DB2 for OS/390

Application Programming Guide and Reference FOR JAVA™

Version 5

SC26-9547-02

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Note!

Before using this information and the product it supports, be sure to read the general information under “Notices” on page 99.

First Edition (October 1998)

This edition applies to Version 5 of IBM DATABASE 2 Server for OS/390 (DB2 for OS/390), 5655-DB2, and to any subsequent releases until otherwise indicated in new editions. Make sure you are using the correct edition for the level of the product.

This softcopy version is based on the printed edition of the book and includes the changes indicated in the printed version by vertical bars. Additional changes made to this softcopy version of the manual since the hardcopy manual was published are indicated by the hash (#) symbol in the left-hand margin.

Contents

Chapter 1. Introduction

This book describes DB2 for OS/390 Java™ Edition, a feature of DB2 for OS/390 that lets you access relational databases from Java application programs.

Who should read this book

This book is for DB2 application developers who are familiar with Structured Query Language (SQL) and who know the Java programming language.

How this book is organized

This book is organized as follows:

- "Chapter 1. Introduction" describes this book and gives general information about Version 5 of DB2 for OS/390.
- "Chapter 2. JDBC application support" on page 9 describes the DB2 for OS/390 implementation of JDBC.
- "Chapter 3. Writing SQLJ programs for DB2 for OS/390" on page 17 introduces SQLJ and describes the basic elements of an SQLJ application program.
- "Chapter 4. SQLJ statement reference" on page 37 gives the syntax and a description of each SQLJ clause.
- "Chapter 5. Creating Java stored procedures" on page 51 describes how to write Java stored procedures.
- "Chapter 6. Preparing Java programs" on page 59 describes how to prepare SQLJ and JDBC programs to run in a JVM or under VisualAge for Java, and how to prepare Java stored procedures to run under VisualAge for Java.
- "Chapter 7. JDBC and SQLJ administration" on page 79 discusses the following topics that are related to JDBC and SQLJ administration on DB2 for OS/390:
  - How to install JDBC and SQLJ
  - How JDBC and SQLJ authorization works
  - How JDBC and SQLJ multiple OS/390 context support works
- The appendixes provide the following information:
  - "Appendix A. Selected sqlj.runtime classes and interfaces" on page 91 contains information on the methods of the `sqlj.runtime` package that you can call in your SQLJ programs.
  - "Appendix B. Special considerations for CICS applications" on page 95 contains information for users who write JDBC and SQLJ programs for the CICS environment.

Located after the appendixes are:

- Legal notices
- A glossary of terms and abbreviations used in the book
- A bibliography of other books that might be useful
- An index

Other books you might need

This book describes Java interfaces to DB2, rather than the Java programming language itself. For information on the OS/390 implementation of the Java language, see the Web site for Java for OS/390:

`http://www.s390.ibm.com/java`

This book does not include detailed information about the JDBC™ API. You can find that information at:

`http://java.sun.com/products.jdbc.`

DB2 for OS/390 is one of several IBM relational database management systems. Each of these systems understands its own variety of SQL. This book discusses only the variety that is used by DB2 for OS/390. Other IBM books describe the other varieties. For a list of these books, see "Bibliography" on page 119.

If DB2 for OS/390 is the only product you plan to use, you should also refer to *SQL Reference*, which is an encyclopedic reference to the syntax and semantics of every SQL statement in DB2 for OS/390. For SQL fundamentals and concepts, see Chapter 2 of *SQL Reference*.

If you intend to develop applications that adhere to the definition of IBM SQL, see *IBM SQL Reference* for more information.

Product terminology and citations

In this book, DB2 Server for OS/390 is referred to as "DB2 for OS/390." In cases where the context makes the meaning clear, DB2 for OS/390 is referred to as "DB2." When this book refers to other books in this library, a short title is used. (For example, "See *SQL Reference*" is a citation to IBM DATABASE 2 Server for OS/390 *SQL Reference*.)

The following terms are used as indicated:

DB2	Represents either the DB2 licensed program or a particular DB2 subsystem.
MVS	Represents the MVS/Enterprise Systems Architecture (MVS/ESA) element of OS/390.

How to read the syntax diagrams

The following rules apply to the syntax diagrams used in this book:

- Read the syntax diagrams from left to right, from top to bottom, following the path of the line.

  The ►►── symbol indicates the beginning of a statement.

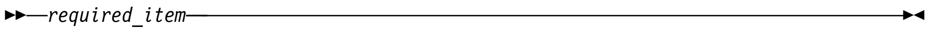
  The ──► symbol indicates that the statement syntax is continued on the next line.

  The ►── symbol indicates that a statement is continued from the previous line.

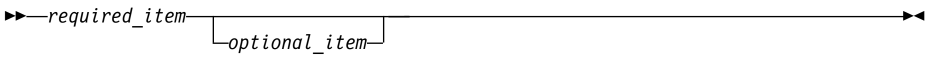
  The ──►◄ symbol indicates the end of a statement.

Diagrams of syntactical units other than complete statements start with the ►—— symbol and end with the ——► symbol.

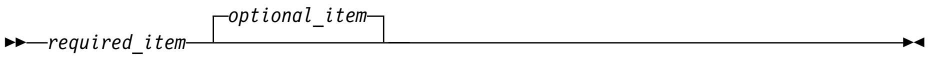
- Required items appear on the horizontal line (the main path).



- Optional items appear below the main path.

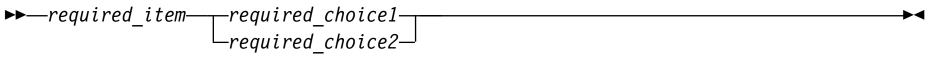


If an optional item appears above the main path, that item has no effect on the execution of the statement and is used only for readability.

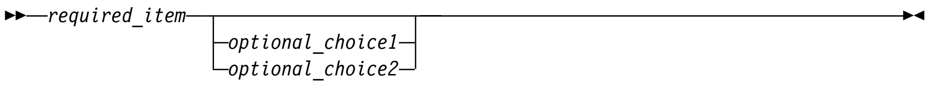


- If you can choose from two or more items, they appear vertically, in a stack.

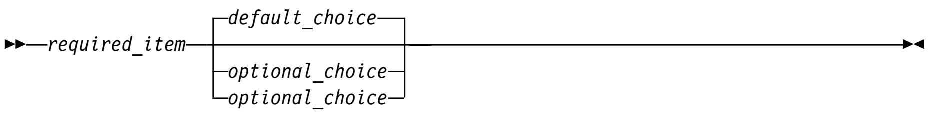
If you *must* choose one of the items, one item of the stack appears on the main path.



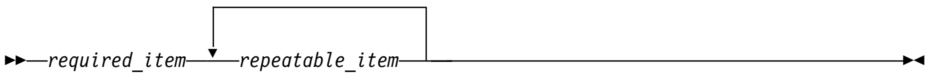
If choosing one of the items is optional, the entire stack appears below the main path.



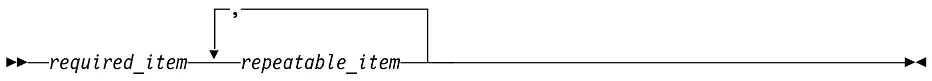
If one of the items is the default, it appears above the main path and the remaining choices are shown below.



- An arrow returning to the left, above the main line, indicates an item that can be repeated.



If the repeat arrow contains a comma, you must separate repeated items with a comma.



A repeat arrow above a stack indicates that you can repeat the items in the stack.

- Keywords appear in uppercase (for example, `FROM`). They must be spelled exactly as shown. Variables appear in all lowercase letters (for example, *column-name*). They represent user-supplied names or values.
- If punctuation marks, parentheses, arithmetic operators, or other such symbols are shown, you must enter them as part of the syntax.

How to use the DB2 library

Titles of books in the library begin with DB2 for OS/390 Version 5. However, references from one book in the library to another are shortened and do not include the product name, version, and release. Instead, they point directly to the section that holds the information. For a complete list of books in the library, and the sections in each book, see the bibliography at the back of this book.

Throughout the library, the DB2 for OS/390 licensed program and a particular DB2 for MVS/ESA subsystem are each referred to as “DB2”. In each case, the context makes the meaning clear.

The most rewarding task associated with a database management system is asking questions of it and getting answers, the task called *end use*. Other tasks are also necessary—defining the parameters of the system, putting the data in place, and so on. The tasks associated with DB2 are grouped into the following major categories (but supplemental information relating to all of the below tasks for new releases of DB2 can be found in *Release Guide*):

Installation: If you are involved with DB2 only to install the system, *Installation Guide* might be all you need.

If you will be using data sharing then you also need *Data Sharing: Planning and Administration*, which describes installation considerations for data sharing.

End use: End users issue SQL statements to retrieve data. They can also insert, update, or delete data, with SQL statements. They might need an introduction to SQL, detailed instructions for using SPUFI, and an alphabetized reference to the types of SQL statements. This information is found in *Application Programming and SQL Guide* and *SQL Reference*.

End users can also issue SQL statements through the Query Management Facility (QMF) or some other program, and the library for that program might provide all the instruction or reference material they need. For a list of some of the titles in the QMF library, see the bibliography at the end of this book.

Application Programming: Some users access DB2 without knowing it, using programs that contain SQL statements. DB2 application programmers write those programs. Because they write SQL statements, they need *Application Programming and SQL Guide*, *SQL Reference*, and *Call Level Interface Guide and Reference* just as end users do.

Application programmers also need instructions on many other topics:

- How to transfer data between DB2 and a host program—written in COBOL, C, or FORTRAN, for example
- How to prepare to compile a program that embeds SQL statements
- How to process data from two systems simultaneously, say DB2 and IMS or DB2 and CICS
- How to write distributed applications across platforms
- How to write applications that use DB2 Call Level Interface to access DB2 servers
- How to write applications that use Open Database Connectivity (ODBC) to access DB2 servers
- How to write applications in the Java programming language to access DB2 servers

The material needed for writing a host program containing SQL is in *Application Programming and SQL Guide* and *Application Programming Guide and Reference for Java*. The material needed for writing applications that use DB2 Call Level Interface or ODBC to access DB2 servers is in *Call Level Interface Guide and Reference*.

For handling errors, see *Messages and Codes*.

Information about writing applications across platforms can be found in *Distributed Relational Database Architecture: Application Programming Guide*.

System and Database Administration: *Administration* covers almost everything else. *Administration Guide* divides those tasks among the following sections:

- Section 2 (Volume 1) of *Administration Guide* discusses the decisions that must be made when designing a database and tells how to bring the design into being by creating DB2 objects, loading data, and adjusting to changes.
- Section 3 (Volume 1) of *Administration Guide* describes ways of controlling access to the DB2 system and to data within DB2, to audit aspects of DB2 usage, and to answer other security and auditing concerns.
- Section 4 (Volume 1) of *Administration Guide* describes the steps in normal day-to-day operation and discusses the steps one should take to prepare for recovery in the event of some failure.
- Section 5 (Volume 2) of *Administration Guide* explains how to monitor the performance of the DB2 system and its parts. It also lists things that can be done to make some parts run faster.

In addition, the appendixes in *Administration Guide* contain valuable information on DB2 sample tables, National Language Support (NLS), writing exit routines, interpreting DB2 trace output, and character conversion for distributed data.

If you are involved with DB2 only to design the database, or plan operational procedures, you need *Administration Guide*. If you also want to carry out your own plans by creating DB2 objects, granting privileges, running utility jobs, and so on, then you also need:

- *SQL Reference*, which describes the SQL statements you use to create, alter, and drop objects and grant and revoke privileges
- *Utility Guide and Reference*, which explains how to run utilities
- *Command Reference*, which explains how to run commands

If you will be using data sharing, then you need *Data Sharing: Planning and Administration*, which describes how to plan for and implement data sharing.

Additional information about system and database administration can be found in *Messages and Codes*, which lists messages and codes issued by DB2, with explanations and suggested responses.

Diagnosis: Diagnosticians detect and describe errors in the DB2 program. They might also recommend or apply a remedy. The documentation for this task is in *Diagnosis Guide and Reference* and *Messages and Codes*.

How to send your comments

Your feedback helps IBM to provide quality information. Please send any comments that you have about this book or other DB2 for OS/390 documentation. You can use any of the following methods to provide comments:

- Send your comments from the Web. Visit the Web site at:

  http://www.software.ibm.com/data/db2/os390/

  The Web site has a feedback page that you can use to enter and send comments.
- Send your comments by electronic mail. Use one of the following IDs:
  - IBMMail: USIBMXFC@IBMMAIL
  - IBMlink: DB2PUBS@STLVM27
  - Internet: DB2PUBS@VNET.IBM.COM

  Be sure to include the name of the product, the version number of the product, and the name and part number of the book (if applicable). If you are commenting on specific text, please include the location of the text (for example, a chapter and section title, a table number, a page number, or a help topic title).
- Complete the readers' comment form at the back of the book and return it by mail, by fax (800-426-7773 for the United States and Canada), or by giving it to an IBM representative.

Summary of changes to this book

The principle changes to this book are:

- # Chapter 5. Creating Java stored procedures contains information on writing and
  # running Java stored procedures.
- # Preparing your applications with VisualAge for Java contains information on
  # preparing programs for execution under VisualAge for Java.
- # Appendix B. Special considerations for CICS applications contains information on
  # running JDBC and SQLJ programs in the CICS environment.

Chapter 2. JDBC application support

This chapter explains DB2 for OS/390's support for applications using JavaSoft^{TM} JDBC^{TM} interfaces to access DB2 data. It provides an overview that explains what JDBC is, more detailed information about DB2 for OS/390's implementation of JDBC, and guidelines for writing a JDBC program.

What is JDBC?

JDBC is a Java application programming interface (API) that Java applications use to access any relational database. DB2 for OS/390's support for JDBC enables you to write Java applications that access local DB2 data or remote relational data on a server that supports DRDA. DB2 for OS/390 is fully compliant with the JavaSoft JDBC 1.2 specification.

JDBC background information

To understand JDBC, knowing about its purpose and background is helpful. Sun Microsystem's^{TM} JavaSoft developed the specifications for a set of APIs that allow Java applications to access relational data. The purpose of the APIs is to provide a generic interface for writing platform-independent applications that can access any SQL database. The APIs are defined within 16 classes that support basic SQL functionality for connecting to a database, executing SQL statements, and processing results. Together, these interfaces and classes represent the JDBC capabilities by which a Java application can access relational data.

Advantages of using DB2 JDBC

DB2 JDBC offers a number of advantages for accessing DB2 data:

- JDBC combines the benefit of running your applications in an OS/390 environment with the portability and ease of writing Java applications. Using the Java language, you can write an application on any platform and execute it on any platform to which the Java Development Kit (JDK) is ported.
- JDBC combines the benefit of running your applications in an OS/390 environment with the portability and ease of writing Java applications.
- The ability to develop an application once and execute it anywhere offers the potential benefits of reduced development, maintenance, and systems management costs, and flexibility in supporting diverse hardware and software configurations.
- The JDBC interface offers the ability to change between drivers and access a variety of databases without recoding your Java program.
- JDBC applications do not require precompiles.

DB2's JDBC implementation

# DB2 for OS/390 is fully compliant with the JavaSoft JDBC 1.2 specification: *JDBC: A*
# *Java SQL API*. You can download the specification from the JDBC Web site:
# http://java.sun.com/products/jdbc. You should familiarize yourself with the specification to understand how to use the JDBC APIs. Documentation that includes detailed information about each of the JDBC API interfaces, classes, and exceptions is also available at this Web site.

# DB2 for OS/390 requires the JDK for OS/390 (Version 1.1.6 or higher). The contents of the JDK include a Java compiler, Java Virtual Machine (JVM), and Java Debugger. You can learn more about the JDK from the Java for OS/390 Web site: http://www.ibm.com/s390/java.

How does it work?

Figure 1 shows how a Java application connects to the DB2 for OS/390 SQLJ/JDBC driver.

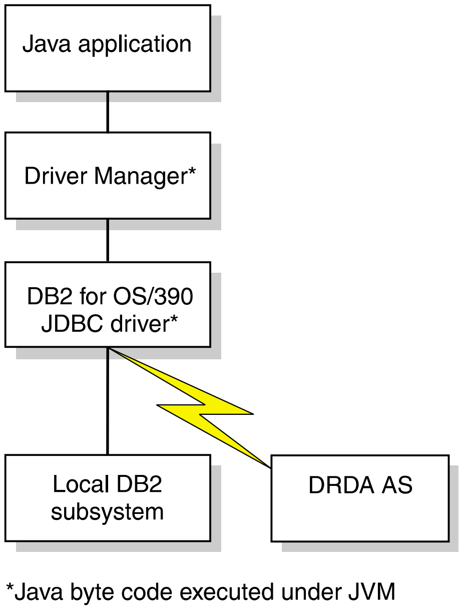

Java application
Driver Manager*
DB2 for OS/390 JDBC driver*
Local DB2 subsystem
DRDA AS
*Java byte code executed under JVM

Figure 1. Java application flow

A Java application executes under the JVM. The Java application first loads the JDBC driver (by invoking the `Class.forName()`method), in this case the DB2 for OS/390 SQLJ/JDBC driver, and subsequently connects to the local DB2 subsystem or a remote DRDA application server (by invoking the `DriverManager.getConnection` method, described in "Getting started" on page 13).

Identifying a target data source

The Java application identifies the target data source it wants to connect to by passing a database Uniform Resource Locator (URL) to the `DriverManager`.

The basic structure for the URL is:

```
jdbc:<subprotocol>:<subname>
```

Specify either of the following URL values for a DB2 for OS/390 data source:

```
# jdbc:db2os390:<location-name>
# jdbc:db2os390sqlj:<location-name>
```

Each format results in the same behavior. Both subprotocols are provided for
compatibility with existing DB2 for OS/390 JDBC applications.

If *location-name* is not the local site, *location-name* must be defined in the SYSIBM.LOCATIONS catalog table. If *location-name* is the local site, *location-name* must have been specified in field DB2 LOCATION NAME of the DISTRIBUTED DATA FACILITY panel during DB2 installation.

In addition to the URL values shown above for a DB2 for OS/390 data source, there are
two URL values that have special meaning for the DB2 for OS/390 SQLJ/JDBC driver.

- # If a URL value does not specify a location-name, for example, ″jdbc:db2os390:″, you
  # will be connected to the local DB2 site. This format of the URL value is a DB2 for
  # OS/390 defined extension. By using this URL value, a DB2 for OS/390 JDBC
  # application does not need to know the location-name of the local DB2 subsystem that
  # the driver is using.
- # The SQLJ specification defines the following URL:

  ```
  # jdbc:default:connection
  ```

  # When you use this URL value, your application is connected to the local DB2 site.

Connecting to a data source

When the application attempts a connection to a data source, it requests a `java.sql.Connection` implementation from the `DriverManager` (part of the `java.sql` package). The `DriverManager` searches all of the registered `java.sql.Driver` implementations for a driver that is capable of accepting the database URL. It then invokes the first JDBC driver that supports the subprotocol that is specified in the URL (and is registered with the `DriverManager`).

In this case, the DB2 for OS/390 SQLJ/JDBC driver (which is registered with the `DriverManager`) accepts the URL, and returns a `java.sql.Connection` implementation that represents the database connection.

DB2 for OS/390 SQLJ/JDBC driver

The DB2 for OS/390 SQLJ/JDBC driver is implemented as a type 2 driver, one of four types of JDBC drivers defined by JavaSoft. The type 2 driver translates JDBC calls into calls to a DB2 language interface module.

Several packages are included with the DB2 for OS/390 SQLJ/JDBC driver. These packages represent the DB2 for OS/390 implementation of the `java.sql` JDBC API. The driver packages include all of the JDBC classes, interfaces, and exceptions that comply with the JDBC 1.2 specification.

The DB2 for OS/390 SQLJ/JDBC driver is available under two different Java class names. The preferred driver name is:

```
 COM.ibm.db2os390.sqlj.jdbc.DB2SQLJDriver
```

However, to maintain compatibility with existing DB2 for OS/390 JDBC applications, the following driver name is also supported:

```
ibm.sql.DB2Driver
```

The `ibm.sql.DB2Driver` class will automatically forward all driver API calls to the `COM.ibm.db2os390.sqlj.jdbc.DB2SQLJDriver`.

JDBC API

The JDBC API consists of the abstract Java interfaces that an application program uses to access databases, execute SQL statements, and process the results. Like ODBC, JDBC is a dynamic SQL interface. Writing a JDBC application is similar to writing a C application using ODBC to access a database. The four main interfaces that perform these functions are:

- The `DriverManager` class loads drivers and creates database connections.
- The `Connection` interface supports the connection to a specific database.
- The `Statement` interface supports all SQL statement execution. This interface has two underlying interfaces:
  - The `PreparedStatement` interface supports any SQL statement containing input parameter markers.
  - The `CallableStatement` interface supports the invocation of a stored procedure and allows the application to retrieve output parameters.
- The `ResultSet` interface provides access to the results that a query generates. The `ResultSet` interface is similar to the cursor that is used in SQL applications in other languages.

Running a JDBC application

When you create a Java application that uses the JDBC interfaces, you import the `java.sql` package and invoke methods according to the JDBC specification.

Getting started

When you begin coding your program, use the sample program, sample01.java shown in Figure 2 on page 14, as a guide. The sample JDBC application code is located in a samples subdirectory. Assuming the driver is installed in `/usr/lpp/db2`, the samples subdirectory is:

```
/usr/lpp/db2/db2510/samples
```

```
//  NAME = sample01.java
//
//  DESCRIPTIVE NAME = JDBC sample01 application
//
//  DB2 JDBC sample01.java application:
//
//    (a) Load the DB2 for OS/390 JDBC Driver
//    (b) Create Connection instance
//    (c) Create a Statement instance
//    (d) Execute a Query and generate a ResultSet instance
//    (e) Print column 1 (table name) to system.out
//    (f) Close the ResultSet
//    (g) Close the Statement
//    (h) Close the Connection
//

1 import java.sql.*;

public class sample01 {

   static {
      try {
         // register the DB2 for OS/390 SQLJ/JDBC driver with DriverManager
2           Class.forName("COM.ibm.db2os390.sqlj.jdbc.DB2SQLJDriver");
      } catch (ClassNotFoundException e) {
         e.printStackTrace();
      }
   }

   public static void main(String args[]) {

      String URLprefix = "jdbc:db2os390sqlj:";
      String url;
      try {
         System.out.println("**** JDBC Entry within class sample01.");

         // If an alternate URL is passed, then use it
         if (args.length > 0)
            url = new String(URLprefix + args[0]);
         else
            url = new String(URLprefix);   //else use "local" DB2 location

3           // Create the connection
         Connection con = DriverManager.getConnection (url);
         System.out.println("**** JDBC Connection to DB2 for OS/390.");

4           // Create the Statement
         Statement stmt = con.createStatement();
         System.out.println("**** JDBC Statement Created");
```

Figure 2. Sample Java application (Part 1 of 2)

```
5           // Execute a Query and generate a ResultSet instance
         // The Query is a Select from SYSIBM.SYSTABLES
         ResultSet rs = stmt.executeQuery("SELECT NAME FROM SYSIBM.SYSTABLES");
         System.out.println("**** JDBC Result Set Created");
6           // Print all of the table names to sysout
         while (rs.next()) {
           String s = rs.getString(1);
           System.out.println("Table NAME = " + s);
         }
         System.out.println("**** JDBC Result Set output completed");

7           // Close the resultset
         rs.close();
8           // Close the statement
         stmt.close();
         System.out.println("**** JDBC Statement Closed");

9           // Close the connection
         con.close();
         System.out.println("**** JDBC Disconnect from DB2 for OS/390.");

         System.out.println("**** JDBC Exit from class sample01 - no  Errors.");

      } catch( SQLException sqle ) {

         System.out.println ("SQLException: " + sqle + ".  SQLSTATE=" +
          sqle.getSQLState() + " SQLCODE=" + sqle.getErrorCode());
         sqle.printStackTrace();
      } catch( Exception e ) {
         System.out.println ("Exception: " + e );
         e.printStackTrace();
      }

   }
}
```

Figure 2. Sample Java application (Part 2 of 2)

Notes to Figure 2 on page 14:

1 The first statement imports the appropriate Java package, `java.sql`.

2 The `Class.forName` method loads the appropriate JDBC driver, in this case, DB2 for OS/390 SQLJ/JDBC driver (`COM.ibm.db2os390.sqlj.jdbc.DB2SQLJDriver`) and registers it with the `DriverManager`. #

3 The `getConnection` method creates a `Connection` instance to connect to the database, specifying the location with a URL and using the DB2 subprotocol (as defined in the JDBC specification and explained in “Connecting to a data source” on page 11). You must modify the URL in the sample01.java application to match the location name of your local DB2 for OS/390.

4 The `createStatement` method creates a `Statement` instance.

5 The `executeQuery` method executes a query and generates a `ResultSet` instance.

6 The `next()` method on the `ResultSet` instance advances the iterator to successive rows of the result set. For each row, the `getString` method is called to retrieve column 1.

7 close() closes the result set.
8 close() closes the statement and frees all resources associated with the statement.
9 close() closes the connection and frees all resources associated with the connection.

After coding your program, compile it as you would any other Java program. No precompile or bind steps are required to run a Java program.

Chapter 3. Writing SQLJ programs for DB2 for OS/390

SQLJ provides support for embedded static SQL in Java applications and servlets. SQLJ was initially developed by Oracle, Tandem, and IBM to complement the dynamic SQL JDBC model with a static SQL model.

In general, Java applications use JDBC for dynamic SQL and SQLJ for static SQL. However, because SQLJ includes JDBC 1.2, an application program can create a JDBC connection and then use that connection to execute dynamic SQL statements through JDBC and embedded static SQL statements through SQLJ.

The SQLJ specification consists of three parts:

- **Database Languages – SQL – Part 10: Object Language Bindings (SQL/OLB)** is also known as SQLJ Part 0. It was approved by ANSI in 1998, and it specifies the SQLJ language syntax and semantics for embedded SQL statements in a Java application.
- **Database Languages – SQLJ – Part 1: SQL Routines using the Java™ Programming Language** was approved by ANSI in 1999, and it specifies extensions that define:
  - Installation of Java classes in an SQL database
  - Invocation of static methods as stored procedures
- **Database Languages – SQLJ – Part 2: SQL Types using the Java™ Programming Language** is under development. It specifies extensions for accessing Java classes as SQL user-defined types.

The DB2 for OS/390 implementation of SQLJ includes support for the following portions of the specification:

- Part 0
- The ability to invoke a Java static method as a stored procedure, which is in Part 1

Some of the major differences between SQLJ and JDBC are:

- SQLJ follows the static SQL model, and JDBC follows the dynamic SQL model.
- SQLJ source programs are smaller than equivalent JDBC programs, because certain code that the programmer must include in JDBC programs is generated automatically by SQLJ.
- SQLJ can do data type checking during the program preparation process to determine whether table columns are compatible with Java host expressions. JDBC passes values to and from SQL tables without compile-time data type checking.
- In SQLJ programs, you can embed Java host expressions in SQL statements. JDBC requires a separate call statement for each bind variable and specifies the binding by position number.
- SQLJ provides the advantages of static SQL authorization checking. With SQLJ, the authorization ID under which SQL statements execute is the plan or package owner. DB2 checks table privileges at bind time. Because JDBC uses dynamic SQL, the authorization ID under which SQL statements execute is not known until run time, so no authorization checking of table privileges can occur until run time.

This chapter and the following two chapters explain DB2 for OS/390 support for SQLJ. This chapter gives you the information that you need to write SQLJ programs that run on DB2 for OS/390. Subsequent chapters describe how to prepare SQLJ programs for execution and provide detailed syntax for the components of SQLJ.

The following topics are discussed in this chapter:

- “Executing SQL statements in an SQLJ program”
- “Including code to access SQLJ support” on page 20
- “Connecting to a data source” on page 20
- “Using result set iterators to retrieve rows from a result table” on page 22
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Executing SQL statements in an SQLJ program

This section discusses the following basic information about writing an SQLJ program:

- How to include SQL statements, host variables, and comments in the program
- Which SQL statements are valid in an SQLJ program
- How to do error handling

Including SQL statements in an SQLJ program

In an SQLJ program, all statements that are used for database access are in *SQLJ clauses*. SQLJ clauses that contain SQL statements are called *executable clauses*. An executable clause begins with the characters #sql and contains an SQL statement that is enclosed in curly brackets. The SQL statement itself has no terminating character. An example of an executable clause is:

```
#sql {DELETE FROM EMP};
```

“executable-clause” on page 45 contains a list of the SQL statements that you can include in an SQLJ program. An executable clause can appear anywhere in a program that a Java statement can appear.

Using Java variables and expressions as host expressions

To pass data between a Java application program and DB2, use host expressions. A Java host expression is a Java simple identifier or complex expression, preceded by a
# colon. The result of a complex expression must be a single value. An array element is
# considered to be a complex expression. A complex expression must be surrounded by
parentheses. When you use a host expression as a parameter in a stored procedure call, you can follow the colon with the IN, OUT, or INOUT parameter, which indicates whether the host expression is intended for input, output, or both. The IN, OUT, or INOUT value must agree with the value you specify in the stored procedure definition in catalog table SYSIBM.SYSPROCEDURES.

The following SQLJ clause uses a host expression that is a simple Java variable named empname:

```
#sql {SELECT LASTNAME INTO :empname FROM EMP WHERE EMPNO='000010'};
```

The following SQLJ clause calls stored procedure A and uses a simple Java variable named EMPNO as an input or output parameter:

```
#sql {CALL A (:INOUT EMPNO)};
```

SQLJ evaluates host expressions from left to right before DB2 processes the SQL statements that contain them. For example, suppose that the value of `i` is 1 before the following SQL clause is executed:

```
#sql {SET :(z[i++]) = :(x[i++]) + :(y[i++])};
```

The array index that determines the location in array `z` is 1. The array index that determines the location in array `x` is 2. The array index that determines the location in array `y` is 3. The value of `i` in the Java space is now 4. The statement is then executed. After statement execution, the output value is assigned to `z[1]`.

In an executable clause, host expressions, which are Java tokens, are case sensitive.

Including comments

To include comments in an SQLJ program, use either Java comments or SQL comments.

- Java comments are denoted by /* */ or //. You can include Java comments outside SQLJ clauses, wherever the Java language permits them. Within an SQLJ clause, use Java comments in host expressions.
- SQL comments are denoted by * at the beginning of a line or -- anywhere on a line in an SQL statement. You can use SQL comments in executable clauses, anywhere except in host expressions.

Handling SQL errors and warnings

SQLJ clauses use the JDBC class `java.sql.SQLException` for error handling. SQLJ generates an SQLException when an SQL statement returns a negative SQLCODE. You can use the `getErrorCode` method to retrieve SQLCODEs and the `getSQLState` method to retrieve SQLSTATEs.

To handle SQL errors in your SQLJ application, import the `java.sql.SQLException` class, and use the Java error handling `try/catch` blocks to modify program flow when an SQL error occurs. For example:

```
try {
  #sql {SELECT LASTNAME INTO :empname
    FROM EMP WHERE EMPNO='000010'};
}
catch(SQLException e) {
  System.out.println("SQLCODE returned: " + e.getErrorCode());
}
```

DB2 warnings do not throw SQLExceptions. To handle DB2 warnings, you need to import the `java.sql.SQLWarning` class. To check for a DB2 warning, invoke the `getWarnings` method after you execute an SQL clause. `getWarnings` returns the first warning code that an SQL statement generates. Subsequent SQL warning codes are chained to the first SQL warning code.

Before you can execute `getWarnings` for an SQL clause, you need to set up an execution context for that SQL clause. See “Controlling the execution of SQL statements” on page 30 for information on how to set up an execution context. The following example demonstrates how to retrieve an SQL warning code for an SQL clause with execution context ExecCtx:

```
SQLWarning SQLWarn;
#sql [ExecCtx] {SELECT LASTNAME INTO :empname
  FROM EMP WHERE EMPNO='000010'};
if (SQLWarn = ExecCtx.getWarnings() != null) then
System.out.println("SQLWarning " + SQLWarn);
```

Including code to access SQLJ support

Before you can execute any SQLJ clauses in your application program, you must include code to accomplish these tasks:

- Import the Java packages for SQLJ run-time support and the JDBC interfaces that are used by SQLJ.
- Load the DB2 for OS/390 SQLJ/JDBC driver, which is the SQLJ implementation of JDBC 1.2 function.

To import the Java packages for SQLJ and JDBC, include these lines in your application program:

```
import sqlj.runtime.*;          // SQLJ runtime support
import java.sql.*;              // JDBC interfaces
```

To load the DB2 for OS/390 SQLJ/JDBC driver and register it with the `DriverManager`, invoke method `Class.forName` with an argument of `COM.ibm.db2os390.sqlj.jdbc.DB2SQLJDriver`. For example:

```
try {
  Class.forName("COM.ibm.db2os390.sqlj.jdbc.DB2SQLJDriver");
}
catch (ClassNotFoundException e) {
   e.printStackTrace();
}
```

Connecting to a data source

In an SQLJ application, as in any other DB2 application, you must be connected to a data source before you can execute SQL statements. A data source in DB2 for OS/390 is a DB2 location name.

To execute an SQL statement at a data source, use one of the following methods:

- Use an *explicit connection.*

Specify a *connection context*, enclosed in square brackets, at the beginning of the execution clause that contains the SQL statement. For example, the following SQL clause executes an UPDATE statement at the data source that is associated with connection context myconn:

```
#sql [myconn] {UPDATE DEPT SET MGRNO=:hvmgr WHERE DEPTNO=:hvdeptno};
```

- Use a *default connection.*

  When you specify an execution clause without a connection context, SQLJ uses the default context to access a data source. If you create a connection context object for accessing a remote data source, you can use the setDefaultContext method to install that connection context object as the default connection. If you do not use setDefaultContext to override the default connection is to the local DB2 subsystem.

A connection context is an instance of a *connection context class*. To define the connection context class and set up the connection context, use one of the following methods *before* you specify the connection context in any SQL statements:

- Connection method 1:
  1. Execute a type of SQLJ clause called a *connection declaration clause* to generate a connection context class.
  2. Invoke the constructor for the connection context class with the following arguments:
     – A string that specifies the location name that is associated with the data source. That argument has the form:

       ```
       jdbc:db2os390sqlj:location-name
       ```

       If *location-name* is not the local site, *location-name* must be defined in the SYSIBM.LOCATIONS DB2 catalog table. If *location-name* is the local site, *location-name* must have been specified in field DB2 LOCATION NAME of the DISTRIBUTED DATA FACILITY panel during DB2 installation.

     – A boolean that specifies whether autoCommit is on or off for the connection.

  For example, suppose that you want to use the first method to set up connection context myconn to access data at a data source that is associated with location NEWYORK. For this connection, you want autoCommit to be off. First, execute a connection declaration clause to generate a connection context class:

  ```
  #sql context Ctx;
  ```

  Then invoke the constructor for generated class Ctx with arguments jdbc:db2os390sqlj:NEWYORK and `false`:

  ```
  Ctx myconn=new Ctx("jdbc:db2os390sqlj:NEWYORK",false);
  ```

- Connection method 2:
  1. Execute a connection declaration clause to generate a connection context class.
  2. Invoke the JDBC `java.sql.DriverManager.getConnection` method. The argument for java.sql.DriverManager.getConnection is a string that specifies the location name that is associated with the data source. That argument has the form:

     ```
     jdbc:db2os390sqlj:location-name
     ```

If *location-name* is not the local site, *location-name* must be defined in SYSIBM.LOCATIONS. If *location-name* is the local site, *location-name* must have been specified in field DB2 LOCATION NAME of the DISTRIBUTED DATA FACILITY panel during DB2 installation. The invocation returns an instance of class `Connection`, which represents a JDBC connection to the data source.

# 3. For environments other than the CICS environment, the default state of autoCommit for a JDBC connection is on. To disable autoCommit, invoke the setAutoCommit method with an argument of `false`.
4. Invoke the constructor for the connection context class. For the argument of the constructor, use the JDBC connection that results from invoking `java.sql.DriverManager.getConnection`.

To use the second method to set up connection context myconn to access data at the data source associated with location NEWYORK with autoCommit off, first execute a connection declaration clause to generate a connection context class:

```
#sql context Ctx;
```

Then invoke `java.sql.Driver.getConnection` with the argument jdbc:db2os390sqlj:NEWYORK:

```
Connection jdbccon=DriverManager.getConnection("jdbc:db2os390sqlj:NEWYORK");
```

Next, to set autoCommit off for the connection, invoke setAutoCommit with an argument `false`:

```
jdbccon.setAutoCommit(false);
```

Finally, invoke the constructor for class Ctx using the JDBC connection as the argument:

```
Ctx myconn=new Ctx(jdbccon);
```

SQLJ uses the JDBC `java.sql.Connection` class to connect to data sources. Your application can invoke any method in the `java.sql.Connection` class.

Using result set iterators to retrieve rows from a result table

In DB2 application programs that are written in traditional host languages, you use a cursor to retrieve individual rows from the result table that is generated by a SELECT statement. The SQLJ equivalent of a cursor is a *result set iterator*. A result set iterator is a Java object that you use to retrieve rows from a result table. Unlike a cursor, a result set iterator can be passed as a parameter to a method.

You define a result set iterator using an *iterator declaration clause*. The iterator declaration clause specifies the following information:

- A list of Java data types
- Information for a Java class declaration, such as whether the iterator is public or static
- A set of attributes, such as whether the iterator is holdable, or whether its columns can be updated

The data type declarations represent columns in the result table and are referred to as columns of the result set iterator. Table 1 shows each Java data type that you can specify in a result set iterator declaration and the equivalent SQL data type.

Table 1. Equivalent Java and SQL data types

Java data type	**SQL data type**
java.lang.String	CHAR, VARCHAR, GRAPHIC, VARGRAPHIC
java.math.BigDecimal	NUMERIC, INTEGER, DECIMAL, SMALLINT, FLOAT, REAL, DOUBLE
Boolean	INTEGER, SMALLINT
int, Integer	SMALLINT, INTEGER, DECIMAL, NUMERIC, FLOAT, DOUBLE
float, Float	SMALLINT, INTEGER, DECIMAL, NUMERIC, FLOAT, DOUBLE
double, Double	SMALLINT, INTEGER, DECIMAL, DECIMAL, NUMERIC, FLOAT, DOUBLE
byte[][1]	CHAR FOR BIT DATA, VARCHAR FOR BIT DATA
java.sql.Date[2]	DATE
java.sql.Time[2]	TIME
java.sql.Timestamp[2]	TIMESTAMP

Notes to Table 1:

1. Because this data type is equivalent to a DB2 data type with a subtype of BIT, SQLJ performs no conversion for data of this type.
2. This class is part of the JDBC API.

If you declare an iterator without the public modifier, you can declare and use the iterator in the same file. If you declare the iterator as public, you can declare and use the iterator in one of the following ways:

- Declare the iterator in one file, and use it in a different file. The name of the file in which you declare the iterator must match the iterator name.
- Declare and use the iterator in the same file. If you do this, you need to declare the iterator with the public and static modifiers, and declare the iterator in the class that uses it.

Examples in this chapter that use a public iterator declare the iterator in a different file from the file in which it is used.

The two types of result set iterators are *positioned iterators* and *named iterators*. The type of result set iterator that you choose depends on the way that you plan to use that result set iterator. The following sections explain how to use each type of iterator.

Using positioned iterators

For a positioned iterator, the columns of the result set iterator correspond to the columns of the result table, in left-to-right order. For example, if an iterator declaration clause has two data type declarations, the first data type declaration corresponds to the first column in the result table, and the second data type declaration corresponds to the second column in the result table. You declare positioned iterators to execute FETCH statements.

For example, the following iterator declaration clause defines a positioned iterator named ByPos with two columns. The first column is of type `String`, and the second column is of type `Date`.

```
#sql iterator ByPos(String,Date);
```

When SQLJ encounters an iterator declaration clause for a positioned iterator, it generates a *positioned iterator class* with the name that you specify in the iterator declaration clause. You can then declare an object of the positioned iterator class to retrieve rows from a result table.

For example, suppose that you want to retrieve rows from a result table that contains the values of the LASTNAME and HIREDATE columns from the DB2 sample employee table. Figure 3 shows how you can declare an iterator named ByPos and use an object of the generated class ByPos to retrieve those rows.

```
   {
     #sql iterator ByPos(String,Date);
                                 // Declare positioned iterator class ByPos
     ByPos positer;              // Declare object of ByPos class
     String name = null;
     Date hrdate;
1    #sql positer = { SELECT LASTNAME, HIREDATE FROM EMP };
2    #sql { FETCH :positer INTO :name, :hrdate };
                                  // Retrieve the first row
3    while ( !positer.endFetch() )
     { System.out.println(name + " was hired in " +
         hrdate);
       #sql { FETCH :positer INTO :name, :hrdate };
                                 // Retrieve the rest of the rows
     }
   }
```

Figure 3. Retrieving rows using a positioned iterator

Notes to Figure 3:

1 This SQLJ clause executes the SELECT statement, constructs an iterator object that contains the result table for the SELECT statement, and assigns the iterator object to variable positer.

2 The DB2 for OS/390 customizer can validate that the iterator types is compatible with the SQL data type of the corresponding column.

3 Method endFetch(), which is a method of the generated iterator class ByPos, returns a value of `true` when all rows have been retrieved from the iterator. The first FETCH statement needs to be executed before endFetch() is called.

Using named iterators

Using named iterators is an alternative way to select rows from a result table. When you declare a named iterator for a query, you specify names for each of the iterator columns. Those names must match the names of columns in the result table for the query. An iterator column name and a result table column name that differ only in case are considered to be matching names.

When SQLJ encounters a named iterator declaration, it generates a *named iterator class* with the same name that you use in the iterator declaration clause. In the named iterator class, SQLJ generates an *accessor method* for each column name in the iterator declaration clause. The accessor method name is the same name as the column name in the iterator declaration clause. The data type that is returned by the accessor method is the same as the data type of the corresponding column in the iterator declaration clause.

When you execute an SQL clause that has a named iterator, SQLJ matches the name of each iterator column to the name of a column in the result table.

The following iterator declaration clause defines the named iterator ByName, which has two columns. The first column of the iterator is named LastName and is of type `String`. The second column is named HireDate and is of type `Date`.

```
#sql iterator ByName(String LastName, Date HireDate);
```

To use a named iterator, you use an SQLJ *assignment clause* to assign the result table from a SELECT statement to an instance of a named iterator class. Then you use the accessor methods to retrieve the data from the iterator.

Figure 4 shows how you can use a named iterator to retrieve rows from a result table that contains the values of the LASTNAME and HIREDATE columns of the employee table.

```
  {
1   #sql iterator ByName(String LastName, Date HireDate);
    ByName nameiter;          // Declare object of ByName class
2   #sql nameiter={SELECT LASTNAME, HIREDATE FROM EMP};
3   while (nameiter.next())
    {
      System.out.println( nameiter.LastName() + " was hired on "
        + nameiter.HireDate());
    }
  }
```

Figure 4. Retrieving rows using a named iterator

Notes to Figure 4 on page 25:

1 This SQLJ clause creates the named iterator class ByName, which has accessor methods LastName() and HireDate() that return the data from result table columns LASTNAME and HIREDATE.

2 This SQLJ clause executes the SELECT statement, constructs an iterator object that contains the result table for the SELECT statement, and assigns the iterator object to variable nameiter.

3 next(), which is a method of the generated class ByName, advances the iterator to successive rows of the result set. `next` returns a value of `true` when a next row is available, and a value of `false` when all rows have been fetched from the iterator.

The column names for named iterators must be valid Java identifiers. The column names must also match the column names in the result table from which the iterator retrieves rows. If a SELECT statement that uses a named iterator selects data from columns with names that are not valid Java identifiers, you need to use SQL AS clauses in the SELECT statement to give the columns of the result table acceptable names.

For example, suppose you want to use a named iterator to retrieve the rows that are specified by this SELECT statement:

```
SELECT PUBLIC FROM GOODTABLE
```

The iterator column name must match the column name of the result table, but you cannot specify an iterator column name of `PUBLIC` because `PUBLIC` is a reserved Java keyword. You must therefore use an AS clause to rename `PUBLIC` to a valid Java identifier in the result table. For example:

```
SELECT PUBLIC AS IS_PUBLIC FROM GOODTABLE
```

You can then declare a named iterator with a column name that is a valid Java identifier and matches the column name of the result table:

```
#sql iterator ByName(String IS_PUBLIC);
ByName nameiter;
#sql nameiter={SELECT PUBLIC AS IS_PUBLIC FROM GOODTABLE};
```

Using iterators for positioned UPDATE and DELETE operations

When you declare an iterator for a positioned UPDATE or DELETE statement, you must use an SQLJ *implements clause* to implement the `sqlj.runtime.ForUpdate` interface. You must also declare the iterator as public. For example, suppose that you declare the iterator ByPos for use in a positioned DELETE statement. The declaration looks like this:

```
#sql public iterator ByPos(String) implements sqlj.runtime.ForUpdate
  with(updateColumns="EmpNo");
```

Because you declare the iterator as public but not static, you need to use the iterator in a different source file. To use the iterator:

1. Import the generated iterator class.
2. Declare an instance of the generated iterator class.

3. Assign the SELECT statement for the positioned UPDATE or DELETE to the iterator instance.
4. Execute positioned UPDATE or DELETE statements using the iterator.

After the iterator is created, any SQLJ source file that has addressability to the iterator and imports the generated class can retrieve data and execute positioned UPDATE or DELETE statements using the iterator. The authorization ID under which a positioned UPDATE or DELETE statement executes is the authorization ID under which the DB2 package that contains the UPDATE or DELETE executes.

For example, suppose that you declare iterator UpdByName like this in UpdByName.sqlj:

```
#sql public iterator UpdByName(String EMPNO, BigDecimal SALARY)
  implements sqlj.runtime.ForUpdate
  with(updateColumns="SALARY");
```

To use UpdByName for a positioned UPDATE in another file, execute statements like those in Figure 5.

```
1  import UpdByName;
   {
     UpdByName upditer;         // Declare object of UpdByName class
     String enum;
2    #sql upditer = { SELECT EMPNO, SALARY FROM EMP
                        WHERE WORKDEPT='D11'};
3    while (upditer.next())
     {
       enum = upditer.EmpNo();  // Get value from result table
4      #sql { UPDATE EMP SET SALARY=SALARY*1.05 WHERE CURRENT OF :upditer };
                                // Update row where cursor is positioned
       System.out.println("Updating row for " + enum);
     }
     #sql {COMMIT};             // Commit the changes

   }
```

Figure 5. Updating rows using a positioned iterator

Notes to Figure 5:

1 This statement imports named iterator class UpdByName, which was created by the iterator declaration clause for UpdByName in UpdByName.sqlj. The import command is not needed if UpdByName is in the same package as the Java source file that references it.

2 This SQLJ clause executes the SELECT statement, constructs an iterator object that contains the result table for the SELECT statement, and assigns the iterator object to variable upditer.

3 This statement positions the iterator to the next row to be updated.

4 This SQLJ clause performs the positioned UPDATE.

Using JDBC result sets in SQLJ applications

You can combine SQLJ clauses and JDBC calls in a single program to take advantage of the flexibility of JDBC and the type checking of SQLJ. To do this effectively, you need to be able to use SQLJ iterators to retrieve data from JDBC result sets or generate JDBC result sets from SQLJ iterators.

Retrieving JDBC result sets using SQLJ iterators

Use the *iterator conversion statement* to manipulate a JDBC result set as an SQLJ iterator. The general form of an iterator conversion statement is:

```
#sql iterator={CAST :result-set};
```

Before you can successfully cast a result set to an iterator, the iterator must conform to the following rules:

- If the iterator is a positioned iterator, the number of columns in the result set must match the number of columns in the iterator. In addition, the data type of each column in the result set must match the data type of the corresponding column in the iterator.
- If the iterator is a named iterator, the name of each accessor method must match the name of a column in the result set. In addition, the data type of the object that an accessor method returns must match the data type of the corresponding column in the result set.

When you close an iterator that is generated from a result set, you also close the result set.

The code in Figure 6 builds and executes a query using a JDBC call, executes an iterator conversion statement to convert the JDBC result set to an SQLJ iterator, and retrieves rows from the result table using the iterator.

```
   public void hireDates(Connection conn, String whereClause)
   {
1    #sql iterator ByName(String LastName, Date HireDate);
     ByName nameiter;           // Declare object of ByName class
2    PreparedStatement stmt = conn.prepareStatement();
     String query = "SELECT LASTNAME, HIREDATE FROM EMP";
     query+=whereClause;   // Build the query
3    ResultSet rs = stmt.executeQuery(query);
4    #sql nameiter = {CAST :rs};
     while (nameiter.next())
     {
       System.out.println( nameiter.LastName() + " was hired on "
         + nameiter.HireDate());
     }
5    nameiter.close();
     stmt.close();
   }
```

Figure 6. Converting a JDBC result set to an SQLJ iterator

Notes to Figure 6 on page 28:

1 This SQLJ clause creates the named iterator class ByName, which has accessor methods LastName() and HireDate() that return the data from result table columns LASTNAME and HIREDATE.

2 This statement and the following two statements build and prepare a query for dynamic execution using JDBC.

3 This JDBC statement executes the SELECT statement and assigns the result table to result set rs.

4 This iterator conversion clause converts the JDBC result set RS to SQLJ iterator nameiter, and the following statements use nameiter to retrieve values from the result table.

5 The close() method closes the SQLJ iterator and JDBC result set rs.

Generating JDBC result sets from SQLJ iterators

Use the getResultSet method to generate a JDBC result set from an SQLJ iterator. Every SQLJ iterator has a getResultSet method. After you convert an iterator to a result set, you need to fetch rows using only the result set.

The code in Figure 7 generates a positioned iterator for a query, converts the iterator to a result set, and uses JDBC methods to fetch rows from the table.

```
  {
        sqlj.runtime.ResultSetIterator unTyped;
1   #sql unTyped = { SELECT LASTNAME, HIREDATE FROM EMP };
2   ResultSet rs = unTyped.getResultSet();
3   while (rs.next())
    { System.out.println(rs.getString(1) + " was hired in " +
        rs.getDate(2));
    }
4   unTyped.close();
  }
```

Figure 7. Converting an SQLJ iterator to a JDBC result set

Notes to Figure 7:

1 This SQLJ clause executes the SELECT statement, constructs an iterator object that contains the result table for the SELECT statement, and assigns the iterator object to variable unTyped.

2 The getResultSet() method converts iterator unTyped to result set rs.

3 The JDBC getString() and getDate() methods retrieve values from the result set. The next() method moves the cursor to the next row in the result set.

4 The close() method closes the SQLJ iterator.

Controlling the execution of SQL statements

You can use selected methods of the SQLJ `ExecutionContext` class to query and modify the characteristics of SQL statements during execution. “Appendix A. Selected sqlj.runtime classes and interfaces” on page 91 describes those methods.

To execute `ExecutionContext` methods for an SQL statement, you must create an *execution context* and associate that execution context with the SQL statement.

To create an execution context, invoke the constructor for `ExecutionContext` and assign the result to a variable of type `ExecutionContext`. For example:

```
ExecutionContext ExecCtx=new ExecutionContext();
```

To associate an execution context with an SQL statement, specify the name of the execution context, enclosed in square brackets, at the beginning of the execution clause that contains the SQL statement. For example:

```
#sql [ExecCtx] {DELETE FROM EMP WHERE SALARY > 10000};
```

You can associate a different execution context with each SQL statement. If you also use an explicit connection context for an SQL statement, specify the connection context, followed by the execution context in the execution clause for the SQL statement. For example:

```
#sql [ConnCtx, ExecCtx] {DELETE FROM EMP WHERE SALARY > 10000};
```

If you do not specify an execution context for an execution clause, SQLJ uses the execution context that is associated with the connection context for the execution clause.

After you associate an execution context with an SQL statement, you can execute ExecutionContext methods for that SQL statement. For example, you can use method `getUpdateCount` to count the number of rows that are deleted by a DELETE statement:

```
#sql [ConnCtx, ExecCtx] {DELETE FROM EMP WHERE SALARY > 10000};
System.out.println("Deleted " + ExecCtx.getUpdateCount() + " rows");
```

Retrieving multiple result sets from a stored procedure

Some stored procedures return one or more result sets to the calling program. To retrieve the rows from those result sets, you execute these steps:

- Create an execution context that is used to retrieve the result set from the stored procedure.

  If you plan to cast the result set from the stored procedure to an SQLJ iterator, create a second execution context for that purpose. You cannot use the same execution context to retrieve a result set and to cast that result set to an iterator.
- Associate the execution context with the CALL statement for the stored procedure.
- For each result set:
  – Use the ExecutionContext method getNextResultSet to retrieve the result set.
  – Use an iterator or JDBC ResultSet to retrieve the rows from the result set.

Each call to getNextResultSet closes the previous result set and advances to the next result set. Result sets are returned to the calling program in the same order that their cursors are opened in the stored procedure. When there are no more result sets to retrieve, getNextResultSet returns a null value.

The code in Figure 8 calls a stored procedure that returns multiple result sets. For this example, it is assumed that the caller does not know the number of result sets to be returned or the contents of those result sets.

```
1  #sql context ConnCtx;
   Connection Connjdbc=
     DriverManager.getConnection("jdbc:db2os390sqlj:SANJOSE");
   Connjdbc.setAutoCommit(false);
   ConnCtx myconn=new ConnCtx(Connjdbc);
2  #sql [myconn] {CALL MULTRSSP()};
3  ExecutionContext ExecCtx=myconn.getExecutionContext();
4  ResultSet rs;
5  while ((rs = ExecCtx.getNextResultSet()) != null)
   {
6    ResultSetMetaData rsmeta=rs.getMetaData();
     int numcols=rsmeta.getColumnCount();
7    while (rs.next())
     {
       for (int i=1; i<=numcols; i++)
       {
         String colval=rs.getString(i);
         System.out.println("Column " + i + "value is " + colval);
       }
     }
     rs.close();
   }
```

Figure 8. Retrieving multiple result sets from a stored procedure

Notes to Figure 8:

1 This statement and the following three statements set the connection context for the program that calls the stored procedure.

2 MULTRSSP is a stored procedure that returns multiple result sets.

3 This statement gets the execution context from the connection that is used to call the stored procedure.

4 Result set rs is used to retrieve rows from each result set that is returned from the stored procedure.

5 Each invocation of the getNextResultSet method returns a result set from the stored procedure. When there are no more result sets to retrieve, getNextResultSet returns null.

6 Because the caller does not know the contents of the result sets that are returned from the stored procedure, JDBC ResultSetMetaData methods are used to obtain this information.

7 The statements in this loop retrieve rows from a result set and print out the contents of each column.

Setting the isolation level for a transaction

To set the isolation level for a unit of work within an SQLJ program, use the SET TRANSACTION ISOLATION LEVEL clause. Table 2 shows the values that you can specify in the SET TRANSACTION ISOLATION LEVEL clause and their DB2 for OS/390 equivalents.

Table 2. Equivalent SQLJ and DB2 isolation levels

SET TRANSACTION value	DB2 for OS/390 isolation level
READ COMMITTED	Cursor stability
READ UNCOMMITTED	Uncommitted read
REPEATABLE READ	Read stability
SERIALIZABLE	Repeatable read

You can set the isolation level only at the beginning of a transaction.

Setting the read-only mode for a transaction

To set the read-only mode for a unit of work within an SQLJ program, use the SET TRANSACTION READ ONLY or SET TRANSACTION READ WRITE clause. SET TRANSACTION READ ONLY puts a connection into read-only mode so that DB2 can optimize execution of SQL statements for read-only access. If you execute SET TRANSACTION READ WRITE, DB2 does not optimize for read-only access.

You can set the read-only mode only at the beginning of a transaction.

An SQLJ sample program

Figure 9 on page 33 contains an example of an SQLJ program that prints the names and salaries of employees with salaries that exceed the average for the company. The program uses the DB2 sample employee table.

```
1   import sqlj.runtime.*;
    import java.sql.*;
    import java.math.*;
2   #sql context HSCtx;
3   #sql iterator HSByName(String LastName, BigDecimal Salary);
    public class HighSalary
    {
      public static void main (String[] args) // Main entry point
        throws SQLException
      {
          try {
4           Class.forName("COM.ibm.db2os390.sqlj.jdbc.DB2SQLJDriver");
          }
          catch (ClassNotFoundException e) {
             e.printStackTrace();
          }
5       Connection HSjdbccon=
          DriverManager.getConnection("jdbc:db2os390sqlj:SANJOSE");
        HSjdbccon.setAutoCommit(false);
        HSCtx myconn=new HSCtx(HSjdbccon);
        BigDecimal AvgSal;
        #sql [myconn] {SELECT AVG(SALARY) INTO :AvgSal FROM EMP};
        printSalary(AvgSal,myconn);
        HSjdbccon.close();
      }
      static void printSalary(BigDecimal AvgSalary, HSCtx hsconn)
        throws SQLException                   // Method to get high salaries
      {
6       HSByName nameiter;
7       #sql [hsconn] nameiter =
          {SELECT LASTNAME, SALARY FROM EMP
             WHERE SALARY >= :AvgSalary
             ORDER BY SALARY DESC};
8       while (nameiter.next())
9        System.out.println( nameiter.LastName() + " " +
           nameiter.Salary());
10      nameiter.close();
      }
    }
```

Figure 9. SQLJ sample program

Notes to Figure 9:

1 The first two statements import the JDBC and SQLJ packages that are used by SQLJ.

2 This connection declaration clause declares connection context HSCtx, which will be used to connect to location SANJOSE. When you prepare the application program, SQLJ generates a class named HSCtx. You must therefore ensure that HSCtx is a valid Java class name that is unique within its scope.

3 This iterator declaration clause declares named iterator HSByName, which will be used to select rows from the employee table. When you prepare the application program, SQLJ generates a class named HSByName. You must therefore ensure that HSByName is a valid Java class name that is unique within its scope.

4 The `Class.ForName` method loads the DB2 for OS/390 SQLJ JDBC driver and registers it with the `DriverManager`.

5 This statement and the two statements that follow it set up the connection to the data source at location SANJOSE and set autoCommit for the connection to off. Executable clauses that specify the connection instance myconn will be executed at location SANJOSE.

6 This statement declares nameiter as an instance of the named iterator class HSByName.

7 This assignment clause executes the SELECT statement, constructs an iterator object that contains the result table for the SELECT statement, and assigns the iterator object to variable nameiter.

8 `next`, which is a method of the generated class HSByName, advances the iterator to successive rows of the result set. `next` returns a value of `true` when a next row is available and a value of `false` when all rows have been fetched from the iterator.

9 Accessor methods nameiter.LastName and nameiter.Salary retrieve the values of the LASTNAME and SALARY column from the current row of the result table.

10 `close`, which is a method of generated iterator class HSByName, closes the iterator to free any database resources that the iterator holds.

Running SQLJ programs

After you have set the environmental variables discussed in “Configuring JDBC and SQLJ” on page 83 and prepared your program for execution, your program is ready to run.

To ensure that the program can find all the files that it needs:

- Put the serialized profiles for the program in the same directory as the class files for the program.
- Include class files that are used by the program in the CLASSPATH.

To run your SQLJ program, execute the `java` command from the OS/390 OpenEdition command line:

```
java program-name
```

Diagnosing SQLJ problems

SQLJ programs can generate two types of errors:

- Recoverable errors

  SQLJ reports recoverable SQL errors through the JDBC `java.sql.SQLException` class. You can use methods `getErrorCode` and `getSQLState` to retrieve SQLCODEs and SQLSTATEs. See “Handling SQL errors and warnings” on page 19 for information on how to write your application program to retrieve SQLCODEs and SQLSTATEs.

  All SQLSTATEs except FFFFF are documented in Section 2 of *Messages and Codes*. FFFFF is a special SQLSTATE that indicates an internal error in the SQLJ/JDBC driver.
- Non-recoverable errors

These errors do not throw an SQLException, or the application cannot catch the exception.

To diagnose recoverable errors that generate SQLSTATE FFFFF or repeatable, non-recoverable errors, you can collect trace data and run three utilities that generate additional diagnostic information. You should run the trace and diagnostic utilities only under the direction of your IBM service representative.

Formatting trace data

Before you can format SQLJ trace data, you must set several environmental variables. You must also set several parameters in the run-time properties file that you name in environmental variable DB2SQLJPROPERTIES. “Configuring JDBC and SQLJ” on page 83 describes these variables and parameters.

In the CICS environment, configuring for traces is somewhat different than in other environments. See “Appendix B. Special considerations for CICS applications” on page 95 for information on tracing in the CICS environment.

When you set the parameter DB2SQLJ_TRACE_FILENAME in the run-time properties file, you enable SQLJ/JDBC tracing. The SQLJ/JDBC driver generates two trace files:

- One trace file has a proprietary, binary format and must be formatted using the `db2sqljtrace` command. The name of that trace file is *trace-file*, where *trace-file* is the value to which you set DB2SQLJ_TRACE_FILENAME.
- The other trace file contains readable text, which requires no additional formatting. The name of that trace file is *trace-file*.JTRACE.

If your IBM service representative requests a DB2 SQLJ/JDBC trace, you need to format *trace-file* using `db2sqljtrace`. Send the `db2sqljtrace` output and *trace-file*.JTRACE to IBM.

The `db2sqljtrace` command writes the formatted data to stdout. The format of `db2sqljtrace` is:

```
►►──db2sqljtrace──┬─fmt─┬──input-file-name──────────────────────────────►◄
                  └─flw─┘
```

The meanings of the parameters are:

fmt
Specifies that the output trace file is to contain a record of each time a function is entered or exited before the failure occurs.

flw Specifies that the output trace file is to contain the function flow before the failure occurs.

input-file-name
Specifies the name of the file from which db2sqljtrace is to read the unformatted trace data. This name is the name you specified for environmental variable DB2SQLJ_TRACE_FILENAME.

Running diagnosis utilities

If an SQLJ application program receives a recoverable, internal error (SQLSTATE FFFFF) or a repeatable, non-recoverable error, run diagnosis utilities `profp`, `profdb`, and `db2profp`, which are provided with SQLJ, to obtain additional information about the error.

The `profp` utility captures information about each SQLJ clause in a serialized profile. The format of the `profdb` utility is:

```
►►──profp──serialized-profile-name──────────────────────────────────────────►◄
```

Run the `profp` utility on the serialized profile for the connection in which the error occurs. If an exception is thrown, a Java stack trace is generated. You can determine which serialized profile was in use when the exception was thrown from the stack trace.

The `db2profp` utility captures information about each SQLJ clause in a customized serialized profile. A customized serialized profile is a serialized profile on which the DB2 for OS/390 SQLJ customizer has been run. The format of the `db2profp` utility is:

```
►►──db2profp──customized-serialized-profile-name────────────────────────────►◄
```

Run the `db2profp` utility on the customized serialized profile for the connection in which the error occurs.

The `profdb` utility customizes serialized profiles so that SQLJ captures extra information about run-time calls. The syntax of the `profdb` utility is:

```
             ┌──────────────────────────┐
             ▼                          │
►►──profdb─────serialized-profile-name──┴───────────────────────────────────►◄
```

Run the `profdb` utility on every serialized profile that is associated with the SQLJ application program that received the internal error. After you run `profdb`, rerun the application program to gather the diagnostic information.

Chapter 4. SQLJ statement reference

The SQL statements in your SQLJ program are in SQLJ clauses. The general syntax of an SQLJ clause is:

```
►►──#sql──┬─connection-declaration-clause─┬──;───────────────────────────────►◄
          ├─iterator-declaration-clause───┤
          └─executable-clause─────────────┘
```

This chapter describes each of the three clauses that can appear in an SQLJ clause and the elements that you can include in each of those clauses. Elements that are subcomponents of several other elements are discussed first.

For more information and examples of using the clauses described in this chapter, see “Chapter 3. Writing SQLJ programs for DB2 for OS/390” on page 17.

Common elements

This section describes the elements that are common to several SQLJ clauses.

host-expression

A host expression is a Java variable or expression that is referenced by SQLJ clauses in an SQLJ application program.

Syntax

```
►►─:─┬───────┬──┬─simple-variable──────┬──────────────────────────────────────►◄
     ├─IN────┤  └─(complex-expression)─┘
     ├─OUT───┤
     └─INOUT─┘
```

Description

: Indicates that the variable or expression that follows is a host expression. The colon must immediately precede the variable or expression.

IN|OUT|INOUT
For a host expression that is used as a parameter in a stored procedure call, identifies whether the parameter provides data to the stored procedure (IN), retrieves data from the stored procedure (OUT), or does both (INOUT). This is an optional parameter.

simple-variable
Specifies a Java unqualified identifier.

complex-expression
Specifies a Java expression that results in a single value.

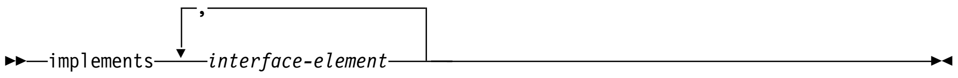
Usage notes

- A complex expression must be enclosed in parentheses.
- ANSI/ISO rules govern where a host expression can appear in a static SQL statement.
- The string __sJT_ is a reserved prefix for variable names that are generated by SQLJ. Do not begin the following types of names with __sJT_:
  – Host expression names
  – Java variable names that are declared in blocks that include executable SQL statements
  – Names of parameters for methods that contain executable SQL statements
  – Names of fields in classes that contain executable SQL statements, or in classes with subclasses or enclosed classes that contain executable SQL statements
- The string _SJ is a reserved suffix for resource files and classes that are generated by SQLJ. Avoid using the string _SJ in class names and input source file names.

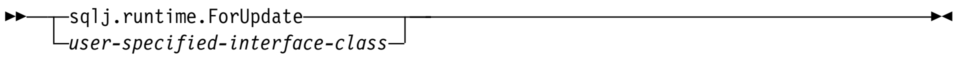
implements-clause

The implements clause derives one or more classes from a Java interface.

Syntax



interface-element:



Description

interface-element

Specifies a user-defined Java interface, or the SQLJ interface `sqlj.runtime.ForUpdate`.

You must implement `sqlj.runtime.ForUpdate` when you declare an iterator for a positioned UPDATE or positioned DELETE operation. See “Using iterators for positioned UPDATE and DELETE operations” on page 26 for information on performing a positioned UPDATE or positioned DELETE operation in SQLJ.

with-clause

The with clause specifies a set of one or more attributes for an iterator or a connection context.

Syntax

```
                 ┌─,──────────────┐
                 ▼                │
>>──with──(──────with-element─────┴──)──────────────────────────────────────><
```

with-element:

```
#  >>───┬─holdability=──┬─true──┬──────────────────┬───────────────────────><
        │               └─false─┘                  │
        ├─returnability=──┬─true──┬────────────────┤
        │                 └─false─┘                │
        │                  ┌─,──────────────┐      │
        │                  ▼                │      │
        ├─updateColumns=─"───column-name────┴──"───┤
        └─Java-ID=Java-constant-expression─────────┘
```

#

Description

holdability
: Specifies whether an iterator keeps its position in a table after a COMMIT is executed. The value for holdability must be true or false.

returnability
: Specifies whether an iterator can return result sets from a stored procedure call. The value for returnability must be true or false.

updateColumns
: Specifies the columns that are to be modified when the iterator is used for a positioned UPDATE statement. The value for updateColumns must be a literal string that contains the column names, separated by commas.

column-name
: Specifies a column of the result table that is to be updated using the iterator.

Java-ID
: Specifies a Java variable that identifies a user-defined attribute of an iterator or connection context. The value of *Java-constant-expression* is also user-defined.

Usage notes

- The value on the left side of a with element must be unique within its with clause.
- For a connection declaration clause, only user-defined attributes (*Java-ID=Java-constant-expression*) can be specified in a with clause.

- If you specify updateColumns in a with element of an iterator declaration clause, the iterator declaration clause must also contain an implements clause that specifies the sqlj.runtime.ForUpdate interface.

connection-declaration-clause

The connection declaration clause declares a connection to a data source in an SQLJ application program.

Syntax

```
►►──┬────────────────┬──context──Java-class-name──┬───────────────────┬──────────►
    └─Java-modifiers─┘                            └─implements-clause─┘

►──┬─────────────┬─────────────────────────────────────────────────────────────►◄
   └─with-clause─┘
```

Description

Java-modifiers
Specifies modifiers that are valid for Java class declarations, such as static, public, private, or protected.

Java-class-name
Specifies a valid Java identifier. During the program preparation process, SQLJ generates a connection context class whose name is this identifier.

implements-clause
See “implements-clause” on page 39 for a description of this clause. In a connection declaration clause, the interface class to which the implements clause refers must be a user-defined interface class.

with-clause
See “with-clause” on page 40 for a description of this clause. In a connection declaration clause, all attributes in a with clause must be user defined.

Usage notes

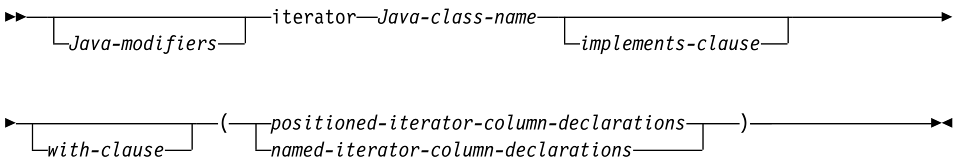
- SQLJ generates a connection class declaration for each connection declaration clause you specify. SQLJ data source connections are objects of those generated connection classes.
- You can specify a connection declaration clause anywhere that a Java class definition can appear in a Java program.

iterator-declaration-clause

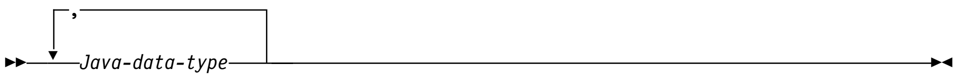
An iterator declaration clause declares a positioned iterator class or a named iterator class in an SQLJ application program. An iterator contains the result table from a query. SQLJ generates an iterator class for each iterator declaration clause you specify. An iterator is an object of an iterator class.

An iterator declaration clause has a form for a positioned iterator and a form for a named iterator. The two kinds of iterators are distinct and incompatible Java types that are implemented with different interfaces. See “Using result set iterators to retrieve rows from a result table” on page 22 for information on how to use each type of iterator.

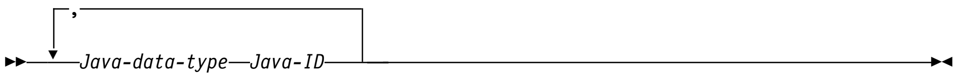
Syntax


Java-modifiers
iterator
Java-class-name
implements-clause
with-clause
(
positioned-iterator-column-declarations
named-iterator-column-declarations
)

positioned-iterator-column declarations:



named-iterator-column-declarations:



Description

Java-modifiers
Any modifiers that are valid for Java class declarations, such as static, public, private, or protected.

Java-class-name
Any valid Java identifier. During the program preparation process, SQLJ generates an iterator class whose name is this identifier.

implements-clause
See “implements-clause” on page 39 for a description of this clause. For an iterator

declaration clause that declares an iterator for a positioned UPDATE or positioned DELETE operation, the implements clause must specify interface `sqlj.runtime.ForUpdate`.

with-clause
See “with-clause” on page 40 for a description of this clause.

positioned-iterator-column-declarations
Specifies a list of Java data types, which are the data types of the columns in the positioned iterator. The data types in the list must be separated by commas. The order of the data types in the positioned iterator declaration is the same as the order of the columns in the result table. The data types of the columns in the iterator must be compatible with the data types of the columns in the result table. See Table 1 on page 23 for a list of compatible data types. A positioned iterator can be used only for FETCH statements.

named-iterator-column-declarations
Specifies a list of Java data types and Java identifiers, which are the data types and names of the columns in the named iterator. Pairs of data types and names must be separated by commas. The name of a column in the iterator must match, except for case, the name of a column in the result table. The data types of the columns in the iterator must be compatible with the data types of the columns in the result table. See Table 1 on page 23 for a list of compatible data types. A named iterator cannot be used for a FETCH statement.

Usage notes

- An iterator declaration clause can appear anywhere in a Java program that a Java class declaration can appear.
- When a named iterator declaration contains more than one pair of Java data types and Java IDs, all Java IDs within the list must be unique.

executable-clause

An executable clause contains an SQL statement or an assignment statement. An assignment statement assigns the result of an SQL operation to a Java variable.

This section first describes the executable clause in general. The next two sections describe each of the components of an executable clause.

Syntax

```
►►──┬────────────────┬──┬─statement-clause──┬──────────────────────►◄
    └─context-clause─┘  └─assignment-clause─┘
```

Usage notes

- An executable clause can appear anywhere in a Java program that a Java statement can appear.
- SQLJ reports negative SQL codes from executable clauses through class `java.sql.SQLException`.

  If SQLJ raises a run-time exception during the execution of an executable clause, the value of any host expression of type OUT or INOUT is undefined.

context-clause

A context clause specifies a connection context or an execution context. You use a connection context to connect to a data source. You use an execution context to monitor and modify SQL statement execution. See “Connecting to a data source” on page 20 for information on using a connection context. See “Controlling the execution of SQL statements” on page 30 for information on using an execution context.

Syntax

```
►►──[──┬─connection-context──────────────────────┬──]──────────────►◄
       ├─execution-context───────────────────────┤
       └─connection-context──,──execution context─┘
```

Description

connection-context
Specifies a valid Java identifier that is declared earlier in the SQLJ program. That identifier must be declared as an instance of the connection context class that SQLJ generates for a connection declaration clause.

execution-context
Specifies a valid Java identifier that is declared earlier in the SQLJ program. That identifier must be declared as an instance of class `sqlj.runtime.ExecutionContext`.

Usage notes

- If you do not specify a connection context in an executable clause, SQLJ uses the default connection context.
- If you do not specify an execution context, SQLJ obtains the execution context from the connection context of the statement.

statement-clause

A statement clause contains an SQL statement or a SET TRANSACTION clause. All SQL statements are described in Chapter 6 of *SQL Reference*. The SET TRANSACTION clause is described in “SET-TRANSACTION-clause” on page 49.

Syntax

```
►►──{──┬─SQL-statement──────────┬──}──────────────────────────────────────────►◄
       └─SET-TRANSACTION-clause─┘
```

Description

SQL-statement
You can include the statements in Table 3 in a statement clause.

SET-TRANSACTION-clause
Sets the isolation level for SQL statements in the program and the access mode for the connection. The SET TRANSACTION clause is equivalent to the SET TRANSACTION statement, which is described in the ANSI/ISO SQL standard of 1992 and is supported in some implementations of SQL. See “SET-TRANSACTION-clause” on page 49 for more information.

Table 3. Valid SQL statements in an SQLJ statement clause

ALTER DATABASE
ALTER INDEX
ALTER STOGROUP
ALTER TABLE
ALTER TABLESPACE
CALL
COMMIT
CREATE ALIAS
CREATE DATABASE
CREATE GLOBAL TEMPORARY TABLE
CREATE INDEX
CREATE STOGROUP
CREATE SYNONYM
CREATE TABLE
CREATE TABLESPACE
CREATE VIEW
DELETE
DROP ALIAS

Table 3. *Valid SQL statements in an SQLJ statement clause (continued)*

DROP DATABASE
DROP INDEX
DROP PACKAGE
DROP STOGROUP
DROP SYNONYM
DROP TABLE
DROP TABLESPACE
DROP VIEW
EXPLAIN
FETCH
GRANT
INSERT
LOCK TABLE
RENAME
REVOKE
ROLLBACK
SELECT
SET CURRENT DEGREE
SET CURRENT LOCALE LC_CTYPE
SET CURRENT PRECISION
SET CURRENT RULES
SET CURRENT SQLID
UPDATE

Usage notes

- SQLJ supports both positioned and searched DELETE and UPDATE operations.
- For a FETCH statement, a positioned DELETE statement, or a positioned UPDATE statement, you must use an iterator to obtain rows from a result table. See “Using result set iterators to retrieve rows from a result table” on page 22 for more information on iterators.

assignment-clause

The assignment clause assigns the result table from a SELECT statement to an iterator.

Syntax

```
►►──Java-ID=──{──┬─subselect────────────────┬──}──────────────────────►◄
                 └─iterator-conversion-clause─┘
```

Description

Java-ID
Identifies an iterator that was declared previously as an instance of an iterator class.

subselect
Generates a result table. The syntax of the subselect is defined in Chapter 5 of *SQL Reference*.

iterator-conversion-clause
See “iterator-conversion-clause” for a description of this clause.

Usage notes

- If the iterator is a positioned iterator, the number of columns in the result set must match the number of columns in the iterator. In addition, the data type of each column in the result set must match the data type of the corresponding column in the iterator.
- If the iterator is a named iterator, the name of each accessor method must match the name of a column in the result set. In addition, the data type of the object that an accessor method returns must match the data type of the corresponding column in the result set.
- You can put an assignment clause anywhere in a Java program that a Java assignment statement can appear. However, you cannot put an assignment clause where a Java assignment expression can appear. For example, you cannot specify an assignment clause in the control list of a for statement.

iterator-conversion-clause

The iterator conversion clause converts a JDBC result set to an iterator.

Syntax

```
►►──CAST──host-expression──────────────────────────────────────────►◄
```

Description

host-expression
Identifies the JDBC result set that is to be converted to an SQLJ iterator.

Usage notes

- If the iterator is a positioned iterator, the number of columns in the result set must match the number of columns in the iterator. In addition, the data type of each column in the result set must match the data type of the corresponding column in the iterator.
- If the iterator is a named iterator, the name of each accessor method must match the name of a column in the result set. In addition, the data type of the object that an accessor method returns must match the data type of the corresponding column in the result set.
- When an iterator that is generated through the iterator conversion clause is closed, the result set from which the iterator is generated is also closed.

SET-TRANSACTION-clause

The SET TRANSACTION clause performs one of the following functions:

- Sets the isolation level for the current unit of work. For a detailed discussion of isolation levels, see Section 5 (Volume 2) of *Administration Guide*.
- Sets or disables read-only mode for a connection.

Syntax

```
►►──SET TRANSACTION──┬─ISOLATION LEVEL──┬─READ COMMITTED───┬─┬──────────────────────►◄
                     │                  ├─READ UNCOMMITTED─┤ │
                     │                  ├─REPEATABLE READ──┤ │
                     │                  └─SERIALIZABLE─────┘ │
                     ├─READ ONLY─────────────────────────────┤
                     └─READ WRITE────────────────────────────┘
```

Description

ISOLATION LEVEL
: Specifies one of the following DB2 for OS/390 isolation levels:

  READ COMMITTED
  : Specifies that the current DB2 isolation level is cursor stability.

  READ UNCOMMITTED
  : Specifies that the current DB2 isolation level is uncommitted read.

  REPEATABLE READ
  : Specifies that the current DB2 isolation level is read stability.

  SERIALIZABLE
  : Specifies that the current DB2 isolation level is repeatable read.

READ ONLY
: Set the connection object to read-only mode. Executing `SET TRANSACTION READ ONLY;` is equivalent to invoking the JDBC method `*connection*.setReadOnly(true);`.

READ WRITE
: Set the connection object to read-write mode. Executing `SET TRANSACTION READ WRITE;` is equivalent to invoking the JDBC method `*connection*.setReadOnly(false);`.

Usage notes

You can execute SET TRANSACTION only at the beginning of a transaction.

Chapter 5. Creating Java stored procedures

A stored procedure is a program that can contain SQL statements and is called by a client program using the SQL CALL statement. A Java stored procedure is a Java program that has the following additional characteristics:

- The SQL statements are in SQLJ clauses or JDBC method invocations, or both.
- The stored procedure is a compiled Java program.

  The program preparation process converts the Java bytecodes into Java program objects that can run in the DB2 environment. Those Java program objects reside in an OS/390 PDSE.

This chapter contains information that is specific to defining and writing Java stored procedures. For general information on stored procedures, see Section 6 of *Application Programming and SQL Guide*. For information on preparing Java stored procedures for execution, see “Preparing compiled Java stored procedures for execution” on page 65.

This chapter covers the following topics:
- “Defining your Java stored procedure to DB2”
- “Writing a Java stored procedure” on page 53
- “Running a stored procedure” on page 55
- “Testing a Java stored procedure” on page 58

Defining your Java stored procedure to DB2

Before a stored procedure can run, you must define it to DB2. To do that, insert a row into catalog table SYSIBM.SYSPROCEDURES. To alter the definition, update the SYSIBM.SYSPROCEDURES row.

A Java stored procedure definition is much like the definition for any other stored procedure. However, the following SYSIBM.SYSPROCEDURES columns have different meanings for Java stored procedures.

LOADMOD
: Specifies the program that runs when the procedure name is specified in a CALL statement.

  For a Java stored procedure, this column is not used.

LANGUAGE
: Specifies the application programming language in which the stored procedure is written.

  For a compiled Java stored procedure, the value of this column is COMPJAVA.

LINKAGE
: Identifies the linkage convention that is used to pass parameters to the stored procedure.

  For a Java stored procedure, the only value that is valid is N, which indicates the SIMPLE WITH NULLS linkage convention.

#
WLM_ENV
Identifies the MVS workload manager (WLM) environment in which the stored procedure is to run when the DB2 stored procedure address space is WLM-established.

A Java stored procedure must run in a WLM-established address space, so the value of this column must not be blank.

PGM_TYPE
Specifies whether the stored procedure runs as a main routine or a subroutine.

This parameter value must be S, which indicates that the program runs as a subroutine. However, you can write a Java stored procedure as a main method.

RUNOPTS
For a compiled Java stored procedure, specifies the name of the Java executable code for the stored procedure, in the format *class-name.method-name*.

If the class is defined in a package, the format is *package-name.class-name.method-name*.

For information on using the hpj command to prepare a Java stored procedure for execution, see “Preparing compiled Java stored procedures for execution” on page 65.

EXTERNAL_SECURITY
Indicates whether DB2 establishes a RACF environment when the stored procedure is called. The values of the EXTERNAL_SECURITY column are the same for a Java stored procedure as for any other stored procedure. However, the value of the EXTERNAL_SECURITY column determines the authorization ID that must have authority to access to OS/390 UNIX System Services. The values of EXTERNAL_SECURITY, and the IDs that must have access to OS/390 UNIX System Services are:

N The user ID that is defined for the stored procedures address space in the RACF started-procedure table.

Y The invoker of the stored procedure.

For a complete explanation of the parameters in a SYSIBM.SYSPROCEDURES, see Section 6 of *Application Programming and SQL Guide*.

Example: Defining a Java stored procedure: Suppose that you have written and prepared a stored procedure that has these characteristics:

Procedure name	S1SAL
Parameters	DECIMAL(10,2) INOUT
Language	Compiled Java
Collection ID for the stored procedure package	DSNJDBC
Java executable name	s1.s1Sal.getSals
WLM environment name	WLMENV1
Maximum number of result sets returned	1

This INSERT statement defines the stored procedure to DB2:

```
INSERT INTO  SYSIBM.SYSPROCEDURES
      (PROCEDURE, AUTHID, LUNAME, LOADMOD, LINKAGE, COLLID,
       LANGUAGE, ASUTIME, STAYRESIDENT, IBMREQD, RUNOPTS,
       PARMLIST,RESULT_SETS,WLM_ENV,
       PGM_TYPE,EXTERNAL_SECURITY,COMMIT_ON_RETURN)
VALUES('S1SAL', ' ', ' ', 'S1SAL', 'N', 'DSNJDBC',
       'COMPJAVA', 0, ' ', 'N', 's1.s1Sal.getSals',
'DECIMAL(10,2) INOUT', 1, 'WLMENV1',
       'S', 'N', 'N');
```

Example: Altering a stored procedure definition: Suppose that you have made the following modifications to stored procedure S1SAL:

Java executable name	s2.s1Sal.getSals
Maximum number of result sets returned	3

This UPDATE statement makes the changes to the definition of S1SAL:

```
UPDATE SYSIBM.SYSPROCEDURES
 SET RUNOPTS='s2.s1Sal.getSals', RESULT_SETS=3
 WHERE PROCEDURE='GETSAL' AND AUTHID=' ' AND LUNAME=' ';
```

Writing a Java stored procedure

A Java stored procedure is a JDBC or SQLJ application program that runs in a stored procedures address space. A Java stored procedure is much like any other Java program and follows the same rules as stored procedures in other languages. It receives input parameters, executes Java statements, optionally executes SQLJ clauses, JDBC methods, or a combination of both, and returns output parameters.

Differences between Java stored procedures and Java programs

A Java stored procedure differs from a Java program in the following ways:

- A Java stored procedure does not establish its own connection to the local data source. Instead, the stored procedure uses the default RRS connection to the data source that processes the CALL statement. If you want to execute SQLJ clauses or JDBC methods at another location, use the same methods to connect to those locations as you do in SQLJ or JDBC application programs.
- A Java stored procedure must be declared as static and public.
- As in other stored procedures, you cannot include the following SQL statements in a Java stored procedure:
  - CALL
  - COMMIT
  - CONNECT
  - RELEASE
  - SET CONNECTION
  - SET CURRENT SQLID

Differences between Java stored procedures and other stored procedures

A Java stored procedure differs from stored procedures that are written in other languages in the following ways:

- A Java stored procedure must use the SIMPLE WITH NULLS linkage convention. You can pass null values in parameters with corresponding Java variables that permit nulls. However, you cannot pass nulls in parameters that correspond to Java native types, which cannot be assigned null values.
- Java main programs must have a signature of String array. If your Java stored procedure is a main program, it must be possible to map all the parameters to Java variables of type java.lang.String.
- You cannot make IFI calls in Java stored procedures.
- Specifying the `with returnability` clause in an SQLJ iterator declaration clause, which is the equivalent of specifying the WITH RETURN clause on the DECLARE CURSOR statement in other languages, is not enough to cause result sets to be returned from a stored procedure. See “Writing a Java stored procedure to return result sets” for information on how to cause a stored procedure to return result sets.
- The mappings between data types for stored procedure parameters and host data types follow the rules for mappings between SQL and SQLJ data types shown in Table 1 on page 23.

Writing a Java stored procedure to return result sets

Your stored procedure can return multiple query result sets to a DRDA client if the following conditions are satisfied:

- The client supports the DRDA code points used to return query result sets.
- The value of RESULT_SETS in the stored procedure definition is greater than 0.

For each result set you want to be returned, your Java stored procedure must:

- Include an object of type ResultSet in the parameter list for the stored procedure method but *not* in the parameter list of the stored procedure definition.
- Execute a SELECT statement to obtain the contents of the result set.
- Retrieve any rows that you do *not* want to return to the client.
- Assign the contents of the result set to the ResultSet object that is in the parameter list.

DB2 does not return result sets for result sets that are closed before the stored procedure terminates.

Figure 10 on page 55 shows an example of a Java stored procedure that uses an SQLJ iterator to retrieve a result set.

```
    package s1;

    import sqlj.runtime.*;
    import java.sql.*;
    import java.math.*;
1   #sql iterator NameSal(String LastName, BigDecimal Salary);
    public class s1Sal
    {
2     public static void GetSals(BigDecimal[] AvgSalParm, ResultSet[] rs)
        throws SQLException
      {
        NameSal iter1;
        try
        {
3         #sql iter1 = {SELECT LASTNAME, SALARY FROM EMP
            WHERE SALARY>0 ORDER BY SALARY DESC};
4         #sql {SELECT AVG(SALARY) INTO :(AvgSalParm[0]) FROM EMP};
        }
        catch (SQLException e)
        {
          System.out.println("SQLCODE returned: " + e.getErrorCode());
          throw(e);
        }
5       rs[0] = iter1.getResultSet();
      }
    }
```

Figure 10. Java stored procedure that returns a result set

Notes to Figure 10:

1 This SQLJ clause declares the iterator named NameSal, which is used to retrieve the rows that will be returned to the stored procedure caller in a result set.

2 The declaration for the stored procedure method contains declarations for a single passed parameter, followed by the declaration for the result set object.

3 This SQLJ clause executes the SELECT to obtain the rows for the result set, constructs an iterator object that contains those rows, and assigns the iterator object to variable iter1.

4 This SQLJ clause retrieves a value into the parameter that is returned to the stored procedure caller.

5 This statement uses the GetResultSet method to assign the contents of the iterator to the result set that is returned to the caller.

Running a stored procedure

Like other stored procedures, Java stored procedures run under Language Environment and in a stored procedures address space. They are invoked when a client program executes the SQL CALL statement. A Java stored procedure always runs as a subprogram.

Running Java stored procedures requires the Enterprise ToolKit for OS/390 (ET/390), which is part of VisualAge® for Java, Enterprise Edition for OS/390.

The stored procedures address space for Java stored procedures

A Java stored procedure must run in a WLM-established stored procedures address space. The startup procedure for Java stored procedures requires extra DD statements that other stored procedures do not need. Figure 11 shows an example of a startup procedure for an address space in which Java stored procedures can run.

```
  //DSNWLM   PROC RGN=0K,APPLENV=WLMCJAV,DB2SSN=DSN,NUMTCB=1
  //IEFPROC EXEC PGM=DSNX9WLM,REGION=&RGN,TIME=NOLIMIT,
  //        PARM='&DB2SSN,&NUMTCB,&APPLENV'
  //STEPLIB  DD  DISP=SHR,DSN=DSN510.RUNLIB.LOAD
1 //         DD  DISP=SHR,DSN=USER.HPJSP.PDSE
  //         DD  DISP=SHR,DSN=CEE.SCEERUN
  //         DD  DISP=SHR,DSN=DSN510.SDSNEXIT
  //         DD  DISP=SHR,DSN=DSN510.SDSNLOAD
2 //         DD  DISP=SHR,DSN=HPJ.SQLJ,DISP=SHR
3 //         DD  DISP=SHR,DSN=HPJ.SHPJMOD
  //         DD  DISP=SHR,DSN=HPJ.SHPOMOD
  //         DD  DISP=SHR,DSN=VAJAVA.V2R0M0.SHPOMOD
4 //JAVAENV  DD  DISP=SHR,DSN=WLMCJAV.JSPENV
5 //JSPDEBUG DD  SYSOUT=A
  //CEEDUMP  DD  SYSOUT=A
  //SYSPRINT DD  SYSOUT=A
```

Figure 11. Startup procedure for a WLM address space in which DSNTPSMP runs

Notes to Figure 11:

1 This DD statement specifies the PDSE that contains the Java program objects for compiled Java stored procedures.

2 This DD statement specifies the PDSE that contains Java program objects for Java classes that are referenced by the stored procedure.

3 This DD statement and the following DD statement specify the PDSEs that contains the VisualAge for Java compiler and run-time library.

4 JAVAENV specifies a data set that contains environmental variables that specify system properties for the ET/390 Java execution environment. See “Setting environmental variables for Java stored procedures” on page 57 for more information.

5 JSPDEBUG specifies a data set into which DB2 puts information that you can use to debug your stored procedure.

If you specify SYSOUT=A in the JSPDEBUG DD statement, the debug information is written to your SYSOUT data set. If you specify a data set name, you also need to specify the MSGFILE(*ddname*) run-time option in your JAVAENV data set. Specify JSPDEBUG for *ddname* to direct all diagnostic output to the JSPDEBUG data set. If you do not redirect standard output, println statements in your stored procedure program write text to the JSPDEBUG data set.

Setting environmental variables for Java stored procedures

The JAVAENV DD statement in the startup procedure for your Java stored procedures
address space specifies a data set that contains environmental variables for the ET/390
Java execution environment. If the default values are not appropriate, you need to set
the following environmental variables in the JAVAENV data set:

CLASSPATH
Modify CLASSPATH to include the following HFS directories:

• The directories that contain the external links to the compiled java stored
procedures that run in the WLM-established stored procedures address space

• The directory in which the ET/390 links are defined ($IBMHPJ_HOME/lib)

For example:

```
# CLASSPATH=.:/u/sysadm/links:/usr/lpp/hpj/lib
```

LIBPATH and LD_LIBRARY_PATH
Modify LIBPATH and LD_LIBRARY_PATH to include the following HFS directories:

• The path for the ET/390 code ($IBMHPJ_HOME/lib)

• The path for the SQLJ/JDBC driver code, if the stored procedures contain SQL

For example:

```
# LIBPATH=/u/sysadm/links:/usr/lpp/hpj/lib:/u/hpjsp/lib
# LD_LIBRARY_PATH=/u/sysadm/links:/usr/lpp/hpj/lib:/u/hpjsp/lib
```

LANG
Modify LANG to change the locale to use for the locale categories when neither the
LC_ALL environment variable nor the individual locale environment variables
specify locale information. For example:

```
# LANG="En_US.IBM-037"
```

LC_ALL
Modify LC_ALL to change the locale to be used to override any values for locale
categories specified by the settings of the LANG environment variable or any
individual locale environmental variables. For example:

```
# LC_ALL="S370"
```

LC_CTYPE
Modify LC_CTYPE to change the locale for character classification, case
conversion, and other character attributes. This value should match the DB2 for
OS/390 installation default. For example:

```
# LC_CTYPE="En_US.IBM-037"
```

MSGFILE
Specify MSGFILE to direct diagnostic output to a data set other than the SYSOUT
data set. If you specify a data set name in the JSPDEBUG statement, you need to
specify MSGFILE=(JSPDEBUG). The default is
MSGFILE=((SYSOUT,FBA,121,0,NOENQ),OVR).

TZ Modify TZ to change the local timezone. For example:

```
# TZ="PST08"
```

The default is GMT.

This following example shows the contents of a JAVAENV data set.

```
ENVAR("CLASSPATH=.:/u/sysadm/links:/usr/lpp/hpj/lib",
 "TZ=PST08",
 "LIBPATH=/u/sysadm/links:/usr/lpp/hpj/lib:/u/hpjsp/lib",
 "LD_LIBRARY_PATH=/u/sysadm/links:/usr/lpp/hpj/lib:/u/hpjsp/lib"),
 MSGFILE(JSPDEBUG)
```

For information on environmental variables that are related to locales, see *OS/390 C/C++ Programming Guide*.

Testing a Java stored procedure

To help you debug your Java stored procedures, include a JSPDEBUG DD statement in your WLM startup procedure. This DD statement specifies a data set to which DB2 writes debug information as stored procedures execute.

Chapter 6. Preparing Java programs

DB2 for OS/390 Java programs run in the OS/390 OpenEdition environment. These
applications can run in a JVM or under VisualAge for Java. This chapter explains how to prepare SQLJ programs and Java stored procedures. The following topics are discussed:

- “Steps in the SQLJ program preparation process”
- “Preparing compiled Java stored procedures for execution” on page 65
- # “Preparing your applications with VisualAge for Java” on page 67

Steps in the SQLJ program preparation process

After you write an SQLJ application, you must generate an executable form of the application, which involves:

1. Translating the source code to produce modified Java source code and serialized profiles
2. Compiling the modified Java source code to produce Java bytecodes
3. Customizing the serialized profiles to produce DBRMs
4. Binding the DBRMs into packages and binding the packages into a plan, or binding the DBRMs directly into a plan

Figure 12 on page 60 shows the steps of the program preparation process.

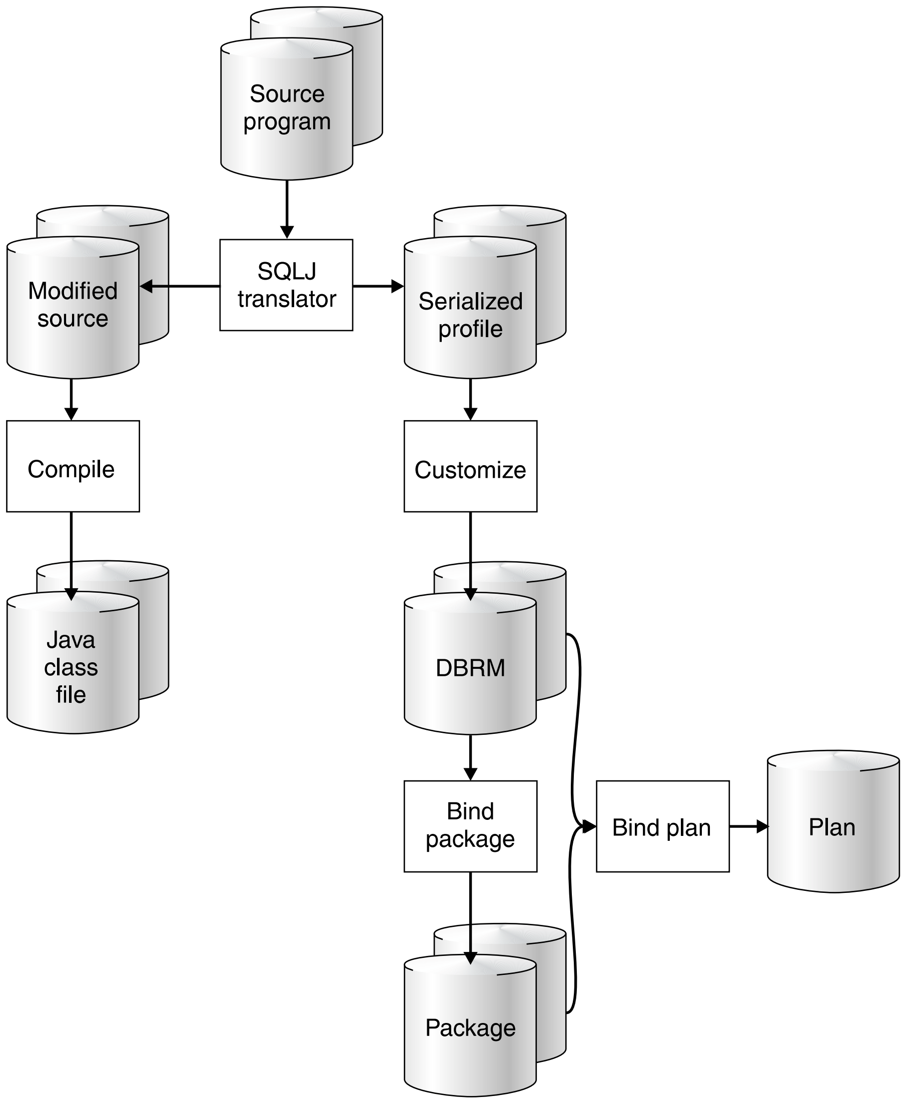


Figure 12. The SQLJ program preparation process

This section discusses each of those steps.

Translating and compiling SQLJ source code

The first steps in preparing an executable SQLJ program are to use the SQLJ translator to generate a Java source program, compile the Java source program, and produce zero or more serialized profiles. Executing the `sqlj` command from the OpenEdition command line invokes the DB2 for OS/390 SQLJ translator. The SQLJ translator runs without connecting to DB2.

Syntax

```
►►──sqlj──┬───────┬──┬─────────────────┬──┬──────────────────────────┬──────────────►
          └─-help─┘  └─-dir=directory──┘  └─-props=properties-file──┘

►──┬─────────────────────────────┬──file-list──────────────────────────────────────►◄
   │          ┌─all─────────┐    │
   └─-warn=───┼─none────────┼────┘
              ├─verbose─────┤
              ├─nonverbose──┤
              ├─portable────┤
              └─nonportable─┘
```

Parameter descriptions

-help
Specifies that the SQLJ translator describes each of the options that the translator supports. If any other options are specified with -help, they are ignored.

-dir=*directory*
Specifies the name of the directory into which SQLJ puts output from the translator. This output consists of Java source files and serialized profile files. The default directory is the current directory.

The translator uses the directory structure of the SQLJ source files when it puts the generated files in directories. For example, suppose that you want the translator to process two files:
- file1.sqlj, which is not in a Java package
- file2.sqlj, which is in Java package sqlj.test

Also suppose that you specify the parameter -dir=/src when you invoke the translator. Then the translator puts the serialized profiles and Java source file for file1.sqlj in directory /src and puts the serialized profiles and Java source file for file2.sqlj in directory /src/sqlj/test.

-props=*properties-file*
Specifies the name of a file from which the SQLJ translator is to obtain a list of options.

-warn=*warning-level*
Specifies the types of messages that the SQLJ translator is to return. The meanings of the warning levels are:

all The translator displays all warnings and informational messages. This is the default.

none
The translator displays no warnings or informational messages.

verbose
The translator displays informational messages about the semantic analysis process.

nonverbose
The translator displays no informational messages about the semantic analysis process.

portable
The translator displays warning messages about the portability of SQLJ clauses.

nonportable
The translator displays no warning messages about the portability of SQLJ clauses.

file-list
Specifies a list of SQLJ source files to be translated. This is a required parameter. All SQLJ source file names must have the extension .sqlj.

Output from the SQLJ translator

For each source file, *program-name*.sqlj, the SQLJ translator produces the following files:

- The modified source program

  The modified source file is named *program-name*.java.
- A serialized profile file for each connection declaration clause in the program, and one serialized profile for the default context, if it is used

  A serialized profile file is named *program-name*_SJProfile*n*.ser, where *n* is 0 for the first serialized profile generated for the program, 1 for the second serialized profile generated, and so on.

  You must run the SQLJ customizer on each serialized profile file to produce a standard DB2 for OS/390 DBRM. See “Customizing a serialized profile” for information on how to customize a serialized profile.

Customizing a serialized profile

After you use the SQLJ translator to generate serialized profiles for an SQLJ program, customize each serialized profile to produce a standard DB2 for OS/390 DBRM and a serialized profile that is customized for DB2 for OS/390. Executing the `db2profc` on the OpenEdition command line customizes a serialized profile. The customizer can run with or without connecting to DB2. Connecting to DB2 provides better mapping of Java data types to DB2 data types.

Syntax

```
►►──db2profc──┬─────────┬──┬────────────┬──┬─────────────────┬──┬─────────────────┬──┬───────────────┬──►
              └─-help───┘  └─-version───┘  │        ┌─ISO─┐  │  │        ┌─ISO─┐  │  │      ┌─ALL─┐  │
                                           └─-date=─┼─USA─┼──┘  └─-time=─┼─USA─┼──┘  └─-sql=─┴─DB2─┴──┘
                                                    ├─EUR─┤              ├─EUR─┤
                                                    └─JIS─┘              └─JIS─┘

►──┬────────────────────────────────────────────────────────────────────────────────────────────────┬──►
   └─-online=location-name──┬──────────────────────────────────────────────────────────────────┬────┘
                            │                             ┌─-inform──=──YES─┐ ┌─-validate=CUSTOMIZE─┐ │
                            └─┬──────────────────────────┬─┴─-inform──=──NO──┴─┴─-validate=RUN───────┴─┘
                              └─-schema=authorization-ID─┘
```

```
►─-pgmname=DBRM-member-name──serialized-profile-name──────────────────────────────►◄
```

Parameter descriptions

-help
Specifies that the SQLJ customizer describes each of the options that the customizer supports. If any other options are specified with -help, they are ignored.

-version
Specifies that the SQLJ customizer returns the version of the SQLJ customizer. If any other options are specified with -version, they are ignored.

-date=ISO|USA|EUR|JIS
Specifies that date values that you retrieve from an SQL table should always be in a particular format, regardless of the format that is specified as the location default. For a description of these formats, see Chapter 3 of *SQL Reference*. The default is `ISO`.

-time=ISO|USA|EUR|JIS
Specifies that time values that you retrieve from an SQL table should always be in a particular format, regardless of the format that is specified as the location default. For a description of these formats, see Chapter 3 of *SQL Reference*. The default is `ISO`.

-sql=ALL|DB2
Indicates whether the source program contains SQL statements other than those that DB2 for OS/390 recognizes.

`ALL`, which is the default, indicates that the SQL statements in the program are not necessarily for DB2 for OS/390. Use `ALL` for application programs whose SQL statements must execute on a server other that DB2 for OS/390.

`DB2` indicates that the SQLJ customizer should interpret SQL statements and check syntax for use by DB2 for OS/390. Use `DB2` when the application server is DB2 for OS/390.

-online=*location-name*
Specifies that the SQLJ customizer does online checking of data types in the SQLJ
program. *location-name* is the location name that corresponds to a DB2 subsystem
to which the SQLJ customizer connects to do online checking. The name of the
DB2 subsystem is specified in the DB2SQLJSSID keyword in the SQLJ run-time
properties file.

Before you can do online checking your SQLJ/JDBC environment must include a
JDBC profile. See “Creating a JDBC profile” on page 82 for information.

Online checking is optional. However, to get the best mapping of Java data types
to DB2 data types, it is recommended that you request online checking.

-schema=*authorization-ID*
Specifies the authorization ID that the SQLJ customizer uses to qualify unqualified
DB2 object names in the SQLJ program during online checking.

-inform=YES|NO
Indicates whether informational messages are generated when online checking is bypassed. The default is YES.

-validate=CUSTOMIZE|RUN
Indicates whether customization terminates when online checking detects errors in the application. CUSTOMIZE causes customization to terminate when online checking detects errors. RUN causes customization to continue when online checking detects errors. RUN should be used if tables that are used by the application do not exist at customization time. The default is CUSTOMIZE.

-pgmname=*DBRM-name*
Specifies the common part of the names for the four DBRMs that the SQLJ customizer generates. *DBRM-name* must be seven or fewer characters in length and must conform to the rules for naming members of MVS partitioned data sets. See “Binding a plan for an SQLJ program” for information on how to bind each of the DBRMs.

serialized-profile-name
Specifies the name of the serialized profile that is to be customized. Serialized profiles are generated by the SQLJ translator and have names of the form

```
program-name_SJProfilen.ser
```

program-name is the name of the SQLJ source program, without the extension .sqlj. *n* is an integer between 0 and *m-1*, where *m* is the number of serialized profiles that the SQLJ translator generated from the SQLJ source program.

Output from the SQLJ customizer

When the SQLJ customizer runs, it creates a DBRM and a modified serialized profile.

Binding a plan for an SQLJ program

After you have customized the serialized profiles for your SQLJ application program, you must bind the DBRMs that are produced by the SQLJ customizer. You can bind the DBRMs directly into a plan or bind the DBRMs into packages and then bind the packages into a plan.

The SQLJ customizer produces four DBRMs, one for each DB2 isolation level with which the application can run. Table 4 shows the name of each DBRM and the isolation level that you need to specify when you bind that DBRM.

Table 4. SQLJ DBRMs and their isolation levels

DBRM name	Bind with isolation level
*DBRM-name*1	Uncommitted read (UR)
*DBRM-name*2	Cursor stability (CS)
*DBRM-name*3	Read stability (RS)
*DBRM-name*4	Repeatable read (RR)

For more information on binding packages and plans, see Chapter 2 of *Command Reference*.

Customizing SQLJ and JDBC to work together

With interoperability established, a Java application can contain both static and dynamic SQL. The application can execute SQLJ clauses and invoke JDBC methods.

Complete the following steps to establish interoperability:

- When you bind a plan for SQLJ, include JDBC packages in the PKLIST of that SQLJ plan. The default names of the JDBC packages are:
  - DSNJDBC.DSNJDBC1
  - DSNJDBC.DSNJDBC2
  - DSNJDBC.DSNJDBC3
  - DSNJDBC.DSNJDBC4
- Make sure that the JDBC profile is accessible in a directory specified in the CLASSPATH environmental variable. “Creating a JDBC profile” on page 82 explains how to create the JDBC profile.

Preparing compiled Java stored procedures for execution

Preparing a compiled Java stored procedure for execution is similar to preparing any other DB2 Java application, except that there is one extra step: You need to use the VisualAge for Java hpj command to convert your stored procedure program to a Java DLL.

This section outlines the program preparation steps for Java stored procedures. See “Steps in the SQLJ program preparation process” on page 59 for information on program preparation steps that are common to all Java programs. See “Preparing your applications with VisualAge for Java” on page 67 for information about preparing programs to run under VisualAge for Java.

Preparing compiled Java stored procedures with no SQLJ statements

If the program contains only JDBC methods or no SQL statements, the program preparation process includes these steps:

1. Compile the Java program using the `javac` command to produce Java bytecodes.
2. Use the VisualAge for Java hpj command to bind the Java bytecode file for the stored procedure and for any packages that are used by the stored procedure into Java DLLs in PDSEs.

Preparing compiled Java stored procedures with SQLJ statements

If the program contains SQLJ clauses, the program preparation process includes these steps:

1. Translate the source code using the `sqlj` command to produce modified Java source code and serialized profiles.
2. Customize the serialized profiles using the `db2profc` command to produce DBRMs.
3. Compile the Java program using the `javac` command to produce Java bytecodes.

4. Use the VisualAge for Java hpj command to bind the Java bytecode file for the stored procedure and for any packages that are used by the stored procedure into Java DLLs in PDSEs.
5. Bind the DBRMs into packages and plans, or directly into plans, using the DB2 `BIND` command.

Using VisualAge for Java to prepare a compiled Java stored procedure

To convert Java bytecodes into a compiled Java program that runs as a stored procedure, you need to execute the hpj command under OS/390 UNIX System Services. You need to specify hpj options that create the Java DLLs in a PDSE and create an external link to the DLLs.

The input to the hpj command needs to include all classes that are used by the stored procedure. Those classes include:

- The class for the stored procedure program
- Generated classes for any iterators that are used by the stored procedure
- Internal classes that are generated by the SQLJ translator

See “Preparing your applications with VisualAge for Java” on page 67 for more information on executing the hpj command.

Example: Create an executable Java stored procedure: Suppose that you have written the Java stored procedure shown in Figure 10 on page 55 and stored the source code in a file named s1sal.sqlj. Prepare the stored procedure for execution.

The steps that you need to perform are:

1. Run the sqlj command to produce Java bytecodes and a serialized profile:
   ```
   sqlj s1/s1Sal.sqlj
   ```
2. Run the db2profc command to produce DBRM S1SAL from serialized profile s1Sal_SJProfile0.ser in path s1:
   ```
   db2profc -pgmname=S1SAL s1/s1Sal_SJProfile0.ser
   ```
3. Run the hpj command to convert the Java bytecodes that were produced by the SQLJ translator into a compiled Java program that runs as a stored procedure. Include the following input files:

   s1/s1Sal
   The class for the stored procedure program

   s1/NameSal
   The generated class for iterator NameSal, which is used by the program

   s1/s1Sal_SJProfileKeys
   An internal class that is generated by the SQLJ translator

   Save the link-edit information in a file called s1.map.

```
hpj -o="//'HPJSP.PDSE1(S1)'" -alias=s1.jll -O  \
-classpath=.:/usr/lpp/hpj/lib/classes.zip -jll -nofollow \
-t=/u/sysadm/links s1/s1Sal s1/NameSal \
s1/s1Sal_SJProfileKeys > s1.map
```

This example uses three options that are useful but not required for compiled Java stored procedures:

-O Specifies that hpj produces optimized code.

-classpath
Overrides the default classpath.

-nofollow
Specifies that referenced classes are not bound into the Java DLL for the stored procedure.

Preparing your applications with VisualAge for Java

If you want to run your JDBC and SQLJ applications as compiled Java applications, you
need to install VisualAge for Java, Enterprise Edition for OS/390 and use the Enterprise
Toolkit for OS/390. This appendix explains how to customize the SQLJ/JDBC driver to
work with VisualAge for Java and how to prepare JDBC and SQLJ applications for
execution under VisualAge for Java. See the documentation that is distributed with
VisualAge for Java and the following web sites for detailed information on how to install
and use VisualAge for Java and how to prepare and run VisualAge for Java programs.

VisualAge for Java web site:
`www.ibm.com/software/ad/vajava`

VisualAge Developer Domain web site:
`www.ibm.com/software/ad/vadd`

Installing and accessing SQLJ/JDBC DLLs for VisualAge for Java support

After you install SQLJ, JDBC, and VisualAge for Java, you need to install two DLLs that
make SQLJ and JDBC work with VisualAge for Java. This section explains how to
install those DLLs and how your applications can access them.

To help you install the DLLs, use the installVAJDLLs script, which is located in the root
installation directory for SQLJ and JDBC support.

Install DLLs that support VisualAge for Java

To make SQLJ and JDBC work with VisualAge for Java, you need the following DLLs:

• DSNAQDLL

This is the native C/C^{++} DLL for VisualAge for Java. The SQLJ/JDBC driver loads
this DLL when an SQLJ or JDBC application is running in a VisualAge for Java
environment.

For SQLJ and JDBC applications that do not support HFS file access, such as CICS
applications, an alias named `libdb2os390vaj.so` is required. The installVAJDLLs
script creates this alias.

For SQLJ and JDBC applications that require HFS file access for DLL resolution, such as compiled Java stored procedures, an external link to the PDSE member that contains DSNAQDLL is required. The installVAJDLLs script also creates this external link.

- DSNAQJLL

  This DLL provides Java run-time classes for the SQLJ/JDBC driver.

  For SQLJ and JDBC applications that do not support HFS file access, such as CICS applications, three aliases for DSNAQJLL are required. Those aliases are named `sqlj.jll`, `ibm/sql.jll`, and `COM/ibm/db2os390/sqlj.jll`. The installVAJDLLs script creates the aliases.

  For SQLJ and JDBC applications that require HFS file access for DLL resolution, such as compiled Java stored procedures, an external link to the PDSE member that contains DSNAQJLL is required. The installVAJDLLs script also creates that external link.

To install the DLLs, follow these steps:

1. Create a PDSE for the DLLs.

   The PDSE needs to have a primary extent of at least 25 cylinders and secondary extents of at least five cylinders of DASD.
2. Customize and run the installVAJDLLs script to install the DLLs in your PDSE. See the prolog of installVAJDLLs for information on how to customize it.

Accessing DLLs for VisualAge for Java support at run time

The way in which you access the DLLs that let SQLJ and JDBC work with VisualAge for Java depends on whether your applications run in the CICS environment.

Accessing the DLLs outside of the CICS environment: For applications that do not run under CICS, you need to make the following modifications to your LIBPATH, STEPLIB, and CLASSPATH concatenations so that the applications can access the DLLs for VisualAge for Java support:

LIBPATH
Include the directory that contains the external link to the DSNAQDLL DLL.

STEPLIB
Include the PDSE that contains the DSNAQDLL and DSNAQJLL DLLs.

CLASSPATH
Include the directory that contains the external link to the DSNAQJLL DLL.

Accessing the DLLs in the CICS environment: For applications that run under CICS, you do not modify the STEPLIB, CLASSPATH, or LIBPATH concatenations. Instead, you perform the following steps:

1. Include the PDSE that contains the DSNAQDLL and DSNAQJLL DLLs in the DFHRPL concatenation.
2. Define the DSNAQDLL and DSNAQJLL DLLs to CICS as as programs. For example, you might use statements like these to define DSNAQDLL and DSNAQJLL to CICS and add them to a CICS group named JDBCSQLJ:

```
DEFINE PROGRAM(DSNAQDLL)
  DESCRIPTION(JDBC AND SQLJ NATIVE RUNTIME)
  EXECKEY(CICS)
  GROUP(JDBCSQLJ)

DEFINE PROGRAM(DSNAQJLL)
  DESCRIPTION(JDBC AND SQLJ JAVA RUNTIME)
  EXECKEY(CICS)
  GROUP(JDBCSQLJ)
```

Accessing SQLJ and JDBC profiles and the run-time properties file under VisualAge for Java

JDBC and SQLJ support includes the JDBC profile and the SQLJ/JDBC run-time properties file, which all of your SQLJ and JDBC applications need to access. In addition, SQLJ applications must access their SQLJ profiles. When you run your applications under VisualAge for Java, you can use one of two techniques to access these files. The technique that you use depends on whether you are using HFS file access:

- Technique 1 (for VisualAge for Java applications that support HFS file access *only*):

  Include the directory that contains the JDBC profile or SQLJ profiles in your CLASSPATH concatenation. Include the directory that contains the run-time properties file in your DB2SQLJPROPERTIES environment variable.
- Technique 2 (for any VisualAge for Java applications):

  Using VisualAge for Java, bind the file as a Java *resource file*. In VisualAge for Java, a resource file is defined as a non-code file that you can refer to from your Java program.

  CICS applications do not support HFS file access, so you must use this technique for CICS applications.

The following sections explain how to bind your profiles and run-time properties file as resource files and how to access those resource files at run time.

Binding the JDBC and SQLJ profiles as VisualAge for Java resource files

You can bind the JDBC and SQLJ profiles as resource files in one of two ways:

- Bind the profile into individual application executables.

  This is the preferred technique for SQLJ profiles because an SQLJ profile is generally associated with a single application.
- Bind the profile into its own Java DLL.

  This is the preferred technique for JDBC profiles because a JDBC profile is generally associated with many or all applications.

  If one profile works with all your applications, you can bind the profile with the SQLJ/JDBC driver.

  If one profile works for some, but not all, applications, you can bind each version of the profile into its own Java DLL, and make each DLL visible to only those applications with which it works.

You can include several instances of a resource file in a single Java DLL. To distinguish between the instances of the resource, you give them different names. At run time, you need to set the appropriate environment variable or run-time properties file parameter to specify the correct resource name. Because CICS VisualAge for Java applications do not use the SQLJ/JDBC environment variables, you cannot rename the SQLJ/JDBC run-time properties file for CICS applications. This means that for CICS applications, you can have only one copy of the SQLJ/JDBC run-time properties file in a Java DLL. For more information on CICS restrictions, see “Appendix B. Special considerations for CICS applications” on page 95.

Follow these steps to bind a profile as a resource file:

1. Use the jar tool to create a Jar file that contains the JDBC profile.

   An example of invoking the jar tool is:

   ```
   jar -Mcv0f jdbcprofile.jar DSNJDBC_JDBCProfile.ser
   ```

   Always specify the -M option when you create a Jar file from a resource file. The -M option prevents the creation of a manifest.
2. Use the hpj command to bind the profile.

   Include the -resource and -t options when you execute the hpj command so that hpj processes the profile as a resource file and creates the appropriate links for it. See “Building an SQLJ or JDBC program under VisualAge for Java” on page 71 for more information on these options.

Accessing a JDBC or SQLJ profile as a resource file at run time

The way in which you access a JDBC or SQLJ profile in VisualAge for Java applications depends on whether the applications run in a CICS environment.

Accessing the profile outside of the CICS environment: For applications that do not run under CICS, you need to make the following modifications to your STEPLIB and CLASSPATH concatenations so that the applications can access the profiles:

STEPLIB
: If the executable or DLL that contains the profile is a PDSE member, include the PDSE that contains the member.

CLASSPATH
: Include the directory that contains the external link to the profile.

Accessing the profile in the CICS environment: For applications that run under CICS, perform the following steps:

1. Include the PDSE that contains the profile in the DFHRPL concatenation.
2. Define the executable or DLL that contains the profile to CICS as a program.

Binding the SQLJ/JDBC run-time properties file as a VisualAge for Java resource file

Follow these steps to bind the run-time properties file as a resource file:

1. Convert the run-time properties file to ASCII.

Use the OS/390 C/C++ `iconv` utility or the OS/390 UNIX System Services `iconv` shell utility to do this. For example, to convert an EBCDIC run-time properties file named db2sqljjdbc.properties.ebcdic to an ASCII file named db2sqljjdbc.properties, execute a command like this:

```
iconv -f ibm-1047 -t utf-8 db2sqljjdbc.properties.ebcdic > db2sqljjdbc.properties
```

2. Create a Jar file that contains the converted run-time properties file.
3. Bind the Jar file into an application executable or into its own DLL.

   Binding the run-time properties file into a DLL is usually the best approach for CICS applications. If all CICS applications that run in the same address space use the same set of properties, those applications can access the same DLL. For Java stored procedures, which might need different run-time properties than the default properties, accessing a DLL that contains the run-time properties file is also most practical.

Accessing the SQLJ/JDBC run-time properties file as a resource file at run time

The way in which you access the SQLJ/JDBC run-time properties file in VisualAge for Java applications depends on whether the applications run in a CICS environment.

Accessing the run-time properties file outside of the CICS environment: For applications that do not run under CICS, you need to make the following modifications to your STEPLIB and CLASSPATH concatenations so that the applications can access the run-time properties file:

STEPLIB
: If the executable or DLL that contains the run-time properties file is a PDSE member, include the PDSE that contains the member.

CLASSPATH
: Include the directory that contains the external link to the run-time properties file.

Accessing the run-time properties file in the CICS environment: For applications that run under CICS, perform the following steps:

1. Include the PDSE that contains the run-time properties file in the DFHRPL concatenation.
2. Define the executable or DLL that contains the run-time properties file to CICS as a program.

Building an SQLJ or JDBC program under VisualAge for Java

With VisualAge for Java, you can prepare an SQLJ or JDBC program for execution as a Java executable or as a Java DLL. In general, you build executables for stand-alone programs. You build Java DLLs when the source code contains either of the following items:
- Supporting class packages for executables
- Compiled Java stored procedures

A Java executable must have at least one class that contains a main method. A Java DLL does not need to contain a main method.

#	Follow these steps to build an SQLJ or JDBC program for execution under VisualAge
#	for Java:

#	1. For an SQLJ program, translate the source code using the `sqlj` command to
#	produce modified Java source code and serialized profiles.
#	2. For an SQLJ program, customize the serialized profiles using the `db2profc`
#	command to produce DBRMs.
#	3. Compile the Java program using the `javac` command to produce Java bytecodes.
#	4. Create Jar files for any Java resource files that you want to bind with the
#	application, such as SQLJ profiles and the JDBC profile.
#	5. Use the VisualAge for Java hpj command to bind the Java bytecode files for the
#	program.
#	6. If the output from the hpj command is a Java DLL in an HFS file, create HFS links
#	for all packages in the DLL.
#	7. For an SQLJ program, use the DB2 BIND command to bind the DBRMs into
#	packages and plans, or directly into plans, using the DB2 `BIND` command.

#	Steps 1, 2, 3, and 7 are common to all Java applications. They are discussed in
#	“Chapter 6. Preparing Java programs” on page 59. “Binding the JDBC and SQLJ
#	profiles as VisualAge for Java resource files” on page 69 discusses step 4. This section
#	discusses steps 5 and 6.

## #	Binding an SQLJ or JDBC program for VisualAge for Java

#	Use the VisualAge for Java hpj command to bind a Java program into a Java
#	executable or DLL. The VisualAge for Java documentation contains a complete
#	explanation of the hpj command. The following options are commonly used for SQLJ
#	and JDBC applications:

#	**-jll** Indicates that the output from the hpj invocation is a Java DLL.

#	**-exe**
#	Indicates that the output from the hpj invocation is a Java executable.

#	**-nofollow**
#	Indicates that hpj should bind the Java executable using *only* the classes that are
#	in the input list. No referenced classes are automatically included.

#	**-resource**
#	Indicates that when hpj binds the Java executable or DLL, it does the following
#	things with Java resource files that it finds in input Jar or zip files:

#	• Binds the resource files into the Java executable or DLL
#	• If the output from the hpj command is a PDSE member, creates aliases for the
#	resource files.

#	**-alias=***alias-name*
#	Indicates that when hpj binds a Java DLL or executable and puts it in a PDSE, hpj
#	creates an alias for the PDSE member. If you also specify the -t option, hpj creates
#	an HFS external link that matches the alias name.

#	You must specify the -alias option when you bind Java DLLs into PDSE members.
#	At run time, VisualAge for Java uses the alias name to find the DLL.

alias-name is the Java package name with a .jll extension. For example, if you build a Java DLL from a package named a.b.c, you specify -alias=a/b/c.jll.

Java DLLs for compiled Java stored procedures and CICS applications must reside in PDSE members. Therefore, you need to use the -alias option when you bind stored procedures and CICS applications.

-o=*output-file-name*
: Specifies the output file name. The format of the file name indicates whether the file is an HFS file or a PDS member name. For an HFS file, specify only the qualified or unqualified file name. For a PDSE member, specify the name in the format "//'*data-set-name(member-name)*'". For example, if you want to create member S1 in data set HPJSP.PDSE1, the -o parameter that you specify is -o="//'HPJSP.PDSE1(S1)'".

-t=*directory-name*
: Creates links that are required to access Java DLLs in PDSEs or to access resource files. hpj creates the links in *directory-name*.

Use the -t option with the -alias option when you create Java DLLs in PDSE members, and the applications that access the DLLs use HFS file access. The links that hpj creates for DLLs in PDSE members are HFS external links.

Use the -t option with the -resource option to create links for resource files. The links that hpj creates are HFS symbolic links if the resources are bound into an HFS file. The links are HFS external links if the resources are bound into a PDSE member.

Before you run an application that uses the links, you need to put *directory-name* in your CLASSPATH concatenation.

Do not use the -t option for CICS applications, which do not use HFS file access.

Use the -t option for compiled Java stored procedures.

Example: Using hpj to create an SQLJ executable: Suppose that you have completed the first three steps in the SQLJ program preparation process, and you want your SQLJ program to run under VisualAge for Java. This example creates an Java application executable that also contains the JDBC profile, the SQLJ profile, and the run-time properties file. The example uses the following data sets:

a.b.c
: The package that contains all classes for the application. The corresponding relative directory structure for the classes is a/b/c.

App1.class
: The application class that contains the main method.

App1Conn.class
: The SQLJ connection context that the application uses.

App1Iter.class
: The SQLJ iterator that the application uses.

App1_SJProfileKeys.class
: An internal class that the SQLJ translator creates.

App1_SJProfile0.ser
The SQLJ profile that the SQLJ translator creates.

DSNJDBC_JDBCProfile.ser
The JDBC profile. This file is not in the same path as the application classes.

db2sqljjdbc.properties.ebcdic
The run-time properties file, in EBCDIC format. This file is not in the same path as the application classes.

The first step that you need to perform is to create the run-time properties file in ASCII format. To do that, execute the `iconv` utility:

```
iconv -f ibm-1047 -t utf-8 db2sqljjdbc.properties.ebcdic > db2sqljjdbc.properties
```

The ASCII run-time properties file is now in file db2sqljjdbc.properties.

Next, run the jar tool to create Jar files for the Java resource files. As is required for VisualAge for Java, specify the -M option so that you do not include a manifest in any of the Jar files.

```
jar -Mcv0f sqljprofile.jar a/b/c/App1_SJProfile0.ser
jar -Mcv0f jdbcprofile.jar DSNJDBC_JDBCProfile.ser
jar -Mcv0f properties.jar  db2sqljjdbc.properties
```

The Jar file for the SQLJ profile needs to be in the HFS directory structure at the same level as the package.

Next, include the directory path that contains a/b/c in your CLASSPATH concatenation. Then you do not need to refer to files by their full path name when you execute the hpj command. For example, suppose that the full path name for App1.class is `/usr/myname/project1/a/b/c/App1.class`. If you put `/usr/myname/project1` in the CLASSPATH, you can refer to `/usr/myname/project1/a/b/c/App1.class` as `a.b.c.App1.class`.

Now you are ready to use the hpj command to create the executable:

```
hpj -o app1.exe -exe -nofollow \
  a.b.c.App1 \
  a.b.c.App1Conn \
  a.b.c.App1Iter \
  a.b.c.App1_SJProfileKeys \
  -resource \
  sqljprofile.jar jdbcprofile.jar properties.jar \
        -t /usr/lpp/db2510/vajlinks
```

The meanings of the parameters in the hpj invocation are:

a.b.c.App1, a.b.c.App1Conn, a.b.c.App1Iter, a.b.c.App1_SJProfileKeys, sqljprofile.jar, jdbcprofile.jar, properties.jar	The input files. Input files can appear anywhere within the command string. In this example, the Jar files are separated from the other input files to emphasize that they are resources.

-exe	Indicates that the output file is a Java executable.
-o app1.exe	Indicates the name and format of the output file. The format of the file name indicates that the output is an HFS file.
-nofollow	Indicates that hpj should bind the Java executable using *only* the classes that are in the input list and the JDK classes.
-resource	Indicates that when hpj binds the Java executable, it binds the three resource files into the executable.
-t /usr/lpp/db2510/vajlinks	Causes hpj to create symbolic links for the three resource files that are included in the DLL. hpj creates the links in the /usr/lpp/db2510/vajlinks directory.

Example: Using hpj to create a Java DLL: Suppose that you have completed the first three steps in the SQLJ program preparation process on each of two Java classes. The classes are bound into two different packages. This example creates a Java DLL that contains those two packages. The example also creates symbolic links for the packages that are in the DLL. The example uses the following data sets:

a.b.c
The package that contains all classes for application App1. The corresponding relative directory structure for the classes is a/b/c.

x.y.z
The package that contains all classes for application App2. The corresponding relative directory structure for the classes is x/y/z.

App1.class
The application class for application App1.

App2.class
The application class for application App2.

App1Conn.class
The SQLJ connection context that the App1 uses.

App2Conn.class
The SQLJ connection context that the App2 uses.

App2Iter.class
The SQLJ iterator that the App1 uses.

App2Iter.class
The SQLJ iterator that App2 uses.

App1_SJProfileKeys.class
An internal class that the SQLJ translator creates for App1.

App2_SJProfileKeys.class
An internal class that the SQLJ translator creates for App2.

App1_SJProfile0.ser
The SQLJ profile that the SQLJ translator creates for App1.

App2_SJProfile0.ser
The SQLJ profile that the SQLJ translator creates for App2.

DSNJDBC_JDBCProfile.ser
The JDBC profile. This file is not in the same path as the application classes.

db2sqljjdbc.properties.ebcdic
The run-time properties file, in EBCDIC format. This file is not in the same path as the application classes.

The first step that you need to perform is to create the run-time properties file in ASCII format. To do that, execute the `iconv` utility:

```
iconv -f ibm-1047 -t utf-8 db2sqljjdbc.properties.ebcdic > db2sqljjdbc.properties
```

The ASCII run-time properties file is now in file db2sqljjdbc.properties.

Next, run the jar tool to create Jar files for the Java resource files. Include both of the SQLJ profiles in the same Jar file. As is required for VisualAge for Java, specify the -M option so that you do not include a manifest in any of the Jar files.

```
jar -Mcv0f sqljprofile.jar a/b/c/App1_SJProfile0.ser x/y/z/App2_SJProfile0.ser
jar -Mcv0f jdbcprofile.jar DSNJDBC_JDBCProfile.ser
jar -Mcv0f properties.jar  db2sqljjdbc.properties
```

Now you are ready to use the hpj command to create the Java DLL:

```
hpj -o allApps.jll -jll -nofollow \
  a.b.c.App1 \
  a.b.c.App1Conn \
  a.b.c.App1Iter \
  a.b.c.App1_SJProfileKeys \
  x.y.z.App2 \
  x.y.z.App2Conn \
  x.y.z.App2Iter \
  x.y.z.App2_SJProfileKeys \
  -resource \
  sqljprofile.jar jdbcprofile.jar properties.jar \
  -t /usr/lpp/db2510/vajlinks
```

The meanings of the parameters in the hpj invocation are:

a.b.c.App1, a.b.c.App1Conn, a.b.c.App1Iter, a.b.c.App1_SJProfileKeys, x.y.z.App2, x.y.z.App2Conn, x.y.z.App2Iter, x.y.z.App2_SJProfileKeys, sqljprofile.jar, jdbcprofile.jar, properties.jar	The input files. Input files can appear anywhere within the command string. In this example, the Jar files are separated from the other input files to emphasize that they are resources.
-jll	Indicates that the output file is a Java DLL.
-o allApps.jll	Indicates the name and format of the output file. The format of the file name indicates that the output is an HFS file.
-nofollow	Indicates that hpj should bind the Java executable using *only* the classes that are in the input list and the JDK classes.

-resource	Indicates that when hpj binds the Java DLL, it binds the four resource files into the DLL.
-t /usr/lpp/db2510/vajlinks	Causes hpj to create symbolic links for the four resource files that are included in the DLL. hpj creates the links in the /usr/lpp/db2510/vajlinks directory.

Creating symbolic links for packages in a Java DLL

When an application that runs under VisualAge for Java references a class that is not in the Java DLL or executable that is running, that reference is called a *nonlocal reference.* VisualAge for Java needs to be able to associate a nonlocal reference with a Java DLL. Unless the package that contains the referenced class is in the set of directories that VisualAge for Java searches by default, VisualAge for Java needs a link to find the DLL.

When you bind a Java DLL into a PDSE member, you can specify the -t and -alias options to make hpj automatically create a link between a package name and the PDSE member that contains the DLL. However, if the Java DLL is in an HFS file, you need to create the link between the package name and the HFS file yourself. You use the HFS ln command to create the link.

Example: Creating a symbolic link for a Java DLL: In the previous example, the Java DLL that you create contains two packages: `a.b.c` and `x.y.z`. By default, when VisualAge for Java looks for a method in `a.b.c`, it looks for the method in DLL files with one of these relative path names:

```
a/b/c.jll
a/b.jll
a.jll
```

Similarly, when VisualAge for Java looks for a method in `x.y.z`, it looks for the method in DLL files with one of these relative path names:

```
x/y/z.jll
x/y.jll
x.jll
```

Because the real DLL that contains the packages is called allApps.jll, you need to create symbolic links from at least one of the DLL names that VisualAge for Java looks for to the real DLL name.

Suppose that you created allApps.jll in directory /usr/myname/project1/jlls. Use OS/390 UNIX System Services commands similar to these to create symbolic links from the names a/b/c.jll and x/y/z.jll, where VisualAge for Java looks for methods, to /usr/myname/project1/jlls/allApps.jll, where the methods really are:

```
cd /usr/lpp/db2x10/vajlinks
mkdir a
cd a
mkdir b
cd b
ln -s /usr/myname/project1/jlls/allApps.jll c.jll
cd /usr/lpp/db2x10/vajlinks
```

```
#                 mkdir x
#                 cd x
#                 mkdir y
#                 cd y
#                 ln -s /usr/myname/project1/jlls/allApps.jll z.jll
```

#

Chapter 7. JDBC and SQLJ administration

This chapter contains the following topics about the administration of JDBC and SQLJ:

Installing JDBC and SQLJ

The steps in this section describe the SMP/E jobs you need to edit and run to install DB2 JDBC and SQLJ. Customize these jobs to specify data set names for your DB2 installation and SMP/E data sets. Refer to the header notes in each job and to Section 2 of *Installation Guide* for details.

All steps, except for those noted differently, are for both JDBC and SQLJ installation.

Step 1: Copy and edit the SMP/E jobs

Use this sample JCL to invoke the MVS utility IEBCOPY to copy the SMP/E jobs to DASD.

```
//STEP1    EXEC PGM=IEBCOPY
//SYSPRINT DD SYSOUT=A
//IN       DD DSN=IBM.JDB5512.F2,UNIT=tunit,VOL=SER=DB5512,
//         LABEL=(3,SL),DISP=(OLD,KEEP)
//OUT      DD DSNAME=jcl-library-name,
//         DISP=(NEW,CATLG,DELETE),
//         VOL=SER=dasdvol,UNIT=dunit,
//         DCB=*.STEP1.IN,SPACE=(TRK,(1,1,2))
//SYSUT3   DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSIN    DD *
  COPY INDD=IN,OUTDD=OUT
/*
```

Figure 13. Sample JCL to copy SMP/E jobs to DASD

Define the italicized variables in the JCL as follows:

tunit
The unit value matching the product tape or cartridge.

jcl-library-name
The name of the data set where the sample jobs are to reside.

dasdvol
The volume serial of the DASD device where the data set is to reside.

dunit
The DASD unit type of the volume.

Step 2: Run the allocate job: DSNTJJAE

DSNTJJAE allocates the necessary MVS data sets and creates DDDEF entries in target and distribution libraries.

Optional Step: Allocate HFS data set

If you prefer to install DB2 JDBC and SQLJ in a separate HFS data set, rather than the root file system, use the following sample JCL to allocate an HFS data set:

```
//ALLOCHFS EXEC PGM=IEFBR14
//SYSPRINT DD SYSOUT=*
//*
//* NOTE: THIS HFS DATA SET MUST BE DFSMS MANAGED
//*
//SDSNHFS  DD DSN=db2hlq.SDSNHFS,
//         DISP=(NEW,CATLG,DELETE),
//         VOL=SER=dasdvol,UNIT=dunit,
//         SPACE=(CYL,(5,1,1))
//         DSNTYPE=HFS,STORCLAS=storclas
//*
```

Figure 14. Sample JCL to allocate an HFS data set

Define the italicized variables in the JCL as follows:

db2hlq
The high-level data set qualifier that is used for this DB2.

dasdvol
The volume serial of the DASD device where the data set is to reside.

dunit
The DASD unit type of the volume.

storclas
An appropriate SMS storage class that is defined on your system.

Step 3: Create Hierarchical File System (HFS) structure

Use the TSO MKDIR command to create the DB2 installation directory in your HFS:

```
TSO MKDIR '/usr/lpp/db2' MODE(7 5 5)
```

The spaces in ’MODE(7 5 5)’ are important.

Optional: If you installed DB2 JDBC and SQLJ into a separate HFS data set, mount the new HFS data set created on the DB2 JDBC and SQLJ HFS install mountpoint. The following command must be on one line:

```
TSO MOUNT FILESYSTEM('db2hlq.SDSNHFS') MOUNTPOINT('/usr/lpp/db2') TYPE(HFS)
```

db2hlq is the high-level data set qualifier that is used in the preceding optional step.

After mounting the new HFS data set, you must apply the directory permission bits
again by using the following TSO command:

```
# TSO OSHELL chmod 755 /usr/lpp/db2
```

You can now run the sample REXX exec, DSNISMKD, to create the HFS structure. To
run DSNISMKD, you must have write authority for the DB2 for OS/390 JDBC
installation directory, /usr/lpp/db2.

Step 4: Run the receive Job: DSNTJJRC

DSNTJJRC invokes SMP/E to receive the FMIDs for DB2 JDBC and SQLJ into the SMP/E control data sets.

Step 5: Run the apply job: DSNTJJAP

DSNTJJAP invokes SMP/E to apply the FMIDs for DB2 JDBC and SQLJ to the DB2 target libraries.

Step 6: Run the accept job: DSNTJJAC

DSNTJJAC invokes SMP/E to accept the FMIDs for DB2 JDBC and SQLJ into the DB2 distribution libraries.

Step 7: Run the SQLJ allocate jobs

Follow the instructions in APAR PQ18939 to create DDDEF entries in target libraries and allocate the HFS directories for SQLJ installation.

Step 8: Install SQLJ modules

Receive, apply, and accept APAR PQ19814 to install the modules that constitute DB2 for OS/390 SQLJ.

Customizing the JDBC run-time environment

This section describes the steps required to customize the JDBC runtime environment:

1. Optionally, customize the cursor properties file to identify required JDBC resources.
2. Run the db2genJDBC utility to create a JDBC profile and generate DBRMs.
3. Bind the DBRMs into packages and include those packages in the plan that
supports JDBC and SQLJ.
4. Set environmental variables for JDBC and SQLJ in the run-time properties file,
described in “Configuring JDBC and SQLJ” on page 83.

Customizing the cursor properties file

JDBC result sets require a valid DB2 cursor. You can customize the cursor properties
file to modify the number of DB2 cursors available for JDBC and to control cursor
names. The default cursor properties file defines 125 cursors with hold and 125 cursors
without hold.

For CICS applications, you should not use the default value. See “Appendix B. Special considerations for CICS applications” on page 95 for more information.

To customize the cursor properties file, specify the file in the `-cursors` option of the db2genJDBC utility (described in “Creating a JDBC profile”), and define an entry for each JDBC cursor.

Syntax

```
                                ┌─nohold─┐
►►──cursor=──cursorname─────────┼────────┼─────────────────────────────────────────►◄
                                └─hold───┘
```

Parameter descriptions

cursorname
Specifies the cursor name. This name must be 18 or fewer characters in length.

hold|nohold
Specifes hold attribute for the cursor. If a hold attribute is not specified, the cursor is assigned the `nohold` attribute. The default is `nohold`.

For example:

```
cursor=SAMPLECURSORA:hold
cursor=SAMPLECURSORB:nohold
```

Creating a JDBC profile

To create a JDBC profile, execute the db2genJDBC utility. This profile contains the JDBC program properties used at run-time.

Syntax

```
►►──db2genJDBC──┬─────────────────────────────────┬──┬─────────────────────────────┬──►
                │              ┌─DSNJDBC──────┐   │  │                ┌─150─────┐  │
                └─- pgmname=───┴─program-name─┴───┘  └─- statements=──┴─integer─┴──┘

►──┬──────────────────────────────────────────────┬──┬──────────────────────┬──────►◄
   │            ┌─db2jdbc.cursors────────────┐    │  │          ┌─5───────┐ │
   └─- cursors=─┴─cursor-properties-file─────┴────┘  └─- calls=──┴─integer─┴─┘
```

Parameter descriptions

-pgmname
Specifies the JDBC program name. This name must be seven or fewer characters in length. The default is DSNJDBC.

-statements
: Specifes the number of sections to reserve in the DBRMs for JDBC statements and prepared statements for non-result set processing. The default is 150.

  For CICS applications, you should not use the default value. See “Appendix B. Special considerations for CICS applications” on page 95 for more information.

-cursors
: Specifies the name of the cursor properties file, described in “Customizing the cursor properties file” on page 81. The default is db2jdbc.cursors.

  The cursor properties file must be located in a directory specified in the CLASSPATH environmental variable, described in “Configuring JDBC and SQLJ”.

-calls
: Specifes the number of sections to reserve in the DBRMs for JDBC callable statements for non-result set processing. The default is 5.

Output

The db2genJDBC utility creates four DBRMs and a JDBC serialized profile.

The JDBC profile name is in the following format:

```
program name_JDBCProfile.ser
```

Binding the DBRMs

After you create the serialized profile for your JDBC program, you must bind the DBRMs into packages and include them in the plan that the SQLJ application accesses at run time. This step is necessary for SQLJ applications to interoperate with JDBC. There is one DBRM for each transaction isolation level. The DBRM names and isolation levels are as follows:

- *program-name1*: Bind with transaction isolation level = UR
- *program-name2*: Bind with transaction isolation level = CS
- *program-name3*: Bind with transaction isolation level = RS
- *program-name4*: Bind with transaction isolation level = RR

For more information about SQLJ and JDBC interoperability, see “Customizing SQLJ and JDBC to work together” on page 65. For information on binding packages and plans, see Chapter 2 of *Command Reference*.

Configuring JDBC and SQLJ

After you install JDBC and SQLJ, and before you prepare and run JDBC and SQLJ programs, you need to provide information about your environment. You do that by setting environmental variables and by specifying parameters in a file called the *SQLJ run-time properties file.*

For the CICS environment, the settings for some of the environmental variables and run-time properties parameters are different than for other environments. See “Appendix B. Special considerations for CICS applications” on page 95 for information that is specific to CICS.

Environmental variables

The environmental variables that you must set are:

STEPLIB

Modify STEPLIB to include the SDSNEXIT and SDSNLOAD data sets. For example:

```
export STEPLIB=DSN510.SDSNEXIT:DSN510.SDSNLOAD:$STEPLIB
```

PATH

Modify PATH to include the directory that contains the shell scripts that invoke JDBC and SQLJ program preparation and debugging functions. If JDBC and SQLJ are installed in `/usr/lpp/db2`, modify PATH as follows:

```
export PATH=/usr/lpp/db2/db2510/bin:$PATH
```

LIBPATH and LD_LIBRARY_PATH

The DB2 for OS/390 SQLJ/JDBC driver contains several dynamic load libraries (DLLs).

Modify LIBPATH and LD_LIBRARY_PATH to include the directory that contains those DLLs. If SQLJ and JDBC are installed in `/usr/lpp/db2`, modify LIBPATH and LD_LIBRARY_PATH, respectively, as follows:

```
export LIBPATH=/usr:/usr/lib:/usr/lpp/db2/db2510/lib:$LIBPATH
export LD_LIBRARY_PATH=/usr/lpp/db2/db2510/lib:$LD_LIBRARY_PATH
```

CLASSPATH

Modify CLASSPATH to include one of the following class files:

`db2sqljclasses.zip`

Contains all of the classes necessary to prepare and run JDBC and SQLJ programs. Assuming that JDBC and SQLJ are installed in `/usr/lpp/db2`, modify CLASSPATH as follows:

```
export CLASSPATH=/usr/lpp/db2/db2510/classes/db2sqljclasses.zip:$CLASSPATH
```

`db2sqljruntime.zip`

Contains only the classes that are needed to run JDBC and SQLJ programs. This file is smaller than the `db2sqljclasses.zip` file, which contains files for program preparation and execution. Specify this class file only if you do not plan to prepare SQLJ programs on your system. Assuming that JDBC and SQLJ are installed in `/usr/lpp/db2`, modify CLASSPATH as follows:

```
export CLASSPATH=/usr/lpp/db2/db2510/classes/db2sqljruntime.zip:$CLASSPATH
```

`db2jdbcclasses.zip`

The `db2jdbcclasses.zip` file is provided to maintain compatibility with existing DB2 for OS/390 JDBC applications. The contents of `db2jdbcclasses.zip` are equivalent to the contents of `db2sqljruntime.zip`

DB2SQLJPROPERTIES

Specifies the fully-qualified name of the run-time properties file for the DB2 for OS/390 SQLJ/JDBC driver. The run-time properties file contains various entries of the form *parameter=value* that specify program preparation and run-time options that the DB2 for OS/390 SQLJ/JDBC driver uses. The run-time properties file is

read when the driver is loaded. If you do not set the DB2SQLJPROPERTIES
environmental variable, the DB2 for OS/390 SQLJ/JDBC driver uses the default
name `./db2sqljjdbc.properties`.

For example, to use a run-time properties file named `db2sqljjdbc.properties` that
is in the `/usr/lpp/db2/db2610/classes` directory, specify:

```
# export DB2SQLJPROPERTIES=/usr/lpp/db2/db2610/classes/db2sqljjdbc.properties
```

If you use Java stored procedures, you need to set additional environmental variables
in a JAVAENV data set. See “Setting environmental variables for Java stored
procedures” on page 57 for more information.

Parameters in the SQLJ/JDBC run-time properties file

The parameters that you can set in the run-time properties file for the DB2 for OS/390
SQLJ/JDBC driver are:

DB2SQLJDBRMLIB
Specifies the fully-qualified name of the MVS partitioned data set into which
DBRMs are placed. DBRMs are generated by the creation of a JDBC profile and
the customization step of the SQLJ program preparation process. For example:

```
# DB2SQLJDBRMLIB=USER.DBRMLIB.DATA
```

The default DBRM data set name is *prefix*.DBRMLIB.DATA, where *prefix* is the
high-level qualifier that was specified in the TSO profile for the user. *prefix* is
usually the user's TSO user ID.

See “Creating a JDBC profile” on page 82 and “Customizing a serialized profile” on
page 62 for more information on serialized profile customization.

DB2SQLJPLANNAME
Specifies the name of the plan that is associated with a JDBC or an SQLJ
application. The plan is created by the DB2 for OS/390 bind process. For example:

```
# DB2SQLJPLANNAME=SQLJPLAN
```

The default name is DSNJDBC.

DB2SQLJJDBCPROGRAM
Specifies the name of a JDBC connected profile that is used by the DB2 for
OS/390 SQLJ/JDBC driver. For example:

```
# DB2SQLJJDBCPROGRAM=CONNPROF
```

The default connected profile name is DSNJDBC.

See “Creating a JDBC profile” on page 82 for information on creating a JDBC
connected profile.

DB2SQLJSSID
Specifies the name of the DB2 subsystem to which a JDBC or an SQLJ application
connects. For example:

```
# DB2SQLJSSID=DSN
```

The default is the subsystem name that was specified during installation of the local DB2 subsystem.

DB2SQLJATTACHTYPE
Specifies the attachment facility that a JDBC or an SQLJ application program uses to connect to DB2. The value can be CAF or RRSAF. For example:

```
DB2SQLJATTACHTYPE=RRSAF
```

The default is RRSAF.

DB2SQLJMULTICONTEXT
Specifies whether each connection in an application is independent of other connections in the application, and each connection is a separate unit of work, with its own commit scope. The value can be YES or NO. For example:

```
DB2SQLJMULTICONTEXT=NO
```

The default is YES.

For DB2SQLJMULTICONTEXT=YES to be in effect, the following conditions must be met:
- The OS/390 system is OS/390 Version 2 Release 5 or later.
- The value of parameter DB2SQLJATTACHTYPE is RRSAF.

If these conditions are not met, SQLJ operates as if DB2SQLJMULTICONTEXT=NO.

See “JDBC and SQLJ multiple OS/390 context support” on page 88 for more information on multiple OS/390 context support.

DB2CURSORHOLD
For JDBC, specifies the effect of a commit operation on open DB2 cursors (ResultSets). The value can be YES or NO. A value of YES means that cursors are not destroyed when the transaction is committed. A value of NO means that cursors are destroyed when the transaction is committed. For example:

```
DB2CURSORHOLD=NO
```

The default is YES.

This parameter does not affect cursors in a transaction that is rolled back. All cursors are destroyed when a transaction is rolled back.

DB2SQLJ_TRACE_FILENAME
Enables the SQLJ/JDBC trace and specifies the names of the trace files to which the trace is written. This parameter is required for collecting trace data. For example, specifying the following setting for DB2SQLJ_TRACE_FILENAME enables the SQLJ/JDBC trace to two files named /tmp/jdbctrace and /tmp/jdbctrace.JTRACE:

```
DB2SQLJ_TRACE_FILENAME=/tmp/jdbctrace
```

See “Formatting trace data” on page 35 for more information on the SQLJ/JDBC trace.

#	**DB2SQLJ_TRACE_BUFFERSIZE**
#	Specifies the size of the trace buffer in virtual storage in kilobytes. SQLJ rounds the
#	number that you specify down to a multiple of 64 KB. The default is 256 KB. This is
#	an optional parameter. For example:

```
DB2SQLJ_TRACE_BUFFERSIZE=1024
```

#	**DB2SQLJ_TRACE_WRAP**
#	Enables or disables wrapping of the SQLJ trace. DB2J_TRACE_WRAP can have
#	one of the following values:

# **1**	Wrap the trace
# **0**	Do not wrap the trace

#	The default is 1. This parameter is optional. For example:

```
DB2SQLJ_TRACE_WRAP=0
```

#	You should set the parameters for diagnostic traces (`DB2SQLJ_TRACE_FILENAME`, `DB2SQLJ_TRACE_BUFFERSIZE`, and `DB2SQLJ_TRACE_WRAP`) only under the direction of your IBM service representative. See "Formatting trace data" on page 35 for information on formatting trace data.

JDBC and SQLJ security model

This section describes the JDBC and SQLJ security model. It explains how authorization IDs are determined and the use of attachment facilities.

How are authorization IDs established?

An important difference between JDBC and SQLJ on OS/390 and on other operating systems is the manner in which the database authorization ID is determined.

On operating systems other than OS/390, the user ID and password that are passed as parameters on the `java.sql.Connection` constructor determine the authorization ID that the database uses.

In contrast, the security environment created by the OS/390 Security Server (RACF
#	ACEE) determines the DB2 for OS/390 authorization ID that is used for a thread. A user
#	ID and password is not specified for an SQLJ connection context or a JDBC
#	connection.

It is important to note that DB2 does not create the security environment. The application or server that provides the point of entry into the OS/390 system (i.e. TSO logon, Telnet logon, Web Server, etc.) typically creates the security environment.

DB2 attachment types

The security environment (the RACF ACEE) that DB2 uses to establish the DB2 authorization IDs is dependent on which DB2 attachment type you use. JDBC and SQLJ use a DB2 attachment facility to communicate with DB2. They use the call attachment facility (CAF), the RRS attachment facility (RRSAF), or the CICS attachment facility.

All attachment types support multithreading, that is, multiple, concurrent threads (TCBs) that execute within a single process (address space). In a multithreading environment, each process and thread can have its own unique security environment. The DB2 attachment facility that you select determines which security environment DB2 uses to verify the DB2 authorization IDs.

See "Appendix B. Special considerations for CICS applications" on page 95 for
information on using the CICS attachment facility.

Using the call attachment facility

The DB2 call attachment facility (CAF) supports multithreading, single authorization ID applications. As such, the DB2 CAF always uses the process (address space) level security environment, even if a thread level security environment is present. Therefore, all threads that run within a single process are execute using the same DB2 authorization ID.

Using the RRS attachment facility

In contrast to the DB2 call attachment facility, the DB2 RRS attachment facility (RRSAF) supports multithreading, and applications can run under multiple authorization IDs. If you use the RRSAF, DB2 uses a task-level security environment, if present, to establish the DB2 authorization IDs.

JDBC and SQLJ multiple OS/390 context support

An OS/390 context includes the application's logical connection to the data source and the associated internal DB2 connection information that lets the application direct its operations to a data source. For JDBC or SQLJ applications, a context is equivalent to a DB2 thread.

Connecting when multiple OS/390 context support is not enabled

A context is always established when a Java thread creates its first `java.sql.Connection` object. If support for multiple contexts is not enabled, then subsequent `java.sql.Connection` objects created by a Java thread share that single context. Although multiple connections can share a single context, only one connection can have an active transaction at any time. If there is an active transaction on a connection, a COMMIT or ROLLBACK must be issued before the Java thread can use or create another connection object.

Without multiple context support:

- There can be one or more Java threads, any of which can issue JDBC or SQLJ calls.
- # # All `java.sql.Connection` objects must be explicitly closed by the application Java thread that created the connection object.
- # # # # Multiple `java.sql.Connection` objects can be created by a single Java thread if the application uses the connections serially. The application must not create or use a different connection object on the Java thread if the current connection is not on a transaction boundary. Multiple connections cannot create concurrent units of work.

- When more than one connection is opened, those connections are associated with the same DB2 thread. Returning from the current connection to a previous connection might not return you to the DB2 location that the previous connection was originally associated with. Previous connections become associated with the location of the most recently created connection.
- A Java thread can use a `java.sql.Connection` object only when the Java thread creates the `java.sql.Connection` object.
- WebSphere™ Application Server connection pooling using the ″com.ibm.servlet.connmgr″ package is not possible.

Connecting when multiple OS/390 context support is enabled

With multiple OS/390 context support enabled, each `java.sql.Connection` object results in the creation of a unique context (DB2 thread) for that connection. Under this model, a single Java thread (TCB) can have multiple, concurrent connections, each with its own independent transaction. The DB2 JDBC and SQLJ multiple context support requires:

- Use of the DB2 RRSAF attachment facility
- OS/390 Unauthorized Context Services, available in OS/390 Version 2, Release 5 or higher

With multiple OS/390 context support:

- There can be one or more Java threads, any of which can issue JDBC or SQLJ calls.
- The Java threads can create multiple `java.sql.Connection` objects (and derived objects), each of which:
  - Can exist concurrently with other `java.sql.Connection` objects.
  - Has its own transaction scope that is independent from all other `java.sql.Connection`s.
  - Does not need to be on a transaction boundary for a Java thread to create or use different connections.
- The `java.sql.Connection` objects can be shared between Java threads. However, the actions of one Java thread on a given connection object are also visible to all of the Java threads using that connection. Also, the JDBC/SQLJ application is responsible for ensuring proper serialization when sharing connection objects between threads.
- Although it is recommended that all `java.sql.Statement` and `java.sql.Connection` objects be explicitly closed by the application, it is not required.
- WebSphere Application Server connection pooling using the `com.ibm.servlet.connmgr` package is supported for JDBC connections only.

For information about using JDBC connections for SQLJ operations, see “Customizing SQLJ and JDBC to work together” on page 65.

Enabling multiple OS/390 context support

The DB2SQLJMULTICONTEXT parameter in the run-time properties file enables multiple context support. See “Configuring JDBC and SQLJ” on page 83 for information about setting the DB2SQLJMULTICONTEXT parameter.

Multiple context performance

Setting the DB2SQLJMULTICONTEXT parameter to YES enhances SQLJ and JDBC
performance if the operating system is OS/390 Release 6 or higher and OS/390 APAR
OW41492 is applied.

Connection sharing

Connection sharing occurs whenever a Java thread (TCB) attempts to use a `java.sql.Connection` object, or any object derived from a connection, that the Java thread did not create.

One application of connection sharing is for cleanup of connection objects. Under the
Java Virtual Machine (JVM) on OS/390, cleanup of connection objects is usually
performed by a JVM finalizer thread, rather than the Java thread that created the
object.

Connection sharing is supported only in a multiple context environment.

Appendix A. Selected sqlj.runtime classes and interfaces

The `sqlj.runtime` package defines the run-time classes and interfaces that SQLJ uses. This appendix describes:

- Each class of `sqlj.runtime` that contains methods that you can invoke in your SQLJ application programs
- Each of the interfaces that you might need to implement in your SQLJ application programs

sqlj.runtime.ExecutionContext class

The `sqlj.runtime.ExecutionContext` class is defined for execution contexts. You can use an execution context to control the execution of SQL statements. After you declare an execution context and create an instance of that execution context, you can use the following methods.

getMaxFieldSize

Format:

```
public int getMaxFieldSize()
```

Returns the maximum number of bytes that are returned for any character column in queries that use the given execution context. A value of 0 means that the maximum number of bytes is unlimited.

getMaxRows

Format:

```
public int getMaxRows()
```

Returns the maximum number of rows that are returned for any query that uses the given execution context. A value of 0 means that the maximum number of rows is unlimited.

getNextResultSet

Format:

```
#    public ResultSet getNextResultSet()
```

After a stored procedure call, returns a result set from the stored procedure. Each
call to getNextResultSet closes the result set that was retrieved by the previous
call. A value of null means that there are no more result sets to be returned.

getUpdateCount

Format:

```
public abstract int getUpdateCount() throws SQLException
```

Returns the number of rows that were updated by the last SQL operation that was executed using this context.

getWarnings

Format:

```
public SQLWarning getWarnings()
```

Returns the first warning that was reported by the last SQL operation that was executed using this context. Subsequent warnings are chained to the first warning.

Use this method to retrieve positive SQLCODEs.

setMaxFieldSize
Format:

```
public void setMaxFieldSize(int max)
```

Specifies the maximum number of bytes that are returned for any character column in queries that use the given execution context. The default is 0, which means that the maximum number of bytes is unlimited.

setMaxRows
Format:

```
public void setMaxRows(int max)
```

Specifies the maximum number of rows that are returned for any query that uses the given execution context. The default is 0, which means that the maximum number of rows returned is unlimited.

sqlj.runtime.ConnectionContext interface

`sqlj.runtime.ConnectionContext` is an interface that SQLJ implements when you
execute a connection declaration clause and thereby create a connection context class.

Suppose that you declare a connection named Ctx. You can then use the following
methods to determine or change the default context.

getDefaultContext
Format:

```
#     public static Ctx getDefaultContext()
```

Returns the default connection context object for the Ctx class.

SetDefaultContext
Format:

```
#     public static void Ctx setDefaultContext(Ctx default-context)
```

Sets the default connection context object for the Ctx class.

#

sqlj.runtime.ForUpdate interface

Implement the `sqlj.runtime.ForUpdate` interface for positioned UPDATE or DELETE operations. You implement `sqlj.runtime.ForUpdate` in an SQLJ iterator declaration clause. For positioned UPDATE and DELETE operations, you must declare an iterator in one source file and use the iterator in a different source file. See "Using iterators for positioned UPDATE and DELETE operations" on page 26 for more information.

sqlj.runtime.NamedIterator interface

`sqlj.runtime.NamedIterator` is an interface that SQLJ implements when you declare a named iterator. When you declare an instance of a named iterator, SQLJ creates an accessor method for each column in the expected result table. An accessor method returns the data from its column of the result table. The name of an accessor method matches the name of the corresponding column in the named iterator.

In addition to the accessor methods, SQLJ generates the following methods that you can invoke in your SQLJ application.

close

Format:

```
public abstract void close() throws SQLException
```

Releases database resources that the iterator uses.

isClosed

Format:

```
public abstract boolean isClosed() throws SQLException
```

Returns a value of `true` if the `close` method has been invoked.

next

Format:

```
public abstract boolean next() throws SQLException
```

Advances the iterator to the next row. Before an instance of the `next` method is invoked for the first time, the iterator is positioned before the first row of the result table. `next` returns a value of `true` when a next row is available and `false` when all rows have been retrieved.

sqlj.runtime.PositionedIterator interface

`sqlj.runtime.PositionedIterator` is an interface that SQLJ implements when you declare a positioned iterator. After you declare and create an instance of a positioned iterator, you can use the following method.

endFetch

Format:

```
public abstract boolean endFetch() throws SQLException
```

Returns a value of `true` if the iterator is not positioned on a row.

sqlj.runtime.ResultSetIterator interface

`sqlj.runtime.ResultSetIterator` is an interface that SQLJ implements when you
declare an iterator. After you declare and create an instance of an iterator, you can use
the following methods.

#	**clearWarnings**
#	Format:
```
#	public abstract void clearWarnings() throws SQLException
```
#	Returns null until a new warning is reported for this iterator.

#	**close**
#	Format:
```
#	public abstract void close() throws SQLException
```
#	Releases database resources that the iterator uses.

#	**getResultSet**
#	Format:
```
#	public abstract ResultSet getResultSet() throws SQLException
```
#	Returns a JDBC result set representation of an SQLJ iterator.

#	**getWarnings**
#	Format:
```
#	public abstract SQLWarning getWarnings() throws SQLException
```
#	Returns the first warning that is reported by calls on this iterator. Subsequent
#	iterator warnings are be chained to this SQLWarning. The warning chain is
#	automatically cleared each time a new row is read.

#	**isClosed**
#	Format:
```
#	public abstract boolean isClosed() throws SQLException
```
#	Returns a value of `true` if the `close` method has been invoked.

#	**next**
#	Format:
```
#	public abstract boolean next() throws SQLException
```
#	Advances the iterator to the next row. Before an instance of the `next` method is
#	invoked for the first time, the iterator is positioned before the first row of the result
#	table. `next` returns a value of `true` when a next row is available and `false` when all
#	rows have been retrieved.

Appendix B. Special considerations for CICS applications

In general, writing and running JDBC and SQLJ applications for a CICS environment is similar to writing and running any other JDBC and SQLJ applications. However, there are some important differences. This appendix outlines those differences and explains what you need to do about them.

Choosing parameter values for the SQLJ/JDBC run-time properties file

Some parameters in the SQLJ/JDBC run-time properties file have different meanings in the CICS environment from other environments. Those parameters are:

DB2SQLJPLANNAME
This parameter is not used in a CICS environment. Specify the name of the plan that is associated with the SQLJ or JDBC application in one of the following places:
- The PLAN parameter of the DB2CONN definition
- The PLAN parameter of the DB2ENTRY definition
- The CPRMPLAN parameter of a dynamic plan exit

DB2SQLJ_TRACE_FILENAME
For the JVM environment, you can specify a fully-qualified path name or an unqualified file name. If you specify an unqualified file name, the file is allocated in the directory path that is specified by the CICS JVM environment variable CICS_HOME.

For the VisualAge for Java environment, you need to specify a fully-qualified path name.

If you want to use the same properties file for both environments, specify a fully-qualified path name.

DB2SQLJSSID
This parameter is not used in a CICS environment.

DB2SQLJATTACHTYPE
This parameter is not used in a CICS environment.

DB2SQLJMULTICONTEXT
This parameter is not used in a CICS environment. You cannot enable OS/390 multiple context support in the CICS environment. Each CICS Java application can have a maximum of one connection.

Choosing parameter values for the db2genJDBC utility

The db2genJDBC creates a JDBC profile. The default value for the `statements`parameters is not appropriate for CICS applications. The default value generates a large JDBC profile. For VisualAge for Java SQLJ or JDBC applications that run in a CICS environment, large JDBC profiles can degrade performance.

Choose a value for the `statements` parameter that is lower than the default of 150. The default value produces more sections than are necessary for typical CICS applications. A larger number of sections results in a larger JDBC profile size. A value of 10 should be adequate for most CICs applications.

Choosing the number of cursors for JDBC result sets

The cursor properties file describes the DB2 cursors that the SQLJ/JDBC driver uses to process JDBC result sets. The default cursor properties file, db2jdbc.cursors, defines 125 cursors with hold and 125 cursors without hold. This number of cursors is too large for CICS applications, and it results in a JDBC profile size that is large enough to degrade performance.

Specifying five cursors with hold and five cursors without hold should be should be adequate for most CICS applications.

Setting environment variables for the CICS environment

For SQLJ or JDBC applications in a CICS environment, the way that you specify configuration information differs depending on whether you run in the JVM environment or the VisualAge for Java environment.

For CICS Java programs that run in the JVM environment, you specify the environment variables that are listed in “Configuring JDBC and SQLJ” on page 83 in the DFHJVM member of the SDFHENV data set.

For CICS Java programs that run in the VisualAge for Java environment, the environment variables that are listed in “Configuring JDBC and SQLJ” on page 83 are not used. Put DB2 code in a PDSE that you specify in the CICS DFHRPL concatenation. If you use an SQLJ/JDBC run-time properties file other than the default file, bind the properties file into its own DLL in a PDSE, and include the name of that PDSE in the CICS DFHRPL concatenation. Because you cannot use an environment variable to name the run-time properties file, you must use the default name for the file: `db2sqljjdbc.properties`. See “Preparing your applications with VisualAge for Java” on page 67 for more information on binding the run-time properties file.

Choosing VisualAge for Java bind parameters for better performance

To improve performance of an SQLJ or JDBC program that runs in the CICS and VisualAge for Java environment, specify this parameter when you execute the hpj command:

```
-lerunopts="(envar('IBMHPJ_OPTS=-Xskipgc'))"
```

This parameter causes Language Environment to turn off Java garbage collection routines at run time. For more information on recommended hpj options for CICS, see *CICS Application Programming Guide*.

Connecting to DB2 in the CICS environment

For SQLJ or JDBC applications in a CICS environment, the connection to DB2 is always through the CICS attachment facility. Unlike SQLJ and JDBC applications that use other attachment facilities, SQLJ and JDBC applications that use the CICS attachment facility can create only one JDBC `java.sql.Connection` object within a unit of work. That `java.sql.Connection` object is associated with the CICS unit of work. CICS coordinates all DB2 updates within the unit of work.

In CICS DB2 programs that are written in languages other than Java, calling applications and called applications can share a DB2 thread. JDBC does not allow several applications to share a `java.sql.Connection` object, which, in the CICS environment, means that calling applications and called applications cannot share a DB2 thread. Therefore, if a CICS application is doing DB2 work, and that application calls an SQLJ or JDBC application, the calling application needs to commit all updates before calling the SQLJ or JDBC application.

The CICS attachment facility supports multithreading. Multiple Java threads are supported for a single CICS application. However, only the Java thread for the main application is associated with the DB2 attachment. JDBC and SQLJ processing is not supported for Java child threads.

In a CICS SQLJ or JDBC application, you need to explicitly close the `java.sql.Connection` before the program ends. This ensures that work done on the `java.sql.Connection` object is committed and that the `java.sql.Connection` object is available for use by another application.

Commit and rollback processing in CICS SQLJ and JDBC applications

In a CICS environment, the default state of autoCommit for a JDBC connection is off.

You can use JDBC and SQLJ commit and rollback processing in your CICS applications. The SQLJ/JDBC driver translates commit and rollback statements to CICS syncpoint calls. The scope of those calls is the entire CICS transaction.

Abnormal terminations in the CICS attachment facility

Abends in code that is called by the SQLJ/JDBC driver, such as abends in the CICS attachment facility, do not generate exceptions in SQLJ or JDBC programs.

A CICS attachment facility abend causes a rollback to the last syncpoint.

Running traces in a CICS environment

When you trace a JDBC or SQLJ CICS application, the trace output goes to different locations, depending on whether the application runs in a JVM or under VisualAge for Java.

- The program runs in a JVM

The output goes to *trace-file* (the binary trace) and *trace-file*.JTRACE (the readable
trace), as described in “Formatting trace data” on page 35.

• The program runs in the ET/390 Java execution environment

The trace data that is in a proprietary, binary format goes to *trace-file*, as described
in “Formatting trace data” on page 35. The readable trace data is routed by
Language Environment to the CICS transient data destination CESE.

#

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Programming interface information

This book is intended to help the customer write applications that use Java to access IBM DB2 for OS/390 servers. This book documents General-use Programming Interface and Associated Guidance Information provided by DATABASE 2 for OS/390 (DB2 for OS/390).

General-use programming interfaces allow the customer to write programs that obtain the services of DB2 for OS/390.

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Glossary

The following terms and abbreviations are defined as they are used in the DB2 library. If you do not find the term you are looking for, refer to the index or to *Dictionary of Computing*.

A

abend. Abnormal end of task.

abend reason code. A 4-byte hexadecimal code that uniquely identifies a problem with DB2. A complete list of DB2 abend reason codes and their explanations is contained in *Messages and Codes*.

abnormal end of task (abend). Termination of a task, a job, or a subsystem because of an error condition that cannot be resolved during execution by recovery facilities.

access path. The path used to get to data specified in SQL statements. An access path can involve an index or a sequential search.

address space. A range of virtual storage pages identified by a number (ASID) and a collection of segment and page tables which map the virtual pages to real pages of the computer's memory.

address space connection. The result of connecting an allied address space to DB2. Each address space containing a task connected to DB2 has exactly one address space connection, even though more than one task control block (TCB) can be present. See *allied address space* and *task control block*.

alias. An alternate name that can be used in SQL statements to refer to a table or view in the same or a remote DB2 subsystem.

allied address space. An area of storage external to DB2 that is connected to DB2 and is therefore capable of requesting DB2 services.

allied thread. A thread originating at the local DB2 subsystem that may access data at a remote DB2 subsystem.

ambiguous cursor. A database cursor that is not defined with either the clauses FOR FETCH ONLY or FOR UPDATE OF, is not defined on a read-only result table, is not the target of a WHERE CURRENT clause on an SQL UPDATE or DELETE statement, and is in a plan or package that contains SQL statements PREPARE or EXECUTE IMMEDIATE.

API. Application programming interface.

application. A program or set of programs that perform a task; for example, a payroll application.

application plan. The control structure produced during the bind process and used by DB2 to process SQL statements encountered during statement execution.

application process. The unit to which resources and locks are allocated. An application process involves the execution of one or more programs.

application program interface (API). A functional interface supplied by the operating system or by a separately orderable licensed program that allows an application program written in a high-level language to use specific data or functions of the operating system or licensed program.

application requester (AR). See *requester*.

application server. See *server*.

AR. application requester. See *requester*.

AS. Application server. See *server*.

ASCII. An encoding scheme used to represent strings in many environments, typically on PCs and workstations. Contrast with *EBCDIC*.

attribute. A characteristic of an entity. For example, in database design, the phone number of an employee is one of that employee's attributes.

authorization ID. A string that can be verified for connection to DB2 and to which a set of privileges are allowed. It can represent an individual, an organizational group, or a function, but DB2 does not determine this representation.

B

base table. A table created by the SQL CREATE TABLE statement that is used to hold persistent data. Contrast with *result table* and *temporary table*.

binary integer. A basic data type that can be further classified as small integer or large integer.

bind. The process by which the output from the DB2 precompiler is converted to a usable control structure called a package or an application plan. During the process, access paths to the data are selected and some authorization checking is performed.

automatic bind. (More correctly *automatic rebind*). A process by which SQL statements are bound automatically (without a user issuing a BIND command) when an application process begins execution and the bound application plan or package it requires is not valid.

dynamic bind. A process by which SQL statements are bound as they are entered.

incremental bind. A process by which SQL statements are bound during the execution of an application process, because they could not be bound during the bind process, and VALIDATE(RUN) was specified.

static bind. A process by which SQL statements are bound after they have been precompiled. All static SQL statements are prepared for execution at the same time. Contrast with *dynamic bind*.

bit data. Data that is not associated with a coded character set.

BMP. Batch Message Processing (IMS).

built-in function. Scalar function or column function.

C

CAF. Call attachment facility.

call attachment facility (CAF). A DB2 attachment facility for application programs running in TSO or MVS batch. The CAF is an alternative to the DSN command processor and allows greater control over the execution environment.

catalog. In DB2, a collection of tables that contains descriptions of objects such as tables, views, and indexes.

catalog table. Any table in the DB2 catalog.

CCSID. Coded character set identifier.

CDB. See *communications database*.

CDRA. Character data representation architecture.

central processor (CP). The part of the computer that contains the sequencing and processing facilities for instruction execution, initial program load, and other machine operations.

character data representation architecture (CDRA). An architecture used to achieve consistent representation, processing, and interchange of string data.

character set. A defined set of characters.

character string. A sequence of bytes representing bit data, single-byte characters, or a mixture of single and double-byte characters.

check clause. An extension to the SQL CREATE TABLE and SQL ALTER TABLE statements that specifies a table check constraint.

check constraint. See *table check constraint*.

check integrity. The condition that exists when each row in a table conforms to the table check constraints defined on that table. Maintaining check integrity requires enforcing table check constraints on operations that add or change data.

check pending. A state of a table space or partition that prevents its use by some utilities and some SQL statements, because it can contain rows that violate referential constraints, table check constraints, or both.

CICS. Represents (in this publication) CICS/MVS and CICS/ESA.
  CICS/MVS: Customer Information Control System/Multiple Virtual Storage.
  CICS/ESA: Customer Information Control System/Enterprise Systems Architecture.

CICS attachment facility. A DB2 subcomponent that uses the MVS Subsystem Interface (SSI) and cross storage linkage to process requests from CICS to DB2 and to coordinate resource commitment.

clause. In SQL, a distinct part of a statement, such as a SELECT clause or a WHERE clause.

client. See *requester*.

CLIST. Command list. A language for performing TSO tasks.

clustering index. An index that determines how rows are physically ordered in a table space.

coded character set. A set of unambiguous rules that establish a character set and the one-to-one relationships between the characters of the set and their coded representations.

coded character set identifier (CCSID). A 16-bit number that uniquely identifies a coded representation of graphic characters. It designates an encoding scheme identifier and one or more pairs consisting of a character set identifier and an associated code page identifier.

code page. A set of assignments of characters to code points.

code point. In CDRA, a unique bit pattern that represents a character in a code page.

collection. A group of packages that have the same qualifier.

column function. An SQL operation that derives its result from a collection of values across one or more rows. Contrast with *scalar function*.

command. A DB2 operator command or a DSN subcommand. Distinct from an SQL statement.

commit. The operation that ends a unit of work by releasing locks so that the database changes made by that unit of work can be perceived by other processes.

commit point. A point in time when data is considered consistent.

committed phase. The second phase of the multi-site update process that requests all participants to commit the effects of the logical unit of work.

communications database (CDB). A set of tables in the DB2 catalog that are used to establish conversations with remote database management systems.

comparison operator. A token (such as =, >, <) used to specify a relationship between two values.

composite key. An ordered set of key columns of the same table.

concurrency. The shared use of resources by more than one application process at the same time.

connection. The existence of a communication path between two partner LUs that allows information to be exchanged (for example, two DB2s connected and communicating by way of a conversation).

connection context. In SQLJ, a Java object that represents a connection to a data source.

connection declaration clause. In SQLJ, a statement that declares a connection to a data source.

consistency token. A timestamp used to generate the version identifier for an application. See also *version*.

constant. A language element that specifies an unchanging value. Constants are classified as string constants or numeric constants. Contrast with *variable*.

constraint. A rule that limits the values that can be inserted, deleted, or updated in a table. See *referential constraint*, *uniqueness constraint*, and *table check constraint*.

correlated subquery. A subquery (part of a WHERE or HAVING clause) applied to a row or group of rows of a table or view named in an outer sub-SELECT statement.

correlation name. An identifier that designates a table, a view, or individual rows of a table or view within a single SQL statement. It can be defined in any FROM clause or in the first clause of an UPDATE or DELETE statement.

CP. See *central processor (CP)*.

current data. Data within a host structure that is current with (identical to) the data within the base table.

cursor stability (CS). The isolation level that provides maximum concurrency without the ability to read uncommitted data. With cursor stability, a unit of work holds locks only on its uncommitted changes and on the current row of each of its cursors.

D

DASD. Direct access storage device.

database. A collection of tables, or a collection of table spaces and index spaces.

database access thread. A thread accessing data at the local subsystem on behalf of a remote subsystem.

database administrator (DBA). An individual responsible for the design, development, operation, safeguarding, maintenance, and use of a database.

database descriptor (DBD). An internal representation of DB2 database definition which reflects the data definition found in the DB2 catalog. The objects defined in a database descriptor are table spaces, tables, indexes, index spaces, and relationships.

database management system (DBMS). A software system that controls the creation, organization, and modification of a database and access to the data stored within it.

database request module (DBRM). A data set member created by the DB2 precompiler that contains information about SQL statements. DBRMs are used in the bind process.

DATABASE 2 Interactive (DB2I). The DB2 facility that provides for the execution of SQL statements, DB2 (operator) commands, programmer commands, and utility invocation.

data currency. The state in which data retrieved into a host variable in your program is a copy of data in the base table.

data definition name (DD name). The name of a data definition (DD) statement that corresponds to a data control block containing the same name.

Data Language/I (DL/I). The IMS data manipulation language; a common high-level interface between a user application and IMS.

data partition. A VSAM data set that is contained within a partitioned table space.

data sharing. The ability of two or more DB2 subsystems to directly access and change a single set of data.

data sharing group. A collection of one or more DB2 subsystems that directly access and change the same data while maintaining data integrity.

data sharing member. A DB2 subsystem assigned by XCF services to a data sharing group.

data type. An attribute of columns, literals, host variables, special registers, and the results of functions and expressions.

date. A three-part value that designates a day, month, and year.

date duration. A decimal integer that represents a number of years, months, and days.

datetime value. A value of the data type DATE, TIME, or TIMESTAMP.

DBA. Database administrator.

DBCS. Double-byte character set.

DBD. Database descriptor.

DBMS. Database management system.

DBRM. Database request module.

DB2 catalog. Tables maintained by DB2 that contain descriptions of DB2 objects such as tables, views, and indexes.

DB2 command. An instruction to the DB2 subsystem allowing a user to start or stop DB2, to display information on current users, to start or stop databases, to display information on the status of databases, and so on.

DB2I. DATABASE 2 Interactive.

DB2 private protocol access. A method of accessing distributed data by which you can direct a query to another DB2 system by using an alias or a three-part name to identify the DB2 subsystems at which the statements are executed. Contrast with *DRDA access*.

DB2 private protocol connection. A DB2 private connection of the application process. See also *private connection*.

DCLGEN. Declarations generator.

DDF. Distributed data facility.

DD name. Data definition name.

deadlock. Unresolvable contention for the use of a resource such as a table or an index.

declarations generator (DCLGEN). A subcomponent of DB2 that generates SQL table declarations and COBOL, C, or PL/I data structure declarations that conform to the table. The declarations are generated from DB2 system catalog information. DCLGEN is also a DSN subcommand.

default value. A predetermined value, attribute, or option that is assumed when no other is explicitly specified.

degree of parallelism. The number of concurrently executed operations that are initiated to process a query.

delimited identifier. A sequence of characters enclosed within quotation marks ("). The sequence must consist of a letter followed by zero or more characters, each of which is a letter, digit, or the underscore character (_).

delimiter token. A string constant, a delimited identifier, an operator symbol, or any of the special characters shown in syntax diagrams.

dependent. An object (row, table, or table space) is a dependent if it has at least one parent. The object is also said to be a dependent (row, table, or table space) of its parent. See *parent row*, *parent table*, *parent table space*.

direct access storage device (DASD). A device in which access time is independent of the location of the data.

distributed data facility (DDF). A set of DB2 components through which DB2 communicates with another RDBMS.

distributed relational database architecture (DRDA). A connection protocol for distributed relational database processing that is used by IBM's relational database products. DRDA includes protocols for communication between an application and a remote relational database management system, and for communication between relational database management systems.

DL/I. Data Language/I. The IMS data manipulation language; a common high-level interface between a user application and IMS.

double-byte character set (DBCS). A set of characters used by national languages such as Japanese and Chinese that have more symbols than can be represented by a single byte. Each character is two bytes in length, and therefore requires special hardware to be displayed or printed.

drain. To acquire a locked resource by quiescing access to that object.

drain lock. A lock on a claim class which prevents a claim from occurring.

DRDA. Distributed relational database architecture.

DRDA access. A method of accessing distributed data by which you can explicitly connect to another location, using an SQL statement, to execute packages that have been previously bound at that location. The SQL CONNECT statement is used to identify application servers, and SQL statements are executed using packages that were previously bound at those servers. Contrast with *DB2 private protocol access*.

DSN. (1) The default DB2 subsystem name. (2) The name of the TSO command processor of DB2. (3) The first three characters of DB2 module and macro names.

duration. A number that represents an interval of time. See *date duration*, *labeled duration*, and *time duration*.

dynamic SQL. SQL statements that are prepared and executed within an application program while the program is executing. In dynamic SQL, the SQL source is contained in host language variables rather than being coded into the application program. The SQL statement can change several times during the application program's execution.

E

EBCDIC. Extended binary coded decimal interchange code. An encoding scheme used to represent character data in the MVS, VM, VSE, and OS/400 environments. Contrast with *ASCII*.

embedded SQL. SQL statements coded within an application program. See *static SQL*.

equi-join. A join operation in which the join-condition has the form *expression* = *expression*.

escape character. The symbol used to enclose an SQL delimited identifier. The escape character is the quotation mark (″), except in COBOL applications, where the symbol (either a quotation mark or an apostrophe) can be assigned by the user.

EUR. IBM European Standards.

execution context. In SQLJ, a Java object that can be used to control the execution of SQL statements.

explicit hierarchical locking. Locking used to make the parent/child relationship between resources known to IRLM. This is done to avoid global locking overhead when no inter-DB2 interest exists on a resource.

expression. An operand or a collection of operators and operands that yields a single value.

F

false global lock contention. A contention indication from the coupling facility when multiple lock names are hashed to the same indicator and when there is no real contention.

fixed-length string. A character or graphic string whose length is specified and cannot be changed. Contrast with *varying-length string*.

foreign key. A key that is specified in the definition of a referential constraint. Because of the foreign key, the table is a dependent table. The key must have the same number of columns, with the same descriptions, as the primary key of the parent table.

full outer join. The result of a join operation that includes the matched rows of both tables being joined and preserves the unmatched rows of both tables. See also *join*.

function. A scalar function or column function. Same as *built-in function*.

G

global lock. A lock that provides both intra-DB2 concurrency control and inter-DB2 concurrency control, that is, the scope of the lock is across all the DB2s of a data sharing group.

global lock contention. Conflicts on locking requests between different DB2 members of a data sharing group regarding attempts to serialize shared resources.

graphic string. A sequence of DBCS characters.

gross lock. The *shared*, *update*, or *exclusive* mode locks on a table, partition, or table space.

group name. The MVS XCF identifier for a data sharing group.

group restart. A restart of at least one member of a data sharing group after either locks or the shared communications area have been lost.

H

help panel. A screen of information presenting tutorial text to assist a user at the terminal.

host expression. A Java variable or expression that is referenced by SQL clauses in an SQLJ application program.

host identifier. A name declared in the host program.

host language. A programming language in which you can embed SQL statements.

host program. An application program written in a host language that contains embedded SQL statements.

host structure. In an application program, a structure referenced by embedded SQL statements.

host variable. In an application program, an application variable referenced by embedded SQL statements.

I

IFP. IMS Fast Path.

IMS. Information Management System.

IMS attachment facility. A DB2 subcomponent that uses MVS Subsystem Interface (SSI) protocols and cross-memory linkage to process requests from IMS to DB2 and to coordinate resource commitment.

index. A set of pointers that are logically ordered by the values of a key. Indexes can provide faster access to data and can enforce uniqueness on the rows in a table.

index key. The set of columns in a table used to determine the order of index entries.

index partition. A VSAM data set that is contained within a partitioned index space.

index space. A page set used to store the entries of one index.

indicator variable. A variable used to represent the null value in an application program. If the value for the selected column is null, a negative value is placed in the indicator variable.

indoubt. A status of a unit of recovery. If DB2 fails after it has finished its phase 1 commit processing and before it has started phase 2, only the commit coordinator knows if this unit of recovery is to be committed or rolled back. At emergency restart, if DB2 does not have the information needed to make this decision, its unit of recovery is *indoubt* until DB2 obtains this information from the coordinator.

indoubt resolution. The process of resolving the status of an indoubt logical unit of work to either the committed or the rollback state.

inner join. The result of a join operation that includes only the matched rows of both tables being joined. See also *join*.

Interactive System Productivity Facility (ISPF). An IBM licensed program that provides interactive dialog services.

internal resource lock manager (IRLM). An MVS subsystem used by DB2 to control communication and database locking.

inter-DB2 R/W interest. A property of data in a table space, index, or partition that has been opened by more than one member of a data sharing group and that has been opened for writing by at least one of those members.

IRLM. internal resource lock manager.

ISO. International Standards Organization.

isolation level. The degree to which a unit of work is isolated from the updating operations of other units of work. See also *cursor stability*, *repeatable read*, *uncommitted read*, and *read stability*.

ISPF/PDF. Interactive System Productivity Facility/Program Development Facility.

iterator. In SQLJ, an object that contains the result set of a query. An iterator is equivalent to a cursor in other host languages.

iterator declaration clause. In SQLJ, a statement that generates an iterator declaration class. An iterator is an object of an iterator declaration class.

J

Java Database Connectivity (JDBC). A Sun
Microsystems database application programming
interface (API) for Java that allows programs to
access database management systems by using
callable SQL. JDBC does not require the use of
an SQL preprocessor. In addition, JDBC provides
an architecture that lets users add modules called
database drivers, which link the application to their
choice of database management systems at run
time.

JCL. Job control language.

JDBC. Java Database Connectivity.

JIS. Japanese Industrial Standard.

join. A relational operation that allows retrieval of data from two or more tables based on matching column values. See also *full outer join, inner join, left outer join, outer join, right outer join, equi-join*.

K

KB. Kilobyte (1024 bytes).

key. A column or an ordered collection of columns identified in the description of a table, index, or referential constraint.

L

labeled duration. A number that represents a duration of years, months, days, hours, minutes, seconds, or microseconds.

left outer join. The result of a join operation that includes the matched rows of both tables being joined, and preserves the unmatched rows of the first table. See also *join*.

link-edit. To create a loadable computer program using a linkage editor.

L-lock. See *logical lock*.

load module. A program unit that is suitable for loading into main storage for execution. The output of a linkage editor.

local. Refers to any object maintained by the local DB2 subsystem. A *local table*, for example, is a table maintained by the local DB2 subsystem. Contrast with *remote*.

local lock. A lock that provides intra-DB2 concurrency control, but does not provide inter-DB2 concurrency control; that is, its scope is a single DB2.

local subsystem. The unique RDBMS to which the user or application program is directly connected (in the case of DB2, by one of the DB2 attachment facilities).

location name. The name by which DB2 refers to a particular DB2 subsystem in a network of subsystems. Contrast with *LU name*.

lock. A means of controlling concurrent events or access to data. DB2 locking is performed by the IRLM.

lock duration. The interval over which a DB2 lock is held.

lock escalation. The promotion of a lock from a row or page lock to a table space lock because the number of page locks concurrently held on a given resource exceeds a preset limit.

locking. The process by which the integrity of data is ensured. Locking prevents concurrent users from accessing inconsistent data.

lock mode. A representation for the type of access concurrently running programs can have to a resource held by a DB2 lock.

lock object. The resource that is controlled by a DB2 lock.

lock parent. For explicit hierarchical locking, a lock held on a resource that has child locks that are lower in the hierarchy; usually the table space or partition intent locks are the parent locks.

lock promotion. The process of changing the size or mode of a DB2 lock to a higher level.

lock size. The amount of data controlled by a DB2 lock on table data; the value can be a row, a page, a table, or a table space.

logical index partition. The set of all keys that reference the same data partition.

logical lock. The lock type used by transactions to control intra- and inter-DB2 data concurrency between transactions.

logical unit. An access point through which an application program accesses the SNA network in order to communicate with another application program.

logical unit of work (LUW). In IMS, the processing that program performs between synchronization points.

LU name. From *logical unit name*, the name by which VTAM refers to a node in a network. Contrast with *location name*.

LUW. Logical unit of work.

M

mixed data string. A character string that can contain both single-byte and double-byte characters.

modify locks. An L-lock or P-lock that has been specifically requested as having the MODIFY attribute. A list of these active locks are kept at all times in the coupling facilitylock structure. If the requesting DB2 fails, that DB2's modify locks are converted to *retained locks*.

MPP. Message processing program (IMS).

multi-site update. Distributed relational database processing in which data is updated in more than one location within a single unit of work.

MVS. Multiple Virtual Storage.

MVS/ESA. Multiple Virtual Storage/Enterprise Systems Architecture.

MVS/XA. Multiple Virtual Storage/Extended Architecture.

N

negotiable lock. A lock whose mode can be downgraded, by agreement among contending users, to be compatible to all. A physical lock is an example of a negotiable lock.

nonpartitioned index. Any index that is not a partitioned index.

NUL. In C, a single character that denotes the end of the string.

null. A special value that indicates the absence of information.

NUL-terminated host variable. A varying-length host variable in which the end of the data is indicated by the presence of a NUL terminator.

NUL terminator. In C, the value that indicates the end of a string. For character strings, the NUL terminator is X'00'.

O

ordinary identifier. An uppercase letter followed by zero or more characters, each of which is an uppercase letter, a digit, or the underscore character. An ordinary identifier must not be a reserved word.

ordinary token. A numeric constant, an ordinary identifier, a host identifier, or a keyword.

outer join. The result of a join operation that includes the matched rows of both tables being joined and preserves some or all of the unmatched rows of the tables being joined. See also *join*.

P

package. Also *application package*. An object containing a set of SQL statements that have been bound statically and that are available for processing.

page. A unit of storage within a table space (4KB or 32KB) or index space (4KB). In a table space, a page contains one or more rows of a table.

page set. A table space or index space consisting of pages that are either 4KB or 32KB in size. Each page set is made from a collection of VSAM data sets.

parent row. A row whose primary key value is the foreign key value of a dependent row.

parent table. A table whose primary key is referenced by the foreign key of a dependent table.

parent table space. A table space that contains a parent table. A table space containing a dependent of that table is a dependent table space.

partitioned page set. A partitioned table space or an index space. Header pages, space map pages, data pages, and index pages reference data only within the scope of the partition.

partitioned table space. A table space subdivided into parts (based upon index key range), each of which may be processed by utilities independently.

partner logical unit. An access point in the SNA network that is connected to the local DB2 by way of a VTAM conversation.

PCT. Program control table (CICS).

piece. A data set of a nonpartitioned page set.

physical consistency. The state of a page that is not in a partially changed state.

physical lock contention. Conflicting states of the requesters for a physical lock. See *negotiable lock*.

physical lock (P-lock). A lock type used only by data sharing that is acquired by DB2 to provide consistency of data cached in different DB2 subsystems.

plan. See *application plan*.

plan allocation. The process of allocating DB2 resources to a plan in preparation to execute it.

plan member. The bound copy of a DBRM identified in the member clause.

plan name. The name of an application plan.

P-lock. See *physical lock*.

point of consistency. A time when all recoverable data an application accesses is consistent with other data. Synonymous with *sync point* or *commit point*.

precision. In SQL, the total number of digits in a decimal number (called the *size* in the C language). In the C language, the number of digits to the right of the decimal point (called the *scale* in SQL). The DB2 library uses the SQL definitions.

precompilation. A processing of application programs containing SQL statements that takes place before compilation. SQL statements are replaced with statements that are recognized by the host language compiler. Output from this precompilation includes source code that can be submitted to the compiler and the database request module (DBRM) that is input to the bind process.

predicate. An element of a search condition that expresses or implies a comparison operation.

prepared SQL statement. A named object that is the executable form of an SQL statement that has been processed by the PREPARE statement.

primary index. An index that enforces the uniqueness of a primary key.

primary key. A unique, nonnull key that is part of the definition of a table. A table cannot be defined as a parent unless it has a unique key or primary key.

private connection. A communications connection that is specific to DB2.

Q

QMF. Query Management Facility.

R

RACF. OS/VS2 MVS Resource Access Control Facility.

RCT. Resource control table (CICS attachment facility).

RDB. See *relational database*.

RDBMS. Relational database management system.

RDBNAM. See *relational database name*.

read stability (RS). An isolation level that is similar to repeatable read but does not completely isolate an application process from all other concurrently executing application processes. Under level RS, an application that issues the same query more than once might read additional rows, known as *phantom rows*, that were inserted and committed by a concurrently executing application process.

rebind. To create a new application plan for an application program that has been bound previously. If, for example, you have added an index for a table accessed by your application, you must rebind the application in order to take advantage of that index.

record. The storage representation of a row or other data.

recovery. The process of rebuilding databases after a system failure.

referential constraint. The requirement that nonnull values of a designated foreign key are valid only if they equal values of the primary key of a designated table.

referential integrity. The condition that exists when all intended references from data in one column of a table to data in another column of the same or a different table are valid. Maintaining referential integrity requires enforcing referential constraints on all LOAD, RECOVER, INSERT, UPDATE, and DELETE operations.

relational database. A database that can be perceived as a set of tables and manipulated in accordance with the relational model of data.

relational database management system (RDBMS). A relational database manager that operates consistently across supported IBM systems.

relational database name (RDBNAM). A unique identifier for an RDBMS within a network. In DB2, this must be the value in the LOCATION column of table SYSIBM.LOCATIONS in the CDB. DB2 publications refer to the name of another RDBMS as a LOCATION value or a location name.

remote. Refers to any object maintained by a remote DB2 subsystem; that is, by a DB2 subsystem other than the local one. A *remote view*, for instance, is a view maintained by a remote DB2 subsystem. Contrast with *local*.

remote subsystem. Any RDBMS, except the *local subsystem*, with which the user or application can communicate. The subsystem need not be remote in any physical sense, and may even operate on the same processor under the same MVS system.

repeatable read (RR). The isolation level that provides maximum protection from other executing application programs. When an application program executes with repeatable read protection, rows referenced by the program cannot be changed by other programs until the program reaches a commit point.

request commit. The vote submitted to the prepare phase if the participant has modified data and is prepared to commit or roll back.

requester. Also *application requester (AR)*. The source of a request to a remote RDBMS, the system that requests the data.

resource control table (RCT). A construct of the CICS attachment facility, created by site-provided macro parameters, that defines authorization and access attributes for transactions or transaction groups.

resource limit facility (RLF). A portion of DB2 code that prevents dynamic manipulative SQL statements from exceeding specified time limits.

result set. The set of rows returned to a client application by a stored procedure.

result table. The set of rows specified by a SELECT statement.

retained lock. A MODIFY lock that was held by a DB2 when that DB2 failed. The lock is retained in the coupling facility lock structure across a DB2 failure.

right outer join. The result of a join operation that includes the matched rows of both tables being joined and preserves the unmatched rows of the second join operand. See also *join*.

RLF. Resource limit facility.

rollback. The process of restoring data changed by SQL statements to the state at its last commit point. All locks are freed. Contrast with *commit*.

row. The horizontal component of a table. A row consists of a sequence of values, one for each column of the table.

RRSAF. Recoverable Resource Manager Services attachment facility. A DB2 subcomponent that uses OS/390 Transaction Management and Recoverable Resource Manager Services to coordinate resource commitment between DB2 and all other resource managers that also use OS/390 RRS in an OS/390 system.

S

scalar function. An SQL operation that produces a single value from another value and is expressed as a function name followed by a list of arguments enclosed in parentheses. See also *column function*.

scale. In SQL, the number of digits to the right of the decimal point (called the *precision* in the C language). The DB2 library uses the SQL definition.

search condition. A criterion for selecting rows from a table. A search condition consists of one or more predicates.

sequential data set. A non-DB2 data set whose records are organized on the basis of their successive physical positions, such as on magnetic tape. Several of the DB2 database utilities require sequential data sets.

serialized profile. A Java object that contains SQL statements and descriptions of host variables. A serialized profile is produced by the SQLJ translator. The SQLJ translator produces a serialized profile for each connection context.

server. Also *application server (AS)*. The target for a request from a remote RDBMS, the RDBMS that provides the data.

shared lock. A lock that prevents concurrently executing application processes from changing data, but not from reading data.

shift-in character. A special control character (X'0F') used in EBCDIC systems to denote that the following bytes represent SBCS characters. See *shift-out character*.

shift-out character. A special control character (X'0E') used in EBCDIC systems to denote that the following bytes, up to the next shift-in control character, represent DBCS characters.

single-precision floating point number. A 32-bit approximate representation of a real number.

size. In the C language, the total number of digits in a decimal number (called the *precision* in SQL). The DB2 library uses the SQL definition.

source program. A set of host language statements and SQL statements that is processed by an SQL precompiler.

space. A sequence of one or more blank characters.

SPUFI. SQL Processor Using File Input. A facility of the TSO attachment subcomponent that enables the DB2I user to execute SQL statements without embedding them in an application program.

SQL. Structured Query Language.

SQL authorization ID (SQL ID). The authorization ID that is used for checking dynamic SQL statements in some situations.

SQL communication area (SQLCA). A structure used to provide an application program with information about the execution of its SQL statements.

SQL descriptor area (SQLDA). A structure that describes input variables, output variables, or the columns of a result table.

SQL escape character. The symbol used to enclose an SQL delimited identifier. This symbol is the quotation mark ("). See *escape character*.

SQL ID. SQL authorization ID.

SQL return code. Either SQLCODE or SQLSTATE.

SQLCA. SQL communication area.

SQLDA. SQL descriptor area.

SQL/DS. SQL/Data System. Also known as *DB2/VSE & VM*.

SQLJ. An interface for including embedded SQL in a Java application program.

static SQL. SQL statements, embedded within a program, that are prepared during the program preparation process (before the program is executed). After being prepared, the SQL statement does not change (although values of host variables specified by the statement might change).

storage group. A named set of DASD volumes on which DB2 data can be stored.

stored procedure. A user-written application program, that can be invoked through the use of the SQL CALL statement.

string. See *character string* or *graphic string*.

Structured Query Language (SQL). A standardized language for defining and manipulating data in a relational database.

subquery. A SELECT statement within the WHERE or HAVING clause of another SQL statement; a nested SQL statement.

subselect. That form of a query that does not include ORDER BY clause, UPDATE clause, or UNION operators.

substitution character. A unique character that is substituted during character conversion for any characters in the source program that do not have a match in the target coding representation.

subsystem. A distinct instance of a RDBMS.

sync point. See *commit point*.

synonym. In SQL, an alternative name for a table or view. Synonyms can only be used to refer to objects at the subsystem in which the synonym is defined.

system administrator. The person having the second highest level of authority within DB2. System administrators make decisions about how DB2 is to be used and implement those decisions by choosing system parameters. They monitor the system and change its characteristics to meet changing requirements and new data processing goals.

system conversation. The conversation that two DB2s must establish to process system messages before any distributed processing can begin.

T

table. A named data object consisting of a specific number of columns and some number of unordered rows. Synonymous with *base table* or *temporary table*.

table check constraint. A user-defined constraint that specifies the values that specific columns of a base table can contain.

table space. A page set used to store the records in one or more tables.

task control block (TCB). A control block used to communicate information about tasks within an address space that are connected to DB2. An address space can support many task connections (as many as one per task), but only one address space connection. See *address space connection*.

TCB. MVS task control block.

temporary table. A table created by the SQL CREATE GLOBAL TEMPORARY TABLE statement that is used to hold temporary data. Contrast with *result table* and *temporary table*.

thread. The DB2 structure that describes an application's connection, traces its progress, processes resource functions, and delimits its accessibility to DB2 resources and services. Most DB2 functions execute under a thread structure. See also *allied thread* and *database access thread*.

three-part name. The full name of a table, view, or alias. It consists of a location name, authorization ID, and an object name separated by a period.

time. A three-part value that designates a time of day in hours, minutes, and seconds.

time duration. A decimal integer that represents a number of hours, minutes, and seconds.

time-sharing option (TSO). Provides interactive time sharing from remote terminals.

timestamp. A seven-part value that consists of a date and time expressed in years, months, days, hours, minutes, seconds, and microseconds.

transaction lock. A lock used to control concurrent execution of SQL statements.

TSO. Time-sharing option.

TSO attachment facility. A DB2 facility consisting of the DSN command processor and

DB2I. Applications that are not written for the CICS or IMSenvironments can run under the TSO attachment facility.

type 1 indexes. Indexes that were created by a release of DB2 before DB2 Version 4 or that are specified as type 1 indexes in Version 4. Contrast with *type 2 indexes*.

type 2 indexes. A new type of indexes available in Version 4. They differ from *type 1 indexes* in several respects; for example, they are the only indexes allowed on a table space that uses *row locks*.

V

value. The smallest unit of data manipulated in SQL.

variable. A data element that specifies a value that can be changed. A COBOL elementary data item is an example of a variable. Contrast with *constant*.

varying-length string. A character or graphic string whose length varies within set limits. Contrast with *fixed-length string*.

version. A member of a set of similar programs, DBRMs, or packages.

> **A version of a program** is the source code produced by precompiling the program. The program version is identified by the program name and a timestamp (consistency token).
> **A version of a DBRM** is the DBRM produced by precompiling a program. The DBRM version is identified by the same program name and timestamp as a corresponding program version.
> **A version of a package** is the result of binding a DBRM within a particular database system. The package version is identified by the same program name and consistency token as the DBRM.

view. An alternative representation of data from one or more tables. A view can include all or some of the columns contained in tables on which it is defined.

Virtual Telecommunications Access Method (VTAM). An IBM licensed program that controls communication and the flow of data in an SNA network.

VSAM. Virtual storage access method.

VTAM. MVS Virtual telecommunication access method.

Bibliography

DB2 for OS/390 Version 5

- *Administration Guide, SC26-8957*
- *Application Programming and SQL Guide, SC26-8958*
- *Call Level Interface Guide and Reference, SC26-8959*
- *Command Reference, SC26-8960*
- *Data Sharing: Planning and Administration, SC26-8961*
- *Data Sharing Quick Reference Card, SX26-3841*
- *Diagnosis Guide and Reference, LY27-9659*
- *Diagnostic Quick Reference Card, LY27-9660*
- *Installation Guide, GC26-8970*
- *Application Programming Guide and Reference for Java™, SC26-9547*
- *Licensed Program Specifications, GC26-8969*
- *Messages and Codes, GC26-8979*
- *Reference for Remote DRDA Requesters and Servers, SC26-8964*
- *Reference Summary, SX26-3842*
- *Release Guide, SC26-8965*
- *SQL Reference, SC26-8966*
- *Utility Guide and Reference, SC26-8967*
- *What's New?, GC26-8971*
- *Program Directory*

DB2 PM for OS/390 Version 5

- *Batch User's Guide, SC26-8991*
- *Command Reference, SC26-8987*
- *General Information, GC26-8982*
- *Getting Started on the Workstation, SC26-8989*
- *Master Index, SC26-8984*
- *Messages Manual, SC26-8988*
- *Online Monitor User's Guide, SC26-8990*
- *Report Reference Volume 1, SC26-8985*
- *Report Reference Volume 2, SC26-8986*
- *Program Directory*

Ada/370

- *IBM Ada/370 Language Reference, SC09-1297*
- *IBM Ada/370 Programmer's Guide, SC09-1414*
- *IBM Ada/370 SQL Module Processor for DB2 Database Manager User's Guide, SC09-1450*

APL2

- *APL2 Programming Guide, SH21-1072*
- *APL2 Programming: Language Reference, SH21-1061*
- *APL2 Programming: Using Structured Query Language (SQL), SH21-1057*

AS/400

- *DB2 for OS/400 SQL Programming, SC41-4611*
- *DB2 for OS/400 SQL Reference, SC41-4612*

BASIC

- *IBM BASIC/MVS Language Reference, GC26-4026*
- *IBM BASIC/MVS Programming Guide, SC26-4027*

C/370

- *IBM SAA AD/Cycle C/370 Programming Guide, SC09-1356*
- *IBM SAA AD/Cycle C/370 Programming Guide for Language Environment/370, SC09-1840*
- *IBM SAA AD/Cycle C/370 User's Guide, SC09-1763*
- *SAA CPI C Reference, SC09-1308*

Character Data Representation Architecture

#
- *Character Data Representation Architecture Overview, GC09-2207* #
#
- *Character Data Representation Architecture Reference, SC09-2190* #

CICS/ESA

- *CICS/ESA Application Programming Guide, SC33-1169*
- *CICS/ESA Application Programming Reference, SC33-1170*
- *CICS/ESA CICS - RACF Security Guide, SC33-1185*
- *CICS/ESA CICS-Supplied Transactions, SC33-1168*

- *CICS/ESA Customization Guide, SC33-1165*
- *CICS/ESA Data Areas, LY33-6083*
- *CICS/ESA Installation Guide, SC33-1163*
- *CICS/ESA Intercommunication Guide, SC33-1181*
- *CICS/ESA Messages and Codes, SC33-1177*
- *CICS/ESA Operations and Utilities Guide, SC33-1167*
- *CICS/ESA Performance Guide, SC33-1183*
- *CICS/ESA Problem Determination Guide, SC33-1176*
- *CICS/ESA Resource Definition Guide, SC33-1166*
- *CICS/ESA System Definition Guide, SC33-1164*
- *CICS/ESA System Programming Reference, GC33-1171*

CICS/MVS
- *CICS/MVS Application Programming Primer, SC33-0139*
- *CICS/MVS Application Programmer's Reference, SC33-0512*
- *CICS/MVS Facilities and Planning Guide, SC33-0504*
- *CICS/MVS Installation Guide, SC33-0506*
- *CICS/MVS Operations Guide, SC33-0510*
- *CICS/MVS Problem Determination Guide, SC33-0516*
- *CICS/MVS Resource Definition (Macro), SC33-0509*
- *CICS/MVS Resource Definition (Online), SC33-0508*

IBM C/C++ for MVS/ESA or OS/390
- *IBM C/C++ for MVS/ESA Library Reference, SC09-1995*
- *IBM C/C++ for MVS/ESA Programming Guide, SC09-1994*
- *IBM C/C++ for OS/390 User's Guide, SC09-2361*

IBM COBOL for MVS & VM
- *IBM COBOL for MVS & VM Language Reference, SC26-4769*
- *IBM COBOL for MVS & VM Programming Guide, SC26-4767*

Conversion Guides
- *DBMS Conversion Guide: DATACOM/DB to DB2, GH20-7564*
- *DBMS Conversion Guide: IDMS to DB2, GH20-7562*
- *DBMS Conversion Guide: Model 204 to DB2 or SQL/DS, GH20-7565*
- *DBMS Conversion Guide: VSAM to DB2, GH20-7566*
- *IMS-DB and DB2 Migration and Coexistence Guide, GH21-1083*

Cooperative Development Environment
- *CoOperative Development Environment/370: Debug Tool, SC09-1623*

DATABASE 2 for Common Servers
- *DATABASE 2 Administration Guide for common servers, S20H-4580*
- *DATABASE 2 Application Programming Guide for common servers, S20H-4643*
- *DATABASE 2 Software Developer's Kit for AIX: Building Your Applications, S20H-4780*
- *DATABASE 2 Software Developer's Kit for OS/2: Building Your Applications, S20H-4787*
- *DATABASE 2 SQL Reference for common servers, S20H-4665*
- *DATABASE 2 Call Level Interface Guide and Reference for common servers, S20H-4644*

Data Extract (DXT)
- *Data Extract Version 2: General Information, GC26-4666*
- *Data Extract Version 2: Planning and Administration Guide, SC26-4631*

DataPropagator NonRelational
- *DataPropagator NonRelational MVS/ESA Administration Guide, SH19-5036*
- *DataPropagator NonRelational MVS/ESA Reference, SH19-5039*

DataPropagator Relational
- *DataPropagator Relational User's Guide, SC26-3399*
- *IBM An Introduction to DataPropagator Relational, GC26-3398*

Data Facility Data Set Services
- *Data Facility Data Set Services: User's Guide and Reference, SC26-4125*

Database Design

- *DB2 Database Design and Implementation Using DB2, SH24-6101*
- *DB2 Design and Development Guide, Gabrielle Wiorkowski and David Kull, Addison Wesley*
- *Handbook of Relational Database Design, C. Fleming and B Von Halle, Addison Wesley*
- *Principles of Database Systems, Jeffrey D. Ullman, Computer Science Press*

DataHub
- *IBM DataHub General Information, GC26-4874*

DB2 Universal Database
- *DB2 Universal Database Administration Guide, S10J-8157*
- *DB2 Universal Database API Reference, S10J-8167*
- *DB2 Universal Database Application Development Guide, SC09-2845*
- *DB2 Universal Database Building Applications for UNIX Environments, S10J-8161*
- *DB2 Universal Database Building Applications for Windows and OS/2 Environments, S10J-8160*
- *DB2 Universal Database CLI Guide and Reference, S10J-8159*
- *DB2 Universal Database SQL Reference, S10J-8165*

Device Support Facilities
- *Device Support Facilities User's Guide and Reference, GC35-0033*

DFSMS/MVS
- *DFSMS/MVS: Access Method Services for the Integrated Catalog, SC26-4906*
- *DFSMS/MVS: Access Method Services for VSAM Catalogs, SC26-4905*
- *DFSMS/MVS: Administration Reference for DFSMSdss, SC26-4929*
- *DFSMS/MVS: DFSMShsm Managing Your Own Data, SH21-1077*
- *DFSMS/MVS: Diagnosis Reference for DFSMSdfp, LY27-9606*
- *DFSMS/MVS: Macro Instructions for Data Sets, SC26-4913*
- *DFSMS/MVS: Managing Catalogs, SC26-4914*
- *DFSMS/MVS: Program Management, SC26-4916*
- *DFSMS/MVS: Storage Administration Reference for DFSMSdfp, SC26-4920*
- *DFSMS/MVS: Using Advanced Services for Data Sets, SC26-4921*
- *DFSMS/MVS: Utilities, SC26-4926*
- *MVS/DFP: Managing Non-VSAM Data Sets, SC26-4557*

DFSORT
- *DFSORT Application Programming: Guide, SC33-4035*

Distributed Relational Database
- *Data Stream and OPA Reference, SC31-6806*
- *Distributed Relational Database Architecture: Application Programming Guide, SC26-4773*
- *Distributed Relational Database Architecture: Connectivity Guide, SC26-4783*
- *Distributed Relational Database Architecture: Evaluation and Planning Guide, SC26-4650*
- *Distributed Relational Database Architecture: Problem Determination Guide, SC26-4782*
- *Distributed Relational Database: Every Manager's Guide, GC26-3195*
- *IBM SQL Reference, SC26-8416*
- *Open Group Technical Standard (the Open Group presently makes the following books available through their website at www.opengroup.org):*
  - *DRDA Volume 1: Distributed Relational Database Architecture (DRDA), ISBN 1-85912-295-7*
  - *DRDA Volume 3: Distributed Database Management (DDM) Architecture, ISBN 1-85912-206-X*

Education
- *Dictionary of Computing, SC20-1699*
- *IBM Enterprise Systems Training Solutions Catalog, GR28-5467*

Enterprise System/9000 and Enterprise System/3090
- *Enterprise System/9000 and Enterprise System/3090 Processor Resource/System Manager Planning Guide, GA22-7123*

FORTRAN

- *VS FORTRAN Version 2: Language and Library Reference, SC26-4221*
- *VS FORTRAN Version 2: Programming Guide for CMS and MVS, SC26-4222*

High Level Assembler
- *High Level Assembler/MVS and VM and VSE Language Reference, SC26-4940*
- *High Level Assembler/MVS and VM and VSE Programmer's Guide, SC26-4941*

Parallel Sysplex Library
- *System/390 MVS Sysplex Application Migration, GC28-1211*
- *System/390 MVS Sysplex Hardware and Software Migration, GC28-1210*
- *System/390 MVS Sysplex Overview: An Introduction to Data Sharing and Parallelism, GC28-1208*
- *System/390 MVS Sysplex Systems Management, GC28-1209*
- *System/390 MVS 9672/9674 System Overview, GA22-7148*

ICSF/MVS
- *ICSF/MVS General Information, GC23-0093*

IMS/ESA
- *IMS Batch Terminal Simulator General Information, GH20-5522*
- *IMS/ESA Administration Guide: System, SC26-8013*
- *IMS/ESA Application Programming: Database Manager, SC26-8727*
- *IMS/ESA Application Programming: Design Guide, SC26-8016*
- *IMS/ESA Application Programming: Transaction Manager, SC26-8729*
- *IMS/ESA Customization Guide, SC26-8020*
- *IMS/ESA Installation Volume 1: Installation and Verification, SC26-8023*
- *IMS/ESA Installation Volume 2: System Definition and Tailoring, SC26-8024*
- *IMS/ESA Messages and Codes, SC26-8028*
- *IMS/ESA Operator's Reference, SC26-8030*
- *IMS/ESA Utilities Reference: System, SC26-8035*

ISPF
- *ISPF Version 4 Messages and Codes, SC34-4450*
- *ISPF Version 4 for MVS Dialog Management Guide, SC34-4213*
- *ISPF/PDF Version 4 for MVS Guide and Reference, SC34-4258*
- *ISPF and ISPF/PDF Version 4 for MVS Planning and Customization, SC34-4134*

Language Environment for MVS & VM
- *Language Environment for MVS & VM Concepts Guide, GC26-4786*
- *Language Environment for MVS & VM Debugging and Run-Time Messages Guide, SC26-4829*
- *Language Environment for MVS & VM Installation and Customization, SC26-4817*
- *Language Environment for MVS & VM Programming Guide, SC26-4818*
- *Language Environment for MVS & VM Programming Reference, SC26-3312*

MVS/ESA
- *MVS/ESA Analyzing Resource Measurement Facility Monitor I and Monitor II Reference and User's Guide, LY28-1007*
- *MVS/ESA Analyzing Resource Measurement Facility Monitor III Reference and User's Guide, LY28-1008*
- *MVS/ESA Application Development Reference: Assembler Callable Services for OpenEdition MVS, SC23-3020*
- *MVS/ESA Data Administration: Utilities, SC26-4516*
- *MVS/ESA Diagnosis: Procedures, LY28-1844*
- *MVS/ESA Diagnosis: Tools and Service Aids, LY28-1845*
- *MVS/ESA Initialization and Tuning Guide, SC28-1451*
- *MVS/ESA Initialization and Tuning Reference, SC28-1452*
- *MVS/ESA Installation Exits, SC28-1459*
- *MVS/ESA JCL Reference, GC28-1479*
- *MVS/ESA JCL User's Guide, GC28-1473*
- *MVS/ESA JES2 Initialization and Tuning Guide, SC28-1453*
- *MVS/ESA MVS Configuration Program, GC28-1615*
- *MVS/ESA Planning: Global Resource Serialization, GC28-1450*

- *MVS/ESA Planning: Operations, GC28-1441*
- *MVS/ESA Planning: Workload Management, GC28-1493*
- *MVS/ESA Programming: Assembler Services Guide, GC28-1466*
- *MVS/ESA Programming: Assembler Services Reference, GC28-1474*
- *MVS/ESA Programming: Authorized Assembler Services Guide, GC28-1467*
- *MVS/ESA Programming: Authorized Assembler Services Reference, Volumes 1-4, GC28-1475, GC28-1476, GC28-1477, GC28-1478*
- *MVS/ESA Programming: Extended Addressability Guide, GC28-1468*
- *MVS/ESA Programming: Sysplex Services Guide, GC28-1495*
- *MVS/ESA Programming: Sysplex Services Reference, GC28-1496*
- *MVS/ESA Programming: Workload Management Services, GC28-1494*
- *MVS/ESA Routing and Descriptor Codes, GC28-1487*
- *MVS/ESA Setting Up a Sysplex, GC28-1449*
- *MVS/ESA SPL: Application Development Guide, GC28-1852*
- *MVS/ESA System Codes, GC28-1486*
- *MVS/ESA System Commands, GC28-1442*
- *MVS/ESA System Management Facilities (SMF), GC28-1457*
- *MVS/ESA System Messages Volume 1, GC28-1480*
- *MVS/ESA System Messages Volume 2, GC28-1481*
- *MVS/ESA System Messages Volume 3, GC28-1482*
- *MVS/ESA Using the Subsystem Interface, SC28-1502*

Net.Data for OS/390

- *Net.Data Language Environment Guide,*
http://www.ibm.com/software/net.data/docs
- *Net.Data Programming Guide,*
http://www.ibm.com/software/net.data/docs
- *Net.Data Reference Guide,*
http://www.ibm.com/software/net.data/docs

NetView

- *NetView Installation and Administration Guide, SC31-8043*
- *NetView User's Guide, SC31-8056*

ODBC

- *ODBC 2.0 Programmer's Reference and SDK Guide, ISBN 1-55615-658-8*
- *Inside ODBC, ISBN 1-55615-815-7*

OS/390

- *OS/390 C/C++ Programming Guide, SC09-2362*
- *OS/390 C/C++ Run-Time Library Reference, SC28-1663*
- *OS/390 Information Roadmap, GC28-1727*
- *OS/390 Introduction and Release Guide, GC28-1725*
- *OS/390 JES2 Initialization and Tuning Guide, SC28-1791*
- *OS/390 JES3 Initialization and Tuning Guide, SC28-1802*
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