IBM DB2 10.5
for Linux, UNIX, and Windows

Call Level Interface Guide and Reference Volume 1

Updated October, 2014

SC27-5511-01

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Note
Before using this information and the product it supports, read the general information under Appendix B, "Notices," on page 299.

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About this book

The Call Level Interface (CLI) Guide and Reference is in two volumes. Volume 1 describes how to use CLI to create database applications for DB2® for Linux, UNIX, and Windows. Volume 2 is a reference that describes CLI functions, keywords and configuration.

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

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

Chapter 1. Introduction to DB2 Call Level Interface and ODBC

DB2 Call Level Interface (CLI) is IBM's callable SQL interface to the DB2 family of database servers. It is a 'C' and 'C++' application programming interface for relational database access that uses function calls to pass dynamic SQL statements as function arguments.

CLI is an alternative to embedded dynamic SQL, but unlike embedded SQL, it does not require host variables or a precompiler. Applications can be run against a variety of databases without having to be compiled against each of these databases. Applications use procedure calls at run time to connect to databases, issue SQL statements, and retrieve data and status information.

The CLI interface provides many features not available in embedded SQL. For example:

- CLI provides function calls that support a way of querying database catalogs that is consistent across the DB2 family. This reduces the need to write catalog queries that must be tailored to specific database servers.
- CLI provides the ability to scroll through a cursor:
  - Forward by one or more rows
  - Backward by one or more rows
  - Forward from the first row by one or more rows
  - Backward from the last row by one or more rows
  - From a previously stored location in the cursor.
- Stored procedures called from application programs that were written using CLI can return result sets to those programs.

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

The CLI driver also acts as an ODBC driver when loaded by an ODBC driver manager. It conforms to ODBC 3.51.

CLI Background information

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

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

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

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

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

The CLI load library can be loaded as an ODBC driver by an ODBC driver manager. For ODBC application development, you must obtain an ODBC Software Development Kit. For the Windows platform, the ODBC SDK is available as part of the Microsoft Data Access Components (MDAC) SDK, available for download from http://www.microsoft.com/downloads. For non-Windows platforms, the ODBC SDK is provided by other vendors. When developing ODBC applications that may connect to DB2 servers, use the Call Level Interface Guide and Reference Volume 1 and the Call Level Interface Guide and Reference Volume 2 (for information about DB2 specific extensions and diagnostic information), in conjunction with the ODBC Programmer's Reference and SDK Guide available from Microsoft.

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

The following DB2 features are available to both ODBC and CLI applications:

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

Comparison of CLI and ODBC

The level of support that is provided depends on whether you use a DB2 ODBC driver or a CLI driver. In environments without a DB2 ODBC driver manager, CLI is a self-sufficient driver that supports a subset of the functions that are provided by the DB2 ODBC driver.

Figure 1 on page 3 compares CLI and the DB2 ODBC driver. The left side shows an ODBC driver under the ODBC Driver Manager, and the right side illustrates CLI, the callable interface designed for DB2 applications.

Data Server Client refers to all available IBM® Data Server Clients. DB2 server refers to all DB2 server products on Linux, UNIX, and Windows.

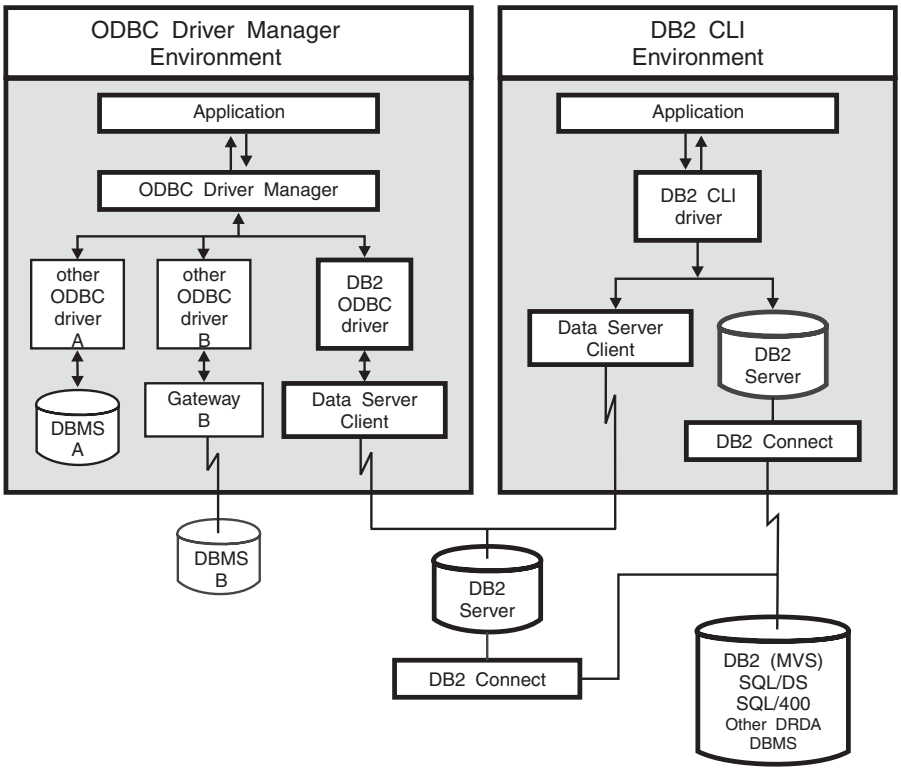


Figure 1. CLI and ODBC.

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

For ODBC application development, you must obtain an ODBC Software Development Kit. For the Windows platform, the ODBC SDK is available as part of the Microsoft Data Access Components (MDAC) SDK, available for download from http://www.microsoft.com/downloads. For non-Windows platforms, the ODBC SDK is provided by other vendors.

Table 1 summarizes the two levels of support, and the CLI and ODBC function summary provides a complete list of ODBC functions and indicates if they are supported.

Table 1. CLI ODBC support

ODBC features	**DB2 ODBC Driver**	**CLI**
Core level functions	All	All
Level 1 functions	All	All
Level 2 functions	All	All, except for `SQLDrivers()`
Additional CLI functions	All, functions can be accessed by dynamically loading the CLI library.	• `SQLSetConnectAttr()` • `SQLGetEnvAttr()` • `SQLSetEnvAttr()` • `SQLSetColAttributes()` • `SQLGetSQLCA()` • `SQLBindFileToCol()` • `SQLBindFileToParam()` • `SQLExtendedBind()` • `SQLExtendedPrepare()` • `SQLGetLength()` • `SQLGetPosition()` • `SQLGetSubString()`
SQL data types	All the types listed for CLI.	• SQL_BIGINT • SQL_BINARY • SQL_BIT • SQL_BLOB • SQL_BLOB_LOCATOR • SQL_CHAR • SQL_CLOB • SQL_CLOB_LOCATOR • SQL_DBCLOB • SQL_DBCLOB_LOCATOR • SQL_DECIMAL • SQL_DOUBLE • SQL_FLOAT • SQL_GRAPHIC • SQL_INTEGER • SQL_LONGVARBINARY • SQL_LONGVARCHAR • SQL_LONGVARGRAPHIC • SQL_NUMERIC • SQL_REAL • SQL_SMALLINT • SQL_TINYINT • SQL_TYPE_DATE • SQL_TYPE_TIME • SQL_TYPE_TIMESTAMP • SQL_VARBINARY • SQL_VARCHAR • SQL_VARGRAPHIC • SQL_WCHAR

Table 1. CLI ODBC support (continued)

ODBC features	DB2 ODBC Driver	CLI
C data types	All the types listed for CLI.	• SQL_C_BINARY • SQL_C_BIT • SQL_C_BLOB_LOCATOR • SQL_C_CHAR • SQL_C_CLOB_LOCATOR • SQL_C_TYPE_DATE • SQL_C_DBCHAR • SQL_C_DBCLOB_LOCATOR • SQL_C_DOUBLE • SQL_C_FLOAT • SQL_C_LONG • SQL_C_SHORT • SQL_C_TYPE_TIME • SQL_C_TYPE_TIMESTAMP • SQL_C_TIMESTAMP_EXT • SQL_C_TINYINT • SQL_C_SBIGINT • SQL_C_UBIGINT • SQL_C_NUMERIC [1] • SQL_C_WCHAR
Return codes	All the codes listed for CLI.	• SQL_SUCCESS • SQL_SUCCESS_WITH_INFO • SQL_STILL_EXECUTING • SQL_NEED_DATA • SQL_NO_DATA_FOUND • SQL_ERROR • SQL_INVALID_HANDLE
SQLSTATES	Mapped to X/Open SQLSTATES with additional IBM SQLSTATES, with the exception of the ODBC type **08**S01.	Mapped to X/Open SQLSTATES with additional IBM SQLSTATES
Multiple connections per application	Supported	Supported
Dynamic loading of driver	Supported	Not applicable

Note:

1. Only supported on Windows operating systems.
2. The listed SQL data types are supported for compatibility with ODBC 2.0.
   - SQL_DATE
   - SQL_TIME
   - SQL_TIMESTAMP

   You should use the SQL_TYPE_DATE, SQL_TYPE_TIME, or SQL_TYPE_TIMESTAMP instead to avoid any data type mappings.
3. The listed SQL data types and C data types are supported for compatibility with ODBC 2.0.
   - SQL_C_DATE
   - SQL_C_TIME
   - SQL_C_TIMESTAMP

   You should use the SQL_C_TYPE_DATE, SQL_C_TYPE_TIME, or SQL_C_TYPE_TIMESTAMP instead to avoid any data type mappings.

Isolation levels

The table 2 maps IBM RDBMSs isolation levels to ODBC transaction isolation levels. The `SQLGetInfo()` function indicates which isolation levels are available.

Table 2. Isolation levels under ODBC

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

Restriction

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

Chapter 2. IBM Data Server CLI and ODBC drivers

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

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

New with DB2 Version 9, there is also a separate CLI and ODBC driver called the IBM Data Server Driver for ODBC and CLI.

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

- For more information about the IBM Data Server Driver for ODBC and CLI, see: "IBM Data Server Driver for ODBC and CLI overview."

IBM Data Server Driver for ODBC and CLI overview

The IBM Data Server Driver for ODBC and CLI provides runtime support for the CLI application programming interface (API) and the ODBC API. .

Though the IBM Data Server Client and IBM Data Server Runtime Client both support the CLI and ODBC APIs, this driver is not a part of either IBM Data Server Client or IBM Data Server Runtime Client. It is available separately, installed separately, and supports a subset of the functionality of the IBM Data Server Client.

Advantages of the IBM Data Server Driver for ODBC and CLI

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

Functionality of the IBM Data Server Driver for ODBC and CLI

The IBM Data Server Driver for ODBC and CLI provides:

- runtime support for the CLI API;
- runtime support for the ODBC API;
- runtime support for the XA API;
- database connectivity;
- support for DB2 Interactive Call Level Interface (db2cli);
- LDAP Database Directory support; and
- tracing, logging, and diagnostic support.
- See: "Restrictions of the IBM Data Server Driver for ODBC and CLI" on page 36.

Obtaining the IBM Data Server Driver for ODBC and CLI software

The IBM Data Server Driver for ODBC and CLI product contains the CLI driver. The IBM Data Server Driver for ODBC and CLI product does not require creation of the DB2 instance.

You can obtain the IBM Data Server Driver for ODBC and CLI product from the DB2 installation media or the IBM Data Server Driver for ODBC and CLI product can be download from the internet. If you are installing from the DB2 installation media, copy the IBM Data Server Driver for ODBC and CLI product image to the target computer.

The IBM Data Server Driver for ODBC and CLI product is a lightweight deployment solution that is designed for independent software vendors (ISV) deployments.

The following steps can be used to obtain the IBM Data Server Driver for ODBC and CLI product from the internet:

Procedure

1. Go to the IBM Support Fix Central website: http://www-933.ibm.com/support/fixcentral/
2. Select the `Information Management` from the **Product Group** drop down box.
3. Select the `IBM Data Server Client Packages` from the **Select from Information Management** drop-down box.
4. Select the IBM Data Server Driver for ODBC and CLI product version that you require from the **Installed Version** drop-down box.
5. Select the platform from the **Platform** drop-down box then click **Continue**.
6. Click **Continue** from the **Identify fixes** window.
7. Select the `DSClients-XXXX-odbc_cli-XX.X.XXX.XXX-FPXXX` product from the list then click **Continue**.
8. Sign in with your IBM ID to proceed with the product download.

   The IBM Data Server Driver for ODBC and CLI product is in a compressed file that is called "`vxxxfpx_ntxxx_odbc_cli.zip`" on Windows operating systems, and "`vxxxfpx_xxxxx_odbc_cli.tar.gz`" on other operating systems.

Installing the IBM Data Server Driver for ODBC and CLI software on Windows operating systems

The IBM Data Server Driver for ODBC and CLI software is a small footprint IBM data server product that provides runtime support for the CLI application programming interface (API) and the ODBC API. The IBM Data Server Driver for ODBC and CLI software does not contain installation program and you must install it manually.

The IBM Data Server Driver for ODBC and CLI product is a lightweight deployment solution that is designed for independent software vendors (ISV) deployments.

Procedure

1. Create a directory for installation of the IBM Data Server Driver for ODBC and CLI software. Following example creates `C:\IBMDB2\CLIDRIVER\` directory when command issue from the `C:\` directory:

   ```
   mkdir IBMDB2\CLIDRIVER\
   ```

   You can install multiple copies of the IBM Data Server Driver for ODBC and CLI software, each on a separate unique directory.
2. Copy the IBM Data Server Driver for ODBC and CLI software that is distributed in compressed file format into the target directory. Following command example copies the IBM Data Server Driver for ODBC and CLI software file into a target installation directory:

   ```
   copy vxxxfpx_ntxxx_odbc_cli.zip C:\IBMDB2\CLIDRIVER\
   ```
3. Extract the IBM Data Server Driver for ODBC and CLI software file. To extract the file, you can use third-party software or right click the IBM Data Server Driver for ODBC and CLI software file in Windows explorer. If you install multiple copies of the IBM data server client products on a same system, ensure that your application references the correct IBM data server client files. The use of the **$PATH** environment variable can lead to inadvertent loading of the incorrect library files. To avoid loading an incorrect driver library, dynamically load the driver library form the target installation directory within your application. Ensure that the following requirements are met if you installed the IBM Data Server Driver for ODBC and CLI software on a network file system (NFS):
   - The following directories must have global write permission
     - `db2dump`
     - `db2`
     - The path that is referenced in the **diagpath** parameter
   - If DB2 for z/OS® or DB2 for i servers are being accessed directly, you must ensure that the `license` directory has both global read and write permissions.
4. Optional: Remove the archived IBM Data Server Driver for ODBC and CLI software file. Following example removes the archived IBM Data Server Driver for ODBC and CLI software file.

   ```
   del vxxxfpx_ntxxx_odbc_cli.zip
   ```
5. Register the CLI driver with Windows ODBC driver manager by issuing the **db2cli install -setup** command with administrator authority. The **db2cli install -setup** command also creates sample configuration files in the application data path. Following command registers the CLI driver with Windows ODBC driver manager:

   ```
   db2cli install -setup
   ```

Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems

The IBM Data Server Driver for ODBC and CLI software is a small footprint IBM data server product that provides runtime support for the CLI application programming interface (API) and the ODBC API. The IBM Data Server Driver for ODBC and CLI software does not contain installation program and you must install it manually.

The IBM Data Server Driver for ODBC and CLI product is a lightweight deployment solution that is designed for independent software vendors (ISV) deployments.

Procedure

1. Create a directory for installation of the IBM Data Server Driver for ODBC and CLI software. Following example creates `db2_cli_odbc_driver` subdirectory under the *$HOME*/`db2user` directory:

   ```
   mkdir $HOME/db2user/db2_cli_odbc_driver
   ```

   You can install multiple copies of the IBM Data Server Driver for ODBC and CLI software, each on a separate unique directory.
2. Copy the IBM Data Server Driver for ODBC and CLI software that is distributed in compressed file format into the target directory. Following command example copies the IBM Data Server Driver for ODBC and CLI software file into a target installation directory:

   ```
   cp vxxxfpx_xxxxx_odbc_cli.tar.gz $HOME/db2user/db2_cli_odbc_driver
   ```
3. Extract and unarchive the IBM Data Server Driver for ODBC and CLI software file. Issue the **gunzip** command and the **tar xvf** command to extract and unarchive the IBM Data Server Driver for ODBC and CLI software file. Following command examples uncompress and unarchive the IBM Data Server Driver for ODBC and CLI software file:

   ```
   gunzip vxxxfpx_xxxxx_odbc_cli.tar.gz
   tar -xvf vxxxfpx_xxxxx_odbc_cli.tar
   ```

   If you installed multiple copies of the IBM data server client products on a same system, ensure that your application references the correct IBM data server client installation. The use of the **LD_LIBRARY_PATH** environment variable (or **LIBPATH** in AIX® operating systems) can lead to inadvertent loading of the incorrect library files. To avoid loading an incorrect driver library, dynamically load the driver library from the target installation directory within your application. Ensure that the following requirements are met if you installed the IBM Data Server Driver for ODBC and CLI software on a network file system (NFS):
   - The following directories must have global write permission
     - `db2dump`
     - `db2`
     - The path that is referenced in the **diagpath** parameter
   - If DB2 for z/OS or DB2 for i servers are being accessed directly, you must ensure that the `license` directory has both global read and write permissions.
4. Optional: Remove the archived IBM Data Server Driver for ODBC and CLI software file. Following example removes the archived IBM Data Server Driver for ODBC and CLI software file.

   ```
   rm vxxxfpx_xxxxx_odbc_cli.tar
   ```

Configuring the IBM Data Server Driver for ODBC and CLI

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

Before you begin

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

- one or more copies of the driver installed.

  See "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.

Procedure

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

1. Configure aspects of the driver's behavior such as data source name, user name, performance options, and connection options by updating the `db2cli.ini` initialization file.

   The location of the`db2cli.ini` file might change based on whether the Microsoft ODBC Driver Manager is used, the type of data source names (DSN) used, the type of client or driver being installed, and whether the registry variable **DB2CLIINIPATH** is set.

   - See "db2cli.ini initialization file."

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

   If you have multiple copies of the IBM Data Server Driver for ODBC and CLI installed, each copy of the driver will have its own `db2cli.ini` file. Ensure you make the additions to the `db2cli.ini` for the correct copy of the driver.
2. Configure application environment variables.
   - See "Configuring environment variables for the IBM Data Server Driver for ODBC and CLI" on page 14.
3. For applications participating in transactions managed by the Microsoft Distributed Transaction Coordinator (DTC) only, you must register the driver with the DTC.
   - See "Registering the IBM Data Server Driver for ODBC and CLI with the Microsoft DTC" on page 18.
4. For ODBC applications using the Microsoft ODBC driver manager only, you must register the driver with the Microsoft driver manager.
   - See "Registering the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager" on page 19.

db2cli.ini initialization file

The `db2cli.ini` file contains various keywords and values that you can use to configure the behavior of the CLI/ODBC driver and CLI/ODBC applications. The

keywords can be associated with a specific database connection or all database connections by CLI and ODBC applications.

To help you get started, the db2cli.ini.sample sample configuration file is included with the IBM data server products.

You can create a db2cli.ini file that is based on the db2cli.ini.sample file and place the db2cli.ini file in the same location as the db2cli.ini.sample file. The db2cli.ini.sample file location is the default location from which the db2cli.ini file is read. The location of the sample configuration file depends on your IBM data server product and the operating system.

On Windows operating systems, there might also be a user-level db2cli.ini initialization file. Depending on the version of Windows operating system, the user-level db2cli.ini initialization file is stored in the \Documents and Settings\UserName or the \Users\UserName directory, where *UserName* represents the name of the logged in user. If there is a user-level db2cli.ini initialization file for the logged in user, the values in the user-level db2cli.ini initialization file take precedence over any other db2cli.ini initialization file. That is, if the same CLI configuration parameter is present in the user-level db2cli.ini initialization file as in any other db2cli.ini initialization file, it is the value in the user-leveldb2cli.ini initialization file that takes effect

For IBM Data Server Client, IBM Data Server Runtime Client, or IBM Data Server Driver Package, the sample configuration file is created in one of the following paths:

- On AIX, HP-UX, Linux, or Solaris operating systems: the *installation_path*/cfg directory
- On Windows operating systems: the C:\ProgramData\IBM\DB2*driver_copy_name*\cfg directory

The *installation_path* value represents the directory into which you installed the IBM data server product. For example, if you install the IBM Data Server Driver Package product on the Windows 7 operating system, and the data server driver copy name is IBMDBCL1, the db2cli.ini.sample file is created in the C:\ProgramData\IBM\DB2\IBMDBCL1\cfg directory.

For the IBM Data Server Driver for ODBC and CLI product installation, the sample configuration file is created in one of the following paths:

- On AIX, HP-UX, Linux, or Solaris operating systems: the *installation_path*/cfg directory
- On Windows operating systems: the C:\ProgramData\IBM\DB2*installation_path*\cfg directory when you run the **db2cli install -setup** command with administrator authority

The *installation_path* value represents the directory into which you extracted the IBM Data Server Driver for ODBC and CLI product. For example, if you install the IBM Data Server Driver for ODBC and CLI product on the Windows 7 operating system into the C:\IBMDB2\CLIDRIVER\ directory, the db2cli.ini.sample file is created in the C:\ProgramData\IBM\DB2\C_IBMDB2_CLIDRIVER\cfg directory.

You can use the **DB2CLIINIPATH** environment variable to specify a different location for the db2cli.ini file.

You can use the CLI/ODBC configuration keywords to perform the following tasks:

- Configure general settings such as the data source name, user name, and password.
- Set options that can affect performance.
- Set query parameters such as wildcard characters.
- Specify patches or workarounds for various ODBC applications.
- Specify settings that are associated with the connection, such as code pages and IBM GRAPHIC data types.
- Override default connection options that are specified by an application. For example, if an application requests Unicode support from the CLI driver by setting the SQL_ATTR_ANSI_APP connection attribute, setting the **DisableUnicode** keyword to 1 in the `db2cli.ini` file forces the CLI driver not to provide the application with Unicode support.

  Important: If the values of the CLI/ODBC configuration keywords that you set in the `db2cli.ini` file conflict with the values of keywords in the `SQLDriverConnect()` connection string, the values of the `SQLDriverConnect()` keywords take precedence.

You can set most CLI/ODBC keywords in the `db2cli.ini` initialization file. However, you must set some keywords in the connection string for the `SQLDriverConnect()` function call.

The scope of the CLI/ODBC keywords is determined by the placement of the keywords within the `db2cli.ini` initialization file. If you specify the CLI keywords in a specific database section (data source section) within the `db2cli.ini` initialization file, the keywords are applicable only when your CLI/ODBC application is connected to that particular database. If the CLI keywords are listed in the `[COMMON]` section within the `db2cli.ini` initialization file, the keywords affect all CLI application connections to databases.

You can specify the following CLI keywords only in the `[COMMON]` section:

- **CheckForFork**
- **DiagPath**
- **DisableMultiThread**
- **JDBCTrace**
- **JDBCTraceFlush**
- **JDBCTracePathName**
- **QueryTimeoutInterval**
- **ReadCommonSectionOnNullConnect**
- **Trace**
- **TraceComm**
- **TraceErrImmediate**
- **TraceFileName**
- **TraceFlush**
- **TraceFlushOnError**
- **TraceLocks**
- **TracePathName**
- **TracePIDList**
- **TracePIDTID**
- **TraceRefreshInterval**

- **TraceStmtOnly**
- **TraceTime**
- **TraceTimeStamp**

The [COMMON] section of the db2cli.ini file begins with the heading [COMMON].

Before you set a common keyword for a client, it is important to evaluate the effect of the keyword on all CLI/ODBC connections from that client. For example, the **TRACE** keyword generates information about all CLI/ODBC applications that connect to DB2 database servers on that client.

The database-specific section begins with the data source name (DSN) between square brackets:

[*data_source_name*]

The name that is enclosed between square brackets is called a *section header*.

You set a keyword to a value by using the following format:

KeywordName=keywordValue

The following other rules apply:

- All the keywords and their associated values for a particular database must be located under the database section header.
- If the database-specific section does not contain a **DBAlias** keyword, the data source name is used as the database alias when the connection is established.
- The keywords are not case-sensitive; however, their values can be.
- If a database is not found in the db2cli.ini file, the default values for the keywords apply.
- You introduce comments by putting a semicolon in the first position of a new line.
- Blank lines are allowed.
- If duplicate entries for a keyword exist, the first entry is used, and no warning is given.

The following sample db2cli.ini file contains two database alias sections:

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

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

Although you can edit the db2cli.ini file manually on all operating systems, you can also use the **UPDATE CLI CONFIGURATION** command if it is available. You must add a blank line after the last entry if you manually edit the db2cli.ini file.

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

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

To use the IBM Data Server Driver for ODBC and CLI, there are two types of environment variables that you might have to set: environment variables that have replaced some DB2 registry variables; and an environment variable that tells your applications where to find the driver libraries.

Before you begin

To configure environment variables for the IBM Data Server Driver for ODBC and CLI, you need one or more copies of the driver installed. See "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.

Restrictions

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

IBM Data Server Driver for ODBC and CLI on 64 bit UNIX and Linux systems also packages 32 bit driver library to support 32 bit CLI applications. On UNIX and Linux systems, you can associate either 32 bit or 64 bit libraries with an instance, not both. You can set **LIBPATH** or **LD_LIBRARY_PATH** to either `lib32` or `lib64` library directories of IBM Data Server Driver for ODBC and CLI. You can also access `lib64` library using a preset soft link from the `lib` directory. The IBM Data Server Driver for ODBC and CLI on Windows systems contains both 32 bit and 64 bit necessary runtime DLLs in the same `bin` directory.

Procedure

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

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

   There is no support for the command line processor (CLP) with the IBM Data Server Driver for ODBC and CLI. For this reason, you cannot configure DB2 registry variables using the **db2set** CLP command. Required DB2 registry variables have been replaced with environment variables.

   For a list of the environment variables that can be used instead of DB2 registry variables, see: "Environment variables supported by the IBM Data Server Driver for ODBC and CLI" on page 16.
2. Optional: You can set the local environment variable **DB2_CLI_DRIVER_INSTALL_PATH** to the directory in which the driver is installed.

   If there are multiple copies of the IBM Data Server Driver for ODBC and CLI installed, ensure that the **DB2_CLI_DRIVER_INSTALL_PATH** points to the intended copy of the driver. Setting the **DB2_CLI_DRIVER_INSTALL_PATH** variable forces IBM Data Server Driver for ODBC and CLI to use the directory specified with the **DB2_CLI_DRIVER_INSTALL_PATH** variable as the install location of the driver. For example:

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

where /home/db2inst1/db2clidriver is the install path where the CLI driver is installed

3. Optional: Set the environment variable **LIBPATH** (on AIX operating systems), **SHLIB_PATH** (on HP-UX systems), or **LD_LIBRARY_PATH** (on rest of the UNIX and Linux systems) to the lib directory in which the driver is installed. For example (on AIX systems):

   ```
   export LIBPATH=/home/db2inst1/db2clidriver/clidriver/lib
   ```

   If there are multiple copies of the IBM Data Server Driver for ODBC and CLI installed, ensure **LIBPATH** or **LD_LIBRARY_PATH** points to the intended copy of the driver. Do not set **LIBPATH** or **LD_LIBRARY_PATH** variables to multiple copies of the IBM Data Server Driver for ODBC and CLI that are installed on your system. Do not set **LIBPATH** or **LD_LIBRARY_PATH** variables to both lib32 and lib64 (or lib) library directories.

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

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

4. Optional: Set the **PATH** environment variable to include the bin directory of the driver installation in all systems if you require the use of utilities like **db2level**, **db2cli**, and **db2trc**. In UNIX and Linux systems, add adm directory of the driver installation to the **PATH** environment variable in addition to the bin directory. For Example (on all UNIX and Linux systems) :

   ```
   export PATH=/home/db2inst1/db2clidriver/clidriver/bin:/home/db2inst1/db2clidriver/clidriver/adm:$PATH
   ```

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

The IBM Data Server Driver for ODBC and CLI does not support the command line processor (CLP), which means that you cannot set DB2 registry variables by using the **db2set** CLP command. Relevant DB2 registry variables are supported with the IBM Data Server Driver for ODBC and CLI as environment variables instead.

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

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

Table 3. DB2 registry variables supported as environment variables

Type of variable	Variable name(s)
General variables	**DB2ACCOUNT** **DB2BIDI** **DB2CODEPAGE** **DB2GRAPHICUNICODESERVER** **DB2LOCALE** **DB2TERRITORY**
System environment variables	**DB2DOMAINLIST**

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

Type of variable	Variable name(s)
Communications variables	**DB2_FORCE_NLS_CACHE** **DB2SORCVBUF** **DB2SOSNDBUF** **DB2TCP_CLIENT_RCVTIMEOUT**
Performance variables	**DB2_NO_FORK_CHECK**
Miscellaneous variables	**DB2CLIINIPATH** **DB2DSDRIVER_CFG_PATH** **DB2DSDRIVER_CLIENT_HOSTNAME** **DB2_ENABLE_LDAP** **DB2LDAP_BASEDN** **DB2LDAP_CLIENT_PROVIDER** **DB2LDAPHOST** **DB2LDAP_KEEP_CONNECTION** **DB2LDAP_SEARCH_SCOPE** **DB2NOEXITLIST**
Diagnostic variables	**DB2_DIAGPATH**
Connection variables	**AUTHENTICATION** **PROTOCOL** **PWDPLUGIN** **KRBPLUGIN** **ALTHOSTNAME** **ALTPORT** **INSTANCE** **BIDI**

db2oreg1.exe overview

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

You need to use the `db2oreg1.exe` utility on Windows operating systems only.

The `db2oreg1.exe` utility is deprecated and will become unavailable in a future release. Use the **db2cli** DB2 interactive CLI command instead.

For IBM Data Server client packages on Windows 64-bit operating systems, the 32-bit version of the `db2oreg1.exe` utility (`db2oreg132.exe`) is supported in addition to the 64-bit version of `db2oreg1.exe`.

Conditions requiring that you run the db2oreg1.exe utility

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

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

You can also run the `db2oreg1.exe` utility to create the `db2dsdriver.cfg.sample` and `db2cli.ini.sample` sample configuration files.

When to run the db2oreg1.exe utility

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

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

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

How to run the db2oreg1.exe utility

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

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

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

To use the IBM Data Server Driver for ODBC and CLI with database applications that participate in transactions managed by the Microsoft Distributed Transaction Coordinator (DTC), you must register the driver with the DTC.

Here is a link to the Microsoft article outlining the details of this security requirement: Registry Entries Are Required for XA Transaction Support

Before you begin

To register the IBM Data Server Driver for ODBC and CLI with the DTC, you need one or more copies of the driver installed. See: "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.

Restrictions

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

Procedure

To register the IBM Data Server Driver for ODBC and CLI with the DTC, run the `db2cli install -setup` command for each copy of the driver that is installed: The `db2cli install -setup` command makes changes to the Windows registry when you run it after installing the driver. If you uninstall the driver, you should run the `db2cli install -cleanup` command to undo those changes.

Example

For example, the following command registers the IBM Data Server Driver for ODBC and CLI in the Windows registry, and creates the configuration folders under the application data path:

```
> db2cli install -setup

The IBM Data Server Driver for ODBC and CLI registered successfully.
The configuration folders are created successfully.
```

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

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

Before you begin

To register the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager, you need one or more copies of the driver installed. See: "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.

About this task

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

Procedure

To register the IBM Data Server Driver for ODBC and CLI with the Microsoft driver manager, run the **db2cli install -setup** command for each copy of the driver that is installed.

Results

The **db2cli install -setup** command changes the Windows registry when you run it after installing the driver. If you uninstall the driver, run the **db2cli install -cleanup** command to undo those changes.

Example

For example, the following command registers the IBM Data Server Driver for ODBC and CLI in the Windows registry, and creates the configuration folders under the application data path:

```
> db2cli install -setup

The IBM Data Server Driver for ODBC and CLI registered successfully.
The configuration folders are created successfully.
```

Connecting to databases for ODBC and CLI

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

The IBM Data Server Driver for ODBC and CLI does not create a local database directory. This means that when you use this driver, you must make connectivity information available to your applications in other ways.

Before you begin

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

- Databases to which to connect; and
- One or more copies of the driver installed.
  - For more information, see "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.

About this task

There are several ways to specify connectivity information so that your CLI and ODBC database applications can use the IBM Data Server Driver for ODBC and CLI to connect to a database. When CLI settings are specified in multiple places, they are used in the listed order:

1. Connection strings parameters
2. `db2cli.ini` file
3. `db2dsdriver.cfg` file

Procedure

To configure connectivity for a database when using the IBM Data Server Driver for ODBC and CLI, use one of the listed methods:

- Specify the database connectivity information in the connection string parameter to SQLDriverConnect.
  - For more information, see "SQLDriverConnect function (CLI) - Connect to a data source" on page 25.
- For CLI applications only: put the database connectivity information in the CLI configuration file.

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

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

  For more information about the location of the `db2cli.ini` file, see "db2cli.ini initialization file" on page 11.
- Use the `db2dsdriver.cfg` configuration file to provide connection information and parameters. For example, you can specify the listed information in the `db2dsdriver.cfg` configuration file, and pass the connection string in SQLDriverConnect() as `DSN=myDSN;PWD=XXXXX`:

```
<configuration>
  <dsncollection>
    <dsn alias="myDSN" name="sample" host="server.domain.com" port="446">
    </dsn>
  </dsncollection>
  <databases>
    <database name="sample" host="server.domain.com" port="446">
      <parameter name="CommProtocol" value="TCPIP"/>
      <parameter name="UID" value="username"/>
    </database>
  </databases>
</configuration>
```

- You can register the ODBC data source names (DSN) during silent installation on Windows platforms.

  Specify the DB2_ODBC_DSN_TYPE and DB2_ODBC_DSN_ACTION keywords in the installation response file to register the ODBC DSNs. You can specify the type of DSN and also provide a complete list of DSNs.

  DSNs are registered during silent installation for the current copy name only. Installation does not update ODBC DSN registries of any other copy available on the same client system.

  For a 32-bit client package, installation creates ODBC DSNs under 32-bit registry hierarchy. For a 64-bit client package, installation creates ODBC DSNs under both the 32-bit and 64-bit registry hierarchy. However, for `USER` DSNs in a 64-bit client package, because Windows maintains a common ODBC DSN registry entry for both 32-bit and 64-bit product environments, installation modifies only the 64-bit user DSNs.

  Note: The Windows platform maintains different registry paths to track 32-bit and 64-bit product environment settings for `SYSTEM` DSNs. So this restriction is not applicable for `SYSTEM` DSNs and installation adds system DSNs to both 32-bit and 64-bit registry hierarchy.
- For ODBC applications only: register the database as an ODBC data source with the ODBC driver manager. For more information, see "Registering ODBC data sources for applications that use the IBM Data Server Driver for ODBC and CLI" on page 22.
- Use the **FileDSN** CLI/ODBC keyword to identify a file data source name (DSN) that contains the database connectivity information. For more information, see "FileDSN CLI/ODBC configuration keyword" on page 31.

  A file DSN is a file that contains database connectivity information. You can create a file DSN by using the **SaveFile** CLI/ODBC keyword. On Windows operating systems, you can use the Microsoft ODBC driver manager to create a file DSN.
- For local database servers only: use the **PROTOCOL** and the **INSTANCE** CLI/ODBC keywords to identify the local database.
  1. Set the **PROTOCOL** CLI/ODBC keyword to the value `Local`.
  2. Set the **INSTANCE** CLI/ODBC keyword to the instance name of the local database server on which the database is located.

  For more information, see "Protocol CLI/ODBC configuration keyword" on page 33 and "Instance CLI/ODBC configuration keyword" on page 31.

Example

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

- "AltHostName CLI/ODBC configuration keyword" on page 29;
- "AltPort CLI/ODBC configuration keyword" on page 30;
- "Authentication CLI/ODBC configuration keyword" on page 30;
- "BIDI CLI/ODBC configuration keyword" on page 31;
- "FileDSN CLI/ODBC configuration keyword" on page 31;
- "Instance CLI/ODBC configuration keyword" on page 31;
- "Interrupt CLI/ODBC configuration keyword" on page 32;
- "KRBPlugin CLI/ODBC configuration keyword" on page 33;
- "Protocol CLI/ODBC configuration keyword" on page 33;

- "PWDPlugin CLI/ODBC configuration keyword" on page 33;
- "SaveFile CLI/ODBC configuration keyword" on page 34;
- "DiagLevel CLI/ODBC configuration keyword" on page 39;
- "NotifyLevel CLI/ODBC configuration keyword" on page 39;

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

- The database or subsystem is called `db1` on the server
- The server is located at `11.22.33.44`
- The access port is `56789`
- The transfer protocol is `TCPIP`.

To make a connection to the database in a CLI application, you can perform one of the listed actions:

- Call SQLDriverConnect with a connection string that contains: `Database=db1; Protocol=tcpip; Hostname=11.22.33.44; Servicename=56789;`
- Add the example to `db2cli.ini`:

```
[db1]
Database=db1
Protocol=tcpip
Hostname=11.22.33.44
Servicename=56789
```

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

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

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

You must install and configure the IBM Data Server Driver for ODBC and CLI before an ODBC database application can use the driver. This driver is not part of the IBM Data Server Client or the IBM Data Server Runtime Client.

Before you begin

To register a database as an ODBC data source and associate the IBM Data Server Driver for ODBC and CLI with the database, listed requirements must be met:

- Databases to which your ODBC applications connect
- An ODBC driver manager installed
- One or more copies of the IBM Data Server Driver for ODBC and CLI installed
  - See: "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.
- one or more copies of the driver installed.
  - See: "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.

About this task

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

If you have multiple copies of the IBM Data Server Driver for ODBC and CLI installed, ensure that the intended copy is identified in the `odbc.ini` file. When possible, avoid installing multiple copies of this driver.

Procedure

This procedure depends on which driver manager you are using for your applications.

- For the Microsoft ODBC driver manager, perform the listed actions:
  1. Register the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager by using the `db2cli install -setup` command. See "Registering the IBM Data Server Driver for ODBC and CLI with the Microsoft ODBC driver manager" on page 19.
  2. Register the database as an ODBC data source. See "Setting up the Windows CLI environment" on page 265.
- For open source ODBC driver managers, perform the listed actions:
  1. Identify the database as an ODBC data source by adding database information to the `odbc.ini` file. See "Setting up the ODBC environment (Linux and UNIX)" on page 261.
  2. Associate the IBM Data Server Driver for ODBC and CLI with the data source by adding it in the database section of the `odbc.ini` file. You must use the fully qualified library file name.

Results

Whenever you create a Microsoft ODBC data source by using the ODBC Driver Manager, you must manually open the ODBC data source Administrator and create a data source by checking the contents of the `db2cli.ini` file or the `db2dsdriver.cfg` file. There is no command-line utility that reads the `db2cli.ini` file or the `db2dsdriver.cfg` file and creates a Microsoft ODBC data source. The **db2cli** command provides additional options to create a Microsoft ODBC data source through the **registerdsn** command parameter, which offers the listed functions:

- Registers a Microsoft system or user ODBC data source if a data source entry is available in the `db2cli.ini` or `db2dsdriver.cfg` file or in the local database directory as a cataloged database.
- Lists all the DB2 system or user data sources that are already registered in the Microsoft Data Source Administrator.
- Removes the system or user data sources that are already registered in the Microsoft Data Source Administrator.

Note: The **db2cli registerdsn** command is supported only on Microsoft Windows operating systems.

Example

You want to register ODBC data sources with an open source driver manager under the listed conditions:

- The operating system for the target database server is AIX.
- There are two copies of the IBM Data Server Driver for ODBC and CLI installed at
  - `$HOME/db2_cli_odbc_driver1` and
  - `$HOME/db2_cli_odbc_driver2`

- You have two ODBC database applications:
  - ODBCapp_A
    - ODBCapp_A connects to two data sources, db1 and db2
    - The application should use the copy of the driver installed at $HOME/db2_cli_odbc_driver1.
  - ODBCapp_B
    - ODBCapp_B connects to the data source db3
    - The application should use the copy of the driver installed at $HOME/db2_cli_odbc_driver2.

To register ODBC data sources with an open source driver manager, add the example entries in the odbc.ini file:

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

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

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

Every time when a Microsoft ODBC Data Source (using ODBC Driver Manager) has to be created, user has to manually open the ODBC Data Source Administrator and create a Data Source by checking the contents of db2cli.ini or the db2dsdriver.cfg files. There is no command line utility which reads the db2cli.ini file or the db2dsdriver.cfg file and creates a Microsoft ODBC Data Source. Hence to overcome this concern, the **db2cli** provides additional options to create a Microsoft ODBC Data Source through the new **registerdsn** command parameter which offers the listed functions:

- Register a Microsoft System/User ODBC Data Source if a Data Source entry is available in db2cli.ini or in db2dsdriver.cfg file
- Register all the Data Sources available in the db2cli.ini file or the db2dsdriver.cfg file at the same time. The data sources can be registered either as a System Data Source or as a User Data Source
- Lists all the DB2 System or User Data Sources that are already registered in the Microsoft Data Source Administrator
- Remove the System or User Data Sources that are already registered in the Microsoft Data Source Administrator

Note: The **db2cli registerdsn** is supported only on Microsoft Windows platforms.

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

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

Procedure

Using security plug-ins with the IBM Data Server Driver for ODBC and CLI is no different from using security plug-ins with an IBM Data Server Client or IBM Data

Server Runtime Client.
When you read about using security plug-ins throughout the DB2 Information Center and DB2 books, consider the IBM Data Server Driver for ODBC and CLI like an IBM Data Server Client. Details about using security plug-ins with IBM Data Server Clients apply to using security plug-ins with the IBM Data Server Driver for ODBC and CLI too.

SQLDriverConnect function (CLI) - Connect to a data source

Establishes a connection to a target database. The SQLDriverConnect() function supports connection strings and the ability to prompt the user for connection information.

Specification:

- **CLI** 2.1
- **ODBC** 1.0

The SQLDriverConnect() function is an alternative to the SQLConnect() function. You can use the SQLDriverConnect() function when the data source requires more than the three parameters that are supported by the SQLConnect() function (data source name, user ID, and password) or when you require the CLI driver to prompt the user for required connection information.

A complete connection string is returned in plain text only after a connection is successful. You can code your application to store the returned connection string for subsequent connection requests.

Syntax

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

Function arguments

Table 4. SQLDriverConnect function arguments

Data type	Argument	Use	Description
SQLHDBC	*ConnectionHandle*	Input	Connection handle.
SQLHWND	*WindowHandle*	Input	Window handle. The *WindowHandle* argument value is the parent Windows operating system handle. The window handle is supported only on Windows operating systems. If a `NULL` value is passed, no user prompt is presented.
SQLCHAR *	*InConnectionString*	Input	Connection string. See the usage section for details.
SQLSMALLINT	*InConnectionStringLength*	Input	Number of SQLCHAR elements (or SQLWCHAR elements for the Unicode variant of this function) that are needed to store the connection string that is specified for the *InConnectionString* argument.

Table 4. SQLDriverConnect function arguments (continued)

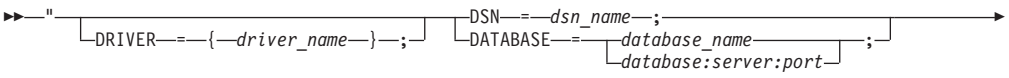
Data type	Argument	Use	Description
SQLSMALLINT *	*OutConnectionString*	Output	Pointer to a buffer for the completed connection string for a successful connection or the NULL value. For this buffer, applications must allocate at least the number of bytes that you specify for the predefined maximum length (SQL_MAX_OPTION_STRING_LENGTH).
SQLSMALLINT	*OutConnectionString Capacity*	Input	Number of SQLCHAR elements (or SQLWCHAR elements for the Unicode variant of this function) that are needed to store the connection string that is returned through the buffer that is specified for the *OutConnectionString* argument.
SQLSMALLINT *	*OutConnectionString LengthPtr*	Output	Pointer to the number of SQLCHAR elements (or SQLWCHAR elements for the Unicode variant of this function), excluding the null-termination character, that is available to return in the buffer that is specified by the *OutConnectionString* argument. If the returned length value in the **OutConnectionStringLengthPtr* argument is greater than or equal to the *OutConnectionStringCapacity* argument value, the completed connection string in the buffer that is specified by the *OutConnectionString* argument is truncated to *OutConnectionStringCapacity* - 1 SQLCHAR or SQLWCHAR elements.
SQLUSMALLINT	*DriverCompletion*	Input	Indicator of when the CLI driver prompts the user for more information. Possible values are as follows: • SQL_DRIVER_COMPLETE • SQL_DRIVER_COMPLETE_REQUIRED • SQL_DRIVER_NOPROMPT • SQL_DRIVER_PROMPT

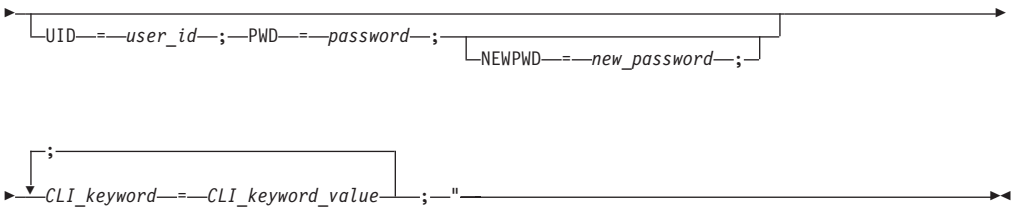
Usage

Unicode equivalent: You can also use this function with the Unicode character set. The corresponding Unicode function is SQLDriverConnectW().

InConnectionString argument

The *InConnectionString* argument consists of a valid connection string. A connection string has the following syntax:





DRIVER=*driver_name*
Name of the database driver. You can obtain the name of the database driver with the SQLDrivers() function.

DSN=*dsn_name*
The name of the data source that you are connecting to. The **DSN** keyword value is required for a connection unless the *DriverCompletion* argument is equal to SQL_DRIVER_NOPROMPT or the **DATABASE** keyword value is specified.

DATABASE=*database_name*
The database identifier. The database name can consist of just the database name or can consist of the database name, server name, and port number. If you do not provide a server name and port number, the default values are used. The default server name is LOCALHOST and the default port number is 50000. The **DATABASE** keyword value is required for a connection unless the *DriverCompletion* argument is equal to SQL_DRIVER_NOPROMPT or the **DSN** keyword value is specified.

UID A user ID that is specified for the connection authentication request.

PWD The password that corresponds to the specified user ID.

NEWPWD A new password that is used as part of a change password request. You can specify a new password in the connection string, or specify NEWPWD=; in the connection string for a new password prompt if you do not set the *DriverCompletion* argument to SQL_DRIVER_NOPROMPT.

CLI_keyword
A CLI configuration keyword that is used to configure the behavior of the CLI driver. If any CLI keywords are specified more than once in the connection string, the first occurrence of the keyword is used.

For connection string keywords (other than the **PWD** and **NEWPWD** keywords) and their values, avoid the use of the following characters:

- Opening bracket ([)
- Closing bracket (])
- Opening brace ({)
- Closing brace (})
- Comma (,)
- Semicolon (;)
- Question mark (?)
- Asterisk (*)
- Equal sign (=)
- Exclamation mark (!)
- At sign (@)
- Backslash (\)

The CLI driver supports special characters for the **PWD** and **NEWPWD** keywords, with limitations. See the "Password rules for drivers and CLPPlus" topic in the related reference for details.

OutConnectionString argument

The *OutConnectionString* argument can be a pointer to a buffer or the NULL value. If a pointer to a buffer is specified, the buffer is populated with the connection string upon a successful connection. Applications that require multiple connections to the same database for the same user ID can store this output connection string. The returned connection string can then be used as the input connection string value on future calls to the SQLDriverConnect() function. The NULL value causes the pointer that is specified for the *OutConnectionString LengthPtr* argument to return the number of characters in the connection string upon successful connection.

If any keywords exist in the CLI initialization file, the keywords and their values are used to augment the information that is passed to the CLI driver in the connection string. If the information in the CLI initialization file contradicts information in the connection string, the values in the connection string take precedence.

DriverCompletion argument

The following values of the *DriverCompletion* argument determine whether the CLI driver prompts the user for more information:

SQL_DRIVER_COMPLETE
A dialog is initiated only if there is insufficient information in the connection string. The information from the connection string is used as initial values and is supplemented by data that is entered when the user is prompted.

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

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

SQL_DRIVER_PROMPT
A dialog is always initiated. The information from the connection string and the CLI initialization file is used as initial values.

After a connection is established, the complete connection string is returned. Applications that require multiple connections to the same database with the same user ID can store this output connection string. This string can then be used as the input connection string value on future SQLDriverConnect() calls.

Return codes

- SQL_ERROR
- SQL_INVALID_HANDLE
- SQL_NO_DATA_FOUND
- SQL_SUCCESS
- SQL_SUCCESS_WITH_INFO

Diagnostics

The following table contains the diagnostic messages that the SQLDriverConnect() function can return:

Table 5. The SQLSTATES values that can be returned by the SQLDriverConnect function

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

Example

The following code example demonstrates the use of the SQLDriverConnect() function:

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

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

AltHostName CLI/ODBC configuration keyword:

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

db2cli.ini keyword syntax:

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

Usage notes:

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

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

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

AltPort CLI/ODBC configuration keyword:

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

db2cli.ini keyword syntax:

AltPort = *port number*

Usage notes:

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

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

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

Authentication CLI/ODBC configuration keyword:

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

db2cli.ini keyword syntax:

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

Default setting:

Not specified

Usage notes:

The **Authentication** keyword can be set in the data source section ([data source]) of the db2cli.ini file, or in a connection string.

When you set the **Authentication** keyword, you must also set the following CLI/ODBC keywords in the db2cli.ini file:

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

If the **Protocol** keyword is set to IPC (**Protocol**=IPC), you must also set the **Instance** keyword.

If the **Protocol** keyword is set to TCPIP (**Protocol**=TCPIP), you must set the following CLI/ODBC keywords in the db2cli.ini file:

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

If the **Authentication** keyword is set to KERBEROS, you must also set the **TargetPrinciple** keyword. When the **Authentication** keyword is set to

Kerberos, you can optionally specify the **KRBPlugin** keyword. If the **KRBPlugin** keyword is not specified, the default IBMkrb5 plug-in is used.

You can specify the SSL client authentication by setting the **Authentication** keyword to the CERTIFICATE value in the db2cli.ini for connection to DB2 for z/OS servers with following conditions:

- A connection to the server must be established with the CLI driver. The CERTIFICATE authentication is specific to CLI, and ODBC connections.
- DB2 for z/OS server must be Version 10 or later. If you are connecting to DB2 for z/OS Version 10 server, APAR PM53450 must be installed.
- Connections to DB2 for z/OS server must be a direct connection between DB2 client and supported DB2 for z/OS server. You cannot use DB2 Connect server as a gateway to establish connection to target DB2 for z/OS servers.
- The **SSLClientLabel** keyword must set.
- A connection to supported DB2 for z/OS servers must be made with the application connection string, the IBM data server driver configuration file or the db2cli.ini file. You cannot use the local database catalog to establish connections to DB2 for z/OS servers.
- You cannot specify a user password.

BIDI CLI/ODBC configuration keyword:

Specifies the BIDI code page when connected to a DB2 for z/OS.

db2cli.ini keyword syntax:

BIDI = *code page*

Usage notes:

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

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

- Database
- Protocol=TCPIP
- Hostname
- Port

FileDSN CLI/ODBC configuration keyword:

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

db2cli.ini keyword syntax:

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

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

```
FileDSN = file name
```

Instance CLI/ODBC configuration keyword:

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

db2cli.ini keyword syntax:

Instance = *instance name*

Usage notes:

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

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

- Database
- Protocol=IPC

Interrupt CLI/ODBC configuration keyword:

Sets the interrupt processing mode.

db2cli.ini keyword syntax:

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

Default setting:

In Version 10.5 GA client:

1

In Version 10.5 Fix Pack 2 and later client:

1 for connection to all database servers other than DB2 for z/OS servers.

2 for connection to DB2 for z/OS servers.

Important: The default value affects direct connection to DB2 for z/OS server.

Usage notes:

The **Interrupt** keyword can be set in the [*Data_Source*] section of the db2cli.ini file for a specific data source, or in a connection string.

The **Interrupt** keyword can be set to following values:

0 Disables interrupt processing. The SQLCancel function call does not interrupt the processing.

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

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

When you connect to a DB2 for z/OS server with the interrupt mode 1 setting, the following operations are not interrupted:

- Stored procedure operations.
- SQL statement operations that hold a DB2 internal resource lock manager (IRLM) lock used by DB2 for z/OS servers to serialize access to your data. DB2 for z/OS servers request locks from IRLM to ensure data integrity when applications, utilities, and commands attempt to access the same data.

2 Interrupt drops the connection regardless of server's interrupt capabilities. The SQLCancel function call drops the connection.

The TCPIP protocol is required for the **Interrupt** setting 2.

In Version 10.5 Fix Pack 2 and later, interrupt processing mode 2 is the default value when you are directly connecting to a DB2 for z/OS server.

KRBPlugin CLI/ODBC configuration keyword:

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

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

Default setting:
By default, the value is null on UNIX operating systems, and `IBMkrb5` on Windows operating systems.

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

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

Protocol CLI/ODBC configuration keyword:

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

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

Default setting:
none

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

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

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

- Database;
- ServiceName; and
- Hostname.

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

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

PWDPlugin CLI/ODBC configuration keyword:

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

db2cli.ini keyword syntax:
PWDPlugin = *plug-in name*

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

Usage notes:

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

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

SaveFile CLI/ODBC configuration keyword:

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

db2cli.ini keyword syntax:

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

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

```
SaveFile = file name
```

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

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

Before you begin

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

- one or more copies of the driver installed.
  - See: "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.
- to have configured the application environment for the driver.
  - See: "Configuring the IBM Data Server Driver for ODBC and CLI" on page 11.

Procedure

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

- Ensure your applications use only the CLI, ODBC and XA API functions that are supported by the driver.
  - See:
    - "CLI and ODBC API support in the IBM Data Server Driver for ODBC and CLI" on page 35
    - "XA API support in the IBM Data Server Driver for ODBC and CLI" on page 35

- Ensure your applications are not attempting to make use of IBM Data Server Client or IBM Data Server Runtime Client functionality that is restricted in the driver.
  - See: "Restrictions of the IBM Data Server Driver for ODBC and CLI" on page 36
- Use the 32-bit version of the driver with 32-bit database applications, and use the 64-bit version of the driver with 64-bit database applications.
- Understand the available tracing, logging, and diagnostic support provided by the driver for investigating problems.
  - See: "Diagnostic support in the IBM Data Server Driver for ODBC and CLI" on page 37

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

The IBM Data Server Driver for ODBC and CLI supports the ANSI and the Unicode versions of some ODBC and CLI functions where they exist.

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

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

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

The IBM Data Server Driver for ODBC and CLI product is not part of the IBM Data Server Client product or the IBM Data Server Runtime Client product. You must install and configure it separately; and it provides a subset of the functionality of either IBM data server client product.

You can use the XA API functions with the IBM Data Server Driver for ODBC and CLI product.

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

xa_open
xa_close
xa_start
xa_end
xa_prepare
xa_commit
xa_rollback
xa_forget
xa_recover

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

The IBM Data Server Driver for ODBC and CLI supports the LDAP Database Directory. However, the LDAP cache is not saved to disk. The LDAP cache is an in-memory cache only and the DB2LDAPCACHE registry variable is ignored.

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. You must install and configure it separately; and it provides a subset of the functionality of either IBM Data Server client. It also supports LDAP Database Directory.

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

Restrictions of the IBM Data Server Driver for ODBC and CLI

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

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

- The DB2 CLI application programming interface (API)
- The ODBC API
- The XA API
- Database connectivity
- The DB2 Interactive Call Level Interface (db2cli)

The following restrictions apply to the IBM Data Server Driver for ODBC and CLI:

- No other database product can be installed in the same path if the IBM Data Server Driver for ODBC and CLI is already installed.
- On Windows operating systems, you can install a maximum of 16 copies of the IBM Data Server Driver for ODBC and CLI.
- To connect to a z/OS server or a System i® server, you must register a DB2 Connect license key. (Retrieve the license file from your Passport Advantage® distribution, for example db2conpe.lic, then copy the license file to the license directory under the directory where the driver was installed.)
- XA connections against a z/OS server are supported. However, XA connections against a System i server are not supported.

- If you use the configuration file db2dsdriver.cfg to specify aliases, the following entries must contain a value:
  - <dsncollection> entries (alias, name, host, and port)
  - <database> entries (name, host, port).

  These entries must be specified and cannot be empty.
- The CLI/ODBC configuration keyword DBNAME is not supported.
- The CLI LOAD utility statement attribute, sql_attr_use_load_api, is not supported.

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

- CLI and ODBC application development
- the DB2 Command Line Processor (CLP)
- administrative APIs
- the CLIENT authentication type is not supported by the IBM Data Server Driver for ODBC and CLI and by the IBM Data Server Driver Package
- installation program
  - You must install the driver manually.
    - See: "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.
  - You must configure the driver manually.
    - See: "Configuring the IBM Data Server Driver for ODBC and CLI" on page 11.

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

- Messages will be reported only in English.
- There is no local database directory.
  - LDAP is supported, but the LDAP cache is not saved to disk.
    - See: "LDAP support in the IBM Data Server Driver for ODBC and CLI" on page 36.
- Not all diagnostic utilities are available.
  - See: "Diagnostic support in the IBM Data Server Driver for ODBC and CLI."

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

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

You can install and configure the IBM Data Server Driver for ODBC and CLI product to obtain only the CLI driver and the CLI related features. You can use the tracing, logging, and diagnostic utilities to help troubleshoot a problem with the IBM Data Server Driver for ODBC and CLI installation.

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

CLI trace

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

DB2 trace

To turn on the DB2 trace from the IBM Data Server Driver for ODBC and CLI product installation, you must issue the **db2trc** command from the following directory:

- On Windows operating systems, issue the **db2trc** command from the `bin` subdirectory.
- On UNIX and Linux operating systems, issue the **db2trc** command from the `adm` subdirectory.

For example, if you installed the IBM Data Server Driver for ODBC and CLI product at `$HOME/ibm_data_server_driver_for_odbc_cli`, you must be in the `$HOME/ibm_data_server_driver_for_odbc_cli/adm` directory when you issue the **db2trc** command.The trace output path must have the write permission for trace files to be generated.

db2diag.log file

When you are using the IBM Data Server Driver for ODBC and CLI product, the `db2diag.log` file can be found in the following location:

- On Windows operating systems: The `db2diag.log` file is found in the *Drive:*`\ProgramData\IBM\DB2\`*%UNZIPPED PATH%* directory. For example, if the IBM Data Server Driver for ODBC and CLI product was extracted to the `D:\Program Files\IBM\clidriver` directory, the *%UNZIPPED PATH%* value is `D_Program Files_IBM_clidriver`.
- On UNIX and Linux operating systems: The `db2diag.log` file is in the `db2dump` subdirectory of the driver installation directory.

Note: On Windows operating systems, the sample configuration file is created when you run the **db2cli install -setup** command with the administrator authority:

The **DB2_DIAG** system environment variable and the **DIAGPATH** `db2cli.ini` keyword can be used to alter the location of the `db2diag.log` file.

db2support.zip file

The DB2 command line processor is not available with the IBM Data Server Driver for ODBC and CLI product, so the CLP utility is not available. However, an executable version of the **db2support** command is provided in the IBM Data Server Driver for ODBC and CLI product installation.

The **db2support** command collects the following information:

- The **db2level** command output.
- Environment variables.
- A listing of the contents of the IBM Data Server Driver for ODBC and CLI product installation directory.

You must issue the **db2support** command from the `bin` subdirectory of the installation directory.

For example, if you installed the driver at `$HOME/ibm_data_server_driver_for_odbc_cli`, you must be in the `$HOME/ibm_data_server_driver_for_odbc_cli/bin` directory when you issue the **db2support** command.

Setting diagnostic options

The IBM Data Server Driver for ODBC and CLI product does not support the command line processor (CLP). Therefore, you cannot use the `db2set` command to set DB2 registry variables. The registry variables that are related to diagnostics gathering are supported through the following `db2cli.ini` keywords:

- "DiagLevel CLI/ODBC configuration keyword"
- "NotifyLevel CLI/ODBC configuration keyword"
- "DiagPath CLI/ODBC configuration keyword" on page 40

You can also set and get following environment attributes with the SQLSetEnvAttr() function and the SQSGetEnvAttr function:

- **SQL_ATTR_DIAGLEVEL**
- **SQL_ATTR_NOTIFYLEVEL**
- **SQL_ATTR_DIAGPATH**

See "Environment attributes (CLI) list" on page 40.

You can also set the path of the `db2diag.log` file with the following system environment variable:

- **DB2_DIAGPATH**

See "Environment variables supported by the IBM Data Server Driver for ODBC and CLI" on page 16.

The following list of keywords and attribute can be used to specify an alternative location for the diagnostic output:

- The **DiagPath** `db2cli.ini` keyword.
- The **DB2_DIAGPATH** system environment variable.
- The SQL_ATTR_DIAGPATH environment attribute.

If you installed the IBM Data Server Driver for ODBC and CLI product on a read-only network file system (NFS), the **DB2_DIAGPATH** system environment variable must be set to a directory with the write permission.

DiagLevel CLI/ODBC configuration keyword:

Sets the diagnostic level.

db2cli.ini keyword syntax:

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

Default setting:

3

Usage notes:

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

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

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

NotifyLevel CLI/ODBC configuration keyword:

Sets the diagnostic level.

db2cli.ini keyword syntax:

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

Default setting:

3

Usage notes:

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

This is equivalent to the database manager parameter NOTIFYLEVEL.

DiagPath CLI/ODBC configuration keyword:

Sets the path of the **db2diag** log files.

db2cli.ini keyword syntax:

DiagPath = *existing directory*

Default setting:

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

Usage notes:

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

This is equivalent to the database manager parameter DIAGPATH.

Environment attributes (CLI) list:

You can set the CLI driver attributes that are specific to an environment handle with the SQLSetEnvAttr() function. The current environment attribute value is obtained with the SQLGetEnvAttr() function. Some environment attributes are specific to the CLI driver.

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

SQL_ATTR_CONNECTION_POOLING

This attribute was deprecated in DB2 Version 8.

This attribute is not supported when accessing the Informix® database server.

SQL_ATTR_CONNECTTYPE

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

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

SQL. In contrast to the SQL_CONCURRENT_TRANS setting that was previously described, the application is permitted only one open connection per database.

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

If you change this attribute from the default, you must set it before any connections are established on the environment handle.

Applications typically set this attribute as an environment attribute with a call to the `SQLSetEnvAttr()` function. The `SQLSetEnvAttr()` function is called as soon as the environment handle is allocated. However, because ODBC applications cannot access `SQLSetEnvAttr()` function, ODBC applications must set this attribute by using the `SQLSetConnectAttr()` function after each connection handle is allocated, but before any connections are established.

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

You can also set the default connection type by using the "ConnectType CLI/ODBC configuration keyword" on page 173.

The SQL_ATTR_CONNECTTYPE attribute is an IBM defined extension.

SQL_ATTR_CP_MATCH

This attribute was deprecated in DB2 for Linux, UNIX, and Windows Version 8.

This attribute is not supported when accessing the Informix database server.

SQL_ATTR_DATE_FMT

The SQL_ATTR_DATE_FMT attribute specifies the date format. You can set the SQL_ATTR_DATE_FMT attribute to one of the following values:

- `SQL_IBMi_FMT_ISO`: Specifies the International Standards Organization (ISO) date format of `yyyy-mm-dd`.
- `SQL_IBMi_FMT_USA`: Specifies the United States date format of `mm/dd/yyyy`.
- `SQL_IBMi_FMT_EUR`: Specifies the European date format of `dd.mm.yyyy`.
- `SQL_IBMi_FMT_JIS`: Specifies the Japanese Industrial Standard date format of `yyyy-mm-dd`.
- `SQL_IBMi_FMT_MDY`: Specifies the date format of `mm/dd/yy`.
- `SQL_IBMi_FMT_DMY`: Specifies the date format of `dd/mm/yy`.
- `SQL_IBMi_FMT_YMD`: Specifies the date format of `yy/mm/dd`.
- `SQL_IBMi_FMT_JUL`: Specifies the Julian date format of `yy/ddd`.
- `SQL_IBMi_FMT_JOB`: Specifies the job default for the date format.

The default value for the SQL_ATTR_DATE_FMT attribute is determined by the `DATETIME` bind option that is specified for packages. If the default `DATETIME` bind option is specified for the CLI packages, `SQL_IBMi_FMT_ISO`

is the default value for the SQL_ATTR_DATE_FMT attribute. The SQL_ATTR_DATE_FMT attribute is valid only for use with the DB2 for i server.

Note: The SQL_ATTR_DATE_FMT attribute is an IBM defined attribute.

SQL_ATTR_DATE_SEP

The SQL_ATTR_DATE_SEP attribute specifies the date separator. You can set the SQL_ATTR_DATE_SEP attribute to one of the following values:

- SQL_SEP_SLASH: Specifies a slash (/) for the date separator.
- SQL_SEP_DASH: Specifies a dash (-) for the date separator.
- SQL_SEP_PERIOD: Specifies a period (.) for the date separator.
- SQL_SEP_COMMA: Specifies a comma (,) for the date separator.
- SQL_SEP_BLANK: Specifies a blank for the date separator.
- SQL_SEP_JOB: Specifies the job default for the date separator.

The default value for the SQL_ATTR_DATE_SEP attribute is determined by the DATETIME bind option that is specified for packages. If the default DATETIME bind option is specified for the CLI packages, SQL_SEP_SLASH is the default value for the SQL_ATTR_DATE_SEP attributeThe SQL_ATTR_DATE_SEP attribute is only valid for use with DB2 for i servers after you set the SQL_ATTR_DATE_FMT attribute to one of the following values:

- SQL_IBMi_FMT_MDY
- SQL_IBMi_FMT_DMY
- SQL_IBMi_FMT_YMD
- SQL_IBMi_FMT_JUL

.

Note: The SQL_ATTR_DATE_SEP attribute is an IBM defined attribute.

SQL_ATTR_DB2TRC_STARTUP_SIZE

Description

A 32-bit integer value that allocates the DB2 trace buffer in MB.

Values

The **SQL_ATTR_DB2TRC_STARTUP_SIZE** attribute value must be in the range of 1-1024 MB and in power of 2. If the **SQL_ATTR_DB2TRC_STARTUP_SIZE** attribute value is not set to a value in power of 2, the specified **SQL_ATTR_DB2TRC_STARTUP_SIZE** value is rounded down to the closest power of 2 value.

Usage notes

The **SQL_ATTR_DB2TRC_STARTUP_SIZE** attribute value takes effect only if the following conditions are met:

- No environment handle is allocated by the process that uses DB2 libraries.
- A trace buffer is not already allocated before you set the **SQL_ATTR_DB2TRC_STARTUP_SIZE** attribute value.

You cannot change the trace facility buffer that is allocated by the **SQL_ATTR_DB2TRC_STARTUP_SIZE** attribute value while the DB2 libraries are still loaded in the operating system.

The trace facility buffer is deallocated when all running processes that use DB2 libraries exits.

If the trace facility buffer is already allocated, the **SQL_ATTR_DB2TRC_STARTUP_SIZE** attribute value cannot be greater than the buffer size that is already allocated. You can allocate the trace facility buffer by using any of the following methods:

- The **db2start** command.
- The **db2trc on** or **db2trc alloc** command.
- The **db2trcStartupSize** keyword in the `db2dsdriver.cfg` file.
- The **SQL_ATTR_DB2TRC_STARTUP_SIZE** environment attribute.

If the allocated trace buffer size is smaller than the value specified for the **SQL_ATTR_DB2TRC_STARTUP_SIZE** attribute, the SQLSetEnvAttr() function returns an SQL_SUCCESS_WITH_INFO message. You cannot retrieve any warning message details if the SQLSetEnvAttr() function is called with SQL_NULL_HANDLE. You can obtain the value of allocated trace buffer by calling the SQLGetEnvAttr() function with the SQL_ATTR_DB2TRC_STARTUP environment attribute.

SQL_ATTR_DECIMAL_SEP

The SQL_ATTR_DECIMAL_SEP attribute specifies the decimal separator. You can set the SQL_ATTR_DECIMAL_SEP attribute to one of the following values:

- `SQL_SEP_PERIOD`: Specifies a period (**.**) for the decimal separator.
- `SQL_SEP_COMMA`: Specifies a comma (**,**) for the decimal separator.
- `SQL_SEP_JOB`: Specifies the job default for the decimal separator.

The default value for the SQL_ATTR_DECIMAL_SEP attribute is determined by the `DECDEL` bind option that is specified for packages. If the default `DECDEL` bind option is specified for the CLI packages, `SQL_SEP_PERIOD` is the default value for the SQL_ATTR_DECIMAL_SEP attribute.The SQL_ATTR_DECIMAL_SEP attribute is valid only for use with the DB2 for i server.

Note: The SQL_ATTR_DECIMAL_SEP attribute is an IBM defined attribute.

SQL_ATTR_DIAGLEVEL

Description

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

Values

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

Usage notes

You must set this attribute before any connection handles are created.

SQL_ATTR_DIAGPATH

Description

A pointer to a null-terminated character string that contains the name of the directory where diagnostic data is to be placed. The SQL_ATTR_DIAGPATH is equivalent to the database manager `DIAGPATH` parameter.

Values

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

Usage notes

You must set this attribute before any connection handles are created.

SQL_ATTR_INFO_ACCTSTR

Description

A pointer to a null-terminated character string that is used to identify the client accounting string that is sent to a database.

Values

The CLI driver has limit of 255 characters for the SQL_ATTR_INFO_ACCTSTR attribute.

Database servers enforce different limitation in the length of the value and can truncate it. Note the following conditions:

- DB2 for z/OS Version 11 servers in new function mode (NFM) support a length of up to 255 characters for the CURRENT CLIENT_ACCTNG special register.
- DB2 for z/OS servers remove trailing spaces that are specified in the SQL_ATTR_INFO_ACCTSTR attribute value.
- DB2 for z/OS Version 10 and earlier servers support a length of up to 200 characters.
- CLI applications can set the SQL_ATTR_INFO_ACCTSTR attribute on DB2 for i V6R1 and later servers. DB2 for i servers support a length of up to 255 characters.

To ensure that the data is converted correctly when transmitted to DB2 for z/OS Version 9 and earlier servers, use only the characters A-Z and 0-9 and the underscore (_) or period (.).

For connection to DB2 for z/OS servers, the SQL_ATTR_INFO_ACCTSTR attribute is replayed upon connection failover when the automatic client reroute (ACR) feature and the workload balance (WLB) feature are enabled.

The SQL_ATTR_INFO_ACCTSTR attribute is an IBM defined attribute.

SQL_ATTR_INFO_APPLNAME

Description

A pointer to a null-terminated character string that is used to identify the client application name that is sent to a database.

Values

The CLI driver has limit of 255 characters for the SQL_ATTR_INFO_APPLNAME attribute.

Database servers enforce different limitations in the length of the value and can truncate it. Note the following conditions:

- DB2 for z/OS Version 11 servers in new function mode (NFM) support a length of up to 255 characters for the CURRENT CLIENT_APPLNAME special register.

- DB2 for z/OS servers remove trailing spaces that are specified in the SQL_ATTR_INFO_APPLNAME attribute value.
- DB2 for z/OS Version 10 and earlier servers support a length of up to 32 characters.
- CLI applications can set the SQL_ATTR_INFO_APPLNAME attribute on DB2 for i V6R1 and later servers. DB2 for i servers support a length of up to 255 characters.

To ensure that the data is converted correctly when transmitted to DB2 for z/OS Version 9 and earlier server, use only the characters A-Z and 0-9 and the underscore (_) or period (.).

For connection to DB2 for z/OS servers, the SQL_ATTR_INFO_APPLNAME attribute is replayed upon connection failover when the automatic client reroute (ACR) feature and the workload balance (WLB) feature are enabled.

If you change the client application name and the accounting string is set by the WLM_SET_CLIENT_INFO procedure, the accounting string stored on the server is updated with the value of the accounting string from the client information.

The SQL_ATTR_INFO_APPLNAME attribute is an IBM defined attribute.

SQL_ATTR_INFO_CRRTKN

Description

A pointer to a null-terminated character string that is used to identify the client correlation token that is sent to DB2 for z/OS Version 11 and later servers.

Values

- You can specify the SQL_ATTR_INFO_CRRTKN attribute when you are connecting to DB2 for z/OS Version 11 server in new function mode (NFM).
- DB2 for z/OS servers set the CURRENT CLIENT_CORR_TOKEN special register with the SQL_ATTR_INFO_CRRTKN attribute value.
- DB2 for z/OS servers remove trailing spaces that are specified in the SQL_ATTR_INFO_CRRTKN attribute value.
- The default SQL_ATTR_INFO_CRRTKN attribute value is the DRDA® correlation token that is generated during a connection. A database client typically generates the DRDA correlation token value. However, if the database client cannot generate the value, the database server generates the value.
- There is no monitoring support for the client correlation token value in the DB2 connect gateway server.
- The SQL_ATTR_INFO_CRRTKN attribute value is sent to the server without any client side validation.
- The SQL_ATTR_INFO_CRRTKN attribute has limit of 255 characters.
- The character string that is provided for the SQL_ATTR_INFO_CRRTKN attribute must be null terminated.
- The SQL_ATTR_INFO_CRRTKN attribute is replayed upon connection failover when the automatic client reroute (ACR) feature and the workload balance (WLB) feature are enabled.

The SQL_ATTR_INFO_CRRTKN attribute is an IBM defined attribute.

SQL_ATTR_INFO_USERID

Description

A pointer to a null-terminated character string that is used to identify the client user ID that is sent to a database.

Values

Do not confuse the client user ID with the authentication user ID. The client user ID is for identification purposes only and is not used for any authentication.

The CLI driver has limit of 255 characters for the SQL_ATTR_INFO_USERID attribute.

Database servers enforce different limitations in the length of the value and can truncate it. Note the following conditions:

- DB2 for z/OS Version 11 servers in new function mode (NFM) support a length of up to 128 characters for the CURRENT CLIENT_USERID special register.
- DB2 for z/OS servers remove trailing spaces that are specified in the SQL_ATTR_INFO_USERID attribute value.
- DB2 for z/OS Version 10 and earlier servers support a length of up to 16 characters.
- CLI applications can set the SQL_ATTR_INFO_USERID attribute on DB2 for i V6R1 and later servers. DB2 for i servers support a length of up to 255 characters.

To ensure that the data is converted correctly when transmitted to DB2 for z/OS Version 9 and earlier servers, use only the characters A-Z and 0-9 and the underscore (_) or period (.).

For connection to DB2 for z/OS servers, the SQL_ATTR_INFO_USERID attribute is replayed upon connection failover when the automatic client reroute (ACR) feature and the workload balance (WLB) feature are enabled.

If you change the client user ID and the accounting string is set by the WLM_SET_CLIENT_INFO procedure, the accounting string that is stored on the server is updated with the value of the accounting string from the client information.

The SQL_ATTR_INFO_USERID attribute is an IBM defined attribute.

SQL_ATTR_INFO_WRKSTNNAME

Description

A pointer to a null-terminated character string that is used to identify the client workstation name that is sent to a database.

Values

The CLI driver has limit of 255 characters for the SQL_ATTR_INFO_WRKSTNNAME attribute.

Database servers enforce different limitations in the length of the value and can truncate it. Note the following conditions:

- DB2 for z/OS Version 11 servers in new function mode (NFM) support a length of up to 255 characters for the CURRENT CLIENT_WRKSTNNAME special register.
- DB2 for z/OS servers remove trailing spaces that are specified in the SQL_ATTR_INFO_WRKSTNNAME attribute value.
- DB2 for z/OS Version 10 and earlier servers support a length of up to 16 characters.
- DB2 for z/OS Version 10 and earlier servers support a length of up to 18 characters.
- CLI applications can set the SQL_ATTR_INFO_WRKSTNNAME attribute on DB2 for i V6R1 and later servers. DB2 for i servers support a length of up to 255 characters.

To ensure that the data is converted correctly when transmitted to DB2 for z/OS Version 9 and earlier servers, use only the characters A-Z and 0-9 and the underscore (_) or period (.).

If the SQL_ATTR_INFO_WRKSTNNAME attribute is not specified, a default value that consists of the host name is used. The host name is obtained by calling the gethostname() function. If the host name is not configured or an error is encountered during the gethostname() function call, no value for the SQL_ATTR_INFO_WRKSTNNAME attribute is sent to the server.

For connection to DB2 for z/OS servers, the SQL_ATTR_INFO_WRKSTNNAME attribute is replayed upon connection failover when the automatic client reroute (ACR) feature and the workload balance (WLB) feature are enabled.

The SQL_ATTR_INFO_WRKSTNNAME attribute is an IBM defined attribute.

SQL_ATTR_MAXCONN

This attribute was deprecated in DB2 for Linux, UNIX, and Windows Version 8.

This attribute is not supported when accessing the Informix database servers.

SQL_ATTR_NOTIFYLEVEL

Description

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

Values

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

Usage notes

You must set this attribute value before any connection handles are created.

This attribute is not supported when accessing the Informix database servers.

SQL_ATTR_ODBC_VERSION

Description

A 32-bit integer that determines whether certain functionality exhibits ODBC 2.x (CLI v2) behavior or ODBC 3.0 (CLI v5) behavior. ODBC applications must set this environment attribute

before calling any function that has an SQLHENV argument, or the call will return SQLSTATE HY010 (Function sequence error.).

Values

To set the value of this attribute, use one of the following values:

- SQL_OV_ODBC3: Causes the listed ODBC 3.0 (CLI v5) behavior:
  - CLI returns and expects ODBC 3.0 (CLI v5) codes for date, time, and timestamp.
  - CLI returns ODBC 3.0 (CLI v5) SQLSTATE codes when `SQLError()`, `SQLGetDiagField()`, or `SQLGetDiagRec()` functions are called.
  - The *CatalogName* argument in a call to `SQLTables()` function accepts a search pattern.
- SQL_OV_ODBC2: Causes the listed ODBC 2.x (CLI v2) behavior:
  - CLI returns and expects ODBC 2.x (CLI v2) codes for date, time, and timestamp.
  - CLI returns ODBC 2.0 (CLI v2) SQLSTATE codes when `SQLError()`, `SQLGetDiagField()`, or `SQLGetDiagRec()` functions are called.
  - The *CatalogName* argument in a call to `SQLTables()` function does not accept a search pattern.
- SQL_OV_ODBC3_80: Causes the listed ODBC 3.0 (CLI v5) behavior:
  - CLI returns and expects ODBC 3.x codes for date, time, and timestamp.
  - CLI returns ODBC 3.x SQLSTATE codes when `SQLError()`, `SQLGetDiagField()`, or `SQLGetDiagRec()` functions are called.
  - The *CatalogName* argument in a call to `SQLTables()` function accepts a search pattern.

SQL_ATTR_OUTPUT_NTS

Description

A 32-bit integer value that controls the use of null-termination in output arguments.

Values

The possible values are:

- **SQL_TRUE**: CLI uses null termination to indicate the length of output character strings (default).
- **SQL_FALSE**: CLI does not use null termination in output character strings.

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

You can set this attribute only when there are no connection handles that are allocated under this environment.

SQL_ATTR_PROCESSCTL

Description

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

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

Values

You can combine the listed values to form a bit mask:

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

The SQL_ATTR_PROCESSCTL attribute is an IBM defined extension.

SQL_ATTR_RESET_CONNECTION

Description

A 32-bit unsigned integer value that specifies whether the ODBC Driver Manager notifies the ODBC drivers that a connection has been placed in the connection pool on Windows operating systems. If the SQL_ATTR_ODBC_VERSION environment attribute is set to SQL_OV_ODBC3_80, the ODBC Driver Manager sets this attribute before placing a connection in the connection pool so that the driver can reset the other connection attributes to their default values.

Values

The only possible value is:

- SQL_RESET_CONNECTION_YES (default): The ODBC Driver Manager notifies the ODBC drivers that a connection has been placed in the connection pool.

Note: You should use SQL_ATTR_RESET_CONNECTION only for communication between the ODBC Driver Manager and an ODBC driver. You should not set this attribute from an application because all connection attributes will be reset to their default value. For example, any connection attribute values that you set by using the SQLSetConnectAttr () function will be reset to CLI default values and your application could behave unexpectedly.

SQL_ATTR_SYNC_POINT

This attribute was deprecated in DB2 for Linux, UNIX, and Windows Version 8.

This attribute is not supported when accessing the Informix database servers.

SQL_ATTR_TIME_FMT

The SQL_ATTR_TIME_FMT attribute specifies the time format. The SQL_ATTR_TIME_FMT attribute can be set to one of the following values:

- SQL_IBMi_FMT_ISO: Specifies the International Standards Organization (ISO) time format of hh.mm.ss.
- SQL_IBMi_FMT_USA: Specifies the United States time format of hh:mm xx, where xx is AM or PM.
- SQL_IBMi_FMT_EUR: Specifies the European time format of hh.mm.ss.
- SQL_IBMi_FMT_JIS: Specifies the Japanese Industrial Standard time format of hh:mm:ss.
- SQL_IBMi_FMT_HMS: Specifies the time format of hh:mm:ss.

The default value for the SQL_ATTR_TIME_FMT attribute is determined by the DATETIME bind option that is specified for packages. If the default DATETIME bind option is specified for the CLI packages, SQL_IBMi_FMT_JIS is the default value for the SQL_ATTR_TIME_FMT attribute.The SQL_ATTR_TIME_FMT attribute is only valid for use with the DB2 for i server.

Note: The SQL_ATTR_TIME_FMT attribute is an IBM defined attribute.

SQL_ATTR_TIME_SEP

The SQL_ATTR_TIME_SEP attribute specifies the time separator. Set the SQL_ATTR_TIME_SEP attribute to one of the following values:

- SQL_SEP_COLON: Specifies a colon (:) for the time separator.
- SQL_SEP_PERIOD: Specifies a period (.) for the time separator.
- SQL_SEP_COMMA: Specifies a comma (,) for the time separator.
- SQL_SEP_BLANK: Specifies a blank for the time separator.
- SQL_SEP_JOB: Specifies the job default for the time separator.

The default value for the SQL_ATTR_TIME_SEP attribute is determined by the DATETIME bind option that is specified for packages. If the default DATETIME bind option is specified for the CLI packages, SQL_SEP_COLON is the default value for the SQL_ATTR_TIME_SEP attribute.The SQL_ATTR_TIME_SEP attribute is valid for use with DB2 for i servers after you set the SQL_ATTR_TIME_FMT attribute to SQL_IBMi_FMT_HMS.

Note: The SQL_ATTR_TIME_SEP attribute is an IBM defined attribute.

SQL_ATTR_TRACE

Description

A pointer to a null-terminated character string that is used to turn on the CLI/ODBC trace facility.

Values

The string must include the CLI keywords **TRACE** and **TRACEPATHNAME**. For example:

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

Usage notes

This attribute is not supported when accessing the Informix database servers.

SQL_ATTR_TRACENOHEADER

Description

A 32-bit integer value that specifies whether header information is included in the CLI trace file.

Values

The possible values are:

- **0** - Header information is included in the CLI trace file.
- **1** - No header information is included in the CLI trace file.

You can use the SQL_ATTR_TRACENOHEADER attribute with an SQL_NULL_HANDLE or with a valid environment handle.

SQL_ATTR_USE_2BYTES_OCTET_LENGTH

This attribute is deprecated in DB2 for Linux, UNIX, and Windows Version 8.

This attribute is not supported when accessing the Informix database servers.

SQL_ATTR_USE_LIGHT_OUTPUT_SQLDA

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

SQL_ATTR_USER_REGISTRY_NAME

Description

This attribute is used only when authenticating a user on a server that is using an identity mapping service.

Values

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

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

Usage notes

This attribute is not supported when accessing the Informix database servers.

SQL_CONNECTTYPE

This attribute is replaced with SQL_ATTR_CONNECTTYPE.

SQL_MAXCONN

This attribute is replaced with SQL_ATTR_MAXCONN.

SQL_SYNC_POINT

This attribute is replaced with SQL_ATTR_SYNC_POINT.

This attribute is not supported when accessing the Informix database servers.

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

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client . It must be installed and configured separately. You can simplify the deployment of your CLI and ODBC database applications by creating an install program.

You can deploy the IBM Data Server Driver for ODBC and CLI with your CLI and ODBC database applications by obtaining the compressed file that contains the driver and following the installation and configuration steps required for the driver into your install program.

Before you begin

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

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

Restrictions

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

Procedure

To incorporate the IBM Data Server Driver for ODBC and CLI into your install program:

1. Copy the driver files into your install program. See the restrictions mentioned previously about which driver files can be redistributed.
2. Set the install program to install the driver on the target machine. See: "Installing the IBM Data Server Driver for ODBC and CLI software on Linux and UNIX operating systems" on page 10.
3. Set the install program to configure the environment on the target machine. See: "Configuring the IBM Data Server Driver for ODBC and CLI" on page 11.

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

The IBM Data Server Driver for ODBC and CLI is not part of the IBM Data Server Client or the IBM Data Server Runtime Client. You must install and configure it separately.

You can download and install the IBM Data Server Driver for ODBC and CLI and use it with your ODBC and CLI applications without a special license.

The IBM Data Server Driver for ODBC and CLI can connect to the following properly licensed servers:

- DB2 for Linux, UNIX, and Windows
- DB2 Connect Server
- InfoSphere® Federation Server
- IBM Informix
- DB2 for z/OS
- IBM DB2 for IBM i
- DB2 Server for VM and VSE

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

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

  No other product provides the required license file or the license rights afforded by the presence of this file. Tampering with or unauthorized distribution of this file is a breach of the license agreement. The relevant license file can be located on the DB2 Connect activation image in the `/db2/license` directory. The license must be copied to the `license` subdirectory of the data server driver installation path, for example: *`installation_path`*`/license`. The name of the file varies with the product:
  - DB2 Connect Application Server Edition: `db2consv_as.lic`
  - DB2 Connect Enterprise Edition: `db2consv_ee.lic`
  - DB2 Connect Unlimited Edition for System i: `db2consv_is.lic`
  - DB2 Connect Unlimited Edition for System z: `db2consv_zs.lic`

Chapter 3. ODBC driver managers

DB2 Call Level Interface (CLI) supports a variety of ODBC driver managers in connections to DB2.

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

unixODBC driver manager

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

Support statement

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

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

Compiling the unixODBC driver manager

You can compile the unixODBC Driver Manager on Linux or UNIX operating systems for use with CLI and ODBC applications.

Procedure

To compile the unixODBC Driver Manager:

1. Download the latest unixODBC source code from http://www.unixodbc.org.
2. Untar the source files. For example:
   ```
   gzip -d unixODBC-2.2.11.tar.gz
   tar xf unixODBC-2.2.11.tar
   ```
3. For AIX only: Configure the C compiler to be thread-enabled:
   ```
   export CC=xlc_r
   export CCC=xlC_r
   ```
4. To compile a 64-bit version of the driver manager with the xlc_r compilers, set the environment variables **OBJECT_MODE** and **CFLAGS**:
   ```
   export OBJECT_MODE=64
   export CFLAGS=-q64 -DBUILD_REAL_64_BIT_MODE
   ```
5. Install the driver manager in either your home directory or the default `/usr/local` prefix:
   - (Home directory) Issue the following command in the directory where you untarred the source files:

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

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

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

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

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

7. Build and install the driver manager:

   ```
   make
   make install
   ```

   Libraries are copied to the [prefix]/lib directory, and executable files are copied to the [prefix]/bin directory.

8. For AIX only: Extract the shared library from the ODBC driver for DB2 to yield shr.o on 32-bit operating systems and shr_64.o on 64-bit operating systems. To avoid confusion, rename the files db2.o and db2_64.o. These steps are necessary on AIX because the unixODBC Driver Manager loads the driver dynamically.

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

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

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

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

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

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

   Ensure that your INI file references the correct library.

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

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

   The **ar** commands in previous example produce libodbc.so.1, libodbcinst.so.1, and libodbccr.so.1 in the [prefix]/lib/so directory.

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

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

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

    Note: If you are compiling 64-bit applications for the ODBC Driver, use the -DODBC64 option to enable the 64-bit definitions in the driver manager.

Installing the unixODBC driver manager

The unixODBC driver manager is an open source ODBC driver manager that can be used with the DB2 ODBC driver on all supported Linux and UNIX operating systems.

Procedure

To install the unixODBC driver manager:

1. Obtain the unixODBC driver manager.
   - You can download and compile the unixODBC driver manager source code. For information about compiling the source code, see "Compiling the unixODBC driver manager" on page 55.
   - You can download the compiled version of the unixODBC driver manager from the following URLs:
     a. For an AIX RPM file, see http://www.perzl.org/aix/index.php?n=Main.UnixODBC
     b. For a Linux RPM file, see http://rpmfind.net/linux/rpm2html/search.php?query=unixODBC
2. Install the unixODBC driver manager. You can issue the **apt-get install** command to install the unixODBC driver manager:

   ```
   apt-get install unixodbc unixodbc-dev
   ```

   Tip: You can also use different package manager command that is based on your operating system architecture and distribution to install a compiled version of the unixODBC driver manager. For example, on Red-Hat Linux operating system, you can use the **yum** command:

   ```
   yum install unixODBC unixODBC-devel
   ```
3. Configure the unixODBC driver manager by adding the following lines in the `odbcinst.ini` configuration file:

   ```
   [DB2]
   Description = DB2 Driver
   Driver = <instance_path>/lib/libdb2o.so
   fileusage=1
   dontdlclose=1
   ```

   The *<instance_path>* is your DB2 instance path if you installed the full IBM Data Server Client, such as IBM Data Server Client, IBM Data Server Runtime Client or DB2 database server product. If you installed the IBM Data Server Driver for ODBC and CLI, the *<instance_path>* is your installation path. You can determine the location of the `odbcinst.ini` configuration file by issuing the following command:

   ```
   odbcinst –j
   ```

   For more information about configuring the unixODBC driver manager, see links in the related reference topics.

Microsoft ODBC driver manager

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

DataDirect ODBC driver manager

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

Restrictions

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

To avoid this problem, the DataDirect Connect for ODBC Driver Manager 4.2 Service Pack 2 recognizes a CLI/ODBC driver and not use the Unicode functions, effectively treating the CLI/ODBC driver as an ANSI-only driver. Before release 4.2 Service Pack 2, the DataDirect Connect for ODBC Driver Manager had to be linked with the _36 version of the CLI/ODBC driver which does not export the SQLConnectW function.

Chapter 4. Initializing CLI applications

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

Procedure

To initialize the application:

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

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

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

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

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

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

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

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

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

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

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

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

Results

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

Overview of the CLI application initialization and termination phases

CLI applications must allocate the required resources during the initialization phase and cleanup the resources during the termination phase. The required resources include environment handle, statement handle, connection handle, descriptor handle (if required), connection to the target database and any other resources that are required to complete the required transaction.

Figure 2 on page 61 shows the common function call sequences for both the initialization and termination phases.

In the initialization phase, all CLI application must allocate and initialize the environment, statement, and connection handles with the SQLAllocHandle() function. An environment handle and statement handle must be allocated before a connection handle can be created. When the handles are allocated, connection can be established to the target database in the initialization phase.

The transaction processing phase in the middle of the diagram is described in the Chapter 6, “Transaction processing in CLI overview,” on page 77 topic.

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

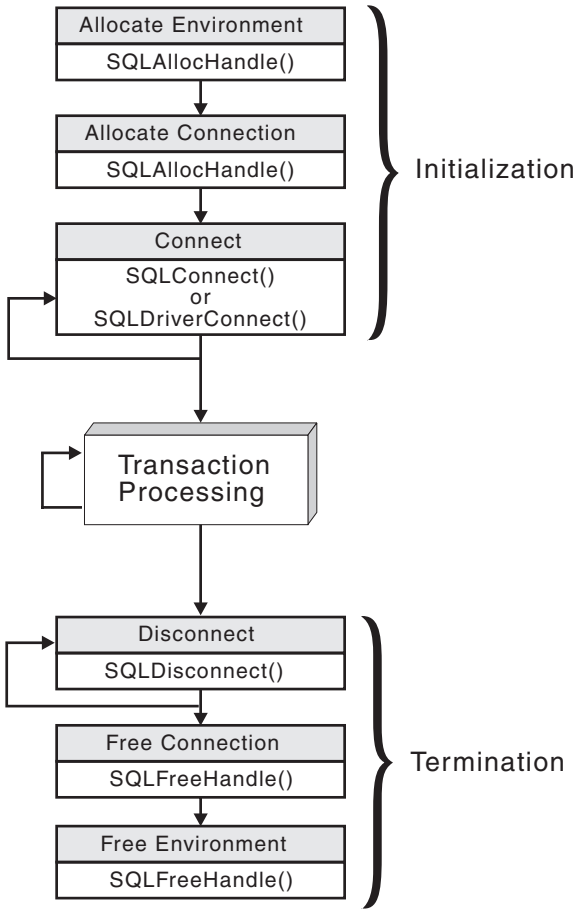


Figure 2. Conceptual view of initialization and termination phases

Handles in CLI

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

There are four types of handles in CLI:

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

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

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

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

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

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

Statement handle

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

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

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

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

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

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

Descriptor handle

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

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

Chapter 5. Data types and data conversion in CLI applications

You must work with both SQL data types and C data types when you code a CLI application. The SQL data types are associated with the DBMS, while the C data types are referenced by the application.

The application, therefore, must match C data types to SQL data types when applications calls CLI functions to transfer data between the DBMS and the application.

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

Data type conversion can occur under one of two conditions:

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

Note:

- GRAPHIC and VARGRAPHIC columns are not supported by Informix data server. Due to this limitation, conversion from sql_c_dbchar (C data type) and sql_graphic (SQL Datatype) are not supported. NCHAR and NVARCHAR datatypes and SQL_C_BINARY and SQL_BINARY conversions may be used instead of GRAPHIC and VARGRAPHIC.
- The SQL_XML data type is not supported for use with an Informix data server.

Example of how to use data types

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

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

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

SQLSMALLINT represents the base C type of short int.

- The application binds the application variable to the symbolic C data type of SQL_C_SHORT:

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

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

Data conversion

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

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

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

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

Note: When using CLI with an Informix data server, binary values can not be inserted into CHAR columns. User can only insert binary values into a LOB column. This is an Informix data server limitation on converting to STRING types. When binding a TIMESTAMP column to a sql_c_char/sql_c_wchar string with an Informix data server, the input value must be specified using the ODBC escape sequence or as a literal. DATETIME functions can not be specified.

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

String handling in CLI applications

CLI functions have conventions for passing strings as input that determine what information is returned from the function call. Strings are a series of characters ending with a null terminator. The DB2 CLI has mechanisms for detecting the length of string arguments.

Length of string arguments

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

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

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

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

If a function is called with a null pointer for an output length argument, CLI will not return a length. When the output data is a NULL value, CLI cannot indicate that the value is NULL. If it is possible that a column in a result set can contain a NULL value, a valid pointer to the output length argument must always be provided. It is highly recommended that a valid output length argument always be used.

Performance hint

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

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

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

Null-termination of strings

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

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

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

String truncation

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

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

Interpretation of strings

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

Blank padding of strings

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

Large object usage in CLI applications

There are three large object (LOB) data types: binary large object (BLOB), character large object (CLOB), and double-byte character large object (DBCLOB). These LOB data types are represented symbolically as SQL_BLOB, SQL_CLOB, SQL_DBCLOB.

You can specify or return the LOB symbolic constants on any of the CLI functions that take in or return an SQL data type argument, such as `SQLBindParameter()`, `SQLDescribeCol()`.

LOB locators versus file input and output

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

When a CLI application calls the function `SQLGetData()` to retrieve the LOB data, it will, by default, make one request to the server, and will store the entire LOB in

memory provided *BufferLength* is large enough. If *BufferLength* is not large enough to hold the entire LOB value, it will be retrieved piecewise.

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

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

Note: When accessing Informix database servers, Large Binary Object blocking is not supported.

Figure 3 on page 68 shows the retrieval of a character LOB (CLOB).

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

  A LOB locator is fetched, which is then used as an input parameter to search the CLOB for a substring, the substring is then retrieved.
- The right side shows how the CLOB can be fetched directly into a file.

  The file is first bound to the CLOB column, and when the row is fetched, the entire CLOB value is transferred directly to a file.

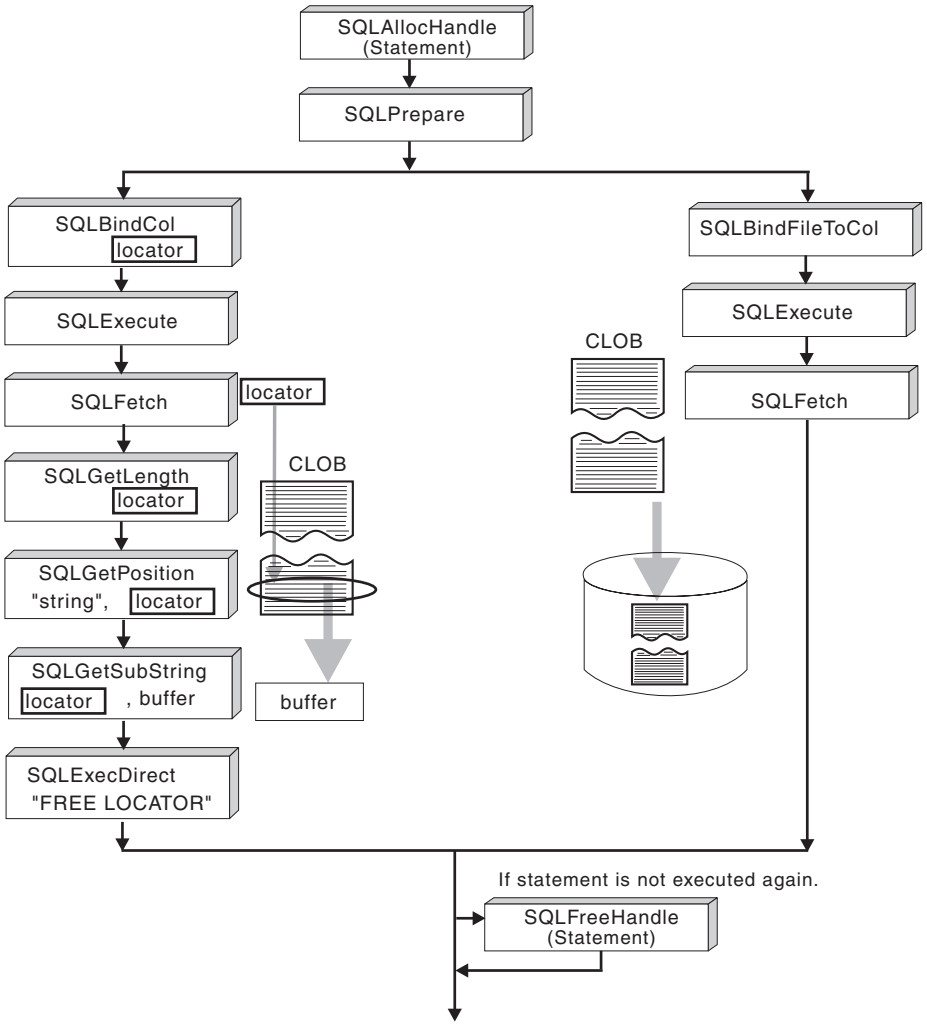


Figure 3. Fetching CLOB data

LOB locators in CLI applications

CLI applications can use a LOB locator to perform SQL operations on a large object (LOB) value of a result-set, without transferring entire LOB value from the database server into application memory.

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

A LOB locator is not stored in the database. It refers to a LOB value during a transaction, and does not persist beyond the transaction in which it was created. It is a simple token value created to reference a single large object *value*, and not a column in a row. There is no operation that could be performed on a locator that would have an effect on the original LOB value stored in the row.

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

Locators are implicitly allocated by:

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

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

Differences between regular data types and LOB locators

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

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

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

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

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

Examples of using LOB locators

LOB locators also provide an efficient method of moving data from one column of a table in a database to another column (of the same or different table) without having to pull the data first into application memory and then sending it back to

the server. The following INSERT statement inserts a LOB value that is a concatenation of 2 LOB values as represented by their locators:

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

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

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

Direct file input and output for LOB handling in CLI applications

Database queries, updates, and inserts might involve a transfer of individual LOB column values to and from files. In CLI applications, if you require the entire LOB column instead of a single column value, you can request a direct file input and output for LOBs.

The two CLI LOB file access functions are:

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

Example:

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

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

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

Example:

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

/* ... */

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

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

Use of `SQLBindFileToParam()` is more efficient than the sequential input of data segments using `SQLPutData()`, since `SQLPutData()` essentially puts the input segments into a temporary file and then uses the `SQLBindFileToParam()` technique to send the LOB data value to the server. Applications should take advantage of `SQLBindFileToParam()` instead of using `SQLPutData()`.

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

LOB usage in ODBC applications

You can still access LOB columns from ODBC-compliant applications by setting the LongDataCompat configuration keyword in the initialization file, or by setting the SQL_ATTR_LONGDATA_COMPAT connection attribute using `SQLSetConnectAttr()`.

Once this is done, CLI will map the ODBC long data types to the DB2 LOB data types.

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

When this mapping is in effect:

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

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

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

Long data for bulk inserts and updates in CLI applications

You can process long data for bulk inserts and updates by using the `SQLBulkOperations()` function.

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

The application places the result of the SQL_LEN_DATA_AT_EXEC(*length*) macro in the **StrLen_or_IndPtr* buffer. If the SQL data type of the column is SQL_LONGVARBINARY, SQL_LONGVARCHAR, or a long, data source-specific data type and CLI returns "Y" for the SQL_NEED_LONG_DATA_LEN information type in `SQLGetInfo()`, *length* is the number of bytes of data to be sent for the parameter; otherwise, it must be a non-negative value and is ignored.

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

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

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

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

On DB2 for z/OS, calls to the SQLEndTran() function specifying SQL_ROLLBACK as completion type are allowed when the SQL_ATTR_FORCE_ROLLBACK connection attribute is set, the StreamPutData configuration keyword is set to 1, and autocommit mode is enabled.

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

User-defined type (UDT) usage in CLI applications

User-defined types (UDTs) are database types that you define to provide structure or strong typing that is not available with conventional SQL types. There are three kinds of UDTs: distinct types, structured types, and reference types.

Note: User-defined types (UDTs) are not currently supported by CLI when running with an Informix database server. Using a UDT with an Informix database server will return `CLI Error -999 [IBM][CLI Driver][IDS] Not implemented yet`.

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

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

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

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

Descriptor fields return a schema as part of the name. If the schema is less than 8 letters, it is padded with blanks.

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

A CLI application may not want to repeatedly obtain the value of the SQL_DESC_USER_DEFINED_TYPE_CODE descriptor field to determine if columns contain UDTs. For this reason, there is an attribute called SQL_ATTR_RETURN_USER_DEFINED_TYPES at both the connection and the statement handle level. When set to SQL_TRUE using SQLSetConnectAttr(), CLI returns SQL_DESC_USER_DEFINED_TYPE where you would normally find SQL types in results from calls to SQLColAttribute(), SQLDescribeCol() and

SQLGetDescField(). This allows the application to check for this special type, and then do special processing for UDTs. The default value for this attribute is SQL_FALSE.

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

Note that SQLBindParameter() will not allow you to bind a parameter of the type SQL_USER_DEFINED_TYPE. You must still bind parameters using the base SQL type, which you can obtain using the descriptor field SQL_DESC_BASE_TYPE. For example, here is the SQLBindParameter() call used when binding to a column with a distinct type based on SQL_VARCHAR:

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

Distinct type usage in CLI applications

Distinct types help provide the strong typing control that is required in object-oriented programming. Distinct types ensure that only functions and operators explicitly defined on a distinct type can be applied to its instances.

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

Applications continue to work with C data types for application variables, and only need to consider the distinct types when constructing SQL statements.

This means:

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

XML data handling in CLI applications - Overview

You can use the SQL_XML data type in CLI applications to retrieve and store XML data. This data type corresponds to the native XML data type of the DB2 database, which is used to define columns that store well-formed XML documents.

You can bind the SQL_XML type to the following C types: SQL_C_BINARY, SQL_C_CHAR, SQL_C_WCHAR, and SQL_C_DBCHAR. Use the default SQL_C_BINARY type, instead of character types, to avoid possible data loss or corruption, which could result from code page conversion when character types are used.

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

When an XML value is retrieved into an application data buffer, the DB2 server performs an implicit serialization on the XML value to convert it from its stored hierarchical form to the serialized string form. For character-typed buffers, the XML value is implicitly serialized to the application character code page that is associated with the character type.

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

You can issue and execute XQuery expressions and SQL/XML functions in CLI applications. SQL/XML functions are issued and executed like any other SQL statements. You must add a prefix to the XQuery expressions with the not case sensitive keyword **XQUERY**, or you must set the SQL_ATTR_XQUERY_STATEMENT statement attribute for the statement handle that is associated with the XQuery expression.

Note: Starting with DB2 Version 9.7 Fix Pack 5, the SQL_XML data type is supported for DB2 for i V7R1 servers or later releases.

Changing of default XML type handling in CLI applications

CLI supports CLI/ODBC configuration keywords that provide compatibility for applications that do not expect the default types to be returned when describing or specifying SQL_C_DEFAULT for XML columns and parameter markers.

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

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

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

Chapter 6. Transaction processing in CLI overview

Transaction processing shows the typical order of function calls in the transaction processing task of a CLI application.

Not all functions or possible paths are shown.

Figure 4 on page 78 shows the typical order of function calls in the transaction processing task of a CLI application. Not all functions or possible paths are shown.

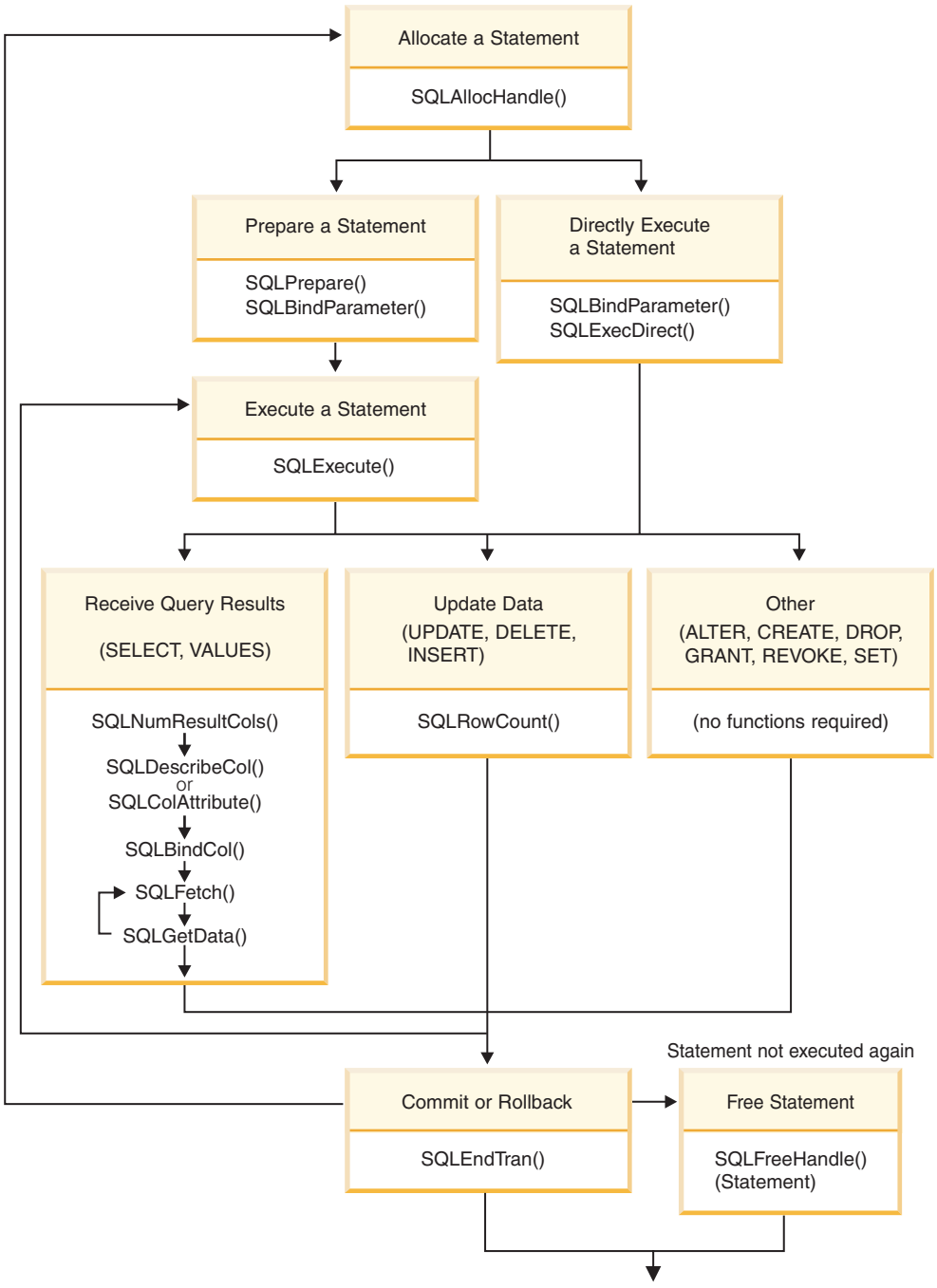


Figure 4. Transaction processing

The transaction processing task contains five steps:

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

Allocating statement handles in CLI applications

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

Before you begin

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

Procedure

To allocate a statement handle:

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

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

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

Results

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

Issuing SQL statements in CLI applications

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

Before you begin

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

Procedure

Perform either of the following steps to issue SQL statements:

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

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

  or

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

- To issue multiple SQL statements on the same statement handle:

  1. Initialize an array of SQLCHAR elements, where each element represents an individual SQL statement, or initialize a single SQLCHAR variable that contains the multiple statements delimited by a ";" character. For example:

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

or

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

2. Call SQLExecDirect() to issue the first statement in the statement handle and then call SQLMoreResults() to issue subsequent statements in the statement handle, as shown in the following example:

```
/* Issuing the first SELECT statement of multiple_stmts */
cliRC = SQLExecDirect (hstmt, multiple_stmts, SQL_NTS);
/* ... process result-set of first SELECT statement ... */

/* Issuing the second SELECT statement of multiple_stmts */
cliRC = SQLMoreResults(hstmt);
/* ... process result-set of second SELECT statement ... */

/* Issuing the INSERT statement of multiple_stmts */
cliRC = SQLMoreResults(hstmt);
/* cliRC is set to SQL_NO_DATA_FOUND to indicate that */
/* there are no more SQL statements to issue */
```

   When a list of SQL statements is specified on the same statement handle, only one statement is issued at a time, starting with the first statement in the list. Each subsequent statement is issued in the order it appears.

- To issue SQL statements with parameter markers, see "Binding parameter markers in CLI applications" on page 82.
- To capture and convert SQL statements dynamically executed with CLI (dynamic SQL) to static SQL, see "Creating static SQL by using CLI/ODBC static profiling" on page 132.

Parameter marker binding in CLI applications

Parameter markers indicate the position in an SQL statement where the contents of application variables are to be substituted when the statement is executed. You can use a parameter marker to indicate where a host variable might be used if the statement string were a static embedded SQL statement.

CLI supports unnamed parameter markers, which are represented by a question mark (?), and named parameter markers, which are represented by a colon followed by a name (for example, :*name*, where *name* is a valid identifier). To use named parameter markers, you must explicitly enable named parameter processing by setting the EnableNamedParameterSupport configuration keyword to TRUE.

Parameter markers can be bound to:

- An application variable.

  SQLBindParameter() is used to bind the application storage area to the parameter marker.

- A LOB value from the database server (by specifying a LOB locator).

  SQLBindParameter() is used to bind a LOB locator to the parameter marker. The LOB value itself is supplied by the database server, so only the LOB locator is transferred between the database server and the application.

- A file within the application's environment containing a LOB value.

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

An application cannot place parameter markers in the listed locations:

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

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

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

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

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

Information about each parameter remains in effect until:

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

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

to parameter markers and the time CLI accesses them at execution time. Doing so can result in CLI reading garbage data, or accessing invalid memory resulting in an application trap.

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

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

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

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

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

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

Binding parameter markers in CLI applications

This topic describes how to bind parameter markers to application variables before executing SQL statements.

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

Before you begin

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

Procedure

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

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

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

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

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

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

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

To process an SQL statement that will be repeated with different values, you can use column-wise array input to achieve bulk inserts, deletes, or updates.

This results in fewer network flows to the server because `SQLExecute()` does not have to be called repeatedly on the same SQL statement for each value. Column-wise array input allows arrays of storage locations to be bound to parameter markers. A different array is bound to each parameter.

Before you begin

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

About this task

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

Procedure

To bind parameter markers using column-wise array input:

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

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

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

To process an SQL statement that will be repeated with different values, you can use row-wise array input to achieve bulk inserts, deletes, or updates.

This results in fewer network flows to the server because `SQLExecute()` does not have to be called repeatedly on the same SQL statement for each value. Row-wise array input allows an array of structures to be bound to parameters.

Before you begin

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

Procedure

To bind parameter markers using row-wise array input:

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

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

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

4. Bind each parameter to the first row of the array created in step 1 using `SQLBindParameter()`. For example,

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

/* Parameter B */
rc = SQLBindParameter(hstmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR, SQL_CHAR,
         3, 0, R[0].B, 3, &R.Lb);

/* Parameter C */
rc = SQLBindParameter(hstmt, 3, SQL_PARAM_INPUT, SQL_C_CHAR, SQL_CHAR,
         10, 0, R[0].C, 10, &R.Lc);
```

Parameter diagnostic information in CLI applications

A *parameter status array* is an array of one or more SQLSMALLINT data type elements that is allocated by a CLI application. Each element in the array corresponds to an element in the input or output parameter array.

If specified, the CLI driver updates the parameter status array with information about the processing status of each set of parameters included in an `SQLExecute()` or `SQLExecDirect()` call.

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

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

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

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

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

Changing parameter bindings in CLI applications with offsets

When an application needs to change parameter bindings, it can call `SQLBindParameter()` a second time.

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

Before you begin

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

Procedure

To change parameter bindings by using offsets:

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

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

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

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

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

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

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

When manipulating long data, it might not be feasible for the application to load the entire parameter data value into storage at the time the statement is executed, or when the data is fetched from the database.

A method has been provided to allow the application to handle the data in a piecemeal fashion. The technique of sending long data in pieces is called *specifying parameter values at execute time*.

It can also be used to specify values for fixed size non-character data types such as integers.

Before you begin

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

About this task

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

- SQLParamData() and SQLPutData() functions.
- The SQLCancel() function which is used to cancel the flow and force an exit from the loops without executing the SQL statement.
- The SQLGetDiagRec() function.

A data-at-execute parameter is a bound parameter for which a value is prompted at execution time instead of stored in memory before SQLExecute() or SQLExecDirect() is called.

Procedure

To indicate such a parameter on an SQLBindParameter() call:

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

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

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

   For example:

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

        while ( sqlrc == SQL_NEED_DATA)
        {   /*
            if more than 1 parms used DATA_AT_EXEC then valuePtr would
            have to be checked to determine which param needed data
            */
            while ( feof( pFile ) == 0 )
            {   n = fread( buffer, sizeof(char), BUFSIZ, pFile);
                sqlrc = SQLPutData(hstmt, buffer, n);
                STMT_HANDLE_CHECK( hstmt, sqlrc);
                fileSize = fileSize + n;
                if ( fileSize > 102400u)
                {   /* BLOB column defined as 100K MAX */
                    /* ... */
                    break;
                }
            }
            /* ... */
            sqlrc = SQLParamData( hstmt, (SQLPOINTER *) &valuePtr);
            /* ... */
        }
    }
```

Results

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

Commit modes in CLI applications

In CLI applications, you can use auto-commit or manual-commit mode to handle transactions. In manual-commit mode, the transaction ends when you use `SQLEndTran()` to either rollback or commit the transaction. In auto-commit mode, every SQL statement is a complete transaction, which is automatically committed.

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

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

CLI supports two commit modes:

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

manual-commit

This means that any statements executed (on the same connection) between the start of a transaction and the call to SQLEndTran() are treated as a single transaction. If CLI is in manual-commit mode, a new transaction will be implicitly started if the application is not already in a transaction and an SQL statement that can be contained within a transaction is executed.

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

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

- Setting auto-commit on:

```
/* ... */

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

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

- Setting auto-commit off:

```
/* ... */

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

/* ... */

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

/* ... */

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

/* ... */
```

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

When to call the CLI SQLEndTran() function

In manual-commit mode, you must call the `SQLEndTran()` function before calling `SQLDisconnect()`. In auto-commit mode, even if you do not specify `SQLEndTran()`, a commit is issued implicitly at the end of each statement execution or when a cursor is closed.

If a distributed unit of work is involved, additional rules might apply.

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

- Each connection cannot have more than one current transaction at any given time, so keep dependent statements within the same unit of work. Note that statements must always be kept on the same connection under which they were allocated.
- Various resources may be held while the current transaction on a connection is running. Ending the transaction will release the resources for use by other applications.
- Once a transaction has successfully been committed or rolled back, it is fully recoverable from the system logs. Open transactions are not recoverable.

Effects of calling SQLEndTran()

When a transaction ends:

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

Preparing and executing SQL statements in CLI applications

After you have allocated a statement handle, you can perform operations using SQL statements or XQuery expressions.

An SQL statement or XQuery expression must be prepared before it can be executed, and CLI offers two ways of preparing and executing: perform the prepare and execute operations in separate steps, and combine the prepare and execute operations into one step.

Before you begin

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

Procedure

- To prepare and execute an SQL statement or XQuery expression in separate steps:

1. Prepare the SQL statement or XQuery expression by calling `SQLPrepare()` and passing the statement or expression as the *StatementText* argument.

   Note: XQuery expressions must be prefixed with the case-insensitive "XQUERY" keyword, unless the statement attribute SQL_ATTR_XQUERY_STATEMENT has been set to SQL_TRUE for this statement handle.
2. Call `SQLBindParameter()` to bind any parameter markers you have in the SQL statement. CLI supports named parameter markers (for example, `:name`) and unnamed parameter markers represented by a question mark (?).

   Note:
   - To use named parameter markers, you must explicitly enable named parameter processing by setting the EnableNamedParameterSupport configuration keyword to TRUE.
   - For XQuery expressions, you cannot specify parameter markers in the expression itself. You can, however, use the XMLQUERY function to bind parameter markers to XQuery variables. The values of the bound parameter markers are then passed to the XQuery expression specified in XMLQUERY for execution.
3. Execute the prepared statement by calling `SQLExecute()`.

Use this method when:

- The same SQL statement or XQuery expression is executed repeatedly (usually with different parameter values). This avoids having to prepare the same statement or expression more than once. The subsequent executions use the access plans already generated by the prepared statement, thus increasing driver efficiency and delivering better application performance.
- The application requires information about the parameters or columns in the result set before the statement execution.

- To prepare and execute an SQL statement or XQuery expression in one step:
  1. Call `SQLBindParameter()` to bind any parameter markers you may have in the SQL statement. CLI supports named parameter markers (for example, `:name`) and unnamed parameter markers represented by a question mark (?).

     Note:
     - To use named parameter markers, you must explicitly enable named parameter processing by setting the EnableNamedParameterSupport configuration keyword to TRUE.
     - For XQuery expressions, you cannot specify parameter markers in the expression itself. You can, however, use the XMLQUERY function to bind parameter markers to XQuery variables. The values of the bound parameter markers are then passed to the XQuery expression specified in XMLQUERY for execution.
  2. Prepare and execute the statement or expression by calling `SQLExecDirect()` with the SQL statement or XQuery expression as the *StatementText* argument.

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

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

- The statement or expression is executed only once. This avoids having to call two functions to execute the statement or expression.
- The application does not require information about the columns in the result set before the statement is executed.

Deferred prepare in CLI applications

Deferred prepare is a CLI feature that minimize communication with the server by sending both the prepare and execute requests for SQL statements in the same network flow.

The default value for this property can be overridden using the CLI/ODBC configuration keyword DeferredPrepare. This property can be set on a per-statement handle basis by calling `SQLSetStmtAttr()` to change the SQL_ATTR_DEFERRED_PREPARE statement attribute.

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

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

Executing compound SQL (CLI) statements in CLI applications

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

About this task

- Compound SQL (CLI) does not guarantee the order in which the substatements are executed, therefore there must not be any dependencies among the substatements.
- Compound SQL (CLI) statements cannot be nested.
- The BEGIN COMPOUND and END COMPOUND statements must be executed with the same statement handle.
- The value specified in the STOP AFTER FIRST ? STATEMENTS clause of the BEGIN COMPOUND SQL statement must be of type SQL_INTEGER, and you can only bind an application buffer of type SQL_C_INTEGER or SQL_C_SMALLINT for this value.
- Each substatement must have its own statement handle.
- All statement handles must belong to the same connection and have the same isolation level.

- Atomic array input is not supported within a BEGIN COMPOUND and END COMPOUND block of SQL statements. Atomic array input refers to the behavior where all inserts will be undone if any single insert fails.
- All statement handles must remain allocated until the END COMPOUND statement is executed.
- `SQLEndTran()` cannot be called for the same connection or any connect requests between BEGIN COMPOUND and END COMPOUND.
- Only the following functions may be called using the statement handles allocated for the compound substatements:
  - `SQLAllocHandle()`
  - `SQLBindParameter()`
  - `SQLBindFileToParam()`
  - `SQLExecute()`
  - `SQLParamData()`
  - `SQLPrepare()`
  - `SQLPutData()`

Procedure

To execute compound SQL (CLI) statements in CLI applications:

1. Allocate a parent statement handle. For example:
   ```
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmtparent);
   ```
2. Allocate statement handles for each of the compound substatements. For example:
   ```
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmtsub1);
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmtsub2);
   SQLAllocHandle (SQL_HANDLE_STMT, hdbc, &hstmtsub3);
   ```
3. Prepare the substatements. For example:
   ```
   SQLPrepare (hstmtsub1, stmt1, SQL_NTS);
   SQLPrepare (hstmtsub2, stmt2, SQL_NTS);
   SQLPrepare (hstmtsub3, stmt3, SQL_NTS);
   ```
4. Execute the BEGIN COMPOUND statement using the parent statement handle. For example:
   ```
   SQLExecDirect (hstmtparent, (SQLCHAR *) "BEGIN COMPOUND NOT ATOMIC STATIC",
                  SQL_NTS);
   ```
5. If this is an atomic compound SQL operation, execute the substatements using the `SQLExecute()` function only. For example:
   ```
   SQLExecute (hstmtsub1);
   SQLExecute (hstmtsub2);
   SQLExecute (hstmtsub3);
   ```

   Note: All statements to be executed inside an atomic compound block must first be prepared. Attempts to use the `SQLExecDirect()` function within an atomic compound block will result in errors.
6. Execute the END COMPOUND statement using the parent statement handle. For example:
   ```
   SQLExecDirect (hstmtparent, (SQLCHAR *) "END COMPOUND NOT ATOMIC STATIC",
                  SQL_NTS);
   ```
7. Optional: If you used an input parameter value array, call `SQLRowCount()` with the parent statement handle to retrieve the aggregate number of rows affected by all elements of the input array. For example:
   ```
   SQLRowCount (hstmtparent, &numRows);
   ```

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

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

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

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

Results

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

Cursors in CLI applications

In CLI applications, you use a cursor to retrieve rows from a result set. A cursor is a moveable pointer that you use to select a row in the result table of an active query statement.

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

Types of cursors

There are two types of cursors supported by CLI:

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

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

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

keyset-driven
Unlike a static scrollable cursor, a keyset-driven scrollable cursor can detect and make changes to the underlying data. Keyset cursors are based on row keys. When a keyset-driven cursor is first opened, it stores the keys in a keyset for the life of the entire result set. The keyset is used to determine the order and set of rows that are included in the cursor. As the cursor scrolls through the result set, it uses the keys in this keyset to retrieve the most recent values

in the database, which are not necessarily the values that existed when the cursor was first opened. For this reason, changes are not reflected until the application scrolls to the row.

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

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

dynamic

Dynamic scrollable cursors can detect all changes (inserts, deletes, and updates) to the result set, and make insertions, deletions and updates to the result set. Unlike keyset-driven cursors, dynamic cursors:

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

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

Cursor attributes

The table 1 lists the default attributes for cursors in CLI.

Table 6. Default attributes for cursors in CLI

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

Table 6. Default attributes for cursors in CLI (continued)

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

Update of keyset-driven cursors

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

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

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

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

Cursor considerations for CLI applications

When you are writing an application that uses cursors, you must decide which type of cursor to use, how your cursor affects units of work, and how to troubleshoot applications that existed prior to the cursor application.

Which cursor type to use

The first decision to make is between a forward-only cursor and a scrollable cursor. A forward-only cursor incurs less resource usage than a scrollable cursor, and scrollable cursors have the potential for decreased concurrency.

If your application does not need the additional features of a scrollable cursor, then you should use a non-scrollable cursor.

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

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

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

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

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

- SQL_DYNAMIC_CURSOR_ATTRIBUTES1
- SQL_DYNAMIC_CURSOR_ATTRIBUTES2
- SQL_FORWARD_ONLY_CURSOR_ATTRIBUTES1
- SQL_FORWARD_ONLY_CURSOR_ATTRIBUTES2
- SQL_KEYSET_CURSOR_ATTRIBUTES1
- SQL_KEYSET_CURSOR_ATTRIBUTES2
- SQL_STATIC_CURSOR_ATTRIBUTES1
- SQL_STATIC_CURSOR_ATTRIBUTES2

Unit of work considerations

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

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

- Set the statement attribute SQL_ATTR_CURSOR_HOLD to SQL_CURSOR_HOLD_ON (default) or SQL_CURSOR_HOLD_OFF. This setting only affects cursors opened on the statement handle after this value has been set. It will not affect cursors already open.

- Set the CLI/ODBC configuration keyword CursorHold to change the default CLI driver behavior. Setting CursorHold=1 preserves the default behavior of cursors declared as WITH HOLD, and CursorHold=0 results in cursors being closed when each transaction is committed. You can override this keyword by setting the SQL_ATTR_CURSOR_HOLD statement attribute.

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

Troubleshooting for applications created before scrollable cursor support

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

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

Configuration keyword setting	Description
`Patch2=6`	Returns a message that scrollable cursors (keyset-driven, dynamic and static) are not supported. CLI automatically downgrades any request for a scrollable cursor to a forward-only cursor.
`DisableKeysetCursor=1`	Disables keyset-driven scrollable cursors. This can be used to force the CLI driver to give the application a static cursor when a keyset-driven or dynamic cursor is requested.

Result sets in CLI applications

A result set is the complete set of rows that satisfy an SQL SELECT statement. You use a fetch statement to retrieve rows from the result set to populate the row set.

The following terms describe result handling:

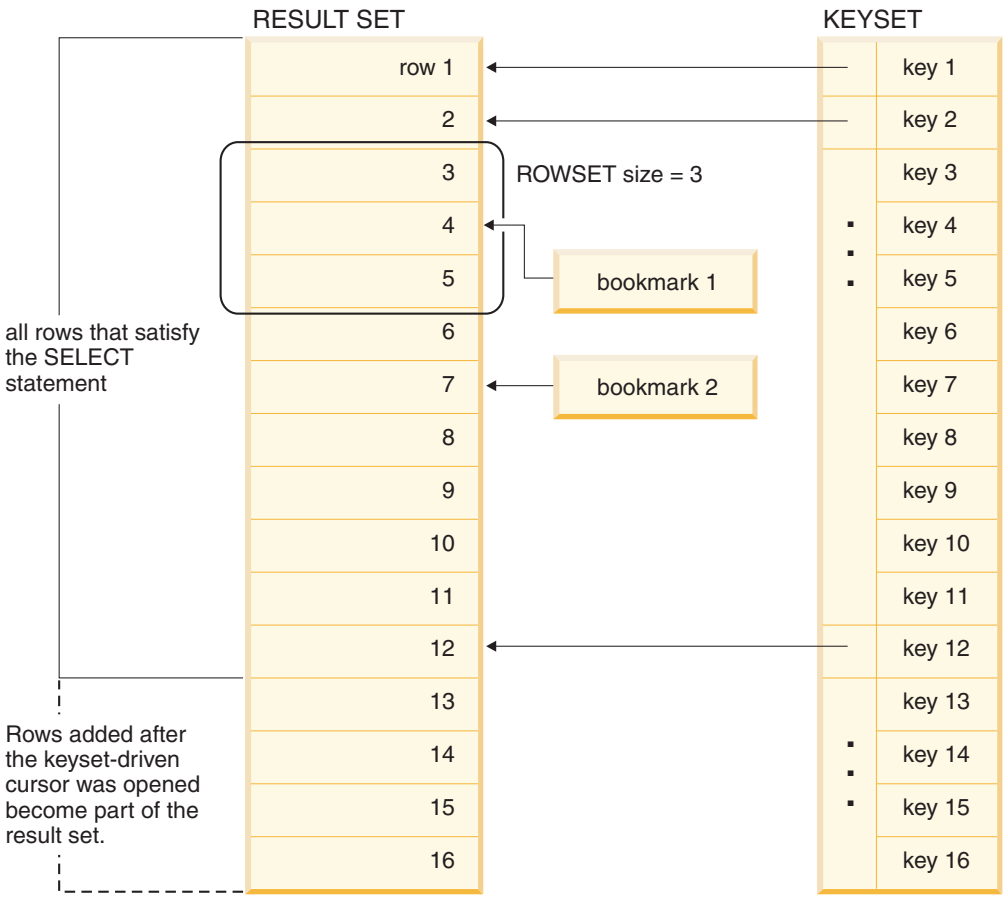
rowset
The subset of rows from the result set that is returned after each fetch. The application indicates the size of the rowset before the first fetch of data, and can modify the size before each subsequent fetch. Each call to `SQLFetch()`, `SQLFetchScroll()`, or `SQLExtendedFetch()` populates the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

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

keyset A set of key values used to identify the set and order of rows that are included in a keyset-driven cursor. The keyset is created when a

keyset-driven cursor is first opened. As the cursor scrolls through the result set, it uses the keys in the keyset to retrieve the current data values for each row.

The following figure demonstrates the relationship between result set, rowset, bookmark, and keyset:



Bookmarks in CLI applications

When you use scrollable cursors, you can save a reference to any row in the result set by using a bookmark.

The application can then use that bookmark as a relative position to retrieve a rowset of information or to update or delete a row when using keyset cursors. You can retrieve a rowset starting from the bookmarked row, or specify a positive or negative offset.

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

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

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

Rowset retrieval examples in CLI applications

The rowset is a cache that holds predefined rows of data that are returned in the result set.

Partial rowset example

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

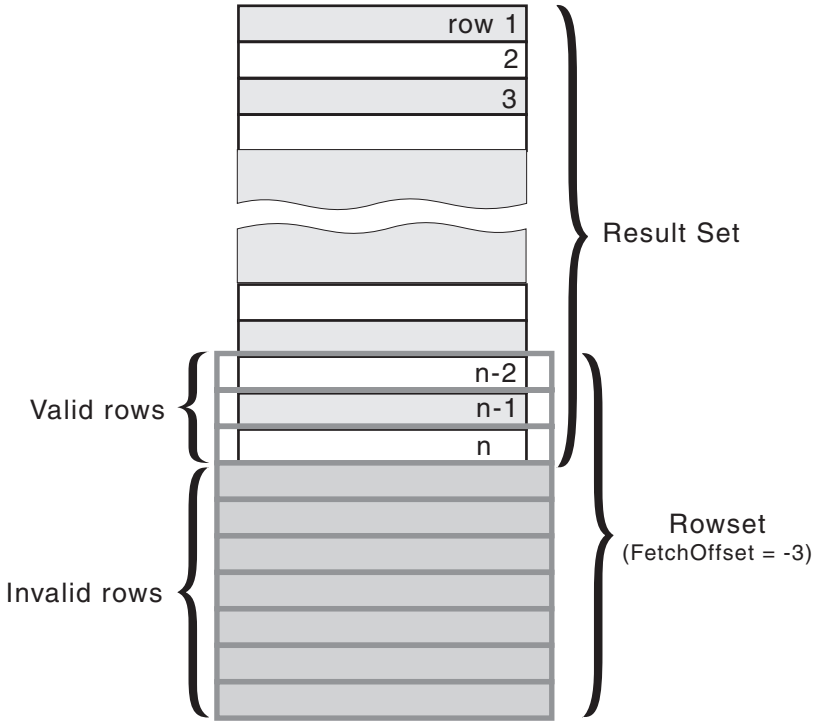


Figure 5. Partial rowset example

Fetch orientations example

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

1. SQL_FETCH_LAST
2. SQL_FETCH_FIRST

3. SQL_FETCH_NEXT
4. SQL_FETCH_RELATIVE
5. SQL_FETCH_ABSOLUTE

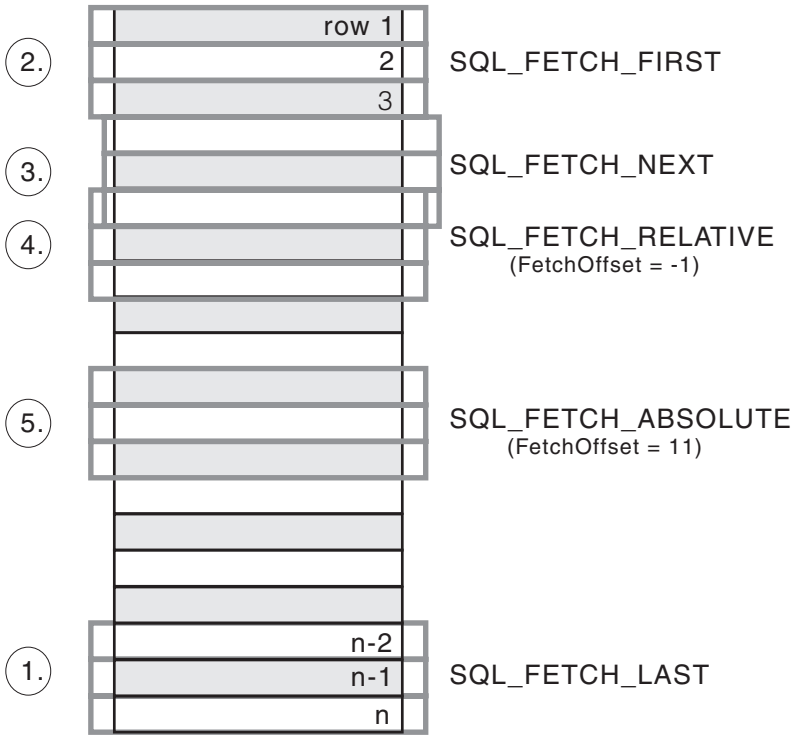


Figure 6. Example of retrieving rowsets

Retrieving query results in CLI applications

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

Before you begin

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

Procedure

To retrieve each row of the result set:

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

   Note: Performing this step can reduce performance if done before the query has been executed, because it forces CLI to describe the query's columns. Information about the result set's columns is available after successful execution, and describing the result set does not incur any additional resource usage if the describe is performed after successful execution.

2. Bind an application variable to each column of the result set, by calling SQLBindCol(), ensuring that the variable type matches the column type. For example:

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

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

/* ... */

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

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

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

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

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

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

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

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

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

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

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

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

if (cliRC == SQL_NO_DATA_FOUND)
{
  printf("\n  Data not found.\n");
}
while (cliRC != SQL_NO_DATA_FOUND)
{
  /* use SQLGetData() to get the results */
  /* get data from column 1 */
  cliRC = SQLGetData(hstmt,
                     1,
                     SQL_C_SHORT,
                     &deptnumb.val,
                     0,
                     &deptnumb.ind);
  STMT_HANDLE_CHECK(hstmt, hdbc, cliRC);

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

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

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

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

Column binding in CLI applications

The column binding is associating columns in a result set to C data type variables, and associating LOB columns to LOB locators or LOB file references.

Columns may be bound to:

- Application storage

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

- LOB locators

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

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

  Once an application receives a locator it can be used in `SQLGetSubString()`, `SQLGetPosition()`, `SQLGetLength()`, or as the value of a parameter marker in another SQL statement. `SQLGetSubString()` can either return another locator, or the data itself. All locators remain valid until the end of the transaction in which

they were created (even when the cursor moves to another row), or until it is freed using the FREE LOCATOR statement.

- Lob file references

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

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

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

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

An application can choose not to bind every column, or even not to bind any columns. Data in any of the columns can also be retrieved using SQLGetData() after the bound columns have been fetched for the current row. It is usually more efficient to bind application variables or file references to result sets than to use SQLGetData(). When the data is in a LOB column, LOB functions are preferable to SQLGetData() . Use SQLGetData() when the data value is large variable-length data that:

- must be received in pieces, or
- may not need to be retrieved.

Instead of multiple calls to SQLBindCol(), CLI also supports column binding offsets. Rather than re-binding each time, an offset can be used to specify new buffer and length/indicator addresses which will be used in a subsequent call to SQLFetch() or SQLFetchScroll(). This can only be used with row wise binding, but will work whether the application retrieves a single row or multiple rows at a time.

When binding any variable length column, CLI will be able to write *StrLen_or_IndPtr* and *TargetValuePtr* in one operation if they are allocated contiguously. For example:

```
struct {  SQLINTEGER  StrLen_or_IndPtr;
          SQLCHAR     TargetValuePtr[MAX_BUFFER];
       } column;
```

The most recent bind column function call determines the type of binding that is in effect.

Specifying the rowset returned from the result set

Before you begin to retrieve data, you need to establish the rowset that will be returned. This topic describes the steps associated with setting up the rowset.

Before you begin

Before specifying the rowset, ensure that you have initialized your CLI application.

About this task

CLI allows an application to specify a rowset for a non-scrollable or scrollable cursor that spans more than one row at a time.

Procedure

To effectively work with a rowset, an application should perform the following steps:

1. Specify the size of the rowset returned from calls to `SQLFetch()` or `SQLFetchScroll()` by setting the statement attribute SQL_ATTR_ROW_ARRAY_SIZE to the number of rows in the rowset. The default number of rows is 1. For example, to declare a rowset size of 35 rows, issue the following call:

   ```
   #define ROWSET_SIZE 35
   /* ... */
   rc = SQLSetStmtAttr(hstmt,
                       SQL_ATTR_ROW_ARRAY_SIZE,
                       (SQLPOINTER) ROWSET_SIZE,
                       0);
   ```

2. Set up a variable that will store the number of rows returned. Declare a variable of type SQLUINTEGER and set the SQL_ATTR_ROWS_FETCHED_PTR statement attribute to point to this variable. In the following example, *rowsFetchedNb* will hold the number of rows returned in the rowset after each call to `SQLFetchScroll()`:

   ```
   /* ... */

   SQLUINTEGER rowsFetchedNb;

   /* ... */

   rc = SQLSetStmtAttr(hstmt,
                       SQL_ATTR_ROWS_FETCHED_PTR,
                       &rowsFetchedNb,
                       0);
   ```

3. Set up the row status array. Declare an array of type SQLUSMALLINT with the same number of rows as the size of the rowset (as determined in Step 1). Then specify the address of this array with the statement attribute SQL_ATTR_ROW_STATUS_PTR. For example:

   ```
   /* ... */
   SQLUSMALLINT    row_status[ROWSET_SIZE];
   /* ... */
   /* Set a pointer to the array to use for the row status */
   rc = SQLSetStmtAttr(
               hstmt,
               SQL_ATTR_ROW_STATUS_PTR,
               (SQLPOINTER) row_status,
               0);
   ```

   The row status array provides additional information about each row in the rowset. After each call to `SQLFetch()` or `SQLFetchScroll()`, the array is updated. If the call to `SQLFetch()` or `SQLFetchScroll()` does not return SQL_SUCCESS or SQL_SUCCESS_WITH_INFO, then the contents of the row status array are undefined. Otherwise, any of the row status array values will be returned (refer to the row status array section of the SQLFetchScroll() documentation for a complete list of values).

4. Position the rowset within the result set, indicating the position you want the rowset to begin. Specify this position by calling `SQLFetch()`, or

SQLFetchScroll() with *FetchOrientation* and *FetchOffset* values. For example, the following call generates a rowset starting on the 11th row in the result set:

```
SQLFetchScroll(hstmt,   /* Statement handle */
    SQL_FETCH_ABSOLUTE, /* FetchOrientation value */
    11);                /* Offset value */
```

Scroll bar operations of a screen-based application can be mapped directly to the positioning of a rowset. By setting the rowset size to the number of lines displayed on the screen, the application can map the movement of the scroll bar to calls to SQLFetchScroll().

Note: If the application can buffer data in the display and regenerate the result set to see updates, then use a forward-only cursor instead. This yields better performance for small result sets.

Rowset retrieved	FetchOrientation value	Scroll bar
First rowset	SQL_FETCH_FIRST	Home: Scroll bar at the top
Last rowset	SQL_FETCH_LAST	End: Scroll bar at the bottom
Next rowset	SQL_FETCH_NEXT (same as calling SQLFetch())	Page Down
Previous rowset	SQL_FETCH_PRIOR	Page Up
Rowset starting on next row	SQL_FETCH_RELATIVE with *FetchOffset* set to 1	Line Down
Rowset starting on previous row	SQL_FETCH_RELATIVE with *FetchOffset* set to -1	Line Up
Rowset starting on a specific row	SQL_FETCH_ABSOLUTE with *FetchOffset* set to an offset from the start (a positive value) or the end (a negative value) of the result set	Application generated
Rowset starting on a previously bookmarked row	SQL_FETCH_BOOKMARK with *FetchOffset* set to a positive or negative offset from the bookmarked row	Application generated

5. Check the rows fetched pointer after each rowset is created to determine the number of rows returned. Check the row status array for the status of each row, because there are instances where the rowset will not contain a complete set of rows. The application cannot assume that the entire rowset will contain data.

   For instance, consider the case where the rowset size is set to 10, and SQLFetchScroll() is called using SQL_FETCH_ABSOLUTE and *FetchOffset* is set to -3. This will attempt to return 10 rows starting 3 rows from the end of the result set. Only the first three rows of the rowset will contain meaningful data, however, and the application must ignore the rest of the rows.

Retrieving data with scrollable cursors in a CLI application

Scrollable cursors allow you to move throughout a result set. You can make use of this feature when retrieving data. This topic describes how to use scrollable cursors to retrieve data.

Before you begin

Before you retrieve data using scrollable cursors, ensure that you have initialized your CLI application.

Procedure

To use scrollable cursors to retrieve data:

1. Specify the size of the rowset returned by setting the statement attribute SQL_ATTR_ROW_ARRAY_SIZE to the number of rows in the rowset. The default number of rows is 1. For example, to declare a rowset size of 35 rows, issue the following call:

```
#define ROWSET_SIZE 35
/* ... */
rc = SQLSetStmtAttr(hstmt,
                    SQL_ATTR_ROW_ARRAY_SIZE,
                    (SQLPOINTER) ROWSET_SIZE,
                    0);
```

2. Specify the type of scrollable cursor to use. Using SQLSetStmtAttr(), set the SQL_ATTR_CURSOR_TYPE statement attribute to SQL_CURSOR_STATIC for a static read-only cursor or to SQL_CURSOR_KEYSET_DRIVEN for a keyset-driven cursor. For example:

```
sqlrc = SQLSetStmtAttr (hstmt,
                        SQL_ATTR_CURSOR_TYPE,
                        (SQLPOINTER) SQL_CURSOR_STATIC,
                        0);
```

   If the type of cursor is not set, the default forward-only non-scrollable cursor will be used.

3. Set up a variable that will store the number of rows returned. Declare a variable of type SQLUINTEGER and set the SQL_ATTR_ROWS_FETCHED_PTR statement attribute to point to this variable. In the following example, *rowsFetchedNb* will hold the number of rows returned in the rowset after each call to SQLFetchScroll():

```
/* ... */

SQLUINTEGER rowsFetchedNb;

/* ... */

rc = SQLSetStmtAttr(hstmt,
                    SQL_ATTR_ROWS_FETCHED_PTR,
                    &rowsFetchedNb,
                    0);
```

4. Set up the row status array. Declare an array of type SQLUSMALLINT with the same number of rows as the size of the rowset (as determined in Step 1). Then specify the address of this array with the statement attribute SQL_ATTR_ROW_STATUS_PTR. For example:

```
/* ... */
SQLUSMALLINT    row_status[ROWSET_SIZE];
/* ... */
/* Set a pointer to the array to use for the row status */
rc = SQLSetStmtAttr(
            hstmt,
            SQL_ATTR_ROW_STATUS_PTR,
            (SQLPOINTER) row_status,
            0);
```

The row status array provides additional information about each row in the rowset. After each call to SQLFetchScroll(), the array is updated. If the call to SQLFetchScroll() does not return SQL_SUCCESS or SQL_SUCCESS_WITH_INFO, then the contents of the row status array are undefined. Otherwise, any of the row status array values will be returned (refer to the row status array section of the SQLFetchScroll() documentation for a complete list of values).

5. Optional: If you want to use bookmarks with the scrollable cursor, set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE. For example:

```
sqlrc = SQLSetStmtAttr (hstmt,
                        SQL_ATTR_USE_BOOKMARKS,
                        (SQLPOINTER) SQL_UB_VARIABLE,
                        0);
```

6. Issue an SQL SELECT statement.
7. Execute the SQL SELECT statement.
8. Bind the result set using either column-wise or row-wise binding.
9. Fetch a rowset of rows from the result set.
   a. Call `SQLFetchScroll()` to fetch a rowset of data from the result set. Position the rowset within the result set indicating the position you want the rowset to begin. Specify this position by calling `SQLFetchScroll()` with *FetchOrientation* and *FetchOffset* values. For example, the following call generates a rowset starting on the 11th row in the result set:

```
SQLFetchScroll(hstmt,              /* Statement handle */
               SQL_FETCH_ABSOLUTE, /* FetchOrientation value */
               11);                /* Offset value */
```

   b. Check the row status array after each rowset is created to determine the number of rows returned, because there are instances where the rowset will not contain a complete set of rows. The application cannot assume that the entire rowset will contain data.

      For instance, consider the case where the rowset size is set to 10, and `SQLFetchScroll()` is called using SQL_FETCH_ABSOLUTE and *FetchOffset* is set to `-3`. This will attempt to return 10 rows starting 3 rows from the end of the result set. Only the first three rows of the rowset will contain meaningful data, however, and the application must ignore the rest of the rows.

   c. Display or manipulate the data in the rows returned.
10. Close the cursor by calling `SQLCloseCursor()` or free the statement handle by calling `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_STMT.

    Freeing the statement handles is not required every time retrieval has finished. The statement handles can be freed at a later time, when the application is freeing other handles.

Retrieving data with bookmarks in a CLI application

Bookmarks, available only when scrollable cursors are used, allow you to save a reference to any row in a result set. You can take advantage of this feature when retrieving data. This topic describes how to retrieve data using bookmarks.

Before you begin

Before you retrieve data with bookmarks, ensure that you have initialized your CLI application. The steps explained here should be performed in addition to those described in "Retrieving Data with Scrollable Cursors in a CLI Application".

Procedure

To use bookmarks with scrollable cursors to retrieve data:

1. Indicate that bookmarks will be used (if not already done so) by setting the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE. For example:

```
sqlrc = SQLSetStmtAttr (hstmt,
                        SQL_ATTR_USE_BOOKMARKS,
                        (SQLPOINTER) SQL_UB_VARIABLE,
                        0);
```

2. Get the bookmark value from the required row in the rowset after executing the SELECT statement and retrieving the rowset using SQLFetchScroll(). Do this by calling SQLSetPos() to position the cursor within the rowset. Then call SQLGetData() to retrieve the bookmark value. For example:

```
sqlrc = SQLFetchScroll(hstmt, SQL_FETCH_ABSOLUTE, 15);
/* ... */
sqlrc = SQLSetPos(hstmt, 3, SQL_POSITION, SQL_LOCK_NO_CHANGE);
/* ... */
sqlrc = SQLGetData(hstmt, 0, SQL_C_LONG, bookmark.val, 4,
                   &bookmark.ind);
```

   In most cases, you will not want to bind column 0 and retrieve the bookmark value for every row, but use SQLGetData() to retrieve the bookmark value for the specific row you require.

3. Store the bookmark location for the next call to SQLFetchScroll(). Set the SQL_ATTR_FETCH_BOOKMARK statement attribute to the variable that contains the bookmark value. For example, *bookmark.val* stores the bookmark value, so call SQLSetStmtAttr() as follows:

```
sqlrc = SQLSetStmtAttr(hstmt,
                       SQL_ATTR_FETCH_BOOKMARK_PTR,
                       (SQLPOINTER) bookmark.val,
                       0);
```

4. Retrieve a rowset based on the bookmark. Once the bookmark value is stored, the application can continue to use `SQLFetchScroll()` to retrieve data from the result set. The application can then move throughout the result set, but still retrieve a rowset based on the location of the bookmarked row at any point before the cursor is closed.

   The following call to `SQLFetchScroll()` retrieves a rowset starting from the bookmarked row:

```
sqlrc = SQLFetchScroll(hstmt, SQL_FETCH_BOOKMARK, 0);
```

   The value 0 specifies the offset. You would specify -3 to begin the rowset 3 rows before the bookmarked row, or specify 4 to begin 4 rows after. For example, the following call from retrieves a rowset 4 rows after the bookmarked row:

```
sqlrc = SQLFetchScroll(hstmt, SQL_FETCH_BOOKMARK, 4);
```

   Note that the variable used to store the bookmark value is not specified in the `SQLFetchScroll()` call. It was set in the previous step using the statement attribute SQL_ATTR_FETCH_BOOKMARK_PTR.

Retrieving bulk data with bookmarks using SQLBulkOperations() in CLI applications

You can retrieve, or fetch, bulk data using bookmarks and the CLI `SQLBulkOperations()` function.

Before you begin

Before fetching bulk data using bookmarks and `SQLBulkOperations()`, ensure you have initialized your CLI application.

About this task

Bookmarks in CLI do not persist across cursor close operations. This means that an application cannot use bookmarks that it has stored from a previous cursor. Instead, it has to call SQLFetch() or SQLFetchScroll() to retrieve the bookmarks before updating with bookmarks.

Procedure

To perform bulk fetches using bookmarks with `SQLBulkOperations()`:

1. Set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE using `SQLSetStmtAttr()`.
2. Execute a query that returns a result set.
3. Set the SQL_ATTR_ROW_ARRAY_SIZE statement attribute to the number of rows you want to fetch by calling `SQLSetStmtAttr()`.
4. Call `SQLBindCol()` to bind the data you want to fetch.

   The data is bound to an array with a size equal to the value of SQL_ATTR_ROW_ARRAY_SIZE.
5. Call `SQLBindCol()` to bind column 0, the bookmark column.
6. Copy the bookmarks for rows you want to fetch into the array bound to column 0.

   Note: The size of the array pointed to by the SQL_ATTR_ROW_STATUS_PTR statement attribute should either be equal to SQL_ATTR_ROW_ARRAY_SIZE, or the SQL_ATTR_ROW_STATUS_PTR statement attribute should be a null pointer.
7. Fetch the data by calling `SQLBulkOperations()` with an *Operation* argument of SQL_FETCH_BY_BOOKMARK.

   If the application has set the SQL_ATTR_ROW_STATUS_PTR statement attribute, then it can inspect this array to see the result of the operation.

Result set retrieval into arrays in CLI applications

One of the most common tasks performed by an application is to issue a query statement, and then fetch each row of the result set into application variables that have been bound by using the `SQLBindCol()` function.

If the application requires that each column or each row of a result set be stored in an array, each fetch must be followed by either a data copy operation or a new set of `SQLBindCol()` calls to assign new storage areas for the next fetch.

Alternatively, applications can eliminate the resource usage of extra data copies or extra `SQLBindCol()` calls by retrieving multiple rows of data (called a rowset) at one time into an array.

Note: A third method of reducing resource usage, which can be used on its own or with arrays, is to specify a binding offset. Rather than re-binding each time, an

offset can be used to specify new buffer and length/indicator addresses which will be used in a subsequent call to `SQLFetch()` or `SQLFetchScroll()`. This can only be used with row offset binding.

When retrieving a result set into an array, `SQLBindCol()` is also used to assign storage for application array variables. By default, the binding of rows is in column-wise fashion: this is similar to using `SQLBindParameter()` to bind arrays of input parameter values. Figure 7 is a logical view of column-wise binding.

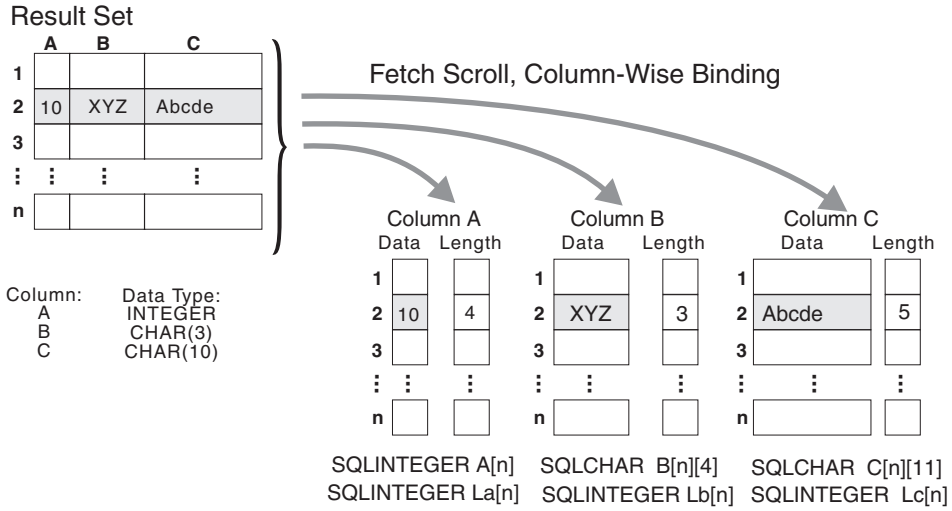


Figure 7. Column-wise binding

The application can also do row-wise binding which associates an entire row of the result set with a structure. In this case the rowset is retrieved into an array of structures, each of which holds the data in one row and the associated length fields. Figure 8 gives a pictorial view of row-wise binding.

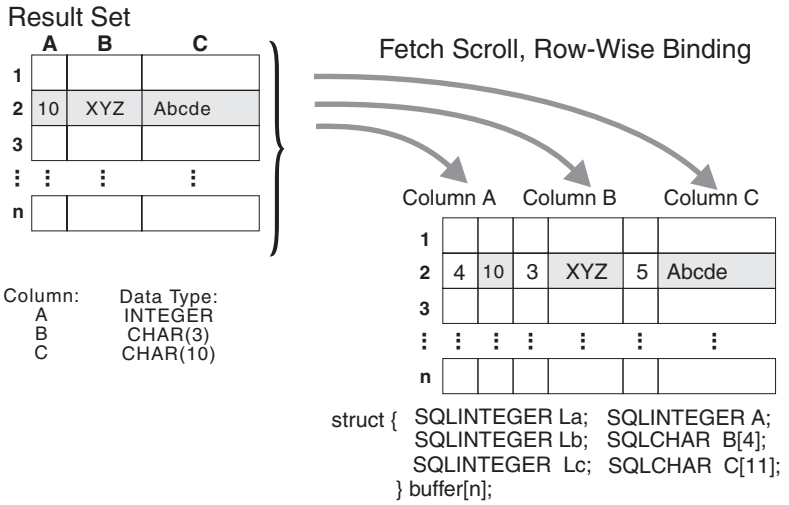


Figure 8. Row-wise binding

Retrieving array data in CLI applications using column-wise binding

When retrieving data, you may want to retrieve more than one row at a time and store the data in an array.

Instead of fetching and copying each row of data into an array, or binding to new storage areas, you can retrieve multiple rows of data at once using column-wise binding. Column-wise binding is the default row-binding method whereby each data value and its length is stored in an array.

Before you begin

Before using column-wise binding to retrieve data into arrays, ensure you have initialized your CLI application.

Procedure

To retrieve data using column-wise binding:

1. Allocate an array of the appropriate data type for each column data value. This array will hold the retrieved data value.
2. Allocate an array of SQLINTEGER for each column. Each array will store the length of each column's data value.
3. Specify that column-wise array retrieval will be used by setting the SQL_ATTR_ROW_BIND_TYPE statement attribute to SQL_BIND_BY_COLUMN using `SQLSetStmtAttr()`.
4. Specify the number of rows that will be retrieved by setting the SQL_ATTR_ROW_ARRAY_SIZE statement attribute using `SQLSetStmtAttr()`.

   When the value of the SQL_ATTR_ROW_ARRAY_SIZE attribute is greater than 1, CLI treats the deferred output data pointer and length pointer as pointers to arrays of data and length rather than to one single element of data and length of a result set column.
5. Prepare and execute the SQL statement used to retrieve the data.
6. Bind each array to its column by calling `SQLBindCol()` for each column.
7. Retrieve the data by calling `SQLFetch()` or `SQLFetchScroll()`.

   When returning data, CLI uses the maximum buffer size argument (*BufferLength*) of `SQLBindCol()` to determine where to store successive rows of data in the array. The number of bytes available for return for each element is stored in the deferred length array. If the number of rows in the result set is greater than the SQL_ATTR_ROW_ARRAY_SIZE attribute value, multiple calls to `SQLFetchScroll()` are required to retrieve all the rows.

Retrieving array data in CLI applications using row-wise binding

When retrieving data, you might want to retrieve more than one row at a time and store the data in an array.

Instead of fetching and copying each row of data into an array, or binding to new storage areas, you can retrieve multiple rows of data using row-wise binding. Row-wise binding associates an entire row of the result set with a structure. The rowset is retrieved into an array of structures, each of which holds the data in one row and the associated length fields.

Before you begin

Before using row-wise binding to retrieve data into arrays, ensure you have initialized your CLI application.

Procedure

To retrieve data using row-wise binding:

1. Allocate an array of structures of size equal to the number of rows to be retrieved, where each element of the structure is composed of each row's data value and each data value's length.

   For example, if each row of the result set consisted of Column A of type INTEGER, Column B of type CHAR(3), and Column C of type CHAR(10), then you can allocate the example structure, where n represents the number of rows in the result set:

   ```
   struct { SQLINTEGER La; SQLINTEGER A;
            SQLINTEGER Lb; SQLCHAR B[4];
            SQLINTEGER Lc; SQLCHAR C[11];
          } buffer[n];
   ```

2. Specify that row-wise array retrieval will be used by setting the SQL_ATTR_ROW_BIND_TYPE statement attribute, using `SQLSetStmtAttr()` to the size of the structure to which the result columns will be bound.
3. Specify the number of rows that will be retrieved by setting the SQL_ATTR_ROW_ARRAY_SIZE statement attribute using `SQLSetStmtAttr()`.
4. Prepare and execute the SQL statement used to retrieve the data.
5. Bind each structure to the row by calling `SQLBindCol()` for each column of the row.

   CLI treats the deferred output data pointer of `SQLBindCol()` as the address of the data field for the column in the first element of the array of structures. The deferred output length pointer is treated as the address of the associated length field of the column.
6. Retrieve the data by calling `SQLFetchScroll()`.

   When returning data, CLI uses the structure size provided with the SQL_ATTR_ROW_BIND_TYPE statement attribute to determine where to store successive rows in the array of structures.

Changing column bindings in a CLI application with column binding offsets

When an application needs to change bindings (for a subsequent fetch, for example) it can call `SQLBindCol()` a second time.

This will change the buffer address and length/indicator pointer used. Instead of multiple calls to SQLBindCol(), CLI supports column binding offsets. Rather than re-binding each time, an offset can be used to specify new buffer and length/indicator addresses which will be used in a subsequent call to SQLFetch() or SQLFetchScroll().

Before you begin

Before using column binding offsets to change result set bindings, ensure you have initialized your CLI application.

About this task

This method can only be used with row-wise binding, but will work whether the application retrieves a single row or multiple rows at a time.

Procedure

To change result set bindings using column binding offsets:

1. Call SQLBindCol() as usual to bind the result set. The first set of bound data buffer and length/indicator buffer addresses will act as a template. The application will then move this template to different memory locations using the offset.
2. Call SQLFetch() or SQLFetchScroll() as usual to fetch the data. The data returned will be stored in the locations bound in step 1.
3. Set up a variable to hold the memory offset value.

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

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

   The offset value is always added to the memory location of the originally bound values. This sum must point to a valid memory address with sufficient space to hold the next set of data.
5. Call SQLFetch() or SQLFetchScroll() again. CLI will add the offset value to the locations used in the original call to SQLBindCol(). This will determine where in memory to store the results.
6. Repeat steps 4 and 5 as required.

Data retrieval in pieces in CLI applications

In CLI applications, you retrieve data in pieces because character or binary data columns can be arbitrarily long. You can call the `SQLGetData()` function after calling the`SQLFetch()` function to get the SQL_SUCCESS_WITH_INFO to indicate if more data exists for a column.

Typically, an application might choose to allocate the maximum memory the column value could occupy and bind it via `SQLBindCol()`, based on information about a column in the result set (obtained via a call to `SQLDescribeCol()`, for example, or prior knowledge).

However, in the case of character and binary data, the column can be arbitrarily long. If the length of the column value exceeds the length of the buffer the application can allocate or afford to allocate, a feature of `SQLGetData()` lets the application use repeated calls to obtain in sequence the value of a single column in more manageable pieces.

For example:

```
/* dtlob.c */
/* ... */
sqlrc = SQLGetData(hstmt, 1, SQL_C_BINARY, (SQLPOINTER) buffer,
                   BUFSIZ, &bufInd);
```

```
/* ... */
while( sqlrc == SQL_SUCCESS_WITH_INFO || sqlrc == SQL_SUCCESS )
{   if ( bufInd > BUFSIZ)  /* full buffer */
    {   fwrite( buffer, sizeof(char), BUFSIZ, pFile);
    }
    else /* partial buffer on last GetData */
    {   fwrite( buffer, sizeof(char), bufInd, pFile);
    }

    sqlrc = SQLGetData( hstmt, 1, SQL_C_BINARY, (SQLPOINTER)buffer,
                        BUFSIZ, &bufInd);
    /* ... */
}
```

The function SQLGetSubString() can also be used to retrieve a specific portion of a large object value. For other alternative methods to retrieve long data, refer to the documentation on large object usage.

Fetching LOB data with LOB locators in CLI applications

There are many cases where an application needs to fetch a large object value by referencing a large object locator (LOB locator).

An example is used to demonstrate how using a locator to retrieve CLOB data allows a character string to be extracted from the CLOB, without having to transfer the entire CLOB to an application buffer. The LOB locator is fetched and then used as an input parameter to search the CLOB for a substring. This substring is then retrieved.

Before you begin

Before fetching LOB data with LOB locators, ensure that you have initialized your CLI application.

Procedure

To fetch LOB data using LOB locators:

1. Retrieve a LOB locator into an application variable using the SQLBindCol() or SQLGetData() functions. For example:

```
SQLINTEGER  clobLoc ;
SQLINTEGER  pcbValue ;

/* ... */
sqlrc = SQLBindCol( hstmtClobFetch, 1, SQL_C_CLOB_LOCATOR,
                    &clobLoc, 0, &pcbValue);
```

2. Fetch the locator using SQLFetch():

```
sqlrc = SQLFetch( hstmtClobFetch );
```

3. Call SQLGetLength() to get the length of a string that is represented by a LOB locator. For example:

```
sqlrc = SQLGetLength( hstmtLocUse, SQL_C_CLOB_LOCATOR,
                      clobLoc, &clobLen, &ind ) ;
```

4. Call SQLGetPosition() to get the position of a search string within a source string where the source string is represented by a LOB locator. The search string can also be represented by a LOB locator. For example:

```
sqlrc = SQLGetPosition( hstmtLocUse,
                        SQL_C_CLOB_LOCATOR,
                        clobLoc,
                        0,
                        ( SQLCHAR * ) "Interests",
```

```
                                strlen( "Interests"),
                                1,
                                &clobPiecePos,
                                &ind ) ;
```

5. Call SQLGetSubString() to retrieve the substring. For example:

```
sqlrc = SQLGetSubString( hstmtLocUse,
                         SQL_C_CLOB_LOCATOR,
                         clobLoc,
                         clobPiecePos,
                         clobLen - clobPiecePos,
                         SQL_C_CHAR,
                         buffer,
                         clobLen - clobPiecePos + 1,
                         &clobPieceLen,
                         &ind ) ;
```

6. Free the locator. All LOB locators are implicitly freed when a transaction ends. The locator can be explicitly freed before the end of a transaction by executing the FREE LOCATOR statement.

   Although this statement cannot be prepared dynamically, CLI will accept it as a valid statement on SQLPrepare() and SQLExecDirect(). The application uses SQLBindParameter() with the SQL data type argument set to the appropriate SQL and C symbolic data types. For example,

```
sqlrc = SQLSetParam( hstmtLocFree,
                     1,
                     SQL_C_CLOB_LOCATOR,
                     SQL_CLOB_LOCATOR,
                     0,
                     0,
                     &clobLoc,
                     NULL ) ;

/* ... */
sqlrc = SQLExecDirect( hstmtLocFree, stmtLocFree, SQL_NTS ) ;
```

XML data retrieval in CLI applications

You can retrieve data from XML columns with use of the `SQLBindCol()` function in your CLI application. The `SQLBindCol()` function is called to bind XML columns in a result-set to variables, arrays, or LOB locators after the SQLPrepare(), SQLExecDirect() or one of the schema function calls.

The data is retrieved when the SQLFetch() or SQLFetchScroll() function is called by a CLI application.

When you use the `SQLBindCol()` function to bind XML columns in a query result-set to application variables, you can specify the data type of the application variables as SQL_C_BINARY, SQL_C_CHAR, SQL_C_DBCHAR or SQL_C_WCHAR. When you select data from XML columns in a table by using the `SQLBindCol()` function, the output is returned as the serialized data.

When you are retrieving a result-set from an XML column, you can bind your application variable to the SQL_C_BINARY type to avoid possible data corruption. Binding to character types can result in possible data corruption as result of a code page conversion. Data corruption can occur when characters in the source code page cannot be represented in the target code page.

XML data is returned to the application as internally encoded data. The CLI determines the encoding of the data as follows:

- If the C type is SQL_C_BINARY, the CLI driver returns the data in the UTF-8 encoding scheme.
- If the C type is SQL_C_CHAR or SQL_C_DBCHAR, the CLI driver returns the data in the application code page encoding scheme.
- If the C type is SQL_C_WCHAR, the CLI driver returns the data in the UCS-2 encoding scheme.

An implicit serialization of data takes place on the database server before XML data is sent to the application. You can explicitly serialize the XML data to a specific data type by calling the XMLSERIALIZE() function. However, the explicitly serializing to character types with the XMLSERIALIZE() function can introduce encoding issues.

The following example shows how to retrieve XML data from an XML column into a binary application variable.

```
char xmlBuffer[10240];
// xmlBuffer is used to hold the retrieved XML document
integer length;

// Assume a table named dept has been created with the following statement:
// CREATE TABLE dept (id CHAR(8), deptdoc XML)

length = sizeof (xmlBuffer);
SQLExecute (hStmt, "SELECT deptdoc FROM dept WHERE id='001'", SQL_NTS);
SQLBindCol (hStmt, 1, SQL_C_BINARY, xmlBuffer, &length, NULL);
SQLFetch (hStmt);
SQLCloseCursor (hStmt);
// xmlBuffer now contains a valid XML document encoded in UTF-8
```

Inserting data

Inserting bulk data with bookmarks using SQLBulkOperations() in CLI applications

You can insert data in bulk with bookmarks using `SQLBulkOperations()`.

Before you begin

Before inserting bulk data with `SQLBulkOperations()`, ensure you have initialized your CLI application.

About this task

Bookmarks in CLI do not persist across cursor close operations. This means that an application cannot use bookmarks that it has stored from a previous cursor. Instead, it has to call SQLFetch() or SQLFetchScroll() to retrieve the bookmarks before updating with bookmarks.

Procedure

To perform a bulk data insert using `SQLBulkOperations()`:

1. Set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE using `SQLSetStmtAttr()`.
2. Execute a query that returns a result set.
3. Set the SQL_ATTR_ROW_ARRAY_SIZE statement attribute to the number of rows you want to insert using `SQLSetStmtAttr()`.

4. Call `SQLBindCol()` to bind the data you want to insert.

   The data is bound to an array with a size equal to the value of SQL_ATTR_ROW_ARRAY_SIZE, set in the previous step.

   Note: The size of the array pointed to by the SQL_ATTR_ROW_STATUS_PTR statement attribute should either be equal to SQL_ATTR_ROW_ARRAY_SIZE or SQL_ATTR_ROW_STATUS_PTR should be a null pointer.
5. Insert the data by calling `SQLBulkOperations()` with SQL_ADD as the *Operation* argument.

   CLI will update the bound column 0 buffers with the bookmark values for the newly inserted rows. For this to occur, the application must have set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE before executing the statement.

   Note: If `SQLBulkOperations()` is called with an *Operation* argument of SQL_ADD on a cursor that contains duplicate columns, an error is returned.

Importing data with the CLI LOAD utility in CLI applications

The CLI **LOAD** functionality provides an interface to the IBM DB2 **LOAD** utility from CLI.

This functionality allows you to insert data in CLI using **LOAD** instead of array insert. This option can yield significant performance benefits when large amounts of data need to be inserted. Because this interface invokes **LOAD**, the same consideration given for using **LOAD** should also be taken into account when using the CLI **LOAD** interface.

Before you begin

Before importing data with the CLI **LOAD** utility, ensure you have initialized your CLI application.

Note: The CLI **LOAD** interface to the IBM DB2 **LOAD** utility is not supported when accessing Informix database servers.

About this task

Note: Starting from Version 9.7, Fix Pack 4, this feature can also be used with the CLI async processing feature.

- Unlike the IBM DB2 **LOAD** utility, the CLI **LOAD** utility does not load data directly from an input file. Instead, if required, the application should retrieve the data from the input file and insert it into the appropriate application parameters that correspond to the parameter markers in the prepared statement.
- If the prepared SQL statement for inserting data contains a SELECT clause, parameter markers are not supported.
- The prepared SQL statement for inserting data must include parameter markers for all columns in the target table, unless a fullselect is used instead of the VALUES clause in the INSERT statement.
- The insertion of data is non-atomic because the load utility precludes atomicity. **LOAD** might not be able to successfully insert all the rows passed to it. For example, if a unique key constraint is violated by a row being inserted, **LOAD** will not insert this row but will continue loading the remaining rows.

- A COMMIT will be issued by **LOAD**. Therefore, if the insertion of the data completes successfully, the **LOAD** and any other statements within the transaction cannot be rolled back.
- The error reporting for the CLI **LOAD** interface differs from that of array insert. Non-severe errors or warnings, such as errors with specific rows, will only appear in the **LOAD** message file.

Procedure

To import data using the CLI **LOAD** utility:

1. Specify the statement attribute SQL_ATTR_USE_LOAD_API in SQLSetStmtAttr() with one of the following supported values:

   SQL_USE_LOAD_INSERT
   Use the **LOAD** utility to append to existing data in the table.

   SQL_USE_LOAD_REPLACE
   Use the **LOAD** utility to replace existing data in the table.

   For example, the following call indicates that the CLI **LOAD** utility will be used to add to the existing data in the table:

   ```
   SQLSetStmtAttr (hStmt, SQL_ATTR_USE_LOAD_API,
                   (SQLPOINTER) SQL_USE_LOAD_INSERT, 0);
   ```

   Note: When SQL_USE_LOAD_INSERT or SQL_USE_LOAD_REPLACE is set, no other CLI functions except for the following CLI function can be called until SQL_USE_LOAD_OFF is set (see Step 3):

   - SQLBindParameter()
   - SQLExecute()
   - SQLExtendedBind()
   - SQLParamOptions()
   - SQLSetStmtAttr()
2. Create a structure of type db2LoadStruct and specify the required load options through this structure. Set the SQL_ATTR_LOAD_INFO statement attribute to a pointer to this structure.
3. Optional: The ANYORDER file type modifier option of the LOAD API can potentially increase the performance of the load. Set the statement attribute SQL_ATTR_LOAD_MODIFIED_BY in SQLSetStmtAttr() to specify the file type modifier option ANYORDER.

   For example, the following call specifies the `anyorder` file type modifier for the CLI LOAD:

   ```
   char *filemod="anyorder";
   SQLSetStmtAttr (hstmt, SQL_ATTR_LOAD_MODIFIED_BY,
                   (SQLPOINTER) filemod, SQL_NTS);
   ```
4. Issue SQLExecute() on the prepared SQL statement for the data to be inserted. The INSERT SQL statement can be a fullselect which allows data to be loaded from a table using the SELECT statement. With a single execution of the INSERT statement, all of the data from the SELECT is loaded. The following example shows how a fullselect statement loads data from one table into another:

   ```
   SQLPrepare (hStmt,
               (SQLCHAR *) "INSERT INTO tableB SELECT * FROM tableA",
        SQL_NTS);
   SQLExecute (hStmt);
   ```

5. Call SQLSetStmtAttr() with SQL_USE_LOAD_OFF. This ends the processing of data using the **LOAD** utility. Subsequently, regular CLI array insert will be in effect until SQL_ATTR_USE_LOAD_API is set again (see Step 1).
6. Optional: After the CLI **LOAD** operation, you can query the number of rows that were affected by it by using the following statement attributes:
   - SQL_ATTR_LOAD_ROWS_COMMITTED_PTR: A pointer to an integer that represents the total number of rows processed. This value equals the number of rows successfully loaded and committed to the database, plus the number of skipped and rejected rows.
   - SQL_ATTR_LOAD_ROWS_DELETED_PTR: A pointer to an integer that represents the number of duplicate rows deleted.
   - SQL_ATTR_LOAD_ROWS_LOADED_PTR: A pointer to an integer that represents the number of rows loaded into the target table.
   - SQL_ATTR_LOAD_ROWS_READ_PTR: A pointer to an integer that represents the number of rows read.
   - SQL_ATTR_LOAD_ROWS_REJECTED_PTR: A pointer to an integer that represents the number of rows that could not be loaded.
   - SQL_ATTR_LOAD_ROWS_SKIPPED_PTR: A pointer to an integer that represents the number of rows skipped before the CLI **LOAD** operation began.

   To use the statement attributes to query the number of rows affected by the CLI **LOAD**, the application must call SQLSetStmtAttr before the CLI **LOAD**, and pass a pointer to the memory location where the value will be stored.

   For example, after you turn on CLI **LOAD** by calling SQLSetStmtAttr and specify the statement attribute SQL_ATTR_USE_LOAD_API as in step 1, before executing the INSERT to do the CLI **LOAD**, you can call SQLSetStmtAttr to pass a pointer to the memory location where the value will be stored.

```
int *rowsLoaded;
int *rowsDeleted;

rowsLoaded = (int *)malloc(sizeof(int));
if (rowsLoaded == NULL)
{
  // Handle any memory allocation failure by malloc
}
rc = SQLSetStmtAttr(hstmt, SQL_ATTR_LOAD_ROWS_LOADED_PTR, rowsLoaded,
SQL_IS_POINTER);

rowsDeleted = (int *)malloc(sizeof(int));
if (rowsLoaded == NULL)
{
  // Handle any memory allocation failure by malloc
}
rc = SQLSetStmtAttr(hstmt, SQL_ATTR_LOAD_ROWS_DELETED_PTR, rowsDeleted,
SQL_IS_POINTER);
```

   After the CLI **LOAD**, you can retrieve the statement attribute values as follows:

```
printf("\n  Value of SQL_ATTR_LOAD_ROWS_LOADED_PTR is %d", *rowsLoaded);
printf("\n  Value of SQL_ATTR_LOAD_ROWS_DELETED_PTR is %d", *rowsDeleted);
```

   You can also retrieve the statement attribute values by calling SQLGetStmtAttr, as shown in the following example. Note that you must call SQLSetStmtAttr to pass a pointer to the memory location where the value will be stored before you issue the INSERT statement for the CLI **LOAD**.

```
int *pStmtAttrValue;

rc = SQLGetStmtAttr(hstmt,
                    SQL_ATTR_LOAD_ROWS_LOADED_PTR,
                    &pStmtAttrValue,
                    sizeof(pStmtAttrValue),
```

```
                    NULL);
printf("\n  Value of SQL_ATTR_LOAD_ROWS_LOADED_PTR  is %d", *pStmtAttrValue);

rc = SQLGetStmtAttr(hstmt,
                    SQL_ATTR_LOAD_ROWS_DELETED_PTR,
                    &pStmtAttrValue,
                    sizeof(pStmtAttrValue),
                    NULL);
printf("\n  Value of SQL_ATTR_LOAD_ROWS_DELETED_PTR is %d", *pStmtAttrValue);
```

XML column inserts and updates in CLI applications

When you update or insert data into XML columns of a table, the input data must be in the serialized string format.

For XML data, when you use `SQLBindParameter()` to bind parameter markers to input data buffers, you can specify the data type of the input data buffer as SQL_C_BINARY, SQL_C_CHAR, SQL_C_DBCHAR or SQL_C_WCHAR. When you bind a data buffer that contains XML data as SQL_C_BINARY, CLI processes the XML data as internally encoded data. This is the preferred method because it avoids additional resource usage and potential data loss of character conversion when character types are used.

Important: If the XML data is encoded in an encoding scheme and CCSID other than the application code page encoding scheme, you must include internal encoding in the data and bind the data as SQL_C_BINARY to avoid character conversion.

When you bind a data buffer that contains XML data as SQL_C_CHAR, SQL_C_DBCHAR or SQL_C_WCHAR, CLI processes the XML data as externally encoded data. CLI determines the encoding of the data as follows:

- If the C type is SQL_C_WCHAR, CLI assumes that the data is encoded as UCS-2.
- If the C type is SQL_C_CHAR or SQL_C_DBCHAR, CLI assumes that the data is encoded in the application code page encoding scheme.

If you want the database server to implicitly parse the data before storing it in an XML column, the parameter marker data type in `SQLBindParameter()` should be specified as SQL_XML.

Implicit parsing is recommended, because explicit parsing of a character type with XMLPARSE can introduce encoding issues.

The following example shows how to update XML data in an XML column using the recommended SQL_C_BINARY type.

```
char xmlBuffer[10240];
integer length;

// Assume a table named dept has been created with the following statement:
// CREATE TABLE dept (id CHAR(8), deptdoc XML)

// xmlBuffer contains an internally encoded XML document that is to replace
// the existing XML document
length = strlen (xmlBuffer);
SQLPrepare (hStmt, "UPDATE dept SET deptdoc = ? WHERE id = '001'", SQL_NTS);
SQLBindParameter (hStmt, 1, SQL_PARAM_INPUT, SQL_C_BINARY, SQL_XML, 0, 0,
                  xmlBuffer, 10240, &length);
SQLExecute (hStmt);
```

Updating and deleting data in CLI applications

Updating and deleting data is part of the larger task of processing transactions in CLI. There are two types of update and delete operations available in CLI programming: simple and positioned.

A simple update or delete operation only requires that you issue and execute the UPDATE or DELETE SQL statements as you would any other SQL statement. You could, in this case, use `SQLRowCount()` to obtain the number of rows affected by the SQL statement. Positioned updates and deletes involve modifying the data of a result set. A positioned update is the update of a column of a result set, and a positioned delete is when a row of a result set is deleted. Positioned update and delete operations require cursors to be used. This document describes how to perform positioned update and delete operations by first getting the name of the cursor associated with the result set, and then issuing and executing the UPDATE or DELETE on a second statement handle using the retrieved cursor name.

Before you begin

Before you perform a positioned update or delete operation, ensure that you have initialized your CLI application.

Procedure

To perform a positioned update or delete operation:

1. Generate the result set that the update or delete will be performed on by issuing and executing the SELECT SQL statement.
2. Call `SQLGetCursorName()` to get the name of the cursor, using the same statement handle as the handle that executed the SELECT statement. This cursor name will be needed in the UPDATE or DELETE statement.

   When a statement handle is allocated, a cursor name is automatically generated. You can define your own cursor name using `SQLSetCursorName()`, but it is recommended that you use the name that is generated by default because all error messages will reference the generated name, not the name defined using `SQLSetCursorName()`.
3. Allocate a second statement handle that will be used to execute the positioned update or delete.

   To update a row that has been fetched, the application uses two statement handles, one for the fetch and one for the update. You cannot reuse the fetch statement handle to execute the positioned update or delete, because it is still in use when the positioned update or delete is executing.
4. Fetch data from the result set by calling `SQLFetch()` or `SQLFetchScroll()`.
5. Issue the UPDATE or DELETE SQL statement with the WHERE CURRENT of clause and specify the cursor name obtained in step 2. For example:

   ```
   sprintf((char *)stmtPositionedUpdate,
           "UPDATE org SET location = 'Toronto' WHERE CURRENT of %s",
           cursorName);
   ```
6. Position the cursor on the row of the data fetched and execute the positioned update or delete statement.

Updating bulk data with bookmarks using SQLBulkOperations() in CLI applications

You can update data in bulk with bookmarks using `SQLBulkOperations()`.

Before you begin

Before updating data in bulk, ensure you have initialized your CLI application.

About this task

Bookmarks in CLI do not persist across cursor close operations. This means that an application cannot use bookmarks that it has stored from a previous cursor. Instead, it has to call SQLFetch() or SQLFetchScroll() to retrieve the bookmarks before updating with bookmarks.

Procedure

To update data in bulk:

1. Set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE using `SQLSetStmtAttr()`.
2. Execute a query that returns a result set.
3. Set the SQL_ATTR_ROW_ARRAY_SIZE statement attribute to the number of rows you want to update using `SQLSetStmtAttr()`.
4. Call `SQLBindCol()` to bind the data you want to update.

   The data is bound to an array with a size equal to the value of SQL_ATTR_ROW_ARRAY_SIZE, set in the previous step.
5. Bind the bookmark column to column 0 by calling `SQLBindCol()`.
6. Copy the bookmarks for rows that you want to update into the array bound to column 0.
7. Update the data in the bound buffers.

   Note: The size of the array pointed to by the SQL_ATTR_ROW_STATUS_PTR statement attribute should either be equal to SQL_ATTR_ROW_ARRAY_SIZE or SQL_ATTR_ROW_STATUS_PTR should be a null pointer.
8. Update the data by calling `SQLBulkOperations()` with an *Operation* argument of SQL_UPDATE_BY_BOOKMARK.

   Note: If the application has set the SQL_ATTR_ROW_STATUS_PTR statement attribute, then it can inspect this array to see the result of the operation.
9. Optional: Verify that the update has occurred by calling `SQLBulkOperations()` with an *Operation* argument of SQL_FETCH_BY_BOOKMARK. This will fetch the data into the bound application buffers.

   If data has been updated, CLI changes the value in the row status array for the appropriate rows to SQL_ROW_UPDATED.

   Note: If SQLBulkOperations() is called with an *Operation* argument of SQL_UPDATE_BY_BOOKMARK on a cursor that contains duplicate columns, an error is returned.

Deleting bulk data with bookmarks using SQLBulkOperations() in CLI applications

You can use `SQLBulkOperations()` and bookmarks to delete data in bulk.

Before you begin

Before deleting data in bulk, ensure you have initialized your CLI application.

About this task

Bookmarks in CLI do not persist across cursor close operations. This means that an application cannot use bookmarks that it has stored from a previous cursor. Instead, it has to call SQLFetch() or SQLFetchScroll() to retrieve the bookmarks before updating by bookmarks.

Procedure

To perform bulk deletions using bookmarks and `SQLBulkOperations()`:

1. Set the SQL_ATTR_USE_BOOKMARKS statement attribute to SQL_UB_VARIABLE using `SQLSetStmtAttr()`.
2. Execute a query that returns a result set.
3. Set the SQL_ATTR_ROW_ARRAY_SIZE statement attribute to the number of rows you want to delete.
4. Bind the bookmark column to column 0 by calling `SQLBindCol()`.
5. Copy the bookmarks for the rows you want to delete into the array bound to column 0.

   Note: The size of the array pointed to by the SQL_ATTR_ROW_STATUS_PTR statement attribute should either be equal to SQL_ATTR_ROW_ARRAY_SIZE, or the SQL_ATTR_ROW_STATUS_PTR statement attribute should be a null pointer.
6. Perform the deletion by calling `SQLBulkOperations()` with an *Operation* argument of SQL_DELETE_BY_BOOKMARK.

   If the application has set the SQL_ATTR_ROW_STATUS_PTR statement attribute, then it can inspect this array to see the result of the operation.

Calling stored procedures from CLI applications

CLI applications call stored procedures by issuing the CALL procedure statement.

Before you begin

Ensure that you have the CLI environment initialized and the database connection is established before calling the stored procedure.

Procedure

To call a stored procedure:

1. Declare application host variables corresponding to each of the IN, INOUT, and OUT parameters of the stored procedure. Ensure that data types and lengths of the application variable match the data types and lengths of the stored procedure arguments. The CLI driver supports calling stored procedures with parameter markers.
2. Initialize the application variables that correspond to the IN, INOUT, and OUT parameters.
3. Compose a CALL SQL statement. The following example is a CALL statement with a parameter marker argument:

```
SQLCHAR *stmt = (SQLCHAR *)"CALL OUT_LANGUAGE (?)";
```

To use named parameter markers (for example, `:language`), you must explicitly enable a named parameter processing by setting the **`EnableNamedParameterSupport`** configuration keyword to `TRUE`:

```
SQLCHAR *stmt = (SQLCHAR *)"CALL OUT_LANGUAGE (:language)";
```

You can optimize application performance through use of the parameter markers in the CALL procedure statement and bind the host variables to those parameter markers. You can specify string literals for IN arguments in a CALL statement by enclosing the literal CALL statement within the ODBC call escape clause delimiters { }. The following example is a literal CALL statement:

```
SQLCHAR *stmt = (SQLCHAR *)"{CALL IN_PARAM (123, 'Hello World!')}";
```

When string literals and the ODBC escape clause are used in a CALL procedure statement, the string literals can be specified only for IN mode stored procedure arguments. The INOUT and OUT mode stored procedure arguments must still be specified with parameter markers.

4. Optional: Prepare the CALL statement by calling the `SQLPrepare()` function.
5. Bind each parameter of the CALL procedure statement by calling the `SQLBindParameter()` function. Ensure that each parameter is bound correctly to the SQL_PARAM_INPUT parameter type, the SQL_PARAM_OUTPUT parameter type, or the SQL_PARAM_INPUT_OUTPUT parameter type. Unless each parameter is bound correctly to the corresponding parameter type, unexpected result can occur from the CALL procedure statement processing. An example of incorrect parameter binding is when an input parameter is bound incorrectly with the SQL_PARAM_OUTPUT parameter type.

   You can make a batch CALL statement for a stored procedure to reduce network flow between the database client and the database server. When a batch CALL statement is made for a stored procedure, CLI applications can avoid repeated calls to the `SQLExecute()` function or the `SQLExecDirect()` function for each different set of stored procedure arguments. The CLI application can make a batch CALL statement with the following additional steps:

   a. Declare array variables for the stored procedure arguments. If the declared array variable is for INPUT argument, you must populate the array with required data. The stored procedure arguments that are of the INOUT type or the OUT type can also retrieve data in the form of array after the execution of the CALL statement:

      ```
      SQLINTEGER param1[5] = {1,2,3,4,5};
      SQLINTEGER param2[5] = {0,0,0,0,0};
      ```

   b. Set the SQL_ATTR_PARAMSET_SIZE statement attribute to specify the array size to be used for the stored procedure arguments:

      ```
      // specifying batching array size of 5
      cliRC = SQLSetStmtAttr( hstmt,
                              SQL_ATTR_PARAMSET_SIZE,
                              (SQLPOINTER) 5,
                              SQL_IS_INTEGER );
      ```

   c. Bind the array variable with the `SQLBindParameter()` function for each parameter of the CALL procedure statement:

      ```
      cliRC = SQLBindParameter( hstmt,
                                1,
                                SQL_PARAM_INPUT,
                                SQL_C_LONG,
                                SQL_INTEGER,
                                0, 0,
                                param1, ...);

      cliRC = SQLBindParameter( hstmt,
      ```

```
2,
SQL_PARAM_OUTPUT,
SQL_C_LONG,
SQL_INTEGER,
0, 0,
param2, ...);
```

Important: The following statement attributes are not supported by batch call statements:

- SQL_ATTR_INTERLEAVED_PUTDATA
- SQL_ATTR_INTERLEAVED_STREAM_PUTDATA
- SQL_ATTR_INTERLEAVED_GETDATA
- SQL_ATTR_INTERLEAVED_STREAM_GETDATA
- SQL_ATTR_STREAM_OUTPUTLOB_ON_CALL

6. Run the CALL procedure statement with the `SQLExecDirect()` function, or if the CALL procedure statement was prepared in step 4, use the `SQLExecute()` function.

   Note:

   - If an application or thread that calls a stored procedure is terminated before the stored procedure completes, execution of the stored procedure is also terminated. A stored procedure must contain logic to ensure that the database is in both a consistent and desirable state when the stored procedure is terminated.
   - The CLI driver saves extra network traffic that is associated with sending the implicit COMMIT statement when the following conditions are met:
     - The connected database server is DB2 for z/OS Version 11 in new function mode (NFM).
     - The autocommit behavior is enabled (SQL_ATTR_AUTOCOMMIT is `ON`) when the stored procedure is called.
     - Entire result-set that is returned from the stored procedure is contained within the single query block. The default query block size is 64K and it can be adjusted with the **`FET_BUF_SIZE`** `db2cli.ini` keyword or the **`FetchBufferSize`** IBM data server driver configuration keyword.
7. Check the return code of the `SQLExecDirect()` function or the `SQLExecute()` function. If the return code is SQL_SUCCESS_WITH_INFO or SQL_ERROR, use the `SQLGetDiagRec()` function and the `SQLGetDiagField()` function to determine the cause of the error.

   If a batch CALL statement was issued for a stored procedure that returns multiple result-sets, the result-sets are available in order of parameter values that were specified in the parameter array. The SQLMoreResults() function, the SQLNextResult() function and the SQLFetch() function can be used to fetch the result-sets across multiple cursors.

Results

If a stored procedure ran successfully, any variables that are bound as OUT parameters contains data that the stored procedure passed back to the CLI application. The OUT parameter data can be retrieved with the SQLGetData() function. If the stored procedure returns one or more result sets through nonscrollable cursors, the result sets can be retrieved with the SQLFetch() function.

If a CLI application is unsure of the number or type of columns in a result-set that is returned by a stored procedure, the SQLNumResultCols(), SQLDescribeCol(), and SQLColAttribute() functions can be called (in listed order) on the result-set to determine this information.

If DATETYPE data is returned from the stored procedure, the returned DATETYPE data is in locale-dependent format. You can change the format of returned DATETYPE data by setting the **DB2_SQLROUTINE_PREPOPTS** registry variable to locale-independent value, such as ISO:

```
db2set DB2_SQLROUTINE_PREPOPTS="DATETIME ISO"
```

Example

The following example makes a batch CALL statement for a stored procedure that has one INPUT parameter and one OUTPUT parameter:

```
CREATE PROCEDURE testproc (IN var1 INTEGER, OUT var2 INTEGER )
LANGUAGE SQL
BEGIN
   var2 = var1 * 10;
END
```

```
//For IN parameter var1
SQLINTEGER param1[5] = {1,2,3,4,5};

//For OUT parameter var2
SQLINTEGER param2[5] = {0,0,0,0,0};
...
cliRC = SQLPrepare( hstmt, "CALL testproc(?,?)", SQL_NTS );

cliRC = SQLBindParameter( hstmt,
                          1,
                          SQL_PARAM_INPUT,
                          SQL_C_LONG,
                          SQL_INTEGER,
                          0, 0,
                          param1, ...);

cliRC = SQLBindParameter( hstmt,
                          2,
                          SQL_PARAM_OUTPUT,
                          SQL_C_LONG,
                          SQL_INTEGER,
                          0, 0,
                          param2, ...);

// Specify batching array size of 5
cliRC = SQLSetStmtAttr( hstmt,
                        SQL_ATTR_PARAMSET_SIZE,
                        (SQLPOINTER) 5,
                        SQL_IS_INTEGER );

// The single SQLExecute() will be equivalent to making five CALL statements
cliRC = SQLExecute( hstmt );

// Print values of param2 used for OUTPUT type
for (i=0; i<5; i++)
{
    printf ("param2[%d] = %d\n", i, param2[i]);
}
```

Following example makes a batch CALL statement for a stored procedure that returns multiple result-sets:

```
CREATE PROCEDURE testproc (IN var1 INTEGER)
LANGUAGE SQL
BEGIN
   INSERT INTO myTable VALUES (var1);

   DECLARE CURSOR c1 ...
   DECLARE CURSOR c2 ...
   DECLARE CURSOR c3 ...

   OPEN c1 ...
   OPEN c2 ...
   OPEN c3 ...
END
```

```
SQLINTEGER param1[5] = {1,2,3};
...
cliRC = SQLPrepare( hstmt, "CALL testproc(?)", SQL_NTS );
```

```
cliRC = SQLBindParameter( hstmt,
                          1,
                          SQL_PARAM_INPUT,
                          SQL_C_LONG,
                          SQL_INTEGER,
                          0, 0,
                          param1, ...);

// Specify batching array size of 3
cliRC = SQLSetStmtAttr( hstmt,
                        SQL_ATTR_PARAMSET_SIZE,
                        (SQLPOINTER) 3,
                        SQL_IS_INTEGER );

// The single SQLExecute() will be equivalent to making five CALL statements
cliRC = SQLExecute( hstmt );

//Sequentially Fetch all result sets opened by cursors

//Start with first result-set
while ((cliRC = SQLFetch(hstmt)) != SQL_NO_DATA_FOUND)
    { // Take some action }

//Done with 1st result set. Move on to next result set
cliRC=SQLMoreResults(hstmt);

//Start with 2nd result set
while ((cliRC = SQLFetch(hstmt)) != SQL_NO_DATA_FOUND)
    { // Take some action }

//Done with 2nd result set. Move on to next result set
cliRC=SQLMoreResults(hstmt);

//Start with 3rd result set
while ( (cliRC = SQLFetch(hstmt)) != SQL_NO_DATA_FOUND)
    { // Take some action }
...
```

Calling stored procedures with array parameters from CLI applications

CLI applications can use a SQL CALL statement to call stored procedures with array parameters.

Before you begin

Ensure that you have the CLI environment initialized and the database connection established.

Procedure

To call a stored procedure with array parameters:

1. Declare application host variables corresponding to each of the IN, INOUT, and OUT parameters of the stored procedure. Ensure that data types and lengths of the application variable match the data types and lengths of the stored procedure arguments. The CLI driver supports calling stored procedures with parameter markers.
2. Initialize the application variables that correspond to the IN, INOUT, and OUT parameters.
3. Create a CALL SQL statement.

   Remember: If the uncataloged stored procedure is called, ensure that it does not call any of the CLI schema functions. Calling CLI schema functions from uncataloged stored procedures are not supported. The CLI schema functions include following functions:

   - `SQLColumns()`
   - `SQLColumnPrivileges()`
   - `SQLForeignKeys()`
   - `SQLPrimaryKeys()`
   - `SQLProcedures()`
   - `SQLProcedureColumns()`

- SQLSpecialColumns()
- SQLStatistics()
- SQLTables()
- SQLTablePrivileges()

4. Optional: Prepare the CALL statement by calling the SQLPrepare() function.
5. Bind each parameter of the CALL procedure statement by calling the SQLBindParameter() function. Ensure that each parameter is bound correctly (to SQL_PARAM_INPUT, SQL_PARAM_OUTPUT, or SQL_PARAM_INPUT_OUTPUT), otherwise unexpected results can occur when the CALL procedure statement is made.

   Remember:

   - When you are calling stored procedures on DB2 for z/OS servers, the call to stored procedures with array parameters are supported on the following DB2 for z/OS servers:
     – DB2 for z/OS Version 11 server in new function mode (NFM).
   - When you are calling stored procedures on DB2 for i servers, the call to stored procedures with array parameters are supported on DB2 for i V7R1 and later servers.

6. For each array parameter, use the SQLSetDescField() function with the SQL_DESC_CARDINALITY and SQL_DESC_CARDINALITY_PTR arguments to set the maximum cardinality of the array value and pointer to a variable that contains the cardinality of a parameter. You must specify appropriate descriptor handle parameter for the SQLSetDescField() function that is based on stored procedure argument type:
   - Implementation parameter descriptor handle (hIPD) for INPUT stored procedure argument.
   - Application parameter descriptor handle (hAPD) for OUTPUT stored procedure argument.
   - Both hIPD and hAPD for INOUT stored procedure argument.

```
cliRC = SQLSetDescField( hIPD,
                         1,
                         SQL_DESC_CARDINALITY,
                         (SQLPOINTER) 5,
                         SQL_IS_SMALLINT);

cliRC = SQLSetDescField( hAPD,
                         1,
                         SQL_DESC_CARDINALITY_PTR,
                         &actInCardinality,
                         SQL_IS_SMALLINT);
```

7. Run the CALL procedure statement with the SQLExecDirect() function, or if the CALL procedure statement was prepared in step 4, run the SQLExecute() function.

   Note:

   - If an application that called a stored procedure is terminated before the stored procedure completes, execution of the stored procedure is also terminated. It is important that a stored procedure contains a logic to ensure that the database is in both a consistent and desirable state when the stored procedure is terminated prematurely.
   - The CLI driver saves extra network traffic that is associated with sending the implicit COMMIT statement when the following conditions are met:

- When the application is connected to the DB2 for z/OS Version 11 server in new function mode (NFM).
- The autocommit behavior is enabled (SQL_ATTR_AUTOCOMMIT is ON) when the stored procedure is called.
- Entire result-set that is returned from the stored procedure is contained within the single query block. The default query block size is 64K and it can be adjusted with the **FET_BUF_SIZE** db2cli.ini keyword or the **FetchBufferSize** IBM data server driver configuration keyword.

8. Check the return code of the SQLExecDirect() function or the SQLExecute() function. If the return code is SQL_SUCCESS_WITH_INFO or SQL_ERROR, use the SQLGetDiagRec() function and the SQLGetDiagField() function to determine the cause of the error.

   If the stored procedure ran successfully, any variables that are bound as OUT parameters contains data that the stored procedure passed back to the CLI application. If the stored procedure returns one or more result sets through non-scrollable cursors, the result sets can be retrieved with the **SQLFetch()** function.

Example

Following example calls a SQL stored procedure that has IN parameter of INTEGER array:

```
CREATE TYPE int_array AS INTEGER array[5];
CREATE PROCEDURE array_out (IN var1 int_array, OUT var2 int_array)
LANGUAGE SQL
BEGIN
  FOR v AS SELECT val, idx FROM UNNEST(var1) WITH ORDINALITY AS T(val, idx) ORDER BY idx ASC
  DO
    SET var2[idx] = val - 1;
  END FOR;
END
```

Following CLI application example calls the stored procedure with an array parameter:

```
SQLINTEGER param1[5] = {1,2,3,4,5};
SQLINTEGER param2[5];
SQLINTEGER actInCardinality = 5;
SQLINTEGER actOutCardinality = 0;

...

cliRC = SQLPrepare(hstmt,
  "CALL ARRAY_OUT (?, ?)",
  SQL_NTS);
cliRC = SQLBindParameter( hstmt,
                          1,
                          SQL_PARAM_INPUT,
                          SQL_C_LONG,
                          SQL_INTEGER,
                          4,
                          0,
                          param1,
                          4,
                          NULL);

cliRC = SQLBindParameter( hstmt,
                          2,
                          SQL_PARAM_OUTPUT,
                          SQL_C_LONG,
                          SQL_INTEGER,
                          4,
                          0,
```

```
                            param2,
                            4,
                            NULL);

 cliRC = SQLSetDescField( hIPD,
                          1,
                          SQL_DESC_CARDINALITY,
                          (SQLPOINTER) 5,
                          SQL_IS_SMALLINT);

 cliRC = SQLSetDescField( hAPD,
                          2,
                          SQL_DESC_CARDINALITY,
                          (SQLPOINTER) 5,
                          SQL_IS_SMALLINT);


cliRC = SQLSetDescField( hAPD,
                          1,
                          SQL_DESC_CARDINALITY_PTR,
                          &actInCardinality,
                          SQL_IS_SMALLINT);

cliRC = SQLSetDescField( hAPD,
                          2,
                          SQL_DESC_CARDINALITY_PTR,
                          &actOutCardinality,
                          SQL_IS_SMALLINT);

clciRC = SQLExecute(hstmt);
```

CLI stored procedure commit behavior

The commit behavior of SQL statements, both in a CLI client application and in the called stored procedure running on a DB2 server, depends on the commit combinations applied in the application and the stored procedure.

The possible combinations and the resulting commit behavior are described in the following table.

Table 8. CLI Stored procedure commit behavior

CLI client	Stored procedure	Commit behavior
autocommit on	autocommit on	All successfully executed SQL statements in the stored procedure are committed, even if other SQL statements in the stored procedure fail and an error or warning SQLCODE is returned to the CALL statement.
autocommit on	autocommit off	If the stored procedure returns an SQLCODE >= 0, all successfully executed SQL statements in the stored procedure are committed. Otherwise, all SQL statements in the stored procedure are rolled back.
autocommit on	manual commit	All successfully executed SQL statements in the stored procedure that are manually committed will not be rolled back, even if an error SQLCODE is returned to the CALL statement. **Note:** If the stored procedure returns an SQLCODE >= 0, any successfully executed SQL statements in the stored procedure that occur after the last manual commit will be committed; otherwise, they will be rolled back to the manual commit point.

Table 8. CLI Stored procedure commit behavior (continued)

CLI client	Stored procedure	Commit behavior
autocommit off	autocommit on	All successfully executed SQL statements in the stored procedure are committed and will not be rolled back, even if an error SQLCODE is returned to the CALL statement. In addition, all uncommitted and successfully executed SQL statements in the CLI client application up to and including the CALL statement are committed. **Note:** Exercise caution when using this commit combination in a multi-SQL statement client-side transaction, because the transaction cannot be fully rolled back after the CALL statement has been issued.
autocommit off	autocommit off	If the stored procedure returns an SQLCODE >= 0, all successfully executed SQL statements in the stored procedure will be committed when the transaction that includes the CALL statement is committed. Otherwise, all SQL statements in the stored procedure will be rolled back when the transaction that includes the CALL statement is rolled back.
autocommit off	manual commit	All successfully executed SQL statements in the stored procedure that are manually committed will not be rolled back, even if an error SQLCODE is returned to the CALL statement. In addition, all uncommitted and successfully executed SQL statements in the CLI client application up to the CALL statement are committed. **Note:** If the stored procedure returns an SQLCODE >= 0, any successfully executed SQL statements within the stored procedure that occur after the last manual commit will be committed; otherwise, they will be rolled back to the manual commit point. **Note:** Exercise caution when using this commit combination in a multi-SQL statement client-side transaction, because the transaction cannot be fully rolled back after the CALL statement has been issued.

Creating static SQL by using CLI/ODBC static profiling

You can use the CLI/ODBC static profiling feature to replace dynamic SQL statements with static SQL statements, potentially improving runtime performance and security through the package-based authorization mechanism.

About this task

When you run an application with prebound static SQL statements, dynamic registers that control the dynamic statement behavior have no effect on the statements that are converted to static SQL statements.

If an application issues Data Definition Language (DDL) statements for objects that are referenced in subsequent Data Manipulation Language (DML) statements, all of these statements are in the capture file. The CLI/ODBC static package binding tool command, **db2cap**, attempts to bind them. The bind attempt is successful only for a database management system (DBMS) that supports the `VALIDATE RUN` bind option. If the DBMS does not support the `VALIDATE RUN` bind option, the application should not use static profiling.

You can edit the capture file to add, change, or remove SQL statements, based on application-specific requirements.

The following restrictions apply when you are running an application during the profiling session:

- An SQL statement must have successfully run (generated a positive SQLCODE value) for it to be captured in a profiling session. In a statement-matching session, unmatched dynamic statements continue to execute as dynamic CLI/ODBC calls.
- An SQL statement must be identical, character-by-character, to the one that was captured and bound to be a valid candidate for statement matching. Spaces are significant, for example, COL = 1 is considered to be different from COL=1. Use parameter markers in place of literals to improve match hits.

Not all dynamic CLI/ODBC calls can be captured and grouped into a static package. Possible reasons why calls are not captured and grouped are as follows:

- The application does not regularly free environment handles. During a capture session, statements that are captured under a particular environment handle are written to the capture file or files only when that environment handle is freed.
- The application has complex control flows that make it difficult to cover all runtime conditions in a single application run.
- The application executes SET statements to change registry variable values. These statements are not recorded. There is a limited capability in match mode to detect dynamic SET SQLID and SET SCHEMA statements and suspend running static statements accordingly. However, other SET statements and subsequent SQL statements that depend on the registry variables being set might not behave correctly.
- The application issues DML statements. Depending on application complexities and the nature of these statements, they might not be matched, or they might not execute correctly at run time.

Because dynamic and static SQL are different, always verify the behaviour of the application in static match mode. Furthermore, static SQL does not offer improved runtime performance over dynamic SQL for all statements. If testing shows that static execution decreases performance for a particular statement, you can force that statement to be dynamically executed by removing the statement from the capture file. In addition, static SQL, unlike dynamic SQL, might require occasional rebinding of packages to maintain performance, particularly if the database objects that are referred to in the packages frequently change. If CLI/ODBC static profiling does not fit the type of application that you are running, there are other programming methods that you can use to obtain the benefits of static SQL, such as embedded SQL and stored procedures.

Procedure

To create static SQL statements from dynamic SQL statements:

1. Profile the application by capturing all the dynamic SQL statements that the application issues. This process is known as running the application in static capture mode. To turn on static capture mode, set the following CLI/ODBC configuration keywords for the CLI/ODBC data source in the `db2cli.ini` configuration file before running the application:
   - `StaticMode = CAPTURE`
   - `StaticPackage = qualified_package_name`
   - `StaticCapFile = capture_file_name`

   An example of the settings follows:

   ```
   [DSN1]
   StaticMode = CAPTURE
   StaticPackage = MySchema.MyPkg
   StaticCapFile = E:\Shared\MyApp.cpt
   ```

Note: For the **StaticPackage** keyword, ensure that you specify a schema name (MySchema in the previous sample). If you do not specify a schema, the database object name that you provide is considered to be the container name instead of the package name, and the package name is blank.
The resulting static profile takes the form of a text-based *capture file*, containing information about the SQL statements that are captured.

The previous example file yields the following results for Data Source Name 1 (DSN1):

- Capture mode will be used.
- The package will be named `MySchema.MyPkg`
- The capture file, `MyApp.cpt`, will be saved in the `E:\Shared\` directory.

Until you change the **StaticMode** keyword to a value other than `CAPTURE`, such as `DISABLED`(which turns off static capture mode), each subsequent run of the application captures SQL statements and appends them to the capture file (`MyApp.cpt` in the example. Only unique SQL statements are captured, however; duplicate executions are ignored.

2. Optional: To generate a CLI/ODBC static profiling log file, set the **StaticLogFile**CLI/ODBC configuration keyword. This file contains useful information to determine the state of the statement capturing process.
3. Run the application. Unique SQL statements are captured in the capture file. Duplicate statements are ignored.
4. Disable static capture mode by setting the **StaticMode**CLI/ODBC configuration keyword to `DISABLED` or by removing the keywords that you set in the first step.
5. From the Command Line Processor, issue the **db2cap** command. The **db2cap** command generates a static package that is based on the capture file. If the **db2cap** command does not return a message indicating successful completion, a statement in the capture file could not be statically bound. Remove the failing statement from the capture file, and run the **db2cap** command again.
6. Make a copy of the capture file that you processed with the **db2cap** command available to each user of the application. You can give the file to the users or, if all users use the same client platform, place a read-only copy of this file in a network directory that is accessible to all users.
7. Enable your application for dynamic-to-static SQL statement mapping, known as static match mode, by setting the following configuration keywords:
   - `StaticMode = MATCH`
   - `StaticCapFile = capture_file_name`

   An example of settings follows:

   ```
   [DSN1]
   StaticMode = MATCH
   StaticCapFile = E:\Shared\MyApp.cpt
   ```
8. Optional: Set the CLI/ODBC **StaticLogFile** configuration keyword to log useful information such as how many statements were matched (therefore statically executed) and how many statements were unmatched (therefore dynamically executed) during a match session. You should use this information to verify that static profiling in match mode is yielding an acceptable match ratio.
9. Run the application.

Capture file for CLI/ODBC/JDBC Static Profiling

The capture file that is generated during static profiling contains the text of SQL statements and other associated information that is captured in static capture mode, such as configurable bind options.

The capture file also keeps track of a number of configurable bind options; some already contain specific values obtained from the capture run, and some are left blank, in which case the precompiler will use default values during package binding. Before binding the package(s), the DBA may want to examine the capture file and make necessary changes to these bind options using a text editor.

To help you understand how to edit SQL statements, here is the description of the fields in a statement:

Field	Description
SQLID	If present, indicates the SCHEMA or SQLID when the statement was captured is different from the default QUALIFIER of the package(s).
SECTNO	Section number of the static package that the statement was bound to.
ISOLATION	Isolation level for the statement. It determines which one of the five possible package the statement belongs to.
STMTTEXT	Statement string
STMTTYPE	There are 3 possible values: • SELECT_CURSOR_WITHHOLD: SELECT statement using a withhold cursor • SELECT_CURSOR_NOHOLD: SELECT statement using a nohold cursor • OTHER: non-SELECT statements
CURSOR	Cursor name declared for the SELECT statement
INVARnn	Description of the n-th input variable The 7 comma-separated fields refer to: 1. SQL data type 2. Length of the data. For decimal or floating point types, this is the precision. 3. For decimal or floating point types only, this is the scale. 4. TRUE if the character data is a for-bit-data type; otherwise FALSE. 5. TRUE if the variable is nullable; otherwise FALSE. 6. Column name 7. SQL_NAMED if this variable refers to a real column name; SQL_UNNAMED if the variable is a system-generate name.
OUTVARn	Description of the n-th output variable for the SELECT statement. The comma-separated fields follow the same convention as in INVARs.

Considerations for mixing embedded SQL and CLI

You can use CLI in conjunction with embedded static SQL in an application.

Consider the scenario where the application developer wants to take advantage of the ease of use provided by the CLI catalog functions and maximize the portion of the application's processing where performance is critical. In order to mix the use of CLI and embedded SQL, the application must comply with the listed rules:

- All connection management and transaction management must be performed completely using either CLI or embedded SQL - never a mixture of the two. Two options are available to the application:
  - it performs all connects and commits/rollbacks using CLI calls, and then calls functions written using embedded SQL;
  - or it performs all connects and commits/rollbacks using embedded SQL, and then calls functions that use CLI APIs, notably, a null connection.
- Query statement processing cannot straddle CLI and embedded SQL interfaces for the same statement. For example, the application cannot open a cursor using embedded SQL, and then call the CLI `SQLFetch()` function to retrieve row data.

Since CLI permits multiple connections, the `SQLSetConnection()` function must be called before executing any embedded SQL. This allows the application to explicitly specify the connection under which the embedded SQL processing is performed.

If the CLI application is multithreaded and also makes embedded SQL calls or DB2 API calls, then each thread must have a DB2 context.

Freeing statement resources in CLI applications

After a transaction has completed, end the processing for each statement handle by freeing the resources associated with it.

About this task

There are four main tasks that are involved with freeing resources for a statement handle:

- close the open cursor
- unbind the column bindings
- unbind the parameter bindings
- free the statement handle

There are two ways you can free statement resources: using `SQLFreeHandle()` or `SQLFreeStmt()`.

Before you can free statement resources, you must have initialized your CLI application and allocated a statement handle.

To free statement resources with `SQLFreeHandle()`, call `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_STMT and the handle you want to free. This will close any open cursor associated with this statement handle, unbind column and parameter bindings, and free the statement handle. This invalidates the statement handle. You do not need to explicitly carry out each of the four tasks listed previously.

Procedure

To free statement resources with SQLFreeStmt(), you need to call SQLFreeStmt() for each task (depending on how the application was implemented, all of these tasks may not be necessary):

- To close the open cursor, call `SQLCloseCursor()`, or call SQLFreeStmt() with the SQL_CLOSE *Option* and statement handle as arguments. This closes the cursor and discards any pending results.
- To unbind column bindings, call SQLFreeStmt() with an *Option* of SQL_UNBIND and the statement handle. This unbinds all columns for this statement handle except the bookmark column.
- To unbind parameter bindings, call SQLFreeStmt() with an *Option* of SQL_RESET_PARAMS and the statement handle. This releases all parameter bindings for this statement handle.
- To free the statement handle, call SQLFreeStmt() with an *Option* of SQL_DROP and the statement handle to be freed. This invalidates this statement handle.

  Note: Although this option is still supported, use SQLFreeHandle() in your CLI applications so that they conform to the latest standards.

Freeing handles in CLI applications

You must free all allocated handles after their use to free resources that are no longer required. You can free all statement handles by using the `SQLFreeHandle()` function.

Environment handle

Before calling the `SQLFreeHandle()` function with a *HandleType* of SQL_HANDLE_ENV, an application must call `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_DBC for all connections allocated under the environment. Otherwise, the call to `SQLFreeHandle()` returns SQL_ERROR and the environment remains valid, as well as any connection associated with that environment.

Connection handle

If a connection is open on the handle, an application must call `SQLDisconnect()` for the connection before calling `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_DBC. Otherwise, the call to `SQLFreeHandle()` returns SQL_ERROR and the connection remains valid.

Statement handle

A call to `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_STMT frees all resources that were allocated by a call to `SQLAllocHandle()` with a *HandleType* of SQL_HANDLE_STMT. When an application calls `SQLFreeHandle()` to free a statement that has pending results, the pending results are discarded. When an application frees a statement handle, CLI frees all the automatically generated descriptors associated with that handle.

Note that `SQLDisconnect()` automatically drops any statements and descriptors open on the connection.

Descriptor Handle

A call to `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_DESC frees the descriptor handle in *Handle*. The call to `SQLFreeHandle()` does not release any memory allocated by the application that may be referenced by the deferred fields (SQL_DESC_DATA_PTR, SQL_DESC_INDICATOR_PTR, and SQL_DESC_OCTET_LENGTH_PTR) of any descriptor record of *Handle*. When an explicitly allocated descriptor handle is freed, all statements that the freed handle had been associated with revert to their automatically allocated descriptor handle.

Note that `SQLDisconnect()` automatically drops any statements and descriptors open on the connection. When an application frees a statement handle, CLI frees all the automatically generated descriptors associated with that handle.

Chapter 7. Terminating a CLI application

After you have initialized your CLI application and processed transactions, you must terminate the application to properly disconnect from the data source and free resources.

Before you begin

Before terminating your application, you should have initialized your CLI application and completed processing of all transactions.

Procedure

To terminate a CLI application:

1. Disconnect from the data source by calling `SQLDisconnect()`.
2. Free the connection handle by calling `SQLFreeHandle()` with a *HandleType* argument of SQL_HANDLE_DBC.

   If multiple database connections exist, repeat steps 1 - 2 until all connections are closed and connection handles freed.
3. Free the environment handle by calling `SQLFreeHandle()` with a *HandleType* argument of SQL_HANDLE_ENV.

Chapter 8. Trusted connections through DB2 Connect

Some DB2 database servers support trusted contexts. A *trusted context* allows the database administrator to, among other things, define conditions under which a client application will be allowed to create a trusted connection. A *trusted connection* is allowed to do things that a normal connection cannot.

There are two types of trusted connection, implicit and explicit. When you create a connection, whether you get an explicit trusted connection, an implicit trusted connection, or a regular connection depends on whether you ask for a trusted connection and whether the connection meets the criteria defined in the trusted context on the server, as summarized in Table 9.

Table 9. What type of connections result from different combinations of actions

	The connection meets the server's criteria for being trusted	**The connection does not meet the server's criteria for being trusted**
You request that the connection be trusted	Explicit trusted connection	Regular connection and warning SQL20360W (SQLSTATE 01679) is returned.
You do not request that the connection be trusted	Implicit trusted connection	Regular connection

An *implicit trusted connection* is identical to a regular connection except that it grants temporary role privileges to the user while they are using the connection. The role privileges that are granted (if any) are specified in the trusted context that caused the connection to be trusted.

Implicit trusted connections can be created by any application that connects using DB2 Connect. Implicit trusted connections are made and used in the same way that regular connections are made and used. This means that no code changes are necessary for an existing application to take advantage of implicit trusted connections as long as the application connects through DB2 Connect.

An *explicit trusted connection* grants temporary role privileges to the user the same way that an implicit trusted connection does. In addition, an explicit trusted connection lets you change the authorization ID used when performing actions across that connection. Changing the authorization ID on an explicit trusted connection is referred to as *switching users*. The authorization IDs to which you can switch and whether a given authorization ID requires a password when switching to it are defined as part of the trusted context that allowed the trusted connection to be created.

User switching can significantly reduce the processing usage of sharing a connection among several users, especially for user names that do not require a password because in that case the database server does not authenticate the authorization ID. When using the feature, however, you must be very certain that your application does not allow switching to an authorization ID without validating and authenticating that authorization ID. Otherwise you are creating a security hole in your system.

Explicit trusted connections can be created and the user can be switched when connecting through DB2 Connect using CLI or JDBC, including XA established connections. Creating an explicit trusted connection and switching users requires setting special connection attributes. This means that existing applications will need to be modified in order to take advantage of explicit trusted connections.

Other than the differences just mentioned, you can use a trusted connection (whether implicit or explicit) the same way you would used a regular connection. You must be certain, however, to explicitly disconnect an explicit trusted connection when you are done with it, even if it is in a broken or disconnected state. Otherwise resources used by the connection might not be released. This is not a problem with implicit trusted connections.

Note:

1. Explicit trusted connections should not use CLIENT authentication. This does not apply to implicit trusted connections.
2. Applications using explicit trusted connections should be run on secure machines which are password protected and accessible only to authorized personnel. This does not apply to implicit trusted connections.

Creating and terminating a trusted connection through CLI

If the database server you are connecting to is configured to allow it, you can create an explicit trusted connection when connecting through CLI.

Before you begin

This procedure assumes that you are not using an XA transaction manager. If you are using an XA transaction manager you only need to make sure that the transaction manager is configured to set the configuration value TCTX to TRUE when it calls xa_open. If that is done then any connection that can be an explicit trusted connection will be. To verify that a connection is an explicit trusted connection see step 3.

- The database that you are connecting to must support trusted contexts.
- A trusted context must be defined that will recognize the client as being trustable.
- You must know the system authorization ID that is specified in the trusted context. The system authorization ID of a trusted connection is the authorization ID you provide to the server as a user name when creating the connection. For your connection to be trusted by a particular trusted context the system authorization ID must be the one specified in that trusted context. Ask your security administrator for a valid system authorization ID and the password for that ID.

About this task

The examples in these instructions use the C language and assume that *conn* is a pointer to a valid, but unconnected, connection handle. The variable *rc* is assumed to have a data type of SQLRETURN.

Procedure

1. In addition to setting any connection attributes that you would set for a regular connection, set the connection attribute SQL_ATTR_USE_TRUSTED_CONTEXT to SQL_TRUE with a call to the SQLSetConnectAttr function.

```
rc = SQLSetConnectAttr(
    conn,
    SQL_ATTR_USE_TRUSTED_CONTEXT, SQL_TRUE, SQL_IS_INTEGER
);
```

2. Connect to the database as you would for a regular connection, for example by calling the SQLConnect function. Use the system authorization ID as the user name and its password as the password. Be sure to check for errors and warnings, especially those listed in table Table 10.

Table 10. Errors indicating failure to create a trusted connection

SQLCODE	SQLSTATE	Meaning
SQL20360W	01679	The connection could not be established as a trusted connection. It was established as a regular connection instead.

   If no errors or warnings tell you differently, then the connection is established and is an explicit trusted connection.
3. Optional: You can verify that an established connection is an explicit trusted connection by checking the value of the connection attribute SQL_ATTR_USE_TRUSTED_CONTEXT using the SQLGetConnectAttr function. If it is set to SQL_TRUE the connection is an explicit trusted connection.
4. When you are finished using the connection you must be very careful to explicitly disconnect it, even if it is in a broken or disconnected state. If you do not explicitly disconnect an explicit trusted connection some of the resources used by the connection might not be released.

Results

Note:

1. Explicit trusted connections should not use CLIENT authentication. This does not apply to implicit trusted connections.
2. Applications using explicit trusted connections should only be run on secure computers which are password protected and accessible only to authorized personnel. This does not apply to implicit trusted connections.

Switching users on a trusted connection through CLI

You can switch users on an explicit trusted connection through the command line interface (CLI).

For a description of what it means to switch users using a trusted connection see the topic in the related links.

Before you begin

- The connection must have been successfully created as an explicit trusted connection.
- The explicit trusted connection must not be in a transaction.
- The trusted context that allowed the explicit trusted connection to be created must be configured to allow switching to the authorization ID you are switching to.

About this task

The examples in these instructions use the C language and assume that *conn* is a pointer to a connected explicit trusted connection. The variable *rc* is assumed to have a data type of SQLRETURN. The variable *newuser* is assumed to be a pointer

to a character string holding the authorization ID of the user you want to switch to. The variable *passwd* is assumed to be a pointer to a character string containing the password for that authorization ID.

Procedure

1. Call the SQLSetConnectAttr function to set the SQL_ATTR_TRUSTED_CONTEXT_USERID attribute. Set it to the authorization ID you want to switch to.

   ```
   rc = SQLSetConnectAttr(
       conn,
       SQL_ATTR_TRUSTED_CONTEXT_USERID, newuser, SQL_NTS
   );
   //Check for errors
   ```

   Be sure to check for errors and warnings, especially those listed in table Table 11.

   Table 11. Errors indicating failure to set a new authorization ID when switching users

SQLCODE	Meaning
CLI0106E	The connection is not connected.
CLI0197E	The connection is not a trusted connection.
CLI0124E	There is a problem with the value provided. Check that it is not null, or not too long, for example.
CLI0196E	The connection is involved in a unit of work that prevents it from switching users. To be able to switch users the connection must not be in a transaction.

2. Optional: (This step is optional unless the trusted context that allowed this trusted connection requires a password for the authorization ID you are switching to.) Call the SQLSetConnectAttr function to set the SQL_ATTR_TRUSTED_CONTEXT_PASSWORD attribute. Set it to the password for the new authorization ID.

   ```
   rc = SQLSetConnectAttr(
       conn,
       SQL_ATTR_TRUSTED_CONTEXT_PASSWORD, passwd, SQL_NTS
   );
   //Check for errors
   ```

   Be sure to check for errors and warnings, both those listed in table Table 11 and those listed in table Table 12.

   Table 12. Errors indicating failure to set a password when switching users

SQLCODE	Meaning
CLI0198E	The attribute SQL_ATTR_TRUSTED_CONTEXT_USERID has not yet been set.

3. Proceed as with a regular connection. If you are using an XA transaction manager the user switch is attempted as part of the next request, otherwise the user switch is attempted just before initiating the next function call that accesses the database (SQLExecDirect for example). In either case, in addition to the errors and warnings you would normally check for, be sure to check for the errors listed in Table 13 on page 145. The errors in Table 13 on page 145 indicate that the user switch failed.

Table 13. Errors indicating failure to switch users

SQLCODE	Meaning
SQL1046N	The trusted context that allowed this trusted connection is not configured to allow switching to the authorization ID you are trying to switch to. You will not be able to switch to that authorization ID until the trusted context is changed.
SQL30082N	The password provided is not correct for the authorization ID you are switching to.
SQL0969N with a native error of -20361	There is some database level constraint that prevent you from switching to the user.

If the user switch fails the connection will be in an unconnected state until you successfully switch to another user. You can switch users on a trusted connection in an unconnected state but cannot access the database server with it. A connection in an unconnected state will remain in that state until you successfully switch users on it.

What to do next

Note:

1. **Important:** Switching users without supplying a password bypasses the database server's authentication. Your application must not allow a switch to an authorization ID without a password unless that application has already validated and authenticated that authorization ID. To do otherwise creates a security hole.
2. Specifying a NULL value for the SQL_ATTR_TRUSTED_CONTEXT_USERID attribute is equivalent to specifying the trusted context system authorization ID (the user id used when the explicit trusted connection was created).
3. When you successfully set the value of the SQL_ATTR_TRUSTED_CONTEXT_USERID connection attribute on an explicit trusted connection the connection is immediately reset. The result of resetting is as if a new connection were created using the original connection attributes of that connection. This reset happens even if the value you set the connection attribute to is the system authorization ID or NULL or the same value that the attribute currently holds.
4. If the SQL_ATTR_TRUSTED_CONTEXT_PASSWORD attribute is set, the password will be authenticated during the switch user processing, even if the trusted context that allowed the trusted connection doesn't require authentication on a switch user for that authorization ID. This results in unnecessary processing time. This rule doesn't apply to the trusted context system authorization ID. If the trusted context system authorization ID doesn't require authentication when you switch to it then it is not authenticated even if a password is provided.

Chapter 9. Descriptors in CLI applications

In CLI, you can store information, such as data types, sizes, and pointers, about columns in a result set and the associated parameters in an SQL statement. Descriptors are a logical view of this information and provide a way for applications to query and update this information.

The bindings of application buffers to columns and parameters must also be stored. *Descriptors*

Many CLI functions make use of descriptors, but the application itself does not need to manipulate them directly.

For instance:

- When an application binds column data using `SQLBindCol()`, descriptor fields are set that completely describe the binding.
- A number of statement attributes correspond to the header fields of a descriptor. In this case you can achieve the same effect calling `SQLSetStmtAttr()` as calling the corresponding function `SQLSetDescField()` that sets the values in the descriptor directly.

Although no database operations require direct access to descriptors, there are situations where working directly with the descriptors will be more efficient or result in simpler code. For instance, a descriptor that describes a row fetched from a table can then be used to describe a row inserted back into the table.

There are four types of descriptors:

Application Parameter Descriptor (APD)
Describes the application buffers (pointers, data types, scale, precision, length, maximum buffer length, and so on) that are bound to parameters in an SQL statement. If the parameters are part of a CALL statement they may be input, output, or both. This information is described using the application's C data types.

Application Row Descriptor (ARD)
Describes the application buffers bound to the columns. The application may specify different data types from those in the implementation row descriptor (IRD) to achieve data conversion of column data. This descriptor reflects any data conversion that the application may specify.

Implementation Parameter Descriptor (IPD)
Describes the parameters in the SQL statement (SQL type, size, precision, and so on).

- If the parameter is used as input, this describes the SQL data that the database server will receive after CLI has performed any required conversion.
- If the parameter is used as output, this describes the SQL data before CLI performs any required conversion to the application's C data types.

Implementation Row Descriptor (IRD)
Describes the row of data from the result set before CLI performs any required data conversion to the application's C data types.

The only difference between four types of descriptors is how they are used. One of the benefits of descriptors is that a single descriptor can be used to serve multiple purposes. For instance, a row descriptor in one statement can be used as a parameter descriptor in another statement.

As soon as a descriptor exists, it is either an application descriptor or an implementation descriptor. This is the case even if the descriptor has not yet been used in a database operation. If the descriptor is allocated by the application using `SQLAllocHandle()` then it is an application descriptor.

Values stored in a descriptor

Each descriptor contains both header fields and record fields. These fields together completely describe the column or parameter.

Header fields

Each header field occurs once in each descriptor. Changing one of these fields affects all columns or parameters.

Many of the following header fields correspond to a statement attribute. Setting the header field of the descriptor using `SQLSetDescField()` is the same as setting the corresponding statement attribute using `SQLSetStmtAttr()`. The same holds true for retrieving the information using `SQLGetDescField()` or `SQLGetStmtAttr()`. If your application does not already have a descriptor handle allocated then it is more efficient to use the statement attribute calls instead of allocating the descriptor handle, and then using the descriptor calls.

The list of the header fields are:

SQL_DESC_ALLOC_TYPE
SQL_DESC_BIND_TYPE[a]
SQL_DESC_ARRAY_SIZE[a]
SQL_DESC_COUNT
SQL_DESC_ARRAY_STATUS_PTR[a]
SQL_DESC_ROWS_PROCESSED_PTR[a]
SQL_DESC_BIND_OFFSET_PTR[a]

Note:

[a] This header field corresponds to a statement attribute.

The descriptor header field SQL_DESC_COUNT is the one-based index of the highest-numbered descriptor record that contains information (and not a count of the number of columns or parameters). CLI automatically updates this field (and the physical size of the descriptor) as columns or parameters are bound and unbound. The initial value of SQL_DESC_COUNT is 0 when a descriptor is first allocated.

Descriptor records

A single descriptor can contain zero or more descriptor records. As new columns or parameters are bound, new descriptor records can be added to the descriptor. The descriptor record is removed when a column or parameter is unbound.

The fields in a descriptor record describe a column or parameter. A specific field occurs only once in each descriptor record. The fields in a descriptor record follow:

SQL_DESC_AUTO_UNIQUE_VALUE
SQL_DESC_BASE_COLUMN_NAME
SQL_DESC_BASE_TABLE_NAME
SQL_DESC_CARDINALITY
SQL_DESC_CARDINALITY_PTR
SQL_DESC_CASE_SENSITIVE
SQL_DESC_CATALOG_NAME
SQL_DESC_CONCISE_TYPE
SQL_DESC_DATA_PTR
SQL_DESC_DATETIME_INTERVAL_CODE
SQL_DESC_DATETIME_INTERVAL_PRECISION
SQL_DESC_DISPLAY_SIZE
SQL_DESC_FIXED_PREC_SCALE
SQL_DESC_IDENTITY_VALUE
SQL_DESC_INDICATOR_PTR
SQL_DESC_LABEL
SQL_DESC_LENGTH
SQL_DESC_LITERAL_PREFIX
SQL_DESC_LITERAL_SUFFIX
SQL_DESC_LOCAL_TYPE_NAME
SQL_DESC_NAME
SQL_DESC_NULLABLE
SQL_DESC_OCTET_LENGTH
SQL_DESC_OCTET_LENGTH_PTR
SQL_DESC_PARAMETER_TYPE
SQL_DESC_PRECISION
SQL_DESC_SCALE
SQL_DESC_SCHEMA_NAME
SQL_DESC_SEARCHABLE
SQL_DESC_TABLE_NAME
SQL_DESC_TYPE
SQL_DESC_TYPE_NAME
SQL_DESC_UNNAMED
SQL_DESC_UNSIGNED
SQL_DESC_UPDATABLE

Deferred fields

Deferred fields are created when the descriptor header or a descriptor record is created. The addresses of the defined variables are stored but not used until a later point in the application. The application must not deallocate or discard these variables between the time it associates them with the fields and the time CLI reads or writes them.

The following table lists the deferred fields and the meaning or a null pointer where applicable:

Table 14. Deferred fields

Field	Meaning of Null value
SQL_DESC_DATA_PTR	The record is unbound.
SQL_DESC_INDICATOR_PTR	(none)
SQL_DESC_OCTET_LENGTH_PTR (ARD and APD only)	• ARD: The length information for that column is not returned. • APD: If the parameter is a character string, the driver assumes that string is null-terminated. For output parameters, a null value in this field prevents the driver from returning length information. (If the SQL_DESC_TYPE field does not indicate a character-string parameter, the SQL_DESC_OCTET_LENGTH_PTR field is ignored.)
SQL_DESC_ARRAY_STATUS_PTR (multirow fetch only)	A multirow fetch failed to return this component of the per-row diagnostic information.
SQL_DESC_ROWS_PROCESSED_PTR (multirow fetch only)	(none)
SQL_DESC_CARDINALITY_PTR	(none)

Bound descriptor records

The SQL_DESC_DATA_PTR field in each descriptor record points to a variable that contains the parameter value (for APDs) or the column value (for ARDs). This is a deferred field that defaults to null. When the column or parameter is bound, it points to the parameter or column value. At this point the descriptor record is said to be bound.

Application Parameter Descriptors (APD)
Each bound record constitutes a bound parameter. The application must bind a parameter for each input and output parameter marker in the SQL statement before the statement is executed.

Application Row Descriptors (ARD)
Each bound record relates to a bound column.

Consistency checks for descriptors in CLI applications

You can use a consistency check to ensure that various fields are consistent with each other and that appropriate data types have been specified. A consistency check is performed automatically whenever an application sets the SQL_DESC_DATA_PTR field of the application parameter descriptor (APD) or application row descriptor (ARD).

Calling `SQLSetDescRec()` always prompts a consistency check. If any of the fields is inconsistent with other fields, `SQLSetDescRec()` will return `SQLSTATE HY021 Inconsistent descriptor information.`

To force a consistency check of IPD fields, the application can set the SQL_DESC_DATA_PTR field of the IPD. This setting is only used to force the consistency check. The value is not stored and cannot be retrieved by a call to `SQLGetDescField()` or `SQLGetDescRec()`.

A consistency check cannot be performed on an IRD.

Application descriptors

Whenever an application sets the SQL_DESC_DATA_PTR field of an APD, ARD, or IPD, CLI checks that the value of the SQL_DESC_TYPE field and the values applicable to that SQL_DESC_TYPE field are valid and consistent. This check is always performed when `SQLBindParameter()` or `SQLBindCol()` is called, or when `SQLSetDescRec()` is called for an APD, ARD, or IPD. This consistency check includes the following checks on application descriptor fields:

- The SQL_DESC_TYPE field must be one of the valid C or SQL types. The SQL_DESC_CONCISE_TYPE field must be one of the valid C or SQL types.
- If the SQL_DESC_TYPE field indicates a numeric type, the SQL_DESC_PRECISION and SQL_DESC_SCALE fields are verified to be valid.
- If the SQL_DESC_CONCISE_TYPE field is a time data type the SQL_DESC_PRECISION field is verified to be a valid seconds precision.

The SQL_DESC_DATA_PTR field of an IPD is not normally set; however, an application can do so to force a consistency check of IPD fields. A consistency check cannot be performed on an IRD. The value that the SQL_DESC_DATA_PTR field of the IPD is set to is not actually stored, and cannot be retrieved by a call to `SQLGetDescField()` or `SQLGetDescRec()`; the setting is made only to force the consistency check.

Descriptor allocation and freeing

Descriptors can be allocated implicitly or explicitly. The implicitly allocated descriptors are freed implicitly when an object, such as statement handle, is freed. The descriptors can be explicitly allocated only after database connection is established.

Descriptors are allocated in one of two ways:

Implicitly allocated descriptors

When a statement handle is allocated, a set of four descriptors are implicitly allocated. When the statement handle is freed, all implicitly allocated descriptors on that handle are freed as well.

To obtain handles to these implicitly allocated descriptors an application can call `SQLGetStmtAttr()`, passing the statement handle and an *Attribute* value of:

- SQL_ATTR_APP_PARAM_DESC (APD)
- SQL_ATTR_APP_ROW_DESC (ARD)
- SQL_ATTR_IMP_PARAM_DESC (IPD)
- SQL_ATTR_IMP_ROW_DESC (IRD)

The following example gives access to the statement's implicitly allocated implementation parameter descriptor:

```
/* dbuse. c */
/* ... */
sqlrc = SQLGetStmtAttr ( hstmt,
```

```
                                SQL_ATTR_IMP_PARAM_DESC,
                                &hIPD,
                                SQL_IS_POINTER,
                                NULL);
```

Note: The descriptors whose handles are obtained in this manner will still be freed when the statement for which they were allocated is freed.

Explicitly allocated descriptors

An application can explicitly allocate application descriptors. It is not possible, however, to allocate implementation descriptors.

An application descriptor can be explicitly allocated any time the application is connected to the database. To explicitly allocate the application descriptor, call `SQLAllocHandle()` with a *HandleType* of SQL_HANDLE_DESC. The following example explicitly allocates an application row descriptor:

```
rc = SQLAllocHandle( SQL_HANDLE_DESC, hdbc, &hARD ) ;
```

To use an explicitly allocated application descriptor instead of a statement's implicitly allocated descriptor, call `SQLSetStmtAttr()`, and pass the statement handle, the descriptor handle, and an *Attribute* value of either:

- SQL_ATTR_APP_PARAM_DESC (APD), or
- SQL_ATTR_APP_ROW_DESC (ARD)

When there are explicitly and implicitly allocated descriptors, the explicitly specified one is used. An explicitly allocated descriptor can be associated with more than one statement.

Field initialization

When an application row descriptor is allocated, its fields are initialized to the values listed in the descriptor header and record field initialization values documentation. The SQL_DESC_TYPE field is set to SQL_DEFAULT which provides for a standard treatment of database data for presentation to the application. The application may specify different treatment of the data by setting fields of the descriptor record.

The initial value of the SQL_DESC_ARRAY_SIZE header field is 1. To enable multirow fetch, the application can set this value in an ARD to the number of rows in a rowset.

There are no default values for the fields of an IRD. The fields are set when there is a prepared or executed statement.

The following fields of an IPD are undefined until a call to `SQLPrepare()` automatically populates them:

- SQL_DESC_CASE_SENSITIVE
- SQL_DESC_FIXED_PREC_SCALE
- SQL_DESC_TYPE_NAME
- SQL_DESC_DESC_UNSIGNED
- SQL_DESC_LOCAL_TYPE_NAME

Automatic population of the IPD

There are times when the application will need to discover information about the parameters of a prepared SQL statement. A good example is when a dynamically generated query is prepared; the application will not know anything about the parameters in advance. If the application enables automatic population of the IPD, by setting the SQL_ATTR_ENABLE_AUTO_IPD statement attribute to SQL_TRUE (using `SQLSetStmtAttr()`), then the fields of the IPD are automatically populated to describe the parameter. This includes the data type, precision, scale, and so on (the same information that `SQLDescribeParam()` returns). The application can use this information to determine if data conversion is required, and which application buffer is the most appropriate to bind the parameter to.

Automatic population of the IPD involves increased resource usage. If it is not necessary for this information to be automatically gathered by the CLI driver then the SQL_ATTR_ENABLE_AUTO_IPD statement attribute should be set to SQL_FALSE.

When automatic population of the IPD is active, each call to `SQLPrepare()` causes the fields of the IPD to be updated. The resulting descriptor information can be retrieved by calling the following functions:

- `SQLGetDescField()`
- `SQLGetDescRec()`
- `SQLDescribeParam()`

Freeing of descriptors

Explicitly allocated descriptors

When an explicitly allocated descriptor is freed, all statement handles to which the freed descriptor applied automatically revert to the original descriptors implicitly allocated for them.

Explicitly allocated descriptors can be freed in one of two ways:

- by calling `SQLFreeHandle()`with a *HandleType* of SQL_HANDLE_DESC
- by freeing the connection handle that the descriptor is associated with

Implicitly allocated descriptors

An implicitly allocated descriptor can be freed in one of the following ways:

- by calling `SQLDisconnect()` which drops any statements or descriptors open on the connection
- by calling `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_STMT to free the statement handle and all of the implicitly allocated descriptors associated with the statement

An implicitly allocated descriptor cannot be freed by calling `SQLFreeHandle()` with a *HandleType* of SQL_HANDLE_DESC.

Descriptor manipulation with descriptor handles in CLI applications

You can manipulate descriptors by using descriptor handles. If your descriptor does not use descriptor handles, you can use CLI functions instead.

The handle of an explicitly allocated descriptor is returned in the *OutputHandlePtr* argument when the application calls `SQLAllocHandle()` to allocate the descriptor.

The handle of an implicitly allocated descriptor is obtained by calling SQLGetStmtAttr() with either SQL_ATTR_IMP_PARAM_DESC or SQL_ATTR_IMP_ROW_DESC.

Retrieval of descriptor field values

The CLI function SQLGetDescField() can be used to obtain a single field of a descriptor record. SQLGetDescRec() retrieves the settings of multiple descriptor fields that affect the data type and storage of column or parameter data.

Setting of descriptor field values

Two methods are available for setting descriptor fields: one field at a time or multiple fields at once.

Setting of individual fields

Some fields of a descriptor are read-only, but others can be set using the function SQLSetDescField(). Refer to the list of header and record fields in the descriptor FieldIdentifier values documentation.

Record and header fields are set differently using SQLSetDescField() as follows:

Header fields
The call to SQLSetDescField() passes the header field to be set and a record number of 0. The record number is ignored since there is only one header field per descriptor. In this case the record number of 0 does not indicate the bookmark field.

Record fields
The call to SQLSetDescField() passes the record field to be set and a record number of 1 or higher, or 0 to indicate the bookmark field.

The application must follow the sequence of setting descriptor fields described in the SQLSetDescField() documentation when setting individual fields of a descriptor. Setting some fields will cause CLI to automatically set other fields. A consistency check will take place after the application follows the defined steps. This will ensure that the values in the descriptor fields are consistent.

If a function call that would set a descriptor fails, the content of the descriptor fields are undefined after the failed function call.

Setting of multiple fields

A predefined set of descriptor fields can be set with one call rather than setting individual fields one at a time. SQLSetDescRec() sets the following fields for a single column or parameter:

- SQL_DESC_TYPE
- SQL_DESC_OCTET_LENGTH
- SQL_DESC_PRECISION
- SQL_DESC_SCALE
- SQL_DESC_DATA_PTR
- SQL_DESC_OCTET_LENGTH_PTR
- SQL_DESC_INDICATOR_PTR

(SQL_DESC_DATETIME_INTERVAL_CODE is also defined by ODBC but is not supported by CLI.)

For example, all of the descriptor fields are set with the following call:

```
/* dbuse.c */
/* ... */
rc = SQLSetDescRec(hARD, 1, type, 0,
                   length, 0, 0, &id_no, &datalen, NULL);
```

Copying of descriptors

One benefit of descriptors is the fact that a single descriptor can be used for multiple purposes. For instance, an ARD on one statement handle can be used as an APD on another statement handle.

There will be other instances, however, where the application will want to make a copy of the original descriptor, then modify certain fields. In this case `SQLCopyDesc()` is used to overwrite the fields of an existing descriptor with the values from another descriptor. Only fields that are defined for both the source and target descriptors are copied (with the exception of the SQL_DESC_ALLOC_TYPE field which cannot be changed).

Fields can be copied from any type of descriptor, but can only be copied to an application descriptor (APD or ARD) or an IPD. Fields cannot be copied to an IRD. The descriptor's allocation type will not be changed by the copy procedure (again, the SQL_DESC_ALLOC_TYPE field cannot be changed).

Descriptor manipulation without using descriptor handles in CLI applications

Many CLI functions use descriptors, but an application does not have to manipulate the descriptors directly. Instead, the application can use a different function that sets or retrieves one or more fields of a descriptor. This category of CLI functions is called *concise* functions.

The `SQLBindCol()` function is an example of a concise function that manipulates descriptor fields.

In addition to manipulating multiple fields, concise functions are called without explicitly specifying the descriptor handle. The application does not even need to retrieve the descriptor handle to use a concise function.

The following types of concise functions exist:

- The functions `SQLBindCol()` and `SQLBindParameter()` bind a column or parameter by setting the descriptor fields that correspond to their arguments. These functions also perform other tasks unrelated to descriptors.

  If required, an application can also use the descriptor calls directly to modify individual details of a binding. In this case the descriptor handle must be retrieved, and the functions `SQLSetDescField()` or `SQLSetDescRec()` are called to modify the binding.
- The following functions always retrieve values in descriptor fields:
  - `SQLColAttribute()`
  - `SQLDescribeCol()`
  - `SQLDescribeParam()`

  - SQLNumParams()
  - SQLNumResultCols()
- The functions SQLSetDescRec() and SQLGetDescRec() set or get the multiple descriptor fields that affect the data type and storage of column or parameter data. A single call to SQLSetDescRec() can be used to change the values used in the binding of a column or parameter.
- The functions SQLSetStmtAttr() and SQLGetStmtAttr() modify or return descriptor fields in some cases, depending on which statement attribute is specified. Refer to the "Values Stored in a Descriptor" section of the descriptors documentation for more information.

Chapter 10. Catalog functions for querying system catalog information in CLI applications

Catalog functions, which are also called schema functions, provide a generic interface so that you can issue queries and receive consistent result sets across the DB2 family of servers. By using catalog functions, you can avoid receiving server-specific and release-specific catalog queries.

One of the first tasks an application often performs is to display a list of tables from which one or more are selected by the user. Although the application can issue its own queries against the database system catalog to get catalog information for such a DB2 command, it is best that the application calls the CLI catalog functions instead.

The catalog functions operate by returning to the application a result set through a statement handle. Calling these functions is conceptually equivalent to using `SQLExecDirect()` to execute a select against the system catalog tables. After calling these functions, the application can fetch individual rows of the result set as it would process column data from an ordinary `SQLFetch()`. The CLI catalog functions are:

- `SQLColumnPrivileges()`
- `SQLColumns()`
- `SQLExtendedProcedures()`
- `SQLExtendedProcedureColumns()`
- `SQLForeignKeys()`
- `SQLGetTypeInfo()`
- `SQLPrimaryKeys()`
- `SQLProcedureColumns()`
- `SQLProcedures()`
- `SQLSpecialColumns()`
- `SQLStatistics()`
- `SQLTablePrivileges()`
- `SQLTables()`

The result sets returned by these functions are defined in the descriptions for each catalog function. The columns are defined in a specified order. In future releases, other columns might be added to the end of each defined result set, therefore applications should be written in a way that would not be affected by such changes.

Note: By default, Informix database servers return schema information (such as table names, and column names) in the system catalog in lowercase. This is different from DB2 data servers which return schema information in upper case.

Some of the catalog functions result in execution of fairly complex queries. It is recommended that the application save the information returned rather than making repeated calls to get the same information.

Input arguments on catalog functions in CLI applications

All of the catalog functions have *CatalogName* and *SchemaName* components and their associated lengths on the input argument list. Other input arguments can also include *TableName*, *ProcedureName*, or *ColumnName*, and their associated lengths.

You can use these input arguments to either identify or constrain the amount of information to be returned.

Input arguments to catalog functions may be treated as ordinary arguments or pattern value arguments. An ordinary argument is treated as a literal, and the case of letters is significant. These arguments limit the scope of the query by identifying the object of interest. An error results if the application passes a null pointer for the argument.

Some catalog functions accept pattern values on some of their input arguments. For example, `SQLColumnPrivileges()` treats *SchemaName* and *TableName* as ordinary arguments and *ColumnName* as a pattern value. Refer to the "Function Arguments" section of the specific catalog function to see if a particular input argument accepts pattern values.

Inputs treated as pattern values are used to constrain the size of the result set by including only matching rows as though the underlying query's WHERE clause contained a LIKE predicate. If the application passes a null pointer for a pattern value input, the argument is not used to restrict the result set (that is, there is no corresponding LIKE in the WHERE clause). If a catalog function has more than one pattern value input argument, they are treated as though the LIKE predicates of the WHERE clauses in the underlying query were joined by AND; a row appears in this result set only if it meets all the conditions of the LIKE predicates.

Each pattern value argument can contain:

- The underscore (_) character which stands for any single character.
- The percent (%) character which stands for any sequence of zero or more characters. Note that providing a pattern value containing a single % is equivalent to passing a null pointer for that argument.
- Characters with no special meaning which stand for themselves. The case of a letter is significant.

These argument values are used on conceptual LIKE predicate(s) in the WHERE clause. To treat the metadata characters (_, %) as themselves, an escape character must immediately precede the _ or %. The escape character itself can be specified as part of the pattern by including it twice in succession. An application can determine the escape character by calling `SQLGetInfo()` with SQL_SEARCH_PATTERN_ESCAPE.

For example, the following calls would retrieve all the tables that start with 'ST':

```
/* tbinfo.c */
/* ... */
struct
{   SQLINTEGER ind ;
    SQLCHAR    val[129] ;
} tbQualifier, tbSchema, tbName, tbType;

struct
{   SQLINTEGER ind ;
    SQLCHAR val[255] ;
} tbRemarks;
```

```
SQLCHAR tbSchemaPattern[] = "
SQLCHAR tbNamePattern[] = "ST  /* all the tables starting with ST */

/* ... */
sqlrc = SQLTables( hstmt, NULL, 0,
                   tbSchemaPattern, SQL_NTS,
                   tbNamePattern, SQL_NTS,
                   NULL, 0);
/* ... */

/* bind columns to variables */
sqlrc = SQLBindCol( hstmt, 1, SQL_C_CHAR, tbQualifier.val, 129,
                    &tbQualifier.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);
sqlrc = SQLBindCol( hstmt, 2, SQL_C_CHAR, tbSchema.val, 129,
                    &tbSchema.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);
sqlrc = SQLBindCol( hstmt, 3, SQL_C_CHAR, tbName.val, 129,
                    &tbName.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);
sqlrc = SQLBindCol( hstmt, 4, SQL_C_CHAR, tbType.val, 129,
                    &tbType.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);
sqlrc = SQLBindCol( hstmt, 5, SQL_C_CHAR, tbRemarks.val, 255,
                    &tbRemarks.ind ) ;
STMT_HANDLE_CHECK( hstmt, sqlrc);

/* ... */
sqlrc = SQLFetch( hstmt );
/* ... */
while (sqlrc != SQL_NO_DATA_FOUND)
{   /* ... */
    sqlrc = SQLFetch( hstmt );
    /* ... */
}
```

Chapter 11. Programming hints and tips for CLI applications

These hints and tips can help you tune and improve the logic of your CLI applications.

- KEEPDYNAMIC support
- Common connection attributes
- Common statement attributes
- Reusing statement handles
- Binding and SQLGetData()
- Limiting use of catalog functions
- Column names of function generated result sets
- CLI-specific functions loaded from ODBC applications
- Global dynamic statement caching
- Data insertion and retrieval optimization
- Large object data optimization
- Case sensitivity of object identifiers
- SQLDriverConnect() versus SQLConnect()
- Turning off statement scanning
- Holding cursors across rollbacks
- Preparing compound SQL sub-statements
- User-defined types casting
- Deferred prepare to reduce network flow

KEEPDYNAMIC behavior refers to the server's ability to keep a dynamic statement in a prepared state, even after a commit has been performed. This behavior eliminates the need for the client to prepare the statement again, the next time the statement is executed. Some CLI/ODBC applications on the client might improve their performance by taking advantage of the **KEEPDYNAMIC** behavior on servers that are DB2 for z/OS and OS/390 Version 7 and later. Complete the listed steps to enable **KEEPDYNAMIC** behavior:

1. Enable the dynamic statement cache on the DB2 for z/OS and OS/390 server (see the DB2 for z/OS and OS/390 server documentation).
2. Bind the `db2clipk.bnd` file on your DB2 for Linux, UNIX, and Windows client with the KEEPDYNAMIC and COLLECTION options. The example shows how to bind `db2clipk.bnd`, creating a collection named **KEEPDYNC**:
   - db2 connect to *database_name* user *userid* using *password*
   - db2 bind db2clipk.bnd SQLERROR CONTINUE BLOCKING ALL KEEPDYNAMIC YES COLLECTION KEEPDYNC GRANT PUBLIC
   - db2 connect reset
3. Inform the client that the **KEEPDYNAMIC** bind option is enabled for your collection by performing either of the listed examples:
   - Set the CLI/ODBC configuration keywords in the `db2cli.ini` file: **KeepDynamic = 1**, **CurrentPackageSet = collection name** created in Step 2. For example:

     ```
     [dbname]
     KeepDynamic=1
     CurrentPackageSet=KEEPDYNC
     ```

- Set the SQL_ATTR_KEEPDYNAMIC and SQL_ATTR_CURRENT_PACKAGE_SET connection attributes in the CLI/ODBC application. For example:

```
SQLSetConnectAttr(hDbc,
                  SQL_ATTR_KEEP_DYNAMIC,
                  (SQLPOINTER) 1,
                   SQL_IS_UINTEGER );

SQLSetConnectAttr(hDbc,
                  SQL_ATTR_CURRENT_PACKAGE_SET,
                   (SQLPOINTER) "KEEPDYNC",
                  SQL_NTS);
```

See the DB2 for z/OS and OS/390 server documentation for further information about **KEEPDYNAMIC** behavior and configuration.

Common connection attributes

The listed connection attributes can be set by CLI applications:

- SQL_ATTR_AUTOCOMMIT - Generally this attribute should be set to SQL_AUTOCOMMIT_OFF, because each commit request can generate extra network flow. Only leave SQL_AUTOCOMMIT_ON on if specifically needed.

  Note: The default is SQL_AUTOCOMMIT_ON.
- SQL_ATTR_TXN_ISOLATION - This connection attribute determines the isolation level at which the connection or statement will operate. The isolation level determines the level of concurrency possible, and the level of locking required to execute the statement. Applications must choose an isolation level that maximizes concurrency, yet ensures data consistency.

Common statement attributes

The listed statement attributes might be set by CLI applications:

- SQL_ATTR_MAX_ROWS - Setting this attribute limits the number of rows returned to the application from query operations. This can be used to avoid overwhelming an application with a very large result set generated inadvertently, which is especially useful for applications on clients with limited memory resources.

  Setting SQL_ATTR_MAX_ROWS while connected to DB2 for z/OS and OS/390 Version 7 and later will add “OPTIMIZE FOR n ROWS” and “FETCH FIRST n ROWS ONLY” clauses to the statement. For versions of DB2 for OS/390 before Version 7 and any DBMS that does not support the “FETCH FIRST n ROWS ONLY” clause, the full result set is still generated at the server using the “OPTIMIZE FOR n ROWS” clause, however CLI will count the rows on the client and only fetch up to SQL_ATTR_MAX_ROWS rows.
- SQL_ATTR_CURSOR_HOLD - This statement attribute determines if the cursor for this statement will be declared by CLI using the WITH HOLD clause.

  Resources associated with statement handles can be better utilized by the server if the statements that do not require cursor-hold behavior have this attribute set to SQL_CURSOR_HOLD_OFF. The efficiency gains obtained by the appropriate use of this attribute are considerable on OS/390 and z/OS.

  Note: Many ODBC applications expect a default behavior where the cursor position is maintained after a commit.
- SQL_ATTR_TXN_ISOLATION - CLI allows the isolation level to be set at the statement level, however, it is recommended that the isolation level be set at the

connection level. The isolation level determines the level of concurrency possible, and the level of locking required to execute the statement.

Resources associated with statement handles can be better utilized by CLI if statements are set to the required isolation level, rather than leaving all statements at the default isolation level. This should only be attempted with a thorough understanding of the locking and isolation levels of the connected DBMS.

Applications should use the minimum isolation level possible to maximize concurrency.

Reusing statement handles

Each time a CLI application declares a statement handle, the CLI driver allocates and then initializes an underlying data structure for that handle. To increase performance, CLI applications can reuse statement handles with different statements, thereby avoiding the costs associated with statement handle allocation and initialization.

Note: Before reusing statement handles, memory buffers and other resources used by the previous statement might need to be released by calling the `SQLFreeStmt()` function. Also, statement attributes previously set on a statement handle (for example, SQL_ATTR_PARAMSET_SIZE) must be explicitly reset, otherwise they might be inherited by all future statements using the statement handle.

Binding and SQLGetData()

Generally it is more efficient to bind application variables or file references to result sets than to use `SQLGetData()`. When the data is in a LOB column, LOB functions are preferable to `SQLGetData()` (see Large object data optimization for more information). Use `SQLGetData()` when the data value is large variable-length data that:

- must be received in pieces, or
- might not need to be retrieved.

Limiting use of catalog functions

Catalog functions, such as `SQLTables()`, force the CLI driver to query the DBMS catalog tables for information. The queries issued are complex and the DBMS catalog tables can be very large. In general, try to limit the number of times the catalog functions are called, and limit the number of rows returned.

The number of catalog function calls can be reduced by calling the function once, and having the application store (cache) the data.

The number of rows returned can be limited by specifying a:

- Schema name or pattern for all catalog functions
- Table name or pattern for all catalog functions other than `SQLTables()`
- Column name or pattern for catalog functions that return detailed column information.

Remember that although an application might be developed and tested against a data source with hundreds of tables, it might be run against a database with thousands of tables. Consider this likelihood when developing applications.

Close any open cursors (call SQLCloseCursor() or SQLFreeStmt() with SQL_CLOSE *Option*) for statement handles used for catalog queries to release any locks against the catalog tables. Outstanding locks on the catalog tables can prevent CREATE, DROP or ALTER statements from executing.

Column names of function generated result sets

The column names of the result sets generated by catalog and information functions might change as the ODBC and CLI standards evolve. The *position* of the columns, however, will not change.

Any application dependency might be based on the column position (*iCol* parameter used in SQLBindCol(), SQLGetData(), and SQLDescribeCol()) and not the name.

CLI-specific functions loaded from ODBC applications

The ODBC Driver Manager maintains its own set of statement handles which it maps to the CLI statement handles on each call. When a CLI function is called directly, it must be passed to the CLI driver statement handle, as the CLI driver does not have access to the ODBC mapping.

Call SQLGetInfo() with the SQL_DRIVER_HSTMT option to obtain the CLI statement handle (HSTMT). The CLI functions can then be called directly from the shared library or DLL, passing the HSTMT argument where required.

Global dynamic statement caching

DB2 servers at version 5 or later for UNIX or Windows have a *global dynamic statement cache*. This cache is used to store the most popular access plans for prepared dynamic SQL statements.

Before each statement is prepared, the server automatically searches this cache to see if an access plan has already been created for this exact SQL statement (by this application or any other application or client). If so, the server does not need to generate a new access plan, but will use the one in the cache instead. There is now no need for the application to cache connections at the client unless connecting to a server that does not have a global dynamic statement cache.

Data insertion and retrieval optimization

The methods that describe using arrays to bind parameters and retrieve data use compound SQL to optimize network flow. Use these methods as much as possible.

Large object data optimization

Use LOB data types and the supporting functions for long strings whenever possible. Unlike LONG VARCHAR, LONG VARBINARY, and LONG VARGRAPHIC types, LOB data values can use LOB locators and functions such as SQLGetPosition() and SQLGetSubString() to manipulate large data values at the server.

LOB values can also be fetched directly to a file, and LOB parameter values can be read directly from a file. This saves the resource utilization of the application transferring data through application buffers.

Case sensitivity of object identifiers

All database object identifiers, such as table names, view names and column names are stored in the catalog tables in uppercase unless the identifier is delimited. If an identifier is created using a delimited name, the exact case of the name is stored in the catalog tables.

When an identifier is referenced within an SQL statement, it is treated as case *insensitive* unless it is delimited.

For example, if the listed two tables are created,

```
CREATE TABLE MyTable   (id INTEGER)
CREATE TABLE "YourTable" (id INTEGER)
```

two tables will exist, `MYTABLE` and `YourTable`

Both of the statements are equivalent:

```
SELECT * FROM MyTable (id INTEGER)
SELECT * FROM MYTABLE (id INTEGER)
```

The second statement in the example will fail with `TABLE NOT FOUND` because there is no table named `YOURTABLE`:

```
SELECT * FROM "YourTable" (id INTEGER)   // executes without error
SELECT * FROM YourTable (id INTEGER)     // error, table not found
```

All CLI catalog function arguments treat the names of objects as *case sensitive*, that is, as if each name was delimited.

SQLDriverConnect() versus SQLConnect()

Using `SQLDriverConnect()` allows the application to rely on the dialog box provided by CLI to prompt the user for the connection information.

If an application uses its own dialog boxes to query the connect information, the user might be able to specify additional connect options in the connection string. The string can also be stored and used as a default on subsequent connections.

Turning off statement scanning

CLI by default, scans each SQL statement searching for vendor escape clause sequences.

If the application does not generate SQL statements that contain vendor escape clause sequences, then the SQL_ATTR_NOSCAN statement attribute must be set to SQL_NOSCAN_ON at the connection level so that CLI does not perform a scan for vendor escape clauses.

Holding cursors across rollbacks

Applications that must deal with complex transaction management issues might benefit from establishing multiple concurrent connections to the same database. Each connection in CLI has its own transaction scope, so any actions performed on one connection do not affect the transactions of other connections.

For example, all open cursors within a transaction get closed if a problem causes the transaction to be rolled back. An application can use multiple connections to

the same database to separate statements with open cursors; because the cursors are in separate transactions, a rollback on one statement does not affect the cursors of the other statements.

However, using multiple connections might mean bringing some data across to the client on one connection, and then sending it back to the server on the other connection. For example:

- Suppose in connection #1 you are accessing large object columns and have created LOB locators that map to portions of large object values.
- If in connection #2, you want to use (for example to insert) the portion of the LOB values represented by the LOB locators, you must move the LOB values in connection #1 first to the application, and then pass them to the tables that you are working with in connection #2. This is because connection #2 does not know anything about the LOB locators in connection #1.
- If you only had one connection, then you can just use the LOB locators directly. However, the LOB locators are lost as soon as you rolled back your transaction.

Note: When multiple connections to a single database are used by an application, the application must be careful to synchronize access to database objects or it might experience various lock contention issues, as database locks are not shared between transactions. Updates by one connection can easily force other connections into a lock-wait state until the first connection releases the lock (through a COMMIT or ROLLBACK).

Preparing compound SQL sub-statements

In order to maximize efficiency of the compound statement, sub-statements might be prepared before the BEGIN COMPOUND statement, and then executed within the compound statement.

This also simplifies error handling because prepare errors can be handled outside of the compound statement.

User-defined types and casting

If a parameter marker is used in a predicate of a query statement, and the parameter is a user defined type, the statement must use a CAST function to cast either the parameter marker or the UDT.

For example, suppose the listed type and table is defined:

```
CREATE DISTINCT TYPE CNUM AS INTEGER WITH COMPARISONS

CREATE TABLE CUSTOMER (
        Cust_Num     CNUM NOT NULL,
        First_Name   CHAR(30) NOT NULL,
        Last_Name    CHAR(30) NOT NULL,
        Phone_Num    CHAR(20) WITH DEFAULT,
        PRIMARY KEY  (Cust_Num) )
```

Suppose also that the listed SQL statement was then issued:

```
SELECT first_name, last_name, phone_num from customer
WHERE cust_num = ?
```

This statement fails because the parameter marker cannot be of type CNUM and thus the comparison fails due to incompatible types.

Casting the column to integer (its base SQL type), allows the comparison to work because a parameter can be provided for type integer:

```
SELECT  first_name, last_name, phone_num from customer
where cast( cust_num as integer ) = ?
```

Alternatively the parameter marker can be cast to INTEGER and the server can then apply the INTEGER to CNUM conversion:

```
SELECT  first_name, last_name, phone_num FROM customer
where cust_num = cast( ? as integer )
```

Deferred prepare to reduce network flow

In CLI, deferred prepare is on by default. The PREPARE request is not sent to the server until the corresponding execute request is issued. The two requests are then combined into one command/reply flow (instead of two) to minimize network flow and to improve performance. This is of greatest benefit when an application generates queries with very small answer sets, because the resource utilization for requests and replies flowing over the network represents a large percentage of the processing time. In an environment where a DB2 Connect or DDCS gateway is used, there is a greater opportunity for cost reduction because four request and reply combinations are reduced to two.

Note: Functions such as `SQLDescribeParam()`, `SQLDescribeCol()`, `SQLNumParams()`, and `SQLNumResultCols()` require that the statement has been prepared. If the statement has not already been prepared, these functions trigger an immediate PREPARE request to the server, and the benefit of deferred prepare does not occur.

Reduction of network flows with CLI array input chaining

CLI array input chaining causes requests for the execution of prepared statements to be held and queued at the client until the chain is ended. After the chain is finished, all of the chained `SQLExecute()` function requests at the client are sent to the server in a single network flow.

The following sequence of events (presented as pseudocode) is an example of how CLI array input chaining can reduce the number of network flows to the server:

```
SQLPrepare (statement1)
SQLExecute (statement1)
SQLExecute (statement1)
/* the two execution requests for statement1 are sent to the server in
two network flows */

SQLPrepare (statement2)

/* enable chaining */
SQLSetStmtAttr (statement2, SQL_ATTR_CHAINING_BEGIN)

SQLExecute (statement2)
SQLExecute (statement2)
SQLExecute (statement2)

/* end chaining */
SQLSetStmtAttr (statement2, SQL_ATTR_CHAINING_END)

/* the three execution requests for statement2 are sent to the server
in a single network flow, instead of three separate flows */
```

If SQL_ERROR or SQL_SUCCESS_WITH_INFO is returned when you set the SQL_ATTR_CHAINING_END statement attribute, then at least one statement in

the chain of statements returned SQL_ERROR or SQL_SUCCESS_WITH_INFO when it was executed. Use the CLI diagnostic functions `SQLGetDiagRec()` and `SQLGetDiagField()` to retrieve the information about the cause of a returned message.

Restriction: The CLI driver does not support array input chaining for compound SQL (compiled) or compound SQL (inline) statements.

Chapter 12. Unicode CLI applications

The CLI Unicode application must connect to the database with either the `SQLConnectW()` or `SQLDriverConnectW()` function.

The connecting to the database with either the `SQLConnectW()` or `SQLDriverConnectW()` function ensures that the CLI driver considers Unicode as the preferred method of communication between itself and the database.

There are two main areas of support for CLI Unicode applications:

- The addition of a set of functions that accept Unicode string arguments in place of ANSI string arguments.
- The addition of new C and SQL data types to describe Unicode data.

ODBC adds types to the set of C and SQL types that already exist to accommodate Unicode, and CLI uses these additional types accordingly. The new C type, SQL_C_WCHAR, indicates that the C buffer contains Unicode data. The CLI/ODBC driver considers all Unicode data exchanged with the application to be UCS-2 in native-endian format. The new SQL types, SQL_WCHAR, SQL_WVARCHAR, and SQL_WLONGVARCHAR, indicate that a particular column or parameter marker contains Unicode data. For DB2 Unicode databases, graphic columns are described using the new types. Conversion is allowed between SQL_C_WCHAR and SQL_CHAR, SQL_VARCHAR, SQL_LONGVARCHAR and SQL_CLOB, as well as with the graphic data types.

Note: UCS-2 is a fixed-length character encoding scheme that uses 2 bytes to represent each character. When referring to the number of characters in a UCS-2 encoded string, the count is simply the number of SQLWCHAR elements needed to store the string.

Obsolete CLI/ODBC keyword values

Before Unicode applications were supported, applications that were written to work with single-byte character data could be made to work with double-byte graphic data by a series of CLI configuration keywords, such as Graphic=1,2 or 3, Patch2=7. These workarounds presented graphic data as character data, and also affected the reported length of the data. These keywords are no longer required for Unicode applications, and should not be used due to the risk of potential side effects. If it is not known if a particular application is a Unicode application, try without any of the keywords that affect the handling of graphic data.

Literals in unicode databases

In non-Unicode databases, data in LONG VARGRAPHIC and LONG VARCHAR columns cannot be compared. Data in GRAPHIC/VARGRAPHIC and CHAR/VARCHAR columns can only be compared, or assigned to each other, using explicit cast functions since no implicit code page conversion is supported. This includes GRAPHIC/VARGRAPHIC and CHAR/VARCHAR literals where a GRAPHIC/VARGRAPHIC literal is differentiated from a CHAR/VARCHAR literal by a G prefix. For Unicode databases, casting between GRAPHIC/VARGRAPHIC and CHAR/VARCHAR literals is not required. Also, a G prefix is not required in front of a GRAPHIC/VARGRAPHIC literal. Provided at least one of the arguments is a literal, implicit conversions occur. This allows literals with or without the G

prefix to be used within statements that use either `SQLPrepareW()` or `SQLExecDirect()`. Literals for LONG VARGRAPHICs still must have a G prefix.

Unicode functions (CLI)

CLI Unicode functions accept Unicode string arguments in place of ANSI string arguments. The Unicode string arguments must be in UCS-2 encoding (native-endian format).

ODBC API functions have suffixes to indicate the format of their string arguments: those that accept Unicode end in W, and those that accept ANSI have no suffix (ODBC adds equivalent functions with names that end in A, but these are not offered by CLI). The following list of CLI functions are available in both ANSI and Unicode versions:

- SQLBrowseConnect
- SQLColAttribute
- SQLColAttributes
- SQLColumnPrivileges
- SQLColumns
- SQLConnect
- SQLCreateDb
- SQLCreatePkg
- SQLDataSources
- SQLDescribeCol
- SQLDriverConnect
- SQLDropDb
- SQLError
- SQLExecDirect
- SQLExtendedPrepare
- SQLExtendedProcedures
- SQLExtendedProcedureColumns
- SQLForeignKeys
- SQLGetConnectAttr
- SQLGetConnectOption
- SQLGetCursorName
- SQLGetDescField
- SQLGetDescRec
- SQLGetDiagField
- SQLGetDiagRec
- SQLGetInfo
- SQLGetPosition
- SQLGetStmtAttr
- SQLNativeSQL
- SQLPrepare
- SQLPrimaryKeys
- SQLProcedureColumns
- SQLProcedures

- SQLReloadConfig
- SQLSetConnectAttr
- SQLSetConnectOption
- SQLSetCursorName
- SQLSetDescField
- SQLSetStmtAttr
- SQLSpecialColumns
- SQLStatistics
- SQLTablePrivileges
- SQLTables

For unicode functions that take a string length as an argument, the length is calculated as the number of SQL_WCHAR elements that are needed to store the string. For unicode functions that return string data from the server, the returned length of the string data is the number of SQL_WCHAR elements that are needed to store the string. However, the length of data that can be a string or non-string is calculated in number of bytes that are needed to store the data.

For example, the SQLGetInfoW() API takes the length as the number of bytes while the SQLExecDirectW() function interprets the length as the number of SQL_WCHAR elements. On Windows operating systems, where the UTF-16 extended character set is used, the single character SQL_WCHAR is equivalent to 2 SQL_C_CHAR elements. Each SQL_C_CHAR element has length of 2 bytes. The CLI driver returns data from the result sets in either unicode or ANSI, depending on the API called by the application and the data that are bound. If an application binds data to a SQL_C_CHAR type, the CLI driver converts SQL_WCHAR data to SQL_CHAR in the unicode function.

ANSI to Unicode function mappings

The syntax for a CLI Unicode function is the same as the syntax for its corresponding ANSI function, except that SQL_CHAR parameters are defined as SQL_WCHAR. Character buffers defined as SQLPOINTER in the ANSI syntax can be defined as either SQL_CHAR or SQL_WCHAR in the unicode function.

Unicode function calls to ODBC driver managers

CLI applications that are ODBC-compliant can access a DB2 database through the CLI/ODBC driver in one of two ways: linking to the CLI/ODBC driver library or linking to the ODBC driver manager library.

CLI applications can access a database by:

- Direct access - An application links to the CLI/ODBC driver library and makes calls to exported CLI/ODBC functions. Unicode applications accessing the CLI/ODBC driver directly should access and perform transactions against the database using the CLI Unicode functions, and use SQLWCHAR buffers with the understanding that all Unicode data is UCS-2. To identify itself as a Unicode application, the application must connect to the database using either `SQLConnectW()` or `SQLDriverConnectW()`.
- Indirect access - An application links to an ODBC driver manager library and makes calls to standard ODBC functions. The ODBC driver manager then loads the CLI/ODBC driver and calls exported ODBC functions on behalf of the application. The data passed to the CLI/ODBC driver from the application

might be converted by the ODBC driver manager. An application identifies itself to an ODBC driver manager as a Unicode application by calling `SQLConnectW()` or `SQLDriverConnectW()`.

When connecting to a data source, the ODBC driver manager checks to see if the requested driver exports the `SQLConnectW()` function. If the function is supported, the ODBC driver is considered a Unicode driver, and all subsequent calls in the application to ODBC functions are routed to the functions' Unicode equivalents (identified by the 'W' suffix; for example, `SQLConnectW()`) by the ODBC driver manager. If the application calls Unicode functions, no string conversion is necessary, and the ODBC driver manager calls the Unicode functions directly. If the application calls ANSI functions, the ODBC driver manager converts all ANSI strings to Unicode strings before calling the equivalent Unicode function.

If an application calls Unicode functions, but the driver does not export `SQLConnectW()`, then the ODBC driver manager routes any Unicode function calls to their ANSI equivalents. All Unicode strings are converted by the ODBC driver manager to ANSI strings in the application's code page before calling the equivalent ANSI function. This might result in data loss if the application uses Unicode characters which cannot be converted to the application's code page.

Various ODBC driver managers use different encoding schemes for Unicode strings, depending on the operating system:

Table 15. Unicode string encoding schemes by operating system

Driver manager	Operating system	
	Microsoft Windows	**Linux and UNIX**
Microsoft ODBC Driver Manager	UTF-16*	not applicable
unixODBC Driver Manager	UCS-2	UCS-2
DataDirect Connect for ODBC Driver Manager	UTF-16*	UTF-8
* UTF-16 is a superset of UCS-2 and therefore is compatible		

Chapter 13. Multisite updates (two phase commit) in CLI applications

You can use the multisite update function to update data in multiple remote database servers with integrity. DB2 database products provide comprehensive support for multisite updates.

A typical transaction scenario portrays an application which interacts with only one database server in a transaction. Even though concurrent connections allow for concurrent transactions, the different transactions are not coordinated.

Note: Multisite update is also known as Distributed Unit of Work (DUOW).

A typical banking transaction is a good example of a multisite update. Consider the transfer of money from one account to another in a different database server. In such a transaction it is critical that the updates that implement the debit operation on one account do not get committed unless the updates required to process the credit to the other account are committed as well. Multisite update considerations apply when data representing these accounts is managed by two different database servers

Some multisite updates involve the use of a transaction manager (TM) to coordinate two-phase commit among multiple databases. CLI applications can be written to use various transaction managers:

- DB2 as transaction manager
- Process-based XA-compliant transaction program monitor
- Host and IBM Power Systems™ database servers

  Note: There is no specific DB2 CLI/ODBC client configuration required when connecting to a host or IBM Power Systems database server, although the machine running DB2 Connect might require certain configuration settings to enable running multisite update mode against the host.

ConnectType CLI/ODBC configuration keyword

Controls whether the application is to operate in a remote or distributed unit of work.

db2cli.ini keyword syntax:

ConnectType = **1** | **2**

Default setting:

Remote unit of work.

Equivalent environment or connection attribute:

SQL_ATTR_CONNECTTYPE

Usage notes:

This option allows you to specify the default connect type. The options are:

- 1 = Remote unit of work. Multiple concurrent connections, each with its own commit scope. The concurrent transactions are not coordinated. This is the default.

- 2= Distributed unit of work. Coordinated connections where multiple databases participate under the same distributed unit of work.

The first connection determines the connect type for all other connections that are allocated under the same environment handle.

This keyword takes precedence over the environment or connection attribute.

DB2 as transaction manager in CLI applications

In CLI/ODBC applications, you can use the DB2 transaction manager to coordinate distributed transactions against all IBM database servers.

Configuration of DB2 as transaction manager

The DB2 Transaction Manager must be set up according to the information in the DB2 transaction manager configuration documentation.

To use DB2 as the transaction manager in CLI/ODBC applications, the following configurations must be applied:

- The SQL_ATTR_CONNECTTYPE environment attribute must be set. This attribute controls whether the application is to operate in a coordinated or uncoordinated distributed environment. Commits or rollbacks among multiple database connections are coordinated in a coordinated distributed environment. The two possible values for this attribute are:
  - SQL_CONCURRENT_TRANS - supports single database per transaction semantics. Multiple concurrent connections to the same database and to different databases are permitted. Each connection has its own commit scope. No effort is made to enforce coordination of transactions. This is the default and corresponds to a Type 1 CONNECT in embedded SQL.
  - SQL_COORDINATED_TRANS - supports multiple databases per transaction semantics. A coordinated transaction is one in which commits or rollbacks among multiple database connections are coordinated. Setting SQL_ATTR_CONNECTTYPE to this value corresponds to Type 2 CONNECT in embedded SQL.

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

  All connections on an environment handle must have the same SQL_ATTR_CONNECTTYPE setting. An environment cannot have a mixture of concurrent and coordinated connections. The type of the first connection will determine the type of all subsequent connections. `SQLSetEnvAttr()` will return an error if an application attempts to change the connect type while there is an active connection.
- If SQL_ATTR_CONNECTTYPE is set to SQL_COORDINATED_TRANS, two-phase commit is used to commit the work done by each database in a multiple database transaction. This requires the use of a Transaction Manager to coordinate two-phase commits amongst the databases that support this protocol. Multiple readers and multiple updaters are allowed within a transaction.
- The function `SQLEndTran()` must be used in a multisite update environment when DB2 is acting as the transaction manager.

Application flows in concurrent and coordinated transactions

Figure 9 shows the logical flow of an application executing statements on two SQL_CONCURRENT_TRANS connections ('A' and 'B'), and indicates the scope of the transactions.

Figure 10 on page 176 shows the same statements being executed on two SQL_COORDINATED_TRANS connections ('A' and 'B'), and the scope of a coordinated distributed transaction.

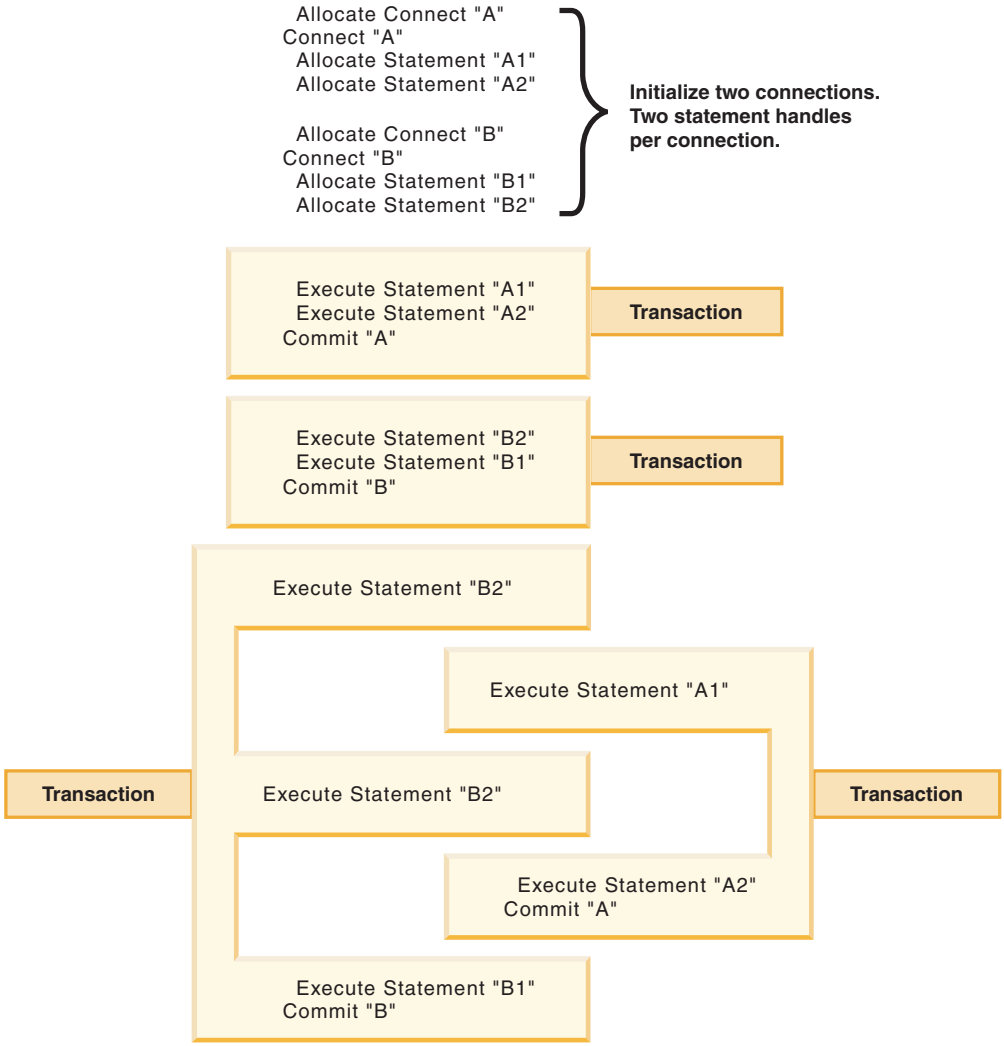


Figure 9. Multiple connections with concurrent transactions

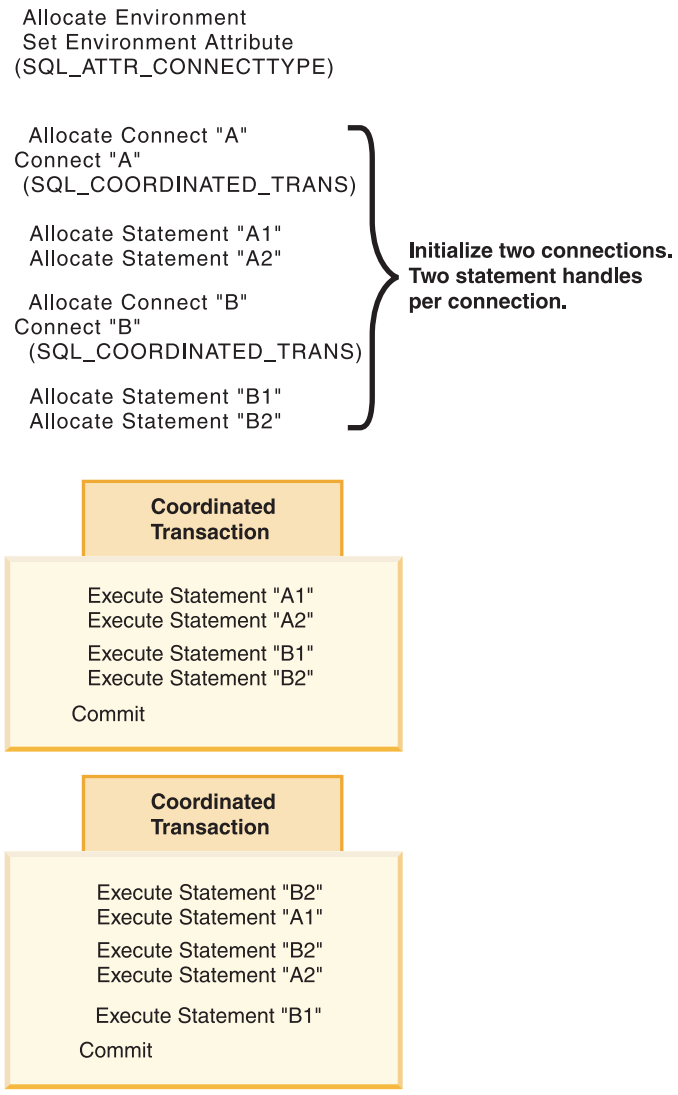


Figure 10. Multiple connections with coordinated transactions

Restrictions

Mixing embedded SQL and CLI/ODBC calls in a multisite update environment is supported, but all the same restrictions of writing mixed applications are imposed.

Process-based XA-compliant Transaction Program Monitor (XA TP) programming considerations for CLI applications

Process-based XA transaction managers, such as a CICS® server, start one application server per process. In each application-server process, the connections are established by using the XA API (xa_open).

Configuration

The XA Transaction Manager must be set up according to the configuration considerations for XA transaction managers.

Note: Setting the CLI/ODBC configuration keywords for connections is no longer required when in an XA Transactional processing environment.

Programming considerations

CLI/ODBC applications written for this environment must complete the following steps:

- The application must first call `SQLConnect()` or `SQLDriverConnect()` to associate the TM-opened connections with the CLI/ODBC connection handle. The data source name must be specified. User ID and Password are optional.
- The application must call the XA TM to do a commit or rollback. As a result, since the CLI/ODBC driver does not know that the transaction has ended, the application should do the following tasks before exiting:
  - Drop all CLI/ODBC statement handles.
  - Free up the connection handle by calling `SQLDisconnect()` and `SQLFreeHandle()`. The actual database connection will not be disconnected until the XA TM performs an xa_close.

Restrictions

Mixing embedded SQL and CLI/ODBC calls in a multisite update environment is supported, but all the same restrictions of writing mixed applications are imposed.

Chapter 14. Asynchronous execution of CLI functions

CLI can run a subset of CLI functions asynchronously. Asynchronous execution is possible for those functions that normally send a request to the server and then wait for a response.

For asynchronous functions, the CLI driver returns control to the application after calling the function but before that function has finished executing. The functions return SQL_STILL_EXECUTING each time they are called until they are finished running, at which point they return a different value (for example, SQL_SUCCESS). Rather than waiting for a response, a function executing asynchronously returns control to the application. The application can then perform other tasks and poll the function until a return code other than SQL_STILL_EXECUTING is returned. Refer to the SQL_ATTR_ASYNC_ENABLE connection or statement attribute for a list of functions that can be executed asynchronously.

In order for an application to run CLI functions asynchronously, the application must include following function calls:

1. A call to the function `SQLGetInfo()` with the SQL_ASYNC_MODE option to ensure support for asynchronous calls.
2. A call to `SQLSetConnectAttr()` or `SQLSetStmtAttr()` with the SQL_ATTR_ASYNC_ENABLE attribute to enable asynchronous calls once it has been established that there is support for asynchronous calls.
3. A call to a function that supports asynchronous execution and polling of the asynchronous function. When the application calls a function that can be run asynchronously, one of two things can happen:
   - If the function will not benefit from being run asynchronously, CLI can decide to run it synchronously and return the normal return code (other than SQL_STILL_EXECUTING). In this case the application runs as it would if the asynchronous mode had not been enabled.
   - CLI will perform some minimal processing (such as checking the arguments for errors), then pass the statement on to the server. Once this quick processing is complete a return code of SQL_STILL_EXECUTING is returned to the application.

Functions that can be called during asynchronous execution

Once a function has been called asynchronously, only the original function, `SQLAllocHandle()`, `SQLCancel()`, `SQLGetDiagField()`, or `SQLGetDiagRec()` can be called on the statement or the connection associated with *StatementHandle*, until the original function returns a code other than SQL_STILL_EXECUTING. Any other function called on *StatementHandle* or the connection associated with *StatementHandle* returns SQL_ERROR with an SQLSTATE of HY010 (Function sequence error.).

Diagnostic information while a function is running asynchronously

`SQLGetDiagField()` returns the following values when it is called on a statement handle that has an asynchronous function executing:

- The values of SQL_DIAG_CURSOR_ROW_COUNT, SQL_DIAG_DYNAMIC_FUNCTION, SQL_DIAG_DYNAMIC_FUNCTION_CODE, and SQL_DIAG_ROW_COUNT header fields are undefined.
- SQL_DIAG_NUMBER header field returns 0.
- SQL_DIAG_RETURN_CODE header field returns SQL_STILL_EXECUTING.
- All record fields return SQL_NO_DATA.

`SQLGetDiagRec()` always returns SQL_NO_DATA when it is called on a statement handle that has an asynchronous function executing.

Cancelling the asynchronous function call

The application can issue a request to cancel any function that is running asynchronously by calling `SQLCancel()`. A function that has already finished executing cannot be cancelled.

The return code from the `SQLCancel()` call indicates whether the cancel request was received, not whether the execution of the asynchronous function was stopped.

The only way to tell if the function was cancelled is to call it again, using the original arguments.

- If the cancel was successful, the function will return SQL_ERROR and an SQLSTATE of HY008 (Operation was Canceled.).
- If the cancel was not successful, the function will return a value other than SQL_ERROR with an SQLSTATE of HY008. For example, the function might return SQL_STILL_EXECUTING.

Executing functions asynchronously in CLI applications

Executing functions asynchronously in CLI applications is part of the larger task of programming with CLI.

The task of enabling asynchronous functions and working with those functions involves ensuring that asynchronous execution is supported, initializing the application for asynchronous execution, and working with the functions to take advantage of asynchronous execution.

Before you begin

Before you begin setting up your CLI application for asynchronous execution, you must allocate an environment handle and a connection handle. This is part of the task of initializing your CLI application.

About this task

Note: Starting from Version 9.7, Fix Pack 4, this feature can also be used with the CLI load processing feature.

An application can have at most 1 active function running in asynchronous mode on any one connection. If asynchronous mode is enabled at the connection level, all statements already allocated, as well as future statement handles allocated on the connection will be enabled for asynchronous execution.

Procedure

1. Call SQLGetInfo() with *InfoType* SQL_ASYNC_MODE to ensure that functions can be called asynchronously. For example:

```
/* See what type of Asynchronous support is available. */
rc = SQLGetInfo( hdbc, /* Connection handle */
                 SQL_ASYNC_MODE, /* Query the support available */
                 &ubuffer, /* Store the result in this variable */
                 4,
                 &outlen);
```

   The call to the SQLGetInfo() function will return one of the following values:

   - SQL_AM_STATEMENT: asynchronous execution can be turned on or off at a statement level.
   - SQL_AM_CONNECTION: asynchronous execution can be turned on or off at a connection level.
   - SQL_AM_NONE: asynchronous execution is not supported. Your application cannot be set up for asynchronous execution. This will be returned for one of two reasons:
     - The datasource itself does not support asynchronous execution.
     - The CLI/ODBC configuration keyword ASYNCENABLE has been specifically set to disable asynchronous execution.

2. Set the SQL_ATTR_ASYNC_ENABLE attribute using SQLSetStmtAttr() or SQLSetConnectAttr() to enable your application for asynchronous execution if the return value from SQLGetInfo() is either SQL_AM_STATEMENT or SQL_AM_CONNECTION.

   - If the return value is SQL_AM_STATEMENT, set SQL_ATTR_ASYNC_ENABLE to SQL_ASYNC_ENABLE_ON using SQLSetStmtAttr(). For example:

```
/* Set statement level asynchronous execution on */
rc = SQLSetStmtAttr( hstmt, /* Statement handle */
                     SQL_ATTR_ASYNC_ENABLE,
                     (SQLPOINTER) SQL_ASYNC_ENABLE_ON,
                     0);
```

   - If the return value is SQL_AM_CONNECTION, set the SQL_ATTR_ASYNC_ENABLE to SQL_ASYNC_ENABLE_ON using SQLSetConnectAttr(). For example:

```
/* Set connection level asynchronous execution on */
rc = SQLSetConnectAttr( hstmt, /* Connection handle */
                        SQL_ATTR_ASYNC_ENABLE,
                        (SQLPOINTER) SQL_ASYNC_ENABLE_ON,
                        0);
```

3. Call a function that supports asynchronous execution and poll the asynchronous function. Refer to the SQL_ATTR_ASYNC_ENABLE connection or statement attribute for a list of functions that can be executed asynchronously.

   The application determines whether the function has completed by calling it repeatedly with the same arguments it used to call the function the first time. A return code of SQL_STILL_EXECUTING indicates it is not yet finished, any other value indicates it has completed. The value other than SQL_STILL_EXECUTING is the same return code it would have returned if it had executed synchronously.

   The following example demonstrates a common while loop that takes both possible outcomes into account:

```
while ( (rc = SQLExecDirect(hstmt, sqlstmt, SQL_NTS) ) == SQL_STILL_EXECUTING)
{
    /* Other processing can be performed here, between each call to
```

```
     * see if SQLExecDirect() has finished running asynchronously.
     * This section will never run if CLI runs the function
     * synchronously.
     */
}
/* The application continues at this point when SQLExecDirect() */
/* has finished running. */
```

Chapter 15. Multithreaded CLI applications

The CLI driver supports concurrent execution of threads.

Concurrent execution means that two threads can run independently of each other (on a multi-processor computer they can run simultaneously). For example, an application can implement a database-to-database copy in the following scenario:

- One thread connects to database A and uses `SQLExecute()` and `SQLFetch()` calls to read data from one connection into a shared application buffer.
- The other thread connects to database B and concurrently reads from the shared buffer and inserts the data into database B.

If you are writing applications that use CLI calls and either embedded SQL or DB2 API calls, see the documentation for multithreaded mixed applications.

In contrast, if CLI serializes all function calls, only one thread may be executing a CLI function at a time. All other threads would have to wait until the current thread is done before it would get a chance to execute.

When to use multiple threads

The most common reason to create another thread in a CLI application is so a thread other than the one executing can be used to call `SQLCancel()` (to cancel a long running query for example).

Most GUI-based applications use threads in order to ensure that user interaction can be handled on a higher priority thread than other application tasks. The application can simply delegate one thread to run all CLI functions (with the exception of `SQLCancel()`). In this case there are no thread-related application design issues since only one thread will be accessing the data buffers that are used to interact with CLI.

Applications that use multiple connections, and are executing statements that may take some time to execute, should consider executing CLI functions on multiple threads to improve throughput. Such an application should follow standard practices for writing any multi-threaded application, most notably, those concerned with sharing data buffers.

Programming tips

Any resource allocated by CLI is guaranteed to be thread-safe. This is accomplished by using either a shared global or connection specific semaphore. At any one time, only one thread can be executing a CLI function that accepts an environment handle as input. All other functions that accept a connection handle (or a statement or descriptor allocated on that connection handle) will be serialized on the connection handle.

This means that once a thread starts executing a function with a connection handle, or child of a connection handle, any other thread will block and wait for the executing thread to return. The one exception to this is `SQLCancel()`, which must be able to cancel a statement currently executing on another thread. For this

reason, the most natural design is to map one thread per connection, plus one thread to handle SQLCancel() requests. Each thread can then execute independently of the others.

If an object is shared across threads, application timing issues may arise. For example, if a thread is using a handle in one thread, and another thread frees that handle between function calls, the next attempt to use that handle would result in a return code of SQL_INVALID_HANDLE.

Note:

1. Thread safety for handles only applies for CLI applications. ODBC applications may trap since the handle in this case is a pointer and the pointer may no longer be valid if another thread has freed it. For this reason, it is best when writing an ODBC application to follow the application model for multithreaded CLI applications.
2. There may be platform or compiler specific link options required for multi-threaded applications. Refer to your compiler documentation for further details.

Application model for multithreaded CLI applications

A multithreaded CLI application allows parallel execution of tasks under a single process.

The typical application model for multithreaded CLI application consists of following attributes:

- Designate a master thread which allocates:
  - *m* "child" threads
  - *n* connection handles
- Each task that requires a connection is executed by one of the child threads, and is given one of the *n* connections by the master thread.
- Each connection is marked as in use by the master thread until the child thread returns it to the master thread.
- Any SQLCancel() request is handled by the master thread.

This model allows the master thread to have more threads than connections if the threads are also used to perform non-SQL related tasks, or more connections than threads if the application wants to maintain a pool of active connections to various databases, but limit the number of active tasks.

Note: A multithreaded CLI stored procedure can only connect to the database where the stored procedure is currently executing.

Most importantly, this ensures that two threads are not trying to use the same connection handle at any one time. Although CLI controls access to its resources, the application resources such as bound columns and parameter buffers are not controlled by CLI, and the application must guarantee that a pointer to a buffer is not being used by two threads at any one time. Any deferred arguments must remain valid until the column or parameter has been unbound.

If it is necessary for two threads to share a data buffer, the application must implement some form of synchronization mechanism. For example, in the database-to-database copy scenario where one thread connects to database A and reads data from one connection into a shared application buffer while the other

thread connects to database B and concurrently reads from the shared buffer and inserts data into database B, the use of the shared buffer must be synchronized by the application.

Application deadlocks

The application must be aware of the possibility of creating deadlock situations with shared resources in the database and the application.

DB2 can detect deadlocks at the server and rollback one or more transactions to resolve them. An application may still deadlock if:

- two threads are connected to the same database, and
- one thread is holding an application resource 'A' and is waiting for a database resource 'B', and
- the other thread has a lock on the database resource 'B' while waiting for the application resource 'A'.

In this case the DB2 server is only going to see a lock, not a deadlock, and unless the database LockTimeout configuration keyword is set, the application will wait forever.

The application model discussed earlier avoids this problem by not sharing application resources between threads once a thread starts executing on a connection.

Mixed multithreaded CLI applications

When you use CLI, it is possible for a multithreaded application to mix CLI calls with DB2 API calls and embedded SQL. The type of the call that is executed earliest in the application determines the best way to organize the application.

CLI Calls first

The CLI driver automatically calls the DB2 context APIs to allocate and manage contexts for the application. This means that any application that calls `SQLAllocEnv()` before calling any other DB2 API or embedded SQL will be initialized with the context type set to SQL_CTX_MULTI_MANUAL.

In this case the application should allow CLI to allocate and manage all contexts. Use CLI to allocate all connection handles and to perform all connections. Call the `SQLSetConnect()` function in each thread before calling any embedded SQL. DB2 APIs can be called after any CLI function has been called in the same thread.

DB2 API or embedded SQL calls first

The CLI driver does not automatically call the DB2 context APIs if the application calls any DB2 API or embedded SQL functions before a CLI function.

This means that any thread that calls a DB2 API or embedded SQL function must be attached to a context, otherwise the call will fail with an SQLCODE of SQL1445N. This can be done by calling the DB2 API `sqleAttachToCtx()` which will explicitly attach the thread to a context, or by calling any CLI function (`SQLSetConnection()` for example). In this case, the application must explicitly manage all contexts.

Use the context APIs to allocate and attach to contexts before calling CLI functions (`SQLAllocEnv()` will use the existing context as the default context). Use the SQL_ATTR_CONN_CONTEXT connection attribute to explicitly set the context that each CLI connection should use.

Note: It is recommended that you do not use the default application stack size, but instead increase the stack size to at least 256 000. DB2 requires a minimum application stack size of 256 000 when calling a DB2 function. You must ensure therefore, that you allocate a total stack size that is large enough for both your application and the minimum requirements for a DB2 function call.

Chapter 16. Vendor escape clauses in CLI applications

Escape clauses are used extensively by ODBC to define SQL extensions. CLI translates the ODBC extensions into the correct DB2 syntax. Use the `SQLNativeSql()` function to display the resulting syntax.

The X/Open SQL CAE specification defined an **escape clause** as: "a syntactic mechanism for vendor-specific SQL extensions to be implemented in the framework of standardized SQL". Both CLI and ODBC support vendor escape clauses as defined by X/Open.

If an application is only going to access DB2 data sources, then there is no reason to use the escape clauses. If an application is going to access other data sources that offer the same support through a different syntax, then the escape clauses increase the portability of the application.

CLI used both the standard and shorthand syntax for escape clauses. The standard syntax has been deprecated (although CLI still supports it). An escape clause using the standard syntax took the form:

```
--(*vendor(vendor-identifier),
      product(product-identifier) extended SQL text*)--
```

Applications should now only use the shorthand syntax per current ODBC standard.

Shorthand escape clause syntax

The format of an escape clause definition is:

```
{ extended SQL text }
```

to define the listed SQL extensions:

- Extended date, time, timestamp data
- Outer join
- LIKE predicate
- Stored procedure call
- Extended scalar functions
  - Numeric functions
  - String functions
  - System functions

ODBC date, time, timestamp data

The ODBC escape clauses for date, time, and timestamp data are:

```
{d 'value'}
{t 'value'}
{ts 'value'}
```

- **d** indicates *value* is a date in the *yyyy-mm-dd* format,
- **t** indicates *value* is a time in the *hh:mm:ss* format
- **ts** indicates *value* is a timestamp in the *yyyy-mm-dd hh:mm:ss[.f...]* format.

For example, the `SELECT * FROM EMPLOYEE WHERE HIREDATE={d '1994-03-29'}` statement can be used to issue a query against the **EMPLOYEE** table.

CLI will translate the select statement to a DB2 format. `SQLNativeSql()` can be used to return the translated statement.

The ODBC escape clauses for date, time, and timestamp literals can be used in input parameters with a C data type of SQL_C_CHAR.

ODBC outer join

The ODBC escape clause for outer join is:

```
{oj outer-join}
```

where *outer join* is

```
table-name  {LEFT | RIGHT | FULL} OUTER JOIN
            {table-name | outer-join}
            ON search-condition
```

For example, CLI will translate the statement:

```
SELECT * FROM {oj T1 LEFT OUTER JOIN T2 ON T1.C1=T2.C3}
    WHERE T1.C2>20
```

to IBM's format, which corresponds to the SQL92 outer join syntax:

```
SELECT * FROM T1 LEFT OUTER JOIN T2 ON T1.C1=T2.C3 WHERE T1.C2>20
```

Note: Not all DB2 servers support outer join. To determine if the current server supports outer joins, call `SQLGetInfo()` with the SQL_SQL92_RELATIONAL_JOIN_OPERATORS and SQL_OJ_CAPABILITIES options.

LIKE predicate

In a SQL LIKE predicate, the metacharacter % matches zero or more of any character, and the metacharacter _ matches any one character. The SQL ESCAPE clause allows the definition of patterns intended to match values that contain the actual percent and underscore characters by preceding them with an escape character. The escape clause ODBC uses to define the LIKE predicate escape character is:

```
{escape 'escape-character'}
```

where *escape-character* is any character supported by the DB2 rules governing the use of the SQL ESCAPE clause.

As an example of how to use an "escape" ODBC escape clause, suppose you had a table Customers with the columns Name and Growth. The Growth column contains data having the metacharacter '%'. The `SELECT Name FROM Customers WHERE Growth LIKE '1_\%'{escape '\'}` statement would select all of the values from Name that have values in Growth only between 10% and 19%.

Applications that are not concerned about portability across different vendor DBMS products should pass an SQL ESCAPE clause directly to the data source. To determine when LIKE predicate escape characters are supported by a particular DB2 data source, an application can call `SQLGetInfo()` with the SQL_LIKE_ESCAPE_CLAUSE information type.

Stored procedure call

The ODBC escape clause for calling a stored procedure is:

{[?=]call *procedure-name[([parameter][,[parameter]]...)]***}**

where:

- [?=] indicates the optional parameter marker for the return value
- *procedure-name* specifies the name of a procedure stored at the data source
- *parameter* specifies a procedure parameter.

A procedure can have zero or more parameters.

ODBC specifies the optional parameter **?=** to represent the procedure's return value, which if present, will be stored in the location specified by the first parameter marker as defined through `SQLBindParameter()`. CLI will return the return code as the procedure's return value if **?=** is present in the escape clause. If **?=** is not present, and if the stored procedure return code is not SQL_SUCCESS, then the application can retrieve diagnostics, including the SQLCODE, using the `SQLGetDiagRec()` and `SQLGetDiagField()` functions. CLI supports literals as procedure arguments, however vendor escape clauses must be used. For example, the `CALL storedproc ('aaaa', 1)` statement would not succeed, but `{CALL storedproc ('aaaa', 1)}` statement would. If a parameter is an output parameter, it must be a parameter marker.

For example, CLI will translate the statement:

```
{CALL NETB94(?,?,?)}
```

To an internal CALL statement format:

```
CALL NEBT94(?, ?, ?)
```

ODBC scalar functions

Scalar functions such as string length, substring, or trim can be used on columns of a result set and on columns that restrict rows of a result set. The ODBC escape clause for scalar functions is:

{fn *scalar-function***}**

Where, *scalar-function* can be any function listed in the list of extended scalar functions.

For example, CLI will translate the statement:

```
SELECT {fn CONCAT(FIRSTNAME,LASTNAME)} FROM EMPLOYEE
```

to:

```
SELECT FIRSTNAME CONCAT LASTNAME FROM EMPLOYEE
```

`SQLNativeSql()` can be called to obtain the translated SQL statement.

To determine which scalar functions are supported by the current server referenced by a specific connection handle, call `SQLGetInfo()` with the options: SQL_NUMERIC_FUNCTIONS, SQL_STRING_FUNCTIONS, SQL_SYSTEM_FUNCTIONS, and SQL_TIMEDATE_FUNCTIONS.

Extended scalar functions for CLI applications

You use scalar functions when you want a measure of a value or if you want a value that is dependant on a numerical value, such as location in a string.

You can use escape clauses in ODBC by calling a function with the escape clause syntax or by calling the equivalent DB2 function. The following functions are defined by ODBC using vendor escape clauses. Each function can be called using the escape clause syntax, or calling the equivalent DB2 function.

These functions are presented in the following categories:

- String functions
- Numeric functions
- Date and time functions
- System functions
- Conversion function

The tables in the following sections indicates for which servers (and the earliest versions) that the function can be accessed, when called from an application using CLI.

All errors detected by the following functions, when connected to a DB2 Version 5 or later server, will return SQLSTATE 38552. The text portion of the message is of the form SYSFUN:*nn* where *nn* is one of the following reason codes:

01 Numeric value out of range

02 Division by zero

03 Arithmetic overflow or underflow

04 Invalid date format

05 Invalid time format

06 Invalid timestamp format

07 Invalid character representation of a timestamp duration

08 Invalid interval type (must be one of 1, 2, 4, 8, 16, 32, 64, 128, 256)

09 String too long

10 Length or position in string function out of range

11 Invalid character representation of a floating point number

String functions

The string functions in this section are supported by CLI and defined by ODBC using vendor escape clauses.

- Character string literals used as arguments to scalar functions must be bounded by single quotation marks.
- Arguments denoted as *string_exp* can be the name of a column, a string literal, or the result of another scalar function, where the underlying data type can be represented as SQL_CHAR, SQL_VARCHAR, SQL_LONGVARCHAR, or SQL_CLOB.

- Arguments denoted as *start*, *length*, *code* or *count* can be a numeric literal or the result of another scalar function, where the underlying data type is integer based (SQL_SMALLINT, SQL_INTEGER).
- The first character in the string is considered to be at position 1.

Table 16. String scalar functions

String scalar function	Description	Servers that support the function
ASCII(string_exp)	Returns the ASCII code value of the leftmost character of *string_exp* as an integer.	DB2 for Linux, UNIX, and Windows
CHAR(code)	Returns the character that has the ASCII code value specified by *code*. The value of *code* should be between 0 and 255; otherwise, the return value is null.	DB2 for Linux, UNIX, and Windows
CONCAT(string_exp1, string_exp2)	Returns a character string that is the result of concatenating *string_exp2* to *string_exp1*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
DIFFERENCE(string_exp1, string_exp2)	Returns an integer value indicating the difference between the values returned by the SOUNDEX function for *string_exp1* and *string_exp2*.	DB2 for Linux, UNIX, and Windows, IBM DB2 for IBM i
INSERT(string_exp1, start, length, string_exp2)	Returns a character string where *length* number of characters beginning at *start* has been replaced by *string_exp2* which contains *length* characters.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
LCASE(string_exp)	Converts all uppercase characters in *string_exp* to lowercase.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE
LEFT(string_exp,count)	Returns the leftmost *count* of characters of *string_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
LENGTH(string_exp)	Returns the number of characters in *string_exp*, excluding trailing blanks and the string termination character. **Note:** Trailing blanks are included for DB2 Server for VM and VSE.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i

Table 16. String scalar functions (continued)

String scalar function	Description	Servers that support the function
LOCATE(string_exp1, string_exp2 [,start])	Returns the starting position of the first occurrence of *string_exp1* within *string_exp2*. The search for the first occurrence of *string_exp1* begins with first character position in *string_exp2* unless the optional argument, *start*, is specified. If *start* is specified, the search begins with the character position indicated by the value of *start*. The first character position in *string_exp2* is indicated by the value 1. If *string_exp1* is not found within *string_exp2*, the value 0 is returned.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
LTRIM(string_exp)	Returns the characters of *string_exp* with the leading blanks removed.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
REPEAT(string_exp, count)	Returns a character string composed of *string_exp* repeated *count* times.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
REPLACE(string_exp1, string_exp2, string_exp3)	Replaces all occurrences of *string_exp2* in *string_exp1* with *string_exp3*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS,
RIGHT(string_exp, count)	Returns the rightmost count of characters of *string_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
RTRIM(string_exp)	Returns the characters of *string_exp* with trailing blanks removed.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
SOUNDEX(string_exp1)	Returns a four character code representing the sound of *string_exp1*. Note that different data sources use different algorithms to represent the sound of *string_exp1*.	DB2 for Linux, UNIX, and Windows, IBM DB2 for IBM i
SPACE(count)	Returns a character string consisting of *count* spaces.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
SUBSTRING(string_exp, start, length)	Returns a character string that is derived from *string_exp* beginning at the character position specified by *start* for *length* characters.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i

Table 16. String scalar functions (continued)

String scalar function	Description	Servers that support the function
UCASE(string_exp)	Converts all lowercase characters in *string_exp* to uppercase.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i

Numeric functions

The numeric functions in this section are supported by CLI and defined by ODBC using vendor escape clauses.

- Arguments denoted as *numeric_exp* can be the name of a column, the result of another scalar function, or a numeric literal, where the underlying data type can be either floating point based (SQL_NUMERIC, SQL_DECIMAL, SQL_FLOAT, SQL_REAL, SQL_DOUBLE) or integer based (SQL_SMALLINT, SQL_INTEGER).
- Arguments denoted as *double_exp* can be the name of a column, the result of another scalar functions, or a numeric literal where the underlying data type is floating point based.
- Arguments denoted as *integer_exp* can be the name of a column, the result of another scalar functions, or a numeric literal, where the underlying data type is integer based.

Table 17. Numeric scalar functions

Numeric scalar function	Description	Servers that support the function
ABS(numeric_exp)	Returns the absolute value of *numeric_exp*	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
ACOS(double_exp)	Returns the arccosine of *double_exp* as an angle, expressed in radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
ASIN(double_exp)	Returns the arcsine of *double_exp* as an angle, expressed in radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
ATAN(double_exp)	Returns the arctangent of *double_exp* as an angle, expressed in radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i

Table 17. Numeric scalar functions (continued)

Numeric scalar function	Description	Servers that support the function
ATAN2(double_exp1, double_exp2)	Returns the arctangent of *x* and *y* coordinates specified by *double_exp1* and *double_exp2*, as an angle expressed in radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
CEILING(numeric_exp)	Returns the smallest integer greater than or equal to *numeric_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
COS(double_exp)	Returns the cosine of *double_exp*, where *double_exp* is an angle expressed in radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
COT(double_exp)	Returns the cotangent of *double_exp*, where *double_exp* is an angle expressed in radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
DEGREES(numeric_exp)	Returns the number of degrees converted from *numeric_exp* radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
EXP(double_exp)	Returns the exponential value of *double_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
FLOOR(numeric_exp)	Returns the largest integer less than or equal to *numeric_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
LOG(double_exp)	Returns the natural logarithm of *double_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
LOG10(double_exp)	Returns the base 10 logarithm of *double_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
MOD(integer_exp1, integer_exp2)	Returns the remainder (modulus) of *integer_exp1* divided by *integer_exp2*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i

Table 17. Numeric scalar functions (continued)

Numeric scalar function	Description	Servers that support the function
PI()	Returns the constant value of pi as a floating point value.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
POWER(numeric_exp, integer_exp)	Returns the value of *numeric_exp* to the power of *integer_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
RADIANS(numeric_exp)	Returns the number of radians converted from *numeric_exp* degrees.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
RAND([integer_exp])	Returns a random floating point value using *integer_exp* as the optional seed value.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
ROUND(numeric_exp, integer_exp.)	Returns *numeric_exp* rounded to *integer_exp* places right of the decimal point. If *integer_exp* is negative, *numeric_exp* is rounded to | *integer_exp* | places to the left of the decimal point.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
SIGN(numeric_exp)	Returns an indicator or the sign of *numeric_exp*. If *numeric_exp* is less than zero, -1 is returned. If *numeric_exp* equals zero, 0 is returned. If *numeric_exp* is greater than zero, 1 is returned.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
SIN(double_exp)	Returns the sine of *double_exp*, where *double_exp* is an angle expressed in radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
SQRT(double_exp)	Returns the square root of *double_exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
TAN(double_exp)	Returns the tangent of *double_exp*, where *double_exp* is an angle expressed in radians.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
TRUNCATE(numeric_exp, integer_exp)	Returns *numeric_exp* truncated to *integer_exp* places right of the decimal point. If *integer_exp* is negative, *numeric_exp* is truncated to | *integer_exp* | places to the left of the decimal point.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i

Date and time functions

The date and time functions in this section are supported by CLI and defined by ODBC using vendor escape clauses.

- Arguments denoted as *timestamp_exp* can be the name of a column, the result of another scalar function, or a time, date, or timestamp literal.
- Arguments denoted as *date_exp* can be the name of a column, the result of another scalar function, or a date or timestamp literal, where the underlying data type can be character based, or date or timestamp based.
- Arguments denoted as *time_exp* can be the name of a column, the result of another scalar function, or a time or timestamp literal, where the underlying data types can be character based, or time or timestamp based.

Table 18. Date and time scalar functions

Date and time scalar function	Description	Servers that support the function
CURDATE()	Returns the current date as a date value.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
CURTIME()	Returns the current local time as a time value.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
DAYNAME(date_exp)	Returns a character string containing the name of the day (Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday) for the day portion of *date_exp*.	DB2 for Linux, UNIX, and Windows
DAYOFMONTH (date_exp)	Returns the day of the month in *date_exp* as an integer value in the range of 1-31.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
DAYOFWEEK(date_exp)	Returns the day of the week in *date_exp* as an integer value in the range 1-7, where 1 represents Sunday.	DB2 for Linux, UNIX, and Windows, IBM DB2 for IBM i
DAYOFWEEK_ISO(date_exp)	Returns the day of the week in *date_exp* as an integer value in the range 1-7, where 1 represents Monday. Note the difference between this function and the DAYOFWEEK() function, where 1 represents Sunday.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, IBM DB2 for IBM i
DAYOFYEAR(date_exp)	Returns the day of the year in *date_exp* as an integer value in the range 1-366.	DB2 for Linux, UNIX, and Windows, IBM DB2 for IBM i

Table 18. Date and time scalar functions (continued)

Date and time scalar function	Description	Servers that support the function
HOUR(time_exp)	Returns the hour in *time_exp* as an integer value in the range of 0-23.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
JULIAN_DAY(date_exp)	Returns the number of days between *date_exp* and January 1, 4712 B.C. (the start of the Julian date calendar).	DB2 for Linux, UNIX, and Windows, IBM DB2 for IBM i
MINUTE(time_exp)	Returns the minute in *time_exp* as integer value in the range of 0-59.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
MONTH(date_exp)	Returns the month in *date_exp* as an integer value in the range of 1-12.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
MONTHNAME(date_exp)	Returns a character string containing the name of month (January, February, March, April, May, June, July, August, September, October, November, December) for the month portion of *date_exp*.	DB2 for Linux, UNIX, and Windows
NOW()	Returns the current date and time as a timestamp value.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
QUARTER(date_exp)	Returns the quarter in *date_exp* as an integer value in the range of 1-4.	DB2 for Linux, UNIX, and Windows, IBM DB2 for IBM i
SECOND(time_exp)	Returns the second in *time_exp* as an integer value in the range of 0-59.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
SECONDS_SINCE_MIDNIGHT(time_exp)	Returns the number of seconds in *time_exp* relative to midnight as an integer value in the range of 0-86400. If *time_exp* includes a fractional seconds component, the fractional seconds component will be discarded.	DB2 for Linux, UNIX, and Windows

Table 18. Date and time scalar functions (continued)

Date and time scalar function	Description	Servers that support the function
TIMESTAMPADD(interval, integer_exp, timestamp_exp)	Returns the timestamp calculated by adding *integer_exp* intervals of type *interval* to *timestamp_exp*. Valid values of interval are: • SQL_TSI_FRAC_SECOND • SQL_TSI_SECOND • SQL_TSI_MINUTE • SQL_TSI_HOUR • SQL_TSI_DAY • SQL_TSI_WEEK • SQL_TSI_MONTH • SQL_TSI_QUARTER • SQL_TSI_YEAR where fractional seconds are expressed in 1/1000000000 second. If *timestamp_exp* specifies a time value and *interval* specifies days, weeks, months, quarters, or years, the date portion of *timestamp_exp* is set to the current date before calculating the resulting timestamp. If *timestamp_exp* is a date value and *interval* specifies fractional seconds, seconds, minutes, or hours, the time portion of *timestamp_exp* is set to 00:00:00.000000 before calculating the resulting timestamp. An application determines which intervals are supported by calling ***SQLGetInfo()*** with the SQL_TIMEDATE_ADD_INTERVALS option.	DB2 for Linux, UNIX, and Windows
TIMESTAMPDIFF(interval, timestamp_exp1, timestamp_exp2)	Returns the integer number of intervals of type *interval* by which *timestamp_exp2* is greater than *timestamp_exp1*. Valid values of interval are: • SQL_TSI_FRAC_SECOND • SQL_TSI_SECOND • SQL_TSI_MINUTE • SQL_TSI_HOUR • SQL_TSI_DAY • SQL_TSI_WEEK • SQL_TSI_MONTH • SQL_TSI_QUARTER • SQL_TSI_YEAR where fractional seconds are expressed in 1/1000000000 second. If either timestamp expression is a time value and *interval* specifies days, weeks, months, quarters, or years, the date portion of that timestamp is set to the current date before calculating the difference between the timestamps. If either timestamp expression is a date value and *interval* specifies fractional seconds, seconds, minutes, or hours, the time portion of that timestamp is set to 0 before calculating the difference between the timestamps. An application determines which intervals are supported by calling ***SQLGetInfo()*** with the SQL_TIMEDATE_DIFF_INTERVALS option.	DB2 for Linux, UNIX, and Windows
WEEK(date_exp)	Returns the week of the year in *date_exp* as an integer value in the range of 1-54.	DB2 for Linux, UNIX, and Windows, IBM DB2 for IBM i

Table 18. Date and time scalar functions (continued)

Date and time scalar function	Description	Servers that support the function
WEEK_ISO(date_exp)	Returns the week of the year in *date_exp* as an integer value in the range of 1-53. Week 1 is defined as the first week of the year to contain a Thursday. Therefore, Week1 is equivalent to the first week that contains Jan 4, since Monday is considered to be the first day of the week. Note that WEEK_ISO() differs from the current definition of WEEK(), which returns a value up to 54. For the WEEK() function, Week 1 is the week containing the first Saturday. This is equivalent to the week containing Jan. 1, even if the week contains only one day.	DB2 for Linux, UNIX, and Windows
YEAR(date_exp)	Returns the year in *date_exp* as an integer value in the range of 1-9999.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i

For those functions that return a character string containing the name of the day of week or the name of the month, these character strings will be National Language Support enabled.

DAYOFWEEK_ISO() and WEEK_ISO() are automatically available in a database created in DB2 Version 7 or later. If a database was created before Version 7, these functions might not be available. To make DAYOFWEEK_ISO() and WEEK_ISO() functions available in such a database, use the **db2updb** system command.

System functions

The system functions in this section are supported by CLI and defined by ODBC using vendor escape clauses.

- Arguments denoted as *exp* can be the name of a column, the result of another scalar function, or a literal.
- Arguments denoted as *value* can be a literal constant.

Table 19. System scalar functions

System scalar function	Description	Servers that support the function
DATABASE()	Returns the name of the database corresponding to the connection handle (*hdbc*). (The name of the database is also available via ***SQLGetInfo()*** by specifying the information type SQL_DATABASE_NAME.)	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i

Table 19. System scalar functions (continued)

System scalar function	Description	Servers that support the function
IFNULL(exp, value)	If *exp* is null, *value* is returned. If *exp* is not null, *exp* is returned. The possible data type(s) of *value* must be compatible with the data type of *exp*.	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i
USER()	Returns the user's authorization name. (The user's authorization name is also available via ***SQLGetInfo()*** by specifying the information type SQL_USER_NAME.)	DB2 for Linux, UNIX, and Windows, DB2 for z/OS, DB2 Server for VM and VSE, IBM DB2 for IBM i

Conversion function

The conversion function is supported by CLI and defined by ODBC using vendor escape clauses.

Each driver and data source determines which conversions are valid between the possible data types. As the driver translates the ODBC syntax into native syntax it will reject the conversions that are not supported by the data source, even if the ODBC syntax is valid.

Use the function ***SQLGetInfo()*** with the appropriate convert function masks to determine which conversions are supported by the data source.

Table 20. Conversion Function

Conversion scalar function	Description	Servers that support the function
CONVERT(expr_value, data_type)	• *data_type* indicates the data type of the converted representation of *expr_value*, and can be either SQL_CHAR or SQL_DOUBLE. • *expr_value* is the value to convert. It can be of various types, depending on the conversions supported by the driver and data source. Use the function ***SQLGetInfo()*** with the appropriate convert function masks to determine which conversions are supported by the data source.	DB2 for Linux, UNIX, and Windows

Chapter 17. Non-Java client support for high availability on IBM data servers

Client applications that connect to DB2 for Linux, UNIX, and Windows, DB2 for z/OS, or IBM Informix can easily take advantage of the high availability features of those data servers.

Client applications can use the following high availability features:

- Automatic client reroute

  Automatic client reroute capability is available on all IBM data servers. Automatic client reroute uses information that is provided by the data servers to redirect client applications from a server that experiences an outage to an alternate server. Automatic client reroute enables applications to continue their work with minimal interruption. Redirection of work to an alternate server is called *failover*.

  For connections to DB2 for z/OS data servers, automatic client reroute is part of the workload balancing feature. In general, for DB2 for z/OS, automatic client reroute should not be enabled without workload balancing.
- Client affinities

  Client affinities is a failover solution that is controlled completely by the client. It is intended for situations in which you need to connect to a particular primary server. If an outage occurs during the connection to the primary server, you use client affinities to enforce a specific order for failover to alternate servers.

  Client affinities is not applicable to a DB2 for z/OS data sharing environment, because all members of a data sharing group can access data concurrently. Data sharing is the recommended solution for high availability for DB2 for z/OS.
- Workload balancing

  Workload balancing is available on all IBM data servers. Workload balancing ensures that work is distributed efficiently among servers in an IBM Informix high-availability cluster, DB2 for z/OS data sharing group, or DB2 for Linux, UNIX, and Windows DB2 pureScale® instance.

The following table provides links to server-side information about these features.

Table 21. Server-side information about high availability

Data server	Related topics
DB2 for Linux, UNIX, and Windows	• DB2 pureScale: DB2 pureScale Feature roadmap documentation • Automatic client reroute: Automatic client reroute roadmap
IBM Informix	Manage Cluster Connections with the Connection Manager
DB2 for z/OS	Communicating with data sharing groups

Attention: All the high availability features that can be implemented by the client application require a direct connection to the database server. You must ensure that successful connection can be established to all potential server or members in a high availability environment. If you are using a firewall, you must ensure that ports can be opened to communicate directly to all members in a high availability environment.

Non-Java client support for high availability for connections to DB2 for Linux, UNIX, and Windows

DB2 for Linux, UNIX, and Windows servers provide high availability for client applications, through workload balancing and automatic client reroute. This support is available for applications that use non-Java clients (ODBC, CLI, .NET, OLE DB, PHP, Ruby, or embedded SQL), as well as Java™ clients (JDBC, SQLJ, or pureQuery).

For non-Java clients, you must use one of the listed clients or client packages to take advantage of high availability support:

- IBM Data Server Client
- IBM Data Server Runtime Client
- IBM Data Server Driver Package
- IBM Data Server Driver for ODBC and CLI

High availability support for connections to DB2 for Linux, UNIX, and Windows servers includes:

Automatic client reroute

This support enables a client to recover from a failure by attempting to reconnect to the database through an alternate server. Reconnection to another server is called *failover*. Client support for automatic client reroute is enabled by default for non-Java clients that connect to DB2 for Linux, UNIX, and Windows.

Servers can provide automatic client reroute capability in any of the following ways:

- Several servers are configured in a DB2 pureScale instance. A connection to a database is a connection to a member of that DB2 pureScale instance. Failover involves reconnection to another member of the DB2 pureScale instance. This environment requires that clients use TCP/IP to connect to the DB2 pureScale instance.
- A DB2 pureScale instance and an alternate server that is defined for a database. Failover first involves reconnection to another member of the DB2 pureScale instance. Failover to the server is attempted only if no member of the DB2 pureScale instance is available.
- A DB2 pureScale instance is defined for the primary server, and another DB2 pureScale instance is defined for the server. Failover first involves reconnection to another member of the primary DB2 pureScale instance. Failover to the alternate DB2 pureScale instance is attempted only if no member of the primary DB2 pureScale instance is available.
- A database is defined on a single server. The configuration for that database includes specification of an alternate server. Failover involves reconnection to the alternate server.

Alternate groups are an additional failover mechanism for automatic client rerouting when connectivity to the current group cannot be re-established. A *group* is a database that is created in a DB2 instance. In DB2 pureScale or partitioned database environments, all the participant database servers for a database are also considered a group. The database to which your application explicitly connects to is called the *primary group*.

For CLI or .NET client applications, failover for automatic client reroute can be *seamless* or *non-seamless*. With non-seamless failover, when the client application

reconnects to another server an error is always returned to the application to indicate that failover (connection to the alternate server) occurred. With seamless failover, the client does not return an error if a connection failure and successful reconnection to an alternate server or alternate group occurs during the execution of the first SQL statement in a transaction.

In a DB2 pureScale instance, you can use automatic client reroute support without workload balancing or with workload balancing.

Workload balancing
Workload balancing can improve the availability of a DB2 pureScale instance.

With workload balancing, a DB2 pureScale instance ensures that work is distributed efficiently among members.

Non-Java clients on any operating system support workload balancing. The connection from the client to the DB2 pureScale instance must use TCP/IP.

When workload balancing is enabled, the client gets frequent status information about the members of the DB2 pureScale instance through a server list. The client caches the server list and uses the information in it to determine the member to which the next transaction should be routed.

For non-Java clients, the server list is cached in the application process. It is shared for workload balancing only by connections in that process.

DB2 for Linux, UNIX, and Windows supports two types of workload balancing:

Connection-level workload balancing
Connection-level workload balancing is performed at connection boundaries. It is supported only by non-Java clients. Client support for connection-level workload balancing is enabled by default for non-Java clients that connect to DB2 for Linux, UNIX, and Windows.

Connection-level load balancing is most effective for connections whose duration is short.

Transaction-level workload balancing
Transaction-level workload balancing is performed at transaction boundaries. Client support for transaction-level workload balancing is disabled by default for clients that connect to DB2 for Linux, UNIX, and Windows.

Transaction-level load balancing is most effective for connections whose duration is long.

Client affinities
Client affinities is an automatic client reroute solution that is controlled completely by the client. It is intended for situations in which you must connect to a particular primary server. If an outage occurs during the connection to the primary server, you use client affinities to enforce a specific order for failover to alternate servers.

Configuration of DB2 for Linux, UNIX, and Windows automatic client reroute support for applications other than Java

For connections to DB2 for Linux, UNIX, and Windows databases, the process for configuration of automatic client reroute support for applications other than Java is the same for DB2 pureScale environment and other environments.

Automatic client reroute capability is enabled by default. You must connect to a DB2 pureScale instance in a DB2 pureScale environment or to the primary server in other environments.

At the first successful connection to the server, the client obtains a list from the server of all the available alternate servers, which the client stores in memory. If the first connection fails, the client checks for a list of alternate servers that is defined in the `db2dsdriver.cfg` file, in the <acr> section under the <alternateserverlist> tag. If the `db2dsdriver.cfg` file has no alternate servers that are defined in the <acr> section, upon the first successful connection to the server, the client creates a local cache file, `srvrlst.xml`. The client updates the file with the server's list of available alternate servers. This file is refreshed whenever a new connection is made and the server's list differs from the contents of the client `srvrlst.xml` file.

When a client uses the `srvrlst.xml` file to locate an alternate server, it writes a record in the `db2diag.log` file. You can monitor this log to determine how frequently initial server connections fail.

Table 1 describes the basic settings to establish a connection for applications other than Java.

Table 22. Basic settings to establish a connection to a DB2 for Linux, UNIX, and Windows database for applications other than Java

Client setting	Value for a DB2 pureScale environment	Value for other environments
Database host (host)[1]	The IP address of a member of a DB2 pureScale instance[2]	The IP address of the primary server
Database port (port)[1]	The SQL port number of a member of a DB2 pureScale instance[2]	The SQL port number of the primary server
Database name (name)[1]	The database name	The database name

Table 22. Basic settings to establish a connection to a DB2 for Linux, UNIX, and Windows database for applications other than Java (continued)

Client setting	Value for a DB2 pureScale environment	Value for other environments

Note:

1. Depending on the client that you use, connection information is defined in one of several possible sources:
   - If you are connecting with a CLI application, or an open source application that uses the IBM Data Server Client or IBM Data Server Runtime Client, you can define connection information as follows:
     – If you provide host, port, and database information in the connection string in an application, the CLI driver and the open source driver uses that information.
     – If host, port, and database information is not provided in the connection string in an application but the information is in the `db2cli.ini` file, the driver uses the information in that file.
     – If host, port, and database information is not provided in the connection string in the application or the `db2cli.ini` file, the driver uses information in the IBM data server driver configuration file (`db2dsdriver.cfg`).
   - If you are using a .NET application with the IBM Data Server Client or the IBM Data Server Runtime Client, you can define connection information in the database catalog, connection string, `db2dsdriver.cfg` file, or .NET object properties.
   - If you are using an embedded SQL application with the IBM Data Server Client or the IBM Data Server Runtime Client, connection information can be defined in the database catalog, connection string, or `db2dsdriver` configuration file.
2. Alternatively, you can use a distributor, such as WebSphere® Application Server Network Deployment or multihomed DNS, to establish the initial connection to the database:
   - For a distributor, you specify the IP address and port number of the distributor. The distributor analyzes the current workload distribution and uses the information to forward the connection request to one of the members of the DB2 pureScale instance.
   - For multihomed DNS, you specify an IP address and port number that can resolve to the IP address and port number of any member of the DB2 pureScale instance. Multihomed DNS processing selects a member based on criteria, such as simple round-robin selection or member workload distribution.

You can set configuration keywords or registry variables in the IBM data server driver configuration file (`db2dsdriver.cfg`) to modify the automatic client reroute behavior. The configuration keywords that you can use to control automatic client reroute are in Table 2. The keywords are described for the case in which client affinities are not enabled.

Table 23. Settings to control automatic client reroute behavior

Element in the <acr> section of the db2dsdriver configuration file	Value
acrRetryInterval keyword	Specifies the number of seconds to wait between consecutive connection retries. The value of the **DB2_CONNRETRIES_INTERVAL** registry variable overrides this value. The range of the **acrRetryInterval** keyword is `0` - the maximum integer value (`MAX_INT`). If you do not set the **DB2_CONNRETRIES_INTERVAL** registry variable, the default value of the **acrRetryInterval** keyword is no wait (`0`).

Table 23. Settings to control automatic client reroute behavior (continued)

Element in the <acr> section of the db2dsdriver configuration file	Value
alternateserverlist keyword	Specifies a set of server names and port numbers that identify alternate servers to which a connection is attempted if a failure occurs on the first connection to the database. The alternate server list is not used after the first connection. In a DB2 pureScale environment, the entries in the list can be members of a DB2 pureScale instance. In other environments, the list contains an entry for the primary server and an entry for the high availability disaster recovery (HADR) standby server.
detectReadonlyTxn keyword	Specifies whether a connection to a new member can seamlessly fail over with the automatic client reroute feature enabled, even if the failed statement is not the first SQL statement in a transaction. The **detectReadonlyTxn** keyword is valid when you are connecting to DB2 for Linux, UNIX, and Windows Version 10.5 Fix Pack 4 and later fix packs. The default value of the **detectReadonlyTxn** keyword is `true` for connection to supported DB2 for Linux, UNIX, and Windows servers. The `true` value forces the connected server to return the current values of special registers whenever they are modified. **Restriction:** You cannot set the **detectReadonlyTxn** keyword to `true` in a transaction with the repeatable read (RR) or read stability (RS) isolation level.
enableAcr keyword	Specifies whether automatic client reroute is in effect. The default is `true`.
enableAlternateGroupSeamlessACR keyword	Specifies seamless or non-seamless failover behavior across groups. The default is `false`. You must define this keyword in the <alternategroup> element in the <acr> section. To set this keyword to `true`, you must also set the **enableSeamlessACR** keyword to `true`. Setting the **enableAlternateGroupSeamlessACR** keyword to `true` does not affect the setting of the **enableSeamlessACR** keyword. If a successful connection is established to a server in the *alternategroup* section, the rules for seamless or non-seamless behavior still apply.

Table 23. Settings to control automatic client reroute behavior (continued)

Element in the <acr> section of the db2dsdriver configuration file	Value
enableAlternateServerListFirstConnect keyword	Specifies whether there is an alternate server list that is used only if a failure occurs on the first connection to the data server. The default is `false`. When the value of the `enableAlternateServerListFirstConnect` keyword is `true`, automatic client reroute with seamless failover is implicitly enabled, regardless of the other settings that you specify for automatic client reroute in the `db2dsdriver.cfg` file. To use this feature, you also require a <alternateserverlist> element in the `db2dsdriver.cfg` file.
enableSeamlessAcr keyword	Specifies whether seamless failover can occur. If the **enableAcr** keyword is set to `true`, the default for the **enableSeamlessAcr** keyword is `true`. The **enableSeamlessACR** keyword applies only to the members within a group or cluster.
maxAcrRetries keyword	Specifies the maximum number of connection attempts for automatic client reroute. The valid range is `0` - the maximum integer value (`MAX_INT`). The value of the **DB2_MAX_CLIENT_CONNRETRIES** registry variable overrides the value of the **maxAcrRetries** keyword. If you do not set the **DB2_MAX_CLIENT_CONNRETRIES** registry variable or **maxAcrRetries** keyword, by default, the connection is tried again for 10 minutes. However, if you defined alternate groups, by default, a connection is attempted for 2 minutes. Setting the **maxAcrRetries** keyword value to **0** disables automatic client reroute.

In case of changes to the `db2dsdriver.cfg` file, your CLI application can issue the SQLReloadConfig function to validate the entries for all alternate servers within the <acr> section.

The registry variables in Table 3 control the retry behavior of automatic client reroute.

Table 24. Registry variables to control automatic client reroute retry behavior

Registry variable	Value
DB2_CONNRETRIES_INTERVAL	The number of seconds between consecutive connection retries. The default is `10` if you set the **DB2_MAX_CLIENT_CONNRETRIES** registry variable.
DB2_MAX_CLIENT_CONNRETRIES	The maximum number of connection retries for automatic client reroute. The default is `30` if you set the **DB2_CONNRETRIES_INTERVAL** registry variable.

If you do not set either registry variable and also do not set the **maxAcrRetries** and **acrRetryInterval** keywords, automatic client reroute processing tries the connection to a database again for up to 10 minutes, with no wait between retries.

For embedded SQL, CLI, OLE DB, and ADO.NET applications, you can set a connection timeout value by setting the **ConnectionTimeout** keyword. That value specifies the number of seconds that the client application waits for a connection to a database to be established. You must set the connection timeout value to a value that is equal to or greater than the maximum time that it takes to connect to the server. Otherwise, the connection might time out and be rerouted to the alternate server by client reroute. For example, if on a normal day it takes approximately 10 seconds to connect to the server and on a busy day it takes approximately 20 seconds, you should set the connection timeout value to at least 20 seconds.

Example of enabling DB2 for Linux, UNIX, and Windows automatic client reroute support in non-Java clients

You can fine-tune non-Java client setup for DB2 for Linux, UNIX, and Windows automatic client reroute (acr) support by setting values for several keywords in the `db2dsdriver.cfg` configuration file.

Note that if you do not define a list of alternate servers in the `db2dsdriver.cfg` configuration file, at the first successful connection to the server, the client obtains from the server a list of all available alternate servers. The client stores the list in memory and also creates a local cache file, `srvrlst.xml` that contains the server's list of alternate servers. This file is refreshed whenever a new connection is made and the server's list differs from the contents of the client `srvrlst.xml` file.

Suppose that database sample is a DB2 pureScale instance with two members, at server db2luwa and port 446, and server db2luwb and port 446. The database has alternate server db2luwc and port 446 defined.

You want to fine-tune default automatic client reroute support by modifying these items:

Automatic client reroute characteristic	db2dsdriver.cfg configuration keyword	Desired value
Number of times to retry the connection to the alternate server	maxAcrRetries	10
Number of seconds to wait between retries	acrRetryInterval	5
Whether to try another server if the initial connection to the database fails	enableAlternateServerListFirstConnect	true

Automatic client reroute characteristic	db2dsdriver.cfg configuration keyword	Desired value
The host names and port numbers of the servers to try if the initial connection to the database fails	<alternateserverlist> Note that if you do not define a list of alternate servers in the db2dsdriver.cfg configuration file, at the first successful connection to the server, the client obtains from the server a list of all available alternate servers. The client stores the list in memory and also creates a local cache file, srvrlst.xml that contains the server's list of alternate servers. This file is refreshed whenever a new connection is made and the server's list differs from the contents of the client srvrlst.xml file. The srvrlst.xml file is located under CLIENT_CONFIG_DIR in the cfgcache directory.	Host names and port numbers: • db2luwa.luw.ibm.com, 446 • db2luwb.luw.ibm.com, 446 • db2luwc.luw.ibm.com, 446

Use the following db2dsdriver.cfg configuration file to implement these changes to automatic reroute behavior:

```
<configuration>
  <dsncollection>
    <dsn alias="sample" name="sample" host="db2luw.luw.ibm.com" port="446">
    </dsn>
  </dsncollection>
  <databases>
    <database name="sample" host="db2luw.luw.ibm.com" port="446">
      <acr>
        <parameter name="enableAcr" value="true">
        </parameter>
        <parameter name=
        <parameter name="maxAcrRetries" value="10">
        </parameter>
        <parameter name="acrRetryInterval" value="5">
        </parameter>
        <parameter name="enableAlternateServerListFirstConnect"
          value="true"></parameter>
        <alternateserverlist>
           <server name="server1" hostname="db2luwa.luw.ibm.com" port="446">
           </server>
           <server name="server2" hostname="db2luwb.luw.ibm.com" port="446">
           </server>
           <server name="server3" hostname="db2luwc.luw.ibm.com" port="446">
           </server>
        </alternateserverlist>
      </acr>
    </database>
  </databases>
</configuration>
```

Configuration of DB2 for Linux, UNIX, and Windows workload balancing support for non-Java clients

For connections to DB2 for Linux, UNIX, and Windows data servers in a DB2 pureScale instance, connection-level workload balancing is enabled at a non-Java client by default. Transaction-level workload balancing capability must be enabled explicitly.

The following table describes the basic settings to enable connection-level workload balancing support for non-Java applications.

Table 25. Basic settings to enable DB2 for Linux, UNIX, and Windows connection-level workload balancing support in non-Java applications

Client setting	Value
Connection address:	
database host[1]	The IP address of a member of a DB2 pureScale instance.[2]
database port[1]	The SQL port number of a member of a DB2 pureScale instance[2]
database name[1]	The database name

Note:

1. Depending on the client that you use, connection information is defined in one of several possible sources:
   - If you are using one of the data server drivers or a CLI or open source application that uses IBM Data Server Client or IBM Data Server Runtime Client:
     - If host, port, and database information is provided in a connection string in an application, DB2 uses that information.
     - If host, port, and database information is not provided in the connection string in an application, the driver uses a `db2cli.ini` file, and this information is provided in the `db2cli.ini` file, DB2 uses that information.
     - If host, port, and database information is not provided in the connection string in the application or the `db2cli.ini` file, the DB2 driver uses the information in the `db2dsdriver.cfg` configuration file.
   - If you are using a .NET application or an application that uses embedded SQL with the IBM Data Server Client or the IBM Data Server Runtime Client, connection information comes a source that is not the `db2dsdriver.cfg` configuration file. Possible sources include the database catalog, connection string, `db2cli.ini` file, or .NET object properties.
2. Alternatively, you can use a distributor, such as Websphere Application Server Network Deployment, or multihomed DNS to establish the initial connection to the database.
   - For a distributor, you specify the IP address and port number of the distributor. The distributor analyzes the current workload distribution, and uses that information to forward the connection request to one of the members of the DB2 pureScale instance.
   - For multihomed DNS, you specify an IP address and port number that can resolve to the IP address and port number of any member of the DB2 pureScale instance. Multihomed DNS processing selects a member based on some criterion, such as simple round-robin selection or member workload distribution.

The following configuration keyword in the `db2dsdriver.cfg` file can be used to change the connection-level workload balancing setting.

Table 26. Setting to control connection-level workload balancing behavior

Element in the db2dsdriver.cfg configuration file	Section	Value
connectionLevelLoadBalancing parameter	<database>	Specifies whether connection-level load balancing is in effect. It is true by default.

You can use the following configuration keywords in the `db2dsdriver.cfg` file to enable and fine-tune transaction-level workload balancing.

Table 27. Settings to control transaction-level workload balancing behavior

Element in the db2dsdriver.cfg configuration file	Section	Value
connectionLevelLoadBalancing parameter	<database>	Must be set to true if you want to use transaction-level workload balancing. The setting is `true` by default unless the server accessed is a DB2 for z/OS server; in that case, the default is `false`.
enableWLB parameter	<wlb>	Specifies whether transaction-level workload balancing is in effect. It is false by default.
maxTransportIdleTime	<wlb>	Specifies the maximum elapsed time in number of seconds before an idle transport is dropped. The default is `60` . The minimum value is `0`.
maxTransportWaitTime	<wlb>	Specifies the number of seconds that the client waits for a transport to become available. The default is `1`. Specifying a value as -1 means unlimited wait time. The minimum supported value is `0`.
maxTransports	<wlb>	Specifies the maximum number of physical connections can be made for each application process that connects to the DB2 pureScale instance.The default is -1 which means establish as many as needed.
maxRefreshInterval	<wlb>	Specifies the maximum elapsed time in number of seconds before the server list is refreshed. The default is `10`. The minimum supported value is `0`.

Example of enabling DB2 for Linux, UNIX, and Windows workload balancing support in non-Java clients

DB2 for Linux, UNIX, and Windows workload balancing requires a DB2 pureScale environment. Before you can use DB2 for Linux, UNIX, and Windows workload balancing support in CLI, .NET, or embedded SQL applications, you need to update the `db2dsdriver.cfg` configuration file with the appropriate settings, and connect to a member of the DB2 pureScale environment.

The following example demonstrates setting up a CLI client to take advantage of DB2 for Linux, UNIX, and Windows workload balancing support.

Before you can set up the client, you need to configure a DB2 pureScale instance.

These steps demonstrate client setup:

1. Create a `db2dsdriver.cfg` file that enables transaction-level workload balancing. In this example:
   - If the first connection to the database fails, the connection needs to be tried on alternate servers.

     Note that if you do not define a list of alternate servers in the `db2dsdriver.cfg` configuration file, at the first successful connection to the server, the client obtains from the server a list of all available alternate servers. The client stores the list in memory and also creates a local cache file, `srvrlst.xml` that contains the server's list of alternate servers. This file is

refreshed whenever a new connection is made and the server's list differs from the contents of the client `srvrlst.xml` file.

- For transaction-level workload balancing for this database, the maximum number of physical connections needs to be 80.
- Connections can use the defaults for all other transaction-level workload balancing parameters.

The `db2dsdriver.cfg` file looks like this:

```
<configuration>
  <dsncollection>
    <dsn alias="LUWDS1" name="LUWDS1" host="luw1ds.toronto.ibm.com"
      port="50000">
    </dsn>
  </dsncollection>
  <databases>
    <!-- In this example, the host and port represent a member of a
         DB2 pureScale instance -->
    <database name="LUWDS1" host="luw.ds1.ibm.com" port="50000">
       <!-- database-specific parameters -->
       <wlb>
          <!-- Enable transaction-level workload balancing -->
          <parameter name="enableWLB" value="true" />
          <!-- maxTransports represents the maximum number of physical
               connections -->
          <parameter name="maxTransports" value="80" />
       </wlb>
       <acr>
         <!-- acr is already enabled by default -->
         <!-- Enable server list for application first connect -->
         <parameter name="enableAlternateServerListFirstConnect"
           value="true" />
         <alternateserverlist>
           <!-- Alternate server 1 -->
           <parameter name="server" value="luw2ds.toronto.ibm.com" />
           <parameter name="port" value="50001" />
           <!-- Alternate server 2 -->
           <parameter name="server" value="luw3ds.toronto.ibm.com" />
           <parameter name="port" value="50002" />
           <!-- Alternate server 3 -->
           <parameter name="server" value="luw4ds.toronto.ibm.com" />
           <parameter name="port" value="50003" />
         </alternateserverlist>
       </acr>
    </database>
  </databases>
</configuration>
```

2. Suppose that the database name LUWDS1 represents a DB2 pureScale instance. In a CLI application, use code like this to connect to the DB2 pureScale instance:

```
...
   SQLHDBC         hDbc    = SQL_NULL_HDBC;
   SQLRETURN       rc      = SQL_SUCCESS;
   SQLINTEGER      RETCODE = 0;
   char            *ConnStrIn =
                   "DSN=LUWDS1;PWD=mypass";
                /* dsn matches the database name in the configuration file */
   char            ConnStrOut [200];
   SQLSMALLINT     cbConnStrOut;
   int             i;
   char            *token;
...
  /*************************************************************/
  /* Invoke SQLDriverConnect                                   */
  /*************************************************************/
```

```
   RETCODE = SQLDriverConnect (hDbc                ,
                               NULL                ,
                               (SQLCHAR *)ConnStrIn ,
                               strlen(ConnStrIn)    ,
                               (SQLCHAR *)ConnStrOut,
                               sizeof(ConnStrOut)   ,
                               &cbConnStrOut        ,
                               SQL_DRIVER_NOPROMPT);
...
```

Operation of automatic client reroute for connections to the DB2 for Linux, UNIX, and Windows server from an application other than a Java application

Automatic client reroute (ACR) provides failover support when an IBM data server client loses connectivity to the primary server for a DB2 for Linux, UNIX, and Windows database. Automatic client reroute enables the client to recover from the failure by attempting to reconnect to the database through an alternate server.

If automatic client reroute is enabled for a connection to a database, the following process typically occurs when a client attempts to execute an SQL statement by using an existing connection and that connection fails.

1. The client uses the server list that was returned after the last successful connection to identify which server to access and attempts to reconnect to the database.

   In an environment other than a DB2 pureScale environment, the server list contains two entries: one for the primary server and one for the alternate server.

   In a DB2 pureScale environment, the server list contains an entry for each member of the DB2 pureScale instance. In addition, if you defined an alternate server for the database, the server list contains an entry for that alternate server. An entry for a member of the DB2 pureScale instance includes capacity information. If connection-level workload balancing is enabled at the client, the client uses that information to connect to the server with the highest unused capacity. The entry for an alternate server has no capacity information. A connection to the alternate server is attempted only if connections to all the DB2 pureScale members fail.
2. If the automatic client reroute process can reconnect the application to the database, the client reconstructs the execution environment for the new connection. The client receives an updated copy of the server list with updated server information. Error SQL30108N is returned to the application to indicate that the failed database connection was recovered and that the transaction was rolled back. The application is then responsible for further recovery, including repeating any work that was rolled back. If the SQL statement that fails is the first SQL statement in the transaction, automatic client reroute with seamless failover is enabled, and the client is CLI or .NET, the driver replays the failed SQL operation as part of automatic client reroute processing. If the connection is successful, no error is reported to the application, and the transaction is not rolled back. The connectivity failure and subsequent recovery are hidden from the application.

   If automatic client reroute is unable to reconnect the application to the database, error SQL30081N is returned to the application. The application is then responsible for recovering from the connection failure (for example, by attempting to connect to the database by itself).

Automatic client reroute is also used when a new connection attempt fails. In this case, however, if reconnection is successful, no error is returned to the application to indicate that the failed database connection was recovered. If reconnection fails, error SQL30081N is returned.

A seamless failover connection can be established under the following conditions:

- If the connection failure occurs for the first SQL statement in a transaction and a complete result set is returned to the client, the CLI driver can fail over seamlessly when you issue a COMMIT or ROLLBACK statement after the server becomes unreachable. For seamless failover to take place, the following conditions must also be met:
  - You must enable both the **enableAcr** and **enableSeamlessAcr** keywords.
  - No error is reported to the application.
  - The cursor must have blocking enabled.
  - The cursor must be either read-only or forward-only.
- If the connection failure occurs in a transaction that was read-only before the point of connection failure, seamless failover can take place if all the following conditions are met:
  - Application is connecting to a server with DB2 for Linux, UNIX, and Windows Version 10.5 Fix Pack 4 or later fix packs installed.
  - You enable both the **enableAcr** and **enableSeamlessAcr** keywords.
  - The **detectReadonlyTxn** keyword is set to `true`.
  - No error is reported to the application.
  - The completed statements in the transaction up to the point of connection failure are read-only, and complete result sets from the transaction up to the point of connection failure are available to the client. The failed SQL statement does not have to be read-only, but statements that are issued before the failure must be read-only.
  - The transaction does not use the repeatable read (RR) or read stability (RS) isolation level.

If the application turned off the automatic closing of cursors at the server side by setting the **SQL_ATTR_EARLYCLOSE** attribute to `OFF`, the CLI driver can perform seamless failover only if the application processed the entire result set.

You can configure the **FetchBufferSize** keyword to ensure that the size of the result set that the CLI driver prefetches is sufficient to include the EOF character in the first query block. See the Related reference section for further details on **FetchBufferSize**.

Non-seamless ACR environments have one of the following combinations of settings:

- The **enableAcr** keyword is set to `TRUE`, but the **enableSeamlessAcr** keyword is set to `FALSE`.
- The **enableACR** keyword and the **enableSeamlessAcr** keyword are set to `TRUE` but the seamless ACR environment cannot be enabled for the following reasons:
  - Session resources are created in the transaction.
  - The failed SQL statement was not the first SQL statement of the transaction.

In the non-seamless ACR environment, the receive timeout event triggers the ACR connection error (SQL30108N). The receive timeout event occurs when the **ReceiveTimeout** keyword value is reached

If you set the **QueryTimeout** keyword in the non-seamless ACR environment, the following behaviors occur:

- If the connection failure occurs before the query timeout event, the ACR connection error (SQL30108N, with reason code 1 and failure code 1, 2, or 3) is returned to the application.
- If the **Interrupt** keyword is set to the default value of 1 and the query timeout event occurs, the SQL0952N error is returned to the application.
- If the **Interrupt** keyword is set to the value of 2 and the query timeout event occurs, the ACR connection error (SQL30108N, with failure code 4 and error code 1) is returned to the application.

If the **Interrupt** keyword is set to the value of 2 and the SQLCancel() API is explicitly called from the application while an SQL statement is being executed, the ACR connection error (SQL30108N, with failure code 4 and error code 2) is returned to the application.

If you set the **tcpipConnectTimeout** and **memberConnectTimeout** keywords and the TCPIP connection timeout or the member connection timeout event occurs in the non-seamless ACR environment, the CLI driver reconnects to a new available member. However, the ACR error (SQL30108N) is not returned to the application.

Operation of transaction-level workload balancing for connections to DB2 for Linux, UNIX, and Windows

Transaction-level workload balancing for connections to DB2 for Linux, UNIX, and Windows contributes to high availability by balancing work among servers in a DB2 pureScale instance at the start of a transaction.

The following overview describes the steps that occur when a client connects to a DB2 for Linux, UNIX, and Windows DB2 pureScale instance, and transaction-level workload balancing is enabled:

1. When the client first establishes a connection to the DB2 pureScale instance, the member to which the client connects returns a server list with the connection details (IP address, port, and weight) for the members of the DB2 pureScale instance.

   The server list is cached by the client. The default lifespan of the cached server list is 30 seconds.
2. At the start of a new transaction, the client reads the cached server list to identify a server that has unused capacity, and looks in the transport pool for an idle transport that is tied to the under-utilized server. (An idle transport is a transport that has no associated connection object.)
   - If an idle transport is available, the client associates the connection object with the transport.
   - If, after a user-configurable timeout period (db2.jcc.maxTransportObjectWaitTime for a Java client or maxTransportWaitTime for a non-Java client), no idle transport is available in the transport pool and no new transport can be allocated because the transport pool has reached its limit, an error is returned to the application.
3. When the transaction runs, it accesses the server that is tied to the transport.
4. When the transaction ends, the client verifies with the server that transport reuse is still allowed for the connection object.

5. If transport reuse is allowed, the server returns a list of SET statements for special registers that apply to the execution environment for the connection object.

   The client caches these statements, which it replays in order to reconstruct the execution environment when the connection object is associated with a new transport.
6. The connection object is then dissociated from the transport, if the client determines that it needs to do so.
7. The client copy of the server list is refreshed when a new connection is made, or every 30 seconds, or the user-configured interval.
8. When transaction-level workload balancing is required for a new transaction, the client uses the previously described process to associate the connection object with a transport.

Alternate groups for connections to DB2 for Linux, UNIX, and Windows from non-Java clients

To improve high availability for non-Java clients in Version 9.7 Fix Pack 5 or later fix pack releases, use alternate groups as an additional failover mechanism for automatic client rerouting when connectivity to the current group cannot be re-established.

By default, non-Java clients have the automatic client reroute (ACR) enabled. This capability provides automatic failover to alternate servers within the current group when connectivity to a server cannot be re-established.

In addition to this ACR capability, you can define *alternate groups* as failover targets when connectivity to the current group cannot be established. To define alternate groups for non-Java clients:

- Define a <database> element for each alternate group inside the <alternategroup> element in the <acr> section of the `db2dsdriver.cfg` file. Do not specify <parameter> elements inside the <database> element, parameter settings are inherited from the primary group. You can define multiple <database> elements inside the <alternategroup> element. The order of the <database> elements is the order that is used during failover.
- If you want to suppress error messages from failover connections to the alternate group, set the enableAlternateGroupSeamlessACR parameter to `true` in <alternategroup> element.

The default ACR retry time period is 10 minutes. When you define alternate groups, that time period is reduced to 2 minutes.

When a non-Java client is connected to an alternate group, all the connection settings and the parameter settings for the <database> element in the primary group are inherited by the connection to the database in the alternate group.

After a non-Java client is connected to a database in the alternate group, no failback to the primary group is provided. To connect to the primary group again, the application or client must be restarted.

Alternate groups are only supported for ACR and workload balancing. If client affinities is configured, alternate group definitions are ignored.

Examples

Here is an example of alternate group definitions in the db2dsdriver.cfg file:

```
<dsncollection>
  <dsn alias="mydsn2" name="mydb2" host="myserver2.ibm.com" port="5912">
  ...
</dsncollection>

<databases>
  <database name="mydb2" host="myserver2.ibm.com" port="5912">
   <parameter name="IsolationLevel" value="4"/>
   ...
   <wlb>
     <parameter name="enableWLB" value="true"/>
   </wlb>
   <acr>
    ... (ACR parameters definition)
    <alternateserverlist>
      <server name="server1" hostname="db2luwa.luw.ibm.com" port="5912">
      </server>
      <server name="server2" hostname="db2luwb.luw.ibm.com" port="5912">
      </server>
    </alternateserverlist>
    <alternategroup>
     <parameter name="enableAlternateGroupSeamlessACR" value="true"/>
     <database name="mydb3" host="myserver3.ibm.com" port="5912">
     </database>
     <database name="mydb4" host="myserver4.ibm.com" port="5912">
     </database>
     </alternategroup>   </acr>
  </database>

  <database name="mydb3" host="myserver3.ibm.com" port="5912">
   <parameter name="IsolationLevel" value="2"/>
   <acr>
    <parameter name="enableACR" value="true"/>
   <alternateserverlist>
     <server name="server4" hostname="db2luwd.luw.ibm.com" port="5912">
     </server>
   </alternateserverlist>
   <alternategroup>
    <parameter name="enableAlternateGroupSeamlessACR" value="true"/>
    <database name="mydb5" host="myserver5.ibm.com" port="5912">
    </database>
    </alternategroup>    </acr>
  ...
  </database>
</databases>
```

The following example scenarios demonstrate how automatic client rerouting works for alternate groups. The details about ACR failover to the current group are not covered in these scenarios to focus on the alternate groups failover details. These scenarios use the db2dsdriver.cfg sample file that is described in the previous paragraph.

First connection to the primary group fails

After a non-Java client fails to connect to the primary group on its first attempt, automatic client reroute failover to alternate servers in the current group also fails. In this example, the client performs the following actions:

1. The client fails to connect to *mydb2*.
2. The client fails to connect to *server1*.
3. The client fails to connect to *server2*.

4. The client tries to connect to an alternate group listed in the <alternategroup> section of the `db2dsdriver.cfg` file in the order specified in this file:
   a. The client fails to connect to *mydb3*.
   b. The client successfully connects to *mydb4*.

   After connecting to *mydb4*, the rules for seamless or non-seamless behavior still apply. If the client would not be able to connect to *mydb4*, it would receive the SQL30081N error message.

Subsequent connection or existing connection to the primary server fails

After a non-Java client loses its connection to *mydb2*, automatic client reroute failover to alternate servers in the current group also fails. In this example, the client performs the following actions:

1. The client fails to connect to *server1*.
2. The client fails to connect to *server2*.
3. The client tries to connect to an alternate group listed in the <alternategroup> section of the `db2dsdriver.cfg` file in the order specified in this file:
   a. The client successfully connects to *mydb3*.

   After connecting to *mydb3*, the rules for seamless or non-seamless behavior still apply.

Existing connection to an alternate group fails

A non-Java client fails to connect to *mydb2*, automatic client reroute failover to alternate servers in the current group also fails, and then it successfully connects to the *mydb3* alternate group.

After the client loses its connection to *mydb3*, it attempts to connect to *mydb4*. In this example, the client fails to connect to *mydb4*.

The client receives the SQL30081N error message. You must restart the client or the application to try connecting to the primary group again.

Application programming requirements for high availability connections to DB2 for Linux, UNIX, and Windows servers

A connection failover with the automatic client reroute feature can be seamless or non-seamless.

If the connection failover is non-seamless, all the work that occurred within the current transaction is rolled back. To handle a non-seamless failover, you must include an error-handling routine in your application. The error-handling routine must include the following steps:

- Check the reason code that is returned with the SQL30108N error to determine whether special register settings on the failing data sharing member are carried over to the new (failover) data sharing member.
- Reset any special register values that are not current.
- Rerun all uncommitted SQL operations that occurred during the failed transaction.

The following conditions must be satisfied for the failover connections to the DB2 for Linux, UNIX, and Windows server to be seamless:

- You must use the CLI driver or IBM Data Server Provider for .NET to connect to the database server.

- You must enable both the **enableAcr** and **enableSeamlessAcr** keywords.
- If the connection has uncommitted statement or statements in a transaction and meets one of the following conditions:
  - If the connection failure occurs for the first SQL statement in a transaction and a complete result set is returned to the client, the CLI driver can fail over seamlessly when you issue a COMMIT or ROLLBACK statement after the server becomes unreachable.
  - If the connection failure occurs in a transaction that was read-only before the point of connection failure, a seamless connection is possible if all the following conditions are met:
    - Application is connecting to a server with DB2 for Linux, UNIX, and Windows Version 10.5 Fix Pack 4 or later fix packs installed.
    - The **detectReadonlyTxn** keyword is set to `true`.
    - No error is reported to the application.
    - The completed statements in the transaction up to the point of connection failure are read-only, and complete result sets from the transaction up to the point of connection failure are available to the client. The failed SQL statement does not have to be read-only, but statements that are issued before the failure must be read-only.
    - The transaction does not use the repeatable read (RR) or read stability (RS) isolation level.
- If transaction-level load balancing is enabled, the data server allows transport reuse at the end of the previous transaction.
- All global temporary tables are closed or dropped.
- There are no open or held cursors.
- If the CLI driver is used, the application cannot perform any actions that require the driver to maintain a history of previously called APIs in order to replay the SQL statement. Examples of action that requires the driver to maintain a history include specifying data at execution time, running compound SQL statements, or use of array input.
- The application is not a stored procedure.

Avoid enabling autocommit. Although seamless connection failover can occur when autocommit is enabled, this situation might cause previously committed SQL statements to be reissued.

Client affinities for clients that connect to DB2 for Linux, UNIX, and Windows

Client affinities is a client-only method for providing automatic client reroute capability.

Client affinities is available for applications that use CLI, .NET, Java (IBM Data Server Driver for JDBC and SQLJ type 4 connectivity) or embedded SQL. All rerouting is controlled by the driver.

Client affinities is intended for situations in which you need to connect to a particular primary server. If an outage occurs during the connection to the primary server, you need to enforce a specific order for failover to alternate servers. You should use client affinities for automatic client reroute only if automatic client reroute that uses server failover capabilities does not work in your environment.

As part of configuration of client affinities, you specify a list of alternate servers, and the order in which connections to the alternate servers are tried. When client affinities is in use, connections are established based on the list of alternate servers instead of the host name and port number that are specified by the application. For example, if an application specifies that a connection is made to server1, but the configuration process specifies that servers should be tried in the order (server2, server3, server1), the initial connection is made to server2 instead of server1.

When you use client affinities, you can specify that if the primary server returns to operation after an outage, connections return from an alternate server to the primary server on a transaction boundary. This activity is known as *failback*.

Configuring client affinities in non-Java clients for connection to DB2 for Linux, UNIX, and Windows

To enable support for client affinities in CLI and .NET applications, you set values in the `db2dsdriver.cfg` configuration file to indicate that you want to use client affinities, and to specify the primary and alternate servers.

The following table describes the settings in the `db2dsdriver.cfg` file for enabling client affinities for CLI and .NET applications.

Table 28. Settings to enable client affinities for CLI and .NET applications

Element in the acr section of the db2dsdriver configuration file	Values
enableAcr parameter	true
maxAcrRetries parameter	The maximum number of connection attempts to each server in the list of alternate servers for automatic client reroute (ACR). The valid range is 0 - (the value of the MAX_INT).
acrRetryInterval parameter	The number of seconds to wait between retries.
affinityFailbackInterval parameter	The number of seconds to wait after the first transaction boundary to fail back to the primary server. Set this value if you want to fail back to the primary server. The default is 0, which means that no attempt is made to fail back to the primary server.
alternateserverlist	<server> elements that identify the host name and port number for each server that is used for automatic client reroute through client affinities. One of the elements must identify the primary server. The presence of these elements does not activate automatic client reroute.
affinitylist	<list> elements with serverorder attributes. The serverorder attribute value specifies a list of servers, in the order that they should be tried during automatic client reroute with client affinities. The servers in <list> elements must also be defined in <server> elements in the <alternateserverlist>. You can specify multiple <list> elements, each of which has different server orders. The presence of the <affinitylist> element does not activate automatic client reroute.

Table 28. Settings to enable client affinities for CLI and .NET applications (continued)

Element in the acr section of the db2dsdriver configuration file	Values
client_affinity	A <clientaffinitydefined> element or a <clientaffinityroundrobin> element that defines the order in which to try server connections for each client. When you include a <clientaffinitydefined> element, you define the server order by defining <client> elements, each of which specifies a <list> element that defines the server order. When you include a <clientaffinityroundrobin> element, you also specify <client> elements, but those <client> elements do not specify a <list> element. Instead, the order of the <client> elements, defines the server order. All clients that connect to a database must be specified within a <clientaffinitydefined> or a <clientaffinityroundrobin> element. In case of multiple network interface cards on a given client machine, client host name will be self discovered and matched with the configuration file entry, by CLI driver, to compute the affinity list. CLI driver will get all network interfaces and will try to match it with the host names available in the db2dsdriver configuration file. When a hostname without domain name is specified in `db2dsdriver.cfg`, CLI will try to resolve it using the default domain and will try to match with the discovered hostname. If the IP address is defined under client affinity section of the cfg file, the respective IP address will be discovered and matched (for hostname) with configuration file entry, by CLI driver, to compute the affinity list.
clientaffinitydefined	<client> elements that define the server order for automatic client reroute for each client. Each <client> element contains a listname attribute that associates a client with a <list> element from the <affinitylist> element.
clientaffinityroundrobin	<client> elements whose order in the <clientaffinityroundrobin> element defines the first server that is chosen for automatic client reroute. Each <client> element has an index. The first <client> element in the <clientaffinityroundrobin> element has index 0, the second <client> element has index 1, and so on. Suppose that the number of servers in the <alternateserverlist> element is *n* and the index in the <clientaffinityroundrobin> element of a <client> element is *i*. The first server to be tried is the server whose index in the <alternateserverlist> element is *i* mod *n*. The next server to be tried is the server whose index in the <alternateserverlist> element is (*i* +1) mod *n*), and so on.

The following restrictions apply to configuration of client affinities for CLI or .NET clients:

- If the total number of qualifying alternate servers for a given client is greater than 128, error SQL1042N occurs.
- Workload balancing cannot be enabled when client affinity is enabled. That is, if enableWLB is set to true, and the client_affinity element is specified, error SQL5162N occurs.
- If the required attributes are not specified in the <alternateserverlist>, <affinitylist> or <client_affinity> elements, error SQL5163N occurs.
- If client affinity is enabled, and the <alternateserverlist> element is empty, error SQL5164N occurs.
- If client affinity is enabled, and the host name for a client that is attempting to connect to a server is not in one of the <client_affinity> subgroups (<clientaffinitydefined> or <clientaffinityroundrobin>), or is in more than one of the subgroups, error SQL5164N occurs.
- For each client machine, there should be only one entry, either in <clientaffinitydefined> or <clientaffinityroundrobin> section. If there are entries in db2dsdriver.cfg where the same client machine has been specified by different host names, the error SQL5162N occurs.

Example of enabling client affinities for non-Java clients for DB2 for Linux, UNIX, and Windows connections

Before you can use client affinities for automatic client reroute in CLI or .NET applications, you need to include elements in the <acr> section of the `db2dsdriver.cfg` configuration file to indicate that you want to use client affinities, and to identify the primary and alternate servers.

The following example shows how to enable client affinities for failover without failback.

Suppose that your `db2dsdriver` configuration file looks like this:

```
<database name="SAMPLE" host="v33ec065.svl.ibm.com" port="446">
  <acr>
    <parameter name="enableAcr" value="true"/>
    <parameter name="maxAcrRetries" value="1"/>
    <parameter name="acrRetryInterval" value="2"/>
    <alternateserverlist>
      <server name="server1"
              hostname="v33ec067.svl.ibm.com"
              port="446">
      </server>
      <server name="server2"
              hostname="v33ec066.svl.ibm.com"
              port="446">
      </server>
      <server name="server3"
              hostname="v33ec065.svl.ibm.com"
              port="446">
      </server>
    </alternateserverlist>
    <affinitylist>
      <list name="list1" serverorder="server1,server2,server3">
      </list>
      <list name="list2" serverorder="server3,server2,server1">
      </list>
    </affinitylist>
    <clientaffinitydefined>
```

```
    <!- this section has specific defined affinities -->
      <client name="client1"
              hostname="appsrv1.svl.ibm.com"
              listname="list2">
      </client>
      <client name="client2"
              hostname="appsrv2.svl.ibm.com"
              listname="list1">
      </client>
    </clientaffinitydefined>
    <clientaffinityroundrobin>
      <client name="client3" hostname="appsrv3.svl.ibm.com">
          <!- This entry is index 0. The number of servers is 3.
              0 mod 3 is 0, so the first that is tried
              during automatic client reroute is the server whose
              index in <alternateserverlist> is 0 (server1).
              The next server has index 1 mod 3, which is 1
              (server2). The final server has index 2 mod 3,
              which is 2 (server3). -->
      </client>
      <client name="client4" hostname="appsrv4.svl.ibm.com">
          <!- This entry is index 1. The number of servers is 3.
              1 mod 3 is 1, so the first that is tried
              during automatic client reroute is the server whose
              index in <alternateserverlist> is 1 (server2).
              The next server has index 2 mod 3, which is 2
              (server3). The final server has index 3 mod 3,
              which is 0 (server1). -->
      </client>
    </clientaffinityroundrobin>
  </acr>
</database>
```

Suppose that a communication failure occurs during a connection from the client with host name appsrv4.svl.ibm.com (client4) to the server that is identified by v33ec065.svl.ibm.com:446. The following steps demonstrate the process that occurs for automatic client reroute with client affinities.

1. The driver tries to connect to v33ec066.svl.ibm.com:446 (server2).
2. The connection to v33ec066.svl.ibm.com:446 fails.
3. The driver waits two seconds.
4. The driver tries to connect to v33ec065.svl.ibm.com:446 (server3).
5. The connection to v33ec065.svl.ibm.com:446 fails.
6. The driver waits two seconds.
7. The driver tries to connect to v33ec067.svl.ibm.com (server1).
8. The connection to v33ec067.svl.ibm.com fails.
9. The driver waits two seconds.
10. The driver returns error code SQL30081N.

The following example shows how to enable client affinities for failover with failback.

Suppose that your db2dsdriver configuration file looks like this:

```
<database name="SAMPLE" host="v33ec065.svl.ibm.com" port="446">
  <acr>
    <parameter name="enableAcr" value="true"/>
    <parameter name="maxAcrRetries" value="1"/>
    <parameter name="acrRetryInterval" value="2"/>
    <parameter name="affinityFailbackInterval" value="300"/>
    <alternateserverlist>
      <server name="server1"
```

```
            hostname="v33ec067.svl.ibm.com"
            port="446">
      </server>
      <server name="server2"
            hostname="v33ec066.svl.ibm.com"
            port="446">
      </server>
      <server name="server3"
            hostname="v33ec065.svl.ibm.com"
            port="446">
      </server>
    </alternateserverlist>
    <affinitylist>
      <list name="list1" serverorder="server1,server2,server3">
      </list>
      <list name="list2" serverorder="server3,server2,server1">
      </list>
    </affinitylist>
    <clientaffinitydefined>
    <!- this section has specific defined affinities -->
      <client name="client1"
            hostname="appsrv1.svl.ibm.com"
            listname="list2">
      </client>
      <client name="client2"
            hostname="appsrv2.svl.ibm.com"
            listname="list1">
      </client>
    </clientaffinitydefined>
    <clientaffinityroundrobin>
      <client name="client3" hostname="appsrv3.svl.ibm.com">
          <!- This entry is index 0. The number of servers is 3.
              0 mod 3 is 0, so the first that is tried
              during automatic client reroute is the server whose
              index in <alternateserverlist> is 0 (server1).
              The next server has index 1 mod 3, which is 1
              (server2). The final server has index 2 mod 3,
              which is 2 (server3). -->
      </client>
      <client name="client4" hostname="appsrv4.svl.ibm.com">
          <!- This entry is index 1. The number of servers is 3.
              1 mod 3 is 1, so the first that is tried
              during automatic client reroute is the server whose
              index in <alternateserverlist> is 1 (server2).
              The next server has index 2 mod 3, which is 2
              (server3). The final server has index 3 mod 3,
              which is 0 (server1). -->
      </client>
    </clientaffinityroundrobin>
  </acr>
</database>
```

Suppose that the database administrator takes the server that is identified by v33ec065.svl.ibm.com:446 down for maintenance after a connection is made from client appsrv2.svl.ibm.com (client2) to v33ec065.svl.ibm.com:446. The following steps demonstrate failover to an alternate server and failback to the primary server after maintenance is complete.

1. The driver successfully connects to v33ec065.svl.ibm.com:446 on behalf of client appsrv1.svl.ibm.com.
2. The database administrator brings down v33ec065.svl.ibm.com:446.
3. The application tries to do work on the connection.
4. The driver successfully fails over to v33ec066.svl.ibm.com:446.
5. After 200 seconds, the work is committed.

6. The driver tests whether the failback interval (300 seconds) has elapsed. It has not elaspsed, so no failback occurs.
7. The application does more work on the connection to v33ec066.svl.ibm.com:446.
8. After 105 seconds, the work is committed.
9. The driver tests whether the failback interval (300 seconds) has elapsed. It has elapsed, so failback to v33ec065.svl.ibm.com:446 occurs.

Non-Java client support for high availability for connections to Informix servers

High-availability cluster support on IBM Informix servers provides high availability for client applications, through workload balancing and automatic client reroute. This support is available for applications that use Java clients (JDBC, SQLJ, or pureQuery), or non-Java clients (ODBC, CLI, .NET, OLE DB, PHP, Ruby, or embedded SQL).

For Java clients, you need to use IBM Data Server Driver for JDBC and SQLJ type 4 connectivity to take advantage of IBM Informix high-availability cluster support.

For non-Java clients, you need to use one of the following clients or client packages to take advantage of high-availability cluster support:

- IBM Data Server Client
- IBM Data Server Runtime Client
- IBM Data Server Driver Package
- IBM Data Server Driver for ODBC and CLI

Cluster support for high availability for connections to IBM Informix servers includes:

Automatic client reroute
This support enables a client to recover from a failure by attempting to reconnect to the database through any available server in a high-availability cluster. Reconnection to another server is called *failover*. You enable automatic client reroute on the client by enabling workload balancing on the client.

In an IBM Informix environment, primary and standby servers correspond to members of a high-availability cluster that is controlled by a Connection Manager. If multiple Connection Managers exist, the client can use them to determine primary and alternate server information. The client uses alternate Connection Managers only for the initial connection.

Failover for automatic client reroute can be *seamless* or *non-seamless*. With non-seamless failover, when the client application reconnects to an alternate server, the server always returns an error to the application, to indicate that failover (connection to the alternate server) occurred.

For Java, CLI, or .NET client applications, failover for automatic client reroute can be seamless or non-seamless. Seamless failover means that when the application successfully reconnects to an alternate server, the server does not return an error to the application.

Workload balancing
Workload balancing can improve availability of an IBM Informix high-availability cluster. When workload balancing is enabled, the client gets frequent status information about the members of a high-availability cluster. The client uses this information to determine the server to which the next

transaction should be routed. With workload balancing, IBM Informix Connection Managers ensure that work is distributed efficiently among servers and that work is transferred to another server if a server has a failure.

Connection concentrator
This support is available for Java applications that connect to IBM Informix. The connection concentrator reduces the resources that are required on IBM Informix database servers to support large numbers of workstation and web users. With the connection concentrator, only a few concurrent, active physical connections are needed to support many applications that concurrently access the database server. When you enable workload balancing on a Java client, you automatically enable the connection concentrator.

Client affinities
Client affinities is an automatic client reroute solution that is controlled completely by the client. It is intended for situations in which you need to connect to a particular primary server. If an outage occurs during the connection to the primary server, you use client affinities to enforce a specific order for failover to alternate servers.

Configuration of Informix high-availability support for non-Java clients

To configure a non-Java client application that connects to an Informix high-availability cluster, you must connect to an address that represents a Connection Manager. You must also set the properties that enable workload balancing and the maximum number of connections.

Before you can enable the IBM Data Server Driver for JDBC and SQLJ to connect to Informix database server for high availability, your installation must have one or more Connection Managers, a primary server, and one or more alternate servers.

The following table describes the basic settings, for non-Java applications.

Table 29. Basic settings to enable Informix high availability support in non-Java applications

Connection address	Value
database host[1]	The IP address of a Connection Manager. See "Setting server and port properties for connecting to a Connection Manager" on page 229.
database port[1]	The SQL port number of a Connection Manager. See "Setting server and port properties for connecting to a Connection Manager" on page 229.
database name[1]	The database name

Table 29. Basic settings to enable Informix high availability support in non-Java applications (continued)

Connection address	Value

Notes:

1. Depending on the DB2 product and driver you use, connection information can be defined in one of several possible sources.
   - In scenario that involves CLI or open source application with IBM data server client, connection information can be obtained from following sources:
     - If host, port, and database information is provided in a connection string of an application, CLI driver uses that information to establish a connection.
     - Information from the database catalog.
     - If host and port information is not provided in the connection string of an application or database catalog, the driver searches for required information in the `db2cli.ini` file, and this information provided in the `db2cli.ini` file is used by CLI driver to establish a connection.
     - If host and port information is not provided in the connection string of an application, database catalog or the `db2cli.ini` file, CLI driver uses information in the `db2dsdriver.cfg` configuration file.
   - In scenario that involves CLI or open source application with IBM data server driver, connection information can be obtained from following sources:
     - If host, port, and database information is provided in a connection string of an application, CLI driver uses that information to establish a connection.
     - If host and port information is not provided in the connection string of an application, the driver searches for required information in the `db2cli.ini` file, and this information provided in the `db2cli.ini` file is used by CLI driver to establish a connection.
     - If host and port information is not provided in the connection string of the application or the `db2cli.ini` file, CLI driver uses information in the `db2dsdriver.cfg` configuration file.
   - In scenario that involves .NET application with IBM data server client, connection information can be obtained from following sources:
     - If host, port, and database information is provided in a connection string of an application, .NET data provider uses that information to establish a connection.
     - If host, port and database information provided through .NET object properties, .NET data provider uses that information to establish a connection.
     - Information from the database catalog.
     - If host and port information is not provided in the connection string of an application or the database catalog, .NET data provider uses information in the `db2dsdriver.cfg` configuration file.
   - In scenario that involves .NET application with IBM data server driver, connection information can be obtained from following sources:
     - If host, port, and database information is provided in a connection string of an application, .NET data provider uses that information to establish a connection.
     - If host, port and database information provided through .NET object properties, .NET data provider uses that information to establish a connection.
     - If host and port information is not provided in the connection string of an application or the database catalog, .NET data provider uses information in the `db2dsdriver.cfg` configuration file.

To fine-tune the workload balancing function of Informix high-availability support, additional properties are available. The additional properties for non-Java applications are listed in the following table.

Table 30. Properties for fine-tuning workload balancing support for connections from non-Java applications to Informix database server

Element in the db2dsdriver configuration file	Section in the db2dsdriver file	Description
enableWLB	<wlb>	Specifies whether workload balancing is enabled. Set this element to `true` to enable workload balancing.
maxTransportIdleTime	<wlb>	Specifies the maximum elapsed time before an idle transport is dropped. The default is `60`. The minimum supported value is `0`.
maxTransportWaitTime	<wlb>	Specifies the number of seconds that the client waits for a transport to become available. The default is `1`. Specifying a value as -1 means unlimited wait time. The minimum supported value is `0`.
maxTransports	<wlb>	Specifies the maximum number of connections that the requester can make to the high availability cluster. The default is `-1` (unlimited). The minimum supported value is `1`.
maxRefreshInterval	<wlb>	Specifies the maximum elapsed time in seconds before the server list is refreshed. The default is `10`. The minimum supported value is `0`.

If you must use workload balancing but your applications cannot handle the errors that are returned for automatic client reroute processing, set the following parameters in the `db2dsdriver.cfg` configuration file.

Table 31. Properties for enabling only Sysplex workload balancing for connections from non-Java applications to Informix database server

Element in the db2dsdriver configuration file	Section in the db2dsdriver file	Description	Value to set
enableWLB	<wlb>	Specifies whether workload balancing is enabled.	`true`. If the value of the **enableAcr** parameter is `true`, the connection manager retries the server connection. This parameter is supported by the DB2 for z/OS Version 9.0 and later server. The DB2 Version 9.7 Fix Pack 3 and later is required to use **enableAcr** parameter with connections to DB2 for z/OS Version 10.0 and later server. If the **enableAcr** and **enableWLB** parameter values are `false`, the server connection fails.
enableAcr	<acr>	Specifies whether automatic client reroute is enabled. For CLI or .NET applications, enabling automatic client reroute automatically enables seamless failover.	`false`.

Table 31. Properties for enabling only Sysplex workload balancing for connections from non-Java applications to Informix database server (continued)

Element in the db2dsdriver configuration file	Section in the db2dsdriver file	Description	Value to set
enableSeamlessAcr	<acr>	Specifies whether seamless failover is enabled. Seamless failover is supported for CLI, .NET, and embedded SQL applications. The default is `true`.	If the value of the **enableAcr** parameter is `false`, **enableSeamlessAcr** value is `false`, so you do not have to set it.

Setting server and port properties for connecting to a Connection Manager

To set the server and port number in the `db2dsdriver.cfg` configuration file for connecting to a Connection Manager, follow this process:

- If your high-availability cluster is using a single Connection Manager, set the server name and port number to the server name and port number of the Connection Manager.
- If your high-availability cluster is using more than one Connection Manager, follow this process:
  1. Specify the server name and port number of the main Connection Manager that you want to use.
  2. In the <acr> subsection in the database entry in the `db2dsdriver.cfg` configuration file, set the value of the **enableAlternateServerListFirstConnect** parameter to `true`.
  3. In the<alternateserverlist> parameter entries for the <acr> section of the `db2dsdriver.cfg` configuration file, set the server names and port numbers of alternative Connection Managers.

Example of enabling Informix high availability support in non-Java clients

Before you can use Informix high availability support in CLI, .NET, or embedded SQL applications that connect directly to Informix database server, you need to update the `db2dsdriver` configuration file with the appropriate settings, and connect to a Connection Manager.

The following example demonstrates setting up a CLI client to take advantage of Informix high availability support with one Connection Manager.

Before you can set up the client, you need to configure one or more high availability clusters that are controlled by Connection Managers.

Follow these steps to set up the client:

1. Create a `db2dsdriver.cfg` file with the basic settings for Informix high availability support. When you set enableWLB to true, you enable workload balancing and automatic client reroute capability.

```
<configuration>
  <dsncollection>
    <dsn alias="IDSCM1" name="IDSCM1" host="ids.cm1.ibm.com" port="446">
    </dsn>
  </dsncollection>
  <databases>
```

```
    <database name="IDSCM1" host="ids.cm1.ibm.com" port="446">
       <!-- database-specific parameters -->
       <wlb>
          <!-- Enable workload balancing to get
          automatic client reroute
          functionality -->
          <parameter name="enableWLB" value="true" />
          <!-- maxTransports represents the maximum number of transports -->
          <parameter name="maxTransports" value="80" />
       </wlb>
    </database>
  </databases>
  <parameters>
    <parameter name="connectionLevelLoadBalancing" value="true"/>
  </parameters>
</configuration>
```

2. Suppose that the DSN definition for IDSCM1 provides connectivity information for a Connection Manager for database IDSCM1. In a CLI application, use code like this to connect to the Connection Manager:

```
...
   SQLHDBC         hDbc    = SQL_NULL_HDBC;
   SQLRETURN       rc      = SQL_SUCCESS;
   SQLINTEGER      RETCODE = 0;
   char            *ConnStrIn =
                   "DSN=IDSCM1;PWD=mypass";
                /* dsn matches the database name in the configuration file */
   char            ConnStrOut [200];
   SQLSMALLINT     cbConnStrOut;
   int             i;
   char            *token;
...
  /*************************************************************/
  /* Invoke SQLDriverConnect                                   */
  /*************************************************************/
   RETCODE = SQLDriverConnect (hDbc                ,
                               NULL                ,
                               (SQLCHAR *)ConnStrIn ,
                               strlen(ConnStrIn)    ,
                               (SQLCHAR *)ConnStrOut,
                               sizeof(ConnStrOut)   ,
                               &cbConnStrOut        ,
                               SQL_DRIVER_NOPROMPT);
...
```

Operation of the automatic client reroute feature when connecting to the Informix database server server from an application other than a Java application

Automatic client reroute support provides failover support when an IBM data server client loses connectivity to a server in an Informix high availability cluster. Automatic client reroute enables the client to recover from a failure by attempting to reconnect to the database through any available server in the cluster.

Automatic client reroute is enabled by default when workload balancing is enabled.

If automatic client reroute is enabled, the following process typically occurs when a client encounters a connection failure with an existing connection:

1. The client attempts to execute an SQL statement using an existing connection and encounters a failure.

2. The client uses the server list that is returned by the Connection Manager to identify the server to access, and attempts to reconnect to the database.
3. If the automatic client reroute process can reconnect the application to the database, the client reconstructs the execution environment for the newly established connection. The error SQL30108N is returned to the application to indicate that the failed database connection has been recovered and that the transaction has been rolled back. The application is then responsible for further recovery, including repeating any work that was rolled back.

   If the SQL statement that fails is the first SQL statement in the transaction, automatic client reroute with seamless failover is enabled, and the client is CLI or .NET, the driver replays the failed SQL operation as part of automatic client reroute processing. If the connection is successful, no error is reported to the application, and the transaction is not rolled back. The connectivity failure and subsequent recovery are hidden from the application.
4. If automatic client reroute is unable to reconnect to the database, the error SQL30081N is returned to the application. The application is then responsible for recovering from the connection failure (for example, by attempting to connect to the database by itself).

Automatic client reroute is also used when a client encounters a connection failure with a new connection. In this case, however, if reconnection is successful, no error is returned to the application to indicate that the failed database connection has been recovered. If reconnection fails, the error SQL30081N is returned.

If all the data, including the end of file (EOF) character, is returned in the first query block or in a subsequent fetch request, the CLI driver can perform seamless failover when you issue a `COMMIT` or `ROLLBACK` statement after the server becomes unreachable. For seamless failover to take place, the following conditions must be met:

- You must enable both the **enableAcr** and **enableSeamlessAcr** parameters.
- The cursor must have blocking enabled.
- The cursor must be either read only or forward only.

You can configure the **FetchBufferSize** keyword to ensure that the size of the result set that the CLI driver prefetches is sufficient to include the EOF character in the first query block. See the Related reference section for further details on **FetchBufferSize**.

In the non-seamless ACR environment, the **ReceiveTimeout** event triggers the ACR connection error (SQL30108N).

If the **QueryTimeout**parameter is set in the non-seamless ACR environment, following behaviors are observed:

- If the connection failure occurs before the query timeout event, the ACR connection error (SQL30108N with reason code 1, and failure code 1, 2 or 3) is returned to the application.
- If the **Interrupt** parameter is set to the default value of 1 and the query timeout event occurs, the SQL0952N error is returned to the application.
- If the **Interrupt** parameter is set to the value of 2 and the query timeout event occurs, the ACR connection error (SQL30108N with failure code 4 and error code 1) is returned to the application.

When the **Interrupt** parameter is set to the value of 2 and SQLCancel() API is explicitly sent from the application while SQL statement is being executed, the ACR connection error (SQL30108N failure code 4 and error code 2) is returned to the application.

If the **tcpipConnectTimeout** parameter and the **memberConnectTimeout** parameter is set and the TCPIP Connection timeout or the member connection timeout event occurs in the non-seamless ACR environment, the CLI driver reconnects to a new available member but the ACR error (SQL30108N) is not returned to the application.

Operation of workload balancing for connections to Informix from non-Java clients

Workload balancing (also called transaction-level workload balancing) for connections to IBM Informix contributes to high availability by balancing work among servers in a high-availability cluster at the start of a transaction.

The following overview describes the steps that occur when a client connects to an IBM Informix Connection Manager, and workload balancing is enabled:

1. When the client first establishes a connection using the IP address of the Connection Manager, the Connection Manager returns the server list and the connection details (IP address, port, and weight) for the servers in the cluster.

   The server list is cached by the client. The default lifespan of the cached server list is 30 seconds.
2. At the start of a new transaction, the client reads the cached server list to identify a server that has untapped capacity, and looks in the transport pool for an idle transport that is tied to the under-utilized server. (An idle transport is a transport that has no associated connection object.)
   - If an idle transport is available, the client associates the connection object with the transport.
   - If, after a user-configurable timeout, no idle transport is available in the transport pool and no new transport can be allocated because the transport pool has reached its limit, an error is returned to the application.
3. When the transaction runs, it accesses the server that is tied to the transport.
4. When the transaction ends, the client verifies with the server that transport reuse is still allowed for the connection object.
5. If transport reuse is allowed, the server returns a list of SET statements for special registers that apply to the execution environment for the connection object.

   The client caches these statements, which it replays in order to reconstruct the execution environment when the connection object is associated with a new transport.
6. The connection object is then dissociated from the transport, if the client determines that it needs to do so.
7. The client copy of the server list is refreshed when a new connection is made, or every 30 seconds, or at the user-configured interval.
8. When workload balancing is required for a new transaction, the client uses the previously described process to associate the connection object with a transport.

Application programming requirements for high availability connections to the Informix database server

The connection failover for the automatic client reroute feature can be seamless or non-seamless. You must include error handling routine in your application to handle the non-seamless failover to the Informix database server.

If failover is non-seamless, all the work that occurred within the current transaction is rolled back. Your application can include following tasks to the error handling routine for successful non-seamless connection failover:

- Check the reason code that is returned with the error to determine whether special register settings on the failing data sharing member are carried over to the new (failover) data sharing member. Reset any special register values that are not current.
- Rerun all uncommitted SQL operations that occurred during the previous transaction.

The following conditions must be satisfied for the failover connections to the Informix database server to be seamless:

- The CLI driver, or IBM .NET data provider is used to connect to the database server.
- The connection does not have a pending uncommitted statement in a transaction. However, a seamless connection is possible in the following uncommitted statement conditions:
  - The failure occurs on the first SQL statement in a transaction.
  - If all the data, including the end of file (EOF) character, is returned in the first query block or in a subsequent fetch request, the CLI driver fails over seamlessly when you issue a COMMIT or ROLLBACK statement after the server becomes unreachable.
- The data server must allow transport reuse at the end of the previous transaction.
- All global temporary tables are closed or dropped.
- There are no open, or held cursors.
- If the CLI driver is used, the application cannot perform any actions that require the driver to maintain a history of previously called APIs in order to replay the SQL statement. Examples include specifying data at execution time, running compound SQL, or use of array input.
- The application is not a stored procedure.
- Autocommit is not enabled.

  Note: Although the seamless connection failover can occur when autocommit is enabled, this situation can potentially cause previously committed SQL statement to be reissued when connection is reestablished. For example, if the connection to the database server is disconnected before acknowledgment of the commit operation is sent back to the client, when the client reestablishes the connection, client replays the previously committed SQL statement. The result is that the SQL statement is executed twice. To avoid this situation, turn autocommit off when you enable seamless failover.

Client affinities for connections to Informix database server from non-Java clients

Client affinities is a client-only method for providing automatic client reroute capability.

Client affinities is available for applications that use CLI, .NET, or Java (IBM Data Server Driver for JDBC and SQLJ type 4 connectivity). All rerouting is controlled by the driver.

Client affinities is intended for situations in which you need to connect to a particular primary server. If an outage occurs during the connection to the primary server, you need to enforce a specific order for failover to alternate servers. You should use client affinities for automatic client reroute only if automatic client reroute that uses server failover capabilities does not work in your environment.

As part of configuration of client affinities, you specify a list of alternate servers, and the order in which connections to the alternate servers are tried. When client affinities is in use, connections are established based on the list of alternate servers instead of the host name and port number that are specified by the application. For example, if an application specifies that a connection is made to server1, but the configuration process specifies that servers should be tried in the order (server2, server3, server1), the initial connection is made to server2 instead of server1.

Failover with client affinities is seamless, if the following conditions are true:

- The connection is not in a transaction. That is, the failure occurs when the first SQL statement in the transaction is executed.
- There are no global temporary tables in use on the server.
- There are no open, held cursors.

When you use client affinities, you can specify that if the primary server returns to operation after an outage, connections return from an alternate server to the primary server on a transaction boundary. This activity is known as *failback*.

Configuring client affinities in non-Java clients for connection to Informix database server connections

To enable support for client affinities in CLI and .NET applications, you set values in the `db2dsdriver.cfg` configuration file to indicate that you want to use client affinities, and to specify the primary and alternate servers.

The following table describes the settings in the `db2dsdriver.cfg` file for enabling client affinities for CLI and .NET applications.

Table 32. Settings to enable client affinities for CLI and .NET applications

Element in the acr section of the db2dsdriver configuration file	Values
enableAcr parameter	true

Table 32. Settings to enable client affinities for CLI and .NET applications (continued)

Element in the acr section of the db2dsdriver configuration file	Values
maxAcrRetries parameter	The maximum number of connection attempts to each server in the list of alternate servers for automatic client reroute (ACR). The valid range is 0 - (the value of the MAX_INT). The value of the **DB2_MAX_CLIENT_CONNRETRIES** registry variable overrides the value of the **maxAcrRetries** parameter. If you do not set the **DB2_MAX_CLIENT_CONNRETRIES** registry variable or **maxAcrRetries** parameter, the **maxAcrRetries** parameter is set to 3. Setting the **maxAcrRetries** parameter to 0 disables ACR.
acrRetryInterval parameter	The number of seconds to wait between retries. The valid range is 0 to MAX_INT. The default is no wait (0).
affinityFailbackInterval parameter	The number of seconds to wait after the first transaction boundary to fail back to the primary server. Set this value if you want to fail back to the primary server. The default is 0, which means that no attempt is made to fail back to the primary server.
alternateserverlist	<server> elements that identify the host name and port number for each server that is used for automatic client reroute through client affinities. One of the elements must identify the primary server. The presence of these elements does not activate automatic client reroute.
affinitylist	<list> elements with serverorder attributes. The serverorder attribute value specifies a list of servers, in the order that they should be tried during automatic client reroute with client affinities. The servers in <list> elements must also be defined in <server> elements in the <alternateserverlist>. You can specify multiple <list> elements, each of which has different server orders. The presence of the <affinitylist> element does not activate automatic client reroute.

Table 32. Settings to enable client affinities for CLI and .NET applications (continued)

Element in the acr section of the db2dsdriver configuration file	Values
client_affinity	A <clientaffinitydefined> element or a <clientaffinityroundrobin> element that defines the order in which to try server connections for each client. When you include a <clientaffinitydefined> element, you define the server order by defining <client> elements, each of which specifies a <list> element that defines the server order. When you include a <clientaffinityroundrobin> element, you also specify <client> elements, but those <client> elements do not specify a <list> element. Instead, the order of the <client> elements, defines the server order. All clients that connect to a database must be specified within a <clientaffinitydefined> or a <clientaffinityroundrobin> element. In case of multiple network interface cards on a given client machine, client host name will be self discovered and matched with the configuration file entry, by CLI driver, to compute the affinity list. CLI driver will get all network interfaces and will try to match it with the host names available in the db2dsdriver configuration file. When a hostname without domain name is specified in db2dsdriver.cfg, CLI will try to resolve it using the default domain and will try to match with the discovered hostname. If the IP address is defined under client affinity section of the cfg file, the respective IP address will be discovered and matched (for hostname) with configuration file entry, by CLI driver, to compute the affinity list.
clientaffinitydefined	<client> elements that define the server order for automatic client reroute for each client. Each <client> element contains a listname attribute that associates a client with a <list> element from the <affinitylist> element.
clientaffinityroundrobin	<client> elements whose order in the <clientaffinityroundrobin> element defines the first server that is chosen for automatic client reroute. Each <client> element has an index. The first <client> element in the <clientaffinityroundrobin> element has index 0, the second <client> element has index 1, and so on. Suppose that the number of servers in the <alternateserverlist> element is *n* and the index in the <clientaffinityroundrobin> element of a <client> element is *i*. The first server to be tried is the server whose index in the <alternateserverlist> element is *i* mod *n*. The next server to be tried is the server whose index in the <alternateserverlist> element is (*i* +1) mod *n*), and so on.

The following restrictions apply to configuration of client affinities for CLI or .NET clients:

- If the total number of qualifying alternate servers for a given client is greater than 128, error SQL1042N occurs.
- Workload balancing cannot be enabled when client affinity is enabled. That is, if enableWLB is set to true, and the client_affinity element is specified, error SQL5162N occurs.
- If the required attributes are not specified in the <alternateserverlist>, <affinitylist> or <client_affinity> elements, error SQL5163N occurs.
- If client affinity is enabled, and the <alternateserverlist> element is empty, error SQL5164N occurs.
- If client affinity is enabled, and the host name for a client that is attempting to connect to a server is not in one of the <client_affinity> subgroups (<clientaffinitydefined> or <clientaffinityroundrobin>), or is in more than one of the subgroups, error SQL5164N occurs.
- For each client machine, there should be only one entry, either in <clientaffinitydefined> or <clientaffinityroundrobin> section. If there are entries in db2dsdriver.cfg where the same client machine has been specified by different host names, the error SQL5162N occurs.

Example of enabling client affinities for non-Java clients for Informix database server connections

Before you can use client affinities for automatic client reroute in CLI or .NET applications, you need to include elements in the <acr> section of the `db2dsdriver.cfg` configuration file to indicate that you want to use client affinities, and to identify the primary and alternate servers.

The following example shows how to enable client affinities for failover without failback.

Suppose that your `db2dsdriver` configuration file looks like this:

```
<database name="SAMPLE" host="v33ec065.svl.ibm.com" port="446">
  <acr>
    <parameter name="enableAcr" value="true"/>
    <parameter name="maxAcrRetries" value="1"/>
    <parameter name="acrRetryInterval" value="2"/>
    <alternateserverlist>
      <server name="server1"
              hostname="v33ec067.svl.ibm.com"
              port="446">
      </server>
      <server name="server2"
              hostname="v33ec066.svl.ibm.com"
              port="446">
      </server>
      <server name="server3"
              hostname="v33ec065.svl.ibm.com"
              port="446">
      </server>
    </alternateserverlist>
    <affinitylist>
      <list name="list1" serverorder="server1,server2,server3">
      </list>
      <list name="list2" serverorder="server3,server2,server1">
      </list>
    </affinitylist>
    <clientaffinitydefined>
```

```
    <!- this section has specific defined affinities -->
      <client name="client1"
              hostname="appsrv1.svl.ibm.com"
              listname="list2">
      </client>
      <client name="client2"
              hostname="appsrv2.svl.ibm.com"
              listname="list1">
      </client>
    </clientaffinitydefined>
    <clientaffinityroundrobin>
      <client name="client3" hostname="appsrv3.svl.ibm.com">
          <!- This entry is index 0. The number of servers is 3.
              0 mod 3 is 0, so the first that is tried
              during automatic client reroute is the server whose
              index in <alternateserverlist> is 0 (server1).
              The next server has index 1 mod 3, which is 1
              (server2). The final server has index 2 mod 3,
              which is 2 (server3). -->
      </client>
      <client name="client4" hostname="appsrv4.svl.ibm.com">
          <!- This entry is index 1. The number of servers is 3.
              1 mod 3 is 1, so the first that is tried
              during automatic client reroute is the server whose
              index in <alternateserverlist> is 1 (server2).
              The next server has index 2 mod 3, which is 2
              (server3). The final server has index 3 mod 3,
              which is 0 (server1). -->
      </client>
    </clientaffinityroundrobin>
  </acr>
</database>
```

Suppose that a communication failure occurs during a connection from the client with host name appsrv4.svl.ibm.com (client4) to the server that is identified by v33ec065.svl.ibm.com:446. The following steps demonstrate the process that occurs for automatic client reroute with client affinities.

1. The driver tries to connect to v33ec066.svl.ibm.com:446 (server2).
2. The connection to v33ec066.svl.ibm.com:446 fails.
3. The driver waits two seconds.
4. The driver tries to connect to v33ec065.svl.ibm.com:446 (server3).
5. The connection to v33ec065.svl.ibm.com:446 fails.
6. The driver waits two seconds.
7. The driver tries to connect to v33ec067.svl.ibm.com (server1).
8. The connection to v33ec067.svl.ibm.com fails.
9. The driver waits two seconds.
10. The driver returns error code SQL30081N.

The following example shows how to enable client affinities for failover with failback.

Suppose that your db2dsdriver configuration file looks like this:

```
<database name="SAMPLE" host="v33ec065.svl.ibm.com" port="446">
  <acr>
    <parameter name="enableAcr" value="true"/>
    <parameter name="maxAcrRetries" value="1"/>
    <parameter name="acrRetryInterval" value="2"/>
    <parameter name="affinityFailbackInterval" value="300"/>
    <alternateserverlist>
      <server name="server1"
```

```
            hostname="v33ec067.svl.ibm.com"
            port="446">
      </server>
      <server name="server2"
            hostname="v33ec066.svl.ibm.com"
            port="446">
      </server>
      <server name="server3"
            hostname="v33ec065.svl.ibm.com"
            port="446">
      </server>
    </alternateserverlist>
    <affinitylist>
      <list name="list1" serverorder="server1,server2,server3">
      </list>
      <list name="list2" serverorder="server3,server2,server1">
      </list>
    </affinitylist>
    <clientaffinitydefined>
    <!- this section has specific defined affinities -->
      <client name="client1"
            hostname="appsrv1.svl.ibm.com"
            listname="list2">
      </client>
      <client name="client2"
            hostname="appsrv2.svl.ibm.com"
            listname="list1">
      </client>
    </clientaffinitydefined>
    <clientaffinityroundrobin>
      <client name="client3" hostname="appsrv3.svl.ibm.com">
          <!- This entry is index 0. The number of servers is 3.
              0 mod 3 is 0, so the first that is tried
              during automatic client reroute is the server whose
              index in <alternateserverlist> is 0 (server1).
              The next server has index 1 mod 3, which is 1
              (server2). The final server has index 2 mod 3,
              which is 2 (server3). -->
      </client>
      <client name="client4" hostname="appsrv4.svl.ibm.com">
          <!- This entry is index 1. The number of servers is 3.
              1 mod 3 is 1, so the first that is tried
              during automatic client reroute is the server whose
              index in <alternateserverlist> is 1 (server2).
              The next server has index 2 mod 3, which is 2
              (server3). The final server has index 3 mod 3,
              which is 0 (server1). -->
      </client>
    </clientaffinityroundrobin>
  </acr>
</database>
```

Suppose that the database administrator takes the server that is identified by v33ec065.svl.ibm.com:446 down for maintenance after a connection is made from client appsrv2.svl.ibm.com (client2) to v33ec065.svl.ibm.com:446. The following steps demonstrate failover to an alternate server and failback to the primary server after maintenance is complete.

1. The driver successfully connects to v33ec065.svl.ibm.com:446 on behalf of client appsrv1.svl.ibm.com.
2. The database administrator brings down v33ec065.svl.ibm.com:446.
3. The application tries to do work on the connection.
4. The driver successfully fails over to v33ec066.svl.ibm.com:446.
5. After 200 seconds, the work is committed.

6. The driver tests whether the failback interval (300 seconds) has elapsed. It has not elaspsed, so no failback occurs.
7. The application does more work on the connection to v33ec066.svl.ibm.com:446.
8. After 105 seconds, the work is committed.
9. The driver tests whether the failback interval (300 seconds) has elapsed. It has elapsed, so failback to v33ec065.svl.ibm.com:446 occurs.

Non-Java client support for high availability for connections to DB2 for z/OS servers

Sysplex workload balancing functionality on DB2 for z/OS servers provides high availability for client applications that connect directly to a data sharing group.

Sysplex workload balancing functionality provides workload balancing and automatic client reroute capability. This support is available for applications that use Java clients (JDBC, SQLJ, or pureQuery), or non-Java clients (ODBC, CLI, .NET, OLE DB, PHP, Ruby, or embedded SQL).

A Sysplex is a set of z/OS systems that communicate and cooperate with each other through certain multisystem hardware components and software services to process customer workloads. DB2 for z/OS subsystems on the z/OS systems in a Sysplex can be configured to form a data sharing group. With data sharing, applications that run on more than one DB2 for z/OS subsystem can read from and write to the same set of data concurrently. One or more coupling facilities provide high-speed caching and lock processing for the data sharing group. The Sysplex, together with the Workload Manager (WLM), dynamic virtual IP address (DVIPA), and the Sysplex distributor, allow a client to access a DB2 for z/OS subsystem over TCP/IP with network resilience, and distribute transactions for an application in a balanced manner across members within the data sharing group.

Central to these capabilities is a server list that the data sharing group returns on connection boundaries and optionally on transaction boundaries. This list contains the IP address and WLM weight for each data sharing group member. With this information, a client can distribute transactions in a balanced manner, or identify the member to use when there is a communication failure.

The server list is returned on the first successful connection to the DB2 for z/OS data server. After the client has received the server list, the client directly accesses a data sharing group member based on information in the server list.

DB2 for z/OS provides several methods for clients to access a data sharing group. The access method that is set up for communication with the data sharing group determines whether Sysplex workload balancing is possible. The following table lists the access methods and indicates whether Sysplex workload balancing is possible.

Table 33. Data sharing access methods and Sysplex workload balancing

Data sharing access method[1]	Description	Sysplex workload balancing possible?
Group access	A requester uses the group's dynamic virtual IP address (DVIPA) to make an initial connection to the DB2 for z/OS location. A connection to the data sharing group that uses the group IP address and SQL port is always successful if at least one member is started. The server list that is returned by the data sharing group contains: • A list of members that are currently active and can do work. • The WLM weight for each member. The group IP address is configured by using the z/OS Sysplex distributor. To clients that are outside the Sysplex, the Sysplex distributor provides a single IP address that represents a DB2 location. In addition to providing fault tolerance, you can configure the Sysplex distributor to provide connection load balancing.	Yes
Member-specific access	A requester uses a location alias to make an initial connection to one of the members that is represented by the alias. A connection to the data sharing group that uses the group IP address and alias SQL port is always successful if at least one member is started. The server list that is returned by the data sharing group contains: • A list of members that are currently active, can do work, and have been configured as an alias. • The WLM weight for each member. The requester uses this information to connect to the member or members with the most capacity that are also associated with the location alias. Member-specific access is used when requesters are required to take advantage of Sysplex workload balancing among a subset of members of a data sharing group.	Yes
Single-member access	Single-member access is used when requesters are required to access only one member of a data sharing group. For single-member access, the connection uses the member-specific IP address.	No

Note:

1. For information about data sharing access methods, search IBM Knowledge Center for the communicating with data sharing groups topic in your specific DB2 for z/OS server version.

Sysplex workload balancing includes automatic client reroute: Automatic client reroute support enables a client to recover from a failure by attempting to reconnect to the database through any available member of a Sysplex. Reconnection to another member is called *failover*.

Alternate groups are an additional failover mechanism for automatic client rerouting when connectivity to the current group cannot be re-established. A *group* is a database created in a Sysplex data sharing environment. The database to which your application explicitly connects to is called the *primary group*.

For Java, CLI, or .NET client applications, failover for automatic client reroute can be *seamless* or *non-seamless*. Seamless failover means that when the application successfully reconnects to an alternate server or alternate group, the server does not return an error to the application.

Client direct connect support for high availability with a DB2 Connect server: Client direct connect support for high availability requires a DB2 Connect license, but does not require a DB2 Connect server. The client connects directly to DB2 for z/OS. If you use a DB2 Connect server, but set up your environment for client high availability, you cannot use some of the features that a direct connection to DB2 for z/OS provides. For example, you cannot use the transaction-level workload balancing or automatic client reroute capability that is provided by the sysplex.

Do not use client affinities: You should not use client affinities as a high availability solution for direct connections to DB2 for z/OS. Client affinities is not applicable to a DB2 for z/OS data sharing environment, because all members of a data sharing group can access data concurrently. A major disadvantage of client affinities in a data sharing environment is that if failover occurs because a data sharing group member fails, the member that fails might have retained locks that can severely affect transactions on the member to which failover occurs.

Configuration of Sysplex workload balancing and automatic client reroute for applications other than Java

To configure a client application other than a Java application that connects directly to a DB2 for z/OS server to use Sysplex workload balancing and automatic client reroute (ACR), set keyword values in the IBM data server driver configuration file (`db2dsdriver.cfg`).

These keyword values specify a connection to an address that represents the data sharing group (for group access) or a subset of the data sharing group (for member-specific access) and that enables Sysplex workload balancing and automatic client reroute.

Always configure Sysplex workload balancing and automatic client reroute together. When you configure a client to use Sysplex workload balancing, automatic client reroute is enabled. Therefore, you must change keyword values that are related to automatic client reroute only to fine-tune automatic client reroute operation.

You can enable the workload balancing (WLB) feature by setting the **enableWLB** keyword to `true`. If you enable the WLB feature, it is important to set timeout values as follows to help ensure a timely response:

- For CLI and embedded SQL applications, set the **QueryTimeout** keyword to a value that is less than the required guaranteed response time.
- For .NET applications, set the **CommandTimeout** property to a value that is less than the required guaranteed response time.

For clients other than Java clients, use one of the listed clients or client packages to take advantage of Sysplex workload balancing:

- IBM Data Server Client
- IBM Data Server Runtime Client
- IBM Data Server Driver Package
- IBM Data Server Driver for ODBC and CLI

Important: To establish direct connections to a DB2 for z/OS data sharing group by using the Sysplex workload balancing feature, you need either a DB2 Connect server product installation or DB2 Connect server license file in the license directory of the DB2 installation path.

Table 1 describes the basic configuration settings that are necessary to enable Sysplex workload balancing for applications other than Java applications.

Table 34. Basic settings to enable Sysplex workload balancing for applications other than Java applications

Data-sharing access method	Client setting	Value
Group access	The **enableWLB** keyword in the <wlb> section of the IBM data server driver configuration file (`db2dsdriver.cfg`)	`true`: The default value that enables the WLB feature.
	Database host (host)[1]	The group IP address or domain name of the data sharing group.
	Database port (port)[1]	The SQL port number for the DB2 location.
	Database name (name)[1]	The DB2 location name that is defined during installation.
Member-specific access	The **enableWLB** keyword in the <wlb> section of the IBM data server driver configuration file (`db2dsdriver.cfg`)	`true`: The default value that enables the WLB feature.
	Database host (host)[1]	The group IP address or domain name of the data sharing group.
	Database port (port)[1]	The port number for the DB2 location alias.
	Database name (name)[1]	The DB2 location alias that represents a subset of the members of the data sharing group.

Remember: The open source driver utilizes the CLI driver under the covers.

1. Depending on the DB2 product and driver that you use, connection information can be obtained from one of several possible sources:
   - In a scenario that involves a CLI or open-source application with anIBM data server client, connection information can be obtained from the following sources:
     - If host, port, and database information is provided in the connection string of the application, the CLI driver uses that information to establish a connection.
     - If only database name is specified in the connection string of the application, the CLI driver uses information from the database catalog.

  - If host and port information is not provided in the connection string of the application or database catalog, the CLI driver searches for required information in the db2cli.ini file. If the driver finds that information, it uses it to establish a connection.
  - If host and port information is not provided in the connection string of the application, the database catalog, or the db2cli.ini file, the CLI driver uses information in the IBM data server driver configuration file (db2dsdriver.cfg).
- In a scenario that involves a CLI or open-source application with an IBM data server driver, connection information can be obtained from following sources:
  - If host, port, and database information is provided in the connection string of the application, the CLI driver uses that information to establish a connection.
  - If host and port information is not provided in the connection string of the application, the CLI driver searches for the required information in the db2cli.ini file. If the driver finds that information, it uses it to establish a connection.
  - If host and port information is not provided in the connection string of the application or the db2cli.ini file, the CLI driver uses information in the IBM data server driver configuration file (db2dsdriver.cfg).
- In a scenario that involves a .NET application with a IBM data server client, connection information can be obtained from following sources:
  - If host, port, and database information is provided in the connection string of the application, the .NET data provider uses that information to establish a connection.
  - If host, port and database information is provided through .NET object properties, the .NET data provider uses that information to establish a connection.
  - If only database name is specified in the connection string of the application, the .NET data provider uses information from the database catalog.
  - If host and port information is not provided in the connection string of the application, .NET object properties, or the database catalog, the .NET data provider uses information in the IBM data server driver configuration file (db2dsdriver.cfg).
- In a scenario that involves a .NET application with an IBM data server driver, connection information can be obtained from following sources:
  - If host, port, and database information is provided in the connection string of the application, the .NET data provider uses that information to establish a connection.
  - If host, port, and database information is provided through .NET object properties, the .NET data provider uses that information to establish a connection.
  - If host and port information is not provided in the connection string of the application, the .NET data provider uses information in the IBM data server driver configuration file (db2dsdriver.cfg).

To fine-tune Sysplex workload balancing, additional keywords are available. The additional keywords for applications other than Java applications are listed in Table 2.

Table 35. Properties for fine-tuning Sysplex workload balancing for direct connections from applications other than Java applications to DB2 for z/OS

Keyword in the IBM data server driver configuration file (db2dsdriver.cfg)	Section in the IBM data server driver configuration file (db2dsdriver.cfg)	Description
maxRefreshInterval	<wlb>	Specifies the maximum elapsed time in seconds before the server list is refreshed. The default is 10. The minimum supported value is 0.
maxTransportIdleTime	<wlb>	Specifies the maximum elapsed time in seconds before an idle transport is dropped. The default is 60. The minimum supported value is 0.
maxTransports	<wlb>	Specifies the maximum number of physical connections (or transports) that the requester can make to the data sharing group. A maximum of one transport per member can be opened for each application connection. For example, 25 application connections that access a six-member group can open a maximum of 150 transports to the group. That means that six transports, one to each member, can be opened for each application connection. The default value of the **maxTransports** keyword is 1000. The value of -1 specifies the use of as many transports as necessary based on the number of application connections and members in use.
maxTransportWaitTime	<wlb>	Specifies the number of seconds that the client waits for a transport to become available. The default value is 1 second. Specifying the value as -1 means unlimited wait time. The minimum supported wait time is 0.

Automatic client reroute capability is enabled in a client by default when the WLB feature is enabled. At the first connection to the server, the client obtains a list of servers from the connected group. The server list contains all available servers with the capacity to run work. The server list might not contain all members of the DB2 data sharing group because only the available servers with capacity to run work are included in the list. Other than the case where the server list is used to connect to the alternate servers, a connection to a DB2 data sharing group uses the z/OS Sysplex distributor that is configured with the distributed dynamic virtual IP address. The z/OS Sysplex distributor uses the dynamic virtual IP address (VIPA) and automatic VIPA takeover to distribute incoming connections among the DB2 subsystems within the Sysplex environment. The z/OS Sysplex workload balancing feature helps ensures the high availability of a DB2 data sharing group.

To control automatic client reroute behavior, you can set configuration keywords and registry variables in the IBM data server driver configuration file (db2dsdriver.cfg) . The keyword descriptions in Table 3 are for the case in which client affinities are not enabled. If the IBM data server driver configuration file (db2dsdriver.cfg) changes, your CLI application can invoke the SQLReloadConfig function to validate the entries for all alternate servers within the **<acr>** section.

Table 36. Settings to control automatic client reroute behavior

Keyword in the <acr> section of the db2dsdriver.cfg configuration file	Value
acrRetryInterval	Specifies the number of seconds to wait between consecutive connection attempts. The valid range is `0` - maximum integer value. The value of the **DB2_CONNRETRIES_INTERVAL** registry variable overrides the value of the **acrRetryInterval** keyword. The default is `0` (no wait) if you do not set the **DB2_CONNRETRIES_INTERVAL** registry variable. If you enable automatic client reroute to a DB2 for z/OS data sharing group, the default value of no wait is recommended.
detectReadonlyTxn	Specifies whether a connection can seamlessly fail over to a new member when the automatic client reroute feature is enabled, even if the failed statement is not the first SQL statement in a transaction. You can specify the **detectReadonlyTxn** keyword for a connection to DB2 for z/OS Version 11 in new function mode (NFM) with the automatic client reroute and Sysplex workload balancing features enabled. The default value of the **detectReadonlyTxn** keyword is `false` for connection to supported DB2 for z/OS servers. Setting the **detectReadonlyTxn** keyword to `true` forces the connected server to return the latest values of special registers and session global variables whenever they are modified. **Restriction:** You cannot set the **detectReadonlyTxn** keyword to `true` in a transaction with the repeatable read (RR) or read stability (RS) isolation level.
enableAcr	Specifies whether automatic client reroute is in effect. The default is `true`.
enableSeamlessAcr	Specifies whether seamless failover can occur. If the **enableAcr** keyword is set to `true`, the default for the **enableSeamlessAcr** keyword is `true`. The **enableSeamlessACR** keyword applies only to the members within a group or cluster. When you enable automatic client reroute to a DB2 for z/OS data sharing group, you must ensure that the **enableSeamlessACR** keyword is set to the default value of `true` and that the application can handle the SQL30108N exception.

Table 36. Settings to control automatic client reroute behavior (continued)

Keyword in the <acr> section of the db2dsdriver.cfg configuration file	Value
maxAcrRetries	Specifies the maximum number of connection attempts for automatic client reroute. The valid range is 0 - maximum integer value (MAX_INT). The value of the **DB2_MAX_CLIENT_CONNRETRIES** registry variable overrides the value of the **maxAcrRetries** keyword. If you do not set the **DB2_MAX_CLIENT_CONNRETRIES** registry variable or **maxAcrRetries** keyword, by default, one retry of each server in the server list and the group IP address is attempted. Setting the value of the **maxAcrRetries** keyword to `0` disables ACR.

The registry variables in Table 4 control retry behavior for automatic client reroute.

Table 37. Registry variables to control automatic client reroute retry behavior

Registry variable	Value
DB2_CONNRETRIES_INTERVAL	Specifies the number of seconds between consecutive connection retries. The default is `10` if you set the **DB2_MAX_CLIENT_CONNRETRIES** variable.
DB2_MAX_CLIENT_CONNRETRIES	Specifies the maximum number of connection retries for automatic client reroute. The default is `30` if you set the **DB2_CONNRETRIES_INTERVAL** variable.

When enabling automatic client reroute in a connection to a DB2 for z/OS data sharing group, set the **maxAcrRetries** keyword. If you do not set both the **DB2_MAX_CLIENT_CONNRETRIES** and **DB2_CONNRETRIES_INTERVAL** registry variables or do not set both the **maxAcrRetries** and **acrRetryInterval** keywords, automatic client reroute attempts to connect to a z/OS group for up to 10 minutes, with no wait between attempts.

For CLI, OLE DB, ADO.NET, and embedded SQL applications, there are three connection timeout keywords, which you can set in the IBM data server driver configuration file (`db2dsdriver.cfg`):

MemberConnectTimeout
The **MemberConnectTimeout** keyword specifies the number of seconds that a client application waits before being routed to the next IP address in the server list. When you enable automatic client reroute for connections to a DB2 for z/OS data sharing group, you should use the **MemberConnectTimeout** keyword to manage the time to wait before rerouting. The default value of the **MemberConnectTimeout** keyword is 1 second. In most cases, the default value is adequate, but you might require a higher **MemberConnectTimeout** value to prevent frequent network timeouts.

tcipipConnectionTimeout
The **tcipipConnectionTimeout** keyword specifies the number of seconds before an attempt to open a socket fails. Do not use this keyword with automatic client reroute.

ConnectionTimeout
The **ConnectionTimeout** keyword specifies the number of seconds that a client application waits for a connection to a DB2 for z/OS data sharing group to be established.

The **ConnectionTimeout** keyword setting takes precedence over the **tcpipConnectTimeout** and **MemberConnectTimeout** keyword settings.

If you must use the Sysplex workload balancing feature but your applications cannot handle the errors that are returned for automatic client reroute processing, set the following keywords in the IBM data server driver configuration file (db2dsdriver.cfg).

Table 38. Keywords for enabling only Sysplex workload balancing for connections from applications other than Java applications to DB2 for z/OS

Keyword in the IBM data server driver configuration file (db2dsdriver.cfg)	Section in the IBM data server driver configuration file (db2dsdriver.cfg)	Description	Value to set
connectionLevelLoadBalancing	<database>	Specifies whether connection-level load balancing is in effect. By default, if the **enableWLB** configuration keyword is set to true, the **connectionLevelLoadBalancing** keyword is set to true. Otherwise, the default value of the **connectionLevelLoadBalancing** keyword is false.	true
enableAcr	<acr>	Specifies whether automatic client reroute is enabled. For CLI or .NET applications, enabling automatic client reroute automatically enables seamless failover. By default, if the **enableWLB** keyword is set to true, the **enableAcr** keyword is set to true. Otherwise, the default of the**enableAcr** keyword is false. If your application cannot handle the seamless failover exception (SQL30108N), set the **enableAcr** keyword to false if you set the **enableWLB** keyword to true.	true
enableAlternateGroupSeamlessACR	<acr>	Specifies seamless or non-seamless failover behavior across groups. The default is false. To set this keyword to true, you must also set the **enableSeamlessACR** configuration keyword to true. Setting the **enableAlternateGroupSeamlessACR** keyword to true does not affect the setting of the **enableSeamlessACR** keyword. If a connection is established to a server in the **alternategroup** subsection, the rules for seamless or non-seamless behavior still apply.	true
enableSeamlessAcr	<acr>	Specifies whether seamless failover is enabled. Seamless failover is supported only for Java, CLI, and .NET applications. By default, the **enableSeamlessAcr** keyword is set to the same value as the **enableAcr** keyword.	true
enableWLB	<wlb>	Specifies whether workload balancing is enabled. By default, the **enableWLB** keyword is set to false.	true

Example of enabling DB2 for z/OS Sysplex workload balancing and automatic client reroute in non-Java client applications

Before you can use Sysplex workload balancing and automatic client reroute in applications other than Java applications that connect directly to DB2 for z/OS servers, you need to update the db2dsdriver.cfg configuration file with the appropriate settings, and connect to a data sharing group.

Before you can set up the client, you need to configure the listed server software:
- WLM for z/OS

  For workload balancing to work efficiently, DB2 work needs to be classified. Classification applies to the first non-SET SQL statement in each transaction. Among the areas by which you need to classify the work are:
  - Authorization ID
  - Client info properties
  - Stored procedure name

The stored procedure name is used for classification only if the first statement that is issued by the client in the transaction is an SQL CALL statement.

For a complete list of classification attributes, search IBM Knowledge Center for the classification attributes topic in your specific DB2 for z/OS server version.

- DB2 for z/OS, set up for data sharing

Automatic client reroute capability is enabled in a client by default when the Sysplex workload balancing (WLB) feature is enabled. At the first successful connection to the server, the client obtains a list of all available servers (server list) from the connected group. The server list contains all available servers with capacity to run work. The server list may not contain all members of the DB2 data sharing group as only the available servers with capacity to run work are included in the list. Other than the case where server list is used to connect to the alternate servers, connection to a DB2 data sharing group uses the z/OS Sysplex distributor configured with the distributed dynamic virtual IP address. The z/OS Sysplex distributor uses the dynamic virtual IP address (VIPA) and automatic VIPA takeover to distribute incoming connection among the DB2 subsystems within the Sysplex environment. The z/OS Sysplex feature ensures the high availability of a DB2 data sharing group.

You can fine-tune default automatic client reroute feature by modifying these items:

Automatic client reroute characteristic	db2dsdriver.cfg configuration keyword	Desired value
Number of times to try connecting to the alternate server	**maxAcrRetries**	< 6
Number of seconds to wait between tries	**acrRetryInterval**	0 (default)

The example demonstrates how to set up a client application other than a Java application to take advantage of Sysplex and automatic client reroute high availability support.

1. Create a db2dsdriver.cfg file with the basic settings for Sysplex support and automatic client reroute. When you set enableWLB and enableAcr to true, you enable Sysplex workload balancing and automatic client reroute capabilities.

```
<configuration>
  <dsncollection>
    <dsn alias="DSGROUP1" name="DSGROUP1"
      host="db2a.sysplex1.ibm.com" port="446">
    </dsn>
  </dsncollection>
  <database name="DSGROUP1" host="db2a.sysplex1.ibm.com" port="446">
   <!-- database-specific parameters -->
   <wlb>
      <!-- Enable Sysplex workload balancing to get
      automatic client reroute
      functionality -->
      <parameter name="enableWLB" value="true" />
      <!-- maxTransports represents the maximum number of transports -->
      <parameter name="maxTransports" value="80" />
   </wlb>
   <acr>
      <parameter name="enableAcr" value="true">
      </parameter>
      <parameter name="maxAcrRetries" value="5">
      </parameter>
      <parameter name="acrRetryInterval" value="0">
```

```
      </parameter>
    </acr>
  </database>
</configuration>
```

2. Suppose that database name DSGROUP1 represents a data sharing group that is set up for group access. In a CLI application, you can use the following sample code to connect to the data sharing group:

```
...
   SQLHDBC         hDbc    = SQL_NULL_HDBC;
   SQLRETURN       rc      = SQL_SUCCESS;
   SQLINTEGER      RETCODE = 0;
   char            *ConnStrIn =
                   "DSN=DSGROUP1;PWD=mypass";
                /* dsn matches the database name in the configuration file */
   char            ConnStrOut [200];
   SQLSMALLINT     cbConnStrOut;
   int             i;
   char            *token;
...
  /*************************************************************/
  /* Invoke SQLDriverConnect                                   */
  /*************************************************************/
   RETCODE = SQLDriverConnect (hDbc                ,
                               NULL                ,
                               (SQLCHAR *)ConnStrIn ,
                               strlen(ConnStrIn)    ,
                               (SQLCHAR *)ConnStrOut,
                               sizeof(ConnStrOut)   ,
                               &cbConnStrOut        ,
                               SQL_DRIVER_NOPROMPT);
...
```

Operation of Sysplex workload balancing for connections from non-Java clients to DB2 for z/OS servers

Sysplex workload balancing (also called transaction-level workload balancing) for connections to DB2 for z/OS contributes to high availability by balancing work among members of a data sharing group at the start of a transaction.

The following overview describes the steps that occur when a client connects to a DB2 for z/OS Sysplex, and Sysplex workload balancing is enabled:

1. When the client first establishes a connection using the sysplex-wide IP address called the group IP address, or when a connection is reused by another connection object, the server returns member workload distribution information.

   The default lifespan of the cached server list is 30 seconds.
2. At the start of a new transaction, the client reads the cached server list to identify a member that has untapped capacity, and looks in the transport pool for an idle transport that is tied to the under-utilized member. (An idle transport is a transport that has no associated connection object.)
   - If an idle transport is available, the client associates the connection object with the transport.
   - If, after a user-configurable timeout, no idle transport is available in the transport pool and no new transport can be allocated because the transport pool has reached its limit, an error is returned to the application.
3. When the transaction runs, it accesses the member that is tied to the transport.
4. When the transaction ends, the client verifies with the server that transport reuse is still allowed for the connection object.

5. If transport reuse is allowed, the server returns a list of SET statements for special registers that apply to the execution environment for the connection object.

   The client caches these statements, which it replays in order to reconstruct the execution environment when the connection object is associated with a new transport.
6. The connection object is then disassociated from the transport.
7. The client copy of the server list is refreshed when a new connection is made, or every 30 seconds.
8. When workload balancing is required for a new transaction, the client uses the same process to associate the connection object with a transport.

Operation of automatic client reroute for connections to the DB2 for z/OS server from an application other than a Java application

The automatic client reroute (ACR) feature provides failover support when an application loses connectivity to a member of a DB2 for z/OS data sharing group.

The ACR feature enables an application to recover from a connection failure by reconnecting through an available member of the DB2 for z/OS data sharing group.

When you enable the Sysplex workload balancing feature, the ACR feature is enabled by default. Client support for the ACR feature is available in the IBM data server clients with a DB2 Connect license.

The following example demonstrates ACR operation when an application other than a Java application connects to a DB2 for z/OS data sharing group with the Sysplex workload balancing feature enabled:

1. The data server returns the following items as part of the response to a commit request from the client:
   - An indicator that specifies whether transports can be reused. Transports can be reused if there are no session resources remaining, such as held cursors.
   - The SET statements that the client can use to replay the connection state during transport reuse. The SET statements are also known as special registers.
   - The session global variables, if a connection is made to DB2 for z/OS Version 11 in new function mode (NFM).
2. If the first SQL statement in a transaction fails due to a connection loss, the following behavior occurs:
   - No error is reported to the application.
   - The failing SQL statement is run again on the next available member in the returned server list.The number of times that the connection is retried and the duration between retry attempts are based on the values of the **maxAcrRetries** and **acrRetryInterval** keywords.
   - The SET statements that are associated with the connection are replayed to restore the connection state.
3. The following example applies to only DB2 for z/OS Version 11 in NFM. If the **detectReadonlyTxn** keyword is set to `true` and the connection fails in a transaction, the following behavior occurs:

- If the completed statements in the transaction before connection failure are read-only and complete result sets from the transaction up to the point of connection failure are available to the client, the following behavior occurs:
  - No error is reported to the application.
  - The SET statements that are associated with the connection are replayed to restore the connection state. The special registers and session global variables are reissued.
  - The failed SQL statement is run again in a new connection that is made to the next available member, which is based on the returned server list. The failed SQL statement does not have to be read-only, but completed statements that are issued before the failure must be read-only. Also, the transaction cannot use the repeatable read (RR) or read stability (RS) isolation level.
- If a transaction up to the point of connection failure is not read-only, the following behavior occurs:
  - The transaction is rolled back.
  - The application is reconnected to the DB2 data sharing group.
  - The SET statements (special registers) that are associated with the connection are reissued to restore the connection state.
  - The SQL30108N error is returned to the application to notify it of the rollback and successful reconnection. The application must include code to handle the message and retry the failed transaction.

4. If an SQL statement that is not the first SQL statement in a transaction fails and transports can be reused, the following behavior occurs:
   - The transaction is rolled back.
   - The application is reconnected to the data server.
   - The SET statements (special registers) that are associated with the connection are replayed to restore the connection state.
   - The SQL30108N error is returned to the application to notify it of the rollback and successful reconnection. The application must include code to retry the failed transaction.

   The transports can be reused if no session resources remain open.
5. If an SQL statement that is not the first SQL statement in a transaction fails and transports cannot be reused, the following behavior occurs:
   - The special registers and global variables are reset to the values that were in effect at the last commit point.
   - The SQL30081N error is returned to the application to notify it that reconnection was unsuccessful. The application must reconnect to the data server, reestablish the connection state, and retry the failed transaction.
6. If all the data, including the end of file (EOF) character, is returned in the first query block or in a subsequent fetch request, the CLI driver can perform seamless failover when you issue a COMMIT or ROLLBACK statement after the member becomes unreachable. If you declare any session resources in a transaction, seamless ACR connections are changed into non-seamless ACR connections. The session resources include the following ones:
   - Open cursors with cursor-hold behavior
   - Open cursors with locators
   - Declared global temporary tables
   - Accelerated queries

You can configure the **FetchBufferSize** keyword to ensure that the size of the result set that the CLI driver prefetches is sufficient to include the EOF character in the first query block. See the Related reference section for further details on the **FetchBufferSize** parameter.

7. If connections to all members of the data sharing member list were tried and none succeeded, a connection is tried using the DB2 group-wide IP address that is associated with the data sharing group, to determine whether any members are now available.

The behavior of the non-seamless ACR feature changes when you connect to a DB2 for z/OS data sharing group for which you configure an alternate group and you enable the Sysplex workload balancing feature:

- The CLI driver does not associate a transport with the connection until the application issues an SQL statement or a SET statement. When the application issues an SQL statement or a SET statement, the CLI driver allocates a transport and sets special registers to the values that were in effect at the time of the last commit point.
- The SQL30108N error with reason code 2 is returned to the application if the CLI driver fails to reconnect to members of the primary group and must switch to the alternate group. The error is returned a second time with reason code 4 if you specify the alternate group in the `db2dsdriver.cfg` file by using the **alternategroup** keyword and the **enableAlternateGroupSeamlessAcr** keyword is set to `FALSE`. The SQL30108N error with reason code 2 is returned when the existing connection to a member in the current group fails. The SQL30108N error with reason code 4 is returned when all the connection attempts to all members in the existing primary group fail. The application can then resubmit the SET statement or the SQL statement again for the second time if reconnection to the alternate group is warranted. The CLI driver tracks the failed member on the same connection handle when the SQL30108N error is returned to avoid resubmitting the statement to the failed member.

  Attention: The SQL30108N error is not returned twice in the following scenarios:

  – When you use the DB2 Connect server as a gateway
  – When you enable the ACR feature without enabling the Sysplex workload balancing feature

When connecting to a DB2 for z/OS data sharing group, you should not disable the seamless ACR feature and the Sysplex workload balancing feature unless directed by IBM Support.

The following example demonstrates non-seamless ACR operation:

1. As part of the response to a commit request from the client, the data server returns the SET statements (special registers) that the client replays when the transport is associated at the next SQL statement submission or the SET statement submission based on the WLB routing decisions.
2. If the SQL statement in a transaction fails, the ACR connection error (SQL30108N, with reason code 2) is returned to the application, but the CLI driver does not attempt to allocate a new transport. Any session resources that were created in the failed connection are dropped. The session resources include the following ones:
   - Open cursors with cursor-hold behavior
   - Open cursors with locators
   - Declared global temporary tables

- Accelerated queries

3. If the application submits the SET statement or the SQL statement, the CLI driver attempts to obtain a new transport to connect to the next available member in the same group.
4. If the **enableAlternateGroupSeamlessACR** keyword is set to FALSE and the CLI driver cannot reconnect to any of the members in the primary group, a second ACR connection error (SQL30108N with reason code 4) is returned to the application.
5. If the application submits the SET statement or the SQL statement again for the second time, the CLI driver attempts to obtain a new transport to connect to the next available member in the alternate group.
6. When the CLI driver successfully reconnects to a new member, the SET statements (special registers) that were returned from the last commit point are replayed, followed by the SET statement or SQL statement that was submitted by the application. You must re-create any required session resources that existed in a previous failed connection. If the reconnection is not successful, a communication error (SQL30081N) is returned to the application.

In the non-seamless ACR environment, the receive timeout event triggers the ACR connection error (SQL30108N). The receive timeout event occurs when the **ReceiveTimeout** keyword value is reached

If you set the **QueryTimeout** keyword in the non-seamless ACR environment, the following behaviors occur:

- If the connection failure occurs before the query timeout event, the ACR connection error (SQL30108N, with reason code 2 or 4 and failure code 1, 2, or 3) is returned to the application.
- If the **Interrupt** keyword is set to the value of 2 and the query timeout event occurs, the ACR connection error (SQL30108N, with failure code 4 and error code 1) is returned to the application.

When the **Interrupt** keyword is set to the default value of 2 and the SQLCancel() API is explicitly called from the application while an SQL statement is being executed, the ACR connection error (SQL30108N, with failure code 4 and error code 2) is returned to the application.

Operation of transaction-level workload balancing for connections to the DB2 for z/OS data sharing group

Transaction-level workload balancing for connections to the DB2 for z/OS database contributes to high availability by balancing work among servers in a DB2 for z/OS data sharing group at the start of a transaction.

When a client connects to a DB2 for z/OS server and transaction-level workload balancing is enabled, the following steps occur:

1. When the client first establishes a connection to the DB2 for z/OS data sharing group that is using the distributed group IP address, the client returns a server list with the connection details (IP address, port, and weight) for the members of the DB2 for z/OS data sharing group.

   The server list is cached by the client. The default life span of the cached server list is 30 seconds.
2. At the start of a new transaction, the client reads the cached server list to identify a server that has unused capacity, and looks in the transport pool for

an idle transport that is tied to the under-utilized server. An idle transport is a transport that has no associated connection object.

- If an idle transport is available, the client associates the connection object with the transport.
- If, after a user-configurable timeout period (**db2.jcc.maxTransportObjectWaitTime** for a Java client or **maxTransportWaitTime** for other clients), no idle transport is available in the transport pool and no new transport can be allocated because the transport pool reached its limit, an error is returned to the application.

3. When the transaction runs, it accesses the server that is tied to the transport.
4. When the transaction ends, the client verifies with the server that transport reuse is still allowed for the connection object.
5. If transport reuse is allowed, the server returns a list of SET statements for special registers that apply to the execution environment for the connection object.

   The client caches these statements, which it replays in order to reconstruct the execution environment when the connection object is associated with a new transport.
6. The connection object is then dissociated from the transport, if the client determines that it needs to do so.
7. The client copy of the server list is refreshed when a new connection is made, every 30 seconds, or each user-configured interval.
8. When transaction-level workload balancing is required for a new transaction, the client uses the previously described process to associate the connection object with a transport.

Alternate groups for connections to DB2 for z/OS servers from non-Java clients

To improve high availability for non-Java clients in Version 9.7 Fix Pack 5 or later fix pack releases, use alternate groups as an additional failover mechanism for automatic client rerouting when connectivity to the current group cannot be re-established.

By default, non-Java clients have the automatic client reroute (ACR) enabled. This capability provides automatic failover to alternate servers within the current group when connectivity to a server cannot be re-established.

In addition to this ACR capability, you can define *alternate groups* as failover targets when connectivity to the current group cannot be established. To define alternate groups for non-Java clients:

- Define one <database> element inside the <alternategroup> element in the <acr> section of the `db2dsdriver.cfg` file. Do not specify <parameter> elements inside the <database> element, parameter settings are inherited from the primary group.
- If you want to suppress error messages from failover connections to the alternate group, set the enableAlternateGroupSeamlessACR parameter to `true` in <alternategroup> element.

For DB2 for z/OS, you can define only one database in the alternate group. If you define more than one DB2 for z/OS, the connection is terminated and the client returns an error.

When a non-Java client is connected to an alternate group, all the connection settings and the parameter settings for the <database> element in the primary group are inherited by the connection to the database in the alternate group.

After a non-Java client is connected to a database in the alternate group, no failback to the primary group is provided. To connect to the primary group again, the application or client must be restarted.

Alternate groups are only supported for ACR and workload balancing. If client affinities is configured, alternate group definitions are ignored.

Examples

Here is an example of alternate group definitions in the `db2dsdriver.cfg` file:

```
<dsncollection>
  <dsn alias="mydsn2" name="mydb2" host="myserver2.ibm.com" port="5912">
  ...
</dsncollection>

<databases>
  <database name="mydb2" host="myserver2.ibm.com" port="5912">
   <parameter name="IsolationLevel" value="4"/>
...
   <wlb>
     <parameter name="enableWLB" value="true"/>
   </wlb>
   <acr>
...
    <alternategroup>
       <parameter name="enableAlternateGroupSeamlessACR" value="true"/>
       <database name="mydb3" host="myserver3.ibm.com" port="5912">
       </database>
     </alternategroup>
   </acr>
  </database>

  <database name="mydb3" host="myserver3.ibm.com" port="5912">
   <parameter name="IsolationLevel" value="2"/>
...
   <acr>
     <parameter name="enableACR" value="true"/>
...
    <alternategroup>
       <parameter name="enableAlternateGroupSeamlessACR" value="true"/>
       <database name="mydb4" host="myserver4.ibm.com" port="5912">
       </database>
     </alternategroup>
   </acr>
...
  </database>
</databases>
```

The following example scenarios demonstrate how automatic client rerouting works for alternate groups. The details about ACR failover to the current group are not covered in these scenarios to focus on the alternate groups failover details. These scenarios use the `db2dsdriver.cfg` sample that is described in the previous paragraph.

First connection to the primary

In this example, after a non-Java client fails to connect to the primary group on its first attempt, the connection to an alternate group is attempted:

1. The client fails to connect to the *mydb2* database.
2. The client tries to connect to the alternate group listed in the <alternategroup> section of the `db2dsdriver.cfg` file in the order specified in this file.
   a. The client successfully connects to the *mydb3* database.

Subsequent connection after the loss of existing connection to the primary server In this example, after a non-Java client loses its connection to the *mydb3* database, the following connection attempts are made:

1. The client fails to connect to all the members returned in the server list.
2. The client fails to connect to the *mydb3* database once again.
3. The client tries to connect to an alternate group listed in the <alternategroup> section of the `db2dsdriver.cfg` file.
   a. The client successfully connects to the *mydb4* database.

When connecting to DB2 for z/OS server, only one <database> element is allowed under the <alternategroup> section.

Existing connection to an alternate group

A non-Java client fails to connect to the *mydb2* database, automatic client reroute failover to alternate servers in the current group also fails, and then it successfully connects to the *mydb3* database in the alternate group.

If communication error is encountered, you must restart the client or the application must try connecting to the primary group again.

Application programming requirements for automatic client reroute for connections to DB2 for z/OS servers

Connection failover for the automatic client reroute feature can be seamless or non-seamless. To handle non-seamless failover to a DB2 for z/OS data sharing group, you must include an error-handling routine in your application.

If failover is not seamless and a connection is reestablished with the DB2 for z/OS data sharing group, the ACR connection error (SQL30108N) is returned to the application. All work that occurred within the current transaction is rolled back. The application must perform the following steps:

1. Check the reason code that is returned with the SQL30108N error to determine whether special register settings on the failing data sharing member are carried over to the new (failover) data sharing member.
2. Reset any special register values and global variables that were set after the last commit point.
3. Re-create any session resources that were created in the previous failed connection. The session resources can include the following ones:
   - Open cursors with cursor-hold behavior
   - Open cursors with locators
   - Declared global temporary tables
   - Accelerated queries
4. Rerun all uncommitted SQL operations that occurred during the previous transaction.

Failover connections to a DB2 for z/OS data sharing group are seamless when the following conditions are satisfied:

- The CLI driver or IBM Data Server Provider for .NET is used to connect to the DB2 for z/OS data sharing group.
- If the connection has uncommitted statement or statements in a transaction and meets one of the following conditions:
  - The failure occurs on the first SQL statement in a transaction.
  - In a read-only transaction that uses the CLI driver, all the data in a result set is returned to the client, and a COMMIT or ROLLBACK statement is issued after the server becomes unreachable.
  - For an application that is connected to DB2 for z/OS Version 11 in new function mode (NFM), the transaction was read-only before the point of connection failure, and the **detectReadonlyTxn** keyword is set to `true`. The transaction cannot use the repeatable read (RR) or read stability (RS) isolation level.
- The data server must allow transport reuse at the end of the previous transaction, with one exception. The exception is if transport reuse was not granted because you set the **KEEPDYNAMIC** keyword to `YES`.
- There are no open cursors with cursor-hold behavior.
- There are no open cursors with locators.
- There are no declared global temporary tables.
- There are no accelerated queries.
- If the application uses the CLI driver, the application cannot perform actions that require the driver to maintain a history of previously called APIs in order to replay the SQL statement. Examples of such actions include specifying data at execution time, running a compound SQL statement, or using array input.

Chapter 18. XA support for a Sysplex in non-Java clients

IBM data server clients and non-Java data server drivers that have a DB2 Connect license can directly access a DB2 for z/OS Sysplex and use native XA support without going through a middle-tier DB2 Connect server.

This type of client-side XA support is only available for transaction managers that use a single-transport processing model. In a single-transport model, a transaction, over a single transport (physical connection), is tied to a member from xa_start to xa_end. The transaction end is followed immediately by xa_prepare(readonly), xa_prepare plus xa_commit or xa_rollback, or xa_rollback. All of this must occur within a single application process. Examples of transaction managers that use this model include IBM TXSeries™ CICS, IBM WebSphere Application Server, and Microsoft Distributed Transaction Coordinator.

Support for the single-transport processing model also includes indoubt transaction recovery where member information for each recoverable transaction is retrieved through xa_recover, which allows xa_commit or xa_rollback to be directed at the specified member.

You enable XA support by using the SINGLE_PROCESS parameter in the xa_open string, or by specifying settings for XA in the `db2dsdriver` configuration file.

XA support in non-Java clients has the following restrictions:

- The following transaction manager processing models are not supported:
  - Dual-transport. In this model, a transaction, over transport A, is tied to a member from xa_start to xa_end, but xa_prepare(readonly), xa_prepare plus xa_commit or xa_rollback, or xa_rollback comes in over transport B, possibly from another application process. Examples of transaction managers that use this model are IBM WebSphere MQ and IBM Lotus® Domino®.
  - Multi-transport. This model involves the use of multiple transports from multiple application processes, for the same transaction.
- For XA transaction managers that use a multi-transport processing model, a middle-tier DB2 Connect server is still required.
- When XA support is enabled at the client, seamless failover is automatically disabled.

Important: DB2 for z/OS APAR PK69659 must be installed for direct XA support (needed for transaction managers such as Microsoft Distributed Transaction Coordinator). For more information, see APAR PK69659.

Enabling XA support for a Sysplex in non-Java clients

XA support for a DB2 for z/OS Sysplex can be enabled implicitly either by WLB being enabled or Microsoft Distributed Transaction Coordinator or Microsoft Component Services (COM+) being used for instance-less clients.

To explicitly enable XA support for clients that access a DB2 for z/OS Sysplex, you either specify settings in the `db2dsdriver` configuration file or use the SINGLE_PROCESS parameter in the xa_open string.

Before you begin

A DB2 Connect license is required to access the a DB2 for z/OS Sysplex.

The listed clients provide XA support for applications that access a DB2 for z/OS Sysplex:

- IBM Data Server Client
- IBM Data Server Runtime Client
- IBM Data Server Driver Package
- IBM Data Server Driver for ODBC and CLI

Important: DB2 for z/OS APAR PK69659 must be installed for direct XA support (needed for transaction managers such as Microsoft Distributed Transaction Coordinator). For more information, see APAR PK69659.

About this task

This task describes how to explicitly enable XA support for IBM data server clients and non-Java data server drivers.

Restrictions

XA support is only available for transaction managers that use a single-transport processing model. For more information about this restriction, see the topic about client Sysplex limitations.

Procedure

1. For instance-based clients (IBM data server clients), specify whether XA support is on (true) or off (false) by setting the enableDirectXA parameter in the `db2dsdriver` configuration file, or by using the SINGLE_PROCESS parameter in the xa_open string.
2. For instance-less clients, (IBM data server drivers), XA support is enabled by default for Microsoft Distributed Transaction Coordinator or Microsoft Component Services (COM+). For all other supported transaction managers, specify whether XA support is enabled by setting the SINGLE_PROCESS keyword in the xa_open string. Settings for enableDirectXA in the `db2dsdriver` configuration file are not applicable to instance-less clients.

Results

If XA support is enabled, an application can run a distributed transaction over a single transport within a single application process without going through a middle-tier DB2 Connect server.

Example

Enable single-transport XA support for the database SAMPLE.

```
<database name="SAMPLE" host="v33ec065.my.domain.com" port="446">
   <!-- database-specific parameters -->
   <!-directXA is disabled by default -->
      <parameter name="enableDirectXA" value="true" />
   </parameters>
</database>
```

Chapter 19. Configuring your development environment to build and run CLI and ODBC applications

You can run CLI and ODBC applications against a DB2 database server using the IBM Data Server Client, the IBM Data Server Runtime Client, or the IBM Data Server Driver for ODBC and CLI. However, to compile CLI or ODBC applications, you need the IBM Data Server Client.

Procedure

In order for a CLI application to successfully access a DB2 database:

1. Ensure the CLI/ODBC driver was installed during the DB2 client install.
2. For the IBM Data Server Client and Runtime Client only: If the database is being accessed from a remote client, catalog the database and hostname of the machine the database is on.

   On Windows operating systems, you can use the CLI/ODBC Settings GUI to catalog the DB2 database.
3. Optional: Explicitly bind the CLI /ODBC bind files to the database with the command:

   ```
   db2 bind ~/sqllib/bnd/@db2cli.lst blocking all sqlerror continue \
         messages cli.msg grant public
   ```

   On Windows operating systems, you can use the CLI/ODBC Settings GUI to bind the CLI/ODBC bind files to the database.
4. Optional: Change the CLI /ODBC configuration keywords by editing the `db2cli.ini` file. For information about the location of the `db2cli.ini` file, see "db2cli.ini initialization file" in *Call Level Interface Guide and Reference Volume 1*.

   On Windows operating systems, you can use the CLI/ODBC Settings GUI to set the CLI/ODBC configuration keywords.

Results

Once you have completed steps 1 to 4, proceed to setting up your Windows CLI environment, or setting up your Linux or UNIX ODBC environment if you are running ODBC applications on Linux or UNIX.

Setting up the ODBC environment (Linux and UNIX)

This topic explains how to set up client access to DB2 databases for ODBC applications in Linux and UNIX operating systems. If your application is a CLI application, you are only required to perform the task in the *Before you begin* section to set up your environment.

Before you begin

Before setting up the ODBC environment, ensure you have set up the CLI environment.

Procedure

For ODBC applications on UNIX that need to access a DB2 database, perform the following steps:

1. Ensure that an ODBC driver manager is installed and that each user that will use ODBC has access to it. DB2 does not install an ODBC driver manager, so you must use the ODBC driver manager that was supplied with your ODBC client application or ODBC SDK in order to access DB2 data using that application.
2. Set up `.odbc.ini`, the end-user's data source configuration. Each user ID has a separate copy of this file in their home directory. Note that the file starts with a dot. Although necessary files are usually updated automatically by the tools on most platforms, users of ODBC on UNIX platforms will have to edit them manually.

   Using an ASCII editor, update the file to reflect the appropriate data source configuration information. To register a DB2 database as an ODBC data source there must be one stanza (section) for each DB2 database.

   The `.odbc.ini` file must contain the following lines (examples refer to configuration of the SAMPLE database data source):

   - in the `[ODBC Data Source]` stanza:

     ```
     SAMPLE=IBM DB2 ODBC DRIVER
     ```

     which indicates that there is a data source called SAMPLE that uses the IBM DB2 ODBC DRIVER;

   - in the `[SAMPLE]` stanza:

     on AIX, for example,

     ```
     [SAMPLE]
     Driver=/u/thisuser/sqllib/lib/libdb2.a
     Description=Sample DB2 ODBC Database
     ```

     on the Solaris operating system, for example,

     ```
     [SAMPLE]
     Driver=/u/thisuser/sqllib/lib/libdb2.so
     Description=Sample DB2 ODBC Database
     ```

     which indicates that the SAMPLE database is part of the DB2 instance located in the directory `/u/thisuser`.

     With the introduction of the 64-bit development environment, there have been a number of inconsistencies among vendors regarding the interpretation of the sizes of certain parameters. For example, the 64-bit Microsoft ODBC Driver Manager treats SQLHANDLE and SQLLEN as both 64-bits in length, whereas Data Direct Connect and open source ODBC driver managers treat SQLHANDLE as 64-bit, but SQLLEN as 32-bit. The developer must therefore pay careful attention to which version of the DB2 driver is required. Specify the appropriate DB2 driver in the data source stanza, according to the following information:

Type of application	DB2 driver to specify
32-bit CLI	libdb2.*
32-bit ODBC Driver Manager	libdb2.*
64-bit CLI	libdb2.*
64-bit ODBC Driver Manager	libdb2o.* (db2o.o for AIX)

Note: The file extension of the DB2 driver to specify depends on the operating system. The extensions are as follows:

– .a - AIX

– .so - Linux, Solaris, HP-IPF

– .sl - HP-PA

3. Ensure that the application execution environment has reference to the ODBC driver manager by including the corresponding shared library in the environment variable for the library path. The following table indicates the library name by operating system

Operating system	Environment variable	Library name
AIX	**LIBPATH**	`libodbc.a`
HP-UX, Linux, and Solaris	**LD_LIBRARY_PATH**	`libodbc.so`

4. Enable a system-wide `.odbc.ini` file to be used by setting the **ODBCINI** environment variable to the fully qualified pathname of the .ini file. Some ODBC driver managers support this feature which allows for centralized control. The following examples show how to set **ODBCINI**:

   in the C shell,

   ```
   setenv ODBCINI /opt/odbc/system_odbc.ini
   ```

   in the Bourne or Korn shell,

   ```
   ODBCINI=/opt/odbc/system_odbc.ini;export ODBCINI
   ```

5. Once the `.odbc.ini` file is set up, you can run your ODBC application and access DB2 databases. Refer to the documentation that comes with your ODBC application for additional help and information.

Sample build scripts and configurations for the unixODBC driver manager

The unixODBC driver manager is an open source ODBC driver manager for use on the Linux and UNIX platforms. The unixODBC driver manager is supported for use with ODBC applications on supported DB2 platforms. There are several build scripts and configurations that you can use with the unixODBC driver manager.

Support statement

If you experience problems with the combination of the unixODBC driver manager and the DB2 ODBC driver after they are properly installed and configured, you can contact the DB2 Service (http://www.ibm.com/software/data/db2/udb/support) for assistance in diagnosing the problem. If the source of the problem lies with the unixODBC driver manager, you can:

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

Sample build scripts

The following examples are sample build scripts for setting up your environment to use the unixODBC driver manager.

AIX

```
#! /bin/sh

echo "Unzipping and extracting"
gzip -d unixODBC-2.2.11.tar.gz
tar xf unixODBC-2.2.11.tar

cd unixODBC-2.2.11
```

```
#Comment this out if not AIX
export CC=xlc_r
export CCC=xlC_r

echo "Configuring, compiling and installing"
configure --prefix=$HOME --enable-gui=no --enable-drivers=no
make
make install

echo "Setting ini env vars."
export ODBCHOME=~/etc
export ODBCINI=~/odbc.ini

#Comment this out if not AIX
echo "Extracting unixODBC libraries"
cd ~/lib
ar -x libodbc.a
ar -x libodbcinst.a
ar -x libodbccr.a

echo "\n***Still need to set up your ini files"
```

UNIX (other than the AIX platform)

```
#! /bin/sh

echo "Unzipping and extracting"
gzip -d unixODBC-2.2.11.tar.gz
tar xf unixODBC-2.2.11.tar

cd unixODBC-2.2.11

echo "Configuring, compiling and installing"
configure --prefix=$HOME --enable-gui=no --enable-drivers=no
make
make install

echo "Setting ini env vars."
export ODBCHOME=~/etc
export ODBCINI=~/odbc.ini

echo "\n***Still need to set up your ini files"
```

Sample INI file configurations

The following examples are sample user and system INI files for using the unixODBC driver manager.

User INI file (`odbc.ini`)

The `odbc.ini` file is in the `bin` subdirectory of the unixODBC driver manager installation path.

```
[DEFAULT]
Driver = DB2

[SAMPLE]
DESCRIPTION = Connection to DB2
DRIVER = DB2
```

System INI file (`odbcinst.ini`)

The `odbcinst.ini` file is in the `bin` subdirectory of the unixODBC driver manager installation path. The **`Driver`** entry for each database section must point to the location where DB2 libraries are located.

There are multiple library files that are associated with DB2 ODBC driver. You must specify a DB2 library based on your application environment.

- For a 32-bit unixODBC driver manager on the AIX platform, you must specify the `libdb2.a` library for the **Driver** entry.
- For a 32-bit unixODBC driver manager on the Linux and UNIX platform other than AIX, you must specify the `libdb2.so` library for the **Driver** entry.
- For a 64-bit unixODBC driver manager on the AIX platform, you must specify the `db2o.o` library for the **Driver** entry.
- For a 64-bit unixODBC driver manager on the Linux and UNIX platform other than AIX, you must specify the `libdb2o.so` library for the **Driver** entry.

The following sample system INI file has the ODBC trace enabled, with the trace log file set to `trc.log`.

```
[DEFAULT]
Description = Default Driver
Driver = /u/db2inst1/sqllib/lib/db2o.o
fileusage=1
dontdlclose=1

[DB2]
Description = DB2 Driver
Driver = /u/db2inst1/sqllib/lib/db2o.o
fileusage=1
dontdlclose=1

[ODBC]
Trace = yes
Tracefile = /u/user/trc.log
```

Note:

- If you encounter problems when closing the driver manager, such as during `SQLDisconnect()`, set the value `dontdlclose=1` in the `odbcinst.ini` file, as shown in the sample system INI file.
- The 64-bit unixODBC driver manager version 2.3.0 and later treats the SQLHANDLE and SQLLEN value as 64-bits in length. The 64-bit unixODBC driver manager versions before the version 2.3.0 treats the SQLHANDLE value as 64-bit in length, but the SQLLEN value as 32-bit in length.

Setting up the Windows CLI environment

On Windows platforms, CLI driver must be registered with the Windows ODBC Data Source Administrator (`odbcad32.exe`), before it can be used by an ODBC application.

Before you begin

Before setting up the Windows CLI environment, ensure that the CLI environment is set up.

About this task

The CLI driver implements both CLI application programming interface (API) and the ODBC API. In Windows environment, CLI driver must be registered with the Windows ODBC Data Source Administrator (`odbcad32.exe`) before it can be used by an ODBC application. When using the ODBC Data Source Administrator on Windows 64-bit platforms, by default ODBC data sources can be configured only for 64-bit applications. ODBC data sources for 32-bit applications should be

configured by using the Microsoft 32-bit ODBC Data Source Administrator (32-bit `odbcad32.exe`) that is included with the Windows 64-bit operating system.

- To set up Data Sources for 32-bit applications, you must use `%WINDIR%\SysWOW64\odbcad32.exe`.
- To set up Data Sources for 64-bit applications, you must use `%WINDIR%\System32\odbcad32.exe`.

Procedure

Before CLI and ODBC applications can successfully access a DB2 database from a Windows client, perform the listed steps on the client system:

1. Verify that the Microsoft ODBC Driver Manager and the CLI/ODBC driver are installed. On Windows operating systems, both drivers are installed with the DB2 database products. If a newer version of the Microsoft ODBC Driver Manager is already installed or you manually cleared the option to install it, the Microsoft ODBC Driver Manager is not installed. To verify that both drivers are installed perform the listed actions:
   a. Double-click the Microsoft ODBC data sources icon in the Control Panel, or run the **odbcad32.exe** command from the command line.
   b. Click the **Drivers** tab.
   c. Verify that the `IBM DB2 ODBC DRIVER - DB2_Copy_Name` is shown in the list. *DB2_Copy_Name* is the DB2 copy name that you want to use.

   If either the Microsoft ODBC Driver Manager or the IBM Data Server Driver for ODBC and CLI is not installed, then rerun the DB2 installation and select the ODBC component on Windows operating systems.

   Note: The latest version of the Microsoft ODBC Driver Manager is included as part of the Microsoft Data Access Components (MDAC) and can be downloaded from www.microsoft.com.
2. Register the DB2 database with the ODBC driver manager as a data source. On Windows operating systems, you can make the data source available to all users of the system (a system data source), or only the current user (a user data source). Use any of these methods to add the data source:
   - Use the **db2cli** command with the **registerdsn** parameter:
     – Issue the **db2cli** command for each data source that you want to add as follows:

       ```
       db2cli registerdsn -add data-source-name
       ```
   - Use the Microsoft ODBC Administration tool, which you can access from the Control Panel or by running the **odbcad32.exe** command from the command line:
     a. The list of user data sources is shown by default. If you want to add a system data source click the **System DSN** button, or the **System DSN** tab (depending on the platform).
     b. Click **Add**.
     c. Double-click the IBM DB2 ODBC DRIVER - *DB2_Copy_Name* in the list. *DB2_Copy_Name* is the DB2 copy name that you want to use.
     d. Select the DB2 database to add and click **OK**.
   - Use the **CATALOG** command to register the DB2 database with the ODBC driver manager as a data source. For example:

     ```
     CATALOG [ user | system ] ODBC DATA SOURCE
     ```

Using this command, an administrator can create a command line processor script to register the required databases. This script can then be run on all computers that require access to DB2 databases through ODBC.

Results

After configuring the Windows CLI environment, you can now access DB2 data source from Windows ODBC applications.

Selecting a different DB2 copy for your Windows CLI application

By default, CLI applications running on Windows systems make use of the default DB2 copy. However, applications can use any DB2 copy that is installed on the system.

Before you begin

Ensure your Windows CLI environment is set up.

Procedure

The following methods allow CLI applications to successfully access a different DB2 copy on Windows operating systems:

- Using the DB2 command window from the **Start** > **Programs** > **IBM DB2** *Copy Name* > **Command Line Tools** > **DB2 Command Window**: the command window is already set up with the correct environment variables for the particular DB2 copy chosen.
- Using `db2envar.bat` from a command window:
  1. Open a command window.
  2. Run the `db2envar.bat` file using the fully qualified path for the DB2 copy that you want the application to use:

     DB2_Copy_install_dir`\bin\db2envar.bat`
  3. Run the CLI application from the same command window.

  This will set up all the environment variables for the selected DB2 copy in the command window where the `db2envar.bat` was run. Once the command window has been closed and a new one opened, the CLI application will run against the default DB2 Copy unless the `db2envar.bat` for another DB2 copy is run again.
- Using the **`db2SelectDB2Copy`** API: For applications that are dynamically linked, you can call this API before loading any DB2 DLLs within your application process. This API sets up the required environment for your application to use the DB2 copy that you want to use. The **`/delayload`** linking option can be used to delay the loading of any DB2 DLL. For example, if your CLI application links `db2api.lib`, then you must use the **`/delayload`** option of your linker to delay the load `db2app.dll`:

  ```
  cl -Zi -MDd -Tp App.C /link /DELAY:nobind /DELAYLOAD:db2app.dll
     advapi32.lib psapi.lib db2api.lib delayimp.lib
  ```

  To use the API, you will need to include `db2ApiInstall.h`, which will force your application to statically link in `db2ApiInstall.lib`.
- Using LoadLibraryEx: Instead of using LoadLibrary, you can call LoadLibraryEx with the LOAD_WITH_ALTERED_SEARCH_PATH parameter to load the `db2app.dll` that corresponds to the version of the DB2 copy you want to use. For example:

```
HMODULE hLib = LoadLibraryEx("c:\\sqllib\\bin\\db2app.dll",
   NULL, LOAD_WITH_ALTERED_SEARCH_PATH);
```

CLI bind files and package names

CLI packages are automatically bound to databases when the databases are created or upgraded, or a fix pack is applied to either the client or the server. If a user has intentionally dropped a package, then you must rebind db2cli.lst.

Rebind db2cli.lst by issuing the following command:

Linux and UNIX

```
db2 bind BNDPATH/@db2cli.lst blocking all grant public
```

Windows

```
db2 bind "%DB2PATH%\bnd\@db2cli.lst" blocking all grant public
```

The db2cli.lst file contains the names of the bind files that are required by the CLI driver to connect to IBM database servers. The db2cli.lst file typically contains the following bind file names:

- db2clipk.bnd
- db2clist.bnd

Warnings that are generated when binding CLI packages (such as db2clist.bnd or db2cli.lst) to workstation or host servers are expected. This is because DB2 database systems use generic bind files, but the bind file packages for CLI packages contain sections that apply to specific platforms. Therefore, a DB2 database system might generate warnings during the binding against a server, when it encounters a platform-specific section that does not apply to the server.

The following message is an example of a warning that can be ignored which might occur when binding a CLI package (such as db2clist.bnd or db2cli.lst) to a workstation server:

```
LINE    MESSAGES FOR db2clist.bnd
------  --------------------------------------------------------------------
  235   SQL0440N  No authorized routine named "POSSTR" of type
                  "FUNCTION" having compatible arguments was found.
                  SQLSTATE=42884
```

Table 39. CLI bind files and package names

Bind file name	Package name	Needed by DB2 servers on Linux, UNIX, and Windows	Needed by host servers	Description
db2clipk.bnd	SYSSH*xyy*	Yes	Yes	dynamic placeholders - small package WITH HOLD
	SYSSN*xyy*	Yes	Yes	dynamic placeholders - small Package NOT WITH HOLD
	SYSLH*xyy*	Yes	Yes	dynamic placeholders - large package WITH HOLD
	SYSLN*xyy*	Yes	Yes	dynamic placeholders - large package NOT WITH HOLD
db2clist.bnd	SYSSTAT	Yes	Yes	common static CLI functions
db2schema.bnd	SQLL9*vyy*	Yes	No	catalog function support

Note:

- 'S' represents a small package and 'L' represents a large package
- 'H' represents WITH HOLD, and 'N' represents NOT WITH HOLD.
- '*v*' represents the DB2 server version: for example, E=Version 8, F=Version 9
- '*x*' is the isolation level: 0=NC, 1=UR, 2=CS, 3=RS, 4=RR
- '*yy*' is the package iteration 00 through FF
- '*zz*' is unique for each platform

For example, for the dynamic packages:

- SYSSN100 A small package (65 sections) where all cursor declarations are for non-held cursors. Bound with isolation level UR. This is the first iteration of that package.
- SYSLH401 A large package (385 sections) where all cursor declarations are for held cursors. Bound with isolation level RS. This is the second iteration of that package.

Previous versions of DB2 servers do not need all of the bind files and will therefore return errors at bind time. Use the bind option **SQLERROR CONTINUE** so that the same package can be bound on all platforms and errors will be ignored for any statements not supported there.

db2schema.bnd bind file

The db2schema.bnd bind file is automatically bound when the database is created or upgraded, or a fix pack is applied on DB2 servers on Linux, UNIX, and Windows, and exists only on these types of servers. This bind file is located at the

server and should be bound manually (from the server), if the package was intentionally dropped by a user or if an SQL1088W (+1088) warning is received after database creation or upgrade.

Only the most recent version of this package is needed.

If the package is missing, it must be rebound locally on the server. Do not bind this package against remote servers (for example, against a host database). The bind file is found in the `sqllib/bnd` directory of the instance home directory, and is rebound with the following command:

```
bind db2schema.bnd blocking all grant public
```

If an SQL1088W warning was received after database creation or upgrade, and the `db2schema.bnd` package is missing, increase the **applheapsz** database configuration parameter to 128 or greater, and attempt to rebind. No errors should be reported during binding.

Bind option limitations for CLI packages

Some bind options might not take effect when binding CLI packages with the following list files: `db2cli.lst`, `ddcsmvs.lst`, `ddcs400.lst`, `ddcsvm.lst`, or `ddcsvse.lst`.

Because CLI packages are used by CLI, ODBC, JDBC, OLE DB, .NET, and ADO applications, any changes that you make to the CLI packages affect all applications of these types.

Therefore, only a subset of bind options are supported by default when binding CLI packages. The supported options are: `ACTION`, `COLLECTION`, `CLIPKG`, `OWNER`, `REPLVER`, and `GENERIC`. All other bind options that impact CLI packages are ignored.

To create CLI packages with bind options that are not supported by default, specify the `COLLECTION` bind option with a collection ID that is different from the default collection ID, NULLID. Any bind options specified are then accepted. For example, to create CLI packages with the **KEEPDYNAMIC** `YES` bind option, which is not supported by default, issue the following command:

```
db2 bind @db2cli.lst collection newcolid keepdynamic yes
```

In order for CLI/ODBC applications to access the CLI packages created in the new collection, set the **CurrentPackageSet** CLI/ODBC keyword in the `db2cli.ini` initialization file to the new collection ID.

To overwrite CLI packages that already exist under a particular collection ID, perform either of the following actions:

- Drop the existing CLI package before issuing the bind command for this collection ID.
- Specify the `ACTION REPLACE` bind option when issuing the bind command.

Chapter 20. Building CLI applications

Building CLI applications on UNIX

DB2 provides build scripts for compiling and linking CLI programs. These are located in the `sqllib/samples/cli` directory, along with sample programs that can be built with these files.

The script file `bldapp` contains the commands to build a CLI application. It takes up to four parameters, represented inside the script file by the variables `$1`, `$2`, `$3`, and `$4`. The parameter, `$1`, specifies the name of your source file. This is the only required parameter, and the only one needed for CLI applications that do not contain embedded SQL. Building embedded SQL programs requires a connection to the database so three optional parameters are also provided: the second parameter, `$2`, specifies the name of the database to which you want to connect; the third parameter, `$3`, specifies the user ID for the database, and `$4` specifies the password. If the program contains embedded SQL, indicated by the `.sqc` extension, then the `embprep` script is called to precompile the program, producing a program file with a `.c` extension.

About this task

The following examples show you how to build and run CLI applications. To build the sample program `tbinfo` from the source file `tbinfo.c`, enter:

```
bldapp tbinfo
```

The result is an executable file, `tbinfo`. You can run the executable file by entering the executable name:

```
tbinfo
```

Procedure

- **Building and Running Embedded SQL Applications** There are three ways to build the embedded SQL application, `dbusemx`, from the source file `dbusemx.sqc`:
  1. If connecting to the sample database on the same instance, enter:
     ```
     bldapp dbusemx
     ```
  2. If connecting to another database on the same instance, also enter the database name:
     ```
     bldapp dbusemx database
     ```
  3. If connecting to a database on another instance, also enter the user ID and password of the database instance:
     ```
     bldapp dbusemx database userid password
     ```

  The result is an executable file, `dbusemx`.
- There are three ways to run this embedded SQL application:
  1. If accessing the sample database on the same instance, simply enter the executable name:
     ```
     dbusemx
     ```
  2. If accessing another database on the same instance, enter the executable name and the database name:
     ```
     dbusemx database
     ```

3. If accessing a database on another instance, enter the executable name, database name, and user ID and password of the database instance:

   ```
   dbusemx database userid password
   ```

AIX CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the AIX IBM C compiler. They are demonstrated in the `sqllib/samples/cli/bldapp` build script.

Compile options:

xlc The IBM C compiler.

$EXTRA_CFLAG
Contains the value "-q64" for 64-bit environments; otherwise, contains no value.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`

-c Perform compile only; no link. This script has separate compile and link steps.

Link options:

xlc Use the compiler as a front end for the linker.

$EXTRA_CFLAG
Contains the value "-q64" for 64-bit environments; otherwise, contains no value.

-o $1 Specify the executable program.

$1.o Specify the object file.

utilcli.o
Include the utility object file for error checking.

-L$DB2PATH/$LIB
Specify the location of the DB2 runtime shared libraries. For example: `$HOME/sqllib/$LIB`. If you do not specify the `-L` option, the compiler assumes the following path: `/usr/lib:/lib`.

-ldb2 Link with the DB2 library.

Refer to your compiler documentation for additional compiler options.

HP-UX CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the HP-UX C compiler. They are demonstrated in the `sqllib/samples/cli/bldapp` build script.

Compile options:

cc Use the C compiler.

$EXTRA_CFLAG
If the HP-UX platform is IA64 and 64-bit support is enabled, this flag contains the value **+DD64**; if 32-bit support is enabled, it contains the value **+DD32**.

+DD64 Must be used to generate 64-bit code for HP-UX on IA64.

+DD32 Must be used to generate 32-bit code for HP-UX on IA64.

-Ae Enables HP ANSI extended mode.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`

-mt Enable multi-thread support. This option is required when you are compiling C/C++ applications.

-c Perform compile only; no link. Compile and link are separate steps.

Link options:

cc Use the compiler as a front end for the linker.

$EXTRA_CFLAG
If the HP-UX platform is IA64 and 64-bit support is enabled, this flag contains the value **+DD64**; if 32-bit support is enabled, it contains the value **+DD32**.

+DD64 Must be used to generate 64-bit code for HP-UX on IA64.

+DD32 Must be used to generate 32-bit code for HP-UX on IA64.

-o $1 Specify the executable program.

$1.o Specify the object file.

utilcli.o
Include the utility object file for error checking.

$EXTRA_LFLAG
Specify the runtime path. If set, for 32-bit it contains the value `-Wl,+b$HOME/sqllib/lib32`, and for 64-bit: `-Wl,+b$HOME/sqllib/lib64`. If not set, it contains no value.

-L$DB2PATH/$LIB
Specify the location of the DB2 runtime shared libraries. For 32-bit: `$HOME/sqllib/lib32`; for 64-bit: `$HOME/sqllib/lib64`.

-ldb2 Link with the database manager library.

-mt Enable multi-thread support. This option is required when you are linking to C/C++ applications.

-lunwind
Link with the HP-UX unwind library to support DB2 problem determination features. This option is required.

Refer to your compiler documentation for additional compiler options.

Linux CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the GNU/Linux gcc compiler. They are demonstrated in the `sqllib/samples/cli/bldapp` build script.

Compile options:

gcc The C compiler.

$EXTRA_C_FLAGS
Consists of one of the listed flags:
- `-m31` on Linux for zSeries only, to build a 32-bit library;
- `-m32` on Linux for x86, x64 and POWER®, to build a 32-bit library;
- `-m64` on Linux for zSeries, POWER, x64, to build a 64-bit library; or
- No value on Linux for IA64, to build a 64-bit library.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`

-c Perform compile only; no link. Compile and link are separate steps.

Link options:

gcc Use the compiler as a front end for the linker.

$EXTRA_C_FLAGS
Consists of one of the listed flags:
- `-m31` on Linux for zSeries only, to build a 32-bit library;
- `-m32` on Linux for x86, x64 and POWER, to build a 32-bit library;
- `-m64` on Linux for zSeries, POWER, x64, to build a 64-bit library; or
- No value on Linux for IA64, to build a 64-bit library.

-o $1 Specify the executable.

$1.o Include the program object file.

utilcli.o
Include the utility object file for error checking.

$EXTRA_LFLAG
For 32-bit it contains the value "-Wl,-rpath,$DB2PATH/lib32", and for 64-bit it contains the value "-Wl,-rpath,$DB2PATH/lib64".

-L$DB2PATH/$LIB
Specify the location of the DB2 static and shared libraries at link-time. For example, for 32-bit: `$HOME/sqllib/lib32`, and for 64-bit: `$HOME/sqllib/lib64`.

-ldb2 Link with the DB2 library.

Refer to your compiler documentation for additional compiler options.

Solaris CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the Solaris C compiler. They are demonstrated in the `sqllib/samples/cli/bldapp` build script.

Compile and link options for bldapp

Compile options:

cc Use the C compiler.

-xarch=$CFLAG_ARCH
This option ensures that the compiler will produce valid executables when linking with `libdb2.so`. The value for $CFLAG_ARCH is set as follows:
- "v8plusa" for 32-bit applications on Solaris SPARC

- "v9" for 64-bit applications on Solaris SPARC
- "sse2" for 32-bit applications on Solaris x64
- "amd64" for 64-bit applications on Solaris x64

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`

-c Perform compile only; no link. This script has separate compile and link steps.

Link options:

cc Use the compiler as a front end for the linker.

-xarch=$CFLAG_ARCH
This option ensures that the compiler will produce valid executables when linking with `libdb2.so`. The value for $CFLAG_ARCH is set to either "v8plusa" for 32-bit, or "v9" for 64-bit.

-mt Link in multi-thread support to prevent problems calling fopen.

Note: If POSIX threads are used, DB2 applications also have to link with `-lpthread`, whether or not they are threaded.

-o $1 Specify the executable program.

$1.o Include the program object file.

utilcli.o
Include the utility object file for error checking.

-L$DB2PATH/$LIB
Specify the location of the DB2 static and shared libraries at link-time. For example, for 32-bit: `$HOME/sqllib/lib32`, and for 64-bit: `$HOME/sqllib/lib64`.

$EXTRA_LFLAG
Specify the location of the DB2 shared libraries at run time. For 32-bit it contains the value "-R$DB2PATH/lib32", and for 64-bit it contains the value "-R$DB2PATH/lib64".

-ldb2 Link with the DB2 library.

Refer to your compiler documentation for additional compiler options.

Building CLI multi-connection applications on UNIX

DB2 for Linux, UNIX, and Windows provides build scripts for compiling and linking CLI programs. These are located in the `sqllib/samples/cli` directory, along with sample programs that can be built with these files.

About this task

The build file, `bldmc`, contains the commands to build a DB2 multi-connection program, requiring two databases. The compile and link options are the same as those used in `bldapp`.

The first parameter, $1, specifies the name of your source file. The second parameter, $2, specifies the name of the first database to which you want to

connect. The third parameter, $3, specifies the second database to which you want to connect. These are all required parameters.

Note: The makefile hardcodes default values of "sample" and "sample2" for the database names ($2 and $3) so if you are using the makefile, and accept these defaults, you only have to specify the program name (the $1 parameter). If you are using the bldmc script, you must specify all three parameters.

Optional parameters are not required for a local connection, but are required for connecting to a server from a remote client. These are: $4 and $5 to specify the user ID and password for the first database; and $6 and $7 to specify the user ID and password for the second database.

For the multi-connection sample program, dbmconx, you require two databases. If the sample database is not yet created, you can create it by entering **db2sampl** on the command line. The second database, here called sample2, can be created with one of the following commands:

Procedure

- If creating the database locally:

  ```
  db2 create db sample2
  ```

- If creating the database remotely:

  ```
  db2 attach to node_name
  db2 create db sample2
  db2 detach
  db2 catalog db sample2 as sample2 at node node_name
  ```

  where *node_name* is the database partition where the database resides.

- Multi-connection also requires that the TCP/IP listener is running. To ensure that the TCP/IP listener is running, follow the listed steps:

  1. Set the environment variable **DB2COMM** to TCP/IP as follows:

     ```
     db2set DB2COMM=TCPIP
     ```

  2. Update the database manager configuration file with the TCP/IP service name as specified in the services file:

     ```
     db2 update dbm cfg using SVCENAME TCP/IP_service_name
     ```

     Each instance has a TCP/IP service name listed in the services file. Ask your system administrator if you cannot locate it or do not have the file permission to read the services file. On UNIX and Linux systems, the services file is located in: /etc/services

  3. Stop and restart the database manager in order for these changes to take effect:

     ```
     db2stop
     db2start
     ```

     The dbmconx program consists of five files:

     dbmconx.c
     Main source file for connecting to both databases.

     dbmconx1.sqc
     Source file for creating a package bound to the first database.

dbmconx1.h
Header file for dbmconx1.sqc included in dbmconx.sqc for accessing the SQL statements for creating and dropping a table to be bound to the first database.

dbmconx2.sqc
Source file for creating a package bound to the second database.

dbmconx2.h
Header file for dbmconx2.sqc included in dbmconx.sqc for accessing the SQL statements for creating and dropping a table to be bound to the second database.

- To build the multi-connection sample program, dbmconx, enter:

```
bldmc dbmconx sample sample2
```

  The result is an executable file, dbmconx.
- To run the executable file, enter the executable name:

```
dbmconx
```

  The program demonstrates a two-phase commit to two databases.

Building CLI applications on Windows

DB2 provides batch files for compiling and linking CLI programs. These are located in the sqllib\samples\cli directory, along with sample programs that can be built with these files.

About this task

The batch file bldapp.bat contains the commands to build a CLI program. It takes up to four parameters, represented inside the batch file by the variables %1, %2, %3, and %4.

The parameter, %1, specifies the name of your source file. This is the only required parameter, and the only one needed for CLI programs that do not contain embedded SQL. Building embedded SQL programs requires a connection to the database so three optional parameters are also provided: the second parameter, %2, specifies the name of the database to which you want to connect; the third parameter, %3, specifies the user ID for the database, and %4 specifies the password.

If the program contains embedded SQL, indicated by the .sqc or .sqx extension, then the embprep.bat batch file is called to precompile the program, producing a program file with either a .c or a .cxx extension.

The following examples show you how to build and run CLI applications.

To build the sample program tbinfo from the source file tbinfo.c, enter:

```
bldapp tbinfo
```

The result is an executable file tbinfo. You can run the executable file by entering the executable name:

```
tbinfo
```

Building and running embedded SQL applications

There are three ways to build the embedded SQL application, dbusemx, from the source file dbusemx.sqc:

Procedure

1. If connecting to the sample database on the same instance, enter:
   ```
   bldapp dbusemx
   ```
2. If connecting to another database on the same instance, also enter the database name:
   ```
   bldapp dbusemx database
   ```
3. If connecting to a database on another instance, also enter the user ID and password of the database instance:
   ```
   bldapp dbusemx database userid password
   ```

   The result is an executable file, dbusemx.

   There are three ways to run this embedded SQL application:

   a. If accessing the sample database on the same instance, simply enter the executable name:
      ```
      dbusemx
      ```
   b. If accessing another database on the same instance, enter the executable name and the database name:
      ```
      dbusemx database
      ```
   c. If accessing a database on another instance, enter the executable name, database name, and user ID and password of the database instance:
      ```
      dbusemx database userid password
      ```

Windows CLI application compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI applications with the Microsoft Visual C++ compiler. They are demonstrated in the sqllib\samples\cli\bldapp.bat batch file.

Compile options:

%BLDCOMP%
: Variable for the compiler. The default is cl, the Microsoft Visual C++ compiler. It can be also set to icl, the Intel C++ Compiler for 32-bit and 64-bit applications, or ecl, the Intel C++ Compiler for Itanium 64-bit applications.

-Zi
: Enable debugging information.

-Od
: Disable optimizations. It is easier to use a debugger with optimization off.

-c
: Perform compile only; no link.

-W2
: Set warning level.

-DWIN32
: Compiler option necessary for Windows operating systems.

-J
: Compiler option that changes the default char type from signed char to unsigned char. The char type is zero-extended when widened to an int type. If a char type is explicitly declared as signed char then the –J option has no effect.

Link options:

link
: Use the linker.

-debug Include debugging information.

-out:%1.exe
Specify the executable.

%1.obj Include the object file.

utilcli.obj
Include the utility object file for error checking.

db2api.lib
Link with the DB2 API library.

/delayload:db2app.dll
Used to ensure that db2app.dll is not loaded until the first call to a DB2 API. This is required when using the db2SelectDB2Copy API.

db2ApiInstall.lib
Library to statically link in your application if you need to select a particular DB2 copy that is installed on the computer using the db2SelectDB2Copy API. Note: to use this functionality, you need to either dynamically load db2app.dll or use the /delayload:db2app.dll option of your compiler and call the db2SelectDB2Copy API before running any other DB2 API's.

Refer to your compiler documentation for additional compiler options.

Building CLI multi-connection applications on Windows

DB2 provides batch files for compiling and linking CLI programs. These are located in the sqllib\samples\cli directory, along with sample programs that can be built with these files.

About this task

The batch file, bldmc.bat, contains the commands to build a DB2 multi-connection program requiring two databases. The compile and link options are the same as those used in bldapp.bat.

The first parameter, %1, specifies the name of your source file. The second parameter, %2, specifies the name of the first database to which you want to connect. The third parameter, %3, specifies the second database to which you want to connect. These are all required parameters.

Note: The makefile hardcodes default values of "sample" and "sample2" for the database names (%2 and %3) so if you are using the makefile, and accept these defaults, you only have to specify the program name (the %1 parameter). If you are using the bldmc.bat file, you must specify all three parameters.

Optional parameters are not required for a local connection, but are required for connecting to a server from a remote client. These are: %4 and %5 to specify the user ID and password for the first database; and %6 and %7 to specify the user ID and password for the second database.

For the multi-connection sample program, dbmconx, you require two databases. If the sample database is not yet created, you can create it by entering db2sampl on the command line. The second database, here called sample2, can be created with one of the following commands:

Procedure

- If creating the database locally:

  ```
  db2 create db sample2
  ```

- If creating the database remotely:

  ```
  db2 attach to <node_name>
  db2 create db sample2
  db2 detach
  db2 catalog db sample2 as sample2 at node <node_name>
  ```

  where <node_name> is the database partition where the database resides.

- Multi-connection also requires that the TCP/IP listener is running. To ensure that the TCP/IP listener is running, follow the listed steps:

  1. Set the environment variable DB2COMM to TCP/IP as follows:

     ```
     db2set DB2COMM=TCPIP
     ```

  2. Update the database manager configuration file with the TCP/IP service name as specified in the services file:

     ```
     db2 update dbm cfg using SVCENAME <TCP/IP service name>
     ```

     Each instance has a TCP/IP service name listed in the services file. Ask your system administrator if you cannot locate it or do not have the file permission to read the services file.

  3. Stop and restart the database manager in order for these changes to take effect:

     ```
     db2stop
     db2start
     ```

  The dbmconx program consists of five files:

  dbmconx.c
  Main source file for connecting to both databases.

  dbmconx1.sqc
  Source file for creating a package bound to the first database.

  dbmconx1.h
  Header file for dbmconx1.sqc included in dbmconx.sqc for accessing the SQL statements for creating and dropping a table to be bound to the first database.

  dbmconx2.sqc
  Source file for creating a package bound to the second database.

  dbmconx2.h
  Header file for dbmconx2.sqc included in dbmconx.sqc for accessing the SQL statements for creating and dropping a table to be bound to the second database.

- To build the multi-connection sample program, dbmconx, enter:

  ```
  bldmc dbmconx sample sample2
  ```

  The result is an executable file, dbmconx.

- To run the executable file, enter the executable name:

  ```
  dbmconx
  ```

  The program demonstrates a two-phase commit to two databases.

Building CLI applications with configuration files

The configuration file, cli.icc, in sqllib/samples/cli allows you to build CLI programs.

Procedure

To use the configuration file to build the CLI sample program tbinfo from the source file tbinfo.c:

1. Set the CLI environment variable:
   ```
   export CLI=tbinfo
   ```
2. If you have a cli.ics file in your working directory, produced by building a different program with the cli.icc file, delete the cli.ics file with this command:
   ```
   rm cli.ics
   ```
   An existing cli.ics file produced for the same program you are going to build again does not have to be deleted.
3. Compile the sample program by entering:
   ```
   vacbld cli.icc
   ```
   Note: The vacbld command is provided by VisualAge® C++.
   The result is an executable file, tbinfo. You can run the program by entering the executable name:
   ```
   tbinfo
   ```

Results

Building and running embedded SQL applications

You use the configuration file after the program is precompiled with the embprep file. The embprep file precompiles the source file and binds the program to the database. You use the cli.icc configuration file to compile the precompiled file.

There are three ways to precompile the embedded SQL application, dbusemx, from the source file dbusemx.sqc:

- If connecting to the sample database on the same instance, enter:
  ```
  embprep dbusemx
  ```
- If connecting to another database on the same instance, also enter the database name:
  ```
  embprep dbusemx database
  ```
- If connecting to a database on another instance, also enter the user ID and password of the database instance:
  ```
  embprep dbusemx database userid password
  ```

The result is a precompiled C file, dbusemx.c.

After it is precompiled, the C file can be compiled with the cli.icc file as follows:

1. Set the CLI environment variable to the program name by entering:
   ```
   export CLI=dbusemx
   ```
2. If you have a cli.ics file in your working directory, produced by building a different program with the cli.icc or cliapi.icc file, delete the cli.ics file with this command:

```
rm cli.ics
```

An existing `cli.ics` file produced for the same program you are going to build again does not have to be deleted.

3. Compile the sample program by entering:

```
vacbld cli.icc
```

There are three ways to run this embedded SQL application:

- If accessing the `sample` database on the same instance, simply enter the executable name:

```
dbusemx
```

- If accessing another database on the same instance, enter the executable name and the database name:

```
dbusemx database
```

- If accessing a database on another instance, enter the executable name, database name, and user ID and password of the database instance:

```
dbusemx database userid password
```

Building CLI stored procedures with configuration files

The configuration file, `clis.icc`, in `sqllib/samples/cli`, allows you to build CLI stored procedures.

Procedure

To use the configuration file to build the CLI stored procedure `spserver` from the source file `spserver.c`:

1. Set the CLIS environment variable to the program name by entering:

```
export CLIS=spserver
```

2. If you have a `clis.ics` file in your working directory, produced by building a different program with the `clis.icc` file, delete the `clis.ics` file with this command:

```
rm clis.ics
```

An existing `clis.ics` file produced for the same program you are going to build again does not have to be deleted.

3. Compile the sample program by entering:

```
vacbld clis.icc
```

Note: The `vacbld` command is provided by VisualAge C++.

4. The stored procedure is copied to the server in the path `sqllib/function`

Next, catalog the stored procedures by running the `spcreate.db2` script on the server. First, connect to the database with the user ID and password of the instance where the database is located:

```
db2 connect to sample userid password
```

If the stored procedures were previously cataloged, you can drop them with this command:

```
db2 -td@ -vf spdrop.db2
```

Then catalog them with this command:

```
db2 -td@ -vf spcreate.db2
```

Then, stop and restart the database to allow the new shared library to be recognized. If necessary, set the file mode for the shared library so the DB2 instance can access it.

Once you build the stored procedure `spserver`, you can build the CLI client application `spclient` that calls the stored procedure. You can build `spclient` by using the configuration file, `cli.icc`.

To call the stored procedure, run the sample client application by entering:

`spclient` *database userid password*

where

database
Is the name of the database to which you want to connect. The name could be `sample`, or its remote alias, or some other name.

userid Is a valid user ID.

password
Is a valid password.

The client application accesses the shared library, `spserver`, and executes a number of stored procedure functions on the server database. The output is returned to the client application.

Chapter 21. Building CLI routines

Building CLI routines on UNIX

DB2 for Linux, UNIX, and Windows provides build scripts for compiling and linking DB2 Call Level Interface (CLI) programs.

These are located in the `sqllib/samples/cli` directory, along with sample programs that can be built with these files. The script file `bldrtn` contains the commands to build CLI routines (stored procedures and user-defined functions). `bldrtn` creates a shared library on the server. It takes a parameter for the source file name, represented inside the script file by the variable `$1`.

Procedure

To build the sample program `spserver` from the source file `spserver.c`:

1. Enter the build script name and program name:

   ```
   bldrtn spserver
   ```

   The script file copies the shared library to the `sqllib/function` directory.
2. Next, catalog the routines by running the `spcat` script on the server:

   ```
   spcat
   ```

   This script connects to the sample database, uncatalogs the routines if they were previously cataloged by calling `spdrop.db2`, then catalogs them by calling `spcreate.db2`, and finally disconnects from the database. You can also call the `spdrop.db2` and `spcreate.db2` scripts individually.
3. Then, unless this is the first time the shared library was built, stop and restart the database to allow the new version of the shared library to be recognized. If necessary, set the file mode for the shared library so the DB2 instance can access it.

Results

Once you build the shared library, `spserver`, you can build the CLI client application, `spclient`, that calls the routines within the shared library.

The client application can be built like any other CLI client application by using the script file, `bldapp`.

To access the shared library, run the sample client application by entering:

`spclient` *database userid password*

where

database
: Is the name of the database to which you want to connect. The name could be `sample`, or its alias, or another database name.

userid Is a valid user ID.

password
Is a valid password.

The client application accesses the shared library, `spserver`, and executes the routines on the server database. The output is returned to the client application.

AIX CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines (stored procedures and user-defined functions) with the AIX IBM C compiler. They are demonstrated in the `sqllib/samples/cli/bldrtn` build script.

Compile options:

xlc_r Use the multi-threaded version of the IBM C compiler, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED).

$EXTRA_CFLAG
Contains the value "-q64" for 64-bit environments; otherwise, contains no value.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`.

-c Perform compile only; no link. Compile and link are separate steps.

Link options:

xlc_r Use the multi-threaded version of the compiler as a front end for the linker.

$EXTRA_CFLAG
Contains the value "-q64" for 64-bit environments; otherwise, contains no value.

-qmkshrobj
Create the shared library.

-o $1 Specify the executable program.

$1.o Specify the object file.

utilcli.o
Include the utility object file for error checking.

-L$DB2PATH/$LIB
Specify the location of the DB2 runtime shared libraries. For example: `$HOME/sqllib/$LIB`. If you do not specify the `-L` option, the compiler assumes the following path: `/usr/lib:/lib`.

-ldb2 Link with the DB2 library.

-bE:$.exp
Specify an export file. The export file contains a list of routines.

Refer to your compiler documentation for additional compiler options.

HP-UX CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines with the HP-UX C compiler. They are demonstrated in the `sqllib/samples/cli/bldrtn` build script.

Compile options:

cc The C compiler.

$EXTRA_CFLAG
If the HP-UX platform is IA64 and 64-bit support is enabled, this flag contains the value **+DD64**; if 32-bit support is enabled, it contains the value **+DD32**.

+DD64 Must be used to generate 64-bit code for HP-UX on IA64.

+DD32 Must be used to generate 32-bit code for HP-UX on IA64.

+u1 Allow unaligned data access. Use only if your application uses unaligned data.

+z Generate position-independent code.

-Ae Enables HP ANSI extended mode.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`

-D_POSIX_C_SOURCE=199506L
POSIX thread library option that ensures _REENTRANT is defined, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED).

-mt Enable multi-thread support. This option is required when you are compiling C/C++ routines.

-c Perform compile only; no link. Compile and link are separate steps.

Link options:

ld Use the linker to link.

-b Create a shared library rather than a normal executable.

-o $1 Specify the executable.

$1.o Specify the object file.

utilcli.o
Link in the error-checking utility object file.

$EXTRA_LFLAG
Specify the runtime path. If set, for 32-bit it contains the value `+b$HOME/sqllib/lib32`, and for 64-bit: `+b$HOME/sqllib/lib64`. If not set, it contains no value.

-L$DB2PATH/$LIB
Specify the location of the DB2 runtime shared libraries. For 32-bit: `$HOME/sqllib/lib32`; for 64-bit: `$HOME/sqllib/lib64`.

-ldb2 Link with the DB2 library.

-lpthread
Link with the POSIX thread library.

-lunwind
Link with the HP-UX unwind library to support DB2 problem determination features. This option is required.

Refer to your compiler documentation for additional compiler options.

Linux CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines with the GNU/Linux gcc compiler. They are demonstrated in the `sqllib/samples/cli/bldrtn` build script.

Compile options:

gcc The C compiler.

$EXTRA_C_FLAGS
Consists of one of the listed flags:

- `-m31` on Linux for zSeries only, to build a 32-bit library;
- `-m32` on Linux for x86, x64 and POWER, to build a 32-bit library;
- `-m64` on Linux for zSeries, POWER, x64, to build a 64-bit library; or
- No value on Linux for IA64, to build a 64-bit library.

-fpic Allows position independent code.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`.

-c Perform compile only; no link. Compile and link are separate steps.

-D_REENTRANT
Defines _REENTRANT, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED).

Link options:

gcc Use the compiler as a front end for the linker.

$EXTRA_C_FLAGS
Consists of one of the listed flags:

- `-m31` on Linux for zSeries only, to build a 32-bit library;
- `-m32` on Linux for x86, x64 and POWER, to build a 32-bit library;
- `-m64` on Linux for zSeries, POWER, x64, to build a 64-bit library; or
- No value on Linux for IA64, to build a 64-bit library.

-o $1 Specify the executable.

$1.o Include the program object file.

utilcli.o
Include the utility object file for error-checking.

-shared
Generate a shared library.

$EXTRA_LFLAG
Specify the location of the DB2 shared libraries at run time. For 32-bit it contains the value "-Wl,-rpath,$DB2PATH/lib32". For 64-bit it contains the value "-Wl,-rpath,$DB2PATH/lib64".

-L$DB2PATH/$LIB
Specify the location of the DB2 static and shared libraries at link-time. For example, for 32-bit: `$HOME/sqllib/lib32`, and for 64-bit: `$HOME/sqllib/lib64`.

-ldb2 Link with the DB2 library.

-lpthread
Link with the POSIX thread library.

Refer to your compiler documentation for additional compiler options.

Solaris CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines with the Solaris C compiler. They are demonstrated in the `sqllib/samples/cli/bldrtn` build script.

Compile options:

cc The C compiler.

-xarch=$CFLAG_ARCH
This option ensures that the compiler will produce valid executables when linking with `libdb2.so`. The value for $CFLAG_ARCH is set as follows:

- "v8plusa" for 32-bit applications on Solaris SPARC
- "v9" for 64-bit applications on Solaris SPARC
- "sse2" for 32-bit applications on Solaris x64
- "amd64" for 64-bit applications on Solaris x64

-mt Allow multi-threaded support, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED).

-DUSE_UI_THREADS
Allows Sun's "UNIX International" threads APIs.

-Kpic Generate position-independent code for shared libraries.

-I$DB2PATH/include
Specify the location of the DB2 include files. For example: `$HOME/sqllib/include`.

-c Perform compile only; no link. Compile and link are separate steps.

Link options:

cc Use the compiler as a front end for the linker.

-xarch=$CFLAG_ARCH
This option ensures that the compiler will produce valid executables when linking with `libdb2.so`. The value for $CFLAG_ARCH is set to either "v8plusa" for 32-bit, or "v9" for 64-bit.

-mt Allow multi-threaded support, needed as the routines may run in the same process as other routines (THREADSAFE) or in the engine itself (NOT FENCED).

-G Generate a shared library.

-o $1 Specify the executable.

$1.o Include the program object file.

utilcli.o
Include the utility object file for error-checking.

-L$DB2PATH/$LIB
Specify the location of the DB2 static and shared libraries at link-time. For example, for 32-bit: `$HOME/sqllib/lib32`, and for 64-bit: `$HOME/sqllib/lib64`.

$EXTRA_LFLAG
Specify the location of the DB2 shared libraries at run time. For 32-bit it contains the value "-R$DB2PATH/lib32", and for 64-bit it contains the value "-R$DB2PATH/lib64".

-ldb2 Link with the DB2 library.

Refer to your compiler documentation for additional compiler options.

Building CLI routines on Windows

DB2 for Linux, UNIX, and Windows provides batch files for compiling and linking CLI programs.

These are located in the `sqllib\samples\cli` directory, along with sample programs that can be built with these files. The batch file `bldrtn.bat` contains the commands to build CLI routines (stored procedures and user-defined functions). `bldrtn.bat` creates a DLL on the server. It takes one parameter, represented inside the batch file by the variable `%1`, which specifies the name of your source file. The batch file uses the source file name for the DLL name.

Procedure

To build the `spserver` DLL from the source file `spserver.c`:

1. Enter the batch file name and program name:
   ```
   bldrtn spserver
   ```
   The batch file uses the module definition file `spserver.def`, contained in the same directory as the CLI sample programs, to build the DLL. The batch file then copies the DLL, `spserver.dll`, to the server in the path `sqllib\function`.
2. Next, catalog the routines by running the `spcat` script on the server:
   ```
   spcat
   ```
   This script connects to the sample database, uncatalogs the routines if they were previously cataloged by calling `spdrop.db2`, then catalogs them by calling `spcreate.db2`, and finally disconnects from the database. You can also call the `spdrop.db2` and `spcreate.db2` scripts individually.
3. Then, unless this is the first time the shared library was built, stop and restart the database to allow the new version of the shared library to be recognized. If necessary, set the file mode for the shared library so the DB2 instance can access it.

Results

Once you build the DLL `spserver`, you can build the CLI client application `spclient` that calls the routines within it.

You can build `spclient` by using the script file, `bldapp`.

To call the routines, run the sample client application by entering:

`spclient` *database userid password*

where

database
Is the name of the database to which you want to connect. The name could be `sample`, or its alias, or another database name.

userid Is a valid user ID.

password
Is a valid password.

The client application accesses the DLL, `spserver`, which executes the routines on the server database. The output is returned to the client application.

Windows CLI routine compile and link options

The compile and link options in this topic are recommended by DB2 for building CLI routines with the Microsoft Visual C++ compiler. They are demonstrated in the `sqllib\samples\cli\bldrtn.bat` batch file.

Compile options:

%BLDCOMP%
Variable for the compiler. The default is `cl`, the Microsoft Visual C++ compiler. It can be also set to `icl`, the Intel C++ Compiler for 32-bit and 64-bit applications, or `ecl`, the Intel C++ Compiler for Itanium 64-bit applications.

-Zi Enable debugging information

-Od Disable optimizations. It is easier to use a debugger with optimization off.

-c Perform compile only; no link. The batch file has separate compile and link steps.

-W2 Set warning level.

-DWIN32
Compiler option necessary for Windows operating systems.

-MD Link using MSVCRT.LIB

Link options:

link Use the 32-bit linker.

-debug Include debugging information.

-out:%1.dll
Build a .DLL file.

%1.obj Include the object file.

utilcli.obj
Include the utility object file for error-checking.

db2api.lib
Link with the DB2 API library.

-def:%1.def
Use the module definition file.

/delayload:db2app.dll
Used to ensure that `db2app.dll` is not loaded until the first call to a DB2 API. This is required when using the db2SelectDB2Copy API.

db2ApiInstall.lib
Library to statically link in your application if you need to select a particular DB2 copy that is installed on the computer using the db2SelectDB2Copy API. Note: to use this functionality, you need to either dynamically load `db2app.dll` or use the `/delayload:db2app.dll` option of your compiler and call the db2SelectDB2Copy API before running any other DB2 API's.

Refer to your compiler documentation for additional compiler options.

Appendix A. DB2 technical information

DB2 technical information is available in multiple formats that can be accessed in multiple ways.

DB2 technical information is available through the following tools and methods:

- Online DB2 documentation in IBM Knowledge Center:
  - Topics (task, concept, and reference topics)
  - Sample programs
  - Tutorials
- Locally installed DB2 Information Center:
  - Topics (task, concept, and reference topics)
  - Sample programs
  - Tutorials
- DB2 books:
  - PDF files (downloadable)
  - PDF files (from the DB2 PDF DVD)
  - Printed books
- Command-line help:
  - Command help
  - Message help

Important: The documentation in IBM Knowledge Center and the DB2 Information Center is updated more frequently than either the PDF or the hardcopy books. To get the most current information, install the documentation updates as they become available, or refer to the DB2 documentation in IBM Knowledge Center.

You can access additional DB2 technical information such as technotes, white papers, and IBM Redbooks® publications online at ibm.com. Access the DB2 Information Management software library site at http://www.ibm.com/software/data/sw-library/.

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DB2 technical library in hardcopy or PDF format

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English and translated DB2 Version 10.5 manuals in PDF format can be downloaded from DB2 database product documentation at www.ibm.com/support/docview.wss?rs=71&uid=swg27009474.

The following tables describe the DB2 library available from the IBM Publications Center at http://www.ibm.com/e-business/linkweb/publications/servlet/pbi.wss. Although the tables identify books that are available in print, the books might not be available in your country or region.

The form number increases each time that a manual is updated. Ensure that you are reading the most recent version of the manuals, as listed in the following tables.

The DB2 documentation online in IBM Knowledge Center is updated more frequently than either the PDF or the hardcopy books.

Table 40. DB2 technical information

Name	Form number	Available in print	Availability date
Administrative API Reference	SC27-5506-00	Yes	28 July 2013
Administrative Routines and Views	SC27-5507-01	No	1 October 2014
Call Level Interface Guide and Reference Volume 1	SC27-5511-01	Yes	1 October 2014
Call Level Interface Guide and Reference Volume 2	SC27-5512-01	No	1 October 2014
Command Reference	SC27-5508-01	No	1 October 2014
Database Administration Concepts and Configuration Reference	SC27-4546-01	Yes	1 October 2014
Data Movement Utilities Guide and Reference	SC27-5528-01	Yes	1 October 2014
Database Monitoring Guide and Reference	SC27-4547-01	Yes	1 October 2014
Data Recovery and High Availability Guide and Reference	SC27-5529-01	No	1 October 2014
Database Security Guide	SC27-5530-01	No	1 October 2014
DB2 Workload Management Guide and Reference	SC27-5520-01	No	1 October 2014
Developing ADO.NET and OLE DB Applications	SC27-4549-01	Yes	1 October 2014
Developing Embedded SQL Applications	SC27-4550-00	Yes	28 July 2013

Table 40. DB2 technical information (continued)

Name	Form number	Available in print	Availability date
Developing Java Applications	SC27-5503-01	No	1 October 2014
Developing Perl, PHP, Python, and Ruby on Rails Applications	SC27-5504-01	No	1 October 2014
Developing RDF Applications for IBM Data Servers	SC27-5505-00	Yes	28 July 2013
Developing User-defined Routines (SQL and External)	SC27-5501-00	Yes	28 July 2013
Getting Started with Database Application Development	GI13-2084-01	Yes	1 October 2014
Getting Started with DB2 Installation and Administration on Linux and Windows	GI13-2085-01	Yes	1 October 2014
Globalization Guide	SC27-5531-00	No	28 July 2013
Installing DB2 Servers	GC27-5514-01	No	1 October 2014
Installing IBM Data Server Clients	GC27-5515-01	No	1 October 2014
Message Reference Volume 1	SC27-5523-00	No	28 July 2013
Message Reference Volume 2	SC27-5524-00	No	28 July 2013
Net Search Extender Administration and User's Guide	SC27-5526-01	No	1 October 2014
Partitioning and Clustering Guide	SC27-5532-01	No	1 October 2014
pureXML Guide	SC27-5521-00	No	28 July 2013
Spatial Extender User's Guide and Reference	SC27-5525-00	No	28 July 2013
SQL Procedural Languages: Application Enablement and Support	SC27-5502-00	No	28 July 2013
SQL Reference Volume 1	SC27-5509-01	No	1 October 2014
SQL Reference Volume 2	SC27-5510-01	No	1 October 2014
Text Search Guide	SC27-5527-01	Yes	1 October 2014
Troubleshooting and Tuning Database Performance	SC27-4548-01	Yes	1 October 2014
Upgrading to DB2 Version 10.5	SC27-5513-01	Yes	1 October 2014
What's New for DB2 Version 10.5	SC27-5519-01	Yes	1 October 2014
XQuery Reference	SC27-5522-01	No	1 October 2014

Table 41. DB2 Connect technical information

Name	Form number	Available in print	Availability date
Installing and Configuring DB2 Connect Servers	SC27-5517-00	Yes	28 July 2013
DB2 Connect User's Guide	SC27-5518-01	Yes	1 October 2014

Displaying SQL state help from the command line processor

DB2 products return an SQLSTATE value for conditions that can be the result of an SQL statement. SQLSTATE help explains the meanings of SQL states and SQL state class codes.

Procedure

To start SQL state help, open the command line processor and enter:

```
? sqlstate or ? class code
```

where *sqlstate* represents a valid five-digit SQL state and *class code* represents the first two digits of the SQL state.
For example, `? 08003` displays help for the 08003 SQL state, and `? 08` displays help for the 08 class code.

Accessing DB2 documentation online for different DB2 versions

You can access online the documentation for all the versions of DB2 products in IBM Knowledge Center.

About this task

All the DB2 documentation by version is available in IBM Knowledge Center at http://www.ibm.com/support/knowledgecenter/SSEPGG/welcome. However, you can access a specific version by using the associated URL for that version.

Procedure

To access online the DB2 documentation for a specific DB2 version:

- To access the DB2 Version 10.5 documentation, follow this URL: http://www.ibm.com/support/knowledgecenter/SSEPGG_10.5.0/com.ibm.db2.luw.kc.doc/welcome.html.
- To access the DB2 Version 10.1 documentation, follow this URL: http://www.ibm.com/support/knowledgecenter/SSEPGG_10.1.0/com.ibm.db2.luw.kc.doc/welcome.html.
- To access the DB2 Version 9.8 documentation, follow this URL: http://www.ibm.com/support/knowledgecenter/SSEPGG_9.8.0/com.ibm.db2.luw.kc.doc/welcome.html.
- To access the DB2 Version 9.7 documentation, follow this URL: http://www.ibm.com/support/knowledgecenter/SSEPGG_9.7.0/com.ibm.db2.luw.kc.doc/welcome.html.

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Spine information:

IBM DB2 10.5 for Linux, UNIX, and Windows

Call Level Interface Guide and Reference Volume 1