only to a subset of the rows or columns in data source tables or views. If you are accessing data sources through nicknames, you can create local Db2 database views that reference nicknames. These views can reference nicknames from one or many data sources.

  Note: Because you can create a view that contains nickname references for more than one data source, your users can access data in multiple data sources from one view. These views are called *multi-location views*. Such views are useful when joining information in columns of sensitive tables across a distributed environment or when individual users lack the privileges needed at data sources for specific objects.

To create a view, a user must have DATAACCESS authority, or CONTROL or SELECT privilege for each table, view, or nickname referenced in the view definition. The user must also be able to create an object in the schema specified for the view. That is, DBADM authority, CREATEIN privilege for an existing schema, or IMPLICIT_SCHEMA authority on the database if the schema does not already exist.

If you are creating views that reference nicknames, you do not need additional authority on the data source objects (tables and views) referenced by nicknames in the view; however, users of the view must have SELECT authority or the equivalent authorization level for the underlying data source objects when they access the view.

If your users do not have the proper authority at the data source for underlying objects (tables and views), you can:

1. Create a data source view over those columns in the data source table that are OK for the user to access
2. Grant the SELECT privilege on this view to users
3. Create a nickname to reference the view

Users can then access the columns by issuing a SELECT statement that references the new nickname.

The following scenario provides a more detailed example of how views can be used to restrict access to information.

Many people might require access to information in the STAFF table, for different reasons. For example:

- The personnel department needs to be able to update and look at the entire table.

  This requirement can be easily met by granting SELECT and UPDATE privileges on the STAFF table to the group PERSONNL:

```
GRANT SELECT,UPDATE ON TABLE STAFF TO GROUP PERSONNL
```

- Individual department managers need to look at the salary information for their employees.

  This requirement can be met by creating a view for each department manager. For example, the following view can be created for the manager of department number 51:

```
CREATE VIEW EMP051 AS
   SELECT NAME,SALARY,JOB FROM STAFF
   WHERE DEPT=51
GRANT SELECT ON TABLE EMP051 TO JANE
```

  The manager with the authorization name JANE would query the EMP051 view just like the STAFF table. When accessing the EMP051 view of the STAFF table, this manager views the following information:

NAME	SALARY	JOB
Fraye	45150.0	Mgr
Williams	37156.5	Sales
Smith	35654.5	Sales
Lundquist	26369.8	Clerk
Wheeler	22460.0	Clerk

- All users need to be able to locate other employees. This requirement can be met by creating a view on the NAME column of the STAFF table and the LOCATION column of the ORG table, and by joining the two tables on their corresponding DEPT and DEPTNUMB columns:

```
CREATE VIEW EMPLOCS AS
   SELECT NAME, LOCATION FROM STAFF, ORG
   WHERE STAFF.DEPT=ORG.DEPTNUMB
GRANT SELECT ON TABLE EMPLOCS TO PUBLIC
```

  Users who access the employee location view will see the following information:

NAME	LOCATION
Molinare	New York
Lu	New York
Daniels	New York
Jones	New York
Hanes	Boston
Rothman	Boston
Ngan	Boston
Kermisch	Boston
Sanders	Washington
Pernal	Washington
James	Washington
Sneider	Washington
Marenghi	Atlanta
O'Brien	Atlanta
Quigley	Atlanta

NAME	LOCATION
Naughton	Atlanta
Abrahams	Atlanta
Koonitz	Chicago
Plotz	Chicago
Yamaguchi	Chicago
Scoutten	Chicago
Fraye	Dallas
Williams	Dallas
Smith	Dallas
Lundquist	Dallas
Wheeler	Dallas
Lea	San Francisco
Wilson	San Francisco
Graham	San Francisco
Gonzales	San Francisco
Burke	San Francisco
Quill	Denver
Davis	Denver
Edwards	Denver
Gafney	Denver

Controlling access for database administrators (DBAs)

You may want to monitor, control, or prevent access to data by database administrators (users holding DBADM authority).

Monitoring access to data

You can use the Db2 audit facility to monitor access by database administrators. To do so, follow these steps:

1. Create an audit policy that monitors the events you want to capture for users who hold DBADM authority.
2. Associate this audit policy with the DBADM authority.

Controlling access to data

You can use trusted contexts in conjunction with a role to control access by database administrators. To do so, follow these steps:

1. Create a role and grant DBADM authority to that role.
2. Define a trusted context and make the role the default role for this trusted context.

Do not grant membership in the role to any authorization ID explicitly. This way, the role is available only through this trusted context and a user acquires DBADM capability only when they are within the confines of the trusted context.

3. There are two ways you can control how users access the trusted context:
   - Implicit access: Create a unique trusted context for each user. When the user establishes a regular connection that matches the attributes of the trusted context, they are implicitly trusted and gain access to the role.
   - Explicit access: Create a trusted context using the WITH USE FOR clause to define all users who can access it. Create an application through which those users can make database requests. The application establishes an explicit trusted connection, and when a user issues a request, the application switches to that user ID and executes the request as that user on the database.

If you want to monitor the use of this trusted context, you can create an audit policy that captures the events you are interested in for users of this trusted context. Associate this audit policy with the trusted context.

Preventing access to data

To prevent access to data in tables, choose one of these options:

- To prevent access to data in all tables, revoke DATAACCESS from your DBADM user, role or group. Alternatively, you could grant DBADM to the user, role or group of interest without the DATAACCESS option
- To prevent access to data in one particular table, follow these steps:
  - Assign a security label to every column in the table.
  - Grant that security label to a role.
  - Grant that role to all users (or roles) that have a legitimate need to access the table.

  No user, regardless of their authority, will be able to access data in that table unless they are a member in that role.

Gaining access to data through indirect means

To successfully manage security, you need to be aware of indirect ways that users can gain access to data.

The following list represents the indirect means through which users can gain access to data they might not be authorized to access:

- **Catalog views:** The Db2 database system catalog views store metadata and statistics about database objects. Users with SELECT access to the catalog views can gain some knowledge about data that they might not be qualified for. For better security, make sure that only qualified users have access to the catalog views.

  Note: In Db2 Universal Database Version 8, or earlier, SELECT access on the catalog views was granted to PUBLIC by default. In Db2 Version 9.1, or later, database systems, users can choose whether SELECT access to the catalog views is granted to PUBLIC or not by using the new **RESTRICTIVE** option on the **CREATE DATABASE** command.
- **Explain snapshot:** The explain snapshot is compressed information that is collected when an SQL or XQuery statement is explained. It is stored as a binary large object (BLOB) in the EXPLAIN_STATEMENT table, and contains column statistics that can reveal information about table data. For better security, access to the explain tables should be granted to qualified users only.
- **Section explain:** The section explain procedures (EXPLAIN_FROM_SECTION, EXPLAIN_FROM_CATALOG, EXPLAIN_FROM_ACTIVITY and EXPLAIN_FROM_DATA) can populate explain tables with information from any section that resides in the package cache. This information includes statement text which may contain input data values. For better security, access to the section explain procedures and explain tables should be granted to qualified users only.

- **Log reader functions:** A user authorized to run a function that reads the logs can gain access to data they might not be authorized for if they are able to understand the format of a log record. These functions read the logs:

Function	Authority needed in order to execute the function
db2ReadLog	SYSADM or DBADM
db2ReadLogNoConn	None.

- **Replication:** When you replicate data, even the protected data is reproduced at the target location. For better security, make sure that the target location is at least as secure as the source location.
- **Exception tables:** When you specify an exception table while loading data into a table, users with access to the exception table can gain information that they might not be authorized for. For better security, only grant access to the exception table to authorized users and drop the exception table as soon as you are done with it.
- **Backup table space or database:** Users with the authority to run the **BACKUP DATABASE** command can take a backup of a database or a table space, including any protected data, and restore the data somewhere else. The backup can include data that the user might not otherwise have access to.

  The **BACKUP DATABASE** command can be executed by users with SYSADM, SYSCTRL, or SYSMAINT authority.
- **Set session authorization:** In Db2 Universal Database Version 8, or earlier, a user with DBADM authority could use the SET SESSION AUTHORIZATION SQL statement to set the session authorization ID to any database user. In Db2 Version 9.1, or later, database systems a user must be explicitly authorized through the GRANT SETSESSIONUSER statement before they can set the session authorization ID.

  When upgrading an existing Version 8 database to a Db2 Version 9.1, or later, database system, however, a user with existing explicit DBADM authority (for example, granted in SYSCAT.DBAUTH) will keep the ability to set the session authorization to any database user. This is allowed so that existing applications will continue to work. Being able to set the session authorization potentially allows access to all protected data. For more restrictive security, you can override this setting by executing the REVOKE SETSESSIONUSER SQL statement.
- **Lock monitoring:** As part of the lock monitoring activity of Db2 database management systems, values associated with parameter markers are written to the monitoring output when the HIST_AND_VALUES collection level is specified. Values may also be embedded in the statement text captured by the lock event monitor. A user with access to the monitoring output can gain access to information for which they might not be authorized.
- **Activity monitoring:** As part of monitoring activities in a Db2 database management system using an activity event monitor, the values associated with parameter markers are written to the monitoring output when the VALUES clause is specified, and the statement text (which may contain input data values) is written to the monitoring output when the WITH DETAILS clause is specified. A user with access to the monitoring output can gain access to information for which they might not be authorized. For better security, access to the CREATE EVENT MONITOR statement and any event monitor tables should be granted to qualified users only.
- **Package cache monitoring:** As part of monitoring the package cache in a Db2 database management system using a package cache event monitor, the statement text (which may contain input data values) is written to the monitoring output whenever a section is ejected from the package cache. For better security, access to the CREATE EVENT MONITOR statement and any event monitor tables should be granted to qualified users only.
- **Monitor table functions, views and reports:** The following monitor table functions, views and reports expose statement text for either currently executing statements or statements in the package cache:
  - SYSPROC.MON_GET_ACTIVITY_DETALS
  - SYSPROC.MON_GET_PKG_CACHE_STMT
  - SYSPROC.MON_GET_PKG_CACHE_STMT_DETALS

  - SYSIBMADM.MON_PKG_CACHE_SUMMARY
  - SYSIBMADM.MON_CURRENT_SQL
  - SYSIBMADM.MON_LOCKWAITS
  - SYSIBMADM.MONREPORT.LOCKWAIT
  - SYSIBMADM.MONREPORT.CURRENTSQL
  - SYSIBMADM.MONREPORT.PKGCACHE

  The statement text may contain input data values. For better security, EXECUTE privilege on these table functions and reports and SELECT privilege on these views should be granted to qualified users only.
- **Traces:** A trace can contain table data. A user with access to such a trace can gain access to information that they might not be authorized for.
- **Dump files:** To help in debugging certain problems, Db2 database products might generate memory dump files in the `sqllib\db2dump` directory. These memory dump files might contain table data. If they do, users with access to the files can gain access to information that they might not be authorized for. For better security you should limit access to the `sqllib\db2dump` directory.
- **db2dart:** The **db2dart** tool examines a database and reports any architectural errors that it finds. The tool can access table data and Db2 does not enforce access control for that access. A user with the authority to run the **db2dart** tool or with access to the **db2dart** output can gain access to information that they might not be authorized for.
- **REOPT bind option:** When the **REOPT** bind option is specified, explain snapshot information for each reoptimizable incremental bind SQL statement is placed in the explain tables at run time. The explain will also show input data values.
- **db2cat:** The **db2cat** tool is used to dump a table's packed descriptor. The table's packed descriptor contains statistics that can reveal information about a table's contents. A user who runs the **db2cat** tool or has access to the output can gain access to information that they might not be authorized for.

Data encryption

The Db2 database system offers several ways to encrypt data, both while in storage, and while in transit over the network.

Encrypting data at rest

Important: The DATA_ENCRYPT authentication type is deprecated and might be removed in a future release. To encrypt data in-transit between clients and Db2 databases, we recommend that you use the Db2 database system support of Transport Layer Security (TLS). For more information, see *Configuring TLS support in a Db2 instance* in the *Data encryption* section of the Db2 Security Guide.

You have the following options for encrypting data at rest:

- You can use Db2 native encryption to encrypt your databases and backup images.
- You can use IBM InfoSphere® Guardium® Data Encryption to encrypt the underlying operating system data and backup files.
- You can use encrypted file system (EFS) to encrypt your operating system data and backup files. Use EFS if you are running a Db2 system on the AIX operating system, and you are interested in file-level encryption only.

Encrypting data in transit

To encrypt data in-transit between clients and Db2 databases, use the Db2 database system support of Transport Layer Security (TLS).

Attention: TLS was developed in 1999 as the successor to the popular encryption protocol Secure Socket Layer (SSL). Because of the popularity of SSL, the acronym is now synonymous with encryption technology and by association, TLS. As a result, some Db2 commands and database objects that are related to TLS encryption still contain 'ssl' in their names. However, Db2 does not

use the SSL protocol for data encryption. Any references to SSL in this guide can be interpreted as TLS.

- We recommend that you use Db2 support for TLS to encrypt communication between the following:
  - Db2 clients and servers
  - Primary and Standby nodes in a Db2 HADR environment
  - Db2 clients and a Db2 Federation server

    Note: Db2 Federation Server also supports TLS encryption of outbound transmissions to some data sources.

Note: DATA_ENCRYPT and SERVER_ENCRYPT with DES use algorithms that are not compliant with NIST SP 800-131A. If you must comply with NIST SP 800-131A, they must not be used. If compliance to NIST SP 800-131A is not an issue, they are still valid.

The IBM Global Security Kit (GSKit)

Db2 uses the cryptographic and TLS capabilities of the IBM® Global Security Kit (GSKit) for encrypting both data at rest (native encryption) and data in transit. The GSKit is used to implement the TLS protocol that enable protected Db2 communications over the network.

For information about the GSKit tool GSKCapiCmd, download the *GSKCapiCmd User's Guide* from the Db2 Version 11.5 for Linux, UNIX, and Windows English Manuals page

Encryption of data at rest

To keep important data safe from unauthorized access, Db2 offers native encryption to protect databases and backup images, IBM InfoSphere Guardium Data Encryption for underlying operating system data and backup files, and (for Db2 on AIX users) Encrypted file system (EFS) for file-level encryption of operating system data and backup files.

Db2 native encryption

Db2 native encryption provides a built-in encryption capability to protect database backup images and key database files from inappropriate access while they are at rest on external storage media.

Encryption is a key component in the protection of offline data. Many government regulations and industry standards require its use.

Db2 native encryption features:

- simple deployment
- does not require changes to the data schema or database applications
- free use on all supported Db2 platforms and configurations.

The encryption capabilities that are used by Db2 are FIPS 140-2 certified and employ NIST SP 800-131A compliant cryptographic algorithms. Db2 also automatically detects and uses any underlying CPU hardware acceleration for encryption when available.

When you encrypt a database, Db2 native encryption protects all files that contain your data, such as:

- All table spaces (both system-defined and user-defined)
- All types of data in a table space (including LOB and XML data types)
- All transaction logs, including archived log files
- LOAD COPY data
- LOAD staging files

Db2 native encryption can also be used to encrypt database backups, even if the source database is not encrypted.

Overview of Db2 native encryption

Db2 native encryption uses a two-tier approach to data encryption. Data is encrypted with a Data Encryption Key (DEK), which is in turn encrypted with a Master Key (MK). The encrypted DEK is stored with the data while the MK is stored in a keystore external to Db2.

Db2 native encryption ensures that the DEK is never exposed outside of the encrypted database, transaction log, or backup file. There are no interfaces provided to access the DEK in either its clear text or encrypted forms. As the MK is stored in a different location from the encrypted data, the chance of the encrypted DEK being concurrently exposed with the MK used to encrypt it is very unlikely. Since the risk of the DEK being exposed is extremely low, the need to rotate it is negligible. The rotation of the MK, which is used to protect the DEK, can be done efficiently without the need to decrypt and re-encrypt the data

Data Encryption Key (DEK)

Db2 encrypts data with a data encryption key (DEK) before the data is written to disk. The DEK is stored, encrypted by the master key (MK), within the database or backup image. The DEK itself is generated by Db2 as needed, such as when an encrypted database or encrypted database backup is created. A unique DEK exists for each encrypted database and for each encrypted backup.

Master Key (MK)

A master key (MK) is an encryption key that is used to encrypt a data encryption key (DEK). Each encrypted database is associated with one master key at one time. Unless directed otherwise, Db2 generates an MK automatically during these operations:

- Database creation
- Master key rotation
- Restoring into a new database

Master keys are identified by a label that Db2 uses to uniquely identify each master key. By default, Db2 creates a label for every new MK created. You can override this behavior by supplying a specific label for a particular MK. Reasons for creating an MK with a particular label include:

- tracking the MK labels and their corresponding keys for offsite recovery without having the entire keystore available on the backup site
- having an HADR pair that requires synchronized keys
- encrypting a backup for an unencrypted database

Keystore

Master keys are stored in a keystore. A keystore can be a file that is directly accessed by Db2 (local) or a third-party keystore with which Db2 communicates over the network (centralized).

Note: A Db2 instance can be configured for one keystore for native encryption at one time.

Keystores supported by Db2

Db2 native encryption can interact with the following keystores:

- A local keystore file that follows the Public Key Cryptography Standards (PKCS) #12 archive file format for storing cryptography objects

  Note: PKCS is an OASIS standard for public key cryptography. The numbers 11 and 12 refer to specific parts of the standard.
- A centralized keystore that is accessed using one of the following methods:
  - Any key manager product that supports Key Management Interoperability Protocol (KMIP) version 1.1 or higher. A key manager is software that you can use to create, update, and secure a keystore.

    Note: KMIP is an OASIS standard for network protocol that is related to key management.

– One of the following supported Hardware Security Modules (HSM) that use the PKCS #11 API:
  - Gemalto Safenet HSM (formerly Luna) version 6.1 (firmware version 6.23.0) and higher
  - nCipher nShield HSM, security world software version 11.50 and higher

MKs and the keystore

An MK can either be created directly within the keystore or generated by Db2, upon request, and stored within the keystore. One or more MKs can exist and each MK can be referenced by different Db2 databases or backup images.

Keystore access by Db2 native encryption
Whenever Db2 needs access to the Data Encryption Key (DEK), the Master Key (MK) is used to decrypt the DEK, which requires the keystore to be opened to access the MK. Depending on the type of keystore being used, the MK is either fetched from the keystore into Db2 for decryption of the DEK, or the DEK is shipped to the keystore for decryption.

The keystore access requests occur independently from each Db2 member that is associated with the active database. The connection to the keystore, which is established by an access request, is maintained during the requested action and is then released.

If the keystore is not available, Db2 attempts the request again on any keystore clones that are defined. If none exist, Db2 attempts the request again on the primary keystore for a configurable number of retry attempts. If the retry attempts fail, then Db2 returns an error.

The following are some of the points where access to the keystore is required by Db2:

- db2start
- Create Database
- Database start (for example, first connect to, or activation of, a database)
- Transaction log file access (for example, first use)
- Backup of a database
- Restore of a database
- Roll forward

The frequency of access to the keystore varies, depending on the specific processing that is occurring within Db2. This frequency can change in subsequent updates to Db2. In places where Db2 knows that it requires multiple accesses to the DEK, some caching of the DEK occurs in memory to reduce the impact on Db2 performance.

Encryption considerations

Keystore availability and recoverability
One of the unique attributes of data encryption is that, while it effectively guards your offline data from inappropriate access, it can also prevent you from accessing your own data, if you lose access to the master key.

This potential access restriction makes managing the availability and recoverability of your keystore, and its related credentials, a mission-critical aspect of your database environment.

Important: Do not lose access to your master key (MK). If you lose access to the MK, you irrevocably lose access to the data in your encrypted database or database backup.

As you plan for this requirement, keystore network and availability issues become data availability issues. As a result, you need to apply the same objectives to the planning for keystore availability as you do for data availability.

The impact of encryption on performance
Introducing Db2 native encryption to an existing database increases required system resources, and impacts the throughput of running workloads.

The extent of this impact depends on two primary factors:

- Whether CPU hardware acceleration exists that can be leveraged by Db2
- How insulated your workload is from an increase in the latency of physical I/O requests

Db2 native encryption relies on the embedded IBM Global Security Kit (GSKit) software product to recognize and leverage built-in CPU hardware acceleration where possible. This acceleration makes a significant difference in the impact on both system resource consumption and application throughput. As of Db2 11.1, Db2 leverages the following CPU enhancements:

- Intel Advanced Encryption Standard New Instructions (AES-NI) support
- Power8 in-core support for the AES
- zSeries CP Assist for Cryptographic Functions (CPACF)

Given that Db2 native encryption is implemented to encrypt and decrypt data as it goes to and from disk, the effect of encryption appears on any physical I/O request from Db2. In practical terms, the effect is that the I/O bandwidth of your system is reduced from its current level. How your workloads react to this change determines the impact to performance.

Since this change in the latency of physical I/O can negate the tuned configuration of an existing database system, it is recommended that you plan to retune a newly encrypted database. Retuning the database ensures that the impact of any new physical I/O wait time that is introduced by encryption is properly addressed.

The impact of encryption on database operations
In addition to keystore availability and recoverability issues, there are other factors that can impact your database operations that you need to consider before encrypting a database.

The following section outlines changes that encryption can introduce to a production database environment, and how to plan for them.

Management of keystore credentials

As part of its own protection mechanisms, the keystore that is used by Db2 has its own authentication requirements. Users that attempt to access the keystore need to present valid credentials. Db2 needs access to these credentials to initiate connections to the keystore. How these credentials are stored and made available to Db2 in your environment needs to be considered. See the topics "Keystore selection" on page 76 and "Keystore configuration" on page 76 for information on choosing and setting up a keystore.

Keystore archiving and retention

While you must keep the keystore contents protected, you must also ensure that you keep all the master keys for the lifetime of any database backups and logs that you create. To recover an old backup and roll-forward through its related logs, you need the master key(s) that were used at the time that the backup and logs were created.

Potential change in storage requirements for archived logs and database backups

Many Db2 customers rely on data deduplication techniques, provided by their media devices, to minimize the size of archived transaction logs and database backups. But compression works by finding repeating patterns in data, while encryption randomizes data. Because of this conflict, the compression of an encrypted object does not reduce the objects size. As a result, you might need to change your approach in this area by considering how to compress before encrypting your database, This could be done using active compression within Db2 or by using the combined compression and encryption backup library provided with Db2.

Keystore coordination between HADR databases

If you have an HADR system, both the primary and standby databases need to be encrypted. You will need to consider how the keystore is shared between the sites.

Getting started with Db2 native encryption

Prerequisites for Db2 native encryption
To use Db2 native encryption, you must verify that GSKit is installed and configured.

Keystore selection
The first critical decision that must be made is which keystore to use to store the master key that is required by Db2 native encryption.

Db2 can integrate with several types of keystores, each with its own strengths and weaknesses that need to be evaluated against the projected needs of the database.

Choosing the keystore that is best for your environment depends on your current and future needs as well as the following key attributes:

- Recovery options
- Availability options
- Flexibility
- Direct cost

For example, using a local PKCS #12 keystore file is the least expensive option in terms of direct cost. However, it is also the option that requires you to implement all of the availability and recovery considerations that are needed for a keystore. A local PCKS #12 keystore file also requires more manual intervention when trying to share the same keystore across multiple members (for a Db2 pureScale® or partitioned database) or among databases (for HADR). This can mean that the indirect costs of using a local keystore file might far outweigh the savings in the direct costs. Using a more advanced keystore approach might be more expensive initially, but it provides you with the flexibility to easily share the keystore across the enterprise.

Keystore configuration
Once you have selected your keystore, you must implement it and configure Db2 to recognize the keystore.

For instructions on how to implement a local PKCS #12 keystore file, refer to Creating a local keystore.

To interact with a centralized keystore using KMIP or PKCS #11, you must also create a keystore configuration file to inform Db2 of the keystore behaviors and configuration. For information on how to create a configuration file for a centralized keystore:

- For a keystore using KMIP, refer to Creating a KMIP configuration file.
- For a keystore using PKCS #11, refer to Creating a PKCS #11 configuration file

Once you have implemented your keystore and, if required, created the appropriate configuration file, you can configure Db2 to recognize and interact with the keystore. This configuration is done by setting two database manager configuration parameters: keystore_type and keystore_location. For more information, see Configuring a Db2 instance to use a keystoreFor more information about the keystore_type and keystore_location configuration parameters, see the Db2 Configuration Parameters Guide.

Local keystores

Creating a local keystore
You can create a keystore on the local system by using the GSKit library command **gsk8capicmd_64**.

About this task

Local keystore considerations for multi-member database

When using a local keystore with a Db2 multi-member configuration, such as Db2 pureScale or Db2 Database Partitioning Facility, a copy of the keystore must be present on each member. In addition, coordination of keystore updates must be done manually. For this reason, a centralized keystore is recommended for these database environments.

Procedure

Log in as the Db2 instance owner, and then create the local keystore by running the **gsk8capicmd_64** command.

Example

```
gsk8capicmd_64 -keydb -create -db "/home/thomas/keystores/ne-keystore.p12"
    -pw "g00d.pWd" -type pkcs12 -stash
```

Basic command syntax

```
gsk8capicmd_64 -keydb -create -db "<file-name>" -pw "<password>" -type pkcs12 -stash
```

- <file-name> is the full path and file name you want to give the keystore file
- Keystore format:
  - For use with native encryption, the format of the keystore must be PKCS#12, so it is mandatory to specify `-type pkcs12`
  - PKCS#12 keystore file names must have the extension ".p12"
- Stashing the password:
  - If you specify the `-stash` parameter, the keystore password is stored (or *stashed*) in a stash file with the same base name as the keystore file but with the file extension ".sth".
  - If the password is not stashed, you are prompted for a password whenever the database manager accesses the keystore, including during `db2start`.

  Note: You can stash the password in a stash file later by running the **gsk8capicmd_64** command with the `-stashpw` parameter.

  Note: Stashing the password with the **gsk8capicmd_64** command is intended to be used in a local keystore only. Do not attempt to stash a password in a local keystore with the **db2credman** command. The **db2credman** command is intended to be used with a PKCS #11 keystore.

For information about the full syntax of the **gsk8capicmd_64** command, see the GSKCapiCmd Users Guide .

Adding a master key to a local keystore

With Db2 native encryption, when you create a database with the **ENCRYPT** parameter, by default the database manager creates a new master key for the database and adds that master key to the keystore. Alternatively, you can generate a master key in a local keystore yourself, and then specify that your generated master key should be used for a new database instead of the default.

Procedure

- Generate a master key in an existing, local keystore by issuing the **gsk8capicmd_64** command.

  Example

  ```
  gsk8capicmd_64 -secretkey -create -db "/home/thomas/keystores/ne-keystore.p12"
      -stashed -label "my_manual_master_key" -size "16"
  ```

  Basic syntax

  ```
  gsk8capicmd_64 -secretkey -create -db "<keystore-file-name>"
  ```

```
    [-pw "<password>" | -stashed ]
    -label "<label>" -size "<key-length-in-bytes>"
```

- <keystore-file-name> is the full path and name of the keystore file
- If the keystore password is stashed, you can specify the `-stashed` parameter to cause the password to be retrieved from the stash file
- If the password is not stashed, you may specify the password with the `-pw` parameter
- If neither `-stashed` nor `-pw` is specified, you will be prompted for the keystore password

For information about the full syntax of the **gsk8capicmd_64** command, see: GSKCapiCmd Users Guide .

Centralized keystores

Setting up a centralized KMIP keystore
To set up a centralized keystore, with a key manager that is configured for the Key Management Interoperability Protocol (KMIP), for use with Db2 native encryption, you need to create a KMIP keystore configuration file. Once you have created the configuration file, you can enter parameter values to configure Db2 communication between the Db2 instance and the key manager.

Before you begin

Set up the centralized key manager.

- If you are using IBM Security Key Lifecycle Manager, see: Quick Start Guide

Procedure

1. Create a KMIP keystore configuration file
2. Configure Db2 between the Db2 instance and the key manager, by using one of the following methods:
   - The KMIP server must support TLS 1.2.
   - All certificates must be signed with a signature algorithm that uses SHA2 (SHA256, SHA384, SHA512). The use of SHA1 is not supported.
   - All certificates must have a key size of at least 2048 bits.

     Note: The "All certificates" mentioned above refers to the Db2 client certificate, the KMIP server certificate, and any Certificate Authority (CA) and intermediate CA root certificates.
   - Configure Db2 with ISKLM
   - Configure Db2 with KeySecure

   Note: Other key manager products can be configured in a similar manner.

What to do next

Configure the Db2 instance to use this centralized KMIP keystore to store database master keys for Db2 native encryption.

Creating a KMIP keystore configuration file
To use Db2 native encryption to store your master key or keys in a centralized keystore using KMIP, you need to create a configuration file that lists details about the keystore.

Procedure

On the Db2 server, create the KMIP keystore configuration file in a text editor.

Example

```
VERSION=1
PRODUCT_NAME=ISKLM
ALLOW_KEY_INSERT_WITHOUT_KEYSTORE_BACKUP=true
```

```
SSL_KEYDB=/home/userName/sqllib/security/keydb.p12
SSL_KEYDB_STASH=/home/userName/sqllib/security/keydb.sth
SSL_KMIP_CLIENT_CERTIFICATE_LABEL=db2_client_label
PRIMARY_SERVER_HOST=serverName.domainName
PRIMARY_SERVER_KMIP_PORT=kmipPortNumber
CLONE_SERVER_HOST=clone1.domainName
CLONE_SERVER_KMIP_PORT=kmipPortNumber
CLONE_SERVER_HOST=clone2.domainName
CLONE_SERVER_KMIP_PORT=kmipPortNumber
```

Keywords

VERSION
Required. Version of the configuration file. Currently, 1 is the only supported value.

PRODUCT_NAME
Required. Key manager product. Supported values:

- ISKLM for IBM Security Key Lifecycle Manager
- KEYSECURE for SafeNet KeySecure
- OTHER for any other key manager that supports the Key Management Interoperability Protocol (KMIP) version 1.1 or higher

ALLOW_KEY_INSERT_WITHOUT_KEYSTORE_BACKUP
Optional: Allow the database manager to insert new keys into the KMIP key manager. New keys are inserted when the **CREATE DATABASE ENCRYPT** or **ADMIN_ROTATE_MASTER_KEY** commands are run without a specified existing master key label, or when the migration tool **db2p12tokmip** is run. When this parameter is set to TRUE, new keys are allowed to be inserted, if set to FALSE an error is returned if the database manager attempts to insert a new key. You should only set this to TRUE if you are not creating your master keys within the KMIP key manager, and you have an automated backup solution of your KMIP key manager for newly inserted keys. This parameter must be set to TRUE if you are migrating keys by using the **db2p12tokmip** command. It can be changed to FALSE after the tool has completed. Default value: FALSE.

ALLOW_NONCRITICAL_BASIC_CONSTRAINT
Optional. If you set the parameter to TRUE, this allows Db2 to use local Certificate Authority within KMIP server that does not have a "critical" keyword set and avoids "414" error that is returned by GSKit. This parameter was introduced in Db2 V11.1.2.2. Default value: FALSE.[1]

SSL_KEYDB
Required. Absolute path and name of the local keystore file that holds the TLS certificates for communication between the Db2 server and the KMIP key manager.

SSL_KEYDB_STASH
Optional. Absolute path and name of the stash file for the local keystore that holds the TLS certificates for communication between the Db2 server and the KMIP key manager. Default value: None.

[1] Error SQL1782N is returned by the GSKit layer (manifested as error DIA3604E: The TLS function "gsk_secure_soc_init" failed with the return code "414" in "sqlccSSLSocketSetup" in the db2diag.log) in case the basic constraints extension of the certificate that is issued by the Certificate Authority (CA) does not have the 'critical' keyword asserted. Using the command "gsk8capicmd_64 -cert -details -db <filename> -stashed -label <localCALabel>" you can check the basic constraints of the CA to see whether the keyword 'critical' is asserted. For a local CA the keyword 'critical' might not be set.

Example:

```
Extensions
    basicConstraints
        ca = true
        pathLen = 140730370034921
        critical
```

SSL_KMIP_CLIENT_CERTIFICATE_LABEL
Required. The label of the TLS certificate for authenticating the client during communication with the KMIP key manager.

SSL_KMIP_CLIENT_HOSTNAME_VALIDATION
If you set this value to **BASIC**, Db2 validates that the hostname of the KMIP server is contained within the certificate used by the KMIP server when establishing the TLS connection. This hostname is sourced from either the **MASTER_SERVER_HOST** or **CLONE_SERVER_HOST** parameter. The validation rules follow RFC 6125 for validating the hostname in the common name or Subject Alternate Name (SAN) fields of the certificate. The KMIP server product documentation will need to be consulted to determine how to create an appropriate certificate. For more information about TLS hostname validation, see "Hostname validation for Db2 11.5.6 clients" on page 112. If you set this value to **OFF**, Db2 does not validate the hostname. Default value: **OFF**.

DEVICE_GROUP
Name of the KMIP key manager device group containing the keys used by the Db2 server. This parameter is only required for IBM Security Key Lifecycle Manager (ISKLM).

PRIMARY_SERVER_HOST
Required. Host name or IP address of the KMIP key manager. (For ISKLM, this information is available on the "Welcome" tab of the web console.)

PRIMARY_SERVER_KMIP_PORT
Required. The "KMIP TLS port" of the KMIP key manager. (For ISKLM, this information is available on the "Welcome" tab of the web console.)

Note: The KMIP configuration file parameters **MASTER_SERVER_HOST** and **MASTER_SERVER_KMIP_PORT** are still accepted but have been deprecated. Use **PRIMARY_SERVER_HOST** and **PRIMARY_SERVER_KMIP_PORT** instead.

CLONE_SERVER_HOST
Optional. Host name or IP address of secondary KMIP keystore. Default value: None.
You can specify up to five clone servers by repeating the **CLONE_SERVER_HOST** and **CLONE_SERVER_KMIP_PORT** parameter pairs in the configuration file, each host with a different value. Clone servers are considered read-only and are only used for retrieving existing master keys from the KMIP keystore. Clone servers are not used when inserting a new key, which occurs when an existing master key label has not been specified for the **CREATE DATABASE ENCRYPT** or **ADMIN_ROTATE_MASTER_KEY** commands, or for the **db2p12tokmip** executable.

CLONE_SERVER_KMIP_PORT
Optional. The "KMIP TLS port" of secondary KMIP keystore. Default value: None. You can specify up to five clone servers by repeating the **CLONE_SERVER_HOST** and **CLONE_SERVER_KMIP_PORT** parameter pairs in the configuration file, each host with a different value.

COMMUNICATION_ERROR_RETRY_TIME
Optional. The number of times the Db2 database manager cycles through the list of configured master and clone KMIP key managers if the connection fails or an error is returned from all of the KMIP key managers. A wait of a length specified in the **ALL_SERVER_UNAVAILABLE_SLEEP** parameter is inserted before each cycle. Default value: 50.

UNAVAILABLE_SERVER_BLACKOUT_PERIOD
Optional. The amount of time, in seconds, to skip sending key requests to a particular master or clone KMIP key manager after a failed connection attempt or it has returned errors. This parameter was introduced in Db2 V11.1.2.2. Default value: 300 seconds.

(Optional) ALL_SERVER_UNAVAILABLE_SLEEP
When all master and clone KMIP key managers are unavailable and in a blackout period, this parameter is the amount of time to wait, in seconds, before removing the blackout period and reattempting connections to all KMIP key managers. This parameter was introduced in Db2 V11.1.2.2. Default value: 0 seconds.

TLS configuration between Db2 and the key manager
To store master keys in a centralized keystore with Db2 native encryption, you need to set up TLS communication between the Db2 instance and the centralized key manager.

Configuring TLS between a Db2 instance and a centralized KMIP key manager (ISKLM)
To store master keys in a centralized keystore with Db2 native encryption, you need to set up TLS communication between the Db2 instance and the centralized KMIP key manager.

Before you begin

On the Db2 server, create a local keystore to store TLS certificates.

About this task

- On the Db2 server, the **gsk8capicmd_64** command is used to create, extract, and add TLS certificates to the local keystore. For detailed information about the command, see: GSKCapiCmd Users Guide .
- Some examples below show self-signed certificates. Self-signed certificates are suitable for test environments, but for production environments certificates that are signed by third party certificate authorities are more appropriate.
- Some information about using the IBM Security Key Lifecycle Manager web interface and command line interface is included below. For more complete information, see: Setup for TLS handshake between IBM Security Key Lifecycle Manager server and client device .

Procedure

1. On the Db2 server: create an TLS signer certificate.
   a) Create the certificate by issuing the **gsk8capicmd_64** command.

   Example

   ```
   gsk8capicmd_64 -cert -create -db "clientkeydb.p12"
       -label "DB2_signer_certificate"
       -dn "CN=weblinux.Raleigh.ibm.com,O=ibm,OU=IBM HTTP Server,L=RTP,ST=NC,C=US"
       -sig_alg SHA256_WITH_RSA -size 2048
   ```

   b) Extract the certificate to a file by issuing the **gsk8capicmd_64** command.

   Example

   ```
   gsk8capicmd_64 -cert -extract -db "clientkeydb.p12"
       -label "DB2_signer_certificate"
       -target "/path/to/DB2_certificate_file.pem"
       -format ascii
   ```

   c) Securely transmit the Db2 server certificate file to the centralized key manager.
2. On the centralized key manager: add the Db2 server certificate to the keystore.

   The following substeps describe how to add a certificate to IBM Security Key Lifecycle Manager using the web console.

   a) Create a device group :

      i) Select "Create" in the "Device Group" list of the "Advanced Configuration" tab.

      ii) Select the device family "General Parallel File System (GPFS)" and then enter "DB2" as the new device group name.

      iii) Leave the "Enable machine affinity" check box unselected.

   b) Import the DB2 server certificate file :

      i) On the "Welcome" tab select your new group, "DB2".

ii) From the "Go to" list, select "Manage Keys and Devices". This will bring you to the Advanced Configuration tab.

iii) Select "Certificates" from the "Add" list.

iv) Specify the certificate name and the file path when prompted.

v) In the "Advanced Configuration" window, select "Import" from the "Client Device Communication Certificates" menu.

3. On the centralized key manager: create an TLS signer certificate.

   The following substeps describe how to create a certificate and then extract it to a file using the IBM Security Key Lifecycle Manager web console and command-line interface.

   a) Create a self-signed certificate or obtain a certificate from a certificate authority .

   b) Extract the certificate to a file using the command-line interface :

      i) Enable the Jython scripting language.

      Example

```
./wsadmin.sh -username "<admin-user>"
    -password "<password>" -lang jython
```

      ii) Export the certificate using the tklmCertExport command.

      Example

```
print AdminTask.tklmCertExport
    ('[-uuid CERTIFICATE-61f8e7ca-62aa-47d5-a915-8adbfbdca9de
    -format DER
    -fileName d:\\ISKLM_certificate_file.pem]')
```

   c) Securely transmit the centralized key manager certificate file to the Db2 server.

4. On the Db2 server: add the centralized key manager certificate to the local keystore.

   a) Add the certificate by issuing the **gsk8capicmd_64** command.

   Example

```
gsk8capicmd_64 -cert -add -db "clientkeydb.p12"
    -label "ISKLM_signer_certificate"
    -file "/path/to/ISKLM_certificate_file.pem"
```

Results

When the Db2 database manager connects to the centralized key manager, TLS communication will be used.

What to do next

Configuring a Db2 instance to use a keystore

Note: TLS 1.3 support is available starting in SGKLM Version 4.1.1. For compatibility with Db2, SGKLM installations running 4.1.1 FP1 to FP4 must apply a fix for IJ39961. Before turning on TLS 1.3, ensure that Db2 is updated to version 11.5.8 or later. For more information, see TransportListener.ssl.protocols in the SGKLM Documentation.

Configuring TLS between a Db2 instance and a centralized KMIP key manager (KeySecure)

To store master keys in a centralized KMIP keystore with Db2 native encryption, you need to set up TLS communication between the Db2 instance and the centralized key manager.

Before you begin

On the Db2 server, create a local keystore to store TLS certificates.

About this task

- On the Db2 server, the **gsk8capicmd_64** command is used to create, extract, and add TLS certificates to the local keystore. For detailed information about the command, see the GSKCapiCmd Users Guide.

Procedure

On KeySecure, create a CA and add it to the Trusted CA list:

1. Verify that a CA certificate is created or installed. Make sure that the CA is added to the trusted CA list.
2. Make sure that a server certificate request is created and signed with the CA certificate.
3. Check that a Cryptographic Key Server is created. Also, verify that the appropriate authentication settings are configured.
   a) Ensure the appropriate Cryptographic Key Server Properties:
      - **Protocol:** Select KMIP.
      - **IP:** Select ALL or a specific IP address.
      - **Port:** Select a port number. The standard KMIP port number is 5696. In the centralized keystore configuration file, the value for the MASTER_SERVER_KMIP_PORT or CLONE_SERVER_KMIP_PORT parameter must be configured according to the value specified for the port number.
      - **Use TLS:** Select True
      - **Server Certificate:** Select the label of the server certificate.
   b) Ensure the appropriate Authentication Settings:
      - **Password Authentication:** Select *Not Used*.
      - **Client Certification Authentication:** Select *Used for TLS session and username*.
      - **Trusted CA list Profile:** Select the profile that contains the Trusted CA list to which the CA was added.
      - **User name Field in Client Certificate:** Select either the CN or OU value from the dropdown list.
      - **Require Client Certificate to Contain Source IP:** Leave unticked.
   c) Create a Local User whose user name matches the *User name field in Client Certificate* field in the client certificate.
4. Download the CA certificate to the client keystore.

On the Db2 server, add the CA certificate and create a client certificate request:

5. Add the CA certificate that was previously downloaded to the local keystore.

```
gsk8capicmd_64 -cert -add -db "clientkeydb.p12" -stashed -label "trustedCA" -file
"trustedCA.crt"
```

6. Create a client certificate request.

```
gsk8capicmd_64 -certreq -create -db "clientkeydb.p12" -stashed -label "clientCert"
    -dn "CN=db2KeySecureUser,O=IBM,OU=DB2,L=Toronto,ST=Ontario,C=CA" -target
"client_cert_request.arm"
```

At your CA, sign the client certificate request:

7. Sign the client certificate request with the CA certificate, and then download the signed certificate.

On the Db2 server, add the signed client certificate:

8. Add the signed client certificate to the local keystore.

```
gsk8capicmd_64 -cert -receive -db "clientkeydb.p12" -stashed
    -file "client_cert_signed.arm"
```

Results

When the Db2 database manager connects to the centralized KMIP key manager, TLS communication is used.

What to do next

Configure the Db2 instance to use the centralized keystore

Migrating from a local keystore to a centralized KMIP keystore

If you want to migrate your Db2 local keystore to a centralized keystore that is configured for the Key Management Interoperability Protocol (KMIP), you can copy your master keys to the centralized keystore by issuing the **db2p12tokmip** command.

Before you begin

- Create a KMIP keystore configuration file
- Configure TLS between the DB2 instance and the centralized key manager

Procedure

1. Back up the centralized KMIP keystore. See: Backing up IBM Security Key Lifecycle Manager .
2. Set the **allow_key_insert_without_keystore_backup** parameter to TRUE in the centralized KMIP keystore configuration file.
3. Copy all master keys from the local keystore to the centralized KMIP keystore by issuing the **db2p12tokmip** command.

   Example

   ```
   db2p12tokmip -from /home/thomas/keystores/ne-keystore.p12
       -to /home/thomas/keystores/isklm.cfg
   ```

   To see full syntax information, type db2p12tokmip -h in the Db2 command line window, or refer to *db2p12tokmip command* topic in the Db2 Command Reference PDF.
4. Set the **allow_key_insert_without_keystore_backup** parameter to FALSE in the centralized KMIP keystore configuration file.

What to do next

1. Configure the Db2 instance to use the centralized keystore.
2. Change the master key by running the ADMIN_ROTATE_MASTER_KEY procedure.

Setting up a centralized PKCS #11 keystore

To set up a PKCS #11 keystore for use with Db2 native encryption, begin by creating a PKCS #11 keystore configuration file.

Before you begin

1. Install and configure the vendor software that lets you access the PKCS #11 keystore. Refer to Overview of Db2 native encryption for a list of supported key managers.
2. Check the ability to connect to the PKCS #11 keystore by using vendor utilities. For example:
   - For SafeNet (formerly Luna) hardware security module (HSM), use **vtl verify**
   - For nCipher nShield HSM, use **enquiry**

Procedure

1. Create a PKCS #11 keystore configuration file
2. Create a stash file

What to do next

Configure the Db2 instance to use this centralized PKCS #11 keystore to store database master keys for Db2 native encryption.

Creating a PKCS #11 keystore configuration file

To store master keys in a centralized PKCS #11 keystore with Db2 native encryption, you need to create a configuration file that contains details about the PKCS #11 keystore.

Procedure

On the Db2 server, create the PKCS #11 keystore configuration file in a text editor.

Example

```
VERSION=1
PRODUCT_NAME=Luna
ALLOW_KEY_INSERT_WITHOUT_KEYSTORE_BACKUP=true
LIBRARY=/usr/safenet/lunaclient/luna6.1/lib/libCryptoki2_64.so
SLOT_LABEL=DB2Partition
NEW_OBJECT_TYPE=PRIVATE
KEYSTORE_STASH=/home/userName/sqllib/security/pkcs11_pw.sth
```

Keywords

VERSION
Required. Version of the configuration file. Currently, 1 is the only supported value.

PRODUCT_NAME
Optional. Use this value to override the PKCS #11 keystore type that is determined from product information returned by PKCS #11 API calls.. Supported values are:

- `Luna` for SafeNet (formerly Luna) hardware security module (HSM)
- `nCipher` for nCipher nShield HSM (Thales is supported for backwards compatibility)
- `Other` for any other key manager that supports PKCS #11

ALLOW_KEY_INSERT_WITHOUT_KEYSTORE_BACKUP
Optional. Allow the database manager to insert new keys into the centralized key manager. New keys are inserted when the **CREATE DATABASE ENCRYPT** or **ADMIN_ROTATE_MASTER_KEY** commands are run without a specified existing master key label, or when the migration tool **db2p12tokmip** is run. When this parameter is set to TRUE, new keys are allowed to be inserted, if set to FALSE an error is returned if the database manager attempts to insert a new key. You should only set this to TRUE if you are not creating your master keys within the centralized key manager, and you have an automated backup solution of your centralized key manager for newly inserted keys. This parameter must be set to TRUE if you are migrating keys by using the **db2p12tokmip** command. It can be changed to FALSE after the tool has completed. Default value: FALSE.

LIBRARY
Required. The absolute path and name (including extension) of the centralized PKCS #11 keystore vendor-supplied shared library. The format is platform-dependent:

Examples for AIX or Linux:
`/usr/safenet/lunaclient/luna6.1/lib/libCryptoki2_64.so`
`/opt/nfast/toolkits/pkcs11/libcknfast.so`

Examples for Windows:
`C:\safenet\lunaclient\luna6.1\lib\libCryptoki2_64.dll`
`C:\nfast\toolkits\pkcs11\libcknfast.dll`

SLOT_LABEL
Optional. Identifies the slot in the HSM by a label. The label is a name that is defined by the application, and is assigned during token initialization. If specified, the value must be 1 - 32 characters long. This parameter cannot be specified if SLOT_ID is specified.

SLOT_ID
Optional. Identifies the slot in the HSM by an ID. Must be an integer value. This parameter cannot be specified if SLOT_LABEL is specified.

NEW_OBJECT_TYPE
Optional. Defines whether new master keys generated at the PKCS #11 keystore are created as private or public objects. The default value is PRIVATE. The supported values are:

- PRIVATE for private objects
- PUBLIC for public objects

KEYSTORE_STASH
Optional. Absolute path and name of the stash file that holds the PKCS #11 keystore password. The instance uses the stash file to authenticate to the PKCS #11 keystore.

What to do next

Create a stash file, if you choose to store the HSM credentials in a stash file.

Creating a stash file
Create a stash file to address operational concerns that involve access to PKCS #11 keystore credentials.

Before you begin

- Create a PKCS #11 keystore configuration file

About this task

A stash file stores the password of a keystore in obfuscated form. The stash file contributes to enhanced operations. If you create a stash file, the database manager can access credentials that it requires to log in to the PKCS #11 keystore. Without a stash file, the only realistic solutions to restart an instance immediately in the event of an unplanned outage are less than ideal:

- Store the credentials in plain form so that an automated script can restart the instance. However, storing the password in plain form is not desirable since it violates security policies and best practices.
- Have a DBA always available to provide the access credentials for the PKCS #11 keystore when the instance restarts. However, having to rely on human intervention, with the expectancy of instant response time, is rarely feasible from an operational perspective.

Restrictions

The following procedure is intended to be used in a PKCS #11 keystore. Do not attempt to stash a password by using the **gsk8capicmd_64** command, since that command is intended to be used exclusively with a local keystore. Conversely, do not attempt to stash a password for a local keystore by using the following procedure.

Procedure

To create a stash file in a PKCS #11 keystore:

1. Run the **db2credman** command to stash the provided password to a file.

```
db2credman -stash -password Str0ngPassw0rd -to /home/db2inst1/keystore/pkcs11_pw.sth
```

2. Update the PKCS #11 keystore configuration file by adding the **KEYSTORE_STASH** parameter.

```
...
KEYSTORE_STASH=/home/db2inst1/keystore/pkcs11_pw.sth
```

3. Run the **db2stop** command to remove the in-memory copy of the password.
4. Run the **db2start** command without the `OPEN KEYSTORE USING` *`password`* option.

Results

The PKCS #11 keystore password is now stored in the stash file, in obfuscated form. The next operation that requires the PKCS #11 keystore password will read it from the stash file.

What to do next

If you are currently using Db2 native encryption with master keys that are stored in a local keystore and you want to start to use a PKCS #11 keystore instead, Migrate the local keystore to a PKCS #11 keystore.

If you decide to stop using the stash file, in favor of providing PKCS #11 keystore credentials on instance start, follow these steps:

1. Run the **db2start** command with the `OPEN KEYSTORE USING` *`password`* option.
2. Update the PKCS #11 keystore configuration file by removing the **KEYSTORE_STASH** parameter.
3. Delete the stash file to eliminate any potential security risks that this unused file poses.

The next operation that requires the PKCS #11 keystore password will read it from memory.

Migrating from a local keystore to a centralized PKCS #11 keystore
If you want to migrate your Db2 nativity-encrypted local keystore to a centralized PKCS #11 keystore, you can copy the master keys to the centralized keystore by issuing the **db2p12top11** command.

Before you begin

- Create a centralized PKCS #11 keystore configuration file

Procedure

1. Back up the PKCS #11 keystore by using the vendor's key manager software.
2. Set the ALLOW_KEY_INSERT_WITHOUT_KEYSTORE_BACKUP parameter to TRUE in the centralized PKCS #11 keystore configuration file.
3. If you are migrating to a hardware security module (HSM) of the nCipher nShield family, you must assign the **unwrap_kek** parameter to the CKNFAST_OVERRIDE_SECURITY_ASSURANCES environment variable.
4. Copy all master keys from the local keystore to the centralized PKCS #11 keystore by issuing the **db2p12top11** command.

   Example

   ```
   db2p12top11 -to ~/pkcs11_keystore.cfg -pin Str0ngPassw0rd
   ```

   To see full syntax information, type `db2p12top11 -h` in the Db2 Command Window, or refer to the *db2p12top11 command* topic in the Db2 Command Reference PDF.
5. Set the ALLOW_KEY_INSERT_WITHOUT_KEYSTORE_BACKUP parameter to FALSE in the centralized PKCS #11 keystore configuration file.

What to do next

1. Configure the DB2 instance to use the centralized PKCS #11 keystore.
2. Change the master key by running the ADMIN_ROTATE_MASTER_KEY procedure.

Configuring a Db2 instance to use a keystore
To configure a Db2 instance to use a keystore for native encryption, you need to set two database manager configuration parameters: **keystore_type** and **keystore_location**.

Procedure

- For a local keystore, set **keystore_type** to "PKCS12", and set **keystore_location** to the absolute path and file name of the local keystore file.

  Example

  ```
  update dbm cfg using keystore_location /home/thomas/keystores/ne-keystore.p12
  keystore_type pkcs12
  ```

- For a centralized keystore, where the key manager product uses the Key Management Interoperability Protocol (KMIP), set **keystore_type** to "KMIP", and set **keystore_location** to the absolute path and file name of the centralized keystore configuration file.

  Example

  ```
  update dbm cfg using keystore_location /home/thomas/keystores/isklm.cfg keystore_type
  kmip
  ```

- For a centralized keystore, where the hardware security module (HSM) uses the PKCS #11 keystore API, set **keystore_type** to "PKCS11", and set **keystore_location** to the absolute path and file name of the PKCS #11 keystore configuration file.

  Example

  ```
  update dbm cfg using keystore_location /home/thomas/keystores/pkcs11.cfg keystore_type
  pkcs11
  ```

What to do next

Restart the database manager instance to cause the configuration changes to take effect.

Encrypted backups
With Db2 native encryption, you can encrypt your database, your database backups, or both. Database backups can be encrypted regardless of whether the database itself is encrypted.

You can encrypt individual backups manually, by specifying the ENCRYPT option on the BACKUP DATABASE command. You can also configure Db2 to automatically encrypt backups by setting the *encrlib* and *encropts* database manager configuration parameters. By default, when an encrypted database is created, these parameters are set to ensure that backups are automatically encrypted. For more information, refer to Encrypted database backup images.

Important consideration for encrypted backups

When a database backup is encrypted, it is no longer affected by subsequent attempts to reduce its size. Size reduction methods include attempts through compression or data deduplication technologies that are offered on some storage media devices. Encryption removes repetitive patterns from the data that these technologies rely upon. To reduce the size of database backups, compression needs to be applied before encryption. Compression can be done by actively compressing the data in the database itself, or by specifying the `libdb2compr_encr.so` or `libdb2nx842_encr.a` library on the BACKUP DATABASE command.

Related information
BACKUP DATABASE command

Encrypted database backup images
You can create an encrypted backup image of your database, then retrieve it using the **RESTORE DATABASE** or **RECOVER DATABASE** command. **RECOVER DATABASE** runs both the **RESTORE DATABASE** and **ROLLFORWARD DATABASE** command.

Encrypted database creation
The ENCRYPT keyword, which is an option of the CREATE DATABASE command, is used to encrypt a database, and to set encryption options.

Creating an encrypted database

By default, when running the CREATE DATABASE command with no options beyond the ENCRYPT keyword, a new master key is generated and inserted into the keystore as part of database creation. The AES encryption algorithm, with a key length of 256, will be used to encrypt the database.

See Creating an encrypted database for detailed steps on using the ENCRYPT command when creating a new database.

Encrypting an existing database

To encrypt an existing unencrypted database, it is necessary to unload and reload the database to ensure that all of the data is encrypted. The most effective way to do this is to restore a full backup of the database using the ENCRYPT option on the RESTORE DATABASE command. As with database creation, if no further options are provided, the ENCRYPT option will cause a new master key to be generated and inserted into the keystore. The master key is created with the AES encryption algorithm with a key length of 256 to encrypt the database.

For more information on the restore approach, refer to Encrypting an existing database.

It is also possible to use HADR to minimize the outage time by having an unencrypted copy of the database available on the standby while the primary is being encrypted. Refer to "Configuring native encryption in an HADR environment" on page 93 for more information.

Creating an encrypted database
Create an encrypted database by specifying the ENCRYPT option when using the **CREATE DATABASE** command.

Before you begin

- If you are using a local key manager, configure GSKit, then create the local keystore file and master key.
- If you are using a centralized keystore, with a key manager configured for the Key Management Interoperability Protocol (KMIP), configure the KMIP key manager and master key. You must also have TLS set up correctly between the KMIP key manager and your database server.
- If you are using a centralized keystore that utilizes a Hardware Security Module (HSM) configured for the PKCS #11 API, create a PKCS #11 keystore configuration file. You must also create a stash file to address operational concerns that involve access to PKCS #11 keystore credentials.

Procedure

- To create an encrypted database with the default settings, specify the ENCRYPT keyword on the **CREATE DATABASE** command:

```
db2 create db <encrypted_database_name> encrypt
```

- To create an encrypted database with custom settings, specify the ENCRYPT keyword with additional encryption options on the **CREATE DATABASE** command:

```
db2 create db <encrypted_database_name> encrypt
  cipher aes key length <length_of_data_encryption_key>
  master key label <master_key_label>
```

Where:

- CIPHER *cipher-name* specifies the encryption algorithm that is to be used for encrypting the database.
- KEY LENGTH *key-length* specifies the length in bits of the data encryption key that is to be used for encrypting the database.
- MASTER KEY LABEL *label-name* specifies a label for the master key that is used to encrypt the database. If you specify this option, the master key must already exist. If you exclude this option, a master key for the database is automatically generated and added to the keystore.

Results

The information in your database can be accessed only by using the appropriate stash file or password.

Encrypting an existing database

To encrypt the data in an existing, unencrypted database, you must create a backup image of the database, drop it, and then restore it into an encrypted database.

Procedure

To encrypt an existing database:

1. Create a keystore. If you are using a local key manager. If you are using a centralized key manager, ensure you have set up a centralized KMIP or PKCS #11 keystore.
2. Configure the database instance with the new keystore.
3. Generate a backup image of the database you would like to encrypt:

   ```
   db2 backup database <database_name>
   ```

4. Drop the original copy of the database you wanted to encrypt:

   ```
   db2 drop database <database_name>
   ```

5. Restore the backup image into a new encrypted database:

   ```
   db2 restore database <database_name> into <new_database_name> encrypt
   ```

   Note: This example uses the default set of RESTORE DATABASE encryption options to complete the restore process. For a full set of available encryption and master key options, see the RESTORE DATABASE command topic in the Db2 Command Reference PDF.

Results

The new database will contain the same information as the original, except with encrypted data.

Creating encrypted backup images

Create an encrypted backup image of your database using the **BACKUP DATABASE** command and specifying which library you would like to use in backup operations.

Procedure

- If you have the **encrlib** value set in the database configuration file, simply run the **BACKUP DATABASE** command:

  ```
  db2 backup database <database_name>
  ```

- If you do not have the **encrlib** value set in the database configuration file, specify the encrypt keyword:

  ```
  db2 backup database <database_name> encrypt
  ```

Note: These examples use the default set of options for backing up an encrypted database. For the full set of encryption and master key options available, refer to the BACKUP DATABASE reference topic in the Db2 Command Reference PDF.

Encrypted database restoration
Retrieve encrypted backup images of your databases on the same system or on a different system.

One process is used to restore encrypted backup images to the same system, whether the key manager is local or centralized. To restore an encrypted backup image, run the **RESTORE DATABASE** or **RECOVER DATABASE** command.

If you restore an encrypted backup image to a different system with a centralized key manager, simply configure the new system with the centralized key manager. If you are using local key management, you must take into account the security settings of the original and new system.

Restoring encrypted backup images to the same system
You can restore an encrypted database backup image to the same system with the **RESTORE DATABASE** command.

Procedure

Run the **RESTORE DATABASE** command:

```
db2 restore database <database_name> ENCRLIB 'db2encr.dll'
```

Note: While this example uses the `db2encr.dll` option for restoring an encrypted database, other options are available. For the full set of encryption options, refer to the RESTORE DATABASE reference topic in the Db2 Command Reference PDF.

Restoring an encrypted backup image to a different system with a local key manager
To restore a backup image to a different system, the local keystore file on that system must have the master key that is used by all the entities that are involved in the restoration. The entities include the backup image and potentially the transaction log files from the source system. If the database on the target system is also to be encrypted, it too needs to reference a master key in the local keystore file on the target system.

About this task

A simple way to achieve this goal is to copy the keystore file securely from the source system to the target system. If needed, add a new master key to the target system for the new copy of the database. You can also copy the needed master keys to the target system and then add them to the local keystore file.

Procedure

The procedure depends on the security protocol:

- When the source system keystore file is to be copied to the target system:
  a) Use a secure copy protocol such as SCP to copy the keystore and its associated stash file from System A to System B. An SCP is available with most Secure Shell (SSH) implementations.
  b) Update the value of the keystore_location database manager configuration parameter to point to the copied keystore on System B.
  c) If a new master key is wanted for the new database copy:
     a. Have the System B administrator add the new master key for the database copy to the keystore on System B.
     b. Have the System B administrator restore the backup image on System B, specifying the new master key on the restore command:

```
db2 restore database <database_name> encropts 'Master
Key Label=<systemB_admin_label>'
encrypt cipher aes key length <key_length_in_bits>
```

d) If using the same master key as the original database for the new copy, restore the backup image on System B:

```
db2 restore database <database_name> encrypt;
```

- When the source system keystore file is not going to be used for the new system:

a) Add a new master key for the backup:

a. Add a new master key to the local keystone file on the source system for use by the backup.

b. Generate an encrypted backup on System A:

```
db2 backup database <database_name>
  encrypt encrlib 'db2encr.dll'
  encropts 'Master Key Label=<label_backup_admin>'
```

b) Extract the newly created master key from the key database:

```
gsk8capicmd_64 -secretkey -extract -db <source-key-database-path> -stashed -label
<label_backup_admin> -format ascii -target <extracted-key-file>
```

c) Send the secret key file for the backup master key securely to the System B administrator.

d) Have the System B administrator add the key to the keystore on System B:

```
gsk8capicmd_64 -secretkey -add -db <destination-key-database-path> -stashed -label
<label_backup_admin> -format ascii -file <extracted-key-file>
```

Note: When adding the secret key used to encrypt the backup to the destination key database, the label used must be identical to the label of the secret key in the source key database.

e) If a new master key is wanted for the new database copy:

a. Have the System B administrator add the new master key for the database copy to the keystore on System B.

b. Have the System B administrator restore the backup image on System B specifying the new master key on the restore command:

```
db2 restore database <database_name> encropts 'Master Key Label=<systemB_admin_label>'
  encrypt cipher aes key length <key_length_in_bits>
```

f) If using the same master key as the backup for the database new copy, restore the backup image on System B:

```
db2 restore database <database_name> encrypt;
```

Restoring an encrypted backup image to a different system with a centralized key manager
If you are using a centralized key manager, restore an encrypted backup image on a different system by configuring that system with the centralized key manager, then running the **RESTORE DATABASE** command.

Procedure

To restore an encrypted backup image from System A to System B:

1. Copy the centralized keystore configuration file securely to System B.
2. Copy the keystore file which stores the TLS certificates securely to System B.
3. Configure System B with the centralized key manager by updating the **keystore_location** configuration parameter. Also update the SSL_KEYDB keyword in the centralized keystore configuration file to point to where you copied the keystore file with the TLS certificates. Update SSL_KEYDB_STASH as well if you have a stash file.

4. Restore the backup image on System B:

```
db2 restore database <database_name> encrypt;
```

Keystore migration
If you are implementing Db2 native encryption with a local PKCS #12 keystore file, you might want to migrate the master keys that are stored in that file to a centralized keystore. Db2 provides tools to help with this migration.

For detailed instructions to migrate your local keystore to a centralized keystore, refer to one of the following tasks::

- Migrating from a local keystore to a centralized KMIP keystore
- Migrating from a local keystore to a centralized PKCS #11 keystore

Configuring native encryption in an HADR environment
When you are encrypting a Db2 HADR configuration, it is important to remember that you are encrypting more than one database. Both the primary and standby databases need to be encrypted to provide the highest level of security.

Before you begin

It is possible to run an encrypted primary database and an unencrypted standby database. However, this configuration is recommended only if the standby database does not need to access any of the files that are encrypted on the primary. An example of such an encrypted file is an archived transaction log file.

While the primary and standby databases each have an independent, unique data encryption key, they must also have access to the same master key (MK). This access ensures that the MK label can flow between the databases when a MK rotation is done, and when the primary and standby databases need to access shared encrypted files.

It is recommended that all of the databases in an HADR environment have access to the same keystore. This can be a PKCS12 key store on a shared file system, or a centralized key store such as a KMIP key manager or PKCS11 hardware security module. It is not recommended to use separate PKCS12 key stores, since they must be manually kept in sync. In cases where a centralized keystore is being used, the databases might each be configured to treat different clones of the same keystore as their primary keystore.

It is also recommended that you consider implementing encryption for the HADR communication as well, to ensure that the data is never exposed. Refer to *Configuring TLS for the communication between primary and standby HADR servers* for setup instructions.

Procedure

To implement an HADR relationship for encrypted database, take the following steps:

1. Create and configure a common keystore for both the primary and standby databases and place the MK in the keystore. Save the keystore on a shared keystore service that can be accessed by both the primary and standby databases.

   For a non-encrypted database, configure Db2 to recognize the keystore. You can also migrate an old, local keystore to a new centralized KMIP or PKCS #11 keystore on the primary node.
2. Back up the primary database:

   ```
   db2 backup db <dbname>
   ```
3. Stop the HADR service on the primary node:

   ```
   db2 stop hadr on db <dbname>
   ```
4. Deactivate the database on the standby node:

```
db2 deactivate db <dbname>
```

5. Drop the standby database:

```
db2 drop db <dbname>
```

6. Restore the database on the standby node with the ENCRYPT option, specifying the encryption options and the label for the MK:

```
db2 restore db <dbname> encrypt
```

7. Start the encrypted standby database:

```
db2 start hadr on database <dbname> as standby
```

8. Reenter the HADR environment through the primary database:

```
db2 start hadr on database <dbname> as primary
```

9. When the standby database catches up to the primary database, run the following command on the standby database to have it take over as the new primary:

```
db2 takeover hadr on db <dbname>
```

10. Repeat steps 2 through 8, using the new primary database as the starting point.
11. When the standby database catches up to the primary database, have it take over as the primary database, to restore the HADR environment to its original configuration.
12. Repeat the entire procedure, as needed, for auxiliary standby databases.

Results

The primary and standby servers of your Db2 HADR configuration are now properly encrypted.

Encrypted database operations

Keystore availability
Access to the keystore is required for Db2 to work with an encrypted database. If the keystore is not available, then the database is not available.

When using a local keystore file, you need to provide an identical copy of the keystore at each Db2 member that is associated with the database. If you choose to use a shared file system, ensure that network access is maintained for that file system while Db2 is actively working with the encrypted database.

Using a centralized keystore means that network communication exists between Db2 and the keystore, and you need to account for potential network failures. With Db2, you can add multiple secondary keystore definitions in the keystore configuration for those products that support this feature. Consult the documentation for your keystore product to understand their recommendations for multiple secondary keystore definitions.

Keystore best practices
Employ security best practices to keep your keystores and master keys secure.

Keystore credentials

Most keystore configurations require that credentials be passed to the keystore before access to the stored keys is allowed. Since Db2 needs to have access to the keystore, Db2 also needs to have access to the keystore credentials. This information is required when the `db2start` command is run. There are a number of ways to securely provide Db2 the keystone credentials:

- A prompt for operator input of the credentials
- Access through a provided file argument

- Use of a “stash” file

A stash file is an obfuscated file that contains the credentials that are needed to access the keystore. Set this file to be readable by only the Db2 instance owner. Details on how to create a stash file is provided in the detailed keystore configuration information.

Note: Ensure that you back up your passwords, in addition to using a stash file. This applies particularly to the password used for a local keystore file. Should your stash file ever become corrupted, you will need to manually supply the password. If you forget the password, and do not created a backup, access to your keys and data is lost.

When creating or changing passwords for local keystone files, ensure that the passwords are strong, by using the `–strong` parameter of the **gsk8capicmd_64** command. For more information about the full syntax of the **gsk8capicmd_64** command, see: GSKCapiCmd Users Guide.

Keystore backups

The contents of your keystore are critical and it is important that you back up the keystore at regular intervals. Backups should be done whenever the contents of the keystore changes, such as when a key or certificate is added, a master key (MK) is rotated, or the password is changed.

Note: Backing up when there is a password change applies only to stash files, and not to all keystores. It also applies to the local keystore files.

The keystore configuration files are not included as part of a Db2 database backup and must be backed up manually. Keystore credentials, if stored on disk, must also be backed up manually.

For local keystore files, the configuration file is not included as part of a Db2 database backup and must be backed up manually.

For a centralized keystore, consult the documentation for your keystore product to understand their recommendations for keystore backups.

MK label uniqueness

Db2 uses the MK label to uniquely identify each MK, and stores the label value in each encrypted object, be it a database, transaction log, or backup file. This stored label value identifies the MK that is used to decrypt the data encryption key (DEK), which is used to encrypt the data in the object. It is critical to use unique MK labels to avoid duplication. If unique labels are not used, access to encrypted data can be lost. Access to encrypted data is lost when the MK that is retrieved from the keystore for a label is different from the MK that is used to encrypt the DEK in the object.

Master key retention

MKs are needed to access the DEKs that are stored in encrypted databases, transaction logs, and backup images. Since multiple MKs can exist over the life time of these objects, it is necessary to retain them while the encrypted data is retained. Therefore, do not delete MKs from the keystore.

Keystore configuration changes

Thoughtful planning needs to precede any changes to the Db2 database managed keystore configuration parameters or the contents of a keystore configuration, as not all changes can be completed online. Each new key request reads these values when it is accessing the keystore. With some exceptions, changes to these configuration values are reflected in the Db2 processing on the next key request. Although the Db2 database manager configuration parameters keystore_type and keystore_location are configurable online, you should set them in the a single `db2 update dbm cfg` command. Otherwise, Db2 might attempt to access the keystore between the updates and report an access error. For more information, see the Db2 Configuration Parameters Guide.

Changes to the SSL_KEYDB, SSL_KEYDB_STASH, and SSL_KMIP_CLIENT_CERTIFICATE_LABEL keystore configuration values require an instance restart to take effect. Changes to the LIBRARY keystore configuration value do not take effect until Db2 is restarted. Similarly, if the configuration value is not

changed, changes to the physical copy of the library do not take effect until Db2 is restarted. As Db2 can access the keystore periodically, it is highly recommended that you stop Db2 when making configuration changes, to avoid potential errors. If a mixture of encrypted and unencrypted databases exists under the same instance, it is sufficient to quiesce those databases that are encrypted.

Key rotation

Key rotation refers to the process of changing encryption keys and is often required for compliance purposes. Key rotation is done to reduce the risk that can come from exposure of the key, while it exists. Since the DEK used by Db2 for encryption is never outside of the encrypted database, backup, or transaction log, there is little risk of exposure. The same is not true for the MK, which lives outside of the database. Db2 provides a simple way to rotate the MK by using the SYSPROC.ADMIN_ROTATE_MASTER_KEY procedure. This procedure decrypts the embedded DEK, using the old MK, and then re-encrypts it with the new one. The rotation of the MK does not affect the encryption of the DEK within existing backups or archived transaction logs, but it does affect future DEK entries. A key rotation on the primary database in an HADR environment drives a key rotation automatically on the standby. The change, however, does not occur until other log records are sent to the standby database. If you want to force the rotated key to the standby, the archive log command can be used to generate the log records that are needed to replay the rotation on the standby. When the MK is rotated, the database begins to use the new key immediately, but access to the old MK value is still needed in the following scenarios:

- Transaction log files that have not been reused since the key rotation
- Archived encrypted transaction log files that used the previous MK value
- Encrypted backup images that used the previous MK value

Do not delete an MK from the keystore unless you are certain it is no longer referenced by any encrypted object.

Configuring native encryption in an HADR environment

When you are encrypting a Db2 HADR configuration, it is important to remember that you are encrypting more than one database. Both the primary and standby databases need to be encrypted to provide the highest level of security.

Before you begin

It is possible to run an encrypted primary database and an unencrypted standby database. However, this configuration is recommended only if the standby database does not need to access any of the files that are encrypted on the primary. An example of such an encrypted file is an archived transaction log file.

While the primary and standby databases each have an independent, unique data encryption key, they must also have access to the same master key (MK). This access ensures that the MK label can flow between the databases when a MK rotation is done, and when the primary and standby databases need to access shared encrypted files.

It is recommended that all of the databases in an HADR environment have access to the same keystore. This can be a PKCS12 key store on a shared file system, or a centralized key store such as a KMIP key manager or PKCS11 hardware security module. It is not recommended to use separate PKCS12 key stores, since they must be manually kept in sync. In cases where a centralized keystore is being used, the databases might each be configured to treat different clones of the same keystore as their primary keystore.

It is also recommended that you consider implementing encryption for the HADR communication as well, to ensure that the data is never exposed. Refer to *Configuring TLS for the communication between primary and standby HADR servers* for setup instructions.

Procedure

To implement an HADR relationship for encrypted database, take the following steps:

1. Create and configure a common keystore for both the primary and standby databases and place the MK in the keystore. Save the keystore on a shared keystore service that can be accessed by both the primary and standby databases.

   For a non-encrypted database, configure Db2 to recognize the keystore. You can also migrate an old, local keystore to a new centralized KMIP or PKCS #11 keystore on the primary node.
2. Back up the primary database:

   ```
   db2 backup db <dbname>
   ```
3. Stop the HADR service on the primary node:

   ```
   db2 stop hadr on db <dbname>
   ```
4. Deactivate the database on the standby node:

   ```
   db2 deactivate db <dbname>
   ```
5. Drop the standby database:

   ```
   db2 drop db <dbname>
   ```
6. Restore the database on the standby node with the ENCRYPT option, specifying the encryption options and the label for the MK:

   ```
   db2 restore db <dbname> encrypt
   ```
7. Start the encrypted standby database:

   ```
   db2 start hadr on database <dbname> as standby
   ```
8. Reenter the HADR environment through the primary database:

   ```
   db2 start hadr on database <dbname> as primary
   ```
9. When the standby database catches up to the primary database, run the following command on the standby database to have it take over as the new primary:

   ```
   db2 takeover hadr on db <dbname>
   ```
10. Repeat steps 2 through 8, using the new primary database as the starting point.
11. When the standby database catches up to the primary database, have it take over as the primary database, to restore the HADR environment to its original configuration.
12. Repeat the entire procedure, as needed, for auxiliary standby databases.

Results

The primary and standby servers of your Db2 HADR configuration are now properly encrypted.

General diagnostics and troubleshooting

Verifying a database is protected by native encryption
Verify whether or not your database is encrypted by native encryption by verifying the value of the **Encrypted database db** configuration parameter. You can also use the ADMIN_GET_ENCRYPTION_INFO table function if you would like more information on your encryption settings.

Procedure

To verify that your database has been successfully encrypted by Db2 native encryption, ensure that the value of the **Encrypted database db** configuration parameter value is YES:

```
db2 get db cfg for <example_encrypted_database>
          Encrypted database               = YES
```

Verifying the database backup image is encrypted
By default, backups of encrypted databases are also encrypted. However, if you would still like to ensure that your backup image is encrypted, you can run the **db2ckbkp** command and verify that it returns valid values for **compression**.

Procedure

To verify that the database backup image is encrypted, run the **db2ckbkp** command:

```
db2ckbkp -h <backup_image> | grep Compression
```

If the image has been successfully encrypted by Db2 native encryption, the **compression** parameter should return 2 if the backup image is encrypted, or 3 if it is both encrypted and compressed.

Determining whether hardware acceleration is being used
Db2 native encryption is designed to transparently recognize and take advantage of hardware acceleration for cryptographic operations. This feature, provided by some Intel and Power processors, dramatically reduces the impact of these operations on performance.

Procedure

To determine whether hardware acceleration is being used by Db2 for encryption:

1. Set the `diaglevel` configuration parameter to the value **3**.
2. Start Db2.
3. Open the `db2diag.log` file and look for a message similar to the following example:

```
2018-03-03-00.33.33.097480-300 I5523A542          LEVEL: Event
PID : 67043698         TID : 1      KTID : 21103435
PROC : db2dasftool
INSTANCE: pbird        NODE : 000
HOSTNAME: hotelaix15
EDUID : 1
FUNCTION: DB2 Common, Cryptography, cryptContextRealInit, probe:1774
DATA #1 : String, 37 bytes
CPU flags(string): 0x0000000000000006
DATA #2 : String, 37 bytes
CPU flags(Uint64): 0x0000000000000006
DATA #3 : String, 40 bytes
PowerPC VCipher capability not available
DATA #4 : String, 1 bytes
```

Results

A short text message is displayed in the DATA #3 line, indicating whether GSKit recognizes the presence of hardware acceleration, and whether it uses it on your system. If acceleration is detected, the message is displayed as `Encryption hardware acceleration detected -` "<the platform specific name>".

Related information
diaglevel - Diagnostic error capture level configuration parameter

Testing your keystore configuration
To test a new or changed valid keystore configuration file against a centralized keystore, without disturbing your Db2 system, you can use the appropriate key migration tool.

Procedure

To test your keystore configuration file:

1. Create a temporary PKCS #12 local keystore file.
2. Place a dummy master key in the local keystore file.

3. Place a copy of the new or modified Db2 keystore configuration file in a safe, temporary location (for example, not one used by Db2).
4. Run the appropriate migration tool with the local keystore file as the source and pass the new or modified keystore configuration file as input:
   - For KMIP, run the db2p12tokmip command
   - For PKCS #11, run the db2p12top11 command

Results

If successful, the dummy master key is replaced in the target centralized keystore.

Example

If you create a local keystore file that is called temporary.p12 and place a copy of the modified keystore configuration in a file that is called testkeystore.cfg, you would test the validity of the keystore configuration by running the following command:

```
db2p12top11 –from temporary.p12 –to testkeystore.cfg
```

Where to obtain diagnostic information
If Db2 is unable to access the keystore, or if it encounters a problem during its interaction with the keystore, it places diagnostic information into the Db2 diagnostic log (db2diag.log).

In addition, if you are using a centralized keystore, the keystore might record diagnostic information of its own that could further clarify the problem. Centralized keystores often use a diagnostic logging facility to record such information.

Common problems with keystore integration
When you attempt to integrate Db2 with a keystore, some configuration issues might arise that cause errors.

Lack of keystore credentials (SQL1728N rc = 3)

Issue

Db2 does not have access to the keystore, due to the lack of credentials.

Symptom

The -1728 SQLCODE with reason code **3** is returned.

Solution

To open the keystore, the db2start command must be executed again with the OPEN KEYSTORE option and the needed credential; you do not need to issue a db2stop command before rerunning the db2start command.

Error when DEVICE_GROUP parameter set (SQL1782N rc = 8)

Issue

Some KMIP keystores return an error when the DEVICE_GROUP parameter is set in the Db2 keystore configuration file.

Symptom

The -1782 SQLCODE error with reason code **8** is returned.

Solution

The DEVICE_GROUP parameter needs to be set only when using the IBM Security Key Lifecycle Manager (ISKLM) product. Remove the parameter for other KMIP keystore products.

Adding new certificates with gsk8capicmd_64(CTGSK2043W) generates an error

Issue

GSKit returns what appears to be an error when adding new certificates.

Symptom

The error that is returned appears similar to the following example:

```
$ gsk8capicmd_64 -cert -receive -db "clientkeydb.p12" -stashed -file
"client.crt" -default_cert yes
CTGSK2052W An invalid basic constraint extension was found. CTGSK2043W Key
entry validation failed.
```

Solution

What appears to be an error is a warning. The *W* at the end of both GSKit codes indicates that it is a warning (for example, `CTGSK2052W`). The warning indicates that, while the certificate was received, there might be some problems with it. In this case, GSKit is complaining that the basic constraint was not properly set, which could lead to a future **414** error from GSKit if the `ALLOW_NONCRITICAL_BASIC_CONSTRAINT` parameter is not set in the configuration.

Common GSKit errors
Db2 native encryption relies on the IBM® Global Security Kit (GSKit) product to process its cryptographic requests. If the GSKit encounters an error, a message token is returned by Db2 in the SQLCA, along with an appropriate SQLCODE, to report the error.

These tokens can take the form of `GSKit Error: XXX` (where 'XXX' is a number representing the GSKIT return code) or, if the tokens are being returned with `SQL1782N` and reason code **5**, they can be concatenated with the reason code message token in the SQLCA in the form of `5:XXX`.

To see the General, and Key Management return codes for the GSKit, see GSKit return codes.

The following information provides some details on how to address some common GSKit errors that can arise with Db2 native encryption.

Note: Not all possible scenarios are represented in the following examples, only the ones most frequently encountered.

GSKit: 407

This return code indicates that the specified label cannot be found. The most common cause of this error is an incorrect value in the `SSL_KMIP_CLIENT_CERTIFICATE_LABEL` keystore configuration parameter, which results in no matching certificate being found. This problem can be caused by a misspelling or placing quotation marks around the label value. Another possible cause is that the label represents a certificate without a private key that is required by Db2.

GSKit: 408

This return code indicates that the key file cannot be used because the specified key file password is incorrect. The key file might also be corrupted.

This error can be returned in these scenarios:

- The password to access the key file is incorrect.
- Db2 does not have the correct permissions to access the password stash file, if a password stash file is being used.
- The password stash file was created with an incompatible version of GSKit.

  Note: GSKit version 8.0.50.69 (and higher) generates a password stash file that older versions of GSKit cannot read. If you believe that this scenario might apply, try recreating the stash file with the current GSKit version.

GSKit: 410

This return code indicates that an incorrectly formatted TLS message was received from the partner in an TLS relationship. This error can be returned when the computer that is attempting to access the keystore does not have the required firewall access.

GSKit: 414

This return code indicates that an incorrectly formatted certificate was received from the partner in an TLS relationship.

This error can be returned in these scenarios:

- You are using self-signed certificates and the certificate is missing.
- The certificate that is being used is from a local certificate authority that does not have the `Basic Constraints` extension active.

  Note: You can use the `ALLOW_NONCRITICAL_BASIC_CONSTRAINT` keystore configuration parameter to bypass this problem.

Related tasks

"Encrypting an existing database" on page 90
To encrypt the data in an existing, unencrypted database, you must create a backup image of the database, drop it, and then restore it into an encrypted database.

Performance tuning

The simplest statement that can be made about the impact of Db2 native encryption is that it effectively reduces the physical I/O bandwidth on the Db2 system. How your workload reacts to this change determines the impact to its overall performance.

Note: If enabling this feature on AIX, review the following for performance considerations.

Determining the actual impact on workload depends on a number of factors, such as:

- The amount and speed of CPU available for encryption and decryption, or the existence of CPU hardware acceleration support.
- The amount of buffer pool page reuse by the workload or, how often the workload brings in new pages or forces old ones out.
- The volume of physical read or write operations in the buffer pool relative to the throughput efficiency of the background processes.
- The amount of non-buffer pool I/O such as LOBs.

The biggest factor in reducing the impact of Db2 native encryption is the existence of hardware acceleration that can be used by Db2. After the use of hardware acceleration, the next best way to further reduce the impact on workload is to do the following, where possible:

- Shelter the workload from the physical I/O by reducing I/O wait through normal tuning actions where possible. For example, increase the buffer pool size to avoid having queries that are waiting on physical I/O.
- Introduce parallelism for any work that is doing the physical I/O.

The latter recommendation comes from the fact that the number of cores that are being used for encryption purposes is limited to the actual number of threads that are doing physical I/O. While each thread runs on a single core and uses as much CPU processing power as it can, that core might not be fully used, nor might all available cores be in use. So, it is possible to have a situation where you still have CPU available to do work while your system is encountering more I/O wait time on physical I/O due to encryption. The only way to overcome this behavior is, where possible, to increase the number of threads that are doing the physical I/O. This means that you might find it helpful to increase the parallelism of utilities and the background infrastructure in Db2, such as page cleaners, prefetchers, and so on..

Do a full performance tuning exercise on a newly encrypted system, as new and possibly different bottlenecks could be introduced from the reduced physical I/O volume. Follow the normal Db2 tuning exercises to ensure that I/O latency is reduced. If excess CPU capacity exists, revisit areas where physical I/O bottlenecks or latency exist to see whether parallelism can be increased in those areas. For more information, see Performance overview and Tuning and Monitoring Database System Performance.

IBM InfoSphere Guardium Data Encryption for encryption of data at rest

IBM InfoSphere Guardium Data Encryption is a comprehensive software data security solution that when used in conjunction with native Db2 security provides effective protection of the data and the database application against a broad array of threats.

InfoSphere Guardium Data Encryption helps organizations ensure that private and confidential data is strongly protected and in compliance with regulations and legislative acts. The key benefits of InfoSphere Guardium Data Encryption are:

- Proven, strong data security for the Db2 database system
- Protection of live files, configuration files, log files and back-up data
- Transparent to application, database and storage environments
- Unified policy and key management for protecting data in both online and offline environments
- Meets performance requirements

InfoSphere Guardium Data Encryption enables you to encrypt offline database backups and to encrypt online ("live") database files. This is encryption of data on the disk, sometimes called "data at rest" as opposed to "data in flight", which is traveling over the network.

- For backups, data is encrypted as it is being backed up, so the data on the backup device is encrypted. Should the data need to be recovered, the recovery server recognizes that the data is encrypted and will un-encrypt the data.
- For database files, the operating system data files containing the data from the Db2 database are encrypted. This protects the data files from unauthorized users trying to read the "raw" database file.

InfoSphere Guardium Data Encryption is transparent to users, databases, applications, and storage. No code changes or changes to existing infrastructure are required. InfoSphere Guardium Data Encryption can protect data in any storage environment, while users continue to access data the in the same way as before.

InfoSphere Guardium Data Encryption can protect database applications, because it can prevent changes to executable files, configuration files, libraries, and so on, thereby preventing attacks on the application.

Note: For Db2 pureScale environments, InfoSphere Guardium Data Encryption is supported only on AIX. InfoSphere Guardium Data Encryption is not supported on other platforms that are running Db2 pureScale environments.

Architecture of InfoSphere Guardium Data Encryption

InfoSphere Guardium Data Encryption is a set of agent and server software packages that you administer by using a Web-based user-interface and command-line utilities. The InfoSphere Guardium Data Encryption administrator configures security policies that govern how security and encryption are implemented.

According to how these security policies are defined, the InfoSphere Guardium Data Encryption backup agent encrypts Db2 backups, and the InfoSphere Guardium Data Encryption file system agent encrypts Db2 data files.

The security server stores the security policies, encryption keys and event log files. Security policies contain sets of security rules that must be satisfied in order to allow or deny access. Each security rule evaluates who, what, when, and how protected data is accessed and, if these criteria match, the security server either permits or denies access.

Figure 5 on page 103 illustrates the architecture of InfoSphere Guardium Data Encryption.

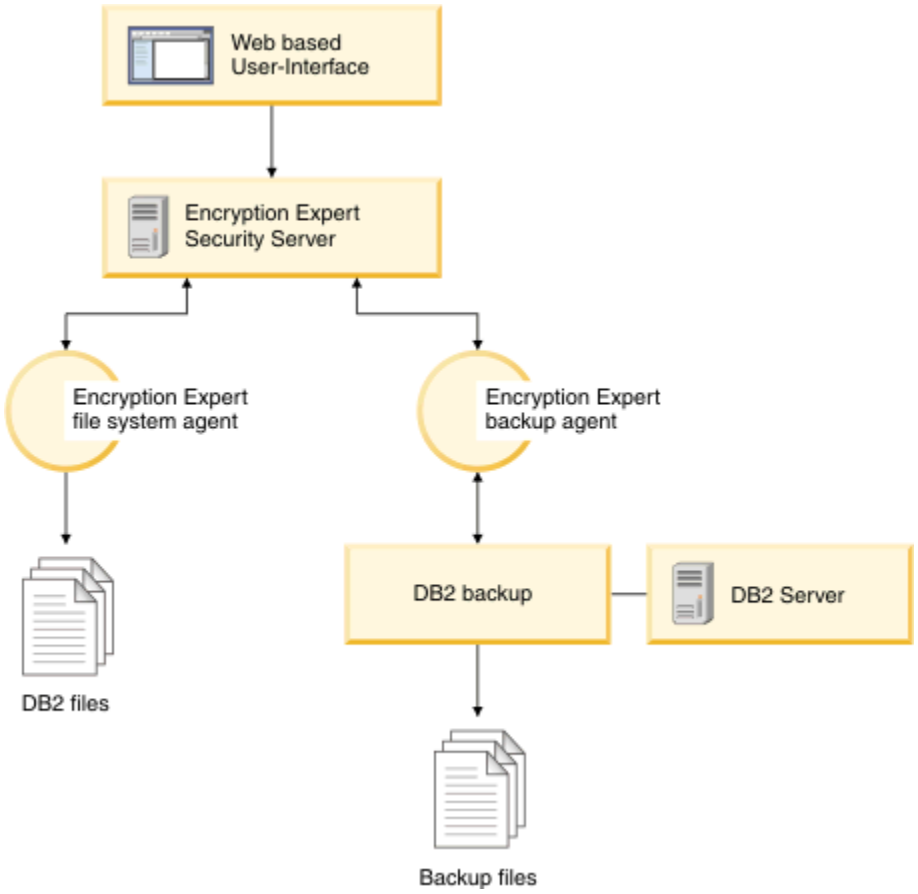


Figure 5. Architecture of InfoSphere Guardium Data Encryption

File system agent

The InfoSphere Guardium Data Encryption file system agent process is always running in the background. The agent intercepts any attempt to access data files, directories, or executables that you are protecting. The InfoSphere Guardium Data Encryption file system agent forwards the access attempt to the security server and, based upon the applied policy, the security server grants or denies the attempted access.

InfoSphere Guardium Data Encryption protection extends beyond simply allowing or denying access to a file, you can also encrypt files. Just the file contents is encrypted, but the file metadata is left intact. Therefore, you do not have to decrypt an encrypted file just to see it's name, timestamps, file type, and so on. This allows data management applications to perform their functions without exposing the file contents. For example, backup managers can backup specific data, without being able to see the contents.

If an encrypted file is accessed by an unauthorized user, its contents are worthless without the appropriate security server approval and encryption keys. However, users with the correct policies and permissions are unaware that encryption and decryption are taking place.

Backup agent

All database backup functions that are normally performed by the Db2 backup API system are supported by the InfoSphere Guardium Data Encryption server, including native database compression. Other than an additional command-line argument, Db2 backup operators are unaware of InfoSphere Guardium Data Encryption intervention. InfoSphere Guardium Data Encryption backs up and restores static data-at-rest and active online data.

Basic backup and restore configuration is supported. In the basic configuration, data is encrypted and backed up with one server and multiple agents; data is decrypted and restored on an agent that is configured with the same server that was originally used to make the backup.

Single-site and multi-site configurations are also supported for backup and restore. In a single-site scenario, configuration data is mirrored across multiple security servers in a single data center. In a multi-site scenario, backups are restored on different security servers in different data centers.

Audit logging

InfoSphere Guardium Data Encryption agent activity is closely monitored and logged through a centralized audit logging facility. All auditable events, including backups, restores, and security administration operations can be logged. This includes InfoSphere Guardium Data Encryption system events, such as initialization, shut down and restart; and network connects and disconnects between different InfoSphere Guardium Data Encryption components.

Database encryption using AIX encrypted file system (EFS)

If you are running a Db2 system on the AIX operating system, you have the option to set up an encrypted database by using AIX encrypted file system (EFS). For detailed information about EFS, see your AIX documentation.

Note: If you are working in a partitioned database environment, to use EFS, your database should be in a single database partition.

You can encrypt the operating system files that contain the data in database tables by using the underlying EFS with JFS2 file system.

To set up encryption, the steps are as follows:

1. Enable EFS on the system.
2. Load the keystores for the user account under which the Db2 database daemons run.
3. Enable EFS on the database file system.
4. Determine the operating system file to encrypt.
5. Encrypt the file that contains the database table that requires EFS protection.

Enabling EFS on the system

Before you enable EFS, the `clic.rte` fileset must be installed. The `clic.rte` install image can be found on the Expansion Pack CD.

Run the following command as root to enable EFS on the system:

```
% efsenable -a
```

You need to run the **efsenable** command only once.

Loading the keystores

In the following configuration examples, the Db2 user account under which the database daemons run is called abst. The user abst must have a keystore and any group that abst is a member of must also have a keystore.

1. All keystores must be associated with the abst process before starting the Db2 daemons.

   You can verify that they are associated by using the **efskeymgr -V** command, as shown in the following example:

```
# lsuser abst
abst id=203 pgrp=abstgp groups=abstgp,staff ...

# efskeymgr -V
List of keys loaded in the current process:
  Key #0:
                    Kind ..................... User key
                    Id (uid / gid) ......... 203
                    Type ..................... Private
key
```

```
                    Algorithm ................ RSA_1024
                    Validity ................. Key is
valid
                    Fingerprint ..............
24c88df2:d91cb6a2:c3e11b6a:4c13f8b4:666fabd8

  Key #1:
                    Kind ..................... Group
key
                    Id (uid / gid) ......... 1
                    Type ..................... Private
key
                    Algorithm ................ RSA_1024
                    Validity ................. Key is
valid
                    Fingerprint ..............
03fead42:57e7646e:a1715626:cfa56c8e:8abed1c1

  Key #2:
                    Kind ..................... Group
key
                    Id (uid / gid) ......... 212
                    Type ..................... Private
key
                    Algorithm ................ RSA_1024
                    Validity ................. Key is
valid
                    Fingerprint ..............
339dfb19:bc850f4c:5551c975:7fe4961b:2dddf3bc
```

2. If there are no keystores shown as associated with the abst process, try loading the keystores using the command: `% efskeymgr -o ksh`

   This command prompts for the keystore password, which is initially set to the login password.

3. Confirm that the user and group keys are loaded by rerunning the command: `% efskeymgr -V`

   Both the user and group keys should be listed. If the group keystores are still not listed, continue with Step 4.

4. Depending on how a group was created, the group keystore may not exist. If the **efskeymgr -V** command does not list the user's group keystores, you must create the group keystores.

   As root or the RBAC role aix.efs_admin, create the group keystore:

   ```
   % efskeymgr -C group_name
   ```

5. Assign group keystore access to each applicable user:

   ```
   % efskeymgr -k group /group_name -s user/user_name
   ```

   If a user is already logged in, they will not immediately have access to the group keystore, and they should reload their keystore using the **efskeymgr -o ksh** command, or re-login.

Enabling EFS on the database file system

EFS only runs on JFS2 file systems and must be specifically enabled.

If your database resides on an existing file system, run the `% chfs -a efs=yes filesystem` command to enable EFS, for example:

```
% chfs -a efs=yes /test01
```

If you are creating a new file system, you can enable EFS using the `-a efs=yes` option with the **smit** command or the **crfs** command. For example:

```
% crfs -v jfs2 -a efs=yes -m mount_point -d device -A yes
```

EFS is now enabled on the file system but is not turned on. Turn on EFS only for the particular database tables requiring encrypted data (for more information, see your AIX EFS documentation about the **efsmgr** command and inheritance).

Determining the file to encrypt

To determine which file contains a particular database table that you want to protect with EFS encryption, follow these steps that use the EMPLOYEE table as an example.

1. Use a query similar to the following example to find the TBSPACEID for the table:

   ```
   SELECT TABNAME, TBSPACEID FROM syscat.tables WHERE tabname='EMPLOYEE'
   ```

   Assume the results of this query are as follows:

TABNAME	TBSPACEID
EMPLOYEE	2

2. Look up the table spaces for that TBSPACEID with a query similar to the following example:

   ```
   LIST TABLESPACE CONTAINERS FOR 2
   ```

   Assume the results of this query are as follows:

Container ID	Name	Type
0	/test01/abst/NODE0000/BAR/T0000002/C0000000.LRG	File

   You now know that this table space is contained in the operating system file called `/test01/abst/NODE0000/BAR/T0000002/C0000000.LRG`. This is the file you need to encrypt.

Encrypting the file

First, as you would do before making any major change to data or databases, back up your database.

Follow these steps to encrypt the file:

1. List the file, for example:

   ```
   # ls -U /test01/abst/NODE0000/BAR/T0000002/C0000000.LRG

   -rw-------- 1 abst abstgp 33554432 Jul 30 18:01
   /test01/abst/NODE0000/BAR/T0000002/C0000000.LRG
   ```

2. Encrypt the file using the **efsmgr** command, for example:

   ```
   # efsmgr -e /test01/abst/NODE0000/BAR/T0000002/C0000000.LRG
   ```

   If you list the file again you will see an "e" at the end of the permissions string that indicates the file is encrypted. For example:

   ```
   # ls -U /test01/abst/NODE0000/BAR/T0000002/C0000000.LRG

   -rw-------e 1 abst abstgp 33554432 Jul 30 18:03
   /test01/abst/NODE0000/BAR/T0000002/C0000000.LRG
   ```

3. Start the Db2 database manager and use it as normal. All data added to the EMPLOYEE table and this encrypted table space will be encrypted by EFS in the underlying file system. Whenever the data is retrieved, it will be decrypted and presented as normal through the Db2 database manager.

Encryption of data in transit

Db2 uses the Transport Layer Security (TLS) protocol to securely transmit data between servers and clients. TLS technology uses both asymmetric cryptography (for example, public key encryption) and symmetric cryptography to make this work.

You can use TLS to protect data in transit on all networks that use TCP/IP. In other words, a TLS connection is a secured TCP/IP connection.

Public key encryption for server authentication

TLS uses public-key algorithms to exchange encryption key information and digital certificate information. Public key encryption is used to ensure that a client can trust the certificate that is used by a server.

Public key cryptography uses two different encryption keys during a TLS session:

- A public key to encrypt data.
- An associated private key to decrypt it.

With public-key cryptography, the public key is not secret, but the messages it encrypts can be decrypted only by using it's associated private key. The private key must be securely stored in a file that is called a keystore.

Public-key algorithms alone do not ensure secure communication, you also need to verify the identity of whoever is communicating with you. To do this authentication, TLS uses digital certificates.

Distribution and use of digital certificates

To facilitate encryption of data in a Db2 environment, the following tasks need to happen for each Db2 server within your organization:

1. A member of your organization uses GSKit to create a public and private key pair.
2. The public key is sent to a certificate authority (CA) where a certificate is created and signed.
3. The server's certificate (which includes the server's public key) is distributed to all of the Db2 clients (and servers) within your organization for storage within their local keystores.

Once the certificates for each server have been distributed within your network, all of the parts needed to make TLS work are in place.

Before data is encrypted for transmission between Db2 nodes in your network, a TLS handshake occurs. This enables a client to check the validity of a server's certificate and, if the certificate is trusted, create a session key by using the server's public key. The session key is used to encrypt data traveling between the client and server for the duration of the connection.

Keystores

To ensure secure storage of private keys and certificates, you need to use a keystore. You can use the IBM® Global Security Kit (GSKit) to create a PKCS#12 keystore (with the .p12 extension) or a CMS keystore (with the .kdb extension).

Certificate Management System (CMS) is the native GSKit keystore, containing:

- X.509 certificates.
- Certificate requests (pending signing by an authority).
- Private keys for the stored certificates where applicable.

If a certificate has an associated private key, it is stored in an encrypted state in the keystore with its associated certificate.

Note: Private keys cannot be stored without an associated certificate.

Creating a keystore with GSKit

A keystore is an industry recognized way of securely storing TLS private keys, root certificates, and certificate chains. Db2 supports both the IBM proprietary Certificate Management System (CMS) format and the Public-Key Cryptography Standards #12 (PKCS12) open standard format.

Before you begin

This procedure explains how to use the IBM Global Security Kit (GSKit) to create a keystore for digital certificates and keys that enable secure transmission of data between servers and clients on your Db2 network, by using TLS.

Before you attempt to user GSKit, verify that GSKit is installed properlyverify that GSKit is installed properly.

About this task

For information about the GSKit tool GSKCapiCmd, see the GSKCapiCmd User's Guide.

Procedure

1. Use the GSKCapiCmd tool to create your keystore. The keystore must be of a CMS type (extension `.kdb`) or a PKCS12 type (extension `.p12`).

   The GSKCapiCmd is a non-Java-based command-line tool, and Java does not need to be installed on your system to use this tool.

   You start GSKCapiCmd by running the command,**gskcapicmd** as described in the *GSKCapiCmd User's Guide*. The path for the command is `sqllib/gskit/bin` on Linux and UNIX operating systems, and `C:\Program Files\IBM\GSK8\bin` on both 32-bit and 64-bit Windows operating systems. (On 64-bit platforms, the 32-bit GSKit executable files and libraries are also present; in this case, the path for the command is `C:\Program Files (x86)\IBM\GSK8\bin`.) Ensure **PATH** (on Windows operating systems) includes the proper GSKit library path, and *LIBPATH, SHLIB_PATH*, or *LD_LIBRARY_PATH* (on UNIX or Linux operating systems) include the proper GSKit library path, such as `sqllib/lib64/gskit`.

   For example, the following command creates a keystore that is called `mykeystore.kdb` and a stash file that is called `mykeystore.sth`:

   ```
   gsk8capicmd_64 -keydb -create -db "mykeystore.kdb" -pw "myServerPassw0rdpw0"
         -stash
   ```

   A stash file is an obfuscated (altered to impair its readability by humans) form of a keystore password. Having a stash file allows Db2 to access a keystore file without user intervention, and prevents the keystore's files from being casually read.

   The **-stash** option creates a stash file at the same path as the keystore, with a file extension of `.sth`. At instance start-up, GSKit uses the stash file to obtain the password to the keystore.

   Note: Use strong file system protection on the stash file. By default, only the instance owner has access to this file (both read and write access).
2. Add a certificate for your server to your keystore.

What to do next

Viewing the contents of your keystore

To view the contents of your keystore, run the GSKit command **gsk8capicmd_64** with the **-cert -list** options. For example, the following command lists the contents of the keystore `mydbserver.kdb`:

```
gsk8capicmd_64 -cert -list -db mykeystore.p12 –stashed
Certificates found
* default, - personal, ! trusted, # secret key
!  MyRootCA
-  Db2Server
```

Where

- "**!**" identifies a certificate that is being trusted to sign other certificates. This option should appear only before root and intermediate CA certificates.
- "**-**" identifies an end-point (or personal) certificate. Only end-point certificates are valid to specify in SSL_SVR_LABEL.

Viewing details about a certificate in your keystore

To view details about a certificate in your keystore file, such as the key size and CA information, run the GSKit command **gsk8capicmd_64** with the **-cert -details** options. For example, the following command shows the details of the certificate db2Server from the keystore file mydbserver.kdb:

```
gsk8capicmd_64 -cert -details -label db2Server -db mydbserver.kdb -stashed
```

Simplify keystore setup in Microsoft Windows environments

You can simplify access to certificates on Db2 clients that run on Windows, by using the Microsoft Certificate Store (MSCS).

You can integrate the IBM Global Security Kit (GSKit) with MSCS, which is a native component of supported Windows operating systems.

The MSCS can be used to store both root certificates and endpoint certificates. If Windows servers on your Db2 network are already using MSCS, it can save you the time and effort of creating your own keystores.

Accessing the MSCS

You access the MSCS through the *Internet Options* dialog box (for example, **Control Panel** > **Internet Options**). By clicking the **Contents** tab and then **Certificates**, you can access all of the certificates that are contained in the MSCS.

Certificates include:

- Personal certificates that are issued to the current user account.
- Certificates that are assigned to other users on the current server.
- Intermediate and Root certificate authorities (CAs)
- Trusted and untrusted publishers of certificates

Note: Entries in the *Friendly Name* column equal the Label values that are found in a certificate file or keystore. Watch for duplicate *Friendly Name* values as only the first occurrence is used by the MSCS.

You can use the MSCS to import or export certificates and certificate chains, or you can use the command-line tools that are found in GSKit.

Integrating the MSCS with GSKit

To get GSKit to recognize the MSCS as a key database:

1. Log in to your Db2 server as the Db2 instance owner and set the following DBM CFG configuration parameters:

   ```
   SSL_[CLNT|SVR]_KEYDB  GSK_MS_CERTIFICATE_STORE
   SSL_[CLN|SVR]_STASH  NULL
   ```

2. Open GSKit and run the **gsk8capicmd_64** command with the **-db** option, by using GSK_MS_CERTIFICATE_STORE as the target.

Note: GSKit works with certificates that are associated with the current user account, not the computer account.

Digital certificates

A digital certificate consists of the public portion of a private/public key pair and metadata values that identify the holder of the certificate (name, company name, certificate expiry date, etc.). A certificate is said to be ‘signed’ when a CA or individual uses a private key to encrypt a hash of a message.

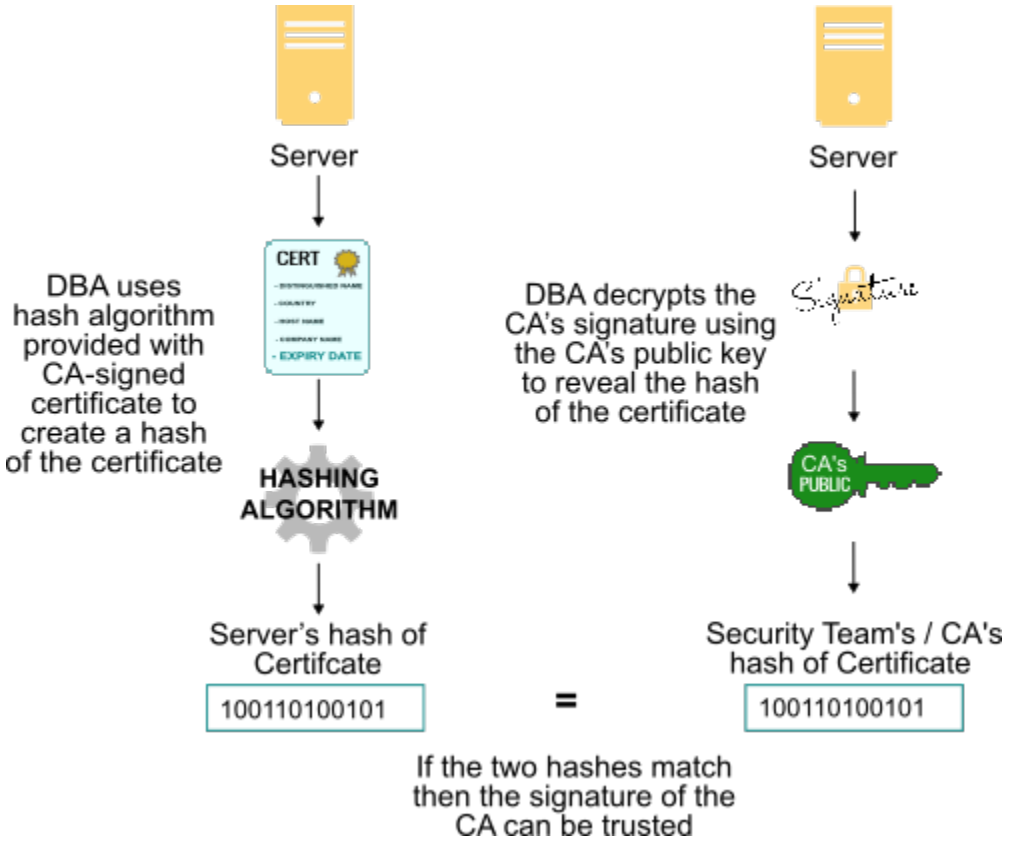
Signing of digital certificates

Note: In TLS encryption, a hash is a mathematical reworking of a message to reduce it to a manageable size. It is created by using a hashing algorithm, which is included as part of a signed message.

The hash can be decrypted only by someone who has the public portion of the private/public key pair. Decrypting the hash proves that the sender (or holder of the certificate) is trusted by the signer and that secure communication can begin.

In the following diagram, the receiver of a signed message is verifying the identity of the signer. Authentication is done by comparing a hash of the certificate that the receiver creates with a similar hash that the signer created and then encrypted using their private key. The receiver uses the signer's public key to decrypt the signer's signature to expose the original hash of the certificate.

If the two hashes match, then the receiver can trust the signature of the message, as only the signer could have encrypted the hash with the private portion of their key pair.



Note: If you have a small network of only a few servers and clients, you can . You then send certificates for each server to trusted clients within your network, and these clients trust the certificates as if they were signed by a CA.

The certificate chain

Your certificate might in turn depend on the digital certificate of another CA; there might be a hierarchy of certificates that are issued by multiple CAs, each depending on the validity of the next. However, the receiver needs the public key of the root CA, eventually. The root CA is the CA at the top of the hierarchy, and this hierarchy, or dependency, is known as a certificate chain.

To trust the validity of the digital certificate of the root CA, the user must receive that digital certificate in a secure manner. Examples of secure transfer include downloading from an authenticated server, or with preinstalled software received from a reliable source. Applications that send a digital certificate to a receiver send not just their own certificate: They also all the CA digital certificates necessary to verify the hierarchy of certificates up to the root CA certificate.

For a digital certificate to be entirely trustworthy, the owner of the digital certificate must be careful to protect their private key in their keystore. If their private key has been compromised, an imposter could misuse their digital certificate.

Distributing a signed certificate

When you receive your signed certificates from a CA, you can use GSKit to add (receive) them to a keystore and to import them to a certificate file. You can then distribute the certificate file to the Db2 servers and clients within your network. This process allows receiving clients and servers to validate a sending server's certificate against the one that they added to their local keystore. Once the certificate is validated, the client and server can establish encrypted communication.

Note: In some cases, your security team might do all the work for you. They might act as your CA and create the needed keys and certificates for each Db2 server in your network. They might provide these components in a certificate file like a *.crt or they might provide you with a keystore that contains all of required elements.

The TLS handshake

During a *TLS handshake*, a public-key algorithm is used to securely exchange digital signatures and encryption keys between a client and a server. This identity and key information is used to establish a secure connection for the session between the client and the server. After the secure session is established, data transmission between the client and server is encrypted using a symmetric algorithm, such as AES.

The client and server perform the following steps during the TLS handshake:

1. The client requests a TLS connection and lists the default set of supported cipher suites.

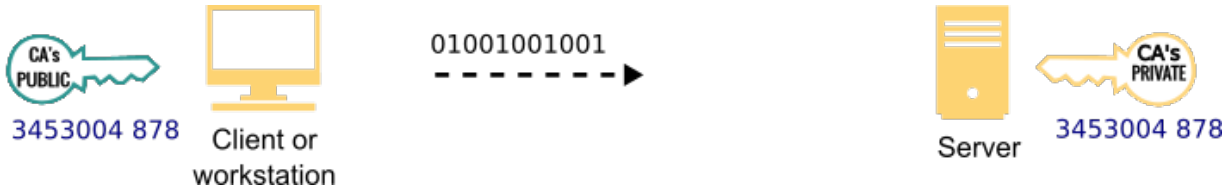
   Note: While the set of cipher suites used by the Db2 server can be altered, The client always uses the default set.

2. The server responds with a selected cipher suite.
3. The server sends its digital certificate to the client.

4. The client verifies the validity of the server certificate ('Was this cert signed by someone I've been told to trust?') by comparing a decrypted hash of the certificate against a similar one in its keystore.

5. If hostname validation is enabled, the client then checks that the hostname to which it is configured to connect matches what is present in the certificate. This option is available in Db2 11.5.6 and later clients.
6. If the server's certificate is trusted by the client, the client uses the server's public key to encrypt a random number and send it to the server. The server then uses it's private key to decrypt the number, which becomes the session key.

   Note: Values assigned to the `dbm cfg` parameter *SSL_CIPHERSPECS* influence the size of the session key.



7. The client and server securely exchange information using the negotiated session key.

Attention: The Db2 database system supports the (optional) authentication of the client during the TLS handshake only when connecting to a Db2 for z/OS server.

Hostname validation for Db2 11.5.6 clients

Db2 11.5.6 clients can verify the hostname that appears in a Db2 server's Transport Layer Security (TLS, formerly known as SSL) certificate against the server for which they are configured to connect. Using hostname validation, Db2 clients have an added layer of security when negotiating secure connections to Db2 servers during a TLS handshake.

How hostname validation works

When a Db2 client sends a `client hello` message to a Db2 server during a TLS handshake, the server responds with it's own `server hello` message, which includes, among other things, its certificate. It is at this point that the client authenticates the server using this certificate.

If hostname validation is enabled, the client verifies that the hostname to which it is configured to connect matches one of the hostnames present in the certificate. The server's identity can be represented using different fields in the certificate. Once the client authenticates the server, both parties perform key exchange and a successful TLS connection is established.

Here is an example scenario where the client connects to the database server at *xyz.example.com* with TLS and hostname validation enabled:

1. A Db2 client initiates a connection with a Db2 server:

```
Hostname=xyz.example.com;Security=SSL;SSLClientHostnameValidation=Basic;Database=….
```

2. The server responds with its certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=xyz.example.com
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST
```

```
Extensions
    subjectAlternativeName
        dNSName: xyz.example.com

Signature Algorithm : SHA1WithRSASignature
```

3. The client performs hostname validation. In this case, it is successful because the certificate contains *xyz.example.com* as its subject alternate name (SAN).
4. The rest of the handshake takes place and a secure connection is established with the server.

Note: If hostname validation fails, SQL20576N with SQLSTATE 08001 is returned to the client and an error message is logged to the `db2diag.log`. This message includes one or more hostnames contained in the server certificate and any hostnames that the client used to match against this certificate.

Configuring Db2 clients for hostname validation when negotiating a TLS connection

You can configure Db2 clients to validate the hostname of a Db2 instance when negotiating a Transport Layer Security (TLS, formerly SSL) connection. While this feature can be used when connecting to any supported Db2 server, it is only available in Db2 11.5.6 clients, or newer clients.

Hostname validation can be enabled for the following client interfaces.

- CLI/ODBC
- Embedded SQL
- JDBC

For CLI, ODBC or embedded SQL, the `SSLClientHostnameValidation` parameter needs to be set to `Basic` in the connection string, db2cli.ini, or db2dsdriver.cfg.

For Java applications, the `db2.jcc.sslClientHostnameValidation` property needs to be set to `BASIC`. For more information, see the description for the db2.jcc.sslClientHostnameValidation configuration property in IBM Data Server Driver for JDBC and SQLJ configuration properties.

Configuring hostname validation for connections to alternate servers

The **`alternateserverlist`** Data Server Driver configuration parameter specifies alternate servers that a Db2 client can use if the initial connection to the database fails.

As explained in the topic Configuration of Db2 automatic client reroute support for applications other than Java, these alternate servers are not used after the initial connection.

When connecting to one of the alternate servers from this parameter, hostname validation is successful if the server certificate matches one of the following:

- The primary hostname that the client configured
- The hostname of this alternate server as specified in **`alternateserverlist`** parameter

For example, if we have the following `db2dsdriver.cfg` file and the client tries the alternate server **abc.db2.example.com** during the initial connection because **xyz.db2.example.com** is down, the certificate returned by the server must include either **abc.db2.example.com** or **xyz.db2.example.com** for hostname validation to be successful.

```
<configuration>
  <dsncollection>
    <dsn alias="test" name="testdb" host="xyz.db2.example.com" port="1234">
    </dsn>
  </dsncollection>
  <databases>
    <database name="testdb" host="xyz.db2.example.com" port="1234">
      <acr>
        <parameter name="enableAcr" value="true"/>
        <parameter name="maxAcrRetries" value="10"/>
        <parameter name="acrRetryInterval" value="5"/>
        <parameter name="enableAlternateServerListFirstConnect" value="true"/>
        <alternateserverlist>
          <server name="server1" hostname="abc.db2.example.com" port="1234"/>
        </alternateserverlist>
      </acr>
    </database>
```

```
  </databases>
</configuration>
```

Configuring hostname validation for connections to alternate groups
The **alternategroup** Data Server Driver configuration parameter specifies alternate groups that a Db2 client can use as an additional failover mechanism for the initial connection and existing connections.

If any alternate servers are cached for a given group in the `srvrlst.xml` file, they are added as alternate servers to this group. Each alternate group's representative host is always added as an alternate server to the respective group, to ensure there is always at least one alternate server for a given alternate group.

When connecting to one of the alternate servers in an alternate group, hostname validation is successful if the server certificate matches one of the following:

- The hostname representing the alternate group as specified in **alternategroup** parameter
- The hostname of the alternate server as specified in the server list returned by the server

For example, in the following `db2dsdriver.cfg`, we have an alternate group represented by **abc.db2.example.com**. Let us say that a client connects to it because the primary group host, **xyz.db2.example.com**, is down. For this example, let us assume that **abc.db2.example.com** returns a server list (**abc.db2.example.com** and **pqr.db2.example.com**) that is associated with the alternate group.

When the client reroutes to **pqr.db2.example.com** because the configured alternate group host, **abc.db2.example.com**, is down, hostname validation succeeds only if the hostname in the server's returned certificate matches either the alternate group hostname configured at the client, **abc.db2.example.com**, or the hostname in the server list that is returned to the client (**pqr.db2.example.com**)

```
<configuration>
  <dsncollection>
    <dsn alias="test" name="testdb" host="xyz.db2.example.com" port="1234"/>
  </dsncollection>
<databases>

  <database name="testdb" host="xyz.db2.example.com" port="1234">
   <wlb>
    <parameter name="enableWLB" value="true" />
   </wlb>
     <acr>

     <alternategroup>
       <parameter name="enableAlternateGroupSeamlessACR" value="true"/>
       <database name="testdb" host="abc.db2.example.com" port="1234">
       </database>
     </alternategroup>

       <parameter name="acrRetryInterval" value="1" />
       <parameter name="enableACR" value="true" />
       <parameter name="enableseamlessACR" value="true" />
       <parameter name="maxAcrRetries" value="3" />
     </acr>

     <parameter name="TcpipConnectTimeout" value="1" />
     <parameter name="keepAliveTimeout" value="10" />
  </database>
</databases>
</configuration>
```

Related concepts
Alternate groups for connections to from non-Java clients

Adding a client affinity list to the db2dsdriver.cfg file for hostname validation
A client affinity lists allows a client to fail-over to one or more alternate servers in the given order.

When connecting to one of these alternate servers, hostname validation is successful if the server certificate matches one of the following:

- The primary hostname to which the client is configured to connect

- The hostname of an alternate server specified by the **alternateserverlist** parameter

For example, the following db2dsdriver.cfg file is configured so that the client's attempts to connect are targeted at **pqr.db2.example.com**, **abc.db2.example.com**, and then **xyz.db2.example.com** in sequence until a connection is established. For hostname validation to be successful for any of these connections, the server's certificate must match either **xyz.db2.example.com** or the hostname of the alternate server to which the client is attempting to connect.

```
<configuration>
  <dsncollection>
    <dsn alias="test" name="testdb" host="xyz.db2.example.com" port="1234"/>
  </dsncollection>
<databases>

  <database name="testdb" host="xyz.db2.example.com" port="1234">

     <acr>

       <parameter name="enableAcr" value="true"/>
       <parameter name="maxAcrRetries" value="1"/>
       <parameter name="acrRetryInterval" value="2"/>

       <alternateserverlist>
         <server name="server1" hostname="xyz.db2.example.com" port="1234">
         </server>
         <server name="server2" hostname="abc.db2.example.com" port="1234">
         </server>
         <server name="server3" hostname="pqr.db2.example.com" port="1234">
         </server>
       </alternateserverlist>

       <affinitylist>
         <list name="list1" serverorder="server3,server2,server1">
         </list>
       </affinitylist>

       <clientaffinitydefined>
         <client name="client1" hostname="client.example.com" listname="list1">
         </client>
       </clientaffinitydefined>

     </acr>

  </database>
</databases>
</configuration>
```

Configuring Db2 instances for hostname validation

For hostname validation to work on your Db2 clients, the TLS certificates on the Db2 instances to which they will connect need to include the required hostname information. You include this information when creating the certificate signing request (CSR) for a CA-signed certificate or when creating a self-signed certificate. The hostnames you include when creating this certificate depends on the configuration of the Db2 server.

Applications beyond single server connections

Hostname validation is also supported for client connections to the following non-serial Db2 server environments:

- Client connections to Db2 pureScale clusters.
- Client connections to HADR servers.
- Client connections to Db2 pureScale clusters in an HADR environment.
- Client connections to Database Partitioning Feature (DPF) clusters.
- Client connections to Db2 for z/OS servers.
- Outbound connections to Federated data sources.
- Client connections to Db2 servers with multiple host names (multi-homed).

Representing servers in a TLS certificate
Certificates need to be created for the Db2 servers to which your clients connect. These certificates are generated from certificate signing requests (CSRs) sent to internal or third party certificate authorities for signing, or are self-signed within your organization. Hostname validation at the Db2 client is successful if the hostname which the client has been configured to connect matches one of the hostnames present in the server certificate. There are several options for representing a Db2 instance in a certificate.

Examples included in this section apply to both and created using GSKit.

Using a common name (CN) value

The Common Name field in the subject name of the certificate can be used to specify the hostname of the server. Hostname validation will be successful if the hostname that the client configured matches what is present in the Common Name of the certificate.

- If a subject alternate name (SAN) entry is present in the certificate, then the common name is ignored.
- Wildcard (*) hostnames in the common name field are supported when performing hostname validation.

Warning: In accordance with RFC 6125, use a Subject Alternate Name (SAN) instead of a common name to specify the server's hostname in the certificate.

For example, to create a certificate with **xyz.db2.example.com** as the common name, `CN=xyz.db2.example.com` needs to be present as part of the `-dn` option in the **gsk8capicmd_64 -cert -create** command (for self-signed certificates) or **gsk8capicmd_64 -certreq** command (for CSRs).

The following example shows how the common name appears in the generated certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=xyz.db2.example.com
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Signature Algorithm : SHA1WithRSASignature
```

Using DNS Names as SAN values

One or more hostnames can be specified in the certificate using dNSName entries under the Subject Alternate Name (SAN) extension. Hostname validation is successful if the hostname to which the client is configured to connect matches at least one of the dNSName entries. These entries are also referred as DNS Name in some places.

For example, to create a certificate with **xyz.db2.example.com** in the SAN, you include `-san_dnsname "xyz.db2.example.com"` option of the GSKit command

The following example shows a certificate generated to include a single DNS name in the SAN.

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: xyz.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

To create a certificate with multiple DNS names in the SAN, simply separate them with commas (`-san_dnsname "xyz.db2.example.com,abc.db2.example2.com`) in the GSKit command.

The following example shows a certificate generated to include multiple DNS names in the SAN:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: xyz.db2.example.com
        dNSName: abc.db2.example2.com

Signature Algorithm : SHA1WithRSASignature
```

You can also configure your certificate to include a common name value as well as a SAN value that is used for hostname validation.

Note: With this configuration, the common name value is ignored when doing hostname validation since a SAN is specified in the certificate.

To create a certificate with **xyz.db2.example.com** in the common name and **abc.db2.example2.com** in the SAN, include both `CN=xyz.db2.example.com` as part of the `-dn` option and `"abc.db2.example2.com"` as the `-san_dnsname` option in your GSKit command.

The following example shows a certificate generated to include both a common name value and a DNS name in the SAN:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=xyz.db2.example.com
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: abc.db2.example2.com

Signature Algorithm : SHA1WithRSASignature
```

Using IP addresses as SAN values

You can specify one or more IP addresses in your GSKit command using the `-san_ippaddr` field.

As a best practice, use hostnames instead of IP addresses in the certificate for the following reasons:

- An IP address is not necessarily a reliable identifier for a server, due to private networks, NAT, etc.
- According to RFC 6125, less than 1% of TLS certificates issued use them.
- A certificate has to be recreated every time a server's IP address changes.

However, if the client connects to a server using an IP address (IPV4 or IPV6), this IP address has to be present in the server's certificate for hostname validation to be successful.

Note: When an IP address is used to connect to a server, this address is not resolved to its hostname to match against the server certificate when performing hostname validation.

To create a certificate with 127.0.0.1 in the SAN, include `-san_ippaddr "127.0.0.1"` in the GSKit command.

The following example shows a certificate generated to include an IP address in the SAN:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
```

```
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        iPAddress=127.0.0.1

Signature Algorithm : SHA1WithRSASignature
```

To create a certificate with multiple IP addresses in the SAN, simply separate them with commas (`-san_ipaddr "127.0.0.1,127.0.0.2"`) in the GSKit command.

The following example shows a certificate generated to include multiple IP addresses in the SAN:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        iPAddress=127.0.0.1
        iPAddress=127.0.0.2

Signature Algorithm : SHA1WithRSASignature
```

To create a certificate with a common name value as well as an IP address in the SAN, simply include both of the options (`-dn "CN=xyz.db2.example.com,..." -san_ipaddr "127.0.0.1"`) in the GSKit command.

Note: In this case, the common name value is ignored when doing hostname validation since a SAN is specified in the certificate.

The following example shows a certificate generated to include both a common name and an IP address in the SAN:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=xyz.db2.example.com
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        iPAddress=127.0.0.1

Signature Algorithm : SHA1WithRSASignature
```

To create a certificate with both a DNS Name and an IP address in the SAN, simply add `-san` statements for both options (`-san_dnsname "xyz.db2.example.com" -san_ipaddr "127.0.0.1",`) in the GSKit command.

The following example shows a certificate generated to include both a DNS name and an IP address in the SAN:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
```

```
        dNSName: xyz.db2.example.com
        iPAddress=127.0.0.1

Signature Algorithm : SHA1WithRSASignature
```

Using wildcards in hostnames

Certificates with wildcard character, *, as part of the hostnames are supported when performing hostname validation on the client. However as specified in RFC 6125, the client employs the following rules when comparing hostnames against wildcard certificates:

- The wildcard character can only be present in the left-most label and can only be included once.
- The wildcard character can only be used to match a single label.
- The wildcard character doesn't have to be the only character in the label.
- The wildcard character can match zero or more characters in the label.

Note: The term label in these rules refers to domain name label. Labels are strung together separated by dots to form a fully qualified hostname. For example, **xyz**, **db2**, **example**, and **com** are the labels that constitute the fully qualified hostname, **xyz.db2.example.com**.

For example the following use of wildcards is permitted:

```
"*.db2.example.com"
"f*.db2.example.com"
```

However, the following examples are not permitted, as the wildcard is used in labels other than the leftmost label in the hostname:

```
"foo.*.db2.example.com"
"*.db2.example.*.com"
```

To create a certificate with ***.db2.example.com** as the common name, include `CN=*.db2.example.com` as part of the `-dn` field in the GSKit command

To create a certificate with ***.db2.example.com** in the SAN, include `-san_dnsname "*.db2.example.com"` in the GSKit command. This allows the SAN to represent all hostnames in the `example.com` domain.

The following example shows a certificate generated to include a single wildcard hostname in the SAN:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: *.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

To create a certificate with multiple wildcard hostnames in the SAN, you need to include both hostnames, separated by a comma, within the `-san_dnsname` field of the GSKit command.

The following example shows a certificate generated to include multiple wildcard hostnames:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST
```

```
Extensions
    subjectAlternativeName
        dNSName: *.db2.example.com
        dNSName: a*.db2.example2.com

Signature Algorithm : SHA1WithRSASignature
```

To create a certificate with a combination of hostnames and wildcard hostnames, simply include both in the `-san_dnsname` field of the GSKit command.

```
-san_dnsname "xyz.db2.example.com,*.db2.example2.com"
```

Using short hostnames

A short hostname is essentially the first label of your fully qualified domain name (**xyz**.db2.example.com). When a Db2 client is configured to connect to a server using a short hostname, this hostname is not resolved into a fully qualified domain name when hostname validation is performed. The reasoning is that figuring out which domain name to append to this short hostname depends on the contents of your `/etc/resolv.conf` file. The client shouldn't necessarily place its trust in the `resolv.conf` file, since it is possible for this file to be modified by a remote actor through DHCP.

This is also the industry standard method of hostname validation.

Because of this, use of short hostnames is not recommend when configuring your Db2 clients for hostname validation. However, your business may require you to use a short hostname when configuring the server connection information on the client. When this is the case, the certificate returned by the server during the TLS handshake must also contain this short hostname.

For example, if the client connects using a connection string that looks like `Hostname=xyz;Security=SSL;SSLClientHostnameValidation=Basic;Database=…`, the certificate returned by the server should look something like the following.

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=xyz.db2.example.com
Not Before : November 26, 20204:44:11 PM EST

Not After : November 27, 20214:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: xyz

Signature Algorithm : SHA1WithRSASignature
```

Configuring hostname validation for TLS connections to pureScale clusters
You can configure your Db2 clients to complete hostname validation during Transport Layer Security (TLS, formerly SSL) connections to Db2 pureScale clusters.

The pureScale feature in Db2 provides continuous availability, extreme capacity, and application transparency. A typical non-HADR pureScale cluster consists of the following components:

- Members that are responsible for processing transactions.
- A shared disk that all members can access.
- One or more cluster caching facilities (CFs) that coordinate data access in the cluster.
- Cluster services that oversee heartbeat failure detection and automatic recovery.

For hostname validation to be successful, one or more certificates must be set up on each server in one of the following three ways:

- Using a separate certificate for each member in the cluster
- Using a common certificate containing multiple subject alternative names (SANs)
- Using a common certificate containing a wildcard hostname

Using a separate certificate per member

The first way is to have a separate certificate per member in the cluster. In this configuration, each member has its fully qualified hostname in its certificate.

For example, assume you have the following pureScale cluster with four members and two CFs.

```
cf1.db2.example.com - CF 1
cf2.db2.example.com - CF 2
h1.db2.example.com - Member 1
h2.db2.example.com - Member 2
h3.db2.example.com - Member 3
h4.db2.example.com - Member 4
```

If a client connects to `h1.db2.example.com` with a connection string that looks like `Hostname=h1.db2.example.com;Security=SSL;SSLClientHostnameValidation=Basic;Database=...`, the certificate that is returned by this host must have `h1.db2.example.com` in the SAN or Common Name for hostname validation to be successful.

The following example shows how the certificate appears for hostname validation to be successful. Note the hostname in the `Extensions` section of the returned certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=h1.db2.example.com
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: h1.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

In most scenarios, this certificate setup is effective. However, if a member is identified by multiple hostnames in the DNS, and the server-side `/etc/nsswitch.conf` file prioritizes `dns` over `files` for the `hosts` database, these hostnames might need to be included in the certificate for hostname validation to succeed during automatic client reroute (ACR) or workload balancing (WLB).

For example, if Member 2 can be reached using `h2.db2.example.com` and `anothername.db2.example.com`, with both hostnames resolving to the same IP address, it is possible for the latter hostname to be returned to the client as part of a server list. If that is the case, during client reroute or workload balancing, the client uses `anothername.db2.example.com` to complete hostname validation. If this hostname is not found in the member's certificate, then validation fails.

The following example shows how the certificate appears for hostname validation to be successful. Note the hostnames in the `Extensions` section of the returned certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=h2.db2.example.com
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: h2.db2.example.com
        dNSName: anothername.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Using a common certificate with multiple SANs

When using a common certificate for all hosts in the cluster, include multiple SAN entries with fully qualified hostnames for each member in the cluster. This ensures that hostname validation is successful since the returned certificate contains the member's hostname, regardless of the member to which the client connects. In addition, if a connection is routed to another member in the cluster due to workload balancing or ACR, hostname validation is successful for the new connection, since the certificate returned by this member contains the hostname that was originally configured on the client.

The following example shows how the certificate appears for hostname validation to be successful. Note the hostnames that appear in the *Extensions* section:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: h1.db2.example.com
        dNSName: h2.db2.example.com
        dNSName: h3.db2.example.com
        dNSName: h4.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Using a common certificate with a wildcard hostname

When using a common certificate for all hosts in the cluster, rather than including multiple hostnames, you can have a single SAN entry with a wildcard hostname that represents all of the hosts in the cluster. When validating the hostname, the client acknowledges the wildcard hostname as representing all members in the cluster. This ensures that, regardless of the member to which the client connects, hostname validation is successful.

In addition, if a connection is routed to another member in the cluster due to workload balancing or ACR, hostname validation is successful for this new connection since the certificate returned by this member matches the hostname to which the client was originally configured.

The following example shows how the certificate appears for hostname validation to be successful. Note the single SAN entry containing the wildcard symbol in the *Extensions* section:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: h*.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Note: Wildcard hostnames only represent members that share the same domain name, such as **example.com**. For more information about the rules around use of wildcards, see Using wildcards in hostnames.

It is possible to include both wildcard and non-wildcard hostnames in the SANs of a certificate.

Adding and removing a member from a pureScale cluster

When adding a new member to the cluster, one or more of the server certificate might have to be updated depending on how they're set up. Please note that server certificates can be updated online: the instance doesn't have to be brought down to make this change.

If a separate certificate is used for each member in a cluster, the new member needs to have its fully qualified hostname in its certificate. Since a separate certificate is used per member, the other members in the cluster don't need to be updated.

If a common certificate is used for all members in a cluster, the common certificate has to be recreated to contain an additional SAN entry for this new member and all of the members in the cluster need to be updated to use this newly created certificate if they're not using a shared keystore.

If a common certificate containing a wildcard hostname is used for all members in a cluster, no updates are needed given that the wildcard hostname in the common certificate can match the new hostname. This certificate configuration might be preferable if new members are frequently added to the cluster since it removes the need to keep creating new certificates.

When removing a member from the cluster, no changes to the certificate used by the cluster are required for hostname validation to be successful.

IP addresses used in the nicbinding.cfg file

If the `nicbinding.cfg` file is configured to bind each member of a cluster to the IP address of a network interface card (NIC), the server list returned to the client contains IP addresses instead of hostnames for these members. This means that during client reroute or workload balancing, the IP address of the corresponding member is what gets used for the connection and, by extension, hostname validation.

When referencing NIC addresses using the `nicbinding.cfg` file, use a common certificate for all members in the cluster. The client validates the hostname in the certificate against the hostname to which it was originally configured to connect, which is successful when using a common certificate.

The other option is to have a separate certificate per member, but include the member's IP address in its certificate. This configuration should be avoided.

Configuring hostname validation for TLS connections to Db2 servers in HADR environments
You can configure your Db2 clients to use hostname validation when attempting TLS connections to servers in an HADR environment.

Connections to servers in HADR clusters not using a VIP

For hostname validation to be successful when attempting a TLS handshake with servers in an HADR environment, the certificate returned by each host in the cluster must represent its fully qualified hostname. This applies when the HADR cluster is not using a virtual IP address (VIP). To accomplish this, you need to configure the server certificate using one of the following methods:

- Using a separate certificate per host
- Using a common certificate containing multiple subject alternative names (SANs)
- Using a common certificate containing a wildcard hostname

Using a separate certificate per host

When using a separate certificate for each host in the cluster, the certificate returned for each host must contain its fully qualified hostname.

For example, let us say that we have the following HADR cluster with a primary and two standby hosts:

- primary.db2.example.com - Primary
- standby1.db2.example.com - Standby 1
- standby2.db2.example.com - Standby 2

If the client connects to the primary host with a connection string similar to the following,

```
Hostname=primary.db2.example.com;Security=SSL;SSLClientHostnameValidation=Basic;Database=…
```

then the certificate returned by this host must have **primary.db2.example.com** in the SAN or Common Name.

Similarly, if the client connects to **standby1.db2.example.com** because it assumed the role of the primary, or if reads on standby is enabled, then the certificate returned by this host must have **standby1.db2.example.com** in the SAN or Common Name.

Using a common certificate containing multiple SANs

When creating a common certificate for all hosts in an HADR cluster, include multiple SAN entries with fully qualified hostnames of each host in the cluster. This ensures that, whether the client connects to the primary host or one of the standby hosts, hostname validation is successful.

Note the entries that appear in the `Extensions` section of the certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=ExampleCA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: primary.db2.example.com
        dNSName: standby1.db2.example.com
        dNSName: standby2.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Using a common certificate containing a wildcard hostname

When creating a common certificate for all hosts in an HADR cluster, rather than including multiple hostnames, use a single SAN entry with a wildcard hostname that represents all of the hosts in the cluster. This ensures that, whether the client connects to the primary host or one of the standby hosts, hostname validation is successful.

Note the single SAN entry containing the wildcard symbol in the `Extensions` section:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=ExampleCA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: *.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Note: Wildcard hostnames only represent members that share the same domain name, such as **db2.example.com**. For more information about the rules around use of wildcards, see Using wildcards in hostnames.

It is possible to include both wildcard and non-wildcard hostnames in the SANs of a certificate.

Connections to servers in HADR clusters that use a VIP

In this configuration of HADR, there is a single virtual IP address. A cluster manager, such as TSA or Pacemaker, specifies which machine in the cluster that the VIP points to at any given moment. If there is a

power outage and the primary host goes down, the cluster manager initiates a failover to the standby host to which the VIP now points.

From a Db2 client's point of view, there is no change since it still uses the hostname associated with the VIP to connect to the database. For hostname validation to be successful in this scenario, all of the hosts in the cluster need to use a common certificate that represents this hostname.

For example, let us say we have the following HADR cluster, with `v1.db2.example.com` as the hostname of the virtual IP address that points to one of the hosts at any given moment.

```
primary.db2.example.com - Primary
standby1.db2.example.com - Standby
```

When the client connects to `v1.db2.example.com` with a connection string similar to the following,

```
Hostname=v1.db2.example.com;Security=SSL;SSLClientHostnameValidation=Basic;Database=…
```

the certificate returned by all of the above hosts must contain `v1.db2.example.com` for hostname validation to be successful.

Note the entry in the `Extensions` section in the following example certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: v1.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Connections to servers in HADR clusters using ACR

When creating certificates for an HADR cluster that is not using a VIP, the instructions listed in the HADR with no VIP section is sufficient, if the UPDATE ALTERNATE SERVER command that is run on the primary host uses the fully qualified hostname of the alternate server.

```
UPDATE ALTERNATE SERVER FOR DATABASE <DATABASE
          ALIAS> USING HOST <HOSTNAME> PORT <PORT NUMBER>
```

This hostname gets returned to the client as part of the server list. When the client connects to this standby host during ACR, it uses this hostname to check against the server certificate.

You should avoid using a short hostname or an IP address when configuring this alternate server. For more information, see "Using IP addresses as SAN values" on page 117 and "Using short hostnames" on page 120. If your business requires you to use a short hostname or an IP address when configuring the alternate server, this value must be present in the certificate setup on the standby host that is acting as the alternate server.

The opposite applies if the primary host is acting as the alternate server for any of the standby hosts.

Similarly, with an HADR cluster that is using a VIP, following the recommendations listed in the HADR with VIP section is sufficient.

Adding or removing a host from an HADR cluster

When adding a new host to an HADR cluster, each server certificate might have to be updated, depending on how the certificates were configured.

If a separate certificate is used for each host, the new host needs to have its fully qualified hostname in its certificate. Since a separate certificate is used per host, the other hosts in the cluster do not need to be updated.

If a common certificate containing multiple SANs is used for all hosts in a cluster, the common certificate has to be recreated to contain an additional SAN for this new host.

If a common certificate containing a wildcard hostname is used for all hosts in a cluster, no updates are needed, so long as the wildcard hostname in the common certificate matches the new hostname.

If you are removing a host from an HADR cluster, no changes to the certificate used by the cluster are required for hostname validation to be successful.

Configuring hostname validation for TLS connections to Db2 pureScale clusters in HADR environments
HADR can be enabled between two pureScale clusters, with one cluster acting as the primary host and another acting as the standby node.

The processes for creating certificates for each pureScale cluster are sufficient if the fully qualified hostname of the standby member is used in the UPDATE ALTERNATE SERVER command that is run on the primary cluster.

```
UPDATE ALTERNATE SERVER FOR DATABASE <DATABASE
          ALIAS> USING HOST <HOSTNAME> PORT <PORT NUMBER>
```

This hostname is returned to the client as part of the server list. When the client connects to the standby member during automatic client reroute (ACR), it uses this hostname to check against the server certificate.

You should avoid using a short hostname or an IP address when configuring this alternate server. For more information, see “Using IP addresses as SAN values” on page 117 and “Using short hostnames” on page 120. If your business requires you to use a short hostname or an IP address when configuring the alternate server, this value must be present in the certificate set up on the standby host that is acting as the alternate server.

The opposite applies when a primary host is acting as the alternate server for the standby cluster.

Configuring hostname validation for TLS connections to Database Partitioning Feature (DPF) servers
The Database Partitioning Feature (DPF) is a Db2 scalability feature that enables you to divide a database into multiple partitions, with each partition having its own set of resources. These partitions can be set up on different hosts and the certificates on these hosts need to be set up in a specific way for hostname validation to be successful.

Connecting to catalog partitions

The following example shows a four partition DPF cluster:

```
partition 0 - h1.db2.example.com (catalog partition)
partition 1 - h2.db2.example.com
partition 2 - h3.db2.example.com
partition 3 - h4.db2.example.com
```

If a client only connects to the catalog partition, then **h1.db2.example.com** must be the hostname that is configured at the client and in the certificate for the catalog partition. Examine the following client connection string:

```
Hostname=h1.db2.example.com;Security=SSL;SSLClientHostnameValidation=Basic;Database=…
```

Note the dNSName value in the `Extensions` section of the certificate returned by the DPF node::

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST
```

```
Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: h1.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Connecting to non-catalog partitions

Clients can also connect directly to non-catalog partitions in a DPF cluster. For hostname validation to be successful in this case, one or more certificates on the server must be set up in one of three ways:

- Using a separate certificate per host
- Using a common certificate containing multiple subject alternative names (SANs)
- Using a common certificate containing a wildcard hostname

Using a separate certificate for each DPF host

When creating a separate certificate for each host, the SAN or Common Name in the certificate must contain the host's fully qualified hostname.

For example, if a client connects to **h2.db2.example.com** in the previously mentioned cluster, the certificate returned by this host must contain **h2.db2.example.com** in the SAN or the Common Name for hostname validation to be successful.

Using a common certificate with multiple SANs

When using a common certificate for all hosts in the cluster, include multiple SAN entries with fully qualified hostname of each host in the cluster. This ensures that hostname validation is successful, regardless of the partition to which the client connects, since the returned common certificate contains the hostname to which the client is configured to connect.

Note the hostnames in the SAN in the `Extensions` section of the certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=ExampleCA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: h1.db2.example.com
        dNSName: h2.db2.example.com
        dNSName: h3.db2.example.com
        dNSName: h4.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Using a common certificate containing a wildcard hostname

When using a common certificate for all hosts in the cluster, rather than including multiple hostnames, include a single SAN entry with a wildcard hostname that represents all of the hosts in the cluster. When validating the hostname, the client acknowledges the wildcard hostname as representing all hosts in the cluster. This ensures that, regardless of the host to which the client connects, hostname validation is successful.

Note the single SAN entry containing the wildcard symbol in the *Extensions* section:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=ExampleCA
Subject : CN=none
```

```
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: h*.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Note: Wildcard hostnames only represent hosts that share the same domain name, such as **db2.example.com**. For more information about the rules around use of wildcards, see Using wildcards in hostnames.

It is possible to include both wildcard and non-wildcard hostnames in the SANs of a certificate.

Adding and removing a host from a DPF cluster

When adding a new host to the cluster, one or more of the server certificate might have to be updated depending on how they're set up.

If a separate certificate is used for each host in a cluster, the new host needs to have its fully qualified hostname in its certificate. Since a separate certificate is used per host, the other hosts in the cluster don't need to be updated.

If a common certificate is used for all hosts in a cluster, the common certificate has to be recreated to contain an additional SAN entry for this new host and all of the hosts in the cluster need to be updated to use this newly created certificate if they're not using a shared keystore.

If a common certificate containing a wildcard hostname is used for all hosts in a cluster, no updates are needed given that the wildcard hostname in the common certificate can match the new hostname. This certificate configuration might be preferable if new hosts are frequently added to the cluster since it removes the need to keep creating new certificates.

When removing a host from the cluster, no changes to the certificate used by the cluster are required for hostname validation to be successful.

Node hopping

The **SET CLIENT CONNECT_MEMBER** <node number> parameter and the *DB2NODE* environment variable allow the client to connect to a partition that is not part of the host to which it is configured to connect. There are two separate connections established in this case:

- The connection between the client and the host to which it is configured to connect.
- The connection between the host and the partition specified in the **CONNECT_MEMBER** parameter.

The second connection is referred to as a hopped connection. TLS can be enabled for both connections, but hostname validation can only be enabled for the first connection.

Configuring hostname validation for TLS connections to alternate servers, federated servers, and other topologies
You can configure the Db2 11.5.6 client to validate hostnames of servers listed in returned certificates when negotiating TLS connections to various Db2 instances. This topic discussed configuring hostname validation for connections to alternate Db2 servers, federated data sources and other network topologies.

Connections to alternate servers

An alternate server is a Db2 server to which a Db2 client is rerouted during ACR, if the original connection to the database is lost. For hostname validation to succeed for this rerouted connection, the hostname in the certificate returned by the alternate server must match the hostname specified in the UPDATE ALTERNATE SERVER command run on the original server:

```
UPDATE ALTERNATE SERVER FOR DATABASE USING <HOSTNAME> PORT <PORT NUMBER>
```

Use a fully qualified hostname when running this command.

Connections to z/OS servers

In a sysplex environment, a Db2 client must connect to the Db2 for z/OS server using the hostname that maps to the distributor's IP address. When setting up certificates on the server, use a common certificate across all the members containing this hostname.

For example, if a Db2 client attempts to connect to **xyz.db2.example.com** with a connection string that includes the hostname, the returned certificate must include **xyz.db2.example.com** in the SAN or the Common Name for hostname validation to be successful. This is regardless of where the connections gets routed to by the distributor.

Example connection string:

```
 Hostname=xyz.db2.example.com;Security=SSL;SSLClientHostnameValidation=Basic;Database=…
```

The following example shows how the certificate should appear for hostname validation to be successful.

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: xyz.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

If a Db2 client is connecting to one of the sysplex members directly instead of going through the distributor, the certificate returned by the target member must include the hostname of the member to which the client is configured to connect.

Note: If an IP address is used instead of a hostname to connect to a Db2 for z/OS server, the certificate returned by the server should contain this IP address for hostname validation to be successful.

Connections to federated data sources

When a federated data source is configured on a Db2 server, the server is acting as an application requestor when communicating with this data source. TLS is supported for these outbound connections and the following federated DRDA wrapper server option controls the hostname validation behavior.

Server option syntax:

```
SSL_HOSTNAMEVALIDATION = 'Basic' | 'OFF'
```

where

- Basic = Hostname validation is enabled
- OFF = Hostname validation is disabled. This is the default value.

  Note: TLS needs to be enabled when setting **SSL_HOSTNAMEVALIDATION** to **OFF**.

  This server option is restricted currently to the DRDA wrapper, and it can only be set when TLS is enabled. When TLS is not enabled, setting SSL_HOSTNAMEVALIDATION to 'Basic' or 'OFF' for the federation server generates the SQL1881N error. Use the following server options to enable TLS:

  – SSL_KEYSTORE
  – SSL_KEYSTASH
  – SSL_SERVERCERTIFICATE

For more information, see “Hostname validation for Db2 11.5.6 clients” on page 112.

Connections to Db2 Connect gateways

When Db2 is acting as a gateway server, as is the case for a Db2 Connect server, hostname validation can be enabled for inbound TLS connections.

You enable hostname validation for inbound connections by setting the **SSLHostnameValidation DS Driver** parameter to **Basic** on the client. Hostname validation is not available for outbound TLS connections from the Gateway server.

Connection to KMIP servers

If you set the SSL_KMIP_CLIENT_HOSTNAME_VALIDATION keyword in your keystore configuration file to **BASIC**, Db2 validates that the hostname of the KMIP server is contained within the certificate used by the KMIP server when establishing the TLS connection. For more information, see “Creating a KMIP keystore configuration file” on page 78

Connections to multi-homed servers

A multi-homed server can be known by more than one hostname. This means that a Db2 client can connect to the same database server using multiple hostnames. The server’s certificate must contain all of the hostnames that the clients use to connect to the database.

For example, if a Db2 server is known by the hostnames **xyz.db2.example1.com**, **abc.db2.example2.com**, and **pqr.db2.example3.com**, you must include these hostnames, separated by commas, in the SAN statement of the GSKit command:

The following example shows how the certificate should appear for hostname validation to be successful. Note the hostnames listed in the `Extensions` section of the returned certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=ExampleCA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: xyz.db2.example1.com
        dNSName: abc.db2.example2.com
        dNSName: pqr.db2.example3.com

Signature Algorithm : SHA1WithRSASignature
```

Note: Wild card hostnames can also be used if these hostnames are part of the same domain.

Connections using CNAME and DNAME DNS record names

In a DNS server, CNAME and DNAME records can be used to create aliases to a Db2 server’s hostname. If a client connects to the database using an alias hostname, the server certificate must contain this alias in the SAN statement or common name statement for hostname validation to be successful.

For example, if a client connects to **xyz.db2.example.com**, whose CNAME record in the DNS server points to **abc.db2.example.com**, the server’s certificate needs to contain the alias in the SAN for hostname validation to be successful.

Note the value in the `Extensions` section of the returned certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
```

```
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: xyz.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Connections to multiple A records for IP addresses

Recommendations from the multi-homed servers section apply here as well. In short, if there are multiple A records in the DNS for a given Db2 server, the certificate setup on the server should contain all of the hostnames that the clients use to connect to the server.

Connections to distributors or load balancers

When a Db2 client connects to a distributor or a load balancer, the network traffic from the client is redirected to an actual database server. The certificate returned by the target database server must contain the hostname of the distributor or the load balancer in the SAN or Common Name for hostname validation to be successful.

For example, if the client connects to **xyz.balancer.com** which is the hostname of a load balancer that forwards traffic to the real target server, **abc.db2.example.com**, then the certificate returned by the server must contain **xyz.balancer.com** as its SAN value.

Note the value in the `Extensions` section of the returned certificate:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=ExampleCA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: xyz.balancer.com

Signature Algorithm : SHA1WithRSASignature
```

Troubleshooting hostname validation at the client when negotiating a TLS connection

When hostname validation fails at the client during a TLS handshake, the details of the failure are saved to the db2diag.log file.

Analyzing the details in the db2diag.log file

The first three data points in the **db2diag.log** record specify which hostnames the client used to perform hostname validation against the server's certificate. The rest of the data points list the hostnames that are present in the common name or subject alternate name (SAN) of the certificate.

The following example shows the details of the **db2daig.log** file:

```
2021-04-06-16.35.00.951803-240 E9461858E1589         LEVEL: Error
PID     : 2996888              TID : 140497763679360 PROC : db2bp
INSTANCE: <instance user>      NODE : 000
HOSTNAME: <client hostname>
FUNCTION: DB2 UDB, common communication, sqlccHostnameValidationDumpCert, probe:500
MESSAGE : Failed to validate the hostname against the server certificate sent
          by the server. Dumping the expected hostname(s), certficate CN(s), and
          certificate SAN(s).
DATA #1 : String, 19 bytes
Hostname configured
DATA #2 : String
<Hostname that the client configured>
DATA #3 : String, 33 bytes
```

```
Hostname in the server list entry
DATA #4 : String
<Hostname associated with the server list entry>
DATA #5 : String, 47 bytes
Hostname of the last connected alternate server
DATA #7 : String, 29 bytes
Certificate Dump: Common Name
DATA #8 : String
<hostname in the common name of the subject>
DATA #9 : String, 52 bytes
Certificate Dump: Subject Alternative Name (DNSNAME)
DATA #10: String, 27 bytes
<Hostnames in the SAN>
DATA #11: String, 55 bytes
Certificate Dump: Subject Alternative Name (RFC822NAME)
DATA #12: String, 50 bytes
Server certificate does not have any RFC822 names.
DATA #13: String, 58 bytes
Certificate Dump: Subject Alternative Name (DIRECTORYNAME)
DATA #14: String, 53 bytes
Server certificate does not have any Directory names.
DATA #15: String, 48 bytes
Certificate Dump: Subject Alternative Name (URI)
DATA #16: String, 42 bytes
Server certificate does not have any URIs.
DATA #17: String, 54 bytes
Certificate Dump: Subject Alternative Name (IPADDRESS)
DATA #18: String, 50 bytes
Server certificate does not have any IP addresses.
```

Reviewing this data can help figure out why hostname validation is failing. For example, if the hostnames in the Common Name and the SAN fields are not trusted, you should not connect to this server as a malicious site could be intercepting the connection. However if these hostnames are trusted, then either the configured hostname on the client is incorrect or the server certificate has been setup with incorrect hostnames.

Consult the TLS hostname validation documentation for more information about how to properly create server certificates for your environment.

Configuring hostname validation for encrypted communication between primary and standby hosts in an HADR environment

Transport Layer Security can be used to encrypt communication between the primary and standby hosts in a non-pureScale environment. You enable hostname validation for this communication, using the HADR_SSL_HOST_VAL database configuration parameter.

The HADR_SSL_HOST_VAL database configuration keyword

The HADR_SSL_HOST_VAL database configuration keyword specifies whether hostname validation for Transport Layer Security (TLS, formerly SSL) connections between primary and standby hosts is enabled.

The HADR_SSL_HOST_VAL keyword is currently supported on environments that do not use IBM Db2 pureScale. If you upgrade from Enterprise Server Edition (ESE) to Db2 pureScale while the HADR_SSL_HOST_VAL is set, db2checkSD returns the error DBT5038N. Users should set the value to **OFF** before trying to upgrade to Db2 pureScale.

Changes to this parameter do not affect HADR connections that are already established. Change takes effect for new connections between primary and standby servers.

When hostname validation fails for these connections, the ADM12510E admin message with reason code **14** is logged to the db2diag.log file. Message text for this reason code is as follows:

```
Hostname validation is enabled for SSL communication between
the primary and standby hosts and it failed because the specified
hostname does not match any of the hostname fields in the
certificate returned by this host. Details about this certificate
have been logged to the db2diag.log file.
```

For hostname validation to be successful, each host must set up a certificate that includes a SAN of its fully qualified hostname. There are two ways to set up certificates in this way:

- Using a separate certificate for the primary host and each standby host
- Using a common certificate for all hosts

Note: The following instructions for setting up hostname validation for primary and standby TLS require that fully qualified hostnames are used when configuring the **hadr_remote_host** and **hadr_target_list** database configuration parameters.

Using a separate certificate for the primary host and each standby host

When using a separate certificate for each host in an two-site multiple standby HADR cluster, each host must include its the fully qualified hostname in the certificate it returns to its peer during the TLS handshake.

The following example shows an HADR cluster containing a primary and two standby hosts:

```
primary.db2.example.com - Primary
standby1.db2.example.com - Standby 1
standby2.db2.example.com - Standby 2
```

The following example shows how the certificate on the primary host needs to be configured for hostname validation to be successful when it communicates with the standby hosts. Note that the SAN contains the fully qualified host name of the primary server, **primary.db2.example.com**, in the `Extensions` section.

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: primary.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

As with the primary host, each standby host must contains its fully qualified hostname in its certificate.

The following example shows how the certificate on **standby1** needs to be configured for successfully communicating with the primary host when hostname validation is enabled. Note that the SAN contains the fully qualified host name of the primary server, **standby1.db2.example.com**, in the `Extensions` section :

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: standby1.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Using a common certificate for all hosts

When using a common certificate for all hosts in a two-site multiple standby HADR cluster, the certificate you create must include representations for the hostnames of each host in the SAN.

There are two ways to configure the SAN to represent the hostnames of all hosts in the HADR cluster:

- Using multiple hostnames

- Using a wildcard hostname

Using multiple hostnames in the SAN

When using multiple hostname entries in the SAN, use the fully qualified hostname of each host.

The following example shows how a common certificate using multiple SAN entries is configured. Note the fully qualified hostname entries for the SAN in the `Extensions` section:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=ExampleCA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: primary.db2.example.com
        dNSName: standby1.db2.example.com
        dNSName: standby2.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Using a wildcard hostname

One drawback of using multiple hostnames in the SAN is that every time a host is either added to, or removed from, the cluster the certificate has to be recreated. If all of the hosts in the cluster are part of the same sub-domain, a single wildcard hostname in the SAN can be used to represent all the hosts in the cluster.

The following example shows how a common certificate using a single wildcard hostname is configured. Note the single entry for the SAN in the **`Extensions`** section:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: *.db2.example.com

Signature Algorithm : SHA1WithRSASignature
```

Note: You can include both fully qualified hostnames and wildcard hostnames in the SAN.

Using hostname validation between HADR hosts in a NAT environment

Network Address Translation (NAT) is designed for IP address conservation. In certain HADR configurations, the primary host is located inside a NAT environment, along with a subset of the standby hosts. The remainder of the standby hosts are located outside of the NAT environment. In this configuration, the primary host is known by different names to the different subsets of the standby hosts. For hostname validation to work in a NAT environment, the certificate for the primary host must contain the different hostnames that it is known by to the rest of the cluster. In addition, any of the standby hosts behind the NAT that could potentially take over as the primary host must also contain all the different hostnames that they could be identified as in their certificates.

The following example shows an HADR cluster, containing a primary host and two standby hosts:

```
nat.router.com/primary.xyz.com - Primary
standby1.xyz.com - Standby 1
standby2.abc.com - Standby 2
```

- The **primary** host and **standby 1** are inside a NAT environment.
- **standby 2** is outside of the NAT environment.
- **primary** is known as **nat.router.com** to **standby2.abc.com**.
- **primary** is known as **primary.xyz.com** to **standby1.xyz.com**.
- the NAT router is exposed to the outside world as **nat.router.com**.

The following example shows how the certificate on **primary** needs to be configured, for hostname validation to be successful when the standby and primary hosts communicate using TLS. Note that both the **nat.router.com** and **primary.xyz.com** hostnames are included in the SAN:

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: nat.router.com
        dNSName: primary.xyz.com

Signature Algorithm : SHA1WithRSASignature
```

In addition, certificates on each of the standby hosts that are inside the NAT environment must contain the NAT router hostname in their certificates. This enables these standby hosts to take over as primary in the future, and ensures that hostname validation is successful after the transition.

The following example shows how the certificate of a standby server (**standby 1**), that sits inside the NAT environment, needs to be configured to ensure that hostname validation is successful. Note the entries for the SAN in the **Extensions** section :

```
Key Size : 2048
Version : X509 V3
Serial : xxx
Issuer : CN=Example Enterprise CA
Subject : CN=none
Not Before : November 26, 2020 4:44:11 PM EST

Not After : November 27, 2021 4:44:11 PM EST

Extensions
    subjectAlternativeName
        dNSName: nat.router.com
        dNSName: standby1.xyz.com

Signature Algorithm : SHA1WithRSASignature
```

TLS configuration of Db2

The Db2 database system supports the use of the Transport Layer Security (TLS) protocol, to enable a client to validate the certificate of a Db2 server, and to provide private communication between the client and server by use of encryption.

This section provided detailed instruction on how to configure Db2 environments for secure data transfer using TLS.

Note: You can configure Db2 11.5.6 and newer clients to validate the hostname of Db2 instances to which they are connecting, during a TLS handshake. For more information, see Hostname validation for Db2 11.5.6 clients.

Note: If enabling this feature on AIX, review the following performance considerations.

Renewing a CA-signed certificate

Certificate authority (CA) signed certificates are only valid for a limited period of time. If a certificate is close to expiry, it is possible to renew a certificate by recreating a new certificate signing request.

Before you begin

The new certificate signing request will contain the same details as the previous certificate.

To renew a self-signed certificate, a new certificate must be created. For more information, refer to .

About this task

For the purpose of this example, Db2 is assumed to have already been pre-configured with a key database and a password stored in a stash file. We will refer to this keystore as `server.p12` in this example. This `server.p12` is also presumed to have been configured with a CA-signed certificate by the label of `CA-Signed`.

Procedure

1. Identify the expiring certificate and label by running:

```
$ gsk8capicmd_64 -cert -list -db server.p12 -stashed

    Certificates found
    * default, - personal, ! trusted, # secret key
    !       My_CA_Root
    -      CA-Signed   <-----

$ gsk8capicmd_64 -cert -details -label "CA-Signed" -db server.p12 -stashed

    Label : CA-Signed
    Key Size : 1024
    Version : X509 V3
    Serial : 7f9e2b79e210cc26
    Issuer : CN=CA,O=CA,C=US
    Subject : CN=host.mycompany.com,OU=unit,O=company
    Not Before : May 6, 2018 9:32:48 AM PDT
    Not After : May 6, 2019 9:32:48 AM PDT M  <------------------
    ...
```

2. Recreate the certificate signing request for `CA-Signed` by running:

```
gsk8capicmd_64 -certreq -recreate -db server.p12 -stashed -label "CA-Signed" -target
new_cert_request.csr
```

3. Send the resulting `new_cert_request.csr` certificate to be signed by the original Certificate Authority (CA).
4. Once the signed certificate has been returned, then receive it back into your server keystore by running:

```
gsk8capicmd_64 -cert -receive -db server.p12 -stashed -file new_cert_signed.pem
```

   In this example, the returned certificate is called `new_cert_signed.pem`.
5. Verify the new dates on the received certificate by running:

```
gsk8capicmd_64 -cert -details -label CA-Signed -db server.p12 -stashed

    Label : CA-Signed
    Key Size : 1024
    Version : X509 V3
    Serial : 61840a0badecc11a
    Issuer : CN=CA,O=CA,C=US
    Subject : CN=host.mycompany.com,OU=unit,O=company
    Not Before : May 6, 2021 9:59:05 AM PDT
    Not After : *May 6, 2022 9:59:05* AM PDT
```

6. If the Db2 level is Version 11.5 Mod Pack 3 or later, refresh the SSL certificate used by Db2 by attaching to the instance and updating the **SSL_SVR_LABEL** database manager configuration parameter. This can be done by running:

```
db2 attach to <instance name>
db2 update dbm cfg using SSL_SVR_LABEL CA-Signed
```

7. If the Db2 level is Version 11.5 Mod Pack 2 or earlier, the instance must be recycled for the new certificate to take effect. This can be done by running:

```
db2stop
db2start
```

Configuring TLS support in Db2 clients

You can configure Db2 client applications to use TLS data encryption. These can be Java clients or non-Java clients.

Configuring TLS support in non-Java Db2 clients

You can configure Db2 database clients, such as CLI, CLP, and .Net Data Provider clients, to support Transport Layer Security (TLS)for communication with the Db2 server.

Configuring TLS support in Java Db2 clients

The IBM Data Server Driver for JDBC and SQLJ provides support for Transport Layer Security (TLS) encryption through the Java Secure Socket Extension (JSSE).

You can use TLS support in your Java applications if you use IBM Data Server Driver for JDBC and SQLJ type 4 connectivity to Db2 Version 10.5 or later.

Connections to all supported data servers can use server authentication. For server authentication, the server sends a certificate to the client, and the client confirms the identity of the server. Connections to Db2 for z/OS data servers can also use client authentication. For client authentication, the client sends a certificate to the server, and the server confirms the identity of the client. Client authentication can be used with TLS encryption or without TLS encryption.

To use TLS connections, you need to:

- Configure connections to the data server to use TLS.
- Configure your Java Runtime Environment to use TLS.

Configuring connections under the IBM Data Server Driver for JDBC and SQLJ to use TLS

To configure database connections under the IBM Data Server Driver for JDBC and SQLJ to use Transport Layer Security (TLS), you need to set the `DB2BaseDataSource.sslConnection` property to `true`.

Before you begin

Before a connection to a data source can use Transport Layer Security (TLS), the port to which the application connects must be configured in the database server as the TLS listener port.

Note: You can configure Db2 11.5.6 and newer clients to validate the hostname of Db2 instances to which they are connecting, during a TLS handshake. For more information, see Configuring Db2 clients for hostname validation when negotiating a TLS connection.

Procedure

1. Set `DB2BaseDataSource.sslConnection` on a Connection or DataSource instance.
2. Optional: Set the location of the truststore and the truststore password. The truststore location can be set without the password, but it is best to set both values.
   a) Set `DB2BaseDataSource.sslTrustStoreLocation` on a Connection or DataSource instance to identify the location of the truststore.

Setting the `sslTrustStoreLocation` property is an alternative to setting the Java `javax.net.ssl.trustStore` property. If you set `DB2BaseDataSource.sslTrustStoreLocation`, `javax.net.ssl.trustStore` is not used.

b) Optional: Set `DB2BaseDataSource.sslTrustStorePassword` on a Connection or DataSource instance to identify the truststore password.

Setting the `sslTrustStorePassword` property is an alternative to setting the Java `javax.net.ssl.trustStorePassword` property. If you set `DB2BaseDataSource.sslTrustStorePassword`, `javax.net.ssl.trustStorePassword` is not used.

3. Optional: Set `DB2BaseDataSource.sslCipherSuites` on a Connection or DataSource instance, if you do not want to use the default cipher suites that are enabled in the JRE (Java Runtime Environment). The driver enables only the cipher suites that you set.

Example

The following example demonstrates how to set the `sslConnection` property on a Connection instance:

```
java.util.Properties properties = new java.util.Properties();
properties.put("user", "xxxx");
properties.put("password", "yyyy");
properties.put("sslConnection", "true");
java.sql.Connection con =
  java.sql.DriverManager.getConnection(url, properties);
```

Configuring the Java Runtime Environment to use TLS

Before you can use Transport Layer Security (TLS) connections in your JDBC and SQLJ applications, you need to configure the Java Runtime Environment to use TLS. An example procedure is provided. However, the procedure might be different depending on the Java Runtime Environment that you use.

Before you begin

Before you can configure your Java Runtime Environment for TLS, you need to satisfy the following prerequisites:

- The Java Runtime Environment must include a Java security provider. The IBM JSSE provider or the SunJSSE provider must be installed. The IBM JSSE provider is automatically installed with the IBM SDK for Java.

  Restriction: You can use the SunJSSE provider only with an Oracle Java Runtime Environment. The SunJSSE provider does not work with an IBM Java Runtime Environment.
- TLS support must be configured on the database server.

Procedure

To configure your Java Runtime Environment to use TLS, follow these steps:

1. Import a certificate from the database server to a Java truststore on the client.

   Use the Java `keytool` utility to import the certificate into the truststore.

   Example: Suppose that the server certificate is stored in a file named cacerts. Issue the following `keytool` utility statement to read the certificate from file `jcc.cacert`, and store it in a truststore named cacerts.

   ```
   keytool -import -file jcc.cacert -keystore cacerts
   ```

   Example: Suppose that the server certificate is stored in a file named `mydbserver.arm`. Issue the following `keytool` utility statement to read the certificate from file `mydbserver.arm`, and store it in a truststore named `mynewdbclient.jks`.

   ```
   keytool -import -trustcacerts -alias myalias -file mydbserver.arm -keystore mynewdbclient.jks
   ```

2. Configure the Java Runtime Environment for the Java security providers by adding entries to the `java.security` file.

   The format of a security provider entry is:

   ```
   security.provider.n=provider-package-name
   ```

   A provider with a lower value of *n* takes precedence over a provider with a higher value of *n*.

   The Java security provider entries that you add depend on whether you use the IBM JSSE provider or the SunJSSE provider.

   - If you use the SunJSSE provider, add entries for the Oracle security providers to your `java.security` file.
   - If you use the IBM JSSE provider, use one of the following methods:
     - **Use the IBMJSSE2 provider (supported for the IBM SDK for Java 1.4.2 and later):**

       Recommendation: Use the IBMJSSE2 provider, and use it in FIPS mode.

       - If you do not need to operate in FIPS-compliant mode:
         - For the IBM SDK for Java 1.4.2, add an entry for the `IBMJSSE2Provider` to the `java.security` file. Ensure that an entry for the `IBMJCE` provider is in the `java.security` file. The `java.security` file that is shipped with the IBM SDK for Java contains an entry for entries for `IBMJCE`.
         - For later versions of the IBM SDK for Java, ensure that entries for the `IBMJSSE2Provider` and the `IBMJCE` provider are in the `java.security` file. The `java.security` file that is shipped with the IBM SDK for Java contains entries for those providers.
       - If you need to operate in FIPS-compliant mode:
         - Add an entry for the `IBMJCEFIPS` provider to your `java.security` file before the entry for the `IBMJCE` provider. Do not remove the entry for the `IBMJCE` provider.
         - Enable FIPS mode in the `IBMJSSE2` provider. See step "3" on page 140.
     - **Use the IBMJSSE provider (supported for the IBM SDK for Java 1.4.2 only):**

       - If you do not need to operate in FIPS-compliant mode, ensure that entries for the `IBMJSSEProvider` and the `IBMJCE` provider are in the `java.security` file. The `java.security` file that is shipped with the IBM SDK for Java contains entries for those providers.
       - If you need to operate in FIPS-compliant mode, add entries for the FIPS-approved provider `IBMJSSEFIPSProvider` and the `IBMJCEFIPS` provider to your `java.security` file before the entry for the `IBMJCE` provider.

     Restriction: If you use the IBMJSSE provider on the Solaris operating system, you need to include an entry for the SunJSSE provider before entries for the `IBMJCE`, `IBMJCEFIPS`, `IBMJSSE`, or `IBMJSSE2` providers.

   Example: If you need to run in FIPS-compliant mode, and you enabled FIPS mode in the IBMJSSE2 provider, use a `java.security` file similar to this example:

   ```
   # Set the Java security providers
   security.provider.1=com.ibm.jsse2.IBMJSSEProvider2
   security.provider.2=com.ibm.crypto.fips.provider.IBMJCEFIPS
   security.provider.3=com.ibm.crypto.provider.IBMJCE
   security.provider.4=com.ibm.security.jgss.IBMJGSSProvider
   security.provider.5=com.ibm.security.cert.IBMCertPath
   security.provider.6=com.ibm.security.sasl.IBMSASL
   ```

   Example: If you need to run in FIPS-compliant mode, and you are using the IBMJSSE provider, use a `java.security` file similar to this example:

   ```
   # Set the Java security providers
   security.provider.1=com.ibm.fips.jsse.IBMJSSEFIPSProvider
   ```

```
security.provider.2=com.ibm.crypto.fips.provider.IBMJCEFIPS
security.provider.3=com.ibm.crypto.provider.IBMJCE
security.provider.4=com.ibm.security.jgss.IBMJGSSProvider
security.provider.5=com.ibm.security.cert.IBMCertPath
security.provider.6=com.ibm.security.sasl.IBMSASL
```

Example: If you are using the SunJSSE provider, use a `java.security` file similar to this example:

```
# Set the Java security providers
security.provider.1=sun.security.provider.Sun
security.provider.2=com.sun.rsajca.Provider
security.provider.3=com.sun.crypto.provider.SunJCE
security.provider.4=com.sun.net.ssl.internal.ssl.Provider
```

3. If you plan to use the IBM Data Server Driver for JDBC and SQLJ in FIPS-compliant mode, you need to set the `com.ibm.jsse2.JSSEFIPS` Java system property:

   ```
   com.ibm.jsse2.JSSEFIPS=true
   ```

   Restriction: Non-FIPS-mode JSSE applications cannot run in a JVM that is in FIPS mode.

   Restriction: When the `IBMJSSE2` provider runs in FIPS mode, it cannot use hardware cryptography.
4. Configure the Java Runtime Environment for the TLS socket factory providers by adding entries to the `java.security` file. This step is not necessary if you are using the SunJSSE provider and the Java Runtime Environment, 7 or later.

   The format of TLS socket factory provider entries is shown:

   ```
   ssl.SocketFactory.provider=provider-package-name
   ssl.ServerSocketFactory.provider=provider-package-name
   ```

   Specify the TLS socket factory provider for the Java security provider that you are using.

   Example: When you enable FIPS mode in the IBMJSSE2 provider, include TLS socket factory provider entries in the `java.security` file:

   ```
   # Set the TLS socket factory provider
   ssl.SocketFactory.provider=com.ibm.jsse2.SSLSocketFactoryImpl
   ssl.ServerSocketFactory.provider=com.ibm.jsse2.SSLServerSocketFactoryImpl
   ```

   Example: When you enable FIPS mode in the IBMJSSE provider, include TLS socket factory provider entries in the `java.security` file:

   ```
   # Set the TLS socket factory provider
   ssl.SocketFactory.provider=com.ibm.fips.jsse.JSSESocketFactory
   ssl.ServerSocketFactory.provider=com.ibm.fips.jsse.JSSEServerSocketFactory
   ```

   Example: When you use the SunJSSE provider, and the Java Runtime Environment, 6 or earlier, include TLS socket factory provider entries:

   ```
   # Set the TLS socket factory provider
   ssl.SocketFactory.provider=com.sun.net.ssl.internal.ssl.SSLSocketFactoryImpl
   ssl.ServerSocketFactory.provider=com.sun.net.ssl.internal.ssl.SSLServerSocketFactoryImpl
   ```
5. Configure Java system properties to use the truststore.

   To do that, set the following Java system properties:

   `javax.net.ssl.trustStore`
   Specifies the name of the truststore that you specified with the -keystore parameter in the keytool utility in step "1" on page 138.

   `javax.net.ssl.trustStorePassword` (optional)
   Specifies the password for the truststore. You do not need to set a truststore password. However, if you do not set the password, you cannot protect the integrity of the truststore.

   Example: One way that you can set Java system properties is to specify them as the arguments of the -D option when you run a Java application. Suppose that you want to run a Java application

that is named MyTLS.java, which accesses a data source by using a TLS connection. If you defined a truststore named `cacerts`, then the following command sets the truststore name when you run the application.

```
java -Djavax.net.ssl.trustStore=cacerts MyTLS
```

6. To enable the Common Access Card (IBMCAC) provider, overwrite the default truststore and keystore definitions:

```
-Djavax.net.ssl.trustStoreType=Windows-ROOT
-Djavax.net.ssl.keyStoreType=Windows-MY
```

Configuring TLS for the communication between primary and standby HADR servers

Transport Layer Security (TLS) is supported between the HADR primary and standby servers on environments that do not use IBM Db2 pureScale.

Before you begin

Configuring TLS on all instances

To use TLS for the transmission of transaction logs between HADR primary and standby, you need to configure Transport Layer Security (TLS) on all instances in HADR environment. The procedures are similar to the ones described in Configuring TLS support in a Db2 instance. In particular, the steps that describe how to set up your TLS key database and certificate must be done for all the instances. The steps for configuring the HADR environment by using a self-signed certificate are described in the following section.

Considerations for implementing TLS for HADR:

- It is possible to implement TLS via a shared key database. For example, the **SSL_SVR_KEYDB** and **SSL_SVR_STASH** configuration parameters on all instances are set to a shared location. When implementing TLS via a shared key database, it is important that the shared key database itself is also highly available to avoid having a single point of failure.
- It is also possible to implement TLS on each instance via a separate key database. This can be done either by executing the same set of commands on each instance to set up TLS key database and certificate, or by creating the TLS key database and certificate on the first instance then copy them to the other instance(s).
- When implementing TLS on each instance as a separate key database, it is important to have completed all certificate updates to the key databases on all instances prior to making use of those certifications in Db2.

An activated connection concentrator does not inhibit the use of TLS for HADR communications.

Prior to configuring TLS support, perform the following steps on each primary and standby in the HADR configuration

Ensure that the path to the IBM Global Security Kit (GSKit) libraries appear in the *LIBPATH*, *SHLIB_PATH*, or *LD_LIBRARY_PATH* environment variables on Linux and UNIX operating systems. GSKit is automatically included when you install a Db2 database server product.

On UNIX and Linux operating systems, the GSKit libraries are located in `sqllib/lib/gskit`. On Linux platforms, the GSKit is installed locally when Db2 is installed. The GSKit libraries are located in `sqllib/lib/gskit` or `sqllib/lib64/gskit`. It is unnecessary to have another copy of GSKit installed in a global location to start the instance. If a global copy of GSKit does exist, keep the version of the global GSKit at the same version of the local GSKit.

For information about the GSKit tool GSKCapiCmd, see the *GSKCapiCmd User's Guide*, available at ftp://ftp.software.ibm.com/software/webserver/appserv/library/v80/GSK_CapiCmd_UserGuide.pdf.

About this task

Configuring TLS support

The general steps for configuring TLS support are:

1. Create a key database on the primary and each standby instance to manage your digital certificates. These certificates and encryption keys are used for establishing the TLS connections.
2. Configure the Db2 instance for TLS support. This step is done by Db2 instance owner.
3. Configured TLS for the particular database for which TLS is to be used.

The procedure section details this configuration process for the communication between primary and standby HADR servers.

Restrictions

Table 4. TLS support between the HADR primary and standby servers:

Platform	Supported starting in Db2 Version
Linux on AMD64 and Intel EM64T	11.1.1.1
All other platforms	11.1.3.3

Procedure

1. Create a key database and set up your digital certificates on the primary and standby instances.
   a) Use the **gskcapicmd** command to create your key database. The key database must be of a Certificate Management System (CMS) type (extension `.kdb`) or a Public-Key Cryptography Standards #12 (PKCS12) type (extension `.p12`). GSKCapiCmd is a non Java based command-line tool, and Java does not need to be installed on your system to use this tool.

   The **gskcapicmd** command is described in the *GSKCapiCmd User's Guide*. The path for the command is `sqllib/gskit/bin` on Linux and UNIX operating systems. On Linux and UNIX, ensure that the *LIBPATH*, *SHLIB_PATH*, or *LD_LIBRARY_PATH* environment variables include the proper GSKit library path, such as `sqllib/lib64/gskit`.

   For example, the following command creates a key database that is called `myprimary.kdb` and a stash file that is called `myprimary.sth`:

   ```
   gsk8capicmd_64 -keydb -create -db "primary.kdb" -pw "myPrimaryPassw0rdpw0" -stash
   ```

   The `-stash` option creates a stash file at the same path as the key database, with a file extension of `.sth`. At instance start-up, GSKit uses the stash file to obtain the password to the key database.

   When you create a key database, it is automatically populated with signer certificates from a few certificate authorities (CAs), such as Verisign.

   Note: You should use strong file system protection on the stash file. By default, only the instance owner has read and write access to this file. Since this file is a user-managed file, it is not to be stored in the Db2 `sqllib` directory. Create a keystore directory under each instance's home directory to store the key database and stash files. For example,

   ```
   mkdir /home/test/keystore
   ```

   b) Add a certificate for your primary instance to your key database. The standby instance sends this certificate to the primary instance during the TLS handshake to provide authentication for the standby instance. To obtain a certificate, you can either use the **gskcapicmd** command to create a new certificate request and submit it to a CA to be signed, or you can create a self-signed certificate. The following examples are for a self-signed certificate:

   To create a self-signed certificate with a label of *myPrimarysigned*, use the following **gskcapicmd**:

   ```
   gsk8capicmd_64 -cert -create -db "primary.kdb" -pw "myPrimaryPassw0rdpw0" -label
   "myPrimarysigned"
   ```

```
   -dn
"CN=myhost.mycompany.com,O=myOrganization,OU=myOrganizationUnit,L=myLocation,ST=ON,C=CA"
```

To use a CA signed certificate, you must obtain one, as described in .

c) Extract the certificate that you created to a file so that you can distribute it to each standby instance.

For example, the following **gskcapicmd** command extracts the certificate to a file called `primary.arm`:

```
gsk8capicmd_64 -cert -extract -db "primary.kdb" -pw "myPrimaryPassw0rdpw0" -label
"myPrimarysigned"
   -target "primary.arm" -format ascii
```

d) Repeat steps “1.a” on page 142 through “1.c” on page 143 on each standby database.

To create a keydb on the standby:

```
gsk8capicmd_64 -keydb -create -db "standby1.kdb" -pw "myStandby1Passw0rdpw0" -stash
```

Create the certificate on the standby:

```
gsk8capicmd_64 -cert -create -db "standby1.kdb" -pw "myStandby1Passw0rdpw0" -label
"myStandby1signed"
   -dn
"CN=myhost.mycompany.com,O=myOrganization,OU=myOrganizationUnit,L=myLocation,ST=ON,C=CA"
```

Extract the standby certificate into a file called `standby1.arm`:

```
gsk8capicmd_64 -cert -extract -db "standby1.kdb" -pw "myStandby1Passw0rdpw0" -label
"myStandby1signed"
   -target "standby1.arm" -format ascii
```

2. Add the primary and standby certificates to the key database at each primary and standby instance.
   a) FTP the file that contains the primary instance's certificate to the standby instance. This file was extracted in a previous step into a file called `primary.arm`. Also, FTP the file that contains the standby instance's certificate, `standby1.arm`, to the primary instance. Place these files into the directory where you created your key database on each instance.
   b) Add the primary instance's certificate into the standby's key database.

   For example, the following **gsk8capicmd** command imports the certificate from the file `primary.arm` into the key database called `standby1.kdb`:

```
gsk8capicmd_64 -cert -add -db "standby1.kdb" -pw "myStandby1Passw0rdpw0" -label
"myPrimarysigned"
   -file "primary.arm" -format ascii
```

   c) On the primary instance, add the standby's certificate into the primary's key database.

   For example, the following **gsk8capicmd** command imports the certificate from the file `standby1.arm` into the key database called `primary.kdb`.

```
gsk8capicmd_64 -cert -add -db "primary.kdb" -pw "myPrimaryPassw0rdpw0" -label
"myStandby1signed"
   -file "standby1.arm" -format ascii
```

   d) If multiple standby databases exist, the certificate from each instance in the HADR configuration must be imported into the key database of each instance, in the same manner described in steps “2.a” on page 143 through “2.c” on page 143.
3. Set up your Db2 instances for TLS support.
   To set up your Db2 instances for TLS support, log in as the Db2 instance owner and set the following configuration parameters. This step must be done on the Db2 instance of the primary and all standby databases.

a) Set the ssl_svr_keydb configuration parameter to the fully qualified path of the key database file on the instance. For example, on the primary instance:

```
db2 update dbm cfg using SSL_SVR_KEYDB /home/test/keystore/primary.kdb
```

On the standby instance:

```
db2 update dbm cfg using SSL_SVR_KEYDB /home/test/keystore/standby1.kdb
```

If ssl_svr_keydb is null (unset) on any instance in the HADR configuration, TLS support fails.

The paths do not have to be the same on the primary and each standby.

b) Set the ssl_svr_stash configuration parameter to the fully qualified path of the stash file. For example, on the primary instance:

```
db2 update dbm cfg using SSL_SVR_STASH /home/test/keystore/primary.sth
```

On the standby instance:

```
db2 update dbm cfg using SSL_SVR_STASH /home/test/keystore/standby1.sth
```

If ssl_svr_stash is null (unset) on any instance in the HADR configuration, TLS support fails.

The paths do not have to be the same on the primary and each standby.

c) Restart each primary and standby Db2 instance.

```
db2stop
```

```
db2start
```

4. Enable TLS communications for each primary and standby database.

On the primary and each standby database, set the hadr_ssl_label database configuration parameter to the label of the digital certificate, which you added in steps "1" on page 142 and "2" on page 143. For example, on the primary database:

```
db2 update db cfg for db2db using HADR_SSL_LABEL myPrimarysigned
```

Where db2db is the database name and myPrimarysigned is the label that is created in step "1" on page 142.

On the secondary database:

```
db2 update db cfg for db2db using HADR_SSL_LABEL myStandby1signed
```

If hadr_ssl_label is set for one primary or standby, then it must be set for all primary and standby databases in the configuration. If hadr_ssl_label is not set for all databases, then some HADR connections between primary and standby databases fail.

The label does not have to be the same on each primary and standby.

If the hadr_ssl_label is set, then both the ssl_svr_keydb and ssl_svr_stash must be set. If not, then HADR cannot be started, or some HADR connections between primary and standby databases fail.

Related reference

HADR_SSL_LABEL - Label name in the key file for TLS communication between HADR primary and standby instances configuration parameter

Configuring TLS support in federation server for DRDA wrapper

The Db2 database system supports Transport Layer Security (TLS), which means that a Db2 client application that also supports Transport Layer Security (TLS) can connect to a Db2 database using a Transport Layer Security (TLS) socket.

Before you begin

- Ensure to update DB2COMM registry variable

```
db2set -i db2inst1 DB2COMM=SSL
```

- Ensure to enable both TCP/IP and TLS communication protocols

```
db2set -i db2inst1 DB2COMM=SSL,TCPIP
```

  Note: Specify different service ports for TLS and TCPIP.

- Ensure to enable TLS connection on data source side. For more information, see . Some important configuration parameters are:
  - SSL_SVR_KEYDB
  - SSL_SVR_STASH
  - SSL_SVR_LABEL
  - SSL_SVCENAME

Procedure

To configure TLS support in a federation server:

1. Obtain the signer certificate of the server digital certificate on the client. The server certificate can either be a self-signed certificate or a certificate signed by a certificate authority (CA).
   - If your server certificate is a self-signed certificate, you must extract its signer certificate to a file on the server computer and then distribute it to computers running clients that will be establishing TLS connections to that server. See for information about how to extract the certificate to a file.
   - If your server certificate is signed by a well known CA, your client key database might already contain the CA certificate that signed your server certificate. If it does not, you must obtain the CA certificate, which is usually done by visiting the website of the CA.
2. On the Db2 client system, use the GSKCapiCmd tool to create a key database, of CMS type.

   The GSKCapiCmd tool is a non-Java-based command-line tool (Java does not need to be installed on your system to use this tool).

   You invoke GSKCapiCmd using the **gskcapicmd** command, as described in the *GSKCapiCmd User's Guide*. The path for the command is `sqllib/gskit/bin` on Linux and UNIX operating systems, and `C:\Program Files\IBM\GSK8\bin` on both 32-bit and 64-bit Windows operating systems. (On 64-bit operating systems, the 32-bit GSKit executable files and libraries are also present; in this case, the path for the command is `C:\Program Files (x86)\IBM\GSK8\bin`.)

   For example, the following command creates a key database called `mydbclient.kdb` and a stash file called `mydbclient.sth`:

```
gsk8capicmd_64 -keydb -create -db "mydbclient.kdb" -pw "myClientPassw0rdpw0"
      -stash
```

   The **-stash** option creates a stash file at the same path as the key database, with a file extension of `.sth`. At connect time, GSKit uses the stash file to obtain the password to the key database.
3. Add the signer certificate into the client key database

   .

For example, the following **gsk8capicmd** command imports the certificate from the file `mydbserver.arm` into the key database called `mydbclient.kdb`:

```
gsk8capicmd_64 -cert -add -db "mydbclient.kdb" -pw "myClientPassw0rdpw0"
      -label "dbselfsigned" -file "mydbserver.arm" -format ascii -fips
```

4. To connect to the data source by using `mydbclient.kdb` and `mydbclient.sth`, perform the following steps
   a) Configure and start the federation server.
   b) Run the CREATE SERVER command.

```
create server SERVERNAME type TYPE version Version_Number wrapper drda
authorization "uid" password "password" options(host remote_host, port port,
dbname 'database', ssl_keystore '/path_to_keystore/mydbclient.kdb', ssl_keystash '/
path_to_keystash/mydbclient.sth', password 'Y', pushdown 'Y'
```

   c) Run the CREATE USER MAPPING command

```
create user mapping for user server SERVERNAME options(remote_authid
'remote_userid',remote_password 'remote_password')
If everything goes fine, now you are connect to data source using TLS. You can check it
on server side by issue command
netstat -anp | grep server_ssl_listen_port
```

   Connection is established to the data source using TLS. Run the following command to check the connection on the server side.

```
netstat -anp | grep server_ssl_listen_port
```

   If the status of server TLS listen port is 'ESTABLISHED' then it is connected.
5. To connect to the data source by using the server signer certificate only, run the following command:

```
create server SERVERNAME type TYPE version Version_Number wrapper drda authorization
"uid" password "password" options(host remote_host, port port, dbname 'database',
ssl_servercertificate '/path_to_keystore/mydbserver.arm', password 'Y', pushdown 'Y'
```

Auditing DB2 activities

Introduction to the Db2 audit facility

To manage access to your sensitive data, you can use a variety of authentication and access control mechanisms to establish rules and controls for acceptable data access. But to protect against and discover unknown or unacceptable behaviors you can monitor data access by using the Db2 audit facility.

Successful monitoring of unwanted data access and subsequent analysis can lead to improvements in the control of data access and the ultimate prevention of malicious or careless unauthorized access to data. The monitoring of application and individual user access, including system administration actions, can provide a historical record of activity on your database systems.

The Db2 audit facility generates, and allows you to maintain, an audit trail for a series of predefined database events. The records generated from this facility are kept in an audit log file. The analysis of these records can reveal usage patterns that would identify system misuse. Once identified, actions can be taken to reduce or eliminate such system misuse.

The audit facility provides the ability to audit at both the instance and the individual database level, independently recording all instance and database level activities with separate logs for each. The system administrator (who holds SYSADM authority) can use the **db2audit** tool to configure audit at the instance level as well as to control when such audit information is collected. The system administrator can use the **db2audit** tool to archive both instance and database audit logs as well as to extract audit data from archived logs of either type.

The security administrator (who holds SECADM authority within a database) can use audit policies in conjunction with the SQL statement, AUDIT, to configure and control the audit requirements for an

individual database. The security administrator can use the following audit routines to perform the specified tasks:

- The SYSPROC.AUDIT_ARCHIVE stored procedure archives audit logs.
- The SYSPROC.AUDIT_LIST_LOGS table function allows you to locate logs of interest.
- The SYSPROC.AUDIT_DELIM_EXTRACT stored procedure extracts data into delimited files for analysis.

The security administrator can grant EXECUTE privilege on these routines to another user, therefore enabling the security administrator to delegate these tasks, if required.

When working in a partitioned database environment, many of the auditable events occur at the database partition at which the user is connected (the coordinator partition) or at the catalog partition (if they are not the same database partition). The implication of this is that audit records can be generated by more than one database partition. Part of each audit record contains information identifying the coordinator partition and originating partition (the partition where audit record originated).

At the instance level, the audit facility must be stopped and started explicitly by use of the **db2audit start** and **db2audit stop** commands. When you start instance-level auditing, the audit facility uses existing audit configuration information. Since the audit facility is independent of the Db2 database server, it will remain active even if the instance is stopped. In fact, when the instance is stopped, an audit record may be generated in the audit log. To start auditing at the database level, first you need to create an audit policy, then you associate this audit policy with the objects you want to monitor, such as, authorization IDs, database authorities, trusted contexts or particular tables.

Categories of audit records

There are different categories of audit records that may be generated. In the following description of the categories of events available for auditing, you should notice that following the name of each category is a one-word keyword used to identify the category type. The categories of events available for auditing are:

- Audit (AUDIT). Generates records when audit settings are changed or when the audit log is accessed.
- Authorization Checking (CHECKING). Generates records during authorization checking of attempts to access or manipulate Db2 database objects or functions.
- Object Maintenance (OBJMAINT). Generates records when creating or dropping data objects, and when altering certain objects.
- Security Maintenance (SECMAINT). Generates records when:
  - Granting or revoking object privileges or database authorities
  - Granting or revoking security labels or exemptions
  - Altering the group authorization, role authorization, or override or restrict attributes of an LBAC security policy
  - Granting or revoking the SETSESSIONUSER privilege
  - Modifying any of the SYSADM_GROUP, SYSCTRL_GROUP, SYSMAINT_GROUP, or SYSMON_GROUP configuration parameters.
- System Administration (SYSADMIN). Generates records when operations requiring SYSADM, SYSMAINT, or SYSCTRL authority are performed.
- User Validation (VALIDATE). Generates records when authenticating users or retrieving system security information.
- Operation Context (CONTEXT). Generates records to show the operation context when a database operation is performed. This category allows for better interpretation of the audit log file. When used with the log's event correlator field, a group of events can be associated back to a single database operation. For example, a query statement for dynamic queries, a package identifier for static queries, or an indicator of the type of operation being performed, such as CONNECT, can provide needed context when analyzing audit results.

  Note: The SQL or XQuery statement providing the operation context might be very long and is completely shown within the CONTEXT record. This can make the CONTEXT record very large.

- Execute (EXECUTE). Generates records during the execution of SQL statements.

For any of the categories listed previously, you can audit failures, successes, or both.

Any operations on the database server may generate several records. The actual number of records generated in the audit log depends on the number of categories of events to be recorded as specified by the audit facility configuration. It also depends on whether successes, failures, or both, are audited. For this reason, it is important to be selective of the events to audit.

Audit policies

The security administrator can use audit policies to configure the audit facility to gather information only about the data and objects that are needed.

The security administrator can create audit policies to control what is audited within an individual database. The following objects can have an audit policy associated with them:

- The entire database

  All auditable events that occur within the database are audited according to the audit policy.
- Tables

  All data manipulation language (DML) and XQUERY access to the table (untyped), MQT (materialized query table), or nickname is audited. Only EXECUTE category audit events with or without data are generated when the table is accessed even if the policy indicates that other categories should be audited.
- Trusted contexts

  All auditable events that happen within a trusted connection defined by the particular trusted context are audited according to the audit policy.
- Authorization IDs representing users, groups, or roles

  All auditable events that are initiated by the specified user are audited according to the audit policy.

  All auditable events that are initiated by users that are a member of the group or role are audited according to the audit policy. Indirect role membership, such as through other roles or groups, is also included.

  You can capture similar data by using the Work Load Management event monitors by defining a work load for a group and capturing the activity details. You should be aware that the mapping to workloads can involve attributes in addition to just the authorization ID, which can cause you to not achieve the wanted granularity in auditing, or if those other attributes are modified, connections may map to different (possibly unmonitored) workloads. The auditing solution provides a guarantee that a user, group or role will be audited.
- Authorities (SYSADM, SECADM, DBADM, SQLADM, WLMADM, ACCESSCTRL, DATAACCESS, SYSCTRL, SYSMAINT, SYSMON)

  All auditable events that are initiated by a user that holds the specified authority, even if that authority is unnecessary for the event, are audited according to the audit policy.

The security administrator can create multiple audit policies. For example, your company might want a policy for auditing sensitive data and a policy for auditing the activity of users holding DBADM authority. If multiple audit policies are in effect for a statement, all events required to be audited by each of the audit policies are audited (but audited only once). For example, if the database's audit policy requires auditing successful EXECUTE events for a particular table and the user's audit policy requires auditing failures of EXECUTE events for that same table, both successful and failed attempts at accessing that table are audited.

For a specific object, there can only be one audit policy in effect. For example, you cannot have multiple audit policies associated with the same table at the same time.

An audit policy cannot be associated with a view or a typed table. Views that access a table that has an associated audit policy are audited according to the underlying table's policy.

The audit policy that applies to a table does not automatically apply to a MQT based on that table. If you associate an audit policy with a table, associate the same policy with any MQT based on that table.

Auditing performed during a transaction is done based on the audit policies and their associations at the start of the transaction. For example, if the security administrator associates an audit policy with a user and that user is in a transaction at the time, the audit policy does not affect any remaining statements performed within that transaction. Also, changes to an audit policy do not take effect until they are committed. If the security administrator issues an ALTER AUDIT POLICY statement, it does not take effect until the statement is committed.

The security administrator uses the CREATE AUDIT POLICY statement to create an audit policy, and the ALTER AUDIT POLICY statement to modify an audit policy. These statements can specify:

- The status values for events to be audited: `None`, `Success`, `Failure`, or `Both`.

  Only auditable events that match the specified status value are audited.
- The server behavior when errors occur during auditing.

The security administrator uses the AUDIT statement to associate an audit policy with the current database or with a database object, at the current server. Any time the object is in use, it is audited according to this audit policy.

To delete an audit policy, the security administrator uses the DROP statement. You cannot drop an audit policy if it is associated with any object. Use the AUDIT REMOVE statement to remove any remaining association with an object. To add metadata to an audit policy, the security administrator uses the COMMENT statement.

Events generated before a full connection has been established

For some events generated during connect and a switch user operation, the only audit policy information available is the policy that is associated with the database. These events are shown in the following table:

Table 5. Connection events

Event	Audit category	Comment
CONNECT	CONTEXT	
CONNECT_RESET	CONTEXT	
AUTHENTICATION	VALIDATE	This includes authentication during both connect and switch user within a trusted connection.
CHECKING_FUNC	CHECKING	The access attempted is SWITCH_USER.

These events are audited based only on the audit policy associated with the database and not with audit policies associated with any other object such as a user, their groups, or authorities. For the CONNECT and AUTHENTICATION events that occur during connect, the instance-level audit settings are used until the database is activated. The database is activated either during the first connection or when the ACTIVATE DATABASE command is issued.

Effect of switching user

If a user is switched within a trusted connection, no remnants of the original user are left behind. In this case, the audit policies associated with the original user are no longer considered, and the applicable audit policies are re-evaluated according to the new user. Any audit policy associated with the trusted connection is still in effect.

If a SET SESSION USER statement is used, only the session authorization ID is switched. The audit policy of the authorization ID of the original user (the system authorization ID) remains in effect and the audit policy of the new user is used as well. If multiple SET SESSION USER statements are issued within a

session, only the audit policies associated with the original user (the system authorization ID) and the current user (the session authorization ID) are considered.

Data definition language restrictions

The following data definition language (DDL) statements are called AUDIT exclusive SQL statements:

- AUDIT
- CREATE AUDIT POLICY, ALTER AUDIT POLICY, and DROP AUDIT POLICY
- DROP ROLE and DROP TRUSTED CONTEXT, if the role or trusted context being dropped is associated with an audit policy

AUDIT exclusive SQL statements have some restrictions in their use:

- Each statement must be followed by a COMMIT or ROLLBACK.
- These statements cannot be issued within a global transaction, for example an XA transaction.

Only one uncommitted AUDIT exclusive DDL statement is allowed at a time across all partitions. If an uncommitted AUDIT exclusive DDL statement is executing, subsequent AUDIT exclusive DDL statements wait until the current AUDIT exclusive DDL statement commits or rolls back.

Note: Changes are written to the catalog, but do not take effect until COMMIT, even for the connection that issues the statement.

Use cases

Example of auditing any access to a specific table

Consider a company where the EMPLOYEE table contains extremely sensitive information and the company wants to audit any and all SQL access to the data in that table. The EXECUTE category can be used to track all access to a table; it audits the SQL statement, and optionally the input data value provided at execution time for that statement.

There are two steps to track activity on the table. First, the security administrator creates an audit policy that specifies the EXECUTE category, and then the security administrator associates that policy with the table:

```
CREATE AUDIT POLICY SENSITIVEDATAPOLICY
    CATEGORIES EXECUTE STATUS BOTH ERROR TYPE AUDIT
COMMIT

AUDIT TABLE EMPLOYEE USING POLICY SENSITIVEDATAPOLICY
COMMIT
```

Example of auditing any actions by specific authority

In order to complete their security compliance certification, a company must show that any and all activities within the database by those people holding system administration (SYSADM) or database administrative (DBADM) authority can be monitored.

To capture all actions within the database, both the EXECUTE and SYSADMIN categories should be audited. The security administrator creates an audit policy that audits these two categories. The security administrator can use the AUDIT statement to associate this audit policy with the SYSADM and DBADM authorities. Any user that holds either SYSADM or DBADM authority will then have any auditable events logged. The following example shows how to create such an audit policy and associate it with the SYSADM and DBADM authorities:

```
CREATE AUDIT POLICY ADMINSPOLICY CATEGORIES EXECUTE STATUS BOTH,
   SYSADMIN STATUS BOTH ERROR TYPE AUDIT
COMMIT
AUDIT SYSADM, DBADM USING POLICY ADMINSPOLICY
COMMIT
```

Example of auditing any access by a specific role

A company has allowed its web applications access to their corporate database. The exact individuals using the web applications are unknown. Only the role that is used is known and that role is used to manage the database authorizations. The company wants to monitor the actions of anyone who is a member of that role in order to examine the requests they are submitting to the database and to ensure that they only access the database through the web applications.

The EXECUTE category contains the necessary level of auditing to track the activity of the users for this situation. The first step is to create the appropriate audit policy and associate it with the roles that are used by the web applications (in this example, the roles are TELLER and CLERK):

```
CREATE AUDIT POLICY WEBAPPPOLICY CATEGORIES EXECUTE WITH DATA
   STATUS BOTH ERROR TYPE AUDIT
COMMIT
AUDIT ROLE TELLER, ROLE CLERK USING POLICY WEBAPPPOLICY
COMMIT
```

Example of enabling auditing for a database

A company wants to determine who is making DDL changes (example: ALTER TABLE) on the database named SAMPLE.

```
CONNECT TO SAMPLE

CREATE AUDIT POLICY ALTPOLICY CATEGORIES AUDIT STATUS BOTH,
                OBJMAINT STATUS BOTH,  CHECKING STATUS BOTH,
                EXECUTE STATUS BOTH, ERROR TYPE NORMAL

AUDIT DATABASE USING POLICY ALTPOLICY
```

Storage and analysis of audit logs

Archiving the audit log moves the active audit log to an archive directory while the server begins writing to a new, active audit log. Later, you can extract data from the archived log into delimited files and then load data from these files into Db2 database tables for analysis.

Configuring the location of the audit logs allows you to place the audit logs on a large, high-speed disk, with the option of having separate disks for each member in a multiple member database environment, such as a Db2 pureScale environment or a partitioned database environment. In a multiple member database environment, the path for the active audit log can be a directory that is unique to each member. Having a unique directory for each member helps to avoid file contention, because each member is writing to a different disk.

The default path for the audit logs on Windows operating systems is *instance*\security\auditdata and on Linux and UNIX operating systems is *instance*/security/auditdata. If you do not want to use the default location, you can choose different directories (you can create new directories on your system to use as alternative locations, if they do not already exist). To set the path for the active audit log location and the archived audit log location, use the **db2audit configure** command with the **datapath** and **archivepath** parameters, as shown in this example:

```
db2audit configure datapath /auditlog archivepath /auditarchive
```

The audit log storage locations you set using **db2audit** apply to all databases in the instance.

Note: If there are multiple instances on the server, then each instance should each have separate data and archive paths.

The path for active audit logs (datapath) in a multiple member database environment

In a multiple member database environment, the same active audit log location (set by the **datapath** parameter) must be used on each member. There are two ways to accomplish this:

1. Use database member expressions when you specify the **datapath** parameter. Using database member expressions allows the member number to be included in the path of the audit log files and results in a different path on each database member.
2. Use a shared drive that is the same on all members.

You can use database member expressions anywhere within the value you specify for the **datapath** parameter. For example, on a three member system, where the database member number is 10, the following command:

```
db2audit configure datapath '/pathForNode $N'
```

uses the following paths:

- `/pathForMember10`
- `/pathForMember20`
- `/pathForMember30`

Note: You cannot use database member expressions to specify the archive log file path (**archivepath** parameter).

Archiving active audit logs

The system administrator can use the **db2audit** tool to archive both instance and database audit logs as well as to extract audit data from archived logs of either type.

The security administrator, or a user to whom the security administrator has granted EXECUTE privilege on the audit routines, can archive the active audit log by running the SYSPROC.AUDIT_ARCHIVE stored procedure. To extract data from the log and load it into delimited files, they can use the SYSPROC.AUDIT_DELIM_EXTRACT stored procedure.

These are the steps to archive and extract the audit logs using the audit routines:

1. Schedule an application to perform regular archives of the active audit log using the stored procedure SYSPROC.AUDIT_ARCHIVE.
2. Determine which archived log files are of interest. Use the SYSPROC.AUDIT_LIST_LOGS table function to list all of the archived audit logs.
3. Pass the file name as a parameter to the SYSPROC.AUDIT_DELIM_EXTRACT stored procedure to extract data from the log and load it into delimited files.
4. Load the audit data into Db2 database tables for analysis.

The archived log files do not need to be immediately loaded into tables for analysis; they can be saved for future analysis. For example, they may only need to be looked at when a corporate audit is taking place.

If a problem occurs during archive, such as running out of disk space in the archive path, or the archive path does not exist, the archive process fails and an interim log file with the file extension `.bk` is generated in the audit log data path, for example, `db2audit.instance.log.0.20070508172043640941.bk`. After the problem is resolved (by allocating sufficient disk space in the archive path, or by creating the archive path) you must move this interim log to the archive path. Then, you can treat it in the same way as a successfully archived log.

Archiving active audit logs in a multiple member database environment

In a multiple member database environment, if the archive command is issued while the instance is running, the archive process automatically runs on every member. The same timestamp is used in the archived log file name on all members. For example, on a three member system, where the database member number is 10, the following command:

```
db2audit archive to /auditarchive
```

creates the following files:

- /auditarchive/db2audit.log.10.*timestamp*
- /auditarchive/db2audit.log.20.*timestamp*
- /auditarchive/db2audit.log.30.*timestamp*

If the archive command is issued while the instance is not running, you can control on which member the archive is run by one of the following methods:

- Use the **node** option with the **db2audit** command to perform the archive for the current member only.
- Use the **db2_all** command to run the archive on all members.

  For example:

```
db2_all db2audit archive node to /auditarchive
```

  This sets the **DB2NODE** environment variable to indicate on which members the command is invoked.

Alternatively, you can issue an individual archive command on each member separately. For example:

- On member 10:

```
db2audit archive node 10 to /auditarchive
```

- On member 20:

```
db2audit archive node 20 to /auditarchive
```

- On member 30:

```
db2audit archive node 30 to /auditarchive
```

Note: When the instance is not running, the timestamps in the archived audit log file names are not the same on each member.

Note: It is recommended that the archive path is shared across all members, but it is not required.

Note: The AUDIT_DELIM_EXTRACT stored procedure and AUDIT_LIST_LOGS table function can only access the archived log files that are visible from the current (coordinator) member.

Example of archiving a log and extracting data to a table

To ensure their audit data is captured and stored for future use, a company needs to create a new audit log every six hours and archive the current audit log to a WORM drive. The company schedules the following call to the SYSPROC.AUDIT_ARCHIVE stored procedure to be issued every six hours by the security administrator, or by a user to whom the security administrator has granted EXECUTE privilege on the AUDIT_ARCHIVE stored procedure. The path to the archived log is the default archive path, /auditarchive, and the archive runs on all members:

```
CALL SYSPROC.AUDIT_ARCHIVE( '/auditarchive', -2 )
```

As part of their security procedures, the company has identified and defined a number of suspicious behaviors or disallowed activities that it needs to watch for in the audit data. They want to extract all the data from the one or more audit logs, place it in a relational table, and then use SQL queries to look for these activities. The company has decided on appropriate categories to audit and has associated the necessary audit policies with the database or other database objects.

For example, they can call the SYSPROC.AUDIT_DELIM_EXTRACT stored procedure to extract the archived audit logs for all categories from all members that were created with a timestamp in April 2006, using the default delimiter:

```
CALL SYSPROC.AUDIT_DELIM_EXTRACT(
     '', '', '/auditarchive',  'db2audit.%.200604%', '' )
```

In another example, they can call the SYSPROC.AUDIT_DELIM_EXTRACT stored procedure to extract the archived audit records with success events from the EXECUTE category and failure events from the CHECKING category, from a file with the timestamp they are interested in:

```
CALL SYSPROC.AUDIT_DELIM_EXTRACT( '', '', '/auditarchive',
    'db2audit.%.20060419034937', 'category
     execute status success, checking status failure );
```

Audit log file names

The audit log files have names that distinguish whether they are instance-level or database-level logs and which member they originate from in a multiple member database environment, such as a Db2 pureScale environment or a partitioned database environment. Archived audit logs have the timestamp of when the archive command was run appended to their file name.

Active audit log file names

In a multiple member database environment, the path for the active audit log can be a directory that is unique to each member so that each member writes to an individual file. In order to accurately track the origin of audit records, the member number is included as part of the audit log file name. For example, on member 20, the instance level audit log file name is `db2audit.instance.log.20`. For a database called testdb in this instance, the audit log file is `db2audit.db.testdb.log.20`.

In a single member database environment the member number is considered to be 0 (zero). In this case, the instance level audit log file name is `db2audit.instance.log.0`. For a database called testdb in this instance, the audit log file is `db2audit.db.testdb.log.0`.

Archived audit log file names

When the active audit log is archived, the current timestamp in the following format is appended to the filename: *YYYYMMDDHHMMSS* (where *YYYY* is the year, *MM* is the month, *DD* is the day, *HH* is the hour, *MM* is the minutes, and *SS* is the seconds.

The file name format for an archive audit log depends on the level of the audit log:

instance-level archived audit log
The file name of the instance-level archived audit log is:
`db2audit.instance.log.`*member*`.`*YYYYMMDDHHMMSS*.

database-level archived audit log
The file name of the database-level archived audit log is:
`db2audit.db`*database*`.log.`*member*`.`*YYYYMMDDHHMMSS*.

In a single member database environment, the value for *member* is `0` (zero).

The timestamp represents the time that the archive command was run, therefore it does not always precisely reflect the time of the last record in the log. The archived audit log file may contain records with timestamps a few seconds later than the timestamp in the log file name because:

- When the archive command is issued, the audit facility waits for the writing of any in-process records to complete before creating the archived log file.
- In a multi-machine environment, the system time on a remote machine may not be synchronized with the machine where the archive command is issued.

In a multiple member database environment, if the server is running when archive is run, the timestamp is consistent across members and reflects the timestamp generated at the member at which the archive was performed.

Creating tables to hold the Db2 audit data

Before you can work with audit data in database tables, you need to create the tables to hold the data. You should consider creating these tables in a separate schema to isolate the data in the tables from unauthorized users.

Before you begin

- See the CREATE SCHEMA statement for the authorities and privileges that you require to create a schema.
- See the CREATE TABLE statement for the authorities and privileges that you require to create a table.
- Decide which table space you want to use to hold the tables. (This topic does not describe how to create table spaces.)

Note: The format of the tables you need to create to hold the audit data might change from release to release. New columns might be added or the size of an existing column might change. The script, `db2audit.ddl`, creates tables of the correct format to contain the audit records.

About this task

The examples that follow show how to create the tables to hold the records from the delimited files. If you want, you can create a separate schema to contain these tables.

If you do not want to use all of the data that is contained in the files, you can omit columns from the table definitions, or bypass creating certain tables, as required. If you omit columns from the table definitions, you must modify the commands that you use to load data into these tables.

Procedure

1. Issue the **db2** command to open a Db2 command window.
2. Optional: Create a schema to hold the tables.

   For this example, the schema is called AUDIT:

   ```
   CREATE SCHEMA AUDIT
   ```

3. Optional: If you created the AUDIT schema, switch to the schema before creating any tables:

   ```
   SET CURRENT SCHEMA = 'AUDIT'
   ```

4. Run the script, `db2audit.ddl`, to create the tables that will contain the audit records.

   The script `db2audit.ddl` is located in the `sqllib/misc` directory (`sqllib\misc` on Windows). The script assumes that a connection to the database exists and that an 8K table space is available. The command to run the script is: **db2 +o -tf sqllib/misc/db2audit.ddl** The tables that the script creates are: AUDIT, CHECKING, OBJMAINT, SECMAINT, SYSADMIN, VALIDATE, CONTEXT, and EXECUTE.
5. After you have created the tables, the security administrator can use the SYSPROC.AUDIT_DELIM_EXTRACT stored procedure, or the system administrator can use the **db2audit extract** command, to extract the audit records from the archived audit log files into delimited files.

   You can load the audit data from the delimited files into the database tables you just created.

Loading Db2 audit data into tables

After you have archived and extracted the audit log file into delimited files, and you have created the database tables to hold the audit data, you can load the audit data from the delimited files into the database tables for analysis.

About this task

You use the load utility to load the audit data into the tables. Issue a separate load command for each table. If you omitted one or more columns from the table definitions, you must modify the version of the **LOAD** command that you use to successfully load the data. Also, if you specified a delimiter character other than the default when you extracted the audit data, you must also modify the version of the **LOAD** command that you use.

Procedure

1. Issue the **db2** command to open a Db2 command window.
2. To load the AUDIT table, issue the following command:

   ```
   LOAD FROM audit.del OF DEL MODIFIED BY DELPRIORITYCHAR LOBSINFILE
            INSERT INTO schema.AUDIT
   ```

   Note: Specify the **DELPRIORITYCHAR** modifier to ensure proper parsing of binary data.

   Note: Specify the **LOBSINFILE** option of the **LOAD** command (due to the restriction that any inline data for large objects must be limited to 32K). In some situations, you might also need to use the **LOBS FROM** option.

   Note: When specifying the file name, use the fully qualified path name. For example, if you have the Db2 database system installed on the C: drive of a Windows operating system, you would specify `C:\Program Files\IBM\SQLLIB\`*`instance`*`\security\audit.del` as the fully qualified file name for the `audit.del` file.
3. To load the CHECKING table, issue the following command:

   ```
   LOAD FROM checking.del OF DEL MODIFIED BY DELPRIORITYCHAR LOBSINFILE
            INSERT INTO schema.CHECKING
   ```
4. To load the OBJMAINT table, issue the following command:

   ```
   LOAD FROM objmaint.del OF DEL MODIFIED BY DELPRIORITYCHAR LOBSINFILE
            INSERT INTO schema.OBJMAINT
   ```
5. To load the SECMAINT table, issue the following command:

   ```
   LOAD FROM secmaint.del OF DEL MODIFIED BY DELPRIORITYCHAR LOBSINFILE
            INSERT INTO schema.SECMAINT
   ```
6. To load the SYSADMIN table, issue the following command:

   ```
   LOAD FROM sysadmin.del OF DEL MODIFIED BY DELPRIORITYCHAR LOBSINFILE
            INSERT INTO schema.SYSADMIN
   ```
7. To load the VALIDATE table, issue the following command:

   ```
   LOAD FROM validate.del OF DEL MODIFIED BY DELPRIORITYCHAR LOBSINFILE
            INSERT INTO schema.VALIDATE
   ```
8. To load the CONTEXT table, issue the following command:

   ```
   LOAD FROM context.del OF DEL MODIFIED BY DELPRIORITYCHAR LOBSINFILE
            INSERT INTO schema.CONTEXT
   ```
9. To load the EXECUTE table, issue the following command:

```
LOAD FROM execute.del OF DEL MODIFIED BY DELPRIORITYCHAR LOBSINFILE
          INSERT INTO schema.EXECUTE
```

10. After you finish loading the data into the tables, delete the `.del` files from the `security/auditdata` subdirectory of the `sqllib` directory.
11. When you have loaded the audit data into the tables, you are ready to select data from these tables for analysis.

What to do next

If you have already populated the tables a first time, and want to do so again, use the **INSERT** option to have the new table data added to the existing table data. If you want to have the records from the previous **db2audit extract** operation removed from the tables, load the tables again using the **REPLACE** option.

Audit archive and extract stored procedures

The security administrator can use the SYSPROC.AUDIT_ARCHIVE stored procedure and table function, the SYSPROC.AUDIT_DELIM_EXTRACT stored procedure, and the SYSPROC.AUDIT_LIST_LOGS table function to archive audit logs and extract data to delimited files.

The security administrator can delegate use of these routines to another user by granting the user EXECUTE privilege on these routines. Only the security administrator can grant EXECUTE privilege on these routines. EXECUTE privilege WITH GRANT OPTION cannot be granted for these routines (SQLSTATE 42501).

You must be connected to a database in order to use these stored procedures and table functions to archive or list that database's audit logs.

If you copy the archived files to another database system, and you want to use the stored procedures and table functions to access them, ensure that the database name is the same, or rename the files to include the same database name.

These stored procedures and table functions do not archive or list the instance level audit log. The system administrator must use the **db2audit** command to archive and extract the instance level audit log.

You can use these stored procedures and table functions to perform the following operations:

Table 6. Audit system stored procedures and table functions

Stored procedure and table function	Operation	Comments
AUDIT_ARCHIVE	Archives the current audit log.	Takes the archive path as input. If the archive path is not supplied, this stored procedure takes the archive path from the audit configuration file. The archive is run on each member, and a synchronized timestamp is appended to the name of the audit log file.
AUDIT_LIST_LOGS	Returns a list of the archived audit logs at the specified path, for the current database.	

Table 6. Audit system stored procedures and table functions (continued)		
Stored procedure and table function	**Operation**	**Comments**
AUDIT_ DELIM_EXTRACT	Extracts data from the binary archived logs and loads it into delimited files.	The extracted audit records are placed in a delimited format suitable for loading into Db2 database tables. The output is placed in separate files, one for each category. In addition, the file **auditlobs** is created to hold any large objects that are included in the audit data. The file names are: • **audit.del** • **checking.del** • **objmaint.del** • **secmaint.del** • **sysadmin.del** • **validate.del** • **context.del** • **execute.del** • **auditlobs** If the files already exist, the output is appended to them. The **auditlobs** file is created if the CONTEXT or EXECUTE categories are extracted. Only archived audit logs for the current database can be extracted. Only files that are visible to the coordinator member are extracted. Only the instance owner can delete archived audit logs.

The EXECUTE category for auditing SQL statements

Use the EXECUTE category to accurately track the SQL statements that are issued by a user. In Version 9.5 and earlier releases, you had to use the CONTEXT category to find this information.

As part of a comprehensive security policy, a company can require the ability to retroactively go back a set number of years and analyze the effects of any particular request against certain tables in their database. To do this, a company must institute a policy of archiving their weekly backups and associated log files such that they can reconstitute the database for any chosen moment in time. Also required, is sufficient database audit information captured about every request made against the database to allow, at any future time, the replay and analysis of any request against the relevant, restored database. This requirement can cover both static and dynamic SQL statements.

This EXECUTE category captures the SQL statement text as well as the compilation environment and other values that are needed to replay the statement at a later date. For example, replaying the statement can show you exactly which rows a SELECT statement returned. In order to re-run a statement, the database tables must first be restored to their state when the statement was issued.

When you audit using the EXECUTE category, the statement text for both static and dynamic SQL is recorded, as are input parameter markers and host variables. You can configure the EXECUTE category to be audited with or without input values.

Note: Global variables are not audited.

The auditing of EXECUTE events takes place at the completion of the event (for SELECT statements this is on cursor close). The status that the event completed with is also stored. Because EXECUTE events are audited at completion, long-running queries do not immediately appear in the audit log.

Note: The preparation of a statement is not considered part of the execution. Most authorization checks are performed at prepare time (for example, SELECT privilege). This means that statements that fail during prepare due to authorization errors do not generate EXECUTE events.

Statement Value Index, Statement Value Type and Statement Value Data fields may be repeated for a given execute record. For the report format generated by the extraction, each record lists multiple values. For the delimited file format, multiple rows are used. The first row has an event type of STATEMENT and no values. Following rows have an event type of DATA, with one row for each data value associated with the SQL statement. You can use the event correlator and application ID fields to link STATEMENT and DATA rows together. The columns Statement Text, Statement Isolation Level, and Compilation Environment Description are not present in the DATA events.

The statement text and input data values that are audited are converted into the database code page when they are stored on disk (all audited fields are stored in the database code page). No error is returned if the code page of the input data is not compatible with the database code page; the unconverted data will be logged instead. Because each database has it's own audit log, databases having different code pages does not cause a problem.

ROLLBACK and COMMIT are audited when executed by the application, and also when issued implicitly as part of another command, such as BIND.

After an EXECUTE event has been audited due to access to an audited table, all statements that affect which other statements are executed within a unit of work, are audited. These statements are COMMIT, ROLLBACK, ROLLBACK TO SAVEPOINT and SAVEPOINT.

Savepoint ID field

You can use the Savepoint ID field to track which statements were affected by a ROLLBACK TO SAVEPOINT statement. An ordinary DML statement (such as SELECT, INSERT, and so on) has the current savepoint ID audited. However, for the ROLLBACK TO SAVEPOINT statement, the savepoint ID that is rolled back to will be audited instead. Therefore, every statement with a savepoint ID greater than or equal to that ID will be rolled back, as demonstrated by the following example. The table shows the sequence of statements run; all events with a Savepoint ID greater than or equal to 2 will be rolled back. Only the value of 3 (from the first INSERT statement) is inserted into the table T1.

Table 7. Sequence of statements to demonstrate effect of ROLLBACK TO SAVEPOINT statement

Statement	**Savepoint ID**
INSERT INTO T1 VALUES (3)	1
SAVEPOINT A	2
INSERT INTO T1 VALUES (5)	2
SAVEPOINT B	3
INSERT INTO T1 VALUES (6)	3
ROLLBACK TO SAVEPOINT A	2
COMMIT	

WITH DATA option

Not all input values are audited when you specify the WITH DATA option. LOB, LONG, XML and structured type parameters appear as NULL.

Date, time, and timestamp fields are recorded in ISO format.

If WITH DATA is specified in one policy, but WITHOUT DATA is specified in another policy associated with objects involved in the execution of the SQL statement, then WITH DATA takes precedence and data is audited for that particular statement. For example, if the audit policy associated with a user specifies WITHOUT DATA, but the policy associated with a table specifies WITH DATA, when that user accesses that table, the input data used for the statement is audited.

You are not able to determine which rows were modified on a positioned-update or positioned-delete statement. Only the execution of the underlying SELECT statement is logged, not the individual FETCH. It is not possible from the EXECUTE record to determine which row the cursor is on when the statement is issued. When replaying the statement at a later time, it is only possible to issue the SELECT statement to see what range of rows may have been affected.

Example of replaying past activities

Consider in this example that as part of their comprehensive security policy, a company requires that they retain the ability to retroactively go back up to seven years to analyze the effects of any particular request against certain tables in their database. To do this, they institute a policy of archiving their weekly backups and associated log files such that they can reconstitute the database for any chosen moment in time. They require that the database audit capture sufficient information about every request made against the database to allow the replay and analysis of any request against the relevant, restored database. This requirement covers both static and dynamic SQL statements.

This example shows the audit policy that must be in place at the time the SQL statement is issued, and the steps to archive the audit logs and later to extract and analyze them.

1. Create an audit policy that audits the EXECUTE category and apply this policy to the database:

```
CREATE AUDIT POLICY STATEMENTS CATEGORIES EXECUTE WITH DATA
   STATUS BOTH ERROR TYPE AUDIT
COMMIT

AUDIT DATABASE USING POLICY STATEMENTS
COMMIT
```

2. Regularly archive the audit log to create an archive copy.

   The following statement should be run by the security administrator, or a user to whom they grant EXECUTE privilege for the SYSPROC.AUDIT_ARCHIVE stored procedure, on a regular basis, for example, once a week or once a day, depending on the amount of data logged. These archived files can be kept for whatever period is required. The AUDIT_ARCHIVE procedure is called with two input parameters: the path to the archive directory and -2, to indicate that the archive should be run on all members:

```
CALL SYSPROC.AUDIT_ARCHIVE( '/auditarchive', -2 )
```

3. The security administrator, or a user to whom they grant EXECUTE privilege for the SYSPROC.AUDIT_LIST_LOGS table function, uses AUDIT_LIST_LOGS to examine all of the available audit logs from April 2006, to determine which logs may contain the necessary data:

```
SELECT FILE FROM TABLE(SYSPROC.AUDIT_LIST_LOGS('/auditarchive'))
   AS T WHERE FILE LIKE 'db2audit.dbname.log.0.200604%'
FILE
------------------------------------
...
db2audit.dbname.log.0.20060418235612
db2audit.dbname.log.0.20060419234937
db2audit.dbname.log.0.20060420235128
```

4. From this output, the security administrator observes that the necessary logs should be in one file: `db2audit.dbname.log.20060419234937`. The timestamp shows this file was archived at the end of the day for the day the auditors want to see.

   The security administrator, or a user to whom they grant EXECUTE privilege for the SYSPROC.AUDIT_DELIM_EXTRACT stored procedure, uses this filename as input to AUDIT_DELIM_EXTRACT to extract the audit data into delimited files. The audit data in these files

can be loaded into Db2 database tables, where it can be analyzed to find the particular statement the auditors are interested in. Even though the auditors are only interested in a single SQL statement, multiple statements from the unit of work may need to be examined in case they have any impact on the statement of interest.

5. In order to replay the statement, the security administrator must take the following actions:
   - Determine the exact statement to be issued from the audit record.
   - Determine the user who issued the statement from the audit record.
   - Re-create the exact permissions of the user at the time they issued the statement, including any LBAC protection.
   - Reproduce the compilation environment, by using the compilation environment column in the audit record in combination with the SET COMPILATION ENVIRONMENT statement.
   - Restore the database to its exact state at the time the statement was issued.

   To avoid disturbing the production system, any restore of the database and replay of the statement should be done on a second database system. The security administrator, running as the user who issued the statement, can reissue the statement as found in the statement text with any input variables that are provided in the statement value data elements.

Enabling replay of past activities

As part of a comprehensive security policy, a company can require the ability to retroactively go back a set number of years and analyze the effects of any particular request against certain tables in their database.

Before you begin

A company must institute a policy of archiving their weekly backups and associated log files such that they can reconstitute the database for any chosen moment in time.

About this task

To allow, at any future time, the replay and analysis of any request against the relevant, restored database, sufficient database audit information must be captured about every request made against the database. This requirement can cover both static and dynamic SQL statements. The EXECUTE category, when logged WITH DATA contains the necessary information to replay past SQL statements, assuming that the data in the database is restored to the state it was when the statement was issued.

Restrictions

The following authority and privileges are required:

- SECADM authority is required to create the audit policies,
- EXECUTE privilege is required for the audit routines and procedures.

Procedure

To enable replay of past activities, as the SECADM:

1. Create an audit policy that audits the EXECUTE category and apply this policy to the database.

```
CREATE AUDIT POLICY STATEMENTS CATEGORIES EXECUTE WITH DATA
   STATUS BOTH ERROR TYPE AUDIT
COMMIT
AUDIT DATABASE USING POLICY STATEMENTS
COMMIT
```

2. Regularly archive the audit log to create an archive copy.

   To archive the audit log, run the following command on a regular basis, specifying the path to the archive directory and -2 to indicate the archive should be run on all members:

```
CALL SYSPROC.AUDIT_ARCHIVE( '/auditarchive', -2 )
```

3. Check that the audit log files were created.

   These archived files will then be kept for the number of years specified by the company's business policy.

   To check the audit log files run:

```
SELECT FILE FROM SESSION.AUDIT_ARCHIVE_RESULTS
```

Results

Your environment is now set up so data and information is archived to allow future replay of logged database activity.

Replaying past database activities

Replaying past database activity is possible if all required data, logs and information is available. This reference topic shows how a SECADM might replay past database activity via example.

Description

At some point, company auditors might want to analyze the activities of a particular user that occurred in the past. The SECADM can use the backup database images, coupled with the backup logs, and audit logs to reconstitute the database in question and replay the activity the auditors want to analyze. Suppose the activities of a particular user that occurred on April 19, 2006 are in question, the following example shows the flow of how a SECADM would help the auditors carry out their analysis.

Examples

1. The SECADM would issue the AUDIT_LIST_LOGS to find all available audit logs from April 2006.

```
SELECT FILE FROM TABLE(SYSPROC.AUDIT_LIST_LOGS('/auditarchive'))
   AS T WHERE FILE LIKE 'db2audit.db.sample.log.0.200604%'
FILENAME
----------------------------------------
...
db2audit.db.sample.log.0.20060418235612
db2audit.db.sample.log.0.20060419234937
db2audit.db.sample.log.0.20060420235128
```

2. From this output, the SECADM observes that the necessary logs should be in the db2audit.db.sample.log.20060419234937 file. The log was taken at the end of the business day on April 19, 2006.
3. This is used as input to the SYSPROC.AUDIT_DELIM_EXTRACT stored procedure. The arguments passed into the procedure are:
   - character delimiter (default),
   - output path,
   - path to the archived audit logs,
   - the filename filter to determine what files are extracted from,
   - the status for each category to be extracted, in this case the only category is EXECUTE.

```
CALL SYSPROC.AUDIT_DELIM_EXTRACT( '', '', '/auditarchive',
   'db2audit.db.sample.log.0.20060419234937',
   'category execute' )
```

4. The audit data is now in delimited files. The SECADM will load the audit data from the EXECUTE category into the AUDITDATA.EXECUTE table. The table can be created by executing the following:

```
db2 CONNECT TO sample
db2 SET CURRENT SCHEMA AUDITDATA
db2 -tvf sqllib/misc/db2audit.ddl
```

5. Next, load the data from execute.del to the AUDITDATA.EXECUTE table. The do this run the following command:

```
db2 LOAD FROM FILE execute.del OF DEL MODIFIED BY LOBSINFILE
           INSERT INTO AUDITDATA.EXECUTE
```

6. The SECADM now has all the audit data in the audit tables located within the AUDITDATA schema. This data can now be analyzed to find the particular statement the auditors are interested in.

   Note: Even though the auditors are only interested in a single SQL statement, multiple statements from the unit of work may need to be examined in case they have any impact on the statement of interest.

7. In order to replay the statement, the following actions must be taken:

   - The exact statement issued must be determined from the audit record.
   - The user who issued the statement must be determined from the audit record.
   - The exact permissions of the user at the time they issued the statement must be re-created, including any LBAC protection.
   - The compilation environment must be reproduced, by using the compilation environment column in the audit record in combination with the SET COMPILATION ENVIRONMENT statement.
   - The exact state of the database at the time the statement was issued must be re-created.

   Note: So as not to disturb the production system, any restore of the database and replay of the statement should be done on a secondary database system.

8. The SECADM would need to roll forward to the time the statement will start executing. The statement local start time (local_start_time) is part of the EXECUTE audit record. Using the following EXECUTE audit record as an example:

```
timestamp=2006-04-10-13.20.51.029203;
  category=EXECUTE;
  audit event=STATEMENT;
  event correlator=1;
  event status=0;
  database=SAMPLE;
  userid=smith;
  authid=SMITH;
  session authid=SMITH;
  application id=*LOCAL.prodrig.060410172044;
  application name=myapp;
  package schema=NULLID;
  package name=SQLC2F0A;
  package section=201;
  uow id=2;
  activity id=3;
  statement invocation id=0;
  statement nesting level=0;
  statement text=SELECT * FROM DEPARTMENT WHERE DEPTNO = ? AND DEPTNAME = ?;
  statement isolation level=CS;
  compilation environment=
    isolation level=CS
    query optimization=5
    degree=1
    sqlrules=DB2
    refresh age=+00000000000000.000000
    schema=SMITH
    maintained table type=SYSTEM
    resolution timestamp=2006-04-10-13.20.51.000000
    federated asynchrony=0;
  value index=0;
  value type=CHAR;
  value data=C01;
  value index=1;
  value type=VARCHAR;
  value index=INFORMATION CENTER;
  local_start_time=2006-04-10-13.20.51.021507;
```

   The rollforward statement would look like this:

```
ROLLFORWARD DATABASE sample
TO 2006-04-10-13.20.51.021507
USING LOCAL TIME AND COMPLETE
```

9. The compilation environment needs to be set as well. The compilation environment variable can be set by the SET COMPILATION ENVIRONMENT statement. The SECADM, running as the user who issued the statement, can now replay the statement as found in statement text with any input variables that are provided in the statement value data elements. Here is a sample program in C embedded SQL that will set the COMPILATION ENVIRONMENT and replay the SELECT statement the auditors want to analyze:

```
EXEC SQL INCLUDE SQLCA;

EXEC SQL  BEGIN DECLARE SECTION;
     SQL TYPE IS BLOB(1M) hv_blob;
EXEC SQL  END DECLARE SECTION;

EXEC SQL DECLARE c1 CURSOR FOR SELECT COMPENVDESC
            FROM AUDITDATA.EXECUTE TIMESAMP= '2006-04-10-13.20.51.029203';
EXEC SQL DECLARE c2 CURSOR FOR SELECT *
            FROM DEPARTMENT
            WHERE DEPTNO = 'C01'
            AND DEPTNAME = 'INFORMATION CENTER';
EXEC SQL OPEN c1;

EXEC SQL FETCH c1 INTO :hv_blob;

EXEC SQL SET COMPILATION ENVIRONMENT :hv_blob;

EXEC SQL OPEN c2;

....

EXEC SQL CLOSE c1;
EXEC SQL CLOSE c2;
```

Audit facility management

Audit facility behavior

This topic provides background information to help you understand how the timing of writing audit records to the log can affect database performance; how to manage errors that occur within the audit facility; and how audit records are generated in different situations.

Controlling the timing of writing audit records to the active log

The writing of the audit records to the active log can take place synchronously or asynchronously with the occurrence of the events causing the generation of those records. The value of the **audit_buf_sz** database manager configuration parameter determines when the writing of audit records is done.

If the value of **audit_buf_sz** is zero (0), the writing is done synchronously. The event generating the audit record waits until the record is written to disk. The wait associated with each record causes the performance of the Db2 database to decrease.

If the value of **audit_buf_sz** is greater than zero, the record writing is done asynchronously. The value of the **audit_buf_sz** when it is greater than zero is the number of 4 KB pages used to create an internal buffer. The internal buffer is used to keep a number of audit records before writing a group of them out to disk. The statement generating the audit record as a result of an audit event will not wait until the record is written to disk, and can continue its operation.

In the asynchronous case, it could be possible for audit records to remain in an unfilled buffer for some time. To prevent this from happening for an extended period, the database manager forces the writing of the audit records regularly. An authorized user of the audit facility can also flush the audit buffer with an explicit request. Also, the buffers are automatically flushed during an archive operation.

There are differences when an error occurs dependent on whether there is synchronous or asynchronous record writing. In asynchronous mode, there might be some records lost because the audit records are

buffered before being written to disk. In synchronous mode, there might be one record lost because the error could only prevent at most one audit record from being written.

Managing audit facility errors

The setting of the ERRORTYPE audit facility parameter controls how errors are managed between the Db2 database system and the audit facility. When the audit facility is active, and the setting of the ERRORTYPE audit facility parameter is AUDIT, then the audit facility is treated in the same way as any other part of Db2 database. An audit record must be written (to disk in synchronous mode; or to the audit buffer in asynchronous mode) for an audit event associated with a statement to be considered successful. Whenever an error is encountered when running in this mode, a negative SQLCODE is returned to the application for the statement generating an audit record.

If the error type is set to NORMAL, then any error from **db2audit** is ignored and the operation's SQLCODE is returned.

Audit records generated in different situations

Depending on the API or query statement and the audit settings, none, one, or several audit records might be generated for a particular event. For example, an SQL UPDATE statement with a SELECT subquery might result in one audit record containing the results of the authorization check for UPDATE privilege on a table and another record containing the results of the authorization check for SELECT privilege on a table.

For dynamic data manipulation language (DML) statements, audit records are generated for all authorization checking at the time that the statement is prepared. Reuse of those statements by the same user will not be audited again since no authorization checking takes place at that time. However, if a change was made to one of the catalog tables containing privilege information, then in the next unit of work, the statement privileges for the cached dynamic SQL or XQuery statements are checked again and one or more new audit records created.

For a package containing only static DML statements, the only auditable event that could generate an audit record is the authorization check to see if a user has the privilege to execute that package. The authorization checking and possible audit record creation required for the static SQL or XQuery statements in the package is carried out at the time the package is precompiled or bound. The execution of the static SQL or XQuery statements within the package is auditable using the EXECUTE category. When a package is bound again either explicitly by the user, or implicitly by the system, audit records are generated for the authorization checks required by the static SQL or XQuery statements.

For statements where authorization checking is performed at statement execution time (for example, data definition language (DDL), GRANT, and REVOKE statements), audit records are generated whenever these statements are used.

Note: When executing DDL, the section number recorded for all events (except the context events) in the audit record will be zero (0) no matter what the actual section number of the statement might have been.

Audit facility tips and techniques

Best practices for managing your audit include regularly archiving the audit log, using the error type AUDIT when you create an audit policy, and other tips as described here.

Archiving the audit log

You should archive the audit log on a regular basis. Archiving the audit log moves the current audit log to an archive directory while the server begins writing to a new, active audit log. The name of each archived log file includes a timestamp that helps you identify log files of interest for later analysis.

For long-term storage, you might want to compress groups of archived files.

For archived audit logs that you are no longer interested in, the instance owner can simply delete the files from the operating system.

Error handling

When you create an audit policy, you should use the error type AUDIT, unless you are just creating a test audit policy. For example, if the error type is set to AUDIT, and an error occurs, such as running out of disk space, then an error is returned. The error condition must be corrected before any more auditable actions can continue. However, if the error type was set to NORMAL, the logging would simply fail and no error is returned to the user. Operation continues as if the error did not happen.

If a problem occurs during archive, such as running out of disk space in the archive path, or the archive path does not exist, the archive process fails and an interim log file with the file extension `.bk` is generated in the audit log data path, for example, `db2audit.instance.log.0.20070508172043640941.bk`. After the problem is resolved (by allocating sufficient disk space in the archive path, or by creating the archive path) you must move this interim log to the archive path. Then, you can treat it in the same way as a successfully archived log.

DDL statement restrictions

Some data definition language (DDL) statements, called AUDIT exclusive SQL statements, do not take effect until the next unit of work. Therefore, you are advised to use a COMMIT statement immediately after each of these statements.

The AUDIT exclusive SQL statements are:

- AUDIT
- CREATE AUDIT POLICY, ALTER AUDIT POLICY, and DROP AUDIT POLICY
- DROP ROLE and DROP TRUSTED CONTEXT, if the role or trusted context being dropped is associated with an audit policy

Table format for holding archived data might change

The security administrator can use the SYSPROC.AUDIT_DEL_EXTRACT stored procedure, or the system administrator can use the **db2audit extract** command, to extract audit records from the archived audit log files into delimited files. You can load the audit data from the delimited files into Db2 database tables for analysis. The format of the tables you need to create to hold the audit data might change from release to release.

Important: The script, `db2audit.ddl`, creates tables of the correct format to contain the audit records. You should expect to run `db2audit.ddl` for each release, as columns might be added or the size of an existing column might change.

Using CHECKING events

In most cases, when working with CHECKING events, the object type field in the audit record is the object being checked to see if the required privilege or authority is held by the user ID attempting to access the object. For example, if a user attempts to ALTER a table by adding a column, then the CHECKING event audit record indicates the access attempted was "ALTER" and the object type being checked was "TABLE" (not the column, because it is table privileges that are checked).

However, when the checking involves verifying if a database authority exists to allow a user ID to CREATE or BIND an object, or to DROP an object, then although there is a check against the database, the object type field will specify the object being created, bound, or dropped (rather than the database itself).

When creating an index on a table, the privilege to create an index is required, therefore the CHECKING event audit record has an access attempt type of "index" rather than "create".

Audit records created for binding a package

When binding a package that already exists, then an OBJMAINT event audit record is created for the DROP of the package and then another OBJMAINT event audit record is created for the CREATE of the new copy of the package.

Using CONTEXT event information after ROLLBACK

Data Definition Language (DDL) might generate OBJMAINT or SECMAINT events that are logged as successful. It is possible however that following the logging of the event, a subsequent error might cause a ROLLBACK to occur. This would leave the object as not created; or the GRANT or REVOKE actions as incomplete. The use of CONTEXT events becomes important in this case. Such CONTEXT event audit records, especially the statement that ends the event, indicates the nature of the completion of the attempted operation.

The load delimiter

When extracting audit records in a delimited format suitable for loading into a Db2 database table, you should be clear regarding the delimiter used within the statement text field. This can be done when extracting the delimited file, using:

```
db2audit extract delasc delimiter load_delimiter
```

The *load _delimiter* can be a single character (such as ") or a four-byte string representing a hexadecimal value (such as "0x3b"). Examples of valid commands are:

```
db2audit extract delasc
db2audit extract delasc delimiter !
db2audit extract delasc delimiter 0x3b
```

If you have used anything other than the default load delimiter as the delimiter when extracting, you should use the **MODIFIED BY** option on the **LOAD** command. A partial example of the **LOAD** command with "0x3b" used as the delimiter follows:

```
db2 load from context.del of del modified by chardel0x3b replace into ...
```

This overrides the default load character string delimiter which is " (double quote).

Security model for the db2cluster command

The **db2cluster** command is the main interface into Db2 cluster services, and as such acts on both the cluster manager and shared file system cluster provided for the IBM Db2 pureScale Feature. The **db2cluster** command options that are available to a user depend on the user's authority.

In terms of the security model for the **db2cluster** command, there are three user groups, broken down by the type of tasks each user group is likely to perform:

- Anyone with a userid on the system

  Users in this group are able to use the **db2cluster** command to report information about the Db2 pureScale instance, but not to make any changes.
- The SYSADM, SYSCTL or SYSMAINT group

  Users in this group are able to use the **db2cluster** command to keep the instance up and running, and to perform some administrative tasks on the cluster manager. By definition, a user in this group is either the userid of the instance, a member of the primary group of the instance owner, or a member of a non-primary group of the instance owner. Db2 recommends that normal day to day activities are performed using a userid with membership in a non-primary group of the instance owner
- The Db2 cluster services administrator

  Users in this group have no requirements to access data in the database; this is an administrative role used for:

  – installation and configuration of the Db2 cluster services portion of Db2

  – maintaining clustered instances in the cluster domain and maintaining the shared file system cluster

  The Db2 cluster services administrator role is an end user with access to a root-owned userid for the operating system; for example, an operating system administrator. Db2 cluster services can affect all

clustered environments, whether you are using the Db2 pureScale Feature or a partitioned database environment with integrated HA. Therefore, roles such as DBADM, SECADM, SQLADM, WLMADM, EXPLAIN, ACCESSCTRL, and DATAACCESS that act on databases, do not provide the appropriate level of authority for cluster management. The Db2 cluster services administrator can be the same person as someone with a userid in the SYSADM, SYSCTL or SYSMAINT groups.

Note: Just because a user has SYSADM privileges, it does not necessarily mean the user has operating system administration privileges.

Cluster manager tasks for db2cluster

- Anyone with a userid on the system can retrieve information about the current state of the cluster domain using the **-list** and **-verify** options.
- Users in the SYSADM, SYSMAINT or SYSCTL group can query and change the preferred primary cluster caching facility using the **-list** and **-set** options. As well, these users can use the **-clear -alert** option to clear alerts for any of the hosts, members, and cluster caching facilities in the current instance (as defined by the DB2INSTANCE registry variable). Users in this group can also create and delete cluster resources, and repair the cluster manager resource model; however, it is strongly recommended that these tasks be performed only under the advisement of Db2 service personnel.
- The Db2 cluster services administrator can perform administrative tasks that affect Db2 cluster services as a whole across all clustered instances on all hosts in the cluster domain. This user can perform configuration tasks such as setting the tiebreaker device and the host failure detection time, using the **-set** option. As well, the Db2 cluster services administrator can perform maintenance-related tasks, such as putting hosts into maintenance mode, using the **-enter** option, or committing changes or updates to the cluster manager, using the **-commit** option. This user can also perform advanced maintenance operations on the cluster manager peer domain, such as creating, deleting, starting, or stopping the domain, and adding or removing hosts; however, it is strongly recommended that these tasks be performed only under the advisement of Db2 service personnel. Certain DB2® cluster administrative commands require *DB2INSTANCE* environment variable to be set.

Shared file system tasks for db2cluster

- Anyone with a userid on the system can retrieve information about the current state of the cluster domain using the **-list** and **-verify** options. These users can also perform a wide variety of file system operations with the **db2cluster** command options, but what they can do is constrained by regular file system permissions. As long as the userid running the command has read and write ownership of the device being used, that user can create file systems and add disks. Once a file system has been created or mounted, access to that file system is limited to the userid that created it and to the Db2 cluster services administrator, so only those users can remove, delete, or rebalance a file system. Either the userid that created it, or the Db2 cluster services administrator can create directories that are accessible to other users, much as with a normal file system.
- The Db2 cluster services administrator can perform administrative tasks that affect Db2 cluster services as a whole across all clustered instances on all hosts in the cluster domain. This user can change options for the tiebreaker device, using the **-set** option. As well, the Db2 cluster services administrator can perform maintenance-related tasks, such as putting hosts into maintenance mode, using the **-enter** option, or committing changes or updates to the shared file system, using the **-commit** option. This user can also perform advanced maintenance operations on the shared file system cluster, such as creating, deleting, starting, or stopping the domain, and adding or removing hosts; however, it is strongly recommended that these tasks be performed only under the advisement of Db2 service personnel.

Chapter 2. Roles

Roles simplify the administration and management of privileges by offering an equivalent capability as groups but without the same restrictions.

A role is a database object that groups together one or more privileges and can be assigned to users, groups, PUBLIC, or other roles by using a GRANT statement, or can be assigned to a trusted context by using a CREATE TRUSTED CONTEXT or ALTER TRUSTED CONTEXT statement. A role can be specified for the SESSION_USER ROLE connection attribute in a workload definition.

Roles provide several advantages that make it easier to manage privileges in a database system:

- Security administrators can control access to their databases in a way that mirrors the structure of their organizations (they can create roles in the database that map directly to the job functions in their organizations).
- Users are granted membership in the roles that reflect their job responsibilities. As their job responsibilities change, their membership in roles can be easily granted and revoked.
- The assignment of privileges is simplified. Instead of granting the same set of privileges to each individual user in a particular job function, the administrator can grant this set of privileges to a role representing that job function and then grant that role to each user in that job function.
- A role's privileges can be updated and all users who have been granted that role receive the update; the administrator does not need to update the privileges for every user on an individual basis.
- The privileges and authorities granted to roles are always used when you create views, triggers, materialized query tables (MQTs), static SQL and SQL routines, whereas privileges and authorities granted to groups (directly or indirectly) are not used.

  This is because the Db2 database system cannot determine when membership in a group changes, as the group is managed by third-party software (for example, the operating system or an LDAP directory). Because roles are managed inside the database, the Db2 database system can determine when authorization changes and act accordingly. Roles granted to groups are not considered, due to the same reason groups are not considered.
- All the roles assigned to a user are enabled when that user establishes a connection, so all privileges and authorities granted to roles are taken into account when a user connects. Roles cannot be explicitly enabled or disabled.
- The security administrator can delegate management of a role to others.

All Db2 privileges and authorities that can be granted within a database can be granted to a role. For example, a role can be granted any of the following authorities and privileges:

- DBADM, SECADM, DATAACCESS, ACCESSCTRL, SQLADM, WLMADM, LOAD, and IMPLICIT_SCHEMA database authorities
- CONNECT, CREATETAB, CREATE_NOT_FENCED, BINDADD, CREATE_EXTERNAL_ROUTINE, or QUIESCE_CONNECT database authorities
- Any database object privilege (including CONTROL)

A user's roles are automatically enabled and considered for authorization when a user connects to a database; you do not need to activate a role by using the SET ROLE statement. For example, when you create a view, a materialized query table (MQT), a trigger, a package, or an SQL routine, the privileges that you gain through roles apply. However, privileges that you gain through roles granted to groups of which you are a member do not apply.

A role does not have an owner. The security administrator can use the WITH ADMIN OPTION clause of the GRANT statement to delegate management of the role to another user, so that the other user can control the role membership.

Restrictions

There are a few restrictions in the use of roles:

- A role cannot own database objects.
- Permissions and roles granted to groups are not considered when you create the following database objects:
  - Packages containing static SQL
  - Views
  - Materialized query tables (MQT)
  - Triggers
  - SQL Routines

  Only roles granted to the user creating the object or to PUBLIC, directly or indirectly (such as through a role hierarchy), are considered when creating these objects.

Creating and granting membership in roles

The security administrator holds the authority to create, drop, grant, revoke, and comment on a role. The security administrator uses the GRANT (Role) statement to grant membership in a role to an authorization ID and uses the REVOKE (Role) statement to revoke membership in a role from an authorization ID.

The security administrator can delegate the management of membership in a role to an authorization ID by granting the authorization ID membership in the role with the WITH ADMIN OPTION. The WITH ADMIN OPTION clause of the GRANT (Role) statement gives another user the ability to:

- Grant roles to others.
- Revoke roles from others.
- Comment on the role.

The WITH ADMIN OPTION clause does not give the ability to:

- Drop the role.
- Revoke the WITH ADMIN OPTION for a role from an authorization ID.
- Grant WITH ADMIN OPTION to someone else (if you do not hold SECADM authority).

After the security administrator has created a role, the database administrator can use the GRANT statement to assign authorities and privileges to the role. All Db2 privileges and authorities that can be granted within a database can be granted to a role. Instance level authorities, such as SYSADM authority, cannot be assigned to a role.

The security administrator, or any user who the security administrator has granted membership in a role with WITH ADMIN OPTION can use the GRANT (Role) statement to grant membership in that role to other users, groups, PUBLIC or roles. A user may have been granted membership in a role with WITH ADMIN OPTION either directly, or indirectly through PUBLIC, a group or a role.

All the roles assigned to a user are enabled when that user establishes a session. All the privileges and authorities associated with a user's roles are taken into account when the Db2 database system checks for authorization. Some database systems use the SET ROLE statement to activate a particular role. The Db2 database system supports SET ROLE to provide compatibility with other products using the SET ROLE statement. In a Db2 database system, the SET ROLE statement checks whether the session user is a member of the role and returns an error if they are not.

To revoke a user's membership in a role, the security administrator, or a user who holds WITH ADMIN OPTION privilege on the role, uses the REVOKE (Role) statement.

Example

A role has a certain set of privileges and a user who is granted membership in this role inherits those privileges. This inheritance of privileges eliminates managing individual privileges when reassigning the privileges of one user to another user. The only operations required when using roles is to revoke membership in the role from one user and grant membership in the role to the other user.

For example, the employees BOB and ALICE, working in department DEV, have the privilege to SELECT on the tables SERVER, CLIENT and TOOLS. One day, management decides to move them to a new department, QA, and the database administrator has to revoke their privilege to select on tables SERVER, CLIENT and TOOLS. Department DEV later hires a new employee, TOM, and the database administrator has to grant SELECT privilege on tables SERVER, CLIENT and TOOLS to TOM.

When using roles, the following steps occur:

1. The security administrator creates a role, DEVELOPER:

```
CREATE ROLE DEVELOPER
```

2. The database administrator (who holds DBADM authority) grants SELECT on tables SERVER, CLIENT, and TOOLS to role DEVELOPER:

```
GRANT  SELECT ON TABLE SERVER TO ROLE DEVELOPER
GRANT  SELECT ON TABLE CLIENT TO ROLE DEVELOPER
GRANT  SELECT ON TABLE TOOLS TO ROLE DEVELOPER
```

3. The security administrator grants the role DEVELOPER to the users in department DEV, BOB and ALICE:

```
GRANT ROLE DEVELOPER TO USER BOB, USER ALICE
```

4. When BOB and ALICE leave department DEV, the security administrator revokes the role DEVELOPER from users BOB and ALICE:

```
REVOKE ROLE DEVELOPER FROM USER BOB, USER ALICE
```

5. When TOM is hired in department DEV, the security administrator grants the role DEVELOPER to user TOM:

```
GRANT ROLE DEVELOPER TO USER TOM
```

Role hierarchies

A role hierarchy is formed when one role is granted membership in another role.

A role *contains* another role when the other role is granted to the first role. The other role inherits all of the privileges of the first role. For example, if the role DOCTOR is granted to the role SURGEON, then SURGEON is said to contain DOCTOR. The role SURGEON inherits all the privileges of role DOCTOR.

Cycles in role hierarchies are not allowed. A *cycle* occurs if a role is granted in circular way such that one role is granted to another role and that other role is granted to the original role. For example, the role DOCTOR is granted to role SURGEON, and then the role SURGEON is granted back to the role DOCTOR. If you create a cycle in a role hierarchy, an error is returned (SQLSTATE 428GF).

Example of building a role hierarchy

The following example shows how to build a role hierarchy to represent the medical levels in a hospital.

Consider the following roles: DOCTOR, SPECIALIST, and SURGEON. A role hierarchy is built by granting a role to another role, but without creating cycles. The role DOCTOR is granted to role SPECIALIST, and role SPECIALIST is granted to role SURGEON.

Granting role SURGEON to role DOCTOR would create a cycle and is not allowed.

The security administrator runs the following SQL statements to build the role hierarchy:

```
CREATE ROLE DOCTOR
CREATE ROLE SPECIALIST
CREATE ROLE SURGEON

GRANT ROLE DOCTOR TO ROLE SPECIALIST

GRANT ROLE SPECIALIST TO ROLE SURGEON
```

Effect of revoking privileges from roles

When privileges are revoked, this can sometimes cause dependent database objects, such as views, packages or triggers, to become invalid or inoperative.

The following examples show what happens to a database object when some privileges are revoked from an authorization identifier and privileges are held through a role or through different means.

Example of revoking privileges from roles

1. The security administrator creates the role DEVELOPER and grants the user BOB membership in this role:

   ```
   CREATE ROLE DEVELOPER
   GRANT ROLE DEVELOPER TO USER BOB
   ```

2. User ALICE creates a table, WORKITEM:

   ```
   CREATE TABLE WORKITEM (x int)
   ```

3. The database administrator grants SELECT and INSERT privileges on table WORKITEM to PUBLIC and also to the role DEVELOPER:

   ```
   GRANT SELECT ON TABLE ALICE.WORKITEM TO PUBLIC
   GRANT INSERT ON TABLE ALICE.WORKITEM TO PUBLIC
   GRANT SELECT ON TABLE ALICE.WORKITEM TO ROLE DEVELOPER
   GRANT INSERT ON TABLE ALICE.WORKITEM TO ROLE DEVELOPER
   ```

4. User BOB creates a view, PROJECT, that uses the table WORKITEM, and a package, PKG1, that depends on the table WORKITEM:

   ```
   CREATE VIEW PROJECT AS SELECT * FROM ALICE.WORKITEM
   PREP emb001.sqc BINDFILE PACKAGE USING PKG1 VERSION 1
   ```

5. If the database administrator revokes SELECT privilege on table ALICE.WORKITEM from PUBLIC, then the view BOB.PROJECT remains operative and package PKG1 remains valid because the view definer, BOB, still holds the privileges required through his membership in the role DEVELOPER:

   ```
   REVOKE SELECT ON TABLE ALICE.WORKITEM FROM PUBLIC
   ```

6. If the database administrator revokes SELECT privilege on table ALICE.WORKITEM from the role DEVELOPER, the view BOB.PROJECT becomes inoperative and package PKG1 becomes invalid because the view and package definer, BOB, does not hold the required privileges through other means:

   ```
   REVOKE SELECT ON TABLE ALICE.WORKITEM FROM ROLE DEVELOPER
   ```

Example of revoking DBADM authority

In this example, the role DEVELOPER holds DBADM authority and is granted to user BOB.

1. The security administrator creates the role DEVELOPER:

   ```
   CREATE ROLE DEVELOPER
   ```

2. The system administrator grants DBADM authority to the role DEVELOPER:

```
GRANT DBADM ON DATABASE TO ROLE DEVELOPER
```

3. The security administrator grants user BOB membership in this role:

```
GRANT ROLE DEVELOPER TO USER BOB
```

4. User ALICE creates a table, WORKITEM:

```
CREATE TABLE WORKITEM (x int)
```

5. User BOB creates a view PROJECT that uses table WORKITEM, a package PKG1 that depends on table WORKITEM, and a trigger, TRG1, that also depends on table WORKITEM:

```
CREATE VIEW PROJECT AS SELECT * FROM ALICE.WORKITEM
PREP emb001.sqc BINDFILE PACKAGE USING PKG1 VERSION 1
CREATE TRIGGER TRG1 AFTER DELETE ON ALICE.WORKITEM
               FOR EACH STATEMENT MODE DB2SQL
       INSERT INTO ALICE.WORKITEM VALUES (1)
```

6. The security administrator revokes the role DEVELOPER from user BOB:

```
REVOKE ROLE DEVELOPER FROM USER BOB
```

   Revoking the role DEVELOPER causes the user BOB to lose DBADM authority because the role that held that authority was revoked. The view, package, and trigger are affected as follows:

   - View BOB. PROJECT is still valid.
   - Package PKG1 becomes invalid.
   - Trigger BOB.TRG1 is still valid.

   View BOB.PROJECT and trigger BOB.TRG1 are usable while package PKG1 is not usable. View and trigger objects created by an authorization ID holding DBADM authority are not affected when DBADM authority is lost.

Delegating role maintenance by using the WITH ADMIN OPTION clause

Using the WITH ADMIN OPTION clause of the GRANT (Role) SQL statement, the security administrator can delegate the management and control of membership in a role to someone else.

The WITH ADMIN OPTION clause gives another user the authority to grant membership in the role to other users, to revoke membership in the role from other members of the role, and to comment on a role, but not to drop the role.

The WITH ADMIN OPTION clause does not give another user the authority to grant WITH ADMIN OPTION on a role to another user. It also does not give the authority to revoke WITH ADMIN OPTION for a role from another authorization ID.

Example demonstrating use of the WITH ADMIN OPTION clause

1. A security administrator creates the role, DEVELOPER, and grants the new role to user BOB using the WITH ADMIN OPTION clause:

```
CREATE ROLE DEVELOPER
GRANT ROLE DEVELOPER TO USER BOB WITH ADMIN OPTION
```

2. User BOB can grant membership in the role to and revoke membership from the role from other users, for example, ALICE:

```
GRANT ROLE DEVELOPER TO USER ALICE
REVOKE ROLE DEVELOPER FROM USER ALICE
```

3. User BOB cannot drop the role or grant WITH ADMIN OPTION to another user (only a security administrator can perform these two operations). These commands issued by BOB will fail:

```
DROP ROLE DEVELOPER  - FAILURE!
                     - only a security administrator is allowed to drop the role
GRANT ROLE DEVELOPER TO USER ALICE WITH ADMIN OPTION    - FAILURE!
                     - only a security administrator can grant WITH ADMIN OPTION
```

4. User BOB cannot revoke role administration privileges (conferred by WITH ADMIN OPTION) from users for role DEVELOPER, because he does not have security administrator (SECADM) authority. When BOB issues the following command, it fails:

```
REVOKE ADMIN OPTION FOR ROLE DEVELOPER FROM USER SANJAY - FAILURE!
```

5. A security administrator is allowed to revoke the role administration privileges for role DEVELOPER (conferred by WITH ADMIN OPTION) from user BOB , and user BOB still has the role DEVELOPER granted:

```
REVOKE ADMIN OPTION FOR ROLE DEVELOPER FROM USER BOB
```

   Alternatively, if a security administrator simply revokes the role DEVELOPER from user BOB, then BOB loses all the privileges he received by being a member of the role DEVELOPER and the authority on the role he received through the WITH ADMIN OPTION clause:

```
REVOKE ROLE DEVELOPER FROM USER BOB
```

Roles compared to groups

Privileges and authorities granted to groups are not considered when creating views, materialized query tables (MQTs), SQL routines, triggers, and packages containing static SQL. Avoid this restriction by using roles instead of groups.

Roles allow users to create database objects using their privileges acquired through roles, which are controlled by the Db2 database system. Groups and users are controlled externally from the Db2 database system, for example, by an operating system or an LDAP server.

Example of replacing the use of groups with roles

This example shows how you can replace groups by using roles.

Assume that there are three groups, DEVELOPER_G, TESTER_G and SALES_G. The users BOB, ALICE, and TOM are members of these groups, as shown in the following table:

Table 8. Example groups and users

Group	Users belonging to this group
DEVELOPER_G	BOB
TESTER_G	ALICE, TOM
SALES_G	ALICE, BOB

1. The security administrator creates the roles DEVELOPER, TESTER, and SALES to be used instead of the groups.

```
CREATE ROLE DEVELOPER
CREATE ROLE TESTER
CREATE ROLE SALES
```

2. The security administrator grants membership in these roles to users (setting the membership of users in groups was the responsibility of the system administrator):

```
GRANT  ROLE DEVELOPER TO USER BOB
GRANT  ROLE TESTER TO USER ALICE, USER TOM
GRANT  ROLE SALES TO USER BOB, USER ALICE
```

3. The database administrator can grant to the roles similar privileges or authorities as were held by the groups, for example:

```
GRANT privilege ON object TO ROLE DEVELOPER
```

   The database administrator can then revoke these privileges from the groups, as well as ask the system administrator to remove the groups from the system.

Example of creating a trigger using privileges acquired through a role

This example shows that user BOB can successfully create a trigger, TRG1, when he holds the necessary privilege through the role DEVELOPER.

1. First, user ALICE creates the table, WORKITEM:

```
CREATE TABLE WORKITEM (x int)
```

2. Then, the privilege to alter ALICE's table is granted to role DEVELOPER by the database administrator.

```
GRANT ALTER ON ALICE.WORKITEM TO ROLE DEVELOPER
```

3. User BOB successfully creates the trigger, TRG1, because he is a member of the role, DEVELOPER.

```
CREATE TRIGGER TRG1 AFTER DELETE ON ALICE.WORKITEM
           FOR EACH STATEMENT MODE DB2SQL INSERT INTO ALICE.WORKITEM VALUES (1)
```

Notes

- Roles that are granted to groups are not considered.

Using roles after migrating from IBM Informix Dynamic Server

If you have migrated from IBM Informix® Dynamic Server to the Db2 database system and are using roles there are a few things you need to be aware of.

The Informix Dynamic Server (IDS) SQL statement, GRANT ROLE, provides the clause WITH GRANT OPTION. The Db2 database system GRANT ROLE statement provides the clause WITH ADMIN OPTION (this conforms to the SQL standard) that provides the same functionality. During an IDS to Db2 database system migration, after the **dbschema** tool generates CREATE ROLE and GRANT ROLE statements, the **dbschema** tool replaces any occurrences of WITH GRANT OPTION with WITH ADMIN OPTION.

In an IDS database system, the SET ROLE statement activates a particular role. The Db2 database system supports the SET ROLE statement, but only to provide compatibility with other products using that SQL statement. The SET ROLE statement checks whether the session user is a member of the role and returns an error if they are not.

Example dbschema output

Assume that an IDS database contains the roles DEVELOPER, TESTER and SALES. Users BOB, ALICE, and TOM have different roles granted to each of them; the role DEVELOPER is granted to BOB, the role TESTER granted to ALICE, and the roles TESTER and SALES granted to TOM. To migrate to the Db2 database system, use the **dbschema** tool to generate the CREATE ROLE and GRANT ROLE statements for the database:

```
CREATE ROLE DEVELOPER
CREATE ROLE TESTER
CREATE ROLE SALES

GRANT  DEVELOPER TO BOB
```

```
GRANT  TESTER TO ALICE, TOM
GRANT  SALES TO TOM
```

You must create the database in the Db2 database system, and then you can run the preceding statements in that database to re-create the roles and assignment of the roles.

Chapter 3. Using trusted contexts and trusted connections

You can establish an explicit trusted connection by making a request within an application when a connection to a Db2 database is established. The security administrator must have previously defined a trusted context, using the CREATE TRUSTED CONTEXT statement, with attributes matching those of the connection you are establishing (see Step 1, later).

Before you begin

The API you use to request an explicit trusted connection when you establish a connection depends on the type of application you are using (see the table in Step 2).

After you have established an explicit trusted connection, the application can switch the user ID of the connection to a different user ID using the appropriate API for the type of application (see the table in Step 3).

Procedure

1. The security administrator defines a trusted context in the server by using the CREATE TRUSTED CONTEXT statement.
   For example:

```
CREATE TRUSTED CONTEXT MYTCX
       BASED UPON CONNECTION USING SYSTEM AUTHID NEWTON
       ATTRIBUTES (ADDRESS   '192.0.2.1')
       WITH USE FOR PUBLIC WITHOUT AUTHENTICATION
       ENABLE
```

2. To establish a trusted connection, use one of the following APIs in your application:

Option	Description
Application	**API**
CLI/ODBC	SQLConnect, SQLSetConnectAttr
XA CLI/ODBC	Xa_open
JAVA	getDB2TrustedPooledConnection, getDB2TrustedXAConnection

3. To switch to a different user, with or without authentication, use one of the following APIs in your application:

Option	Description
Application	**API**
CLI/ODBC	SQLSetConnectAttr
XA CLI/ODBC	SQLSetConnectAttr
JAVA	getDB2Connection, reuseDB2Connection
.NET	DB2Connection.ConnectionString keywords: TrustedContextSystemUserID and TrustedContextSystemPassword

   The switching can be done either with or without authenticating the new user ID, depending on the definition of the trusted context object associated with the explicit trusted connection. For example, suppose that the security administrator creates the following trusted context object:

```
CREATE TRUSTED CONTEXT CTX1
    BASED UPON CONNECTION USING SYSTEM AUTHID USER1
```

```
    ATTRIBUTES (ADDRESS   '192.0.2.1')
  WITH USE FOR USER2 WITH AUTHENTICATION,
               USER3 WITHOUT AUTHENTICATION
  ENABLE
```

Further, suppose that an explicit trusted connection is established. A request to switch the user ID on the trusted connection to USER3 without providing authentication information is allowed because USER3 is defined as a user of trusted context CTX1 for whom authentication is not required. However, a request to switch the user ID on the trusted connection to USER2 without providing authentication information will fail because USER2 is defined as a user of trusted context CTX1 for whom authentication information must be provided.

Example of establishing an explicit trusted connection and switching the user

In the following example, a middle-tier server needs to issue some database requests on behalf of an end-user, but does not have access to the end-user's credentials to establish a database connection on behalf of that end-user.

You can create a trusted context object on the database server that allows the middle-tier server to establish an explicit trusted connection to the database. After establishing an explicit trusted connection, the middle-tier server can switch the current user ID of the connection to a new user ID without the need to authenticate the new user ID at the database server. The following CLI code snippet demonstrates how to establish a trusted connection using the trusted context, MYTCX, defined in Step 1, earlier, and how to switch the user on the trusted connection without authentication.

```
int main(int argc, char *argv[])
{
    SQLHANDLE henv;              /* environment handle */
    SQLHANDLE hdbc1;            /* connection handle */
    char origUserid[10] = "newton";
  char password[10] = "test";
      char switchUserid[10] = "zurbie";
    char dbName[10] = "testdb";

// Allocate the handles
SQLAllocHandle( SQL_HANDLE_ENV, &henv );
SQLAllocHandle( SQL_HANDLE_DBC, &hdbc1 );

// Set the trusted connection attribute
SQLSetConnectAttr( hdbc1, SQL_ATTR_USE_TRUSTED_CONTEXT,
SQL_TRUE, SQL_IS_INTEGER );

// Establish a trusted connection
SQLConnect( hdbc1, dbName, SQL_NTS, origUserid, SQL_NTS,
password, SQL_NTS );

//Perform some work under user ID "newton"
. . . . . .

 // Commit the work
SQLEndTran(SQL_HANDLE_DBC, hdbc1, SQL_COMMIT);


// Switch the user ID on the trusted connection
SQLSetConnectAttr( hdbc1,
SQL_ATTR_TRUSTED_CONTEXT_USERID, switchUserid,
SQL_IS_POINTER
);

//Perform new work using user ID "zurbie"
. . . . . .

//Commit the work
SQLEndTranSQL_HANDLE_DBC, hdbc1, SQL_COMMIT);

// Disconnect from database
SQLDisconnect( hdbc1 );

    return 0;

}  /* end of main */
```

What to do next

When does the user ID actually get switched?

After the command to switch the user on the trusted connection is issued, the switch user request is not performed until the next statement is sent to the server. This is demonstrated by the following example where the **`list applications`** command shows the original user ID until the next statement is issued.

1. Establish an explicit trusted connection with USERID1.
2. Issue the switch user command, such as **`getDB2Connection`** for USERID2.
3. Run `db2 list applications`. It still shows that USERID1 is connected.
4. Issue a statement on the trusted connection, such as `executeQuery("values current sqlid")`, to perform the switch user request at the server.
5. Run `db2 list applications` again. It now shows that USERID2 is connected.

Trusted contexts and trusted connections

A trusted context is a database object that defines a trust relationship for a connection between the database and an external entity such as an application server.

The trust relationship is based upon the following set of attributes:

- System authorization ID: Represents the user that establishes a database connection
- IP address (or domain name): Represents the host from which a database connection is established
- Data stream encryption: Represents the encryption setting (if any) for the data communication between the database server and the database client

When a user establishes a database connection, the Db2 database system checks whether the connection matches the definition of a trusted context object in the database. When a match occurs, the database connection is said to be trusted.

A trusted connection cannot be established if the connection is to a local database using inter-process communication (IPC).

A trusted connection allows the initiator of this trusted connection to acquire additional capabilities that may not be available outside the scope of the trusted connection. The additional capabilities vary depending on whether the trusted connection is explicit or implicit.

The initiator of an explicit trusted connection has the ability to:

- Switch the current user ID on the connection to a different user ID with or without authentication
- Acquire additional privileges via the role inheritance feature of trusted contexts

An implicit trusted connection is a trusted connection that is not explicitly requested; the implicit trusted connection results from a normal connection request rather than an explicit trusted connection request. No application code changes are needed to obtain an implicit connection. Also, whether you obtain an implicit trusted connection or not has no effect on the connect return code (when you request an explicit trusted connection, the connect return code indicates whether the request succeeds or not). The initiator of an implicit trusted connection can only acquire additional privileges via the role inheritance feature of trusted contexts; they cannot switch the user ID.

How using trusted contexts enhances security

The three-tiered application model extends the standard two-tiered client and server model by placing a middle tier between the client application and the database server. It has gained great popularity in recent years particularly with the emergence of web-based technologies and the Java 2 Enterprise Edition (J2EE) platform. An example of a software product that supports the three-tier application model is IBM WebSphere® Application Server (WAS).

In a three-tiered application model, the middle tier is responsible for authenticating the users running the client applications and for managing the interactions with the database server. Traditionally, all the

interactions with the database server occur through a database connection established by the middle tier using a combination of a user ID and a credential that identify that middle tier to the database server. This means that the database server uses the database privileges associated with the middle tier's user ID for all authorization checking and auditing that must occur for any database access, including access performed by the middle tier on behalf of a user.

While the three-tiered application model has many benefits, having all interactions with the database server (for example, a user request) occur under the middle tier's authorization ID raises several security concerns, which can be summarized as follows:

- Loss of user identity

  Some enterprises prefer to know the identity of the actual user accessing the database for access control purposes.

- Diminished user accountability

  Accountability through auditing is a basic principle in database security. Not knowing the user's identity makes it difficult to distinguish the transactions performed by the middle tier for its own purpose from those performed by the middle tier on behalf of a user.

- Over granting of privileges to the middle tier's authorization ID

  The middle tier's authorization ID must have all the privileges necessary to execute all the requests from all the users. This has the security issue of enabling users who do not need access to certain information to obtain access anyway.

- Weakened security

  In addition to the privilege issue raised in the previous point, the current approach requires that the authorization ID used by the middle tier to connect must be granted privileges on all resources that might be accessed by user requests. If that middle-tier authorization ID is ever compromised, then all those resources will be exposed.

- "Spill over" between users of the same connection

  Changes by a previous user can affect the current user.

Clearly, there is a need for a mechanism whereby the actual user's identity and database privileges are used for database requests performed by the middle tier on behalf of that user. The most straightforward approach of achieving this goal would be for the middle-tier to establish a new connection using the user's ID and password, and then direct the user's requests through that connection. Although simple, this approach suffers from several drawbacks which include the following:

- Inapplicability for certain middle tiers. Many middle-tier servers do not have the user authentication credentials needed to establish a connection.
- Performance overhead. There is an obvious performance overhead associated with creating a new physical connection and re-authenticating the user at the database server.
- Maintenance overhead. In situations where you are not using a centralized security set up or are not using single sign-on, there is maintenance overhead in having two user definitions (one on the middle tier and one at the server). This requires changing passwords at different places.

The trusted contexts capability addresses this problem. The security administrator can create a trusted context object in the database that defines a trust relationship between the database and the middle-tier. The middle-tier can then establish an explicit trusted connection to the database, which gives the middle tier the ability to switch the current user ID on the connection to a different user ID, with or without authentication. In addition to solving the end-user identity assertion problem, trusted contexts offer another advantage. This is the ability to control when a privilege is made available to a database user. The lack of control on when privileges are available to a user can weaken overall security. For example, privileges may be used for purposes other than they were originally intended. The security administrator can assign one or more privileges to a role and assign that role to a trusted context object. Only trusted database connections (explicit or implicit) that match the definition of that trusted context can take advantage of the privileges associated with that role.

Enhancing performance

When you use trusted connections, you can maximize performance because of the following advantages:

- No new connection is established when the current user ID of the connection is switched.
- If the trusted context definition does not require authentication of the user ID to switch to, then the overhead associated with authenticating a new user at the database server is not incurred.

Example of creating a trusted context

Suppose that the security administrator creates the following trusted context object:

```
CREATE TRUSTED CONTEXT CTX1
     BASED UPON CONNECTION USING SYSTEM AUTHID USER2
     ATTRIBUTES (ADDRESS   '192.0.2.1')
  DEFAULT ROLE managerRole
   ENABLE
```

If user *user1* requests a trusted connection from IP address 192.0.2.1, the Db2 database system returns a warning (SQLSTATE 01679, SQLCODE +20360) to indicate that a trusted connection could not be established, and that user *user1* simply got a non-trusted connection. However, if user *user2* requests a trusted connection from IP address 192.0.2.1, the request is honored because the connection attributes are satisfied by the trusted context CTX1. Now that use *user2* has established a trusted connection, he or she can now acquire all the privileges and authorities associated with the trusted context role managerRole. These privileges and authorities may not be available to user *user2* outside the scope of this trusted connection

Role membership inheritance through a trusted context

The current user of a trusted connection can acquire additional privileges through the automatic inheritance of a role through the trusted context, if this was specified by the security administrator as part of the relevant trusted context definition.

A role can be inherited by all users of the trusted connection by default. The security administrator can also use the trusted context definition to specify a role for specific users to inherit.

The active roles that a session authorization ID can hold while on a trusted connection are:

- The roles of which the session authorization ID is normally considered a member, plus
- Either the trusted context default role or the trusted context user-specific role, if they are defined

Note:

- If you configure user authentication using a custom security plugin that is built such that the system authorization ID and the session authorization ID produced by this security plug-in upon a successful connection are different from each other, then a trusted contexts role cannot be inherited through that connection, even if it is a trusted connection.
- Trusted context privileges acquired through a role are effective only for dynamic DML operations. They are not effective for:
  - DDL operations
  - Non-dynamic SQL (operations involving static SQL statements such as BIND, REBIND, implicit rebind, incremental bind, and so on)
- Trusted context privileges acquired through a role are not considered when evaluating EXECUTE privilege on any packages required by the session.

Acquiring trusted context user-specific privileges

The security administrator can use the trusted context definition to associate roles with a trusted context so that:

- All users of the trusted connection can inherit a specified role by default

- Specific users of the trusted connection can inherit a specified role

When the user on a trusted connection is switched to a new authorization ID and a trusted context user-specific role exists for this new authorization ID, the user-specific role overrides the trusted context default role, if one exists, as demonstrated in the example.

Example of creating a trusted context that assigns a default role and a user-specific role

Suppose that the security administrator creates the following trusted context object:

```
CREATE TRUSTED CONTEXT CTX1
     BASED UPON CONNECTION USING SYSTEM AUTHID USER1
    ATTRIBUTES (ADDRESS   '192.0.2.1')
  WITH USE FOR USER2 WITH AUTHENTICATION,
               USER3 WITHOUT AUTHENTICATION
  DEFAULT ROLE AUDITOR
  ENABLE
```

When USER1 establishes a trusted connection, the privileges granted to the role AUDITOR are inherited by this authorization ID. Similarly, these same privileges are also inherited by USER3 when the current authorization ID on the trusted connection is switched to his or her user ID. (If the user ID of the connection is switched to USER2 at some point, then USER2 would also inherit the trusted context default role, AUDITOR.) The security administrator may choose to have USER3 inherit a different role than the trusted context default role. They can do so by assigning a specific role to this user as follows:

```
CREATE TRUSTED CONTEXT CTX1
    BASED UPON CONNECTION USING SYSTEM AUTHID USER1
    ATTRIBUTES (ADDRESS   '192.0.2.1')
  WITH USE FOR USER2 WITH AUTHENTICATION,
               USER3 WITHOUT AUTHENTICATION ROLE OTHER_ROLE
  DEFAULT ROLE AUDITOR
  ENABLE
```

When the current user ID on the trusted connection is switched to USER3, this user no longer inherits the trusted context default role. Rather, they inherit the specific role, OTHER_ROLE, assigned to him or her by the security administrator.

Rules for switching the user ID on an explicit trusted connection

On an explicit trusted connection, you can switch the user ID of the connection to a different user ID. Certain rules apply.

1. If the switch request is not made from an explicit trusted connection, and the switch request is sent to the server for processing, the connection is shut down and an error message is returned (SQLSTATE 08001, SQLCODE -30082 with reason code 41).
2. If the switch request is not made on a transaction boundary, the transaction is rolled back, and the switch request is sent to the server for processing, the connection is put into an unconnected state and an error message is returned (SQLSTATE 58009, SQLCODE -30020).
3. If the switch request is made from within a stored procedure, an error message is returned (SQLCODE -30090, reason code 29), indicating this is an illegal operation in this environment. The connection state is maintained and the connection is not placed into an unconnected state. Subsequent requests may be processed.
4. If the switch request is delivered to the server on an instance attach (rather than a database connection), the attachment is shut down and an error message is returned (SQLCODE -30005).
5. If the switch request is made with an authorization ID that is not allowed on the trusted connection, error (SQLSTATE 42517, SQLCODE -20361) is returned, and the connection is put in an unconnected state.
6. If the switch request is made with an authorization ID that is allowed on the trusted connection WITH AUTHENTICATION, but the appropriate authentication token is not provided, error (SQLSTATE 42517, SQLCODE -20361) is returned, and the connection is put in an unconnected state.

7. If the trusted context object associated with the trusted connection is disabled, and a switch request for that trusted connection is made, error (SQLSTATE 42517, SQLCODE -20361) is returned, and the connection is put in an unconnected state.

   In this case, the only switch user request that is accepted is one that specifies the user ID that established the trusted connection or the NULL user ID. If a switch to the user ID that established the trusted connection is made, this user ID does not inherit any trusted context role (neither the trusted context default role nor the trusted context user-specific role).

8. If the system authorization ID attribute of the trusted context object associated with the trusted connection is changed, and a switch request for that trusted connection is made, error (SQLSTATE 42517, SQLCODE -20361) is returned, and the connection is put in an unconnected state.

   In this case, the only switch user request that is accepted is one that specifies the user ID that established the trusted connection or the NULL user ID. If a switch to the user ID that established the trusted connection is made, this user ID does not inherit any trusted context role (neither the trusted context default role nor the trusted context user-specific role).

9. If the trusted context object associated with the trusted connection is dropped, and a switch request for that trusted connection is made, error (SQLSTATE 42517, SQLCODE -20361) is returned, and the connection is put in an unconnected state.

   In this case, the only switch user request that is accepted is one that specifies the user ID that established the trusted connection or the NULL user ID. If a switch to the user ID that established the trusted connection is made, this user ID does not inherit any trusted context role (neither the trusted context default role nor the trusted context user-specific role).

10. If the switch request is made with a user ID allowed on the trusted connection, but that user ID does not hold CONNECT privilege on the database, the connection is put in an unconnected state and an error message is returned (SQLSTATE 08004, SQLCODE -1060).
11. If the trusted context system authorization ID appears in the WITH USE FOR clause, the Db2 database system honors the authentication setting for the system authorization ID on switch user request to switch back to the system authorization ID. If the trusted context system authorization ID does not appear in the WITH USE FOR clause, then a switch user request to switch back to the system authorization ID is always allowed even without authentication.

Note: When the connection is put in the unconnected state, the only requests that are accepted and do not result in returning the error "The application state is in error. A database connection does not exist." (SQLCODE -900) are:

- A switch user request
- A COMMIT or ROLLBACK statement
- A DISCONNECT, CONNECT RESET or CONNECT request

Note: When the user ID on the trusted connection is switched to a new user ID, all traces of the connection environment under the old user are gone. In other words, the switching of user IDs results in an environment that is identical to a new connection environment. For example, if the old user ID on the connection had any temporary tables or WITH HOLD cursors open, these objects are completely lost when the user ID on that connection is switched to a new user ID.

Note: Java trusted connections do not have an unconnected state. If the switch user operation fails, Java will throw an exception and the connection will be disconnected.

Trusted context problem determination

An explicit trusted connection is a connection that is successfully established by a specific, explicit request for a trusted connection. When you request an explicit trusted connection and you do not qualify for one, you get a regular connection and a warning (+20360).

To determine why a user could not establish a trusted connection, the security administrator needs to look at the trusted context definition in the system catalogs and at the connection attributes. In particular, the IP address from which the connection is established, the encryption level of the data stream or

network, and the system authorization ID making the connection. The **-application** option of the **db2pd** utility returns this information, as well as the following additional information:

- Connection Trust Type: Indicates whether the connection is trusted or not. When the connection is trusted, this also indicates whether this is an explicit trusted connection or an implicit trusted connection.
- Trusted Context name: The name of the trusted context associated with the trusted connection.
- Role Inherited: The role inherited through the trusted connection.

The following are the most common causes of failing to obtain an explicit trusted connection:

- The client application is not using TCP/IP to communicate with the Db2 server. TCP/IP is the only supported protocol for a client application to communicate with the Db2 server that can be used to establish a trusted connection (explicit or implicit).
- The database server authentication type is set to CLIENT.
- The database server does not have an enabled trusted context object. The definition of the trusted context object must explicitly state ENABLE in order for that trusted context to be considered for matching the attributes of an incoming connection.
- The trusted context objects on the database server do not match the trust attributes that are presented. For example, one of the following situations may apply:
  - The system authorization ID of the connection does not match any trusted context object system authorization ID.
  - The IP address from which the connection originated does not match any IP address in the trusted context object considered for the connection.
  - The data stream encryption used by the connection does not match the value of the ENCRYPTION attribute in the trusted context object considered for the connection.

  You can use the **db2pd** tool to find out the IP address from which the connection is established, the encryption level of the data stream or network used by the connection, and the system authorization ID making the connection. You can consult the SYSCAT.CONTEXTS and SYSCAT.CONTEXTATTRIBUTES catalog views to find out the definition of a particular trusted context object, such as its system authorization ID, its set of allowed IP addresses and the value of its ENCRYPTION attribute.

The following are the most common causes of a switch user failure:

- The user ID to switch to does not have CONNECT privileges on the database. In this case, SQL1060N is returned.
- The user ID to switch to, or PUBLIC, is not defined in the WITH USE FOR clause of the trusted context object associated with the explicit trusted connection.
- Switching the user is allowed with authentication, but the user presents no credentials or the wrong credentials.
- A switch-user request is not made on a transaction boundary.
- The trusted context that is associated with a trusted connection has been disabled, dropped, or altered. In this case, only switching to the user ID that established the trusted connection is allowed.

Chapter 4. Row and column access control (RCAC) overview

Db2 10.1 introduces row and column access control (RCAC), as an additional layer of data security. Row and column access control is sometimes referred to as fine-grained access control or FGAC. RCAC controls access to a table at the row level, column level, or both. RCAC can be used to complement the table privileges model.

To comply with various government regulations, you might implement procedures and methods to ensure that information is adequately protected. Individuals in your organization are permitted access to only the subset of data that is required to perform their job tasks. For example, government regulations in your area might state that a doctor is authorized to view the medical records of their own patients, but not of other patients. The same regulations might also state that, unless a patient gives their consent, a healthcare provider is not permitted access to patient personal information, such as the patients home phone number.

You can use row and column access control to ensure that your users have access to only the data that is required for their work. For example, a hospital system running Db2 and RCAC can filter patient information and data to include only that data which a particular doctor requires. Other patients do not exist as far as the doctor is concerned. Similarly, when a patient service representative queries the patient table at the same hospital, they are able to view the patient name and telephone number columns, but the medical history column is masked for them. If data is masked, a NULL, or an alternate value is displayed, instead of the actual medical history.

Row and column access control, or RCAC, has the following advantages:

- No database user is inherently exempted from the row and column access control rules.

  Even higher level authorities such as users with DATAACCESS authority are not exempt from these rules. Only users with security administrator (SECADM) authority can manage row and column access controls within a database. Therefore, you can use RCAC to prevent users with DATAACCESS authority from freely accessing all data in a database.
- Table data is protected regardless of how a table is accessed via SQL.

  Applications, improvised query tools, and report generation tools are all subject to RCAC rules. The enforcement is data-centric.
- No application changes are required to take advantage of this additional layer of data security.

  That is, row and column level access controls are established and defined in a way that is not apparent to existing applications. However, RCAC represents an important shift in paradigm in the sense that it is no longer what is being asked but rather who is asking what. Result sets for the same query change based on the context in which the query was asked and there is no warning or error returned. This behavior is the exact intent of the solution. It means that application designers and DBAs must be conscious that queries do not see the whole picture in terms of the data in the table, unless granted specific permissions to do so.

Related information

Best practices: A practical guide to implementing row and column access control

Row and column access control (RCAC) rules

Row and column access control (RCAC) places access control at the table level around the data itself. SQL rules created on rows and columns are the basis of the implementation of this capability.

Row and column access control is an access control model in which a security administrator manages privacy and security policies. RCAC permits all users to access the same table, as opposed to alternative views of a table. RCAC does however, restrict access to the table based upon individual user permissions

or rules as specified by a policy associated with the table. There are two sets of rules, one set operates on rows, and the other on columns.

- Row permission
  - A row permission is a database object that expresses a row access control rule for a specific table.
  - A row access control rule is an SQL search condition that describes what set of rows a user has access to.
- Column mask
  - A column mask is a database object that expresses a column access control rule for a specific column in a table.
  - A column access control rule is an SQL CASE expression that describes what column values a user is permitted to see and under what conditions.

SQL statements for managing RCAC rules

Using the following SQL statements, you can create, alter, and drop RCAC rules. For more information, see the Db2 v11.5 SQL reference guide.

CREATE PERMISSION

ALTER PERMISSION

CREATE MASK

ALTER MASK

DROP

GRANT (database authorities)

REVOKE (database authorities)

AUDIT

COMMENT

CREATE TABLE

ALTER TABLE

RENAME

CREATE FUNCTION (external scalar)

CREATE FUNCTION (external table)

CREATE FUNCTION (OLE DB external table)

CREATE FUNCTION (SQL scalar, table, or row)

CREATE FUNCTION (sourced or template)

ALTER FUNCTION

CREATE TRIGGER

ALTER TRIGGER

Built-in functions for managing RCAC permissions and masks

Use the following built-in scalar functions to express conditions in your permissions and masks. For example, a user must belong to one or more roles, or to one or more groups to access a particular row.

Scenario: ExampleHMO using row and column access control

This scenario presents ExampleHMO, a national organization with a large and active list of patients, as a user of row and column access control. ExampleHMO uses row and column access control to ensure that their database policies reflect government regulatory requirements for privacy and security, as well as management business objectives.

Organizations that handle patient health information and their personal information, like ExampleHMO, must comply with government privacy and data protection regulations, for example the Health Insurance Portability and Accountability Act (HIPAA). These privacy and data protection regulations ensure that any sensitive patient medical or personal information is shared, viewed, and modified only by authorities who are privileged to do so. Any violation of the act results in huge penalties including civil and criminal suits.

ExampleHMO must ensure that the data stored in their database systems is secure and only privileged users have access to the data. According to typical privacy regulations, certain patient information can be accessed and modified by only privileged users.

Scenario: ExampleHMO using row and column access control - Security policies

ExampleHMO implements a security strategy where data access to databases are made available according to certain security policies.

The security policies conform to government privacy and data protection regulations. The first column outlines the policies and the challenges faced by the organization, the second column outlines the row and column access control feature which addresses the challenge.

Security challenge	**Row and column access control feature which addresses the security challenge**
Limiting column access to only privileged users. For example, Jane, who is a drug researcher at a partner company, is not permitted to view sensitive patient medical information or personal data like their insurance number.	Column masks can be used to filter or hide sensitive data from Jane.
Limiting row access to only privileged users. Dr. Lee is only permitted to view patient information for his own patients, not all patients in the ExampleHMO system.	Row permissions can be implemented to control which user can view any particular row.
Restricting data on a need-to-know basis.	Row permissions can help with this challenge as well by restricting table level data at the user level.
Restricting other database objects like UDFs, triggers, views on RCAC secured data.	Row and column access control protects data at the data level. It is this data-centric nature of the row and column access control solution that enforces security policies on even database objects like UDFs, triggers, and views.

Scenario: ExampleHMO using row and column access control - Database users and roles

In this scenario, a number of different people create, secure, and use ExampleHMO data. These people have different user rights and database authorities.

ExampleHMO implemented their security strategy to classify the way data is accessed from the database. Internal and external access to data is based on the separation of duties to users who access the data and their data access privileges. ExampleHMO created the following database roles to separate these duties:

PCP
For primary care physicians.

DRUG_RESEARCH
For researchers.

ACCOUNTING
For accountants.

MEMBERSHIP
For members who add patients for opt-in and opt-out.

PATIENT
For patients.

The following people create, secure, and use ExampleHMO data:

Alex
ExampleHMO Chief Security Administrator. He holds the SECADM authority.

Peter
ExampleHMO Database Administrator. He holds the DBADM authority.

Paul
ExampleHMO Database Developer. He has the privileges to create triggers and user-defined functions.

Dr. Lee
ExampleHMO Physician. He belongs to the PCP role.

Jane
Drug researcher at Innovative Pharmaceutical Company, a ExampleHMO partner. She belongs to the DRUG_RESEARCH role.

John
ExampleHMO Accounting Department. He belongs to the ACCOUNTING role.

Tom
ExampleHMO Membership Officer. He belongs to the MEMBERSHIP role.

Bob
ExampleHMO Patient. He belongs to the PATIENT role.

If you want to try any of the example SQL statements and commands presented in this scenario, create these user IDs with their listed authorities.

The following example SQL statements assume that the users have been created on the system. The SQL statements create each role and grant **SELECT** and **INSERT** permissions to the various tables in the ExampleHMO database to the users:

```
--Creating roles and granting authority

CREATE ROLE PCP;

CREATE ROLE DRUG_RESEARCH;

CREATE ROLE ACCOUNTING;

CREATE ROLE MEMBERSHIP;

CREATE ROLE PATIENT;

GRANT ROLE PCP TO USER LEE;
```

```
GRANT ROLE DRUG_RESEARCH TO USER JANE;
GRANT ROLE ACCOUNTING  TO USER JOHN;
GRANT ROLE MEMBERSHIP TO USER TOM;
GRANT ROLE PATIENT TO USER BOB;
```

Scenario: ExampleHMO using row and column access control - Database tables

This scenario focuses on two tables in the ExampleHMO database: the PATIENT table and the PATIENTCHOICE table.

The PATIENT table stores basic patient information and health information. This scenario considers the following columns within the PATIENT table:

SSN
The patient's insurance number. A patient's insurance number is considered personal information.

NAME
The patient's name. A patient's name is considered personal information.

ADDRESS
The patient's address. A patient's address is considered personal information.

USERID
The patient's database ID.

PHARMACY
The patient's medical information.

ACCT_BALANCE
The patient's billing information.

PCP_ID
The patient's primary care physician database ID

The PATIENTCHOICE table stores individual patient opt-in and opt-out information which decides whether a patient wants to expose his health information to outsiders for research purposes in this table. This scenario considers the following columns within the PATIENTCHOICE table:

SSN
The patient's insurance number is used to match patients with their choices.

CHOICE
The name of a choice a patient can make.

VALUE
The decision made by the patients about the choice.

For example, the row 123-45-6789, drug_research, opt-in says that patient with SSN 123-45-6789 agrees to disclose their information for medical research purposes.

The following example SQL statements create the PATIENT, PATIENTCHOICE, and ACCT_HISTORY tables. Authority is granted on the tables and data is inserted:

```
--Patient table storing information regarding patient
CREATE TABLE PATIENT (
    SSN CHAR(11),
    USERID VARCHAR(18),
    NAME VARCHAR(128),
    ADDRESS VARCHAR(128),
    PHARMACY VARCHAR(250),
    ACCT_BALANCE DECIMAL(12,2) WITH DEFAULT,
    PCP_ID VARCHAR(18)
    );


--Patientchoice table which stores what patient opts
--to expose regarding his health information

CREATE TABLE PATIENTCHOICE (
    SSN CHAR(11),
    CHOICE VARCHAR(128),
```

```
    VALUE VARCHAR(128)
);

--Log table to track account balance
CREATE TABLE ACCT_HISTORY(
    SSN         CHAR(11),
    BEFORE_BALANCE    DECIMAL(12,2),
    AFTER_BALANCE    DECIMAL(12,2),
    WHEN     DATE,
    BY_WHO    VARCHAR(20)
);


--Grant authority

GRANT SELECT, UPDATE ON TABLE PATIENT TO ROLE PCP;

GRANT SELECT ON TABLE PATIENT TO ROLE DRUG_RESEARCH;

GRANT SELECT, UPDATE ON TABLE PATIENT TO ROLE ACCOUNTING;
GRANT SELECT ON TABLE ACCT_HISTORY TO ROLE ACCOUNTING;

GRANT SELECT, UPDATE, INSERT ON TABLE PATIENT TO ROLE MEMBERSHIP;
GRANT INSERT ON TABLE PATIENTCHOICE TO ROLE MEMBERSHIP;

GRANT SELECT ON TABLE PATIENT TO ROLE PATIENT;

GRANT SELECT, ALTER ON TABLE PATIENT TO USER ALEX;

GRANT ALTER, SELECT ON TABLE PATIENT TO USER PAUL;
GRANT INSERT ON TABLE ACCT_HISTORY TO USER PAUL;

--Insert patient data

INSERT INTO PATIENT
  VALUES('123-55-1234', 'MAX', 'Max', 'First Strt', 'hypertension', 89.70,'LEE');
INSERT INTO PATIENTCHOICE
  VALUES('123-55-1234', 'drug-research', 'opt-out');


INSERT INTO PATIENT
  VALUES('123-58-9812', 'MIKE', 'Mike', 'Long Strt', null, 8.30,'JAMES');
INSERT INTO PATIENTCHOICE
  VALUES('123-58-9812', 'drug-research', 'opt-out');


INSERT INTO PATIENT
  VALUES('123-11-9856', 'SAM', 'Sam', 'Big Strt', null, 0.00,'LEE');
INSERT INTO PATIENTCHOICE
  VALUES('123-11-9856', 'drug-research', 'opt-in');


INSERT INTO PATIENT
  VALUES('123-19-1454', 'DUG', 'Dug', 'Good Strt', null, 0.00,'JAMES');
INSERT INTO PATIENTCHOICE
  VALUES('123-19-1454', 'drug-research', 'opt-in');
```

Scenario: ExampleHMO using row and column access control - Security administration

Security administration and the security administrator (SECADM) role play important parts in securing patient and company data at ExampleHMO. At ExampleHMO, management decided that different people hold database administration authority and security administration authority.

The management team at ExampleHMO decides to create a role for administering access to their data. The team also decides that even users with DATAACCESS authority are not able to view protected health and personal data by default.

The management team selects Alex to be the sole security administrator for ExampleHMO. From now on, Alex controls all data access authority. With this authority, Alex defines security rules such as row permissions, column masks, and whether functions and triggers are secure or not. These rules control which users have access to any given data under his control.

After Peter, the database administrator, creates the required tables and sets up the required roles, duties are separated. The database administration and security administration duties are separated by making Alex the security administrator.

Peter connects to the database and grants Alex SECADM authority. Peter can grant SECADM authority since he currently holds the DBADM, DATAACCESS, and SECADM authorities.

```
-- To separate duties of security administrator from system administrator,
-- the SECADMN Peter grants SECADM authority to user Alex.

GRANT SECADM ON DATABASE TO USER ALEX;
```

Alex, after receiving the SECADM authority, connects to the database and revokes the security administrator privilege from Peter. The duties are now separated and Alex becomes the sole authority to grant data access to others within and outside ExampleHMO. The following SQL statement shows how Alex revoked SECADM authority from Peter:

```
--revokes the SECADMIN authority for Peter

REVOKE SECADM ON DATABASE FROM USER PETER;
```

Scenario: ExampleHMO using row and column access control - Row permissions

Alex, the security administrator, starts to restrict data access on the ExampleHMO database by using row permissions, a part of row and column access control. Row permissions filter the data returned to users by row.

Patients are permitted to view their own data. A physician is permitted to view the data of all his patients, but not the data of patients who see other physicians. Users belonging to the MEMBERSHIP, ACCOUNTING, or DRUG_RESEARCH roles can access all patient information. Alex, the security administrator, is asked to implement these permissions to restrict who can see any given row on a need-to-know basis.

Row permissions restrict or filter rows based on the user who has logged on to the database. At ExampleHMO, the row permissions create a horizontal data restriction on the table named PATIENT.

Alex implements the following row permissions so that a user in each role is restricted to view a result set that they are privileged to view:

```
CREATE PERMISSION ROW_ACCESS ON PATIENT
------------------------------------------------------
-- Accounting information:
-- ROLE PATIENT is allowed to access his or her own row
-- ROLE PCP is allowed to access his or her patients' rows
-- ROLE MEMBERSHIP, ACCOUNTING, and DRUG_RESEARCH are
-- allowed to access all rows
------------------------------------------------------------
FOR ROWS WHERE(VERIFY_ROLE_FOR_USER(SESSION_USER,'PATIENT') = 1
AND
PATIENT.USERID = SESSION_USER) OR
(VERIFY_ROLE_FOR_USER(SESSION_USER,'PCP') = 1
AND
PATIENT.PCP_ID = SESSION_USER) OR
    (VERIFY_ROLE_FOR_USER(SESSION_USER,'MEMBERSHIP') = 1 OR
    VERIFY_ROLE_FOR_USER(SESSION_USER,'ACCOUNTING') = 1 OR
    VERIFY_ROLE_FOR_USER(SESSION_USER, 'DRUG_RESEARCH') = 1)
ENFORCED FOR ALL ACCESS
ENABLE;
```

Alex observes that even after creating a row permission, all data can still be viewed by the other employees. A row permission is not applied until it is activated on the table for which it was defined. Alex must now activate the permission:

```
--Activate row access control to implement row permissions

ALTER TABLE PATIENT ACTIVATE ROW ACCESS CONTROL;
```

Scenario: ExampleHMO using row and column access control - Column masks

Alex, the security administrator, further restricts data access on the ExampleHMO database by using column masks, a part of row and column access control. Column masks hide data returned to users by column unless they are permitted to view the data.

Patient payment details must only be accessible to the users in the accounts department. The account balance must not be seen by any other database users. Alex is asked to prevent access by anyone other than users belonging to the ACCOUNTING role.

Alex implements the following column mask so that a user in each role is restricted to view a result set that they are privileged to view:

```
--Create a Column MASK ON ACCT_BALANCE column on the PATIENT table

CREATE MASK ACCT_BALANCE_MASK ON PATIENT FOR
-------------------------------------------------------------
-- Accounting information:
-- Role ACCOUNTING is allowed to access the full information
-- on column ACCT_BALANCE.
-- Other roles accessing this column will strictly view a
-- zero value.
-------------------------------------------------------------
COLUMN ACCT_BALANCE RETURN
    CASE WHEN VERIFY_ROLE_FOR_USER(SESSION_USER,'ACCOUNTING') = 1
            THEN ACCT_BALANCE
        ELSE 0.00
    END
ENABLE;
```

Alex observes that even after creating a column mask, the data can still be viewed by the other employees. A column mask is not applied until it is activated on the table for which it was defined. Alex must now activate the mask:

```
--Activate column access control to implement column masks

ALTER TABLE PATIENT ACTIVATE COLUMN ACCESS CONTROL;
```

Alex is asked by management to hide the insurance number of the patients. Only a patient, physician, accountant, or people in the MEMBERSHIP role can view the SSN column.

Also, to protect the PHARMACY detail of a patient, the information in the PHARMACY column must only be viewed by a drug researcher or a physician. Drug researchers can see the data only if the patient has agreed to disclose the information.

Alex implements the following column masks so that a user in each role is restricted to view a result set that they are privileged to view:

```
CREATE MASK SSN_MASK ON PATIENT FOR
-------------------------------------------------
-- Personal contact information:
-- Roles PATIENT, PCP, MEMBERSHIP, and ACCOUNTING are allowed
-- to access the full information on columns SSN, USERID, NAME,
-- and ADDRESS. Other roles accessing these columns will
-- strictly view a masked value.
-------------------------------------------------
COLUMN SSN RETURN
    CASE WHEN
        VERIFY_ROLE_FOR_USER(SESSION_USER,'PATIENT') = 1 OR
        VERIFY_ROLE_FOR_USER(SESSION_USER,'PCP') = 1 OR
        VERIFY_ROLE_FOR_USER(SESSION_USER,'MEMBERSHIP') = 1 OR
        VERIFY_ROLE_FOR_USER(SESSION_USER,'ACCOUNTING') = 1
    THEN SSN
        ELSE CHAR('XXX-XX-' || SUBSTR(SSN,8,4))    END
ENABLE;

CREATE MASK PHARMACY_MASK ON PATIENT FOR
-------------------------------------------------------
-- Medical information:
-- Role PCP is allowed to access the full information on
-- column PHARMACY.
```

```
-- For the purposes of drug research, Role DRUG_RESEARCH can
-- conditionally see a patient's medical information
-- provided that the patient has opted-in.
-- In all other cases, null values are rendered as column
-- values.
-------------------------------------------------
COLUMN PHARMACY RETURN
        CASE WHEN
        VERIFY_ROLE_FOR_USER(SESSION_USER,'PCP') = 1 OR
        (VERIFY_ROLE_FOR_USER(SESSION_USER,'DRUG_RESEARCH')=1
        AND
            EXISTS (SELECT 1 FROM PATIENTCHOICE C
    WHERE PATIENT.SSN = C.SSN AND C.CHOICE = 'drug-research' AND C.VALUE = 'opt-in'))
        THEN PHARMACY
        ELSE NULL
END
ENABLE;
```

Alex observes that after creating these two column masks that the data is only viewable to the intended users. The PATIENT table already had column access control activated.

Scenario: ExampleHMO using row and column access control - Data insertion

When a new patient is admitted for treatment in the hospital, the new patient record must be added to the ExampleHMO database.

Bob is a new patient, and his records must be added to the ExampleHMO database. A user with the required security authority must create the new record for Bob. Tom, from the ExampleHMO membership department, with the MEMBERSHIP role, enrolls Bob as a new member. After connecting to the ExampleHMO database, Tom runs the following SQL statements to add Bob to the ExampleHMO database:

```
INSERT INTO PATIENT
  VALUES('123-45-6789', 'BOB', 'Bob', '123 Some St.', 'hypertension', 9.00,'LEE');
INSERT INTO PATIENTCHOICE
  VALUES('123-45-6789', 'drug-research', 'opt-in');
```

Tom confirmed that Bob was added to the database by querying the same from the PATIENT table in the ExampleHMO database:

```
Select * FROM PATIENT WHERE NAME = 'Bob';

SSN         USERID    NAME    ADDRESS       PHARMACY     ACCT_BALANCE  PCP_ID

----------- --------- ------- ------------- ------------ ------------- ------
123-45-6789 BOB       Bob     123 Some St.  XXXXXXXXXX  0.00          LEE
```

Scenario: ExampleHMO using row and column access control - Data updates

While in the hospital, Bob gets his treatment changed. As a result his records in the ExampleHMO database need updating.

Dr. Lee, who is Bob's physician, advises a treatment change and changes Bob's medicine. Bob's record in the ExampleHMO systems must be updated. The row permission rules set in the ExampleHMO database specify that anyone who cannot view the data in a row cannot update the data in that row. Since Bob's PCPID contains Dr. Lee's ID, and the row permission is set, Dr. Lee can both view, and update Bob's record using the following example SQL statement:

```
UPDATE PATIENT SET PHARMACY = 'codeine' WHERE NAME = 'Bob';
```

Dr. Lee checks the update:

```
Select * FROM PATIENT WHERE NAME = 'Bob';

SSN         USERID    NAME    ADDRESS      PHARMACY    ACCT_BALANCE   PCP_ID
```

```
----------- --------- ------- ------------ ----------- -------------- ------
123-45-6789 BOB       Bob     123 Some St. codeine     0.00           LEE
```

Dug is a patient who is under the care of Dr. James, one of Dr. Lee's colleagues. Dr. Lee attempts the same update on the record for Dug:

```
UPDATE PATIENT SET PHARMACY = 'codeine' WHERE NAME = 'Dug';
SQL0100W  No row was found for FETCH, UPDATE or DELETE; or the result of a query
 is an empty table. SQLSTATE=02000
```

Since Dug's PCPID does not contain Dr. Lee's ID, and the row permission is set, Dr. Lee cannot view, or update Dug's record.

Scenario: ExampleHMO using row and column access control - Data queries

With row and column access control, people in different roles can have different result sets from the same database queries. For example, Peter, the database administrator with DATAACCESS authority, cannot see any data on the PATIENT table.

Peter, Bob, Dr. Lee, Tom, Jane, and John each connect to the database and try the following SQL query:

```
SELECT SSN, USERID, NAME, ADDRESS, PHARMACY, ACCT_BALANCE, PCP_ID FROM PATIENT;
```

Results of the query vary according to who runs the query. The row and column access control rules created by Alex are applied on these queries.

Here is the result set Peter sees:

```
SSN         USERID    NAME      ADDRESS     PHARMACY    ACC_BALANCE PCP_ID

----------- --------- --------- ----------- ----------- ----------- -----------

  0 record(s) selected.
```

Even though there is data in the table and Peter is the database administrator, he lacks the authority to see all data.

Here is the result set Bob sees:

```
SSN         USERID    NAME     ADDRESS     PHARMACY    ACC_BALANCE PCP_ID

----------- --------- --------- ----------- ----------- ----------- ------
123-45-6789 BOB       Bob      123 Some St.XXXXXXXXXX 0.00        LEE

1 record(s) selected.
```

Bob, being a patient, can only see his own data. Bob belongs to the PATIENT role. The PHARMACY and ACC_BALANCE column data have been hidden from him.

Here is the result set Dr. Lee sees:

```
SSN         USERID   NAME     ADDRESS     PHARMACY            ACC_BALANCE PCP_ID

----------- -------- -------- ----------- ------------------- ----------- ------
123-55-1234 MAX      Max      First Strt  hypertension        0.00        LEE
123-11-9856 SAM      Sam      Big Strt    High blood pressure 0.00        LEE
123-45-6789 BOB      Bob      123 Some St.codeine             0.00        LEE

3 record(s) selected.
```

Dr. Lee can see only the data for patients under his care. Dr. Lee belongs to the PCP role. The ACC_BALANCE column data is hidden from him.

Here is the result set Tom sees:

```
SSN         USERID   NAME     ADDRESS     PHARMACY    ACC_BALANCE PCP_ID

----------- -------- -------- ----------- ----------- ----------- -----------
123-55-1234 MAX      Max      First Strt  XXXXXXXXXX 0.00        LEE
```

```
123-58-9812 MIKE     Mike     Long Strt   XXXXXXXXXX 0.00        JAMES
123-11-9856 SAM      Sam      Big Strt    XXXXXXXXXX 0.00        LEE
123-19-1454 DUG      Dug      Good Strt   XXXXXXXXXX 0.00        JAMES
123-45-6789 BOB      Bob      123 Some St.XXXXXXXXXX 0.00        LEE

5 record(s) selected.
```

Tom can see all members. Tom belongs to the membership role. He is not privileged to see any data in the PHARMACY and ACC_BALANCE columns.

Here is the result set Jane sees:

```
SSN         USERID   NAME     ADDRESS     PHARMACY            ACC_BALANCE PCP_ID

----------- -------- -------- ----------- ------------------- ----------- -------
XXX-XX-1234 MAX      Max      First Strt  XXXXXXXXXX          0.00        LEE
XXX-XX-9812 MIKE     Mike     Long Strt   XXXXXXXXXX          0.00        JAMES
XXX-XX-9856 SAM      Sam      Big Strt    High blood pressure 0.00        LEE
XXX-XX-1454 DUG      Dug      Good Strt   Influenza           0.00        JAMES
XXX-XX-6789 BOB      Bob      123 Some St.codeine             0.00        LEE

5 record(s) selected.
```

Jane can see all members. She belongs to the DRUG_RESEARCH role. The SSN and ACC_BALANCE column data are hidden from her. The PHARMACY data is only available if the patients have opted-in to share their data with drug research companies.

Here is the result set John sees:

```
SSN         USERID   NAME     ADDRESS     PHARMACY    ACC_BALANCE PCP_ID

----------- -------- -------- ----------- ----------- ----------- --------
123-55-1234 MAX      Max      First Strt  XXXXXXXXXX 89.70       LEE
123-58-9812 MIKE     Mike     Long Strt   XXXXXXXXXX 8.30        JAMES
123-11-9856 SAM      Sam      Big Strt    XXXXXXXXXX 0.00        LEE
123-19-1454 DUG      Dug      Good Strt   XXXXXXXXXX 0.00        JAMES
123-45-6789 BOB      Bob      123 Some St.XXXXXXXXXX 9.00        LEE

5 record(s) selected.
```

John can see all members. He belongs to the ACCOUNTING role. The PHARMACY column data is hidden from him.

Scenario: ExampleHMO using row and column access control - View creation

Views can be created on tables that have row and column access control defined. Alex, the security administrator, is asked to create a view on the PATIENT table that medical researchers can use.

Researchers, that have a partnership with ExampleHMO, can have access to limited patient data if patients have opted-in to permit this access. Alex and the IT team are asked to create a view to list only specific information related to research of the patient. The report must contain the patient insurance number, name of the patient and the disclosure option chosen by the patient.

The view created fetches the patient basic information and the health condition disclosure option. This view ensures that patient information is protected and fetched only with their permission for any other purpose.

Alex and the IT team implement the following view:

```
CREATE VIEW PATIENT_INFO_VIEW AS
SELECT P.SSN, P.NAME FROM PATIENT P, PATIENTCHOICE C
WHERE P.SSN = C.SSN AND
      C.CHOICE = 'drug-research' AND
      C.VALUE = 'opt-in';
```

After Alex and his team create the view, users can query the view. They see data according to the row and column access control rules defined on the base tables on which the view is created.

Alex sees the following result-set from the following query on the view:

```
SELECT SSN, NAME FROM PATIENT_INFO_VIEW;

SSN         NAME
----------- ----------

  0 record(s) selected.
```

Dr. Lee sees the following result-set from the following query on the view:

```
SELECT SSN, NAME FROM PATIENT_INFO_VIEW;

SSN         NAME
----------- ----------
123-11-9856 Sam
123-45-6789 Bob

  2 record(s) selected.
```

Bob sees the following result-set from the following query on the view:

```
SELECT SSN, NAME FROM PATIENT_INFO_VIEW;

SSN         NAME
----------- ----------
123-45-6789 Bob

  1 record(s) selected.
```

Scenario: ExampleHMO using row and column access control - Secure functions

Functions must be deemed secure before they can be called within row and column access control definitions. Alex, the security administrator, discusses how Paul, a database developer at ExampleHMO, can create a secure function for his new accounting application.

After the privacy and security policy went into effect at ExampleHMO, Alex is notified that the accounting department has developed a powerful accounting application. ExampleHMOAccountingUDF is a SQL scalar user-defined function (UDF) that is used in the column mask ACCT_BALANCE_MASK on the PATIENT.ACCT_BALANCE table and row.

Only UDFs that are secure can be invoked within a column mask. Alex first discusses the UDF with Paul, who wrote the UDF, to ensure the operation inside the UDF is secure.

When Alex is satisfied that the function is secure, he grants a system privilege to Paul so Paul can alter the UDF to be secure:

```
GRANT CREATE_SECURE_OBJECT ON DATABASE TO USER PAUL;
```

To create a secured UDF, or alter a UDF to be secured, a developer must be granted CREATE_SECURE_OBJECT authority.

Paul creates the function:

```
CREATE FUNCTION EXAMPLEHMOACCOUNTINGUDF(X DECIMAL(12,2))
       RETURNS DECIMAL(12,2)
       LANGUAGE SQL
       CONTAINS SQL
       DETERMINISTIC
       NO EXTERNAL ACTION
       RETURN X*(1.0 + RAND(X));
```

Paul alters the function so it is secured:

```
ALTER FUNCTION EXAMPLEHMOACCOUNTINGUDF SECURED;
```

Alex now drops and recreates the mask ACC_BALANCE_MASK so the new UDF is used:

```
--Drop the mask to recreate

DROP MASK ACCT_BALANCE_MASK;



CREATE MASK EXAMPLEHMO.ACCT_BALANCE_MASK ONPATIENT FOR
-------------------------------------------------------------
-- Accounting information:
-- Role ACCOUNTING is allowed to invoke the secured UDF
-- ExampleHMOAccountingUDFL passing column ACCT_BALANCE as
-- the input argument
-- Other ROLEs accessing this column will strictly view a
-- zero value.
-------------------------------------------------------------
COLUMN ACCT_BALANCE RETURN
CASE WHEN VERIFY_ROLE_FOR_USER(SESSION_USER,'ACCOUNTING') = 1
THEN EXAMPLEHMOACCOUNTINGUDF(ACCT_BALANCE)
ELSE 0.00
END
ENABLE;
```

Dr. Lee, who has the PCP role, must call a drug analysis user-defined function. DrugUDF returns patient drug information. In the past, Dr. Lee issues a SELECT statement that calls DrugUDF and receives the result set quickly. After the PATIENT table has been protected with row and column access control, the same query takes more time to return a result set.

Dr. Lee consults with the ExampleHMO IT staff and Alex, the security administrator, about this performance degradation. Alex tells Dr. Lee, if the UDF is not secure, the query cannot be optimized as well and it takes longer to return a result set.

Alex looks into the UDF with Dr. Lee and the owner, Paul, to ensure the operation inside the UDF is secure. Alex asks Paul to alter the UDF to be secure as Paul still has the CREATE_SECURE_OBJECT privilege granted by Alex:

```
--Function for ExampleHMO Pharmacy department

CREATE FUNCTION DRUGUDF(PHARMACY VARCHAR(5000))
      RETURNS VARCHAR(5000)
      NO EXTERNAL ACTION
      BEGIN ATOMIC
          IF PHARMACY IS NULL THEN
                RETURN NULL;
              ELSE
                RETURN 'Normal';
              END IF;
      END;

--Secure the UDF

ALTER FUNCTION DRUGUDF SECURED;

--Grant execute permissions to Dr.Lee

GRANT EXECUTE ON FUNCTION DRUGUDF TO USER LEE;
```

Dr. Lee can issue the query and the query can be optimized as expected:

```
--Querying after the function is secured

SELECT PHARMACY FROM PATIENT
      WHERE DRUGUDF(PHARMACY) = 'Normal' AND SSN = '123-45-6789';

PHARMACY
--------
codeine

  1 record(s) selected.
```

Scenario: ExampleHMO using row and column access control - Secure triggers

Triggers defined on a table with row or column access control activated must be secure. Alex, the security administrator, discusses how Paul, a database developer at ExampleHMO, can create a secure trigger for his new accounting application.

Alex speaks to the accounting department and learns that an AFTER UPDATE trigger is needed for the PATIENT table. This trigger monitors the history of the ACCT_BALANCE column.

Alex explains to Paul, who has the necessary privileges to create the trigger, that any trigger defined on a row and column access protected table must be marked secure. Paul and Alex review the action of the new trigger and deem it to be secure.

ExampleHMO_ACCT_BALANCE_TRIGGER monitors the ACCT_BALANCE column in the PATIENT table. Every time that column is updated, the trigger is fired, and inserts the current account balance details into the ACCT_HISTORY table.

Paul creates the trigger:

```
CREATE TRIGGER HOSPITAL.NETHMO_ACCT_BALANCE_TRIGGER
  AFTER UPDATE OF ACCT_BALANCE ON PATIENT
  REFERENCING OLD AS O NEW AS N
  FOR EACH ROW MODE DB2SQL SECURED
  BEGIN  ATOMIC
  INSERT INTO ACCT_HISTORY
  (SSN, BEFORE_BALANCE, AFTER_BALANCE, WHEN, BY_WHO)
  VALUES(O.SSN, O.ACCT_BALANCE, N.ACCT_BALANCE,
  CURRENT TIMESTAMP, SESSION_USER);
END;
```

John, from the accounting department, must update the account balance for the patient Bob whose SSN is '123-45-6789'.

John looks at the data for Bob before running the update:

```
SELECT ACCT_BALANCE FROM PATIENT WHERE SSN = '123-45-6789';

ACCT_BALANCE
--------------
9.00

  1 record(s) selected.

SELECT * FROM ACCT_HISTORY WHERE SSN = '123-45-6789';

SSN         BEFORE_BALANCE AFTER_BALANCE  WHEN       BY_WHO
----------- -------------- -------------- ---------- --------------------

  0 record(s) selected.
```

John then runs the update:

```
UPDATE PATIENT SET ACCT_BALANCE = ACCT_BALANCE * 0.9 WHERE SSN = '123-45-6789';
```

Since there is a trigger defined on the PATIENT table, the update fires the trigger. Since the trigger is defined SECURED, the update completes successfully. John looks at the data for Bob after running the update:

```
SELECT ACCT_BALANCE FROM PATIENT WHERE SSN = '123-45-6789';

ACCT_BALANCE
--------------
8.10

  1 record(s) selected.

SELECT * FROM ACCT_HISTORY WHERE SSN = '123-45-6789';

SSN         BEFORE_BALANCE AFTER_BALANCE  WHEN       BY_WHO
----------- -------------- -------------- ---------- --------------------
```

```
123-45-6789 9.00          8.10          2010-10-10 JOHN
  1 record(s) selected.
```

Scenario: ExampleHMO using row and column access control - Revoke authority

Alex, as security administrator, is responsible for controlling who can create secure objects. When developers are done creating secure objects, Alex revokes their authority on the database.

Paul, the database developer, is done with development activities. Alex immediately revokes the create authority from Paul:

```
REVOKE CREATE_SECURE_OBJECT ON DATABASE FROM USER PAUL;
```

If Paul must create secure objects in the future, he must speak to Alex to have the create authority granted again.

Scenario: ExampleBANK using row and column access control

This scenario presents ExampleBANK, a banking institution with a large customer base spanning many branches, as a user of row and column access control. ExampleBANK uses row and column access control to ensure that their database policies reflect company requirements for privacy and security, as well as management business objectives.

Organizations that handle client investments, savings, and their personal information, like ExampleBANK, only share information within their organization on a must know basis. This data protection ensures that any sensitive client financial or personal information is shared, viewed, and modified only by employees who are privileged to do so.

Scenario: ExampleBANK using row and column access control - Security policies

ExampleBANK implements a security strategy where data access to databases is made available according to certain security policies.

The security policies conform to privacy and data protection regulations at ExampleBANK. The first column outlines the policies and the challenges faced by ExampleBANK, the second column outlines the row and column access control (RCAC) feature which addresses the challenge.

Security challenge	**Row and column access control feature which addresses the security challenge**
Limiting row access to only authorized users. Tellers are only permitted to view client data that belong to their own branch, not all clients of ExampleBANK in the company-wide system.	Row permissions can be implemented to control which user can view any particular row.
The account number is accessible by customer service representatives only when they are using the account update application. This application is identified through stored procedure ACCOUNTS.ACCTUPDATE.	Column masks can be used to filter or hide sensitive data from customer service representatives if they query the data outside of the ACCOUNTS.ACCTUPDATE application.

Scenario: ExampleBANK using row and column access control - Database users and roles

In this scenario, a number of different people use ExampleBANK data. These people have different user rights.

ExampleBANK implemented their security strategy to classify the way data is accessed from the database. Internal access to data is based on the separation of duties to users who access the data and their data access privileges. ExampleBANK created the following database roles to separate these duties:

TELLER
For tellers of branch locations.

TELEMARKERTER
For telephone marketing and sales people.

CSR
For customer service representatives.

The following people use ExampleBANK data:

ZURBIE
A customer service representative at ExampleBANK. She belongs to the CSR role.

NEWTON
A teller at an ExampleBANK branch. He belongs to the TELLER role.

PLATO
A telephone marketing and sales person at ExampleBANK. He belongs to the TELEMARKETER role.

If you want to try any of the example SQL statements and commands presented in this scenario, create these user IDs with their listed authorities.

The following example SQL statements assume that the users have been created on the system. The SQL statements create each role and grant SELECT permission to the various tables in the ExampleBANK database to the users:

```
--Creating roles and granting authority

CREATE ROLE TELLER;

CREATE ROLE CSR;

CREATE ROLE TELEMARKERTER;

GRANT ROLE TELLER TO USER NEWTON;
GRANT ROLE CSR TO USER ZURBIE;
GRANT ROLE TELEMARKERTER TO USER PLATO;
```

Scenario: ExampleBANK using row and column access control - Database tables

This scenario focuses on two tables in the ExampleBANK database: the CUSTOMER table and the INTERNAL_INFO table.

The INTERNAL_INFO table stores information about employees who work for ExampleBANK. This scenario considers the following columns within the INTERNAL_INFO table:

HOME_BRANCH
The employee home branch ID.

EMP_ID
The employee ID.

The CUSTOMER table stores individual client information:

ACCOUNT
The client account number.

NAME
The client name.

INCOME
The client income.

BRANCH
The client branch ID.

The following example SQL statements create the customer, and INTERNAL_INFO tables. Authority is granted on the tables and data is inserted:

```
--Client table storing information regarding client information
CREATE TABLE RCACTSPM.CUSTOMER (
   ACCOUNT VARCHAR(19),
   NAME VARCHAR(20),
   INCOME INTEGER,
   BRANCH CHAR(1)
);

--Internal_info table which stores employee information

CREATE TABLE RCACTSPM.INTERNAL_INFO (
   HOME_BRANCH CHAR(1),
   EMP_ID VARCHAR(10));

--Grant authority

GRANT SELECT ON RCACTSPM.CUSTOMER TO USER NEWTON, USER ZURBIE, USER PLATO;

--Insert data

INSERT INTO RCACTSPM.CUSTOMER VALUES ('1111-2222-3333-4444', 'Alice', 22000, 'A');
INSERT INTO RCACTSPM.CUSTOMER VALUES ('2222-3333-4444-5555', 'Bob', 71000, 'A');
INSERT INTO RCACTSPM.CUSTOMER VALUES ('3333-4444-5555-6666', 'Carl', 123000, 'B');
INSERT INTO RCACTSPM.CUSTOMER VALUES ('4444-5555-6666-7777', 'David', 172000, 'C');

INSERT INTO RCACTSPM.INTERNAL_INFO VALUES ('A', 'NEWTON');
INSERT INTO RCACTSPM.INTERNAL_INFO VALUES ('B', 'ZURBIE');
INSERT INTO RCACTSPM.INTERNAL_INFO VALUES ('C', 'PLATO');
```

Scenario: ExampleBANK using row and column access control - Row permissions

The security administrator at ExampleBANK, starts to restrict data access by using row permissions, a part of row and column access control. Row permissions filter the data returned to users by row.

Tellers are permitted to view client data only from their home branch. Telemarketers and CSRs are permitted to see all ExampleBANK clients in the system, but telemarketers cannot see the full account number.

Row permissions restrict or filter rows based on the user who has logged on to the database. At ExampleBANK, the row permissions create a horizontal data restriction on the CUSTOMER table.

The security administrator implements the following row permissions so that a user in each role is restricted to view a result set that they are privileged to view:

```
CREATE PERMISSION TELLER_ROW_ACCESS ON RCACTSPM.CUSTOMER
-------------------------------------------------------
-- Teller information:
-- ROLE TELLER is allowed to access client data only
-- in their branch.
-------------------------------------------------------------
FOR ROWS WHERE VERIFY_ROLE_FOR_USER(USER, 'TELLER') = 1
AND
BRANCH = (SELECT HOME_BRANCH FROM RCACTSPM.INTERNAL_INFO WHERE EMP_ID = USER)
ENFORCED FOR ALL ACCESS
ENABLE;

CREATE PERMISSION CSR_ROW_ACCESS ON RCACTSPM.CUSTOMER
```

```
-------------------------------------------------------
-- CSR and telemarketer information:
-- ROLE TELEMARKETER and CSR are allowed to access all client
-- data rows in ExampleBANK.
-------------------------------------------------------------
FOR ROWS WHERE VERIFY_ROLE_FOR_USER (USER, 'CSR') = 1
OR
VERIFY_ROLE_FOR_USER (USER, 'TELEMARKETER') = 1
ENFORCED FOR ALL ACCESS
ENABLE;
```

The security administrator observes that even after creating a row permission, all data can still be viewed by the employees. A row permission is not applied until it is activated on the table for which it was defined. The security administrator must now activate the permission:

```
--Activate row access control to implement row permissions

ALTER TABLE RCACTSPM.CUSTOMER ACTIVATE ROW ACCESS CONTROL;
```

Scenario: ExampleBANK using row and column access control - Column masks

The ExampleBANK security administrator, further restricts data access by using column masks, a part of row and column access control. Column masks hide data returned to users or applications by column unless they are permitted to view the data.

Customer service representatives can see all clients in the ExampleBANK system, but, they are not permitted to view full account numbers unless they are using a specific application.

The security administrator implements the following column mask so that a customer service representative is restricted to view a result set that they are privileged to view:

```
CREATE MASK ACCOUNT_COL_MASK ON RCACTSPM.CUSTOMER FOR
-------------------------------------------------------------
-- Account number information:
-- Role customer service representative (CSR) is allowed to
-- access account number information only when they are using
-- the account update application. This application is
-- identified through stored procedure ACCOUNTS.ACCTUPDATE.
-- If a CSR queries this data outside of this application, the
-- account information is masked and the first 12 digits are
-- replaced with "x".
-------------------------------------------------------------
COLUMN ACCOUNT RETURN
  CASE WHEN (VERIFY_ROLE_FOR_USER (USER, 'CSR') = 1 AND
             ROUTINE_SPECIFIC_NAME = 'ACCTUPDATE' AND
             ROUTINE_SCHEMA = 'ACCOUNTS' AND
             ROUTINE_TYPE = 'P')
       THEN ACCOUNT
       ELSE 'xxxx-xxxx-xxxx-' || SUBSTR(ACCOUNT,16,4)
  END
ENABLE;
```

The security administrator observes that even after creating a column mask, the data can still be viewed by all employees. A column mask is not applied until it is activated on the table for which it was defined. The security administrator must now activate the mask:

```
--Activate column access control to implement column masks

ALTER TABLE RCACTSPM.CUSTOMER ACTIVATE COLUMN ACCESS CONTROL;
```

Scenario: ExampleBANK using row and column access control - Data queries

With row and column access control, people in different roles can have different result sets from the same database queries. For example, Newton, a teller, cannot see any data of clients outside of their branch.

Newton, Zurbie, and Plato each connect to the database and try the following SQL query:

```
SELECT * FROM RCACTSPM.CUSTOMER;
```

Results of the query vary according to who runs the query. The row and column access control rules created by the security administrator are applied on these queries.

Here is the result set Newton sees:

```
ACCOUNT             NAME                 INCOME      BRANCH
------------------- -------------------- ----------- ------
xxxx-xxxx-xxxx-4444 Alice                      22000 A
xxxx-xxxx-xxxx-5555 Bob                        71000 A

  2 record(s) selected.
```

Newton, being a teller at branch A, can see only ExampleBANK clients that belong to that branch.

Here is the result set Zurbie sees:

```
ACCOUNT             NAME                 INCOME      BRANCH
------------------- -------------------- ----------- ------
xxxx-xxxx-xxxx-4444 Alice                      22000 A
xxxx-xxxx-xxxx-5555 Bob                        71000 A
xxxx-xxxx-xxxx-6666 Carl                      123000 B
xxxx-xxxx-xxxx-7777 David                     172000 C

  4 record(s) selected.
```

Zurbie, being a customer service representative, can see all ExampleBANK clients in the system, but not their full account number unless he uses the ACCOUNTS.ACCTUPDATE application. Since this query was issued outside of ACCOUNTS.ACCTUPDATE, part of that number is masked.

Here is the result set Plato sees:

```
ACCOUNT             NAME                 INCOME      BRANCH
------------------- -------------------- ----------- ------
xxxx-xxxx-xxxx-4444 Alice                      22000 A
xxxx-xxxx-xxxx-5555 Bob                        71000 A
xxxx-xxxx-xxxx-6666 Carl                      123000 B
xxxx-xxxx-xxxx-7777 David                     172000 C

  4 record(s) selected.
```

Plato, being a telemarketer, can see all ExampleBANK clients in the system.

Chapter 5. Label-based access control (LBAC)

Label-based access control (LBAC) greatly increases the control you have over who can access your data. LBAC lets you decide exactly who has write access and who has read access to individual rows and individual columns.

What LBAC does

The LBAC capability is very configurable and can be tailored to match your particular security environment. All LBAC configuration is performed by a *security administrator*, which is a user that has been granted the SECADM authority.

A security administrator configures the LBAC system by creating security label components. A *security label component* is a database object that represents a criterion you want to use to determine if a user should access a piece of data. For example, the criterion can be whether the user is in a certain department, or whether they are working on a certain project. A *security policy* describes the criteria that will be used to decide who has access to what data. A security policy contains one or more security label components. Only one security policy can be used to protect any one table but different tables can be protected by different security policies.

After creating a security policy, a security administrator creates objects, called *security labels* that are part of that policy. Security labels contain security label components. Exactly what makes up a security label is determined by the security policy and can be configured to represent the criteria that your organization uses to decide who should have access to particular data items. If you decide, for example, that you want to look at a person's position in the company and what projects they are part of to decide what data they should see, then you can configure your security labels so that each label can include that information. LBAC is flexible enough to let you set up anything from very complicated criteria, to a very simple system where each label represents either a "high" or a "low" level of trust.

Once created, a security label can be associated with individual columns and rows in a table to protect the data held there. Data that is protected by a security label is called *protected data*. A security administrator allows users access to protected data by granting them security labels. When a user tries to access protected data, that user's security label is compared to the security label protecting the data. The protecting label will block some security labels and not block others.

A user, a role, or a group is allowed to hold security labels for multiple security policies at once. For any given security policy, however, a use, a role, or a group can hold at most one label for read access and one label for write access.

A security administrator can also grant exemptions to users. An *exemption* allows you to access protected data that your security labels might otherwise prevent you from accessing. Together your security labels and exemptions are called your *LBAC credentials*.

If you try to access a protected column that your LBAC credentials do not allow you to access then the access will fail and you will get an error message.

If you try to read protected rows that your LBAC credentials do not allow you to read then Db2 acts as if those rows do not exist. Those rows cannot be selected as part of any SQL statement that you run, including SELECT, UPDATE, or DELETE. Even the aggregate functions ignore rows that your LBAC credentials do not allow you to read. The COUNT(*) function, for example, will return a count only of the rows that you have read access to.

Views and LBAC

You can define a view on a protected table the same way you can define one on a non-protected table. When such a view is accessed the LBAC protection on the underlying table is enforced. The LBAC credentials used are those of the session authorization ID. Two users accessing the same view might see different rows depending on their LBAC credentials.

Referential integrity constraints and LBAC

The following rules explain how LBAC rules are enforced in the presence of referential integrity constraints:

- **Rule 1**: The LBAC read access rules are NOT applied for internally generated scans of child tables. This is to avoid having orphan children.
- **Rule 2**: The LBAC read access rules are NOT applied for internally generated scans of parent tables
- **Rule 3**: The LBAC write rules are applied when a CASCADE operation is performed on child tables. For example, If a user deletes a parent, but cannot delete any of the children because of an LBAC write rule violation, then the delete should be rolled-back and an error raised.

Storage overhead when using LBAC

When you use LBAC to protect a table at the row level, the additional storage cost is the cost of the row security label column. This cost depends on the type of security label chosen. For example, if you create a security policy with two components to protect a table, a security label from that security policy will occupy 16 bytes (8 bytes for each component). Because the row security label column is treated as a not nullable VARCHAR column, the total cost in this case would be 20 bytes per row. In general, the total cost per row is (*N**8 + 4) bytes where *N* is the number of components in the security policy protecting the table.

When you use LBAC to protect a table at the column level, the column security label is meta-data (that is, it is stored together with the column's meta-data in the SYSCOLUMNS catalog table). This meta-data is simply the ID of the security label protecting the column. The user table does not incur any storage overhead in this case.

What LBAC does not do

- LBAC will never allow access to data that is forbidden by discretionary access control.

  Example: If you do not have permission to read from a table then you will not be allowed to read data from that table--even the rows and columns to which LBAC would otherwise allow you access.
- Your LBAC credentials only limit your access to protected data. They have no effect on your access to unprotected data.
- LBAC credentials are not checked when you drop a table or a database, even if the table or database contains protected data.
- LBAC credentials are not checked when you back up your data. If you can run a backup on a table, which rows are backed up is not limited in any way by the LBAC protection on the data. Also, data on the backup media is not protected by LBAC. Only data in the database is protected.
- LBAC cannot be used to protect any of the following types of tables:
  - A staging table
  - A table that a staging table depends on
  - A typed table
- LBAC protection cannot be applied to a nickname.

LBAC security policies

The security administrator uses a security policy to define criteria that determine who has write access and who has read access to individual rows and individual columns of tables.

A security policy includes this information:

- What security label components are used in the security labels that are part of the policy
- What rules are used when comparing those security label components
- Which of certain optional behaviors are used when accessing data protected by the policy

- What additional security labels and exemptions are to be considered when enforcing access to data protected by the security policy. For example, the option to consider or not to consider security labels granted to roles and groups is controlled through the security policy.

Every protected table must have one and only one security policy associated with it. Rows and columns in that table can only be protected with security labels that are part of that security policy and all access of protected data follows the rules of that policy. You can have multiple security policies in a single database but you cannot have more than one security policy protecting any given table.

Creating a security policy

You must be a security administrator to create a security policy. You create a security policy with the SQL statement CREATE SECURITY POLICY. The security label components listed in a security policy must be created before the CREATE SECURITY POLICY statement is executed. The order in which the components are listed when a security policy is created does not indicate any sort of precedence or other relationship among the components but it is important to know the order when creating security labels with built-in functions like SECLABEL.

From the security policy you have created, you can create security labels to protect your data.

Altering a security policy

A security administrator can use the ALTER SECURITY POLICY statement to modify a security policy.

Dropping a security policy

You must be a security administrator to drop a security policy. You drop a security policy using the SQL statement DROP.

You cannot drop a security policy if it is associated with (added to) any table.

LBAC security label components overview

A *security label component* is a database object that is part of label-based access control (LBAC). You use security label components to model your organization's security structure.

A security label component can represent any criteria that you might use to decide if a user should have access to a given piece of data. Typical examples of such criteria include:

- How well trusted the user is
- What department the user is in
- Whether the user is involved in a particular project

Example: If you want the department that a user is in to affect which data they can access, you could create a component named dept and define elements for that component that name the various departments in your company. You would then include the component dept in your security policy.

An *element* of a security label component is one particular "setting" that is allowed for that component.

Example: A security label component that represents a level of trust might have the four elements: Top Secret, Secret, Classified, and Unclassified.

Creating a security label component

You must be a security administrator to create a security label component. You create security label components with the SQL statement CREATE SECURITY LABEL COMPONENT.

When you create a security label component you must provide:

- A name for the component
- What type of component it is (ARRAY, TREE, or SET)

- A complete list of allowed elements
- For types ARRAY and TREE you must describe how each element fits into the structure of the component

After creating your security label components, you can create a security policy based on these components. From this security policy, you can create security labels to protect your data.

Types of components

There are three types of security label components:

- TREE: Each element represents a node in a tree structure
- ARRAY: Each element represents a point on a linear scale
- SET: Each element represents one member of a set

The types are used to model the different ways in which elements can relate to each other. For example, if you are creating a component to describe one or more departments in a company you would probably want to use a component type of TREE because most business structures are in the form of a tree. If you are creating a component to represent the level of trust that a person has, you would probably use a component of type ARRAY because for any two levels of trust, one will always be higher than the other.

The details of each type, including detailed descriptions of the relationships that the elements can have with each other, are described in their own section.

Altering security label components

The security administrator can use the ALTER SECURITY LABEL COMPONENT statement to modify a security label component.

Dropping a security label component

You must be a security administrator to drop a security label component. You drop a security label component with the SQL statement DROP.

LBAC security label component type: SET

SET is one type of security label component that can be used in a label-based access control (LBAC) security policy.

Components of type SET are unordered lists of elements. The only comparison that can be made for elements of this type of component is whether or not a given element is in the list.

LBAC security label component type: ARRAY

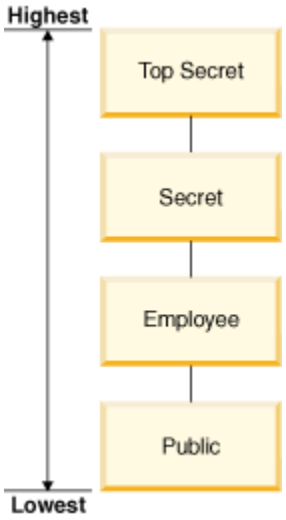
ARRAY is one type of security label component.

In the ARRAY type of component the order in which the elements are listed when the component is created defines a scale with the first element listed being the highest value and the last being the lowest.

Example: If the component mycomp is defined in this way:

```
CREATE SECURITY LABEL COMPONENT mycomp
  ARRAY [ 'Top Secret', 'Secret', 'Employee', 'Public' ]
```

Then the elements are treated as if they are organized in a structure like this:



In a component of type ARRAY, the elements can have these sorts of relationships to each other:

Higher than
Element A is higher than element B if element A is listed earlier in the ARRAY clause than element B.

Lower than
Element A is lower than element B if element A is listed later in the ARRAY clause than element B

LBAC security label component type: TREE

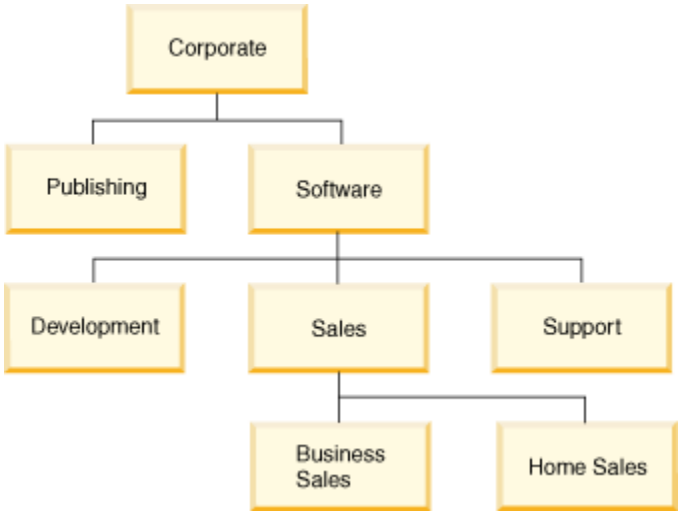
TREE is one type of security label component that can be used in a label-based access control (LBAC) security policy.

In the TREE type of component the elements are treated as if they are arranged in a tree structure. When you specify an element that is part of a component of type TREE you must also specify which other element it is under. The one exception is the first element which must be specified as being the ROOT of the tree. This allows you to organize the elements in a tree structure.

Example: If the component mycomp is defined this way:

```
CREATE SECURITY LABEL COMPONENT mycomp
TREE (
    'Corporate'      ROOT,
    'Publishing'     UNDER 'Corporate',
    'Software'       UNDER 'Corporate',
    'Development'    UNDER 'Software',
    'Sales'          UNDER 'Software',
    'Support'        UNDER 'Software'
    'Business Sales' UNDER 'Sales'
    'Home Sales'     UNDER 'Sales'
)
```

Then the elements are treated as if they are organized in a tree structure like this:

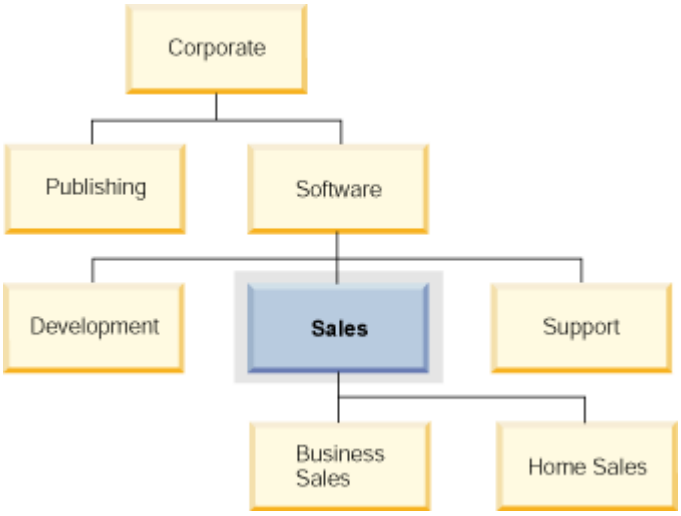


In a component of type TREE, the elements can have these types of relationships to each other:

Parent

Element A is a parent of element B if element B is UNDER element A.

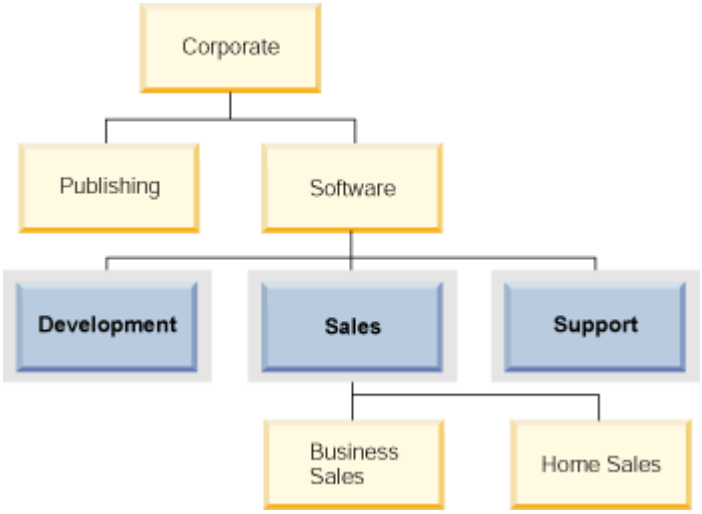
Example: This diagram shows the parent of the Business Sales element:



Child

Element A is a child of element B if element A is UNDER element B.

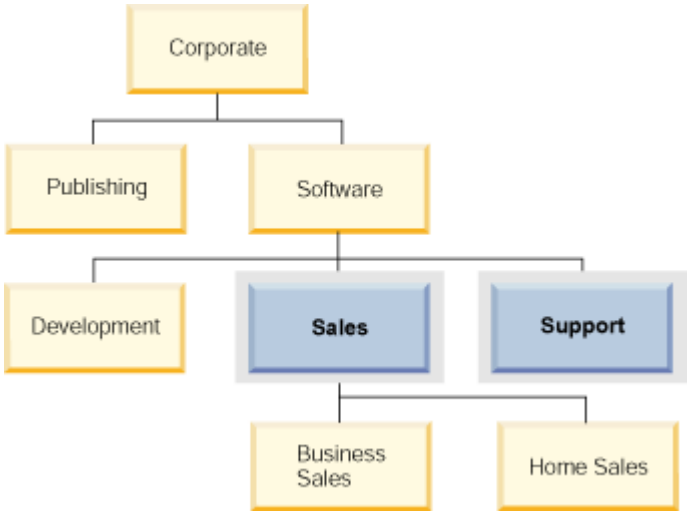
Example: This diagram shows the children of the Software element:



Sibling

Two elements are siblings of each other if they have the same parent.

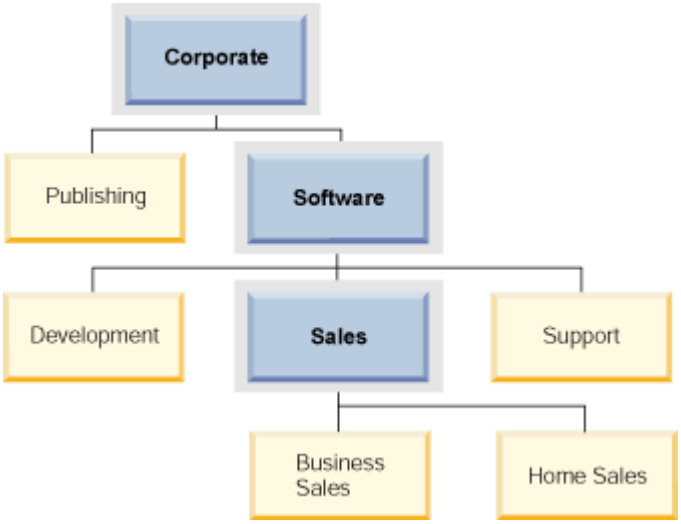
Example: This diagram shows the siblings of the Development element:



Ancestor

Element A is an ancestor of element B if it is the parent of B, or if it is the parent of the parent of B, and so on. The root element is an ancestor of all other elements in the tree.

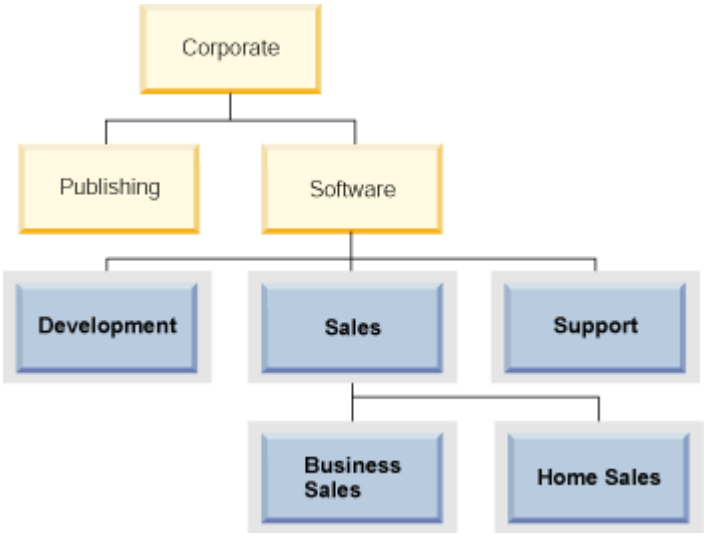
Example: This diagram shows the ancestors of the Home Sales element:



Descendent

Element A is a descendent of element B if it is the child of B, or if it is the child of a child of B, and so on.

Example: This diagram shows the descendents of the Software element:



LBAC security labels

In label-based access control (LBAC) a *security label* is a database object that describes a certain set of security criteria. Security labels are applied to data in order to protect the data. They are granted to users to allow them to access protected data.

When a user tries to access protected data, their security label is compared to the security label that is protecting the data. The protecting security label will block some security labels and not block others. If a user's security label is blocked then the user cannot access the data.

Every security label is part of exactly one security policy and includes one value for each component in that security policy. A *value* in the context of a security label component is a list of zero or more of the elements allowed by that component. Values for ARRAY type components can contain zero or one element, values for other types can have zero or more elements. A value that does not include any elements is called an *empty value*.

Example: If a TREE type component has the three elements Human Resources, Sales, and Shipping then these are some of the valid values for that component:

- Human Resources (or any of the elements by itself)
- Human Resources, Shipping (or any other combination of the elements as long as no element is included more than once)
- *An empty value*

Whether a particular security label will block another is determined by the values of each component in the labels and the LBAC rule set that is specified in the security policy of the table. The details of how the comparison is made are given in the topic that discusses how LBAC security labels are compared.

When security labels are converted to a text string they use the format described in the topic that discusses the format for security label values.

Creating security labels

You must be a security administrator to create a security label. You create a security label with the SQL statement CREATE SECURITY LABEL. When you create a security label you provide:

- A name for the label
- The security policy that the label is part of
- Values for one or more of the components included in the security policy

Any components for which a value is not specified is assumed to have an empty value. A security label must have at least one non-empty value.

Altering security labels

Security labels cannot be altered. The only way to change a security label is to drop it and re-create it. However, the *components* of a security label can be modified by a security administrator (using the ALTER SECURITY LABEL COMPONENT statement).

Dropping security labels

You must be a security administrator to drop a security label. You drop a security label with the SQL statement DROP. You cannot drop a security label that is being used to protect data anywhere in the database or that is currently held by one or more users.

Granting security labels

You must be a security administrator to grant a security label to a user, a group, or a role. You grant a security label with the SQL statement GRANT SECURITY LABEL. When you grant a security label you can grant it for read access, for write access, or for both read and write access. A user, a group, or a role cannot hold more than one security label from the same security policy for the same type of access.

Revoking security labels

You must be a security administrator to revoke a security label from a user, group, or role. To revoke a security label, use the SQL statement REVOKE SECURITY LABEL.

Data types compatible with security labels

Security labels have a data type of SYSPROC.DB2SECURITYLABEL. Data conversion is supported between SYSPROC.DB2SECURITYLABEL and VARCHAR(128) FOR BIT DATA.

Determining the security labels held by users

You can use the following query to determine the security labels that are held by users:

```
SELECT A.grantee, B.secpolicyname, c.seclabelname
FROM syscat.securitylabelaccess A, syscat.securitypolicies B, syscat.securitylabels
C
WHERE A.seclabelid = C.seclabelid and B.secpolicyid = C.secpolicyid
```

Format for security label values

Sometimes the values in a security label are represented in the form of a character string, for example when using the built-in function SECLABEL.

When the values in a security label are represented as a string, they are in the following format:

- The values of the components are listed from left to right in the same order that the components are listed in the CREATE SECURITY POLICY statement for the security policy
- An element is represented by the name of that element
- Elements for different components are separated by a colon (:)
- If more than one element are given for the same component the elements are enclosed in parentheses (()) and are separated by a comma (,)
- Empty values are represented by a set of empty parentheses (())

Example: A security label is part of a security policy that has these three components in this order: Level, Department, and Projects. The security label has these values:

Table 9. Example values for a security label	
Component	**Values**
Level	Secret
Department	*Empty value*
Projects	• Epsilon 37 • Megaphone • Cloverleaf

This security label values look like this as a string:

```
'Secret:():(Epsilon 37,Megaphone,Cloverleaf)'
```

How LBAC security labels are compared

When you try to access data protected by label-based access control (LBAC), your LBAC credentials are compared to one or more security labels to see if the access is blocked. Your LBAC credentials are any security labels you hold plus any exemptions that you hold.

There are only two types of comparison that can be made. Your LBAC credentials can be compared to a single security label for read access or your LBAC credentials compared to a single security label for write access. Updating and deleting are treated as being a read followed by a write. When an operation requires multiple comparisons to be made, each is made separately.

Which of your security labels is used

Even though you might hold multiple security labels only one is compared to the protecting security label. The label used is the one that meets these criteria:

- It is part of the security policy that is protecting the table being accessed.
- It was granted for the type of access (read or write).

If you do not have a security label that meets these criteria then a default security label is assumed that has empty values for all components.

How the comparison is made

Security labels are compared component by component. If a security label does not have a value for one of the components then an empty value is assumed. As each component is examined, the appropriate rules of the LBAC rule set are used to decide if the elements in your value for that component should be blocked by the elements in the value for the same component in the protecting label. If any of your values are blocked then your LBAC credentials are blocked by the protecting security label.

The LBAC rule set used in the comparison is designated in the security policy. To find out what the rules are and when each one is used, see the description of that rule set.

How exemptions affect comparisons

If you hold an exemption for the rule that is being used to compare two values then that comparison is not done and the protecting value is assumed not to block the value in your security label.

Example: The LBAC rule set is DB2LBACRULES and the security policy has two components. One component is of type ARRAY and the other is of type TREE. The user has been granted an exemption on the rule DB2LBACREADTREE, which is the rule used for read access when comparing values of components of type TREE. If the user attempts to read protected data then whatever value the user has for the TREE component, even if it is an empty value, will not block access because that rule is not used. Whether the user can read the data depends entirely on the values of the ARRAY component of the labels.

LBAC rule sets overview

An LBAC rule set is a predefined set of rules that are used when comparing security labels. When the values of a two security labels are being compared, one or more of the rules in the rule set will be used to determine if one value blocks another.

Each LBAC rule set is identified by a unique name. When you create a security policy you must specify the LBAC rule set that will be used with that policy. Any comparison of security labels that are part of that policy will use that LBAC rule set.

Each rule in a rule set is also identified by a unique name. You use the name of a rule when you are granting an exemption on that rule.

How many rules are in a set and when each rule is used can vary from rule set to rule set.

There is currently only one supported LBAC rule set. The name of that rule set is DB2LBACRULES.

LBAC rule set: DB2LBACRULES

The DB2LBACRULES LBAC rule set provides a traditional set of rules for comparing the values of security label components. It protects from both write-up and write-down.

What are write-up and write down?

Write-up and write-down apply only to components of type ARRAY and only to write access. Write up occurs when the value protecting data that you are writing to is higher than your value. Write-down is when the value protecting the data is lower than yours. By default neither write-up nor write-down is allowed, meaning that you can only write data that is protected by the same value that you have.

When comparing two values for the same component, which rules are used depends on the type of the component (ARRAY, SET, or TREE) and what type of access is being attempted (read, or write). This table lists the rules, tells when each is used, and describes how the rule determines if access is blocked.

Table 10. Summary of the DB2LBACRULES rules

Rule name	Used to compare values of this type of component	Used for this type of access	Access is blocked when this condition is met
DB2LBACREADARRAY	ARRAY	Read	The user's value is lower than the protecting value.
DB2LBACREADSET	SET	Read	There are one or more protecting values that the user does not hold.
DB2LBACREADTREE	TREE	Read	None of the user's values is equal to or an ancestor of one of the protecting values.
DB2LBACWRITEARRAY	ARRAY	Write	The user's value is higher than the protecting value or lower than the protecting value.[1]
DB2LBACWRITESET	SET	Write	There are one or more protecting values that the user does not hold.
DB2LBACWRITETREE	TREE	Write	None of the user's values is equal to or an ancestor of one of the protecting values.

Note:

1. The DB2LBACWRITEARRAY rule can be thought of as being two different rules combined. One prevents writing to data that is higher than your level (write-up) and the other prevents writing to data that is lower than your level (write-down). When granting an exemption to this rule you can exempt the user from either of these rules or from both.

How the rules handle empty values

All rules treat empty values the same way. An empty value blocks no other values and is blocked by any non-empty value.

DB2LBACREADSET and DB2LBACWRITESET examples

These examples are valid for a user trying to read or trying to write protected data. They assume that the values are for a component of type SET that has these elements: one two three four

Table 11. Examples of applying the DB2LBACREADSET and DB2LBACWRITESET rules.

User's value	Protecting value	Access blocked?
'one'	'one'	Not blocked. The values are the same.
'(one,two,three)'	'one'	Not blocked. The user's value contains the element 'one'.
'(one,two)'	'(one,two,four)'	Blocked. The element 'four' is in the protecting value but not in the user's value.
'()'	'one'	Blocked. An empty value is blocked by any non-empty value.
'one'	'()'	Not blocked. No value is blocked by an empty value.
'()'	'()'	Not blocked. No value is blocked by an empty value.

DB2LBACREADTREE and DB2LBACWRITETREE

These examples are valid for both read access and write access. They assume that the values are for a component of type TREE that was defined in this way:

```
CREATE SECURITY LABEL COMPONENT mycomp
TREE (
    'Corporate'      ROOT,
    'Publishing'     UNDER 'Corporate',
    'Software'       UNDER 'Corporate',
    'Development'    UNDER 'Software',
    'Sales'          UNDER 'Software',
    'Support'        UNDER 'Software'
    'Business Sales' UNDER 'Sales'
    'Home Sales'     UNDER 'Sales'
)
```

This means the elements are in this arrangement:

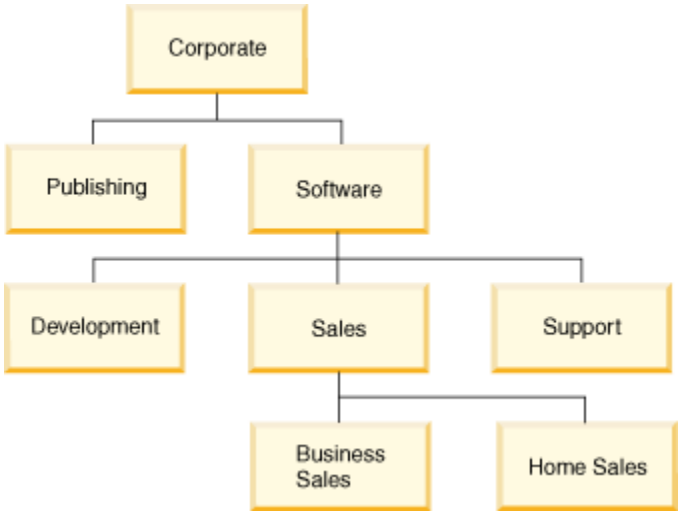


Table 12. Examples of applying the DB2LBACREADTREE and DB2LBACWRITETREE rules.		
User's value	**Protecting value**	**Access blocked?**
'(Support,Sales)'	'Development'	Blocked. The element 'Development' is not one of the user's values and neither 'Support' nor 'Sales' is an ancestor of 'Development'.
'(Development,Software)'	'(Business Sales,Publishing)'	Not blocked. The element 'Software' is an ancestor of 'Business Sales'.
'(Publishing,Sales)'	'(Publishing,Support)'	Not blocked. The element 'Publishing' is in both sets of values.
'Corporate'	'Development'	Not blocked. The root value is an ancestor of all other values.
'()'	'Sales'	Blocked. An empty value is blocked by any non-empty value.
'Home Sales'	'()'	Not blocked. No value is blocked by an empty value.
'()'	'()'	Not blocked. No value is blocked by an empty value.

DB2LBACREADARRAY examples

These examples are for read access only. They assume that the values are for a component of type ARRAY that includes these elements in this arrangement:

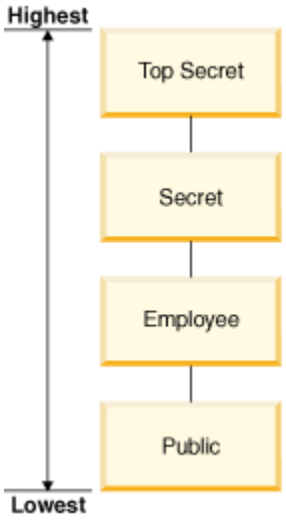


Table 13. Examples of applying the DB2LBACREADARRAY rule.		
User's value	**Protecting value**	**Read access blocked?**
'Secret'	'Employee'	Not blocked. The element 'Secret' is higher than the element 'Employee'.
'Secret'	'Secret'	Not blocked. The values are the same.
'Secret'	'Top Secret'	Blocked. The element 'Top Secret' is higher than the element 'Secret'.
'()'	'Public'	Blocked. An empty value is blocked by any non-empty value.
'Public'	'()'	Not blocked. No value is blocked by an empty value.
'()'	'()'	Not blocked. No value is blocked by an empty value.

DB2LBACWRITEARRAY examples

These examples are for write access only. They assume that the values are for a component of type ARRAY that includes these elements in this arrangement:

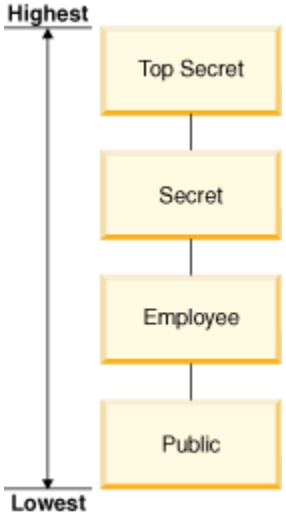


Table 14. Examples of applying the DB2LBACWRITEARRAY rule.		
User's value	**Protecting value**	**Write access blocked?**
'Secret'	'Employee'	Blocked. The element 'Employee' is lower than the element 'Secret'.
'Secret'	'Secret'	Not blocked. The values are the same.
'Secret'	'Top Secret'	Blocked. The element 'Top Secret' is higher than the element 'Secret'.
'()'	'Public'	Blocked. An empty value is blocked by any non-empty value.
'Public'	'()'	Not blocked. No value is blocked by an empty value.
'()'	'()'	Not blocked. No value is blocked by an empty value.

LBAC rule exemptions

When you hold an LBAC rule exemption on a particular rule of a particular security policy, that rule is not enforced when you try to access data protected by that security policy.

An exemption has no effect when comparing security labels of any security policy other than the one for which it was granted.

Example:

There are two tables: T1 and T2. T1 is protected by security policy P1 and T2 is protected by security policy P2. Both security policies have one component. The component of each is of type ARRAY. T1 and T2 each contain only one row of data. The security label that you hold for read access under security policy P1 does not allow you access to the row in T1. The security label that you hold for read access under security policy P2 does not allow you read access to the row in T2.

Now you are granted an exemption on DB2LBACREADARRAY under P1. You can now read the row from T1 but not the row from T2 because T2 is protected by a different security policy and you do not hold an exemption to the DB2LBACREADARRAY rule in that policy.

You can hold multiple exemptions. If you hold an exemption to every rule used by a security policy then you will have complete access to all data protected by that security policy.

Granting LBAC rule exemptions

You must be a security administrator to grant an LBAC rule exemption. To grant an LBAC rule exemption, use the SQL statement GRANT EXEMPTION ON RULE.

When you grant an LBAC rule exemption you provide this information:

- The rule or rules that the exemption is for
- The security policy that the exemption is for
- The user, group, or role to which you are granting the exemption

Important: LBAC rule exemptions provide very powerful access. Do not grant them without careful consideration.

Revoking LBAC rule exemptions

You must be a security administrator to revoke an LBAC rule exemption. To revoke an LBAC rule exemption, use the SQL statement REVOKE EXEMPTION ON RULE.

Determining the rule exemptions held by users

You can use the following query to determine the rule exemptions that are held by users:

```
SELECT A.grantee, A.accessrulename, B.secpolicyname
FROM syscat.securitypolicyexemptions A, syscat.securitypolicies B
WHERE A.secpolicyid = B.secpolicyid
```

Built-in functions for managing LBAC security labels

The built-in functions SECLABEL, SECLABEL_BY_NAME, and SECLABEL_TO_CHAR are provided for managing label-based access control (LBAC) security labels.

Each is described briefly here and in detail in the *SQL Reference*

SECLABEL

This built-in function is used to build a security label by specifying a security policy and values for each of the components in the label. The returned value has a data type of DB2SECURITYLABEL and is a security label that is part of the indicated security policy and has the indicated values for the components. It is not necessary that a security label with the indicated values already exists.

Example: Table T1 has two columns, the first has a data type of DB2SECURITYLABEL and the second has a data type of INTEGER. T1 is protected by security policy P1, which has three security label components: level, departments, and groups. If UNCLASSIFIED is an element of the component level, ALPHA and SIGMA are both elements of the component departments, and G2 is an element of the component groups then a security label could be inserted like this:

```
INSERT INTO T1 VALUES
   ( SECLABEL( 'P1', 'UNCLASSIFIED:(ALPHA,SIGMA):G2' ), 22 )
```

SECLABEL_BY_NAME

This built-in function accepts the name of a security policy and the name of a security label that is part of that security policy. It then returns the indicated security label as a DB2SECURITYLABEL. You must use this function when inserting an existing security label into a column that has a data type of DB2SECURITYLABEL.

Example: Table T1 has two columns, the first has a data type of DB2SECURITYLABEL and the second has a data type of INTEGER. The security label named L1 is part of security policy P1. This SQL inserts the security label:

```
INSERT INTO T1 VALUES ( SECLABEL_BY_NAME( 'P1', 'L1' ), 22 )
```

This SQL statement does not work:

```
INSERT INTO T1 VALUES ( P1.L1, 22 )     // Syntax Error!
```

SECLABEL_TO_CHAR

This built-in function returns a string representation of the values that make up a security label.

Example: Column C1 in table T1 has a data type of DB2SECURITYLABEL. T1 is protected by security policy P1, which has three security label components: level, departments, and groups. There is one row in T1 and the value in column C1 that has these elements for each of the components:

Component	Elements
level	SECRET
departments	DELTA and SIGMA

Component	Elements
groups	G3

A user that has LBAC credentials that allow reading the row executes this SQL statement:

```
SELECT SECLABEL_TO_CHAR( 'P1', C1 ) AS C1 FROM T1
```

The output looks like this:

```
C1

'SECRET:(DELTA,SIGMA):G3'
```

Protection of data using LBAC

Label-based access control (LBAC) can be used to protect rows of data, columns of data, or both. Data in a table can only be protected by security labels that are part of the security policy protecting the table. Data protection, including adding a security policy, can be done when creating the table or later by altering the table.

You can add a security policy to a table and protect data in that table as part of the same CREATE TABLE or ALTER TABLE statement.

As a general rule you are not allowed to protect data in such a way that your current LBAC credentials do not allow you to write to that data.

Adding a security policy to a table

You can add a security policy to a table when you create the table by using the SECURITY POLICY clause of the CREATE TABLE statement. You can add a security policy to an existing table by using the ADD SECURITY POLICY clause of the ALTER TABLE statement. You do not need to have SECADM authority or have LBAC credentials to add a security policy to a table.

Adding a security policy to a table does not activate row or column protection by itself. It simply associates a security policy with the table which is to be used when row or column protection is activated. Refer to the “Protecting rows” on page 221 and “Protecting columns” on page 222 sections below for more information on how to activate row and column protection. The value of the PROTECTIONGRANULARITY column in the SYSCAT.TABLES catalog view indicates what level of LBAC protection is currently active for a table.

Security policies cannot be added to types of tables that cannot be protected by LBAC. See the overview of LBAC for a list of table types that cannot be protected by LBAC.

No more than one security policy can be added to any table.

Protecting rows

You can allow protected rows in a new table by including a column with a data type of DB2SECURITYLABEL when you create the table. The CREATE TABLE statement must also add a security policy to the table. You do not need to have SECADM authority or have any LBAC credentials to create such a table.

You can allow protected rows in an existing table by adding a column that has a data type of DB2SECURITYLABEL. To add such a column, either the table must already be protected by a security policy or the ALTER TABLE statement that adds the column must also add a security policy to the table. When the column is added, the security label you hold for write access is used to protect all existing rows. If you do not hold a security label for write access that is part of the security policy protecting the table then you cannot add a column that has a data type of DB2SECURITYLABEL.

After a table has a column of type DB2SECURITYLABEL you protect each new row of data by storing a security label in that column. The details of how this works are described in the topics about inserting

and updating LBAC protected data. You must have LBAC credentials to insert rows into a table that has a column of type DB2SECURITYLABEL.

A column that has a data type of DB2SECURITYLABEL cannot be dropped and cannot be changed to any other data type.

Protecting columns

You can protect a column when you create the table by using the SECURED WITH column option of the CREATE TABLE statement. You can add protection to an existing column by using the SECURED WITH option in an ALTER TABLE statement.

To protect a column with a particular security label you must have LBAC credentials that allow you to write to data protected by that security label. You do not have to have SECADM authority.

Columns can only be protected by security labels that are part of the security policy protecting the table. You cannot protect columns in a table that has no security policy. You are allowed to protect a table with a security policy and protect one or more columns in the same statement.

You can protect any number of the columns in a table but a column can be protected by no more than one security label.

Reading of LBAC protected data

When you try to read data protected by label-based access control (LBAC), your LBAC credentials for reading are compared to the security label that is protecting the data. If the protecting label does not block your credentials you are allowed to read the data.

In the case of a protected column the protecting security label is defined in the schema of the table. The protecting security label for that column is the same for every row in the table. In the case of a protected row the protecting security label is stored in the row in a column of type DB2SECURITYLABEL. It can be different for every row in the table.

The details of how your LBAC credentials are compared to a security label are given in the topic about how LBAC security labels are compared.

Reading protected columns

When you try to read from a protected column your LBAC credentials are compared with the security label protecting the column. Based on this comparison access will either be blocked or allowed. If access is blocked then an error is returned and the statement fails. Otherwise, the statement proceeds as usual.

Trying to read a column that your LBAC credentials do not allow you to read, causes the entire statement to fail.

Example:

Table T1 has two protected columns. The column C1 is protected by the security label L1. The column C2 is protected by the security label L2.

Assume that user Jyoti has LBAC credentials for reading that allow access to security label L1 but not to L2. If Jyoti issues the following SQL statement, the statement will fail:

```
SELECT * FROM T1
```

The statement fails because column C2 is included in the SELECT clause as part of the wildcard (*).

If Jyoti issues the following SQL statement it will succeed:

```
SELECT C1 FROM T1
```

The only protected column in the SELECT clause is C1, and Jyoti's LBAC credentials allow her to read that column.

Reading protected rows

If you do not have LBAC credentials that allow you to read a row it is as if that row does not exist for you.

When you read protected rows, only those rows to which your LBAC credentials allow read access are returned. This is true even if the column of type DB2SECURITYLABEL is not part of the SELECT clause.

Depending on their LBAC credentials, different users might see different rows in a table that has protected rows. For example, two users executing the statement `SELECT COUNT(*) FROM T1` may get different results if T1 has protected rows and the users have different LBAC credentials.

Your LBAC credentials affect not only SELECT statements but also other SQL statements like UPDATE, and DELETE. If you do not have LBAC credentials that allow you to read a row, you cannot affect that row.

Example:

Table T1 has these rows and columns. The column ROWSECURITYLABEL has a data type of DB2SECURITYLABEL.

Table 15. Example values in table T1

LASTNAME	DEPTNO	ROWSECURITYLABEL
Rjaibi	55	L2
Miller	77	L1
Fielding	11	L3
Bird	55	L2

Assume that user Dan has LBAC credentials that allow him to read data that is protected by security label L1 but not data protected by L2 or L3.

Dan issues the following SQL statement:

```
SELECT * FROM T1
```

The SELECT statement returns only the row for Miller. No error messages or warning are returned.

Dan's view of table T1 is this:

Table 16. Example values in view of table T1

LASTNAME	DEPTNO	ROWSECURITYLABEL
Miller	77	L1

The rows for Rjaibi, Fielding, and Bird are not returned because read access is blocked by their security labels. Dan cannot delete or update these rows. They will also not be included in any aggregate functions. For Dan it is as if those rows do not exist.

Dan issues this SQL statement:

```
SELECT COUNT(*) FROM T1
```

The statement returns a value of 1 because only the row for Miller can be read by the user Dan.

Reading protected rows that contain protected columns

Column access is checked before row access. If your LBAC credentials for read access are blocked by the security label protecting one of the columns you are selecting then the entire statement fails. If not, the statement continues and only the rows protected by security labels to which your LBAC credentials allow read access are returned.

Example

The column LASTNAME of table T1 is protected with the security label L1. The column DEPTNO is protected with security label L2. The column ROWSECURITYLABEL has a data type of DB2SECURITYLABEL. T1, including the data, looks like this:

Table 17. Example values in table T1

LASTNAME ***Protected by L1***	**DEPTNO** ***Protected by L2***	**ROWSECURITYLABEL**
Rjaibi	55	L2
Miller	77	L1
Fielding	11	L3

Assume that user Sakari has LBAC credentials that allow reading data protected by security label L1 but not L2 or L3.

Sakari issues this SQL statement:

```
SELECT * FROM T1
```

The statement fails because the SELECT clause uses the wildcard (*) which includes the column DEPTNO. The column DEPTNO is protected by security label L2, which Sakari's LBAC credentials do not allow her to read.

Sakari next issues this SQL statement:

```
SELECT LASTNAME, ROWSECURITYLABEL FROM T1
```

The select clause does not include any columns that Sakari is not able to read so the statement continues. Only one row is returned, however, because each of the other rows is protected by security label L2 or L3.

Table 18. Example output from query on table T1

LASTNAME	**ROWSECURITYLABEL**
Miller	L1

Inserting of LBAC protected data

When you try to insert data into a protected column, or to insert a new row into a table with protected rows, your LBAC credentials determine how that INSERT statement is handled.

Inserting to protected columns

When you try to insert data into a protected column your LBAC credentials for writing are compared with the security label protecting that column. Based on this comparison access will either be blocked or allowed.

The details of how two security labels are compared are given in the topic about how LBAC security labels are compared.

If access is allowed, the statement proceeds as usual. If access is blocked, then the insert fails and an error is returned.

If you are inserting a row but do not provide a value for a protected column then a default value is inserted if one is available. This happens even if your LBAC credentials do not allow write access to that column. A default is available in the following cases:

- The column was declared with the WITH DEFAULT option

- The column is a generated column
- The column has a default value that is given through a BEFORE trigger
- The column has a data type of DB2SECURITYLABEL, in which case security label that you hold for write access is the default value

Inserting to protected rows

When you insert a new row into a table with protected rows, you do not have to provide a value for the column that is of type DB2SECURITYLABEL. If you do not provide a value for that column, the column is automatically populated with the security label you have been granted for write access. If you have not been granted a security label for write access, an error is returned and the insert fails.

By using built-in functions like SECLABEL, you can explicitly provide a security label to be inserted in a column of type DB2SECURITYLABEL. The provided security label is only used, however, if your LBAC credentials would allow you to write to data that is protected with the security label you are trying to insert.

If you provide a security label that you would not be able to write, then what happens depends on the security policy that is protecting the table. If the security policy has the RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL option, then the insert fails and an error is returned. If the security policy does not have the RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL option or if it instead has the OVERRIDE NOT AUTHORIZED WRITE SECURITY LABEL option, then the security label you provide is ignored and if you hold a security label for write access, it is used instead. If you do not hold a security label for write access, an error is returned.

Examples

Table T1 is protected by a security policy named P1 that was created without the RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL option. Table T1 has two columns but no rows. The columns are LASTNAME and LABEL. The column LABEL has a data type of DB2SECURITYLABEL.

User Joe holds a security label L2 for write access. Assume that the security label L2 allows him to write to data protected by security label L2 but not to data protected by security labels L1 or L3.

Joe issues the following SQL statement:

```
INSERT INTO T1 (LASTNAME, DEPTNO) VALUES ('Rjaibi', 11)
```

Because no security label was included in the INSERT statement, Joe's security label for write access is inserted into the LABEL row.

Table T1 now looks like this:

Table 19. Values in the example table T1 after first INSERT statement

LASTNAME	LABEL
Rjaibi	L2

Joe issues the following SQL statement, in which he explicitly provides the security label to be inserted into the column LABEL:

```
INSERT INTO T1 VALUES ('Miller', SECLABEL_BY_NAME('P1', 'L1') )
```

The SECLABEL_BY_NAME function in the statement returns a security label that is part of security policy P1 and is named L1. Joe is not allowed to write to data that is protected with L1 so he is not allowed to insert L1 into the column LABEL.

Because the security policy protecting T1 was created without the RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL option the security label that Joe holds for writing is inserted instead. No error or message is returned.

The table now looks like this:

Table 20. Values in example table T1 after second INSERT statement

LASTNAME	LABEL
Rjaibi	L2
Miller	L2

If the security policy protecting the table had been created with the RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL option then the insert would have failed and an error would have been returned.

Next Joe is granted an exemption to one of the LBAC rules. Assume that his new LBAC credentials allow him to write to data that is protected with security labels L1 and L2. The security label granted to Joe for write access does not change, it is still L2.

Joe issues the following SQL statement:

```
INSERT INTO T1 VALUES ('Bird', SECLABEL_BY_NAME('P1', 'L1') )
```

Because of his new LBAC credentials Joe is able to write to data that is protected by the security label L1. The insertion of L1 is therefore allowed. The table now looks like this:

Table 21. Values in example table T1 after third INSERT statement

LASTNAME	LABEL
Rjaibi	L2
Miller	L2
Bird	L1

Updating of LBAC protected data

Your LBAC credentials must allow you write access to data before you can update it. In the case of updating a protected row, your LBAC credentials must also allow read access to the row.

Updating protected columns

When you try to update data in a protected column, your LBAC credentials are compared to the security label protecting the column. The comparison made is for write access. If write access is blocked then an error is returned and the statement fails, otherwise the update continues.

The details of how your LBAC credentials are compared to a security label are given in the topic about how LBAC security labels are compared.

Example:

Assume there is a table T1 in which column DEPTNO is protected by a security label L2 and column PAYSCALE is protected by a security label L3. T1, including its data, looks like this:

Table 22. Table T1

EMPNO	LASTNAME	DEPTNO *Protected by* L2	PAYSCALE *Protected by* L3
1	Rjaibi	11	4
2	Miller	11	7
3	Bird	11	9

User Lhakpa has no LBAC credentials. He issues this SQL statement:

```
UPDATE T1 SET EMPNO = 4
   WHERE LASTNAME = "Bird"
```

This statement executes without error because it does not update any protected columns. T1 now looks like this:

Table 23. Table T1 After Update

EMPNO	**LASTNAME**	**DEPTNO** ***Protected by*** **L2**	**PAYSCALE** ***Protected by*** **L3**
1	Rjaibi	11	4
2	Miller	11	7
4	Bird	11	9

Lhakpa next issues this SQL statement:

```
UPDATE T1 SET DEPTNO = 55
   WHERE LASTNAME = "Miller"
```

This statement fails and an error is returned because DEPTNO is protected and Lhakpa has no LBAC credentials.

Assume Lhakpa is granted LBAC credentials and that allow the access summarized in the following table. The details of what those credentials are and what elements are in the security labels are not important for this example.

Security label protecting the data	**Can read?**	**Can Write?**
L2	No	Yes
L3	No	No

Lhakpa issues this SQL statement again:

```
UPDATE T1 SET DEPTNO = 55
   WHERE LASTNAME = "Miller"
```

This time the statement executes without error because Lhakpa's LBAC credentials allow him to write to data protected by the security label that is protecting the column DEPTNO. It does not matter that he is not able to read from that same column. The data in T1 now looks like this:

Table 24. Table T1 After Second Update

EMPNO	**LASTNAME**	**DEPTNO** ***Protected by*** **L2**	**PAYSCALE** ***Protected by*** **L3**
1	Rjaibi	11	4
2	Miller	55	7
4	Bird	11	9

Next Lhakpa issues this SQL statement:

```
UPDATE T1 SET DEPTNO = 55, PAYSCALE = 4
   WHERE LASTNAME = "Bird"
```

The column PAYSCALE is protected by the security label L3 and Lhakpa's LBAC credentials do not allow him to write to it. Because Lhakpa is unable to write to the column, the update fails and no data is changed.

Updating protected rows

If your LBAC credentials do not allow you to read a row, then it is as if that row does not exist for you so there is no way for you to update that row. For rows that you are able to read, you must also be able to write to the row in order to update it.

When you try to update a row, your LBAC credentials for writing are compared to the security label protecting the row. If write access is blocked, the update fails and an error is returned. If write access is not blocked, then the update continues.

The update that is performed is done the same way as an update to a non-protected row except for the treatment of the column that has a data type of DB2SECURITYLABEL. If you do not explicitly set the value of that column, it is automatically set to the security label that you hold for write access. If you do not have a security label for write access, an error is returned and the statement fails.

If the update explicitly sets the column that has a data type of DB2SECURITYLABEL, then your LBAC credentials are checked again. If the update you are trying to perform would create a row that your current LBAC credentials would not allow you to write to, then what happens depends on the security policy that is protecting the table. If the security policy has the RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL option, then the update fails and an error is returned. If the security policy does not have the RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL option or if it instead has the OVERRIDE NOT AUTHORIZED WRITE SECURITY LABEL option, then the security label you provide is ignored and if you hold a security label for write access, it is used instead. If you do not hold a security label for write access, an error is returned.

Example:

Assume that table T1 is protected by a security policy named P1 and has a column named LABEL that has a data type of DB2SECURITYLABEL.

T1, including its data, looks like this:

Table 25. Table T1

EMPNO	LASTNAME	DEPTNO	LABEL
1	Rjaibi	11	L1
2	Miller	11	L2
3	Bird	11	L3

Assume that user Jenni has LBAC credentials that allow her to read and write data protected by the security labels L0 and L1 but not data protected by any other security labels. The security label she holds for both read and write is L0. The details of her full credentials and of what elements are in the labels are not important for this example.

Jenni issues this SQL statement:

```
SELECT * FROM T1
```

Jenni sees only one row in the table:

Table 26. Jenni's SELECT Query Result

EMPNO	LASTNAME	DEPTNO	LABEL
1	Rjaibi	11	L1

The rows protected by labels L2 and L3 are not included in the result set because Jenni's LBAC credentials do not allow her to read those rows. For Jenni it is as if those rows do not exist.

Jenni issues these SQL statements:

```
UPDATE T1 SET DEPTNO = 44 WHERE DEPTNO = 11;
SELECT * FROM T1;
```

The result set returned by the query looks like this:

Table 27. Jenni's UPDATE & SELECT Query Result

EMPNO	LASTNAME	DEPTNO	LABEL
1	Rjaibi	44	L0

The actual data in the table looks like this:

Table 28. Table T1

EMPNO	LASTNAME	DEPTNO	LABEL
1	Rjaibi	44	L0
2	Miller	11	L2
3	Bird	11	L3

The statement executed without error but affected only the first row. The second and third rows are not readable by Jenni so they are not selected for update by the statement even though they meet the condition in the WHERE clause.

Notice that the value of the LABEL column in the updated row has changed even though that column was not explicitly set in the UPDATE statement. The column was set to the security label that Jenni held for writing.

Now Jenni is granted LBAC credentials that allow her to read data protected by any security label. Her LBAC credentials for writing do not change. She is still only able to write to data protected by L0 and L1.

Jenni again issues this SQL statement:

```
UPDATE T1 SET DEPTNO = 44 WHERE DEPTNO = 11
```

This time the update fails because of the second and third rows. Jenni is able to read those rows, so they are selected for update by the statement. She is not, however, able to write to them because they are protected by security labels L2 and L3. The update does not occur and an error is returned.

Jenni now issues this SQL statement:

```
UPDATE T1
 SET DEPTNO = 55, LABEL = SECLABEL_BY_NAME( 'P1', 'L2' )
 WHERE LASTNAME = "Rjaibi"
```

The SECLABEL_BY_NAME function in the statement returns the security label named L2. Jenni is trying to explicitly set the security label protecting the first row. Jenni's LBAC credentials allow her to read the first row, so it is selected for update. Her LBAC credentials allow her to write to rows protected by the security label L0 so she is allowed to update the row. Her LBAC credentials would not, however, allow her to write to a row protected by the security label L2, so she is not allowed to set the column LABEL to that value. The statement fails and an error is returned. No columns in the row are updated.

Jenni now issues this SQL statement:

```
UPDATE T1 SET LABEL = SECLABEL_BY_NAME( 'P1', 'L1' ) WHERE LASTNAME = "Rjaibi"
```

The statement succeeds because she would be able to write to a row protected by the security label L1.

T1 now looks like this:

Table 29. Table T1

EMPNO	LASTNAME	DEPTNO	LABEL
1	Rjaibi	44	L1
2	Miller	11	L2
3	Bird	11	L3

Updating protected rows that contain protected columns

If you try to update protected columns in a table with protected rows then your LBAC credentials must allow writing to of all of the protected columns affected by the update, otherwise the update fails and an error is returned. This is as described in section about updating protected columns, earlier. If you are allowed to update all of the protected columns affected by the update you will still only be able to update rows that your LBAC credentials allow you to both read from and write to. This is as described in the section about updating protected rows, earlier. The handling of a column with a data type of DB2SECURITYLABEL is the same whether the update affects protected columns or not.

If the column that has a data type of DB2SECURITYLABEL is itself a protected column then your LBAC credentials must allow you to write to that column or you cannot update any of the rows in the table.

Deleting or dropping of LBAC protected data

Your ability to delete data in tables protected by LBAC depend on your LBAC credentials.

Deleting protected rows

If your LBAC credentials do not allow you to read a row, it is as if that row does not exist for you so there is no way for you to delete it. To delete a row that you are able to read, your LBAC credentials must also allow you to write to the row. To delete any row in a table that has protected columns you must have LBAC credentials that allow you to write to all protected columns in the table.

When you try to delete a row, your LBAC credentials for writing are compared to the security label protecting the row. If the protecting security label blocks write access by your LBAC credentials, the DELETE statement fails, an error is returned, and no rows are deleted.

Example

Protected table T1 has these rows:

LASTNAME	DEPTNO	LABEL
Rjaibi	55	L2
Miller	77	L1
Bird	55	L2
Fielding	77	L3

Assume that user Pat has LBAC credentials such that her access is as summarized in this table:

Security label	Read access?	Write access?
L1	Yes	Yes
L2	Yes	No
L3	No	No

The exact details of her LBAC credentials and of the security labels are unimportant for this example.

Pat issues the following SQL statement:

```
SELECT * FROM T1 WHERE DEPTNO != 999
```

The statement executes and returns this result set:

LASTNAME	DEPTNO	LABEL
Rjaibi	55	L2
Miller	77	L1
Bird	55	L2

The last row of T1 is not included in the results because Pat does not have read access to that row. It is as if that row does not exist for Pat.

Pat issues this SQL statement:

```
DELETE FROM T1 WHERE DEPTNO != 999
```

Pat does not have write access to the first or third row, both of which are protected by L2. So even though she can read the rows she cannot delete them. The DELETE statement fails and no rows are deleted.

Pat issues this SQL statement:

```
DELETE FROM T1 WHERE DEPTNO = 77;
```

This statement succeeds because Pat is able to write to the row with Miller in the LASTNAME column. That is the only row selected by the statement. The row with Fielding in the LASTNAME column is not selected because Pat's LBAC credentials do not allow her to read that row. That row is never considered for the delete so no error occurs.

The actual rows of the table now look like this:

LASTNAME	DEPTNO	LABEL
Rjaibi	55	L2
Bird	55	L2
Fielding	77	L3

Deleting rows that have protected columns

To delete any row in a table that has protected columns you must have LBAC credentials that allow you to write to all protected columns in the table. If there is any row in the table that your LBAC credentials do not allow you to write to then the delete will fail and an error will be returned.

If the table has both protected columns and protected rows then to delete a particular row you must have LBAC credentials that allow you to write to every protected column in the table and also to read from and write to the row that you want to delete.

Example

In protected table T1, the column DEPTNO is protected by the security label L2. T1 contains these rows:

LASTNAME	DEPTNO *Protected by* L2	LABEL
Rjaibi	55	L2
Miller	77	L1
Bird	55	L2
Fielding	77	L3

Assume that user Benny has LBAC credentials that allow him the access summarized in this table:

Security label	Read access?	Write access?
L1	Yes	Yes
L2	Yes	No
L3	No	No

The exact details of his LBAC credentials and of the security labels are unimportant for this example.

Benny issues the following SQL statement:

```
DELETE FROM T1 WHERE DEPTNO = 77
```

The statement fails because Benny does not have write access to the column DEPTNO.

Now Benny's LBAC credentials are changed so that he has access as summarized in this table:

Security label	Read access?	Write access?
L1	Yes	Yes
L2	Yes	Yes
L3	Yes	No

Benny issues this SQL statement again:

```
DELETE FROM T1 WHERE DEPTNO = 77
```

This time Benny has write access to the column DEPTNO so the delete continues. The delete statement selects only the row that has a value of Miller in the LASTNAME column. The row that has a value of Fielding in the LASTNAME column is not selected because Benny's LBAC credentials do not allow him to read that row. Because the row is not selected for deletion by the statement it does not matter that Benny is unable to write to the row.

The one row selected is protected by the security label L1. Benny's LBAC credentials allow him to write to data protected by L1 so the delete is successful.

The actual rows in table T1 now look like this:

LASTNAME	DEPTNO *Protected by* L2	LABEL
Rjaibi	55	L2
Bird	55	L2
Fielding	77	L3

Dropping protected data

You cannot drop a column that is protected by a security label unless your LBAC credentials allow you to write to that column.

A column with a data type of DB2SECURITYLABEL cannot be dropped from a table. To remove it you must first drop the security policy from the table. When you drop the security policy the table is no longer protected with LBAC and the data type of the column is automatically changed from DB2SECURITYLABEL to VARCHAR(128) FOR BIT DATA. The column can then be dropped.

Your LBAC credentials do not prevent you from dropping entire tables or databases that contain protected data. If you would normally have permission to drop a table or a database you do not need any LBAC credentials to do so, even if the database contains protected data.

Removal of LBAC protection from data

You must have SECADM authority to remove the security policy from a table. To remove the security policy from a table you use the DROP SECURITY POLICY clause of the ALTER TABLE statement. This also automatically removes protection from all rows and all columns of the table.

Removing protection from rows

In a table that has protected rows every row must be protected by a security label. There is no way to remove LBAC protection from individual rows.

A column of type DB2SECURITYLABEL cannot be altered or removed except by removing the security policy from the table.

Removing protection from columns

Protection of a column can be removed using the DROP COLUMN SECURITY clause of the SQL statement ALTER TABLE. To remove the protection from a column you must have LBAC credentials that allow you to read from and write to that column in addition to the normal privileges and authorities needed to alter a table.

Chapter 6. Using the system catalog for security information

Information about each database is automatically maintained in a set of views called the system catalog, which is created when the database is created. This system catalog describes tables, columns, indexes, programs, privileges, and other objects.

The following views and table functions list information about privileges held by users, identities of users granting privileges, and object ownership:

SYSCAT.COLAUTH
Lists the column privileges

SYSCAT.DBAUTH
Lists the database privileges

SYSCAT.INDEXAUTH
Lists the index privileges

SYSCAT.MODULEAUTH
Lists the module privileges

SYSCAT.PACKAGEAUTH
Lists the package privileges

SYSCAT.PASSTHRUAUTH
Lists the server privilege

SYSCAT.ROLEAUTH
Lists the role privileges

SYSCAT.ROUTINEAUTH
Lists the routine (functions, methods, and stored procedures) privileges

SYSCAT.SCHEMAAUTH
Lists the schema privileges

SYSCAT.SEQUENCEAUTH
Lists the sequence privileges

SYSCAT.SURROGATEAUTHIDS
Lists the authorization IDs for which another authorization ID can act as a surrogate.

SYSCAT.TABAUTH
Lists the table and view privileges

SYSCAT.TBSPACEAUTH
Lists the table space privileges

SYSCAT.VARIABLEAUTH
Lists the variable privileges

SYSCAT.WORKLOADAUTH
Lists the workload privileges

SYSCAT.XSROBJECTAUTH
Lists the XSR object privileges

Privileges granted to users by the system will have SYSIBM as the grantor. SYSADM, SYSMAINT SYSCTRL, and SYSMON are not listed in the system catalog.

The CREATE and GRANT statements place privileges in the system catalog. Users with ACCESSCTRL and SECADM authority can grant and revoke SELECT privilege on the system catalog views.

Retrieving authorization names with granted privileges

You can use the PRIVILEGES and other administrative views to retrieve information about the authorization names that have been granted privileges in a database.

About this task

For example, the following query retrieves all explicit privileges and the authorization IDs to which they were granted, plus other information, from the PRIVILEGES administrative view:

```
SELECT AUTHID, PRIVILEGE, OBJECTNAME, OBJECTSCHEMA, OBJECTTYPE
       FROM SYSIBMADM.PRIVILEGES
```

The following query uses the AUTHORIZATIONIDS administrative view to find all the authorization IDs that have been granted privileges or authorities, and to show their types:

```
SELECT AUTHID, AUTHIDTYPE FROM SYSIBMADM.AUTHORIZATIONIDS
```

You can also use the SYSIBMADM.OBJECTOWNERS administrative view and the SYSPROC.AUTH_LIST_GROUPS_FOR_AUTHID table function to find security-related information.

Prior to Version 9.1, no single system catalog view contained information about all privileges. For releases earlier than version 9.1, the following statement retrieves all authorization names with privileges:

```
    SELECT DISTINCT GRANTEE, GRANTEETYPE, 'DATABASE' FROM SYSCAT.DBAUTH
   UNION
   SELECT DISTINCT GRANTEE, GRANTEETYPE, 'TABLE   ' FROM SYSCAT.TABAUTH
   UNION
   SELECT DISTINCT GRANTEE, GRANTEETYPE, 'PACKAGE ' FROM SYSCAT.PACKAGEAUTH
   UNION
   SELECT DISTINCT GRANTEE, GRANTEETYPE, 'INDEX   ' FROM SYSCAT.INDEXAUTH
   UNION
   SELECT DISTINCT GRANTEE, GRANTEETYPE, 'COLUMN  ' FROM SYSCAT.COLAUTH
   UNION
   SELECT DISTINCT GRANTEE, GRANTEETYPE, 'SCHEMA  ' FROM SYSCAT.SCHEMAAUTH
   UNION
   SELECT DISTINCT GRANTEE, GRANTEETYPE, 'SERVER  ' FROM SYSCAT.PASSTHRUAUTH
   ORDER BY GRANTEE, GRANTEETYPE, 3
```

Periodically, the list retrieved by this statement should be compared with lists of user and group names defined in the system security facility. You can then identify those authorization names that are no longer valid.

Note: If you are supporting remote database clients, it is possible that the authorization name is defined at the remote client only and not on your database server machine.

Retrieving all names with DBADM authority

The following statement retrieves all authorization names that have been directly granted DBADM authority:

About this task

```
   SELECT DISTINCT GRANTEE, GRANTEETYPE FROM SYSCAT.DBAUTH
      WHERE DBADMAUTH = 'Y'
```

Retrieving names authorized to access a table

You can use the PRIVILEGES and other administrative views to retrieve information about the authorization names that have been granted privileges in a database.

About this task

The following statement retrieves all authorization names (and their types) that are directly authorized to access the table EMPLOYEE with the qualifier JAMES:

```
SELECT DISTINCT AUTHID, AUTHIDTYPE FROM SYSIBMADM.PRIVILEGES
    WHERE OBJECTNAME = 'EMPLOYEE' AND OBJECTSCHEMA = 'JAMES'
```

For releases earlier than Version 9.1, the following query retrieves the same information:

```
    SELECT DISTINCT GRANTEETYPE, GRANTEE FROM SYSCAT.TABAUTH
       WHERE TABNAME = 'EMPLOYEE'
         AND TABSCHEMA = 'JAMES'
    UNION
    SELECT DISTINCT GRANTEETYPE, GRANTEE FROM SYSCAT.COLAUTH
       WHERE TABNAME = 'EMPLOYEE'
         AND TABSCHEMA = 'JAMES'
```

To find out who can update the table EMPLOYEE with the qualifier JAMES, issue the following statement:

```
     SELECT DISTINCT GRANTEETYPE, GRANTEE FROM SYSCAT.TABAUTH
       WHERE TABNAME = 'EMPLOYEE' AND TABSCHEMA = 'JAMES' AND
          (CONTROLAUTH  = 'Y' OR
           UPDATEAUTH IN ('G','Y'))
    UNION
    SELECT DISTINCT GRANTEETYPE, GRANTEE FROM SYSCAT.DBAUTH
       WHERE DBADMAUTH = 'Y'
    UNION
    SELECT DISTINCT GRANTEETYPE, GRANTEE FROM SYSCAT.COLAUTH
       WHERE TABNAME = 'EMPLOYEE' AND TABSCHEMA = 'JAMES' AND
       PRIVTYPE = 'U'
```

This retrieves any authorization names with DBADM authority, as well as those names to which CONTROL or UPDATE privileges have been directly granted.

Remember that some of the authorization names may be groups, not just individual users.

Retrieving all privileges granted to users

By making queries on the system catalog views, users can retrieve a list of the privileges they hold and a list of the privileges they granted other users.

About this task

You can use the PRIVILEGES and other administrative views to retrieve information about the authorization names that were granted privileges in a database. For example, the following query retrieves all the privileges that are granted to the current session authorization ID:

```
SELECT * FROM SYSIBMADM.PRIVILEGES
 WHERE AUTHID = SESSION_USER AND AUTHIDTYPE = 'U'
```

The keyword SESSION_USER in this statement is a special register that is equal to the value of the current user's authorization name.

For releases earlier than Version 9.1, the following examples provide similar information. For example, the following statement retrieves a list of the database privileges that were directly granted to the individual authorization name JAMES:

```
     SELECT * FROM SYSCAT.DBAUTH
      WHERE GRANTEE = 'JAMES' AND GRANTEETYPE = 'U'
```

The following statement retrieves a list of the table privileges that were directly granted by the user JAMES:

```
SELECT * FROM SYSCAT.TABAUTH
 WHERE GRANTOR  = 'JAMES'
```

The following statement retrieves a list of the individual column privileges that were directly granted by the user JAMES:

```
SELECT * FROM SYSCAT.COLAUTH
   WHERE GRANTOR  = 'JAMES'
```

Securing the system catalog view

Because the system catalog views describe every object in the database, if you have sensitive data, you might want to restrict their access.

About this task

The following authorities have SELECT privilege on all catalog tables:

- ACCESSCTRL
- DATAACCESS
- DBADM
- SECADM
- SQLADM

In addition, the following instance level authorities have the ability to select from SYSCAT.BUFFERPOOLS, SYSCAT.DBPARTITIONGROUPS, SYSCAT.DBPARTITIONGROUPDEF, SYSCAT.PACKAGES, and SYSCAT.TABLES:

- SYSADM
- SYSCTRL
- SYSMAINT
- SYSMON

You can use the CREATE DATABASE ... RESTRICTIVE command to create a database in which no privileges are automatically granted to PUBLIC. In this case, none of the following normal default grant actions occur:

- CREATETAB
- BINDADD
- CONNECT
- IMPLICIT_SCHEMA
- EXECUTE with GRANT on all procedures in schema SQLJ
- EXECUTE with GRANT on all functions and procedures in schema SYSPROC
- BIND on all packages created in the NULLID schema
- EXECUTE on all packages created in the NULLID schema
- CREATEIN on schema SQLJ
- CREATEIN on schema NULLID
- USE on table space USERSPACE1
- SELECT access to the SYSIBM catalog tables
- SELECT access to the SYSCAT catalog views
- SELECT access to the SYSIBMADM administrative views

- SELECT access to the SYSSTAT catalog views
- UPDATE access to the SYSSTAT catalog views

If you have created a database using the RESTRICTIVE option, no permissions are granted to PUBLIC. You can run the following query to verify that no schemas are accessibly by PUBLIC:

```
SELECT DISTINCT OBJECTSCHEMA FROM SYSIBMADM.PRIVILEGES WHERE AUTHID='PUBLIC'
```

```
OBJECTSCHEMA
------------
```

For releases earlier than Version 9.1 of the Db2 database manager, during database creation, SELECT privilege on the system catalog views is granted to PUBLIC. In most cases, this does not present any security problems. For very sensitive data, however, it may be inappropriate, as these tables describe every object in the database. If this is the case, consider revoking the SELECT privilege from PUBLIC; then grant the SELECT privilege as required to specific users. Granting and revoking SELECT on the system catalog views is done in the same way as for any view, but you must have either ACCESSCTRL or SECADM authority to do this.

At a minimum, if you don't want any user to be able to know what objects other users have access to, you should consider restricting access to the following catalog and administrative views:

- SYSCAT.COLAUTH
- SYSCAT.DBAUTH
- SYSCAT.INDEXAUTH
- SYSCAT.PACKAGEAUTH
- SYSCAT.PASSTHRUAUTH
- SYSCAT.ROUTINEAUTH
- SYSCAT.SCHEMAAUTH
- SYSCAT.SECURITYLABELACCESS
- SYSCAT.SECURITYPOLICYEXEMPTIONS
- SYSCAT.SEQUENCEAUTH
- SYSCAT.SURROGATEAUTHIDS
- SYSCAT.TABAUTH
- SYSCAT.TBSPACEAUTH
- SYSCAT.XSROBJECTAUTH
- SYSIBMADM.AUTHORIZATIONIDS
- SYSIBMADM.OBJECTOWNERS
- SYSIBMADM.PRIVILEGES

This would prevent information about user privileges from becoming available to everyone with access to the database.

You should also examine the columns for which statistics are gathered. Some of the statistics recorded in the system catalog contain data values which could be sensitive information in your environment. If these statistics contain sensitive data, you may want to revoke SELECT privilege from PUBLIC for the SYSCAT.COLUMNS and SYSCAT.COLDIST catalog views.

If you want to limit access to the system catalog views, you could define views to let each authorization name retrieve information about its own privileges.

For example, the following view MYSELECTS includes the owner and name of every table on which a user's authorization name has been directly granted SELECT privilege:

```
CREATE VIEW MYSELECTS AS
   SELECT TABSCHEMA, TABNAME FROM SYSCAT.TABAUTH
   WHERE GRANTEETYPE = 'U'
```

```
        AND GRANTEE = USER
        AND SELECTAUTH = 'Y'
```

The keyword USER in this statement is equal to the value of the current session authorization name.

The following statement makes the view available to every authorization name:

```
     GRANT SELECT ON TABLE MYSELECTS TO PUBLIC
```

And finally, remember to revoke SELECT privilege on the view and base table by issuing the following two statements:

```
   REVOKE SELECT ON TABLE SYSCAT.TABAUTH FROM PUBLIC
```

```
   REVOKE SELECT ON TABLE SYSIBM.SYSTABAUTH FROM PUBLIC
```

Chapter 7. Firewall support

A *firewall* is a set of related programs, located at a network gateway server, that are used to prevent unauthorized access to a system or network.

There are four types of firewalls:

1. Network level, packet-filter, or screening router firewalls
2. Classical application level proxy firewalls
3. Circuit level or transparent proxy firewalls
4. Stateful multi-layer inspection (SMLI) firewalls

There are existing firewall products that incorporate one of the firewall types listed previously. There are many other firewall products that incorporate some combination of the types listed previously.

Screening router firewalls

The screening router firewall is also known as a network level or packet-filter firewall. Such a firewall works by screening incoming packets by protocol attributes. The protocol attributes screened may include source or destination address, type of protocol, source or destination port, or some other protocol-specific attributes.

For all firewall solutions (except SOCKS), you need to ensure that all the ports used by Db2 database are open for incoming and outgoing packets. Db2 database uses port 523 for the Db2 Administration Server (DAS), which is used by the Db2 database tools. Determine the ports used by all your server instances by using the services file to map the service name in the server database manager configuration file to its port number.

In addition, for partitioned database environments and Db2 pureScale environments, if the DB2_FIREWALL_PORT_RANGE registry variable has been set, connections must be allowed on the specified port range between members of the same Db2 instance. If this registry variable has not been set, connections must be allowed on all non-privileged ports between members of the same Db2 instance. Non-privileged ports have port numbers greater than or equal to 1024.

Application proxy firewalls

A proxy or proxy server is a technique that acts as an intermediary between a Web client and a Web server. A proxy firewall acts as a gateway for requests arriving from clients.

When client requests are received at the firewall, the final server destination address is determined by the proxy software. The application proxy translates the address, performs additional access control checking and logging as necessary, and connects to the server on behalf of the client.

The Db2 Connect product on a firewall machine can act as a proxy to the destination server. Also, a Db2 database server on the firewall, acting as a hop server to the final destination server, acts like an application proxy.

Circuit level firewalls

The circuit level firewall is also known as a transparent proxy firewall.

A transparent proxy firewall does not modify the request or response beyond what is required for proxy authentication and identification. An example of a transparent proxy firewall is SOCKS.

The Db2 database system supports SOCKS Version 4.

Stateful multi-layer inspection (SMLI) firewalls

The stateful multi-layer inspection (SMLI) firewall uses a sophisticated form of packet-filtering that examines all seven layers of the Open System Interconnection (OSI) model.

Each packet is examined and compared against known states of friendly packets. While screening router firewalls only examine the packet header, SMLI firewalls examine the entire packet including the data.

Chapter 8. Security plug-ins

Authentication for the Db2 database system is done using *security plug-ins*. A security plug-in is a dynamically loadable library that provides authentication security services.

Important: The DATA_ENCRYPT authentication type is deprecated and might be removed in a future release. To encrypt data in-transit between clients and Db2 databases, we recommend that you use the Db2 database system support of Transport Layer Security (TLS). For more information, see *Configuring TLS support in a Db2 instance* in the *Data encryption* section of the Db2 Security Guide.

Group retrieval plug-in
Retrieves group membership information for a particular user.

User ID/password authentication plug-in
The following authentication types are implemented using a user ID and password authentication plug-in:

- `CLIENT`
- `SERVER`
- `SERVER_ENCRYPT`
- `DATA_ENCRYPT`
- `DATA_ENCRYPT_CMP`

These authentication types determine how and where authentication of a user occurs. The authentication type that is used is determined by the following method:

- For connect or attach operations, if you specify a value for the **srvcon_auth** configuration parameter, then that value takes precedence over the value of the **authentication** configuration parameter.
- In all other cases, the value of the **authentication** configuration parameter is used.

GSS-API authentication plug-in
GSS-API is formally known as Generic Security Service Application Program Interface, Version 2 (IETF RFC2743) and Generic Security Service API Version 2: C-Bindings (IETF RFC2744). The Kerberos protocol is the predominant means of implementing the GSS-API authentication mechanism. The following authentication types are implemented using GSS-API authentication plug-ins:

- `KERBEROS`
- `GSSPLUGIN`
- `KRB_SERVER_ENCRYPT`
- `GSS_SERVER_ENCRYPT`

`KRB_SERVER_ENCRYPT` and `GSS_SERVER_ENCRYPT` support both GSS-API authentication and user ID/password authentication. However, GSS-API authentication is the preferred authentication type. Client-side Kerberos support is available on AIX, Windows, and Linux operating systems. For Windows operating systems, Kerberos support is enabled by default.

The Db2 database manager supports these plug-ins at both the client and the server.

Note: Authentication types determine how and where a user is authenticated. To use a particular authentication type, set the value of the **authentication** database manager configuration parameter.

You can use each of the plug-ins independently, or with the other plug-ins. For example, you might use a specific sever-side authentication plug-in, but accept the Db2 default values for client and group authentication. Alternatively, you might have only a group retrieval, or a client authentication plug-in, but without a server-side plug-in.

If you want to use GSS-API authentication, plug-ins are required on both the client and the server.

The default behavior for authentication is to use a user ID/password plug-in that implements an operating-system-level mechanism to authenticate.

The Db2 database product includes plug-ins for group retrieval, user ID/password authentication, and GSS-API authentication. You can customize Db2 client and server authentication behavior further by developing your own plug-ins, or by purchasing plug-ins from a third party.

Deployment of security plug-ins on Db2 clients

Db2 clients can support one group retrieval plug-in and one user ID/password authentication plug-in.

Alternatively, clients using GSS-API authentication plug-in determine which plug-in to use by scanning the list of implemented GSS-API plug-ins on the Db2 server. The first authentication plug-in name that matches a GSS-API authentication plug-in implemented on the client is the one chosen. You specify the list of implemented server GSS-API plug-ins using the **srvcon_gssplugin_list** database manager configuration parameter. The following figure portrays the security plug-in infrastructure on a Db2 client:

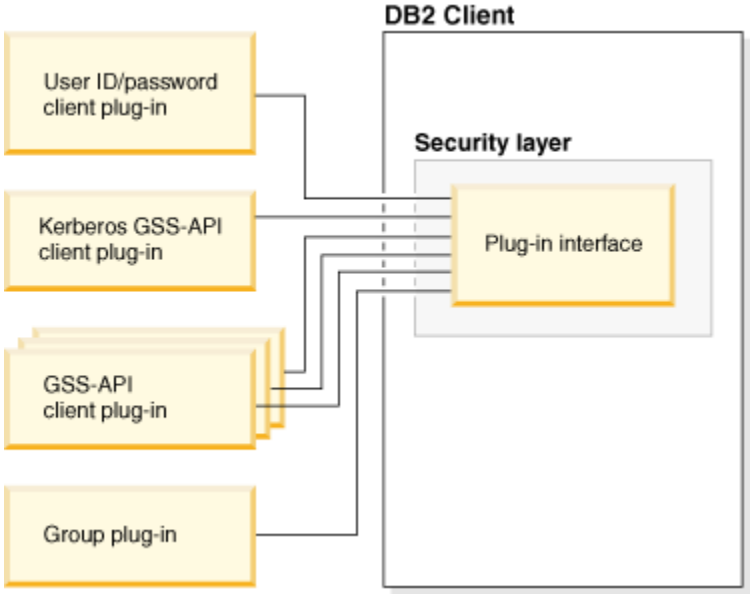


Figure 6. Deploying Security Plug-ins on Db2 Clients

Deployment of security plug-ins on Db2 servers

Db2 servers can support one group retrieval plug-in, one user ID/password authentication plug-in, and multiple GSS-API plug-ins. You can specify the available GSS-API plug-ins as a list of values for the **srvcon_gssplugin_list** database manager configuration parameter. However, only one GSS-API plug-in in this list can be a Kerberos plug-in.

In addition to deploying the server-side security plug-ins on your database server, you might have to deploy client authentication plug-ins on your database server. When you run instance-level operations, such as the **db2start** and **db2trc** commands, the Db2 database manager performs authorization checking for these operations using client authentication plug-ins. Therefore, you might need to install the client authentication plug-in that corresponds to the authentication plug-in on the server. This plug-in name is specified by the **authentication** database manager configuration parameter on the server.

You can set the **authentication** and **srvcon_auth** configuration parameters to different values. This scenario causes one mechanism to be used to authenticate database connections and the other mechanism to be used for local authorization.

The most common method for this approach is to:

- Set the **srvcon_auth** configuration parameter to GSSPLUGIN; and
- Set the **authentication** configuration parameter to SERVER.

The **srvcon_auth** configuration parameter is a means to override the authentication type used by incoming connections. These connections use the authentication method specified by the **srvcon_auth** configuration parameter, but if this value is left empty, the value of the **authentication** parameter is used instead.

If you do not use client authentication plug-ins on the database server, instance-level operations, such as the **db2start** command, fail.

The following figure outlines the security authentication plug-in infrastructure on a Db2 server:

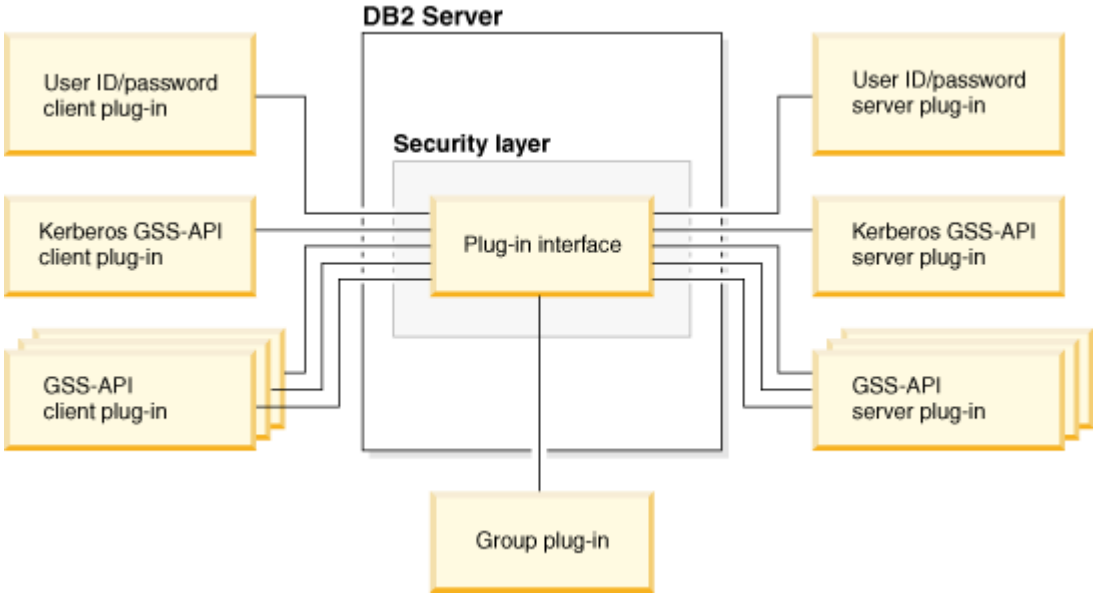


Figure 7. Deploying Security Plug-ins on Db2 Servers

Enabling security plug-ins

You can specify the plug-ins to use for each authentication mechanism by setting database manager configuration parameters. The following table outlines these parameters:

Table 30. Database Manager configuration parameters for security authentication plug-ins

Description	Parameter name
Client Userid-Password Plugin	CLNT_PW_PLUGIN
Client Kerberos Plugin	CLNT_KRB_PLUGIN
Group Plugin	GROUP_PLUGIN
GSS Plugin for Local Authorization	LOCAL_GSSPLUGIN
Server Plugin Mode	SRV_PLUGIN_MODE
Server List of GSS Plugins	SRVCON_GSSPLUGIN_LIST
Server Userid-Password Plugin	SRVCON_PW_PLUGIN
Server Connection Authentication	SRVCON_AUTH
Database manager authentication	AUTHENTICATION

If you do not set the values for these parameters, the default plug-ins that the Db2 product supplies are used for group retrieval, user ID/password management, and Kerberos authentication (if the **authentication**parameter is set to KERBEROS on the server). However, a default GSS-API plug-in is not provided. Therefore, if you specify an authentication type of GSSPLUGIN for the **authentication** parameter, you must also specify a GSS-API authentication plug-in for the **srvcon_gssplugin_list** configuration parameter.

Loading security plug-ins

All of the supported plug-ins that are identified by the database manager configuration parameters are loaded when the database manager starts.

During connect or attach operations, the Db2 client loads a plug-in that is appropriate for the security mechanism that the client negotiated with the server. A client application can cause multiple security plug-ins to be concurrently loaded and used. This situation can occur, for example, in a threaded program that has concurrent connections to different databases from different instances. In this scenario, the client program makes an initial connection to server A that uses a GSS-API plug-in (G1). Server A sends a list of supported plug-ins to the client, and the matching G1 plug-in is loaded on the client. The client program then has another thread, which connects to server B that uses a GSS-API plug-in (G2). The client is informed about G2, which is then loaded, and now both G1 and G2 plug-ins are simultaneously in use on the client.

Actions other than connect or attach operations (such as updating the database manager configuration, starting and stopping the database manager, or turning a Db2 trace on and off) also require an authorization mechanism. For such actions, the Db2 client program loads a plug-in that is specified by another database manager configuration parameter:

- If you set the **authentication** configuration parameter to GSSPLUGIN, the Db2 database manager uses the plug-in specified by the **local_gssplugin** configuration parameter.
- If you set the **authentication** configuration parameter to KERBEROS, the Db2 database manager uses the plug-in specified by the **clnt_krb_plugin** configuration parameter.
- Otherwise, the Db2 database manager uses the plug-in specified by the **clnt_pw_plugin** configuration parameter.

Security plug-ins are supported for connections made to the database server over both IPv4 and IPv6 address protocols.

Developing security plug-ins

If you are developing a security authentication plug-in, you must implement the standard authentication functions used by the Db2 database manager. The functionality that you must implement for the three types of plug-ins:

Group retrieval plug-in

- Find and return the list of groups to which a user belongs

User ID/password authentication plug-in

- Identify the default security context (for a client plug-in only)
- Validate and, optionally, change a password
- Determine whether a particular string represents a valid user (for a server plug-in only)
- Modify the user ID or password that is provided on the client before it is sent to the server (for a client plug-in only)
- Return the Db2 authorization ID that is associated with a particular user

GSS-API authentication plug-in

- Identify the default security context (for a client plug-in only)
- Implement the required GSS-API functions
- Generate initial credentials based on a user ID and password and, optionally, change a password (for a client plug-in only)
- Create and accept security tickets
- Return the Db2 authorization ID that is associated with a particular GSS-API security context

You can pass a user ID of up to 255 characters for a connect statement that you issue through the CLP or via a dynamic SQL statement.

Important: The integrity of your Db2 database system installation can be compromised if security plug-ins are not adequately coded, reviewed, and tested. The Db2 database product takes precautions against many common types of failures, but it cannot guarantee complete integrity if user-written security plug-ins are deployed.

Security plug-in library locations

After you acquire your security plug-ins (either by developing them yourself, or purchasing them from a third party), copy them to specific locations on your database server.

Db2 clients looks for client-side user authentication plug-ins in the following directory:

- UNIX 32-bit: `$DB2PATH/security32/plugin/client`
- UNIX 64-bit: `$DB2PATH/security64/plugin/client`
- WINDOWS 32-bit and 64-bit: `$DB2PATH\security\plugin\`*`instance name`*`\client`

Note: On Windows-based platforms, the subdirectories *instance name* and *client* are not created automatically. The instance owner has to manually create them.

The Db2 database manager looks for server-side user authentication plug-ins in the following directory:

- UNIX 32-bit: `$DB2PATH/security32/plugin/server`
- UNIX 64-bit: `$DB2PATH/security64/plugin/server`
- WINDOWS 32-bit and 64-bit: `$DB2PATH\security\plugin\`*`instance name`*`\server`

Note: On Windows-based platforms, the subdirectories *instance name* and *server* are not created automatically. The instance owner has to manually create them.

The Db2 database manager looks for group plug-ins in the following directory:

- UNIX 32-bit: `$DB2PATH/security32/plugin/group`
- UNIX 64-bit: `$DB2PATH/security64/plugin/group`
- WINDOWS 32-bit and 64-bit: `$DB2PATH\security\plugin\`*`instance name`*`\group`

Note: On Windows-based platforms, the subdirectories *instance name* and *group* are not created automatically. The instance owner has to manually create them.

Security plug-in naming conventions

Security plug-in libraries must have a platform-specific file name extension. Security plug-in libraries written in C or C++ must have a platform-specific file name extension:

- Windows: `.dll`
- AIX: `.a or .so`, and if both extensions exist, `.a` extension is used.
- Linux and HP IPF: `.so`

Note: Users can also develop security plug-ins with the Db2 Universal JDBC Driver.

For example, assume you have a security plug-in library called `MyPlugin`. For each supported operating system, the appropriate library file name follows:

- Windows 32-bit: MyPlugin.dll
- Windows 64-bit: MyPlugin64.dll
- AIX 32 or 64-bit: MyPlugin.a or MyPlugin.so
- SUN 32 or 64-bit, Linux 32 or 64 bit, HP 32 or 64 bit on IPF: MyPlugin.so

Note: The suffix "64" is only required on the library name for 64-bit Windows security plug-ins.

When you update the database manager configuration with the name of a security plug-in, use the full name of the library without the "64" suffix and omit both the file extension and any qualified path portion

of the name. Regardless of the operating system, a security plug-in library called `MyPlugin` would be registered as follows:

```
UPDATE DBM CFG USING CLNT_PW_PLUGIN MyPlugin
```

The security plug-in name is case sensitive, and must exactly match the library name. Db2 database systems use the value from the relevant database manager configuration parameter to assemble the library path, and then uses the library path to load the security plug-in library.

To avoid security plug-in name conflicts, you should name the plug-in using the authentication method used, and an identifying symbol of the firm that wrote the plug-in. For instance, if the company `Foo, Inc.` wrote a plug-in implementing the authentication method `FOOsomemethod`, the plug-in could have a name like `FOOsomemethod.dll`.

The maximum length of a plug-in name (not including the file extension and the "64" suffix) is limited to 32 bytes. There is no maximum number of plug-ins supported by the database server, but the maximum length of the comma-separated list of plug-ins in the database manager configuration is 255 bytes. Two defines located in the include file `sqlenv.h` identifies these two limits:

```
#define SQL_PLUGIN_NAME_SZ     32     /* plug-in name */
#define SQL_SRVCON_GSSPLUGIN_LIST_SZ 255 /* GSS API plug-in list */
```

The security plug-in library files must have the following file permissions:

- Owned by the instance owner.
- Readable by all users on the system.
- Executable by all users on the system.

Security plug-in support for two-part user IDs

The Db2 database manager on Windows supports the use of two-part user IDs, and the mapping of two-part user IDs to two-part authorization IDs.

For example, consider a Windows operating system two-part user ID composed of a domain and user ID such as: `MEDWAY\pieter`. In this example, `MEDWAY` is a domain and `pieter` is the user name. In Db2 database systems, you can specify whether this two-part user ID should be mapped to either a one-part authorization ID or a two-part authorization ID.

The mapping of a two-part user ID to a two-part authorization ID is supported, but is not the default behavior. By default, both one-part user IDs and two-part user IDs map to one-part authorization IDs. The mapping of a two-part user ID to a two-part authorization ID is supported, but is not the default behavior.

The default mapping of a two-part user ID to a one-part user ID allows a user to connect to the database using:

```
db2 connect to db user MEDWAY\pieter using pw
```

In this situation, if the default behavior is used, the user ID `MEDWAY\pieter` is resolved to the authorization ID `PIETER`. If the support for mapping a two-part user ID to a two-part authorization ID is enabled, the authorization ID would be `MEDWAY\PIETER`.

To enable Db2 to map two-part user IDs to two-part authorization IDs, Db2 supplies two sets of authentication plug-ins:

- One set exclusively maps a one-part user ID to a one-part authorization ID and maps a two-part user-ID to a one-part authorization ID.
- Another set maps both one-part user ID or two-part user ID to a two-part authorization ID.

If a user name in your work environment can be mapped to multiple accounts defined in different locations (such as local account, domain account, and trusted domain accounts), you can specify the plug-ins that enable two-part authorization ID mapping.

It is important to note that a one-part authorization ID, such as, PIETER and a two-part authorization ID that combines a domain and a user ID like MEDWAY\pieter are functionally distinct authorization IDs. The set of privileges associated with one of these authorization IDs can be completely distinct from the set of privileges associated with the other authorization ID. Care should be taken when working with one-part and two-part authorization IDs.

The following table identifies the kinds of plug-ins supplied by Db2 database systems, and the plug-in names for the specific authentication implementations.

Table 31. Db2 security plug-ins

Authentication type	Name of one-part user ID plug-in	Name of two-part user ID plug-in
User ID/password (client)	IBMOSauthclient	IBMOSauthclientTwoPart
User ID/password (server)	IBMOSauthserver	IBMOSauthserverTwoPart
Kerberos	IBMkrb5	IBMkrb5TwoPart

Note: On Windows 64-bit platforms, the characters "64" are appended to the plug-in names listed here.

When you specify an authentication type that requires a user ID/password or Kerberos plug-in, the plug-ins that are listed in the "Name of one-part user ID plug-in" column in the previous table are used by default.

To map a two-part user ID to a two-part authorization ID, you must specify that the two-part plug-in, which is not the default plug-in, be used. Security plug-ins are specified at the instance level by setting the security related database manager configuration parameters as follows:

For server authentication that maps two-part user IDs to two-part authorization IDs, you must set:

- `srvcon_pw_plugin` to `IBMOSauthserverTwoPart`
- `clnt_pw_plugin` to `IBMOSauthclientTwoPart`

For client authentication that maps two-part user IDs to two-part authorization IDs, you must set:

- `srvcon_pw_plugin` to `IBMOSauthserverTwoPart`
- `clnt_pw_plugin` to `IBMOSauthclientTwoPart`

For Kerberos authentication that maps two-part user IDs to two-part authorization IDs, you must set:

- `srvcon_gssplugin_list` to `IBMOSkrb5TwoPart`
- `clnt_krb_plugin` to `IBMkrb5TwoPart`

The security plug-in libraries accept two-part user IDs specified in a Microsoft Windows Security Account Manager compatible format. For example, in the format: *domain**user ID*. Both the domain and user ID information will be used by the Db2 authentication and authorization processes at connection time.

You should consider implementing the two-part plug-ins when creating new databases to avoid conflicts with one-part authorization IDs in existing databases. New databases that use two-part authorization IDs must be created in a separate instance from databases that use single-part authorization IDs.

Security plug-in API versioning

The Db2 database system supports version numbering of the security plug-in APIs. These version numbers are integers starting with 1 for Db2 UDB, Version 8.2.

The version number that Db2 passes to the security plug-in APIs is the highest version number of the API that Db2 can support, and corresponds to the version number of the structure. If the plug-in can support a higher API version, it must return function pointers for the version that Db2 has requested. If the plug-in only supports a lower version of the API, the plug-in should specify the function pointers for the lower version. In either situation, the security plug-in APIs should return the version number for the API it is supporting in the version field of the functions structure.

For Db2, the version numbers of the security plug-ins will only change when necessary (for example, when there are changes to the parameters of the APIs). Version numbers will not automatically change with Db2 release numbers.

32-bit and 64-bit considerations for security plug-ins

In general, a 32-bit Db2 instance uses the 32-bit security plug-in and a 64-bit Db2 instance uses the 64-bit security plug-in. However, on a 64-bit instance, Db2 supports 32-bit applications, which require the 32-bit plug-in library.

A database instance where both the 32-bit and the 64-bit applications can run is known as a hybrid instance. If you have a hybrid instance and intend to run 32-bit applications, ensure that the required 32-bit security plug-ins are available in the 32-bit plug-in directory. For 64-bit Db2 instances on Linux and UNIX operating systems, excluding Linux on IPF, the directories `security32` and `security64` appear. For a 64-bit Db2 instance on Windows on x64 or IPF, both 32-bit and 64-bit security plug-ins are located in the same directory, but 64-bit plug-in names have a suffix, "64".

If you want to upgrade from a 32-bit instance to a 64-bit instance, you should obtain versions of your security plug-ins that are recompiled for 64-bit.

If you acquired your security plug-ins from a vendor that does not supply 64-bit plug-in libraries, you can implement a 64-bit stub that executes a 32-bit application. In this situation, the security plug-in is an external program rather than a library.

Security plug-in problem determination

Problems with security plug-ins are reported in two ways: through SQL errors and through the administration notification log.

Following are the SQLCODE values related to security plug-ins:

- SQLCODE -1365 is returned when a plug-in error occurs during **db2start** or **db2stop**.
- SQLCODE -1366 is returned whenever there is a local authorization problem.
- SQLCODE -30082 is returned for all connection-related plug-in errors.

The administration notification logs are a good resource for debugging and administrating security plug-ins. To see the an administration notification log file on UNIX, check `sqllib/db2dump/`*`instance name`*`.N.nfy`. To see an administration notification log on Windows operating systems, use the Event Viewer tool. The Event Viewer tool can be found by navigating from the Windows operating system "Start" button to `Settings -> Control Panel -> Administrative Tools -> Event Viewer`. Following are the administration notification log values related to security plug-ins:

- 13000 indicates that a call to a GSS-API security plug-in API failed with an error, and returned an optional error message.

```
SQLT_ADMIN_GSS_API_ERROR (13000)
Plug-in "plug-in name" received error code "error code" from
GSS API  "gss api name" with the error message "error message"
```

- 13001 indicates that a call to a Db2 security plug-in API failed with an error, and returned an optional error message.

```
SQLT_ADMIN_PLUGIN_API_ERROR(13001)
Plug-in "plug-in name" received error code "error code" from Db2
security plug-in API "gss api name" with the error message
"error message"
```

- 13002 indicates that Db2 failed to unload a plug-in.

```
SQLT_ADMIN_PLUGIN_UNLOAD_ERROR (13002)
Unable to unload plug-in "plug-in name". No further action required.
```

- 13003 indicates a bad principal name.

```
SQLT_ADMIN_INVALID_PRIN_NAME (13003)
The principal name "principal name" used for "plug-in name"
is invalid. Fix the principal name.
```

- 13004 indicates that the plug-in name is not valid. Path separators (On UNIX "/" and on Windows "\") are not allowed in the plug-in name.

```
SQLT_ADMIN_INVALID_PLGN_NAME (13004)
The plug-in name "plug-in name" is invalid. Fix the plug-in name.
```

- 13005 indicates that the security plug-in failed to load. Ensure the plug-in is in the correct directory and that the appropriate database manager configuration parameters are updated.

```
SQLT_ADMIN_PLUGIN_LOAD_ERROR (13005)
Unable to load plug-in "plug-in name". Verify the plug-in existence and
directory where it is located is correct.
```

- 13006 indicates that an unexpected error was encountered by a security plug-in. Gather all the **db2support** information, if possible capture a **db2trc**, and then call IBM support for further assistance.

```
SQLT_ADMIN_PLUGIN_UNEXP_ERROR (13006)
Plug-in encountered unexpected error. Contact IBM Support for further assistance.
```

Note: If you are using security plug-ins on a Windows 64-bit database server and are seeing a load error for a security plug-in, see the topics about 32-bit and 64-bit considerations and security plug-in naming conventions. The 64-bit plug-in library requires the suffix "64" on the library name, but the entry in the security plug-in database manager configuration parameters should not indicate this suffix.

Enabling plug-ins

Deploying a group retrieval plug-in

To customize the Db2 security system's group retrieval behavior, you can develop your own group retrieval plug-in or buy one from a third party.

Before you begin

After you acquire a group retrieval plug-in that is suitable for your database management system, you can deploy it.

Procedure

- To deploy a group retrieval plug-in on the database server, perform the following steps:
  a) Copy the group retrieval plug-in library into the server's group plug-in directory.
  b) Update the database manager configuration parameter **group_plugin** with the name of the plug-in.
- To deploy a group retrieval plug-in on database clients, perform the following steps:
  a) Copy the group retrieval plug-in library in the client's group plug-in directory.
  b) On the database client, update the database manager configuration parameter **group_plugin** with the name of the plug-in.

Deploying a user ID/password plug-in

To customize the Db2 security system's user ID/password authentication behavior, you can develop your own user ID/password authentication plug-ins or buy one from a third party.

Before you begin

Depending on their intended usage, all user ID-password based authentication plug-ins must be placed in either the client plug-in directory or the server plug-in directory. If a plug-in is placed in the client plug-in directory, it will be used both for local authorization checking and for validating the client when it attempts to connect with the server. If the plug-in is placed in the server plug-in directory, it will be used for handling incoming connections to the server and for checking whether an authorization ID exists and is valid whenever the GRANT statement is issued without specifying either the keyword USER or GROUP. In most situations, user ID/password authentication requires only a server-side plug-in. It is possible, though generally deemed less useful, to have only a client user ID/password plug-in. It is possible, though quite unusual to require matching user ID/password plug-ins on both the client and the server.

Note: You must stop the Db2 server or any applications using the plug-ins before you deploy a *new* version of an *existing* plug-in. Undefined behavior including traps will occur if a process is still using a plug-in when a new version (with the same name) is copied over it. This restriction is not in effect when you deploy a plugin for the first time or when the plug-in is not in use.

After you acquire user ID/password authentication plug-ins that are suitable for your database management system, you can deploy them.

Procedure

- To deploy a user ID/password authentication plug-in on the database server, perform the following steps on the database server:
  a) Copy the user ID/password authentication plug-in library in the server plug-in directory.
  b) Update the database manager configuration parameter **srvcon_pw_plugin** with the name of the server plug-in.
     This plug-in is used by the server when it is handling CONNECT and **ATTACH** requests.
  c) Either:
     – Set the database manager configuration parameter **srvcon_auth** to the CLIENT, SERVER, or SERVER_ENCRYPT authentication type. Or:
     – Set the database manager configuration parameter **srvcon_auth** to NOT_SPECIFIED and set **authentication** to CLIENT, SERVER, or SERVER_ENCRYPT authentication type.
- To deploy a user ID/password authentication plug-in on database clients, perform the following steps on each client:
  a) Copy the user ID/password authentication plug-in library in the client plug-in directory.
  b) Update the database manager configuration parameter **clnt_pw_plugin** with the name of the client plug-in. This plug-in is loaded and called regardless of where the authentication is being done, not only when the database configuration parameter, **authentication** is set to CLIENT.
- For local authorization on a client, server, or gateway using a user ID/password authentication plug-in, perform the following steps on each client, server, or gateway:
  a) Copy the user ID/password authentication plug-in library in the client plug-in directory on the client, server, or gateway.
  b) Update the database manager configuration parameter **clnt_pw_plugin** with the name of the plug-in.
  c) Set the **authentication** database manager configuration parameter to CLIENT, SERVER, or SERVER_ENCRYPT.

Deploying a GSS-API plug-in

To customize the Db2 security system's authentication behavior, you can develop your own authentication plug-ins using the GSS-API, or buy one from a third party.

Before you begin

In the case of plug-in types other than Kerberos, you must have matching plug-in names on the client and the server along with the same plug-in type. The plug-ins on the client and server need not be from the same vendor, but they must generate and consume compatible GSS-API tokens. Any combination of Kerberos plug-ins deployed on the client and the server is acceptable since Kerberos plug-ins are standardized. However, different implementations of less standardized GSS-API mechanisms, such as *x.509* certificates, might only be partially compatible with Db2 database systems. Depending on their intended usage, all GSS-API authentication plug-ins must be placed in either the client plug-in directory or the server plug-in directory. If a plug-in is placed in the client plug-in directory, it will be used for local authorization checking and when a client attempts to connect with the server. If the plug-in is placed in the server plug-in directory, it will be used for handling incoming connections to the server and for checking whether an authorization ID exists and is valid whenever the GRANT statement is issued without specifying either the keyword USER or GROUP.

Note: You must stop the Db2 server or any applications using the plug-ins before you deploy a *new* version of an *existing* plug-in. Undefined behavior including traps will occur if a process is still using a plug-in when a new version (with the same name) is copied over it. This restriction is not in effect when you deploy a plugin for the first time or when the plug-in is not in use.

After you acquire GSS-API authentication plug-ins that are suitable for your database management system, you can deploy them.

Procedure

- To deploy a GSS-API authentication plug-in on the database server, perform the following steps on the server:
  a) Copy the GSS-API authentication plug-in library in the server plug-in directory.
     You can copy numerous GSS-API plug-ins into this directory.
  b) Update the database manager configuration parameter **srvcon_gssplugin_list** with an ordered, comma-delimited list of the names of the plug-ins installed in the GSS-API plug-in directory.
  c) Either:
     – Setting the database manager configuration parameter **srvcon_auth** to GSSPLUGIN or GSS_SERVER_ENCRYPT is a way to enable the server to use GSSAPI PLUGIN authentication method. Or:
     – Setting the database manager configuration parameter **srvcon_auth** to NOT_SPECIFIED and setting **authentication** to GSSPLUGIN or GSS_SERVER_ENCRYPT is a way to enable the server to use GSSAPI PLUGIN authentication method.
- To deploy a GSS-API authentication plug-in on database clients, perform the following steps on each client:
  a) Copy the GSS-API authentication plug-in library in the client plug-in directory.
     You can copy numerous GSS-API plug-ins into this directory. The client selects a GSS-API plug-in for authentication during a CONNECT or ATTACH operation by picking the first GSS-API plug-in contained in the server's plug-in list that is available on the client.
  b) Optional: Catalog the databases that the client will access, indicating that the client will only accept a GSS-API authentication plug-in as the authentication mechanism.
     For example:

```
CATALOG DB testdb AT NODE testnode AUTHENTICATION GSSPLUGIN
```

- For local authorization on a client, server, or gateway using a GSS-API authentication plug-in, perform the following steps:
  a) Copy the GSS-API authentication plug-in library in the client plug-in directory on the client, server, or gateway.
  b) Update the database manager configuration parameter **local_gssplugin** with the name of the plug-in.
  c) Set the **authentication** database manager configuration parameter to GSSPLUGIN, or GSS_SERVER_ENCRYPT.

Deploying a Kerberos plug-in

To customize the Kerberos authentication behavior of the Db2 security system, you can develop your own Kerberos authentication plug-ins or purchase one from a third party.

Before you begin

If you want to deploy a new version of an existing plug-in, you must stop the Db2 server and any applications using the plug-in. Undefined behaviors, including traps, occur if a process is using a plug-in when you deploy a new version of that plug-in (with the same name).

About this task

The Kerberos authentication plug-in can be deployed on a database server or a database client.

Procedure

- To deploy a Kerberos authentication plug-in on the database server, perform the following steps on the server:
  a) Copy the Kerberos authentication plug-in library into the server plug-in directory.
  b) Update the setting of the **srvcon_gssplugin_list** database manager configuration parameter, which is an ordered, comma-delimited list, to include the Kerberos server plug-in name. Only one plug-in in this list can be a Kerberos plug-in. If there is no Kerberos plug-in in the list, an error is returned. If there is more than one Kerberos plug-in in the list, an error is returned. If the configuration parameter value is blank and the **authentication** configuration parameter is set to KERBEROS or KRB_SVR_ENCRYPT, the default Db2 Kerberos plug-in, IBMkrb5, is used.
  c) If necessary, set the value of the **srvcon_auth** database manager configuration parameter.
     If you want to deploy a Kerberos plug-in, the acceptable values for the **srvcon_auth** database manager configuration parameter are as follows:
     - KERBEROS
     - KRB_SERVER_ENCRYPT
     - GSSPLUGIN
     - GSS_SERVER_ENCRYPT
     - Blank, but only if the **authentication** configuration parameter is set to one of the previous values in this list.
- To deploy a Kerberos authentication plug-in on a database client, perform the following steps on the client:
  a) Copy the Kerberos authentication plug-in library into the client plug-in directory.
  b) Set the **clnt_krb_plugin** database manager configuration parameter to the name of the Kerberos plug-in. If the value of the **clnt_krb_plugin** configuration parameter is blank, the client cannot use Kerberos authentication. On Windows, the default value is IBMkrb5. It only needs to be altered for a customized Kerberos plugin. On UNIX, the value must be set since the default value is blank. For local authorization on a client, server, or gateway using a Kerberos authentication plug-in, perform the following steps:

a. Copy the Kerberos authentication plug-in library in the client plug-in directory on the client, server, or gateway.

b. Set the **clnt_krb_plugin** database manager configuration parameter to the name of the plug-in.

c. Set the **authentication** database manager configuration parameter to KERBEROS or KRB_SERVER_ENCRYPT.

c) Optional: Catalog the databases that the client will access, indicating that the client will use only a Kerberos authentication plug-in. The following example catalogs the `testdb` database:

```
CATALOG DB testdb AT NODE testnode AUTHENTICATION KERBEROS
        TARGET PRINCIPAL service/host@REALM
```

LDAP-based authentication and group lookup support

The Db2 database manager and Db2 Connect support LDAP-based authentication and group lookup functionality through the use of LDAP security plug-in modules and also through transparent LDAP

LDAP-based authentication support has been enhanced on the AIX operating system. Starting with Db2 V9.7 Fix Pack 1, transparent LDAP support has also been extended to Linux operating systems at the same version levels that the Db2 product supports. LDAP now enables central management of user authentication and group membership using transparent LDAP authentication. You can configure Db2 instances to authenticate users and acquire their groups through the operating system. The operating system will, in turn, perform the authentication through an LDAP server. To enable transparent LDAP authentication, set the **DB2AUTH** miscellaneous registry variable to OSAUTHDB. Supported operating systems are:

- AIX
- Linux

Another option for implementing LDAP-based authentication is through the use of LDAP security plug-ins. LDAP security plug-in modules allow the Db2 database manager to authenticate users defined in an LDAP directory, removing the requirement that users and groups be defined to the operating system at the same version levels that the Db2 product supports.

The LDAP security plugins support any RFC2307 compliant LDAP server.

Note: When you use the LDAP plug-in modules, all users associated with the database must be defined on the LDAP server. This includes both the Db2 instance owner ID as well as the fenced user. (These users are typically defined in the operating system, but must also be defined in LDAP.) Similarly, if you use the LDAP group plug-in module, any groups required for authorization must be defined on the LDAP server. This includes the SYSADM, SYSMAINT, SYSCTRL and SYSMON groups defined in the database manager configuration.

Db2 security plug-in modules are available for server-side authentication, client-side authentication and group lookup, described later. Depending on your specific environment, you may need to use one, two or all three types of plug-in.

To use Db2 security plug-in modules, follow these steps:

1. Decide if you need server, client, or group plug-in modules, or a combination of these modules.
2. Configure the plug-in modules by setting values in the IBM LDAP security plug-in configuration file (default name is `IBMLDAPSecurity.ini`). You will need to consult with your LDAP administrator to determine appropriate values.
3. Enable the plug-in modules
4. Test connecting with various LDAP User IDs.

Server authentication plug-in

The server authentication plug-in module performs server validation of user IDs and passwords supplied by clients on CONNECT and ATTACH statements. It also provides a way to map LDAP user IDs to Db2 authorization IDs, if required. The server plug-in module is generally required if you want users to authenticate to the Db2 database manager using their LDAP user ID and password.

Client authentication plug-in

The client authentication plug-in module is used where user ID and password validation occurs on the client system; that is, where the Db2 server is configured with SRVCON_AUTH or AUTHENTICATION settings of CLIENT. The client validates any user IDs and passwords supplied on CONNECT or ATTACH statements, and sends the user ID to the Db2 server. Note that CLIENT authentication is difficult to secure, and not generally recommended.

The client authentication plug-in module may also be required if the local operating system user IDs on the database server are different from the Db2 authorization IDs associated with those users. You can use the client-side plugin to map local operating system user IDs to Db2 authorization IDs before performing authorization checks for local commands on the database server, such as for:`db2start`.

Group lookup plug-in

The group lookup plug-in module retrieves group membership information from the LDAP server for a particular user. It is required if you want to use LDAP to store your group definitions. The most common scenario is where:

- All users and groups are defined in the LDAP server
- Any users defined locally on the database server are also defined with the same user ID on the LDAP server (including the instance owner and the fenced user)
- Password validation occurs on the Db2 server (that is, an AUTHENTICATION or SRVCON_AUTH value of SERVER or SERVER_ENCRYPT is set in the server DBM config file).

It is generally sufficient to install only the server authentication plug-in module and the group lookup plug-in module on the server. Db2 clients typically do not need to have the LDAP plug-in module installed.

It is possible to use only the LDAP group lookup plug-in module in combination with some other form of authentication plug-in (such as Kerberos). In this case, the LDAP group lookup plug-in module will be provided the Db2 authorization IDs associated with a user. The plug-in module searches the LDAP directory for a user with a matching AUTHID_ATTRIBUTE, then retrieves the groups associated with that user object.

Configuring transparent LDAP for authentication and group lookup (AIX)

Starting in Db2 V9.7, transparent LDAP-based authentication and group look up are supported on the AIX operating system. Some configuration steps are required before this support is enabled.

Before you begin

These steps assume that the LDAP server is RFC 2307 compliant and configured to store user and group information.

Procedure

1. To configure your AIX client system for LDAP, perform the following steps:
   a) Log in as a user with root authority.
   b) Ensure that the LDAP client file set has been installed on your AIX system.

AIX works with all versions of LDAP clients: ITDS V6.1 which ships with AIX V6.1, and ITDS V6.2 which ships with the AIX expansion pack. The following shows ITDS V5.2 file sets installed on and AIX system:

```
$ lslpp -l "ldap*"
  Fileset                      Level  State      Description
  ----------------------------------------------------------------------------
Path: /usr/lib/objrepos
  ldap.client.adt            5.2.0.0  COMMITTED  Directory Client SDK
  ldap.client.rte            5.2.0.0  COMMITTED  Directory Client Runtime (No
                                                 SSL)
  ldap.html.en_US.config     5.2.0.0  COMMITTED  Directory Install/Config
                                                 Gd-U.S. English
  ldap.html.en_US.man        5.2.0.0  COMMITTED  Directory Man Pages - U.S.
                                                 English
  ldap.msg.en_US             5.2.0.0  COMMITTED  Directory Messages - U.S.
                                                 English

Path: /etc/objrepos
  ldap.client.rte            5.2.0.0  COMMITTED  Directory Client Runtime (No
                                                 SSL)
```

c) Using the **mksecldap** command with the **-c** option, configure the client.

For more information about the **mksecldap** command and how to use it to configure the client, see Setting up an IBM Security Directory Server

d) Update the default stanza in the `/etc/security/user` file.
The **SYSTEM** attribute in the `/etc/security/user` file is used to specify the authentication method used for user management. To enable LDAP authentication, set the **SYSTEM** attribute in the default stanza to include **LDAP** in addition to local user authentication. The default stanza must be modified so that **LDAP** is searched for users that are not defined locally. For example:

```
chsec -f /etc/security/user -s default -a "SYSTEM=files or LDAP"
```

Db2 supports the following **SYSTEM** attribute values:

- LDAP
- KRB5LDAP
- KRB5ALDAP
- files
- KRB5files
- KRB5Afiles

Configurations that use other **SYSTEM** attribute values might work, but are not supported.

For more information on the stanza **SYSTEM** attribute, see User authentication.

For more details, refer to the redbook titled, Integrating AIX into Heterogeneous LDAP Environments, at: http://www.redbooks.ibm.com/abstracts/sg247165.html

2. To configure transparent LDAP authentication on your Db2 instance:

a) Set the **DB2AUTH** miscellaneous registry variable to OSAUTHDB. As a user with SYSADM authority run **db2set DB2AUTH=OSAUTHDB**.

b) Using the **UPDATE DBM CFG** command, set the authentication on the database server instance to any one of the following:

- SERVER
- SERVER_ENCRYPT

c) Ensure that you are using the default `Client Userid-Password Plugin (clnt_pw_plugin)`, `Server Userid-Password Plugin (srvcon_pw_plugin)` and `Group Plugin (group_plugin)`.

d) Restart the Db2 instance.

Considerations when using various authentication methods

Transparent LDAP-based authentication and group look up support on AIX extends support to Kerberos authentication.

Additional work was done on AIX for using Kerberos authentication with Transparent LDAP. The following is what needs to be included in `/usr/lib/security/methods.cfg` and `/etc/security/users` when there is a need to manage accounts in different locations and use different authentication methods, such as Kerberos.

In `/usr/lib/security/methods.cfg` you need to have the following to have files, LDAP and Kerberos authentication.

Note: KRB5A is for using Microsoft Active Directory as the Keberos Key Distribution Center (KDC).

For LDAP:

```
        program = /usr/lib/security/LDAP
        program_64 =/usr/lib/security/LDAP64
```

For KRB5A:

```
        program = /usr/lib/security/KRB5A
        program_64 = /usr/lib/security/KRB5A_64
        options = tgt_verify=no,authonly,is_kadmind_compat=no
```

For KRB5:

```
        program = /usr/lib/security/KRB5
        program_64 = /usr/lib/security/KRB5_64
        options = kadmind=no
```

For KRB5Afiles:

```
        options = db=BUILTIN,auth=KRB5A
```

For KRB5files:

```
        options = db=BUILTIN,auth=KRB5
```

For KRB5ALDAP:

```
        options = db=LDAP,auth=KRB5A
```

For KRB5LDAP:

```
        options = db=LDAP,auth=KRB5
```

Examples

The following example shows four accounts managed differently. Each uses different authentication methods.

If frank's account is stored on file and is authenticated using files, then this is what frank's stanza would look like in `/etc/security/users`.

```
frank:
        SYSTEM = files
        registry = files
```

If karen's account is stored on file and is authenticated using Kerberos, then this is what karen's stanza would look like in `/etc/security/users`.

```
karen:
        SYSTEM = KRB5files
        registry = KRB5files
```

If luke's account is stored on LDAP and is authenticated using Kerberos, then this is what luke's stanza would look like in `/etc/security/users`.

```
luke:
        SYSTEM = KRB5LDAP
        registry = KRB5LDAP
```

If lucy's account is stored on LDAP and is authenticated using LDAP, then this is what lucy's stanza would look like in `/etc/security/users`.

```
lucy:
        SYSTEM = LDAP
        registry = LDAP
```

To determine if a user is defined on LDAP you can use the following command to query a user.

```
$ lsuser -R LDAP lucy
lucy id=1234 pgrp=staff groups=staff home=/home/lucy shell=/bin/ksh registry=LDAP
```

Configuring transparent LDAP for authentication and group lookup (Linux)

To ensure that the Db2 database server transparently uses LDAP-based authentication on the Linux operating system, use Pluggable Authentication Modules (PAM). Your LDAP server should already be configured to store user and group information.

Before you begin

Before attempting to configure transparent LDAP on your system , ensure that the following conditions exist:

- An RFC 2307 compliant LDAP server is set up on your system.
- The required client software packages and dependencies are installed on your system.
  - For RHEL 7 systems, run the following command:

    ```
    yum install openldap openldap-clients sssd sssd-client authconfig
    ```

  - For RHEL 8 systems, run the following command:

    ```
    yum install openldap openldap-clients sssd sssd-client authselect
    ```

  - For SUSE Linux Enterprise Server (SLES) 12 or 15 systems, run the following command:

    ```
    zypper install sssd-ldap sssd
    ```

  - For Ubuntu systems, run the following command:

    ```
    apt install sssd-ldap ldap-utils
    ```

About this task

The procedure configures the System Security Services Daemon (SSSD) and its associated PAM module (`pam_sss`) to provide authentication services to the operating system and Db2. Using SSSD is the recommended configuration.

Note: SSSD requires TLS support to be enabled at the LDAP server.

Configurations that use `pam_ldap`, `pam_unix`, `pam_unix2`, and `pam_krb5` for authentication are also supported by Db2. Configurations using other PAM modules might work, but are unsupported. If the desired authentication method is already configured on the system, go to Db2 Authentication Configuration.

To successfully configure transparent LDAP, the following details are needed:

- Hostname of the LDAP server
- Port of the LDAP server (default for full time TLS is 636, if StartTLS is supported, the default is 389)
- LDAP search base DN
- The root certificate, or the URL to the root certificate, for the LDAP server.
- If authentication is required, the Bind DN and password

For the purposes of this procedure, the following details are used for the LDAP configuration:

Item	Value
Hostname	ldap.example.com
Port	636 (Default for LDAP over TLS)
TLS enabled	Yes
TLS certificate URL	http://example.com/cacombined.pem
LDAP search base DN	ou=Anytown, o=example.com
Authentication	Not required

Procedure

1. Enable system LDAP authentication through SSSD. If the desired authentication method has already been configured on the system, go to step 2.
2. Configure Db2 to use Pluggable Authentication Modules (PAM), also known as Transparent LDAP, to authenticate with the operating system.
3. Optional: Configure any additional authentication options.

System authentication configuration

You enable system LDAP authentication through the System Security Services Daemon (SSSD). The correct procedure for configuring system authentication depends on your operating system.

If the desired authentication method is already configured on the system, refer to Db2 authentication configuration.

Important: All the following commands must be run as root.

RHEL 6 and RHEL 7 configuration using `authconfig`

1. Back up the current authentication configuration for your system:

   ```
   authconfig --savebackup=config_backup
   ```

   Your backup is saved to the following folder: `/var/lib/authconfig/backup-config_backup`.
2. Configure your system using the **`authconfig`** command:

   ```
   authconfig --enableshadow --passalgo=sha512 --enablesssd --enablesssdauth --enableldap --
   enableldapauth --enableldaptls --ldapserver="ldap.example.com"
   --ldaploadcacert="http://example.com/cacombined.pem" --ldapbasedn="ou=Anytown,o=example.com"
   --update
   ```

   where

   --enableshadow
   Enable authentication of local users.

   --passalgo=sha512
   Use SHA512 hashes for passwords of local users.

   --enablesssd --enablesssdauth
   Enable authentication using System Security Services Daemon (SSSD).

--enableldap --enableldapauth
Enable LDAP as an authentication provider in SSSD.

--ldapserver=
Hostname of the LDAP server.

--enableldaptls
Enable secure LDAP (LDAP over TLS).

--ldaploadcacert=
Save the CA certificate for the LDAP server from the given URL.

--ldapbasedn=
LDAP search base distinguished name (DN).

--update
Commit the authconfig changes to the system

3. If the CA certificate is present in a file instead of being available at a given URL, remove the `--ldaploadcacert` option of the **authconfig** command. Copy the certificate to the directory specified by the `ldap_tls_cacertdir` parameter under the `[domain/default]` section of `/etc/sssd/sssd.conf`. This is usually `/etc/openldap/cacerts`.
4. Once the necessary certificates have been added to `/etc/openldap/cacerts`, rename the files in the `cacerts` directory so that the SSSD can properly recognize the certificate:

```
cacertdir_rehash /etc/openldap/cacerts
```

5. Restart and enable the SSSD service for the authentication changes to take effect:

```
systemctl restart sssd
systemctl enable sssd
```

Note: For more information, refer to the following RHEL documentation.

RHEL 8 configuration using `authselect`

1. Enable the SSSD authentication profile:

```
authselect select sssd
```

2. Add the LDAP server URL and the base search DN to the `/etc/openldap/ldap.conf` file:

```
URI ldap://ldap.example.com/
BASE ou=Anytown,o=example.com
```

3. If the directory `/etc/openldap/cacerts` does not exist, create the directory.
4. Copy the certificate to `/etc/openldap/cacerts`. If the certificate is available from a URL, you can download it using the following command:

```
wget <certificate URL> -P /etc/openldap/cacerts
```

5. Examine the downloaded file and determine if there are multiple certificates present in the file.

   If there is only one certificate present in the file, run the following commands to configure the certificate for use:

   a. Rename the files in the `cacerts` directory, so that the SSSD properly recognizes the certificates:

   ```
   openssl rehash /etc/openldap/cacerts
   ```

   b. Add the following line to the `/etc/openldap/ldap.conf` file:

   ```
   TLS_CACERTDIR /etc/openldap/cacerts
   ```

If multiple certificates are present in the PEM file containing the CA certificate, add the following line to the /etc/openldap/ldap.conf file, using TLS_CACERT in place of TLS_CACERTDIR:

```
TLS_CACERT /etc/openldap/cacerts/<cacombined.pem>
```

where <cacombined.pem> is the file name of the certificate.

6. In the /etc/sssd directory, create the file sssd.conf with the following contents:

```
[domain/default]

autofs_provider = ldap
cache_credentials = True
ldap_search_base = ou=Anytown,o=example.com
id_provider = ldap
auth_provider = ldap
chpass_provider = ldap
ldap_uri = ldap://ldap.example.com/
ldap_id_use_start_tls = True
ldap_tls_cacertdir = /etc/openldap/cacerts
[sssd]
services = nss, pam, autofs

domains = default
[nss]
homedir_substring = /home
```

Update the ldap_search_base parameter with the base DN, and update ldap_uri with the URL to the LDAP server.

If multiple certificates are present in the PEM file used in step 5, remove the ldap_tls_cacertdir parameter, and add the following in its place:

```
ldap_tls_cacert = /etc/openldap/cacerts/cacombined.pem
```

7. Change the permissions on the /etc/sssd/sssd.conf file:

```
chmod 600 /etc/sssd/sssd.conf
```

8. Restart and enable SSSD:

```
systemctl restart sssd
systemctl enable sssd
```

SLES 12 and SLES 15 configurations

1. Add SSSD to the system PAM configuration:

```
pam-config --add --sss
```

2. Add the LDAP server URL and the base search DN to the /etc/openldap/ldap.conf file:

```
URI ldap://ldap.example.com/
BASE ou=Anytown,o=example.com
```

3. If it does not exist, create the directory /etc/openldap/cacerts.
4. Copy the CA certificate file for the LDAP server to /etc/openldap/cacerts.
5. Set up the directory so that the SSSD can find the appropriate certificates:

```
c_rehash /etc/openldap/cacerts
```

6. Add the following line to the /etc/openldap/ldap.conf file:

```
TLS_CACERTDIR /etc/openldap/cacerts
```

7. The contents of the /etc/nsswitch.conf file must be modified to instruct the system to look for user information using SSSD.

Add the `sss` option to the `passwd` and `group` properties to enable authentication of both local and LDAP users. For example:

```
passwd: files sss
group:  files sss
```

8. Add the following contents to the beginning of the `/etc/sssd/sssd.conf` file:

```
[domain/default]
cache_credentials = True
ldap_search_base = ou=Anytown,o=example.com
id_provider = ldap
auth_provider = ldap
chpass_provider = ldap
ldap_uri = ldap://ldap.example.com/
ldap_id_use_start_tls = True
ldap_tls_cacertdir = /etc/openldap/cacerts
```

   Update the `ldap_search_base` parameter with the base DN, and update `ldap_uri` with the URL to the LDAP server.

9. Add the following line under the `[sssd]` section of `/etc/sssd/sssd.conf`:

```
domains = default
```

10. Enable and restart SSSD for the changes to take effect:

```
chkconfig sssd on
systemctl restart sssd
```

Ubuntu 18.04 and Ubuntu 20.04 configurations

1. Add SSSD to the system PAM configuration:

```
pam-auth-update --enable sss
```

2. Copy the CA certificate file for the LDAP server to `/usr/local/share/ca-certificates`. If the certificate is available from a URL, you can download it using the following command:

```
wget <certificate URL> -P /usr/local/share/ca-certificates
```

3. If the CA certificate does not have a `.crt` extension, rename the file. For example:

```
mv /usr/local/share/ca-certificates/cacombined.pem /usr/local/share/ca-certificates/
cacombined.crt
```

4. Instruct the system to trust the CA certificate:

```
update-ca-certificates
```

5. You can configure your system to use the certificate only for LDAP, if you do not wish to have the system trust the CA certificate.

   Edit the `/etc/ldap/ldap.conf` file and update the TLS_CACERT parameter to point to the CA certificate present in `/usr/local/share/ca-certificates`. For example:

```
TLS_CACERT /usr/local/share/ca-certificates/cacombined.crt
```

6. Create the `/etc/sssd/sssd.conf` file with the following contents:

```
[sssd]
services = nss, pam
domains = default

[domain/default]
id_provider = ldap
auth_provider = ldap
chpass_provider = ldap
cache_credentials = True
```

```
ldap_uri = ldap://ldap.example.com/
ldap_search_base = ou=Anytown,o=example.com

ldap_id_use_start_tls = True
```

Update the `ldap_search_base` parameter with the base DN, and update `ldap_uri` with the URL to the LDAP server.

7. Change the permissions on the `/etc/sssd/sssd.conf` file by running:

```
chmod 600 /etc/sssd/sssd.conf
```

8. Restart and enable SSSD by running:

```
systemctl restart sssd.service
systemctl enable sssd.service
```

Authentication Configuration Verification

If LDAP is configured successfully, LDAP users should be able to log in to the system and, using the `id` command, should be able to resolve the userid and groups of an LDAP user. For example:

```
$ id db2inst1
uid=1007(db2inst1) gid=1007(db2inst1) groups=1007(db2inst1),7777(ldapgroup)
```

Db2 authentication configuration

These are the authentication configurations for Db2 based on your operating system.

The Db2 PAM configuration file must be created first before you can configure the authentication. The next steps are different based on your operating system.

Red Hat configuration

The OS configuration steps must be run as root.

1. For Db2 to mirror the system authentication configuration, create the configuration file `/etc/pam.d/db2` (the Db2 PAM configuration file) with the following content:

```
#%PAM-1.0
auth     include system-auth
account  include system-auth
password include system-auth
session  include system-auth
```

The Db2 PAM configuration file should be owned and writable only by root.

SLES configuration

The OS configuration steps must be run as root.

1. For Db2 to mirror the system authentication configuration, create the configuration file `/etc/pam.d/db2` (the Db2 PAM configuration file) with the following content:

```
#%PAM-1.0
auth     include common-auth
account  include common-account
password include common-password
session  include common-session
```

The Db2 PAM configuration file should be owned and writable only by root.

Ubuntu Configuration

The OS configuration steps must be run as root.

1. For Db2 to mirror the system authentication configuration, create the configuration file `/etc/pam.d/db2` (the Db2 PAM configuration file) with the following content:

```
@include common-auth
@include common-account
@include common-password
@include common-session
```

   The Db2 PAM configuration file should be owned and writable only by root.

Db2 configuration

Once the PAM configuration is completed, users need to configure Db2 to enable authentication through the operating system. The Db2 commands must be run as a user with SYSADM authority.

1. Set the **DB2AUTH** miscellaneous registry variable to **OSAUTHDB** by running:

```
db2set DB2AUTH=OSAUTHDB
```

2. Set the authentication on the server to any one of the following:

```
SERVER
SERVER_ENCRYPT
```

3. Ensure that you are using the default Client Userid-Password Plugin (`clnt_pw_plugin`), Server Userid-Password Plugin (`srvcon_pw_plugin`) and Group Plugin (`group_plugin`).
4. Restart the Db2 instance.

Additional configuration options

These are additional configuration options to keep in mind as users configure LDAP-based authentication.

Making customizations to the PAM configuration of Db2

To make customizations to the Db2 PAM configuration that do not apply to the rest of the system, make a copy of the system PAM configuration to create the Db2 PAM configuration file.

- On RHEL systems run:

```
cp /etc/pam.d/system-auth /etc/pam.d/db2
```

- On SLES and Ubuntu systems run:

```
cat /etc/pam.d/common-auth /etc/pam.d/common-account /etc/pam.d/common-password /etc/pam.d/
common-session > /etc/pam.d/db2
```

If this step is done, the Db2 authentication configuration will not match the system authentication configuration and future changes made to the system authentication configuration may not be reflected in Db2.

Enforce password history and password quality requirements during a password change

Because the Db2 check password daemons run as the root user, some PAM modules such as `pam_pwhistory` and `pam_pwquality` will not enforce password requirements.

To ensure password quality and history requirements are enforced for a password change, the `enforce_for_root` option must be added to the module's entry in the PAM configuration file.

Alternate group base DN

If the base DN for group searches is different than the default search base, add the following line to the `[domain/default]` section of the `/etc/sssd/sssd.conf` file:

```
ldap_group_search_base = <Group base DN>
```

LDAP authenticated bind

If your LDAP server requires authentication (anonymous binds are not allowed), add the following lines to the `[domain/default]` section of the `/etc/sssd/sssd.conf` file after running the **authconfig** or **authselect** commands:

```
ldap_default_bind_dn=<bind DN>
ldap_default_authtok=<password>
```

Then, restart the SSSD for the changes to take effect by running:

```
systemctl restart sssd
```

Disallow interactive login from all LDAP users by changing the default shell

Add the following parameter under the `[domain/default]` section of the `/etc/sssd/sssd.conf` file. This will override the shell of all users authenticated through SSSD and will prevent an interactive login but will allow users to authenticate with Db2.

- For RHEL and SLES: `override_shell = /sbin/nologin`
- For Ubuntu: `override_shell = /usr/sbin/nologin`

Control who can login to the server using the pam_access module

More granular control over who is allowed access to the system can be provided by the `pam_access` module. It can be enabled using the following commands based on your operating system:

- RHEL 7: `authconfig --enablepamaccess --update`
- RHEL 8: `authselect select sssd with with-pamaccess`
- SLES: `pam-config --add --access`
- Ubuntu: Add the following line to the beginning of `/etc/pam.d/common-account`: `account required pam_access.so`

Then modify the `/etc/security/access.conf` file and add the following lines:

```
+ : root wheel : ALL
+ : db2inst1 : ALL
-: ALL : ALL
```

This configuration will allow root, members of the wheel group, and the Db2 instance owner (`db2inst1`) access to the system.

To allow other users to log in to Db2 only, take a backup of the Db2 PAM configuration file and run the following command based on your operating system:

- For RHEL:

  ```
  grep -v pam_access.so /etc/pam.d/system-auth > /etc/pam.d/db2
  ```

- For SLES and Ubuntu:

  ```
  grep -v pam_access.so /etc/pam.d/common-auth  /etc/pam.d/common-account /etc/pam.d/common-
  password /etc/pam.d/common-session > /etc/pam.d/db2
  ```

This will make a copy of the system authentication configuration, except for lines containing the `pam_access.so` module. This will allow any user to connect to Db2, but they will be denied access to other services in the operating system.

Note: The Db2 authentication configuration will no longer match the system authentication configuration.

Configuring the LDAP plug-in modules

To configure the LDAP plug-in modules, you need to update your IBM LDAP security plug-in configuration file to suit your environment. In most cases, you will need to consult with your LDAP administrator to determine the appropriate configuration values.

Important: Use of versions 1.0 and 1.1 of the Transport Layer Security (TLS) protocol is deprecated. We recommend to use TLS version 1.2.

Note: If enabling this feature on AIX, review the following for performance considerations.

The default name and location for the IBM LDAP security plug-in configuration file is:

- On UNIX: `INSTHOME/sqllib/cfg/IBMLDAPSecurity.ini`
- On Windows: `%DB2PATH%\cfg\IBMLDAPSecurity.ini`

Optionally, you can specify the location of this file using the DB2LDAPSecurityConfig environment variable. On Windows, you should set DB2LDAPSecurityConfig in the global system environment, to ensure it is picked up by the Db2 service.

The following tables provide information to help you determine appropriate configuration values.

Table 32. Server-related values

Parameter	Description
LDAP_HOST	The name of your LDAP server(s). This is a space separated list of LDAP server host names or IP addresses, with an optional port number for each one. For example: `host1[:port] [host2:[port2] ... ]` The default port number is 389, or 636 if TLS is enabled.
ENABLE_SSL	To enable TLS support, set ENABLE_SSL to TRUE. This is an optional parameter; it defaults to FALSE (no TLS support).
SSL_KEYFILE	The path for the TLS keyring. A keyfile is only required if your LDAP server is using a certificate that is not automatically trusted by your GSKit installation. For example:`SSL_KEYFILE = /home/db2inst1/IBMLDAPSecurity.kdb`
SSL_PW	The TLS keyring password. For example: `SSL_PW = keyfile-password`
SECURITY_PROTOCOL	To enable TLS 1.2 support, set SECURITY_PROTOCOL to TLSV12. To enable TLS 1.0, 1.1, and 1.2 support, set SECURITY_PROTOCOL to ALL. By default, SECURITY_PROTOCOL is not set. This setting means TLS 1.2 is not supported.

Table 32. Server-related values (continued)	
Parameter	**Description**
SSL_EXTN_SIGALG	SSL_EXTN_SIGALG specifies a list of signature algorithms that will be supported for a TLS secured LDAP connection. When using TLS 1.2, a value for SSL_EXTN_SIGALG should be specified, otherwise the server may assume only RSA+SHA1 is supported. This is a problem with some LDAP servers because they require that all certificates be signed with SHA2 or better. SSL_EXTN_SIGALG can be set to one of the following values (multiple values can be specified, separated by commas): GSK_TLS_SIGALG_RSA_WITH_SHA224 GSK_TLS_SIGALG_RSA_WITH_SHA256 GSK_TLS_SIGALG_RSA_WITH_SHA384 GSK_TLS_SIGALG_RSA_WITH_SHA512 GSK_TLS_SIGALG_ECDSA_WITH_SHA224 GSK_TLS_SIGALG_ECDSA_WITH_SHA256 GSK_TLS_SIGALG_ECDSA_WITH_SHA384 GSK_TLS_SIGALG_ECDSA_WITH_SHA512
SASL_BIND	The SASL_BIND keyword is available starting in version 11.5.6. When SASL_BIND is set to `true` in the `IBMLDAPSecurity.ini` file, the LDAP plugin will add a `PasswordPolicyRequest` control when authenticating users. This indicates to the LDAP server that the LDAP plugin is requesting data about the state of a user's password, and that the server should respond with a `passwordPolicyResponse`. If a `passwordPolicyResponse` control is included in the response from the LDAP server, the LDAP plugin will examine the `passwordPolicyResponse` to determine the status of the user's password. If the `passwordPolicyResponse` indicates that the user's password is expired, or must change before the next logon, authentication will be denied.

Table 33. User-related values	
Parameter	**Description**
USER_ OBJECTCLASS	The LDAP object class used for users. Generally, set USER_OBJECTCLASS to `inetOrgPerson` (the user for Microsoft Active Directory) For example: `USER_OBJECTCLASS = inetOrgPerson`
USER_BASEDN	The LDAP base DN to use when searching for users. If not specified, user searches start at the root of the LDAP directory. Some LDAP servers require that you specify a value for this parameter. For example: `USER_BASEDN = o=ibm`

Table 33. User-related values (continued)	
Parameter	**Description**

USERID_
ATTRIBUTE
	The LDAP user attribute that represents the user ID.
	The USERID_ATTRIBUTE attribute is combined with the USER_OBJECTCLASS and USER_BASEDN (if specified) to construct an LDAP search filter when a user issues a Db2 CONNECT statement with an unqualified user ID.
	For example, if `USERID_ATTRIBUTE = uid`, then issuing this statement:
	`db2 connect to MYDB user bob using bobpass`
	results in the following search filter:
	`&(objectClass=inetOrgPerson)(uid=bob)`

AUTHID_ ATTRIBUTE	The LDAP user attribute that represents the Db2 authorization ID. Usually this is the same as the USERID_ATTRIBUTE. For example: `AUTHID_ATTRIBUTE = uid`

Table 34. Group-related values	
Parameter	**Description**
GROUP_ OBJECTCLASS	The LDAP object class used for groups. Generally this is `groupOfNames` or `groupOfUniqueNames` (for Microsoft Active Directory, it is `group`) For example: `GROUP_OBJECTCLASS = groupOfNames`
GROUP_BASEDN	The LDAP base DN to use when searching for groups If not specified, group searches start at the root of the LDAP directory. Some LDAP servers require that you specify a value for this parameter. For example: `GROUP_BASEDN = o=ibm`
GROUPNAME_ ATTRIBUTE	The LDAP group attribute that represents the name of the group. For example: `GROUPNAME_ATTRIBUTE = cn`
GROUP_LOOKUP_ METHOD	Determines the method used to find the group memberships for a user. Possible values are: • SEARCH_BY_DN Indicates to search for groups that list the user as a member. Membership is indicated by the group attribute defined as GROUP_LOOKUP_ATTRIBUTE (typically, `member` or `uniqueMember`). • USER_ATTRIBUTE In this case, a user's groups are listed as attributes of the user object itself. This setting indicates to search for the user attribute defined as GROUP_LOOKUP_ATTRIBUTE to get the user's groups (typically `memberOf` for Microsoft Active Directory or `ibm-allGroups` for IBM Tivoli® Directory Server). For example:`GROUP_LOOKUP_METHOD = SEARCH_BY_DN` `GROUP_LOOKUP_METHOD = USER_ATTRIBUTE`

Table 34. Group-related values (continued)	
Parameter	**Description**

GROUP_LOOKUP_ ATTRIBUTE	Name of the attribute used to determine group membership, as described for GROUP_LOOKUP_METHOD.
	For example:
	`GROUP_LOOKUP_ATTRIBUTE = member`
	`GROUP_LOOKUP_ATTRIBUTE = ibm-allGroups`

NESTED_GROUPS	If NESTED_GROUPS is TRUE, the Db2 database manager recursively searches for group membership by attempting to look up the group memberships for every group that is found. Cycles (such as A belongs to B, and B belongs to A) are handled correctly. This parameter is optional, and defaults to FALSE.

Table 35. Miscellaneous values	
Parameter	**Description**

SEARCH_DN, SEARCH_PW	If your LDAP server does not support anonymous access, or if anonymous access is not sufficient when searching for users or groups, then you can optionally define a DN and password that will be used to perform searches.
	For example:
	`SEARCH_DN = cn=root`
	`SEARCH_PW = rootpassword`

DEBUG	Set DEBUG to TRUE to write extra information to the **db2diag** log files to aid in debugging LDAP related issues. Most of the additional information is logged at DIAGLEVEL 4 (INFO). DEBUG defaults to false.

Enabling the LDAP plug-in modules

Compiled binary LDAP plug-in modules are found in your Db2 instance directory.

The following tables show where the LDAP plug-in modules are located on your Db2 instance.

Table 36. For 64-bit UNIX and Linux systems	
Plug-in module type	**Location**
server	`/sqllib/security64/plugin/IBM/server`
client	`/sqllib/security64/plugin/IBM/client`
group	`/sqllib/security64/plugin/IBM/group`

Table 37. For 32-bit UNIX and Linux systems	
Plug-in module type	**Location**
server	`/sqllib/security32/plugin/IBM/server`

Table 37. For 32-bit UNIX and Linux systems (continued)	
Plug-in module type	**Location**
client	/sqllib/security32/plugin/IBM/client
group	/sqllib/security32/plugin/IBM/group

Table 38. For Windows systems (both 64-bit and 32-bit)	
Plug-in module type	**Location**
server	%DB2PATH%\security\plugin\IBM*instance-name*\server
client	%DB2PATH%\security\plugin\IBM*instance-name*\client
group	%DB2PATH%\security\plugin\IBM*instance-name*\group

Note: 64-bit Windows plug-in modules include the digits 64 in the file name.

Use the Db2 command line processor to update the database manager configuration to enable the plug-in modules that you require:

- For the server plug-in module:

```
UPDATE DBM CFG USING SRVCON_PW_PLUGIN IBMLDAPauthserver
```

- For the client plug-in module:

```
UPDATE DBM CFG USING CLNT_PW_PLUGIN IBMLDAPauthclient
```

- For the group plug-in module:

```
UPDATE DBM CFG USING GROUP_PLUGIN IBMLDAPgroups
```

Terminate all running Db2 command line processor backend processes, by using the **db2 terminate** command, and then stop and restart the instance by using the **db2stop** and **db2start** commands.

Connecting with an LDAP user ID

After the LDAP security plug-ins have been configured in a Db2 instance, a user can connect to the databases using a variety of different user strings.

The location of an object within an LDAP directory is defined by its distinguished name (DN). A DN is typically a multi-part name that reflects some sort of hierarchy, for example:

```
cn=John Smith, ou=Sales, o=WidgetCorp
```

A user's *user ID* is defined by an attribute associated with the user object (typically the **uid** attribute). It may be a simple string (such as jsmith), or look like an email address (such as jsmith@sales.widgetcorp.com), that reflects part of the organizational hierarchy.

A user's Db2 *authorization ID* is the name associated with that user within the Db2 database.

In the past, users were typically defined in the server's host operating system, and the user ID and authorization ID were the same (though the authorization ID is usually in uppercase). The Db2 LDAP plug-in modules give you the ability to associate different attributes of the LDAP user object with the user ID and the authorization ID. In most cases, the user ID and authorization ID can be the same string, and you can use the same attribute name for both the USERID_ATTRIBUTE and the AUTHID_ATTRIBUTE. However, if in your environment the user ID attribute typically contains extra information that you do not want to carry over to the authorization ID, you can configure a different AUTHID_ATTRIBUTE in the

plug-in initialization file. The value of the AUTHID_ATTRIBUTE attribute is retrieved from the server and used as the internal Db2 representation of the user.

For example, if your LDAP user IDs look like email addresses (such as jsmith@sales.widgetcorp.com), but you would rather use just the user portion (jsmith) as the Db2 authorization ID, then you can:

1. Associate a new attribute containing the shorter name with all user objects on your LDAP server
2. Configure the AUTHID_ATTRIBUTE with the name of this new attribute

Users are then able to connect to a Db2 database by specifying their full LDAP user ID and password, for example:

```
db2 connect to MYDB user 'jsmith@sales.widgetcorp.com' using 'pswd'
```

But internally, the Db2 database manager refers to the user using the short name retrieved using the AUTHID_ATTRIBUTE (jsmith in this case).

After an LDAP plug-in module has been enabled and configured, a user can connect to a Db2 database using a variety of different strings:

- A full DN. For example:

  ```
  connect to MYDB user 'cn=John Smith, ou=Sales, o=WidgetCorp'
  ```

- A partial DN, provided that a search of the LDAP directory using the partial DN and the appropriate search base DN (if defined) results in exactly one match. For example:

  ```
  connect to MYDB user 'cn=John Smith' connect to MYDB user uid=jsmith
  ```

- A simple string (containing no equals signs). The string is qualified with the USERID_ATTRIBUTE and treated as a partial DN. For example:

  ```
  connect to MYDB user jsmith
  ```

Note: Any string supplied on a CONNECT statement or **ATTACH** command must be delimited with single quotation marks if it contains spaces or special characters.

You must configure the CLNT_PW_PLUGIN and GROUP_PLUGIN parameters on the Db2 client if you want to use full or partial DNs:

```
update dbm cfg using CLNT_PW_PLUGIN IBMLDAPauthclient
update dbm cfg using GROUP_PLUGIN IBMLDAPgroups
```

You must also update the LDAP plug-in configuration file, `IBMLDAPSecurityt.ini`.

Considerations for group lookup

Group membership information is typically represented on an LDAP server either as an attribute of the user object, or as an attribute of the group object:

- As an attribute of the user object

  Each user object has an attribute called GROUP_LOOKUP_ATTRIBUTE that you can query to retrieve all of the group membership for that user.

- As an attribute of the group object

  Each group object has an attribute, also called GROUP_LOOKUP_ATTRIBUTE, that you can use to list all the user objects that are members of the group. You can enumerate the groups for a particular user by searching for all groups that list the user object as a member.

Many LDAP servers can be configured in either of these ways, and some support both methods at the same time. Consult with your LDAP administrator to determine how your LDAP server is configured.

When configuring the LDAP plug-in modules, you can use the GROUP_LOOKUP_METHOD parameter to specify how group lookup should be performed:

- If you need to use the GROUP_LOOKUP_ATTRIBUTE attribute of the user object to find group membership, set GROUP_LOOKUP_METHOD = USER_ATTRIBUTE
- If you need to use the GROUP_LOOKUP_ATTRIBUTE attribute of the group object to find group membership, set GROUP_LOOKUP_METHOD = SEARCH_BY_DN

Many LDAP servers use the GROUP_LOOKUP_ATTRIBUTE attribute of the group object to determine membership. They can be configured as shown in this example:

```
GROUP_LOOKUP_METHOD = SEARCH_BY_DN
GROUP_LOOKUP_ATTRIBUTE = groupOfNames
```

Microsoft Active Directory typically stores group membership as a user attribute, and could be configured as shown in this example:

```
GROUP_LOOKUP_METHOD = USER_ATTRIBUTE
GROUP_LOOKUP_ATTRIBUTE = memberOf
```

The IBM Tivoli Directory Server supports both methods at the same time. To query the group membership for a user you can make use of the special user attribute **ibm-allGroups**, as shown in this example:

```
GROUP_LOOKUP_METHOD = USER_ATTRIBUTE
GROUP_LOOKUP_ATTRIBUTE = ibm-allGroups
```

Other LDAP servers may offer similar special attributes to aid in retrieving group membership. In general, retrieving membership through a user attribute is faster than searching for groups that list the user as a member.

Troubleshooting authenticating LDAP users or retrieving groups

If you encounter problems authenticating LDAP users or retrieving their groups, the **db2diag** log files and administration log are a good source of information to aid in troubleshooting.

The LDAP plug-in modules typically log LDAP return codes, search filters, and other useful data when a failure occurs. If you enable the DEBUG option in the LDAP plug-in configuration file, the plug-in modules will log even more information in the **db2diag** log files. While this might be an aid in troubleshooting, it is not recommended for extended use on production systems due to the overhead associated with writing all of the extra data to a single file.

Ensure that the **diaglevel** configuration parameter in the database manager is set to 4 so that all messages from the LDAP plug-in modules will be captured.

Writing security plug-ins

How Db2 loads security plug-ins

So that the Db2 database system has the necessary information to call security plug-in functions, a security plug-in must have a correctly set up initialization function.

Each plug-in library must contain an initialization function with a specific name determined by the plug-in type:

- Server side authentication plug-in: `db2secServerAuthPluginInit()`
- Client side authentication plug-in: `db2secClientAuthPluginInit()`
- Group plug-in: `db2secGroupPluginInit()`

This function is known as the plug-in initialization function. The plug-in initialization function initializes the specified plug-in and provides Db2 with information that it requires to call the plug-in's functions. The plug-in initialization function accepts the following parameters:

- The highest version number of the function pointer structure that the Db2 instance invoking the plug-in can support

- A pointer to a structure containing pointers to all the APIs requiring implementation
- A pointer to a function that adds log messages to the **db2diag** log files
- A pointer to an error message string
- The length of the error message

The following is a function signature for the initialization function of a group retrieval plug-in:

```
SQL_API_RC SQL_API_FN db2secGroupPluginInit(
  db2int32 version,
  void *group_fns,
  db2secLogMessage *logMessage_fn,
  char **errormsg,
  db2int32  *errormsglen);
```

Note: If the plug-in library is compiled as C++, all functions must be declared with: `extern "C"`. Db2 relies on the underlying operating system dynamic loader to handle the C++ constructors and destructors used inside of a C++ user-written plug-in library.

The initialization function is the only function in the plug-in library that uses a prescribed function name. The other plug-in functions are referenced through function pointers returned from the initialization function. Server plug-ins are loaded when the Db2 server starts. Client plug-ins are loaded when required on the client. Immediately after Db2 loads a plug-in library, it will resolve the location of this initialization function and call it. The specific task of this function is as follows:

- Cast the functions pointer to a pointer to an appropriate functions structure
- Specify the pointers to the other functions in the library
- Specify the version number of the function pointer structure being returned

Db2 can potentially call the plug-in initialization function more than once. This situation can occur when an application dynamically loads the Db2 client library, unloads it, and reloads it again, then performs authentication functions from a plug-in both before and after reloading. In this situation, the plug-in library might not be unloaded and then re-loaded; however, this behavior varies depending on the operating system.

Another example of Db2 issuing multiple calls to a plug-in initialization function occurs during the execution of stored procedures or federated system calls, where the database server can itself act as a client. If the client and server plug-ins on the database server are in the same file, Db2 could call the plug-in initialization function twice.

If the plug-in detects that `db2secGroupPluginInit` is called more than once, it should handle this event as if it was directed to terminate and reinitialize the plug-in library. As such, the plug-in initialization function should do the entire cleanup tasks that a call to `db2secPluginTerm` would do before returning the set of function pointers again.

On a Db2 server running on a UNIX or Linux-based operating system, Db2 can potentially load and initialize plug-in libraries more than once in different processes.

Restrictions for developing security plug-in libraries

There are certain restrictions that affect how you develop plug-in libraries.

The following list outlines the restrictions for developing plug-in libraries.

C-linkage
Plug-in libraries must be linked with C-linkage. Header files providing the prototypes, data structures needed to implement the plug-ins, and error code definitions are provided for C/C++ only. Functions that Db2 will resolve at load time must be declared with extern "C" if the plug-in library is compiled as C++.

.NET common language runtime is not supported
The .NET common language runtime (CLR) is not supported for compiling and linking source code for plug-in libraries.

Signal handlers
Plug-in libraries must not install signal handlers or change the signal mask, because this will interfere with the Db2 signal handlers. Interfering with the Db2 signal handlers could seriously interfere with the ability for Db2 to report and recover from errors, including traps in the plug-in code itself. Plug-in libraries should also never throw C++ exceptions, as this can also interfere with the error handling used in Db2.

Thread-safe
Plug-in libraries must be thread-safe and re-entrant. The plug-in initialization function is the only API that is not required to be re-entrant. The plug-in initialization function could potentially be called multiple times from different processes; in which case, the plug-in will cleanup all used resources and reinitialize itself.

Exit handlers and overriding standard C library and operating system calls
Plug-in libraries should not override standard C library or operating system calls. Plug-in libraries should also not install exit handlers or `pthread_atfork` handlers. The use of exit handlers is not recommended because they could be unloaded before the program exits.

Library dependencies
On Linux or UNIX, the processes that load the plug-in libraries can be `setuid` or `setgid`, which means that they will not be able to rely on the `$LD_LIBRARY_PATH, $SHLIB_PATH`, or `$LIBPATH` environment variables to find dependent libraries. Therefore, plug-in libraries should not depend on additional libraries, unless any dependent libraries are accessible through other methods, such as the following situations:

- By being in `/lib` or `/usr/lib`
- By having the directories they reside in being specified OS-wide (such as in the `ld.so.conf` file on Linux)
- By being specified in the RPATH in the plug-in library itself

This restriction is not applicable to Windows operating systems.

Symbol collisions
When possible, plug-in libraries should be compiled and linked with any available options that reduce the likelihood of symbol collisions, such as those that reduce unbound external symbolic references. For example, use of the "-Bsymbolic" linker option on HP and Linux can help prevent problems related to symbol collisions. However, for plug-ins written on AIX, do not use the "`-brtl`" linker option explicitly or implicitly.

32-bit and 64-bit applications
32-bit applications must use 32-bit plug-ins. 64-bit applications must use 64-bit plug-ins. Refer to the topic about 32-bit and 64-bit considerations for more details.

Text strings
Input text strings are not guaranteed to be null-terminated, and output strings are not required to be null-terminated. Instead, integer lengths are given for all input strings, and pointers to integers are given for lengths to be returned.

Passing authorization ID parameters
An authorization ID (authid) parameter that Db2 passes into a plug-in (an input authid parameter) will contain an upper-case authid, with padded blanks removed. An authid parameter that a plug-in returns to Db2 (an output authid parameter) does not require any special treatment, but Db2 will fold the authid to upper-case and pad it with blanks according to the internal Db2 standard.

Size limits for parameters
The plug-in APIs use the following as length limits for parameters:

```
#define DB2SEC_MAX_AUTHID_LENGTH 255
#define DB2SEC_MAX_USERID_LENGTH 255
#define DB2SEC_MAX_USERNAMESPACE_LENGTH 255
#define DB2SEC_MAX_PASSWORD_LENGTH 255
#define DB2SEC_MAX_DBNAME_LENGTH 128
```

A particular plug-in implementation may require or enforce smaller maximum lengths for the authorization IDs, user IDs, and passwords. In particular, the operating system authentication plug-

ins supplied with Db2 database systems are restricted to the maximum user, group and namespace length limits enforced by the operating system for cases where the operating system limits are lower than those stated previously.

Security plug-in library extensions in AIX

On AIX systems, security plug-in libraries can have a file name extension of *.a* or *.so*. The mechanism used to load the plug-in library depends on which extension is used:

- Plug-in libraries with a file name extension of *.a* are assumed to be archives containing shared object members. These members must be named *shr.o* (32-bit) or *shr64.o* (64-bit). A single archive can contain both the 32-bit and 64-bit members, allowing it to be deployed on both types of platforms.

  For example, to build a 32-bit archive style plug-in library:

  ```
  xlc_r -qmkshrobj -o shr.o MyPlugin.c -bE:MyPlugin.exp
  ar rv MyPlugin.a shr.o
  ```

- Plug-in libraries with a file name extension of *.so* are assumed to be dynamically loadable shared objects. Such an object is either 32-bit or 64-bit, depending on the compiler and linker options used when it was built. For example, to build a 32-bit plug-in library:

  ```
  xlc_r -qmkshrobj -o MyPlugin.so MyPlugin.c -bE:MyPlugin.exp
  ```

On all platforms other than AIX, security plug-in libraries are always assumed to be dynamically loadable shared objects.

Fork

Plug-in libraries should not fork because file descriptors and sockets will be duplicated in the child process, and this can cause hangs or incorrect behavior. In particular, it can cause false file lock conflicts if child was forked when we had an open file descriptor on that file. There is also the possibility that the fork will inherit many other resources like semaphores.

Restrictions on security plug-ins

There are certain restrictions on the use of security plug-ins.

Db2 database family support restrictions

You cannot use a GSS-API plug-in to authenticate connections between Db2 clients on Linux, UNIX, and Windows and another Db2 family servers such as Db2 for z/OS.

You also cannot authenticate connections from another Db2 database family product, acting as a client, to a Db2 server on Linux, UNIX, or Windows.

If you use a Db2 client on Linux, UNIX, or Windows to connect to other Db2 database family servers, you can use client-side user ID/password plug-ins (such as the IBM shipped operating system authentication plug-in), or you can write your own user ID/password plug-in. You can also use the built-in Kerberos plug-ins, or implement your own.

With a Db2 client on Linux, UNIX, or Windows, you should not catalog a database using the GSSPLUGIN authentication type.

Restrictions on the authorization ID: In Db2 Version 9.5 and later, you can have a 128-byte authorization ID. However, when the authorization ID is interpreted as an operating system user ID or group name, Db2 imposed naming restrictions apply. For example, the Linux and UNIX operating systems can contain up to 8 characters and the Windows operating systems can contain up to 30 characters for user IDs and group names. Therefore, if you want to connect as a user that has a 128-byte authorization ID, you need to write your own security plug-in. In the plug-in, you can use the extended sizes for the authorization ID. For example, you can give your security plug-in a 30-byte user ID and, during authentication, it returns a 128-byte authorization ID that you can connect to.

InfoSphere Federation Server support restrictions

Db2 II does not support the use of delegated credentials from a GSS_API plug-in to establish outbound connections to data sources. Connections to data sources must continue to use the CREATE USER MAPPING command.

Database Administration Server support restrictions

The Db2 Administration Server (DAS) does not support security plug-ins. The DAS only supports the operating system authentication mechanism.

Security plug-in problem and restriction for Db2 clients (Windows)

When developing security plug-ins that will be deployed in Db2 clients on Windows operating systems, do not unload any auxiliary libraries in the plug-in termination function. This restriction applies to all types of client security plug-ins, including group, user ID and password, Kerberos, and GSS-API plug-ins. Since these termination APIs such as db2secPluginTerm, db2secClientAuthPluginTerm and db2secServerAuthPluginTerm are not called on any Windows platform, you need to do the appropriate resource cleanup.

This restriction is related to cleanup issues associated with the unloading of DLLs on Windows.

Loading plug-in libraries on AIX with extension of .a or .so

On AIX, security plug-in libraries can have a file name extension of `.a` or `.so`. The mechanism used to load the plug-in library depends on which extension is used:

- Plug-in libraries with a file name extension of `.a`

  Plug-in libraries with file name extensions of .a are assumed to be archives containing shared object members. These members must be named `shr.o` (32-bit) or `shr64.o` (64-bit). A single archive can contain both the 32-bit and 64-bit members, allowing it to be deployed on both types of platforms.

  For example, to build a 32-bit archive style plug-in library:

  ```
  xlc_r -qmkshrobj -o shr.o MyPlugin.c -bE:MyPlugin.exp
  ar rv MyPlugin.a shr.o
  ```

- Plug-in libraries with a file name extension of `.so`

  Plug-in libraries with file name extensions of .so are assumed to be dynamically loadable shared objects. Such an object is either 32-bit or 64-bit, depending on the compiler and linker options used when it was built. For example, to build a 32-bit plug-in library:

  ```
  xlc_r -qmkshrobj -o MyPlugin.so MyPlugin.c -bE:MyPlugin.exp
  ```

On all platforms other than AIX, security plug-in libraries are always assumed to be dynamically loadable shared objects.

GSS-API security plug-ins do not support message encryption and signing

Message encryption and signing is not available in GSS-API security plug-ins.

Return codes for security plug-ins

All security plug-in APIs must return an integer value to indicate the success or failure of the execution of the API. A return code value of `0` indicates that the API ran successfully. All negative return codes, with the exception of `-3`, `-4`, and `-5`, indicate that the API encountered an error.

All negative return codes returned from the security-plug-in APIs are mapped to SQLCODE -1365, SQLCODE -1366, or SQLCODE -30082, with the exception of return codes with the `-3`, `-4`, or `-5`. The

values -3, -4, and -5 are used to indicate whether or not an authorization ID represents a valid user or group.

All the security plug-in API return codes are defined in db2secPlugin.h, which can be found in the Db2 include directory: SQLLIB/include.

Details regarding all of the security plug-in return codes are presented in the following table:

Table 39. Security plug-in return codes

Return code	Define value	Meaning	Applicable APIs
0	DB2SEC_PLUGIN_OK	The plug-in API executed successfully.	All
-1	DB2SEC_PLUGIN_UNKNOWNERROR	The plug-in API encountered an unexpected error.	All
-2	DB2SEC_PLUGIN_BADUSER	The user ID passed in as input is not defined.	db2secGenerateInitialCred db2secValidatePassword db2secRemapUserid db2secGetGroupsForUser
-3	DB2SEC_PLUGIN_INVALIDUSERORGROUP	No such user or group.	db2secDoesAuthIDExist db2secDoesGroupExist
-4	DB2SEC_PLUGIN_USERSTATUSNOTKNOWN	Unknown user status. This is not treated as an error by Db2; it is used by a GRANT statement to determine if an authid represents a user or an operating system group.	db2secDoesAuthIDExist
-5	DB2SEC_PLUGIN_GROUPSTATUSNOTKNOWN	Unknown group status. This is not treated as an error by Db2; it is used by a GRANT statement to determine if an authid represents a user or an operating system group.	db2secDoesGroupExist
-6	DB2SEC_PLUGIN_UID_EXPIRED	User ID expired.	db2secValidatePassword db2GetGroupsForUser db2secGenerateInitialCred
-7	DB2SEC_PLUGIN_PWD_EXPIRED	Password expired.	db2secValidatePassword db2GetGroupsForUser db2secGenerateInitialCred
-8	DB2SEC_PLUGIN_USER_REVOKED	User revoked.	db2secValidatePassword db2GetGroupsForUser
-9	DB2SEC_PLUGIN_USER_SUSPENDED	User suspended.	db2secValidatePassword db2GetGroupsForUser

Table 39. Security plug-in return codes (continued)

Return code	Define value	Meaning	Applicable APIs
-10	DB2SEC_PLUGIN_BADPWD	Bad password.	db2secValidatePassword db2secRemapUserid db2secGenerateInitialCred
-11	DB2SEC_PLUGIN_BAD_NEWPASSWORD	Bad new password.	db2secValidatePassword db2secRemapUserid
-12	DB2SEC_PLUGIN_CHANGEPASSWORD_NOTSUPPORTED	Change password not supported.	db2secValidatePassword db2secRemapUserid db2secGenerateInitialCred
-13	DB2SEC_PLUGIN_NOMEM	Plug-in attempt to allocate memory failed due to insufficient memory.	All
-14	DB2SEC_PLUGIN_DISKERROR	Plug-in encountered a disk error.	All
-15	DB2SEC_PLUGIN_NOPERM	Plug-in attempt to access a file failed because of wrong permissions on the file.	All
-16	DB2SEC_PLUGIN_NETWORKERROR	Plug-in encountered a network error.	All
-17	DB2SEC_PLUGIN_CANTLOADLIBRARY	Plug-in is unable to load a required library.	db2secGroupPluginInit db2secClientAuthPluginInit db2secServerAuthPluginInit
-18	DB2SEC_PLUGIN_CANT_OPEN_FILE	Plug-in is unable to open and read a file for a reason other than missing file or inadequate file permissions.	All
-19	DB2SEC_PLUGIN_FILENOTFOUND	Plug-in is unable to open and read a file, because the file is missing from the file system.	All
-20	DB2SEC_PLUGIN_CONNECTION_DISALLOWED	The plug-in is refusing the connection because of the restriction on which database is allowed to connect, or the TCP/IP address cannot connect to a specific database.	All server-side plug-in APIs.
-21	DB2SEC_PLUGIN_NO_CRED	GSS API plug-in only: initial client credential is missing.	db2secGetDefaultLoginContext db2secServerAuthPluginInit

Table 39. Security plug-in return codes (continued)

Return code	Define value	Meaning	Applicable APIs
-22	DB2SEC_PLUGIN_CRED_EXPIRED	GSS API plug-in only: client credential has expired.	db2secGetDefaultLoginContext db2secServerAuthPluginInit
-23	DB2SEC_PLUGIN_BAD_PRINCIPAL_NAME	GSS API plug-in only: the principal name is invalid.	db2secProcessServerPrincipalName
-24	DB2SEC_PLUGIN_NO_CON_DETAILS	This return code is returned by the db2secGetConDetails callback (for example, from Db2 to the plug-in) to indicate that Db2 is unable to determine the client's TCP/IP address.	db2secGetConDetails
-25	DB2SEC_PLUGIN_BAD_INPUT_PARAMETERS	Some parameters are not valid or are missing when plug-in API is called.	All
-26	DB2SEC_PLUGIN_INCOMPATIBLE_VER	The version of the APIs reported by the plug-in is not compatible with Db2.	db2secGroupPluginInit db2secClientAuthPluginInit db2secServerAuthPluginInit
-27	DB2SEC_PLUGIN_PROCESS_LIMIT	Insufficient resources are available for the plug-in to create a new process.	All
-28	DB2SEC_PLUGIN_NO_LICENSES	The plug-in encountered a user license problem. A possibility exists that the underlying mechanism license has reached the limit.	All
-29	DB2SEC_PLUGIN_ROOT_NEEDED	The plug-in is trying to run an application that requires root privileges.	All
-30	DB2SEC_PLUGIN_UNEXPECTED_SYSTEM_ERROR	The plug-in encountered an unexpected system error. A possibility exists that the current system configuration is not supported.	All

Error message handling for security plug-ins

When an error occurs in a security plug-in API, the API can return an ASCII text string in the errormsg field to provide a more specific description of the problem than the return code.

For example, the errormsg string can contain "File /home/db2inst1/mypasswd.txt does not exist." Db2 will write this entire string into the Db2 administration notification log, and will also include a truncated version as a token in some SQL messages. Because tokens in SQL messages can only be of limited length, these messages should be kept short, and important variable portions of these messages

should appear at the front of the string. To aid in debugging, consider adding the name of the security plug-in to the error message.

For non-urgent errors, such as password expired errors, the `errormsg` string will only be dumped when the DIAGLEVEL database manager configuration parameter is set at 4.

The memory for these error messages must be allocated by the security plug-in. Therefore, the plug-ins must also provide an API to free this memory: `db2secFreeErrormsg`.

The `errormsg` field will only be checked by Db2 if an API returns a non-zero value. Therefore, the plug-in should not allocate memory for this returned error message if there is no error.

At initialization time a message logging function pointer, `logMessage_fn`, is passed to the group, client, and server plug-ins. The plug-ins can use the function to log any debugging information to the **db2diag** log files. For example:

```
// Log an message indicate init successful
(*(logMessage_fn))(DB2SEC_LOG_CRITICAL,
                   "db2secGroupPluginInit successful",
                    strlen("db2secGroupPluginInit successful"));
```

For more details about each parameter for the `db2secLogMessage` function, refer to the initialization API for each of the plug-in types.

Calling sequences for the security plug-in APIs

The sequence with which the Db2 database manager calls the security plug-in APIs varies according to the scenario in which the security plug-in API is called.

These are the main scenarios in which the Db2 database manager calls security plug-in APIs:

- On a client for a database connection (implicit and explicit)
  - CLIENT
  - Server-based (SERVER, SERVER_ENCRYPT)
  - GSSAPI and Kerberos
- On a client, server, or gateway for local authorization
- On a server for a database connection
- On a server for a grant statement
- On a server to get a list of groups to which an authorization ID belongs

Note: The Db2 database servers treat database actions requiring local authorizations, such as **db2start**, **db2stop**, and **db2trc** like client applications.

For each of these operations, the sequence with which the Db2 database manager calls the security plug-in APIs is different. Following are the sequences of APIs called by the Db2 database manager for each of these scenarios.

CLIENT - implicit

When the user-configured authentication type is CLIENT, the Db2 client application calls the following security plug-in APIs:

- `db2secGetDefaultLoginContext();`
- `db2secValidatePassword();`
- `db2secFreetoken();`

For an implicit authentication, that is, when you connect without specifying a particular user ID or password, the `db2secValidatePassword` API is called if you are using a user ID/password plug-in. This API permits plug-in developers to prohibit implicit authentication if necessary.

CLIENT - explicit

On an explicit authentication, that is, when you connect to a database in which both the user ID and password are specified, if the **authentication** database manager configuration parameter is set

to CLIENT, the Db2 client application calls the following security plug-in APIs multiple times if the implementation requires it:

- db2secRemapUserid();
- db2secValidatePassword();
- db2secFreeToken();

Server-based (SERVER, SERVER_ENCRYPT) - implicit
On an implicit authentication, when the client and server negotiate user ID/password authentication (for example, when the **srvcon_auth** parameter at the server is set to SERVER; SERVER_ENCRYPT), the client application calls the following security plug-in APIs:

- db2secGetDefaultLoginContext();
- db2secFreeToken();

Server-based (SERVER, SERVER_ENCRYPT) - explicit
On an explicit authentication, when the client and server negotiate userid/password authentication (for example, when the **srvcon_auth** parameter at the server is set to SERVER; SERVER_ENCRYPT), the client application calls the following security plug-in APIs:

- db2secRemapUserid();

GSSAPI and Kerberos - implicit
On an implicit authentication, when the client and server negotiate GSS-API or Kerberos authentication (for example, when the **srvcon_auth** parameter at the server is set to KERBEROS; KRB_SERVER_ENCRYPT, GSSPLUGIN, or GSS_SERVER_ENCRYPT), the client application calls the following security plug-in APIs. (The call to gss_init_sec_context() uses GSS_C_NO_CREDENTIAL as the input credential.)

- db2secGetDefaultLoginContext();
- db2secProcessServerPrincipalName();
- gss_init_sec_context();
- gss_release_buffer();
- gss_release_name();
- gss_delete_sec_context();
- db2secFreeToken();

With multi-flow GSS-API support, gss_init_sec_context() can be called multiple times if the implementation requires it.

GSSAPI and Kerberos - explicit
If the negotiated authentication type is GSS-API or Kerberos, the client application calls the following security plug-in APIs for GSS-API plug-ins in the following sequence. These APIs are used for both implicit and explicit authentication unless otherwise stated.

- db2secProcessServerPrincipalName();
- db2secGenerateInitialCred(); (For explicit authentication only)
- gss_init_sec_context();
- gss_release_buffer ();
- gss_release_name();
- gss_release_cred();
- db2secFreeInitInfo();
- gss_delete_sec_context();
- db2secFreeToken();

The API gss_init_sec_context() might be called multiple times if a mutual authentication token is returned from the server and the implementation requires it.

On a client, server, or gateway for local authorization
For a local authorization, the Db2 command being used calls the following security plug-in APIs:

- `db2secGetDefaultLoginContext();`
- `db2secGetGroupsForUser();`
- `db2secFreeToken();`
- `db2secFreeGroupList();`

These APIs are called for both user ID/password and GSS-API authentication mechanisms.

On a server for a database connection
For a database connection on the database server, the Db2 agent process or thread calls the following security plug-in APIs for the user ID/password authentication mechanism:

- `db2secValidatePassword();` Only if the **`authentication`** database configuration parameter is not `CLIENT`
- `db2secGetAuthIDs();`
- `db2secGetGroupsForUser();`
- `db2secFreeToken();`
- `db2secFreeGroupList();`

For a CONNECT to a database, the Db2 agent process thread calls the following security plug-in APIs for the GSS-API authentication mechanism:

- `gss_accept_sec_context();`
- `gss_release_buffer();`
- `db2secGetAuthIDs();`
- `db2secGetGroupsForUser();`
- `gss_delete_sec_context();`
- `db2secFreeGroupListMemory();`

On a server for a GRANT statement
For a GRANT statement that does not specify the USER or GROUP keyword, (for example, "`GRANT CONNECT ON DATABASE TO user1`"), the Db2 agent process or thread must be able to determine if `user1` is a user, a group, or both. Therefore, the Db2 agent process or thread calls the following security plug-in APIs:

- `db2secDoesGroupExist();`
- `db2secDoesAuthIDExist();`

On a server to get a list of groups to which an authid belongs
From your database server, when you need to get a list of groups to which an authorization ID belongs, the Db2 agent process or thread calls the following security plug-in API with only the authorization ID as input:

- `db2secGetGroupsForUser();`

There will be no token from other security plug-ins.

Chapter 9. Security plug-in APIs

To enable you to customize the Db2 database system authentication and group membership lookup behavior, the Db2 database system provides APIs that you can use to modify existing plug-in modules or build new security plug-in modules.

When you develop a security plug-in module, you need to implement the standard authentication or group membership lookup functions that the Db2 database manager will invoke. For the three available types of plug-in modules, the functionality you need to implement is as follows:

Group retrieval
Retrieves group membership information for a given user and determines if a given string represents a valid group name.

User ID/password authentication
Authentication that identifies the default security context (client only), validates and optionally changes a password, determines if a given string represents a valid user (server only), modifies the user ID or password provided on the client before it is sent to the server (client only), returns the Db2 authorization ID associated with a given user.

GSS-API authentication
Authentication that implements the required GSS-API functions, identifies the default security context (client side only), generates initial credentials based on user ID and password, and optionally changes password (client side only), creates and accepts security tickets, and returns the Db2 authorization ID associated with a given GSS-API security context.

The following list shows the definitions for terminology used in the descriptions of the plug-in APIs.

Plug-in
A dynamically loadable library that Db2 will load to access user-written authentication or group membership lookup functions.

Implicit authentication
A connection to a database without specifying a user ID or a password.

Explicit authentication
A connection to a database in which both the user ID and password are specified.

Authid
An internal ID representing an individual or group to which authorities and privileges within the database are granted. Internally, a Db2 authid is folded to upper-case and is a minimum of 8 characters (blank padded to 8 characters). Currently, Db2 requires authids, user IDs, passwords, group names, namespaces, and domain names that can be represented in 7-bit ASCII.

Local authorization
Authorization that is local to the server or client that implements it, that checks if a user is authorized to perform an action (other than connecting to the database), such as starting and stopping the database manager, turning Db2 trace on and off, or updating the database manager configuration.

Namespace
A collection or grouping of users within which individual user identifiers must be unique. Common examples include Windows domains and Kerberos Realms. For example, within the Windows domain "usa.company.com" all user names must be unique. For example, "user1@usa.company.com". The same user ID in another domain, as in the case of "user1@canada.company.com", however refers to a different person. A fully qualified user identifier includes a user ID and namespace pair; for example, "user@domain.name" or "domain\user".

Input
Indicates that Db2 will enter in the value for the security plug-in API parameter.

Output
Indicates that the security plug-in API will specify the value for the API parameter.

APIs for group retrieval plug-ins

For the group retrieval plug-in module, you need to implement the following APIs:

- `db2secGroupPluginInit`

  Note: The db2secGroupPluginInit API takes as input a pointer, `*logMessage_fn`, to an API with the following prototype:

```
SQL_API_RC (SQL_API_FN db2secLogMessage)
(
db2int32 level,
void    *data,
db2int32 length
);
```

  The db2secLogMessage API allows the plug-in to log messages to the **db2diag** log files for debugging or informational purposes. This API is provided by the Db2 database system, so you need not implement it.
- `db2secPluginTerm`
- `db2secGetGroupsForUser`
- `db2secDoesGroupExist`
- `db2secFreeGroupListMemory`
- `db2secFreeErrormsg`
- The only API that must be resolvable externally is `db2secGroupPluginInit`. This API will take a `void *` parameter, which should be cast to the type:

```
typedef struct db2secGroupFunctions_1
{
db2int32 version;
db2int32 plugintype;
SQL_API_RC (SQL_API_FN * db2secGetGroupsForUser)
(
const char *authid,
db2int32    authidlen,
const char *userid,
db2int32    useridlen,
const char *usernamespace,
db2int32    usernamespacelen,
db2int32    usernamespacetype,
const char *dbname,
db2int32    dbnamelen,
const void *token,
db2int32    tokentype,
db2int32    location,
const char *authpluginname,
db2int32    authpluginnamelen,
void      **grouplist,
db2int32   *numgroups,
char      **errormsg,
db2int32   *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secDoesGroupExist)
(
const char *groupname,
db2int32    groupnamelen,
char      **errormsg,
db2int32   *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secFreeGroupListMemory)
(
void     *ptr,
char    **errormsg,
db2int32 *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secFreeErrormsg)
(
char *msgtobefree
);
```

```
SQL_API_RC (SQL_API_FN * db2secPluginTerm)
(
char    **errormsg,
db2int32 *errormsglen
);

} db2secGroupFunctions_1;
```

The db2secGroupPluginInit API assigns the addresses for the rest of the externally available functions.

Note: The _1 indicates that this is the structure corresponding to version 1 of the API. Subsequent interface versions will have the extension _2, _3, and so on.

db2secDoesGroupExist API - Check if group exists

Determines whether an authid represents a group.

If the **groupname** exists, the API must be able to return the value DB2SEC_PLUGIN_OK, to indicate success. It must also be able to return the value DB2SEC_PLUGIN_INVALIDUSERORGROUP if the group name is not valid. It is permissible for the API to return the value DB2SEC_PLUGIN_GROUPSTATUSNOTKNOWN if it is impossible to determine if the input is a valid group. If an invalid group (DB2SEC_PLUGIN_INVALIDUSERORGROUP) or group not known (DB2SEC_PLUGIN_GROUPSTATUSNOTKNOWN) value is returned, Db2 might not be able to determine whether the authid is a group or user when issuing the GRANT statement without the keywords USER and GROUP, which would result in the error SQLCODE -569, SQLSTATE 56092 being returned to the user.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secDoesGroupExist)
                       ( const char *groupname,
                         db2int32 groupnamelen,
                         char      **errormsg,
                         db2int32 *errormsglen );
```

db2secDoesGroupExist API parameters

groupname
Input. An authid, upper-cased, with no trailing blanks.

groupnamelen
Input. Length in bytes of the **groupname** parameter value.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secDoesGroupExist API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secFreeErrormsg API - Free error message memory

Frees the memory used to hold an error message from a previous API call. This is the only API that does not return an error message. If this API returns an error, Db2 will log it and continue.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secFreeErrormsg)
                       ( char *errormsg );
```

db2secFreeErrormsg API parameters

errormsg
Input. A pointer to the error message allocated from a previous API call.

db2secFreeGroupListMemory API - Free group list memory

Frees the memory used to hold the list of groups from a previous call to db2secGetGroupsForUser API.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secFreeGroupListMemory)
                      ( void *ptr,
                        char      **errormsg,
                        db2int32 *errormsglen );
```

db2secFreeGroupListMemory API parameters

ptr
Input. Pointer to the memory to be freed.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secFreeGroupListMemory API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in the **errormsg** parameter.

db2secGetGroupsForUser API - Get list of groups for user

Returns the list of groups to which a user belongs.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secGetGroupsForUser)
                      ( const char *authid,
                        db2int32 authidlen,
                        const char *userid,
                        db2int32 useridlen,
                        const char *usernamespace,
                        db2int32 usernamespacelen,
                        db2int32 usernamespacetype,
                        const char *dbname,
                        db2int32 dbnamelen,
                        void *token,
                        db2int32 tokentype,
                        db2int32 location,
                        const char *authpluginname,
                        db2int32 authpluginnamelen,
                        void      **grouplist,
                        db2int32 *numgroups,
                        char      **errormsg,
                        db2int32 *errormsglen );
```

db2secGetGroupsForUser API parameters

authid
Input. This parameter value is an SQL authid, which means that Db2 converts it to an uppercase character string with no trailing blanks. Db2 always provides a non-null value for the **authid** parameter. The API must be able to return a list of groups to which the authid belongs without depending on the other input parameters. It is permissible to return a shortened or empty list if this cannot be determined.

If a user does not exist, the API must return the return code DB2SEC_PLUGIN_BADUSER. Db2 does not treat the case of a user not existing as an error, since it is permissible for an authid to not have any groups associated with it. For example, the db2secGetAuthids API can return an authid that does not exist on the operating system. The authid is not associated with any groups, however, it can still be assigned privileges directly.

If the API cannot return a complete list of groups using only the authid, then there will be some restrictions on certain SQL functions related to group support. For a list of possible problem scenarios, see the Usage notes section in this topic.

authidlen
Input. Length in bytes of the **authid** parameter value. The Db2 database manager always provides a non-zero value for the **authidlen** parameter.

userid
Input. This is the user ID corresponding to the **authid**. When this API is called on the server in a non-connect scenario, this parameter will not be filled by Db2.

useridlen
Input. Length in bytes of the **userid** parameter value.

usernamespace
Input. The namespace from which the user ID was obtained. When the user ID is not available, this parameter will not be filled by the Db2 database manager.

usernamespacelen
Input. Length in bytes of the **usernamespace** parameter value.

usernamespacetype
Input. The type of namespace. Valid values for the **usernamespacetype** parameter (defined in db2secPlugin.h) are:

- DB2SEC_NAMESPACE_SAM_COMPATIBLE Corresponds to a username style like domain\myname
- DB2SEC_NAMESPACE_USER_PRINCIPAL Corresponds to a username style like myname@domain.ibm.com

Currently, the Db2 database system only supports the value DB2SEC_NAMESPACE_SAM_COMPATIBLE. When the user ID is not available, the **usernamespacetype** parameter is set to the value DB2SEC_USER_NAMESPACE_UNDEFINED (defined in db2secPlugin.h).

dbname
Input. Name of the database being connected to. This parameter can be NULL in a non-connect scenario.

dbnamelen
Input. Length in bytes of the **dbname** parameter value. This parameter is set to 0 if **dbname** parameter is NULL in a non-connect scenario.

token
Input. A pointer to data provided by the authentication plug-in. It is not used by Db2. It provides the plug-in writer with the ability to coordinate user and group information. This parameter might not be provided in all cases (for example, in a non-connect scenario), in which case it will be NULL. If the authentication plug-in used is GSS-API based, the token will be set to the GSS-API context handle (gss_ctx_id_t).

tokentype
Input. Indicates the type of data provided by the authentication plug-in. If the authentication plug-in used is GSS-API based, the token will be set to the GSS-API context handle (gss_ctx_id_t). If the authentication plug-in used is user ID/password based, it will be a generic type. Valid values for the **tokentype** parameter (defined in db2secPlugin.h) are:

- DB2SEC_GENERIC: Indicates that the token is from a user ID/password based plug-in.
- DB2SEC_GSSAPI_CTX_HANDLE: Indicates that the token is from a GSS-API (including Kerberos) based plug-in.

location
Input. Indicates whether Db2 is calling this API on the client side or server side. Valid values for the location parameter (defined in `db2secPlugin.h`) are:

- `DB2SEC_SERVER_SIDE`: The API is to be called on the database server.
- `DB2SEC_CLIENT_SIDE`: The API is to be called on a client.

authpluginname
Input. Name of the authentication plug-in that provided the data in the token. The `db2secGetGroupsForUser` API might use this information in determining the correct group memberships. This parameter might not be filled by Db2 if the **authid** is not authenticated (for example, if the **authid** does not match the current connected user).

authpluginnamelen
Input. Length in bytes of the **authpluginname** parameter value.

grouplist
Output. List of groups to which the user belongs. The list of groups must be returned as a pointer to a section of memory allocated by the plug-in containing concatenated varchars (a varchar is a character array in which the first byte indicates the number of bytes following the first byte). The length is an unsigned char (1 byte) and that limits the maximum length of a groupname to 255 characters. For example, "\006GROUP1\007MYGROUP\008MYGROUP3". Each group name should be a valid Db2 authid. The memory for this array must be allocated by the plug-in. The plug-in must therefore provide an API, such as the `db2secFreeGroupListMemory` API that Db2 will call to free the memory.

numgroups
Output. The number of groups contained in the **grouplist** parameter.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the `db2secGetGroupsForUser` API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

Usage notes

The following list describes the scenarios that which problems can occur if an incomplete group list is returned by this API to Db2:

- Alternate authorization is provided in CREATE SCHEMA statement. Group lookup will be performed against the AUTHORIZATION NAME parameter if there are nested CREATE statements in the CREATE SCHEMA statement.
- Processing a jar file in an MPP environment. In an MPP environment, the jar processing request is sent from the coordinator node with the session authid. The catalog node received the requests and process the jar files based on the privilege of the session authid (the user executing the jar processing requests).
  - Install jar file. The session authid needs to have one of the following rights: DBADM, or CREATEIN (implicit or explicit on the jar schema). The operation will fail if the rights stated previously are granted to group containing the session authid, but not explicitly to the session authid.
  - Remove jar file. The session authid needs to have one of the following rights: DBADM, or DROPIN (implicit or explicit on the jar schema), or is the definer of the jar file. The operation will fail if the rights stated previously are granted to group containing the session authid, but not explicitly to the session authid, and if the session authid is not the definer of the jar file.
  - Replace jar file. This is same as removing the jar file, followed by installing the jar file. Both of the scenarios described previously apply.
- When SET SESSION_USER statement is issued. Subsequent Db2 operations are run under the context of the authid specified by this statement. These operations will fail if the privileges required are owned by one of the SESSION_USER's group is not explicitly granted to the SESSION_USER authid.

db2secGroupPluginInit API - Initialize group plug-in

Initialization API, for the group-retrieval plug-in, that the Db2 database manager calls immediately after loading the plug-in.

API and data structure syntax

```
SQL_API_RC SQL_API_FN db2secGroupPluginInit
                            ( db2int32 version,
                              void *group_fns,
                              db2secLogMessage *logMessage_fn,
                              char     **errormsg,
                              db2int32 *errormsglen );
```

db2secGroupPluginInit API parameters

version
Input. The highest version of the API supported by the instance loading that plugin. The value DB2SEC_API_VERSION (in db2secPlugin.h) contains the latest version number of the API that the Db2 database manager currently supports.

group_fns
Output. A pointer to the db2secGroupFunctions_<version_number> (also known as group_functions_<version_number>) structure. The db2secGroupFunctions_<version_number> structure contains pointers to the APIs implemented for the group-retrieval plug-in. In future, there might be different versions of the APIs (for example, db2secGroupFunctions_<version_number>), so the **group_fns** parameter is cast as a pointer to the db2secGroupFunctions_<version_number> structure corresponding to the version the plug-in has implemented. The first parameter of the group_functions_<version_number> structure tells Db2 the version of the APIs that the plug-in has implemented. Note: The casting is done only if the Db2 version is higher or equal to the version of the APIs that the plug-in has implemented. The version number represents the version of the APIs implemented by the plugin, and the **pluginType** should be set to DB2SEC_PLUGIN_TYPE_GROUP.

logMessage_fn
Input. A pointer to the db2secLogMessage API, which is implemented by the Db2 database system. The db2secGroupPluginInit API can call the db2secLogMessage API to log messages to the **db2diag** log files for debugging or informational purposes. The first parameter (**level**) of db2secLogMessage API specifies the type of diagnostic errors that will be recorded in the **db2diag** log files and the last two parameters are the message string and its length. The valid values for the first parameter of db2secLogMessage API (defined in db2secPlugin.h) are:

- DB2SEC_LOG_NONE: (0) No logging
- DB2SEC_LOG_CRITICAL: (1) Severe Error encountered
- DB2SEC_LOG_ERROR: (2) Error encountered
- DB2SEC_LOG_WARNING: (3) Warning
- DB2SEC_LOG_INFO: (4) Informational

The message text shows up in the db2diag log files only if the value of the **level** parameter of the db2secLogMessage API is less than or equal to the **diaglevel** database manager configuration parameter. So for example, if you use the DB2SEC_LOG_INFO value, the message text shows up in the **db2diag** log files only if the **diaglevel** database manager configuration parameter is set to 4.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secGroupPluginInit API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secPluginTerm - Clean up group plug-in resources

Frees resources used by the group-retrieval plug-in.

This API is called by the Db2 database manager just before it unloads the group-retrieval plug-in. It should be implemented in a manner that it does a proper cleanup of any resources the plug-in library holds, for example, free any memory allocated by the plug-in, close files that are still open, and close network connections. The plug-in is responsible for keeping track of these resources in order to free them. This API is not called on any Windows operating systems.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secPluginTerm)
                        ( char      **errormsg,
                          db2int32 *errormsglen );
```

db2secPluginTerm API parameters

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secPluginTerm API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

APIs for user ID/password authentication plug-ins

For the user ID/password plug-in module, you need to implement the following client-side APIs:

- db2secClientAuthPluginInit

  Note: The db2secClientAuthPluginInit API takes as input a pointer, *logMessage_fn, to an API with the following prototype:

  ```
  SQL_API_RC (SQL_API_FN db2secLogMessage)
  (
  db2int32 level,
  void    *data,
  db2int32 length
  );
  ```

  The db2secLogMessage API allows the plug-in to log messages to the **db2diag** log files for debugging or informational purposes. This API is provided by the Db2 database system, so you do not need to implement it.
- db2secClientAuthPluginTerm
- db2secGenerateInitialCred (Only used for gssapi)
- db2secRemapUserid (Optional)
- db2secGetDefaultLoginContext
- db2secValidatePassword
- db2secProcessServerPrincipalName (This is only for GSS-API)
- db2secFreeToken (Functions to free memory held by the DLL)
- db2secFreeErrormsg
- db2secFreeInitInfo
- The only API that must be resolvable externally is db2secClientAuthPluginInit. This API will take a void * parameter, which should be cast to either:

  ```
  typedef struct db2secUseridPasswordClientAuthFunctions_1
  {
  ```

```
db2int32 version;
db2int32 plugintype;

SQL_API_RC (SQL_API_FN * db2secGetDefaultLoginContext)
(
char        authid[DB2SEC_MAX_AUTHID_LENGTH],
db2int32   *authidlen,
char        userid[DB2SEC_MAX_USERID_LENGTH],
db2int32   *useridlen,
db2int32    useridtype,
char        usernamespace[DB2SEC_MAX_USERNAMESPACE_LENGTH],
db2int32   *usernamespacelen,
db2int32   *usernamespacetype,
const char *dbname,
db2int32    dbnamelen,
void      **token,
char      **errormsg,
db2int32   *errormsglen
);
/* Optional */
SQL_API_RC (SQL_API_FN * db2secRemapUserid)
(
char        userid[DB2SEC_MAX_USERID_LENGTH],
db2int32   *useridlen,
char        usernamespace[DB2SEC_MAX_USERNAMESPACE_LENGTH],
db2int32   *usernamespacelen,
db2int32   *usernamespacetype,
char        password[DB2SEC_MAX_PASSWORD_LENGTH],
db2int32   *passwordlen,
char        newpassword[DB2SEC_MAX_PASSWORD_LENGTH],
db2int32   *newpasswordlen,
const char *dbname,
db2int32    dbnamelen,
char      **errormsg,
db2int32   *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secValidatePassword)
(
const char *userid,
db2int32    useridlen,
const char *usernamespace,
db2int32    usernamespacelen,
db2int32    usernamespacetype,
const char *password,
db2int32    passwordlen,
const char *newpassword,
db2int32    newpasswordlen,
const char *dbname,
db2int32    dbnamelen,
db2Uint32   connection_details,
void      **token,
char      **errormsg,
db2int32   *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secFreeToken)
(
void     **token,
char     **errormsg,
db2int32  *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secFreeErrormsg)
(
char *errormsg
);

SQL_API_RC (SQL_API_FN * db2secClientAuthPluginTerm)
(
char     **errormsg,
db2int32  *errormsglen
);
}
```

or

```
typedef struct db2secGssapiClientAuthFunctions_1
{
db2int32 version;
db2int32 plugintype;
```

```
SQL_API_RC (SQL_API_FN * db2secGetDefaultLoginContext)
(
char        authid[DB2SEC_MAX_AUTHID_LENGTH],
db2int32   *authidlen,
char        userid[DB2SEC_MAX_USERID_LENGTH],
db2int32   *useridlen,
db2int32    useridtype,
char        usernamespace[DB2SEC_MAX_USERNAMESPACE_LENGTH],
db2int32   *usernamespacelen,
db2int32   *usernamespacetype,
const char *dbname,
db2int32    dbnamelen,
void      **token,
char      **errormsg,
db2int32   *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secProcessServerPrincipalName)
(
const void *data,
gss_name_t *gssName,
char      **errormsg,
db2int32   *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secGenerateInitialCred)
(
const char    *userid,
db2int32       useridlen,
const char    *usernamespace,
db2int32       usernamespacelen,
db2int32       usernamespacetype,
const char    *password,
db2int32       passwordlen,
const char    *newpassword,
db2int32       newpasswordlen,
const char    *dbname,
db2int32       dbnamelen,
gss_cred_id_t *pGSSCredHandle,
void         **initInfo,
char         **errormsg,
db2int32      *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secFreeToken)
(
void      *token,
char     **errormsg,
db2int32  *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secFreeErrormsg)
(
char *errormsg
);


SQL_API_RC (SQL_API_FN * db2secFreeInitInfo)
(
void      *initInfo,
char     **errormsg,
db2int32  *errormsglen
);

SQL_API_RC (SQL_API_FN * db2secClientAuthPluginTerm)
(
char     **errormsg,
db2int32  *errormsglen
);

/* GSS-API specific functions -- refer to db2secPlugin.h
   for parameter list*/

  OM_uint32 (SQL_API_FN * gss_init_sec_context )(<parameter list>);
  OM_uint32 (SQL_API_FN * gss_delete_sec_context )(<parameter list>);
  OM_uint32 (SQL_API_FN * gss_display_status )(<parameter list>);
  OM_uint32 (SQL_API_FN * gss_release_buffer )(<parameter list>);
  OM_uint32 (SQL_API_FN * gss_release_cred )(<parameter list>);
  OM_uint32 (SQL_API_FN * gss_release_name )(<parameter list>);
  }
```

You should use the db2secUseridPasswordClientAuthFunctions_1 structure if you are writing a user ID/password plug-in. If you are writing a GSS-API (including Kerberos) plug-in, you should use the db2secGssapiClientAuthFunctions_1 structure.

For the user ID/password plug-in library, you will need to implement the following server-side APIs:

- db2secServerAuthPluginInit

  The db2secServerAuthPluginInit API takes as input a pointer, *logMessage_fn, to the db2secLogMessage API, and a pointer, *getConDetails_fn, to the db2secGetConDetails API with the following prototypes:

```
SQL_API_RC (SQL_API_FN db2secLogMessage)
(
db2int32 level,
void    *data,
db2int32 length
);

SQL_API_RC (SQL_API_FN db2secGetConDetails)
(
db2int32    conDetailsVersion,
const void *pConDetails
);
```

  The db2secLogMessage API allows the plug-in to log messages to the **db2diag** log files for debugging or informational purposes. The db2secGetConDetails API allows the plug-in to obtain details about the client that is trying to attempt to have a database connection. Both the db2secLogMessage API and db2secGetConDetails API are provided by the Db2 database system, so you do not need to implement them. The db2secGetConDetails API in turn, takes as its second parameter,**pConDetails**, a pointer to one of the following structures:

  db2sec_con_details_1:

```
typedef struct db2sec_con_details_1
{
  db2int32  clientProtocol;
  db2Uint32 clientIPAddress;
  db2Uint32 connect_info_bitmap;
  db2int32  dbnameLen;
  char      dbname[DB2SEC_MAX_DBNAME_LENGTH + 1];
} db2sec_con_details_1;
```

  db2sec_con_details_2:

```
typedef struct db2sec_con_details_2
{
  db2int32  clientProtocol;     /* See SQL_PROTOCOL_ in sqlenv.h */
  db2Uint32 clientIPAddress;    /* Set if protocol is TCPIP4     */
  db2Uint32 connect_info_bitmap;
  db2int32  dbnameLen;
  char dbname[DB2SEC_MAX_DBNAME_LENGTH + 1];
  db2Uint32 clientIP6Address[4];/* Set if protocol is TCPIP6     */
} db2sec_con_details_2;
```

  db2sec_con_details_3:

```
typedef struct db2sec_con_details_3
{
  db2int32 clientProtocol; /* See SQL_PROTOCOL_ in sqlenv.h */
  db2Uint32 clientIPAddress; /* Set if protocol is TCPIP4 */
  db2Uint32 connect_info_bitmap;
  db2int32 dbnameLen;
  char dbname[DB2SEC_MAX_DBNAME_LENGTH + 1];
  db2Uint32 clientIP6Address[4];/* Set if protocol is TCPIP6 */
  db2Uint32 clientPlatform; /* SQLM_PLATFORM_* from sqlmon.h */
  db2Uint32 _reserved[16];
} db2sec_con_details_3;
```

  The possible values for **conDetailsVersion** are DB2SEC_CON_DETAILS_VERSION_1, DB2SEC_CON_DETAILS_VERSION_2, and DB2SEC_CON_DETAILS_VERSION_3 representing the version of the API.

Note: While using db2sec_con_details_1, db2sec_con_details_2, or db2sec_con_details_3, consider the following:

- Existing plugins that are using the db2sec_con_details_1 structure and the DB2SEC_CON_DETAILS_VERSION_1 value will continue to work as they did with Version 8.2 when calling the db2GetConDetails API. If this API is called on an IPv4 platform, the client IP address is returned in the **clientIPAddress** field of the structure. If this API is called on an IPv6 platform, a value of 0 is returned in the **clientIPAddress** field. To retrieve the client IP address on an IPv6 platform, the security plug-in code should be changed to use either the db2sec_con_details_2 structure and the DB2SEC_CON_DETAILS_VERSION_2 value, or the db2sec_con_details_3 structure and the DB2SEC_CON_DETAILS_VERSION_3 value.
- New plugins should use the db2sec_con_details_3 structure and the DB2SEC_CON_DETAILS_VERSION_3 value. If the db2secGetConDetails API is called on an IPv4 platform, the client IP address is returned in the **clientIPAddress** field of the db2sec_con_details_3 structure and if the API is called on an IPv6 platform the client IP address is returned in the **clientIP6Address** field of the db2sec_con_details_3 structure. The **clientProtocol** field of the connection details structure will be set to one of SQL_PROTOCOL_TCPIP (IPv4, with v1 of the structure), SQL_PROTOCOL_TCPIP4 (IPv4, with v2 of the structure) or SQL_PROTOCOL_TCPIP6 (IPv6, with v2 or v3 of the structure).
- The structure db2sec_con_details_3 is identical to the structure db2sec_con_details_2 except that it contains an additional field (**clientPlatform**) that identifies the client platform type (as reported by the communication layer) using platform type constants defined in sqlmon.h, such as SQLM_PLATFORM_AIX.

- db2secServerAuthPluginTerm
- db2secValidatePassword
- db2secGetAuthIDs
- db2secDoesAuthIDExist
- db2secFreeToken
- db2secFreeErrormsg
- The only API that must be resolvable externally is db2secServerAuthPluginInit. This API will take a void * parameter, which should be cast to either:

```
typedef struct db2secUseridPasswordServerAuthFunctions_1
{
db2int32 version;
db2int32 plugintype;

  /* parameter lists left blank for readability
       see above for parameters */
SQL_API_RC (SQL_API_FN * db2secValidatePassword)(<parameter list>);
SQL_API_RC (SQL_API_FN * db2secGetAuthIDs)(<parameter list);
SQL_API_RC (SQL_API_FN * db2secDoesAuthIDExist)(<parameter list>);
SQL_API_RC (SQL_API_FN * db2secFreeToken)(<parameter list>);
SQL_API_RC (SQL_API_FN * db2secFreeErrormsg)(<parameter list>);
SQL_API_RC (SQL_API_FN * db2secServerAuthPluginTerm)();
} userid_password_server_auth_functions;
```

or

```
typedef struct db2secGssapiServerAuthFunctions_1
{
db2int32 version;
db2int32 plugintype;
gss_buffer_desc serverPrincipalName;
gss_cred_id_t ServerCredHandle;
SQL_API_RC (SQL_API_FN * db2secGetAuthIDs)(<parameter list);
SQL_API_RC (SQL_API_FN * db2secDoesAuthIDExist)(<parameter list>);
SQL_API_RC (SQL_API_FN * db2secFreeErrormsg)(<parameter list>);
SQL_API_RC (SQL_API_FN * db2secServerAuthPluginTerm)();

/* GSS-API specific functions
refer to db2secPlugin.h for parameter list*/
OM_uint32 (SQL_API_FN * gss_accept_sec_context )(<parameter list>);
OM_uint32 (SQL_API_FN * gss_display_name )(<parameter list>);
```

```
OM_uint32 (SQL_API_FN * gss_delete_sec_context )(<parameter list>);
OM_uint32 (SQL_API_FN * gss_display_status )(<parameter list>);
OM_uint32 (SQL_API_FN * gss_release_buffer )(<parameter list>);
OM_uint32 (SQL_API_FN * gss_release_cred )(<parameter list>);
OM_uint32 (SQL_API_FN * gss_release_name )(<parameter list>);

} gssapi_server_auth_functions;
```

You should use the db2secUseridPasswordServerAuthFunctions_1 structure if you are writing a user ID/password plug-in. If you are writing a GSS-API (including Kerberos) plug-in, you should use the db2secGssapiServerAuthFunctions_1 structure.

db2secClientAuthPluginInit API - Initialize client authentication plug-in

Initialization API, for the client authentication plug-in, that the Db2 database manager calls immediately after loading the plug-in.

API and data structure syntax

```
SQL_API_RC SQL_API_FN db2secClientAuthPluginInit
                             ( db2int32 version,
                               void *client_fns,
                               db2secLogMessage *logMessage_fn,
                               char    **errormsg,
                               db2int32 *errormsglen );
```

db2secClientAuthPluginInit API parameters

version
Input. The highest version number of the API that the Db2 database manager currently supports. The DB2SEC_API_VERSION value (in db2secPlugin.h) contains the latest version number of the API that Db2 currently supports.

client_fns
Output. A pointer to memory provided by the Db2 database manager for a db2secGssapiClientAuthFunctions_<version_number> structure (also known as gssapi_client_auth_functions_<version_number>), if GSS-API authentication is used, or a db2secUseridPasswordClientAuthFunctions_<version_number> structure (also known as userid_password_client_auth_functions_<version_number>), if userid/password authentication is used. The db2secGssapiClientAuthFunctions_<version_number> structure and db2secUseridPasswordClientAuthFunctions_<version_number> structure contain pointers to the APIs implemented for the GSS-API authentication plug-in and userid/password authentication plug-in. In future versions of Db2, there might be different versions of the APIs, so the **client_fns** parameter is cast as a pointer to the gssapi_client_auth_functions_<version_number> structure corresponding to the version the plug-in has implemented.

The first parameter of the gssapi_client_auth_functions_<version_number> structure or the userid_password_client_auth_functions_<version_number> structure tells the Db2 database manager the version of the APIs that the plug-in has implemented.

Note: The casting is done only if the Db2 version is higher or equal to the version of the APIs that the plug-in has implemented.

Inside the gssapi_server_auth_functions_<version_number> or userid_password_server_auth_functions_<version_number> structure, the **plugintype** parameter should be set to one of DB2SEC_PLUGIN_TYPE_USERID_PASSWORD, DB2SEC_PLUGIN_TYPE_GSSAPI, or **DB2SEC_PLUGIN_TYPE_KERBEROS**. Other values can be defined in future versions of the API.

logMessage_fn
Input. A pointer to the db2secLogMessage API, which is implemented by the Db2 database manager. The db2secClientAuthPluginInit API can call the db2secLogMessage API to log

messages to the **db2diag** log files for debugging or informational purposes. The first parameter (**level**) of db2secLogMessage API specifies the type of diagnostic errors that will be recorded in the **db2diag** log files and the last two parameters are the message string and its length. The valid values for the first parameter of db2secLogMessage API (defined in db2secPlugin.h) are:

- DB2SEC_LOG_NONE (0) No logging
- DB2SEC_LOG_CRITICAL (1) Severe Error encountered
- DB2SEC_LOG_ERROR (2) Error encountered
- DB2SEC_LOG_WARNING (3) Warning
- DB2SEC_LOG_INFO (4) Informational

The message text will show up in the **db2diag** log files only if the value of the 'level' parameter of the db2secLogMessage API is less than or equal to the **diaglevel** database manager configuration parameter. For example, if you use the DB2SEC_LOG_INFO value, the message text will appear in the **db2diag** log files only if the **diaglevel** database manager configuration parameter is set to 4.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secClientAuthPluginInit API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secClientAuthPluginTerm API - Clean up client authentication plug-in resources

Frees resources used by the client authentication plug-in.

This API is called by the Db2 database manager just before it unloads the client authentication plug-in. It should be implemented in a manner that it does a proper cleanup of any resources the plug-in library holds, for example, free any memory allocated by the plug-in, close files that are still open, and close network connections. The plug-in is responsible for keeping track of these resources in order to free them. This API is not called on any Windows operating systems.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secClientAuthPluginTerm)
                        ( char     **errormsg,
                          db2int32 *errormsglen);
```

db2secClientAuthPluginTerm API parameters

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secClientAuthPluginTerm API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secDoesAuthIDExist - Check if authentication ID exists

Determines if the **authid** represents an individual user (for example, whether the API can map the **authid** to an external user ID).

The API should return the value DB2SEC_PLUGIN_OK if it is successful - the **authid** is valid, DB2SEC_PLUGIN_INVALID_USERORGROUP if it is not valid, or DB2SEC_PLUGIN_USERSTATUSNOTKNOWN if the **authid** existence cannot be determined.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secDoesAuthIDExist)
                       ( const char *authid,
                         db2int32 authidlen,
                         char       **errormsg,
                         db2int32 *errormsglen );
```

db2secDoesAuthIDExist API parameters

authid
Input. The authid to validate. This is upper-cased, with no trailing blanks.

authidlen
Input. Length in bytes of the **authid** parameter value.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secDoesAuthIDExist API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length of the error message string in **errormsg** parameter.

db2secFreeInitInfo API - Clean up resources held by the db2secGenerateInitialCred

Frees any resources allocated by the db2secGenerateInitialCred API. This can include, for example, handles to underlying mechanism contexts or a credential cache created for the GSS-API credential cache.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secFreeInitInfo)
                       ( void *initinfo,
                         char     **errormsg,
                         db2int32 *errormsglen);
```

db2secFreeInitInfo API parameters

initinfo
Input. A pointer to data that is not known to the Db2 database manager. The plug-in can use this memory to maintain a list of resources that are allocated in the process of generating the credential handle. These resources are freed by calling this API.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secFreeInitInfo API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secFreeToken API - Free memory held by token

Frees the memory held by a token. This API is called by the Db2 database manager when it no longer needs the memory held by the token parameter.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secFreeToken)
                       ( void *token,
```

```
                              char       **errormsg,
                              db2int32 *errormsglen );
```

db2secFreeToken API parameters

token
Input. Pointer to the memory to be freed.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secFreeToken API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secGenerateInitialCred API - Generate initial credentials

The db2secGenerateInitialCred API obtains the initial GSS-API credentials based on the user ID and password that are passed in.

For Kerberos, this is the ticket-granting ticket (TGT). The credential handle that is returned in **pGSSCredHandle** parameter is the handle that is used with the gss_init_sec_context API and must be either an INITIATE or BOTH credential. The db2secGenerateInitialCred API is only called when a user ID, and possibly a password are supplied. Otherwise, the Db2 database manager specifies the value GSS_C_NO_CREDENTIAL when calling the gss_init_sec_context API to signify that the default credential obtained from the current login context is to be used.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secGenerateInitialCred)
                       ( const char *userid,
                         db2int32 useridlen,
                         const char *usernamespace,
                         db2int32 usernamespacelen,
                         db2int32 usernamespacetype,
                         const char *password,
                         db2int32 passwordlen,
                         const char *newpassword,
                         db2int32 newpasswordlen,
                         const char *dbname,
                         db2int32 dbnamelen,
                         gss_cred_id_t *pGSSCredHandle,
                         void          **InitInfo,
                         char          **errormsg,
                         db2int32 *errormsglen );
```

db2secGenerateInitialCred API parameters

userid
Input. The user ID whose password is to be verified on the database server.

useridlen
Input. Length in bytes of the **userid** parameter value.

usernamespace
Input. The namespace from which the user ID was obtained.

usernamespacelen
Input. Length in bytes of the **usernamespace** parameter value.

usernamespacetype
Input. The type of namespace.

password
Input. The password to be verified.

passwordlen
Input. Length in bytes of the **password** parameter value.

newpassword
Input. A new password if the password is to be changed. If no change is requested, the **newpassword** parameter is set to NULL. If it is not NULL, the API should validate the old password before setting the password to its new value. The API does not have to honor a request to change the password, but if it does not, it should immediately return with the return value DB2SEC_PLUGIN_CHANGEPASSWORD_NOTSUPPORTED without validating the old password.

newpasswordlen
Input. Length in bytes of the **newpassword** parameter value.

dbname
Input. The name of the database being connected to. The API is free to ignore this parameter, or the API can return the value DB2SEC_PLUGIN_CONNECTION_DISALLOWED if it has a policy of restricting access to certain databases to users who otherwise have valid passwords.

dbnamelen
Input. Length in bytes of the **dbname** parameter value.

pGSSCredHandle
Output. Pointer to the GSS-API credential handle.

InitInfo
Output. A pointer to data that is not known to Db2. The plug-in can use this memory to maintain a list of resources that are allocated in the process of generating the credential handle. The Db2 database manager calls the db2secFreeInitInfo API at the end of the authentication process, at which point these resources are freed. If the db2secGenerateInitialCred API does not need to maintain such a list, then it should return NULL.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secGenerateInitialCred API execution is not successful.

Note: For this API, error messages should not be created if the return value indicates a bad user ID or password. An error message should be returned only if there is an internal error in the API that prevented it from completing properly.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secGetAuthIDs API - Get authentication IDs

Returns an SQL authid for an authenticated user. This API is called during database connections for both user ID/password and GSS-API authentication methods.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secGetAuthIDs)
                       ( const char *userid,
                         db2int32 useridlen,
                         const char *usernamespace,
                         db2int32 usernamespacelen,
                         db2int32 usernamespacetype,
                         const char *dbname,
                         db2int32 dbnamelen,
                         void      **token,
                         char SystemAuthID[DB2SEC_MAX_AUTHID_LENGTH],
                         db2int32 *SystemAuthIDlen,
                         char InitialSessionAuthID[DB2SEC_MAX_AUTHID_LENGTH],
                         db2int32 *InitialSessionAuthIDlen,
                         char username[DB2SEC_MAX_USERID_LENGTH],
                         db2int32 *usernamelen,
                         db2int32 *initsessionidtype,
                         char      **errormsg,
                         db2int32 *errormsglen );
```

db2secGetAuthIDs API parameters

userid
Input. The authenticated user. This is usually not used for GSS-API authentication unless a trusted context is defined to permit switch user operations without authentication. In those situations, the user name provided for the switch user request is passed in this parameter.

useridlen
Input. Length in bytes of the **userid** parameter value.

usernamespace
Input. The namespace from which the user ID was obtained.

usernamespacelen
Input. Length in bytes of the **usernamespace** parameter value.

usernamespacetype
Input. Namespace type value. Currently, the only supported namespace type value is DB2SEC_NAMESPACE_SAM_COMPATIBLE (corresponds to a username style like domain\myname).

dbname
Input. The name of the database being connected to. The API can ignore this, or it can return differing authids when the same user connects to different databases. This parameter can be NULL.

dbnamelen
Input. Length in bytes of the **dbname** parameter value. This parameter is set to 0 if **dbname** parameter is NULL.

token
Input or output. Data that the plug-in might pass to the db2secGetGroupsForUser API. For GSS-API, this is a context handle (gss_ctx_id_t). Ordinarily, token is an input-only parameter and its value is taken from the db2secValidatePassword API. It can also be an output parameter when authentication is done on the client and therefore db2secValidatePassword API is not called. In environments where a trusted context is defined that allows switch user operations without authentication, the db2secGetAuthIDs API must be able to accommodate receiving a NULL value for this token parameter and be able to derive a system authorization ID based on the **userid** and **useridlen** input parameters mentioned previously.

SystemAuthID
Output. The system authorization ID that corresponds to the ID of the authenticated user. The size is 255 bytes, but the Db2 database manager currently uses only up to (and including) 30 bytes.

SystemAuthIDlen
Output. Length in bytes of the **SystemAuthID** parameter value.

InitialSessionAuthID
Output. Authid used for this connection session. This is usually the same as the **SystemAuthID** parameter but can be different in some situations, for example, when issuing a SET SESSION AUTHORIZATION statement. The size is 255 bytes, but the Db2 database manager currently uses only up to (and including) 30 bytes.

InitialSessionAuthIDlen
Output. Length in bytes of the **InitialSessionAuthID** parameter value.

username
Output. A username corresponding to the authenticated user and authid. This will be used only for auditing and will be logged in the "User ID" field in the audit record for CONNECT statement. If the API does specify the **username** parameter, the Db2 database manager copies it from the userid.

usernamelen
Output. Length in bytes of the **username** parameter value.

initsessionidtype
Output. Session authid type indicating whether the **InitialSessionAuthid** parameter is a role or an authid. The API should return one of the following values (defined in db2secPlugin.h):

- DB2SEC_ID_TYPE_AUTHID (0)

- DB2SEC_ID_TYPE_ROLE (1)

Currently, Db2 only supports authid (DB2SEC_ID_TYPE_AUTHID).

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secGetAuthIDs API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secGetDefaultLoginContext API - Get default login context

Determines the user associated with the default login context, that is, determines the Db2 authid of the user invoking a Db2 command without explicitly specifying a user ID (either an implicit authentication to a database, or a local authorization). This API must return both an authid and a user ID.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secGetDefaultLoginContext)
                       ( char authid[DB2SEC_MAX_AUTHID_LENGTH],
                         db2int32 *authidlen,
                         char userid[DB2SEC_MAX_USERID_LENGTH],
                         db2int32 *useridlen,
                         db2int32 useridtype,
                         char usernamespace[DB2SEC_MAX_USERNAMESPACE_LENGTH],
                         db2int32 *usernamespacelen,
                         db2int32 *usernamespacetype,
                         const char *dbname,
                         db2int32 dbnamelen,
                         void      **token,
                         char      **errormsg,
                         db2int32 *errormsglen );
```

db2secGetDefaultLoginContext API parameters

authid
Output. The parameter in which the authid should be returned. The returned value must conform to Db2 authid naming rules, or the user will not be authorized to perform the requested action.

authidlen
Output. Length in bytes of the **authid** parameter value.

userid
Output. The parameter in which the user ID associated with the default login context should be returned.

useridlen
Output. Length in bytes of the **userid** parameter value.

useridtype
Input. Indicates if the real or effective user ID of the process is being specified. On Windows, only the real user ID exists. On UNIX and Linux, the real user ID and effective user ID can be different if the uid user ID for the application is different than the ID of the user executing the process. Valid values for the **userid** parameter (defined in db2secPlugin.h) are:

DB2SEC_PLUGIN_REAL_USER_NAME
Indicates that the real user ID is being specified.

DB2SEC_PLUGIN_EFFECTIVE_USER_NAME
Indicates that the effective user ID is being specified.

Note: Some plug-in implementations might not distinguish between the real and effective user ID. In particular, a plug-in that does not use the UNIX or Linux identity of the user to establish the Db2 authorization ID can safely ignore this distinction.

usernamespace
Output. The namespace of the user ID.

usernamespacelen
Output. Length in bytes of the **usernamespace** parameter value. Under the limitation that the **usernamespacetype** parameter must be set to the value DB2SEC_NAMESPACE_SAM_COMPATIBLE (defined in db2secPlugin.h), the maximum length currently supported is 15 bytes.

usernamespacetype
Output. Namespace type value. Currently, the only supported namespace type is DB2SEC_NAMESPACE_SAM_COMPATIBLE (corresponds to a username style like domain\myname).

dbname
Input. Contains the name of the database being connected to, if this call is being used in the context of a database connection. For local authorization actions or instance attachments, this parameter is set to NULL.

dbnamelen
Input. Length in bytes of the **dbname** parameter value.

token
Output. This is a pointer to data allocated by the plug-in that it might pass to subsequent authentication calls in the plug-in, or possibly to the group retrieval plug-in. The structure of this data is determined by the plug-in writer.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secGetDefaultLoginContext API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secProcessServerPrincipalName API - Process service principal name returned from server

The db2secProcessServerPrincipalName API processes the service principal name returned from the server and returns the principal name in the gss_name_t internal format to be used with the gss_init_sec_context API.

The db2secProcessServerPrincipalName API also processes the service principal name cataloged with the database directory when Kerberos authentication is used. Ordinarily, this conversion uses the gss_import_name API. After the context is established, the gss_name_t object is freed through the call to gss_release_name API. The db2secProcessServerPrincipalName API returns the value **DB2SEC_PLUGIN_OK** if the **gssName** parameter points to a valid GSS name; a DB2SEC_PLUGIN_BAD_PRINCIPAL_NAME error code is returned if the principal name is invalid.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secProcessServerPrincipalName)
                        ( const char *name,
                          db2int32 namelen,
                          gss_name_t *gssName,
                          char       **errormsg,
                          db2int32 *errormsglen );
```

db2secProcessServerPrincipalName API parameters

name
Input. Text name of the service principal in GSS_C_NT_USER_NAME format; for example, service/host@REALM.

namelen
Input. Length in bytes of the **name** parameter value.

gssName
Output. Pointer to the output service principal name in the GSS-API internal format.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secProcessServerPrincipalName API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secRemapUserid API - Remap user ID and password

This API is called by the Db2 database manager on the client side to remap a given user ID and password (and possibly new password and usernamespace) to values different from those given at connect time.

The Db2 database manager only calls this API if a user ID and a password are supplied at connect time. This prevents a plug-in from remapping a user ID by itself to a user ID/password pair. This API is optional and is not called if it is not provided or implemented by the security plug-in.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secRemapUserid)
                      ( char userid[DB2SEC_MAX_USERID_LENGTH],
                        db2int32 *useridlen,
                        char usernamespace[DB2SEC_MAX_USERNAMESPACE_LENGTH],
                        db2int32 *usernamespacelen,
                        db2int32 *usernamespacetype,
                        char password[DB2SEC_MAX_PASSWORD_LENGTH],
                        db2int32 *passwordlen,
                        char newpasswd[DB2SEC_MAX_PASSWORD_LENGTH],
                        db2int32 *newpasswdlen,
                        const char *dbname,
                        db2int32 dbnamelen,
                        char      **errormsg,
                        db2int32 *errormsglen);
```

db2secRemapUserid API parameters

userid
Input or output. The user ID to be remapped. If there is an input user ID value, then the API must provide an output user ID value that can be the same or different from the input user ID value. If there is no input user ID value, then the API should not return an output user ID value.

useridlen
Input or output. Length in bytes of the **userid** parameter value.

usernamespace
Input or output. The namespace of the user ID. This value can optionally be remapped. If no input parameter value is specified, but an output value is returned, then the **usernamespace** will be used by the Db2 database manager only for CLIENT type authentication and is disregarded for other authentication types.

usernamespacelen
Input or output. Length in bytes of the **usernamespace** parameter value. Under the limitation that the **usernamespacetype** parameter must be set to the value DB2SEC_NAMESPACE_SAM_COMPATIBLE (defined in db2secPlugin.h), the maximum length currently supported is 15 bytes.

usernamespacetype
Input or output. Old and new namespace type value. Currently, the only supported namespace type value is DB2SEC_NAMESPACE_SAM_COMPATIBLE (corresponds to a username style like domain\myname).

password
Input or output. As an input, it is the password that is to be remapped. As an output it is the remapped password. If an input value is specified for this parameter, the API must be able to return an output value that differs from the input value. If no input value is specified, the API must not return an output password value.

passwordlen
Input or output. Length in bytes of the **password** parameter value.

newpasswd
Input or output. As an input, it is the new password that is to be set. As an output it is the confirmed new password.

Note: This is the new password that is passed by the Db2 database manager into the **newpassword** parameter of the db2secValidatePassword API on the client or the server (depending on the value of the **authentication** database manager configuration parameter). If a new password was passed as input, then the API must be able to return an output value and it can be a different new password. If there is no new password passed in as input, then the API should not return an output new password.

newpasswdlen
Input or output. Length in bytes of the **newpasswd** parameter value.

dbname
Input. Name of the database to which the client is connecting.

dbnamelen
Input. Length in bytes of the **dbname** parameter value.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secRemapUserid API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secServerAuthPluginInit - Initialize server authentication plug-in

The db2secServerAuthPluginInit API is the initialization API for the server authentication plug-in that the Db2 database manager calls immediately after loading the plug-in.

In the case of GSS-API, the plug-in is responsible for filling in the server's principal name in the **serverPrincipalName** parameter inside the gssapi_server_auth_functions structure at initialization time and providing the server's credential handle in the **serverCredHandle** parameter inside the gssapi_server_auth_functions structure. The freeing of the memory allocated to hold the principal name and the credential handle must be done by the db2secServerAuthPluginTerm API by calling the gss_release_name and gss_release_cred APIs.

API and data structure syntax

```
SQL_API_RC SQL_API_FN db2secServerAuthPluginInit
                            ( db2int32 version,
                              void *server_fns,
                              db2secGetConDetails *getConDetails_fn,
                              db2secLogMessage *logMessage_fn,
                              char               **errormsg,
                              db2int32 *errormsglen );
```

db2secServerAuthPluginInit API parameters

version
Input. The highest version number of the API that the Db2 database manager currently supports. The DB2SEC_API_VERSION value (in db2secPlugin.h) contains the latest version number of the API that the Db2 database manager currently supports.

server_fns
Output. A pointer to memory provided by the Db2 database manager for a db2secGssapiServerAuthFunctions_<version_number> structure (also known as gssapi_server_auth_functions_<version_number>), if GSS-API authentication is used, or a db2secUseridPasswordServerAuthFunctions_<version_number> structure (also known as userid_password_server_auth_functions_<version_number>), if userid/password authentication is used. The db2secGssapiServerAuthFunctions_<version_number> structure and db2secUseridPasswordServerAuthFunctions_<version_number> structure contain pointers to the APIs implemented for the GSS-API authentication plug-in and userid/password authentication plug-in.

The **server_fns** parameter is cast as a pointer to the gssapi_server_auth_functions_<version_number> structure corresponding to the version the plug-in has implemented. The first parameter of the gssapi_server_auth_functions_<version_number> structure or the userid_password_server_auth_functions_<version_number> structure tells theDb2 database manager the version of the APIs that the plug-in has implemented.

Note: The casting is done only if the Db2 version is higher or equal to the version of the APIs that the plug-in has implemented.

Inside the gssapi_server_auth_functions_<version_number> or userid_password_server_auth_functions_<version_number> structure, the **plugintype** parameter should be set to one of DB2SEC_PLUGIN_TYPE_USERID_PASSWORD, DB2SEC_PLUGIN_TYPE_GSSAPI, or DB2SEC_PLUGIN_TYPE_KERBEROS. Other values can be defined in future versions of the API.

getConDetails_fn
Input. Pointer to the db2secGetConDetails API, which is implemented by Db2. The db2secServerAuthPluginInit API can call the db2secGetConDetails API in any one of the other authentication APIs to obtain details related to the database connection. These details include information about the communication mechanism associated with the connection (such as the IP address, in the case of TCP/IP), which the plug-in writer might need to reference when making authentication decisions. For example, the plug-in could disallow a connection for a particular user, unless that user is connecting from a particular IP address. The use of the db2secGetConDetails API is optional.

If the db2secGetConDetails API is called in a situation not involving a database connection, it returns the value DB2SEC_PLUGIN_NO_CON_DETAILS, otherwise, it returns 0 on success.

The db2secGetConDetails API takes two input parameters; **pConDetails**, which is a pointer to the db2sec_con_details_<version_number> structure, and **conDetailsVersion**, which is a version number indicating which db2sec_con_details structure to use. Possible values are DB2SEC_CON_DETAILS_VERSION_1 when db2sec_con_details1 is used or DB2SEC_CON_DETAILS_VERSION_2 when db2sec_con_details2. The recommended version number to use is DB2SEC_CON_DETAILS_VERSION_2.

Upon a successful return, the db2sec_con_details structure (either db2sec_con_details1 or db2sec_con_details2) will contain the following information:

- The protocol used for the connection to the server. The listing of protocol definitions can be found in the file sqlenv.h (located in the include directory) (SQL_PROTOCOL_*). This information is filled out in the **clientProtocol** parameter.

- The TCP/IP address of the inbound connect to the server if the **clientProtocol** is SQL_PROTOCOL_TCPIP or SQL_PROTOCOL_TCPIP4. This information is filled out in the **clientIPAddress** parameter.
- The database name the client is attempting to connect to. This will not be set for instance attachments. This information is filled out in the **dbname** and **dbnameLen** parameters.
- A connection information bit-map that contains the same details as documented in the **connection_details** parameter of the db2secValidatePassword API. This information is filled out in the **connect_info_bitmap** parameter.
- The TCP/IP address of the inbound connect to the server if the **clientProtocol** is SQL_PROTOCOL_TCPIP6. This information is filled out in the **clientIP6Address** parameter and it is only available if DB2SEC_CON_DETAILS_VERSION_2 is used for db2secGetConDetails API call.

logMessage_fn

Input. A pointer to the db2secLogMessage API, which is implemented by the Db2 database manager. The db2secClientAuthPluginInit API can call the db2secLogMessage API to log messages to the **db2diag** log files for debugging or informational purposes. The first parameter (**level**) of db2secLogMessage API specifies the type of diagnostic errors that will be recorded in the **db2diag** log files and the last two parameters are the message string and its length. The valid values for the first parameter of db2secLogMessage API (defined in db2secPlugin.h) are:

- DB2SEC_LOG_NONE (0): No logging
- DB2SEC_LOG_CRITICAL (1): Severe Error encountered
- DB2SEC_LOG_ERROR (2): Error encountered
- DB2SEC_LOG_WARNING (3): Warning
- DB2SEC_LOG_INFO (4): Informational

The message text will appear in the **db2diag** log files only if the value of the **level** parameter of the db2secLogMessage API is less than or equal to the **diaglevel** database manager configuration parameter.

So for example, if you use the DB2SEC_LOG_INFO value, the message text will appear in the **db2diag** log files only if the **diaglevel** database manager configuration parameter is set to 4.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secServerAuthPluginInit API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secServerAuthPluginTerm API - Clean up server authentication plug-in resources

The db2secServerAuthPluginTerm API frees resources used by the server authentication plug-in.

This API is called by the Db2 database manager just before it unloads the server authentication plug-in. It should be implemented in a manner that it does a proper cleanup of any resources the plug-in library holds, for example, free any memory allocated by the plug-in, close files that are still open, and close network connections. The plug-in is responsible for keeping track of these resources in order to free them. This API is not called on any Windows operating systems.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secServerAuthPluginTerm)
                      ( char     **errormsg,
                        db2int32 *errormsglen );
```

db2secServerAuthPluginTerm API parameters

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the db2secServerAuthPluginTerm API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **errormsg** parameter.

db2secValidatePassword API - Validate password

Provides a method for performing user ID and password style authentication during a database connect operation.

Note: When the API is run on the client side, the API code is run with the privileges of the user executing the CONNECT statement. This API will only be called on the client side if the **authentication** configuration parameter is set to CLIENT.

When the API is run on the server side, the API code is run with the privileges of the instance owner.

The plug-in writer should take the previous scenarios into consideration if authentication requires special privileges (such as root level system access on UNIX).

This API must return the value DB2SEC_PLUGIN_OK (success) if the password is valid, or an error code such as DB2SEC_PLUGIN_BADPWD if the password is invalid.

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN *db2secValidatePassword)
                       ( const char *userid,
                         db2int32 useridlen,
                         const char *usernamespace,
                         db2int32 usernamespacelen,
                         db2int32 usernamespacetype,
                         const char *password,
                         db2int32 passwordlen,
                         const char *newpasswd,
                         db2int32 newpasswdlen,
                         const char *dbname,
                         db2int32 dbnamelen,
                         db2Uint32 connection_details,
                         void      **token,
                         char      **errormsg,
                         db2int32 *errormsglen );
```

db2secValidatePassword API parameters

userid
Input. The user ID whose password is to be verified.

useridlen
Input. Length in bytes of the **userid** parameter value.

usernamespace
Input. The namespace from which the user ID was obtained.

usernamespacelen
Input. Length in bytes of the **usernamespace** parameter value.

usernamespacetype
Input. The type of namespace. Valid values for the **usernamespacetype** parameter (defined in db2secPlugin.h) are:

- DB2SEC_NAMESPACE_SAM_COMPATIBLE Corresponds to a username style like domain\myname
- DB2SEC_NAMESPACE_USER_PRINCIPAL Corresponds to a username style like myname@domain.ibm.com

Currently, the Db2 database system only supports the value DB2SEC_NAMESPACE_SAM_COMPATIBLE. When the user ID is not available, the **usernamespacetype** parameter is set to the value DB2SEC_USER_NAMESPACE_UNDEFINED (defined in db2secPlugin.h).

password
Input. The password to be verified.

passwordlen
Input. Length in bytes of the **password** parameter value.

newpasswd
Input. A new password, if the password is to be changed. If no change is requested, this parameter is set to NULL. If this parameter is not NULL, the API should validate the old password before changing it to the new password. The API does not have to fulfill a request to change the password, but if it does not, it should immediately return with the return value DB2SEC_PLUGIN_CHANGEPASSWORD_NOTSUPPORTED without validating the old password.

newpasswdlen
Input. Length in bytes of the **newpasswd** parameter value.

dbname
Input. The name of the database being connected to. The API is free to ignore the **dbname** parameter, or it can return the value DB2SEC_PLUGIN_CONNECTIONREFUSED if it has a policy of restricting access to certain databases to users who otherwise have valid passwords. This parameter can be NULL.

dbnamelen
Input. Length in bytes of the **dbname** parameter value. This parameter is set to 0 if **dbname** parameter is NULL.

connection_details
Input. A 32-bit parameter of which 3 bits are currently used to store the following information:

- The rightmost bit indicates whether the source of the user ID is the default from the db2secGetDefaultLoginContext API, or was explicitly provided during the connect.
- The second-from-right bit indicates whether the connection is local (using Inter Process Communication (IPC) or a connect from one of the nodes in the db2nodes.cfg in the partitioned database environment), or remote (through a network or loopback). This gives the API the ability to decide whether clients on the same machine can connect to the Db2 server without a password. Due to the default operating-system-based user ID/password plugin, local connections are permitted without a password from clients on the same machine (assuming the user has connect privileges).
- The third-from-right bit indicates whether the Db2 database manager is calling the API from the server side or client side.

The bit values are defined in db2secPlugin.h:

- DB2SEC_USERID_FROM_OS (0x00000001) Indicates that the user ID is obtained from OS and not explicitly given on the connect statement.
- DB2SEC_CONNECTION_ISLOCAL (0x00000002) Indicates a local connection.
- DB2SEC_VALIDATING_ON_SERVER_SIDE (0x0000004) Indicates whether the Db2 database manager is calling from the server side or client side to validate password. If this bit value is set, then the Db2 database manager is calling from server side; otherwise, it is calling from the client side.

The Db2 database system default behavior for an implicit authentication is to allow the connection without any password validation. However, plug-in developers can disallow implicit authentication by returning a DB2SEC_PLUGIN_BADPASSWORD error.

token
Input/output. A pointer to data which can be passed as a parameter to subsequent API calls during the current connection. Possible APIs that might be called include `db2secGetAuthIDs` API and `db2secGetGroupsForUser` API.

errormsg
Output. A pointer to the address of an ASCII error message string allocated by the plug-in that can be returned in this parameter if the `db2secValidatePassword` API execution is not successful.

errormsglen
Output. A pointer to an integer that indicates the length in bytes of the error message string in **`errormsg`** parameter.

Required APIs and definitions for GSS-API authentication plug-ins

The following table is a complete list of GSS-APIs required for the Db2 security plug-in interface.

The supported APIs follow these specifications: *Generic Security Service Application Program Interface, Version 2* (IETF RFC2743) and *Generic Security Service API Version 2: C-Bindings* (IETF RFC2744). Before implementing a GSS-API based plug-in, you should have a complete understanding of these specifications.

Table 40. Required APIs and Definitions for GSS-API authentication plug-ins

API type	API name	Description
Client-side APIs	`gss_init_sec_context`	Initiate a security context with a peer application.
Server-side APIs	`gss_accept_sec_context`	Accept a security context initiated by a peer application.
Server-side APIs	`gss_display_name`	Convert an internal format name to text.
Common APIs	`gss_delete_sec_context`	Delete an established security context.
Common APIs	`gss_display_status`	Obtain the text error message associated with a GSS-API status code.
Common APIs	`gss_release_buffer`	Delete a buffer.
Common APIs	`gss_release_cred`	Release local data structures associated with a GSS-API credential.
Common APIs	`gss_release_name`	Delete internal format name.
Required definitions	`GSS_C_DELEG_FLAG`	Requests delegation.
Required definitions	`GSS_C_EMPTY_BUFFER`	Signifies that the `gss_buffer_desc` does not contain any data.
Required definitions	`GSS_C_GSS_CODE`	Indicates a GSS major status code.
Required definitions	`GSS_C_INDEFINITE`	Indicates that the mechanism does not support context expiration.
Required definitions	`GSS_C_MECH_CODE`	Indicates a GSS minor status code.
Required definitions	`GSS_C_MUTUAL_FLAG`	Mutual authentication requested.

Table 40. Required APIs and Definitions for GSS-API authentication plug-ins (continued)		
API type	**API name**	**Description**
Required definitions	`GSS_C_NO_BUFFER`	Signifies that the `gss_buffer_t` variable does not point to a valid `gss_buffer_desc` structure.
Required definitions	`GSS_C_NO_CHANNEL_BINDINGS`	No communication channel bindings.
Required definitions	`GSS_C_NO_CONTEXT`	Signifies that the `gss_ctx_id_t` variable does not point to a valid context.
Required definitions	`GSS_C_NO_CREDENTIAL`	Signifies that `gss_cred_id_t` variable does not point to a valid credential handle.
Required definitions	`GSS_C_NO_NAME`	Signifies that the `gss_name_t` variable does not point to a valid internal name.
Required definitions	`GSS_C_NO_OID`	Use default authentication mechanism.
Required definitions	`GSS_C_NULL_OID_SET`	Use default mechanism.
Required definitions	`GSS_S_COMPLETE`	API completed successfully.
Required definitions	`GSS_S_CONTINUE_NEEDED`	Processing is not complete and the API must be called again with the reply token received from the peer.

Restrictions for GSS-API authentication plug-ins

The following list describes the restrictions for GSS-API authentication plug-ins.

- The default security mechanism is always assumed; therefore, there is no OID consideration.
- The only GSS services requested in `gss_init_sec_context()` are mutual authentication and delegation. The Db2 database manager always requests a ticket for delegation, but does not use that ticket to generate a new ticket.
- Only the default context time is requested.
- Context tokens from `gss_delete_sec_context()` are not sent from the client to the server and vice-versa.
- Anonymity is not supported.
- Channel binding is not supported
- If the initial credentials expire, the Db2 database manager does not automatically renew them.
- The GSS-API specification stipulates that even if `gss_init_sec_context()` or `gss_accept_sec_context()` fail, either function must return a token to send to the peer. However, because of DRDA limitations, the Db2 database manager only sends a token if `gss_init_sec_context()` fails and generates a token on the first call.

Chapter 10. Communication buffer exit libraries

With communication buffer exit libraries, you can examine communication buffers to provide solutions such as auditing or other security solutions that are based on the contents of the buffers.

Important: The DATA_ENCRYPT authentication type is deprecated and might be removed in a future release. To encrypt data in-transit between clients and Db2 databases, we recommend that you use the Db2 database system support of Transport Layer Security (TLS). For more information, see *Configuring TLS support in a Db2 instance* in the *Data encryption* section of the Db2 Security Guide.

Db2 provides access to each buffer received from clients, and each buffer about to be sent to clients. Buffers are provided before they are encrypted with either DATA_ENCRYPT authentication or TLS. Db2 uses the DRDA protocol to communicate between clients and the server. The communication buffers that are passed to the communication buffer exit library are formatted according to the DRDA protocol. The communication buffer exit library must understand the DRDA protocol that is used for communication.

Db2 provides the buffers regardless of communication protocol. Communication buffer exit libraries work consistently with TCPIP (IPv4 and IPv6), TLS, Inter-Process Communication (IPC), and named pipe.

In addition to the buffers, Db2 also makes available identity information, including the user name and session authorization ID established for the connection to the database. This information is useful for scenarios that involve GSS-API plug-ins such as Kerberos. In this scenario, there is no standard user name, but rather generic tickets from which the database manager derives the user name. This detail is not available solely by looking at the communication buffer.

The database manager ensures that only trusted libraries are loaded. The libraries must be installed in a specific location that can be modified by only the instance owner. Furthermore, only a user with SYSADM authority can enable the library. This authority level is the same which is required to enable encryption (DATA_ENCRYPT or TLS).

The communication buffer exit library can terminate a connection if any buffer provided contains data that the library considers harmful. Both data that is sent to the server, and data that is returned to the client is included. For example, the communication buffer exit library might detect that the data returned from a select statement is inappropriate for the client to receive. A return code from the library indicates to the database manager that the connection must be terminated. The database managers stops that or any further communication buffers to the client and terminates the connection.

Note: Third-party vendors typically provide these communication buffer exit libraries. Db2 does provide samples of libraries in the `sqllib/samples/security/commexit` directory. You might choose to develop your own libraries with the samples as a guide.

Communication exit library deployment

Certain considerations must be taken with the deployment of a communication exit library.

In typical scenarios communication exit libraries are provided by vendors. In these scenarios, the deployment of communication exit libraries is handled by the vendor supplied installation scripts. The deployment steps are outlined here so you can deploy your own communication exit library if you choose to do so. The steps apply to the deployment of both runtime communication exit libraries and communication buffer exit libraries.

Communication exit library location

Communication exit libraries must exist in specific directories.

The database manager looks for communication exit libraries in the following directories:

Linux and UNIX 32-bit
`$DB2PATH/security32/plugin/commexit`

Linux and UNIX 64-bit
`$DB2PATH/security64/plugin/commexit`

Windows 32-bit and 64-bit
`$DB2PATH\security\plugin\commexit\instance_name`

Note: On Windows operating systems, the subdirectories `instance_name` and `commexit` are not created automatically. The instance owner must manually create them.

Naming conventions and permissions of communication exit libraries

Communication exit libraries must adhere to platform-specific naming and permission rules.

The maximum length of a communication exit library name, not including the file extension and the 64 suffix, is limited to 32 bytes.

The following list outlines the naming convention for the library file extension on each operating system:

AIX
The extension must be `.a` or `.so`

Note: If both the `.a` and `.so` extensions exist, `.a` is used.

Linux and HP IPF
The extension must be `.so`

Windows
The extension must be `.dll`

The following list outlines the permission for the library file on each operating system:

UNIX and Linux
Owned by the instance owner and readable and executable by only the instance owner.

Windows
Owned by a member of the DB2AMINS group and readable and executable by a member of the DB2ADMINS group.

Examples

The following example shows the communication exit library extensions on a library that is called `mycommexit` on all operating systems:

- AIX 64-bit `mycommexit.a` or `mycommexit.so`
- Linux 32-bit, or 64-bit, HP 64-bit on IPF: `mycommexit.so`
- Windows 32-bit: `mycommexit.dll`
- Windows 64-bit: `mycommexit64.dll`

Note: The file name suffix 64 is required only on the library name for Windows 64-bit.

When you update the database manager configuration with the name of a communication exit library, use the full name of the library without the 64 suffix. The file extension, and qualified path to the file, must not be specified either when you update the database manager configuration.

The following example updates the database manager configuration on a Windows 64-bit system that sets the `mycommexit64.dll` library as the communication exit library.

```
UPDATE DBM CFG USING COMM_EXIT_LIST mycommexit
```

Note: The **COMM_EXIT_LIST** name is case-sensitive, and must exactly match the library name.

Enabling communication exit libraries outside of Db2 pureScale environments

The steps that are outlined in this task are typically run by third party supplied installation scripts. The steps are outlined to help you enable a communication exit library that you develop.

Before you begin

You must have SYSADM authority to run the steps in this task.

Restrictions

The communication exit library files must follow strict file permission guidelines. For more information about these guidelines, see the related concepts.

Procedure

To enable a communication exit library:

1. Stop the database manager. To stop the database manager, run the **db2stop** command.
2. Copy the communication exit library file to the correct directory.

   For more information about the location of communication exit libraries, see the related concepts. The file can be a symbolic link to another location if wanted.
3. Update the database manager configuration parameter **COMM_EXIT_LIST** with the name of the library.

   To update the configuration parameter, use the **UPDATE DBM CFG** command.
4. Start the database manager. To start the database manager, run the **db2start** command.

Results

The library is loaded and initialized.

Enabling communication exit libraries in Db2 pureScale environments

The steps that are outlined in this task are typically run by third party supplied installation scripts. The steps are outlined to help you enable a communication exit library that you develop.

About this task

By using a communication exit library that contains a version number in the file name, and a symbolic link to this file for a library without the version number, it is possible to deploy the library on a member by member basis. In this scenario, it is not necessary to stop the whole instance, only individual members.

Restrictions

The communication exit library files must follow strict file permission guidelines. For more information about these guidelines, see the related concepts.

Procedure

To enable a communication exit library:

1. Copy the communication exit library that contains the version number in file name to the correct directory.

   For more about the location of communication exit libraries, see the related concepts.
2. Create a symbolic link from the library without a version to the library that contains the version in the file name.
3. Update the database manager configuration parameter **comm_exit_list** with the name of the library.

To update the configuration parameter, use the **UPDATE DBM CFG** command.

4. Stop each member individually.
   To stop each member, run the **db2stop** command on each member
5. Restart the stopped members.
   To start the stopped members, run the **db2start** command.

Results

The library is loaded and initialized.

Communication exit library problem determination

Some options are available to help diagnose problems with a communication exit library.

The communication exit library is not provided as part of Db2. Rather, it is a library that you install. It might be automatically installed and configured by a tool or application that you are using, or it might be written by you.

The name of the library that is specified in the database manager configuration parameter **comm_exit_list** gives some indication as to the source of the library.

If you experience any issue with the library, the documentation for the tool or application must be consulted. The tool or application documentation outlines what problem determination steps must be taken.

An interface to write to the db2diag log files is available to communication exit libraries. The db2diag log files can be checked whether there are concerns if the library is functioning properly.

If there are concerns about the performance of the communication exit library, monitoring wait times can be used to investigate how long the library is taking. For more information about these monitor tools, see the related reference.

Communication exit library development

Certain considerations must be taken with the development of a communication exit library.

In typical scenarios communication exit libraries are provided by vendors. In these scenarios, the development of communication buffer exit libraries is handled by the vendor.

Communication exit libraries are C or C++ shared objects that are dynamically loaded into the process space of the database manager. You can develop your own library if you choose to do so.

How a communication exit library is loaded

When the database manager is started, the communication exit library is dynamically loaded and initialized. The library must contain the initialization function db2commexitInit. This function is known as the library initialization function.

The library initialization function initializes the specified communication exit library. The initialization provides the database manager with the information needed to call the library functions. The library initialization function accepts the following parameters:

- The highest version number of the function pointer structure that the database instance which starts the library can support.
- A pointer to a structure which contains pointers to all the APIs that require implementation.
- A pointer to a function that adds log messages to the db2diag log files.
- A pointer to an error message string.
- The length of the error message.

The function signature for the initialization function is:

```
SQL_API_RC SQL_API_FN db2commexitInit
 ( db2int32 version,
   void *commexit_fns,
   db2commexitLogMessage *logMessage_fn,
   char     **errormsg,
   db2int32 *errormsglen );
```

The initialization function is the only function in the library that uses a prescribed function name. The other library functions are referenced through function pointers that are returned from the initialization function.

The specific tasks of this function are:

- Cast the functions pointer to a pointer of an appropriate functions structure.
- Assign the pointers to the other functions in the library.
- Assign the version number of the function pointer structure that is returned.

The communication exit library infrastructure supports both the communication buffer exit library and the runtime communication exit library. The input version parameter contains the highest version numbers for both of these libraries. This function must use the DB2COMMEXIT_GET_BUFFER_FN_VER macro to obtain the highest supported version number of the function pointer structure for DRDA style functions. The function must also use the DB2COMMEXIT_GET_RUNTIME_FN_VER macro to obtain the highest supported version number of the function pointer structure for the runtime communication exit library functions.

To use the communication buffer exit library, this function must cast commexit_fns to db2commexitFunctions_v1. The function must also define the function pointers and call the DB2COMMEXIT_SET_BUFFER_FN_VER macro to set the version number. To use the runtime communication exit library, this function must cast commexit_fns to db2commexitRuntimeFunctions_v1. The function must also define the function pointers and call the DB2COMMEXIT_SET_RUNTIME_FN_VER macro to set the version number. Only one of the macros must be called by this function.

The function `db2commexitInit` must be declared `extern "C"` if the library is compiled as C++.

Communication exit library APIs

APIs are implemented in the communication exit library. Some of the following APIs can be called by both communication buffer exit libraries and runtime communication exit libraries. Other APIs can be called by only one of those communication exit library types.

db2commexitInit API - Initialization

When the database manager is started with the **db2start** command, the communication buffer exit library is loaded. Immediately following the load of the library, this function is called. This function is responsible for initializing the communication buffer exit library. The function is also responsible for returning all of the implemented functions back to the database manager. It can be called by both types of communication exit libraries.

This function must be declared `extern "C"` if the library is compiled as C++.

This function is not required to be threadsafe, since it is only called a single time.

API header file

`db2commexit.h`

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN * db2commexitInit )
(
      db2int32 version,
      void *commexit_fns,
      db2commexitLogMessage *logMessage_fn,
      char     **errormsg,
```

```
      db2int32 *errormsglen
);
```

db2commexiInit API Parameters

version
Input. The highest version of the API supported by the instance loading that library. The value DB2COMMEXIT_API_VERSION, in db2commexit.h, contains the latest version number of the API that the database manager currently supports. If the library implements a communication buffer exit library, then db2commexitInit function must call the DB2COMMEXIT_GET_BUFFER_FN_VER macro to get the highest version of the API supported. If the library implements a runtime communication exit library, then db2commexitInit function must call the DB2COMMEXIT_GET_RUNTIME_FN_VER macro to get the highest version of the API supported.

commexit_fns
Output. A pointer to the db2commexitFunctions_<version_number> structure, that contains pointers to the APIs implemented for the communication buffer exit library. There might be different versions of the APIs, so the **commexit_fns** parameter is cast to the db2commexitFunctions_<version_number> structure corresponding to the version implemented by the library. The first parameter of the db2commexitFunctions_<version_number> structure indicates the version of the APIs implemented by the plug-in. If the library implements a communication buffer exit library, the version number must by set by calling the DB2COMMEXIT_SET_BUFFER_FN_VER macro. If the library implements a runtime communication exit library, the version number must be set by calling the DB2COMMEXIT_SET_RUNTIME_FN_VER macro. Another member, nonSQLAPIVersion, of the structure tells the database manager which version number of the non-SQL APIs that the library can handle. Currently, only DB2COMMEXIT_NONSQL_API_VERSION_KEPLER is supported.

logMessage_fn
Input. A pointer to the db2commexitLogMessage API, which is implemented by the database manager. The db2commexitInit API can call the db2commexitLogMessage API to log messages to the db2diag log files for debugging or informational purposes. The first parameter of the db2commexitLogMessage API specifies the type of diagnostic errors that are recorded in the db2diag log files and the last two parameters are the message string and its length. The valid values for the first parameter of the db2commexitLogMessage API, defined in db2commexit.h, are:

- DB2COMMEXIT_LOG_NONE: (0) No logging
- DB2COMMEXIT_LOG_CRITICAL: (1) Severe Error encountered
- DB2COMMEXIT_LOG_ERROR: (2) Error encountered
- DB2COMMEXIT_LOG_WARNING: (3) Warning
- DB2COMMEXIT_LOG_INFO: (4) Informational

The message text is logged in the db2diag log files only if the value of the 'level' parameter of the db2commexitLogMessage API is less than or equal to the **diaglevel** database manager configuration parameter. For example, if you use the DB2COMMEXIT_LOG_INFO value, the message text is logged only if the **diaglevel** database manager configuration parameter is set to 4.

errormsg
Output. A pointer to the address of an ASCII error message string. This pointer is allocated by the plug-in and can be returned in this parameter if the function execution is not successful. This memory is freed by calling db2commexitFreeErrormsg.

errormsglen
Output. A pointer to an integer that indicates the length, in bytes, of the error message string in the **errormsg** parameter.

db2commexitTerm API - Termination

This function frees resources that are used by the communication exit library. It can be called by both types of communication exit libraries.

This API is called by the database manager just before it unloads the communication exit library during **db2stop** processing. The API must be implemented in a manner so it does a complete cleanup of any resources the library holds. For instance, the API must free any memory that is allocated by the library, close files that are still open, and close network connections. The library is responsible for tracking these resources to free them.

This function is not required to be threadsafe as it is called only one time.

API header file

`db2commexit.h`

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN * db2commexitTerm )
(
   char     **errormsg,
   db2int32 *errormsglen
);
```

db2commexitTerm API Parameters

errormsg
Output. A pointer to the address of an ASCII error message string that is allocated by the communication buffer exit library. This error messages string might be returned in this parameter if the function execution is not successful. This memory is freed by calling `db2commexitFreeErrormsg`.

errormsglen
Output. A pointer to an integer that indicates the length, in bytes, of the error message string in the **errormsg** parameter.

db2commexitRegister API - Registration

This function registers the agent to the connection. It is applicable only in communication buffer exit libraries.

This function is called by the database manager whenever an agent accepts a socket and starts receiving and sending data on the socket. This activity is typically associated with a new SQL connection to the database or instance attachment.

This function is also called when an idle connection is dispatched to an agent to handle a new request from the client.

This function is not directly associated with SQL connections to the database. An input parameter to the function differentiates between a new socket and existing one that is dispatched to a new agent.

API header file

`db2commexit.h`

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN * db2commexitRegister )
(
   void                         ** pConnectionContext,
   const db2commexitCommInfo_v1  * pCommInfo,
   db2int32                        state,
```

```
   db2int64                      * pReservedFlags,
   char                         ** errormsg,
   db2int32                      * errormsglen
);
```

db2commexitRegister API Parameters

pConnectionContext
Input/output. A pointer to communication buffer exit library-specific data. This pointer is specific to the inbound connection. This parameter is passed as input to each function call for that connection. The library might allocate and store connection-specific information and make it available in each function call. The memory for the parameter must be freed in the call to `db2commexitDeregister`. The database manager cannot access the memory pointed to by this parameter.

pCommInfo
Input. A pointer to a structure that contains information which identifies the database server and protocol-specific information for the incoming connection. Some of the fields in the structure are not setup until multiple buffers are exchanged with the client. The fields are available in later calls to `db2commexitRecv` and `db2commexitSend`. This scenario applies specifically to **inbound_appl_id**, **outbound_appl_id**, and **connection_type**. When these values are known, the **connection_type** parameter indicates whether the connection is for a local database or a gateway connection.

State
Input. Indicates under which condition the function called. Possible values are:

- `NEW_CONNECTION` - indicates a new physical incoming client connection.
- `AGENT_ASSOCIATION` - indicates an existing idle client connection that becomes active again and is associated with an agent to handle the request.

pReservedFlags
Input/output. Reserved for future use. The value must be set to `0` on output.

errormsg
Output. A pointer to the address of an ASCII error message string that is allocated by the communication buffer exit library. This error messages string might be returned in this parameter if the function execution is not successful. This memory is not freed by calling `db2commexitFreeErrormsg`.

errormsglen
Output. A pointer to an integer that indicates the length, in bytes, of the error message string in the **errormsg** parameter.

db2commexitDeregister API - Deregistration

This function releases the agent from the connection with which it was associated. It is applicable only in communication buffer exit libraries.

This function is called by the database manager whenever the agent stops handling requests on the connection. This situation occurs when the physical connection with the client is terminated, or the client is idle and the agent is disassociating with it.

API header file

`db2commexit.h`

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN * db2commexitDeregister )
(
   void                          * pConnectionContext,
   const db2commexitCommInfo_v1  * pCommInfo,
   db2int32                        state,
   db2int64                      * pReservedFlags,
```

```
   char                         ** errormsg,
   db2int32                      * errormsglen
);
```

db2commexitDeregister API Parameters

pConnectionContext
Input. A pointer to communication buffer exit library-specific data. This pointer is specific to the inbound connection. This parameter is passed as input to each function call for that connection. The database manager cannot access the memory pointed to by this parameter. This memory must be deallocated by this function.

pCommInfo
Input. A pointer to a structure that contains information which identifies the database server and protocol-specific information for the incoming connection.

State
Input. Indicates under which condition the function is called. Possible values are

- `CONNECTION_TERM` - indicates that the physical connection with the client is terminated.
- `AGENT_DISASSOCIATION` - indicates that the client connection is idle and the agent is disassociated from it.

pReservedFlags
Input/Output. Reserved for future use. The value must be set to `0` on output.

errormsg
Output. A pointer to the address of an ASCII error message string that is allocated by the communication buffer exit library. This error messages string might be returned in this parameter if the function execution is not successful. This memory is not freed by calling `db2commexitFreeErrormsg`.

errormsglen
Output. A pointer to an integer that indicates the length, in bytes, of the error message string in the **`errormsg`** parameter.

db2commexitRecv API - Receive

This function is called for each buffer that the database manager receives from a client. It is applicable only in communication buffer exit libraries.

This function is called by the database manager immediately after it receives a communication buffer from the client. The function is called after the buffer is decrypted so that the communication buffer exit library can access the unencrypted buffer.

API header file

`db2commexit.h`

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN * db2commexitRecv )
(
   void                          * pConnectionContext,
   const db2commexitCommInfo_v1  * pCommInfo,
   const db2commexitBuffer       * pBuffer,
   db2int64                      * pReservedFlags,
   char                         ** errormsg,
   db2int32                      * errormsglen
);
```

db2commexitRecv API Parameters

pConnectionContext
Input. A pointer to communication buffer exit library-specific data. This pointer is specific to the inbound connection. This parameter is passed as input to each function call for that connection. The database manager cannot access the memory pointed to by this parameter. This memory must be deallocated by this function.

pCommInfo
Input. A pointer to a structure that contains information which identifies the database server and protocol-specific information for the incoming connection. Some of the fields in the structure are not setup until multiple buffers are exchanged with the client. The fields are available in later calls to `db2commexitRecv` and `db2commexitSend`. This scenario applies specifically to **`inbound_appl_id`**, **`outbound_appl_id`**, and **`connection_type`**.

pBuffer
Input. A pointer to a structure that contains the length of the buffer that is received by the database manager and a pointer to the buffer. If the buffer is encrypted, it is unencrypted before this function is called.

pReservedFlags
Input/Output. The bit `DB2COMMEXIT_RECV_IN_FLAG_END_DECRYPT` is set to indicate that this call is the final call to this function for a DSS that is encrypted. The length of the DSS that is passed as input indicates the length of the encrypted DSS. However, the DSS is then unencrypted and the padding removed. Since there is always padding, the length of the DSS is less than indicated. The length indicated in the `pBuffer` structure is the final data for the DSS. It is possible that it is zero if a full block size of padding is added.

For output, this value is reserved for future use. The value must be set to `0` on output.

errormsg
Output. A pointer to the address of an ASCII error message string that is allocated by the communication buffer exit library. This error messages string might be returned in this parameter if the function execution is not successful. This memory is not freed by calling `db2commexitFreeErrormsg`.

errormsglen
Output. A pointer to an integer that indicates the length, in bytes, of the error message string in the **`errormsg`** parameter.

db2commexitSend API - Send

This function is called for each buffer that the database manager sends to a client. It is applicable only in communication buffer exit libraries.

This function is called by the database manager immediately before a communication buffer is sent to the client. The function is called before the buffer is encrypted so that the communication buffer exit library can access the unencrypted buffer.

API header file

`db2commexit.h`

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN * db2commexitSend )
(
   void                          * pConnectionContext,
   const db2commexitCommInfo_v1  * pCommInfo,
   const db2commexitBuffer       * pBuffer,
   db2int64                      * pReservedFlags,
   char                         ** errormsg,
   db2int32                      * errormsglen
);
```

db2commexitSend API Parameters

pConnectionContext
Input. A pointer to communication buffer exit library-specific data. This pointer is specific to the inbound connection. This parameter is passed as input to each function call for that connection. The database manager cannot access the memory pointed to by this parameter.

pCommInfo
Input. A pointer to a structure that contains information which identifies the database server and protocol-specific information for the incoming connection. Some of the fields in the structure are not setup until multiple buffers are exchanged with the client. The fields are available in later calls to db2commexitRecv and db2commexitSend. This scenario applies specifically to **inbound_appl_id**, **outbound_appl_id**, and **connection_type**.

pBuffer
Input. A pointer to a structure that contains the length of the buffer that is sent to the client and a pointer to the buffer. If the buffer is encrypted, it is unencrypted before this function is called.

pReservedFlags
Input/Output. The bit DB2COMMEXIT_SEND_IN_FLAG_PURGE is set if the database manager encounters an error and must purge some buffers that were prepared to send to the client. Some of these buffers might be input to the communication buffer exit library.

For output, this value is reserved for future use. The value must be set to 0 on output.

errormsg
Output. A pointer to the address of an ASCII error message string that is allocated by the communication buffer exit library. This error messages string might be returned in this parameter if the function execution is not successful. This memory is not freed by calling db2commexitFreeErrormsg.

errormsglen
Output. A pointer to an integer that indicates the length, in bytes, of the error message string in the **errormsg** parameter.

db2commexitUserIdentity API - User identity

This function is called to provide the identity of the user for the current socket. It is applicable only in communication buffer exit libraries.

This function is called to inform the communication buffer exit library of the user name and session authorized ID used to establish the connection. The function is also called if these parameters change because of a trusted context switch user or SET SESSION AUTHORIZATION. The user name and session authorization ID are not determined until after the database manager authenticates the user. This function is not called until db2commexitRegister and multiple db2commexitSend and db2commexitRecv functions are called during authentication.

API header file

db2commexit.h

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN * db2commexitUserIdentity )
(
   void                          * pConnectionContext,
   const db2commexitCommInfo_v1  * pCommInfo,
   db2int32                        state,
   db2int32                        usernameLen,
   const char                    * pUserame,
   db2int32                        sessionAuthidLen,
   const char                    * pSessionAuthid,
   db2int64                      * pReservedFlags,
   char                         ** errormsg,
   db2int32                      * errormsglen
);
```

db2commexitUserIdentity API Parameters

pConnectionContext
Input. A pointer to communication buffer exit library-specific data. This pointer is specific to the inbound connection. This parameter is passed as input to each function call for that connection. The database manager does not access the memory pointed to by this parameter.

pCommInfo
Input. A pointer to a structure that contains information which identifies the database server and protocol-specific information for the incoming connection. Some of the fields in the structure are not setup until multiple buffers are exchanged with the client. The fields are available in later calls to db2commexitRecv and db2commexitSend. This scenario applies specifically to **inbound_appl_id**, **outbound_appl_id**, and **connection_type**.

State
Input. Indicates under which condition the function is called. Possible values are:

- DB2COMMEXIT_USERIDENT_NEW_CONNECTION - a new connection.
- DB2COMMEXIT_USERIDENT_TC_SWITCH_USER - a trusted context switch user is issued.
- DB2COMMEXIT_USERIDENT_SET_SESSION_USER - SET SESSION AUTHORIZATION SQL statement is issued to change the session authorization ID.

usernameLen
Input. The length of **pUsername**.

pUsername
Input. The user name that is used to establish the connection.

sessionAuthidLen
Input. The length of **pSessionAuthid**.

pSessionAuthid
Input. The session authorization ID established for this connection.

pReservedFlags
Input/Output. Reserved for future use. The value must be set to 0 on output.

errormsg
Output. A pointer to the address of an ASCII error message string that is allocated by the communication buffer exit library. This error messages string might be returned in this parameter if the function execution is not successful. This memory is not freed by calling db2commexitFreeErrormsg.

errormsglen
Output. A pointer to an integer that indicates the length, in bytes, of the error message string in the **errormsg** parameter.

db2commexitFreeErrormsg API - Free error message memory

This function frees the memory that is used to hold an error message from a previous API call. It is applicable for both types of communication exit libraries.

API header file

db2commexit.h

API and data structure syntax

```
SQL_API_RC ( SQL_API_FN * db2commexitFreeErrormsg )
    ( char * errormsg );
```

db2commexitFreeErrormsg API Parameters

errormsg
Input. A pointer to the error message returned from a previous API call.

Communication buffer exit library functions structure

The db2commexitInit function takes a `void * commexit_fns` parameter. This parameter is cast to the version-specific structure which contains all of the functions that are implemented by the communication buffer exit library. The db2commexitInit function must assign the function pointers so that the database manager can call those functions.

The structure that must be completed, including a function pointer for each API, follows.

```
struct db2commexitFunctions_v1
{
    db2int32 version;

    SQL_API_RC ( SQL_API_FN * db2commexitTerm )
    (
       char     **errormsg,
       db2int32 *errormsglen
    );

    SQL_API_RC ( SQL_API_FN * db2commexitRegister )
    (
       void                          ** ppConnectionContext,
       const db2commexitCommInfo_v1  * pCommInfo,
       db2int32                        state,
       db2int64                      * pReservedFlags,
       char                          ** errormsg,
       db2int32                      * errormsglen
    );

    SQL_API_RC ( SQL_API_FN * db2commexitDeregister )
    (
       void                           * pConnectionContext,
       const db2commexitCommInfo_v1  * pCommInfo,
       db2int32                        state,
       db2int64                      * pReservedFlags,
       char                          ** errormsg,
       db2int32                      * errormsglen
    );

    SQL_API_RC ( SQL_API_FN * db2commexitRecv )
    (
       void                           * pConnectionContext,
       const db2commexitCommInfo_v1  * pCommInfo,
       const db2commexitBuffer       * pBuffer,
       db2int64                      * pReservedFlags,
       char                          ** errormsg,
       db2int32                      * errormsglen
    );

    SQL_API_RC ( SQL_API_FN * db2commexitSend )
    (
       void                           * pConnectionContext,
       const db2commexitCommInfo_v1  * pCommInfo,
       const db2commexitBuffer       * pBuffer,
       db2int64                      * pReservedFlags,
       char                          ** errormsg,
       db2int32                      * errormsglen
    );

    SQL_API_RC ( SQL_API_FN * db2commexitUserIdentity )
    (
       void                           * pConnectionContext,
       const db2commexitCommInfo_v1  * pCommInfo,
       db2int32                        state,
       db2int32                        usernameLen,
       const char                    * pUserame,
       db2int32                        sessionAuthidLen,
       const char                    * pSessionAuthid,
       db2int64                      * pReservedFlags,
       char                          ** errormsg,
       db2int32                      * errormsglen
    );
```

```
    SQL_API_RC ( SQL_API_FN * db2commexitFreeErrormsg )
    (
       char * errormsg
    );

};
```

Communication buffer exit library information structure

The information structure indicates the communication protocol information for the current physical connection.

The db2commexitCommInfo_v1 structure that is passed to each communication buffer exit library function follows. This structure is included in the db2commexit.h file.

```
struct db2commexitIPV4Info
{
   sockaddr_in client_sockaddr;
   sockaddr_in server_sockaddr;
};

struct db2commexitIPV6Info
{
   sockaddr_in6 client_sockaddr;
   sockaddr_in6 server_sockaddr;
};

struct db2commexitIPCInfo
{
   void * pSharedMemSegmentHandle;
};

struct db2commexitNamedPipeInfo
{
   void * handle;
};


struct db2commexitCommInfo_v1
{
   db2int32 clientProtocol;   // SQL_PROTOCOL_ ...
   db2int32 connectionType; // unknown, local or gateway

   db2int32 hostnameLen;
   db2int32 instanceLen;
   db2int32 dbnameLen;
   db2int32 dbaliasLen;
   db2int32 inbound_appl_id_len;
   db2int32 outbound_appl_id_len;

   db2int32 clientPID;      // Client PID
   db2int32 reserved2;

   db2NodeType member;

   char hostname[SQL_HOSTNAME_SZ+1];
   char instance[DB2COMMEXIT_INSTANCE_SZ + 1];
   char dbname[DB2COMMEXIT_DBNAME_SZ + 1];
   char dbalias[DB2COMMEXIT_DBNAME_SZ + 1];
   char inbound_appl_id[SQLM_APPLID_SZ + 1];
   char outbound_appl_id[SQLM_APPLID_SZ + 1];

   char reservedChar1[128];

   union
   {
      db2commexitIPV4Info ipv4Info;
      db2commexitIPV6Info ipv6Info;
      db2commexitIPCInfo  ipcInfo;
      db2commexitNamedPipeInfo namedPipeInfo;
   }
};
```

Communication exit library buffer structure

The buffer structure is the structure that is passed as input to communication exit library functions.

The buffer structure follows:

```
struct db2commexitBuffer
{
   const unsigned char * pBuffer;
   db2int64 buffer_len;

   db2int32 reserved1;
   db2int32 reserved2;
};
```

Communication buffer exit library control over connections

The communication buffer exit library can force a drop of the connection to the client at any time.

If the communication buffer exit library returns the appropriate error return code on any of the calls to `db2commexitUserIdentity`, `db2commexitRegister`, `db2commexitDeregister`, `db2commexitRecv`, or `db2commexitSend`, the database manager immediately closes the connection with the client.

This capability allows the communication buffer exit library to determine, based on the buffers reviewed, if some inappropriate activity is taking place. If such a determination is made, any further action by the database manager for that connection can be prevented.

Communication exit library API versions

The Db2 database system supports multiple versions of communication exit library APIs. Versions are numbered with integers that start with 1.

The version number that the database manager passes to the security library initialization function is the highest supported version number of the API.

The communication exit library infrastructure supports both communication buffer exit libraries and runtime communication exit libraries. The input version parameter contains the highest version numbers for both sets of the libraries. Functions must use the DB2COMMEXIT_GET_BUFFER_FN_VER macro to obtain the highest supported version number of the function pointer structure for DRDA style functions. Functions must use the DB2COMMEXIT_GET_RUNTIME_FN_VER macro to obtain the highest supported version number of the function pointer structure for the runtime communication exit library functions.

This function must cast commexit_fns to db2commexitFunctions_v1, define the function pointers, and call the DB2COMMEXIT_SET_BUFFER_FN_VER macro to set the version number. To use the runtime communication exit library, this function must cast commexit_fns to db2commexitRuntimeFunctions_v1. The function must also define the function pointers, and call the DB2COMMEXIT_SET_RUNTIME_FN_VER macro to set the version number. Only one of the macros must be called by this function.

The version numbers of the communication exit library APIs change only when necessary. For example, when there are changes to the parameters of the APIs. Version numbers are not automatically changed with database manager release numbers.

The version numbers allow the introduction of new or changed APIs. Library support for older versions is maintained

Communication exit library error handing and return codes

When an error occurs in a communication exit library API, the API can return an ASCII text string in the **`errormsg`** field. That ASCII text string provides a more specific description of the problem than the return code. The database manager writes this entire string into the `db2diag` log files.

The memory for these error messages must be allocated by the communication exit library. Therefore, the library must also provide an API to free this memory: `db2commexitFreeErrormsg`.

In addition to the **errormsg** field, at initialization time a message log function pointer, `logMessage_fn`, is passed to the communication buffer exit library. The library can use the function to log any debugging information to the db2diag log files. For example:

```
// Log an message indicate init successful
  (*(logMessage_fn))(DB2COMMEXIT_LOG_CRITICAL,
                     "comm exit initialization successful",
                      strlen("comm. exit initialization successful"));
```

For more details about each parameter for the db2secLogMessage function, refer to the initialization API db2commexitInit in the related reference.

Return codes

Table 41. Return codes that a communication exit library can return to the database manager.

Return code	Define value	Details
0	DB2COMMEXIT_SUCCESS	Successful execution
-1	DB2COMMEXIT_ERR_UNKNOWN	The library encountered an unexpected error.
-2	DB2COMMEXIT_ERR_DROP_CONNECTION	The library determined that the connection for which it was called must be terminated.

Communication exit library development restrictions

Certain restrictions and considerations must be taken when you develop a communication exit library.

Restrictions

C-linkage
The communication exit library must be written in C or C++ and linked with C-linkage. Header files that provide the prototypes, data structures that are required to implement the libraries, and error code definitions are provided only for C and C++. The function db2commexitInit must be declared `extern "C"` if the library is compiled as C++.

Signal handlers
The communication exit library must not install signal handlers or change the signal mask. Doing so interferes with the signal handlers of the database manager. Interfering with the database manager signal handlers might seriously interfere with the ability to report and recover from errors.

Exceptions
The communication exit library APIs must not throw C++ exceptions. Such exceptions can interfere with database manager error handling.

Thread-safe
The communication exit library functions must be thread-safe. The db2commexitInit and db2commexitTerm functions are the only APIs that are not required to be thread-safe.

Exit handlers
The communication exit library must not install exit handlers or pthread_atfork handlers. The use of exit handlers is not supported because the communication exit library is unloaded before the database manager process exits.

Fork/threads
The communication exit library must not call, fork, or create new threads. This situation can lead to undefined behavior such as traps in the database manager.

Library dependencies
On Linux and UNIX, the communication exit library is loaded from a process that is **setuid** or **setgid**. It cannot rely on the **LD_LIBRARY_PATH**, **SHLIB_PATH**, or **LIBPATH** environment variables to find dependent libraries. Therefore, the library must not depend on more libraries, unless any dependent libraries are accessible through other methods, such as:

- The dependent libraries exist in /lib or /usr/lib.

- The directories in which dependent libraries are found are specified OS-wide (such as in the `ld.so.conf` file on Linux).
- Dependent libraries are specified in the RPATH in the library itself.

Symbol collisions
When possible, communication exit libraries might be compiled and linked with any available options that reduce the likelihood of symbol collisions. Such as, options that reduce unbound external symbolic references. For example, use of the **`-Bsymbolic`**linker option on HP and Linux can help prevent problems that are related to symbol collisions. However, for libraries that are written on AIX, do not use the **`-brtl`** linker option explicitly or implicitly.

32-bit versus 64-bit considerations
The database manager has both 32-bit and 64-bit versions, depending on the operating system. A 32-bit communication exit library must be enabled on a 32-bit database manager. A 64-bit communication exit library must be enabled on a 64-bit database manager. You cannot mix the two.

Stored procedures, triggers, and other internal SQL
Stored procedure interaction with the server is passed onto the communication exit library. Much of the interaction does not occur over standard communication channels and does not fit the model that is used for the exit library. Similarly, triggers, and other sources of internal SQL do not pass over standard communication channels and are not passed onto the communication exit library.

Communication buffers must not be manipulated
It is expected that the communication exit library does not manipulate or change the buffers that it is passed.

Rolling updates support
Db2 supports updating the fix pack level of individual members in Db2 pureScale environments without stopping other members. This operation is known as rolling updates. Similarly, it is possible to update the level of the library that is used on individual members. It is possible that two different versions of the communication exit library might be running simultaneously on two different members. Similarly, each member can be at a different fix pack level. The communication exit library must tolerate such conditions without error.

Loading plug-in libraries on AIX with an extension of `.a` or `.so`
On AIX, security plug-in libraries can have a file name extension of `.a` or `.so`. The mechanism that is used to load the plug-in library depends on which extension is used:

- Plug-in libraries with a file name extension of `.a`

  Plug-in libraries with file name extensions of `.a` are assumed to be archives which contain shared object members. These members must be named `shr.o` for 32-bit or `shr64.o` for 64-bit. A single archive can contain both the 32-bit and 64-bit members, allowing it to be deployed on both types of operating systems.
- Plug-in libraries with a file name extension of `.so`

  Plug-in libraries with file name extensions of `.so` are assumed to be dynamically loadable shared objects. Such an object is 32-bit or 64-bit depending on the compiler and linker options that are used when it was built.

On all operating systems, other than AIX, security plug-in libraries are always assumed to be dynamically loadable shared objects.

Communication exit library API calling sequences

API calling sequences differ depending on specific scenarios and which exit library you use.

The following topics outline specific scenarios that you must be aware of when you develop communication exit libraries. Some topics apply to only communication buffer exit libraries. Some topics apply to only runtime communication exit libraries. Some topics apply to both types of communication exit libraries. The topics help you determine the calling sequence most appropriate for your environment.

API calling sequence - Normal connect in a single agent

The most typical scenario is a client that connects to the database manager, issuing some SQL, and then disconnecting. This API calling sequence applies to communication buffer exit libraries.

In this case, a single agent, or thread handles the connection, and the following calls are made:

1. `db2commexitRegister` for a new socket connection.
2. `db2commexitRecv` and `db2commexitSend` to handle authentication, possibly multiple times.
3. `db2commexitUserIdentity` for a new connection
4. `db2commexitRecv` and `db2commexitSend` to handle clients SQL requests, possibly multiple times.
5. `db2commexitDeregister` to terminate socket connection.

API calling sequence - Connect without a connect reset

This scenario covers a connect over an existing socket. The client might initiate another SQL connection without first issuing a connect reset. Two API calling sequences are illustrated. One shows how to implement the sequence for a runtime communication exit library. The other shows how to implement the sequence for a communication buffer exit library.

Communication buffer exit library

When the database manager receives the SQL connect statement from the client, it implicitly drives an internal connect reset before it continues with the connect. Regular requests and replies flow back and forth as there is no change to the status of the socket. In this case, a single agent is handling all requests. As the buffers that contain the connect request from the client is made available through `db2commexitRecv`, the communication buffer exit library is able to determine a new connect is started when the buffer is parsed. The following calls are made:

1. `db2commexitRegister` for a new socket connection.
2. `db2commexitRecv` and `db2commexitSend` to handle authentication, possibly multiple times.
3. `db2commexitUserIdentity` for a new connection.
4. `db2commexitRecv` and `db2commexitSend` to handle client SQL requests, possibly multiple times.
5. `db2commexitRecv` and `db2commexitSend` to handle authentication, possibly multiple times.
6. `db2commexitUserIdentity` for a new connection.
7. `db2commexitRecv` and `db2commexitSend` to handle client SQL requests, possibly multiple times.
8. `db2commexitDeregister` to terminate socket connection.

Note: `db2commexitRegister` and `db2commexitDeregister` are called only a single time each, even though the database manager processed two SQL connections.

Runtime communication exit library

When the database manager receives the SQL connect statement from the client, it implicitly drives an internal connect reset before it continues with the connect. In this case, a single agent is handling all requests. The following calls are made:

1. `db2commexitSessionInit` for a new connection.
2. `db2commexitSQL*` to handle SQL requests.
3. `db2commexitSessionTerm` to close a connection.
4. `db2commexitSessionInit` for a new connection.
5. `db2commexitSQL*` to handle SQL requests.
6. `db2commexitSessionTerm` to close a connection.

API calling sequence - Trusted context and switch user

This scenario is similar to connecting without a connect reset. The difference is the client requests a trusted context switch user rather than sending a new SQL connect request. Two API calling sequences are illustrated. One shows how to implement the sequence for a runtime communication exit library. The other shows how to implement the sequence for a communication buffer exit library.

Communication buffer exit library

The following calls are made:

1. `db2commexitRegister` for a new socket connection.
2. `db2commexitRecv` and `db2commexitSend` to handle authentication, possibly multiple times.
3. `db2commexitUserIdentity` for a new connection
4. `db2commexitRecv` and `db2commexitSend` to handle clients SQL requests, possibly multiple times.
5. `db2commexitRecv` and `db2commexitSend` to handle authentication, possibly multiple times.

   At some future point, the client sends a trusted context switch user request to the server to switch the user for the connection.
6. `db2commexitUserIdentity` for a trusted context switch user.
7. `db2commexitRecv` and `db2commexitSend` to handle clients SQL requests, possibly multiple times.
8. `db2commexitDeregister` to terminate socket connection.

Runtime communication exit library

The following calls are made:

1. `db2commexitSessionInit` for a new connection.
2. `db2commexitSQL*` to handle SQL requests.
3. `db2commexitSessionTerm` to close a user session.
4. `db2commexitSessionInit` for a new user session.
5. `db2commexitSQL*` to handle SQL requests.
6. `db2commexitSessionTerm` to close a connection.

API calling sequence - Connection concentrator

This scenario covers the API calling sequence when connection concentrator is used. The connection concentrator feature allows the database manager to handle many more clients than there are coordinating agents or threads. This API calling sequence applies to communication buffer exit libraries.

When a client reaches a unit of work boundary and does not send another request immediately, client sockets are placed into an idle pool. The agent that previously handled client requests moves on to another client. When the idle socket has data to read, a dispatcher finds an idle agent to handle it. Over the life of an SQL connection, there might be multiple agents that handle the client requests. Each time the socket is moved in and out of the idle pool, `db2commexitDeregister` and `db2commexitRegister` are called. The following calls are made:

1. `db2commexitRegister` for a new socket connection.
2. `db2commexitRecv` and `db2commexitSend` to handle authentication, possibly multiple times.
3. `db2commexitUserIdentity` for a new connection
4. `db2commexitRecv` and `db2commexitSend` to handle client SQL requests, possibly multiple times.

   The client does not send another request immediately and the socket is placed into an idle pool.
5. `db2commexitDeregister` to disassociate with the agent.

At some future point, the client sends another request, at which point the dispatcher chooses an idle agent. The agent is likely a different one than used previously:

6. db2commexitRegister to associate an agent.
7. db2commexitRecv and db2commexitSend to handle client SQL requests, possibly multiple times.
8. db2commexitDeregister to terminate socket connection.

Note: There are multiple calls to db2commexitRegister and db2commexitDeregister for a single SQL connection.

API calling sequence - SET SESSION AUTHORIZATION statement

This scenario covers the API calling sequence when the SET SESSION AUTHORIZATION statement is used. Two API calling sequences are illustrated. One shows how to implement the sequence for a runtime communication exit library. The other shows how to implement the sequence for a communication buffer exit library.

Communication buffer exit library

The SET SESSION AUTHORIZATION statement changes the session authorization ID in use for the current connection. Db2commexitUserIdentity is called to inform the communication buffer exit library that identity information changed for the current connection. The following calls are made:

1. db2commexitRegister for a new socket connection.
2. db2commexitRecv and db2commexitSend to handle authentication, possibly multiple times.
3. db2commexitUserIdentity for a new connection.
4. db2commexitRecv and db2commexitSend to handle clients SQL requests, possibly multiple times.

   The user issues a SET SESSION AUTHORIZATION statement. This request is passed to db2commexitRecv. It is no different from other SQL statement.
5. db2commexitUserIdentity for a SET SESSION AUTHORIZATION.
6. db2commexitRecv and db2commexitSend to handle client SQL requests, possibly multiple times.
7. db2commexitDeregister to terminate socket connection.

Runtime communication exit library

The SET SESSION AUTHORIZATION statement changes the session authorization ID in use for the current connection. Db2commexitSetSessionAuth is called to inform the communication buffer exit library that identity information changed for the current connection. The following calls are made:

1. db2commexitSessionInit for a new connection.
2. db2commexitSQL* to handle new SQL requests.

   The user issues a SET SESSION AUTHORIZATION statement. This request is no different from other SQL statement
3. db2commexitSetSessionAuth for a SET SESSION AUTHORIZATION.
4. db2commexitSQL* to handle new SQL requests.
5. db2commexitSessionTerm to close the connection.

Considerations for setting the target logical node

Considerations must be taken when you set the target logical node with the *DB2NODE* variable, or with the **SET CLIENT** command. The information applies to communication buffer exit libraries.

In a partitioned database environment, if the client specifies a member through the *DB2NODE* variable that is not the member it is configured to connect to, the database manager switches the connection to the new member specified in the variable. The client connection is forwarded through the connected

member to the remote member. In this case, the communication buffer exit library is called at both members. There are a few features to note:

- At the connected member, the client address reflects the actual client.
- At the remote member, the client address reflects the connected member.
- The outbound application id at the connected member is the same as the inbound application id at the remote member.
- At the connected member, the database alias used reflects the database alias provided by the actual client.
- At the remote member, the database alias used is the actual database name.

When the application IDs are established, the **connectionType** in the db2commexitCommInfo_v1 structure is set to GATEWAY.

Considerations for a connect gateway

Considerations must be taken when the database manager acts as a connect gateway to another DRDA database server.

When Db2 acts as a connect gateway, the communication exit library is called in the same manner as a standard connection. When authentication is complete and the application IDs are established, the **connectionType** in the db2commexitCommInfo_v1 structure is set to GATEWAY. The outbound_application_id matches the application ID for the connection at the DRDA database server.

Considerations for DATA_ENCRYPT

Considerations must be taken when the DATA_ENCRYPT authentication type is used. The information applies to only communication buffer exit libraries.

Important: The DATA_ENCRYPT authentication type is deprecated and might be removed in a future release. To encrypt data in-transit between clients and Db2 databases, we recommend that you use the Db2 database system support of Transport Layer Security (TLS). For more information, see *Configuring TLS support in a Db2 instance* in the *Data encryption* section of the Db2 Security Guide.

The handling of communications that is protected with the authentication type DATA_ENCRYPT requires special mention. Unlike SSL, the encryption and decryption necessary to support DATA_ENCRYPT is run by the database manager. It is run after data is received from the client and before a reply is sent to the client.

Receive and DATA_ENCRYPT

When an encrypted DSS is received from the client, the buffer is decrypted as needed by the database manager. That is, the whole buffer is not decrypted all at one time. The communication buffer exit library is called with the decrypted data as it is decrypted.

The DSS length, or the DSS continuation length if the DSS is longer than a logical record, contains the length of the encrypted DSS. It does not contain the length of the decrypted buffer. As the encryption always adds padding, this length is always larger than the plaintext length. The length of the padding for DSS is a maximum of 8 bytes.

When the final call to db2CommexitRecv is made, the *DB2COMMEXIT_RECV_IN_FLAG_END_DECRYPT* flag is passed as input to indicate the end of the encrypted DSS.

Note: It is possible the length in such a case is 0, indicating that a full block size of padding is added.

Send and DATA_ENCRYPT

When a DSS reply to the client is encrypted, multiple plaintext DSS and encrypted DSS might make up the buffer which is sent to the client. As these DSS are prepared, they are passed as input to the db2commexitSend routine. These passes are done one at a time as the plaintext data must be used

as input before encryption. The database manager might receive an error condition which requires it to purge previously prepared, but not sent, DSS. The communication buffer exit library might already know about these libraries. The db2CommexitSend function is called with a length of 0 and a flag DB2COMMEXIT_SEND_IN_FLAG_PURGE indicating that a purge occurred.

Chapter 11. Audit facility record layouts

When an audit record is extracted from the audit log, each record has one of the formats shown in the following tables. Each table is preceded by a sample record.

The description of each item in the record is shown one row at a time in the associated table. Each item is shown in the table in the same order as it is output in the delimited file after the extract operation.

Note:

1. Depending on the audit event, not all fields in the audit records will have values. When there is no values in the field, the field will not be shown in the audit output.
2. Some fields such as "Access Attempted" are stored in the delimited ASCII format as bit maps. In this flat report file, however, these fields appear as a set of strings representing the bit map values.

Audit record object types

The following table shows for each audit record object type whether it can generate CHECKING, OBJMAINT, and SECMAINT events.

Table 42. Audit Record Object Types Based on Audit Events

Object type	CHECKING events	OBJMAINT events	SECMAINT events
ACCESS_RULE			X
ALIAS	X	X	
ALL	X		
AUDIT_POLICY	X	X	
BUFFERPOOL	X	X	
CHECK_CONSTRAINT		X	
DATABASE	X		X
DATA TYPE		X	
EVENT_MONITOR	X	X	
FOREIGN_KEY		X	
FUNCTION	X	X	X
FUNCTION MAPPING	X	X	
GLOBAL_VARIABLE	X	X	X
HISTOGRAM TEMPLATE	X	X	
INDEX	X	X	X
INDEX EXTENSION		X	
INSTANCE	X		
JAR_FILE		X	
MASK	X	X	X
METHOD_BODY	X	X	X
MODULE	X	X	X

Table 42. Audit Record Object Types Based on Audit Events (continued)

Object type	CHECKING events	OBJMAINT events	SECMAINT events
NICKNAME	X	X	X
NODEGROUP	X	X	
NONE	X	X	X
OPTIMIZATION PROFILE	X		
PACKAGE	X	X	X
PACKAGE CACHE	X		
PERMISSION	X	X	X
PRIMARY_KEY		X	
REOPT_VALUES	X		
ROLE	X	X	X
SCHEMA	X	X	X
SECURITY LABEL		X	X
SECURITY LABEL COMPONENT		X	
SECURITY POLICY		X	X
SEQUENCE	X	X	
SERVER	X	X	X
SERVER OPTION	X	X	
SERVICE CLASS	X	X	
STORED_PROCEDURE	X	X	X
SUMMARY TABLES	X	X	X
TABLE	X	X	X
TABLESPACE	X	X	X
TENANT	X	X	
THRESHOLD	X	X	
TRIGGER		X	
TRUSTED CONTEXT	X	X	X
TYPE MAPPING	X	X	
TYPE&TRANSFORM	X	X	
UNIQUE_CONSTRAINT		X	
USER MAPPING	X	X	
USER_TEMPORARY_TABLE	X	X	X
VIEW	X	X	X
WORK ACTION SET	X	X	
WORK CLASS SET	X	X	

Table 42. Audit Record Object Types Based on Audit Events (continued)			
Object type	**CHECKING events**	**OBJMAINT events**	**SECMAINT events**
WORKLOAD	X	X	X
WRAPPER	X	X	
XSR object	X	X	X

Audit record layout for AUDIT events

The following table shows the layout of the audit record for AUDIT events.

Sample audit record:

```
timestamp=2007-04-10-08.29.52.000001;
category=AUDIT;
audit event=START;
event correlator=0;
event status=0;
userid=newton;
authid=NEWTON;
application id=*LOCAL_APPLICATION;
application name=db2audit.exe;
```

Table 43. Audit Record Layout for AUDIT Events		
NAME	**FORMAT**	**DESCRIPTION**
Timestamp	CHAR(26)	Date and time of the audit event.
Category	CHAR(8)	Category of audit event. Possible values are: AUDIT
Audit Event	VARCHAR(32)	Specific Audit Event. For a list of possible values, refer to the section for the AUDIT category in “Audit events” on page 369.
Event Correlator	INTEGER	Correlation identifier for the operation being audited. Can be used to identify what audit records are associated with a single event.
Event Status	INTEGER	Status of audit event, represented by an SQLCODE where Successful event > = 0 Failed event < 0
User ID	VARCHAR(1024)	User ID at time of audit event.
Authorization ID	VARCHAR(128)	Authorization ID at time of audit event.
Database Name	CHAR(8)	Name of the database for which the event was generated. Blank if this was an instance level audit event.
Origin Node Number	SMALLINT	Member number at which the audit event occurred.
Coordinator Node Number	SMALLINT	Member number of the coordinator member.
Application ID	VARCHAR(255)	Application ID in use at the time the audit event occurred.
Application Name	VARCHAR(1024)	Application name in use at the time the audit event occurred.
Package Schema	VARCHAR(128)	Schema of the package in use at the time of the audit event.
Package Name	VARCHAR(128)	Name of package in use at the time the audit event occurred.

Table 43. Audit Record Layout for AUDIT Events (continued)

NAME	FORMAT	DESCRIPTION
Package Section	SMALLINT	Section number in package being used at the time the audit event occurred
Package Version	VARCHAR(64)	Version of the package in use at the time the audit event occurred.
Local Transaction ID	VARCHAR(10) FOR BIT DATA	The local transaction ID in use at the time the audit event occurred. This is the SQLU_TID structure that is part of the transaction logs.
Global Transaction ID	VARCHAR(30) FOR BIT DATA	The global transaction ID in use at the time the audit event occurred. This is the data field in the SQLP_GXID structure that is part of the transaction logs.
Client User ID	VARCHAR(255)	The value of the CURRENT CLIENT USERID special register at the time the audit event occurred.
Client Workstation Name	VARCHAR(255)	The value of the CURRENT CLIENT_WRKSTNNAME special register at the time the audit event occurred.
Client Application Name	VARCHAR(255)	The value of the CURRENT CLIENT_APPLNAME special register at the time the audit event occurred.
Client Accounting String	VARCHAR(255)	The value of the CURRENT CLIENT_ACCTNG special register at the time the audit event occurred.
Trusted Context Name	VARCHAR(255)	The name of the trusted context associated with the trusted connection.
Connection Trust Type	CHAR(1)	Possible values are: '' - NONE '1' - IMPLICIT_TRUSTED_CONNECTION '2' - EXPLICIT_TRUSTED_CONNECTION
Role Inherited	VARCHAR(128)	The role inherited through a trusted connection.
Policy Name	VARCHAR(128)	The audit policy name.
Policy Association Object Type	CHAR(1)	The type of the object that the audit policy is associated with. Possible values include: • N = Nickname • S = MQT • T = Table (untyped) • i = Authorization ID • g= Authority • x = Trusted context • blank = Database

Table 43. Audit Record Layout for AUDIT Events (continued)

NAME	FORMAT	DESCRIPTION
Policy Association Subobject Type	CHAR(1)	The type of sub-object that the audit policy is associated with. If the Object Type is ? (authorization id), then possible values are: • U = User • G = Group • R = Role
Policy Association Object Name	VARCHAR(128)	The name of the object that the audit policy is associated with.
Policy Association Object Schema	VARCHAR(128)	The schema name of the object that the audit policy is associated with. This is NULL if the Policy Association Object Type identifies an object to which a schema does not apply.
Audit Status	CHAR(1)	The status of the AUDIT category in an audit policy. Possible values are: • B-Both • F-Failure • N-None • S-Success
Checking Status	CHAR(1)	The status of the CHECKING category in an audit policy. Possible values are: • B-Both • F-Failure • N-None • S-Success
Context Status	CHAR(1)	The status of the CONTEXT category in an audit policy. Possible values are: • B-Both • F-Failure • N-None • S-Success
Execute Status	CHAR(1)	The status of the EXECUTE category in an audit policy. Possible values are: • B-Both • F-Failure • N-None • S-Success
Execute With Data	CHAR(1)	The WITH DATA option of the EXECUTE category in the audit policy. Possible values are: • Y-WITH DATA • N-WITHOUT DATA

Table 43. Audit Record Layout for AUDIT Events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Objmaint Status	CHAR(1)	The status of the OBJMAINT category in an audit policy. Possible values are: • B-Both • F-Failure • N-None • S-Success
Secmaint Status	CHAR(1)	The status of the SECMAINT category in an audit policy. See Audit Status field for possible values.
Sysadmin Status	CHAR(1)	The status of the SYSADMIN category in an audit policy. Possible values are: • B-Both • F-Failure • N-None • S-Success
Validate Status	CHAR(1)	The status of the VALIDATE category in an audit policy. Possible values are: • B-Both • F-Failure • N-None • S-Success
Error Type	CHAR(8)	The error type in an audit policy. Possible values are: AUDIT and NORMAL.
Data Path	VARCHAR(1024)	The path to the active audit logs specified on the **db2audit configure** command.
Archive Path	VARCHAR(1024)	The path to the archived audit logs specified on the **db2audit configure** command
Original User ID	VARCHAR(1024)	The value of the CLIENT_ORIGUSERID global variable at the time the audit event occurred.
Tenant name	VARCHAR(128)	Tenant name in use at the time the audit event occurred.

Audit record layout for CHECKING events

The format of the audit record for CHECKING events is shown in the following table.

Sample audit record:

```
timestamp=1998-06-24-08.42.11.622984;
category=CHECKING;
audit event=CHECKING_OBJECT;
event correlator=2;
event status=0;
database=FOO;
userid=boss;
authid=BOSS;
application id=*LOCAL.newton.980624124210;
application name=testapp;
package schema=NULLID;
package name=SYSSH200;
```

```
package section=0;
object schema=GSTAGER;
object name=NONE;
object type=REOPT_VALUES;
access approval reason=DBADM;
access attempted=STORE;
```

Table 44. Audit record layout for CHECKING events

NAME	FORMAT	DESCRIPTION
Timestamp	CHAR(26)	Date and time of the audit event.
Category	CHAR(8)	Category of audit event. Possible values are: CHECKING
Audit Event	VARCHAR(32)	Specific Audit Event. For a list of possible values, refer to the section for the CHECKING category in “Audit events” on page 369.
Event Correlator	INTEGER	Correlation identifier for the operation being audited. Can be used to identify what audit records are associated with a single event.
Event Status	INTEGER	Status of audit event, represented by an SQLCODE where Successful event > = 0 Failed event < 0
Database Name	CHAR(8)	Name of the database for which the event was generated. Blank if this was an instance level audit event.
User ID	VARCHAR(1024)	User ID at time of audit event.
Authorization ID	VARCHAR(128)	Authorization ID at time of audit event.
Origin Node Number	SMALLINT	Member number at which the audit event occurred.
Coordinator Node Number	SMALLINT	Member number of the coordinator Member.
Application ID	VARCHAR(255)	Application ID in use at the time the audit event occurred.
Application Name	VARCHAR(1024)	Application name in use at the time the audit event occurred.
Package Schema	VARCHAR(128)	Schema of the package in use at the time of the audit event.
Package Name	VARCHAR(128)	Name of package in use at the time the audit event occurred.
Package Section Number	SMALLINT	Section number in package being used at the time the audit event occurred.
Object Schema	VARCHAR(128)	Schema of the object for which the audit event was generated.
Object Name	VARCHAR(128)	Name of object for which the audit event was generated.
Object Type	VARCHAR(32)	Type of object for which the audit event was generated. Possible values include: those shown in the topic titled "Audit record object types".
Access Approval Reason	CHAR(34)	Indicates the reason why access was approved for this audit event. Possible values include: those shown in the topic titled "List of possible CHECKING access approval reasons".
Access Attempted	CHAR(34)	Indicates the type of access that was attempted. Possible values include: those shown in the topic titled "List of possible CHECKING access attempted types".

Table 44. Audit record layout for CHECKING events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Package Version	VARCHAR (64)	Version of the package in use at the time that the audit event occurred.
Checked Authorization ID	VARCHAR(128)	Authorization ID is checked when it is different than the authorization ID at the time of the audit event. For example, this can be the target owner in a TRANSFER OWNERSHIP statement. When the audit event is SWITCH_USER, this field represents the authorization ID that is switched to.
Local Transaction ID	VARCHAR(10) FOR BIT DATA	The local transaction ID in use at the time the audit event occurred. This is the SQLU_TID structure that is part of the transaction logs.
Global Transaction ID	VARCHAR(30) FOR BIT DATA	The global transaction ID in use at the time the audit event occurred. This is the data field in the SQLP_GXID structure that is part of the transaction logs.
Client User ID	VARCHAR(255)	The value of the CURRENT CLIENT USERID special register at the time the audit event occurred.
Client Workstation Name	VARCHAR(255)	The value of the CURRENT CLIENT_WRKSTNNAME special register at the time the audit event occurred.
Client Application Name	VARCHAR(255)	The value of the CURRENT CLIENT_APPLNAME special register at the time the audit event occurred.
Client Accounting String	VARCHAR(255)	The value of the CURRENT CLIENT_ACCTNG special register at the time the audit event occurred.
Trusted Context Name	VARCHAR(255)	The name of the trusted context associated with the trusted connection.
Connection Trust Type	CHAR(1)	Possible values are: '' - NONE '1' - IMPLICIT_TRUSTED_CONNECTION '2' - EXPLICIT_TRUSTED_CONNECTION
Role Inherited	VARCHAR(128)	The role inherited through a trusted connection.
Original User ID	VARCHAR(1024)	The value of the CLIENT_ORIGUSERID global variable at the time the audit event occurred.
Tenant name	VARCHAR(128)	Tenant name in use at the time the audit event occurred.

CHECKING access approval reasons

The following list shows the possible CHECKING access approval reasons.

Note that an audit record might contain multiple access approval reasons, for example: `access approval reason=DATAACCESS,ACCESSCTRL;`. When multiple access approval reasons are present, the user must have all stated authorities and privileges in order to pass the authorization check for the attempted access.

0x00000000000000000000000000000001 ACCESS DENIED
Access is not approved; rather, it was denied.

0x00000000000000000000000000000002 SYSADM
Access is approved; the application or user has SYSADM authority.

0x00000000000000000000000000000004 SYSCTRL
Access is approved; the application or user has SYSCTRL authority.

0x00000000000000000000000000000008 SYSMAINT
Access is approved; the application or user has SYSMAINT authority.

0x00000000000000000000000000000010 DBADM
Access is approved; the application or user has DBADM authority.

0x00000000000000000000000000000020 DATABASE
Access is approved; the application or user has an explicit privilege on the database.

0x00000000000000000000000000000040 OBJECT
Access is approved; the application or user has a privilege on the object or function.

0x00000000000000000000000000000080 DEFINER
Access is approved; the application or user is the definer of the object or function.

0x00000000000000000000000000000100 OWNER
Access is approved; the application or user is the owner of the object or function.

0x00000000000000000000000000000200 CONTROL
Access is approved; the application or user has CONTROL privilege on the object or function.

0x00000000000000000000000000000400 BIND
Access is approved; the application or user has bind privilege on the package.

0x00000000000000000000000000000800 SYSQUIESCE
Access is approved; if the instance or database is in quiesce mode, the application or user may connect or attach.

0x00000000000000000000000000001000 SYSMON
Access is approved; the application or user has SYSMON authority.

0x00000000000000000000000000002000 SECADM
Access is approved; the application or user has SECADM authority.

0x00000000000000000000000000004000 SETSESSIONUSER
Access is approved; the application or user has SETSESSIONUSER authority.

0x00000000000000000000000000008000 TRUSTED_CONTEXT_MATCH
Connection attributes matched the attributes of a unique trusted context defined at the Db2 server.

0x00000000000000000000000000010000 TRUSTED_CONTEXT_USE
Access is approved to use a trusted context.

0x00000000000000000000000000020000 SQLADM
Access is approved; the application or user has SQLADM authority.

0x00000000000000000000000000040000 WLMADM
Access is approved; the application or user has WLMADM authority.

0x00000000000000000000000000080000 EXPLAIN
Access is approved; the application or user has EXPLAIN authority.

0x00000000000000000000000000100000 DATAACCESS
Access is approved; the application or user has DATAACCESS authority.

0x00000000000000000000000000200000 ACCESSCTRL
Access is approved; the application or user has ACCESSSCTRL authority.

0x00000000000000000000000000400000 CREATE_SECURE_OBJECT
Access is approved; the application or user has the SECUREOBJECTAUTH authority.

0x00000000000000000000000000800000 SCHEMA
Access is approved; the application or user has the SELECTIN, INSERTIN, UPDATEIN, or DELETEIN privileges or the SCHEMA_LOAD authority.

0x00000000000000000000000001000000 SCHEMAADM
Access is approved; the application or user has the SCHEMAADM authority.

0x00000000000000000000000002000000 SCHEMA_ACCESSCTRL
Access is approved; the application or user has the SCHEMA_ACCESSCTRL authority.

0x00000000000000000000000004000000 SCHEMA_DATAACCESS
Access is approved; the application or user has the SCHEMA_DATAACCESS authority.

CHECKING access attempted types

The following list shows the possible CHECKING access attempted types.

If Audit Event is CHECKING_TRANSFER, then the audit entry reflects that a privilege is held or not.

0x00000000000000000000000000000001 CONTROL
Attempt to verify whether CONTROL privilege is held.

0x00000000000000000000000000000002 ALTER
Attempt to alter an object or to verify whether ALTER privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000000000004 DELETE
Attempt to delete an object or to verify whether DELETE privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000000000008 INDEX
Attempt to use an index or to verify whether INDEX privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000000000010 INSERT
Attempt to insert into an object or to verify whether INSERT privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000000000020 SELECT
Attempt to query a table or view or to verify whether SELECT privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000000000040 UPDATE
Attempt to update data in an object or to verify whether UPDATE privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000000000080 REFERENCE
Attempt to establish referential constraints between objects or to verify whether REFERENCE privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000000000100 CREATE
Attempt to create an object.

0x00000000000000000000000000000200 DROP
Attempt to drop an object.

0x00000000000000000000000000000400 CREATEIN
Attempt to create an object within another schema.

0x00000000000000000000000000000800 DROPIN
Attempt to drop an object found within another schema.

0x00000000000000000000000000001000 ALTERIN
Attempt to alter or modify an object found within another schema.

0x00000000000000000000000000002000 EXECUTE
Attempt to execute or run an application or to invoke a routine, create a function sourced from the routine (applies to functions only), or reference a routine in any DDL statement or to verify whether EXECUTE privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000000004000 BIND
Attempt to bind or prepare an application.

0x00000000000000000000000000008000 SET_EVENT MONITOR
Attempt to set event monitor switches.

0x00000000000000000000000000010000 SET_CONSTRAINTS
Attempt to set constraints on an object.

0x00000000000000000000000000020000 COMMENT ON
Attempt to create comments on an object.

0x00000000000000000000000000040000 GRANT
Attempt to grant privileges or roles on an object to another authorization ID.

0x00000000000000000000000000080000 REVOKE
Attempt to revoke privileges or roles from an object from an authorization ID.

0x00000000000000000000000000100000 LOCK
Attempt to lock an object.

0x00000000000000000000000000200000 RENAME
Attempt to rename an object.

0x00000000000000000000000000400000 CONNECT
Attempt to connect to a database.

0x00000000000000000000000000800000 MEMBER_OF_SYS_GROUP
Attempt to access or use a member of the SYS group.

0x00000000000000000000000001000000 ALL
Attempt to execute a statement with all required privileges on objects held (only used for DBADM/SYSADM).

0x00000000000000000000000002000000 DROP ALL
Attempt to drop multiple objects.

0x00000000000000000000000004000000 LOAD
Attempt to load a table in a table space.

0x00000000000000000000000008000000 USE
Attempt to create a table in a table space or to verify whether USE privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000000010000000 SET_SESSION_USER
Attempt to execute the SET SESSION_USER statement.

0x00000000000000000000000020000000 FLUSH
Attempt to execute the FLUSH statement.

0x00000000000000000000000040000000 STORE
Attempt to view the values of a reoptimized statement in the EXPLAIN_PREDICATE table.

0x00000000000000000000000100000000 SET_OWNER
Attempt to set an owner that does not match the current user when binding a package.

0x00000000000000000000000200000000 SET_PASSTHRU
Attempt to issue the SET PASSTHRU statement.

0x00000000000000000000000400000000 TRANSFER
Attempt to transfer an object.

0x00000000000000000000000800000000 ALTER_WITH_GRANT
Attempt to verify whether ALTER with GRANT privilege is held.

0x00000000000000000000001000000000 DELETE_WITH_GRANT
Attempt to verify whether DELETE with GRANT privilege is held.

0x00000000000000000000002000000000 INDEX_WITH_GRANT
Attempt to verify whether INDEX with GRANT privilege is held

0x00000000000000000000004000000000 INSERT_WITH_GRANT
Attempt to verify whether INSERT with GRANT privilege is held.

0x00000000000000000000008000000000 SELECT_WITH_GRANT
Attempt to verify whether SELECT with GRANT privilege is held.

0x00000000000000000000010000000000 UPDATE_WITH_GRANT
Attempt to verify whether UPDATE with GRANT privilege is held.

0x00000000000000000000020000000000 REFERENCE_WITH_GRANT
Attempt to verify whether REFERENCE with GRANT privilege is held.

0x00000000000000000000040000000000 USAGE
Attempt to use a sequence or an XSR object or to verify whether USAGE privilege is held if Audit Event is CHECKING_TRANSFER.

0x00000000000000000000080000000000 SET ROLE
Attempt to set a role.

0x00000000000000000000100000000000 EXPLICIT_TRUSTED_CONNECTION
Attempt to establish an explicit trusted connection.

0x00000000000000000000200000000000 IMPLICIT_TRUSTED_CONNECTION
Attempt to establish an implicit trusted connection.

0x00000000000000000000400000000000 READ
Attempt to read a global variable.

0x00000000000000000000800000000000 WRITE
Attempt to write a global variable.

0x00000000000000000001000000000000 SWITCH_USER
Attempt to switch a user ID on an explicit trusted connection.

0x00000000000000000002000000000000 AUDIT_USING
Attempt to associate an audit policy with an object.

0x00000000000000000004000000000000 AUDIT_REPLACE
Attempt to replace an audit policy association with an object.

0x00000000000000000008000000000000 AUDIT_REMOVE
Attempt to remove an audit policy association with an object.

0x00000000000000000010000000000000 AUDIT_ARCHIVE
Attempt to archive the audit log.

0x00000000000000000020000000000000 AUDIT_EXTRACT
Attempt to extract the audit log.

0x00000000000000000040000000000000 AUDIT_LIST_LOGS
Attempt to list the audit logs.

0x00000000000000000080000000000000 IGNORE_TRIGGERS
Attempt to ignore the triggers associated with a database object.

0x00000000000000000100000000000000 PREPARE
Attempt to prepare an SQL statement and the user does not hold the necessary object level privilege or DATAACCESS authority.

0x00000000000000000200000000000000 DESCRIBE
Attempt to describe a statement and the user does not hold the necessary object level privilege or DATAACCESS authority.

0x00000000000000000400000000000000 SET_USAGELIST
Attempt to set the usage list state.

Audit record layout for OBJMAINT events

The format of the audit record for OBJMAINT events is shown in the following table.

Sample audit record:

```
timestamp=1998-06-24-08.42.41.957524;
category=OBJMAINT;
audit event=CREATE_OBJECT;
event correlator=3;
event status=0;
database=FOO;
userid=boss;
authid=BOSS;
application id=*LOCAL.newton.980624124210;
application name=testapp;
package schema=NULLID;
package name=SQLC28A1;
```

```
package section=0;
object schema=BOSS;
object name=AUDIT;
object type=TABLE;
```

Table 45. Audit Record Layout for OBJMAINT Events

NAME	FORMAT	DESCRIPTION
Timestamp	CHAR(26)	Date and time of the audit event.
Category	CHAR(8)	Category of audit event. Possible values are: OBJMAINT
Audit Event	VARCHAR(32)	Specific Audit Event. For a list of possible values, refer to the section for the OBJMAINT category in "Audit events" on page 369.
Event Correlator	INTEGER	Correlation identifier for the operation being audited. Can be used to identify what audit records are associated with a single event.
Event Status	INTEGER	Status of audit event, represented by an SQLCODE where Successful event > = 0 Failed event < 0
Database Name	CHAR(8)	Name of the database for which the event was generated. Blank if this was an instance level audit event.
User ID	VARCHAR(1024)	User ID at time of audit event.
Authorization ID	VARCHAR(128)	Authorization ID at time of audit event.
Origin Node Number	SMALLINT	Member number at which the audit event occurred.
Coordinator Node Number	SMALLINT	Member number of the coordinator member.
Application ID	VARCHAR(255)	Application ID in use at the time the audit event occurred.
Application Name	VARCHAR(1024)	Application name in use at the time the audit event occurred.
Package Schema	VARCHAR(128)	Schema of the package in use at the time of the audit event.
Package Name	VARCHAR(256)	Name of package in use at the time the audit event occurred.
Package Section Number	SMALLINT	Section number in package being used at the time the audit event occurred.
Object Schema	VARCHAR(128)	Schema of the object for which the audit event was generated.
Object Name	VARCHAR(128)	Name of object for which the audit event was generated.
Object Type	VARCHAR(32)	Type of object for which the audit event was generated. Possible values include: those shown in the topic titled "Audit record object types".
Package Version	VARCHAR(64)	Version of the package in use at the time the audit event occurred.
Security Policy Name	VARCHAR(128)	The name of the security policy if the object type is TABLE and that table is associated with a security policy.

Table 45. Audit Record Layout for OBJMAINT Events (continued)

NAME	FORMAT	DESCRIPTION
Alter Action	VARCHAR(32)	Specific Alter operation Possible values include: • ADD_PROTECTED_COLUMN • ADD_COLUMN_PROTECTION • DROP_COLUMN_PROTECTION • ADD_ROW_PROTECTION • ADD_SECURITY_POLICY • ADD_ELEMENT • ADD COMPONENT • USE GROUP AUTHORIZATIONS • IGNORE GROUP AUTHORIZATIONS • USE ROLE AUTHORIZATIONS • IGNORE ROLE AUTHORIZATIONS • OVERRIDE NOT AUTHORIZED WRITE SECURITY LABEL • RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL • SECURE • UNSECURE • ENABLE • DISABLE • ACTIVATE_ROW_ACCESS_CONTROL • ACTIVATE_COLUMN_ACCESS_CONTROL • ACTIVATE_ROW_COLUMN_ACCESS_CONTROL
Protected Column Name	VARCHAR(128)	If the Alter Action is ADD_COLUMN_PROTECTION or DROP_COLUMN_PROTECTION this is the name of the affected column.
Column Security Label	VARCHAR(128)	The security label protecting the column specified in the field Column Name.
Security Label Column Name	VARCHAR(128)	Name of the column containing the security label protecting the row.
Local Transaction ID	VARCHAR(10) FOR BIT DATA	The local transaction ID in use at the time the audit event occurred. This is the SQLU_TID structure that is part of the transaction logs.
Global Transaction ID	VARCHAR(30) FOR BIT DATA	The global transaction ID in use at the time the audit event occurred. This is the data field in the SQLP_GXID structure that is part of the transaction logs.
Client User ID	VARCHAR(255)	The value of the CURRENT CLIENT USERID special register at the time the audit event occurred.
Client Workstation Name	VARCHAR(255)	The value of the CURRENT CLIENT_WRKSTNNAME special register at the time the audit event occurred.
Client Application Name	VARCHAR(255)	The value of the CURRENT CLIENT_APPLNAME special register at the time the audit event occurred.

Table 45. Audit Record Layout for OBJMAINT Events (continued)

NAME	FORMAT	DESCRIPTION
Client Accounting String	VARCHAR(255)	The value of the CURRENT CLIENT_ACCTNG special register at the time the audit event occurred.
Trusted Context Name	VARCHAR(255)	The name of the trusted context associated with the trusted connection.
Connection Trust Type	CHAR(1)	Possible values are: '' - NONE '1' - IMPLICIT_TRUSTED_CONNECTION '2' - EXPLICIT_TRUSTED_CONNECTION
Role Inherited	VARCHAR(128)	The role inherited through a trusted connection.
Object Module	VARCHAR(128)	Name of module to which the object belongs.
Associated Object Name	VARCHAR(128)	Name of the object for which an association exists. The meaning of the association depends on the Object Type for the event. If the Object Type is PERMISSION or MASK, then the associated object is the table on which the permission or mask has been created.
Associated Object Schema	VARCHAR(128)	Name of the object schema for which an association exists. The meaning of the association depends on the Object Type for the event.
Associated Object Type	VARCHAR(128)	The type of the object for which an association exists. The meaning of the association depends on the Object Type for the event.
Associated Subobject Type	VARCHAR(128)	The type of the subobject for which an association exists. The meaning of the association depends on the Object Type for the event. If the Object Type is MASK and the associated object type is TABLE, then the associated subobject is the column of the table on which the mask has been created.
Associated Subobject Name	VARCHAR(128)	Name of the subobject for which an association exists. The meaning of the association depends on the Object Type for the event.
Secured	VARCHAR(32)	Specifies if the object is a secured object.
State	VARCHAR(32)	The state of the object. The state depends on the Object Type. Possible values include: • ENABLED • DISABLED
Access Control	VARCHAR(32)	Specifies what access control the object is protected with. Possible values include: • ROW - Row access control has been activated on the object • COLUMN - Column access control has been activated on the object • ROW_COLUMN - Row and column access control has been activated on the object
Original User ID	VARCHAR(1024)	The value of the CLIENT_ORIGUSERID global variable at the time the audit event occurred.

Table 45. Audit Record Layout for OBJMAINT Events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Tenant name	VARCHAR(128)	Tenant name in use at the time the audit event occurred.

Audit record layout for SECMAINT events

The format of the audit record for SECMAINT events is shown in the following table.

Sample audit record:

```
timestamp=1998-06-24-11.57.45.188101;
category=SECMAINT;
audit event=GRANT;
event correlator=4;
event status=0;
database=FOO;
userid=boss;
authid=BOSS;
application id=*LOCAL.boss.980624155728;
application name=db2bp;
package schema=NULLID;
package name=SQLC28A1;
package section=0;
object schema=BOSS;
object name=T1;
object type=TABLE;
grantor=BOSS;
grantee=WORKER;
grantee type=USER;
privilege=SELECT;
```

Table 46. Audit Record Layout for SECMAINT Events		
NAME	**FORMAT**	**DESCRIPTION**
Timestamp	CHAR(26)	Date and time of the audit event.
Category	CHAR(8)	Category of audit event. Possible values are: SECMAINT
Audit Event	VARCHAR(32)	Specific Audit Event. For a list of possible values, refer to the section for the SECMAINT category in “Audit events” on page 369.
Event Correlator	INTEGER	Correlation identifier for the operation being audited. Can be used to identify what audit records are associated with a single event.
Event Status	INTEGER	Status of audit event, represented by an SQLCODE where Successful event > = 0 Failed event < 0
Database Name	CHAR(8)	Name of the database for which the event was generated. Blank if this was an instance level audit event.
User ID	VARCHAR(1024)	User ID at time of audit event.
Authorization ID	VARCHAR(128)	Authorization ID at time of audit event.
Origin Node Number	SMALLINT	Member number at which the audit event occurred.
Coordinator Node Number	SMALLINT	Member number of the coordinator member.
Application ID	VARCHAR(255)	Application ID in use at the time the audit event occurred.

Table 46. Audit Record Layout for SECMAINT Events (continued)

NAME	FORMAT	DESCRIPTION
Application Name	VARCHAR(1024)	Application name in use at the time the audit event occurred.
Package Schema	VARCHAR(128)	Schema of the package in use at the time of the audit event.
Package Name	VARCHAR(128)	Name of package in use at the time the audit event occurred.
Package Section Number	SMALLINT	Section number in package being used at the time the audit event occurred.
Object Schema	VARCHAR(128)	Schema of the object for which the audit event was generated. If the object type field is ACCESS_RULE then this field contains the security policy name associated with the rule. The name of the rule is stored in the field Object Name. If the object type field is SECURITY_LABEL, then this field contains the name of the security policy that the security label is part of. The name of the security label is stored in the field Object Name.
Object Name	VARCHAR(128)	Name of object for which the audit event was generated. Represents a role name when the audit event is any of: • ADD_DEFAULT_ROLE • DROP_DEFAULT_ROLE • ALTER_DEFAULT_ROLE • ADD_USER • DROP_USER • ALTER_USER_ADD_ROLE • ALTER_USER_DROP_ROLE • ALTER_USER_AUTHENTICATION If the object type field is ACCESS_RULE then this field contains the name of the rule. The security policy name associated with the rule is stored in the field Object Schema. If the object type field is SECURITY_LABEL, then this field contains the name of the security label. The name of the security policy that it is part of is stored in the field Object Schema.
Object Type	VARCHAR(32)	Type of object for which the audit event was generated. Possible values include: those shown in the topic titled "Audit record object types". The value is ROLE when the audit event is any of: • ADD_DEFAULT_ROLE • DROP_DEFAULT_ROLE • ALTER_DEFAULT_ROLE • ADD_USER • DROP_USER • ALTER_USER_ADD_ROLE • ALTER_USER_DROP_ROLE • ALTER_USER_AUTHENTICATION

Table 46. Audit Record Layout for SECMAINT Events (continued)

NAME	FORMAT	DESCRIPTION
Grantor	VARCHAR(128)	The ID of the grantor or the revoker of the privilege or authority.
Grantee	VARCHAR(128)	Grantee ID for which a privilege or authority was granted or revoked. Represents a trusted context object when the audit event is any of: • ADD_DEFAULT_ROLE • DROP_DEFAULT_ROLE • ALTER_DEFAULT_ROLE • ADD_USER, DROP_USER • ALTER_USER_ADD_ROLE • ALTER_USER_DROP_ROLE • ALTER_USER_AUTHENTICATION
Grantee Type	VARCHAR(32)	Type of the grantee that was granted to or revoked from. Possible values include: USER, GROUP, ROLE, AMBIGUOUS, or is TRUSTED_CONTEXT when the audit event is any of: • ADD_DEFAULT_ROLE • DROP_DEFAULT_ROLE • ALTER_DEFAULT_ROLE • ADD_USER • DROP_USER • ALTER_USER_ADD_ROLE • ALTER_USER_DROP_ROLE • ALTER_USER_AUTHENTICATION
Privilege or Authority	CHAR(34)	Indicates the type of privilege or authority granted or revoked. Possible values include: those shown in the topic titled "List of possible SECMAINT privileges or authorities". The value is ROLE MEMBERSHIP when the audit event is any of the following: • ADD_DEFAULT_ROLE, DROP_DEFAULT_ROLE • ALTER_DEFAULT_ROLE • ADD_USER • DROP_USER • ALTER_USER_ADD_ROLE • ALTER_USER_DROP_ROLE • ALTER_USER_AUTHENTICATION
Package Version	VARCHAR(64)	Version of the package in use at the time the audit event occurred.

Table 46. Audit Record Layout for SECMAINT Events (continued)

NAME	FORMAT	DESCRIPTION
Access Type	VARCHAR(32)	The access type for which a security label is granted. Possible values: • READ • WRITE • ALL The access type for which a security policy is altered. Possible values: • USE GROUP AUTHORIZATIONS • IGNORE GROUP AUTHORIZATIONS • USE ROLE AUTHORIZATIONS • IGNORE ROLE AUTHORIZATIONS • OVERRIDE NOT AUTHORIZED WRITE SECURITY LABEL • RESTRICT NOT AUTHORIZED WRITE SECURITY LABEL
Assumable Authid	VARCHAR(128)	When the privilege granted is a SETSESSIONUSER privilege this is the authorization ID that the grantee is allowed to set as the session user.
Local Transaction ID	VARCHAR(10) FOR BIT DATA	The local transaction ID in use at the time the audit event occurred. This is the SQLU_TID structure that is part of the transaction logs.
Global Transaction ID	VARCHAR(30) FOR BIT DATA	The global transaction ID in use at the time the audit event occurred. This is the data field in the SQLP_GXID structure that is part of the transaction logs.
Grantor Type	VARCHAR(32)	Type of the grantor. Possible values include: USER.
Client User ID	VARCHAR(255)	The value of the CURRENT CLIENT USERID special register at the time the audit event occurred.
Client Workstation Name	VARCHAR(255)	The value of the CURRENT CLIENT_WRKSTNNAME special register at the time the audit event occurred.
Client Application Name	VARCHAR(255)	The value of the CURRENT CLIENT_APPLNAME special register at the time the audit event occurred.
Client Accounting String	VARCHAR(255)	The value of the CURRENT CLIENT_ACCTNG special register at the time the audit event occurred.
Trusted Context User	VARCHAR(128)	Identifies a trusted context user when the audit event is ADD_USER or DROP_USER.
Trusted Context User Authentication	INTEGER	Specifies the authentication setting for a trusted context user when the audit event is ADD_USER, DROP_USER or ALTER_USER_AUTHENTICATION 1 : Authentication is required 0 : Authentication is not required
Trusted Context Name	VARCHAR(255)	The name of the trusted context associated with the trusted connection.

Table 46. Audit Record Layout for SECMAINT Events (continued)

NAME	FORMAT	DESCRIPTION
Connection Trust Type	CHAR(1)	Possible values are: '' - NONE '1' - IMPLICIT_TRUSTED_CONNECTION '2' - EXPLICIT_TRUSTED_CONNECTION
Role Inherited	VARCHAR(128)	The role inherited through a trusted connection.
Associated Object Name	VARCHAR(128)	Name of the object for which an association exists. The meaning of the association depends on the Object Type for the event. If the Object Type is PERMISSION or MASK, then the Associated Object is the table on which that permission or mask has been created.
Associated Object Schema	VARCHAR(128)	Name of the object schema for which an association exists. The meaning of the association depends on the Object Type of the event.
Associated Object Type	VARCHAR(128)	The type of the object for which an association exists. The meaning of the association depends on the Object Type of the event.
Associated Subobject Type	VARCHAR(128)	The type of the subobject for which an association exists. The meaning of the association depends on the Object Type of the event. If the Object Type is MASK and the Associated Object type is TABLE, then the associated subobject is the column of the table on which the mask has been created.
Associated Subobject Name	VARCHAR(128)	Name of the subobject for which an association exists. The meaning of the association depends on the Object Type of the event.
Alter Action	VARCHAR(32)	Specific Alter Action. Possible values include: • SECURE • UNSECURE • ENABLE • DISABLE • ACTIVATE_ROW_ACCESS_CONTROL • ACTIVATE_COLUMN_ACCESS_CONTROL • ACTIVATE_ROW_COLUMN_ACCESS_CONTROL
Secured	VARCHAR(32)	Specifies if the object is a secure object.
State	VARCHAR(32)	Specifies the state of the object. The state depends on the Object Type. Possible values include: • ENABLED • DISABLED

Table 46. Audit Record Layout for SECMAINT Events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Access Control	VARCHAR(32)	Specifies what access control type the object is protected with. Possible values include: • ROW - Row access control has been activated for the object • COLUMN - Column access control has been activated for the object • ROW_COLUMN - Row and column access have been activated for the object
Original User ID	VARCHAR(1024)	The value of the CLIENT_ORIGUSERID global variable at the time the audit event occurred.
Tenant name	VARCHAR(128)	Tenant name in use at the time the audit event occurred.

SECMAINT privileges or authorities

The following list shows the possible SECMAINT privileges or authorities.

0x00000000000000000000000000000001 Control Table
Control privilege granted or revoked on or from a table or view.

0x00000000000000000000000000000002 ALTER
Privilege granted or revoked to alter a table or sequence.

0x00000000000000000000000000000004 ALTER with GRANT
Privilege granted or revoked to alter a table or sequence with granting of privileges allowed.

0x00000000000000000000000000000008 DELETE TABLE
Privilege granted or revoked to drop a table or view.

0x00000000000000000000000000000010 DELETE TABLE with GRANT
Privilege granted or revoked to drop a table with granting of privileges allowed.

0x00000000000000000000000000000020 Table Index
Privilege granted or revoked on or from an index.

0x00000000000000000000000000000040 Table Index with GRANT
Privilege granted or revoked on or from an index with granting of privileges allowed.

0x00000000000000000000000000000080 Table INSERT
Privilege granted or revoked on or from an insert on a table or view.

0x00000000000000000000000000000100 Table INSERT with GRANT
Privilege granted or revoked on or from an insert on a table with granting of privileges allowed.

0x00000000000000000000000000000200 Table SELECT
Privilege granted or revoked on or from a select on a table.

0x00000000000000000000000000000400 Table SELECT with GRANT
Privilege granted or revoked on or from a select on a table with granting of privileges allowed.

0x00000000000000000000000000000800 Table UPDATE
Privilege granted or revoked on or from an update on a table or view.

0x00000000000000000000000000001000 Table UPDATE with GRANT
Privilege granted or revoked on or from an update on a table or view with granting of privileges allowed.

0x00000000000000000000000000002000 Table REFERENCE
Privilege granted or revoked on or from a reference on a table.

0x00000000000000000000000000004000 Table REFERENCE with GRANT
Privilege granted or revoked on or from a reference on a table with granting of privileges allowed.

0x00000000000000000000000000020000 CREATEIN Schema
CREATEIN privilege granted or revoked on or from a schema.

0x00000000000000000000000000040000 CREATEIN Schema with GRANT
CREATEIN privilege granted or revoked on or from a schema with granting of privileges allowed.

0x00000000000000000000000000080000 DROPIN Schema
DROPIN privilege granted or revoked on or from a schema.

0x00000000000000000000000000100000 DROPIN Schema with GRANT
DROPIN privilege granted or revoked on or from a schema with granting of privileges allowed.

0x00000000000000000000000000200000 ALTERIN Schema
ALTERIN privilege granted or revoked on or from a schema.

0x00000000000000000000000000400000 ALTERIN Schema with GRANT
ALTERIN privilege granted or revoked on or from a schema with granting of privileges allowed.

0x00000000000000000000000000800000 DBADM Authority
DBADM authority granted or revoked.

0x00000000000000000000000001000000 CREATETAB Authority
Createtab authority granted or revoked.

0x00000000000000000000000002000000 BINDADD Authority
Bindadd authority granted or revoked.

0x00000000000000000000000004000000 CONNECT Authority
CONNECT authority granted or revoked.

0x00000000000000000000000008000000 Create not fenced Authority
Create not fenced authority granted or revoked.

0x00000000000000000000000010000000 Implicit Schema Authority
Implicit schema authority granted or revoked.

0x00000000000000000000000020000000 Server PASSTHRU
Privilege granted or revoked to use the pass-through facility with this server (federated database data source).

0x00000000000000000000000040000000 ESTABLISH TRUSTED CONNECTION
Trusted connection was created

0x00000000000000000000000100000000 Table Space USE
Privilege granted or revoked to create a table in a table space.

0x00000000000000000000000200000000 Table Space USE with GRANT
Privilege granted or revoked to create a table in a table space with granting of privileges allowed.

0x00000000000000000000000400000000 Column UPDATE
Privilege granted or revoked on or from an update on one or more specific columns of a table.

0x00000000000000000000000800000000 Column UPDATE with GRANT
Privilege granted or revoked on or from an update on one or more specific columns of a table with granting of privileges allowed.

0x00000000000000000000001000000000 Column REFERENCE
Privilege granted or revoked on or from a reference on one or more specific columns of a table.

0x00000000000000000000002000000000 Column REFERENCE with GRANT
Privilege granted or revoked on or from a reference on one or more specific columns of a table with granting of privileges allowed.

0x00000000000000000000004000000000 LOAD Authority
LOAD authority granted or revoked.

0x00000000000000000000008000000000 Package BIND
BIND privilege granted or revoked on or from a package.

0x00000000000000000000010000000000 Package BIND with GRANT
BIND privilege granted or revoked on or from a package with granting of privileges allowed.

0x00000000000000000000020000000000 EXECUTE
EXECUTE privilege granted or revoked on or from a package or a routine.

0x00000000000000000000040000000000 EXECUTE with GRANT
EXECUTE privilege granted or revoked on or from a package or a routine with granting of privileges allowed.

0x00000000000000000000080000000000 EXECUTE IN SCHEMA
EXECUTE privilege granted or revoked for all routines in a schema.

0x00000000000000000000100000000000 EXECUTE IN SCHEMA with GRANT
EXECUTE privilege granted or revoked for all routines in a schema with granting of privileges allowed.

0x00000000000000000000200000000000 EXECUTE IN TYPE
EXECUTE privilege granted or revoked for all routines in a type.

0x00000000000000000000400000000000 EXECUTE IN TYPE with GRANT
EXECUTE privilege granted or revoked for all routines in a type with granting of privileges allowed.

0x00000000000000000000800000000000 CREATE EXTERNAL ROUTINE
CREATE EXTERNAL ROUTINE privilege granted or revoked.

0x00000000000000000001000000000000 QUIESCE_CONNECT
QUIESCE_CONNECT privilege granted or revoked.

0x00000000000000000004000000000000 SECADM Authority
SECADM authority granted or revoked

0x00000000000000000008000000000000 USAGE Authority
USAGE privilege granted or revoked on or from a sequence

0x00000000000000000010000000000000 USAGE with GRANT Authority
USAGE privilege granted or revoked on or from a sequence with granting of privileges allowed.

0x00000000000000000020000000000000 WITH ADMIN Option
WITH ADMIN Option is granted or revoked to or from a role.

0x00000000000000000040000000000000 SETSESSIONUSER Privilege
SETSESSIONUSER granted or revoked

0x00000000000000000080000000000000 Exemption
Exemption granted or revoked

0x00000000000000000100000000000000 Security label
Security label granted or revoked

0x00000000000000000200000000000000 WRITE with GRANT
Privilege granted or revoked to write a global variable with granting of privileges allowed.

0x00000000000000000400000000000000 Role Membership
Role membership that is granted or revoked

0x00000000000000000800000000000000 Role Membership with ADMIN Option
Role membership with ADMIN Option that is granted or revoked

0x00000000000000001000000000000000 READ
Privilege granted or revoked to read a global variable.

0x00000000000000002000000000000000 READ with GRANT
Privilege granted or revoked to read a global variable with granting of privileges allowed.

0x00000000000000004000000000000000 WRITE
Privilege granted or revoked to write a global variable.

0x00000000000000010000000000000000 SQLADM
SQLADM authority granted or revoked.

0x00000000000000020000000000000000 WLMADM
WLMADM authority granted or revoked.

0x00000000000000040000000000000000 EXPLAIN
EXPLAIN authority granted or revoked.

0x00000000000000080000000000000000 DATAACCESS
DATAACCESS authority granted or revoked.

0x00000000000000100000000000000000 ACCESSCTRL
ACCESSCTRL authority granted or revoked.

0x00000000000000200000000000000000 CREATE_SECURE_OBJECT
CREATE_SECURE_OBJECT authority granted or revoked.

0x00000000000000400000000000000000 SELECTIN
SELECTIN privilege granted or revoked.

0x00000000000000800000000000000000 SELECTIN with GRANT
SELECTIN with GRANT privilege granted or revoked.

0x00000000000001000000000000000000 INSERTIN
INSERTIN privilege granted or revoked.

0x00000000000002000000000000000000 INSERTIN with GRANT
INSERTIN with GRANT privilege granted or revoked.

0x00000000000004000000000000000000 UPDATEIN
UPDATEIN privilege granted or revoked.

0x00000000000008000000000000000000 UPDATEIN with GRANT
UPDATEIN with GRANT privilege granted or revoked.

0x00000000000010000000000000000000 DELETEIN
DELETEIN privilege granted or revoked.

0x00000000000020000000000000000000 DELETEIN with GRANT
DELETEIN with GRANT privilege granted or revoked.

0x00000000000040000000000000000000 EXECUTEIN
EXECUTEIN privilege granted or revoked.

0x00000000000080000000000000000000 EXECUTEIN with GRANT
EXECUTEIN with GRANT privilege granted or revoked.

0x00000000001000000000000000000000 SCHEMA_LOAD
SCHEMA_LOAD authority granted or revoked.

0x00000000002000000000000000000000 SCHEMAADM
SCHEMAADM authority granted or revoked.

0x00000000004000000000000000000000 SCHEMA_ACCESSCTRL
SCHEMA_ACCESSCTRL authority granted or revoked.

0x00000000008000000000000000000000 SCHEMA_DATAACCESS
SCHEMA_DATAACCESS authority granted or revoked.

Audit record layout for SYSADMIN events

The following table shows the audit record layout for SYSADMIN events.

Sample audit record:

```
timestamp=1998-06-24-11.54.04.129923;
category=SYSADMIN;
audit event=DB2AUDIT;
event correlator=1;
event status=0;
userid=boss;authid=BOSS;
application id=*LOCAL.boss.980624155404;
application name=db2audit;
```

Table 47. Audit Record Layout for SYSADMIN Events		
NAME	**FORMAT**	**DESCRIPTION**
Timestamp	CHAR(26)	Date and time of the audit event.
Category	CHAR(8)	Category of audit event. Possible values are: SYSADMIN
Audit Event	VARCHAR(32)	Specific Audit Event. For a list of possible values, refer to the section for the SYSADMIN category in "Audit events" on page 369.
Event Correlator	INTEGER	Correlation identifier for the operation being audited. Can be used to identify what audit records are associated with a single event.
Event Status	INTEGER	Status of audit event, represented by an SQLCODE where Successful event > = 0 Failed event < 0
Database Name	CHAR(8)	Name of the database for which the event was generated. Blank if this was an instance level audit event.
User ID	VARCHAR(1024)	User ID at time of audit event.
Authorization ID	VARCHAR(128)	Authorization ID at time of audit event.
Origin Node Number	SMALLINT	Member number at which the audit event occurred.
Coordinator Node Number	SMALLINT	Member number of the coordinator member.
Application ID	VARCHAR(255)	Application ID in use at the time the audit event occurred.
Application Name	VARCHAR(1024)	Application name in use at the time the audit event occurred.
Package Schema	VARCHAR(128)	Schema of the package in use at the time of the audit event.
Package Name	VARCHAR(128)	Name of package in use at the time the audit event occurred.
Package Section Number	SMALLINT	Section number in package being used at the time the audit event occurred.
Package Version	VARCHAR(64)	Version of the package in use at the time the audit event occurred.
Local Transaction ID	VARCHAR(10) FOR BIT DATA	The local transaction ID in use at the time the audit event occurred. This is the SQLU_TID structure that is part of the transaction logs.
Global Transaction ID	VARCHAR(30) FOR BIT DATA	The global transaction ID in use at the time the audit event occurred. This is the data field in the SQLP_GXID structure that is part of the transaction logs.

Table 47. Audit Record Layout for SYSADMIN Events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Client User ID	VARCHAR(255)	The value of the CURRENT CLIENT USERID special register at the time the audit event occurred.
Client Workstation Name	VARCHAR(255)	The value of the CURRENT CLIENT_WRKSTNNAME special register at the time the audit event occurred.
Client Application Name	VARCHAR(255)	The value of the CURRENT CLIENT_APPLNAME special register at the time the audit event occurred.
Client Accounting String	VARCHAR(255)	The value of the CURRENT CLIENT_ACCTNG special register at the time the audit event occurred.
Trusted Context Name	VARCHAR(255)	The name of the trusted context associated with the trusted connection.
Connection Trust Type	CHAR(1)	Possible values are: '' - NONE '1' - IMPLICIT_TRUSTED_CONNECTION '2' - EXPLICIT_TRUSTED_CONNECTION
Role Inherited	VARCHAR(128)	The role inherited through a trusted connection.
Original User ID	VARCHAR(1024)	The value of the CLIENT_ORIGUSERID global variable at the time the audit event occurred.
Event Details	VARCHAR(2048)	Information that is specific to the audit event.
Tenant name	VARCHAR(128)	Tenant name in use at the time the audit event occurred.

Audit record layout for VALIDATE events

The format of the audit record for VALIDATE events is shown in the following table.

Sample audit record:

```
timestamp=2007-05-07-10.30.51.585626;
category=VALIDATE;
audit event=AUTHENTICATION;
event correlator=1;
event status=0;
userid=newton;
authid=NEWTON;
execution id=gstager;
application id=*LOCAL.gstager.070507143051;
application name=db2bp;
auth type=SERVER;
plugin name=IBMOSauthserver;
```

Table 48. Audit Record Layout for VALIDATE Events		
NAME	**FORMAT**	**DESCRIPTION**
Timestamp	CHAR(26)	Date and time of the audit event.

Table 48. Audit Record Layout for VALIDATE Events (continued)

NAME	FORMAT	DESCRIPTION
Category	CHAR(8)	Category of audit event. Possible values are: VALIDATE
Audit Event	VARCHAR(32)	Specific Audit Event. Possible values include: `GET_GROUPS`, `GET_USERID`, `AUTHENTICATE_PASSWORD`, `VALIDATE_USER`, `AUTHENTICATION` and `GET_USERMAPPING_FROM_PLUGIN`.
Event Correlator	INTEGER	Correlation identifier for the operation being audited. Can be used to identify what audit records are associated with a single event.
Event Status	INTEGER	Status of audit event, represented by an SQLCODE where Successful event > = 0 Failed event < 0
Database Name	CHAR(8)	Name of the database for which the event was generated. Blank if this was an instance level audit event.
User ID	VARCHAR(1024)	User ID at time of audit event.
Authorization ID	VARCHAR(128)	Authorization ID at time of audit event.
Execution ID	VARCHAR(1024)	Execution ID in use at the time of the audit event.
Origin Node Number	SMALLINT	Member number at which the audit event occurred.
Coordinator Node Number	SMALLINT	Member number of the coordinator member.
Application ID	VARCHAR(255)	Application ID in use at the time the audit event occurred.
Application Name	VARCHAR(1024)	Application name in use at the time the audit event occurred.
Authentication Type	VARCHAR(32)	Authentication type at the time of the audit event.
Package Schema	VARCHAR(128)	Schema of the package in use at the time of the audit event.
Package Name	VARCHAR(128)	Name of package in use at the time the audit event occurred.
Package Section Number	SMALLINT	Section number in package being used at the time the audit event occurred.
Package Version	VARCHAR(64)	Version of the package in use at the time the audit event occurred.
Plug-in Name	VARCHAR(32)	The name of the plug-in in use at the time the audit event occurred.
Local Transaction ID	VARCHAR(10) FOR BIT DATA	The local transaction ID in use at the time the audit event occurred. This is the SQLU_TID structure that is part of the transaction logs.
Global Transaction ID	VARCHAR(30) FOR BIT DATA	The global transaction ID in use at the time the audit event occurred. This is the data field in the SQLP_GXID structure that is part of the transaction logs.
Client User ID	VARCHAR(255)	The value of the CURRENT CLIENT USERID special register at the time the audit event occurred.

Table 48. Audit Record Layout for VALIDATE Events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Client Workstation Name	VARCHAR(255)	The value of the CURRENT CLIENT_WRKSTNNAME special register at the time the audit event occurred.
Client Application Name	VARCHAR(255)	The value of the CURRENT CLIENT_APPLNAME special register at the time the audit event occurred.
Client Accounting String	VARCHAR(255)	The value of the CURRENT CLIENT_ACCTNG special register at the time the audit event occurred.
Trusted Context Name	VARCHAR(255)	The name of the trusted context associated with the trusted connection.
Connection Trust Type	CHAR(1)	Possible values are: '' - NONE '1' - IMPLICIT_TRUSTED_CONNECTION '2' - EXPLICIT_TRUSTED_CONNECTION
Role Inherited	VARCHAR(128)	The name of the role inherited through the trusted context.
Original User ID	VARCHAR(1024)	The value of the CLIENT_ORIGUSERID global variable at the time the audit event occurred.
Tenant name	VARCHAR(128)	Tenant name in use at the time the audit event occurred.

Audit record layout for CONTEXT events

The following table shows the audit record layout for CONTEXT events.

Sample audit record:

```
timestamp=1998-06-24-08.42.41.476840;
category=CONTEXT;
audit event=EXECUTE_IMMEDIATE;
event correlator=3;
database=FOO;
userid=boss;
authid=BOSS;
application id=*LOCAL.newton.980624124210;
application name=testapp;
package schema=NULLID;
package name=SQLC28A1;
package section=203;
text=create table audit(c1 char(10), c2 integer);
```

Table 49. Audit Record Layout for CONTEXT Events		
NAME	**FORMAT**	**DESCRIPTION**
Timestamp	CHAR(26)	Date and time of the audit event.
Category	CHAR(8)	Category of audit event. Possible values are: CONTEXT
Audit Event	VARCHAR(32)	Specific Audit Event. For a list of possible values, refer to the section for the CONTEXT category in “Audit events” on page 369.
Event Correlator	INTEGER	Correlation identifier for the operation being audited. Can be used to identify what audit records are associated with a single event.

Table 49. Audit Record Layout for CONTEXT Events (continued)

NAME	FORMAT	DESCRIPTION
Database Name	CHAR(8)	Name of the database for which the event was generated. Blank if this was an instance level audit event.
User ID	VARCHAR(1024)	User ID at time of audit event. When the audit event is SWITCH_USER, this field represents the user ID that is switched to.
Authorization ID	VARCHAR(128)	Authorization ID at time of audit event. When the audit event is SWITCH_USER, this field represents the authorization ID that is switched to.
Origin Node Number	SMALLINT	Member number at which the audit event occurred.
Coordinator Node Number	SMALLINT	Member number of the coordinator member.
Application ID	VARCHAR(255)	Application ID in use at the time the audit event occurred.
Application Name	VARCHAR(1024)	Application name in use at the time the audit event occurred.
Package Schema	VARCHAR(128)	Schema of the package in use at the time of the audit event.
Package Name	VARCHAR(128)	Name of package in use at the time the audit event occurred.
Package Section Number	SMALLINT	Section number in package being used at the time the audit event occurred.
Statement Text	CLOB(8M)	Text of the SQL or XQuery statement, if applicable. Null if no SQL or XQuery statement text is available.
Package Version	VARCHAR(64)	Version of the package in use at the time the audit event occurred.
Local Transaction ID	VARCHAR(10) FOR BIT DATA	The local transaction ID in use at the time the audit event occurred. This is the SQLU_TID structure that is part of the transaction logs.
Global Transaction ID	VARCHAR(30) FOR BIT DATA	The global transaction ID in use at the time the audit event occurred. This is the data field in the SQLP_GXID structure that is part of the transaction logs.
Client User ID	VARCHAR(255)	The value of the CURRENT CLIENT USERID special register at the time the audit event occurred.
Client Workstation Name	VARCHAR(255)	The value of the CURRENT CLIENT_WRKSTNNAME special register at the time the audit event occurred.
Client Application Name	VARCHAR(255)	The value of the CURRENT CLIENT_APPLNAME special register at the time the audit event occurred.
Client Accounting String	VARCHAR(255)	The value of the CURRENT CLIENT_ACCTNG special register at the time the audit event occurred.
Trusted Context Name	VARCHAR(255)	The name of the trusted context associated with the trusted connection.

Table 49. Audit Record Layout for CONTEXT Events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Connection Trust Type	CHAR(1)	Possible values are: '' - NONE '1' - IMPLICIT_TRUSTED_CONNECTION '2' - EXPLICIT_TRUSTED_CONNECTION
Role Inherited	VARCHAR(128)	The role inherited through a trusted connection.
Original User ID	VARCHAR(1024)	The value of the CLIENT_ORIGUSERID global variable at the time the audit event occurred.
Tenant name	VARCHAR(128)	Tenant name in use at the time the audit event occurred.

Audit record layout for EXECUTE events

The following table describes all of the fields that are audited as part of the EXECUTE category.

Sample audit record:

Note: Unlike other audit categories, the EXECUTE category, when the audit log is viewed in a table format, can show multiple rows describing one event. The first record describes the main event, and its event column contains the key word STATEMENT. The remaining rows describe the parameter markers or host variables, one row per parameter, and their event column contains the key word DATA. When the audit log is viewed in report format, there is one record, but it has multiple entries for the Statement Value. The DATA key word is only be present in table format.

```
timestamp=2006-04-10-13.20.51.029203;
  category=EXECUTE;
  audit event=STATEMENT;
  event correlator=1;
  event status=0;
  database=SAMPLE;
  userid=smith;
  authid=SMITH;
  session authid=SMITH;
  application id=*LOCAL.prodrig.060410172044;
  application name=myapp;
  package schema=NULLID;
  package name=SQLC2F0A;
  package section=201;
  uow id=2;
  activity id=3;
  statement invocation id=0;
  statement nesting level=0;
  statement text=SELECT * FROM DEPARTMENT WHERE DEPTNO = ? AND DEPTNAME = ?;
  statement isolation level=CS;
  compilation environment=
    isolation level=CS
    query optimization=5
    degree=1
    sqlrules=DB2
    refresh age=+00000000000000.000000
    schema=SMITH
    maintained table type=SYSTEM
    resolution timestamp=2006-04-10-13.20.51.000000
    federated asynchrony=0;
  value index=0;
  value type=CHAR;
  value data=C01;
  value index=1;
  value type=VARCHAR;
  value extended indicator=-1;
  value index=INFORMATION CENTER;
  local_start_time=2006-04-10-13.20.51.021507
```

Table 50. Audit Record Layout for EXECUTE Events		
NAME	**FORMAT**	**DESCRIPTION**
Timestamp	CHAR(26)	Date and time of the audit event
Category	CHAR(8)	Category of audit event. Possible values are: EXECUTE
Audit Event	VARCHAR(32)	Specific Audit Event. For a list of possible values, refer to the section for the EXECUTE category in "Audit events" on page 369.
Event Correlator	INTEGER	Correlation identifier for the operation being audited. Can be used to identify what audit records are associated with a single event.
Event Status	INTEGER	Status of audit event, represented by an SQLCODE where Successful event > = 0 Failed event < 0
Database Name	CHAR(8)	Name of the database for which the event was generated. Blank if this was an instance level audit event
User ID	VARCHAR(1024)	User ID at time of audit event.
Authorization ID	VARCHAR(128)	The Statement Authorization ID at time of audit event.
Session Authorization ID	VARCHAR(128)	The Session Authorization ID at the time of the audit event.
Origin Node Number	SMALLINT	Member number at which the audit event occurred
Coordinator Node Number	SMALLINT	Member number of the coordinator member
Application ID	VARCHAR(255)	Application ID in use at the time the audit event occurred.
Application Name	VARCHAR(1024)	Application name in use at the time the audit event occurred.
Client User ID	VARCHAR(255)	The value of the CURRENT CLIENT USERID special register at the time the audit event occurred
Client Accounting String	VARCHAR(255)	The value of the CURRENT CLIENT_ACCTNG special register at the time the audit event occurred

Table 50. Audit Record Layout for EXECUTE Events (continued)

NAME	FORMAT	DESCRIPTION
Client Workstation Name	VARCHAR(255)	The value of the CURRENT CLIENT_WRKSTNNAME special register at the time the audit event occurred
Client Application Name	VARCHAR(255)	The value of the CURRENT CLIENT_APPLNAME special register at the time the audit event occurred
Trusted Context Name	VARCHAR(255)	The name of the trusted context associated with the trusted connection.
Connection Trust type	CHAR(1)	Possible values are: '' - NONE '1' - IMPLICIT_TRUSTED_CONNECTION '2' - EXPLICIT_TRUSTED_CONNECTION
Role Inherited	VARCHAR(128)	The role inherited through a trusted connection.
Package Schema	VARCHAR(128)	Schema of the package in use at the time of the audit event.
Package Name	VARCHAR(128)	Name of package in use at the time the audit event occurred.
Package Section	SMALLINT	Section number in package being used at the time the audit event occurred.
Package Version	VARCHAR(164)	Version of the package in use at the time the audit event occurred.
Local Transaction ID	VARCHAR(10) FOR BIT DATA	The local transaction ID in use at the time the audit event occurred. This is the SQLU_TID structure that is part of the transaction logs.
Global Transaction ID	VARCHAR(30) FOR BIT DATA	The global transaction ID in use at the time the audit event occurred. This is the data field in the SQLP_GXID structure that is part of the transaction logs
UOW ID	BIGINT	The unit of work identifier in which an activity originates. This value is unique within an application ID for each unit of work.

Table 50. Audit Record Layout for EXECUTE Events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Activity ID	BIGINT	The unique activity ID within the unit of work.
Statement Invocation ID	BIGINT	An identifier that distinguishes one invocation of a routine from others at the same nesting level within a unit of work. It is unique within a unit of work for a specific nesting level.
Statement Nesting Level	BIGINT	The level of nesting or recursion in effect when the statement was being run; each level of nesting corresponds to nested or recursive invocation of a stored procedure or user-defined function (UDF).
Activity Type	VARCHAR(32)	The type of activity. Possible values are: • READ_DML • WRITE_DML • DDL • CALL • OTHER
Statement Text	CLOB(8M)	Text of the SQL or XQuery statement, if applicable.
Statement Isolation Level	CHAR(8)	The isolation value in effect for the statement while it was being run. Possible values are: • NONE (no isolation specified) • UR (uncommitted read) • CS (cursor stability) • RS (read stability) • RR (repeatable read)
Compilation Environment Description	BLOB(8K)	The compilation environment used when compiling the SQL statement. You can provide this element as input to the COMPILATION_ENV table function, or to the SET COMPILATION ENVIRONMENT SQL statement

Table 50. Audit Record Layout for EXECUTE Events (continued)

NAME	FORMAT	DESCRIPTION
Rows Modified	INTEGER	Contains the total number of rows deleted, inserted, or updated as a result of both: • The enforcement of constraints after a successful delete operation • The processing of triggered SQL statements from activated inlined triggers If compound SQL is invoked, contains an accumulation of the number of such rows for all sub-statements. In some cases, when an error is encountered, this field contains a negative value that is an internal error pointer. This value is equivalent to the sqlerrd(5) field of the SQLCA.
Rows Returned	BIGINT	Contains the total number of rows returned by the statement.
Savepoint ID	BIGINT	The Savepoint ID in effect for the statement while it is being run. If the Audit Event is SAVEPOINT, RELEASE_SAVEPOINT or ROLLBACK_SAVEPOINT, then the Savepoint ID is the save point that is being set, released, or rolled back to.
Statement Value Index	INTEGER	The position of the input parameter marker or host variable used in the SQL statement.
Statement Value Type	CHAR(16)	A string representation of the type of a data value associated with the SQL statement. INTEGER or CHAR are examples of possible values.
Statement Value Data	CLOB(128K)	A string representation of a data value to the SQL statement. LOB, LONG, XML, and structured type parameters are not present. Date, time, and timestamp fields are recorded in ISO format.

Table 50. Audit Record Layout for EXECUTE Events (continued)		
NAME	**FORMAT**	**DESCRIPTION**
Statement Value Extended Indicator	INTEGER	The value of the extended indicator specified for this statement value. The possible values are: • 0 if the statement value was specified as assigned by the indicator value, • -1 if NULL was specified by the indicator value, • -5 if DEFAULT was specified by the indicator value, • -7 if UNASSIGNED was specified by the indicator value.
Local Start Time	CHAR(26)	The time that this activity began working on the partition. This field can be an empty string when the activity does not require a package, that is, for CONNECT, CONNECT RESET, COMMIT, and ROLLBACK, as an example. The value is logged in local time.
Original User ID	VARCHAR(1024)	The value of the CLIENT_ORIGUSERID global variable at the time the audit event occurred.
Tenant name	VARCHAR(128)	Tenant name in use at the time the audit event occurred.

Audit events

For each audit category, certain types of events can create audit records.

Events for the AUDIT category

- ALTER_AUDIT_POLICY
- ARCHIVE
- AUDIT_REMOVE
- AUDIT_REPLACE
- AUDIT_USING
- CONFIGURE
- CREATE_AUDIT_POLICY
- DB2AUD
- DROP_AUDIT_POLICY
- EXTRACT
- FLUSH
- LIST_LOGS

- PRUNE (not generated in Version 9.5, and later).
- START
- STOP
- UPDATE_DBM_CFG

Events for the CHECKING category

- CHECKING_FUNCTION
- CHECKING_MEMBERSHIP_IN_ROLES
- CHECKING_OBJECT
- CHECKING_TRANSFER

Events for the CONTEXT category

- ADD_NODE
- ATTACH
- BACKUP_DB
- BIND
- CLOSE_CONTAINER_QUERY
- CLOSE_CURSOR
- CLOSE_HISTORY_FILE
- CLOSE_TABLESPACE_QUERY
- COMMIT
- CONNECT
- CONNECT_RESET
- CREATE_DATABASE
- DARI_START
- DARI_STOP
- DBM_CFG_OPERATION
- DESCRIBE
- DESCRIBE_DATABASE
- DETACH
- DISCOVER
- DROP_DATABASE
- ENABLE_MULTIPAGE
- ESTIMATE_SNAPSHOT_SIZE
- EXECUTE
- EXECUTE_IMMEDIATE
- EXTERNAL_CANCEL
- FETCH_CONTAINER_QUERY
- FETCH_CURSOR
- FETCH_HISTORY_FILE
- FETCH_TABLESPACE
- FORCE_APPLICATION
- GET_DB_CFG

- GET_DFLT_CFG
- GET_SNAPSHOT
- GET_TABLESPACE_STATISTIC
- HADR
- IMPLICIT_REBIND
- LOAD_MSG_FILE
- LOAD_TABLE
- OPEN_CONTAINER_QUERY
- OPEN_CURSOR
- OPEN_HISTORY_FILE
- OPEN_TABLESPACE_QUERY
- PREPARE
- PRUNE_RECOVERY_HISTORY
- QUIESCE_TABLESPACE
- READ_ASYNC_LOG_RECORD
- REBIND
- REDISTRIBUTE
- REORG
- REQUEST_ROLLBACK
- RESET_DB_CFG
- RESET_MONITOR
- RESTORE_DB
- ROLLBACK
- ROLLFORWARD_DB
- RUNSTATS
- SET_APPL_PRIORITY
- SET_MONITOR
- SET_RUNTIME_DEGREE
- SET_TABLESPACE_CONTAINERS
- SINGLE_TABLESPACE_QUERY
- SWITCH_USER
- UNLOAD_TABLE
- UNQUIESCE_TABLESPACE
- UPDATE_AUDIT
- UPDATE_DBM_CFG
- UPDATE_RECOVERY_HISTORY

Events for the EXECUTE category

- COMMIT Execution of a COMMIT statement
- CONNECT Establishment of a database connection
- CONNECT RESET Termination of a database connection
- DATA A host variable or parameter marker data values for the statement

This event is repeated for each host variable or parameter marker that is part of the statement. It is only present in a delimited extract of an audit log.

- GLOBAL COMMIT Execution of a COMMIT within a global transaction
- GLOBAL ROLLBACK Execution of a ROLLBACK within a global transaction
- RELEASE SAVEPOINT Execution of a RELEASE SAVEPOINT statement
- ROLLBACK Execution of a ROLLBACK statement
- SAVEPOINT Execution of a SAVEPOINT statement
- STATEMENT Execution of an SQL statement
- SWITCH USER Switching of a user within a trusted connection

Events for the OBJMAINT category

- ALTER_OBJECT (generated when altering protected tables and when altering modules)
- CREATE_OBJECT
- DROP_OBJECT
- RENAME_OBJECT

Events for the SECMAINT category

- ADD_DEFAULT_ROLE
- ADD_USER
- ALTER_DEFAULT_ROLE
- ALTER_OBJECT
- ALTER SECURITY POLICY
- ALTER_USER_ADD_ROLE
- ALTER_USER_AUTHENTICATION
- ALTER_USER_DROP_ROLE
- CREATE_OBJECT
- DROP_DEFAULT_ROLE
- DROP_OBJECT
- DROP_USER
- GRANT
- IMPLICIT_GRANT
- IMPLICIT_REVOKE
- RENAME_OBJECT
- REVOKE
- SET_SESSION_USER
- TRANSFER_OWNERSHIP
- UPDATE_DBM_CFG

Events for the SYSADMIN category

- ACTIVATE_DB
- ADD_NODE
- ALTER_BUFFERPOOL
- ALTER_DATABASE
- ALTER_NODEGROUP

- ALTER_TABLESPACE
- ATTACH_DEBUGGER
- BACKUP_DB
- CATALOG_DB
- CATALOG_DCS_DB
- CATALOG_NODE
- CHANGE_DB_COMMENT
- CLOSE_CONTAINER_QUERY
- CLOSE_TABLESPACE_QUERY
- COMMIT_DSF_CFS
- COMMIT_DSF_CM
- COMMIT_DSF_INSTANCE
- CREATE_BUFFERPOOL
- CREATE_DATABASE
- CREATE_DB_AT_NODE
- CREATE_EVENT_MONITOR
- CREATE_INSTANCE
- CREATE_NODEGROUP
- CREATE_TABLESPACE
- DB2AUD
- DB2AUDIT
- DB2REMOT
- DB2SET
- DB2TRC
- DEACTIVATE_DB
- DELETE_INSTANCE
- DESCRIBE_DATABASE
- DROP_BUFFERPOOL
- DROP_DATABASE
- DROP_EVENT_MONITOR
- DROP_NODEGROUP
- DROP_NODE_VERIFY
- DROP_TABLESPACE
- ENABLE_MULTIPAGE
- ESTIMATE_SNAPSHOT_SIZE
- FETCH_CONTAINER_QUERY
- FETCH_TABLESPACE
- FORCE_APPLICATION
- GET_SNAPSHOT
- GET_TABLESPACE_STATISTIC
- GRANT_DBADM (V97:no longer generated)
- GRANT_DB_AUTH (V97:no longer generated)
- KILLDBM

- LIST_DRDA_INDOUBT_TRANSACTIONS
- LOAD_TABLE
- MAINTENANCE_DSF_MODE
- MERGE_DBM_CONFIG_FILE
- MIGRATE_DB
- MIGRATE_DB_DIR
- MIGRATE_SYSTEM_DIRECTORY
- OPEN_CONTAINER_QUERY
- OPEN_TABLESPACE_QUERY
- PRUNE_RECOVERY_HISTORY
- QUIESCE_TABLESPACE
- READ_ASYNC_LOG_RECORD
- REDISTRIBUTE_NODEGROUP
- RENAME_TABLESPACE
- RESET_ADMIN_CFG
- RESET_DBM_CFG
- RESET_DB_CFG
- RESET_MONITOR
- RESTORE_DB
- REVOKE_DBADM (V97:no longer generated)
- REVOKE_DB_AUTH (V97:no longer generated)
- ROLLFORWARD_DB
- SET_APPL_PRIORITY
- SET_EVENT_MONITOR_STATE
- SET_RUNTIME_DEGREE
- SET_TABLESPACE_CONTAINERS
- SINGLE_TABLESPACE_QUERY
- START_CF
- START_DB2
- START_DSF_INSTANCE
- START_HADR
- STOP_CF
- STOP_DB2
- STOP_DSF_INSTANCE
- STOP_HADR
- TAKEOVER_HADR
- UNCATALOG_DB
- UNCATALOG_DCS_DB
- UNCATALOG_NODE
- UNLOAD_TABLE
- UPDATE_ADMIN_CFG
- UPDATE_CLI_CONFIGURATION
- UPDATE_DSF_MEMBER_OR_CF

- UPDATE_DB_VERSION
- UPDATE_DBM_CFG
- UPDATE_DB_CFG
- SET_MONITOR
- UPDATE_RECOVERY_HISTORY

Events for the VALIDATE category

- AUTHENTICATE
- CHECK_GROUP_MEMBERSHIP (not generated in Version 9.5, and later)
- GET_USERMAPPING_FROM_PLUGIN
- GET_GROUPS (not generated in Version 9.5, and later)
- GET_USERID (not generated in Version 9.5, and later)

Chapter 12. Working with operating system security

Operating systems provide security features that you can use to support security for your database installation.

Db2 and Windows security

A Windows domain is an arrangement of client and server computers referenced by a specific and unique name; and, that share a single user accounts database called the Security Access Manager (SAM). One of the computers in the domain is the domain controller. The domain controller manages all aspects of user-domain interactions.

The domain controller uses the information in the domain user accounts database to authenticate users logging onto domain accounts. For each domain, one domain controller is the primary domain controller (PDC). Within the domain, there may also be backup domain controllers (BDC) which authenticate user accounts when there is no primary domain controller or the primary domain controller is not available. Backup domain controllers hold a copy of the Windows Security Account Manager (SAM) database which is regularly synchronized against the master copy on the PDC.

User accounts, user IDs, and passwords only need to be defined at the primary domain controller to be able to access domain resources.

Note: Two-part user IDs are supported by the CONNECT statement and the ATTACH command. The qualifier of the SAM-compatible user ID is a name of the style 'Domain\User' which has a maximum length of 15 characters.

During the setup procedure when a Windows server is installed, you may select to create:

- A primary domain controller in a new domain
- A backup domain controller in a known domain
- A stand-alone server in a known domain.

Selecting "controller" in a new domain makes that server the primary domain controller.

The user may log on to the local machine, or when the machine is installed in a Windows Domain, the user may log on to the Domain. To authenticate the user, Db2 checks the local machine first, then the Domain Controller for the current Domain, and finally any Trusted Domains known to the Domain Controller.

To illustrate how this works, suppose that the Db2 instance requires Server authentication. The configuration is as follows:

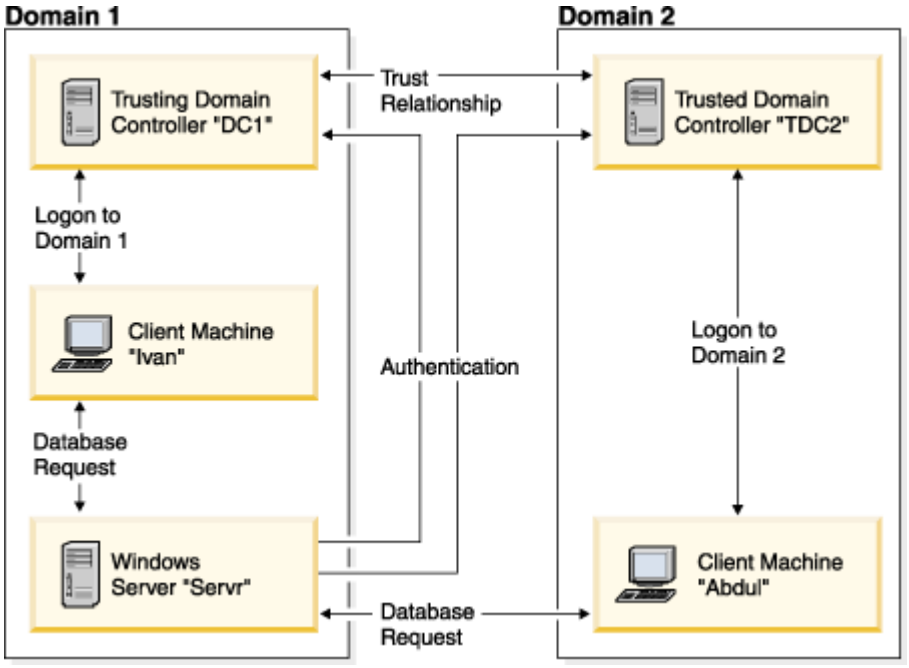


Figure 8. Authentication Using Windows Domains

Each machine has a security database, Security Access Management (SAM). DC1 is the domain controller, in which the client machine, Ivan, and the Db2 server, Servr, are enrolled. TDC2 is a trusted domain for DC1 and the client machine, Abdul, is a member of TDC2's domain.

Authentication scenarios

A scenario with server authentication (Windows)

The following example demonstrates authentication of a user by a server.

1. Abdul logs on to the TDC2 domain (that is, he is known in the TDC2 SAM database).
2. Abdul then connects to a Db2 database that is cataloged to reside on SRV3:

   ```
   db2 connect to remotedb user Abdul using fredpw
   ```

3. SRV3 determines where Abdul is known. The API that is used to find this information first searches the local machine (SRV3) and then the domain controller (DC1) before trying any trusted domains. Username Abdul is found on TDC2. This search order requires a single namespace for users and groups.
4. SRV3 then:
   a. Validates the username and password with TDC2.
   b. Finds out whether Abdul is an administrator by asking TDC2.
   c. Enumerates all Abdul's groups by asking TDC2.

A scenario with client authentication and a Windows client machine

The following example demonstrates authentication of a user by a client computer.

1. Dale, the administrator, logs on to SRV3 and changes the authentication for the database instance to Client:

   ```
   db2 update dbm cfg using authentication client
   db2stop
   db2start
   ```

2. Ivan, at a Windows client machine, logs on to the DC1 domain (that is, he is known in the DC1 SAM database).
3. Ivan then connects to a Db2 database that is cataloged to reside on SRV3:

```
DB2 CONNECT to remotedb user Ivan using johnpw
```

4. Ivan's machine validates the username and password. The API used to find this information first searches the local machine (Ivan) and then the domain controller (DC1) before trying any trusted domains. Username Ivan is found on DC1.
5. Ivan's machine then validates the username and password with DC1.
6. SRV3 then:
   a. Determines where Ivan is known.
   b. Finds out whether Ivan is an administrator by asking DC1.
   c. Enumerates all Ivan's groups by asking DC1.

Note: Before attempting to connect to the Db2 database, ensure that Db2 Security Service has been started. The Security Service is installed as part of the Windows installation. Db2 is then installed and "registered" as a Windows service however, it is not started automatically. To start the Db2 Security Service, enter the `NET START DB2NTSECSERVER` command.

Support for global groups (Windows)

The Db2 database system supports global groups.

To use global groups, you must include global groups inside a local group. When the Db2 database manager enumerates all the groups that a person is a member of, it also lists the local groups that the user is a member of indirectly (by the virtue of being in a global group that is itself a member of one or more local groups).

Global groups are used in two possible situations:

- Included inside a local group. Permission must be granted to this local group.
- Included on a domain controller. Permission must be granted to the global group.

User authentication and group information with DB2 on Windows

User name and group name restrictions (Windows)

There are a few limitations that are specific to the Windows environment. Be aware that general Db2 object naming rules also apply.

- User names under Windows are not case sensitive; however, passwords are case sensitive.
- User names and group names can be a combination of upper- and lowercase characters. However, they are usually converted to uppercase when used within the Db2 database. For example, if you connect to the database and create the table schema1.table1, this table is stored as SCHEMA1.TABLE1 within the database. (If you want to use lowercase object names, issue commands from the command line processor, enclosing the object names in quotation marks, or use third-party ODBC front-end tools.)
- The Db2 database manager supports a single namespace. That is, when running in a trusted domains environment, you should not have a user account of the same name that exists in multiple domains, or that exists in the local SAM of the server machine and in another domain.
- A user name should not be the same name as a group name.
- A local group should not have the same name as a domain level group.

Groups and user authentication on Windows

Users are defined on Windows by creating user accounts using the Windows administration tool called the "User Manager". An account containing other accounts, also called members, is a group.

Groups give Windows administrators the ability to grant rights and permissions to the users within the group at the same time, without having to maintain each user individually. Groups, like user accounts, are defined and maintained in the Security Access Manager (SAM) database.

There are two types of groups:

- Local groups. A local group can include user accounts created in the local accounts database. If the local group is on a machine that is part of a domain, the local group can also contain domain accounts and groups from the Windows domain. If the local group is created on a workstation, it is specific to that workstation.
- Global groups. A global group exists only on a domain controller and contains user accounts from the domain's SAM database. That is, a global group can only contain user accounts from the domain on which it is created; it cannot contain any other groups as members. A global group can be used in servers and workstations of its own domain, and in trusting domains.

Trust relationships between domains on Windows

Trust relationships are an administration and communication link between two domains. A trust relationship between two domains enables user accounts and global groups to be used in a domain other than the domain where the accounts are defined.

Account information is shared to validate the rights and permissions of user accounts and global groups residing in the trusted domain without being authenticated. Trust relationships simplify user administration by combining two or more domains into an single administrative unit.

There are two domains in a trust relationship:

- The trusting domain. This domain trusts another domain to authenticate users for them.
- The trusted domain. This domain authenticates users on behalf of (in trust for) another domain.

Trust relationships are not transitive. This means that explicit trust relationships need to be established in each direction between domains. For example, the trusting domain may not necessarily be a trusted domain.

Authentication with groups and domain security (Windows)

The Db2 database system allows you to specify either a local group or a global group when granting privileges or defining authority levels.

About this task

A user is determined to be a member of a group if the user's account is defined explicitly in the local or global group, or implicitly by being a member of a global group defined to be a member of a local group.

The Db2 database manager supports the following types of groups:

- Local groups
- Global groups
- Global groups as members of local groups.

  The Db2 database manager enumerates the local and global groups of which the user is a member, using the security database where the user was found. The Db2 database system provides an override that forces group enumeration to occur on the local Windows server where the Db2 database is installed, regardless of where the user account was found. This override can be achieved using the following commands:

  – For global settings:

```
db2set -g DB2_GRP_LOOKUP=local
```

– For instance settings:

```
db2set -i instance_name DB2_GRP_LOOKUP=local
```

After issuing this command, you must stop and start the Db2 database instance for the change to take effect. Then create local groups and include domain accounts or global groups in the local group.

To view all Db2 profile registry variables that are set, type

```
db2set -all
```

If the **DB2_GRP_LOOKUP** profile registry variable is set to local, then the Db2 database manager tries to enumerate the user's groups on the local machine only. If the user is not defined as a member of a local group, or of a global group nested in a local group, then group enumeration fails. The Db2 database manager does **not** try to enumerate the user's groups on another machine in the domain or on the domain controllers.

If the Db2 database manager is running on a machine that is a primary or backup domain controller in the resource domain, it is able to locate any domain controller in any trusted domain. This occurs because the names of the domains of backup domain controllers in trusted domains are only known if you are a domain controller.

Using an access token to acquire users' group information (Windows)

An access token is an object that describes the security context of a process or thread. The information in an access token includes the identity and privileges of the user account associated with the process or thread.

When you log on, the system verifies your password by comparing it with information stored in a security database. If the password is authenticated, the system produces an access token. Every process run on your behalf uses a copy of this access token.

An access token can also be acquired based on cached credentials. After you have been authenticated to the system, your credentials are cached by the operating system. The access token of the last logon can be referenced in the cache when it is not possible to contact the domain controller.

The access token includes information about all of the groups you belong to: local groups and various domain groups (global groups, domain local groups, and universal groups).

Note: Group lookup using client authentication is not supported using a remote connection even though access token support is enabled.

To enable access token support, you must use the **db2set** command to update the **DB2_GRP_LOOKUP** registry variable. **DB2_GRP_LOOKUP** can have up to two parameters, separated by a comma:

- The first parameter is for conventional group lookup and can take the values: " ", "LOCAL", or "DOMAIN".
- The second parameter is for token style group lookup and can take the values: "TOKEN", "TOKENDOMAIN", or "TOKENLOCAL".

If the second parameter (TOKEN, TOKENDOMAIN, or TOKENLOCAL) is specified, it takes precedence over conventional group enumeration. If token group enumeration fails, conventional group lookup occurs, if the first parameter of **DB2_GRP_LOOKUP** was specified.

The meaning of the values TOKEN, TOKENDOMAIN, and TOKENLOCAL are as follows:

- TOKENLOCAL

  The token is used to enumerate groups at the local machine (this is equivalent to conventional "LOCAL" group lookup).
- TOKENDOMAIN

The token is used to enumerate groups at the location where the user is defined (at local machine for a local user and at the domain for a domain user). This is equivalent to conventional " ", or "DOMAIN" group lookup.

- TOKEN

  The token is used to enumerate groups at both the domain and on the local machine. For a local user, the groups returned will contain local groups. For a domain user, the groups returned will contain both domain and local groups. There is no equivalent in conventional group lookup.

For example, the following setting of **DB2_GRP_LOOKUP** enables access token support for enumerating local groups:

```
db2set DB2_GRP_LOOKUP=LOCAL,TOKENLOCAL
```

The next example enables access token support for enumerating groups at both the local machine as well as the location where the user ID is defined (if the account is defined at the domain):

```
db2set DB2_GRP_LOOKUP=,TOKEN
```

This final example enables access token support for enumerating domain groups at the location where the user ID is defined:

```
db2set DB2_GRP_LOOKUP=DOMAIN,TOKENDOMAIN
```

Note: Access token support can be enabled with all authentications types except CLIENT authentication.

The DB2_GRP_LOOKUP environment variable and Db2 group enumeration (Windows)

On Windows, a user can belong to groups defined at the domain level, groups defined on the local machine, or to both.

The **DB2_GRP_LOOKUP** environment variable controls whether groups are enumerated on the local machine, or where the users are defined (on the local machine if they are a local user, or at the domain level if they are a domain user). Therefore, when the security administrator grants authorities and privileges, care must be taken that **DB2_GRP_LOOKUP** is set as intended and the correct users receive the intended authorization.

If the **DB2_GRP_LOOKUP** profile registry variable is not set:

1. The Db2 database system first tries to find the user on the same machine.
2. If the user name is defined locally, the user is authenticated locally.
3. If the user is not found locally, the Db2 database system attempts to find the user name on it's domain, and then on trusted domains.

For example, consider the following situation where **DB2_GRP_LOOKUP** is not set:

1. The domain user DUSER1 is a member of the local group, GROUP1.
2. The security administrator (who holds SECADM authority) grants DBADM authority to group GROUP1.

   ```
   GRANT DBADM ON database TO GROUP GROUP1
   ```

3. Because **DB2_GRP_LOOKUP** is not set, groups are enumerated where users are defined. So, groups for DUSER1 are enumerated at the domain level. Since DUSER1 does not belong to group GROUP1 at the domain level, DUSER1 does not receive DBADM authority.

Further, consider this more complex scenario involving the **UPGRADE DATABASE** command where **DB2_GRP_LOOKUP** is not set:

1. The domain user DUSER2 is a member of the local Administrators group.
2. The **sysadm_group** configuration parameter is not set, therefore members of the local Administrators group automatically hold SYSADM authority.

3. User DUSER2 is able to issue the **UPGRADE DATABASE** command (since DUSER2 holds SYSADM authority). The **UPGRADE DATABASE** command grants DBADM authority on the database being upgraded to the SYSADM group, in this case, the Administrators group.
4. Because **DB2_GRP_LOOKUP** is not set, groups are enumerated where users are defined. So, groups for DUSER2 are enumerated at the domain level. Since DUSER2 does not belong to the Administrators group at the domain level, DUSER2 does not receive DBADM authority.

Possible solutions for this scenario are to make one of the following changes:

- Set **DB2_GRP_LOOKUP** = `local`
- Add the users that should have DBADM authority to the Administrators or GROUP1 group at the Domain Controller.

You can use the SYSPROC.AUTH_LIST_AUTHORITIES_FOR_AUTHID table function to verify the authorities held by a user, as shown in the following example for DUSER1:

```
SELECT AUTHORITY, D_USER, D_GROUP, D_PUBLIC, ROLE_USER, ROLE_GROUP, ROLE_PUBLIC,
D_ROLE
   FROM TABLE (SYSPROC.AUTH_LIST_AUTHORITIES_FOR_AUTHID ('DUSER1', 'U') ) AS T
   ORDER BY AUTHORITY
```

You can use the SYSPROC.AUTH_LIST_GROUPS_FOR_AUTHID table function to verify the groups to which the Db2 database manager has determined a user belongs, as shown in the following example for DUSER1:

```
SELECT * FROM TABLE (SYSPROC.AUTH_LIST_GROUPS_FOR_AUTHID ('DUSER1')) AS T
```

Note: If you use the same group name at both the domain level and on the local machine, because the Db2 database manager does not fully qualify the groups, this can lead to confusion.

Authentication using an ordered domain list

User IDs may be defined more than once in a trusted domain forest. A trusted domain forest is a collection of domains that are interrelated through a network.

About this task

It is possible for a user on one domain to have the same user ID as that for another user on a different domain. This may cause difficulties when attempting to do any of the following actions:

- Authenticating multiple users having the same user ID but on different domains.
- Group lookup for the purposes of granting and revoking privileges based on groups.
- Validation of passwords.
- Control of network traffic.

To prevent difficulties arising from the possibility of multiple users with the same user ID across a domain forest, you should use an ordered domain list as defined using the **db2set** and the registry variable **DB2DOMAINLIST**. When setting the order, the domains to be included in the list are separated by a comma. You must make a conscious decision regarding the order that the domains are searched when authenticating users.

Those user IDs that are present on domains further down the domain list will have to be renamed by you if they are to be authenticated for access.

Control of access can be done through the domain list. For example, if the domain of a user is not in the list, the user will not be allowed to connect.

Note: The **DB2DOMAINLIST** registry variable is effective only when CLIENT authentication is set in the database manager configuration and is needed if a single signon from a Windows desktop is required in a Windows domain environment. **DB2DOMAINLIST** is supported by some versions of Db2 servers however **DB2DOMAINLIST** will not be enforced if neither the client nor the server are in a Windows environment.

Domain security support (Windows)

The following example illustrates how the Db2 database management system can support Windows domain security. The connection works because the user name and local group are on the same domain.

The connection works in the following scenario because the user name and local or global group are on the same domain.

Note that the user name and local or global group do not need to be defined on the domain where the database server is running, but they must be on the same domain as each other.

Table 51. Successful Connection Using a Domain Controller

Domain1	**Domain2**
A trust relationship exists with Domain2.	• A trust relationship exists with Domain1. • The local or global group `grp2` is defined. • The user name `id2` is defined. • The user name `id2` is part of `grp2`.

The Db2 server runs in this domain. The following Db2 commands are issued from it:
`REVOKE CONNECT ON db FROM public`
`GRANT CONNECT ON db TO GROUP grp2`
`CONNECT TO db USER id2`	

The local or global domain is scanned but `id2` is not found. Domain security is scanned.	
	The user name `id2` is found on this domain. Db2 gets additional information about this user name (that is, it is part of the group `grp2`).
The connection works because the user name and local or global group are on the same domain.	

Defining which users hold SYSADM authority (Windows)

Certain users have SYSADM authority if the **sysadm_group** database manager configuration parameter is not set (that is, it is NULL).

These users are:

- Members of the local Administrators group
- Members of the Administrators group at the Domain Controller, if the Db2 database manager is configured to enumerate groups for users at the location where the users are defined (you can use the **DB2_GRP_LOOKUP** environment variable to configure group enumeration)
- Members of the DB2ADMNS group, if Windows extended security is enabled. The location of the DB2ADMNS group is decided during installation.
- The LocalSystem account

There are cases where the previously mentioned default behavior is not desirable. You can use the **sysadm_group** database manager configuration parameter to override this behavior by using one of the following methods:

- Create a local group on the Db2 server machine and add to it users (domain users or local users) that you want to have SYSADM authority. The Db2 database manager should be configured to enumerate groups for the user on the local machine.

- Create a domain group and add to it the users that you want to have SYSADM authority. The Db2 database manager should be configured to enumerate groups for users at the location where the users are defined.

Then update the **sysadm_group** database manager configuration parameter to this group, using the following commands:

```
DB2 UPDATE DBM CFG USING SYSADM_GROUP group_name
DB2STOP
DB2START
```

Windows LocalSystem account support

On Windows platforms, the Db2 database system supports applications running under the context of the LocalSystem account (LSA) with local implicit connection. The authorization ID for the LocalSystem account is SYSTEM.If you are using a non-English version of a Windows operating system, you need to check that the authorization ID for the LocalSystem account does not have an invalid character. For example, if you are using a French version of a Windows operating system, the LocalSystem account is Système, but you cannot use this account as an authorization ID because it has an invalid character, è.

The LocalSystem account is considered a system administrator (holding SYSADM authority) when the **sysadm_group** database manager configuration parameter is set to NULL.

If there is a need for applications running under the context of the LocalSystem account to perform database actions that are not within the scope of SYSADM, you must grant the LocalSystem account the required database privileges or authorities. For example, if an application requires database administrator capabilities, grant the LocalSystem account DBADM authority using the GRANT (Database Authorities) statement.

Developers writing applications to be run under this account need to be aware that the Db2 database system has restrictions on objects with schema names starting with "SYS". Therefore if your applications contain DDL statements that create Db2 database objects, they should be written such that:

- For static queries, they should be bound with a value for the QUALIFIER options other than the default one (SYSTEM).
- For dynamic queries, the objects to be created should be explicitly qualified with a schema name supported by the Db2 database manager, or the CURRENT SCHEMA register must be set to a schema name supported by the Db2 database manager.

Group information for the LocalSystem account is gathered at the first group lookup request after the Db2 database instance is started and is not refreshed until the instance is restarted.

Extended Windows security using the DB2ADMNS and DB2USERS groups

Extended security is enabled by default in all Db2 database products on Windows operating systems except IBM Data Server Runtime Client and Db2 Drivers. IBM Data Server Runtime Client and Db2 Drivers do not support extended security on Windows platforms.

An **Enable operating system security** check box appears on the **Enable operating system security for Db2 objects** panel when you install Db2 database products. Unless you disable this option, the installer creates two new groups, DB2ADMNS and DB2USERS. DB2ADMNS is the Db2 Administrators Group and DB2USERS is the Db2 Users Group. DB2ADMNS and DB2USERS are the default group names; optionally, you can specify different names for these groups at installation time (if you select silent installation, you can change these names within the installation response file). If you choose to use groups that exist on your system, be aware that the privileges of these groups are modified. They are given the privileges, as required, listed in the table, below.

It is important to understand that these groups are used for protection at the operating-system level and are in no way associated with Db2 authority levels. However, the Db2 Administrators Group (ex. DB2ADMNS) is used as the default group for SYSADM, SYSMAINT, and SYSCTRL when no values are specified for database manager configuration parameters SYSADM_GROUP, SYSMAINT_GROUP and

SYSCTRL_GROUP. It is recommended that if you are specifying a SYSADM group, then that group should be the Db2 Administrators Group. This setting can be established after installation, by an administrator.

Note: You can specify your Db2 Administrators Group (DB2ADMNS or the name you chose during installation) and Db2 Users Group (DB2USERS or the name you chose during installation) either as local groups or as domain groups. Both groups must be of the same type, so either both local or both domain.

If you change the computer name, and the computer groups DB2ADMNS and DB2USERS are local computer groups, you must update the DB2_ADMINGROUP and DB2_USERSGROUP global registries. To update the registry variables after renaming and restarting the computer run the following command:

1. Open a command prompt.
2. Run the **db2extsec** command to update security settings:

```
db2extsec -a new computer name\DB2ADMNS -u new computer name\DB2USERS
```

Note: If extended security is enabled in Db2 database products on Windows 7, only users that belong to the DB2ADMNS group can run the graphical Db2 administration tools. In addition, members of the DB2ADMNS group need to launch the tools with full administrator privileges. This is accomplished by right-clicking on the shortcut and then choosing "Run as administrator".

Abilities acquired through the DB2ADMNS and DB2USERS groups

The DB2ADMNS and DB2USERS groups provide members with the following abilities:

- DB2ADMNS

  Full control over all Db2 objects (see the following list of protected objects)
- DB2USERS

  Read and Execute access for all Db2 objects located in the installation and instance directories, but no access to objects under the database system directory and limited access to IPC resources

  For certain objects, there may be additional privileges available, as required (for example, write privileges, add or update file privileges, and so on). Members of this group have no access to objects under the database system directory.

  Note: The meaning of Execute access depends on the object; for example, for a **.dll** or **.exe** file having Execute access means you have authority to execute the file, however, for a directory it means you have authority to traverse the directory.

Ideally, all Db2 administrators should be members of the DB2ADMNS group (as well as being members of the local Administrators group), but this is not a strict requirement. Everyone else who requires access to the Db2 database system *must* be a member of the DB2USERS group. To add a user to one of these groups:

1. Launch the Users and Passwords Manager tool.
2. Select the user name to add from the list.
3. Click Properties. In the Properties window, click the Group membership tab.
4. Select the Other radio button.
5. Select the appropriate group from the drop-down list.

Adding extended security after installation (db2extsec command)

If the Db2 database system was installed without extended security enabled, you can enable it by executing the command **db2extsec**. To execute the **db2extsec** command you must be a member of the local Administrators group so that you have the authority to modify the ACL of the protected objects.

You can run the **db2extsec** command multiple times, if necessary, however, if this is done, you cannot disable extended security unless you issue the **db2extsec -r** command immediately after *each* execution of **db2extsec**.

Removing extended security

CAUTION: Do not remove extended security after it has been enabled unless absolutely necessary.

You can remove extended security by running the command **db2extsec -r**, however, this will only succeed if no other database operations (such as creating a database, creating a new instance, adding table spaces, and so on) have been performed after enabling extended security. The safest way to remove the extended security option is to uninstall the Db2 database system, delete all the relevant Db2 directories (including the database directories) and then reinstall the Db2 database system without extended security enabled.

Protected objects

The *static* objects that can be protected using the DB2ADMNS and DB2USERS groups are:

- File system
  - File
  - Directory
- Services
- Registry keys

The *dynamic* objects that can be protected using the DB2ADMNS and DB2USERS groups are:

- IPC resources, including:
  - Pipes
  - Semaphores
  - Events
- Shared memory

Privileges owned by the DB2ADMNS and DB2USERS groups

The privileges assigned to the DB2ADMNS and DB2USERS groups are listed in the following table:

Table 52. Privileges for DB2ADMNS and DB2USERS groups

Privilege	DB2ADMNS	DB2USERS	Reason
Create a token object (SeCreateTokenPrivilege)	Y	N	Token manipulation (required for certain token manipulation operations and used in authentication and authorization)
Replace a process level token (SeAssignPrimaryTokenPrivilege)	Y	N	Create process as another user
Increase quotas (SeIncreaseQuotaPrivilege)	Y	N	Create process as another user
Act as part of the operating system (SeTcbPrivilege)	Y	N	LogonUser
Generate security audits (SeSecurityPrivilege)	Y	N	Manipulate audit and security log
Take ownership of files or other objects (SeTakeOwnershipPrivilege)	Y	N	Modify object ACLs
Increase scheduling priority (SeIncreaseBasePriorityPrivilege)	Y	N	Modify the process working set

Table 52. Privileges for DB2ADMNS and DB2USERS groups (continued)			
Privilege	**DB2ADMNS**	**DB2USERS**	**Reason**
Backup files and directories (SeBackupPrivilege)	Y	N	Profile/Registry manipulation (required to perform certain user profile and registry manipulation routines: LoadUserProfile, RegSaveKey(Ex), RegRestoreKey, RegReplaceKey, RegLoadKey(Ex))
Restore files and directories (SeRestorePrivilege)	Y	N	Profile/Registry manipulation (required to perform certain user profile and registry manipulation routines: LoadUserProfile, RegSaveKey(Ex), RegRestoreKey, RegReplaceKey, RegLoadKey(Ex))
Debug programs (SeDebugPrivilege)	Y	N	Token manipulation (required for certain token manipulation operations and used in authentication and authorization)
Manage auditing and security log (SeAuditPrivilege)	Y	N	Generate auditing log entries
Log on as a service (SeServiceLogonRight)	Y	N	Run Db2 as a service
Access this computer from the network (SeNetworkLogonRight)	Y	Y	Allow network credentials (allows the Db2 database manager to use the LOGON32_LOGON_NETWORK option to authenticate, which has performance implications)
Impersonate a client after authentication (SeImpersonatePrivilege)	Y	N	Client impersonation (required for Windowsto allow use of certain APIs to impersonate Db2 clients: ImpersonateLoggedOnUser, ImpersonateSelf, RevertToSelf, and so on)
Lock pages in memory (SeLockMemoryPrivilege)	Y	N	Large Page support
Create global objects (SeCreateGlobalPrivilege)	Y	Y	Terminal Server support (required on Windows)

Considerations for Windows7: User Access Control feature

The User Access Control (UAC) feature of Windows 7 impacts the Db2 database system in the following ways.

Starting applications with full administrative privileges

On Windows 7, by default, applications start with only standard user rights, even if the user is a local administrator. To start an application with further privileges, you need to launch the command from a command window that is running with full administrative privileges. The Db2 installation process creates a shortcut called "Command window - Administrator" specifically for Windows 7 users. It is recommended that you launch this shortcut if you want to run administrative commands.

If you do not have full administrative privileges and you attempt to perform Db2 administration tasks from a command prompt or graphical tool on Windows 7, you can encounter various error messages implying that your access is denied and the tasks will fail to complete successfully.

To determine whether the action you are performing is considered to be an administration task, check whether any of the following are true:

- It requires SYSADM, SYSCTRL or SYSMAINT authority
- It modifies registry keys under the HKLM branch in the registry
- It writes to the directories under the `Program Files` directory

For example, the following actions are all considered to be administration tasks:

- Creating and dropping Db2 instances
- Starting and stopping Db2 instances
- Creating databases
- Updating database manager configuration parameters or Db2 Administration Server (DAS) configuration parameters
- Updating CLI configuration parameters and configuring system data source names (DSN)
- Starting the Db2 trace facility
- Running the **db2pd** utility
- Changing Db2 profile registry variables

To resolve the problem, you must perform Db2 administration tasks from a command prompt or graphical tool that is running with full administrator privileges. To launch a command prompt or graphical tool with full administrator privileges, right-click on the shortcut and then select **Run as administrator**.

Note: If extended security is enabled, you also need to be a member of the DB2ADMNS group in order to launch the graphical administration tools (such as the IBM Data Studio).

User data location

User data (for example, files under instance directories) is stored in `ProgramData\IBM\DB2\`*copy_name*, where *copy_name* is the name of the Db2 copy (by default, DB2COPY1 is the name of the first copy installed). On Windows versions other than Windows 7, user data is stored in `Documents and Settings\All Users\Application Data\IBM\DB2\`*copy_name*.

Db2 and UNIX security

There are some security considerations specific to UNIX platforms that you need to be aware of.

The Db2 database does not support root acting directly as a database administrator. You should use **su - <instance owner>** as the database administrator.

For security reasons, in general, do not use the instance name as the Fenced ID. However, if you are not planning to use fenced UDFs or stored procedures, you can set the Fenced ID to the instance name instead of creating another user ID.

The recommendation is to create a user ID that is recognized as being associated with this group. The user for fenced UDFs and stored procedures is specified as a parameter of the instance creation script (**db2icrt ... -u <FencedID>**). This is not required if you install the Db2 Clients or the Db2 Software Developer's Kit.

Db2 and Linux security

There are some security considerations specific to Linux platforms that you might need to be aware of.

Change password support (Linux)

Db2 database products provide support for changing passwords on Linux operating systems.

This support is implemented through the use of security plug-in libraries called `IBMOSchgpwdclient.so` and `IBMOSchgpwdserver.so`.

To enable password change support on Linux, set the database manager configuration parameter **clnt_pw_plugin** to IBMOSchgpwdclient and **srvcon_pw_plugin** to IBMOSchgpwdserver.

You must also create a PAM configuration file called "db2" in the /etc/pam.d directory.

Deploying a change password plug-in

To enable support for changing passwords in the Db2 database products on Linux or AIX, you must configure the Db2 instance to use Transparent LDAP.

About this task

Important: The IBMOSchgpwdclient and IBMOSchgpwdserver plugins have been deprecated as of Db2 version 11.5, and will be removed in a future release. The default password plugins (IBMOSauthserver and IBMOSauthclient) are functionally identical, and should be used instead of the change password plugins.

Procedure

To configure transparent LDAP, refer to the following documentation based on your specific operating system:

- For Linux, refer to: “Configuring transparent LDAP for authentication and group lookup (Linux) ” on page 259.
- For AIX, refer to: “Configuring transparent LDAP for authentication and group lookup (AIX)” on page 256.

SELinux

SELinux (Security Enhanced Linux) is code that runs in user-space, taking advantage of kernel code (Linux Security Modules) to provide Mandatory Access Control (MAC) over system resources. Processes are confined to domains, which can be thought of as sandboxes. Access to system objects and capabilities like files, message queues, semaphores, networking is controlled on a per-domain basis following the principle of least privilege.

Directories and files are labeled with a persistent type in SELinux that is separate from usual UNIX Discretionary Access Controls (DAC). This extra layer allows tighter control over access to objects: if an intruder gains control of a process owned by a user, access to all files owned by that user is not automatically granted. The type of access (read, write, create) can also be controlled by SELinux.

SELinux can operate in three modes: disabled, permissive, or enforcing. Switching between modes may require a reboot.

- "Disabled" means no access checking or logging is performed.
- "Permissive" means access violations are logged, but are permitted to occur.
- "Enforcing" means the policy is enforced, and access will be denied if it has not been permitted in the policy.

SELinux depends on operating system configurations that exist outside of Db2. Db2 is not an "SELinux-aware" application that is aware of SELinux in operation, and as such does not make dynamic changes to SELinux properties while the database server is in operation. Thus all configuration changes must be made to the policy files that governs behavior permitted by Db2.

When Db2 is installed, and the default "targeted" policy is configured, the Db2 processes will run in the "unconfined" domain. This will work and Db2 is able to run as it did before SELinux was introduced or enabled.

For samples on SELinux policies, refer to SELinux sample policies.

Sample policy files are provided to enable Db2 processes to run in the confined domain providing additional protection. These samples are provided as a starting point, they will require modification for

your environment. Db2 technical support is not able to assist with the configuration of SELinux or the use of the samples. Any failures introduced by SELinux policies are the customers responsibilities to resolve. However, the use of Db2 in an environment where SELinux is in permissive or enforcing modes is supported, as long as failures are not the result of SELinux policy configuration.

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