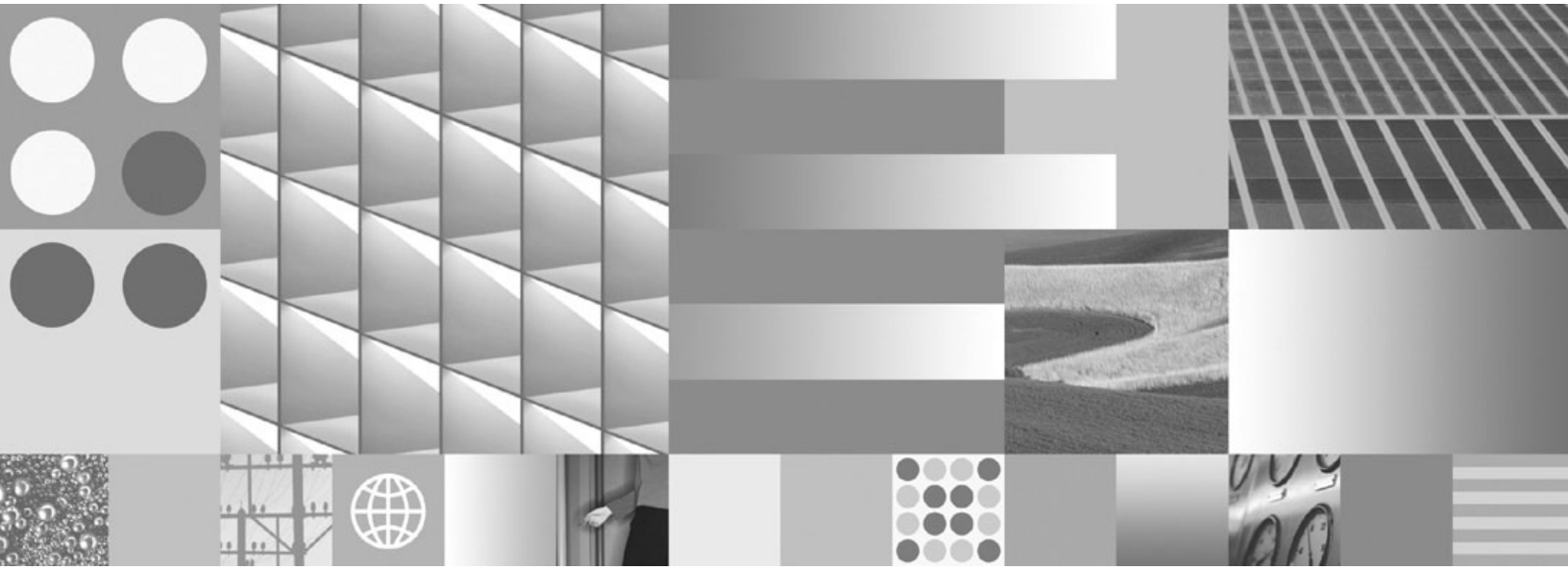
DB2 Version 9.5
for Linux, UNIX, and Windows



Call Level Interface Guide and Reference, Volume 1

Updated April, 2009

SC23-5844-02

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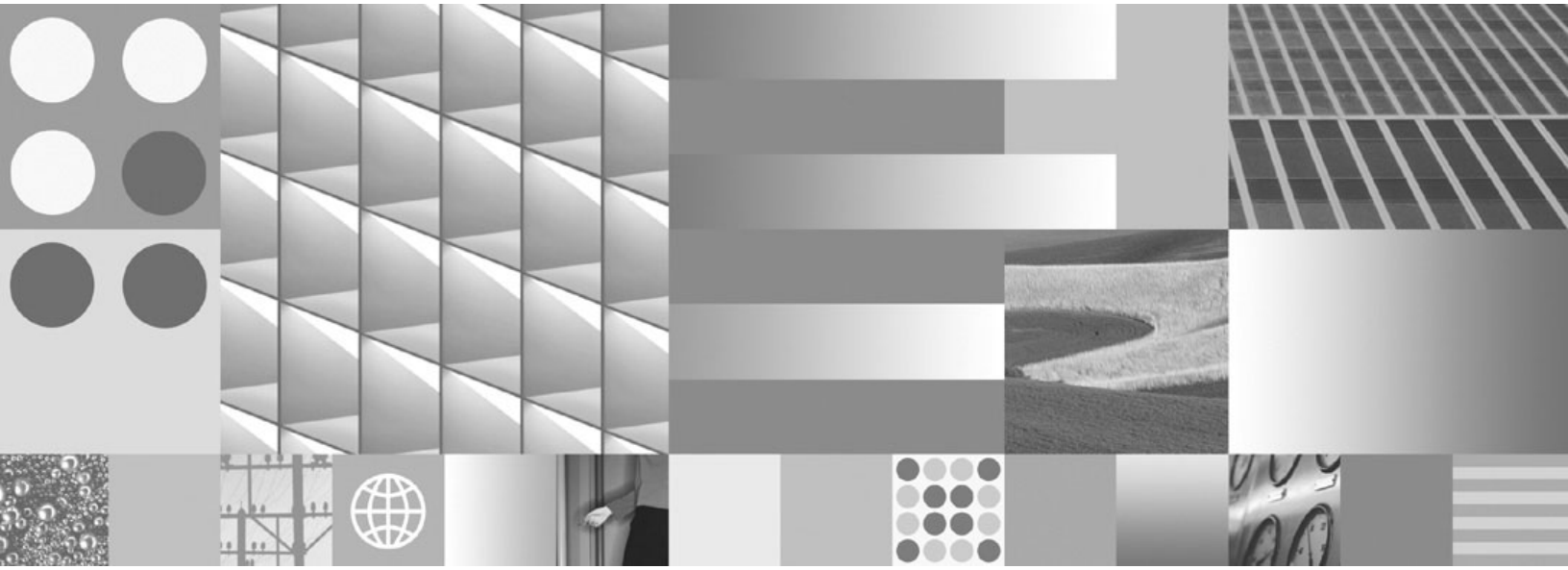

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Note
Before using this information and the product it supports, read the general information under Appendix B, "Notices," on page 235.

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Contents

About this book

The Call Level Interface (CLI) Guide and Reference is in two volumes:

- Volume 1 describes how to use CLI to create database applications for DB2® Database for Linux®, UNIX®, and Windows®.
- Volume 2 is a reference that describes CLI functions, keywords and configuration.

Part 1. Introduction to DB2 Call Level Interface and ODBC

DB2 Call Level Interface (DB2 CLI) is IBM's callable SQL interface to the DB2 family of database servers. It is a 'C' and 'C++' application programming interface for relational database access that uses function calls to pass dynamic SQL statements as function arguments. It is an alternative to embedded dynamic SQL, but unlike embedded SQL, DB2 Call Level Interface does not require host variables or a precompiler.

DB2 Call Level Interface is based on the Microsoft®** Open Database Connectivity** (ODBC) specification, and the International Standard for SQL/CLI. These specifications were chosen as the basis for the DB2 Call Level Interface in an effort to follow industry standards and to provide a shorter learning curve for those application programmers already familiar with either of these database interfaces. In addition, some DB2 specific extensions have been added to help the application programmer specifically exploit DB2 features.

The DB2 Call Level Interface driver also acts as an ODBC driver when loaded by an ODBC driver manager. It conforms to ODBC 3.51.

DB2 Call Level Interface Background information

To understand DB2 Call Level Interface or any callable SQL interface, it is helpful to understand what it is based on, and to compare it with existing interfaces.

The X/Open Company and the SQL Access Group jointly developed a specification for a callable SQL interface referred to as the *X/Open Call Level Interface*. The goal of this interface is to increase the portability of applications by enabling them to become independent of any one database vendor's programming interface. Most of the X/Open Call Level Interface specification has been accepted as part of the ISO Call Level Interface International Standard (ISO/IEC 9075-3:1995 SQL/CLI).

Microsoft developed a callable SQL interface called Open Database Connectivity (ODBC) for Microsoft operating systems based on a preliminary draft of X/Open CLI.

The ODBC specification also includes an operating environment where database specific ODBC Drivers are dynamically loaded at run time by a driver manager based on the data source (database name) provided on the connect request. The application is linked directly to a single driver manager library rather than to each DBMS's library. The driver manager mediates the application's function calls at run time and ensures they are directed to the appropriate DBMS specific ODBC driver. Since the ODBC driver manager only knows about the ODBC-specific functions, DBMS-specific functions cannot be accessed in an ODBC environment. DBMS-specific dynamic SQL statements are supported via a mechanism called an escape clause.

ODBC is not limited to Microsoft operating systems; other implementations are available on various platforms.

The DB2 Call Level Interface load library can be loaded as an ODBC driver by an ODBC driver manager. For ODBC application development, you must obtain an ODBC Software Development Kit. For the Windows platform, the ODBC SDK is

available as part of the Microsoft Data Access Components (MDAC) SDK, available for download from http://www.microsoft.com/data/. For non-Windows platforms, the ODBC SDK is provided by other vendors. When developing ODBC applications that may connect to DB2 servers, use the Call Level Interface Guide and Reference, Volume 1 and the Call Level Interface Guide and Reference, Volume 2 (for information on DB2 specific extensions and diagnostic information), in conjunction with the ODBC Programmer's Reference and SDK Guide available from Microsoft.

Applications written directly to DB2 Call Level Interface link directly to the DB2 Call Level Interface load library. DB2 Call Level Interface includes support for many ODBC and ISO SQL/CLI functions, as well as DB2 specific functions.

The following DB2 features are available to both ODBC and DB2 Call Level Interface applications:

- double byte (graphic) data types
- stored procedures
- Distributed Unit of Work (DUOW), two phase commit
- compound SQL
- user defined types (UDT)
- user defined functions (UDF)

Chapter 1. Comparison of DB2 CLI and Microsoft ODBC

This topic discusses the support provided by the DB2 ODBC driver, and how it differs from DB2 CLI.

Figure 1 below compares DB2 CLI and the DB2 ODBC driver. The left side shows an ODBC driver under the ODBC Driver Manager, and the right side illustrates DB2 CLI, the callable interface designed for DB2 specific applications.

DB2 Client refers to all available DB2 Clients. DB2 refers to all DB2 Database for Linux, UNIX, and Windows products.

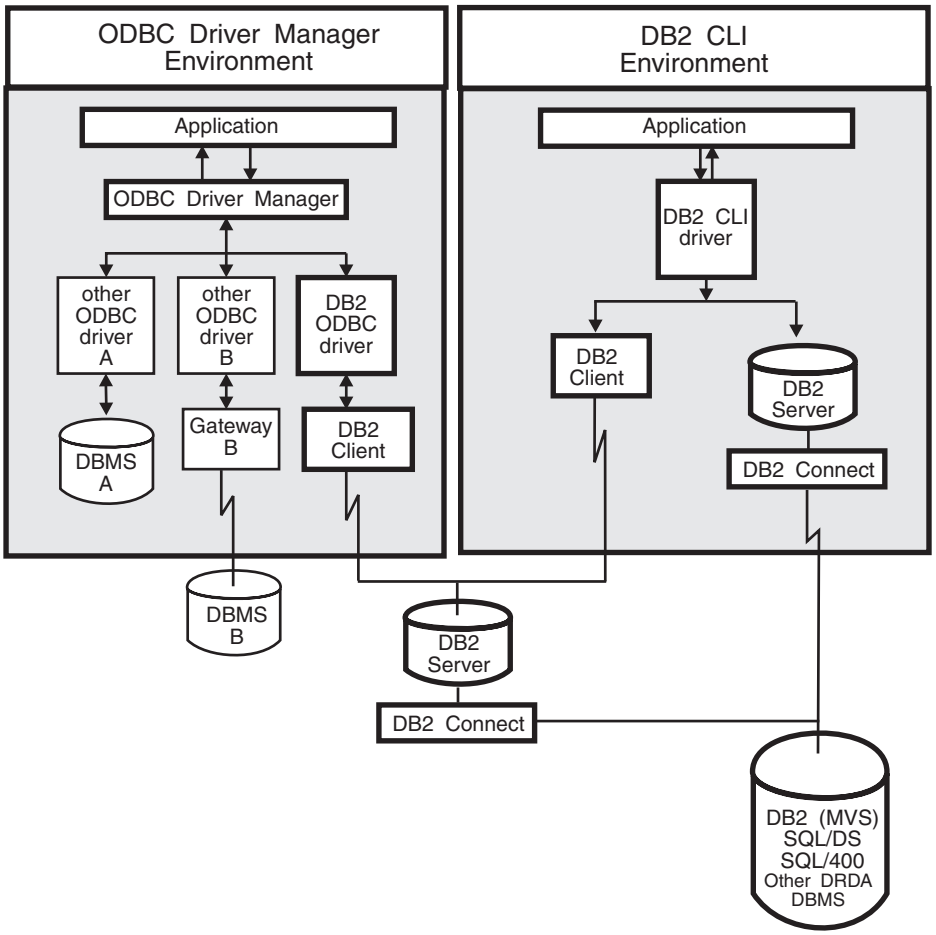


Figure 1. DB2 CLI and ODBC.

In an ODBC environment, the Driver Manager provides the interface to the application. It also dynamically loads the necessary *driver* for the database server that the application connects to. It is the driver that implements the ODBC function set, with the exception of some extended functions implemented by the Driver Manager. In this environment DB2 CLI conforms to ODBC 3.51.

For ODBC application development, you must obtain an ODBC Software Development Kit. For the Windows platform, the ODBC SDK is available as part of

the Microsoft Data Access Components (MDAC) SDK, available for download from http://www.microsoft.com/data/. For non-Windows platforms, the ODBC SDK is provided by other vendors.

In environments without an ODBC driver manager, DB2 CLI is a self sufficient driver which supports a subset of the functions provided by the ODBC driver. Table 1 summarizes the two levels of support, and the CLI and ODBC function summary provides a complete list of ODBC functions and indicates if they are supported.

Table 1. DB2 CLI ODBC support

ODBC features	**DB2 ODBC Driver**	**DB2 CLI**
Core level functions	All	All
Level 1 functions	All	All
Level 2 functions	All	All, except for `SQLDrivers()`
Additional DB2 CLI functions	All, functions can be accessed by dynamically loading the DB2 CLI library.	• `SQLSetConnectAttr()` • `SQLGetEnvAttr()` • `SQLSetEnvAttr()` • `SQLSetColAttributes()` • `SQLGetSQLCA()` • `SQLBindFileToCol()` • `SQLBindFileToParam()` • `SQLExtendedBind()` • `SQLExtendedPrepare()` • `SQLGetLength()` • `SQLGetPosition()` • `SQLGetSubString()`

Table 1. DB2 CLI ODBC support (continued)

ODBC features	DB2 ODBC Driver	DB2 CLI
SQL data types	All the types listed for DB2 CLI.	• SQL_BIGINT • SQL_BINARY • SQL_BIT • SQL_BLOB • SQL_BLOB_LOCATOR • SQL_CHAR • SQL_CLOB • SQL_CLOB_LOCATOR • SQL_DBCLOB • SQL_DBCLOB_LOCATOR • SQL_DECIMAL • SQL_DOUBLE • SQL_FLOAT • SQL_GRAPHIC • SQL_INTEGER • SQL_LONG • SQL_LONGVARBINARY • SQL_LONGVARCHAR • SQL_LONGVARGRAPHIC • SQL_NUMERIC • SQL_REAL • SQL_SHORT • SQL_SMALLINT • SQL_TINYINT • SQL_TYPE_DATE • SQL_TYPE_TIME • SQL_TYPE_TIMESTAMP • SQL_VARBINARY • SQL_VARCHAR • SQL_VARGRAPHIC • SQL_WCHAR
C data types	All the types listed for DB2 CLI.	• SQL_C_BINARY • SQL_C_BIT • SQL_C_BLOB_LOCATOR • SQL_C_CHAR • SQL_C_CLOB_LOCATOR • SQL_C_DATE • SQL_C_DBCHAR • SQL_C_DBCLOB_LOCATOR • SQL_C_DOUBLE • SQL_C_FLOAT • SQL_C_LONG • SQL_C_SHORT • SQL_C_TIME • SQL_C_TIMESTAMP • SQL_C_TINYINT • SQL_C_SBIGINT • SQL_C_UBIGINT • SQL_C_NUMERIC ** • SQL_C_WCHAR **** Only supported on Windows platform**

Table 1. DB2 CLI ODBC support (continued)

ODBC features	DB2 ODBC Driver	DB2 CLI
Return codes	All the codes listed for DB2 CLI.	• SQL_SUCCESS • SQL_SUCCESS_WITH_INFO • SQL_STILL_EXECUTING • SQL_NEED_DATA • SQL_NO_DATA_FOUND • SQL_ERROR • SQL_INVALID_HANDLE
SQLSTATES	Mapped to X/Open SQLSTATES with additional IBM® SQLSTATES, with the exception of the ODBC type **08**S01.	Mapped to X/Open SQLSTATES with additional IBM SQLSTATES
Multiple connections per application	Supported	Supported
Dynamic loading of driver	Supported	Not applicable

Isolation levels

The following table map IBM RDBMs isolation levels to ODBC transaction isolation levels. The `SQLGetInfo()` function indicates which isolation levels are available.

Table 2. Isolation levels under ODBC

IBM isolation level	ODBC isolation level
Cursor stability	SQL_TXN_READ_COMMITTED
Repeatable read	SQL_TXN_SERIALIZABLE_READ
Read stability	SQL_TXN_REPEATABLE_READ
Uncommitted read	SQL_TXN_READ_UNCOMMITTED
No commit	(no equivalent in ODBC)
Note: `SQLSetConnectAttr()` and `SQLSetStmtAttr()` will return SQL_ERROR with an SQLSTATE of **HY**009 if you try to set an unsupported isolation level.	

Restriction

Mixing ODBC and DB2 CLI features and function calls in an application is not supported on the Windows 64-bit operating system.

Chapter 2. IBM Data Server CLI and ODBC drivers

In the IBM Data Server Client and the IBM Data Server Runtime Client there is a driver for the DB2 CLI application programming interface (API) and the ODBC API. This driver is commonly referred to throughout the DB2 Information Center and DB2 books as the IBM Data Server CLI driver or the IBM Data Server CLI/ODBC driver.

New with DB2 Version 9, there is also a separate CLI and ODBC driver called the IBM Data Server Driver for ODBC and CLI. The IBM Data Server Driver for ODBC and CLI provides runtime support for the DB2 CLI and ODBC APIs. However, this driver is installed and configured separately, and supports a subset of the functionality of the DB2 clients, such as connectivity, in addition to the CLI and ODBC API support.

Information that applies to the CLI and ODBC driver that is part of the DB2 client generally applies to the IBM Data Server Driver for ODBC and CLI too. However, there are some restrictions and some functionality that is unique to the IBM Data Server Driver for ODBC and CLI. Information that applies only to the IBM Data Server Driver for ODBC and CLI will use the full title of the driver to distinguish it from general information that applies to the ODBC and CLI driver that comes with the DB2 clients.

IBM Data Server Driver for ODBC and CLI overview

The IBM Data Server Driver for ODBC and CLI provides runtime support for the DB2 CLI application programming interface (API) and the ODBC API. Though the IBM Data Server Client and IBM Data Server Runtime Client both support the DB2 CLI and ODBC APIs, this driver is not a part of either IBM Data Server Client or IBM Data Server Runtime Client. It is available separately, installed separately, and supports a subset of the functionality of the IBM Data Server Clients.

Advantages of the IBM Data Server Driver for ODBC and CLI

- The driver has a much smaller footprint than the IBM Data Server Client and the IBM Data Server Runtime Client.
- You can have multiple installations of the driver on a single machine.
- You can install the driver on a machine that already has an IBM Data Server Client installed.
- You can include the driver in your database application installation package, and redistribute the driver with your applications. Under certain conditions, you can redistribute the driver with your database applications royalty-free.
- The driver can reside on an NFS mounted file system.

Functionality of the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI provides:

- runtime support for the DB2 CLI API;
- runtime support for the ODBC API;
- runtime support for the XA API;
- database connectivity;

- support for DB2 Interactive Call Level Interface (db2cli);
- LDAP Database Directory support; and
- tracing, logging, and diagnostic support.
- See: "Restrictions of the IBM Data Server Driver for ODBC and CLI" on page 33.

Obtaining the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It is available to download from the internet, and it is on the DB2 Version 9 install CD.

To obtain the IBM Data Server Driver for ODBC and CLI, you need:

- internet access, so you can download the driver; or
- a DB2 Version 9 installation CD.

You can obtain the IBM Data Server Driver for ODBC and CLI by doing either of the following:

- Search for the IBM DB2 Driver for ODBC and CLI driver from and download the driver for your platform.

  or

- Copy the driver from the DB2 Version 9.5 install CD.

The driver is in a compressed file called "`db2_driver_for_odbc_cli.zip`" on Windows operating systems, and "`db2_driver_for_odbc_cli.tar.Z`" on other operating systems.
The compressed file is located on the CD at:

```
<CD top>\db2\<platform>\clidriver
```

where `<platform>` is one of:

```
aix
hpipf
hpux
linux
linux390
linux64
linuxamd64
linuxppc
sunos
Windows
```

For example,

- on Windows the driver is located at:

  `/db2/Windows/clidriver/db2_driver_for_odbc_cli.zip`

- on AIX the driver is located at:

  `/db2/aix/clidriver/db2_driver_for_odbc_cli.tar.Z`

- on Linux the driver is located at:

  `/db2/linux/clidriver/db2_driver_for_odbc_cli.tar.Z`

Installing the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed separately.

To install the IBM Data Server Driver for ODBC and CLI, you need:

- to obtain the compressed file that contains the driver.

– See: “Obtaining the IBM Data Server Driver for ODBC and CLI” on page 8.

There is no installation program for the IBM Data Server Driver for ODBC and CLI. You must install the driver manually:

1. Copy the compressed file that contains the driver onto the target machine from the internet or a DB2 Version 9 installation CD.
2. Uncompress that file into your chosen install directory on the target machine.
3. Optional: remove the compressed file.

If you are installing the IBM Data Server Driver for ODBC and CLI under the following conditions:

- the operating systems on the target machine is AIX®; and
- the DB2 Version 9 CD is mounted on the target machine.

the steps you would follow are:

1. Create the directory `$HOME/db2_cli_odbc_driver`, where you will install the driver.
2. Locate the compressed file `/db2/aix/clidriver/db2_driver_for_odbc_cli.tar.Z` on the install CD.
3. Copy `db2_driver_for_odbc_cli.tar.Z` to the install directory, `$HOME/db2_cli_odbc_driver`.
4. Uncompress `db2_driver_for_odbc_cli.tar.Z`:

   ```
   cd $HOME/db2_cli_odbc_driver
   uncompress db2_driver_for_odbc_cli.tar.Z
   tar -xvf db2_driver_for_odbc_cli.tar
   ```

5. Delete `db2_driver_for_odbc_cli.tar.Z`.
6. Ensure the following if you installed the driver on a NFS file system:
   - On UNIX or Linux platforms the `db2dump` and the `db2` directory need to be writable. Alternatively, the path you have referenced in the `diagpath` parameter must be writable.
   - If host or i5/OS data servers are being accessed directly ensure the `license` directory is writable.

Installing multiple copies of the IBM Data Server Driver for ODBC and CLI on the same machine

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the Data Server Runtime Client. It must be installed separately. You can install multiple copies of the IBM Data Server Driver for ODBC and CLI on the same machine. You might want to do this if you have two database applications on the same machine that require different versions of the driver.

To install multiple copies of the IBM Data Server Driver for ODBC and CLI on the same machine, you need:

- to obtain the compressed file that contains the driver.
  – See: “Obtaining the IBM Data Server Driver for ODBC and CLI” on page 8.

For each copy of the IBM Data Server Driver for ODBC and CLI that you are installing:

1. create a unique target installation directory; and
2. follow the installation steps outlined in “Installing the IBM Data Server Driver for ODBC and CLI” on page 8.

3. Ensure the application is using the correct copy of the driver. Avoid relying on the LD_LIBRARY_PATH environment variable as this can lead to inadvertent loading of the incorrect driver. Dynamically load the driver explicitly from the target installation directory.

If you are installing two copies of the IBM Data Server Driver for ODBC and CLI under the following conditions:

- the operating systems on the target machine is AIX; and
- the DB2 Version 9 CD is mounted on the target machine.

the steps you would follow are:

1. Create the two directories, $HOME/db2_cli_odbc_driver1 and $HOME/db2_cli_odbc_driver2, where you will install the driver.
2. Locate the compressed file that contains the driver on the install CD. In this scenario, the file would be called db2_driver_for_odbc_cli.tar.Z.
3. Copy db2_driver_for_odbc_cli.tar.Z to the install directories, $HOME/db2_cli_odbc_driver1 and $HOME/db2_cli_odbc_driver2.
4. Uncompress db2_driver_for_odbc_cli.tar.Z in each directory:

```
cd $HOME/db2_cli_odbc_driver1
uncompress db2_driver_for_odbc_cli.tar.Z
tar -xvf db2_driver_for_odbc_cli.tar
cd $HOME/db2_cli_odbc_driver2
uncompress db2_driver_for_odbc_cli.tar.Z
tar -xvf db2_driver_for_odbc_cli.tar
```

5. Delete db2_driver_for_odbc_cli.tar.Z.

Installing the IBM Data Server Driver for ODBC and CLI on a machine with an existing DB2 client

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed separately. You can install one or more copies of the IBM Data Server Driver for ODBC and CLI on a machine where an IBM Data Server Client or IBM Data Server Runtime Client is already installed. You might want to do this if you have developed some ODBC or CLI database applications with the IBM Data Server Client that you plan to deploy with the IBM Data Server Driver for ODBC and CLI, because it enables you to test the database applications with the driver on the same machine as your development environment.

To install the IBM Data Server Driver for ODBC and CLI on the same machine as an IBM Data Server Client or IBM Data Server Runtime Client, you need:

- to obtain the compressed file that contains the driver.
  - See: "Obtaining the IBM Data Server Driver for ODBC and CLI" on page 8.

The procedure for installing one or more copies of the IBM Data Server Driver for ODBC and CLI on a machine that already has an IBM Data Server Client or IBM Data Server Runtime Client installed is the same as the procedure for installing the driver on a machine that has no IBM Data Server Client installed.

See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8 and "Installing multiple copies of the IBM Data Server Driver for ODBC and CLI on the same machine" on page 9.

Ensure the application is using the correct copy of the driver. Avoid relying on the LD_LIBRARY_PATH environment variable as this can lead to inadvertent loading of the incorrect driver installation. Dynamically load the driver explicitly from the target installation directory.

Configuring the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately. You must configure the IBM Data Server Driver for ODBC and CLI, and the software components of your database application runtime environment in order for your applications to use the driver successfully.

To configure the IBM Data Server Driver for ODBC and CLI and your application environment for the driver, you need:

- one or more copies of the driver installed.
  - See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8.

To configure the IBM Data Server Driver for ODBC and CLI, and the runtime environment of your IBM Data Server CLI and ODBC applications to use the driver:

1. Configure aspects of the driver's behaviour such as data source name, user name, performance options, and connection options by updating the db2cli.ini initialization file.
   - See: "db2cli.ini initialization file"

   There is no support for the Command Line Processor (CLP) with the IBM Data Server Driver for ODBC and CLI. For this reason, you can not update CLI configuration using the CLP command "db2 update CLI cfg"; you must update the db2cli.ini initialization file manually.

   The db2cli.ini file can be specified to be installed in the same directory where the clidriver is installed. On Windows operating systems db2cli.ini is located in <install_dir>\clidriver, and in the <install_dir>\clidriver\cfg directory on UNIX operating systems.
   - See: "db2cli.ini initialization file"

   If you have multiple copies of the IBM Data Server Driver for ODBC and CLI installed, each copy of the driver will have its own db2cli.ini file. Ensure you make the additions to the db2cli.ini for the correct copy of the driver.
2. Configure application environment variables.
   - See: "Configuring environment variables for the IBM Data Server Driver for ODBC and CLI" on page 14
3. For applications participating in transactions managed by the Microsoft Distributed Transaction Coordinator (DTC) only: you must register the driver with the DTC.
   - See: "Registering the IBM Data Server Driver for ODBC and CLI with the Microsoft DTC" on page 17.
4. For ODBC applications using the Microsoft ODBC driver manager only: you must register the driver with the Microsoft driver manager.
   - See: "Registering the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager" on page 17.

db2cli.ini initialization file

The db2cli.ini initialization file contains various keywords and values that can be used to configure the behavior of DB2 CLI and the applications using it. The

keywords are associated with the database *alias name*, and affect all DB2 CLI and ODBC applications that access the database.

By default, the location of the DB2 CLI/ODBC configuration keyword file is in the sqllib directory on Window platforms, and in the sqllib/cfg directory of the database instance running the CLI/ODBC applications on UNIX platforms. If the ODBC Driver Manager is used to configure a User Data Source on the Windows platform, a db2cli.ini might be created in:

- On the Windows XP and Windows 2003 operating systems, Documents and Settings\All Users\Application Data\IBM\DB2\<Copy Name>
- On the Windows Vista operating system, ProgramData\IBM\DB2\<Copy Name>

The environment variable *DB2CLIINIPATH* can also be used to override the default and specify a different location for the file.

The configuration keywords enable you to:

- Configure general features such as data source name, user name, and password.
- Set options that will affect performance.
- Indicate query parameters such as wild card characters.
- Set patches or work-arounds for various ODBC applications.
- Set other, more specific features associated with the connection, such as code pages and IBM GRAPHIC data types.
- Override default connection options specified by an application. For example, if an application requests Unicode support from the CLI driver by setting the SQL_ATTR_ANSI_APP connection attribute, then setting DisableUnicode=1 in the db2cli.ini file will force the CLI driver not to provide the application with Unicode support.

  Note: If the CLI/ODBC configuration keywords set in the db2cli.ini file conflict with keywords in the `SQLDriverConnect()` connection string, then the `SQLDriverConnect()` keywords will take precedence.

The db2cli.ini initialization file is an ASCII file which stores values for the DB2 CLI configuration options. A sample file is shipped to help you get started. While most CLI/ODBC configuration keywords are set in the db2cli.ini initialization file, some keywords are set by providing the keyword information in the connection string to `SQLDriverConnect()` instead.

There is one section within the file for each database (data source) the user wishes to configure. If needed, there is also a common section that affects all database connections.

Only the keywords that apply to all database connections through the DB2 CLI/ODBC driver are included in the COMMON section. This includes the following keywords:

- CheckForFork
- DiagPath
- DisableMultiThread
- JDBCTrace
- JDBCTraceFlush
- JDBCTracePathName

- QueryTimeoutInterval
- ReadCommonSectionOnNullConnect
- Trace
- TraceComm
- TraceErrImmediate
- TraceFileName
- TraceFlush
- TraceFlushOnError
- TraceLocks
- TracePathName
- TracePIDList
- TracePIDTID
- TraceRefreshInterval
- TraceStmtOnly
- TraceTime
- TraceTimeStamp

All other keywords are to be placed in the database specific section, described below.

Note: Configuration keywords are valid in the COMMON section, however, they will apply to all database connections.

The COMMON section of the db2cli.ini file begins with:

```
[COMMON]
```

Before setting a common keyword it is important to evaluate its impact on all DB2 CLI/ODBC connections from that client. A keyword such as TRACE, for instance, will generate information on all DB2 CLI/ODBC applications connecting to DB2 on that client, even if you are intending to troubleshoot only one of those applications.

Each database specific section always begins with the name of the data source name (DSN) between square brackets:

```
[data source name]
```

This is called the ***section header***.

The parameters are set by specifying a keyword with its associated keyword value in the form:

```
KeywordName =keywordValue
```

- All the keywords and their associated values for each database must be located below the database section header.
- If the database-specific section does not contain a DBAlias keyword, the data source name is used as the database alias when the connection is established. The keyword settings in each section apply only to the applicable database alias.
- The keywords are not case sensitive; however, their values can be if the values are character based.
- If a database is not found in the .INI file, the default values for these keywords are in effect.
- Comment lines are introduced by having a semicolon in the first position of a new line.

- Blank lines are permitted.
- If duplicate entries for a keyword exist, the first entry is used (and no warning is given).

The following is a sample .INI file with 2 database alias sections:

```
; This is a comment line.
[MYDB22]
AutoCommit=0
TableType="'TABLE','SYSTEM TABLE'"

; This is another comment line.
[MYDB2MVS]
CurrentSQLID=SAAID
TableType="'TABLE'"
SchemaList="'USER1',CURRENT SQLID,'USER2'"
```

Although you can edit the db2cli.ini file manually on all platforms, it is recommended that you use the Configuration Assistant if it is available on your platform or the UPDATE CLI CONFIGURATION command. You must add a blank line after the last entry if you manually edit the db2cli.ini file.

Configuring environment variables for the IBM Data Server Driver for ODBC and CLI

The IBM IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately. To use the IBM Data Server Driver for ODBC and CLI, there are two types of environment variables that you might have to set: environment variables that have replaced some DB2 registry variables; and an environment variable that tells your applications where to find the driver libraries.

To configure environment variables for the IBM Data Server Driver for ODBC and CLI, you need:

- one or more copies of the driver installed.
  - See:"Installing the IBM Data Server Driver for ODBC and CLI" on page 8.

To configure environment variables for the IBM Data Server Driver for ODBC and CLI:

1. Optional: set any applicable DB2 environment variables corresponding to its equivalent DB2 registry variables.

   There is no support for the Command Line Processor (CLP) with the IBM Data Server Driver for ODBC and CLI. For this reason, you can not configure DB2 registry variables using the `db2set` CLP command. Required DB2 registry variables have been replaced with environment variables.

   For a list of the environment variables that can be used instead of DB2 registry variables, see: "Environment variables supported by the IBM DB2 Driver for ODBC and CLI" on page 15.

2. Required for AIX operating systems only: Set the local environment variable `DB2_CLI_DRIVER_INSTALL_PATH` to the directory in which the driver is installed. (If there are multiple copies of the IBM Data Server Driver for ODBC and CLI installed, ensure `DB2_CLI_DRIVER_INSTALL_PATH` points to the intended copy of the driver.) Only AIX requires that this variable be set. This variable is supported, but not required, on all other operating systems.

   For example,

```
export DB2_CLI_DRIVER_INSTALL_PATH=/home/db2inst1/db2clidriver/clidriver
```

where /home/db2inst1/db2clidriver is the install path where the clidriver is installed

3. Optional: set the environment variable LIBPATH (on AIX systems) or LD_LIBRARY_PATH (on UNIX systems) to the directory in which the driver is installed. (If there are multiple copies of the IBM Data Server Driver for ODBC and CLI installed, ensure LIBPATH or LD_LIBRARY_PATH points to the intended copy of the driver.)

   This step is not necessary if your applications statically link to, or dynamically load the driver's library (db2cli.dll on Windows systems, or libdb2.a on other systems) with the fully qualified name.

   You are recommended to dynamically load the library using the fully qualified library name. On Windows operating systems, you are recommended to use the LoadLibraryEx method specifying the LOAD_WITH_ALTERED_SEARCH_PATH parameter and the path to the driver's DLL.

Restrictions

If there are multiple versions of the IBM Data Server Driver for ODBC and CLI installed on the same machine, or if there are other DB2 Version 9 products installed on the same machine, setting environment variables (for example, setting LIBPATH or LD_LIBRARY_PATH to point to the IBM Data Server Driver for ODBC and CLI library) might break existing applications. When setting an environment variable, ensure that it is appropriate for all applications running in the scope of that environment.

Environment variables supported by the IBM DB2 Driver for ODBC and CLI:

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately.

The IBM Data Server Driver for ODBC and CLI does not support the command line processor (CLP.) This means that the usual mechanism to set DB2 registry variables, using the db2set CLP command, is not possible. Relevant DB2 registry variables will be supported with the IBM Data Server Driver for ODBC and CLI as environment variables instead.

The DB2 registry variables that will be supported by the IBM Data Server Driver for ODBC and CLI as environment variables are:

Table 3. DB2 registry variables supported as environment variables

Type of variable	Variable name(s)
General variables	**DB2ACCOUNT** **DB2BIDI** **DB2CODEPAGE** **DB2COUNTRY** **DB2GRAPHICUNICODESERVER** **DB2LOCALE** **DB2TERRITORY**

Table 3. DB2 registry variables supported as environment variables (continued)

Type of variable	Variable name(s)
System environment variables	**DB2DOMAINLIST**
Communications variables	**DB2_FORCE_NLS_CACHE** **DB2SORCVBUF** **DB2SOSNDBUF** **DB2TCP_CLIENT_RCVTIMEOUT**
Performance variables	**DB2_NO_FORK_CHECK**
Miscellaneous variables	**DB2CLIINIPATH** **DB2_ENABLE_LDAP** **DB2LDAP_BASEDN** **DB2LDAP_CLIENT_PROVIDER** **DB2LDAPHOST** **DB2LDAP_KEEP_CONNECTION** **DB2LDAP_SEARCH_SCOPE** **DB2NOEXITLIST**
Diagnostic variables	**DB2_DIAGPATH**
Connection variables	**AUTHENTICATION** **PROTOCOL** **PWDPLUGIN** **KRBPLUGIN** **ALTHOSTNAME** **ALTPORT** **INSTANCE** **BIDI**

db2oreg1.exe overview

You can use the `db2oreg1.exe` utility to register the XA library of the IBM Data Server Driver for ODBC and CLI with the Microsoft Distributed Transaction Coordinator (DTC), and to register the driver with the Microsoft ODBC driver manager. You need to use the `db2oreg1.exe` utility on Windows operating systems only.

Conditions requiring that you run the db2oreg1.exe utility

You must run the `db2oreg1.exe` utility if:

- your applications that use the IBM Data Server Driver for ODBC and CLI will be participating in distributed transactions managed by the DTC; or
- your applications that use the IBM Data Server Driver for ODBC and CLI will be connecting to ODBC data sources.

When to run the db2oreg1.exe utility

If you use the `db2oreg1.exe` utility, you must run it when:

- you install the IBM Data Server Driver for ODBC and CLI; and
- you uninstall the IBM Data Server Driver for ODBC and CLI.

The db2oreg1.exe utility makes changes to the Windows registry when you run it after installing the driver. If you uninstall the driver, you should run the utility again to undo those changes.

How to run the db2oreg1.exe utility

- db2oreg1.exe is located in bin subdirectory where the IBM Data Server Driver for ODBC and CLI is installed.
- To list the parameters the db2oreg1.exe utility takes, and how to use them, run the utility with the "-h" option.

Registering the IBM Data Server Driver for ODBC and CLI with the Microsoft DTC

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately. To use the IBM Data Server Driver for ODBC and CLI with database applications that participate in transactions managed by the Microsoft Distributed Transaction Coordinator (DTC), you must register the driver with the DTC. Here is a link to the Microsoft article outlining the details of this security requirement: Registry Entries Are Required for XA Transaction Support

To register the IBM Data Server Driver for ODBC and CLI with the DTC, you need:

- one or more copies of the driver installed.
  - See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8.

Restrictions

You only need to register the IBM Data Server Driver for ODBC and CLI with the DTC if your applications that use the driver are participating in transactions managed by the DTC.

To register the IBM Data Server Driver for ODBC and CLI with the DTC, do the following for each copy of the driver that is installed:

- run the db2oreg1.exe utility.
  - See: "db2oreg1.exe overview" on page 16.

  The db2oreg1.exe utility makes changes to the Windows registry when you run it after installing the driver. If you uninstall the driver, you should run the utility again to undo those changes.

Registering the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately. For ODBC applications to use the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager, you must register the driver with the driver manager.

To register the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager, you need:

- one or more copies of the driver installed.
  - See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8.

Restrictions

The Microsoft ODBC driver manager is the only ODBC driver manager with which you must register the IBM Data Server Driver for ODBC and CLI. The other ODBC driver managers do not require this.

To register the IBM Data Server Driver for ODBC and CLI with the Microsoft driver manager, do the following for each copy of the driver that is installed:

- run the `db2oreg1.exe` utility.
  - See: "db2oreg1.exe overview" on page 16.

  The db2oreg1.exe utility makes changes to the Windows registry when you run it after installing the driver. If you uninstall the driver, you should run the utility again to undo those changes.

Connecting to databases with the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately. The IBM Data Server Driver for ODBC and CLI does not create a local database directory. This means that when you use this driver, you must make connectivity information available to your applications in other ways.

To connect to databases with the IBM Data Server Driver for ODBC and CLI, you need:

- database(s) to which to connect; and
- one or more copies of the driver installed.
  - See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8.

There are five ways to specify connectivity information so that your CLI and ODBC database applications can use the IBM Data Server Driver for ODBC and CLI to connect to a database. To configure connectivity for a database when using the IBM Data Server Driver for ODBC and CLI, do one of:

1. Specify the database connectivity information in the connection string parameter to `SQLDriverConnect`.
   - See: "SQLDriverConnect function (CLI) - (Expanded) Connect to a data source" on page 22.

or

1. For CLI applications only: put the database connectivity information in the DB2 CLI configuration file.
   - See: "db2cli.ini initialization file" on page 11.

   There is no support for the Command Line Processor (CLP) with the IBM Data Server Driver for ODBC and CLI. For this reason, you can not update CLI configuration using the CLP command "`db2 update CLI cfg`"; you must update the `db2cli.ini` initialization file manually.

   The `db2cli.ini` file can be specified to be installed in the same directory where the clidriver is installed. On Windows operating systems `db2cli.ini` is located in <install_dir>\clidriver, and in the <install_dir>\clidriver\cfg directory on UNIX operating systems.

   If you have multiple copies of the IBM Data Server Driver for ODBC and CLI installed, each copy of the driver will have its own `db2cli.ini` file. Ensure you make the additions to the `db2cli.ini` for the correct copy of the driver.

or

1. For ODBC applications only: register the database as an ODBC data source with the ODBC driver manager.
   - See: "Registering ODBC data sources for applications using the IBM Data Server Driver for ODBC and CLI" on page 20

or

1. Use the `FileDSN` CLI/ODBC keyword to identify a file DSN that contains the database connectivity information.
   - See: "FileDSN CLI/ODBC configuration keyword" on page 28.

   A file DSN is a file that contains database connectivity information. You can create a file DSN by using the Save File CLI/ODBC keyword. On Microsoft Windows you can use the Microsoft ODBC driver manager to create a file DSN.

or

1. For local database servers only: use the `PROTOCOL` and `DB2INSTANCE` CLI/ODBC keywords to identify the local database:
   - Set the `PROTOCOL` CLI/ODBC keyword to the value "`Local`"; and
   - Set the `DB2INSTANCE` CLI/ODBC keyword to the instance name of the local database server on which the database is located.
   - See: "Protocol CLI/ODBC configuration keyword" on page 30.

Here is a list of CLI/ODBC keywords that work with file DSN or DSN-less connections:

- "AltHostName CLI/ODBC configuration keyword" on page 27;
- "AltPort CLI/ODBC configuration keyword" on page 27;
- "Authentication CLI/ODBC configuration keyword" on page 27;
- "BIDI CLI/ODBC configuration keyword" on page 28;
- "FileDSN CLI/ODBC configuration keyword" on page 28;
- "Instance CLI/ODBC configuration keyword" on page 28;
- "Interrupt CLI/ODBC configuration keyword" on page 29;
- "KRBPlugin CLI/ODBC configuration keyword" on page 29;
- "Protocol CLI/ODBC configuration keyword" on page 30;
- "PWDPlugin CLI/ODBC configuration keyword" on page 30;
- "SaveFile CLI/ODBC configuration keyword" on page 30;
- "DiagLevel CLI/ODBC configuration keyword" on page 35;
- "NotifyLevel CLI/ODBC configuration keyword" on page 36;

For the following examples, consider a database with the following properties:

- the database or subsystem is called `db1` on the server;
- the server is located at `11.22.33.444`;
- the access port is `56789`; and
- the transfer protocol is `TCPIP`.

To make a connection to the database in a CLI application, you could do one of the following:

1. Call `SQLDriverConnect` with a connection string that contains:
   - "`Database=db1; Protocol=tcpip; Hostname=11.22.33.444; Servicename=56789;`"

or

1. Add the following to `db2cli.ini`:
   •
   ```
   [db1]
   Database=db1
   Protocol=tcpip
   Hostname=11.22.33.444
   Servicename=56789
   ```

To make a connection to the database in an ODBC application:

1. Register the database as an ODBC data source called `odbc_db1` with the driver manager; and
2. call `SQLConnect` with a connection string that contains:
   • `"Database=odbc_db1;"`

Registering ODBC data sources for applications using the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately. Before an ODBC database application can use the IBM Data Server Driver for ODBC and CLI to connect to a database, you must: 1) register the database as an ODBC data source with the ODBC driver manager; and 2) identify the IBM Data Server Driver for ODBC and CLI as the ODBC driver for the data source.

To register a database as an ODBC data source and associate the IBM Data Server Driver for ODBC and CLI with it, you need:

- databases to which your ODBC applications are going to connect;
- an ODBC driver manager installed; and
- one or more copies of the driver installed.
  – See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8.

The procedure for registering a database as an ODBC data source and associating the IBM Data Server Driver for ODBC and CLI with it depends on which driver manager you are using.

- For the Microsoft ODBC driver manager:
  1. Register the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager using the `db2oreg1.exe` utility.
     – See: "Registering the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager" on page 17.
  2. Register the database as an ODBC data source.
     – See: Chapter 21, "Setting up the Windows CLI environment," on page 219.
- For open source ODBC driver managers:
  1. Identify the database as an ODBC data source by adding database information to the `odbc.ini` file.
     – See: Chapter 20, "Setting up the UNIX ODBC environment," on page 215.
  2. Associate the IBM Data Server Driver for ODBC and CLI with the data source by adding the fully qualified driver library file in the section of the `odbc.ini` file for the database.

The name of the IBM Data Server Driver for ODBC and CLI library file is `db2app.dll` on Windows platorms, and `db2app.lib` on other platforms. The driver library file is located in the "`lib`" subdirectory of the directory in which you installed the driver.

If you have multiple copies of the IBM Data Server Driver for ODBC and CLI installed, ensure the intended copy is identified in the odbc.ini file.

If you are registering ODBC data sources with an open source driver manager under the following conditions:

- the operating system on the target machine is a AIX;
- there are two copies of the IBM Data Server Driver for ODBC and CLI installed at
  - $HOME/db2_cli_odbc_driver1 and
  - $HOME/db2_cli_odbc_driver2
- there are two ODBC database applications:
  1. ODBCapp_A
     - connects to two data sources, db1 and db2; and
     - is intended to use the copy of the driver installed at $HOME/db2_cli_odbc_driver1.
  2. ODBCapp_B
     - connects to the data source db3; and
     - is intended to use the copy of the driver installed at $HOME/db2_cli_odbc_driver2.

add the following the entries in the odbc.ini file:

-
```
[db1]
Driver=$HOME/db2_cli_odbc_driver1/lib/libdb2.a
Description=First ODBC data source for ODBCapp1,
       using the first copy of the IBM Data Server Driver for ODBC and CLI

[db2]
Driver=$HOME/db2_cli_odbc_driver1/lib/libdb.a
Description=Second ODBC data source for ODBCapp1,
       using the first copy of the IBM Data Server Driver for ODBC and CLI

[db3]
Driver=$HOME/db2_cli_odbc_driver2/lib/libdb2.a
Description=First ODBC data source for ODBCapp2,
       using the second copy of the IBM Data Server Driver for ODBC and CLI
```

Using security plugins with the IBM Data Server Driver for ODBC and CLI

A security plug-in is a dynamicaly-loadable library that provides authentication security services.

Using security plug-ins with the IBM Data Server Driver for ODBC and CLI is no different from using security plug-ins with an IBM Data Server Client or IBM Data Server Runtime Client.
When you read about using security plug-ins throughout the DB2 Information Center and DB2 books, consider the IBM Data Server Driver for ODBC and CLI like an IBM Data Server Client. Details about using security plug-ins with IBM Data Server Clients apply to using security plug-ins with the IBM Data Server Driver for ODBC and CLI too.

SQLDriverConnect function (CLI) - (Expanded) Connect to a data source

Purpose

Specification:	DB2 CLI 2.1	ODBC 1.0	

`SQLDriverConnect()` is an alternative to `SQLConnect()`. Both functions establish a connection to the target database, but `SQLDriverConnect()` supports additional connection parameters and the ability to prompt the user for connection information.

Use `SQLDriverConnect()` when the data source requires parameters other than the 3 input arguments supported by `SQLConnect()` (data source name, user ID and password), or when you want to use DB2 CLI's graphical user interface to prompt the user for mandatory connection information.

Once a connection is established, the completed connection string is returned. Applications can store this string for future connection requests.

Syntax

Generic

```
SQLRETURN  SQLDriverConnect (
        SQLHDBC       ConnectionHandle,              /* hdbc */
        SQLHWND       WindowHandle,                  /* hwnd */
        SQLCHAR       *InConnectionString,           /* szConnStrIn */
        SQLSMALLINT   InConnectionStringLength,      /* cbConnStrIn */
        SQLCHAR       *OutConnectionString,          /* szConnStrOut */
        SQLSMALLINT   OutConnectionStringCapacity,   /* cbConnStrOutMax */
        SQLSMALLINT   *OutConnectionStringLengthPtr, /* pcbConnStrOut */
        SQLUSMALLINT  DriverCompletion);             /* fDriverCompletion */
```

Function arguments

Table 4. SQLDriverConnect arguments

Data type	Argument	Use	Description
SQLHDBC	*ConnectionHandle*	input	Connection handle
SQLHWND	*WindowHandle*	input	Window handle. On the Windows platform, this is the parent Windows handle. Currently the window handle is only supported on Windows. If a NULL is passed, then no dialog will be presented.
SQLCHAR *	*InConnectionString*	input	A full, partial or empty (null pointer) connection string (see syntax and description below).
SQLSMALLINT	*InConnectionStringLength*	input	Number of SQLCHAR elements (or SQLWCHAR elements for the Unicode variant of this function) needed to store *InConnectionString*.
SQLCHAR *	*OutConnectionString*	output	Pointer to buffer for the completed connection string. If the connection was established successfully, this buffer will contain the completed connection string. Applications should allocate at least SQL_MAX_OPTION_STRING_LENGTH bytes for this buffer.

Table 4. SQLDriverConnect arguments (continued)

Data type	Argument	Use	Description
SQLSMALLINT	*OutConnectionString Capacity*	input	Number of SQLCHAR elements (or SQLWCHAR elements for the Unicode variant of this function) needed to store *OutConnectionString*.
SQLSMALLINT *	*OutConnectionString LengthPtr*	output	Pointer to the number of SQLCHAR elements (or SQLWCHAR elements for the Unicode variant of this function), excluding the null-termination character, available to return in the *OutConnectionString* buffer. If the value of **OutConnectionStringLengthPtr* is greater than or equal to *OutConnectionStringCapacity*, the completed connection string in *OutConnectionString* is truncated to *OutConnectionStringCapacity* - 1 SQLCHAR or SQLWCHAR elements.
SQLUSMALLINT	*DriverCompletion*	input	Indicates when DB2 CLI should prompt the user for more information. Possible values: • SQL_DRIVER_PROMPT • SQL_DRIVER_COMPLETE • SQL_DRIVER_COMPLETE_REQUIRED • SQL_DRIVER_NOPROMPT

Usage

InConnectionString Argument

A request connection string has the following syntax:

connection-string ::= attribute[;] | attribute; connection-string

attribute ::= attribute-keyword=attribute-value
| DRIVER=[{]attribute-value[}]

attribute-keyword ::= DSN | UID | PWD | NEWPWD
| driver-defined-attribute-keyword

attribute-value ::= character-string
driver-defined-attribute-keyword ::= identifier

where
- character-string has zero or more SQLCHAR or SQLWCHAR elements
- identifier has one or more SQLCHAR or SQLWCHAR elements
- attribute-keyword is case insensitive
- attribute-value may be case sensitive
- the value of the **DSN** keyword does not consist solely of blanks
- NEWPWD is used as part of a change password request. The application can either specify the new string to use, for example, NEWPWD=anewpass; or specify NEWPWD=; and rely on a dialog box generated by the DB2 CLI driver to prompt for the new password

Because of connection string and initialization file grammar, keywords and attribute values that contain the characters **[]{}(),;?*=!@** should be avoided. Because of the grammar in the system information, keywords and data source names cannot contain the backslash (\) character. For DB2 CLI Version 2, braces are required around the DRIVER keyword.

If any keywords are repeated in the browse request connection string, DB2 CLI uses the value associated with the first occurrence of the keyword. If the **DSN** and **DRIVER** keywords are included in the same browse request connection string, DB2 CLI uses whichever keyword appears first.

OutConnectionString Argument

The result connection string is a list of connection attributes. A connection attribute consists of an attribute keyword and a corresponding attribute value. The browse result connection string has the following syntax:

connection-string ::= attribute[;] | attribute; connection-string

attribute ::= [*]attribute-keyword=attribute-value
attribute-keyword ::= ODBC-attribute-keyword
| driver-defined-attribute-keyword

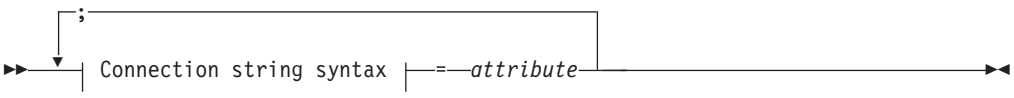
ODBC-attribute-keyword = {UID | PWD}:[localized-identifier]
driver-defined-attribute-keyword ::= identifier[:localized-identifier]

attribute-value ::= {attribute-value-list} | ?
(The braces are literal; they are returned by
DB2 CLI.)
attribute-value-list ::= character-string [:localized-character
string] | character-string [:localized-character string], attribute-value-list

where
- character-string and localized-character string have zero or more SQLCHAR or SQLWCHAR elements
- identifier and localized-identifier have one or more SQLCHAR or SQLWCHAR elements; attribute-keyword is case insensitive
- attribute-value may be case sensitive

Because of connection string and initialization file grammar, keywords, localized identifiers, and attribute values that contain the characters **[]{}(),;?*=!@** should be avoided. Because of the grammar in the system information, keywords and data source names cannot contain the backslash (\) character.

The connection string is used to pass one or more values needed to complete a connection. The contents of the connection string and the value of *DriverCompletion* will determine if DB2 CLI needs to establish a dialog with the user.



Connection string syntax

Each keyword above has an attribute that is equal to the following:

DSN Data source name. The name or alias-name of the database. Required if *DriverCompletion* is equal to SQL_DRIVER_NOPROMPT.

UID Authorization-name (user identifier).

PWD The password corresponding to the authorization name. If there is no password for the user ID, an empty value is specified (PWD=;).

NEWPWD
New password used as part of a change password request. The application can either specify the new string to use, for example, NEWPWD=anewpass; or specify NEWPWD=; and rely on a dialog box generated by the DB2 CLI driver to prompt for the new password (set the *DriverCompletion* argument to anything other than SQL_DRIVER_NOPROMPT).

Any one of the CLI keywords can be specified on the connection string. If any keywords are repeated in the connection string, the value associated with the first occurrence of the keyword is used.

If any keywords exists in the CLI initialization file, the keywords and their respective values are used to augment the information passed to DB2 CLI in the connection string. If the information in the CLI initialization file contradicts information in the connection string, the values in connection string take precedence.

If the end user *Cancel*s a dialog box presented, SQL_NO_DATA_FOUND is returned.

The following values of *DriverCompletion* determines when a dialog will be opened:

SQL_DRIVER_PROMPT:
A dialog is always initiated. The information from the connection string and the CLI initialization file are used as initial values, to be supplemented by data input via the dialog box.

SQL_DRIVER_COMPLETE:
A dialog is only initiated if there is insufficient information in the connection string. The information from the connection string is used as initial values, to be supplemented by data entered via the dialog box.

SQL_DRIVER_COMPLETE_REQUIRED:
A dialog is only initiated if there is insufficient information in the connection string. The information from the connection string is used as initial values. Only mandatory information is requested. The user is prompted for required information only.

SQL_DRIVER_NOPROMPT:
The user is not prompted for any information. A connection is attempted with the information contained in the connection string. If there is not enough information, SQL_ERROR is returned.

Once a connection is established, the complete connection string is returned. Applications that need to set up multiple connections to the same database for a given user ID should store this output connection string. This string can then be used as the input connection string value on future `SQLDriverConnect()` calls.

Unicode equivalent: This function can also be used with the Unicode character set. The corresponding Unicode function is `SQLDriverConnectW()`. Refer to "Unicode functions (CLI)" on page 178 for information on ANSI to Unicode function mappings.

Return codes

- SQL_SUCCESS
- SQL_SUCCESS_WITH_INFO
- SQL_NO_DATA_FOUND
- SQL_INVALID_HANDLE
- SQL_ERROR

Diagnostics

All of the diagnostics generated by `SQLConnect()` can be returned here as well. The following table shows the additional diagnostics that can be returned.

Table 5. SQLDriverConnect SQLSTATEs

SQLSTATE	Description	Explanation
01004	Data truncated.	The buffer *szConnstrOut* was not large enough to hold the entire connection string. The argument **OutConnectionStringLengthPtr* contains the actual length of the connection string available for return. (Function returns SQL_SUCCESS_WITH_INFO)
01S00	Invalid connection string attribute.	An invalid keyword or attribute value was specified in the input connection string, but the connection to the data source was successful anyway because one of the following occurred: • The unrecognized keyword was ignored. • The invalid attribute value was ignored, the default value was used instead. (Function returns SQL_SUCCESS_WITH_INFO)
HY000	General error. Dialog Failed	The information specified in the connection string was insufficient for making a connect request, but the dialog was prohibited by setting *fCompletion* to SQL_DRIVER_NOPROMPT. The attempt to display the dialog failed.
HY090	Invalid string or buffer length.	The value specified for *InConnectionStringLength* was less than 0, but not equal to SQL_NTS. The value specified for *OutConnectionStringCapacity* was less than 0.
HY110	Invalid driver completion.	The value specified for the argument *fCompletion* was not equal to one of the valid values.

Restrictions

None.

Example

```
rc = SQLDriverConnect(hdbc,
                      (SQLHWND)sqlHWND,
                      InConnectionString,
                      InConnectionStringLength,
                      OutConnectionString,
                      OutConnectionStringCapacity,
                      StrLength2,
                      DriveCompletion);
```

CLI/ODBC keywords for file DSN or DSN-less connections

AltHostName CLI/ODBC configuration keyword:

Specifies the alternate host name to be used if the primary server specified by HOSTNAME cannot be contacted (Client Reroute.)

db2cli.ini keyword syntax:

AltHostName = *fully qualified alternate host name | IP address of node*

Usage notes:

This can be set in the [Data Source] section of the db2cli.ini file for the given data source, or in a connection string.

This parameter specifies a fully qualified host name or the IP address of the node where the alternate server for the database resides.

If the primary server returns alternate server information, it will override this AltHostName setting. However, this keyword is read only. That means the db2cli.ini will not be updated with the alternate server information received from the primary server.

AltPort CLI/ODBC configuration keyword:

Specifies the alternate port to be used if the primary server specified by HOSTNAME and PORT cannot be contacted (Client Reroute.)

db2cli.ini keyword syntax:

AltPort = *port number*

Usage notes:

This can be set in the [Data Source] section of the db2cli.ini file for the given data source, or in a connection string.

This parameter specifies the port number of the alternate server of the database manager instance where the alternate server for the database resides.

If the primary server returns alternate server information, it will override this AltPort setting. However, this keyword is read only. That means the db2cli.ini will not be updated with the alternate server information received from the primary server.

Authentication CLI/ODBC configuration keyword:

Specifies the type of authentication to be used with file DSN or DSN-less connectivity.

db2cli.ini keyword syntax:

Authentication = **SERVER** | **SERVER_ENCRYPT** | **SERVER_ENCRYPT_AES** | **DATA_ENCRYPT** | **KERBEROS** | **GSSPLUGIN**

Default setting:
SERVER

Usage notes:
This can be set in the [Data Source] section of the db2cli.ini file for the given data source, or in a connection string.

When you set this option, you must also set the following options:

- **Database**
- **Protocol**.

If **Protocol**=IPC, you need to set the following too:

- **Instance**.

If **Protocol**=TCPIP, you need to set the following too:

- **Port**
- **Hostname**.

If Kerberos is specified, then the **KRBPlugin** may also be optionally specified. If **KRBPlugin** is not specified, the default plugin IBMkrb5 will be used.

The SERVER_ENCRYPT_AES authentication type is available as of DB2 Version 9.5 Fix Pack 3.

BIDI CLI/ODBC configuration keyword:

Specifies the BIDI codepage when we are connected to a DB2 for z/OS®.

db2cli.ini keyword syntax:
BIDI = *codepage*

Usage notes:
This can be set in the [Data Source] section of the db2cli.ini file for the given data source, or in a connection string.

When you set this option, you must also set the following options:

- Database
- Protocol=TCPIP
- Hostname
- Port

FileDSN CLI/ODBC configuration keyword:

Specifies a DSN file from which a connection string will be built for the data source.

db2cli.ini keyword syntax:
You can not set this keyword in the db2cli.ini file.

You can specify the value of this keyword in the connection string in SQLDriverConnect like this:

```
FileDSN = file name
```

Instance CLI/ODBC configuration keyword:

Specifies the instance name for a local IPC connection for file DSN or DSN-less connectivity.

db2cli.ini keyword syntax:

Instance = *instance name*

Usage notes:

This can be set in the [Data Source] section of the db2cli.ini file for the given data source, or in a connection string.

When you set this keyword, you must also set the following options:

- Database
- Protocol=IPC

Interrupt CLI/ODBC configuration keyword:

Sets the interrupt processing mode.

db2cli.ini keyword syntax:

Interrupt = **0** | **1** | **2**

Default setting:

1

Usage notes:

This can be set in the [Data Source] section of the db2cli.ini file for the given data source, or in a connection string.

When you set this option, you must also set the following options:

- Database
- Protocol=IPC

The keyword values have the following meaning:

0 Disables interrupt processing (SQLCancel calls will not interrupt the processing.)

1 Interrupts are supported (default.) In this mode, if the server supports an interrupt, an interrupt will be sent. Otherwise the connection is dropped.

The settings for INTERRUPT_ENABLED (a DB2 Connect gateway setting) and the DB2 registry variable DB2CONNECT_DISCONNECT_ON_INTERRUPT will take precedence over the Interrupt keyword setting of 1.

2 Interrupt drops the connection regardless of server's interrupt capabilities (SQLCancel will drop the connection.)

KRBPlugin CLI/ODBC configuration keyword:

Specifies the name of the Kerberos plug-in library to be used for client side authentication for file DSN or DSN-less connectivity.

db2cli.ini keyword syntax:

KRBPlugin = *plugin name*

Default setting:

By default, the value is null on UNIX operating systems, and IBMkrb5 on Windows operating systems.

Usage notes:

This can be set in the [Data Source] section of the db2cli.ini file for the given data source, or in a connection string.

This parameter specifies the name of the Kerberos plug-in library to be used for client-side connection authentication. The plug-in is used when the client is authenticated using KERBEROS authentication.

Protocol CLI/ODBC configuration keyword:

Communications protocol used for File DSN or in a DSN-less connection.

db2cli.ini keyword syntax:
Protocol = **TCPIP** | **TCPIP6** | **TCPIP4** | **IPC** | **LOCAL**

Default setting:
none

Usage notes:
This can be set in the `[Data Source]` section of the `db2cli.ini` file for the given data source, or in a connection string.

TCP/IP is the only protocol supported when using a File DSN. Set the option to the string TCPIP (without the slash).

When this option is set then the following options must also be set:

- Database;
- ServiceName; and
- Hostname.

IPC connectivity can be specified by setting Protocol to either **IPC** or **LOCAL**.

When Protocol = **IPC** | **LOCAL** the Instance keyword must also be set.

PWDPlugin CLI/ODBC configuration keyword:

Specifies the name of the userid-password plug-in library to be used for client side authentication for file DSN or DSN-less connectivity.

db2cli.ini keyword syntax:
PWDPlugin = *plugin name*

Default setting:
By default, the value is null and the DB2-supplied userid-password plug-in library is used.

Usage notes:
This can be set in the `[Data Source]` section of the `db2cli.ini` file for the given data source, or in a connection string.

This parameter specifies the name of the userid-password plug-in library to be used for client-side connection authentication. The plug-in is used when the client is authenticated using SERVER or SERVER_ENCRYPT authentication.

SaveFile CLI/ODBC configuration keyword:

Specifies the file name of a DSN file in which to save the attribute values of the keywords used in making the present, successful connection.

db2cli.ini keyword syntax:
You can not set this keyword in the `db2cli.ini` file.

You can specify the value of this keyword in the connection string in SQLDriverConnect like this:

```
SaveFile = file name
```

Running DB2 CLI and ODBC applications using the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately; and it provides a subset of the functionality of either IBM Data Server client. The IBM Data Server Driver for ODBC and CLI provides runtime support for: the DB2 CLI application programming interface (API), the ODBC API, the XA API; and connecting to databases.

To run database applications with the IBM Data Server Driver for ODBC and CLI, you need:

- one or more copies of the driver installed.
  - See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8.
- to have configured the application environment for the driver.
  - See: "Configuring the IBM Data Server Driver for ODBC and CLI" on page 11.

When writing applications for, or migrating applications to using the IBM Data Server Driver for ODBC and CLI:

- Ensure your applications use only the DB2 CLI, ODBC and XA API functions that are supported by the driver.
  - See:
    - "DB2 CLI and ODBC API support in the IBM Data Server Driver for ODBC and CLI"
    - "XA API support in the IBM Data Server Driver for ODBC and CLI" on page 32
- Ensure your applications are not attempting to make use of IBM Data Server Client or IBM Data Server Runtime Client functionality that is restricted in the driver.
  - See: "Restrictions of the IBM Data Server Driver for ODBC and CLI" on page 33
- Use the 32-bit version of the driver with 32-bit database applications, and use the 64-bit version of the driver with 64-bit database applications.
- Understand the available tracing, logging, and diagnostic support provided by the driver for investigating problems.
  - See: "Diagnostic support in the IBM Data Server Driver for ODBC and CLI" on page 34

DB2 CLI and ODBC API support in the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately; and it provides a subset of the functionality of either IBM Data Server client.

The IBM Data Server Driver for ODBC and CLI supports the ANSI and (where they exist) the Unicode versions of the following ODBC and DB2 CLI functions:

```
SQLAllocConnect       SQLExtendedPrepare    SQLNumParams
SQLAllocEnv           SQLFetch              SQLNumResultCols
SQLAllocHandle        SQLFetchScroll        SQLParamData
SQLAllocStmt          SQLForeignKeys        SQLParamOptions
SQLBindCol            SQLFreeConnect        SQLPrepare
SQLBindFileToCol      SQLFreeEnv            SQLPrimaryKeys
SQLBindFileToParam    SQLFreeHandle         SQLProcedureColumns
SQLBindParameter      SQLFreeStmt           SQLProcedures
SQLBrowseConnect      SQLGetConnectAttr     SQLPutData
SQLBuildDataLink      SQLGetConnectOption   SQLRowCount
SQLBulkOperations     SQLGetCursorName      SQLSetColAttributes
SQLCancel             SQLGetData            SQLSetConnectAttr
SQLCloseCursor        SQLGetDataLinkAttr    SQLSetConnectOption
SQLColAttribute       SQLGetDescField       SQLSetConnection
SQLColAttributes      SQLGetDescRec         SQLSetCursorName
SQLColumnPrivileges   SQLGetDiagField       SQLSetDescField
SQLColumns            SQLGetDiagRec         SQLSetDescRec
SQLConnect            SQLGetEnvAttr         SQLSetEnvAttr
SQLCopyDesc           SQLGetFunctions       SQLSetParam
SQLDataSources        SQLGetInfo            SQLSetPos
SQLDescribeCol        SQLGetLength          SQLSetScrollOptions
SQLDescribeParam      SQLGetPosition        SQLSetStmtAttr
SQLDisconnect         SQLGetSQLCA           SQLSetStmtOption
SQLDriverConnect      SQLGetStmtAttr        SQLSpecialColumns
SQLEndTran            SQLGetStmtOption      SQLStatistics
SQLError              SQLGetSubString       SQLTablePrivileges
SQLExecDirect         SQLGetTypeInfo        SQLTables
SQLExecute            SQLMoreResults        SQLTransact
SQLExtendedBind       SQLNativeSql
SQLExtendedFetch      SQLNextResult
```

XA API support in the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately; and it provides a subset of the functionality of either IBM Data Server client.

The IBM Data Server Driver for ODBC and CLI supports the following XA API functions:

-

  xa_open
  xa_close
  xa_start
  xa_end
  xa_prepare
  xa_commit
  xa_rollback
  xa_forget
  xa_recover

LDAP support in the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately; and it provides a subset of the functionality of either IBM Data Server client.

The IBM Data Server Driver for ODBC and CLI supports the LDAP Database Directory support with one restriction:

- the LDAP cache is not saved to disk; it is an in-memory cache only. The DB2LDAPCACHE registry variable is ignored.

The steps for configuring the database application environment to enable LDAP when using the IBM Data Server Driver for ODBC and CLI are the same as for other scenarios, except that the DB2LDAPCACHE registry variable is ignored.

Restrictions of the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately; and it provides a subset of the functionality of either IBM Data Server client.

The IBM Data Server Driver for ODBC and CLI provides runtime support for:

- the DB2 CLI application programming interface (API);
- the DB2 Interactive Call Level Interface (db2cli);
- the ODBC API;
- the XA API; and
- connecting to databases.

Functionality not supported by the IBM Data Server Driver for ODBC and CLI

- CLI and ODBC application development;
- the Command Line Processor (CLP);
- administrative APIs;
- installation program.
  - You must install the driver manually.
    - See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8.
  - You must configure the driver manually.
    - See: "Configuring the IBM Data Server Driver for ODBC and CLI" on page 11.

Functionality supported with restrictions by the IBM Data Server Driver for ODBC and CLI

- Messages will be reported only in English.
- There is no local database directory.
  - LDAP is supported, but the LDAP cache is not saved to disk.
    - See: "LDAP support in the IBM Data Server Driver for ODBC and CLI" on page 32.
- Not all diagnostic utilities are available.
  - See: "Diagnostic support in the IBM Data Server Driver for ODBC and CLI" on page 34.

For an up-to-date list of current restrictions, see http://www.ibm.com/developerworks/wikis/display/DB2/IBM+Data+Server+Driver+Limitations.

Diagnostic support in the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately; and it provides a subset of the functionality of either IBM Data Server client.

The following tracing, logging, and diagnostic utilities are provided with the IBM Data Server Driver for ODBC and CLI:

CLI trace

The method for using CLI trace with the IBM Data Server Driver for ODBC and CLI is the same as the method for using CLI trace with an IBM Data Server client.

DB2 trace

To turn on DB2 trace when you are using the IBM Data Server Driver for ODBC and CLI, you must invoke the `db2trc` utility from the `adm` subdirectory of the driver's install directory on Linux and UNIX or the `bin` subdirectory for Windows.

For example, if you installed the driver at `$HOME/db2_cli_odbc_driver`, you must be in the `$HOME/db2_cli_odbc_driver/adm` directory when you invoke `db2trc`.

The IBM Data Server Driver for ODBC and CLI can be installed on a Network File System (NFS). If the driver is installed on a read-only NFS, the environment variable DB2_DIAGPATH must be set to allow DB2 trace to work.

`db2diag.log`

When you are using the IBM DB2 Driver for ODBC and CLI, the `db2diag.log` file will be located in the `db2dump` subdirectory of the driver install directory On UNIX and Linux operating systems, and in the `db2` subdirectory of the driver install directory on Windows operating systems. The DB2_DIAG environment variable and the DIAGPATH CLI keyword can be used to alter the location of the `db2diag.log` file.

`db2support`

The DB2 command line processor is not available with the IBM Data Server Driver for ODBC and CLI, so the CLP utility is not available. However, an executable version of `db2support` will be available with the driver.

This executable version of `db2support` will collect the following information:

- db2level output;
- environment variables; and
- a listing of the contents of the IBM Data Server Driver for ODBC and CLI install directory.

You must activate the database prior to running `db2support`, otherwise the information collected does not contain enough information.

You must invoke `db2support` from the `bin` subdirectory of the driver install directory.

For example, if you installed the driver at `$HOME/db2_cli_odbc_driver`, you must be in the `$HOME/db2_cli_odbc_driver/bin` directory when you invoke `db2support`.

Setting diagnostic options

The IBM Data Server Driver for ODBC and CLI does not support the command line processor (CLP.) This means that the usual mechanism to set DB2 registry variables, using the `db2set` command, is not possible. However, the functionality of registry variables related to diagnostics is supported through CLI/ODBC keywords:

- "DiagLevel CLI/ODBC configuration keyword"
- "NotifyLevel CLI/ODBC configuration keyword" on page 36
- "DiagPath CLI/ODBC configuration keyword" on page 36

and attributes for `SQLSetEnvAttr` and `SQSGetEnvAttr`:

- SQL_ATTR_DIAGLEVEL
- SQL_ATTR_NOTIFY_LEVEL
- SQL_ATTR_DIAGPATH
- See: "Environment attributes (CLI) list" on page 36.

and environment variables:

- DB2_DIAGPATH
- See: "Environment variables supported by the IBM DB2 Driver for ODBC and CLI" on page 15.

The CLI/ODBC keyword DiagPath, the attribute SQL_ATTR_DIAGPATH, and the environment variable DB2_DIAGPATH all have the same purpose: to specify where diagnostic output is located. There is one situation, however, where DB2_DIAGPATH must be used:

- The IBM Data Server Driver for ODBC and CLI can be installed on a Network File System (NFS). If the driver is installed on a read-only NFS, the environment variable DB2_DIAGPATH must be set to a writable directory to allow DB2 trace to work.

Otherwise, the CLI/ODBC keyword DiagPath, the attribute SQL_ATTR_DIAGPATH, and the environment variable DB2_DIAGPATH all have the same effect.

DiagLevel CLI/ODBC configuration keyword:

Sets the diagnostic level.

db2cli.ini keyword syntax:

DiagLevel = **0** | **1** | **2** | **3** | **4**

Default setting:

3

Usage notes:

This can be set in the `[COMMON]` section of the `db2cli.ini` file only.

This is applicable only at Environment Handle allocation time for an entire process.

This is equivalent to the database manager parameter `DIAGLEVEL`.

NotifyLevel CLI/ODBC configuration keyword:

Sets the diagnostic level.

db2cli.ini keyword syntax:
NotifyLevel = **0** | **1** | **2** | **3** | **4**

Default setting:
3

Usage notes:
This can be set in the [COMMON] section of the db2cli.ini file only.

This is equivalent to the database manager parameter NOTIFYLEVEL.

DiagPath CLI/ODBC configuration keyword:

Sets the path of the db2diag.log file.

db2cli.ini keyword syntax:
DiagPath = *existing directory*

Default setting:
The default value is the db2dump directory on UNIX and Linux operating systems, and the db2 directory on Windows operating systems.

Usage notes:

This can be set in the [COMMON] section of the db2cli.ini file only.

This is equivalent to the database manager parameter DIAGPATH.

Environment attributes (CLI) list:

Note: ODBC does not support setting driver-specific environment attributes using SQLSetEnvAttr(). Only CLI applications can set the DB2 CLI-specific environment attributes using this function.

SQL_ATTR_CONNECTION_POOLING
This attribute has been deprecated in DB2 Universal Database (DB2 luw) Version 8.

SQL_ATTR_CONNECTTYPE

Note: This attribute replaces SQL_CONNECTTYPE.
A 32-bit integer value that specifies whether this application is to operate in a coordinated or uncoordinated distributed environment. . The possible values are:

- **SQL_CONCURRENT_TRANS**: The application can have concurrent multiple connections to any one database or to multiple databases. Each connection has its own commit scope. No effort is made to enforce coordination of transaction. If an application issues a commit using the environment handle on SQLEndTran() and not all of the connections commit successfully, the application is responsible for recovery. This is the default.
- SQL_COORDINATED_TRANS: The application wishes to have commit and rollbacks coordinated among multiple database connections. This option setting corresponds to the specification of the Type 2 CONNECT in embedded SQL. In contrast to the SQL_CONCURRENT_TRANS setting described above, the application is permitted only one open connection per database.

Note: This connection type results in the default for SQL_ATTR_AUTOCOMMIT connection option to be SQL_AUTOCOMMIT_OFF.

If changing this attribute from the default then it must be set before any connections have been established on the environment handle.

It is recommended that the application set this attribute as an environment attribute with a call to `SQLSetEnvAttr()`, if necessary, as soon as the environment handle has been allocated. However, since ODBC applications cannot access `SQLSetEnvAttr()`, they must set this attribute using `SQLSetConnectAttr()` after each connection handle is allocated, but before any connections have been established.

All connections on an environment handle must have the same SQL_ATTR_CONNECTTYPE setting. An environment cannot have a mixture of concurrent and coordinated connections. The type of the first connection will determine the type of all subsequent connections. `SQLSetEnvAttr()` will return an error if an application attempts to change the connection type while there is an active connection.

The default connect type can also be set using the "ConnectType CLI/ODBC configuration keyword" on page 163.

Note: This is an IBM defined extension.

SQL_ATTR_CP_MATCH
This attribute has been deprecated in DB2 luw Version 8.

SQL_ATTR_DIAGLEVEL

Description
A 32-bit integer value which represents the diagnostic level. This is equivalent to the database manager parameter `DIAGLEVEL`.

Values
Valid values are: 0, 1, 2, 3, or 4. (The default value is 3.)

Usage notes
This attribute must be set before any connection handles have been created.

SQL_ATTR_DIAGPATH

Description
A pointer to a null-terminated character string containing the name of the directory where diagnostic data is to be placed. This is equivalent to the database manager parameter `DIAGPATH`.

Values
The default value is the `db2dump` directory on UNIX and Linux operating systems, and the `db2` directory on Windows operating systems.

Usage notes
This attribute must be set before any connection handles have been created.

SQL_ATTR_INFO_ACCTSTR
A pointer to a null-terminated character string used to identify the client accounting string sent to the host database server when using DB2® Connect™.

Please note:

- When the value is being set, some servers might not handle the entire length provided and might truncate the value.
- DB2 for z/OS and OS/390® servers support up to a length of 200 characters.
- To ensure that the data is converted correctly when transmitted to a host system, use only the characters A to Z, 0 to 9, and the underscore (_) or period (.).

Note: This is an IBM defined extension.

SQL_ATTR_INFO_APPLNAME
A pointer to a null-terminated character string used to identify the client application name sent to the host database server when using DB2 Connect.

Please note:

- When the value is being set, some servers might not handle the entire length provided and might truncate the value.
- DB2 for z/OS and OS/390 servers support up to a length of 32 characters.
- To ensure that the data is converted correctly when transmitted to a host system, use only the characters A to Z, 0 to 9, and the underscore (_) or period (.).

Note: This is an IBM defined extension.

SQL_ATTR_INFO_USERID
A pointer to a null-terminated character string used to identify the client user ID sent to the host database server when using DB2 Connect.

Please note:

- When the value is being set, some servers might not handle the entire length provided and might truncate the value.
- DB2 for z/OS and OS/390 servers support up to a length of 16 characters.
- This user-id is not to be confused with the authentication user-id. This user-id is for identification purposes only and is not used for any authorization.
- To ensure that the data is converted correctly when transmitted to a host system, use only the characters A to Z, 0 to 9, and the underscore (_) or period (.).

Note: This is an IBM defined extension.

SQL_ATTR_INFO_WRKSTNNAME
A pointer to a null-terminated character string used to identify the client workstation name sent to the host database server when using DB2 Connect.

Please note:

- When the value is being set, some servers might not handle the entire length provided and might truncate the value.
- DB2 for z/OS and OS/390 servers support up to a length of 18 characters.

- To ensure that the data is converted correctly when transmitted to a host system, use only the characters A to Z, 0 to 9, and the underscore (_) or period (.).

Note: This is an IBM defined extension.

SQL_ATTR_MAXCONN
This attribute has been deprecated in DB2 luw Version 8.

SQL_ATTR_NOTIFY_LEVEL

Description
A 32-bit integer value which represents the notification level. This is equivalent to the database manager parameter `NOTIFYLEVEL`.

Values
Valid values are: 0, 1, 2, 3, or 4. (The default value is 3.)

Usage notes
This attribute must be set before any connection handles have been created.

SQL_ATTR_ODBC_VERSION
A 32-bit integer that determines whether certain functionality exhibits ODBC 2.x (DB2 CLI v2) behavior or ODBC 3.0 (DB2 CLI v5) behavior.

It is recommended that all DB2 CLI applications set this environment attribute. ODBC applications must set this environment attribute before calling any function that has an SQLHENV argument, or the call will return SQLSTATE HY010 (Function sequence error.).

The following values are used to set the value of this attribute:

- SQL_OV_ODBC3: Causes the following ODBC 3.0 (DB2 CLI v5) behavior:
  - DB2 CLI returns and expects ODBC 3.0 (DB2 CLI v5) codes for date, time, and timestamp.
  - DB2 CLI returns ODBC 3.0 (DB2 CLI v5) SQLSTATE codes when `SQLError()`, `SQLGetDiagField()`, or `SQLGetDiagRec()` are called.
  - The *CatalogName* argument in a call to `SQLTables()` accepts a search pattern.
- SQL_OV_ODBC2 Causes the following ODBC 2.x (DB2 CLI v2) behavior:
  - DB2 CLI returns and expects ODBC 2.x (DB2 CLI v2) codes for date, time, and timestamp.
  - DB2 CLI returns ODBC 2.0 (DB2 CLI v2) SQLSTATE codes when `SQLError()`, `SQLGetDiagField()`, or `SQLGetDiagRec()` are called.
  - The *CatalogName* argument in a call to `SQLTables()` does not accept a search pattern.

SQL_ATTR_OUTPUT_NTS
A 32-bit integer value which controls the use of null-termination in output arguments. The possible values are:

- **SQL_TRUE**: DB2 CLI uses null termination to indicate the length of output character strings (default).

  This is the default.
- SQL_FALSE: DB2 CLI does not use null termination in output character strings.

The CLI functions affected by this attribute are all functions called for the environment (and for any connections and statements allocated under the environment) that have character string parameters.

This attribute can only be set when there are no connection handles allocated under this environment.

SQL_ATTR_PROCESSCTL
A 32-bit mask that sets process level attributes which affect all environments and connections for the process. This attribute must be set before the environment handle is allocated.

The call to `SQLSetEnvAttr()` must have the *EnvironmentHandle* argument set to SQL_NULL_HANDLE. The settings remain in effect for the life of the process. Generally this attribute is only used for performance sensitive applications, where large numbers of CLI function calls are being made. Before setting any of these bits, ensure that the application, and any other libraries that the application calls, comply with the restrictions listed.

The following values can be combined to form a bitmask:

- SQL_PROCESSCTL_NOTHREAD - This bit indicates that the application does not use multiple threads, or if it does use multiple threads, guarantees that all DB2 calls will be serialized by the application. If set, DB2 CLI does not make any system calls to serialize calls to CLI, and sets the DB2 context type to SQL_CTX_ORIGINAL.
- SQL_PROCESSCTL_NOFORK - This bit indicates that the application will never fork a child process. By default, DB2 CLI does not check to see if an application forks a child process. However, if the CheckForFork CLI/ODBC configuration keyword is set, DB2 CLI checks the current process id for each function call for all applications connecting to the database for which the keyword is enabled. This attribute can be set so that DB2 CLI does not check for forked processes for that application.

Note: This is an IBM defined extension.

SQL_ATTR_SYNC_POINT
This attribute has been deprecated in DB2 luw Version 8.

SQL_ATTR_TRACE
A pointer to a null-terminated character string used to turn on the DB2 CLI/ODBC trace facility. The string must include the keywords TRACE and TRACEPATHNAME. For example:

```
"TRACE=1; TRACEPATHNAME=<dir>;"
```

SQL_ATTR_USE_2BYTES_OCTET_LENGTH
This attribute has been deprecated in DB2 luw Version 8.

SQL_ATTR_USE_LIGHT_OUTPUT_SQLDA
Setting this attribute is equivalent to setting the connection attribute SQL_ATTR_DESCRIBE_OUTPUT_LEVEL to 0. SQL_ATTR_USE_LIGHT_OUTPUT_SQLDA has been deprecated and applications should now use the connection attribute SQL_ATTR_DESCRIBE_OUTPUT_LEVEL.

SQL_ATTR_USER_REGISTRY_NAME
This attribute is only used when authenticating a user on a server that is using an identity mapping service. It is set to a user defined string that names an identity mapping registry. The format of the name varies depending on the identity mapping service. By providing this attribute you tell the server that the user name provided can be found in this registry.

After setting this attribute the value will be used on subsequent attempts to establish a normal connection, establish a trusted connection, or switch the user id on a trusted connection.

SQL_CONNECTTYPE
This *Attribute* has been replaced with SQL_ATTR_CONNECTTYPE.

SQL_MAXCONN
This *Attribute* has been replaced with SQL_ATTR_MAXCONN.

SQL_SYNC_POINT
This *Attribute* has been replaced with SQL_ATTR_SYNC_POINT.

Deploying the IBM Data Server Driver for ODBC and CLI with database applications

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately. You can simplify the deployment of your DB2 CLI and ODBC database applications by creating an install program. You can deploy the IBM Data Server Driver for ODBC and CLI with your DB2 CLI and ODBC database applications by obtaining the compressed file that contains the driver and following the installation and configuration steps required for the driver into your install program.

To deploy the IBM Data Server Driver for ODBC and CLI with your applications you will need:

- a mechanism for deploying the applications, such as an install program;
- to obtain the compressed file that contains the driver; See: "Obtaining the IBM Data Server Driver for ODBC and CLI" on page 8
- a redistribution license. See: "License requirements for the IBM Data Server Driver for ODBC and CLI."

Restrictions

Under the terms of the redistribution licence, only some of the IBM Data Server Driver for ODBC and CLI files can be redistributed. Which files may be redistributed is listed in the file `redist.txt`. This file can be found in the compressed file that contains the driver, called `db2_driver_for_odbc_cli.zip` on the Windows platforms and `db2_driver_for_odbc_cli.tar.Z` on all other platforms.

To incorporate the IBM Data Server Driver for ODBC and CLI into your install program, you must do the following:

1. Copy the driver files into your install program. See the restrictions above about which driver files can be redistributed.
2. Set the install program to install the driver on the target machine. See: "Installing the IBM Data Server Driver for ODBC and CLI" on page 8.
3. Set the install program to configure the environment on the target machine. See: "Configuring the IBM Data Server Driver for ODBC and CLI" on page 11.

License requirements for the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. It must be installed and configured separately.

You can download and install the IBM Data Server Driver for ODBC and CLI and use it with your ODBC and CLI applications without a special license. Please refer to any of the files in the `/license/Windows` or `/license/UNIX` directory for terms and conditions.

The IBM Data Server ODBC and CLI Driver can be used to connect only to a properly licensed:

- DB2 for Linux, UNIX and Windows server;
- DB2 Connect server;
- WebSphere® Federation server;
- Cloudscape® Server;
- Informix® Database Server;
- DB2 for OS/390 and z/OS server (see below);
- DB2 for iSeries® server (see below); and
- DB2 for VM/VSE server (see below).

The IBM Data Server ODBC and CLI Driver can be used to connect to DB2 for OS/390 and z/OS, DB2 for i5/OS and DB2 for VM/VSE servers only if:

- a connection is established through a properly licensed DB2 Connect server; or
- directly to the server if and only if a properly formatted authentic DB2 Connect license file is present. The license file is distributed as part of the DB2 Connect products, so the only way to obtain this license key file is to purchase one of the following DB2 Connect products:
  - DB2 Connect Personal Edition;
  - DB2 Connect Enterprise Edition;
  - DB2 Connect Application Server Edition;
  - DB2 Connect Unlimited Edition for zSeries®;
  - DB2 Connect Unlimited Edition for iSeries;

  No other product will provide the proper license file or the license rights afforded by the presence of this file. Tampering with or unauthorized distribution of this file will constitute a breach of the license agreement. The relevant license file can be located on the DB2 Connect install image in the /db2/license directory. The name of the file varies with the product:
  - DB2 Connect Personal Edition : db2conpe.lic
  - DB2 Connect Application Server : db2consv_as.lic
  - DB2 Connect Enterprise Edition : db2consv_ee.lic
  - DB2 Connect Unlimited Edition for iSeries : db2consv_is.lic
  - DB2 Connect Unlimited Edition for zSeries : db2consv_zs.lic

ODBC driver managers

DB2 CLI supports a variety of ODBC driver managers in connections to DB2.

An ODBC driver manager is not supplied on UNIX platforms as part of the operating system. Using ODBC on UNIX systems requires a separate commercial or open source ODBC driver manager. Refer to the unixODBC Web site (http://www.unixodbc.com), as well as the README files within the unixODBC distribution package for more information.

unixODBC driver manager

The unixODBC Driver Manager is an open source ODBC driver manager supported for DB2 ODBC applications on all supported Linux and UNIX operating systems.

Support statement

If you experience problems with the combination of the unixODBC Driver Manager and the DB2 ODBC driver after they have been properly installed and configured, you can contact DB2 Support (http://www.ibm.com/software/data/db2/support/db2_9/) for assistance in diagnosing the problem. If the source of the problem lies with the unixODBC Driver Manager, then you can:

- Purchase a service contract for technical support from Easysoft, a commercial sponsor of unixODBC (http://www.easysoft.com).
- Participate in any open source support channels at http://www.unixodbc.com.

Setting up the unixODBC driver manager

To run ODBC applications on Linux or UNIX operating systems, you must configure the unixODBC Driver Manager.

To set up the unixODBC Driver Manager for use with DB2 CLI and ODBC applications:

1. Download the latest unixODBC source code from http://www.unixodbc.com.
2. Untar the source files. For example:

   ```
   gzip -d unixODBC-2.2.11.tar.gz
   tar xf unixODBC-2.2.11.tar
   ```

3. For AIX only: Configure the C compiler to be thread-enabled:

   ```
   export CC=xlc_r
   export CCC=xlC_r
   ```

4. To compile a 64-bit version of the driver manager using the xlc_r compilers, set the environment variables **OBJECT_MODE** and **CFLAGS**:

   ```
   export OBJECT_MODE=64
   export CFLAGS=-q64 -DBUILD_REAL_64_BIT_MODE
   ```

5. Install the driver manager in either your home directory or the default /usr/local prefix:
   - (Home directory) Issue the following command in the directory where you untarred the source files:

     ```
     ./configure --prefix=$HOME -DBUILD_REAL_64_BIT_MODE --enable-gui=no
                                        --enable-drivers=no
     ```

   - (/usr/local as root) Issue the following command:

     ```
     ./configure --enable-gui=no --enable-drivers=no
     ```

6. Optional: Examine all configuration options by issuing the following command:

   ```
   ./configure --help
   ```

7. Build and install the driver manager:

   ```
   make
   make install
   ```

   Libraries will be copied to the [prefix]/lib directory, and executables will be copied to the [prefix]/bin directory.

8. For AIX only: Extract the shared library from the ODBC driver for DB2 to yield shr.o on 32-bit operating systems and shr_64.o on 64-bit operating

systems. To avoid confusion, rename the files db2.o and db2_64.o, respectively. These steps are necessary on AIX because the unixODBC Driver Manager loads the driver dynamically.

- On 32-bit operating systems, issue the following commands:

```
cd INSTHOME/sqllib/lib
ar -x libdb2.a
mv shr.o db2.o
```

  where *INSTHOME* is the home directory of the instance owner.

- On 64-bit operating systems, issue the following commands:

```
cd INSTHOME/sqllib/lib
ar -x -X 64 libdb2.a
mv shr_64.o db2_64.o
```

  where *INSTHOME* is the home directory of the instance owner.

Ensure that your INI file references the correct library.

9. (Optional) For AIX only: Extract libodbc.a, libodbcinst.a, and libodbccr.a if you will be dynamically loading the driver manager:

```
ar -x libodbc.a
ar -x libodbcinst.a
ar -x libodbccr.a
```

   This produces libodbc.so.1, libodbcinst.so.1, and libodbccr.so.1 respectively in the [prefix]/lib/so directory.

10. Build the application and ensure it is linked to the unixODBC Driver Manager by including the `-L[prefix]/lib -lodbc` option in the compile and link command.

11. Specify the paths for at least the user INI file (odbc.ini) or the system INI file (odbcinst.ini), and set the **ODBCHOME** environment variable to the directory where the system INI file was created.

    Important: Provide absolute paths when specifying the paths of the user and system INI files. Do not use relative paths or environment variables.

Microsoft ODBC driver manager

The Microsoft ODBC driver manager can be used for connections to remote DB2 databases when using TCP/IP networks or Microsoft SNA servers.

DataDirect ODBC driver manager

The DataDirect ODBC driver manager for DB2 can be used for connections to the DB2 database.

Restrictions

Complications arise when using the DB2 CLI/ODBC driver with the DataDirect Connect for ODBC Driver Manager in the UNIX environment because of the use of UTF-8 character encoding by the driver manager. UTF-8 is a variable length character encoding scheme using anywhere from 1 to 6 bytes to store characters. UTF-8 and UCS-2 are not inherently compatible, and passing UTF-8 data to the DB2 CLI/ODBC driver (which expects UCS-2) might result in application errors, data corruption, or application exceptions.

To avoid this problem, the DataDirect Connect for ODBC Driver Manager 4.2 Service Pack 2 recognizes a DB2 CLI/ODBC driver and not use the Unicode

functions, effectively treating the DB2 CLI/ODBC driver as an ANSI-only driver. Before release 4.2 Service Pack 2, the DataDirect Connect for ODBC Driver Manager had to be linked with the _36 version of the DB2 CLI/ODBC driver which does not export the SQLConnectW() function.

Chapter 3. Initializing CLI applications

Initializing CLI applications is part of the larger task of programming with CLI. The task of initializing CLI applications involves allocating environment and connection handles and then connecting to the data source.

To initialize the application:

1. Allocate an environment handle by calling `SQLAllocHandle()` with a *HandleType* of SQL_HANDLE_ENV and an *InputHandle* of SQL_NULL_HANDLE. For example:

   ```
   SQLAllocHandle (SQL_HANDLE_ENV, SQL_NULL_HANDLE, &henv);
   ```

   Use the allocated environment handle, returned in the *OutputHandlePtr argument (henv in the example above), for all subsequent calls that require an environment handle.
2. Optional: Set environment attributes for your application by calling `SQLSetEnvAttr()` with the desired environment attribute for each attribute you want set.

   Important: If you plan to run your application as an ODBC application, you must set the SQL_ATTR_ODBC_VERSION environment attribute using `SQLSetEnvAttr()`. Setting this attribute for applications that are strictly DB2 CLI applications is recommended but not required.
3. Allocate a connection handle by calling `SQLAllocHandle()` with a *HandleType* of SQL_HANDLE_DBC using the environment handle returned from Step 1 as the *InputHandle* argument. For example:

   ```
   SQLAllocHandle (SQL_HANDLE_DBC, henv, &hdbc);
   ```

   Use the allocated connection handle, returned in the **OutputHandlePtr* argument (hdbc in the example above), for all subsequent calls that require a connection handle.
4. Optional: Set connection attributes for your application by calling `SQLSetConnectAttr()` with the desired connection attribute for each attribute you want set.
5. Connect to a data source by calling one of following functions with the connection handle you allocated in Step 3 for each data source you want to connect to:
   - SQLConnect(): basic database connection method. For example:

     ```
     SQLConnect (hdbc, server, SQL_NTS, user, SQL_NTS, password, SQL_NTS);
     ```

     where SQL_NTS is a special string length value that indicates the referenced string is null-terminated.
   - SQLDriverConnect(): extended connect function that allows additional connect options and offers Graphical User Interface support. For example:

     ```
     char * connStr = "DSN=SAMPLE;UID=;PWD=;";

     SQLDriverConnect (hdbc, (SQLHWND)NULL, connStr, SQL_NTS,
                       NULL, 0, NULL, SQL_DRIVER_NOPROMPT);
     ```
   - SQLBrowseConnect(): least common connection method that iteratively returns the attributes and attribute values for connecting to a data source. For example:

```
char * connInStr = "DSN=SAMPLE;UID=;PWD=;";
char outStr[512];

SQLBrowseConnect (hdbc, connInStr, SQL_NTS, outStr,
                  512, &strLen2Ptr);
```

Now that your application has been initialized, you can proceed to processing transactions.

Initialization and termination in CLI overview

Figure 2 on page 49 shows the function call sequences for both the initialization and termination tasks. The transaction processing task in the middle of the diagram is shown in Chapter 5, "Transaction processing in CLI overview," on page 63.

The initialization task consists of the allocation and initialization of environment and connection handles. An environment handle must be allocated before a connection handle can be created. Once a connection handle is created, the application can then establish a connection. When a connection exists, the application can proceed to the transaction processing task. An application then passes the appropriate handle when it calls other DB2 CLI functions.

The termination task consists of disconnecting from the data source and freeing those handles that were allocated during the initialization phase. The connection handle should be freed before freeing the environment handle.

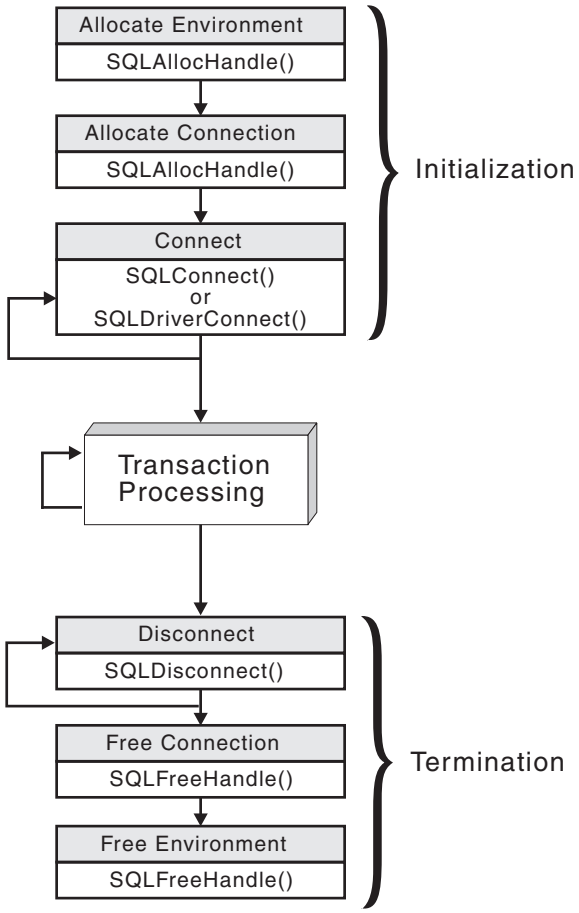


Figure 2. Conceptual view of initialization and termination tasks

Handles in CLI

A CLI handle is a variable that refers to a data object allocated and managed by DB2 CLI. Using handles relieves the application from having to allocate and manage global variables or data structures, such as the SQLDA.

There are four types of handles in CLI:

Environment handle

An environment handle refers to a data object that holds information about the global state of the application, such as attributes or valid connections. An environment handle must be allocated before a connection handle can be allocated.

Connection handle

A connection handle refers to a data object that holds information associated with a connection to a particular data source (database). Examples of such information include valid statement and descriptor handles on a connection, transaction status, and diagnostic information.

An application can be connected to several data sources at the same time, and can establish several distinct connections to the same data source. A

separate connection handle must be allocated for each concurrent connection. A connection handle must be allocated before a statement or descriptor handle can be allocated.

Connection handles ensure that multithreaded applications which use one connection per thread are thread-safe, because separate data structures are allocated and maintained by DB2 CLI for each connection.

Note: There is a limit of 512 active connections per environment handle.

Statement handle

A statement handle refers to a data object that is used to track the execution of a single SQL statement. It provides access to statement information such as error messages, the associated cursor name, and status information for SQL statement processing. A statement handle must be allocated before an SQL statement can be issued.

When a statement handle is allocated, DB2 CLI automatically allocates four descriptors and assigns the handles for these descriptors to the SQL_ATTR_APP_ROW_DESC, SQL_ATTR_APP_PARAM_DESC, SQL_ATTR_IMP_ROW_DESC, and SQL_ATTR_IMP_PARAM_DESC statement attributes. Application descriptors can be explicitly allocated by allocating descriptor handles.

The number of statement handles available to a CLI application depends on the number of large packages the application has defined and is limited by overall system resources (usually stack size). By default, there are 3 small and 3 large packages. Each small package allows a maximum of 64 statement handles per connection, and each large package allows a maximum of 384 statement handles per connection. The number of available statement handles by default is therefore (3 * 64) + (3 * 384) = 1344.

To get more than the default 1344 statement handles, increase the number of large packages by setting the value of the CLI/ODBC configuration keyword CLIPkg to a value up to 30. CLIPkg indicates the number of large packages that will be generated. If you set CLIPkg to the maximum value of 30, then the maximum number of statement handles that is available becomes (3 * 64) + (30 * 384) = 11 712.

An HY014 SQLSTATE may be returned on the call to `SQLPrepare()`, `SQLExecute()`, or `SQLExecDirect()` if this limit is exceeded.

It is recommended that you only allocate as many large packages as your application needs to run, as packages take up space in the database.

Descriptor handle

A descriptor handle refers to a data object that contains information about the columns in a result set and dynamic parameters in an SQL statement.

On operating systems that support multiple threads, applications can use the same environment, connection, statement, or descriptor handle on different threads. DB2 CLI provides thread safe access for all handles and function calls. The application itself might experience unpredictable behavior if the threads it creates do not co-ordinate their use of DB2 CLI resources.

Chapter 4. Data types and data conversion in CLI applications

When writing a DB2 CLI application it is necessary to work with both SQL data types and C data types. This is unavoidable because the DBMS uses SQL data types, while the application uses C data types. The application, therefore, must match C data types to SQL data types when calling DB2 CLI functions to transfer data between the DBMS and the application.

To facilitate this, DB2 CLI provides symbolic names for the various data types, and manages the transfer of data between the DBMS and the application. It also performs data conversion (from a C character string to an SQL INTEGER type, for example) if required. DB2 CLI needs to know both the source and target data type. This requires the application to identify both data types using symbolic names.

Data type conversion can occur under one of two conditions:

- The application specified a C type that is not the default C type for the SQL type.
- The application specified an SQL type that does not match the base column SQL type at the server, and there was no describe information available to the DB2 CLI driver.

Example of how to use data types

Because the data source contains SQL data types and the CLI application works with C data types, the data to be retrieved needs to be handled with the correct data types. The following example shows how SQL and C data types are used by an application to retrieve data from the source into application variables. The following code snippet examines how data is retrieved from the DEPTNUMB column of the ORG table in the sample database.

- The DEPTNUMB column of the ORG table is declared as the SQL data type SMALLINT.
- The application variable which will hold the retrieved data is declared using C types. Since the DEPTNUMB column is of SQL type SMALLINT, the application variable needs to be declared using the C type SQLSMALLINT, which is equivalent to the SQL type SMALLINT.

  ```
  struct
  {   SQLINTEGER ind;
      SQLSMALLINT val;
  } deptnumb;         /* variable to be bound to the DEPTNUMB column */
  ```

  SQLSMALLINT represents the base C type of short int.
- The application binds the application variable to the symbolic C data type of SQL_C_SHORT:

  ```
  sqlrc = SQLBindCol(hstmt, 1, SQL_C_SHORT, &deptnumb.val, 0,
                     &deptnumb.ind);
  ```

  The data types are now consistent, because the result data type SQL_C_SHORT represents the C type SQLSMALLINT.

Data conversion

DB2 CLI manages the transfer and any required conversion of data between the application and the DBMS. Before the data transfer actually takes place, either the source, the target or both data types are indicated when calling `SQLBindParameter()`, `SQLBindCol()` or `SQLGetData()`. These functions use the symbolic type names to identify the data types involved.

For example, to bind a parameter marker that corresponds to an SQL data type of DECIMAL(5,3), to an application's C buffer type of double, the appropriate `SQLBindParameter()` call would look like:

```
SQLBindParameter (hstmt, 1, SQL_PARAM_INPUT, SQL_C_DOUBLE,
                  SQL_DECIMAL, 5, 3, double_ptr, 0, NULL);
```

The functions mentioned in the previous paragraph can be used to convert data from the default to other data types, but not all data conversions are supported or make sense.

The rules that specify limits on precision and scale, as well as truncation and rounding rules for type conversions apply in DB2 CLI, with the following exception: truncation of values to the right of the decimal point for numeric values may return a truncation warning, whereas truncation to the left of the decimal point returns an error. In cases of error, the application should call `SQLGetDiagRec()` to obtain the SQLSTATE and additional information on the failure. When moving and converting floating point data values between the application and DB2 CLI, no correspondence is guaranteed to be exact as the values may change in precision and scale.

String handling in CLI applications

The following conventions deal with the various aspects of string arguments in DB2 CLI functions.

Length of string arguments

Input strings can have an associated length argument which indicates either the exact length of the string (not including the null terminator), the special value SQL_NTS to indicate a null-terminated string, or SQL_NULL_DATA to pass a NULL value. If the length is set to SQL_NTS, DB2 CLI will determine the length of the string by locating the null terminator.

Output strings have two associated length arguments: an input length argument to specify the length of the allocated output buffer, and an output length argument to return the actual length of the string returned by DB2 CLI. The returned length value is the total length of the string available for return, regardless of whether it fits in the buffer or not.

For SQL column data, if the output is a null value, SQL_NULL_DATA is returned in the length argument and the output buffer is untouched. The descriptor field SQL_DESC_INDICATOR_PTR is set to SQL_NULL_DATA if the column value is a null value. For more information, including which other fields are set, see the descriptor FieldIdentifier argument values.

If a function is called with a null pointer for an output length argument, DB2 CLI will not return a length. When the output data is a NULL value, DB2 CLI cannot indicate that the value is NULL. If it is possible that a column in a result set can

contain a NULL value, a valid pointer to the output length argument must always be provided. It is highly recommended that a valid output length argument always be used.

Performance hint

If the length argument (*StrLen_or_IndPtr*) and the output buffer (*TargetValuePtr*) are contiguous in memory, DB2 CLI can return both values more efficiently, improving application performance. For example, if the following structure is defined:

```
struct
{   SQLINTEGER pcbValue;
    SQLCHAR    rgbValue [BUFFER_SIZE];
} buffer;
```

and `&buffer.pcbValue` and `buffer.rgbValue` is passed to `SQLBindCol()`, DB2 CLI would update both values in one operation.

Null-termination of strings

By default, every character string that DB2 CLI returns is terminated with a null terminator (hex 00), except for strings returned from graphic and DBCLOB data types into SQL_C_CHAR application variables. Graphic and DBCLOB data types that are retrieved into SQL_C_DBCHAR application variables are null terminated with a double byte null terminator. Also, string data retrieved into SQL_C_WCHAR are terminated with the Unicode null terminator 0x0000. This requires that all buffers allocate enough space for the maximum number of bytes expected, plus the null terminator.

It is also possible to use `SQLSetEnvAttr()` and set an environment attribute to disable null termination of variable length output (character string) data. In this case, the application allocates a buffer exactly as long as the longest string it expects. The application must provide a valid pointer to storage for the output length argument so that DB2 CLI can indicate the actual length of data returned; otherwise, the application will not have any means to determine this. The DB2 CLI default is to always write the null terminator.

It is possible, using the Patch1 CLI/ODBC configuration keyword, to force DB2 CLI to null terminate graphic and DBCLOB strings.

String truncation

If an output string does not fit into a buffer, DB2 CLI will truncate the string to the size of the buffer, and write the null terminator. If truncation occurs, the function will return SQL_SUCCESS_WITH_INFO and an SQLSTATE of **01**004 indicating truncation. The application can then compare the buffer length to the output length to determine which string was truncated.

For example, if `SQLFetch()` returns SQL_SUCCESS_WITH_INFO, and an SQLSTATE of **01**004, it means at least one of the buffers bound to a column is too small to hold the data. For each buffer that is bound to a column, the application can compare the buffer length with the output length and determine which column was truncated. You can also call `SQLGetDiagField()` to find out which column failed.

Interpretation of strings

Normally, DB2 CLI interprets string arguments in a case-sensitive manner and does not trim any spaces from the values. The one exception is the cursor name input argument on the `SQLSetCursorName()` function: if the cursor name is not delimited (enclosed by double quotes) the leading and trailing blanks are removed and case is ignored.

Blank padding of strings

DB2 UDB Version 8.1.4 and later do not pad strings with blanks to fit the column size, as was the behavior in releases of DB2 UDB from Version 8.1 through to Version 8.1.4. With DB2 UDB Version 8.1.4 and later, a string may have a length which differs from the length defined for the CHAR column if code page conversion occurred. For releases of DB2 UDB before Version 8.1.4, strings would be padded with blanks to fill the column size; these blanks would be returned as part of the string data when the string was fetched from the CHAR column.

Large object usage in CLI applications

The term *large object* and the generic acronym *LOB* are used to refer to any type of large object. There are three LOB data types: Binary Large Object (BLOB), Character Large Object (CLOB), and Double-Byte Character Large Object (DBCLOB). These LOB data types are represented symbolically as SQL_BLOB, SQL_CLOB, SQL_DBCLOB respectively. The LOB symbolic constants can be specified or returned on any of the DB2 CLI functions that take in or return an SQL data type argument (such as `SQLBindParameter()`, `SQLDescribeCol()`).

LOB locators versus file input and output

By default row data is returned with LOB locators. For example, if a CLI application does not provide an output buffer, the DB2 Client will request a LOB locator on behalf of the application for each LOB column in the result set. However, if the application binds a buffer of adequate size to a LOB column, the LOB value will be returned in the buffer.

When a CLI application calls the function `SQLGetData()` to retrieve the LOB data, it will, by default, make one request to the server, and will store the entire LOB in memory provided *BufferLength* is large enough. If *BufferLength* is not large enough to hold the entire LOB value, it will be retrieved piecewise.

Since LOB values can be very large, transfer of data using the piecewise sequential method provided by `SQLGetData()` and `SQLPutData()` can be quite time consuming. Applications dealing with such data will often do so in random access segments using LOB locators or via direct file input and output.

To determine if any of the LOB functions are supported for the current server, call `SQLGetFunctions()` with the appropriate function name argument value, or `SQLGetTypeInfo()` with the particular LOB data type.

Figure 3 on page 55 shows the retrieval of a character LOB (CLOB).

- The left hand side shows a locator being used to extract a character string from the CLOB, without having to transfer the entire CLOB to an application buffer.

  A LOB locator is fetched, which is then used as an input parameter to search the CLOB for a substring, the substring is then retrieved.

- The right hand side shows how the CLOB can be fetched directly into a file.
  The file is first bound to the CLOB column, and when the row is fetched, the entire CLOB value is transferred directly to a file.

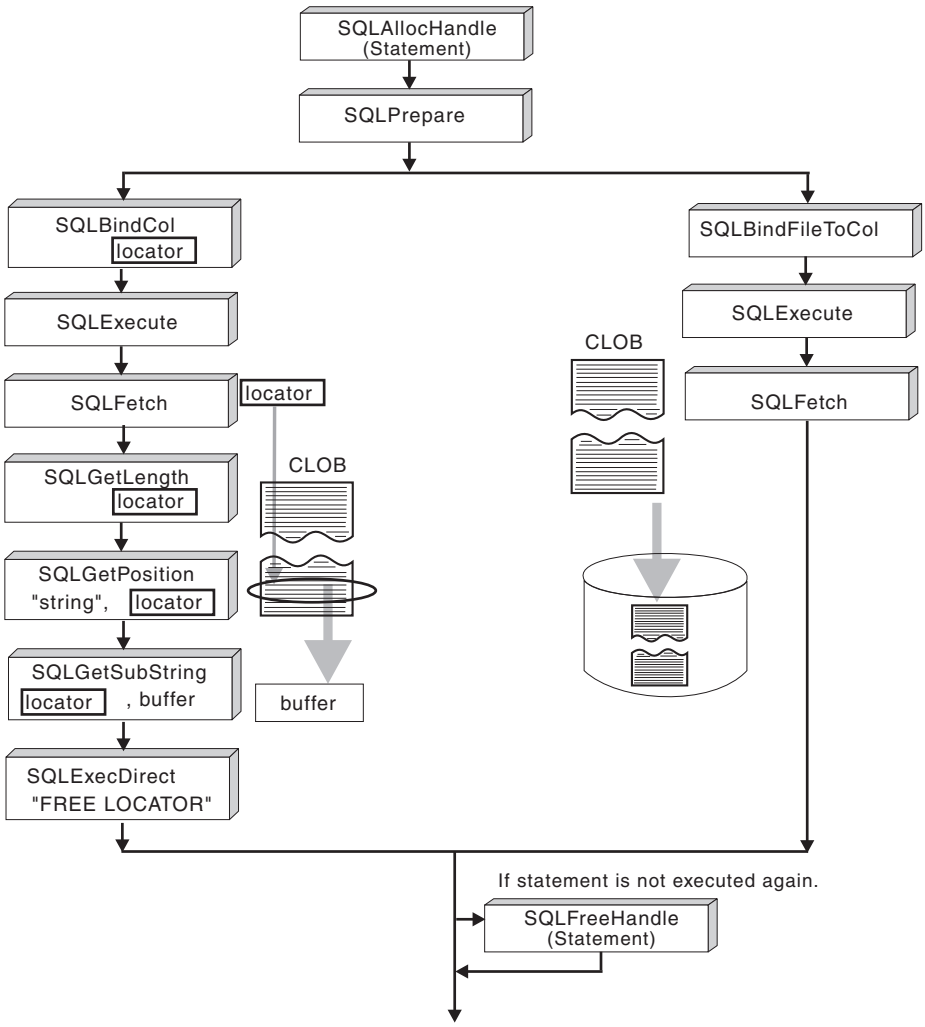


Figure 3. Fetching CLOB data

LOB locators in CLI applications

There are many cases where an application needs to select a large object value and operate on pieces of it, but does not need or want the entire value to be transferred from the database server into application memory. In these cases, the application can reference an individual LOB value via a large object locator (LOB locator).

A LOB locator is a token value, defined as type SQLINTEGER, that allows for efficient random access of a large object. When a LOB locator is used, the server performs the query and instead of placing the value of the LOB column in the result set, it updates the LOB locator with an integer that corresponds to the value of the LOB. When the application later requests the result, the application then passes the locator to the server and the server returns the LOB result.

A LOB locator is not stored in the database. It refers to a LOB value during a transaction, and does not persist beyond the transaction in which it was created. It is a simple token value created to reference a single large object *value*, and not a

column in a row. There is no operation that could be performed on a locator that would have an effect on the original LOB value stored in the row.

Each of the three LOB locator types has its own C data type (SQL_C_BLOB_LOCATOR, SQL_C_CLOB_LOCATOR, SQL_C_DBCLOB_LOCATOR). These types are used to enable transfer of LOB locator values to and from the database server.

Locators are implicitly allocated by:

- Fetching a bound LOB column to the appropriate C locator type.
- Calling `SQLGetSubString()` and specifying that the substring be retrieved as a locator.
- Calling `SQLGetData()` on an unbound LOB column and specifying the appropriate C locator type. The C locator type must match the LOB column type or an error will occur.

In a CLI application, for a statement that retrieves LOB data, by default the row data is returned with LOB locators to reference the LOB values. In cases where a buffer of an adequate size has been bound to a LOB column, the LOB value will be returned in the buffer and not as a LOB locator.

Differences between regular data types and LOB locators

LOB locators can in general be treated as any other data type, but there are some important differences:

- Locators are generated at the server when a row is fetched and a LOB locator C data type is specified on `SQLBindCol()`, or when `SQLGetSubString()` is called to define a locator on a portion of another LOB. Only the locator is transferred to the application.
- The value of the locator is only valid within the current transaction. You cannot store a locator value and use it beyond the current transaction, even if the cursor used to fetch the LOB locator has the WITH HOLD attribute.
- A locator can also be freed before the end of the transaction with the FREE LOCATOR statement.
- Once a locator is received, the application can use `SQLGetSubString()`, to either receive a portion of the LOB value, or to generate another locator representing the sub-string. The locator value can also be used as input for a parameter marker (using `SQLBindParameter()`).

  A LOB locator is not a pointer to a database position, but rather it is a reference to a LOB value: a snapshot of that LOB value. There is no association between the current position of the cursor and the row from which the LOB value was extracted. This means that even after the cursor has moved to a different row, the LOB locator (and thus the value that it represents) can still be referenced.
- `SQLGetPosition()` and `SQLGetLength()` can be used with `SQLGetSubString()` to define the sub-string.

For a given LOB column in the result set, the binding can be to a:

- storage buffer for holding the entire LOB data value,
- LOB locator, or
- LOB file reference (using `SQLBindFileToCol()`).

Examples of using LOB locators

LOB locators also provide an efficient method of moving data from one column of a table in a database to another column (of the same or different table) without having to pull the data first into application memory and then sending it back to the server. The following INSERT statement inserts a LOB value that is a concatenation of 2 LOB values as represented by their locators:

```
INSERT INTO lobtable values (CAST ? AS CLOB(4k) || CAST ? AS CLOB(5k))
```

CLI applications may also obtain LOB values in pieces using the following VALUES statement:

```
VALUES (SUBSTR(:locator, :offset, :length))
```

Direct file input and output for LOB handling in CLI applications

As an alternative to using LOB locators, if an application requires the entire LOB column value, it can request direct file input and output for LOBs. Database queries, updates, and inserts may involve transfer of single LOB column values into and from files. The two DB2 CLI LOB file access functions are:

SQLBindFileToCol()
Binds (associates) a LOB column in a result set with a file name.

Example:

```
SQLUINTEGER     fileOption = SQL_FILE_OVERWRITE;
SQLINTEGER      fileInd = 0;
SQLSMALLINT     fileNameLength = 14;
/* ... */
SQLCHAR         fileName[14] = "";

/* ... */
rc = SQLBindFileToCol(hstmt, 1, fileName, &fileNameLength,
                      &fileOption, 14, NULL, &fileInd);
```

SQLBindFileToParam()
Binds (associates) a LOB parameter marker with a file name.

Example:

```
SQLUINTEGER     fileOption = SQL_FILE_OVERWRITE;
SQLINTEGER      fileInd = 0;
SQLSMALLINT     fileNameLength = 14;
/* ... */
SQLCHAR         fileName[14] = "";

/* ... */

rc = SQLBindFileToParam(hstmt, 3, SQL_BLOB, fileName,
        &fileNameLength, &fileOption, 14, &fileInd);
```

The file name is either the complete path name of the file (which is recommended), or a relative file name. If a relative file name is provided, it is appended to the current path (of the operating environment) of the client process. On execute or fetch, data transfer to and from the file would take place, in a similar way to that of bound application variables. A file options argument associated with these 2 functions indicates how the files are to be handled at time of transfer.

Use of `SQLBindFileToParam()` is more efficient than the sequential input of data segments using `SQLPutData()`, since `SQLPutData()` essentially puts the input segments into a temporary file and then uses the `SQLBindFileToParam()` technique

to send the LOB data value to the server. Applications should take advantage of SQLBindFileToParam() instead of using SQLPutData().

Note: DB2 CLI uses a temporary file when inserting LOB data in pieces. If the data originates in a file, the use of a temporary file can be avoided by using SQLBindFileToParam(). Call SQLGetFunctions() to query if support is provided for SQLBindFileToParam(), since SQLBindFileToParam() is not supported against servers that do not support LOBs.

LOB usage in ODBC applications

Existing ODBC-compliant applications use SQL_LONGVARCHAR and SQL_LONGVARBINARY instead of the DB2 BLOB and CLOB data types. You can still access LOB columns from these ODBC-compliant applications by setting the LongDataCompat configuration keyword in the initialization file, or setting the SQL_ATTR_LONGDATA_COMPAT connection attribute using SQLSetConnectAttr(). Once this is done, DB2 CLI will map the ODBC long data types to the DB2 LOB data types. The LOBMaxColumnSize configuration keyword allows you to override the default COLUMN_SIZE for LOB data types.

When this mapping is in effect:

- SQLGetTypeInfo() will return CLOB, BLOB and DBCLOB characteristics when called with SQL_LONGVARCHAR, SQL_LONGVARBINARY or SQL_LONGVARGRAPHIC.
- The following functions will return SQL_LONGVARCHAR, SQL_LONGVARBINARY or SQL_LONGVARGRAPHIC when describing CLOB, BLOB or DBCLOB data types:
  - SQLColumns()
  - SQLSpecialColumns()
  - SQLDescribeCol()
  - SQLColAttribute()
  - SQLProcedureColumns()
- LONG VARCHAR and LONG VARCHAR FOR BIT DATA will continue to be described as SQL_LONGVARCHAR and SQL_LONGVARBINARY.

The default setting for SQL_ATTR_LONGDATA_COMPAT is SQL_LD_COMPAT_NO; that is, mapping is not in effect.

With mapping in effect, ODBC applications can retrieve and input LOB data by using the SQLGetData(), SQLPutData() and related functions.

Long data for bulk inserts and updates in CLI applications

Long data can be provided for bulk inserts and updates performed by calls to SQLBulkOperations().

1. When an application binds the data using SQLBindCol(), the application places an application-defined value, such as the column number, in the **TargetValuePtr* buffer for data-at-execution columns. The value can be used later to identify the column.

   The application places the result of the SQL_LEN_DATA_AT_EXEC(*length*) macro in the **StrLen_or_IndPtr* buffer. If the SQL data type of the column is SQL_LONGVARBINARY, SQL_LONGVARCHAR, or a long, data source-specific data type and CLI returns "Y" for the

SQL_NEED_LONG_DATA_LEN information type in SQLGetInfo(), *length* is the number of bytes of data to be sent for the parameter; otherwise, it must be a non-negative value and is ignored.

2. When SQLBulkOperations() is called, if there are data-at-execution columns, the function returns SQL_NEED_DATA and proceeds to the next event in the sequence, described in the next item. (If there are no data-at-execution columns, the process is complete.)
3. The application calls SQLParamData() to retrieve the address of the **TargetValuePtr* buffer for the first data-at-execution column to be processed. SQLParamData() returns SQL_NEED_DATA. The application retrieves the application-defined value from the **TargetValuePtr* buffer.

   Note: Although data-at-execution parameters are similar to data-at-execution columns, the value returned by SQLParamData() is different for each.

   Data-at-execution columns are columns in a rowset for which data will be sent with SQLPutData() when a row is updated or inserted with SQLBulkOperations(). They are bound with SQLBindCol(). The value returned by SQLParamData() is the address of the row in the **TargetValuePtr* buffer that is being processed.
4. The application calls SQLPutData() one or more times to send data for the column. More than one call is needed if all the data value cannot be returned in the **TargetValuePtr* buffer specified in SQLPutData(); note that multiple calls to SQLPutData() for the same column are allowed only when sending character C data to a column with a character, binary, or data source-specific data type or when sending binary C data to a column with a character, binary, or data source-specific data type.
5. The application calls SQLParamData() again to signal that all data has been sent for the column.
   - If there are more data-at-execution columns, SQLParamData() returns SQL_NEED_DATA and the address of the *TargetValuePtr* buffer for the next data-at-execution column to be processed. The application repeats steps 4 and 5 above.
   - If there are no more data-at-execution columns, the process is complete. If the statement was executed successfully, SQLParamData() returns SQL_SUCCESS or SQL_SUCCESS_WITH_INFO; if the execution failed, it returns SQL_ERROR. At this point, SQLParamData() can return any SQLSTATE that can be returned by SQLBulkOperations().

If the operation is canceled, or an error occurs in SQLParamData() or SQLPutData(), after SQLBulkOperations() returns SQL_NEED_DATA, and before data is sent for all data-at-execution columns, the application can call only SQLCancel(), SQLGetDiagField(), SQLGetDiagRec(), SQLGetFunctions(), SQLParamData(), or SQLPutData() for the statement or the connection associated with the statement. If it calls any other function for the statement or the connection associated with the statement, the function returns SQL_ERROR and SQLSTATE HY010 (Function sequence error).

If the application calls SQLCancel() while CLI still needs data for data-at-execution columns, CLI cancels the operation. The application can then call SQLBulkOperations() again; canceling does not affect the cursor state or the current cursor position.

User-defined type (UDT) usage in CLI applications

User-defined types (UDTs) are database types defined by the user to provide structure or strong typing not available with conventional SQL types. There are three varieties of UDT: distinct types, structured types, and reference types.

A CLI application may want to determine whether a given database column is a UDT, and if so, the variety of UDT. The descriptor field SQL_DESC_USER_DEFINED_TYPE_CODE may be used to obtain this information. When SQL_DESC_USER_DEFINED_TYPE_CODE is retrieved using `SQLColAttribute()` or directly from the IPD using `SQLGetDescField()`, it will have one of the following numeric values:

```
SQL_TYPE_BASE  (this is a regular SQL type, not a UDT)
SQL_TYPE_DISTINCT  (this value indicates that the column
                          is a distinct type)
SQL_TYPE_STRUCTURED  (this value indicates that the column
                           is a structured type)
SQL_TYPE_REFERENCE  (this value indicates that the column
                           is a reference type)
```

Additionally, the following descriptor fields may be used to obtain the type names:

- SQL_DESC_REFERENCE_TYPE contains the name of the reference type, or an empty string if the column is not a reference type.
- SQL_DESC_STRUCTURED_TYPE contains the name of the structured type, or an empty string if the column is not a structured type.
- SQL_DESC_USER_TYPE or SQL_DESC_DISTINCT_TYPE contains the name of the distinct type, or an empty string if the column is not a distinct type.

The descriptor fields listed above return the schema as part of the name. If the schema is less than 8 letters, it is padded with blanks.

The connection attribute SQL_ATTR_TRANSFORM_GROUP allows an application to set the transform group, and is an alternative to the SQL statement SET CURRENT DEFAULT TRANSFORM GROUP.

A CLI application may not wish to repeatedly obtain the value of the SQL_DESC_USER_DEFINED_TYPE_CODE descriptor field to determine if columns contain UDTs. For this reason, there is an attribute called SQL_ATTR_RETURN_USER_DEFINED_TYPES at both the connection and the statement handle level. When set to SQL_TRUE using `SQLSetConnectAttr()`, CLI returns SQL_DESC_USER_DEFINED_TYPE where you would normally find SQL types in results from calls to `SQLColAttribute()`, `SQLDescribeCol()` and `SQLGetDescField()`. This allows the application to check for this special type, and then do special processing for UDTs. The default value for this attribute is SQL_FALSE.

When the SQL_ATTR_RETURN_USER_DEFINED_TYPES attribute is set to SQL_TRUE, the descriptor field SQL_DESC_TYPE will no longer return the ″base″ SQL type of the UDT, that is, the SQL type that the UDT is based on or transforms to. For this reason, the descriptor field SQL_DESC_BASE_TYPE will always return the base type of UDTs, and the SQL type of normal columns. This field simplifies modules of a program that do not deal specifically with UDTs that would otherwise have to change the connection attribute.

Note that `SQLBindParameter()` will not allow you to bind a parameter of the type SQL_USER_DEFINED_TYPE. You must still bind parameters using the base SQL

type, which you can obtain using the descriptor field SQL_DESC_BASE_TYPE. For example, here is the SQLBindParameter() call used when binding to a column with a distinct type based on SQL_VARCHAR:

```
sqlrc = SQLBindParameter (hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
            SQL_VARCHAR, 30, 0, &c2, 30, NULL);
```

Distinct type usage in CLI applications

In addition to SQL data types (referred to as *base* SQL data types), new distinct types can be defined by the user. This variety of user defined types (UDTs) shares its internal representation with an existing type, but is considered to be a separate and incompatible type for most operations. Distinct types are created using the CREATE DISTINCT TYPE SQL statement.

Distinct types help provide the strong typing control needed in object oriented programming by ensuring that only those functions and operators explicitly defined on a distinct type can be applied to its instances. Applications continue to work with C data types for application variables, and only need to consider the distinct types when constructing SQL statements.

This means:

- All SQL to C data type conversion rules that apply to the built-in type apply to distinct types.
- Distinct types will have the same default C Type as the built-in type.
- SQLDescribeCol() will return the built-in type information. The user defined type name can be obtained by calling SQLColAttribute() with the input descriptor type set to SQL_DESC_DISTINCT_TYPE.
- SQL predicates that involve parameter markers must be explicitly cast to the distinct type. This is required since the application can only deal with the built-in types, so before any operation can be performed using the parameter, it must be cast from the C built-in type to the distinct type; otherwise an error will occur when the statement is prepared.

XML data handling in CLI applications - Overview

DB2 CLI applications can retrieve and store XML data using the SQL_XML data type. This data type corresponds to the native XML data type of the DB2 database, which is used to define columns that store well-formed XML documents. The SQL_XML type can be bound to the following C types: SQL_C_BINARY, SQL_C_CHAR, SQL_C_WCHAR, and SQL_C_DBCHAR. Using the default SQL_C_BINARY type, however, instead of character types, is recommended to avoid possible data loss or corruption resulting from code page conversion when character types are used.

To store XML data in an XML column, bind a binary (SQL_C_BINARY) or character (SQL_C_CHAR, SQL_C_WCHAR, or SQL_C_DBCHAR) buffer that contains the XML value to the SQL_XML SQL type and execute the INSERT or UPDATE SQL statements. To retrieve XML data from the database, bind the result set to a binary (SQL_C_BINARY) or character (SQL_C_CHAR, SQL_C_WCHAR, or SQL_C_DBCHAR) type. Character types should be used with caution because of encoding issues.

When an XML value is retrieved into an application data buffer, the DB2 server performs an implicit serialization on the XML value to convert it from its stored

hierarchical form to the serialized string form. For character typed buffers, the XML value is implicitly serialized to the application character code page associated with the character type.

By default, an XML declaration is included in the output serialized string. This default behavior can be changed by setting the SQL_ATTR_XML_DECLARATION statement or connection attribute, or by setting the XMLDeclaration CLI/ODBC configuration keyword in the db2cli.ini file.

XQuery expressions and SQL/XML functions can be issued and executed in DB2 CLI applications. SQL/XML functions are issued and executed like any other SQL statements. XQuery expressions must either be prepended with the case-insensitive keyword "XQUERY", or the SQL_ATTR_XQUERY_STATEMENT statement attribute must be set for the statement handle associated with the XQuery expression.

Changing of default XML type handling in CLI applications

DB2 CLI supports CLI/ODBC configuration keywords that provide compatibility for applications that do not expect the default types returned when describing or specifying SQL_C_DEFAULT for XML columns and parameter markers. Older CLI and ODBC applications might not recognize or expect the default SQL_XML type when describing XML columns or parameters. Some CLI or ODBC applications might also expect a default type other than SQL_C_BINARY for XML columns and parameter markers. To provide compatibility for these types of applications, DB2 CLI supports the MapXMLDescribe and MapXMLCDefault keywords.

MapXMLDescribe specifies which SQL data type is returned when XML columns or parameter markers are described.

MapXMLCDefault specifies the C type that is used when SQL_C_DEFAULT is specified for XML columns and parameter markers in DB2 CLI functions.

Chapter 5. Transaction processing in CLI overview

Figure 4 shows the typical order of function calls in the transaction processing task of a DB2 CLI application. Not all functions or possible paths are shown.

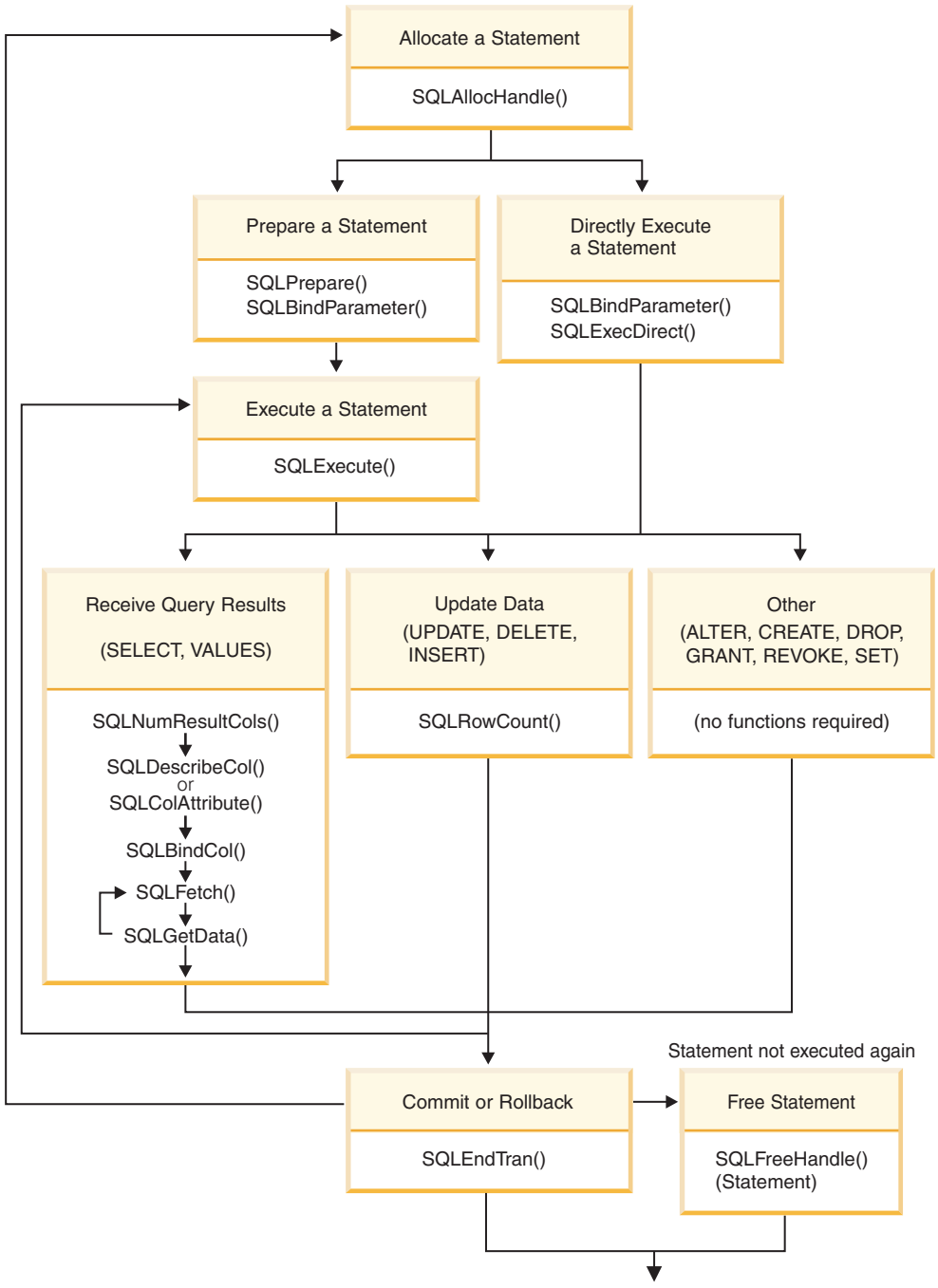


Figure 4. Transaction processing

The transaction processing task contains five steps:

- Allocating statement handle(s)

- Preparing and executing SQL statements
- Processing results
- Committing or Rolling Back
- (Optional) Freeing statement handle(s) if the statement is unlikely to be executed again.

Allocating statement handles in CLI applications

To issue an SQL statement in a CLI application, you need to allocate a statement handle. A statement handle tracks the execution of a single SQL statement and is associated with a connection handle. Allocating statement handles is part of the larger task of processing transactions.

Before you begin allocating statement handles, you must allocate an environment handle and a connection handle. This is part of the task of initializing your CLI application.

To allocate a statement handle:

1. Call `SQLAllocHandle()` with a *HandleType* of SQL_HANDLE_STMT. For example:

   ```
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmt);
   ```

2. Optional: To set attributes for this statement, call `SQLSetStmtAttr()` for each desired attribute option.

After allocating environment, connection, and statement handles, you can now prepare, issue, or execute SQL statements.

Issuing SQL statements in CLI applications

SQL statements are passed to DB2 CLI functions as SQLCHAR string variables. The variable can consist of one or more SQL statements, with or without parameter markers, depending on the type of processing you want. This topic describes the various ways SQL statements can be issued in DB2 CLI applications.

Before you issue an SQL statement, ensure you have allocated a statement handle.

Perform either of the following steps to issue SQL statements:

- To issue a single SQL statement, either initialize an SQLCHAR variable with the SQL statement and pass this variable to the CLI function, or directly pass a string argument cast to an SQLCHAR * to the function. For example:

  ```
  SQLCHAR * stmt = (SQLCHAR *) "SELECT deptname, location FROM org";
  /* ... */
  SQLExecDirect (hstmt, stmt, SQL_NTS);
  ```

  or

  ```
  SQLExecDirect (hstmt, (SQLCHAR *) "SELECT deptname, location FROM org",
                 SQL_NTS);
  ```

- To issue multiple SQL statements on the same statement handle, either initialize an array of SQLCHAR elements, where each element represents an individual SQL statement, or initialize a single SQLCHAR variable that contains the multiple statements delimited by a ";" character. For example:

```
SQLCHAR * multiple_stmts[] = {
  (SQLCHAR *) "SELECT deptname, location FROM org",
  (SQLCHAR *) "SELECT id, name FROM staff WHERE years > 5",
  (SQLCHAR *) "INSERT INTO org VALUES (99,'Hudson',20,'Western','Seattle')"
};
```

or

```
SQLCHAR * multiple_stmts =
  "SELECT deptname, location FROM org;
   SELECT id, name FROM staff WHERE years > 5;
   INSERT INTO org VALUES (99, 'Hudson', 20, 'Western', 'Seattle')";
```

Note: When a list of SQL statements is specified, only one statement is executed at a time, starting with the first statement in the list. Each subsequent statement is executed in the order it appears. (To execute subsequent statements, you must call `SQLMoreResults()`.)

- To issue SQL statements with parameter markers, see "Binding parameter markers in CLI applications" on page 67.
- To capture and convert SQL statements dynamically executed with DB2 CLI (dynamic SQL) to static SQL, see "Creating static SQL with CLI/ODBC/JDBC Static Profiling" on page 108.

Parameter marker binding in CLI applications

Parameter markers are represented by the '?' character and indicate the position in the SQL statement where the contents of application variables are to be substituted when the statement is executed. (A parameter marker is used where a host variable would be used in static embedded SQL.) This value can be obtained from:

- An application variable.

  `SQLBindParameter()` is used to bind the application storage area to the parameter marker.
- A LOB value from the database server (by specifying a LOB locator).

  `SQLBindParameter()` is used to bind a LOB locator to the parameter marker. The LOB value itself is supplied by the database server, so only the LOB locator is transferred between the database server and the application.
- A file within the application's environment containing a LOB value.

  `SQLBindFileToParam()` is used to bind a file to a LOB parameter marker. When `SQLExecDirect()` is executed, DB2 CLI will transfer the contents of the file directly to the database server.

An application cannot place parameter markers in the following locations:

- In a SELECT list
- As both expressions in a comparison-predicate
- As both operands of a binary operator
- As both the first and second operands of a BETWEEN operation
- As both the first and third operands of a BETWEEN operation
- As both the expression and the first value of an IN operation
- As the operand of a unary + or – operation
- As the argument of a SET FUNCTION reference

Parameter markers are referenced sequentially, from left to right, starting at 1. `SQLNumParams()` can be used to determine the number of parameters in a statement.

The application must bind an application variable to each parameter marker in the SQL statement before it executes that statement. Binding is carried out by calling the `SQLBindParameter()` function with a number of arguments to indicate:

- the ordinal position of the parameter,
- the SQL type of the parameter,
- the type of parameter (input, output, or inout),
- the C data type of the variable,
- a pointer to the application variable,
- the length of the variable.

The bound application variable and its associated length are called *deferred* input arguments because only the pointers are passed when the parameter is bound; no data is read from the variable until the statement is executed. Deferred arguments allow the application to modify the contents of the bound parameter variables, and re-execute the statement with the new values.

Information about each parameter remains in effect until:

- it is overridden by the application
- the application unbinds the parameter by calling `SQLFreeStmt()` with the SQL_RESET_PARAMS *Option*
- the application drops the statement handle by calling `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_STMT or `SQLFreeStmt()` with the SQL_DROP *Option*.

Information for each parameter remains in effect until overridden, or until the application unbinds the parameter or drops the statement handle. If the application executes the SQL statement repeatedly without changing the parameter binding, then DB2 CLI uses the same pointers to locate the data on each execution. The application can also change the parameter binding to a different set of deferred variables by calling `SQLBindParameter()` again for one or more parameters and specifying different application variables. The application must not deallocate or discard variables used for deferred input fields between the time it binds the fields to parameter markers and the time DB2 CLI accesses them at execution time. Doing so can result in DB2 CLI reading garbage data, or accessing invalid memory resulting in an application trap.

It is possible to bind the parameter to a variable of a different type from that required by the SQL statement. The application must indicate the C data type of the source, and the SQL type of the parameter marker, and DB2 CLI will convert the contents of the variable to match the SQL data type specified. For example, the SQL statement may require an integer value, but your application has a string representation of an integer. The string can be bound to the parameter, and DB2 CLI will convert the string to the corresponding integer value when you execute the statement.

By default, DB2 CLI does not verify the type of the parameter marker. If the application indicates an incorrect type for the parameter marker, it could cause:

- an extra conversion by the DBMS
- an error at the DBMS which forces DB2 CLI to describe the statement being executed and re-execute it, resulting in extra network traffic
- an error returned to the application if the statement cannot be described, or the statement cannot be re-executed successfully.

Information about the parameter markers can be accessed using descriptors. If you enable automatic population of the implementation parameter descriptor (IPD) then information about the parameter markers will be collected. The statement attribute SQL_ATTR_ENABLE_AUTO_IPD must be set to SQL_TRUE for this to work.

If the parameter marker is part of a predicate on a query and is associated with a User Defined Type, then the parameter marker must be cast to the built-in type in the predicate portion of the statement; otherwise, an error will occur.

After the SQL statement has been executed, and the results processed, the application may wish to reuse the statement handle to execute a different SQL statement. If the parameter marker specifications are different (number of parameters, length or type) then `SQLFreeStmt()` should be called with SQL_RESET_PARAMS to reset or clear the parameter bindings.

Binding parameter markers in CLI applications

This topic describes how to bind parameter markers to application variables before executing SQL statements. Parameter markers in SQL statements can be bound to single values or to arrays of values. Binding each parameter marker individually requires a network flow to the server for each set of values. Using arrays, however, allows several sets of parameter values to be bound and sent at once to the server.

Before you bind parameter markers, ensure you have initialized your application.

To bind parameter markers, perform either of the following steps:

- To bind parameter markers one at a time to application variables, call `SQLBindParameter()` for each application variable you want to bind. Ensure you specify the correct parameter type: SQL_PARAM_INPUT, SQL_PARAM_OUTPUT, or SQL_PARAM_INPUT_OUTPUT. The following example shows how two parameter markers are bound with two application variables:

```
SQLCHAR *stmt =
   (SQLCHAR *)"DELETE FROM org WHERE deptnumb = ? AND division = ? ";
SQLSMALLINT parameter1 = 0;
char parameter2[20];

/* bind parameter1 to the statement */
cliRC = SQLBindParameter(hstmt,
                         1,
                         SQL_PARAM_INPUT,
                         SQL_C_SHORT,
                         SQL_SMALLINT,
                         0,
                         0,
                         &parameter1,
                         0,
                         NULL);

/* bind parameter2 to the statement */
cliRC = SQLBindParameter(hstmt,
                         2,
                         SQL_PARAM_INPUT,
                         SQL_C_CHAR,
                         SQL_VARCHAR,
                         20,
                         0,
                         parameter2,
                         20,
                         NULL);
```

- To bind at once many values to parameter markers, perform either of the following tasks which use arrays of values:
  - binding parameter markers with column-wise array inputbinding parameter markers with column-wise array input
  - binding parameter markers with row-wise array inputbinding parameter markers with row-wise array input

Binding parameter markers in CLI applications with column-wise array input

To process an SQL statement that will be repeated with different values, you can use column-wise array input to achieve bulk inserts, deletes, or updates. This results in fewer network flows to the server because `SQLExecute()` does not have to be called repeatedly on the same SQL statement for each value. Column-wise array input allows arrays of storage locations to be bound to parameter markers. A different array is bound to each parameter.

Before binding parameter markers with column-wise binding, ensure that you have initialized your CLI application.

For character and binary input data, the application uses the maximum input buffer size argument (*BufferLength*) of the `SQLBindParameter()` call to indicate to DB2 CLI the location of values in the input array. For other input data types, the length of each element in the array is assumed to be the size of the C data type. To bind parameter markers using column-wise array input:

1. Specify the size of the arrays (the number rows to be inserted) by calling `SQLSetStmtAttr()` with the SQL_ATTR_PARAMSET_SIZE statement attribute.
2. Initialize and populate an array for each parameter marker to be bound.

   Note: Each array must contain at least SQL_ATTR_PARAMSET_SIZE elements, otherwise, memory access violations may occur.
3. Optional: Indicate that column-wise binding is to be used by setting the SQL_ATTR_BIND_TYPE statement attribute to SQL_PARAMETER_BIND_BY_COLUMN (this is the default setting).
4. Bind each parameter marker to its corresponding array of input values by calling `SQLBindParameter()` for each parameter marker.

Binding parameter markers in CLI applications with row-wise array input

To process an SQL statement that will be repeated with different values, you can use row-wise array input to achieve bulk inserts, deletes, or updates. This results in fewer network flows to the server because `SQLExecute()` does not have to be called repeatedly on the same SQL statement for each value. Row-wise array input allows an array of structures to be bound to parameters.

Before binding parameter markers with row-wise binding, ensure that you have initialized your CLI application.

To bind parameter markers using row-wise array input:

1. Initialize and populate an array of structures that contains two elements for each parameter: the first element contains the length/indicator buffer, and the second element holds the value itself. The size of the array corresponds to the number of values to be applied to each parameter. For example, the following array contains the length and value for three parameters:

```
struct { SQLINTEGER La; SQLINTEGER A;  /* Information for parameter A */
         SQLINTEGER Lb; SQLCHAR B[4];  /* Information for parameter B */
         SQLINTEGER Lc; SQLCHAR C[11]; /* Information for parameter C */
       } R[n];
```

2. Indicate that row-wise binding is to by used by setting the SQL_ATTR_PARAM_BIND_TYPE statement attribute to the length of the struct created in the previous step, using `SQLSetStmtAttr()`.
3. Set the statement attribute SQL_ATTR_PARAMSET_SIZE to the number of rows of the array, using `SQLSetStmtAttr()`.
4. Bind each parameter to the first row of the array created in step 1 using `SQLBindParameter()`. For example,

```
/* Parameter A */
rc = SQLBindParameter(hstmt, 1, SQL_PARAM_INPUT, SQL_C_LONG,
         SQL_INTEGER, 5, 0, &R[0].A, 0, &R.La);

/* Parameter B */
rc = SQLBindParameter(hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR, SQL_CHAR,
         10, 0, R[0].B, 10, &R.Lb);

/* Parameter C */
rc = SQLBindParameter(hstmt, 3, SQL_PARAM_INPUT, SQL_C_CHAR, SQL_CHAR,
         3, 0, R[0].C, 3, &R.Lc);
```

Parameter diagnostic information in CLI applications

A *parameter status array* is an array of one or more SQLSMALLINTs allocated by a CLI application. Each element in the array corresponds to an element in the input (or output) parameter array. If specified, the DB2 CLI driver updates the parameter status array with information about the processing status of each set of parameters included in an `SQLExecute()` or `SQLExecDirect()` call.

DB2 CLI updates the elements in the parameter status array with the following values:

- SQL_PARAM_SUCCESS: The SQL statement was successfully executed for this set of parameters.
- SQL_PARAM_SUCCESS_WITH_INFO: The SQL statement was successfully executed for this set of parameters, however, warning information is available in the diagnostics data structure.
- SQL_PARAM_ERROR: An error occurred in processing this set of parameters. Additional error information is available in the diagnostics data structure.
- SQL_PARAM_UNUSED: This parameter set was unused, possibly because a previous parameter set caused an error that aborted further processing.
- SQL_PARAM_DIAG_UNAVAILABLE: Diagnostic information is not available, possibly because an error was detected before the parameter set was even used (for example, an SQL statement syntax error).

A CLI application must call the `SQLSetStmtAttr()` function to set the SQL_ATTR_PARAM_STATUS_PTR attribute before DB2 CLI will update the parameter status array. Alternatively, the application can call the `SQLSetDescField()` function to set the SQL_DESC_ARRAY_STATUS_PTR field in the IPD descriptor to point to the parameter status array.

The statement attribute SQL_ATTR_PARAMS_PROCESSED, or the corresponding IPD descriptor header field SQL_DESC_ROWS_PROCESSED_PTR, can be used to return the number of sets of parameters that have been processed.

Once the application has determined what parameters had errors, it can use the statement attribute SQL_ATTR_PARAM_OPERATION_PTR, or the corresponding APD descriptor header field SQL_DESC_ARRAY_STATUS_PTR, (both of which point to an array of values) to control which sets of parameters are ignored in a second call to `SQLExecute()` or `SQLExecDirect()`.

Changing parameter bindings in CLI applications with offsets

When an application needs to change parameter bindings it can call `SQLBindParameter()` a second time. This will change the bound parameter buffer address and the corresponding length/indicator buffer address used. Instead of multiple calls to `SQLBindParameter()`, however, DB2 CLI also supports parameter binding offsets. Rather than re-binding each time, an offset can be used to specify new buffer and length/indicator addresses which will be used in a subsequent call to `SQLExecute()` or `SQLExecDirect()`.

Before changing your parameter bindings, ensure that your application has been initialized.

To change parameter bindings by using offsets:

1. Call `SQLBindParameter()` as you had been to bind the parameters.

   The first set of bound parameter buffer addresses and the corresponding length/indicator buffer addresses will act as a template. The application will then move this template to different memory locations using the offset.
2. Call `SQLExecute()` or `SQLExecDirect()` as you had been to execute the statement.

   The values stored in the bound addresses will be used.
3. Initialize a variable to hold the memory offset value.

   The statement attribute SQL_ATTR_PARAM_BIND_OFFSET_PTR points to the address of an SQLINTEGER buffer where the offset will be stored. This address must remain valid until the cursor is closed.

   This extra level of indirection enables the use of a single memory variable to store the offset for multiple sets of parameter buffers on different statement handles. The application need only set this one memory variable and all of the offsets will be changed.
4. Store an offset value (number of bytes) in the memory location pointed to by the statement attribute set in the previous step.

   The offset value is always added to the memory location of the originally bound values. This sum must point to a valid memory address.
5. Call `SQLExecute()` or `SQLExecDirect()` again. CLI will add the offset specified above to the locations used in the original call to `SQLBindParameter()` to determine where the parameters to be used are stored in memory.
6. Repeat steps 4 and 5 above as required.

Specifying parameter values at execute time for long data manipulation in CLI applications

When manipulating long data, it may not be feasible for the application to load the entire parameter data value into storage at the time the statement is executed, or when the data is fetched from the database. A method has been provided to allow the application to handle the data in a piecemeal fashion. The technique of sending long data in pieces is called *specifying parameter values at execute time*. It can also be used to specify values for fixed size non-character data types such as integers.

Before specifying parameter values at execute time, ensure you have initialized your CLI application.

While the data-at-execution flow is in progress, the only DB2 CLI functions the application can call are:

- SQLParamData() and SQLPutData() as given in the sequence below.
- The SQLCancel() function which is used to cancel the flow and force an exit from the loops described below without executing the SQL statement.
- The SQLGetDiagRec() function.

A data-at-execute parameter is a bound parameter for which a value is prompted at execution time instead of stored in memory before SQLExecute() or SQLExecDirect() is called. To indicate such a parameter on an SQLBindParameter() call:

1. Set the input data length pointer to point to a variable that, at execute time, will contain the value SQL_DATA_AT_EXEC. For example:

```
/* dtlob.c */
/* ... */
SQLINTEGER      blobInd ;
/* ... */
blobInd = SQL_DATA_AT_EXEC;
sqlrc = SQLBindParameter(hstmt, 3, SQL_PARAM_INPUT, SQL_C_BINARY,
                         SQL_BLOB, BUFSIZ, 0, (SQLPOINTER)inputParam,
                         BUFSIZ, &blobInd);
```

2. If there is more than one data-at-execute parameter, set each input data pointer argument to some value that it will recognize as uniquely identifying the field in question.
3. If there are any data-at-execute parameters when the application calls SQLExecDirect() or SQLExecute(), the call returns with SQL_NEED_DATA to prompt the application to supply values for these parameters. The application responds with the subsequent steps.
4. Call SQLParamData() to conceptually advance to the first such parameter. SQLParamData() returns SQL_NEED_DATA and provides the contents of the input data pointer argument specified on the associated SQLBindParameter()call to help identify the information required.
5. Pass the actual data for the parameter by calling SQLPutData(). Long data can be sent in pieces by calling SQLPutData() repeatedly.
6. Call SQLParamData() again after providing the entire data for this data-at-execute parameter.
7. If more data-at-execute parameters exist, SQLParamData() again returns SQL_NEED_DATA and the application repeats steps 4 and 5 above.

   For example:

```
/* dtlob.c */
/* ... */
    else
    {   sqlrc = SQLParamData( hstmt, (SQLPOINTER *) &valuePtr);
        /* ... */

        while ( sqlrc == SQL_NEED_DATA)
        {   /*
            if more than 1 parms used DATA_AT_EXEC then valuePtr would
            have to be checked to determine which param needed data
            */
            while ( feof( pFile ) == 0 )
            {   n = fread( buffer, sizeof(char), BUFSIZ, pFile);
                sqlrc = SQLPutData(hstmt, buffer, n);
```

```
                STMT_HANDLE_CHECK( hstmt, sqlrc);
                fileSize = fileSize + n;
                if ( fileSize > 102400u)
                {   /* BLOB column defined as 100K MAX */
                    /* ... */
                    break;
                }
            }
            /* ... */
            sqlrc = SQLParamData( hstmt, (SQLPOINTER *) &valuePtr);
            /* ... */
        }
    }
```

When all data-at-execute parameters have been assigned values, `SQLParamData()` completes execution of the SQL statement and returns a return value and diagnostics as the original `SQLExecDirect()` or `SQLExecute()` would have produced.

Commit modes in CLI applications

A *transaction* is a recoverable unit of work, or a group of SQL statements that can be treated as one atomic operation. This means that all the operations within the group are guaranteed to be completed (committed) or undone (rolled back), as if they were a single operation. When the transaction spans multiple connections, it is referred to as a distributed unit of work (DUOW).

Transactions are started implicitly with the first access to the database using `SQLPrepare()`, `SQLExecDirect()`, `SQLGetTypeInfo()`, or any function that returns a result set, such as catalog functions. At this point a transaction has begun, even if the call failed.

DB2 CLI supports two commit modes:

auto-commit
: In auto-commit mode, every SQL statement is a complete transaction, which is automatically committed. For a non-query statement, the commit is issued at the end of statement execution. For a query statement, the commit is issued after the cursor has been closed. The default commit mode is auto-commit (except when participating in a coordinated transaction).

manual-commit
: In manual-commit mode, the transaction ends when you use `SQLEndTran()` to either rollback or commit the transaction. This means that any statements executed (on the same connection) between the start of a transaction and the call to `SQLEndTran()` are treated as a single transaction. If DB2 CLI is in manual-commit mode, a new transaction will be implicity started if the application is not already in a transaction and an SQL statement that can be contained within a transaction is executed.

An application can switch between manual-commit and auto-commit modes by calling `SQLSetConnectAttr()`. Auto-commit can be useful for query-only applications, because the commits can be chained to the SQL execution request sent to the server. Another benefit of auto-commit is improved concurrency since locks are removed as soon as possible. Applications that need to perform updates to the database should turn off auto-commit as soon as the database connection has been established and should not wait until the disconnect before committing or rolling back the transaction.

The following are examples of how to set auto-commit on and off:

- Setting auto-commit on:

```
/* ... */

/* set AUTOCOMMIT on */
sqlrc = SQLSetConnectAttr( hdbc,
                           SQL_ATTR_AUTOCOMMIT,
                           (SQLPOINTER)SQL_AUTOCOMMIT_ON, SQL_NTS) ;

/* continue with SQL statement execution */
```

- Setting auto-commit off:

```
/* ... */

/* set AUTOCOMMIT OFF */
sqlrc = SQLSetConnectAttr( hdbc,
                           SQL_ATTR_AUTOCOMMIT,
                           (SQLPOINTER)SQL_AUTOCOMMIT_OFF, SQL_NTS) ;

/* ... */

/* execute the statement */
/* ... */
sqlrc = SQLExecDirect( hstmt, stmt, SQL_NTS ) ;

/* ... */

sqlrc = SQLEndTran( SQL_HANDLE_DBC, hdbc, SQL_ROLLBACK );
DBC_HANDLE_CHECK( hdbc, sqlrc);

/* ... */
```

When multiple connections exist to the same or different databases, each connection has its own transaction. Special care must be taken to call `SQLEndTran()` with the correct connection handle to ensure that only the intended connection and related transaction is affected. It is also possible to rollback or commit all the connections by specifying a valid environment handle, and a NULL connection handle on the `SQLEndTran()` call. Unlike distributed unit of work connections, there is no coordination between the transactions on each connection in this case.

When to call the CLI SQLEndTran() function

In auto-commit mode, a commit is issued implicitly at the end of each statement execution or when a cursor is closed.

In manual-commit mode, `SQLEndTran()` must be called before calling `SQLDisconnect()`. If a Distributed Unit of Work is involved, additional rules may apply.

Consider the following when deciding where in the application to end a transaction:

- Each connection cannot have more than one current transaction at any given time, so keep dependent statements within the same unit of work. Note that statements must always be kept on the same connection under which they were allocated.
- Various resources may be held while the current transaction on a connection is running. Ending the transaction will release the resources for use by other applications.

- Once a transaction has successfully been committed or rolled back, it is fully recoverable from the system logs. Open transactions are not recoverable.

Effects of calling SQLEndTran()

When a transaction ends:

- All locks on DBMS objects are released, except those that are associated with a held cursor.
- Prepared statements are preserved from one transaction to the next. Once a statement has been prepared on a specific statement handle, it does not need to be prepared again even after a commit or rollback, provided the statement continues to be associated with the same statement handle.
- Cursor names, bound parameters, and column bindings are maintained from one transaction to the next.
- By default, cursors are preserved after a commit (but not a rollback). All cursors are by default defined with the WITH HOLD clause, except when the CLI application is running in a Distributed Unit of Work environment.

Preparing and executing SQL statements in CLI applications

Once you have allocated a statement handle, you can then perform operations using SQL statements or XQuery expressions. An SQL statement or XQuery expression must be prepared before it can be executed, and DB2 CLI offers two ways of preparing and executing: perform the prepare and execute operations in separate steps, and combine the prepare and execute operations into one step.

Before preparing and executing your SQL statement or XQuery expression, ensure you have allocated a statement handle for it.

- To prepare and execute an SQL statement or XQuery expression in separate steps:
  1. Prepare the SQL statement or XQuery expression by calling `SQLPrepare()` and passing the statement or expression as the *StatementText* argument.

     Note: XQuery expressions must be prefixed with the case-insensitive "XQUERY" keyword, unless the statement attribute SQL_ATTR_XQUERY_STATEMENT has been set to SQL_TRUE for this statement handle.
  2. Call `SQLBindParameter()` to bind any parameter markers you may have in the SQL statement.

     Note: For XQuery expressions, you cannot specify parameter markers in the expression itself. You can, however, use the XMLQUERY function to bind parameter markers to XQuery variables. The values of the bound parameter markers will then be passed to the XQuery expression specified in XMLQUERY for execution.
  3. Execute the prepared statement by calling `SQLExecute()`.

  Use this method when:

  – The same SQL statement or XQuery expression will be executed repeatedly (usually with different parameter values). This avoids having to prepare the same statement or expression more than once. The subsequent executions make use of the access plans already generated by the prepare, thus increasing driver efficiency and delivering better application performance.

– The application requires information about the parameters or columns in the result set prior to statement execution.

- To prepare and execute an SQL statement or XQuery expression in one step:
  1. Call `SQLBindParameter()` to bind any parameter markers you may have in the SQL statement.

     Note: For XQuery expressions, you cannot specify parameter markers in the expression itself. You can, however, use the XMLQUERY function to bind parameter markers to XQuery variables. The values of the bound parameter markers will then be passed to the XQuery expression specified in XMLQUERY for execution.
  2. Prepare and execute the statement or expression by calling `SQLExecDirect()` with the SQL statement or XQuery expression as the *StatementText* argument.

     Note: XQuery expressions must be prefixed with the case-insensitive "XQUERY" keyword, unless the statement attribute SQL_ATTR_XQUERY_STATEMENT has been set to SQL_TRUE for this statement handle.
  3. Optional: If a list of SQL statements are to be executed, call `SQLMoreResults()` to advance to the next SQL statement.

  Use this method of preparing and executing in one step when:

  – The statement or expression will be executed only once. This avoids having to call two functions to execute the statement or expression.

  – The application does not require information about the columns in the result set before the statement is executed.

Deferred prepare in CLI applications

Deferred prepare is the name of the CLI feature that seeks to minimise communication with the server by sending both the prepare and execute requests for SQL statements in the same network flow. The default value for this property can be overridden using the CLI/ODBC configuration keyword DeferredPrepare. This property can be set on a per-statement handle basis by calling `SQLSetStmtAttr()` to change the SQL_ATTR_DEFEFERRED_PREPARE statement attribute.

When deferred prepare is on, the prepare request is not sent to the server until the corresponding execute request is issued. The two requests are then combined into one command/reply flow (instead of two) to minimize network flow and to improve performance. Because of this behavior, any errors that would typically be generated by `SQLPrepare()` will appear at execute time, and `SQLPrepare()` will always return SQL_SUCCESS. Deferred prepare is of greatest benefit when the application generates queries where the answer set is very small, and the overhead of separate requests and replies is not spread across multiple blocks of query data.

Note: Even if deferred prepare is enabled, operations that require a statement to be prepared prior to the operation's execution will force the prepare request to be sent to the server before the execute. Describe operations resulting from calls to `SQLDescribeParam()` or `SQLDescribeCol()` are examples of when deferred prepare will be overridden, because describe information is only available after the statement has been prepared.

Executing compound SQL statements in CLI applications

Compound SQL allows multiple SQL statements to be grouped into a single executable block. This block of statements, together with any input parameter values, can then be executed in a single continuous stream, reducing the execution time and network traffic.

- Compound SQL does not guarantee the order in which the substatements are executed, therefore there must not be any dependencies among the substatements.
- Compound SQL statements cannot be nested.
- The BEGIN COMPOUND and END COMPOUND statements must be executed with the same statement handle.
- The value specified in the STOP AFTER FIRST ? STATEMENTS clause of the BEGIN COMPOUND SQL statement must be of type SQL_INTEGER, and you can only bind an application buffer of type SQL_C_INTEGER or SQL_C_SMALLINT for this value.
- Each substatement must have its own statement handle.
- All statement handles must belong to the same connection and have the same isolation level.
- Atomic array input is not supported within a BEGIN COMPOUND and END COMPOUND block of SQL statements. Atomic array input refers to the behavior where all inserts will be undone if any single insert fails.
- All statement handles must remain allocated until the END COMPOUND statement is executed.
- `SQLEndTran()` cannot be called for the same connection or any connect requests between BEGIN COMPOUND and END COMPOUND.
- Only the following functions may be called using the statement handles allocated for the compound substatements:
  - `SQLAllocHandle()`
  - `SQLBindParameter()`
  - `SQLBindFileToParam()`
  - `SQLExecute()`
  - `SQLParamData()`
  - `SQLPrepare()`
  - `SQLPutData()`

To execute compound SQL statements in CLI applications:

1. Allocate a parent statement handle. For example:

   ```
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmtparent);
   ```

2. Allocate statement handles for each of the compound substatements. For example:

   ```
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmtsub1);
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmtsub2);
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmtsub3);
   ```

3. Prepare the substatements. For example:

   ```
   SQLPrepare (hstmtsub1, stmt1, SQL_NTS);
   SQLPrepare (hstmtsub2, stmt2, SQL_NTS);
   SQLPrepare (hstmtsub3, stmt3, SQL_NTS);
   ```

4. Execute the BEGIN COMPOUND statement using the parent statement handle. For example:

```
SQLExecDirect (hstmtparent, (SQLCHAR *) "BEGIN COMPOUND NOT ATOMIC STATIC",
               SQL_NTS);
```

5. If this is an atomic compound SQL operation, execute the substatements using the `SQLExecute()` function only. For example:

   ```
   SQLExecute (hstmtsub1);
   SQLExecute (hstmtsub2);
   SQLExecute (hstmtsub3);
   ```

   Note: All statements to be executed inside an atomic compound block must first be prepared. Attempts to use the `SQLExecDirect()` function within an atomic compound block will result in errors.

6. Execute the END COMPOUND statement using the parent statement handle. For example:

   ```
   SQLExecDirect (hstmtparent, (SQLCHAR *) "END COMPOUND NOT ATOMIC STATIC",
                  SQL_NTS);
   ```

7. Optional: If you used an input parameter value array, call `SQLRowCount()` with the parent statement handle to retrieve the aggregate number of rows affected by all elements of the input array. For example:

   ```
   SQLRowCount (hstmtparent, &numRows);
   ```

8. Free the handles of the substatements. For example:

   ```
   SQLFreeHandle (SQL_HANDLE_STMT, hstmtsub1);
   SQLFreeHandle (SQL_HANDLE_STMT, hstmtsub2);
   SQLFreeHandle (SQL_HANDLE_STMT, hstmtsub3);
   ```

9. Free the parent statement handle when you have finished using it. For example:

   ```
   SQLFreeHandle (SQL_HANDLE_STMT, hstmtparent);
   ```

If the application is not operating in auto-commit mode and the COMMIT option is not specified, the sub-statements will not be committed. If the application is operating in auto-commit mode, however, then the sub-statements will be committed at END COMPOUND, even if the COMMIT option is not specified.

Cursors in CLI applications

A CLI application uses a cursor to retrieve rows from a result set. A cursor is a moveable pointer to a row in the result table of an active query statement. With the introduction of the DB2 UDB Version 8 client, the support for an updatable scrollable cursor has been moved from the client to the server. This means that an application using the DB2 UDB client, Version 8 or higher, that requires updatable scrollable cursor needs to ensure that the server supports updatable scrollable cursors. DB2 UDB servers on Linux, UNIX and Windows, Version 8 and above, and DB2 for z/OS servers Version 7 and above support this feature. To access a scrollable cursor in a three-tier environment on DB2 for z/OS or DB2 for OS/390 Version 7 and above, the gateway must be running DB2 UDB Version 8 or above.

A cursor is opened when a dynamic SQL SELECT statement is successfully executed by `SQLExecute()` or `SQLExecDirect()`. There is typically a one-to-one correlation between application cursor operations and the operations performed by the DB2 CLI driver with the cursor. Immediately after the successful execution, the cursor is positioned before the first row of the result set, and FETCH operations through calls to `SQLFetch()`, `SQLFetchScroll()`, or `SQLExtendedFetch()` will advance the cursor one row at a time through the result set. When the cursor has reached the end of the result set, the next fetch operation will return SQLCODE +100. From the perspective of the CLI application, `SQLFetch()` returns SQL_NO_DATA_FOUND when the end of the result set is reached.

Types of cursors

There are two types of cursors supported by DB2 CLI:

non-scrollable
Forward-only non-scrollable cursors are the default cursor type used by the DB2 CLI driver. This cursor type is unidirectional and requires the least amount of overhead processing.

scrollable
There are three types of scrollable cursors supported by DB2 CLI:

static This is a read-only cursor. Once it is created, no rows can be added or removed, and no values in any rows will change. The cursor is not affected by other applications accessing the same data. The isolation level of the statement used to create the cursor determines how the rows of the cursor are locked, if at all.

keyset-driven
Unlike a static scrollable cursor, a keyset-driven scrollable cursor can detect and make changes to the underlying data. Keyset cursors are based on row keys. When a keyset-driven cursor is first opened, it stores the keys in a keyset for the life of the entire result set. The keyset is used to determine the order and set of rows that are included in the cursor. As the cursor scrolls through the result set, it uses the keys in this keyset to retrieve the most recent values in the database, which are not necessarily the values that existed when the cursor was first opened. For this reason, changes are not reflected until the application scrolls to the row.

There are various types of changes to the underlying data that a keyset-driven cursor might or might not reflect:

- Changed values in existing rows. The cursor will reflect these types of changes. Because the cursor fetches a row from the database each time it is required, keyset-driven cursors always detect changes made by themselves and other cursors.
- Deleted rows. The cursor will reflect these types of changes. If a selected row in the rowset is deleted after the keyset is generated, it will appear as a ″hole″ in the cursor. When the cursor goes to fetch the row again from the database, it will realize that the row is no longer there.
- Added rows. The cursor will not reflect these types of changes. The set of rows is determined once, when the cursor is first opened. To see the inserted rows, the application must re-execute the query.

Note: DB2 CLI currently only supports keyset-driven cursors if the server supports them. The DB2 UDB Version 8 server now supports updatable scrollable cursors. This means that if applications require keyset cursor functionality and currently access DB2 for OS/390 Version 6 or DB2 for Unix and Windows Version 7 and earlier, the clients should not be migrated to DB2 UDB Version 8 or higher. The servers can be migrated to Version 8 or above.

dynamic
Dynamic scrollable cursors can detect all changes (inserts, deletes,

and updates) to the result set, and make insertions, deletions and updates to the result set. Unlike keyset-driven cursors, dynamic cursors:

- detect rows inserted by other cursors
- omit deleted rows from the result set (keyset-driven cursors recognize deleted rows as ″holes″ in the result set)

Currently, dynamic scrollable cursors are only supported in DB2 CLI when accessing servers that are DB2 for z/OS Version 8.1 and later.

Note: A column with a LOB type, distinct type on a LOB type, A column with a LONG VARCHAR, LONG VARGRAPHIC, DATALINK, LOB, XML type, distinct type on any of these types, or structured type cannot be specified in the select-list of a scrollable cursor. DB2 CLI will downgrade the cursor type from scrollable to forward-only and return a CLI0005W (SQLSTATE 01S02) warning message.

Cursor attributes

The table below lists the default attributes for cursors in DB2 CLI.

Table 6. Default attributes for cursors in CLI

Cursor type	Cursor sensitivity	Cursor updatable	Cursor concurrency	Cursor scrollable
forward-only[a]	unspecified	non-updatable	read-only concurrency	non-scrollable
static	insensitive	non-updatable	read-only concurrency	scrollable
keyset-driven	sensitive	updatable	values concurrency	scrollable
dynamic[b]	sensitive	updatable	values concurrency	scrollable

- **a** Forward-only is the default behavior for a scrollable cursor without the `FOR UPDATE` clause. Specifying `FOR UPDATE` on a forward-only cursor creates an updatable, lock concurrency, non-scrollable cursor.
- **b** Values concurrency is the default behavior, however, DB2 on Linux, UNIX and Windows will also support lock concurrency, which will result with pessimistic locking.

Update of keyset-driven cursors

A keyset-driven cursor is an updatable cursor. The CLI driver appends the `FOR UPDATE` clause to the query, except when the query is issued as a `SELECT ... FOR READ ONLY` query, or if the `FOR UPDATE` clause already exists. The default keyset-driven cursor is a values concurrency cursor. A values concurrency cursor results in optimistic locking, where locks are not held until an update or delete is attempted. If lock concurrency has been explicitly asked for, then pessimistic locking will be used and locks will be held as soon as the row is read. This level of locking is only supported against DB2 on Linux, UNIX and Windows servers. When an update or delete is attempted, the database server compares the previous values the application retrieved to the current values in the underlying table. If the values match, then the update or delete succeeds. If the values do not match, then the operation fails. If failure occurs, the application should query the values again and re-issue the update or delete if it is still applicable.

An application can update a keyset-driven cursor in two ways:

- Issue an `UPDATE WHERE CURRENT OF <cursor name>` or `DELETE WHERE CURRENT OF <cursor name>` using `SQLPrepare()` with `SQLExecute()` or `SQLExecDirect()`
- Use `SQLSetPos()` or `SQLBulkOperations()` to update, delete, or add a row to the result set.

  Note: Rows added to a result set via `SQLSetPos()` or `SQLBulkOperations()` are inserted into the table on the server, but are not added to the server's result set. Therefore, these rows are not updatable nor are they sensitive to changes made by other transactions. The inserted rows will appear, however, to be part of the result set, since they are cached on the client. Any triggers that apply to the inserted rows will appear to the application as if they have not been applied. To make the inserted rows updatable, sensitive, and to see the result of applicable triggers, the application must issue the query again to regenerate the result set.

Cursor considerations for CLI applications

Which cursor type to use

The first decision to make is between a forward-only cursor and a scrollable cursor. A forward-only cursor incurs less overhead than a scrollable cursor, and scrollable cursors have the potential for decreased concurrency. If your application does not need the additional features of a scrollable cursor, then you should use a non-scrollable cursor.

If a scrollable cursor is required then you have to decide between a static cursor, a keyset-driven cursor, or a dynamic cursor. A static cursor involves the least overhead. If the application does not need the additional features of a keyset-driven or dynamic cursor then a static cursor should be used.

Note: Currently, dynamic cursors are only supported when accessing servers that are DB2 for z/OS Version 8.1 and later.

If the application needs to detect changes to the underlying data or needs to add, update, or delete data from the cursor, then the application must use either a keyset-driven or dynamic cursor. To perform updates and deletions on rows in a dynamic scrollable cursor's result set, the UPDATE or DELETE statement must include all the columns of at least one unique key in the base table. This can be the primary key or any other unique key. Because dynamic cursors incur more overhead and might have less concurrency than keyset-driven cursors, only choose dynamic cursors if the application needs to detect both changes made and rows inserted by other cursors.

If an application requests a scrollable cursor that can detect changes without specifying a particular cursor type, then DB2 CLI will assume that a dynamic cursor is not needed and provide a keyset-driven cursor. This behavior avoids the increased overhead and reduced concurrency that is incurred with dynamic cursors.

To determine the attributes of the types of cursors supported by the driver and DBMS, the application should call `SQLGetInfo()` with an *InfoType* of:

- SQL_DYNAMIC_CURSOR_ATTRIBUTES1
- SQL_DYNAMIC_CURSOR_ATTRIBUTES2
- SQL_FORWARD_ONLY_CURSOR_ATTRIBUTES1
- SQL_FORWARD_ONLY_CURSOR_ATTRIBUTES2

- SQL_KEYSET_CURSOR_ATTRIBUTES1
- SQL_KEYSET_CURSOR_ATTRIBUTES2
- SQL_STATIC_CURSOR_ATTRIBUTES1
- SQL_STATIC_CURSOR_ATTRIBUTES2

Unit of work considerations

A cursor can be closed either explicitly or implicitly. An application can explicitly close a cursor by calling `SQLCloseCursor()`. Any further attempts to manipulate the cursor will result in error, unless the cursor is opened again. The implicit closure of a cursor depends on a several factors including how the cursor was declared and whether or not a COMMIT or ROLLBACK occurs.

By default, the DB2 CLI driver declares all cursors as WITH HOLD. This means that any open cursor will persist across COMMITs, thereby requiring the application to explicitly close each cursor. Be aware, however, that if a cursor is closed in autocommit mode, then any other open cursors that are not defined with the WITH HOLD option will be closed and all remaining open cursors will become unpositioned. (This means that no positioned updates or deletes can be performed without issuing another fetch.) There are two ways to change whether a cursor is declared WITH HOLD:

- Set the statement attribute SQL_ATTR_CURSOR_HOLD to SQL_CURSOR_HOLD_ON (default) or SQL_CURSOR_HOLD_OFF. This setting only affects cursors opened on the statement handle after this value has been set. It will not affect cursors already open.
- Set the CLI/ODBC configuration keyword CursorHold to change the default DB2 CLI driver behavior. Setting CursorHold=1 preserves the default behavior of cursors declared as WITH HOLD, and CursorHold=0 results in cursors being closed when each transaction is committed. You can override this keyword by setting the SQL_ATTR_CURSOR_HOLD statement attribute described above.

Note: A ROLLBACK will close all cursors, including those declared WITH HOLD.

Troubleshooting for applications created before scrollable cursor support

Because scrollable cursor support is a newer feature, some CLI/ODBC applications that were working with previous releases of DB2 for OS/390 or DB2 for Linux, UNIX and Windows might encounter behavioral or performance changes. This occurs because before scrollable cursors were supported, applications that requested a scrollable cursor would receive a forward-only cursor. To restore an application's previous behavior before scrollable cursor support, set the following configuration keywords in the `db2cli.ini` file:

Table 7. Configuration keyword values restoring application behavior before scrollable cursor support

Configuration keyword setting	Description
`Patch2=6`	Returns a message that scrollable cursors (keyset-driven, dynamic and static) are not supported. CLI automatically downgrades any request for a scrollable cursor to a forward-only cursor.

Table 7. Configuration keyword values restoring application behavior before scrollable cursor support (continued)

Configuration keyword setting	Description
`DisableKeysetCursor=1`	Disables keyset-driven scrollable cursors. This can be used to force the CLI driver to give the application a static cursor when a keyset-driven or dynamic cursor is requested.

Result set terminology in CLI applications

The following terms describe result handling:

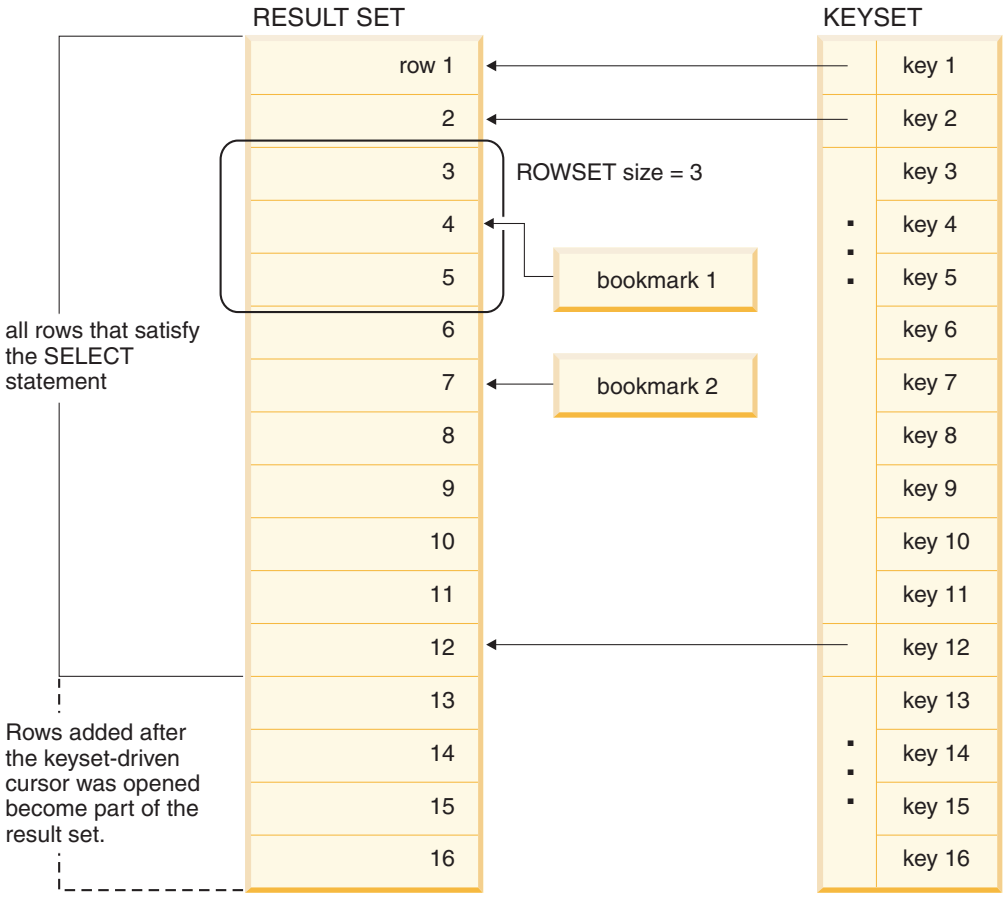
result set
The complete set of rows that satisfy the SQL SELECT statement. This is the set from which fetches retrieve rows to populate the rowset.

rowset
The subset of rows from the result set that is returned after each fetch. The application indicates the size of the rowset before the first fetch of data, and can modify the size before each subsequent fetch. Each call to `SQLFetch()`, `SQLFetchScroll()`, or `SQLExtendedFetch()` populates the rowset with the appropriate rows from the result set.

bookmark
It is possible to store a reference to a specific row in the result set called a bookmark. Once stored, the application can continue to move through the result set, then return to the bookmarked row to generate a rowset. You can also use a bookmark to perform updates and deletions with `SQLBulkOperations()`.

keyset A set of key values used to identify the set and order of rows that are included in a keyset-driven cursor. The keyset is created when a keyset-driven cursor is first opened. As the cursor scrolls through the result set, it uses the keys in the keyset to retrieve the current data values for each row.

The following figure demonstrates the relationship between the terms described above:



Bookmarks in CLI applications

When scrollable cursors are used, you can save a reference to any row in the result set using a bookmark. The application can then use that bookmark as a relative position to retrieve a rowset of information, or to update or delete a row when using keyset cursors. You can retrieve a rowset starting from the bookmarked row, or specify a positive or negative offset.

Once you have positioned the cursor to a row in a rowset using `SQLSetPos()`, you can obtain the bookmark value starting from column 0 using `SQLGetData()`. In most cases you will not want to bind column 0 and retrieve the bookmark value for every row, but use `SQLGetData()` to retrieve the bookmark value for the specific row you require.

A bookmark is only valid within the result set in which it was created. The bookmark value will be different if you select the same row from the same result set in two different cursors.

The only valid comparison is a byte-by-byte comparison between two bookmark values obtained from the same result set. If they are the same then they both point to the same row. Any other mathematical calculations or comparisons between bookmarks will not provide any useful information. This includes comparing bookmark values within a result set, and between result sets.

Rowset retrieval examples in CLI applications

Partial rowset example

When working with rowsets, you should verify what portion of the result set returned contains meaningful data. The application cannot assume that the entire rowset will contain data. It must check the row status array after each rowset is created to determine the number of rows returned, because there are instances where the rowset will not contain a complete set of rows. For instance, consider the case where the rowset size is set to 10, and `SQLFetchScroll()` is called using SQL_FETCH_ABSOLUTE and *FetchOffset* is set to -3. This will attempt to return 10 rows starting 3 rows from the end of the result set. Only the first three rows of the rowset will contain meaningful data, however, and the application must ignore the rest of the rows.

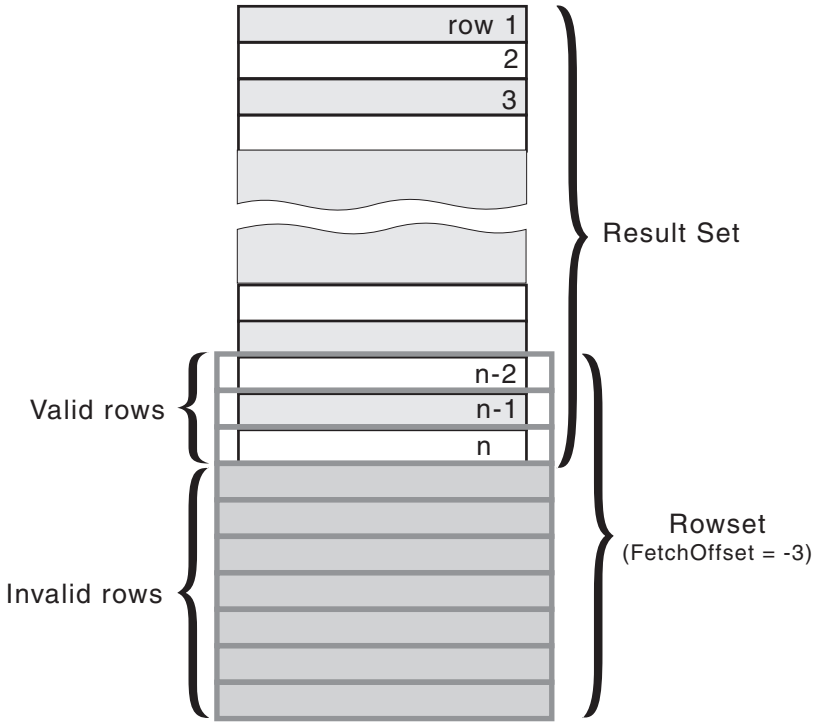


Figure 5. Partial rowset example

Fetch orientations example

The following figure demonstrates a number of calls to `SQLFetchScroll()` using various *FetchOrientation* values. The result set includes all of the rows (from 1 to n), and the rowset size is 3. The order of the calls is indicated on the left, and the *FetchOrientation* values are indicated on the right.

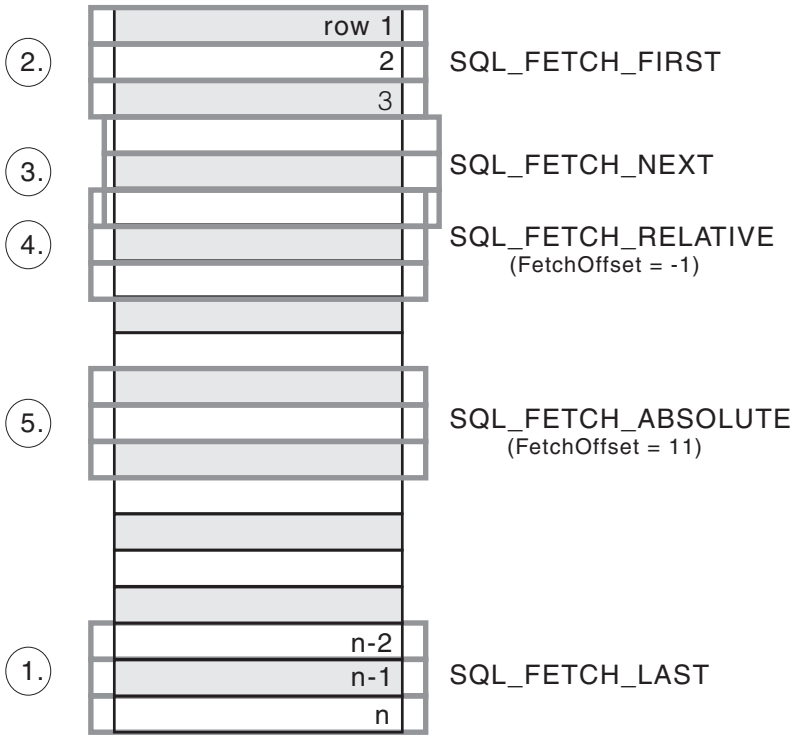


Figure 6. Example of retrieving rowsets

Retrieving query results in CLI applications

Retrieving query results is part of the larger task of processing transactions in CLI applications. Retrieving query results involves binding application variables to columns of a result set and then fetching the rows of data into the application variables. A typical query is the SELECT statement.

Before you retrieve results, ensure you have initialized your application and prepared and executed the necessary SQL statements.

To retrieve each row of the result set:

1. Optional: Determine the structure of the result set, number of columns, and column types and lengths by calling `SQLNumResultCols()` and `SQLDescribeCol()`.

   Note: Performing this step can reduce performance if done before the query has been executed, because it forces CLI to describe the query's columns. Information about the result set's columns is available after successful execution, and describing the result set does not incur any additional overhead if the describe is performed after successful execution.
2. Bind an application variable to each column of the result set, by calling `SQLBindCol()`, ensuring that the variable type matches the column type. For example:

```
struct
{
  SQLINTEGER ind;
  SQLSMALLINT val;
}
```

```
deptnumb; /* variable to be bound to the DEPTNUMB column */

struct
{
  SQLINTEGER ind;
  SQLCHAR val[15];
}
location; /* variable to be bound to the LOCATION column */

/* ... */

/* bind column 1 to variable */
cliRC = SQLBindCol(hstmt, 1, SQL_C_SHORT, &deptnumb.val, 0,
                   &deptnumb.ind);
STMT_HANDLE_CHECK(hstmt, hdbc, cliRC);

/* bind column 2 to variable */
cliRC = SQLBindCol(hstmt, 2, SQL_C_CHAR, location.val, 15,
                   &location.ind);
STMT_HANDLE_CHECK(hstmt, hdbc, cliRC);
```

The application can use the information obtained in step 1 to determine an appropriate C data type for the application variable and to allocate the maximum storage the column value could occupy. The columns are bound to deferred output arguments, which means the data is written to these storage locations when it is fetched.

Important: Do not de-allocate or discard variables used for deferred output arguments between the time the application binds them to columns of the result set and the time DB2 CLI writes to these arguments.

3. Repeatedly fetch the row of data from the result set by calling `SQLFetch()` until SQL_NO_DATA_FOUND is returned. For example:

```
/* fetch each row and display */
cliRC = SQLFetch(hstmt);

if (cliRC == SQL_NO_DATA_FOUND)
{
  printf("\n  Data not found.\n");
}
while (cliRC != SQL_NO_DATA_FOUND)
{
  printf(" %-8d %-14.14s \n", deptnumb.val, location.val);

  /* fetch next row */
  cliRC = SQLFetch(hstmt);
}
```

`SQLFetchScroll()` can also be used to fetch multiple rows of the result set into an array.

If data conversion was required for the data types specified on the call to `SQLBindCol()`, the conversion will occur when `SQLFetch()` is called.

4. Optional: Retrieve columns that were not previously bound by calling `SQLGetData()` after each successful fetch. You can retrieve all unbound columns this way. For example:

```
/* fetch each row and display */
cliRC = SQLFetch(hstmt);

if (cliRC == SQL_NO_DATA_FOUND)
{
  printf("\n  Data not found.\n");
}
while (cliRC != SQL_NO_DATA_FOUND)
{
```

```
    /* use SQLGetData() to get the results */
    /* get data from column 1 */
    cliRC = SQLGetData(hstmt,
                       1,
                       SQL_C_SHORT,
                       &deptnumb.val,
                       0,
                       &deptnumb.ind);
    STMT_HANDLE_CHECK(hstmt, hdbc, cliRC);

    /* get data from column 2 */
    cliRC = SQLGetData(hstmt,
                       2,
                       SQL_C_CHAR,
                       location.val,
                       15,
                       &location.ind);

    /* display the data */
    printf("  %-8d %-14.14s \n", deptnumb.val, location.val);

    /* fetch the next row */
    cliRC = SQLFetch(hstmt);
  }
```

Note: Applications perform better if columns are bound, rather than having them retrieved as unbound columns using `SQLGetData()`. However, an application may be constrained in the amount of long data it can retrieve and handle at one time. If this is a concern, then `SQLGetData()` may be the better choice.

Column binding in CLI applications

Columns may be bound to:

- Application storage

  `SQLBindCol()` is used to bind application storage to the column. Data will be transferred from the server to the application at fetch time. Length of the available data to return is also set.

- LOB locators

  `SQLBindCol()` is used to bind LOB locators to the column. Only the LOB locator (4 bytes) will be transferred from the server to the application at fetch time.

  If a CLI application does not provide an output buffer for a LOB column using the function `SQLBindCol()` the DB2 Client will, by default, request a LOB locator on behalf of the application for each LOB column in the result sets.

  Once an application receives a locator it can be used in `SQLGetSubString()`, `SQLGetPosition()`, `SQLGetLength()`, or as the value of a parameter marker in another SQL statement. `SQLGetSubString()` can either return another locator, or the data itself. All locators remain valid until the end of the transaction in which they were created (even when the cursor moves to another row), or until it is freed using the FREE LOCATOR statement.

- Lob file references

  `SQLBindFileToCol()` is used to bind a file to a LOB or XML column. DB2 CLI will write the data directly to a file, and update the *StringLength* and *IndicatorValue* buffers specified on `SQLBindFileToCol()`.

  If the data value for the column is NULL and `SQLBindFileToCol()` was used, then *IndicatorValue* will be set to SQL_NULL_DATA and *StringLength* to 0.

The number of columns in a result set can be determined by calling SQLNumResultCols() or by calling SQLColAttribute() with the *DescType* argument set to SQL_COLUMN_COUNT.

The application can query the attributes (such as data type and length) of the column by first calling SQLDescribeCol() or SQLColAttribute(). This information can then be used to allocate a storage location of the correct data type and length, to indicate data conversion to another data type, or in the case of LOB data types, optionally return a locator.

An application can choose not to bind every column, or even not to bind any columns. Data in any of the columns can also be retrieved using SQLGetData() after the bound columns have been fetched for the current row. It is usually more efficient to bind application variables or file references to result sets than to use SQLGetData(). When the data is in a LOB column, LOB functions are preferable to SQLGetData() . Use SQLGetData() when the data value is large variable-length data that:

- must be received in pieces, or
- may not need to be retrieved.

Instead of multiple calls to SQLBindCol(), DB2 CLI also supports column binding offsets. Rather than re-binding each time, an offset can be used to specify new buffer and length/indicator addresses which will be used in a subsequent call to SQLFetch() or SQLFetchScroll(). This can only be used with row wise binding, but will work whether the application retrieves a single row or multiple rows at a time.

When binding any variable length column, DB2 CLI will be able to write *StrLen_or_IndPtr* and *TargetValuePtr* in one operation if they are allocated contiguously. For example:

```
struct {  SQLINTEGER  StrLen_or_IndPtr;
          SQLCHAR     TargetValuePtr[MAX_BUFFER];
       } column;
```

The most recent bind column function call determines the type of binding that is in effect.

Specifying the rowset returned from the result set

Before you begin to retrieve data, you need to establish the rowset that will be returned. This topic describes the steps associated with setting up the rowset.

Before specifying the rowset, ensure that you have initialized your CLI application.

DB2 CLI allows an application to specify a rowset for a non-scrollable or scrollable cursor that spans more than one row at a time. To effectively work with a rowset, an application should perform the following:

1. Specify the size of the rowset returned from calls to SQLFetch() or SQLFetchScroll() by setting the statement attribute SQL_ATTR_ROW_ARRAY_SIZE to the number of rows in the rowset. The default number of rows is 1. For example, to declare a rowset size of 35 rows, issue the following call:

```
#define ROWSET_SIZE 35
/* ... */
rc = SQLSetStmtAttr(hstmt,
                    SQL_ATTR_ROW_ARRAY_SIZE,
                    (SQLPOINTER) ROWSET_SIZE,
                    0);
```

2. Set up a variable that will store the number of rows returned. Declare a variable of type SQLUINTEGER and set the SQL_ATTR_ROWS_FETCHED_PTR statement attribute to point to this variable. In the following example, *rowsFetchedNb* will hold the number of rows returned in the rowset after each call to `SQLFetchScroll()`:

```
/* ... */

SQLUINTEGER rowsFetchedNb;

/* ... */

rc = SQLSetStmtAttr(hstmt,
                    SQL_ATTR_ROWS_FETCHED_PTR,
                    &rowsFetchedNb,
                    0);
```

3. Set up the row status array. Declare an array of type SQLUSMALLINT with the same number of rows as the size of the rowset (as determined in Step 1). Then specify the address of this array with the statement attribute SQL_ATTR_ROW_STATUS_PTR. For example:

```
/* ... */
SQLUSMALLINT    row_status[ROWSET_SIZE];
/* ... */
/* Set a pointer to the array to use for the row status */
rc = SQLSetStmtAttr(
            hstmt,
            SQL_ATTR_ROW_STATUS_PTR,
            (SQLPOINTER) row_status,
            0);
```

   The row status array provides additional information about each row in the rowset. After each call to `SQLFetch()` or `SQLFetchScroll()`, the array is updated. If the call to `SQLFetch()` or `SQLFetchScroll()` does not return SQL_SUCCESS or SQL_SUCCESS_WITH_INFO, then the contents of the row status array are undefined. Otherwise, any of the row status array values will be returned (refer to the row status array section of the SQLFetchScroll() documentation for a complete list of values).

4. Position the rowset within the result set, indicating the position you want the rowset to begin. Specify this position by calling `SQLFetch()`, or `SQLFetchScroll()` with *FetchOrientation* and *FetchOffset* values. For example, the following call generates a rowset starting on the 11th row in the result set:

```
SQLFetchScroll(hstmt,   /* Statement handle */
    SQL_FETCH_ABSOLUTE, /* FetchOrientation value */
    11);                /* Offset value */
```

   Scroll bar operations of a screen-based application can be mapped directly to the positioning of a rowset. By setting the rowset size to the number of lines displayed on the screen, the application can map the movement of the scroll bar to calls to `SQLFetchScroll()`.

   Note: If the application can buffer data in the display and regenerate the result set to see updates, then use a forward-only cursor instead. This yields better performance for small result sets.

Rowset retrieved	FetchOrientation value	Scroll bar
First rowset	SQL_FETCH_FIRST	Home: Scroll bar at the top
Last rowset	SQL_FETCH_LAST	End: Scroll bar at the bottom
Next rowset	SQL_FETCH_NEXT (same as calling `SQLFetch()`)	Page Down
Previous rowset	SQL_FETCH_PRIOR	Page Up
Rowset starting on next row	SQL_FETCH_RELATIVE with *FetchOffset* set to 1	Line Down
Rowset starting on previous row	SQL_FETCH_RELATIVE with *FetchOffset* set to -1	Line Up
Rowset starting on a specific row	SQL_FETCH_ABSOLUTE with *FetchOffset* set to an offset from the start (a positive value) or the end (a negative value) of the result set	Application generated
Rowset starting on a previously bookmarked row	SQL_FETCH_BOOKMARK with *FetchOffset* set to a positive or negative offset from the bookmarked row	Application generated

5. Check the rows fetched pointer after each rowset is created to determine the number of rows returned. Check the row status array for the status of each row, because there are instances where the rowset will not contain a complete set of rows. The application cannot assume that the entire rowset will contain data.

   For instance, consider the case where the rowset size is set to 10, and `SQLFetchScroll()` is called using SQL_FETCH_ABSOLUTE and *FetchOffset* is set to -3. This will attempt to return 10 rows starting 3 rows from the end of the result set. Only the first three rows of the rowset will contain meaningful data, however, and the application must ignore the rest of the rows.

Retrieving data with scrollable cursors in a CLI application

Scrollable cursors allow you to move throughout a result set. You can make use of this feature when retrieving data. This topic describes how to use scrollable cursors to retrieve data.

Before you retrieve data using scrollable cursors, ensure that you have initialized your CLI application.

To use scrollable cursors to retrieve data:

1. Specify the size of the rowset returned by setting the statement attribute SQL_ATTR_ROW_ARRAY_SIZE to the number of rows in the rowset. The default number of rows is 1. For example, to declare a rowset size of 35 rows, issue the following call:

```
#define ROWSET_SIZE 35
/* ... */
rc = SQLSetStmtAttr(hstmt,
                    SQL_ATTR_ROW_ARRAY_SIZE,
                    (SQLPOINTER) ROWSET_SIZE,
                    0);
```

2. Specify the type of scrollable cursor to use. Using SQLSetStmtAttr(), set the SQL_ATTR_CURSOR_TYPE statement attribute to SQL_CURSOR_STATIC for a static read-only cursor or to SQL_CURSOR_KEYSET_DRIVEN for a keyset-driven cursor. For example:

```
sqlrc = SQLSetStmtAttr (hstmt,
                        SQL_ATTR_CURSOR_TYPE,
                        (SQLPOINTER) SQL_CURSOR_STATIC,
                        0);
```

   If the type of cursor is not set, the default forward-only non-scrollable cursor will be used.

3. Set up a variable that will store the number of rows returned. Declare a variable of type SQLUINTEGER and set the SQL_ATTR_ROWS_FETCHED_PTR statement attribute to point to this variable. In the following example, *rowsFetchedNb* will hold the number of rows returned in the rowset after each call to SQLFetchScroll():

```
/* ... */

SQLUINTEGER rowsFetchedNb;

/* ... */

rc = SQLSetStmtAttr(hstmt,
                    SQL_ATTR_ROWS_FETCHED_PTR,
                    &rowsFetchedNb,
                    0);
```

4. Set up the row status array. Declare an array of type SQLUSMALLINT with the same number of rows as the size of the rowset (as determined in Step 1). Then specify the address of this array with the statement attribute SQL_ATTR_ROW_STATUS_PTR. For example:

```
/* ... */
SQLUSMALLINT    row_status[ROWSET_SIZE];
/* ... */
/* Set a pointer to the array to use for the row status */
rc = SQLSetStmtAttr(
            hstmt,
            SQL_ATTR_ROW_STATUS_PTR,
            (SQLPOINTER) row_status,
            0);
```

   The row status array provides additional information about each row in the rowset. After each call to SQLFetchScroll(), the array is updated. If the call to SQLFetchScroll() does not return SQL_SUCCESS or SQL_SUCCESS_WITH_INFO, then the contents of the row status array are undefined. Otherwise, any of the row status array values will be returned (refer to the row status array section of the SQLFetchScroll() documentation for a complete list of values).

5. Optional: If you want to use bookmarks with the scrollable cursor, set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE. For example:

```
sqlrc = SQLSetStmtAttr (hstmt,
                        SQL_ATTR_USE_BOOKMARKS,
                        (SQLPOINTER) SQL_UB_VARIABLE,
                        0);
```

6. Issue an SQL SELECT statement.
7. Execute the SQL SELECT statement.
8. Bind the result set using either column-wise or row-wise binding.
9. Fetch a rowset of rows from the result set. o

a. Call SQLFetchScroll() to fetch a rowset of data from the result set. Position the rowset within the result set indicating the position you want the rowset to begin. Specify this position by calling SQLFetchScroll() with *FetchOrientation* and *FetchOffset* values. For example, the following call generates a rowset starting on the 11th row in the result set:

```
SQLFetchScroll(hstmt,              /* Statement handle */
               SQL_FETCH_ABSOLUTE, /* FetchOrientation value */
               11);                /* Offset value */
```

b. Check the row status array after each rowset is created to determine the number of rows returned, because there are instances where the rowset will not contain a complete set of rows. The application cannot assume that the entire rowset will contain data.

   For instance, consider the case where the rowset size is set to 10, and SQLFetchScroll() is called using SQL_FETCH_ABSOLUTE and *FetchOffset* is set to -3. This will attempt to return 10 rows starting 3 rows from the end of the result set. Only the first three rows of the rowset will contain meaningful data, however, and the application must ignore the rest of the rows.

c. Display or manipulate the data in the rows returned.

10. Close the cursor by calling SQLCloseCursor() or free the statement handle by calling SQLFreeHandle() with a *HandleType* of SQL_HANDLE_STMT.

    Freeing the statement handles is not required every time retrieval has finished. The statement handles can be freed at a later time, when the application is freeing other handles.

Retrieving data with bookmarks in a CLI application

Bookmarks, available only when scrollable cursors are used, allow you to save a reference to any row in a result set. You can take advantage of this feature when retrieving data. This topic describes how to retrieve data using bookmarks.

Before you retrieve data with bookmarks, ensure that you have initialized your CLI application. The steps explained here should be performed in addition to those described in "Retrieving Data with Scrollable Cursors in a CLI Application".

To use bookmarks with scrollable cursors to retrieve data:

1. Indicate that bookmarks will be used (if not already done so) by setting the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE. For example:

```
sqlrc = SQLSetStmtAttr (hstmt,
                        SQL_ATTR_USE_BOOKMARKS,
                        (SQLPOINTER) SQL_UB_VARIABLE,
                        0);
```

2. Get the bookmark value from the desired row in the rowset after executing the SELECT statement and retrieving the rowset using SQLFetchScroll(). Do this by calling SQLSetPos() to position the cursor within the rowset. Then call SQLGetData() to retrieve the bookmark value. For example:

```
sqlrc = SQLFetchScroll(hstmt, SQL_FETCH_ABSOLUTE, 15);
/* ... */
sqlrc = SQLSetPos(hstmt, 3, SQL_POSITION, SQL_LOCK_NO_CHANGE);
/* ... */
sqlrc = SQLGetData(hstmt, 0, SQL_C_LONG, bookmark.val, 4,
                   &bookmark.ind);
```

   In most cases, you will not want to bind column 0 and retrieve the bookmark value for every row, but use SQLGetData() to retrieve the bookmark value for the specific row you require.

3. Store the bookmark location for the next call to SQLFetchScroll(). Set the SQL_ATTR_FETCH_BOOKMARK statement attribute to the variable that contains the bookmark value. For example, continuing from the example above, *bookmark.val* stores the bookmark value, so call SQLSetStmtAttr() as follows:

```
sqlrc = SQLSetStmtAttr(hstmt,
                       SQL_ATTR_FETCH_BOOKMARK_PTR,
                       (SQLPOINTER) bookmark.val,
                       0);
```

4. Retrieve a rowset based on the bookmark. Once the bookmark value is stored, the application can continue to use `SQLFetchScroll()` to retrieve data from the result set. The application can then move throughout the result set, but still retrieve a rowset based on the location of the bookmarked row at any point before the cursor is closed.

   The following call to `SQLFetchScroll()` retrieves a rowset starting from the bookmarked row:

```
sqlrc = SQLFetchScroll(hstmt, SQL_FETCH_BOOKMARK, 0);
```

   The value 0 specifies the offset. You would specify -3 to begin the rowset 3 rows before the bookmarked row, or specify 4 to begin 4 rows after. For example, the following call from retrieves a rowset 4 rows after the bookmarked row:

```
sqlrc = SQLFetchScroll(hstmt, SQL_FETCH_BOOKMARK, 4);
```

   Note that the variable used to store the bookmark value is not specified in the `SQLFetchScroll()` call. It was set in the previous step using the statement attribute SQL_ATTR_FETCH_BOOKMARK_PTR.

Retrieving bulk data with bookmarks using SQLBulkOperations() in CLI applications

You can retrieve, or fetch, bulk data using bookmarks and the DB2 CLI `SQLBulkOperations()` function.

Before fetching bulk data using bookmarks and `SQLBulkOperations()`, ensure you have initialized your CLI application.

Bookmarks in DB2 CLI do not persist across cursor close operations. This means that an application cannot use bookmarks that it has stored from a previous cursor. Instead, it has to call `SQLFetch()` or `SQLFetchScroll()` to retrieve the bookmarks before updating with bookmarks.

To perform bulk fetches using bookmarks with `SQLBulkOperations()`:

1. Set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE using `SQLSetStmtAttr()`.
2. Execute a query that returns a result set.
3. Set the SQL_ATTR_ROW_ARRAY_SIZE statement attribute to the number of rows you want to fetch by calling `SQLSetStmtAttr()`.
4. Call `SQLBindCol()` to bind the data you want to fetch.

   The data is bound to an array with a size equal to the value of SQL_ATTR_ROW_ARRAY_SIZE.
5. Call `SQLBindCol()` to bind column 0, the bookmark column.
6. Copy the bookmarks for rows you want to fetch into the array bound to column 0.

Note: The size of the array pointed to by the SQL_ATTR_ROW_STATUS_PTR statement attribute should either be equal to SQL_ATTR_ROW_ARRAY_SIZE, or the SQL_ATTR_ROW_STATUS_PTR statement attribute should be a null pointer.

7. Fetch the data by calling `SQLBulkOperations()` with an *Operation* argument of SQL_FETCH_BY_BOOKMARK.

   If the application has set the SQL_ATTR_ROW_STATUS_PTR statement attribute, then it can inspect this array to see the result of the operation.

Result set retrieval into arrays in CLI applications

One of the most common tasks performed by an application is to issue a query statement, and then fetch each row of the result set into application variables that have been bound using `SQLBindCol()`. If the application requires that each column or each row of the result set be stored in an array, each fetch must be followed by either a data copy operation or a new set of `SQLBindCol()` calls to assign new storage areas for the next fetch.

Alternatively, applications can eliminate the overhead of extra data copies or extra `SQLBindCol()` calls by retrieving multiple rows of data (called a rowset) at one time into an array.

Note: A third method of reducing overhead, which can be used on its own or with arrays, is to specify a binding offset. Rather than re-binding each time, an offset can be used to specify new buffer and length/indicator addresses which will be used in a subsequent call to `SQLFetch()` or `SQLFetchScroll()`. This can only be used with row offset binding.

When retrieving a result set into an array, `SQLBindCol()` is also used to assign storage for application array variables. By default, the binding of rows is in column-wise fashion: this is similar to using `SQLBindParameter()` to bind arrays of input parameter values. Figure 7 is a logical view of column-wise binding.

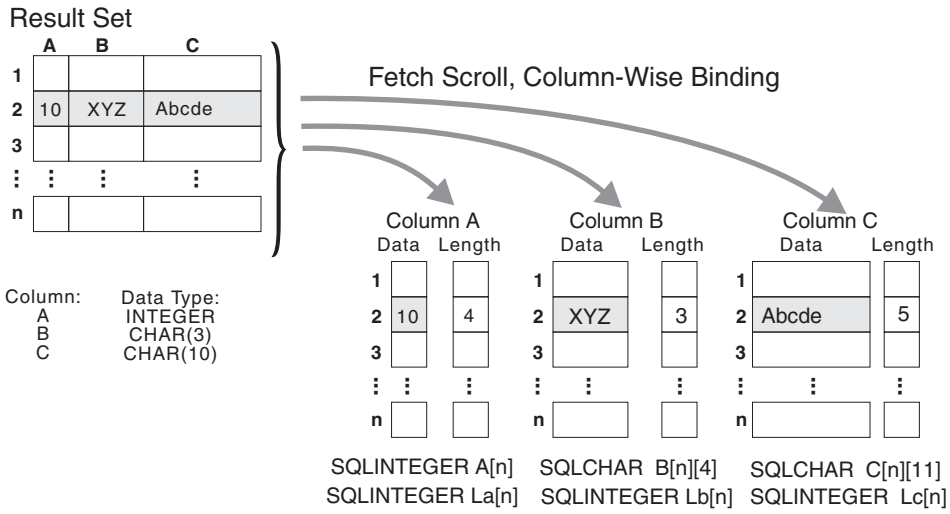


Figure 7. Column-wise binding

The application can also do row-wise binding which associates an entire row of the result set with a structure. In this case the rowset is retrieved into an array of structures, each of which holds the data in one row and the associated length

fields. Figure 8 gives a pictorial view of row-wise binding.

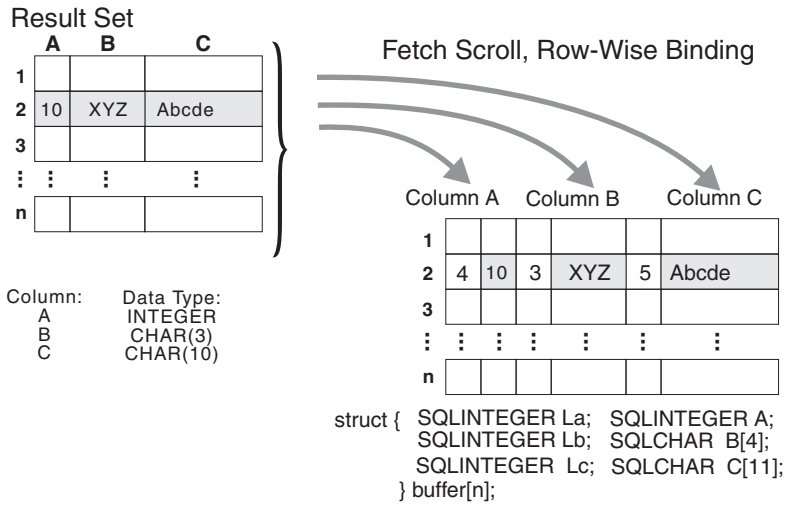


Figure 8. Row-wise binding

Retrieving array data in CLI applications using column-wise binding

When retrieving data, you may want to retrieve more than one row at a time and store the data in an array. Instead of fetching and copying each row of data into an array, or binding to new storage areas, you can retrieve multiple rows of data at once using column-wise binding. Column-wise binding is the default row-binding method whereby each data value and its length is stored in an array.

Before using column-wise binding to retrieve data into arrays, ensure you have initialized your CLI application.

To retrieve data using column-wise binding:

1. Allocate an array of the appropriate data type for each column data value. This array will hold the retrieved data value.
2. Allocate an array of SQLINTEGER for each column. Each array will store the length of each column's data value.
3. Specify that column-wise array retrieval will be used by setting the SQL_ATTR_ROW_BIND_TYPE statement attribute to SQL_BIND_BY_COLUMN using `SQLSetStmtAttr()`.
4. Specify the number of rows that will be retrieved by setting the SQL_ATTR_ROW_ARRAY_SIZE statement attribute using `SQLSetStmtAttr()`.

   When the value of the SQL_ATTR_ROW_ARRAY_SIZE attribute is greater than 1, DB2 CLI treats the deferred output data pointer and length pointer as pointers to arrays of data and length rather than to one single element of data and length of a result set column.
5. Prepare and execute the SQL statement used to retrieve the data.
6. Bind each array to its column by calling `SQLBindCol()` for each column.
7. Retrieve the data by calling `SQLFetch()` or `SQLFetchScroll()`.

   When returning data, DB2 CLI uses the maximum buffer size argument (*BufferLength*) of `SQLBindCol()` to determine where to store successive rows of data in the array. The number of bytes available for return for each element is stored in the deferred length array. If the number of rows in the result set is

greater than the SQL_ATTR_ROW_ARRAY_SIZE attribute value, multiple calls to SQLFetchScroll() are required to retrieve all the rows.

Retrieving array data in CLI applications using row-wise binding

When retrieving data, you may want to retrieve more than one row at a time and store the data in an array. Instead of fetching and copying each row of data into an array, or binding to new storage areas, you can retrieve multiple rows of data using row-wise binding. Row-wise binding associates an entire row of the result set with a structure. The rowset is retrieved into an array of structures, each of which holds the data in one row and the associated length fields.

Before using row-wise binding to retrieve data into arrays, ensure you have initialized your CLI application.

To retrieve data using row-wise binding:

1. Allocate an array of structures of size equal to the number of rows to be retrieved, where each element of the structure is composed of each row's data value and each data value's length.

   For example, if each row of the result set consisted of Column A of type INTEGER, Column B of type CHAR(3), and Column C of type CHAR(10), then you would allocate the following structure, where n represents the number of rows in the result set:

   ```
   struct { SQLINTEGER La; SQLINTEGER A;
            SQLINTEGER Lb; SQLCHAR B[4];
            SQLINTEGER Lc; SQLCHAR C[11];
          } buffer[n];
   ```

2. Specify that row-wise array retrieval will be used by setting the SQL_ATTR_ROW_BIND_TYPE statement attribute, using SQLSetStmtAttr() to the size of the structure to which the result columns will be bound.
3. Specify the number of rows that will be retrieved by setting the SQL_ATTR_ROW_ARRAY_SIZE statement attribute using SQLSetStmtAttr().
4. Prepare and execute the SQL statement used to retrieve the data.
5. Bind each structure to the row by calling SQLBindCol() for each column of the row.

   DB2 CLI treats the deferred output data pointer of SQLBindCol() as the address of the data field for the column in the first element of the array of structures. The deferred output length pointer is treated as the address of the associated length field of the column.
6. Retrieve the data by calling SQLFetchScroll().

   When returning data, DB2 CLI uses the structure size provided with the SQL_ATTR_ROW_BIND_TYPE statement attribute to determine where to store successive rows in the array of structures.

Changing column bindings in a CLI application with column binding offsets

When an application needs to change bindings (for a subsequent fetch, for example) it can call SQLBindCol() a second time. This will change the buffer address and length/indicator pointer used. Instead of multiple calls to SQLBindCol(), DB2 CLI supports column binding offsets. Rather than re-binding each time, an offset can be used to specify new buffer and length/indicator addresses which will be used in a subsequent call to SQLFetch() or SQLFetchScroll().

Before using column binding offsets to change result set bindings, ensure you have initialized your CLI application.

This method can only be used with row-wise binding, but will work whether the application retrieves a single row or multiple rows at a time.

To change result set bindings using column binding offsets:

1. Call `SQLBindCol()` as usual to bind the result set. The first set of bound data buffer and length/indicator buffer addresses will act as a template. The application will then move this template to different memory locations using the offset.
2. Call `SQLFetch()` or `SQLFetchScroll()` as usual to fetch the data. The data returned will be stored in the locations bound above.
3. Set up a variable to hold the memory offset value.

   The statement attribute SQL_ATTR_ROW_BIND_OFFSET_PTR points to the address of an SQLINTEGER buffer where the offset will be stored. This address must remain valid until the cursor is closed.

   This extra level of indirection enables the use of a single memory variable to store the offset for multiple sets of bindings on different statement handles. The application need only set this one memory variable and all of the offsets will be changed.
4. Store an offset value (number of bytes) in the memory location pointed to by the statement attribute set in the previous step.

   The offset value is always added to the memory location of the originally bound values. This sum must point to a valid memory address with sufficient space to hold the next set of data.
5. Call `SQLFetch()` or `SQLFetchScroll()` again. CLI will add the offset specified above to the locations used in the original call to `SQLBindCol()`. This will determine where in memory to store the results.
6. Repeat steps 4 and 5 above as required.

Data retrieval in pieces in CLI applications

Typically, an application might choose to allocate the maximum memory the column value could occupy and bind it via `SQLBindCol()`, based on information about a column in the result set (obtained via a call to `SQLDescribeCol()`, for example, or prior knowledge). However, in the case of character and binary data, the column can be arbitrarily long. If the length of the column value exceeds the length of the buffer the application can allocate or afford to allocate, a feature of `SQLGetData()` lets the application use repeated calls to obtain in sequence the value of a single column in more manageable pieces.

A call to `SQLGetData()` (which is called after `SQLFetch()`) returns SQL_SUCCESS_WITH_INFO (with SQLSTATE 01004) to indicate more data exists for this column. `SQLGetData()` is called repeatedly to get the remaining pieces of data until it returns SQL_SUCCESS, signifying that the entire data has been retrieved for this column.

For example:

```
/* dtlob.c */
/* ... */
sqlrc = SQLGetData(hstmt, 1, SQL_C_BINARY, (SQLPOINTER) buffer,
                   BUFSIZ, &bufInd);
/* ... */
while( sqlrc == SQL_SUCCESS_WITH_INFO || sqlrc == SQL_SUCCESS )
```

```
{   if ( bufInd > BUFSIZ)  /* full buffer */
    {   fwrite( buffer, sizeof(char), BUFSIZ, pFile);
    }
    else /* partial buffer on last GetData */
    {   fwrite( buffer, sizeof(char), bufInd, pFile);
    }

    sqlrc = SQLGetData( hstmt, 1, SQL_C_BINARY, (SQLPOINTER)buffer,
                        BUFSIZ, &bufInd);
    /* ... */
}
```

The function SQLGetSubString() can also be used to retrieve a specific portion of a large object value. For other alternative methods to retrieve long data, refer to the documentation on large object usage.

Fetching LOB data with LOB locators in CLI applications

The following are typical steps for fetching LOB data using a LOB locator. The examples shown in each step illustrate how using a locator to retrieve CLOB data allows a character string to be extracted from the CLOB, without having to transfer the entire CLOB to an application buffer. The LOB locator is fetched and then used as an input parameter to search the CLOB for a substring. This substring is then retrieved.

Before fetching LOB data with LOB locators, ensure you have initialized your CLI application.

To fetch LOB data using LOB locators:

1. Retrieve a LOB locator into an application variable using the SQLBindCol() or SQLGetData() functions. For example:

```
SQLINTEGER  clobLoc ;
SQLINTEGER  pcbValue ;

/* ... */
sqlrc = SQLBindCol( hstmtClobFetch, 1, SQL_C_CLOB_LOCATOR,
                    &clobLoc, 0, &pcbValue);
```

2. Fetch the locator using SQLFetch():

```
sqlrc = SQLFetch( hstmtClobFetch );
```

3. Call SQLGetLength() to get the length of a string that is represented by a LOB locator. For example:

```
sqlrc = SQLGetLength( hstmtLocUse, SQL_C_CLOB_LOCATOR,
                      clobLoc, &clobLen, &ind ) ;
```

4. Call SQLGetPosition() to get the position of a search string within a source string where the source string is represented by a LOB locator. The search string can also be represented by a LOB locator. For example:

```
sqlrc = SQLGetPosition( hstmtLocUse,
                        SQL_C_CLOB_LOCATOR,
                        clobLoc,
                        0,
                        ( SQLCHAR * ) "Interests",
                        strlen( "Interests"),
                        1,
                        &clobPiecePos,
                        &ind ) ;
```

5. Call SQLGetSubString() to retrieve the substring. For example:

```
sqlrc = SQLGetSubString( hstmtLocUse,
                         SQL_C_CLOB_LOCATOR,
                         clobLoc,
```

```
                                clobPiecePos,
                                clobLen - clobPiecePos,
                                SQL_C_CHAR,
                                buffer,
                                clobLen - clobPiecePos + 1,
                                &clobPieceLen,
                                &ind ) ;
```

6. Free the locator. All LOB locators are implicitly freed when a transaction ends. The locator can be explicitly freed before the end of a transaction by executing the FREE LOCATOR statement.

   Although this statement cannot be prepared dynamically, DB2 CLI will accept it as a valid statement on `SQLPrepare()` and `SQLExecDirect()`. The application uses `SQLBindParameter()` with the SQL data type argument set to the appropriate SQL and C symbolic data types. For example,

```
sqlrc = SQLSetParam( hstmtLocFree,
                     1,
                     SQL_C_CLOB_LOCATOR,
                     SQL_CLOB_LOCATOR,
                     0,
                     0,
                     &clobLoc,
                     NULL ) ;

/* ... */
sqlrc = SQLExecDirect( hstmtLocFree, stmtLocFree, SQL_NTS ) ;
```

XML data retrieval in CLI applications

When you select data from XML columns in a table, the output data is in the serialized string format.

For XML data, when you use `SQLBindCol()` to bind columns in a query result set to application variables, you can specify the data type of the application variables as SQL_C_BINARY, SQL_C_CHAR, SQL_C_DBCHAR or SQL_C_WCHAR. When retrieving a result set from an XML column, it is recommended that you bind your application variable to the SQL_C_BINARY type. Binding to character types can result in possible data loss resulting from code page conversion. Data loss can occur when characters in the source code page cannot be represented in the target code page. Binding your variable to the SQL_C_BINARY C type avoids these issues.

XML data is returned to the application as internally encoded data. DB2 CLI determines the encoding of the data as follows:

- If the C type is SQL_C_BINARY, DB2 CLI returns the data in the UTF-8 encoding scheme.
- If the C type is SQL_C_CHAR or SQL_C_DBCHAR, DB2 CLI returns the data in the application code page encoding scheme.
- If the C type is SQL_C_WCHAR, DB2 CLI returns the data in the UCS-2 encoding scheme.

The database server performs an implicit serialization of the data before returning it to the application. You can explicitly serialize the XML data to a specific data type by calling the XMLSERIALIZE function. Implicit serialization is recommended, however, because explicitly serializing to character types with XMLSERIALIZE can introduce encoding issues.

The following example shows how to retrieve XML data from an XML column into a binary application variable.

```
char xmlBuffer[10240];
// xmlBuffer is used to hold the retrieved XML document
integer length;

// Assume a table named dept has been created with the following statement:
// CREATE TABLE dept (id CHAR(8), deptdoc XML)

length = sizeof (xmlBuffer);
SQLExecute (hStmt, "SELECT deptdoc FROM dept WHERE id='001'", SQL_NTS);
SQLBindCol (hStmt, 1, SQL_C_BINARY, xmlBuffer, &length, NULL);
SQLFetch (hStmt);
SQLCloseCursor (hStmt);
// xmlBuffer now contains a valid XML document encoded in UTF-8
```

Inserting data

Inserting bulk data with bookmarks using SQLBulkOperations() in CLI applications

You can insert data in bulk with bookmarks using `SQLBulkOperations()`.

Before inserting bulk data with `SQLBulkOperations()`, ensure you have initialized your CLI application.

Bookmarks in DB2 CLI do not persist across cursor close operations. This means that an application cannot use bookmarks that it has stored from a previous cursor. Instead, it has to call `SQLFetch()` or `SQLFetchScroll()` to retrieve the bookmarks before updating with bookmarks.

To perform a bulk data insert using `SQLBulkOperations()`:

1. Set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE using `SQLSetStmtAttr()`.
2. Execute a query that returns a result set.
3. Set the SQL_ATTR_ROW_ARRAY_SIZE statement attribute to the number of rows you want to insert using `SQLSetStmtAttr()`.
4. Call `SQLBindCol()` to bind the data you want to insert.

   The data is bound to an array with a size equal to the value of SQL_ATTR_ROW_ARRAY_SIZE, set in the previous step.

   Note: The size of the array pointed to by the SQL_ATTR_ROW_STATUS_PTR statement attribute should either be equal to SQL_ATTR_ROW_ARRAY_SIZE or SQL_ATTR_ROW_STATUS_PTR should be a null pointer.
5. Insert the data by calling `SQLBulkOperations()` with SQL_ADD as the *Operation* argument.

   CLI will update the bound column 0 buffers with the bookmark values for the newly inserted rows. For this to occur, the application must have set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE before executing the statement.

   Note: If `SQLBulkOperations()` is called with an *Operation* argument of SQL_ADD on a cursor that contains duplicate columns, an error is returned.

Importing data with the CLI LOAD utility in CLI applications

The CLI LOAD functionality provides an interface to the IBM DB2 LOAD utility from CLI. This functionality allows you to insert data in CLI using LOAD instead

of array insert. This option can yield significant performance benefits when large amounts of data need to be inserted. Because this interface invokes LOAD, the same consideration given for using LOAD should also be taken into account when using the CLI LOAD interface.

Before importing data with the CLI LOAD utility, ensure you have initialized your CLI application.

- Unlike the IBM DB2 LOAD utility, the CLI LOAD utility does not load data directly from an input file. Instead, if desired, the application should retrieve the data from the input file and insert it into the appropriate application parameters that correspond to the parameter markers in the prepared statement.
- If the prepared SQL statement for inserting data contains a SELECT clause, parameter markers are not supported.
- The prepared SQL statement for inserting data must include parameter markers for all columns in the target table, unless a fullselect is used instead of the VALUES clause in the INSERT statement.
- The insertion of data is non-atomic because the load utility precludes atomicity. LOAD might not be able to successfully insert all the rows passed to it. For example, if a unique key constraint is violated by a row being inserted, LOAD will not insert this row but will continue loading the remaining rows.
- A COMMIT will be issued by LOAD. Therefore, if the insertion of the data completes successfully, the LOAD and any other statements within the transaction cannot be rolled back.
- The error reporting for the CLI LOAD interface differs from that of array insert. Non-severe errors or warnings, such as errors with specific rows, will only appear in the LOAD message file.

To import data using the CLI LOAD utility:

1. Specify the statement attribute SQL_ATTR_USE_LOAD_API in `SQLSetStmtAttr()` with one of the following supported values:

   SQL_USE_LOAD_INSERT
   Use the LOAD utility to append to existing data in the table.

   SQL_USE_LOAD_REPLACE
   Use the LOAD utility to replace existing data in the table.

   For example, the following call indicates that the CLI LOAD utility will be used to add to the existing data in the table:

   ```
   SQLSetStmtAttr (hStmt, SQL_ATTR_USE_LOAD_API,
                   (SQLPOINTER) SQL_USE_LOAD_INSERT, 0);
   ```

   Note: When SQL_USE_LOAD_INSERT or SQL_USE_LOAD_REPLACE is set, no other CLI functions except for the following can be called until SQL_USE_LOAD_OFF is set (see Step 3 below):

   - SQLBindParameter()
   - SQLExecute()
   - SQLExtendedBind()
   - SQLParamOptions()
   - SQLSetStmtAttr()

2. Create a structure of type db2LoadStruct and specify the desired load options through this structure. Set the SQL_ATTR_LOAD_INFO statement attribute to a pointer to this structure.

3. Issue SQLExecute() on the prepared SQL statement for the data to be inserted. The INSERT SQL statement can be a fullselect which allows data to be loaded from a table using the SELECT statement. With a single execution of the INSERT statement, all of the data from the SELECT is loaded. The following example shows how a fullselect statement loads data from one table into another:

```
SQLPrepare (hStmt,
            (SQLCHAR *) "INSERT INTO tableB SELECT * FROM tableA",
     SQL_NTS);
SQLExecute (hStmt);
```

4. Call SQLSetStmtAttr() with SQL_USE_LOAD_OFF. This ends the processing of data using the LOAD utility. Subsequently, regular CLI array insert will be in effect until SQL_ATTR_USE_LOAD_API is set again (see Step 1).
5. Optional: Query the results of the completed CLI LOAD operation by calling SQLGetStmtAttr() with any of the following statement attributes:
   - SQL_ATTR_LOAD_ROWS_COMMITTED_PTR: A pointer to an integer that represents the total number of rows processed. This value equals the number of rows successfully loaded and committed to the database, plus the number of skipped and rejected rows.
   - SQL_ATTR_LOAD_ROWS_DELETED_PTR: A pointer to an integer that represents the number of duplicate rows deleted.
   - SQL_ATTR_LOAD_ROWS_LOADED_PTR: A pointer to an integer that represents the number of rows loaded into the target table.
   - SQL_ATTR_LOAD_ROWS_READ_PTR: A pointer to an integer that represents the number of rows read.
   - SQL_ATTR_LOAD_ROWS_REJECTED_PTR: A pointer to an integer that represents the number of rows that could not be loaded.
   - SQL_ATTR_LOAD_ROWS_SKIPPED_PTR: A pointer to an integer that represents the number of rows skipped before the CLI LOAD operation began.

XML column inserts and updates in CLI applications

When you update or insert data into XML columns of a table, the input data must be in the serialized string format.

For XML data, when you use SQLBindParameter() to bind parameter markers to input data buffers, you can specify the data type of the input data buffer as SQL_C_BINARY, SQL_C_CHAR, SQL_C_DBCHAR or SQL_C_WCHAR.

When you bind a data buffer that contains XML data as SQL_C_BINARY, DB2 CLI processes the XML data as internally encoded data. This is the preferred method because it avoids the overhead and potential data loss of character conversion when character types are used.

Important: If the XML data is encoded in an encoding scheme and CCSID other than the application code page encoding scheme, you need to include internal encoding in the data and bind the data as SQL_C_BINARY to avoid character conversion.

When you bind a data buffer that contains XML data as SQL_C_CHAR, SQL_C_DBCHAR or SQL_C_WCHAR, DB2 CLI processes the XML data as externally encoded data. DB2 CLI determines the encoding of the data as follows:

- If the C type is SQL_C_WCHAR, DB2 CLI assumes that the data is encoded as UCS-2.

- If the C type is SQL_C_CHAR or SQL_C_DBCHAR, DB2 CLI assumes that the data is encoded in the application code page encoding scheme.

If you want the database server to implicitly parse the data before storing it in an XML column, the parameter marker data type in `SQLBindParameter()` should be specified as SQL_XML.

Implicit parsing is recommended, because explicit parsing of a character type with XMLPARSE can introduce encoding issues.

The following example shows how to update XML data in an XML column using the recommended SQL_C_BINARY type.

```
char xmlBuffer[10240];
integer length;

// Assume a table named dept has been created with the following statement:
// CREATE TABLE dept (id CHAR(8), deptdoc XML)

// xmlBuffer contains an internally encoded XML document that is to replace
// the existing XML document
length = strlen (xmlBuffer);
SQLPrepare (hStmt, "UPDATE dept SET deptdoc = ? WHERE id = '001'", SQL_NTS);
SQLBindParameter (hStmt, 1, SQL_PARAM_INPUT, SQL_C_BINARY, SQL_XML, 0, 0,
                  xmlBuffer, 10240, &length);
SQLExecute (hStmt);
```

Updating and deleting data in CLI applications

Updating and deleting data is part of the larger task of processing transactions in CLI. There are two types of update and delete operations available in CLI programming: simple and positioned. A simple update or delete operation only requires that you issue and execute the UPDATE or DELETE SQL statements as you would any other SQL statement. You could, in this case, use `SQLRowCount()` to obtain the number of rows affected by the SQL statement. Positioned updates and deletes involve modifying the data of a result set. A positioned update is the update of a column of a result set, and a positioned delete is when a row of a result set is deleted. Positioned update and delete operations require cursors to be used. This document describes how to perform positioned update and delete operations by first getting the name of the cursor associated with the result set, and then issuing and executing the UPDATE or DELETE on a second statement handle using the retrieved cursor name.

Before you perform a positioned update or delete operation, ensure that you have initialized your CLI application.

To perform a positioned update or delete operation:

1. Generate the result set that the update or delete will be performed on by issuing and executing the SELECT SQL statement.
2. Call `SQLGetCursorName()` to get the name of the cursor, using the same statement handle as the handle that executed the SELECT statement. This cursor name will be needed in the UPDATE or DELETE statement.

   When a statement handle is allocated, a cursor name is automatically generated. You can define your own cursor name using `SQLSetCursorName()`, but it is recommended that you use the name that is generated by default because all error messages will reference the generated name, not the name defined using `SQLSetCursorName()`.

3. Allocate a second statement handle that will be used to execute the positioned update or delete.

   To update a row that has been fetched, the application uses two statement handles, one for the fetch and one for the update. You cannot reuse the fetch statement handle to execute the positioned update or delete, because it is still in use when the positioned update or delete is executing.
4. Fetch data from the result set by calling `SQLFetch()` or `SQLFetchScroll()`.
5. Issue the UPDATE or DELETE SQL statement with the WHERE CURRENT of clause and specify the cursor name obtained in step 2. For example:

```
sprintf((char *)stmtPositionedUpdate,
        "UPDATE org SET location = 'Toronto' WHERE CURRENT of %s",
        cursorName);
```

6. Position the cursor on the row of the data fetched and execute the positioned update or delete statement.

Updating bulk data with bookmarks using SQLBulkOperations() in CLI applications

You can update data in bulk with bookmarks using `SQLBulkOperations()`.

Before updating data in bulk, ensure you have initialized your CLI application.

Bookmarks in DB2 CLI do not persist across cursor close operations. This means that an application cannot use bookmarks that it has stored from a previous cursor. Instead, it has to call `SQLFetch()` or `SQLFetchScroll()` to retrieve the bookmarks before updating with bookmarks.

To update data in bulk:

1. Set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE using `SQLSetStmtAttr()`.
2. Execute a query that returns a result set.
3. Set the SQL_ATTR_ROW_ARRAY_SIZE statement attribute to the number of rows you want to update using `SQLSetStmtAttr()`.
4. Call `SQLBindCol()` to bind the data you want to update.

   The data is bound to an array with a size equal to the value of SQL_ATTR_ROW_ARRAY_SIZE, set in the previous step.
5. Bind the bookmark column to column 0 by calling `SQLBindCol()`.
6. Copy the bookmarks for rows that you want to update into the array bound to column 0.
7. Update the data in the bound buffers.

   Note: The size of the array pointed to by the SQL_ATTR_ROW_STATUS_PTR statement attribute should either be equal to SQL_ATTR_ROW_ARRAY_SIZE or SQL_ATTR_ROW_STATUS_PTR should be a null pointer.
8. Update the data by calling `SQLBulkOperations()` with an *Operation* argument of SQL_UPDATE_BY_BOOKMARK.

   Note: If the application has set the SQL_ATTR_ROW_STATUS_PTR statement attribute, then it can inspect this array to see the result of the operation.
9. Optional: Verify that the update has occurred by calling `SQLBulkOperations()` with an *Operation* argument of SQL_FETCH_BY_BOOKMARK. This will fetch the data into the bound application buffers.

If data has been updated, CLI changes the value in the row status array for the appropriate rows to SQL_ROW_UPDATED.

Note: If `SQLBulkOperations()` is called with an *Operation* argument of SQL_UPDATE_BY_BOOKMARK on a cursor that contains duplicate columns, an error is returned.

Deleting bulk data with bookmarks using SQLBulkOperations() in CLI applications

You can use `SQLBulkOperations()` and bookmarks to delete data in bulk.

Before deleting data in bulk, ensure you have initialized your CLI application.

Bookmarks in DB2 CLI do not persist across cursor close operations. This means that an application cannot use bookmarks that it has stored from a previous cursor. Instead, it has to call `SQLFetch()` or `SQLFetchScroll()` to retrieve the bookmarks before updating by bookmarks.

To perform bulk deletions using bookmarks and `SQLBulkOperations()`:

1. Set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE using `SQLSetStmtAttr()`.
2. Execute a query that returns a result set.
3. Set the SQL_ATTR_ROW_ARRAY_SIZE statement attribute to the number of rows you want to delete.
4. Bind the bookmark column to column 0 by calling `SQLBindCol()`.
5. Copy the bookmarks for the rows you want to delete into the array bound to column 0.

   Note: The size of the array pointed to by the SQL_ATTR_ROW_STATUS_PTR statement attribute should either be equal to SQL_ATTR_ROW_ARRAY_SIZE, or the SQL_ATTR_ROW_STATUS_PTR statement attribute should be a null pointer.
6. Perform the deletion by calling `SQLBulkOperations()` with an *Operation* argument of SQL_DELETE_BY_BOOKMARK.

   If the application has set the SQL_ATTR_ROW_STATUS_PTR statement attribute, then it can inspect this array to see the result of the operation.

Calling stored procedures from CLI applications

CLI applications invoke stored procedures by executing the CALL procedure SQL statement. This topic describes how to call stored procedures from CLI applications.

Before calling a stored procedure, ensure that you have initialized your CLI application.

If the stored procedure being called is uncataloged, ensure that it does not call any of the CLI schema functions. Calling CLI schema functions from uncataloged stored procedures is not supported.

The CLI schema functions are: `SQLColumns()`, `SQLColumnPrivileges()`, `SQLForeignKeys()`, `SQLPrimaryKeys()`, `SQLProcedureColumns()`, `SQLProcedures()`, `SQLSpecialColumns()`, `SQLStatistics()`, `SQLTables()`, and `SQLTablePrivileges()`.

To call a stored procedure:

1. Declare application host variables corresponding to each of the IN, INOUT, and OUT parameters of the stored procedure. Ensure the application variable data types and lengths match the data types and lengths of the arguments in the stored procedure signature. DB2 CLI supports calling stored procedures with all SQL types as parameter markers.
2. Initialize the IN, INOUT, and OUT parameter application variables.
3. Issue the CALL SQL statement. For example:

   ```
   SQLCHAR *stmt = (SQLCHAR *)"CALL OUT_LANGUAGE (?)";
   ```

   For optimal performance, applications should use parameter markers for stored procedure arguments in the CALL procedure string and then bind the host variables to those parameter markers. If inbound stored procedure arguments must be specified as string literals rather than parameter markers, however, include the ODBC call escape clause delimiters { } in the CALL procedure statement. For example:

   ```
   SQLCHAR *stmt = (SQLCHAR *)"{CALL IN_PARAM (123, 'Hello World!')}";
   ```

   When string literals and the ODBC escape clause are used in a CALL procedure statement, the string literals can only be specified as IN mode stored procedure arguments. INOUT and OUT mode stored procedure arguments must still be specified using parameter markers.
4. Optional: Prepare the CALL statement by calling `SQLPrepare()`.
5. Bind each parameter of the CALL procedure statement by calling `SQLBindParameter()`.

   Note: Ensure each parameter is bound correctly (to SQL_PARAM_INPUT, SQL_PARAM_OUTPUT, or SQL_PARAM_INPUT_OUTPUT), otherwise unexpected results could occur when the CALL procedure statement is executed. This would happen, for example, if an input parameter was incorrectly bound with an *InputOutputType* of SQL_PARAM_OUTPUT.
6. Execute the CALL procedure statement using `SQLExecDirect()`, or if the CALL procedure statement was prepared in step 4, `SQLExecute()`.

   Note: If an application or thread that has invoked a stored procedure is terminated before the stored procedure completes, execution of the stored procedure will also be terminated. It is important that a stored procedure contain logic to ensure that the database is in both a consistent and desirable state if the stored procedure is terminated prematurely.
7. Check the return code of `SQLExecDirect()` or `SQLExecute()` when the function has returned to determine if any errors occurred during execution of either the CALL procedure statement or the stored procedure. If the return code is SQL_SUCCESS_WITH_INFO or SQL_ERROR, use the CLI diagnostic functions `SQLGetDiagRec()` and `SQLGetDiagField()` to determine why the error occurred.

   If a stored procedure has executed successfully, any variables bound as OUT parameters may contain data that the stored procedure has passed back to the CLI application. If applicable, the stored procedure may also return one or more result sets through non-scrollable cursors. CLI applications should process stored procedure result sets as they would process result sets generated by executing SELECT statements.

   Note: If a CLI application is unsure of the number or type of parameters in a result set returned by a stored procedure, the `SQLNumResultCols()`,

`SQLDescribeCol()`, and `SQLColAttribute()` functions can be called (in this order) on the result set to determine this information.

Once you have executed the CALL statement, you can retrieve result sets from the stored procedure if applicable.

Note:

The numeric month and day parts of a DATETYPE data type value will appear to be reversed in procedure result sets that are returned to DB2 CLI applications if the values are not returned in ISO format. For example, this can happen if a local format is used instead. To ensure that DATETYPE data type value information is correctly intepreted by a client application, the procedures should be bound to the database with a locale-independent DATETIME format such as ISO. For example:

-
```
db2set DB2_SQLROUTINE_PREPOPTS="DATETIME ISO"
```

Note:

DB2 CLI packages are automatically bound to databases when the databases are created or migrated.

DB2 CLI stored procedure commit behavior

The commit behavior of SQL statements, both in a DB2 CLI client application and in the called stored procedure running on a DB2 server, depends on the commit combinations applied in the application and the stored procedure.

The possible combinations and the resulting commit behavior are described in the following table.

Table 8. DB2 CLI Stored procedure commit behavior

CLI client	Stored procedure	Commit behavior
autocommit on	autocommit on	All successfully executed SQL statements in the stored procedure are committed, even if other SQL statements in the stored procedure fail and an error or warning SQLCODE is returned to the CALL statement.
autocommit on	autocommit off	If the stored procedure returns an SQLCODE >= 0, all successfully executed SQL statements in the stored procedure are committed. Otherwise, all SQL statements in the stored procedure are rolled back.
autocommit on	manual commit	All successfully executed SQL statements in the stored procedure that are manually committed will not be rolled back, even if an error SQLCODE is returned to the CALL statement. **Note:** If the stored procedure returns an SQLCODE >= 0, any successfully executed SQL statements in the stored procedure that occur after the last manual commit will be committed; otherwise, they will be rolled back to the manual commit point.
autocommit off	autocommit on	All successfully executed SQL statements in the stored procedure are committed and will not be rolled back, even if an error SQLCODE is returned to the CALL statement. In addition, all uncommitted and successfully executed SQL statements in the CLI client application up to and including the CALL statement are committed. **Note:** Exercise caution when using this commit combination in a multi-SQL statement client-side transaction, because the transaction cannot be fully rolled back after the CALL statement has been issued.

Table 8. DB2 CLI Stored procedure commit behavior (continued)

CLI client	Stored procedure	Commit behavior
autocommit off	autocommit off	If the stored procedure returns an SQLCODE >= 0, all successfully executed SQL statements in the stored procedure will be committed when the transaction that includes the CALL statement is committed. Otherwise, all SQL statements in the stored procedure will be rolled back when the transaction that includes the CALL statement is rolled back.
autocommit off	manual commit	All successfully executed SQL statements in the stored procedure that are manually committed will not be rolled back, even if an error SQLCODE is returned to the CALL statement. In addition, all uncommitted and successfully executed SQL statements in the CLI client application up to the CALL statement are committed. **Note:** If the stored procedure returns an SQLCODE >= 0, any successfully executed SQL statements within the stored procedure that occur after the last manual commit will be committed; otherwise, they will be rolled back to the manual commit point. **Note:** Exercise caution when using this commit combination in a multi-SQL statement client-side transaction, because the transaction cannot be fully rolled back after the CALL statement has been issued.

Creating static SQL with CLI/ODBC/JDBC Static Profiling

The CLI/ODBC/JDBC Static Profiling feature enables an application's end users to replace the use of dynamic SQL with static SQL, potentially resulting in runtime performance improvement and better security from the package-based authorization mechanism.

- When executing an application with pre-bound static SQL statements, dynamic registers that control the dynamic statement behavior will have no effect on the statements that are converted to static.
- If an application issues DDL (data definition language) statements for objects that are referenced in subsequent DML (data manipulation language) statements, you will find all of these statements in the capture file. The CLI/ODBC/JDBC Static Profiling Bind Tool, db2cap, will attempt to bind them. The bind attempt will be successful with DBMSs that support the VALIDATE(RUN) bind option, but it will fail with ones that do not. In this case, the application should not use Static Profiling.
- The database administrator (DBA) may edit the capture file to add, change, or remove SQL statements, based on application-specific requirements.

Before running the application during the profiling session, ensure that the following conditions have been noted:

- An SQL statement must have successfully executed (generated a positive SQLCODE) for it to be captured in a profiling session. In a statement matching session, unmatched dynamic statements will continue to execute as dynamic CLI/ODBC/JDBC calls.
- An SQL statement must be identical character-by-character to the one that was captured and bound to be a valid candidate for statement matching. Spaces are significant: for example, ″COL = 1″ is considered different than ″COL=1″. Use parameter markers in place of literals to improve match hits.

Be aware that there are times when not all dynamic CLI/ODBC calls can be captured and grouped into a static package. Possible reasons are:

- The application does not regularly free environment handles. During a capture session, statements captured under a particular environment handle are only written to the capture file or files when that environment handle is freed.
- The application has complex control flows that make it difficult to cover all runtime conditions in a single application run.
- The application executes SET statements to change register variables. These statements are not recorded. Note that there is a limited capability in match mode to detect dynamic SET SQLID and SET SCHEMA statements, and suspend executing static statements accordingly. However, for other SET statements, subsequent SQL statements which depend on the register variables being set may not behave properly.
- The application issues DML (Data Manipulation Language) statements. Depending on application complexities and the nature of these statements, either: (1) they may not be matched, or (2) they may not execute properly at runtime.

Since dynamic and static SQL are quite different, the DBA should always verify the behaviour of the application in static match mode before making it available to end users. Furthermore, while static SQL may offer improved runtime performance over dynamic SQL, this is not necessarily true for all statements. If testing shows that static execution decreases performance for a particular statement, the DBA can force that statement to be dynamically executed by removing the statement from the capture file. In addition, static SQL, unlike dynamic SQL, may require occasional rebinding of packages to maintain performance, particularly if the database objects referred to in the packages frequently change. If CLI/ODBC/JDBC Static Profiling does not fit the type of application you are running, there are other programming methods which allow you to obtain the benefits of static SQL, such as embedded SQL and stored procedures.

To create static SQL statements from existing dynamic SQL statements, perform the following steps:

1. Profile the application by capturing all the dynamic SQL statements issued by the application. This process is known as running the application in static capture mode. To turn on static capture mode, set the following CLI/ODBC configuration keywords for the CLI/ODBC/JDBC data source in the db2cli.ini configuration file, before running the application:
   - `StaticMode = CAPTURE`
   - `StaticPackage = qualified package name`
   - `StaticCapFile = capture file name`

   For example:

   ```
   [DSN1]
   StaticMode = CAPTURE
   StaticPackage = MySchema.MyPkg
   StaticCapFile = E:\Shared\MyApp.cpt
   ```

   Attention: For the `StaticPackage` keyword, ensure that you specify a schema name (MySchema in the sample above). If a schema is not specified, the name you provide will be considered to be the container name instead of the package name, and the package name will be blank.

   The resulting static profile takes the form of a text-based *capture file*, containing information about the SQL statements captured.

   The above example file yields the following results: Data Source Name 1 (DSN1) is set to capture mode; the package will be named `MySchema.MyPkg`; and the capture file, `MyApp.cpt`, will be saved in the `E:\Shared\` directory. Until the

StaticMode keyword is changed to a value other than CAPTURE, such as DISABLED which is used to turn off static capture mode, each subsequent run of this application will capture SQL statements and append them to the capture file MyApp.cpt. Only unique SQL statements will be captured however, as duplicate executions are ignored.

2. Optional: Set the CLI/ODBC configuration keyword StaticLogFile to generate a CLI/ODBC/JDBC Static Profiling log file. It contains useful information to determine the state of the statement capturing process.
3. Run the application. Unique SQL statements will now be captured in the capture file. Duplicate statements are ignored.
4. Disable static capture mode by setting the CLI/ODBC configuration keyword StaticMode to DISABLED, or remove the keywords set in the first step from the db2cli.ini file.
5. Issue the db2cap command from the Command Line Processor. The db2cap utility will generate a static package based on the capture file. If the db2cap utility does not return a message indicating successful completion, then a statement in the capture file could not be statically bound. The DBA should remove the failing statement from the capture file and run the db2cap utility again.
6. Distribute a copy of the capture file, processed with db2cap to each end user of the application. If all users reside on the same client platform, an alternative is to place a read-only copy of this capture file in a network directory accessible to all users.
7. Enable your application for dynamic-to-static SQL statement mapping, known as static match mode. Do this by setting the following configuration keywords:
   - `StaticMode = MATCH`
   - `StaticCapFile = capture file name`

   For example:

   ```
   [DSN1]
   StaticMode = MATCH
   StaticCapFile = E:\Shared\MyApp.cpt
   ```
8. Optional: Set the CLI/ODBC configuration keyword StaticLogFile keyword to log useful information such as how many statements were matched (therefore statically executed) and how many statements were unmatched (therefore dynamically executed) during a match session. The DBA should use this information to verify that static profiling in match mode is yielding an acceptable match ratio before making static profiling available to end users.
9. Run the application.

Capture file for CLI/ODBC/JDBC Static Profiling

The capture file generated during static profiling is a text file. It contains the text of SQL statements and other associated information obtained in static capture mode. As well, it keeps track of a number of configurable bind options; some already contain specific values obtained from the capture run, and some are left blank, in which case the precompiler will use default values during package binding. Before binding the package(s), the DBA may want to examine the capture file and make necessary changes to these bind options using a text editor.

To help you understand how to edit SQL statements, here is the description of the fields in a statement:

Field	Description
SQLID	If present, indicates the SCHEMA or SQLID when the statement was captured is different from the default QUALIFIER of the package(s).
SECTNO	Section number of the static package that the statement was bound to.
ISOLATION	Isolation level for the statement. It determines which one of the five possible package the statement belongs to.
STMTTEXT	Statement string
STMTTYPE	There are 3 possible values: • SELECT_CURSOR_WITHHOLD: SELECT statement using a withhold cursor • SELECT_CURSOR_NOHOLD: SELECT statement using a nohold cursor • OTHER: non-SELECT statements
CURSOR	Cursor name declared for the SELECT statement
INVARnn	Description of the n-th input variable The 7 comma-separated fields refer to: 1. SQL data type 2. Length of the data. For decimal or floating point types, this is the precision. 3. For decimal or floating point types only, this is the scale. 4. TRUE if the character data is a for-bit-data type; otherwise FALSE. 5. TRUE if the variable is nullable; otherwise FALSE. 6. Column name 7. SQL_NAMED if this variable refers to a real column name; SQL_UNNAMED if the variable is a system-generate name.
OUTVARn	Description of the n-th output variable for the SELECT statement. The comma-separated fields follow the same convention as in INVARs.

Considerations for mixing embedded SQL and DB2 CLI

It is possible, and sometimes desirable, to use DB2 CLI in conjunction with embedded static SQL in an application. Consider the scenario where the application developer wishes to take advantage of the ease of use provided by the DB2 CLI catalog functions and maximize the portion of the application's processing where performance is critical. In order to mix the use of DB2 CLI and embedded SQL, the application must comply with the following rules:

- All connection management and transaction management must be performed completely using either DB2 CLI or embedded SQL - never a mixture of the two. Two options are available to the application:
  - it performs all connects and commits/rollbacks using DB2 CLI calls, and then calls functions written using embedded SQL;
  - or it performs all connects and commits/rollbacks using embedded SQL, and then calls functions that use DB2 CLI APIs, notably, a null connection.

- Query statement processing cannot straddle DB2 CLI and embedded SQL interfaces for the same statement. For example, the application cannot open a cursor using embedded SQL, and then call the DB2 CLI `SQLFetch()` function to retrieve row data.

Since DB2 CLI permits multiple connections, the `SQLSetConnection()` function must be called prior to executing any embedded SQL. This allows the application to explicitly specify the connection under which the embedded SQL processing is performed.

If the DB2 CLI application is multithreaded and also makes embedded SQL calls or DB2 API calls, then each thread must have a DB2 context.

Freeing statement resources in CLI applications

After a transaction has completed, end the processing for each statement handle by freeing the resources associated with it.

There are four main tasks that are involved with freeing resources for a statement handle:

- close the open cursor
- unbind the column bindings
- unbind the parameter bindings
- free the statement handle

There are two ways you can free statement resources: using `SQLFreeHandle()` or `SQLFreeStmt()`.

Before you can free statement resources, you must have initialized your CLI application and allocated a statement handle.

To free statement resources with `SQLFreeHandle()`, call `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_STMT and the handle you want to free. This will close any open cursor associated with this statement handle, unbind column and parameter bindings, and free the statement handle. This invalidates the statement handle. You do not need to explicitly carry out each of the four tasks listed above.

To free statement resources with SQLFreeStmt(), you need to call SQLFreeStmt() for each task (depending on how the application was implemented, all of these tasks may not be necessary):

- To close the open cursor, call `SQLCloseCursor()`, or call `SQLFreeStmt()` with the SQL_CLOSE *Option* and statement handle as arguments. This closes the cursor and discards any pending results.
- To unbind column bindings, call `SQLFreeStmt()` with an *Option* of SQL_UNBIND and the statement handle. This unbinds all columns for this statement handle except the bookmark column.
- To unbind parameter bindings, call `SQLFreeStmt()` with an *Option* of SQL_RESET_PARAMS and the statement handle. This releases all parameter bindings for this statement handle.
- To free the statement handle, call `SQLFreeStmt()` with an *Option* of SQL_DROP and the statement handle to be freed. This invalidates this statement handle.

Note: Although this option is still supported, we recommend that you use `SQLFreeHandle()` in your DB2 CLI applications so that they conform to the latest standards.

Handle freeing in CLI applications

Environment handle

Prior to calling `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_ENV, an application must call `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_DBC for all connections allocated under the environment. Otherwise, the call to `SQLFreeHandle()` returns SQL_ERROR and the environment remains valid, as well as any connection associated with that environment.

Connection handle

If a connection is open on the handle, an application must call `SQLDisconnect()` for the connection prior to calling `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_DBC. Otherwise, the call to `SQLFreeHandle()` returns SQL_ERROR and the connection remains valid.

Statement handle

A call to `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_STMT frees all resources that were allocated by a call to `SQLAllocHandle()` with a *HandleType* of SQL_HANDLE_STMT. When an application calls `SQLFreeHandle()` to free a statement that has pending results, the pending results are discarded. When an application frees a statement handle, DB2 CLI frees all the automatically generated descriptors associated with that handle.

Note that `SQLDisconnect()` automatically drops any statements and descriptors open on the connection.

Descriptor Handle

A call to `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_DESC frees the descriptor handle in *Handle*. The call to `SQLFreeHandle()` does not release any memory allocated by the application that may be referenced by the deferred fields (SQL_DESC_DATA_PTR, SQL_DESC_INDICATOR_PTR, and SQL_DESC_OCTET_LENGTH_PTR) of any descriptor record of *Handle*. When an explicitly allocated descriptor handle is freed, all statements that the freed handle had been associated with revert to their automatically allocated descriptor handle.

Note that `SQLDisconnect()` automatically drops any statements and descriptors open on the connection. When an application frees a statement handle, DB2 CLI frees all the automatically generated descriptors associated with that handle.

Chapter 6. Terminating a CLI application

After you have initialized your CLI application and processed transactions, you must terminate the application to properly disconnect from the data source and free resources.

Before terminating your application, you should have initialized your CLI application and completed processing of all transactions.

To terminate a CLI application:

1. Disconnect from the data source by calling `SQLDisconnect()`.
2. Free the connection handle by calling `SQLFreeHandle()` with a *HandleType* argument of SQL_HANDLE_DBC.

   If multiple database connections exist, repeat steps 1 - 2 until all connections are closed and connection handles freed.
3. Free the environment handle by calling `SQLFreeHandle()` with a *HandleType* argument of SQL_HANDLE_ENV.

Chapter 7. Descriptors in CLI applications

DB2 CLI stores information (data types, size, pointers, and so on) about columns in a result set, and parameters in an SQL statement. The bindings of application buffers to columns and parameters must also be stored. *Descriptors* are a logical view of this information, and provide a way for applications to query and update this information.

Many CLI functions make use of descriptors, but the application itself does not need to manipulate them directly.

For instance:

- When an application binds column data using `SQLBindCol()`, descriptor fields are set that completely describe the binding.
- A number of statement attributes correspond to the header fields of a descriptor. In this case you can achieve the same effect calling `SQLSetStmtAttr()` as calling the corresponding function `SQLSetDescField()` that sets the values in the descriptor directly.

Although no database operations require direct access to descriptors, there are situations where working directly with the descriptors will be more efficient or result in simpler code. For instance, a descriptor that describes a row fetched from a table can then be used to describe a row inserted back into the table.

There are four types of descriptors:

Application Parameter Descriptor (APD)
: Describes the application buffers (pointers, data types, scale, precision, length, maximum buffer length, and so on) that are bound to parameters in an SQL statement. If the parameters are part of a CALL statement they may be input, output, or both. This information is described using the application's C data types.

Application Row Descriptor (ARD)
: Describes the application buffers bound to the columns. The application may specify different data types from those in the implementation row descriptor (IRD) to achieve data conversion of column data. This descriptor reflects any data conversion that the application may specify.

Implementation Parameter Descriptor (IPD)
: Describes the parameters in the SQL statement (SQL type, size, precision, and so on).
  - If the parameter is used as input, this describes the SQL data that the database server will receive after DB2 CLI has performed any required conversion.
  - If the parameter is used as output, this describes the SQL data before DB2 CLI performs any required conversion to the application's C data types.

Implementation Row Descriptor (IRD)
: Describes the row of data from the result set before DB2 CLI performs any required data conversion to the application's C data types.

The only difference between the four types of descriptors described above is how they are used. One of the benefits of descriptors is that a single descriptor can be used to serve multiple purposes. For instance, a row descriptor in one statement can be used as a parameter descriptor in another statement.

As soon as a descriptor exists, it is either an application descriptor or an implementation descriptor. This is the case even if the descriptor has not yet been used in a database operation. If the descriptor is allocated by the application using `SQLAllocHandle()` then it is an application descriptor.

Values stored in a descriptor

Each descriptor contains both header fields and record fields. These fields together completely describe the column or parameter.

Header fields

Each header field occurs once in each descriptor. Changing one of these fields affects all columns or parameters.

Many of the following header fields correspond to a statement attribute. Setting the header field of the descriptor using `SQLSetDescField()` is the same as setting the corresponding statement attribute using `SQLSetStmtAttr()`. The same holds true for retrieving the information using `SQLGetDescField()` or `SQLGetStmtAttr()`. If your application does not already have a descriptor handle allocated then it is more efficient to use the statement attribute calls instead of allocating the descriptor handle, and then using the descriptor calls.

The following is a list of the header fields:

SQL_DESC_ALLOC_TYPE
SQL_DESC_BIND_TYPE[a]
SQL_DESC_ARRAY_SIZE[a]
SQL_DESC_COUNT
SQL_DESC_ARRAY_STATUS_PTR[a]
SQL_DESC_ROWS_PROCESSED_PTR[a]
SQL_DESC_BIND_OFFSET_PTR[a]

Note:

[a] This header field corresponds to a statement attribute.

The descriptor header field SQL_DESC_COUNT is the one-based index of the highest-numbered descriptor record that contains information (and not a count of the number of columns or parameters). DB2 CLI automatically updates this field (and the physical size of the descriptor) as columns or parameters are bound and unbound. The initial value of SQL_DESC_COUNT is 0 when a descriptor is first allocated.

Descriptor records

Zero or more descriptor records are contained in a single descriptor. As new columns or parameters are bound, new descriptor records are added to the descriptor. When a column or parameter is unbound, the descriptor record is removed.

The following is a list of the fields in a descriptor record. They describe a column or parameter, and occur once in each descriptor record.

SQL_DESC_AUTO_UNIQUE_VALUE
SQL_DESC_LOCAL_TYPE_NAME
SQL_DESC_BASE_COLUMN_NAME
SQL_DESC_NAME
SQL_DESC_BASE_TABLE_NAME
SQL_DESC_NULLABLE
SQL_DESC_CASE_SENSITIVE
SQL_DESC_OCTET_LENGTH
SQL_DESC_CATALOG_NAME
SQL_DESC_OCTET_LENGTH_PTR
SQL_DESC_CONCISE_TYPE
SQL_DESC_PARAMETER_TYPE
SQL_DESC_DATA_PTR
SQL_DESC_PRECISION
SQL_DESC_DATETIME_INTERVAL_CODE
SQL_DESC_SCALE
SQL_DESC_DATETIME_INTERVAL_PRECISION
SQL_DESC_SCHEMA_NAME
SQL_DESC_DISPLAY_SIZE
SQL_DESC_SEARCHABLE
SQL_DESC_FIXED_PREC_SCALE
SQL_DESC_TABLE_NAME
SQL_DESC_INDICATOR_PTR
SQL_DESC_TYPE
SQL_DESC_LABEL
SQL_DESC_TYPE_NAME
SQL_DESC_LENGTH
SQL_DESC_UNNAMED
SQL_DESC_LITERAL_PREFIX
SQL_DESC_UNSIGNED
SQL_DESC_LITERAL_SUFFIX
SQL_DESC_UPDATABLE
SQL_DESC_CARDINALITY
SQL_DESC_CARDINALITY_PTR

Deferred fields

Deferred fields are created when the descriptor header or a descriptor record is created. The addresses of the defined variables are stored but not used until a later point in the application. The application must not deallocate or discard these variables between the time it associates them with the fields and the time CLI reads or writes them.

The following table lists the deferred fields and the meaning or a null pointer where applicable:

Table 9. Deferred fields

Field	Meaning of Null value
SQL_DESC_DATA_PTR	The record is unbound.
SQL_DESC_INDICATOR_PTR	(none)
SQL_DESC_OCTET_LENGTH_PTR (ARD and APD only)	• ARD: The length information for that column is not returned. • APD: If the parameter is a character string, the driver assumes that string is null-terminated. For output parameters, a null value in this field prevents the driver from returning length information. (If the SQL_DESC_TYPE field does not indicate a character-string parameter, the SQL_DESC_OCTET_LENGTH_PTR field is ignored.)
SQL_DESC_ARRAY_STATUS_PTR (multirow fetch only)	A multirow fetch failed to return this component of the per-row diagnostic information.
SQL_DESC_ROWS_PROCESSED_PTR (multirow fetch only)	(none)
SQL_DESC_CARDINALITY_PTR	(none)

Bound descriptor records

The SQL_DESC_DATA_PTR field in each descriptor record points to a variable that contains the parameter value (for APDs) or the column value (for ARDs). This is a deferred field that defaults to null. Once the column or parameter is bound it points to the parameter or column value. At this point the descriptor record is said to be bound.

Application Parameter Descriptors (APD)
Each bound record constitutes a bound parameter. The application must bind a parameter for each input and output parameter marker in the SQL statement before the statement is executed.

Application Row Descriptors (ARD)
Each bound record relates to a bound column.

Consistency checks for descriptors in CLI applications

A consistency check is performed automatically whenever an application sets the SQL_DESC_DATA_PTR field of the APD or ARD. The check ensures that various fields are consistent with each other, and that appropriate data types have been specified. Calling `SQLSetDescRec()` always prompts a consistency check. If any of the fields is inconsistent with other fields, `SQLSetDescRec()` will return SQLSTATE HY021, Inconsistent descriptor information.

To force a consistency check of IPD fields, the application can set the SQL_DESC_DATA_PTR field of the IPD. This setting is only used to force the consistency check. The value is not stored and cannot be retrieved by a call to `SQLGetDescField()` or `SQLGetDescRec()`.

A consistency check cannot be performed on an IRD.

Application descriptors

Whenever an application sets the SQL_DESC_DATA_PTR field of an APD, ARD, or IPD, DB2 CLI checks that the value of the SQL_DESC_TYPE field and the values applicable to that SQL_DESC_TYPE field are valid and consistent. This check is always performed when `SQLBindParameter()` or `SQLBindCol()` is called, or when `SQLSetDescRec()` is called for an APD, ARD, or IPD. This consistency check includes the following checks on application descriptor fields:

- The SQL_DESC_TYPE field must be one of the valid C or SQL types. The SQL_DESC_CONCISE_TYPE field must be one of the valid C or SQL types.
- If the SQL_DESC_TYPE field indicates a numeric type, the SQL_DESC_PRECISION and SQL_DESC_SCALE fields are verified to be valid.
- If the SQL_DESC_CONCISE_TYPE field is a time data type the SQL_DESC_PRECISION field is verified to be a valid seconds precision.

The SQL_DESC_DATA_PTR field of an IPD is not normally set; however, an application can do so to force a consistency check of IPD fields. A consistency check cannot be performed on an IRD. The value that the SQL_DESC_DATA_PTR field of the IPD is set to is not actually stored, and cannot be retrieved by a call to `SQLGetDescField()` or `SQLGetDescRec()`; the setting is made only to force the consistency check.

Descriptor allocation and freeing

Descriptors are allocated in one of two ways:

Implicitly allocated descriptors

When a statement handle is allocated, a set of four descriptors are implicitly allocated. When the statement handle is freed, all implicitly allocated descriptors on that handle are freed as well.

To obtain handles to these implicitly allocated descriptors an application can call `SQLGetStmtAttr()`, passing the statement handle and an *Attribute* value of:

- SQL_ATTR_APP_PARAM_DESC (APD)
- SQL_ATTR_APP_ROW_DESC (ARD)
- SQL_ATTR_IMP_PARAM_DESC (IPD)
- SQL_ATTR_IMP_ROW_DESC (IRD)

For example, the following gives access to the statement's implicitly allocated implementation parameter descriptor:

```
/* dbuse. c */
/* ... */
sqlrc = SQLGetStmtAttr ( hstmt,
                         SQL_ATTR_IMP_PARAM_DESC,
                         &hIPD,
                         SQL_IS_POINTER,
                         NULL);
```

Note: The descriptors whose handles are obtained in this manner will still be freed when the statement for which they were allocated is freed.

Explicitly allocated descriptors

An application can explicitly allocate application descriptors. It is not possible, however, to allocate implementation descriptors.

An application descriptor can be explicitly allocated any time the application is connected to the database. To explicitly allocate the

application descriptor, call SQLAllocHandle() with a *HandleType* of SQL_HANDLE_DESC. For example, the following call explicitly allocates an application row descriptor:

```
rc = SQLAllocHandle( SQL_HANDLE_DESC, hdbc, &hARD ) ;
```

To use an explicitly allocated application descriptor instead of a statement's implicitly allocated descriptor, call SQLSetStmtAttr(), and pass the statement handle, the descriptor handle, and an *Attribute* value of either:

- SQL_ATTR_APP_PARAM_DESC (APD), or
- SQL_ATTR_APP_ROW_DESC (ARD)

When there are explicitly and implicitly allocated descriptors, the explicitly specified one is used. An explicitly allocated descriptor can be associated with more than one statement.

Field initialization

When an application row descriptor is allocated, its fields are initialized to the values listed in the descriptor header and record field initialization values documentation. The SQL_DESC_TYPE field is set to SQL_DEFAULT which provides for a standard treatment of database data for presentation to the application. The application may specify different treatment of the data by setting fields of the descriptor record.

The initial value of the SQL_DESC_ARRAY_SIZE header field is 1. To enable multirow fetch, the application can set this value in an ARD to the number of rows in a rowset.

There are no default values for the fields of an IRD. The fields are set when there is a prepared or executed statement.

The following fields of an IPD are undefined until a call to SQLPrepare() automatically populates them:

- SQL_DESC_CASE_SENSITIVE
- SQL_DESC_FIXED_PREC_SCALE
- SQL_DESC_TYPE_NAME
- SQL_DESC_DESC_UNSIGNED
- SQL_DESC_LOCAL_TYPE_NAME

Automatic population of the IPD

There are times when the application will need to discover information about the parameters of a prepared SQL statement. A good example is when a dynamically generated query is prepared; the application will not know anything about the parameters in advance. If the application enables automatic population of the IPD, by setting the SQL_ATTR_ENABLE_AUTO_IPD statement attribute to SQL_TRUE (using SQLSetStmtAttr()), then the fields of the IPD are automatically populated to describe the parameter. This includes the data type, precision, scale, and so on (the same information that SQLDescribeParam() returns). The application can use this information to determine if data conversion is required, and which application buffer is the most appropriate to bind the parameter to.

Automatic population of the IPD involves some overhead. If it is not necessary for this information to be automatically gathered by the CLI driver then the SQL_ATTR_ENABLE_AUTO_IPD statement attribute should be set to SQL_FALSE.

When automatic population of the IPD is active, each call to SQLPrepare() causes the fields of the IPD to be updated. The resulting descriptor information can be retrieved by calling the following functions:

- SQLGetDescField()
- SQLGetDescRec()
- SQLDescribeParam()

Freeing of descriptors

Explicitly allocated descriptors

When an explicitly allocated descriptor is freed, all statement handles to which the freed descriptor applied automatically revert to the original descriptors implicitly allocated for them.

Explicitly allocated descriptors can be freed in one of two ways:

- by calling SQLFreeHandle()with a *HandleType* of SQL_HANDLE_DESC
- by freeing the connection handle that the descriptor is associated with

Implicitly allocated descriptors

An implicitly allocated descriptor can be freed in one of the following ways:

- by calling SQLDisconnect() which drops any statements or descriptors open on the connection
- by calling SQLFreeHandle() with a *HandleType* of SQL_HANDLE_STMT to free the statement handle and all of the implicitly allocated descriptors associated with the statement

An implicitly allocated descriptor cannot be freed by calling SQLFreeHandle() with a *HandleType* of SQL_HANDLE_DESC.

Descriptor manipulation with descriptor handles in CLI applications

Descriptors can be manipulated using descriptor handles or with DB2 CLI functions that do not use descriptor handles. This topic describes accessing descriptors through descriptor handles. The handle of an explicitly allocated descriptor is returned in the *OutputHandlePtr* argument when the application calls SQLAllocHandle() to allocate the descriptor. The handle of an implicitly allocated descriptor is obtained by calling SQLGetStmtAttr() with either SQL_ATTR_IMP_PARAM_DESC or SQL_ATTR_IMP_ROW_DESC.

Retrieval of descriptor field values

The DB2 CLI function SQLGetDescField() can be used to obtain a single field of a descriptor record. SQLGetDescRec() retrieves the settings of multiple descriptor fields that affect the data type and storage of column or parameter data.

Setting of descriptor field values

Two methods are available for setting descriptor fields: one field at a time or multiple fields at once.

Setting of individual fields

Some fields of a descriptor are read-only, but others can be set using the function SQLSetDescField(). Refer to the list of header and record fields in the descriptor FieldIdentifier values documentation.

Record and header fields are set differently using SQLSetDescField() as follows:

Header fields
The call to SQLSetDescField() passes the header field to be set and a record number of 0. The record number is ignored since there is only one header field per descriptor. In this case the record number of 0 does not indicate the bookmark field.

Record fields
The call to SQLSetDescField() passes the record field to be set and a record number of 1 or higher, or 0 to indicate the bookmark field.

The application must follow the sequence of setting descriptor fields described in the SQLSetDescField() documentation when setting individual fields of a descriptor. Setting some fields will cause DB2 CLI to automatically set other fields. A consistency check will take place after the application follows the defined steps. This will ensure that the values in the descriptor fields are consistent.

If a function call that would set a descriptor fails, the content of the descriptor fields are undefined after the failed function call.

Setting of multiple fields

A predefined set of descriptor fields can be set with one call rather than setting individual fields one at a time. SQLSetDescRec() sets the following fields for a single column or parameter:

- SQL_DESC_TYPE
- SQL_DESC_OCTET_LENGTH
- SQL_DESC_PRECISION
- SQL_DESC_SCALE
- SQL_DESC_DATA_PTR
- SQL_DESC_OCTET_LENGTH_PTR
- SQL_DESC_INDICATOR_PTR

(SQL_DESC_DATETIME_INTERVAL_CODE is also defined by ODBC but is not supported by DB2 CLI.)

For example, all of the descriptor fields listed above are set with the following call:

```
/* dbuse.c */
/* ... */
rc = SQLSetDescRec(hARD, 1, type, 0,
                   length, 0, 0, &id_no, &datalen, NULL);
```

Copying of descriptors

One benefit of descriptors is the fact that a single descriptor can be used for multiple purposes. For instance, an ARD on one statement handle can be used as an APD on another statement handle.

There will be other instances, however, where the application will want to make a copy of the original descriptor, then modify certain fields. In this case SQLCopyDesc() is used to overwrite the fields of an existing descriptor with the values from another descriptor. Only fields that are defined for both the source and target descriptors are copied (with the exception of the SQL_DESC_ALLOC_TYPE field which cannot be changed).

Fields can be copied from any type of descriptor, but can only be copied to an application descriptor (APD or ARD) or an IPD. Fields cannot be copied to an IRD. The descriptor's allocation type will not be changed by the copy procedure (again, the SQL_DESC_ALLOC_TYPE field cannot be changed).

Descriptor manipulation without using descriptor handles in CLI applications

Many CLI functions make use of descriptors, but the application itself does not need to manipulate them directly. Instead, the application can use a different function which will set or retrieve one or more fields of a descriptor as well as perform other functions. This category of CLI functions is called *concise* functions. `SQLBindCol()` is an example of a concise function that manipulates descriptor fields.

In addition to manipulating multiple fields, concise functions are called without explicitly specifying the descriptor handle. The application does not even need to retrieve the descriptor handle to use a concise function.

The following types of concise functions exist:

- The functions `SQLBindCol()` and `SQLBindParameter()` bind a column or parameter by setting the descriptor fields that correspond to their arguments. These functions also perform other tasks unrelated to descriptors.

  If required, an application can also use the descriptor calls directly to modify individual details of a binding. In this case the descriptor handle must be retrieved, and the functions `SQLSetDescField()` or `SQLSetDescRec()` are called to modify the binding.
- The following functions always retrieve values in descriptor fields:
  - `SQLColAttribute()`
  - `SQLDescribeCol()`
  - `SQLDescribeParam()`
  - `SQLNumParams()`
  - `SQLNumResultCols()`
- The functions `SQLSetDescRec()` and `SQLGetDescRec()` set or get the multiple descriptor fields that affect the data type and storage of column or parameter data. A single call to `SQLSetDescRec()` can be used to change the values used in the binding of a column or parameter.
- The functions `SQLSetStmtAttr()` and `SQLGetStmtAttr()` modify or return descriptor fields in some cases, depending on which statement attribute is specified. Refer to the ″Values Stored in a Descriptor″ section of the descriptors documentation for more information.

Chapter 8. Diagnostics in CLI applications overview

Diagnostics refers to dealing with warning or error conditions generated within an application. There are two levels of diagnostics returned when calling DB2 CLI functions:

- return codes
- detailed diagnostics (SQLSTATEs, messages, SQLCA)

Each CLI function returns the function return code as a basic diagnostic. Both `SQLGetDiagRec()` and `SQLGetDiagField()` provide more detailed diagnostic information. If the diagnostic originates at the DBMS, the `SQLGetSQLCA()` function provides access to the SQLCA. This arrangement lets applications handle the basic flow control based on return codes, and use the SQLSTATES along with the SQLCA to determine the specific causes of failure and to perform specific error handling.

Both `SQLGetDiagRec()` and `SQLGetDiagField()` return three pieces of information:

- SQLSTATE
- Native error: if the diagnostic is detected by the data source, this is the SQLCODE; otherwise, this is set to -99999.
- Message text: this is the message text associated with the SQLSTATE.

`SQLGetSQLCA()` returns the SQLCA for access to specific fields, but should only be used when `SQLGetDiagRec()` or `SQLGetDiagField()` cannot provide the desired information.

CLI function return codes

The following table lists all possible return codes for DB2 CLI functions.

Table 10. DB2 CLI Function return codes

Return code	Explanation
SQL_SUCCESS	The function completed successfully, no additional SQLSTATE information is available.
SQL_SUCCESS_WITH_INFO	The function completed successfully with a warning or other information. Call `SQLGetDiagRec()` or `SQLGetDiagField()` to receive the SQLSTATE and any other informational messages or warnings. The SQLSTATE will have a class of '01'.
SQL_STILL_EXECUTING	The function is running asynchronously and has not yet completed. The DB2 CLI driver has returned control to the application after calling the function, but the function has not yet finished executing.
SQL_NO_DATA_FOUND	The function returned successfully, but no relevant data was found. When this is returned after the execution of an SQL statement, additional information may be available and can be obtained by calling `SQLGetDiagRec()` or `SQLGetDiagField()`.

Table 10. DB2 CLI Function return codes (continued)

Return code	Explanation
SQL_NEED_DATA	The application tried to execute an SQL statement but DB2 CLI lacks parameter data that the application had indicated would be passed at execute time.
SQL_ERROR	The function failed. Call `SQLGetDiagRec()` or `SQLGetDiagField()` to receive the SQLSTATE and any other error information.
SQL_INVALID_HANDLE	The function failed due to an invalid input handle (environment, connection or statement handle). This is a programming error. No further information is available.

The following code segment shows how a function return code, SQL_NO_DATA_FOUND, can be used to control when data retrieval should stop:

```
while (cliRC != SQL_NO_DATA_FOUND)
{
  printf(" %-8d %-14.14s \n", deptnumb.val, location.val);
  /* fetch next row */
  cliRC = SQLFetch(hstmt);
  STMT_HANDLE_CHECK(hstmt, hdbc, cliRC);
}
```

SQLSTATES for DB2 CLI

SQLSTATEs are alphanumeric strings of 5 characters (bytes) with a format of `ccsss`, where `cc` indicates class and `sss` indicates subclass. Any SQLSTATE that has a class of:

- '01', is a warning.
- 'HY', is generated by the DB2 CLI or ODBC driver.
- 'IM', is generated by the ODBC driver manager.

Note: Versions of DB2 CLI before Version 5 returned SQLSTATEs with a class of 'S1' rather than 'HY'. To force the CLI driver to return 'S1' SQLSTATEs, the application should set the environment attribute SQL_ATTR_ODBC_VERSION to the value SQL_OV_ODBC2.

DB2 CLI SQLSTATEs include both additional IBM defined SQLSTATEs that are returned by the database server, and DB2 CLI defined SQLSTATEs for conditions that are not defined in the ODBC version 3 and ISO SQL/CLI specifications. This allows for the maximum amount of diagnostic information to be returned. When running applications in an ODBC environment, it is also possible to receive ODBC defined SQLSTATEs.

Follow these guidelines for using SQLSTATEs within your application:

- Always check the function return code before calling `SQLGetDiagRec()` to determine if diagnostic information is available.
- Use the SQLSTATEs rather than the native error code.
- To increase your application's portability, only build dependencies on the subset of DB2 CLI SQLSTATEs that are defined by the ODBC version 3 and ISO SQL/CLI specifications, and return the additional ones as information only. A dependency in an application is a logic flow decision based on specific SQLSTATEs.

Note: It may be useful to build dependencies on the class (the first 2 characters) of the SQLSTATEs.

- For maximum diagnostic information, return the text message along with the SQLSTATE (if applicable, the text message will also include the IBM defined SQLSTATE). It is also useful for the application to print out the name of the function that returned the error.
- Ensure that the string allocated for the SQLSTATE includes space for the null termination character returned by DB2 CLI.

The following code segment from `utilcli.c` shows how diagnostic information, such as SQLSTATEs, can be retrieved and displayed:

```
void HandleDiagnosticsPrint(SQLSMALLINT htype, /* handle type identifier */
                            SQLHANDLE hndl /* handle */ )
{
  SQLCHAR message[SQL_MAX_MESSAGE_LENGTH + 1];
  SQLCHAR sqlstate[SQL_SQLSTATE_SIZE + 1];
  SQLINTEGER sqlcode;
  SQLSMALLINT length, i;

  i = 1;

  /* get multiple field settings of diagnostic record */
  while (SQLGetDiagRec(htype,
                       hndl,
                       i,
                       sqlstate,
                       &sqlcode,
                       message,
                       SQL_MAX_MESSAGE_LENGTH + 1,
                       &length) == SQL_SUCCESS)
  {
    printf("\n  SQLSTATE          =
    printf("  Native Error Code =
    printf("
    i++;
  }

  printf("-------------------------\n");
}
```

You can use the CLI/ODBC trace facility to gain a better understanding of how your application calls DB2, including any errors that may occur.

Return codes for compound SQL in CLI applications

Return codes are generated on the call to `SQLExecute()` or `SQLExecDirect()` for the END COMPOUND statement. The following lists the return codes for ATOMIC and NOT ATOMIC compound statements:

ATOMIC

- SQL_SUCCESS: all substatements have executed without any warnings or errors.
- SQL_SUCCESS_WITH_INFO: all substatements executed successfully with one or more warnings. Call `SQLGetDiagRec()` or `SQLGetDiagField()` to retrieve additional information on the error or warning. The handle used by `SQLGetDiagRec()` or `SQLGetDiagField()` must be the same one used to process the BEGIN COMPOUND and END COMPOUND statements.

- SQL_NO_DATA_FOUND: BEGIN COMPOUND and END COMPOUND statements executed without any substatements, or none of the substatements affected any rows.
- SQL_ERROR: one or more substatements failed and all substatements were rolled back.

NOT ATOMIC

- SQL_SUCCESS: all substatements executed without any errors.
- SQL_SUCCESS_WITH_INFO: the COMPOUND statement executed with one or more warnings returned by one or more substatements. Call `SQLGetDiagRec()` or `SQLGetDiagField()` to retrieve additional information on the error or warning. The handle used by `SQLGetDiagRec()` or `SQLGetDiagField()` must be the same one used to process the BEGIN COMPOUND and END COMPOUND statements.
- SQL_NO_DATA_FOUND: the BEGIN COMPOUND and END COMPOUND statements executed without any substatements, or none of the substatements affected any rows.
- SQL_ERROR: the COMPOUND statement failed. At least one substatement returned an error. Examine the SQLCA to determine which statements failed.

CLI/ODBC/JDBC trace facility

This topic discusses the following subjects:

- DB2 CLI and DB2 JDBC trace configuration
- DB2 CLI trace options and the db2cli.ini file
- DB2 JDBC trace options and the db2cli.ini file
- DB2 CLI driver trace versus ODBC driver manager trace
- DB2 CLI driver, DB2 JDBC Type 2 Driver, and DB2 traces
- DB2 CLI and DB2 JDBC traces and CLI or Java stored procedures

The DB2 CLI and the DB2 JDBC Type 2 Driver for Linux, UNIX, and Windows offer comprehensive tracing facilities. By default, these facilities are disabled and use no additional computing resources. When enabled, the trace facilities generate one or more text log files whenever an application accesses the appropriate driver (DB2 CLI or DB2 JDBC Type 2 Driver). These log files provide detailed information about:

- the order in which CLI or JDBC functions were called by the application
- the contents of input and output parameters passed to and received from CLI or JDBC functions
- the return codes and any error or warning messages generated by CLI or JDBC functions

Note: This trace facility does not apply to the DB2 Universal JDBC Driver.

DB2 CLI and DB2 JDBC trace file analysis can benefit application developers in a number of ways. First, subtle program logic and parameter initialization errors are often evident in the traces. Second, DB2 CLI and DB2 JDBC traces might suggest ways of better tuning an application or the databases it accesses. For example, if a DB2 CLI trace shows a table being queried many times on a particular set of attributes, an index corresponding to those attributes might be created on the table

to improve application performance. Finally, analysis of DB2 CLI and DB2 JDBC trace files can help application developers understand how a third party application or interface is behaving.

DB2 CLI and DB2 JDBC trace configuration

The configuration parameters for both DB2 CLI and DB2 JDBC traces facilities are read from the DB2 CLI configuration file db2cli.ini. By default, this file is located in the \sqllib path on the Windows platform and the /sqllib/cfg path on UNIX platforms. You can override the default path by setting the DB2CLIINIPATH environment variable. On the Windows platform, an additional db2cli.ini file can be found in the user's profile (or home) directory if there are any user-defined data sources defined using the ODBC Driver Manager. This db2cli.ini file will override the default file.

To view the current db2cli.ini trace configuration parameters from the command line processor, issue the following command:

```
db2 GET CLI CFG FOR SECTION COMMON
```

There are three ways to modify the db2cli.ini file to configure the DB2 CLI and DB2 JDBC trace facilities:

- use the DB2 Configuration Assistant if it is available
- manually edit the db2cli.ini file using a text editor
- issue the UPDATE CLI CFG command from the command line processor

For example, the following command issued from the command line processor updates the db2cli.ini file and enables the JDBC tracing facility:

```
db2 UPDATE CLI CFG FOR SECTION COMMON USING jdbctrace 1
```

Note:

1. Typically the DB2 CLI and DB2 JDBC trace configuration options are only read from the db2cli.ini configuration file at the time an application is initialized. However, a special db2cli.ini trace option, TraceRefreshInterval, can be used to indicate an interval at which specific DB2 CLI trace options are reread from the db2cli.ini file.
2. The DB2 CLI tracing facility can also be configured programmatically by setting the SQL_ATTR_TRACE environment attribute. This setting will override the settings contained in the db2cli.ini file.

Important: Disable the DB2 CLI and DB2 JDBC trace facilities when they are not needed. Unnecessary tracing can reduce application performance and generate unwanted trace log files. DB2 does not delete any generated trace files and will append new trace information to any existing trace files.

DB2 CLI Trace options and the db2cli.ini file

When an application using the DB2 CLI driver begins execution, the driver checks for trace facility options in the [COMMON] section of the db2cli.ini file. These trace options are specific trace keywords that are set to certain values in the db2cli.ini file under the [COMMON] section.

Note: Because DB2 CLI trace keywords appear in the [COMMON] section of the db2cli.ini file, their values apply to all database connections through the DB2 CLI driver.

The DB2 CLI trace keywords that can be defined are:

- Trace
- TraceComm
- TraceErrImmediate
- TraceFileName
- TraceFlush
- TraceFlushOnError
- TraceLocks
- TracePathName
- TracePIDList
- TracePIDTID
- TraceRefreshInterval
- TraceStmtOnly
- TraceTime
- TraceTimeStamp

Note: DB2 CLI trace keywords are only read from the db2cli.ini file once at application initialization time unless the TraceRefreshInterval keyword is set. If this keyword is set, the Trace and TracePIDList keywords are reread from the db2cli.ini file at the specified interval and applied, as appropriate, to the currently executing application.

An example db2cli.ini file trace configuration using these DB2 CLI keywords and values is:

```
[COMMON]
trace=1
TraceFileName=\temp\clitrace.txt
TraceFlush=1
```

Note:

1. CLI trace keywords are NOT case sensitive. However, path and file name keyword values might be case-sensitive on some operating systems (such as UNIX).
2. If either a DB2 CLI trace keyword or its associated value in the db2cli.ini file is invalid, the DB2 CLI trace facility will ignore it and use the default value for that trace keyword instead.

DB2 JDBC Trace options and the db2cli.ini file

When an application using the DB2 JDBC Type 2 Driver begins execution, the driver also checks for trace facility options in the db2cli.ini file. As with the DB2 CLI trace options, DB2 JDBC trace options are specified as keyword/value pairs located under the [COMMON] section of the db2cli.ini file.

Note: Because DB2 JDBC trace keywords appear in the [COMMON] section of the db2cli.ini file, their values apply to all database connections through the DB2 JDBC Type 2 Driver.

The DB2 JDBC trace keywords that can be defined are:

- JDBCTrace
- JDBCTracePathName
- JDBCTraceFlush

JDBCTrace = 0 | 1

The JDBCTrace keyword controls whether or not other DB2 JDBC tracing keywords have any effect on program execution. Setting JDBCTrace to its default value of 0 disables the DB2 JDBC trace facility. Setting JDBCTrace to 1 enables it.

By itself, the JDBCTrace keyword has little effect and produces no trace output unless the JDBCTracePathName keyword is also specified.

JDBCTracePathName = <fully_qualified_trace_path_name>

The value of JDBCTracePathName is the fully qualified path of the directory to which all DB2 JDBC trace information is written. The DB2 JDBC trace facility attempts to generate a new trace log file each time a JDBC application is executed using the DB2 JDBC Type 2 Driver. If the application is multithreaded, a separate trace log file will be generated for each thread. A concatenation of the application process ID, the thread sequence number, and a thread-identifying string are automatically used to name trace log files. There is no default path name to which DB2 JDBC trace output log files are written.

JDBCTraceFlush = 0 | 1

The JDBCTraceFlush keyword specifies how often trace information is written to the DB2 JDBC trace log file. By default, JDBCTraceFlush is set to 0 and each DB2 JDBC trace log file is kept open until the traced application or thread terminates normally. If the application terminates abnormally, some trace information that was not written to the trace log file might be lost.

To ensure the integrity and completeness of the trace information written to the DB2 JDBC trace log file, the JDBCTraceFlush keyword can be set to 1. After each trace entry has been written to the trace log file, the DB2 JDBC driver closes the file and then reopens it, appending new trace entries to the end of the file. This guarantees that no trace information will be lost.

Note: *Each DB2 JDBC log file close and reopen operation incurs significant input/output overhead and can reduce application performance considerably*.

An example db2cli.ini file trace configuration using these DB2 JDBC keywords and values is:

```
[COMMON]
jdbctrace=1
JdbcTracePathName=\temp\jdbctrace\
JDBCTraceFlush=1
```

Note:

1. JDBC trace keywords are NOT case sensitive. However, path and file name keyword values might be case-sensitive on some operating systems (such as UNIX).
2. If either a DB2 JDBC trace keyword or its associated value in the db2cli.ini file is invalid, the DB2 JDBC trace facility will ignore it and use the default value for that trace keyword instead.
3. Enabling DB2 JDBC tracing does not enable DB2 CLI tracing. The DB2 JDBC Type 2 Driver depends on the DB2 CLI driver to access the database. Consequently, Java™ developers might also want to enable DB2 CLI tracing for additional information on how their applications interact with the database through the various software layers. DB2 JDBC and DB2 CLI trace options are

independent of each other and can be specified together in any order under the [COMMON] section of the db2cli.ini file.

DB2 CLI Driver trace versus ODBC driver manager trace

It is important to understand the difference between an ODBC driver manager trace and a DB2 CLI driver trace. An ODBC driver manager trace shows the ODBC function calls made by an ODBC application to the ODBC driver manager. In contrast, a DB2 CLI driver trace shows the function calls made by the ODBC driver manager to the DB2 CLI driver *on behalf of the application*.

An ODBC driver manager might forward some function calls directly from the application to the DB2 CLI driver. However, the ODBC driver manager might also delay or avoid forwarding some function calls to the driver. The ODBC driver manager might also modify application function arguments or map application functions to other functions before forwarding the call on to the DB2 CLI driver.

Reasons for application function call intervention by the ODBC driver manager include:

- Applications written using ODBC 2.0 functions that have been deprecated in ODBC 3.0 will have the old functions mapped to new functions.
- ODBC 2.0 function arguments deprecated in ODBC 3.0 will be mapped to equivalent ODBC 3.0 arguments.
- The Microsoft cursor library will map calls such as `SQLExtendedFetch()` to multiple calls to `SQLFetch()` and other supporting functions to achieve the same end result.
- ODBC driver manager connection pooling will usually defer `SQLDisconnect()` requests (or avoid them altogether if the connection gets reused).

For these and other reasons, application developers might find an ODBC driver manager trace to be a useful complement to the DB2 CLI driver trace.

For more information on capturing and interpreting ODBC driver manager traces, refer to the ODBC driver manager documentation. On the Windows platforms, refer to the Microsoft ODBC 3.0 Software Development Kit and Programmer's Reference, also available online at: http://www.msdn.microsoft.com/.

DB2 CLI Driver, DB2 JDBC Type 2 Driver, and DB2 traces

Internally, the DB2 JDBC Type 2 Driver makes use of the DB2 CLI driver for database access. For example, the Java getConnection() method is internally mapped by the DB2 JDBC Type 2 Driver to the DB2 CLI `SQLConnect()` function. As a result, Java developers might find a DB2 CLI trace to be a useful complement to the DB2 JDBC trace.

The DB2 CLI driver makes use of many internal and DB2 specific functions to do its work. These internal and DB2 specific function calls are logged in the DB2 trace. Application developers will not find DB2 traces useful, as they are only meant to assist IBM Service in problem determination and resolution.

DB2 CLI and DB2 JDBC traces and CLI or Java stored procedures

On all workstation platforms, the DB2 CLI and DB2 JDBC trace facilities can be used to trace DB2 CLI and DB2 JDBC stored procedures.

Most of the DB2 CLI and DB2 JDBC trace information and instructions given in earlier sections is generic and applies to both applications and stored procedures equally. However, unlike applications which are clients of a database server (and typically execute on a machine separate from the database server), stored procedures execute at the database server. Therefore, the following additional steps must be taken when tracing DB2 CLI or DB2 JDBC stored procedures:

- Ensure the trace keyword options are specified in the db2cli.ini file located at the DB2 server.
- If the TraceRefreshInterval keyword is not set to a positive, non-zero value, ensure all keywords are configured correctly prior to database startup time (that is, when the db2start command is issued). Changing trace settings while the database server is running can cause unpredictable results. For example, if the TracePathName is changed while the server is running, then the next time a stored procedure is executed, some trace files might be written to the new path, while others are written to the original path. To ensure consistency, restart the server any time a trace keyword other than Trace or TracePIDList is modified.

CLI and JDBC trace files

Applications that access the DB2 CLI and DB2 JDBC drivers can make use of the DB2 CLI and DB2 JDBC trace facilities. These utilities record all function calls made by the DB2 CLI or DB2 JDBC drivers to a log file which is useful for problem determination. This topic discusses how to access and interpret these log files generated by the tracing facilities:

- CLI and JDBC trace file location
- CLI trace file interpretation
- JDBC trace file interpretation

CLI and JDBC trace file location

If the TraceFileName keyword was used in the db2cli.ini file to specify a fully qualified file name, then the DB2 CLI trace log file will be in the location specified. If a relative file name was specified for the DB2 CLI trace log file name, the location of that file will depend on what the operating system considers to be the current path of the application.

Note: If the user executing the application does not have sufficient authority to write to the trace log file in the specified path, no file will be generated and no warning or error is given.

If either or both of the TracePathName and JDBCTracePathName keywords were used in the db2cli.ini file to specify fully qualified directories, then the DB2 CLI and DB2 JDBC trace log files will be in the location specified. If a relative directory name was specified for either or both trace directories, the operating system will determine its location based on what it considers to be the current path of the application.

Note: If the user executing the application does not have sufficient authority to write trace files in the specified path, no file will be generated and no warning or error is given. If the specified trace path does not exist, it will not be created.

The DB2 CLI and DB2 JDBC trace facilities automatically use the application's process ID and thread sequence number to name the trace log files when the TracePathName and JDBCTracePathName keywords have been set. For example, a

DB2 CLI trace of an application with three threads might generate the following DB2 CLI trace log files: 100390.0, 100390.1, 100390.2.

Similarly, a DB2 JDBC trace of a Java application with two threads might generate the following JDBC trace log files: 7960main.trc, 7960Thread-1.trc.

Note: If the trace directory contains both old and new trace log files, file date and time stamp information can be used to locate the most recent trace files.

If no DB2 CLI or DB2 JDBC trace output files appear to have been created:

- Verify that the trace configuration keywords are set correctly in the db2cli.ini file. Issuing the `db2 GET CLI CFG FOR SECTION COMMON` command from the command line processor is a quick way to do this.
- Ensure the application is restarted after updating the db2cli.ini file. Specifically, the DB2 CLI and DB2 JDBC trace facilities are initialized during application startup. Once initialized, the DB2 JDBC trace facility cannot be reconfigured. The DB2 CLI trace facility can be reconfigured at run time but only if the TraceRefreshInterval keyword was appropriately specified prior to application startup.

  Note: Only the Trace and TracePIDList DB2 CLI keywords can be reconfigured at run time. *Changes made to other DB2 CLI keywords, including TraceRefreshInterval, have no effect without an application restart*.
- If the TraceRefreshInterval keyword was specified prior to application startup, and if the Trace keyword was initially set to 0, ensure that enough time has elapsed for the DB2 CLI trace facility to reread the Trace keyword value.
- If either or both the TracePathName and JDBCTracePathName keywords are used to specify trace directories, ensure those directories exist prior to starting the application.
- Ensure the application has write access to the specified trace log file or trace directory.
- Check the DB2CLIINIPATH environment variable. If set, the DB2 CLI and DB2 JDBC trace facilities expect the db2cli.ini file to be at the location specified by this variable.
- If the application uses ODBC to interface with the DB2 CLI driver, verify that one of the `SQLConnect()`, `SQLDriverConnect()` or `SQLBrowseConnect()` functions have been successfully called. No entries will be written to the DB2 CLI trace log files until a database connection has successfully been made.

CLI trace file interpretation

DB2 CLI traces always begin with a header that identifies the process ID and thread ID of the application that generated the trace, the time the trace began, and product specific information such as the local DB2 build level and DB2 CLI driver version. For example:

```
1   [ Process: 1227, Thread: 1024 ]
2   [ Date, Time:           01-27-2002 13:46:07.535211 ]
3   [ Product:              QDB2/LINUX 7.1.0 ]
4   [ Level Identifier:     02010105 ]
5   [ CLI Driver Version:   07.01.0000 ]
6   [ Informational Tokens: "DB2 v7.1.0","n000510","" ]
```

Note: Trace examples used in this section have line numbers added to the left hand side of the trace. These line numbers have been added to aid the discussion and will *not* appear in an actual DB2 CLI trace.

Immediately following the trace header, there are usually a number of trace entries related to environment and connection handle allocation and initialization. For example:

```
7   SQLAllocEnv( phEnv=&bffff684 )
8       ---> Time elapsed - +9.200000E-004 seconds

9   SQLAllocEnv( phEnv=0:1 )
10      <--- SQL_SUCCESS   Time elapsed - +7.500000E-004 seconds

11  SQLAllocConnect( hEnv=0:1, phDbc=&bffff680 )
12      ---> Time elapsed - +2.334000E-003 seconds

13  SQLAllocConnect( phDbc=0:1 )
14      <--- SQL_SUCCESS   Time elapsed - +5.280000E-004 seconds

15  SQLSetConnectOption( hDbc=0:1, fOption=SQL_ATTR_AUTOCOMMIT, vParam=0 )
16      ---> Time elapsed - +2.301000E-003 seconds

17  SQLSetConnectOption( )
18      <--- SQL_SUCCESS   Time elapsed - +3.150000E-004 seconds

19  SQLConnect( hDbc=0:1, szDSN="SAMPLE", cbDSN=-3, szUID="", cbUID=-3,
                            szAuthStr="", cbAuthStr=-3 )
20      ---> Time elapsed - +7.000000E-005 seconds
21  ( DBMS NAME="DB2/LINUX", Version="07.01.0000", Fixpack="0x22010105" )

22  SQLConnect( )
23      <--- SQL_SUCCESS   Time elapsed - +5.209880E-001 seconds
24  ( DSN=""SAMPLE"" )

25  ( UID=" " )

26  ( PWD="*" )
```

In the above trace example, notice that there are two entries for each DB2 CLI function call (for example, lines 19-21 and 22-26 for the `SQLConnect()` function call). This is always the case in DB2 CLI traces. The first entry shows the input parameter values passed to the function call while the second entry shows the function output parameter values and return code returned to the application.

The above trace example shows that the `SQLAllocEnv()` function successfully allocated an environment handle (phEnv=0:1) at line 9. That handle was then passed to the `SQLAllocConnect()` function which successfully allocated a database connection handle (phDbc=0:1) as of line 13. Next, the `SQLSetConnectOption()` function was used to set the phDbc=0:1 connection's SQL_ATTR_AUTOCOMMIT attribute to SQL_AUTOCOMMIT_OFF (vParam=0) at line 15. Finally, `SQLConnect()` was called to connect to the target database (SAMPLE) at line 19.

Included in the input trace entry of the `SQLConnect()` function on line 21 is the build and FixPak level of the target database server. Other information that might also appear in this trace entry includes input connection string keywords and the code pages of the client and server. For example, suppose the following information also appeared in the `SQLConnect()` trace entry:

```
( Application Codepage=819, Database  Codepage=819,
  Char Send/Recv Codepage=819, Graphic Send/Recv Codepage=819,
  Application Char Codepage=819, Application Graphic Codepage=819 )
```

This would mean the application and the database server were using the same code page (819).

The return trace entry of the SQLConnect() function also contains important connection information (lines 24-26 in the above example trace). Additional information that might be displayed in the return entry includes any PATCH1 or PATCH2 keyword values that apply to the connection. For example, if PATCH2=27,28 was specified in the db2cli.ini file under the COMMON section, the following line should also appear in the SQLConnect() return entry:

```
( PATCH2="27,28" )
```

Following the environment and connection related trace entries are the statement related trace entries. For example:

```
27  SQLAllocStmt( hDbc=0:1, phStmt=&bffff684 )
28      ---> Time elapsed - +1.868000E-003 seconds

29  SQLAllocStmt( phStmt=1:1 )
30      <--- SQL_SUCCESS   Time elapsed - +6.890000E-004 seconds

31  SQLExecDirect( hStmt=1:1, pszSqlStr="CREATE TABLE GREETING (MSG
                                  VARCHAR(10))", cbSqlStr=-3 )
32      ---> Time elapsed - +2.863000E-003 seconds
33  ( StmtOut="CREATE TABLE GREETING (MSG VARCHAR(10))" )

34  SQLExecDirect( )
35      <--- SQL_SUCCESS   Time elapsed - +2.387800E-002 seconds
```

In the above trace example, the database connection handle (phDbc=0:1) was used to allocate a statement handle (phStmt=1:1) at line 29. An unprepared SQL statement was then executed on that statement handle at line 31. If the TraceComm=1 keyword had been set in the db2cli.ini file, the SQLExecDirect() function call trace entries would have shown additional client-server communication information as follows:

```
SQLExecDirect( hStmt=1:1, pszSqlStr="CREATE TABLE GREETING (MSG
                             VARCHAR(10))", cbSqlStr=-3 )
    ---> Time elapsed - +2.876000E-003 seconds
( StmtOut="CREATE TABLE GREETING (MSG VARCHAR(10))" )

    sqlccsend( ulBytes - 232 )
    sqlccsend( Handle - 1084869448 )
    sqlccsend( ) - rc - 0, time elapsed - +1.150000E-004
    sqlccrecv( )
    sqlccrecv( ulBytes - 163 ) - rc - 0, time elapsed - +2.243800E-002

SQLExecDirect( )
    <--- SQL_SUCCESS   Time elapsed - +2.384900E-002 seconds
```

Notice the additional sqlccsend() and sqlccrecv() function call information in this trace entry. The sqlccsend() call information reveals how much data was sent from the client to the server, how long the transmission took, and the success of that transmission (0 = SQL_SUCCESS). The sqlccrecv() call information then reveals how long the client waited for a response from the server and the amount of data included in the response.

Often, multiple statement handles will appear in the DB2 CLI trace. By paying close attention to the statement handle identifier, one can easily follow the execution path of a statement handle independent of all other statement handles appearing in the trace.

Statement execution paths appearing in the DB2 CLI trace are usually more complicated than the example shown above. For example:

```
36  SQLAllocStmt( hDbc=0:1, phStmt=&bffff684 )
37      ---> Time elapsed - +1.532000E-003 seconds

38  SQLAllocStmt( phStmt=1:2 )
39      <--- SQL_SUCCESS   Time elapsed - +6.820000E-004 seconds

40  SQLPrepare( hStmt=1:2, pszSqlStr="INSERT INTO GREETING VALUES ( ? )",
                cbSqlStr=-3 )
41      ---> Time elapsed - +2.733000E-003 seconds
42  ( StmtOut="INSERT INTO GREETING VALUES ( ? )" )

43  SQLPrepare( )
44      <--- SQL_SUCCESS   Time elapsed - +9.150000E-004 seconds

45  SQLBindParameter( hStmt=1:2, iPar=1, fParamType=SQL_PARAM_INPUT,
                      fCType=SQL_C_CHAR, fSQLType=SQL_CHAR, cbColDef=14,
                      ibScale=0, rgbValue=&080eca70, cbValueMax=15,
                      pcbValue=&080eca4c )
46      ---> Time elapsed - +4.091000E-003 seconds

47  SQLBindParameter( )
48      <--- SQL_SUCCESS   Time elapsed - +6.780000E-004 seconds

49  SQLExecute( hStmt=1:2 )
50      ---> Time elapsed - +1.337000E-003 seconds
51  ( iPar=1, fCType=SQL_C_CHAR, rgbValue="Hello World!!!", pcbValue=14,
      piIndicatorPtr=14 )

52  SQLExecute( )
53      <--- SQL_ERROR   Time elapsed - +5.951000E-003 seconds
```

In the above trace example, the database connection handle (phDbc=0:1) was used to allocate a second statement handle (phStmt=1:2) at line 38. An SQL statement with one parameter marker was then prepared on that statement handle at line 40. Next, an input parameter (iPar=1) of the appropriate SQL type (SQL_CHAR) was bound to the parameter marker at line 45. Finally, the statement was executed at line 49. Notice that both the contents and length of the input parameter (rgbValue=″Hello World!!!″, pcbValue=14) are displayed in the trace on line 51.

The `SQLExecute()` function fails at line 52. If the application calls a diagnostic DB2 CLI function like `SQLError()` to diagnose the cause of the failure, then that cause will appear in the trace. For example:

```
54  SQLError( hEnv=0:1, hDbc=0:1, hStmt=1:2, pszSqlState=&bffff680,
              pfNativeError=&bfffee78, pszErrorMsg=&bffff280,
              cbErrorMsgMax=1024, pcbErrorMsg=&bfffee76 )
55      ---> Time elapsed - +1.512000E-003 seconds

56  SQLError( pszSqlState="22001", pfNativeError=-302, pszErrorMsg="[IBM][CLI
       Driver][DB2/LINUX] SQL0302N  The value of a host variable in the EXECUTE
       or OPEN statement is too large for its corresponding use.
       SQLSTATE=22001", pcbErrorMsg=157 )
57      <--- SQL_SUCCESS   Time elapsed - +8.060000E-004 seconds
```

The error message returned at line 56 contains the DB2 native error code that was generated (SQL0302N), the sqlstate that corresponds to that code (SQLSTATE=22001) and a brief description of the error. In this example, the source of the error is evident: on line 49, the application is trying to insert a string with 14 characters into a column defined as VARCHAR(10) on line 31.

If the application does not respond to a DB2 CLI function warning or error return code by calling a diagnostic function like `SQLError()`, the warning or error message

should still be written to the DB2 CLI trace. However, the location of that message in the trace may not be close to where the error actually occurred. Furthermore, the trace will indicate that the error or warning message was not retrieved by the application. For example, if not retrieved, the error message in the above example might not appear until a later, seemingly unrelated DB2 CLI function call as follows:

```
SQLDisconnect( hDbc=0:1 )
    ---> Time elapsed - +1.501000E-003 seconds
    sqlccsend( ulBytes - 72 )
    sqlccsend( Handle - 1084869448 )
    sqlccsend( ) - rc - 0, time elapsed - +1.080000E-004
    sqlccrecv( )
    sqlccrecv( ulBytes - 27 ) - rc - 0, time elapsed - +1.717950E-001
( Unretrieved error message="SQL0302N  The value of a host variable in the
  EXECUTE or OPEN statement is too large for its corresponding use.
  SQLSTATE=22001" )

SQLDisconnect( )
    <--- SQL_SUCCESS   Time elapsed - +1.734130E-001 seconds
```

The final part of a DB2 CLI trace should show the application releasing the database connection and environment handles that it allocated earlier in the trace. For example:

```
58  SQLTransact( hEnv=0:1, hDbc=0:1, fType=SQL_ROLLBACK )
59      ---> Time elapsed - +6.085000E-003 seconds
60  ( ROLLBACK=0 )

61  SQLTransact( )
        <--- SQL_SUCCESS   Time elapsed - +2.220750E-001 seconds

62  SQLDisconnect( hDbc=0:1 )
63      ---> Time elapsed - +1.511000E-003 seconds

64  SQLDisconnect( )
65      <--- SQL_SUCCESS   Time elapsed - +1.531340E-001 seconds

66  SQLFreeConnect( hDbc=0:1 )
67      ---> Time elapsed - +2.389000E-003 seconds

68  SQLFreeConnect( )
69      <--- SQL_SUCCESS   Time elapsed - +3.140000E-004 seconds

70  SQLFreeEnv( hEnv=0:1 )
71      ---> Time elapsed - +1.129000E-003 seconds

72  SQLFreeEnv( )
73      <--- SQL_SUCCESS   Time elapsed - +2.870000E-004 seconds
```

JDBC trace file interpretation

DB2 JDBC traces always begin with a header that lists important system information such as key environment variable settings, the SDK for Java or JRE level, the DB2 JDBC driver level, and the DB2 build level. For example:

```
1   ============================================================
2   |    Trace beginning on 2002-1-28 7:21:0.19
3   ============================================================

4   System Properties:
5   ------------------
6   user.language = en
7   java.home = c:\Program Files\SQLLIB\java\jdk\bin\..
8   java.vendor.url.bug =
9   awt.toolkit = sun.awt.windows.WToolkit
```

```
10  file.encoding.pkg = sun.io
11  java.version = 1.1.8
12  file.separator = \
13  line.separator =
14  user.region = US
15  file.encoding = Cp1252
16  java.compiler = ibmjitc
17  java.vendor = IBM Corporation
18  user.timezone = EST
19  user.name = db2user
20  os.arch = x86
21  java.fullversion = JDK 1.1.8 IBM build n118p-19991124 (JIT ibmjitc
                       V3.5-IBMJDK1.1-19991124)
22  os.name = Windows NT
23  java.vendor.url = http://www.ibm.com/
24  user.dir = c:\Program Files\SQLLIB\samples\java
25  java.class.path =
         .:C:\Program Files\SQLLIB\lib;C:\Program Files\SQLLIB\java;
         C:\Program Files\SQLLIB\java\jdk\bin\
26  java.class.version = 45.3
27  os.version = 5.0
28  path.separator = ;
29  user.home = C:\home\db2user
30  ----------------------------------------
```

Note: Trace examples used in this section have line numbers added to the left hand side of the trace. These line numbers have been added to aid the discussion and will *not* appear in an actual DB2 JDBC trace.

Immediately following the trace header, one usually finds a number of trace entries related to initialization of the JDBC environment and database connection establishment. For example:

```
31  jdbc.app.DB2Driver -> DB2Driver() (2002-1-28 7:21:0.29)
32  | Loaded db2jdbc from java.library.path
33  jdbc.app.DB2Driver <- DB2Driver() [Time Elapsed = 0.01]

34  DB2Driver - connect(jdbc:db2:sample)

35  jdbc.app.DB2ConnectionTrace -> connect( sample, info, db2driver, 0, false )
                  (2002-1-28 7:21:0.59)
36  | 10: connectionHandle = 1
37  jdbc.app.DB2ConnectionTrace <- connect() [Time Elapsed = 0.16]

38  jdbc.app.DB2ConnectionTrace -> DB2Connection (2002-1-28 7:21:0.219)
39  | source = sample
40  | Connection handle = 1
41  jdbc.app.DB2ConnectionTrace <- DB2Connection
```

In the above trace example, a request to load the DB2 JDBC driver was made on line 31. This request returned successfully as reported on line 33.

The DB2 JDBC trace facility uses specific Java classes to capture the trace information. In the above trace example, one of those trace classes, DB2ConnectionTrace, has generated two trace entries numbered 35-37 and 38-41.

Line 35 shows the connect() method being invoked and the input parameters to that method call. Line 37 shows that the connect() method call has returned successfully while line 36 shows the output parameter of that call (Connection handle = 1).

Following the connection related entries, one usually finds statement related entries in the JDBC trace. For example:

```
42  jdbc.app.DB2ConnectionTrace -> createStatement() (2002-1-28 7:21:0.219)
43  | Connection handle = 1
44  | jdbc.app.DB2StatementTrace -> DB2Statement( con, 1003, 1007 )
          (2002-1-28 7:21:0.229)
45  | jdbc.app.DB2StatementTrace <- DB2Statement() [Time Elapsed = 0.0]
46  | jdbc.app.DB2StatementTrace -> DB2Statement (2002-1-28 7:21:0.229)
47  | | Statement handle = 1:1
48  | jdbc.app.DB2StatementTrace <- DB2Statement
49  jdbc.app.DB2ConnectionTrace <- createStatement - Time Elapsed = 0.01

50  jdbc.app.DB2StatementTrace -> executeQuery(SELECT * FROM EMPLOYEE WHERE
                                  empno = 000010) (2002-1-28 7:21:0.269)
51  | Statement handle = 1:1
52  | jdbc.app.DB2StatementTrace -> execute2( SELECT * FROM EMPLOYEE WHERE
                                    empno = 000010 ) (2002-1-28 7:21:0.269)
52  | | jdbc.DB2Exception -> DB2Exception() (2002-1-28 7:21:0.729)
53  | | | 10: SQLError = [IBM][CLI Driver][DB2/NT] SQL0401N  The data types of
              the operands for the operation "=" are not compatible.
              SQLSTATE=42818
54  | | |     SQLState = 42818
55  | | |     SQLNativeCode = -401
56  | | |     LineNumber = 0
57  | | |     SQLerrmc = =
58  | | jdbc.DB2Exception <- DB2Exception() [Time Elapsed = 0.0]
59  | jdbc.app.DB2StatementTrace <- executeQuery - Time Elapsed = 0.0
```

On line 42 and 43, the DB2ConnectionTrace class reported that the JDBC createStatement() method had been called with connection handle 1. Within that method, the internal method DB2Statement() was called as reported by another DB2 JDBC trace facility class, DB2StatementTrace. Notice that this internal method call appears 'nested' in the trace entry. Lines 47-49 show that the methods returned successfully and that statement handle 1:1 was allocated.

On line 50, an SQL query method call is made on statement 1:1, but the call generates an exception at line 52. The error message is reported on line 53 and contains the DB2 native error code that was generated (SQL0401N), the sqlstate that corresponds to that code (SQLSTATE=42818) and a brief description of the error. In this example, the error results because the EMPLOYEE.EMPNO column is defined as CHAR(6) and not an integer value as assumed in the query.

Trace CLI/ODBC configuration keyword

Turns on the DB2 CLI/ODBC trace facility.

db2cli.ini keyword syntax:

Trace = **0** | **1** | **db2trc**

Default setting:

No trace information is captured.

Equivalent environment attribute:

SQL_ATTR_TRACE

Usage notes:

When you set this configuration keyword to 1, CLI/ODBC trace records are appended to the file indicated by the **TraceFileName** configuration parameter or to files in the subdirectory indicated by the **TracePathName** configuration parameter. **Trace** has no effect if you do not set either **TraceFileName** or **TracePathName**.

When you set this configuration keyword to db2trc, the CLI application automatically invokes the db2trc process with the -cli option and logs tracing information for the CLI applications. The db2trc process that is invoked by the CLI

application captures only CLI application tracing. To capture information about components outside the CLI application, run db2trc before running the CLI application, with appropriate masking applied (including the CLI application).

The **TraceRefreshInterval** keyword sets the interval in seconds at which the **Trace** keyword is read from the db2cli.ini file. Use **TraceRefreshInterval** to dynamically turn off the CLI/ODBC trace within *n* seconds.

The following example shows how to set up a CLI/ODBC trace file to be written to disk after each trace entry:

```
[COMMON]
Trace=1
TraceFileName=E:\TRACES\CLI\MONDAY.CLI
TraceFlush=1
```

The **Trace** keyword is in the Common section of the initialization file and therefore applies to all connections to DB2 databases.

Options for invoking and storing the CLI trace

Here are the various options for invoking and storing the CLI trace.

db2trc	CLI/ODBC trace facility	Stored in the CLI trace file	Stored in memory
`db2trc off|on`	`Trace=0`	No	No
`db2trc on -cli`	`Trace=0`	No	Yes
`db2trc off`	`Trace=1`	Yes	No
`db2trc on -cli`	`Trace=1`	Yes	Yes
`db2trc off`	`Trace=db2trc`	No	Yes[1, 2]
`db2trc on`	`Trace=db2trc`	No	No[3]
`db2trc on -cli`	`Trace=db2trc`	No	Yes[2]

Notes:

1. Assuming that no db2trc process is already running on the system, the CLI application automatically invokes the db2trc process (with the -cli option enabled) and starts logging tracing information for the CLI application.
2. Because the db2trc process remains active even after the CLI application ends, you must turn off db2trc explicitly. Also, you must immediately dump the tracing details into a file; otherwise, the details might be wrapped in the file when more trace information is captured. You can format the dump file later when needed.
3. To capture the CLI tracing details, temporarily stop running db2trc, add the -cli option, and then re-enable db2trc.

TraceComm CLI/ODBC configuration keyword

Specifies whether information about each network request is included in the trace file.

db2cli.ini keyword syntax:

TraceComm = **0** | **1**

Default setting:

0 - No network request information is captured.

Only applicable when:

the CLI/ODBC Trace option is turned on.

Usage notes:

When TraceComm is set on (1) then the following information about each network request will be included in the trace file:

- which DB2 CLI functions are processed completely on the client and which DB2 CLI functions involve communication with the server
- the number of bytes sent and received in each communication with the server
- the time spent communicating data between the client and server

This option is only used when the Trace CLI/ODBC option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TraceErrImmediate CLI/ODBC configuration keyword

Specifies whether diagnostic records are written to the CLI/ODBC trace when records are generated.

db2cli.ini keyword syntax:

TraceErrImmediate = **0** | **1**

Default setting:

Diagnostic records are only written to the trace file when `SQLGetDiagField()` or `SQLGetDiagRec()` is called; or "Unretrieved Error Message" is written to the trace file for handles which had diagnostic records that were left unretreived.

Only applicable when:

the CLI/ODBC Trace option is turned on.

Usage notes:

Setting TraceErrImmediate=1 helps in determining when errors occur during application execution by writing diagnostic records to the CLI/ODBC trace file at the time the records are generated. This is especially useful for applications that do not retrieve diagnostic information using `SQLGetDiagField()` and `SQLGetDiagRec()`, because the diagnostic records that were generated on a handle will be lost if they are not retrieved or written to the trace file before the next function is called on the handle.

If TraceErrImmediate=0 (the default setting), then diagnostic records will only be written to the trace file if an application calls `SQLGetDiagField()` or `SQLGetDiagRec()` to retrieve diagnostic information. If the application does not retrieve diagnostic information through function calls and this keyword is set to 0, then the "Unretrieved Error Message" entry will be written to the trace file if a diagnostic record exists, when a function is next called on the handle.

This option is only used when the Trace CLI/ODBC option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TraceFileName CLI/ODBC configuration keyword

Specifies a file to which all DB2 CLI/ODBC trace information is written.

db2cli.ini keyword syntax:
TraceFileName = < **fully qualified file name** >

Default setting:
None

Only applicable when:
the Trace option is turned on.

Usage notes:

If the file specified does not exist, then it will be created; otherwise, the new trace information will be appended to the end of the file. However, the path the file is expected in must exist.

If the filename given is invalid or if the file cannot be created or written to, no trace will occur and no error message will be returned.

This option is only used when the Trace option is turned on. This will be done automatically when you set this option in the CLI/ODBC Configuration utility.

The TracePathName option will be ignored if this option is set.

DB2 CLI trace should only be used for debugging purposes. It will slow down the execution of the CLI/ODBC driver, and the trace information can grow quite large if it is left on for extended periods of time.

The TraceFileName keyword option should not be used with multi-process or multithreaded applications as the trace output for all threads or processes will be written to the same log file, and the output for each thread or process will be difficult to decipher. Furthermore, semaphores are used to control access to the shared trace file which could change the behavior of multithreaded applications. There is no default DB2 CLI trace output log file name.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2 databases.)

TraceFlush CLI/ODBC configuration keyword

Forces a write to disk after n CLI/ODBC trace entries.

db2cli.ini keyword syntax:
TraceFlush = **0** | **positive integer**

Default setting:
Do not write after every entry.

Only applicable when:
the CLI/ODBC Trace option is turned on.

Usage notes:

TraceFlush specifies how often trace information is written to the CLI trace file. By default, TraceFlush is set to 0 and each DB2 CLI trace file is kept open until the traced application or thread terminates normally. If the application terminates abnormally, some trace information that was not written to the trace log file may be lost.

Set this keyword to a positive integer to force the DB2 CLI driver to close and re-open the appropriate trace file after the specified number of trace entries. The smaller the value of the TraceFlush keyword, the greater the impact DB2 CLI tracing has on the performance of the application. Setting TraceFlush=1 has the most impact on performance, but will ensure that each entry is written to disk before the application continues to the next statement.

This option is only used when the Trace CLI/ODBC option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TraceFlushOnError CLI/ODBC configuration keyword

Specifies whether all CLI/ODBC trace entries are written to disk when an error occurs.

db2cli.ini keyword syntax:

TraceFlushOnError = **0** | **1**

Default setting:

Do not write CLI/ODBC trace entries as soon as an error occurs.

Only applicable when:

the CLI/ODBC Trace option is turned on.

Usage notes:

Setting TraceFlushOnError=1 forces the DB2 CLI driver to close and re-open the trace file each time an error is encountered. If TraceFlushOnError is left at its default value of 0, then trace file will only be closed when the application terminates normally or the interval specified by the TraceFlush keyword is reached. If the application process were to terminate abnormally when TraceFlushOnError=0, then valuable trace information may be lost. Setting TraceFlushOnError=1 may impact performance, but will ensure that trace entries associated with errors are written to disk.

This option is only used when the Trace CLI/ODBC option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TraceLocks CLI/ODBC configuration keyword

Only trace lock timeouts in the CLI/ODBC trace.

db2cli.ini keyword syntax:

TraceLocks = **0** | **1**

Default setting:

Trace information is not limited to only lock timeouts.

Only applicable when:

the Trace option is turned on.

Usage notes:

When TraceLocks is set to 1, lock timeouts will be recorded in the trace file.

This option is only used when the CLI/ODBC TRACE option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TracePathName CLI/ODBC configuration keyword

Specifies the subdirectory to be used to store individual DB2 CLI/ODBC trace files.

db2cli.ini keyword syntax:

TracePathName = < **fully qualified subdirectory name** >

Default setting:

None

Only applicable when:

the Trace option is turned on.

Not applicable when:

the TraceFileName option is turned on.

Usage notes:

Each thread or process that uses the same DLL or shared library will have a separate DB2 CLI/ODBC trace file created in the specified directory. A concatenation of the application process ID and the thread sequence number is automatically used to name trace files.

No trace will occur, and no error message will be returned, if the subdirectory given is invalid or if it cannot be written to.

This option is only used when the Trace option is turned on. This will be done automatically when you set this option in the CLI/ODBC Configuration utility.

It will be ignored if the DB2 CLI/ODBC option TraceFileName is used.

DB2 CLI trace should only be used for debugging purposes. It will slow down the execution of the CLI/ODBC driver, and the trace information can grow quite large if it is left on for extended periods of time.

If both TraceFileName and TracePathName are specified, the TraceFileName keyword takes precedence and TracePathName will be ignored.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TracePIDList CLI/ODBC configuration keyword

Restricts the process IDs for which the CLI/ODBC trace will be enabled.

db2cli.ini keyword syntax:

TracePIDList = **<no value specified>** | **<comma-delimited list of process IDs>**

Default setting:

All of the process IDs will be traced when the CLI/ODBC trace is run.

Usage notes:

Use this keyword for applications that create many processes. Capturing the CLI/ODBC trace for such applications can generate many trace files. By using this keyword you can collect the trace of specific problematic processes of applications.

If no value is specified for this keyword, all process IDs will be traced. Otherwise, specify a comma-delimited list of process IDs which you want to be traced when the CLI/ODBC trace runs.

The TraceRefreshInterval keyword must be set to some value before initializing your application, otherwise, the TracePIDList keyword will not take effect.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2 databases.)

To use the TracePIDList keyword:

1. Ensure the Trace CLI/ODBC keyword is set to zero or is not specified in the db2cli.ini file.
2. Add the TraceRefreshInterval CLI/ODBC keyword to the Common section of the db2cli.ini file as follows:

   ```
   [COMMON]
   TraceRefreshInterval=<some positive integer>
   ```
3. Start your application.
4. Using an operating system command such as ps (on a UNIX and Linux-based operating systems), determine the process IDs of the processes that you want to collect the CLI/ODBC trace for.
5. Turn CLI/ODBC tracing on and add the process IDs identified to the Common section of the db2cli.ini file by including the following keywords:

   ```
   [COMMON]
   Trace=1
   TracePathName=<fully-qualified subdirectory name>
   TracePIDList=<comma-delimited list of process IDs>
   ```

CLI/ODBC traces containing information of the process IDs specified will be located in the directory specified by the TracePathName keyword.. You might also see extra empty files that can be ignored.

TracePIDTID CLI/ODBC configuration keyword

Captures the process ID and thread ID for each item being traced.

db2cli.ini keyword syntax:

TracePIDTID = **0** | **1**

Default setting:

The process ID and thread ID for the trace entries are not captured.

Only applicable when:

the Trace option is turned on.

Usage notes:

When TracePIDTID is set to 1, the process ID and thread ID for each captured item will be recorded in the trace file. This effect is helpful when the Trace keyword is enabled and multiple applications are executing. This is because Trace writes trace information for all executing applications to a single file. Enabling TracePIDTID differentiates the recorded information by process and thread.

This option is only used when the CLI/ODBC Trace option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TraceRefreshInterval CLI/ODBC configuration keyword

Sets the interval (in seconds) at which the **Trace** and **TracePIDList** keywords are read from the Common section of the db2cli.ini file.

db2cli.ini keyword syntax:

TraceRefreshInterval = **0** | **positive integer**

Default setting:

The **Trace** and **TracePIDList** keywords will only be read from the db2cli.ini file when the application is initialized.

Usage notes:

Setting this keyword before an application is initialized allows you to dynamically turn off the CLI/ODBC trace within *n* seconds.

Note: Setting **TraceRefreshInterval** while the application is running will have no effect. For this keyword to take effect, it must be set before the application is initialized.

Only the **Trace** and **TracePIDList** keywords will be refreshed from the db2cli.ini file if this keyword is set. No other CLI or ODBC configuration keywords will be reread.

When **TraceRefreshInterval** is set to a nonzero positive integer value, a thread is spawned to monitor the db2cli.ini. In this situation, the applications connected to the database need to be multithread safe; otherwise the application might behave in an unexpected manner.

This keyword is contained in the Common section of the initialization file and therefore applies to all connections to DB2.

TraceStmtOnly CLI/ODBC configuration keyword

Only trace dynamic SQL statements in the CLI/ODBC trace.

db2cli.ini keyword syntax:

TraceStmtOnly = **0** | **1**

Default setting:

Trace information is not limited to only dynamic SQL statements.

Only applicable when:

the Trace option is turned on.

Usage notes:

When TraceStmtOnly is set to 1, only dynamic SQL statements will be recorded in the trace file.

This option is only used when the CLI/ODBC Trace option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TraceTime CLI/ODBC configuration keyword

Captures elapsed time counters in the trace file.

db2cli.ini keyword syntax:

TraceTime = **1** | **0**

Default setting:
Elapsed time counters are included in the trace file.

Only applicable when:
the Trace option is turned on.

Usage notes:

When TraceTime is set to 1, elapsed time counters will be captured in the trace file. For example:

```
SQLPrepare( hStmt=1:1, pszSqlStr="SELECT * FROM ORG", cbSqlStr=-3 )
  ---> Time elapsed - +6.785751E+000 seconds ( StmtOut="SELECT * FROM ORG" )
SQLPrepare( )
  <--- SQL_SUCCESS Time elapsed - +2.527400E-002 seconds
```

Turn TraceTime off, by setting it to 0, to improve performance or to generate smaller trace files. For example:

```
SQLPrepare( hStmt=1:1, pszSqlStr="SELECT * FROM ORG", cbSqlStr=-3 )
( StmtOut="SELECT * FROM ORG" )
SQLPrepare( )
  <--- SQL_SUCCESS
```

This option is only used when the CLI/ODBC Trace option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

TraceTimestamp CLI/ODBC configuration keyword

Specifies what type of timestamp information (if any) is recorded in the CLI/ODBC trace.

db2cli.ini keyword syntax:
TraceTimestamp = **0** | **1** | **2** | **3**

Default setting:
No timestamp information is written to the trace file.

Only applicable when:
the Trace option is turned on.

Usage notes:

Setting TraceTimeStamp to a value other than the default of 0 means the current timestamp or absolute execution time is added to the beginning of each line of trace information as it is being written to the DB2 CLI trace file. The following settings indicate what type of timestamp information is captured in the trace file:

- 0 = no timestamp information
- 1 = processor ticks and ISO timestamp (absolute execution time in seconds and milliseconds, followed by a timestamp)
- 2 = processor ticks (absolute execution time in seconds and milliseconds)
- 3 = ISO timestamp

This option is only used when the CLI/ODBC Trace option is turned on.

(This option is contained in the Common section of the initialization file and therefore applies to all connections to DB2.)

Chapter 9. Catalog functions for querying system catalog information in CLI applications

One of the first tasks an application often performs is to display a list of tables from which one or more are selected by the user. Although the application can issue its own queries against the database system catalog to get catalog information for such a DB2 command, it is best that the application calls the DB2 CLI catalog functions instead. These catalog functions, also called schema functions, provide a generic interface to issue queries and return consistent result sets across the DB2 family of servers. This allows the application to avoid server-specific and release-specific catalog queries.

The catalog functions operate by returning to the application a result set through a statement handle. Calling these functions is conceptually equivalent to using `SQLExecDirect()` to execute a select against the system catalog tables. After calling these functions, the application can fetch individual rows of the result set as it would process column data from an ordinary `SQLFetch()`. The DB2 CLI catalog functions are:

- `SQLColumnPrivileges()`
- `SQLColumns()`
- `SQLForeignKeys()`
- `SQLGetTypeInfo()`
- `SQLPrimaryKeys()`
- `SQLProcedureColumns()`
- `SQLProcedures()`
- `SQLSpecialColumns()`
- `SQLStatistics()`
- `SQLTablePrivileges()`
- `SQLTables()`

The result sets returned by these functions are defined in the descriptions for each catalog function. The columns are defined in a specified order. In future releases, other columns may be added to the end of each defined result set, therefore applications should be written in a way that would not be affected by such changes.

Some of the catalog functions result in execution of fairly complex queries, and for this reason should only be called when needed. It is recommended that the application save the information returned rather than making repeated calls to get the same information.

Input arguments on catalog functions in CLI applications

All of the catalog functions have *CatalogName* and *SchemaName* (and their associated lengths) on their input argument list. Other input arguments may also include *TableName*, *ProcedureName*, or *ColumnName* (and their associated lengths). These input arguments are used to either identify or constrain the amount of information to be returned.

Input arguments to catalog functions may be treated as ordinary arguments or pattern value arguments. An ordinary argument is treated as a literal, and the case of letters is significant. These arguments limit the scope of the query by identifying the object of interest. An error results if the application passes a null pointer for the argument.

Some catalog functions accept pattern values on some of their input arguments. For example, `SQLColumnPrivileges()` treats *SchemaName* and *TableName* as ordinary arguments and *ColumnName* as a pattern value. Refer to the "Function Arguments" section of the specific catalog function to see if a particular input argument accepts pattern values.

Inputs treated as pattern values are used to constrain the size of the result set by including only matching rows as though the underlying query's WHERE clause contained a LIKE predicate. If the application passes a null pointer for a pattern value input, the argument is not used to restrict the result set (that is, there is no corresponding LIKE in the WHERE clause). If a catalog function has more than one pattern value input argument, they are treated as though the LIKE predicates of the WHERE clauses in the underlying query were joined by AND; a row appears in this result set only if it meets all the conditions of the LIKE predicates.

Each pattern value argument can contain:

- The underscore (_) character which stands for any single character.
- The percent (%) character which stands for any sequence of zero or more characters. Note that providing a pattern value containing a single % is equivalent to passing a null pointer for that argument.
- Characters with no special meaning which stand for themselves. The case of a letter is significant.

These argument values are used on conceptual LIKE predicate(s) in the WHERE clause. To treat the metadata characters (_, %) as themselves, an escape character must immediately precede the _ or %. The escape character itself can be specified as part of the pattern by including it twice in succession. An application can determine the escape character by calling `SQLGetInfo()` with SQL_SEARCH_PATTERN_ESCAPE.

For example, the following calls would retrieve all the tables that start with 'ST':

```
/* tbinfo.c */
/* ... */
struct
{   SQLINTEGER ind ;
    SQLCHAR    val[129] ;
} tbQualifier, tbSchema, tbName, tbType;

struct
{   SQLINTEGER ind ;
    SQLCHAR val[255] ;
} tbRemarks;

SQLCHAR tbSchemaPattern[] = "
SQLCHAR tbNamePattern[] = "ST  /* all the tables starting with ST */

/* ... */
sqlrc = SQLTables( hstmt, NULL, 0,
                   tbSchemaPattern, SQL_NTS,
                   tbNamePattern, SQL_NTS,
                   NULL, 0);
/* ... */
```

```
/* bind columns to variables */
sqlrc = SQLBindCol( hstmt, 1, SQL_C_CHAR, tbQualifier.val, 129,
                    &tbQualifier.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);
sqlrc = SQLBindCol( hstmt, 2, SQL_C_CHAR, tbSchema.val, 129,
                    &tbSchema.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);
sqlrc = SQLBindCol( hstmt, 3, SQL_C_CHAR, tbName.val, 129,
                    &tbName.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);
sqlrc = SQLBindCol( hstmt, 4, SQL_C_CHAR, tbType.val, 129,
                    &tbType.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);
sqlrc = SQLBindCol( hstmt, 5, SQL_C_CHAR, tbRemarks.val, 255,
                    &tbRemarks.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);

/* ... */
sqlrc = SQLFetch( hstmt );
/* ... */
while (sqlrc != SQL_NO_DATA_FOUND)
{   /* ... */
    sqlrc = SQLFetch( hstmt );
    /* ... */
}
```

Chapter 10. Programming hints and tips for CLI applications

This topic discusses the following subjects:

- KEEPDYNAMIC support
- Common connection attributes
- Common statement attributes
- Reusing statement handles
- Binding and SQLGetData()
- Limiting use of catalog functions
- Column names of function generated result sets
- DB2 CLI-specific functions loaded from ODBC applications
- Global dynamic statement caching
- Data insertion and retrieval optimization
- Large object data optimization
- Case sensitivity of object identifiers
- SQLDriverConnect() versus SQLConnect()
- Turning off statement scanning
- Holding cursors across rollbacks
- Preparing compound SQL sub-statements
- User-defined types casting
- Deferred prepare to reduce network flow

KEEPDYNAMIC behavior refers to the server's ability to keep a dynamic statement in a prepared state, even after a commit has been performed. This behavior eliminates the need for the client to prepare the statement again, the next time the statement is executed. Some DB2 CLI/ODBC applications on the client might improve their performance by taking advantage of the KEEPDYNAMIC behavior on servers that are DB2 for z/OS and OS/390 Version 7 and later. Complete the following steps to enable KEEPDYNAMIC behavior:

1. Enable the dynamic statement cache on the DB2 for z/OS and OS/390 server (refer to the DB2 for z/OS and OS/390 server documentation).
2. Bind the db2clipk.bnd file on your DB2 Database for Linux, UNIX, and Windows client with the KEEPDYNAMIC and COLLECTION options. The following example shows how to bind db2clipk.bnd, creating a collection named KEEPDYNC:
   - db2 connect to *database_name* user *userid* using *password*
   - db2 bind db2clipk.bnd SQLERROR CONTINUE BLOCKING ALL KEEPDYNAMIC YES COLLECTION KEEPDYNC GRANT PUBLIC
   - db2 connect reset
3. Inform the client that the KEEPDYNAMIC bind option is enabled for your collection by performing either of the following:
   - Set the following CLI/ODBC configuration keywords in the db2cli.ini file: KeepDynamic = 1, CurrentPackageSet = collection name created in Step 2. For example:

     ```
     [dbname]
     KeepDynamic=1
     CurrentPackageSet=KEEPDYNC
     ```

- Set the SQL_ATTR_KEEPDYNAMIC and SQL_ATTR_CURRENT_PACKAGE_SET connection attributes in the DB2 CLI/ODBC application. For example:

```
SQLSetConnectAttr(hDbc,
                  SQL_ATTR_KEEP_DYNAMIC,
                  (SQLPOINTER) 1,
                   SQL_IS_UINTEGER );

SQLSetConnectAttr(hDbc,
                  SQL_ATTR_CURRENT_PACKAGE_SET,
                   (SQLPOINTER) "KEEPDYNC",
                  SQL_NTS);
```

Refer to the DB2 for OS/390 and z/OS documentation for further information on KEEPDYNAMIC behavior and configuration.

Common connection attributes

The following connection attributes might need to be set by DB2 CLI applications:

- SQL_ATTR_AUTOCOMMIT - Generally this attribute should be set to SQL_AUTOCOMMIT_OFF, since each commit request can generate extra network flow. Only leave SQL_AUTOCOMMIT_ON on if specifically needed.

  Note: The default is SQL_AUTOCOMMIT_ON.
- SQL_ATTR_TXN_ISOLATION - This connection attribute determines the isolation level at which the connection or statement will operate. The isolation level determines the level of concurrency possible, and the level of locking required to execute the statement. Applications need to choose an isolation level that maximizes concurrency, yet ensures data consistency.

Common statement attributes

The following statement attributes might need to be set by DB2 CLI applications:

- SQL_ATTR_MAX_ROWS - Setting this attribute limits the number of rows returned to the application from query operations. This can be used to avoid overwhelming an application with a very large result set generated inadvertently, which is especially useful for applications on clients with limited memory resources.

  Setting SQL_ATTR_MAX_ROWS while connected to DB2 for z/OS and OS/390 Version 7 and later will add “OPTIMIZE FOR n ROWS” and “FETCH FIRST n ROWS ONLY” clauses to the statement. For versions of DB2 for OS/390 prior to Version 7 and any DBMS that does not support the “FETCH FIRST n ROWS ONLY” clause, the full result set is still generated at the server using the “OPTIMIZE FOR n ROWS” clause, however DB2 CLI will count the rows on the client and only fetch up to SQL_ATTR_MAX_ROWS rows.
- SQL_ATTR_CURSOR_HOLD - This statement attribute determines if the cursor for this statement will be declared by DB2 CLI using the WITH HOLD clause.

  Resources associated with statement handles can be better utilized by the server if the statements that do not require cursor-hold behavior have this attribute set to SQL_CURSOR_HOLD_OFF. The efficiency gains obtained by the proper use of this attribute are considerable on OS/390 and z/OS.

  Note: Many ODBC applications expect a default behavior where the cursor position is maintained after a commit.
- SQL_ATTR_TXN_ISOLATION - DB2 CLI allows the isolation level to be set at the statement level, however, it is recommended that the isolation level be set at

the connection level. The isolation level determines the level of concurrency possible, and the level of locking required to execute the statement.

Resources associated with statement handles can be better utilized by DB2 CLI if statements are set to the required isolation level, rather than leaving all statements at the default isolation level. This should only be attempted with a thorough understanding of the locking and isolation levels of the connected DBMS.

Applications should use the minimum isolation level possible to maximize concurrency.

Reusing statement handles

Each time a CLI application declares a statement handle, the DB2 CLI driver allocates and then initializes an underlying data structure for that handle. To increase performance, CLI applications can reuse statement handles with different statements, thereby avoiding the costs associated with statement handle allocation and initialization.

Note: Before reusing statement handles, memory buffers and other resources used by the previous statement might need to be released by calling the `SQLFreeStmt()` function. Also, statement attributes previously set on a statement handle (for example, SQL_ATTR_PARAMSET_SIZE) need to be explicitly reset, otherwise they might be inherited by all future statements using the statement handle.

Binding and SQLGetData()

Generally it is more efficient to bind application variables or file references to result sets than to use `SQLGetData()`. When the data is in a LOB column, LOB functions are preferable to `SQLGetData()` (see Large object data optimization for more information). Use `SQLGetData()` when the data value is large variable-length data that:

- must be received in pieces, or
- might not need to be retrieved.

Limiting use of catalog functions

Catalog functions, such as `SQLTables()`, force the DB2 CLI driver to query the DBMS catalog tables for information. The queries issued are complex and the DBMS catalog tables can be very large. In general, try to limit the number of times the catalog functions are called, and limit the number of rows returned.

The number of catalog function calls can be reduced by calling the function once, and having the application store (cache) the data.

The number of rows returned can be limited by specifying a:

- Schema name or pattern for all catalog functions
- Table name or pattern for all catalog functions other than `SQLTables()`
- Column name or pattern for catalog functions that return detailed column information.

Remember that although an application might be developed and tested against a data source with hundreds of tables, it might be run against a database with thousands of tables. Consider this likelihood when developing applications.

Close any open cursors (call SQLCloseCursor() or SQLFreeStmt() with SQL_CLOSE *Option*) for statement handles used for catalog queries to release any locks against the catalog tables. Outstanding locks on the catalog tables can prevent CREATE, DROP or ALTER statements from executing.

Column names of function generated result sets

The column names of the result sets generated by catalog and information functions might change as the ODBC and CLI standards evolve. The *position* of the columns, however, will not change.

Any application dependency should be based on the column position (*iCol* parameter used in SQLBindCol(), SQLGetData(), and SQLDescribeCol()) and not the name.

DB2 CLI-specific functions loaded from ODBC applications

The ODBC Driver Manager maintains its own set of statement handles which it maps to the CLI statement handles on each call. When a DB2 CLI function is called directly, it must be passed to the CLI driver statement handle, as the CLI driver does not have access to the ODBC mapping.

Call SQLGetInfo() with the SQL_DRIVER_HSTMT option to obtain the DB2 CLI statement handle (HSTMT). The DB2 CLI functions can then be called directly from the shared library or DLL, passing the HSTMT argument where required.

Global dynamic statement caching

DB2 servers at version 5 or later for UNIX or Windows have a *global dynamic statement cache*. This cache is used to store the most popular access plans for prepared dynamic SQL statements.

Before each statement is prepared, the server automatically searches this cache to see if an access plan has already been created for this exact SQL statement (by this application or any other application or client). If so, the server does not need to generate a new access plan, but will use the one in the cache instead. There is now no need for the application to cache connections at the client unless connecting to a server that does not have a global dynamic statement cache.

Data insertion and retrieval optimization

The methods that describe using arrays to bind parameters and retrieve data use compound SQL to optimize network flow. Use these methods as much as possible.

Large object data optimization

Use LOB data types and the supporting functions for long strings whenever possible. Unlike LONG VARCHAR, LONG VARBINARY, and LONG VARGRAPHIC types, LOB data values can use LOB locators and functions such as SQLGetPosition() and SQLGetSubString() to manipulate large data values at the server.

LOB values can also be fetched directly to a file, and LOB parameter values can be read directly from a file. This saves the overhead of the application transferring data via application buffers.

Case sensitivity of object identifiers

All database object identifiers, such as table names, view names and column names are stored in the catalog tables in uppercase unless the identifier is delimited. If an identifier is created using a delimited name, the exact case of the name is stored in the catalog tables.

When an identifier is referenced within an SQL statement, it is treated as case *insensitive* unless it is delimited.

For example, if the following two tables are created,

```
CREATE TABLE MyTable   (id INTEGER)
CREATE TABLE "YourTable" (id INTEGER)
```

two tables will exist, `MYTABLE` and `YourTable`

Both of the following statements are equivalent:

```
SELECT * FROM MyTable (id INTEGER)
SELECT * FROM MYTABLE (id INTEGER)
```

The second statement below will fail with `TABLE NOT FOUND` since there is no table named `YOURTABLE`:

```
SELECT * FROM "YourTable" (id INTEGER)   // executes without error
SELECT * FROM YourTable (id INTEGER)     // error, table not found
```

All DB2 CLI catalog function arguments treat the names of objects as *case sensitive*, that is, as if each name was delimited.

SQLDriverConnect() versus SQLConnect()

Using `SQLDriverConnect()` allows the application to rely on the dialog box provided by DB2 CLI to prompt the user for the connection information.

If an application uses its own dialog boxes to query the connect information, the user should be able to specify additional connect options in the connection string. The string should also be stored and used as a default on subsequent connections.

Turning off statement scanning

DB2 CLI by default, scans each SQL statement searching for vendor escape clause sequences.

If the application does not generate SQL statements that contain vendor escape clause sequences, then the SQL_ATTR_NOSCAN statement attribute should be set to SQL_NOSCAN_ON at the connection level so that DB2 CLI does not perform a scan for vendor escape clauses.

Holding cursors across rollbacks

Applications that need to deal with complex transaction management issues might benefit from establishing multiple concurrent connections to the same database. Each connection in DB2 CLI has its own transaction scope, so any actions performed on one connection do not affect the transactions of other connections.

For example, all open cursors within a transaction get closed if a problem causes the transaction to be rolled back. An application can use multiple connections to

the same database to separate statements with open cursors; since the cursors are in separate transactions, a rollback on one statement does not affect the cursors of the other statements.

However, using multiple connections might mean bringing some data across to the client on one connection, and then sending it back to the server on the other connection. For example:

- Suppose in connection #1 you are accessing large object columns and have created LOB locators that map to portions of large object values.
- If in connection #2, you want to use (for example to insert) the portion of the LOB values represented by the LOB locators, you would have to move the LOB values in connection #1 first to the application, and then pass them to the tables that you are working with in connection #2. This is because connection #2 does not know anything about the LOB locators in connection #1.
- If you only had one connection, then you could just use the LOB locators directly. However, you would lose the LOB locators as soon as you rolled back your transaction.

Note: When multiple connections to a single database are used by an application, the application must be careful to synchronize access to database objects or it might experience various lock contention issues, as database locks are not shared between transactions. Updates by one connection can easily force other connections into a lock-wait state until the first connection releases the lock (through a COMMIT or ROLLBACK).

Preparing compound SQL sub-statements

In order to maximize efficiency of the compound statement, sub-statements should be prepared before the BEGIN COMPOUND statement, and then executed within the compound statement.

This also simplifies error handling since prepare errors can be handled outside of the compound statement.

User-defined types and casting

If a parameter marker is used in a predicate of a query statement, and the parameter is a user defined type, the statement must use a CAST function to cast either the parameter marker or the UDT.

For example, suppose the following type and table is defined:

```
CREATE DISTINCT TYPE CNUM AS INTEGER WITH COMPARISONS

CREATE TABLE CUSTOMER (
        Cust_Num     CNUM NOT NULL,
        First_Name   CHAR(30) NOT NULL,
        Last_Name    CHAR(30) NOT NULL,
        Phone_Num    CHAR(20) WITH DEFAULT,
        PRIMARY KEY  (Cust_Num) )
```

Suppose also that the following SQL statement was then issued:

```
SELECT first_name, last_name, phone_num from customer
WHERE cust_num = ?
```

This statement would fail because the parameter marker cannot be of type CNUM and thus the comparison fails due to incompatible types.

Casting the column to integer (its base SQL type), allows the comparison to work since a parameter can be provided for type integer:

```
SELECT  first_name, last_name, phone_num from customer
where cast( cust_num as integer ) = ?
```

Alternatively the parameter marker can be cast to INTEGER and the server can then apply the INTEGER to CNUM conversion:

```
SELECT  first_name, last_name, phone_num FROM customer
where cust_num = cast( ? as integer )
```

Deferred prepare to reduce network flow

In DB2 CLI, deferred prepare is on by default. The PREPARE request is not sent to the server until the corresponding execute request is issued. The two requests are then combined into one command/reply flow (instead of two) to minimize network flow and to improve performance. This is of greatest benefit when an application generates queries with very small answer sets, because the overhead of requests and replies flowing over the network represents a large percentage of the processing time. In an environment where a DB2 Connect or DDCS gateway is used, there is a greater opportunity for cost reduction because four request and reply combinations are reduced to two.

Note: Functions such as `SQLDescribeParam()`, `SQLDescribeCol()`, `SQLNumParams()`, and `SQLNumResultCols()` require that the statement has been prepared. If the statement has not already been prepared, these functions trigger an immediate PREPARE request to the server, and the benefit of deferred prepare does not appear.

Reduction of network flows with CLI array input chaining

CLI array input chaining is a feature that, when enabled, causes requests for the execution of prepared statements to be held and queued at the client until the chain is ended. Once the chain has been ended, all of the chained SQLExecute() requests at the client are then sent to the server in a single network flow.

The following sequence of events (presented as pseudocode) is an example of how CLI array input chaining can reduce the number of network flows to the server:

```
SQLPrepare (statement1)
SQLExecute (statement1)
SQLExecute (statement1)
/* the two execution requests for statement1 are sent to the server in
two network flows */

SQLPrepare (statement2)

/* enable chaining */
SQLSetStmtAttr (statement2, SQL_ATTR_CHAINING_BEGIN)

SQLExecute (statement2)
SQLExecute (statement2)
SQLExecute (statement2)

/* end chaining */
SQLSetStmtAttr (statement2, SQL_ATTR_CHAINING_END)

/* the three execution requests for statement2 are sent to the server
in a single network flow, instead of three separate flows */
```

If SQL_ERROR or SQL_SUCCESS_WITH_INFO is returned when setting SQL_ATTR_CHAINING_END, then at least one statement in the chain of statements returned SQL_ERROR or SQL_SUCCESS_WITH_INFO when it was executed. Use the CLI diagnostic functions `SQLGetDiagRec()` and `SQLGetDiagField()` to retrieve information about what has caused the error or warning.

Chapter 11. Multisite updates (two phase commit) in CLI applications

A typical transaction scenario portrays an application which interacts with only one database server in a transaction. Even though concurrent connections allow for concurrent transactions, the different transactions are not coordinated.

With multisite updates, the two phase commit (2PC) protocol, and coordinated distributed transactions, an application is able to update data in multiple remote database servers with guaranteed integrity.

Note: Multisite update is also known as Distributed Unit of Work (DUOW).

A typical banking transaction is a good example of a multisite update. Consider the transfer of money from one account to another in a different database server. In such a transaction it is critical that the updates that implement the debit operation on one account do not get committed unless the updates required to process the credit to the other account are committed as well. Multisite update considerations apply when data representing these accounts is managed by two different database servers

Some multisite updates involve the use of a transaction manager (TM) to coordinate two-phase commit among multiple databases. DB2 CLI applications can be written to use various transaction managers:

- DB2 as transaction manager
- Process-based XA-compliant transaction program monitor
- Host and AS/400® database servers

  Note: There is no specific DB2 CLI/ODBC client configuration required when connecting to a host or iSeries database server, although the machine running DB2 Connect might require certain configuration settings to enable running multisite update mode against the host.

ConnectType CLI/ODBC configuration keyword

Controls whether the application is to operate in a remote or distributed unit of work.

db2cli.ini keyword syntax:

ConnectType = **1** | **2**

Default setting:

Remote unit of work.

Equivalent environment or connection attribute:

SQL_ATTR_CONNECTTYPE

Usage notes:

This option allows you to specify the default connect type. The options are:

- 1 = Remote unit of work. Multiple concurrent connections, each with its own commit scope. The concurrent transactions are not coordinated. This is the default.

- 2= Distributed unit of work. Coordinated connections where multiple databases participate under the same distributed unit of work.

The first connection determines the connect type for all other connections that are allocated under the same environment handle.

This keyword takes precedence over the environment or connection attribute.

DB2 as transaction manager in CLI applications

Configuration of DB2 as transaction manager

DB2 CLI/ODBC applications can use DB2 itself as the Transaction Manager (DB2 TM) to coordinate distributed transactions against all IBM database servers.

The DB2 Transaction Manager must be set up according to the information in the DB2 transaction manager configuration documentation.

To use DB2 as the transaction manager in CLI/ODBC applications, the following configurations must be applied:

- The SQL_ATTR_CONNECTTYPE environment attribute must be set. This attribute controls whether the application is to operate in a coordinated or uncoordinated distributed environment. Commits or rollbacks among multiple database connections are coordinated in a coordinated distributed environment. The two possible values for this attribute are:
  - SQL_CONCURRENT_TRANS - supports single database per transaction semantics. Multiple concurrent connections to the same database and to different databases are permitted. Each connection has its own commit scope. No effort is made to enforce coordination of transactions. This is the default and corresponds to a Type 1 CONNECT in embedded SQL.
  - SQL_COORDINATED_TRANS - supports multiple databases per transaction semantics. A coordinated transaction is one in which commits or rollbacks among multiple database connections are coordinated. Setting SQL_ATTR_CONNECTTYPE to this value corresponds to Type 2 CONNECT in embedded SQL.

  It is recommended that the application set this environment attribute with a call to `SQLSetEnvAttr()`, if necessary, as soon as the environment handle has been allocated. However, since ODBC applications cannot access `SQLSetEnvAttr()`, they must set this using `SQLSetConnectAttr()` after each connection handle is allocated, but before any connections have been established.

  All connections on an environment handle must have the same SQL_ATTR_CONNECTTYPE setting. An environment cannot have a mixture of concurrent and coordinated connections. The type of the first connection will determine the type of all subsequent connections. `SQLSetEnvAttr()` will return an error if an application attempts to change the connect type while there is an active connection.
- If SQL_ATTR_CONNECTTYPE is set to SQL_COORDINATED_TRANS as described above, two-phase commit is used to commit the work done by each database in a multiple database transaction. This requires the use of a Transaction Manager to coordinate two-phase commits amongst the databases that support this protocol. Multiple readers and multiple updaters are allowed within a transaction.
- The function `SQLEndTran()` must be used in a multisite update environment when DB2 is acting as the transaction manager.

Application flows in concurrent and coordinated transactions

Figure 9 shows the logical flow of an application executing statements on two SQL_CONCURRENT_TRANS connections ('A' and 'B'), and indicates the scope of the transactions.

Figure 10 on page 166 shows the same statements being executed on two SQL_COORDINATED_TRANS connections ('A' and 'B'), and the scope of a coordinated distributed transaction.

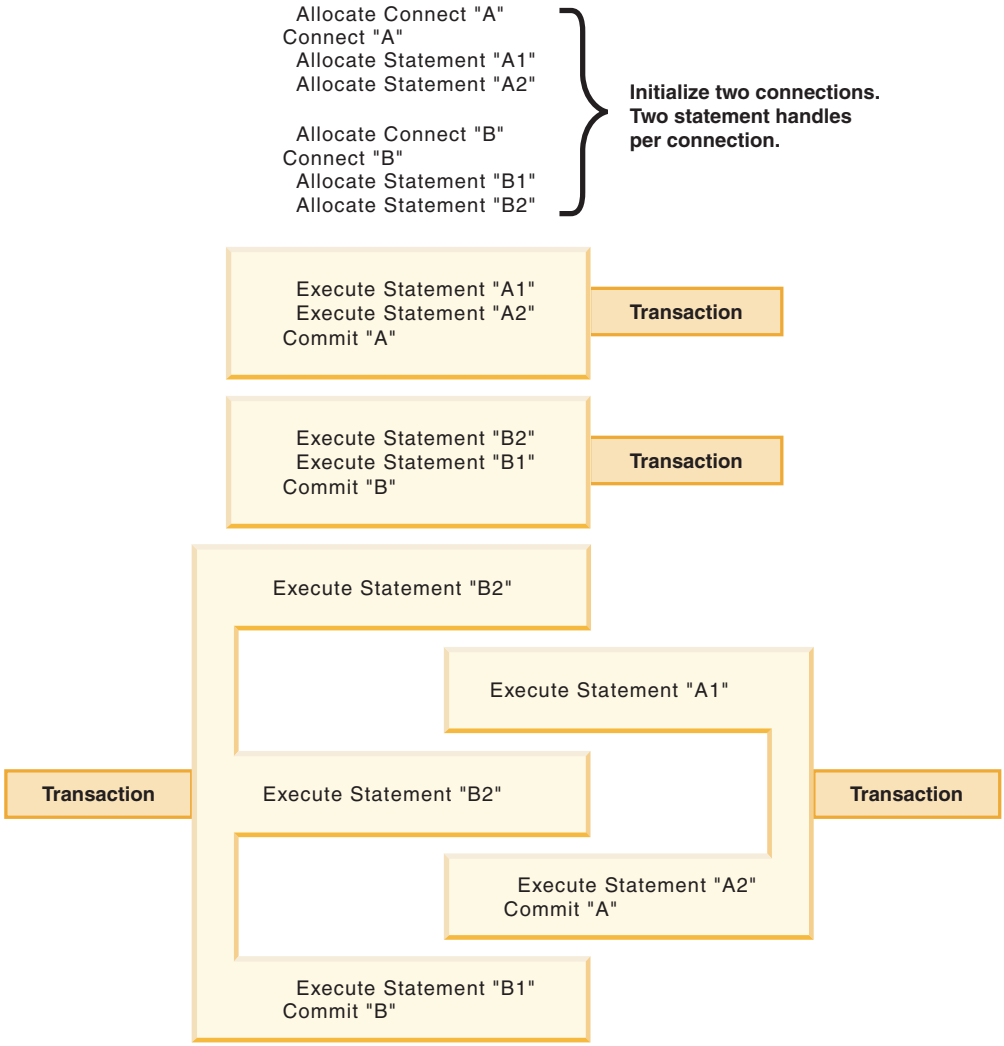


Figure 9. Multiple connections with concurrent transactions

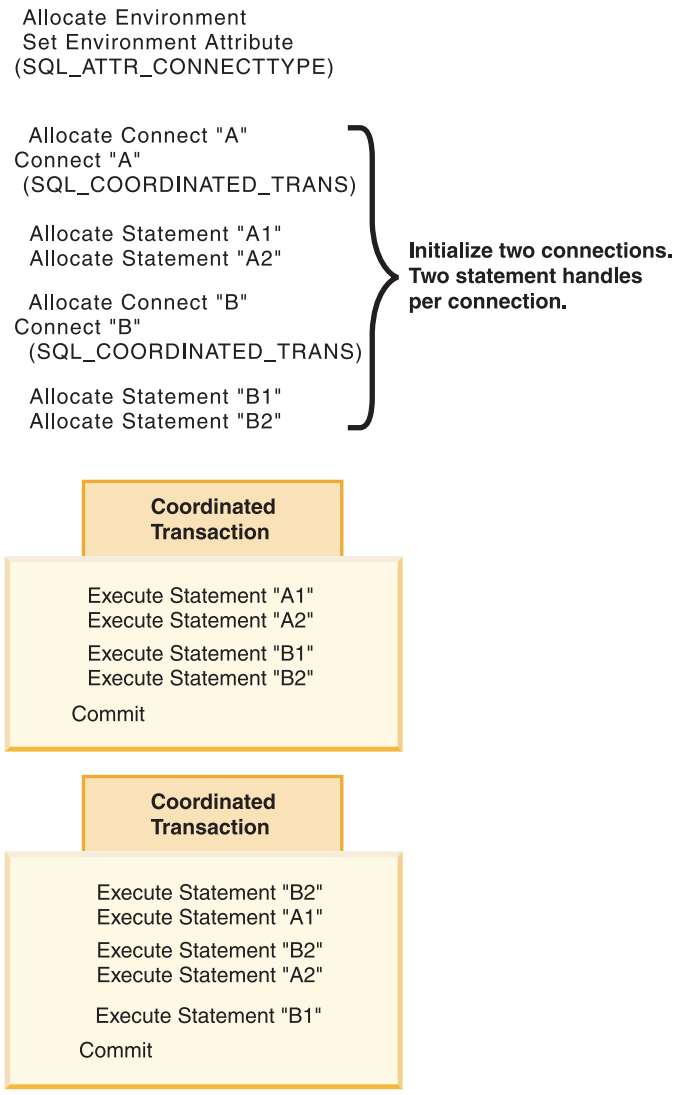


Figure 10. Multiple connections with coordinated transactions

Restrictions

Mixing embedded SQL and CLI/ODBC calls in a multisite update environment is supported, but all the same restrictions of writing mixed applications are imposed.

Process-based XA-compliant Transaction Program Monitor (XA TP) programming considerations for CLI applications

Process-based XA TPs, such as CICS® and Encina®, start up one application server per process. In each application-server process, the connections are already established using the XA API (xa_open). This section describes the environment configurations and considerations for running DB2 CLI/ODBC applications under this environment.

Configuration

The XA Transaction Manager must be set up according to the configuration considerations for XA transaction managers.

Note: Setting the CLI/ODBC configuration keywords for connections is no longer required when in an XA Transactional processing environment.

Programming considerations

DB2 CLI/ODBC applications written for this environment must complete the following steps:

- The application must first call `SQLConnect()` or `SQLDriverConnect()` to associate the TM-opened connections with the CLI/ODBC connection handle. The data source name must be specified. User ID and Password are optional.
- The application must call the XA TM to do a commit or rollback. As a result, since the CLI/ODBC driver does not know that the transaction has ended, the application should do the following before exiting:
  - Drop all CLI/ODBC statement handles.
  - Free up the connection handle by calling `SQLDisconnect()` and `SQLFreeHandle()`. The actual database connection will not be disconnected until the XA TM performs an xa_close.

Restrictions

Mixing embedded SQL and CLI/ODBC calls in a multisite update environment is supported, but all the same restrictions of writing mixed applications are imposed.

Chapter 12. Asynchronous execution of CLI functions

DB2 CLI can run a subset of CLI functions asynchronously. For these functions, the DB2 CLI driver returns control to the application after calling the function but before that function has finished executing.

Asynchronous execution is possible for those functions that normally send a request to the server and then wait for a response. The functions return SQL_STILL_EXECUTING each time they are called until they are finished running, at which point they return a different value (for example, SQL_SUCCESS). Rather than waiting for a response, a function executing asynchronously returns control to the application. The application can then perform other tasks and poll the function until a return code other than SQL_STILL_EXECUTING is returned. Refer to the SQL_ATTR_ASYNC_ENABLE connection or statement attribute for a list of functions that can be executed asynchronously.

In order for an application to run CLI functions asynchronously, the application must include the following:

1. A call to the function `SQLGetInfo()` with the SQL_ASYNC_MODE option to ensure support for asynchronous calls.
2. A call to `SQLSetConnectAttr()` or `SQLSetStmtAttr()` with the SQL_ATTR_ASYNC_ENABLE attribute to enable asynchronous calls once it has been established that there is support for asynchronous calls.
3. A call to a function that supports asynchronous execution and polling of the asynchronous function. When the application calls a function that can be run asynchronously, one of two things can happen:
   - If the function will not benefit from being run asynchronously, DB2 CLI can decide to run it synchronously and return the normal return code (other than SQL_STILL_EXECUTING). In this case the application runs as it would if the asynchronous mode had not been enabled.
   - DB2 CLI will perform some minimal processing (such as checking the arguments for errors), then pass the statement on to the server. Once this quick processing is complete a return code of SQL_STILL_EXECUTING is returned to the application.

Functions that can be called during asynchronous execution

Once a function has been called asynchronously, only the original function, `SQLAllocHandle()`, `SQLCancel()`, `SQLGetDiagField()`, or `SQLGetDiagRec()` can be called on the statement or the connection associated with *StatementHandle*, until the original function returns a code other than SQL_STILL_EXECUTING. Any other function called on *StatementHandle* or the connection associated with *StatementHandle* returns SQL_ERROR with an SQLSTATE of HY010 (Function sequence error.).

Diagnostic information while a function is running asynchronously

`SQLGetDiagField()` returns the following values when it is called on a statement handle that has an asynchronous function executing:

- The values of SQL_DIAG_CURSOR_ROW_COUNT, SQL_DIAG_DYNAMIC_FUNCTION, SQL_DIAG_DYNAMIC_FUNCTION_CODE, and SQL_DIAG_ROW_COUNT header fields are undefined.
- SQL_DIAG_NUMBER header field returns 0.
- SQL_DIAG_RETURN_CODE header field returns SQL_STILL_EXECUTING.
- All record fields return SQL_NO_DATA.

`SQLGetDiagRec()` always returns SQL_NO_DATA when it is called on a statement handle that has an asynchronous function executing.

Cancelling the asynchronous function call

The application can issue a request to cancel any function that is running asynchronously by calling `SQLCancel()`. A function that has already finished executing cannot be cancelled.

The return code from the `SQLCancel()` call indicates whether the cancel request was received, not whether the execution of the asynchronous function was stopped.

The only way to tell if the function was canceled is to call it again, using the original arguments.

- If the cancel was successful, the function will return SQL_ERROR and an SQLSTATE of HY008 (Operation was cancelled.).
- If the cancel was not successful, the function will return a value other than SQL_ERROR with an SQLSSTATE of HY008. For example, the function might return SQL_STILL_EXECUTING.

Executing functions asynchronously in CLI applications

Executing functions asynchronously in CLI applications is part of the larger task of programming with CLI. The task of enabling asynchronous functions and working with those functions involves ensuring that asynchronous execution is supported, initializing the application for asynchronous execution, and working with the functions to take advantage of asynchronous execution.

Before you begin setting up your CLI application for asynchronous execution, you must allocate an environment handle and a connection handle. This is part of the task of initializing your CLI application.

An application can have at most 1 active function running in asynchronous mode on any one connection. If asynchronous mode is enabled at the connection level, all statements already allocated, as well as future statement handles allocated on the connection will be enabled for asynchronous execution.

1. Call `SQLGetInfo()` with *InfoType* SQL_ASYNC_MODE to ensure that functions can be called asynchronously. For example:

```
/* See what type of Asynchronous support is available. */
rc = SQLGetInfo( hdbc, /* Connection handle */
                 SQL_ASYNC_MODE, /* Query the support available */
                 &ubuffer, /* Store the result in this variable */
                 4,
                 &outlen);
```

   The call to the `SQLGetInfo()` function will return one of the following values:

- SQL_AM_STATEMENT: asynchronous execution can be turned on or off at a statement level.
- SQL_AM_CONNECTION: asynchronous execution can be turned on or off at a connection level.
- SQL_AM_NONE: asynchronous execution is not supported. Your application cannot be set up for asynchronous execution. This will be returned for one of two reasons:
  - The datasource itself does not support asynchronous execution.
  - The DB2 CLI/ODBC configuration keyword ASYNCENABLE has been specifically set to disable asynchronous execution.

2. Set the SQL_ATTR_ASYNC_ENABLE attribute using `SQLSetStmtAttr()` or `SQLSetConnectAttr()` to enable your application for asynchronous execution if the return value from `SQLGetInfo()` is either SQL_AM_STATEMENT or SQL_AM_CONNECTION.
   - If the return value is SQL_AM_STATEMENT, set SQL_ATTR_ASYNC_ENABLE to SQL_ASYNC_ENABLE_ON using `SQLSetStmtAttr()`. For example:

     ```
     /* Set statement level asynchronous execution on */
     rc = SQLSetStmtAttr( hstmt, /* Statement handle */
                          SQL_ATTR_ASYNC_ENABLE,
                          (SQLPOINTER) SQL_ASYNC_ENABLE_ON,
                          0);
     ```

   - If the return value is SQL_AM_CONNECTION, set the SQL_ATTR_ASYNC_ENABLE to SQL_ASYNC_ENABLE_ON using `SQLSetConnectAttr()`. For example:

     ```
     /* Set connection level asynchronous execution on */
     rc = SQLSetConnectAttr( hstmt, /* Connection handle */
                          SQL_ATTR_ASYNC_ENABLE,
                          (SQLPOINTER) SQL_ASYNC_ENABLE_ON,
                          0);
     ```

3. Call a function that supports asynchronous execution and poll the asynchronous function. Refer to the SQL_ATTR_ASYNC_ENABLE connection or statement attribute for a list of functions that can be executed asynchronously.

   The application determines whether the function has completed by calling it repeatedly with the same arguments it used to call the function the first time. A return code of SQL_STILL_EXECUTING indicates it is not yet finished, any other value indicates it has completed. The value other than SQL_STILL_EXECUTING is the same return code it would have returned if it had executed synchronously.

   The following example demonstrates a common `while` loop that takes both possible outcomes into account:

   ```
   while ( (rc = SQLExecDirect(hstmt, sqlstmt, SQL_NTS) ) == SQL_STILL_EXECUTING)
   {
       /* Other processing can be performed here, between each call to
        * see if SQLExecDirect() has finished running asynchronously.
        * This section will never run if CLI runs the function
        * synchronously.
        */
   }
   /* The application continues at this point when SQLExecDirect() */
   /* has finished running. */
   ```

Chapter 13. Multithreaded CLI applications

DB2 CLI supports concurrent execution of threads on the following platforms:

- AIX
- HP-UX
- Linux
- Solaris
- Windows

On any other platform that supports threads, DB2 CLI is guaranteed to be thread safe by serializing all threaded access to the database. In other words, applications or stored procedures that use DB2 CLI can be invoked multiple times and at the same time.

Note: If you are writing applications that use DB2 CLI calls and either embedded SQL or DB2 API calls, see the documentation for multithreaded mixed applications.

Concurrent execution means that two threads can run independently of each other (on a multi-processor machine they may run simultaneously). For example, an application could implement a database-to-database copy in the following way:

- One thread connects to database A and uses `SQLExecute()` and `SQLFetch()` calls to read data from one connection into a shared application buffer.
- The other thread connects to database B and concurrently reads from the shared buffer and inserts the data into database B.

In contrast, if DB2 CLI serializes all function calls, only one thread may be executing a DB2 CLI function at a time. All other threads would have to wait until the current thread is done before it would get a chance to execute.

When to use multiple threads

The most common reason to create another thread in a DB2 CLI application is so a thread other than the one executing can be used to call `SQLCancel()` (to cancel a long running query for example).

Most GUI-based applications use threads in order to ensure that user interaction can be handled on a higher priority thread than other application tasks. The application can simply delegate one thread to run all DB2 CLI functions (with the exception of `SQLCancel()`). In this case there are no thread-related application design issues since only one thread will be accessing the data buffers that are used to interact with DB2 CLI.

Applications that use multiple connections, and are executing statements that may take some time to execute, should consider executing DB2 CLI functions on multiple threads to improve throughput. Such an application should follow standard practices for writing any multi-threaded application, most notably, those concerned with sharing data buffers.

Programming tips

Any resource allocated by DB2 CLI is guaranteed to be thread-safe. This is accomplished by using either a shared global or connection specific semaphore. At

any one time, only one thread can be executing a DB2 CLI function that accepts an environment handle as input. All other functions that accept a connection handle (or a statement or descriptor allocated on that connection handle) will be serialized on the connection handle.

This means that once a thread starts executing a function with a connection handle, or child of a connection handle, any other thread will block and wait for the executing thread to return. The one exception to this is `SQLCancel()`, which must be able to cancel a statement currently executing on another thread. For this reason, the most natural design is to map one thread per connection, plus one thread to handle `SQLCancel()` requests. Each thread can then execute independently of the others.

If an object is shared across threads, application timing issues may arise. For example, if a thread is using a handle in one thread, and another thread frees that handle between function calls, the next attempt to use that handle would result in a return code of SQL_INVALID_HANDLE.

Note:

1. Thread safety for handles only applies for DB2 CLI applications. ODBC applications may trap since the handle in this case is a pointer and the pointer may no longer be valid if another thread has freed it. For this reason, it is best when writing an ODBC application to follow the application model for multithreaded CLI applications.
2. There may be platform or compiler specific link options required for multi-threaded applications. Refer to your compiler documentation for further details.

Application model for multithreaded CLI applications

The following model of a typical multithreaded CLI application is intended as an example:

- Designate a master thread which allocates:
  - *m* "child" threads
  - *n* connection handles
- Each task that requires a connection is executed by one of the child threads, and is given one of the *n* connections by the master thread.
- Each connection is marked as in use by the master thread until the child thread returns it to the master thread.
- Any `SQLCancel()` request is handled by the master thread.

This model allows the master thread to have more threads than connections if the threads are also used to perform non-SQL related tasks, or more connections than threads if the application wants to maintain a pool of active connections to various databases, but limit the number of active tasks.

Note: A multithreaded DB2 CLI stored procedure can only connect to the database where the stored procedure is currently executing.

Most importantly, this ensures that two threads are not trying to use the same connection handle at any one time. Although DB2 CLI controls access to its resources, the application resources such as bound columns and parameter buffers are not controlled by DB2 CLI, and the application must guarantee that a pointer

to a buffer is not being used by two threads at any one time. Any deferred arguments must remain valid until the column or parameter has been unbound.

If it is necessary for two threads to share a data buffer, the application must implement some form of synchronization mechanism. For example, in the database-to-database copy scenario where one thread connects to database A and reads data from one connection into a shared application buffer while the other thread connects to database B and concurrently reads from the shared buffer and inserts data into database B, the use of the shared buffer must be synchronized by the application.

Application deadlocks

The application must be aware of the possibility of creating deadlock situations with shared resources in the database and the application.

DB2 can detect deadlocks at the server and rollback one or more transactions to resolve them. An application may still deadlock if:

- two threads are connected to the same database, and
- one thread is holding an application resource 'A' and is waiting for a database resource 'B', and
- the other thread has a lock on the database resource 'B' while waiting for the application resource 'A'.

In this case the DB2 server is only going to see a lock, not a deadlock, and unless the database LockTimeout configuration keyword is set, the application will wait forever.

The model suggested above avoids this problem by not sharing application resources between threads once a thread starts executing on a connection.

Mixed multithreaded CLI applications

It is possible for a multi-threaded application to mix CLI calls with DB2 API calls and embedded SQL. The type of the call executed earliest in the application determines the best way to organize the application:

DB2 CLI Calls first

The DB2 CLI driver automatically calls the DB2 context APIs to allocate and manage contexts for the application. This means that any application that calls `SQLAllocEnv()` before calling any other DB2 API or embedded SQL will be initialized with the context type set to SQL_CTX_MULTI_MANUAL.

In this case the application should allow DB2 CLI to allocate and manage all contexts. Use DB2 CLI to allocate all connection handles and to perform all connections. Call the `SQLSetConnect()` function in each thread prior to calling any embedded SQL. DB2 APIs can be called after any DB2 CLI function has been called in the same thread.

DB2 API or embedded SQL calls first

The DB2 CLI driver does not automatically call the DB2 context APIs if the application calls any DB2 API or embedded SQL functions before a CLI function.

This means that any thread that calls a DB2 API or embedded SQL function must be attached to a context, otherwise the call will fail with an SQLCODE of SQL1445N. This can be done by calling the DB2 API `sqleAttachToCtx()` which will explicitly attach the thread to a context, or by calling any DB2 CLI function (`SQLSetConnection()` for example). In this case, the application must explicitly manage all contexts.

Use the context APIs to allocate and attach to contexts prior to calling DB2 CLI functions (`SQLAllocEnv()` will use the existing context as the default context). Use the SQL_ATTR_CONN_CONTEXT connection attribute to explicitly set the context that each DB2 CLI connection should use.

Note: It is recommended that you do not use the default application stack size, but instead increase the stack size to at least 256 000. DB2 requires a minimum application stack size of 256 000 when calling a DB2 function. You must ensure therefore, that you allocate a total stack size that is large enough for both your application and the minimum requirements for a DB2 function call.

Chapter 14. Unicode CLI applications

There are two main areas of support for DB2 CLI Unicode applications:

- The addition of a set of functions that accept Unicode string arguments in place of ANSI string arguments.
- The addition of new C and SQL data types to describe Unicode data.

To be considered a Unicode application, the application must connect to the database using either `SQLConnectW()` or `SQLDriverConnectW()`. This will ensure that CLI will consider Unicode the preferred method of communication between itself and the database.

ODBC adds types to the set of C and SQL types that already exist to accommodate Unicode, and CLI uses these additional types accordingly. The new C type, SQL_C_WCHAR, indicates that the C buffer contains Unicode data. The DB2 CLI/ODBC driver considers all Unicode data exchanged with the application to be UCS-2 in native-endian format. The new SQL types, SQL_WCHAR, SQL_WVARCHAR, and SQL_WLONGVARCHAR, indicate that a particular column or parameter marker contains Unicode data. For DB2 Unicode databases, graphic columns are described using the new types. Conversion is allowed between SQL_C_WCHAR and SQL_CHAR, SQL_VARCHAR, SQL_LONGVARCHAR and SQL_CLOB, as well as with the graphic data types.

Note: UCS-2 is a fixed-length character encoding scheme that uses 2 bytes to represent each character. When referring to the number of characters in a UCS-2 encoded string, the count is simply the number of SQLWCHAR elements needed to store the string.

Obsolete CLI/ODBC keyword values

Before Unicode applications were supported, applications that were written to work with single-byte character data could be made to work with double-byte graphic data by a series of DB2 CLI configuration keywords, such as Graphic=1,2 or 3, Patch2=7. These workarounds presented graphic data as character data, and also affected the reported length of the data. These keywords are no longer required for Unicode applications, and should not be used due to the risk of potential side effects. If it is not known if a particular application is a Unicode application, try without any of the keywords that affect the handling of graphic data.

Literals in unicode databases

In non-Unicode databases, data in LONG VARGRAPHIC and LONG VARCHAR columns cannot be compared. Data in GRAPHIC/VARGRAPHIC and CHAR/VARCHAR columns can only be compared, or assigned to each other, using explicit cast functions since no implicit code page conversion is supported. This includes GRAPHIC/VARGRAPHIC and CHAR/VARCHAR literals where a GRAPHIC/VARGRAPHIC literal is differentiated from a CHAR/VARCHAR literal by a G prefix. For Unicode databases, casting between GRAPHIC/VARGRAPHIC and CHAR/VARCHAR literals is not required. Also, a G prefix is not required in front of a GRAPHIC/VARGRAPHIC literal. Provided at least one of the arguments is a literal, implicit conversions occur. This allows literals with or without the G

prefix to be used within statements that use either SQLPrepareW() or SQLExecDirect(). Literals for LONG VARGRAPHICs still must have a G prefix.

Unicode functions (CLI)

DB2 CLI Unicode functions accept Unicode string arguments in place of ANSI string arguments. The Unicode string arguments must be in UCS-2 encoding (native-endian format). ODBC API functions have suffixes to indicate the format of their string arguments: those that accept Unicode end in W, and those that accept ANSI have no suffix (ODBC adds equivalent functions with names that end in A, but these are not offered by DB2 CLI). The following is a list of functions available in DB2 CLI which have both ANSI and Unicode versions:

SQLBrowseConnect	SQLForeignKeys	SQLPrimaryKeys
SQLColAttribute	SQLGetConnectAttr	SQLProcedureColumns
SQLColAttributes	SQLGetConnectOption	SQLProcedures
SQLColumnPrivileges	SQLGetCursorName	SQLSetConnectAttr
SQLColumns	SQLGetDescField	SQLSetConnectOption
SQLConnect	SQLGetDescRec	SQLSetCursorName
SQLDataSources	SQLGetDiagField	SQLSetDescField
SQLDescribeCol	SQLGetDiagRec	SQLSetStmtAttr
SQLDriverConnect	SQLGetInfo	SQLSpecialColumns
SQLError	SQLGetStmtAttr	SQLStatistics
SQLExecDirect	SQLNativeSQL	SQLTablePrivileges
SQLExtendedPrepare	SQLPrepare	SQLTables

Unicode functions that have arguments which are always the length of strings interpret these arguments as the number of SQLWCHAR elements needed to store the string. For functions that return length information for server data, the display size and precision are again described in terms of the number of SQLWCHAR elements used to store them. When the length (transfer size of the data) could refer to string or non-string data, it is interpreted as the number of bytes needed to store the data.

For example, SQLGetInfoW() will still take the length as the number of bytes, but SQLExecDirectW() will use the number of SQLWCHAR elements. Consider a single character from the UTF-16 extended character set (UTF-16 is an extended character set of UCS-2; Microsoft Windows 2000 and Microsoft Windows XP use UTF-16). Microsoft Windows 2000 will use two SQL_C_WCHAR elements, which is equivalent to 4 bytes, to store this single character. The character therefore has a display size of 1, a string length of 2 (when using SQL_C_WCHAR), and a byte count of 4. CLI will return data from result sets in either Unicode or ANSI, depending on the application's binding. If an application binds to SQL_C_CHAR, the driver will convert SQL_WCHAR data to SQL_CHAR. An ODBC driver manager, if used, maps SQL_C_WCHAR to SQL_C_CHAR for ANSI drivers but does no mapping for Unicode drivers.

ANSI to Unicode function mappings

The syntax for a DB2 CLI Unicode function is the same as the syntax for its corresponding ANSI function, except that SQLCHAR parameters are defined as SQLWCHAR. Character buffers defined as SQLPOINTER in the ANSI syntax can be defined as either SQLCHAR or SQLWCHAR in the Unicode function. Refer to the ANSI version of the CLI Unicode functions for ANSI syntax details.

Unicode function calls to ODBC driver managers

ODBC-compliant applications can access a DB2 database through the DB2 CLI/ODBC driver in one of two ways: linking to the DB2 CLI/ODBC driver library or linking to the ODBC driver manager library. This topic discusses CLI applications that link to the ODBC driver manager library.

- Direct access - An application links to the DB2 CLI/ODBC driver library and makes calls to exported CLI/ODBC functions. Unicode applications accessing the DB2 CLI/ODBC driver directly should access and perform transactions against the database using the CLI Unicode functions, and use SQLWCHAR buffers with the understanding that all Unicode data is UCS-2. To identify itself as a Unicode application, the application must connect to the database using either `SQLConnectW()` or `SQLDriverConnectW()`.
- Indirect access - An application links to an ODBC driver manager library and makes calls to standard ODBC functions. The ODBC driver manager then loads the DB2 CLI/ODBC driver and calls exported ODBC functions on behalf of the application. The data passed to the DB2 CLI/ODBC driver from the application might be converted by the ODBC driver manager. An application identifies itself to an ODBC driver manager as a Unicode application by calling `SQLConnectW()` or `SQLDriverConnectW()`.

When connecting to a data source, the ODBC driver manager checks to see if the requested driver exports the `SQLConnectW()` function. If the function is supported, the ODBC driver is considered a Unicode driver, and all subsequent calls in the application to ODBC functions are routed to the functions' Unicode equivalents (identified by the 'W' suffix; for example, `SQLConnectW()`) by the ODBC driver manager. If the application calls Unicode functions, no string conversion is necessary, and the ODBC driver manager calls the Unicode functions directly. If the application calls ANSI functions, the ODBC driver manager converts all ANSI strings to Unicode strings prior to calling the equivalent Unicode function.

If an application calls Unicode functions, but the driver does not export `SQLConnectW()`, then the ODBC driver manager routes any Unicode function calls to their ANSI equivalents. All Unicode strings are converted by the ODBC driver manager to ANSI strings in the application's code page before calling the equivalent ANSI function. This might result in data loss if the application uses Unicode characters which cannot be converted to the application's code page.

Various ODBC driver managers use different encoding schemes for Unicode strings, depending on the operating system:

Table 11. Unicode string encoding schemes by operating system

Driver manager	Operating system	
	Microsoft Windows	**Linux and UNIX**
Microsoft ODBC Driver Manager	UTF-16*	not applicable
unixODBC Driver Manager	UCS-2	UCS-2
DataDirect Connect for ODBC Driver Manager	UTF-16*	UTF-8
* UTF-16 is a superset of UCS-2 and therefore is compatible		

Chapter 15. DB2 CLI bind files and package names

DB2 CLI packages are automatically bound to databases when the databases are created or migrated. If a user has intentionally dropped a package, then you must rebind db2cli.lst.

Rebind db2cli.lst by issuing the following command:

UNIX

```
db2 bind <BNDPATH>/@db2cli.lst blocking all grant public
```

Windows

```
db2 bind "%DB2PATH%\bnd\@db2cli.lst" blocking all grant public
```

The db2cli.lst file contains the names of the required bind files for DB2 CLI to connect to DB2 servers on Linux, UNIX, and Windows (db2clipk.bnd and db2clist.bnd).

For host and iSeries servers use one of ddcsvm.lst, ddcsmvs.lst, ddcsvse.lst, or ddcs400.lst bind list files.

Warnings that are generated when binding DB2 CLI packages (such as db2clist.bnd or db2cli.lst) to workstation or host servers are expected. This is because DB2 uses generic bind files, but the bind file packages for DB2 CLI packages contain sections that apply to specific platforms. Therefore, DB2 might generate warnings during the binding against a server, when it encounters a platform-specific section that does not apply to the server.

The following is an example of a warning that can be ignored which might occur when binding a DB2 CLI package (such as db2clist.bnd or db2cli.lst) to a workstation server:

```
LINE    MESSAGES FOR db2clist.bnd
------  --------------------------------------------------------------------
  235   SQL0440N  No authorized routine named "POSSTR" of type
                  "FUNCTION" having compatible arguments was found.
                  SQLSTATE=42884
```

Table 12. DB2 CLI Bind files and package names

Bind file name	Package name	Needed by DB2 servers on Linux, UNIX, and Windows	Needed by host servers	Description
db2clipk.bnd	SYSSHxyy	Yes	Yes	dynamic placeholders - small package WITH HOLD
	SYSSNxyy	Yes	Yes	dynamic placeholders - small Package NOT WITH HOLD
	SYSLHxyy	Yes	Yes	dynamic placeholders - large package WITH HOLD
	SYSLNxyy	Yes	Yes	dynamic placeholders - large package NOT WITH HOLD
db2clist.bnd	SYSSTAT	Yes	Yes	common static CLI functions
db2schema.bnd	SQLL9vyy	Yes	No	catalog function support

Note:

- 'S' represents a small package and 'L' represents a large package
- 'H' represents WITH HOLD, and 'N' represents NOT WITH HOLD.
- 'v' represents the DB2 server version: for example, E=Version 8, F=Version 9
- 'x' is the isolation level: 0=NC, 1=UR, 2=CS, 3=RS, 4=RR
- 'yy' is the package iteration 00 through FF
- 'zz' is unique for each platform

For example, for the dynamic packages:

- SYSSN100 A small package (65 sections) where all cursor declarations are for non-held cursors. Bound with isolation level UR. This is the first iteration of that package.
- SYSLH401 A large package (385 sections) where all cursor declarations are for held cursors. Bound with isolation level RS. This is the second iteration of that package.

Previous versions of DB2 servers do not need all of the bind files and will therefore return errors at bind time. Use the bind option SQLERROR(CONTINUE) so that the same package can be bound on all platforms and errors will be ignored for any statements not supported there.

db2schema.bnd bind file

The db2schema.bnd bind file is automatically bound when the database is created or migrated on DB2 servers on Linux, UNIX, and Windows, and exists only on these types of servers. This bind file is located at the server and should be bound manually (from the server), if the package was intentionally dropped by a user or if an SQL1088W (+1088) warning is received after database creation or migration.

Only the most recent version of this package is needed.

If the package is missing, it must be rebound locally on the server. Do not bind this package against remote servers (for example, against a host database). The bind file is found in the sqllib/bnd directory of the instance home directory, and is rebound with the following command:

```
bind db2schema.bnd blocking all grant public
```

If an SQL1088W warning was received after database creation or migration, and the db2schema.bnd package is missing, increase the APPLHEAPSZ database configuration parameter to 128 or greater, and attempt to rebind. No errors should be reported during binding.

Bind option limitations for CLI packages

Some bind options might not take effect when binding DB2 CLI packages with any of the following list files: db2cli.lst, ddcsmvs.lst, ddcs400.lst, ddcsvm.lst, or ddcsvse.lst. Because DB2 CLI packages are used by DB2 CLI, ODBC, JDBC, OLE DB, .NET, and ADO applications, any changes made to the DB2 CLI packages affect all applications of these types. Only a subset of bind options are therefore supported by default when binding DB2 CLI packages. The supported options are: ACTION, COLLECTION, CLIPKG, OWNER, and REPLVER. All other bind options that impact CLI packages are ignored.

To create DB2 CLI packages with bind options that are not supported by default, specify the COLLECTION bind option with a collection ID that is different from the default collection ID, NULLID. Any bind options specified are then accepted. For example, to create DB2 CLI packages with the KEEPDYNAMIC YES bind option, which is not supported by default, issue the following command:

```
db2 bind @db2cli.lst collection newcolid keepdynamic yes
```

In order for CLI/ODBC applications to access the DB2 CLI packages created in the new collection, set the CurrentPackageSet CLI/ODBC keyword in the db2cli.ini initialization file to the new collection ID.

To overwrite DB2 CLI packages that already exist under a particular collection ID, perform either of the following actions:

- Drop the existing CLI package before issuing the bind command for this collection ID.
- Specify the ACTION REPLACE bind option when issuing the bind command.

Chapter 16. Building CLI applications

Building CLI applications on UNIX

DB2 provides build scripts for compiling and linking CLI programs. These are located in the `sqllib/samples/cli` directory, along with sample programs that can be built with these files. The script file `bldapp` contains the commands to build a DB2 CLI application. It takes up to four parameters, represented inside the script file by the variables `$1`, `$2`, `$3`, and `$4`. The parameter, `$1`, specifies the name of your source file. This is the only required parameter, and the only one needed for CLI applications that do not contain embedded SQL. Building embedded SQL programs requires a connection to the database so three optional parameters are also provided: the second parameter, `$2`, specifies the name of the database to which you want to connect; the third parameter, `$3`, specifies the user ID for the database, and `$4` specifies the password. If the program contains embedded SQL, indicated by the `.sqc` extension, then the `embprep` script is called to precompile the program, producing a program file with a `.c` extension.

The following examples show you how to build and run CLI applications. To build the sample program `tbinfo` from the source file `tbinfo.c`, enter:

```
bldapp tbinfo
```

The result is an executable file, `tbinfo`. You can run the executable file by entering the executable name:

```
tbinfo
```

- **Building and Running Embedded SQL Applications** There are three ways to build the embedded SQL application, `dbusemx`, from the source file `dbusemx.sqc`:
  1. If connecting to the sample database on the same instance, enter:
     ```
     bldapp dbusemx
     ```
  2. If connecting to another database on the same instance, also enter the database name:
     ```
     bldapp dbusemx database
     ```
  3. If connecting to a database on another instance, also enter the user ID and password of the database instance:
     ```
     bldapp dbusemx database userid password
     ```

  The result is an executable file, `dbusemx`.
- There are three ways to run this embedded SQL application:
  1. If accessing the sample database on the same instance, simply enter the executable name:
     ```
     dbusemx
     ```
  2. If accessing another database on the same instance, enter the executable name and the database name:
     ```
     dbusemx database
     ```
  3. If accessing a database on another instance, enter the executable name, database name, and user ID and password of the database instance:
     ```
     dbusemx database userid password
     ```

AIX CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the AIX IBM C compiler. They are demonstrated in the `sqllib/samples/cli/bldapp` build script.

Compile and link options for bldapp
Compile options: **xlc** The IBM C compiler. **$EXTRA_CFLAG** Contains the value "-q64" for 64-bit environments; otherwise, contains no value. **-I$DB2PATH/include** Specify the location of the DB2 include files. For example: `$HOME/sqllib/include` **-c** Perform compile only; no link. This script has separate compile and link steps.
Link options: **xlc** Use the compiler as a front end for the linker. **$EXTRA_CFLAG** Contains the value "-q64" for 64-bit environments; otherwise, contains no value. **-o $1** Specify the executable program. **$1.o** Specify the object file. **utilcli.o** Include the utility object file for error checking. **-L$DB2PATH/$LIB** Specify the location of the DB2 runtime shared libraries. For example: `$HOME/sqllib/$LIB`. If you do not specify the `-L` option, the compiler assumes the following path: `/usr/lib:/lib`. **-ldb2** Link with the DB2 library. Refer to your compiler documentation for additional compiler options.

HP-UX CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the HP-UX C compiler. They are demonstrated in the `sqllib/samples/cli/bldapp` build script.

Compile and link options for bldapp

Compile options:

cc Use the C compiler.

$EXTRA_CFLAG
If the HP-UX platform is IA64 and 64-bit support is enabled, this flag contains the value **+DD64**; if 32-bit support is enabled, it contains the value **+DD32**. If the HP-UX platform is PA-RISC and 64-bit support is enabled, it contains the value **+DA2.0W**. For 32-bit support on a PA-RISC platform, this flag contains the value **+DA2.0N**.

+DD64 Must be used to generate 64-bit code for HP-UX on IA64.

+DD32 Must be used to generate 32-bit code for HP-UX on IA64.

+DA2.0W
Must be used to generate 64-bit code for HP-UX on PA-RISC.

+DA2.0N
Must be used to generate 32-bit code for HP-UX on PA-RISC.

-Ae Enables HP ANSI extended mode.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`

-c Perform compile only; no link. Compile and link are separate steps.

Link options:

cc Use the compiler as a front end for the linker.

$EXTRA_CFLAG
If the HP-UX platform is IA64 and 64-bit support is enabled, this flag contains the value **+DD64**; if 32-bit support is enabled, it contains the value **+DD32**. If the HP-UX platform is PA-RISC and 64-bit support is enabled, it contains the value **+DA2.0W**. For 32-bit support on a PA-RISC platform, this flag contains the value **+DA2.0N**.

+DD64 Must be used to generate 64-bit code for HP-UX on IA64.

+DD32 Must be used to generate 32-bit code for HP-UX on IA64.

+DA2.0W
Must be used to generate 64-bit code for HP-UX on PA-RISC.

+DA2.0N
Must be used to generate 32-bit code for HP-UX on PA-RISC.

-o $1 Specify the executable program.

$1.o Specify the object file.

utilcli.o
Include the utility object file for error checking.

$EXTRA_LFLAG
Specify the runtime path. If set, for 32-bit it contains the value `-Wl,+b$HOME/sqllib/lib32`, and for 64-bit: `-Wl,+b$HOME/sqllib/lib64`. If not set, it contains no value.

-L$DB2PATH/$LIB
Specify the location of the DB2 runtime shared libraries. For 32-bit: `$HOME/sqllib/lib32`; for 64-bit: `$HOME/sqllib/lib64`.

-ldb2 Link with the database manager library.

Refer to your compiler documentation for additional compiler options.

Linux CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the GNU/Linux gcc compiler. They are demonstrated in the `sqllib/samples/cli/bldapp` build script.

Compile and link options for bldapp
Compile options: **gcc** The C compiler. **$EXTRA_C_FLAGS** Contains one of the following: • `-m31` on Linux for zSeries only, to build a 32-bit library; • `-m32` on Linux for x86, x86_64 and POWER, to build a 32-bit library; • `-m64` on Linux for zSeries, POWER, x86_64, to build a 64-bit library; or • No value on Linux for IA64, to build a 64-bit library. **-I$DB2PATH/include** Specify the location of the DB2 include files. For example: `$HOME/sqllib/include` **-c** Perform compile only; no link. Compile and link are separate steps.
Link options: **gcc** Use the compiler as a front end for the linker. **$EXTRA_C_FLAGS** Contains one of the following: • `-m31` on Linux for zSeries only, to build a 32-bit library; • `-m32` on Linux for x86, x86_64 and POWER, to build a 32-bit library; • `-m64` on Linux for zSeries, POWER, x86_64, to build a 64-bit library; or • No value on Linux for IA64, to build a 64-bit library. **-o $1** Specify the executable. **$1.o** Include the program object file. **utilcli.o** Include the utility object file for error checking. **$EXTRA_LFLAG** For 32-bit it contains the value ″-Wl,-rpath,$DB2PATH/lib32″, and for 64-bit it contains the value ″-Wl,-rpath,$DB2PATH/lib64″. **-L$DB2PATH/$LIB** Specify the location of the DB2 static and shared libraries at link-time. For example, for 32-bit: `$HOME/sqllib/lib32`, and for 64-bit: `$HOME/sqllib/lib64`. **-ldb2** Link with the DB2 library. Refer to your compiler documentation for additional compiler options.

Solaris CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the Solaris C compiler. They are demonstrated in the sqllib/samples/cli/bldapp build script.

Compile and link options for bldapp

Compile options:

cc Use the C compiler.

-xarch=$CFLAG_ARCH
This option ensures that the compiler will produce valid executables when linking with libdb2.so. The value for $CFLAG_ARCH is set as follows:

- ″v8plusa″: For 32-bit applications on Solaris SPARC
- ″v9″: For 64-bit applications on Solaris SPARC
- ″sse2″: For 32-bit applications on Solaris x64
- ″amd64″: For 64-bit applications on Solaris x64

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: $HOME/sqllib/include

-c Perform compile only; no link. This script has separate compile and link steps.

Link options:

cc Use the compiler as a front end for the linker.

-xarch=$CFLAG_ARCH
This option ensures that the compiler will produce valid executables when linking with libdb2.so. The value for $CFLAG_ARCH is set as follows:

- ″v8plusa″: For 32-bit applications on Solaris SPARC
- ″v9″: For 64-bit applications on Solaris SPARC
- ″sse2″: For 32-bit applications on Solaris x64
- ″amd64″: For 64-bit applications on Solaris x64

-mt Link in multi-thread support to prevent problems calling fopen.
Note: If POSIX threads are used, DB2 applications also have to link with `-lpthread`, whether or not they are threaded.

-o $1 Specify the executable program.

$1.o Include the program object file.

utilcli.o
Include the utility object file for error checking.

-L$DB2PATH/$LIB
Specify the location of the DB2 static and shared libraries at link-time. For example, for 32-bit: $HOME/sqllib/lib32, and for 64-bit: `$HOME/sqllib/lib64`.

$EXTRA_LFLAG
Specify the location of the DB2 shared libraries at run-time. For 32-bit it contains the value ″-R$DB2PATH/lib32″, and for 64-bit it contains the value ″-R$DB2PATH/lib64″.

-ldb2 Link with the DB2 library.

Refer to your compiler documentation for additional compiler options.

Building CLI multi-connection applications on UNIX

DB2 provides build scripts for compiling and linking CLI programs. These are located in the `sqllib/samples/cli` directory, along with sample programs that can be built with these files.

The build file, `bldmc`, contains the commands to build a DB2 multi-connection program, requiring two databases. The compile and link options are the same as those used in `bldapp`.

The first parameter, $1, specifies the name of your source file. The second parameter, $2, specifies the name of the first database to which you want to connect. The third parameter, $3, specifies the second database to which you want to connect. These are all required parameters.

Note: The makefile hardcodes default values of ″sample″ and ″sample2″ for the database names ($2 and $3, respectively) so if you are using the makefile, and accept these defaults, you only have to specify the program name (the $1 parameter). If you are using the bldmc script, you must specify all three parameters.

Optional parameters are not required for a local connection, but are required for connecting to a server from a remote client. These are: $4 and $5 to specify the user ID and password, respectively, for the first database; and $6 and $7 to specify the user ID and password, respectively, for the second database.

For the multi-connection sample program, dbmconx, you require two databases. If the sample database is not yet created, you can create it by entering db2sampl on the command line. The second database, here called sample2, can be created with one of the following commands:

- If creating the database locally:

  ```
  db2 create db sample2
  ```

- If creating the database remotely:

  ```
  db2 attach to <node_name>
  db2 create db sample2
  db2 detach
  db2 catalog db sample2 as sample2 at node <node_name>
  ```

  where <node_name> is the database partition where the database resides.

- Multi-connection also requires that the TCP/IP listener is running. To ensure it is, do the following:

  1. Set the environment variable DB2COMM to TCP/IP as follows:

     ```
     db2set DB2COMM=TCPIP
     ```

  2. Update the database manager configuration file with the TCP/IP service name as specified in the services file:

     ```
     db2 update dbm cfg using SVCENAME <TCP/IP service name>
     ```

     Each instance has a TCP/IP service name listed in the services file. Ask your system administrator if you cannot locate it or do not have the file permission to read the services file. On UNIX and Linux systems, the services file is located in: /etc/services

  3. Stop and restart the database manager in order for these changes to take effect:

     ```
     db2stop
     db2start
     ```

     The dbmconx program consists of five files:

     dbmconx.c
     Main source file for connecting to both databases.

     dbmconx1.sqc
     Source file for creating a package bound to the first database.

dbmconx1.h
Header file for dbmconx1.sqc included in dbmconx.sqc for accessing the SQL statements for creating and dropping a table to be bound to the first database.

dbmconx2.sqc
Source file for creating a package bound to the second database.

dbmconx2.h
Header file for dbmconx2.sqc included in dbmconx.sqc for accessing the SQL statements for creating and dropping a table to be bound to the second database.

- To build the multi-connection sample program, dbmconx, enter:

```
bldmc dbmconx sample sample2
```

  The result is an executable file, dbmconx.
- To run the executable file, enter the executable name:

```
dbmconx
```

  The program demonstrates a two-phase commit to two databases.

Building CLI applications on Windows

DB2 provides batch files for compiling and linking CLI programs. These are located in the sqllib\samples\cli directory, along with sample programs that can be built with these files.

The batch file bldapp.bat contains the commands to build a DB2 CLI program. It takes up to four parameters, represented inside the batch file by the variables %1, %2, %3, and %4.

The parameter, %1, specifies the name of your source file. This is the only required parameter, and the only one needed for CLI programs that do not contain embedded SQL. Building embedded SQL programs requires a connection to the database so three optional parameters are also provided: the second parameter, %2, specifies the name of the database to which you want to connect; the third parameter, %3, specifies the user ID for the database, and %4 specifies the password.

If the program contains embedded SQL, indicated by the .sqc or .sqx extension, then the embprep.bat batch file is called to precompile the program, producing a program file with either a .c or a .cxx extension, respectively.

The following examples show you how to build and run CLI applications.

To build the sample program tbinfo from the source file tbinfo.c, enter:

```
bldapp tbinfo
```

The result is an executable file tbinfo. You can run the executable file by entering the executable name:

```
tbinfo
```

Building and running embedded SQL applications

There are three ways to build the embedded SQL application, dbusemx, from the source file dbusemx.sqc:

1. If connecting to the sample database on the same instance, enter:
   ```
   bldapp dbusemx
   ```
2. If connecting to another database on the same instance, also enter the database name:
   ```
   bldapp dbusemx database
   ```
3. If connecting to a database on another instance, also enter the user ID and password of the database instance:
   ```
   bldapp dbusemx database userid password
   ```

   The result is an executable file, `dbusemx`.

   There are three ways to run this embedded SQL application:

   a. If accessing the sample database on the same instance, simply enter the executable name:
      ```
      dbusemx
      ```
   b. If accessing another database on the same instance, enter the executable name and the database name:
      ```
      dbusemx database
      ```
   c. If accessing a database on another instance, enter the executable name, database name, and user ID and password of the database instance:
      ```
      dbusemx database userid password
      ```

Windows CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the Microsoft Visual C++ compiler. They are demonstrated in the `sqllib\samples\cli\bldapp.bat` batch file.

Compile and link options for bldapp	
Compile options:	
%BLDCOMP%	Variable for the compiler. The default is `cl`, the Microsoft Visual C++ compiler. It can be also set to `icl`, the Intel® C++ Compiler for 32-bit and 64-bit applications, or `ecl`, the Intel C++ Compiler for Itanium 64-bit applications.
-Zi	Enable debugging information.
-Od	Disable optimizations. It is easier to use a debugger with optimization off.
-c	Perform compile only; no link.
-W2	Set warning level.
-DWIN32	Compiler option necessary for Windows operating systems.

Link options:

link Use the linker.

-debug Include debugging information.

-out:%1.exe
Specify the executable.

%1.obj Include the object file.

utilcli.obj
Include the utility object file for error checking.

db2api.lib
Link with the DB2 API library.

/delayload:db2app.dll
Used to ensure that db2app.dll is not loaded until the first call to a DB2 API. This is required when using the db2SelectDB2Copy API.

db2ApiInstall.lib
Library to statically link in your application if you need to select a particular DB2 copy that is installed on the computer using the db2SelectDB2Copy API. Note: to use this functionality, you need to either dynamically load db2app.dll or use the `/delayload:db2app.dll` option of your compiler and call the db2SelectDB2Copy API prior to running any other DB2 API's.

Refer to your compiler documentation for additional compiler options.

Building CLI multi-connection applications on Windows

DB2 provides batch files for compiling and linking CLI programs. These are located in the `sqllib\samples\cli` directory, along with sample programs that can be built with these files.

The batch file, `bldmc.bat`, contains the commands to build a DB2 multi-connection program requiring two databases. The compile and link options are the same as those used in `bldapp.bat`.

The first parameter, `%1`, specifies the name of your source file. The second parameter, `%2`, specifies the name of the first database to which you want to connect. The third parameter, `%3`, specifies the second database to which you want to connect. These are all required parameters.

Note: The makefile hardcodes default values of "sample" and "sample2" for the database names (`%2` and `%3`, respectively) so if you are using the makefile, and accept these defaults, you only have to specify the program name (the `%1` parameter). If you are using the `bldmc.bat` file, you must specify all three parameters.

Optional parameters are not required for a local connection, but are required for connecting to a server from a remote client. These are: `%4` and `%5` to specify the user ID and password, respectively, for the first database; and `%6` and `%7` to specify the user ID and password, respectively, for the second database.

For the multi-connection sample program, `dbmconx`, you require two databases. If the `sample` database is not yet created, you can create it by entering `db2sampl` on the command line. The second database, here called `sample2`, can be created with one of the following commands:

- If creating the database locally:

  ```
  db2 create db sample2
  ```

- If creating the database remotely:

  ```
  db2 attach to <node_name>
  db2 create db sample2
  db2 detach
  db2 catalog db sample2 as sample2 at node <node_name>
  ```

  where <node_name> is the database partition where the database resides.

- Multi-connection also requires that the TCP/IP listener is running. To ensure it is, do the following:

  1. Set the environment variable DB2COMM to TCP/IP as follows:

     ```
     db2set DB2COMM=TCPIP
     ```

  2. Update the database manager configuration file with the TCP/IP service name as specified in the services file:

     ```
     db2 update dbm cfg using SVCENAME <TCP/IP service name>
     ```

     Each instance has a TCP/IP service name listed in the services file. Ask your system administrator if you cannot locate it or do not have the file permission to read the services file.

  3. Stop and restart the database manager in order for these changes to take effect:

     ```
     db2stop
     db2start
     ```

  The dbmconx program consists of five files:

  dbmconx.c
  Main source file for connecting to both databases.

  dbmconx1.sqc
  Source file for creating a package bound to the first database.

  dbmconx1.h
  Header file for dbmconx1.sqc included in dbmconx.sqc for accessing the SQL statements for creating and dropping a table to be bound to the first database.

  dbmconx2.sqc
  Source file for creating a package bound to the second database.

  dbmconx2.h
  Header file for dbmconx2.sqc included in dbmconx.sqc for accessing the SQL statements for creating and dropping a table to be bound to the second database.

- To build the multi-connection sample program, dbmconx, enter:

  ```
  bldmc dbmconx sample sample2
  ```

  The result is an executable file, dbmconx.

- To run the executable file, enter the executable name:

  ```
  dbmconx
  ```

  The program demonstrates a two-phase commit to two databases.

Building CLI applications with configuration files

The configuration file, cli.icc, in sqllib/samples/cli allows you to build DB2 CLI programs.

To use the configuration file to build the DB2 CLI sample program tbinfo from the source file tbinfo.c, do the following:

1. Set the CLI environment variable:
   ```
   export CLI=tbinfo
   ```
2. If you have a cli.ics file in your working directory, produced by building a different program with the cli.icc file, delete the cli.ics file with this command:
   ```
   rm cli.ics
   ```
   An existing cli.ics file produced for the same program you are going to build again does not have to be deleted.
3. Compile the sample program by entering:
   ```
   vacbld cli.icc
   ```
   Note: The vacbld command is provided by VisualAge® C++.
   The result is an executable file, tbinfo. You can run the program by entering the executable name:
   ```
   tbinfo
   ```

Building and running embedded SQL applications

You use the configuration file after the program is precompiled with the embprep file. The embprep file precompiles the source file and binds the program to the database. You use the cli.icc configuration file to compile the precompiled file.

There are three ways to precompile the embedded SQL application, dbusemx, from the source file dbusemx.sqc:

- If connecting to the sample database on the same instance, enter:
  ```
  embprep dbusemx
  ```
- If connecting to another database on the same instance, also enter the database name:
  ```
  embprep dbusemx database
  ```
- If connecting to a database on another instance, also enter the user ID and password of the database instance:
  ```
  embprep dbusemx database userid password
  ```

The result is a precompiled C file, dbusemx.c.

After it is precompiled, the C file can be compiled with the cli.icc file as follows:

1. Set the CLI environment variable to the program name by entering:
   ```
   export CLI=dbusemx
   ```
2. If you have a cli.ics file in your working directory, produced by building a different program with the cli.icc or cliapi.icc file, delete the cli.ics file with this command:
   ```
   rm cli.ics
   ```

An existing cli.ics file produced for the same program you are going to build again does not have to be deleted.

3. Compile the sample program by entering:

```
vacbld cli.icc
```

There are three ways to run this embedded SQL application:

- If accessing the sample database on the same instance, simply enter the executable name:

```
dbusemx
```

- If accessing another database on the same instance, enter the executable name and the database name:

```
dbusemx database
```

- If accessing a database on another instance, enter the executable name, database name, and user ID and password of the database instance:

```
dbusemx database userid password
```

Building CLI stored procedures with configuration files

The configuration file, clis.icc, in sqllib/samples/cli, allows you to build DB2 CLI stored procedures.

To use the configuration file to build the DB2 CLI stored procedure spserver from the source file spserver.c, do the following:

1. Set the CLIS environment variable to the program name by entering:

```
export CLIS=spserver
```

2. If you have a clis.ics file in your working directory, produced by building a different program with the clis.icc file, delete the clis.ics file with this command:

```
rm clis.ics
```

An existing clis.ics file produced for the same program you are going to build again does not have to be deleted.

3. Compile the sample program by entering:

```
vacbld clis.icc
```

Note: The vacbld command is provided by VisualAge C++.

4. The stored procedure is copied to the server in the path sqllib/function

Next, catalog the stored procedures by running the spcreate.db2 script on the server. First, connect to the database with the user ID and password of the instance where the database is located:

```
db2 connect to sample userid password
```

If the stored procedures were previously cataloged, you can drop them with this command:

```
db2 -td@ -vf spdrop.db2
```

Then catalog them with this command:

```
db2 -td@ -vf spcreate.db2
```

Then, stop and restart the database to allow the new shared library to be recognized. If necessary, set the file mode for the shared library so the DB2 instance can access it.

Once you build the stored procedure `spserver`, you can build the CLI client application `spclient` that calls the stored procedure. You can build `spclient` by using the configuration file, `cli.icc`.

To call the stored procedure, run the sample client application by entering:

`spclient` *database userid password*

where

database
Is the name of the database to which you want to connect. The name could be `sample`, or its remote alias, or some other name.

userid Is a valid user ID.

password
Is a valid password.

The client application accesses the shared library, `spserver`, and executes a number of stored procedure functions on the server database. The output is returned to the client application.

Chapter 17. Building CLI routines

Building CLI routines on UNIX

DB2 provides build scripts for compiling and linking CLI programs. These are located in the `sqllib/samples/cli` directory, along with sample programs that can be built with these files. The script file `bldrtn` contains the commands to build DB2 CLI routines (stored procedures and user-defined functions). `bldrtn` creates a shared library on the server. It takes a parameter for the source file name, represented inside the script file by the variable $1.

To build the sample program `spserver` from the source file `spserver.c`:

1. Enter the build script name and program name:

   ```
   bldrtn spserver
   ```

   The script file copies the shared library to the `sqllib/function` directory.
2. Next, catalog the routines by running the `spcat` script on the server:

   ```
   spcat
   ```

   This script connects to the sample database, uncatalogs the routines if they were previously cataloged by calling `spdrop.db2`, then catalogs them by calling `spcreate.db2`, and finally disconnects from the database. You can also call the `spdrop.db2` and `spcreate.db2` scripts individually.
3. Then, unless this is the first time the shared library was built, stop and restart the database to allow the new version of the shared library to be recognized. If necessary, set the file mode for the shared library so the DB2 instance can access it.

Once you build the shared library, `spserver`, you can build the CLI client application, `spclient`, that calls the routines within the shared library.

The client application can be built like any other CLI client application by using the script file, `bldapp`.

To access the shared library, run the sample client application by entering:

`spclient` *database userid password*

where

database
Is the name of the database to which you want to connect. The name could be `sample`, or its alias, or another database name.

userid Is a valid user ID.

password
Is a valid password.

The client application accesses the shared library, `spserver`, and executes the routines on the server database. The output is returned to the client application.

AIX CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines (stored procedures and user-defined functions) with the AIX IBM C compiler. They are demonstrated in the `sqllib/samples/cli/bldrtn` build script.

Compile and link options for bldrtn
Compile options: **xlc_r** Use the multi-threaded version of the IBM C compiler, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED). **$EXTRA_CFLAG** Contains the value "-q64" for 64-bit environments; otherwise, contains no value. **-I$DB2PATH/include** Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`. **-c** Perform compile only; no link. Compile and link are separate steps.
Link options: **xlc_r** Use the multi-threaded version of the compiler as a front end for the linker. **$EXTRA_CFLAG** Contains the value "-q64" for 64-bit environments; otherwise, contains no value. **-qmkshrobj** Create the shared library. **-o $1** Specify the executable program. **$1.o** Specify the object file. **utilcli.o** Include the utility object file for error checking. **-L$DB2PATH/$LIB** Specify the location of the DB2 runtime shared libraries. For example: `$HOME/sqllib/$LIB`. If you do not specify the `-L` option, the compiler assumes the following path: `/usr/lib:/lib`. **-ldb2** Link with the DB2 library. **-bE:$.exp** Specify an export file. The export file contains a list of routines. Refer to your compiler documentation for additional compiler options.

HP-UX CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines with the HP-UX C compiler. They are demonstrated in the `sqllib/samples/cli/bldrtn` build script.

Compile and link options for bldrtn

Compile options:

cc The C compiler.

$EXTRA_CFLAG
If the HP-UX platform is IA64 and 64-bit support is enabled, this flag contains the value **+DD64**; if 32-bit support is enabled, it contains the value **+DD32**. If the HP-UX platform is PA-RISC and 64-bit support is enabled, it contains the value **+DA2.0W**. For 32-bit support on a PA-RISC platform, this flag contains the value **+DA2.0N**.

+DD64 Must be used to generate 64-bit code for HP-UX on IA64.

+DD32 Must be used to generate 32-bit code for HP-UX on IA64.

+DA2.0W
Must be used to generate 64-bit code for HP-UX on PA-RISC.

+DA2.0N
Must be used to generate 32-bit code for HP-UX on PA-RISC.

+u1 Allow unaligned data access. Use only if your application uses unaligned data.

+z Generate position-independent code.

-Ae Enables HP ANSI extended mode.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`

-D_POSIX_C_SOURCE=199506L
POSIX thread library option that ensures _REENTRANT is defined, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED).

-c Perform compile only; no link. Compile and link are separate steps.

Link options:

ld Use the linker to link.

-b Create a shared library rather than a normal executable.

-o $1 Specify the executable.

$1.o Specify the object file.

utilcli.o
Link in the error-checking utility object file.

$EXTRA_LFLAG
Specify the runtime path. If set, for 32-bit it contains the value `+b$HOME/sqllib/lib32`, and for 64-bit: `+b$HOME/sqllib/lib64`. If not set, it contains no value.

-L$DB2PATH/$LIB
Specify the location of the DB2 runtime shared libraries. For 32-bit: `$HOME/sqllib/lib32`; for 64-bit: `$HOME/sqllib/lib64`.

-ldb2 Link with the DB2 library.

-lpthread
Link with the POSIX thread library.

Refer to your compiler documentation for additional compiler options.

Linux CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines with the GNU/Linux gcc compiler. They are demonstrated in the `sqllib/samples/cli/bldrtn` build script.

Compile and link options for bldrtn
Compile options: **gcc** The C compiler. **$EXTRA_C_FLAGS** Contains one of the following: • `-m31` on Linux for zSeries only, to build a 32-bit library; • `-m32` on Linux for x86, x86_64 and POWER, to build a 32-bit library; • `-m64` on Linux for zSeries, POWER, x86_64, to build a 64-bit library; or • No value on Linux for IA64, to build a 64-bit library. **-fpic** Allows position independent code. **-I$DB2PATH/include** Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`. **-c** Perform compile only; no link. Compile and link are separate steps. **-D_REENTRANT** Defines _REENTRANT, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED).
Link options: **gcc** Use the compiler as a front end for the linker. **$EXTRA_C_FLAGS** Contains one of the following: • `-m31` on Linux for zSeries only, to build a 32-bit library; • `-m32` on Linux for x86, x86_64 and POWER, to build a 32-bit library; • `-m64` on Linux for zSeries, POWER, x86_64, to build a 64-bit library; or • No value on Linux for IA64, to build a 64-bit library. **-o $1** Specify the executable. **$1.o** Include the program object file. **utilcli.o** Include the utility object file for error-checking. **-shared** Generate a shared library. **$EXTRA_LFLAG** Specify the location of the DB2 shared libraries at run-time. For 32-bit it contains the value ″-Wl,-rpath,$DB2PATH/lib32″. For 64-bit it contains the value ″-Wl,-rpath,$DB2PATH/lib64″. **-L$DB2PATH/$LIB** Specify the location of the DB2 static and shared libraries at link-time. For example, for 32-bit: `$HOME/sqllib/lib32`, and for 64-bit: `$HOME/sqllib/lib64`. **-ldb2** Link with the DB2 library. **-lpthread** Link with the POSIX thread library. Refer to your compiler documentation for additional compiler options.

Solaris CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines with the Solaris C compiler. They are demonstrated in the sqllib/samples/cli/bldrtn build script.

Compile and link options for bldrtn
Compile options: **cc** The C compiler. **-xarch=$CFLAG_ARCH** This option ensures that the compiler will produce valid executables when linking with libdb2.so. The value for $CFLAG_ARCH is set as follows: • ″v8plusa″: For 32-bit applications on Solaris SPARC • ″v9″: For 64-bit applications on Solaris SPARC • ″sse2″: For 32-bit applications on Solaris x64 • ″amd64″: For 64-bit applications on Solaris x64 **-mt** Allow multi-threaded support, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED). **-DUSE_UI_THREADS** Allows Sun's ″UNIX International″ threads APIs. **-Kpic** Generate position-independent code for shared libraries. **-I$DB2PATH/include** Specify the location of the DB2 include files. For example: $HOME/sqllib/include. **-c** Perform compile only; no link. Compile and link are separate steps.

Link options:

cc Use the compiler as a front end for the linker.

-xarch=$CFLAG_ARCH
This option ensures that the compiler will produce valid executables when linking with libdb2.so. The value for $CFLAG_ARCH is set as follows:

- ″v8plusa″: For 32-bit applications on Solaris SPARC
- ″v9″: For 64-bit applications on Solaris SPARC
- ″sse2″: For 32-bit applications on Solaris x64
- ″amd64″: For 64-bit applications on Solaris x64

-mt Allow multi-threaded support, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED).

-G Generate a shared library.

-o $1 Specify the executable.

$1.o Include the program object file.

utilcli.o
Include the utility object file for error-checking.

-L$DB2PATH/$LIB
Specify the location of the DB2 static and shared libraries at link-time. For example, for 32-bit: $HOME/sqllib/lib32, and for 64-bit: $HOME/sqllib/lib64.

$EXTRA_LFLAG
Specify the location of the DB2 shared libraries at run-time. For 32-bit it contains the value ″-R$DB2PATH/lib32″, and for 64-bit it contains the value ″-R$DB2PATH/lib64″.

-ldb2 Link with the DB2 library.

Refer to your compiler documentation for additional compiler options.

Building CLI routines on Windows

DB2 provides batch files for compiling and linking CLI programs. These are located in the `sqllib\samples\cli` directory, along with sample programs that can be built with these files. The batch file `bldrtn.bat` contains the commands to build CLI routines (stored procedures and user-defined functions). `bldrtn.bat` creates a DLL on the server. It takes one parameter, represented inside the batch file by the variable `%1`, which specifies the name of your source file. The batch file uses the source file name for the DLL name.

To build the `spserver` DLL from the source file `spserver.c`:

1. Enter the batch file name and program name:

   ```
   bldrtn spserver
   ```

   The batch file uses the module definition file `spserver.def`, contained in the same directory as the CLI sample programs, to build the DLL. The batch file then copies the DLL, `spserver.dll`, to the server in the path `sqllib\function`.
2. Next, catalog the routines by running the `spcat` script on the server:

   ```
   spcat
   ```

   This script connects to the sample database, uncatalogs the routines if they were previously cataloged by calling `spdrop.db2`, then catalogs them by calling `spcreate.db2`, and finally disconnects from the database. You can also call the `spdrop.db2` and `spcreate.db2` scripts individually.

3. Then, unless this is the first time the shared library was built, stop and restart the database to allow the new version of the shared library to be recognized. If necessary, set the file mode for the shared library so the DB2 instance can access it.

Once you build the DLL `spserver`, you can build the CLI client application `spclient` that calls the routines within it.

You can build `spclient` by using the script file, `bldapp`.

To call the routines, run the sample client application by entering:

`spclient` *database userid password*

where

database
Is the name of the database to which you want to connect. The name could be `sample`, or its alias, or another database name.

userid Is a valid user ID.

password
Is a valid password.

The client application accesses the DLL, `spserver`, which executes the routines on the server database. The output is returned to the client application.

Windows CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines with the Microsoft Visual C++ compiler. They are demonstrated in the `sqllib\samples\cli\bldrtn.bat` batch file.

Compile and link options for bldrtn	
Compile options:	
%BLDCOMP%	Variable for the compiler. The default is `cl`, the Microsoft Visual C++ compiler. It can be also set to `icl`, the Intel C++ Compiler for 32-bit and 64-bit applications, or `ecl`, the Intel C++ Compiler for Itanium 64-bit applications.
-Zi	Enable debugging information
-Od	Disable optimizations. It is easier to use a debugger with optimization off.
-c	Perform compile only; no link. The batch file has separate compile and link steps.
-W2	Set warning level.
-DWIN32	Compiler option necessary for Windows operating systems.
-MD	Link using MSVCRT.LIB

Link options:

link Use the 32-bit linker.

-debug Include debugging information.

-out:%1.dll
Build a .DLL file.

%1.obj Include the object file.

utilcli.obj
Include the utility object file for error-checking.

db2api.lib
Link with the DB2 API library.

-def:%1.def
Use the module definition file.

/delayload:db2app.dll
Used to ensure that db2app.dll is not loaded until the first call to a DB2 API. This is required when using the db2SelectDB2Copy API.

db2ApiInstall.lib
Library to statically link in your application if you need to select a particular DB2 copy that is installed on the computer using the db2SelectDB2Copy API. Note: to use this functionality, you need to either dynamically load db2app.dll or use the `/delayload:db2app.dll` option of your compiler and call the db2SelectDB2Copy API prior to running any other DB2 API's.

Refer to your compiler documentation for additional compiler options.

Chapter 18. Vendor escape clauses in CLI applications

The X/Open SQL CAE specification defined an **escape clause** as: "a syntactic mechanism for vendor-specific SQL extensions to be implemented in the framework of standardized SQL". Both DB2 CLI and ODBC support vendor escape clauses as defined by X/Open.

Currently, escape clauses are used extensively by ODBC to define SQL extensions. DB2 CLI translates the ODBC extensions into the correct DB2 syntax. The `SQLNativeSql()` function can be used to display the resulting syntax.

If an application is only going to access DB2 data sources, then there is no reason to use the escape clauses. If an application is going to access other data sources that offer the same support through a different syntax, then the escape clauses increase the portability of the application.

DB2 CLI used both the standard and shorthand syntax for escape clauses. The standard syntax has been deprecated (although DB2 CLI still supports it). An escape clause using the standard syntax took the form:

```
--(*vendor(vendor-identifier),
      product(product-identifier) extended SQL text*)--
```

Applications should now only use the shorthand syntax, as described below, to remain current with the latest ODBC standards.

Shorthand escape clause syntax

The format of an escape clause definition is:

```
{ extended SQL text }
```

to define the following SQL extensions:

- Extended date, time, timestamp data
- Outer join
- LIKE predicate
- Stored procedure call
- Extended scalar functions
  - Numeric functions
  - String functions
  - System functions

ODBC date, time, timestamp data

The ODBC escape clauses for date, time, and timestamp data are:

```
{d 'value'}
{t 'value'}
{ts 'value'}
```

- **d** indicates *value* is a date in the *yyyy-mm-dd* format,
- **t** indicates *value* is a time in the *hh:mm:ss* format
- **ts** indicates *value* is a timestamp in the *yyyy-mm-dd hh:mm:ss[.f...]* format.

For example, the following statement can be used to issue a query against the **EMPLOYEE** table:

```
SELECT * FROM EMPLOYEE WHERE HIREDATE={d '1994-03-29'}
```

DB2 CLI will translate the above statement to a DB2 format. `SQLNativeSql()` can be used to return the translated statement.

The ODBC escape clauses for date, time, and timestamp literals can be used in input parameters with a C data type of SQL_C_CHAR.

ODBC outer join

The ODBC escape clause for outer join is:

```
{oj outer-join}
```

where *outer join* is

```
table-name  {LEFT | RIGHT | FULL} OUTER JOIN
            {table-name | outer-join}
            ON search-condition
```

For example, DB2 CLI will translate the following statement:

```
SELECT * FROM {oj T1 LEFT OUTER JOIN T2 ON T1.C1=T2.C3}
    WHERE T1.C2>20
```

to IBM's format, which corresponds to the SQL92 outer join syntax:

```
SELECT * FROM T1 LEFT OUTER JOIN T2 ON T1.C1=T2.C3 WHERE T1.C2>20
```

Note: Not all DB2 servers support outer join. To determine if the current server supports outer joins, call `SQLGetInfo()` with the SQL_SQL92_RELATIONAL_JOIN_OPERATORS and SQL_OJ_CAPABILITIES options.

LIKE predicate

In a SQL LIKE predicate, the metacharacter % matches zero or more of any character, and the metacharacter _ matches any one character. The SQL ESCAPE clause allows the definition of patterns intended to match values that contain the actual percent and underscore characters by preceding them with an escape character. The escape clause ODBC uses to define the LIKE predicate escape character is:

```
{escape 'escape-character'}
```

where *escape-character* is any character supported by the DB2 rules governing the use of the SQL ESCAPE clause.

As an example of how to use an ″escape″ ODBC escape clause, suppose you had a table Customers with the columns Name and Growth. The Growth column contains data having the metacharacter '%'. The following statement would select all of the values from Name that have values in Growth only between 10% and 19%, excluding 100% and above:

```
SELECT Name FROM Customers WHERE Growth LIKE '1_\%'{escape '\'}
```

Applications that are not concerned about portability across different vendor DBMS products should pass an SQL ESCAPE clause directly to the data source. To determine when LIKE predicate escape characters are supported by a particular

DB2 data source, an application should call SQLGetInfo() with the SQL_LIKE_ESCAPE_CLAUSE information type.

Stored procedure call

The ODBC escape clause for calling a stored procedure is:

{[?=]call *procedure-name[([parameter][,[parameter]]...)]***}**

where:

- [?=] indicates the optional parameter marker for the return value
- *procedure-name* specifies the name of a procedure stored at the data source
- *parameter* specifies a procedure parameter.

A procedure may have zero or more parameters.

ODBC specifies the optional parameter **?=** to represent the procedure's return value, which if present, will be stored in the location specified by the first parameter marker as defined via SQLBindParameter(). DB2 CLI will return the return code as the procedure's return value if **?=** is present in the escape clause. If **?=** is not present, and if the stored procedure return code is not SQL_SUCCESS, then the application can retrieve diagnostics, including the SQLCODE, using the SQLGetDiagRec() and SQLGetDiagField() functions. DB2 CLI supports literals as procedure arguments, however vendor escape clauses must be used. For example, the following statement would not succeed: CALL storedproc ('aaaa', 1), but this statement would: {CALL storedproc ('aaaa', 1)}. If a parameter is an output parameter, it must be a parameter marker.

For example, DB2 CLI will translate the following statement:

```
{CALL NETB94(?,?,?)}
```

To an internal CALL statement format:

```
CALL NEBT94(?, ?, ?)
```

ODBC scalar functions

Scalar functions such as string length, substring, or trim can be used on columns of a result set and on columns that restrict rows of a result set. The ODBC escape clause for scalar functions is:

{fn *scalar-function***}**

Where, *scalar-function* can be any function listed in the list of extended scalar functions.

For example, DB2 CLI will translate the following statement:

```
SELECT {fn CONCAT(FIRSTNAME,LASTNAME)} FROM EMPLOYEE
```

to:

```
SELECT FIRSTNAME CONCAT LASTNAME FROM EMPLOYEE
```

SQLNativeSql() can be called to obtain the translated SQL statement.

To determine which scalar functions are supported by the current server referenced by a specific connection handle, call SQLGetInfo() with the options:

SQL_NUMERIC_FUNCTIONS, SQL_STRING_FUNCTIONS,
SQL_SYSTEM_FUNCTIONS, and SQL_TIMEDATE_FUNCTIONS.

Chapter 19. Considerations for accessing a DB2 for z/OS Sysplex

Client applications that access a DB2 for z/OS Sysplex can take advantage of Sysplex capabilities to perform workload balancing, recover from connectivity failures, and perform XA distributed transactions.

Historically, this support has been available only by going through a DB2 Connect server. Starting with DB2 Version 9.5 Fix Pack 3, client-side Sysplex support is available in DB2 Connect licensed clients, and applications no longer need to go through a DB2 Connect server to use Sysplex features.

The following Version 9.5 Fix Pack 3 or later clients provide Sysplex support:

- IBM Data Server Client
- IBM Data Server Runtime Client
- IBM Data Server Driver Package
- IBM Data Server Driver for ODBC and CLI

For more information, see the topic about client Sysplex support in the DB2 Information Center.

Part 2. Setting up your application development environment to run DB2 CLI and ODBC applications

You can run DB2 CLI and ODBC applications against a DB2 database server using the IBM Data Server Client, the IBM Data Server Runtime Client, or the IBM Data Server Driver for ODBC and CLI. However, to compile DB2 CLI or ODBC applications, you need the IBM Data Server Client.

Before you set up your CLI environment, ensure you have set up the application development environment.

In order for a DB2 CLI application to successfully access a DB2 database:

1. Ensure the DB2 CLI/ODBC driver was installed during the DB2 client install.
2. For the IBM Data Server Client and Runtime Client only: If the database is being accessed from a remote client, catalog the database and hostname of the machine the databse is on.

   On the Windows platform, you can use the CLI/ODBC Settings GUI to catalog the DB2 database.
3. Optional: Explicitly bind the DB2 CLI/ODBC bind files to the database with the command:

   ```
   db2 bind ~/sqllib/bnd/@db2cli.lst blocking all sqlerror continue \
              messages cli.msg grant public
   ```

   On the Windows platform, you can use the CLI/ODBC Settings GUI to bind the DB2 CLI/ODBC bind files to the database.
4. Optional: Change the DB2 CLI/ODBC configuration keywords by editing the `db2cli.ini file`, located in the `sqllib` directory on Windows, and in the `sqllib/cfg` directory on UNIX platforms.

   On the Windows platform, you can use the CLI/ODBC Settings GUI to set the DB2 CLI/ODBC configuration keywords.

Once you have completed the above steps, proceed to setting up your Windows CLI environment, or setting up your UNIX ODBC environment if you are running ODBC applications on UNIX.

Chapter 20. Setting up the UNIX ODBC environment

This topic explains how to set up UNIX client access to DB2 for ODBC applications. (If your application is a DB2 CLI application, your CLI environmental setup will be complete once the task in the Prerequisites section is performed.)

Before setting up the UNIX ODBC environment, ensure you have set up the CLI environment.

For ODBC applications on UNIX that need to access a DB2 database, follow the steps described below.

1. Ensure that an ODBC driver manager is installed and that each user that will use ODBC has access to it. DB2 does not install an ODBC driver manager, so you must use the ODBC driver manager that was supplied with your ODBC client application or ODBC SDK in order to access DB2 data using that application.
2. Set up `.odbc.ini`, the end-user's data source configuration. Each user ID has a separate copy of this file in their home directory. Note that the file starts with a dot. Although necessary files are usually updated automatically by the tools on most platforms, users of ODBC on UNIX platforms will have to edit them manually.

   Using an ASCII editor, update the file to reflect the appropriate data source configuration information. To register a DB2 database as an ODBC data source there must be one stanza (section) for each DB2 database.

   The .odbc.ini file must contain the following lines (examples refer to configuration of the SAMPLE database data source):

   - in the `[ODBC Data Source]` stanza:

     ```
     SAMPLE=IBM DB2 ODBC DRIVER
     ```

     which indicates that there is a data source called SAMPLE that uses the IBM DB2 ODBC DRIVER;
   - in the `[SAMPLE]` stanza:

     on AIX, for example,

     ```
     [SAMPLE]
     Driver=/u/thisuser/sqllib/lib/libdb2.a
     Description=Sample DB2 ODBC Database
     ```

     on the Solaris operating system, for example,

     ```
     [SAMPLE]
     Driver=/u/thisuser/sqllib/lib/libdb2.so
     Description=Sample DB2 ODBC Database
     ```

     which indicates that the SAMPLE database is part of the DB2 instance located in the directory `/u/thisuser`.

     With the introduction of the 64-bit development environment, there have been a number of inconsistencies among vendors regarding the interpretation of the sizes of certain parameters. For example, the 64-bit Microsoft ODBC Driver Manager treats SQLHANDLE and SQLLEN as both 64-bits in length, whereas Data Direct Connect and open source ODBC driver managers treat SQLHANDLE as 64-bit, but SQLLEN as 32-bit. The developer must therefore pay careful attention to which version of the DB2 driver is required. Specify the appropriate DB2 driver in the data source stanza, according to the following information:

Table 13. DB2 driver for CLI and ODBC applications

Type of application	DB2 driver to specify
32-bit CLI	libdb2.*
32-bit ODBC Driver Manager	libdb2.*
64-bit CLI	libdb2.*
64-bit ODBC Driver Manager	libdb2o.* (db2o.o for AIX)

Note: The file extension of the DB2 driver to specify depends on the operating system. The extensions are as follows:

- .a - AIX
- .so - Linux, Solaris, HP-IPF
- .sl - HP-PA

3. Ensure that the application execution environment has reference to the ODBC driver manager by including `libodbc.a` (for AIX) or `libodbc.so` (for UNIX) in the LIBPATH (for AIX) or LD_LIBRARY_PATH (for UNIX) environment variables.
4. Enable a system-wide `.odbc.ini` file to be used by setting the ODBCINI environment variable to the fully qualified pathname of the .ini file. Some ODBC driver managers support this feature which allows for centralized control. The following examples show how to set ODBCINI:

   in the C shell,

   ```
   setenv ODBCINI /opt/odbc/system_odbc.ini
   ```

   in the Bourne or Korn shell,

   ```
   ODBCINI=/opt/odbc/system_odbc.ini;export ODBCINI
   ```

5. Once the `.odbc.ini` file is set up, you can run your ODBC application and access DB2 databases. Refer to the documentation that comes with your ODBC application for additional help and information.

Sample build scripts and configurations for the unixODBC Driver Manager

The unixODBC Driver Manager is an open source ODBC driver manager for use on UNIX platforms. This driver manager is supported for ODBC applications on supported DB2 platforms. This topic presents some examples of possible build scripts and configurations you might want to use when using the unixODBC Driver Manager.

Support statement

If you experience problems with the combination of the unixODBC Driver Manager and the DB2 ODBC driver after they have been properly installed and configured, you can contact DB2 Service (http://www.ibm.com/software/data/db2/udb/support) for assistance in diagnosing the problem. If the source of the problem lies with the unixODBC Driver Manager, then you can:

- Purchase a service contract for technical support from Easysoft, a commercial sponsor of unixODBC (http://www.easysoft.com).
- Participate in any open source support channels at http://www.unixodbc.com.

Sample build scripts

The following are sample build scripts for setting up your environment to use the unixODBC Driver Manager.

AIX

```
#! /bin/sh

echo "Unzipping and extracting"
gzip -d unixODBC-2.2.11.tar.gz
tar xf unixODBC-2.2.11.tar

cd unixODBC-2.2.11

#Comment this out if not AIX
export CC=xlc_r
export CCC=xlC_r

echo "Configuring, compiling and installing"
configure --prefix=$HOME --enable-gui=no --enable-drivers=no
make
make install

echo "Setting ini env vars."
export ODBCHOME=~/etc
export ODBCINI=~/odbc.ini

#Comment this out if not AIX
echo "Extracting unixODBC libraries"
cd ~/lib
ar -x libodbc.a
ar -x libodbcinst.a
ar -x libodbccr.a

echo "\n***Still need to set up your ini files"
```

UNIX (non-AIX)

```
#! /bin/sh

echo "Unzipping and extracting"
gzip -d unixODBC-2.2.11.tar.gz
tar xf unixODBC-2.2.11.tar

cd unixODBC-2.2.11

echo "Configuring, compiling and installing"
configure --prefix=$HOME --enable-gui=no --enable-drivers=no
make
make install

echo "Setting ini env vars."
export ODBCHOME=~/etc
export ODBCINI=~/odbc.ini

echo "\n***Still need to set up your ini files"
```

Sample INI file configurations

The following are sample user and system INI files for using the unixODBC Driver Manager.

User INI file (odbc.ini)

```
[DEFAULT]
Driver = DB2

[SAMPLE]
DESCRIPTION = Connection to DB2
DRIVER = DB2
```

System INI file (odbcinst.ini)

```
[DEFAULT]
Description = Default Driver
Driver = /u/db2inst1/sqllib/lib/db2.o
fileusage=1
dontdlclose=1

[DB2]
Description = DB2 Driver
Driver = /u/db2inst1/sqllib/lib/db2.o
fileusage=1
dontdlclose=1

[ODBC]
Trace = yes
Tracefile = /u/user/trc.log
```

This system INI file has the ODBC trace enabled, with the trace log file set to `trc.log`.

Note: If you encounter problems when closing the driver manager (such as during `SQLDisconnect()`), set the value `dontdlclose=1` in the `odbcinst.ini` file, as shown in the example above.

Chapter 21. Setting up the Windows CLI environment

This task tells you how to perform Windows client access to DB2 using CLI or ODBC.

Before setting up the Windows CLI environment, ensure that the CLI environment has been set up.

When using the Configuration Assistant on Windows 64-bit platforms, ODBC Data Sources can be configured *only* for 64-bit applications. ODBC Data Sources for 32-bit applications need to be configured using the Microsoft 32-bit ODBC Data Source Administrator (32-bit odbcad32.exe) that is included with the Windows 64-bit operating system.

Before DB2 CLI and ODBC applications can successfully access a DB2 database from a Windows client, perform the following steps on the client system:

1. Verify that the Microsoft ODBC Driver Manager and the DB2 CLI/ODBC driver are installed. On Windows operating systems they are both installed with DB2 unless the ODBC component is manually unselected during the install. DB2 will not overwrite a newer version of the Microsoft ODBC Driver Manager if one is found. To verify that they both exist on the machine:
   a. Start the Microsoft ODBC Data Sources icon in the Control Panel, or run the `odbcad32.exe` command from the command line.
   b. Click on the ″Drivers″ tab.
   c. Verify that `IBM DB2 ODBC DRIVER - <DB2 Copy Name>` is shown in the list. <DB2 Copy name> is the DB2 copy name that you want to use.

   If either the Microsoft ODBC Driver Manager or the IBM DB2 CLI/ODBC driver is not installed, then rerun the DB2 install and select the ODBC component on Windows operating systems.

   Note: The latest version of the Microsoft ODBC Driver Manager is included as part of the Microsoft Data Access Components (MDAC) and is available for download from http://www.microsoft.com/data/.
2. Register the DB2 database with the ODBC driver manager as a data source. On Windows operating systems you can make the data source available to all users of the system (a system data source), or only the current user (a user data source). Use either of these methods to add the data source:
   - Using the Configuration Assistant:
     a. Select the DB2 database alias that you want to add as a data source.
     b. Click on the ″Properties″ push button. The Database Properties window opens.
     c. Select the ″Register this database for ODBC″ check box.
     d. Use the radio buttons to add the data source as either a user, system, or file data source.
   - Using the Microsoft ODBC Administration tool, which you can access from the icon in the Control Panel or by running `odbcad32.exe` from the command line:
     a. The list of user data sources appears by default. If you want to add a system data source click on the ″System DSN″ button, or the ″System DSN″ tab (depending on the platform).

b. Click on the "Add" push button.
c. Double-click on the IBM DB2 ODBC DRIVER - <DB2 Copy name> in the list. <DB2 Copy name> is the DB2 copy name that you want to use.
d. Select the DB2 database to add and click on OK.

- Use the CATALOG command to register the DB2 database with the ODBC driver manager as a data source:

```
CATALOG [ user | system ] ODBC DATA SOURCE
```

Using this command, an administrator could create a command line processor script to register the required databases. This script could then be run on all machines that require access to DB2 databases through ODBC.

3. Optional: Configure the DB2 CLI/ODBC driver using the Configuration Assistant:
   a. Select the DB2 database alias you want to configure.
   b. Click on the "Properties" push button. The Database Properties window opens.
   c. Click on the "Settings" push button. The CLI/ODBC Settings window opens.
   d. Click on the "Advanced" push button. You can set the configuration keywords in the window that opens. These keywords are associated with the database alias name, and affect all DB2 CLI/ODBC applications that access the database.
4. If you have installed ODBC access (as described above), you can now access DB2 data using ODBC applications.

Selecting a different DB2 copy for your Windows CLI application

By default, DB2 CLI applications running on Windows systems make use of the default DB2 copy. However, applications can use any DB2 copy that is installed on the system.

Ensure your Windows DB2 CLI environment is set up.

Procedure

The following are different methods that allow DB2 CLI applications to successfully access a different DB2 copy on the Windows platform.

- Using the DB2 command window from the Start -> Programs -> IBM DB2 -> *<DB2 Copy Name>* -> Command Line Tools -> DB2 Command Window: the command window is already set up with the correct environment variables for the particular DB2 copy chosen.
- Using db2envar.bat from a command window:
  1. Open a command window.
  2. Run the db2envar.bat file using the fully qualified path for the DB2 copy that you want the application to use:

     ```
     <DB2 Copy install dir>\bin\db2envar.bat
     ```

  3. Run the DB2 CLI application from the same command window.

  This will set up all the environment variables for the selected DB2 copy in the command window where the db2envar.bat was run. Once the command window has been closed and a new one opened, the DB2 CLI application will run against the default DB2 Copy unless the db2envar.bat for another DB2 copy is run again.

- Using the db2SelectDB2Copy API: For applications that are dynamically linked, you can call this API prior to loading any DB2 DLLs within your application process. This API sets up the required environment for your application to use the DB2 copy that you want to use. The /delayload linking option can be used to delay the loading of any DB2 DLL. For example, if your DB2 CLI application links db2api.lib, then you must use the /delayload option of your linker to delay the load db2app.dll:

  ```
  cl -Zi -MDd -Tp App.C /link /DELAY:nobind /DELAYLOAD:db2app.dll
     advapi32.lib psapi.lib db2api.lib delayimp.lib
  ```

  – To use the API, you will need to include db2ApiInstall.h, which will force your application to statically link in db2ApiInstall.lib.
  – When linking with db2api.lib, the functions will resolve to different dlls on Windows 32-bit and Windows 64-bit platforms. The runtime dlls on a 64-bit platform will have the same base name as the 32-bit version with the addition of the ″64″ suffix. For example, db2app.dll on a Windows 32-bit operating system is equivalent to db2app64.dll on a Windows 64-bit operating system.
- Using LoadLibraryEx: Instead of using LoadLibrary, you can call LoadLibraryEx with the LOAD_WITH_ALTERED_SEARCH_PATH parameter to load the db2app.dll that corresponds to the version of the DB2 copy you want to use. For example:

  ```
  HMODULE hLib = LoadLibraryEx("c:\\sqllib\\bin\\db2app.dll",
     NULL, LOAD_WITH_ALTERED_SEARCH_PATH);
  ```

Part 3. Appendixes

Appendix A. Overview of the DB2 technical information

DB2 technical information is available through the following tools and methods:

- *DB2 Information Center*
  - Topics (Task, concept and reference topics)
  - Help for DB2 tools
  - Sample programs
  - Tutorials
- DB2 books
  - PDF files (downloadable)
  - PDF files (from the DB2 PDF DVD)
  - printed books
- Command line help
  - Command help
  - Message help

Note: The *DB2 Information Center* topics are updated more frequently than either the PDF or the hard-copy books. To get the most current information, install the documentation updates as they become available, or refer to the *DB2 Information Center* at ibm.com®.

You can access additional DB2 technical information such as technotes, white papers, and IBM Redbooks® publications online at ibm.com. Access the DB2 Information Management software library site at http://www.ibm.com/software/data/sw-library/.

Documentation feedback

We value your feedback on the DB2 documentation. If you have suggestions for how to improve the DB2 documentation, send an email to db2docs@ca.ibm.com. The DB2 documentation team reads all of your feedback, but cannot respond to you directly. Provide specific examples wherever possible so that we can better understand your concerns. If you are providing feedback on a specific topic or help file, include the topic title and URL.

Do not use this email address to contact DB2 Customer Support. If you have a DB2 technical issue that the documentation does not resolve, contact your local IBM service center for assistance.

If you would like to help IBM make the IBM Information Management products easier to use, take the Consumability Survey: http://www.ibm.com/software/data/info/consumability-survey/.

DB2 technical library in hardcopy or PDF format

The following tables describe the DB2 library available from the IBM Publications Center at www.ibm.com/shop/publications/order. English DB2 Version 9.5 manuals in PDF format and translated versions can be downloaded from www.ibm.com/support/docview.wss?rs=71&uid=swg2700947.

Although the tables identify books available in print, the books might not be available in your country or region.

The form number increases each time a manual is updated. Ensure that you are reading the most recent version of the manuals, as listed below.

Note: The *DB2 Information Center* is updated more frequently than either the PDF or the hard-copy books.

Table 14. DB2 technical information

Name	Form Number	Available in print	Last updated
Administrative API Reference	SC23-5842-02	Yes	April, 2009
Administrative Routines and Views	SC23-5843-02	No	April, 2009
Call Level Interface Guide and Reference, Volume 1	SC23-5844-02	Yes	April, 2009
Call Level Interface Guide and Reference, Volume 2	SC23-5845-02	Yes	April, 2009
Command Reference	SC23-5846-02	Yes	April, 2009
Data Movement Utilities Guide and Reference	SC23-5847-02	Yes	April, 2009
Data Recovery and High Availability Guide and Reference	SC23-5848-02	Yes	April, 2009
Data Servers, Databases, and Database Objects Guide	SC23-5849-02	Yes	April, 2009
Database Security Guide	SC23-5850-02	Yes	April, 2009
Developing ADO.NET and OLE DB Applications	SC23-5851-02	Yes	April, 2009
Developing Embedded SQL Applications	SC23-5852-02	Yes	April, 2009
Developing Java Applications	SC23-5853-02	Yes	April, 2009
Developing Perl and PHP Applications	SC23-5854-02	No	April, 2009
Developing User-defined Routines (SQL and External)	SC23-5855-02	Yes	April, 2009
Getting Started with Database Application Development	GC23-5856-02	Yes	April, 2009
Getting Started with DB2 installation and administration on Linux and Windows	GC23-5857-02	Yes	April, 2009
Internationalization Guide	SC23-5858-02	Yes	April, 2009

Table 14. DB2 technical information (continued)

Name	Form Number	Available in print	Last updated
Message Reference, Volume 1	GI11-7855-01	No	April, 2009
Message Reference, Volume 2	GI11-7856-01	No	April, 2009
Migration Guide	GC23-5859-02	Yes	April, 2009
Net Search Extender Administration and User's Guide	SC23-8509-02	Yes	April, 2009
Partitioning and Clustering Guide	SC23-5860-02	Yes	April, 2009
Query Patroller Administration and User's Guide	SC23-8507-01	Yes	April, 2009
Quick Beginnings for IBM Data Server Clients	GC23-5863-02	No	April, 2009
Quick Beginnings for DB2 Servers	GC23-5864-02	Yes	April, 2009
Spatial Extender and Geodetic Data Management Feature User's Guide and Reference	SC23-8508-02	Yes	April, 2009
SQL Reference, Volume 1	SC23-5861-02	Yes	April, 2009
SQL Reference, Volume 2	SC23-5862-02	Yes	April, 2009
System Monitor Guide and Reference	SC23-5865-02	Yes	April, 2009
Text Search Guide	SC23-5866-01	Yes	April, 2009
Troubleshooting Guide	GI11-7857-02	No	April, 2009
Tuning Database Performance	SC23-5867-02	Yes	April, 2009
Visual Explain Tutorial	SC23-5868-00	No	
What's New	SC23-5869-02	Yes	April, 2009
Workload Manager Guide and Reference	SC23-5870-02	Yes	April, 2009
pureXML Guide	SC23-5871-02	Yes	April, 2009
XQuery Reference	SC23-5872-02	No	April, 2009

Table 15. DB2 Connect-specific technical information

Name	Form Number	Available in print	Last updated
Quick Beginnings for DB2 Connect Personal Edition	GC23-5839-02	Yes	April, 2009
Quick Beginnings for DB2 Connect Servers	GC23-5840-02	Yes	April, 2009
DB2 Connect User's Guide	SC23-5841-02	Yes	April, 2009

Table 16. Information Integration technical information

Name	Form Number	Available in print	Last updated
Information Integration: Administration Guide for Federated Systems	SC19-1020-01	Yes	March, 2008
Information Integration: ASNCLP Program Reference for Replication and Event Publishing	SC19-1018-02	Yes	March, 2008
Information Integration: Configuration Guide for Federated Data Sources	SC19-1034-01	No	
Information Integration: SQL Replication Guide and Reference	SC19-1030-01	Yes	March, 2008
Information Integration: Introduction to Replication and Event Publishing	SC19-1028-01	Yes	March, 2008

Ordering printed DB2 books

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Note: The most up-to-date and complete DB2 documentation is maintained in the DB2 Information Center at http://publib.boulder.ibm.com/infocenter/db2luw/v9r5.

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3. Provide your representative with the titles and form numbers of the books that you want to order. For titles and form numbers, see "DB2 technical library in hardcopy or PDF format" on page 225.

Displaying SQL state help from the command line processor

DB2 returns an SQLSTATE value for conditions that could be the result of an SQL statement. SQLSTATE help explains the meanings of SQL states and SQL state class codes.

To invoke SQL state help, open the command line processor and enter:

```
? sqlstate or ? class code
```

where *sqlstate* represents a valid five-digit SQL state and *class code* represents the first two digits of the SQL state.
For example, `? 08003` displays help for the 08003 SQL state, and `? 08` displays help for the 08 class code.

Accessing different versions of the DB2 Information Center

For DB2 Version 9.5 topics, the DB2 Information Center URL is http://publib.boulder.ibm.com/infocenter/db2luw/v9r5/

For DB2 Version 9 topics, the DB2 Information Center URL is http://publib.boulder.ibm.com/infocenter/db2luw/v9/

For DB2 Version 8 topics, go to the Version 8 Information Center URL at: http://publib.boulder.ibm.com/infocenter/db2luw/v8/

Displaying topics in your preferred language in the DB2 Information Center

The DB2 Information Center attempts to display topics in the language specified in your browser preferences. If a topic has not been translated into your preferred language, the DB2 Information Center displays the topic in English.

- To display topics in your preferred language in the Internet Explorer browser:
  1. In Internet Explorer, click the **Tools** —> **Internet Options** —> **Languages...** button. The Language Preferences window opens.
  2. Ensure your preferred language is specified as the first entry in the list of languages.
     - To add a new language to the list, click the **Add...** button.

       Note: Adding a language does not guarantee that the computer has the fonts required to display the topics in the preferred language.
     - To move a language to the top of the list, select the language and click the **Move Up** button until the language is first in the list of languages.
  3. Clear the browser cache and then refresh the page to display the DB2 Information Center in your preferred language.
- To display topics in your preferred language in a Firefox or Mozilla browser:

1. Select the button in the **Languages** section of the **Tools** —> **Options** —> **Advanced** dialog. The Languages panel is displayed in the Preferences window.
2. Ensure your preferred language is specified as the first entry in the list of languages.
   - To add a new language to the list, click the **Add...** button to select a language from the Add Languages window.
   - To move a language to the top of the list, select the language and click the **Move Up** button until the language is first in the list of languages.
3. Clear the browser cache and then refresh the page to display the DB2 Information Center in your preferred language.

On some browser and operating system combinations, you might have to also change the regional settings of your operating system to the locale and language of your choice.

Updating the DB2 Information Center installed on your computer or intranet server

If you have installed the DB2 Information Center locally, you can obtain and install documentation updates from IBM.

Updating your locally-installed *DB2 Information Center* requires that you:

1. Stop the *DB2 Information Center* on your computer, and restart the Information Center in stand-alone mode. Running the Information Center in stand-alone mode prevents other users on your network from accessing the Information Center, and allows you to apply updates. Non-Administrative and Non-Root *DB2 Information Centers* always run in stand-alone mode. .
2. Use the update feature to see what updates are available. If there are updates that you would like to install, you can use the update feature to obtain and install them.

   Note: If your environment requires installing the *DB2 Information Center* updates on a machine that is not connected to the internet, you have to mirror the update site to a local file system using a machine that is connected to the internet and has the *DB2 Information Center* installed. If many users on your network will be installing the documentation updates, you can reduce the time required for individuals to perform the updates by also mirroring the update site locally and creating a proxy for the update site.
   If update packages are available, use the update feature to get the packages. However, the update feature is only available in stand-alone mode.
3. Stop the stand-alone Information Center, and restart the *DB2 Information Center* on your computer.

Note: On Windows Vista, the commands listed below must be run as an administrator. To launch a command prompt or graphical tool with full administrator privileges, right-click on the shortcut and then select **Run as administrator**.

To update the *DB2 Information Center* installed on your computer or intranet server:

1. Stop the *DB2 Information Center*.
   - On Windows, click **Start** → **Control Panel** → **Administrative Tools** → **Services**. Then right-click on **DB2 Information Center** service and select **Stop**.

- On Linux, enter the following command:
  ```
  /etc/init.d/db2icdv95 stop
  ```

2. Start the Information Center in stand-alone mode.
   - On Windows:
     a. Open a command window.
     b. Navigate to the path where the Information Center is installed. By default, the *DB2 Information Center* is installed in the *Program_files*\IBM\DB2 Information Center\Version 9.5 directory, where *Program_files* represents the location of the Program Files directory.
     c. Navigate from the installation directory to the doc\bin directory.
     d. Run the help_start.bat file:
        ```
        help_start.bat
        ```
   - On Linux:
     a. Navigate to the path where the Information Center is installed. By default, the *DB2 Information Center* is installed in the /opt/ibm/db2ic/V9.5 directory.
     b. Navigate from the installation directory to the doc/bin directory.
     c. Run the help_start script:
        ```
        help_start
        ```

   The systems default Web browser launches to display the stand-alone Information Center.
3. Click the **Update** button ( ). On the right hand panel of the Information Center, click **Find Updates**. A list of updates for existing documentation displays.
4. To initiate the installation process, check the selections you want to install, then click **Install Updates**.
5. After the installation process has completed, click **Finish**.
6. Stop the stand-alone Information Center:
   - On Windows, navigate to the installation directory's doc\bin directory, and run the help_end.bat file:
     ```
     help_end.bat
     ```

     Note: The help_end batch file contains the commands required to safely terminate the processes that were started with the help_start batch file. Do not use `Ctrl-C` or any other method to terminate help_start.bat.
   - On Linux, navigate to the installation directory's doc/bin directory, and run the help_end script:
     ```
     help_end
     ```

     Note: The help_end script contains the commands required to safely terminate the processes that were started with the help_start script. Do not use any other method to terminate the help_start script.
7. Restart the *DB2 Information Center*.
   - On Windows, click **Start** → **Control Panel** → **Administrative Tools** → **Services**. Then right-click on **DB2 Information Center** service and select **Start**.
   - On Linux, enter the following command:
     ```
     /etc/init.d/db2icdv95 start
     ```

The updated *DB2 Information Center* displays the new and updated topics.

DB2 tutorials

The DB2 tutorials help you learn about various aspects of DB2 products. Lessons provide step-by-step instructions.

Before you begin

You can view the XHTML version of the tutorial from the Information Center at http://publib.boulder.ibm.com/infocenter/db2help/.

Some lessons use sample data or code. See the tutorial for a description of any prerequisites for its specific tasks.

DB2 tutorials

To view the tutorial, click on the title.

"pureXML™" in *pureXML Guide*
Set up a DB2 database to store XML data and to perform basic operations with the native XML data store.

"Visual Explain" in *Visual Explain Tutorial*
Analyze, optimize, and tune SQL statements for better performance using Visual Explain.

DB2 troubleshooting information

A wide variety of troubleshooting and problem determination information is available to assist you in using DB2 database products.

DB2 documentation
Troubleshooting information can be found in the DB2 Troubleshooting Guide or the Database fundamentals section of the DB2 Information Center. There you will find information on how to isolate and identify problems using DB2 diagnostic tools and utilities, solutions to some of the most common problems, and other advice on how to solve problems you might encounter with your DB2 database products.

DB2 Technical Support Web site
Refer to the DB2 Technical Support Web site if you are experiencing problems and want help finding possible causes and solutions. The Technical Support site has links to the latest DB2 publications, TechNotes, Authorized Program Analysis Reports (APARs or bug fixes), fix packs, and other resources. You can search through this knowledge base to find possible solutions to your problems.

Access the DB2 Technical Support Web site at http://www.ibm.com/software/data/db2/support/db2_9/

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