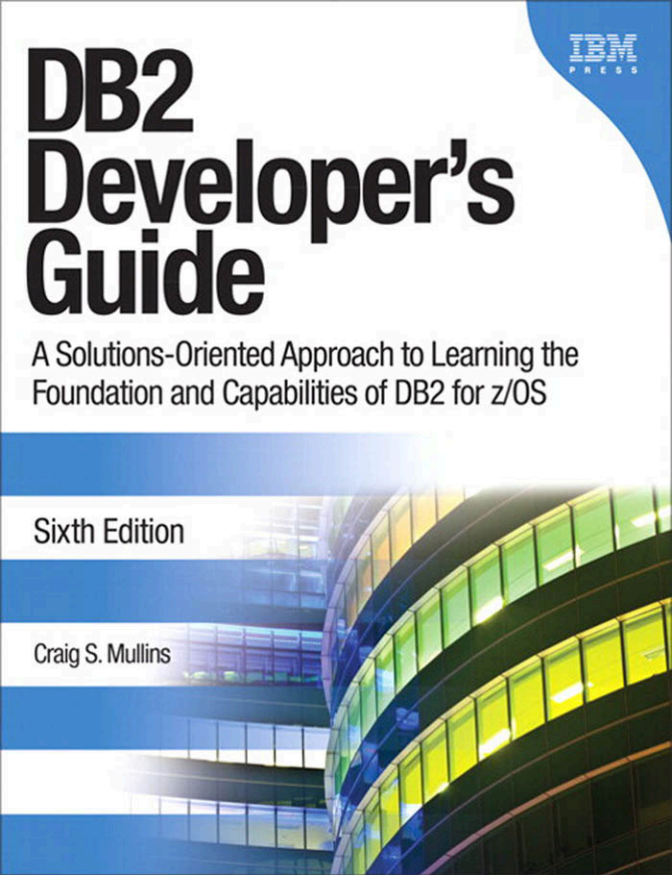


# DB2 Developer's Guide

A Solutions-Oriented Approach to Learning the  
Foundation and Capabilities of DB2 for z/OS

Sixth Edition

Craig S. Mullins



# Common DB2 SQLCODE Values

SQLCODE	SQLSTATE	Description
+000	00000	The SQL statement finished successfully.
+100	02000	No rows found to satisfy the SQL statement.
+117	01525	Number of values being inserted does not equal number of columns in the table.
-101	54001	SQL statement is too complex.
-104	42601	Illegal symbol encountered in SQL statement. Usually, this means you have a syntax error somewhere in your SQL statement.
-122	42803	Column function used illegally; all columns not applied to the column function must be in the GROUP BY.
-150	42807	Invalid view UPDATE requested; or an invalid INSERT, UPDATE, or DELETE was requested on a transition table during a triggered action.
-305	22002	A null was returned but no indicator variable is available to assign null to the host variable.
-501	24501	Must open a cursor before attempting to fetch from it or close it.
-502	24502	Cannot open a cursor twice without first closing it.
-510	42828	The table specified by the cursor of the UPDATE or DELETE statement cannot be modified as requested.
-530	23503	Invalid foreign key value supplied for the specified constraint name.
-532	23504	Deletion violates the named referential constraint.
-545	23513	INSERT or UPDATE caused a check constraint violation.
-552	42502	User is attempting to perform an operation for which he or she is not authorized.
-803	23505	Insert violates uniqueness constraint.
-805	51002	The DBRM or package name was not found in the plan.
-811	21000	Must use a cursor when more than one row is returned as the result of an embedded SELECT statement.
-818	51003	Plan/Package vs. load module timestamp mismatch. The DBRM in the executing plan or package was not created from the same precompilation as the load module.
-904	57011	The specified resource is unavailable. Determine why, and retry the request.
-911	40001	The current unit of work has been rolled back.
-913	57033	Unsuccessful execution caused by deadlock or timeout.
-922	42505	The user is not authorized to perform the task

# **DB2 Developer's Guide: A Solutions-Oriented Approach to Learning the Foundation and Capabilities of DB2 for z/OS**

## **Table of Contents**

Contents

Preface

Part I: SQL Techniques, Tips, and Tricks

1 The Magic Words

An Overview of SQL

SQL Tools of the Trade

Static SQL

Dynamic SQL

SQL Performance Factors

2 Data Manipulation Guidelines

A Bag of Tricks

SQL Access Guidelines

Complex SQL Guidelines

Common Table Expressions and Recursion

Working with Nulls

Date and Time Guidelines

Data Modification Guidelines

3 Using DB2 Functions

# **Table of Contents**

Aggregate Functions

Scalar Functions

Table Functions

MQSeries Built-In Functions

XML Built-In Functions

The RAISE\_ERROR Function

The CAST Operation

Built-In Function Guidelines

## **4 Using DB2 User-Defined Functions and Data Types**

What Is a User-Defined Function?

Types of User-Defined Functions (UDFs)

What Is a User-Defined Data Type?

User-Defined Data Types (UDTs) and Strong Typing

## **5 Data Definition Guidelines**

An Overview of DB2 Database Objects

DB2 Databases

Creating and Using DB2 Table Spaces

DB2 Storage and STOGROUPs

Table Guidelines

General Table Guidelines

Normalization and Denormalization

Assuring Data Integrity in DB2

Referential Integrity

Views, Aliases, and Synonyms

Index Guidelines

Naming Conventions

Miscellaneous DDL Guidelines

# **Table of Contents**

## **6 DB2 Indexing and Hashing Guidelines**

How an Index Works

Creating Indexes

DB2 Hashing and Hash Organized Tables

Index and Hash Guidelines

## **7 Database Change Management, Schema Evolution, and Database Definition On Demand**

Online Schema Changes

Versioning for Online Schema Changes

## **8 Using DB2 Triggers**

What Is a Trigger?

Trigger Guidelines

## **9 Large Objects and Object/Relational Databases**

Defining the Term Object/Relational

What Is a Large Object?

LOB Guidelines

DB2 Extenders

## **10 pureXML: Using XML in DB2 for z/OS**

What Is XML?

pureXML

XML-DB2 Guidelines

## **11 Supporting Temporal Data in DB2 for z/OS**

The Need for Temporal Data

DB2 Temporal Support

Temporal Data Guidelines

Summary

# **Table of Contents**

## **12 DB2 Security, Authorization, and Auditing**

Authorization and Privileges

Database Auditing

Using External Security (for Example, RACF, ACF2, and Top Secret)

## **Part II: DB2 Application Development**

## **13 Using DB2 in an Application Program**

Embedded SQL Basics

Embedded SQL Guidelines

Host Variables

Programming with Cursors

Modifying Data with Embedded SQL

Application Development Guidelines

Batch Programming Guidelines

Online Programming Guidelines

General SQL Coding Guidelines

Introduction to Java

Using REXX and DB2

Developing Applications Using Only SQL

## **14 Dynamic SQL Programming**

What Is Dynamic SQL?

Dynamic SQL Versus Static SQL

The Four Classes of Dynamic SQL

pureQuery

Making Dynamic SQL More Static and Vice Versa

Dynamic SQL Guidelines

## **15 Program Preparation**

# **Table of Contents**

Program Preparation Steps

Running a DB2 Program

Preparing a DB2 Program

What Is a DBRM?

What Is a Plan?

What Is a Package?

What Is a Collection?

Versions

Converting DBRM-Based Plans in DB2 V10

Program Preparation Objects

Program Preparation Guidelines

## **16 Using DB2 Stored Procedures**

What Is a Stored Procedure?

Implementing DB2 Stored Procedures

Procedural SQL

The Procedural DBA

IBM Data Studio

## **17 DB2 and the Internet**

The Internet Phenomenon

Accessing DB2 over the Internet

Finding DB2 Information Using the Internet

## **Part III: DB2 In-Depth**

### **18 The Doors to DB2**

DB2 Program Execution Basics

TSO (Time-Sharing Option)

CICS (Customer Information Control System)

IMS (Information Management System)

# **Table of Contents**

CAF (Call Attach Facility)

RRSAF (Recoverable Resource Manager Services Attach Facility)

Comparison of the Environments

## **19 Data Sharing**

Data Sharing Benefits

Data Sharing Requirements

The DB2 Coupling Facility

Data Sharing Naming Conventions

Data Sharing Administration

Data Sharing Application Development Guidelines

Data Sharing Administration Guidelines

## **20 DB2 Behind the Scenes**

The Physical Storage of Data

What Makes DB2 Tick

Specialty Processors

## **21 The Optimizer**

Physical Data Independence

How the Optimizer Works

Filter Factors

Screening

Access Path Strategies

Other Operations Performed by the Optimizer

## **22 The Table-Based Infrastructure of DB2**

The DB2 Catalog

The DB2 Directory

## **23 Locking DB2 Data**

# **Table of Contents**

How DB2 Manages Locking

Locks Versus Latches

Lock Duration

Table Space Locks

Table Locks

Page Locks

Row Locks

Lock Suspensions, Timeouts, and Deadlocks

Partition Independence

Lock Avoidance

Data Sharing Global Lock Management

LOBs and Locking

DB2 Locking Guidelines

Other DB2 Components

The Big Picture

## **Part IV: DB2 Performance Monitoring**

Defining DB2 Performance

Types of DB2 Performance Monitoring

24 DB2 Performance Monitoring

DB2 Traces

Trace Destinations

Using IFCIDs

Tracing Guidelines

Performance Monitoring and Reporting: Online and Batch

Monitoring and Reporting Strategy

Performance Profiles

Viewing DB2 Console Messages

# **Table of Contents**

Displaying the Status of DB2 Resources

Monitoring z/OS

## **25 Using EXPLAIN**

How EXPLAIN Works

Access Paths and the PLAN\_TABLE

Cost Estimates and the DSN\_STATEMNT\_TABLE

Function Resolution and the DSN\_FUNCTION\_TABLE

Additional Explain Tables

Explaining the Dynamic Statement Cache

EXPLAIN Guidelines

Additional Tools for Managing Access Paths

## **26 The Five Rs**

Approaches to Rebinding

A Best Practice Approach to Rebinding

## **27 DB2 Object Monitoring Using the DB2 Catalog and RTS**

DB2 Catalog Queries

Real Time Statistics

Reviewing the Rules for an Effective Monitoring Strategy

## **Part V: DB2 Performance Tuning**

### **28 Tuning DB2s Environment**

Tuning the z/OS Environment

Tuning the Teleprocessing Environment

### **29 Tuning DB2s Components**

Tuning the DB2 Subsystem

Tuning the Database Design

Tuning the Application

# **Table of Contents**

The Causes of DB2 Performance Problems

## **30 DB2 Resource Governing**

The Resource Limit Facility

## **Part VI: DB2 Utilities and Commands**

## **31 An Introduction to DB2 Utilities**

Generating Utility JCL

Monitoring DB2 Utilities

The IBM DB2 Utilities

Using LISTDEF and TEMPLATE

Issuing SQL Statements in DB2 Utilities

## **32 Data Consistency Utilities**

The CHECK Utility

The CHECK DATA Option

The CHECK LOB Option

The CHECK INDEX Option

The REPAIR Utility

The REPAIR DBD Option

The REPAIR LOCATE Option

The REPAIR SET Option

REPAIR and Versions

The REPORT Utility

The DIAGNOSE Utility

## **33 Backup and Recovery Utilities**

The COPY Utility

The COPYTOCOPY Utility

The MERGECOPY Utility

# **Table of Contents**

- The QUIESCE Utility
- The RECOVER Utility
- The REBUILD INDEX Utility
- The REPAIR Utility
- The REPORT RECOVERY Utility
- Backing Up and Restoring the System

## **34 Data Movement and Organization Utilities**

- The LOAD Utility
- The UNLOAD Utility
- The REORG Utility

## **35 Catalog Manipulation Utilities**

- The CATENFM Utility
- The CATMAINT Utility
- The DSNJCNVB Utility
- The MODIFY RECOVERY Utility
- The MODIFY STATISTICS Utility
- The RUNSTATS Utility
- The STOSPACE Utility

## **36 Stand-Alone Utilities and Sample Programs**

- The Stand-Alone Utilities
- DB2 Sample Programs

## **37 DB2 Commands**

- DB2 Environment Commands
- Information-Gathering Commands
- Administrative Commands
- Environment Control Commands
- DSN Commands

# **Table of Contents**

IMS Commands

CICS Commands

TSO Commands

IRLM Commands

## **38 DB2 Utility and Command Guidelines**

Utility Guidelines

The Pending States

## **39 DB2 Contingency Planning**

What Is a Disaster?

DB2 Recovery Basics

Additional DB2 Disaster Recovery Technologies

DB2 Environmental Considerations

DB2 Contingency Planning Guidelines

## **Part VII: The Ideal DB2 Environment**

### **40 Components of a Total DB2 Solution**

DB2 Tools

DB2 Tools Vendors

### **41 Organizational Issues**

Education

Standards and Procedures

Operational Support

Political Issues

Environmental Support

Tool Requirements

## **Part VIII: Distributed DB2**

The Advantages of Data Distribution

# **Table of Contents**

DB2 Data Distribution

DB2 Data Warehousing

## **42 DRDA**

What Is DRDA?

DRDA Functions

DRDA Architectures and Standards

The Five DRDA Levels

Putting It All Together

## **43 Distributed DB2**

Distributing Data Using DB2

DB2 Support for the DRDA Levels

Methods of Accessing Distributed Data

Packages for Static SQL

Two-Phase Commit

Miscellaneous Distributed Topics

## **44 DB2 Connect**

An Overview of IBM DB2 Connect

## **45 Distribution Guidelines**

Distribution Behind the Scenes

Block Fetch

Dynamic Cursor Pre-Open

Distributed Performance Problems

Distributed Database Design Issues

Distributed Data Placement

Distributed Optimization

Distributed Security Guidelines

Miscellaneous Distributed Guidelines

# **Table of Contents**

## **46 Data Warehousing with DB2**

Defining the Basic Terms

Designing a Data Warehouse

Populating a Data Warehouse

Accessing the Data Warehouse

Managing the Data Warehouse

The Big Picture

IBM Data Warehousing Solutions

Materialized Query Tables

General Data Warehouse Guidelines

DB2-Specific Data Warehousing Guidelines

**Index**