

DB2 9 Fundamentals exam 730 prep, Part 5: Working with DB2 objects

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This tutorial discusses data types, tables, views, and indexes as defined by DB2 9. It explains the features of these objects, how to create and manipulate them using Structured Query Language (SQL), and how they can be used in an application. This tutorial is the fifth in a [series of seven tutorials](#) that you can use to help prepare for DB2 9 Fundamentals Certification exam 730.

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Section 1. Before you start

About this series

DB2 fundamentals for professionals: Certification preparation <http://www.ibm.com/developerworks/training/kp/dm-kp-db2certification/index.html>

Thinking about seeking certification on DB2 fundamentals (Exam 730)? If so, you've landed in the right spot. This [series of seven DB2 certification preparation tutorials](#) covers all the basics -- the topics you'll need to understand before you read the first exam question. Even if you're not planning to seek certification right away, this set of tutorials is a great place to start getting to learn what's new in DB2 9.

About this tutorial

The material in this tutorial primarily covers the objectives in Section 5 of the exam, entitled "Working with DB2 Objects." You can view these objectives at: <http://www-03.ibm.com/certify/tests/obj730.shtml>.

Topics covered in this tutorial include:

- A description of the built-in data types DB2 provides, and which are appropriate to use when defining a table. (For a different treatment of data type, see [the fourth tutorial in this series](#)).
- An introduction to advanced data types.
- Tables, views, and indexes.
- An explanation of the various types of constraints and their uses.

Objectives

After completing this tutorial, you should be able to:

- Understand data types and advanced data types
- Create tables, views, and indexes in a DB2 database
- Understand the features and use of unique constraints, referential integrity constraints, and table check constraints
- Use views to restrict access to data
- Understand the features of indexes

System Requirements

You do not need a copy of DB2 to complete this tutorial. However, if you'd like, you can download a free trial version of [IBM DB2 9](#) to work along with this tutorial.

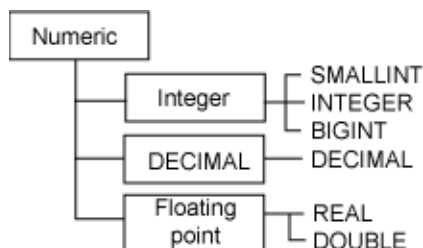
Section 2. Data types

DB2 provides a rich and flexible assortment of data types. DB2 comes with basic data types such as `INTEGER`, `CHAR`, and `DATE`. It also includes facilities to create user-defined data types (UDTs) so that you can create complex, nontraditional data types suited to today's complex programming environments. Choosing which type to use in a given situation depends on the type and range of information that is stored in the column.

There are four categories of built-in data types: numeric, string, datetime, and XML.

The user-defined data types are categorized as: distinct, structured, and reference.

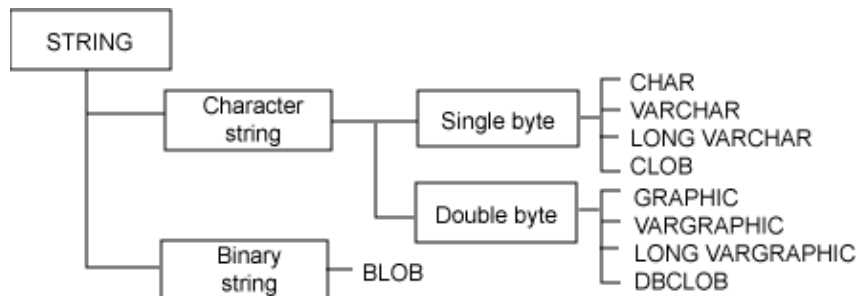
Numeric data types



There are three categories of numeric data types, as diagrammed in the preceding figure. These types vary in the range and precision of numeric data they can store.

- *Integer*: `SMALLINT`, `INTEGER`, and `BIGINT` are used to store integer numbers. For example, an inventory count could be defined as `INTEGER`. `SMALLINT` can store integers from -32,768 to 32,767 in 2 bytes. `INTEGER` can store integers from -2,147,483,648 to 2,147,483,647 in 4 bytes. `BIGINT` can store integers from -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807 in 8 bytes.
- *Decimal*: `DECIMAL` is used to store numbers with fractional parts. To define this data type, specify a *precision* (p), which indicates the total number of digits, and a *scale* (s), which indicates the number of digits to the right of the decimal place. A column defined by `DECIMAL(10,2)` that held currency values could hold values up to 99999999.99 dollars. The amount of storage required in the database depends on the precision and is calculated by the formula $p/2 + 1$. So, `DECIMAL(10,2)` would require $10/2 + 1$ or 6 bytes.
- *Floating point*: `REAL` and `DOUBLE` are used to store approximations of numbers. For example, very small or very large scientific measurements could be defined as `REAL`. `REAL` can be defined with a length between 1 and 24 digits and requires 4 bytes of storage. `DOUBLE` can be defined with a length of between 25 and 53 digits and requires 8 bytes of storage. `FLOAT` can be used as a synonym for `REAL` or `DOUBLE`.

String data types



DB2 provides several data types for storing character data or strings, as diagrammed in the preceding figure. Choose a data type based on the size of the string you are going to store and what data will be in the string.

The following data types are used to store single-byte character strings:

- `CHAR` or `CHARACTER` is used to store fixed-length character strings up to 254 bytes. For example, a manufacturer may assign an identifier to a part with a specific length of eight characters, and therefore store that identifier in the database as a column of `CHAR(8)`.
- `VARCHAR` is used to store variable-length character strings. For example, a manufacturer may deal with a number of parts with identifiers of different lengths, and thus store those identifiers as a column of `VARCHAR(100)`. The maximum length of a `VARCHAR` column is 32,672 bytes. In the database, `VARCHAR` data only takes as much space as required.

The following data types are used to store double-byte character strings:

- `GRAPHIC` is used to store fixed-length double-byte character strings. The maximum length of a `GRAPHIC` column is 127 characters.
- `VARGRAPHIC` is used to store variable-length double-byte character strings. The maximum length of a `VARGRAPHIC` column is 16,336 character

DB2 also provides data types to store very long strings of data. All long string data types have similar characteristics. First, the data is not stored physically with the row data in the database, which means that additional processing is required to access this data. Long data types can be defined up to 2GB in length. However, only the space required is actually used. The long data types are:

- `LONG VARCHAR`
- `CLOB` (character large object)
- `LONG VARGRAPHIC`
- `DBCLOB` (double-byte character large object)
- `BLOB` (binary large object)

Datetime data types

DB2 provides three data types to store dates and times:

- `DATE`
- `TIME`
- `TIMESTAMP`

The values of these data types are stored in the database in an internal format; however, applications can manipulate them as strings. When one of these data types is retrieved, it is represented as a character string. Enclose the value in quotation marks when updating these data types.

DB2 provides built-in functions to manipulate datetime values. For example, you can determine the day of the week of a date value using the `DAYOFWEEK` or `DAYNAME` functions. Use the `DAYS` function to calculate how many days lie between two dates. DB2 also provides special registers to generate the current date, time, or timestamp based on the time-of-day clock. For example, `CURRENT DATE` returns a string representing the current date on the system.

The format of the date and time values depends on the country code of the database, which is specified when the database is created. There are several formats available: ISO, USA, EUR, and JIS. For example, if your database is using the USA format, the format of date values would be `mm/dd/yyyy`. You can change the format by using the `DATETIME` option of the `BIND` command when creating your application.

There is a single format for the `TIMESTAMP` data type. The string representation is `yyyy-mm-dd-hh.mm.ss.nnnnnn`.

XML data type

DB2 provides the XML data type to store well-formed XML documents.

Values in XML columns are stored in an internal representation different from string data types. To store XML data in an XML data type column, transform the data using the XMLPARSE function. An XML data type value can be transformed into a serialized string value representing of the XML document using the XMLSERIALIZE function. DB2 provides many other built-in functions to manipulate XML data types.

User-defined data types

DB2 allows you to define data types that suit your application. There are three user-defined data types:

- *User-defined distinct*: Define a new data type based on a built-in type. This new type has the same features of the built-in type, but you can use it to ensure that only values of the same type are compared. For example, you can define a Canadian dollar type (CANDOL) and a US dollar type (USADOL) both based on DECIMAL(10,2). Both types are based on the same built-in type, but you won't be able to compare them unless a conversion function is applied. The following CREATE TYPE statements create the CANDOL and USADOL UDTs:

```
CREATE DISTINCT TYPE CANDOL AS DECIMAL(10,2) WITH COMPARISONS
CREATE DISTINCT TYPE USADOL AS DECIMAL(10,2) WITH COMPARISONS
```

DB2 automatically generates functions to perform casting between the base type and the distinct type, and comparison operators for comparing instances of the distinct type. The following statements show how to create a table with a column of CANDOL type and then insert data into the table using the CANDOL casting function:

```
CREATE TABLE ITEMS (ITEMID CHAR(5), PRICE CANDOL )
INSERT INTO ITEMS VALUES('ABC11',CANDOL(30.50) )
```

- *User-defined structured*: Create a type that consists of several columns of built-in types. Then use this structured type when creating a table. For example, you can create a structured type named ADDRESS that contains data for street number, street name, city, and so forth. Then you can use this type when defining other tables, such as employees or suppliers, because the same data is required for both. Also, structured types can have subtypes in a hierarchical structure. This lets you store objects that belong to a hierarchy in the database.
- *User-defined reference*: When using structured types, you can define references to rows in another table using reference types. These references appear similar to referential constraints; however, they do not enforce relationships between the tables. References in tables let you specify queries in a different way.

User-defined structured and reference types are an advanced topic; the information presented here serves only as an introduction to these types.

DB2 Extenders

DB2 Extenders provide support for complex, nontraditional data types. They are packaged separately from the DB2 server code and installed on the server and into each database that uses the data type.

There are many DB2 Extenders available from IBM and from independent software vendors. The first four extenders provided by IBM are for storing audio, video, image, and text data. For example, use the DB2 Image Extender store an image of a book cover and the DB2 Text Extender to store the text of a book. Now, there are several other extenders available. The DB2 Spatial Extender could be used for storing and analyzing spatial data and the XML Extender for managing XML documents.

DB2 Extenders are implemented using the features of user-defined types and user-defined functions (UDFs). Each extender comes with one or more UDTs, UDFs for operating on the UDT, specific application programming interfaces (APIs), and perhaps other tools. For example, the DB2 Image Extender includes:

- The DB2IMAGE UDT
- UDFs to insert and retrieve from a DB2IMAGE column
- APIs to search based on characteristics of images

Before using these data types, install the extender support into the database. The installation process for each extender defines the required UDTs and UDFs in the database. Once you've done this, you can use the UDTs when defining a table and the UDFs when working with data. (For more on DB2 Extenders, see the [first tutorial in this series](#).)

The XML data type, which is new in DB2 9, provides advanced features for handling XML documents. Applications and data using the XML Extender must be migrated to use the native XML support in DB2.

Section 3. Tables

All data is stored in tables in the database. A *table* consists of one or more columns of various data types. The data is stored in rows or records.

Tables are defined using the `CREATE TABLE` SQL statement. DB2 also provides a GUI tool, the DB2 Control Center, for creating tables, which creates a table based on information you specify. It also generates the `CREATE TABLE` SQL statement, which can be used in a script or application program at a later time.

A database has a set of tables, called the *system catalog tables*, which hold information about all the objects in the database. DB2 provides views for the base

system catalog tables. The catalog view SYSCAT.TABLES contains a row for each table defined in the database. SYSCAT.COLUMNS contains a row for each column of each table in the database. Look at the catalog views using `SELECT` statements, just like any other table in the database; however, you cannot modify the data using `INSERT`, `UPDATE`, or `DELETE` statements. The tables are automatically updated as a result of data definition statements (DDL), such as `CREATE`, and other operations, such as `RUNSTATS`.

Creating a table

Use the `CREATE TABLE` SQL statement to define a table in the database. The following statement creates a simple table named `BOOKS` that contains three columns:

```
CREATE TABLE BOOKS ( BOOKID INTEGER,  
                     BOOKNAME VARCHAR(100),  
                     ISBN CHAR(10) )
```

You can also use the `CREATE TABLE` SQL statement to create a table that is like another table or view in the database:

```
CREATE TABLE MYBOOKS LIKE BOOKS
```

This statement creates a table with the same columns as the original table or view. The columns of the new table have the same names, data types, and nullability attributes as the columns in the old one. You can also specify clauses that copy other attributes, like column defaults and identify attributes.

There are many options available for the `CREATE TABLE` statement (they are presented in the following sections as new concepts are introduced). The details of the `CREATE TABLE` SQL statement can be found in the SQL Reference (see [Resources](#)).

Once you've created a table, there are several ways to populate it with data. The `INSERT` statement lets you insert a row or several rows of data into the table. DB2 also provides utilities to insert large amounts of data from a file. The `IMPORT` utility inserts rows using `INSERT` statements. It is designed for loading small amounts of data into the database. The `LOAD` utility, intended for loading large volumes of data, inserts rows directly onto data pages in the database and is much faster than the `IMPORT` utility.

Storing tables in the database

Tables are stored in the database in *tablespaces*. Tablespaces have physical space allocated to them. Create the tablespace before creating the table.

When you create a table, let DB2 place the table in a default tablespace or specify the tablespace in which you'd like the table to reside. The following `CREATE TABLE` statement places the `BOOKS` table in the `BOOKINFO` tablespace:

```
CREATE TABLE BOOKS ( BOOKID INTEGER,  
                     BOOKNAME VARCHAR(100),  
                     ISBN CHAR(10) )  
IN BOOKINFO
```

Although tablespaces are not covered in detail here, it is important to understand that defining tablespaces appropriately has an effect on the performance and maintainability of the database. For more information on tablespaces, check out the [second tutorial in this series](#).

Altering a table

Use the `ALTER TABLE` SQL statement to change characteristics of a table. For instance, you can add or drop:

- A column
- A primary key
- One or more unique or referential constraints
- One or more check constraints

The following statement adds a column called `BOOKTYPE` to the `BOOKS` table:

```
ALTER TABLE BOOKS ADD BOOKTYPE CHAR(1)
```

You can also change characteristics of specific columns in a table:

- The identity attributes of a column
- The length of a string column
- The datatype of a column
- The nullability of a column
- The constraint of a column

There are restrictions on altering columns:

- When altering the length of a string column, you can only increase the length.
- When altering the datatype of a column, the new datatype must be compatible with the existing data type. For example, you can convert `CHAR` columns to `VARCHAR` columns, but cannot convert them to `GRAPHIC` or numeric columns. Numeric columns can be converted to any other numeric data type as long as the new datatype is large enough to hold the values. For example, convert an `INTEGER` column to `BIGINT`, but, a `DECIMAL(10,2)` column cannot be converted to `SMALLINT`.
- Fixed length strings can be converted to variable length string and variable length strings can be converted to fixed length. For example, a `CHAR(100)` can be converted to `VARCHAR(150)`. Similar restrictions exist for variable length graphic strings.

The following statement changes the DATATYPE of column BOOKNAME from VARCHAR(100) to VARCHAR(200) and changes the nullability of the ISBN column to NOT NULL:

```
ALTER TABLE BOOKS ALTER BOOKNAME SET DATA TYPE VARCHAR(200) ALTER ISBN SET NOT NULL
```

Certain characteristics of a table cannot be changed. For example, you cannot change the tablespace in which the table resides, the order of columns, or change the datatype of some columns. To change characteristics such as these, save the table data, drop the table, and recreate it.

Dropping a table

The `DROP TABLE` statement removes a table from the database, deleting the data and the table definition. If there are indexes or constraints defined on the table, they are dropped as well.

The following `DROP TABLE` statement deletes the BOOKS table from the database:

```
DROP TABLE BOOKS
```

NOT NULL, DEFAULT, and GENERATED column options

The columns of a table are specified in the `CREATE TABLE` statement by a column name and data type. The columns can have additional clauses specified that restrict the data in the column.

By default, a column allows null values. If you do not want to allow null values, specify the `NOT NULL` clause for the column. Specify a default value using the `WITH DEFAULT` clause and a default value. The following `CREATE TABLE` statement creates a table called BOOKS, where the BOOKID column does not allow null values and the default value for BOOKNAME is TBD:

```
CREATE TABLE BOOKS ( BOOKID INTEGER NOT NULL,  
                     BOOKNAME VARCHAR(100) WITH DEFAULT 'TBD',  
                     ISBN CHAR(10) )
```

In the BOOKS table, the BOOKID is a unique number assigned to each book. Rather than have the application generate the identifier, you can specify that DB2 is to generate a BOOKID using the `GENERATED ALWAYS AS IDENTITY` clause:

```
CREATE TABLE BOOKS ( BOOKID INTEGER NOT NULL GENERATED ALWAYS AS IDENTITY  
                    (START WITH 1, INCREMENT BY 1),  
                    BOOKNAME VARCHAR(100) WITH DEFAULT 'TBD',  
                    ISBN CHAR(10) )
```

`GENERATED ALWAYS AS IDENTITY` causes a BOOKID to be generated for each record. The first value generated is 1 and succeeding values are generated by incrementing the previous value by 1.

Also use the `GENERATED ALWAYS` option to have DB2 calculate the value of a column automatically. The following example defines a table called `AUTHORS`, with columns `FICTIONBOOKS` and `NONFICTIONBOOKS` that hold counts for fiction and nonfiction books, respectively. The `TOTALBOOKS` column is calculated by adding the `FICTIONBOOKS` and `NONFICTIONBOOKS` columns:

```
CREATE TABLE AUTHORS (AUTHORID INTEGER NOT NULL PRIMARY KEY,  
                       LNAME VARCHAR(100),  
                       FNAME VARCHAR(100),  
                       FICTIONBOOKS INTEGER,  
                       NONFICTIONBOOKS INTEGER,  
                       TOTALBOOKS INTEGER GENERATED ALWAYS  
                           AS (FICTIONBOOKS + NONFICTIONBOOKS) )
```

Section 4. Constraints

DB2 provides several ways to control what data can be stored in a column. These features are called *constraints* or *rules* that the database manager enforces on a data column or set of columns.

DB2 provides three types of constraints: unique, referential integrity, and table check.

The following sections provide detailed descriptions of each type of constraint.

Unique constraints

Unique constraints are used to ensure that values in a column are unique. Unique constraints can be defined over one or more columns. Each column included in the unique constraint must be defined as `NOT NULL`.

Unique constraints can be defined either as the `PRIMARY KEY` or `UNIQUE` constraint. These are defined when a table is created as part of the `CREATE TABLE SQL` statement or added after the table is created using the `ALTER TABLE` statement.

When do you define a `PRIMARY KEY`, and when do you define a `UNIQUE` key? This depends on the nature of the data. In the previous example, the `BOOKS` table has a `BOOKID` column which is used to uniquely identify a book. This value is also used in other tables that contain information related to this book. In this case, you would define `BOOKID` as a primary key. DB2 allows only one primary key to be defined on a table.

The ISBN number column needs to be unique but is not a value that is otherwise referenced in the database. In this case, the ISBN column is defined as `UNIQUE`:

```
CREATE TABLE BOOKS (BOOKID INTEGER NOT NULL PRIMARY KEY,  
                    BOOKNAME VARCHAR(100),  
                    ISBN CHAR(10) NOT NULL CONSTRAINT BOOKSISBN UNIQUE )
```

The `CONSTRAINT` keyword lets you specify a name for the constraint. In this example, the name of the unique constraint is `BOOKSISBN`. Use this name in the `ALTER TABLE` statement if you want to drop the specific constraint.

DB2 lets you define only one primary key on a table; however, you can define multiple unique constraints.

Whenever you define a `PRIMARY KEY` or `UNIQUE` constraint on a column, DB2 creates a unique index to enforce uniqueness on the column. DB2 does not let you create more than one unique index defined on the same columns. Therefore, you cannot define a `PRIMARY KEY` and `UNIQUE` constraint on the same columns. For example, both of the following statements against the `BOOKS` table fail because a `PRIMARY KEY` already exists:

```
ALTER TABLE BOOKS ADD CONSTRAINT UNIQUE (BOOKID)
CREATE UNIQUE INDEX IBOOKS ON BOOKS (BOOKID)
```

Referential integrity constraints

Referential integrity constraints are used to define relationships between tables and ensure that these relationships remain valid. Suppose you have one table that holds information about authors and another table that lists the books that those authors have written. There is a relationship between the `BOOKS` table and the `AUTHORS` table -- each book has an author and that author must exist in the `AUTHOR` table. Each author has a unique identifier stored in the `AUTHORID` column. The `AUTHORID` is used in the `BOOKS` table to identify the author of each book. To define this relationship, define the `AUTHORID` column of the `AUTHORS` table as a primary key and then define a foreign key on the `BOOKS` table to establish the relationship with the `AUTHORID` column in the `AUTHORS` table:

```
CREATE TABLE AUTHORS (AUTHORID INTEGER NOT NULL PRIMARY KEY,
                      LNAME VARCHAR(100),
                      FNAME VARCHAR(100))
CREATE TABLE BOOKS (BOOKID INTEGER NOT NULL PRIMARY KEY,
                    BOOKNAME VARCHAR(100),
                    ISBN CHAR(10),
                    AUTHORID INTEGER REFERENCES AUTHORS)
```

The table that has a primary key that relates to another table -- `AUTHOR`, here -- is called a *parent table*. The table to which the parent table relates -- `BOOKS`, here -- is called a *dependent table*. You may define more than one dependent table on a single parent table.

You can also define relationships between rows of the same table. In such a case, the parent table and dependent tables are the same table.

When you define referential constraints on a set of tables, DB2 enforces referential integrity rules on those tables when update operations are performed against them:

- DB2 ensures that only valid data is inserted into columns where referential integrity constraints are defined. This means that you must always have a row in the parent table with a key value that is equal to the foreign key value in the row that you are inserting into a dependent table. For example, if a new book is being inserted into the BOOKS table with an AUTHORID of 437, then there must already be a row in the AUTHORS table where AUTHORID is 437.
- DB2 also enforces rules when rows that have dependent rows in a dependent table are deleted from a parent table. The action DB2 takes depends on the delete rule defined on the table. There are four rules that can be specified: RESTRICT, NO ACTION, CASCADE and SET NULL.
 - If RESTRICT or NO ACTION is specified, DB2 does not allow the parent row to be deleted. The rows in dependent tables must be deleted before the row in the parent table. This is the default, so this rule applies to the AUTHORS and BOOKS tables as defined so far.
 - If CASCADE is specified, then deleting a row from the parent table automatically also deletes dependent rows in all dependent tables.
 - If SET NULL is specified, then the parent row is deleted from the parent table and the foreign key value in the dependent rows is set to null (if nullable).
- When updating key values in the parent table, there are two rules that can be specified: RESTRICT and NO ACTION. RESTRICT does not allow a key value to be updated if there are dependent rows in a dependent table. NO ACTION causes the update operation on a parent key value to be rejected if, at the end of the update, there are dependent rows in a dependent table that do not have a parent key in the parent table.

Table check constraints

Table check constraints are used to verify that column data does not violate rules defined for the column and to restrict the values in a certain column of a table. DB2 ensures that the constraint is not violated during inserts and updates.

Suppose that you add a column to the BOOKS table for a book type, and the values that you wish to allow are F (fiction) and N (nonfiction). You can add a column BOOKTYPE with a check constraint as follows:

```
ALTER TABLE BOOKS ADD BOOKTYPE CHAR(1) CHECK (BOOKTYPE IN ('F', 'N'))
```

You can define check constraints when you create the table or add them later using the ALTER TABLE SQL statement. You can modify check constraints by dropping and then recreating them using the ALTER TABLE SQL statement.

Section 5. Views

Views allow different users or applications to look at the same data in different ways. This not only makes the data simpler to access, but it can also be used to restrict which rows and columns users view or update.

For example, suppose that a company has a table containing information about its employees. A manager needs to see address, telephone number, and salary information about his employees only, while a directory application needs to see all employees in the company along with their address and telephone numbers, but not their salaries. You can create one view that shows all the information for the employees in a specific department and another that shows only the name, address, and telephone number of all employees.

To the user, a view just looks like a table. Except for the view definition, a view does not take up space in the database; the data presented in a view is derived from another table. You can create a view on an existing table (or tables), on another view, or some combination of the two. A view defined on another view is called a *nested view*.

You can define a view with column names that are different than the corresponding column names of the base table. You can also define views that check to see if data inserted or updated stays within the conditions of the view.

The list of views defined in the database is stored in the system catalog table SYSIBM.SYSVIEWS, which also has a view defined on it called SYSCAT.VIEWS. The system catalog also has a SYSCAT.VIEWDEP which, for each view defined in the database, has a row for each view or table dependent on that view. Also, each view has an entry in SYSIBM.SYSTABLES and entries in SYSIBM.SYSCOLUMNS because views can be used just like tables.

Creating a view

The `CREATE VIEW` SQL statement is used to define a view. A `SELECT` statement is used to specify which rows and columns are presented in the view.

For example, imagine that you want to create a view that shows only the nonfiction books in our BOOKS table:

```
CREATE VIEW NONFICTIONBOOKS AS
  SELECT * FROM BOOKS WHERE BOOKTYPE = 'N'
```

After you define this view, there are entries for it in SYSCAT.VIEWS, SYSCAT.VIEWDEP, and SYSCAT.TABLES.

To define column names in the view that are different from those in the base table, you can specify them in the `CREATE VIEW` statement. The following statement creates a MYBOOKVIEW view that contains two columns: TITLE, which represents the BOOKNAME column, and TYPE, which represents the BOOKTYPE column.

```
CREATE VIEW MYBOOKVIEW (TITLE,TYPE) AS
  SELECT BOOKNAME,BOOKTYPE FROM BOOKS
```

The `DROP VIEW` SQL statement is used to drop a view from the database. If you drop a table or another view on which a view is based, the view remains defined in the database but becomes inoperative. The `VALID` column of `SYSCAT.VIEWS` indicates whether a view is valid (Y) or not (X). Even if you recreate the base table, the orphaned view remains invalid; you have to recreate it as well.

You can drop the `NONFICTIONBOOKS` view from the database:

```
DROP VIEW NONFICTIONBOOKS
```

You cannot modify a view; to change a view definition, drop it and recreate it. Use the `ALTER VIEW` statement provided only to modify reference types.

Read-only and updatable views

When you create a view, you can define it as either a *read-only* view or as an *updatable* view. The `SELECT` statement of a view determines whether the view is read-only or updatable. Generally, if the rows of a view can be mapped to rows of the base table, then the view is updatable. For example, the view `NONFICTIONBOOKS`, as you defined it in the previous example, is updatable because each row in the view is a row in the base table.

The rules for creating updatable views are complex and depend on the definition of the query. For example, views that use `VALUES`, `DISTINCT`, or `JOIN` features are not updatable. You can easily determine whether a view is updatable by looking at the `READONLY` column of `SYSCAT.VIEWS`: Y means it is ready-only and N means it is not.

The detailed rules for creating updatable views are documented in the [DB2 SQL Reference](#) (see [Resources](#)).

The `NONFICTIONBOOKS` view defined previously includes only the rows where the `BOOKTYPE` is N. If you insert into the view a row where the `BOOKTYPE` is F, DB2 inserts the row into the base table `BOOKS`. However, if you then select from the view, the newly inserted row cannot be seen through the view. If you do not want to allow a user to insert rows that are outside the scope of the view, you can define the view with the *check option*. Defining a view using `WITH CHECK OPTION` tells DB2 to check that statements using the view satisfy the conditions of the view.

The following statement defines a view using `WITH CHECK OPTION`:

```
CREATE VIEW NONFICTIONBOOKS AS
  SELECT * FROM BOOKS WHERE BOOKTYPE = 'N'
  WITH CHECK OPTION
```

This view still restricts the user to seeing only non-fiction books; in addition, it also prevents the user from inserting rows that do not have a value of N in the BOOKTYPE column and updating the value of the BOOKTYPE column in existing rows to a value other than N. The following statements, for instance, are no longer be allowed:

```
INSERT INTO NONFICTIONBOOKS VALUES (...,'F');
UPDATE NONFICTIONBOOKS SET BOOKTYPE = 'F' WHERE BOOKID = 111
```

Nested views with check option

When defining nested views, the check option can be used to restrict operations. However, there are other clauses you can specify to define how the restrictions are inherited. The check option can be defined either as `CASCADED` or `LOCAL`. `CASCADED` is the default if the keyword is not specified. Several possible scenarios explain the differences between the behavior of `CASCADED` and `LOCAL`.

When a view is created `WITH CASCADED CHECK OPTION`, all statements executed against the view must satisfy the conditions of the view and all underlying views -- even if those views were not defined with the check option. Suppose that the view `NONFICTIONBOOKS` is created without the check option, and you also create a view `NONFICTIONBOOKS1` based on the view `NONFICTIONBOOKS` using the `CASCADED` keyword:

```
CREATE VIEW NONFICTIONBOOKS AS
  SELECT * FROM BOOKS WHERE BOOKTYPE = 'N'
CREATE VIEW NONFICTIONBOOKS1 AS
  SELECT * FROM NONFICTIONBOOKS WHERE BOOKID > 100
  WITH CASCADED CHECK OPTION
```

The following `INSERT` statements would not be allowed because they do not satisfy the conditions of at least one of the views:

```
INSERT INTO NONFICTIONBOOKS1 VALUES( 10,...,'N')
INSERT INTO NONFICTIONBOOKS1 VALUES(120,...,'F')
INSERT INTO NONFICTIONBOOKS1 VALUES( 10,...,'F')
```

However, the following `INSERT` statement *would* be allowed because it satisfies the conditions of both of the views:

```
INSERT INTO NONFICTIONBOOKS1 VALUES(120,...,'N')
```

Next, suppose you create a view `NONFICTIONBOOKS2` based on the view `NONFICTIONBOOKS` using `WITH LOCAL CHECK OPTION`. Now, statements executed against the view need only satisfy conditions of views that have the check option specified:

```
CREATE VIEW NONFICTIONBOOKS AS
  SELECT * FROM BOOKS WHERE BOOKTYPE = 'N'
CREATE VIEW NONFICTIONBOOKS2 AS
  SELECT * FROM NONFICTIONBOOKS WHERE BOOKID > 100
  WITH LOCAL CHECK OPTION
```

In this case, the following `INSERT` statements would not be allowed because they do not satisfy the `BOOKID > 100` condition of the `NONFICTIONBOOKS2` view:

```
INSERT INTO NONFICTIONBOOKS2 VALUES(10, .., 'N')
INSERT INTO NONFICTIONBOOKS2 VALUES(10, .., 'F')
```

However, the following `INSERT` statements *would* be allowed even though the value `N` does not satisfy the `BOOKTYPE = 'N'` condition of the `NONFICTIONBOOKS` view:

```
INSERT INTO NONFICTIONBOOKS2 VALUES(120, .., 'N')
INSERT INTO NONFICTIONBOOKS2 VALUES(120, .., 'F')
```

Section 6. Indexes

An *index* is an ordered list of the key values of a column or columns of a table. There are two reasons why you might create an index:

- To ensure uniqueness of values in a column or columns.
- To improve performance of queries against the table. The DB2 optimizer uses indexes to improve performance when performing queries or to present results of a query in the order of the index.

Indexes can be defined as unique or nonunique. *Nonunique* indexes allow duplicate key values; *unique* indexes allow only one occurrence of a key value in the list. Unique indexes do allow a single null value to be present. However, a second null value would cause a duplicate and therefore is not allowed.

Indexes are created using the `CREATE INDEX` SQL statement. Indexes are also created implicitly in support of a `PRIMARY KEY` or `UNIQUE` constraint. When a unique index is created, the key data is checked for uniqueness and the operation fails if duplicates are found.

Indexes are created as ascending, descending, or bidirectional. The option you choose depends on how the application accesses the data.

Creating indexes

In the example, you have a primary key on the `BOOKID` column. Often, users conduct searches on the book title, so an index on `BOOKNAME` would be appropriate. The following statement creates a nonunique ascending index on the `BOOKNAME` column:

```
CREATE INDEX IBOOKNAME ON BOOKS (BOOKNAME)
```

The index name, IBOOKNAME, is used to create and drop the index. Other than that, the name is not used in queries or updates to the table.

By default, an index is created in ascending order, but you can also create indexes that are descending. You can even specify different orders for the columns in the index. The following statement defines an index on the AUTHORID and BOOKNAME columns. The values of the AUTHORID column are sorted in descending order, and the values of the BOOKNAME column are sorted in ascending order within the same AUTHORID:

```
CREATE INDEX I2BOOKNAME ON BOOKS (AUTHORID DESC, BOOKNAME ASC)
```

When an index is created in a database, the keys are stored in the specified order. The index helps improve the performance of queries requiring the data in the specified order. An ascending index is also used to determine the result of the `MIN` column function; a descending index is used to determine the result of the `MAX` column function. If the application requires the data to be ordered in the opposite sequence to the index as well, DB2 allows the creation of a bidirectional index. A *bidirectional* index eliminates the need to create an index in the reverse order, and it eliminates the need for the optimizer to sort the data in the reverse order. It also allows the efficient retrieval of `MIN` and `MAX` functions values. To create a bidirectional index, specify the `ALLOW REVERSE SCANS` option on the `CREATE INDEX` statement:

```
CREATE INDEX BIBOOKNAME ON BOOKS (BOOKNAME) ALLOW REVERSE SCANS
```

DB2 does not let you create multiple indexes with the same definition. This applies even to indexes that you create implicitly in support of a primary key or unique constraint. Because the BOOKS table already has a primary key defined on the BOOKID column, attempting to create an index on BOOKID column fails.

Creating an index can take a long time. DB2 reads each row to extract the keys, sort those keys, and then write the list to the database. If the table is large, then a temporary tablespace is used sort the keys.

The index is stored in a tablespace. If your table resides in a database-managed tablespace, you have the option of separating the indexes into a separate tablespace. Define this when you create the table, using the `INDEXES IN` clause. The location of a table's indexes is set when the table is created and cannot be changed unless the table is dropped and recreated.

DB2 also provides the `DROP INDEX` SQL statement to remove an index from the database. There is no way to modify an index. If you need to change an index -- to add another column to the key, for example -- you have to drop and re-create it.

Clustering indexes

You can create one index on each table as the clustering index. A clustering index is useful when the table data is often referenced in a particular order. The *clustering index* defines the order in which data is stored in the database. During inserts, DB2 attempts to place new rows close to rows with similar keys. Then, during queries requiring data in the clustering index sequence, the data can be retrieved faster.

To create an index as the clustering index, specify the `CLUSTER` clause on the `CREATE INDEX` statement:

```
CREATE INDEX IAUTHBKNAME ON BOOKS (AUTHORID,BOOKNAME) CLUSTER
```

This statement creates an index on the `AUTHORID` and `BOOKNAME` columns as the clustering index. This index would improve the performance of queries written to list authors and all the books that they have written.

Using included columns in indexes

When creating an index, you have the option to include extra column data that is stored with the key, but is not actually part of the key itself and is not sorted. The main reason for including additional columns in an index is to improve the performance of certain queries: with this data already available in the index page, DB2 does not need to access the data page to fetch it. Included columns can only be defined for unique indexes. However, the included columns are not considered when enforcing uniqueness of the index.

Suppose that you often need to get a list of book names ordered by `BOOKID`. The query would look like this:

```
SELECT BOOKID,BOOKNAME FROM BOOK ORDER BY BOOKID
```

Create an index that might improve performance:

```
CREATE UNIQUE INDEX IBOOKID ON BOOKS (BOOKID) INCLUDE(BOOKNAME)
```

As a result, all the data required for the query result is present in the index and no data pages need to be retrieved.

So why not just include all the data in the indexes? First of all, this would require more physical space in the database because the table data would essentially be duplicated in the index. Second, all the copies of the data would need to be updated whenever the data value is updated, and this would be significant overhead in a database where many updates occur.

What indexes should I create?

Consider the following when creating indexes:

- Because indexes are a permanent list of the key values, they require space in the database. Creating many indexes requires additional storage space in your database. The amount of space required is determined by the length of the key columns. DB2 provides a tool to help you estimate the size of an index.
- Indexes are additional copies of the values so they must be updated if the data in the table is updated. If table data is frequently updated, consider what impact additional indexes have on update performance.
- Indexes significantly improve performance of queries when defined on the appropriate columns.

DB2 provides a tool called the Index Advisor to help you determine which indexes to define. The Index Advisor lets you specify the workload that is executed against a table, and it recommends indexes to be created on the table.

Section 7. Summary

Summary

This tutorial was designed to familiarize you with the features of data types, tables, constraints, views, and indexes defined in DB2. It also showed you how to use the `CREATE`, `ALTER`, and `DROP` statements to manage these objects. Examples were provided so you could try your hand at using these objects in a controlled setting.

[Part 6: Data concurrency](#), introduces you to the concept of data consistency and to the various mechanisms that are used by DB2 to maintain database consistency in both single- and multi-user environments.

To keep an eye on this series, bookmark the series page, [DB2 9 DBA exam 730 prep tutorials](#).

Resources

- A [trial version of DB2 9](#) is available for free download.
- Download [DB2 Express-C](#), a no-charge version of DB2 Express Edition for the community that offers the same core data features as DB2 Express Edition and provides a solid base to build and deploy applications.
- Check out the other parts of the [DB2 9 Fundamentals exam 730 prep tutorial series](#).
- [Certification exam](#) site. Click the exam number to see more information about Exams 730 and 731. If it's not there, it's coming soon.
- [DB2 9 overview](#). Find information about the new data server that includes patented pureXML™ technology.
- [DB2 XML evaluation guide: A step-by-step introduction to the XML storage and query capabilities of DB2 9](#)
- Visit the [developerWorks DBA Central zone](#) to read articles and tutorials and connect to other resources to expand your database administration skills.
- Check out the [developerWorks DB2 basics](#) series, a group of articles geared toward beginning users.

About the author

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