DB2® Server for VM

Application Programming

Version 6 Release 1

SC09-2661-00

DB2® Server for VM

Application Programming

Version 6 Release 1

SC09-2661-00

Note!

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

This book is also provided as an online book that can be viewed with the IBM® BookManager® READ and IBM Library Reader™ licensed programs.

| **First Edition (December 1998)**

| This edition, SC09-2661, applies to Version 6 Release 1 of the IBM DATABASE 2™ Server for VSE & VM Program 5648-A70, and to
| all subsequent releases of this product until otherwise indicated in new editions. Make sure you are using the correct edition for the
| level of the product.

Changes or additions to the text and illustrations are indicated by a vertical line to the left of the change or addition.

Order publications through your IBM representative or the IBM branch office serving your locality. Publications are not stocked at the address given below.

A form for readers' comments is provided at the back of this publication. If the form has been removed, address your comments to: IBM Canada Ltd. Laboratory Information Development 2G/345/1150/TOR 1150 Eglinton Ave East, North York, Ontario, Canada M3C 1H7.

You can also send your comments by facsimile to (416) 448-6161 addressed to the attention of the RCF Coordinator. If you have access to Internet, you can send your comments electronically to **torrcf@ca.ibm.com**; IBMLink™, to **toribm(torrcf)**; IBM/PROFS®, to **torolab4(torrcf)**; IBMMAIL, to **ibmmail(caibmwt9)**; or through our home page at
| **http://www.software.ibm.com/data/db2/vse-vm/**

If you choose to respond through Internet, please include either your entire Internet network address, or a postal address.

When you send information to IBM, you grant IBM a nonexclusive right to use or distribute the information in any way it believes appropriate without incurring any obligation to you.

Contents

Notices ix
Programming Interface Information ix
Trademarks ix

About This Manual xi
Audience and Purpose of This Book xi
Organization of This Book xii
Related Publications xiii
Syntax Notation Conventions xiii
SQL Reserved Words xvi
Conventions for Representing DBCS Characters xvii
Components of the Relational Database Management System xviii

| **Summary of Changes for DB2 Version 6 Release 1** xxi
| Enhancements, New Functions, and New Capabilities xxi
| DRDA® RUOW Application Requestor for VSE (Online) xxi
| Stored Procedures xxi
| TCP/IP Support for DB2 Server for VM . xxii
| New Code Page and Euro Symbol Code Page Support xxii
| DataPropagator™ Capture xxiii
| QMF for VM, QMF for VSE, and QMF for Windows® xxiii
| RDS Above the Line xxiii
| Combining of NLS Feature Installation Tapes with Base Product Installation Tape xxiii
| Control Center Feature xxiv
| Data Restore Feature xxiv
| DB2 REXX SQL Feature xxiv
| Reliability, Availability, and Serviceability Improvements xxiv
| Migration Considerations xxiv
| Library Enhancements xxv

Chapter 1. Getting Started 1
Contents 1
What is the DB2 Server for VM Product? . . . 2
What is SQL? 3
Embedding SQL Statements in Host Language Programs 3
Writing a Program 4

Chapter 2. Designing a Program 5
Contents 5
Defining the Main Parts of a Program 6
Creating the Prolog 6
Creating the Body 10
Creating the Epilog 12
Using Logical Units of Work 13
Defining the Logical Unit of Work 13
Beginning a Logical Unit of Work 13
Ending a Logical Unit of Work 13
Summary 14
Using Host-Dependent Sample Applications 15

Chapter 3. Coding the Body of a Program 17
Contents 17
Defining Static SQL Statements 20
Naming Conventions 20
Coding SQL Statements to Retrieve and Manipulate Data 21
Retrieving Data 21
Defining an SQL Query 21
Retrieving or Inserting Multiple Rows . . . 28
Retrieving Single Rows 33
Constructing Search Conditions 34
Performing Arithmetic Operations 34
Using Null Values 36
Using the Predicates of a Search Condition 36
Using Functions 38
Using Column Functions 38
Using Scalar Functions 39
Using Data Types 39
Assigning Data Types When the Column Is Created 39
Using Long Strings 41
Using Datetime Data Types 41
Using Character Subtypes and CCSIDs . 42
Converting Data 44
Truncating Data 45
Using a Double-Byte Character Set (DBCS) 46
Using Expressions 48
Using Arithmetic Operators 48
Using Special Registers 49
Concatenating Character and Graphic Strings 50
Using Host Variables 51
Using Host Structures 51
Using Constants 52
Using Indicator Variables 55
Using Views 57
Creating a View 58
Querying Tables through a View 59
Using Views to Manipulate Data 60

Dropping a View 62
Joining Tables 62
Joining Tables Using the Database Manager 63
Performing a Simple Join Query 63
Joining Another User's Tables 64
Analyzing How a Join Works 64
Using VARCHAR and VARGRAPHIC within Join Conditions 65
Using Nulls within Join Conditions 65
Joining a Table to Itself Using a Correlation Name 65
Imposing Limits on Join Queries 67
Using SELECT * In a Join 68
Grouping the Rows of a Table 68
Using VARCHAR and VARGRAPHIC within Groups 69
Using Nulls within Groups 69
Using Select-Lists in Grouped Queries . . 69
Using a WHERE Clause with a GROUP BY Clause 70
Using the HAVING Clause 70
Combining Joins 71
Illustrating Grouping with an Exercise . . 71
Nesting Queries 74
Using the IN Predicate with a Subquery . 77
Considering Other Subquery Issues . . . 78
Executing Subqueries Repeatedly: Correlation 78
Writing a Correlated Subquery 79
How the Database Manager Does Correlation 80
Illustrating a Correlated Subquery 82
Using a Subquery to Test for the Existence of a Row 87
Table Designation Rule for Correlated Subqueries 87
Combining Queries into a Single Query: UNION 88
SQL Comments within Static SQL Statements 91
| Using Stored Procedures 92
| Writing Stored Procedures 94
| Returning Information from the SQLCA . 95
| Language Environment® (LE) Considerations 95
| Preparing to Run a Stored Procedure . . 95
| Calling Stored Procedures 96
| Authorization 97
| AUTHIDs 97
| Stored Procedure Parameters 97
| Datatype Compatibility 98
| Conventions for Passing Stored Procedure Parameters 98
| Coding Examples 100
| Special Considerations for C 100
| Special Considerations for PL/I 100
| Result Sets 101

Chapter 4. Preprocessing and Running a Program 103
Contents 103
Defining the Steps to Execute the Program . 104
Comparing Single User Mode to Multiple User Mode 104
Using 31-Bit Addressing 104
Initializing the User Machine 105
Using VM Implicit Connect 105
Preprocessing the Program 106
Using the SQLPREP EXEC Procedure . . 106
Preprocessing with an Unlike Application Server 121
Using the Preprocessor Option File 122
Using the Flagger at Preprocessor Time . 122
Improving Performance Using Preprocessing Parameters 123
Using the INCLUDE Statement 131
Compiling the Program 132
Link-Editing and Loading the Program 132
Link-Editing the Program with DB2 Server for VM TEXT Files 132
Including the TEXT File in the Link-Editing 133
Creating a Load Module Using the CMS GENMOD Command 134
Running the Program 134
Using a Consistency Token 134
Loading the Package and Rebinding . . . 134
Using Multiple User Mode 135
Using Single User Mode 136
Specifying User Parameters in Single User Mode 136
Distributing Packages across Like and Unlike Systems 137

Chapter 5. Testing and Debugging 139
Contents 139
Doing Your Own Testing 140
Checking Warnings and Errors at Preprocessor Time 140
Testing SQL Statements 141
Using the Automatic Error-Handling Facilities 141
Using the SQLCA 143
Examining Errors 144
Handling Errors in a Select-List 149
Handling Arithmetic Errors 149
Handling Numeric Conversion Errors . . . 150
Handling CCSID Conversion Errors 152

Chapter 6. Using Dynamic Statements . 153

Contents 153
Dynamically Defining SQL Statements . . . 154
Comparing Non-Query Statements to Query Statements 154
Using Non-Query Statements 154
  Executing Non-Parameterized Statements 155
  Executing Parameterized Statements . . 156
Using Query Statements 158
  Executing a Non-Parameterized Select-Statement 158
  Executing a Parameterized SELECT Statement 165
Executing a Parameterized Non-Query Statement 169
  Generating a SELECT Statement 169
Using an Alternative to a Scanning Routine 170
Ensuring Data Type Equivalence in a Dynamically Defined Query 172
Summarizing the Fields of the SQLDA . . . 173
  Using the SQLN Field 174
  Using the SQLD Field in the SQLDA . . . 175
Using the PREPARE Statement 175
SQL Functions Not Supported in Dynamic Statements 177

Chapter 7. Using Extended Dynamic Statements 179
Contents 179
Using Extended Dynamic Statements to Maintain Packages 180
Illustrating the Use of Extended Dynamic Statements 183
  Developing a Query Application 183
  Developing a Language Preprocessor . . 185
Grouping Extended Dynamic Statements in an LUW 189
  Considering Virtual Storage in an LUW . 192
Mapping Extended Dynamic Statements to Static and Dynamic Statements 192
SQL Functions Not Supported in Extended Dynamic Statements 194

Chapter 8. Maintaining Objects Used by a Program 195
Contents 195
Managing Dbspaces 196
  Defining Dbspaces 196
  Modifying the Size of Dbspaces 200
  Automatically Locking Dbspaces 200
  Overriding Automatic Locking 201
  Deleting the Contents of Dbspaces 202
Other Data Definition Statements 202
  Using Tables, Indexes, Statistics, Synonyms, Comments, and Labels . . . 203
| Using Stored Procedures and PSERVERS 205

Chapter 9. Assigning Authority and Privileges 209
Contents 209
Defining User Access to the Database . . . 210
  Defining Authority Types for the Database 210
  Granting Authority to Users 210
  Revoking Authority from Users 211
Defining Privileges 212
  Defining Privileges on Tables and Views 212
  Defining Privileges on Packages 213

Chapter 10. Special Topics 217
Contents 217
Using Datetime Values with Durations 219
  Using Durations 219
  Resolving Peculiarities of Date Arithmetic 219
Using Field Procedures 222
  Assigning Field Procedures to Columns . 224
  Understanding Field Procedure Rules . . 224
Using CMS Work Units 228
  Using Work Units in Application Programs 228
  How Locking Works with CMS Work Units 230
  Environmental Considerations 231
Ensuring Data Integrity 231
  Ensuring Entity Integrity 231
  Using Unique Constraints 232
  When Creating a View 232
  Ensuring Referential Integrity 232
Switching Application Servers 244
  Identifying Switching Options 245
  Comparing Switching to Other Methods . 245
  Accessing a New Application Server . . . 246
  Illustrating Sample Code 247
  Preprocessing the Program on Multiple Application Servers 247

Appendix A. Using SQL in Assembler Language 249
Contents 249
Using ARIS6ASC, an Assembler Language Sample Program 250
Acquiring the SQLDSECT Area 250
Imposing Usage Restrictions on the SQLDSECT Area 251
Rules for Using SQL Statements in Assembler Language 253
  Identifying Rules for Case 253
  Declaring Host Variables 253
  Embedding SQL Statements 255
  Using the INCLUDE Statement 256
  Using Host Variables in SQL Statements 256

Using DBCS Characters in Assembler Language 256
Handling SQL Errors 256
Using Dynamic SQL Statements in Assembler Language 257
Defining DB2 Server for VM Data Types for Assembler Language 258
Using Reentrant Assembler Language Programs 260
| Using Stored Procedures 265

Appendix B. Using SQL in C 269
Contents 269
Using C Sample Program ARIS6CC 270
Rules for Using SQL in C 270
Placing and Continuing SQL Statements 271
Delimiting SQL Statements 271
Identifying Rules for Case 271
Identifying Rules for Character Constants 272
Using the INCLUDE Statement 272
Using the C Compiler Preprocessor . . . 272
Declaring Host Variables 272
Using Host Variables in SQL Statements 278
Using the Pointer Type Attribute 278
Using Host Variables as Function Parameters 280
Using C Variables in SQL: Data Conversion Considerations 280
Using C NUL-Terminated Strings and Truncation 281
Calculating Dates 281
Using Trigraphs 282
Using DBCS Characters in C 282
Considering Preprocessor-Generated Statements 282
Handling SQL Errors 285
Using Dynamic SQL Statements in C 286
Defining DB2 Server for VM Data Types for C 287
Using Reentrant C Programs 289
| Using Stored Procedures 289

Appendix C. Using SQL in COBOL 293
Contents 293
Using COBOL Sample Program ARIS6CBC 294
Rules for Using SQL in COBOL 294
Placing and Continuing SQL Statements 294
Delimiting SQL Statements 295
Identifying Rules for Case 296
Declaring Host Variables 296
Using Host Variables in SQL Statements 299
Using Preprocessor Options 300
Handling SQL Errors 303
Using Dynamic SQL Statements in COBOL 304
Defining DB2 Server for VM Data Types for COBOL 306
Using Reentrant COBOL Programs 308
Using the DYNAM Compiler Option 308
| Using Stored Procedures 309

Appendix D. Using SQL in FORTRAN . . 311
Contents 311
Using FORTRAN Sample Program ARIS6FTC 312
Rules for Using SQL in FORTRAN 312
Placing and Continuing SQL Statements 312
Placing Data Statements 313
Identifying Rules for Case 313
Declaring Host Variables 313
Embedding SQL Statements 315
Using Host Variables in SQL Statements 315
Using Variable Length Character Strings 315
Using DBCS Characters in FORTRAN . . 318
Using the INCLUDE Statement 318
Using FORTRAN Variables in SQL: Data Conversion Considerations 318
Handling SQL Errors 318
Handling Program Interrupts 319
Using Dynamic SQL Statements in FORTRAN 319
Restrictions When Using the FORTRAN Preprocessor 320
Defining DB2 Server for VM Data Types for FORTRAN 321

Appendix E. Using SQL in PL/I 325
Contents 325
Using PL/I Sample Program ARIS6PLC . . . 326
Rules for Using SQL in PL/I 326
Placing and Continuing SQL Statements 326
Delimiting SQL Statements 326
Using the INCLUDE Statement 327
Declaring Static External Variables 327
Identifying Rules for Case 327
Declaring Host Variables 327
Using Host Variables in SQL Statements 330
Using PL/I Variables in SQL: Data Conversion Considerations 330
Using DBCS Characters in PL/I 331
Using SQL Statements in PL/I Subroutines 331
Handling SQL Errors 332
Handling Program Interrupts 333
Using Dynamic SQL Statements in PL/I . . . 334
Defining DB2 Server for VM Data Types for PL/I 336
| Using Stored Procedures 337

Appendix F. Decision Tables to Grant Privileges on Packages 339
Contents 339
How to Use the Decision Tables 340
Decision Tables 341

Bibliography 349

Index 353

Notices

Programming Interface Information

| This manual documents intended Programming Interfaces that allow the customer
| to write programs to obtain services of DB2 Server for VM.

Trademarks

About This Manual

This preface:

- Identifies the book's audience and purpose
- Describes the book's organization
- Lists related publications
- Explains how to read the syntax diagrams
- Presents the conventions for describing MIXED data values.

Audience and Purpose of This Book

This book is for application programmers writing programs in assembler language, | C, COBOL,[1] FORTRAN, or PL/I. Throughout the book, the term host languages will often be used to refer to any or all of these particular languages.

This book assumes that you can write programs in one of these host languages in a Virtual Machine/Enterprise Systems Architecture (VM/ESA) environment. You may also find it useful to know how to use the conversational monitor system (CMS) for VM/ESA system.

The purpose of the book is to explain how to write application programs that use the Structured Query Language (SQL) to access data stored in DATABASE 2 Server for Virtual Machine/Enterprise Systems Architecture (DB2 Server for VM) tables. To achieve its purpose, the book:

- Introduces basic concepts
- Provides in-depth discussion of complex areas
- Offers tips of what to do and what not to do
- Focuses more on the Data Manipulation Language of SQL than on the Data Definition Language or the Data Control Language. (The details of the latter two components of SQL are of greater interest to the database administrator than to the application programmer.)
- Describes the host language interfaces and the preprocessor process
- Supplements the material with examples
- Acts as a reference pointer to the appropriate chapters of the *DB2 Server for VSE & VM SQL Reference* manual for details on such technical facts as naming conventions, rules, and syntax.

The REXX Interface to the DB2 Server for VM product (DB2 Server RXSQL) is a separately priced feature of this product. For information on this interface, see the *DB2 REXX SQL for VM/ESA Reference* manual.

Programmers writing in APL2 should refer to the *APL2 Programming: Using Structured Query Language* manual.

| [1] Throughout this book, COBOL is used to represent either OS/VS COBOL, VS COBOL II, or IBM COBOL for MVS and VM; except
| where noted otherwise.

Organization of This Book

The following information provides a brief description of each chapter and appendix in the book.

This preface identifies the audience, the purpose, and the use of the book.

Summary of Changes for DB2 Version 6 Release 1 describes the new features of DB2 Server for VM Version 6 Release 1.

Chapter 1, “Getting Started” on page 1 provides an overview of the application server, the SQL language that accesses the application server, and the host application languages that embed the SQL language.

Chapter 2, “Designing a Program” on page 5 describes the basic framework for designing a DB2 Server for VM application based on its three main parts: the prolog, body, and epilog.

Chapter 3, “Coding the Body of a Program” on page 17 describes the coding entered in the program body to retrieve and manipulate DB2 Server for VM data. Data retrieval is described in terms of tables, associated views, and the various means of accessing and selecting table data. Data manipulation focuses on inserting, updating, and deleting data.

Chapter 4, “Preprocessing and Running a Program” on page 103 provides information on the steps you take to preprocess and run an application program. These steps include initial preparation of the system, as well as preprocessing, compiling, link-editing, loading, and running the program.

Chapter 5, “Testing and Debugging” on page 139 shows you how to test a new program, process program errors, and monitor program execution.

Chapter 6, “Using Dynamic Statements” on page 153 describes how to dynamically process SQL statements that are specified at run time.

Chapter 7, “Using Extended Dynamic Statements” on page 179 explains how extended dynamic SQL statements can be used to create and maintain packages of SQL statements. The SQL statements that create and maintain the packages are available only in an application written in the assembler language.

Chapter 8, “Maintaining Objects Used by a Program” on page 195 discusses the management of DB2 Server for VM objects. First it describes the database space (dbspace); then it discusses the data objects used to manage the data itself, including tables, indexes, synonyms, comments, and labels.

Chapter 9, “Assigning Authority and Privileges” on page 209 explains the techniques used to control user access to, and user manipulation of, the data. A section on user access discusses granting and revoking database authority, while a section on privileges describes assigning of user privileges for tables, views and packages.

Chapter 10, “Special Topics” on page 217 covers various special topics, such as ensuring data integrity, that supplement the material in the preceding chapters.

Appendixes A through E describe information specific to each application host language.

Appendix F contains decision tables used by the system to grant privileges on packages.

The Bibliography lists the full titles and order numbers of related publications. It is followed by the Index.

Related Publications

- *DB2 Server for VSE & VM Overview*
- *DB2 Server for VSE & VM Interactive SQL Guide and Reference*
- *DB2 Server for VSE & VM Database Services Utility*
- *DB2 Server for VSE & VM Quick Reference*
- *DB2 Server for VSE & VM SQL Reference*
- *DB2 Server for VM Messages and Codes*.

You will need to consult the *DB2 Server for VSE & VM SQL Reference* manual extensively for technical details and the sample tables while working with this book. The sample tables are used for many of the examples in this book.

Syntax Notation Conventions

Throughout this manual, syntax is described using the structure defined below.

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

  The >>─── symbol indicates the beginning of a statement or command.

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

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

  The ───>< symbol indicates the end of a statement.

  Diagrams of syntactical units that are not complete statements start with the >─── symbol and end with the ───> symbol.

- Some SQL statements, Interactive SQL (ISQL) commands, or database services utility (DBS Utility) commands can stand alone. For example:

```
►►──SAVE───────────────────────────────────────────────────────────►◄
```

  Others must be followed by one or more keywords or variables. For example:

```
►►──SET AUTOCOMMIT OFF─────────────────────────────────────────────►◄
```

- Keywords may have parameters associated with them which represent user-supplied names or values. These names or values can be specified as either constants or as user-defined variables called *host_variables* (*host_variables* can only be used in programs).

```
►►──DROP SYNONYM──synonym─────────────────────────────────────────────►◄
```

- Keywords appear in either uppercase (for example, SAVE) or mixed case (for example, CHARacter). All uppercase characters in keywords must be present; you can omit those in lowercase.
- Parameters appear in lowercase and in italics (for example, *synonym*).
- If such symbols as punctuation marks, parentheses, or arithmetic operators are shown, you must use them as indicated by the syntax diagram.
- All items (parameters and keywords) must be separated by one or more blanks.
- Required items appear on the same horizontal line (the main path). For example, the parameter *integer* is a required item in the following command:

```
►►──SHOW DBSPACE──integer─────────────────────────────────────────────►◄
```

  This command might appear as:

```
SHOW DBSPACE 1
```

- Optional items appear below the main path. For example:

```
►►──CREATE──┬──────────┬──INDEX───────────────────────────────────────►◄
            └─UNIQUE───┘
```

  This statement could appear as either:

```
CREATE INDEX
```

  or

```
CREATE UNIQUE INDEX
```

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

  If you must choose one of the items, one item appears on the main path. For example:

```
►►──SHOW LOCK DBSPACE──┬─ALL──────┬───────────────────────────────────►◄
                       └─integer──┘
```

  Here, the command could be either:

```
SHOW LOCK DBSPACE ALL
```

  or

```
SHOW LOCK DBSPACE 1
```

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

```
►►──BACKWARD──┬─────────┬──────────────────────────────────────────►◄
              ├─integer─┤
              └─MAX─────┘
```

Here, the command could be:

```
BACKWARD
```

or

```
BACKWARD 2
```

or

```
BACKWARD MAX
```

- The repeat symbol indicates that an item can be repeated. For example:

```
               ┌───────┐
►►──ERASE────▼─name─┴──────────────────────────────────────────────►◄
```

This statement could appear as:

```
ERASE NAME1
```

or

```
ERASE NAME1 NAME2
```

A repeat symbol above a stack indicates that you can make more than one choice from the stacked items, or repeat a choice. For example:

```
                  ┌─,──────────────────┐
►►──VALUES──(───▼─┬─constant──────────┬┴──)──────────────────────►◄
                  ├─host_variable_list─┤
                  ├─NULL───────────────┤
                  └─special_register───┘
```

- If an item is above the main line, it represents a default, which means that it will be used if no other item is specified. In the following example, the ASC keyword appears above the line in a stack with DESC. If neither of these values is specified, the command would be processed with option ASC.

```
     ┌─ASC──┐
►►───┼──────┼──────────────────────────────────────────────────────►◄
     └─DESC─┘
```

- When an optional keyword is followed on the same path by an optional default parameter, the default parameter is assumed if the keyword is not entered.

However, if this keyword is entered, one of its associated optional parameters must also be specified.

In the following example, if you enter the optional keyword PCTFREE =, you also have to specify one of its associated optional parameters. If you do not enter PCTFREE =, the database manager will set it to the default value of 10.

```
     ┌─PCTFREE = 10──────┐
►►───┼───────────────────┼──────────────────────────────────────────────►◄
     └─PCTFREE = integer─┘
```

- Words that are only used for readability and have no effect on the execution of the statement are shown as a single uppercase default. For example:

```
                ┌─PRIVILEGES─┐
►►──REVOKE ALL──┴────────────┴──────────────────────────────────────────►◄
```

Here, specifying either REVOKE ALL or REVOKE ALL PRIVILEGES means the same thing.

- Sometimes a single parameter represents a fragment of syntax that is expanded below. In the following example, **fieldproc_block** is such a fragment and it is expanded following the syntax diagram containing it.

```
►►──┬──────────────────────────────┬──┤ fieldproc_block ├─────────────►◄
    └─NOT NULL──┬───────────────┬──┘
                ├─UNIQUE────────┤
                └─PRIMARY KEY───┘
```

```
fieldproc_block:
├──FIELDPROC──program_name──┬──────────────────────────┬────────────────┤
                            │      ┌─,──────────┐      │
                            └─(────▼─constant───┴──)───┘
```

SQL Reserved Words

The following words are reserved in the SQL language. They cannot be used in SQL statements except for their defined meaning in the SQL syntax or as host variables, preceded by a colon.

In particular, they cannot be used as names for tables, indexes, columns, views, or dbspaces unless they are enclosed in double quotation marks (").

ACQUIRE
ADD
ALL
ALTER
AND
ANY
AS
ASC
AVG

BETWEEN
BY

CHAR
CHARACTER
COLUMN
COMMENT
COMMIT
CONCAT
CONNECT
COUNT
CREATE
CURRENT

DBA
DBSPACE
DELETE
DESC
DISTINCT
DOUBLE
DROP

EXCLUSIVE
EXECUTE
EXISTS
EXPLAIN

FIELDPROC
FOR
FROM

GRANT
GRAPHIC
GROUP

HAVING

IDENTIFIED
IN
INDEX
INSERT
INTO
IS

LIKE
LOCK
LONG

MAX
MIN
MODE

NAMED
NHEADER
NOT
NULL

OF
ON
OPTION
OR
ORDER

PACKAGE
PAGE
PAGES
PCTFREE
PCTINDEX
PRIVATE
PRIVILEGES
PROGRAM
PUBLIC

RESOURCE
REVOKE
ROLLBACK
ROW
RUN

SCHEDULE
SELECT
SET
SHARE
SOME
STATISTICS
STORPOOL
SUM
SYNONYM

TABLE
TO

UNION
UNIQUE
UPDATE
USER

VALUES
VIEW

WHERE
WITH
WORK

Conventions for Representing DBCS Characters

When MIXED data values are shown in examples then the following conventions are used:

Convention	**Meaning**
<	Represents the DBCS delimiter character X `'0E'`.
>	Represents the DBCS delimiter character X `'0F'`.
x	Represents an SBCS character (x can be any lowercase letter).
XX	Represents a DBCS character (XX can be any double-byte uppercase letter).

Components of the Relational Database Management System

Figure 1 depicts a typical configuration with one database and two users.

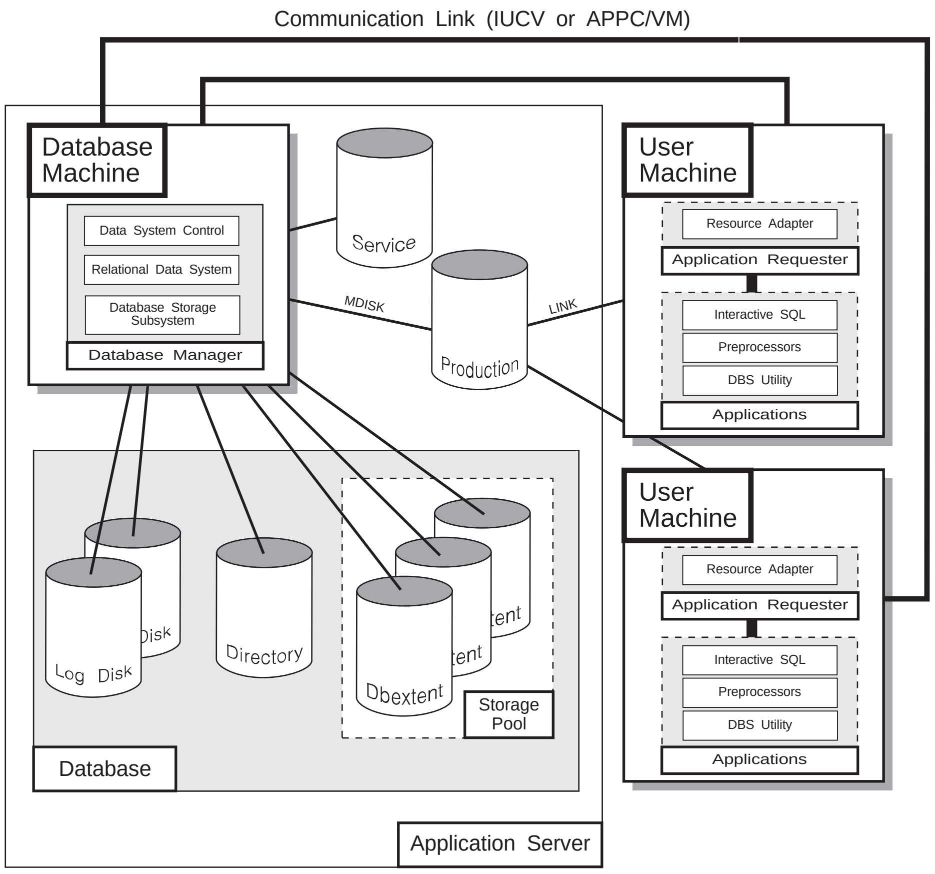


Figure 1. Basic Components of the RDBMS

The **database** is composed of:

- A collection of data contained in one or more *storage pools*, each of which in turn is composed of one or more *database extents (dbextents).* A dbextent is a VM minidisk.
- A *directory* that identifies data locations in the storage pools. There is only one directory per database.
- A *log* that contains a record of operations performed on the database. A database can have either one or two logs.

The **database manager** is the program that provides access to the data in the database. It is loaded into the database virtual machine from the production disk.

The **application server** is the facility that responds to requests for information from and updates to the database. It is composed of the database and the database manager.

The **application requester** is the facility that transforms a request from an application into a form suitable for communication with an application server.

Summary of Changes for DB2 Version 6 Release 1

This is a summary of the technical changes to the DB2 Server for VSE & VM Version 6 Release 1 database management system. All manuals are affected by some or all of the changes discussed here. This summary does not list incompatibilities between releases of the DB2 Server for VSE & VM product; see either the *DB2 Server for VSE & VM SQL Reference*, *DB2 Server for VM System Administration*, or the *DB2 Server for VSE System Administration* manuals for a discussion of incompatibilities. Version 6 Release 1 of the DB2 Server for VSE & VM database management system is intended to run on the Virtual Machine/Enterprise Systems Architecture (VM/ESA®) Version 2 Release 2 or later environment and on the Virtual Storage Extended/Enterprise Systems Architecture (VSE/ESA™) Version 2 Release 2 or later environment.

Enhancements, New Functions, and New Capabilities

DRDA® RUOW Application Requestor for VSE (Online)

DRDA Remote Unit of Work Application Requestor provides read and update capability in one location in a single unit of work.

This support provides CICS/VSE® online application programs with the ability to execute SQL statements to access and manipulate data managed by any remote application server that implements the DRDA architecture. Online application programs that access remote application servers need to be preprocessed to create a bind file and then bound (using CBND) to the remote application server. Online application programs that access a local application server are preprocessed as in previous releases.

See the following DB2 Server for VSE & VM manuals for further information:

- *DB2 Server for VSE System Administration*
- *DB2 Server for VSE & VM SQL Reference*
- *DB2 Server for VSE Database Administration*
- *DB2 Server for VSE Application Programming*
- *DB2 Server for VSE Installation*

Stored Procedures

The ability to use stored procedures provides distributed solutions that let more people access data faster.

A stored procedure is a user-written application program compiled and stored at the server. When the database is running in multiple user mode, local applications or remote DRDA applications can invoke the stored procedure. SQL statements are local to the server and issued by a stored procedure so they do not incur the high network costs of distributed statements. Instead, a single network send and receive operation is used to invoke a series of SQL statements contained in a stored procedure.

See the following DB2 Server for VSE & VM manuals for further information:

- *DB2 Server for VM System Administration*
- *DB2 Server for VM Database Administration*
- *DB2 Server for VSE & VM SQL Reference*
- *DB2 Server for VSE & VM Operation*

TCP/IP Support for DB2 Server for VM

TCP/IP support allows:

- VM applications to use SQLDS-private protocol to connect to VM databases over TCP/IP.
- VM applications to use DRDA protocol to connect to DB2 family databases (and any other database that supports DRDA connections) over TCP/IP.
- non-VM applications to use DRDA-protocol to access VM database over TCP/IP.

TCP/IP support for DB2 Server for VM integrated with the DB2 Server for VM application server means a system easier to configure and maintain.

The database manager will optionally secure TCP/IP connections using any external security manager that supports the RACROUTE interface.

New Code Page and Euro Symbol Code Page Support

The following CCSIDs are now supported:

- 1112: Latvian/Lithuanian
- 1122: Estonian
- 1123: Ukrainian
- 1130: Vietnamese
- 1132: Lao
- 1148: E-International
- 1140: E-English
- 1141: E-German
- 1144: E-Italian
- 1146: E-UK-English
- 1147: E-French

Additional support has been added for conversions from Unicode (UCS-2) to host CCSIDs.

For a complete list of CCSIDs supported refer to the *DB2 Server for VM System Administration* and *DB2 Server for VSE System Administration* manuals.

DataPropagator™ Capture

DataPropagator Capture is part of the DB2 Family of DataPropagator products. DataPropagator Capture is updated for Version 6 Release 1 compatibility.

QMF for VM, QMF for VSE, and QMF for Windows®

IBM Query Management Facility (QMF™) is now an separately priced feature of DB2 Server for VSE & VM. QMF is a tightly integrated, powerful, and reliable tool that performs query and reporting for IBM's DB2 relational database Management System Family. It offers an easy-to-learn, interactive interface. Users with little or no data processing experience can easily retrieve, create, update, insert, or delete data that is stored in DB2.

QMF offers a total solution that includes accessing large amounts of data and sharing central repositories of queries and enterprise reports. It also allows you to implement tightly-controlled, distributed, or client-server solutions. In addition, you can use QMF to publish reports to the World Wide Web that you can view with your favorite web browser.

Using QMF, users can access a wide variety of data sources, including operational or warehouse data from many platforms: DB2 for VSE, VM, OS/390® and Windows. Via IBM Data Joiner, you can access non-relational data, such as IMS™ and VSAM, as well as data from other vendor platforms.

RDS Above the Line

The RDS component will load and execute above the 16 megabyte line. This support frees up approximately 1.5 megabytes of storage below the 16 megabyte line (or approximately 2.5 megabytes, if DRDA is installed) when compared to Version 5 Release 1. No installation or migration changes are required for this support to be used (except for the definition of VM Shared Segments and for users who execute the database server with AMODE(24)). If sufficient storage is available, the RDS component will be automatically loaded above the 16 megabyte line. When using VM Shared Segments, the RDS Segment should be defined above the 16 megabyte line.

VM users who wish to run the database server in 24-bit addressing mode (i.e. use the AMODE(24) parameter) **must** use a virtual storage size no greater than 16 megabytes. See the *DB2 Server for VM System Administration* or *DB2 Server for VSE System Administration* for release to release incompatibility information.

Combining of NLS Feature Installation Tapes with Base Product Installation Tape

All available NLS features for DB2 Server for VSE, DB2 Server for VM, Control Center for VSE and REXX SQL for VM have been combined with the respective base product installation tape. Customers interested in an NLS feature language will no longer need to order an additional NLS feature tape because all NLS languages will be available to all customers. In all cases, the default language as shipped is American English. The installation and migration processes have been changed to allow you to choose the default language. Refer to the *DB2 Server for VM Program Directory*, *DB2 Server for VSE Installation*, *DB2 for VSE Control Center Installation and Operations Guide*, and *DB2 REXX SQL for VM/ESA Installation* for the details of how these changes affect the installation process and how you can choose to have a different default language.

Control Center Feature

DB2 Server for VSE & VM Version 6 Release 1 enhances the new Control Center feature as follows:

For both VM/ESA and VSE/ESA:

- Access to the Query Management Facility (QMF)

For VM/ESA:

- Compatibility with DB2 Server for VM Version 6 Release 1 initialization parameters and operator commands
- Shared File System Support (SFS) in a VM/ESA environment
- CA-DYNAM/T Interface Support in a VM/ESA environment
- Data Restore Incremental Backup Support in a VM/ESA environment

For VSE/ESA:

- Control Center code installation on any library
- Ability to use while viewing a list of tables online
- Ability to create, reorganize, unload, reload, move and copy tables in batch mode
- Ability to update table statistics in batch mode
- Ability to drop tables online

Data Restore Feature

The Data Restore feature provides archiving and recovery functions in addition to those provided in DB2 for VSE & VM. Data Restore is enhanced in Version 6 Release 1 with incremental database archiving support. The support allows you to archive only the areas of the database that have been updated since the last database archive, instead of having to archive the entire database. This can provide significant savings for customers with large databases which are updated infrequently, or where only a small fraction of the database is updated frequently.

DB2 REXX SQL Feature

The DB2 REXX SQL feature provides a REXX interface for VM customers to allow SQL calls to be executed from REXX programs. The DB2 REXX SQL feature is updated for Version 6 Release 1 compatibility.

Reliability, Availability, and Serviceability Improvements

Migration Considerations

Migration is supported from SQL/DS™ Version 3 and DB2 Server for VSE & VM Version 5. Migration from SQL/DS Version 2 Release 2 or earlier releases is not supported. Refer to the *DB2 Server for VM System Administration* or *DB2 Server for VSE System Administration* manual for migration considerations.

Library Enhancements

Some general library enhancements include:

- The following books have been removed from the library:
  - *DB2 Server for VM Operation*
  - *DB2 Server for VSE Operation*
  - *DB2 Server for VM Interactive SQL Guide and Reference*
  - *DB2 Server for VSE Interactive SQL Guide and Reference*
  - *DB2 Server for VM Database Services Utility*
  - *DB2 Server for VSE Database Services Utility*
- The following books have been added to the library:
  - *DB2 Server for VSE & VM Operation*
  - *DB2 Server for VSE & VM Interactive SQL Guide and Reference*
  - *DB2 Server for VSE & VM Database Services Utility*

Refer to the new *DB2 Server for VSE & VM Overview* for a better understanding of the benefits DB2 Server for VSE & VM can provide.

Chapter 1. Getting Started

Contents

What is the DB2 Server for VM Product? 2
What is SQL? 3
  Embedding SQL Statements in Host Language Programs 3
    Using DB2 Server RXSQL 3
Writing a Program 4

What is the DB2 Server for VM Product?

The DB2 Server for VM product is a database management system that uses the relational data model. You can think of a relational data model as a collection of ordinary two-dimensional tables, where each table has a specific number of columns, unordered rows, and a specific item of data at the intersection of every column and row. You access data by performing operations on tables. All you need to know are the names of tables and of the columns that contain the desired data.

The sample tables in Appendix G of the *DB2 Server for VSE & VM SQL Reference* manual are used in examples throughout this manual. In Figure 2, the DEPARTMENT table has columns DEPTNO, DEPTNAME, MGRNO, and ADMRDEPT.

Figure 2. DEPARTMENT Table Contents

DEPTNO	DEPTNAME	MGRNO	ADMRDEPT
A00	SPIFFY COMPUTER SERVICE DIV.	000010	A00
B01	PLANNING	000020	A00
C01	INFORMATION CENTER	000030	A00
D01	DEVELOPMENT CENTER	?	A00
D11	MANUFACTURING SYSTEMS	000060	D01
D21	ADMINISTRATION SYSTEMS	000070	D01
E01	SUPPORT SERVICES	000050	A00
E11	OPERATIONS	000090	E01
E21	SOFTWARE SUPPORT	000100	E01

Suppose, for example, you want a list of all the different departments (DEPTNAME) in your company. You could get this information simply by knowing the name of the table DEPARTMENT and of the column DEPTNAME that the data is in, and coding this in an appropriate SQL statement.

You can use the DB2 Server for VM database management system under any supported Virtual Machine (VM) operating system. Application programs running under VM can be:

- Online programs that operate in virtual machines and are controlled by the conversational monitor system (CMS).
- Noninteractive programs that operate in virtual machines in VM.

You can also write distributed applications that can access multiple application servers, as well as application servers other than DB2 Server for VSE & VM such as DB2 for MVS. The DB2 Server for VM application server is the facility that receives and processes requests to access data.

For a discussion of terms and concepts, such as application server, that are used throughout this manual, refer to the *DB2 Server for VSE & VM Overview*, the *DB2 Server for VSE & VM SQL Reference*, and the *DRDA: Every Manager's Guide* manuals.

What is SQL?

DB2 Server for VM data is handled by the Structured Query Language (SQL), which contains statements that retrieve, delete, insert, and update tables in a DB2 Server for VM database. You can embed these statements in application programs
| written in any of the following *host languages*: assembler language, C, COBOL, FORTRAN, PL/I, or REXX.

These SQL statements do all data handling, thereby decreasing the data handling done by the programs themselves. Programs that access DB2 Server for VM data can also access it from other sources, such as CMS files.

Embedding SQL Statements in Host Language Programs

Programs that use the DB2 Server for VM database management system are *host programs* because they act as hosts for SQL. How you embed SQL statements varies for each of the supported host languages.

The core of SQL is the same for each host language. For this reason, the SQL statements are presented throughout this book in *basic form* unless otherwise noted: that is, without any of the language-dependent delimiters.

In this book, examples that have combinations of SQL statements and host language statements are shown in a language-independent form called *pseudocode*. Pseudocode shows program logic but must be recoded in a specific programming language before it can be used. When SQL statements are shown in pseudocode examples, they are preceded by the words EXEC SQL to help you distinguish them from the pseudocode. When shown by themselves, they are not preceded by these words.

To use SQL statements in a programming language, you must be familiar with the rules for embedding them in that language. These rules are discussed in Appendixes A through F (one for each language).

You should browse through the appropriate appendix before you continue reading, and refer to it as needed when you are ready to code your first DB2 Server for VM application. You can also refer to Chapter 6 of the *DB2 Server for VSE & VM SQL Reference* manual for information on SQL statements.

Using DB2 Server RXSQL

The REXX Interface Installation (DB2 Server RXSQL) extends the support of the database manager to include REXX as a host language. SQL statements are supported in DB2 Server RXSQL by DB2 Server RXSQL requests that are imbedded in REXX programs. Because REXX is an interpretive language, DB2 Server RXSQL requests do not need to be preprocessed or compiled before they are run. You can compile REXX programs, but this has no effect on the DB2 Server RXSQL requests. You can use DB2 Server RXSQL to:

- Make prototypes and test application programs
- Write application programs for production environment

- Write interpretive as well as compiled code.

For a discussion of application programming using REXX, refer to the *DB2 REXX SQL for VM/ESA Reference* manual.

Writing a Program

Writing a program that accesses DB2 Server for VM data consists of the following steps: **Designing** the program entails determining what tasks the program must perform, and then creating a plan for the program to perform these tasks. The structure of the program should be based on its three main parts: prolog, body, and epilog. **Coding** the program entails using SQL statements and tools to manipulate DB2 Server for VM data. The operations on the data must conform to the design of the program. **Preparing** the program for execution entails preprocessing, compiling, link-editing, and loading it. **Testing** and **debugging** the program entails:

- Executing the program using test data
- Checking the results
- Identifying errors created in the previous steps
- Correcting the errors.

Releasing the program entails putting it into production (that is, making it available to its intended users). In this step, you control who will be allowed to run the program and to work with the data that it accesses.

Chapter 2. Designing a Program

Contents

Defining the Main Parts of a Program . . . 6
  Creating the Prolog . . . 6
    Declaring Variables That Interact with the Database Manager . . . 6
      Relating Host Variables to an SQL Statement . . . 6
    Handling Errors with the SQL Communications Area . . . 9
    Using Additional Nonexecutable Statements . . . 10
  Creating the Body . . . 10
    Connecting to the Application Server . . . 10
    Defining Objects . . . 11
    Manipulating Objects . . . 11
    Controlling Application Server Resources . . . 11
    Granting Authorities and Privileges . . . 12
  Creating the Epilog . . . 12
    Ending the Program . . . 12
Using Logical Units of Work . . . 13
  Defining the Logical Unit of Work . . . 13
  Beginning a Logical Unit of Work . . . 13
  Ending a Logical Unit of Work . . . 13
    Using the COMMIT Statement . . . 13
    Using the ROLLBACK Statement . . . 14
Summary . . . 14
Using Host-Dependent Sample Applications . . . 15

Defining the Main Parts of a Program

A DB2 Server for VM application program contains three main parts: the prolog, the body, and the epilog. Certain SQL statements must appear at the beginning and end of the program to handle the transition from the host language to the embedded SQL statements.

The prolog is at the beginning of every program and must contain:

- SQL statements that provide for error handling by setting up the SQL communications area or by declaring an SQLCODE variable.
- Declarations of all variables that the database manager uses to interact with the host program.

The body contains the SQL statements that will enable you to access and manage data. Among the statements included in this section are:

- The CONNECT statement, which establishes a connection to an application server
- Data manipulation statements (for example, the select-statement)
- Data definition statements (for example, the CREATE statement)
- Data control statements (for example, the GRANT statement).

The epilog is at the end of the application program, and contains SQL statements that:

- Save (commit) or do not use (rollback) changes made to data.
- Release the program’s connection to the application server.

Creating the Prolog

Declaring Variables That Interact with the Database Manager

All host program variables that interact with the database manager must be declared in an SQL declare section. A program may contain multiple SQL declare sections. An SQL declare section is a group of host program variable declarations that are preceded by the SQL statement `BEGIN DECLARE SECTION` and followed by the SQL statement `END DECLARE SECTION`. Host program variables declared in an SQL declare section are host variables and can be used in host-variable references in SQL statements.

The attributes of each host variable depend on how the variable is used in the SQL statement. For example, variables that receive data from or store data in DB2 Server for VM tables must have data type and length attributes compatible with the column being accessed. To determine the data type for each variable, you must be familiar with DB2 Server for VM data types, shown in Figure 22 on page 39. Each column of every table is assigned a data type when the table is created.

Relating Host Variables to an SQL Statement: Host variables can be used to receive data from the database manager or to transfer data from the host program to the database manager. Host variables that receive data from the database manager are **output host variables**. Host variables that transfer data from the host program to the database manager are **input host variables**.

Consider the following SELECT INTO statement:

```
SELECT HIREDATE, EDLEVEL
INTO :HDATE, :LVL
FROM EMPLOYEE
WHERE EMPNO = :IDNO
```

It contains two output host variables, HDATE and LVL, and one input host variable, IDNO. The database manager uses the data stored in the host variable IDNO to determine the EMPNO of the row that is retrieved from the EMPLOYEE table If a row that meets the search criteria is found, HDATE and LVL receive the data stored in the columns HIREDATE and EDLEVEL respectively. This statement illustrates an interaction between the host program and the database manager using columns of the EMPLOYEE table.

Each column of a table is assigned a data type and each data type can be related to a host language data type. For example, the INTEGER data type is a 31-bit binary integer. This is equivalent to the following data description entries in each of the host languages, respectively:

COBOL:

```
01  variable-name  PICTURE S9(9) COMPUTATIONAL.
```

Assembler:

```
variable-name   DS     F
```

C:

```
long variable-name;
```

FORTRAN

```
INTEGER variable-name
```

PL/I:

```
DCL variable-name BINARY FIXED(31);
```

All the host language equivalents for a particular DB2 Server for VM data type are listed at the end of each host language appendix.

After you determine which column a host variable interacts with, you need to find out what DB2 Server for VM data type that column has. Do this by querying the DB2 Server for VM catalog, which is a set of tables containing information about all tables created in the database. This catalog is described in the *DB2 Server for VSE & VM SQL Reference* manual.

After you have determined the data types, you can refer to the conversion charts at the end of the host language appendixes, and code the appropriate declarations. Figure 3 shows the declarations in each host language.

Figure 3 (Page 1 of 2). Examples of Declarations and Embedded SQL Statements

Assembler

```
Col. 1         Col. 16                          Col. 72
     |               |                                 |
      EXEC SQL   BEGIN DECLARE SECTION
     HDATE   DS  CL10
     LVL     DS  H
     IDNO    DS  CL6
      EXEC SQL   END DECLARE SECTION
      EXEC SQL   INCLUDE SQLCA
      EXEC SQL   WHENEVER SQLERROR GOTO ERRCHK
      EXEC SQL   SELECT HIREDATE, EDLEVEL              *
                     INTO :HDATE, :LVL                 *
                     FROM EMPLOYEE                     *
                     WHERE EMPNO = :IDNO
     .
     .
     .
     ERRCHK
```

C

```
  EXEC SQL BEGIN DECLARE SECTION;
         char  HDATE[11];
         short LVL;
         char  IDNO[7];
  EXEC SQL END DECLARE SECTION;
  EXEC SQL INCLUDE SQLCA;
  EXEC SQL WHENEVER SQLERROR GOTO ERRCHK;
  EXEC SQL SELECT HIREDATE, EDLEVEL
           INTO :HDATE, :LVL
           FROM EMPLOYEE
           WHERE EMPNO = :IDNO;
         .
         .
         .
  ERRCHK: errout();
```

COBOL

```
Cols. 8  12
      |   |
      DATA DIVISION.

      FILE SECTION.

      WORKING-STORAGE SECTION.
          EXEC SQL BEGIN DECLARE SECTION END-EXEC.
          01  HDATE       PICTURE X(10).
          01  LVL         PICTURE S9(4) COMPUTATIONAL.
          01  IDNO        PICTURE X(6).
          EXEC SQL END DECLARE SECTION END-EXEC.
          EXEC SQL INCLUDE SQLCA END-EXEC.

      PROCEDURE DIVISION.
          EXEC SQL WHENEVER SQLERROR GOTO ERRCHK END-EXEC.
          EXEC SQL SELECT HIREDATE, EDLEVEL
                   INTO :HDATE, :LVL
                   FROM EMPLOYEE
                   WHERE EMPNO = :IDNO END-EXEC.
           .
           .
           .
      ERRCHK.
```

Figure 3 (Page 2 of 2). Examples of Declarations and Embedded SQL Statements

FORTRAN	
	```
	Col. 7
	     |
	     EXEC SQL BEGIN DECLARE SECTION
	     CHARACTER*10   HDATE
	     INTEGER*2      LVL
	     CHARACTER*6    IDNO
	     EXEC SQL END DECLARE SECTION
	     EXEC SQL INCLUDE SQLCA
	     EXEC SQL WHENEVER SQLERROR GOTO 4000
	     EXEC SQL SELECT HIREDATE, EDLEVEL
	    *         INTO :HDATE, :LVL
	    *         FROM EMPLOYEE
	    *         WHERE EMPNO = :IDNO
	            .
	            .
	            .
	4000 CONTINUE
	```

PL/I	
	```
	Col. 2
	     |
	     EXEC SQL BEGIN DECLARE SECTION;
	         DCL HDATE CHARACTER(10);
	         DCL LVL   BINARY FIXED(15);
	         DCL IDNO  CHARACTER(6);
	     EXEC SQL END DECLARE SECTION;
	     EXEC SQL INCLUDE SQLCA;
	     EXEC SQL WHENEVER SQLERROR GOTO ERRCHK;

	     EXEC SQL SELECT HIREDATE, EDLEVEL
	              INTO :HDATE, :LVL
	              FROM EMPLOYEE
	              WHERE EMPNO = :IDNO;
	            .
	            .
	            .
	     ERRCHK:
	```

Observe how the delimiters for SQL statements differ for each language. For the exact rules of placement, continuation, and delimiting of these statements, see the appendixes of this book.

Handling Errors with the SQL Communications Area

The SQL Communications Area (SQLCA) is discussed in detail in “Using the Automatic Error-Handling Facilities” on page 141. This section presents an overview. To declare the SQLCA, code this statement in your program:

```
INCLUDE SQLCA
```

When you preprocess your program, the database manager inserts host language variable declarations in place of the INCLUDE SQLCA statement. The system communicates with your program using the variables for warning flags, error codes, and diagnostic information.

The system returns a return code in SQLCODE after executing each SQL statement. The SQLCODE is an integer value that summarizes the execution of the statement. Refer to the *DB2 Server for VSE & VM SQL Reference* manual for a detailed description of the SQLCODE field. Refer to the *DB2 Server for VM Messages and Codes* manual for information about specific SQLCODEs.

A return code is also returned in SQLSTATE after each SQL statement is executed. SQLSTATE is a character field that provides common error codes across IBM's relational database products. SQLSTATE values comply with the SQL92 standard. For a discussion of SQLSTATE, refer to the *DB2 Server for VSE & VM SQL Reference* manual. For more information about specific SQLSTATEs, refer to the *DB2 Server for VM Messages and Codes* manual.

When a statement is executed successfully, SQLCODE is set to `0` (SQLSTATE is `'00000'`). A negative SQLCODE indicates an error condition. Positive SQLCODES indicate that a statement has executed successfully but a warning code may be issued which means that you must verify whether the SQL statement was executed without unexpected results.

The system supports the use of a stand-alone SQLCODE. If you request this support, do not include the SQLCA definition in your program. However, you must provide the integer variable SQLCODE (SQLCOD in FORTRAN). For a detailed discussion, see “Using the Automatic Error-Handling Facilities” on page 141.

If you want the system to control error checking after each SQL statement, use the WHENEVER statement. The following WHENEVER statement indicates to the system what to do when it encounters a negative SQLCODE:

```
WHENEVER SQLERROR GO TO errchk
```

That is, whenever an SQL error (SQLERROR) occurs, program control is transferred to code that follows a specific label, such as ERRCHK. This code should include logic to analyze the error indicators in the SQLCA. Depending upon the ERRCHK definition, action may be taken to execute the next sequential program instruction, to perform some special functions, or, as in most situations, to roll back the current *logical unit of work* (LUW) and terminate the program. See “Using Logical Units of Work” on page 13 for more information on LUWs.

Using Additional Nonexecutable Statements

Generally, other *nonexecutable* SQL statements are also part of the prolog. These are discussed later in this manual, and in the *DB2 Server for VSE & VM SQL Reference* manual. Examples of other nonexecutable statements are:

- INCLUDE *text_file_name*
- INCLUDE SQLDA

Creating the Body

Connecting to the Application Server

Your program must establish a connection to the application server before it can run any executable SQL statements. This connection identifies the authorization ID of the user who is running the program, and the name of the application server on which the program will be run.

The program can establish the connection in two ways:

- Issue the CONNECT statement to explicitly request the connection.

  You can then specify the authorization ID and the name of the target application server. See the *DB2 Server for VSE & VM SQL Reference* manual for a detailed discussion of the CONNECT statement. Not all forms of the CONNECT statement are available when you are using DRDA protocol.

- Allow the application requester to connect implicitly, using the VM logon ID established by the SQLINIT command.

The authorization ID established by the connection must have been granted both the privilege to execute the program’s package and CONNECT authority for the target application server. The package has authority to perform the actions specified in the statements in the program if the owner of the package has the authority.

Defining Objects

The following are some of the statements that you can use to create and drop database objects such as tables, indexes, and synonyms. (These statements are discussed in Chapter 8, “Maintaining Objects Used by a Program” on page 195.)

- CREATE TABLE
- DROP TABLE
- ALTER TABLE
- CREATE INDEX
- DROP INDEX
- CREATE VIEW
- DROP VIEW
- CREATE SYNONYM
- DROP SYNONYM
- | CREATE PROCEDURE
- | ALTER PROCEDURE
- | DROP PROCEDURE
- | CREATE PSERVER
- | ALTER PSERVER
- | DROP PSERVER

Manipulating Objects

The following are some of the statements that you can use to manipulate database objects:

- SELECT
- INSERT
- UPDATE
- DELETE

These statements are discussed in detail in Chapter 3, “Coding the Body of a Program” on page 17 .

Note: Refer to the *DB2 Server for VSE & VM SQL Reference* manual for a description of select-statements.

Controlling Application Server Resources

The following are some of the statements that you can use to manage logical units of work, dbspaces, and locks:

- CONNECT
- ACQUIRE DBSPACE
- DROP DBSPACE
- ALTER DBSPACE
- UPDATE STATISTICS

Granting Authorities and Privileges

There are two statements to use to assign and withdraw privileges on objects or authorities to user IDs:

- GRANT
- REVOKE

They are discussed in detail in Chapter 9, “Assigning Authority and Privileges” on page 209.

Creating the Epilog

Ending the Program

The application epilog is the logical end of your DB2 Server for VM application program. To properly end your program:

1. End the current logical unit of work (if one is in progress) by explicitly issuing either a COMMIT statement if you want the changes to be committed (saved in the database), or a ROLLBACK statement if you do not want them to be saved.
2. Release your connection to the application server.

Although an implicit COMMIT or ROLLBACK statement is automatic for any application that accesses an application server, you should still issue an explicit COMMIT or ROLLBACK statement. For DB2 Server for VM application programs that are not executed through an EXEC, implicit COMMIT or ROLLBACK processing occurs when the application program is completed. For those that are executed through an EXEC, this processing does not occur until the EXEC is completed. To sever the connection and cause the COMMIT or ROLLBACK to take effect from an EXEC, the SQLRMEND EXEC must be invoked. See “Invoking Applications in CMS SUBSET” on page 230 for limitations on the use of SQLRMEND, and the *DB2 Server for VM Database Administration* manual for more information on this EXEC.

When an implicit COMMIT or ROLLBACK is invoked, the logical unit of work will be committed if the termination was normal, or rolled back if the termination was abnormal. An application is terminated normally when it returns to CMS or, in single virtual machine mode, to the DB2 Server for VM calling routine. Any other kind of termination, such as HX, CMS abend, program check, or any user machine termination, is abnormal.

In the VM environment, user-written interactive SQL applications are provided with an inherent facility to cancel an SQL statement without terminating the running application. This cancelation facility is invoked with the SQLHX immediate command established by the DB2 application requester. The only special processing ability required of the application is that it be sensitive to the -914 SQLCODE (SQLSTATE `'57014'`). If the user ID and password were established with an explicit SQL CONNECT, you must reissue the CONNECT statement. If you do not, the user ID password and application server revert to the value established by the implicit CONNECT.

The application can modify the basic cancel facility by defining additional names for the DB2 Server for VM-defined SQLHX command or by requesting the system to remove the SQLHX command and the exit it invokes. Use the ARIRCAN macro to do these modifications. For more details on the ARIRCAN macro interface (RMXC) and the SQLHX command, see the *DB2 Server for VM System Administration* manual.

For more information on CMS, consult the *VM/ESA: CMS Command Reference* or the *VM/ESA: CMS User's Guide* manuals.

Using Logical Units of Work

Defining the Logical Unit of Work

A logical unit of work (LUW) is a sequence of SQL statements (possibly with intervening host language code) that the database manager treats as a whole.

The system ensures the consistency of data at the LUW level, by ensuring that either *all* operations within an LUW are completed, or *none* are completed. Suppose, for example, that money is to be deducted from one account and added to another. If both these updates are placed in a single LUW, and if a system failure occurs while they are in progress, then when the system is restarted, the data is automatically restored to the state it was in before the LUW began. If a program error occurs, all changes made by the statement in error are restored. Work done in the LUW prior to execution of the statement in error is not undone, unless you specifically roll it back. To determine whether the LUW terminated automatically, you should check the value of SQLWARN6 in the SQLCA. See "Using the Automatic Error-Handling Facilities" on page 141 for more information.

Note: All SQL statements within an LUW must access the same application server.

Beginning a Logical Unit of Work

An LUW is begun implicitly with the first *executable* SQL statement and is ended by either a COMMIT or a ROLLBACK statement, or when the program ends.

The following are examples of statements that do not start a logical unit of work:

```
BEGIN DECLARE SECTION          INCLUDE SQLCA
END DECLARE SECTION            INCLUDE SQLDA
WHENEVER
```

An executable SQL statement always occurs within an LUW. If such a statement is encountered after you end an LUW, it automatically starts another.

Ending a Logical Unit of Work

When you end an LUW, you can use either the COMMIT statement to save its changes, or the ROLLBACK statement to ensure that these changes are not saved.

Using the COMMIT Statement

This statement ends the current LUW, and commits any changes made during it.

Changes should be committed as soon as application requirements permit. In particular, programs should be written so that uncommitted changes are not held over a terminal read request, which can result in locks and other resources being held for a long time.

Each application program must explicitly end its LUW before terminating. If you do not end it explicitly, the system automatically commits (upon successful termination of the program) all changes made by the program during its pending LUW unless one of the following conditions occurs:

- A log full condition is encountered.
- Some other system condition occurs that causes database manager processing to end.
- Control is not returned to CMS. For a discussion of this subject, see the section on the SQLRMEND EXEC in the *DB2 Server for VM Database Administration* manual.

See “Creating the Epilog” on page 12 and “Using the Automatic Error-Handling Facilities” on page 141 for more information about program termination.

Note: The COMMIT statement has no effect on the contents of host variables.

Using the ROLLBACK Statement

This statement ends the current LUW, and restores the data to the state it was in prior to the LUW beginning.

Note: The ROLLBACK statement has no effect on the contents of host variables.

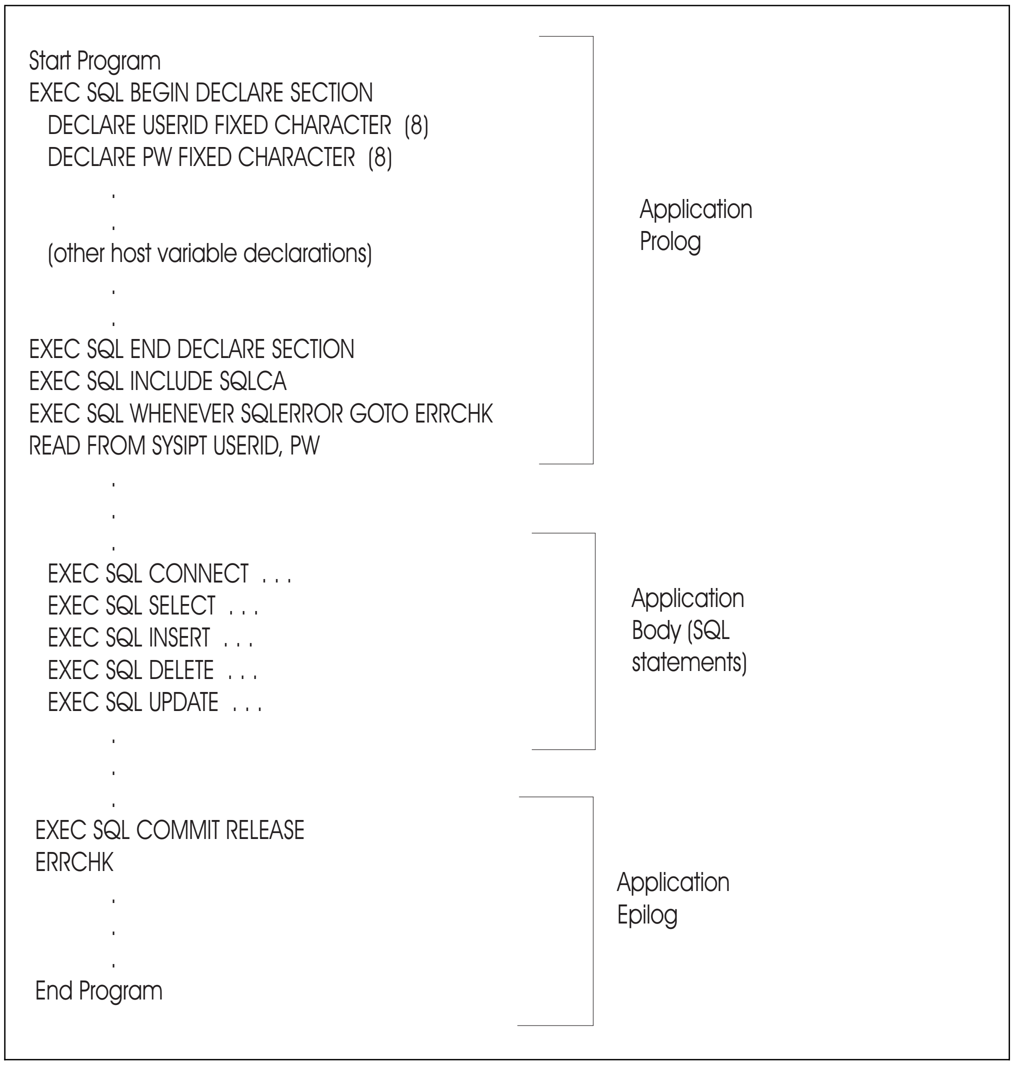
Under some circumstances, the system automatically backs out of an LUW. Refer to “Automatically Locking Dbspaces” on page 200 for more information.

Note: If you use a ROLLBACK statement in a routine that was entered because of an error or warning and you use the SQL WHENEVER statement, specify WHENEVER SQLERROR CONTINUE and WHENEVER SQLWARNING CONTINUE before the ROLLBACK. This avoids a program loop if the ROLLBACK fails with an error or warning.

The ROLLBACK statement should not be issued if a severe error occurs (indicated by an S in the SQLWARN0 field of the SQLCA). The only statement that can be issued after a severe error is a CONNECT statement.

Summary

Figure 4 on page 15 summarizes the general framework for a DB2 Server for VM application in pseudocode format. This framework must, of course, be tailored to suit your own program.



```
Start Program
EXEC SQL BEGIN DECLARE SECTION
  DECLARE USERID FIXED CHARACTER  (8)
  DECLARE PW FIXED CHARACTER  (8)
          .
          .
  (other host variable declarations)
          .
          .
EXEC SQL END DECLARE SECTION
EXEC SQL INCLUDE SQLCA
EXEC SQL WHENEVER SQLERROR GOTO ERRCHK
READ FROM SYSIPT USERID, PW
          .
          .
          .
  EXEC SQL CONNECT  . . .
  EXEC SQL SELECT  . . .
  EXEC SQL INSERT  . . .
  EXEC SQL DELETE  . . .
  EXEC SQL UPDATE  . . .
          .
          .
          .
 EXEC SQL COMMIT RELEASE
 ERRCHK
          .
          .
          .
 End Program
```

Figure 4. Pseudocode Framework for Coding Programs

Using Host-Dependent Sample Applications

Some host-dependent sample application programs and the EXECs that can be used to preprocess, compile, link-edit, and run them are shipped with this product. These programs manipulate data in the tables by using embedded SQL statements and printing the results. You may want to model your initial programs from these sample applications. See Figure 5 for information on these samples.

Figure 5. Sample Application Programs

Language	**Program Name**	**EXEC**	**Appendix**
Assembler	ARIS6ASC	SQLASMC	A
C	ARIS6CC	SQLC	B
COBOL	ARIS6CBC	SQLCBLC	C
FORTRAN	ARIS6FTC	SQLFTN	D
PL/I	ARIS6PLC	SQLPLI	E

| As an example, to preprocess, compile, link edit, and run the sample COBOL
| program from a DB2 Server for VM user machine enter:

```
SQLCBLC
```

The sample programs and EXECs were written for the compiler levels stated in the prolog of these programs. If you wish to run them on a different level compiler, refer to the appropriate compiler manual.

Chapter 3. Coding the Body of a Program

Contents

Defining Static SQL Statements 20
Naming Conventions 20
Coding SQL Statements to Retrieve and Manipulate Data 21
  Retrieving Data 21
  Defining an SQL Query 21
    Using the SELECT Clause 23
    Using the FROM Clause 25
    Using the WHERE Clause 25
    Using the GROUP BY Clause 25
    Using the HAVING Clause 26
    Using the ORDER BY Clause 26
    Using the FOR UPDATE OF Clause 27
    Using the WITH Clause 28
  Retrieving or Inserting Multiple Rows 28
    Using the Cursor with a Select-Statement 28
    Declaring a Cursor 28
    Using a Cursor in an Application Program 29
    Manipulating the Cursor 29
      The OPEN Statement 29
      The FETCH Statement 30
      The PUT Statement 31
      The Positioned DELETE Statement 31
      The Positioned UPDATE Statement 32
      The CLOSE Statement 32
    Illustrating the Use of the Query Cursor 33
  Retrieving Single Rows 33
Constructing Search Conditions 34
  Performing Arithmetic Operations 34
  Using Null Values 36
  Using the Predicates of a Search Condition 36
    Evaluating Predicates 37
    Using Additional Types of Predicates 38
Using Functions 38
  Using Column Functions 38
  Using Scalar Functions 39
Using Data Types 39
  Assigning Data Types When the Column Is Created 39
  Using Long Strings 41
    Defining Long Strings 41
    Performing Operations on Long Strings 41
    Programming Tip 41
  Using Datetime Data Types 41
  Using Character Subtypes and CCSIDs 42
    Determining Default Subtypes and CCSIDs 43
    Assigning Subtypes and CCSIDs When a Column Is Created 43
    Assigning Subtypes and CCSIDs to Data in a Program 43
  Converting Data 44

Summarizing Data Conversion 45
Truncating Data 45
Using a Double-Byte Character Set (DBCS) 46
Using Expressions 48
Using Arithmetic Operators 48
Using Special Registers 49
Concatenating Character and Graphic Strings 50
Using Host Variables 51
Using Host Structures 51
Using Constants 52
Using Numeric Constants 52
Using Character Constants 53
Using Graphic Constants 54
Using Date and Time Constants 55
Using Indicator Variables 55
Notes Common to Both Input and Output Indicator Variables 56
Notes on Input Indicator Variables 56
Notes on Output Indicator Variables 57
Using Views 57
Creating a View 58
Querying Tables through a View 59
Using Views to Manipulate Data 60
Dropping a View 62
Joining Tables 62
Joining Tables Using the Database Manager 63
Performing a Simple Join Query 63
Joining Another User’s Tables 64
Analyzing How a Join Works 64
Using VARCHAR and VARGRAPHIC within Join Conditions 65
Using Nulls within Join Conditions 65
Joining a Table to Itself Using a Correlation Name 65
Rules for Table Designation 67
Imposing Limits on Join Queries 67
Using SELECT * In a Join 68
Grouping the Rows of a Table 68
Using VARCHAR and VARGRAPHIC within Groups 69
Using Nulls within Groups 69
Using Select-Lists in Grouped Queries 69
Using a WHERE Clause with a GROUP BY Clause 70
Using the HAVING Clause 70
Combining Joins 71
Illustrating Grouping with an Exercise 71
Nesting Queries 74
Using the IN Predicate with a Subquery 77
Considering Other Subquery Issues 78
Executing Subqueries Repeatedly: Correlation 78
Writing a Correlated Subquery 79
How the Database Manager Does Correlation 80
Illustrating a Correlated Subquery 82
Using a Subquery to Test for the Existence of a Row 87
Table Designation Rule for Correlated Subqueries 87
Combining Queries into a Single Query: UNION 88
String Columns 90
Numeric Columns 90

Datetime/Timestamp Columns 91
SQL Comments within Static SQL Statements 91
| Using Stored Procedures 92
| Writing Stored Procedures 94
| Returning Information from the SQLCA 95
| Language Environment® (LE) Considerations 95
| Preparing to Run a Stored Procedure 95
| Calling Stored Procedures 96
| Authorization 97
| AUTHIDs 97
| Stored Procedure Parameters 97
| Datatype Compatibility 98
| Conventions for Passing Stored Procedure Parameters 98
| The GENERAL Linkage Convention 99
| The GENERAL WITH NULLS Linkage Convention 99
| Coding Examples 100
| Special Considerations for C 100
| Special Considerations for PL/I 100
| Result Sets 101

Defining Static SQL Statements

This chapter describes how to code SQL statements directly into a program for subsequent preprocessing. These statements which are known in advance of running the program are called *static SQL* statements. Those that are not known until the program is actually run, and have to be built dynamically at run time from input by the user, are called *dynamic* and *extended dynamic SQL* statements. Refer to Chapter 6, “Using Dynamic Statements” on page 153 for a detailed description of dynamic statements and, Chapter 7, “Using Extended Dynamic Statements” on page 179 for a detailed description of extended dynamic statements.

Naming Conventions

The following is a list of the identifiers that must conform in general to specific naming rules:

- Authorization names
- Column names
- Constraint names
- Correlation names
- Cursor names
- Dbspace names
- Descriptor names
- Host variable names
- Index names
- Package names
- Passwords
- Procedure names
- Server names
- Statement names
- Synonyms
- Table names
- View names.

For a description of the naming rules, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

You can access a data object (table, view, dbspace, or package) owned by someone else if you know the owner’s authorization-name and have the appropriate DB2 Server for VM privileges. You need to qualify references to the object by prefixing its name with the owner’s authorization-name followed by a period. For example, to access the table called EMPLOYEE which is owned by SMITH, enter `SMITH.EMPLOYEE`.

When you specify the owner along with an object name, you have *fully qualified* the object and *uniquely* identified the table. For example, you cannot have two SMITH.EMPLOYEE tables at the same time.

To avoid confusion and errors, use fully qualified object names. This is especially true if you are coding programs that will be preprocessed by another user.

Coding SQL Statements to Retrieve and Manipulate Data

The DB2 Server for VM product provides application programmers with statements for retrieving and manipulating data; the coding task consists of embedding these statements into the host language code. This chapter shows how to code statements that will retrieve and manipulate data for one or more rows of data in DB2 Server for VM tables. (It does not go into the details of the different host languages. For exact rules of placement, continuation, and delimiting SQL statements, see the host language appendixes.)

Retrieving Data

One of the most common tasks of an SQL application programmer is to retrieve data. This is done using the *select-statement*, which is a form of query that searches for rows of tables in the database that meet specified search conditions. If such rows exist, the data is retrieved and put into specified variables in the host program, where it can be used for whatever it was designed to do.

After you have written a *select-statement*, you code the SQL statements that define how information will be passed to your application.

You can think of the result of a select-statement as being a table having rows and columns, much like a table in the database. If only one row is returned, you can deliver the results directly into host variables specified by the SELECT INTO statement. For example, the following statement will deliver the salary of the employee with the last name of `'HAAS'` into the host variable EMPSAL:

```
SELECT SALARY
INTO :EMPSAL
FROM EMPLOYEE
WHERE LASTNAME='HAAS'
```

If more than one row is returned, you must use a *cursor* to fetch them one at a time. A cursor is a named control structure used by an application program to point to a specific row within an ordered set of rows.

Writing select-statements, defining cursors, and using the SELECT INTO statement are discussed in the next few sections. For a detailed definition of queries, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

Defining an SQL Query

This section discusses the three forms of a query: the *subselect*, the *fullselect*, and the *select-statement*.

Figure 6 shows the most basic form, the *subselect* query.

```
►──┤ select-clause ├──┤ from-clause ├──┬────────────────────┬──────────►
                                       └─┤ where-clause ├───┘

►──┬───────────────────────┬──┬─────────────────────┬──────────────────►
   └─┤ group-by-clause ├───┘  └─┤ having-clause ├───┘
```

Figure 6. Format of the Subselect

The *subselect* query retrieves the columns specified in the SELECT clause from the tables specified in the FROM clause, applies whatever restrictions the optional clauses; (WHERE, GROUP BY, and HAVING) might put on the scope of the rows selected; and presents the results in a result table, which will be called R. The rows of R are unordered. Only the SELECT clause and the FROM clause are mandatory.

An example of a *subselect* query is:

```
SELECT EMPNO, LASTNAME
FROM EMPLOYEE
WHERE WORKDEPT = 'E11'
```

Figure 7 shows the *fullselect* query.

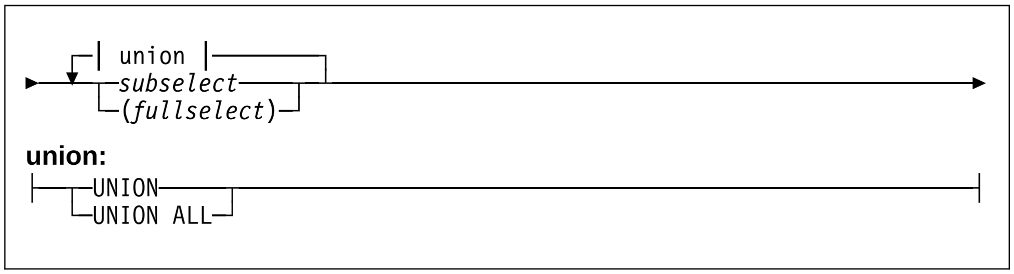


Figure 7. Format of the Fullselect

The *fullselect* query is a merge of two result tables (R1 and R2) from two *subselects* into one final result table (R). The merging is done by the UNION operator. The rows of R are unordered. (For a description of the UNION operation, see "Combining Queries into a Single Query: UNION" on page 88.)

An example of a *fullselect* is:

```
SELECT EMPNO, WORKDEPT, 'EDUCATION'
FROM EMPLOYEE
WHERE EDLEVEL > 16
UNION ALL
SELECT RESPEMP, DEPTNO, 'STAFFING'
FROM PROJECT
WHERE PRSTAFF > 5
```

By using the literal `'EDUCATION'` in the first *subselect* and `'STAFFING'` in the second, you will be able to tell from R which row was included as a result of which criterion (or query).

Figure 8 shows the *select-statement*.

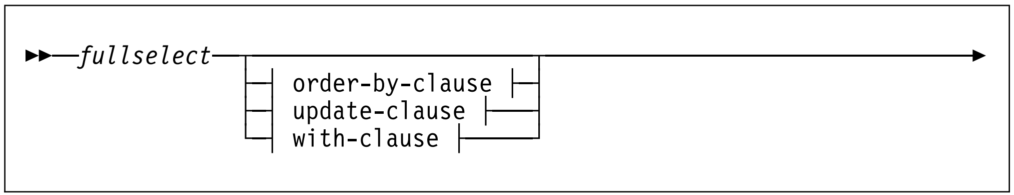


Figure 8. Format of the Select-statement

The *select-statement* can optionally put the rows of R from the *fullselect* in order by the values of the columns identified in the ORDER BY clause. Alternatively, the select-statement can allow the rows of R to be subsequently updated in the application program, under the restriction that this only be done to those columns listed in the update-clause (FOR UPDATE OF). (This explanation excludes consideration of the preprocessor NOFOR support, which is discussed in the next chapter.) Also, the with-clause may be used to select which isolation level that is to be used by the query. This overrides any other isolation level specification.

An example of a *select-statement* is:

```
SELECT EMPNO, FIRSTNME, LASTNAME, HIREDATE
FROM EMPLOYEE
ORDER BY HIREDATE, LASTNAME
```

Note: In this example, the UNION operator and some of the optional clauses in the *fullselect* are not used.

The distinction among these three forms of query is often quite subtle and academic. It can be useful, however, when other SQL statements specify the form of query that is allowed as part of the statement. For example, CREATE VIEW and INSERT are two statements that use the *subselect*. This tells you that you *cannot* incorporate UNION or ORDER BY in the query component of those statements.

Using the SELECT Clause

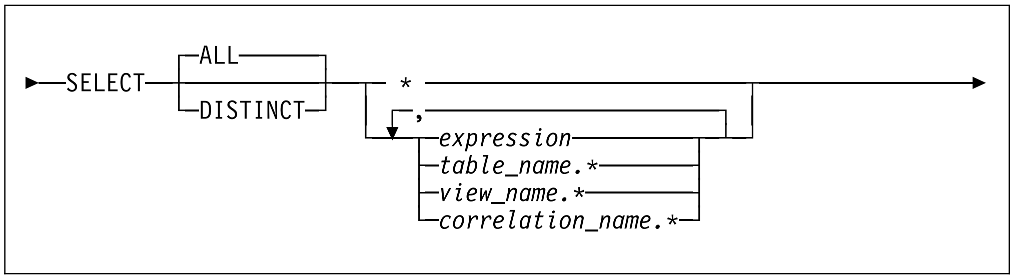


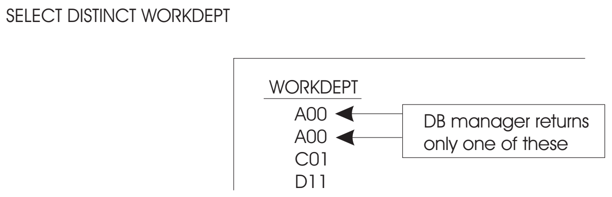
Figure 9. Format of the SELECT clause

This clause is the first part of a *subselect* query. It consists of the keyword SELECT followed by a *select-list*, which usually consists of one or more *expressions*. (Expressions are discussed later in this chapter.)

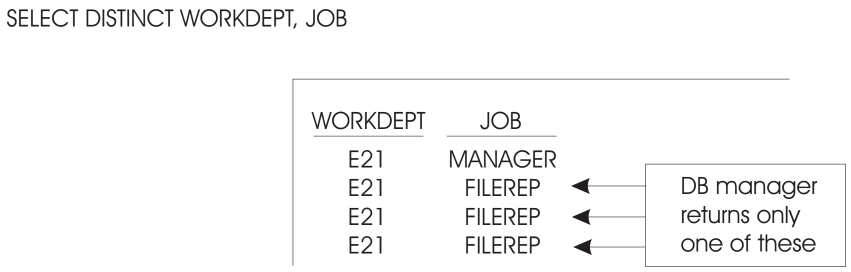
The following are examples of *select-lists* that can occur in queries to the sample tables:

```
SELECT EMPNO, FIRSTNME, LASTNAME

SELECT EMPNO, BONUS + COMM

SELECT SALARY * 1.10

SELECT 250

SELECT HIREDATE + 1 YEAR
```

If you specify DISTINCT immediately after SELECT, the system eliminates duplicates from the query-result. (You can use DISTINCT only once in any query.) For example, the following SELECT clause returns the set of different departments:



Similarly, the following SELECT clause returns the set of different departments and jobs:


SELECT DISTINCT WORKDEPT, JOB
WORKDEPT
JOB
E21 MANAGER
E21 FILEREP
E21 FILEREP
E21 FILEREP
DB manager returns only one of these

ALL indicates that duplicates are not to be eliminated. This is the default.

SQL provides a special shorthand notation for selecting all the columns of a table:

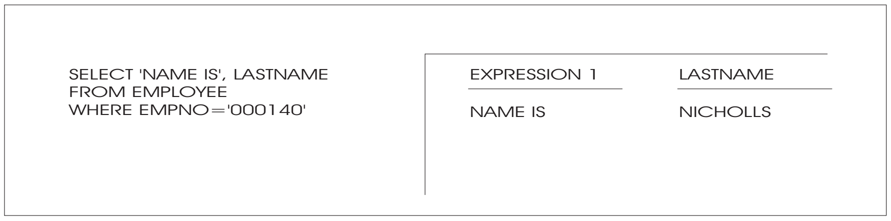
```
SELECT *
```

For example, the following statement returns the entire row from the DEPARTMENT table for manager number 000010:

```
SELECT *
INTO :DEPART, :NAME, :MGR, :EMPDEPT
FROM DEPARTMENT WHERE MGRNO = '000010'
```

As a good programming practice, however, you should explicitly specify every column you want to be returned by your query. This will avoid programming errors when, for example, a new column is added to a table but your program is using SELECT * and making no provision to store the extra column value.

If you specify a constant as a *select-list* expression, that constant occurs in every row returned by the query. For example, the following figure shows a query that returns a constant:



```
SELECT 'NAME IS', LASTNAME
FROM EMPLOYEE
WHERE EMPNO='000140'
```

EXPRESSION 1	LASTNAME
NAME IS	NICHOLLS

An alphabetic constant, such as `'NAME IS'`, is *always* enclosed within single quotation marks (`'`) when used in an SQL statement. A numeric constant should not be enclosed this way.

Using the FROM Clause

```
            ┌,─────────────────────────────────────┐
►──FROM─────▼─┬─table_name─┬──┬──────────────────┬─┴──────────────────────►
              └─view_name──┘  └─correlation_name─┘
```

Figure 10. Format of the FROM Clause

This clause specifies the name of the table from which you want to retrieve data. If you are authorized, you can access a table that is owned by someone else, by adding the name of the owner in front of the *table_name* with a period. For example, to specify the table EMPLOYEE owned by user SMITH:

```
FROM SMITH.EMPLOYEE
```

Because any number of users can define a table with the same name, you should always use fully qualified table names. This avoids confusion if you are writing a program that someone else will preprocess.

As Figure 10 indicates, multiple table names are possible, and some or all of these names can have corresponding correlation names. These aspects of the FROM clause are discussed later in this chapter.

Using the WHERE Clause

```
►──WHERE──search_condition──────────────────────────────────────────►
```

Figure 11. Format of the WHERE Clause

This clause specifies your search conditions. If you do not include it, all the rows of the table will be used to calculate the expressions in the *select-list*. Here are some examples of WHERE clauses:

```
WHERE SALARY > 30000

WHERE EMPNO = :X

WHERE SALARY < :R1 AND EDLEVEL = :Y
```

Search conditions are discussed in “Constructing Search Conditions” on page 34.

Using the GROUP BY Clause

```
               ┌,───────────┐
►──GROUP BY────▼─column_name─┴──────────────────────────────────────►
```

Figure 12. Format of the GROUP BY Clause

This clause enables you to group rows with matching values in one or more columns. Here is an example of the use of the GROUP BY clause:

```
SELECT WORKDEPT, SUM(SALARY)
FROM EMPLOYEE
GROUP BY WORKDEPT
```

For more information, see “Grouping the Rows of a Table” on page 68.

Using the HAVING Clause

```
►──HAVING──search_condition─────────────────────────────────────────►
```

Figure 13. Format of the HAVING Clause

This clause specifies the conditions that must be satisfied by the group. Here is an example:

```
SELECT WORKDEPT, SUM(SALARY)
FROM EMPLOYEE
GROUP BY WORKDEPT HAVING WORKDEPT <> 'A00'
```

For more information, see “Grouping the Rows of a Table” on page 68.

Using the ORDER BY Clause

```
                ┌─,─────────────────────────┐
                ↓                   ┌─ASC──┐ │
►──ORDER BY─────┬─column_name─┬─────┼──────┼─┴──────────────────────────►
                └─integer─────┘     └─DESC─┘
```

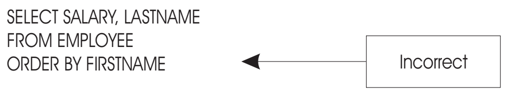
Figure 14. Format of the ORDER BY Clause

This clause delivers the rows of the result table in the order specified. You can indicate order by specifying a list of column names or integers that refer to *select-list* items. For example, ORDER BY 3,5 denotes ordering primarily by the third item and secondarily by the fifth item in the *select-list*. By using integers in the ORDER BY clause, you can order the query result by a selected expression that is not a simple column name.

The following query returns results ordered by the expression SALARY + COMM:

```
SELECT EMPNO, SALARY+COMM
FROM EMPLOYEE
WHERE WORKDEPT='D11'
ORDER BY 2
```

You cannot specify ordering by a column that is not in the *select-list*. For example, the following statement would fail because FIRSTNME is not in the *select-list*:


```
SELECT SALARY, LASTNAME
FROM EMPLOYEE
ORDER BY FIRSTNAME
```

The optional word ASC indicates ascending order, and is the default. DESC indicates descending order. ORDER BY 2,5 DESC indicates ascending order on item 2 and descending order on item 5. Character data is ordered alphabetically, numeric data algebraically, and datetime data chronologically. Null values are sorted first in descending order, and last in ascending order. If you do not specify an ORDER BY clause, rows will be delivered in an order determined by the system.

By default, string data is sorted based on the System/390® collating sequence. However, the collating sequence required for certain alphabets is different from the default System/390 collating sequence. Users expect that sorted data will match the order that is culturally correct for them, and that searches on data will return the result that is correct for the sorting sequence of their language. They are at ease with only one sort order, the one used in their dictionaries, telephone directories, book indexes, and so on.

A way to accommodate special sorting requirements is to use Field Procedures. Field Procedures can be used to encode data being inserted into a column. The encoding effectively alters the collating sequence for the data in the column, enabling the special sorting requirements to be met by the System/390 collating sequence. For more information, see “Using Field Procedures” on page 222.

Trailing blanks in variable string (VARCHAR and VARGRAPHIC) columns do not affect the relative order of rows delivered by the ORDER BY clause. Because the system does not use the trailing blanks when it compares VARCHAR or VARGRAPHIC rows, two columns that differ only by their number of trailing blanks may not maintain their relative positions.

Using the FOR UPDATE OF Clause

```
                  ┌─,───────────┐
►──FOR UPDATE OF──▼─column_name─┴──────────────────────────────────►
```

Figure 15. Format of the UPDATE clause

This clause is optional for static SQL if NOFOR support is specified at preprocessor time.

The *update-clause* (FOR UPDATE OF) tells the system that you might want to update some columns of the result table. To update with a cursor, use the WHERE CURRENT OF clause in an UPDATE statement. (See “Manipulating the Cursor” on page 29.) You can update only those columns that you list in the *update-clause*. A column can be in the *update-clause* without being in the *select-list*; therefore, you can update columns that are not explicitly retrieved by the cursor. The *update-clause* is not required for deletion of the current row of a cursor. Deletion with a cursor is done using the WHERE CURRENT OF clause in a DELETE statement. For an explanation of the DELETE statement, see the *DB2 Server for VSE & VM SQL Reference* manual.

Note: If you do not want to be bound by the above restriction on which columns can be updated, you simply invoke NOFOR support at preprocessor time and omit the *update-clause*. In this situation, the preprocessor will assist you by issuing warning or error messages if your program tries to update columns that are not in the current database. If the conditions identified by the warning messages are not corrected, unexpected error messages can subsequently occur at program run time.

Using the WITH Clause

```
►──WITH──┬─RR─┬──────────────────────────────────────────────────────►
         ├─CS─┤
         └─UR─┘
```

Figure 16. Format of the WITH clause

The WITH clause specifies the isolation level for the query, which overrides any other isolation level specification. For example, a statement specifying WITH UR in a package prepped with ISOL(CS) will use an isolation level of uncommitted read.

For more information on isolation levels, see "Selecting the Isolation Level to Lock Data" on page 123 .

Retrieving or Inserting Multiple Rows

Using the Cursor with a Select-Statement

The previous section showed how to use a *select-statement* to create an SQL query. You can now use that query to retrieve values into an application program from multiple rows in a table.

To do so, you must first declare an SQL cursor, which is a control structure that points to a row in a table. The rows returned by the query are called the *result table* of the cursor.

A cursor can be in an *open* or a *closed* state. In the open state, it maintains a position in its result table on a certain row (called the *current row*). If you delete the current row, the cursor will be positioned between the two rows that surrounded the deleted rows. If you request the next row and receive a message that there are no more rows (SQLCODE 100 and SQLSTATE '02000'), the cursor will be positioned after the last row. Before you OPEN the cursor, it is said to be positioned before the first row.

Declaring a Cursor

```
►►──DECLARE──cursor_name──CURSOR FOR──┬─┤ select-statement ├─┬──────────►◄
                                      ├─┤ insert-statement ├─┤
                                      └─statement_name───────┘
```

Figure 17. Format of the DECLARE CURSOR statement

Use the DECLARE CURSOR statement to define a cursor. This statement associates a *cursor_name* with a specified *select-statement*, *insert-statement*, or *statement-name*. For example:

```
DECLARE C1 CURSOR FOR SELECT LASTNAME, FIRSTNME
       FROM EMPLOYEE WHERE SALARY>:AMT

DECLARE C2 CURSOR FOR INSERT INTO ACTIVITY
       (ACTNO, ACTKWD, ACTDESC)
       VALUES (:ACT, :KEYWORD, :DESC)
```

Note: *Statement-name* is only used with dynamic SQL. For an explanation of its use, see “Retrieving the Query Result” on page 164.

The *select-statement* or *insert-statement* is a part of the DECLARE CURSOR statement, so you must not place EXEC SQL in front of SELECT or INSERT (however, do place it in front of the DECLARE).

Using a Cursor in an Application Program

Your program may contain many DECLARE CURSOR statements that define different cursors and associate them with different queries. During the processing of a program, several cursors may be in the open state at one time. It is possible to define more than one cursor that operates on the same data within the same logical unit of work. It is also possible to open a cursor and then operate on the same data with a non-cursor operation such as a Searched DELETE. However, mixing these operations should be avoided, because the result of one operation can adversely affect another. For example, do not update a row using a Positioned UPDATE and subsequently delete it with another cursor operation or with a Searched DELETE.

The DECLARE CURSOR statement that defines a cursor must occur earlier in the program than any statement operating on that cursor. It does not result in any processing when the program is executed (that is, it does not automatically open the cursor).

The *scope* of a cursor-definition is an entire program. Therefore, cursor names must be unique within a program. You cannot have two DECLARE CURSOR statements in the same program that use the same cursor-name, even if they are in different blocks or procedures.

For additional detail on the DECLARE CURSOR statement, see the *DB2 Server for VSE & VM SQL Reference* manual.

Manipulating the Cursor

After you define a cursor, you can manipulate it using the SQL statements shown in Figure 18. (See the *DB2 Server for VSE & VM SQL Reference* manual for a complete description of these statements.)

Figure 18. SQL Statements for Manipulating Cursors

Statements for Manipulating Query and Insert Cursors	**Statements for Manipulating Query Cursors**	**Statements for Manipulating Insert Cursors**
OPEN	FETCH	PUT
CLOSE	Positioned DELETE	
	Positioned UPDATE	

The OPEN Statement:

Partial Format:

```
►►──OPEN──cursor_name──────────────────────────────────────────►◄
```

If you are opening a query-cursor (a cursor defined in terms of a select-statement), this statement examines the input host variables (if any) used in the definition of the cursor, determines the result table for the cursor, and leaves it in the open state. When the system executes an OPEN statement for a query-cursor, it positions the cursor *before* the first row of the result table. After the query-cursor is opened, the system does not reexamine its input variables until you close and reopen the cursor. No rows in the result table are fetched to the host program until a FETCH statement is executed. Always open the cursor before issuing the first FETCH or PUT statement.

If you are opening an insert-cursor and your program is blocking, this statement prepares the system to block the rows that are to be inserted. With an insert-cursor, you can change the values of the input host variables between inserts; you do not have to close and reopen the cursor.

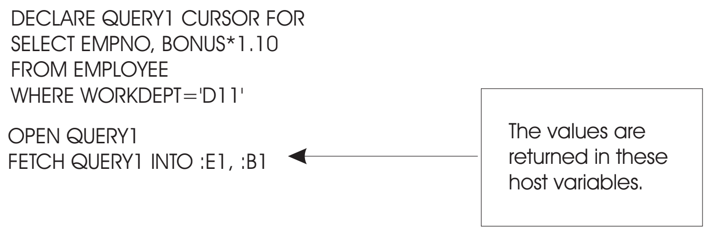
The FETCH Statement:

Partial Format:

```
                            ┌─,──────────────────┐
►►──FETCH──cursor_name──INTO──▼──host_variable_list──┴──────────────►◄
```

This statement can be executed only when the indicated cursor is in the open state. The position of the cursor is advanced to the next row of the result table, and the selected columns of this row are delivered into the output host variables referenced in the *host_variable_list*.

The following is an example of the FETCH statement:



```
DECLARE QUERY1 CURSOR FOR
SELECT EMPNO, BONUS*1.10
FROM EMPLOYEE
WHERE WORKDEPT='D11'

OPEN QUERY1
FETCH QUERY1 INTO :E1, :B1
```

The values are returned in these host variables.

A cursor can move forward only when it is in its result table; the system cannot return to rows that have already been fetched (other than closing the cursor and reopening it).

If the result table of the cursor is empty, or if all its rows have already been fetched, the system returns the *not found* return code (SQLCODE=100 and SQLSTATE='02000') and the cursor is positioned after the last row of the result table. To perform further operations with the cursor, you must close and reopen it.

It is possible for two or more rows in the result table to have exactly the same values. (For example, many rows of the EMPLOYEE table may have the same WORKDEPT, and you might define a cursor that selects only WORKDEPT from the table.) These duplicate values are not eliminated from the result table unless you specify DISTINCT in the SELECT clause of the DECLARE CURSOR statement.

You can use indicator variables in the INTO clause. (For a detailed discussion of indicator variables, see "Using Indicator Variables" on page 55.) Each main variable in the INTO clause may, at your option, have an associated indicator variable. If a null value is returned, and you haven't provided an indicator variable, a negative SQLCODE is returned to your program and execution of the statement is halted.

The PUT Statement:

Partial Format:

```
►►──PUT──cursor_name──────────────────────────────────────────────►◄
```

This statement can be executed only when the indicated cursor is in the open state. The PUT statement inserts one row of data as defined by a cursor. The contents of input host variables referenced in the *host_variable_list* (defined in the VALUES clause of the DECLARE CURSOR statement for insert) are delivered to the database.

For instance, the following statements insert a new row of data into the EMPLOYEE table:

```
DECLARE CC CURSOR FOR
INSERT INTO EMPLOYEE (EMPNO, FIRSTNME, MIDINIT, LASTNAME, EDLEVEL)
VALUES (:EMP, :FIRST, :MID, :LAST, :ED)

OPEN CC
PUT CC
CLOSE CC
```

The values represented by the host variables :EMP, :FIRST, :MID, :LAST, and :ED are placed into the corresponding columns of the new row. The other columns are assigned the null value.

After the PUT statement is executed, you can assign different values to the input host variables to add another row. Alternatively, you can place constants in the VALUES clause of the DECLARE CURSOR statement instead of host variables. This causes identical values to be inserted into the related columns for each PUT.

The PUT statement is used mostly for inserting multiple rows of data into a table in groups or blocks (although, it also works with non-blocked inserts). Blocked inserts are specified with the BLOCK preprocessor parameter. If blocking is in effect, rows are not inserted until the block is full, or until a CLOSE statement is issued. For information on preprocessing your program with the BLOCK option specified, see “Preprocessing the Program” on page 106. For information on using the BLOCK option in DRDA protocol, see “Using the Blocking Option to Process Rows in Groups” on page 128.

The Positioned DELETE Statement

Partial Format:

```
►►──DELETE FROM──table_name──WHERE CURRENT OF──cursor_name──────────►◄
```

This statement can be executed only when the indicated cursor is in the open state and positioned on a row of the result table. It deletes that particular row from the table. The cursor itself remains where it was; it is considered to be in the *between* position and, cannot be used for further deletions or updates until it is repositioned by a FETCH statement.

From the example under the FETCH statement, you could delete a row from the EMPLOYEE table after doing a FETCH, by issuing:

```
DELETE FROM EMPLOYEE
WHERE CURRENT OF QUERY1
```

The Positioned UPDATE Statement:

Partial Format:

```
►►──UPDATE──table_name──set_clause──WHERE CURRENT OF──cursor_name──────►
```

This statement is similar to the DELETE statement, except that it updates the row of the table on which the cursor is positioned rather than deleting it, leaving the position of the cursor unchanged. When using this statement, you must specify the update-clause in the select-statement.

The following example updates the SALARY column of each fetched row of the EMPLOYEE table:

```
DECLARE QUERY2 CURSOR FOR
SELECT LASTNAME, FIRSTNAME, MIDINITT
FROM EMPLOYEE
WHERE WORKDEPT = 'D21'
FOR UPDATE OF SALARY

OPEN QUERY2

FETCH QUERY2 INTO :LAST, :FIRST, :MID

UPDATE EMPLOYEE
SET SALARY = SALARY + :DELTA
WHERE CURRENT OF QUERY2

CLOSE QUERY2
```

The CLOSE Statement:

Format:

```
►►──CLOSE──cursor_variable──────────────────────────────────────────►◄
```

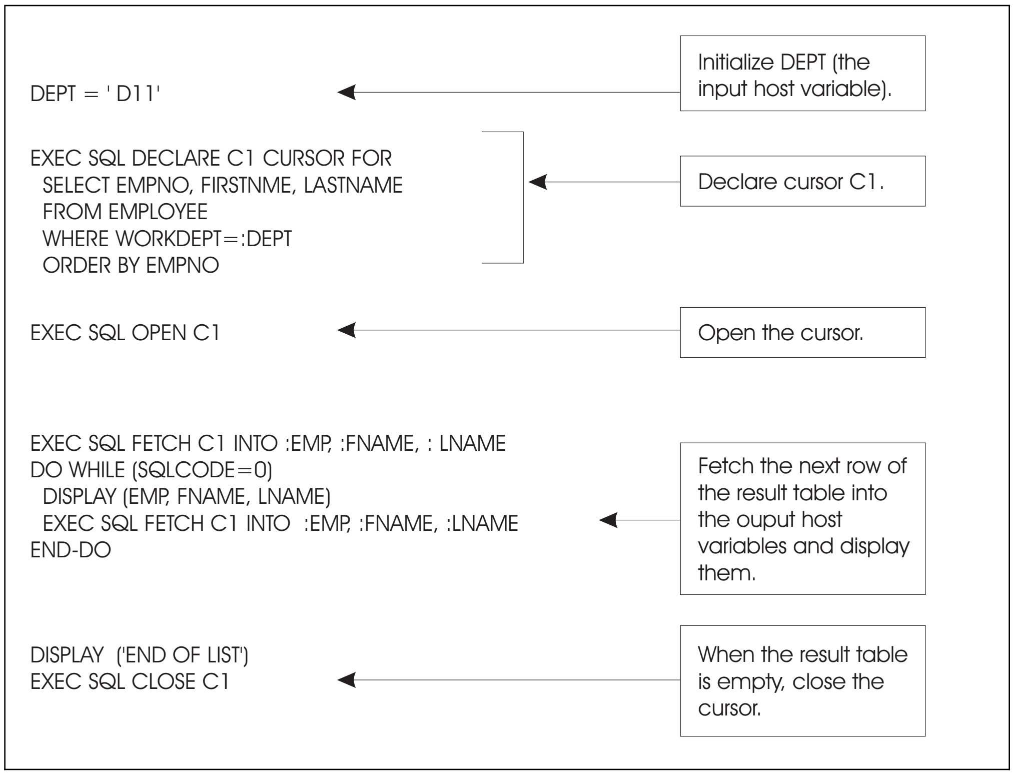
The indicated cursor leaves the open state, and its result table becomes undefined. No FETCH or PUT statement can be executed on the cursor, and no DELETE or UPDATE statement can refer to its current position until the cursor is reopened by an OPEN statement. The CLOSE statement permits the resources associated with maintaining an open cursor to be released. It should be placed in your program so that it is executed as soon as the program is finished using a cursor.

If your program is blocking, you can close an insert-cursor with an incomplete block to insert the remaining rows.

Always close a cursor before committing changes. If changes are committed before an insert cursor (that is being blocked) is closed, an error occurs.

Illustrating the Use of the Query Cursor

Figure 19, which shows a fragment of pseudocode, illustrates the use of a query cursor C1. It finds the employees of all the rows of the EMPLOYEE table whose department number matches host variable DEPT. The FETCH statements retrieve the selected columns successively into host variables EMP, FNAME, and LNAME. After the results are retrieved, they are displayed on the console.



```
DEPT = ' D11'

EXEC SQL DECLARE C1 CURSOR FOR
  SELECT EMPNO, FIRSTNME, LASTNAME
  FROM EMPLOYEE
  WHERE WORKDEPT=:DEPT
  ORDER BY EMPNO

EXEC SQL OPEN C1

EXEC SQL FETCH C1 INTO :EMP, :FNAME, : LNAME
DO WHILE (SQLCODE=0)
  DISPLAY (EMP, FNAME, LNAME)
  EXEC SQL FETCH C1 INTO  :EMP, :FNAME, :LNAME
END-DO

DISPLAY  ('END OF LIST')
EXEC SQL CLOSE C1
```

Initialize DEPT (the input host variable).
Declare cursor C1.
Open the cursor.
Fetch the next row of the result table into the ouput host variables and display them.
When the result table is empty, close the cursor.

Figure 19. Using a Cursor

Recall that SQLCODE is set to +100 (SQLSTATE '02000') when there are no rows remaining to be fetched.

Retrieving Single Rows

The SELECT INTO statement finds the only row of the table specified in the FROM clause that satisfies the given search condition. From this row, the system selects the columns that you supplied in the *select-list*. The results are inserted in the host variables that you specified in the INTO clause. The data type and length attributes of the host variables must be compatible with the data type and length attributes of the expressions in the select-list. If specified, the WITH clause specifies the isolation level to be used on the query and overrides any other isolation level specification.

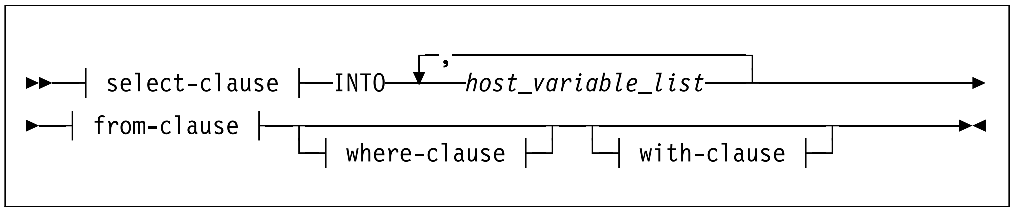


Figure 20. Format of the SELECT INTO statement

For example, the following statement selects the employee number, last name, and yearly salary from the EMPLOYEE table where the employee number is '000130'. It places the result in the host variables EMP, NAME, and PAY:

```
SELECT EMPNO, LASTNAME, SALARY
INTO :EMP, :NAME, :PAY
FROM EMPLOYEE
WHERE EMPNO = '000130'
```

If the number of expressions in the *select-list* is greater than the number of output host variables in the INTO clause, a warning flag (called SQLWARN3) in the SQLCA is set to W. Also, if more than one row satisfies the search condition in a SELECT INTO statement, an error condition occurs, and the values of the host variables are unpredictable.

Constructing Search Conditions

One of the most common operations in SQL is to search through a table, choosing certain rows for processing. A *search condition* is the criterion for choosing rows.

In the following select-statement example, CODE = 'A' AND PART='B' AND TYPE='X' constitute the search condition:

```
SELECT * FROM T1
WHERE CODE = 'A' AND PART='B' AND TYPE='X'
```

When you are constructing search conditions, be careful to perform arithmetical operations only on numeric data types, and to make comparisons only among compatible data types. Graphic data types are compatible only with other graphic data types. If you use a host variable in an expression, its host language data type must be compatible with the rest of the expression.

Performing Arithmetic Operations

Whenever an arithmetic or comparison operator has operands of two different types, the database manager evaluates it in the greater of the two types: FLOAT takes precedence over DECIMAL, which takes precedence over INTEGER, which takes precedence over SMALLINT. For example, if the PRICE column is of type INTEGER and has the value 25, the expression PRICE*.5 will evaluate to 12.5, a decimal value. The predicate PRICE*.5=12 is false, because the decimal value forces the predicate to be evaluated in decimal. (Decimal values are stored in
| System/390™ packed decimal format.)

The system computes all floating-point values in normalized form, as described in
| the *ESA/390 Principles of Operation* manual. When a floating-point value is stored in a table, it may not be stored exactly as entered. For example, an SQL INSERT statement could specifically insert the constant 3E0 into a column. Internally, however, the value might actually be stored as 2.9999. Floating-point values may become even more imprecise when arithmetic operations are performed on them. You should use the BETWEEN predicate (described later) when comparing floating-point values.

If the operands of an arithmetic or comparison operator are both single-precision and double-precision floating-point data, the former is converted to the latter before any comparison is made or any arithmetic operation performed. If the equals (=) comparison operator compares these two types of data, the result of the comparison may not be what you expected. In the following examples, column C1 is defined to contain single-precision floating-point data and column C2 is defined to contain double-precision floating-point data:

```
   INSERT INTO T1 (C1, C2) VALUES (10.95, 10.95)

   SELECT * FROM T1
   WHERE C1 = 10.95

   SELECT * FROM T1
   WHERE C2 = 10.95

   SELECT * FROM T1
   WHERE C1 = C2
```

The first and second select statements here will return rows that contain the value 10.95. The third select will not return any rows. This is because the 10.95 cannot be exactly expressed as a floating-point value. The double-precision floating-point representation has more significant bits than the single-precision floating-point representation. When the single-precision floating-point value is converted to double-precision float, X'00's are added to the last four bytes of the double-precision equivalent. The single-precision float data is therefore not equal to the double-precision float data and hence the search condition in the last select above is not satisfied.

| Decimal numbers have a maximum precision of up to 31 digits. In contrast, a
| double-precision floating point number preserves up to approximately 17 digits. So
| when a decimal number with precision greater than 17 is promoted to a
| floating-point number, digits are lost. Because floating-point numbers can have a
| larger magnitude than decimal numbers, the float data type is higher than the
| decimal in the data type promotion scheme. The following example shows how this
| can cause unexpected results:

```
   SELECT * FROM DEPARTMENT WHERE 1E0 + 12345678901234567890.1
     = 12345678901234567890.1;
```

You would expect this statement to return no rows, because adding one to a constant makes it unequal to itself. To execute this statement, the system promotes the two decimal numbers to floating-point values. When this is done, all but the first 17 digits are lost. When '1E0' is added to the first decimal number, > it is not large enough to change the converted decimal value. The end result is that both sides of the expression evaluate as being equal. It is therefore important to be careful when combining floating-point and decimal data types in expressions.

Arithmetic operations between two items of type SMALLINT produce a result of type INTEGER, in order to avoid possible overflow problems (as might easily occur in multiplication). When INTEGER or SMALLINT values are used in a division computation, the result is of type INTEGER, and any remainder is dropped. (See “Converting Data” on page 44 for conversion information.)

Using Null Values

The system allows nulls in values in a table. A null is a nonexistent value; that is, it represents a value that is undefined. You can think of a null value as an empty space, or as a space reserved for later insertion of data.

When null values occur within expressions, the value of the expression is also null. For example, in the following predicate both SALARY and COMM may be a null value:

$$\underbrace{\text{SALARY} + \text{COMM}}_{\text{expression1}} < \underbrace{100}_{\text{expression2}}$$

If either SALARY or COMM is null, expression1 above is null.

Using the Predicates of a Search Condition

A search condition is a collection of one or more *predicates*. Each predicate specifies a test that is applied to the rows of the table. You can connect predicates with the logical operators AND and OR. For example:

```
predicate1  AND  predicate2  OR  predicate3
```

The keyword NOT can be used to negate a predicate:

```
predicate1 AND NOT predicate2
```

The precedence rule among the keywords is as follows:

1. NOT is applied
2. AND is applied
3. OR is applied.

Use parentheses to override this precedence rule if necessary. For example, the search condition in Figure 21 contains three predicates; it is used to find the rows of the EMPLOYEE table pertaining to an employee from department D11 who also has 17 or 18 years of education.

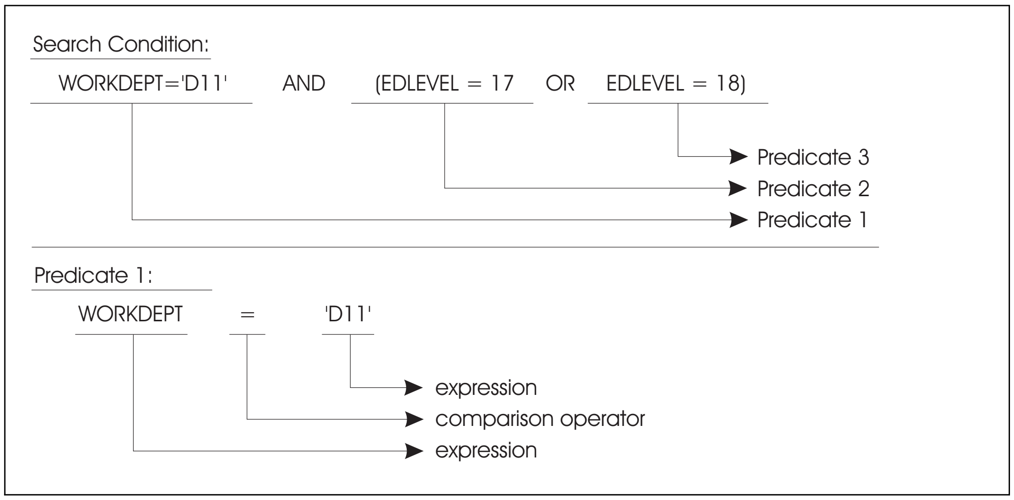


Figure 21. Breakdown of Search Conditions and Predicates

Figure 21 also shows that the format of a predicate is a comparison between two values or expressions. This format is represented as follows:

```
expression  comparison-operator  expression
```

A *comparison-operator* may be any of the following:

```
=     "equal to"
¬=    "not equal to"
<>    "not equal to"
>     "greater than"
>=    "greater than or equal to"
<     "less than"
<=    "less than or equal to"
```

The above symbols are the only comparison operators that you can use in SQL statements. For example, the system does *not* recognize ≠ even if it is supported in the host language. The correct representation of inequality is ¬= or <>.

For a detailed description of search conditions, see the *DB2 Server for VSE & VM SQL Reference* manual.

Evaluating Predicates

The following rules apply when the system evaluates predicates:

1. When two character strings are compared, EBCDIC alphabetic ordering is used. For example:

   ```
   'A' < 'B'
   'A' < 'ABLE'
   'Z' < '35'
   'A1' < 'B'
   'a' < 'A'
   ```

2. When two short strings are compared, trailing blanks are not significant. For example, if the NAME column of a table is of type CHAR(10), you can write NAME='SMITH' in your search condition, and the condition will be satisfied by the database value:

   ```
   'SMITH     '.
   ```

Trailing blanks are significant in the LIKE predicate; see the *DB2 Server for VSE & VM SQL Reference* manual.

3. In performing an arithmetic operation, if either of the operands is null, the result of the operation is null.
4. In performing a comparison operation, if either of the expressions is null, the result of the comparison is unknown, and the row being evaluated does not qualify for inclusion in the result table.
5. No predicates are permitted on long host variables. Except for LIKE, predicates are not permitted on long columns.
6. When decimal numbers of different scales are compared, the shorter scale is extended with trailing zeros sufficient to match the scale of the larger number. For example, 25.45 is equal to 25.4500.
7. When two graphic strings are compared, the value of the respective data columns is compared in a manner similar to that used for character data types. The single character sequencing is generally of no value for graphic ordering. However, you can specify the sorting sequence of graphic characters in a graphic column by associating the column with a field procedure. For more information on field procedures refer to “Using Field Procedures” on page 222.
8. If a query is executed against an empty table, the database manager may not, for performance reasons, carry out all validation checks. For example, an invalid date string in a host variable is not flagged as an error unless a row is being evaluated.

Using Additional Types of Predicates

In addition to the basic predicates that compare two expressions, the system provides the predicates listed below, which you can use either alone or with other predicates by including the keywords AND, OR, and NOT to form a search condition. For detailed information on the rules and use of these predicates, see the *DB2 Server for VSE & VM SQL Reference* manual.

- BETWEEN
- IN
- LIKE
- NULL
- EXISTS
- Quantified (SOME, ALL).

Using Functions

There are two types of functions. *Column functions* apply the function to a group of values in a column and produce one result value. *Scalar functions* apply the function to one or more values in each row and produce a result value for each row.

Using Column Functions

The column functions are:

```
   AVG   MAX   MIN   SUM   COUNT
```

The argument of a column function is an expression containing a column name (optionally preceded by DISTINCT or ALL— ALL is the default). The argument follows the function and must be enclosed in parentheses.

DISTINCT indicates that duplicate values are to be eliminated before the function is applied. The following example counts the number of different projects that satisfy the search condition:

```
SELECT COUNT(DISTINCT PROJNO)
```

For a detailed discussion of each of the column functions, see the *DB2 Server for VSE & VM SQL Reference* manual.

Using Scalar Functions

The scalar functions are:

```
CHAR     FLOAT        MINUTE    TIMESTAMP
DATE     HEX          MONTH     TRANSLATE
DAY      HOUR         SECOND    VALUE
DAYS     INTEGER      STRIP     VARGRAPHIC
DECIMAL  LENGTH       SUBSTR    YEAR
DIGITS   MICROSECOND  TIME
```

You can use scalar functions wherever an expression can be used. The first or only argument of each scalar function is an expression. If the value of any expression is a null value, the result will be a null value as well, except for the VALUE function.

For a detailed discussion of each of the scalar functions, see the *DB2 Server for VSE & VM SQL Reference* manual.

Using Data Types

Assigning Data Types When the Column Is Created

Each column of every DB2 Server for VM table is given an SQL data type when the column is created. Figure 22 shows the data types and how they are stored internally.

Figure 22 (Page 1 of 2). SQL Data Types

SQL Data Type	How Stored
INTEGER or INT	Stored as a signed 31-bit binary integer
SMALLINT	Stored as a signed 15-bit binary integer
DECIMAL[(*p*[,*s*])] or DEC[(*p*[,*s*])] (4) , (5)	Stored as a packed decimal number of precision *p* and scale *s*. Precision is the total number of digits; scale is the number of digits to the right of the decimal point. For example, 251.66 fits in a DECIMAL(5,2) data area. When precision and scale are calculated, if the precision is greater than 31, leading zeros will be removed until it is equal to 31. Trailing zeros are not removed. The default scale is 0 and the default precision is 5.
| FLOAT(*n*) (1)	Stored as a single-precision (4-byte) floating-point number in short System/390 floating-point format, or as a double-precision (8-byte) floating-point number in long System/390 floating-point format.

Figure 22 (Page 2 of 2). SQL Data Types

SQL Data Type	**How Stored**
CHARACTER[(*n*)] or CHAR[(*n*)] (3)	Stored as a character string of fixed length *n*, where ≤ 254. The default length is 1.
VARCHAR(*n*) (2) , (3)	Stored as a varying-length character string of maximum length *n*, where *n* ≤ 32767. If 254 < *n* ≤ 32767, VARCHAR(*n*) is considered a long string.
LONG VARCHAR (3)	Stored as a varying-length character string of maximum length 32767.
GRAPHIC[(*n*)]	Stored as a string of double-byte character set (DBCS) characters of fixed length *n*, where *n* ≤ 127. The default length is one DBCS character.
VARGRAPHIC(*n*) (2)	Stored as a varying-length string of DBCS characters of maximum length *n*, where *n* ≤ 16383. If 127 < *n* ≤ 16383, VARGRAPHIC(*n*) is considered a long string.
LONG VARGRAPHIC	Stored as a varying-length string of DBCS characters of maximum length 16383.
DATE	Stored as a string of 4 bytes. Each byte is two packed decimal digits. The first two bytes are the year, the next is the month, and the last is the day.
TIME	Stored as a string of 3 bytes. Each byte is two packed decimal digits. The first byte is the hour, the next is the minute, and the last is the second.
TIMESTAMP	Stored as a string of 10 bytes. Each byte is two packed decimal digits. The first 4 bytes are the date, the next 3 are the time, and the last 3 are the microsecond.

Notes:

1. The FLOAT data type refers to either single-precision floating-point data (4 bytes) or double-precision floating point-data (8 bytes).
   - REAL and FLOAT(*n*), where *n* is from 1 to 21, are synonyms. They are both stored as 4 bytes.
   - FLOAT, DOUBLE PRECISION, and FLOAT(*n*), where *n* is from 22 to 53, are synonyms. They are all stored as 8 bytes.
   - When single- and double-precision floating-point data are compared to one another, the result of the comparison may not be what you expected. See "Constructing Search Conditions" on page 34.
2. These data types have some special considerations to watch out for.
   - For the CREATE TABLE and ALTER TABLE statements, when VARCHAR(*n*) or VARGRAPHIC(*n*) has "n" greater than 254 or 127 respectively, the database manager treats the column as a long string when storing and retrieving data. Long strings are discussed in the next section.

     The column is treated as VARCHAR or VARGRAPHIC, however, in two respects:

     – The value stored in the LENGTH and SYSLENGTH columns of SYSTEM.SYSCOLUMNS is "n".
     – The value returned to the user in the SQLLEN field of the SQLDA is "n".

     When *n* is less than 255 (VARCHAR) or 128 (VARGRAPHIC) on these statements, the treatment of the column is unchanged.
   - Trailing blanks are not considered relevant in comparisons of VARCHAR or VARGRAPHIC values, unless these values are either concatenated, returned to the application program, or used in a scalar function.

For example, if string `X1 = "STRING "` and string `X2 = "STRING"` and `X3 = X1 CONCAT X2` then `X3` will be equal to `"STRING STRING"`. However, `X1` is considered equal to `X2` in a compare statement such as a SELECT...WHERE.

3. Columns defined with these data types can contain MIXED or BIT data.
4. NUMERIC is a synonym for DECIMAL, and may be used when creating or altering tables. In such cases, however, the CREATE or ALTER function will establish the column (or columns) as DECIMAL.
5. C application programs can use the decimal data type so that host variables can match table definitions and do not have to do C numeric conversions for table columns that are defined as decimal.

Using Long Strings

Defining Long Strings

A long string column is either a LONG VARCHAR, LONG VARGRAPHIC, VARCHAR(*n*) (where 254 < n ≤ 32 767), or VARGRAPHIC(*n*) (where 127 < *n* ≤ 16 383). Long strings are intended for storage of unstructured data such as text strings, images, and drawings. For a list of restrictions on the use of long strings, refer to the section on data types in the *DB2 Server for VSE & VM SQL Reference* manual.

Performing Operations on Long Strings

The only operations permitted on long strings are:

- SELECT in an outer-level query (not in a subquery).
- INSERT into the database from an input host variable (not from a constant or from a subquery). You can, however, insert null values into long strings with the usual INSERT statement mechanisms. (That is, you are not restricted to host variables when inserting nulls.)
- UPDATE from an input host variable or UPDATE to the null value. (SET LONGFIELD=:X and SET LONGFIELD=NULL are permitted, but SET LONGFIELD='HELLO' and SET LONGFIELD=OTHERFIELD are not permitted.)
- DELETE of rows containing long strings.

Programming Tip

The restrictions on the use of long strings can usually be avoided by the appropriate use of the SUBSTR function.

Using Datetime Data Types

Datetime is a collective DB2 Server for VM term that includes date, time, and timestamp. Although datetime values can be used in certain arithmetic operations and are compatible with certain strings, they are neither strings nor numbers. Conversely, strings and numbers are not datetime values. A datetime value is either:

- A DATE, TIME, or TIMESTAMP column value
- A value returned by the DATE, TIME, or TIMESTAMP scalar functions
- A value returned by the CURRENT DATE, CURRENT TIME, or CURRENT TIMESTAMP special registers.

Datetime values of the same type can be subtracted. If date1 and date2 are DATE columns, date1 - date2 is a valid expression. Date1 - '01/01/1994' is also a valid expression because '01/01/1994' is a valid string representation of a date. However, '01/01/1994' - '12/20/1932' is not valid because strings cannot be subtracted and a string is interpreted as a date only if the other operand is a value of data type DATE. Scalar functions are provided to explicitly convert strings to datetime values. The following expression is valid:
DATE('01/01/1994') - '12/20/1932'.

For detailed information on the components and valid formats and lengths of the date, time, and timestamp data types and the assignment of these data types to host variables or CHAR-type columns, see the *DB2 Server for VSE & VM SQL Reference* manual.

Using Character Subtypes and CCSIDs

Character subtypes and coded character set identifiers (CCSIDs) provide a means of identifying the character data representation scheme to be used for character and graphic data in your system. For example, by using a certain CCSID, you can specify that all character data in your system is single-byte EBCDIC data.

Subtypes are a way of specifying that you want to use the application server system default CCSID associated with that subtype. CCSIDs apply to both character and graphic data, while subtypes apply only to character data.

For a detailed description of coded character sets and CCSIDs, see the *DB2 Server for VSE & VM SQL Reference* manual.

For most applications, you do not need to specify subtypes or CCSIDs, because the system defaults can usually meet your character data representation requirements.

If this is not the case, you may have to become familiar with Character Data Representation Architecture (CDRA). Refer to the section about data integrity concerns in the *Character Data Representation Architecture Reference and Registry* manual for a discussion of using CDRA to meet your requirements.

The following are examples of problems that can be solved by the specification of CCSIDs or subtypes. The solutions to these problems are discussed in “Assigning Subtypes and CCSIDs When a Column Is Created” on page 43 and “Assigning Subtypes and CCSIDs to Data in a Program” on page 43.

- A column is required in a table to contain mixed data (that is, data that can contain both double-byte and single-byte characters), but the system default specifies that all newly created columns will be used to contain single-byte character set data only.
- A table creation program is required that is to be used at multiple sites, all of which can use different system default subtype and CCSID values. The tables to be created must have the ability to store data of a particular CCSID.
- An application program written in assembler language must insert data into a graphic column, but variables with a graphic data type are not supported.

Determining Default Subtypes and CCSIDs

Refer to the SYSTEM.SYSOPTIONS catalog table to determine the application server system defaults. The rows containing the following values in the SQLOPTION column are important: CHARSUB, CCSIDSBCS, CCSIDMIXED, CCSIDGRAPHIC, and CHARNAME.

For the application requester system defaults, invoke the SQLINIT EXEC using the QUERY option. The fields that contain important information are CCSIDSBCS, CCSIDMIXED, CCSIDGRAPHIC, and CHARNAME. (For a discussion of the SQLINIT EXEC, refer to the *DB2 Server for VM Database Administration* manual.)

Examples of items that assume application requester system defaults are input and output SQLDA elements (the default can be overridden), and host variables.

The following are examples of items that assume application server system defaults:

- Columns (default can be overridden)
- Special registers.

The following are examples of items that assume application requester system defaults:

- Input and output SQLDA elements (default can be overridden)
- Host variables.

For information on setting system defaults, refer to the *DB2 Server for VM System Administration* manual.

Assigning Subtypes and CCSIDs When a Column Is Created

There are three ways to assign subtypes or CCSIDs to a column:

- Use the application server system defaults.
- Use the preprocessor parameters CHARSUB, CCSIDSBCS, CCSIDMIXED, and CCSIDGRAPHIC to override the system default for columns created by the CREATE TABLE and ALTER TABLE statements in the package. (See “Preprocessing the Program” on page 106 for information on these parameters.)
- Use the subtype or CCSID clause in a column’s definition within the CREATE TABLE or ALTER TABLE statement to override the application server system default or the preprocessor default. (For more information on these statements, refer to the *DB2 Server for VSE & VM SQL Reference* manual.)

Assigning Subtypes and CCSIDs to Data in a Program

There are two ways to assign subtypes or CCSIDs to the data items in a program:

- Use the application requester system defaults.
- Execute the SQL statement using dynamic SQL so that the data items can be described in a user-defined SQLDA. A CCSID can be assigned to each data item in the SQLDA.

  For examples of how to build an SQLDA that contains CCSID information, see Chapter 6, “Using Dynamic Statements” on page 153. For a more detailed discussion on using the SQLDA, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

Converting Data

For the database manager, the operands in an assignment or comparison operation must be compatible. For example, a character string cannot be compared to a numeric string, a graphic string cannot be compared to a character string, and an arithmetic operation cannot contain a character string operand. Refer to the *DB2 Server for VSE & VM SQL Reference* manual for more details about compatible data types.

Operands that are compatible but are not identical in data types, lengths, datetime formats, or CCSIDs, can be used in assignment and comparison operations but require data conversion as follows:

- For assignment operations, conversion is done before the data is assigned. For example, if a host variable is defined as a SMALLINT field and a column is defined as INTEGER, a SELECT INTO operation converts the INTEGER column to SMALLINT before it is assigned to the host variable. In this situation, overflow may occur if the value is too large to fit into a SMALLINT field. Depending on the data types and the host language, some data may be lost. The *DB2 Server for VSE & VM SQL Reference* manual discusses potential data loss in the assignment of COBOL integers.

  To retrieve a datetime value, (that is, a DATE, TIME, or TIMESTAMP), it must be assigned to a character string host variable. The assignment operation converts the datetime value to a character string representation. Whenever a string representation of a datetime value is used in any other operation with a datetime value, the operation is performed with a temporary copy of the string that has been converted to the data type of the datetime value.

  If a conversion error occurs when the database manager assigns a value to a host variable in the INTO clause of a SELECT or FETCH statement, and if you have provided an indicator variable for the affected host variable, the system returns the following:

  – A value of −2 in the indicator variable

  – An undefined value in the host variable

  – Warning values in both SQLCODE and SQLSTATE that are appropriate for the condition.

  If you have not provided an indicator variable, both SQLCODE and SQLSTATE return error codes (a negative value for SQLCODE, and a data exception for SQLSTATE).

- For comparison operations, one field may be converted if necessary to match the data type, length, or CCSID of another. For example, if two character strings in a comparison operation have different CCSIDs (one is an SBCS string and the other is a mixed string), a temporary copy of the SBCS data is converted to the mixed data CCSID before the data is compared.

For more information about data conversion and conversion errors, see the discussion about assignments and comparisons in the *DB2 Server for VSE & VM SQL Reference* manual.

Summarizing Data Conversion

Data conversion is summarized in tabular form in the *DB2 Server for VSE & VM SQL Reference* manual. Overflow (loss on the left) or truncation (loss on the right) may occur on some conversion attempts.

Truncating Data

Truncations are handled differently for numeric, character, and datetime data.

Numeric data

Truncation of zeros on the left, or of the fractional part of decimal or floating-point values (single-precision or double-precision) takes place without error or warning. Any other loss of data on conversion is an overflow error. If overflow occurs in an outer select and an indicator variable is supplied for the host variable, the indicator variable is set to −2 and a positive SQLCODE is returned; otherwise, a negative SQLCODE is returned.

Character data

When output from the database manager does not fit into a host variable, a warning is returned. SQLWARN1 is set to indicate truncation. In this case, if you provide an indicator variable, the value within it denotes the actual length of the variable in characters before truncation.

When an input character string value does not fit into a DB2 Server for VM column, an error results.

Whenever truncation occurs, it follows specific rules depending on the character subtype involved. Also, padding may occur when a string is assigned to either a fixed-length host variable or to a fixed-length column and the source string is shorter than the length of the target. Padding, like truncation, follows rules depending on subtype. These rules are in the *DB2 Server for VSE & VM SQL Reference* manual.

SBCS and mixed are the only two types of character data truncation. In mixed truncation, the integrity of target data is ensured. For example, if `'ab< CCDDEE >cd'` is truncated to a length of 6, the result with mixed truncation is `'ab< CC >'`. The system counts to byte 6. Because this would split a double-byte character, the number of bytes is rounded to the next lowest whole number. It also always ensures that the < and > characters correctly identify the double-byte characters.

Figure 23 shows the type of truncation that occurs depending on the subtype of the source and target data.

Figure 23. Truncation Types

Subtype of Source	Subtype of Target	Result
Mixed	Mixed	Mixed truncation
SBCS	SBCS	SBCS truncation
Mixed	SBCS	SBCS truncation[1]
SBCS	Mixed	SBCS truncation[1]

Note:

1. If the source data contains DBCS data, a conversion error occurs during SBCS truncation.

Figure 24 shows the results of SBCS and mixed truncation when selecting `'ab<CCDDEE>fg'` into various host variables:

Figure 24. Examples of Mixed Data Truncation and SBCS Truncation

Target Host Variable	SBCS Truncation	Mixed Truncation
CHAR(6)	`'ab<CCD'`	`'ab<CC>'`
CHAR(7)	`'ab<CCDD'`	`'ab<CC>b'`
VARCHAR(7)	`'ab<CCDD'`	`'ab<CC>'`

Note: For mixed data, the only difference between the second and the third example is the length of the resulting VARCHAR string. A blank is added to the fixed string.

TIME data
When the seconds part of a retrieved ISO, JIS, or EUR format TIME value is truncated, SQLWARN1 is set to indicate that truncation has occurred. The seconds that are truncated are placed in the indicator variable if one is provided.

TIMESTAMP data
On output, any portion of the microseconds part of a TIMESTAMP may be truncated (including the decimal point). However, no warning is given (SQLWARN1 is not set). If an indicator variable is provided, it is unchanged.

For more information about how computations are performed internally or how overflows can occur, refer to the section about arithmetic operations in the *DB2 Server for VM Database Administration* manual.

Using a Double-Byte Character Set (DBCS)

DBCS characters can be used in identifiers, constants, and data in DB2 Server for VM programs. Strings containing DBCS characters are formatted as <XXXX>, where < represents the shift-out character, and > represents the shift-in character. Each XX represents one double-byte character set character. The <> delimiters are single-byte character set (SBCS) characters.

In identifiers, characters constants, and character data, the delimiters are significant so redundant delimiter pairs are not removed. For example, the following strings of DBCS characters are not equivalent:

```
< AABB >< CCDD > and < AABBCCDD >
```

In graphic data and constants, the delimiters are not significant.

Each DBCS character requires 2 bytes for its representation; therefore, an even number of bytes must be between the < and >. The number of bytes used to represent a string of DBCS characters is equal to:

```
    2 * the number of DBCS characters + 2 (for mixed data)

    2 * the number of DBCS characters (for graphic data)
```

Strings of DBCS characters cannot span lines, whereas mixed strings containing strings of DBCS and SBCS characters can span lines if each string of DBCS characters in the mixed string is on one input record. For a discussion of the rules for using DBCS characters in constants, see “Using Character Constants” on page 53 and “Using Graphic Constants” on page 54.

To use DBCS characters in application programs, you must know the following:

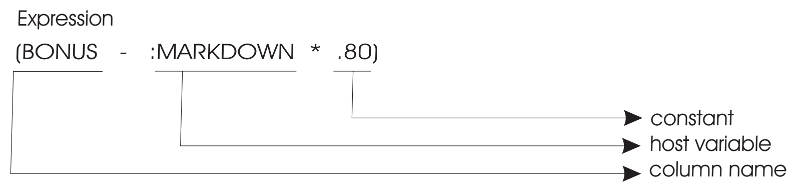
- To use host identifiers that contain DBCS characters, your compiler must support DBCS and the application requester must have the DBCS option set to YES. To check whether this setting is correct, do an SQLINIT QRY; if you need to change this setting, issue an SQLINIT with the DBCS option set to YES. (For a detailed discussion of the SQLINIT EXEC, see the *DB2 Server for VM Database Administration* manual.)
- To use SQL identifiers that contain DBCS characters, the application server must support DBCS characters and mixed data. To verify this for the application server, make sure that in the SYSTEM.SYSOPTIONS catalog table the CHARNAME setting identifies a mixed character set and the DBCS setting is YES. In addition, DBCS characters must be permitted in the particular identifier. For a discussion of rules for using DBCS characters in identifiers, refer to the *DB2 Server for VSE & VM SQL Reference* manual.
- To use host variables with graphic data type, the preprocessor must allow a graphic data type for the host language of the source program. The DB2 Server for VM preprocessors that allow graphic data type are COBOL and PL/I. If you need this facility when using another language, see the appendix for that language for a discussion of alternative actions.
- To use graphic and mixed constants (that is, character constants that contain DBCS characters) in an application program, the application server and application requester must support mixed data. To verify this for the application server, make sure that the CHARNAME setting in the SYSTEM.SYSOPTIONS catalog table identifies a mixed character set. for the application requester, issue an SQLINIT command with the QRY option. The CHARNAME value returned identifies a mixed character set. For a discussion of character sets, refer to the *DB2 Server for VM System Administration* manual. If the application requester does not support DBCS characters, you can obtain this support by using the SQLPREP GRaphic option (available to COBOL and PL/I only).

Using Expressions

An *expression* refers to a column, a constant, a host variable, an SQL special register (for example, the USER special register), the SQL keyword NULL, a column function, a scalar function, an arithmetic expression, or any of these that can be connected by the concatenation operator. (The concatenation operator is discussed later in this chapter.) Using expressions, you can do calculations on data as part of a query. The calculations are performed before the data is returned to your program.

Figure 25 shows a simple arithmetic expression:

Figure 25. Breakdown of an Arithmetic Expression



Using Arithmetic Operators

There are four *arithmetic operators* that you can use:

```
*    multiplication
/    division
+    addition
-    subtraction
```

Usually, the system reads an arithmetic expression from left to right, first applying any negations, then any multiplication or division operations, and then finally any additions and subtractions. For example, in the following expression:

```
BONUS - :MARKDOWN * .80
```

The system would take the value of the host variable MARKDOWN, multiply it by .80, and then subtract the result from the bonus.

You can change this order-of-precedence by using parentheses. For instance, if the above example were coded:

```
(BONUS - :MARKDOWN) * .80
```

The system would first subtract MARKDOWN from BONUS, and then multiply the result by .80. The two results would probably end up being quite different.

Host variables can be used in arithmetic expressions. For example:

```
PRICE * :QUANTITY + 1.44
```

As mentioned earlier, you must precede the names of host variables by a colon (:) to distinguish them from column names. That is, the following is interpreted as a host variable:

```
:PROJNO
```

The following, however, is interpreted as a column name:

```
PROJNO
```

Numeric constants can stand alone or be used in arithmetic combination with other constants or host variables or column names to form expressions. All three of the following are valid expressions:

```
200            -798.9768           PRICE * :QUANTITY + 1.44
```

Character constants cannot be used in arithmetic combinations, except when a character string representing a datetime value is used in datetime arithmetic. The following expression is valid:

```
HIRE_DATE - '1994-01-01'
```

The following expression is not valid:

```
'FUDGE'*'GUMDROP'+'LEMON'
```

If you attempt to combine two pieces of data that do not have compatible data types with arithmetic operators, an error code is returned. The system performs data conversion on different types of data that are compatible.

Using Special Registers

Any of the following special registers can be used wherever an expression of the appropriate data type is used:

- CURRENT DATE (defined as DATE)
- CURRENT SERVER (defined as CHAR(18))
- CURRENT TIME (defined as TIME)
- CURRENT TIMESTAMP (defined as TIMESTAMP)
- CURRENT TIMEZONE (defined as DECIMAL(6,0))
- USER (defined as CHAR(8))

Using CURRENT DATE, TIME, and TIMESTAMP: The values of all datetime special registers in the same statement are based on the same time-of-day (TOD) clock reading.

In the examples below, one uses the select-statement and the other uses the UPDATE statement.

```
SELECT CURRENT DATE, PRSTDATE
       FROM PROJECT
       ORDER BY PRSTDATE

UPDATE PROJECT SET PRSTDATE = CURRENT DATE,
                  PRENDATE = '1996-01-20'
            WHERE PROJNAME = 'OPERATION'
```

Using CURRENT TIMEZONE: The CURRENT TIMEZONE is a signed time-duration containing the local time zone value. A negative value represents differentials west of the Greenwich-Mean-Time (GMT). A positive value represents differentials east of the GMT. CURRENT TIMEZONE can be used to convert local time into GMT by subtracting CURRENT TIMEZONE from local time. CURRENT TIMEZONE can be subtracted from a TIME or TIMESTAMP data type.

The following example shows a query that involves CURRENT TIMEZONE.

```
SELECT RECEIVED - CURRENT TIMEZONE
       FROM IN_TRAY
```

Using CURRENT SERVER: This special register holds the server name of the application server currently connected. It has a CHAR(18) data type.

The following example shows a query that includes the CURRENT SERVER special register:

```
SELECT ID, INDATE, INTIME
  FROM SAMP1
  WHERE INRDB=CURRENT SERVER
```

Using USER: This special register is evaluated as the currently connected *userid* that is, the user ID of the person who is running the program, regardless of who preprocessed it. USER behaves exactly like a fixed-length character string constant of length 8, with trailing blanks if the user ID has fewer than eight characters.

Notes:

1. You cannot use this keyword in an arithmetic expression (for example, USER+3).
2. You can use it in a predicate where you compare it to a character string (for example, USER = 'JIM').
3. You can use it in the LIKE predicate, where it is treated as a pattern.
4. You can, with some restrictions, use it in the SET clause of an UPDATE statement, or in the VALUES clause of an INSERT statement. In both cases, the data in the target column must be character data type (CHAR or VARCHAR).

The following is a valid expression that includes the USER special register:

```
SELECT *
FROM SYSTEM.SYSCATALOG
WHERE CREATOR = USER
```

Concatenating Character and Graphic Strings

You can use the concatenation operator (CONCAT) to concatenate character strings or graphic strings. Long strings cannot be used with the concatenation operator.

The following example shows the concatenation of employees' last names and jobs, separated by a hyphen:

```
SELECT LASTNAME CONCAT '-' CONCAT JOB FROM EMPLOYEE
```

For a full description of this operation, including rules for character subtypes and CCSIDs, see the *DB2 Server for VSE & VM SQL Reference* manual.

Note: The || symbol is a synonym for CONCAT. Because the | symbol is not in a consistent position in all code pages, the use of || could impair code portability.

Using Host Variables

As previously stated, host variables are host program variables that are declared in an SQL declare section. The host program can use these variables to interact with the database manager.

You can use host variables to pass data to or receive data from the database manager. Host variables used to contain column data or data used to evaluate an expression are called main variables. The data type and length attributes of a main variable depend on the data type and length of the column or expression to which the variable relates.

You can also use host variables to communicate information to and from the database manager about the contents of the main variable. If a host variable is used in this context, it is an indicator variable. Only use host variables that are declared with a data type equivalent to 15-bit integer as indicator variables. Refer to "Using Indicator Variables" on page 55 for a description of their use.

Several SQL statements permit the use of host variables. Refer to the *DB2 Server for VSE & VM SQL Reference* manual for the syntax of these SQL statements. The syntax diagrams indicate whether host variables are permitted or required.

For a description of how to declare host variables, refer to the appropriate host language appendix.

Using Host Structures

A host structure is a special form of host variable. It is any two-level structure or substructure declared in an SQL declare section. Host structures can replace all or part of a *host_variable_list*. A *host_variable_list* can contain references to more than one host structure.

The elements of the host structure comprise the list of main variables in the *host_variable_list*. To provide indicator variable support for the elements of the host structure, you must use an indicator array. An indicator array of n elements provides indicator variable support for the first n elements of the host structure.

The elements of host structures and structures that contain host structures can replace scalar host variables in an SQL statement. You can qualify the element name with the names of parent structures and substructures. The following syntax diagram shows the format of a structure element reference.

```
►►──┬────────────────┬──element_name──────────────────────────►◄
    └──struct_name.──┘
```

It is only necessary to qualify a structure or element name where failure to do so would result in an ambiguous reference.

Elements of indicator arrays cannot be used as host variables and host structures (or structures that contain host structures) cannot be declared as arrays or contain arrays.

Refer to the appropriate host language appendix for rules on the declaration of host structures and indicator arrays. Refer to the *DB2 Server for VSE & VM SQL Reference* manual for more information on the use of host structures and indicator arrays in SQL statements.

Using Constants

Constants (also called *literals*) can be numeric or character data. They are fixed values that can be coded into SQL statements. Like host variables, they are used in various clauses in a number of different SQL statements.

The following example shows a character string constant coded in a WHERE clause:

```
DECLARE C CURSOR FOR
SELECT *
FROM EMPLOYEE
WHERE LASTNAME = 'PEREZ'
```

Constants can be used in the SELECT clause to set up a new column in the result table, which has the specified constant in each of its occurrences. For example, the statement:

```
DECLARE C CURSOR FOR
SELECT LASTNAME, 'WOW', 100.0
FROM EMPLOYEE
WHERE COMM > 3200
```

would have the following result table:

```
LASTNAME      EXPRESSION 1      EXPRESSION 2
___________   _______________   _________________
LUCCHESI      WOW                        100.0
HAAS          WOW                        100.0
THOMPSON      WOW                        100.0
GEYER         WOW                        100.0
```

Using Numeric Constants

Integer constants consist of a number with an optional sign, such as -56, 103, or +786. (If you do not include a sign, the system assumes that the number is positive.) All integer constants are 4 bytes long; that is, there are no constants with a data type of SMALLINT.

Decimal constants consist of a number with a decimal point, such as 78.9687, -.00132, 64570., or +1672.80. If you do not supply a decimal point, the constant is interpreted as an integer. In storage, the number occupies a maximum of 16 bytes. Precision p, where $1 \leq p \leq 31$, is the total number of digits. Scale s, where $0 \leq s \leq p$, is the number of those digits that are to the right of the decimal point. Leading and trailing zeros are included in both precision and scale. When the precision and scale are calculated, if the precision is greater than 31, leading zeros are removed until the precision is equal to 31. Trailing zeros are never removed. When decimal data values are multiplied or divided, an overflow condition may occur.

Consider the following:

```
a string of thirty one 9's. * 1.0
```

The string of 9’s is treated as DECIMAL(31,0) and 1.0 as DECIMAL(2,1). The precision and scale of the product will then be 31 and 1 (DECIMAL(31,1)), respectively. This will result in a decimal overflow and an arithmetic exception will occur.

This decimal overflow, can be prevented by changing the constant `'1.0'` to `'1.'` This would define this constant as DECIMAL (1,0) and the resulting product as DECIMAL (31,0) instead of DECIMAL (31,1). If an expression contains decimal constants, you can influence its precision and scale by adding leading or trailing zeros to those constants.

A floating-point constant is an integer or a decimal constant followed by an exponent marked by the letter E. The E must be followed by an exponent. The 1E0 is acceptable and evaluates to 1. All these are permissible floating-point constants: -2E5, 2.2E-1, .2E6, +5E+2 or 4E0. All floating-point constants are double-precision in the system.

Using Character Constants

Character string constants are coded within quotation marks, and are varying-length character strings of letters, digits, or special characters, such as `'SMITH'`, `'52'`, or `'k@r -5B'`. A character constant implicitly assumes either a FOR SBCS DATA or a FOR MIXED DATA attribute. You cannot assign the FOR BIT DATA attribute to a character constant. The constant is assumed to have a subtype of SBCS unless the following conditions are true. If the following conditions are true, the constant is assigned a subtype of mixed.

- The application server supports mixed data.
- The constant contains mixed data.

Mixed data is composed of a mix of SBCS and DBCS characters in one string. The DBCS portions of the string must be correctly formatted strings of DBCS characters. (For a discussion of the format and rules for using strings of DBCS characters, see “Using a Double-Byte Character Set (DBCS)” on page 46.) An example of mixed data is:

```
'abc< DEFG >hi< JKLM >nop'
```

where `abc`, `hi`, and `nop` represent SBCS characters, and **DEFG** and **JKLM** represent DBCS characters.

| To obtain a single quotation mark in a string of SBCS characters, you must code two consecutive single quotation marks. For example, the constant `'DON''T GO'` is interpreted as `DON'T GO`. To obtain a single quotation mark in a string of DBCS characters, you only need to code a single quotation mark. Refer to the *DB2 Server for VSE & VM SQL Reference* manual for more information on mixed strings of SBCS and DBCS characters.

You can also code a character constant using its hexadecimal representation. Hexadecimal constants are treated like regular character constants. Hexadecimal constants are converted from the application requester default CCSID to the application server default CCSID before they are used.

The hexadecimal representation of a constant value must be enclosed within single quotation marks and preceded by an X. For example:

```
   X'2D'     X'C1C2C3C4'     X'4256457D'
```

Each pair of hexadecimal numbers (0-9, A-F) represents a single byte. (Either uppercase or lowercase letters can be used.) Therefore, the number of hexadecimal numbers must be even and, when representing a DBCS character in a mixed constant, it must be a multiple of 4 (each DBCS character occupies 2 bytes in storage).

You can use hexadecimal constants to represent SBCS and mixed character data only. The maximum size for hexadecimal constants is 254 hexadecimal digits (that is, 127 SBCS characters or 63 DBCS characters).

The following is a valid expression using a hexadecimal constant:

```
   LASTNAME CONCAT X'FF' CONCAT FIRSTNME
```

Using Graphic Constants

Graphic string constants are fully supported in COBOL and PL/I programs, but with different formats. The system supports three formats of the graphic constant: the SQL format and two PL/I formats.

The SQL format of the graphic constant is:

```
    G'< XXXX >'
```

Note: N is a synonym for G.

The G identifies the constant that follows as graphic; the < XXXX > is any valid string of DBCS characters, and the single quotation marks delimit the constant. You do not need to double the quotation marks in a graphic constant to obtain a single quotation mark. Use this format of the graphic constant in all situations except static SQL statements in PL/I programs.

The PL/I formats of the graphic constant are:

1. `'< XXXX >'G`
2. `< @'XXXX@'@G >`

Note: N is a synonym for G.

Again, the G indicates that the constant is a graphic constant, and that the string bound by < and > must be a valid string of DBCS characters. In the second format, the single quotation marks and the G are within the string of DBCS characters; they are the DBCS format of the quotation mark and the G. In the second format, to obtain a single DBCS quotation mark, double the occurrence of the DBCS quotation mark within the string of DBCS characters. Use either of these formats of the graphic constant in static SQL statements in PL/I programs.

The PL/I preprocessor converts PL/I format graphic constants into SQL format graphic constants (G'< XXXX >') when they appear in SQL statements. This is done before passing the SQL statement to the application server for processing. Therefore, some DB2 Server for VM messages for incorrect syntax may refer to the SQL format of the constant, even though a PL/I format constant was coded in your program.

Graphic constants assume the default graphic CCSID. Subtypes do not apply to graphic data. For example, you cannot assign the FOR BIT DATA attribute to a graphic constant. For detailed information on CCSIDs and subtypes, see “Using Character Subtypes and CCSIDs” on page 42.

For information on the rules for the format and use of strings of DBCS characters, see “Using a Double-Byte Character Set (DBCS)” on page 46.

Using Date and Time Constants

A datetime constant is a character string constant or a decimal constant in a datetime context, as shown in the following examples:

```
END_DATE - '1994-09-13'

END_DATE - 10000101.
```

In the first example, `'1994-09-13'` is a datetime character string constant; in the second, 10000101. is a decimal constant. A datetime decimal constant is a date duration, a time duration, or a timestamp duration. A date duration represents a number of years, months, and days, and is expressed as a DEC(8,0) number. A time duration represents a number of hours, minutes, and seconds, and is expressed as a DEC(6,0) number. A timestamp duration represents a number of years, months, days, hours, minutes, seconds, and microseconds, and is expressed as a DEC (20,6) number.

For more detailed information on date and time values, as well as durations, see “Using Datetime Values with Durations” on page 219.

Using Indicator Variables

Using indicator variables is optional in a host-variable reference. In static SQL statements, indicator variables can be used to indicate that the corresponding host variables should be treated as null values or truncated values. *Output* indicator variables appear in the INTO clause of a SELECT or FETCH statement, and are associated with output that is passed from the database to the application program. *Input* indicator variables appear in the predicates of WHERE and HAVING clauses, in the SET clause of an UPDATE statement, with VALUES in an INSERT statement or in the SELECT clause, and are associated with input that is passed from the application program to the database.

Output indicator variables should always be used wherever null values are allowed in the database. Input indicator variables can be used to put null values into the database. They should, however, not be used in predicates unless there is a very good reason for doing so, because there may be a significant cost in performance.

Refer to the *DB2 Server for VSE & VM SQL Reference* manual for a description of the format of a host-variable reference that contains an indicator variable.

The following example illustrates the use of indicator variables.

```
SELECT FIRSTNME, LASTNAME
INTO :FNME:FNMEIND, :LNME      :LNMEIND
FROM EMPLOYEE WHERE WORKDEPT = 'A00'
```

In this example, the indicator variable FNMEIND provides indicator variable support for the main variable FNME. The indicator variable LNMEIND provides indicator variable support for the main variable LNME.

The following notes on the use of indicator variables are grouped according to the type of indicator variable to which they apply.

Notes Common to Both Input and Output Indicator Variables

1. The indicator variable must be of a host language data type equivalent to an SQL SMALLINT.
2. A negative indicator variable indicates a null value for its main variable.

Notes on Input Indicator Variables

When using input indicator variables, be aware of the following:

1. Input indicator variables can be used to indicate that a column value is to be set to null (when the indicator variable is negative). If you provide an input indicator variable and assign it a negative value, the null value is inserted in the column value for the row. If the indicator variable is zero or a positive value, the main variable is inserted. Truncation does not apply to input variables.
2. A negative indicator variable can be used in static SQL for any of the following predicates:

   - The basic comparison ones (such as = or >)
   - BETWEEN
   - IN
   - LIKE
   - The quantified ones (ANY, ALL)

   See the *DB2 Server for VSE & VM SQL Reference* manual for the different sets of rules for truth values for these predicates.
3. Do not use input indicator variables in search conditions (WHERE or HAVING clauses) to test for null values. The correct way to test for nulls is with the NULL predicate (described earlier):

```
WHERE MGRNO IS NULL                Correct
```

   This will return every row where MGRNO is null.

```
WHERE MGRNO = :MGR:MGRIND                Incorrect
```

   If MGRIND has been set negative to make MGR null, the truth value is “UNKNOWN”, and nothing will be returned.
4. On the other hand, there are cases where setting up a negative input indicator variable in the predicate can prove useful and efficient. For example, if an application prompts the user to interactively supply information that will identify an employee (by either number or name), you can design the program to use only one select-statement to extract the indicated employee data from the database.

Here is the pseudocode:

```
get either empno or lastname from user
if empno is entered then empnoind = 0, else empnoind = -1
if lastname is entered then nameind = 0, else nameind = -1
SELECT * FROM EMPLOYEE
WHERE EMPNO = :EMPNO:EMPNOIND
OR LASTNAME = :NAME:NAMEIND
```

Notes on Output Indicator Variables

When using output indicator variables, be aware of the following:

1. The value returned in an output indicator variable is coded as shown in Figure 26.
2. Output indicator variables are optional. If a null value is returned, however, and you have not provided an indicator variable, a negative SQLCODE and an error SQLSTATE are returned to your program. If your data is truncated and there is no indicator variable, no error condition results. See “Converting Data” on page 44 for more information about truncation.

Figure 26. Values Returned in Output Indicator Variables

Value Returned	Meaning
0	Denotes that a non-null value that has been returned in the associated host variable is not null.
< 0	Denotes that the value associated with the host variable is null, and should be treated exactly the same way as null column values. A **-1** denotes that the null value resulted from a normal operation. A **-2** denotes that the null value resulted from either a conversion error or an error while evaluating an arithmetic expression in an outer-select clause.
> 0	Denotes that the system truncated the returned value in the associated host variable because the host variable was not of sufficient length. In addition, if the truncated item was a DBCS character or a string of DBCS characters, the indicator variable contains the length in characters before truncation. If the truncated item was a TIME value, truncated at its seconds part, the indicator variable contains the seconds. The SQLWARN1 warning flag in the SQLCA is set to `'W'` whenever truncation occurs.

Using Views

Views allow multiple users to see different presentations of the same data. For example, several users may be operating on a table of data about employees. One may see data about some employees but not others; another may see data about all employees but none of their salaries; and a third may see data about employees joined together with some data from another table. Each of these users is operating on a *view* that is derived from the real table of data about employees. Each view appears to be a table and has a name of its own.

You can create views with authorization statements to control access to sensitive data. For example, you might create a view based on a GROUP BY query that gives certain users access to the *average* salary of employees in each department, but prevents them from seeing any individual salaries.

A view is a dynamic “window” on tables. When you update a real table, you can see the updates through a view; when you update a view, the real table underlying the view is updated. There are, however, restrictions on modifying tables through a view.

Because a view is not physically stored, you cannot create an index on it. However, if you create an index on the real table underlying a view, you may improve the performance of queries on the view.

Creating a View

```
►►──CREATE VIEW──view_name──┬─────────────────────────┬──────────────────►
                            │      ┌─,───────────┐    │
                            └─(────▼─column_name─┴──)─┘
►──AS──subselect──┬───────────────────┬──────────────────────────────────►◄
                  └─WITH CHECK OPTION─┘
```

In the following example, a view is created from the EMPLOYEE table:

```
CREATE VIEW PHONEBOOK (FNAME, LNAME, NUMBER, DEPART, JOBTITLE) AS
     SELECT FIRSTNME, LASTNAME, PHONENO, WORKDEPT, JOB
     FROM EMPLOYEE WHERE JOB <> 'PRES' WITH CHECK OPTION
```

The CREATE VIEW statement causes the indicated *select-statement* to be stored as the definition of a new view, and gives a name to the view and (optionally) to each column in it. If you do not specify the column names, the columns of the view inherit the names of the columns from which they are derived.

You must specify a name for any view column that is not derived directly from a single table column (for example, if a view column is defined as AVG(SALARY) or SALARY+COMMISSION). Columns derived in this manner are often called *virtual columns*, (and contain *virtual data*). You must also specify new column names if the selected columns of the view do not have unique names (for example, if the view is a join of two tables, each of which has a column named PROJNO).

In general, the data types of the columns of the view are inherited from the columns on which they are defined. If a view column is defined on a function, the data type of the view column will be the data type of the function result. (For more details on functions, refer to the *DB2 Server for VSE & VM SQL Reference* manual.)

If you want to prevent the execution of subsequent inserts or updates to the view that involve data that is outside the domain of the view’s definition (as specified in the WHERE clause of its subselect), you can add the WITH CHECK OPTION clause. This clause, however, is not allowed for updateable views that are built on subqueries. The checking that is performed at insert or update time is performed according to a set of rules that cover the situation in which a view is dependent on other views. See the *DB2 Server for VSE & VM SQL Reference* manual for these rules.

Some other considerations when creating views are:

- Internal database manager limitations restrict a view to approximately 140 columns. The number of referenced tables, lengths of column names, and WHERE clauses all further reduce this number.
- If the *subselect* in a view definition has a “SELECT *” clause, the view has as many columns as the underlying table. If columns are later added to the underlying table by ALTER statements, the new columns will *not* appear in the view (unless you drop and re-create the view).
- The name of the view must be unique among all the tables, views, and synonyms that you have already created. You can refer to another user’s views, if so authorized, by using the owner-name as a prefix (for example, SMITH.PHONEBOOK).
- You can define a view in terms of another view: that is, the *subselect* that defines a view may refer to one or more other views. In this case, follow the rules listed under “Using Views to Manipulate Data” on page 60.
- There is no ORDER BY clause in a *subselect*; therefore, like a table, a view has no intrinsic order. (Of course, you can specify an ORDER BY clause when you write queries against the view.)
- Host variables are not permitted in a CREATE VIEW statement. (For example, predicates such as PRICE = :X are not permitted.)
- The owner of the view is considered to be the authorization ID under which the program is preprocessed.
- When you define a new view, you receive the same privileges that you have on the underlying table. If you possess these privileges with the GRANT option, you can grant privileges on your view to other users. (See Chapter 9, “Assigning Authority and Privileges” on page 209 for information on the GRANT option.) If the view is derived from more than one underlying table, you receive the SELECT privilege, provided that you have this privilege on all the tables from which it is derived. (If you have *no* privileges on the underlying tables, the CREATE VIEW statement returns an error code.) Only the SELECT privilege is possible, because multi-table views do not permit insertion, deletion, or update.
- Primary keys and foreign keys (discussed in “Ensuring Data Integrity” on page 231) cannot be defined on a view.
- If you defined your view on a table that has a primary key, and you make changes to that view, the view should contain all the columns of the key.
- The *subselect* is not executed when the view is created, which means that semantic errors (for example, specifying `"WHERE COL = '10'"` when COL is a decimal column) are not detected until the view is used. To determine whether a statement contains semantic errors, you can enter `'SELECT *'` against the view after creating it.

Querying Tables through a View

You can write queries (select-statements) against views exactly as if they were real tables. When you make a query against a view, the query is combined with the definition of the view to produce a new query against real stored tables. This query is then processed in the usual way. For example, the following query might be written against the view PHONEBOOK that was defined under “Creating a View” on page 58:

```
SELECT FNAME,LNAME
FROM PHONEBOOK
WHERE DEPART = 'D11'
ORDER BY 2
```

The system combines the query with the definition of PHONEBOOK, and processes the resulting internal query:

```
SELECT FIRSTNME, LASTNAME
FROM EMPLOYEE
WHERE JOB <> 'PRES'
AND WORKDEPT = 'D11'
ORDER BY 2
```

During the processing of a query on a view, the system may detect and report errors (by a negative SQLCODE) in either of two phases:

- The combination of the query with the view-definition (for example, attempting to add together two strings of character-type)
- The execution of the resulting query on real tables (for example, attempting to fetch a null value when no indicator variable is provided).

Note: If a view materialization is required to process the view, this view must not contain any LONG VARCHAR columns in the view definition. For a detailed description of view materialization, refer to the *DB2 Server for VM Database Administration* manual.

Using Views to Manipulate Data

Like select-statements, INSERT, DELETE, and UPDATE statements can be applied to a view just as though it were a real stored table. The SQL statement that operates on the view is combined with the definition of the view to form a new SQL statement that operates on a stored table. Any data modification made by such a statement is visible to users of the view, the underlying table, or other views defined on the same table (if the views “overlap” in the modified area).

The following is an example of an update applied to the view PHONEBOOK, showing how the update can be modified to operate on the real table EMPLOYEE:

View Definition for PHONEBOOK:

```
CREATE VIEW PHONEBOOK (FNAME, LNAME, NUMBER, DEPART, JOBTITLE) AS
SELECT FIRSTNME, LASTNAME, PHONENO, WORKDEPT, JOB
FROM EMPLOYEE WHERE JOB <> 'PRES' WITH CHECK OPTION
```

```
UPDATE PHONEBOOK
SET NUMBER = '9111'
WHERE LNAME = 'SMITH'
AND FNAME = 'DANIEL'
```

becomes:

```
UPDATE EMPLOYEE
SET PHONENO = '9111'
WHERE LASTNAME = 'SMITH'
AND FIRSTNME = 'DANIEL'
AND JOB <> 'PRES'
```

Note: Because of the WITH CHECK OPTION, the following update will not be allowed when Sally takes over as president:

```
UPDATE PHONEBOOK
SET JOBTITLE = 'PRES'
WHERE LNAME = 'KWAN'
AND FNAME = 'SALLY'
```

You must observe the following rules when modifying tables through a view:

1. INSERT, DELETE, and UPDATE of the view are not permitted if the view involves any of the following operations: join, GROUP BY, DISTINCT, or any column function such as AVG.
2. A column of a view can be updated only if it is derived directly from a column of a single stored table. Columns defined by expressions such as SALARY + BONUS or SALARY * 1.25 cannot be updated. (These columns are sometimes called virtual columns.) If a view is defined containing one or more such columns, the owner does not receive the UPDATE privilege on these columns. INSERT statements are not permitted on views containing such columns, but DELETE statements are.
3. The ALTER TABLE, CREATE INDEX, and UPDATE STATISTICS statements cannot be applied to a view.

You can use an INSERT statement on a view that does not contain all the columns of the stored table on which it is based. For example, consider the EMPLOYEE table with none of the columns defined as NOT NULL. You could insert rows into the view PHONEBOOK even though it does not contain the MIDINIT, EDLEVEL or any other columns of the underlying table EMPLOYEE.

You can insert or update rows of a view in such a way that they do not satisfy the definition of the view. For example, the view PHONEBOOK is defined by the condition JOB <> 'PRES'. It would be possible to insert rows into PHONEBOOK having a value equal to 'PRES' in the JOB column. This insertion takes effect on the underlying table, EMPLOYEE, but the resulting rows are not visible in the view PHONEBOOK, because they do not satisfy the definition of PHONEBOOK. In fact, an update to PHONEBOOK that sets JOB='PRES' causes a row to “vanish” from PHONEBOOK (a cursor positioned on the row retains its position, but later scans through PHONEBOOK do not see this row). If you want to ensure that all rows inserted or updated are subsequently visible in the view, then define your view with 'WITH CHECK OPTION'.

However, the EMPLOYEE table does have columns defined as NOT NULL, and two of them (MIDINIT and EDLEVEL) are not available through the PHONE view. If you try to insert a row through the view, the system attempts to insert NULL values into all the EMPLOYEE columns that are “invisible” through the view. Because the MIDINIT and the EDLEVEL columns are not included in the view, and do not permit null values, the system does not permit the insertion through the view.

Be extremely careful when updating tables through views that may contain duplicate rows. For example, suppose a view JOBS is defined on the EMPLOYEE table containing only the columns WORKDEPT and JOB. Because EMPNO is not included in the view, and many employees may have the same job description, a user of the view cannot tell which EMPNO corresponds to a given row of the view. If the user positions a cursor on a row where JOB = 'CLERK', and then updates the current row of this cursor, a row of the stored EMPLOYEE table is updated. However, because there may be many clerks in the EMPLOYEE table, and the unique qualifier EMPNO is not part of the view, the user cannot control which employee is updated.

Dropping a View

Format

```
►►──DROP VIEW──view_name──────────────────────────────────────────►◄
```

The DROP VIEW statement drops the definition of the indicated view from the database. When you drop a view, the system also:

- Drops all other views defined in terms of the indicated view. (The underlying tables on which the views are defined are not affected.)
- Deletes all privileges on the dropped views from the authorization catalog tables.
- Marks invalid all packages that refer to the dropped views.

  The invalid packages remain in the database until they are explicitly dropped by a DROP PACKAGE statement. When an invalid package is next invoked, the system attempts to regenerate it and restore its validity. However, if the program contains any SQL statement that refers to a dbspace, table, or view that has been dropped, that SQL statement returns an error code at run time.

If a DROP VIEW statement attempts to drop a view that is currently in use by another running logical unit of work, the statement is queued until that LUW ends.

Joining Tables

With joins, you can write a query against the combined data of two or more tables. (You can also join views.)

To join tables, follow these steps:

1. In the FROM clause, list all the tables you want to join.
2. In the WHERE clause, specify a *join condition* to express a relationship between the tables to be joined.

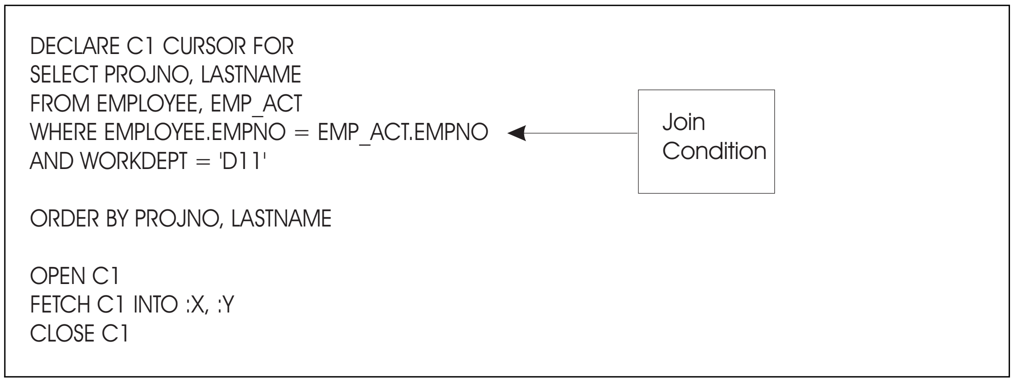
   Note: The data types of the columns involved in the join condition do not have to be identical; however, they must be compatible. The join condition is evaluated the same way as any other search condition, and the same rules for comparisons apply. (These rules are discussed under “Using Expressions” on page 48.)

Joining Tables Using the Database Manager

The system forms all combinations of rows from the indicated tables. For each combination, it tests the join condition. If you do not specify a join condition, all combinations of rows from tables listed in the FROM clause are returned, even though the rows may be completely unrelated.

Performing a Simple Join Query

The join query in Figure 27 finds the project number and the last name of the employees in department D11:



```
DECLARE C1 CURSOR FOR
SELECT PROJNO, LASTNAME
FROM EMPLOYEE, EMP_ACT
WHERE EMPLOYEE.EMPNO = EMP_ACT.EMPNO
AND WORKDEPT = 'D11'

ORDER BY PROJNO, LASTNAME

OPEN C1
FETCH C1 INTO :X, :Y
CLOSE C1
```

Figure 27. A Simple Join

The WHERE clause above expresses a join condition. If a row from one of the participating tables does not satisfy the join condition, that row does not appear in the result of the join. So, if a EMPNO in the EMPLOYEE table has no matching EMPNO in the EMP_ACT table (or if EMPNO in the EMP_ACT table has no matching EMPNO in the EMPLOYEE table), that row does not appear in your result.

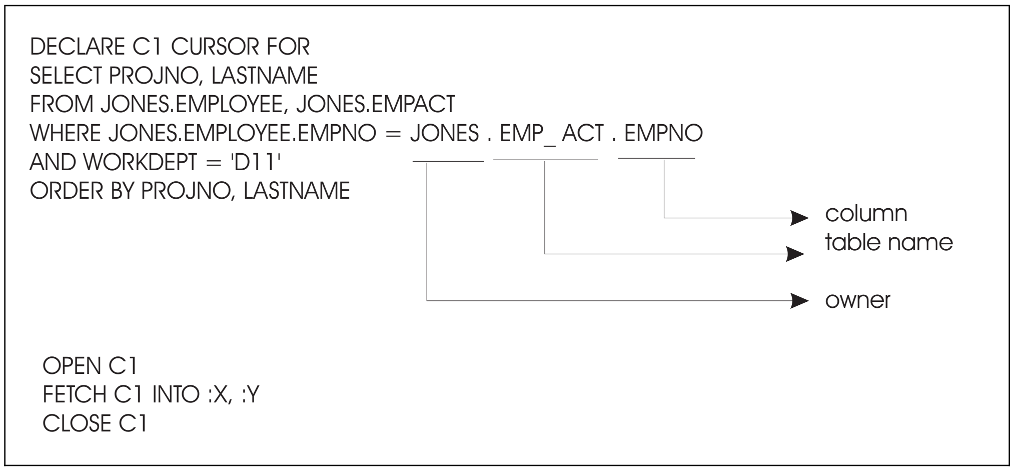
Note: More than one table in a join may have a common column name. To identify exactly which column you are referring to, you must use the table name as a prefix, as in the example above. Unique column names do not require a table name prefix.

Here is the query result (based on the example tables):

```
PROJNO  LASTNAME
______  _____________
MA2111  BROWN
MA2111  BROWN
MA2111  LUTZ
MA2112  ADAMSON
MA2112  ADAMSON
MA2112  WALKER
MA2112  WALKER
MA2112  YOSHIMURA
MA2112  YOSHIMURA
MA2113  JONES
MA2113  JONES
MA2113  PIANKA
MA2113  SCOUTTEN
MA2113  YOSHIMURA
```

Joining Another User’s Tables

If you are referring to another user’s table, you must prefix the table name with the owner-name. If, for example, the tables in the query above belonged to JONES, you would write:



```
DECLARE C1 CURSOR FOR
SELECT PROJNO, LASTNAME
FROM JONES.EMPLOYEE, JONES.EMPACT
WHERE JONES.EMPLOYEE.EMPNO = JONES . EMP_ ACT . EMPNO
AND WORKDEPT = 'D11'
ORDER BY PROJNO, LASTNAME

 OPEN C1
 FETCH C1 INTO :X, :Y
 CLOSE C1
```

Analyzing How a Join Works

When writing a join query, it is often helpful to mentally go through the query to see how SQL develops a JOIN.

For example, look at the previous select-statement. It refers to the EMPLOYEE and EMP_ACT tables. Joining the two tables will produce one table that contains all the columns in both tables.

Each EMPNO in the EMPLOYEE table is compared to every EMPNO in the EMP_ACT table. When the EMPNO column of both tables matches, a row is formed that contains the combined columns of the “matching” rows. Notice that the only column name that is common to both tables is EMPNO. If the name of this EMPNO column were different in each table, the EMPNO column of the result could have been called either name. This is because of the equality expressed in the join condition. In fact, the *select-list* could have specified EMPLOYEE.EMPNO instead of EMP_ACT.EMPNO, and identical results would have been produced.

Now consider what happens when the second part of the WHERE clause (AND WORKDEPT='D11') is applied.

The result is further reduced so that only the rows with a department name of D11 remain. The entire search condition is now satisfied. The system strips off the columns not specified in the *select-list*. This produces the query result previously shown.

Using VARCHAR and VARGRAPHIC within Join Conditions

If you are joining VARCHAR or VARGRAPHIC columns, trailing blanks are not used. For example, "JONES" and "JONES " match. If they were from two different EMPLOYEE tables joined on the LASTNAME column, they would form one row.

Using Nulls within Join Conditions

Like other predicates, a join condition is never satisfied by a null value. For example, if a row in the EMPLOYEE table and a row in the EMP_ACT table both have a null EMPNO, neither row will appear in the result of the join.

Joining a Table to Itself Using a Correlation Name

You can write a query in which you join a table to itself, by repeating the table name two or more times in the FROM clause. This tells the system that the join consists of combinations of rows from the same table. When you repeat the table name in the FROM clause, it is no longer unique. You must give one or both table names in the FROM clause a unique *correlation_name* to correctly designate the tables.

You use the correlation names to resolve column name ambiguities in the *select-list* and the WHERE clause. Rules for table designation are given at the end of this section.

For example, the following query finds the total of the values from the ACSTAFF column (PROJ_ACT table) for activities 60 and 70 for any project that contains both these activities:

```
DECLARE C1 CURSOR FOR
SELECT PA1.PROJNO, PA1.ACSTAFF + PA2.ACSTAFF
FROM   PROJ_ACT PA1, PROJ_ACT PA2
WHERE  PA1.PROJNO = PA2.PROJNO AND
       PA1.ACTNO = 60 AND PA2.ACTNO = 70
ORDER BY 1

OPEN C1
FETCH C1 INTO
     :PRONUM, :TOTAL
CLOSE C1
```

This type of join query can also be easily visualized. Each PROJNO in the PROJ_ACT table is compared to every other PROJNO in the PROJ_ACT table.

When two rows with the same PROJNO are found, a row is formed. The new row contains the combined columns of the “matching” rows.

Now consider what happens when the second part of the WHERE clause (PA1.ACTNO = 60 AND PA2.ACTNO = 70) is applied.

The result is further reduced to only the rows with an ACTNO of 60 in the first ACTNO column and with an ACTNO of 70 in the second ACTNO column.

Finally, the system sorts the query by PROJNO and strips off the columns not specified in the *select-list*. This produces:

```
        PROJNO    EXPRESSION 1              PROJNO   EXPRESSION 1
        ------    ------------              ------   ------------
        AD3111            2.30              AD3113           2.00
        AD3111            1.30              AD3113           1.25
        AD3111            2.00              AD3113           1.75
        AD3111            1.00              AD3113           1.50
        AD3112            1.50              AD3113           1.75
        AD3112            1.25              AD3113           2.25
        AD3112            1.75              AD3113           1.50
        AD3112            1.00              AD3113           2.00
        AD3112            1.25              AD3113           1.75
        AD3112            1.00              AD3113           2.00
        AD3112            1.50              AD3113           1.50
        AD3112            0.75              AD3113           0.75
        AD3112            1.50              AD3113           1.25
        AD3112            1.25              AD3113           1.00
        AD3112            1.75              AD3113           1.25
        AD3112            1.00              MA2112           3.00
        AD3112            1.75              MA2112           3.50
        AD3112            1.50              MA2112           3.00
        AD3112            2.00              MA2113           3.00
        AD3112            1.25              MA2113           3.00
```

If the table is owned by another user, the table name must be qualified in the usual fashion. For example, here is how to write the above query if the owner of the PROJ_ACT table is SCOTT:

```
DECLARE C1 CURSOR FOR
SELECT PA1.PROJNO, PA1.ACSTAFF + PA2.ACSTAFF
FROM   SCOTT.PROJ_ACT PA1, SCOTT.PROJ_ACT PA2
WHERE  PA1.PROJNO = PA2.PROJNO AND
       PA1.ACTNO = 60 AND PA2.ACTNO = 70
ORDER BY 1
OPEN C1
FETCH C1 INTO
     :PRONUM, :TOTAL
CLOSE C1
```

Rules for Table Designation

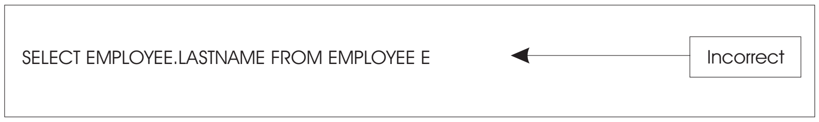
1. Only exposed table names and correlation names in the FROM clause can be referenced in other clauses.

   An exposed table name is one that is not followed by a *correlation_name* (for example, PROJECT). A nonexposed table name is a table name which is followed by a *correlation_name* (for example, PROJECT P). In the latter example, PROJECT has no scope in the query and cannot be referenced; the table designator in this case is P.

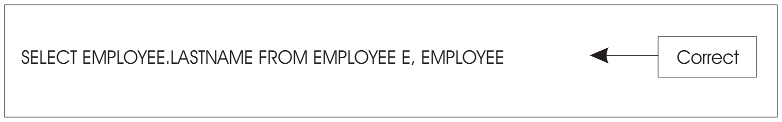
2. Exposed table names in the FROM clause must be different from each other.

3. Correlation names in the FROM clause must be different from each other and different from any exposed table names.

These rules are illustrated here:



The above query is not allowed. EMPLOYEE is a nonexposed table name and cannot be used to qualify column LASTNAME.



The above query is allowed. The second table in the FROM clause can be designated by the exposed table name EMPLOYEE. There is no ambiguity or conflict with the table name EMPLOYEE in the first table of the FROM clause, because that is a nonexposed table name.

Imposing Limits on Join Queries

The example of a simple join query in Figure 27 on page 63 had only one join condition relating the values of EMPNO in two tables.

Note: A query has the following limitations:

- You can join up to 15 tables
- A query can have up to 40 join conditions (predicates)
- The WHERE clause of a query may have a total of up to 200 conditions (predicates)

For more information on these limits, see the section on 'SQL Limits' in the *DB2 Server for VSE & VM SQL Reference* manual.

Using SELECT * In a Join

The notation SELECT * in a join query means “select all the columns of the first table, followed by all the columns of the second table, and so on.” You can also use the notation SELECT T1.*. to select all the columns of the table T1. However, it is not recommended that you use either SELECT * or SELECT T1.* for join queries written in programs because if someone adds a new column to the first table in the join (by an ALTER TABLE statement), the columns of the second table are no longer delivered into the correct host variables. To avoid this problem, use a *select-list* in which all the columns are specifically listed.

Grouping the Rows of a Table

The *DB2 Server for VSE & VM SQL Reference* manual shows how to apply the column functions (SUM, AVG, MIN, MAX, and COUNT) to a table. However, you can apply these functions only to particular columns in rows that satisfy a search condition. For example, the following statement finds the average number of employees for all occurrences of project number AD3111 in the PROJ_ACT table:

```
SELECT AVG(ACSTAFF)
FROM PROJ_ACT
WHERE PROJNO = 'AD3111'
```

In contrast, the *grouping* feature of the database manager permits you to conceptually divide a table into groups of rows with matching values in one or more columns. You can then apply a function to each group. For example, to find the average number of employees for each project in the PROJ_ACT table:

```
SELECT PROJNO,AVG(ACSTAFF)
FROM PROJ_ACT
GROUP BY PROJNO
ORDER BY PROJNO
```

The query yields this result based on the sample table PROJ_ACT:

```
PROJNO      AVG(ACSTAFF)
------  -----------------
AD3100     0.5000000000000000000000000
AD3110     1.0000000000000000000000000
AD3111     0.9357142857142857142857142
AD3112     0.6227272727272727272727272
AD3113     0.8461538461538461538461538
IF1000     0.6000000000000000000000000
IF2000     0.5500000000000000000000000
MA2100     0.7500000000000000000000000
MA2110     1.0000000000000000000000000
MA2111     1.0000000000000000000000000
MA2112     1.2142857142857142857142857
MA2113     1.0714285714285714285714285
OP1000     0.2500000000000000000000000
OP1010     2.5000000000000000000000000
OP2000     0.7500000000000000000000000
OP2010     1.0000000000000000000000000
OP2011     0.5000000000000000000000000
OP2012     0.5000000000000000000000000
OP2013     0.5000000000000000000000000
PL2100     1.0000000000000000000000000
```

One or more column functions can be applied to the groups. The following query finds the maximum, minimum, and average salary for each department, along with the count of the number of rows in each group (the column function COUNT(*) evaluates to the number of rows in the group):

```
SELECT WORKDEPT, MAX(SALARY), MIN(SALARY), AVG(SALARY), COUNT(*)
FROM EMPLOYEE
GROUP BY WORKDEPT
```

Using VARCHAR and VARGRAPHIC within Groups

If you are grouping a VARCHAR or VARGRAPHIC column, trailing blanks are ignored. For example, if a select-statement was grouped by DESCRIPTION, “BOLT” and “BOLT   ” would match. They would be placed in the same group.

Using Nulls within Groups

If you are grouping columns that return null values, the null values are grouped in those columns. The null values may be returned because of undefined column values or arithmetic exception errors.

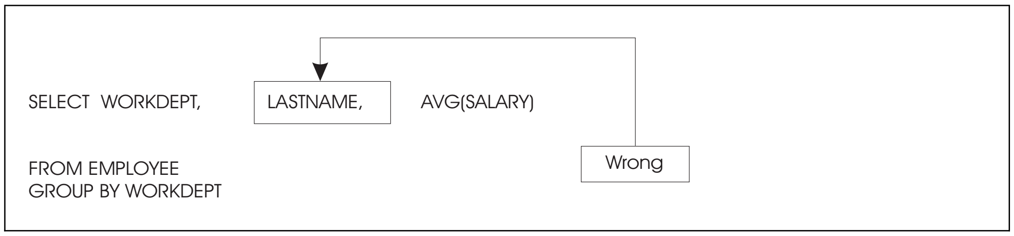
If you have defined a VIEW that contains a GROUP BY clause, the view columns named in the GROUP BY have the same nullability as the corresponding base table columns.

Using Select-Lists in Grouped Queries

When you use the GROUP BY clause in a query, the database manager returns only one result row for each group. The *select-list* of such a query can contain only:

- GROUP BY columns
- Column functions.

For example, this statement is incorrect:



You cannot include LASTNAME in the *select-list* because LASTNAME does not occur in the GROUP BY clause, and is not the operand of a column function. Aside from breaking language rules, the above statement is incorrect because a department may have many employees. It is as though you were asking the system to return multiple values to the same variable at the same time.

Using a WHERE Clause with a GROUP BY Clause

A grouping query can have a standard WHERE clause that eliminates non-qualifying rows before the groups are formed and the column functions are computed. Write the WHERE clause *before* the GROUP BY clause. For example:

```
SELECT WORKDEPT, AVG(SALARY)
FROM EMPLOYEE
WHERE HIREDATE > '1970-01-01'
GROUP BY WORKDEPT
```

Using the HAVING Clause

You can apply a qualifying condition to groups so that the system returns a result only for the groups that satisfy the condition, by including a HAVING clause *after* the GROUP BY clause. A HAVING clause can contain one or more group-qualifying predicates connected by ANDs and ORs. Each group-qualifying predicate compares a property of the group such as AVG(ACSTAFF) with one of the following:

1. Another property of the group (for example,HAVING AVG(ACSTAFF) > 2 * MIN(ACSTAFF))
2. A constant (for example, HAVING AVG(ACSTAFF) > 1.00)
3. A host variable (for example, HAVING AVG(ACSTAFF) > :LIMIT).

For example, the following query finds the average mean number of employees for projects having more than three activities:

```
SELECT PROJNO,AVG(ACSTAFF)
   FROM PROJ_ACT
   GROUP BY PROJNO
   HAVING COUNT(*) > 3
   ORDER BY PROJNO
```

You can specify DISTINCT as part of the argument of a column function in the HAVING clause, because DISTINCT eliminates duplicate values before a function is applied. Thus, COUNT(DISTINCT PROJNO) computes the number of different project numbers. You cannot use DISTINCT in both the *select-list* and HAVING clause; you can use it only once in a query.

It is possible (though unusual) for a query to have a HAVING clause but no GROUP BY clause. In this case, the system treats the entire table as one group. Because the table is treated as a single group, you can have at most one result row. If the HAVING condition is true for the table as a whole, the selected result (which must consist entirely of column functions) is returned; otherwise the “not found” code (SQLCODE = 100 and SQLSTATE=`'02000'`) is returned.

Combining Joins

This section discusses the WHERE, GROUP BY, HAVING, and ORDER BY clauses of the select-statement.

You can use the various query techniques together in any combination. A query can join two or more tables and can also have a WHERE clause, a GROUP BY clause, a HAVING clause, and, if defined in a cursor, an ORDER BY clause. The sequence of application for these clauses is listed below:

1. Conceptually, all possible combinations of rows from the listed tables are formed.
2. The WHERE clause, which may contain join conditions, is applied to filter the rows of the conceptual table.
3. The GROUP BY clause is applied to form groups from the surviving rows.
4. The HAVING clause is applied to filter the groups. Only the surviving groups will return a result.
5. The *select-list* expressions are evaluated.
6. The ORDER BY clause determines the order in which the query result is returned.

Illustrating Grouping with an Exercise

By now you may be wondering when you need to use which feature. Consider this problem:

Write a query that returns:

- *The department number*
- *The manager's employee number*
- *The total number of activities for all the projects in the department*
- *The sum of the estimated mean number of employees needed to staff the activities for all the projects in the department.*

Consider only projects that are estimated to end after January, 1 1994, and only include departments with more than two activities. Finally, order the result by department name.

The first thing that you must do is to find in the example tables the names of the columns that contain the requested information, so that you can create a *select-list*:

- “department number” is the DEPTNO column of the DEPARTMENT table.
- “manager's employee number” is the MGRNO column of the DEPARTMENT table.
- “activities” is the ACTNO column of the PROJ_ACT table, but the problem requests the *total number of activities for all the projects in a department*, so you must include the column function COUNT(*) in the *select-list*.

Note: You need the total number of activities for a particular department; this means that the query will have to group by department.

- "estimated mean number of employees needed to staff the activities" implies the ACSTAFF column of the PROJ_ACT table. However, the problem requests **The sum of** *the estimated mean number of employees needed to staff the activities* **for all the projects in the department**. So you must include the column function SUM in the *select-list*; this means that the query will have to group by department.

Note: The columns DEPTNO and MGRNO (from the DEPARTMENT table) and ACSTAFF (from the PROJ_ACT table) come from different tables so you will need a join. However, the DEPARTMENT, and PROJ_ACT tables do not have a common column. To join them, you will have to use the PROJECT table in a three-table join. PROJECT contains both the DEPTNO column of the DEPARTMENT table and the PROJNO column of the PROJ_ACT table.

First, define the cursor(s) to be used in your program:

```
DECLARE C1 CURSOR FOR
```

Now write a SELECT clause:

```
SELECT DEPARTMENT.DEPTNO, MGRNO, SUM(ACSTAFF), COUNT(*)
```

Note: Since a DEPTNO column appears in both the DEPARTMENT and the PROJECT tables, you must qualify which table it is from.

Write a FROM clause that lists the three tables used in the join:

```
FROM DEPARTMENT, PROJECT, PROJ_ACT
```

You must include a WHERE clause because of the join condition; one line to join the DEPARTMENT table to the PROJECT table, and one to join the PROJECT table to the PROJ_ACT table:

```
WHERE DEPARTMENT.DEPTNO = PROJECT.DEPTNO
AND PROJECT.PROJNO = PROJ_ACT.PROJNO
```

However, the problem states that only projects that are estimated to end on or after January 1, 1994 should be considered. This condition needs to be added to the WHERE clause:

```
AND PRENDATE >= '1994-01-01'
```

Note that PRENDATE is a column in the PROJ_ACT table and is unique among all the column names of the joined tables, so it does not have to be qualified. So far, the SQL statement is:

```
DECLARE C1 CURSOR FOR
SELECT DEPARTMENT.DEPTNO, MGRNO, SUM(ACSTAFF), COUNT(*)
FROM DEPARTMENT, PROJECT, PROJ_ACT
WHERE DEPARTMENT.DEPTNO = PROJECT.DEPTNO
AND PROJECT.PROJNO = PROJ_ACT.PROJNO
AND PRENDATE >= '1994-01-01'
```

It is now necessary to group by DEPTNO to find the sum for each part, but MGRNO is also in the *select-list*, so it must be listed in the GROUP BY clause (recall the rules for grouping). Including MGRNO in the GROUP BY clause does not affect the formation of the groups, however, because MGRNO is a property of a given DEPTNO. The GROUP BY clause is:

```
GROUP BY DEPARTMENT.DEPTNO, MGRNO
```

Note: You can group by PROJECT.DEPTNO if you choose, because of the equality expressed between DEPARTMENT.DEPTNO and PROJECT.DEPTNO in the join condition. If you use PROJECT.DEPTNO in the GROUP BY clause, however, you must also use it in the *select-list*.

If the table name is fully qualified in the FROM clause, it is good practice to fully qualify it in the whole statement.

The problem requires that the departments included in the query have at least two activities for all the projects in the department; a HAVING clause is needed to filter out the unwanted groups:

```
HAVING COUNT(*) > 2
```

To have the system return the results in DEPTNO order, type:

```
DECLARE C1 CURSOR FOR
SELECT DEPARTMENT.DEPTNO, MGRNO, SUM(ACSTAFF), COUNT(*)
FROM DEPARTMENT, PROJECT, PROJ_ACT
WHERE DEPARTMENT.DEPTNO = PROJECT.DEPTNO
AND PROJECT.PROJNO = PROJ_ACT.PROJNO
AND PRENDATE >= '1994-01-01'
GROUP BY DEPARTMENT.DEPTNO, MGRNO
HAVING COUNT(*) > 2
ORDER BY 1
```

Now you must position the cursor and identify the corresponding host variables used in your program:

```
OPEN C1
FETCH C1 INTO :DEPT, :MGRN, :TOTSTAFF, :NUMACT
CLOSE C1
```

By incorporating the FETCH statement in a suitable host program loop along with an appropriate output command, this query produces the following result:

```
DEPTNO MGRNO       SUM(ACSTAFF) COUNT(EXPRESSION 1)
------ ------ ----------------- -------------------
C01    000030              5.75                  10
D01    ?                   2.00                   3
D21    000070             25.40                  32
E21    000100              4.00                   7
```

Nesting Queries

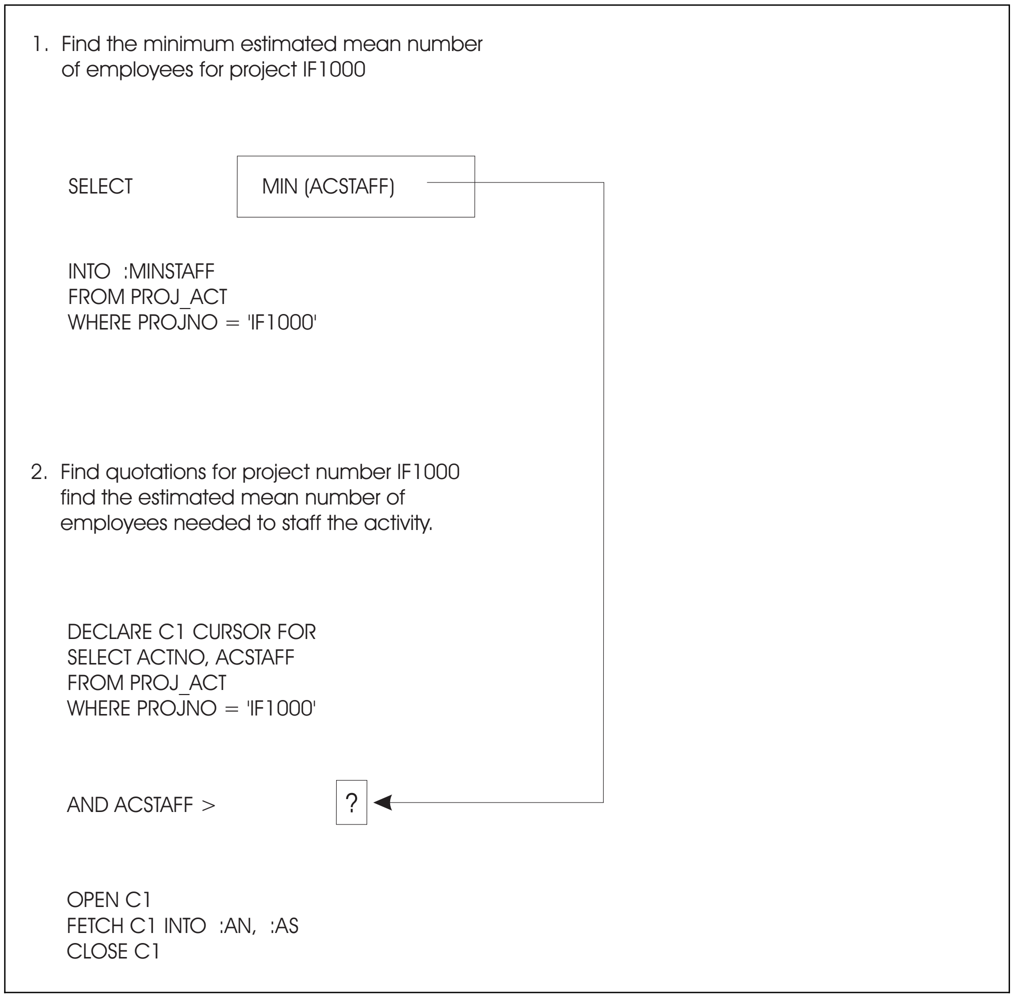
In all previous queries, the WHERE clause contained search conditions that the database manager used to choose rows for computing expressions in the select-list. A query can refer to a value or set of values computed by another query (called a *subquery*).

Consider this query which finds all the activities for project IF1000:

```
SELECT ACTNO, ACSTAFF
FROM PROJ_ACT
WHERE PROJNO = 'IF1000'
```

Suppose that you want to modify the query so it finds the activities for project IF1000 whose estimated mean number of employees is greater than the minimum estimated mean for that project.

The problem involves two queries:

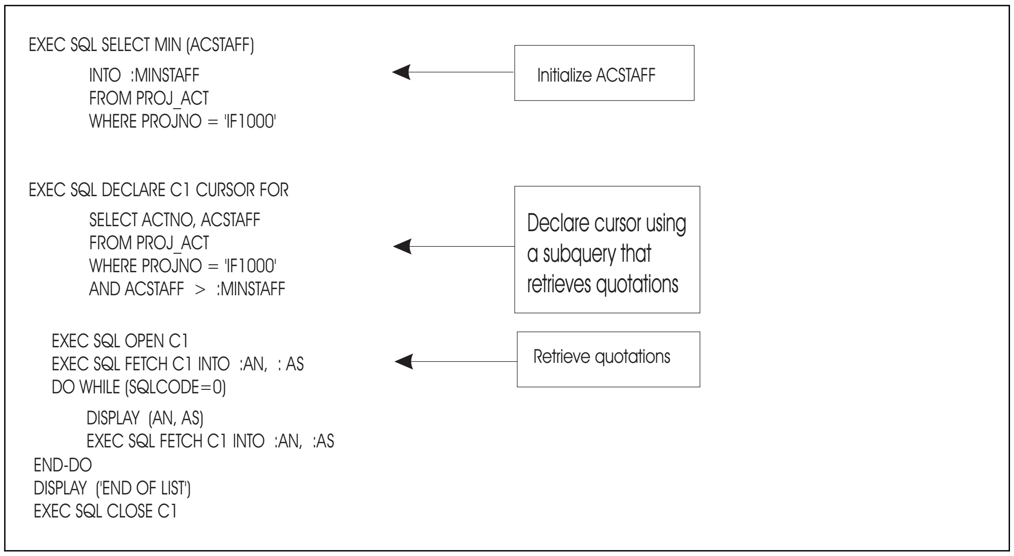

1. Find the minimum estimated mean number of employees for project IF1000

```
SELECT        MIN (ACSTAFF)

INTO  :MINSTAFF
FROM PROJ_ACT
WHERE PROJNO = 'IF1000'
```

2. Find quotations for project number IF1000 find the estimated mean number of employees needed to staff the activity.

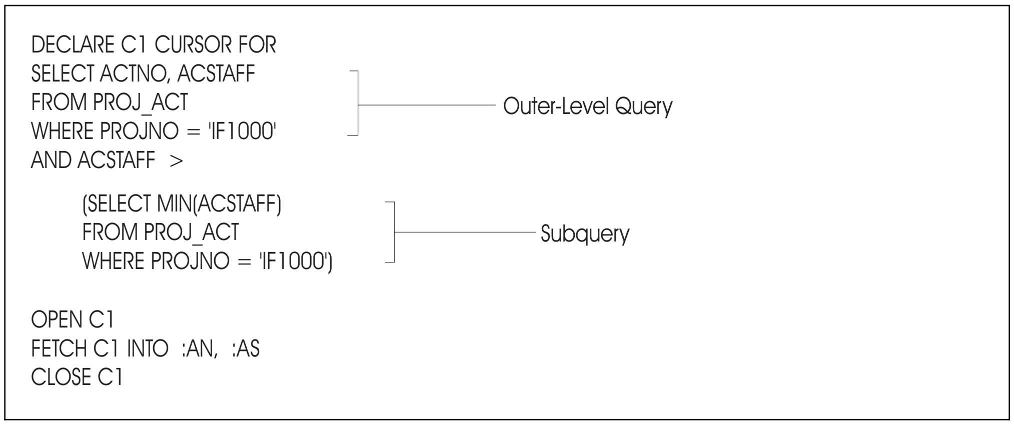
```
DECLARE C1 CURSOR FOR
SELECT ACTNO, ACSTAFF
FROM PROJ_ACT
WHERE PROJNO = 'IF1000'

AND ACSTAFF >        ?

OPEN C1
FETCH C1 INTO  :AN,  :AS
CLOSE C1
```

A pseudocode solution for the problem is as follows:



```
EXEC SQL SELECT MIN (ACSTAFF)
         INTO  :MINSTAFF
         FROM PROJ_ACT
         WHERE PROJNO = 'IF1000'

EXEC SQL DECLARE C1 CURSOR FOR
         SELECT ACTNO, ACSTAFF
         FROM PROJ_ACT
         WHERE PROJNO = 'IF1000'
         AND ACSTAFF  >  :MINSTAFF

   EXEC SQL OPEN C1
   EXEC SQL FETCH C1 INTO  :AN,  : AS
   DO WHILE (SQLCODE=0)
        DISPLAY  (AN, AS)
        EXEC SQL FETCH C1 INTO  :AN,  :AS
END-DO
DISPLAY  ('END OF LIST')
EXEC SQL CLOSE C1
```

You can arrive at the same result by using a single query with a subquery. Subqueries must be enclosed in parentheses, and may appear in a WHERE clause or a HAVING clause. The result of the subquery is substituted directly into the outer-level predicate in which the subquery appears; thus, there must not be an INTO clause in a subquery. For example, this query solves the above problem:



```
DECLARE C1 CURSOR FOR
SELECT ACTNO, ACSTAFF
FROM PROJ_ACT
WHERE PROJNO = 'IF1000'
AND ACSTAFF  >

       (SELECT MIN(ACSTAFF)
       FROM PROJ_ACT
       WHERE PROJNO = 'IF1000')

OPEN C1
FETCH C1 INTO  :AN,  :AS
CLOSE C1
```

The example subquery above is indented for ease of reading. Remember, however, that the syntax of SQL is fully linear and no syntactic meaning is carried by indentation or by breaking a query into several lines.

By using a subquery, the pseudocode is simplified:

```
EXEC SQL DECLARE C1 CURSOR FOR
     SELECT ACTNO, ACSTAFF
     FROM PROJ_ACT
     WHERE PROJNO = 'IF1000'
     AND ACSTAFF >
         (SELECT MIN(ACSTAFF)
         FROM PROJ_ACT
         WHERE PROJNO = 'IF1000')

EXEC SQL OPEN C1
EXEC SQL FETCH C1 INTO :AN, : AS
DO WHILE (SQLCODE=0)
     DISPLAY (AN, AS)
     EXEC SQL FETCH C1 INTO :AN, :AS
END-DO
DISPLAY ('END OF LIST')
EXEC SQL CLOSE C1
```

The subquery above returns a single value MIN(ACSTAFF) to the outer-level query. Subqueries can return either a single value, no value, or a set of values; each variation has different considerations. In any case, a subquery must have only a single column or expression in its *select-list*, and must not have an ORDER BY clause.

Returning a Single Value: If a subquery returns a single value, as the one subquery above did, you can use it on the right side of any predicate in the WHERE clause or HAVING clause.

Returning No Value: If a subquery returns no value (an empty set), the outer-level predicate containing the subquery evaluates to the unknown truth-value.

Returning Many Values: If a subquery returns more than one value, you must modify the comparison operators in your predicate by attaching the suffix ALL, ANY, or SOME. These suffixes determine how the set of values returned is to be treated in the outer-level predicate. The > comparison operator is used as an example (the remarks below apply to the other operators as well):

expression > **(subquery)**
: denotes that the subquery must return one value at most (otherwise an error condition results). The predicate is true if the given column is greater than the value returned by the subquery.

expression >**ALL (subquery)**
: denotes that the subquery may return a set of zero, one, or more values. The predicate is true if the given column is greater than each individual value in the returned set. If the subquery returns no values, the predicate is true.

expression >**ANY (subquery)**
: denotes that the subquery may return a set of zero, one, or more values. The predicate is true if the given column is greater than at least one of the values in the set. If the subquery returns no values, the predicate is false.

expression >SOME (subquery)
SOME and ANY are synonymous.

The following example uses a > ALL comparison to find those projects with activities whose estimated mean number of employees is greater than all of the corresponding numbers for project AD3111:

```
DECLARE C1 CURSOR FOR
SELECT PROJNO, ACTNO
FROM PROJ_ACT
WHERE ACSTAFF > ALL
         (SELECT ACSTAFF
          FROM PROJ_ACT
          WHERE PROJNO = 'AD3111')

OPEN C1
FETCH C1 INTO :PN, :AN
CLOSE C1
```

Using the IN Predicate with a Subquery

Your query can also use the operators IN and NOT IN when a subquery returns a set of values. For example, the following query lists the surnames of employees responsible for projects MA2100 and OP2012:

```
DECLARE C1 CURSOR FOR
SELECT LASTNAME
FROM EMPLOYEE
WHERE EMPNO IN
         (SELECT RESPEMP
         FROM PROJECT
         WHERE PROJNO = 'MA2100'
         OR PROJNO = 'OP2012')

OPEN C1
FETCH C1 INTO :LNAME
CLOSE C1
```

The subquery is evaluated once, and the resulting list is substituted directly into the outer-level query. For example, if the subquery above selects employee numbers 60 and 330, the outer-level query is evaluated as if its WHERE clause were:

```
WHERE EMPNO IN (60, 330)
```

The list of values returned by the subquery can contain zero, one, or more values. The operator IN is equivalent to =ANY, and NOT IN is equivalent to <>ALL.

Considering Other Subquery Issues

A subquery can contain GROUP BY or HAVING clauses. If it is linked by an unmodified comparison operator such as = or >, the subquery may return one group. If it is linked by a modified comparison operator ALL, ANY, or SOME, [NOT] IN, or [NOT] EXISTS , it may return more than one group.

A subquery may include a join, a grouping, or one or more inner-level subqueries. You may include many subqueries in the same outer-level query, each in its own predicate and enclosed in parentheses.

Executing Subqueries Repeatedly: Correlation

In all the examples of subqueries above, the subquery is evaluated only once and the resulting value or set of values is substituted into the outer-level predicate. For example, recall this query from the previous section:

```
DECLARE C1 CURSOR FOR
SELECT ACTNO, ACSTAFF
FROM PROJ_ACT
WHERE PROJNO = 'IF1000'
AND ACSTAFF >
    (SELECT MIN(ACSTAFF)
    FROM PROJ_ACT
    WHERE PROJNO = 'IF1000')
```

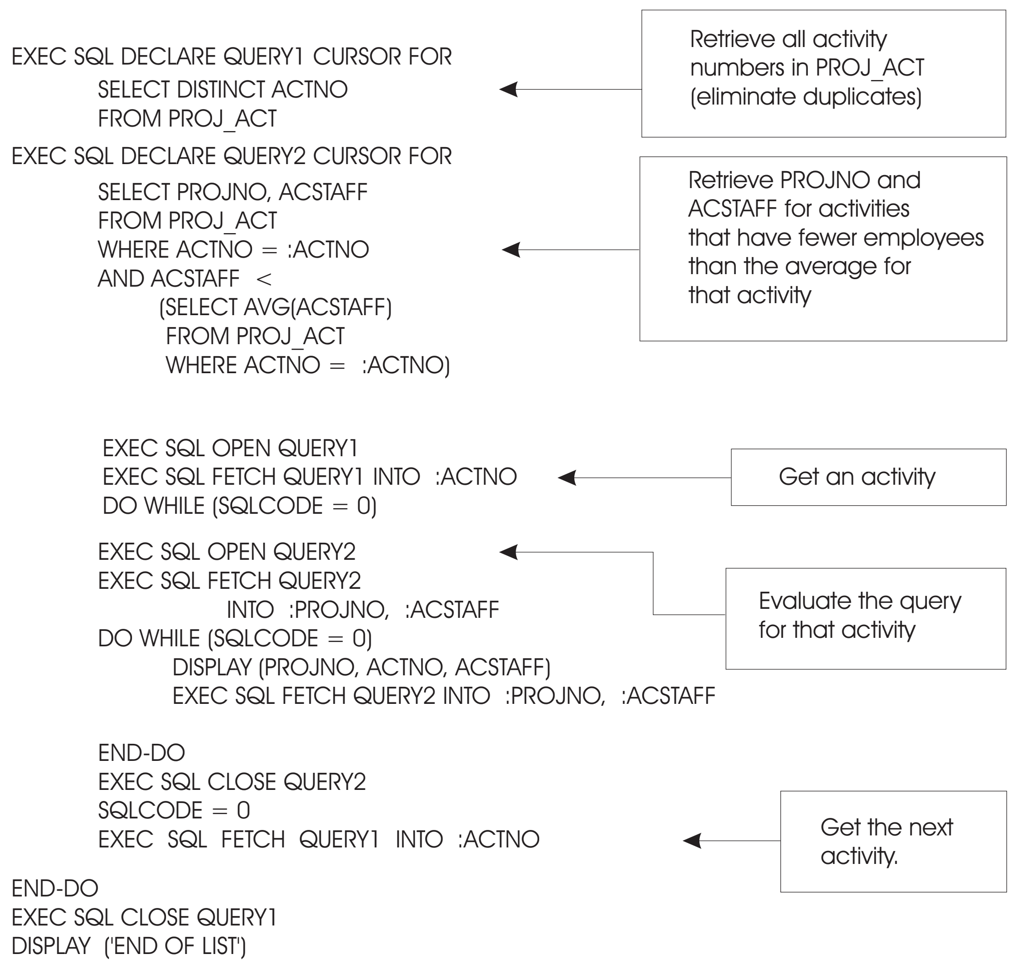
This query finds the activities for project IF1000 whose estimated mean number of employees is greater than the minimum estimated mean for that project. Now consider the following problem:

> *Find the project and activity numbers for activities that have an estimated mean number of employees that is less than the average estimated mean for that activity as calculated across all projects.*

The subquery needs to be evaluated once for every activity number. You can do this by using the *correlation* capability of SQL, which permits you to write a subquery that is executed *repeatedly*, once for each row of the table identified in the outer-level query. This type of “correlated subquery” computes some property of each row of the outer-level table that is needed to evaluate a predicate in the subquery.

In the first query, the subquery was evaluated *once* for a particular project; in the new problem, it must be evaluated once for *every* activity. One way to solve the problem is to place the query in a cursor definition and open the cursor once for each different activity. The activities are determined by using a separate cursor.

Here is a pseudocode solution:



```
EXEC SQL DECLARE QUERY1 CURSOR FOR
        SELECT DISTINCT ACTNO
        FROM PROJ_ACT
EXEC SQL DECLARE QUERY2 CURSOR FOR
        SELECT PROJNO, ACSTAFF
        FROM PROJ_ACT
        WHERE ACTNO = :ACTNO
        AND ACSTAFF  <
             (SELECT AVG(ACSTAFF)
              FROM PROJ_ACT
              WHERE ACTNO =  :ACTNO)


        EXEC SQL OPEN QUERY1
        EXEC SQL FETCH QUERY1 INTO  :ACTNO
        DO WHILE (SQLCODE = 0)

        EXEC SQL OPEN QUERY2
        EXEC SQL FETCH QUERY2
                    INTO  :PROJNO,  :ACSTAFF
        DO WHILE (SQLCODE = 0)
              DISPLAY (PROJNO, ACTNO, ACSTAFF)
              EXEC SQL FETCH QUERY2 INTO  :PROJNO,  :ACSTAFF

        END-DO
        EXEC SQL CLOSE QUERY2
        SQLCODE = 0
        EXEC  SQL  FETCH  QUERY1  INTO  :ACTNO

END-DO
EXEC SQL CLOSE QUERY1
DISPLAY  ('END OF LIST')
```

Retrieve all activity numbers in PROJ_ACT (eliminate duplicates)
Retrieve PROJNO and ACSTAFF for activities that have fewer employees than the average for that activity
Get an activity
Evaluate the query for that activity
Get the next activity.

By using a correlated subquery, you can let the system do the work for you and reduce the amount of code you need to write.

Writing a Correlated Subquery

To write a query with a correlated subquery, you use the same basic format as an ordinary outer query with a subquery. However, in the FROM clause of the outer query, just after the table name, you place a *correlation_name*. (See “Joining a Table to Itself Using a Correlation Name” on page 65 for more information on correlation names.) The subquery may then contain column references qualified by the *correlation_name*. For example, if X is a *correlation_name*, then “X.ACTNO” means “the ACTNO value of the current row of the table in the outer query.” The subquery is (conceptually) reevaluated for each row of the table in the outer query.

The following query solves the problem presented earlier. That is, it finds the project and activity numbers for activities that have an estimated mean number of employees that is less than the average estimated mean for that activity, as calculated across all projects.

```
SELECT PROJNO,ACTNO,ACSTAFF
   FROM PROJ_ACT X
   WHERE ACSTAFF < (SELECT AVG(ACSTAFF)
           FROM PROJ_ACT
           WHERE ACTNO = X.ACTNO)
```

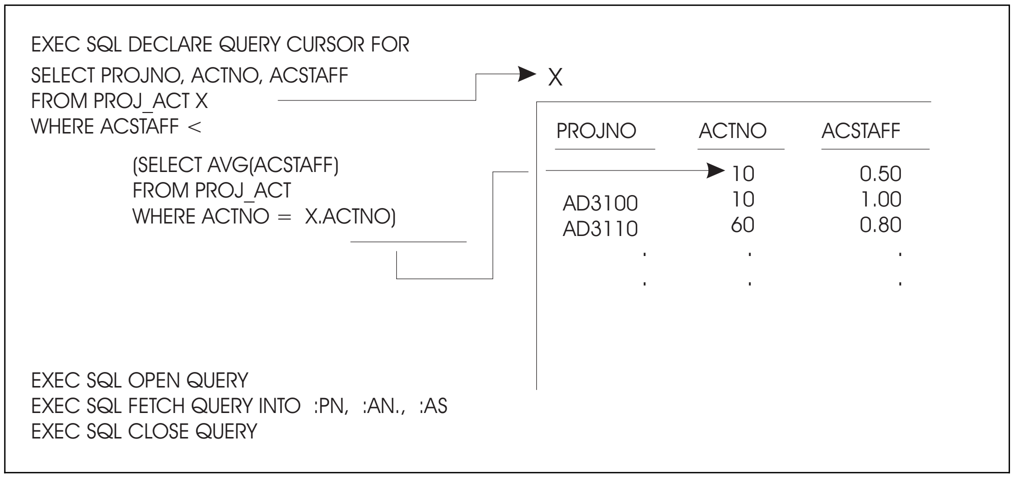
The pseudocode for the correlated subquery solution is:

```
EXEC SQL DECLARE QUERY CURSOR FOR
   SELECT PROJNO,ACTNO,ACSTAFF
      FROM PROJ_ACT X
      WHERE ACSTAFF < (SELECT AVG(ACSTAFF)
              FROM PROJ_ACT
              WHERE ACTNO = X.ACTNO)
EXEC SQL OPEN QUERY
EXEC SQL FETCH QUERY INTO :PROJNO, :ACTNO, :ACSTAFF
DO WHILE (SQLCODE=0)
     DISPLAY (PROJNO, ACTNO, ACSTAFF)
     EXEC SQL FETCH QUERY INTO :PROJNO, :ACTNO, :ACSTAFF
END-DO
DISPLAY ('END OF LIST')
EXEC SQL CLOSE QUERY
```

How the Database Manager Does Correlation

Conceptually, the query is evaluated as follows:

1. PROJ_ACT, the table identified with the *correlation_name* X, is placed to the side for reference. Let this table be called X, because it is the *correlation table*.
2. The system identifies X.ACTNO with the X table, and uses the values in that column to evaluate the query. (The entire query is evaluated once for every ACTNO in the X table.)



Note: ACTNO = X.ACTNO is not used in the WHERE clause of the outer-level query as it was in the uncorrelated subquery, because the system keeps track of the X.ACTNO for which it is evaluating the query.

Suppose another condition is added to the problem:

Find the project and activity numbers **for activities that have an estimated end date after January 1, 1994 and** *have an estimated mean number of employees that is less than the average estimated mean for that activity.*

The new query is:

```
EXEC SQL DECLARE QUERY CURSOR FOR
SELECT PROJNO, ACTNO, ACSTAFF
FROM PROJ_ACT X
WHERE ACENDATE > '1994-01-01'
AND   ACSTAFF <
      (SELECT AVG(ACSTAFF)
      FROM PROJ_ACT
      WHERE ACTNO = X.ACTNO)


EXEC SQL OPEN QUERY
EXEC SQL FETCH QUERY INTO :PN, :AN., :AS
EXEC SQL CLOSE QUERY
```

The X table in this query is slightly different. Conceptually, whenever there are other conditions besides the one containing the subquery, they are applied to the *correlation table* first. The X table that is derived from the PROJ_ACT table is:

```
 PROJNO  ACTNO ACSTAFF ACSTDATE   ACENDATE
 ------ ------ ------- ---------- ----------
 AD3111     80    1.25 1991-04-15 1994-01-15
 MA2112     70    1.50 1991-02-15 1994-02-01
 MA2113     70    2.00 1991-04-01 1994-12-15
 MA2113     80    1.50 1991-09-01 1994-02-01
 OP1010    130    4.00 1991-01-01 1994-02-01

Only rows with an ACENDATE greater than '1994-01-01' are included
in this "correlation table".
```

The values 70, 80, and 130 are used for X.ACTNO. Similarly, if you include a GROUP BY clause in the outer-level query, that grouping is applied to the conceptual correlation table first. Thus, if you use a correlated subquery in a HAVING clause, it is evaluated once per *group* of the conceptual table (as defined by the outer-level query's GROUP BY clause). When you use a correlated subquery in a HAVING clause, the correlated column-reference in the subquery must be a property of each group (that is, must be either the *group-identifying* column or another column used with a column function).

The use of a column function with a correlated reference in a subquery is called a *correlated function*. The argument of a correlated function must be exactly one correlated column (for example, X.ACSTAFF), not an expression. A correlated function may specify the DISTINCT option; for example: COUNT(DISTINCT X.ACTNO). If so, the DISTINCT counts as the single permitted DISTINCT specification for the outer-level query-block (remember that each query-block may use DISTINCT only once). For information on query-block, refer to the *DB2 Server for VM Database Administration* manual.

Illustrating a Correlated Subquery

When would you want to use a correlated subquery? The use of a column function is sometimes a clue. Consider this problem:

> *List the employees whose level of education is higher than the average for their department*.

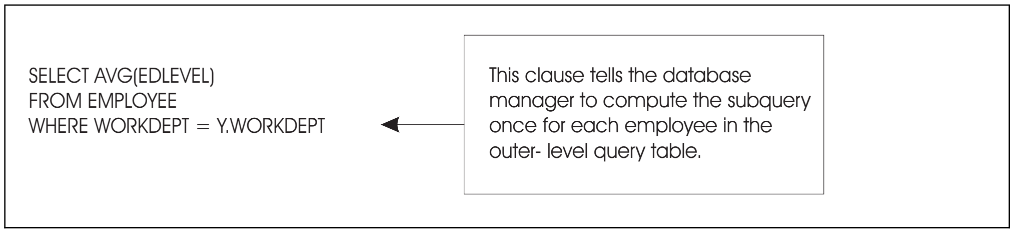
First you must determine the *select-list* items. The problem says to “List the employees”. This implies that the query should return something to identify the employees. LASTNAME from the EMPLOYEE table should be sufficient. The problem also discusses the level of education (EDLEVEL) and the employees' departments (WORKDEPT). While the problem does not explicitly ask for these columns, including them in the *select-list* will help illustrate the solution. A part of the query can now be constructed:

```
SELECT LASTNAME, WORKDEPT, EDLEVEL
FROM EMPLOYEE
```

Next, a search condition (WHERE clause) is needed. The problem statement says, “...whose level of education is higher than the average for that employee's department”. This means that for every employee in the table, the average education level for that employee's department must be computed. This statement fits the description of a correlated subquery. Some property (average level of education of the current employee's department) is being computed for each row. A *correlation_name* is needed on the EMPLOYEE table:

```
SELECT LASTNAME, WORKDEPT, EDLEVEL
FROM EMPLOYEE Y
```

The subquery needed is simple; it computes the average level of education for each department:



```
SELECT AVG(EDLEVEL)
FROM EMPLOYEE
WHERE WORKDEPT = Y.WORKDEPT
```

This clause tells the database manager to compute the subquery once for each employee in the outer- level query table.

The complete SQL statement is:

```
SELECT LASTNAME, WORKDEPT, EDLEVEL
      FROM EMPLOYEE Y
      WHERE EDLEVEL >
            (SELECT AVG(EDLEVEL)
             FROM EMPLOYEE
             WHERE WORKDEPT = Y.WORKDEPT)

This will produce the following:

 LASTNAME        WORKDEPT EDLEVEL
 --------------- -------- -------
 HAAS            A00           18
 KWAN            C01           20
 PULASKI         D21           16
 HENDERSON       E11           16
 LUCCHESI        A00           19
 PIANKA          D11           17
 SCOUTTEN        D11           17
 JONES           D11           17
 LUTZ            D11           18
 MARINO          D21           17
 JOHNSON         D21           16
 SCHNEIDER       E11           17
 MEHTA           E21           16
 GOUNOT          E21           16
```

Suppose that instead of listing the employee's department number, you list the department name. A glance at the sample tables will tell you that the information you need (DEPTNAME) is in a separate table (DEPARTMENT). The outer-level query that defines a correlation variable can also be a join query.

When you use joins in an outer-level query, list the tables to be joined in the FROM clause, and place the *correlation_name* next to one of these table names.

To modify the query to list the department's name instead of the number, replace WORKDEPT by DEPTNAME in the *select-list*. The FROM clause must now also include the DEPARTMENT table, and the WHERE clause must express the appropriate join condition.

This is the modified query:

```
SELECT LASTNAME, DEPTNAME, EDLEVEL
       FROM EMPLOYEE Y, DEPARTMENT
       WHERE Y.WORKDEPT = DEPARTMENT.DEPTNO
       AND EDLEVEL >
             (SELECT AVG(EDLEVEL)
              FROM EMPLOYEE
              WHERE WORKDEPT = Y.WORKDEPT)
```

This will produce the following:

```
LASTNAME        DEPTNAME                             EDLEVEL
--------------- ------------------------------------ -------
HAAS            SPIFFY COMPUTER SERVICE DIV.              18
LUCCHESI        SPIFFY COMPUTER SERVICE DIV.              19
KWAN            INFORMATION CENTER                        20
PIANKA          MANUFACTURING SYSTEMS                     17
SCOUTTEN        MANUFACTURING SYSTEMS                     17
JONES           MANUFACTURING SYSTEMS                     17
LUTZ            MANUFACTURING SYSTEMS                     18
PULASKI         ADMINISTRATION SYSTEMS                    16
MARINO          ADMINISTRATION SYSTEMS                    17
JOHNSON         ADMINISTRATION SYSTEMS                    16
HENDERSON       OPERATIONS                                16
SCHNEIDER       OPERATIONS                                17
MEHTA           SOFTWARE SUPPORT                          16
GOUNOT          SOFTWARE SUPPORT                          16
```

The above examples show that the *correlation_name* used in a subquery must be defined in the FROM clause of some query that contains the correlated subquery. However, this containment may involve several levels of nesting. Suppose that some departments have only a few employees and therefore their average education level may be misleading. You might decide that in order for the average level of education to be a meaningful number to compare an employee against, there must be at least five employees in a department. The new statement of the problem is:

> *List the employees whose level of education is higher than the average for that employee's department. Only consider departments with at least five employees*.

The problem implies another subquery because, for each employee in the outer-level query, the total number of employees in that persons department must be counted:

```
SELECT COUNT(*)
FROM EMPLOYEE
WHERE WORKDEPT = Y.WORKDEPT
```

Only if the count is greater than or equal to 5 is an average to be computed:

```
SELECT AVG(EDLEVEL)
       FROM EMPLOYEE
            WHERE WORKDEPT = Y.WORKDEPT
             AND 5 <=
                (SELECT COUNT(*)
                 FROM EMPLOYEE
                 WHERE WORKDEPT = Y.WORKDEPT)
```

Finally, only those employees whose level of education is greater than the average for that department are included:

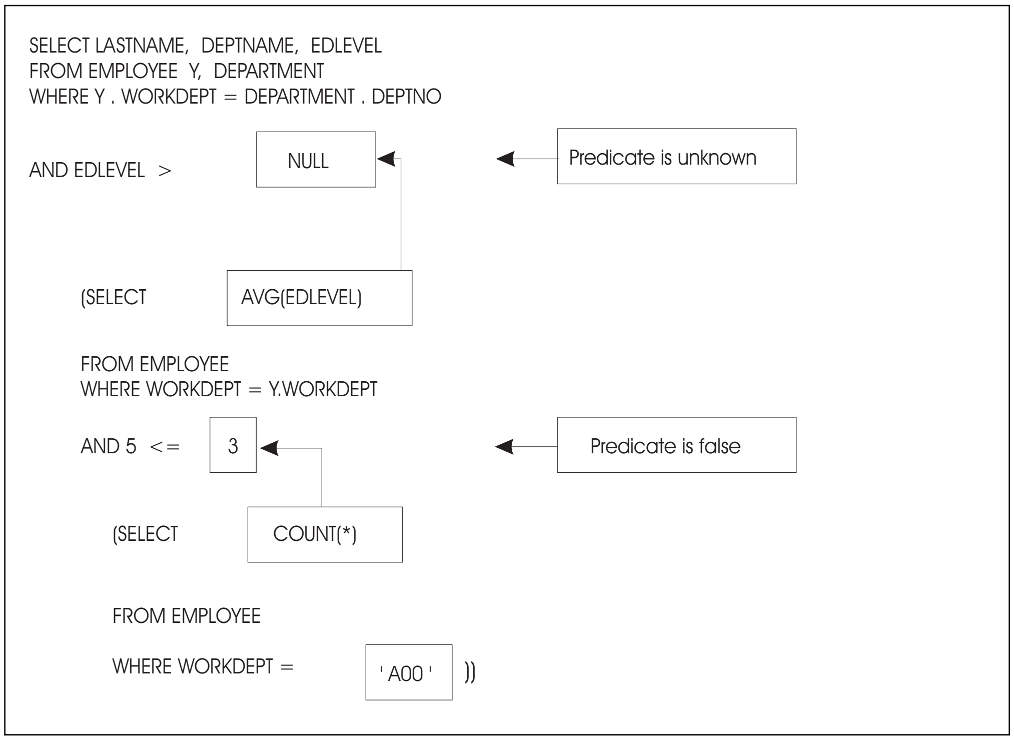
```
SELECT LASTNAME, DEPTNAME, EDLEVEL
   FROM EMPLOYEE Y, DEPARTMENT
   WHERE Y.WORKDEPT = DEPARTMENT.DEPTNO
   AND EDLEVEL >
         (SELECT AVG(EDLEVEL)
          FROM EMPLOYEE
          WHERE WORKDEPT = Y.WORKDEPT
          AND 5 <=
              (SELECT COUNT(*)
               FROM EMPLOYEE
               WHERE WORKDEPT = Y.WORKDEPT));
```

This will produce the following:

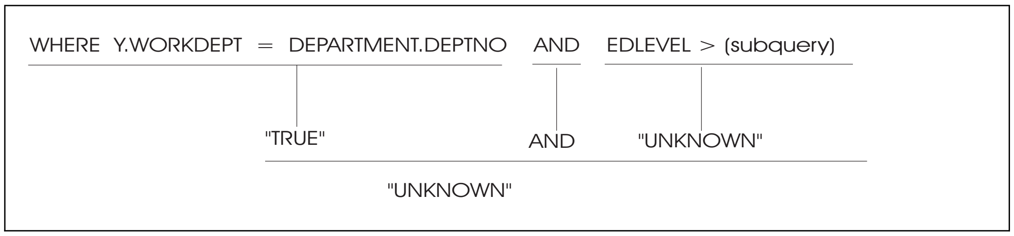
```
LASTNAME        DEPTNAME                             EDLEVEL
--------------- ------------------------------------ -------
PIANKA          MANUFACTURING SYSTEMS                     17
SCOUTTEN        MANUFACTURING SYSTEMS                     17
JONES           MANUFACTURING SYSTEMS                     17
LUTZ            MANUFACTURING SYSTEMS                     18
PULASKI         ADMINISTRATION SYSTEMS                    16
MARINO          ADMINISTRATION SYSTEMS                    17
JOHNSON         ADMINISTRATION SYSTEMS                    16
HENDERSON       OPERATIONS                                16
SCHNEIDER       OPERATIONS                                17
```

Note: The above query is different from the previous correlated subqueries in that the first subquery may return no values. Suppose that a department with three employees is being evaluated.

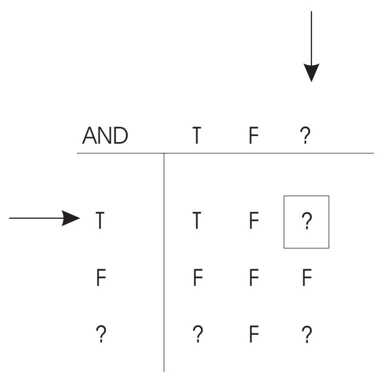
Working from bottom to top, the following occurs:



The inner-most subquery evaluates to 3. Thus, the expression “AND 5 <= 3” is false. Because that expression is false, no rows satisfy the search condition of the next subquery, and a null value is returned to the outer-most query. This causes the predicate “EDLEVEL > subquery)” to evaluate to the unknown truth value. The join condition “Y.WORKDEPT = DEPARTMENT.DEPTNO”, however, is always true:



The following figure is the “AND” truth table for search conditions; “TRUE AND UNKNOWN” causes the search condition in the query to be “UNKNOWN,” as indicated above.



AND	T	F	?
T	T	F	$\boxed{?}$
F	F	F	F
?	?	F	?

No rows satisfy the search condition, so no employee is listed for department A00; exactly the result wanted in this case.

Using a Subquery to Test for the Existence of a Row

You can use a subquery to test for the *existence* of a row satisfying some condition. In this case, the subquery is linked to the outer-level query by the predicate EXISTS or NOT EXISTS. (Refer to the *DB2 Server for VSE & VM SQL Reference* manual for the syntax of the EXISTS predicate.)

When you link a subquery to an outer query by an EXISTS predicate, the subquery does not return a value. Rather, the EXISTS predicate is true if the answer set of the subquery contains one or more rows, and false if it contains no rows.

The EXISTS predicate is often used with correlated subqueries. The example below lists the departments that currently have no entries in the PROJECT table:

```
DECLARE C1 CURSOR FOR
SELECT   DEPTNO, DEPTNAME
FROM     DEPARTMENT X
WHERE    NOT EXISTS
         (SELECT *
         FROM PROJECT
         WHERE DEPTNO = X.DEPTNO)
ORDER BY DEPTNO
```

You may connect the EXISTS and NOT EXISTS predicates to other predicates by using AND and OR in the WHERE clause of the outer-level query.

Table Designation Rule for Correlated Subqueries

Unqualified correlated references are allowed. For example, assume that table EMP has a column named SALARY and that table DEPT has a column named BUDGET, but no column named SALARY.

```
SELECT * FROM EMP
WHERE EXISTS (SELECT * FROM DEPT
              WHERE BUDGET < SALARY)
```

In this example, the system checks the innermost FROM clause for a SALARY column. Not finding one, it then checks the next innermost FROM clause (which in this case is the outer FROM clause). It is only necessary to use a qualified correlated reference when you want the system to ignore a column with the same name in the innermost tables.

To assist you in these situations, a warning message SQLCODE +12 (SQLSTATE '01545') is issued whenever an SQL statement is executed that contains an unqualified correlated reference in a subquery.

Combining Queries into a Single Query: UNION

The UNION operator enables you to combine two or more outer-level queries into a single query. Each of the queries connected by UNION is executed to produce an answer set; these answer sets are then combined, and duplicate rows are eliminated from the result.

When ALL is used with UNION (that is, UNION ALL), duplicate rows are not eliminated when two or more outer-level queries are combined into a single query. If you are using the ORDER BY clause, you must write it after the last query in the UNION. The system applies the ordering to the combined answer set before it delivers the results to your program using the usual cursor mechanism.

It is possible (though unusual) to write a query using the UNION operator that does not return results with a cursor. In this instance, only one row must be retrieved from the tables, and an INTO clause must be placed only in the first query.

The UNION operator is useful when you want to merge lists of values derived from two or more tables and eliminate any duplicates from the final result. UNION ALL will give better performance, however, because no internal sort is done. This sort is done with the UNION operator to facilitate the elimination of duplicates.

When both UNION and UNION ALL are used in the same query, processing is from left-to-right. If the last union operation is UNION, the duplicates will be eliminated from the final results; if it is UNION ALL, the duplicates will not be eliminated. However, the left-to-right priority can be altered by the use of parenthesis. A parenthesized subselect is evaluated first, followed, from left-to-right, by the other components of the statement. For example, the results of the following two queries, where A, B, and C are subselects, could be quite different:

```
A UNION (B UNION ALL C)
(A UNION B) UNION ALL C
```

In the following example, the query returns all projects for which the estimated mean number of employees is greater than 0.50, and it returns all the projects where the proportion of employee time spent on the project is greater than 0.50:

```
    SELECT PROJNO,'MEAN'
    FROM PROJ_ACT
    WHERE ACSTAFF > .50

    UNION

    SELECT PROJNO,'PROPORTION'
    FROM EMP_ACT
    WHERE EMPTIME > .50
```

The database manager combines the results of both queries, eliminates the duplicates, and returns the final result in ascending order.

Note: The ascending order is a direct result of the internal sort, which is performed to facilitate the elimination of duplicates.

```
  PROJNO EXPRESSION
  ------ ------------
  AD3110 MEAN
  AD3110 PROPORTION
  AD3111 MEAN
  AD3111 PROPORTION
  AD3112 MEAN
  AD3112 PROPORTION
  AD3113 MEAN
  AD3113 PROPORTION
  IF1000 MEAN
  IF1000 PROPORTION
  IF2000 MEAN
  IF2000 PROPORTION
  MA2100 MEAN
  MA2100 PROPORTION
  MA2110 MEAN
  MA2110 PROPORTION
  MA2111 MEAN
  MA2111 PROPORTION
  MA2112 MEAN
  MA2112 PROPORTION
  MA2113 MEAN
  MA2113 PROPORTION
  OP1010 MEAN
  OP1010 PROPORTION
  OP2000 MEAN
  OP2010 MEAN
  OP2010 PROPORTION
  OP2011 MEAN
  OP2011 PROPORTION
  OP2012 MEAN
  OP2012 PROPORTION
  PL2100 MEAN
  PL2100 PROPORTION
```

To connect queries by the UNION operator, you must ensure that they obey the following rules:

- All corresponding items in the *select-lists* of the queries in the union must be *compatible*.
- An ORDER BY clause, if used, must be placed after the last query in the union. The order-list must contain only integers, not column names. In the example query above, ORDER BY 1 is acceptable, but ORDER BY PROJNO is not.
- None of the queries in a union may select long strings.
- A union may not be specified inside a subquery.
- A union may not be used in the definition of a view.
- VARCHAR and VARGRAPHIC values that differ only by trailing blanks are considered equal. One of the values will be eliminated as a duplicate value unless UNION ALL is selected.

Unions between columns that have the same data type and the same length produce a column with that type and length. If they are not of the same type and length but they are union-compatible, the resulting column-type is a combination of the two original columns.

The results of a UNION between two union-compatible items is summarized below. The first row and first column of the table represent the data-type of the first and second columns of the UNION join.

String Columns

	CHAR	**VARCHAR**	**GRAPHIC**	**VARGRAPHIC**
CHAR	CHAR	VARCHAR	ERROR	ERROR
VARCHAR	VARCHAR	VARCHAR	ERROR	ERROR
GRAPHIC	ERROR	ERROR	GRAPHIC	VARGRAPHIC
VARGRAPHIC	ERROR	ERROR	VARGRAPHIC	VARGRAPHIC

The length attribute of the resulting column will be the greater of the length attributes of the original columns.

The UNION operators between columns that have the same character subtype and CCSID produce a column with that subtype and CCSID. If they do not have the same subtype and CCSID, the resulting subtype and CCSID are determined following specific rules. For a detailed discussion of these rules, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

Numeric Columns

	SMALLINT	**INTEGER**	**DECIMAL**	**SINGLE PRECISION**	**DOUBLE PRECISION**
SMALLINT	SMALLINT	INTEGER	DECIMAL	DOUBLE PRECISION	DOUBLE PRECISION
INTEGER	INTEGER	INTEGER	DECIMAL	DOUBLE PRECISION	DOUBLE PRECISION
DECIMAL	DECIMAL	DECIMAL	DECIMAL	DOUBLE PRECISION	DOUBLE PRECISION
SINGLE PRECISION	DOUBLE PRECISION	DOUBLE PRECISION	DOUBLE PRECISION	SINGLE PRECISION	DOUBLE PRECISION
DOUBLE PRECISION	DOUBLE PRECISION	DOUBLE PRECISION	DOUBLE PRECISION	DOUBLE PRECISION	DOUBLE PRECISION

When both of the original columns are DECIMAL data-types, special rules apply for determining the scale and precision of the resulting column.

Where *s* is the scale of the first column of the UNION join, *s'* is the scale of the second column, *p* is the precision of the first column, and *p'* is the precision of the second, the resulting column's precision is:

```
MIN( 31,MAX( s , s' ) + MAX( p-s , p'-s' ) )
```

The scale of the resulting column is the maximum scale of the original columns of the UNION join, **MAX(s, s')**.

When a UNION is performed on a DECIMAL and either an INTEGER or SMALLINT column, the resulting column's scale and precision can be calculated with the previous formulas. However, remember to substitute 11 and 0 for the precision and scale of an INTEGER column, and 5 and 0 for a SMALLINT column.

Datetime/Timestamp Columns

	DATE	**TIME**	**TIMESTAMP**
DATE	DATE	ERROR	ERROR
TIME	ERROR	TIME	ERROR
TIMESTAMP	ERROR	ERROR	TIMESTAMP

Note: CHAR, VARCHAR, GRAPHIC, and VARGRAPHIC are not union-compatible with DATE, TIME, or TIMESTAMP.

SQL Comments within Static SQL Statements

You can use a comment as a separator within static SQL statements written in the various host languages. This comment is referred to as an SQL comment (as opposed to host language comments), and is identified by two consecutive hyphens (--) on the same line, not separated by a space and not part of a literal, a string of DBCS characters, a quoted identifier, or an embedded host language comment. In COBOL, the two hyphens must be preceded by a blank. The comment ends at the end of the line.

Here is the sample query from the previous discussion on UNION, documented with a few SQL comments:

```
SELECT PROJNO,'MEAN'
FROM PROJ_ACT -- PROJECT ACTIVITY TABLE
WHERE ACSTAFF > .50
-- FIRST QUERY IS FOR ESTIMATED MEAN NUMBER OF EMPLOYEES
UNION
-- SECOND QUERY IS FOR PROPORTION OF EMPLOYEE TIME
SELECT PROJNO,'PROPORTION'
FROM EMP_ACT -- EMPLOYEE ACTIVITY TABLE
WHERE EMPTIME > .50
```

The *DB2 Server for VSE & VM SQL Reference* manual for the detailed syntax rules on the use of SQL comments within application programs.

Using Stored Procedures

A stored procedure is a user-written application program that is compiled and stored at the server. When the database manager is running in multiple user mode, local applications or remote DRDA applications can invoke the stored procedure. Since the SQL statements issued by a stored procedure are local to the server, they do not incur the high network costs of distributed statements. Instead, a single network send and receive operation is used to invoke a series of SQL statements contained in the stored procedure.

Figure 28 and Figure 29 on page 93 illustrate how the use of stored procedures reduces network traffic by decreasing the number of commands that flow between the application requester and the application server.

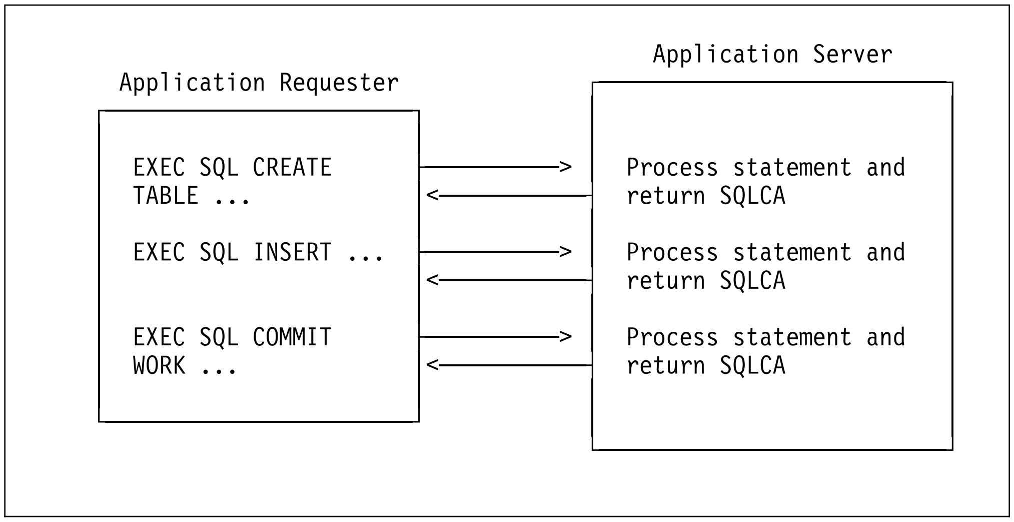

Application Server
Application Requester
EXEC SQL CREATE TABLE ...
Process statement and return SQLCA
EXEC SQL INSERT ...
Process statement and return SQLCA
EXEC SQL COMMIT WORK ...
Process statement and return SQLCA

Figure 28. Without Stored Procedures

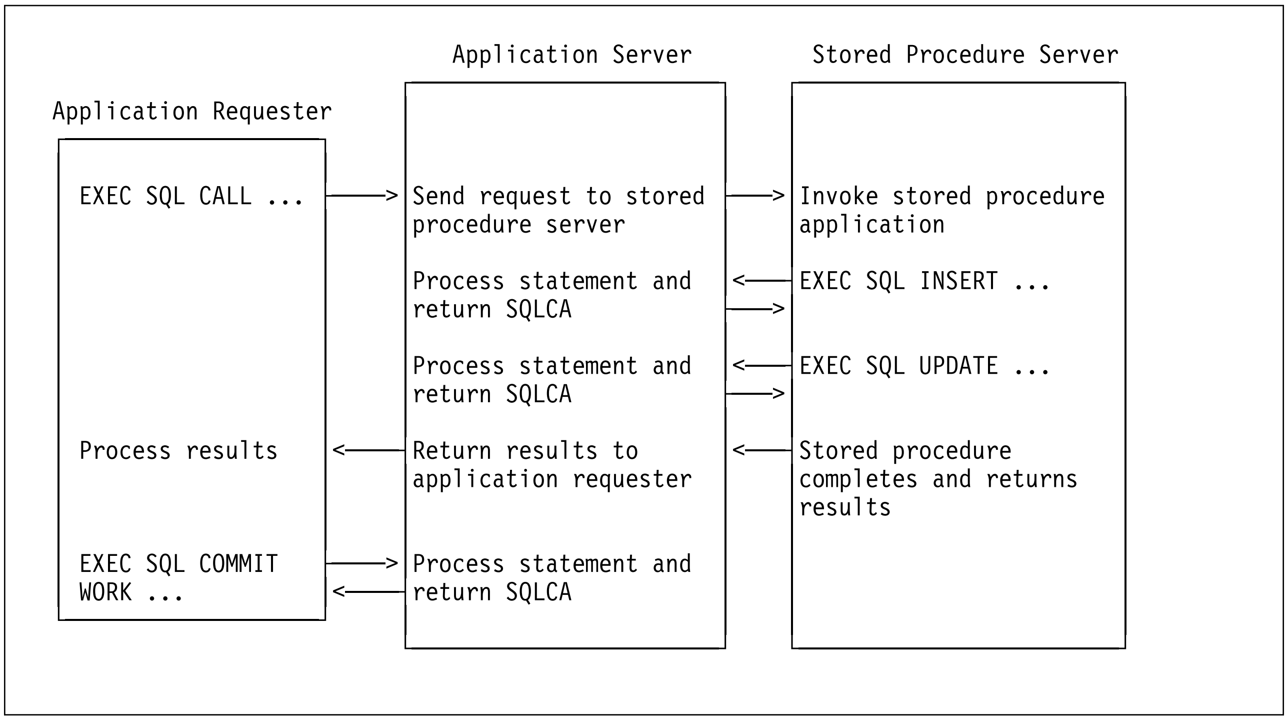

Application Server
Stored Procedure Server
Application Requester
EXEC SQL CALL ...
Send request to stored procedure server
Invoke stored procedure application
Process statement and return SQLCA
EXEC SQL INSERT ...
Process statement and return SQLCA
EXEC SQL UPDATE ...
Process results
Return results to application requester
Stored procedure completes and returns results
EXEC SQL COMMIT WORK ...
Process statement and return SQLCA

Figure 29. With Stored Procedures

For information on the stored procedure environment, including stored procedure servers, refer to the *DB2 Server for VM Database Administration* manual.

There are several other benefits that can be gained through the use of stored procedures, including:

- In many applications, the integrity of the host variables used in SQL statements is critical to the business function provided by the application. For example, a debit/credit application might need to guarantee that the host variable values do not change between debit and credit operations. In these applications, the application designer would like to guarantee that sophisticated users cannot employ online debugging tools to manipulate the content of SQL statements or host variables used by the SQL application. By using stored procedures, the application designer can encapsulate the application's SQL statements into a single message to the server, which moves the sensitive processing beyond the reach of even the most sophisticated workstation user.
- Stored procedures can be used to hide the details of the database design from client applications. In addition to simplifying the writing of client applications, this means that if the database design is changed, only the stored procedure needs to be modified. The more client applications that use the stored procedure, the greater the benefit.
- Stored procedures can be used to hide sensitive data from application programs.
- Business logic can be encapsulated at the server, rather than being included in numerous application programs.
- It is easier to maintain an environment in which applications are kept at the server rather than spread across a number of requesters.

Writing Stored Procedures

Stored procedure that are to be used on a DB2 Server for VSE & VM database can be written in PL/I, COBOL, C, or Assembler. Stored procedures are very much like regular application programs, with the following exceptions:

- They must be LE compliant
- They cannot contain the following SQL statements: CONNECT, COMMIT, ROLLBACK, or CALL

Note: Stored procedures must be written as MAIN programs; they cannot be SUB programs.

The following is an example of a simple stored procedure. It contains one SQL statement that SELECTs the salary of a given employee from the SQLDBA.EMPLOYEE table. The employee number is provided as input, and the salary and the SQLCODE for the SELECT statement are returned.

```
       IDENTIFICATION DIVISION.
       PROGRAM-ID. SAMP1.

       ENVIRONMENT DIVISION.
       INPUT-OUTPUT SECTION.
       FILE-CONTROL.

       DATA DIVISION.
       FILE SECTION.
       WORKING-STORAGE SECTION.

           EXEC SQL BEGIN DECLARE SECTION END-EXEC.

       01  CHAR6HV                 PIC X(6).
       01  SALHV                   PIC S9(7)V9(2) COMPUTATIONAL-3.

           EXEC SQL END DECLARE SECTION END-EXEC.

           EXEC SQL INCLUDE SQLCA END-EXEC.

       LINKAGE SECTION.
       01  CHAR6                   PIC X(6).
       01  SALARY                  PIC S9(7)V9(2) COMPUTATIONAL-3.
       01  SQLCD                   PIC S9(9) COMP.

       PROCEDURE DIVISION USING CHAR6 SALARY SQLCD.

      * TURN OFF SQL EXCEPTION PROCESSING *
           EXEC SQL WHENEVER SQLWARNING CONTINUE END-EXEC.
           EXEC SQL WHENEVER SQLERROR CONTINUE END-EXEC.
           EXEC SQL WHENEVER NOT FOUND CONTINUE END-EXEC.

           MOVE CHAR6 TO CHAR6HV.

           EXEC SQL
             SELECT SALARY INTO :SALHV FROM SQLDBA.EMPLOYEE
               WHERE EMPNO = :CHAR6HV
           END-EXEC.

           MOVE SALHV TO SALARY.
           MOVE SQLCODE TO SQLCD.

           STOP RUN.
```

The following is an example of a CALL statement that could be used to invoke the procedure shown above:

```
CALL SAMP_PROC ('000250', :SALARY, :SQLCD)
```

The SQL CALL statement is discussed in more detail in “Calling Stored Procedures” on page 96.

Returning Information from the SQLCA

Information about the execution of SQL statements within a stored procedure is not returned to the application that invoked the stored procedure. If SQLCODE, SQLSTATE, or any other information from the SQLCA is required by the calling application, that information must be included in the parameter list of the stored procedure and the parameters must be set explicitly in the stored procedure. This is because there are many situations in which a negative SQLCODE does not necessarily indicate a problem (such as dropping a table that does not exist). The person who writes the stored procedure application must determine what SQLCODEs should be returned to the caller.

See “Writing Stored Procedures” on page 94 for an example of a stored procedure that returns an SQLCODE.

Language Environment® (LE) Considerations

As mentioned previously, stored procedures must be LE-compliant. IBM Language Environment for MVS and VM establishes a common run-time environment for different programming languages. It combines essential run-time services, such as condition handling and storage management. All of these services are available through a set of interfaces that are consistent across programming languages. With LE, you can use one run-time environment for your applications, regardless of the application's programming languages or system resource requirements.

Language Environment is the prerequisite run-time environment for applications generated with the following IBM compiler products:

- IBM C for VM/ESA
- IBM SAA AD/Cycle C/370
- IBM COBOL for MVS and VM
- IBM SAA AD/Cycle COBOL/370
- IBM PL/I for MVS and VM
- IBM SAA AD/Cycle PL/I MVS and VM

Stored procedures can be written in assembly language as long as the assembly language program uses the required macros to operate as an IBM Language Environment application program.

For complete details, see the Language Environment documentation.

Preparing to Run a Stored Procedure

Once the stored procedure has been written, it must be preprocessed, compiled, and linked like any application program, and the load module must be put on a disk that can be accessed by the stored procedure server that will run the stored procedure. In addition, the CREATE PROCEDURE statement must be used to define the stored procedure to the database manager. See the *DB2 Server for VSE & VM SQL Reference* manual for information on the CREATE PROCEDURE statement.

Calling Stored Procedures

Once a stored procedure has been created and the CREATE PROCEDURE statement has been used to define it, it can be invoked. The SQL CALL statement is used in an application program to invoke a stored procedure. The syntax of the CALL statement is shown in Figure 30.

```
►►──CALL──┬─procedure-name─┬──────────────────────────────────────►
          └─host-variable──┘

►──┬──────────────────────────────────────┬───────────────────────►◄
   ├─(──┬─────────────────────┬──)────────┤
   │    │  ┌─,───────────────┐ │           │
   │    └──▼┬─host-variable─┬┴─┘           │
   │        ├─constant──────┤              │
   │        └─NULL──────────┘              │
   └─USING DESCRIPTOR──descriptor-name─────┘
```

Figure 30. Syntax of SQL CALL statement

For a complete description of the CALL statement, see the *DB2 Server for VSE & VM SQL Reference* manual.

As indicated in Figure 30, the procedure name can be a host variable or a constant, and parameters can be provided in a parameter list or in a descriptor (SQLDA). A simple example of a CALL statement might look like this:

```
EXEC SQL CALL PROC1 ('000250', :lastname, :salary, :sqlcd)
```

The CALL statement shown above assumes that none of the input parameters can have null values. If you need to allow for null values, use indicator variables with the host variables, as follows:

```
EXEC SQL CALL PROC1 (:empno :empnoi,
                     :lastname :lnamei,
                     :salary :salaryi,
                     :sqlcd :sqlcdi)
```

If you do not know the parameter structure of the procedure, or if you prefer to use one structure rather than several host variables, you would use the following form of the CALL statement:

```
EXEC SQL CALL PROC1 USING DESCRIPTOR :sqlda
```

where *sqlda* is the name of an SQLDA. The parameter information must be put in the SQLDA before the CALL is issued.

The final example provides maximum flexibility:

```
EXEC SQL CALL :procname USING DESCRIPTOR :sqlda
```

where *sqlda* is the name of an SQLDA. The parameter information must be put in the SQLDA before the CALL is issued.

Authorization

Authorization for stored procedures is done on a package level. That is, the issuer of the CALL statement must be authorized to run the package associated with the stored procedure. See Chapter 9, “Assigning Authority and Privileges” on page 209 for more information on authorization.

AUTHIDs

On the CREATE PROCEDURE statement, you can specify an AUTHID. If you do, then only a user with that AUTHID can run the stored procedure. The AUTHID corresponds to the SQL ID of a connected user. This facility is useful for testing modifications to a stored procedure. It allows the database administrator to create a private copy of the stored procedure, modify and test it, without affecting the copy of the stored procedure that is publicly accessible. Once the stored procedure is fully tested, it can replace the existing, publicly accessible stored procedure.

Stored Procedure Parameters

The parameters for a stored procedure are defined on the CREATE PROCEDURE statement. The CREATE PROCEDURE statement makes an entry in SYSTEM.SYSPARMS for each parameter. The entry in SYSTEM.SYSPARMS indicates the datatype, size, and purpose (input, output, or both) of the parameter.

The stored procedure must have a declaration for each parameter that is passed to it. The declaration of each parameter must be compatible with the datatype and size specified for it in SYSTEM.SYSPARMS. Figure 31 shows the compatible definitions for parameters in C, COBOL, PL/I, and Assembler.

Figure 31. Definitions of Stored Procedure Parameters

SYSPARMS	C	COBOL	PL/I	Assembler
CHAR(n)	char varname[n+1]	PIC X(n)	CHAR(n)	CLn
CHAR(1)	char	PIC X(1)	CHAR(1)	CL1
VARCHAR(n)	char varname[n+1]	`01 parm` `49 parml` `PIC S9(4) COMP` `49 parmd` `PIC X(n)`	CHAR(n) VARYING	H,CLn
SMALLINT	short	PIC S9(4) COMP	BIN FIXED(15)	H
INTEGER	long	PIC S9(9) COMP	BIN FIXED(31)	F
DECIMAL(x,y)	DECIMAL[(p,[s])] or DEC[(p,[s])]	PIC S9(x-y)V9(y) COMP-3	DEC FIXED(x,y)	PLn['decimal constant'] or P'decimal constant'
REAL	float	COMP-1	BIN FLOAT(21)	E
FLOAT	double	COMP-2	BIN FLOAT(53)	D
GRAPHIC(n)	not supported	PIC G(n) DISPLAY-1 or PIC N(n)	GRAPHIC(n)	not supported
VARGRAPHIC(n)	not supported	`01 parm` `49 parml` `PIC S9(4) COMP` `49 parmd` `PIC G(n)` `USAGE IS DISPLAY-1` `or` `49 parmd PIC N(n)`	GRAPHIC(n) VARYING	not supported

Each of the high-level language definitions for stored procedure parameters support only a single instance (scalar value) of the parameter. There is no support for structure, array, or vector parameters. In some applications, it may be necessary to return a table of results, where the table represents multiple occurrences of one or more of the parameters passed to the stored procedure. Since this support is not provided by the SQL CALL statement, one of the following techniques may be used by the application to provide the required capability:

- If the data to be returned is in a table in the database, the calling program can fetch the rows directly using SQL. Since a DRDA requester can intermix SELECT and CALL statements in a unit of work, the DRDA block fetch protocol can be used to retrieve the required data efficiently.
- Tabular data can be converted to string format and returned as a character string parameter to the calling program. The calling program and the stored procedure can establish a convention for interpreting the content of the character string. For example, the SQL CALL statement can pass a 1920 byte character string parameter to a stored procedure, allowing the stored procedure to return a 24 by 80 screen image to the calling program.

Datatype Compatibility

The datatype of a parameter provided on the CALL does not have to be identical to the datatype expected by the stored procedure, but it must be compatible. That is, if the stored procedure expects a CHAR(4) parameter, the caller can provide a character or varchar value with a length of 4 or less. Similarly, if the procedure expects an integer, most numeric datatypes (decimal, smallint, float) are acceptable, as long as the number is not too large to be represented by an integer. In general, datatypes that are considered compatible in other SQL statements are also considered compatible in an SQL CALL. That is, if the value being provided on the SQL CALL could be inserted into a column that has the same datatype as the stored procedure parameter, then it is valid for the SQL CALL statement.

For more information on datatype compatibility, see the *DB2 Server for VSE & VM SQL Reference* manual.

Conventions for Passing Stored Procedure Parameters

When an SQL CALL statement is issued, DB2 Server for VSE & VM builds a parameter list for the stored procedure, containing the parameters provided on the SQL CALL statement. When the the initial parameter list is built, the parameters contain the values established on entry to the SQL CALL statement. Eventually, the database manager will run the stored procedure and return values for the parameters to the calling program. If a stored procedure fails to set one or more of the output parameters, the database manager will not detect this fact. Instead, it will return the output parameter(s) to the calling program, with the value(s) established on entry to the SQL CALL statement.

In order for the stored procedure to receive parameters correctly, the stored procedure must be coded to accept the parameter list supplied by the database manager. DB2 Server for VSE & VM supports two parameter list conventions. The parameter list convention is determined by the value of the PARAMETERSTYLE column in the SYSTEM.SYSROUTINES catalog table, which can be GENERAL or GENERAL WITH NULLS.

The GENERAL Linkage Convention

If the GENERAL linkage convention is used:

- Input parameters cannot be NULL.
- NULLs can be passed for output parameters only.
- The stored procedure cannot return NULLs for output parameters.
- A parameter must be defined in the stored procedure for each parameter passed in the SQL CALL statement.

For performance reasons, the calling application may choose to pass null indicators with the output parameters on the SQL CALL statement. If the null indicator associated with an output parameter is negative on entry to the SQL CALL statement, the application requester transmits only the null indicator to the server. This can be beneficial when dealing with large output parameters, since the entire output parameter is not transmitted to the server. Upon successful completion of the SQL CALL statement, none of the null indicators associated with the output parameters will be null, since the stored procedure is restricted to non-null parameter values.

When the GENERAL parameter list format is used, register 1 points to a list of addresses, which in turn point to the individual parameters. Figure 32 describes the GENERAL parameter list convention.

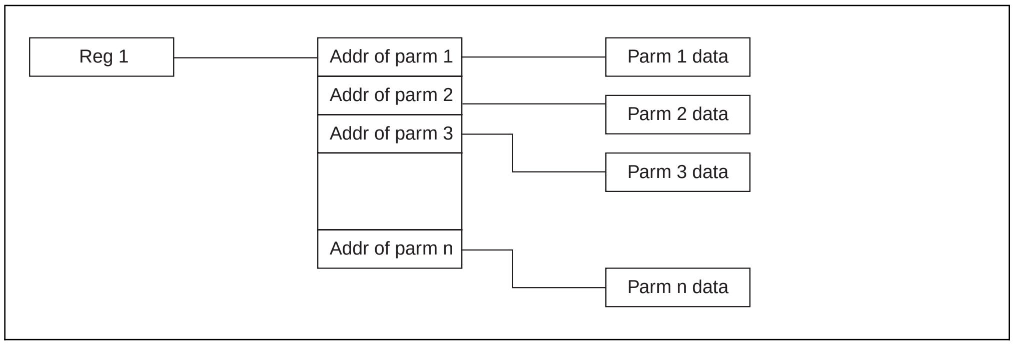


Figure 32. GENERAL parameter list

The GENERAL WITH NULLS Linkage Convention

This is the default. If the GENERAL WITH NULLS linkage convention is used:

- Input parameters can be NULL. This is achieved through the use of indicator variables, or by specifying the keyword NULL.
- The stored procedure can return NULLs for output parameters, by using indicator variables.
- A parameter must be defined in the stored procedure for each parameter passed in the SQL CALL statement. An array of indicator variables, with one indicator variable for each parameter, must also be defined in the stored procedure.

The indicator variables are passed to the stored procedure as a single parameter - an array of SMALLINT variables with an element for each indicator variable.

Figure 33 on page 100 describes the GENERAL WITH NULLS parameter list convention.

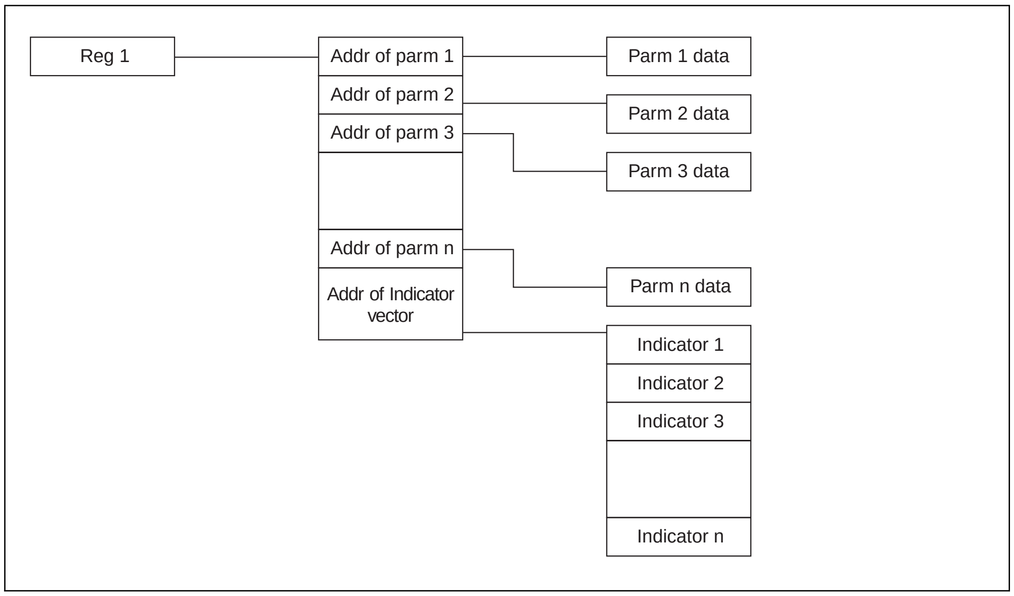


Figure 33. GENERAL WITH NULLS parameter list

The stored procedure must determine which input parameters are null by examining the array of indicator variables. The stored procedure must also assign values to the indicator variables when returning the output parameters to the calling program.

The array of indicator variables is not defined in the PARMLIST column of SYSTEM.SYSROUTINES, and is not specified as a parameter in the SQL CALL statement. In the SQL CALL statement in the client program, the indicator variables are coded after each parameter, for example:

```
EXEC SQL CALL PROCX (:parm1:indicator1, :parm2:indicator2)
    or
EXEC SQL CALL PROCX (:parm1 INDICATOR :indicator1, :parm2 INDICATOR :indicator2)
```

In order to support the linkage conventions described above, the high level language application must be coded to support the required parameter list convention.

Coding Examples

For examples of how to code stored procedures to receive and return parameters in C, COBOL, PL/I, or Assembler, refer to the appendix for that language.

Special Considerations for C

The PLIST(OS) run-time option must be supplied.

Special Considerations for PL/I

The NOEXECOPS procedure option must be supplied.

Result Sets

In addition to returning parameters, a stored procedure can return query data, known as result sets. A result set is defined by declaring a cursor with the WITH RETURN clause, opening the cursor within the stored procedure, and leaving it open when the procedure returns. The resulting rows of data that can be fetched constitute a result set.

Notes:

1. For a procedure to return result sets, the RESULT_SETS column in the SYSTEM.SYSROUTINES entry for that procedure must contain a non-zero value.
2. The DB2 Server for VSE & VM requester does not have the capability to process result sets. As a result, DB2 Server for VSE & VM returns result sets only to DRDA clients other than DB2 Server for VSE & VM (for example, DB2 Universal Database).
3. A DB2 Server for VSE & VM application requester can issue the CALL statement in SQLDS protocol only.
4. If any FETCHes are issued within the stored procedure, the result set rows returned to the client start with the row after the last row that was fetched within the stored procedure. That is, if the stored procedure issues three FETCHes, the result set returned to the client starts with the fourth row.
5. The stored procedure must not use blocking. This is because if blocking is on, the application server returns a full block of rows when a FETCH is issued, leaving the cursor positioned on the row after the last row of the block. If the stored procedure does not FETCH all of the rows in the block, the rows that have already been returned to the stored procedure will not be returned to the application requester.

For information on how to process result sets on the client side, refer to the following manuals:

1. *IBM DB2 Universal Database Call Level Interface Guide and Reference*
2. *DB2 for OS/390 Application Programming and SQL Guide*.

Chapter 4. Preprocessing and Running a Program

Contents

Defining the Steps to Execute the Program 104
Comparing Single User Mode to Multiple User Mode 104
Using 31-Bit Addressing 104
Initializing the User Machine 105
  Using VM Implicit Connect 105
Preprocessing the Program 106
  Using the SQLPREP EXEC Procedure 106
    Executing the SQLPREP EXEC in Single User Mode 107
    Executing the SQLPREP EXEC in Multiple User Mode 107
    DB2 Server for VM Program Preparation Parameters 107
    Parameters for SQLPREP EXEC for Single and Multiple User Modes . 109
    Parameters for SQLPREP EXEC for Single User Mode Only 120
    Parameters for SQLPREP EXEC in Multiple User Mode Only 121
  Preprocessing with an Unlike Application Server 121
  Using the Preprocessor Option File 122
  Using the Flagger at Preprocessor Time 122
  Improving Performance Using Preprocessing Parameters 123
    Selecting the Isolation Level to Lock Data 123
    Using the Blocking Option to Process Rows in Groups 128
      Imposing Blocking Restrictions 130
      Using the Blocking Option in DRDA Protocol 130
  Using the INCLUDE Statement 131
    Including External Source Files 131
    Including Secondary Input 131
Compiling the Program 132
Link-Editing and Loading the Program 132
  Link-Editing the Program with DB2 Server for VM TEXT Files 132
    Using the Resource Adapter Stub Routine 132
    Using Other TEXT Files 132
  Including the TEXT File in the Link-Editing 133
    Using the CMS LOAD Command 133
    Using the CMS TXTLIB Command 133
  Creating a Load Module Using the CMS GENMOD Command 134
Running the Program 134
  Using a Consistency Token 134
  Loading the Package and Rebinding 134
  Using Multiple User Mode 135
  Using Single User Mode 136
  Specifying User Parameters in Single User Mode 136
Distributing Packages across Like and Unlike Systems 137

Defining the Steps to Execute the Program

This section discusses the factors involved in preparing a DB2 Server for VM application program for operation. The major steps are:

1. Preprocessing
2. Compiling
3. Link-editing and loading
4. Running.

You also have to consider a few points before creating a DB2 Server for VM package. They are:

- Running in single or multiple user mode
- Initializing your machine
- Using VM implicit connect.

Comparing Single User Mode to Multiple User Mode

One important factor that affects how application programs are preprocessed and executed is whether the database manager is running in single or multiple user mode.

Running a Program in Single User Mode

In single user mode, the system and your application programs run in a single virtual machine. The application or preprocessor starts the database machine, processes the SQL statements, and returns control to CMS. The application server must be restarted for every invocation of an application program or preprocessor. The database machine may have more than one application server defined for it, but only a single application server can be active at any time.

Running a Program in Multiple User Mode

In multiple user mode, one or more applications concurrently access the same application server. The system runs in one virtual machine while one or more DB2 Server for VM application programs or preprocessors operate in other virtual machines. More than one application can access the same application server at the same time, and an application program can access more than one application server. Use the CONNECT statement to switch application servers from within an application. This facility is called switching application servers (see “Switching Application Servers” on page 244).

Using 31-Bit Addressing

| The addressing mode of the application server is established when the application
| server is started. The addressing mode of the application server is determined by
| the information stored in the addressing mode (AMODE) field of the SQLDBN file
| associated with the application server.

| The addressing mode of the application requester is always 31-bit addressing.

Single user mode applications are invoked in the addressing mode of the application server. If your single user mode application or user exit requires 24-bit addressing and the addressing mode of the application server is 31-bit, you will need to change the operating mode or the addressing mode of the application server.

If the addressing mode of the application server does not match the addressing mode of the single user mode application, errors may result.

Refer to the *DB2 Server for VM System Administration* manual for information on single user mode, user exits, and how to determine and change the addressing mode. To determine your dependencies on 24-bit addressing, see the *VM/ESA: CMS Application Migration Guide* manual.

Initializing the User Machine

To preprocess or run a DB2 Server for VM application program in multiple user mode, you must associate your user ID with the application server that you want your program to access. To do this, specify the application server in the SQLINIT EXEC.

You need only do this once, as long as you continue to operate on the same application server or are using the CONNECT statement to switch application servers. Even if you log off and log back on to your virtual machine, you retain your association with the application server that was established by the SQLINIT EXEC (the association is recorded on your A-disk).

If you want to switch to a different application server and cannot use the CONNECT statement to do so, you must end your application program and invoke the SQLINIT EXEC again, specifying the new application server.

For information on the SQLINIT EXEC, refer to the *DB2 Server for VM Database Administration* manual.

Using VM Implicit Connect

In the VM environment, an explicit CONNECT statement is not required. Instead, the database manager accepts the password verification of the VM virtual machine and uses the VM user ID as the DB2 Server for VM user ID. This support is called “implicit connect.” Implicit connect is possible if either the special user ID ALLUSERS or the individual users have been granted CONNECT authority.

For example, assume the following GRANT statement:

```
GRANT CONNECT TO A, B, C, ALLUSERS
```

After this statement, any VM user may be implicitly connected to the system. However, if the following statement is used, only users A, B, C can be implicitly connected to the system:

```
REVOKE CONNECT FROM ALLUSERS
```

Thus, the special user ID “ALLUSERS” can be used to selectively turn the implicit connect capability on or off for the total user set, while individual users can retain implicit connect authority.

If no explicit CONNECT is performed, an implicit connect occurs when the database manager receives a request to execute the first executable SQL statement. If the implicit connect is processed successfully, the statement is executed. As a result, the SQLCA contains information on the status of the execution of that statement. Information regarding warning conditions encountered while the connection was processed is lost. If the connection fails, the SQLCA contains information on the status of the connection.

Preprocessing the Program

Preprocessing does two things:

- It changes the SQL source code so that it can be processed during host language compiling
- It converts the SQL statements into a package, and binds the package to the database.

The preprocessor replaces all the SQL statements in the program with host language code that invokes the new package. The new version of the program also contains the SQL statements in comment form. The package contains information to carry out the SQL requests made by the program. The database manager follows the best access path to the data for each SQL statement in the program, using available indexes and data statistics of which the system keeps track.

When the program is run, the new code calls the system to handle each SQL statement. It also links the program to the application server and translates messages and statements between the two.

Using the SQLPREP EXEC Procedure

The SQLPREP EXEC is used in both single and multiple user mode to preprocess application programs.

The preprocessors supplied with the database manager have the following program names:

ASM	Assembler Preprocessor
C	C Preprocessor
COBOL	COBOL Preprocessor
FORTRAN	FORTRAN Preprocessor
PLI	PL/I Preprocessor

The preprocessor takes source program input from SYSIN, and produces a modified source program, a source listing, and a package in the database. The modified source program output is sent to SYSPUNCH, and the source listing to SYSPRINT. Using the SQLPREP EXEC, you can direct SYSIN, SYSPUNCH, and SYSPRINT to various virtual devices and CMS files.

The syntax diagram on page “DB2 Server for VM Program Preparation Parameters” on page 107 lists all the parameters for the SQLPREP EXEC. An explanation of each parameter follows the figure.

Executing the SQLPREP EXEC in Single User Mode

In single user mode, the SQLPREP EXEC is executed on the database machine. (The DBname parameter indicates that you are in single user mode, and identifies the application server that you want to access.) The SQLPREP EXEC then issues an SQLSTART and passes the DBname parameter. If the preprocessor encounters no errors (warnings are permissible), a package is created or replaced on the specified application server.

Executing the SQLPREP EXEC in Multiple User Mode

Use the SQLPREP EXEC in multiple user mode to preprocess an application program on one or more application servers. Use the SQLINIT EXEC to establish the default application server. If you want to preprocess your application program on other application servers, use the DBList or DBFile parameter to specify the other application servers on which you want to preprocess your application. Either of these parameters temporarily overrides the application server specified by the SQLINIT EXEC.

For each application server specified, the SQLPREP EXEC:

1. Establishes a link to the application server
2. Preprocesses the application program against the application server
3. Displays summary messages showing the results for this preprocessing step.

A package is created for each application server on which the program was successfully preprocessed. If an error is encountered during preprocessing on one of these application servers, and the ERROR parameter was not specified, a package is not created for that application server. See page 112 for a discussion of the ERROR option.

When the SQLPREP EXEC is used for more than one application server, only one copy of the modified source program output is retained (the PUNCH parameter), but all the source listings (the PRINT parameter) are appended to produce a single source listing. The NOPUNCH and NOPRINT parameters may be used to suppress modified source program output and source listings, respectively.

DB2 Server for VM Program Preparation Parameters

The following are parameters for all DB2 Server for VM preprocessors unless otherwise noted.

```
►►──SQLPREP──┬─ASM─────┬──PrepParm──(──PREPname=──┬────────────────┬─package_id──────────►
             ├─C───────┤                          └─collection_id.─┘
             ├─COBol───┤
             ├─FORTran─┤
             └─PLI─────┘

►──┬─────────────────────────────────┬──┬─────────────────────────────────────────┬──)────►
   ├─,PrepFile=──(──┤ fileparms ├──)─┤  └─,USERid=──authorization_name/password──┘
   └─┤ prepparms ├───────────────────┘

►──┬──────────────────────────────────┬──┬───────────────────────────────────────┬────────►
   └─sysIN──(──┬─┤ fileparms ├─┬──)───┘  └─sysPRint──(──┬─┤ fileparms ├─┬──)──────┘
               └─Reader────────┘                        ├─Printer───────┤
                                                        └─Terminal──────┘

►──┬─────────────────────────────────────┬──┬─┤ multiple-user-mode-parms ├─(2, 1)─┬───────►◄
   └─sysPUnch──(──┬─┤ fileparms ├─┬──)───┘  └─┤ single-user-mode-parms ├─(1)──────┘
                  └─Punch─────────┘
```

Notes:

1 Valid for DB2 Server for VM only.

2 Optional for multiple-user-mode.

fileparms:

```
├──filename──┬────────────────────────────┬──────────────────────────────────────────────────────┤
             └─filetype──┬──────────────┬─┘
                         └─filemode─────┘
```

prepparms:

```
   ┌─,APOST────┐    ┌─,NOBLocK──┐
├──┼───────────┼────┼───────────┼──┬────────────────────────────┬──┬───────────────────────────┬──►
   └─,Quote(1)─┘    ├─,BLocK────┤  └─,CCSIDGraphic──(integer)───┘  └─,CCSIDMixed──(integer)────┘
                    └─,SBLocK(2)┘

                                                                ┌─,NOCHECK─┐
►──┬──────────────────────────┬──┬─────────────────────────────┬──┼──────────┼──┬──────────┬──────►
   └─,CCSIDSbcs──(integer)────┘  └─,CHARSUB──(──┬─Sbcs──┬──)──┘  ├─,CHECK───┤  └─,COB2(1)─┘
                                                ├─Mixed─┤         └─,ERROR───┘
                                                └─Bit───┘

                     ┌─,CTOKEN──(NO)──────────┐                                 ┌─,NOEXIST─┐
►──┬───────────┬(1)──┼────────────────────────┼──┬────────────────────────────┬──┼──────────┼─────►
   └─,COBRC────┘     └─,CTOKEN──(──NO──YES──)─┘  └─,DATE──(──┬─EUR───┬──)─────┘  └─,EXIST───┘
                                                             ├─ISO───┤
                                                             ├─JIS───┤
                                                             ├─LOCAL─┤
                                                             └─USA───┘

   ┌─,EXPLAIN──(NO)─────────────┐
►──┼────────────────────────────┼──┬───────────┬───────────────────────────────────────────────────┤
   └─,EXPLAIN──(──┬─NO──┬──)────┘  └─,NOFOR(3)─┘
                  └─YES─┘
```

Notes:

1 COBOL only.

2 Not meaningful for DB2 Server for VSE.

3 Implied if STDSQL(89) is specified.

prepparms (continued):

```
   ┌─,NOGRaphic─┐   ┌─,ISOLation──(RR)────────────┐   ┌─,KEEP───┐
├──┼────────────┼───┼─────────────────────────────┼───┼─────────┼──┬─────────────────────────────┬──►
   └─,GRaphic(1)┘   └─,ISOLation──(──┬─CS──────┬─)─┘   └─,REVOKE─┘  └─,LABEL──(label_text)─┘
                                     ├─RR──────┤
                                     ├─RS(2)───┤
                                     ├─UR──────┤
                                     └─USER────┘

   ┌─,LineCount──(60)────────┐                                        ┌─,PERiod───┐
►──┼─────────────────────────┼──┬────────────────────────────────────┬─┼───────────┼──►
   └─,LineCount──(integer)───┘  └─,OWner──(authorization_name(2))────┘ └─,COMma(2)─┘

   ┌─,PRint───┐  ┌─,PUnch───┐
►──┼──────────┼──┼──────────┼──┬──────────────────────────────────┬──►
   └─,NOPRint─┘  └─,NOPUnch─┘  └─,QUALifier──(collection_id(2))───┘

   ┌─,RELease──(COMMIT)───────────────────┐   ┌─,REPLACE─┐   ┌─,SEQuence───────┐
►──┼──────────────────────────────────────┼───┼──────────┼───┼─────────────────┼──►
   └─,RELease──(──┬─COMMIT───────────┬─)──┘   └─,NEW─────┘   └─,NOSEQuence(3)──┘
                  └─DEALLOCATE(2)────┘

   ┌─,SQLApost──────┐
►──┼────────────────┼──┬─────────────────┬──┬───────────────────────────────────────┬──►
   └─,SQLQuote(2, 4)┘  └─,NOSQLCA(5)─────┘  └─,SQLFLAG──(──┬─SAA──────────────────┬─)─┘
                                                           └─89──┬──────────────┬─┘
                                                                 └─(COMPLETE)───┘

   ┌─,STDSQL──(NO)───────────┐
►──┼─────────────────────────┼──┬────────────────────────────┬──────────────────────┤
   └─,STDSQL──(──┬─NO────┬─)─┘  └─,TIME──(──┬─EUR─────┬─)────┘
                 └─89(6)─┘                  ├─ISO─────┤
                                            ├─JIS─────┤
                                            ├─LOCAL───┤
                                            └─USA─────┘
```

Notes:

1 COBOL and PL/I only.

2 Only meaningful for a non-DB2 Server for VM or -DB2 Server for VSE application server.

3 C only.

4 COBOL only.

5 Implied if STDSQL(89) is specified.

6 86 is a synonym for 89.

multiple-user-mode-parms:

```
├──┬─────────────────────────────────┬─────────────────────────────────────────────┤
   ├─DBFile──(──┤ fileparms ├──)─────┤
   │             ┌─,───────────┐     │
   └─DBList──(───▼─server_name─┴──)──┘
```

single-user-mode-parms:

```
├──Dbname──(server_name)──┬───────────────────────┬──────────────────────────────►
                          └─dcssID──(dcss_id)─────┘

►──┬─────────────────────────────────────────────────────┬──────────────────────┤
   └─LOGmode──(──┬─A─┬──)──┬──────────────────────────┬──┘
                 ├─L─┤     └─PARMID──(filename)───────┘
                 ├─N─┤
                 └─Y─┘
```

Parameters for SQLPREP EXEC for Single and Multiple User Modes

The parameters for the SQLPREP EXEC that apply to both single and multiple user mode are described below. When choosing names within any of these parameters, avoid whatever line-end-delimiter character (normally #) is being used in your installation.

ASM
C
COBol
FORTran
PLI

This parameter identifies to the EXEC the preprocessor to be executed. This parameter is required, and *must be specified first*. The order in which you specify the other keywords is not important..

PREPname=*package_id*
PREPname=*collection_id.package-id*

The *collection_id.package_id* is the name by which the database manager identifies the package. The *collection_id* portion is optional, and fully qualifies the *package_id* and any unqualified objects referenced within the package.

If *collection_id* is not specified, it defaults to the's authorization ID at the application requester site. In the database manager, however, an object's *collection_id* must be the same as the user's authorization ID at the application server site. If the *collection_id* does not match the application server authorization ID, a preprocessing error results. This restriction does not apply if the application server authorization ID has DBA authority.

The authorization ID at the application requester and application server sites is the *authorization_name* specified on the USERid parameter. If the USERid parameter is not specified, the authorization ID is the VM logon ID at the application requester site. In some situations, the VM logon ID is converted before it is received at the application server site. If the authorization ID is the VM logon ID, the conversion can cause the authorization IDs at each site to differ.

To avoid a situation in which the *collection_id* does not match the application server authorization ID, explicitly state the *collection_id* equal to the application server authorization ID.

For information on how to determine the authorization ID at the application server site, refer to the *DB2 Server for VM System Administration* and the *Distributed Relational Database Connectivity Guide* manuals.

USERid=*authorization_name***/***password*

The *authorization_name* is the name by which the application server identifies the owner of a package. The password should agree with the one established for this *authorization_name* by a DB2 Server for VM GRANT CONNECT statement. This information is used when executing a CONNECT statement to gain access to the application server, which determines whether proper authorization exists for the static SQL statements in the program.

If the USERid option is not specified, the VM logon user ID will be implicitly connected to the application server. All the static SQL statements in the program will have their authorization checked against the implicitly connected *userid*.

The USERid parameter is not supported when you are using DRDA protocol.

PrepFile=(*filename***)**
PrepFile=(*filename filetype***)**
PrepFile=(*filename filetype filemode***)**

The PrepFile parameter identifies the file name (and optionally the file type and file mode) of the CMS (or SFS) file containing the list of preprocessor parameters. If *filetype* is not specified, PREPPP is used as the default. If *filemode* is not specified, A is used as the default and the first file found with the default file name and file type are used. For a detailed discussion of the options file, see “Using the Preprocessor Option File” on page 122.

The following parameters can be specified in the PrepFile or on the command line.

PrepParm
These parameters specify the preprocessor options.

APOST
Quote (COBOL preprocessor only)
You must include the Quote preprocessor parameter whenever you use the Quote parameter in the COBOL compiler. Quote causes the preprocessor to use double quotation marks (") as constant delimiters in the VALUE clauses of the declarations it generates. If you do not specify this parameter, the COBOL preprocessor defaults to APOST and generates single quotation mark (') delimiters for its internal source declarations.

The use of a single or double quotation marks in SQL statements is not affected by this parameter.

NOBLocK
BLocK
SBLocK
When the BLocK parameter is specified, all eligible query cursors return results in groups of rows, and all eligible insert cursors process inserts in groups of rows. This improves the performance of programs running in multiple user mode, where many rows are inserted or retrieved. For a discussion of eligible cursors, see “Using the Blocking Option to Process Rows in Groups” on page 128.

When NOBLocK is specified, rows are not grouped.

SBLocK is primarily for use with application servers that support the FOR FETCH ONLY clause on the DECLARE CURSOR statement. Application servers do not support this clause, but application requesters can connect to application servers that do support FOR FETCH ONLY.

Following is a comparison of the BLocK and SBLocK options as they apply to the DB2 Server for VM preprocessors:

- If there are COMMIT, ROLLBACK, or dynamically defined statements in a program, then:
  - With BLocK, all eligible cursors are blocked (that is, the data on which the cursor operates is transferred in groups of rows).
  - With SBLocK, the FOR FETCH ONLY clause of the DECLARE CURSOR statement can be used to select the cursors that are to be blocked. Cursors without this clause are not blocked.
- If there are no COMMIT, ROLLBACK, or dynamically defined statements in a program, the effects of BLocK and SBLocK are the same: all eligible cursors are blocked.

Note: Only the DB2 Server for VM preprocessors turn off SBLocK blocking because of the presence of COMMIT and ROLLBACK statements. In non-DB2 Server for VM preprocessors, only the presence of dynamically defined statements has this effect.

If you want to change the BLocK option, you must recompile (or reassemble) and relink your program after preprocessing it. Preprocessing alone does not change the BLocK setting.

The blocking of FETCH statements is supported when you use the DRDA protocol, but blocking of INSERT statements is not. The blocking of INSERT statements is only supported when you use SQLDS protocol. See “Using the Blocking Option to Process Rows in Groups” on page 128 for guidelines on deciding the programs for which to specify blocking.

CCSIDGraphic (*integer*)
This parameter specifies the default CCSID attribute to be used for graphic columns created in the package, if an explicit CCSID is not specified on the CREATE or ALTER statements in the package. If this parameter is not specified, the target application server uses the system default.

CCSIDMixed (*integer*)
This parameter specifies the default CCSID attribute to be used for character columns created with the mixed subtype in the package, if an explicit CCSID is not specified on the CREATE or ALTER statements in the package. If this parameter is not specified, the target application server uses the system default.

CCSIDSbcs (*integer*)
This parameter specifies the default CCSID attribute to be used for character columns created with the SBCS subtype in the package, if an explicit CCSID is not specified on the CREATE or ALTER statements in the package. If this parameter is not specified, the target application server uses the system default.

CHARSUB (Sbcs)
CHARSUB (Mixed)
CHARSUB (Bit)
This parameter specifies the character subtype attribute to be used for character columns created in the package, if an explicit subtype or CCSID is not specified. If you do not specify this parameter, the target application server uses the system default.

NOCHECK
CHECK
ERROR
If you specify the NOCHECK parameter, the preprocessor executes normally; that is, it generates modified source code and performs package functions. NOCHECK is the default.

If you specify the CHECK parameter, the preprocessor checks all SQL statements for validity and generates error messages if necessary, but does not generate a package or modified source code.

If you specify ERROR, the preprocessor executes normally except that most statement-parsing errors are tolerated; that is, it generates modified source code and performs package functions. When one of these errors is detected, the preprocessor generates an error message in the output listing and the modified source code in commented form, and continues processing. The program can be compiled and executed, but the erroneous statement cannot be executed. Use this option when you are preprocessing against multiple application servers, where at least one statement in the program is specific to an unlike application server. This option lets you successfully preprocess on each application server regardless of the presence of statements which that application server does not allow. In some situations, the ERROR option is overridden and a severe error condition results. Refer to “Checking Warnings and Errors at Preprocessor Time” on page 140 for a discussion on debugging your SQL statements when using the ERROR option.

COB2 (COBOL preprocessor only)
This parameter enables you to use certain COBOL II functions that are supported by the COBOL II Release 3 compiler and later. Refer to “Using the COB2 Parameter” on page 300 for a list of those functions.

COBRC (COBOL preprocessor only)
If this parameter is specified, the preprocessor will generate the statement `'MOVE ZEROS TO RETURN-CODE'` after it generates a call to ARIPRDI. For more information, see “Using the COBRC Parameter” on page 301.

CTOKEN (NO)
CTOKEN (YES)
This parameter causes the preprocessor to store a consistency token in the modified source code and the package. At run time, consistency tokens in the program’s load module and package must match before the application server executes the package. CTOKEN(NO) is the default. If CTOKEN(YES) is specified, the consistency token generated by the preprocessor will be an 8-byte 390 Time-of-Day (TOD) clock value. If CTOKEN(NO) is specified, the consistency token will be 8 blanks. For a more detailed discussion of consistency tokens, see “Using a Consistency Token” on page 134.

DATE (EUR)
DATE (ISO)
DATE (JIS)
DATE (LOCAL)
DATE (USA)
If this parameter is specified, the output date format chosen overrides the default format specified at installation time; otherwise, all dates will be returned in the default format specified at installation time. (See the *DB2 Server for VSE & VM SQL Reference* manual for a description of these formats.)

NOEXIST
EXIST
If the EXIST parameter is specified, the preprocessor executes normally; that is, it generates modified source code and performs package functions. An error will be generated if objects (such as tables) referenced in statements in the program do not exist or if proper authorization does not exist.

If the NOEXIST parameter is specified, object and authorization existence is not required, and if not found, a warning will be issued. NOEXIST is the default.

EXPLAIN(NO)
EXPLAIN(YES)

This parameter specifies whether explanatory information for all explainable SQL statements in a package should be produced. EXPLAIN(NO) is the default.

If EXPLAIN(YES) is specified, each explainable SQL statement in the program is explained during preprocessing. If you specify EXPLAIN(YES), an EXPLAIN ALL is executed. The complete set of explanation tables must, therefore, be available. If they are not available, you receive an SQLCODE -649 (SQLSTATE = 42704) and preprocessing is not successful. To interpret the explanation tables, refer to the *DB2 Server for VSE & VM Performance Tuning Handbook* manual.

NOFOR

This parameter enables you to omit the FOR UPDATE OF clause in the static cursor query statement, and execute positioned updates to any column in the result table for which you have UPDATE authority. It is referred to in this manual as NOFOR support.

Note: This option is also implied if the STDSQL (89) or STDSQL (86) parameter is specified.

NOGRaphic
GRaphic (COBOL and PL/I preprocessors only)

The GRaphic parameter indicates to the preprocessor whether graphic constants can be used in SQL statements and whether DBCS string format should be validated. NOGRaphic is the default.

If GRaphic is specified, the preprocessor accepts SQL statements containing graphic constants, and checks that all strings of DBCS characters are correctly formatted.

If NOGRaphic is specified, the preprocessor does not allow graphic constants in SQL statements, and does not verify the format of strings of DBCS characters.

Note: If the DBCS parameter of the SQLINIT EXEC is specified as YES, the graphic option is not used and preprocessing occurs as though GRaphic had been specified. Refer to "Initializing the User Machine" on page 105 for a discussion of the SQLINIT EXEC.

ISOLation (RR)
ISOLation (CS)
ISOLation (RS)
ISOLation (UR)
ISOLation (USER)

This parameter lets you specify one of the following isolation levels at which your program runs:

- Specify RR (repeatable read) to have the database manager hold a lock on all data read by the program in the current logical unit of work. This is the default.
- Specify CS (cursor stability) to have the database manager hold a lock only on the row or page of data pointed to by a cursor.

- Specify UR (uncommitted read) to have the database manager allow applications to read data without locking, including uncommitted changes made by other applications.
- RS (read stability) is not supported by application servers. For a description of RS, see the *IBM SQL Reference* manual.
- Specify USER to have the application program control its isolation level. You cannot specify the USER option when you are using DRDA protocol (if you do, it is ignored and the isolation level defaults to CS).

See "Selecting the Isolation Level to Lock Data" on page 123 for guidelines on choosing the isolation level for your program.

Note: If you want to change the ISOLation option, you must recompile (or reassemble) and relink your program after preprocessing it. Preprocessing alone does not change the ISOLation setting.

KEEP
REVOKE
These parameters are applicable if the program has previously been preprocessed, and the owner has granted the RUN privilege on the resulting package to some other users. Specify the KEEP parameter to have these grants of the RUN privilege remain in effect when the preprocessor produces the new package. Specify the REVOKE parameter to remove all existing grants of the RUN privilege. (These grants will also be removed if the owner of the program is not entitled to grant all the privileges embodied in the program.)

KEEP is the default.

LABEL (*label_text***)**
This parameter specifies a label for the package. *Label_text* can be up to 30 characters in length; the default is spaces.

LineCount (*integer***)**
The parameter determines how many lines per page are to be printed in the output listing. The value *integer* specifies the number of lines per page. The valid range for this value is 10 to 32 767. If no value is specified, or if there is an error in the specification of the LineCount parameter, then the default value of 60 is used.

OWner (*authorization_name***)**
This parameter specifies the *authorization_name* of the owner of the package being created. The OWner parameter is to be used when you are preprocessing against a non-DB2 Server for VM application server. However, if you specify this parameter when preprocessing against an application server, the *authorization_name* must be the same as the application server authorization ID. If this parameter is not specified, the application server selects the default.

See the section on PREPname on page 110 for a discussion on application server and application requester authorization IDs.

PERiod
COMma
This parameter specifies the character that delimits decimals in SQL statements. PERiod is the default.

For an application server, the only acceptable decimal delimiter is a period.

PRint
NOPRint
The PRint parameter specifies that the entire preprocessor modified source listing output is produced. The NOPRint parameter specifies that the preprocessor listing output is suppressed, except for the summary messages that are normally printed at the end. PRint is the default.

PUnch
NOPUnch
The PUnch parameter specifies that the preprocessor modified source output is produced. The NOPUnch parameter specifies that the preprocessor modified source output is suppressed.

QUALifier (*collection_id***)**
This parameter specifies the default *collection_id* to be used within the package to resolve unqualified object names in static SQL statements.

The QUALifier parameter is meant to be used when preprocessing against a non-DB2 Server for VM application server. If you specify this parameter when preprocessing against an application server, the *collection_id* must be the same as the application server authorization ID. If you do not specify this parameter, the default is selected by the application server.

RELease (COMMIT)
RELease (DEALLOCATE)
This parameter specifies when the application server releases the package execution resources and any associated locks.

For an application server, the only acceptable action is RELEASE(COMMIT), which releases resources at the end of a logical unit of work.

REPLACE
NEW
This parameter specifies whether the package being created is new or whether it will replace an existing package that has the same name. If REPLACE is specified and no previous package exists with the same name, no error or warning is issued, and the package is created. REPLACE is the default. If NEW is specified, an error will occur if the package already exists with the same name.

Note: If NEW is specified along with KEEP or REVOKE, an error will occur.

SEQuence
NOSEQuence (C preprocessor only)
If SEQuence is specified, the preprocessor searches only columns 1 through 72 of the source file. When NOSEQuence is specified, the preprocessor assumes there are no sequence numbers in the input file and it accepts input from columns 1 to 80. SEQuence is the default.

Note: In the latter case, you must use the NOSEQ and MARGINS (1,80) C compiler options when compiling the modified source.

SQLApost
SQLQuote (COBOL preprocessor only)

This parameter specifies the character that delimits strings (quoted literals) in SQL statements. SQLApost and SQLQuote are optional parameters. SQLApost is the default.

For an application server, the only acceptable string delimiter is a single quotation mark.

NOSQLCA

This parameter allows you to declare an SQLCODE without declaring all of the SQLCA structure. It is referred to as NOSQLCA support in this manual.

If you request NOSQLCA support, it is your responsibility to make sure that there are no explicit declarations of the SQLCA in your application program. For more information on using SQLCODE without the SQLCA, refer to “Using the Automatic Error-Handling Facilities” on page 141.

Note: This option is also implied if the STDSQL(89) or STDSQL (86) parameter is specified.

SQLFLAG (SAA)
SQLFLAG (89)
SQLFLAG (89(COMPLETE))

This parameter invokes Flagger, a function that flags those static SQL statements that do not conform to the SQL-89 standard or IBM’s Systems Application Architecture* (SAA*) standard on an SQL dialect. If you specify SAA, it provides syntax checking against the SAA Database Level 1 standard. If you specify 89, it will provide syntax checking against the SQL-89 standard. If you specify 89(COMPLETE), it will provide both syntax and semantics checking against the SQL-89 standard. Note that you cannot check *both* SAA and SQL-89 in the same preprocessor run.

See “Using the Flagger at Preprocessor Time” on page 122 for more details on this facility, including an explanation of the SQL-89 standard.

STDSQL (NO)
STDSQL (89)

STDSQL refers to the SQL Standard that has been implemented in the user’s application program. If NO is specified or the STDSQL parameter is not used, the preprocessor uses DB2 Server for VM standards. If 89 is specified, functions specific to ANS SQL standard 89 are also provided by the preprocessor. STDSQL(NO) is the default. These functions consist of the following support:

- NOSQLCA
- NOFOR

Note: STDSQL(86) is a synonym for STDSQL(89).

TIME (EUR)
TIME (ISO)
TIME (JIS)
TIME (LOCAL)
TIME (USA)

If this parameter is specified, the output time format chosen overrides the default format specified during installation. If it is not specified, all times will be returned in the default format that was specified during installation. (See the *DB2 Server for VSE & VM SQL Reference* manual for a description of these formats.)

sysIN

Two choices exist:

1. sysIN(*filename*)

   sysIN(*filename filetype*)

   sysIN(*filename filetype filemode*)

   This optional parameter identifies the *filename* (fn), and optionally the *filetype* (ft) and *filemode* (fm), of the CMS file containing the preprocessor source input. The *filetype* specification defaults to the following:

ASM	ASMSQL
C	CSQL
COBOL	COBSQL
FORTRAN	FORTSQL
PL/I	PLISQL

   The file mode specification will default to A.

   The following CMS FILEDEF command is issued for the preprocessor source input file:

   ```
   FILEDEF SYSIN DISK fn ft fm (RECFM FB LRECL 80 BLOCK 800)
   ```

2. sysIN(Reader)

   This specification of the sysIN optional parameter identifies that the preprocessor source input file is a virtual reader file. The following CMS FILEDEF command is issued for the preprocessor source input file:

   ```
   FILEDEF SYSIN READER (RECFM F LRECL 80)
   ```

Note: If the sysIN parameter is not specified, you must enter a CMS FILEDEF command for the preprocessor source input (ddname=SYSIN) before issuing the SQLPREP EXEC.

sysPRint

Five choices exist:

1. sysPRint(*filename*)

   sysPRint(*filename filetype*)

   sysPRint(*filename filetype filemode*)

   This optional parameter identifies the *filename* (fn) and optionally the *filetype* (ft) and *filemode* (fm) of the CMS file containing the preprocessor source output listing. The *filetype* specification defaults to LISTPREP, and the *filemode* specification to A.

   If this form of the sysPRint parameter is supplied, the following CMS FILEDEF command is issued for the preprocessor source output listing file:

   ```
   FILEDEF SYSPRINT DISK fn ft fm . . .
               (RECFM FBA LRECL 121 BLOCK 1210 DISP MOD)
   ```

2. sysPRint(Printer)

   This specification of the sysPRint optional parameter identifies that the preprocessor source output listing file is directed to a virtual printer file. If sysPRint(Printer) is specified, the following CMS FILEDEF command is issued for the preprocessor source output listing file:

   ```
   FILEDEF SYSPRINT PRINTER (RECFM FA LRECL 121)
   ```

3. sysPRint(Terminal)

   This specification of the sysPRint optional parameter identifies that the preprocessor source output listing file is directed to the console terminal. If sysPRint(Terminal) is specified, the following CMS FILEDEF command is issued for the preprocessor source output listing file:

   ```
   FILEDEF SYSPRINT TERM (RECFM FA LRECL 121)
   ```

4. If the sysPRint parameter is not specified and the preprocessor source input file was assigned to the virtual reader, then the preprocessor source output listing file is assigned to the virtual printer by the CMS FILEDEF command described in item 2 above.

5. If the sysPRint parameter is not specified and the preprocessor source input file was assigned to a CMS file, then the following default CMS FILEDEF command is issued for the preprocessor source output listing file:

   ```
   FILEDEF SYSPRINT DISK fn LISTPREP A . . .
               (RECFM FBA LRECL 121 BLOCK 1210 DISP MOD)
   ```

   In this example, *fn* is the file name specification used for the preprocessor SYSIN file, and file mode is defaulted to A.

Note: If sysPRint and sysIN information is not specified, then the user must issue a CMS FILEDEF command for the preprocessor source output listing file (ddname=SYSPRINT) before issuing the SQLPREP EXEC.

sysPUnch

Four choices exist:

1. sysPUnch(*filename*)

   sysPUnch(*filename filetype*)

   sysPUnch(*filename filetype filemode*)

   This optional parameter identifies the *filename* (fn) and optionally the *filetype* (ft) and *filemode* (fm) of the CMS file containing the preprocessor modified source output. The file type specification will default to a value based on the preprocessor invoked as follows:

ASM	ASSEMBLE
C	C
COBOL	COBOL
FORTRAN	FORTRAN
PL/I	PLIOPT

   The file mode specification will default to A.

If this form of the sysPUnch parameter is supplied, the following CMS FILEDEF command is issued for the preprocessor modified source output file:

```
FILEDEF SYSPUNCH DISK fn ft fm . . .
            (RECFM FB LRECL 80 BLOCK 800)
```

2. sysPUnch(Punch)

   This specification of the sysPUnch optional parameter identifies that the preprocessor modified source output file is directed to a virtual punch file. If sysPUnch(Punch) is specified, the following CMS FILEDEF command is issued for the preprocessor modified source output file:

   ```
   FILEDEF SYSPUNCH PUNCH (RECFM F LRECL 80)
   ```

3. If the sysPUnch parameter is not specified and the preprocessor source input file was assigned to the virtual reader, then the preprocessor modified source output file is assigned to the virtual punch with the CMS FILEDEF command described above in item 2 above.
4. If the sysPUnch parameter is not specified and the preprocessor source input file is assigned to a CMS file, then the following default CMS FILEDEF command is issued for the preprocessor modified source output file:

   ```
   FILEDEF SYSPUNCH DISK fn ft A . . .
               (RECFM FB LRECL 80 BLOCK 800)
   ```

   In this example, *fn* is the file name specification used for the preprocessor source input file, and file mode is defaulted to A. *ft* is the default file type as determined by the previously mentioned method.

Note: If sysPUnch and sysIN information is not specified, then the user must issue a CMS FILEDEF command for the preprocessor modified source output file (ddname=SYSPUNCH) before issuing the SQLPREP EXEC.

Parameters for SQLPREP EXEC for Single User Mode Only

The parameters for the SQLPREP EXEC that apply only to single user mode are:

DBname(*dbname*)

This mandatory parameter identifies the name of the application server to be accessed by the SQL statements in the preprocessor source input file.

This parameter is used as the DBname parameter for the SQLSTART EXEC that is executed when the database manager is started in single user mode. The system initialization parameters SYSMODE=S and PROGNAME=progname (where progname varies according to which preprocessor is being invoked) will also be supplied in the PARM parameter of the SQLSTART EXEC.

dcssID(*dcssid*)

This parameter identifies the method by which all DB2 Server for VM modules will be loaded for execution. If this parameter is specified, it will be used as the dcssID parameter for the SQLSTART EXEC. If this parameter is omitted, the dcssID parameter will not be passed to the SQLSTART EXEC.

Refer to the *DB2 Server for VM System Administration* manual for more information.

LOGmode (Y)
LOGmode (A)
LOGmode (N)
LOGmode (L)

This parameter identifies the value to be used for the DB2 Server for VM initialization LOGmode parameter when the database manager is started in single user mode. If this parameter is omitted, the LOGmode parameter will not be supplied as an initialization parameter to the SQLSTART EXEC.

Refer to the *DB2 Server for VM System Administration* manual for more information.

PARMID (*filename***)**

This parameter identifies the file name of a CMS file that contains DB2 Server for VM initialization parameters. If this parameter is omitted, the PARMID parameter will not be passed as a parameter to the SQLSTART EXEC.

Refer to the *DB2 Server for VM System Administration* manual for more information.

Parameters for SQLPREP EXEC in Multiple User Mode Only

The parameters for the SQLPREP EXEC that apply only to multiple user mode are:

DBFile (*filename***)**
DBFile (*filename filetype***)**
DBFile (*filename filetype filemode***)**

This optional parameter specifies the file name, the file type, and optionally the file mode of a CMS file containing a list of application servers on which the program will be preprocessed. If *filetype* is not specified, PREPDB will be used as the default file type. If *filemode* is not specified, the first file with the given *filename* and *filetype* will be used.

The rules governing the format of the CMS file are as follows:

- Each record has only one application server name.
- The first word in each record is the application server name.
- Comments can be added to the right of the application server name, separated from the application server name by a blank. will be treated as a comment.
- An empty record or a record with an "*" in the first position will be treated as a comment.

Preprocessing with an Unlike Application Server

The SQLPREP EXEC accepts only those parameters and options which are listed in this manual. Some of those options are only meaningful to one or more of the other IBM relational database server or servers. The SQLPREP EXEC does not filter out options that are not applicable to an application server before sending them to that application server.

Equivalent parameters and options for IBM relational database products are given in the *IBM SQL Reference* manual. For example, the VALIDATE(BIND) parameter in the DB2 product for MVS and the EXIST parameter for the DB2 Server for VM product are equivalent preprocessing parameters.

When the DB2 Server for VM system acts as an application server and receives an unsupported preprocessing parameter value, it returns an error message to the application requester.

Using the Preprocessor Option File

Instead of specifying all the preprocessing parameters (found in PrepParm) in the SQLPREP EXEC you can use an options file. Maintaining a set of standard options files has several advantages: they can save you time; they can ensure consistent use of preprocessing parameters; and the number of parameters that you can use is not limited by the number of positions on the command line.

You can use a preprocessor options file by including the PrepFile parameter when you issue the PREP command. The file itself can contain only one preprocessor parameter per line. If more are found an error message is returned. Blank lines are ignored, and parameters may be in either upper or lower case. Comments may be inserted into the options file by placing an asterisk (*) to the left of the comment. Everything to the right of the asterisk is ignored. The file must be fixed blocked and must have a record length of 80 bytes. Figure 34 is an example of a preprocessor option file.

```
* prep parameters for program SAMPLE
      ISOL(CS)          *cursor stability isolation level
      TIME(ISO)
      BLOCK             *indicate inserts and retrieves in groups
```

Figure 34. An Example of a Preprocessor Option File

Using the Flagger at Preprocessor Time

The Flagger is invoked at preprocessor time by the optional parameter SQLFLAG It provides an auditing function on the static SQL statements in the host program. This function is independent of the other preprocessor functions, and has no bearing on whether the preprocessor run will complete satisfactorily.

The audit compares the static SQL statements with the SAA standard or the SQL-89 standard. SQL-89 is a collective term that implies support of SQL as defined by the Federal Information Processing Standards (FIPS) 127-1. It includes:

- ANSI X.3.135-1989 (without the Integrity Enhancement feature)
- ANSI X.3.168-1989
- ISO 9075-1989 (without the Integrity Enhancement feature)

In addition to basic syntax checking against SQL-89, Flagger optionally performs semantics checking against SQL-89. This includes some integrity checking between the SQL statements and the database. For example, it checks:

- Whether a statement contains column names or table names that do not currently exist.
- Whether a statement contains ambiguity among column names, such as an unqualified name for a column that exists in more than one of the tables in the query.
- Whether a statement contains inconsistencies between the data types of the host variables and their corresponding table columns.

Any statements that do not conform to the standards are flagged in the form of information messages in the preprocessor output listing. Flagger, however, does not force you to comply with the standards. The purpose of Flagger is to provide guidance for those users who want to conform to these standards, so that they can have SQL consistency across operating environments.

Note: The DB2 Server for VM product is a superset of the SQL-89 standard without the Integrity Enhancement feature. For example, the datetime data types are not part of SQL-89 and the CONNECT statement is not part of SQL-89. The use of extensions such as these will generate information messages for deviations from the standard specified in the SQLFLAG parameter.

The Flagger messages generated at preprocessor time range from ARI5500 to ARI5599, and are further classified as follows:

1. ARI5500-ARI5539 and ARI5570-ARI5599 are information messages that indicate that an extension to the SQL-89 standard (nonconformance) has been found. These start with “FLAGGER message.”
2. ARI5540-ARI5569 are warning messages that indicate a failure on the part of Flagger itself.

   In this event, SQL-89 semantics checking will be turned off and its syntax checking may or may not be turned off, depending on the nature of the failure. However, the preprocessor run itself will continue, and any inconsistencies discovered by Flagger prior to the failure will be included in the output listing of the run.

Improving Performance Using Preprocessing Parameters

When preprocessing your program, you can specify two performance parameters, the SBLocK/BLocK/NOBLocK option, and the The format and use of these options within the SQLPREP EXEC was discussed under “Preprocessing the Program” on page 106. The next section discusses when you would want to specify each of these options.

(Other performance considerations are discussed in the *DB2 Server for VM Database Administration* manual.)

Selecting the Isolation Level to Lock Data

The database manager puts locks on data that your program works with, to keep other users from reading or changing that data. You can specify either to lock **all** the data that the current logical unit of work (LUW) has read, to lock just the row or page of data that a cursor is currently pointing to, or to not lock any data being read. This is called specifying the *isolation level* of the lock.

The isolation level used by an application is set using the ISOLation preprocessing parameter. On SELECT, SELECT INTO, INSERT, searched UPDATE, and DELETE statements, the WITH clause may be specified to override the value specified on the preprocessing parameter.

If you choose to put a lock on all the data that your program's current LUW has read, this is called specifying *isolation level repeatable read*. Repeatable read locks are held until the end of the LUW. If you choose to put a lock on just the row or page of data that your cursor is pointing to, then you are specifying *isolation level cursor stability*. With cursor stability locking, when the cursor moves, the system frees all the data previously read by the program that was held by the lock. If you choose not to lock the data that your program will read, this is called specifying *isolation level uncommitted read*. With uncommitted read, no locks are held on the data being read, and as a result, the data can be changed by other applications.

Both repeatable read and cursor stability provide you with the following data isolation from other concurrent users:

- Your LUW cannot modify or read any data that another active LUW has modified. Similarly, if your LUW has modified some data, no one else can modify or read that data until your LUW has ended. Modify means to apply INSERT, DELETE, UPDATE, or PUT commands; READ means to apply SELECT or FETCH commands.
- If your LUW has a cursor pointing to a row of data, no other LUW can modify that data. Similarly, your LUW cannot modify a row to which another user has a cursor pointing.

In addition to the above, repeatable read locking provides you with the following data isolation from other concurrent users:

- No other LUW can modify any row that your active LUW has read. Also, you cannot modify any data that another active LUW, specifying repeatable read, has read.
- You do not have to worry about your data being changed between reads, as long as you do not end your LUW between those reads.

This extra isolation has its drawbacks, however. When you specify repeatable read for data in public dbspaces with PAGE or ROW level locking, you reduce the concurrency of the data. This means that other users may be locked out from the data for a long time, causing delays in their programs' executions.

If you specify cursor stability instead, you reduce these locking problems by making the data more available. With this isolation level, the system does not hold the locks as long. After a cursor has moved past a row or page of data, the lock on that data is dropped. This increases concurrency so that other users can access data faster.

Cursor stability can, however, cause some data inconsistencies. For instance:

1. If a user's LUW reads data twice, it can get different results. This could happen if another user modifies the data and commits the changes between read operations.
2. A modification based on a prior reading can be incorrect. This can occur if another LUW modifies the rows that a user has read and commits the changes before that user can do the modification. (Note that when the user is retrieving data in application programs, the only row that is safe from modification is the one that is currently being pointed to by a cursor.)
3. If an SQL statement in the user's LUW is traversing a table by way of an index, the user might find the same row twice. (This case applies to FETCH cursors, searched INSERT by way of subselect, and searched UPDATE with subselect that traverse a table by way of an index.) This can occur because, after the user's statement reads the row the first time, another user can update the column value that is indexed and commit the change. The change could cause the committed row to be *ahead* of the row currently being retrieved by the

statement. The first user's statement would then find the row again with its updated index column value.

4. If an SQL statement in the LUW is traversing a table by way of an index, it can fail to find a row (or rows) even if the row meets the selection criteria. (This situation applies to FETCH cursors, Searched DELETE, Searched INSERT by way of the subselect, and Searched UPDATE by way of the subselect that traverse a table by way of an index.) This can occur because while the LUW is reading, another user modifies the indexed column in the row and commits the change (as above). The change could cause the committed row to be *behind* the row the user's statement is currently reading. Thus, the statement would not find the row, even if the row met the selection criteria.

5. If you enter a SELECT statement to retrieve a single row, a cursor is opened when the system processes the statement and is closed when the row is returned. All PAGE and ROW level locks are released when the cursor is closed; therefore, no locks are held after the row is returned. For single-row processing using a SELECT statement with a fully qualified unique index, a cursor is not opened and again no locks are held once the row has been returned. As a result, applications which update a selected column based on the values retrieved may have unexpected results because the lock was not held for the duration of the LUW. For example:

   ```
   HOST_EMPNO = '000250'
   EXEC SQL  SELECT SALARY               /* HOST_SALARY is 19180          */
               INTO :HOST_SALARY
               FROM EMPLOYEE
               WHERE EMPNO = :HOST_EMPNO;
   HOST_SALARY = HOST_SALARY + 1000;     /* HOST_SALARY increased to 20180 */

   EXEC SQL  UPDATE EMPLOYEE             /* UPDATE SALARY in EMPLOYEE      */
               SET SALARY = :HOST_SALARY; /* TABLE with HOST_SALARY   */
               WHERE EMPNO = :HOST_EMPNO;
   EXEC SQL  SELECT SALARY               /* HOST_SALARY may not be 20180   */
               INTO :HOST_SALARY         /* because lock was not held for*/
               FROM EMPLOYEE            /* the duration of the LUW       */
               WHERE EMPNO = :HOST_EMPNO;
   COMMIT WORK;
   ```

   In the previous example, it is possible that two or more users could read the salary column with the same value at approximately the same time. They would then each increment the number and issue the UPDATE statement. The second user would wait for the first user's update to finish, and then overwrite it with the same number.

Unlike RR or CS, uncommitted read does not provide any data isolation from other concurrent users. Like CS though, concurrency is improved, although at the risk of data inconsistency. UR can cause similar data inconsistencies as those described for CS and should only be used when it is not necessary that the data you are reading be committed.

An application using isolation level UR is still restricted to access only data for which it has authorization. However, because it will be able to read uncommited changes, it will be able to read additional rows which an application, with the same authorization but using RR or CS, could not. This is illustrated by the following example.

Rows of table:	**Scenario: 1**
A	U1 reads (using UR) A B
B	U2 inserts D
C	U1 continues reading C D E
<---D	U2 rolls back
E	-- U1 has read a non-existent row
	Scenario: 2
	U1 reads (using CS) A B
	U2 inserts D
	U1 continues reading C, must wait to read D
	U2 rolls back
	U1 continues reading E

Note: In scenario 1, U1 has read an extra row which U1 in scenario 2 could not.

When should each of these options be chosen for your program? Usually, you should specify repeatable read locking. Only use cursor stability if your program causes or will cause locking problems. For instance, you would probably want to use cursor stability for transactions that perform terminal reads without performing a COMMIT or ROLLBACK, or programs that do bulk reading, because it is handy for programs that browse through large amounts of data. For programs that perform commits or rollbacks before issuing terminal reads, you should use repeatable read locking, because they probably will not cause locking problems. Also, any application that needs to protect itself against updates should also use repeatable read locking. For programs where concurrency is wanted, for example, data being queried simultaneous to being updated, you would use uncommitted read locking. Of course, this would be for applications where data integrity was not important because the data being read may not necessarily have been committed. For single row processing (UPDATE and DELETE, for example) by way of unique indexes, cursor stability performs no better, and may perform worse, than repeatable read isolation.

One additional isolation level exists in DRDA protocol: Read Stability (RS). RS is not supported by a DB2 Server for VSE & VM application server, but it is recognized as a valid preprocessing option by the database manager. For more information on this option, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

Upon receiving a request for the RS isolation level, an application server escalates it to RR and proceeds without indicating the escalation to the application requester.

You can also mix isolation levels, to have your program set, change, and control its own isolation level as it is running. You can specify mixed isolation level with the USER option of the ISOLation preprocessor parameter, as detailed under “Preprocessing the Program” on page 106.

If you choose this option, your program must pass the isolation level value to the application server by a program variable. It *must* declare a one-character program variable and *must* set this variable to the desired isolation level value before executing SQL statements. For repeatable read, your program should set this variable to R; for cursor stability, the variable should be set to C; and for uncommitted read, the variable should be set to U. The program can change the variable at any time so that subsequent SQL statements are executed at the new isolation level value. However, if your program changes the isolation level while a cursor is OPEN, the change does not take effect for operations on that cursor until it has been closed and opened again. That is, until the cursor is closed all operations on that cursor are executed at the isolation level value that was in effect when the cursor was opened. Note that the changed isolation level *will* be used (without error) for SQL statements not referencing the opened cursor.

If the program sets the isolation level variable to a value other than C, R or U, or if it fails to initialize the variable, the system stops execution and returns an error code in the SQLCA.

Figure 35 shows the isolation level variable name for each of the host languages.

Figure 35. Variable Names for Specifying Mixed Isolation Levels

Host Language	Variable Name	Example
assembler	SQLISL	SQLISL DS CL1
C	SQLISL	char SQLISL;
COBOL	SQL-ISL	01 SQL-ISL PIC X(1).
FORTRAN	SQLISL	CHARACTER SQLISL
PL/I	SQLISL	DCL SQLISL CHAR(1);

Note: If you forget to declare the isolation level variable in a PL/I program, the PL/I compiler issues an informational message which can, in some environments, be suppressed.

If you preprocess using DRDA protocol, the USER isolation level option is not supported. In DRDA protocol, the application requester changes any USER isolation level request to CS. If you preprocess using SQLDS protocol but later invoke the package using DRDA protocol, the application server defaults to the CS isolation level at run time. If a package is preprocessed and invoked using SQLDS protocol, the isolation level setting is not affected.

| Isolation level cursor stability or uncommitted read only has meaning for data in public dbspaces with ROW or PAGE level locking. Data in private dbspaces or in public dbspaces with DBSPACE level locking always uses repeatable read isolation. However, programs which access such data and do not require
| repeatable read should be preprocessed with cursor stability or uncommitted read. The data concurrency requirements might change and cause the data to be moved to a public dbspace with PAGE or ROW level locking. In this case, the program
| would not need to be repreprocessed to run at isolation level cursor stability or
| uncommitted read.

| To use the features of CS or UR, data must reside in public dbspaces with PAGE
| or ROW level locking. DML statements against private dbspaces or public
| dbspaces with PAGE or ROW level locking under isolation level CS or UR are handled the same as if isolation level RR were used.

When the system uses a dbspace scan (that is, does not use an index) to access a table in a dbspace with ROW level locking using isolation level cursor stability, the effect is the same as repeatable read. That is, no other LUW can update the table until the logical unit of work performing the dbspace scan ends. Also, if an LUW is updating a table, another LUW (using cursor stability) cannot access that table with a dbspace scan until the updating LUW ends. This reduced concurrency for dbspace scans does not apply to tables in dbspaces with PAGE level locking, or to accessing tables through indexes. Because most database accesses will typically use indexes, the reduced concurrency caused by dbspace scans should not occur frequently.

The isolation level specification affects UPDATE and DELETE processing as well as SELECT processing. For UPDATE and DELETE processing, the system acquires UPDATE locks. UPDATE locks can be acquired for both cursor stability and repeatable read isolation level settings. If the user actually wants to update or delete the data, the UPDATE lock is changed to an EXCLUSIVE lock; otherwise, the UPDATE lock is changed to a SHARE lock.

Note the following about UPDATE LOCKS:

- They are used for page or row locking, but not for dbspace locking.
- They apply to index pages or index keys only for the Searched DELETE statement.
- For Positioned DELETE processing, the named cursor must have been declared in the FOR UPDATE clause of the DECLARE CURSOR statement.
- For FETCH processing that uses repeatable read isolation level, these locks are acquired only if certain predicates are present in the statement. See the *DB2 Server for VM Database Administration* manual for more information.

Internally generated SELECT, UPDATE, or DELETE statements use cursor stability locking no matter what the isolation level is set to. (See “Enforcing Referential Integrity” on page 242 for information on these statements). Conversely, data
| definition statements such as CREATE, ACQUIRE, or GRANT, use repeatable read locking no matter what the isolation level is set to. These statements, therefore, should not play a role in your choice of isolation level.

Note: Catalog access for SQL statement preprocessing is also always done with repeatable read locking.

Using the Blocking Option to Process Rows in Groups

You can insert and retrieve rows in groups or blocks, instead of one at a time. This is called specifying the *blocking* option. Specifying one of the blocking options (SBLock or BLock), improves performance for DB2 Server for VM application programs that:

- Execute in multiple user mode, and
- Retrieve or insert multiple rows.

You can specify the blocking option as a DB2 Server for VM preprocessor parameter, or as an option on the CREATE PACKAGE statement. After a program has been preprocessed with the blocking option, all *eligible* cursor SELECTs and all *eligible* cursor INSERTs within the program are blocked. You do not have to specify a block size or block factor.

When using DRDA protocol, you can specify the block size by using the SQLINIT EXEC. Performance is closely related to block size when using DRDA protocol.

The programs that would benefit the most from blocking are those that do multiple-row inserts (with PUT statements) or multiple-row SELECTs (with FETCH statements). In both cases, a cursor must be defined. (See “Retrieving or Inserting

Multiple Rows” on page 28; for more information on cursors.) Thus, a general rule for blocking is USE BLOCKING FOR PROGRAMS THAT DECLARE CURSORS.

A program can use either PUT or FETCH statements without being sensitive to whether the system is blocking. These statements work regardless of whether you specified the blocking option. What information is returned in the SQLCA after each PUT or FETCH, however, depends on whether blocking is in effect or not.

Remember that when you preprocess a program with the blocking option, *all* eligible INSERT and SELECT cursors are blocked. You cannot specify blocking for just INSERTs or for just SELECTs. If you specify the blocking option, it automatically applies to both.

When are INSERT or SELECT statements not eligible for blocking? The database manager sometimes overrides blocking for a particular cursor because of storage limitations in the virtual machine, or because of SQL statement ineligibility. The following SQL statements are ineligible for blocking and cause blocking to be overridden automatically for the cursors they refer to:

- DECLARE CURSOR...FOR UPDATE
- Any DECLARE CURSOR statement with a related *select-statement* containing a long string
- Any DECLARE CURSOR statement that has a subsequent DELETE...WHERE CURRENT OF statement
- Any DECLARE CURSOR statement that has a corresponding UPDATE...WHERE CURRENT OF statement and the program is preprocessed with NOFOR support.

The system also disqualifies blocking if it cannot fit at least two rows into a block. (The number of rows that fit into a block may differ from one PUT/FETCH statement to the next, even when such statements operate on the same table.)

The system does *not* halt the program when it overrides blocking. Instead, in each of the above cases, it sets a warning flag in the SQLCA. The warning can be detected by using WHENEVER SQLWARNING in the program. See “Using the Automatic Error-Handling Facilities” on page 141 for more information on the SQLCA and the SQL WHENEVER declarative statement.

Note: The DECLARE CURSOR... statement can also be written without the FOR UPDATE OF clause, even though positioned updating is subsequently done. (This is allowed when NOFOR support is invoked at preprocessor time.) In this case, blocking is also ineligible.

The system also overrides blocking for all programs running in single user mode. In this instance, the system does *not* usually return a warning to the SQLCA. A warning is returned to the SQLCA for programs running in single user mode if:

- The program is preprocessed with the BLocK option
- An SQL statement that is being processed dynamically (with PREPARE) is disqualified for blocking.

The DBS Utility may get blocking ineligible warnings when it is run in single user mode because it is preprocessed with the BLocK option, but uses PREPARE to process SELECT statements.

Note: *Always* CLOSE a cursor before issuing a COMMIT statement, especially when blocking. If you commit changes before closing an insert cursor that is being blocked, you receive an error. If you are using DRDA protocol and if the HOLD option is in effect, your application does not have to close the cursor before committing the LUW.

Imposing Blocking Restrictions

1. The length of host variables in the SQLDA or *host_variable_list* cannot be changed after the first FETCH or PUT when blocking.
2. The data type of host variables in the SQLDA or *host_variable_list* cannot be changed after the first FETCH or PUT when blocking.
3. The number of data elements in the *host_variable_list* or SQLDA cannot be changed after the first FETCH or PUT when blocking.
4. If a COMMIT is issued while a blocking PUT cursor is open, an error occurs.

When blocking is active, a single SQLCA is returned with each block of rows. This SQLCA is returned to the application program with the last row in the block. However, for the final block of rows, the FETCH that returns the “not found” condition (SQLCODE = +100 and SQLSTATE='02000') will return the SQLCA. (For more information on SQLCA refer to “Using the SQLCA” on page 143). This has the following implications for application programming:

- No warning conditions are returned to the application until the SQLCA is returned.

  For example, if SQLWARN3 is set (to indicate that the application has fewer target variables in the INTO clause than the number of items in the SELECT list), the application will not be notified until either the last row in a block or the “not found” condition is returned.

- If SQLWARN1 (truncation occurrence) is set, it is impossible to tell from the SQLCA information which row (or rows) in a block caused the warning condition. However, if the application resets the indicator variable to 0 before each fetch, and then examines the indicator variable after each fetch, truncation can be detected on an ongoing basis.

Using the Blocking Option in DRDA Protocol: When the database manager is acting as an application requester in DRDA protocol, no blocking is provided on a PUT statement. Each PUT statement results in the execution of an INSERT statement. Blocking of inserts is not supported when your application is accessing a remote application server using DRDA protocol. If you are loading a large amount of data while using DRDA protocol, transfer the data through some other means, and then use the local utility to load it into the application server.

In DRDA protocol, the block size for FETCH statements is determined by the QRYBLKSIZE parameter in SQLINIT. For information on SQLINIT, refer to the *DB2 Server for VM Database Administration* manual.

Using the INCLUDE Statement

Including External Source Files

The inclusion of external source files is indicated to the DB2 Server for VM preprocessor by an embedded SQL statement, the INCLUDE statement, in the user’s source code. This statement can appear anywhere that an SQL statement can appear, and indicates within the source code where the external source is to be placed. The syntax for the INCLUDE statement is as follows:

```
►►──INCLUDE──text_file_name──────────────────────────────────────►◄
```

where *text_file_name* is a 1- to 8-character identifier that identifies the file name of the external source file. *Text_file_name* cannot be delimited by double quotation marks. The first character must be a letter (A-Z), $, #, or @; the remaining characters must be letters, digits (0-9), $, #, @, or underscore (_), unless further restricted by the operating system. Also, *text_file_name* cannot be SQLCA or SQLDA, because these are special INCLUDE keywords.

Including Secondary Input

You can use the INCLUDE statement to obtain secondary input from a CMS file. If a source program input to a DB2 Server for VM preprocessor uses the INCLUDE facility, any files to be used as secondary input must be accessed by the user. A search of all accessed CMS mini-disks for the file name and file type is conducted in standard CMS search order and the first match determines the file mode. This *filename*, *filetype*, and *filemode* are used as the secondary input or external source. The CMS file containing the secondary input statements must be fixed-length, 80-character records.

The INCLUDE statement causes input to be read from the specified file name until the end of the file, at which time the SYSIN input resumes. The file to be included must have an appropriate file type:

ASMCOPY	assembler
CCOPY	C
COBCOPY	COBOL
FORTCOPY	FORTRAN
PLICOPY	PL/I

The file mode is determined by the search of the virtual machine's accessed minidisks. If the INCLUDE statement specifies a file name that is not located on any user-accessed CMS mini-disk, an error will result.

Secondary input must not contain preprocessor INCLUDE statements other than INCLUDE SQLDA or INCLUDE SQLCA, although it may contain both host language and SQL statements. If an INCLUDE statement is encountered, an error will result.

Compiling the Program

After you successfully preprocess your program, you can compile it using your normal host language compiler. By preprocessing, you have already done all the translating that the program needs for the database manager. Just use the new code that you got after you preprocessed. Compile this code as you would any other progrm, using the usual compilers.

This book does not cover the specifics of compiling your host-language code. However, there are several special rules for SQL programs, depending on the host language, that you must follow:

- If your PL/I application program contains DBCS data, you must specify the GRAPHIC option for the compiler. If your COBOL application program contains DBCS data or is reentrant, the output of the DB2 Server for VM preprocessor must be processed by the COBOL II Release 2 (or later) program.
- If the QUOTE option is used for the DB2 Server for VM COBOL preprocessor, it should also be used for the COBOL compiler.
- If the NOSEQuence option is used for the DB2 Server for VM C preprocessor, the NOSEQ and MARGINS (1,80) options must be used with the C compiler.
- If the compiler provides a mechanism whereby run-time program interrupts are trapped before control returns to CMS, the database manager may not identify that an abnormal termination has occurred. As a result, an implicit COMMIT is executed instead of an implicit ROLLBACK. See the host language appendixes for a discussion of program interrupts.

Link-Editing and Loading the Program

After compilation, programs must be link-edited and loaded before they can be run.

Link-Editing the Program with DB2 Server for VM TEXT Files

To enable your program to communicate with the application server, you must link-edit your program with one or more DB2 Server for VM TEXT files, one of which is the *resource adapter stub*. Every DB2 Server for VM application program must be link-edited with this stub; FORTRAN and COBOL programs need to be link-edited with additional TEXT files.

Using the Resource Adapter Stub Routine

The resource adapter stub routine has a file name of ARIRVSTC, but is invoked by its entry point name ARIPRDI. To link-edit this stub routine successfully with the user program, you must INCLUDE ARIRVSTC or place the TEXT files in a CMS TXTLIB. This will make the entry point ARIPRDI known to the link-edit process.

Using Other TEXT Files

Other files that need to be link-edited, depending on the host language, include:

- For all programs written in FORTRAN, you must also link-edit the TEXT files ARIPEIFA and ARIPSTR. If the FORTRAN program uses the TEXT file ARISSMF, this file must also be link-edited (refer to “Examining the SQLCA” on page 146 for more information).
- For all reentrant programs written in COBOL, you must also link-edit the TEXT file ARIPADR4. Non-reentrant COBOL programs may continue to link-edit the

TEXT file ARIPADR until they are repreprocessed and recompiled. After, they must link-edit the TEXT file ARIPADR4.

- For all programs that use the DBS Utility, you must also include ARIDBS which is a member of ARISQLLD LOADLIB. (For information on the DBS Utility refer to the *DB2 Server for VSE & VM Database Services Utility* manual.)
- For all programs (except FORTRAN programs) that use the TEXT file ARISSMA, you must also link-edit this file (refer to “Examining the SQLCA” on page 146 for more information).

If you receive an unresolved external reference message for a module name that begins with ARI or SQL, check the link process to ensure that all required extra linkage modules are included.

Some of these modules contain entry points with names that are different from the module name. The code generated by the DB2 Server for VM preprocessor can reference one of these entry points, depending on the SQL statements in your application.

Including the TEXT File in the Link-Editing

Using the CMS LOAD Command

One way to link-edit these TEXT files to your program is to INCLUDE them after your program name in the CMS LOAD command. Then, when you load your program, the CMS linkage editor automatically links your program to the TEXT files relocatable modules that you specified, and resolves virtual storage addresses among the TEXT files.

For example, SAMPLE1 is the user’s program name and ARIRVSTC is the TEXT file in the CMS LOAD command below:

```
LOAD SAMPLE1 ARIRVSTC
```

| To see other examples of REXX EXEC's that use the CMS LOAD command, see
| any of the REXX EXEC's listed in Figure 5 on page 15.

Note that if the user machine has READ access to the production minidisk, the CMS LOAD command will automatically load the needed TEXT file, searching all accessed CMS minidisks in ascending order (A through Z) for TEXT files that it needs. For additional information about CMS LOAD, see the *VM/ESA: CMS Command Reference* manual.

Using the CMS TXTLIB Command

Instead of specifying ARIRVSTC in the CMS LOAD command, you can put ARIRVSTC and all your application TEXT files into a TXTLIB. To create a TXTLIB, enter:

```
TXTLIB GEN my-lib ARIRVSTC program-name  . . .
```

To add new programs to a TXTLIB, enter the following command:

```
TXTLIB ADD my-lib program-name2 program-name3  . . .
```

After a program is in a TXTLIB, enter the following commands to perform the link-edit:

```
GLOBAL TXTLIB my-lib
LOAD program-name
```

For more information about TXTLIB, see the *VM/ESA: CMS Command Reference* manual.

Creating a Load Module Using the CMS GENMOD Command

All of the TEXT files are on the DB2 Server for VM production minidisk (Q-disk). After loading the DB2 Server for VM application, you should create a module by issuing the CMS GENMOD command. This module can be used in multiple user mode, but is not required; it is required, however, to run in single user mode. For example, to create a module for an assembler application program called SAMPLE1 that has been compiled and added to a TXTLIB called LIBRARY1, enter the following commands:

```
GLOBAL TXTLIB LIBRARY1
LOAD SAMPLE1
GENMOD SAMPLE1
```

This creates a CMS file with a file name of SAMPLE1 and a file type of MODULE.

| To see other examples of REXX EXEC's that use the CMS GENMOD command,
| see any of the REXX EXEC's listed in Figure 5 on page 15.

Running the Program

Using a Consistency Token

Consistency tokens ensure that a program's load module and the database package are used together. When preprocessing, you can instruct the preprocessor to place a consistency token in both the load module and the package (see CTOKEN parameter on page 113). If the two tokens do not match, the application server prevents the program from running.

Note: If you inadvertently forget to compile or link-edit a new version of a program, you can run an old version of a program with a new version of the package. Conversely, with multiple application servers, you can inadvertently run a new version of a program with an old version of the package. In either situation, you will probably get program errors or incorrect results if you have not used consistency tokens.

Loading the Package and Rebinding

The package that the preprocessors stored carries out the SQL request. When the application server loads the package, it checks that the package is still valid. A package may not be valid if one of its dependencies has been dropped. For example, some index that the package uses may have been dropped.

Packages are also invalidated when primary keys and referential constraints are added to, dropped from, activated, or deactivated on tables that the modules depend on. The following rules apply:

- If a primary key is added, dropped, activated, or deactivated, all packages that have a dependency on the parent table will be invalidated. This includes any tables that have a foreign key relationship with the parent table.
- If a foreign key is added, dropped, activated, or deactivated, all packages that have a dependency on the dependent table or parent table will be invalidated.

The system has an internal change management facility that keeps track of whether packages are valid or not. If a package is valid, the system begins running the program; if the package is not valid, the system tries to re-create it. The original SQL statements are stored with the package when you preprocess the program. The system uses them to automatically bind the program again. It does this dynamically (that is, while it is running). If the *rebinding* works, a new package is created and stored in the database and the system then continues execution of the program. If the rebinding does not work, an error code is returned to the program in the SQLCA, and the program stops running.

A successful rebinding has no negative effect on your program except for a slight delay in processing your first SQL statement. To minimize this delay, you can use the DBSU REBIND PACKAGE command to rebind the invalid package after it has been invalidated, but before it is executed. See the *DB2 Server for VSE & VM Database Services Utility* manual for information on this command.

Using Multiple User Mode

When the database manager has been started in multiple user mode, the user machine should have IPLed CMS and been initialized for DB2 Server for VM processing (by the SQLINIT EXEC).

If the program has any input or output files, file definitions may be required. The CMS FILEDEF command is described in the *VM/ESA: CMS Command Reference* manual.

| In addition, if your application was compiled using a Language Environment
| Compiler, the Language Environment must be available at runtime for your
| application to use the dynamic library routines. One way to do this is by including
| SCEERUN LOADLIB on the GLOBAL LOADLIB list. For more information, see the
| compiler documentation.

If a module was created, you can execute the program by specifying the name of the module followed by any user program parameters. For example, the following command starts assembler program SAMPLE1 in multiple user mode, and passes the user parameters directly to the program:

```
SAMPLE1 parm1 parm2
```

If a module was not created, you can execute the program by first specifying the CMS LOAD command, as described in the previous section, and then the CMS START command. For example, to execute the program SAMPLE1, enter:

```
LOAD SAMPLE1 ARIRVSTC
START SAMP parm1 parm2
```

where:

SAMP is the control section name or entry point name that receives control at run time. If an asterisk (*) is used (instead of a name), control is passed to the default entry point.

parm1 parm2 are parameters passed to the program. If parameters are passed, the control name or section name or * operand must be specified; otherwise the first parameter is taken as the entry point.

When parameters are passed on the START command, the requirements of both CMS and the language of the application program must be met. See the *VM/ESA: CMS Command Reference* manual, for a description of the CMS START command and the appropriate language guide or reference manuals for details on how to pass parameters.

Using Single User Mode

Single user mode application programs are programs that run in the same machine as the DB2 Server for VM code and that are under the control of the database manager. In this case, the user machine and the database machine are the same.

Single user mode programs are invoked by starting the application server with the SQLSTART EXEC. (Before invoking the system, you must enter IPL CMS.) You must specify both the mode (SYSMODE=S) and your program name (PROGNAME=name) when you enter the SQLSTART EXEC.

When SQLSTART is invoked, the systems loads the program (identified by the PROGNAME parameter) and passes control to it after the system is initialized. For single user mode, the module must be available.

The *DB2 Server for VSE & VM Operation* manual lists all the initialization parameters you can specify when you start the system in single user mode. A system programmer can also determine the best initialization parameters for your system and pass them on to you.

The following is an example of the SQLSTART EXEC for invoking programs in single user mode with no user parameters:

```
SQLSTART DB(SQLDBA) PARM(SYSMODE=S,LOGMODE=A,DUMPTYPE=N,PROGNAME=SAMPLE1)
```

Note: If your program or the database manager ends abnormally, you may receive a minidump (depending on what initialization parameters were specified). Mini-dumps are described in the *DB2 Server for VM Diagnosis Guide and Reference* manual.

Specifying User Parameters in Single User Mode

When starting the database manager in single user mode, you can also specify user parameters to be passed to your application program using the PARM keyword of the SQLSTART EXEC. The SQLSTART EXEC purges the CMS program and console stacks. Thus, any program run in single user mode cannot rely on console or program stack input.

Place a slash (/) between the initialization parameters and the user parameters. For example:

```
SQLSTART DB(SQLDBA)
        PARM(SYSMODE=S,LOGMODE=A,DUMPTYPE=N,PROGNAME=SAMPLE1/parm1,parm2)
```

Note: Only the first 130 characters of the command line are read by CMS. The exception to this rule occurs when SQLSTART is called from a user-written EXEC; then CMS reads the first 256 characters. If you specify many initialization parameters and user parameters, they will not fit on the command line. Thus, you must use a CMS file for some of the parameters. Because user parameters cannot be specified in a CMS file, you should specify the initialization parameters in the CMS file, and the user parameters on the command line.

A program written in C, PL/I, COBOL or FORTRAN requires an interface routine to process the user parameters.

Distributing Packages across Like and Unlike Systems

To run your application program on another DB2 Server for VSE & VM database manager, you can simply distribute its load module and the DB2 Server for VSE & VM package. (You do not have to distribute the source code and then preprocess and compile it on the other system). Reload the package to all application servers that your package accesses, and send the load module to all DB2 Server for VSE & VM application requesters that your program accesses. You can unload the package to be distributed from the application server into a file, and subsequently reload the file into the new application server. Only the owner of the package or the database administrator can unload or reload the package.

If the package is distributed among application servers that are at different release levels of the system or are non-DB2 Server for VM or DB2 Server for VSE servers, a run-time error occurs if the package uses a feature that is not available on the application server on which the package was reloaded. To ensure that the load module and the package that you are distributing are meant to be used together, use the preprocessor parameter CTOKEN to place the same consistency token in both the load module and the package. Refer to “Preprocessing the Program” on page 106. If the two tokens do not match, the application server stops the program from running. For information on distributing packages on both like and unlike systems, and on distributing packages using DRDA protocol, refer to the *DB2 Server for VSE & VM Database Services Utility* manual.

Chapter 5. Testing and Debugging

Contents

Doing Your Own Testing 140
  Checking Warnings and Errors at Preprocessor Time 140
  Testing SQL Statements 141
Using the Automatic Error-Handling Facilities 141
  Using the SQLCA 143
    Using the SQLERRM Field 144
    Using the SQLWARN Field 144
  Examining Errors 144
    Using the WHENEVER Statement 144
    Determining the Scope of the WHENEVER Statement 145
    Examining the SQLCA 146
      Using TEXT Files to Get SQLCA Field Information 147
Handling Errors in a Select-List 149
  Handling Arithmetic Errors 149
  Handling Numeric Conversion Errors 150
  Handling CCSID Conversion Errors 152

Doing Your Own Testing

Checking Warnings and Errors at Preprocessor Time

If errors or warnings are detected during preprocessing, the preprocessor inserts messages into the modified source code and preprocessor listing files to indicate that a problem was encountered. A return code is also issued indicating the severity of the problem.

Messages associated with warning conditions are inserted into the files in comment form so that the compilation of the modified source code is not inhibited. A return code of 4 is issued and, if no problems of greater severity are found, package processing occurs. All warnings should be investigated, because they may indicate a situation that must be corrected before the program is executed. For example, if you use the NOEXIST preprocessor option and a table is not found at preprocessing time, the database manager issues a warning because it assumes that the table will be created before the program is executed. If the program is executed and the table is not found, the successful execution of the program is inhibited and an error results.

Messages associated with error conditions are treated differently if the preprocessor option ERROR is specified.

When you are preprocessing without the ERROR option, messages are inserted in the files in uncommented form so that the compilation process is inhibited. A return code of 8 or greater is issued, and no package processing occurs.

When preprocessing with the ERROR option, most statement-parsing errors are tolerated. Messages associated with these errors are inserted into the files in commented form, and the return code is downgraded to a warning: detection of these errors does not inhibit package processing. However, some statement-parsing errors, such as errors with host identifiers and all errors that could jeopardize the integrity of the package, are too severe to be ignored. Such errors are treated as outlined for preprocessing without the ERROR option.

Because the ERROR option allows preprocessing to complete successfully even though errors have been detected, ensure that each statement is preprocessed successfully on the application server on which the statement will be executed. Check the preprocessor listing associated with the binding application server.

To check for error and warning conditions:

1. Scan the modified source code or preprocessor listing file for error and warning message. Error message numbers are formatted as ARInnnnE, and warning message numbers as ARInnnnW or ARInnnnI.

   Messages generated during preprocessor initialization and termination are stored in the listing file, not in the modified source code. A listing file containing these messages is produced regardless of whether the NOPRint preprocessor parameter is specified.

2. Look up the message numbers *DB2 Server for VM Messages and Codes* manual.

3. If the error was detected by a non-DB2 Server for VM application server, look up the SQLCODE and SQLSTATE explanations in the *Messages and Codes* manual associated with the database management system that detected the problem.
4. Use ISQL HELP for online information about messages and SQLCODEs issued by the database manager. To obtain limited online help information for SQLSTATEs, type HELP SQLSTATE from ISQL.

Testing SQL Statements

Several facilities are available to help you test SQL statements:

- Interactive facilities such as ISQL or QMF can be used for testing statements; however, the range of statements that can be tested with these facilities is limited. For example, you cannot test the following:
  - Statements that use host language delimiters, host variables, cursors, or statement names.
  - Dynamic or extended dynamic SQL statements.

  For other static SQL statements, however, these facilities are fast and easy to use, and you can do data definitions, authorizations, and data control tasks. For information on ISQL, see the *DB2 Server for VSE & VM Interactive SQL Guide and Reference* manual.
- The DBS Utility can be used for testing the same range of SQL statements that can be tested using ISQL or QMF. In addition, it lets you use file input and output, which makes submitting and reviewing test conditions easier, and lets you set up and restore test databases with DBS Utility data load and unload commands. For information on the DBS Utility, see the *DB2 Server for VSE & VM Database Services Utility* manual.
- DB2 Server RXSQL can be used for testing statements with host variables, statement names, and cursors. You can test dynamic and extended dynamic SQL statements. DB2 Server RXSQL can be used to prototype application programs. For information on DB2 Server RXSQL, see the *DB2 REXX SQL for VM/ESA Reference* manual.

Using the Automatic Error-Handling Facilities

Every SQL application program must provide for error handling, by declaring an SQL Communications Area (or alternatively, just the SQLCODE variable, as described later in this section). This area receives messages that the database manager sends to the program. By testing certain fields of this area, you can test for certain conditions during the program's execution.

Error handling helps protect the integrity of the database when a program fails. For example, consider the two-step operation needed to transfer $500 from one account to another in a bank:

1. Subtract $500 from account A
2. Add $500 to account B.

If the system or your program fails after the first statement is executed, some customer has just “lost” $500. This type of incomplete update is said to leave the database in an *inconsistent state*.

To avoid creating an inconsistent state, use a logical unit of work (LUW). An LUW is a group of related SQL statements, possibly with intervening host language code, that you want treated as a unit. The two steps in the previous example would make up a single LUW. SQL requests within an LUW can be made against a remote application server; such an LUW is called a is a *remote unit of work.*

LUWs prevent inconsistencies caused by system errors or SQL statement errors. For system errors, the system automatically restores all changes made during the LUW where it encountered the error. This rollback of the LUW is identified by a negative SQLCODE and a W in the SQLWARN6. When a non-severe SQL error occurs, the system restores all changes made by the statement in error. This statement rollback is identified by a negative SQL code and a blank in SQLWARN6. For work done in the LUW before execution of the statement in error, do the following:

- Declare an SQL Communications Area (or just the SQLCODE variable)
- Code an SQL WHENEVER statement
- Code the actions to be taken if an error occurs.

To declare the SQL Communications Area (SQLCA), code this statement in your program:

```
INCLUDE SQLCA
```

When you preprocess your program, the system inserts host language variable declarations in place of the INCLUDE SQLCA statement, and SQL communicates with your program using this group of variables. The system uses the variables for warning flags, error codes, and diagnostic information. All these variables are discussed in the *DB2 Server for VSE & VM SQL Reference* manual.

The system returns a return code in SQLCODE after executing each SQL statement. When a statement is executed successfully, SQLCODE is set to 0 (SQLSTATE is '00000'). The system indicates error conditions by returning a negative SQLCODE. A positive SQLCODE indicates normal or warning conditions experienced while executing the statement.

The system also returns a return code in SQLSTATE after executing each SQL statement. SQLSTATE provides common return codes for IBM's relational database products. SQLSTATE values comply with the SQL92 standard. For a discussion of return codes in SQLSTATE, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

The system supports a stand-alone SQLCODE. If you request this support, you must not include the SQLCA definition in your program. You must, however, provide the integer variable SQLCODE (SQLCOD in FORTRAN). Refer to "Parameters for SQLPREP EXEC for Single and Multiple User Modes" on page 109 for information on the preprocessor parameters that provide NOSQLCA support.

The following WHENEVER statement specifies a system action that is to occur when an SQL error (that is, a negative SQLCODE) is returned:

```
WHENEVER SQLERROR GO TO ERRCHK
```

That is, whenever an SQL error (SQLERROR) occurs, program control is transferred to code which follows a specific label, such as ERRCHK. This code should include logic to analyze the error indicators in the SQLCA. Depending on how ERRCHK is defined, action may be taken to execute the next sequential program instruction, to carry out some special functions, or, as in most cases, to roll back the current LUW and end the program.

Using the SQLCA

As mentioned previously, the database manager returns a return code in the SQLCA after almost every SQL statement. The only statements that do not return SQLCODEs are SQL declarative statements, which are not executed; therefore, no SQLCODE can be returned. (Never test for an SQLCODE after a declarative statement.) The following are examples of declarative statements:

- BEGIN DECLARE SECTION
- END DECLARE SECTION
- WHENEVER
- INCLUDE SQLCA
- INCLUDE SQLDA.

When a nondeclarative statement is in error, the system reverses any changes to the database caused by that statement. For any previous work done in the LUW, you have to tell the system what action to take.

Figure 36 shows a representation of the SQLCA structure with host-language independent data type descriptions. (Refer to the appendixes for the SQLCA data types of a particular programming language.)

Figure 36. SQLCA Structure (in Pseudocode)

```
SQLCA -- a structure composed of:
         SQLCAID -- character string of length 8
         SQLCABC -- 31-bit binary integer
         SQLCODE -- 31-bit binary integer
         SQLERRM -- varying character string of maximum length 70
         SQLERRP -- character string of length 8
         SQLERRD -- an array composed of:
                    SQLERRD(1) -- 31-bit binary integer
                    SQLERRD(2) -- 31-bit binary integer
                    SQLERRD(3) -- 31-bit binary integer
                    SQLERRD(4) -- 31-bit binary integer
                    SQLERRD(5) -- 31-bit binary integer
                    SQLERRD(6) -- 31-bit binary integer
         SQLWARN -- a sub-structure composed of:
                    SQLWARN0 -- single character
                    SQLWARN1 -- single character
                    SQLWARN2 -- single character
                    SQLWARN3 -- single character
                    SQLWARN4 -- single character
                    SQLWARN5 -- single character
                    SQLWARN6 -- single character
                    SQLWARN7 -- single character
                    SQLWARN8 -- single character
                    SQLWARN9 -- single character
                    SQLWARNA -- single character
         SQLSTATE - character string of length 5
```

The *DB2 Server for VSE & VM SQL Reference* manual explains the structure of the SQLCA, and describes each field in detail. Some tips about SQLERRM and SQLWARN fields are provided below.

Using the SQLERRM Field

The message texts associated with particular SQLCODEs (which can be found in the *DB2 Server for VM Messages and Codes* manual), often include variables which are returned in the SQLERRM field of the SQLCA. In some situations, the format of the last variable in the SQLERRM field is `'FOnn'`, which specifies the format number of the SQLCODE message text. The `'FO'` is an abbreviation for *format*, and `'nn'` represents the number that identifies the version of the message text that applies. If there is more than one variable returned through SQLERRM, the variables are separated by `X'FF'`.

The first two bytes of SQLERRM (which is varying-length) contain the total length of the string.

See “Handling Numeric Conversion Errors” on page 150 for the values of this field when a numeric conversion occurs in an outer select and “Handling Errors in a Select-List” on page 149 for the values when an error occurs while evaluating expressions in an outer select.

Using the SQLWARN Field

This field contains characters that warn of various conditions encountered during the processing of your statement. Alternatively, specific warnings may be indicated by positive values in the SQLCA field, SQLCODE. For example, a warning indicator is set when the system ignores null values in computing an average. When the system encounters a particular condition, it sets the corresponding warning character to a designated value, such as W, N, or Z. When the system encounters two different warning conditions and must set the warning character to either W or N, the system randomly chooses one value. If the system encounters three different warning conditions and must set the value of the warning character to W, N, or Z, the system sets the value of the warning character to W or N, but not Z. The warning character Z is, therefore, overridden by W or N. One or more warning characters may be set to W regardless of the code returned in SQLCODE. The meanings of the warning characters are listed in the *DB2 Server for VSE & VM SQL Reference* manual.

Because there is only one return code structure in each program, you should copy out of the structure any information that you wish to save before the next SQL statement is executed. Of particular note are the SQLCODE and the warning indicators (SQLWARN).

Examining Errors

Using the WHENEVER Statement

The WHENEVER statement is a nonexecutable statement that assists you in reacting to unusual conditions, based on data returned in the SQLCA.

The following three conditions can be addressed with WHENEVER statements:

SQLERROR Occurs when SQLCODE is negative.

SQLWARNING	Occurs when SQLCODE is positive but not 100, or when SQLCODE is zero and SQLWARN0 is W.
NOT FOUND	Occurs when SQLCODE is 100 (SQLSTATE is `'02000'`).

Each SQL statement is within the scope of one WHENEVER statement for each of the three conditions. A WHENEVER statement for an already specified condition can be overridden at any time by coding another WHENEVER statement for the same conditions.

One of three actions can be taken for a WHENEVER statement:

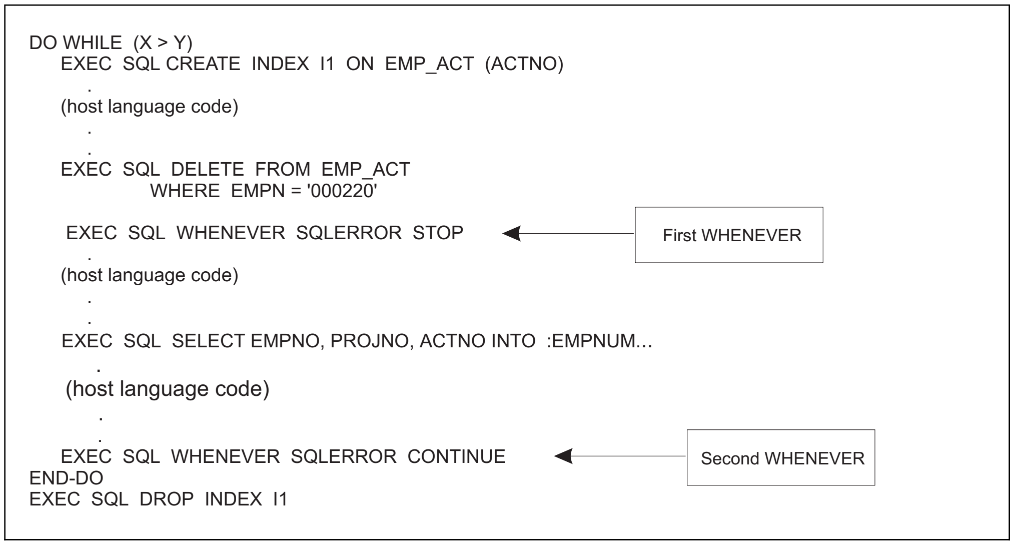
GOTO or GO TO	Transfers control to a specified location.
STOP	Terminates the program. The STOP action cannot be used with the NOT FOUND condition.
CONTINUE	Executes the next sequential instruction.

If a WHENEVER statement is not coded for a condition, it is processed as if the condition were CONTINUE.

For a full discussion of the WHENEVER statement, see the *DB2 Server for VSE & VM SQL Reference* manual.

Determining the Scope of the WHENEVER Statement

The scope of a WHENEVER statement is determined by its position in the source program listing, not by its place in the logic flow. (This is because WHENEVER is a declarative statement.) For example:



```
DO WHILE  (X > Y)
    EXEC  SQL CREATE  INDEX  I1  ON  EMP_ACT  (ACTNO)
        .
    (host language code)
        .
        .
    EXEC  SQL  DELETE  FROM  EMP_ACT
               WHERE  EMPN = '000220'
    EXEC  SQL  WHENEVER  SQLERROR  STOP
        .
    (host language code)
        .
        .
    EXEC  SQL  SELECT EMPNO, PROJNO, ACTNO INTO  :EMPNUM...
         .
     (host language code)
         .
         .
    EXEC  SQL  WHENEVER  SQLERROR  CONTINUE
END-DO
EXEC  SQL  DROP  INDEX  I1
```

In the pseudocode program fragment above, the scope of the first WHENEVER is only the SELECT INTO statement. The second WHENEVER applies to the DROP INDEX statement (and to all SQL statements that follow it until another WHENEVER is encountered). The CREATE INDEX and DELETE statements are not covered by a WHENEVER (there is no preceding WHENEVER); therefore, the default CONTINUE action applies for WHENEVER conditions.

Examining the SQLCA

The SQLCA structure can be examined using the WHENEVER statement. You can test for both general (SQLCODE < 0 | SQLWARN0 <> blank) and specific (SQLCODE = -911 | SQLWARN6 = 'W') warning or error conditions. To do this, use a WHENEVER statement with a GOTO somewhere in the source program before the SQL statements for which you want to directly examine the SQLCA.

For example, Figure 37 shows pseudocode for an error handling routine:

```
          EXEC SQL WHENEVER SQLERROR GOTO ERRCHK
               .
               .
               .
ERRCHK: * Prevent further errors from branching here
          EXEC SQL WHENEVER SQLERROR CONTINUE
        * Handle severe errors first
          IF SQLWARN0 = 'S'
             DISPLAY('A SEVERE ERROR HAS OCCURRED.')
             DISPLAY('SQLCODE = ' SQLCODE)
               .
               .
               .
             STOP
          END-IF
        * Describe the error
          DISPLAY('AN ERROR HAS OCCURRED.')
          DISPLAY('SQLCODE =' SQLCODE)
               .
               .
               .
          EXEC SQL ROLLBACK WORK
        * Check for errors
          IF SQLCODE < 0
             DISPLAY('ROLLBACK WORK FAILED. SQLCODE = ')
             DISPLAY(SQLCODE)
               .
               .
               .
        * Recovery from error is complete.
          ELSE
             DISPLAY('ROLLBACK WORK SUCCEEDED.')
               .
               .
               .
          END-IF
```

Figure 37. Pseudocode Error-Handling Routine

When an error occurs, control is passed to the ERRCHK label. Then, in order to prevent a program loop in this routine, a WHENEVER SQLERROR CONTINUE statement is issued. (It is safe to do this because WHENEVER statements never return an SQLCODE.) Next, the severity of the error is determined. If a severe error occurs, the execution of any SQL statements on this application server (except a CONNECT statement) terminates the application abnormally. The pseudocode example reports the error and ends.

If the error is not severe, the pseudocode example displays an informational message giving the SQLCODE, and an attempt is made to undo any changes. The pseudocode example determines whether the ROLLBACK successfully completed, by checking the SQLCODE after the ROLLBACK statement.

After a severe error, only a CONNECT statement is permitted. If the application program reconnects to the application server in which the severe error occurred, two possibilities exist. If the application server has been restarted or has otherwise recovered, the application may continue; otherwise, another severe error will result. If your application program is accessing multiple application servers, you can enter a CONNECT statement to switch to another like or unlike application server and continue processing.

Using TEXT Files to Get SQLCA Field Information: When an SQL error occurs, you can examine the SQLCA in order to determine the problem. To reduce the time taken to do so, you can issue a call from the application to either TEXT file ARISSMF (for FORTRAN programs) or TEXT file ARISSMA (for all other programs). The pseudo formats of these calls in each of the languages are:

```
CALL ARISSMA,(SQLCA,S1,S2,S3,S4,S5),VL      /* Assembly Language */
ARISSMA(SQLCA,S1,S2,S3,S4,S5)               /* 'C'               */
CALL 'ARISSMA' USING SQLCA S1 S2 S3 S4 S5.  /* COBOL             */
CALL ARISSMF(SQLCA,SQLERP,S1,S2,S3,S4,S5)   /* FORTRAN           */
CALL ARISSMA(SQLCA,S1,S2,S3,S4,S5);         /* PL/I              */
```

In this example, S1, S2, S3, S4, and S5 are character strings declared within the program and according to the rules of the specific language. Each string will contain information on specific SQLCA fields, after the call to ARISSMA/ARISSMF. Figure 38 shows the parameter name for the strings, their SQL name, their lengths, and the corresponding SQLCA fields.

Figure 38. SQLCA Error Information Strings

Parameter Name	**SQL Name**	**Length**	**SQLCA Field**
S1	SQLCSTR1	13	SQLCODE
S2	SQLCSTR2	13	SQLERRD1
S3	SQLCSTR3	13	SQLERRD2
S4	SQLCSTR4	12	SQLERRP (part 1)
S5	SQLCSTR5	14	SQLERRP (part 2)

Notes:

1. For assembler language, load modules ARIRVSTC and ARISSMA, as follows:

   LOAD *program_name* ARIRVSTC ARISSMA

2. For C, you must:

   - Declare the strings one character longer than that shown in the table. Also, within the program itself, you must append the end-of-string character “\0” to the last position within each of the character strings before displaying them on the screen.
   - Include the statement:

     ```
     #pragma linkage (ARISSMA,OS);
     ```

| to indicate that System/390 linkage is used in the call to ARISSMA.

- Load modules ARIRVSTC and ARISSMA:

```
|     LOAD program_name ARIRVSTC ARISSMA (RESET CEESTART
```

3. For COBOL, load modules ARIRVSTC, ARIPADR (or ARIPADR4), and ARISSMA:

```
LOAD program_name ARIRVSTC ARIPADR (or ARIPADR4) ARISSMA
```

4. For FORTRAN, load modules ARIRVSTC, ARIPEIFA, ARIPSTR, and ARISSMF:

```
LOAD program_name ARIRVSTC ARIPEIFA ARIPSTR ARISSMF
```

5. For PL/I, you must:

   - | Declare ARISSMA as an external entry point, to indicate that System/390
   | linkage is used in the call to ARISSMA:

```
|     DCL ARISSMA ENTRY EXTERNAL OPTIONS(ASM,RETCODE);
```

   - Load modules ARIRVSTC and ARISSMA:

```
|     LOAD program_name ARIRVSTC ARISSMA (RESET CEESTART
```

ARISSMA/ARISSMF returns information in the strings to your program. This information can be displayed or can be written to a file. The format in which the information is returned is shown below.

SQLCSTR1	PRCS/*nnnnnnnn*; where *n* is the decimal representation of the absolute value of the SQLCODE, right-justified, and padded with 0's for a total length of 8 digits.
SQLCSTR2	PRCS/*nnnnnnnn*; where *n* is the decimal representation of the absolute value of the SQLERRD1, right-justified and padded with 0's for a total length of 8 digits.
SQLCSTR3	PRCS/*nnnnnnnn*; where *n* is the decimal representation of the absolute value of the SQLERRD2, right-justified and padded with 0's for a total length of 8 digits.
SQLCSTR4	FLDS/SQLERRP. This value is always returned in the string.
SQLCSTR5	VALU/C*aaaaaaaa*; where *a* is left-justified, padded by blanks, and is the module name provided in field SQLERRP.

Suppose the SQLCA fields have the following values when the error occurred:

```
SQLCODE = -901
SQLERRD1 = -160
SQLERRD2 = -33
SQLERRP = ARIXOEX
```

then the values of the strings will be:

```
SQLCSTR1  ==>  PRCS/00000901
SQLCSTR2  ==>  PRCS/00000160
SQLCSTR3  ==>  PRCS/00000033
SQLCSTR4  ==>  FLDS/SQLERRP
SQLCSTR5  ==>  VALU/CARIXOEX
```

These values may be displayed as shown in the pseudocode in Figure 39 on page 149:

```
          EXEC SQL WHENEVER SQLERROR GOTO ERROR
               .
               .
               .
ERROR:  * Display string information
             CALL ARISSMA
             DISPLAY('SQLCSTR1 ='SQLCSTR1)
             DISPLAY('SQLCSTR2 ='SQLCSTR2)
             DISPLAY('SQLCSTR3 ='SQLCSTR3)
             DISPLAY('SQLCSTR4 ='SQLCSTR4)
             DISPLAY('SQLCSTR5 ='SQLCSTR5)
```

Figure 39. Pseudocode to Display Error Information

The processing of the SQLERROR condition not only allows an application to terminate normally, but also permits easy recovery from errors. An example of this is the ISQL application. Rather than terminating the ISQL session, the user is given an error message and allowed to proceed. In fact, the application could give the user the opportunity to indicate whether backout is necessary. ISQL does this when you omit the WHERE clause in an UPDATE or DELETE statement by checking SQLWARN4. That way, you have the chance to confirm that all the rows in the table are to be deleted or updated. Additional code could be added to the pseudocode example to check for this situation.

Handling Errors in a Select-List

The database manager tolerates the occurrence of certain errors resulting from the execution of expressions occurring in a *select_list* of an outer select statement.

Handling Arithmetic Errors

The arithmetic errors that can be tolerated are listed in Figure 40.

Figure 40. Tolerated Arithmetic Errors

Arithmetic Errors That Will Be Tolerated
• DECIMAL – Divide Exception – Decimal Overflow • FLOAT – Divide Exception – Exponent Overflow • INTEGER, SMALLINT – Divide Exception – Fixed Point Overflow

Note: FLOAT can be either single-precision or double-precision float. Refer to “Assigning Data Types When the Column Is Created” on page 39 for more information on floating-point data types.

Errors in date and time arithmetic are not tolerated. For example,

```
DATE('9999-12-31') + 1 DAY
```

results in a negative SQLCODE because the result would be an invalid date.

In the next example however, if the value of C2 is zero, the arithmetic error would be tolerated.

```
   DATE('1996-12-31') + C1/C2 DAYS
```

The expression in the outer *select_list* may be by itself, or it can be an argument in a scalar or column function other than the column functions AVG and SUM.

If the errors occur on an outer *select_list*, *and* every output host variable that is associated with the expression that is in error has an associated output indicator variable, the system does the following:

- The output indicator variable for each arithmetic expression in error is set to -2.
- A positive warning SQLCODE is placed in the SQLCA.
- SQLWARN0 in the SQLCA remains unaffected.
- The value of the associated host variable is undefined.
- Execution of the statement continues, such that all expressions and values not having arithmetic errors are returned.
- If the statement is a FETCH, the cursor remains open.

However, if the errors do not occur on the outer *select_list*, *or* if there are arithmetic errors on the *select_list* and not every output host variable that is associated with the expression in error has an associated output indicator variable, the system takes the following actions:

- A negative error SQLCODE -802 (SQLSTATE '22003') is returned in the SQLCA.
- The values of the host variables and any supplied indicator variables in the *select_list* are undefined.
- Execution of the statement is halted.
- If the statement is a FETCH, the cursor will remain open.

In either case, the SQLERRM of the SQLCA error message will identify the first expression in error in the outer *select_list*. The following are returned in the error message:

- The exception type
- The arithmetic operation being performed at the time of the error
- The data type of the *select_list* items being manipulated
- The ordinal position of the expression in error.

Depending on when the error is detected, some parts of the error message will be blank.

Handling Numeric Conversion Errors

The numeric conversion errors that can be tolerated are listed in Figure 41.

Figure 41. Tolerated Numeric Conversion Errors

- FLOAT to
  - DECIMAL
  - INTEGER
  - SMALLINT
- DECIMAL to
  - DECIMAL
  - FLOAT
  - INTEGER
  - SMALLINT
- INTEGER to
  - DECIMAL
  - SMALLINT
- SMALLINT to
  - DECIMAL

Note: FLOAT can be either single-precision or double-precision float. Refer to "Assigning Data Types When the Column Is Created" on page 39 for more information on floating-point data types.

If an error occurs while converting numeric values into the data type of the host variables, and output indicator variables are provided with host variables, for which numeric conversion errors occurred, the system does the following:

- The output indicator variable for each host variable for which a numeric conversion error occurred is set to -2.
- If no other warning SQLCODE is contained in the SQLCA, then a positive warning SQLCODE is placed in the SQLCA and the error message tokens in SQLERRM will identify the first conversion error.
- SQLWARN0 in the SQLCA is unaffected.
- The values of the associated host variables are undefined.
- Execution of the statement continues such that all values not in error are returned to your program.
- If the statement is a FETCH then the cursor will remain open.

If output indicator variables are *not* provided for host variables for which numeric conversion errors occurred, the system does the following:

- A negative error SQLCODE is placed in the SQLCA
- The SQLCA error message tokens identify the first conversion error
- The values of the host variables and indicators are undefined
- Execution of the statement is halted
- If the statement is a FETCH then the cursor will remain open.

In either case, the SQLERRM of the SQLCA will identify the first expression in error, and the following will be returned in the error message:

1. The data type of the value being moved into the host variable
2. The ordinal position of the expression in error
3. The data type of the host variable.

Handling CCSID Conversion Errors

The database manager tolerates CCSID conversion errors in which a character or characters have been mapped to the defined error byte.

If this occurred during CCSID conversion of data to be returned to the user, and output indicator variables *are* provided with host variables, the system does the following:

- For each host variable for which the CCSID conversion error byte mapping has occurred, the output indicator is set to -2.
- If no other warning SQLCODE is in the SQLCA, a positive warning SQLCODE is placed there, and the error message tokens in SQLERRM will identify the first conversion error.
- SQLWARN0 in the SQLCA is unaffected.
- The values of the associated host variables are undefined.
- Execution of the statement continues and returns all correct values to your program.
- For a FETCH statement, the cursor remains open.

If output indicator variables are *not* provided for host variables for which CCSID conversion errors occurred, the database manager does the following:

- A negative SQLCODE is placed in the SQLCA.
- The SQLCA error message tokens identify the first conversion error.
- The values of the host variables, and any indicators, are undefined.
- Execution of the statement is halted.
- For a FETCH statement, the cursor remains open.

Chapter 6. Using Dynamic Statements

Contents

Dynamically Defining SQL Statements 154
Comparing Non-Query Statements to Query Statements 154
Using Non-Query Statements 154
  Executing Non-Parameterized Statements 155
  Executing Parameterized Statements 156
Using Query Statements 158
  Executing a Non-Parameterized Select-Statement 158
    Using the PREPARE and DESCRIBE Statements 158
    Declaring the SQL Descriptor Area (SQLDA) 159
    Processing a Run-Time Query Using the SQLDA 159
    Allocating Storage for the SQLDA Using the SQLVAR Array 160
    Initializing the SQLN Field of the SQLDA 160
    Inserting Values in the SQLDA 161
    Analyzing the Elements of SQLVAR 162
    Allocating Storage for the Result of the Select-Statement 163
    Retrieving the Query Result 164
  Executing a Parameterized SELECT Statement 165
    Generating an Additional SELECT Statement 165
Executing a Parameterized Non-Query Statement 169
  Generating a SELECT Statement 169
Using an Alternative to a Scanning Routine 170
Ensuring Data Type Equivalence in a Dynamically Defined Query 172
Summarizing the Fields of the SQLDA 173
  Using the SQLN Field 174
  Using the SQLD Field in the SQLDA 175
Using the PREPARE Statement 175
SQL Functions Not Supported in Dynamic Statements 177

Dynamically Defining SQL Statements

Previous chapters have described how to code various SQL statements directly into a program and have the database manager preprocess them. For some kinds of applications, however, it is desirable to execute SQL statements that are not known until the program is actually running. An example would be a program to support an interactive user who wishes to type queries and receive results at a terminal. In this case, you cannot embed the SQL statements in the program and have the DB2 Server for VM preprocessor recognize them, because the program reads the statements from a terminal when it is running. To support applications such as this, the system provides facilities for executing SQL statements that are specified at run time.

For a detailed description of each of these statements, see the *DB2 Server for VSE & VM SQL Reference* manual. The following SQL statements define dynamic statements.

- PREPARE - prepares a single statement for execution
- DESCRIBE - obtains information about columns in the *select_list* of a prepared *select-statement*
- EXECUTE - executes a non-*select-statement* in a package
- EXECUTE IMMEDIATE - prepares a single statement and immediately executes it
- DECLARE CURSOR - in connection with OPEN, FETCH, PUT, and CLOSE, executes a SELECT or an INSERT statement
- OPEN (cursor)
- FETCH (cursor)
- PUT (cursor)
- CLOSE (cursor).

Comparing Non-Query Statements to Query Statements

The SQL statements that you can dynamically define and execute fall into one of two categories: non-query SQL statements (such as ALTER, CREATE, DELETE, INSERT, and UPDATE) and query statements (such as SELECT). General usage techniques for both categories are discussed below; specific statement syntax is shown in the following sections.

Using Non-Query Statements

Executing Non-Parameterized Statements

The simplest SQL statements to execute dynamically are those that do not return any result other than values in the SQLCA. No output host variables are used. This is the case with all data definition and data control statements, and with all data manipulation statements except SELECT.

Suppose an inventory control program is designed around the following table:

```
CREATE TABLE INVENTORY
     (PARTNO         SMALLINT      NOT NULL,
      DESCRIPTION    VARCHAR(24)           ,
      QONHAND        INTEGER               )
```

The program reads SQL DELETE statements similar to these from a terminal:

```
DELETE FROM INVENTORY WHERE PARTNO =221
DELETE FROM INVENTORY WHERE PARTNO =315
DELETE FROM INVENTORY WHERE PARTNO =807
```

After reading a statement, the program immediately executes it.

SQL statements must be prepared before they can be executed. Because the SQL statements are read at run time, they have not been prepared. An SQL statement called EXECUTE IMMEDIATE causes an SQL statement to be prepared and executed—all at run time. Here is a pseudocode solution to the above problem:

```
EXEC SQL BEGIN DECLARE SECTION
     DECLARE DSTRING VARYING CHARACTER (80)
          .
          .
EXEC SQL END DECLARE SECTION


READ DSTRING FROM TERMINAL
EXEC SQL EXECUTE IMMEDIATE :DSTRING
```

A DELETE statement is read into a host variable called DSTRING. DSTRING is then used as a parameter in the EXECUTE IMMEDIATE statement, causing the DELETE statement to be immediately prepared and executed.

A host variable can be used as a parameter for the EXECUTE IMMEDIATE statement. The table below shows how the host variable must be declared in the different languages:

Language	**Fixed-Length Variable**	**Varying-Length Variable**	**String Constant**
Assembler		X	
C		X	
COBOL		X	X
FORTRAN	X		X
PL/I	X	X	X

The *Fixed-Length Variable* refers to CHAR host variables, *Varying-Length Variable* refers to VARCHAR host variables, and *String Constant* refers to quoted character string constants. The following is an example of a *String Constant* dynamic statement:

```
EXECUTE IMMEDIATE 'DELETE FROM INVENTORY WHERE PARTNO=201'
```

The SQL statement submitted to EXECUTE IMMEDIATE must *not* contain host language delimiters or SQL delimited identifiers. That is, the statement must be in basic form. Avoid using either delimited identifiers or strings of DBCS characters in statements specified in string constants.

Note: The preferred method is to use a host variable rather than the string constant.

The EXECUTE IMMEDIATE statement itself, however, must have appropriate delimiters. For example, in COBOL all SQL statements must be preceded by EXEC SQL, and followed by the END-EXEC keyword as follows:

```
EXEC SQL EXECUTE IMMEDIATE
         'DELETE FROM INVENTORY WHERE PARTNO = 201'
         END-EXEC.
```

If the host language you are using permits it, you can concatenate a constant to a variable. For example, PL/I uses two vertical bars (||) as the concatenation symbol:

```
EXEC SQL EXECUTE IMMEDIATE 'DELETE FROM INVENTORY WHERE' || PREDS;
```

Note: The concatenation symbol used here is *not* the same as the concatenation operator discussed in Chapter 3, "Coding the Body of a Program" on page 17.

The "EXEC SQL" and the semicolon (;) are the host language delimiters for PL/I. At run time, the variable PREDS should contain a character string representing one or more predicates that complete the DELETE statement. The variable PREDS must not be used as a host variable, since it is being concatenated to the constant string.

Executing Parameterized Statements

In the example above, note that the DELETE statements that were dynamically executed contained no host variables. That is, they were executed only once, with a single value for PARTNO. Suppose that you wanted to execute the DELETE statement repeatedly with different values, without having to key in the entire statement each time. Consider how it might be done if you coded the DELETE statement directly in a program:

```
READ PART FROM SYSIPT
DO WHILE (PART ¬= 0)
     EXEC SQL DELETE FROM INVENTORY WHERE PARTNO = :PART
     READ PART FROM SYSIPT
END-DO
```

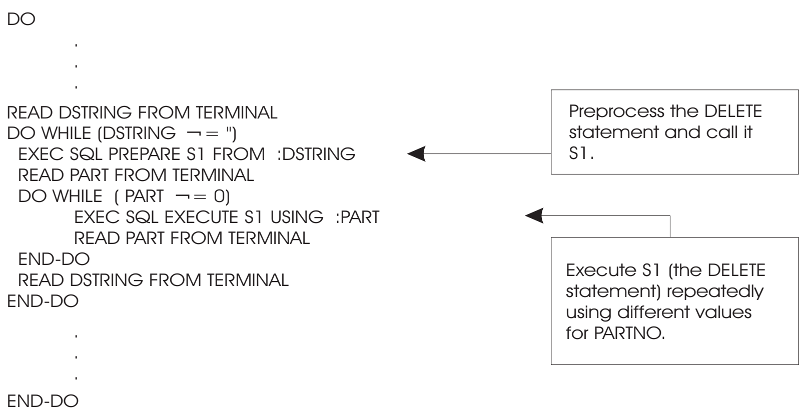
The loop is repeated until a PART of 0 is read.

Now, suppose that you wish to read both the DELETE statement and the part numbers from a terminal for dynamic execution. When this is done, the DELETE statement itself should not contain host variables; rather, it should contain question marks (?) to indicate where the value is to be substituted:

```
DELETE FROM INVENTORY WHERE PARTNO = ?
```

This type of statement is called a *parameterized* SQL statement (a *parameter* is an input host variable). Thus far, none of the dynamic statements contained any parameter markers, and they could be executed using EXECUTE IMMEDIATE. Parameterized SQL statements require a slightly more complex facility called PREPARE and EXECUTE. This facility can be thought of as an EXECUTE

IMMEDIATE performed in two steps. The first step (PREPARE) causes the parameterized statement to be prepared, and gives it a name of your choosing. (This name should not be declared as a host variable.) The second step (EXECUTE) causes the statement to be executed using values that you supply for the parameters. After a statement is prepared, it can be executed many times. Here is the pseudocode:



```
DO
        .
        .
        .
READ DSTRING FROM TERMINAL
DO WHILE (DSTRING ¬= '')
  EXEC SQL PREPARE S1 FROM :DSTRING
  READ PART FROM TERMINAL
  DO WHILE ( PART ¬= 0)
        EXEC SQL EXECUTE S1 USING :PART
        READ PART FROM TERMINAL
  END-DO
  READ DSTRING FROM TERMINAL
END-DO
        .
        .
        .
END-DO
```

Preprocess the DELETE statement and call it S1.

Execute S1 (the DELETE statement) repeatedly using different values for PARTNO.

You must not execute a dynamically defined statement after ending the logical unit of work in which the statement was prepared. If you do, an error is issued.

In routines similar to the above example, the number of parameters and their data types must be known, because the host variables that provide input data are declared when the program is being written.

Naturally, this greatly limits the number of different SQL statements that you can read in. In the above example, the only SQL statements that can be executed are those containing a single parameter. This single parameter is defined as a 15-bit integer in the program, and must be used as such. For example, the pseudocode above can also process the statements below. (At the terminal, the user types in a statement followed by values for the parameter markers.)

```
INSERT INTO INVENTORY (PARTNO) VALUES(?)
```

For each value you provide for "?", the INSERT statement is executed, and a new row is inserted into INVENTORY. The value you provide is placed in the PARTNO column. The other columns of the table are given the null value (provided they are nullable).

```
UPDATE INVENTORY SET DESCRIPTION = 'GEAR' WHERE PARTNO = ?
```

For each value you provide for "?", the UPDATE statement is executed, and the DESCRIPTION column of the INVENTORY table is set to 'GEAR'.

```
UPDATE INVENTORY SET QONHAND = 0 WHERE PARTNO = ?
```

For each value you provide for “?”, the UPDATE statement is executed, and the QONHAND column in the INVENTORY table is set to 0.

Obviously there are some applications for this kind of dynamic statement processing, but they are quite specialized. Suppose new parts are added to the inventory. Each part is a different kind of gear, and none of the parts are yet in the warehouse. The input stream for the pseudocode above would be as follows:

```
INSERT INTO INVENTORY (PARTNO) VALUES (?)
301
302
303
304
0
UPDATE INVENTORY SET DESCRIPTION = 'GEAR' WHERE PARTNO  = ?
301
302
303
304
0
UPDATE INVENTORY SET QONHAND = 0 WHERE PARTNO = ?
301
302
303
304
0
```

Using Query Statements

Executing a Non-Parameterized Select-Statement

Using the PREPARE and DESCRIBE Statements

A somewhat more complex facility is needed for executing a dynamically defined *select-statement.* Usually, a select-statement returns the result of a query into one or more host variables. When the query is read from a terminal at run time, however, you cannot know in advance how many and what type of variables to allocate to receive the result. The database manager therefore provides a special statement called DESCRIBE by which a program can obtain a description of the data types of a query result. After using the DESCRIBE statement, the program can dynamically allocate storage areas of the correct size and type to receive the result of the query. If DESCRIBE is used on a prepared SQL statement that was not a SELECT, the system indicates this by returning a zero in the variable SQLD of the SQL descriptor area.

When handling a run-time query, the program first uses the PREPARE statement which (as in the previous section) preprocesses the SQL statement. The PREPARE step also associates a statement-name with the query. The DESCRIBE statement is then used to obtain a description of the answer set. On the basis of this description, the program dynamically allocates a storage area suitable to hold one row of the result. The program then reads the query result by associating the name of the statement with a cursor and by using cursor manipulation statements (OPEN, FETCH, and CLOSE).

SELECT INTO statements cannot be executed dynamically.

Declaring the SQL Descriptor Area (SQLDA)

Dynamically defined queries center around a structure called the SQL Descriptor Area (SQLDA). The SQLDA is usually a based structure; that is, storage for it is allocated dynamically at run time. Figure 42 is a representation of the SQLDA structure with host-language-independent data type descriptions. Each host language has different considerations for the SQLDA structure; you should read the section on dynamic statements in the appropriate appendix before you attempt to code a program that uses the SQLDA. In addition, see "Summarizing the Fields of the SQLDA" on page 173 for information about the fields of the SQLDA.

```
SQLDA -- a based structure composed of:
         SQLDAID -- character string of length 8
         SQLDABC -- 31-bit binary integer
         SQLN    -- 15-bit binary integer
         SQLD    -- 15-bit binary integer
         SQLVAR  -- an array composed of:
                SQLTYPE -- 15-bit binary integer
                SQLLEN  -- 15-bit binary integer
                       SQLPRCSN -- 1-byte (used for DECIMAL)
                       SQLSCALE -- 1-byte (used for DECIMAL)
                SQLDATA -- 31-bit binary integer (pointer)
                SQLIND  -- 31-bit binary integer (pointer)
                SQLNAME -- varying-length character string
                           of up to 30 characters
```

Figure 42. SQLDA Structure (in Pseudocode)

Note: The SQLLEN field can be divided into two subfields. The subfields are used only when working with DECIMAL values. Such usage is described in the following section.

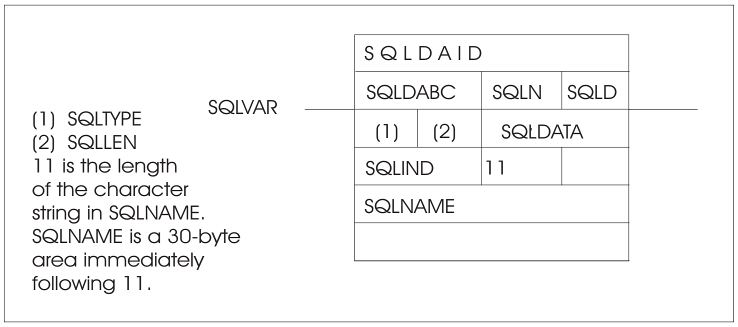
To include the declaration of the descriptor area in an assembler, C, or PL/I program, specify:

```
INCLUDE SQLDA
```

The INCLUDE SQLDA statement must not be placed in the SQL declare section. As with the SQLCA, you can code this structure directly instead of using the INCLUDE SQLDA statement. If you choose to declare the structure directly, you can specify any name for it. For example, you can call it SPACE1 or DAREA instead of SQLDA.

Processing a Run-Time Query Using the SQLDA

To process a run-time query, you must declare the SQLDA structure. Below is an illustration showing the SQLDA structure as a box; similar illustrations are used in following examples. Remember that SQLDA is a based structure (or, in assembler, a DSECT); no storage has actually been allocated yet.


S Q L D A I D
SQLDABC
SQLN
SQLD
SQLVAR
(1)
(2)
SQLDATA
SQLIND
11
SQLNAME
(1) SQLTYPE
(2) SQLLEN
11 is the length of the character string in SQLNAME.
SQLNAME is a 30-byte area immediately following 11.

The meanings of the various fields are described as they are used. A summary of the meanings of the fields of the SQLDA is presented later for quick reference.

If a *select-statement* is assigned to the variable QSTRING, it can be read in from a terminal or assigned within the program itself. In this example, the following *select-statement* is read in from the terminal:

```
SELECT DESCRIPTION, QONHAND FROM INVENTORY WHERE PARTNO = 221
```

This *select-statement* has no INTO clause. When it is read in, it is assigned to the host variable QSTRING, which is then preprocessed by the PREPARE statement:

```
READ QSTRING FROM TERMINAL
EXEC SQL PREPARE S1 FROM :QSTRING
```

Allocating Storage for the SQLDA Using the SQLVAR Array

Now you can allocate storage for the SQLDA. The techniques for acquiring storage are language dependent; refer to the appropriate compiler or assembler manual.

Note: The usage of the SQLDA depends on the USING clause option of the DESCRIBE statement (discussed later in this chapter). In this section, it is assumed that the NAMES option of the USING clause has been specified. The amount of storage you need to allocate depends upon how many elements you want to have in the SQLVAR array. Each *select_list* item must have a corresponding SQLVAR array element. Therefore, the number of *select_list* items determines how many SQLVAR array elements you should allocate. However, because select-statements are specified at run time, it is not possible to know how many *select_list* items there will be. Consequently, you must guess.

Suppose, in this example, that no more than three items are ever expected in the *select_list*. This means that the SQLVAR array should have a dimension of three, because each item in a *select_list* must have a corresponding entry in SQLVAR.

Initializing the SQLN Field of the SQLDA

Having allocated an SQLDA of what you hope will be adequate size, you must now initialize the SQLDA field called SQLN. SQLN is set to the number of SQLVAR array elements you have allocated (that is, SQLN is the dimension of the SQLVAR array). In this example, you must set SQLN to 3. Here's the pseudocode for what was done so far:

```
Allocate an SQLDA of size 3
SQLN = 3
```

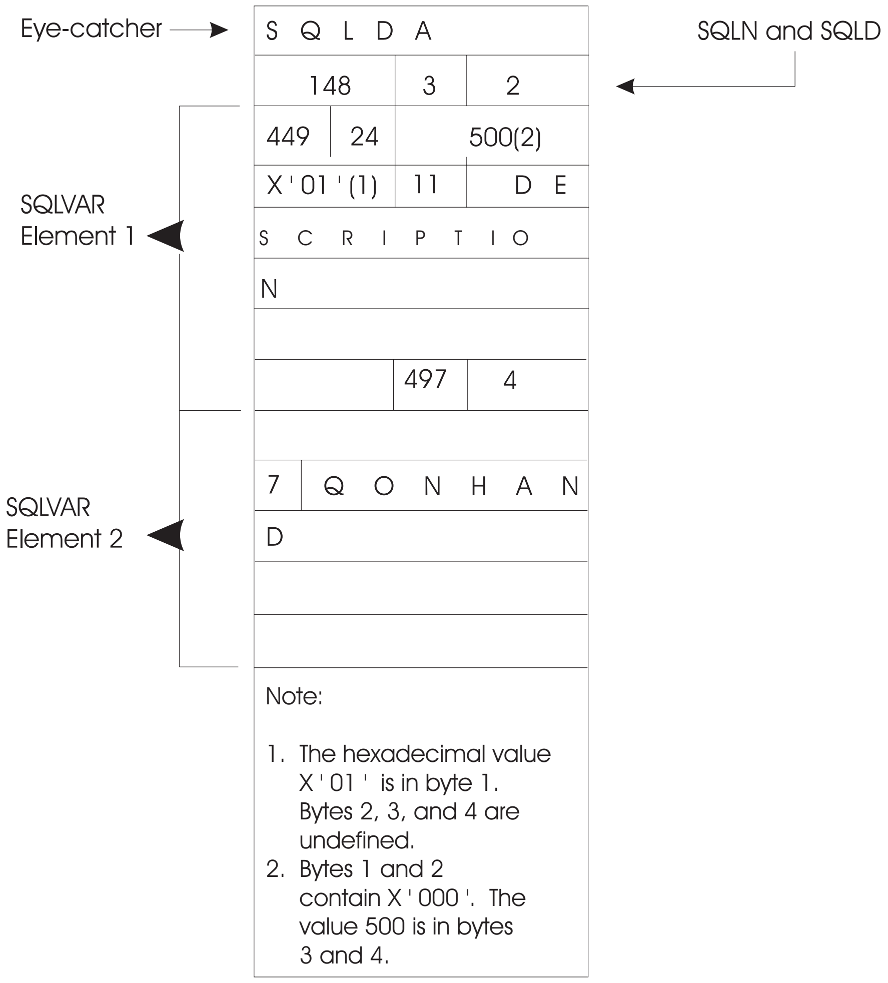
Inserting Values in the SQLDA

Having allocated storage, you can now DESCRIBE the statement. (Make sure that SQLN is set before the DESCRIBE.)

```
DESCRIBE S1 INTO SQLDA
```

When the DESCRIBE is executed, the system places values in the SQLDA. These values provide information about the *select_list*.

Figure 43 shows the contents of the SQLDA after the DESCRIBE is executed for the example *select-statement*. The third SQLVAR element is not shown because it was not used.



Eye-catcher
S Q L D A
SQLN and SQLD
148
3
2
449
24
500(2)
X'01'(1)
11
D E
SQLVAR Element 1
S C R I P T I O
N
497
4
7
Q O N H A N
SQLVAR Element 2
D
Note:
1. The hexadecimal value X'01' is in byte 1. Bytes 2, 3, and 4 are undefined.
2. Bytes 1 and 2 contain X'000'. The value 500 is in bytes 3 and 4.

Figure 43. Contents of SQLDA after Executing the DESCRIBE

The SQLDAID and SQLDABC fields are initialized by the system when a DESCRIBE statement is executed (you can ignore these for now).

If you do not allocate a large enough SQLDA structure, SQLD will be set to the number of required SQLVAR elements after the DESCRIBE. Suppose, for example, that the *select-statement* contained four *select_list* expressions instead of two. The SQLDA was allocated with an SQLVAR dimension of three. The system cannot describe the entire *select_list* because there is not enough storage. In this case, SQLD is set to the actual number of *select_list* expressions; the rest of the structure is ignored. Thus, after a DESCRIBE it is a good practice to check SQLN.

If SQLN is less than SQLD, you need to allocate a larger SQLDA based on the value in SQLD:

```
   EXEC SQL DESCRIBE S1 INTO SQLDA
   IF (SQLN < SQLD)
        Allocate a larger SQLDA using the value of SQLD.
        Reset SQLN to the larger value.
        EXEC SQL DESCRIBE S1 INTO SQLDA
   END-IF
```

For the example *select-statement*, however, the SQLDA was of adequate size. SQLVAR has a dimension of three, and there are only two *select_list* expressions. SQLN remains set to 3, and SQLD is set to 2.

If you use DESCRIBE on a non-select-statement, SQLD is set to 0. If your program is designed to process both query and non-query statements, you can describe each statement (after it is prepared) to determine whether it is a query. This example routine is designed to process only query statements, so no test is provided.

Analyzing the Elements of SQLVAR

Your program must now analyze the elements of SQLVAR. Remember that each element describes a single *select_list* expression. Consider again the select-statement that is being processed:

```
   SELECT DESCRIPTION, QONHAND FROM INVENTORY WHERE PARTNO = 221
```

The first item in the *select_list* is DESCRIPTION. As illustrated in the beginning of this section, each SQLVAR element contains the fields SQLTYPE, SQLLEN, SQLDATA, SQLIND, and SQLNAME. The system returns a code in SQLTYPE that describes the data type of the expression and tells you whether nulls are applicable. For a detailed explanation on how to interpret the codes returned in SQLTYPE, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

For example, SQLTYPE is set to 449 in the first SQLVAR element. This indicates that DESCRIPTION is a VARCHAR column and that nulls are permitted in the column.

The system sets SQLLEN to the length of the column. For character strings, SQLLEN is set to the maximum number of bytes of the string. For graphic strings, SQLLEN is set to the maximum number of double-byte characters in the string. For decimal data, the precision and scale are returned in the first and second bytes, respectively. (Recall that the SQLLEN field has two sub-fields called SQLPRCSN and SQLSCALE for this purpose.) For other data types, SQLLEN is set as follows:

```
SMALLINT                  -- SQLLEN = 2
INTEGER                   -- SQLLEN = 4
Single precision float    -- SQLLEN = 4
Double precision float    -- SQLLEN = 8
DATE                      -- SQLLEN = 10 or LOCAL
TIME                      -- SQLLEN =  8 or LOCAL
TIMESTAMP                 -- SQLLEN = 26
```

Note: For DATE, TIME, and TIMESTAMP, see “Using Datetime Data Types” on page 41.

Because the data type of DESCRIPTION is VARCHAR, SQLLEN is set equal to the maximum length of the character string. For DESCRIPTION, that length is 24. When the select-statement is later executed, a storage area large enough to hold a VARCHAR(24) string will be needed. In addition, because nulls are permitted in DESCRIPTION, a storage area for a null indicator variable would also be needed.

For character and graphic string columns, the system puts the CCSID attribute of the column in bytes 3 and 4 of the SQLDATA field. In Figure 43 on page 161, DESCRIPTION is a character column; therefore, the CCSID of DESCRIPTION is stored in the SQLDATA field of element 1. The example shows a CCSID of 500, which means that the data stored in the column is stored in CCSID 500 format.

For character string columns, the database manager stores an indicator in byte 1 of the SQLIND field. The indicator is set according to the subtype associated with the column. In Figure 43 on page 161, the indicator for DESCRIPTION is set to `X'01'`, which means that DESCRIPTION has a subtype of SBCS. Columns with a subtype of SBCS can contain single-byte character set characters only. Byte 1 is not set when DRDA protocol is in use.

The last field in an SQLVAR element is a varying-length character string called SQLNAME. The first two bytes of SQLNAME contain the length of the character data. The character data itself is usually the name of the field used in the *select_list* expression (DESCRIPTION in the above example). The exceptions to this are *select_list* items that are unnamed, such as functions (for example, SUM(SALARY)) and expressions (A+B-C). These exceptions are described in greater detail under "Summarizing the Fields of the SQLDA" on page 173.

The second SQLVAR element in the above example contains the information for the QONHAND *select_list* item. The 497 code in SQLTYPE indicates that QONHAND is an INTEGER column that permits nulls. For an INTEGER data type, SQLLEN is set to 4. SQLNAME contains the character string QONHAND, and has the length byte set to 7.

Allocating Storage for the Result of the Select-Statement

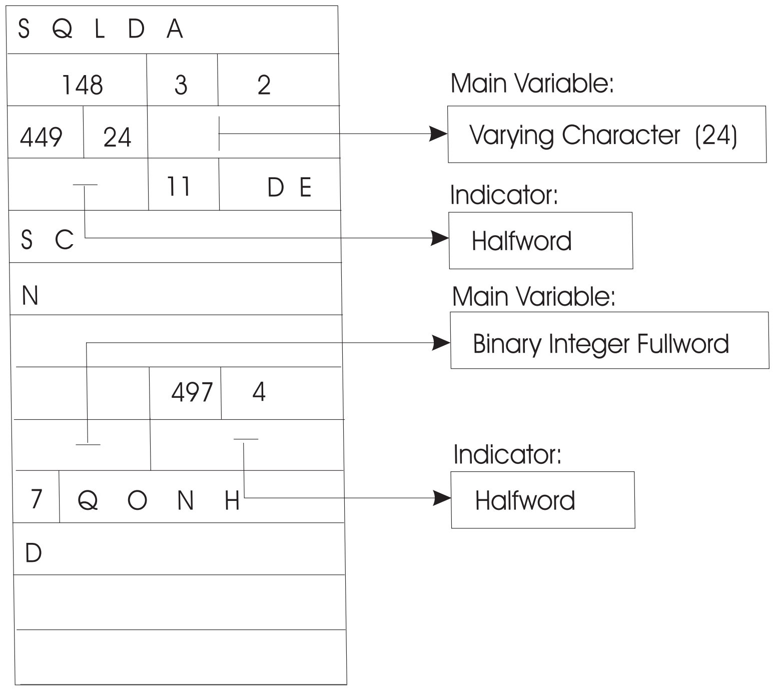
After analyzing the result of the DESCRIBE, you can allocate storage for variables that will contain the result of the select-statement. For DESCRIPTION, a varying character field of length 24 must be allocated; for QONHAND, a binary integer of 31 bits (plus sign) must be allocated. Both QONHAND and DESCRIPTION permit nulls, so you must allocate two additional halfwords to function as indicator variables.

After the storage is allocated, you must change the SQLDA. For each element of the SQLVAR array, do the following:

- Set SQLDATA to the address of the area in which the results will be placed.
- Set SQLIND to the address of the area in which the indicator information will be placed.
- If the data type of the area in which the results will be stored is character or graphic *and* you want to override the CCSID of the data area with, for example, the CCSID of the column, you must do the following:
  - If you are using the SQLDS protocol, change the 6th position of the SQLDAID field to `'+'`. For example, set the SQLDAID field to `'SQLDA+ '`.

Note: When no override is present, the CCSID of the data area defaults to the application requester's default.

In the following example, the SQLDA is updated to contain the appropriate addresses. Because a CCSID override is not required, the SQLNAME field is not modified. Here is what the structure now looks like:



This is the pseudocode for what was done so far:

```
EXEC SQL INCLUDE SQLDA
     .
     .
READ QSTRING FROM TERMINAL
EXEC SQL PREPARE S1 FROM :QSTRING
Allocate an SQLDA of size 3.
SQLN = 3
EXEC SQL DESCRIBE S1 INTO SQLDA
IF (SQLN < SQLD)
     Allocate a larger SQLDA using the value of SQLD.
     Reset SQLN to the larger value.
     EXEC SQL DESCRIBE S1 INTO SQLDA
END-IF
Analyze the results of the DESCRIBE.
Allocate storage to hold select_list results.
Set SQLDATA and SQLIND for each select_list item.
```

Retrieving the Query Result

Now comes the easy part: retrieving the query result. Dynamically defined queries, as noted earlier, must not have an INTO clause. Thus, all dynamically defined queries must use a cursor. Special forms of the DECLARE, OPEN, and FETCH statements are used for dynamically defined queries.

The DECLARE CURSOR statement for the example query is as follows:

```
DECLARE C1 CURSOR FOR S1
```

The only difference is that the name of the prepared select-statement (S1) is used instead of the select-statement.

The actual retrieval of result rows is as follows:

```
EXEC SQL OPEN C1
EXEC SQL FETCH C1 USING DESCRIPTOR SQLDA
DO WHILE (SQLCODE = 0)
     DISPLAY (results pointed to by SQLDATA and SQLIND
              for all pertinent SQLVAR elements)
     EXEC SQL FETCH C1 USING DESCRIPTOR SQLDA
END-DO
DISPLAY ('END OF LIST')
EXEC SQL CLOSE C1
```

The cursor is opened, and the result table is evaluated. (Note that there are no input host variables needed for the example query. Methods of providing input host variables are discussed later.) The query result rows are then returned using a FETCH statement (which does not have output host variables in this example). This statement returns results into the data areas referenced in the descriptor called SQLDA. The same SQLDA that was set up by DESCRIBE is now being used for the *output* of the select-statement.

The next section describes a more general routine in which you can process queries that have parameters in the WHERE clause. You should not read that section until you have coded some of the simpler dynamic queries discussed thus far.

Executing a Parameterized SELECT Statement

In the example above, the query that was dynamically executed had no parameters (input host variables) in the WHERE clause:

```
SELECT DESCRIPTION, QONHAND FROM INVENTORY WHERE PARTNO = 221
```

Suppose you wanted to execute the same query a number of times using different values for PARTNO. A parameterized SQL statement is needed:

```
SELECT DESCRIPTION, QONHAND FROM INVENTORY WHERE PARTNO = ?
```

Generating an Additional SELECT Statement

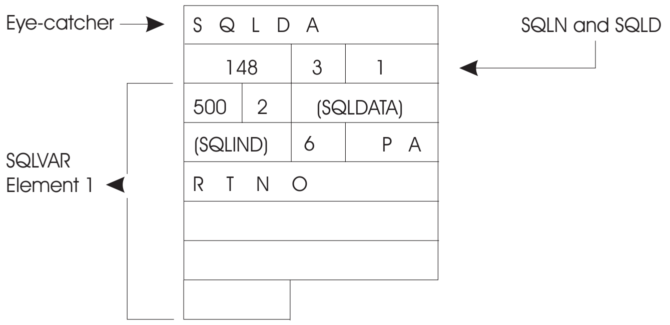
In previous parameterized SQL statements, the number of parameters and their data types had to be known. What if they are unknown? The DESCRIBE statement, at first glance, is not feasible because it describes only *select_list*s. With some additional programming, however, you *can* use the DESCRIBE statement to obtain information about the parameter markers (?). Specifically, the code must scan the FROM and WHERE clauses to determine the table and column with which the parameter marker (?) is associated. The code can then construct a *select-statement* using those column names in the *select_list*. For the parameterized statement above, the following query can be generated:

```
SELECT PARTNO FROM INVENTORY
```

The query (assigned to WSTRING below) can then be preprocessed and described:

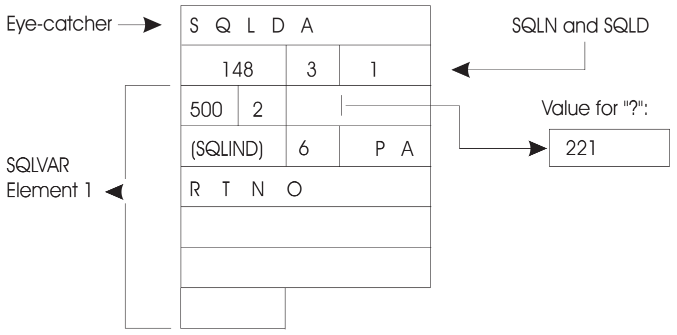
```
Allocate an SQLDA of size 3.
SQLN = 3
EXEC SQL PREPARE S2 FROM :WSTRING
EXEC SQL DESCRIBE S2 INTO SQLDA
```

Here is what the SQLDA looks like after the fabricated *select-statement* is described. Only the first element of SQLVAR is shown because the others are not used:



An analysis of the SQLDA shows that there is only one parameter marker (?), and that parameter is associated with PARTNO. The SQLTYPE value (500) indicates that PARTNO contains integer halfwords. Thus, you need to allocate a binary integer halfword for the parameter marker (?) variable. SQLDATA must then be set to point to this area.

Previously, the SQLDA was used in a FETCH statement, and query results were returned into the storage areas pointed to by SQLDATA and SQLIND. In other words, the SQLDA was used for *output*. Now, the SQLDA is going to be used to provide *input* values for the WHERE clause by an OPEN statement. When the SQLDA is being used for input, you must assign values to the dynamically allocated storage areas pointed to by SQLDATA. If the SQLTYPE value returned by DESCRIBE indicates that the field permits nulls, you must either supply an indicator variable pointed to by SQLIND, or reset SQLTYPE to indicate that nulls are *not* permitted. If indicator variables are not required, you should reset SQLTYPE. For example, if the SQLTYPE returned by DESCRIBE is 501, you should set it to 500 before using the SQLDA to provide input. After the storage for the parameter markers is allocated, you should read in values and assign them to those areas. Here is the completed SQLDA (assuming 221 is read in for the parameter marker (?)):



After an SQLDA is set up in this fashion, it can be referred to in an OPEN statement that contains a USING clause. For example, a previously declared cursor called C1 is opened using SQLDA:

```
OPEN C1 USING DESCRIPTOR SQLDA
```

Because SQLDA currently has 221 in the field pointed to by SQLDATA, C1 is evaluated using that value.

Figure 44 on page 168 shows the pseudocode for the complete example. Two SQLDA-like structures are used. One is called SQLDA, and is the usual structure; the other (declared directly) is called SQLDA1. The fields of SQLDA1 are suffixed with a “1”; for example, SQLDATA1 and SQLN1. An asterisk in position 1 of the pseudocode denotes a comment.

```
  EXEC SQL INCLUDE SQLDA
  Directly declare SQLDA1.
       .
       .
       .
* Read in a parameterized query.
*
  READ QSTRING FROM TERMINAL
*
* PREPARE and DESCRIBE the query; set up the output SQLDA.
*
  EXEC SQL PREPARE S1 FROM :QSTRING
  Allocate an SQLDA of size 3.
  SQLN = 3
  EXEC SQL DESCRIBE S1 INTO SQLDA
  IF (SQLN < SQLD)
       Allocate a larger SQLDA using the value of SQLD.
       Reset SQLN to the larger value.
       EXEC SQL DESCRIBE S1 INTO SQLDA
  END-IF
  Analyze the results of the DESCRIBE.
  Allocate storage to hold select list results.
  Set SQLDATA and SQLIND for each select_list item.
*
* Declare a cursor.
*
  EXEC SQL DECLARE C1 CURSOR FOR S1
*
* Fabricate a query so PREPARE and DESCRIBE can be used to
* set up the input SQLDA1.
*
  Scan the FROM clause and the WHERE clause of QSTRING for
  parameter markers (?) and generate an appropriate
  query in WSTRING.
  Allocate an SQLDA1 of size 1 (1 was obtained from the scan).
  SQLN1 = 1
  EXEC SQL PREPARE S2 FROM :WSTRING
  EXEC SQL DESCRIBE S2 INTO SQLDA1
  Analyze the results of the DESCRIBE.
  Reset SQLTYPE1 to reflect that there is no indicator variable.
  Allocate storage to hold the input values (the parameter marker (?)
  values).
  Set SQLDATA1 for each parameter marker (?) value.
*
* Read in input parameters and retrieve the query results using
* cursor C1.  Note that the pseudocode reads in only one parameter
* marker (?).  Your actual code must provide for the possibility
* that more than one parameter marker (?) might be provided.
*
```

Figure 44 (Part 1 of 2). Parameterized Query Statement

```
READ PARM FROM TERMINAL
DO WHILE (PARM ¬= 0)
     Assign PARM to area pointed to by SQLDATA1.
     EXEC SQL OPEN C1 USING DESCRIPTOR SQLDA1
     EXEC SQL FETCH C1 USING DESCRIPTOR SQLDA
     DO WHILE (SQLCODE = 0)
          DISPLAY (results pointed to by SQLDATA and SQLIND)
          EXEC SQL FETCH C1 USING DESCRIPTOR SQLDA
     END-DO
     EXEC SQL CLOSE C1
     DISPLAY ('ENTER ANOTHER VALUE OR 0')
     READ PARM FROM TERMINAL
END-DO
DISPLAY ('END OF QUERY')
```

Figure 44 (Part 2 of 2). Parameterized Query Statement

Executing a Parameterized Non-Query Statement

"Executing Parameterized Statements" on page 156, introduces parameterized statements, however, it is necessary to know the number of parameter markers (?) and their data types before run time. The preceding section shows how you can analyze a parameterized query so that a *select-statement* can be generated and subsequently described. The same principle can be used for parameterized non-query statements.

Generating a SELECT Statement

For example, suppose this DELETE statement is read from the terminal and assigned to DSTRING:

```
DELETE FROM QUOTATIONS WHERE PARTNO = ? AND SUPPNO = ?
```

Suppose also that the number of parameter markers (?) and their corresponding data types are unknown before run time. The same routine that you coded to scan the FROM and WHERE clauses of select-statements can be used to scan the above DELETE statement. Then, a SELECT statement containing the relevant columns can be constructed:

```
SELECT PARTNO, SUPPNO FROM QUOTATIONS
```

This select-statement is then prepared and described as in the previous section. The setup of the SQLDA is also identical: once the SQLDA is analyzed, space to hold the parameter marker values is allocated, and these values are read in and assigned to these locations. The SQLDA will be used for *input* to the WHERE clause of the SQL statement; no indicator variables are allowed. Because the statement is a non-query statement, the SQLDA is pointed to in the EXECUTE statement. Figure 45 on page 170 illustrates the pseudocode for a parameterized non-query statement.

```
  EXEC SQL INCLUDE SQLDA
       .
       .
       .
  READ DSTRING FROM TERMINAL
  Scan the FROM clause and the WHERE clause of DSTRING for
    parameter markers (?) and generate an appropriate query
    in WSTRING.
  Allocate an SQLDA of size 2 (2 was obtained from the scan).
  SQLN = 2
  EXEC SQL PREPARE S2 FROM :WSTRING
  EXEC SQL DESCRIBE S2 INTO SQLDA
  Analyze the results of the DESCRIBE.
  Reset SQLTYPE to reflect that there is no indicator variable.
  Allocate storage to hold the input values (the parameter marker (?)
  values).
  Set SQLDATA for each parameter marker (?) value.

  EXEC SQL PREPARE S1 FROM :DSTRING
  Read parameter marker (?) values from the terminal.
* A zero parameter value terminates the DO loop.
  DO WHILE (parameters ¬= 0)
      Assign the values to the storage allocated for
        input variables.
      EXEC SQL EXECUTE S1 USING DESCRIPTOR SQLDA
      Prompt user for more values.
      Read parameter marker (?) values from the terminal.
  END-DO
       .
       .
       .
```

Figure 45. Parameterized Non-Query Statement

You may need a more complex scanning routine, depending on how many different non-query statements you wish to process. For example, the above routine would have to be modified if you wanted to process INSERT statements. In that case, you would have to scan for the table and column names.

Note: Indicator variables are permitted when you are providing input to the INSERT statement with EXECUTE.

Using an Alternative to a Scanning Routine

In the previous sections on parameterized statements (both query and non-query), you must rely on a scanning routine to generate a query. Once the query is generated, DESCRIBE obtains information about the columns and expressions associated with a parameter marker.

If you have not coded a scanning routine that generates a query, there is a simple alternative: have the user describe the parameter markers for you, and fill in the SQLDA yourself. There is no rule that says you must use a DESCRIBE to fill in the SQLDA. When using the SQLDA for input or output, it does not matter what fills it in, as long as the needed values are there.

When you use the SQLDA for input (which is always the case for parameter markers), not all fields have to be filled in. Specifically, SQLDAID and SQLDABC need not be filled in. Thus, if you choose this method, you will need to ask the user for the following:

1. How many parameter markers (?) are there?
2. What are the data types and lengths of these parameters?

In addition, if the routine is to handle both query and non-query statements, you may want to ask the user what category of statement it is. (Alternatively, you can write code to look for the SELECT keyword.)

The code that interrogates the user and sets up the SQLDA would take the place of the scanning routine and DESCRIBE in the previous sections:

```
With a Scanning Routine:

       .
       .
       .
READ DSTRING FROM TERMINAL
Scan the FROM and WHERE clauses of DSTRING for parameter markers (?)
and generate an appropriate query in WSTRING.
Allocate an SQLDA of size 2 (2 was obtained from the scan).
SQLN = 2
    EXEC SQL PREPARE S2 FROM :WSTRING
    EXEC SQL DESCRIBE S2 INTO SQLDA
Analyze the results of the DESCRIBE.
Reset SQLTYPE to reflect that there is no indicator variable.
Allocate storage to hold the input values
   (the parameter marker (?) values).
Set SQLDATA for each parameter marker (?) value.
       .
       .
       .

Without a Scanning Routine:

       .
       .
       .
READ DSTRING FROM TERMINAL
Interrogate user for number of parameter markers (?).
Allocate an SQLDA of that size.
Set SQLN and SQLD to the number of parameter markers (?).
For each parameter marker (?):
    Interrogate user for data types, lengths, and
      indicators.
    Set SQLTYPE and SQLLEN.
    Allocate storage to hold the input values
      (the parameter marker (?) values).
    Set SQLDATA and SQLIND (if applicable) for each
      parameter marker (?).
       .
       .
       .
```

The statement can then be processed in the usual manner.

Ensuring Data Type Equivalence in a Dynamically Defined Query

In previous uses of the SQLDA for input or output, SQLTYPE *always* described the data type of the storage area pointed to by SQLDATA. In the following example, the type code 500 (originally obtained with a DESCRIBE of the select-statement) describes the data type of the main variable.

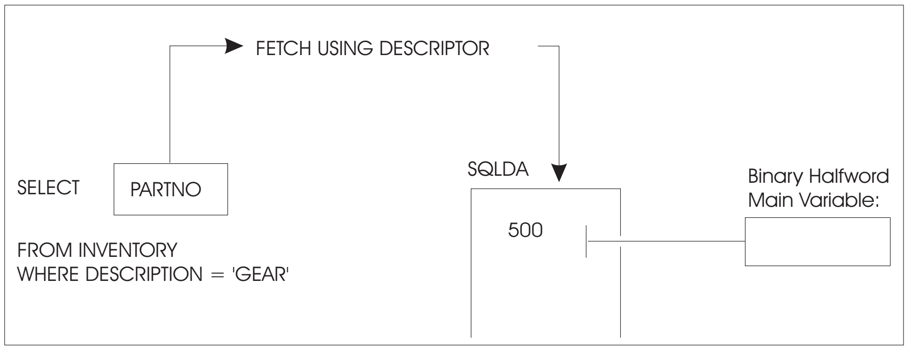


Figure 46. The FETCH Using Descriptor

In previous sections, the *select_list* item, the type code, and the data type of the storage area allocated for holding query results are all equivalent. That is, in the above example, PARTNO is a SMALLINT column (with no nulls permitted), 500 is the type code meaning SMALLINT NOT NULL, and the area allocated is a binary integer halfword. To force a data conversion, you must allocate a storage area having a different data type and then change SQLTYPE in the SQLDA. Suppose that you wanted to select the SMALLINT part numbers into an integer area. Here is the sequence of instructions needed:

```
EXEC SQL PREPARE S1 FROM :STRING
EXEC SQL DESCRIBE S1 INTO SQLDA
Allocate a binary integer fullword of storage.
Set SQLDATA to point to it.
SQLTYPE = 496
```

When the FETCH is executed, SMALLINT is converted to INTEGER. Similarly, you could have converted the retrieved PARTNO values to FLOAT merely by setting SQLTYPE to 480 and by allocating a floating-point word of storage.

This conversion can be done when the SQLDA is used for *input* also. Consider the normal case:

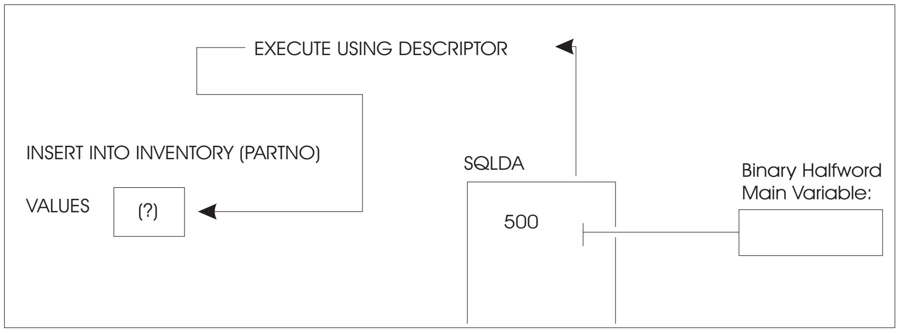


Figure 47. The EXECUTE Using Descriptor

As before, PARTNO is SMALLINT. The main variable is also allocated as SMALLINT (binary integer halfword), and the SQLTYPE that describes the main variable represents a SMALLINT. To perform data conversion on input, you need to change only the SQLTYPE and the type of storage allocated to hold the input values. This is done exactly as in the previous example. To insert a floating-point variable into the SMALLINT PARTNO column, for example, these steps are needed:

```
EXEC SQL PREPARE S1 FROM :STRING
EXEC SQL PREPARE S2 FROM 'SELECT PARTNO FROM INVENTORY'
EXEC SQL DESCRIBE S2 INTO SQLDA
Allocate an 8-byte floating-point area.
Set SQLDATA to point to it.
Assign a floating-point number to the area.
SQLTYPE = 480
EXEC SQL EXECUTE S1 USING DESCRIPTOR SQLDA
```

All dynamic data conversion is done according to the rules summarized under “Converting Data” on page 44.

If you change the SQLTYPE code and then allocate a storage area of an incorrect type, the system treats the storage area as though it were of the type indicated by SQLTYPE. For example, suppose SQLTYPE indicates that the storage area pointed to by SQLDATA is an INTEGER, but that the actual area allocated is a binary integer halfword (SMALLINT). The field is treated as though it is an INTEGER, not a SMALLINT. This type of error may yield confusing results.

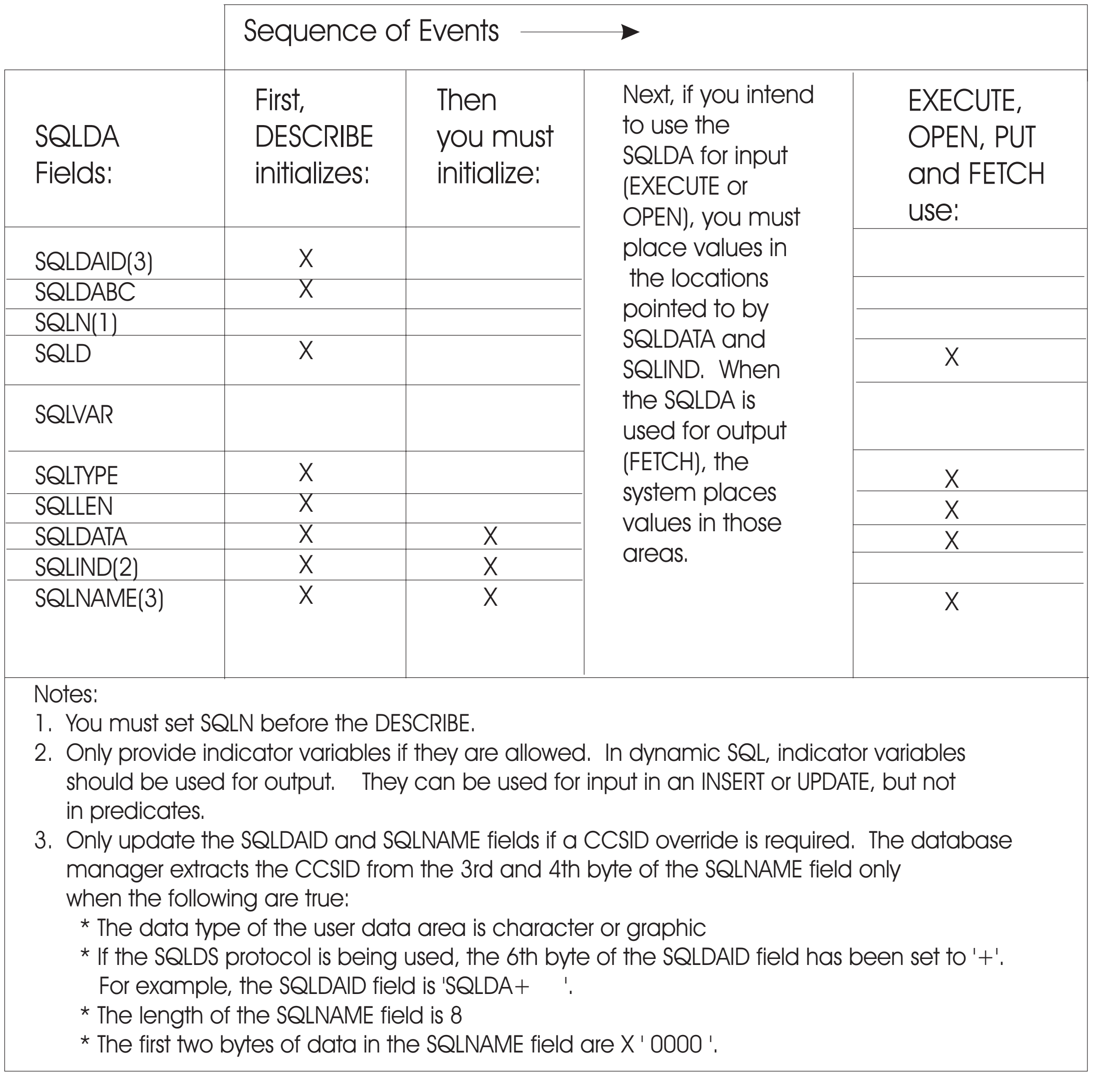
When a datetime data code is used in an SQLDA on a FETCH, the system assumes that the variable declared to hold the result is fixed-length character.

Summarizing the Fields of the SQLDA

This section summarizes the SQLDA structure and related information.

As you have learned in the previous sections, the SQLDA can be used in any number of ways. In general, the fields within the SQLDA must be initialized either by using a DESCRIBE statement or by user code. Once they are initialized, the SQLDA can be used for *input* (in EXECUTE, OPEN, and PUT) or for *output* (in FETCH).

Figure 48 on page 174 summarizes the sequence of events needed to initialize the SQLDA for use in processing dynamically defined statements. In any case, you must always initialize SQLN before the DESCRIBE.



	Sequence of Events →			
SQLDA Fields:	First, DESCRIBE initializes:	Then you must initialize:	Next, if you intend to use the SQLDA for input (EXECUTE or OPEN), you must place values in the locations pointed to by SQLDATA and SQLIND. When the SQLDA is used for output (FETCH), the system places values in those areas.	EXECUTE, OPEN, PUT and FETCH use:
SQLDAID(3)	X			
SQLDABC	X			
SQLN(1)				
SQLD	X			X
SQLVAR				
SQLTYPE	X			X
SQLLEN	X			X
SQLDATA	X	X		X
SQLIND(2)	X	X		
SQLNAME(3)	X	X		X

Notes:
1. You must set SQLN before the DESCRIBE.
2. Only provide indicator variables if they are allowed. In dynamic SQL, indicator variables should be used for output. They can be used for input in an INSERT or UPDATE, but not in predicates.
3. Only update the SQLDAID and SQLNAME fields if a CCSID override is required. The database manager extracts the CCSID from the 3rd and 4th byte of the SQLNAME field only when the following are true:
   * The data type of the user data area is character or graphic
   * If the SQLDS protocol is being used, the 6th byte of the SQLDAID field has been set to '+'. For example, the SQLDAID field is 'SQLDA+ '.
   * The length of the SQLNAME field is 8
   * The first two bytes of data in the SQLNAME field are X ' 0000 '.

Figure 48. SQLDA Initialization

If you do not use a DESCRIBE to set up the SQLDA, you need only fill in those fields that are actually used by the OPEN, FETCH, PUT, or EXECUTE statements.

For applications that override the defaults for subtypes and CCSIDs, the SQLDA provides output information on subtypes and CCSIDs. The *DB2 Server for VSE & VM SQL Reference* manual contains a description of the structure of the SQLDA, and an explanation of each field within the SQLDA. The following are some additional guidelines for using the SQLN and SQLD fields.

Using the SQLN Field

Always set this value when the structure is allocated. When the USING clause of the DESCRIBE statement is set to NAMES, LABELS, or ANY, specify the maximum number of expected *select_list* items. When you set the USING clause option to BOTH, specify twice the number of expected *select_list* items.

Using the SQLD Field in the SQLDA

If the statement being described is not a *select-statement*, the database manager returns a zero in SQLD. If the statement is a *select-statement*, SQLD is set to indicate the number of SQLVAR elements. This number is either the number of *select_list* elements (when the USING clause of the DESCRIBE statement is set to NAMES, LABELS, or ANY), or twice the number of *select_list* elements (if the USING clause is set to BOTH).

In the second case (USING clause set to BOTH), your program should reset SQLD to half its value before issuing a subsequent FETCH or PUT. This is because only the first N/2 elements contain information; the rest contains label information only.

If (after a DESCRIBE) SQLD is greater than SQLN, the SQLVAR array is not large enough to contain descriptions for all the *select_list* items. In this case, you must allocate a larger SQLDA based on the value of SQLD. The value in SQLN is not changed.

If you set the value of SQLD yourself, and you set it to less than SQLN, the excess elements of the SQLVAR array are ignored.

Using the PREPARE Statement

```
►►──PREPARE──statement_name──FROM──┬─string_constant─┬─────────────────►◄
                                   └─host_variable───┘
```

Figure 49. Format of the PREPARE statement

Although a statement to be "prepared" cannot contain any host variables, it can contain parameters to be filled in when the statement is executed. These parameters are denoted by parameter markers (?). You can specify parameters only in places where a data value could be used. (A parameter cannot represent the name of a table or a column.) The pseudocode example below prepares an INSERT statement that has three parameters:

```
QSTRING='INSERT INTO DEPARTMENT(DEPTNO,DEPTNAME,ADMRDEPT) VALUES (?,?,?)'

PREPARE S1 FROM :QSTRING
```

Each time S1 is executed, values must be supplied for the three parameters that were specified with question marks.

If your program constructs dynamic SQL statements by manipulating quoted strings, remember that SQL uses two single quotation marks to represent a quotation mark inside a quoted string. The following example illustrates this rule:

```
   PREPARE S1 FROM 'INSERT INTO DEPARTMENT(DEPTNO,DEPTNAME,ADMRDEPT)
        VALUES ('A00','SPIFFY COMPUTER SERVICE DIV.','A00'')'
```

In this example, the text beginning with INSERT and ending with A00'') is a constant string. Each pair of quotation marks is collapsed to a single quotation mark.

In COBOL, a constant string-spec is treated as a COBOL character string and is affected by the Quote/APOST option. This option determines the character string delimiters. If you use the same character (" or ') in the constant string-spec as the one established by Quote/APOST option for the outer string delimiters, unexpected string termination can result.

It is best to avoid using a constant string-spec whenever it may contain quotation marks. Instead, you should build the SQL statement as a host variable string-spec, using the known host language rules for character strings. For SQL statements that contain graphic constants, be aware that some DBCS characters may contain the encodings for EBCDIC quote. This could cause unintentional termination of host language strings that contain DBCS characters.

A parameter marker (?) can appear in an SQL statement to be “prepared” in any place that a host variable may appear, with the following exceptions:

- A parameter marker cannot be used in a *select_list* or a FROM-clause (but it may be used in the WHERE clause of a SELECT statement).

  The following examples are invalid:

  ```
  SELECT ? FROM EMPLOYEE
  SELECT EMPNO FROM ?
  ```

  The following example is valid:

  ```
  SELECT * FROM EMPLOYEE WHERE EMPNO = ?
  ```

- At least one of the operands of the arithmetic and comparison operators, or of the BETWEEN and IN predicates, must not be a parameter marker.

  The following examples are invalid:

  ```
  SELECT * FROM EMPLOYEE WHERE SALARY > ? + ?
  SELECT * FROM EMPLOYEE WHERE ? = ?
  SELECT * FROM EMPLOYEE WHERE ? IN (?,?)
  ```

  The following examples are valid:

  ```
  SELECT * FROM EMPLOYEE WHERE SALARY > 20000 + ?
  SELECT * FROM EMPLOYEE WHERE SALARY = ?
  SELECT * FROM EMPLOYEE WHERE ? IN (?,?,20000)
  ```

- A parameter marker cannot be the sole argument of a scalar function. It, however, can be used in an arithmetic expression as long as the other parameter is a number.

  The following example is invalid:

  ```
  SELECT * FROM EMPLOYEE WHERE HIREDATE > DATE(?)
  ```

  The following example is valid:

  ```
  SELECT * FROM EMPLOYEE WHERE HIREDATE > DATE(14+?)
  ```

- A parameter marker cannot be used as the sole operand in an arithmetic expression that involves a datetime value.

  The following examples are invalid:

  ```
  SELECT * FROM EMPLOYEE WHERE HIREDATE = START_DATE + ?
  SELECT * FROM EMPLOYEE WHERE HIREDATE = 10000000. + ?
  ```

  The following example is valid:

  ```
  SELECT * FROM EMPLOYEE WHERE HIREDATE = HIREDATE + (1000000.+?)
  ```

SQL Functions Not Supported in Dynamic Statements

The following SQL functions are not supported in dynamic SQL:

- Syntax and semantic flagging of the dynamically executed statement
- SQL comments
- Negative indicator variables in predicates
- Optional choice for the FOR UPDATE OF clause in cursor query statements (NOFOR support).
- SQL CALL statement.

Chapter 7. Using Extended Dynamic Statements

Contents

Using Extended Dynamic Statements to Maintain Packages 180
Illustrating the Use of Extended Dynamic Statements 183
Developing a Query Application 183
Developing a Language Preprocessor 185
Grouping Extended Dynamic Statements in an LUW 189
Considering Virtual Storage in an LUW 192
Mapping Extended Dynamic Statements to Static and Dynamic Statements . 192
SQL Functions Not Supported in Extended Dynamic Statements 194

Using Extended Dynamic Statements to Maintain Packages

Extended dynamic statements support the direct creation and maintenance of packages for DB2 Server for VM data. Extended dynamic statements can only be used with assembler language or in the optional DB2 Server RXSQL feature (described in the *DB2 REXX SQL for VM/ESA Reference* manual). Refer to the *DB2 Server for VSE & VM SQL Reference* manual for a detailed discussion of the restrictions with DRDA protocol.

Note: This topic is more advanced than previous sections and the techniques discussed here are not relevant to all application programs.

Before reading this chapter, you should be familiar with how to use packages as described in "Preprocessing the Program" on page 106, , and dynamically defined statements, as described in Chapter 6, "Using Dynamic Statements" on page 153. Extended dynamic statements provide a function similar to that provided by the DB2 Server for VM preprocessors, but may be particularly useful where:

- The current preprocessors do not support the language of the application or support program.
- SQL statements are conceived and built dynamically, but are executed repetitively (in a different logical unit of work). In this case it is more efficient to avoid having to repeat the preprocessing of statements each time they are executed, as would be required for normal dynamic statements.
- You want to build and maintain an application package of SQL statements to be shared by a group of users.
- The utilization of program storage is critical and there are a significant number of predefined "transactions" involving DB2 Server for VM data.

Individual SQL statements can be added or deleted without affecting or repeating the preprocessing of other SQL statements in the package.

The following extended dynamic statements are supported. (They are described in detail in the *DB2 Server for VSE & VM SQL Reference* manual.)

- CREATE PACKAGE—build an empty package
- PREPARE—add a statement to a package
- DESCRIBE—obtain information about columns in the *select_list* of a prepared *select-statement*
- EXECUTE—execute a statement in a package
- DECLARE CURSOR—in connection with OPEN, FETCH, PUT, and CLOSE, execute a SELECT or an INSERT statement in a package
- OPEN (cursor)
- FETCH (cursor)
- PUT (cursor)
- CLOSE (cursor)
- DROP STATEMENT—delete a statement from a package.

Except for CREATE PACKAGE and DROP STATEMENT, the names of these statements are the same as the corresponding "normal" dynamic statements discussed in Chapter 6, “Using Dynamic Statements” on page 153, but their format and meaning are somewhat different. For example, the statement-id, package-id, and cursor-name fields are all specified by host variables.

Unlike dynamic statements which are related through a specific statement name, extended dynamic statements are related through the symbolic host variables used for the statement-id and package-id. This relationship is shown in Figure 50. Because the statement-id and package-id are host variables, actual values can be substituted when the program is executed. STMTID is returned by an extended PREPARE statement, and is used as input by the subsequent extended EXECUTE (or DECLARE CURSOR) statement.

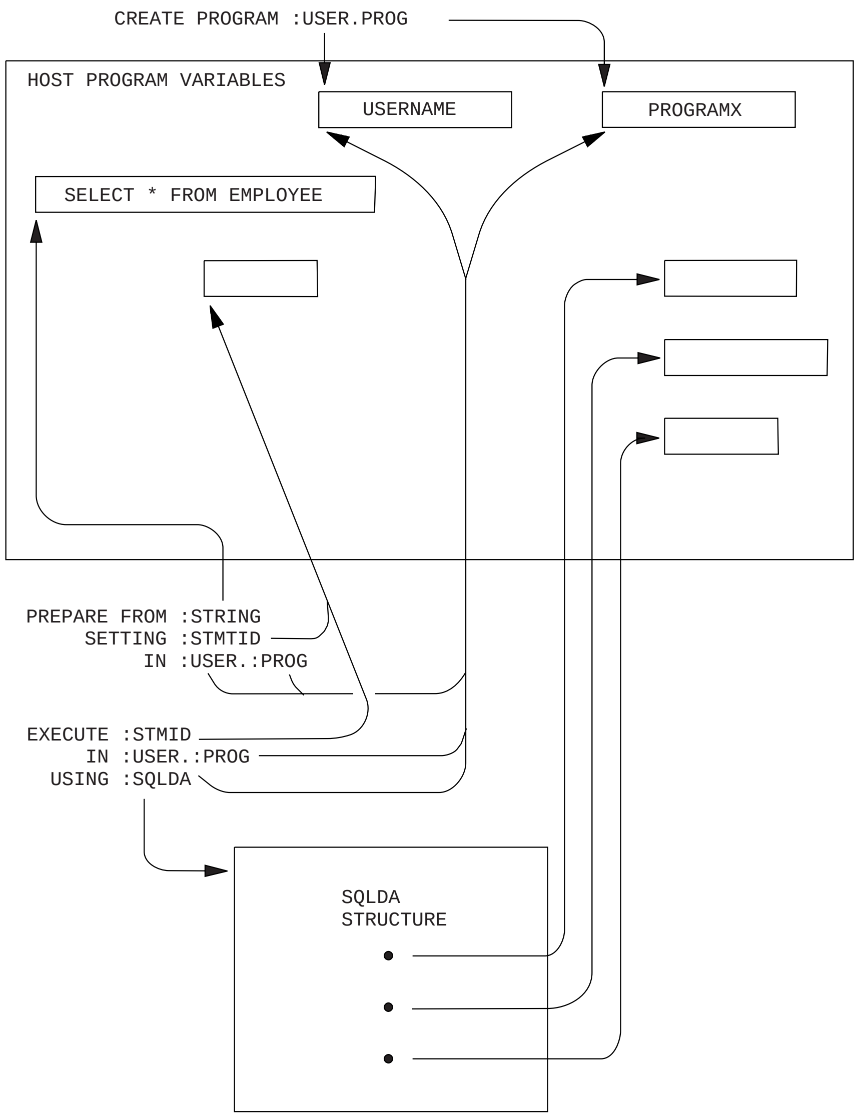


Figure 50. Relationship between Extended Dynamic Statements Expressed Using Host Program Variables

The differences between dynamic and extended dynamic statements are illustrated in Figure 51. As shown in this figure, the normal dynamic statements are intended primarily for supporting an interactive environment. As such, the PREPARE and EXECUTE commands must be used within the same logical unit of work. In contrast, extended dynamic statements are generally used in a compile environment where the EXECUTE (or DECLARE CURSOR) may be in a logical unit of work that is different from the one where the SQL statement was prepared. This makes it possible to PREPARE statements at different times. In DB2 Server for VM terms, they can be prepared in one logical unit of work (stored in a package), and called out for execution from another logical unit of work (from the same or a different program). This is made possible by passing the program and statement identifiers between the preparation environment and the execution environment.

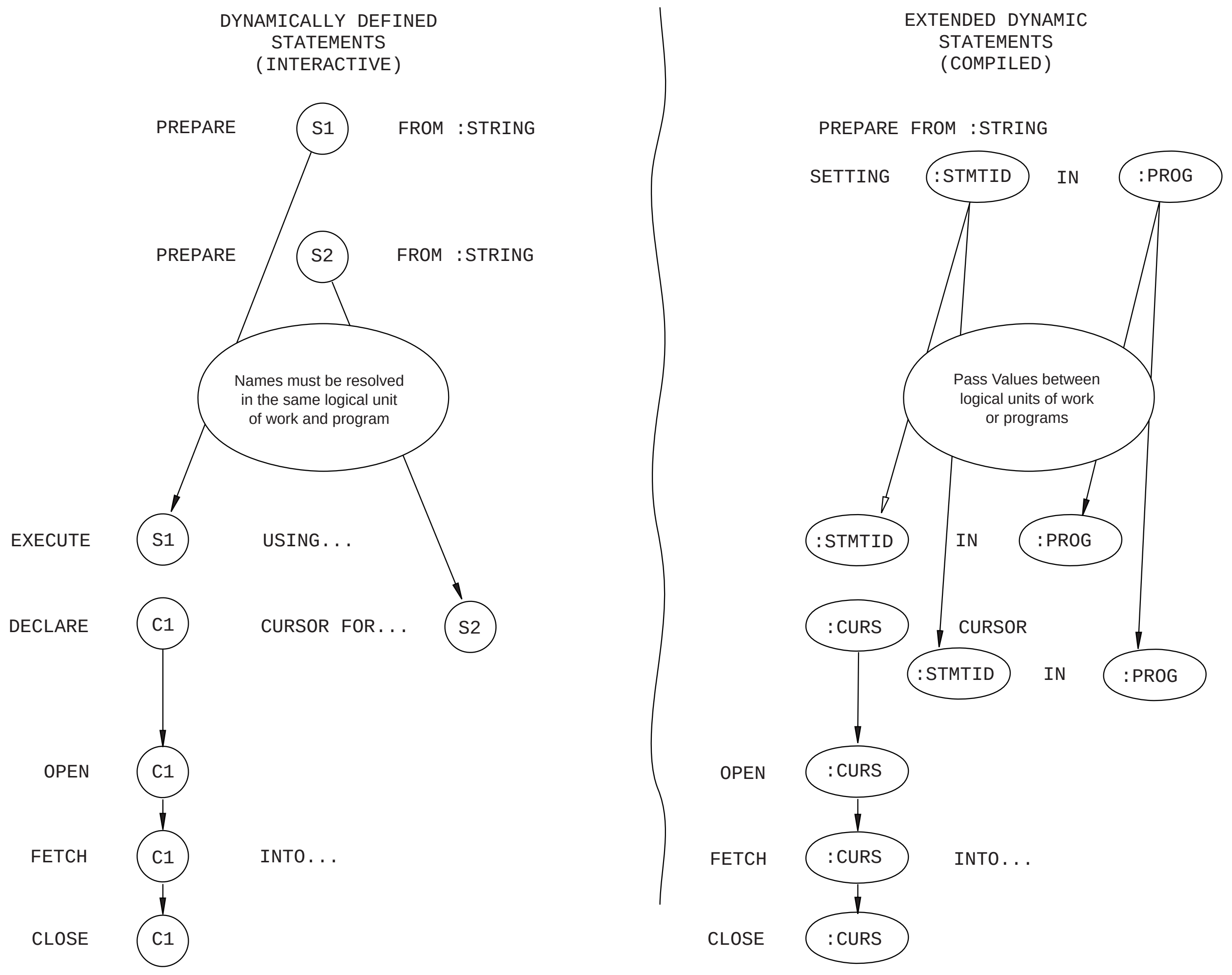

DYNAMICALLY DEFINED STATEMENTS (INTERACTIVE)
PREPARE S1 FROM :STRING
PREPARE S2 FROM :STRING
Names must be resolved in the same logical unit of work and program
EXECUTE S1 USING...
DECLARE C1 CURSOR FOR... S2
OPEN C1
FETCH C1 INTO...
CLOSE C1
EXTENDED DYNAMIC STATEMENTS (COMPILED)
PREPARE FROM :STRING
SETTING :STMTID IN :PROG
Pass Values between logical units of work or programs
:STMTID IN :PROG
:CURS CURSOR
:STMTID IN :PROG
OPEN :CURS
FETCH :CURS INTO...
CLOSE :CURS

Figure 51. Comparing Dynamic to Extended Dynamic Statements

CREATE PACKAGE and DROP STATEMENT have no counterparts in the normal dynamic statement set.

CREATE PACKAGE creates an empty package and is normally followed by extended PREPARE statements to add statements to the package. If the CREATE PACKAGE has a MODIFY option, the package may even be changed in another logical unit of work. The change may take the form of additional extended PREPAREs (adding statements to those already there), or DROP STATEMENTs (deleting statements previously prepared). If a program is created with the NOMODIFY option, it cannot be changed without completely replacing it. You do this by using CREATE PACKAGE with the REPLACE option and specifying the same package-id. When you use DRDA protocol, there is no support for the

MODIFY option. The MODIFY option of the CREATE PACKAGE statement defaults to NOMODIFY.

The DROP PACKAGE statement is not listed as an extended dynamic statement, because it has general applicability for all packages, not just those that are built with extended dynamic statements. (See the *DB2 Server for VSE & VM SQL Reference* manual for more information on the DROP PACKAGE statement.) Like the extended dynamic statements, DROP PACKAGE permits the package name to be specified as a host program variable.

Like all SQL statements, extended dynamic statements require preprocessing, but are only supported by the assembler preprocessor. Once they are preprocessed (and the containing program is compiled), the program holding them may itself be used to process SQL statements and create packages. That is, it may prepare SQL statements for repetitive execution. A package created in SQLDS protocol that uses extended dynamic statements is not supported in DRDA protocol, nor is a package created in DRDA protocol that uses extended dynamic statements supported in SQLDS protocol. The nonmodifiable environment, when using extended dynamic statements, is supported with the following restrictions:

- The Positioned UPDATE or Positioned DELETE statements are not supported.
- If you use the basic format of the extended PREPARE statement to prepare a statement that contains parameter markers, you must include the USING DESCRIPTOR clause to identify an input SQLDA structure.
- The prepare single row format of the extended PREPARE statement is not supported.
- The NODESCRIBE option of the CREATE PACKAGE statement is not supported.

Illustrating the Use of Extended Dynamic Statements

Developing a Query Application

Consider the following example. A support group needs to develop a program that dynamically accepts SQL statements for execution and does not know what SQL statements will be processed. This is a typical application for normal dynamic SQL statements. But since there is also a requirement for repetitively executing the preprocessed statements at a later time (stored SQL application) without having to repeat the PREPARE, it is an application for extended dynamic statements.

A program that handles preparation of end user SQL statements can also execute these statements. This is essentially a query language program (but it supports more than just select-statements). The program may also support deleting statements from and adding them to existing packages. (See the beginning of this chapter for a list of extended dynamic statements for doing this, as well as statements to control execution.)

The program may use CREATE PACKAGE and extended PREPARE to build a package and prepare the end-user SQL statements. However, you must first preprocess the program itself, by running it through the assembler preprocessor and the assembler. See Figure 52 (the application program is referred to as a “Support Program”).

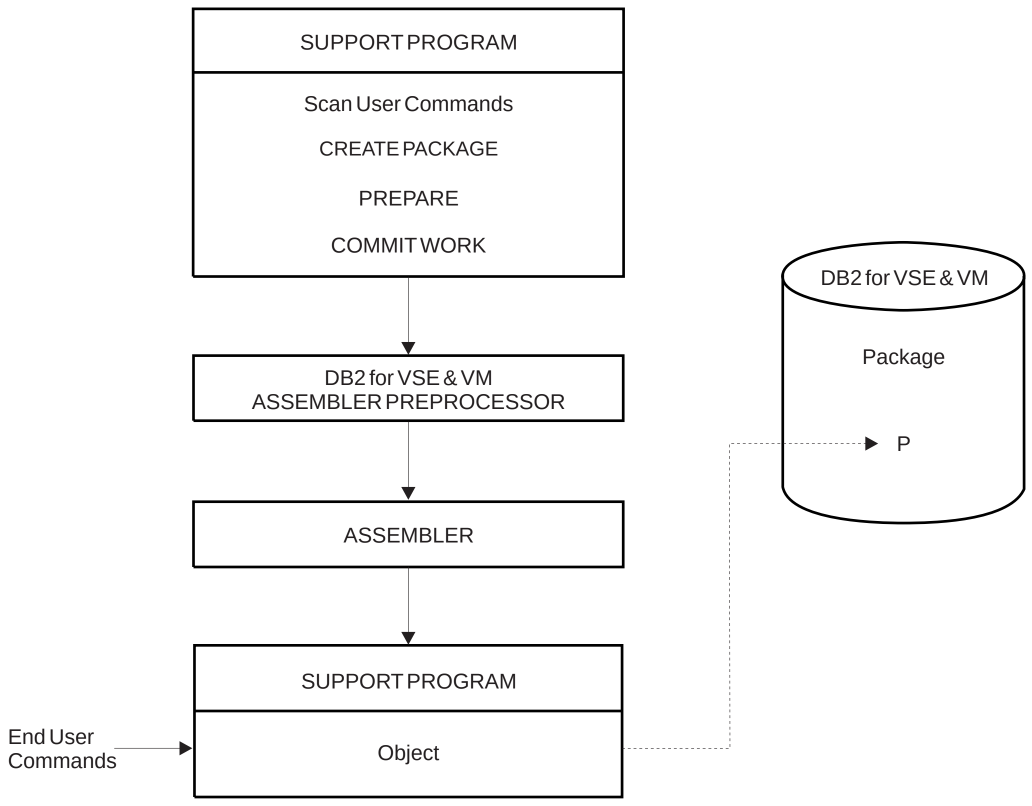


Figure 52. An Example of an Interpretive Support Program for Building and Executing SQL Statements in a Package

The resulting support program can accept end-user SQL statements, and create packages in the database to hold them. For example, there can be a separate package to hold the SQL statements for each end-user. A more advanced support program may even accept end-user commands that are at a higher level than that supported by the system, and then translate them to SQL statements before preparing them.

The package P is built by the support program (by CREATE PACKAGE) for the particular SQL statements. If the support program allows both adding SQL statements to and dropping them from P, then the support program must utilize and be preprocessed with a DROP STATEMENT as well as the PREPARE. Of course, there are a few other ordinary SQL statements that may be appropriate for the support program: WHENEVER, COMMIT/ROLLBACK, and so on to make it complete.

So far, this example has not addressed execution of the end-user SQL statements. We have already listed the extended dynamic statements that support execution (extended EXECUTE, DECLARE CURSOR, and so on). The support program would ordinarily support end-user commands to retrieve data and update data (using either direct SQL statements or higher level commands that require conversion). This addition does not alter the concept shown in Figure 52, except to add additional extended dynamic statements to the support program.

The DESCRIBE statement can be used in the same way as shown under normal dynamic statements.

Note that only one “copy” of each extended dynamic statement need be provided in the support program, because each of these statements is parameterized with host variables that can be dynamically changed for each use. For example, one DECLARE CURSOR statement may service all cursor retrievals, even if they are concurrently open, because each can be given a different cursor name by the host variable value for the cursor name, and a different statement identifier by the host variable value for the statement-id. This is important in cases where the use of program storage is critical and there are a significant number of predefined transactions.

Developing a Language Preprocessor

The previous example is structurally simple. It assumes that the support program remains in control as an interpreter through preparation, maintenance, and execution of the user's SQL statements.

For a typical language preprocessor program such as those provided with the DB2 Server for VM product, however, this is not the case. If you write a support program for a new language preprocessor, you would probably separate the two parts, each with SQL statements:

1. One for preparation of end-user SQL statements and creation of a package.
2. Another for supporting the execution of the SQL statements that were prepared by the first part.

The SQL facilities required are similar to the previous example, except that no package maintenance functions are needed. The language preprocessor has the following characteristics:

- It is a batch program, rather than an interpreter.
- Because it requires extended dynamic statements, it is written in assembler language. (This was also true in the previous example.) Alternatively, at least part of it must be written in assembler language (the part that contains the extended dynamic statements) and the remaining part must be written in a language that is capable of calling an assembler module.
- Rather than accepting predefined commands from the end-user, the end-user's source language code is scanned for SQL statements, which must be identified by some defined convention (for example, EXEC SQL) for proper recognition.
- The support program must record information about host program variables in a control structure that is added to the end-user's source program and passed by a generated call to the execution-time part of the support program. This control structure builds SQLDA structures that are passed to or received from the system (refer to the extended EXECUTE, OPEN and FETCH statements).
- The execution part of the support program is link/loaded with the user's application program, where it is available to handle the execution-time functions.
- As each end-user SQL statement is prepared, the package-id and the statement-id (returned by the system along with the package-id) must be saved in a control structure (again generated into the end-user's source program) for use by the execution-time support program.
- For each SQL statement in the end-user's source program, a call must be generated to the execution-time support program, passing the control structure,

containing the host variable, package-id, and statement-id information for the current SQL statement.

- The execution-time support program must build the SQLDA structures required, set values in host variables required by the execution-time extended dynamic statements, and then execute these statements.

This process is illustrated in Figure 53, Figure 54, Figure 55, and Figure 56. The support program is the preprocessor for language X. It preprocesses the end-user program, modifying the source (adding control structures and generating calls to pass to the support program Part 2 at execution-time). Once the modified end-user source has been compiled by the language X compiler, it is combined in one load module with the object code for the support program Part 2, which provides the DB2 Server for VM support for execution-time functions (DECLARE CURSOR, and so on).

Figure 53 shows the preprocessing and assembly steps for the two parts of the support program. No packages are created, because there are no SQL statements in either part that need to be stored in a package.

Figure 54 on page 187 shows how the two resulting object modules of the support program process end-user SQL statements.

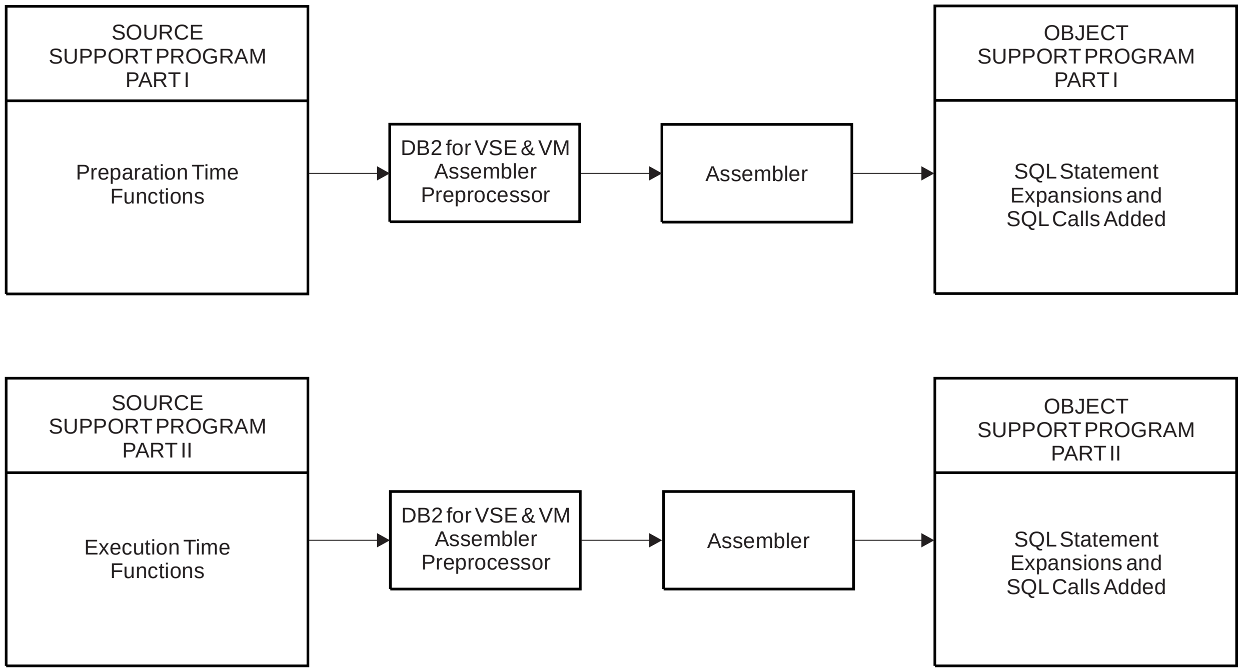
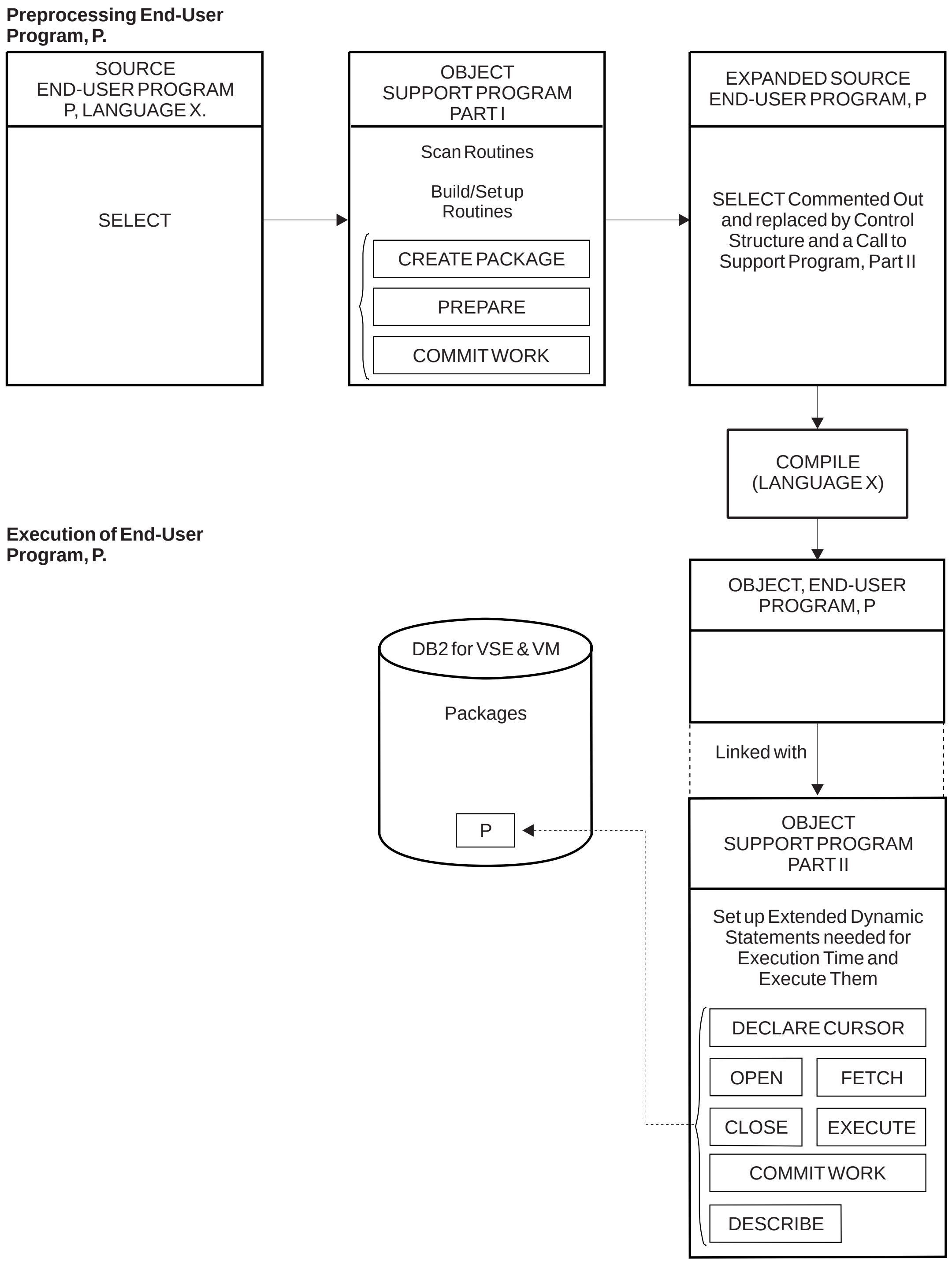

SOURCE SUPPORT PROGRAM PART I
Preparation Time Functions
DB2 for VSE & VM Assembler Preprocessor
Assembler
OBJECT SUPPORT PROGRAM PART I
SQL Statement Expansions and SQL Calls Added
SOURCE SUPPORT PROGRAM PART II
Execution Time Functions
DB2 for VSE & VM Assembler Preprocessor
Assembler
OBJECT SUPPORT PROGRAM PART II
SQL Statement Expansions and SQL Calls Added

Figure 53. Preprocessing and Assembling of a Two-Part Support Program



Preprocessing End-User Program, P.
SOURCE END-USER PROGRAM P, LANGUAGE X.
SELECT
OBJECT SUPPORT PROGRAM PART I
Scan Routines
Build/Set up Routines
CREATE PACKAGE
PREPARE
COMMIT WORK
EXPANDED SOURCE END-USER PROGRAM, P
SELECT Commented Out and replaced by Control Structure and a Call to Support Program, Part II
COMPILE (LANGUAGE X)
Execution of End-User Program, P.
OBJECT, END-USER PROGRAM, P
Linked with
DB2 for VSE & VM
Packages
P
OBJECT SUPPORT PROGRAM PART II
Set up Extended Dynamic Statements needed for Execution Time and Execute Them
DECLARE CURSOR
OPEN
FETCH
CLOSE
EXECUTE
COMMIT WORK
DESCRIBE

Figure 54. Preprocessing and Executing an End-User Program by a Two-Part Support Program

Part 1 scans the end-user’s source for SQL statements, uses CREATE PACKAGE to build an empty package, P, uses extended PREPARE statements to add SQL statements to P, and uses a COMMIT statement to finalize P. It also adds calls and control structures, required by Part 2 of the support program, to the user's source program and comments out the original SQL statement.

Part 2 of the support program works with the package, P, executing the SQL statements scanned and prepared by Part 1, and using the control structures passed in the calls generated by Part 1. Part 2 must be link/loaded with any end-user module that is preprocessed by Part 1.

Figure 55 shows Part 1 of the support program in more detail, with pseudocode to illustrate a simple user program that includes a DECLARE...CURSOR FOR SELECT..., an OPEN of that cursor, and a FETCH for the same cursor. Control structures are shown in more detail, and some particular values for parameters are given. The value 26 returned from the PREPARE statement is only for purposes of illustration, representing a unique identifier returned by the system to identify the statement within the package P. A user ID may be necessary to identify the owner of the package, but it is omitted here for simplicity. Other statements, such as CLOSE (cursor) and COMMIT are not shown in order to simplify the illustration.

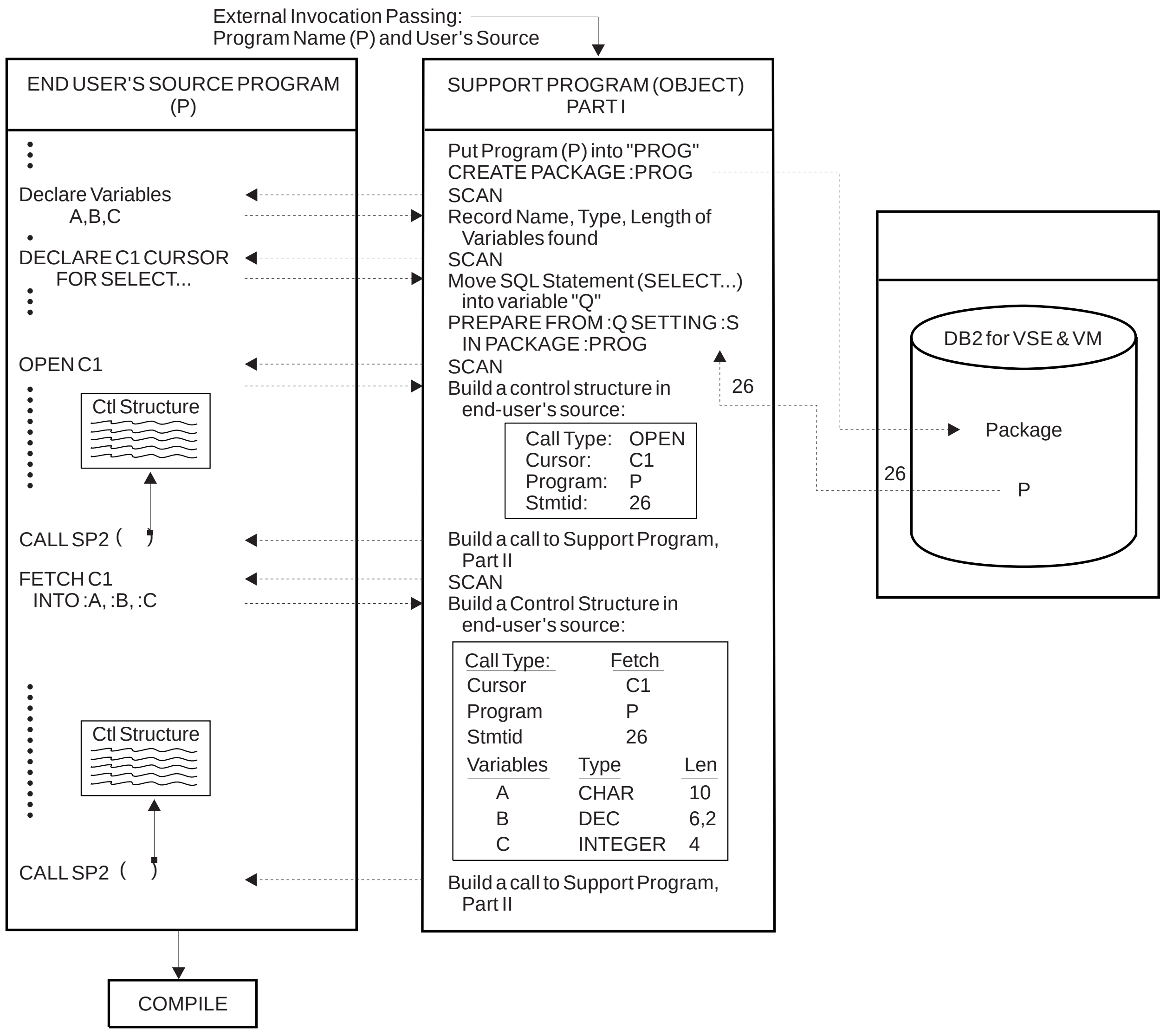

External Invocation Passing:
Program Name (P) and User's Source
END USER'S SOURCE PROGRAM (P)
Declare Variables A,B,C
DECLARE C1 CURSOR FOR SELECT...
OPEN C1
Ctl Structure
CALL SP2 ( )
FETCH C1 INTO :A, :B, :C
Ctl Structure
CALL SP2 ( )
COMPILE
SUPPORT PROGRAM (OBJECT) PART I
Put Program (P) into "PROG"
CREATE PACKAGE :PROG
SCAN
Record Name, Type, Length of Variables found
SCAN
Move SQL Statement (SELECT...) into variable "Q"
PREPARE FROM :Q SETTING :S IN PACKAGE :PROG
SCAN
Build a control structure in end-user's source:
Call Type: OPEN
Cursor: C1
Program: P
Stmtid: 26
Build a call to Support Program, Part II
SCAN
Build a Control Structure in end-user's source:
Call Type: Fetch
Cursor C1
Program P
Stmtid 26
Variables Type Len
A CHAR 10
B DEC 6,2
C INTEGER 4
Build a call to Support Program, Part II
26
DB2 for VSE & VM
Package
26
P

Figure 55. Pseudocode Example of Preprocessing the End-User Program P

Figure 56 on page 189 shows the execution-time flow between the end-user's object program and the support program (Part 2) in more detail. The two calls shown correspond to the two calls generated in Figure 55. This example does not go far enough to illustrate that two calls of the same type (two opens, for example) would share the same set of logic and the same extended dynamic statement (OPEN) in the support program.

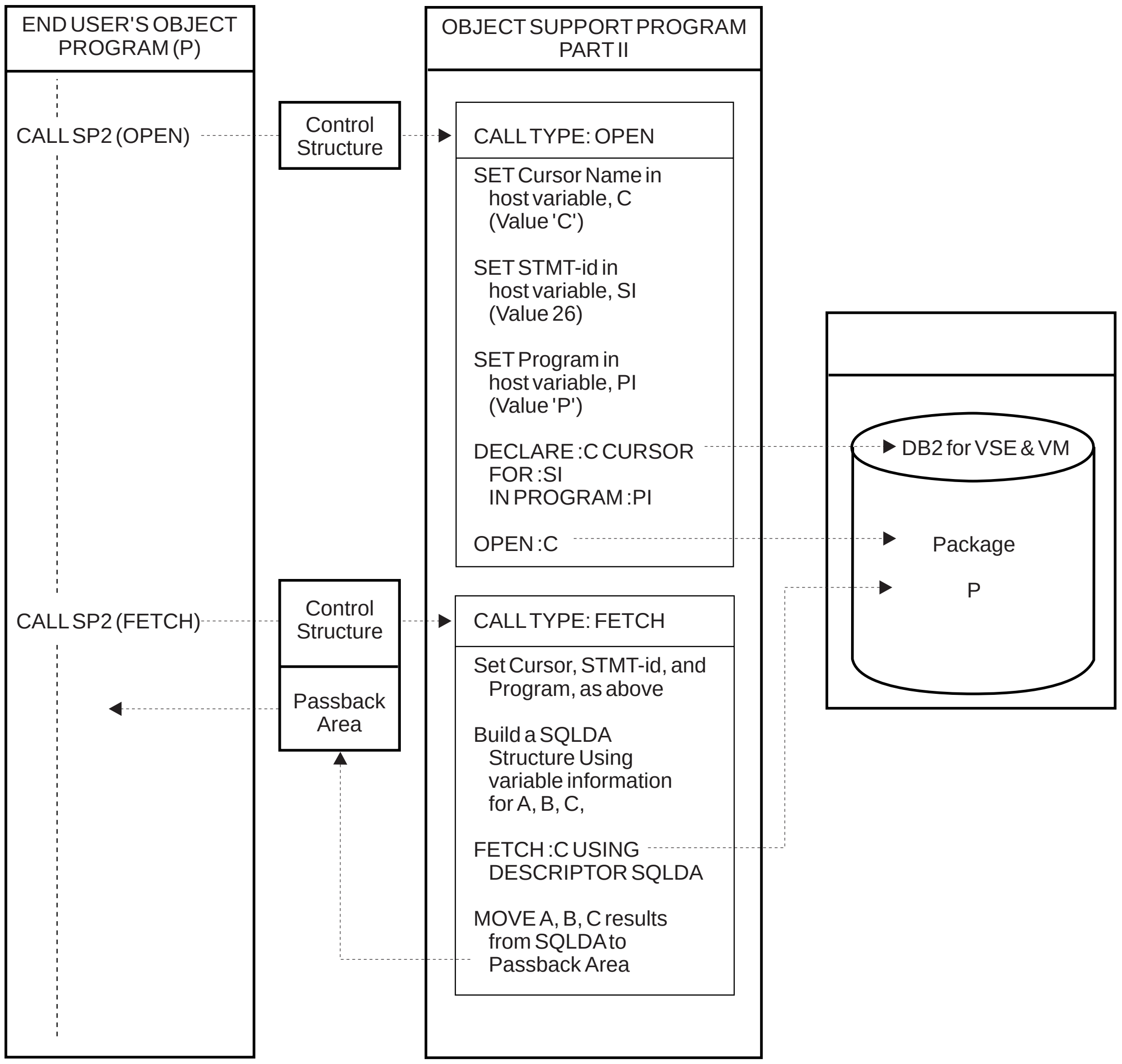

END USER'S OBJECT PROGRAM (P)
CALL SP2 (OPEN)
CALL SP2 (FETCH)
Control Structure
Control Structure
Passback Area
OBJECT SUPPORT PROGRAM PART II
CALL TYPE: OPEN
SET Cursor Name in host variable, C (Value 'C')
SET STMT-id in host variable, SI (Value 26)
SET Program in host variable, PI (Value 'P')
DECLARE :C CURSOR FOR :SI IN PROGRAM :PI
OPEN :C
CALL TYPE: FETCH
Set Cursor, STMT-id, and Program, as above
Build a SQLDA Structure Using variable information for A, B, C,
FETCH :C USING DESCRIPTOR SQLDA
MOVE A, B, C results from SQLDA to Passback Area
DB2 for VSE & VM
Package
P

Figure 56. Pseudocode Example of Executing the End-User Program P

Grouping Extended Dynamic Statements in an LUW

There are primarily three cases to consider when determining the proper grouping of extended dynamic statements in a logical unit of work:

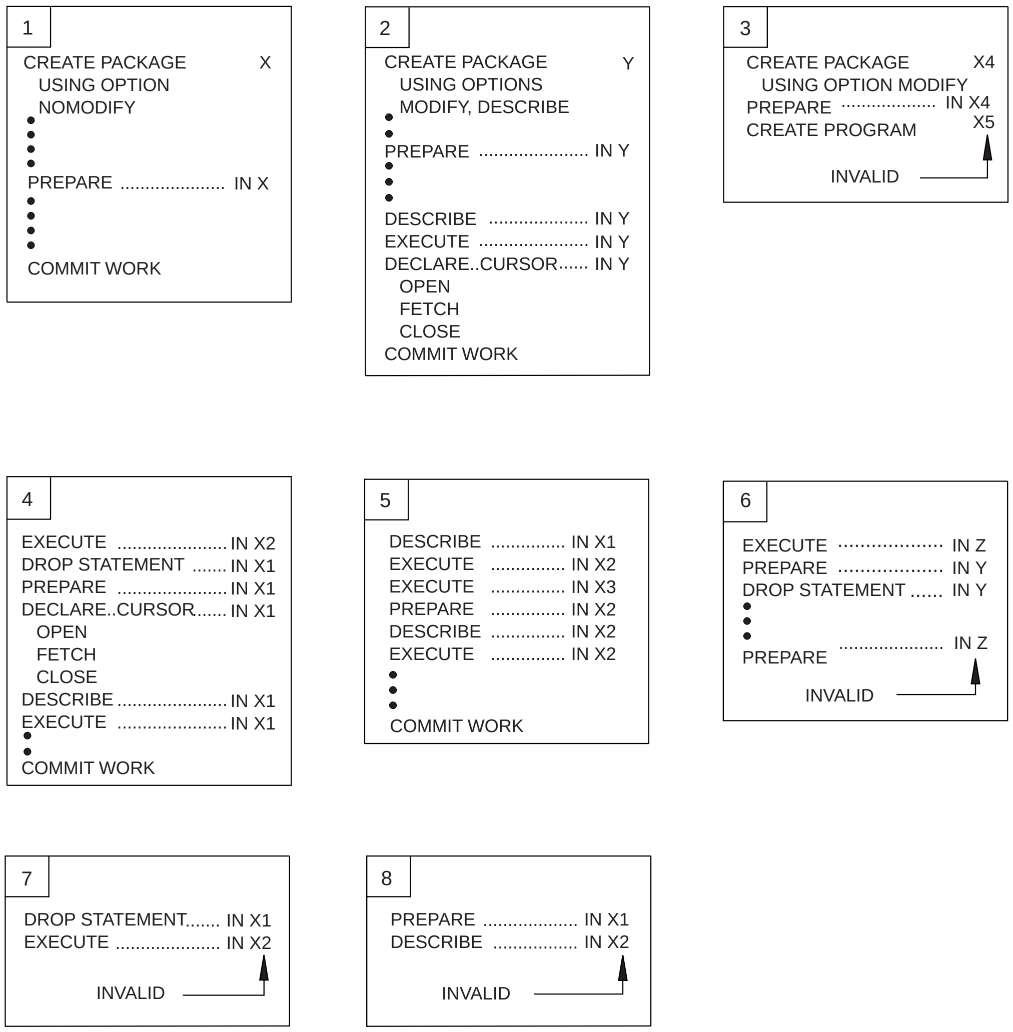
1. An LUW contains a CREATE PACKAGE without the MODIFY option. This would be the case for a language preprocessor application.
2. An LUW contains a CREATE PACKAGE with the MODIFY option. This would be the case for an application that gets new SQL statements from its users, then prepares and executes them immediately (but also has them available for later execution, because they are stored in a package).
3. An LUW contains no CREATE PACKAGE (the referenced package has been created with the MODIFY option in another LUW). This would be the case for

an application that prepares, executes, or changes statements in a package that was created previously.

In the first case, the only other extended dynamic statement permitted is the PREPARE statement, and it must reference only the program that is specified in the CREATE PACKAGE statement. If the LUW is terminated by a COMMIT statement, a DB2 Server for VM package is created. If no extended PREPARE statements were executed, the package is empty and the COMMIT statement returns an SQLCODE of -759 (SQLSTATE '42943'). If a ROLLBACK statement terminates the LUW, no package is created. In Figure 57 on page 191, Example 1 is a valid illustration of this case.

If you are using DRDA protocol, MODIFY defaults to NOMODIFY when specified on the CREATE PACKAGE statement. No error is returned if MODIFY is specified. If a COMMIT statement is used for an empty package (that is, the package contains no statements) created with the NOMODIFY option, one of the following SQLCODEs is received:

- When using the SQLDS protocol, no package is created, and an SQLCODE of -759 (SQLSTATE '42943') is issued.
- When using the DRDA protocol, a package containing an indefinite section is created, and an SQLCODE of 0 (SQLSTATE '00000') is returned.



```
1
CREATE PACKAGE          X
  USING OPTION
  NOMODIFY
•
•
•
•
PREPARE ..................... IN X
•
•
•
•
COMMIT WORK
```

```
2
CREATE PACKAGE          Y
  USING OPTIONS
  MODIFY, DESCRIBE
•
•
PREPARE ...................... IN Y
•
•
•
DESCRIBE .................... IN Y
EXECUTE ...................... IN Y
DECLARE..CURSOR...... IN Y
  OPEN
  FETCH
  CLOSE
COMMIT WORK
```

```
3
CREATE PACKAGE          X4
  USING OPTION MODIFY
PREPARE .................. IN X4
CREATE PROGRAM             X5

        INVALID
```

```
4
EXECUTE ...................... IN X2
DROP STATEMENT ....... IN X1
PREPARE ...................... IN X1
DECLARE..CURSOR...... IN X1
  OPEN
  FETCH
  CLOSE
DESCRIBE ...................... IN X1
EXECUTE ...................... IN X1
•
•
COMMIT WORK
```

```
5
DESCRIBE ............... IN X1
EXECUTE ............... IN X2
EXECUTE ............... IN X3
PREPARE ............... IN X2
DESCRIBE ............... IN X2
EXECUTE ............... IN X2
•
•
•
COMMIT WORK
```

```
6
EXECUTE ................... IN Z
PREPARE ................... IN Y
DROP STATEMENT ...... IN Y
•
•
•
PREPARE ..................... IN Z

      INVALID
```

```
7
DROP STATEMENT....... IN X1
EXECUTE ..................... IN X2

      INVALID
```

```
8
PREPARE ................... IN X1
DESCRIBE ................. IN X2

      INVALID
```

Figure 57. Placement of Extended Dynamic Statements in Logical Units of Work

In the second case, the rules discussed above for case 1 apply, but Extended DESCRIBE, EXECUTE, DECLARE CURSOR, OPEN, FETCH, DROP STATEMENT, and CLOSE statements may also be used in the same LUW, referencing the statements just added to or already contained in the current package. However, you cannot reference a package other than the one created in the current LUW. In Figure 57, example 2 is a valid example of this case. Example 3 illustrates an invalid case 2 sequence. If the current LUW is committed before extended PREPAREs are used to add statements to it (it is empty), it still may be extended in a later LUW (since it is modifiable, it may make sense to leave it empty initially).

In case 3, where the current LUW contains no CREATE PACKAGE, extended dynamic statements may reference any package that has been created with a CREATE PACKAGE statement. However, after an extended dynamic statement that causes modification of the package is used (an extended PREPARE or DROP STATEMENT), subsequent extended dynamic statements in the same LUW may only refer to the modified package. Once the LUW is terminated, reference to any package that has been created by a CREATE PACKAGE may be resumed. (Note that this does not preclude additional restrictions: to modify a package, you must have created it with the MODIFY option, and to DESCRIBE a statement in a package, it must have been created with the DESCRIBE option.)

For example, if packages X1, X2, and X3 have been created with a CREATE PACKAGE, where X1 and X2 have the MODIFY and DESCRIBE options. Examples 1, 2, 4, and 5 in Figure 57 on page 191 are valid, while Examples 3, 6, 7, and 8 are invalid.

Considering Virtual Storage in an LUW

If virtual storage consumption by the database manager is an important consideration, you must be aware of the trade-off in using modifiable packages. The amount of virtual storage required to represent statements prepared in the current LUW may be significantly more than that required for previously prepared statements. If you enter a COMMIT before executing the statement, the virtual storage requirement for the package will be considerably less, but additional work will be performed to store the updated package and to reload it for execution.

You should make this trade-off based on the nature of the preprocessing in your application.

When declaring extended dynamic cursors, you must consider virtual storage requirements. Cursor names are dynamically mapped to statement numbers when DECLARE CURSOR statements are executed. A small amount of virtual storage is required for each uniquely named cursor declared in an LUW. This storage is not released until the end of the LUW. The amount of storage held, therefore, can become quite large when many unique cursor names are declared.

Mapping Extended Dynamic Statements to Static and Dynamic Statements

Figure 58 shows how static and dynamic SQL statements are mapped to the SQL statements that preprocess and execute them.

Figure 58. Mapping Extended Dynamic to Static and Dynamic Statements

Static and Dynamic SQL Statement	**SQL Statement Executed at Preprocessing Time**	**SQL Statement Executed at Run Time**
CLOSE	N/A	Extended CLOSE
COMMIT	N/A	COMMIT
CONNECT	N/A	CONNECT
DECLARE CURSOR FOR *statement*	Basic Extended PREPARE of *statement*	Extended DECLARE CURSOR
DECLARE CURSOR FOR *statement_name*	See Figure 59	Extended DECLARE CURSOR
DESCRIBE *statement_name*	N/A	Extended DESCRIBE
DROP PACKAGE	N/A	DROP PACKAGE
EXECUTE	N/A	Extended EXECUTE
EXECUTE IMMEDIATE *string_constant*	Basic Extended PREPARE of *string_constant*	Extended EXECUTE
EXECUTE IMMEDIATE *host_variable*	Empty Extended PREPARE	Temporary Extended PREPARE Extended EXECUTE
FETCH	N/A	Extended FETCH
OPEN	N/A	Extended OPEN
PREPARE *string_constant*	Basic Extended PREPARE of *string_constant*[1]	N/A
PREPARE *host_variable*	Empty Extended PREPARE[1]	Temporary Extended PREPARE
PUT	N/A	Extended PUT
ROLLBACK	N/A	ROLLBACK
SELECT INTO	Single row Extended PREPARE	Extended EXECUTE
Other executable statements	Basic Extended PREPARE	Extended EXECUTE
Non-executable statements	N/A	N/A

Note:

1. See Figure 59 if used in context of a cursor.

Figure 59 shows the SQL statements that prepare statements executed with a cursor.

Figure 59. *Preprocessing Related PREPARE and DECLARE CURSOR Statements*

Example Statements	**Extended Dynamic SQL Statement Executed at Preprocessing Time**
PREPARE *string_constant* DECLARE CURSOR *statement_name*	Basic Extended PREPARE N/A
PREPARE *host_variable* DECLARE CURSOR *statement_name*	Empty Extended PREPARE N/A
DECLARE CURSOR *statement_name* PREPARE *string_constant*	Empty Extended PREPARE Temporary Extended PREPARE[1]
DECLARE CURSOR *statement_name* PREPARE *host_variable*	Empty Extended PREPARE N/A

Note:

1. This example is not supported in packages created with the NOMODIFY option specified.

SQL Functions Not Supported in Extended Dynamic Statements

The following SQL facilities are not supported for statements that are prepared using extended dynamic SQL, unless the application program that performs the extended PREPARE statement supplies the support:

- Checking of the statement for conformance to SQL-89 or SAA standards
- Use of SQL comments
- Optional choice for the FOR UPDATE OF clause in cursor query statements
- Use of negative indicator values in predicates, unless the statement is prepared using the descriptor format of the extended PREPARE statement.

These restrictions do not apply to FORTRAN application programs, because the DB2 Server for VM preprocessors provide the necessary support.

Refer to the *DB2 Server for VSE & VM SQL Reference* manual for more information on restrictions that apply to extended dynamic statements.

Chapter 8. Maintaining Objects Used by a Program

Contents

Managing Dbspaces . . . 196
  Defining Dbspaces . . . 196
    Finding Available Space . . . 198
    Specifying Properties of Dbspaces . . . 198
  Modifying the Size of Dbspaces . . . 200
  Automatically Locking Dbspaces . . . 200
  Overriding Automatic Locking . . . 201
  Deleting the Contents of Dbspaces . . . 202
Other Data Definition Statements . . . 202
  Using Tables, Indexes, Statistics, Synonyms, Comments, and Labels . . . 203
    Creating Tables . . . 203
    Modifying Tables . . . 204
    Dropping Tables . . . 204
    Using Indexes . . . 204
    Updating Catalog Tables for Table and Index Activity . . . 204
    Using Synonyms . . . 205
    Using Comments . . . 205
    Using Labels . . . 205
| Using Stored Procedures and PSERVERS . . . 205
| Using Stored Procedures . . . 205
| Example of a Stored Procedure Definition . . . 206
| Using PSERVERs . . . 207
| Example of a Stored Procedure Server Definition . . . 208

Managing Dbspaces

This section discusses the data definition statements for dbspaces and should be read in conjunction with the *DB2 Server for VSE & VM SQL Reference* manual, which contains the syntax, authorization rules, and usage rules of these statements.

Note: This section applies to DB2 Server for VSE & VM application servers only.

Defining Dbspaces

A *dbspace* is a portion of the database that can contain one or more tables and any associated indexes. Each table that is stored is placed in a dbspace chosen by the creator of the table.

Dbspaces are defined when the database is generated and may be added later by the ADD DBSPACE process. Each dbspace remains unnamed and *available* until it is *acquired* with an ACQUIRE DBSPACE statement, generally by the Database Administrator (DBA). An acquired dbspace can be later returned to the list of available dbspaces by the DROP DBSPACE statement.

The user who acquires a dbspace can either specify from which *storage pool* the database manager is to acquire the dbspace, or can allow the system to choose the storage pool by default. Storage pool are collections of minidisks called dbextents, and control the distribution of the database across direct access storage devices (DASD).

Storage pools can be *recoverable* or *nonrecoverable*. Recoverable storage pools protect their data using the automatic recovery for data updates. With nonrecoverable storage pools, system overhead is reduced, but if there is a system failure, some data may be lost, because the burden of recovery is placed on the user. Nonrecoverable storage pools are particularly useful in cases where large amounts of data are loaded from an external source, and that data is never modified thereafter. See the *DB2 Server for VM System Administration* manual for more information about storage pools.

The acquiring user also gives a name to the dbspace, and defines certain characteristics for it. If it is to be private, the user who acquires it becomes its *owner*; if it is of type public, its owner becomes public.

If you have DBA authority, you can acquire a dbspace for another user by concatenating the *userid* to the dbspace-name:

```
ACQUIRE PRIVATE dbspace NAMED JONES.SPACE1
```

In the above statement, the owner of the dbspace is user JONES. User JONES can refer to the dbspace as simply SPACE1.

A user holding RESOURCE authority can create new tables in any public dbspace, or in any private dbspace owned by that user. Users who do not have RESOURCE authority can also create tables in any private dbspace that was acquired for that user by the DBA. Only users having DBA authority can create tables in a private dbspace owned by another user.

The ability to access and update tables belonging to another user is controlled by the system. Authorized users can access and update tables in any dbspace of any type, by adding the owner-name as a prefix to the table name (for example, SMITH.INVENTORY).

Note: Even users who are authorized to access data in someone else's dbspace may not be permitted to do so if the dbspace is in use.

An attempt to *read* data in a private dbspace results in a negative SQLCODE if any data in the dbspace has been *modified* by a still-active logical unit of work. An attempt to *modify* data in a private dbspace results in a negative SQLCODE if any data in the dbspace has been *read or modified* by a still-active logical unit of work. If the locked data you attempt to access is in a public dbspace, your program waits and does not regain control until the lock is freed. If you attempt to update locked data in a private dbspace, the system immediately returns control to your program, with a negative SQLCODE.

The size of the space that is locked is the *lock size*. The lock size on a private dbspace is always the entire dbspace, while the default lock size on a public dbspace is somewhat smaller to allow for more concurrency. Thus, you should place tables in public dbspaces if you expect that more than one user may need concurrent access to them. On the other hand, because operations on private dbspaces do not pay the overhead of acquiring individual locks within the dbspace, a private dbspace is an efficient place to store tables for the exclusive use by one user at a time. The cost of smaller locks is higher overhead. Figure 60 and Figure 61 summarize the database manager locking mechanism.

Refer to the *DB2 Server for VM Diagnosis Guide and Reference* manual for more information on locking.

Figure 60. Locking Summary for Private Dbspaces

If you attempt to:	But another user has already: read the data (acquired a share lock)	modified the data (acquired an exclusive lock)
Read data	You are allowed to read the data	You receive a negative SQLCODE
Modify data	You receive a negative SQLCODE	You receive a negative SQLCODE

The lock size for a private dbspace is always the entire dbspace.

Figure 61. Locking Summary for Public Dbspaces

If you attempt to:	But another user has already: read the data (acquired a share lock)	modified the data (acquired an exclusive lock)
Read data	You are allowed to read the data	Your program waits
Modify data	Your program waits	Your program waits

The lock size of a public dbspace defaults to a page (4096 bytes). The lock size can be changed by the ACQUIRE DBSPACE or ALTER DBSPACE statements.

Finding Available Space

The ACQUIRE DBSPACE statement causes the system to find an available dbspace of the requested type (public or private) and give it the dbspace-name you specify. The dbspace-name must be an SQL identifier, as described in the *DB2 Server for VSE & VM SQL Reference* manual; you can use it to refer to the DBSPACE in other SQL statements, such as CREATE TABLE.

If the dbspace type is public, its owner becomes public; if the type is private, its owner becomes the user who preprocessed the program in which the ACQUIRE DBSPACE is embedded. Dbspace names must be unique within all the dbspaces owned by the same user, but may duplicate the name of a dbspace owned by another user.

Specifying Properties of Dbspaces

You can optionally specify one or more of the following properties of a dbspace, in any order. Separate the parameters with commas.

NHEADER Number of Header Pages. The number of 4096-byte logical pages in the dbspace that are reserved for header pages. The system uses header pages to record information about the contents of the dbspace.

Notes:

1. NHEADER cannot be larger than eight pages.
2. If NHEADER is not specified, the default is eight pages.
3. You cannot change NHEADER after the dbspace has been acquired. If you choose a small number for NHEADER, it may limit the number of tables that can be created in the dbspace.

PAGES Number of Pages. The minimum number of 4096-byte logical pages that you require for this dbspace.

Notes:

1. The system may actually give you more pages than you request because it acquires storage in units of 128 pages. However, of the available dbspaces, the one chosen will be the *smallest* that will satisfy the size specified for PAGES. The system determines the number of pages that you receive by rounding the number you specify to the next higher multiple of 128 pages. For example, if you specify PAGES=53, the system acquires a block of 128 pages. If you specify PAGES=130, the system acquires 256 pages.
2. If you do not specify PAGES, the system acquires the smallest available dbspace by default.

PCTINDEX Percentage of Index Pages. The percentage (0 to 99) of *all* pages in the dbspace that are reserved for indexes.

Notes:

1. If you do not specify PCTINDEX, the default is 33 percent.
2. You cannot change PCTINDEX after the dbspace has been acquired. If you choose a small number for PCTINDEX, it may limit the number of indexes that can be created on tables in the dbspace. (If you find that the PCTINDEX is too small, you can acquire another dbspace and move the data there.)

PCTFREE Percentage of Free Space. The percentage (0 to 99) of the space on *each* page that the system is to keep empty when data is inserted into the dbspace.

Notes:

1. If you do not specify PCTFREE, the default is 15 percent.
2. Typically a user might acquire a dbspace with PCTFREE set to some value such as 25 percent. The dbspace is then loaded with data by the Database Services Utility (described in the *DB2 Server for VSE & VM Database Services Utility* manual). The system ensures that at least 25 percent of the space on each page is left empty. After the initial loading of the dbspace, the user can set PCTFREE to zero by means of the ALTER DBSPACE statement (described later). Then, in subsequent insertions, the system places new data in the space reserved during initial loading. Using reserved free space in this way results in a more favorable physical clustering of data on pages when the data is loaded, and, therefore, improves access time. The *DB2 Server for VM Database Administration* manual discusses data clustering in more detail.
3. The value of PCTFREE is critical during mass insertion of data into a dbspace (for example, a DBS Utility DATALOAD command). Refer to the appendix on estimating the number of data pages required in the *DB2 Server for VM Database Administration* manual for more information on the dbspace percent free specification.

LOCK Lock Size. Applicable to public dbspaces only (private always locks a dbspace). The valid specifications for *size* are DBSPACE, PAGE, and ROW.

Notes:

1. The lock size determines the size of the locks that are acquired when a user reads or updates data. If you specify ROW, the system locks only an individual row in the table; PAGE or DBSPACE cause the smallest lockable unit to be a page (4096 bytes) or a dbspace, respectively. Key-level locking is used for indexes on tables in dbspaces for which row-level locking is specified.
2. In general, using larger locking units causes less overhead to be spent in acquiring locks, but also limits concurrency.
3. The default lock size for each public dbspace is PAGE.

STORPOOL Storage Pool Number. Indicates from which storage pool a dbspace is to be acquired.

Notes:

1. If a dbspace of the specified type and size is not available in this storage pool, the ACQUIRE DBSPACE is unsuccessful, and a negative SQLCODE is returned.
2. If you do not specify STORPOOL, the system acquires a dbspace of the correct type and size from *any recoverable* storage pool. To acquire a dbspace from a nonrecoverable storage pool, you *must* specify the STORPOOL parameter.

Modifying the Size of Dbspaces

The ALTER DBSPACE statement enables you to alter the percentage of free space that is reserved on each data page when records are inserted into a public or private dbspace. It also enables you to alter the lock size of a public dbspace. (You cannot alter the lock size of a private dbspace.)

When you acquire a dbspace, you should set the percentage (0 to 99) of free space to some number greater than zero (the default is 15 percent). A typical use of ALTER DBSPACE is to set the percentage of free space to zero (PCTFREE=0) after initial loading of data into a dbspace; subsequent insertions can then take advantage of the free space that is reserved during the loading process. It is also possible to increase PCTFREE again for a later loading phase.

To alter the lock size of a public dbspace at any time, use the LOCK parameter. (You can specify both the PCTFREE and LOCK parameters when altering a public dbspace, in either order, separated with a comma. Each may be specified only once.) The valid lock sizes are ROW, PAGE, and DBSPACE, as described under the ACQUIRE DBSPACE statement. When an ALTER DBSPACE statement is executed to alter the lock size of a dbspace, the system acquires an exclusive lock on the entire dbspace and holds the lock until the end of the current logical unit of work. The newly selected lock size then becomes effective for subsequent logical units of work.

Automatically Locking Dbspaces

When you operate the database manager in single user mode, there is no contention from other users when you attempt to access data; there may be however in multiple user mode. To provide for concurrent access, the system internally acquires locks on data accessed by a logical unit of work.

All LUWs automatically acquire *exclusive locks* on all data that they modify, and *share locks* on data that they are reading. Exclusive locks prevent other users from either reading or modifying the data; share locks permit other users to read, but prevent them from modifying the data.

For UPDATE and DELETE processing, the system acquires *update* locks. If the user wants to change the data, the *update* lock is changed to an *exclusive* lock; otherwise, the *update* lock is changed to a *share* lock. An *update* lock is acquired for a *Positioned* DELETE only if the cursor was declared with the FOR UPDATE clause. This type of lock is also acquired on a parent table when changes are made to its dependent tables. In general, locks are held to the end of the LUW in which they are acquired. (See “Selecting the Isolation Level to Lock Data” on page 123 for more information.)

Potential deadlocks are automatically detected and corrected. A deadlock occurs when two LUWs are each waiting to access data that the other has locked. The system detects this situation and backs out the most recent LUW, meaning that all changes made to the database during the LUW are restored, and then the locks that were acquired for the LUW are released. The other application can then proceed. If your LUW is backed out, a negative SQLCODE is returned and SQLWARN6 is set to W.

Locking is automatic and requires no user intervention. However, certain statements permit users to adjust or override the normal locking. You can adjust the size of the lockable data units with the LOCK option of the ACQUIRE DBSPACE and ALTER DBSPACE statements. You can also override automatic locking and explicitly acquire certain kinds of locks with the LOCK statement as discussed below.

Note: Only single user mode prevents locking.

Overriding Automatic Locking

The LOCK statement overrides the automatic locking mechanism and explicitly acquires a lock on a table or dbspace, which is held the end of the current LUW.

The LOCK statement is useful only in multiple user mode. In single user mode, there is no contention for resources, and, hence, no locking. When running in single user mode, all LOCK statements are ignored.

An *exclusive* lock prevents other users from either reading or changing any data in the locked table or dbspace. A *share* lock permits other users to read, but prevents them from modifying, the data in the locked object.

The requested lock may be unavailable because other LUWs are reading or modifying the indicated data. If this is the case, the LUW that requested the lock waits until the other active LUWs have ended. The system then grants the lock, and the requesting LUW proceeds normally.

The LOCK statement is entirely optional, as the system has fully automatic locking. You may issue all SQL queries and updates independently of explicit LOCK statements.

The LOCK statement is useful mainly for avoiding the overhead of acquiring many small locks when scanning over a table. For example, suppose some dbspace has been acquired with a lock size of ROW. If you know that you will be accessing all the rows of a table within that dbspace, you may want to explicitly lock the entire table to avoid the overhead of acquiring locks on each individual row.

In a private dbspace, a LOCK statement on a table is the same as one on the entire dbspace, because locking is always done at the DBSPACE level for private dbspaces.

Deleting the Contents of Dbspaces

The DROP DBSPACE statement deletes the entire contents of a dbspace. When the logical unit of work is committed, the dbspace is available to be acquired. The DROP DBSPACE statement is a much faster way to delete the contents of a dbspace than by deleting the data one row at a time or dropping one table at a time. (You can use DROP DBSPACE with both public and private dbspaces.)

For any table that is dropped implicitly by the DROP DBSPACE statement, all referential constraints in which it is a dependent are dropped, and all referential constraints in which it is a parent are also dropped. Furthermore, any unique constraints defined in the table are dropped.

When a dbspace is dropped, packages for programs that operate on that dbspace are marked *invalid.* In addition, if a parent table has been dropped, the packages with tables dependent on that parent table are also marked invalid, because the relationship between the parent table and its dependent tables was dropped.

If one of these programs is running, the system does not drop the dbspace until the running program ends its current LUW. The invalid packages remain in the database until they are explicitly dropped using the DROP PACKAGE statement (discussed in the *DB2 Server for VSE & VM SQL Reference* manual).

When an invalid package is invoked, the system attempts to dynamically re-preprocess it. If the package was **not** invalidated because the relationship between a parent table and its dependent tables was dropped, and the program contains any SQL statement that refers to a dbspace or table that has been dropped, that SQL statement returns a negative SQLCODE at execution time.

Other Data Definition Statements

In addition to SQL data definition statements for dbspaces, there are those that enable you to:

- Create and drop tables (CREATE TABLE and DROP TABLE)
- Create and drop indexes on tables (CREATE INDEX and DROP INDEX)
- Add new columns to existing tables; and add, drop, activate, or deactivate primary keys, foreign keys, and unique constraints (ALTER TABLE)
- Create and drop synonyms for table names (CREATE SYNONYM and DROP SYNONYM)
- Enter comments about tables into the DB2 Server for VM catalog tables (COMMENT ON)
- Label tables and columns in dynamic SQL application programs (LABEL ON).

The following discussion is only an introduction to these statements. Refer to the *DB2 Server for VSE & VM SQL Reference* manual for their syntax and detailed usage rules.

Using Tables, Indexes, Statistics, Synonyms, Comments, and Labels

One advantage of the database manager is that you can define new objects in the database without stopping the system or invoking special utilities. This provides great flexibility: for example, your application program can create a table for storing and manipulating some temporary result, and drop the table when it is no longer needed.

Data definition statements automatically update the catalog tables that describe the database. (These catalog tables are explained in the *DB2 Server for VSE & VM SQL Reference* manual.) If an error occurs while you are processing a data definition statement, the system stops processing the statement, and reverses only the changes resulting from the statement in error. Any work done before the execution of the statement in the LUW will not be affected. If you want to, you can enter a ROLLBACK statement to undo any other changes made in the LUW.

Also, if you plan to DROP and re-CREATE the object later in the program, make sure that you start a new LUW after you drop the object. For example, if you write a procedure that creates and drops a temporary table, make sure that your program issues a COMMIT before the end of the procedure. (For more information on the LUW refer to “Using Logical Units of Work” on page 13.)

Some data definition statements may invalidate the packages of one or more programs previously preprocessed. For example, dropping the index used by a program to access a table will invalidate the package of that program. Other examples include adding keys (primary or foreign) to a table, or dropping, activating, or deactivating keys on the table. When the program is used, a new package is created based on the dependencies currently available. No changes need be made to the program. The process of creating the new package called rebinding is entirely transparent to programs, except for a slight delay in processing the first SQL statement. (Rebinding is discussed in Chapter 4, “Preprocessing and Running a Program” on page 103 .)

Creating Tables

Use the CREATE TABLE statement to create a new table in the database and to define the datatypes and subtypes of all the columns in the table. You can also use it to define primary keys and foreign keys which may be used to ensure referential integrity. This is done by specifying a primary key, a foreign key, and a delete or update rule that defines the relationship. Only a primary key is required for entity integrity.

If you specify the NOT NULL option for a column, the system does not permit null values in that column. Any statement that attempts to place a null value in such a column is rejected with an error code.

You can also associate a field procedure with a column. For more information on field procedures see “Using Field Procedures” on page 222.

You can define a *unique constraint* when creating a table. This consists of one or more columns where the combined value in these columns is unique. This enables you to ensure data integrity for columns where a primary key would not be practical.

Note: Instead of declaring a column to be of DECIMAL (or NUMERIC) data type with a scale of 0, you should consider declaring it INTEGER or SMALLINT.

These data types use storage more effectively, and other processing will be more efficient. If the precision is less than 5, use SMALLINT; if the precision ranges from 5 to 7, use INTEGER.

Once a table has been created, you may not change the data types of its columns or drop a column from the table. However, you may add new columns, a primary key, foreign keys, and unique constraints by using the ALTER TABLE statement.

Modifying Tables

Use the ALTER TABLE statement to add a new column to an existing table, or to add, drop, activate or deactivate primary keys, foreign keys, and unique constraints.

Dropping Tables

Use the DROP TABLE statement to drop a table from the database. All indexes, primary and foreign keys, unique constraints, views defined on the table, and all privileges granted on the table, are also dropped. All contents of the table are lost. However, users can have previously defined synonyms (by a CREATE SYNONYM statement) for the name of the table that was dropped; these synonyms remain in effect even though the table no longer exists.

Using Indexes

Use the CREATE INDEX statement to create an index on one or more columns of a table, and to give a name to the new index. The indicated table must exist, but it may be empty.

You can create an index on a column in either ascending (ASC) or descending (DESC) order. Ascending order is the default. Performance may be improved for queries that access the indexed column in the specified order.

An index is maintained until it is explicitly dropped with a DROP INDEX statement, or until its table or dbspace is dropped.

Indexes are invisible to application programs in the sense that the system provides no means for using an index directly. The database manager selects the index, if any, that is to be used in processing a given query or data manipulation statement.

Updating Catalog Tables for Table and Index Activity

Use the UPDATE STATISTICS statement to bring up to date the internal statistics recorded by the system for a table and its indexes. These statistics, which are contained in the catalog tables, include the size of the table, various index characteristics, and other information. The system uses these statistics when choosing access paths for SQL statements. If the statistics are not kept up to date, less efficient access paths may be chosen.

You should invoke the UPDATE STATISTICS statement for a table after a significant number of changes have been made to its data since it updated; for example, if a table has been changed by 20 percent or more.

Using Synonyms

Use the CREATE SYNONYM statement to define an alternative name for a table or view. For example, the following statement defines the alternative name PEOPLE to refer to the table named EMPLOYEE whose owner is SMITH:

```
   CREATE SYNONYM PEOPLE FOR SMITH.EMPLOYEE
```

The right-hand side of the CREATE SYNONYM statement (SMITH.EMPLOYEE in the above example) must be the name of a table or a view, not another synonym.

Synonyms are commonly used when a group of users all want to share a table. Suppose one user, ADAMS, creates a table called DATA. All users sharing this table can then enter the statement:

```
   CREATE SYNONYM DATA FOR ADAMS.DATA
```

Each user can then refer to the shared table as DATA, without using the fully qualified name ADAMS.DATA. (Remember that ADAMS must authorize the other users to access his table.)

Once created, a synonym remains in effect until it is explicitly dropped by a DROP SYNONYM statement.

Using Comments

Use the SQL COMMENT ON statement to associate remarks or comments with your tables or views, or with columns in your tables or views. The comment you specify is placed into one of the catalog tables.

Using Labels

Use the SQL LABEL ON statement to define a label for a table name or a column name. Unlike synonyms, labels cannot be used as identifiers. Instead, they can be used in displays created by applications that process SQL statements dynamically. You can enter SQL statements using the actual table and column names (which are easier to enter). The program can display the results using the labels (which are easier to understand) instead of the table and column names.

Labels are ignored by DBS Utility and ISQL SELECT processing. Only column names will identify SQL *select-statement* output displayed by DBS Utility or ISQL processing.

| ## Using Stored Procedures and PSERVERS

| ### Using Stored Procedures

| Before a stored procedure can run, you must define it to DB2. Use the SQL
| statement CREATE PROCEDURE to define a stored procedure to DB2. To alter
| the definition, use the ALTER PROCEDURE statement.

| Figure 62 on page 206 lists the characteristics of a stored procedure and the
| CREATE PROCEDURE and ALTER PROCEDURE parameters that correspond to
| those characteristics.

Figure 62. Characteristics of a Stored Procedure

Characteristic	CREATE/ALTER PROCEDURE Parameter
Stored procedure name Parameter declarations	PROCEDURE
External name	EXTERNAL NAME
Language	LANGUAGE ASSEMBLE LANGUAGE C LANGUAGE COBOL LANGUAGE PLI
Parameter style	PARAMETER STYLE GENERAL PARAMETER STYLE GENERAL WITH NULLS
Name of group of servers where stored procedure can run	SERVER GROUP *server-group-name*
Whether or not a stored procedure can run in default server group	DEFAULT SERVER GROUP YES DEFAULT SERVER GROUP NO
Load module stays in memory after it executes	STAY RESIDENT NO STAY RESIDENT YES
Run-time options	RUN OPTIONS *options*
Maximum number of result sets returned	RESULT SETS *integer*
Commit work on return from stored procedure	COMMIT ON RETURN YES COMMIT ON RETURN NO

For information on the parameters for the CREATE PROCEDURE or ALTER PROCEDURE statement, see the *DB2 Server for VSE & VM SQL Reference* manual.

Example of a Stored Procedure Definition

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

- The name is B.
- It takes two parameters:
  - An integer input parameter named V1
  - A character output parameter of length 9 named V2
- It is written in the C language.
- The load module name is SUMMOD.
- The parameters can have null values.
- It should be deleted from memory when it completes.
- The Language Environment run-time options it needs are:

```
MSGFILE(OUTFILE),RPTSTG(ON),RPTOPTS(ON)
```

- It can be executed by any stored procedure server in the group named PAYROLL.
- It can return at most 10 result sets.

- When control returns to the client program, DB2 should not commit updates automatically

This CREATE PROCEDURE statement defines the stored procedure to DB2:

```
CREATE PROCEDURE B(V1 INTEGER IN, V2 CHAR(9) OUT)
  LANGUAGE C
  EXTERNAL NAME SUMMOD
  PARAMETER STYLE GENERAL WITH NULLS
  STAY RESIDENT NO
  RUN OPTIONS 'MSGFILE(OUTFILE),RPTSTG(ON),RPTOPTS(ON)'
  SERVER GROUP PAYROLL
  DEFAULT SERVER GROUP NO
  RESULT SETS 10
  COMMIT ON RETURN NO;
```

Later, you need to make the following changes to the stored procedure definition:

- The stored procedure can also be run in the default server group in addition to the group of stored procedure servers named PAYROLL.

Execute this ALTER PROCEDURE statement to make the changes:

```
ALTER PROCEDURE B
  DEFAULT SERVER GROUP YES;
```

Using PSERVERs

Stored procedures are executed by stored procedure servers. These servers are organized into named groups. Use the SQL statement CREATE PSERVER to add a stored procedure server to a group. To alter the definition, use the ALTER PSERVER statement.

Figure 63 lists the characteristics of a stored procedure server and the CREATE PSERVER and ALTER PSERVER parameters that correspond to those characteristics.

Figure 63. Characteristics of a Stored Procedure

Characteristic	**CREATE/ALTER PSERVER Parameter**
Stored Procedure server name	PSERVER *procedure-server*
Name of the group to which the stored procedure server belongs	GROUP *group-name*
Whether or not the database manager should issue a START PSERVER command when the database initializes	AUTOSTART NO AUTOSTART YES
A description of the stored procedure server	DESCRIPTION *description*

For information on the parameters for the CREATE PROCEDURE or ALTER PROCEDURE statement, see the *DB2 Server for VSE & VM SQL Reference* manual.

Example of a Stored Procedure Server Definition

Suppose you must set up a stored procedure server that has these characteristics:

- The name is SERVER1
- It is part of stored procedure group PAYROLL
- The database manager is not to issue a START PSERVER command when it initializes

This CREATE PSERVER statement defines the stored procedure server to DB2:

```
CREATE PSERVER SERVER1
GROUP PAYROLL
AUTOSTART NO
```

Later, you need to make the following changes to the stored procedure server definition:

- The database manager should issue a START PSERVER command when it initializes
- The description of the stored procedure server is to be "This is the first server used by payroll procedures"

Execute this ALTER PROCEDURE statement to make the changes:

```
ALTER PSERVER SERVER1
AUTOSTART YES
DESCRIPTION 'This is the first server used by payroll procedures'
```

Chapter 9. Assigning Authority and Privileges

Contents

Defining User Access to the Database 210
  Defining Authority Types for the Database 210
  Granting Authority to Users 210
  Revoking Authority from Users 211
Defining Privileges 212
  Defining Privileges on Tables and Views 212
    Revoking Privileges 213
  Defining Privileges on Packages 213
    Assigning User Privileges to the Owner 213
    Assigning Privileges to Others 214
      Determining When the Owner Can Grant the RUN Privilege 214
    Differences Between Static and Dynamic Statements 215
    Revoking the Run Privilege 215
    Recording Assigned Privileges in the Catalog Tables 216

Defining User Access to the Database

The following information applies to DB2 Server for VSE & VM application servers only. For a discussion of authorities for another application server, refer to that product's library.

Defining Authority Types for the Database

When a database is initially generated, there is only one user defined for it. This user, referred to as SQLDBA, has a special authority called “DBA” authority. Only someone with DBA authority can grant authorities to other users.

The types of authorities are:

CONNECT	Authorization to access the database
RESOURCE	Authorization to acquire space in the database
SCHEDULE	Authorization to issue a connect without a password (internal to the on-line Resource Adapter)
DBA	Authorization to perform database administration functions.

Granting any one of these authorities to a user who does not already have the CONNECT authority causes that user to be granted CONNECT authority. For example, if resource authority is granted to a user who currently has no authorities, the user will have both RESOURCE and CONNECT authority; if DBA authority is granted, the user will have DBA, CONNECT, SCHEDULE, and RESOURCE authorities.

Granting Authority to Users

The following information applies to the GRANT statement and to DB2 Server for VSE & VM application servers only. For a discussion of authorities for another application server, refer to that product's library.

Note: In discussions about granting authorities and privileges in this chapter, the “grantor” is defined as the user who preprocessed the program in which the GRANT statement appears. However, for dynamically defined GRANT statements, the grantor is determined at run time, based on the connected authorization ID.

The System Authorities form of the GRANT statement allows a *user having DBA authority* to grant authorities to other users. See the *DB2 Server for VSE & VM SQL Reference* manual for the syntax.

The IDENTIFIED BY clause is optional when granting any of the authorities. If the clause is included, a password is added or changed for each user specified. If the password is the same as the one that currently exists for the user, the change has no real effect. If no passwords are given, none is assigned and previously assigned passwords are retained.

User IDs and passwords are limited to eight characters. They can be entered in double quotation marks to bypass checking under the rules of SQL identifier naming. Embedded blanks are not permitted, even in double quotation marks. If you specify IDENTIFIED BY, you must include a password for every user ID specified. The passwords and user IDs must correspond as indicated in the statement format above.

You can change your password by issuing the following form of the CONNECT statement which does not require special authority.

```
 CONNECT ... IDENTIFIED BY ...
```

To do this, you need only have CONNECT authority, and may or may not have already been assigned a password.

Granting CONNECT to ALLUSERS is a special case that establishes implicit connect capability for all users in the system when operating under VM. ALLUSERS may be specified only once. .) (See "Using VM Implicit Connect" on page 105.)

Granting an authority that a user already possesses has no additional effect, except for changing the password if it is specified.

You should not grant CONNECT authority to SYSTEM or PUBLIC. They are used internally.

Revoking Authority from Users

Note: In discussions about revoking authorities and privileges in this chapter, the "revoker" is defined as the user who preprocessed the program in which the REVOKE statement appears. However, for dynamically defined REVOKE statements, the revoker is determined at run time, based on the connected authorization ID.

The System Authorities form of the REVOKE statement allows a *user having DBA authority* to revoke an authority from any other users regardless of who originally granted it. The only exceptions are:

- Anyone with DBA authority cannot revoke their authority
- No one can revoke RESOURCE authority from a user who has DBA authority.

See the *DB2 Server for VSE & VM SQL Reference* manual for the syntax of the REVOKE statement.

If you enter REVOKE for an authority that a user does not have, the revocation is ignored.

Revoking a user's CONNECT authority causes any other authorities to be revoked as well, and the user is deleted from the catalog table SYSUSERAUTH. Revoking CONNECT authority does *not* cause objects owned by that user to be dropped; if they should be dropped, this can be done by a user with DBA authority.

Revoking DBA authority automatically causes all other authorities except CONNECT to be revoked. Revoking RESOURCE or SCHEDULE authority implies no other revocations.

Defining Privileges

The following information applies to DB2 Server for VSE & VM application servers only. For a discussion of authorities for another application server, refer to that product's library.

The system keeps track of the *privileges* that each authorization ID has, and makes sure that each ID performs only authorized operations on the database.

Authorized users can create and drop tables or views, and compile and run programs that operate on these tables or views. Anyone who creates a table or view or compiles a program can selectively share the use of that table, view, or program with other authorization IDs.

The privileges you need vary depending on what operations you want to perform. There are two categories of privileges: privileges on tables and views, and privileges on programs.

Defining Privileges on Tables and Views

You can have any or all of the following privileges on specific tables and views:

ALTER	Privilege to add new columns and keys to a table (does not apply to views)
DELETE	Privilege to delete rows from tables and views
INDEX	Privilege to create new indexes on a table (does not apply to views)
INSERT	Privilege to insert new rows into tables or views
REFERENCES	Privilege to add, drop, activate, or deactivate a foreign key relationship (does not apply to views)
SELECT	Privilege to retrieve data from tables or views
UPDATE	Privilege to change column values in tables or views.

When you create a new table or view, you are automatically given full privileges on it. In most situations, you are also given the GRANT option on each privilege which enables you to grant any or all of these individual privileges to other authorization IDs. When you grant a privilege, you may include the GRANT option so that the recipient will be able to grant the privilege to others in turn.

If you grant the privileges on an object to PUBLIC, all authorization IDs (including those that do not yet exist) will have the same privileges that you have.

If you have DBA authority, you have the same privileges on an object and you can grant those privileges (or drop the object) in the same way that the owner of the object can.

Any privilege that you hold on a table or view may be exercised directly through ISQL and the DBS utility as well as application programs.

Privileges on tables and views are listed in the database manager catalog tables. SYSTABAUTH and SYSCOLAUTH. To check what privileges you hold or have granted to other authorization IDs, make the suitable queries on these tables. See the *DB2 Server for VSE & VM SQL Reference* manual for more information on the catalog tables.

Revoking Privileges

Once you have granted a privilege, you can revoke it by issuing a REVOKE statement. (You can never revoke a privilege from yourself.) If you revoke a privilege from user LEENA, it is automatically revoked from all authorization IDs to whom LEENA granted it, unless the other authorization IDs have another independent source for the same privilege. The most common and most convenient way to to enter a REVOKE statement is through ISQL or the DBS utility. You can code REVOKE statements within a program; however, because the user ID and passwords in the REVOKE statements cannot be host variables, the statements have limited use.

If you attempt to revoke a privilege that is currently in use by a running program, the REVOKE statement is queued until the program ends its current *logical unit of work*. For example, if you revoke the UPDATE privilege from user MARY, but MARY's program is running and is already making updates, your REVOKE statement does not take effect until MARY's updates are finished.

The database manager can also automatically revoke privileges on views, or drop the view definition. Suppose BILL grants GENE the SELECT privilege with the GRANT option on the EMPLOYEES table. GENE then defines a view called SALARY on this table, and grants the SELECT privilege on that view to other users. After some time, BILL decides to revoke the SELECT privilege on the EMPLOYEES table from GENE. When BILL does so, the system also automatically revokes the SELECT privilege from SALARY also, including all SELECT privileges on SALARY that GENE passed on. If after this process GENE holds no privileges on SALARY, the definition of SALARY is dropped.

Defining Privileges on Packages

Assigning User Privileges to the Owner

Application programs must be preprocessed before they are compiled or assembled. Successfully preprocessing an application program results in the creation or replacement of a package in the database. The contents of the package are then used to satisfy database requests at run time.

When the package is created, the system determines the level of the RUN privilege to be given to the owner (EXECUTE privilege can be used as a synonym for RUN privilege). This depends on such factors as the preprocessed SQL statements, the existence and ownership of the referenced objects (tables, indexes, dbspaces, and so on), and the owner's authorization level (DBA, RESOURCE, or CONNECT).

The owner of a package is assigned the RUN privilege based on the following rules:

- If the owner does *not* have DBA authority, the RUN privilege is assigned when the preprocessor successfully creates or replaces the package.
- If the owner has DBA authority, the RUN privilege is assigned when none of the preprocessed SQL statements depends on the owner having DBA authority.

  There is an exception to this rule: if an SQL statement selects information from a table on which the owner does not have the explicit SELECT privilege, and the owner has DBA authority, then the owner may still be assigned the RUN privilege. This will depend on the result of preprocessing all the other SQL statements in the program.

When a particular SQL statement references objects that do not exist or have different attributes at preprocessing time, the system still creates a package for the program and assigns RUN privilege to the owner. In this case, the required objects must be correctly defined at run time, or execution of the program will fail.

In fact, the determination of whether an owner receives the RUN privilege is based on the aggregate *“score”* of all preprocessed SQL statements in the program. Each statement is individually assigned an authorization score; at the end of the preprocessing phase, the system picks the lowest score, and assigns that to the owner.

The scores, and the decision tables used to assign them, are discussed in Appendix F, “Decision Tables to Grant Privileges on Packages” on page 339.

Assigning Privileges to Others

The database manager provides a GRANT statement that allows the owner of a package to grant the RUN privilege on the package to other users.

Determining When the Owner Can Grant the RUN Privilege: The owner of a package is assigned the GRANT RUN privilege when all preprocessed SQL statements in the program allow the owner to GRANT RUN. If the owner can grant the RUN privilege on a package, a user with DBA authority has the same ability.

Circumstances which enable an owner to gain the GRANT RUN privilege include:

- The owner has the necessary privileges (with the GRANT option) to access any referenced objects.
- The package does not contain any statements that require DBA authority. The following are examples of operations that require DBA authority:
  - Acquiring a public dbspace
  - Creating a table in another user's dbspace or in a SYSTEM dbspace
  - Acquiring a dbspace for another user
  - Altering another user's table when the owner doesn't have explicit ALTER authority on the table
  - Locking another user's dbspace
  - Commenting on another user's table
  - Dropping another user's object
  - Locking another user's table
  - Altering another user's dbspace
  - Creating an index on another user's table when the owner doesn't have explicit INDEX authority on that table
  - Creating a table for another user
  - Inserting, deleting, or updating another user's table when the owner doesn't have the explicit authority to do so.

Note: The following statements also require DBA authority, but do not affect the RUN privilege, because they are not checked until run time (when they may be rejected).

- ALTER DBSPACE when the owner qualifier is not given
- LOCK DBSPACE when the owner qualifier is not given
- DROP DBSPACE when the owner qualifier is not given

- CREATE TABLE in someone else's dbspace or in a SYSTEM dbspace when the DBSPACE owner qualifier is not given.

Differences Between Static and Dynamic Statements

There is a difference between static, dynamic, and extended dynamic SQL statements, when determining the privileges of the owner and other users of the package being run.

Static	At preprocessing time the objects referenced in static statements are checked for existence, for usage consistent with the definitions in the database, and to determine whether the package owner has the required privileges. This process allows the person who is preprocessing a package to encapsulate a set of object privileges that he or she possesses into that package and to subsequently grant them to others.
Dynamic	All dynamic statements are checked at the time the PREPARE or EXECUTE IMMEDIATE statement is run and the privileges on the objects referenced in the statement are checked against those of the authorization ID of the runner of the package. There is, therefore, no way to encapsulate object privileges with dynamic statements.
Extended Dynamic	For modifiable packages, all statements are checked against the privileges of the person who is preparing or modifying the package, as per static SQL. For nonmodifiable packages, statements prepared with extended PREPARE Filling Empty Section statement are checked as per dynamic SQL, and statements prepared with the other forms of extended PREPARE are checked as per static SQL.

Revoking the Run Privilege

The REVOKE statement may be used to revoke the RUN privilege on a package in the same way it revokes privileges on tables and views.

In some situations, the system automatically revokes the RUN privilege from a number of users. Suppose user GENE has preprocessed a program that makes use of some privilege, such as SELECT. GENE receives the RUN privilege on the package with the GRANT option, and grants this privilege to other users.

If the SELECT privilege is now revoked from GENE, the package associated with the program is automatically marked invalid. When the program is run (by GENE or any other user), the system attempts to regenerate a valid (fully authorized) package. At the time of this regeneration process, the following outcomes are possible:

1. GENE has all the privileges required by the program, and furthermore has the GRANT option on all these privileges. In this case, the package is regenerated, all existing grants of the RUN privilege on the program remain in effect, and execution proceeds normally.

2. For some SQL statements in the program, GENE lacks the necessary privilege, or has the privilege without the GRANT option. In this case, GENE retains the RUN privilege on the program, but all existing grants of the RUN privilege are revoked. When the program is run, those SQL statements for which GENE has the necessary privilege execute successfully, and others return error codes.

Recording Assigned Privileges in the Catalog Tables

The database manager records the current RUN and GRANT RUN privileges held by all authorization IDs in the SYSPROGAUTH catalog table. The entries in the catalog identify:

- The grantor
- The grantee
- The package that is the subject of the RUN privilege
- A marker indicating that the grantee holds either RUN (‘Y’) or GRANT RUN (‘G’) authority.

The entries are added to the catalog tables as an application is preprocessed. The entries may depend, of course, on whether the package satisfies the various conditions described in the preceding sections. The system also makes entries in the SYSPROGAUTH catalog table when someone grants the RUN privilege to another authorization ID.

The system also updates the SYSUSERAUTH, SYSCOLAUTH, and SYSTABAUTH catalog tables. The package’s dependency on some authorization is recorded in these catalog tables. For example, when a package requires RESOURCE authority to execute successfully, an entry is made in SYSUSERAUTH to reflect that dependency. The system uses the catalog table entries to keep track of valid and invalid packages.

Chapter 10. Special Topics

Contents

Using Datetime Values with Durations 219
Using Durations 219
Resolving Peculiarities of Date Arithmetic 219
Summarizing Addition Operations 221
Summarizing Subtraction Operations 222
Using Field Procedures 222
Assigning Field Procedures to Columns 224
Understanding Field Procedure Rules 224
Input from an Application Program 225
Output to an Application Program 225
Comparison 225
Referential Integrity 225
Scalar Functions 226
Column Functions 227
Concatenation 227
The IN and BETWEEN Predicates 227
The LIKE Predicate 227
Sorting 227
Null Values 227
Unions and Joins 227
Sub-SELECTS 228
Using CMS Work Units 228
Using Work Units in Application Programs 228
Processing the First SQL Statement in the Work Unit 229
Invoking Another Application Program 229
Invoking Applications in CMS SUBSET 230
Processing Applications Concurrently 230
Accessing the Database from Different Points in the Program 230
Copying Data across Databases 230
How Locking Works with CMS Work Units 230
Environmental Considerations 231
Performance Considerations 231
Ensuring Data Integrity 231
Ensuring Entity Integrity 231
Using Unique Constraints 232
When Creating a View 232
Ensuring Referential Integrity 232
Defining Terms 232
Ensuring Referential Integrity in New Tables 234
Adding Referential Integrity to Existing Tables 235
Managing Table Relationships 236
Modifying Applications to Ensure Integrity 237
Modifying Data in Tables Containing Referential Constraints 237
Restrictions on Using Delete Rules 240
Generating SQL Statements in Response to Table Modifications 241
Enforcing Referential Integrity 242
Removing Referential Constraints 244

Switching Application Servers 244
  Identifying Switching Options 245
  Comparing Switching to Other Methods 245
  Accessing a New Application Server 246
  Illustrating Sample Code 247
  Preprocessing the Program on Multiple Application Servers 247

Using Datetime Values with Durations

Using Durations

A duration is a value that represents an interval of time. The value may be a constant, a column name, a host variable, a function, an expression, or an expression followed by a duration attribute. Numbers are interpreted as durations only in certain contexts as defined in the *DB2 Server for VSE & VM SQL Reference* manual; the arithmetic of using date, time, and timestamp is discussed in detail. Figure 65 on page 221 and Figure 66 on page 222 summarize this topic.

Resolving Peculiarities of Date Arithmetic

What does it mean to add a month to a given date? Presumably the result should be the same day of the next month. That is, one month after January 1 is February 1, and one month after February 1 is March 1. But what is one month after January 31? This difficulty (which is the reason why certain contracts are always dated the first of the month) is resolved by the further assumption that the result should be the last day of February. Thus, adding a month to a given date gives the same day of the next month *except when the next month does not have such a day,* in which case the result is the last day of that month. But, one month from the last day of a month is not necessarily the last day of the next month. One month from the last day of February, for example, is not the last day of March. Thus (a date) + (a simple duration of months) - (a simple-duration of months) is not necessarily equal to the original date.

The definition of a month does not permit a consistent system of date arithmetic. If this is a problem, it can be avoided by using days rather than months. For example, to increment the date *date3* by the difference between the dates *date1* and *date2*, the expression:

DATE (DAYS(*date1*) - DAYS(*date2*) + DAYS(*date3*))

will give an accurate result whereas *date1* - *date2* + *date3* may not. Figure 64 on page 220 shows how SQLWARN7 provides warnings during date arithmetic when the resulting date has to be adjusted to derive a valid date.

```
Let D1 be the DATE 1994-02-29, a leap year:
                                                          SQLWARN7

 D1 + 1 DAY    = 1994-03-01                                 ' '
 D1 + 2 MONTHS = 1994-04-29                                 ' '
 D1 + 1 YEAR   = 1995-02-28                                 'W'
 D1 + 4 YEARS  = 1998-02-29                                 ' '

Let N be DEC(8,0) and set to 00010203.
 D1 + N
               = 1994-02-29 + 1 YEAR + 2 MONTHS + 3 DAYS
               = 1995-02-28 + 2 MONTHS + 3 DAYS             'W'
               = 1995-04-28 + 3 DAYS
               = 1995-05-01

Let D2 be the DATE 1995-03-31:
                                                          SQLWARN7

 D2 + 1 MONTH  = 1995-04-30                                 'W'
 D2 + 2 MONTHS = 1995-05-31                                 ' '
```

Figure 64. Setting SQLWARN7 during Date Arithmetic. When incrementing or decrementing dates, SQLWARN7 is set when the resulting date is an invalid date because of a leap year or month difference, and a valid date is derived.

Summarizing Addition Operations

DATETIME ADDITION = OPERAND + OPERAND

	LEFT OR RIGHT OPERAND														
					DURATIONS										
								SIMPLE							
LEFT OR RIGHT OPERAND ↓	DATE	TIME	TIMESTAMP	STRING	DATE	TIME	TIMESTAMP	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND	MICRO SECONDS	RESULT DATA TYPE ↓
DATE					X			X	X	X					DATE
TIME						X					X	X	X		TIME
TIME STAMP					X	X	X	X	X	X	X	X	X	X	TIME STAMP

Figure 65. Datetime Addition

- An X denotes valid datetime addition operation.
- STRING means a character string in a valid datetime format.

Summarizing Subtraction Operations

DATETIME SUBTRACTION = MINUEND - SUBTRAHEND

MINUEND	SUBTRAHEND														RESULT DATA TYPE
					DURATIONS										
								SIMPLE							
	DATE	TIME	TIMESTAMP	STRING	DATE	TIME	TIMESTAMP	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND	MICRO SECONDS	
DATE	1			1	2			2	2	2					1=(8,0) 2=DATE
TIME		1		1		2					2	2	2		1=(6,0) 2=TIME
TIME STAMP			1	1	2	2	2	2	2	2	2	2	2	2	1=(20,6) 2=TIME STAMP

Figure 66. Datetime Subtraction

- 1 or 2 denotes a valid datetime subtraction operation.
- 1 means a result data type of DECIMAL(8,0), DECIMAL(6,0) or DECIMAL(20,6) which is deemed as a date duration, time duration, or timestamp duration respectively. 2 means a result data type of date, time, or timestamp.
- STRING means a character string in a valid datetime format.

Using Field Procedures

Field procedures enable you to alter the sorting sequence of values entered in a single short string column (CHAR, VARCHAR, GRAPHIC, or VARGRAPHIC). For some applications the standard EBCDIC sorting sequence is not appropriate. For example, telephone directories sometimes require that names like “McCabe” and “MacCabe” appear next to each other, and the standard sorting routine would separate them. Another example is a national language character set that does not use the Roman alphabet. For example, Kanji (Japanese) can only be sorted properly using a field procedure.

If you assign a field procedure to a column, it is called whenever values in that column are changed or are inserted, and it transforms (encodes) the original value into one value that sorts properly.

When you retrieve a row from the encoded column, the same field procedure decodes it into the original form. You will never see the encoded string. From a user's point of view, all a field procedure does is change the sorting sequence for a column.

For example, consider a table with a short string column that contains the four divisions in a company: North, South, East, and West. Divisions are usually sorted as follows:

```
East
North
South
West
```

You can, however, write a field procedure that encodes North as 1, South as 2, East as 3 and West as 4. The divisions would then be sorted as follows:

```
North
South
East
West
```

Note: The encoded values do not have to be the same data type as the decoded values. Refer to the *DB2 Server for VSE & VM SQL Reference* manual for a description of the catalog table SYSCOLUMNS, which contains the descriptions of decoded columns, and SYSFIELDS, which contains the descriptions of the corresponding encoded columns.

While field procedures are used primarily to alter the standard EBCDIC sorting sequence, they can also be used in any application program that requires short strings to be stored differently from how they are inserted or retrieved.

For a sample field procedure and the rules for writing field procedures, refer to the *DB2 Server for VM System Administration* manual.

DB2 Server for VM provides two field procedures for performing cultural sorts. They are:

FP870L2 Sample field procedure for cultural sorting for the Latin 2 code page (Regions: Slovenia, Poland, and Romania).

FP102CY Sample field procedure for cultural sorting for the Cyrillic code page (Regions: Russia, Bulgaria, Serbia, and Montenegro).

| If Data Propagator Capture for VM is being used on tables that have columns with
| field procedures, “1-way” field procedures must be defined on the Data Propagator
| Change Data (CD) tables to properly propagate this data. Refer to the *DB2 Server*
| *for VM System Administration* manual for more information.

Assigning Field Procedures to Columns

To assign a field procedure to a new column, include the FIELDPROC clause on either the CREATE TABLE or ALTER TABLE statement. To assign field procedures to columns in an existing table, you must unload the data, recreate the table to include the field procedures, and they reload the data back into the table. If you create a column without a field procedure, you cannot add one later.

Refer to the *DB2 Server for VSE & VM SQL Reference* manual for the syntax diagrams for the CREATE and ALTER TABLE statements. The fieldproc-block for these diagrams is shown below.

```
►──FIELDPROC──program_name──┬──────────────────────┬──────────────────►
                            │     ┌─,────────┐     │
                            └─(───▼─constant─┴───)─┘
```

Figure 67. fieldproc-block Syntax

For example:

```
ALTER TABLE SCOTT.SUPPLIERS ADD RATING CHAR(6) FIELDPROC MYFLDPRO (10,5)
```

The constants **(10,5)**, that follow the *program_name* **MYFLDPRO** are optional parameters, defined when the field procedure is written and passed to the field procedure when it is invoked.

Understanding Field Procedure Rules

In most cases you will not have to worry about the rules that define when a field procedure encodes or decodes a short string. However, if you understand when the database manager calls field procedures, this can help you understand their performance implications. The less you call field procedures to encode or decode strings the better your application's performance will be.

Understanding when field procedures are called can also help you to avoid some pitfalls. For example, consider a table TABLE_A with a column COLUMN_A that has fieldproc F1, and consider these two statements:

```
SELECT SUBSTR(MAX(COLUMN_A,1,5)) FROM TABLE_A

SELECT MAX(SUBSTR(COLUMN_A,1,5)) FROM TABLE_A
```

You might assume that the two statements should return essentially the same result; however, different results can be returned depending on your coding. In the first statement, the database manager does the following:

1. Finds the maximum encoded value in COLUMN_A
2. Decodes the result from MAX with field procedure F1
3. Applies the SUBSTR function to the decoded value of the result from MAX.

In the second statement, the database manager does the following:

1. Decodes the value in COLUMN_A with field procedure F1
2. Applies the SUBSTR function to the decoded value in COLUMN_A
3. Applies the MAX function to the result of the SUBSTR function.

That is, the first statement MAX is applied to encoded values, and the second is applied to decoded values.

The rest of this section covers the rules that define when a field procedure encodes or decodes a short string.

Input from an Application Program

The field procedure is called to encode data when your application program inserts or updates data. This includes the following statements:

- INSERT
- PUT
- UPDATE

Output to an Application Program

The field procedure is called to decode data when your application program fetches or selects data. This includes the following statements:

- FETCH
- SELECT INTO

Comparison

If a column with a field procedure is compared to a constant, the constant is first encoded by the field procedure. The comparison is then performed between the encoded values in the column and the encoded value of the constant. Host-variables, parameter markers, and the USER special register are treated the same way.

For example, consider the following SQL statement where COLUMN_A has field procedure F1:

```
SELECT * FROM MY_TABLE WHERE COLUMN_A > 'SMITH'
```

When processing the above statement, the database manager first encodes `'SMITH'`, and then for each row in MY_TABLE, compares F1 to the encoded value in COLUMN_A.

A field procedure can only encode short strings values. If the variable or constant is of a data type other than CHAR, VARCHAR, GRAPHIC or VARGRAPHIC, a negative SQLCODE is returned.

If a column with a field procedure is compared to another column, both columns must have field procedures with the same *program_name*, comparable encoded data type, and the same CCSID. If not, a negative SQLCODE is returned.

Referential Integrity

If a primary key column has a field procedure, then the foreign key column must have the same field procedure, and the CCSIDs of both key columns must be the same. Otherwise, a negative SQLCODE is returned. For two field procedures to be the same, their *program_name*s, encoded data type, encoded data length, and input parameters must be identical.

For example, the following is correct:

```
CREATE TABLE PRIMARY
       (COLUMN_A CHAR(10) FIELDPROC F1 NOT NULL,
        COLUMN_B INTEGER)
       PRIMARY KEY(COLUMN_A)

CREATE TABLE FOREIGN
       (COLUMN_A CHAR(10) FIELDPROC F1 NOT NULL,
        COLUMN_B CHAR(10))

ALTER TABLE FOREIGN
       ADD FOREIGN KEY (COLUMN_A)
       REFERENCES PRIMARY ON DELETE SET NULL
```

Scalar Functions

All scalar functions operate on decoded values. For example, if 'V' is a string in a column with a field procedure, HEX('V') returns the hexadecimal representation of 'V'. The result is not associated with the original column's field procedure. However, if the result of a scalar function is compared to a column that is associated with a field procedure, this result is encoded by the comparison column's field procedure. The comparison is then made between the encoded value of the column and the encoded result of the scalar function. This is consistent with how columns with field procedures are compared to constants.

For example:

1. Consider a table (MY_TABLE) with COLUMN_A that has field procedure F1 and COLUMN_B that has field procedure F2. Consider the following SQL statement:

   ```
   SELECT * FROM MY_TABLE WHERE COLUMN_A > SUBSTR(COLUMN_B,3,3)
   ```

   For each row of MY_TABLE, the following occurs:

   a. The encoded values of COLUMN_B are decoded by field procedure F2.
   b. The substring operation is applied to the decoded value of COLUMN_B.
   c. The result of the substring operation is encoded by field procedure F1.
   d. Finally, the encoded value of COLUMN_A is compared to the encoded result of the substring operation.

2. Consider a table (MY_TABLE) with three columns, where COLUMN_A has field procedure F1, COLUMN_B has field procedure F2, and COLUMN_C is NOT NULL and has field procedure F3. Consider the following SQL statement:

   ```
   SELECT * FROM MY_TABLE WHERE COLUMN_A > VALUE(COLUMN_B,COLUMN_C)
   ```

   For each row of MY_TABLE, the following occurs:

   a. If the value of COLUMN_B is not null, then COLUMN_B is decoded, using F2. Call the result 'M'.
   b. If the value of B is null, then C is decoded, using F3. Call the result 'M'.
   c. 'M' is then encoded using F1.
   d. The encoded result of the VALUE function is then compared to the encoded value of COLUMN_A.

   Note: A field procedure is never called to encode or decode a NULL value. A NULL value always maps to a NULL.

3. If a column with a field procedure is the argument of the LENGTH function, first it is decoded by the field procedure, and then the length of the result is returned. Of course, if the column data type is a fixed length (for example,

CHAR(15)), there is no need to actually decode the column value. The length returned by the function is simply the fixed length of the column (15 in this example).

Column Functions

The column functions MAX and MIN operate on encoded values. The remaining column functions operate on numeric data, and are not affected by field procedures.

Concatenation

The concatenation operator is basically a scalar function, and follows the same rules as a scalar function.

For example, consider a table (MY_TABLE) with COLUMN_A that has field procedure F1 and COLUMN_B that has field procedure F2. Now, consider the following SQL statement:

```
SELECT * FROM MY_TABLE WHERE COLUMN_A > 'ADDITION' CONCAT COLUMN_B
```

For each row in MY_TABLE, the following occurs:

1. The value of COLUMN_B is decoded by F2.
2. 'ADDITION' is concatenated with the decoded value in COLUMN_B.
3. The result of the concatenation is encoded by field procedure F1.
4. The encoded result of the concatenation is compared to the encoded value of COLUMN_A.

The IN and BETWEEN Predicates

These predicates operate the same as a comparison between a column with a field procedure and a constant.

The LIKE Predicate

This predicate operates on decoded values.

Sorting

Indexes will be based on encoded values. The ORDER BY and GROUP BY clauses will sort the data according to the encoded format. The database manager also sorts values during a UNION operation.

Null Values

While a column with a field procedure may be defined to allow null values, the field procedure is never called to process a null value. A decoded null value always maps to an encoded null value, and an encoded null always maps to a decoded null.

Unions and Joins

The rules for comparing two columns with field procedures apply to unions and joins. The two columns must have the same field procedure.

Sub-SELECTS

All the rules described above apply to sub-SELECTs.

For example:

```
SELECT * FROM TABLE_1
         WHERE COLUMN_A=(SELECT COLUMN_B FROM TABLE_2);

SELECT * FROM TABLE_1
         WHERE COLUMN_A IN (SELECT COLUMN_B FROM TABLE_2);
```

If the columns COLUMN_A and COLUMN_B have different field procedures these statements are invalid (field procedure comparison rules apply). For example:

```
INSERT INTO T1 (COLUMN_A) SELECT COLUMN_B FROM T2;
```

In this statement, the decoded data types for COLUMN_A and COLUMN_B must be compatible. If so, the value in COLUMN_B will be decoded with F2. The decoded value is then encoded by F1, and the resulting value is inserted into COLUMN_A.

Using CMS Work Units

Application programs can use the CMS work unit facility, which supports the following DB2 Server for VM functions:

- One application can invoke another, independent of the processing of the invoked application.
- An application can be invoked in the CMS SUBSET, independent of the program from which the CMS SUBSET was invoked.
- Applications can issue concurrent server requests for DB2 Server for VM resources.
- An application can establish more than one path into the same database.
- An application can copy data from one DB2 Server for VM database to another without first having to write the data to a temporary file.

Note: You should not use the CMS SUBSET function if the WORKUNIT option in SQLINIT/SQLGLOB is set to NO.

Using Work Units in Application Programs

Associated with each work unit is a unique work unit id assigned by CMS. When you invoke your program, a default work unit id identifies the currently active work unit for your program. To switch to a new work unit, you must explicitly change the currently active work unit.

Use the CMS routines shown in Figure 68 to manage work units:

Figure 68 (Page 1 of 2). Routines to Manage Work Units

CSL Call	Function	Description
DMSGETWU	Get work unit id	Obtains and reserves a work unit id from CMS. You must invoke this routine for each separate work unit you wish to manage.

Figure 68 (Page 2 of 2). Routines to Manage Work Units

CSL Call	Function	Description
DMSPUSWU	Push work unit id	Pushes the work unit id onto the work unit stack. Makes the *pushed* work unit the currently active one.
DMSPOPWU	Pop work unit id	Pops the work unit id from the top of the stack. The next work unit on the stack becomes the currently active one.

Processing the First SQL Statement in the Work Unit

Although a work unit may have been established and made the currently active work unit, it is not known to the database manager until the first SQL statement in the work unit is executed. When this SQL statement is processed, the work unit id is obtained from CMS, a logical path (work unit) is established between the application and the DB2 Server for VM resource, and the user is connected to either the default application server or the explicitly connected application server. (The default application server is the one established by the SQLINIT EXEC.) The CONNECT statement can be used to connect to the desired application server.

If the work unit id is already known, no change occurs in the database to which the user is connected in that work unit, unless the user explicitly issues a CONNECT to change the database.

Invoking Another Application Program

One DB2 Server for VM application can be invoked from another. By starting a separate CMS work unit before invoking the second application, the calling application will not be affected by any COMMIT or ROLLBACK statement issued from the called application. When the called application *pops* its work unit id from the top of the stack, control is returned to the first application. The calling application is in the same state as it was before it called the other application. The calling application and the called application can access the same database or different databases.

Figure 69 illustrates how the calling program can be isolated from the work committed or rolled back by the called program.

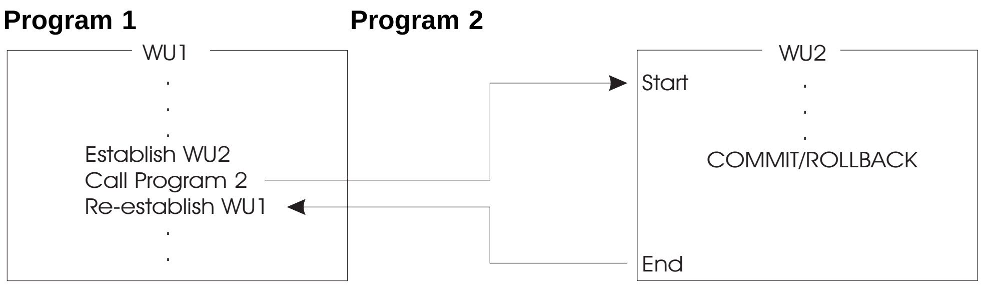


Figure 69. Program Transitioning Using CMS Work Units

Invoking Applications in CMS SUBSET

A DB2 Server for VM application (for example ISQL) can interrupt processing of its logical unit of work to go into CMS SUBSET and invoke another DB2 Server for VM application. The processing done by the invoked application does not affect the invoking program. When control is returned to the invoking program, the LUW is in the same state as it was before going into CMS SUBSET.

To prevent the application in the CMS SUBSET from affecting any work done by the invoking application in normal CMS, the SQLRMEND EXEC cannot be used with the COMMIT ALL or ROLLBACK ALL parameters while in CMS SUBSET mode. (See the *DB2 Server for VM Database Administration* manual for more information on the SQLRMEND EXEC.)

Processing Applications Concurrently

More than one DB2 Server for VM application can concurrently process against the same DB2 Server for VM database or different DB2 Server for VM databases. The application server ensures that processing done by one application is independent of that done by another. In order to do this, the server acquires and manages work units for each application.

Accessing the Database from Different Points in the Program

By acquiring two or more work units, an application can logically access the same database from different points in the application. These work units (and their paths into the database) cannot be processed concurrently.

Copying Data across Databases

Applications can copy data from one database to another by following these steps:

1. Establish a work unit #1.
2. CONNECT to database #1.
3. Establish a work unit #2.
4. CONNECT to database #2.
5. Make work unit #1 the current work unit.
6. Open a cursor and read into an array as many rows as feasible.
7. Make work unit #2 the current work unit.
8. Open an insert cursor and put all rows from an array into a table.
9. Repeat until all rows are read and put into a table.

How Locking Works with CMS Work Units

If an active work unit requests a SHARE lock on a DB2 Server for VM resource, and a suspended work unit has an EXCLUSIVE lock on the same resource, the active work unit has to wait until the EXCLUSIVE lock is released.

Since the suspended work unit cannot resume processing until the active work unit is released or suspended, the user will be in an infinite wait state unless a cancel is issued or the agent is forced off.

This same locking problem will occur if the suspended work unit has a SHARE lock on the resource and the active work unit requests an EXCLUSIVE lock on the same resource.

Environmental Considerations

To use CMS work units, your CMS virtual machine and the database virtual machine must be running under the VM/ESA operating system, the application server must be running in multiple user mode, and the Work Unit option in the SQLINIT EXEC must be set to yes (the default) at initialization time. See the *DB2 Server for VM Database Administration* manual for more information on SQLINIT EXEC.

The database manager does not reuse links for different work units. If you no longer need a work unit, you should enter either COMMIT RELEASE or ROLLBACK RELEASE, to free the (APPC/VM) path for reuse.

Performance Considerations

There is a degradation in performance when SQLINIT WORKUNIT (YES) is specified either directly, or indirectly as the default. This applies even if the application is not using multiple work units.

Ensuring Data Integrity

Data integrity refers to the accuracy and correctness of data in the database. When related changes are made to a database, the database manager maintains integrity of the data by ensuring that either all or none of the changes are made. This protects other users and programs from using inconsistent or wrong data. This type of integrity is called *atomic integrity*.

Data integrity is also maintained by ensuring the uniqueness of certain data in the database. For example, the SUPPLIERS table must not have duplicate supplier numbers (SUPPNO). Using this integrity rule, the database manager ensures that duplicates do not exist. This type of integrity is called *entity integrity*.

For consistency and integrity, when one table references values in another table, the referenced values must exist in both tables, or the reference is not valid. The database manager automatically enforces rules that you define on the tables. These rules are called *referential constraints*. Enforcement of referential constraints ensures the *referential integrity* of the data referenced.

Ensuring Entity Integrity

The rule that each row in the EMPLOYEE table must represent one and only one employee is an example of entity integrity. By defining a *primary key* on the table, you can ensure that duplicate rows do not occur, thereby enforcing entity integrity. For example, in the following SQL statement, the column EMPNO is defined as a primary key, so a unique index is automatically created on that column. This enforces uniqueness of the data in that column.

```
CREATE TABLE EMPLOYEE
 (EMPNO     CHAR(6)      NOT NULL,
  FIRSTNME  VARCHAR(12)  NOT NULL,
  LASTNAME  VARCHAR(15)  NOT NULL,
  SALARY    DECIMAL(9,2)         ,
  PRIMARY KEY (EMPNO)
 )
```

Using Unique Constraints

A unique constraint enables you to enforce data integrity without having to enforce entity integrity. While a primary key can ensure that each row in the EMPLOYEE table represents one and only one employee, a unique constraint can ensure that each entry in another column is unique. For example, a company has one telephone for every employee and wants to maintain a set of unique phone numbers. Its database, however, already uses an employee number as a primary key. A unique constraint can ensure that no phone numbers are repeated in the table. Also, if the phone number consists of several columns (area code, 7-digit number, extension), the unique constraint can include all those columns.

```
CREATE TABLE EMPLOYEE
 (EMPNO     CHAR(6)      NOT NULL,
  FIRSTNME  VARCHAR(12)  NOT NULL,
  LASTNAME  VARCHAR(15)  NOT NULL,
  AREACODE  CHAR(3)      NOT NULL,
  PHONENUM  CHAR(7)      NOT NULL,
  PHONEEXT  CHAR(4)      NOT NULL,
  PRIMARY KEY (EMPNO)
  UNIQUE PHONE (AREACODE,PHONENUM,PHONEEXT)
 )
```

The ALTER TABLE command can be used to add, activate, deactivate, or remove a unique constraint. Another way to remove a unique constraint is either by dropping the table or the dbspace. Although a unique index is created when the unique constraint is created, the constraint cannot be dropped by dropping the index.

When Creating a View

The WITH CHECK OPTION clause in the CREATE VIEW statement is an example of data integrity in the maintenance of data defined by a view. See “Creating a View” on page 58.

Ensuring Referential Integrity

Defining Terms

Referential integrity defines the condition on a set of tables in which the existence of values in one table depends on the existence of the same values in another table. By enforcing referential constraints (referential integrity rules) that are part of the table definitions, the database manager ensures the referential integrity of the data in the tables.

Figure 70 on page 233 shows examples of relationships supported by the database manager.

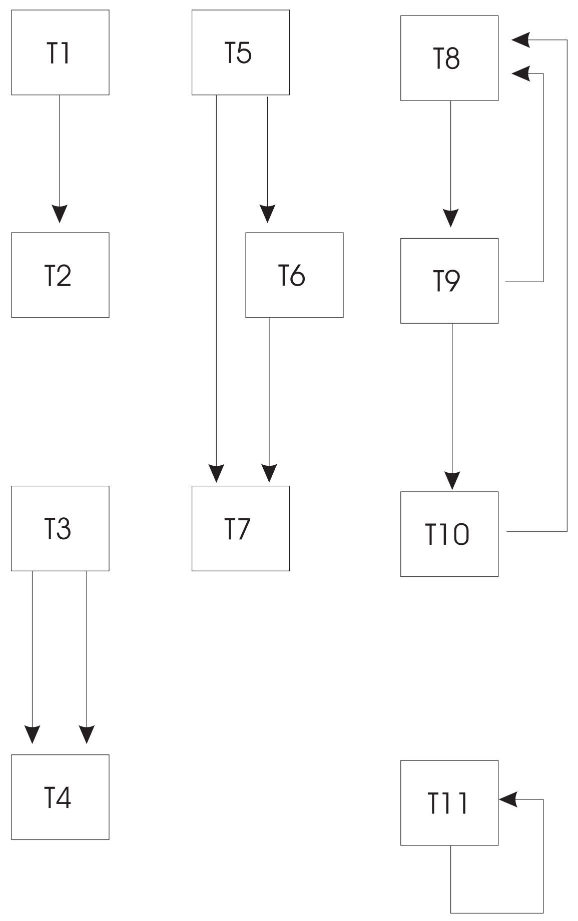


Figure 70. Table Relationships with Referential Integrity. T1, T2, ... are tables. Arrows point from parent tables to dependent tables.

You should be familiar with the following terms:

Relationship	A relationship is formed by connecting two tables directly. The tables are related through matching column values in the tables. For example, in Figure 70, tables T1 and T2 show a simple relationship. T3 has two relationships with T4. T5 has two *paths* to T7 (one directly, the other through T6), but only one *relationship* with T7. T5 also has a relationship with T6. Tables are connected to each other when relationships are formed.
Referential Constraint	A relationship between a primary key and a foreign key, along with a set of rules that define how the relationship is maintained. This relationship is that every foreign key value must match a primary key value or be null.
Referential Cycle	A set of referential constraints such that each table in the set is a descendent of itself.
Referential Structure	A set of tables that are related to each other by referential constraints. For example, T5 is a parent of both T6 and T7, which are its dependents. T7 is also a dependent of T6.

Parent Table	A table whose primary key is referenced in a referential constraint. For example, T1 is the parent of T2.
Dependent Table	A table with a foreign key that is related to another table (the parent) through a referential constraint. For example, T4 is a dependent of T3.
Delete-Connected Table	A table that may be involved in a delete operation on another table.
Descendent Table	A table is a descendent table if it is a dependent table or a dependent of a descendent table. For example, in Figure 70 on page 233, both T6 and T7 are descendent tables of T5.
Parent Row	A row in a parent table with a primary key value that is referenced by the foreign key value in at least one row in a dependent table.
Dependent Row	A row in a dependent table with a foreign key value that matches a primary key value in the parent table referenced in the referential constraint.
Self-Referencing Table	A self-referencing table is both the parent and the dependent table in the same relationship. This relationship is not supported by the DB2 Server for VM product. For example, T11 is a self-referencing table.
Primary Key	A set of non-null columns that together uniquely identify every row in a table. The values in these columns are known as *primary key values*.
Foreign Key	A set of columns whose values are called *foreign key values*. A foreign key only exists as part of a referential constraint.

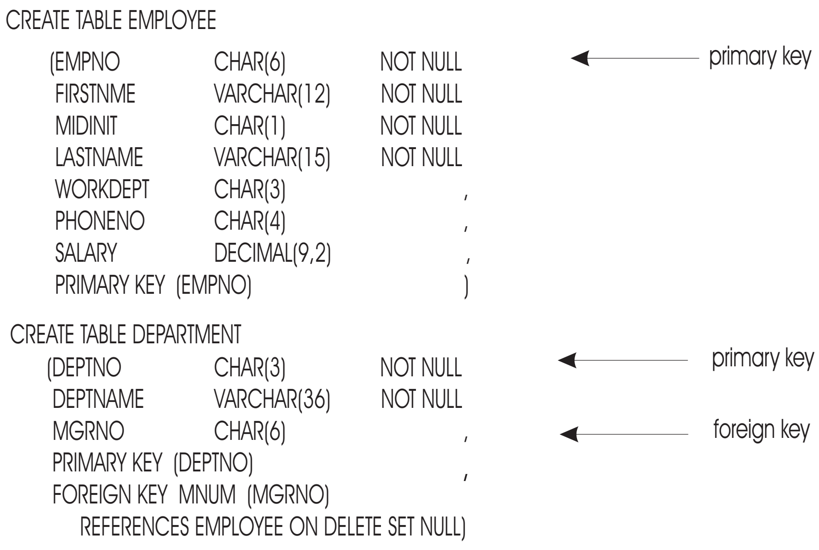
Ensuring Referential Integrity in New Tables

To ensure referential integrity in new tables, you must specify a primary key, a foreign key, and a delete rule that together define the relationship between the parent table and the dependent table. Delete rules specify what will happen to the dependent rows if the corresponding parent row is deleted. Insert and update rules are automatically defined on tables when primary keys and foreign keys are defined on those tables.

The relationship is defined when the new table is created using the CREATE TABLE statement.

You should be aware of the referential constraints of the tables you manipulate, as well as the rules for those tables. In this way you can avoid violating any referential constraints, and take appropriate action should you inadvertently do so.

In the example below, the EMPLOYEE table is the parent of the DEPARTMENT table. This relationship is established by specifying a primary key (EMPNO) on the EMPLOYEE table and a foreign key (MGRNO) on the DEPARTMENT table. This relationship specifies that every manager listed in the DEPARTMENT table is also listed in the EMPLOYEE table. The REFERENCES privilege is required on the parent table. The foreign key is nullable.



```
CREATE TABLE EMPLOYEE
      (EMPNO          CHAR(6)          NOT NULL
       FIRSTNME       VARCHAR(12)      NOT NULL
       MIDINIT        CHAR(1)          NOT NULL
       LASTNAME       VARCHAR(15)      NOT NULL
       WORKDEPT       CHAR(3)                  ,
       PHONENO        CHAR(4)                  ,
       SALARY         DECIMAL(9,2)             ,
       PRIMARY KEY  (EMPNO)                    )
CREATE TABLE DEPARTMENT
      (DEPTNO         CHAR(3)          NOT NULL
       DEPTNAME       VARCHAR(36)      NOT NULL
       MGRNO          CHAR(6)                  ,
       PRIMARY KEY  (DEPTNO)                   ,
       FOREIGN KEY  MNUM  (MGRNO)
           REFERENCES EMPLOYEE ON DELETE SET NULL)
```

primary key
primary key
foreign key

Adding Referential Integrity to Existing Tables

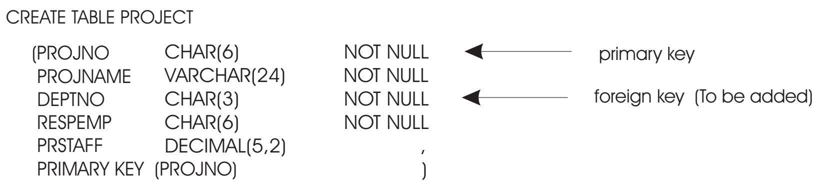
To add referential integrity to existing tables, you must add a primary key, a foreign key, and a delete rule that together define the relationship between the parent table and the dependent table. Delete rules specify what will happen to the dependent rows if the corresponding parent row is deleted. Insert and update rules are implicitly defined on tables when primary keys and foreign keys are defined on those tables.

The relationship is defined using the ALTER TABLE statement.

When keys (primary or foreign) are added to an existing table, any packages that depend on the table are invalidated. When the application programs are run again, the packages will be dynamically repreprocessed. Refer to “Running the Program” on page 134 for more information on dynamic repreprocessing.

As in the case of new tables, you should be aware of the referential constraints of the tables you manipulate as well as the rules for those tables, in order to avoid violating any referential constraints or to take appropriate action should you inadvertently do so.

Consider the existing DEPARTMENT and PROJECT tables. The PROJECT table was created by the following CREATE TABLE statement:



```
CREATE TABLE PROJECT
    (PROJNO        CHAR(6)          NOT NULL
     PROJNAME      VARCHAR(24)      NOT NULL
     DEPTNO        CHAR(3)          NOT NULL
     RESPEMP       CHAR(6)          NOT NULL
     PRSTAFF       DECIMAL(5,2)             ,
     PRIMARY KEY  (PROJNO)                  )
```

primary key
foreign key (To be added)

The following ALTER TABLE statement adds a referential constraint to the PROJECT table, thereby establishing a relationship between it and the existing DEPARTMENT table:

```
ALTER TABLE PROJECT
   ADD FOREIGN KEY DNUM (DEPTNO)
     REFERENCES DEPARTMENT ON DELETE CASCADE;
```

In this relationship, DEPARTMENT is the parent table and PROJECT is the dependent table. This specifies that every department that is responsible for a project is also in the DEPARTMENT table.

Note: The ALTER TABLE statement can also be used to defer the enforcement of referential constraints or cause the removal of referential constraints. These topics are discussed in the section “Enforcing Referential Integrity” on page 242.

Managing Table Relationships

The ALTER TABLE statement can be used to add, drop, activate, or deactivate primary and foreign keys. Various clauses of the statement alter alter the keys and to establish relationships between tables. When the ALTER TABLE statement establishes or changes relationships, specific privileges are required on parent tables and dependent tables. Figure 71 shows the privileges that are required.

Figure 71. Privileges to Use the ALTER TABLE Statement

ALTER TABLE Clause	**Privilege on Parent Table**	**Privilege on Dependent Table**
Add Column	ALTER	
Add Primary Key	ALTER	
Add Foreign Key	REFERENCES	ALTER
Drop Primary Key	ALTER REFERENCES1	ALTER
Drop Foreign Key	REFERENCES	ALTER
Deactivate Primary Key	ALTER REFERENCES1	ALTER
Deactivate Foreign Key	REFERENCES	ALTER
Activate Primary Key	ALTER REFERENCES1	ALTER
Activate Foreign Key	REFERENCES	ALTER

Note: The REFERENCES privilege is required only if the parent table has dependents.

You can grant to or revoke from another user the privilege to add, drop, activate, or deactivate a relationship between a parent table and its dependent. In order to enter any of these statements, you must have the REFERENCES privilege on the parent table whenever a referential constraint is to be:

- Created on a new table (CREATE TABLE)
- Added to an existing table (ALTER TABLE)

- Dropped, activated, or deactivated (ALTER TABLE).

By revoking the privileges previously granted on tables in a referential structure, you can prevent the accidental removal of constraints that your applications may depend on.

Modifying Applications to Ensure Integrity

Applications that currently enforce consistency and integrity of their data can be modified to let the database manager do the checking. Using the referential constraints and the integrity rules that apply to the tables containing the data, the system checks that the rules are adhered to, and thereby enforces integrity of the data. As this function can be performed by the database manager, some existing code can be removed from the application.

Modifying Data in Tables Containing Referential Constraints

To maintain the consistency and integrity of the data, the database manager checks that integrity rules for insert, update, and delete operations are followed.

Applying Insert Rules: The database manager checks the implicit insert rules when a row is inserted into either the parent or a dependent table in a referential structure. When a row is inserted into a parent table, the database manager checks that the primary key remains unique and does not contain null values. When a row is inserted into a dependent table, the database manager checks each foreign key for the following:

- Each has a matching primary key in the parent table, or
- Each contains a null value in one or more of its columns.

Assuming for the moment that department D21 does not already exist in the parent table (DEPARTMENT), the following INSERT statement adds a new row to DEPARTMENT.

```
INSERT INTO DEPARTMENT (DEPTNO,DEPTNAME,MGRNO,ADMRDEPT)
       VALUES ('D21','ADMINISTRATION SYSTEMS','000070','D01')
```

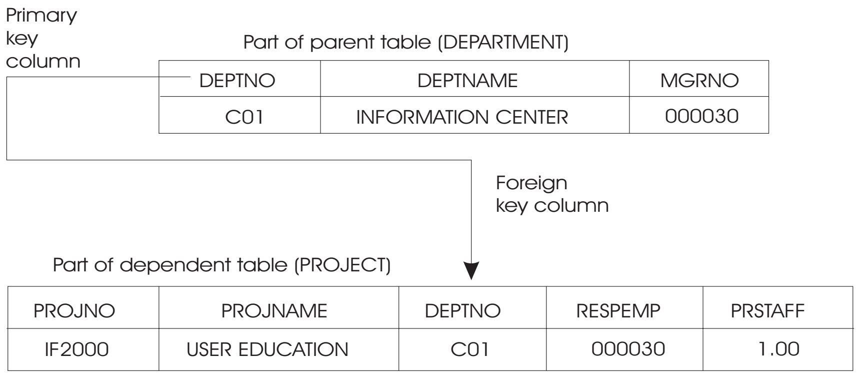
Note: The primary key (the DEPTNO column) in the DEPARTMENT table remains unique and does not contain null values.

Figure 72. Part of Department Table

DEPTNO	DEPTNAME	MGRNO
A00	SPIFFY COMPUTER SERVICE DIV.	000010
B01	PLANNING	000020
C01	INFORMATION CENTER	000030
D01	DEVELOPMENT CENTER	?
D11	MANUFACTURING SYSTEMS	000060
E11	OPERATIONS	000090
D21	ADMINISTRATION SYSTEMS	000070

Assuming for the moment that project IF2000 does not already exist in the dependent table (PROJECT), the following INSERT statement adds a new row with DEPTNO = C01 to PROJECT. This value for DEPTNO must exist in the parent (DEPARTMENT) table.

```
INSERT INTO PROJECT (PROJNO,PROJNAME,DEPTNO,RESPEMP,PRSTAFF)
      VALUES ('IF2000','USER EDUCATION','C01','000030',1.00)
```


Primary key column
Part of parent table (DEPARTMENT)
Foreign key column
Part of dependent table (PROJECT)

DEPTNO	DEPTNAME	MGRNO
C01	INFORMATION CENTER	000030

PROJNO	PROJNAME	DEPTNO	RESPEMP	PRSTAFF
IF2000	USER EDUCATION	C01	000030	1.00

Applying Update Rules: When a key value is updated, the database manager checks the implicit update rules. A key value may be updated when a parent row (primary key) or a dependent row (foreign key) is updated. If the primary key is updated due to updates made to the parent table, the database manager checks that the updated primary key is unique and is not null. All rows in the dependent table that reference the primary key must first be deleted or updated, or an error will occur. This ensures that the dependent table is not referencing an “old” primary key.

If foreign keys are updated, the database manager checks that each updated foreign key has either a matching primary key in the corresponding parent table, or that the updated foreign key is a null key. A foreign key is null when one or more of its column values are null.

Notes:

1. If a searched update contains a subquery, any table referenced in the subquery must not be a dependent of the table in the UPDATE clause. (See the *DB2 Server for VSE & VM SQL Reference* manual for more information.) In the example below, the NAME table must not be a descendent of the EMPLOYEE table:

   ```
   UPDATE EMPLOYEE
   SET SALARY = 65000.00
   WHERE LASTNAME = 'SMITH' AND EXISTS
    (SELECT * FROM NAME
     WHERE LASTNAME = 'SMITH')
   ```

2. In recoverable storage pools, when a searched update is performed against a column or set of columns, defined in a unique index, primary key, or unique constraint, uniqueness is checked after all rows have been updated. If duplicates exist, then the statement is rolled back.
3. In nonrecoverable storage pools, searched updates are sensitive to the order (ascending or descending) of the data. Since a unique index is automatically created on a primary key column, you cannot use a searched update against a primary key column. This ensures that updates to the primary key are independent of the order of the data.
4. Positioned updates are sensitive to the order (ascending or descending) of the data. Since a unique index is automatically created on a primary key column,

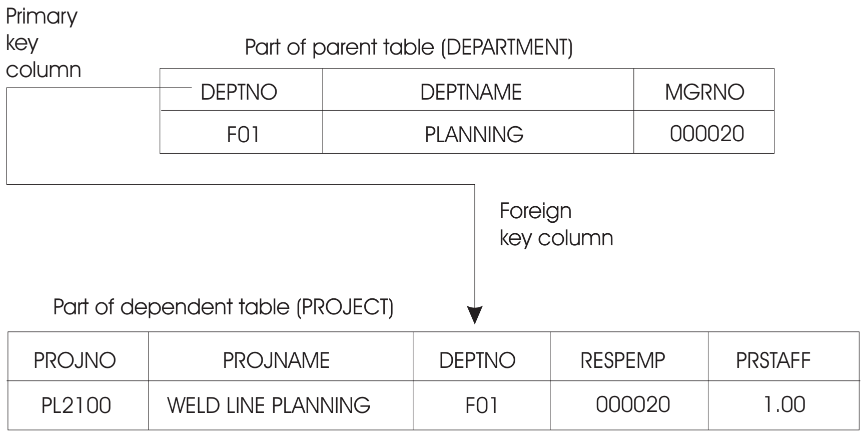
you cannot use a positioned update against a primary key column. This ensures that updates to the primary key are independent of the order of the data.

The following operations change the DEPTNO B01 to F01 in the DEPARTMENT table. Since DEPTNO is a primary key in the parent table, the foreign key with DEPTNO equal to B01 must also be changed in the dependent table (PROJECT).

```
INSERT INTO DEPARTMENT (DEPTNO,DEPTNAME,MGRNO,ADMRDEPT)
       VALUES (‘F01’,‘PLANNING’,‘000020’‘,A00’)
```

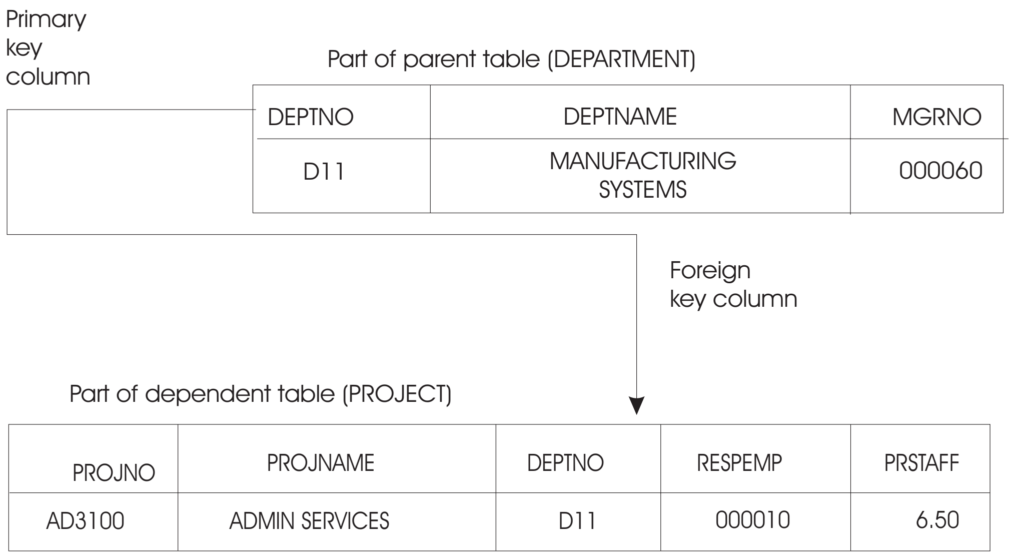
```
UPDATE PROJECT
SET DEPTNO = 'F01'
WHERE DEPTNO = 'B01'
```

```
DELETE FROM DEPARTMENT
WHERE DEPTNO = 'B01'
```



The example below changes the DEPTNO A00 to D11 for the ADMIN SERVICES project in the PROJECT table. Since DEPTNO is a primary key in the parent table, the database manager ensures that DEPTNO D11 in the dependent table (PROJECT) also exists in the parent table (DEPARTMENT).

```
UPDATE PROJECT
SET DEPTNO = 'D11'
WHERE PROJNAME = 'ADMIN SERVICES'
```


Primary key column
Part of parent table (DEPARTMENT)
Foreign key column
Part of dependent table (PROJECT)

DEPTNO	DEPTNAME	MGRNO
D11	MANUFACTURING SYSTEMS	000060

PROJNO	PROJNAME	DEPTNO	RESPEMP	PRSTAFF
AD3100	ADMIN SERVICES	D11	000010	6.50

Applying Delete Rules: The database manager does not do any checking when data is deleted from dependent tables. The delete rule in a referential constraint clause defines what action should be taken by the database manager when a parent row is deleted. The delete rules are:

- The RESTRICT rule prevents the deletion of a parent row unless all the dependent rows have been deleted first. This is the default rule.
- The SET NULL rule sets all nullable columns of the foreign key to null before deleting the parent row. At least one column of the foreign key must be nullable.
- The CASCADE rule deletes rows at each level containing dependent tables that have the referential constraint CASCADE.

Restrictions on Using Delete Rules

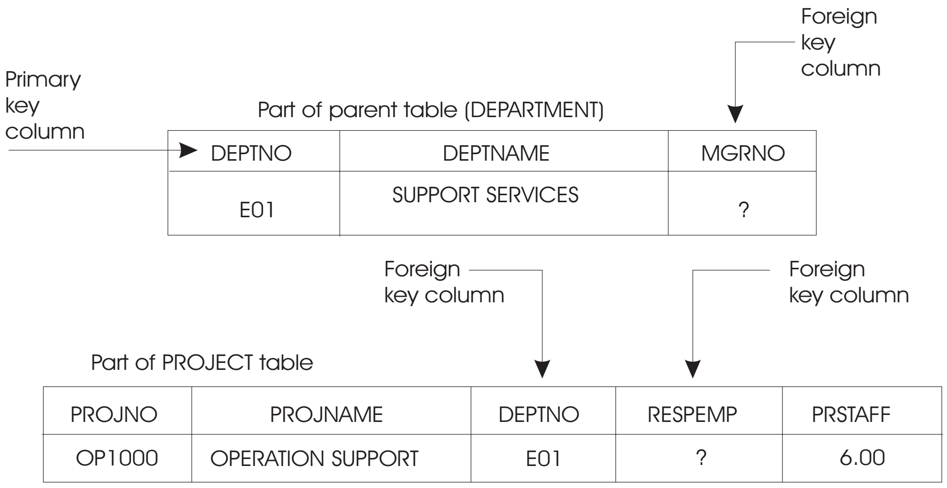
- If a table with a referential constraint of CASCADE has dependent tables that have different delete rules, such as RESTRICT, a delete operation is successful only if the object row is not found in the dependent table. If the object row is found in the dependent table, the CASCADE delete operation is rolled back. That is, the SET NULL and RESTRICT rules maintain their referential integrity between parent and dependent tables.
- A table cannot be delete-connected to itself in a referential cycle involving two or more tables.
- If a dependent table is delete-connected to the parent table through multiple delete paths, each path must have the same delete rule and this rule cannot be SET NULL.
- If a Searched DELETE contains a subquery, any table referenced in the subquery and any table that has a referential constraint of CASCADE or SET NULL with the table referenced in the subquery must not be a dependent of the table in the FROM clause. (See the *DB2 Server for VSE & VM SQL Reference* manual for more information.)

In the following example, the NAME table must not be a descendent of the EMPLOYEE table:

```
DELETE FROM EMPLOYEE
WHERE LASTNAME = 'SMITH' AND EXISTS
 (SELECT * FROM NAME
  WHERE LASTNAME = 'SMITH')
```

In the example below, the row with EMPNO equal to 000050 is deleted from the EMPLOYEE table:

```
DELETE FROM EMPLOYEE
WHERE LASTNAME = 'GEYER'
```



Because the EMPLOYEE table is a parent table and the delete rule is SET NULL in the relationship that exists between the EMPLOYEE table and the DEPARTMENT table, the database manager sets MGRNO equal 000050 to null in the DEPARTMENT table. Also, because the EMPLOYEE table is a parent table and the delete rule is SET NULL in the relationship that exists between the EMPLOYEE table and the PROJECT table, the database manager sets RESEMP equal 000050 to null in the PROJECT table. (Refer to Figure 73 on page 243 for more information.)

In the example below, the row with DEPTNO equal to D01 is deleted from the DEPARTMENT table:

```
DELETE FROM DEPARTMENT
WHERE DEPTNAME = 'DEVELOPMENT CENTER'
```

Because the DEPARTMENT table is a parent table and the CASCADE rule was set in the relationship that exists between the DEPARTMENT table and the PROJECT table, the row with DEPTNO D01 is also deleted from the PROJECT table.

Generating SQL Statements in Response to Table Modifications

When INSERT, UPDATE, and DELETE statements are issued against tables in a referential structure, the database manager generates internal SQL statements, which it uses to ensure the consistency and integrity of the data in the tables. The number of rows affected, the cost of processing the INSERT, UPDATE, DELETE, and the internally generated statements are returned in the SQLERRD fields in the SQLCA. The SQLERRD(3) gives the number of rows that were processed successfully. Upon successful completion of the DELETE statement, SQLERRD(5) contains the number of dependent rows that were successfully deleted or set to null. For other data-manipulating language (DML) statements, SQLERRD(5) is set to zero. The relative cost of processing all the statements is given in the SQLERRD(4) field.

Additional information on internally generated statements can be found in tables updated by the EXPLAIN statement. (This statement is discussed in the *DB2 Server for VSE & VM SQL Reference* manual.) To determine this information, enter the EXPLAIN statement for the INSERT, UPDATE, or DELETE statement.

Enforcing Referential Integrity

Referential constraints may be enforced as soon as they are defined, or their enforcement may be deferred. If the constraints are enforced as soon as they are defined, the insert, update, and delete integrity rules are enforced immediately when the INSERT, UPDATE, and DELETE statements are issued.

To defer the enforcement of a constraint is to render the constraint inactive so that it is not immediately enforced when the INSERT, UPDATE, and DELETE statements are issued. This is done by deactivating either the primary key, the dependent foreign key(s), or the foreign key(s). If any of these keys are deactivated, *both* the parent and the dependent tables become inactive and unavailable for data manipulation statements to general users (that is, other than the DBA and the owner of the tables). However, these tables are available for data definition statements.

When a primary key is deactivated, all active dependent foreign keys are implicitly deactivated, and the primary key index is dropped from the parent table. Both parent and dependent tables become inactive. A primary key cannot be implicitly deactivated.

With a table in an inactive state, only the owner of the table or a database administrator (DBA) can enter data manipulating language (DML) statements against it. No one can enter INSERT, UPDATE, and DELETE statements that cause statements to be generated against an inactive table.

When keys (either primary or foreign) are activated, the constraints are automatically verified. If they cannot be verified because of integrity problems, an error message is returned, and the tables remain unavailable for data manipulation statements entered by users other than the DBA or the owner.

When keys (either primary or foreign) are activated or deactivated, packages that depend on the table are invalidated. When the program is run again, it is dynamically repreprocessed.

In general, you would defer the enforcement of referential constraints between tables when large amounts of data are to be loaded, or when data is to be loaded in an order that violates the referential constraint at some point during the loading operation. For further information, refer to the *DB2 Server for VM Database Administration* manual.

The relationships among the EMPLOYEE, DEPARTMENT, and PROJECT tables are shown in Figure 73 on page 243.

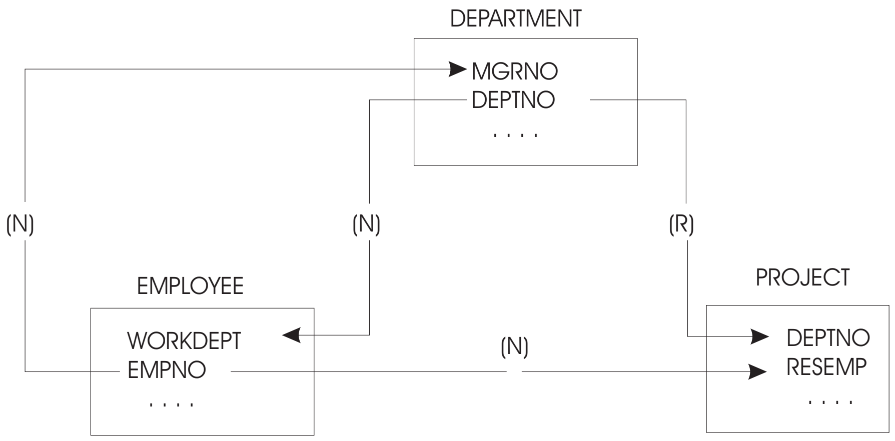


Figure 73. Relationships among the TABLES. Arrows point from primary keys in parent tables to foreign keys in dependent tables. Delete rules are labeled as (C) = CASCADE, (N) = SET NULL, (R) = RESTRICT.

```
CREATE TABLE EMPLOYEE
     (EMPNO          CHAR(6)              NOT NULL,    ◄──────── primary key
      FIRSTNME       VARCHAR(12)          NOT NULL,
      MIDINIT        CHAR(1)              NOT NULL,
      LASTNAME       VARCHAR(15)          NOT NULL,
      WORKDEPT       CHAR(3)                      ,
      PHONENO        CHAR(4)                      ,
      SALARY         DECIMAL(9,2)                 ,
      PRIMARY KEY  (EMPNO)                        )

  CREATE TABLE DEPARTMENT

     (DEPTNO         CHAR(3)              NOT NULL,    ◄──────── primary key
      DEPTNAME       VARCHAR(36)          NOT NULL,
      MGRNO          CHAR(6)                      ,    ◄──────── foreign key
      PRIMARY KEY  (DEPTNO)                       ,
      FOREIGN KEY  MNUM  (MGRNO)
          REFERENCES EMPLOYEE ON DELETE SET NULL)

  ALTER TABLE EMPLOYEE ADD FOREIGN KEY WORKNUM (WORKDEPT)
         REFERENCES DEPARTMENT ON DELETE SET NULL


  CREATE TABLE PROJECT

     (PROJNO         CHAR(6)              NOT NULL,    ◄──────── primary key
      PROJNAME       VARCHAR(24)          NOT NULL,
      DEPTNO         CHAR(3)              NOT NULL,    ◄──────── foreign key
      RESPEMP        CHAR(6)              NOT NULL,
      PRSTAFF        DECIMAL(5,2)                 ,
      PRIMARY KEY  (PROJNO)                       ,
      FOREIGN KEY DNUM (DEPTNO)
          REFERENCES DEPARTMENT ON DELETE CASCADE)
```

Then,

```
ALTER TABLE DEPARTMENT DEACTIVATE PRIMARY KEY
```

explicitly deactivates the primary key in DEPARTMENT, and implicitly deactivates the foreign keys DNUM in the PROJECT table and WORKNUM in the EMPLOYEE table. The DEPARTMENT, EMPLOYEE, and PROJECT tables become inactive.

Therefore, only the owner of these tables or the DBA can enter data manipulation statements against the tables.

However,

```
ALTER TABLE DEPARTMENT DEACTIVATE FOREIGN KEY MNUM
```

will not affect the primary key in the EMPLOYEE table. However, both the EMPLOYEE table and the DEPARTMENT table become inactive since the foreign key affects both tables. As mentioned earlier, when tables become inactive, only the owner of the tables or the DBA can enter data manipulation statements against them.

Removing Referential Constraints

To remove a referential constraint, you must drop the foreign key. When a table that contains foreign keys is dropped, the referential constraints associated with that table are removed. You can drop a table explicitly with the DROP TABLE statement, or implicitly with the DROP DBSPACE statement. You can also drop the foreign key with the ALTER TABLE statement, provided that you have the ALTER privilege on the dependent table and the REFERENCES privilege on the parent table. For descriptions of the above three statements, see Chapter 8, “Maintaining Objects Used by a Program” on page 195.

When a table that contains a primary key is dropped, the database manager drops the primary key and any foreign keys that reference the primary key and removes the referential constraints associated with those foreign keys. The ALTER TABLE statement can also be used to drop a primary key directly. To use the ALTER TABLE statement for this purpose, you must have the ALTER and REFERENCES privileges on the parent table as well as the ALTER privilege on all dependent tables.

When keys are dropped, any packages that depend on the table are invalidated. When the program is run again, it is dynamically repreprocessed. The new package no longer contains internally generated statements to enforce referential integrity.

Switching Application Servers

You can access multiple application servers from within an application program, but only one application server can be accessed at a time. Application servers can reside on the same processor as the user, or on another processor (in the TSAF collection or the SNA network). If a program is written to access multiple application servers, its package must exist on all of them.

This section discusses these authorities in more detail, and explains how to switch application servers from your application program. For a detailed discussion on establishing communication links between application requesters and application servers, refer to the *DB2 Server for VM System Administration* manual.

Identifying Switching Options

Use the CONNECT statement to switch among application servers if you want application programs to connect to different application servers while running. For more information on the CONNECT statement, see the *DB2 Server for VSE & VM SQL Reference* manual.

Comparing Switching to Other Methods

Figure 75 on page 246 and Figure 76 on page 247 show how an application program, indicated by PGM, accesses three application servers with and without switching application servers in the program. The application servers can reside on the same processor as the program or on a different processor.

The application server specified by the SQLINIT EXEC is the default application server. In Figure 76 on page 247 the default application server is DB01.

If you are *not* switching application servers in the program, to access another application server you must terminate the program, reissue the SQLINIT EXEC, and run the program again. In Figure 75 on page 246, for example, to switch from application server DB01 to application server DB02, you must terminate the program PGM, reissue SQLINIT, and run the program again.

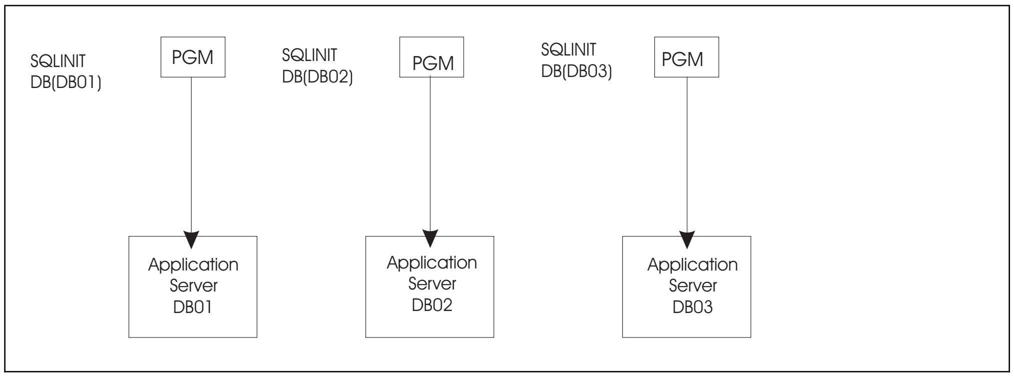


Figure 74. Switching Application Servers NOT Implemented within the Program

When you are switching application servers in the program, an application program can switch to a new application server during execution with the CONNECT statement. Like the SQLINIT method, a package for the program must exist on all application servers it accesses, and each logical unit of work must end before you switch to a different application server. See “Parameters for SQLPREP EXEC for Single and Multiple User Modes” on page 109 for the options used to preprocess the program on multiple application servers.

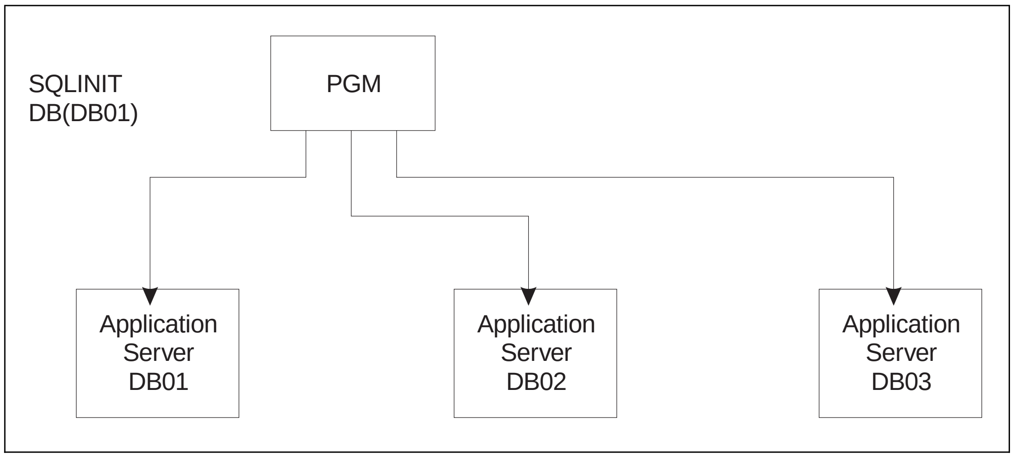


Figure 75. Switching Application Servers Implemented

Accessing a New Application Server

An application accesses the application server established by the SQLINIT command when:

- The first CONNECT statement in an application does not contain the TO clause.
- Either a COMMIT RELEASE or ROLLBACK RELEASE statement is executed and the next statement is not a CONNECT statement with the application server name specified in the TO clause.
- No CONNECT statement is executed by an application. That is, an implicit connect is performed.

The application accesses a new application server after executing:

- a CONNECT statement with the application server name specified in the TO clause.

To query the user ID and the identity of the application server to which you are currently connected, as well as the relational database management system (RDBMS) running the application server, do one of the following:

From within an application program, enter either:

- A null CONNECT statement, which returns the user ID and the identification of the RDBMS and the application server in the SQLCA. Refer to the discussion of the CONNECT statement in the *DB2 Server for VSE & VM SQL Reference* manual for a description of the format and location of the information that is returned.
- A SELECT statement requesting the USER and CURRENT SERVER, which returns the user ID and the identification of the application server in the host variables associated with the USER and CURRENT SERVER special registers.

From your terminal, enter:

- An SQLQRY command, which displays the user ID and the identification of the RDBMS and the application server on the terminal. Refer to the discussion of the SQLQRY command in the *DB2 Server for VM Database Administration* manual for a description of the format of the information that is returned and the restrictions on the use of the SQLQRY command.

Illustrating Sample Code

Figure 76 shows how an application can take advantage of switching application servers.

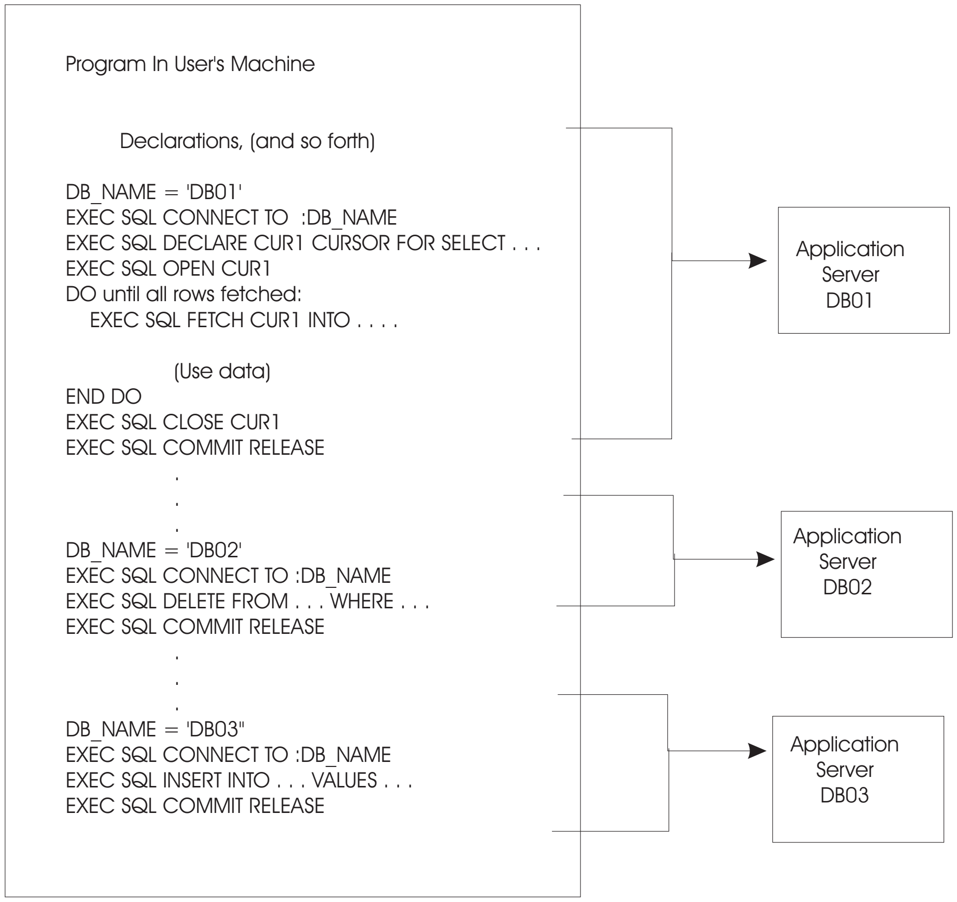

```
Program In User's Machine


        Declarations, (and so forth)

DB_NAME = 'DB01'
EXEC SQL CONNECT TO  :DB_NAME
EXEC SQL DECLARE CUR1 CURSOR FOR SELECT . . .
EXEC SQL OPEN CUR1
DO until all rows fetched:
    EXEC SQL FETCH CUR1 INTO . . . .

                (Use data)
END DO
EXEC SQL CLOSE CUR1
EXEC SQL COMMIT RELEASE
                .
                .
                .
DB_NAME = 'DB02'
EXEC SQL CONNECT TO :DB_NAME
EXEC SQL DELETE FROM . . . WHERE . . .
EXEC SQL COMMIT RELEASE
                .
                .
                .
DB_NAME = 'DB03"
EXEC SQL CONNECT TO :DB_NAME
EXEC SQL INSERT INTO . . . VALUES . . .
EXEC SQL COMMIT RELEASE
```

Figure 76. Pseudocode Illustrating How to Switch Application Servers

In the above example, the application connects to three application servers (DB01, DB02, and DB03), and performs a series of operations when accessing each one. When accessing DB01, the program retrieves information from the application server (with the FETCH statement) and processes the information.

Next, it accesses DB02, and some rows are deleted from a table; then accesses DB03, and rows are inserted into a table.

Preprocessing the Program on Multiple Application Servers

An application program that allows access to multiple application servers with the CONNECT statement must exist on every application server that the program is to access. The SQLPREP EXEC provides the option to preprocess a program on multiple application servers with the DBFile or DBList parameter. However, an application using either of these parameters is preprocessed on one application server at a time. Each of the application servers provided in the DBFile or DBList parameter preprocesses the program separately and consecutively, and generates a source listing. These source listings are concatenated.

When an application that accesses different application servers is being preprocessed, certain warnings may be issued by the preprocessor. For example, if TABLE1 exists in DB01, but your application program is preprocessed against DB02 or DB03, you will receive warning messages that the table does not exist in those application servers. If your program does not access TABLE1 in DB02 or DB03, these messages can be ignored; however, if TABLE1 will be accessed in either DB02 or DB03, you must create TABLE1 in the accessed application server.

You should repreprocess the program on the application servers that you updated before executing the program. If you are using the preprocessing option CTOKEN=NO, you only need to preprocess the application program on one application server. If you specify CTOKEN=YES, you must repreprocess on all application servers that the program accesses to get the same timestamp.

During execution, the table being referenced in an SQL statement may reside in the currently accessed application server or in another application server. In fact, a table of the same name, but with different attributes, may be in the application server. The database manager issues a warning message that there are inconsistencies, but preprocessing will continue. The statement causing the warning remains in the package, and will only cause an application failure if it is referenced at run time. Conditions that will generate a warning and the corresponding SQLCODE include:

- Column *column* was not found in table *owner.table*. (SQLCODE = +205 and SQLSTATE='01533')
- Incompatible data types were found in an expression or compare operation. (SQLCODE = +401 and SQLSTATE='01578')
- The string representation of a date/time value has invalid syntax. (SQLCODE = +180 and SQLSTATE='01572')

For more information on preprocessing against unlike application servers, refer to "Preprocessing the Program" on page 106.

Appendix A. Using SQL in Assembler Language

Contents

Using ARIS6ASC, an Assembler Language Sample Program 250
Acquiring the SQLDSECT Area 250
Imposing Usage Restrictions on the SQLDSECT Area 251
Rules for Using SQL Statements in Assembler Language 253
   Identifying Rules for Case 253
   Declaring Host Variables 253
   Embedding SQL Statements 255
   Using the INCLUDE Statement 256
   Using Host Variables in SQL Statements 256
   Using DBCS Characters in Assembler Language 256
Handling SQL Errors 256
Using Dynamic SQL Statements in Assembler Language 257
Defining DB2 Server for VM Data Types for Assembler Language 258
Using Reentrant Assembler Language Programs 260
| Using Stored Procedures 265

Using ARIS6ASC, an Assembler Language Sample Program

ARIS6ASC is an assembler language sample program for VM systems that is shipped with the DB2 Server for VM product. It resides on the production disk for the base product. You may find it useful to print this sample program before going through this appendix as the hard copy will provide an illustration for many of the topics discussed here.

Note, for example, how the program satisfies the requirements of the application prolog and epilog. Near the beginning of the program, all the host variables are declared, the SQLDSECT area is acquired (and set to zero), and error handling is defined. Near the logical end of the program, the database changes are rolled back, to assure that the database remains consistent for each use of the sample program. (For your own applications, of course, you will enter a COMMIT statement.)

The DS and DC statements for the host variables were determined by referring to Figure 80 on page 258, which shows the assembler representation for each of the DB2 Server for VM data types supported by assembler programs. When you are coding your own applications, you must obtain the data types of the columns that your host variables interact with. This can be done by querying the catalog tables. These tables are described in the *DB2 Server for VSE & VM SQL Reference* manual.

Acquiring the SQLDSECT Area

The assembler preprocessor puts all the variables and structures it generates within a DSECT named SQLDSECT. The preprocessor also generates a fullword variable called SQLDSIZ, which contains the length of the SQLDSECT DSECT in bytes. Thus, for all assembler programs, you must provide an area of size SQLDSIZ, set the area to zero, and provide addressability to the SQLDSECT DSECT.

Use CMSSTOR OBTAIN macros to acquire storage. If you want to use CMS OS or DOS simulation, you can use the following macros:

- GETMAIN for a CMS OS/VS program
- GETVIS for a CMS VSE program.

Note that SQLDSIZ is in bytes, and that you need the length in doublewords for the CMSSTOR macro.

Figure 77 on page 251 shows sample pseudocode that can be used to acquire the SQLDSECT area.

```
TESTNAME CSECT
         STM   14,12,12(13)
         BALR  regx,0
         USING *,regx
         LA    regy,7(0,0)
         A     regy,SQLDSIZ
         SRL   regy,3
         (save computed doubleword length for CMSSTOR RELEASE)
         LR    0,regy
         CMSSTOR OBTAIN,DWORDS=(0)
         LR    regz,1
         USING SQLDSECT,regz
         (add code to zero the area)
           .
           .
           .
         (add code to free storage by CMSSTOR RELEASE)
         END
```

This area is needed only until the program is finished executing all SQL statements, at which time the area should be freed (CMSSTOR RELEASE).

Figure 77. Acquiring a Dynamic SQLDSECT Area

If you know the approximate size of the SQLDSECT that will be generated in your program, you can define an area (AREA DS CL*xxxx*) within your program and use this as your SQLDSECT area. Your program will not be re-entrant if you use this method.

The preprocessor generates the code to calculate SQLDSIZ directly in front of the last statement in the source program. Make the last statement an END statement.

If the assembler preprocessor is run with the CHECK option, SQLDSECT and SQLDSIZ are not generated. Errors occur if you attempt to assemble the output generated by the preprocessor when the CHECK option is specified. See Chapter 4, “Preprocessing and Running a Program” on page 103 for more information about for more information about preprocessor parameters.

Note: You must provide a save area for all assembler programs.

Imposing Usage Restrictions on the SQLDSECT Area

There are two performance considerations about the SQLDSECT area that you should be aware of:

- Acquire and clear the SQLDSECT area only once.

  The example shown in Figure 77 assumes that the TESTNAME is entered once. If TESTNAME is a subroutine of a mainline module, and if TESTNAME is invoked many times, you should acquire the SQLDSECT in the mainline module. The following is an example of how this may be done:

  1. In TESTNAME add an entry card as follows:

     ```
     ENTRY SQLDSIZ
     ```

This allows the field containing the size information for the SQLDSECT area to be accessed externally.

2. The mainline module can now access the size information using the following sequence:

```
 L  regy,=V(SQLDSIZ)       GET POINTER TO FIELD CONTAINING SIZE
 LA 0,7(0,0)               ROUND UP FOR DOUBLEWORDS
 A  0,0(,regy)             SET LENGTH + 7
 SRL 0,3                   CONVERT BYTES TO DOUBLEWORDS
 CMSSTOR OBTAIN,DWORDS=(0) GET STORAGE
 LR regy,1                 SAVE POINTER TO SQLDSECT
(Zero the SQLDSECT area.)
```

3. When the mainline module calls TESTNAME, it should pass the pointer to the SQLDSECT. Assuming that regy still contains the pointer, TESTNAME simply issues the appropriate USING statement as follows:

```
TESTNAME CSECT
         STM   14,12,12(13)
         BALR  regx,0
         USING SQLDSECT,regy
            .
            .
```

Depending on how many times TESTNAME is invoked, the above could be an important performance consideration. Using the technique reduces the path length because you only need to get, clear, and free storage once. Further, the cleared SQLDSECT area serves as a “first pass” flag for the batch/ICCF and CMS resource adapters. Thus, by letting the mainline module initialize the SQLDSECT area only once, you further avoid significant resource adapter “first pass” processing.

- Provide only one SQLDSECT area.

  If you structure an application so that the mainline module invokes several modules that each contain SQL commands, you need to provide only one SQLDSECT area. The area that you provide must be the largest SQLDSECT area. For example, suppose the mainline module invokes MODA and MODB, each of which contains SQL commands, but which have different SQLDSECT area requirements. The mainline module must satisfy the larger of the two requirements.

  By inserting the following into MODA and MODB, you could allow the mainline module to calculate the SQLDSECT area requirement:

```
INTO MODA:                       INTO MODB:


MODADSIZ DC A(SQLDSIZ)           MODBDSIZ DC A(SQLDSIZ)
         ENTRY MODADSIZ                   ENTRY MODBDSIZ
           .                                .
           .                                .
```

  The mainline module could reference the above entries and provide for the maximum SQLDSECT area. The following example shows how the mainline module could determine the requirement of MODA:

```
L  regy,=V(MODADSIZ)  GET POINTER TO POINTER FIELD
L  regy,0(,regy)      GET POINTER TO FIELD CONTAINING SIZE
L  0,0(,regy)         SET LENGTH.
```

The same technique could be used to access the SQLDSIZ of MODB. Given the two SQLDSIZ values, the mainline module should provide for a SQLDSECT area equal in size to the greater SQLDSIZ value.

By using only one SQLDSECT area for your application, you reduce the storage requirement and minimize the first pass processing.

Rules for Using SQL Statements in Assembler Language

This section lists the rules for embedding SQL statements within an assembler program.

Note: OPSYN and ICTL assembler statements may not be used.

Identifying Rules for Case

Uppercase must be used for all SQL statements, except for text within quotation marks, which will be left in the original case.

Declaring Host Variables

The following example shows an SQL declare section for an assembler program:

```
Col. 1         Col.16                                        Col. 72
|              |                                                   |
|              |                                                   |
LABEL EXEC SQL BEGIN DECLARE SECTION
AA       DS    F
BB       DC    H'3'      comment
* comment card or
* comment section
CC       DC    CL80'xxxx......................................xxxx*
               xxxx...............xxxxx'
XYZ      DSECT
DD       DS    D
EE       DS    CL5
FF       DS    H,CL40
         ORG   FF
GG       DS    H
HH       DS    CL40          comment
*                            continued comment
II       DS    PL5
JJ       DC    PL5'123.45'
KK       DS    0H
LL       DS    CL12
XX       DS    CL10                                                *
               continuation of comment
LABEL2   EXEC       SQL   END DECLARE SECTION   comment
```

The preceding example illustrates the following rules:

1. All assembler variables that are to be used in SQL statements must be declared, and their declarations must appear within one or more sections that begin with:

   ```
   EXEC SQL BEGIN DECLARE SECTION
   ```

and end with:

```
EXEC SQL END DECLARE SECTION
```

Each of these two statements must be totally contained on one line.

Note: There is no semicolon delimiter at the end of the SQL statements. There may be a label on either of the statements, and host language comments are allowed after the statements.

2. Host language comments are allowed on any statement within the SQL declare section, as are host language comment line images (* in column 1).
3. The assembler preprocessor processes the statements in the declare section as follows:
   a. If there is no label, the preprocessor ignores the statement and goes on to the next.
   b. If there is a label, but the opcode is not DS or DC, the preprocessor ignores the statement and goes on to the next.
   c. If there is a label and a DS or DC opcode, the operand is checked. The operand must be an acceptable data type, as shown in Figure 80 on page 258. Here are some examples:

      ```
      F
      F'5'
      H
      H'100'
      CL255
      CL5'ABCDE'
      H,CL5
      H'5',CL5'ABCDE'
      D
      D'2.5E10'
      PL2
      PL5'123.45'
      P'123'
      P'123.45'
      P'1234'
      P'123.456'
      H,CL32767
      ```

      The first character of the operand may also be zero and used as follows:

      ```
      0H
      0F
      0D
      0C
      ```

      In this case, the line is ignored and the next line is processed.

      If there are no errors at this stage, the variable is validly defined as a host variable. If there are errors, the line is flagged as an error, and the next line is processed.
4. The database manager allows host variable names, statement labels, and SQL descriptor area names of up to 256 characters in length, subject to any assembler language restrictions mentioned in this appendix.
5. The opcode for a declare statement must be coded on the first line of the statement. Because the line length is 71, this limits the length of host variable names to 68 characters.

6. Continuations are allowed by coding a non-blank character in column 72 of the line to be continued, and coding the continuation anywhere from columns 16 to 71 inclusive on the next line, leaving 1-15 blank.
7. Continuation of *tokens* (the basic syntactical units of a language) is allowed from one line to the next, by coding the first part of the token up to column 71 of the line to be continued, and coding the second part of the token from column 16 on the continuation line. If either column 71 of the continued line or column 16 of the continuation line is blank, the token will not be continued. See the *DB2 Server for VSE & VM SQL Reference* manual for a discussion on tokens.
8. The declare section can be anywhere that a normal DS or DC can be used. Because the assembler preprocessor is a two-pass operation, the declare section can come after the SQL statements that use the host variables.
9. There can be more than one SQL declare section in a program.
10. Host variable names cannot contain variable symbols (for example, &ABCDEFG, &SYSNDX, &SYSPARM). These names must be resolved at preprocessing time. Variable symbols will be resolved at assembly time.

Embedding SQL Statements

The following are the rules for embedding SQL statements within assembler programs:

1. Each SQL statement must be preceded by EXEC SQL, which must be on the same line. Only blanks can appear between the EXEC and SQL. There must not be a semicolon (;) delimiter on the SQL statement.
2. The first line of an SQL statement can have a label beginning in column 1. If there is no label, the statement must begin in column 2 or greater.
3. Rules for continuation of statements and tokens are the same as those described for host variables.
4. No host language comments are allowed within an SQL statement. Any such comments are considered part of the SQL statement.
5. If an entire statement must be contained on one line, there cannot be SQL comments embedded in the statement. There are three such statements:
   - BEGIN DECLARE SECTION
   - END DECLARE SECTION
   - INCLUDE.
6. Avoid using labels or variable names that begin with SQL, ARI, or RDI. Also avoid names beginning with PID, PBC, PA, PB, PC, PD, PE, PL, or PN where these letters are followed by numbers. These names may conflict with names generated by the assembler preprocessor.
7. All SQL statements must be in one CSECT.
8. The EXEC SQL must be coded on the first line of the statement. Because the line length is 71, this limits the length of a LABEL to 62 characters.

Using the INCLUDE Statement

To include external secondary input, specify the following at the point in the source code where the secondary input is to be included:

```
EXEC SQL INCLUDE text_name
```

is the A-Type source member of a VSE library. *Text_name* is the file name of a CMS file with an "ASMCOPY" file type, located on a CMS minidisk accessed by the user.

The INCLUDE statement must be completely contained on one line. There may be a label on the command, and host language comments are allowed after the command.

Using Host Variables in SQL Statements

When you place host variables within an SQL statement, you must put a colon (:) in front of every host variable, to distinguish them from the SQL identifiers (such as a column name). When the same variable is used outside of an SQL statement, do not use a colon.

A host variable can represent a data value, but not an SQL identifier. For example, you cannot assign a character constant, such as "MUSICIANS", to a host variable, and then use that host variable in a CREATE TABLE statement to represent the table name. The following pseudocode sequence is invalid:

```
IT = ' MUSICIANS '
CREATE TABLE :TT (NAME ...      Incorrect
```

Using DBCS Characters in Assembler Language

The rules for the format and use of DBCS characters in SQL statements are the same for assembler language as for other host languages supported by the database manager. For a discussion of these rules, see "Using a Double-Byte Character Set (DBCS)" on page 46.

Assembler language does not provide a way to define graphic host variables. If you want to add graphic data to or retrieve it from DB2 Server for VM tables, you must execute the affected statements dynamically. By doing so, the data areas that are referenced by each statement can be described in an SQLDA. In the SQLDA, you must set the data type of the areas containing graphic data to one of the graphic data types. For a discussion of the SQLDA, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

Handling SQL Errors

There are two ways to declare the SQL communication area (SQLCA):

- You can code the following statement in your source program:

  ```
  EXEC SQL INCLUDE SQLCA
  ```

  The preprocessor replaces this with a declaration of the SQLCA structure.
- You may declare the SQLCA directly, as shown in Figure 78 on page 257.

```
SQLCA    DS    0F
SQLCAID  DS    CL8
SQLCABC  DS    F
SQLCODE  DS    F
SQLERRM  DS    H,CL70
SQLERRP  DS    CL8
SQLERRD  DS    6F
SQLWARN  DS    0C
SQLWARN0 DS    CL1
SQLWARN1 DS    CL1
SQLWARN2 DS    CL1
SQLWARN3 DS    CL1
SQLWARN4 DS    CL1
SQLWARN5 DS    CL1
SQLWARN6 DS    CL1
SQLWARN7 DS    CL1
SQLWARN8 DS    CL1
SQLWARN9 DS    CL1
SQLWARNA DS    CL1
SQLSTATE DS    CL5
```

Figure 78. SQLCA Structure (in Assembler)

You must not declare the SQLCA within the SQL declare section. The meaning of the fields is explained in *DB2 Server for VSE & VM SQL Reference* manual.

You may find that the only variable in the SQLCA you really need is SQLCODE. If this is the case, declare just the SQLCODE variable, and invoke NOSQLCA support at preprocessor time.

Using Dynamic SQL Statements in Assembler Language

An SQLDA structure may be required for dynamically executed SQL statements. There are two ways to declare the SQLDA structure:

- You can code the following statement in your source program:

  ```
  EXEC SQL INCLUDE SQLDA
  ```

  The preprocessor replaces this with a declaration of the SQLDA structure.
- You can declare the SQLDA directly, as shown in Figure 79 on page 258.

```
SQLDA     DSECT
SQLDAID   DS     CL8
SQLDABC   DS     F
SQLN      DS     H
SQLD      DS     H
SQLVAR    DS     0F
SQLVARN   DSECT
SQLTYPE   DS     H
SQLLEN    DS     0H
SQLPRSCN  DS     CL1
SQLSCALE  DS     CL1
SQLDATA   DS     A
SQLIND    DS     A
SQLNAME   DS     H,CL30
&SYSECT   CSECT
```

Figure 79. SQLDA Structure (in Assembler)

The SQLDA structure must not be declared within an SQL declare section. When you specify INCLUDE SQLDA, the assembler preprocessor generates a CSECT statement at the end of the SQLDA. This CSECT is generated with the name of the CSECT currently active in your program.

You must not specify a constant string on a PREPARE or EXECUTE IMMEDIATE statement. You can only specify a host variable defined as a variable-length character string:

```
EXEC SQL PREPARE S1 FROM :STRING1
EXEC SQL EXECUTE IMMEDIATE :STRING1
             .
             .
EXEC SQL BEGIN DECLARE SECTION
STRING1   DS   H,CLxxxxx    (xxxxx <= 8192)
EXEC SQL END DECLARE SECTION
```

The halfword of STRING1 must contain the length of the string, and the character portion must contain the string itself when the PREPARE or EXECUTE IMMEDIATE statement is executed.

See Appendix B of the *DB2 Server for VSE & VM SQL Reference* manual for more information on the individual fields within SQLDA.

Defining DB2 Server for VM Data Types for Assembler Language

Figure 80 (Page 1 of 3). DB2 Server for VM Data Types for Assembler

Description	DB2 Server for VM Keyword	Equivalent Assembler Declaration
A binary integer of 31 bits, plus sign.	INTEGER or INT	F
A binary integer of 15 bits, plus sign.	SMALLINT	H

Figure 80 (Page 2 of 3). DB2 Server for VM Data Types for Assembler

Description	DB2 Server for VM Keyword	Equivalent Assembler Declaration
A packed decimal number, precision *p*, scale *s* (1≤*p*≤31 and 0≤*s*≤*p*). In storage the number occupies a maximum of 16 bytes. Precision is the total number of digits. Scale is the number of digits to the right of the decimal point.	DECIMAL[(*p*[,s])] or DEC[(*p*[,*s*])](1) 1	PL*n*[‘decimal constant’] or P‘decimal constant’ For declarations using PL*n*, the precision is 2*n*-1 (*n* is the number of bytes). For the declarations using P, the length of the decimal constant, excluding the decimal point and sign, is the precision. For the declarations using P or PL, the scale is that of the decimal constant. For the declarations using P, the decimal constant must be specified. For the declarations using PL*n*, the decimal constant is optional. If it is not specified, the scale is 0.
A single precision (4-byte) floating-point number in short System/390 floating-point format.	REAL or FLOAT(p), 1 ≤ *p* ≤ 21	E
A double precision (8-byte) floating-point number in long System/390 floating-point format.	FLOAT or FLOAT(*p*), 22 ≤ *p* ≤ 53 or DOUBLE PRECISION	D
A fixed-length character string of length *n* where 0 < *n* ≤ 254.	CHARACTER[(*n*)] or CHAR[(*n*)]	CLn
A varying-length character string of maximum length *n*. If *n* > 254 or ≤ 32,767; this data type is considered a long field. (See “Using Long Strings” on page 41.) (Only the actual length is stored in the database.)	VARCHAR(*n*)	H,CL*n*
A varying-length character string of maximum length 32 767 bytes.	LONG VARCHAR	H,CL*n*
A fixed-length string of *n* DBCS characters, where 0 < *n* ≤ 127.	GRAPHIC[(*n*)]	Not supported.
A varying-length string of *n* DBCS characters. If *n* > 127 or ≤ 16 383, this data type is considered a long field. (See “Using Long Strings” on page 41.)	VARGRAPHIC(*n*)	Not supported.
A varying-length string of DBCS characters of maximum length 16 383.	LONG VARGRAPHIC	Not supported.
A fixed or varying-length character string representing a date. The minimum and maximum lengths vary with both the format used and whether it is an input or output operation. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	DATE	CL*n* or H,CL*n*
A fixed or varying-length character string representing a time. The minimum and maximum lengths vary with both the format used and whether it is an input or output operation. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	TIME	CL*n* or H,CL*n*

Figure 80 (Page 3 of 3). DB2 Server for VM Data Types for Assembler

Description	DB2 Server for VM Keyword	Equivalent Assembler Declaration
A fixed or varying-length character string representing a timestamp. The lengths can vary on input and output. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	TIMESTAMP	CLn or H,CLn

Notes:

1. NUMERIC is a synonym for DECIMAL, and may be used when creating or altering tables. In such cases, however, the CREATE or ALTER function will establish the column (or columns) as DECIMAL.

Using Reentrant Assembler Language Programs

A reentrant program has the characteristic of dynamic allocation of space for data and save areas. This reentrant characteristic can be used in assembler programs. In this case, the data and save areas are allocated in a calling (driver) program and passed to a called (reentrant) program as parameters. Storage for these areas need not be allocated in the called program.

A convenient use for reentrancy is the use of an SQLDA structure declared as a DSECT in the calling program. This, in combination with an INCLUDE SQLDA statement in the called program, permits the passing back of values, extracted by a SELECT/FETCH in the called program, in a clean and simple manner. A DESCRIBE statement can be used by the called program to fill the SQLDA structure, or it can be hand-filled in the driver program. Other SQL statements (for example, INSERT, DELETE, UPDATE) utilize a single data location to communicate just an SQLCODE.

If statement results other than the SQLCODE are desired, an SQLCA structure can be allocated in the driver program. However, unlike the SQLDA structure allocation by a DSECT, the fields of the SQLCA structure must be hard-coded into the driver, because the driver will not be preprocessed. An INCLUDE SQLCA statement, within a DSECT, is then required in the called program. SQLCA communication between the two programs can be achieved by passing the address of the first field of the SQLCA structure to the reentrant program.

The “Locda DSECT” structure is hard-coded in the Driver Program, instead of being defined by an “EXEC SQL INCLUDE SQLDA”, so that there is no need to preprocess the Driver Program. This example assumes there is only a single host variable returned by the FETCH. For production application programming, it is recommended that macros be created for defining the SQLCA and SQLDA structures (with optional DSECT statement) when used in programs that will *not* be preprocessed.

The following are skeleton programs illustrating the use of the SQLDA structure, and a single data location for communicating SQLCODEs. The reentrant example illustrates only a FETCH statement. If more than one “action” statement (INSERT, DELETE, and so on) is used, then various flags are needed to direct access to the individual operations. The required modifications to include an SQLCA structure follow these skeletons.

```
Driver   CSECT ,              Driver Program
* Standard Linkage Conventions ...
         STM   R14,R12,12(R13)     Save callers registers
         :
Qstring  DC   H'57',CL57'SELECT DESCRIPTION FROM INVENTORY WHERE QONHA $
               ND < 100'      SQL Statement to be executed
         :
         LA    R13,Save1      Subroutine Register Savearea Address
* Forward and backward chain saveareas together
         :
         LA    R4,1           '1' indicates 1st call to subroutine
         ST    R4,Loccode     SQLCODE returned from subroutine
*                             (Also used as 1st call switch)
         :
* Create SQLDA structure to pass to subroutine:
* (OR Subroutine could fill in by using DESCRIBE)
         LA    R4,LSQLDA      Point R4 at SQLDA area
         USING Locda,R4       reference SQLDA fields
         :
         LA    R7,Outarea+1   Address where DESCRIPTION stored
         ST    R7,Locdata
         LA    R7,Indaddr     Address where Indicator Value stored
         ST    R7,Locind
* NOTE: Setting of other SQLDA fields is not shown, but may be required
         :
*
* Loop to call reentrant subroutine (Loop needed for Cursor operation)
LOOP     EQU   *
*
* Blank Output area for next FETCH result:
         :
         LA    R1,Parmlist    Parms passed to subroutine through R1
         L     R15,=V(Reentran)    Load Subroutine Entry Point address
         BALR  R14,R15        Call Reentrant Subroutine
         CLC   Loccode,F0     Any error from subroutine ?
         BE    FetchOK        No, continue as normal
         CLC   Loccode,F100   Cursor EOF occurred ???
         BE    Final          Yes, all done.
         B     Errchk         No, some kind of error, go handle.
*
FetchOK  EQU   *
* Test indicator values for NULL, etc, and handle as appropriate:
         :
*
* Output result from a Fetch:   (Data conversion may be necessary)
         :
*
* Branch back to Loop for another Fetch
         B     LOOP
         :
Errchk   EQU   *
* Handle errors returned by subroutine.
         :
Final    EQU   *
* Program complete, restore registers and return to caller
         :
         BR    R14            Return to caller
         :
```

Figure 81 (Part 1 of 2). Driver Program

```
* Declare Section
         :
         :
F0       DC    F'0'           'NO ERRORS'  retcode from subroutine
F100     DC    F'100'         'CURSOR EOF' retcode from subroutine
         :
SaveRA   DS    18F            register savearea for use by Resource
*                             ... Adapter when called by subroutine
Save1    DS    18F            subroutine register savearea
Loccode  DS    F              SQLCODE variable passed to subroutine
*                             (return code from subroutine)
         :
Parmlist DS    0D             Subroutine Parameter List:
         DC    A(Qstring)     SQL Statement to execute
         DC    A(LSQLDA)      Local SQLDA area
         DC    A(Loccode)     Return Code from subroutine
         DC    A(Hostvar)     Host Variable Workarea
         DC    A(SaveRA)      Resource Adapter register savearea
         :
Indaddr  DS    F              Indicator area
Outarea  DS    CL80           Fetch value return area
         :
LSQLDA   DS    CL500          Local SQLDA area
Hostvar  DS    CL500          Subroutine Host Variable workarea
         :
Locda    DSECT ,              Describes SQLDA fields
Locdaid  DS    CL8
Locdabc  DS    F
Locn     DS    H
Locd     DS    H
Locvar   DS    0F              assumes one one Host Variable used
Loctype  DS    H
Loclen   DS    0H
Locprcsn DS    X
Locscale DS    X
Locdata  DS    A
Locind   DS    A
Locname  DS    H,CL30         ...end of Local SQLDA area
         :
         :
         END Driver           ...end of Driver Program
```

Figure 81 (Part 2 of 2). Driver Program

```
Reentran CSECT ,              Reentrant Subroutine
* Standard Linkage Conventions. Register Savearea address in R13.
         STM   R14,R12,12(R13)     Save callers registers
         :
* Get Parameter addresses
         L     R3,0(0,R1)     Point to Qstring
         L     R4,4(0,R1)     Point to SQLDA area
         USING SQLDA,R4       Reference SQLDA fields
         L     R5,8(0,R1)     Point to Loccode (SQLCODE) return code
         USING LSQLCODE,R5    Reference Passed SQLCODE variable
         L     R6,12(0,R1)    Point to Hostvar workarea
         USING Hostvar,R6     Reference Hostvar workarea
         LR    R7,R13         R7 points to callers savearea
         L     R13,16(0,R1)   Point R13 at "our" passed savearea ...
*                             ... for use by Resource Adapter calls
* Forward and backward chain saveareas together
         ST    R13,8(0,R7)    Caller savearea points to "our" savearea
         ST    R7,4(0,R13)    "our" savearea points to caller savearea
         :
* Check if this is first call to subroutine:
         CLC   F0,0(R5)       If NOT zero, it is first call
         BE    Next           Is zero - NOT first call
    EXEC SQL CONNECT ...
         :
         LH    R1,0(R3)       Get length of Qstring
         LA    R1,1(R1,0)     Length minus 1 for EXecute ...
*                             ... plus 2 for length Halfword ...
*                             ... equals length + 1.
         EX    R1,MOVQSTR     move length & Qstring to Hostvar area
    EXEC SQL PREPARE S1 FROM :QSTRING
         CLC   SQLCODE,F0     Any errors ?
         BNE   Exit           Yes, return it to caller
         :
* Fill in passed SQLDA structure (possibly with DESCRIBE),
* if not done in Driver program.
         :
    EXEC SQL DECLARE C1 CURSOR FOR S1
         :
    EXEC SQL OPEN C1
         :
Next     EQU   *
    EXEC SQL FETCH C1 USING DESCRIPTOR SQLDA
         CLC   SQLCODE,F100   Cursor EOF reached ??
         BNE   Exit           No, return to caller (even if error)
         :
*
* All Fetched, Close Cursor before returning
Done     EQU   *
    EXEC SQL CLOSE C1
         CLC   SQLCODE,F0     Any error ?
         BNE   Exit           Yes, return error to caller
*
* Return 'CURSOR EOF' return code to caller
         MVC   0(4,R5),F100   R5 points to Loccode
         :
Exit     EQU   *              Return to caller
         :
```

Figure 82 (Part 1 of 2). Reentrant Program

```
* Restore registers and return to caller
* Our return code is in Loccode
         L     R13,4(0,R13)        Load callers savearea address
         LM    R14,R12,12(R13)     Restore callers registers
         BR    R14                 Return to caller
         :
* Declare section
MOVQSTR  MVC   QSTRING(1),0(R3)    EXecuted during 1st call
F0       DC    F'0'           'NO ERRORS'  retcode from subroutine
F100     DC    F'100'         'CURSOR EOF' retcode from subroutine
         :
* Include the SQLDA DSECT
    EXEC SQL INCLUDE SQLDA
         :
Hostvar  DSECT ,              Passed Host Variable Workarea
QSTRING  DS   CL500
         :
LSQLCODE DSECT ,              Passed SQLCODE variable
SQLCODE  DS   F
         :
         END   Reentran       ...end of Reentrant Subroutine
```

Figure 82 (Part 2 of 2). Reentrant Program

To include full SQLCA communications between the Driver Program and the Reentrant program, you must modify both programs.

In the Driver program, replace the "Loccode" variable definition with an "SQLCA" structure definition and update the 3rd address constant in the "Parmlist", as follows:

```
         :
Save1    DS    18F            subroutine register savearea
Locca    DS    0D             SQLCA structure passed to subroutine
Loccaid  DS    CL8
Loccabc  DS    F
Loccode  DS    F              SQLCODE
Locerrm  DS    H,CL70
Locerrp  DS    CL8
Locerrd  DS    6F
Locwarn  DS    0C
Locwarn0 DS    CL1
Locwarn1 DS    CL1
Locwarn2 DS    CL1
Locwarn3 DS    CL1
Locwarn4 DS    CL1
Locwarn5 DS    CL1
Locwarn6 DS    CL1
Locwarn7 DS    CL1
Locwarn8 DS    CL1
Locwarn9 DS    CL1
LocwarnA DS    CL1
Locstate DS    CL5            ... end of local SQLCA structure
         :
Parmlist DS    0D             Subroutine Parameter List:
         DC    A(Qstring)     SQL Statement to execute
         DC    A(LSQLDA)      Local SQLDA area
         DC    A(Locca)       SQLCA returned from subroutine  <----
         DC    A(Hostvar)     Host Variable Workarea
         DC    A(SaveRA)      Resource Adapter register savearea
         :
```

In the Reentrant program, change from just referencing the "SQLCODE" variable, through the "LSQLCODE DSECT", to referencing the full "SQLCA" structure, through the "PASSEDCA DSECT", as follows:

```
         :
         L     R5,8(0,R1)     Point to Locca (SQLCA) return codes
         USING PASSEDCA,R5    Reference Passed SQLCA structure
         :
         :
PASSEDCA DSECT ,              Passed SQLCA structure
    EXEC SQL INCLUDE SQLCA         include SQLCA field definitions
         :
```

Figure 83. SQLCA Changes for Driver/Reentrant Programs

Using Stored Procedures

The following example shows how to define the parameters in a stored procedure that uses the GENERAL linkage convention. PLIST=OS must be specified.

```
*******************************************************************
*  CODE FOR AN ASSEMBLER LANGUAGE STORED PROCEDURE THAT USES      *
*  THE GENERAL LINKAGE CONVENTION.                                *
*******************************************************************
A        CEEENTRY AUTO=PROGSIZE,MAIN=YES,PLIST=OS
         USING PROGAREA,R13
  .
  .
*******************************************************************
*  GET THE PASSED PARAMETER VALUES. THE GENERAL LINKAGE CONVENTION*
*  FOLLOWS THE STANDARD ASSEMBLER LINKAGE CONVENTION:             *
*  ON ENTRY, REGISTER 1 POINTS TO A LIST OF POINTERS TO THE       *
*  PARAMETERS.                                                    *
*******************************************************************
         L     R7,0(R1)            GET POINTER TO V1
         MVC   LOCV1(4),0(R7)      MOVE VALUE INTO LOCAL COPY OF V1

  .
  .
  .
         L     R7,4(R1)            GET POINTER TO V2
         MVC   0(9,R7),LOCV2       MOVE A VALUE INTO OUTPUT VAR V2

  .
  .
  .
         CEETERM  RC=0
*******************************************************************
*  VARIABLE DECLARATIONS AND EQUATES                              *
*******************************************************************
R1       EQU   1                   REGISTER 1
R7       EQU   7                   REGISTER 7
PPA      CEEPPA  ,                 CONSTANTS DESCRIBING CODE BLOCK
         LTORG ,                   PLACE LITERAL POOL HERE
PROGAREA DSECT
         ORG   *+CEEDSASZ          LEAVE SPACE FOR DSA FIXED PART
LOCV1    DS    F                   LOCAL COPY OF PARAMETER V1
LOCV2    DS    CL9                 LOCAL COPY OF PARAMETER V2

  .
  .
  .
PROGSIZE EQU   *-PROGAREA
         CEEDSA  ,                 MAPPING OF THE DYNAMIC SAVE AREA
         CEECAA  ,                 MAPPING OF THE COMMON ANCHOR AREA
         END   A
```

Figure 84. Stored Procedures - Using GENERAL Linkage Convention

The following example shows how to define the paramters in a stored procedure that uses the GENERAL WITH NULLS linkage convention.

```
*******************************************************************
*  CODE FOR AN ASSEMBLER LANGUAGE STORED PROCEDURE THAT USES      *
*  THE GENERAL WITH NULLS LINKAGE CONVENTION                      *
*******************************************************************
B        CEEENTRY AUTO=PROGSIZE,MAIN=YES,PLIST=OS
         USING PROGAREA,R13
*******************************************************************
  .
  .
*******************************************************************
*  GET THE PASSED PARAMETER VALUES. THE GENERAL WITH NULLS LINKAGE*
*  CONVENTION IS AS FOLLOWS:                                      *
*  ON ENTRY, REGISTER 1 POINTS TO A LIST OF POINTERS. IF N        *
*  PARAMETERS ARE PASSED, THERE ARE N+1 POINTERS. THE FIRST       *
*  N POINTERS ARE THE ADDRESSES OF THE N PARAMETERS, JUST AS      *
*  WITH THE GENERAL LINKAGE CONVENTION.  THE N+1ST POINTER IS     *
*  THE ADDRESS OF A LIST CONTAINING THE N INDICATOR VARIABLE      *
*  VALUES.                                                        *
*******************************************************************
         L     R7,0(R1)            GET POINTER TO V1
         MVC   LOCV1(4),0(R7)      MOVE VALUE INTO LOCAL COPY OF V1
         L     R7,8(R1)            GET POINTER TO INDICATOR ARRAY
         MVC   LOCIND(2*2),0(R7)   MOVE VALUES INTO LOCAL STORAGE
         LH    R7,LOCIND           GET INDICATOR VARIABLE FOR V1
         LTR   R7,R7               CHECK IF IT IS NEGATIVE
         BM    NULLIN              IF SO, V1 IS NULL

  .
  .
  .
         L     R7,4(R1)            GET POINTER TO V2
         MVC   0(9,R7),LOCV2       MOVE A VALUE INTO OUTPUT VAR V2
         L     R7,8(R1)            GET POINTER TO INDICATOR ARRAY
         MVC   2(2,R7),=H(0)       MOVE ZERO TO V2'S INDICATOR VAR

  .
  .
  .
         CEETERM  RC=0
*******************************************************************
*  VARIABLE DECLARATIONS AND EQUATES                              *
*******************************************************************
R1       EQU   1                   REGISTER 1
R7       EQU   7                   REGISTER 7
PPA      CEEPPA  ,                 CONSTANTS DESCRIBING THE CODE BLOCK
         LTORG ,                   PLACE LITERAL POOL HERE
PROGAREA DSECT
         ORG   *+CEEDSASZ          LEAVE SPACE FOR DSA FIXED PART
LOCV1    DS    F                   LOCAL COPY OF PARAMETER V1
LOCV2    DS    CL9                 LOCAL COPY OF PARAMETER V2
LOCIND   DS    2H                  LOCAL COPY OF INDICATOR ARRAY

  .
  .
  .
PROGSIZE EQU   *-PROGAREA
         CEEDSA  ,                 MAPPING OF THE DYNAMIC SAVE AREA
         CEECAA  ,                 MAPPING OF THE COMMON ANCHOR AREA
         END   B
```

Figure 85. Stored Procedure - Using GENERAL WITH NULLS Linkage Convention

Appendix B. Using SQL in C

Contents

Using C Sample Program ARIS6CC 270
Rules for Using SQL in C 270
  Placing and Continuing SQL Statements 271
  Delimiting SQL Statements 271
  Identifying Rules for Case 271
  Identifying Rules for Character Constants 272
  Using the INCLUDE Statement 272
  Using the C Compiler Preprocessor 272
  Declaring Host Variables 272
  Using Host Variables in SQL Statements 278
  Using the Pointer Type Attribute 278
  Using Host Variables as Function Parameters 280
  Using C Variables in SQL: Data Conversion Considerations 280
  Using C NUL-Terminated Strings and Truncation 281
  Calculating Dates 281
  Using Trigraphs 282
  Using DBCS Characters in C 282
  Considering Preprocessor-Generated Statements 282
Handling SQL Errors 285
Using Dynamic SQL Statements in C 286
Defining DB2 Server for VM Data Types for C 287
Using Reentrant C Programs 289
| Using Stored Procedures 289

Using C Sample Program ARIS6CC

ARIS6CC is a C language sample program for VM systems that is shipped with the DB2 Server for VM product. It resides on the production disk for the base product. You may find it useful to print this sample program before going through this appendix as the hard copy will provide an illustration for many of the topics discussed here.

The program satisfies the requirements of the application prolog and epilog. Near the beginning of the program all the host variables are declared, and error handling is defined. Near the logical end of the program, the database changes are rolled back, to assure that the database remains consistent for each use of the sample program. (For your own applications, of course, you will enter a COMMIT statement.)

To determine the types of C host variables to declare, refer to Figure 90 on page 287 which gives the C representation for each of the DB2 Server for VM data types. Note the following:

- C expects a character array to end in a hex 00 null character when used to contain a character string. This null character is referred to as NUL, and is coded as '\0' in a C program. An SQL character string does not end in a NUL. Therefore, SQL will try to add a NUL to a character string when storing it in a character array host variable, and it will expect a NUL, which it will remove, when setting an SQL column value from a C character host variable. To account for the NUL, declare character array host variables to one character longer than the length of the SQL character data they are to contain. For all the rules concerning NULs, see “Using C NUL-Terminated Strings and Truncation” on page 281.

  There are two other types of nulls to be aware of. Quite separate from the NUL character described above, C refers to a pointer value as NULL, in a similar way to PL/I. A C NULL pointer has a value of 0, and C allows the word NULL in pointer assignments and expressions. This use of NULL is distinct from the DB2 Server for VM NULL, which means an undefined column or expression value. The word NULL can be used in a C program to mean either. You can always determine which is meant by the context.

When you are coding your own applications, you will need to obtain the data types of the columns that your host variables interact with. This can be done by querying the catalog tables. (These tables are described in the *DB2 Server for VSE & VM SQL Reference* manual.)

Rules for Using SQL in C

Placing and Continuing SQL Statements

All statements in your C program, including SQL statements, must be contained in columns 1 through 72 of your source file. Columns 73 through 80 can also be used if the NOSEQuence C preprocessor option is specified; if NOSEQuence is not specified, or if SEQuence is specified, these columns will be ignored by the preprocessor. If NOSEQuence is used, the NOSEQ and MARGINS(1,80) C compiler options must be used to compile the application program.

Continuation of SQL statements and host variable declare statements across lines can be accomplished by breaking the line anywhere a blank can occur. Continuation of tokens (the basic syntactical units of a language) is allowed from one line to the next, by coding a backslash (the C continuation character with hex value `X'E0'`) in the line to be continued immediately after the first part of the token (leaving the remainder of the line blank), and coding the next part of the token from column 1 on the continuation line. If column 1 on the continuation line is blank, the token is not continued. See the *DB2 Server for VSE & VM SQL Reference* manual for a discussion of tokens.

You can also use the trigraph ??/ in place of the backslash as the continuation character. The C preprocessor treats end-of-line like a blank delimiter except when it is in a literal.

Delimiting SQL Statements

Use delimiters on all SQL statements to distinguish them from regular C statements. You must begin each SQL statement in your program with EXEC SQL, and end each statement with a semicolon. EXEC and SQL must be in uppercase on the same line, with only blanks separating them (no in-line C or SQL comments). Also, EXEC SQL must be immediately followed by a blank, C comment, or SQL comment, and it must be preceded by either a blank, C comment, {, }, trigraph ??<, trigraph ??>,), colon, or semicolon.

Elsewhere within SQL statements, C and SQL comments are allowed anywhere that blanks are allowed. However, there must not be any comments within SQL statements that are dynamically defined and executed.

Any SQL statement except INCLUDE can be followed on the same line by another SQL statement, C statement, or C comment.

Identifying Rules for Case

The keywords EXEC SQL must appear in uppercase in your C program. The rest of an SQL statement can appear in mixed case, but will be interpreted as uppercase, except for host variable names and text within quotation marks, which will be left in the original case.

Note: C host variables are always treated with case sensitivity by the C preprocessor. This is true for the C compiler too, except for externals, which C may truncate and fold to uppercase. Keep this in mind when using host variables with external scope.

Identifying Rules for Character Constants

Remember to follow SQL, not C, conventions when coding such character constant strings. These strings must be delimited by single quotation marks, and an embedded backslash is not recognized as an escape character.

Using the INCLUDE Statement

To include external secondary input, specify:

```
   EXEC SQL INCLUDE text_name
```

at the point in the source code where the secondary input is to be included. The *text_name* is the file name of a CMS file with a "CCOPY" file type and located on a CMS minidisk accessed by the user. It is always folded to uppercase. If anything is found after an INCLUDE statement, a warning message is issued and the input is ignored.

Use the SQL INCLUDE statement instead of the C preprocessor #include directive to include files that contain SQL host variables or SQL statements.

Using the C Compiler Preprocessor

The preprocessor must run before the C compiler and its built-in preprocessor. It is therefore not possible to contain any C preprocessor directives within an SQL statement. The SQL INCLUDE statement should be used instead of the C #include for files that contain SQL host variable declarations or statements.

Declaring Host Variables

You must declare all host variables in an SQL declare section. For a description of an SQL declare section, refer to "Declaring Variables That Interact with the Database Manager" on page 6.

Declare host variables in the source file before the first use of the variable in an SQL statement. You can use the following types of variables in an SQL statement:

- Scalar variables
- Structure variables
- Structure elements
- Array variables

Scalar variables, structure elements, and array elements are **data objects**. For information on the use of these variables in an SQL statement, refer to "Using Host Variables" on page 51 and "Using Host Structures" on page 51.

Note: You can declare non-host variables in an SQL declare section; however, declarations that do not conform to DB2 Server for VM declaration rules may return errors.

The definition of a host variable is subject to the following rules:

- A data object declared as a scalar variable or structure element may have any one of the following basic C data types:

short	Short integer
long	Long integer
float	Floating-point

double	Double-precision floating-point
decimal	Decimal

The keyword **int** is optional in the declaration of a short or long integer. You cannot use the unqualified type **int** when declaring a variable to be used in an SQL statement: specify **short** or **long**.

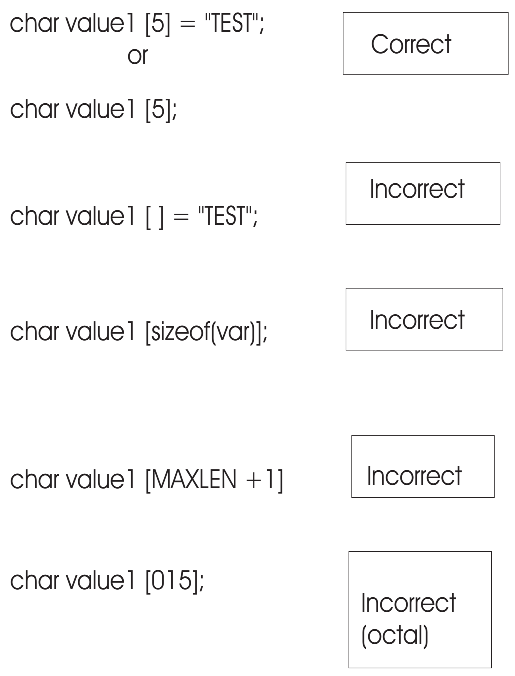
- A data object declared as an array element can have any of the following basic C data types:

short	Short integer
char	Single character

- You can use scalar variables and structure elements as main variables. If they are declared with a data type of short integer, you can also use scalar variables as indicator variables.
- Character arrays hold the SQL CHARACTER data types. You should declare character arrays with one extra character to contain the string terminating NUL.

  You can use the unsigned qualifier with character array host variables. It does not affect the way the system treats them.

  An explicit constant decimal array size is required between the brackets, even if an initializer is used on the declare. Expressions, preprocessor functions (such as sizeof), octal or hex values, and #defined variables cannot be used as the size of character arrays.



```
char value1 [5] = "TEST";
           or
char value1 [5];
```
Correct

```
char value1 [ ] = "TEST";
```
Incorrect

```
char value1 [sizeof(var)];
```
Incorrect

```
char value1 [MAXLEN +1]
```
Incorrect

```
char value1 [015];
```
Incorrect
(octal)

- You can only use short integer arrays as indicator arrays. The following is an example of an indicator array:

  ```
  short  ind_array [10];
  ```

  You cannot use indicator array elements as main or indicator variables.

- You can use a structure variable as a host structure or as a varying-length string definition. The structure declaration must be in the following form when used to define a varying-length string:

  ```
  struct tag {
      short vlen;
      char vstr[nnn];
      } varname1;
  ```

  The structure tag is optional. Any legal C names can be used for the structure and the contained variables. The nnn, defining the length of the largest string to be held in the structure, is specified by you.

  This structure defines a VARCHAR or LONG VARCHAR host variable with the name varnamel and a length nnn You cannot use this structure as a host structure; you cannot use the elements of the structure as host variables.

  The system does not add or expect a NUL at the end of a VARCHAR or LONG VARCHAR string. If one is needed, you can use a character array host variable, or you can add one after the data value has been returned, with the statement:

  ```
   varname1.vstr[varname1.vlen]='/0';
  ```

  If a NUL is required, ensure that the nnn is one larger than the maximum allowable string, so that adding the NUL at the end will never overflow the allocated storage.

  A macro is provided to assist in the declaration of VARCHAR structures:

  ```
  SQLVARCHAR(varname,nnn)

      will expand to:

  struct{
      short sqllen;
      char sqlstr[nnn];
   }varname;
  ```

  You can use this macro wherever a structure declaration defines a varying-length string.

- A structure variable which defines a host structure is any two-level structure, other than a varying-length string definition, declared in an SQL declare section. The following example is a host structure:

  ```
  struct tag{char projno [7];
       short actno;
       long acstaff;
       char acstdate [10];
       char acendate [10];
       }projstrct;
  ```

  Note: The structure tag is optional.

  This structure represents the following list of host variables when used in an SQL statement:

  ```
  projno, actno, acstaff, acstdate, acendate
  ```

  In other words, the two following SQL statements are equivalent:

```
EXEC SQL SELECT PROJNO, ACTNO, ACTSTAFF, ACSTDATE, ACENDATE
          INTO  :projstrct
          FROM PROJ_ACT
         WHERE PROJNO = '100000'


EXEC SQL SELECT PROJNO, ACTNO, ACSTAFF, ACSTDATE, ACENDATE
           INTO  :projno, :actno, :acstaff, :acstdate, :acendate
           FROM PROJ_ACT
          WHERE PROJNO = '100000'
```

A host structure can either be a stand-alone structure or a substructure of a more complex structure. The following example is a complex structure that contains a host structure:

```
struct tag { char  empno [7];
             struct taga { char firstname [13];
                           char midinit [1];
                           char lastname [16];
                         } empname;
             char  workdept [3];
             char  phoneno [4];
           } employee;
```

The structure `empname` is a host structure.

You can use the elements of the host structure and the elements of a complex structure containing a host structure as host variables. In the previous example, you can use `empno`, `firstname`, `midinit`, `lastname`, `workdept` and `phoneno` as host variables.

You can code a substructure in the host structure to represent a varying-length string element if the substructure conforms to the rules for a varying-length string definition. All of the rules in the description of structures that define varying-length strings also apply in this situation. The following example is a host structure that contains a VARCHAR element:

```
struct tag { struct taga { short fnlen;
                           char fntext [12];
                         } firstname;
              char midinit [1];
             struct tagb {short lnlen;
                          char  lntext [15];
                         } lastname;
            } empname;
```

The C preprocessor interprets the structure `empname` as a host structure containing 3 elements: `firstname` with data type VARCHAR and length 12, `midinit` with data type CHAR and length 1, and `lastname` with data type VARCHAR, and length 15.

Note: Any structure matching the description of a varying-length string definition is interpreted as a VARCHAR or LONG VARCHAR variable and cannot be used as a host structure.

- Third level host structures are permitted in C to support varying-length strings. The following is an example of varying-length string declarations in host structures.

```
         EXEC SQL BEGIN DECLARE SECTION;
         struct
            {
            char   last??(9??);
            char   first??(9??);
            struct
               {
               short  addlen;
               char   addtext??(200??);
               } address;
            } empname;
         EXEC SQL END DECLARE SECTION;
main()
{

         EXEC SQL SELECT LASTNAME, FIRSTNME, ADDRESS
                  INTO  :empname
                  FROM EMPLOYEE
                  WHERE LASTNAME = 'JOHANSON';
 }
```

In this example, `empname` is considered by the C preprocessor to be a two-level structure because the structure of `address` matches that of a VARCHAR data type. As a result, `empname` may be used in the SELECT statement. If, for example, `addlen` was changed from short to long, the structure of `address` would no longer match a VARCHAR data type and `empname` would be considered a three-level structure. As a result, `empname` could NOT be used in a SELECT statement.

- Union, enumeration, bitfield, and void types are not supported. Typedefs are not supported.
- Auto, static, extern, const, volatile, and _Packed storage classes are supported. The register storage class is not supported. If no class is specified, the usual C default storage class applies (which depends on the placement of the declaration within the source file).
- The system supports any sequence of declaration keywords that is also supported by the C compiler.
- Initialization of variables on the declaration statement is supported.
- You can declare multiple variables of the same type in the same C declaration statement. For example:

```
static short partno, suppno, time;
static char name [16] , adr[36];
static double qonhand, qonorder, price;
```

Note: You must explicitly declare all structures in C within the multi-level structure. You cannot declare a structure for reference within another structure (except for the SQLVARCHAR macro). In the following example, only `dates` and `product` may be used as host structures. `orderno` and `custnum` may be used as scalar host variables and may be qualified as `custord.orderno` and `ordinfo.custnum` or `custord.ordinfo.custnum`.

```
         EXEC SQL BEGIN DECLARE SECTION;
         struct
            {
            char   orderno??(10??);
            struct
               {
                   char custnum??(10??);
                   struct
                      {
                          char ordate??(7??);
                          char delivdte??(7??);
                      } dates;
               } ordinfo;
            struct
               {
                   char stockno??(11??);
                   char quantity??(4??);
               } product ;
            } custord ;
         EXEC SQL END DECLARE SECTION;
main()
{

         EXEC SQL SELECT STOCKNO, QUANTITY
                  INTO :product
                  FROM ORDER
                  WHERE STOCKNO = '1234567890';
 }
```

- You cannot duplicate variable names in a single source file, even if they are in different blocks or functions. The C preprocessor defines a duplicate variable name as any name that cannot be referenced unambiguously when fully qualified. (After a variable is declared in an SQL declare section, it is known to SQL for all functions and blocks for the rest of the source file, regardless of the host variable's actual scope. Therefore, that variable, or another variable with the same name and type, cannot be used in an SQL statement, even in a scope outside of the original SQL declare section.) See “Using Host Variables as Function Parameters” on page 280 for more information.
- The database manager allows host variable names, statement labels, and SQL descriptor area names of up to 256 characters in length, subject to any C language restrictions mentioned in this appendix.

  Note: Because of the restriction on the number of host variables in a statement, host structures with greater than 256 fields will not be allowed,
- You should not declare variables whose names begin with SQL, sql, RDI, or rdi unless otherwise instructed. These names are reserved for the database manager use.
- Host variable names are case-sensitive. For example, a host variable called partno is different from one called PartNo.
- Rules for continuation are the same as those described for SQL statements.

Note that other program variables can also be declared as usual outside the SQL declare section. The previous restrictions do not apply to non-SQL declarations.

Using Host Variables in SQL Statements

When you reference host variables, host structures, structure fields or indicator arrays in an SQL statement, you must precede each reference by a colon (:) The colon distinguishes these variables from SQL identifiers (such as column names). The colon is not required outside an SQL statement.

Using the Pointer Type Attribute

Scalar host variables can be defined as pointers to any C data type that the database manager supports. The following rules and restrictions apply:

- For the basic C data types, the variable must be declared in the same way it is referenced in an SQL statement. For example:

  ```
  short *partno;
     ...
  SELECT PARTNO INTO :*partno ...
  ```

- In the case of character arrays, the array size must be explicitly defined in the declaration. For example:

char (*v1_ptr) [5];	Correct
char (*v1_ptr) [ ];	Incorrect
char *v1_ptr ;	Incorrect

  The use of parentheses is required in order for arrays to define a pointer to an array of 5 characters, as opposed to an array of 5 pointers to characters. (See "Using C NUL-Terminated Strings and Truncation" on page 281 for the limitations on string lengths.)

  The host variable would then be referenced as *v1_ptr in an SQL statement.

- The asterisk is considered part of the host variable name. This means:
  - The asterisk is included in the 256-character length limitation for host variable names.
  - If a host variable is declared with an asterisk, it must always be used within the SQL statement with the asterisk. If it was declared without an asterisk, then it must never have one in an SQL statement.
- The programmer is responsible for ensuring that the pointer is set before it is used.

There are primarily two uses for pointer types with SQL statements:

1. Allocating or sharing storage.

   A program could contain a single SQL declare section, and use pointers for some or all large data areas. Then, before a pointer is used in an SQL statement, an alloc function could be used to acquire storage and set the pointer, or the pointer could be set to a shared storage area. This allows the program to reduce its overall storage requirement. For example:

```
EXEC SQL BEGIN DECLARE SECTION;
      ...
      struct tag {
          short vlen;
          char vstr[1000];
      } *vstr_ptr;
      ...
EXEC SQL END DECLARE SECTION;

 ...
 vstr_ptr = (struct tag *) malloc(sizeof(struct tag));

 EXEC SQL SELECT DESCRIPTION
          INTO :*vstr_ptr FROM TABLE;

 ...
}
```

2. Passing variables to functions for update.

   C usually passes parameters by value. This prevents the called function from changing the caller's version of a parameter. Passing a parameter by reference can be accomplished by the caller explicitly passing a pointer to the data. The called function then changes the data referenced by the pointer by using the asterisk for indirection. If the value is to be changed with an SQL statement, the called function must also declare the pointer value of the parameter in an SQL DECLARE section. For example:

```
main()
{
EXEC SQL BEGIN DECLARE SECTION;
         ...
         long int partno;
         ...
EXEC SQL END DECLARE SECTION;

    getdata(&partno);
    ...
}

getdata(partno_ptr)
EXEC SQL BEGIN DECLARE SECTION;
long int *partno_ptr;
EXEC SQL END DECLARE SECTION;
{
    EXEC SQL SELECT PARTNO
             INTO :*partno_ptr FROM TABLE;

    ...
}
```

Using Host Variables as Function Parameters

Host variables with the same name can only be declared in one SQL declare section. When passing a host variable to a function within the same file as the calling function, the variable can be used in an SQL statement in the called function without being redeclared in an SQL declare section. For example:

```
main()
{
    EXEC SQL BEGIN DECLARE SECTION;
         ...
         long int partno;
         ...
    EXEC SQL END DECLARE SECTION;

    getdata(partno);
    ...
}

getdata(partno)
long int partno;
{
    EXEC SQL BEGIN DECLARE SECTION;
         long int qonhand;
    EXEC SQL END DECLARE SECTION;

    EXEC SQL SELECT QONHAND
             INTO :qonhand FROM TABLE
             WHERE PARTNO = :partno;
    ...
}
```

Given the SQL declaration of `partno` within main(), `partno` can be used in any SQL statement that follows it in the file. If getdata had a different name for the partno parameter, it would have to be included in getdata's SQL declare section.

For information on how to allow a called function to update a parameter, refer to "Using the Pointer Type Attribute" on page 278.

Using C Variables in SQL: Data Conversion Considerations

Host variables must be type-compatible with the columns with which they are to be used. For example, if you want to retrieve into a program variable the QONHAND column of the database, and the data type of QONHAND is INTEGER, you should declare the program variable to be of type short, long, float, or double.

The database manager considers the numeric data types compatible as well as the character string data types (CHAR, VARCHAR, and LONG VARCHAR, including strings of different declared lengths). Of course, an overflow condition may result if, for example, you assign a 31-bit integer to a 15-bit integer and the current value of the 31-bit integer is too large to fit in 15 bits. Truncation also occurs when a decimal number having a scale greater than zero is assigned to an integer. In general, overflow occurs when significant digits are lost, and truncation occurs when nonsignificant digits are lost.

The system also considers the datetime data types to be compatible with character data types (CHAR, and VARCHAR, but not long fields).

Using C NUL-Terminated Strings and Truncation

The database manager interprets a character string in C as NUL-terminated if the length of the string is greater than 1 byte and less than 32,768 bytes.

The NUL-byte is mandatory when the database manager receives data from a NUL-terminated string. You receive an SQLCODE -302 (SQLSTATE '22024') if the NUL-byte is not found within the defined length of the string. This means that the maximum number of bytes of data that can be stored in a NUL-terminated string is one less than the defined length of the string.

When data is sent from the application server to a NUL-terminated string, a NUL-byte is always appended to the end of the string. If the variable is not big enough to hold the entire string (including the NUL), then a warning condition is indicated using the SQLCA SQLWARN flags and the output indicator value, as shown in the following chart. Truncation will occur even in the case where a character value of actual length *n* is to be assigned to a C variable declared as length *n* due to the NUL character being inserted at the last byte of the declared length. When truncation occurs, that last byte is overwritten by NUL.

Figure 86. Warning Flags after Character Truncation

Condition	**SQLCA SQLWARN0**	**SQLCA SQLWARN1**	**Output Indicator Variable (if supplied)**
Character string, including the NUL, fits in the declared C character array.	blank	blank	0 (zero)
Actual data truncated. That is, the C variable declared as less than or equal to *n*, to hold a character value of actual length *n*.	W	W	Original length of value (*n*) excluding the NUL.

Calculating Dates

Date calculations can result in date durations, and the database manager converts the result into any numeric type of a column or a host variable. However, to involve a date duration in a calculation (for example, to add a duration to a date), the date duration must be in DECIMAL(8,0) format. The system does not automatically convert any numeric type of column or host variable to a decimal value for use in a date calculation. If your C compiler does not support the fixed decimal data format, the scalar “DECIMAL” conversion function must be used to explicitly convert a value to decimal type. For example,

```
long duration=10100;  /* 1 year and 1 month */
long result_dt;

EXEC SQL SELECT START_DATE+DECIMAL(:duration,8,0)
        INTO :result_dt FROM TABLE;
```

Using Trigraphs

A trigraph is a sequence of three characters that you write in place of a C source character that your input device does not generate. The following trigraphs are supported by the C preprocessor in an SQL declare section:

```
??(      [  (left bracket)

??)      ]  (right bracket)

??<      {  (left brace)

??>      }  (right brace)
```

The following trigraph is supported in an SQL statement only when used as a continuation character:

```
??/      \  (backslash)
```

Using DBCS Characters in C

The rules for the format and use of DBCS characters in SQL statements are the same for C as for other host languages supported by the system. For a discussion of these rules, see "Using a Double-Byte Character Set (DBCS)" on page 46.

The C language does not provide a way to define graphic host variables. If you want to add graphic data to or retrieve it from DB2 Server for VM tables, you must execute the affected statements dynamically. By doing so, the data areas that are referenced by each statement can be described in an SQLDA. In the SQLDA, you must set the data type of the areas containing graphic data to one of the graphic data types. For a discussion of the SQLDA, refer to the *DB2 Server for VSE & VM SQL Reference* manual.

Considering Preprocessor-Generated Statements

When preprocessing an SQL C program, every executable SQL statement is translated into control block declarations, assignment statements, and a function call to pass the control block to the preprocessor at run time. To simplify the generation of this code during preprocessing, a number of typedef and communication area definitions are placed just after any initial C compiler directives or comments.

In addition, to assist the application programmer, the SQLVARCHAR macro is inserted with the typedefs and communication area definitions.

The preprocessor-generated statements are described in Figure 87 on page 282. These statements are inserted immediately before the first line in the source program that is not a blank line, a C comment, or a C precompiler directive.

The C preprocessor imposes two restrictions on the coding of C precompiler directives:

1. You may not use the #INCLUDE precompile directive to include the main function of a C program.
2. Conditional precompiler directives that contain C code must come after the first non-precompiler directive.

Figure 87 (Page 1 of 3). C Preprocessor-Generated Statements

Generated Code	Purpose
`#pragma linkage (ARIPRDI,OS)`	To establish correct addressability and parameter passing conventions with the system at run time.

```
#ifndef SQLVARCHAR
  #define SQLVARCHAR(varname,nnn) \\
     struct {                    \\
             short sqllen;        \\
             char  sqlstr[nnn];   \\
     } varname
#endif
```
	Macro that can be used by the application to simplify the C program. The definition of this macro can be changed by including a #define statement before the first non-precompiler directive C statement or SQL statement in your program.

Figure 87 (Page 2 of 3). C Preprocessor-Generated Statements

Generated Code

```
  typedef struct {
                short CALLTYPE;
                char AUTHOR[8];
                short PROG_NAMEL;
                char PROG_NAME[8];
                short SECTION_NUM;
                short CLASS_SECTION;
                char *CODEPTR;
                char *VPARAMPTR;
                char *AUXPARAMPTR;
                char *SQLTIEPTR;
                char SPECIALCALL;
                char CALLFLAG;
                char WAITFLAG;
                char RELEASEFLAG;
                char VPARAMIND;
                char AUXPARAMIND;
                char ERRORFLAG;
                char RDIDESCFLAG;
                long MAILBOXLEN;
                char RDIRELNO;
                char RDICISL;
                char RDIDATE;
                char RDITIME;
                long RDIFDBCK;
                char *RDIEXTP;
                char RDIRESV1[2];
                char RDIRDB16;
                char RDIRESV2;
  } SQL_RDIIN;
  typedef struct {
                char *RDIPTR01;
                char *RDIPTR02;
  } SQL_RDIPT;
  typedef struct {
                short DATA_TYPE;
                short LEN;
                char *DATA_PTR;
                short *INFOPTR;
                short NAMEL;
                char NAME[30];
  } SQL_PVELMS;
  typedef SQL_PVELMS *SQL_PVLMP;
  typedef struct {
                short CURSRLEN;
                char CURSRNAM[18];
  } SQL_RDICURAR;
 typedef union {
               long rdicnstl[2];
               char rdicnstc[8];
  } SQL_RDICONST;
```

Purpose

typedefs of allocated control blocks used when translating executable SQL statements into C function calls.

Figure 87 (Page 3 of 3). C Preprocessor-Generated Statements

Generated Code	Purpose

`static long SQLTIE[12];`
`  static char RDIRDBN[16];`
`  static struct {`
`          char RDIEXTEC[8];`
`          long RDIEXTFLR;`
`          char *RDIDBNMP;`
`          char *RDICONSP;`
`          char *RDIBPOPT;`
`          char *RDIXPTRS[6];`
`  } SQLRDIX;`
	Communication areas used to save information about the state of the C program between run-time calls to the database manager.

Handling SQL Errors

A return code structure (the SQLCA) must be in scope for each executable SQL statement. You can define one by coding the following statement in your source program:

```
EXEC SQL INCLUDE SQLCA;
```

The preprocessor replaces this statement with the declaration of the SQLCA structure, and a set of #defines to make referring to the error codes and flags easier. These are shown in Figure 88.

```
#ifndef SQLCODE
struct sqlca
{
    unsigned char sqlcaid[8];
    long sqlcabc;
    long sqlcode;
    short sqlerrml;
    unsigned char sqlerrmc[70];
    unsigned char sqlerrp[8];
    long sqlerrd[6];
    unsigned char sqlwarn[11];
    unsigned char sqlstate[5];
};
#define SQLCODE  sqlca.sqlcode
#define SQLWARN0 sqlca.sqlwarn[0]
#define SQLWARN1 sqlca.sqlwarn[1]
#define SQLWARN2 sqlca.sqlwarn[2]
#define SQLWARN3 sqlca.sqlwarn[3]
#define SQLWARN4 sqlca.sqlwarn[4]
#define SQLWARN5 sqlca.sqlwarn[5]
#define SQLWARN6 sqlca.sqlwarn[6]
#define SQLWARN7 sqlca.sqlwarn[7]
#define SQLWARN8 sqlca.sqlwarn[8]
#define SQLWARN9 sqlca.sqlwarn[9]
#define SQLWARNA sqlca.sqlwarn[10]
#define SQLSTATE sqlca.sqlstate
#endif
struct sqlca sqlca;
```

Figure 88. SQLCA Structure (in C)

Note: SQLCA character array variables are not NUL-terminated. They cannot be directly used by C string manipulation functions.

The SQLCA must not be declared within the SQL declare section. It may be declared outside all functions in the module, which gives it global scope, or separately within each function that contains executable SQL statements.

Instead of using the SQL INCLUDE SQLCA statement, the SQLCA can be coded directly, or #included from a header file.

You may find that the only variable in the SQLCA that you really need is SQLCODE. If this is the case, declare just the SQLCODE variable, and invoke NOSQLCA support at preprocessor time.

The number of SQLCODE declarations is not limited by the DB2 Server for VM preprocessor. If a stand-alone SQLCODE is specified, the code inserted by the preprocessor into the C code to expand an EXEC SQL statement will refer to the address of that SQLCODE. The C compiler determines if multiple declarations within a program section are not acceptable. In addition, the C compiler determines which region of the code an SQLCODE declaration refers to.

Using Dynamic SQL Statements in C

You must declare an SQLDA structure to execute dynamically defined SQL statements. You can have the database manager include the structure definition automatically, by specifying the following statement in your source code:

```
EXEC SQL INCLUDE SQLDA;
```

You can also include the structure definition by directly coding it as shown in Figure 89.

```
#ifndef SQLDASIZE
struct sqlda {
    unsigned char sqldaid[8];
    long sqldabc;
    short sqln;
    short sqld;
    struct sqlvar {
         short sqltype;
         short sqllen;
         unsigned char *sqldata;
         short *sqlind;
         struct sqlname {
              short length;
              unsigned char data[30];
         } sqlname;
    } sqlvar[1];
};
#define SQLDASIZE(n)                 \
      (sizeof(struct sqlda)+((n)-1)*   \
       sizeof(struct sqlvar))
#endif
```

Figure 89. SQLDA Structure (in C)

Note: The SQLDA character array variables `sqldaid` and `sqlname.data` are not NUL-terminated. They cannot be directly used by C string manipulation functions.

The SQLDA must not be declared within the SQL declare section.

Using the defined preprocessor function SQLDASIZE, your program can dynamically allocate an SQLDA of adequate size for use with each EXECUTE statement. For example, the code fragment below allocates an SQLDA that is adequate for five fields, and uses it in an EXECUTE of statement S3:

```
struct sqlda *daptr;

    daptr = (struct sqlda *)malloc(SQLDASIZE(5));
    daptr->sqln=5;
    /* Add code to set the rest of values and
       pointers in the SQLDA                     */
    EXEC SQL EXECUTE S3 USING DESCRIPTOR *daptr;
```

Note: The variable that points to the SQLDA is not defined in an SQL declare section. Its context within an SQL statement (following INTO or USING DESCRIPTOR) is enough to identify it.

You can use a similar technique to allocate an SQLDA for use with a DESCRIBE statement. The following program fragment illustrates the use of SQLDA with DESCRIBE for three fields and a “prepared” statement S1:

```
struct sqlda *daptr;

    EXEC SQL DECLARE C1 CURSOR FOR S1;
    daptr = (struct sqlda *)malloc(SQLDASIZE(3));
    daptr->sqln=3;
    EXEC SQL DESCRIBE S1 INTO *daptr;
    if (daptr->sqld > daptr->sqln)
            --get a bigger one
    Set sqldata and sqlind
    EXEC SQL OPEN C1;
    EXEC SQL FETCH C1 USING DESCRIPTOR *daptr;
```

There is no standard C type to support packed decimal data. If you want to get data in packed decimal format, the SQLDA must be filled in with an SQLTYPE of 484 and with the appropriate values for precision and scale in SQLLEN. The C program would then have to deal with the data in its packed format.

See the *DB2 Server for VSE & VM SQL Reference* manual for more information on the individual fields within SQLDA.

Defining DB2 Server for VM Data Types for C

Figure 90 (Page 1 of 2). DB2 Server for VM Data Types for C

Description	DB2 Server for VM Keyword	Equivalent C Declaration
A binary integer of 31 bits, plus sign.	INTEGER or INT	long or long int
A binary integer of 15 bits, plus sign.	SMALLINT	short or short int

A packed decimal number, precision *p*, scale *s* (1≤*p*≤31 and 0≤*s*≤*p*). In storage, the number occupies a maximum of 16 bytes. Precision is the total number of digits. Scale is the number of those digits that are to the right of the decimal point.	DECIMAL[(*p*[,*s*])]
	
	or DEC[(*p*[,*s*])] 1
		decimal(*p*,*s*)
		
		If your version of the C compiler does not provide support for the decimal data type, C short, long, float and double host variables are supported for conversion to and from DECIMAL columns.
		
		To preserve decimal places: if
		
		p<7 use float;
		
		else use double.

A single-precision (4-byte) floating-point number, in short System/390 floating-point format.	REAL or FLOAT(*p*), 1 ≤ *p* ≤ 21	FLOAT
A double-precision (8-byte) floating-point number, in long System/390 floating-point format.	FLOAT or FLOAT(*p*), 22 ≤ *p* ≤ 53 or DOUBLE PRECISION	DOUBLE
A fixed-length character string of length 1.	CHARACTER[(1)] or CHAR[(1)]	char or char ..[1]
A NUL-terminated character string of maximum defined length *n*. Range of *n* is 1 ≤ *n* ≤ 254. The terminating NUL is mandatory upon input.	VARCHAR(*n*)	char ..[*n*+1]
A NUL-terminated character string of maximum defined length of 32 767 bytes, subject to certain usage limitations. Range of *n* is 255 ≤ *n* ≤ 32 766. The terminating NUL is mandatory upon input.	LONG VARCHAR	*char* ..[*n*+1]
A varying-length character string of maximum length *n*. If *n* > 254 or ≤ 32 767, this data type is considered a long field. See "Using Long Strings" on page 41 for more information.	VARCHAR(*n*)	struct { short ..; char ..[*n*]; }
A varying-length character string of maximum length 32 767 bytes, subject to certain usage limitations.	LONG VARCHAR	struct { short ..; char ..[*n*]; }

Figure 90 (Page 2 of 2). DB2 Server for VM Data Types for C

Description	DB2 Server for VM Keyword	Equivalent C Declaration
A fixed-length string of *n* DBCS characters where 0 < *n* ≤ 127.	GRAPHIC[(*n*)]	Not supported
A varying-length string of *n* DBCS characters. If *n* > 127 or ≤ 16 383, this data type is considered a long field. See “Using Long Strings” on page 41 for more information.	VARGRAPHIC(*n*)	Not supported
A varying-length string of DBCS characters of maximum length 16 383, subject to certain usage limitations.	LONG VARGRAPHIC	Not supported
A NUL-terminated or varying-length character string representing a date.	DATE	see VARCHAR(*n*)
A NUL-terminated or varying-length character string representing a time.	TIME	see VARCHAR(*n*)
A NUL-terminated or varying-length character string representing a timestamp.	TIMESTAMP	see VARCHAR(*n*)

Notes:

1. NUMERIC is a synonym for DECIMAL, and may be used when creating or altering tables. In such cases, however, the CREATE or ALTER function will establish the column (or columns) as DECIMAL.
2. For a NUL-terminated string, the declared length should be one more than the maximum length of a datetime to allow for the terminating NUL-byte, which is mandatory input. Refer to the *DB2 Server for VSE & VM SQL Reference* manual for information on minimum and maximum lengths.

Using Reentrant C Programs

A reentrant program has the characteristic of dynamic allocation of space for data and save areas. This characteristic can be employed in C programs. In this case, the data and save areas are dynamically allocated in a “static” area by the IBM C Program Product Compiler.

Using Stored Procedures

Figure 91 on page 290 shows how to define the parameters in a stored procedure that uses the GENERAL linkage convention.

- *argv* contains an array of pointers to the parameters that were passed to the stored procedure.
  - *argv*[0] is a special entry containing the address of the stored procedure name
  - *argv*[1] contains the address of parameter 1
  - *argv*[2] contains the address of parameter 2

- *argc* contains the number of parameters that were passed to the stored procedure, plus one to account for the procedure name which is passed in *argv*[0].

```
#pragma options(RENT)
#pragma runopts(PLIST(OS))
#include <stdlib.h>
#include <stdio.h>
/*****************************************************************/
/* Code for a C language stored procedure that uses the          */
/* GENERAL linkage convention.                                   */
/*****************************************************************/
main(argc,argv)
  int argc;                       /* Number of parameters passed */
  char *argv[];         /* Array of strings containing */
                                  /*  the parameter values       */
{
  long int locv1;                 /* Local copy of V1            */
  char locv2[10];       /* Local copy of V2           */
                                  /*  (null-terminated)          */

  .
  .
  .
  /***************************************************************/
  /* Get the passed parameters.                                  */
  /***************************************************************/
  if(argc==3)                     /* Should get 3 parameters:    */
  {                               /* procname, V1, V2            */
    locv1 = *(int *) argv[1];
                                  /* Get local copy of V1        */

  .
  .
  .
    strcpy(argv[2],locv2);
                                  /* Assign a value to V2        */

  .
  .
  .
  }
}
```

Figure 91. Stored Procedure - Using GENERAL Linkage Convention

Figure 92 on page 291 shows how to define the parameters in a stored procedure that uses the GENERAL WITH NULLS linkage convention. In this case:

- *argv*[0] contains the address of the stored procedure name
- *argv*[1] contains the address of parameter 1
- *argv*[2] contains the address of parameter 2
- *argv*[n] contains the address of parameter *n*
- *argv*[*n*+1] contains the address of the indicator variable array

```
#pragma runopts(PLIST(OS))
#include <stdlib.h>
#include <stdio.h>
/*****************************************************************/
/* Code for a C language stored procedure that uses the         */
/* GENERAL WITH NULLS linkage convention.                         *
/*****************************************************************/
main(argc,argv)
  int argc;                       /* Number of parameters passed */
  char *argv[];         /* Array of strings containing */
                                  /*  the parameter values       */
{
  long int locv1;                 /* Local copy of V1            */
  char locv2[10];       /* Local copy of V2           */
                                  /*  (null-terminated)          */
  short int locind[2];  /* Local copy of indicator     */
                                  /*  variable array             */
  short int *tempint;             /* Used for receiving the      */
                                  /*  indicator variable array   */

.
.
.
  /***************************************************************/
  /* Get the passed parameters.                                  */
  /***************************************************************/
  if(argc==4)                     /* Should get 4 parameters:    */
  {                               /*  procname, V1, V2,          */
                                  /*  indicator variable array   */
    locv1 = *(int *) argv[1];
                                  /* Get local copy of V1        */
    tempint = argv[3];  /* Get pointer to indicator    */
                                  /*  variable array             */
    locind[0] = *tempint;
                                  /* Get 1st indicator variable  */
    locind[1] = *(++tempint);
                                  /* Get 2nd indicator variable  */
    if(locind[0]<0)     /* If 1st indicator variable   */
    {                             /*  is negative, V1 is null    */

  .
  .
  .
    }

.
.
.
    strcpy(argv[2],locv2);
                                  /* Assign a value to V2        */
    *(++tempint) = 0;             /* Assign 0 to V2's indicator  */
                                  /*  variable                   */
  }
}
```

Figure 92. Stored Procedure - Using GENERAL WITH NULLS Linkage Convention

Appendix C. Using SQL in COBOL

Contents

Using COBOL Sample Program ARIS6CBC . . . 294
Rules for Using SQL in COBOL . . . 294
  Placing and Continuing SQL Statements . . . 294
  Delimiting SQL Statements . . . 295
  Identifying Rules for Case . . . 296
  Declaring Host Variables . . . 296
  Using Host Variables in SQL Statements . . . 299
  Using Preprocessor Options . . . 300
    Using the QUOTE Parameter . . . 300
    Using the COB2 Parameter . . . 300
    Using the COBRC Parameter . . . 301
    Using the TRUNC Compiler Option . . . 301
    Using the INCLUDE Statement . . . 301
    Using COBOL Variables in SQL: Data Conversion Considerations . . . 301
    Other Coding Considerations . . . 302
    Using DBCS Characters in COBOL . . . 302
  Handling SQL Errors . . . 303
  Using Dynamic SQL Statements in COBOL . . . 304
  Defining DB2 Server for VM Data Types for COBOL . . . 306
  Using Reentrant COBOL Programs . . . 308
  Using the DYNAM Compiler Option . . . 308
| Using Stored Procedures . . . 309

Using COBOL Sample Program ARIS6CBC

ARIS6CBC is a COBOL sample language program for VM systems that is shipped with the DB2 Server for VM product. It resides on the production disk for the base product. You may find it useful to print this sample program before going through this appendix as the hard copy will provide an illustration for many of the topics discussed here.

Here is a summary of the program by COBOL Divisions:

- Identification and Environment Divisions

  You do not have to do anything different in either of these divisions for DB2 Server for VM applications.

- Data Division

  In the Data Division of any COBOL application, you must declare all host variables and the SQLCA structure.

  The only SQL statements allowed in the Data Division are those shown in the sample program and the INCLUDE statement; all others must be placed in the Procedure Division.

  The COBOL PICTURE clauses for the host variables are determined by referring to Figure 95 on page 306 which gives the COBOL representation for each of the DB2 Server for VM data types. When you are coding your own applications, you will need to obtain the data types of the columns that your host variables interact with. This can be done by querying the catalog tables, which are described in the *DB2 Server for VSE & VM SQL Reference* manual.

- Procedure Division

  The program must explicitly connect to the application server. WHENEVER statements should be coded to provide for error handling. Near the logical end of the program, the database changes are rolled back, to ensure that the database remains consistent for each use of the sample program. (For your own applications, of course, you will enter a COMMIT statement.)

Rules for Using SQL in COBOL

| In this appendix, the term COBOL implies OS/VS COBOL, VS COBOL II, or IBM
| COBOL for MVS and VM.

Placing and Continuing SQL Statements

Figure 93 shows how SQL statements can be coded

Figure 93 (Page 1 of 2). Coding SQL Statements in COBOL Program Sections

SQL Statement	Program Section

BEGIN DECLARE SECTION
 	
END DECLARE SECTION
	WORKING STORAGE or
	
	LINKAGE SECTION or
	
	FILE SECTION

Figure 93 (Page 2 of 2). *Coding SQL Statements in COBOL Program Sections*

SQL Statement	Program Section
INCLUDE SQLCA	WORKING-STORAGE SECTION
INCLUDE *text_file_name*	PROCEDURE DIVISION or DATA DIVISION
Other	PROCEDURE DIVISION SQL statements are coded between columns 12 and 72 inclusive.

The system checks that SQL statements are not used in nested programs. Also if one program immediately follows another program, the second program must not contain SQL statements.

The rules for continuation of tokens from one line to the next are the same as the COBOL rules for the continuation of words and constants. If a string-constant is continued from one line to the next, the first non-blank character in that next line must be a single quotation mark (') or a double quotation mark ("). If a delimited SQL identifier (such as “EMP TABLE”) is continued from one line to the next, the first non-blank character in that next line must be a double quotation mark. COBOL comment lines, identified by an asterisk * in column 7, can be coded within an embedded statement.

Delimiting SQL Statements

Delimiters are required on all SQL statements to distinguish them from regular COBOL statements. You must precede each SQL statement with EXEC SQL, and terminate each one with END-EXEC. Any desired COBOL punctuation, such as a period, can be placed after the END-EXEC. For example, suppose an SQL statement occurs as one of several statements nested inside a COBOL IF-statement. In this instance, the SQL statement should not be followed by a period.

EXEC SQL must be specified within one line; the same is true for END-EXEC. A separator (such as a blank space, SQL comment, or end-of-line) must precede the END-EXEC that terminates an SQL statement; however, no punctuation is required after the END-EXEC.

If an SQL statement appears within an IF sentence such that a COBOL ELSE clause immediately follows the SQL statement, the clause must begin with the word ELSE. In addition, this ELSE must be contained entirely on one line. (No continuation is allowed for the word ELSE).

SQL WHENEVER and DECLARE CURSOR statements should *not* be the only contents of COBOL IF or ELSE clauses as the preprocessor does not generate COBOL code for these statements.

If an SQL statement terminates a COBOL IF sentence, a period should immediately follow END-EXEC with no intervening blanks. A blank should follow the period.

Because a COBOL statement can be immediately preceded by a paragraph name, so can an embedded SQL statement. Similarly, an embedded SQL statement in the Procedure Division can be immediately followed by a separator period.

Identifying Rules for Case

Mixed case can be used in your COBOL program. The SQL preprocessor will change the lowercase into uppercase, except for text within quotation marks, which will be left in the original case.

Declaring Host Variables

You must declare all host variables in an SQL declare section. For a description of an SQL declare section, refer to “Declaring Variables That Interact with the Database Manager” on page 6.

Declare host variables in the source file before the first use of the variable in an SQL statement. All SQL declare sections must be located in the Working-Storage Section, the File Section, or the Linkage Section of the Data Division. You can use the following types of variables in an SQL statement:

- Elementary items (independent or subordinate of a group item)
- Group items
- Tables

For information on the use of these variables in an SQL statement, refer to “Using Host Variables” on page 51 and “Using Host Structures” on page 51.

Note: You can declare non-host variables in an SQL declare section; however, declarations that do not conform to DB2 Server for VM declaration rules may return errors.

The declaration of a host variable is subject to the following rules:

- All elementary items that are declared in an SQL declare section can be used as main variables. If these items are declared with a data type of short integer, they can also be used as indicator variables.
- The only tables accepted by the COBOL preprocessor are tables of short integer elements. These may only be used as indicator arrays. The following example is an indicator array declaration:

  ```
  01  IND_ARRAY.
      05 IND-ELEMENT  OCCURS 15 TIMES PIC S9(4) COMP.
  ```

  The COBOL preprocessor recognizes `IND-ELEMENT` as the indicator array.

  You cannot use indicator array elements as main variables or indicator variables.
- You can use a group item as a host structure or as a varying-length string definition. The structure must take the following form when used to define a varying-length string:

  ```
  01  VARCHAR-FIELD.
      49 LEN-FIELD                PIC S9(4) COMP.
      49 TXT-FIELD                PIC X(25).
  ```

  This structure defines a VARCHAR host variable with the name VARCHAR-FIELD and a length of 25. You cannot use this group item as a host structure; you cannot use the elementary items in the structure as host variables.

  For the rules for varying-length string variables, refer to Figure 95 on page 306.

- A group item which defines a host structure is any two-level structure declared in an SQL declare section. The following example is a host structure:

  ```
  01  PROJ-STRCT.
      05 PROJNO                    PIC X(6).
      05 ACTNO                     PIC S9(4) COMP.
      05 ACSTAFF                   PIC S9(9) COMP.
      05 ACSTDATE                  PIC X(10).
      05 ACENDATE                  PIC X(10).
  ```

  This structure represents the following list of host variables when used in an SQL statement:

  ```
  PROJNO, ACTNO, ACSTAFF, ACSTDATE, ACENDATE
  ```

  The two following SQL statements are equivalent:

  ```
  EXEC SQL SELECT PROJNO, ACTNO, ACSTAFF, ACSTDATE, ACENDATE
             INTO  :PROJ-STRCT
             FROM PROJ_ACT
            WHERE PROJNO = '100000'
  ```

  ```
  EXEC SQL SELECT PROJNO, ACTNO, ACSTAFF, ACSTDATE, ACENDATE
             INTO :PROJNO, :ACTNO, : ACSTAFF, :ACSTDATE, :ACENDATE
             FROM PROJ_ACT
            WHERE PROJNO = '100000'
  ```

  A host structure can be a stand-alone group item or a substructure of a more complex group item. The following example is a complex group item that contains a host structure:

  ```
  01  EMPLOYEE.
      05 EMPNO                       PIC X(6).
      05 EMPNAME.
         10 FIRSTNAME                PIC X(12).
         10 MIDINIT                  PIC X(1).
         10 LASTNAME                 PIC X(15).
      05 WORKDEPT                    PIC X(3).
      05 PHONENO                     PIC X(4).
  ```

  The group item `EMPNAME` is a host structure.

  You can use the elementary items in the host structure and the elementary items in the group item containing a host structure as host variables. In the previous example, the following elementary items can be used as host variables:

  ```
  EMPNO, FIRSTNAME, MIDINIT, LASTNAME, WORKDEPT, PHONENO
  ```

  You can include a subordinate group item in the host structure to represent a varying-length string element if that group item conforms to the rules for a varying-length string definition. All of the rules previously stated for the definition of varying-length strings also apply in this situation. The following example is a host structure that contains a VARCHAR element:

  ```
  01  EMPNAME.
      05 FIRSTNAME.
         49 FNLEN                    PIC S9(4) COMP.
         49 FNTEXT                   PIC X(12).
      05 MIDINIT                     PIC X(1).
      05 LASTNAME.
         49 LNLEN                    PIC S9(4)COMP.
         49 LNTEXT                   PIC X(15).
  ```

The COBOL preprocessor interprets the structure EMPNAME as a host structure containing three elements: FIRSTNAME with data type VARCHAR and length 12, MIDINIT with data type CHAR and length 1, and LASTNAME with data type VARCHAR and length 15.

Note: Any structure that matches the description of a varying-length string definition is interpreted as a varying-length definition and cannot be used as a host structure.

- Third-level host structures are permitted in COBOL to support varying-length strings. The following is an example of varying-length string declarations in host structures:

```
WORKING-STORAGE SECTION.
    EXEC SQL BEGIN DECLARE SECTION END-EXEC.
    01  EMPNAME.
      05  FIRST-NM   PIC X(8).
      05  LAST-NM    PIC X(8).
      05  ADDRESS.
        49  ADD-LEN  PIC S9(4) COMP.
        49  ADD-TXT  PIC X(200).
    EXEC SQL END DECLARE SECTION END-EXEC.

PROCEDURE DIVISION.
    EXEC SQL SELECT FIRSTNAME, LASTNAME, ADDRESS
             INTO  :EMPNAME
             FROM   EMPLOYEE
             WHERE  LASTNAME = 'JOHANSON'
    END-EXEC
```

  In this example, empname is considered by the COBOL preprocessor to be a two-level structure because the structure of address matches that of a VARCHAR data type. As a result, empname may be used in the SELECT statement. If, for example, addlen was changed from "PIC S9(4) COMP" to "PIC S9(9) COMP", the structure of address would no longer match a VARCHAR data type and empname would be considered a three-level structure. As a result, empname could NOT be used in a SELECT statement.

- A host structure field in an SQL statement must be qualified as *structurename.fieldname* instead of *fieldname* OF *structurename* or *fieldname* IN *structurename*.

  In the declaration below, only DATES and PRODUCT may be used as host structures. ORDERNO and CUSTNUM may be used as scalar host host variables, and may be qualified as CUSTORD.ORDERNO and ORDINFO.CUSTNUM or CUSTORD.ORDINFO.CUSTNUM.

```
WORKING-STORAGE SECTION.
    EXEC SQL BEGIN DECLARE SECTION END-EXEC.
    01  CUSTORD.
      03  ORDERNO     PIC X(10).
      03  ORDINFO.
        05  CUSTNUM   PIC X(10).
        05  DATES.
            10  ORDDATE  PIC X(6).
            10  DELIVDTE PIC X(6).
      03  PRODUCT.
        05  STOCKNO     PIC X(10).
        05  QUANTITY    PIC X(3).
    EXEC SQL END DECLARE SECTION END-EXEC.
```

```
PROCEDURE DIVISION.
    EXEC SQL SELECT STOCKNO, QUANTITY
             INTO :PRODUCT
             FROM ORDER
             WHERE STOCKNO = '1234567890'
    END-EXEC.
```

- The following restrictions apply to level numbers:
  1. Independent elementary items must have a level number of 01 or 77.
  2. Subordinate elementary items must have a level number from 02 to 49.
  3. The outermost group item must have a level number of 01.
  4. Subordinate group items must have a level number from 02 to 49.
  5. Elementary items in a varying-length string definition must have a level number of 49.
  6. Level 66 and level 88 items will be ignored by the preprocessor.
- Except for an indicator array, FILLER is permitted as the name of an elementary item. If FILLER is used as the name of an elementary item, the item will be ignored.
- In addition to the clauses discussed in Figure 95 on page 306, the COBOL preprocessor supports the following clauses in declarations imbedded in the SQL declare section:

  GLOBAL
  EXTERNAL
  SYNCHRONIZED
  VALUE
- Rules for continuation of variable names and COBOL keywords in declaration statements are the same as those described for SQL statements.
- The database manager allows host variable names, statement labels, and SQL descriptor area names of up to 256 characters in length, subject to any COBOL language restrictions mentioned in this appendix.

  Note: Due to the restriction on the number of host variables in a statement, host structures with greater than 256 fields will not be allowed,
- You should not give any variable a name beginning with SQL or RDI. These names are reserved for database manager use.
- Comma separators are supported between the clauses of a declaration statement.

Using Host Variables in SQL Statements

When you reference host variables, host structures, structures fields, or indicator arrays in an SQL statement, you must precede each reference by a colon (:). The colon distinguishes these variables from SQL identifiers (such as column names). The colon is not required outside an SQL statement.

Using Preprocessor Options

Using the QUOTE Parameter

If the COBOL compiler QUOTE option is used, the QUOTE (or Q) option of the preprocessor should also be specified. Use a single quotation mark (') to delineate constants used in embedded SQL statements, regardless of the COBOL compiler QUOTE option.

Using the COB2 Parameter

When the COB2 parameter is specified, certain functions supported by the COBOL II Release 3 compiler, and later, are also supported by the database manager. These functions include:

- COBOL keywords can be in mixed case. For example, “Data Division” is allowed.
- The COBOL picture clause enhancements:
  - Can be in mixed case. Thus, “Picture” is allowed.
  - Can end in either a period or a comma. For example, “Pic x(10)..”, and “pic x(10),.” are both valid.
- DB2 Server for VM numeric column types are compatible with the COBOL variables

  ```
  Picture S9(4) USAGE BINARY
  and
  Picture S9(p)[V9(s)] USAGE PACKED-DECIMAL
  ```

  where “p” is the precision and “s” is the scale.
- The COBOL FILLER is optional. Thus, the following example is valid even though the fourth field is blank:

  ```
      01 HEADING2.
         03 FILLER       Pic x(6)  VALUE 'ITEM NUMBER'.
         03 FILLER       Pic x(5)  VALUE SPACES.
         03 FILLER       Pic x(11) VALUE 'DESCRIPTION'.
         03              Pic x(4)  VALUE SPACES.
         03 FILLER       Pic x(8)  VALUE 'QUANTITY'.
  ```
- Literals can be 160 characters long.
- The system checks that SQL statements are not used in nested programs. Also, if one program immediately follows another, the second program must not contain SQL statements.
- ENDIF will be generated where appropriate when expanding code for the SQL WHENEVER statement.

In order to make use of these features, you must specify the COB2 option when preprocessing your application. Existing applications that are to make use of these features must be repreprocessed and recompiled.

Using the COBRC Parameter

When the COBRC parameter is specified, the preprocessor will generate the statement 'MOVE ZEROS TO RETURN-CODE' after it generates a call to ARIPRDI. This solves the problem of unexpected or invalid return codes being reported after a COBOL II (or IBM COBOL for MVS and VM) application ends. For example, a REXX EXEC may contain several steps which each execute based on a return code from the previous step. If the application programmer has not set the COBOL special register, RETURN-CODE, the return code is not reliable. This new parameter may be used instead of explicitly setting the special register.

Limitations:

1. If the user's COBOL compiler does not support the special register, RETURN-CODE, the application will not compile successfully. COBOL II supports it and new versions of COBOL support it, but old versions do not.
2. If the application sets the special register, RETURN-CODE, and then does an SQL call, the value is not preserved.

   ```
   MOVE 4 TO RETURN-CODE.
   EXEC SQL INSERT INTO MYTABLE VALUES (1,2).
   STOP RUN.
   ```

   The application will end with return code 0 instead of 4 because when the EXEC SQL statement is expanded the last line generated is 'MOVE ZEROS TO RETURN-CODE'.
3. If the user's compiler does not support the special register, RETURN-CODE, but they have declared a variable called RETURN-CODE, the variable will be updated which can cause unexpected results for the application.

Using the TRUNC Compiler Option

For Version 3.2 of COBOL II or later, use the TRUNC(BIN) compiler option, because the system is half-word boundary sensitive. Under this option, receiving fields are truncated only at halfword, fullword, or doubleword boundaries.

Using the INCLUDE Statement

To include the external secondary input, specify the following at the point in the source code where the secondary input is to be included:

```
EXEC SQL INCLUDE text_file_name END-EXEC.
```

Text_file_name is the file name of a CMS file, with a “COBCOPY” file type, located on a CMS minidisk accessed by the user.

The INCLUDE statement can appear anywhere within the File, Linkage, or Working Storage Sections of the Data Division, and anywhere within the Procedure Division, including the Declaratives Section, if one is used. Note that the INCLUDE statement is the only type of SQL statement that is allowed within the Declaratives Section of a Procedure Division.

Using COBOL Variables in SQL: Data Conversion Considerations

COBOL variables used in SQL statements must be type-compatible with the columns of the tables with which they are to be used (stored, retrieved, or compared). Of course, an overflow condition may occur if, for example, an INTEGER data item is retrieved into a PICTURE S9(4) variable, and its current value is too large to fit.

The database manager recognizes the DISPLAY SIGN LEADING SEPARATE (DSLS) attribute for COBOL host variables. It converts input host variables in the DSLS format to the required column format, and output host variables from the column format to DSLS format.

The character data types CHAR, VARCHAR, and LONG VARCHAR are considered compatible. The graphic data types GRAPHIC, VARGRAPHIC, and LONG VARGRAPHIC are considered compatible. A varying-length string is automatically converted to a fixed-length string, and a fixed-length string is automatically converted to a varying-length string when necessary. If a varying-length string is converted to a fixed-length string, it is truncated or padded on the right with blanks to the correct length. The system also truncates or pads with blanks if a fixed-length string is assigned to another fixed-length string of a different size (for example, a variable of PICTURE X(12) is stored in a column of type CHAR(18)).

The system also considers the datetime data types to be compatible with character data types (fixed or varying, but not LONG VARCHAR and VARCHAR > 254).

Refer to “Converting Data” on page 44 for a data conversion summary.

Other Coding Considerations

You may want to consider the following points when coding SQL statements and host variable declarations:

- The preprocessor scans past COBOL NOTE-type comments and line comments defined by an asterisk (*) in column 7. It does not recognize line comments identified by a slash (/) in column 7.
- An SQL comment entered in a static SQL statement must be preceded by a blank.
- When performing subtraction in an SQL statement, delimit the minus sign (-) with blanks:

```
        blanks
         | |
         V V
QUANT - :ORDER-AMOUNT
```

- COBOL keywords can be coded in mixed case. For example, Data Division is allowed.

Using DBCS Characters in COBOL

| The rules for the format and use of DBCS characters in SQL statements are the
| same for COBOL as for other host languages supported by the system. For a
| discussion of these rules, see “Using a Double-Byte Character Set (DBCS)” on
| page 46.

When coding graphic constants in SQL statements, use the SQL format of the graphic constant:

```
G'< XXXX >'
```

Note: N is a synonym for G.

See “Using Graphic Constants” on page 54 for a discussion of graphic constants.

The COBOL preprocessor does not support options for changing the encoding for the < and > characters.

Handling SQL Errors

You can declare the SQLCA return code structure that is required for the system in two ways:

1. You may write:

   ```
   EXEC SQL INCLUDE SQLCA END-EXEC.
   ```

   in the Working-Storage Section of your source program. The preprocessor replaces this with a declaration of the SQLCA structure.
2. You may declare the SQLCA yourself in the Working-Storage Section, as shown in Figure 94 on page 303.

```
01 SQLCA.
   05 SQLCAID      PIC X(8).
   05 SQLCABC      S9(9) COMPUTATIONAL.
   05 SQLCODE      PIC S9(9) COMPUTATIONAL.
   05 SQLERRM.
      49 SQLERRML  PIC S9(4) COMPUTATIONAL.
      49 SQLERRMC  PIC X(70).
   05 SQLERRP      PIC X(8).
   05 SQLERRD      OCCURS 6 TIMES
                   PIC S9(9) COMPUTATIONAL.
   05 SQLWARN.
      10 SQLWARN0  PIC X(1).
      10 SQLWARN1  PIC X(1).
      10 SQLWARN2  PIC X(1).
      10 SQLWARN3  PIC X(1).
      10 SQLWARN4  PIC X(1).
      10 SQLWARN5  PIC X(1).
      10 SQLWARN6  PIC X(1).
      10 SQLWARN7  PIC X(1).
      10 SQLWARN8  PIC X(1).
      10 SQLWARN9  PIC X(1).
      10 SQLWARNA  PIC X(1).
   05 SQLSTATE     PIC X(5).
```

Figure 94. SQLCA Structure (in COBOL)

A COBOL program containing SQL statements must have a Working-Storage Section. The meanings of the fields within the SQLCA are discussed in the *DB2 Server for VSE & VM SQL Reference* manual.

In COBOL, the object of a GO TO in the SQL WHENEVER statement must be a section name or an unqualified paragraph name.

You may find that the only variable in the SQLCA you really need is SQLCODE. If this is the case, declare just the SQLCODE variable and invoke NOSQLCA support at preprocessor time.

The number of SQLCODE declarations is not limited by the preprocessor. If a stand-alone SQLCODE is specified, the code inserted by the preprocessor into the COBOL code to expand an EXEC SQL statement will refer to the address of that

SQLCODE. The COBOL compiler determines if multiple declarations within a program section are not acceptable. In addition, the COBOL compiler determines which region of the code an SQLCODE declaration refers to.

DB2 Server for VM does not pass the return code in register 15 on completion of SQL statement processing. The return code and any other information is passed in the SQLCA. Furthermore, if the COBRC preprocessor parameter was not specified, DB2 Server for VM does not not set the return code to zeros on completion of SQL statement processing. If IBM COBOL for MVS and VM or COBOL II is being used, this can cause register 15 to be uninitialized and can contain unpredictable data. This appears as very large return codes when the COBOL application ends. This does not occur with the DOS/VS COBOL compiler. It is the responsibility of the application programmer to set the return code to something meaningful. The COBOL special register RETURN-CODE should be set before the application program ends.

The simplest method is to code the following lines just before a STOP RUN or a GOBACK statement.

```
MOVE ZERO TO RETURN-CODE.
STOP RUN.
```

Any return code meaningful to the application can be set. It can also be set to the SQLCODE if desired.

Using Dynamic SQL Statements in COBOL

The COBOL preprocessor lets you use a descriptor area, the SQLDA, to execute dynamically defined SQL statements. (See Chapter 6, “Using Dynamic Statements” on page 153 for more information on dynamic SQL statements and for more information on dynamic SQL statements and the SQLDA.) However, the COBOL preprocessor will not replace the statement `EXEC SQL INCLUDE SQLDA` with a declaration of the SQLDA structure, as is done with the SQLCA. Instead, `EXEC SQL INCLUDE SQLDA` would just include the secondary input file SQLDA, as described in “Using the INCLUDE Statement” on page 301.

Before you can use the descriptor area you must properly allocate and initialize it, and you must manage all its address variables. The following example shows how you could define a descriptor area in the COBOL Working-Storage section for five fields:

```
      01 DASQL.
           02 DAID                  PIC X(8) VALUE 'SQLDA   '.
           02 DABC                  PIC S9(8) COMP VALUE 13216.
           02 DAN                   PIC S9(4) COMP VALUE 5.
           02 DAD                   PIC S9(4) COMP VALUE 0.
           02 DAVAR                 OCCURS 1 TO 300 TIMES
                                            DEPENDING ON DAN.
              03 DATYPE             PIC S9(4) COMP.
              03 DALEN              PIC S9(4) COMP.
              03 FILLER REDEFINES DALEN.
                 15  SQLPRCSN      PIC X.
                 15  SQLSCALE      PIC X.
              03 DADATA             POINTER.
              03 DAIND              POINTER.
              03 DANAME.
                 49 DANAMEL         PIC S9(4) COMP.
                 49 DANAMEC         PIC X(30).
```

Note: DOS/VS COBOL 3.1 users cannot use the "USAGE IS POINTER" clause implied in this example for the `DADATA` and `DAIND` areas. Instead, these areas must be defined with the characteristics of `PIC X(4)`.

The descriptor area must not be declared within the SQL declare section.

The following pseudocode illustrates a use of the descriptor area, adequate for three fields:

```
    - allocate storage for a Descriptor Area of at least size = 3
    - set DAN = 3  (number of fields)
    - set DAD = 3
    - set the rest of the values and pointers in the Descriptor Area
      EXEC SQL EXECUTE S1 USING DESCRIPTOR dasql
```

When decimal data is used, the values of the SQLPRCSN and SQLSCALE field can be determined by declaring additional variables. For example:

```
      01 PRCSNN                   PIC S9(4) COMP.
      01 PRCSNC    REDEFINES  PRCSNN.
         15  FILLCHAR1            PIC X.
         15  PRCSNCHAR            PIC X.
      01 SCALEN                   PIC S9(4) COMP.
      01 SCALEC    REDEFINES  SCALEN.
         15  FILLCHAR2            PIC X.
         15  SCALECHAR            PIC X.
```

The following MOVE statements would move the precision and scale of the nth selected item into PRCSNN and SCALEN, respectively:

```
      MOVE SQLPRCSN(n) TO PRCSNCHAR.
      MOVE SQLSCALE(n) TO SCARECHAR.
```

For COBOL, the string-spec in PREPARE and EXECUTE IMMEDIATE must be in the same format as the SQL VARCHAR data type (you must set the proper length) or a quoted string. If a quoted string is used, its length is limited to 120 characters (the maximum length allowed for COBOL constants). In addition, you cannot use a single (') or double (") quotation mark within a COBOL constant that is the object of a PREPARE or EXECUTE IMMEDIATE statement.

Defining DB2 Server for VM Data Types for COBOL

Figure 95 (Page 1 of 2). DB2 Server for VM Data Types for COBOL

Description	**DB2 Server for VM Keyword**	**Equivalent COBOL Declaration**
A binary integer of 31 bits, plus sign.	INTEGER or INT	01 PICTURE S9(9) COMPUTATIONAL.
A binary integer of 15 bits, plus sign.	SMALLINT	01 PICTURE S9(4) COMPUTATIONAL.
A packed decimal number, precision *p*, scale *s* ($1 \le p \le 31$ and $0 \le s \le p$). In storage the number occupies a maximum of 16 bytes. Precision is the total number of digits. Scale is the number of those digits that are to the right of the decimal point.	DECIMAL[(*p*[,*s*])] or DEC[(*p*[,*s*])]	01 PICTURE S9(*x*)[V9(*y*)] COMPUTATIONAL-3. or 01 PICTURE S9(*x*)[V9(*y*)] PACKED-DECIMAL. or 01 PICTURE S9(*x*)[V9(*y*)] DISPLAY SIGN LEADING SEPARATE Where $x + y = p$ and $y = s$
A single-precision (4-byte) floating-point number, in short System/390 floating-point format.	REAL or FLOAT(*p*), $1 \le p \le 21$	COMPUTATIONAL-1.
A double-precision (8-byte) floating-point number, in long System/390 floating-point format.	FLOAT or FLOAT(*p*), $22 \le p \le 53$ or DOUBLE PRECISION	COMPUTATIONAL-2.
A fixed-length character string of length *n* where $0 < n \le 254$.	CHARACTER[(*n*)] or CHAR[(*n*)]	01 S PICTURE X(*n*).
A varying-length character string of maximum length *n*. If $n > 254$ or $\le 32\,767$, this data type is considered a long field. (See “Using Long Strings” on page 41 for more information.) (Only the actual length is stored in the database.)	VARCHAR(*n*)	01 S. 49 S-LENGTH PICTURE S9(4) COMPUTATIONAL. 49 S-VALUE PICTURE X(*n*).
A varying-length character string of maximum length 32 767 bytes.	LONG VARCHAR	01 S. 49 S-LENGTH PICTURE S9(4) COMPUTATIONAL. 49 S-VALUE PICTURE X(*n*).
A fixed-length string of *n* DBCS characters where $0 < n \le 127$.	GRAPHIC[(*n*)]	01 GNAME PICTURE G(*n*) [DISPLAY-1].

Figure 95 (Page 2 of 2). DB2 Server for VM Data Types for COBOL

Description	DB2 Server for VM Keyword	Equivalent COBOL Declaration
A varying-length string of *n* DBCS characters. If *n* > 127 or ≤ 16383, this data type is considered a long field. (See "Using Long Strings" on page 41 for more information.)	VARGRAPHIC(*n*)	01 GNAME. 49 GGLEN PICTURE S9(4) COMPUTATIONAL. 49 GGVAL PICTURE G(*n*) [DISPLAY-1].
A varying-length string of DBCS characters of maximum length 16383.	LONG VARGRAPHIC	01 XNAME. 49 XNAMLEN PICTURE S9(4) COMPUTATIONAL. 49 XNAMVAL PICTURE G(*n*) [DISPLAY-1].
A fixed or varying-length character string representing a date. The minimum and maximum lengths vary with both the format used and whether it is an input or output operation. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	DATE	01 S PICTURE X(*n*). or 01 S. 49 S-LENGTH PICTURE S9(4) COMPUTATIONAL. 49 S-VALUE PICTURE X(*n*).
A fixed or varying-length character string representing a time. The minimum and maximum lengths vary with both the format used and whether it is an input or output operation. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	TIME	01 S PICTURE X(*n*). or 01 S. 49 S-LENGTH PICTURE S9(4) COMPUTATIONAL. 49 S-VALUE PICTURE X(*n*).
A fixed or varying-length character string representing a timestamp. The lengths can vary on input and output. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	TIMESTAMP	01 S PICTURE X(*n*). or 01 S. 49 S-LENGTH PICTURE S9(4) COMPUTATIONAL. 49 S-VALUE PICTURE X(*n*).

Notes:

1. USAGE or USAGE IS is optional before COMPUTATIONAL, BINARY, PACKED-DECIMAL, and DISPLAY-1.
2. The word IS can follow PICTURE or PIC.
3. COMPUTATIONAL can be abbreviated COMP. PICTURE can be abbreviated PIC.
4. COMPUTATIONAL-4. or USAGE BINARY can be substituted for COMPUTATIONAL.
5. The following synonyms are supported:
   - COMPUTATIONAL-4 for COMPUTATIONAL

- BINARY for COMPUTATIONAL
- PACKED-DECIMAL for COMPUTATIONAL-3
- N(*n*) for G(*g*)

6. INTEGER and SMALLINT data types can have sliding ranges. For example, if you want to declare a SMALLINT variable that you know will remain very small, you could use S9(2) instead of S9(4). Or, you could declare an integer with a range of S9(7) instead of S9(9). However, only the ranges shown in the above table allow for the largest possible values of SMALLINT and INTEGER. Truncation may occur if you declare smaller ranges.
7. For COMPUTATIONAL types, 9's may be repeated rather than using the repetition factors in parentheses (that is, 9999 instead of 9(4)). The same is true for the X's in the character types and the G's in the graphic character types.
8. In DECIMAL data types, precision is the total number of digits. Scale is the number of digits to the right of the decimal point.
9. NUMERIC is a synonym for DECIMAL and, can be used when you are creating or altering tables. In such cases, however, the CREATE or ALTER function will establish the column (or columns) as DECIMAL.
10. When a VALUE clause is used for host variables of the form "PIC S9(4) COMP", the highest value accepted by COBOL is 9999. If you specify the COBOL NOTRUNC option, however, a value up to 32 767 can be *moved* into the host variable. If host variables are to contain long fields where the length exceeds 9999, the NOTRUNC option must be set.

Using Reentrant COBOL Programs

A reentrant program has the characteristic of dynamic allocation of space for data and save areas. This reentrant characteristic can be used in COBOL programs that use the database manager.

| Such programs must follow the COBOL compiler's rules for producing reentrant
| programs, and must be repreprocessed, recompiled, and relinked with the TEXT file
| ARIPADR4.

Existing COBOL programs (preprocessed prior to SQL/DS Version 2 Release 2) may continue to use ARIPADR until they are recompiled. Thereafter, they must link-edit the TEXT file ARIPADR4.

After programs are recompiled, ARIPADR4 must be in their link or load step.

Using the DYNAM Compiler Option

| The DYNAM option of the IBM COBOL for MVS and VM and VS COBOL II compilers can be used by applications. If the DYNAM option is used, then it is not necessary to include any of the linkage modules listed for COBOL programs in "Link-Editing and Loading the Program" on page 132.

COBOL applications that use the DYNAM option must have access to the DB2 Server for VM production disk at run time.

Using Stored Procedures

The following example shows how to define the parameters in a stored procedure that uses the GENERAL linkage convention.

```
IDENTIFICATION DIVISION.
  .
  .
DATA DIVISION.
  .
  .
  LINKAGE SECTION.
  01 PARM1 ...
  01 PARM2 ...
  .
  .
PROCEDURE DIVISION USING PARM1, PARM2.
  .
  .
```

Figure 96. Stored Procedure - Using GENERAL Linkage Convention

The following example shows how to define the parameters in a stored procedure that uses the GENERAL WITH NULLS linkage convention.

```
IDENTIFICATION DIVISION.
  .
  .
DATA DIVISION.
  .
  .
  LINKAGE SECTION.
  01 PARM1 ...
  01 PARM2 ...
  01 INDARRAY PIC S9(4) USAGE COMP OCCURS 2 TIMES.
  .
  .
PROCEDURE DIVISION USING PARM1, PARM2, INDARRAY.
  .
  .
```

Figure 97. Stored Procedure - Using GENERAL WITH NULLS Linkage Convention

Appendix D. Using SQL in FORTRAN

Contents

Using FORTRAN Sample Program ARIS6FTC 312
Rules for Using SQL in FORTRAN 312
  Placing and Continuing SQL Statements 312
  Placing Data Statements 313
  Identifying Rules for Case 313
  Declaring Host Variables 313
  Embedding SQL Statements 315
  Using Host Variables in SQL Statements 315
  Using Variable Length Character Strings 315
  Using DBCS Characters in FORTRAN 318
  Using the INCLUDE Statement 318
  Using FORTRAN Variables in SQL: Data Conversion Considerations . . . 318
Handling SQL Errors 318
Handling Program Interrupts 319
Using Dynamic SQL Statements in FORTRAN 319
Restrictions When Using the FORTRAN Preprocessor 320
Defining DB2 Server for VM Data Types for FORTRAN 321

Using FORTRAN Sample Program ARIS6FTC

ARIS6FTC is a FORTRAN language sample program for VM systems that is shipped with the the DB2 Server for VM product. It resides on the production disk for the base product. You may find it useful to print this sample program before going through this appendix as the hard copy will provide an illustration for many of the topics discussed here.

Note, for example, how the program satisfies the requirements of the application prolog and epilog. Near the beginning of the program all the host variables are declared, and error handling is defined. Near the logical end of the program, the database changes are rolled back, to assure the database remains consistent for each use of the sample program. For your own applications, of course, you will enter a commit.

The data description statements for the host variables are determined by referring to Figure 100 on page 321. When you are coding your own applications you will need to obtain the data types of the columns that your host variables interact with. This can be done by querying the catalog tables. See the *DB2 Server for VSE & VM SQL Reference* manual for more information on catalog tables.

Rules for Using SQL in FORTRAN

The FORTRAN SQL preprocessor supports programs written for the VS FORTRAN compiler with the LANGLVL (77) option specified. Only FIXED-FORM source statements are supported.

If FORTRAN labels are placed on SQL declarative statements, the label will be removed and an information message given.

The FORTRAN preprocessor supports a maximum of 255 program units per input source file (254 subprograms in addition to the main program).

All the restrictions that apply to extended dynamic statements apply to all FORTRAN programs.

Placing and Continuing SQL Statements

All SQL statements must be placed in columns 7 to 72. Columns 73 to 80 may contain sequence numbers and information; columns 1 to 5 may also contain statement numbers.

The rules for continuation of tokens from one line to the next are the same as the FORTRAN rules for the continuation of words and constants.

An SQL statement may use up to 124 continuation lines in addition to the first line (for a total of 125 lines including blanks and comments). A continuation line can be:

- A continued line (that is, a line that does not have a blank or zero in column 6).
- A blank line
- A comment line.

These lines must fall between the start of the SQL statement and the next statement.

Notes:

1. The maximum length of an SQL statement is 8 192 characters
2. This restriction also applies to FORTRAN IF and ELSE statements
3. A statement is terminated by another statement or by end-of-file.

Placing Data Statements

The FORTRAN Release 3.0 compiler restricts the placement of data statements in FORTRAN programs or subroutines. Some precaution is necessary in order to eliminate the following warning message during compilation of the program or subroutine:

```
WARNING MSGIFX1935I
DATA STATEMENT PRECEDES AN EXPLICIT TYPE STATEMENT
```

During preprocessing, the FORTRAN preprocessor places inline calls at the end of the DB2 Server for VM declare section, if one exists; otherwise, the calls are placed at the beginning of the program or subroutine. These calls contain data statements that must be preceded by all declares.

If an SQL declare section does not exist, place the following dummy SQL declare section after all other program declares to avoid the above warning message:

```
EXEC SQL BEGIN DECLARE SECTION
EXEC SQL END DECLARE SECTION
```

Since the preprocessor replaces `EXEC SQL INCLUDE SQLCA` with the declaration of the SQLCA structure, the SQLCA must be included before the declare section.

The FORTRAN preprocessor does not recognize a FUNCTION keyword if it is preceded by a type declaration. The FUNCTION keyword must, therefore, be the first word in the FUNCTION statement.

Identifying Rules for Case

Mixed case can be used in your FORTRAN program. The SQL preprocessor will change the lowercase into uppercase, except for text within quotation marks, which will be left in the original case.

Declaring Host Variables

Host variables must be explicitly declared to be used in SQL statements. The following example shows an SQL declare section for a FORTRAN program:

```
EXEC SQL BEGIN DECLARE SECTION  (at beginning of section)
      .
      .
(Data description entries for host variables)
      .
      .
EXEC SQL END DECLARE SECTION    (at end of section)
```

Place the data description entries for all the host variables within the SQL declare sections. You may use the variables appearing in these SQL declare sections in regular FORTRAN statements as well as in SQL statements.

A host variable declared within the SQL DECLARE SECTION may not be continued. The host variable declaration must appear on a single line in order to be recognized by the preprocessor.

You can also place data description entries for non-host variables in the SQL declare section as the FORTRAN preprocessor ignores data description entries within the SQL declare section that it does not recognize as valid host variable declarations. No error message is generated; instead, the statement is left for the FORTRAN compiler to process. Thus it is possible, though not recommended, to place all data description entries within an SQL declare section.

The rules for declaring variables within SQL declare sections are:

- Host variables must be valid FORTRAN variable names according to the version of the FORTRAN compiler that is being used. FORTRAN host variable names are restricted to a length of 18 bytes.
- Variables named in the SQL declare sections must have data descriptions like those in Figure 100 on page 321.
- Variables cannot be any of the following:
  - Vector or array declarations
  - Constants defined by a PARAMETER statement
  - Any declarations that use expressions to define the length of the variables
  - Character variables declared with an undefined length, such as CHARACTER*(*).
- You should not give any variable a name beginning with SQL, because these names are reserved for database manager use.
- When host variables are declared as INTEGER, and you are using the OPTIMIZE(2) or OPTIMIZE(3) compile option, the host variables should be declared as COMMON.

  Under OPTIMIZE 2 or 3, FORTRAN may make register assignments to the program variables if they are not in COMMON storage. Under some circumstances, this can result in the database manager using an inaccurate variable value.

  In the following example, NUM must be declared as COMMON if OPTIMIZE 2 or 3 is specified:

```
      EXEC SQL DECLARE CURSOR C1 FOR INSERT INTO T1 VALUES (:NUM)
      EXEC SQL OPEN C1
      DO 20  NUM=1,10
         EXEC SQL PUT C1
20    CONTINUE
*
      EXEC SQL CLOSE C1
```

- Only the NONE value of the AUTODBL FORTRAN compile option is supported. AUTODBL changes the precision of declared variables without altering the source code. The preprocessor runs before the FORTRAN compiler and interprets variable types based strictly on their declaration.

A host variable must be declared earlier than the first use of the variable in an SQL statement in the program.

Embedding SQL Statements

You must precede each SQL statement in your program with EXEC SQL. No delimiter should be used at the end of each statement.

FORTRAN source statements and SQL statements cannot be contained on the same line or within the same continued statement, except when an SQL statement is used as the imperative statement of a logical IF. Also, only one SQL statement can be contained in a single line, or within the same continued statement.

Using Host Variables in SQL Statements

When you place host variables within an SQL statement, you must precede each one by a colon (:), to distinguish it from the SQL identifiers (such as a column name). When you place a host variable outside of an SQL statement, do not use a colon.

A host variable can represent a data value, but not an SQL identifier. For example, you cannot assign a character constant such as ‘MUSICIANS’ to a host variable, and then use that host variable in a CREATE TABLE statement to represent the table name. This pseudocode sequence is invalid:

```
IT = ' MUSICIANS '
CREATE TABLE :TT (NAME ...
```

Incorrect

Using Variable Length Character Strings

FORTRAN does not support variable length character strings (VARCHAR, LONG VARCHAR). However, it is possible to circumvent this restriction in the following way:

1. Declare INTEGER*2 to contain the length of the string
2. Declare a CHARACTER*(length) string of data
3. Declare a CHARACTER*(2 + length of string)
4. Declare a COMMON block containing (1) and (2) above
5. Use the EQUIVALENCE statement (name of (1) above, name of (3) above)
6. Specify a DATA BLOCK subroutine to initialize (1) and (2) above
7. When referencing the string in an SQL statement, use (3) above.
8. After preprocessing the FORTRAN program (but before compilation), change all occurrences of the data code for the variable(s) in the input or output data structure(s) from the CHARACTER data code to the corresponding VARCHAR or LONG VARCHAR data code. For information on how to interpret the data codes returned in SQLTYPE, see the *DB2 Server for VSE & VM SQL Reference* manual.

Figure 98 on page 317 shows an example of how to INSERT a row into the INVENTORY table using a VARCHAR variable for description.

Note: It is necessary to set the length field (STRNGL) to the corresponding length of the character string (STRING) before the insert statement is executed.

When the character string is fetched, the first two bytes of the string (STRNGW) contain the length. The variable STRNGL determines the length.

```
C*** DB2 Server for VM STATEMENT ***
C     EXEC SQL BEGIN DECLARE SECTION
      CHARACTER ID*8
      CHARACTER PW*8
      INTEGER*2       STRNGL
      CHARACTER*24    STRING
      CHARACTER*26    STRNGW
      COMMON /SDATA/ STRNGL,STRING
      EQUIVALENCE     (STRNGL,STRNGW)
          ...
          ...
C*** DB2 Server for VM STATEMENT ***
C     EXEC SQL END DECLARE SECTION
          ...
          ...
C*** DB2 Server for VM STATEMENT ***
C     EXEC SQL INSERT INTO SQLDBA.ACTIVITY
C    1         VALUES(190, 'TSTSYS',:STRNGW)
C
      SQI002(  3,  1) =   1
      SQI002(  1,  2) = 452 * SQSHHW +  26  ---> Change 452 to 448
      SQI002(  2,  2) = SQLADD(STRNGW)
      SQI002(  3,  2) = 0
      SQCALL = 'EXECUTE '
      SQSTMT =  -1
      SQLTYP = '0'

      SQLCTL(1) = SQLADD ( SQCALL )
      SQLCTL(2) = SQLADD ( SQCOLL )
      SQLCTL(3) = SQLADD ( SQPROG )
      SQLCTL(4) = SQLADD ( SQSTMT )
      SQLCTL(5) = SQLADD ( SQI002 )
      SQLCTL(6) = 0
      SQLCTL(7) = 0
      SQLCTL(8) = 8
      SQLCTL(9) = SQLADD ( SQLISL )
      SQLCTL(10) = SQLADD ( SQLDAT )
      SQLCTL(11) = SQLADD ( SQLTIM )
      SQLCTL(12) = SQLADD ( SQLCNT )
      SQLCTL(13) = SQLADD ( SQLTYP )
      CALL ARIFOR ( SQLCTL )
          ...
          ...
      END

*********************************************************************
*                    BLOCK DATA SUBROUTINE
*********************************************************************
      BLOCK DATA
         COMMON /SDATA/ STRGNL,STRING
         INTEGER*2 STRGNL/3/
         CHARACTER*24 STRING/'SYSTEM TESTING'/
      END
```

Figure 98. Using a VARCHAR Variable

Using DBCS Characters in FORTRAN

The rules for the format and use of DBCS characters in SQL statements are the same for FORTRAN as for other host languages supported by the system. For a discussion of these rules, see "Using a Double-Byte Character Set (DBCS)" on page 46.

FORTRAN does not provide a way to define graphic host variables. If you want to add graphic data to or retrieve it from DB2 Server for VM tables, you must execute the affected statements dynamically. By doing so, the data areas that are referenced by each statement can be described in an SQLDA. In the SQLDA, you must set the data type of the areas containing graphic data to one of the graphic data types. (For a discussion of the SQLDA, refer to the *DB2 Server for VSE & VM SQL Reference* manual.)

Using the INCLUDE Statement

To include the external secondary input, specify the following at the point in the source code where the secondary input is to be included:

```
EXEC SQL INCLUDE text_name
```

is the G-Type source member of a VSE library. *Text_name* is the file name of a CMS file (with a "FORTCOPY" file type) located on a CMS minidisk accessed by the user.

Using FORTRAN Variables in SQL: Data Conversion Considerations

Host variables must be type-compatible with the columns with which they are to be used.

A column of type INTEGER, SMALLINT, or DECIMAL is compatible with a FORTRAN variable of INTEGER, INTEGER*2, or INTEGER*4. Of course, an overflow condition may occur if, for example, an INTEGER data item is retrieved into an INTEGER*2 variable, and its current value is too large to fit.

Fixed-length and varying-length character data (CHAR, VARCHAR, and LONG VARCHAR) are considered compatible. A varying-length string is automatically converted to a fixed-length string, and a fixed-length string is automatically converted to a varying-length string, when necessary. If a varying-length string is converted to a fixed-length string, it is truncated or padded on the right with blanks to the correct length.

The database manager also considers the datetime data types to be compatible with character data types (CHAR and VARCHAR, but not LONG VARCHAR and VARCHAR > 254).

Refer to "Converting Data" on page 44 for a data conversion summary.

Handling SQL Errors

There are two ways to declare the return code structure (called SQLCA):

1. You may write:

   ```
   EXEC SQL INCLUDE SQLCA
   ```

in your source program. The preprocessor replaces this with the declaration of the SQLCA structure.

2. You may declare the SQLCA structure directly, as shown in Figure 99.

```
 INTEGER*4        SQLCOD,
*                 SQLERR(6),
*                 SQLTXL*2
 COMMON /SQLCA1/  SQLCOD,SQLERR,SQLTXL

 CHARACTER        SQLERP*8,
*                 SQLWRN(0:10),
*                 SQLTXT*70,
*                 SQLSTT*5
 COMMON /SQLCA2/  SQLERP,SQLWRN,SQLTXT,SQLSTT
```

Figure 99. SQLCA Structure (in FORTRAN)

The SQLCA must not be declared within the SQL declare section. The meanings of the fields within the SQLCA are discussed in the *DB2 Server for VSE & VM SQL Reference* manual.

You may find that the only variable in the SQLCA you really need is SQLCODE. If this is the case, declare just the SQLCOD variable and invoke NOSQLCA support at preprocessor time.

Note: FORTRAN requires SQLCOD instead of SQLCODE.

The number of SQLCOD declarations is not limited by the preprocessor. If a stand-alone SQLCOD is specified, the code inserted by the preprocessor into the FORTRAN code to expand an EXEC SQL statement will refer to the address of that SQLCOD. The FORTRAN compiler determines if multiple declarations within a program section are not acceptable. In addition, the FORTRAN compiler determines which region of the code an SQLCOD declaration refers to.

Handling Program Interrupts

If a program interrupt occurs and the database manager is unaware of it, you may get unexpected results. To allow the system to process the interrupt, specify the run time options NOSTAE and NOSPIE. These options are only available in Version 2 of FORTRAN.

Using Dynamic SQL Statements in FORTRAN

The FORTRAN preprocessor lets you use a descriptor area, the SQLDA, to execute dynamically defined SQL statements. (See Chapter 6, “Using Dynamic Statements” on page 153 for information on dynamic SQL statements and the SQLDA.) However, the FORTRAN preprocessor will not replace the statement `EXEC SQL INCLUDE SQLDA` with a declaration of the SQLDA structure, as is done with the SQLCA. Instead `EXEC SQL INCLUDE SQLDA` would just include the secondary input file SQLDA, as described in the section “Using the INCLUDE Statement” on page 318.

Before you can use the descriptor area you must properly allocate and initialize it, and you must manage all its address variables. The following example shows how you could define the descriptor area in FORTRAN for three fields:

```
.
      CHARACTER*8  DAID
      INTEGER*4    DABC
      INTEGER*2    DASQLN,
     *             DAD,
     *             DATYPE_1, DATYPE_2, DATYPE_3,
     *             DALEN_1,  DALEN_2,  DALEN_3,
     *             DANLN_1,  DANLN_2,  DANLN_3
      INTEGER*4    DADATA_1, DADATA_2, DADATA_3,
     *             DAIND_1,  DAIND_2,  DAIND_3
      CHARACTER*30 DANAME_1, DANAME_2, DANAME_3

      COMMON /DASQL/ DAID, DABC, DAN, DAD,
     * DATYPE_1, DALEN_1, DADATA_1, DAIND_1, DANLN_1, DANAME_1,
     * DATYPE_2, DALEN_2, DADATA_2, DAIND_2, DANLN_2, DANAME_2,
     * DATYPE_3, DALEN_3, DADATA_3, DAIND_3, DANLN_3, DANAME_3
```

The descriptor area must not be declared within the SQL declare section.

The following pseudocode illustrates the use of a descriptor area, adequate for three fields:

```
      - allocate storage for a Descriptor Area  of at least size = 3
      - set DAN = 3  (number of fields)
      - set DAD = 3
      - set the rest of the values and pointers in the Descriptor Area
        EXEC SQL EXECUTE S1 USING DESCRIPTOR dasql
```

Restrictions When Using the FORTRAN Preprocessor

The FORTRAN preprocessor is an extended dynamic preprocessor that uses the NOMODIFY and DESCRIBE options of the extended CREATE PACKAGE statement. The other extended CREATE PACKAGE options that are used are taken from the parameters specified when invoking the preprocessor.

FORTRAN programs are preprocessed and executed using extended dynamic SQL. Those that are preprocessed with the DB2 Server for VM FORTRAN preprocessor must, therefore, comply with the same restrictions that apply to extended dynamic SQL, or programs preprocessed or executed using extended dynamic SQL.

The following is a partial list of restrictions when using the FORTRAN preprocessor.

- When declaring a dynamic cursor, if you are using the following format of the PREPARE statement, you must code it in your program before the DECLARE CURSOR statement:

```
PREPARE statement_name FROM string_constant
```

This restriction does not apply when using the following format of the PREPARE statement:

```
PREPARE statement_name FROM host_variable
```

- When using DRDA protocol, the following statements are not supported:

  ```
  SELECT INTO
  Positioned UPDATE
  Positioned DELETE
  ```

- When switching between SQLDS protocol and DRDA protocol, you cannot do the following:
  - Preprocess a program using one protocol and then execute it using another protocol.
  - Preprocess a program using one protocol, and then repreprocess the program using another protocol. If the original program is dropped with the DROP PACKAGE statement, you can repreprocess the program using a different protocol.

Note: If the PROTOCOL option on the application requester is set to AUTO, the system uses SQLDS protocol to communicate with another DB2 Server for VM application server, and uses DRDA protocol to communicate with unlike application servers. The system uses DRDA protocol to communicate with another DB2 Server for VM application server only when the PROTOCOL option on the application requester is set to DRDA protocol. The PROTOCOL option is set and queried using the SQLINIT command.

Refer to “Mapping Extended Dynamic Statements to Static and Dynamic Statements” on page 192 for details about mapping extended dynamic statements to non-extended dynamic statements. Refer to the *DB2 Server for VSE & VM SQL Reference* for a discussion of DRDA restrictions.

Defining DB2 Server for VM Data Types for FORTRAN

Figure 100 (Page 1 of 2). DB2 Server for VM Data Types for FORTRAN

Description	**DB2 Server for VM Keyword**	**Equivalent FORTRAN Declaration**
A binary integer of 31 bits, plus sign.	INTEGER or INT	INTEGER INTEGER*4
A binary integer of 15 bits, plus sign.	SMALLINT	INTEGER*2
A packed decimal number, precision *p*, scale s (1 ≤ p ≤ 31 and 0 ≤ s ≤p). In storage the number occupies a maximum of 16 bytes. Precision is the total number of digits. Scale is the number of those digits that are to the right of the decimal point.	DECIMAL[(*p*[,s])] or DEC[(*p*[,s])](1) 1	Not supported.

Figure 100 (Page 2 of 2). DB2 Server for VM Data Types for FORTRAN

Description	**DB2 Server for VM Keyword**	**Equivalent FORTRAN Declaration**
A single-precision (4- byte) floating-point number, in short System/390 floating-point format.	REAL or FLOAT(*p*), 1 ≤ *p* ≤ 21	REAL REAL*4
A double-precision (8- byte) floating-point number, in long System/390 floating-point format.	FLOAT or FLOAT(*p*), 22 ≤ *p* ≤ 53 or DOUBLE PRECISION	REAL*8 DOUBLE PRECISION DOUBLEPRECISION
A fixed-length character string of length *n* where 0 < *n* ≤ 254.	CHARACTER[(*n*)] or CHAR[(*n*)]	CHARACTER CHARACTER**n*
A varying-length character string of maximum length *n*. If *n* > 254 but ≤ 32767, this data type is considered a long field. (See “Using Long Strings” on page 41 for more information.)	VARCHAR(*n*)	Not supported.
A varying-length character string of maximum length 32765 bytes (two bytes less than the DB2 Server for VM maximum, because of the length field). (Character strings ≥ 255 are not supported in FORTRAN releases prior to Release 1.3.)	LONG VARCHAR	Not supported.
A fixed-length string of *n* DBCS characters where 0 < *n* ≤ 127.	GRAPHIC[(*n*)]	Not supported.
A varying-length string of *n* DBCS characters. If n > 127 but ≤ 16383, this data type is considered a long field. (See “Using Long Strings” on page 41 for more information.)	VARGRAPHIC(*n*)	Not supported.
A varying-length string of DBCS characters of maximum length 16383.	LONG VARGRAPHIC	Not supported.
A fixed-length character string representing a date. The minimum and maximum lengths vary with both the format used and whether it is an input or output operation. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	DATE	CHARACTER CHARACTER**n* No varying-length equivalent is supported.
A fixed-length character string representing a time. The minimum and maximum lengths vary with both the format used and whether it is an input or output operation. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	TIME	CHARACTER CHARACTER**n* No varying-length equivalent is supported.
A fixed-length character string representing a timestamp. The lengths can vary on input and output. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	TIMESTAMP	CHARACTER CHARACTER**n* No varying-length equivalent is supported.

Notes:

1. NUMERIC is a synonym for DECIMAL and can be used when creating or altering tables. In such cases, however, the CREATE or ALTER function establishes the column (or columns) as DECIMAL.

An * length specification can also be used to override a length specification associated with the initial keyword. The following are examples:

Specification	**Valid**	**Invalid (ignored)**
INTEGER VAR001,VAR002(2)	VAR001 4 bytes	VAR002
INTEGER*2 VAR001*4,VAR002	VAR001 4 bytes VAR002 2 bytes	
INTEGER*4 VAR001*2/10/,VAR002*4	VAR001 2 bytes VAR002 4 bytes	
INTEGER*5 VAR001*2,VAR002*4		VAR001,VAR002
REAL VAR001*8,VAR002	VAR001 8 bytes VAR002 4 bytes	
REAL*8 VAR001,VAR002*4,VAR003	VAR001 8 bytes VAR002 4 bytes VAR003 8 bytes	
DOUBLE PRECISION VAR001,VAR002*4	VAR001 8 bytes VAR002 4 bytes	
REAL*8 VAR001(10,10)*4,VAR002	VAR002 8 bytes	VAR001
REAL*16 VAR001,VAR002*4,VAR003*8	VAR002 4 bytes VAR003 8 bytes	VAR001
CHARACTER VAR1,VAR2*80	VAR1 1 byte VAR2 80 bytes	
CHARACTER*10 VAR1,VAR2*80	VAR1 10 bytes VAR2 80 bytes	
CHARACTER*500 VAR1(5),VAR2*1	VAR2 1 byte	VAR1

Appendix E. Using SQL in PL/I

Contents

Using PL/I Sample Program ARIS6PLC 326
Rules for Using SQL in PL/I 326
  Placing and Continuing SQL Statements 326
  Delimiting SQL Statements 326
  Using the INCLUDE Statement 327
  Declaring Static External Variables 327
  Identifying Rules for Case 327
  Declaring Host Variables 327
  Using Host Variables in SQL Statements 330
  Using PL/I Variables in SQL: Data Conversion Considerations 330
  Using DBCS Characters in PL/I 331
  Using SQL Statements in PL/I Subroutines 331
Handling SQL Errors 332
Handling Program Interrupts 333
Using Dynamic SQL Statements in PL/I 334
Defining DB2 Server for VM Data Types for PL/I 336
| Using Stored Procedures 337

Using PL/I Sample Program ARIS6PLC

ARIS6PLC is a PL/I language sample program for VM systems that is shipped with the DB2 Server for VM product. It resides on the production disk for the base product. You may find it useful to print this sample program before going through this appendix as the hard copy will provide an illustration for many of the topics discussed here.

You can learn most of the rules for using SQL within PL/I just by scanning through the program. Note, in particular, how the program satisfies the requirements of the application prolog and epilog. Near the beginning of the program all the host variables are declared and error handling is defined. Near the logical end of the program, the database changes are rolled back, to assure the database remains consistent for each use of the sample program. For your own applications, of course, you will enter a commit.

The DCL statements for the host variables are determined by referring to Figure 105 on page 336. That figure gives the PL/I representation for each of the DB2 Server for VM data types. When you are coding your own applications, you will need to obtain the data types of the columns that your host variables interact with. This can be done by querying the catalog tables, which are described in the *DB2 Server for VSE & VM SQL Reference* manual.

Rules for Using SQL in PL/I

Placing and Continuing SQL Statements

All statements in your PL/I program, including SQL statements, must be contained in columns 2 through 72 of your source deck. Normal PL/I continuation rules apply.

Continuation of tokens (the basic syntactical units of a language) is allowed from one line to the next, by coding the first part of the token up to column 72 on the line to be continued and coding the next part of the token from column 2 on the continuation line. If either column 72 of the continued line or column 2 of the continuation line is blank, the token is not continued.

See the *DB2 Server for VSE & VM SQL Reference* manual for a discussion on tokens.

Delimiting SQL Statements

Delimiters are required on all SQL statements to help the database manager distinguish them from regular PL/I statements. You must precede each SQL statement in your program with EXEC SQL, and end each statement with a semicolon. EXEC and SQL must be on the same line, with only blanks separating them (no in-line host language or SQL comments).

Within SQL statements, host language and SQL comments are allowed anywhere that blanks are allowed. However, there should not be any host language or SQL comments within SQL statements that are dynamically defined and executed.

An SQL statement cannot be followed on the same line by another SQL statement, a normal PL/I statement, or a host language comment. When you preprocess a program containing such a combination, the trailing statements or host language comments are ignored and will not appear in the SYSPRINT listing.

Using the INCLUDE Statement

To include external secondary input, specify the following at the point in the source code where the secondary input is to be included:

```
EXEC SQL INCLUDE text_file-name;
```

The *text_file*-name is the file name of a CMS file (with a “PLICOPY” file type) located on a CMS minidisk accessed by the user.

Declaring Static External Variables

A declaration for a variable with the attributes STATIC and EXTERNAL must also have the attribute INITIAL. If it does not, the declaration generates a common CSECT, which the database manager cannot handle.

PL/I programming using “DEFAULT RANGE (*) STATIC” gives an error message. The preprocessor builds control blocks that are incompatible with this statement.

Identifying Rules for Case

The keywords “EXEC SQL” must appear in uppercase in your PL/I program. The rest of an SQL statement can be in mixed case, but will be interpreted as uppercase, except for text within quotation marks, which will be left in the original case.

Declaring Host Variables

You must declare all host variables in an SQL declare section. For a description of an SQL declare section, refer to “Declaring Variables That Interact with the Database Manager” on page 6.

Declare host variables in the source file before the first use of the variable in an SQL statement. You can use the following types of variables in an SQL statement:

- Scalar variables
- Structure variables
- Structure elements
- Array variables

For information on the use of these variables in an SQL statement, refer to “Using Host Variables” on page 51 and “Using Host Structures” on page 51.

Note: You can declare non-host variables in an SQL declare section; however, declarations that do not conform to DB2 Server for VM declaration rules may return errors.

The declaration of a host variable is subject to the following rules:

- You can use scalar variables and structure elements as main variables. You can also use them as indicator variables if they are declared with a data type of short integer.

- The only arrays accepted by the PL/I preprocessor are arrays of short integer elements. These arrays may be used as indicator arrays only. The following example is an indicator array:

  ```
  DCL IND_ARRAY(10) BINARY FIXED(15);
  ```

  Indicator array elements cannot be used as main or indicator variables.

- A structure variable (which defines a host structure) is any two-level structure declared in an SQL declare section. The following example is a host structure:

  ```
  DCL 01 PROJ_STRCT,
      05 PROJNO            CHAR(6),
      05 ACTNO             BINARY FIXED(15),
      05 ACSTAFF           BINARY FIXED(31),
      05 ACSTDATE          CHAR(10),
      05 ACENDATE          CHAR(10);
  ```

  This structure represents the following list of host variables when used in an SQL statement:

  ```
  PROJNO, ACTNO, ACSTAFF, ACSTDATE, ACENDATE
  ```

  In other words, the two following SQL statements are equivalent:

  ```
  EXEC SQL SELECT PROJNO, ACTNO, ACTSTAFF, ACSTDATE, ACENDATE
            INTO  :PROJ_STRCT
            FROM PROJ_ACT
           WHERE PROJNO = ‘100000’


  EXEC SQL SELECT PROJNO, ACTNO, ACSTAFF, ACSTDATE, ACENDATE
             INTO :PROJNO, :ACTNO, :ACSTAFF, :ACSTDATE, :ACENDATE
             FROM PROJ_ACT
            WHERE PROJNO = ‘100000’
  ```

  A host structure can either be a stand-alone structure or a substructure of a more complex structure. The following example is a complex structure that contains a host structure:

  ```
  DCL 01 EMPLOYEE,
         05 EMPNO            CHAR(6),
         05 EMPNAME
            10 FIRSTNAME              CHAR(12),
            10 MIDINIT                CHAR(1),
            10 LASTNAME               CHAR(15),
         05 WORKDEPT         CHAR(3),
         05 PHONENO          CHAR(4);
  ```

  The structure `EMPNAME` is a host structure.

  You can use the elements of the host structure and the elements of a complex structure containing a host structure as host variables. In the previous example, `EMPNO`, `FIRSTNAME`, `MIDINIT`, `LASTNAME`, `WORKDEPT`, and `PHONENO` can all be used as host variables.

- DCL or DECLARE must be the first character sequence on the line, but cannot start in column 1. You can, however, have a carriage control character in column 1. Otherwise, the line is ignored. (You can place inline host language comments anywhere after the DECLARE or DCL keyword, and you can continue these comments over multiple lines.)

- DECLARE statements can be continued on additional lines, but you cannot have more than one DECLARE statement on the same line. All DECLARE statements must end with a semicolon. Rules for continuation of variable names and PL/I keywords are the same as those described for SQL statements.

- Declare only one host variable per DCL or DECLARE statement. If you declare multiple variables, only the first variable is recognized; the others are ignored. For example:

```
DCL AA FIXED BIN(15) INIT(7),
    BB CHAR(7),                    BB and CC are ignored.
    CC BINARY FLOAT(53);
```

  The next rule provides one exception to this limitation.

- Factoring of scalar variable names, structure element names and indicator array names is supported. For example, the following declarations are valid:

```
DCL (X,Y,Z)   BINARY FIXED(31);

DCL (ARR1(10), ARR2(5), ARR3(6))  BINARY FIXED (15);

DCL 01 STUCT,
       05 (FLD1, FLD2, FLD3)  CHAR(10),
       05 FLD4                CHAR(5);
```

- In addition to the attributes discussed in Figure 105 on page 336, the PL/I preprocessor also supports the following attributes in declarations imbedded in an SQL declare section:

  ALIGNED
  UNALIGNED
  INTERNAL
  EXTERNAL
  STATIC
  AUTOMATIC
  DEFINED
  CONTROLLED
  CONNECTED
  INITIAL

- In PL/I, the BASED and LIKE functions are not permitted in host structure declarations.
- You cannot duplicate variable names in a single source file even if they are in different blocks or functions. The PL/I preprocessor defines a duplicate as any name that cannot be referenced unambiguously when fully qualified.
- You should not declare variables whose names begin with SQL or RDI, because these names are reserved for database manager use.
- The database manager allows host variable names, statement labels, and SQL descriptor area names of up to 256 characters in length, subject to any PL/I language restriction mentioned in this appendix.

You can have a label on the “EXEC SQL BEGIN DECLARE SECTION;”, but not on the “EXEC SQL END DECLARE SECTION;”. If you do place a label on this statement, the preprocessor does not recognize it and assumes that the SQL declare section has not ended.

When placing host language comments after either of these statements, make sure the comment ends on the same line. If it does not, PL/I compiler errors result.

Note: Other program variables can also be declared as usual outside the SQL declare section. The previous restrictions do not apply to non-SQL declarations.

In the declaration below, only `DATES` and `PRODUCTS` may be used as host structures. `ORDERNO` and `CUSTNUM` may be used as scalar host variables and may be qualified as `CUSTORD.ORDERNO` and `ORDINFO.CUSTNUM` or `CUSTORD.ORDINFO.CUSTNUM`.

```
EXEC SQL BEGIN DECLARE SECTION;
     DCL 1 CUSTORD,
          2 ORDERNO CHAR(10),
          2 ORDINFO,
            3 CUSTNUM  CHAR(10),
            3 DATES,
              5 ORDDATE  CHAR(6),
              5 DELIVDTE CHAR(6),
          2 PRODUCT,
            3 STOCKNO  CHAR(10),
            3 QUANTITY CHAR(3);
EXEC SQL END DECLARE SECTION;

EXEC SQL SELECT STOCKNO, QUANTITY
         INTO :PRODUCT
         FROM ORDER
         WHERE STOCKNO = '1234567890';
```

Using Host Variables in SQL Statements

When you reference host variables, host structures, structure fields or indicator arrays in an SQL statement, you must precede each reference by a colon (:) The colon distinguishes these variables from SQL identifiers (such as column names). The colon is not required outside an SQL statement.

Using PL/I Variables in SQL: Data Conversion Considerations

Host variables must be type-compatible with the columns with which they are to be used. For example, if you want to compare a program variable with the QONHAND column of the database, and the data type of QONHAND is INTEGER, you should declare the program variable BIN FIXED(31), BIN FIXED(15), BIN FLOAT, FLOAT BIN, or FIXED DECIMAL(10). (Refer to “Assigning Data Types When the Column Is Created” on page 39 for details on the FLOAT data type.)

The database manager considers the numeric data types compatible, as well as the character string data types (CHAR, VARCHAR, and LONG VARCHAR, including strings of different declared lengths), and the graphic string data types (GRAPHIC, VARGRAPHIC, LONG VARGRAPHIC). Of course, an overflow condition may result if, for example, you assign a 31-bit integer to a 15-bit integer and the current value of the 31-bit integer is too large to fit in 15 bits. Truncation also occurs when a decimal number having a scale greater than zero is assigned to an integer. In general, overflow occurs when significant digits are lost, and truncation occurs when nonsignificant digits are lost.

The datetime data types are also considered compatible with character data types (CHAR, and VARCHAR, but not LONG VARCHAR and VARCHAR > 254).

Refer to “Converting Data” on page 44 for a data conversion summary.

Using DBCS Characters in PL/I

The rules for the format and use of DBCS characters in SQL statements are the same for PL/I as for other host languages supported by the system. For a discussion of these rules, see “Using a Double-Byte Character Set (DBCS)” on page 46.

When using the string-constant format of the PREPARE or EXECUTE IMMEDIATE statement, if the statement in the string-constant contains DBCS characters, you must append an M to the string-constant. For example:

```
EXEC SQL PREPARE S13 FROM
'SELECT TRANSLATE(''laabb'') || ''l< AB >'' FROM SYSTEM.SYSCCSIDS'M;
```

When coding graphic constants in static SQL statements, use one of the following PL/I formats of the graphic constant:

```
1.  '< XXXX >'G

2.  <@' XXXX @'@G>
```

Note: N is a synonym for G.

When coding graphic constants in dynamically executed SQL statements, use the SQL format of the graphic constant (that is, `G'< XXXX >'`). Refer to “Using Graphic Constants” on page 54 for a discussion of graphic constants.

Using SQL Statements in PL/I Subroutines

The first SQL statement encountered in a sequential scan of your program by the PL/I preprocessor that requires an in-line call to the resource adapter results in the generation of control blocks SQLTIE and RDIEXT, and other declarations commonly used by internal DB2 Server for VM code that is associated with the remaining SQL statements in your program. If your program structure involves SQL statements in multiple procedures, you must maintain structures so that the SQLTIE and RDIEXT are addressable by all other SQL statement occurrences in your program.

Figure 101 on page 332 represents an incorrect structure.

```
A: PROC OPTIONS(MAIN);
        .
        .
   CALL B;
   CALL C;
        .
        .
B: PROC;
        .
        .
   EXEC SQL CONNECT.....
   EXEC SQL DECLARE C1 CURSOR....
   EXEC SQL OPEN C1 ...
        .
        .
   END B;
C: PROC;
        .
        .
   EXEC SQL DECLARE C2 CURSOR....
   EXEC SQL OPEN C2 .....
        .
        .
        .
   END C;
        .
        .
   END A;
```

Figure 101. Incorrect PL/I Program Structure

SQLTIE and RDIEXT will be generated from the CONNECT in B, but it is not addressable from C, where other SQL statements appear. This can be solved by putting the CONNECT statement in A, where it will cause SQLTIE and RDIEXT to be generated at a place that is addressable by both B and C.

Handling SQL Errors

There are two ways to declare the return code structure (called SQLCA):

1. You can write the following statement in your source program:

   ```
   EXEC SQL INCLUDE SQLCA;
   ```

   The preprocessor replaces this with the declaration of the SQLCA structure.

2. You may declare the SQLCA structure directly, as shown in Figure 102 on page 333.

```
  DCL 1 SQLCA,
        2 SQLCAID CHAR(8),
        2 SQLCABC BIN FIXED(31),
        2 SQLCODE BIN FIXED(31),
        2 SQLERRM CHAR(70) VAR,
        2 SQLERRP CHAR(8),
        2 SQLERRD (6) BIN FIXED(31),
        2 SQLWARN,
          3 SQLWARN0 CHAR(1),
          3 SQLWARN1 CHAR(1),
          3 SQLWARN2 CHAR(1),
          3 SQLWARN3 CHAR(1),
          3 SQLWARN4 CHAR(1),
          3 SQLWARN5 CHAR(1),
          3 SQLWARN6 CHAR(1),
          3 SQLWARN7 CHAR(1),
          3 SQLWARN8 CHAR(1),
          3 SQLWARN9 CHAR(1),
          3 SQLWARNA CHAR(1),
        2 SQLSTATE CHAR(5);
```

Figure 102. SQLCA Structure (in PL/I)

The SQLCA must not be declared within the SQL declare section. The meanings of the fields in the SQLCA are discussed in the *DB2 Server for VSE & VM SQL Reference* manual.

You may find that the only variable in the SQLCA you really need is SQLCODE. If this is the case, declare just the SQLCODE variable, and invoke NOSQLCA support at preprocessor time.

The number of SQLCODE declarations is not limited by the preprocessor. If a stand-alone SQLCODE is specified, the code inserted by the preprocessor into the PL/I code to expand an EXEC SQL statement will refer to the address of that SQLCODE. The PL/I compiler determines if multiple declarations within a program section are not acceptable. In addition, the PL/I compiler determines which region of the code an SQLCODE declaration refers to.

Handling Program Interrupts

If a program interrupt occurs and the database manager is unaware of it, you may receive unexpected results. To allow the system to process the interrupt, include the following declaration statement **after** the “EXEC SQL END DECLARATION SECTION” statement:

|
```
DCL PLIXOPT CHAR(20) VAR INIT('TRAP(OFF)') STATIC EXTERNAL;
```

| If your PL/I compiler is NOT Language Environment enabled, add the following
| statement instead:

```
DCL PLIXOPT CHAR(20) VAR INIT('NOSTAE,NOSPIE') STATIC EXTERNAL;
```

Using Dynamic SQL Statements in PL/I

You may need to declare an SQLDA structure to execute dynamically defined SQL statements. You can have the system include the structure automatically by specifying:

```
EXEC SQL INCLUDE SQLDA;
```

in your source code, or by directly coding the structure as shown in Figure 103.

```
     DCL 1 SQLDA BASED(SQLDAPTR),
          2 SQLDAID CHAR(8),
          2 SQLDABC BIN FIXED(31),
          2 SQLN BIN FIXED(15),
          2 SQLD BIN FIXED(15),
          2 SQLVAR(SQLSIZE REFER(SQLN)),
               3 SQLTYPE BIN FIXED(15),
               3 SQLLEN BIN FIXED(15),
               3 SQLDATA PTR,
               3 SQLIND PTR,
               3 SQLNAME CHAR(30) VAR;
     DCL SQLSIZE BIN FIXED(15);
     DCL SQLDAPTR PTR;
```

Figure 103. SQLDA Structure (in PL/I)

The SQLDA must not be declared within the SQL declare section. See the *DB2 Server for VSE & VM SQL Reference* manual for more information on the individual fields within the SQLDA.

In addition to the structure above, you should declare an additional mapping for the same area. The SQLPRCSN and SQLSCALE fields of the second mapping are used when decimal data is used. Figure 104 shows this mapping.

Figure 104 (Page 1 of 2). SQLDAX Structure (in PL/I)

```
     DCL 1 SQLDAX BASED(SQLDAPTR),
          2 SQLDAIDX CHAR(8),
          2 SQLDABCX BIN FIXED(31),
          2 SQLNX BIN FIXED(15),
          2 SQLDX BIN FIXED(15),
          2 SQLVARX(SQLSIZE REFER(SQLNX)),
               3 SQLTYPEX BIN FIXED(15),
               3 SQLPRCSN format 1 or format 2,
               3 SQLSCALE format 1 or format 2,
               3 SQLDATAX PTR,
               3 SQLINDX PTR,
               3 SQLNAMEX CHAR(30) VAR;
```

The SQLPRCSN and SQLSCALE fields can be declared in one of two formats.

```
Format 1:      3 SQLPRCSN BIT(8),
               3 SQLSCALE BIT(8),
```

The fields must be set by bit 8 strings. For example, for a precision of 5 and scale of 2, the following assignments are required:

```
  SQLDAPTR->SQLPRCSN = '00000101'B
  SQLDAPTR->SQLSCALE = '00000010'B
```

Figure 104 (Page 2 of 2). SQLDAX Structure (in PL/I)

```
Format 2:      3 SQLPRCSN CHAR(1),
               3 SQLSCALE CHAR(1),
```

This format requires the declaration of additional variables. These are a CHAR(2) variable and a BASED FIXED BIN(15) variable for both precision and scale. For example:

```
DCL PRCSNC CHAR(2);
DCL PRCSNN FIXED BIN(15) BASED (ADDR(PRCSNC));
DCL SCALEC CHAR(2);
DCL SCALEN FIXED BIN(15) BASED (ADDR(SCALEC));
```

The SQLDAX fields for a precision of 5 and scale of 2 would be:

```
PRCSNN = 5;
SCALEN = 2;
SQLDAPTR->SQLPRCSN = SUBSTR(PRCSNC,2,1);
SQLDAPTR->SQLSCALE = SUBSTR(SCALEC,2,1);
```

Format 2, although more complex, allows PL/I manipulation of the precision and scale fields. For example, the value of the SQLPRCSN field can be determined simply by reversing the substring operation above. That is:

```
SUBSTR(PRCSNC,2,1) = SQLDAPTR->SQLPRCSN;
```

Such an operation cannot be done using format 1.

Because the PL/I SQLDA is declared as a based structure, your program can dynamically allocate an SQLDA of adequate size for use with each EXECUTE statement. For example, the code fragment below allocates an SQLDA adequate for five fields and uses it in an EXECUTE of statement S3:

```
SQLSIZE=5;
ALLOCATE SQLDA SET(SQLDAPTR);
/* Add code to set values and pointers in the SQLDA */
EXEC SQL EXECUTE S3 USING DESCRIPTOR SQLDA;
```

The statement SQLSIZE=5 determines the size of the SQLDA to be allocated by means of the PL/I REFER feature. The ALLOCATE statement allocates an SQLDA of the size desired, and sets SQLDAPTR to point to it. (Before an EXECUTE statement is issued using this SQLDA, your program must fill in its contents.)

You can use a similar technique to allocate an SQLDA for use with a DESCRIBE statement. The following program fragment illustrates the use of SQLDA with DESCRIBE for three fields and a “prepared” statement S1:

```
EXEC SQL DECLARE C1 CURSOR FOR S1;
SQLSIZE = 3;
ALLOCATE SQLDA SET(SQLDAPTR);
EXEC SQL DESCRIBE S1 INTO SQLDA;
IF SQLD > SQLN THEN
     - get a bigger one;
Set SQLDATA and SQLIND;
EXEC SQL OPEN C1;
EXEC SQL FETCH C1 USING DESCRIPTOR SQLDA;
```

Defining DB2 Server for VM Data Types for PL/I

Figure 105 (Page 1 of 2). Data Types for PL/I

Description	DB2 Server for VM Keyword	Equivalent PL/I Declaration
A binary integer of 31 bits, plus sign.	INTEGER or INT	BINARY FIXED(31)
A binary integer of 15 bits, plus sign.	SMALLINT	BINARY FIXED(15)
A packed decimal number, precision p, scale s ($1 \le p \le 31$ and $0 \le s \le p$). In storage the number occupies a maximum of 16 bytes. Precision is the total number of digits. Scale is the number of those digits that are to the right of the decimal point.	DECIMAL[(*p*[,*s*])] or DEC[(*p*[,*s*])](1) [1]	FIXED DECIMAL(*p*,*s*)
A single-precision (4- byte) floating-point number, in short System/390 floating-point format.	REAL or FLOAT(*p*), $1 \le p \le 21$	BINARY FLOAT(*p*) or FLOAT BINARY(*p*), $1 \le p \le 21$ DECIMAL FLOAT(*p*) or FLOAT DECIMAL(*p*), $1 \le p \le 7$
A double-precision (8- byte) floating-point number, in long System/390 floating-point format.	FLOAT or FLOAT(*p*), $22 \le p \le 53$ or DOUBLE PRECISION	BINARY FLOAT(*p*) or FLOAT BINARY(*p*), $22 \le p \le 53$ DECIMAL FLOAT(*p*) or FLOAT DECIMAL(*p*), $8 \le p \le 16$
A fixed-length character string of length *n* where $0 < n \le 254$.	CHARACTER[(*n*)] or CHAR[(*n*)]	CHARACTER(*n*)
A varying-length character string of maximum length *n*. If $n > 254$ or $\le$ 32 767, this data type is considered a long field. See "Using Long Strings" on page 41 for more information.	VARCHAR(*n*)	CHARACTER(*n*) VARYING
A varying-length character string of maximum length 32,767 bytes.	LONG VARCHAR	CHARACTER(*n*) VARYING
A fixed-length string of *n* DBCS characters where $0 < n \le 127$.	GRAPHIC[(*n*)]	GRAPHIC(*n*)
A varying-length string of *n* DBCS characters. If $n > 127$ or $\le$ 16 383, this data type is considered a long field. See "Using Long Strings" on page 41 for more information.	VARGRAPHIC(*n*)	GRAPHIC(*n*) VARYING
A varying-length string of DBCS characters of maximum length 16 383.	LONG VARGRAPHIC	GRAPHIC(*n*) VARYING

Figure 105 (Page 2 of 2). Data Types for PL/I

Description	DB2 Server for VM Keyword	Equivalent PL/I Declaration
A fixed or varying-length character string representing a date. The minimum and maximum lengths vary with both the format used and whether it is an input or output operation. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	DATE	CHARACTER(*n*) or CHARACTER(*n*) VARYING
A fixed or varying-length character string representing a time. The minimum and maximum lengths vary with both the format used and whether it is an input or output operation. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	TIME	CHARACTER(*n*) or CHARACTER(*n*) VARYING
A fixed or varying-length character string representing a timestamp. The lengths can vary on input and output. See the *DB2 Server for VSE & VM SQL Reference* manual for more information.	TIMESTAMP	CHARACTER(*n*) or CHARACTER(*n*) VARYING

Notes:

1. NUMERIC is a synonym for DECIMAL and may be used when creating or altering tables. In such cases, however, the CREATE or ALTER function will establish the column (or columns) as DECIMAL.
2. The data type can be stated in any way that is acceptable to PL/I; BIN FIXED(31), BINARY FIXED(31), and FIXED BIN(31) are all equivalent. If several variables have exactly the same attributes, you can combine them in a single DCL statement:

```
DCL (X,Y,Z) BIN FIXED;
```

Using Stored Procedures

The following example shows how to define the parameters in a stored procedure that uses the GENERAL linkage convention. The NOEXECOPS procedure option must be specified.

```
PLISAMP: PROC(PARM1, PARM2, ...)
         OPTIONS(MAIN, NOEXECOPS);

         DCL PARM1 ...        /* first parameter */
         DCL PARM2 ...        /* second parameter */
  .
  .
  .
```

Figure 106. Stored Procedure - Using GENERAL Linkage Convention

The following example shows how to define the parameters in a stored procedure that uses the GENERAL WITH NULLS linkage convention.

```
PLISAMP: PROC(PARM1, PARM2, INDSTRUC)
         OPTIONS(MAIN, NOEXECOPS);

         DCL PARM1 ...        /* first parameter */
         DCL PARM2 ...        /* second parameter */

         DCL 01 INDSTRUC,
                02 IND1 BIN FIXED(15),  /* first ind var */
                02 IND2 BIN FIXED(15);  /* second ind var */
  .
  .
  .
```

Figure 107. Stored Procedure - Using GENERAL WITH NULLS Linkage Convention

Appendix F. Decision Tables to Grant Privileges on Packages

Contents

How to Use the Decision Tables 340
Decision Tables 341

How to Use the Decision Tables

The DB2 Server for VM product uses decision tables to determine whether the owner of a package has the authority or the privilege to execute a given statement. There are three possible scores for each static statement:

'G'	Means that the package owner has the necessary authorization or privilege for this statement such that the owner can receive the RUN privilege.
'Y'	Means that the package owner has the necessary authorization or privilege for this statement such that the owner can receive the RUN privilege, but not the GRANT option on that privilege.
'D'	Means that the package owner must have DBA authority to execute the program containing this statement. No entry is made in the authorization catalog tables.

'G' is the highest score, followed by 'Y', followed by 'D'. For example, suppose a program contains three statements. The package owner receives a 'G', on two of them, but a 'Y' on the third (this occurs when the object referenced in the statement does not exist, or the privileges of the object cannot be resolved). In this situation, the database manager assigns the package a 'Y' (the lower score), allowing the owner to run the package but not to grant the RUN privilege on the package to another user. Because the preprocessor does not distinguish between certain SQL statements that are applied to one application server or to another, you can compensate by doing one of the following:

- Use dynamic statements that cause RUNAUTH=G on both application servers.
- Create separate packages on each application server. These separate packages can then be invoked by a mainline program.
- Create dummy tables that have the same user IDs and table names on the other application server.

Dynamic statements are always given a score of 'G'.

The next few pages show tables. In these tables:

'G', **'Y'**, and **'D'** have the meanings outlined above.

'(G)' and **'(Y)'** mean that the score for the statement is either 'G' or 'Y', an error message is produced when the program is preprocessed, a partial section for the statement is placed into the package, and the authority for the statement is checked again at the time the package is run.

'n/a' means 'not applicable'.

package owner is the authorization ID of the person who preprocesses the program.

Decision Tables

ACQUIRE DBSPACE

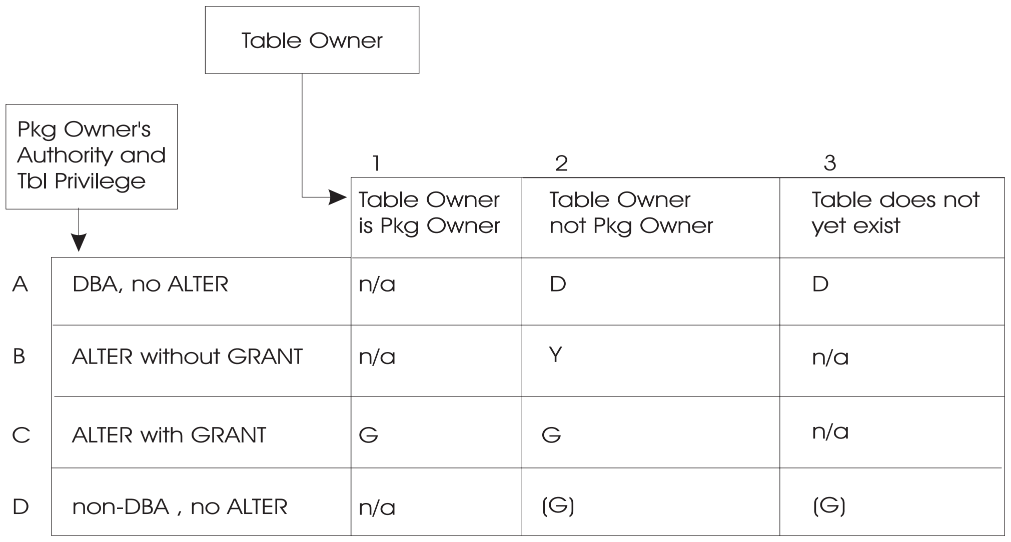
	Pkg Owner's Authority	Dbspace Owner 1	2	3
			PRIVATE	
		PUBLIC	Dbspace Owner is Pkg Owner	Dbspace Owner not Pkg Owner
A	DBA	D	G	D
B	RESOURCE	(G)	G	(G)
C	None of the above	(G)	(G)	(G)

For cases A2 and B2, the system makes an entry in the SYSUSERAUTH catalog table with RESOURCEAUTH set to ‘Y’. In addition, the NAME column is set to the package_id and the AUTHOR column is set to the authorization ID of the person who preprocessed the program. The entry indicates the program's dependency.

ALTER DBSPACE

	Pkg Owner's Authority	Dbspace Owner 1	2
		Dbspace Owner is Pkg Owner	Dbspace Owner not Pkg Owner
A	DBA	G	D
B	non-DBA	G	(G)

ALTER TABLE

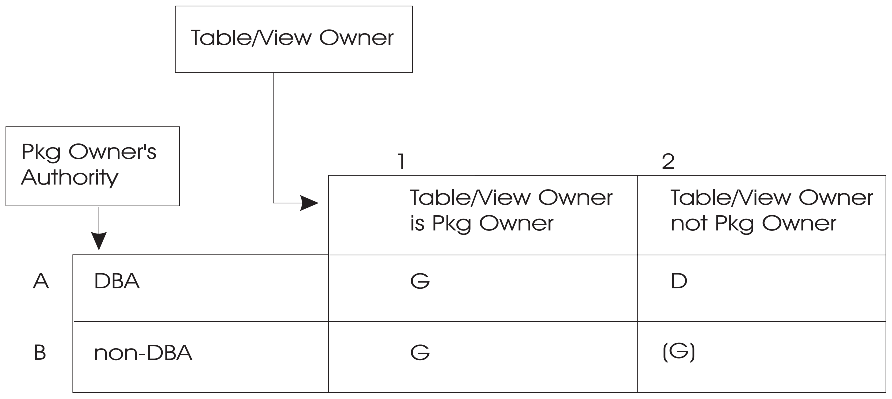


	Pkg Owner's Authority and Tbl Privilege	1 Table Owner is Pkg Owner	2 Table Owner not Pkg Owner	3 Table does not yet exist
A	DBA, no ALTER	n/a	D	D
B	ALTER without GRANT	n/a	Y	n/a
C	ALTER with GRANT	G	G	n/a
D	non-DBA , no ALTER	n/a	(G)	(G)

For cases B2, C1, and C2, the system makes entries in the SYSTABAUTH catalog table with the ALTERAUTH columns set to ‘Y’. The entries represent this package's dependency on ALTER privilege for the table.

The preprocessor determines which level of RUN privilege to give the owner. For some SQL statements, privileges are not checked for all objects affected by the statement. For example, when manipulating primary and foreign keys with the ALTER TABLE statement, ALTER privilege is only checked for the table_name following the ALTER TABLE statement rather than all the tables involved. Additional ALTER and REFERENCES privileges are checked at run time.

COMMENT ON



	Pkg Owner's Authority	1 Table/View Owner is Pkg Owner	2 Table/View Owner not Pkg Owner
A	DBA	G	D
B	non-DBA	G	(G)

CREATE INDEX

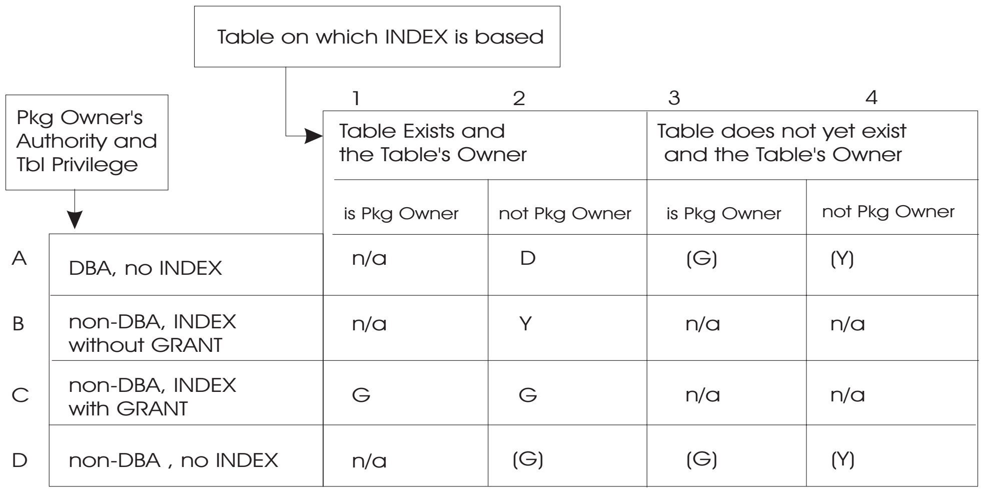


Table on which INDEX is based

Pkg Owner's Authority and Tbl Privilege		1	2	3	4
		Table Exists and the Table's Owner		Table does not yet exist and the Table's Owner	
		is Pkg Owner	not Pkg Owner	is Pkg Owner	not Pkg Owner
A	DBA, no INDEX	n/a	D	(G)	(Y)
B	non-DBA, INDEX without GRANT	n/a	Y	n/a	n/a
C	non-DBA, INDEX with GRANT	G	G	n/a	n/a
D	non-DBA , no INDEX	n/a	(G)	(G)	(Y)

For cases B2, C1, and C2, the system makes an entry in the SYSTABAUTH catalog table with the INDEXAUTH column set to 'Y'. The entries represent this package's dependency on INDEX authority privilege for the table.

Note: It is possible for the owner of a table to create an index on that table in the name of another authorization ID. This is true even if the table owner does not have DBA authority.

CREATE TABLE

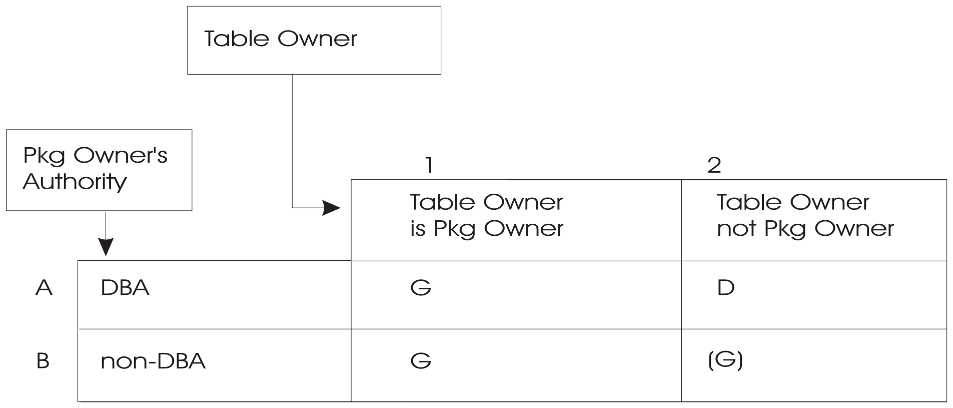


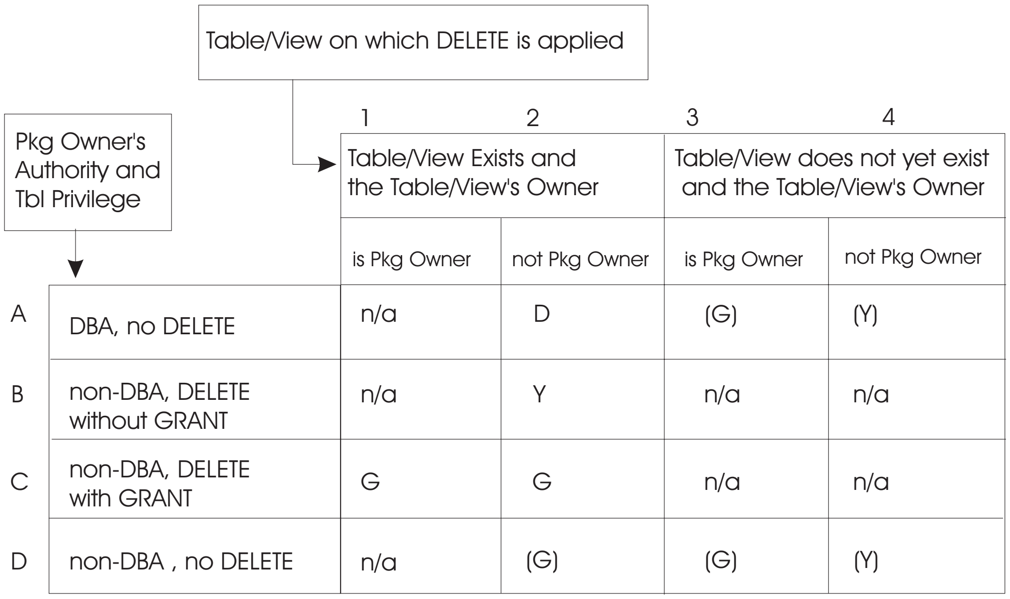
Table Owner

Pkg Owner's Authority		1	2
		Table Owner is Pkg Owner	Table Owner not Pkg Owner
A	DBA	G	D
B	non-DBA	G	(G)

DELETE

There are two decision tables that apply to DELETE:

<u>The Table Where the Deletion Is Applied</u> :



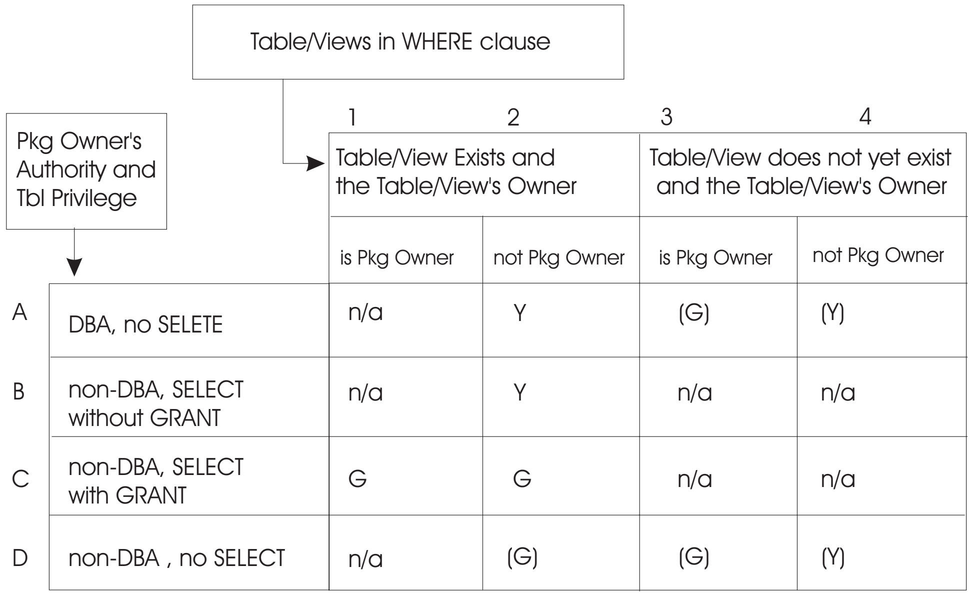
Table/View on which DELETE is applied

	Pkg Owner's Authority and Tbl Privilege	1	2	3	4
		Table/View Exists and the Table/View's Owner		Table/View does not yet exist and the Table/View's Owner	
		is Pkg Owner	not Pkg Owner	is Pkg Owner	not Pkg Owner
A	DBA, no DELETE	n/a	D	(G)	(Y)
B	non-DBA, DELETE without GRANT	n/a	Y	n/a	n/a
C	non-DBA, DELETE with GRANT	G	G	n/a	n/a
D	non-DBA , no DELETE	n/a	(G)	(G)	(Y)

In cases B2, C1, and C2, the application server makes entries in the SYSTABAUTH catalog table with the DELETEAUTH column set to 'Y'. The entries represent this package's dependency on the DELETE privilege for the table.

<u>Any Tables Referenced in a WHERE Clause</u> :

Note: The authorization checking in the previous decision table precedes the logic of this table. If the first decision table yields a negative SQLCODE, processing stops. Otherwise, the system applies the lowest level of authorization gained from the two decision tables.



Table/Views in WHERE clause

	Pkg Owner's Authority and Tbl Privilege	1	2	3	4
		Table/View Exists and the Table/View's Owner		Table/View does not yet exist and the Table/View's Owner	
		is Pkg Owner	not Pkg Owner	is Pkg Owner	not Pkg Owner
A	DBA, no SELETE	n/a	Y	(G)	(Y)
B	non-DBA, SELECT without GRANT	n/a	Y	n/a	n/a
C	non-DBA, SELECT with GRANT	G	G	n/a	n/a
D	non-DBA , no SELECT	n/a	(G)	(G)	(Y)

Figure 108. Tables/Views in WHERE clause

In cases B2, C1, and C2, the application server makes entries in the SYSTABAUTH catalog table with the SELECTAUTH column set to 'Y'. The entries represent this package's dependency on SELECT privilege for the table.

In case A2, the system makes an entry in the SYSUSERAUTH catalog table to show this package's dependency on DBA authority.

GRANT for Authorities Statement

	Authority of Grantor	Authority Granted			
		1	2	3	4
		DBA	RESOURCE	CONNECT to another user	CONNECT to self
A	DBA	D	D	D	G
B	Non-DBA	G	G	G	G

INSERT:

There are two decision tables that apply to INSERT:

<u>The Table Where the Insertion Is Applied</u> :

	Pkg Owner's Authority and Tbl Privilege	Table/Views to which INSERT is applied			
		1	2	3	4
		Table/View Exists and the Table/View's Owner		Table/View does not yet exist and the Table/View's Owner	
		is Pkg Owner	not Pkg Owner	is Pkg Owner	not Pkg Owner
A	DBA, no INSERT	n/a	D	(G)	(Y)
B	non-DBA, INSERT without GRANT	n/a	Y	n/a	n/a
C	non-DBA, INSERT with GRANT	G	G	n/a	n/a
D	non-DBA, no INSERT	n/a	(G)	(G)	(Y)

In cases B2, C1, and C2, the system makes entries in the SYSTABAUTH catalog table with the INSERTAUTH column set to ‘Y’. The entries represent this package's dependency on INSERT privilege for the table.

<u>Any Tables Referenced in a WHERE Clause of a Subselect</u> :

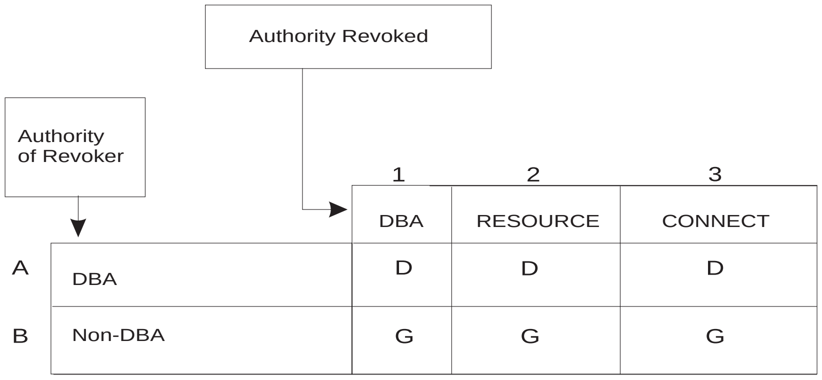
Note: The authorization checking in the previous decision table precedes the logic of this table.

The decision table used here is the same as that used by tables in the WHERE clause of a DELETE in Figure 108 on page 344.

In cases B2, C1, and C2, the system makes entries in the SYSTABAUTH catalog table with the SELECTAUTH column set to 'Y'. The entries represent this package's dependency on SELECT privilege for the table.

In case A2, the system makes an entry in the SYSUSERAUTH catalog table to show this package's dependency on DBA authority.

REVOKE for Authorities Statement

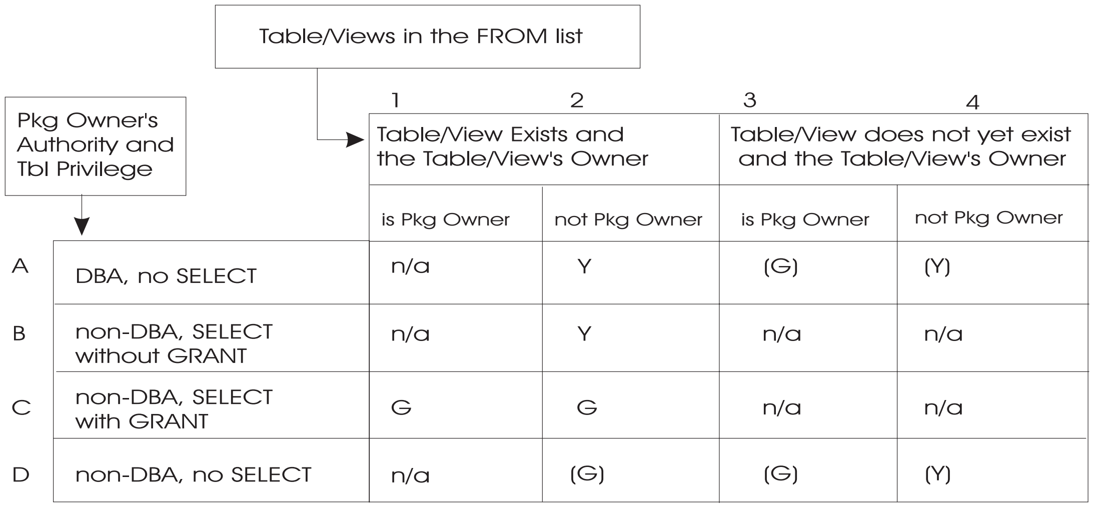


	Authority of Revoker \ Authority Revoked	1 DBA	2 RESOURCE	3 CONNECT
A	DBA	D	D	D
B	Non-DBA	G	G	G

SELECT

There are two decision tables that apply to SELECT:

<u>The Tables in the FROM List</u> :



	Pkg Owner's Authority and Tbl Privilege \ Table/Views in the FROM list	Table/View Exists and the Table/View's Owner		Table/View does not yet exist and the Table/View's Owner	
		1 is Pkg Owner	2 not Pkg Owner	3 is Pkg Owner	4 not Pkg Owner
A	DBA, no SELECT	n/a	Y	(G)	(Y)
B	non-DBA, SELECT without GRANT	n/a	Y	n/a	n/a
C	non-DBA, SELECT with GRANT	G	G	n/a	n/a
D	non-DBA, no SELECT	n/a	(G)	(G)	(Y)

In cases B2, C1, and C2, the application server makes entries in the SYSTABAUTH catalog table with the SELECTAUTH column set to 'Y'. The entries represent this package's dependency on INSERT privilege for the table.

In case A2, there are some instances where a ‘Y’ entry is made in the DBAAUTH column of the SYSUSERAUTH catalog table, showing package dependencies on DBA authority.

Any Tables Referenced in a WHERE Clause :

Note: The authorization checking in the previous decision table precedes the logic of this table.

The decision table used here is the same as that used by tables in the WHERE clause of a DELETE in Figure 108 on page 344.

In cases B2, C1, and C2, the system makes entries in the SYSTABAUTH catalog table with the SELECTAUTH column set to ‘Y’. The entries represent this package's dependency on SELECT privilege for the table.

In case A2, the system makes an entry in the SYSUSERAUTH catalog table to show this package's dependency on DBA authority.

The UPDATE Tables

There are two decision tables that apply to UPDATE:

The Table Where the Update Is Applied :

Table/Views to which UPDATE is applied

	Pkg Owner's Authority and Tbl Privilege	1	2	3	4
		Table/View Exists and the Table/View's Owner		Table/View does not yet exist and the Table/View's Owner	
		is Pkg Owner	not Pkg Owner	is Pkg Owner	not Pkg Owner
A	DBA, no UPDATE	n/a	D	(G)	(Y)
B	non-DBA, UPDATE without GRANT	n/a	Y	n/a	n/a
C	non-DBA, UPDATE with GRANT	G	G	n/a	n/a
D	non-DBA, no UPDATE	n/a	(G)	(G)	(Y)

In cases B2, C1, and C2, the system makes entries in the SYSTABAUTH catalog table with the UPDATEAUTH column set to ‘Y’. The entries represent this package's dependency on UPDATE privilege for the table.

Any Tables Referenced in a WHERE Clause :

Note: The authorization checking in the previous decision table precedes the logic of this table.

The decision table used here is the same as that used by tables in the WHERE clause of a DELETE in Figure 108 on page 344.

In cases B2, C1, and C2, the system makes entries in the SYSTABAUTH catalog table with the SELECTAUTH column set to ‘Y’. The entries represent this package's dependency on SELECT privilege for the table.

In case A2, the system makes an entry in the SYSUSERAUTH catalog table to show this package's dependency on DBA authority.

There are two decision tables that apply to UPDATE:

The LOCK DBSPACE Table

	Pkg Owner's Authority	Dbspace Owner: 1 Dbspace Owner is Pkg Owner	Dbspace Owner: 2 Dbspace Owner not Pkg Owner
A	DBA	G	D
B	non-DBA	G	(G)

The LOCK TABLE Table

	Pkg Owner's Authority and Tbl Privilege	Table Owner: 1 Table Owner is Pkg Owner	Table Owner: 2 Table Owner not Pkg Owner	Table Owner: 3 Table does not yet exist
A	DBA, no SELECT	n/a	D	D
B	SELECT without GRANT	n/a	Y	n/a
C	SELECT with GRANT	G	G	n/a
D	non - DBA , no SELECT	n/a	(G)	(G)

For cases B1, B2, and C2, the system makes entries in the SYSTABAUTH catalog table. The entries have the SELECTAUTH column set to ‘Y’ to show the package's dependency.

Bibliography

This bibliography lists publications that are referenced in this manual or that may be helpful.

DB2 Server for VM Publications

- *DB2 Server for VM Application Programming*, SC09-2661
- *DB2 Server for VM Database Administration*, SC09-2654
- *DB2 Server for VSE & VM Database Services Utility*, SC09-2663
- *DB2 Server for VM Diagnosis Guide and Reference*, LC09-2672
- *DB2 Server for VSE & VM Overview*, GC09-2806
- *DB2 Server for VSE & VM Interactive SQL Guide and Reference*, SC09-2674
- *DB2 Server for VM Master Index and Glossary*, SC09-2666
- *DB2 Server for VM Messages and Codes*, GC09-2664
- *DB2 Server for VSE & VM Operation*, SC09-2668
- *DB2 Server for VSE & VM Quick Reference*, SC09-2670
- *DB2 Server for VM System Administration*, SC09-2657

DB2 Data Spaces Support Publications

- *DB2 Server Data Spaces Support for VM/ESA*, SC09-2675

Related Publications

- *DB2 Server for VSE & VM Data Restore*, SC09-2677
- *DRDA: Every Manager's Guide*, GC26-3195
- *IBM SQL Reference, Version 2, Volume 1*, SC26-8416
- *IBM SQL Reference*, SC26-8415

VM/ESA Publications

- *VM/ESA: General Information*, GC24-5745
- *VM/ESA: VMSES/E Introduction and Reference*, GC24-5837
- *VM/ESA: Installation Guide*, GC24-5836
- *VM/ESA: Service Guide*, GC24-5838
- *VM/ESA: Planning and Administration*, SC24-5750
- *VM/ESA: CMS File Pool Planning, Administration, and Operation*, SC24-5751
- *VM/ESA: REXX/EXEC Migration Tool for VM/ESA*, GC24-5752
- *VM/ESA: Conversion Guide and Notebook*, GC24-5839
- *VM/ESA: Running Guest Operating Systems*, SC24-5755
- *VM/ESA: Connectivity Planning, Administration, and Operation*, SC24-5756
- *VM/ESA: Group Control System*, SC24-5757
- *VM/ESA: System Operation*, SC24-5758
- *VM/ESA: Virtual Machine Operation*, SC24-5759
- *VM/ESA: CP Programming Services*, SC24-5760
- *VM/ESA: CMS Application Development Guide*, SC24-5761
- *VM/ESA: CMS Application Development Reference*, SC24-5762
- *VM/ESA: CMS Application Development Guide for Assembler*, SC24-5763
- *VM/ESA: CMS Application Development Reference for Assembler*, SC24-5764
- *VM/ESA: CMS Application Multitasking*, SC24-5766
- *VM/ESA: CP Command and Utility Reference*, SC24-5773
- *VM/ESA: CMS Primer*, SC24-5458
- *VM/ESA: CMS User's Guide*, SC24-5775
- *VM/ESA: CMS Command Reference*, SC24-5776
- *VM/ESA: CMS Pipelines User's Guide*, SC24-5777
- *VM/ESA: CMS Pipelines Reference*, SC24-5778
- *VM/ESA: XEDIT User's Guide*, SC24-5779
- *VM/ESA: XEDIT Command and Macro Reference*, SC24-5780
- *VM/ESA: Master Index and Glossary*, SC09-2398
- *VM/ESA: Quick Reference*, SX24-5290
- *VM/ESA: Performance*, SC24-5782
- *VM/ESA: Dump Viewing Facility*, GC24-5853
- *VM/ESA: System Messages and Codes*, GC24-5841
- *VM/ESA: Diagnosis Guide*, GC24-5854
- *VM/ESA: CP Diagnosis Reference*, SC24-5855
- *VM/ESA: CP Diagnosis Reference Summary*, SX24-5292
- *VM/ESA: CMS Diagnosis Reference*, SC24-5857

- *VM/ESA: CMS Data Areas and Control Blocks*, SC24-5858
- *VM/ESA: CP Data Areas and Control Blocks*, SC24-5856
- *IBM VM/ESA: CP Exit Customization*, SC24-5672
- *VM/ESA REXX/VM User's Guide*, SC24-5465
- *VM/ESA REXX/VM Reference*, SC24-5770

C for VM/ESA Publications

- *IBM C for VM/ESA Diagnosis Guide*, SC09-2149
- *IBM C for VM/ESA Language Reference*, SC09-2153
- *IBM C for VM/ESA Compiler and Run-Time Migration Guide*, SC09-2147
- *IBM C for VM/ESA Programming Guide*, SC09-2151
- *IBM C for VM/ESA User's Guide*, SC09-2152

Other Distributed Data Publications

- *IBM Distributed Data Management (DDM) Architecture, Architecture Reference, Level 3*, SC21-9526
- *IBM Distributed Data Management (DDM) Architecture, Implementation Programmer's Guide*, SC21-9529
- *VM/Directory Maintenance Licensed Program Operation and User Guide Release 4*, SC23-0437
- *IBM Distributed Relational Database Architecture Reference*, SC26-4651
- *IBM Systems Network Architecture, Format and Protocol*
- *SNA LU 6.2 Reference: Peer Protocols*
- *Reference Manual: Architecture Logic for LU Type 6.2*
- *IBM Systems Network Architecture, Logical Unit 6.2 Reference: Peer Protocols*
- *Distributed Data Management (DDM) List of Terms*
- *IBM Distributed Data Management (DDM) Architecture, Architecture Reference, Level 3*, SC21-9526
- *IBM Distributed Data Management (DDM) Architecture, Architecture Reference, Level 3*, SC21-9526
- *IBM Distributed Data Management (DDM) Architecture, Architecture Reference, Level 3*, SC21-9526

CCSID Publications

- *Character Data Representation Architecture, Executive Overview*, GC09-2207
- *Character Data Representation Architecture Reference and Registry*, SC09-2190

DB2 Server RXSQL Publications

- *DB2 REXX SQL for VM/ESA Installation*, GC09-2660
- *DB2 REXX SQL for VM/ESA Reference*, SC09-2676

C/370 Publications

- *IBM C/370 Installation and Customization Guide*, GC09-1387
- *IBM C/370 Programming Guide*, SC09-1384

Communication Server for OS/2 Publications

- *Up and Running!*,GC31-8189
- *Network Administration and Subsystem Management Guide* SC31-8181
- *Command Reference*, SC31-8183
- *Message Reference*, SC31-8185
- *Problem Determination Guide*, SC31-8186

Distributed Database Connection Services (DDCS) Publications

- *DDCS User's Guide for Common Servers*, S20H-4793
- *DDCS for OS/2 Installation and Configuration Guide* S20H-4795

VTAM Publications

- *VTAM Messages and Codes*, SC31-6493
- *VTAM Network Implementation Guide*, SC31-6494
- *VTAM Operation*, SC31-6495
- *VTAM Programming*, SC31-6496
- *VTAM Programming for LU 6.2*, SC31-6497
- *VTAM Resource Definition Reference*, SC31-6498
- *VTAM Resource Definition Samples*, SC31-6499

CSP/AD and CSP/AE Publications

- *Developing Applications*, SH20-6435
- *CSP/AD and CSP/AE Installation Planning Guide*, GH20-6764
- *Administering CSP/AD and CSP/AE on VM*, SH20-6766
- *Administering CSP/AD and CSP/AE on VSE*, SH20-6767
- *CSP/AD and CSP/AE Planning*, SH20-6770
- *Cross System Product General Information*, GH23-0500

Query Management Facility (QMF) Publications

- *QMF General Information*, GC26-4713
- *QMF VSE/ESA Setup and Usage Guide*, GG24-4196
- *Managing QMF for VSE/ESA*, SC26-3252
- *Installing QMF on VSE/ESA*, SC26-3254
- *QMF Learner's Guide*, SC26-4714
- *QMF Advanced User's Guide*, SC26-4715
- *QMF Reference*, SC26-4716
- *Installing QMF on VM*, SC26-4718
- *QMF Application Development Guide*, SC26-4722
- *QMF Messages and Codes*, SC26-4834
- *Using QMF*, SC26-8078
- *Managing QMF for VM/ESA*, SC26-8219

DL/I DOS/VS Publications

- *DL/I DOS/VS Application Programming*, SH24-5009

COBOL Publications

- *VS COBOL II Migration Guide for VSE*, GC26-3150
- *VS COBOL II Migration Guide for MVS and CMS*, GC26-3151
- *VS COBOL II General Information*, GC26-4042
- *VS COBOL II Language Reference*, GC26-4047
- *VS COBOL II Application Programming Guide*, SC26-4045
- *VS COBOL II Application Programming Debugging*, SC26-4049
- *VS COBOL II Installation and Customization for CMS* SC26-4213
- *VS COBOL II Installation and Customization for VSE* SC26-4696
- *VS COBOL II Application Programming Guide for VSE* SC26-4697

Data Facility Storage Management Subsystem/VM (DFSMS/VM) Publications

- *DFSMS/VM User's Guide*, SC26-4705

Systems Network Architecture (SNA) Publications

- *SNA Transaction Programmer's Reference Manual for LU Type 6.2*, GC30-3084
- *SNA Format and Protocol Reference: Architecture Logic for LU Type 6.2*, SC30-3269
- *SNA LU 6.2 Reference: Peer Protocols*, SC31-6808
- *SNA Synch Point Services Architecture Reference* SC31-8134

Miscellaneous Publications

- *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide*, GA32-0100
- *Dictionary of Computing*, ZC20-1699
- *APL2 Programming: Using Structured Query Language*, SH21-1056
- *ESA/390 Principles of Operation*, SA22-7201

Related Feature Publications

- *Control Center Installation and Operations Guide for VM*, GC09-2678
- *IBM Replication Guide and Reference*, S95H-0999

Index

Special Characters

<
  See also shift-out character
  convention xvii
>
  See also shift-in character
  convention xvii

Numerics

24-bit addressing 104
31-bit addressing 104

A

access
  concurrent 200
  table belonging to other users 25
adding
  columns
    to a table 204
  in SQL expressions 48
additional predicates 38
ALL
  select-clause 24
ALL keyword
  subqueries 76
ALLOCATE statement of PL/I 335
ALTER TABLE
  privileges 236
altering
  table 204
AND operator 36
ANSI 122
ANY 76
APOST preprocessor parameter 111
application
  CMS 12
application program
  example 15
ARIDBS 133
ARIPADR4 132
ARIPEIFA 132
ARIPSTR 132
ARIRCAN 12
ARIS6ASC
  sample program 250
  source code 250
ARIS6CBC
  sample program 294
  source code 294
ARIS6CC
  sample program 270
  source code 270
ARIS6FTC 312
  sample program 312
  source code 312
ARIS6PLC
  sample program 326
  source code 326
ARISSMA 133
ARISSMF 132
arithmetic error
  outer select 222
arithmetic operator
  in syntax diagrams xiv
ASM preprocessor parameter 109
assembler
  acquiring the SQLDSECT area 250
  data types 258
  declaring host variables 253
  declaring the SQLCA 256
  declaring the SQLDA 257
  embedding SQL statements
    example 7, 255
  sample program 250
  stored procedures 265
atomic integrity 231
authority
  granting 210
  overview 212
  revoking from others 213
authorization-ID
  naming conventions 20
automatic
  revocation of privileges 213
automatic rollback
  data definition statements 203
  deadlocks 201

B

backing out
  changes 14
backout
  definition 201
backslash
  hex value 271
based structures 159
basic form
  description 3
BEGIN DECLARE SECTION 6

BLocK
preprocessor parameter 111
blocking 128
remote unit of work 112, 130
blocks
pages 198

C

C programming language
C 287
C compiler preprocessor 272
case sensitivity 271
character constants in SQL statements 272
considerations 270
data conversion considerations 280
data types 287
date calculations 281
DBCS data 282
declaring host variables 272
declaring SQLCA 285
declaring SQLDA 286
delimiting SQL statements 271
dynamic allocation of SQLDA 286
embedding SQL statements
example 7
INCLUDE statement 272
NUL-terminated strings and truncation 281
placement of SQL statements 271
preprocessor generated statements 282
preprocessor parameter 109
reentrant programs 289
stored procedures 289
trigraphs 282
case sensitivity
C 271
catalog tables 216
CCSIDGraphic preprocessor parameter 112
CCSIDMixed preprocessor parameter 112
CCSIDSbcs preprocessor parameter 112
changing
data type of a column 204
CHAR data type
assembler 258
COBOL 306
FORTRAN 321
PL/I 336
character
data 53
string
constant 53
character constant
SQL statements
C 272
character subtype
CCSID 42
character subtype *(continued)*
constant 53
default values 42
overriding defaults 43
CHARSUB preprocessor parameter 112
checking
SQLCA 146
choose
in syntax diagrams xiv
clause
order 71
CLOSE
format 32
closed state of cursor 28
CMS
applications 12
work units 228
CMS SUBSET
LUW 229
SQLRMEND EXEC 229
COB2 preprocessor parameter 300
COBOL
31-bit addressing 104
COB2 compiler option consideration 300
COBRC compiler option consideration 301
column 7 302
continuation of SQL statements 294
data conversion considerations 301
data types 306
DBCS data 302
declaring host variables 296
declaring SQLCA 303
delimiting SQL statements 295
DYNAM compiler option 308
dynamic statement restrictions 304
embedding SQL statements
example 7
placement of SQL statements 294
preprocessor parameter 109
QUOTE compiler option consideration 300
sample program 294
stored procedures 309
using the COB2 parameter 300
using the COBRC parameter 301
using the INCLUDE statement 301
COBRC preprocessor parameter 301
colon
used in indicator variables 56
column
correlation function 81
join considerations 63
naming convention 20
virtual 58
combining
queries 88

COMma preprocessor parameter 115
COMMENT ON 205
COMMIT 13
committing changes
  tables 13
common column names 63
comparison
  operator 37
compiling
  program 132
completion code 9, 142
  See also SQLCODE
concatenation
  EXECUTE IMMEDIATE 156
  operator 50
  symbol 50
concurrent
  access 200
CONNECT
  application programs 10
  statement 105
CONNECT authority
  description 210
  granting 210
connecting DB2 Server for VM
  application programs 10
consistency
  of data 13
  token 113, 134, 137
constant
  CCSID 53
  character subtypes 53
  search conditions 48
  select-list expressions 24
constraint
  defer 242
  enforce 242
  naming conventions 20
  referential 233
contention
  for resources 200
continuation of SQL statements
  assembler 255
  C 271
  COBOL 294
  FORTRAN 312
  PL/I 326
  placement of SQL statements 312
conventions
  syntax diagram notation xiii
conversion of data 172
  See also data conversion
correlation 78
  function 81
  name 79
  subqueries using joins 83
correlation *(continued)*
  subquery 78
  table 80
COUNT(*) in a grouping query 69
CREATE INDEX 204
CREATE SYNONYM 205
CREATE TABLE 203
CREATE VIEW
  WITH CHECK OPTION 58
creating
  indexes 204
  synonym 205
  table 203
    field procedure 203
    NULL value 203
    referential integrity 203
    unique constraint 203
  view 58
CTOKEN preprocessor parameter 113
cultural sorting 27, 223
current row of a cursor 28
cursor
  closed state 28
  closing 32
  current row 28
  declaring 28
  description 28
  fetching 30
  inserting 31
  locking stability 123
  management 28
  name
    syntax rules 29
  naming convention 20
  open state 28
  opening 29
  ordering results 32
  result table 28
  scope 29

D
data
  consistency 13
  inconsistent 13
  virtual 58
data code
  SQLDA
    datetime 173
data conversion
  C 280
  COBOL 301
  dynamically defined statements 172
  FORTRAN 318
  join conditions 62
  PL/I 330

data conversion *(continued)*
  summary 44
  unions 89
data definition 203
data integrity
  atomic integrity 231
  entity integrity 231
  referential integrity 232
  unique on columns 232
Data Propagator Capture
  on tables 223
data type
  assembler 258
  C 287
  CHARACTER 39
  COBOL 306
  DATE 39
  DECIMAL 39
  description 6, 39
  FLOAT 39
  FORTRAN 321
  GRAPHIC 39
  INTEGER 39
  LONG VARCHAR 39
  LONG VARGRAPHIC 39
  PL/I 336
  SMALLINT 39
  TIME 39
  TIMESTAMP 39
  VARCHAR 39
  VARGRAPHIC 39
database administrator (DBA)
  description 210
date arithmetic
  C 281
DATE data type
  assembler 258
  C 289
  COBOL 307
  FORTRAN 321
  PL/I 336
datetime
  constants 55
DB2 Server for VM
  catalog tables 216
  data types, introduction 6
DBA 210
  See also database administrator
DBA (database administrator)
  granting authority 210
DBCS 141
  See also double-byte character set
dbextent
  description 196
DBFile preprocessor parameter
  VM 121
DBname parameter
  preprocessor 120
dbspace 20
  creating 196
  defining 196
  dropping 202
  lock size 200
  naming conventions 20
  owner 196
dcssID parameter
  preprocessor 120
deadlock
  description 201
DECIMAL data type
  assembler 258
  C 287
  COBOL 306
  FORTRAN 321
  PL/I 336
DECLARE CURSOR
  coded queries 28
declaring
  host variables
    assembler 253
    C 272
    COBOL 296
    FORTRAN 313
    PL/I 327
  return code structure
    assembler 256
    C 285
    COBOL 303
    FORTRAN 318
    PL/I 332
  static external variables
    PL/I 327
default
  in syntax diagrams xv
defining
  indexes 204
  synonym 205
  tables 203
    field procedure 203
    NULL value 203
    referential integrity 203
    unique constraint 203
  view on view 59
DELETE
  delete rules 240
  rules 240
delete connected
  table 234
deleting
  tables 204
delimiting SQL statements
  assembler 255

delimiting SQL statements *(continued)*
C 271
COBOL 295
dynamic execution 156
PL/I 326
dependent
table 234
descendent
table 234
DESCRIBE
usage techniques 158
DISPLAY SIGN HEADING SEPARATE 301
DISTINCT
HAVING clause 70
select-clause 23
distributed applications
application server 2
distributing packages 137
division in SQL expressions 48
double precision float 40
double quotation marks
considerations in COBOL 111
double-byte character set (DBCS)
characters for C 287
constants 54
data 282
assembler 256
C 282
COBOL 302
FORTRAN 318
PL/I 331
data type 307, 336
assembler 258
FORTRAN 321
DROP DBSPACE 202
DROP TABLE 204
DROP VIEW 62
dropping
column 204
table 204
view 62
DSECTs used by the database manager 250
duration
date 55, 219
labeled 219
lock 200
time 55, 219
timestamp 55, 221
DYNAM compiler option
COBOL 308
dynamic data conversion 172
assembler 257
C 286
COBOL 304
FORTRAN 319
PL/I 334
dynamic SQL
description 20
dynamic statements
comparison with extended dynamic statements 182
data conversion 172
description 180
extended 180, 189
comparison with dynamic statements 182
introduction 180
relationship between 181
remote unit of work considerations 190
logical unit of work considerations 189
SQLDA use 173

E

END DECLARE SECTION 6
entity integrity 231
erasing
tables 204
error code 9, 142
See also SQLCODE
error handling
application programs 143
description 141
ERROR preprocessor parameter 112
error recovery 141
See also error handling
evaluating
predicates 37
examining the SQLCA 146
exclusive lock
description 200, 201
EXEC
sample programs 16
SQLINIT 105
SQLPREP 106
SQLSTART 136
EXECUTE
usage techniques 157
EXECUTE IMMEDIATE
usage techniques 155
EXECUTE privilege
automatic revocation 213
executing applications
multiple user mode 135
single user mode 136
EXIST preprocessor parameter 113
EXISTS predicate 87
expanding tables 204
EXPLAIN preprocessor parameter 113
expression
adding 48
constants used 48
description 48, 49
dividing 48

expression *(continued)*
host variables 48
multiplying 48
subtracting 48
extended dynamic statement
assembler example 183
comparison with dynamic statements 182
description 180
introduction 180
logical unit of work considerations 189
relationship between 181
remote unit of work considerations 190
external source member
including 131

F
FETCH
description 30
error handling for a select-list 150
format 30
fetch and insert blocking 128
field procedure
collating sequence 27
using 222
FIPS 122
Flagger
description 122
FLOAT data type
assembler 258
C 287
COBOL 306
FORTRAN 321
PL/I 336
FOR update-clause 27
foreign key 234
FORTRAN 318
continuation of SQL statements 312
data types 321
declaring host variables 313
embedding SQL statements 315
example 9
long character strings 315
preprocessor
restrictions 320
preprocessor parameter 109
sample program 312
fragment of syntax
in syntax diagrams xvi
FROM
correlation name 79
description 25
joins 62
PREPARE statement 175
fullselect
description 22
functions
used in grouping 68

G
general rules for naming data objects 20
GRANT option
description 212
granting
authorities 210
already owned 211
graphic constants
PL/I formats 54
SQL format 54
GRAPHIC data type
assembler 258
C 287
COBOL 307
FORTRAN 321
PL/I 336
GRaphic preprocessor parameter 114
GROUP BY clause
correlated subquery considerations 81
description 68
subqueries 78
group query 25
See also group-by-clause
group-by-clause
description 25
grouping
feature 68
grouping queries
VARCHAR 69
VARGRAPHIC 69

H
HAVING clause
correlated subqueries 81
description 26, 70
subqueries 75, 78
header pages 198
hexadecimal constants
within expressions 53
host language
description 3
host structure 253, 272, 296, 313, 327
COBOL 299
description 51
host variable
assembler 256
declared in assembler 253
declared in C 272, 278, 330
declared in COBOL 296
declared in FORTRAN 313
declared in PL/I 327

host variable *(continued)*
- description 51
- dynamically defined statements 175
- FORTRAN 317
- function parameters
  - used in C 280
- in syntax diagrams xiv
- INTO clauses 34
- naming convention 20
- nulls 55
- PL/I 330
- restriction on use in CREATE VIEW 59
- restriction on use in REVOKE 213
- search conditions 48
- truncation 55
- used in a program 51

host-program variable 51
- *See also* host variable

I

identifier
- description 20
- long 65

implicit
- connect 105
- revocation of privileges 213

IN predicate 77

inactive
- constraint 242
- removing referential constraints 244
- table 242

INCLUDE 131
- assembler 256
- C 272
- COBOL 301
- FORTRAN 318
- PL/I 327

INCLUDE SQLCA
- assembler language 256
- C 285
- COBOL 303
- FORTRAN 318
- PL/I 332
- pseudocode 9, 142

INCLUDE SQLDA
- assembler language 257
- C 286
- PL/I 334
- pseudocode 159

including
- external source members 131
- secondary input from VM
  - CMS file 131

inconsistency
- because of cursor stability 124

inconsistency *(continued)*
- cursor stability inconsistencies 124

inconsistent
- data 13
- state 13, 141

index
- creating 204
- naming convention 20
- restriction for view 58

indicator array
- description 51
- in assembler 253
- in C 272
- in COBOL 296
- in FORTRAN 313
- in PL/I 327

INDICATOR keyword
- indicator variables 56

indicator variable
- description 51, 55
- detecting nulls 57
- detecting truncation 57
- FETCH statement 30
- in assembler 253
- in C 272
- in COBOL 296
- in FORTRAN 313
- in PL/I 327
- meaning of values returned 57

initializing
- SQLDA 173
- your user machine 105

input host variables 30

INSERT
- INSERT rules 237
- rules for referential integrity 237

insert and fetch blocking 128

installing
- applications 104

INTEGER data type
- assembler 258
- C 287
- COBOL 306
- data types 336
- FORTRAN 321
- PL/I 336

integrity
- atomic 231
- data 232
- entity 231
- referential 232

internal statistics, updating 204

INTO clause
- description 33
- dynamically defined statements 160
- FETCH statement 30

INTO clause *(continued)*
restriction for subqueries 75
unions 88
invoking the preprocessor 106
ISO 122
isolation level
cursor stability 123
mixing 126
remote unit of work 126
repeatable read 123
USER option 114, 126
ISOLation preprocessor parameter 114, 126

J

join
common column names 63
correlated subqueries 83
data conversion 62
description 62
join variable 65
limits 67
nulls 65
number permitted 67
referring to another user's table 64, 66
SELECT * 68
single table (to itself) 65
trailing blanks 65
without join conditions 63

K

KEEP parameter 115
key
foreign 234
primary 234
keyword
in syntax diagrams xiii

L

LABEL
SQL 205
LABEL preprocessor parameter 115
limits
joins 67
link-editing
module not found 132
loading
COBOL considerations 104
program 132
LOCK 201
ACQUIRE DBSPACE 199
ALTER DBSPACE 200
lock size
definition 197
locking
dbspaces
explicitly 201
modifying 197
reading 197
description 200
duration 200
exclusive 200
isolation level
considerations 123
share 200
tables explicitly 201
update 200
logical operator 36
logical unit of work (LUW)
automatic locking 200
automatic rollback 201, 203
CMS considerations 12, 14
committing work done 13
description 13, 142
error handling 142
revoking privileges 213
rolling back work done 14
using extended dynamic statements 189
LOGmode parameter
preprocessor 120
long character strings in FORTRAN 315
long strings
description 41
use 41
LONG VARCHAR
restrictions 41
unions 90
LONG VARCHAR data type
assembler 258
C 287
COBOL 306
FORTRAN 321
PL/I 336
LONG VARGRAPHIC
restrictions 41
unions 90
LONG VARGRAPHIC data type
assembler 258
C 289
COBOL 307
FORTRAN 321
PL/I 336

M

main variable 51, 253, 272, 296, 313, 327
manipulating a cursor 29
maximum
joins 67

merging results of queries 88
mixing isolation levels 126
modifying
  locked dbspace 197
  tables through a view 60
module not found 132
multiple
  row
    query results 28
multiple row results 28
multiple user mode 104
  executing applications 135
  invoking the preprocessors 106
multiplication in SQL expressions 48

N

naming
  column 20
  data object 20
  dbspace 20
  index 20
  table 20
negative SQLCODE
  description 9, 142
nesting correlated subqueries 84
NHEADER
  ACQUIRE DBSPACE 198
NOBLocK preprocessor parameter 111
NOEXIST preprocessor parameter 113
NOFOR preprocessor parameter 114
NOGRaphic preprocessor parameter 114
nonexecutable SQL statements 10
NOPRint preprocessor parameter 116
NOPUnch preprocessor parameter 116
NOSEQuence preprocessor parameter 116
NOSQLCA
  preprocessor parameter 117
  support 117, 142
NOT EXISTS predicate 87
not found SQLCODE (100)
  FETCH 30
NOT IN predicate 77
NOT keyword
  concatenation 36
NUL-terminated strings and truncation
  C 281
null value 85
  grouping queries 69
  indicator variables 55, 57
  joins 65
  search conditions 36
NUMERIC
  See DECIMAL 41

O

OPEN
  description 29
  format 29
open state of a cursor 28
operator
  arithmetic 48
  comparison 37
  logical 36
optional
  default parameter
    in syntax diagrams xv
  item
    in syntax diagrams xiv
  keyword
    in syntax diagrams xv
OPTIONS(MAIN) clause 326
OR operator 36
order
  clauses 71
ORDER BY clause
  description 32
  restriction for CREATE VIEW 59
  unions 88, 90
ordering
  query results 32
output host variables 30
owner
  dbspace 196
OWner preprocessor parameter 115

P

package
  automatic regeneration 135, 213
  description 106
  distributing 137
  invalidating
    DROP DBSPACE 202
    DROP VIEW 62
    REVOKE 213
page
  header 198
PAGE lock size 200
PAGES parameter of ACQUIRE DBSPACE 198
parameter
  marker 156, 175
  specifying
    user 136
parameterized statement
  description 156
parent table
  table 233
parentheses
  in syntax diagrams xiv

PARMID preprocessor parameter 121
password
  naming convention 20
PCTFREE
  parameter of ACQUIRE dbspace 199
  parameter of ALTER DBSPACE 200
PCTINDEX
  parameter of ACQUIRE DBSPACE 199
performance
  considerations 123, 231
PERiod preprocessor parameter 115
PL/I 336
  attributes of variables 329
  continuation of SQL statements 326
  data conversion considerations 330
  declaring host variables 327
  declaring SQLCA 332
  declaring SQLDA 334
  declaring static external variables 327
  delimiting SQL statements 326
  dynamic allocation of SQLDA 334
  embedding SQL statements
    example 9
  placement of SQL statements 326
  preprocessor parameter 109
  sample program 326
  stored procedures 337
  using the INCLUDE statement 327
placement of SQL statements
  assembler 255
  C 271
  COBOL 294
  FORTRAN 312
  PL/I 326
pointer type attribute
  C 278
positions of a cursor 28
positive SQLCODE
  description 9, 142
potential deadlocks 201
precedence rules 36, 48
predicates
  constants 48
  description 36
  host variables 48
  rules for evaluating 37
PREPARE
  format 175
  usage techniques 157
PrepFile preprocessor parameter 110
PREPNAME preprocessor parameter 110
PREPPARM preprocessor parameter 111
preprocessing
  description 106
  multiple user mode 106
  option file 122
preprocessing *(continued)*
  parameters 107
  single user mode 106
preprocessor 106
preprocessor parameters 123
  APOST 111
  ASM 109
  BLocK 111
  C 109
  CCSIDGraphic 112
  CCSIDMixed 112
  CCSIDSbcs 112
  CHARSUB 112
  COB2 300
  COBOL 109, 301
  COMma 115
  CTOKEN 113
  DATE 113
  DBFile 121
  DBname 120
  dcssID 120
  ERROR 112
  EXIST 113
  EXPLAIN 113
  FORTRAN 109
  GRaphic 114
  ISOLation 114, 126
  KEEP 115
  LABEL 115
  LineCount 115
  LOGmode 120
  NOBLocK 111
  NOEXIST 113
  NOFOR 114
  NOGRaphic 114
  NOPRint 116
  NOPUnch 116
  NOSEQuence 116
  NOSQLCA 117
  OWner 115
  PARMID 121
  PERiod 115
  PL/I 109
  PrepFile 110
  PREPNAME 110
  PREPPARM 111
  PRint 116
  PUnch 116
  QUALifier 116
  QUOTE 111, 300
  RELease 116
  REVOKE 115
  SBLocK 111
  SEQuence 116
  SQLApost 116
  SQLQuote 116

preprocessor parameters *(continued)*
  STDSQL 117
  sysIN 118
  sysPRint 118
  sysPUnch 119
  TIME 117
  USERid 110
primary key 234
PRint preprocessor parameter 116
privilege
  automatic revocation 213
  description 212
  package 213
  programs 215
  references 236
  revoking 215
    from others 213
  table or view
    alter 212
    delete 212
    description 212
    index 212
    insert 212
    references 212
    select 212
    update 212
program
  interrupts
    FORTRAN 319
    PL/I 333
  naming convention 20
  privileges
    revoking 215
  sample 15
program termination
  CMS programs 12
programming interface
  description ix
programs using DBCS data
  assembler 256
  C 282
  COBOL 302
  FORTRAN 318
  PL/I 331
PSERVERs
  characteristics 207
  example of a definition 208
  execution 207
pseudocode
  description 3
PUnch preprocessor parameter 116
punctuation mark
  in syntax diagrams xiv
PUT
  description 31
  format 31

Q
QUALifier preprocessor parameter 116
qualifiers
  column names 63
  table names 20
qualify
  fully 20
qualifying groups 26
  See also having clause
Query
  Connected Database 50
querying
  tables through a view 59
quotation mark
  considerations in COBOL 111
  constants 53
QUOTE preprocessor parameter 111, 300

R
reading from a locked dbspace 197
REBIND PACKAGE 135
reentrant programs
  assembler 260, 289
  C 289
  COBOL 308
REFER feature of PL/I 335
references privilege 236
  existing applications 237
  modifying the contents of tables with referential constraints 237
referential
  constraint 233
  cycle
    definition 233
  description 232
  integrity 232
    existing tables 235
    new tables 234
    rules 242
  structure 233
relationship 233
RELease preprocessor parameter 116
releasing your connection
  CMS applications 13
  to DB2 Server for VM 14
remote unit of work
  application program 2
  blocking 112, 130
  considerations in using extended dynamic statements 190
  CURRENT SERVER 50
  extended dynamic processing 183
  isolation level 126
  special register 50

remote unit of work *(continued)*
  USER isolation 115
repeat symbol
  in syntax diagrams xv
repeatable read locking 123
required item
  in syntax diagrams xiv
reserved words
  SQL xvi
RESOURCE authority
  granting 210
restoring data 14
restriction
  unions 89
result code 9, 142
  See also SQLCODE
result table
  cursor 28
retrieving
  columns of a row 24
return code 9, 142
  See also SQLCODE
REVOKE 213
REVOKE preprocessor parameter 115
revoking
  privileges 213
    automatic 213
    overview 213
    programs 215
ROLLBACK 14
  description 142
ROLLBACK WORK 201
rollback, automatic
  data definition statements 203
  deadlocks 201
rolling back changes 14
ROW lock size 200
rules
  evaluating predicates 37
  naming data object 20
  SQL in assembler 253
  SQL in C 270
  SQL in FORTRAN 312
  SQL in PL/I 326

S

sample program
  ARIS6ASC 250
  ARIS6CBC 294
  ARIS6CC 270
  ARIS6FTC 312
  ARIS6PLC 326
  EXECs 16
  list 15
SBLocK preprocessor parameter 111
scope
  cursor 29
  WHENEVER statement 145
search condition 25
  See also where-clause
  AND operator 36
  arithmetic operators 48
  comparison operators 37
  constant 48
  description 34
  expressions 49
  host variables 48
  join conditions 62
  NOT keyword 36
  OR operator 36
  precedence rules 36, 48
  predicates 36
SELECT
  ALL 24
  ALL keyword 76
  ANY keyword 76
  clause 23
  constants 24
  correlation 78
  DISTINCT keyword 23
  error handling 150
  EXISTS 87
  group-by-clause 25
  grouping 68
  having-clause 26
  INTO clause 33
  introduction 21
  joins 62
  NOT EXISTS predicate 87
  order of clauses 71
  ordering results 32
  SELECT * form 24
  select-clause 23
  select-list 23
  subqueries 74
  unions 88
  where-clause 25
SELECT *
  basic queries 24
  join 68
  views 59
select list
  constants 24
  description 23
  error handling 150
  restrictions
    GROUP BY 69
select-statement
  description 22

selecting
all columns of a row 24
isolation level 125
self-referencing table 234
sequence of clauses 71
SEQuence preprocessor parameter 116
share lock
description 200, 201
shift-in character
convention xvii
shift-out character
convention xvii
single precision float 40
single quotation mark
COBOL considerations 111, 300
considerations in COBOL 111
constant 53
single user mode 104
executing applications 136
invoking a program
example 136
invoking the preprocessors 106
specifying user parameters 136
single virtual machine mode 104
single-row query results 34
SMALLINT data type
assembler 258
C 287
COBOL 306
FORTRAN 321
PL/I 336
SOME keyword 76
source code
ARIS6ASC 250
ARIS6CBC 294
ARIS6CC 270
ARIS6FTC 312
ARIS6PLC 326
source value 44
special register
description 49
expressions 49
remote unit of work 50
special statements
UPDATE STATISTICS 204
SQL comments
assembler 255
C 271
COBOL 295
FORTRAN 312
in static SQL statements 91
PL/I 326
SQL declare section 6, 51, 253, 272, 296, 313, 327
SQL Descriptor Area (SQLDA)
assembler declaration 257
C declaration 286
SQL Descriptor Area (SQLDA) *(continued)*
COBOL declaration 304
FORTRAN declaration 319
PL/I declaration 334
Structure 173
SQL identifier
description 20
SQL statements
embedding in application program
examples 10
SQL-89
conformance checking 122, 194
SQLApost preprocessor parameter 116
SQLCA (SQL Communications Area)
assembler declaration 256
C declaration 285
COBOL 303
description 143
FORTRAN 318
PL/I declaration 332
testing 146
SQLCODE 9, 142
SQLCODE 100 (not found)
FETCH 30
SQLD field in the SQLDA 174
SQLDA (SQL Descriptor Area)
summary 173
SQLDAX structure (in PL/I) 334
SQLDSECT, acquiring 250
SQLDSIZ variable 250
SQLERRM
description 144
SQLHX 12
SQLINIT EXEC 105
optional CMS work unit 231
SQLN
field in SQLDA 174
setting 173
SQLPREP EXEC 106
format 107
parameters 107
SQLQRY
remote unit of work 247
SQLQuote preprocessor parameter 116
SQLRMEND EXEC 12
SQLSTART EXEC 136
example 136
SQLWARN
description 144
SQLWARN6
automatic rollback 201
statements
ALTER TABLE 204
BEGIN DECLARE SECTION 6
CLOSE 32
COMMENT ON 205

statements *(continued)*
- COMMIT 13
- CONNECT 10
- CREATE INDEX 204
- CREATE SYNONYM 205
- CREATE TABLE 203
- CREATE VIEW 58
- DECLARE 28
- DROP DBSPACE 202
- DROP SYNONYM 205
- DROP TABLE 204
- DROP VIEW 62
- END DECLARE SECTION 6
- FETCH 30
- INCLUDE 131
- INCLUDE SQLCA 9, 142
- INCLUDE SQLDA 159
- LABEL 205
- LOCK 201
- naming convention 20
- OPEN 29
- PREPARE 175
- PUT 31
- REVOKE 213
- ROLLBACK 14
- SELECT
  - basic use 21
  - correlation 78
  - grouping 68
  - joins 62
  - subqueries 74
  - testing for existence 87
  - unions 88
- UPDATE STATISTICS 204
- WHENEVER 145

static SQL
- description 20

statistics
- tables 204

storage pool
- definition 196
- nonrecoverable 196
- recoverable 196
- specifying the placement of dbspaces 199

stored procedures
- assembler 265
- authorizing 97
- benefits 93
- C 289
- calling 96
- characteristics 205
- COBOL 309
- coding examples 100
- datatype compatibility 98
- example of a definition 206
- execution of SQL statements 95

stored procedures *(continued)*
- GENERAL linkage convention 99
- GENERAL WITH NULLS linkage convention 99
- Language Environment considerations 95
- parameters 97
- passing parameters 98
- PL/I 337
- preparing 95
- result sets 101
- specifying AUTHIDs 97
- using 92, 205
- writing 94

STORPOOL parameter of ACQUIRE DBSPACE 199

structures
- based 159

subquery
- ALL keyword 76
- ANY keyword 76
- correlation 78
- IN predicate 77
- introduction 74
- involving unions (restriction) 90
- many values returned 76
- NOT IN predicate 77
- single value returned 76

subselect
- description 22

subtraction in SQL expressions 48

subtype
- character 42
  - Using 53

success code 9, 142
- *See also* SQLCODE

summary
- program framework 14

synonym
- creating 205
- naming convention 20

syntax diagram
- notation conventions xiii

sysIN preprocessor parameter 118

sysPRint preprocessor parameter 118

sysPUnch preprocessor parameter 119

Systems Application Architecture (SAA)
- conformance checking 122, 194

T

table
- accessing 25
- altering 204
- creating 203
  - indexes 204
  - synonyms 205
- defining labels 205
- delete-connected 234

table *(continued)*
dependent 234
descendent 234
designator
rules 67, 87
dropping 204
entering comments in catalog tables 205
exposed table name 67
labels 65
naming convention 20
nonexposed table name 67
or view
privileges 212
parent table 233
self-referencing 234
target value 44
terminating
CMS applications 12
testing
existence 87
SQLCA 146
TIME data type
assembler 258
C 289
COBOL 307
FORTRAN 323
PL/I 336
TIMESTAMP
data type
assembler 260
C 289
COBOL 307
FORTRAN 323
PL/I 337
duration 221
trailing blanks 65, 69
trigraphs
C 282

U
UNION ALL 88
UNION operator
CCSID 90
character subtypes 90
description 88
ordering results 88, 90
restriction for CREATE VIEW 59
usage restrictions involving
data types 89
LONG VARCHAR data 90
subqueries 90
VARCHAR and VARGRAPHIC 90
views 90
unions 88
See also UNION operator
unique on columns 232
uniquely identifying an object 20
unresolved external reference 133
UPDATE
rules 238
update rule 238
UPDATE STATISTICS 204
updating
internal statistics 204
user ID
naming convention 20
USER isolation
remote unit of work 115
user parameters
in single user mode 136
USER special register 50
USERid preprocessor parameter 110

V
valid lock size 200
VARCHAR data type
assembler 258
C 287
COBOL 306
FORTRAN 321
PL/I 336
VARGRAPHIC
constants within expressions 54
data type
assembler 258
C 287
COBOL 307
FORTRAN 321
PL/I 336
view
CREATE VIEW 58
description 57
DROP VIEW 62
materialization 60
modifying tables through 60
naming convention 20
privileges 212
querying tables through 59
unions
restriction 90
virtual
columns 58
data 58
VM 132
executing applications 134
implicit connect 105
loading a program 132
preprocessing programs 106
VM/CMS file
including secondary input 131

W

warning
  conditions 144
  flags 144
WHENEVER 10, 142, 145
WHERE clause
  ALL keyword 76
  ANY keyword 76
  correlated subquery 78
  description 25
  EXISTS predicate 87
  grouping considerations 70
  IN predicate 77
  join conditions 62
  NOT EXISTS predicate 87
  NOT IN predicate 77
  subqueries 74
WITH CHECK OPTION 58
WITH clause 28
work units
  CMS 228
  using 228
writing clauses in order 71

Z

zero SQLCODE
  description 9, 142

Communicating Your Comments to IBM

DB2® Server for VM
Application Programming
Version 6 Release 1

Publication No. SC09-2661-00

If there is something you like—or dislike—about this book, please let us know. You can use one of the methods listed below to send your comments to IBM. If you want a reply, include your name, address, and telephone number. If you are communicating electronically, include the book title, publication number, page number, or topic you are commenting on.

The comments you send should only pertain to the information in this book and its presentation. To request additional publications or to ask questions or make comments about the functions of IBM products or systems, you should talk to your IBM representative or to your IBM authorized remarketer.

When you send comments to IBM, you grant IBM a nonexclusive right to use or distribute your comments in any way it believes appropriate without incurring any obligation to you.

If you are mailing a readers' comment form (RCF) from a country other than the United States, you can give it to the local IBM branch office or IBM representative for postage-paid mailing.

- If you prefer to send comments by mail, use the RCF at the back of this book.
- If you prefer to send comments by FAX, use this number:
  - United States and Canada: 416-448-6161
  - Other countries: (+1)-416-448-6161
- If you prefer to send comments electronically, use the network ID listed below. Be sure to include your entire network address if you wish a reply.
  - Internet: torrcf@ca.ibm.com
  - IBMLink: toribm(torrcf)
  - IBM/PROFS: torolab4(torrcf)
  - IBMMAIL: ibmmail(caibmwt9)

Readers' Comments — We'd Like to Hear from You

DB2® Server for VM
Application Programming
Version 6 Release 1

Publication No. SC09-2661-00

Overall, how satisfied are you with the information in this book?

	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Overall satisfaction	☐	☐	☐	☐	☐

How satisfied are you that the information in this book is:

	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Accurate	☐	☐	☐	☐	☐
Complete	☐	☐	☐	☐	☐
Easy to find	☐	☐	☐	☐	☐
Easy to understand	☐	☐	☐	☐	☐
Well organized	☐	☐	☐	☐	☐
Applicable to your tasks	☐	☐	☐	☐	☐

Please tell us how we can improve this book:

Thank you for your responses. May we contact you? ☐ Yes ☐ No

When you send comments to IBM, you grant IBM a nonexclusive right to use or distribute your comments in any way it believes appropriate without incurring any obligation to you.

Name	Address
Company or Organization	
Phone No.	

Readers' Comments — We'd Like to Hear from You
SC09-2661-00

Cut or Fold
Along Line

Fold and Tape **Please do not staple** Fold and Tape

PLACE
POSTAGE
STAMP
HERE

IBM Canada Ltd. Laboratory
Information Development
2G/345/1150/TOR
1150 EGLINTON AVENUE EAST
NORTH YORK ONTARIO CANADA M3C 1H7

Fold and Tape **Please do not staple** Fold and Tape

SC09-2661-00

Cut or Fold
Along Line

File Number: S370/4300-50
Program Number: 5648-A70

Printed in the United States of America
on recycled paper containing 10%
recovered post-consumer fiber.

SC09-2661-00

Spine information:

DB2® Server for VM Application Programming *Version 6 Release 1*