

SQL Server Inside Out

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SQL Server Inside Out

Learner's Guide

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APTECH LIMITED

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First Edition - 2017



Dear Learner,

We congratulate you on your decision to pursue an Aptech Worldwide course.

Aptech Ltd. designs its courses using a sound instructional design model – from conceptualization to execution, incorporating the following key aspects:

- Scanning the user system and needs assessment

Needs assessment is carried out to find the educational and training needs of the learner

Technology trends are regularly scanned and tracked by core teams at Aptech Ltd. TAG* analyzes these on a monthly basis to understand the emerging technology training needs for the Industry.

An annual Industry Recruitment Profile Survey# is conducted during August - October to understand the technologies that Industries would be adapting in the next 2 to 3 years. An analysis of these trends & recruitment needs is then carried out to understand the skill requirements for different roles & career opportunities.

The skill requirements are then mapped with the learner profile (user system) to derive the Learning objectives for the different roles.

- Needs analysis and design of curriculum

The Learning objectives are then analyzed and translated into learning tasks. Each learning task or activity is analyzed in terms of knowledge, skills and attitudes that are required to perform that task. Teachers and domain experts do this jointly. These are then grouped in clusters to form the subjects to be covered by the curriculum.

In addition, the society, the teachers, and the industry expect certain knowledge and skills that are related to abilities such as *learning-to-learn, thinking, adaptability, problem solving, positive attitude etc.* These competencies would cover both cognitive and affective domains.

A precedence diagram for the subjects is drawn where the prerequisites for each subject are graphically illustrated. The number of levels in this diagram is determined by the duration of the course in terms of number of semesters etc. Using the precedence diagram and the time duration for each subject, the curriculum is organized.

- Design & development of instructional materials

The content outlines are developed by including additional topics that are required for the completion of the domain and for the logical development of the competencies identified. Evaluation strategy and scheme is developed for the subject. The topics are arranged/organized in a meaningful sequence.

The detailed instructional material – Training aids, Learner material, reference material, project guidelines, etc.- are then developed. Rigorous quality checks are conducted at every stage.

➤ Strategies for delivery of instruction

Careful consideration is given for the integral development of abilities like thinking, problem solving, learning-to-learn etc. by selecting appropriate instructional strategies (training methodology), instructional activities and instructional materials.

The area of IT is fast changing and nebulous. Hence considerable flexibility is provided in the instructional process by specially including creative activities with group interaction between the students and the trainer. The positive aspects of web based learning –acquiring information, organizing information and acting on the basis of insufficient information are some of the aspects, which are incorporated, in the instructional process.

➤ Assessment of learning

The learning is assessed through different modes – tests, assignments & projects. The assessment system is designed to evaluate the level of knowledge & skills as defined by the learning objectives.

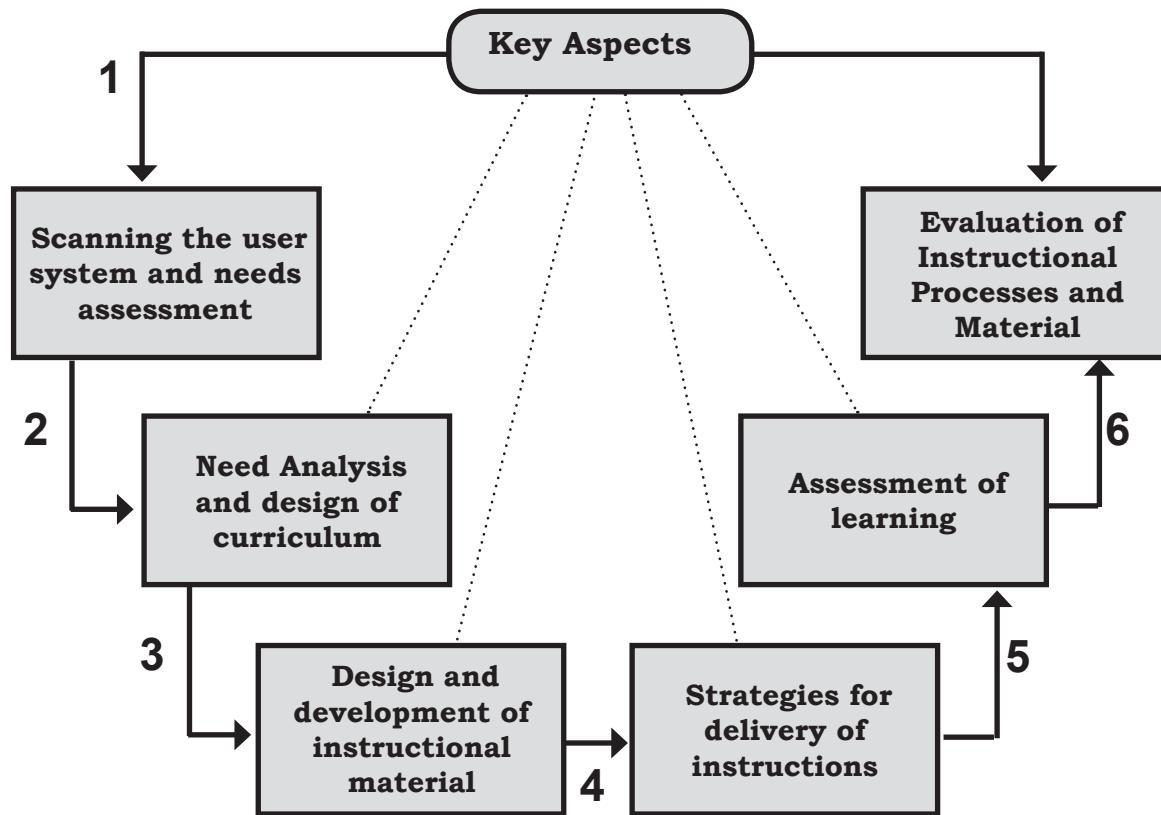
➤ Evaluation of instructional process and instructional materials

The instructional process is backed by an elaborate monitoring system to evaluate - on-time delivery, understanding of a subject module, ability of the instructor to impart learning. As an integral part of this process, we request you to kindly send us your feedback in the reply pre-paid form appended at the end of each module.

*TAG – Technology & Academics Group comprises of members from Aptech Ltd., professors from reputed Academic Institutions, Senior Managers from Industry, Technical gurus from Software Majors & representatives from regulatory organizations/forums.

Technology heads of Aptech Ltd. meet on a monthly basis to share and evaluate the technology trends. The group interfaces with the representatives of the TAG thrice a year to review and validate the technology and academic directions and endeavors of Aptech Ltd.

Aptech New Products Design Model



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**Access To
Learning**



Preface

SQL Server is a client-server based Relational Database Management System (RDBMS) from Microsoft. It provides an enterprise-level data management platform for an organization. SQL Server includes numerous features and tools that make it an outstanding database and data analysis platform. It is also targeted for large-scale Online Transaction Processing (OLTP), data warehousing, and e-commerce applications. One of the key features of SQL Server is that it is now available on the cloud too.

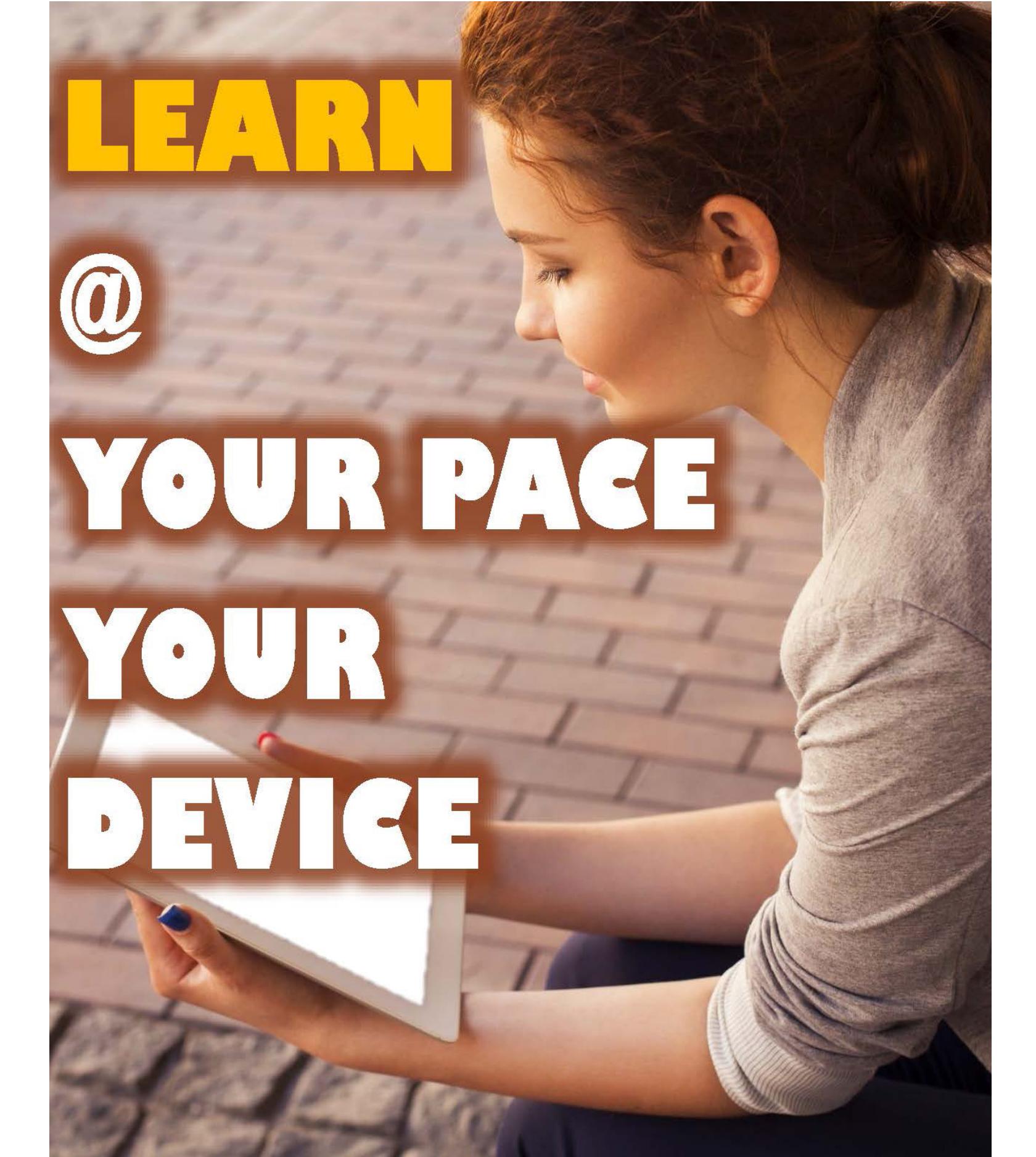
The book begins with an introduction to RDBMS concepts and moves on to introduce SQL Azure briefly. The book then covers various SQL Server 2012 topics such as data types, usage of Transact-SQL, and database objects such as indexes, stored procedures, functions, and so on. The book describes transactions, programming elements with Transact-SQL, and finally troubleshooting errors with error handling techniques.

The book also introduces SQL Server 2016 and explores its new features and enhancements. These include features such as PolyBase, Query Store, Stretch Database, and In-Memory enhancements. Besides these, you will also learn about the improved Performance Tools and Transact-SQL enhancements.

This book is the result of a concentrated effort of the Design Team, which is continuously striving to bring you the best and the latest in Information Technology. The process of design has been a part of the ISO 9001 certification for Aptech-IT Division, Education Support Services. As part of Aptech's quality drive, this team does intensive research and curriculum enrichment to keep it in line with industry trends.

We will be glad to receive your suggestions.

Design Team



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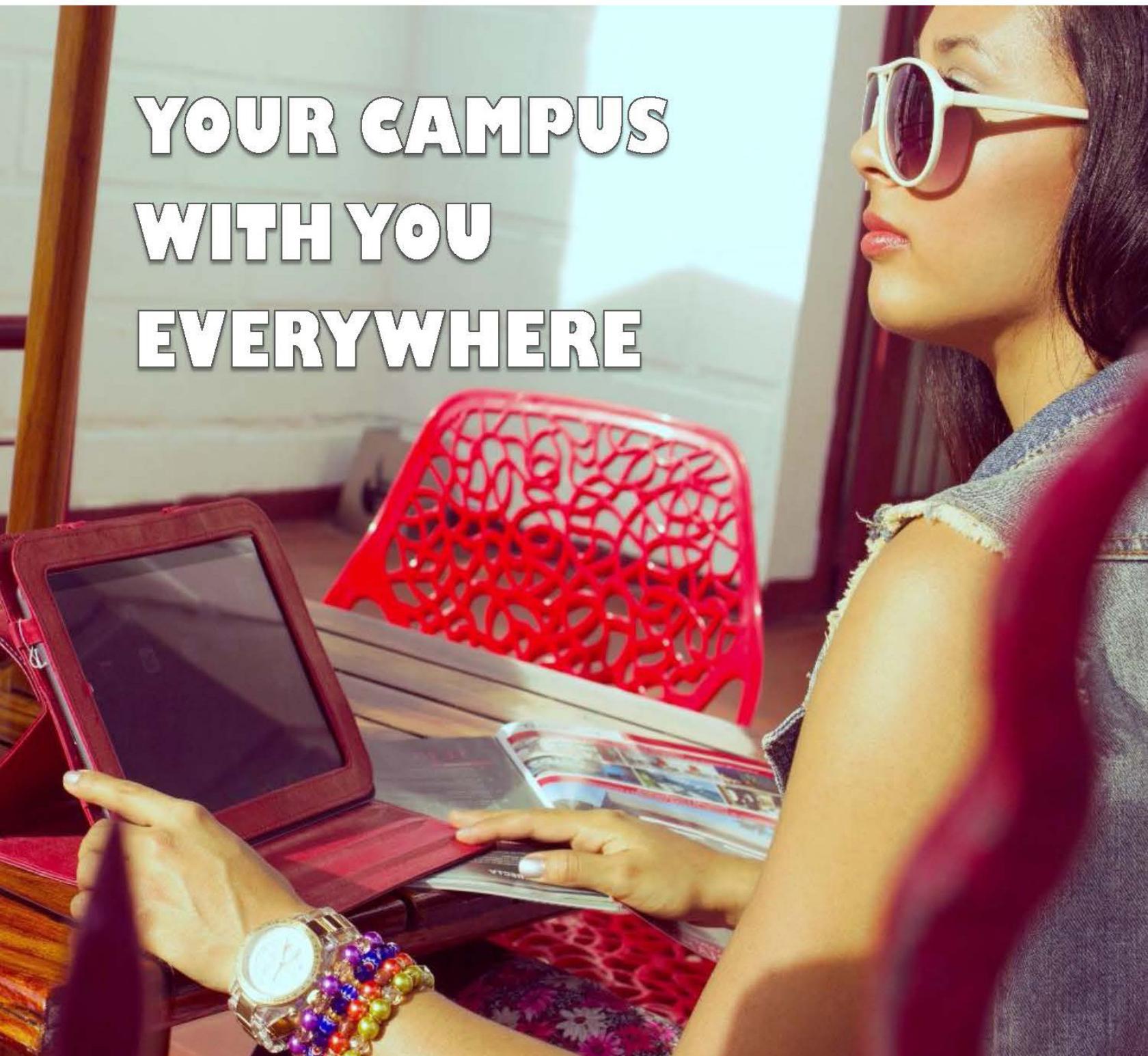
Table of Contents

Module

1. RDBMS Concepts
2. Entity-Relationship (E-R) Model and Normalization
3. Introduction to SQL Server 2012
4. SQL Azure
5. Transact-SQL
6. Creating and Managing Databases
7. Creating Tables
8. Accessing Data
9. Advanced Queries and Joins
10. Using Views, Stored Procedures, and Querying Metadata
11. Indexes
12. Triggers
13. Programming Transact-SQL
14. Transactions
15. Error Handling
16. Introduction to SQL Server 2016
17. New Features of SQL Server 2016
18. Enhancements in SQL Server 2016
19. Security Upgrades and Working with JSON
20. PolyBase, Query Store, and Stretch Database
21. Improved Performance Tools and Transact-SQL Enhancements

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Session - 1

RDBMS Concepts

Welcome to the Session, **RDBMS Concepts**.

This session deals with the concepts related to databases and database management systems, explores various database models, and introduces the concept of an RDBMS.

In this Session, you will learn to:

- Explain the concept of data and database
- Describe the approaches to data management
- Define a Database Management System (DBMS) and list its benefits
- Explain the different database models
- Define and explain RDBMS
- Describe entities and tables and list the characteristics of tables
- List the differences between a DBMS and an RDBMS

1.1 Introduction

Organizations often maintain large amounts of data, which are generated as a result of day-to-day operations. A database is an organized form of such data. It may consist of one or more related data items called records. Think of a database as a data collection to which different questions can be asked. For example, 'What are the phone numbers and addresses of the five nearest post offices?' or 'Do we have any books in our library that deal with health food? If so, on which shelves are they located?' or 'Show me the personnel records and sales figures of five best-performing sales people for the current quarter, but their address details need not be shown'.

1.2 Data and Database

Data means information and it is the most important component in any work that is done. In the day-to-day activity, either existing data is used or more data is generated. When this data is gathered and analyzed, it yields information. It can be any information such as information about the vehicle, sports, airways, and so on. For example, a sport magazine journalist (who is a soccer enthusiast) gathers the score (data) of Germany's performance in 10 world cup matches. These scores constitute data. When this data is compared with the data of 10 world cup matches played by Brazil, the journalist can obtain information as to which country has a team that plays better soccer.

Learning how to learn is life's most important skill.

Information helps to foresee and plan events. Intelligent interpretation of data yields information. In the world of business, to be able to predict an event and plan for it could save time and money. Consider an example, where a car manufacturing company is planning its annual purchase of certain parts of the car, which has to be imported since it is not locally available. If data of the purchase of these parts for the last five years is available, the company heads can actually compile information about the total amount of parts imported. Based on these findings, a production plan can be prepared. Therefore, information is a key-planning factor.

A database is a collection of data. Some like to think of a database as an organized mechanism that has the capability of storing information. This information can be retrieved by the user in an effective and efficient manner.

A phone book is a database. The data contained consists of individuals' names, addresses, and telephone numbers. These listings are in alphabetical order or indexed. This allows the user to reference a particular local resident with ease. Ultimately, this data is stored in a database somewhere on a computer. As people move to different cities or states, entries may have to be added or removed from the phone book. Likewise, entries will have to be modified for people changing names, addresses, or telephone numbers, and so on.

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Figure 1.1 illustrates the concept of a database.

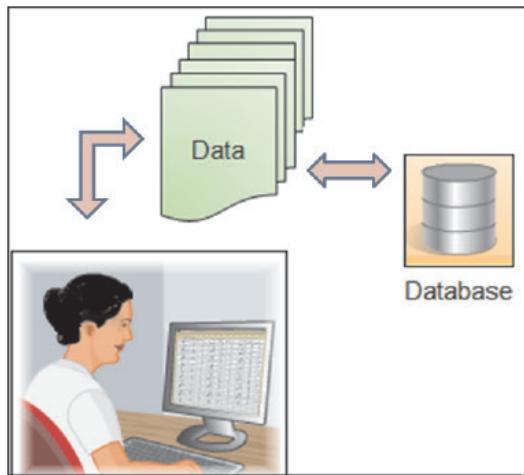


Figure 1.1: Database

Thus, a database is a collection of data that is organized such that its contents can be easily accessed, managed, and updated.

1.3 Data Management

Data management deals with managing large amount of information, which involves both the storage of information and the provision of mechanisms for the manipulation of information. In addition, the system should also provide the safety of the information stored under various circumstances, such as multiple user access and so on. The two different approaches of managing data are file-based systems and database systems.



1.3.1 File-based Systems

Storage of large amounts of data has always been a matter of huge concern. In early days, file-based systems were used. In this system, data was stored in discrete files and a collection of such files was stored on a computer. These could be accessed by a computer operator. Files of archived data were called tables because they looked like tables used in traditional file keeping. Rows in the table were called records and columns were called fields.

Conventionally, before the database systems evolved, data in software systems was stored in flat files.

An example of the file-based system is illustrated in table 1.1.

First Name	Last Name	Address	Phone
Eric	David	ericd@eff.org	213-456-0987
Selena	Sol	selena@eff.org	987-765-4321
Jordan	Lim	nadroj@otherdomain.com	222-3456-123

Table 1.1: File-based System

→ Disadvantages of File-based Systems

In a file-based system, different programs in the same application may be interacting with different private data files. There is no system enforcing any standardized control on the organization and structure of these data files.

- **Data redundancy and inconsistency**

Since data resides in different private data files, there are chances of redundancy and resulting inconsistency. For example, a customer can have a savings account as well as a mortgage loan. Here, the customer details may be duplicated since the programs for the two functions store their corresponding data in two different data files. This gives rise to redundancy in the customer's data. Since the same data is stored in two files, inconsistency arises if a change made in the data of one file is not reflected in the other.

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- **Unanticipated queries**

In a file-based system, handling sudden/ad-hoc queries can be difficult, since it requires changes in the existing programs. For example, the bank officer needs to generate a list of all the customers who have an account balance of \$20,000 or more. The bank officer has two choices: either obtain the list of all customers and have the needed information extracted manually, or hire a system programmer to design the necessary application program. Both alternatives are obviously unsatisfactory. Suppose that such a program is written, and several days later, the officer needs to trim that list to include only those customers who have opened their account one year ago. As the program to generate such a list does not exist, it leads to a difficulty in accessing the data.

- **Data isolation**

Data are scattered in various files, and files may be in a different format. Though data used by different programs in the application may be related, they reside as isolated data files.

- **Concurrent access anomalies**

In large multi-user systems, the same file or record may need to be accessed by multiple users simultaneously. Handling this in a file-based system is difficult.

- **Security problems**

In data-intensive applications, security of data is a major concern. Users should be given access only to required data and not to the whole database.

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

For example, in a banking system, payroll personnel need to view only that part of the database that has information about the various bank employees. They do not need access to information about customer accounts. Since application programs are added to the system in an ad-hoc manner, it is difficult to enforce such security constraints. In a file-based system, this can be handled only by additional programming in each application.

- **Integrity problems**

In any application, there will be certain data integrity rules, which need to be maintained. These could be in the form of certain conditions/constraints on the elements of the data records. In the savings bank application, one such integrity rule could be 'Customer ID, which is the unique identifier for a customer record, should not be empty'. There can be several such integrity rules. In a file-based system, all these rules need to be explicitly programmed in the application program.

Though all these are common issues of concern to any data-intensive application, each application had to handle all these problems on its own. The application programmer needs to bother not only about implementing the application business rules but also, about handling these common issues.

1.3.2 Database Systems

Database Systems evolved in the late 1960s to address common issues in applications handling large volumes of data, which are also data intensive. Some of these issues could be traced back to the disadvantages of File-based systems.

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Databases are used to store data in an efficient and organized manner. A database allows quick and easy management of data. For example, a company may maintain details of its employees in various databases. At any point of time, data can be retrieved from the database, new data can be added into the databases and data can be searched based on some criteria in these databases.

Data storage can be achieved even using simple manual files. For instance, a college has to maintain information about teachers, students, subjects, and examinations.

Details of the teachers can be maintained in a Staff Register and details of the students could be entered in a Student Register and so forth. However, data stored in this form is not permanent. Records in such manual files can only be maintained for a few months or few years. The registers or files are bulky, consume a lot of space, and hence, cannot be kept for many years.

Instead of this, if the same data was stored using database system, it could be more permanent and long-lasting.

→ Advantages of database systems

Information or data can be permanently stored in the form of computerized databases. A database system is advantageous because it provides a centralized control over the data.

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Some of the benefits of using such a centralized database system are as follows:

- **The amount of redundancy in the stored data can be reduced**

In an organization, several departments often store the same data. Maintaining a centralized database helps the same data to be accessed by many departments. Thus, duplication of data or 'data redundancy' can be reduced.

- **No more inconsistencies in data**

When data is duplicated across several departments, any modifications to the data have to be reflected across all departments. Sometimes, this can lead to inconsistency in the data. As there is a central database, it is possible for one person to take up the task of updating the data on a regular basis. Consider that Mr. Larry Finner, an employee of an organization is promoted as a Senior Manager from Manager. In such a case, there is just one record in the database that needs to be changed. As a result, data inconsistency is reduced.

- **The stored data can be shared**

A central database can be located on a server, which can be shared by several users. In this way all users can access the common and updated information all the time.

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- **Standards can be set and followed**

A central control ensures that a certain standard in the representation of data can be set and followed. For example, the name of an employee has to be represented as 'Mr. Larry Finner'. This representation can be broken down into the following components:

- ◆ A title (Mr.)
- ◆ First name (Larry)
- ◆ Last name (Finner)

It is certain that all the names stored in the database will follow the same format if the standards are set in this manner.

- **Data Integrity can be maintained**

Data integrity refers to the accuracy of data in the database. For example, when an employee resigns and leaves the organization, consider that the Accounts department has updated its database and the HR department has not updated its records. The data in the company's records is hence, inaccurate.

Centralized control of the database helps in avoiding these errors. It is certain that if a record is deleted from one table, its linked record in the other table is also deleted.

To learn, you must want to be taught.

- **Security of data can be implemented**

In a central database system, the privilege of modifying the database is not given to everyone. This right is given only to one person who has full control over the database. This person is called as Database Administrator or DBA. The DBA can implement security by placing restrictions on the data. Based on the permissions granted to them, the users can add, modify, or query data.

1.4 Database Management System (DBMS)

A DBMS can be defined as a collection of related records and a set of programs that access and manipulate these records. A DBMS enables the user to enter, store, and manage data. The main problem with the earlier DBMS packages was that the data was stored in the flat file format. So, the information about different objects was maintained separately in different physical files. Hence, the relations between these objects, if any, had to be maintained in a separate physical file. Thus, a single package would consist of too many files and vast functionalities to integrate them into a single system.

A solution to these problems came in the form of a centralized database system. In a centralized database system, the database is stored in the central location. Everybody can have access to the data stored in a central location from their machine. For example, a large central database system would contain all the data pertaining to the employees. The Accounts and the HR department would access the data required using suitable programs. These programs or the entire application would reside on individual computer terminals.

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A Database is a collection of interrelated data, and a DBMS is a set of programs used to add or modify this data. Thus, a DBMS is a set of software programs that allow databases to be defined, constructed, and manipulated.

A DBMS provides an environment that is both convenient and efficient to use when there is a large volume of data and many transactions to be processed. Different categories of DBMS can be used, ranging from small systems that run on personal computers to huge systems that run on mainframes.

Examples of database applications include the following:

- Computerized library systems
- Automated teller machines
- Flight reservation systems
- Computerized parts inventory systems

From a technical standpoint, DBMS products can differ widely. Different DBMS support different query languages, although there is a semi-standardized query language called Structured Query Language (SQL). Sophisticated languages for managing database systems are called Fourth Generation Language (4GLs).

The information from a database can be presented in a variety of formats. Most DBMS include a report writer program that enables the user to output data in the form of a report. Many DBMSs also include a graphics component that enables the user to output information in the form of graphs and charts.



Session**RDBMS Concepts**

It is not necessary to use general-purpose DBMS for implementing a computerized database. The users can write their own set of programs to create and maintain the database, in effect creating their own special-purpose DBMS software. The database and the software together are called a database system. The end user accesses the database system through application programs and queries. The DBMS software enables the user to process the queries and programs placed by the end user. The software accesses the data from the database.

Figure 1.2 illustrates a database system.

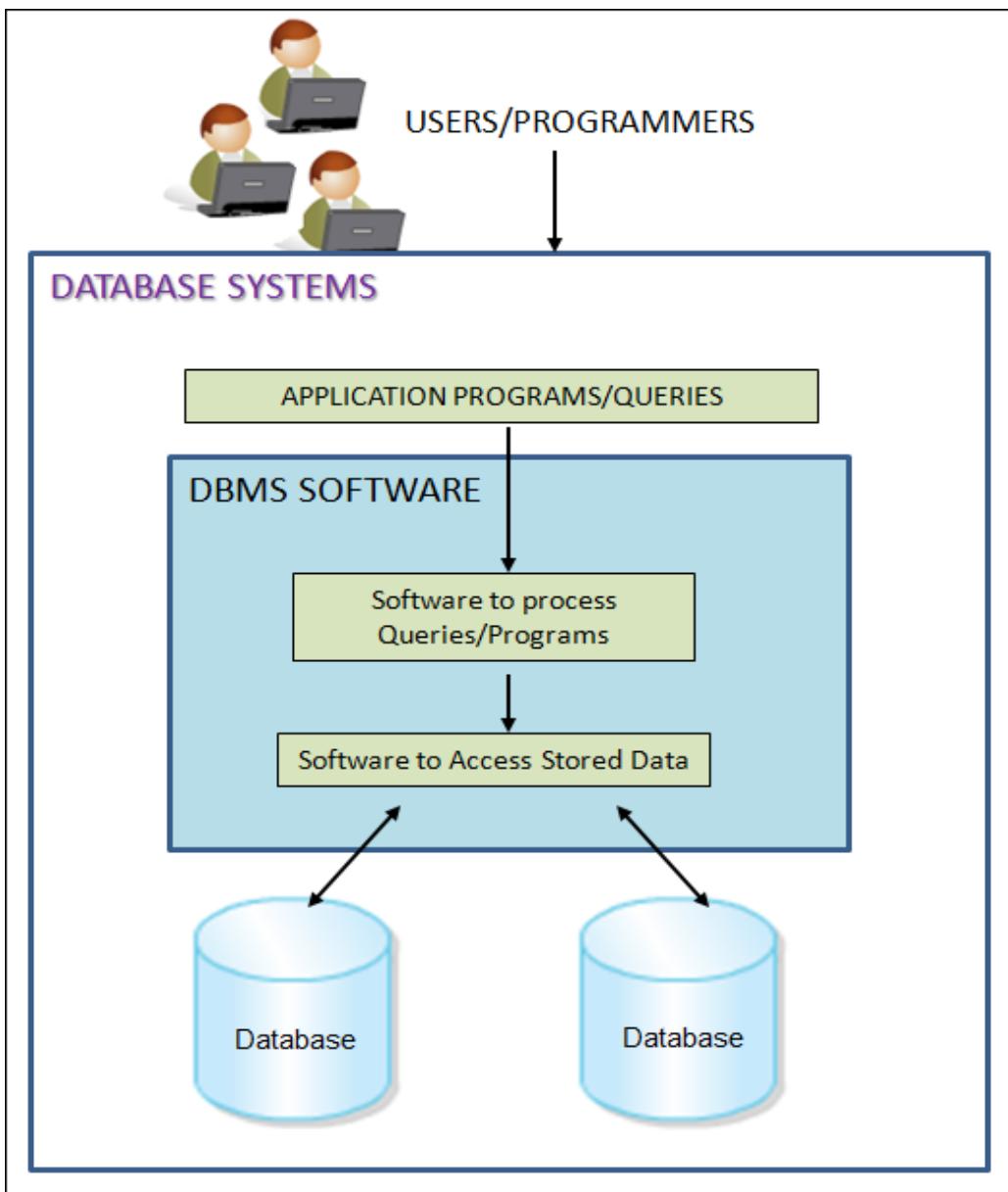


Figure 1.2: A Simplified Database System Environment

1.4.1 Benefits of DBMS

A DBMS is responsible for processing data and converting it into information. For this purpose, the database has to be manipulated, which includes querying the database to retrieve specific data, updating the database, and finally, generating reports.

These reports are the source of information, which is, processed data. A DBMS is also responsible for data security and integrity.

The benefits of a typical DBMS are as follows:

→ **Data storage**

The programs required for physically storing data, handled by a DBMS, is done by creating complex data structures, and the process is called data storage management.

→ **Data definition**

A DBMS provides functions to define the structure of the data in the application. These include defining and modifying the record structure, the type and size of fields, and various constraints/conditions to be satisfied by the data in each field.

→ **Data manipulation**

Once the data structure is defined, data needs to be inserted, modified, or deleted. The functions, which perform these operations, are also part of a DBMS. These functions can handle planned and unplanned data manipulation needs. Planned queries are those, which form part of the application. Unplanned queries are ad-hoc queries, which are performed on a need basis.

Democritus said, words are but the shadows of actions.

→ Data security and integrity

Data security is of utmost importance when there are multiple users accessing the database. It is required for keeping a check over data access by users. The security rules specify, which user has access to the database, what data elements the user has access to, and the data operations that the user can perform.

Data in the database should contain as few errors as possible. For example, the employee number for adding a new employee should not be left blank. Telephone number should contain only numbers. Such checks are taken care of by a DBMS.

Thus, the DBMS contains functions, which handle the security and integrity of data in the application. These can be easily invoked by the application and hence, the application programmer need not code these functions in the programs.

→ Data recovery and concurrency

Recovery of data after a system failure and concurrent access of records by multiple users are also handled by a DBMS.

→ Performance

Optimizing the performance of the queries is one of the important functions of a DBMS. Hence, the DBMS has a set of programs forming the Query Optimizer, which evaluates the different implementations of a query and chooses the best among them.

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→ **Multi-user access control**

At any point of time, more than one user can access the same data. A DBMS takes care of the sharing of data among multiple users, and maintains data integrity.

→ **Database access languages and Application Programming Interfaces (APIs)**

The query language of a DBMS implements data access. SQL is the most commonly used query language. A query language is a non-procedural language, where the user needs to request what is required and need not specify how it is to be done. Some procedural languages such as C, Visual Basic, Pascal, and others provide data access to programmers.

1.5 Database Models

Databases can be differentiated based on functions and model of the data. A data model describes a container for storing data, and the process of storing and retrieving data from that container. The analysis and design of data models has been the basis of the evolution of databases. Each model has evolved from the previous one.

Database Models are briefly discussed in the following sections.



1.5.1 Flat File Data Model

In this model, the database consists of only one table or file. This model is used for simple databases - for example, to store the roll numbers, names, subjects, and marks of a group of students. This model cannot handle very complex data. It can cause redundancy when data is repeated more than once. Table 1.2 depicts the structure of a flat file database.

Roll Number	FirstName	LastName	Subject	Marks
45	Jones	Bill	Maths	84
45	Jones	Bill	Science	75
50	Mary	Mathew	Science	80

Table 1.2: Structure of Flat File Data Model

1.5.2 Hierarchical Data Model

In the Hierarchical Model, different records are inter-related through hierarchical or tree-like structures. In this model, relationships are thought of in terms of children and parents. A parent record can have several children, but a child can have only one parent. To find data stored in this model, the user needs to know the structure of the tree.

The Windows Registry is an example of a hierarchical database storing configuration settings and options on Microsoft Windows operating systems.

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Figure 1.3 illustrates an example of a hierarchical representation.

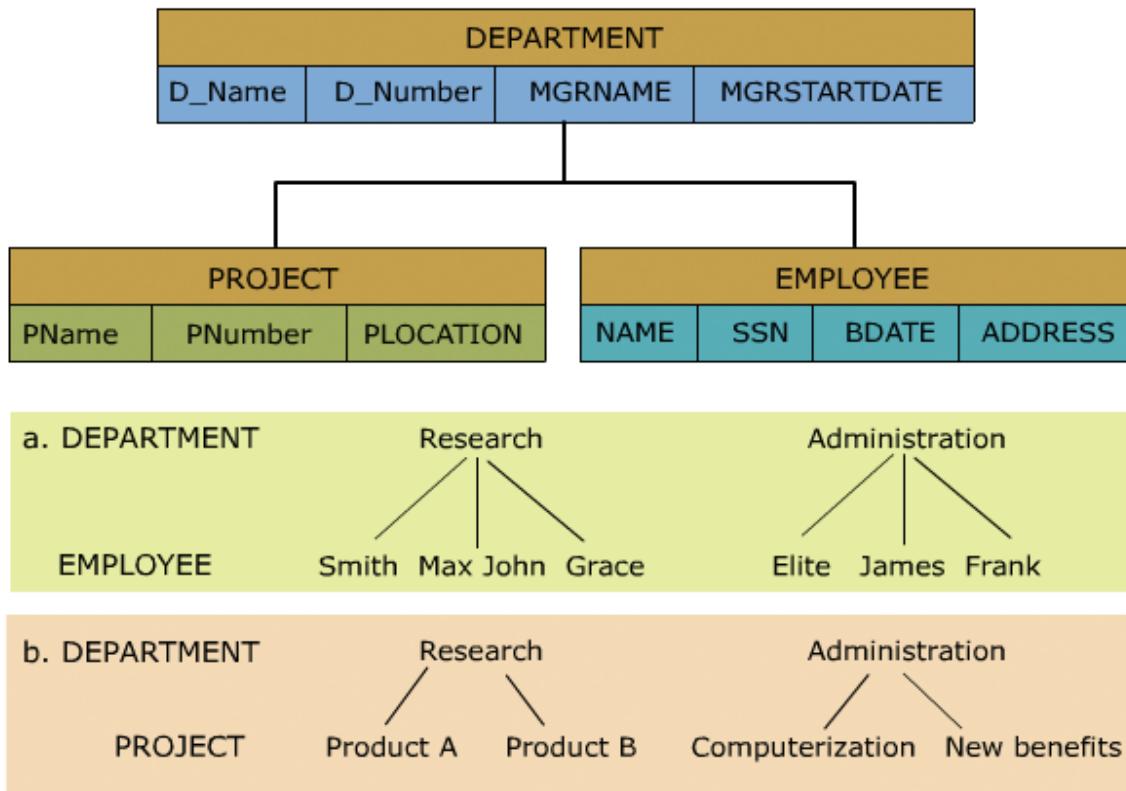


Figure 1.3: Example of a Hierarchical Model

Nothing is a waste of time if you use the experience wisely.

Within the hierarchical model, Department is perceived as the parent of the segment. The tables, Project and Employee, are children. A path that traces the parent segments beginning from the left, defines the tree. This ordered sequencing of segments tracing the hierarchical structure is called the hierarchical path.

It is clear from the figure that in a single department, there can be many employees and a department can have many projects.

→ Advantages of the hierarchical model

The advantages of a hierarchical model are as follows:

- Data is held in a common database so data sharing becomes easier, and security is provided and enforced by a DBMS.
- Data independence is provided by a DBMS, which reduces the effort and costs in maintaining the program.

This model is very efficient when a database contains a large volume of data. For example, a bank's customer account system fits the hierarchical model well because each customer's account is subject to a number of transactions.

1.5.3 Network Data Model

This model is similar to the Hierarchical Data Model. The hierarchical model is actually a subset of the network model. However, instead of using a single-parent tree hierarchy, the network model uses set theory to provide a tree-like hierarchy with the exception that child tables were allowed to have more than one parent.

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In the network model, data is stored in sets, instead of the hierarchical tree format. This solves the problem of data redundancy. The set theory of the network model does not use a single-parent tree hierarchy. It allows a child to have more than one parent. Thus, the records are physically linked through linked-lists. Integrated Database Management System (IDMS) from Computer Associates International Inc. and Raima Database Manager (RDM) Server by Raima Inc. are examples of a Network DBMS.

The network model together with the hierarchical data model was a major data model for implementing numerous commercial DBMS. The network model structures and language constructs were defined by Conference on Data Systems Language (CODASYL).

For every database, a definition of the database name, record type for each record, and the components that make up those records is stored. This is called its network schema. A portion of the database as seen by the application's programs that actually produce the desired information from the data contained in the database is called sub-schema. It allows application programs to access the required data from the database.

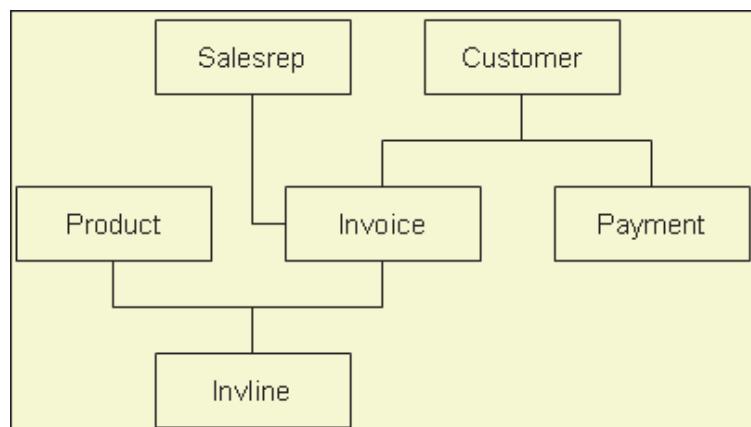


Figure 1.4: Network Model



The network model shown in figure 1.4 illustrates a series of one-to-many relationships, as follows:

1. A sales representative might have written many Invoice tickets, but each Invoice is written by a single Sales representative (Salesrep).
2. A Customer might have made purchases on different occasions. A Customer may have many Invoice tickets, but each Invoice belongs only to a single customer.
3. An Invoice ticket may have many Invoice lines (Invline), but each Invline is found on a single Invoice ticket.
4. A Product may appear in several different Invline, but each Invline contains only a single Product.

The components of the language used with network models are as follows:

1. A Data Definition Language (DDL) that is used to create and remove databases and database objects. It enables the database administrator to define the schema components.
2. A sub-schema DDL that enables the database administrator to define the database components.
3. A Data Manipulation Language (DML), which is used to insert, retrieve, and modify database information. All database users use these commands during the routine operation of the database.
4. Data Control Language (DCL) is used to administer permissions on the databases and database objects.

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→ Advantages of the network model

The advantages of such a structure are specified as follows:

- The relationships are easier to implement in the network database model than in the hierarchical model.
- This model enforces database integrity.
- This model achieves sufficient data independence.

→ Disadvantages of the network model

The disadvantages are specified as follows:

- The databases in this model are difficult to design.
- The programmer has to be very familiar with the internal structures to access the database.
- The model provides a navigational data access environment. Hence, to move from A to E in the sequence A-B-C-D-E, the user has to move through B, C, and D to get to E.

This model is difficult to implement and maintain. Computer programmers, rather than end users, utilize this model.

Learning how to learn is life's most important skill.

1.5.4 Relational Data Model

As the information needs grew and more sophisticated databases and applications were required, database design, management, and use became too cumbersome. The lack of query facility took a lot of time of the programmers to produce even the simplest reports. This led to the development of what came to be called the Relational Model database.

The term 'Relation' is derived from the set theory of mathematics. In the Relational Model, unlike the Hierarchical and Network models, there are no physical links. All data is maintained in the form of tables consisting of rows and columns. Data in two tables is related through common columns and not physical links. Operators are provided for operating on rows in tables.

The popular relational DBMSs are Oracle, Sybase, DB2, Microsoft SQL Server, and so on.

This model represents the database as a collection of relations. In this model's terminology, a row is called a tuple, a column, an attribute, and the table is called a relation. The list of values applicable to a particular field is called domain. It is possible for several attributes to have the same domain. The number of attributes of a relation is called degree of the relation. The number of tuples determines the cardinality of the relation.

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In order to understand the relational model, consider tables 1.3 and 1.4.

Roll Number	Student Name
1	Sam Reiner
2	John Parkinson
3	Jenny Smith
4	Lisa Hayes
5	Penny Walker
6	Peter Jordan
7	Joe Wong

Table 1.3: Students Table

Roll Number	Marks Obtained
1	34
2	87
3	45
4	90
5	36
6	65
7	89

Table 1.4: Marks Table



The **Students** table displays the **Roll Number** and the **Student Name**, and the **Marks** table displays the **Roll Number** and **Marks** obtained by the students. Now, two steps need to be carried out for students who have scored above 50. First, locate the roll numbers of those who have scored above 50 from the **Marks** table. Second, their names have to be located in the **Students** table by matching the roll number. The result will be as shown in table 1.5.

Roll Number	Student Name	Marks Obtained
2	John	87
4	Lisa	90
6	Peter	65
7	Joe	89

Table 1.5: Displaying Student Names and Marks

It was possible to get this information because of two facts: First, there is a column common to both the tables - **Roll Number**. Second, based on this column, the records from the two different tables could be matched and the required information could be obtained.

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In a relational model, data is stored in tables. A table in a database has a unique name that identifies its contents. Each table can be defined as an intersection of rows and columns.

→ **Advantages of the relational model**

The relational database model gives the programmer time to concentrate on the logical view of the database rather than being bothered about the physical view. One of the reasons for the popularity of the relational databases is the querying flexibility. Most of the relational databases use Structured Query Language (SQL). An RDBMS uses SQL to translate the user query into the technical code required to retrieve the requested data. Relational model is so easy to handle that even untrained people find it easy to generate handy reports and queries, without giving much thought to the need to design a proper database.

→ **Disadvantages of the relational model**

Though the model hides all the complexities of the system, it tends to be slower than the other database systems.

As compared to all other models, the relational data model is the most popular and widely used.

1.6 Relational Database Management System (RDBMS)

The Relational Model is an attempt to simplify database structures. It represents all data in the database as simple row-column tables of data values. An RDBMS is a software program that helps to create, maintain, and manipulate a relational database. A relational database is a database divided into logical units called tables, where tables are related to one another within the database.

Who dares to teach must never cease to learn.

Tables are related in a relational database, allowing adequate data to be retrieved in a single query (although the desired data may exist in more than one table). By having common keys, or fields, among relational database tables, data from multiple tables can be joined to form one large resultset.

Figure 1.5 shows two tables related to one another through a common key (data value) in a relational database.

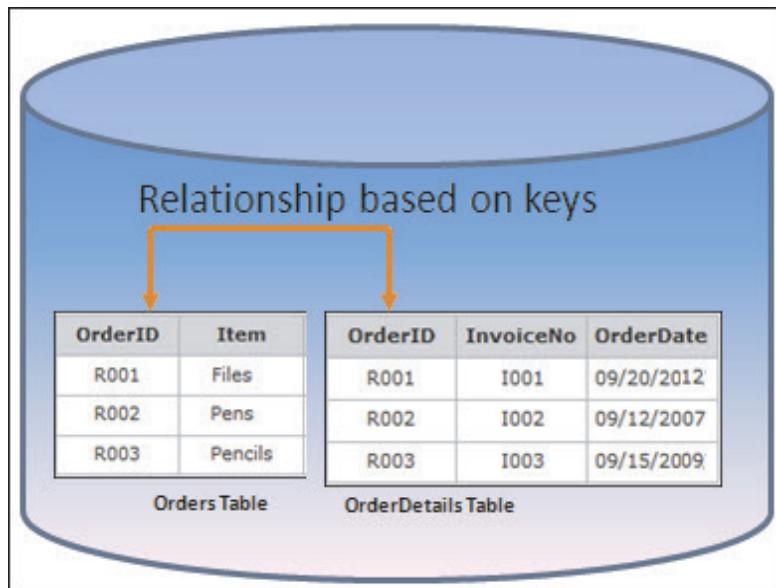


Figure 1.5: Relationship Between Tables

Thus, a relational database is a database structured on the relational model. The basic characteristic of a relational model is that in a relational model, data is stored in relations. To understand relations, consider the following example.

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The **Capitals** table shown in table 1.6 displays a list of countries and their capitals, and the **Currency** table shown in table 1.7 displays the countries and the local currencies used by them.

Country	Capital
Greece	Athens
Italy	Rome
USA	Washington
China	Beijing
Japan	Tokyo
Australia	Sydney
France	Paris

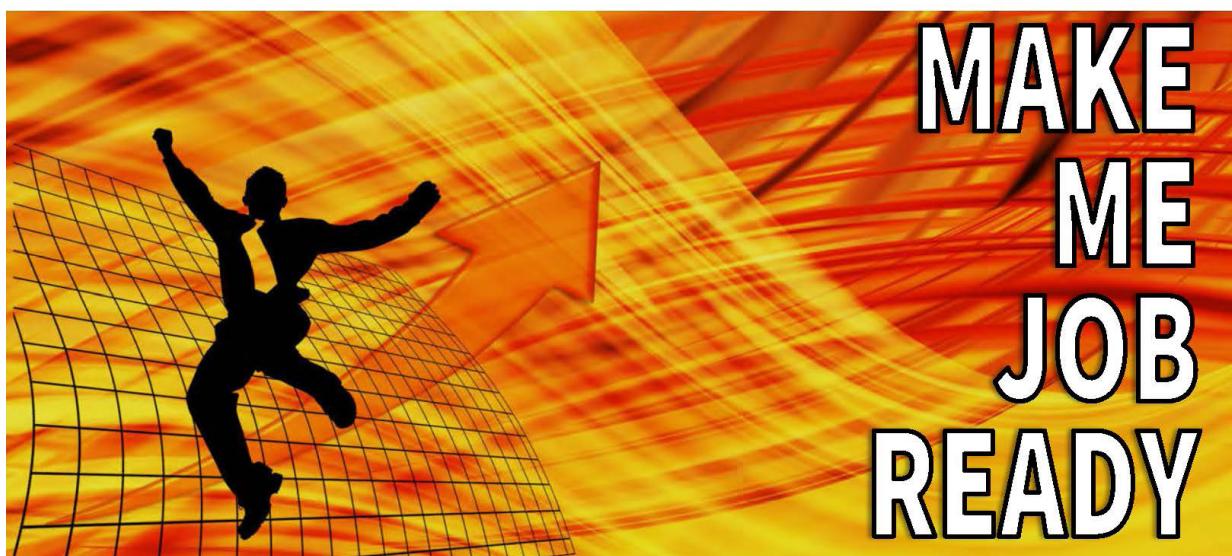
Table 1.6: Capitals

Country	Currency
Greece	Drachma
Italy	Lira
USA	Dollar
China	Renminbi (Yuan)
Japan	Yen
Australia	Australian Dollar
France	Francs

Table 1.7: Currency



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Both the tables have a common column, that is, the **Country** column. Now, if the user wants to display the information about the currency used in Rome, first find the name of the country to which Rome belongs. This information can be retrieved from table 1.6. Next, that country should be looked up in table 1.7 to find out the currency.

It is possible to get this information because it is possible to establish a relation between the two tables through a common column called **Country**.

1.6.1 Terms related to RDBMS

There are certain terms that are mostly used in an RDBMS. These are described as follows:

- Data is presented as a collection of relations.
- Each relation is depicted as a table.
- Columns are attributes.
- Rows ('tuples') represent entities.
- Every table has a set of attributes that are taken together as a 'key' (technically, a 'superkey'), which uniquely identifies each entity.

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For example, a company might have an **Employee** table with a row for each employee. What attributes might be interesting for such a table? This will depend on the application and the type of use the data will be put to, and is determined at database design time.

Consider the scenario of a company maintaining customer and order information for products being sold and customer-order details for a specific month, such as, August.

The tables 1.8, 1.9, 1.10, and 1.11 are used to illustrate this scenario. These tables depict tuples and attributes in the form of rows and columns. Various terms related to these tables are given in table 1.12.

Cust_No	Cust_Name	Phone No
002	David Gordon	0231-5466356
003	Prince Fernandes	0221-5762382
003	Charles Yale	0321-8734723
002	Ryan Ford	0241-2343444
005	Bruce Smith	0241-8472198

Table 1.8: Customer

Item_No	Description	Price
HW1	Power Supply	4000
HW2	Keyboard	2000
HW3	Mouse	800
SW1	Office Suite	15000
SW2	Payroll Software	8000

Table 1.9: Items

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

Ord_No	Item_No	Qty
101	HW3	50
101	SW1	150
102	HW2	10
103	HW3	50
104	HW2	25
104	HW3	100
105	SW1	100

Table 1.10 Order_Details

Ord_No	Ord_Date	Cust_No
101	02-08-12	002
102	11-08-12	003
103	21-08-12	003
104	28-08-12	002
105	30-08-12	005

Table 1.11 Order_August

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Term	Meaning	Example from the Scenario
Relation	A table	Order_August, Order_Details, Customer and Items
Tuple	A row or a record in a relation	A row from Customer relation is a Customer tuple
Attribute	A field or a column in a relation	Ord_Date, Item_No, Cust_Name, and so on
Cardinality of a relation	The number of tuples in a relation	Cardinality of Order_Details relation is 7
Degree of a relation	The number of attributes in a relation	Degree of Customer relation is 3
Domain of an attribute	The set of all values that can be taken by the attribute	Domain of Qty in Order_Details is the set of all values which can represent quantity of an ordered item
Primary Key of a relation	An attribute or a combination of attributes that uniquely defines each tuple in a relation	Primary Key of Customer relation is Cust_No Ord_No and Item_No combination forms the primary key of Order_Details
Foreign Key	An attribute or a combination of attributes in one relation R1 that indicates the relationship of R1 with another relation R2 The foreign key attributes in R1 must contain values matching with those of the values in R2	Cust_No in Order_August relation is a foreign key creating reference from Order_August to Customer. This is required to indicate the relationship between orders in Order_August and Customer

Table 1.12: Terms Related to Tables

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1.6.2 RDBMS Users

The primary goal of a database system is to provide an environment for retrieving information from and storing new information into the database.

For a small personal database, one person typically defines the constructs and manipulates the database. However, many persons are involved in the design, use, and maintenance of a large database with a few hundred users.

→ Database Administrator (DBA)

The DBA is a person who collects the information that will be stored in the database. A database is designed to provide the right information at the right time to the right people.

Administering these resources is the responsibility of the Database Administrator. DBA is responsible for authorizing access to the database, for coordinating and monitoring its use and for acquiring software and hardware resources as needed. DBA is accountable for problems such as breach of security or poor system response time.

→ Database Designer

Database Designers are responsible for identifying the data to be stored in the database and for choosing appropriate structures to represent and store this data. It is the responsibility of database designers to communicate with all prospective database users, in order to understand their requirements, and to come up with a design that meets the requirements.

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→ **System Analysts and Application Programmers**

System Analysts determine the requirements of end users, and develop specifications for pre-determined transactions that meet these requirements. Application Programmers implement these specifications as programs; then, they test, debug, document, and maintain these pre-determined transactions.

In addition to those who design, use, and administer a database, others are associated with the design, development, and operation of the DBMS software and system environment.

→ **DBMS Designers and Implementers**

These people design and implement the DBMS modules and interfaces as a software package. A DBMS is a complex software system that consists of many components or modules, including modules for implementing the catalog, query language, interface processors, data access, and security. A DBMS must interface with other system software such as the operating system and compilers for various programming languages.

→ **End User**

The end user invokes an application to interact with the system, or writes a query for easy retrieval, modification, or deletion of data.

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

1.7 Entities and Tables

The components of an RDBMS are entities and tables, which will be explained in this section.

1.7.1 Entity

An entity is a person, place, thing, object, event, or even a concept, which can be distinctly identified. For example, the entities in a university are students, faculty members, and courses.

Each entity has certain characteristics known as attributes. For example, the student entity might include attributes such as student number, name, and grade. Each attribute should be named appropriately.

A grouping of related entities becomes an entity set. Each entity set is given a name. The name of the entity set reflects the contents. Thus, the attributes of all the students of the university will be stored in an entity set called **Student**.

1.7.2 Tables and their Characteristics

The access and manipulation of data is facilitated by the creation of data relationships based on a construct known as a table. A table contains a group of related entities that is an entity set. The terms entity set and table are often used interchangeably. A table is also called a relation. The rows are known as tuples. The columns are known as attributes.

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Figure 1.6 highlights the characteristics of a table.

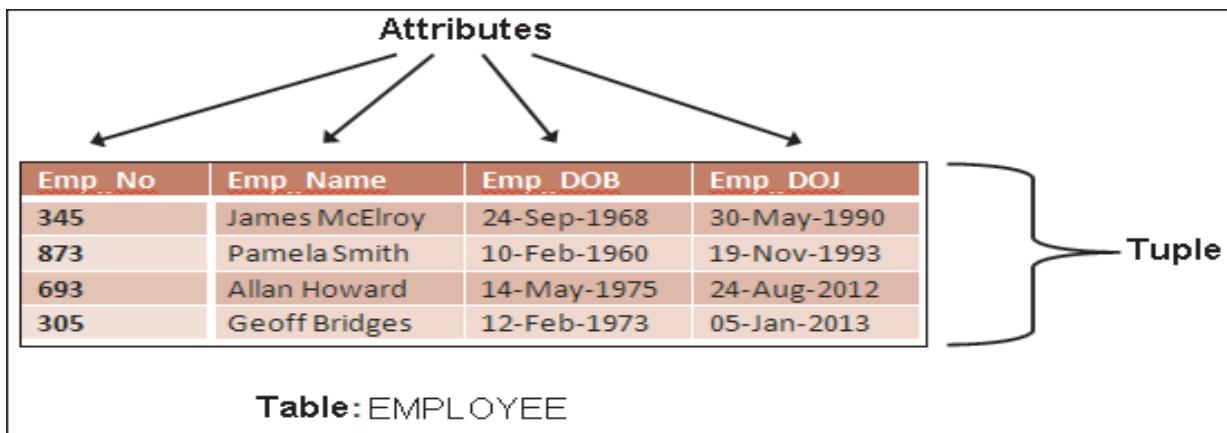


Figure 1.6: Characteristics of a Table



The characteristics of a table are as follows:

- A two-dimensional structure composed of rows and columns is perceived as a table.
- Each tuple represents a single entity within the entity set.
- Each column has a distinct name.
- Each row/column intersection represents a single data value.
- Each table must have a key known as primary key that uniquely identifies each row.
- All values in a column must conform to the same data format. For example, if the attribute is assigned a decimal data format, all values in the column representing that attribute must be in decimals.
- Each column has a specific range of values known as the attribute domain.
- Each row carries information describing one entity occurrence.
- The order of the rows and columns is immaterial in a DBMS.

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1.8 Differences between a DBMS and an RDBMS

The differences between a DBMS and an RDBMS are listed in table 1.13.

DBMS	RDBMS
It does not need to have data in tabular structure nor does it enforce tabular relationships between data items.	In an RDBMS, tabular structure is a must and table relationships are enforced by the system. These relationships enable the user to apply and manage business rules with minimal coding.
Small amount of data can be stored and retrieved.	An RDBMS can store and retrieve large amount of data.
A DBMS is less secure than an RDBMS.	An RDBMS is more secure than a DBMS.
It is a single user system.	It is a multi-user system.
Most DBMSs do not support client/server architecture.	It supports client/server architecture.

Table 1.13: Difference between DBMS and RDBMS

In an RDBMS, a relation is given more importance. Thus, the tables in an RDBMS are dependent and the user can establish various integrity constraints on these tables so that the ultimate data used by the user remains correct. In case of a DBMS, entities are given more importance and there is no relation established among these entities.

To avoid criticism, do nothing, say nothing, be nothing.

1.9 Check Your Progress

1. The _____ data model allows a child node to have more than one parent.

(A)	Flat File	(C)	Network
(B)	Hierarchical	(D)	Relational

2. _____ is used to administer permissions on the databases and database objects.

(A)	Data Definition Language (DDL)	(C)	Sub-schema
(B)	Data Manipulation Language (DML)	(D)	Data Control Language (DCL)

3. In the relational model terminology, a row is called a _____, a column an _____, and a table a _____.

(A)	attribute, tuple, relation	(C)	attribute, relation, tuple
(B)	tuple, attribute, relation	(D)	row, column, tuple

4. A _____ can be defined as a collection of related records and a set of programs that access and manipulate these records.

(A)	Database Management System	(C)	Data Management
(B)	Relational Database Management System	(D)	Network Model

5. A _____ describes a container for storing data and the process of storing and retrieving data from that container.

(A)	Network model	(C)	Data model
(B)	Flat File model	(D)	Relational model

1.9.1 Answers

1.	C
2.	D
3.	B
4.	B
5.	C



Summary

- A database is a collection of related data stored in the form of a table.
- A data model describes a container for storing data and the process of storing and retrieving data from that container.
- A DBMS is a collection of programs that enables the user to store, modify, and extract information from a database.
- A Relational Database Management System (RDBMS) is a suite of software programs for creating, maintaining, modifying, and manipulating a relational database.
- A relational database is divided into logical units called tables. These logical units are interrelated to each other within the database.
- The main components of an RDBMS are entities and tables.
- In an RDBMS, a relation is given more importance, whereas, in case of a DBMS, entities are given more importance and there is no relation established among these entities.

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Session - 2

Entity-Relationship (E-R) Model and Normalization

Welcome to the Session, **Entity-Relationship (E-R) Model and Normalization.**

This session talks about Data Modeling, the E-R model, its components, symbols, diagrams, relationships, Data Normalization, and Relational Operators.

In this Session, you will learn to:

- Define and describe data modeling
- Identify and describe the components of the E-R model
- Identify the relationships that can be formed between entities
- Explain E-R diagrams and their use
- Describe an E-R diagram, the symbols used for drawing, and show the various relationships
- Describe the various Normal Forms
- Outline the uses of different Relational Operators

2.1 Introduction

A data model is a group of conceptual tools that describes data, its relationships, and semantics. It also consists of the consistency constraints that the data adheres to. The Entity-Relationship, Relational, Network, and Hierarchical models are examples of data models. The development of every database begins with the basic step of analyzing its data in order to determine the data model that would best represent it. Once this step is completed, the data model is applied to the data.

2.2 Data Modeling

The process of applying an appropriate data model to the data, in order to organize and structure it, is called data modeling.

Data modeling is as essential to database development as are planning and designing to any project development. Building a database without a data model is similar to developing a project without its plans and design. Data models help database developers to define the relational tables, primary and foreign keys, stored procedures, and triggers required in the database.

Data modeling can be broken down into the following three broad steps:

→ **Conceptual Data Modeling**

The data modeler identifies the highest level of relationships in the data.



→ **Logical Data Modeling**

The data modeler describes the data and its relationships in detail. The data modeler creates a logical model of the database.

→ **Physical Data Modeling**

The data modeler specifies how the logical model is to be realized physically. Figure 2.1 exhibits various steps involved in data modeling.

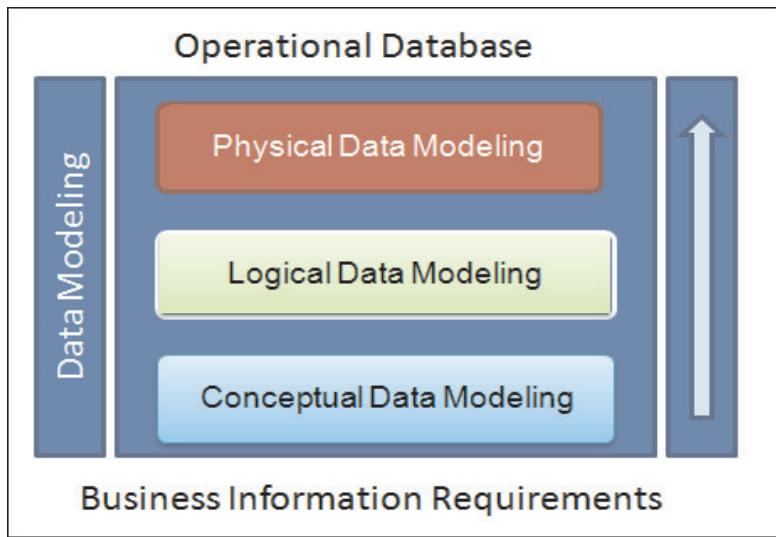


Figure 2.1: Data Modeling Steps

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2.3 Entity-Relationship (E-R) Model

Data models can be classified into three different groups:

- Object-based logical models
- Record-based logical models
- Physical models

The Entity-Relationship (E-R) model belongs to the first classification. The model is based on a simple idea. Data can be perceived as real-world objects called entities and the relationships that exist between them. For example, the data about employees working for an organization can be perceived as a collection of employees and a collection of various departments that form the organization. Both employee and department are real-world objects. An employee belongs to a department. Thus, the relation 'belongs to' links an employee to a particular department.

Learning is not compulsory, but neither is survival.

The employee-department relation can be modeled as shown in figure 2.2.

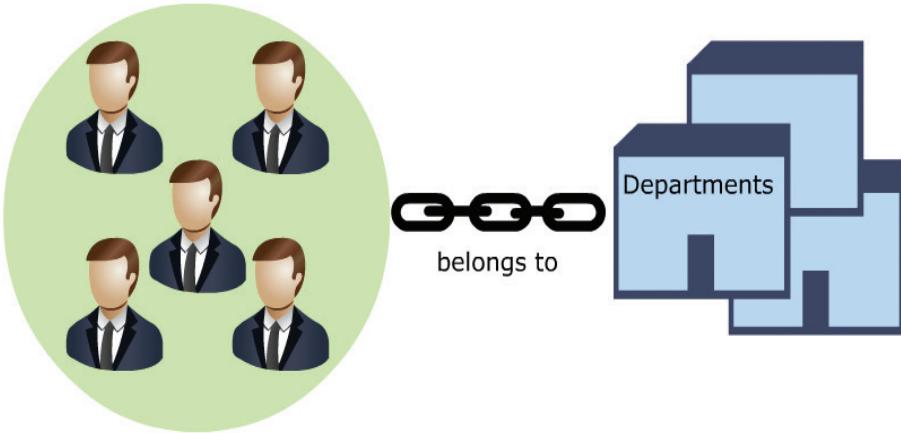


Figure 2.2: E-R Model Depiction of an Organization

An E-R model consists of five basic components. They are as follows:

→ **Entity**

An entity is a real-world object that exists physically and is distinguishable from other objects. For example, employee, department, student, customer, vehicle, and account are entities.

→ **Relationship**

A relationship is an association or bond that exists between one or more entities. For example, belongs to, owns, works for, saves in, purchased, and so on.

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→ **Attributes**

Attributes are features that an entity has. Attributes help distinguish every entity from another. For example, the attributes of a student would be `roll_number`, `name`, `stream`, `semester`, and so on.

The attributes of a car would be `registration_number`, `model`, `manufacturer`, `color`, `price`, `owner`, and so on.

→ **Entity Set**

An entity set is the collection of similar entities. For example, the employees of an organization collectively form an entity set called employee entity set.

→ **Relationship Set**

A collection of similar relationships between two or more entity sets is called a relationship set. For example, employees work in a particular department. The set of all 'work in' relations that exists between the employees and the department is called the 'work in' relationship set.



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 WORKING
 PROFESSIONAL**



The various E-R model components can be seen in figure 2.3.

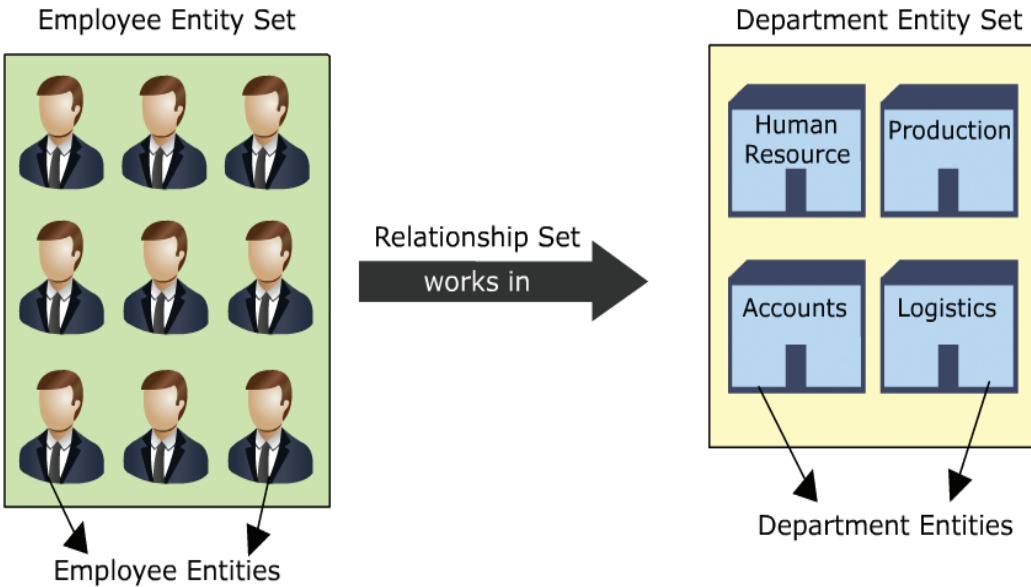


Figure 2.3: Components of the E-R Model

Relationships associate one or more entities and can be of three types. They are as follows:

→ **Self-relationships**

Relationships between entities of the same entity set are called self-relationships. For example, a manager and his team member, both belong to the employee entity set. The team member works for the manager. Thus, the relation, 'works for', exists between two different employee entities of the same employee entity set.

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Entity-Relationship (E-R) Model and Normalization

The relationship can be seen in figure 2.4.

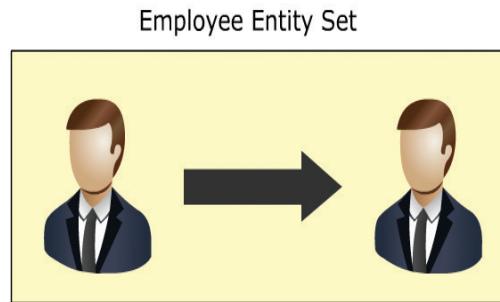


Figure 2.4: Self-Relationship

→ **Binary relationships**

Relationships that exist between entities of two different entity sets are called binary relationships. For example, an employee belongs to a department. The relation exists between two different entities, which belong to two different entity sets. The employee entity belongs to an employee entity set. The department entity belongs to a department entity set.

A wise man learns from the mistakes of others, a fool by his own.

The relationship can be seen in figure 2.5.

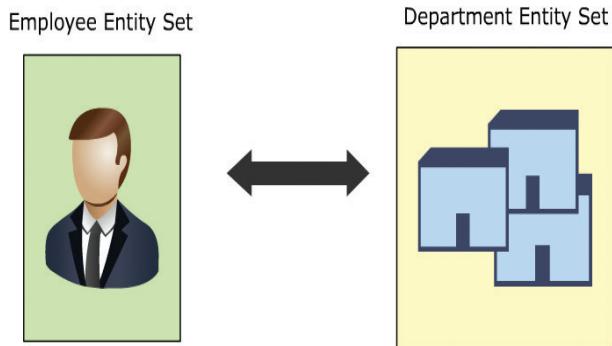


Figure 2.5: Binary Relationship

→ **Ternary relationships**

Relationships that exist between three entities of different entity sets are called ternary relationships. For example, an employee works in the accounts department at the regional branch. The relation, 'works' exists between all three, the employee, the department, and the location.

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The relationship can be seen in figure 2.6.

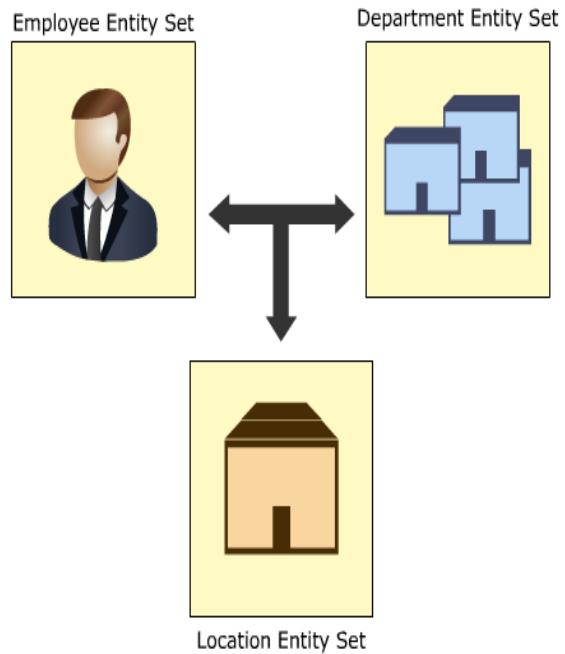


Figure 2.6: Ternary Relationship



Relationships can also be classified as per mapping cardinalities. The different mapping cardinalities are as follows:

→ **One-to-One**

This kind of mapping exists when an entity of one entity set can be associated with only one entity of another set.

Consider the relationship between a vehicle and its registration. Every vehicle has a unique registration. No two vehicles can have the same registration details. The relation is one-to-one, that is, one vehicle-one registration. The mapping cardinality can be seen in figure 2.7.

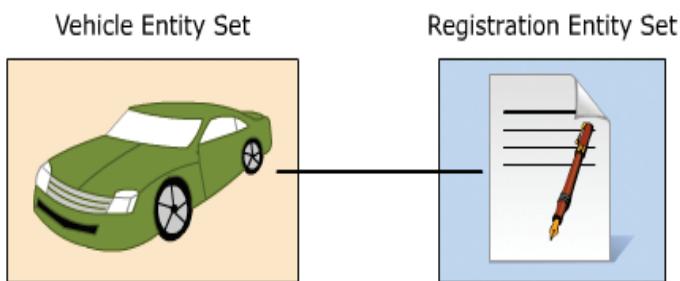


Figure 2.7: One-to-One Mapping Cardinality

→ **One-to-Many**

This kind of mapping exists when an entity of one set can be associated with more than one entity of another entity set.

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Consider the relation between a customer and the customer's vehicles. A customer can have more than one vehicle. Therefore, the mapping is a one to many mapping, that is, one customer - one or more vehicles.

The mapping cardinality can be seen in figure 2.8.

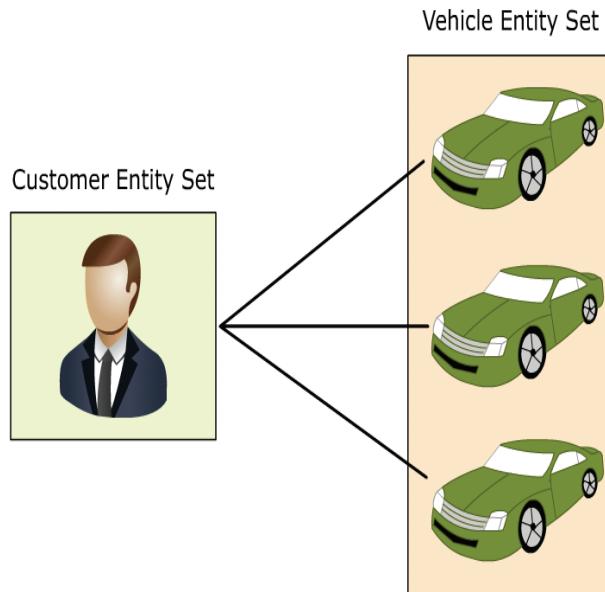


Figure 2.8: One-to-Many Mapping Cardinality

You must do the things you think you cannot do.

→ Many-to-One

This kind of mapping exists when many entities of one set is associated with an entity of another set. This association is done irrespective of whether the latter entity is already associated to other or more entities of the former entity set.

Consider the relation between a vehicle and its manufacturer. Every vehicle has only one manufacturing company or coalition associated to it under the relation, 'manufactured by', but the same company or coalition can manufacture more than one kind of vehicle.

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The mapping can be seen in figure 2.9.

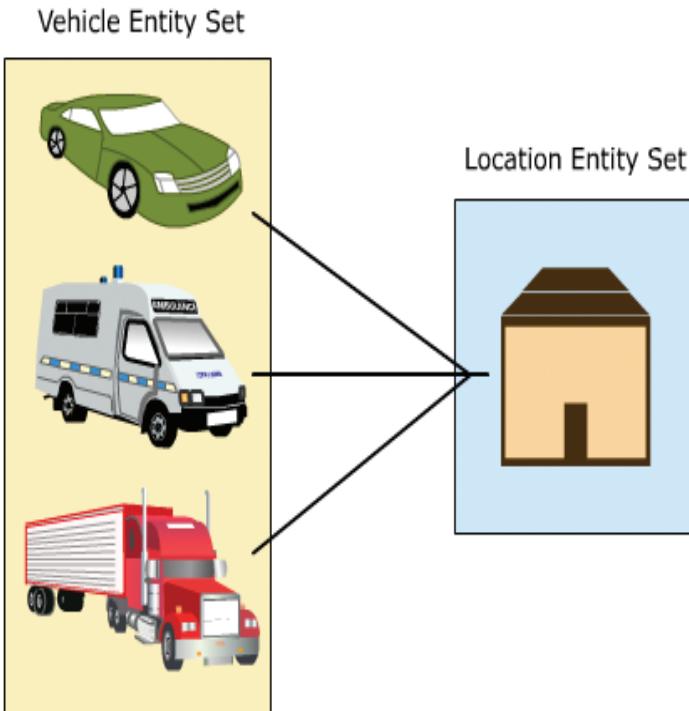


Figure 2.9: Many-to-One Mapping Cardinality

→ **Many-to-Many**

This kind of mapping exists when any number of entities of one set can be associated with any number of entities of the other entity set.

*Woe to him who teaches men faster
than they can learn.*

Consider the relation between a bank's customer and the customer's accounts. A customer can have more than one account and an account can have more than one customer associated with it in case it is a joint account or similar. Therefore, the mapping is many-to-many, that is, one or more customers associated with one or more accounts.

The mapping cardinality can be seen in figure 2.10.

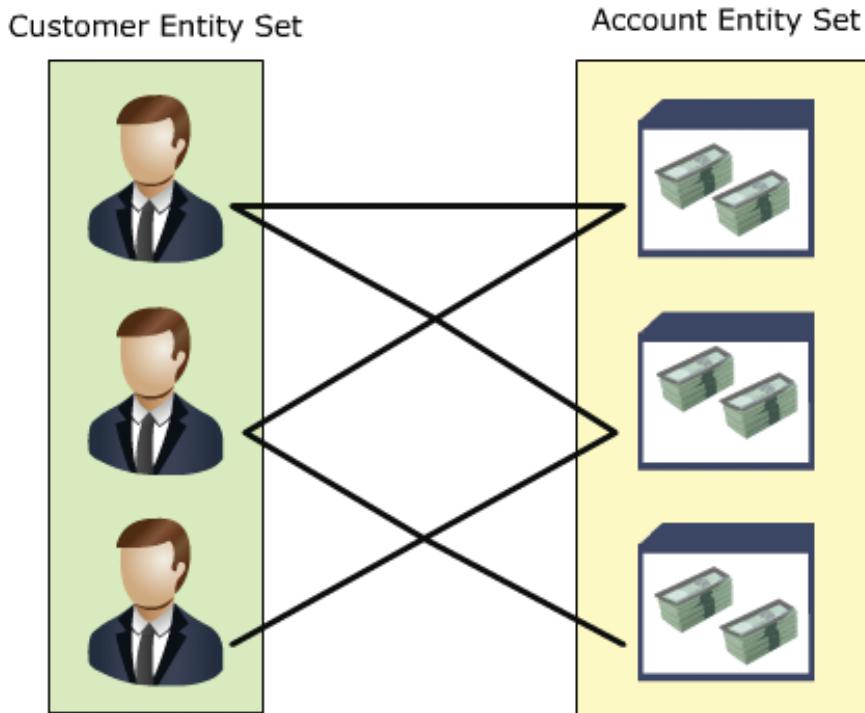


Figure 2.10: Many-to-Many Mapping Cardinality

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Some additional concepts in the E-R model are as follows:

→ **Primary keys**

A primary key is an attribute that can uniquely define an entity in an entity set. Consider table 2.1 containing the details of students in a school.

Enrollment_number	Name	Grade	Division
786	Ashley	Seven	B
957	Joseph	Five	A
1011	Kelly	One	A

Table 2.1: Student Details

In a school, every student has a unique **enrollment number** (such as **enrollment_number** in table 2.1), which is unique to the student. Any student can be identified based on the enrollment number. Thus, the attribute **enrollment_number** plays the role of the primary key in the **Student Details** table.

→ **Weak entity sets**

Entity sets that do not have enough attributes to establish a primary key are called weak entity sets.

→ **Strong entity sets**

Entity sets that have enough attributes to establish a primary key are called strong entity sets.



Consider the scenario of an educational institution where at the end of each semester, students are required to complete and submit a set of assignments. The teacher keeps track of the assignments submitted by the students. Now, an assignment and a student can be considered as two separate entities. The assignment entity is described by the attributes **assignment_number** and **subject**. The student entity is described by **roll_number**, **name**, and **semester**. The assignment entities can be grouped to form an assignment entity set and the student entities can be grouped to form a student entity set. The entity sets are associated by the relation 'submitted by'. This relation is depicted in figure 2.11.

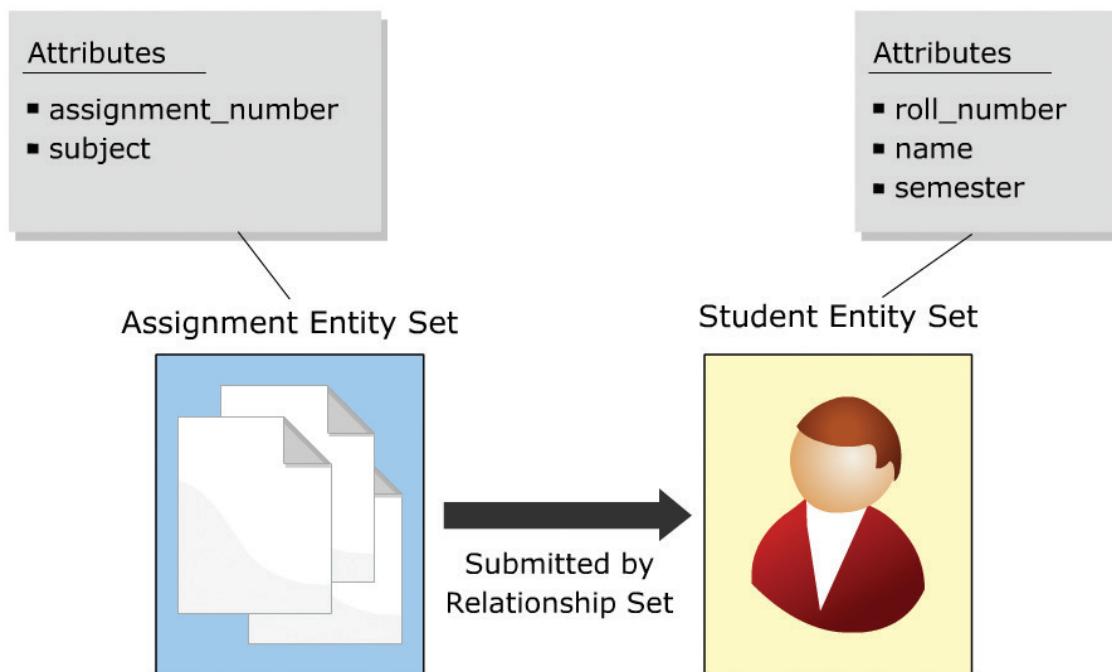


Figure 2.11: Assignment Student Relation

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Entity-Relationship (E-R) Model and Normalization

The attributes, `assignment_number` and `subject`, are not enough to identify an assignment entity uniquely. The `roll_number` attribute alone is enough to uniquely identify any student entity. Therefore, `roll_number` is a primary key for the student entity set. The assignment entity set is a weak entity set since it lacks a primary key. The student entity set is a strong entity set due to the presence of the `roll_number` attribute.

2.3.1 Entity-Relationship Diagrams

The E-R diagram is a graphical representation of the E-R model. The E-R diagram, with the help of various symbols, effectively represents various components of the E-R model.

*Real generosity towards the future lies
in giving all to the present.*

The symbols used for various components can be seen in table 2.2.

Component	Symbol	Example
Entity	Entity	Student
Weak Entity	Weak Entity	Assignments
Attribute	Attribute	Roll_num
Relationship	Relationship	Saves in
Key Attribute	Attribute	Acct_num

Table 2.2: E-R Diagram Symbols

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Attributes in the E-R model can be further classified as follows:

→ **Multi-valued**

A multi-valued attribute is illustrated with a double-line ellipse, which has more than one value for at least one instance of its entity. This attribute may have upper and lower bounds specified for any individual entity value.

The telephone attribute of an individual may have one or more values, that is, an individual can have one or more telephone numbers. Hence, the telephone attribute is a multi-valued attribute.

The symbol and example of a multi-valued attribute can be seen in figure 2.12.

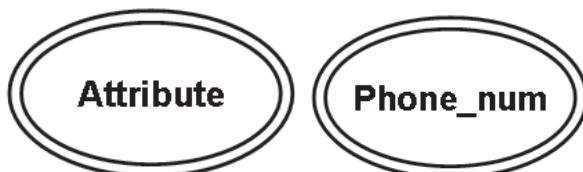


Figure 2.12: Symbol and Example of Multi-valued Attribute

→ **Composite**

A composite attribute may itself contain two or more attributes, which represent basic attributes having independent meanings of their own.



The address attribute is usually a composite attribute, composed of attributes such as street, area, and so on. The symbol and example of a composite attribute can be seen in figure 2.13.

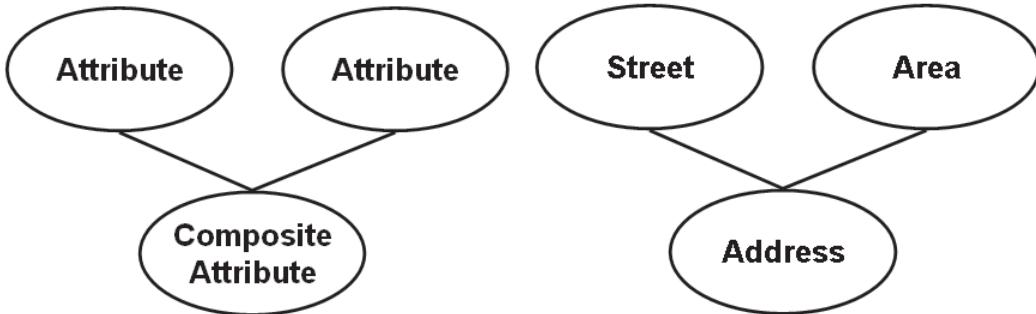


Figure 2.13: Symbol and Example of Composite Attribute

→ Derived

Derived attributes are attributes whose value is entirely dependent on another attribute and are indicated by dashed ellipses.

The age attribute of a person is the best example for derived attributes. For a particular person entity, the age of a person can be determined from the current date and the person's birth date. The symbol and example of a derived attribute can be seen in figure 2.14.



Figure 2.14: Symbol and Example of Derived Attribute

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Steps to construct an E-R diagram are as follows:

1. Gather all the data that needs to be modeled.
2. Identify data that can be modeled as real-world entities.
3. Identify the attributes for each entity.
4. Sort entity sets as weak or strong entity sets.
5. Sort entity attributes as key attributes, multi-valued attributes, composite attributes, derived attributes, and so on.
6. Identify the relations between the different entities.

Using different symbols draw the entities, their attributes, and their relationships. Use appropriate symbols while drawing attributes.

Consider the scenario of a bank, with customers and accounts. The E-R diagram for the scenario can be constructed as follows:

Step 1: Gather data

The bank is a collection of accounts used by customers to save money.

Knowledge is not enough; we must apply. Willing is not enough; we must do.

Step 2: Identify entities

1. Customer
2. Account

Step 3: Identify the attributes

1. Customer: customer_name, customer_address, customer_contact
2. Account: account_number, account_owner, balance_amount

Step 4: Sort entity sets

1. Customer entity set: weak entity set
2. Account entity set: strong entity set

Step 5: Sort attributes

1. Customer entity set: customer_address - composite, customer_contact - multi-valued
2. Account entity set: account_number → primary key, account_owner – multi-valued

Step 6: Identify relations

A customer 'saves in' an account. The relation is 'saves in'.



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Step 7: Draw diagram using symbols

Figure 2.15 shows the E-R diagram for the bank.

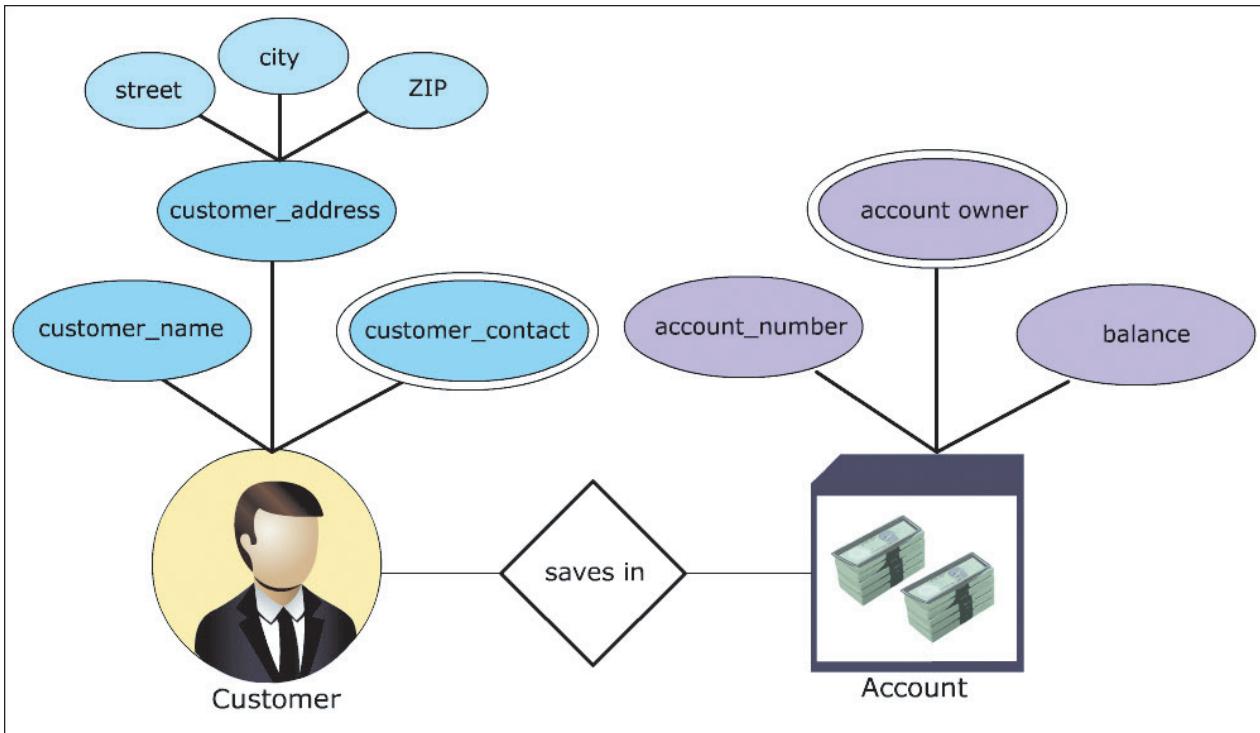


Figure 2.15: E-R Diagram for the Bank

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2.4 Normalization

Initially, all databases are characterized by large number of columns and records. This approach has certain drawbacks. Consider the following details of the employees in a department. Table 2.3 consists of the employee details as well as the details of the project they are working on.

Emp_no	Project_id	Project_name	Emp_name	Grade	Salary
142	113, 124	BLUE STAR, MAGNUM	John	A	20,000
168	113	BLUE STAR	James	B	15,000
263	113	BLUE STAR	Andrew	C	10,000
109	124	MAGNUM	Bob	C	10,000

Table 2.3: Department Employee Details

→ **Repetition anomaly**

The data such as **Project_id**, **Project_name**, **Grade**, and **Salary** repeat many times. This repetition hampers both, performance during retrieval of data and the storage capacity. This repetition of data is called the repetition anomaly.

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The repetition is shown in table 2.4 with the help of shaded cells.

Emp_no	Project_id	Project_name	Emp_name	Grade	Salary
142	113, 124	BLUE STAR, MAGNUM	John	A	20,000
168	113	BLUE STAR	James	B	15,000
263	113	BLUE STAR	Andrew	C	10,000
109	124	MAGNUM	Bob	C	10,000

Table 2.4: Department Employee with Insertion Anomaly

→ **Insertion anomaly**

Suppose the department recruits a new employee named **Ann**. Now, consider that **Ann** has not been assigned any project. Insertion of her details in the table would leave columns **Project_id** and **Project_name** empty. Leaving columns blank could lead to problems later. Anomalies created by such insertions are called insertion anomalies. The anomaly can be seen in table 2.5.

Emp_no	Project_id	Project_name	Emp_name	Grade	Salary
142	113, 124	BLUE STAR, MAGNUM	John	A	20,000
168	113	BLUE STAR	James	B	15,000
263	113	BLUE STAR	Andrew	C	10,000
109	124	MAGNUM	Bob	C	10,000
195	-	-	Ann	C	10,000

Table 2.5: Department Employee Details

*Don't just learn the tricks of the trade,
learn the trade.*

→ **Deletion anomaly**

Suppose, Bob is relieved from the project MAGNUM. Deleting the record deletes Bob's **Emp_no**, **Grade**, and **Salary** details too. This loss of data is harmful as all of Bob's personal details are also lost as seen in the table 2.6. This kind of loss of data due to deletion is called deletion anomaly. The anomaly can be seen in table 2.6.

Emp_no	Project_id	Project_name	Emp_name	Grade	Salary
142	113, 124	BLUE STAR, MAGNUM	John Smith	A	20,000
168	113	BLUE STAR	James Kilber	B	15,000
263	113	BLUE STAR	Andrew Murray	C	10,000

Table 2.6: Employee Project Details

→ **Updating anomaly**

Suppose John was given a hike in **Salary** or John was demoted. The change in John's **Salary** or **Grade** needs to be reflected in all projects John works for. This problem in updating all the occurrences is called updating anomaly.

The **Department Employee Details** table is called an unnormalized table. These drawbacks lead to the need for normalization.

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Normalization is the process of removing unwanted redundancy and dependencies.

Initially, Codd (1972) presented three normal forms (1NF, 2NF, and 3NF), all based on dependencies among the attributes of a relation. The fourth and fifth normal forms are based on multi-value and join dependencies and were proposed later.

2.4.1 First Normal Form

In order to achieve the first normal form, following steps need to be performed:

- Create separate tables for each group of related data
- The table columns must have atomic values
- All the key attributes must be identified

Consider the **Employee Project Details** table shown in table 2.7.

Emp_no	Project_id	Project_name	Emp_name	Grade	Salary
142	113, 124	BLUE STAR, MAGNUM	John	A	20,000
168	113	BLUE STAR	James	B	15,000
263	113	BLUE STAR	Andrew	C	10,000
109	124	MAGNUM	Bob	C	10,000

Table 2.7: Employee Project Details



The table has data related to projects and employees. The table needs to be split into two tables, that is, a **Project Details** table and an **Employee Details** table. The table columns, **Project_id** and **Project_names**, have multiple values. The data needs to be split over different rows. The resultant tables are **Project Details** and **Employee Details** as shown in tables 2.8 and 2.9.

Project_id	Project_name
113	BLUE STAR
124	MAGNUM

Table 2.8: Project Details

Emp_no	Emp_name	Grade	Salary
142	John	A	20,000
168	James	B	15,000
263	Andrew	C	10,000
109	Bob	C	10,000

Table 2.9: Employee Details

The **Project_id** attribute is the primary key for the **Project Details** table.

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The `Emp_no` attribute is the primary key for the `Employee Details` table. Therefore, in first normal form, the initial `Employee Project Details` table has been reduced to the `Project Details` and `Employee Details` tables.

2.4.2 Second Normal Form

The tables are said to be in second normal form if:

- They meet the requirements of the first normal form
- There are no partial dependencies in the tables
- The tables are related through foreign keys

Partial dependency means a non-key attribute should not be partially dependent on more than one key attribute. The `Project Details` and `Employee Details` tables do not exhibit any partial dependencies. The `Project_name` is dependent only on `Project_id` and `Emp_name`, `Grade`, and `Salary` are dependent only on `Emp_no`. The tables also need to be related through foreign keys. A third table, named `Employee Project Details`, is created with only two columns, `Project_id` and `Emp_no`.

Practice is the best of all instructors.

So, the project and employee details tables on conversion to second normal form generates tables **Project Details**, **Employee Details**, and **Employee Project Details** as shown in tables 2.10, 2.11, and 2.12.

Project_id	Project_name
113	BLUE STAR
124	MAGNUM

Table 2.10: Project Details After Conversion to Second Normal Form

Emp_no	Emp_name	Grade	Salary
142	John	A	20,000
168	James	B	15,000
263	Andrew	C	10,000
109	Bob	C	10,000

Table 2.11: Employee Details After Conversion to Second Normal Form

Emp_no	Project_id
142	113
142	124
168	113
263	113
109	124

Table 2.12: Employee Project Details After Conversion to Second Normal Form

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The attributes, **Emp_no** and **Project_id**, of the **Employee Project Details** table combine together to form the primary key. Such primary keys are called composite primary keys.

2.4.3 Third Normal Form

To achieve the third normal form:

- The tables should meet the requirements of the second normal form
- The tables should not have transitive dependencies in them

The **Project Details**, **Employee Details**, and **Employee Project Details** tables are in second normal form. If an attribute can be determined by another non-key attribute, it is called a transitive dependency. To make it simpler, every non-key attribute should be determined by the key attribute only. If a non-key attribute can be determined by another non-key attribute, it needs to put into another table.

On observing the different tables, it is seen that the **Project Details** and **Employee Project Details** tables do not exhibit any such transitive dependencies. The non-key attributes are totally determined by the key attributes. **Project_name** is only determined by **Project_number**. On further scrutinizing the **Employee Details** table, a certain inconsistency is seen. The attribute **Salary** is determined by the attribute **Grade** and not the key attribute **Emp_no**. Thus, this transitive dependency needs to be removed.



The **Employee Details** table can be split into the **Employee Details** and **Grade Salary Details** tables as shown in tables 2.13 and 2.14.

Emp_no	Emp_name	Grade
142	John	A
168	James	B
263	Andrew	C
109	Bob	C

Table 2.13: Employee Details After Conversion

Grade	Salary
A	20,000
B	15,000
C	10,000

Table 2.14: Grade Salary Details Table

Thus, at the end of the three normalization stages, the initial **Employee Project Details** table has been reduced to the **Project Details**, **Employee Project Details**, **Employee Details**, and **Grade Salary Details** tables as shown in tables 2.15, 2.16, 2.17, and 2.18.

Project_id	Project_name
113	BLUE STAR
124	MAGNUM

Table 2.15: Project Details After Conversion to Third Normal Form

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Emp_no	Project_id
142	113
142	124
168	113
263	113
109	124

Table 2.16: Employee Project Details After Conversion to Third Normal Form

Emp_no	Emp_name	Grade
142	John	A
168	James	B
263	Andrew	C
109	Bob	C

Table 2.17: Employee Details After Conversion to Third Normal Form

Grade	Salary
A	20,000
B	15,000
C	10,000

Table 2.18: Grade Salary Details After Conversion to Third Normal Form

It is hard to fail, but it is worse never to have tried to succeed.

2.4.4 Denormalization

By normalizing a database, redundancy is reduced. This, in turn, reduces the storage requirements for the database and ensures data integrity. However, it has some drawbacks. They are as follows:

- Complex join queries may have to be written often to combine the data in multiple tables.
- Joins may practically involve more than three tables depending on the need for information.

If such joins are used very often, the performance of the database will become very poor. The CPU time required to solve such queries will be very large too. In such cases, storing a few fields redundantly can be ignored to increase the performance of the database. The databases that possess such minor redundancies in order to increase performance are called denormalized databases and the process of doing so is called denormalization.

2.5 Relational Operators

The relational model is based on the solid foundation of Relational Algebra. Relational Algebra consists of a collection of operators that operate on relations. Each operator takes one or two relations as its input and produces a new relation as its output.

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Entity-Relationship (E-R) Model and Normalization

Consider the **Branch Reserve Details** table as shown in table 2.19.

Branch	Branch_id	Reserve (Billion €)
London	BS-01	9.2
London	BS-02	10
Paris	BS-03	15
Los Angeles	BS-04	50
Washington	BS-05	30

Table 2.19: Branch Reserve Details

→ **SELECT**

The **SELECT** operator is used to extract data that satisfies a given condition. The lowercase Greek letter sigma, 'σ', is used to denote selection. A select operation, on the **Branch Reserve Details** table, to display the details of the branches in London would result in table 2.20.

Branch	Branch_id	Reserve (Billion €)
London	BS-01	9.2
London	BS-02	10

Table 2.20: Details of Branches in London



A selection on the **Branch Reserve Details** table to display branches with reserve greater than 20 billion Euros would result in table 2.21.

Branch	Branch_id	Reserve (Billion €)
Los Angeles	BS-04	50
Washington	BS-05	30

Table 2.21: Details of Branches with Reserves Greater Than 20 Billion Euros

→ PROJECT

The **PROJECT** operator is used to project certain details of a relational table. The **PROJECT** operator only displays the required details leaving out certain columns. The **PROJECT** operator is denoted by the Greek letter pi, ' π '. Assume that only the **Branch_id** and **Reserve** amounts need to be displayed.

A project operation to do the same, on the **Branch Reserve Details** table, would result in table 2.22.

Branch_id	Reserve (Billion €)
BS-01	9.2
BS-02	10
BS-03	15
BS-04	50
BS-05	30

Table 2.22: Resultant Table with Branch_id and Reserve Amounts

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→ PRODUCT

The PRODUCT operator, denoted by 'x' helps combine information from two relational tables. Consider table 2.23.

Branch_id	Loan Amount (Billion €)
BS-01	0.56
BS-02	0.84

Table 2.23: Branch Loan Details

The product operation on the **Branch Reserve Details** and **Branch Loan Details** tables would result in table 2.24.

Branch	Branch_id	Reserve (Billion €)	Loan Amount (Billion €)
London	BS-01	9.2	0.56
London	BS-01	9.2	0.84
London	BS-02	10	0.56
London	BS-02	10	0.84
Paris	BS-03	15	0.56
Paris	BS-03	15	0.84
Los Angeles	BS-04	50	0.56
Los Angeles	BS-04	50	0.84
Washington	BS-05	30	0.56
Washington	BS-05	30	0.84

Table 2.24: Product of Branch Reserve Details and Branch Loan Details

The future depends on what we do in the present.

The product operation combines each record from the first table with all the records in the second table, somewhat generating all possible combinations between the table records.

→ UNION

Suppose an official of the bank with the data given in tables 2.19 and 2.23 wanted to know which branches had reserves below 20 billion Euros or loans. The resultant table would consist of branches with either reserves below 20 billion Euros or loans or both.

This is similar to the union of two sets of data; first, set of branches with reserve less than 20 billion Euros and second, branches with loans. Branches with both, reserves below 20 billion Euros and loans would be displayed only once. The **UNION** operator does just that, it collects the data from the different tables and presents a unified version of the complete data. The union operation is represented by the symbol, 'U'. The union of the **Branch Reserve Details** and **Branch Loan Details** tables would generate table 2.25.

Branch	Branch_id
London	BS-01
London	BS-02
Paris	BS-03

Table 2.25: Unified Representation of Branches with Less Reserves or Loans

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→ INTERSECT

Suppose the same official after seeing this data wanted to know which of these branches had both low reserves and loans too. The answer would be the intersect relational operation. The INTERSECT operator generates data that holds true in all the tables it is applied on. It is based on the intersection set theory and is represented by the 'n' symbol. The result of the intersection of the **Branch Reserve Details** and **Branch Loan Details** tables would be a list of branches that have both reserves below 20 billion Euros and loans in their account. The resultant table generated is table 2.26.

Branch	Branch_id
London	BS-01
London	BS-02

Table 2.26: Branches with Low Reserves and Loans

→ DIFFERENCE

If the same official now wanted the list of branches that had low reserves but no loans, then the official would have to use the difference operation. The DIFFERENCE operator, symbolized as '—', generates data from different tables too, but it generates data that holds true in one table and not the other. Thus, the branch would have to have low reserves and no loans to be displayed.

Table 2.27 is the result generated.

Branch	Branch_id
Paris	BS-03

Table 2.27: Branches with Low Reserves but No Loans



→ JOIN

The JOIN operation is an enhancement to the product operation. It allows a selection to be performed on the product of tables. For example, if the reserve values and loan amounts of branches with low reserves and loan values was needed, the product of the **Branch Reserve Details** and **Branch Loan Details** would be required. Once the product of tables 2.19 and 2.23 would be generated, only those branches would be listed which have both reserves below 20 billion Euros and loans. Table 2.28 is generated as a result of the JOIN operation.

Branch	Branch_id	Reserve (Billion €)	Loan Amount (Billion €)
London	BS-01	9.2	0.56
London	BS-02	10	0.84

Table 2.28: Detailed List of Branches with Low Reserve and Loans

→ DIVIDE

Suppose an official wanted to see the branch names and reserves of all the branches that had loans. This process can be made very easy by using the DIVIDE operator. All that the official needs to do is divide the **Branch Reserve Details** table (shown earlier in table 2.19) by the list of branches, that is, the **Branch Id** column of the **Branch Loan Details** table (shown earlier in table 2.23). Table 2.29 is the result generated.

Branch	Reserve (Billion €)
London	9.2
London	10

Table 2.29: Resultant Table of Division Operation

Note that the attributes of the divisor table should always be a subset of the dividend table. The resultant table would always be void of the attributes of the divisor table and the records not matching the records in the divisor table.

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2.6 Check Your Progress

1. One or more attributes that can uniquely define an entity from an entity set is called a _____ key.

(A)	Primary	(C)	Alternate
(B)	Foreign	(D)	Super

2. An attribute that contains two or more attribute values in it is called a _____ attribute.

(A)	Derived	(C)	Multi-valued
(B)	Composite	(D)	Network

3. Transitive dependence is eliminated in the _____ normal form.

(A)	First	(C)	Third
(B)	Second	(D)	Fourth

4. Which one of these operations is further enhanced in the Product operation?

(A)	Divide	(C)	Difference
(B)	Intersection	(D)	Join

5. Which of the following are the basic components of an E-R model?

- a. Entity
- b. Relationship
- c. Attributes
- d. Relationship Chart
- e. Relationship Set

(A)	a, b, c	(C)	a, c, e
(B)	a, d, c	(D)	a, b, c, e

2.6.1 Answers

1.	A
2.	B
3.	C
4.	D
5.	D



Summary

- Data modeling is the process of applying an appropriate data model to the data at hand.
- E-R model views the real-world as a set of basic objects and relationships among them.
- Entity, attributes, entity set, relationships, and relationship sets form the five basic components of E-R model.
- Mapping cardinalities express the number of entities that an entity is associated with.
- The process of removing redundant data from the tables of a relational database is called normalization.
- Relational Algebra consists of a collection of operators that help retrieve data from the relational databases.
- SELECT, PRODUCT, UNION, and DIVIDE are some of the relational algebra operators.

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Session - 3

Introduction to SQL Server 2012

Welcome to the Session, **Introduction to SQL Server 2012**.

This session explains the basic architecture of SQL Server 2012 and lists the versions and editions of SQL Server. It also explains the role and structure of SQL Server along with the new features added in SQL Server 2012. Finally, the session explains the process to connect to SQL Server instances, create and organize script files, and execute Transact-SQL queries.

In this Session, you will learn to:

- Describe the basic architecture of SQL Server 2012
- List the various versions and editions of SQL Server
- Explain the role and structure of SQL Server databases
- List the new features of SQL Server 2012
- List the process of connecting to SQL Server Instances
- Explain script file creation and organization
- Explain the process to execute Transact-SQL queries

3.1 Introduction

SQL Server is an RDBMS developed by Microsoft. It provides an enterprise-level data management platform for an organization. SQL Server includes numerous features and tools that make it an outstanding database and data analysis platform. It is also targeted for large-scale Online Transactional Processing (OLTP), data warehousing, and e-commerce applications.

SQL Server 2012 was launched by Microsoft on March 6, 2012. One of the major features of this version of SQL Server is that it is available on the cloud platform. Using SQL Server 2012 not only helps an organization to store and manage huge amount of information, but also to protect and utilize this data at different locations as required.

The latest version of this RDBMS product is SQL Server 2016. You will learn more about it in Session 16.

3.2 Basic Architecture of SQL Server 2012

There are various components that form a part of SQL Server 2012. All the components come together to form the basic architecture of SQL Server 2012.

*Action may not always bring happiness,
but there is no happiness without
action.*

These components can be represented under three major heads that are shown in figure 3.1.

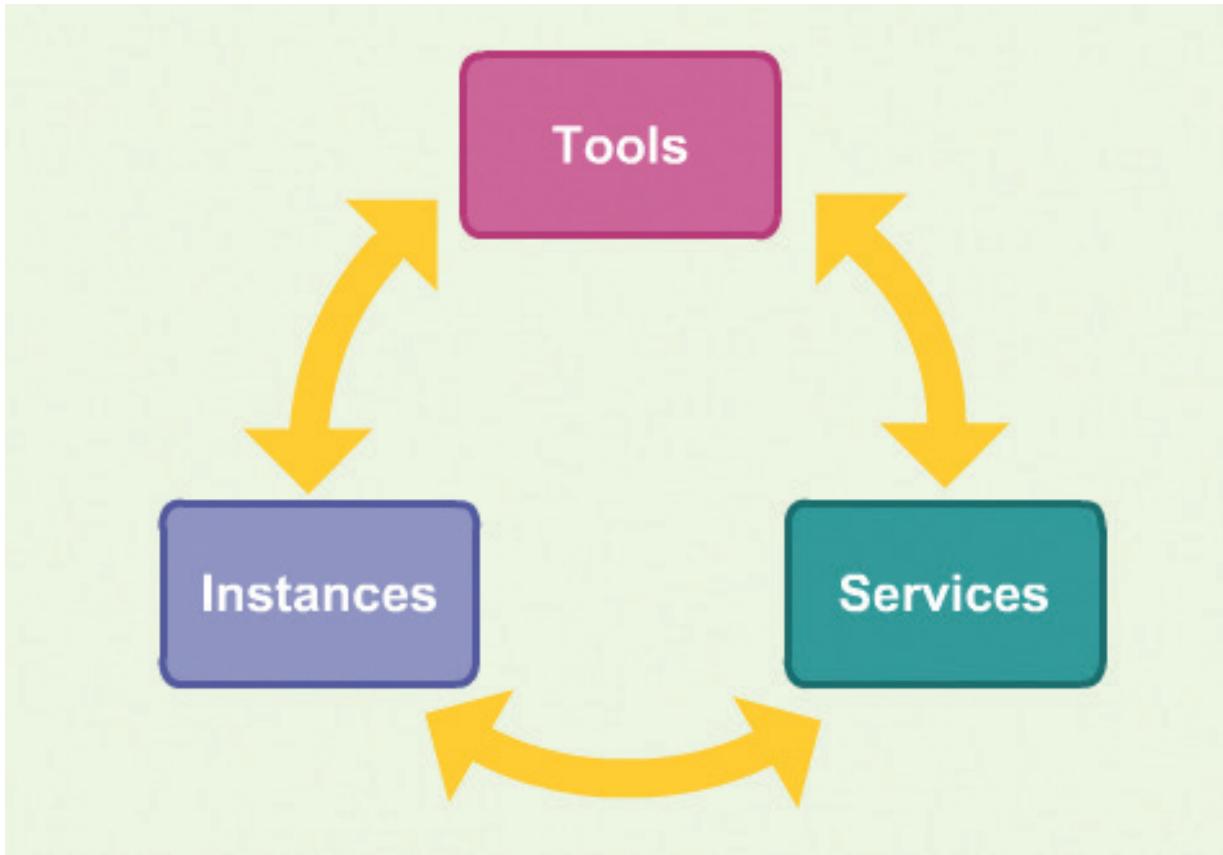


Figure 3.1: Architecture of SQL Server 2012

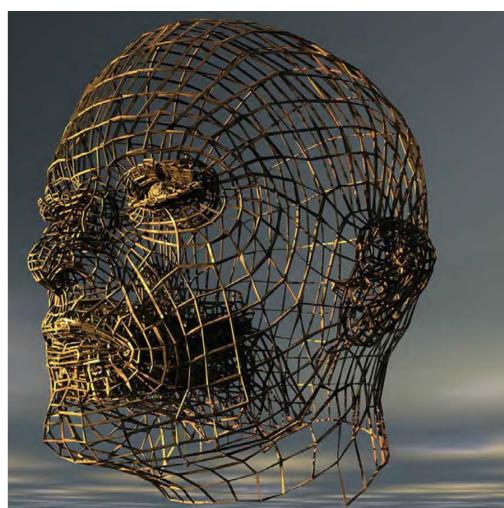
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Tools

There are a number of tools that are provided in SQL Server 2012 for development and query management of a database. The SQL Server Installation Center must be used to install SQL Server program features and tools. Features can also be modified or removed using the SQL Server Installation Center. Table 3.1 lists the different tools available in SQL Server 2012.

Tool	Description
SQL Server Management Studio (SSMS)	One of the most important tools available in SQL Server 2012 is SSMS. SSMS is an application provided with SQL Server 2012 that helps to create databases, database objects, query data, and manage the overall working of SQL Server.
SQLCMD	SQLCMD is a command-line tool that can be used in place of SSMS. It performs similar functions as SSMS, but in command format only.
SQL Server Installation Center	The SQL Server Installation Center tool can also be used to add, remove, and modify SQL Server programs.
SQL Server Configuration Manager	SQL Server Configuration Manager is used by database administrators to manage the features of the SQL software installed in client machines. This tool is not available to all users. It can be used to configure the services, server protocols, client protocols, client aliases, and so on.
SQL Server Profiler	SQL Server Profiler is used to monitor an instance of the Database Engine or Analysis Services.
SQL Server Data Tools (SSDT)	SSDT is an Integrated Development Environment (IDE) used for Business Intelligence Components. It helps to design the database using a tool named Visual Studio.
Connectivity Tools	The connectivity tools include DB-Library, Open Database Connectivity (ODBC), Object Linking and Embedding Database (OLE DB), and so on. These tools are used to communicate between the clients, servers, and network libraries.

Table 3.1: Different Tools in SQL Server 2012



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Services

There are various services that are executed on a computer running SQL Server. These services run along with the other Windows services and can be viewed in the task manager. Some of the SQL Server 2012 services are as follows:

- **SQL Server Database Engine** - Database Engine is a core service that is used for storing, processing, and securing data. It is also used for replication, full-text search, and the Data Quality Services (DQS). It contains tools for managing relational and eXtensible Markup Language (XML) data.
- **SQL Server Analysis Services (SSAS)** - Analysis Services contain tools that help to create and manage Online Analytical Processing (OLAP).
- This is used for personal, team, and corporate business intelligence purposes. Analysis services are also used in data mining applications. These services also help to collaborate with PowerPivot, Excel, and even SharePoint Server Environment.
- **SQL Server Reporting Services (SSRS)** - Reporting Services help to create, manage, publish, and deploy reports. These reports can be in tabular, matrix, graphical, or free-form format. Report applications can also be created using Reporting Services.
- **SQL Server Integration Services (SSIS)** - Integration Services are used for moving, copying, and transforming data using different graphical tools and programmable objects. The DQS component is also included in Integration Services. Integration services help to build high-performance data integration solutions.

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- **SQL Server Master Data Services** - Master Data Services (MDS) are used for master data management. MDS is used for analysis, managing, and reporting information such as hierarchies, granular security, transactions, business rules, and so on.

Instances

All the programs and resource allocations are saved in an instance. An instance can include memory, configuration files, and CPU. Multiple instances can be used for different users in SQL Server 2012. Even though many instances may be present on a single computer, they do not affect the working of other instances. This means that all instances work in isolation. Each instance can be customized as per the requirement. Even permissions for each instance can be granted on individual basis. The resources can also be allocated to the instance accordingly, for example, the number of databases allowed.

In other words, instances can be called as a bigger container that contains sub-containers in the form of databases, security options, server objects, and so on.

Note - Books Online (BOL) is an indirect part of the architecture of SQL Server 2012 that provides information about different concepts related to SQL Server 2012. This not only includes the new features and components of SQL Server 2012, but also has information about development aspects such as syntax creation and query generation. BOL is available online as well as can be accessed through the Help menu in SSMS.

3.3 Versions of SQL Server

The first version of SQL Server was released in the year 1989. After this, there have been new versions released almost every year, with the latest one being SQL Server 2016.

First say to yourself what you would be; and then do what you have to do.

Table 3.2 lists different versions of SQL Server.

Version	Year
SQL Server 1.0	1989
SQL Server 1.1	1991
SQL Server 4.2	1992
SQL Server 6.0	1995
SQL Server 6.5	1996
SQL Server 7.0	1998
SQL Server 2000	2000
SQL Server 2005	2005
SQL Server 2008	2008
SQL Server 2008 R2	2010
SQL Server 2012	2012
SQL Server 2014	2015
SQL Server 2016	2016

Table 3.2: Different Versions of SQL Server

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3.4 Editions of SQL Server

Based on database requirements, an organization can choose from any of the following three editions of SQL Server 2012 that have been released. These main editions of SQL Server 2012 are as follows:

- **Enterprise** – This is the edition that is recurrently released on most versions of SQL Server. This is the full edition of SQL Server which contains all the features of SQL Server 2012. The enterprise edition of SQL Server 2012 supports features such as Power View, xVelocity, Business Intelligence services, virtualization, and so on.
- **Standard** – The standard edition is the basic edition of SQL Server that supports fundamental database and reporting and analytics functionality. However, it does not support critical application development, security, and data warehousing.
- **Business Intelligence** – This is a new edition introduced for the first time in SQL Server 2012. This edition supports basic database, reporting and analytics functionality, and also business intelligence services. This edition supports features such as PowerPivot, PowerView, Business Intelligence Semantic Model, Master Data Services, and so on.



Table 3.3 shows a comparison of the features available for the different editions of SQL Server 2012.

Features	Enterprise	Business Intelligence	Standard
Spatial support	Yes	Yes	Yes
FileTable	Yes	Yes	Yes
Policy-based management	Yes	Yes	Yes
Reporting	Yes	Yes	Yes
Analytics	Yes	Yes	Yes
Multidimensional Business Intelligence semantic model	Yes	Yes	Yes
Basic high availability	Yes	Yes	Yes
Self-service capabilities	Yes	Yes	
Alerting	Yes	Yes	
Power View	Yes	Yes	
PowerPivot for SharePoint Server	Yes	Yes	
Enterprise data management	Yes	Yes	
Data quality services	Yes	Yes	
Master data services	Yes	Yes	
In-memory tabular Business Intelligence semantic model	Yes	Yes	
Unlimited virtualization	Yes		
Data warehousing	Yes		
Advanced security	Yes		
Transparent Data Encryption (TDE)	Yes		
Compression and partitioning	Yes		
Advanced high availability	Yes		

Table 3.3: Comparison of Different Editions of SQL Server 2012

Other than these three editions, there are also other editions available such as Express edition, Web edition, and Developer edition. SQL Server 2012 Express is a free edition of SQL Server 2012. The Web edition is used for Internet-based Web services environment. The Developer edition is used by programmers specifically for development, testing, and demonstration purposes.

3.5 Role and Structure of Object Explorer in SQL Server

The structure of **Object Explorer** in SQL Server 2012 is shown in figure 3.2. The structure includes databases, security, server objects, replications, and features such as AlwaysOn High Availability, Management, Integration Services Catalogs, and so on.

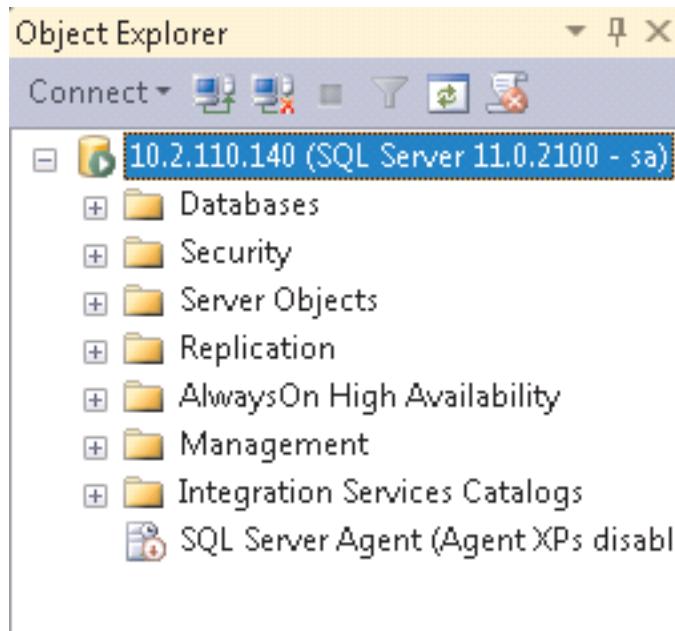


Figure 3.2: Object Explorer

Learning how to learn is life's most important skill.

The various components in the **Object Explorer** are as follows:

- **Databases** – Contains a collection of databases that stores a specific set of structured data.
- **Security** – Used to provide flexible and trustworthy security configuration in SQL Server 2012. This includes logins, roles, credentials, audits, and so on.
- **Server Objects** – Used to monitor activity in computers running an instance of SQL Server.
- **Replication** – Used to copy and distribute data and database objects from one database to another, and then, to synchronize between databases to maintain consistency.
- **AlwaysOn High Availability** – Used for high availability and disaster recovery. It is generally used for applications that require high uptime and failure protection.
- **Management** – Used to manage policies, resources, events, maintenance plans, and so on.
- **Integration Services Catalogs** – Integration Services Catalogs stores all the objects of the project after the project has been deployed.

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3.6 New Features of SQL Server 2012

The new features included in SQL Server 2012 are as follows:

- **Statistics properties** – Information about the statistics of objects can be viewed in SQL Server 2012 by using the `sys.dm_db_stats_properties` function.
- **Failover clustering enhancements** – SQL Server 2012 provides multi-subnet failover clusters. It has also introduced indirect checkpoints and a flexible failover policy for cluster health detection. This has strengthened the existing disaster recovery solution in SQL Server 2012.
- **SQL Azure** – Microsoft SQL Azure is a cloud based relational database service that leverages existing SQL Server technologies. SQL Azure can be used to store and manage data using queries and other functions that are similar to SQL Server 2012. Reporting services and backup feature has been added in SQL Azure. Also, the database size in SQL Azure can now be increased up to 150 Giga Byte (GB).
- **Data-tier Applications** – A new version of the Data-tier Application (DAC) has been introduced in SQL Server 2012. A DAC is a logical database management entity defining SQL Server objects associated with a user's database. This DAC upgrade alters the existing database to match the schema to the new version of DAC.
- **Data Quality Services** – To maintain the integrity, conformity, consistency, accuracy, and validity of the data, the Data Quality Services (DQS) has been integrated with SQL Server 2012. DQS uses techniques such as monitoring, data cleansing, matching and profiling, and so on to maintain the data quality and correctness.



- **Big data support** – Microsoft has announced a partnership with Cloudera to use Hadoop as the platform to support big data. Big data is a large collection of data under data sets that are divided for easier processing. The collection stored under big data can include information from social networking Web sites, roadway traffic and signaling data, and so on. These kinds of data that are large and complex require specific applications such as Hadoop to process the data. SQL Server 2012 in collaboration with Hadoop would now be able to support big data.
- **SQL Server Installation** – The SQL Server Installation Center now includes SQL Server Data Tools (SSDT) and Server Message Block (SMB) file server. SSDT provides an IDE for building business intelligence solutions. SMB file server is a supported storage option that can be used for system databases and database engines.
- **Server mode** – The server mode concept has been added for Analysis Services installation. An Analysis Services instance has three server modes that are Multidimensional, Tabular, and SharePoint.
- **Audit features** – Customized audit specifications can be defined to write custom events in the audit log. New filtering features have also been added in SQL Server 2012.
- **Selective XML Index** – This is a new type of XML index that is introduced in SQL Server 2012. This new index has a faster indexing process, improved scalability, and enhanced query performance.
- **Master Data Services** – This feature provides a central data hub to ensure consistency and integrity across different applications. In SQL Server 2012, an Excel add-in has been created to support master data when working with Excel. This add-in makes it easy to transfer and manage the master data in Excel. This data can be easily edited on Excel and it can also be published back to the database.

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- **PowerView** – A new business intelligence toolkit named PowerView has been introduced in SQL Server 2012. This toolkit helps to create Business Intelligence reports for an entire organization. PowerView is an add-in of SQL Server 2012 that works in collaboration with Microsoft SharePoint Server 2010. This add-in helps to present and visualize SQL Server 2012 data in a compatible view on the SharePoint platform. PowerView is a business intelligence tool that can be used to make customer presentations by using models, animations, visualization, and so on.
- **Full Text Search** - In SQL Server 2012, the data stored in extended properties and metadata is also searched and indexed. All the additional properties of a document are searched along with data present in the document. These additional properties include Name, Type, Folder path, Size, Date, and so on.

3.7 Connecting to SQL Server Instances

SSMS is used to connect to SQL Server instances. SSMS is a tool used for creating, querying, and managing the databases. To open SSMS, connect to SQL Server 2012 by specifying the sever information and login credentials. The login credentials will include username and password. The detailed steps to connect to SQL Server instance are as follows:

1. Click Start → All Programs → Microsoft SQL Server 2012 → SQL Server Management Studio.
2. In the **Connect to Server** dialog box, select the **Server type** as **Database Engine**.
3. Type the **Server name**.
4. Select either **Windows Authentication** or **SQL Server Authentication**, provide the required **Login** and **Password**, and click **Connect**.

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

Figure 3.3 shows the **Connect to Server** dialog box.



Figure 3.3: Connect to Server Dialog Box

Note - The two authentication methods provided by SQL Server 2012 are SQL Server Authentication and Windows Authentication. SQL Server Authentication requires a user account for login and password. Hence, multiple user accounts can access the information using their respective usernames and passwords. With Windows Authentication, the operating system credentials can be used to log in to the SQL Server database. This will work only on a single machine and cannot be used in any other computer.

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Figure 3.4 shows the SSMS window.

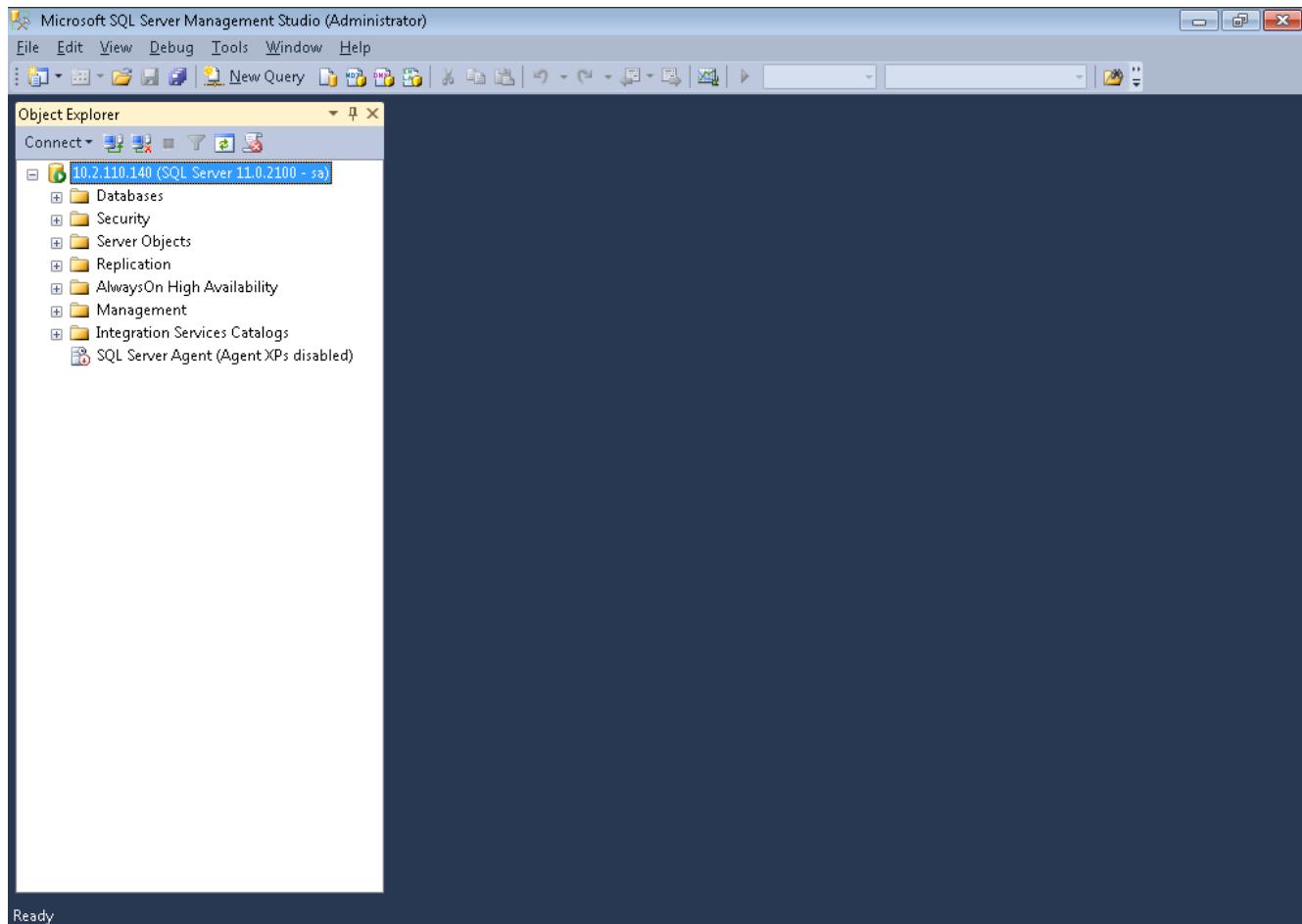


Figure 3.4: SSMS Window



3.8 Creating and Organizing Script Files

Script files are files that contain a set of SQL commands. A script file can contain one or more SQL statements. The script files are stored in .sql format in SQL Server 2012.

The conceptual layers in which the script files must be organized are shown in figure 3.5.

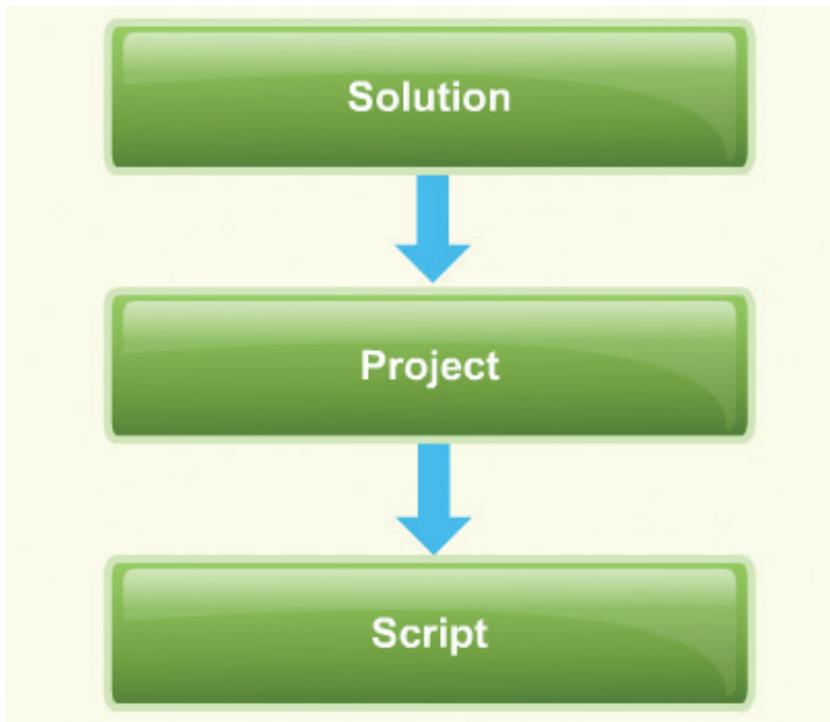


Figure 3.5: Conceptual Layers

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A solution is a file in which all the projects in SQL Server 2012 are saved. This acts as a top-most node in the hierarchy. The solution file is stored as a text file with `.ssmsln` extension. A project comes under a solution node. There can be more than one project in SQL Server 2012. All the data related to database connection metadata and other miscellaneous files are stored under a project. It is stored as a text file with `.ssmsqlproj` extension. The script files are the core files in which the queries are developed and executed. The scripts have a `.sql` extension.

3.9 Transact-SQL Queries

The queries typed in Transact-SQL and saved as `.sql` files can be executed directly in the SSMS query window. The steps to execute Transact-SQL queries are as follows:

1. In the query window, select the code to be executed.

2. On the **SSMS** toolbar, click **Execute**.

OR

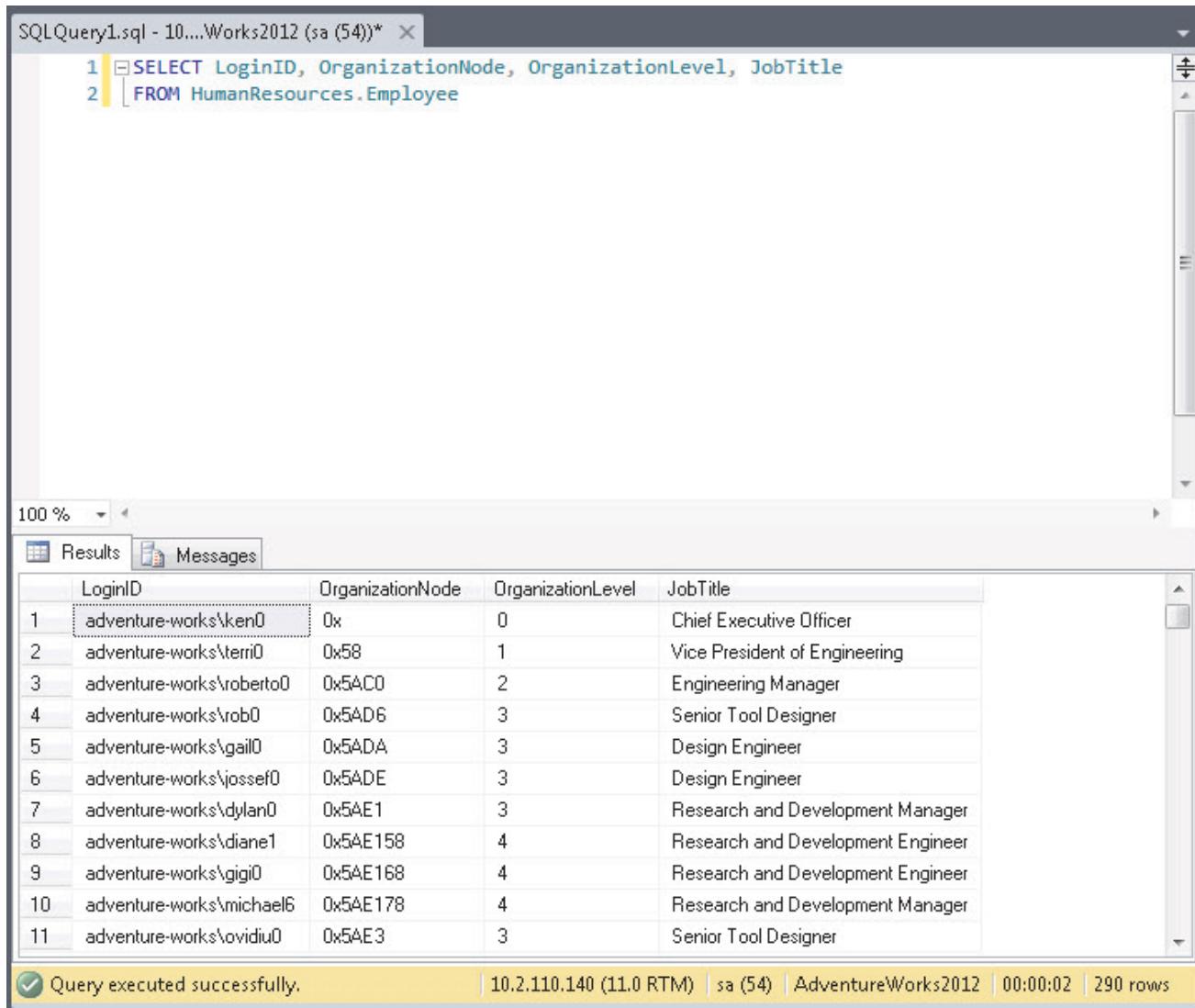
On the **Query** menu, click **Execute**.

OR

Press **F5** or **Alt+X** or **Ctrl+E**.

Figure 3.6 shows the execution of a sample query.

To learn, you must want to be taught.



The screenshot shows the SSMS interface with a query window titled 'SQLQuery1.sql - 10....Works2012 (sa (54))'. The query is:

```

1 | SELECT LoginID, OrganizationNode, OrganizationLevel, JobTitle
2 | FROM HumanResources.Employee

```

The results grid displays the following data:

	LoginID	OrganizationNode	OrganizationLevel	JobTitle
1	adventure-works\ken0	0x	0	Chief Executive Officer
2	adventure-works\terri0	0x58	1	Vice President of Engineering
3	adventure-works\roberto0	0x5AC0	2	Engineering Manager
4	adventure-works\rob0	0x5AD6	3	Senior Tool Designer
5	adventure-works\gail0	0x5ADA	3	Design Engineer
6	adventure-works\jossef0	0x5ADE	3	Design Engineer
7	adventure-works\dyland0	0x5AE1	3	Research and Development Manager
8	adventure-works\diane1	0x5AE158	4	Research and Development Engineer
9	adventure-works\gigi0	0x5AE168	4	Research and Development Engineer
10	adventure-works\michael6	0x5AE178	4	Research and Development Manager
11	adventure-works\ovidiu0	0x5AE3	3	Senior Tool Designer

At the bottom, a message indicates: 'Query executed successfully.' and shows the execution details: '10.2.110.140 (11.0 RTM) | sa (54) | AdventureWorks2012 | 00:00:02 | 290 rows'.

Figure 3.6: Query Result

The query results can be displayed in three different formats. The three formats available are grid, text, and file view.

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3.10 Check Your Progress

1. _____ is a command-line tool in SQL Server 2012.

(A)	SSMS	(C)	SSMSCMD
(B)	SQLCMD	(D)	SQLSSMS

2. The first version of SQL Server was released in the year _____.

(A)	1989	(C)	1992
(B)	1991	(D)	1995

3. Which edition of SQL Server 2012 supports features such as PowerPivot, PowerView, Business Intelligence Semantic Model, Master Data Services, and so on?

(A)	Enterprise	(C)	Business Intelligence
(B)	Standard	(D)	Express

4. Which one of the following components contains Endpoints and Triggers?

(A)	Database	(C)	Server Objects
(B)	Security	(D)	Replication

5. Which of the following statements about the tools in SQL Server 2012 are true?
- a. The SQL Server Installation Center tool can be used to add, remove, and modify SQL Server programs.
 - b. SSQLCMD is an IDE used for Business Intelligence Components. It helps to design the database using Visual Studio.
 - c. SQL Server Profiler is used to monitor an instance of the Database Engine or Analysis Services.
 - d. SQL Server Installation Center is an application provided with SQL Server 2012 that helps to develop databases, query data, and manage the overall working of SQL Server.

(A)	a and b	(C)	b, c, and d
(B)	a, b, and c	(D)	c and d

3.10.1 Answers

1.	B
2.	A
3.	C
4.	C
5.	A



- The basic architecture of SQL Server 2012 includes tools, services, and instances.
- The three editions of SQL Server are Enterprise, Standard, and Business Intelligence.
- The structure of SQL Database includes databases, security, server objects, replications, AlwaysOn High Availability, Management, Integration Services Catalogs, and so on.
- SSMS is used to connect to SQL Server Instances. SSMS is a tool used for developing, querying, and managing the databases.
- The script files should be stored in .sql format in SQL Server 2012.
- The queries typed in Transact-SQL and saved as .sql files can be executed directly into the SSMS query window.

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Session - 4

SQL Azure

Welcome to the Session, **SQL Azure**.

This session explains SQL Azure and its benefits. It also lists the differences between SQL Azure and on-premises SQL Server. Finally, the session explains the process to connect SQL Azure with SSMS.

In this Session, you will learn to:

- Explain SQL Azure
- List the benefits of SQL Azure
- State the differences between SQL Azure and on-premises SQL Server
- List the steps to connect SQL Azure with SSMS

4.1 Introduction

Cloud computing is a technology trend, that involves the delivery of software, platforms, and infrastructure as services through the Internet or networks. Windows Azure is a key offering in Microsoft's suite of cloud computing products and services. The database functions of Microsoft's cloud platform are provided by Windows Azure SQL Database, which is commonly known as SQL Azure.

SQL Azure can be used to store and manage data using queries and other functions that are similar to SQL Server 2012. The data on SQL Azure does not have the constraint of being location-specific. This means that the data stored in SQL Azure can be viewed and edited from any location, as the entire data is stored on cloud storage platform.

4.2 SQL Azure

Consider a scenario of the Income Tax department. During the month of March, the department is flooded with heavy workload. During the rest of the year, the workload may be less. As a result, resources, server, and computing power are under-utilized during those months and over-utilized during peak periods. In such a scenario, using a cloud database service such as SQL Azure can help in optimal use of resources only as and when required.



SQL Azure is a cloud based relational database service that leverages existing SQL Server technologies. Microsoft SQL Azure extends the functionality of Microsoft SQL Server for developing applications that are Web-based, scalable, and distributed.

SQL Azure enables users to perform relational queries, search operations, and synchronize data with mobile users and remote back offices. SQL Azure can store and retrieve both structured and unstructured data.

Both cloud based as well as on-premises applications can use the SQL Azure database.

Applications retrieve data from SQL Azure through a protocol known as Tabular Data Stream (TDS). This protocol is not new to SQL Azure. Whenever on-premises applications involve interaction with SQL Server Database Engine, this protocol is used by the client and the server. Figure 4.1 shows the simplified view of SQL Azure architecture.

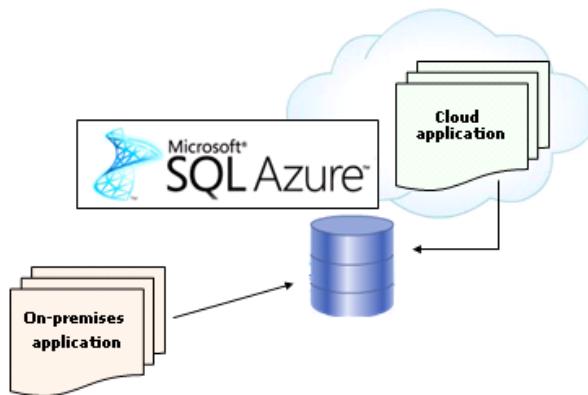


Figure 4.1: Simplified View of SQL Azure Architecture

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The process of SQL Azure operation is explained in the model as shown in figure 4.2.

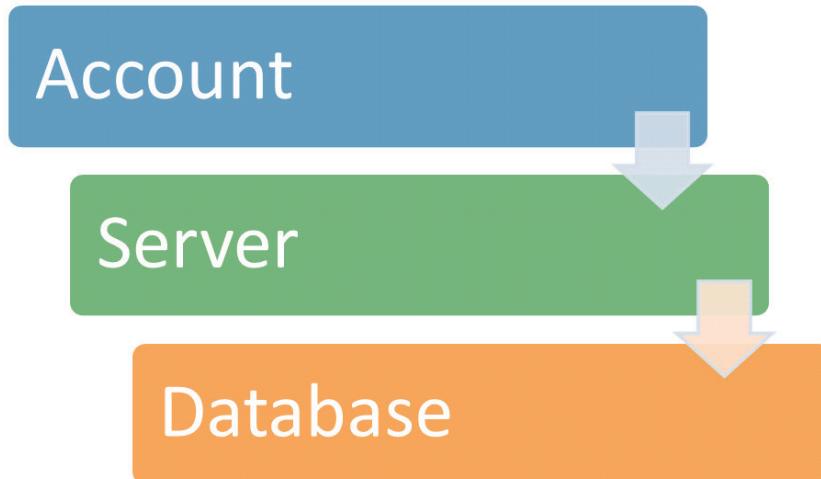


Figure 4.2: SQL Azure Operation Model

The three core objects in the SQL Azure operation model are as follows:

- **Account** – An SQL Azure account must first be created before adding servers that will help to store and manage the data. This account is created for billing purposes. The subscription for an account is recorded and metered and an individual is charged according to the usage. To create an account, the credentials need to be provided. After the user account is created, the requirements need to be provided for the SQL Azure database. This includes the number of databases required, database size, and so on.

Democritus said, words are but the shadows of actions.

- **Server** – The SQL Azure server is the object that helps to interact between the account and the database. After the account is registered, the databases are configured using the SQL Azure server. Other settings such as firewall settings and Domain Name System (DNS) assignment are also configured in the SQL Azure server.
- **Database** – The SQL Azure database stores all the data in a similar manner as any on-premises SQL Server database would store the data. Though present on the cloud, the SQL Azure database has all the functionalities of a normal RDBMS such as tables, views, queries, functions, security settings, and so on.

In addition to these core objects, there is an additional object in SQL Azure. This object is the SQL Azure Data Sync technology. The SQL Azure Data Sync technology is built on Microsoft Sync Framework and SQL Azure database.

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SQL Azure Data Sync helps to synchronize data on the local SQL Server with the data on SQL Azure as shown in figure 4.3.

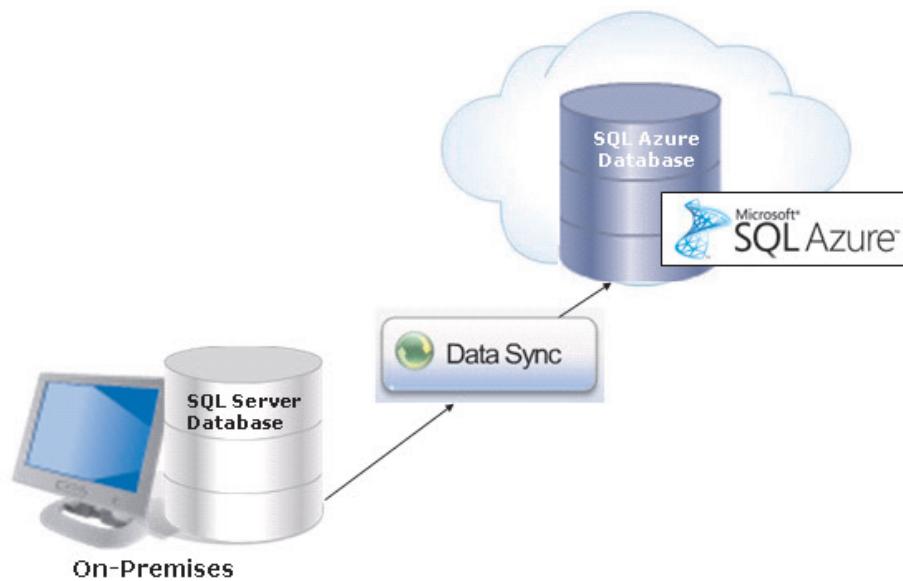


Figure 4.3: Data Sync

Data Sync also has data management capabilities that help to share data easily between different SQL databases. Data Sync is not only used for synchronizing on-premises to SQL Azure, but also to synchronize one SQL Azure account to another.



4.3 Benefits of SQL Azure

The benefits of using SQL Azure are as follows:

- **Lower cost** – SQL Azure provides several functions similar to on-premises SQL Server at a lower cost when compared on-premises instances of SQL Server. Also, as SQL Azure is on the cloud platform, it can be accessed from any location. Hence, there is no additional cost required to develop a dedicated IT infrastructure and department to manage the databases.
- **Usage of TDS** – TDS is used in on-premises SQL Server databases for client libraries. Hence, most developers are familiar with TDS and its use. The same kind of TDS interface is used in SQL Azure to build client libraries. Hence, it is easier for developers to work on SQL Azure.
- **Automatic failover measures** – SQL Azure stores multiple copies of data on different physical locations. Even if there is a hardware failure due to heavy usage or excessive load, SQL Azure helps to maintain the business operations by providing availability of data through other physical locations. This is done by using the automatic failover measures that are provided in SQL Azure.
- **Flexibility in service usage** – Even small organizations can use SQL Azure as the pricing model for SQL Azure is based on the storage capacity that is used by an organization. If the organization needs more storage, the price can be altered to suit the need. This helps the organizations to be flexible in the investment depending on the service usage.
- **Transact-SQL support** – As SQL Azure is completely based on the relational database model, it also supports Transact-SQL operations and queries. This concept is similar to the working of the on-premises SQL Servers. Hence, administrators do not need any additional training or support to use SQL Azure.

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4.4 Difference between SQL Azure and On-Premises SQL Server

The major difference between SQL Azure and on-premises SQL Server is the presence of physical hardware and storage. Some other key distinctions between SQL Azure and on-premises SQL Server are as follows:

- **Tools** – On-premises SQL Server provides a number of tools for monitoring and management. All these tools may not be supported by SQL Azure as there are a limited set of tools that are available in this version.
- **Backup** – Backup and restore function must be supported in on-premises SQL Server for disaster recovery. For SQL Azure, as all the data is on the cloud platform, backup and restore is not required.
- **USE statement** – The `USE` statement is not supported by SQL Azure. Hence, the user cannot switch between databases in SQL Azure as compared to on-premises SQL Server.
- **Authentication** – SQL Azure supports only SQL Server authentication and on-premises SQL Server supports both SQL Server authentication and Windows Authentication.
- **Transact-SQL support** – Not all Transact-SQL functions are supported by SQL Azure.

*Nothing is a waste of time if you use
the experience wisely.*

- **Accounts and Logins** – In SQL Azure, administrative accounts are created in the Azure management portal. Hence, there are no separate instance-level user logins.
- **Firewalls** – Firewalls settings for allowed ports and IP addresses can be managed on physical servers for on-premises SQL Server. As an SQL Azure database is present on cloud, authentication through logins is the only method to verify the user.

4.5 Connect to SQL Azure with SSMS

To access SQL Azure with SSMS, a Windows Azure account must be created. The process of connecting SQL Azure with SSMS is as follows:

1. Create a Windows Azure account online.
2. Open **Microsoft SQL Server Management Studio**.

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3. In the **Connect to Server** dialog box, specify the name of the SQL Azure server as shown in figure 4.4. Each user account of SQL Azure has a specific Server name.



Figure 4.4: Connect to Server Dialog Box with SQL Azure Server

4. In the **Authentication** box, select **SQL Server Authentication**.
5. In the **Login** box, type the name of the SQL Azure administrator account and the password.



6. Click **Connect**. The connection to the Database is successfully established as shown in figure 4.5.

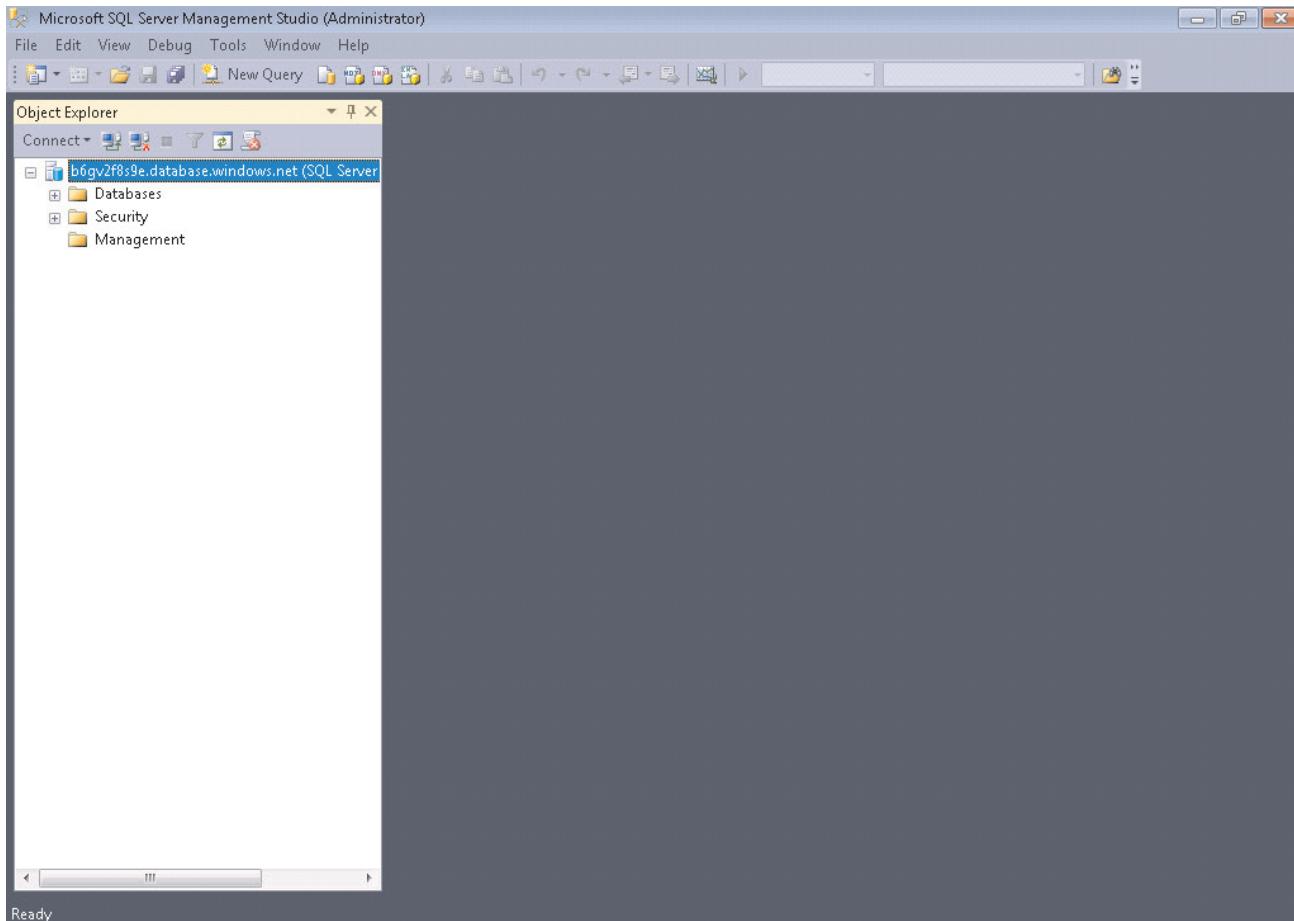


Figure 4.5: Database Window after Successful Connection

Note - The master database is the default database to which SQL Server connects to via SQL Azure. To connect to another database, on the **Connect to Server** box, click **Options** to reveal the **Connection Properties** tab and enter the name of the desired database in the **Connect to database** text box. After a connection to a user-defined database is established, a user cannot switch to other database without disconnecting and reconnecting to the next database. Users can switch from the master database to another database only through SSMS because the `USE` statement is not supported.

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4.6 Check Your Progress

1. Which one of the following protocols is used by applications retrieve data from SQL Server?

(A)	ABS	(C)	TDS
(B)	DTS	(D)	WSQL

2. TDS stands for _____.

(A)	Tabular Data Stream	(C)	Tabular Distinction Stream
(B)	Tabular Data System	(D)	Tabular Direct Stream

3. Which of the following authentication is required to connect to SQL Azure?

(A)	Windows Authentication	(C)	System Administrator Authentication
(B)	SQL Server Authentication	(D)	No Authentication

4. Which of the following helps to synchronize data on the local SQL Server with the data on SQL Azure?

(A)	Authentication	(C)	Data Sync
(B)	TDS	(D)	Server

4.6.1 Answers

1.	C
2.	A
3.	B
4.	C



- Microsoft SQL Azure is a cloud based relational database service that leverages existing SQL Server technologies.
- SQL Azure enables users to perform relational queries, search operations, and synchronize data with mobile users and remote back offices.
- SQL Azure can store and retrieve both structured and unstructured data.
- Applications retrieve data from SQL Azure through a protocol known as Tabular Data Stream (TDS).
- The three core objects in the SQL Azure operation model are account, server, and database.
- SQL Azure Data Sync helps to synchronize data on the local SQL Server with the data on SQL Azure.
- Users can connect to SQL Azure using SSMS.

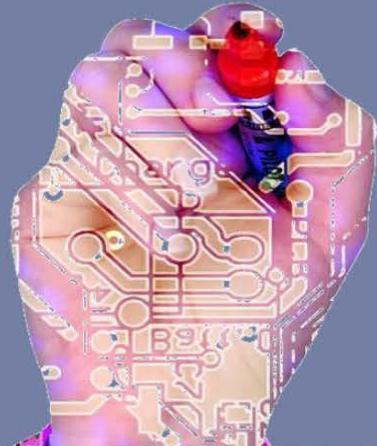
Try It Yourself

1. List out some organizational scenarios where using SQL Azure database would be more advantageous than using on-premises SQL Server database.

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Session - 5

Transact-SQL

Welcome to the Session, **Transact-SQL**.

This session explains Transact-SQL and the different categories of Transact-SQL statements. It also explains the various data types and elements supported by Transact-SQL. Finally, the session explains set theory, predicate logic, and the logical order of operators in the SELECT statement.

In this Session, you will learn to:

- ➔ Explain Transact-SQL
- ➔ List the different categories of Transact-SQL statements
- ➔ Explain the various data types supported by Transact-SQL
- ➔ Explain Transact-SQL language elements
- ➔ Explain sets and predicate logic
- ➔ Describe the logical order of operators in the SELECT statement

5.1 Introduction

SQL is the universal language used in the database world. Most modern RDBMS products use some type of SQL dialect as their primary query language. SQL can be used to create or destroy objects, such as tables, on the database server and to do things with those objects, such as put data into them or query for data. Transact-SQL is Microsoft's implementation of the standard SQL. Usually referred to as T-SQL, this language implements a standardized way to communicate to the database. The Transact-SQL language is an enhancement to SQL, the American National Standards Institute (ANSI) standard relational database language. It provides a comprehensive language that supports defining tables, inserting, deleting, updating, and accessing the data in the table.

5.2 Transact-SQL

Transact-SQL is a powerful language offering features such as data types, temporary objects, and extended stored procedures. Scrollable cursors, conditional processing, transaction control, and exception and error-handling are also some of the features which are supported by Transact-SQL.

The Transact-SQL language in SQL Server 2012 provides improved performance, increased functionality, and enhanced features. Enhancements include scalar functions, paging, sequences, meta-data discovery, and better error handling support.

Learning how to learn is life's most important skill.

Code Snippet 1 shows the Transact-SQL statement, `SELECT`, which is used to retrieve all records of employees with 'Design Engineer' as the `JobTitle` from the `Employee` table.

Code Snippet 1:

```
SELECT LoginID  
FROM Employee  
WHERE JobTitle = 'Design Engineer'
```

Figure 5.1 shows the result that retrieves all records of employees with 'Design Engineer' as the `JobTitle` from the `Employee` table.

LoginID
1
2
3

Figure 5.1: Output of `SELECT` Statement

Transact-SQL includes many syntax elements that are used by or that influence most statements. These elements include data types, predicates, functions, variables, expressions, control-of-flow, comments, and batch separators.

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5.3 Different Categories of Transact-SQL Statements

SQL Server supports three types of Transact-SQL statements, namely, DDL, DML, and DCL.

5.3.1 Data Definition Language (DDL)

DDL, which is usually part of a DBMS, is used to define and manage all attributes and properties of a database, including row layouts, column definitions, key columns, file locations, and storage strategy. DDL statements are used to build and modify the structure of tables and other objects such as views, triggers, stored procedures, and so on. For each object, there are usually CREATE, ALTER, and DROP statements (such as, CREATE TABLE, ALTER TABLE, and DROP TABLE). Most DDL statements take the following form:

- CREATE object_name
- ALTER object_name
- DROP object_name

In DDL statements, object_name can be a table, view, trigger, stored procedure, and so on.

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5.3.2 Data Manipulation Language (DML)

DML is used to select, insert, update, or delete data in the objects defined with DDL. All database users can use these commands during the routine operations on a database. The different DML statements are as follows:

- SELECT statement
- INSERT statement
- UPDATE statement
- DELETE statement

5.3.3 Data Control Language (DCL)

Data is an important part of database, so proper steps should be taken to check that no invalid user accesses the data. Data control language is used to control permissions on database objects. Permissions are controlled by using the GRANT, REVOKE, and DENY statements. DCL statements are also used for securing the database. The three basic DCL statements are as follows:

- GRANT statement
- REVOKE statement
- DENY statement

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5.4 Data Types

A data type is an attribute defining the type of data that an object can contain. Data types must be provided for columns, parameters, variables, and functions that return data values, and stored procedures that have a return code. Transact-SQL includes a number of base data types, such as `varchar`, `text`, and `int`. All data that is stored in SQL Server must be compatible with one of the base data types.

Following objects have data types:

- ➔ Columns present in tables and views
- ➔ Parameters in stored procedures
- ➔ Variables
- ➔ Transact-SQL functions that return one or more data values of a specific data type
- ➔ Stored procedures that have a return code belonging to the integer data type

Who dares to teach must never cease to learn.

Various items in SQL Server 2012 such as columns, variables, and expressions are assigned data types. SQL Server 2012 supports three kinds of data types:

→ System-defined data types

These data types are provided by SQL Server 2012. Table 5.1 shows the commonly used system-defined data types of SQL Server 2012.

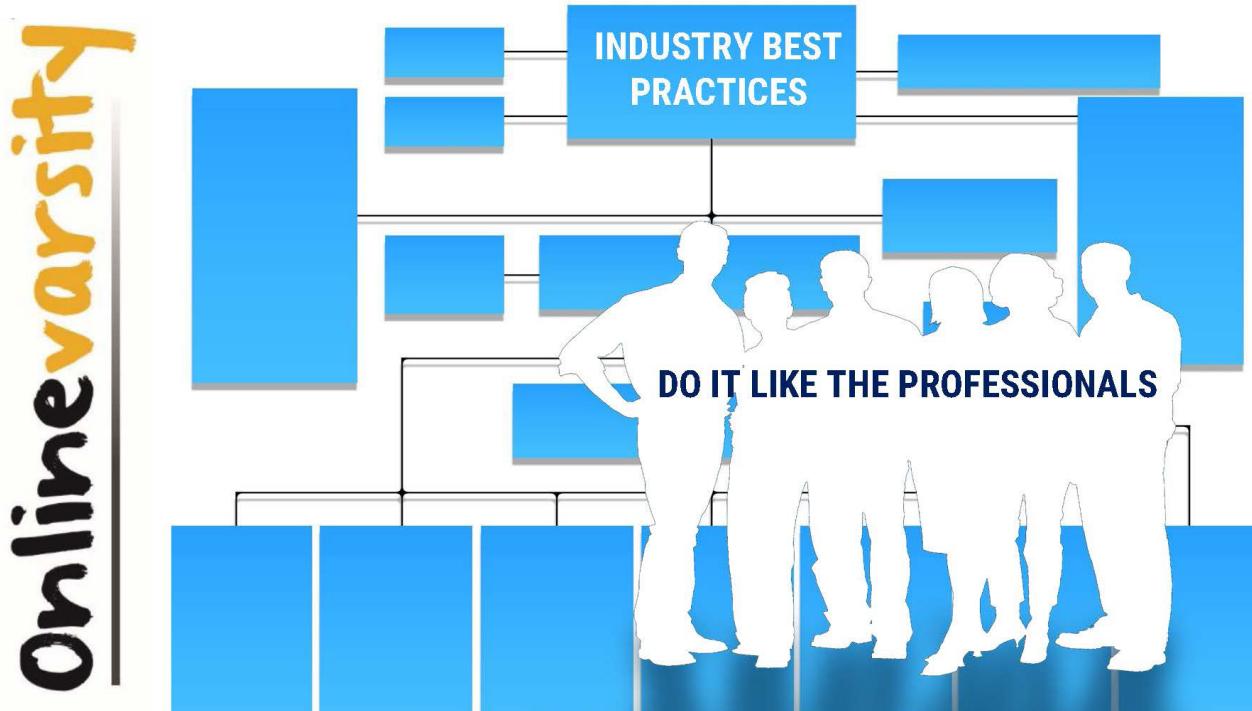
Category	Data Type	Description
Exact Numerics	int	A column of this type occupies 4 bytes of memory space. Is typically used to hold integer values. Can hold integer data from -2^{31} (-2,147,483,648) to $2^{31}-1$ (2,147,483,647).
	smallint	A column of this type occupies 2 bytes of memory space. Can hold integer data from -32,768 to 32,767.
	tinyint	A column of this type occupies 1 byte of memory space. Can hold integer data from 0 to 255.
	bigint	A column of this type occupies 8 bytes of memory space. Can hold data in the range -2^{63} (-9,223,372,036,854,75,808) to $2^{63}-1$ (9,223,372,036,854,775,807).
	numeric	A column of this type has fixed precision and scale.
	money	A column of this type occupies 8 bytes of memory space. Represents monetary data values ranging from $-2^{63}/10000$ (-922,337,203,685,477.5808) to $2^{63}-1$ (922,337,203,685,477.5807).
Approximate Numerics	float	A column of this type occupies 8 bytes of memory space. Represents floating point number ranging from -1.79E+308 through 1.79E+308.
	real	A column of this type occupies 4 bytes of memory space. Represents floating precision number ranging from -3.40E+38 through 3.40E+38.
Date and Time	datetime	Represents date and time. Stored as two 4-byte integers.
	smalldatetime	Represents date and time.
Character String	char	Stores character data that is fixed-length and non-Unicode.
	varchar	Stores character data that is variable-length and non-Unicode with a maximum of 8,000 characters.
	text	Stores character data that is variable-length and non-Unicode with a maximum length of $2^{31}-1$ (2,147,483,647) characters.

Category	Data Type	Description
Unicode Types	nchar	Stores Unicode character data of fixed-length.
	nvarchar	Stores variable-length Unicode character data.
Other Data Types	timestamp	A column of this type occupies 8 bytes of memory space. Can hold automatically generated, unique binary numbers that are generated for a database.
	binary(n)	Stores fixed-length binary data with a maximum length of 8000 bytes.
	varbinary(n)	Stores variable-length binary data with a maximum length of 8000 bytes.
	image	Stores variable-length binary data with a maximum length of $2^{30}-1$ (1,073,741,823) bytes.
	uniqueidentifier	A column of this type occupies 16 bytes of memory space. Also, stores a globally unique identifier (GUID).

Table 5.1: System-Defined Data Types

→ **Alias data types**

These are based on the system-supplied data types. Alias data types are used when more than one table stores the same type of data in a column and has similar characteristics such as length, nullability, and type. In such cases, an alias data type can be created that can be used commonly by all these tables.



Alias data types can be created using the CREATE TYPE statement. The syntax for the CREATE TYPE statement is as follows:

Syntax:

```
CREATE TYPE [ schema_name. ] type_name { FROM base_type [ ( precision [, scale] ) ] [ NULL | NOT NULL ] } [ ; ]
```

where,

schema_name: identifies the name of the schema in which the alias data type is being created. A schema is a collection of objects such as tables, views, and so forth in a database.

type_name: identifies the name of the alias type being created.

base_type: identifies the name of the system-defined data type based on which the alias data type is being created.

precision and scale: specify the precision and scale for numeric data.

NULL | NOT NULL: specifies whether the data type can hold a null value or not.

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Code Snippet 2 shows how to create an alias data type using `CREATE TYPE` statement.

Code Snippet 2:

```
CREATE TYPE usertype FROM varchar (20) NOT NULL
```

In the code, the built-in data type `varchar` is stored as a new data type named `usertype` by using the `CREATE TYPE` statement.

→ **User-defined types**

These are created using programming languages supported by the .NET Framework.

5.5 Transact-SQL Language Elements

The Transact-SQL language elements are used in SQL Server 2012 for working on the data that is entered in SQL Server database. The Transact-SQL language elements includes predicates, operators, functions, variables, expressions, control-of-flow, errors, and transactions, comments, and batch separators.

5.5.1 Predicates and Operators

Predicates are used to evaluate whether an expression is `TRUE`, `FALSE`, or `UNKNOWN`. Some of the predicates available in Transact-SQL are as follows:

- `IN` - Determines whether a specified value matches any value in a subquery or a list.
- `BETWEEN` - Specifies a range of values to test.
- `LIKE` - Used to match characters against a specified pattern.
- `CONTAINS` - Searches for precise or less precise matches to single words and phrases, words within a certain distance of one another, or weighted matches.

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

Table 5.2 shows some examples of the predicates.

Predicate	Example
IN	SELECT UserID, FirstName, LastName, Salary FROM Employee WHERE Salary IN(5000,20000);
BETWEEN	Select UserID, FirstName, LastName, Salary FROM Employee WHERE Salary BETWEEN 5000 and 20000;
LIKE	Select UserID, FirstName, LastName, Salary FROM Employee WHERE FirstName LIKE '%h%'
CONTAINS	SELECT UserID, FirstName, LastName, Salary FROM Employee WHERE Salary CONTAINS(5000);

Table 5.2: Predicate Examples

Operators are used to perform arithmetic, comparison, concatenation, or assignment of values. For example, data can be tested to verify that the **COUNTRY** column for the customer data is populated (or has a NOT NULL value). In queries, anyone who can see the data in the table requiring an operator can perform operations. Appropriate permissions are required before data can be successfully changed. SQL Server has seven categories of operators.

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Table 5.3 describes the different operators supported in SQL Server 2012.

Operator	Description	Example
Comparison	Compares a value against another value or an expression	=, <, >, >=, <=, !=, !=>
Logical	Tests for the truth of a condition	AND, OR, NOT
Arithmetic	Performs arithmetic operations such as addition, subtraction, multiplication, and division	+, -, *, /, %
Concatenation	Combines two strings into one string	+
Assignment	Assigns a value to a variable	=

Table 5.3: Operators

Table 5.4 shows the precedence of predicates and operators.

Order	Operators
1	() Parentheses
2	*, /, %
3	+, -
4	=, <, >, >=, <=, !=, !=>
5	NOT
6	AND
7	BETWEEN, IN, CONTAINS, LIKE, OR
8	=

Table 5.4: Precedence of Predicates and Operators



Code Snippet 3 shows execution of operators according to precedence.

Code Snippet 3:

```
DECLARE @Number int;  
SET @Number = 2 + 2 * (4 + (5 - 3))  
SELECT @Number
```

Here, the steps to arrive at the result are as follows:

1. $2 + 2 * (4 + (5 - 3))$
2. $2 + 2 * (4 + 2)$
3. $2 + 2 * 6$
4. $2 + 12$
5. 14

Hence, the code will display 14.

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5.5.2 Functions

A function is a set of Transact-SQL statements that is used to perform some task. Transact-SQL includes a large number of functions. These functions can be useful when data is calculated or manipulated. In SQL, functions work on the data, or group of data, to return a required value. They can be used in a `SELECT` list, or anywhere in an expression. The four types of functions in SQL Server 2012 are as follows:

- **Rowset functions** - In Transact-SQL, the rowset function is used to return an object that can be used in place of a table reference. For example, `OPENDATASOURCE`, `OPENQUERY`, `OPENROWSET`, and `OPENXML` are rowset functions.
- **Aggregate functions** - Transact-SQL provides aggregate functions to assist with the summarization of large volumes of data. For example, `SUM`, `MIN`, `MAX`, `AVG`, `COUNT`, `COUNTBIG`, and so on are aggregate functions.
- **Ranking functions** - Many tasks, such as creating arrays, generating sequential numbers, finding ranks, and so on can be implemented in an easier and faster way by using ranking functions. For example, `RANK`, `DENSE _ RANK`, `NTILE`, and `ROW _ NUMBER` are ranking functions.
- **Scalar functions** - In scalar functions, the input is a single value and the output received is also a single value.

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

Table 5.5 shows the commonly used scalar functions in SQL.

Function Name	Description	Example
Conversion function	The conversion function is used to transform a value of one data type to another. Additionally, it can be used to obtain a variety of special date formats.	CONVERT
Date and time function	Date and time functions are used to manipulate date and time values. They are useful to perform calculations based on time and dates.	GETDATE, SYSDATETIME, GETUTCDATE, DATEADD, DATEDIFF, YEAR, MONTH, DAY
Mathematical function	Mathematical functions perform algebraic operations on numeric values.	RAND, ROUND, POWER, ABS, CEILING, FLOOR
System function	SQL Server provides system functions for returning metadata or configuration settings.	HOST_ID, HOST_NAME, ISNULL
String function	String functions are used for string inputs such as char and varchar. The output can be a string or a numeric value.	SUBSTRING, LEFT, RIGHT, LEN, DATALENGTH, REPLACE, REPLICATE, UPPER, LOWER, RTRIM, LTRIM

Table 5.5: Scalar Functions

There are also other scalar functions such as cursor functions, logical functions, metadata functions, security functions, and so on that are available in SQL Server 2012.

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5.5.3 Variables

A variable is an object that can hold a data value. In Transact-SQL, variables can be classified into local and global variables.

In Transact-SQL, local variables are created and used for temporary storage while SQL statements are executed. Data can be passed to SQL statements using local variables. The name of a local variable must be prefixed with '@' sign.

Global variables are in-built variables that are defined and maintained by the system. Global variables in SQL Server are prefixed with two '@' signs. The value of any of these variables can be retrieved with a simple `SELECT` query.

5.5.4 Expressions

An expression is a combination of identifiers, values, and operators that SQL Server can evaluate in order to obtain a result. Expressions can be used in several different places when accessing or changing data.

Code Snippet 4 shows an expression that operates on a column to add an integer to the results of the `YEAR` function on a `datetime` column.

Code Snippet 4:

```
SELECT SalesOrderID, CustomerID, SalesPersonID, TerritoryID, YEAR(OrderDate)
AS CurrentYear, YEAR(OrderDate) + 1 AS NextYear
FROM Sales.SalesOrderHeader
```



Figure 5.2 shows the results of the expression.

The screenshot shows a SQL Server Management Studio window with the 'Results' tab selected. The results grid displays a table with seven columns: SalesOrderID, CustomerID, SalesPersonID, TerritoryID, CurrentYear, and NextYear. The data consists of 11 rows, each containing a unique SalesOrderID and corresponding values for the other columns. The first row is highlighted with a yellow background.

	SalesOrderID	CustomerID	SalesPersonID	TerritoryID	CurrentYear	NextYear
1	43659	29825	279	5	2005	2006
2	43660	29672	279	5	2005	2006
3	43661	29734	282	6	2005	2006
4	43662	29994	282	6	2005	2006
5	43663	29565	276	4	2005	2006
6	43664	29898	280	1	2005	2006
7	43665	29580	283	1	2005	2006
8	43666	30052	276	4	2005	2006
9	43667	29974	277	3	2005	2006
10	43668	29614	282	6	2005	2006
11	43669	29747	283	1	2005	2006

Figure 5.2: Expression Result

5.5.5 Control-of-Flow, Errors, and Transactions

Although Transact-SQL is primarily a data retrieval language, it supports control-of-flow statements for executing and finding errors. Control-of-flow language determines the execution flow of Transact-SQL statements, statement blocks, user-defined functions, and stored procedures.

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Table 5.6 shows some of the commonly used control-of-flow statements in Transact-SQL.

Control-of-Flow Statement	Description
IF . . . ELSE	Provides branching control based on a logical test.
WHILE	Repeats a statement or a block of statements as long as the condition is true.
BEGIN . . . END	Defines the scope of a block of Transact-SQL statements.
TRY . . . CATCH	Defines the structure for exception and error handling.
BEGIN TRANSACTION	Marks a block of statements as part of an explicit transaction.

Table 5.6: Control-of-Flow Statements

5.5.6 Comments

Comments are descriptive text strings, also known as remarks, in program code that will be ignored by the compiler. Comments can be included inside the source code of a single statement, a batch, or a stored procedure. Comments explain the purpose of the program, special execution conditions, and provide revision history information. Microsoft SQL Server supports two types of commenting styles:

→ **-- (double hyphens)**

A complete line of code or a part of a code can be marked as a comment, if two hyphens (--) are placed at the beginning. The remainder of the line becomes a comment.

To avoid criticism, do nothing, say nothing, be nothing.

Code Snippet 5 displays the use of this style of comment.

Code Snippet 5:

```
USE AdventureWorks2012
-- HumanResources.Employee table contains the details of an employee.
-- This statement retrieves all the rows of the table
-- HumanResources.Employee.

SELECT * FROM HumanResources.Employee
```

→ /* ... */ (forward slash-asterisk character pairs)

These comment characters can be used on the same line as code to be executed, on lines by themselves, or even within executable code. Everything in the line beginning from the open comment pair /* to the close comment pair */ is considered part of the comment. For a multiple-line comment, the open-comment character pair /* must begin the comment, and the close-comment character pair */ must end the comment.

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Code Snippet 6 displays the use of this style of comment.

Code Snippet 6:

```
USE AdventureWorks2012
/* HumanResources.Employee table contains the details of an employee.
This statement retrieves all the rows of the table
HumanResources.Employee.*/
SELECT * FROM HumanResources.Employee
```

5.5.7 Batch Separators

A batch is a collection of one or more Transact-SQL statements sent at one time from an application to SQL Server for execution. The Transact-SQL statements in a batch are compiled into a single executable unit, called an execution plan. The statements in the execution plan are then executed one at a time. The process wherein a set of commands are processed one at a time from a batch of commands is called batch processing.

A batch separator is handled by SQL Server client tools such as SSMS to execute commands. For example, you need to specify GO as a batch separator in SSMS.



An example of a batch statement is given in Code Snippet 7.

Code Snippet 7:

```
USE AdventureWorks2012  
SELECT * FROM HumanResources.Employee  
GO
```

In Code Snippet 7, the two statements will be grouped into one execution plan, but executed one statement at a time. The GO keyword signals the end of a batch.

5.6 Sets and Predicate Logic

Sets and Predicate Logic are the two mathematical fundamentals that are used in SQL Server 2012. Both these theories are used in querying of data in SQL Server 2012.

5.6.1 Set Theory

Set theory is a mathematical foundation used in relational database model. A set is a collection of distinct objects considered as a whole. For example, all the employees under an **Employee** table can be considered as one set. The employees are the different objects that form a part of the set in the **Employee** table.

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Table 5.7 shows the different applications in the set theory and their corresponding application in SQL Server queries.

Set Theory Applications	Application in SQL Server Queries
Act on the whole set at once.	Query the whole table at once.
Use declarative, set-based processing.	Use attributes in SQL Server to retrieve specific data.
Elements in the set must be unique.	Define unique keys in the table.
No sorting instructions.	The results of querying are not retrieved in any order.

Table 5.7: Application in Set Theory with SQL Server Queries

5.6.2 Predicate Logic

Predicate logic is a mathematical framework that consists of logical tests that gives a result. The results are always displayed as either true or false. In Transact-SQL, expressions such as WHERE and CASE expressions are based on predicate logic. Predicate logic is also used in other situations in Transact-SQL.

Learning is not compulsory, but neither is survival.

Some of the applications of predicate logic in Transact-SQL are as follows:

- Enforcing data integrity using the `CHECK` constraint
- Control-of-flow using the `IF` statement
- Joining tables using the `ON` filter
- Filtering data in queries using the `WHERE` and `HAVING` clause
- Providing conditional logic to `CASE` expressions
- Defining subqueries

5.7 Logical Order of Operators in `SELECT` Statement

Along with the syntax of different SQL Server elements, an SQL Server user must also know the process of how the entire query is executed. This process is a logical process that breaks the query and executes the query according to a predefined sequence in SQL Server 2012. The `SELECT` statement is a query that will be used to explain the logical process of query execution.

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Following is the syntax of the SELECT statement.

Syntax:

```
SELECT <selectlist>
FROM <table source>
WHERE <search condition>
GROUP BY <groupby list>
HAVING <search condition>
ORDER BY <orderby list>
```

Table 5.8 explains the elements of the SELECT statement.

Element	Description
SELECT <select list>	Defines the columns to be returned
FROM <table source>	Defines the table to be queried
WHERE <search condition>	Filters the rows by using predicates
GROUP BY <group by list>	Arranges the rows by groups
HAVING <search condition>	Filters the groups using predicates
ORDER BY <orderby list>	Sorts the output

Table 5.8: Elements of SELECT Statement

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Code Snippet 8 shows a SELECT statement.

Code Snippet 8:

```
SELECT SalesPersonID, YEAR(OrderDate) AS OrderYear  
FROM Sales.SalesOrderHeader  
WHERE CustomerID = 30084  
GROUP BY SalesPersonID, YEAR(OrderDate)  
HAVING COUNT(*) > 1  
ORDER BY SalesPersonID, OrderYear;
```

In the example, the order in which SQL Server will execute the SELECT statement is as follows:

1. First, the `FROM` clause is evaluated to define the source table that will be queried.
2. Next, the `WHERE` clause is evaluated to filter the rows in the source table. This filtering is defined by the predicate mentioned in the `WHERE` clause.
3. After this, the `GROUP BY` clause is evaluated. This clause arranges the filtered values received from the `WHERE` clause.
4. Next, the `HAVING` clause is evaluated based on the predicate that is provided.

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5. Next, the `SELECT` clause is executed to determine the columns that will appear in the query results.

6. Finally, the `ORDER BY` statement is evaluated to display the output.

The order of execution for the `SELECT` statement in Code Snippet 8 would be as follows:

```
5. SELECT SalesPersonID, YEAR(OrderDate) AS OrderYear  
1. FROM SalesOrderHeader  
2. WHERE CustomerID = 30084  
3. GROUP BY SalesPersonID, YEAR(OrderDate)  
4. HAVING COUNT(*) > 1  
6. ORDER BY SalesPersonID, OrderYear;
```

Figure 5.3 shows the result of the `SELECT` statement.

The screenshot shows the SSMS interface with the 'Results' tab selected. A table is displayed with four rows and two columns. The columns are labeled 'SalesPersonID' and 'OrderYear'. The data is as follows:

	SalesPersonID	OrderYear
1	279	2005
2	279	2006
3	279	2007
4	279	2008

Figure 5.3: SELECT Statement Result

A wise man learns from the mistakes of others, a fool by his own.

5.8 Check Your Progress

1. Which of the following is used to define and manage all attributes and properties of a database, including row layouts, column definitions, key columns, file locations, and storage strategy?

(A)	DDL	(C)	DCL
(B)	DML	(D)	DPL

2. Which of the following is not used in DCL?

(A)	GRANT statement	(C)	UPDATE statement
(B)	REVOKE statement	(D)	DENY statement

3. Which of the following specifies a range of values to test?

(A)	IN	(C)	LIKE
(B)	BETWEEN	(D)	CONTAINS

4. Match the following.

Control-of-Flow Statement		Description	
a.	IF... ELSE	1.	Marks a block of statements as part of an explicit transaction.
b.	WHILE	2.	Defines the structure for exception and error handling.
c.	BEGIN... END	3.	Repeats a statement or a block of statements when the condition is true.
d.	TRY... CATCH	4.	Defines the scope of a block of Transact-SQL statements.
e.	BEGIN TRANSACTION	5.	Provides branching control based on a logical test.

(A)	a-4, b-2, c-3, d-1, e-5	(C)	a-1, b-4, c-5, d-3, e-2
(B)	a-1, b-2, c-4, d-3, e-5	(D)	a-5, b-3, c-4, d-2, e-1

5. Which of the following are the two mathematical fundamentals that are used in SQL Server 2012?

(A)	Fractions and Sets	(C)	Predicate Logic and Fractions
(B)	Sets and Predicate Logic	(D)	Probability and Fractions

6. Which of the following will be the result of the code?

```
SET @Number = 2 * (4 + 5) + 2 * (4 + (5 - 3))
```

(A)	120	(C)	42
(B)	62	(D)	26

5.8.1 Answers

1.	A
2.	C
3.	B
4.	D
5.	B
6.	C



- Transact-SQL is a powerful language which offers features such as data types, temporary objects, and extended stored procedures.
- SQL Server supports three types of Transact-SQL statements, namely, DDL, DML, and DCL.
- A data type is an attribute defining the type of data that an object can contain.
- The Transact-SQL language elements includes predicates, operators, functions, variables, expressions, control-of-flow, errors, and transactions, comments, and batch separators.
- Sets and Predicate Logic are the two mathematical fundamentals that are used in SQL Server 2012.
- Set theory is a mathematical foundation used in relational database model, where a set is a collection of distinct objects considered as a whole.
- Predicate logic is a mathematical framework that consists of logical tests that gives a result.

Try It Yourself

1. Use the Query Editor to execute a query. Ensure that a connection to a new server instance is established. Then, in the AdventureWorks2012 database, execute a query to select the columns namely, ProductID, Name, and ProductNumber from Production.Product table, and ProductID and ModifiedDate from Production.ProductDocument table.

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Session - 6

Creating and Managing Databases

Welcome to the Session, **Creating and Managing Databases**.

This session describes system and user defined databases. It also lists the key features of the AdventureWorks2012 database. Finally, the session describes types of database modification.

In this Session, you will learn to:

- Describe system and user-defined databases
- List the key features of the AdventureWorks2012 sample database
- Describe adding of filegroups and transaction logs
- Describe the procedure to create a database
- List and describe types of database modifications
- Describe the procedure to drop a database
- Describe database snapshots

6.1 Introduction

A database is a collection of data stored in data files on a disk or some removable medium. A database consists of data files to hold actual data.

An SQL Server database is made up of a collection of tables that stores sets of specific structured data. A table includes a set of rows (also called as records or tuples) and columns (also called as attributes). Each column in the table is intended to store a specific type of information, for example, dates, names, currency amounts, and numbers.

A user can install multiple instances of SQL Server on a computer. Each instance of SQL Server can include multiple databases. Within a database, there are various object ownership groups called schemas. Within each schema, there are database objects such as tables, views, and stored procedures. Some objects such as certificates and asymmetric keys are contained within the database, but are not contained within a schema.

SQL Server databases are stored as files in the file system. These files are grouped into file groups. When people gain access to an instance of SQL Server, they are identified as a login. When people gain access to a database, they are identified as a database user.

A user who has access to a database can be given permission to access the objects in the database. Though permissions can be granted to individual users, it is recommended to create database roles, add the database users to the roles, and then, grant access permission to the roles. Granting permissions to roles instead of users makes it easier to keep permissions consistent and understandable as the number of users grow and continually change.



SQL Server 2012 supports three kinds of databases, which are as follows:

- System Databases
- User-defined Databases
- Sample Databases

6.2 System Databases

SQL Server uses system databases to support different parts of the DBMS. Each database has a specific role and stores job information that requires to be carried out by SQL Server. The system databases store data in tables, which contain the views, stored procedures, and other database objects. They also have associated database files (for example, .mdf and .ldf files) that are physically located on the SQL Server machine.

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Table 6.1 shows the system databases that are supported by SQL Server 2012.

Database	Description
master	The database records all system-level information of an instance of SQL Server.
msdb	The database is used by SQL Server Agent for scheduling database alerts and various jobs.
model	The database is used as the template for all databases to be created on the particular instance of SQL Server 2012.
resource	The database is a read-only database. It contains system objects included with SQL Server 2012.
tempdb	The database holds temporary objects or intermediate result sets.

Table 6.1: System Databases

6.2.1 Modifying System Data

Users are not allowed to directly update the information in system database objects, such as system tables, system stored procedures, and catalog views. However, users can avail a complete set of administrative tools allowing them to fully administer the system and manage all users and database objects.

You must do the things you think you cannot do.

These are as follows:

- **Administration utilities:** From SQL Server 2005 onwards, several SQL Server administrative utilities are integrated into SSMS. It is the core administrative console for SQL Server installations. It enables to perform high-level administrative functions, schedule routine maintenance tasks, and so forth. Figure 6.1 shows the SQL Server 2012 Management Studio window.

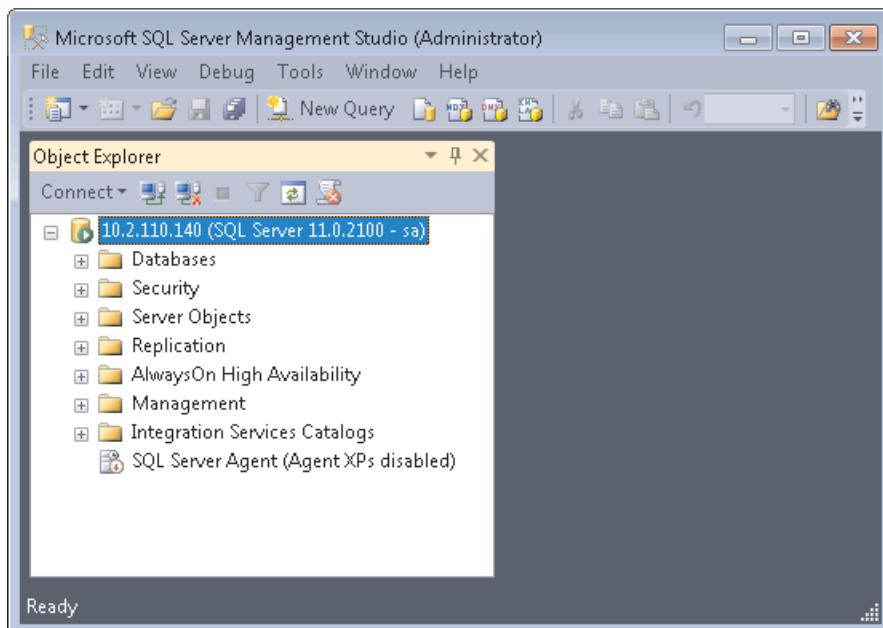


Figure 6.1: SQL Server Management Studio Window

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- **SQL Server Management Objects (SQL-SMO) API:** Includes complete functionality for administering SQL Server in applications.
- **Transact-SQL scripts and stored procedures:** These use system stored procedures and Transact-SQL DDL statements. Figure 6.2 shows a Transact-SQL query window.

```

SQLQuery2.sql - 10...140.master (sa (61)) X
1  /***** Script for SelectTopNRows command from SSMS *****/
2  SELECT TOP 1000 [AddressID]
3    ,[AddressLine1]
4    ,[AddressLine2]
5    ,[City]
6    ,[StateProvinceID]
7    ,[PostalCode]
8    ,[SpatialLocation]
9    ,[rowguid]
10   ,[ModifiedDate]
11  FROM [AdventureWorks2012].[Person].[Address]

```

	AddressID	AddressLine1	AddressLine2	City	StateProvinceID	PostalCode	Spatial
1	1	1970 Napa Ct.	NULL	Bothell	79	98011	0xE6
2	2	9833 Mt. Dias Blv.	NULL	Bothell	79	98011	0xE6
3	3	7484 Roundtree Drive	NULL	Bothell	79	98011	0xE6
4	4	9539 Glenside Dr	NULL	Bothell	79	98011	0xE6
5	5	1226 Shoe St.	NULL	Bothell	79	98011	0xE6
6	6	1399 Firestone Drive	NULL	Bothell	79	98011	0xE6
7	7	5672 Hale Dr.	NULL	Bothell	79	98011	0xE6
8	8	6387 Scenic Avenue	NULL	Bothell	79	98011	0xE6

Query executed successfully. | 10.2.110.140 (11.0 RTM) | sa (61) | master | 00:00:00 | 1000 rows

Figure 6.2: Transact-SQL Query Window



These tools also guard applications from making changes in the system objects.

6.2.2 Viewing System Database Data

Database applications can determine catalog and system information by using any of these approaches:

- **System catalog views:** Views displaying metadata for describing database objects in an SQL Server instance.
- **SQL-SMO:** New managed code object model, providing a set of objects used for managing Microsoft SQL Server.
- **Catalog functions, methods, attributes, or properties of the data API:** Used in ActiveX Data Objects (ADO), OLE DB, or ODBC applications.
- **Stored Procedures and Functions:** Used in Transact-SQL as stored procedures and built-in functions.

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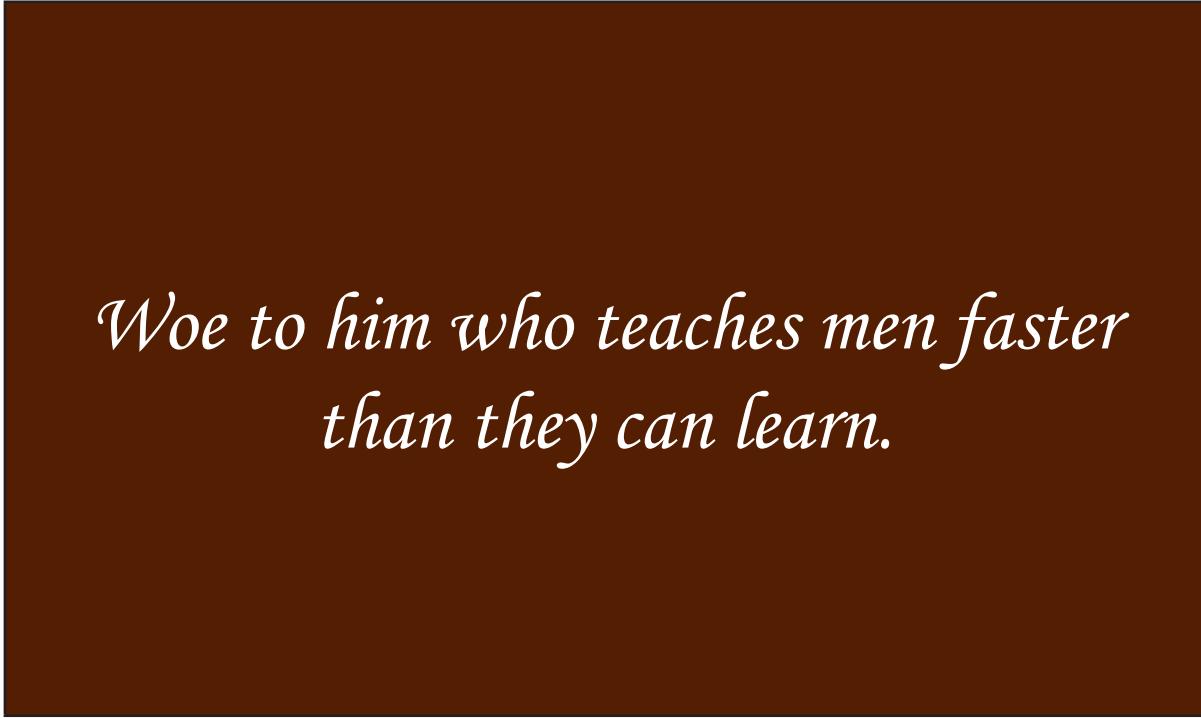
6.3 User-defined Databases

Using SQL Server 2012, users can create their own databases, also called user-defined databases, and work with them. The purpose of these databases is to store user data.

6.3.1 Creating Databases

To create a user-defined database, the information required is as follows:

- Name of the database
- Owner or creator of the database
- Size of the database
- Files and filegroups used to store it



*Woe to him who teaches men faster
than they can learn.*

Following is the syntax to create a user-defined database.

Syntax:

```
CREATE DATABASE DATABASE_NAME
[ ON
[ PRIMARY ] [ <filespec> [ ,...n ]
[ , <filegroup> [ ,...n ] ]
[ LOGON { <filespec> [ ,...n ] } ]
]
[ COLLATE collation_name ]
]
[ ; ]
```

where,

DATABASE_NAME: is the name of the database to be created.

ON: indicates the disk files to be used to store the data sections of the database and data files.

PRIMARY: is the associated <filespec> list defining the primary file.

<filespec>: controls the file properties.

<filegroup>: controls filegroup properties.

LOG ON: indicates disk files to be used for storing the database log and log files.**COLLATE collation_name:** is the default collation for the database. A collation defines rules for comparing and sorting character data based on the standard of particular language and locale. Collation name can be either a Windows collation name or a SQL collation name.

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Code Snippet 1 shows how to create a database with database file and transaction log file with collation name.

Code Snippet 1:

```
CREATE DATABASE [Customer_DB] ON PRIMARY
( NAME = 'Customer_DB', FILENAME = 'C:\Program Files\Microsoft SQL Server\
MSSQL11.MSSQLSERVER\MSSQL\DATA\Customer_DB.mdf')
LOG ON
( NAME = 'Customer_DB_log', FILENAME = 'C:\Program Files\Microsoft SQL Server\
MSSQL11.MSSQLSERVER\MSSQL\DATA\Customer_DB_log.ldf')
COLLATE SQL_Latin1_General_CI_AS
```



TIPS & TRICKS

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~~HARD~~ SMART
 WORKING
 PROFESSIONAL**



After executing the code in Code Snippet 1, SQL Server 2012 displays the message 'Command(s) completed successfully'.

Figure 6.3 shows the database **Customer_DB** listed in the **Object Explorer**.

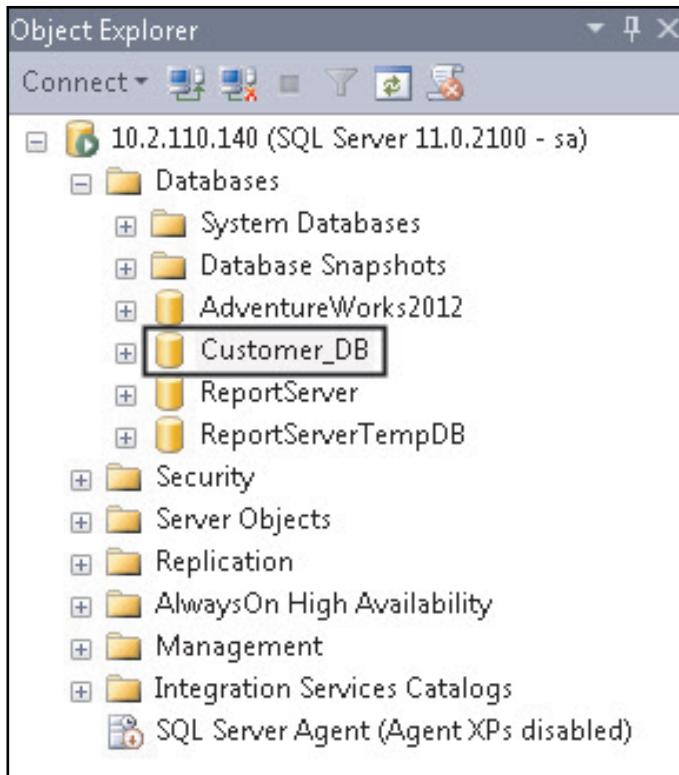


Figure 6.3: Customer_DB Database

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6.3.2 Modifying Databases

As a user-defined database grows or diminishes, the database size will be expanded or be shrunk automatically or manually. Based on changing requirements from time to time, it may be found necessary to modify a database.

Following is the syntax to modify a database:

Syntax:

```
ALTER DATABASE database_name
{
<add_or_modify_files>
| <add_or_modify_filegroups>
| <set_database_options>
| MODIFY NAME = new_database_name
| COLLATE collation_name
}
[ ; ]
```

where,

`database_name`: is the original name of the database.

`MODIFY NAME = new_database_name`: is the new name of the database to which it is to be renamed.

`COLLATE collation_name`: is the collation name of the database.

`<add_or_modify_files>`: is the file to be added, removed, or modified.

`<add_or_modify_filegroups>`: is the filegroup to be added, modified, or removed from the database.

`<set_database_options>`: is the database-level option influencing the characteristics of the database that can be set for each database. These options are unique to each database and do not affect other databases.

*Real generosity towards the future lies
in giving all to the present.*

Code Snippet 2 shows how to rename a database **Customer_DB** with a new database name, **CUST_DB**.

Code Snippet 2:

```
ALTER DATABASE Customer_DB MODIFY NAME = CUST_DB
```

Figure 6.4 shows database **Customer_DB** is renamed with a new database name, **CUST_DB**.

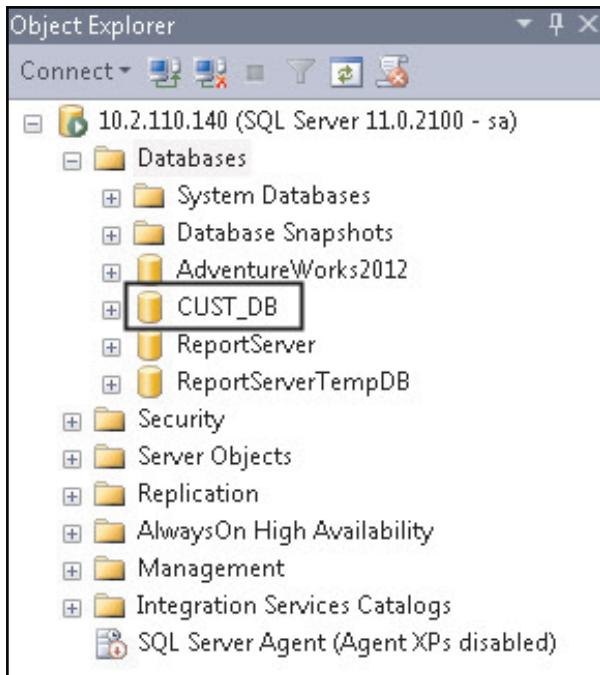


Figure 6.4: New Database Name CUST_DB

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6.3.3 Ownership of Databases

In SQL Server 2012, the ownership of a user-defined database can be changed. Ownership of system databases cannot be changed. The system procedure `sp_changedbowner` is used to change the ownership of a database. The syntax is as follows:

Syntax:

```
sp_changedbowner [ @loginame = ] 'login'
```

where,

`login` is an existing database username.

After `sp_changedbowner` is executed, the new owner is known as the `dbo` user inside the selected database. The `dbo` receives permissions to perform all activities in the database. The owner of the `master`, `model`, or `tempdb` system databases cannot be changed.

Code Snippet 3, when executed, makes the login '`sa`' the owner of the current database and maps '`sa`' to existing aliases that are assigned to the old database owner, and will display 'Command(s) completed successfully'.

Code Snippet 3:

```
USE CUST_DB
EXEC sp_changedbowner 'sa'
```



6.3.4 Setting Database Options

Database-level options determine the characteristics of the database that can be set for each database. These options are unique to each database, so they do not affect other databases. These database options are set to default values when a database is first created, and can then, be changed by using the SET clause of the ALTER DATABASE statement.

Table 6.2 shows the database options that are supported by SQL Server 2012.

Option Type	Description
Automatic options	Controls automatic behavior of database.
Cursor options	Controls cursor behavior.
Recovery options	Controls recovery models of database.
Miscellaneous options	Controls ANSI compliance.
State options	Controls state of database, such as online/offline and user connectivity.

Table 6.2: Databases Options in SQL Server 2012

Note- Server-wide settings are set using the `sp_configure` system stored procedure or SQL Management Studio.

Code Snippet 4 when executed sets `AUTO_SHRINK` option for the `CUST_DB` database to `ON`. The `AUTO_SHRINK` options when set to `ON`, shrinks the database that have free space.

Code Snippet 4:

```
USE CUST_DB;
ALTER DATABASE CUST_DB
SET AUTO_SHRINK ON
```

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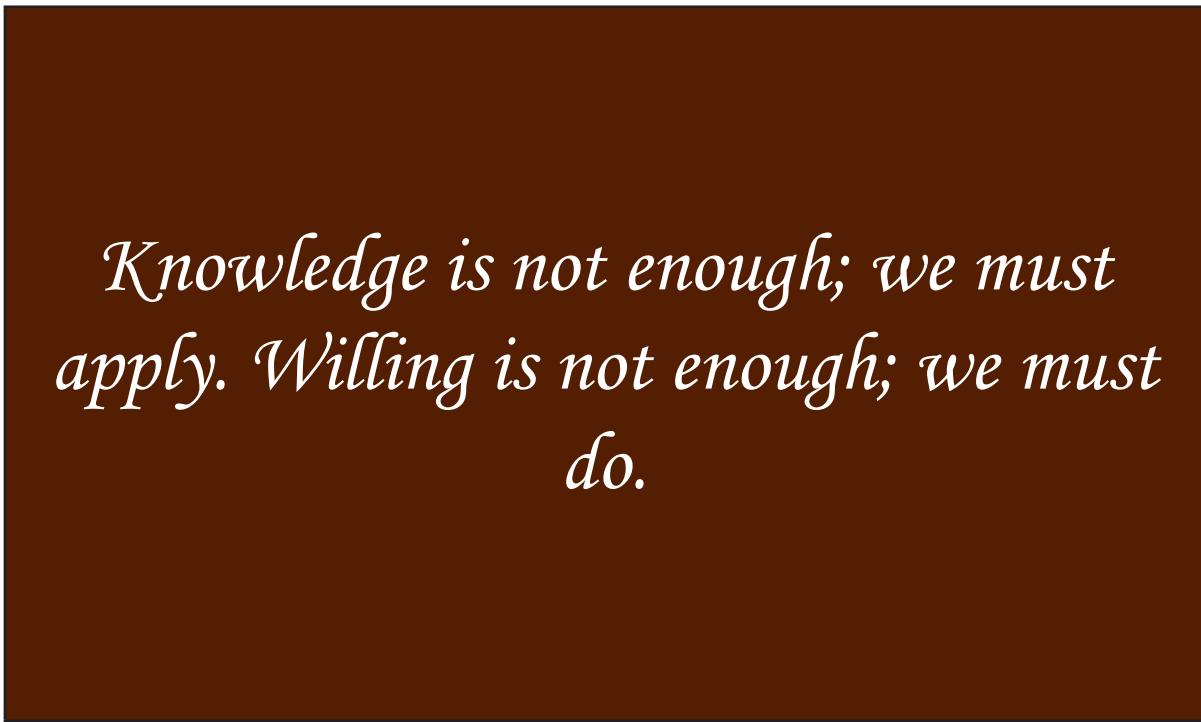
6.4 Sample Database

The sample database, AdventureWorks, was introduced from SQL Server 2005 onwards. This database demonstrates the use of new features introduced in SQL Server. A fictitious company called Adventure Works Cycles is created as a scenario in the database. Adventure Works Cycles is a large, multinational manufacturing company. The company manufactures and sells metal and composite bicycles to North American, European, and Asian commercial markets. In SQL Server 2012, a new version of the sample database AdventureWorks2012 is used.

6.4.1 AdventureWorks2012 Database

The AdventureWorks2012 database consists of around 100 features. Some of the key features are as follows:

- A database engine that includes administration facilities, data access capabilities, Full-Text Search facility, Common Language Runtime (CLR) integration advantage, SMO, Service Broker, and XML.
- Analysis Services
- Integration Services
- Notification Services
- Reporting Services
- Replication Facilities
- A set of integrated samples for two multiple feature-based samples: HRResume and Storefront.



Knowledge is not enough; we must apply. Willing is not enough; we must do.

The sample database consists of these parts:

- ➔ AdventureWorks2012: Sample OLTP database
- ➔ AdventureWorks2012DW: Sample Data warehouse
- ➔ AdventureWorks2012AS: Sample Analysis Services database

6.4.2 Filegroups

In SQL Server, data files are used to store database files. The data files are further subdivided into filegroups for the sake of performance. Each filegroup is used to group related files that together store a database object. Every database has a primary filegroup by default. This filegroup contains the primary data file. The primary file group and data files are created automatically with default property values at the time of creation of the database. User-defined filegroups can then be created to group data files together for administrative, data allocation, and placement purposes.

For example, three files named `Customer_Data1.ndf`, `Customer_Data2.ndf`, and `Customer_Data3.ndf`, can be created on three disk drives respectively. These can then be assigned to the filegroup `Customer_fgroup1`. A table can then be created specifically on the filegroup `Customer_fgroup1`. Queries for data from the table will be spread across the three disk drives thereby, improving performance.

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Table 6.3 shows the filegroups that are supported by SQL Server 2012.

Filegroup	Description
Primary	The filegroup that consists of the primary file. All system tables are placed inside the primary filegroup.
User-defined	Any filegroup that is created by the user at the time of creating or modifying databases.

Table 6.3: Filegroups in SQL Server 2012

Adding Filegroups to an existing database

Filegroups can be created when the database is created for the first time or can be created later when more files are added to the database. However, files cannot be moved to a different filegroup after the files have been added to the database.

A file cannot be a member of more than one filegroup at the same time. A maximum of 32,767 filegroups can be created for each database. Filegroups can contain only data files. Transaction log files cannot belong to a filegroup.



Following is the syntax to add filegroups while creating a database.

Syntax:

```
CREATE DATABASE database_name  
[ ON  
[ PRIMARY ] [ <filespec> [ ,...n ]  
[ ,<filegroup> [ ,...n ] ]  
[ LOG ON { <filespec> [ ,...n ] } ]  
]  
[ COLLATE collation_name ]  
]  
[ ; ]
```

where,

`database_name`: is the name of the new database.

`ON`: indicates the disk files to store the data sections of the database, and data files.

`PRIMARY` and associated `<filespec>` list: define the primary file. The first file specified in the `<filespec>` entry in the primary filegroup becomes the primary file.

`LOG ON`: indicates the disk files used to store the database log files.

`COLLATE collation_name`: is the default collation for the database.

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Code Snippet 5 shows how to add a filegroup (PRIMARY as default) while creating a database, called **SalesDB**.

Code Snippet 5:

```
CREATE DATABASE [SalesDB] ON PRIMARY
  ( NAME = 'SalesDB', FILENAME = 'C:\Program Files\Microsoft SQL Server\MSSQL11.
MSSQLSERVER\MSSQL\DATA\SalesDB.mdf' , SIZE = 3072KB , MAXSIZE = UNLIMITED,
FILEGROWTH = 1024KB ),
FILEGROUP [MyFileGroup]
  ( NAME = 'SalesDB_FG', FILENAME = 'C:\Program Files\Microsoft SQL Server\MSSQL11.
MSSQLSERVER\MSSQL\DATA\SalesDB_FG.ndf' , SIZE = 3072KB , MAXSIZE = UNLIMITED,
FILEGROWTH = 1024KB )
LOG ON
  ( NAME = 'SalesDB_log', FILENAME = 'C:\Program Files\Microsoft SQL Server\
MSSQL11.MSSQLSERVER\MSSQL\DATA\SalesDB_log.ldf' , SIZE = 2048KB , MAXSIZE =
2048GB , FILEGROWTH = 10%)
COLLATE SQL_Latin1_General_CI_AS
```

*Don't just learn the tricks of the trade,
learn the trade.*

Figure 6.5 shows the file groups when creating **SalesDB** database.

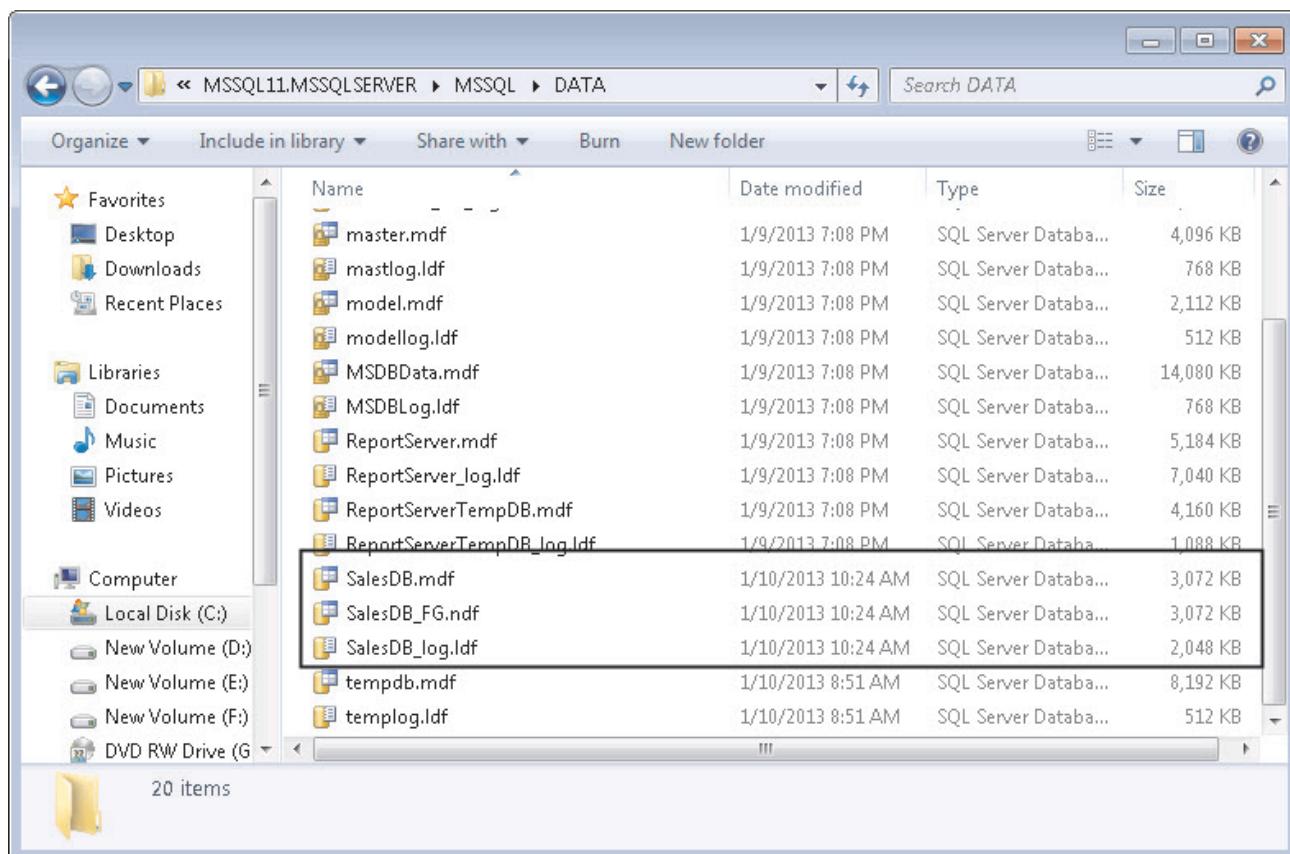


Figure 6.5: A Filegroup Added When Creating SalesDB Database

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Following is the syntax to add a filegroup to an existing database.

Syntax:

```
ALTER DATABASE database_name
{ <add_or_modify_files>
| <add_or_modify_filegroups>
| <set_database_options>
| MODIFY NAME = new_database_name
| COLLATE collation_name
}
[ ; ]
```

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BLOGS

MULTIPLE EXPERTS | MULTIPLE TOPICS

Code Snippet 6 shows how to add a filegroup to an existing database, called **CUST_DB**.

Code Snippet 6:

```
USE CUST_DB;
ALTER DATABASE CUST_DB
ADD FILEGROUP FG_ReadOnly
```

After executing the code, SQL Server 2012 displays the message 'Command(s) completed successfully' and the filegroup **FG_ReadOnly** is added to the existing database, **CUST_DB**.

Default Filegroup

Objects are assigned to the default filegroup when they are created in the database. The **PRIMARY** filegroup is the default filegroup. The default filegroup can be changed using the **ALTER DATABASE** statement. System objects and tables remain within the **PRIMARY** filegroup, but do not go into the new default filegroup.

To make the **FG_ReadOnly** filegroup as default, it should contain at least one file inside it.

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Code Snippet 7 shows how to create a new file, add it to the FG_ReadOnly filegroup and make the FG_ReadOnly filegroup that was created in Code Snippet 6 as the default filegroup.

Code Snippet 7:

```
USE CUST_DB
ALTER DATABASE CUST_DB
ADD FILE (NAME = Cust_DB1, FILENAME = 'C:\Program Files\Microsoft SQL Server\MSSQL11.MSSQLSERVER\MSSQL\DATA\Cust_DB1.ndf')
TO FILEGROUP FG_ReadOnly
ALTER DATABASE CUST_DB
MODIFY FILEGROUP FG_ReadOnly DEFAULT
```

After executing the code in Code Snippet 7, SQL Server 2012 displays the message saying the filegroup property 'DEFAULT' has been set.

Practice is the best of all instructors.

Figure 6.6 shows a new file **Cust_DB1** created.

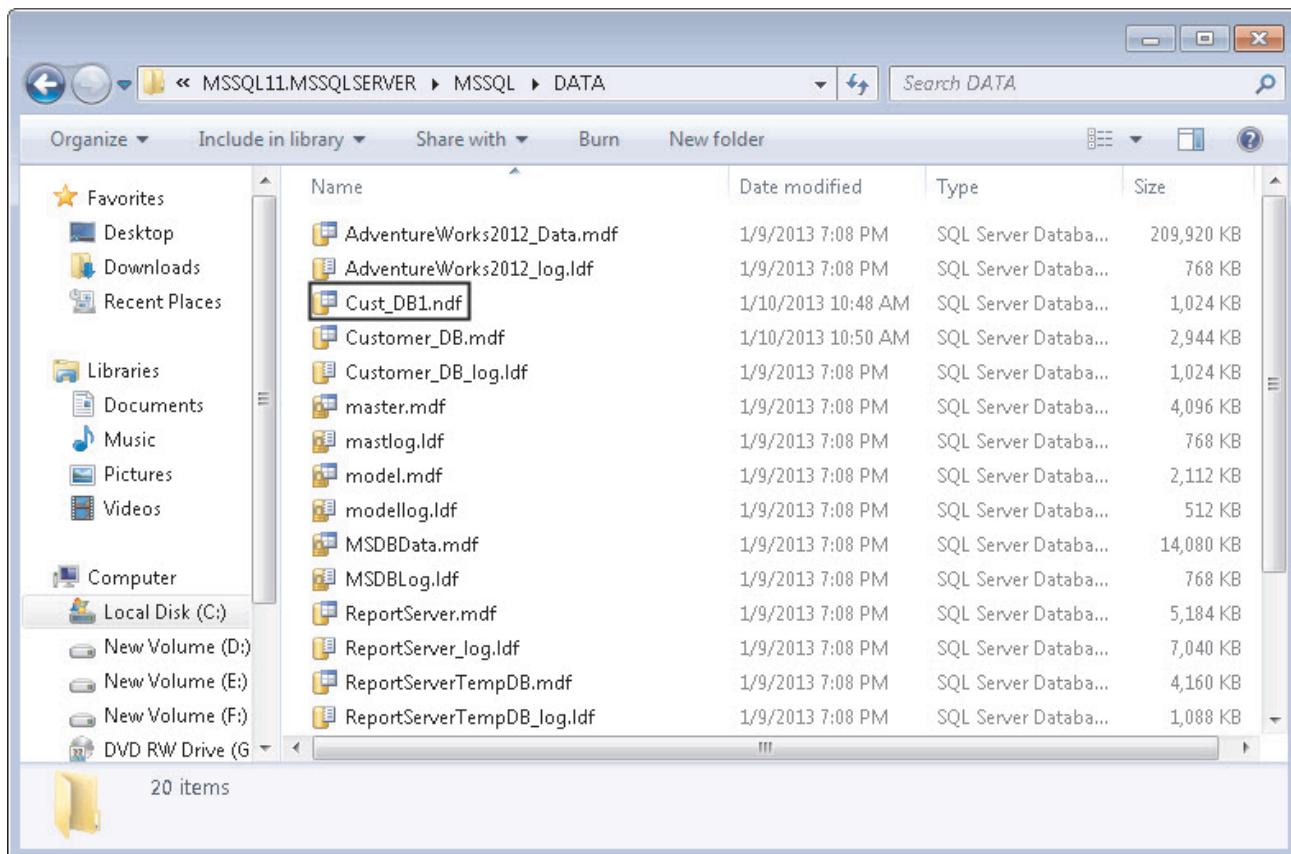


Figure 6.6: New File **Cust_DB1** Created

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6.4.3 Transaction Log

A transaction log in SQL Server records all transactions and the database modifications made by each transaction. The transaction log is one of the critical components of the database. It can be the only source of recent data in case of system failure.

The transaction logs support operations such as the following:

→ **Recovery of individual transactions**

An incomplete transaction is rolled back in case of an application issuing a `ROLLBACK` statement or the Database Engine detecting an error. The log records are used to roll back the modifications.

→ **Recovery of all incomplete transactions when SQL Server is started**

If a server that is running SQL Server fails, the databases may be left in an inconsistent state. When an instance of SQL Server is started, it runs a recovery of each database.

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→ **Rolling a restored database, file, filegroup, or page forward to the point of failure**

The database can be restored to the point of failure after a hardware loss or disk failure affecting the database files.

→ **Supporting transactional replication**

The Log Reader Agent monitors the transaction log of each database configured for replications of transactions.

→ **Supporting standby server solutions**

The standby-server solutions, database mirroring, and log shipping depend on the transaction log.

The next section explains the working of transaction logs and adding log files to a database.

→ **Working of Transaction Logs:**

A database in SQL Server 2012 has at least one data file and one transaction log file. Data and transaction log information are kept separated on the same file. Individual files are used by only one database.

SQL Server uses the transaction log of each database to recover transactions. The transaction log is a serial record of all modifications that have occurred in the database as well as the transactions that performed the modifications. This log keeps enough information to undo the modifications made during each transaction. The transaction log records the allocation and deallocation of pages and the commit or rollback of each transaction. This feature enables SQL Server either to roll forward or to back out. The rollback of each transaction is executed using the following ways:

- A transaction is rolled forward when a transaction log is applied.
- A transaction is rolled back when an incomplete transaction is backed out.

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→ Adding Log files to a database

Following is the syntax to modify a database and add log files.

Syntax:

```
ALTER DATABASE database_name
{
...
}
[ ; ]
<add_or_modify_files> ::=

{
    ADD FILE <filespec> [ ,...n ]
    [ TO FILEGROUP { filegroup_name | DEFAULT } ]
    | ADD LOG FILE <filespec> [ ,...n ]
    | REMOVE FILE logical_file_name
    | MODIFY FILE <filespec>
}
```

It is hard to fail, but it is worse never to have tried to succeed.

Note - By default, the data and transaction logs are put on the same drive and path to accommodate single-disk systems, but may not be optimal for production environments.

6.4.4 Create Database Procedure

When a database created, the data files needs to be as large as possible based on the maximum amount of data, which is expected in the database.

The steps to create a database using SSMS are as follows:

1. In **Object Explorer**, connect to an instance of the SQL Server Database Engine and then, expand that instance.

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Session**Creating and Managing Databases**

2. Right-click **Databases**, and then, click **New Database** as shown in figure 6.7.

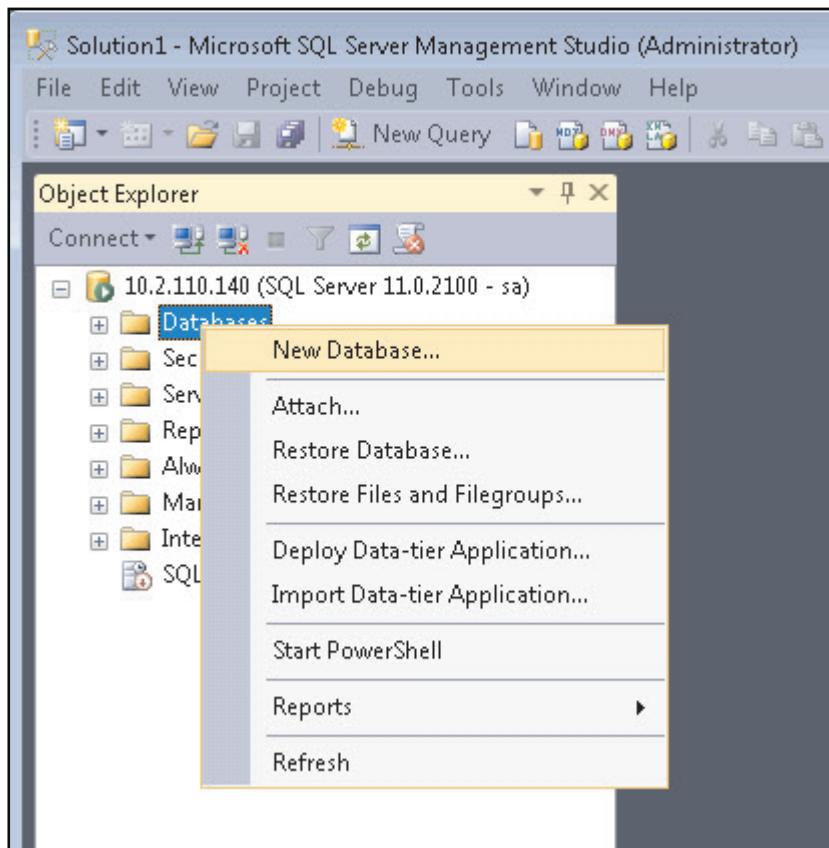


Figure 6.7: Click New Database Option



Session**Creating and Managing Databases**

3. In **New Database**, enter a database name.
4. To create the database by accepting all default values, click **OK**, as shown in figure 6.8; otherwise, continue with the following optional steps.

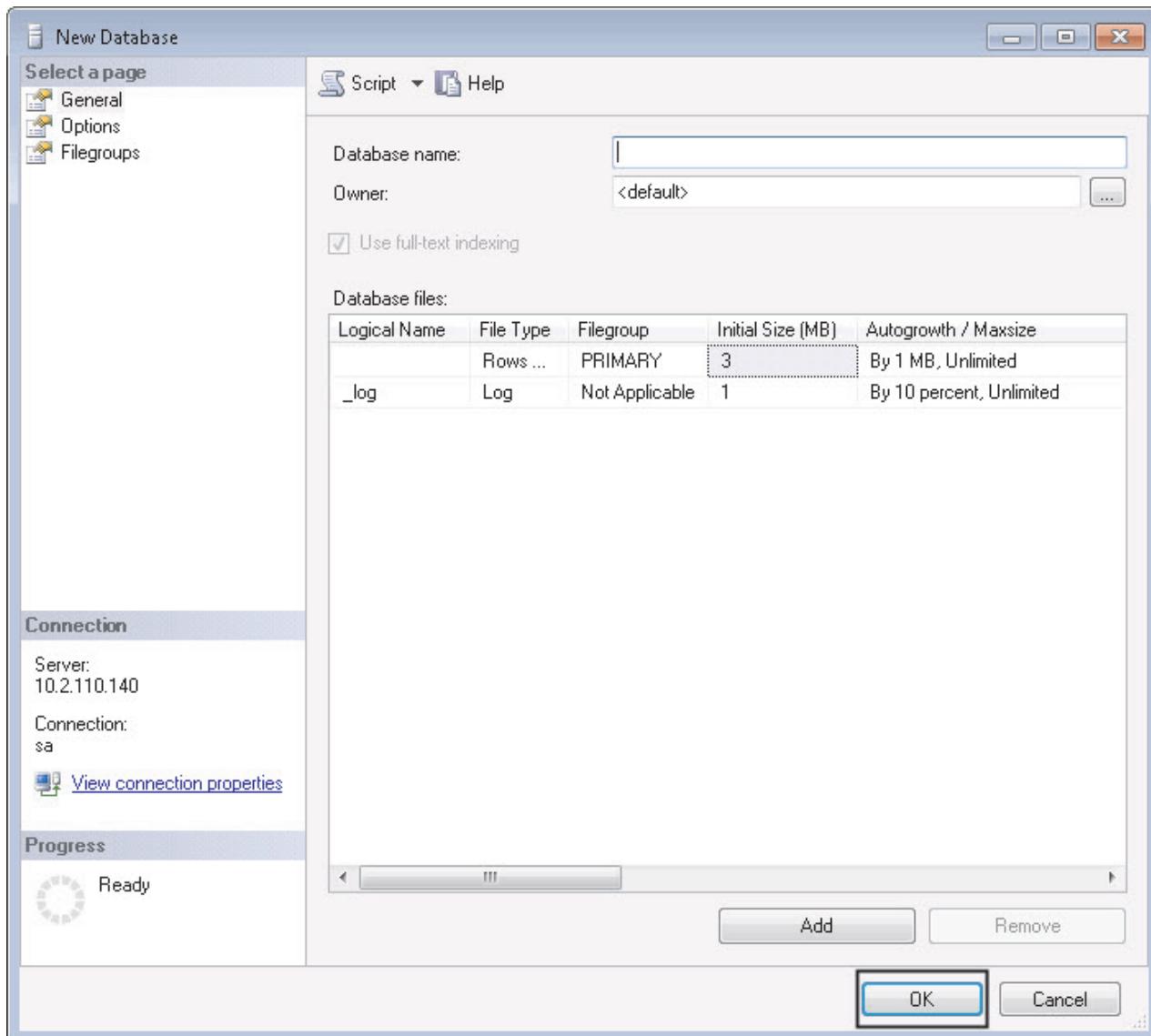


Figure 6.8: New Database Window

5. To change the owner name, click (...) to select another owner.
- Note** - The '**Use full-text indexing**' option is always checked and dimmed because, from SQL Server 2008 onwards, all user-defined databases are full-text enabled.
6. To change the default values of the primary data and transaction log files, in the **Database files** grid, click the appropriate cell and enter the new value.

7. To change the collation of the database, select the **Options** page, and then, select a collation from the list as shown in figure 6.9.

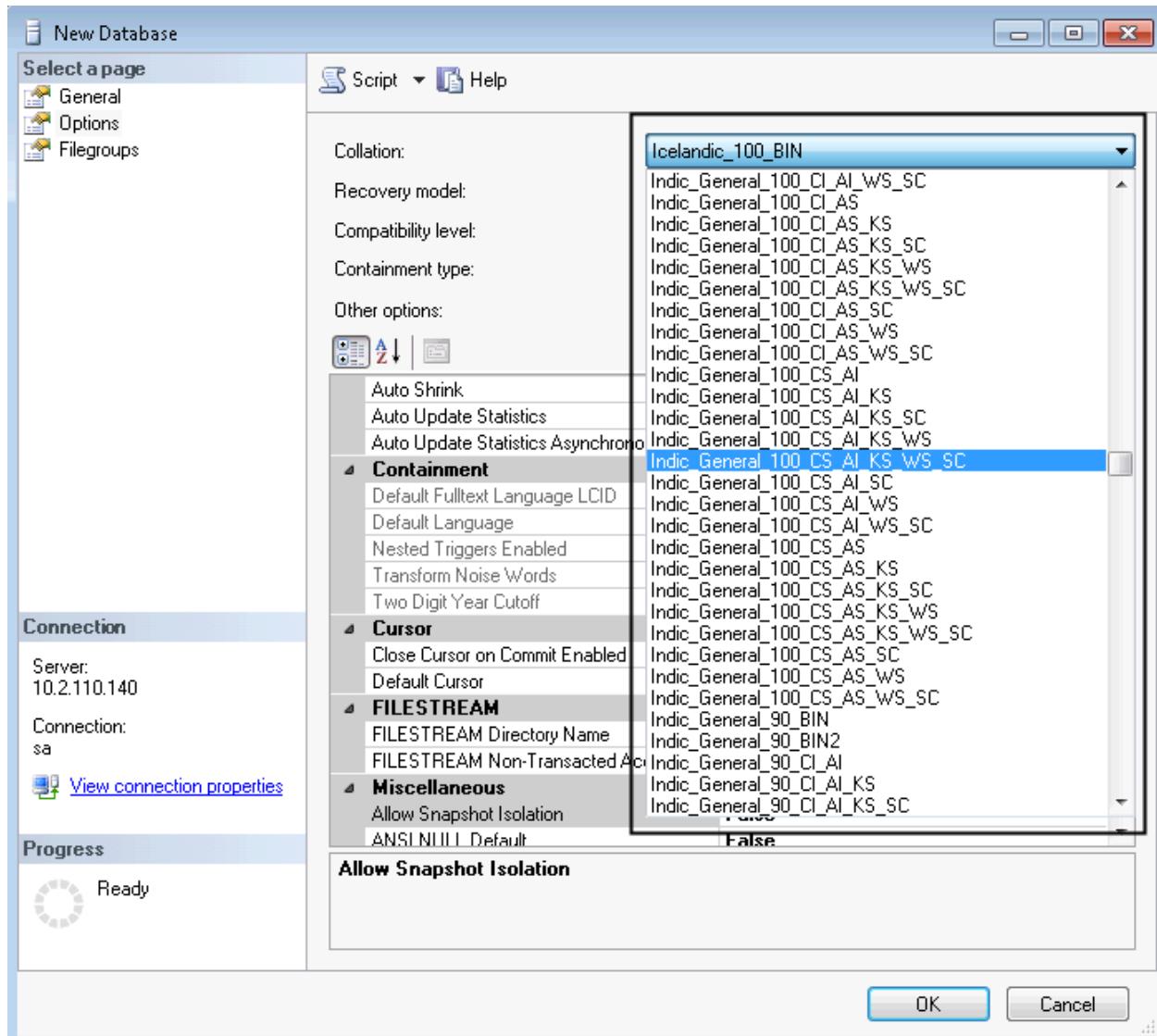


Figure 6.9: Collation List

*The future depends on what we do in
the present.*

8. To change the recovery model, select the **Options** page and then, select a recovery model from the list as shown in figure 6.10.

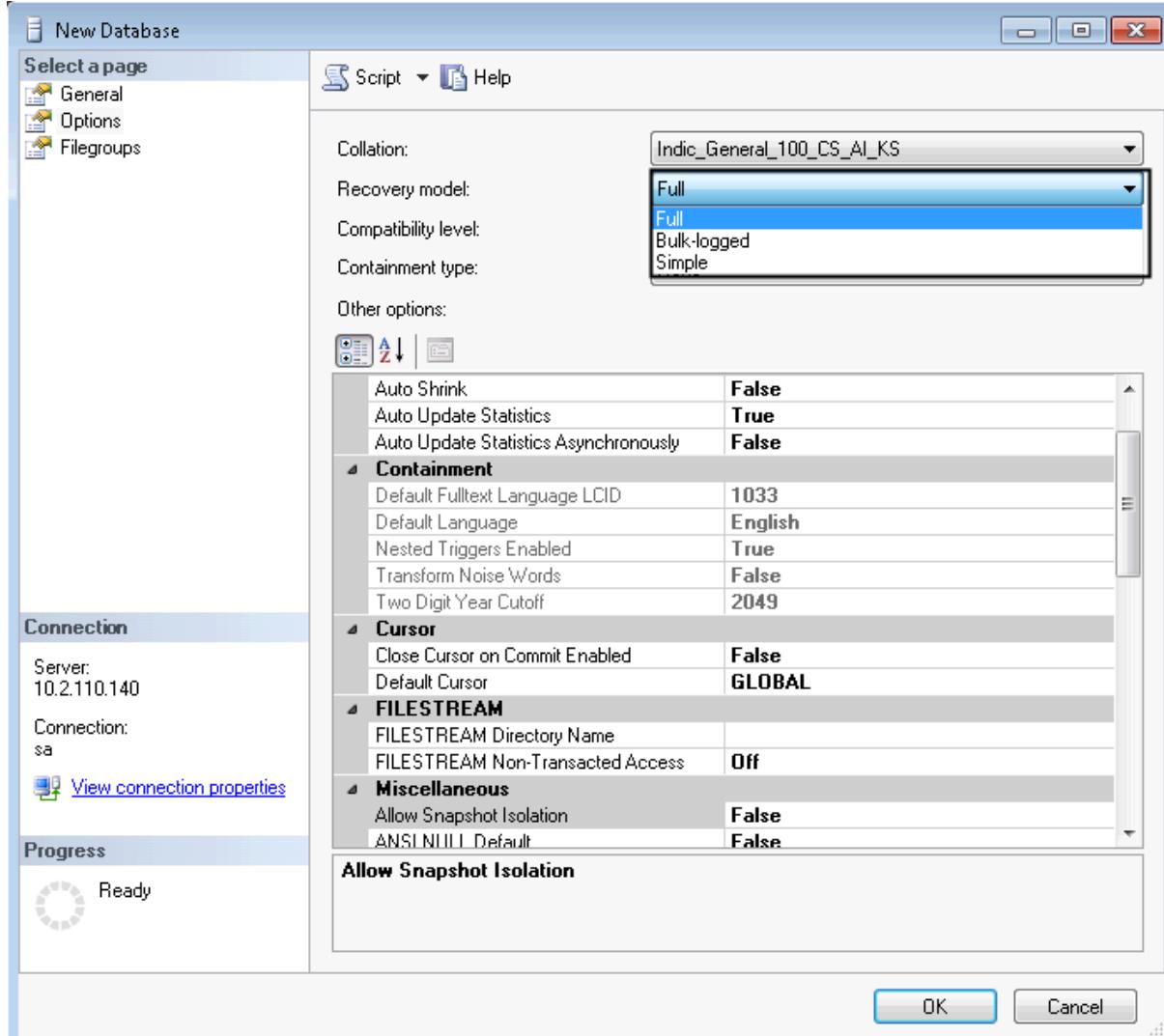


Figure 6.10: Recovery Model

9. To change database options, select the **Options** page, and then, modify the database options.

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10. To add a new filegroup, click the **Filegroups** page. Click **Add** and then, enter the values for the filegroup as shown in figure 6.11.

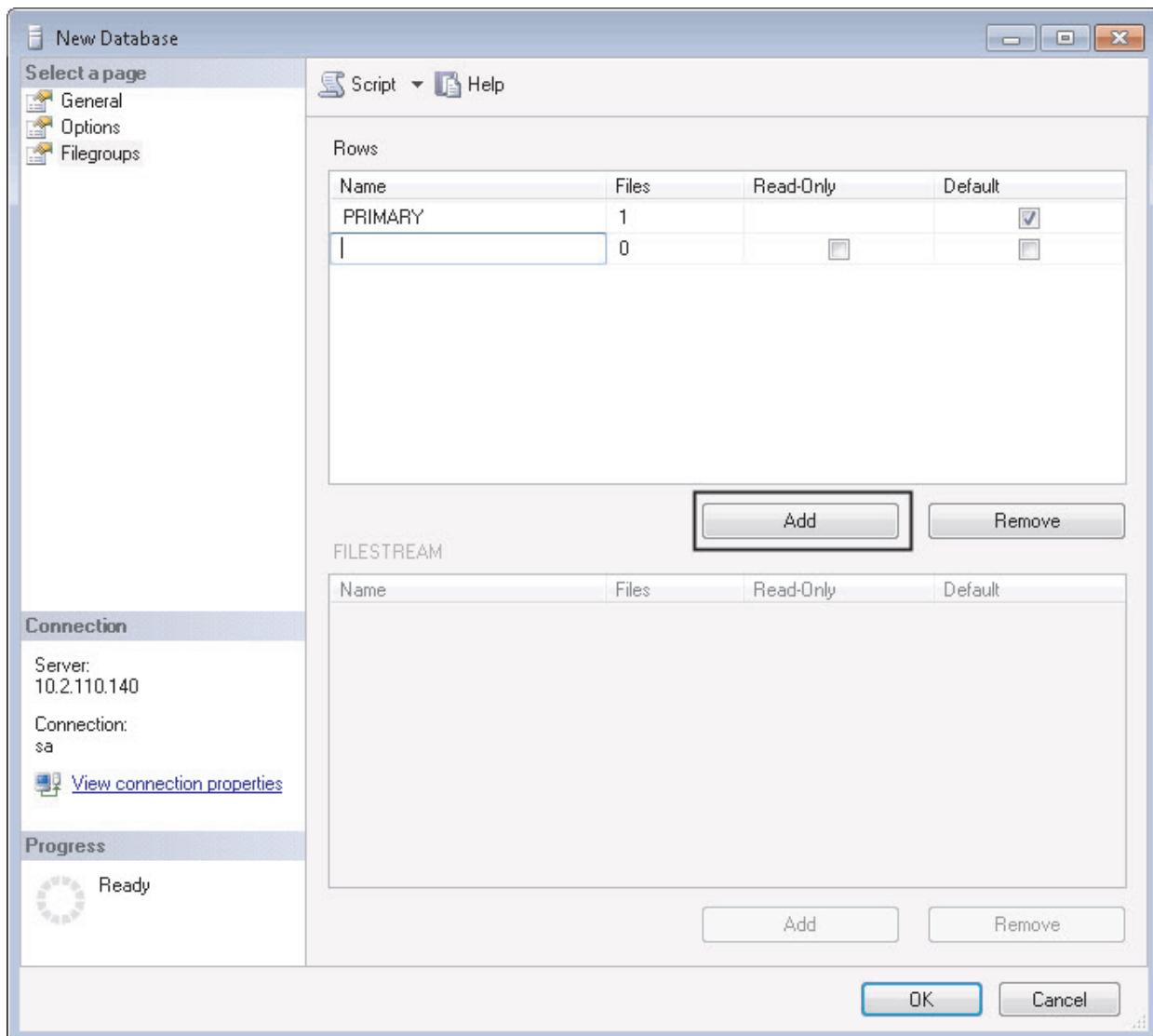


Figure 6.11: Adding a Filegroup



11. To add an extended property to the database, select the **Extended Properties** page.
 - In the **Name** column, enter a name for the extended property.
 - In the **Value** column, enter the extended property text. For example, enter one or more statements that describe the database.
12. To create the database, click **OK**.

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6.4.5 Types of Database Modification Methods

Table 6.4 lists and describes types of modifications of databases and modification methods.

Type of Modifications	Modification Methods
Increasing the size of a database	ALTER DATABASE statement or the database properties in SSMS
Changing the physical location of a database	ALTER DATABASE statement
Adding data or transaction log files	ALTER DATABASE statement or the database properties in SSMS
Shrinking a database	DBCC SHRINKDATABASE statement or the Shrink Database option in SSMS, accessed through the node for the specific database
Shrinking a database file	DBCC SHRINKFILE statement
Deleting data or log files	ALTER DATABASE statement or the database properties in SSMS
Adding a filegroup to a database	ALTER DATABASE statement or the database properties in SSMS
Changing the default filegroup	ALTER DATABASE statement
Changing database options	ALTER DATABASE statement or the database properties in SSMS
Changing the database owner	sp_changedbowner system stored procedure

Table 6.4: System-defined Functions and Stored Procedures in SQL Server 2012

*Action may not always bring happiness,
but there is no happiness without
action.*

The user-defined database can be deleted when it is no longer required. The files and the data associated with the database are automatically deleted from the disk when the database is deleted.

6.4.6 Drop Database Procedure

A full backup of the database needs to be taken before dropping a database. A deleted database can be re-created only by restoring a backup.

The steps to delete or drop a database using SSMS are as follows:

1. In **Object Explorer**, connect to an instance of the SQL Server Database Engine, and then, expand that instance.

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2. Expand **Databases**, right-click the database to delete, and then, click **Delete**, as shown in figure 6.12.

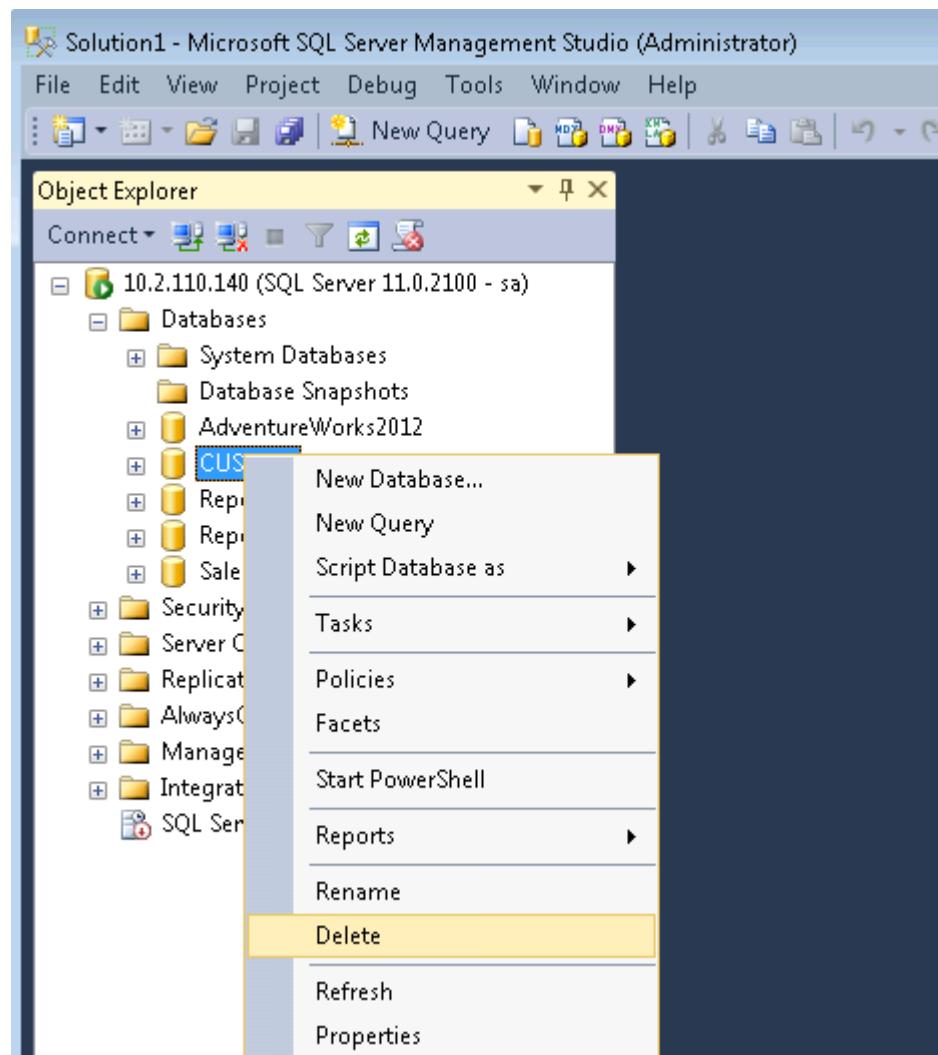


Figure 6.12: Delete a Database



3. Confirm that the correct database is selected, and then, click **OK**.

Following is the syntax to delete or drop a database using Transact-SQL.

Syntax:

```
CREATE DATABASE database_snapshot_name
ON
(
NAME = logical_file_name,
FILENAME = 'os_file_name'
) [ ,...n ]
AS SNAPSHOT OF source_database_name
[;]
```

where,

`database_snapshot_name`: is the name of the new database snapshot.

`ON (NAME = logical_file_name, FILENAME = 'os_file_name') [,... n]`: is the list of files in the source database. For the snapshot to work, all the data files must be specified individually.

`AS SNAPSHOT OF source_database_name`: is the database being created is a database snapshot of the source database specified by `source_database_name`.

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Code Snippet 9 creates a database snapshot on the **CUST_DB** database.

Code Snippet 9:

```
CREATE DATABASE customer_snapshot01 ON  
( NAME = Customer_DB, FILENAME = 'C:\Program Files\Microsoft SQL Server\MSSQL11.  
MSSQLSERVER\MSSQL\DATA\Customerdat_0100.ss')  
AS SNAPSHOT OF CUST_DB;
```

*First say to yourself what you would
be; and then do what you have to do.*

6.5 Check Your Progress

1. Which of the following are system databases that are supported by SQL Server 2012?

(A)	master	(C)	msdt
(B)	tepds	(D)	mod

2. SQL Server databases are stored as files in the _____.

(A)	FAT 16	(C)	Folders
(B)	File System	(D)	Hard Disk

3. Which of the following is an administration utility?

(A)	SQL-SMO	(C)	Transact-SQL
(B)	SQL Server Management Studio	(D)	Stored procedures

4. Which among these are features of the AdventureWorks2012 database?

- a. Integration Services
- b. Reporting Services
- c. Notification Services
- d. Implicit Services

(A)	a, b, and c	(C)	a and b
(B)	b	(D)	c and d

Session***Creating and Managing Databases***

5. Which among these is the correct syntax to create a database?

(A)	<pre>CREATE DATABASE (NAME = 'Customer_DB', FILENAME = 'C:\Program Files\Microsoft SQL Server\ MSSQL11.MSSQLSERVER\MSSQL\ DATA\Customer_DB.mdf')</pre>	(C)	<pre>CREATE DATABASE [Customer_ DB] ON PRIMARY (NAME = 'Customer_DB', FILENAME = 'C:\Program Files\Microsoft SQL Server\ MSSQL11.MSSQLSERVER\MSSQL\ DATA\Customer_DB.mdf')</pre>
(B)	<pre>CREATE Table [Customer_DB] ON PRIMARY (NAME = 'Customer_DB', FILENAME = 'C:\Program Files\Microsoft SQL Server\ MSSQL11.MSSQLSERVER\MSSQL\ DATA\Customer_DB.mdf')</pre>	(D)	All of these

6.5.1 Answers

1.	A
2.	B
3.	B
4.	A
5.	C



- An SQL Server database is made up of a collection of tables that stores sets of specific structured data.
- SQL Server 2012 supports three kinds of databases:
 - System databases
 - User-defined databases
 - Sample Databases
- SQL Server uses system databases to support different parts of the DBMS.
- A fictitious company, Adventure Works Cycles is created as a scenario and the AdventureWorks2012 database is designed for this company.
- The SQL Server data files are used to store database files, which are further subdivided into filegroups for the sake of performance.
- Objects are assigned to the default filegroup when they are created in the database. The PRIMARY filegroup is the default filegroup.
- A database snapshot is a read-only, static view of a SQL Server database.



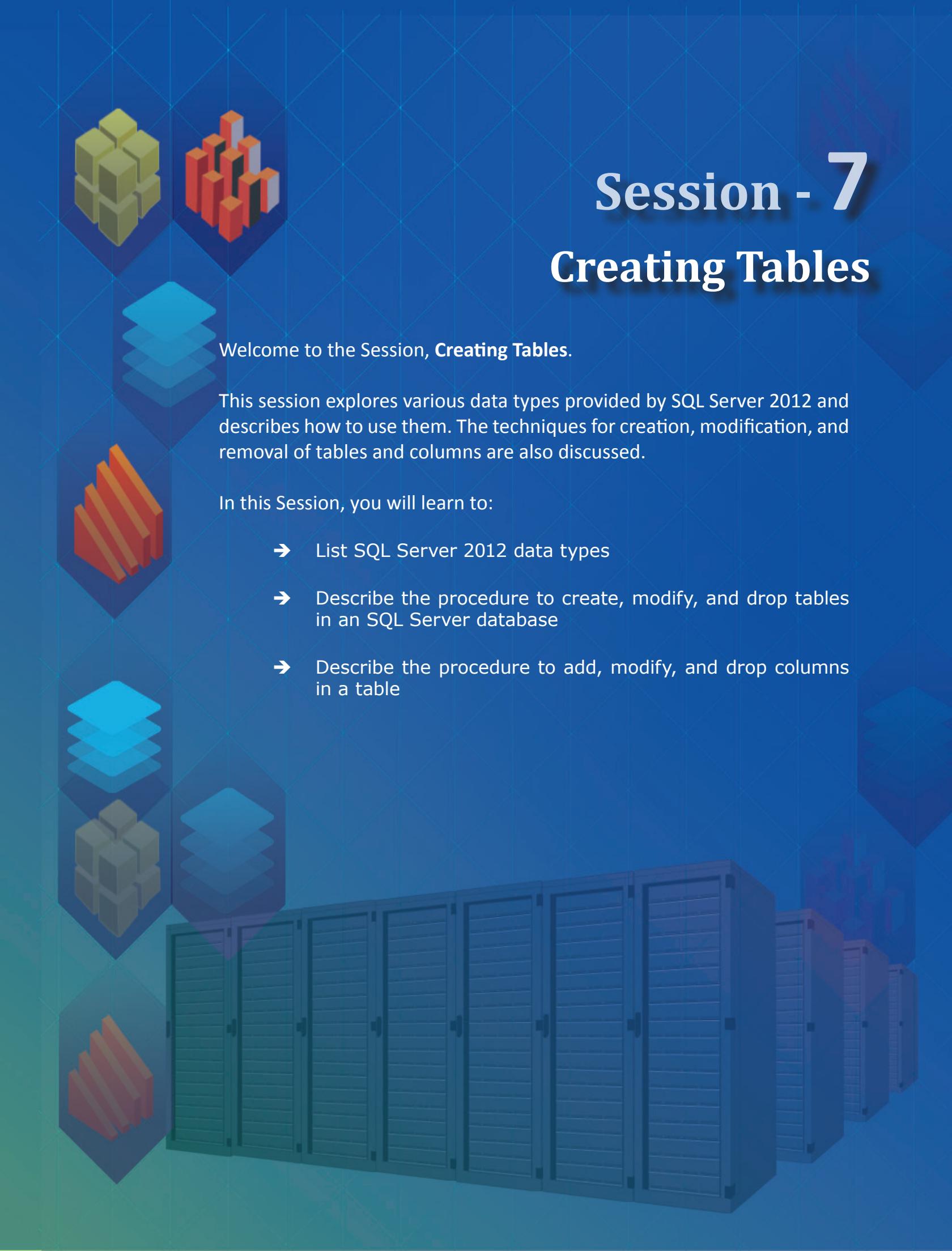
Try It Yourself

1. Create a database named `UnitedAir` using Transact-SQL statements with the following properties:
 - Primary filegroup with files, `UnitedAir1_dat` and `UnitedAir2_dat`. The size, maximum size, and file growth should be 5, 10, and 15% respectively.
 - A filegroup named `UnitedAirGroup1` with the files `UnitedAirGrp1F1` and `UnitedAirGrp1F2`.
 - A filegroup with `UnitedAirGroup2` with the files `UnitedAirGrp2F1` and `UnitedAirGrp2F2`.

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Session - 7

Creating Tables

Welcome to the Session, **Creating Tables**.

This session explores various data types provided by SQL Server 2012 and describes how to use them. The techniques for creation, modification, and removal of tables and columns are also discussed.

In this Session, you will learn to:

- List SQL Server 2012 data types
- Describe the procedure to create, modify, and drop tables in an SQL Server database
- Describe the procedure to add, modify, and drop columns in a table

7.1 Introduction

One of the most important types of database objects in SQL Server 2012 is a table. Tables in SQL Server 2012 contain data in the form of rows and columns. Each column may have data of a specific type and size.

7.2 Data Type

A data type is an attribute that specifies the type of data an object can hold, such as numeric data, character data, monetary data, and so on. A data type also specifies the storage capacity of an object. Once a column has been defined to store data belonging to a particular data type, data of another type cannot be stored in it. In this manner, data types enforce data integrity

Consider a column named **BasicSalary** in a table **Employee**. To ensure that only numeric data is entered, this column is defined to belong to an integer data type. Hence, if an attempt is made to enter character data into that **BasicSalary** column, it will not succeed.

Learning how to learn is life's most important skill.

7.2.1 Different Kinds of Data Types

SQL Server 2012 supports three kinds of data types:

- **System data types** - These are provided by SQL Server 2012.
- **Alias data types** - These are based on the system-supplied data types. One of the typical uses of alias data types is when more than one table stores the same type of data in a column and has similar characteristics such as length, nullability, and type. In such cases, an alias data type can be created that can be used commonly by all these tables.
- **User-defined types** - These are created using programming languages supported by the .NET Framework, which is a software framework developed by Microsoft.

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Table 7.1 shows various data types in SQL Server 2012 along with their categories and description.

Category	Data Type	Description
Exact Numerics	int	Represents a column that occupies 4 bytes of memory space. Is typically used to hold integer values.
	smallint	Represents a column that occupies 2 bytes of memory space. Can hold integer data from -32,768 to 32,767.
	tinyint	Represents a column that occupies 1 byte of memory space. Can hold integer data from 0 to 255.
Exact Numerics	bigint	Represents a column that occupies 8 bytes of memory space. Can hold data in the range -2^{63} (-9,223,372,036,854,775,808) to $2^{63}-1$ (9,223,372,036,854,775,807)
	numeric	Represents a column of this type that fixes precision and scale.
	money	Represents a column that occupies 8 bytes of memory space. Represents monetary data values ranging from $(-2^{63}/10000)$ (-92,337,203,685,477.5808) through $2^{63}-1$ (922,337,203,685,477.5807).
Approximate Numerics	float	Represents a column that occupies 8 bytes of memory space. Represents floating point number ranging from -1.79E +308 through 1.79E+308.
	real	Represents a column that occupies 4 bytes of memory space. Represents floating precision number ranging from -3.40E+38 through 3.40E+38.
Date and Time	datetime	Represents date and time. Stored as two 4-byte integers.
	smalldatetime	Represents date and time.

Category	Data Type	Description
Character String	char	Stores character data that is fixed-length and non-Unicode.
	varchar	Stores character data that is variable-length and non-Unicode.
	text	Stores character data that is variable-length and non-Unicode.
Unicode Types	nchar	Stores Unicode character data of fixed-length.
	nvarchar	Stores variable-length Unicode character data.
Other Data Types	Timestamp	Represents a column that occupies 8 bytes of memory space. Can hold automatically generated, unique binary numbers that are generated for a database.
	binary(n)	Stores fixed-length binary data with a maximum length of 8000 bytes.
Other Data Types	varbinary(n)	Stores variable-length binary data with a maximum length of 8000 bytes.
	image	Stores variable-length binary data with a maximum length of $2^{30}-1$ (1,073,741,823) bytes.
	uniqueidentifier	Represents a column that occupies 16 bytes of memory space. Also, stores a globally unique identifier (GUID).

Table 7.1: Data Types in SQL Server 2012

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Alias data types can be created using the CREATE TYPE statement.

The syntax for the CREATE TYPE statement is as follows:

Syntax:

```
CREATE TYPE [ schema_name.] type_name{FROMbase_type [ ( precision [, scale] ) ] [NULL|NOT NULL] } [;]
```

where,

`schema_name`: identifies the name of the schema in which the alias data type is being created.

`type_name`: identifies the name of the alias type being created.

`base_type`: identifies the name of the system-defined data type based on which the alias data type is being created.

`precision` and `scale`: specify the precision and scale for numeric data.

`NULL|NOT NULL`: specifies whether the data type can hold a null value or not.

Code Snippet 1 shows how to create an alias data type named `usertype` using the CREATE TYPE statement.

Code Snippet 1:

```
CREATE TYPE usertype FROM varchar(20) NOT NULL
```

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

7.3 Creating, Modifying, and Dropping Tables

Most tables have a primary key, made up of one or more columns of the table. A primary key is always unique. The Database Engine will enforce the restriction that any primary key value cannot be repeated in the table. Thus, the primary key can be used to identify each record uniquely.

7.3.1 Creating Tables

The CREATE TABLE statement is used to create tables in SQL Server 2012. The syntax for CREATE TABLE statement is as follows:

Syntax:

```
CREATE TABLE [database_name . [schema_name] . | schema_name . ]table_name  
([<column_name>] [data_type] Null/Not Null,)  
ON [filegroup | "default"]  
GO
```

where,

`database_name`: is the name of the database in which the table is created.

`table_name`: is the name of the new table. `table_name` can be a maximum of 128 characters.

`column_name`: is the name of a column in the table. `column_name` can be up to 128 characters. `column_name` are not specified for columns that are created with a timestamp data type. The default column name of a timestamp column is `timestamp`.

`data_type`: It specifies data type of the column.

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Code Snippet 2 demonstrates creation of a table named `dbo.Customer_1`.

Code Snippet 2:

```
CREATE TABLE [dbo].[Customer_1] (
    [Customer_id] [number] [numeric](10, 0) NOT NULL,
    [Customer_name] [varchar](50) NOT NULL
)
ON [PRIMARY]
GO
```

The next few sections take a look at various features associated with tables such as column nullability, default definitions, constraints, and so forth.

7.3.2 Modifying Tables

The `ALTER TABLE` statement is used to modify a table definition by altering, adding, or dropping columns and constraints, reassigning partitions, or disabling or enabling constraints and triggers.

The syntax for `ALTER TABLE` statement is as follows:

Syntax:

```
ALTER TABLE [ [database_name.] [schema_name]. | schema_name.] table_name
    ALTER COLUMN ([<column_name>] [data_type] Null/Not Null, );
    | ADD ([<column_name>] [data_type] Null/Not Null, );
    | DROP COLUMN ([<column_name>];
```

where,

`ALTER COLUMN`: specifies that the particular column is to be changed or modified.

`ADD`: specifies that one or more column definitions are to be added.

`DROP COLUMN ([<column_name>])`: specifies that `column_name` is to be removed from the table.

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Code Snippet 3 demonstrates altering the `Customer_id` column.

Code Snippet 3:

```
USE [CUST_DB]
ALTER TABLE [dbo].[Customer_1]
ALTER COLUMN [Customer_id] numeric(12, 0) NOT NULL;
```

Code Snippet 4 demonstrates adding the `Contact_number` column.

Code Snippet 4:

```
USE [CUST_DB]
ALTER TABLE [dbo].[Table_1]
ADD [Contact_number] numeric(12, 0) NOT NULL;
```

Code Snippet 5 demonstrates dropping the `Contact_number` column.

Code Snippet 5:

```
USE [CUST_DB]
ALTER TABLE [dbo].[Table_1]
DROP COLUMN [Contact_name];
```

Before attempting to drop columns, however, it is important to ensure that the columns can be dropped. Under certain conditions, columns cannot be dropped, such as, if they are used in a `CHECK`, `FOREIGN KEY`, `UNIQUE`, or `PRIMARY KEY` constraint, associated with a `DEFAULT` definition, and so forth.

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7.3.3 Dropping Tables

The `DROP TABLE` statement removes a table definition, its data, and all associated objects such as indexes, triggers, constraints, and permission specifications for that table.

The syntax for `DROP TABLE` statement is as follows:

Syntax:

```
DROP TABLE <Table_Name>
```

where,

`<Table_Name>`: is the name of the table to be dropped.

Code Snippet 6 demonstrates how to drop a table.

Code Snippet 6:

```
USE [CUST_DB]  
DROP TABLE [dbo].[Table_1]
```

To learn, you must want to be taught.

7.3.4 Data Modification Statements

The statements used for modifying data are `INSERT`, `UPDATE`, and `DELETE` statements. These are explained as follows:

- **INSERT Statement** - The `INSERT` statement adds a new row to a table. The syntax for `INSERT` statement is as follows:

Syntax:

```
INSERT [ INTO ] <Table_Name>
VALUES <values>
```

where,

`<Table_Name>`: is the name of the table in which row is to be inserted.

`[INTO]`: is an optional keyword used between `INSERT` and the target table.

`<values>`: specifies the values for columns of the table.

Code Snippet 7 demonstrates adding a new row to the `Table_2` table.

Code Snippet 7:

```
USE [CUST_DB]
INSERT INTO [dbo].[Table_2] VALUES (101, 'Richard Parker', 'Richy')
GO
```

The outcome of this will be that one row with the given data is inserted into the table.

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- **UPDATE Statement** - The UPDATE statement modifies the data in the table. The syntax for UPDATE statement is as follows:

Syntax:

```
UPDATE <Table_Name>
SET <Column_Name = Value>
[WHERE <Search condition>]
```

where,

<Table_Name>: is the name of the table where records are to be updated.

<Column_Name>: is the name of the column in the table in which record is to be updated.

<Value>: specifies the new value for the modified column.

<Search condition>: specifies the condition to be met for the rows to be deleted.

Code Snippet 8 demonstrates the use of the UPDATE statement to modify the value in column Contact_number.

Code Snippet 8:

```
USE [CUST_DB]
UPDATE [dbo].[Table_2] SET Contact_number = 5432679 WHERE Contact_name LIKE
'Ricky'
GO
```



Figure 7.1 shows the output of UPDATE statement.

Customer_id number	Customer_name	Contact_name	Contact_number
101	Richard Parker	Richy	5432679

Figure 7.1: Output of UPDATE Statement

- **DELETE Statement** - The DELETE statement removes rows from a table. The syntax for DELETE statement is as follows:

Syntax:

```
DELETE FROM <Table_Name>
[WHERE <Search condition>]
```

where,

<Table_Name>: is the name of the table from which the records are to be deleted.

The WHERE clause is used to specify the condition. If WHERE clause is not included in the DELETE statement, all the records in the table will be deleted.

Code Snippet 9 demonstrates how to delete a row from the **Customer_2** table whose **Contact_number** value is 5432679.

Code Snippet 9:

```
USE [CUST_DB]
DELETE FROM [dbo].[Customer_2] WHERE Contact_number = 5432679
GO
```

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7.3.5 Column Nullability

The nullability feature of a column determines whether rows in the table can contain a null value for that column. In SQL Server, a null value is not same as zero, blank, or a zero length character string (such as ''). For example, a null value in the `Color` column of the `Production.Product` table of the `AdventureWorks2012` database does not mean that the product has no color; it just means that the color for the product is unknown or has not been set.

Nullability of a column can be defined either when creating a table or modifying a table.

The `NULL` keyword is used to indicate that null values are allowed in the column, and the `NOT NULL` keywords are used to indicate that null values are not allowed.

When inserting a row, if no value is given for a nullable column (that is, it allows null values), then, SQL Server automatically gives it a null value unless the column has been given a default definition. It is also possible to explicitly enter a null value into a column regardless of what data type it is or whether it has a default associated with it. Making a column non-nullable (that is, not permitting null values) enforces data integrity by ensuring that the column contains data in every row.

In Code Snippet 10, the `CREATE TABLE` statement uses the `NULL` and `NOT NULL` keywords with column definitions.

Code Snippet 10:

```
USE [CUST_DB]
CREATE TABLE StoreDetails ( StoreID int NOT NULL, Name varchar(40) NULL)
GO
```

The result of the code is that the `StoreDetails` table is created with `StoreID` and `Name` columns added to the table.

Democritus said, words are but the shadows of actions.

7.3.6 DEFAULT Definition

Consider a scenario in which details about a product need to be stored in an SQL Server 2012 table but all values for the product details may not be known even at the time of data insertion. However, as per data consistency and integrity rules, the columns in a record should typically contain a value. Storing null values into such columns where the exact value of data is not known may not be desirable or practical.

In such situations, a `DEFAULT` definition can be given for the column to assign it as a default value if no value is given at the time of creation. For example, it is common to specify zero as the default for numeric columns or 'N/A' or 'Unknown' as the default for string columns when no value is specified.

A `DEFAULT` definition for a column can be created at the time of table creation or added at a later stage to an existing table. When a `DEFAULT` definition is added to an existing column in a table, SQL Server applies the new default values only to those rows of data, which have been newly added to the table.

In Code Snippet 11, the `CREATE TABLE` statement uses the `DEFAULT` keyword to define the default value for Price.

Code Snippet 11:

```
USE [CUST_DB]
CREATE TABLE StoreProduct ( ProductID int NOT NULL, Name varchar(40) NOT NULL,
Price money NOT NULL DEFAULT (100))
GO
```

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When a row is inserted using a statement as shown in Code Snippet 12, the value of **Price** will not be blank; it will have a value of 100.00 even though a user has not entered any value for that column.

Code Snippet 12:

```
USE [CUST_DB]
INSERT INTO dbo.StoreProduct (ProductID, Name) VALUES (111, 'Rivets')
GO
```

Figure 7.2 shows the output of Code Snippet 12, where, though values are added only to the **ProductID** and **Name** columns, the **Price** column will still show a value of 100.00. This is because of the **DEFAULT** definition.

	ProductID	Name	Price
1	111	Rivets	100.00

Figure 7.2: Values Added to ProductID and Name Columns



Following cannot be created on columns with `DEFAULT` definitions:

- A timestamp data type
- An `IDENTITY` or `ROWGUIDCOL` property
- An existing default definition or default object

7.3.7 *IDENTITY Property*

The `IDENTITY` property of SQL Server is used to create identifier columns that can contain auto-generated sequential values to uniquely identify each row within a table. For example, an identifier column could be created to generate unique student registration numbers automatically whenever new rows are inserted into the Students table. The identity number for the first row inserted into the table is called seed value and the increment, also called Identity Increment property, is added to the seed in order to generate further identity numbers in sequence. When a new row is inserted into a table with an identifier column, the next identity value is automatically generated by SQL Server by adding the increment to the seed. An identity column is often used for primary key values.

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The characteristics of the `IDENTITY` property are as follows:

- A column having `IDENTITY` property must be defined using one of the following data types: `decimal`, `int`, `numeric`, `smallint`, `bigint`, or `tinyint`.
- A column having `IDENTITY` property need not have a seed and increment value specified. If they are not specified, a default value of 1 will be used for both.
- A table cannot have more than one column with `IDENTITY` property.
- The identifier column in a table must not allow null values and must not contain a `DEFAULT` definition or object.
- Columns defined with `IDENTITY` property cannot have their values updated.
- The values can be explicitly inserted into the identity column of a table only if the `IDENTITY_INSERT` option is set `ON`. When `IDENTITY_INSERT` is `ON`, `INSERT` statements must supply a value.

The advantage of identifier columns is that SQL Server can automatically provide key values, thus reducing costs and improving performance. Using identifier columns simplifies programming and keeps primary key values short.

Once the `IDENTITY` property has been set, retrieving the value of the identifier column can be done by using the `IDENTITYCOL` keyword with the table name in a `SELECT` statement. To know if a table has an `IDENTITY` column, the `OBJECTPROPERTY()` function can be used. To retrieve the name of the `IDENTITY` column in a table, the `COLUMNPROPERTY` function is used.

*Nothing is a waste of time if you use
the experience wisely.*

The syntax for IDENTITY property is as follows:

Syntax:

```
CREATE TABLE <table_name> (column_name data_type [ IDENTITY  
[ (seed_value, increment_value) ] ] NOT NULL )
```

where,

`seed_value`: is the seed value from which to start generating identity values.

`increment_value`: is the increment value by which to increase each time.

Code Snippet 13 demonstrates the use of IDENTITY property. **HRContactPhone** is created as a table with two columns in the schema **Person** that is available in the **CUST_DB** database. The **Person_ID** column is an identity column. The seed value is 500, and the increment value is 1.

Code Snippet 13:

```
USE [CUST_DB]  
GO  
  
CREATE TABLE HRContactPhone ( Person_ID int IDENTITY(500,1) NOT NULL,  
MobileNumber bigint NOT NULL )  
GO
```

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While inserting rows into the table, if `IDENTITY_INSERT` is not turned on, then, explicit values for the `IDENTITY` column cannot be given. Instead, statements similar to Code Snippet 14 can be given.

Code Snippet 14:

```
USE [CUST_DB]
INSERT INTO HRContactPhone (MobileNumber) VALUES (983452201)
INSERT INTO HRContactPhone (MobileNumber) VALUES (993026654)
GO
```

Figure 7.3 shows the output where `IDENTITY` property is incrementing `Person_ID` column values.

	Person_ID	Mobile Number
1	500	983452201
2	501	993026654

Figure 7.3: `IDENTITY` Property Applied on `Person_ID` Column

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7.3.8 Globally Unique Identifiers

In addition to the `IDENTITY` property, SQL Server also supports globally unique identifiers. Often, in a networked environment, many tables may need to have a column consisting of a common globally unique value. Consider a scenario where data from multiple database systems such as banking databases must be consolidated at a single location. When the data from around the world is collated at the central site for consolidation and reporting, using globally unique values prevents customers in different countries from having the same bank account number or customer ID. To satisfy this need, SQL Server provides globally unique identifier columns. These can be created for each table containing values that are unique across all the computers in a network. Only one identifier column and one globally unique identifier column can be created for each table. To create and work with globally unique identifiers, a combination of `ROWGUIDCOL`, `uniqueidentifier` data type, and `NEWID` function are used.

Values for a globally unique column are not automatically generated. One has to create a `DEFAULT` definition with a `NEWID()` function for a `uniqueidentifier` column to generate a globally unique value. The `NEWID()` function creates a unique identifier number which is a 16-byte binary string. The column can be referenced in a `SELECT` list by using the `ROWGUIDCOL` keyword.

To know whether a table has a `ROWGUIDCOL` column, the `OBJECTPROPERTY` function is used. The `COLUMNPROPERTY` function is used to retrieve the name of the `ROWGUIDCOL` column. Code Snippet 15 demonstrates how to `CREATE TABLE` statement to create the `EMPCellularPhone` table.

The `Person_ID` column automatically generates a `GUID` for each new row added to the table.

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Code Snippet 15:

```
USE [CUST_DB]
CREATE TABLE EMP_CellularPhone ( Person_IDuniqueidentifier DEFAULT NEWID() NOT NULL, PersonName varchar(60) NOT NULL)
GO
```

Code Snippet 16 adds a value to **PersonName** column.

Code Snippet 16:

```
USE [CUST_DB]
INSERT INTO EMP_CellularPhone(PersonName) VALUES ('William Smith')
SELECT * FROM EMP_CellularPhone
GO
```

Learning how to learn is life's most important skill.

Figure 7.4 shows the output where a unique identifier is displayed against a specific **PersonName**.

	Person_ID	PersonName
1	362C4377-D194-4607-A466-7FF02064EAFC	William Smith

Figure 7.4: Unique Identifier

7.4 Constraints

One of the important functions of SQL Server is to maintain and enforce data integrity. There are a number of means to achieve this but one of the commonly used and preferred methods is to use constraints. A constraint is a property assigned to a column or set of columns in a table to prevent certain types of inconsistent data values from being entered. Constraints are used to apply business logic rules and enforce data integrity.

Constraints can be created when a table is created, as part of the table definition by using the `CREATE TABLE` statement or can be added at a later stage using the `ALTER TABLE` statement. Constraints can be categorized as column constraints and table constraints. A column constraint is specified as part of a column definition and applies only to that column. A table constraint can apply to more than one column in a table and is declared independently from a column definition. Table constraints must be used when more than one column is included in a constraint.

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SQL Server supports the following types of constraints:

- PRIMARY KEY
- UNIQUE
- FOREIGN KEY
- CHECK
- NOT NULL

7.4.1 PRIMARY KEY

A table typically has a primary key comprising a single column or combination of columns to uniquely identify each row within the table. The PRIMARY KEY constraint is used to create a primary key and enforce integrity of the entity of the table. Only one primary key constraint can be created per table. Two rows in a table cannot have the same primary key value and a column that is a primary key cannot have NULL values. Hence, when a primary key constraint is added to existing columns of a table, SQL Server 2012 checks to see if the rules for primary key are complied with. If the existing data in the columns do not comply with the rules for primary key then, the constraint will not be added.

The syntax to add a primary key while creating a table is as follows:

Syntax:

```
CREATE TABLE <table_name> ( Column_name datatype PRIMARY KEY [  
column_list] )
```



Code Snippet 17 demonstrates how to create a table **EMPContactPhone** to store the contact telephone details of a person. Since the column **EMP_ID** must be a primary key for identifying each row uniquely, it is created with the primary key constraint.

Code Snippet 17:

```
USE [CUST_DB]
CREATE TABLE EMPContactPhone ( EMP_ID int PRIMARY KEY, MobileNumber bigint,
ServiceProvider varchar(30), LandlineNumber bigint)
GO
```

An alternative approach is to use the **CONSTRAINT** keyword. The syntax is as follows:

Syntax:

```
CREATE TABLE <table_name> (<column_name><datatype> [, column_list] CONSTRAINT
constraint_name PRIMARY KEY)
```

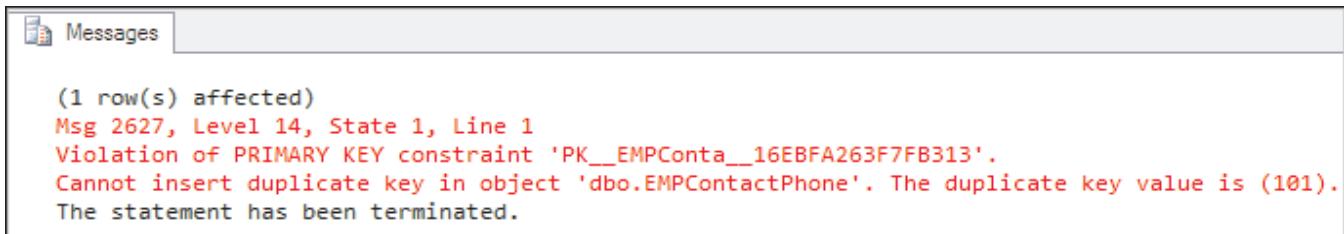
Having created a primary key for **EMP_ID**, a query is written to insert rows into the table with the statements shown in Code Snippet 18.

Code Snippet 18:

```
USE [CUST_DB]
INSERT INTO dbo.EMPContactPhone values (101, 983345674, 'Hutch', NULL)
INSERT INTO dbo.EMPContactPhone values (102, 989010002, 'Airtel', NULL)
GO
```

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The first `INSERT` statement shown in Code Snippet 18 is executed successfully but the next `INSERT` statement will fail because the value for `EMP_ID` is duplicate as shown in figure 7.5.



```
(1 row(s) affected)
Msg 2627, Level 14, State 1, Line 1
Violation of PRIMARY KEY constraint 'PK__EMPConta__16EBFA263F7FB313'.
Cannot insert duplicate key in object 'dbo.EMPContactPhone'. The duplicate key value is (101).
The statement has been terminated.
```

Figure 7.5: Output Error Message for Duplicate EMP_ID

The output of Code Snippet 18 is shown in figure 7.6.



	EMP_ID	MobileNumber	ServiceProvider	LandlineNumber
1	101	983345674	Hutch	NULL

Figure 7.6: Output of the Executed First INSERT Statement

7.4.2 UNIQUE

A `UNIQUE` constraint is used to ensure that only unique values are entered in a column or set of columns. It allows developers to make sure that no duplicate values are entered. Primary keys are implicitly unique. Unique key constraints enforce entity integrity because once the constraints are applied; no two rows in the table can have the same value for the columns. `UNIQUE` constraints allow null values.

Who dares to teach must never cease to learn.

A single table can have more than one UNIQUE constraint.

The syntax to create UNIQUE constraint is as follows:

Syntax:

```
CREATE TABLE <table_name> ([column_list  
] <column_name><data_type> UNIQUE [  
column_list])
```

Code Snippet 19 demonstrates how to make the **MobileNumber** and **LandlineNumber** columns as unique.

Code Snippet 19:

```
USE [CUST_DB]  
GO  
CREATE TABLE EMP_ContactPhone (Person_ID int PRIMARY KEY, MobileNumber bigint  
UNIQUE, ServiceProvider varchar(30), LandlineNumber bigint UNIQUE)
```

Code Snippet 20 demonstrates how to insert a row into the table.

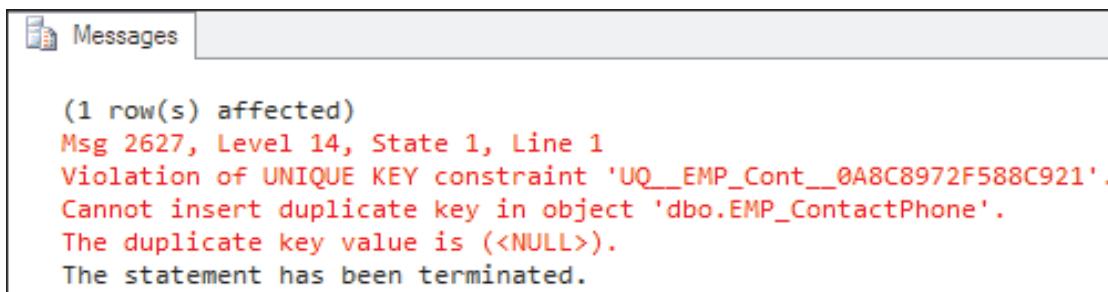
Code Snippet 20:

```
USE [CUST_DB]  
INSERT INTO EMP_ContactPhone values (111, 983345674, 'Hutch', NULL)  
INSERT INTO EMP_ContactPhone values (112, 983345674, 'Airtel', NULL)  
GO
```

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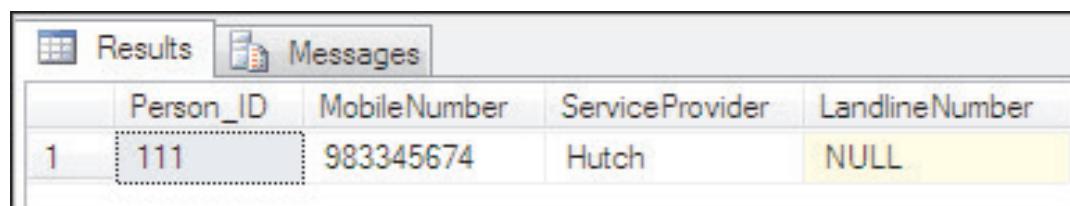
Though a value of `NULL` has been given for the `LandlineNumber` columns, which are defined as `UNIQUE`, the command will execute successfully because `UNIQUE` constraints check only for the uniqueness of values but do not prevent null entries. The first statement shown in Code Snippet 20 is executed successfully but the next `INSERT` statement will fail even though the primary key value is different because the value for `MobileNumber` is a duplicate as shown in figure 7.7. This is because the column `MobileNumber` is defined to be unique and disallows duplicate values.



```
(1 row(s) affected)
Msg 2627, Level 14, State 1, Line 1
Violation of UNIQUE KEY constraint 'UQ__EMP_Cont__0A8C8972F588C921'.
Cannot insert duplicate key in object 'dbo.EMP_ContactPhone'.
The duplicate key value is (<NULL>).
The statement has been terminated.
```

Figure 7.7: Output Error Message for Value Duplicate MobileNumber

The output of Code Snippet 20 is shown in figure 7.8.



	Person_ID	MobileNumber	ServiceProvider	LandlineNumber
1	111	983345674	Hutch	NULL

Figure 7.8: Output of the Executed UNIQUE Constraint



7.4.3 FOREIGN KEY

A foreign key in a table is a column that points to a primary key column in another table. Foreign key constraints are used to enforce referential integrity. The syntax for foreign key is as follows:

Syntax:

```
CREATE TABLE <table_name1>([column_list,] <column_name><datatype> FOREIGN KEY  
REFERENCES <table_name> (pk_column_name) [, column_list])
```

where,

<table_name>: is the name of the table from which to reference primary key.

<pk_column_name>: is the name of the primary key column.

Code Snippet 21 demonstrates how to create a foreign key constraint.

Code Snippet 21:

```
USE [CUST_DB]  
GO  
CREATE TABLE EMP_PhoneExpenses (Expense_ID int PRIMARY KEY, MobileNumber bigint  
FOREIGN KEY REFERENCES EMP_ContactPhone (MobileNumber), Amount bigint)
```

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A row is inserted into the table such that the mobile number is the same as one of the mobile numbers in **EMP_ContactPhone**. The command that will be written is shown in Code Snippet 22.

Code Snippet 22:

```
INSERT INTO dbo.EMP_PhoneExpenses values (101, 993026654, 500)
SELECT * FROM dbo.EMP_PhoneExpenses
```

The error message of Code Snippet 22 is shown in figure 7.9.

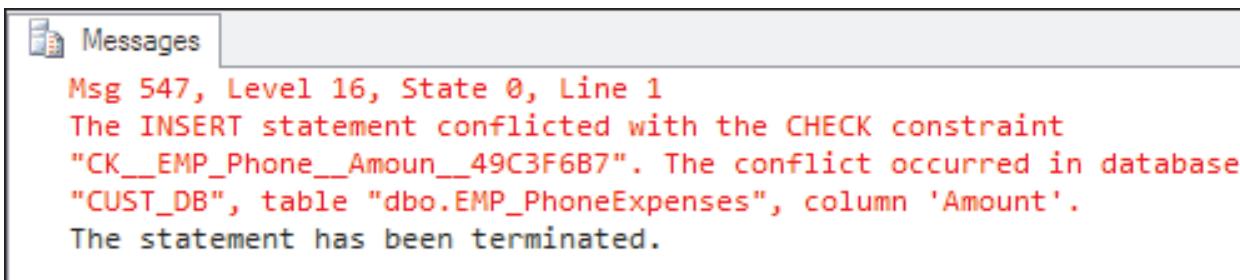


Figure 7.9: Output Error Message of FOREIGN KEY REFERENCES

If there is no key in the referenced table having a value that is being inserted into the foreign key, the insertion will fail as shown in figure 7.9. It is, however, possible to add **NULL** value into a foreign key column.

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

7.4.4 CHECK

A CHECK constraint limits the values that can be placed in a column. Check constraints enforce integrity of data. For example, a CHECK constraint can be given to check if the value being entered into `VoterAge` is greater than or equal to 18. If the data being entered for the column does not satisfy the condition, then, insertion will fail.

A CHECK constraint operates by specifying a search condition, which can evaluate to TRUE, FALSE, or unknown. Values that evaluate to FALSE are rejected. Multiple CHECK constraints can be specified for a single column. A single CHECK constraint can also be applied to multiple columns by creating it at the table level.

Code Snippet 23 demonstrates creating a CHECK constraint to ensure that the `Amount` value will always be non-zero. A NULL value can, however, be added into `Amount` column if the value of `Amount` is not known.

Code Snippet 23:

```
USE [CUST_DB]
CREATE TABLE EMP_PhoneExpenses ( Expense_ID int PRIMARY KEY, MobileNumber bigint
FOREIGN KEY REFERENCES EMP_ContactPhone (MobileNumber) , Amount bigint CHECK
(Amount >10) )
GO
```

Once a CHECK constraint has been defined, if an INSERT statement is written with data that violates the constraint, it will fail as shown in Code Snippet 24.

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Code Snippet 24:

```
USE [CUST_DB]
INSERT INTO dbo.EMP_PhoneExpenses values (101, 983345674, 9)
GO
```

The error message of Code Snippet 24 that appears when the **Amount** constraint is less than 10 is shown in figure 7.10.

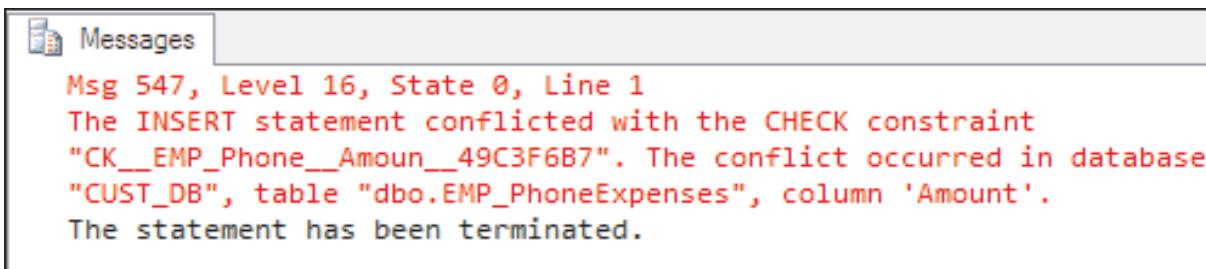


Figure 7.10: Output Error Message of CHECK Constraint

7.4.5 NOT NULL

A NOT NULL constraint enforces that the column will not accept null values. The NOT NULL constraints are used to enforce domain integrity, similar to CHECK constraints.



7.5 Check Your Progress

1. Which of the following feature of a column determines whether rows in the table can contain a null value for that column?

(A)	Default	(C)	Group BY
(B)	Multiplicity	(D)	Nullability

2. A _____ in a table is a column that points to a primary key column in another table.

(A)	Foreign key	(C)	Repeated key
(B)	Secondary key	(D)	Local key

3. Which of the following code is used to drop a table from CUST_DB database?

(A)	DROP TABLE [dbo].[Table_1]	(C)	USE [CUST_DB] GO DELETE TABLE [dbo].[Table_1]
(B)	USE [CUST_DB] GO DROP TABLE [dbo].[Table_1]	(D)	USE [CUST_DB] GO SUBTRACT [dbo].[Table_1]

4. Which of the following property of SQL Server is used to create identifier columns that can contain auto-generated sequential values to uniquely identify each row within a table?

(A)	SELECT	(C)	INSERT
(B)	IDENTITY	(D)	DEFAULT

5. A _____ constraint is used to ensure that only unique values are entered in a column or set of columns.

(A)	UNIQUE	(C)	Foreign key
(B)	DEFAULT	(D)	INSERT

7.5.1 Answers

1.	D
2.	A
3.	B
4.	B
5.	A



Summary

- A data type is an attribute that specifies the storage capacity of an object and the type of data it can hold, such as numeric data, character data, monetary data, and so on.
- SQL Server 2012 supports three kinds of data types:
 - System data types
 - Alias data types
 - User-defined types
- Most tables have a primary key, made up of one or more columns of the table that identifies records uniquely.
- The nullability feature of a column determines whether rows in the table can contain a null value for that column.
- A DEFAULT definition for a column can be created at the time of table creation or added at a later stage to an existing table.
- The IDENTITY property of SQL Server is used to create identifier columns that can contain auto-generated sequential values to uniquely identify each row within a table.
- Constraints are used to apply business logic rules and enforce data integrity.
- A UNIQUE constraint is used to ensure that only unique values are entered in a column or set of columns.
- A foreign key in a table is a column that points to a primary key column in another table.
- A CHECK constraint limits the values that can be placed in a column.



1. Saint Clara Insurance (SCI) services is a leading Insurance company based in New York, USA. SCI Services wanted a faster, more accurate, and less expensive way to handle insurance claims adjusting for its insurance company customers. With an ever-increasing customer base, they decided to create a Web-based application that will be used not only by employees who work on field, but will also be used by the administrators in the head office.

SCI handles approximately 650 claims per month, but that can soar to 15000 or more when a hurricane or some other disaster strikes. Officers can use the software on the device type of their choice: Tablet PCs or laptops in the field, or desktop PCs back in their offices. The use of Microsoft SQL Server 2005 as the software's database enables to receive and update all the necessary information regarding a customer or claimer.

With thousands of customers expected every month, data integrity of the data in the database is very important. You need to perform the following tasks:

- a. Create a database called **SaintClaraServices** to store the details of the company. Create a table **CustomerHeader** with the details given in table 7.2.

Field Name	Data Type	Description
ClientID	int	Stores client id. This column is the Primary Key
FirstName	char	Stores first name of the client
LastName	char	Stores last name of the client
MiddleName	char	Stores middle name of the client
Gender	char	Stores gender of the client
DateOfBirth	datetime	Stores date of birth of the client
Address	varchar(max)	Stores address of the client
MaritalStatus	char	Stores marital status of the client
Age	int	Stores age of the client
Employment	char	Stores occupation of the client
CompanyName	varchar(max)	Stores the company name
CompanyAddress	varchar(max)	Stores the company address

Table 7.2: CustomerHeader Table



Try It Yourself

- b. Create a table **CustomerDetails** with the specifications given in table 7.3.

Field Name	Data Type	Description
ClientID	int	Stores client id. This column is the Primary Key
FatherName	char	Stores the name of the client's father
MotherName	char	Stores the name of the client's mother
Amount	money	Stores the principal amount
Period	int	Stores period for insurance
Plan	char	Stores plan for insurance
Premium	money	Stores premium
NomineeName	char	Stores nominee name
Date	datetime	Stores the date on which insurance is made

Table 7.3: CustomerDetails Table

- c. Add a foreign key to **CustomerDetails** table.

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Session - 8

Accessing Data

Welcome to the Session, **Accessing Data**.

This session describes SELECT statement. It also explains the expressions and the various clauses used with SELECT statement. Finally, the session introduces the new xml data type and describes how to work with XML data in SQL Server 2012 tables. A brief look at the XQuery language, which is used to query XML data, is also discussed in the session.

In this Session, you will learn to:

- Describe the SELECT statement, its syntax, and use
- Explain the various clauses used with SELECT
- State the use of ORDER BY clause
- Describe working with typed and untyped XML
- Explain the procedure to create, use, and view XML schemas
- Explain use of XQuery to access XML data

8.1 Introduction

The `SELECT` statement is a core command used to access data in SQL Server 2012. XML allows developers to develop their own set of tags and makes it possible for other programs to understand these tags. XML is the preferred means for developers to store, format, and manage data on the Web.

8.2 SELECT Statement

A table with its data can be viewed using the `SELECT` statement. The `SELECT` statement in a query will display the required information in a table.

The `SELECT` statement retrieves rows and columns from one or more tables. The output of the `SELECT` statement is another table called resultset. The `SELECT` statement also joins two tables or retrieves a subset of columns from one or more tables. The `SELECT` statement defines the columns to be used for a query. The syntax of `SELECT` statement can consist of a series of expressions separated by commas. Each expression in the statement is a column in the resultset. The columns appear in the same sequence as the order of the expression in the `SELECT` statement.

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

The SELECT statement retrieves rows from the database and enables the selection of one or many rows or columns from a table. Following is the syntax for the SELECT statement.

Syntax:

```
SELECT <column_name1>...<column_nameN> FROM <table_name>
```

where,

`table_name`: is the table from which the data will be displayed.

`<column_name1>...<column_nameN>`: are the columns that are to be displayed.

Note - All commands in SQL Server 2012 do not end with a semicolon.

8.2.1 SELECT Without FROM

Many SQL versions use `FROM` in their query, but in all the versions from SQL Server 2005, including SQL Server 2012, one can use `SELECT` statements without using the `FROM` clause. Code Snippet 1 demonstrates the use of `SELECT` statement without using the `FROM` clause.

Code Snippet 1:

```
SELECT LEFT('International',5)
```

The code will display only the first five characters from the extreme left of the word 'International'.

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The output is shown in figure 8.1.

(No column name)
1 Inter

Figure 8.1: First Five Characters from the Extreme Left of the Word

8.2.2 Displaying All Columns

The asterisk (*) is used in the SELECT statement to retrieve all the columns from the table. It is used as a shorthand to list all the column names in the tables named in the FROM clause. Following is the syntax for selecting all columns.

Syntax:

```
SELECT * FROM <table_name>
```

where,

*: specifies all columns of the named tables in the FROM clause.

<table_name>: is the name of the table from which the information is to be retrieved. It is possible to include any number of tables. When two or more tables are used, the row of each table is mapped with the row of others. This activity takes a lot of time if the data in the tables are huge. Hence, it is recommended to use this syntax with a condition.

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Code Snippet 2 demonstrates the use of '*' in the SELECT statement.

Code Snippet 2:

```
USE AdventureWorks2012
SELECT * FROM HumanResources.Employee
GO
```

The partial output of Code Snippet 2 with some columns of HumanResources.Employee table is shown in figure 8.2.

	BusinessEntityID	NationalIDNumber	LoginID	OrganizationNode	On
1	1	295847284	adventure-works\ken0	0x	0
2	2	245797967	adventure-works\tim0	0x58	1
3	3	509647174	adventure-works\roberto0	0x5AC0	2
4	4	112457891	adventure-works\rob0	0x5AD6	3
5	5	695256908	adventure-works\gail0	0x5ADA	3
6	6	998320692	adventure-works\jossef0	0x5ADE	3
7	7	134969118	adventure-works\dylan0	0x5AE1	3
8	8	811994146	adventure-works\diane1	0x5AE158	4

Figure 8.2: Displaying All Columns

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8.2.3 Displaying Selected Columns

The SELECT statement displays or returns certain relevant columns that are chosen by the user or mentioned in the statement. To display specific columns, the knowledge of the relevant column names in the table is needed. Following is the syntax for selecting specific columns.

Syntax:

```
SELECT <column_name1>..<column_nameN> FROM <table_name>
```

where,

<column_name1>..<column_nameN>: are the columns that are to be displayed.

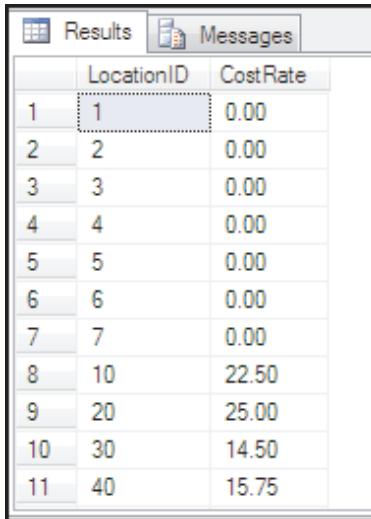
For example, to display the cost rates in various locations from Production.Location table in AdventureWorks2012 database, the SELECT statement is shown in Code Snippet 3.

Code Snippet 3:

```
USE AdventureWorks2012  
SELECT LocationID, CostRate FROM Production.Location  
GO
```

To avoid criticism, do nothing, say nothing, be nothing.

Figure 8.3 shows LocationID and CostRate columns from AdventureWorks2012 database.



The screenshot shows a results grid from a SQL query. The grid has two columns: 'LocationID' and 'CostRate'. The 'LocationID' column contains integer values from 1 to 11. The 'CostRate' column contains decimal values: 0.00 for rows 1 through 6, 22.50 for row 8, 25.00 for row 9, 14.50 for row 10, and 15.75 for row 11. Row 8 is highlighted with a yellow background.

	LocationID	CostRate
1	1	0.00
2	2	0.00
3	3	0.00
4	4	0.00
5	5	0.00
6	6	0.00
7	7	0.00
8	10	22.50
9	20	25.00
10	30	14.50
11	40	15.75

Figure 8.3: LocationID and CostRate Columns

8.3 Different Expressions with SELECT

SELECT statement allows the users to specify different expressions in order to view the resultset in an ordered manner. These expressions assign different names to the columns in the resultset, compute values, and eliminate duplicate values.

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8.3.1 Using Constants in Result Sets

Character string constants are used when character columns are joined. They help in proper formatting or readability. These constants are not specified as a separate column in the resultset.

It is usually more efficient for an application to build the constant values into the results when they are displayed, rather than making use of the server to incorporate the constant values. For example, to include ' : ' and '→' in the resultset so as to display the country name, country region code, and its corresponding group, the SELECT statement is shown in Code Snippet 4.

Code Snippet 4:

```
USE AdventureWorks2012
SELECT [Name] + ' : ' + CountryRegionCode + ' → ' + [Group] FROM Sales.SalesTerritory
GO
```



Figure 8.4 displays the country name, country region code, and corresponding group from Sales.SalesTerritory of AdventureWorks2012 database.

	Results	Messages
(No column name)		
1	Northwest : US --> North America	
2	Northeast : US --> North America	
3	Central : US --> North America	
4	Southwest : US --> North America	
5	Southeast : US --> North America	
6	Canada : CA --> North America	
7	France : FR --> Europe	
8	Germany : DE --> Europe	
9	Australia : AU --> Pacific	
10	United Kingdom : GB --> Europe	

Figure 8.4: Country Name, Country Region Code, and Corresponding Group

8.3.2 Renaming ResultSet Column Names

When columns are displayed in the resultset they come with corresponding headings specified in the table. These headings can be changed, renamed, or can be assigned a new name by using AS clause. Therefore, by customizing the headings, they become more understandable and meaningful.

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Code Snippet 5 demonstrates how to display 'ChangedDate' as the heading for `ModifiedDate` column in the `dbo.Individual` table, the SELECT statement.

Code Snippet 5:

```
USE CUST_DB  
SELECT ModifiedDate as 'ChangedDate' FROM dbo.Individual  
GO
```

The output displays 'ChangedDate' as the heading for `ModifiedDate` column in the `dbo.Individual` table. Figure 8.5 shows the original heading and the changed heading.

Results		Messages	
ModifiedDate		ChangedDate	
1	1981-02-02	1	1981-02-02

Figure 8.5: Column Heading Modified to ChangedDate

Learning is not compulsory, but neither is survival.

8.3.3 Computing Values in ResultSet

A SELECT statement can contain mathematical expressions by applying operators to one or more columns. It allows a resultset to contain values that do not exist in the base table, but which are calculated from the values stored in the base table.

Note - The table used in the `FROM` clause of a query is called as a base table.

For example, consider the table `Production.ProductCostHistory` from `AdventureWorks2012` database. Consider the example where the production people decide to give 15% discount on the standard cost of all the products. The discount amount does not exist but can be calculated by executing the SELECT statement shown in Code Snippet 6.

Code Snippet 6:

```
USE AdventureWorks2012  
SELECT ProductID, StandardCost, StandardCost * 0.15 as Discount FROM  
Production.ProductCostHistory  
GO
```

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Figure 8.6 shows the output where discount amount is calculated using SELECT statement.

	ProductID	StandardCost	Discount
1	707	12.0278	1.804170
2	707	13.8782	2.081730
3	707	13.0863	1.962945
4	708	12.0278	1.804170
5	708	13.8782	2.081730
6	708	13.0863	1.962945
7	709	3.3963	0.509445
8	710	3.3963	0.509445
9	711	12.0278	1.804170
10	711	13.8782	2.081730
11	711	13.0863	1.962945

Figure 8.6: Calculated Discount Amount

8.3.4 Using DISTINCT

The keyword **DISTINCT** prevents the retrieval of duplicate records. It eliminates rows that are repeating from the resultset of a **SELECT** statement. For example, if the **StandardCost** column is selected without using the **DISTINCT** keyword, it will display all the standard costs present in the table. On using the **DISTINCT** keyword in the query,



SQL Server will display every record of StandardCost only once as shown in Code Snippet 7.

Code Snippet 7:

```
USE AdventureWorks2012  
SELECT DISTINCT StandardCost FROM Production.ProductCostHistory  
GO
```

8.3.5 Using *TOP* and *PERCENT*

The *TOP* keyword will display only the first few set of rows as a resultset. The set of rows is either limited to a number or a percent of rows. The *TOP* expression can also be used with other statements such as *INSERT*, *UPDATE*, and *DELETE*. Following is the syntax for the *TOP* keyword.

Syntax:

```
SELECT [ALL | DISTINCT] [TOP expression [PERCENT] [WITH TIES]]
```

where,

expression: is the number or the percentage of rows to be returned as the result.

PERCENT: returns the number of rows limited by percentage.

WITH TIES: is the additional number of rows that is to be displayed.

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The SELECT statement has various clauses associated with it. In this section, each clause is discussed in detail.

8.3.6 SELECT with INTO

The INTO clause creates a new table and inserts rows and columns listed in the SELECT statement into it. INTO clause also inserts existing rows into the new table. In order to execute this clause with the SELECT statement, the user must have the permission to CREATE TABLE in the destination database.

Syntax:

```
SELECT <column_name1>..<column_nameN> [INTO new_table] FROM table_list
```

where,

new_table: is the name of the new table that is to be created.

Code Snippet 8 uses an INTO clause which creates a new table Production.ProductName with details such as the product's ID and its name from the table Production.ProductModel.

Code Snippet 8:

```
USE AdventureWorks2012
SELECT ProductModelID, Name INTO Production.ProductName FROM Production.
ProductModel
GO
```

After executing the code, a message stating '(128 row(s) affected)' is displayed.

A wise man learns from the mistakes of others, a fool by his own.

If a query is written to display the rows of the new table, the output will be as shown in figure 8.7.

	ProductModelID	Name
1	122	All-Purpose Bike Stand
2	119	Bike Wash
3	115	Cable Lock
4	98	Chain
5	1	Classic Vest
6	2	Cycling Cap
7	121	Fender Set - Mountain
8	102	Front Brakes
9	103	Front Derailleur
10	3	Full-Finger Gloves
11	4	Half-Finger Gloves
12	109	Headlights - Dual-Beam
13	110	Headlights - Weather...
14	118	Hitch Rack - 4-Bike
15	97	HL Bottom Bracket
16	101	HL Crankset
17	106	HL Fork

Figure 8.7: New Table Created

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8.3.7 SELECT with WHERE

The WHERE clause with SELECT statement is used to conditionally select or limit the records retrieved by the query. A WHERE clause specifies a Boolean expression to test the rows returned by the query. The row is returned if the expression is true and is discarded if it is false.

Syntax:

```
SELECT <column_name1>...<column_nameN> FROM <table_name> WHERE <search_condition>
```

where,

`search_condition`: is the condition to be met by the rows.

Table 8.1 shows the different operators that can be used with the WHERE clause.

Operator	Description
=	Equal to
< >	Not equal to
>	Greater than
<	Less than
> =	Greater than or equal to
< =	Less than or equal to
!	Not
BETWEEN	Between a range
LIKE	Search for an ordered pattern
IN	Within a range

Table 8.1: Operators

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Code Snippet 9 demonstrates the equal to operator with WHERE clause to display data with **EndDate 6/30/2007 12:00:00 AM**.

Code Snippet 9:

```
USE AdventureWorks2012
SELECT * FROM Production.ProductCostHistory WHERE EndDate = '6/30/2007 12:00:00
AM'
GO
```

Code Snippet 9 will return all records from the table `Production.ProductCostHistory` which has the end date as '`6/30/2007 12:00:00 AM`'.

The output SELECT with WHERE clause is shown in figure 8.8.

	ProductID	StartDate	EndDate	StandardCost	ModifiedDate
1	707	2006-07-01 00:00:0...	2007-06-30 00:0...	13.8782	2007-06-30 00:00:00
2	708	2006-07-01 00:00:0...	2007-06-30 00:0...	13.8782	2007-06-30 00:00:00
3	711	2006-07-01 00:00:0...	2007-06-30 00:0...	13.8782	2007-06-30 00:00:00
4	712	2006-07-01 00:00:0...	2007-06-30 00:0...	5.2297	2007-06-30 00:00:00
5	713	2006-07-01 00:00:0...	2007-06-30 00:0...	29.0807	2007-06-30 00:00:00
6	714	2006-07-01 00:00:0...	2007-06-30 00:0...	29.0807	2007-06-30 00:00:00
7	715	2006-07-01 00:00:0...	2007-06-30 00:0...	29.0807	2007-06-30 00:00:00
8	716	2006-07-01 00:00:0...	2007-06-30 00:0...	29.0807	2007-06-30 00:00:00
9	717	2006-07-01 00:00:0...	2007-06-30 00:0...	722.2568	2007-06-30 00:00:00

Figure 8.8: SELECT with WHERE clause

All queries in SQL use single quotes to enclose the text values. For example, consider the following query, which retrieves all the records from `Person.Address` table having Bothell as city.

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Session**Accessing Data**

Code Snippet 10 demonstrates the equal to operator with WHERE clause to display data with address having Bothell city.

Code Snippet 10:

```
USE AdventureWorks2012
SELECT DISTINCT StandardCost FROM Production.ProductCostHistory
GO
```

The output of the query is shown in figure 8.9.

	AddressID	AddressLine1	AddressLine2	City	StateProvinceID	PostalCode
1	5	1226 Shoe St.	NULL	Bothell	79	98011
2	11	1318 Lasalle Street	NULL	Bothell	79	98011
3	6	1399 Firestone Drive	NULL	Bothell	79	98011
4	18	1873 Lion Circle	NULL	Bothell	79	98011
5	40	1902 Santa Cruz	NULL	Bothell	79	98011
6	1	1970 Napa Ct.	NULL	Bothell	79	98011
7	10	250 Race Court	NULL	Bothell	79	98011
8	868	25111 228th St Sw	NULL	Bothell	79	98011
9	19	3148 Rose Street	NULL	Bothell	79	98011

Figure 8.9: Query with Single Quotes

You must do the things you think you cannot do.

Numeric values are not enclosed within any quotes as shown in Code Snippet 11.

Code Snippet 11:

```
USE AdventureWorks2012
SELECT * FROM HumanResources.Department WHERE DepartmentID < 10
GO
```

The query in Code Snippet 11 displays all those records where the value in DepartmentID is less than 10.

The output of the query is shown in figure 8.10.

	DepartmentID	Name	GroupName	ModifiedDate
1	1	Engineering	Research and Development	2002-01-01
2	2	Tool Design	Research and Development	2002-01-01
3	3	Sales	Sales and Marketing	2002-01-01
4	4	Marketing	Sales and Marketing	2002-01-01
5	5	Purchasing	Inventory Management	2002-01-01
6	6	Research and Development	Research and Development	2002-01-01
7	7	Production	Manufacturing	2002-01-01
8	8	Production Control	Manufacturing	2002-01-01

Figure 8.10: Output of Where Clause with < Operator

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WHERE clause can also be used with wildcard characters as shown in table 8.2. All wildcard characters are used along with LIKE keyword to make the query accurate and specific.

Wildcard	Description	Example
_	It will display a single character	SELECT * FROM Person. Contact WHERE Suffix LIKE 'Jr_'
%	It will display a string of any length	SELECT * FROM Person. Contact WHERE LastName LIKE 'B%'
[]	It will display a single character within the range enclosed in the brackets	SELECT * FROM Sales. CurrencyRate WHERE ToCurrencyCode LIKE 'C [AN] [DY]'
[^]	It will display any single character not within the range enclosed in the brackets	SELECT * FROM Sales. CurrencyRate WHERE ToCurrencyCode LIKE 'A[^R] [^S]'

Table 8.2: Wildcard Characters

WHERE clause also uses logical operators such as AND, OR, and NOT. These operators are used with search conditions in WHERE clauses.

AND operator joins two or more conditions and returns TRUE only when both the conditions are TRUE. So, it returns all the rows from the tables where both the conditions that are listed are true.



Code Snippet 12 demonstrates AND operator.

Code Snippet 12:

```
USE AdventureWorks2012  
SELECT * FROM Sales.CustomerAddress WHERE AddressID > 900 AND AddressTypeID = 5  
GO
```

OR operator returns TRUE and displays all the rows if it satisfies any one of the conditions. Code Snippet 13 demonstrates OR operator.

Code Snippet 13:

```
USE AdventureWorks2012  
SELECT * FROM Sales.CustomerAddress WHERE AddressID < 900 OR AddressTypeID = 5  
GO
```

The query in Code Snippet 13 will display all the rows whose AddressID is less than 900 or whose AddressTypeID is equal to five.

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The NOT operator negates the search condition. Code Snippet 14 demonstrates NOT operator.

Code Snippet 14:

```
USE AdventureWorks2012  
SELECT * FROM Sales.CustomerAddress WHERE NOT AddressTypeID = 5  
GO
```

Code Snippet 14 will display all the records whose AddressTypeID is not equal to 5. Multiple logical operators in a single SELECT statement can be used. When more than one logical operator is used, NOT is evaluated first, then AND, and finally OR.

8.3.8 GROUP BY Clause

The GROUP BY clause partitions the resultset into one or more subsets. Each subset has values and expressions in common. If an aggregate function is used in the GROUP BY clause, the resultset produces single value per aggregate.

The GROUP BY keyword is followed by a list of columns, known as grouped columns. Every grouped column restricts the number of rows of the resultset. For every grouped column, there is only one row. The GROUP BY clause can have more than one grouped column.

*Woe to him who teaches men faster
than they can learn.*

Following is the syntax for GROUP BY clause.

Syntax:

```
SELECT <column_name1>..<column_nameN> FROM <table_name> GROUP BY <column_name>
```

where,

`column_name1`: is the name of the column according to which the resultset should be grouped.

For example, consider that if the total number of resource hours has to be found for each work order, the query in Code Snippet 15 would retrieve the resultset.

Code Snippet 15:

```
USE AdventureWorks2012  
SELECT WorkOrderID, SUM(ActualResourceHrs) FROM Production.WorkOrderRouting  
GROUP BY WorkOrderID  
GO
```

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The output is shown in figure 8.11.

	WorkOrderID	(No column name)
1	13	17.6000
2	14	17.6000
3	15	4.0000
4	16	4.0000
5	17	4.0000
6	18	4.0000
7	19	4.0000
8	20	4.0000
9	21	4.0000
10	22	4.0000

Figure 8.11: GROUP BY Clause

The GROUP BY clause can be used with different clauses.

8.3.9 Clauses and Statements

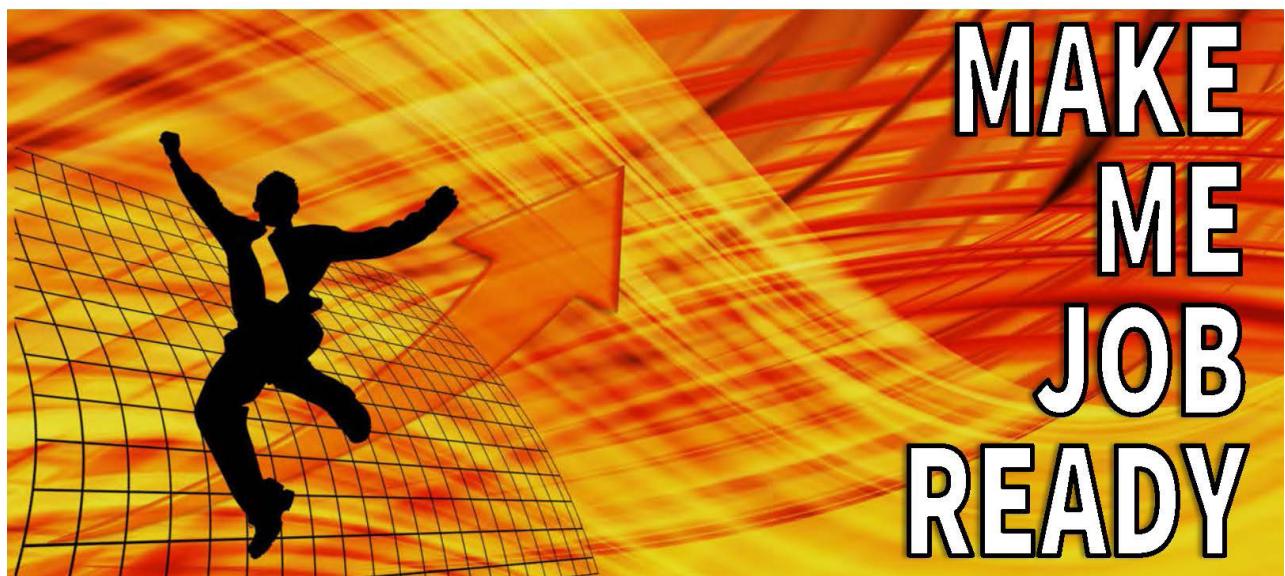
Microsoft SQL Server 2012 provides enhanced query syntax elements for more powerful data accessing and processing.

- Common Table Expression (CTE) in SELECT and INSERT statement

A CTE is a named temporary resultset based on the regular SELECT and INSERT query.



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Code Snippet 16 demonstrates the use of CTE in INSERT statement.

Code Snippet 16:

```
USE CUST_DB

CREATE TABLE NewEmployees (EmployeeID smallint, FirstName char(10), LastName
char(10), Department varchar(50), HiredDate datetime, Salary money);

INSERT INTO NewEmployees
VALUES(11, 'Kevin', 'Blaine', 'Research', '2012-07-31', 54000);

WITH EmployeeTemp (EmployeeID, FirstName, LastName, Department,
HiredDate, Salary)
AS
(
SELECT * FROM NewEmployees
)
SELECT * FROM EmployeeTemp
```

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The statement in Code Snippet 16 inserts a new row for the **NewEmployees** table and transfers the temporary resultset to **EmployeeTemp** as shown in figure 8.12.

	EmployeeID	FirstName	LastName	Department	HiredDate	Salary
1	11	Kevin	Blaine	Research	2012-07-31 00:00:00.000	54000.00

Figure 8.12: Transferring Temporary Result to EmployeeTemp

→ OUTPUT clause in INSERT and UPDATE statements

The OUTPUT clause returns information about rows affected by an **INSERT** statement and an **UPDATE** statement.

*Real generosity towards the future lies
in giving all to the present.*

Code Snippet 17 demonstrates how to use UPDATE statement with an INSERT statement.

Code Snippet 17:

```
USE CUST_DB;
GO
CREATE TABLE dbo.table_3
(
    id INT,
    employee VARCHAR(32)
)
go
INSERT INTO dbo.table_3 VALUES
    (1, 'Matt')
    ,(2, 'Joseph')
    ,(3, 'Renny')
    ,(4, 'Daisy');
GO
DECLARE @updatedTable TABLE
(
    id INT, olldata_employee VARCHAR(32), newdata_employee VARCHAR(32)
);
UPDATE dbo.table_3
    Set employee=UPPER(employee)
OUTPUT
    inserted.id,
    deleted.employee,
    inserted.employee
INTO @updatedTable
SELECT * FROM @updatedTable
```

After executing Code Snippet 17, the output where rows are affected by an `INSERT` statement and an `UPDATE` statement is shown in figure 8.13.

	Results	Messages	
	id	olddata_employee	newdata_employee
1	1	Matt	MATT
2	2	Joseph	JOSEPH
3	3	Renny	RENNY
4	4	Daisy	DAISY

Figure 8.13: Output of `UPDATE` Statement

→ **.WRITE clause**

.`WRITE` clause is used in an `UPDATE` statement to replace a value in a column having large value data type. Following is the syntax for the .`WRITE` clause.

Syntax:

```
.WRITE(expression, @offset, @Length)
```

where,

`expression`: is the character string which is to be placed into the large value data type column.

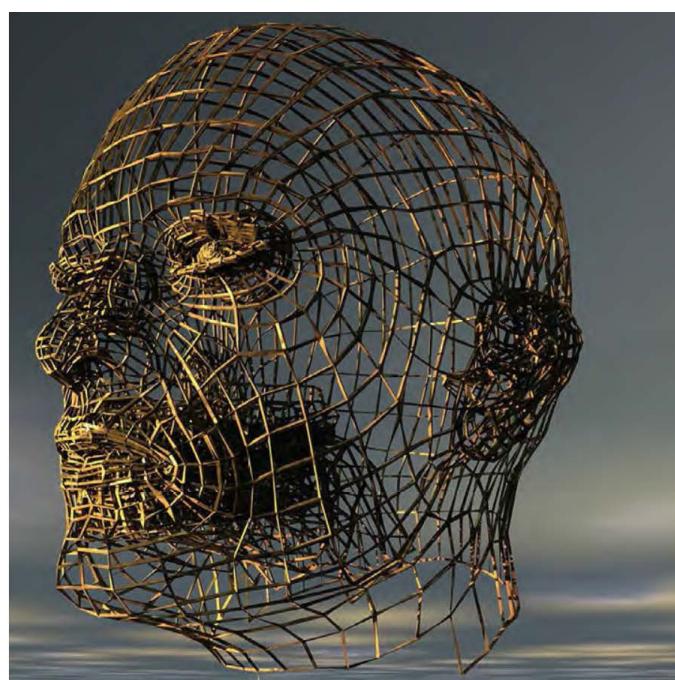
`@offset`: is the starting value (units) where the replacement is to be done.

`@Length`: is the length of the portion in the column, starting from `@offset` that is replaced by `expression`.

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Code Snippet 18 demonstrates how .WRITE clause is used in UPDATE statement.

Code Snippet 18:

```
USE CUST_DB;
GO
CREATE TABLE dbo.table_5
(
    Employee_role VARCHAR(max),
    Summary VARCHAR(max)
)
INSERT INTO dbo.table_5(Employee_role, Summary) VALUES ('Research',
'This a very long non-unicode string')
SELECT *FROM dbo.table_5
UPDATE dbo.table_5 SET Summary .WRITE('n incredibly', 6,5)
WHERE Employee_role LIKE 'Research'
SELECT *FROM dbo.table_5
```

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Figure 8.14 displays the output of .WRITE clause query.

The screenshot shows a database results window with two tables. The top table has columns 'Employee_role' and 'Summary'. It contains one row with 'Research' in 'Employee_role' and 'This a very long non-unicode string' in 'Summary'. The bottom table also has columns 'Employee_role' and 'Summary'. It contains one row with 'Research' in 'Employee_role' and 'This an incredibly long non-unicode string' in 'Summary'. Both rows have a row number '1' in the first column.

	Employee_role	Summary
1	Research	This a very long non-unicode string

	Employee_role	Summary
1	Research	This an incredibly long non-unicode string

Figure 8.14: Output of .WRITE Clause Query

Knowledge is not enough; we must apply. Willing is not enough; we must do.

8.4 ORDER BY Clause

It specifies the order in which the columns should be sorted in a resultset. It sorts query results by one or more columns. A sort can be in either ascending (`ASC`) or descending (`DESC`) order. By default, records are sorted in an `ASC` order. To switch to the descending mode, use the optional keyword `DESC`. When multiple fields are used, SQL Server considers the leftmost field as the primary level of sort and others as lower levels of sort.

Syntax:

```
SELECT <column_name> FROM <table_name> ORDER BY <column_name> {ASC | DESC}
```

The `SELECT` statement in Code Snippet 19 sorts the query results on the `SalesLastYear` column of the `Sales.SalesTerritory` table.

Code Snippet 19:

```
USE AdventureWorks2012  
SELECT * FROM Sales.SalesTerritory ORDER BY SalesLastYear  
GO
```

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The output is shown in figure 8.15.

	TerritoryID	Name	Country...	Group	Sales...	SalesLastYear	Cos
1	8	Germany	DE	Europe	3805...	1307949.7917	0.0
2	10	United Kingdom	GB	Europe	5012...	1635823.3967	0.0
3	9	Australia	AU	Pacific	5977...	2278548.9776	0.0
4	7	France	FR	Europe	4772...	2396539.7601	0.0
5	3	Central	US	North America	3072...	3205014.0767	0.0
6	1	Northwest	US	North America	7887...	3298694.4938	0.0
7	2	Northeast	US	North America	2402...	3607148.9371	0.0
8	5	Southeast	US	North America	2538...	3925071.4318	0.0
9	4	Southwest	US	North America	1051...	5366575.7098	0.0

Figure 8.15: ORDER BY Clause

8.5 Working with XML

Extensible Markup Language (XML) allows developers to develop their own set of tags and makes it possible for other programs to understand these tags. XML is the preferred means for developers to store, format, and manage data on the Web. Applications of today have a mix of technologies such as ASP, Microsoft .NET technologies, XML, and SQL Server 2012 working in tandem. In such a scenario, it is better to store XML data within SQL Server 2012.



Native XML databases in SQL Server 2012 have a number of advantages. Some of them are listed as follows:

- Easy Data Search and Management - All the XML data is stored locally in one place, thus making it easier to search and manage.
- Better Performance - Queries from a well-implemented XML database are faster than queries over documents stored in a file system. Also, the database essentially parses each document when storing it.
- Easy data processing - Large documents can be processed easily.

SQL Server 2012 supports native storage of XML data by using the `xml` data type. Following sections explore the `xml` data type, working with typed and untyped XML, storing them in SQL Server 2012, and using XQuery to retrieve data from columns of `xml` data type.

8.5.1 XML Data Type

In addition to regular commonly used data types, SQL Server 2012 provides a brand new data type in the form of `xml` data type.

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The `xml` data type is used to store XML documents and fragments in an SQL Server database. An XML fragment is an XML instance with the top-level element missing from its structure.

Following is the syntax to create a table with columns of type `xml`.

Syntax:

```
CREATE TABLE <table_name> ( [column_list,] <column_name> xml [, column_list])
```

Code Snippet 20 creates a new table named `PhoneBilling` with one of the columns belonging to `xml` data type.

Code Snippet 20:

```
USE AdventureWorks2012  
CREATE TABLE Person.PhoneBilling (Bill_ID int PRIMARY KEY, MobileNumber bigint  
UNIQUE, CallDetails xml)  
GO
```

A column of type `xml` can be added to a table at the time of creation or after its creation. The `xml` data type columns support `DEFAULT` values as well as the `NOT NULL` constraint.

*Don't just learn the tricks of the trade,
learn the trade.*

Data can be inserted into the `xml` column in the `Person.PhoneBilling` table as shown in Code Snippet 21.

Code Snippet 21:

```
USE AdventureWorks2012
INSERT INTO Person.PhoneBilling VALUES (100, 9833276605,
'<Info><Call>Local</Call><Time>45 minutes</Time><Charges>200</Charges></
Info>')
SELECT CallDetails FROM Person.PhoneBilling
GO
```

The output is shown in figure 8.16.

CallDetails
1 <Info><Call>Local</Call><Time>45 minutes</Time><Charges>200</Charges></Info>

Figure 8.16: XML Data in Columns

The `DECLARE` statement is used to create variables of type `xml`.

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Code Snippet 22 shows how to create a variable of type `xml`.

Code Snippet 22:

```
DECLARE @xmlvar xml
SELECT @xmlvar='<Employee name="Joan" />'
```

The `xml` data type columns cannot be used as a primary key, foreign key, or as a unique constraint.

8.5.2 Typed and Untyped XML

There are two ways of storing XML documents in the `xml` data type columns, namely, typed and untyped XML. An XML instance which has a schema associated with it is called typed XML instance. A schema is a header for an XML instance or document. It describes the structure and limits the contents of XML documents by associating `xml` data types with XML element types and attributes. Associating XML schemas with the XML instances or documents is recommended because data can be validated while it is being stored into the `xml` data type column.

SQL Server does not perform any validation for data entered in the `xml` column. However, it ensures that the data that is stored is well-formed. Untyped XML data can be created and stored in either table columns or variables depending upon the need and scope of the data.



The first step in using typed XML is registering a schema. This is done by using the CREATE XML SCHEMA COLLECTION statement as shown in Code Snippet 23.

Code Snippet 23:

```
USE SampleDB

CREATE XML SCHEMA COLLECTION CricketSchemaCollection
AS N'<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
<xsd:element name="MatchDetails">
<xsd:complexType>
<xsd:complexContent>
<xsd:restriction base="xsd:anyType">
<xsd:sequence>
<xsd:element name="Team" minOccurs="0" maxOccurs="unbounded">
<xsd:complexType>
<xsd:complexContent>
<xsd:restriction base="xsd:anyType">
<xsd:sequence />
<xsd:attribute name="country" type="xsd:string" />
<xsd:attribute name="score" type="xsd:string" />
</xsd:restriction>
</xsd:complexContent>
</xsd:complexType>
</xsd:element>
</xsd:sequence>
</xsd:restriction>
</xsd:complexContent>
</xsd:complexType>
</xsd:element>
</xsd:schema>'

GO
```

The CREATE XML SCHEMA COLLECTION statement creates a collection of schemas, any of which can be used to validate typed XML data with the name of the collection. This example shows a new schema called **CricketSchemaCollection** being added to the **SampleDB** database. Once a schema is registered,

the schema can be used in new instances of the `xml` data type.

Code Snippet 24 creates a table with an `xml` type column and specifies a schema for the column.

Code Snippet 24:

```
USE SampleDB  
  
CREATE TABLE CricketTeam ( TeamID int identity not null, TeamInfo xml (CricketSchemaCollection) )  
  
GO
```

To create new rows with the typed XML data, the `INSERT` statement can be used as shown in Code Snippet 25.

Code Snippet 25:

```
USE SampleDB  
  
INSERT INTO CricketTeam (TeamInfo) VALUES ('<MatchDetails><Team  
country="Australia" score="355"></Team><Team country="Zimbabwe"  
score="200"></Team><Team country="England" score="475"></Team></  
MatchDetails>')  
  
GO
```

Practice is the best of all instructors.

A typed XML variable can also be created by specifying the schema collection name. For instance, in Code Snippet 26, a variable team is declared as a typed XML variable with schema name as **CricketSchemaCollection**. The SET statement is used to assign the variable as an XML fragment.

Code Snippet 26:

```
USE SampleDB
DECLARE @team xml (CricketSchemaCollection)
SET @team = '<MatchDetails><Team country="Australia"></Team></MatchDetails>'
SELECT @team
GO
```

8.5.3 XQuery

After XML data has been stored using the `xml` data type, it can be queried and retrieved using a language named XQuery. XML Query or XQuery is a new query language, which combines syntax that is familiar to developers who work with the relational database, and XPath language, that is used to select individual sections or collections of elements from an XML document. XQuery can be query structured or semi-structured XML data. To query an XML instance stored in a variable or column of `xml` type, `xml` data type methods are used. For example, a variable of `xml` type is declared and queried by using methods of the `xml` data type. Developers need to query XML documents, and this involves transforming XML documents in the required format. XQuery makes it possible to perform complex queries against an XML data source over the Web.

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Some of the `xml` data type methods used with XQuery are described as follows:

→ **`exist()`**

This method is used to determine if one or more specified nodes are present in the XML document. It returns 1 if the XQuery expression returned at least one node, 0 if the Xquery expression evaluated to an empty result, and `NULL` if the `xml` data type instance against which the query was executed is `NULL`.

Code Snippet 27 demonstrates the use of `exist()` method. It is assumed that many records have been inserted into the table.

Code Snippet 27:

```
USE SampleDB
SELECT TeamID FROM CricketTeam WHERE TeamInfo.exist ('(/MatchDetails/
Team)') = 1
GO
```

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This will return only those `TeamID` values where the `Team` element has been specified in the `TeamInfo`. The output is shown in figure 8.17.

Results		Messages
TeamID		
1		
	1	

Figure 8.17: `exist()` Method

→ `query()`

The `query()` method can be used to retrieve either the entire contents of an XML document or a selected section of the XML document. Code Snippet 28 shows the use of `query()` method.

Code Snippet 28:

```
USE SampleDB
SELECT TeamInfo.query('/MatchDetails/Team') AS Info FROM CricketTeam
GO
```

The output is shown in figure 8.18.

Results		Messages
Info		
1	<Team country="Australia" score="355" /><Team co...	

Figure 8.18: `query()` Method

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→ **value()**

The `value()` method can be used to extract scalar values from an `xml` data type. Code Snippet 29 demonstrates this method.

Code Snippet 29:

```
USE SampleDB  
SELECT TeamInfo.value('(/MatchDetails/Team/@score)[1]', 'varchar(20)')  
AS Score FROM CricketTeam WHERE TeamID=1  
GO
```

The output of the command is shown in figure 8.19.

Score
355

Figure 8.19: `value()` Method

It is hard to fail, but it is worse never to have tried to succeed.

8.6 Check Your Progress

1. Which of the following allows developers to develop their own set of tags and makes it possible for other programs to understand these tags?

(A)	Xquery	(C)	DHTML
(B)	HTML	(D)	XML

2. The _____ statement retrieves rows and columns from one or more tables.

(A)	SELECT	(C)	INSERT
(B)	DISPLAY	(D)	SHOW

3. Which of the following is the general format of the .WRITE clause query?

(A)	ADD INTO dbo.table_5(Employee_role, Summary) VALUES ('Research', 'This a very long non-unicode string') SELECT *FROM dbo.table_5 UPDATE dbo.table_5 SET Summary .WRITE ('n incredibly') WHERE Employee_role LIKE 'Research' SELECT *FROM dbo.table_5	(C)	INSERT INTO dbo.table_5 (Employee_role, Summary) VALUES ('Research', 'This a very long non-unicode string') SELECT *FROM dbo.table_5 UPDATE dbo.table_5 SET Summary .WRITE ('n incredibly', 6,5) WHERE Employee_role LIKE 'Research' SELECT *FROM dbo.table_5
(B)	INSERT INTO dbo.table_5 (Employee_role, Summary) VALUES ('Research', 'This a very long non-unicode string') SELECT *FROM dbo.table_5 UPDATE dbo.table_5 SET Summary .WRITE ('n incredibly', 6,5) WHERE Employee_role LIKE 'Research' SELECT *FROM dbo.table_5	(D)	INSERT INTO dbo.table_5 (Employee_role, Summary) VALUES ('Research', 'This a very long non-unicode string') SELECT *FROM dbo.table_5 dbo.table_5 SET Summary ('n incredibly', 6,5) WHERE Employee_role LIKE 'Research' SELECT *FROM dbo.table_5

Session**Accessing Data**

4. Which of the following clause with the SELECT statement is used to specify tables or retrieves the records?

(A)	WHERE	(C)	. VALUE
(B)	FROM	(D)	. WRITE

5. _____ is used to improve the efficiency of queries on XML documents that are stored in an XML column.

(A)	XML indexing	(C)	XML querying
(B)	XMLimport	(D)	XML export

8.6.1 Answers

1.	D
2.	A
3.	B
4.	B
5.	A



- The SELECT statement retrieves rows and columns from tables.
- SELECT statement allows the users to specify different expressions in order to view the resultset in an ordered manner.
- A SELECT statement can contain mathematical expressions by applying operators to one or more columns.
- The keyword DISTINCT prevents the retrieval of duplicate records.
- XML allows developers to develop their own set of tags and makes it possible for other programs to understand these tags.
- A typed XML instance is an XML instance which has a schema associated with it.
- XML data can be queried and retrieved using XQuery language.



Try It Yourself

1. Transcorp United Inc. is an import export company in USA. The database of the company is created in SQL Server 2012. Transcorp has around 3000 employees worldwide. The details of the employees such as Employee Code, Employee Name, Employee Department, Date of Joining, and so on are stored in **EMP _ Details** table.

As the database administrator of Transcorp, you have to perform the following tasks:

- Retrieve data of the employees who has joined the company before the year 2012 and after 2010.
- Edit the name of a female employee Julia Drek to Julia Dean using the .WRITE property.
- Get the data of all the employees who are from Houston.

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Session - 9

Advanced Queries and Joins

Welcome to the Session, **Advanced Queries and Joins**.

This session explains the various techniques to group and aggregate data and describes the concept of subqueries, table expressions, joins, and explores various set operators. The session also covers pivoting and grouping set operations.

In this Session, you will learn to:

- Explain grouping and aggregating data
- Describe subqueries
- Describe table expressions
- Explain joins
- Describe various types of joins
- Explain the use of various set operators to combine data
- Describe pivoting and grouping set operations

9.1 Introduction

SQL Server 2012 includes several powerful query features that help you to retrieve data efficiently and quickly. Data can be grouped and/or aggregated together in order to present summarized information. Using the concept of subqueries, a resultset of a `SELECT` can be used as criteria for another `SELECT` statement or query. Joins help you to combine column data from two or more tables based on a logical relationship between the tables. On the other hand, set operators such as `UNION` and `INTERSECT` help you to combine row data from two or more tables. The `PIVOT` and `UNPIVOT` operators are used to transform the orientation of data from column-oriented to row-oriented and vice versa. The `GROUPING SET` subclause of the `GROUP BY` clause helps to specify multiple groupings in a single query.

9.2 Grouping Data

The `GROUP BY` clause partitions the resultset into one or more subsets. Each subset has values and expressions in common. The `GROUP BY` keyword is followed by a list of columns, known as grouped columns. Every grouped column restricts the number of rows of the resultset. For every grouped column, there is only one row. The `GROUP BY` clause can have more than one grouped column.



Following is the syntax of the GROUP BY clause.

Syntax:

```
CREATE TYPE [ schema_name. ] type_name { FROM base_type [ ( precision [ , scale ] ) ] [  
NULL | NOT NULL ] } [ ; ]
```

where,

column_name: is the name of the column according to which the resultset should be grouped.

Consider the `WorkOrderRouting` table in the `AdventureWorks2012` database. The total resource hours per work order needs to be calculated. To achieve this, the records need to be grouped by work order number, that is, `WorkOrderID`.

Code Snippet 1 retrieves and displays the total resource hours per work order along with the work order number. In this query, a built-in function named `SUM()` is used to calculate the total. `SUM()` is an aggregate function. Aggregate functions will be covered in detail in a later section.

Code Snippet 1:

```
SELECT WorkOrderID, SUM(ActualResourceHrs) AS TotalHoursPerWorkOrder FROM  
Production.WorkOrderRouting GROUP BY WorkOrderID
```

Executing this query will return all the work order numbers along with the total number of resource hours per work order.

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A part of the output is shown in figure 9.1.

	WorkOrderID	TotalHoursPerWorkOrder
1	13	17.6000
2	14	17.6000
3	15	4.0000
4	16	4.0000
5	17	4.0000
6	18	4.0000
7	19	4.0000
8	20	4.0000
9	21	4.0000
10	22	4.0000

Figure 9.1: Using the GROUP BY Clause

The GROUP BY clause can also be used in combination with various other clauses. These clauses are as follows:

→ **GROUP BY with WHERE**

The WHERE clause can also be used with GROUP BY clause to restrict the rows for grouping. The rows that satisfy the search condition are considered for grouping. The rows that do not meet the conditions in the WHERE clause are eliminated before any grouping is done.

*The future depends on what we do in
the present.*

Code Snippet 2 shows a query that is similar to Code Snippet 1 but limits the rows displayed, by considering only those records with WorkOrderID less than 50.

Code Snippet 2:

```
SELECT WorkOrderID, SUM(ActualResourceHrs) AS TotalHoursPerWorkOrder
FROM Production.WorkOrderRouting WHERE WorkOrderID < 50 GROUP BY WorkOrderID
```

As the number of records returned is more than 25, a part of the output is shown in figure 9.2.

	WorkOrderID	TotalHoursPerWorkOrder
1	13	17.6000
2	14	17.6000
3	15	4.0000
4	16	4.0000
5	17	4.0000
6	18	4.0000
7	19	4.0000
8	20	4.0000

Figure 9.2: GROUP BY with Where

→ GROUP BY with NULL

If the grouping column contains a `NULL` value, that row becomes a separate group in the resultset. If the grouping column contains more than one `NULL` value, the `NULL` values are put into a single row. Consider the `Production.Product` table. There are some rows in it that have `NULL` values in the `Class` column.

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Using a GROUP BY on a query for this table will take into consideration the NULL values too. For example, Code Snippet 3 retrieves and displays the average of the list price for each Class.

Code Snippet 3:

```
SELECT Class, AVG (ListPrice) AS 'AverageListPrice' FROM
Production.Product GROUP BY Class
```

As shown in figure 9.3, the NULL values are grouped into a single row in the output.

Class	AverageListPrice
1	NULL
2	H
3	L
4	M
	16.314
	1679.4964
	370.6887
	635.5816

Figure 9.3: GROUP BY with NULL

→ GROUP BY with ALL

The ALL keyword can also be used with the GROUP BY clause. It is significant only when the SELECT has a WHERE clause. When ALL is used, it includes all the groups that the GROUP BY clause produces. It even includes those groups which do not meet the search conditions.



Following is the syntax of using GROUP BY with ALL.

Syntax:

```
SELECT <column_name> FROM <table_name> WHERE <condition> GROUP BY ALL  
<column_name>
```

Consider the Sales.SalesTerritory table. This table has a column named Group indicating the geographic area to which the sales territory belongs to. Code Snippet 4 calculates and displays the total sales for each group. The output needs to display all the groups regardless of whether they had any sales or not. To achieve this, the code makes use of GROUP BY with ALL.

Code Snippet 4:

```
SELECT [Group], SUM(SalesYTD) AS 'TotalSales' FROM Sales.SalesTerritory  
WHERE [Group] LIKE 'N%' OR [Group] LIKE 'E%' GROUP BY ALL [Group]
```

Apart from the rows that are displayed in Code Snippet 4, it will also display the group 'Pacific' with null values as shown in figure 9.4. This is because the Pacific region did not have any sales.

	Group	TotalSales
1	Europe	13590506.0212
2	North America	33182889.0168
3	Pacific	NULL

Figure 9.4: GROUP BY with ALL

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→ GROUP BY with HAVING

HAVING clause is used only with SELECT statement to specify a search condition for a group. The HAVING clause acts as a WHERE clause in places where the WHERE clause cannot be used against aggregate functions such as SUM(). Once you have created groups with a GROUP BY clause, you may wish to filter the results further. The HAVING clause acts as a filter on groups, similar to how the WHERE clause acts as a filter on rows returned by the FROM clause. Following is the syntax of GROUP BY with HAVING.

Syntax:

```
SELECT <column_name> FROM <table_name> GROUP BY <column_name> HAVING  
<search_condition>
```

Code Snippet 5 displays the row with the group 'Pacific' as it has total sales less than 6000000.

Code Snippet 5:

```
SELECT [Group], SUM(SalesYTD) AS 'TotalSales' FROM Sales.SalesTerritory  
WHERE [Group] LIKE 'N%' OR [Group] LIKE 'E%' GROUP BY ALL [Group]
```

The output of this is only row, with Group name Pacific and total sales, 5977814.9154.

*Action may not always bring happiness,
but there is no happiness without
action.*

9.3 Summarizing Data

The GROUP BY clause also uses operators such as CUBE and ROLLUP to return summarized data. The number of columns in the GROUP BY clause determines the number of summary rows in the resultset. The operators are described as follows:

- **CUBE:** CUBE is an aggregate operator that produces a super-aggregate row. In addition to the usual rows provided by the GROUP BY, it also provides the summary of the rows that the GROUP BY clause generates. The summary row is displayed for every possible combination of groups in the resultset. The summary row displays NULL in the resultset but at the same time returns all the values for those. Following is the syntax of CUBE.

Syntax:

```
SELECT <column_name> FROM <table_name> GROUP BY <column_name> WITH CUBE
```

Code Snippet 6 demonstrates the use of CUBE.

Code Snippet 6:

```
SELECT Name, CountryRegionCode, SUM(SalesYTD) AS TotalSales FROM Sales.  
SalesTerritory WHERE Name <> 'Australia' AND Name <> 'Canada' GROUP BY  
Name, CountryRegionCode WITH CUBE
```

Code Snippet 6 retrieves and displays the total sales of each country and also, the total of the sales of all the countries' regions.

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The output is shown in figure 9.5.

	Name	CountryRegionCode	TotalSales
1	Germany	DE	3805202.3478
2	NULL	DE	3805202.3478
3	France	FR	4772398.3078
4	NULL	FR	4772398.3078
5	United Kingdom	GB	5012905.3656
6	NULL	GB	5012905.3656
7	Central	US	3072175.118
8	Northeast	US	2402176.8476
9	Northwest	US	7887186.7882
10	Southeast	US	2538667.2515

Figure 9.5: Using GROUP BY with CUBE

- **ROLLUP:** In addition to the usual rows that are generated by the GROUP BY, it also introduces summary rows into the resultset. It is similar to CUBE operator but generates a resultset that shows groups arranged in a hierarchical order. It arranges the groups from the lowest to the highest. Group hierarchy in the result is dependent on the order in which the columns that are grouped are specified.



Following is the syntax of ROLLUP.

Syntax:

```
SELECT <column_name> FROM <table_name> GROUP BY <column_name> WITH ROLLUP
```

Code Snippet 7 demonstrates the use of ROLLUP. It retrieves and displays the total sales of each country, the total of the sales of all the countries' regions and arranges them in order.

Code Snippet 7:

```
SELECT Name, CountryRegionCode, SUM(SalesYTD) AS TotalSales  
FROM Sales.SalesTerritory  
WHERE Name <> 'Australia' AND Name <> 'Canada'  
GROUP BY Name, CountryRegionCode  
WITH ROLLUP
```

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The output is shown in figure 9.6.

	Name	TotalSales
1	Australia	5977814.9154
2	Canada	6771829.1376
3	Central	3072175.118
4	France	4772398.3078
5	Germany	3805202.3478
6	Northeast	2402176.8476
7	Northwest	7887186.7882
8	Southeast	2538667.2515
9	Southwest	10510853.8...
10	United Kingdom	5012905.3656
11	NULL	52751209.9...

Figure 9.6: Using GROUP BY with ROLLUP

First say to yourself what you would be; and then do what you have to do.

9.4 Aggregate Functions

Occasionally, developers may also need to perform analysis across rows, such as counting rows meeting specific criteria or summarizing total sales for all orders. Aggregate functions enable to accomplish this.

Since aggregate functions return a single value, they can be used in `SELECT` statements where a single expression is used, such as `SELECT`, `HAVING`, and `ORDER BY` clauses. Aggregate functions ignore `NULLS`, except when using `COUNT(*)`.

Aggregate functions in a `SELECT` list do not generate a column alias. You may wish to use the `AS` clause to provide one.

Aggregate functions in a `SELECT` clause operate on all rows passed to the `SELECT` phase. If there is no `GROUP BY` clause, all rows will be summarized.

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SQL Server provides many built-in aggregate functions. Commonly used functions are included in table 9.1:

Function Name	Syntax	Description
AVG	AVG(<expression>)	Calculates the average of all the non-NULL numeric values in a column.
COUNT or COUNT_BIG	COUNT(*) or COUNT(<expression>)	When (*) is used, this function counts all rows, including those with NULL. The function returns count of non-NULL rows for the column when a column is specified as <expression>. The return value of COUNT function is an int. The return value of COUNT_BIG is a big_int.
MAX	MAX(<expression>)	Returns the largest number, latest date/time, or last occurring string.
MIN	MIN(<expression>)	Returns the smallest number, earliest date/time, or first occurring string.
SUM	SUM(<expression>)	Calculates the sum of all the non-NULL numeric values in a column.

Table 9.1: Commonly Used Aggregate Functions

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To use a built-in aggregate in a SELECT clause, consider the following query in Code Snippet 8.

Code Snippet 8:

```
SELECT AVG([UnitPrice]) AS AvgUnitPrice,  
MIN([OrderQty]) AS MinQty,  
MAX([UnitPriceDiscount]) AS MaxDiscount  
  
FROM Sales.SalesOrderDetail;
```

Since the query does not use a GROUP BY clause, all rows in the table will be summarized by the aggregate formulas in the SELECT clause.

The output is shown in figure 9.7.

	AvgUnitPrice	MinQty	MaxDiscount
1	465.0934	1	0.40

Figure 9.7: Using Aggregate Functions

When using aggregates in a SELECT clause, all columns referenced in the SELECT list must be used as inputs for an aggregate function or must be referenced in a GROUP BY clause.

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Failing this, there will be an error. For example, the query in Code Snippet 9 will return an error.

Code Snippet 9:

```
SELECT SalesOrderID, AVG(UnitPrice) AS AvgPrice  
FROM Sales.SalesOrderDetail;
```

This returns an error stating that the column `Sales.SalesOrderDetail.SalesOrderID` is invalid in the `SELECT` list because it is not contained in either an aggregate function or the `GROUP BY` clause. As the query is not using a `GROUP BY` clause, all rows will be treated as a single group. All columns, therefore, must be used as inputs to aggregate functions. To correct or prevent the error, one needs to remove `SalesOrderID` from the query.

Besides using numeric data, aggregate expressions can also include date, time, and character data for summarizing.

Code Snippet 10 returns the earliest and latest order date, using `MIN` and `MAX`.

Code Snippet 10:

```
SELECT MIN(OrderDate) AS Earliest,  
MAX(OrderDate) AS Latest  
FROM Sales.SalesOrderHeader;
```

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Figure 9.8 shows the output.

	Earliest	Latest
1	2005-07-01 00:00:00.000	2008-07-31 00:00:00.000

Figure 9.8: Using Aggregate Functions with Non-Numeric Data

Other functions may also be used in combination with aggregate functions.

9.5 Spatial Aggregates

SQL Server provides several methods that help to aggregate two individual items of geometry or geography data. These methods are listed in table 9.2.

Method	Description
STUnion	Returns an object that represents the union of a geometry/geography instance with another geometry/geography instance.
STIntersection	Returns an object that represents the points where a geometry/geography instance intersects another geometry/geography instance.
STConvexHull	Returns an object representing the convex hull of a geometry/geography instance. A set of points is called convex if for any two points, the entire segment is contained in the set. The convex hull of a set of points is the smallest convex set containing the set. For any given set of points, there is only one convex hull.

Table 9.2: Spatial Aggregate Methods

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Figures 9.9, 9.10, and 9.11 visually depict an example of these methods.

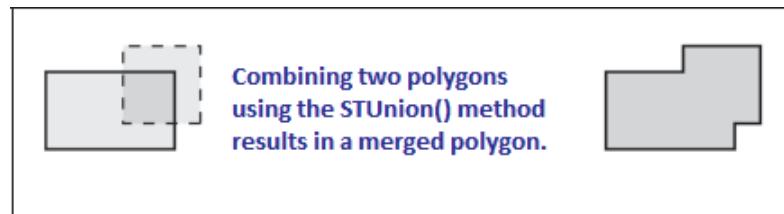


Figure 9.9: `STUnion()`



Figure 9.10: `STIntersection()`

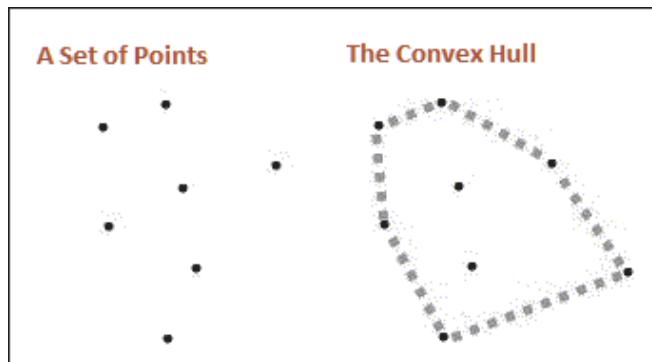
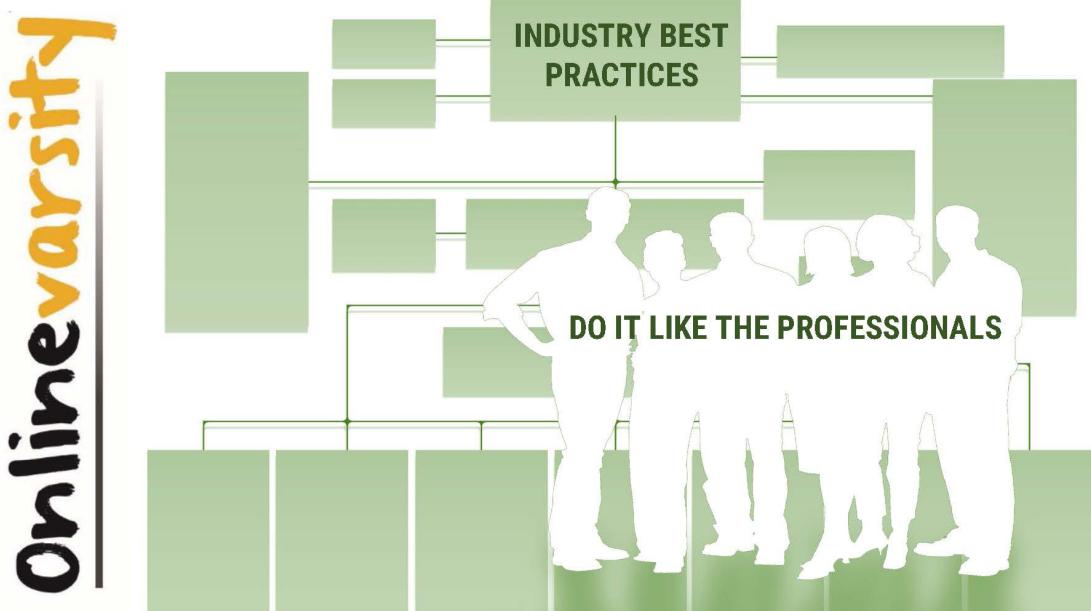


Figure 9.11: `STConvexHull()`



Code Snippet 11 demonstrates the use of STUnion().

Code Snippet 11:

```
SELECT geometry::Point(251, 1, 4326).STUnion(geometry::Point(252, 2, 4326));
```

The output is shown in figure 9.12. It shows two points.

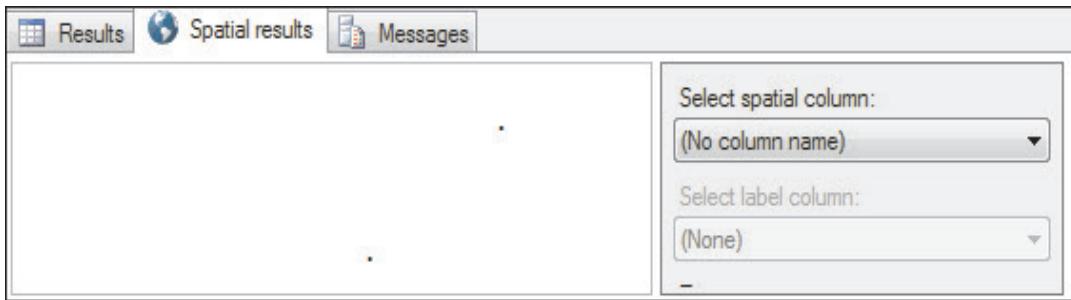


Figure 9.12: Using STUnion() with a geometry Type

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Another example is given in Code Snippet 12.

Code Snippet 12:

```
DECLARE @City1 geography  
SET @City1 = geography::STPolyFromText (  
    'POLYGON((175.3 -41.5, 178.3 -37.9, 172.8 -34.6, 175.3 -41.5))',  
    4326)  
  
DECLARE @City2 geography  
SET @City2 = geography::STPolyFromText (  
    'POLYGON((169.3 -46.6, 174.3 -41.6, 172.5 -40.7, 166.3 -45.8, 169.3 -46.6))',  
    4326)  
  
DECLARE @CombinedCity geography = @City1.STUnion(@City2)  
SELECT @CombinedCity
```

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

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Here, two variables are declared of the `geography` type and appropriate values are assigned to them. Then, they are combined into a third variable of `geography` type by using the `STUnion()` method.

The output of the code is shown in figure 9.13.

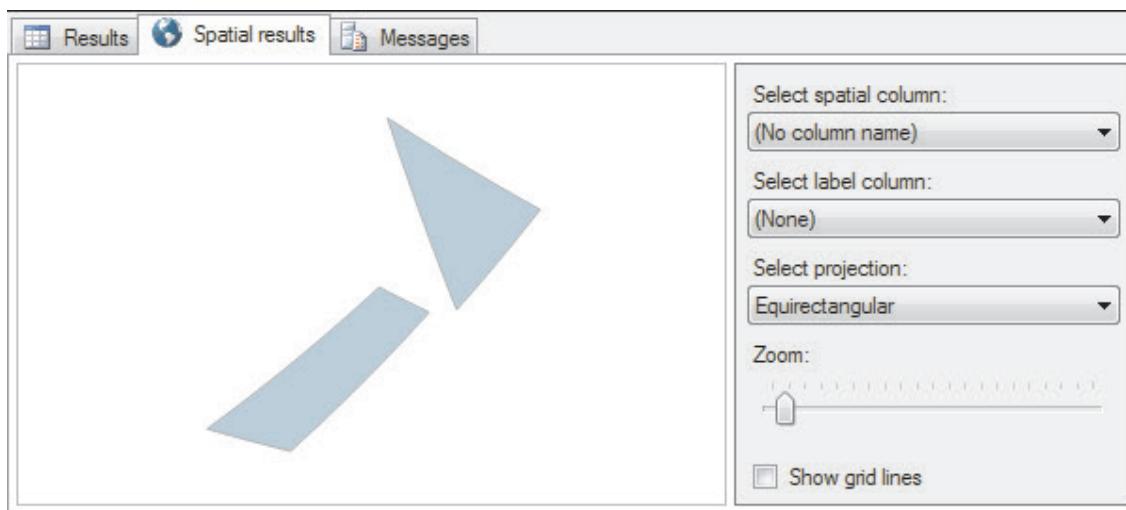


Figure 9.13: Using `STUnion()` with a `geography` Type

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9.5.1 New Spatial Aggregates

It is easy to compute unions of regular numeric data by using basic operators with queries such as `SELECT x + y` or by using the `UNION` operator. You can compute the union of two individual geometries or two geographies using the `STUnion()` operator. What if there was a need to compute the union of a set of geometry/geography objects or all the elements in a spatial column? What if there was a need to find out the average of a set of Point elements? It would not be possible to use the `AVG()` function here. In such a case, you will make use of the new spatial aggregate functions in SQL Server 2012.

SQL Server 2012 has introduced four new aggregates to the suite of spatial operators in SQL Server:

- ➔ Union Aggregate
- ➔ Envelope Aggregate
- ➔ Collection Aggregate
- ➔ Convex Hull Aggregate



These aggregates are implemented as static methods, which work for either the geography or the geometry data types. Although aggregates are applicable to all classes of spatial data, they can be best described with polygons.

→ **Union Aggregate**

It performs a union operation on a set of geometry objects. It combines multiple spatial objects into a single spatial object, removing interior boundaries, where applicable. Following is the syntax of UnionAggregate.

Syntax:

```
UnionAggregate ( geometry_operand or geography_operand)
```

where,

geometry_operand: is a geometry type table column comprising the set of geometry objects on which a union operation will be performed.

geography_operand: is a geography type table column comprising the set of geography objects on which a union operation will be performed.

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Code Snippet 13 demonstrates a simple example of using the Union aggregate. It uses the Person.Address table in the AdventureWorks2012 database.

Code Snippet 13:

```
SELECT Geography::UnionAggregate(SpatialLocation)
AS AVGLocation
FROM Person.Address
WHERE City = 'London';
```

The output of this will be as shown in figure 9.14.

AVGLocation	
1	0xE61000000104A00100003DA82EC605C249407D37109CAD...

Figure 9.14: Using Spatial Aggregates

To learn, you must want to be taught.

To view a visual representation of the spatial data, you can click the **Spatial results** tab in the output window. This will display the output as shown in figure 9.15.



Figure 9.15: Viewing Spatial Results

→ Envelope Aggregate

It returns a bounding area for a given set of geometry or geography objects.

The Envelope Aggregate exhibits different behaviors for geography and geometry types. Based on the type of object it is applied to, it returns different results. For the geometry type, the result is a 'traditional' rectangular polygon, which closely bounds the selected input objects. For the geography type, the result is a circular object, which loosely bounds the selected input objects. Furthermore, the circular object is defined using the new CurvePolygon feature.

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Following is the syntax of EnvelopeAggregate.

Syntax:

```
EnvelopeAggregate (geometry_operand or geography_operand)
```

where,

geometry_operand: is a geometry type table column comprising the set of geometry objects.

geography_operand: is a geography type table column comprising the set of geography objects.

Code Snippet 14 returns a bounding box for a set of objects in a table variable column.

Code Snippet 14:

```
SELECT Geography::EnvelopeAggregate(SpatialLocation)
AS Location
FROM Person.Address
WHERE City = 'London'
```



The visual representation of the output is shown in figure 9.16.



Figure 9.16: EnvelopeAggregate

→ Collection Aggregate

It returns a `GeometryCollection/GeographyCollection` instance with one `geometry/geography` part for each spatial object(s) in the selection set. Following is the syntax of `CollectionAggregate`.

Syntax:

```
CollectionAggregate (geometry_operand or geography_operand)
```

where,

`geometry_operand`: is a `geometry` type table column comprising the set of `geometry` objects.

`geography_operand`: is a `geography` type table column comprising the set of `geography` objects.

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Code Snippet 15 returns a `GeometryCollection` instance that contains a `CurvePolygon` and a `Polygon`.

Code Snippet 15:

```
DECLARE @CollectionDemo TABLE
(
shape geometry,
shapeType nvarchar(50)
)
INSERT INTO @CollectionDemo(shape,shapeType) VALUES ('CURVEPOLYGON(CIRC
ULARSTRING(2 3, 4 1, 6 3, 4 5, 2 3))', 'Circle'),
('POLYGON((1 1, 4 1, 4 5, 1 5, 1 1))', 'Rectangle');

SELECT geometry::CollectionAggregate(shape)
FROM @CollectionDemo;
```

The output of the code will be as shown in figure 9.17.

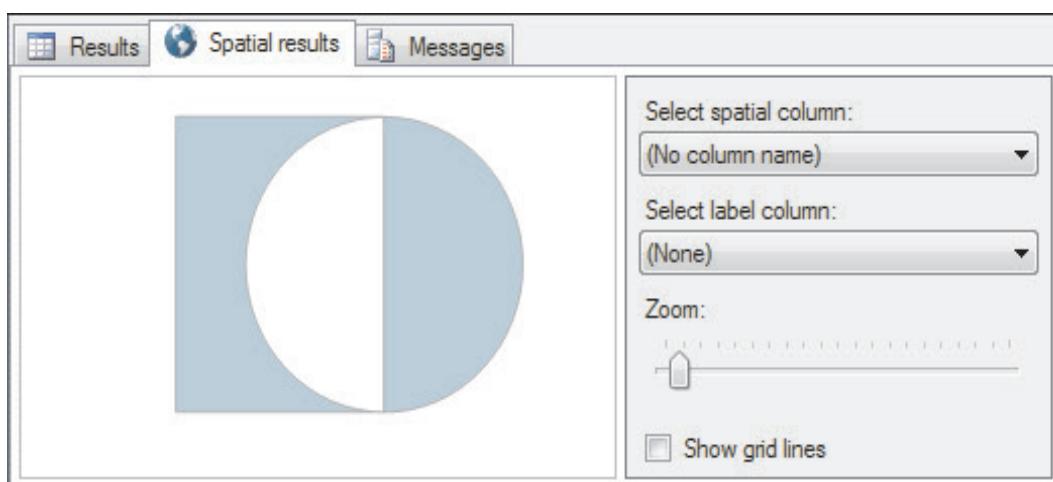


Figure 9.17: Using CollectionAggregate

Democritus said, words are but the shadows of actions.

→ Convex Hull Aggregate

It returns a convex hull polygon, which encloses one or more spatial objects for a given set of geometry/geography objects. Following is the syntax of ConvexHullAggregate.

Syntax:

```
ConvexHullAggregate (geometry_operand or geography_operand)
```

where,

geometry_operand: is a geometry type table column comprising the set of geometry objects.

geography_operand: is a geography type table column comprising the set of geography objects.

Code Snippet 16 demonstrates the use of ConvexHullAggregate.

Code Snippet 16:

```
SELECT Geography::ConvexHullAggregate(SpatialLocation)
AS Location
FROM Person.Address
WHERE City = 'London'
```

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The output is shown in figure 9.18.

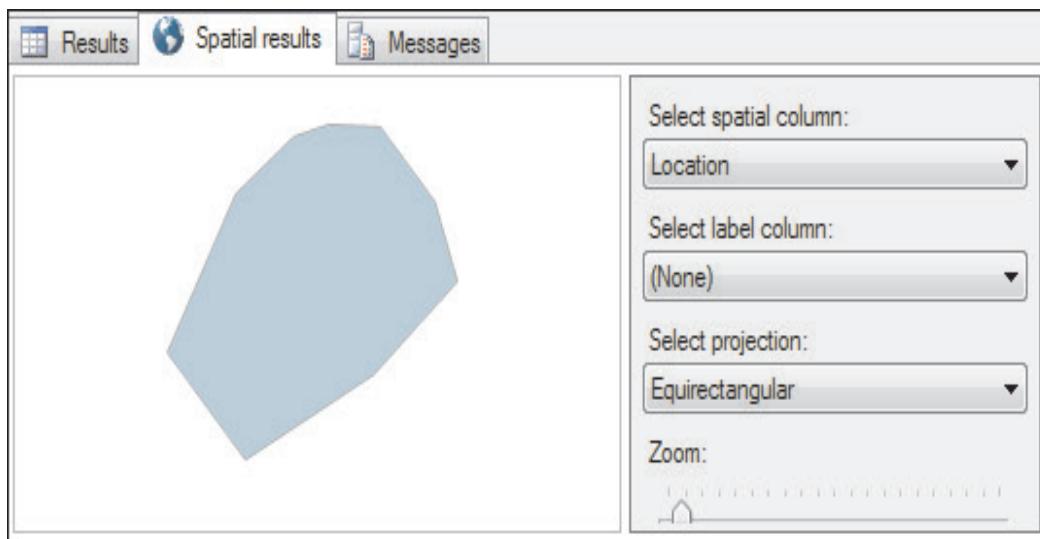


Figure 9.18: Using ConvexHullAggregate

9.6 Subqueries

You can use a `SELECT` statement or a query to return records that will be used as criteria for another `SELECT` statement or query. The outer query is called parent query and the inner query is called a subquery. The purpose of a subquery is to return results to the outer query. In other words, the inner query statement should return the column or columns used in the criteria of the outer query statement.



The simplest form of a subquery is one that returns just one column. The parent query can use the results of this subquery using an = sign.

The syntax for the most basic form of a subquery using just one column with an = sign is shown.

Syntax:

```
SELECT <ColumnName> FROM <table>
WHERE <ColumnName> = ( SELECT <ColumnName> FROM <Table> WHERE <ColumnName> =
<Condition> )
```

In a subquery, the innermost SELECT statement is executed first and its result is passed as criteria to the outer SELECT statement.

Consider a scenario where it is required to determine the due date and ship date of the most recent orders.

Code Snippet 17 shows the code to achieve this.

Code Snippet 17:

```
SELECT DueDate, ShipDate
FROM Sales.SalesOrderHeader
WHERE Sales.SalesOrderHeader.OrderDate =
(SELECT MAX(OrderDate)
FROM Sales.SalesOrderHeader)
```

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Here, a subquery has been used to achieve the desired output. The inner query or subquery retrieves the most recent order date. This is then passed to the outer query, which displays due date and ship date for all the orders that were made on that particular date.

A part of the output of the code is shown in figure 9.19.

	DueDate	ShipDate
1	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
2	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
3	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
4	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
5	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
6	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
7	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
8	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
9	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
10	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000

Figure 9.19: Using a Simple Subquery

*Nothing is a waste of time if you use
the experience wisely.*

Based on the results returned by the inner query, a subquery can be classified as a scalar subquery or a multi-valued subquery. These are described as follows:

- Scalar subqueries return a single value. Here, the outer query needs to be written to process a single result.
- Multi-valued subqueries return a result similar to a single-column table. Here, the outer query needs to be written to handle multiple possible results.

9.6.1 Working with Multi-valued Queries

If an = operator is used with the subquery, the subquery must return a single scalar value. If more than one value is returned, there will be an error and the query will not be processed. In such scenarios, the keywords ANY, ALL, IN, and EXISTS can be used with the WHERE clause of a SELECT statement when the query returns one column but one or more rows. These keywords, also called predicates, are used with multi-valued queries.

For example, consider that all the first names and last names of employees whose job title is 'Research and Development Manager' need to be displayed. Here, the inner query may return more than one row as there may be more than one employee with that job title. To ensure that the outer query can use the results of the inner query, the IN keyword will have to be used.

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Code Snippet 18 demonstrates this.

Code Snippet 18:

```
SELECT FirstName, LastName FROM Person.Person
WHERE Person.Person.BusinessEntityID IN (SELECT BusinessEntityID
FROM HumanResources.Employee WHERE JobTitle = 'Research and Development
Manager');
```

Here, the inner query retrieves the BusinessEntityID from the HumanResources.Employee table for those records having job title 'Research and Development Manager'. These results are then passed to the outer query, which matches the BusinessEntityID with that in the Person.Person table. Finally, from the records that are matching, the first and last names are extracted and displayed.

The output is displayed in figure 9.20.

	FirstName	Last Name
1	Dylan	Miller
2	Michael	Raheem

Figure 9.20: Output of Subquery with IN keyword

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The `SOME` or `ANY` keywords evaluate to true if the result is an inner query containing at least one row that satisfies the comparison. They compare a scalar value with a column of values. `SOME` and `ANY` are equivalent; both return the same result. They are rarely used.

There are some guidelines to be followed when working with subqueries. You should remember the following points when using subqueries:

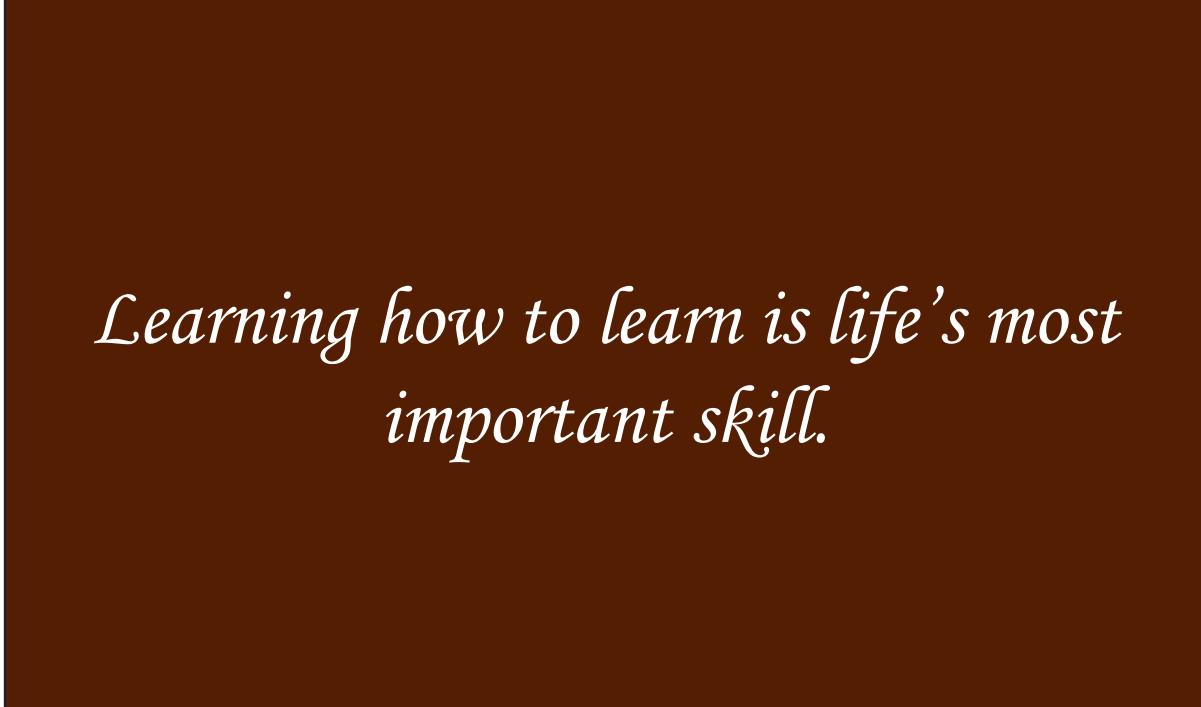
- The `ntext`, `text`, and `image` data types cannot be used in the `SELECT` list of subqueries.
- The `SELECT` list of a subquery introduced with a comparison operator can have only one expression or column name.
- Subqueries that are introduced by a comparison operator not followed by the keyword `ANY` or `ALL` cannot include `GROUP BY` and `HAVING` clauses.
- You cannot use `DISTINCT` keyword with subqueries that include `GROUP BY`.
- You can specify `ORDER BY` only when `TOP` is also specified.

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Besides scalar and multi-valued subqueries, you can also choose between self-contained subqueries and correlated subqueries. These are defined as follows:

- Self-contained subqueries are written as standalone queries, without any dependencies on the outer query. A self-contained subquery is processed once when the outer query runs and passes its results to the outer query.
- Correlated subqueries reference one or more columns from the outer query and therefore, depend on the outer query. Correlated subqueries cannot be run separately from the outer query.

The `EXISTS` keyword is used with a subquery to check the existence of rows returned by the subquery. The subquery does not actually return any data; it returns a value of `TRUE` or `FALSE`.



Learning how to learn is life's most important skill.

Following is the syntax of a subquery containing the word EXISTS.

Syntax:

```
SELECT <ColumnName> FROM <table>
WHERE [NOT] EXISTS
(
    <Subquery_Statement>
)
```

where,

Subquery_Statement: specifies the subquery.

The code in Code Snippet 18 can be rewritten as shown in Code Snippet 19 using the EXISTS keyword to yield the same output.

Code Snippet 19:

```
SELECT FirstName, LastName FROM Person.Person AS A
WHERE EXISTS (SELECT *
FROM HumanResources.Employee AS B WHERE JobTitle = 'Research and Development
Manager' AND A.BusinessEntityID=B.BusinessEntityID);
```

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Here, the inner subquery retrieves all those records that match job title as 'Research and Development Manager' and whose BusinessEntityId matches with that in the Person table. If there are no records matching both these conditions, the inner subquery will not return any rows. Thus, in that case, the EXISTS will return false and the outer query will also not return any rows. However, the code in Code Snippet 19 will return two rows because the given conditions are satisfied. The output will be the same as figure 9.20.

Similarly, one can use the NOT EXISTS keyword. The WHERE clause in which it is used is satisfied if there are no rows returned by the subquery.

9.6.2 Nested Subqueries

A subquery that is defined inside another subquery is called a nested subquery.

Consider that you wanted to retrieve and display the names of persons from Canada. There is no direct way to retrieve this information since the Sales.SalesTerritory table is not related to Person.Person table.



Hence, a nested subquery is used here as shown in Code Snippet 20.

Code Snippet 20:

```
SELECT LastName, FirstName
FROM Person.Person
WHERE BusinessEntityID IN
    (SELECT BusinessEntityID
    FROM Sales.SalesPerson
    WHERE TerritoryID IN
        (SELECT TerritoryID
        FROM Sales.SalesTerritory
        WHERE Name='Canada')
    )
```

The output is shown in figure 9.21.

	Last Name	First Name
1	Vargas	Gamett
2	Saraiva	José

Figure 9.21: Output of Nested Subqueries

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9.6.3 Correlated Queries

In many queries containing subqueries, the subquery needs to be evaluated only once to provide the values needed by the parent query. This is because in most of the queries, the subquery makes no reference to the parent query, so the value in the subquery remains constant.

However, if the subquery refers to a parent query, the subquery needs to be reevaluated for every iteration in the parent query. This is because the search criterion in the subquery is dependent upon the value of a particular record in the parent query.

When a subquery takes parameters from its parent query, it is known as Correlated subquery. Consider that you want to retrieve all the business entity ids of persons whose contact information was last modified not earlier than 2012.

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To do this, you can use a correlated subquery as shown in Code Snippet 21.

Code Snippet 21:

```
SELECT e.BusinessEntityID  
FROM Person.BusinessEntityContact e  
WHERE e.ContactTypeID IN  
(  
    SELECT c.ContactTypeID  
    FROM Person.ContactType c  
    WHERE YEAR(e.ModifiedDate) >= 2012  
)
```

In Code Snippet 21, the inner query retrieves contact type ids for all those persons whose contact information was modified on or before 2012. These results are then passed to the outer query, which matches these contact type ids with those in the `Person.BusinessEntityContact` table and displays the business entity IDs of those records.

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Figure 9.22 shows part of the output.

	BusinessEntityID
1	292
2	294
3	296
4	298
5	300
6	302
7	304

Figure 9.22: Output of Correlated Queries

9.7 Joins

Joins are used to retrieve data from two or more tables based on a logical relationship between tables. A join typically specifies foreign key relationship between the tables. It defines the manner in which two tables are related in a query by:

- Specifying the column from each table to be used for the join. A typical join specifies a foreign key from one table and its associated key in the other table.
- Specifying a logical operator such as =, <> to be used in comparing values from the columns.



Session**Advanced Queries and Joins**

Joins can be specified in either the `FROM` or `WHERE` clauses.

Following is the syntax of the `JOIN` statement.

Syntax:

```
SELECT <ColumnName1>, <ColumnName2>...<ColumnNameN>
FROM Table_A AS Table_Alias_A
    JOIN
Table_B AS Table_Alias_B
    ON
Table_Alias_A.<CommonColumn>=Table_Alias_B.<CommonColumn>
```

where,

`<ColumnName1>, <ColumnName2>`: Is a list of columns that need to be displayed.

`Table_A`: Is the name of the table on the left of the `JOIN` keyword.

`Table_B`: Is the name of the table on the right of the `JOIN` keyword.

`AS Table_Alias`: Is a way of giving an alias name to the table. An alias defined for the table in a query can be used to denote a table so that the full name of the table need not be used.

`<CommonColumn>`: Is a column that is common to both the tables. In this case, the join succeeds only if the columns have matching values.

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Consider that you want to list employee first names, last names, and their job titles from the HumanResources.Employee and Person.Person. To extract this information from the two tables, you need to join them based on BusinessEntityID as shown in Code Snippet 22.

Code Snippet 22:

```
SELECT A.FirstName, A.LastName, B.JobTitle
FROM Person.Person A
JOIN
HumanResources.Employee B
ON
A.BusinessEntityID = B.BusinessEntityID;
```

Here, the tables HumanResources.Employee and Person.Person are given aliases A and B. They are joined together on the basis of their business entity ids. The SELECT statement then retrieves the desired columns through the aliases.



Figure 9.23 shows the output.

	FirstName	LastName	Job Title
1	Ken	Sánchez	Chief Executive Officer
2	Temi	Duffy	Vice President of Engineering
3	Roberto	Tamburello	Engineering Manager
4	Rob	Walters	Senior Tool Designer
5	Gail	Erickson	Design Engineer
6	Jossef	Goldberg	Design Engineer
7	Dylan	Miller	Research and Development Manager

Figure 9.23: Output of Join

There are three types of joins as follows:

- Inner Joins
- Outer Joins
- Self-Joins

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9.7.1 Inner Join

An inner join is formed when records from two tables are combined only if the rows from both the tables are matched based on a common column. Following is the syntax of an inner join.

Syntax:

```
SELECT <ColumnName1>, <ColumnName2>...<ColumnNameN> FROM
Table_A AS Table_Alias_A
INNER JOIN
Table_B AS Table_Alias_B
ON
Table_Alias_A.<CommonColumn>=Table_Alias_B.<CommonColumn>
```

Code Snippet 23 demonstrates the use of inner join. The scenario for this is similar to Code Snippet 22.

Code Snippet 23:

```
SELECT A.FirstName, A.LastName, B.JobTitle
FROM Person.Person A
INNER JOIN HumanResources.Employee B
ON
A.BusinessEntityID = B.BusinessEntityID;
```

In Code Snippet 23, an inner join is constructed between `Person.Person` and `HumanResources.Employee` based on common business entity ids. Here again, the two tables are given aliases of `A` and `B` respectively. The output is the same as shown in figure 9.23.

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

9.7.2 Outer Join

Outer joins are join statements that return all rows from at least one of the tables specified in the `FROM` clause, as long as those rows meet any `WHERE` or `HAVING` conditions of the `SELECT` statement.

The two types of commonly used outer joins are as follows:

- Left Outer Join
- Right Outer Join

Each of these join types are now explained.

→ **Left Outer Join**

Left outer join returns all the records from the left table and only matching records from the right table. Following is the syntax of an outer join.

Syntax:

```
SELECT <ColumnList> FROM  
Table_A AS Table_Alias_A  
LEFT OUTER JOIN  
Table_B AS Table_Alias_B  
ON  
Table_Alias_A.<CommonColumn> = Table_Alias_B.<CommonColumn>
```

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Consider that you want to retrieve all the customer ids from the Sales.Customers table and order information such as ship dates and due dates, even if the customers have not placed any orders. Since the record count would be very huge, it is to be restricted to only those orders that are placed before 2012. To achieve this, you perform a left outer join as shown in Code Snippet 24.

Code Snippet 24:

```
SELECT A.CustomerID, B.DueDate, B.ShipDate
FROM Sales.Customer A LEFT OUTER JOIN
Sales.SalesOrderHeader B
ON
A.CustomerID = B.CustomerID AND YEAR(B.DueDate) < 2012;
```

In Code Snippet 24, the left outer join is constructed between the tables Sales.Customer and Sales.SalesOrderHeader. The tables are joined on the basis of customer ids. In this case, all records from the left table, Sales.Customer and only matching records from the right table, Sales.SalesOrderHeader, are returned.



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Figure 9.24 shows the output.

	CustomerID	DueDate	ShipDate
3...	18178	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
3...	13671	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
3...	11981	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
3...	18749	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
3...	15251	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
3...	15868	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
3...	18759	2008-08-12 00:00:00.000	2008-08-07 00:00:00.000
3...	215	NULL	NULL
3...	46	NULL	NULL
3...	169	NULL	NULL
3...	507	NULL	NULL
3...	630	NULL	NULL

Figure 9.24: Output of Left Outer Join

As shown in the output, some records show the due dates and ship dates as NULL.

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This is because for some customers, no order is placed, hence, their records will show the dates as NULL.

→ **Right Outer Join**

The right outer join retrieves all the records from the second table in the join regardless of whether there is matching data in the first table or not. Following is the syntax of a right outer join.

Syntax:

```
SELECT <ColumnList>
FROM Left_Table_Name
AS
Table_A AS Table_Alias_A
RIGHT OUTER JOIN
Table_B AS Table_Alias_B
ON
Table_Alias_A.<CommonColumn>=Table_Alias_B.<CommonColumn>
```

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

Consider that you want to retrieve all the product names from Product table and all the corresponding sales order ids from the SalesOrderDetail table even if there is no matching record for the products in the SalesOrderDetail table. To do this, you will use a right outer join as shown in Code Snippet 25.

Code Snippet 25:

```
SELECT P.Name, S.SalesOrderID
FROM Sales.SalesOrderDetails S
RIGHT OUTER JOIN
Production.Product P
ON P.ProductID=S.ProductID;
```

In the code, all the records from Product table are shown regardless of whether they have been sold or not.

9.7.3 Self-Join

A self-join is used to find records in a table that are related to other records in the same table. A table is joined to itself in a self-join.

Consider that an **Employee** table in a database named **Sterling** has a column named **mgr_id** to denote information for managers whom employees are reporting to. Assume that the table has appropriate records inserted in it.

A manager is also an employee. This means that the **mgr_id** in the table is the **emp_id** of an employee.

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For example, **Anabela** with **emp_id** as **ARD36773F** is an employee but **Anabela** is also a manager for Victoria, Palle, Karla, and other employees as shown in figure 9.25.

	emp_id	fname	minit	lname	job_id	job_lvl	pub_id	hire_date	mgr_id
1	PMA42628M	Paolo	M	Accorti	13	35	0877	1992-08-27 00:00:00.000	POK93028M
2	PSA89086M	Pedro	S	Afonso	14	89	1389	1990-12-24 00:00:00.000	POK93028M
3	VPA30890F	Victoria	P	Ashworth	6	140	0877	1990-09-13 00:00:00.000	ARD36773F
4	H-B39728F	Helen		Bennett	12	35	0877	1989-09-21 00:00:00.000	POK93028M
5	L-B31947F	Lesley		Brown	7	120	0877	1991-02-13 00:00:00.000	ARD36773F
6	F-C16315M	Francisco		Chang	4	227	9952	1990-11-03 00:00:00.000	MAS70474F
7	PTC11962M	Philip	T	Cramer	2	215	9952	1989-11-11 00:00:00.000	MAS70474F
8	A-C71970F	Aria		Cruz	10	87	1389	1991-10-26 00:00:00.000	POK93028M
9	AMD15433F	Ann	M	Devon	3	200	9952	1991-07-16 00:00:00.000	MAS70474F
10	ARD36773F	Anabela	R	Doming...	8	100	0877	1993-01-27 00:00:00.000	NULL
11	PHF38899M	Peter	H	Franken	10	75	0877	1992-05-17 00:00:00.000	POK93028M
12	PXH22250M	Paul	X	Henriot	5	159	0877	1993-08-19 00:00:00.000	MAS70474F

Figure 9.25: Employee Table



To get a list of the manager names along with other details, you can use a self-join to join the employee table with itself and then, extract the desired records. Code Snippet 26 demonstrates how to use a self-join.

Code Snippet 26:

```
SELECT TOP 7 A.fname + ' ' + A.lname AS 'Employee Name', B.fname + ' ' + B.lname AS
'Manager'

FROM
Employee AS A
INNER JOIN
Employee AS B
ON A.mgr_id=B.emp_id
```

In Code Snippet 26, the **Employee** table is joined to itself based on the **mgr_id** and **emp_id** columns.

The output of the code is shown in figure 9.26.

	Employee Name	Manager
1	Paolo Accorti	Pirkko Koskitalo
2	Pedro Afonso	Pirkko Koskitalo
3	Victoria Ashworth	Anabela Domingues
4	Helen Bennett	Pirkko Koskitalo
5	Lesley Brown	Anabela Domingues
6	Francisco Chang	Margaret Smith
7	Philip Cramer	Margaret Smith

Figure 9.26: Using Self-Join

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9.7.4 MERGE Statement

The MERGE statement allows you to maintain a target table based on certain join conditions on a source table using a single statement. You can now perform the following actions in one MERGE statement:

- Insert a new row from the source if the row is missing in the target
- Update a target row if a record already exists in the source table
- Delete a target row if the row is missing in the source table

For example, assume you have a **Products** table that maintains records of all products. A **NewProducts** table maintains records of new products. You want to update the **Products** table with records from the **NewProducts** table. Here, **NewProducts** table is the source table and **Products** is the target table. The **Products** table contains records of existing products with updated data and new products. Figure 9.27 shows the two tables.

Products				
	ProductID	Name	Type	PurchaseDate
1	101	Rivets	Hardware	2012-12-01
2	102	Nuts	Hardware	2012-12-01
3	103	Washers	Hardware	2011-01-01
4	104	Rings	Hardware	2013-01-15
5	105	Paper Clips	Stationery	2013-01-01

NewProducts				
	ProductID	Name	Type	PurchaseDate
1	102	Nuts	Hardware	2012-12-01
2	103	Washers	Hardware	2011-01-01
3	107	Rings	Hardware	2013-01-15
4	108	Paper Clips	Stationery	2013-01-01

Figure 9.27: Products and NewProducts Tables

To avoid criticism, do nothing, say nothing, be nothing.

Consider that you want to:

- Compare last and first names of customers from both source and target tables
- Update customer information in target table if the last and first names match
- Insert new records in target table if the last and first names in source table do not exist in target table
- Delete existing records in target table if the last and first names do not match with those of source table

The `MERGE` statement accomplishes the tasks in a single statement. `MERGE` also allows you to optionally display those records that were inserted, updated, or deleted by using an `OUTPUT` clause. Following is the syntax of the `MERGE` statement.

Syntax:

```
MERGE target_table
USING source_table
ON match_condition
WHEN MATCHED THEN UPDATE SET Col1=val1 [, Col2=val2...]
WHEN [TARGET] NOT MATCHED THEN INSERT (Col1 [,Col2...]) VALUES (Val1 [,,
Val2...])
WHEN NOT MATCHED BY SOURCE THEN DELETE
[OUTPUT $action, Inserted.Col1, Deleted.Col1,...];
```

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where,

`target_table`: is the table WHERE changes are being made.

`source_table`: is the table from which rows will be inserted, updated, or deleted into the target table.

`match_conditions`: are the JOIN conditions and any other comparison operators.

`MATCHED`: true if a row in the `target_table` and `source_table` matches the `match_condition`.

`NOT MATCHED`: true if a row from the `source_table` does not exist in the `target_table`.

`SOURCE NOT MATCHED`: true if a row exists in the `target_table` but not in the `source_table`.

`OUTPUT`: An optional clause that allows to view those records that have been inserted/deleted/updated in `target_table`.

`MERGE` statements are terminated with a semi-colon (;).

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Code Snippet 27 shows how to use MERGE statement. It makes use of the **Sterling** database.

Code Snippet 27:

```
MERGE INTO Products AS P1
USING
NewProducts AS P2
ON P1.ProductId=P2.ProductId
WHEN MATCHED THEN
    UPDATE SET
        P1.Name = P2.Name,
        P1.Type = P2.Type,
        P1.PurchaseDate = P2.PurchaseDate
WHEN NOT MATCHED THEN
    INSERT (ProductId, Name, Type, PurchaseDate)
        VALUES (P2.ProductId, P2.Name, P2.Type, P2.PurchaseDate)
WHEN NOT MATCHED BY SOURCE THEN
    DELETE

OUTPUT $action, Inserted.ProductId, Inserted.Name, Inserted.Type, Inserted.
PurchaseDate, Deleted.ProductId,Deleted.Name,Deleted.Type,Deleted.
PurchaseDate;
```

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Figure 9.28 shows the output.

	\$action	ProductId	Name	Type	PurchaseDate	ProductId	Name	Type	PurchaseDate
1	INSERT	107	Rings	Hardware	2013-01-15	NULL	NULL	NULL	NULL
2	INSERT	108	Paper Clips	Stationery	2013-01-01	NULL	NULL	NULL	NULL
3	DELETE	NULL	NULL	NULL	NULL	101	Rivets	Hardware	2012-12-01
4	UPDATE	102	Nuts	Hardware	2012-12-01	102	Nuts	Hardware	2012-12-01
5	UPDATE	103	Washers	Hardware	2011-01-01	103	Washers	Hardware	2011-01-01
6	DELETE	NULL	NULL	NULL	NULL	104	Rings	Hardware	2013-01-15
7	DELETE	NULL	NULL	NULL	NULL	105	Paper Clips	Stationery	2013-01-01

Figure 9.28: Using MERGE

The **NewProducts** table is the source table and **Products** table is the target table. The match condition is the column, **ProductId** of both tables. If the match condition evaluates to false (**NOT MATCHED**), then new records are inserted in the target table.

If match condition evaluates to true (**MATCHED**), then records are updated into the target table from the source table.

If records present in the target table do not match with those of source table (**NOT MATCHED BY SOURCE**), then these are deleted from the target table. The last statement displays a report consisting of rows that were inserted/updated/deleted as shown in the output.

Learning is not compulsory, but neither is survival.

9.8 Common Table Expressions (CTEs)

A CTE is similar to a temporary resultset defined within the execution scope of a single SELECT, INSERT, UPDATE, DELETE, or CREATE VIEW statement. A CTE is a named expression defined in a query. A CTE is defined at the start of a query and can be referenced several times in the outer query. A CTE that include references to itself is called as a recursive CTE.

Note - CTEs were first introduced in SQL Server 2005.

Key advantages of CTEs are improved readability and ease in maintenance of complex queries.

Following is the syntax to create a CTE.

Syntax:

```
WITH <CTE_name>
AS (<CTE_definition>)
```

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For example, to retrieve and display the customer count year-wise for orders present in the Sales.SalesOrderHeader table, the code will be as given in Code Snippet 28.

Code Snippet 28:

```
WITH CTE_OrderYear
AS
(
    SELECT YEAR(OrderDate) AS OrderYear, CustomerID
    FROM Sales.SalesOrderHeader
)
SELECT OrderYear, COUNT(DISTINCT CustomerID) AS CustomerCount
FROM CTE_OrderYear
GROUP BY OrderYear;
```

Here, **CTE_OrderYear** is specified as the CTE name. The **WITH...AS** keywords begins the CTE definition. Then, the CTE is used in the **SELECT** statement to retrieve and display the desired results.



Figure 9.29 shows the output.

	OrderYear	CustomerCount
1	2007	9864
2	2008	11844
3	2005	1216
4	2006	3094

Figure 9.29: Output of CTE

Following guidelines need to be remembered while defining CTEs:

- CTEs are limited in scope to the execution of the outer query. Hence, when the outer query ends, the lifetime of the CTE will end.
- You need to define a name for a CTE and also, define unique names for each of the columns referenced in the SELECT clause of the CTE.
- It is possible to use inline or external aliases for columns in CTEs.
- A single CTE can be referenced multiple times in the same query with one definition.

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- Multiple CTEs can also be defined in the same WITH clause. For example, consider Code Snippet 29. It defines two CTEs using a single WITH clause. This snippet assumes that three tables named Student, City, and Status are created.

Code Snippet 29:

```
WITH CTE_Students
AS
(
    Select StudentCode, S.Name,C.CityName, St.Status
        FROM Student S
        INNER JOIN City C
        ON S.CityCode = C.CityCode
    INNER JOIN Status St
        ON S.StatusId = St.StatusId)
,
StatusRecord -- This is the second CTE being defined
AS
(
    SELECT Status, COUNT(Name) AS CountofStudents
        FROM CTE_Students
        GROUP BY Status
)
SELECT * FROM StatusRecord
```

A wise man learns from the mistakes of others, a fool by his own.

Assuming some records are inserted in all three tables, the output may be as shown in figure 9.30.

	Status	CountofStudents
1	Failed	2
2	Passed	2

Figure 9.30: Using Multiple CTE with Single WITH

9.9 Combining Data Using SET Operators

SQL Server 2012 provides certain keywords, also called as operators, to combine data from multiple tables. These operators are as follows:

- UNION
- INTERSECT
- EXCEPT

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9.9.1 UNION Operator

The results from two different query statements can be combined into a single resultset using the UNION operator. The query statements must have compatible column types and equal number of columns. The column names can be different in each statement but the data types must be compatible. By compatible data types, it means that it should be possible to convert the contents of one of the columns into another. For example, if one of the query statements has an `int` data type and the other query statement has a money data type, they are compatible and a union can take place between them because the `int` data can be converted into money data.

Following is the syntax of the UNION operator.

Syntax:

```
Query_Statement1
UNION [ALL]
Query_Statement2
```

where,

`Query_Statement1` and `Query_Statement2` are `SELECT` statements.



Session**Advanced Queries and Joins**

Code Snippet 30 demonstrates the UNION operator.

Code Snippet 30:

```
SELECT Product.ProductId FROM Production.Product  
UNION  
SELECT ProductId FROM Sales.SalesOrderDetail
```

This will list all the product ids of both tables that match with each other. If you include the ALL clause, all rows are included in the resultset including duplicate records.

Code Snippet 31 demonstrates the UNION ALL operator.

Code Snippet 31:

```
SELECT Product.ProductId FROM Production.Product  
UNION ALL  
SELECT ProductId FROM Sales.SalesOrderDetail
```

By default, the UNION operator removes duplicate records from the resultset. However, if you use the ALL clause with UNION operator, then all the rows are returned. Apart from UNION, the other operators that are used to combine data from multiple tables are INTERSECT and EXCEPT.

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9.9.2 INTERSECT Operator

Consider again the two tables `Product` and `SalesOrderDetail` present in `AdventureWorks2012`.

Suppose you want to display only the rows that are common to both the tables. To do this, you will need to use an operator named `INTERSECT`. The `INTERSECT` operator is used with two query statements to return a distinct set of rows that are common to both the query statements. Following is the syntax of the `INTERSECT` operator.

Syntax:

```
Query_statement1  
INTERSECT  
Query_statement2
```

where,

`Query_Statement1` and `Query_Statement2` are `SELECT` statements.

Code Snippet 32 demonstrates the `INTERSECT` operator.

Code Snippet 32:

```
SELECT Product.ProductId FROM Production.Product  
INTERSECT  
SELECT ProductId FROM Sales.SalesOrderDetail
```

*You must do the things you think you
cannot do.*

The basic rules for using `INTERSECT` are as follows:

- The number of columns and the order in which they are given must be the same in both the queries.
- The data types of the columns being used must be compatible.

The result of the intersection of the `Production.Product` and `Sales.SalesOrderDetail` tables would be only those product ids that have matching records in `Production.Product` table. In large enterprises, there are huge volumes of data stored in databases. Instead of storing the entire data in a single table, it can be spread over several tables that are related to one another. When data is stored in such tables, there must be some means to combine and retrieve the data from those tables. Using SQL Server, there are a number of ways to combine data from multiple tables. Following sections explore these ways in detail.

9.9.3 *EXCEPT Operator*

The `EXCEPT` operator returns all of the distinct rows from the query given on the left of the `EXCEPT` operator and removes all the rows from the resultset that match the rows on the right of the `EXCEPT` operator.

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Following is the syntax of the EXCEPT operator.

Syntax:

```
Query_statement1  
EXCEPT  
Query_statement2
```

where,

Query_Statement1 and Query_Statement2 are SELECT statements.

The two rules that apply to INTERSECT operator are also applicable for EXCEPT operator.

Code Snippet 33 demonstrates the EXCEPT operator.

Code Snippet 33:

```
SELECT Product.ProductId FROM Production.Product  
EXCEPT  
SELECT ProductId FROM Sales.SalesOrderDetail
```



If the order of the two tables in this example is interchanged, only those rows are returned from Production.Product table which do not match with the rows present in Sales.SalesOrderDetail.

Thus, in simple terms, EXCEPT operator selects all the records from the first table except those which match with the second table. Hence, when you are using EXCEPT operator, the order of the two tables in the queries is important. Whereas, with the INTERSECT operator, it does not matter which table is specified first.

9.10 Pivoting and Grouping Set Operations

Consider a scenario where data needs to be displayed in a different orientation than it is stored in, in terms of row and column layout. The process of transforming data from a row-based orientation to a column-based orientation is called pivoting. The PIVOT and UNPIVOT operators of SQL Server help to change the orientation of data from column-oriented to row-oriented and vice versa. This is accomplished by consolidating values present in a column to a list of distinct values and then projecting that list in the form of column headings.

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9.10.1 PIVOT Operator

Following is the brief syntax for PIVOT.

Syntax:

```
SELECT <non-pivoted column>,
       [first pivoted column] AS <column name>,
       [second pivoted column] AS <column name>,
       ...
       [last pivoted column] AS <column name>

FROM
    (<SELECT query that produces the data>)
    AS <alias for the source query>

PIVOT
(
    <aggregation function>(<column being aggregated>)
FOR
    [<column that contains the values that will become column headers>]
    IN ( [first pivoted column], [second pivoted column],
          ... [last pivoted column])
) AS <alias for the pivot table>
<optional ORDER BY clause>;
```

*Woe to him who teaches men faster
than they can learn.*

where,

`table_source`: is a table or table expression.

`aggregate_function`: is a user-defined or in-built aggregate function that accepts one or more inputs.

`value_column`: is the value column of the PIVOT operator.

`pivot_column`: is the pivot column of the PIVOT operator. This column must be of a type that can implicitly or explicitly be converted to `nvarchar()`.

`IN (column_list)`: are values in the `pivot_column` that will become the column names of the output table. The list must not include any column names that already exist in the input `table_source` being pivoted.

`table_alias`: is the alias name of the output table.

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The output of this will be a table containing all columns of the `table_source` except the `pivot_column` and `value_column`. These columns of the `table_source`, excluding the `pivot_column` and `value_column`, are called the grouping columns of the pivot operator.

In simpler terms, to use the PIVOT operator, you need to supply three elements to the operator:

- **Grouping:** In the `FROM` clause, the input columns must be provided. The PIVOT operator uses those columns to determine which column(s) to use for grouping the data for aggregation.
- **Spreading:** Here, a comma-separated list of values that occur in the source data is provided that will be used as the column headings for the pivoted data.
- **Aggregation:** An aggregation function, such as `SUM`, to be performed on the grouped rows.

Consider an example to understand the PIVOT operator. Code Snippet 34 is shown without the PIVOT operator and demonstrates a simple GROUP BY aggregation. As the number of records would be huge, the resultset is limited to 5 by specifying TOP 5.

Code Snippet 34:

```
SELECT TOP 5 SUM(SalesYTD) AS TotalSalesYTD, Name
FROM Sales.SalesTerritory
GROUP BY Name
```



Figure 9.31 shows the output.

	TotalSalesYTD	Name
1	7887186.7882	Northwest
2	2402176.8476	Northeast
3	3072175.118	Central
4	10510853.8739	Southwest
5	2538667.2515	Southeast

Figure 9.31: Grouping without PIVOT

The top 5 year to date sales along with territory names grouped by territory names are displayed.

Now, the same query is rewritten in Code Snippet 35 using a PIVOT so that the data is transformed from a row-based orientation to a column-based orientation.

Code Snippet 35:

```
-- Pivot table with one row and six columns
SELECT TOP 5 'TotalSalesYTD' AS GrandTotal,
[Northwest], [Northeast], [Central], [Southwest], [Southeast]
FROM
(SELECT TOP 5 Name, SalesYTD
FROM Sales.SalesTerritory
) AS SourceTable
PIVOT
(
SUM(SalesYTD)
FOR Name IN ([Northwest], [Northeast], [Central], [Southwest], [Southeast])
) AS PivotTable;
```

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Figure 9.32 shows the output.

	GrandTotal	Northwest	Northeast	Central	Southwest	Southeast
1	TotalSalesYTD	7887186.7882	2402176.8476	3072175.118	10510853.8739	2538667.2515

Figure 9.32: Grouping with PIVOT

As shown in figure 9.32, the data is transformed and the territory names are now seen as columns instead of rows. This improves readability. A major challenge in writing queries using `PIVOT` is the need to provide a fixed list of spreading elements to the `PIVOT` operator, such as the specific territory names given in Code Snippet 35. It would not be feasible or practical to implement this for large number of spreading elements. To overcome this, developers can use dynamic SQL. Dynamic SQL provides a means to build a character string that is passed to SQL Server, interpreted as a command, and then, executed.

9.10.2 UNPIVOT Operator

`UNPIVOT` performs almost the reverse operation of `PIVOT`, by rotating columns into rows. Unpivoting does not restore the original data. Detail-level data was lost during the aggregation process in the original pivot. `UNPIVOT` has no ability to allocate values to return to the original detail values. Instead of turning rows into columns, unpivoting results in columns being transformed into rows. SQL Server provides the `UNPIVOT` table operator to return a row-oriented tabular display from a pivoted data.

When unpivoting data, one or more columns are defined as the source to be converted into rows. The data in those columns is spread, or split, into one or more new rows, depending on how many columns are being unpivoted.

*Real generosity towards the future lies
in giving all to the present.*

To use the UNPIVOT operator, you need to provide three elements as follows:

- Source columns to be unpivoted
- A name for the new column that will display the unpivoted values
- A name for the column that will display the names of the unpivoted values

Consider the earlier scenario. Code Snippet 36 shows the code to convert the temporary pivot table into a permanent one so that the same table can be used for demonstrating UNPIVOT operations.

Code Snippet 36:

```
-- Pivot table with one row and six columns
SELECT TOP 5 'TotalSalesYTD' AS GrandTotal,
[Northwest], [Northeast], [Central], [Southwest], [Southeast]
FROM
(SELECT TOP 5 Name, SalesYTD
FROM Sales.SalesTerritory
) AS SourceTable
PIVOT
(
SUM(SalesYTD)
FOR Name IN ([Northwest], [Northeast], Central], [Southwest], [Southeast])
) AS PivotTable;
```

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Code Snippet 37 demonstrates the UNPIVOT operator.

Code Snippet 37:

```
SELECT Name, SalesYTD FROM
  (SELECT GrandTotal, Northwest, Northeast, Central, Southwest, Southeast FROM
  TotalTable) P
UNPIVOT
  (SalesYTD FOR Name IN
  (Northwest, Northeast, Central, Southwest, Southeast))
) AS unpvt;
```

The output will be the same as that in figure 9.32.

9.10.3 GROUPING SETS

The GROUPING SETS operator supports aggregation of multiple column groupings and an optional grand total. Consider that you need a report that groups several columns of a table. Further, you want aggregates of the columns. In earlier versions of SQL Server, you would have to write several distinct GROUP BY clauses followed by UNION clauses to achieve this. First introduced in SQL Server 2008, the GROUPING SETS operator allows you to group together multiple groupings of columns followed by an optional grand total row, denoted by parentheses, (). It is more efficient to use GROUPING SETS operators instead of multiple GROUP BY with UNION clauses because the latter adds more processing overheads on the database server.



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Following is the syntax for the GROUPING SETS operator.

Syntax:

```
GROUP BY  
GROUPING SETS (<grouping set list>)
```

where,

grouping set list: consists of one or more columns, separated by commas.

A pair of parentheses, (), without any column name denotes grand total.

Code Snippet 38 demonstrates the GROUPING SETS operator. It assumes that a table **Students** is created with fields named **Id**, **Name**, and **Marks** respectively.

Code Snippet 38:

```
SELECT Id, Name, AVG(Marks) Marks  
FROM Students  
GROUP BY  
GROUPING SETS  
(  
(Id, Name, Marks),  
(Id),  
()  
)
```

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Figure 9.33 shows the output of the code.

	Id	Name	Marks
1	91	Sasha Goldsmith	78
2	91	NULL	78
3	92	Karen Hues	55
4	92	NULL	55
5	93	William Pinter	67
6	93	NULL	67
7	94	Yuri Gogol	89
8	94	NULL	89
9	NULL	NULL	72

Figure 9.33: GROUPING SETS

Here, the code uses GROUPING SETS to display average marks for every student. NULL values in **Name** indicate average marks for every student. NULL value in both **Id** and **Name** columns indicate grand total.

Knowledge is not enough; we must apply. Willing is not enough; we must do.

9.11 Check Your Progress

1. Which of the following statements can be used with subqueries that return one column and many rows?

(A)	ANY	(C)	IN
(B)	ALL	(D)	=

2. The _____ operator is used to display only the rows that are common to both the tables.

(A)	INTERSECT	(C)	UNION
(B)	EXCEPT	(D)	UNION WITH ALL

3. A subquery that includes another subquery within it is called a _____.

(A)	join	(C)	correlated subquery
(B)	nested subquery	(D)	parent subquery

4. _____ is formed when records from two tables are combined only if the rows from both the tables are matched based on a common column.

(A)	Inner join	(C)	Self-join
(B)	Left Outer join	(D)	Right Outer join

5. _____ return all rows from at least one of the tables in the FROM clause of the SELECT statement, as long as those rows meet any WHERE or HAVING conditions of the SELECT statement.

(A)	Inner join	(C)	Self-join
(B)	Outer join	(D)	Sub queries

Session**Advanced Queries and Joins**

6. Consider you have two tables, **Products** and **Orders** that are already populated. Based on new orders, you want to update **Quantity** in **Products** table. You write the following code:

```
MERGE Products AS T
USING Orders AS S
ON S.ProductID = T.ProductID
```

Which of the following code, when inserted into the blank space, will allow you to achieve this?

(A)	WHEN MATCHED THEN UPDATE SET T.Quantity = S.Quantity	(C)	WHEN NOT MATCHED THEN UPDATE SET T.Quantity = S.Quantity
(B)	WHEN MATCHED THEN UPDATE SET Quantity = Quantity	(D)	WHEN MATCHED THEN UPDATE SET S.Quantity = T.Quantity

7. Which of the following will be the outcome of the given code?

```
SELECT ProdId, Year,
SUM(Purchase) AS TotalPurchase
FROM Products
GROUP BY GROUPING SETS ((ProdId), ())
```

(A)	Syntax Error	(C)	Will display year-wise total purchase data except grand total
(B)	Will execute but will not produce any output	(D)	Will display year-wise total purchase data with grand total

9.11.1 Answers

1.	C
2.	B
3.	B
4.	B
5.	B
6.	A
7.	A



- The GROUP BY clause and aggregate functions enabled to group and/or aggregate data together in order to present summarized information.
- Spatial aggregate functions are newly introduced in SQL Server 2012.
- A subquery allows the resultset of one SELECT statement to be used as criteria for another SELECT statement.
- Joins help you to combine column data from two or more tables based on a logical relationship between the tables.
- Set operators such as UNION and INTERSECT help you to combine row data from two or more tables.
- The PIVOT and UNPIVOT operators help to change the orientation of data from column-oriented to row-oriented and vice versa.
- The GROUPING SET subclause of the GROUP BY clause helps to specify multiple groupings in a single query.

Try It Yourself

1. Write a query to display the employee names and their departments from the AdventureWorks2012 database.
2. Using the tables Sales.SalesPerson and Sales.SalesTerritory, retrieve the IDs of all the sales persons who operate in Canada.
3. Using the tables Sales.SalesPerson and Sales.SalesTerritory, retrieve the IDs of all the sales persons who operate in Northwest or Northeast.
4. Compare the bonus values of salespersons in the Sales.SalesPerson table to find out the sales persons earning more bonuses. Display the SalesPersonID and bonus values in descending order. (Hint: Use a self-join and ORDER BY ...DESC).
5. Retrieve all the values of SalesPersonID from Sales.SalesPerson table, but leave out those values, which are present in the Sales.Store table. (Hint: Use EXCEPT operator).
6. Combine all the SalesPersonIDs of the tables Sales.SalesPerson and Sales.Store.
7. Retrieve all the sales person IDs and territory IDs from Sales.SalesPerson table regardless of whether they have matching records in the Sales.SalesTerritory table. (Hint: Use a left outer join).
8. Retrieve a distinct set of Territory IDs that are present in both Sales.SalesPerson and Sales.SalesTerritory tables. (Hint: Use INTERSECT operator).

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Session - 10

Using Views, Stored Procedures, and Querying Metadata

Welcome to the Session, **Using Views, Stored Procedures, and Querying Metadata**.

This session explains about views and describes creating, altering, and dropping views. The session also describes stored procedures in detail. The session concludes with an explanation of the techniques to query metadata.

In this Session, you will learn to:

- Define views
- Describe the technique to create, alter, and drop views
- Define stored procedures
- Explain the types of stored procedures
- Describe the procedure to create, alter, and execute stored procedures
- Describe nested stored procedures
- Describe querying SQL Server metadata
 - System Catalog views and functions
 - Querying Dynamic Management Objects

10.1 Introduction

An SQL Server database has two main categories of objects: those that store data and those that access, manipulate, or provide access to data. Views and stored procedures belong to this latter category.

10.2 Views

A view is a virtual table that is made up of selected columns from one or more tables. The tables from which the view is created are referred to as base tables. These base tables can be from different databases. A view can also include columns from other views created in the same or a different database. A view can have a maximum of 1024 columns.

The data inside the view comes from the base tables that are referenced in the view definition. The rows and columns of views are created dynamically when the view is referenced.



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10.2.1 Creating Views

A user can create a view using columns from tables or other views only if the user has permission to access these tables and views. A view is created using the `CREATE VIEW` statement and it can be created only in the current database.

SQL Server verifies the existence of objects that are referenced in the view definition.

Note - While creating a view, test the `SELECT` statement that defines the view to make sure that SQL Server returns the expected result. You create the view only after the `SELECT` statement is tested and the resultset has been verified.

Following syntax is used to create a view.

Syntax:

```
CREATE VIEW <view_name>
AS <select_statement>
```

where,

`view_name`: specifies the name of the view.

`select_statement`: specifies the `SELECT` statement that defines the view.

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Using Views, Stored Procedures, and Querying Metadata

Code Snippet 1 creates a view from the `Product` table to display only the product id, product number, name, and safety stock level of products.

Code Snippet 1:

```
CREATE VIEW vwProductInfo AS  
SELECT ProductID, ProductNumber, Name, SafetyStockLevel  
FROM Production.Product;  
GO
```

Note - The words `vw` are prefixed to a view name as per the recommended coding conventions.

Following code in Code Snippet 2 is used to display the details of the `vwProductInfo` view.

Code Snippet 2:

```
SELECT * FROM vwProductInfo
```

*Don't just learn the tricks of the trade,
learn the trade.*

The result will show the specified columns of all the products from the Product table. A part of the output is shown in figure 10.1.

	ProductID	ProductNumber	Name	SafetyStockLevel
1	1	AR-5381	Adjustable Race	1000
2	2	BA-8327	Bearing Ball	1000
3	3	BE-2349	BB Ball Bearing	800
4	4	BE-2908	Headset Ball Bearings	800
5	316	BL-2036	Blade	800
6	317	CA-5965	LL Crankarm	500
7	318	CA-6738	ML Crankarm	500
8	319	CA-7457	HL Crankarm	500
9	320	CB-2903	Chainring Bolts	1000
10	321	CN-6137	Chainring Nut	1000

Figure 10.1: Selecting Records from a View

10.2.2 Creating Views Using JOIN Keyword

The `JOIN` keyword can also be used to create views. The `CREATE VIEW` statement is used along with the `JOIN` keyword to create a view using columns from multiple tables.

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Following syntax is used to create a view with the JOIN keyword.

Syntax:

```
CREATE VIEW <view_name>
AS
SELECT * FROM table_name1
JOIN table_name2
ON table_name1.column_name=table_name2.column_name
```

where,

`view_name`: specifies the name of the view.

`table_name1`: specifies the name of first table.

`JOIN`: specifies that two tables are joined using `JOIN` keyword.

`table_name2`: specifies the name of the second table.



Session**Using Views, Stored Procedures, and Querying Metadata**

Code Snippet 3 creates a view named **vwPersonDetails** with specific columns from the Person and Employee tables. The JOIN and ON keywords join the two tables based on BusinessEntityID column.

Code Snippet 3:

```
CREATE VIEW vwPersonDetails
AS
SELECT
    p.Title
    ,p.[FirstName]
    ,p.[MiddleName]
    ,p.[LastName]
    ,e.[JobTitle]
FROM [HumanResources].[Employee] e
    INNER JOIN [Person].[Person] p
        ON p.[BusinessEntityID] = e.[BusinessEntityID]
GO
```

This view will contain the columns Title, FirstName, MiddleName, and LastName from the Person table and JobTitle from the Employee table. Once the view is created, you can retrieve records from it, and manipulate and modify records as well.

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Using Views, Stored Procedures, and Querying Metadata

Code Snippet 4 shows executing a query on this view.

Code Snippet 4:

```
SELECT * FROM vwPersonDetails
```

The output will be as shown in figure 10.2.

	Title	FirstName	MiddleName	LastName	Job Title
1	NULL	Ken	J	Sánchez	Chief Executive Officer
2	NULL	Temi	Lee	Duffy	Vice President of Engineering
3	NULL	Roberto	NULL	Tamburello	Engineering Manager
4	NULL	Rob	NULL	Walters	Senior Tool Designer
5	Ms.	Gail	A	Erickson	Design Engineer
6	Mr.	Jossef	H	Goldberg	Design Engineer
7	NULL	Dylan	A	Miller	Research and Development Manager
8	NULL	Diane	L	Margheim	Research and Development Engineer
9	NULL	Gigi	N	Matthew	Research and Development Engineer
10	NULL	Michael	NULL	Raheem	Research and Development Manager

Figure 10.2: Creating Views with a Join

Practice is the best of all instructors.

As shown in figure 10.2, all the rows may not have values for the Title or MiddleName columns - some may have NULL in them. A person seeing this output may not be able to comprehend the meaning of the NULL values. Hence, to replace all the NULL values in the output with a null string, the COALESCE () function can be used as shown in Code Snippet 5.

Code Snippet 5:

```
CREATE VIEW vwPersonDetails
AS
SELECT
    COALESCE(p.Title, '') AS Title
    ,p.[FirstName]
    ,COALESCE(p.MiddleName, '') AS MiddleName
    ,p.[LastName]
    ,e.[JobTitle]
FROM [HumanResources].[Employee] e
    INNER JOIN [Person].[Person] p
        ON p.BusinessEntityID = e.BusinessEntityID
GO
```

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Using Views, Stored Procedures, and Querying Metadata

When this view is queried with a `SELECT` statement, the output will be as shown in figure 10.3.

	Title	FirstName	MiddleName	LastName	Job Title
1		Ken	J	Sánchez	Chief Executive Officer
2		Temi	Lee	Duffy	Vice President of Engineering
3		Roberto		Tamburello	Engineering Manager
4		Rob		Walters	Senior Tool Designer
5	Ms.	Gail	A	Erickson	Design Engineer
6	Mr.	Jossef	H	Goldberg	Design Engineer
7		Dylan	A	Miller	Research and Development Manager
8		Diane	L	Margheim	Research and Development Engineer
9		Gigi	N	Matthew	Research and Development Engineer
10		Michael		Raheem	Research and Development Manager

Figure 10.3: Using COALESCE Function in a View



10.2.3 Guidelines and Restrictions on Views

A view can be created using the `CREATE VIEW` command. Before creating a view, the following guidelines and restrictions should be considered:

- A view is created only in the current database. The base tables and views from which the view is created can be from other databases or servers.
- View names must be unique and cannot be the same as the table names in the schema.
- A view cannot be created on temporary tables.
- A view cannot have a full-text index.
- A view cannot contain the `DEFAULT` definition.
- The `CREATE VIEW` statement can include the `ORDER BY` clause only if the `TOP` keyword is used.
- Views cannot reference more than 1024 columns.
- The `CREATE VIEW` statement cannot include the `INTO` keyword.
- The `CREATE VIEW` statement cannot be combined with other Transact-SQL statements in a single batch.

If a view contains columns that have values derived from an expression, such columns have to be given alias names. Also, if a view contains similarly-named columns from different tables, to distinguish these columns, alias names must be specified.

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Code Snippet 6 reuses the code given in Code Snippet 5 with an ORDER BY clause. The TOP keyword displays the name of the first ten employees with their first names in ascending order.

Code Snippet 6:

```
CREATE VIEW vwSortedPersonDetails
AS
SELECT TOP 10
    COALESCE(p.Title, '') AS Title
    ,p.[FirstName]
    ,COALESCE(p.MiddleName, '') AS MiddleName
    ,p.[LastName]
    ,e.[JobTitle]

FROM [HumanResources].[Employee] e
    INNER JOIN [Person].[Person] p
        ON p.BusinessEntityID = e.BusinessEntityID
    ORDER BY p.FirstName

GO

--Retrieve records from the view
SELECT * FROM vwSortedPersonDetails
```

It is hard to fail, but it is worse never to have tried to succeed.

10.3 Modifying Data through Views

Views can be used to modify data in database tables. Data can be inserted, modified, or deleted through a view using the following statements:

- INSERT
- UPDATE
- DELETE

10.3.1 INSERT with Views

The `INSERT` statement is used to add a new row to a table or a view. During the execution of the statement, if the value for a column is not provided, the SQL Server Database Engine must provide a value based on the definition of the column. If the Database Engine is unable to provide this value, then the new row will not be added.

The value for the column is provided automatically if:

- The column has an `IDENTITY` property.
- The column has a default value specified.
- The column has a timestamp data type.
- The column takes null values.
- The column is a computed column.

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While using the `INSERT` statement on a view, if any rules are violated, the record is not inserted.

In the following example, when data is inserted through the view, the insertion does not take place as the view is created from two base tables.

First, create a table `Employee_Personal_Details` as shown in Code Snippet 7.

Code Snippet 7:

```
CREATE TABLE Employee_Personal_Details
(
    EmpID int NOT NULL,
    FirstName varchar(30) NOT NULL,
    LastName varchar(30) NOT NULL,
    Address varchar(30)
)
```

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Then, create a table **Employee_Salary_Details** as shown in Code Snippet 8.

Code Snippet 8:

```
CREATE TABLE Employee_Salary_Details
(
    EmpID
    int NOT NULL,
    Designation varchar(30),
    Salary int NOT NULL
)
```

Code Snippet 9 creates a view **vwEmployee_Details** using columns from the **Employee_Personal_Details** and **Employee_Salary_Details** tables by joining the two tables on the **EmpID** column.

Code Snippet 9:

```
CREATE VIEW vwEmployee_Details
AS
SELECT e1.EmpID, FirstName, LastName, Designation, Salary
FROM Employee_Personal_Details e1
JOIN Employee_Salary_Details e2
ON e1.EmpID = e2.EmpID
```

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Code Snippet 10 uses the `INSERT` statement to insert data through the view `vwEmployee_Details`. However, the data is not inserted as the view is created from two base tables.

Code Snippet 10:

```
INSERT INTO vwEmployee_Details VALUES (2, 'Jack', 'Wilson', 'Software  
Developer', 16000)
```

Following error message is displayed when the `INSERT` statement is executed.

'Msg 4405, Level 16, State 1, Line 1

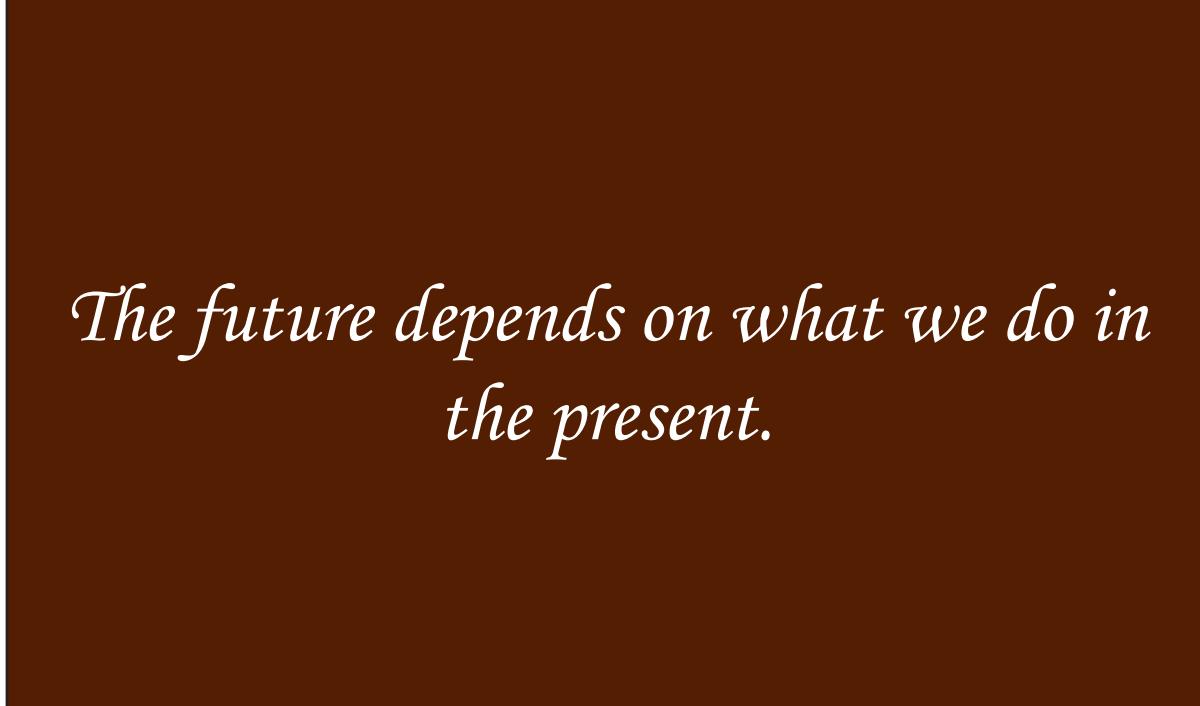
View or function 'vEmployee_Details' is not updatable because the modification affects multiple base tables.'

Values can be inserted into user-defined data type columns by:

- Specifying a value of the user-defined type.
- Calling a user-defined function that returns a value of the user-defined type.

Following rules and guidelines must be followed when using the `INSERT` statement:

- The `INSERT` statement must specify values for all columns in a view in the underlying table that do not allow null values and have no `DEFAULT` definitions.
- When there is a self-join with the same view or base table, the `INSERT` statement does not work.



*The future depends on what we do in
the present.*

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Code Snippet 11 creates a view `vwEmpDetails` using `Employee_Personal_Details` table. The `Employee_Personal_Details` table contains a column named `LastName` that does not allow null values to be inserted.

Code Snippet 11:

```
CREATE VIEW vwEmpDetails  
AS  
SELECT FirstName, Address  
FROM Employee_Personal_Details  
GO
```

Code Snippet 12 attempts to insert values into the `vwEmpDetails` view.

Code Snippet 12:

```
INSERT INTO vwEmpDetails VALUES ('Jack', 'NYC')
```

This insert is not allowed as the view does not contain the `LastName` column from the base table and that column does not allow null values.

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10.3.2 UPDATE with Views

The `UPDATE` statement can be used to change the data in a view. Updating a view also updates the underlying table.

Consider an example. Code Snippet 13 creates a table named `Product_Details`.

Code Snippet 13:

```
CREATE TABLE Product_Details  
(  
    ProductID int,  
    ProductName varchar(30),  
    Rate money  
)
```



Assume some records are added in the table as shown in figure 10.4.

	ProductID	ProductName	Rate
1	5	DVD Writer	2250.00
2	4	DVD Writer	1250.00
3	6	DVD Writer	1250.00
4	2	External Hard Drive	4250.00
5	3	External Hard Drive	4250.00

Figure 10.4: Records in the Product_Details

Code Snippet 14 creates a view based on the `Product_Details` table.

Code Snippet 14:

```
CREATE VIEW vwProduct_Details
AS
SELECT
ProductName, Rate FROM Product_Details
```

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Code Snippet 15 updates the view to change all rates of DVD writers to 3000.

Code Snippet 15:

```
UPDATE vwProduct_Details  
SET Rate=3000  
WHERE ProductName='DVD Writer'
```

The outcome of this code affects not only the view, **vwProduct_Details**, but also the underlying table from which the view was created.

Figure 10.5 shows the updated table which was automatically updated because of the view.

	ProductID	ProductName	Rate
1	5	DVD Writer	3000.00
2	4	DVD Writer	3000.00
3	6	DVD Writer	3000.00
4	2	External Hard Drive	4250.00
5	3	External Hard Drive	4250.00

Figure 10.5: Updated Table

*Action may not always bring happiness,
but there is no happiness without
action.*

Large value data types include `varchar(max)`, `nvarchar(max)`, and `varbinary(max)`. To update data having large value data types, the `.WRITE` clause is used. The `.WRITE` clause specifies that a section of the value in a column is to be modified. The `.WRITE` clause cannot be used to update a `NULL` value in a column. Also, it cannot be used to set a column value to `NULL`.

Syntax:

```
column_name.WRITE (expression, @Offset, @Length)
```

where,

`column_name`: specifies the name of the large value data-type column.

`Expression`: specifies the value that is copied to the column.

`@Offset`: specifies the starting point in the value of the column at which the expression is written.

`@Length`: specifies the length of the section in the column.

`@Offset` and `@Length` are specified in bytes for `varbinary` and `varchar` data types and in characters for the `nvarchar` data type.

Assume that the table `Product_Details` is modified to include a column `Description` having data type `nvarchar(max)`.

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A view is created based on this table, having the columns **ProductName**, **Description**, and **Rate** as shown in Code Snippet 16.

Code Snippet 16:

```
CREATE VIEW vwProduct_Details
AS
SELECT
ProductName,
Description,
Rate FROM Product_Details
```

Code Snippet 17 uses the **UPDATE** statement on the view **vwProduct_Details**. The **.WRITE** clause is used to change the value of Internal in the **Description** column to External.

Code Snippet 17:

```
UPDATE vwProduct_Details
SET Description .WRITE(N'Ex',0,2)
WHERE ProductName='Portable Hard Drive'
```

As a result of the code, all the rows in the view that had 'Portable Hard Drive' as product name will be updated with External instead of Internal in the **Description** column.



Figure 10.6 shows a sample output of the view after the updation.

	ProductName	Description	Rate
1	Hard Disk Drive	Internal 120 GB	3570.00
2	Portable Hard Drive	External Drive 500 GB	5580.00
3	Portable Hard Drive	External Drive 500 GB	5580.00
4	Hard Disk Drive	Internal 120 GB	3570.00
5	Portable Hard Drive	External Drive 500 GB	5580.00

Figure 10.6: Updating a View

Following rules and guidelines must be followed when using the `UPDATE` statement:

- The value of a column with an `IDENTITY` property cannot be updated.
- Records cannot be updated if the base table contains a `TIMESTAMP` column.
- While updating a row, if a constraint or rule is violated, the statement is terminated, an error is returned, and no records are updated.
- When there is a self-join with the same view or base table, the `UPDATE` statement does not work.

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10.3.3 DELETE with Views

SQL Server enables you to delete rows from a view. Rows can be deleted from the view using the `DELETE` statement. When rows are deleted from a view, corresponding rows are deleted from the base table.

For example, consider a view `vwCustDetails` that lists the account information of different customers. When a customer closes the account, the details of this customer need to be deleted. This is done using the `DELETE` statement.

Following syntax is used to delete data from a view.

Syntax:

```
DELETE FROM <view_name>
WHERE <search condition>
```

Assume that a table named `Customer_Details` and a view `vwCustDetails` based on the table are created.

First say to yourself what you would be; and then do what you have to do.

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Code Snippet 18 is used to delete the record from the view **vwCustDetails** that has **CustID C0004**.

Code Snippet 18:

```
DELETE FROM vwCustDetails WHERE CustID='C0004'
```

Figure 10.7 depicts the logic of deleting from views.

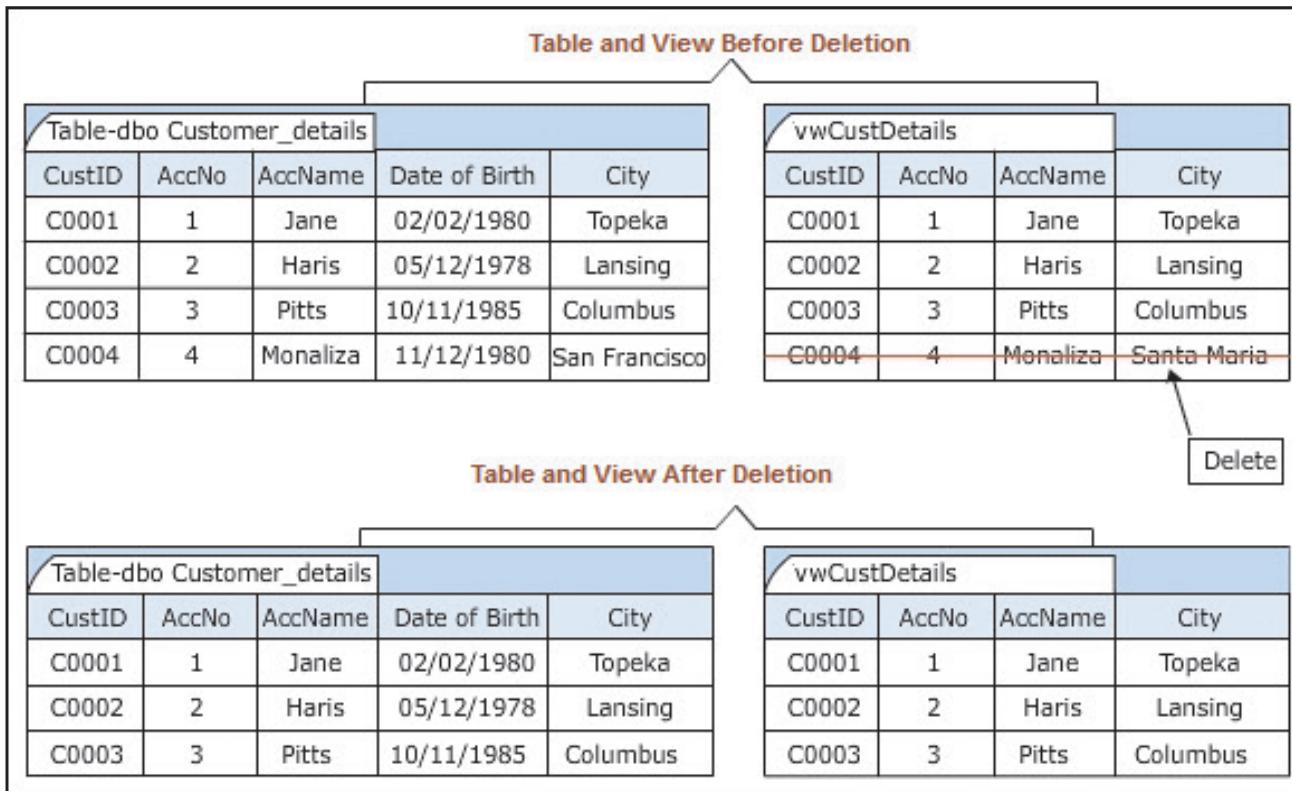


Figure 10.7: Deleting from Views

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10.4 Altering Views

Besides modifying the data within a view, users can also modify the definition of a view. A view can be modified or altered by dropping and recreating it or executing the `ALTER VIEW` statement. The `ALTER VIEW` statement modifies an existing view without having to reorganize its permissions and other properties. `ALTER VIEW` can be applied to indexed views; however, it unconditionally drops all indexes on the view.

Views are often altered when a user requests for additional information or makes changes in the underlying table definition.

Note - After a view is created, if the structure of its underlying tables is altered by adding columns, the new columns do not appear in the view. This is because the column list is interpreted only when you first create the view. To see the new columns in the view, you must alter the view.

Following syntax is used to alter a view.

Syntax:

```
ALTER VIEW <view_name>
AS <select_statement>
```




MULTIPLE EXPERTS | MULTIPLE TOPICS

Code Snippet 19 alters the view, vwProductInfo to include the ReOrderPoint column.

Code Snippet 19:

```
ALTER VIEW vwProductInfo AS  
SELECT ProductID, ProductNumber, Name, SafetyStockLevel, ReOrderPoint  
FROM Production.Product;  
GO
```

10.5 Dropping Views

A view can be removed from the database if it is no longer needed. This is done using the `DROP VIEW` statement. When a view is dropped, the data in the base tables remains unaffected. The definition of the view and other information associated with the view is deleted from the system catalog. All permissions for the view are also deleted. If a user queries any view that references the dropped view, the user receives an error message.

Note - The owner of the view has the permission to drop a view and this permission is nontransferable. However, the system administrator or database owner can drop any object by specifying the owner name in the `DROP VIEW` statement.

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Following syntax is used to drop a view.

Syntax:

```
DROP VIEW <view_name>
```

Code Snippet 20 deletes the view, vwProductInfo.

Code Snippet 20:

```
DROP VIEW vwProductInfo
```

10.6 Definition of a View

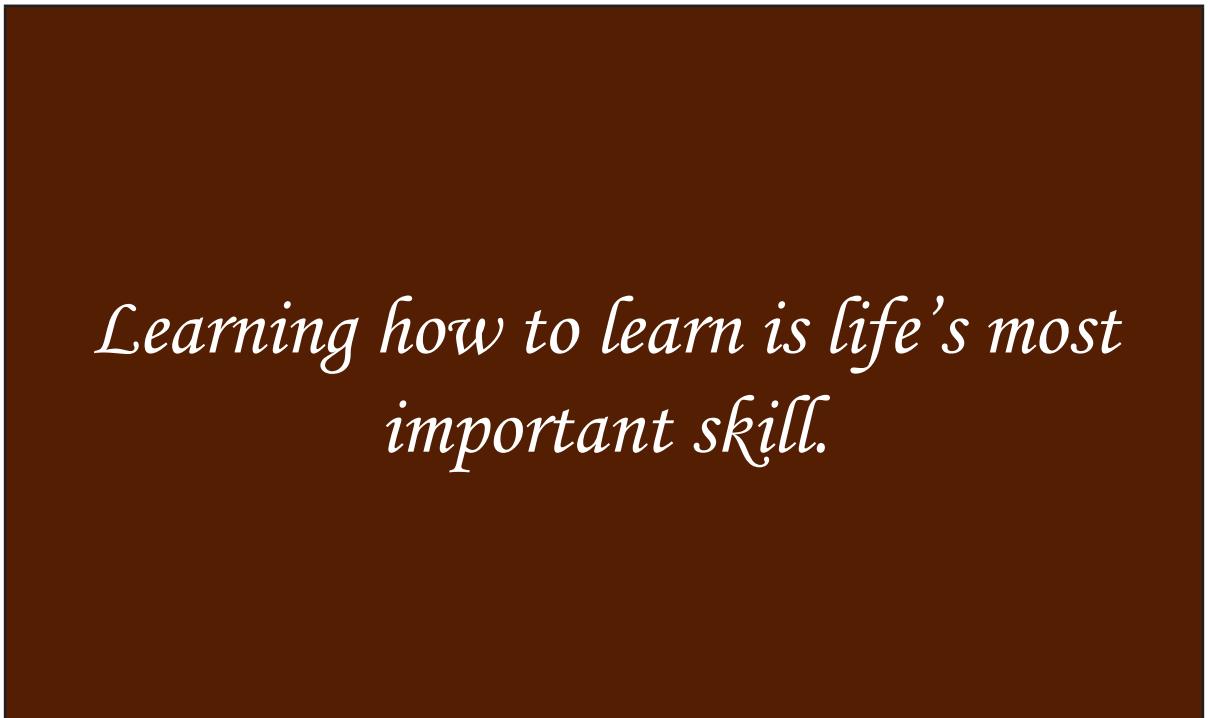
The definition of a view helps to understand how its data is derived from the source tables. There are certain system stored procedures that help to retrieve view definitions.

The `sp_helptext` stored procedure displays view related information when the name of the view is given as its parameter. Information about the definition of a view can be obtained if such information is not encrypted.

Following syntax is used to view the definition information of a view.

Syntax:

```
sp_helptext <view_name>
```



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Code Snippet 21 displays information about the view, **vwProductPrice**.

Code Snippet 21:

```
EXEC sp_helptext vwProductPrice
```

The execution of the code will display the definition about the view as shown in figure 10.8.

	Text
1	CREATE VIEW vwProductPrice AS
2	SELECT ProductID, ProductNumber, Name, SafetySto...
3	FROM Production.Product;

Figure 10.8: Using **sp_helptext** to Display View Definitions

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10.7 Creating a View Using Built-in Functions

Views can be created using built-in functions of SQL Server. When functions are used, the derived column must include the column name in the CREATE VIEW statement.

Consider the view that was created in Code Snippet 16. It has been re-created in Code Snippet 22 to make use of the AVG () function.

Code Snippet 22:

```
CREATE VIEW vwProduct_Details
AS
SELECT
ProductName,
AVG(Rate) AS AverageRate
FROM Product_Details
GROUP BY ProductName
```

Here, the AVG () function calculates the average rate of similar products by using a GROUP BY clause.

Figure 10.9 shows the result when the view is queried.

	ProductName	AverageRate
1	Hard Disk Drive	3570.00
2	Portable Hard Drive	5580.00

Figure 10.9: Using Built-in Functions with Views



10.8 CHECK OPTION

The `CHECK OPTION` is an option associated with the `CREATE VIEW` statement. It is used to ensure that all the updates in the view satisfy the conditions mentioned in the view definition. If the conditions are not satisfied, the database engine returns an error. Thus, the `CHECK OPTION` is used to enforce domain integrity; it checks the definition of the view to see that the `WHERE` conditions in the `SELECT` statement is not violated.

The `WITH CHECK OPTION` clause forces all the modification statements executed against the view to follow the condition set within the `SELECT` statement. When a row is modified, the `WITH CHECK OPTION` makes sure that the data remains visible through the view.

Following syntax creates a view using the `CHECK OPTION`.

Syntax:

```
CREATE VIEW <view_name>
AS select_statement [ WITH CHECK OPTION ]
```

where,

`WITH CHECK OPTION`: specifies that the modified data in the view continues to satisfy the view definition.

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Code Snippet 23 re-creates the view **vwProductInfo** having SafetyStockLevel less than or equal to 1000.

Code Snippet 23:

```
CREATE VIEW vwProductInfo AS  
SELECT ProductID, ProductNumber, Name, SafetyStockLevel,  
ReOrderPoint  
FROM Production.Product  
WHERE SafetyStockLevel <=1000  
WITH CHECK OPTION;  
GO
```

In Code Snippet 24, the **UPDATE** statement is used to modify the view **vwProductInfo** by changing the value of the **SafetyStockLevel** column for the product having id 321 to 2500.

Code Snippet 24:

```
UPDATE vwProductInfo SET SafetyStockLevel=2500  
WHERE ProductID=321
```

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

The UPDATE statement fails to execute as it violates the view definition, which specifies that SafetyStockLevel must be less than or equal to 1000. Thus, no rows are affected in the view **vwProductInfo**.

Note - Any updates performed on the base tables are not verified against the view, even if **CHECK OPTION** is specified.

10.9 SCHEMABINDING Option

A view can be bound to the schema of the base table using the **SCHEMABINDING** option. This option can be used with **CREATE VIEW** or **ALTER VIEW** statements. When **SCHEMABINDING** option is specified, the base table or tables cannot be modified that would affect the view definition. The view definition must be first modified or deleted to remove dependencies on the table that is to be modified.

While using the **SCHEMABINDING** option in a view, you must specify the schema name along with the object name in the **SELECT** statement.

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Using Views, Stored Procedures, and Querying Metadata

Following syntax is used to create a view with the SCHEMABINDING option.

Syntax:

```
CREATE VIEW <view_name> WITH SCHEMABINDING
AS <select_statement>
```

where,

`view_name`: specifies the name of the view.

`WITH SCHEMABINDING`: specifies that the view must be bound to a schema.

`select_statement`: Specifies the `SELECT` statement that defines the view.

Code Snippet 25 creates a view `vwNewProductInfo` with SCHEMABINDING option to bind the view to the Production schema, which is the schema of the table `Product`.

Code Snippet 25:

```
CREATE VIEW vwNewProductInfo
WITH SCHEMABINDING AS
SELECT ProductID, ProductNumber, Name, SafetyStockLevel
FROM Production.Product;
GO
```



10.10 Using sp_refreshview

During the creation of a view, the SCHEMABINDING option is used to bind the view to the schema of the tables that are included in the view. However, a view can also be created without selecting the SCHEMABINDING option. In such a case, if changes are made to the underlying objects (tables or views) on which the view depends, the sp_refreshview stored procedure should be executed. The sp_refreshview stored procedure updates the metadata for the view. If the sp_refreshview procedure is not executed, the metadata of the view is not updated to reflect the changes in the base tables. This results in the generation of unexpected results when the view is queried.

The sp_refreshview stored procedure returns code value zero if the execution is successful or returns a non-zero number in case the execution has failed.

Following syntax is used to run the sp_refreshview stored procedure.

Syntax:

```
sp_refreshview '<view_name>'
```

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Code Snippet 26 creates a table **Customers** with the **CustID**, **CustName**, and **Address** columns.

Code Snippet 26:

```
CREATE TABLE Customers
(
    CustID int,
    CustName varchar(50),
    Address varchar(60)
)
```

Code Snippet 27 creates a view **vwCustomers** based on the table **Customers**.

Code Snippet 27:

```
CREATE VIEW vwCustomers
AS
SELECT * FROM Customers
```

Code Snippet 28 executes the SELECT query on the view.

Code Snippet 28:

```
SELECT * FROM vwCustomers
```

The output of Code Snippet 28 shows the three columns, **CustID**, **CustName**, and **Address**.

To learn, you must want to be taught.

Code Snippet 29 uses the ALTER TABLE statement to add a column **Age** to the table **Customers**.

Code Snippet 29:

```
ALTER TABLE Customers ADD Age int
```

Code Snippet 30 executes the SELECT query on the view.

Code Snippet 30:

```
SELECT * FROM vwCustomers
```

The updated column **Age** is not seen in the view.

To resolve this, the `sp_refreshview` stored procedure must be executed on the view **vwCustomers** as shown in Code Snippet 31.

Code Snippet 31:

```
EXEC sp_refreshview 'vwCustomers'
```

When a SELECT query is run again on the view, the column **Age** is seen in the output. This is because the `sp_refreshview` procedure refreshes the metadata for the view **vwCustomers**.

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Using Views, Stored Procedures, and Querying Metadata

Tables that are schema-bound to a view cannot be dropped unless the view is dropped or changed such that it no longer has schema binding. If the view is not dropped or changed and you attempt to drop the table, the Database Engine returns an error message.

Also, when an `ALTER TABLE` statement affects the view definition of a schema-bound view, the `ALTER TABLE` statement fails.

Consider the schema-bound view that was created in Code Snippet 25. It is dependent on the `Production.Product` table.

Code Snippet 32 tries to modify the data type of `ProductID` column in the `Production.Product` table from `int` to `varchar(7)`.

Code Snippet 32:

```
ALTER TABLE Production.Product ALTER COLUMN ProductID varchar(7)
```

The Database Engine returns an error message as the table is schema-bound to the `vwNewProductInfo` view and hence, cannot be altered such that it violates the view definition of the view.

10.11 Stored Procedures

A stored procedure is a group of Transact-SQL statements that act as a single block of code that performs a specific task. This block of code is identified by an assigned name and is stored in the database in a compiled form. A stored procedure may also be a reference to a .NET Framework Common Language Runtime (CLR) method.

Stored procedures are useful when repetitive tasks have to be performed. This eliminates the need for repetitively typing out multiple Transact-SQL statements and then repetitively compiling them.



Session***Using Views, Stored Procedures, and Querying Metadata***

Stored procedures can accept values in the form of input parameters and return output values as defined by the output parameters.

Using stored procedures offers numerous advantages over using Transact-SQL statements. These are as follows:

→ **Improved Security**

The database administrator can improve the security by associating database privileges with stored procedures. Users can be given permission to execute a stored procedure even if the user does not have permission to access the tables or views.

→ **Precompiled Execution**

Stored procedures are compiled during the first execution. For every subsequent execution, SQL Server reuses this precompiled version. This reduces the time and resources required for compilation.

→ **Reduced Client/Server Traffic**

Stored procedures help in reducing network traffic. When Transact-SQL statements are executed individually, there is network usage separately for execution of each statement. When a stored procedure is executed, the Transact-SQL statements are executed together as a single unit. Network path is not used separately for execution of each individual statement. This reduces network traffic.

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→ **Reuse of code**

Stored procedures can be used multiple times. This eliminates the need to repetitively type out hundreds of Transact-SQL statements every time a similar task is to be performed.

10.11.1 Types of Stored Procedures

SQL Server supports various types of stored procedures. These are described as follows:

→ **User-Defined Stored Procedures**

User-defined stored procedures are also known as custom stored procedures. These procedures are used for reusing Transact-SQL statements for performing repetitive tasks. There are two types of user-defined stored procedures, the Transact-SQL stored procedures and the Common Language Runtime (CLR) stored procedures.

Transact-SQL stored procedures consist of Transact-SQL statements whereas the CLR stored procedures are based on the .NET framework CLR methods. Both the stored procedures can take and return user-defined parameters.

Democritus said, words are but the shadows of actions.

→ Extended Stored Procedures

Extended stored procedures help SQL Server in interacting with the operating system. Extended stored procedures are not resident objects of SQL Server. They are procedures that are implemented as dynamic-link libraries (DLL) executed outside the SQL Server environment. The application interacting with SQL Server calls the DLL at run-time. The DLL is dynamically loaded and run by SQL Server. SQL Server allots space to run the extended stored procedures. Extended stored procedures use the 'xp' prefix. Tasks that are complicated or cannot be executed using Transact-SQL statements are performed using extended stored procedures.

→ System Stored Procedures

System stored procedures are commonly used for interacting with system tables and performing administrative tasks such as updating system tables. The system stored procedures are prefixed with 'sp_'. These procedures are located in the Resource database. These procedures can be seen in the sys schema of every system and user-defined database. System stored procedures allow GRANT, DENY, and REVOKE permissions.

A system stored procedure is a set of pre-compiled Transact-SQL statements executed as a single unit. System procedures are used in database administrative and informational activities. These procedures provide easy access to the metadata information about database objects such as system tables, user-defined tables, views, and indexes.

System stored procedures logically appear in the sys schema of system and user-defined databases. When referencing a system stored procedure, the sys schema identifier is used. The system stored procedures are stored physically in the hidden Resource database and have the sp_ prefix. System stored procedures are owned by the database administrator.

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Note - System tables are created by default at the time of creating a new database. These tables store the metadata information about user-defined objects such as tables and views. Users cannot access or update the system tables using system stored procedures except through permissions granted by a database administrator.

10.11.2 Classification of System Stored Procedures

System stored procedures can be classified into different categories depending on the tasks they perform. Some of the important categories are as follows:

→ **Catalog Stored Procedures**

All information about tables in the user database is stored in a set of tables called the system catalog. Information from the system catalog can be accessed using catalog procedures. For example, the `sp_tables` catalog stored procedure displays the list of all the tables in the current database.

→ **Security Stored Procedures**

Security stored procedures are used to manage the security of the database. For example, the `sp_changedbowner` security stored procedure is used to change the owner of the current database.

→ **Cursor Stored Procedures**

Cursor procedures are used to implement the functionality of a cursor. For example, the `sp_cursor_list` cursor stored procedure lists all the cursors opened by the connection and describes their attributes.



→ Distributed Query Stored Procedures

Distributed stored procedures are used in the management of distributed queries. For example, the `sp_indexes` distributed query stored procedure returns index information for the specified remote table.

→ Database Mail and SQL Mail Stored Procedures

Database Mail and SQL Mail stored procedures are used to perform e-mail operations from within the SQL Server. For example, the `sp_send_dbmail` database mail stored procedure sends e-mail messages to specified recipients. The message may include a query resultset or file attachments or both.

10.11.3 Temporary Stored Procedures

Stored procedures created for temporary use within a session are called temporary stored procedures. These procedures are stored in the `tempdb` database. The `tempdb` system database is a global resource available to all users connected to an instance of SQL Server. It holds all temporary tables and temporary stored procedures.

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SQL Server supports two types of temporary stored procedures namely, local and global. The differences between the two types are given in table 10.1.

Local Temporary Procedure	Global Temporary Procedure
Visible only to the user that created it	Visible to all users
Dropped at the end of the current session	Dropped at the end of the last session
Local Temporary Procedure	Global Temporary Procedure
Can only be used by its owner	Can be used by any user
Uses the # prefix before the procedure name	Uses the ## prefix before the procedure name

Table 10.1: Differences Between Local and Global Temporary Procedures

Note - A session is established when a user connects to the database and is ended when the user disconnects.

The complete name of a global temporary stored procedure including the prefix # # cannot exceed 128 characters. The complete name of a local temporary stored procedure including the prefix # cannot exceed 116 characters.

*Nothing is a waste of time if you use
the experience wisely.*

10.11.4 Remote Stored Procedures

Stored procedures that run on remote SQL Servers are known as remote stored procedures. Remote stored procedures can be used only when the remote server allows remote access.

When a remote stored procedure is executed from a local instance of SQL Server to a client computer, a statement abort error might be encountered. When such an error occurs, the statement that caused the error is terminated but the remote procedure continues to be executed.

10.11.5 Extended Stored Procedures

Extended stored procedures are used to perform tasks that are unable to be performed using standard Transact-SQL statements. Extended stored procedures use the 'xp_' prefix. These stored procedures are contained in the `dbo` schema of the master database.

Following syntax is used to execute an extended stored procedure.

Syntax:

```
EXECUTE <procedure_name>
```

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Code Snippet 33 executes the extended stored procedure `xp_fileexist` to check whether the `MyTest.txt` file exists or not.

Code Snippet 33:

```
EXECUTE xp_fileexist 'c:\MyTest.txt'
```

Note - When you execute an extended stored procedure, either in a batch or in a module, qualify the stored procedure name with `master.dbo`.

10.12 Custom or User-defined Stored Procedures

In SQL Server, users are allowed to create customized stored procedures for performance of various tasks. Such stored procedures are referred to as user-defined or custom stored procedures.

For example, consider a table `Customer_Details` that stores the details about all the customers. You would need to type out Transact-SQL statements every time you wished to view the details about the customers. Instead, you could create a custom stored procedure that would display these details whenever the procedure is executed.

Creating a custom stored procedure requires `CREATE PROCEDURE` permission in the database and `ALTER` permission on the schema in which the procedure is being created.



Following syntax is used to create a custom stored procedure.

Syntax:

```
CREATE { PROC | PROCEDURE } procedure_name
[ { @parameter data_type } ]
AS <sql_statement>
```

where,

`procedure_name`: specifies the name of the procedure.

`@parameter`: specifies the input/output parameters in the procedure.

`data_type`: specifies the data types of the parameters.

`sql_statement`: specifies one or more Transact-SQL statements to be included in the procedure.

Code Snippet 34 creates and then executes a custom stored procedure, `uspGetCustTerritory`, which will display the details of customers such as customer id, territory id, and territory name.

Code Snippet 34:

```
CREATE PROCEDURE uspGetCustTerritory
AS
SELECT TOP 10 CustomerID, Customer.TerritoryID, Sales.SalesTerritory.Name
FROM Sales.Customer JOIN Sales.SalesTerritory ON Sales.Customer.TerritoryID=
Sales.SalesTerritory.TerritoryID
```

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To execute the stored procedure, the `EXEC` command is used as shown in Code Snippet 35.

Code Snippet 35:

```
EXEC uspGetCustTerritory
```

The output is shown in figure 10.10.

	CustomerID	TerritoryID	Name
1	15	9	Australia
2	33	9	Australia
3	51	9	Australia
4	69	9	Australia
5	87	9	Australia
6	105	9	Australia
7	123	9	Australia
8	141	9	Australia
9	159	9	Australia
10	177	9	Australia

Figure 10.10: Output of a Simple Stored Procedure

Learning how to learn is life's most important skill.

10.12.1 Using Parameters

The real advantage of a stored procedure comes into picture only when one or more parameters are used with it. Data is passed between the stored procedure and the calling program when a call is made to a stored procedure. This data transfer is done using parameters. Parameters are of two types that are as follows:

→ **Input Parameters**

Input parameters allow the calling program to pass values to a stored procedure. These values are accepted into variables defined in the stored procedure.

→ **Output Parameters**

Output parameters allow a stored procedure to pass values back to the calling program. These values are accepted into variables by the calling program.

These are now described in detail.

→ **Input Parameters**

Values are passed from the calling program to the stored procedure and these values are accepted into the input parameters of the stored procedure. The input parameters are defined at the time of creation of the stored procedure. The values passed to input parameters could be either constants or variables. These values are passed to the procedure at the time of calling the procedure. The stored procedure performs the specified tasks using these values.

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Following syntax is used to create a stored procedure.

Syntax:

```
CREATE PROCEDURE <procedure_name>
@parameter <data_type>
AS <sql_statement>
```

where,

data_type: specifies the system defined data type.

Following syntax is used to execute a stored procedure and pass values as input parameters.

Syntax:

```
EXECUTE <procedure_name> <parameters>
```

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Code Snippet 36 creates a stored procedure, **uspGetSales** with a parameter **territory** to accept the name of a territory and display the sales details and salesperson id for that territory. Then, the code executes the stored procedure with Northwest being passed as the input parameter.

Code Snippet 36:

```
CREATE PROCEDURE uspGetSales
@territory varchar(40)
AS
SELECT BusinessEntityID, B.SalesYTD, B.SalesLastYear
FROM Sales.SalesPerson A
JOIN Sales.SalesTerritory B
ON A.TerritoryID=B.TerritoryID
WHERE B.Name = @territory;

--Execute the stored procedure
EXEC uspGetSales 'Northwest'
```

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The output is shown in figure 10.11.

	BusinessEntityID	SalesYTD	SalesLastYear
1	280	7887186.7882	3298694.4938
2	283	7887186.7882	3298694.4938
3	284	7887186.7882	3298694.4938

Figure 10.11: Using Stored Procedure with Parameters

→ Output Parameters

Stored procedures occasionally need to return output back to the calling program. This transfer of data from the stored procedure to the calling program is performed using output parameters.

Output parameters are defined at the time of creation of the procedure. To specify an output parameter, the `OUTPUT` keyword is used while declaring the parameter. Also, the calling statement has to have a variable specified with the `OUTPUT` keyword to accept the output from the called procedure.

Who dares to teach must never cease to learn.

Following syntax is used to pass output parameters in a stored procedure and then, execute the stored procedure with the OUTPUT parameter specified.

Syntax:

```
EXECUTE <procedure_name> <parameters>
```

Code Snippet 37 creates a stored procedure, **uspGetTotalSales** with input parameter **@territory** to accept the name of a territory and output parameter **@sum** to display the sum of sales year to date in that territory.

Code Snippet 37:

```
CREATE PROCEDURE uspGetTotalSales
    @territory varchar(40), @sum int OUTPUT
AS
SELECT @sum= SUM(B.SalesYTD)
FROM Sales.SalesPersonA
JOIN Sales.SalesTerritoryB
ON A.TerritoryID=B.TerritoryID
WHERE B.Name = @territory
```

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Code Snippet 38 declares a variable `sumsales` to accept the output of the procedure `uspGetTotalSales`.

Code Snippet 38:

```
DECLARE @sumsales money;
EXEC uspGetTotalSales 'Northwest', @sum = @sum OUTPUT;
PRINT 'The year-to-date sales figure for this territory is ' +
convert(varchar(100), @sumsales);
GO
```

The code passes Northwest as the input to the `uspGetTotalSales` stored procedure and accepts the output in the variable `sumsales`. The output is printed using the `PRINT` command.

`OUTPUT` parameters have the following characteristics:

- The parameter cannot be of text and image data type.
- The calling statement must contain a variable to receive the return value.
- The variable can be used in subsequent Transact-SQL statements in the batch or the calling procedure.
- Output parameters can be cursor placeholders.

The `OUTPUT` clause returns information from each row on which the `INSERT`, `UPDATE`, and `DELETE` statements have been executed. This clause is useful to retrieve the value of an identity or computed column after an `INSERT` or `UPDATE` operation.



10.12.2 Using SSMS to Create Stored Procedures

You can also create a user-defined stored procedure using SSMS. The steps to perform this are as follows:

1. Launch **Object Explorer**.
2. In **Object Explorer**, connect to an instance of Database Engine.
3. After successfully connecting to the instance, expand that instance.
4. Expand **Databases** and then, expand the **AdventureWorks2012** database.
5. Expand **Programmability**, right-click **Stored Procedures**, and then, click **New Stored Procedure**.
6. On the **Query** menu, click **Specify Values for Template Parameters**. The **Specify Values for Template Parameters** dialog box is displayed as shown in figure 10.12.

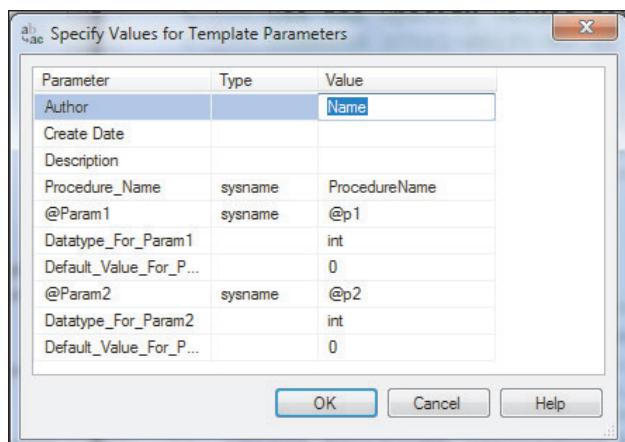


Figure 10.12: Specify Values for Template Parameters Dialog Box

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7. In the **Specify Values for Template Parameters** dialog box, enter the following values for the parameters as shown in table 10.2.

Parameter	Value
Author	Your name
Create Date	Today's date
Description	Returns year to sales data for a territory
Procedure_Name	uspGetTotals
@Param1	@territory
@Datatype_For_Param1	varchar(50)
Default_Value_For_Param1	NULL
@Param2	
@Datatype_For_Param2	
Default_Value_For_Param2	

Table 10.2: Parameter Values

8. After entering these details, click **OK**.
9. In the Query Editor, replace the **SELECT** statement with the following statement:

```
SELECT BusinessEntityID, B.SalesYTD, B.SalesLastYear
FROM Sales.SalesPerson A
JOIN Sales.SalesTerritory B
ON A.TerritoryID = B.TerritoryID
WHERE B.Name = @territory;
```

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

10. To test the syntax, on the **Query** menu, click **Parse**. If an error message is returned, compare the statements with the information and correct as needed.
11. To create the procedure, from the **Query** menu, click **Execute**. The procedure is created as an object in the database.
12. To see the procedure listed in **Object Explorer**, right-click **Stored Procedures** and select **Refresh**.

The procedure name will be displayed in the **Object Explorer** tree as shown in figure 10.13.

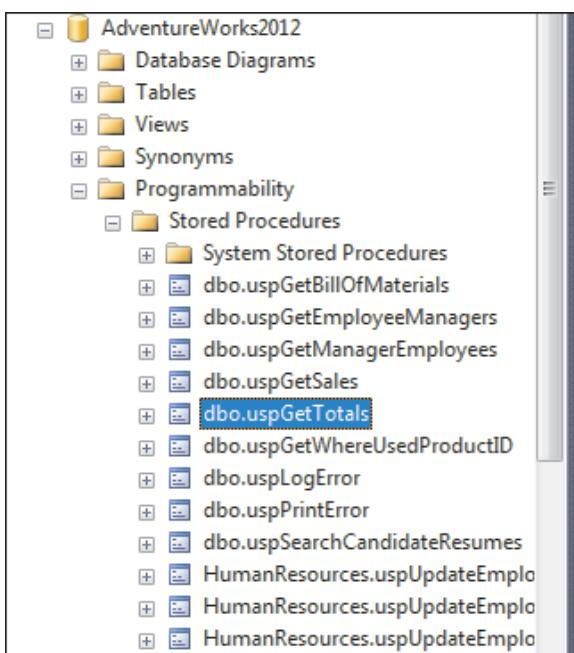


Figure 10.13: Stored Procedure Seen in Object Explorer

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13. To run the procedure, in **Object Explorer**, right-click the stored procedure name **uspGetTotals** and select **Execute Stored Procedure**.
14. In the **Execute Procedure** window, enter **Northwest** as the value for the parameter **@territory**.

Note - In SQL Server 2012, a stored procedure can be up to 250 MB in size. In other words, the bytes in source text of a stored procedure cannot exceed 250 MB.

10.13 Viewing Stored Procedure Definitions

The definition of a stored procedure can be viewed using the **sp_helptext** system stored procedure. To view the definition, you must specify the name of the stored procedure as the parameter when executing **sp_helptext**. This definition is in the form of Transact-SQL statements.

The Transact-SQL statements of the procedure definition include the **CREATE PROCEDURE** statement as well as the SQL statements that define the body of the procedure.

Following syntax is used to view the definition of a stored procedure.

Syntax:

```
sp_helptext '<procedure_name>'
```



Code Snippet 39 displays the definition of the stored procedure named **uspGetTotals**.

Code Snippet 39:

```
EXEC sp_helptext uspGetTotals
```

10.14 Modifying and Dropping Stored Procedures

The permissions associated with the stored procedure are lost when a stored procedure is re-created. However, when a stored procedure is altered, the permissions defined for the stored procedure remain the same even though the procedure definition is changed.

A procedure can be altered using the `ALTER PROCEDURE` statement.

Following syntax is used to modify a stored procedure.

Syntax:

```
ALTER PROCEDURE <procedure_name>
@parameter <data_type> [ OUTPUT ]
[ WITH { ENCRYPTION | RECOMPILE } ]
AS <sql_statement>
```

where,

`ENCRYPTION`: encrypts the stored procedure definition.

`RECOMPILE`: indicates that the procedure is compiled at run-time.

`sql_statement`: specifies the Transact-SQL statements to be included in the body of the procedure.

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Code Snippet 40 modifies the definition of the stored procedure named `uspGetTotals` to add a new column `CostYTD` to be retrieved from `Sales.SalesTerritory`.

Code Snippet 40:

```
ALTER PROCEDURE [dbo].[uspGetTotals]
    @territory varchar = 40
AS
    SELECT BusinessEntityID, B.SalesYTD, B.CostYTD, B.SalesLastYear
    FROM Sales.SalesPerson A
    JOIN Sales.SalesTerritory B
    ON A.TerritoryID=B.TerritoryID
    WHERE B.Name = @territory;
GO
```

Note - When you change the definition of a stored procedure, the dependent objects may fail when executed. This happens if the dependent objects are not updated to reflect the changes made to the stored procedure.

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

→ Guidelines for using ALTER PROCEDURE statement

Stored procedures are altered using the ALTER PROCEDURE statement. Following facts have to be considered while using the ALTER PROCEDURE statement:

- When a stored procedure is created using options such as the WITH ENCRYPTION option, these options should also be included in the ALTER PROCEDURE statement.
- The ALTER PROCEDURE statement alters a single procedure. When a stored procedure calls other stored procedures, the nested stored procedures are not affected by altering the calling procedure.
- The creators of the stored procedure, members of the sysadmin server role and members of the db_owner and db_ddladmin fixed database roles have the permission to execute the ALTER PROCEDURE statement.
- It is recommended that you do not modify system stored procedures. If you need to change the functionality of a system stored procedure, then create a user-defined system stored procedure by copying the statements from an existing stored procedure and modify this user-defined procedure.

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→ Dropping stored procedures

Stored procedures can be dropped if they are no longer needed. If another stored procedure calls a deleted procedure, an error message is displayed.

If a new procedure is created using the same name as well as the same parameters as the dropped procedure, all calls to the dropped procedure will be executed successfully. This is because they will now refer to the new procedure, which has the same name and parameters as the deleted procedure.

Before dropping a stored procedure, execute the `sp_depends` system stored procedure to determine which objects depend on the procedure.

A procedure is dropped using the `DROP PROCEDURE` statement.

Following syntax is used to drop a stored procedure.

Syntax:

```
DROP PROCEDURE <procedure_name>
```

Code Snippet 41 drops the stored procedure, `uspGetTotals`.

Code Snippet 41:

```
DROP PROCEDURE uspGetTotals
```

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10.15 Nested Stored Procedures

SQL Server 2012 enables stored procedures to be called inside other stored procedures. The called procedures can in turn call other procedures. This architecture of calling one procedure from another procedure is referred to as nested stored procedure architecture.

When a stored procedure calls another stored procedure, the level of nesting is said to be increased by one. Similarly, when a called procedure completes its execution and passes control back to the calling procedure, the level of nesting is said to be decreased by one. The maximum level of nesting supported by SQL Server 2012 is 32. If the level of nesting exceeds 32, the calling process fails. Also, note that if a stored procedure attempts to access more than 64 databases, or more than two databases in the nesting architecture, there will be an error.

Code Snippet 42 is used to create a stored procedure **NestedProcedure** that calls two other stored procedures that were created earlier through Code Snippets 34 and 36.

Code Snippet 42:

```
CREATE PROCEDURE NestedProcedure
AS
BEGIN
    EXEC uspGetCustTerritory
    EXEC uspGetSales 'France'
END
```

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When the procedure **NestedProcedure** is executed, this procedure in turn invokes the **uspGetCustTerritory** and **uspGetSales** stored procedures and passes the value France as the input parameter to the **uspGetSales** stored procedure.

Note - Although there can be a maximum of 32 levels of nesting, there is no limit as to the number of stored procedure that can be called from a given stored procedure.

10.15.1 @@NESTLEVEL Function

The level of nesting of the current procedure can be determined using the **@@NESTLEVEL** function. When the **@@NESTLEVEL** function is executed within a Transact-SQL string, the value returned is the current nesting level + 1.

If you use **sp_executesql** to execute the **@@NESTLEVEL** function, the value returned is the current nesting level + 2 (as another stored procedure, namely **sp_executesql**, gets added to the nesting chain).

Syntax:

```
@@NESTLEVEL
```

where,

@@NESTLEVEL: Is a function that returns an integer value specifying the level of nesting.

To avoid criticism, do nothing, say nothing, be nothing.

Session**Using Views, Stored Procedures, and Querying Metadata**

Code Snippet 43 creates and executes a procedure **Nest_Procedure** that executes the @@NESTLEVEL function to determine the level of nesting in three different scenarios.

Code Snippet 43:

```
CREATE PROCEDURE Nest_Procedure
AS
SELECT @@NESTLEVEL AS NestLevel;
EXECUTE ('SELECT @@NESTLEVEL AS [NestLevelWith Execute]');
EXECUTE sp_executesql N'SELECT @@NESTLEVEL AS [NestLevelWith sp_executesql]';
```

Code Snippet 44 executes the **Nest_Procedure** stored procedure.

Code Snippet 44:

```
EXECUTE Nest_Procedure
```

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Using Views, Stored Procedures, and Querying Metadata

Three outputs are displayed in figure 10.14 for the three different methods used to call the @@NESTLEVEL function.

NestLevel	
1	1

NestLevel With Execute	
1	2

NestLevel With sp_executesql	
1	3

Figure 10.14: Using @@NESTLEVEL

Note - The `sp_executesql` stored procedure can also be used to execute Transact-SQL statements.



10.16 Querying System MetaData

The properties of an object such as a table or a view are stored in special system tables. These properties are referred to as metadata. All SQL objects produce metadata. This metadata can be viewed using system views, which are predefined views of SQL Server.

There are over 230 different system views and these are automatically inserted into the user created database. These views are grouped into several different schemas.

→ System Catalog Views

These contain information about the catalog in a SQL Server system. A catalog is similar to an inventory of objects. These views contain a wide range of metadata. In earlier versions of SQL Server, users were required to query a large number of system tables, system views, and system functions. In SQL Server 2012, all user-accessible catalog metadata can easily be found by querying just the catalog views.

Code Snippet 45 retrieves a list of user tables and attributes from the system catalog view sys.tables.

Code Snippet 45:

```
SELECT name, object_id, type, type_desc  
FROM sys.tables;
```

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→ **Information Schema Views**

Users can query information schema views to return system metadata. These views are useful to third-party tools that may not be specific for SQL Server. Information schema views provide an internal, system table-independent view of the SQL Server metadata. Information schema views enable applications to work correctly although significant changes have been made to the underlying system tables.

Following points in table 10.3 will help to decide whether one should query SQL Server-specific system views or information schema views:

Information Schema Views	SQL Server System Views
They are stored in their own schema, INFORMATION_SCHEMA.	They appear in the sys schema.
They use standard terminology instead of SQL Server terms. For example, they use catalog instead of database and domain instead of user-defined data type.	They adhere to SQL Server terminology.
They may not expose all the metadata available to SQL Server's own catalog views. For example, sys.columns includes attributes for the identity property and computed column property, while INFORMATION_SCHEMA.columns does not.	They can expose all the metadata available to SQL Server's catalog views.

Table 10.3: Information Schema Views and SQL Server-specific System Views

Learning is not compulsory, but neither is survival.

Session**Using Views, Stored Procedures, and Querying Metadata**

Code Snippet 46 retrieves data from the INFORMATION_SCHEMA.TABLES view in the AdventureWorks2012 database:

Code Snippet 46:

```
SELECT TABLE_CATALOG, TABLE_SCHEMA, TABLE_NAME, TABLE_TYPE
FROM INFORMATION_SCHEMA.TABLES;
```

→ **System Metadata Functions**

In addition to views, SQL Server provides a number of built-in functions that return metadata to a query. These include scalar functions and table-valued functions, which can return information about system settings, session options, and a wide range of objects.

SQL Server metadata functions come in a variety of formats. Some appear similar to standard scalar functions, such as `ERROR_NUMBER()`. Others use special prefixes, such as `@@VERSION` or `$PARTITION`. Table 10.4 shows some common system metadata functions.

Function Name	Description	Example
<code>OBJECT_ID(<object_name>)</code>	Returns the object ID of a database object.	<code>OBJECT_ID('Sales.Customer')</code>
<code>OBJECT_NAME(<object_id>)</code>	Returns the name corresponding to an object ID.	<code>OBJECT_NAME(197575742)</code>
<code>@@ERROR</code>	Returns 0 if the last statement succeeded; otherwise returns the error number.	<code>@@ERROR</code>
<code>SERVERPROPERTY(<property >)</code>	Returns the value of the specified server property.	<code>SERVERPROPERTY('Collation')</code>

Table 10.4: Common System Metadata Functions

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Code Snippet 47 uses a SELECT statement to query a system metadata function.

Code Snippet 47:

```
SELECT SERVERPROPERTY ('EDITION') AS EditionName;
```

10.17 Querying Dynamic Management Objects

First introduced in SQL Server 2005, Dynamic Management Views (DMVs) and Dynamic Management Functions (DMFs) are dynamic management objects that return server and database state information. DMVs and DMFs are collectively referred to as dynamic management objects. They provide useful insight into the working of software and can be used for examining the state of SQL Server instance, troubleshooting, and performance tuning.

Both DMVs and DMFs return data in tabular format but the difference is that while a DMF normally accepts at least one parameter, a DMV does not accept parameters. SQL Server 2012 provides nearly 200 dynamic management objects. In order to query DMVs, it is required to have VIEW SERVER STATE or VIEW DATABASE STATE permission, depending on the scope of the DMV.



10.17.1 Categorizing and Querying DMVs

Table 10.5 lists the naming convention that helps organize the DMVs by function.

Naming Pattern	Description
db	database related
io	I/O statistics
Os	SQL Server Operating System Information
"tran"	transaction-related
"exec"	query execution-related metadata

Table 10.5: Organizing DMVs by Function

To query a dynamic management object, you use a `SELECT` statement as you would with any user-defined view or table-valued function. For example, Code Snippet 48 returns a list of current user connections from the `sys.dm_exec_sessions` view.

`sys.dm_exec_sessions` is a server-scoped DMV that displays information about all active user connections and internal tasks. This information includes login user, current session setting, client version, client program name, client login time, and more. The `sys.dm_exec_sessions` can be used to identify a specific session and find information about it.

Code Snippet 48:

```
SELECT session_id, login_time, program_name
FROM sys.dm_exec_sessions
WHERE login_name = 'sa' and is_user_process = 1;
```

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Here, `is_user_process` is a column in the view that determines if the session is a system session or not. A value of 1 indicates that it is not a system session but rather a user session. The `program_name` column determines the name of client program that initiated the session. The `login_time` column establishes the time when the session began. The output of Code Snippet 48 is shown in figure 10.15.

	session_id	login_time	program_name
1	51	2013-01-29 12:26:08.443	Microsoft SQL Server Management Studio
2	53	2013-01-29 12:26:20.247	Microsoft SQL Server Management Studio - Query

Figure 10.15: Querying the sys.dm_exec_sessions DMV

A wise man learns from the mistakes of others, a fool by his own.

10.18 Check Your Progress

1. Which of these statements about views are true?

a.	Views enable you to see and manipulate selected parts of a table.		
b.	Only columns from a table can be selected for a view, rows cannot be.		
c.	System views display information about the system or the machine.		
d.	Views have a maximum of 1024 columns.		
e.	When data in a view is changed, it is not reflected in the underlying table.		

(A)	a, c, d, e	(C)	a, b, d
(B)	a, c	(D)	All of these

2. You are creating a view **Supplier _ View** with **FirstName**, **LastName**, and **City** columns from the **Supplier _ Details** table. Which of the following code is violating the definition of a view?

(A)	<pre>CREATE VIEW Supplier_ View AS SELECT FirstName, LastName, City FROM Supplier_Details WHERE City IN('New York', 'Boston', 'Orlando')</pre>	(C)	<pre>CREATE VIEW Supplier_View AS SELECT FirstName, LastName, City FROM Supplier_Details ORDER BY FirstName</pre>
(B)	<pre>CREATE VIEW Supplier_ View AS SELECT TOP 100 FirstName, LastName, City FROM Supplier_Details WHERE FirstName LIKE 'A%' ORDER BY FirstName</pre>	(D)	<pre>CREATE VIEW Supplier_View AS SELECT TOP 100 FirstName, LastName, City FROM Supplier_Details</pre>

3. Which of these statements about CHECK OPTION and SCHEMABINDING options are true?

a.	The CHECK OPTION ensures entity integrity.
b.	The SCHEMABINDING option binds the view to the schema of the base table.
c.	When a row is modified, the WITH CHECK OPTION makes sure that the data remains visible through the view.
d.	SCHEMABINDING option ensures the base table cannot be modified in a way that would affect the view definition.
e.	SCHEMABINDING option cannot be used with ALTER VIEW statements.

(A)	a, b, c	(C)	b, c, d
(B)	b, c	(D)	c, d, e

4. You want to create a view **Account _ Details** with the SCHEMABINDING option. Which of the following code will achieve this objective?

(A)	CREATE VIEW Account_Details AS SELECT AccNo, City FROM dbo.Customer_Details WITH SCHEMABINDING	(C)	CREATE VIEW Account_Details WITH SCHEMABINDING AS SELECT AccNo, City FROM dbo.Customer_Details
(B)	CREATE VIEW Account_Details SCHEMABINDING AS SELECT AccNo, City FROM Customer_Details	(D)	CREATE VIEW Account_Details WITH SCHEMABINDING AS SELECT AccNo, City FROM Customer_Details

Session**Using Views, Stored Procedures, and Querying Metadata**

5. A table **Item _ Details** is created with **ItemCode**, **ItemName**, **Price**, and **Quantity** columns. The **ItemCode** column is defined as the PRIMARY KEY, **ItemName** is defined with UNIQUE and NOT NULL constraints, **Price** is defined with the NOT NULL constraint, and **Quantity** is defined with the NOT NULL constraint and having a default value specified. Which of the following views created using columns from the **Item _ Details** table can be used to insert records in the table?

(A)	<pre>CREATE VIEW ItemDetails AS SELECT ItemCode, ItemName, Price FROM Item_Details</pre>	(C)	<pre>CREATE VIEW ItemDetails AS SELECT ItemName, Price, Quantity FROM Item_Details</pre>
(B)	<pre>CREATE VIEW ItemDetails AS SELECT ItemCode, Price, Quantity FROM Item_Details</pre>	(D)	<pre>CREATE VIEW ItemDetails AS SELECT ItemCode, ItemName, Quantity FROM Item_Details</pre>

6. Which of these statements about stored procedures are true?

a.	A stored procedure is a group of Transact-SQL statements that act as a block of code used to perform a particular task.
b.	All system stored procedures are identified by the 'xp_' prefix.
c.	A distributed stored procedure is used in the management of distributed queries.
d.	Database Mail and SQL mail procedures are used to perform e-mail operations within SQL Server.
e.	User-defined stored procedures are also known as custom stored procedures.

(A)	a, d	(C)	a, c, d, e
(B)	b, c, e	(D)	d

10.18.1 Answers

1.	B
2.	C
3.	C
4.	B
5.	A
6.	C



- A view is a virtual table that is made up of selected columns from one or more tables and is created using the CREATE VIEW command in SQL Server.
- Users can manipulate the data in views, such as inserting into views, modifying the data in views, and deleting from views.
- A stored procedure is a group of Transact-SQL statements that act as a single block of code that performs a specific task.
- SQL Server supports various types of stored procedures, such as User-Defined Stored Procedures, Extended Stored Procedures, and System Stored Procedures.
- System stored procedures can be classified into different categories such as Catalog Stored Procedures, Security Stored Procedures, and Cursor Stored Procedures.
- Input and output parameters can be used with stored procedures to pass and receive data from stored procedures.
- The properties of an object such as a table or a view are stored in special system tables and are referred to as metadata.
- DMVs and DMFs are dynamic management objects that return server and database state information. DMVs and DMFs are collectively referred to as dynamic management objects.



1. In SQL Server 2012 Management Studio, locate the extended stored procedures defined under the master database and execute the following procedures in a query window:

```
sys.xp_readerrorlog  
sys.xp_getnetname  
sys.xp_fixeddrives
```

2. ShoezUnlimited is a trendy shoe store based in Miami. It stocks various kinds of footwear in its store and sells them for profits. ShoezUnlimited maintains the details of all products in an SQL Server 2012 database. The management wants their developer to make use of stored procedures for commonly performed tasks. Assuming that you are the developer, perform the following tasks:

Create the Shoes table having structure as shown in table 10.6 in the database, ShoezUnlimited.

Field Name	Data Type	Key Field	Description
ProductCode	varchar(5)	Primary Key	ProductCode that uniquely identifies each shoe
BrandName	varchar(30)		Brand name of the shoe
Category	varchar(30)		Category of the shoe, such as for example, sports shoe, casual wear, party wear, and so forth
UnitPrice	money		Price of the shoe in dollars
QtyOnHand	int		Quantity available

Table 10.6: Shoes Table

3. Add at least 5 records to the table. Ensure that the value of the column **QtyOnHand** is more than 20 for each of the shoes.
4. Write statements to create a stored procedure named **PriceIncrease** that will increment the **unitprice** of all shoes by 10 dollars.
5. Write statements to create a stored procedure **QtyOnHand** that will decrease the quantity on hand of specified brands by 25. The brand name should be supplied as input.
6. Execute the stored procedures **PriceIncrease** and **QtyOnHand**.

Session - 11

Indexes

Welcome to the Session, **Indexes**.

This session explains indexes and their performance. It also explains different types of indexes. Finally, the session identifies and describes the procedure to query performance data using indexes.

In this Session, you will learn to:

- Define and explain indexes
- Describe the performance of indexes
- Explain clustered indexes
- Explain nonclustered indexes
- Explain partitioning of data
- Explain the steps to display query performance data using indexes

11.1 Introduction

SQL Server 2012 makes use of indexes to find data when a query is processed. The SQL Server engine uses an index in the similar way as a student uses a book index. For example, consider that you need to find all references to `INSERT` statements in an SQL book. The immediate approach taken will be to scan each page of the book beginning from the starting page. You mark each time the word `INSERT` is found, until the end of the book is reached. This approach is time consuming and laborious. The second way is to use the index in the back of the book to find the page numbers for each occurrence of the `INSERT` statements. The second way produces the same results as the first, but by tremendously saving time.

When SQL Server has not defined any index for searching, then the process is similar to the first way in the example; the SQL engine needs to visit every row in a table. In database terminology, this behavior is called table scan, or just scan.

A table scan is not always troublesome, but it is sometimes unavoidable. However, as a table grows up to thousands and millions of rows and beyond, scans become slower and more expensive. In such cases, indexes are strongly recommended.

Creating or removing indexes from a database schema will not affect an application's code. Indexes operate in the backend with support of the database engine. Moreover, creating an appropriate index can significantly increase the performance of an application.

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11.1.1 Overview of Data Storage

A book contains pages, which contain paragraphs made up of sentences. Similarly, SQL Server 2012 stores data in storage units known as data pages. These pages contain data in the form of rows.

In SQL Server 2012, the size of each data page is 8 Kilo Bytes (KB). Thus, SQL Server databases have 128 data pages per Mega Byte (MB) of storage space.

A page begins with a 96-byte header, which stores system information about the page. This information includes the following:

- ➔ Page number
- ➔ Page type
- ➔ Amount of free space on the page
- ➔ Allocation unit ID of the object to which the page is allocated

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Figure 11.1 shows data storage structure of a data page.

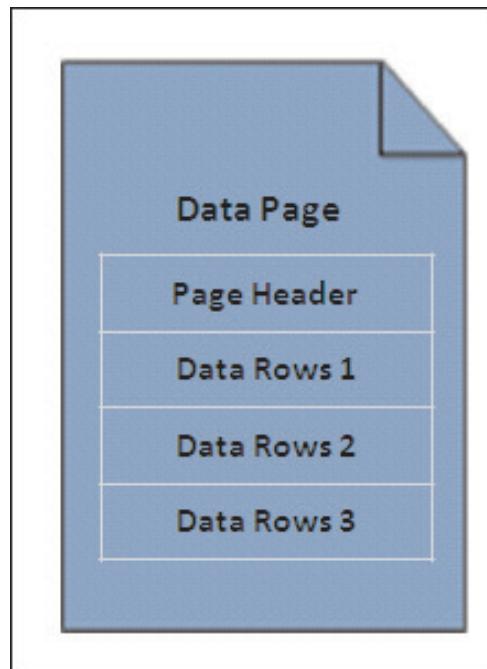


Figure 11.1: Data Storage

Note - A data page is the smallest unit of data storage. An allocation unit is a collection of data pages grouped together based on the page type. This grouping is done for efficient management of data.

You must do the things you think you cannot do.

11.1.2 Data Files

All input and output operations in the database are performed at the page level. This means that the database engine reads or writes data pages. A set of eight contiguous data pages is referred to as an extent.

SQL Server 2012 stores data pages in files known as data files. The space allotted to a data file is divided into sequentially numbered data pages. The numbering starts from zero as shown in figure 11.2.

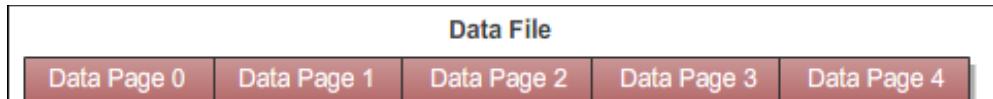


Figure 11.2: Data Files

There are three types of data files in SQL Server 2012. These are as follows:

→ **Primary Data Files**

A primary data file is automatically created at the time of creation of the database. This file has references to all other files in the database. The recommended file extension for primary data files is .mdf.

→ **Secondary Data Files**

Secondary data files are optional in a database and can be created to segregate database objects such as tables, views, and procedures. The recommended file extension for secondary data files is .ndf.

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→ Log Files

Log files contain information about modifications carried out in the database. This information is useful in recovery of data in contingencies such as sudden power failure or the need to shift the database to a different server. There is at least one log file for each database. The recommended file extension for log files is .ldf.

11.1.3 Requirement for Indexes

To facilitate quick retrieval of data from a database, SQL Server 2012 provides the indexing feature. Similar to an index in a book, an index in SQL Server 2012 database contains information that allows you to find specific data without scanning through the entire table as shown in figure 11.3.

Index			
A			
Adapter	1	Border	19
Aggregate	10	Bullet	58
Analysis	13		
Average	23		C
		Consistency	20
B		Connect	22
Board	17	Communication	24
Brilliant	18	Character	30

Figure 11.3: Requirement for Indexes



11.1.4 Indexes

In a table, records are stored in the order in which they are entered. Their storage in the database is unsorted. When data is to be retrieved from such tables, the entire table needs to be scanned. This slows down the query retrieval process. To speed up query retrieval, indexes need to be created.

When an index is created on a table, the index creates an order for the data rows or records in the table as shown in figure 11.4. This assists in faster location and retrieval of data during searches.

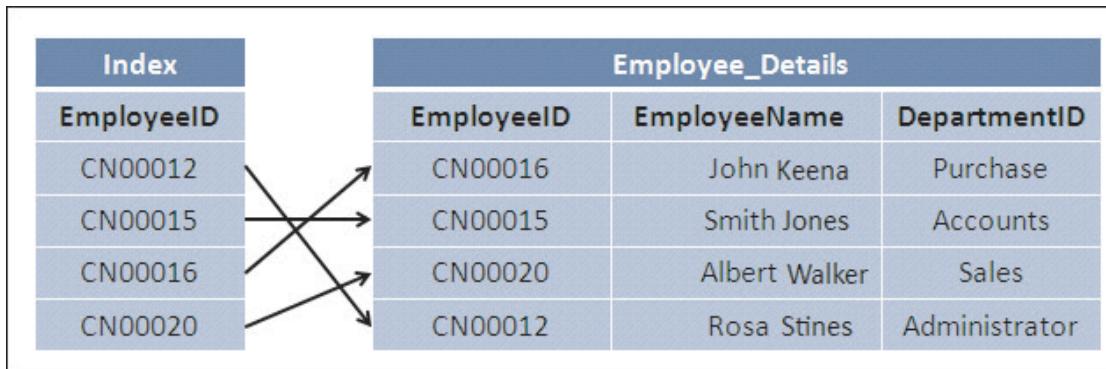


Figure 11.4: Indexes

Note - Multiple indexes can be created on a single table.

Indexes are automatically created when PRIMARY KEY and UNIQUE constraints are defined on a table. Indexes reduce disk I/O operations and consume fewer system resources.

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The CREATE INDEX statement is used to create an index. Following is the syntax for this statement.

Syntax:

```
CREATE INDEX <index_name> ON <table_name> (<column_name>)
```

where,

`index_name`: specifies the name of the index.

`table_name`: specifies the name of the table.

`column_name`: specifies the name of the column.

Code Snippet 1 creates an index, `IX_Country` on the `Country` column in the `Customer_Details` table.

Code Snippet 1:

```
USE CUST_DB  
CREATE INDEX IX_Country ON Customer_Details(Country);  
GO
```

*Woe to him who teaches men faster
than they can learn.*

Figure 11.5 shows the indexed table of **Customer_Details**.

Customer_Details				Index
CustID	AccNo	AccName	Country	IX_Country
01	CN001	John Keena	Spain	Germany
02	CN020	Smith Jones	Russia	London
03	CN011	Albert Walker	Germany	Russia
04	CN021	Rosa Stines	London	Spain

Figure 11.5: Indexed Table of Customer_Details

Indexes point to the location of a row on a data page instead of searching through the table.

Consider the following facts and guidelines about indexes:

- Indexes increase the speed of queries that join tables or perform sorting operations.
- Indexes implement the uniqueness of rows if defined when you create an index.
- Indexes are created and maintained in ascending or descending order.

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11.1.5 Scenario

In a telephone directory, where a large amount of data is stored and is frequently accessed, the storage of data is done in an alphabetical order. If such data were unsorted, it would be nearly impossible to search for a specific telephone number.

Similarly, in a database table having a large number of records that are frequently accessed, the data is to be sorted for fast retrieval. When an index is created on the table, the index either physically or logically sorts the records. Thus, searching for a specific record becomes faster and there is less strain on system resources.

11.1.6 Accessing Data Group-wise

Indexes are useful when data needs to be accessed group-wise. For example, you want to make modifications to the conveyance allowance for all employees based on the department they work in. Here, you wish to make the changes for all employees in one department before moving on to employees in another department. In this case, an index can be created as shown in figure 11.6 on the **Department** column before accessing the records.

This index will create logical chunks of data rows based on the department. This again will limit the amount of data actually scanned during query retrieval.



Hence, retrieval will be faster and there will be less strain on system resources.

Department Name	Employee Name
Marketing	Jenny Woods
Marketing	Merry Thomas
Marketing	John Updeeke
Marketing	Robert Williamson
Sales	Smith Gordon
Sales	Albert Wang

Figure 11.6: Accessing Data Group-wise

11.2 Index Architecture

In SQL Server 2012, data in the database can be stored either in a sorted manner or at random. If data is stored in a sorted manner, the data is said to be present in a clustered structure. If it is stored at random, it is said to be present in a heap structure.

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Figure 11.7 shows an example demonstrating index architecture.

Employee_Details		
EmpID	EmpName	DeptID
CN00020	Rosa Stevens	BN0001
CN00018	John Updeeke	BN0020
CN00019	Smith Gordon	BN0021
CN00012	Robert Tyson	BN0011

Heap Structure

Employee_Details		
EmpID	EmpName	DeptID
CN00012	Robert Tyson	BN0011
CN00018	John Updeeke	BN0020
CN00019	Smith Gordon	BN0021
CN00020	Rosa Stevens	BN0001

Clustered Structure

Figure 11.7: Index Architecture

*Real generosity towards the future lies
in giving all to the present.*

11.2.1 B-Tree

In SQL Server, all indexes are structured in the form of B-Trees. A B-Tree structure can be visualized as an inverted tree with the root right at the top, splitting into branches and then, into leaves right at the bottom as shown in figure 11.8.

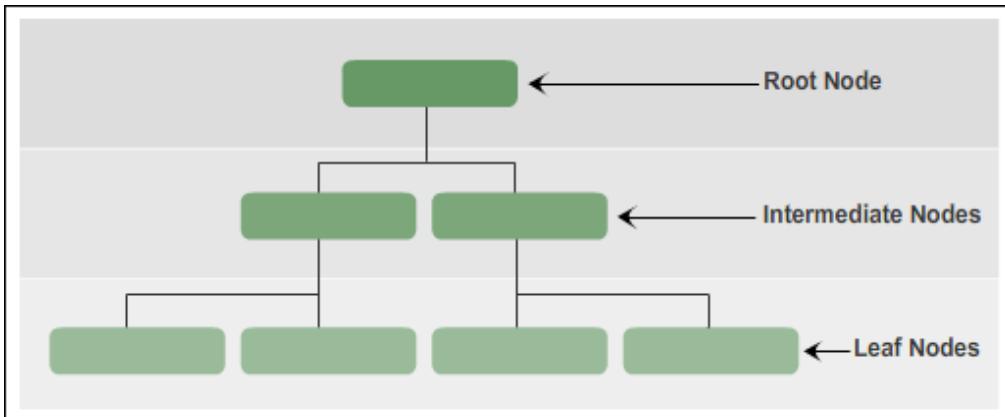


Figure 11.8: B-Tree

In a B-Tree structure, there is a single root node at the top. This node then branches out into the next level, known as the first intermediate level. The nodes at the first intermediate level can branch out further. This branching can continue into multiple intermediate levels and then, finally the leaf level. The nodes at the leaf level are known as the leaf nodes.

Note - A B-Tree index traverses from top to bottom by using pointers.

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11.2.2 Index B-Tree Structure

In the B-Tree structure of an index, the root node consists of an index page. This index page contains pointers that point to the index pages present in the first intermediate level. These index pages in turn point to the index pages present in the next intermediate level. There can be multiple intermediate levels in an index B-Tree. The leaf nodes of the index B-Tree have either data pages containing data rows or index pages containing index rows that point to data rows as shown in figure 11.9.

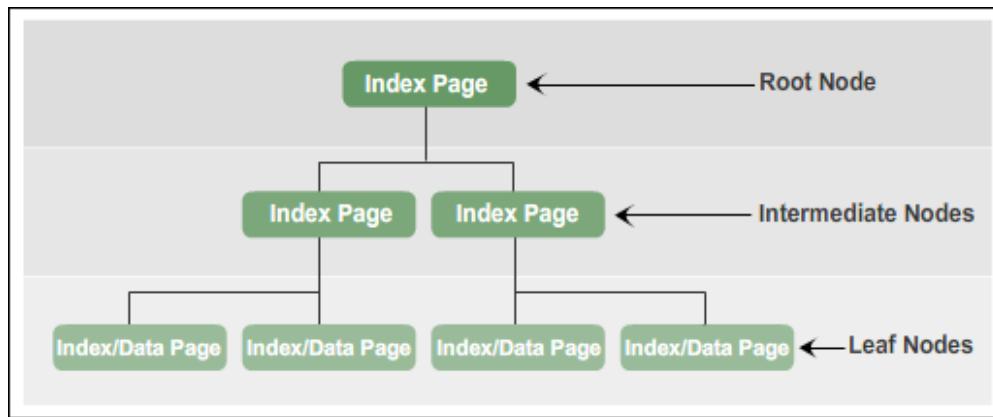


Figure 11.9: Index B-Tree Structure



Different types of nodes are as follows:

- **Root Node** - Contains an index page with pointers pointing to index pages at the first intermediate level.
- **Intermediate Nodes** - Contain index pages with pointers pointing either to index pages at the next intermediate level or to index or data pages at the leaf level.
- **Leaf Nodes** - Contain either data pages or index pages that point to data pages.

Note - A data page containing index entries is called an index page.

11.2.3 Heap Structures

In a heap structure, the data pages and records are not arranged in sorted order. The only connection between the data pages is the information recorded in the Index Allocation Map (IAM) pages.

In SQL Server 2012, IAM pages are used to scan through a heap structure. IAM pages map extents that are used by an allocation unit in a part of a database file.

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A heap can be read by scanning the IAM pages to look for the extents that contain the pages for that heap as shown in figure 11.10.

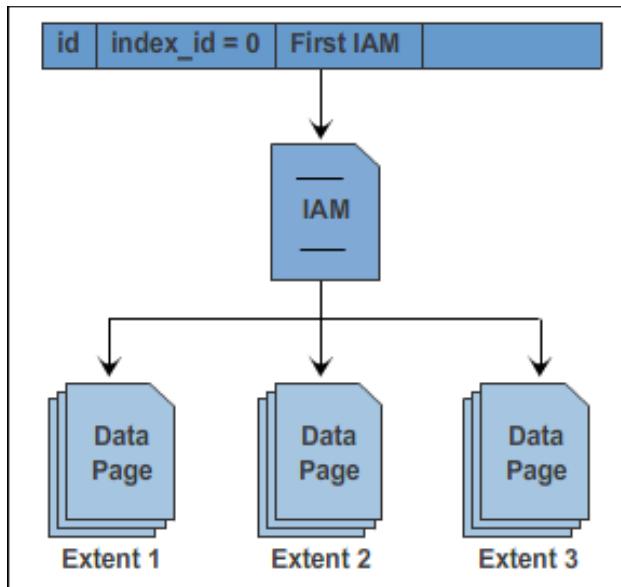


Figure 11.10: Heap Structures

Note - If an allocation unit contains extents from more than one file, there will be multiple IAM pages linked together in an IAM chain to map these extents.

Knowledge is not enough; we must apply. Willing is not enough; we must do.

11.2.4 Partitioning of Heap Structures

A table can be logically divided into smaller groups of rows. This division is referred to as partitioning. Tables are partitioned in order to carry out maintenance operations more efficiently. By default, a table has a single partition.

When partitions are created in a table with a heap structure, each partition will contain data in an individual heap structure. For example, if a heap has three partitions, then there are three heap structures present, one in each partition as shown in figure 11.11.

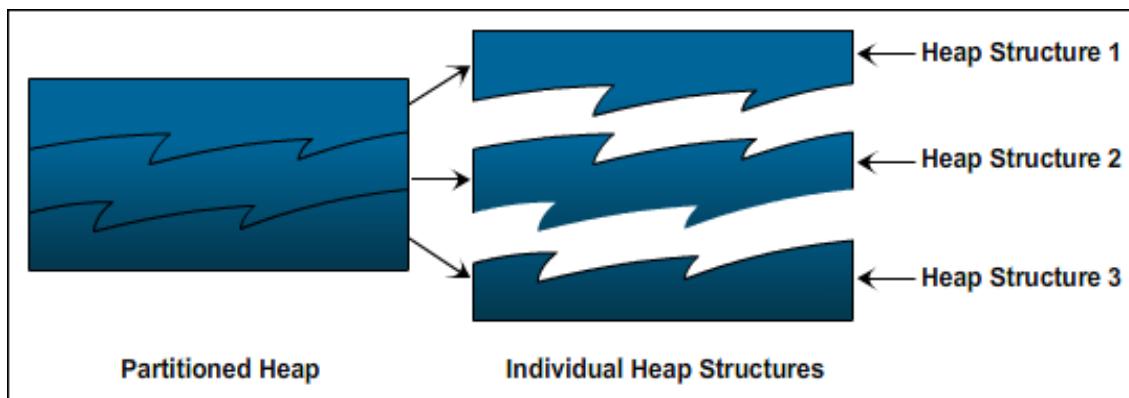


Figure 11.11: Partitioning of Heap Structure

11.2.5 Clustered Index Structures

A clustered index causes records to be physically stored in a sorted or sequential order. A clustered index determines the actual order in which data is stored in the database. Hence, you can create only one clustered index in a table.

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Uniqueness of a value in a clustered index is maintained explicitly using the `UNIQUE` keyword or implicitly using an internal unique identifier as shown in figure 11.12.

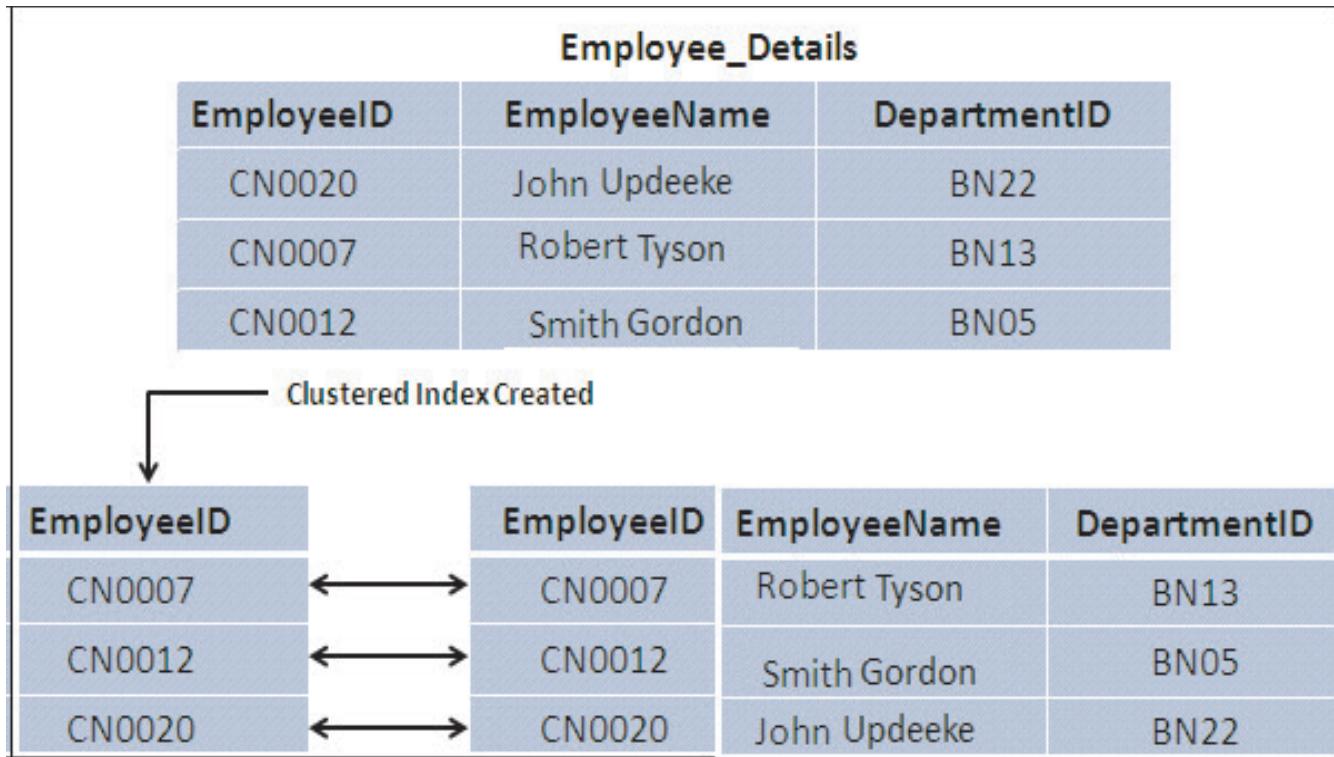


Figure 11.12: Clustered Indexes



11.2.6 Creating Clustered Index

A clustered index causes records to be physically stored in a sorted or sequential order. Thus, a clustered index determines the actual order in which data is stored in the database. Hence, you can create only one clustered index in a table.

Clustered index is created using the `CREATE INDEX` statement with the `CLUSTERED` keyword. The following syntax creates a clustered index on a specified table.

Syntax:

```
CREATE CLUSTERED INDEX index_name ON <table_name> (column_name)
```

where,

`CLUSTERED`: Specifies that a clustered index is created.

Code Snippet 2 creates a clustered index, `IX_CustID` on the `CustID` column in `Customer_Details` table.

Code Snippet 2:

```
USE CUST_DB  
CREATE CLUSTERED INDEX IX_CustID ON Customer_Details (CustID)  
GO
```

Note - Before you create a clustered index, you need to make sure the free space in your system is at least 1.2 times the amount of data in the table.

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11.2.7 Accessing Data with a Clustered Index

A clustered index can be created on a table using a column without duplicate values. This index reorganizes the records in the sequential order of the values in the index column.

Clustered indexes are used to locate a single row or a range of rows. Starting from the first page of the index, the search value is checked against each key value on the page. When the matching key value is found, the database engine moves to the page indicated by that value as shown in figure 11.13. The desired row or range of rows is then accessed.

Clustered indexes are useful for columns that are searched frequently for key values or are accessed in sorted order.

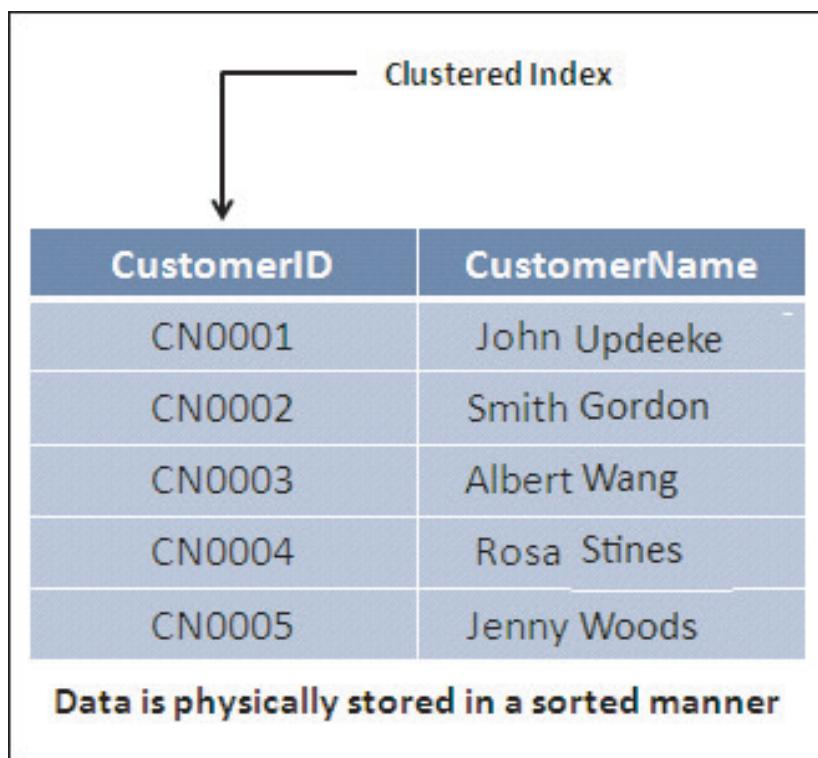


Figure 11.13: Accessing Data with a Clustered Index

*Don't just learn the tricks of the trade,
learn the trade.*

A clustered index is automatically created on a table when a primary key is defined on the table. In a table without a primary key column, a clustered index should ideally be defined on:

- Key columns that are searched on extensively.
- Columns used in queries that return large resultsets.
- Columns having unique data.
- Columns used in table join.

Note - Two or more tables can be logically joined through columns that are common to the tables. Data can then be retrieved from these tables as if they were a single table.

11.2.8 Nonclustered Index Structures

A nonclustered index is defined on a table that has data in either a clustered structure or a heap. Nonclustered index will be the default type if an index is not defined on a table. Each index row in the nonclustered index contains a nonclustered key value and a row locator. This row locator points to the data row corresponding to the key value in the table.

Nonclustered indexes have a similar B-Tree structure as clustered indexes but with the following differences:

- The data rows of the table are not physically stored in the order defined by their nonclustered keys.
- In a nonclustered index structure, the leaf level contains index rows.

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Figure 11.14 shows a nonclustered index structure.

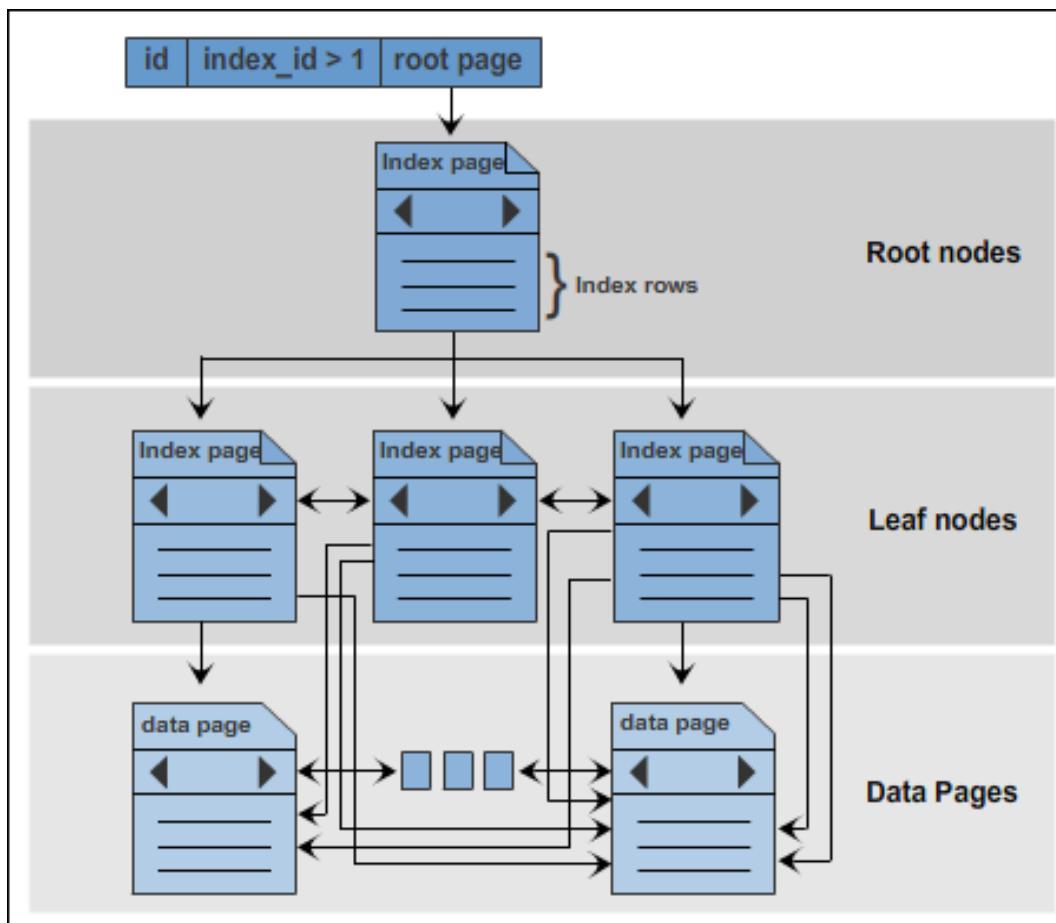


Figure 11.14: Nonclustered Index Structure

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Nonclustered indexes are useful when you require multiple ways to search data. Some facts and guidelines to be considered before creating a nonclustered index are as follows:

- When a clustered index is re-created or the `DROP – EXISTING` option is used, SQL Server rebuilds the existing nonclustered indexes.
- A table can have up to 999 nonclustered indexes.
- Create clustered index before creating a nonclustered index.

Following syntax creates a nonclustered index.

Syntax:

```
CREATE NONCLUSTERED INDEX<index_name> ON<table_name>(column_name)
```

where,

`NONCLUSTERED`: specifies that a nonclustered index is created.

Code Snippet 3 creates a nonclustered index `IX_State` on the `State` column in `Customer_Details` table.

Code Snippet 3:

```
USE CUST_DB  
CREATE NONCLUSTERED INDEX IX_State ON Customer_Details(State)  
GO
```

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11.2.9 Column Store Index

Column Store Index is a new feature in SQL Server 2012. It enhances performance of data warehouse queries extensively. The regular indexes or heaps of older SQL Servers stored data in B-Tree structure row-wise, but the column store index in SQL Server 2012 stores data column-wise. Since the data transfer rate is slow in database servers, so column store index uses compression aggressively to reduce the disk I/O needed to serve the query request.

The B-Tree and heap stores data row-wise, which means data from all the columns of a row are stored together contiguously on the same page.

Practice is the best of all instructors.

For example, if there is a table with ten columns (C1 to C10), the data of all the ten columns from each row gets stored together contiguously on the same page as shown in figure 11.15.

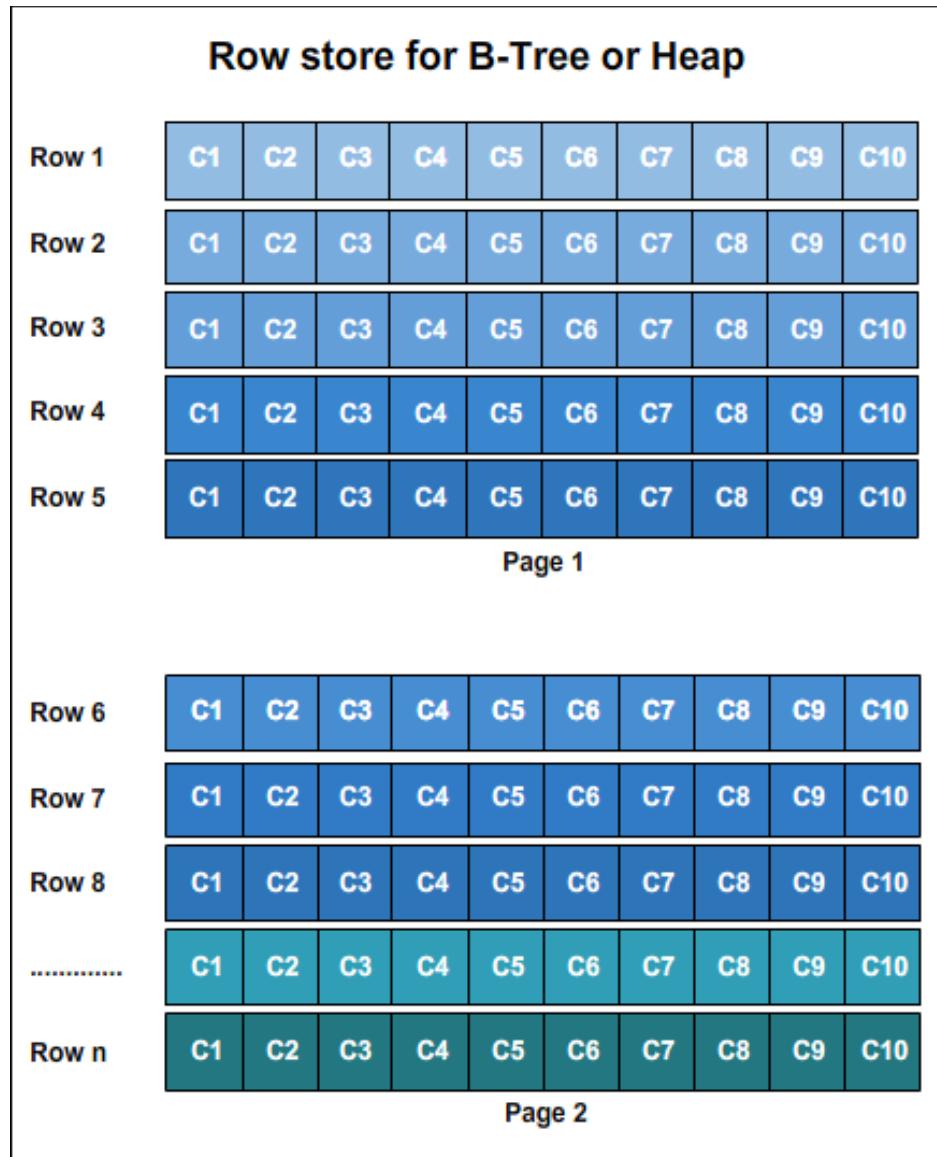


Figure 11.15: B-Tree Index

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When column store index is created, the data is stored column-wise, which means data of each individual column from each rows is stored together on same page.

For example, the data of column C1 of all the rows gets stored together on one page and the data for column C2 of all the rows gets stored on another page and so on as shown in figure 11.16.

Column Store Index										
Row 1	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Row 2	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Row 3	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Row 4	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Row 5	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Row 6	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Row 7	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Row 8	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
.....	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Row n	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	Page 1	Page 2	Page 3	Page 4	Page 5	Page 6	Page 7	Page 8	Page 9	Page 10

Figure 11.16: Column Store Index

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Following is the syntax to create a column store index:

Syntax:

```
CREATE [ NONCLUSTERED ] COLUMNSTORE INDEX index_name ON <object> ( column  
[ ,...n ] )  
[ WITH ( <column_index_option> [ ,...n ] ) ]  
ON
```

Assume that a table named **ResellerSalesPtnd** has been created in AdventureWorks2012 database.

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Code Snippet 4 demonstrates how to create a column store index on this table.

Code Snippet 4:

```
CREATE NONCLUSTERED COLUMNSTORE INDEX [csindx_ResellerSalesPtnd]
ON [ResellerSalesPtnd]
(
    [ProductKey],
    [OrderDateKey],
    [DueDateKey],
    [ShipDateKey],
    [CustomerKey],
    [EmployeeKey],
    [PromotionKey],
    [CurrencyKey],
    [SalesTerritoryKey],
    [SalesOrderNumber],
    [SalesOrderLineNumber],
    [RevisionNumber],
    [OrderQuantity],
    [UnitPrice],
    [ExtendedAmount],
    [UnitPriceDiscountPct],
    [DiscountAmount],
    [ProductStandardCost],
    [TotalProductCost],
    [SalesAmount],
    [TaxAmt],
    [Freight],
    [CarrierTrackingNumber],
    [CustomerPONumber],
    [OrderDate],
    [DueDate],
    [ShipDate]
);
```

Note - COLUMNSTORE INDEX works only on enterprise edition of SQL Server 2012.

11.2.10 Dropping an Index

On dropping a clustered index, the rows in the leaf level of the clustered index are copied to a heap. All the nonclustered indexes on the table should then point to the heap in which the data is stored. This is done by rebuilding nonclustered indexes when the clustered index is dropped. Thus, dropping the clustered index is a time-consuming process. Therefore, while dropping all indexes on a table, you must first drop the nonclustered indexes first and then, the clustered index.

SQL Server 2012 can drop the clustered index and move the heap (unordered table) into another filegroup or a partition scheme using the MOVE TO option.

- This option is not valid for nonclustered indexes.
- The partition scheme or filegroup specified in the MOVE TO clause must already exist.
- The table will be located in the same partition scheme or filegroup of the dropped clustered index.

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Following is the syntax to drop a clustered index.

Syntax:

```
DROP INDEX <index_name> ON <table_name>
[ WITH ( MOVE TO { <partition_scheme_name> ( <column_name> )
| <filegroup_name>
| 'default'
} )
]
```

where,

index_name: specifies the name of the index.

partition_scheme_name: specifies the name of the partition scheme.

filegroup_name: specifies the name of the filegroup to store the partitions.

default: specifies the default location to store the resulting table.



Code Snippet 5 drops the index **IX_SuppID** created on the **SuppID** column of the **Supplier_Details** table.

Code Snippet 5:

```
DROP INDEX IX_SuppID ON Supplier_Details  
WITH (MOVE TO 'default')
```

The data in the resulting **Supplier_Details** table is moved to the default location.

Code Snippet 6 drops the index **IX_SuppID** created on the **SuppID** column of the **Supplier_Details** table.

Code Snippet 6:

```
DROP INDEX IX_SuppID ON Supplier_Details  
WITH (MOVE TO FGCountry)
```

The data in the resulting **Supplier_Details** table is moved to the **FGCountry** filegroup.

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11.2.11 Difference Between Clustered and Nonclustered Indexes

Clustered and nonclustered indexes are different in terms of their architecture and their usefulness in query executions. Table 11.1 highlights the differences between clustered and nonclustered indexes.

Clustered Indexes	Nonclustered Indexes
Used for queries that return large resultsets	Used for queries that do not return large resultsets
Only one clustered index can be created on a table	Multiple nonclustered indexes can be created on a table
The data is stored in a sorted manner on the clustered key	The data is not stored in a sorted manner on the nonclustered key
The leaf nodes of a clustered index contain the data pages	The leaf nodes of a nonclustered index contain index pages

Table 11.1: Differences Between Clustered and Nonclustered Indexes

It is hard to fail, but it is worse never to have tried to succeed.

11.2.12 XML Indexes

The `xml` data type is used to store XML documents and fragments as shown in figure 11.17. An XML fragment is an XML instance that has a single top-level element missing.

Due to the large size of XML columns, queries that search within these columns can be slow. You can speed up these queries by creating an XML index on each column. An XML index can be a clustered or a nonclustered index. Each table can have up to 249 XML indexes.

xml data		
	DocID	DocumentStore
▶	1	<Document Name="Poem"><AuthorName>Bruce...</AuthorName><Content>The&...</Content>
	2	<Document Name="Code"><AuthorName>Hammu...</AuthorName><Content>SELECT * FROM ...</Content>
	3	<Document Name="Jack and Jill"><AuthorName>...</AuthorName><Content>Jack and Jill went up the hill to...</Content>

Figure 11.17: XML Data Type

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Note - XML is a plain-text, Unicode-based language that provides mechanisms for describing document structures using markup tags. For example, consider an organization having the details of the employees stored in XML document. The information per employee is stored in the following form:

```
<Employees>
<Name>John</Name>
<Age>34</Age>
<Salary>500000</Salary>
</Employees>
```

Here, `<Employees>` is the root node and `<Name>`, `<Age>`, and `<Salary>` are the child nodes.

11.2.13 Types of XML Indexes

XML indexes can be created on a table only if there is a clustered index based on the primary key of the table. This primary key cannot exceed 15 columns.

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The different types of XML indexes are as follows:

- **Primary XML Indexes** - The process of carrying out queries within an XML column can sometimes be slow. A primary XML index is created on each XML column to speed up these queries. It is a special index that shreds the XML data to store information. Following is the syntax to create a primary XML index.

Syntax:

```
CREATE PRIMARY XML INDEX index_name ON <table_name> (column_name)
```

Code Snippet 7 creates a primary XML index on the CatalogDescription column in the Production.ProductModel table.

Code Snippet 7:

```
USE AdventureWorks2012;
CREATE PRIMARY XML INDEX PXML_ProductModel_CatalogDescription
    ON Production.ProductModel (CatalogDescription);
GO
```

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- **Secondary XML Indexes** - Secondary XML indexes are specialized XML indexes that help with specific XML queries. The features of secondary XML indexes are as follows:

- Searching for values anywhere in the XML document.
- Retrieving particular object properties from within an XML document.

Secondary XML indexes can only be created on columns that already have a primary XML index.

Code Snippet 8 demonstrates how to create a secondary XML index on the CatalogDescription column in the Production.ProductModel table.

Code Snippet 8:

```
USE AdventureWorks2012;
CREATE XML INDEX IXML_ProductModel_CatalogDescription_Path
    ON Production.ProductModel (CatalogDescription)
    USING XML INDEX PXML_ProductModel_CatalogDescription FOR PATH ;
GO
```

*The future depends on what we do in
the present.*

- **Selective XML Indexes (SXI)** – This is a new type of XML index introduced by SQL Server 2012. The features of this new index is to improve querying performance over the data stored as XML in SQL Server, allows faster indexing of large XML data workloads, and improves scalability by reducing storage costs of the index. Following is the syntax to create selective XML index.

Syntax:

```
CREATE SELECTIVE XML INDEX index_name ON <table_name> (column_name)
```

Following is an XML document in a table of approximately 500,000 rows.

```
<book>
    <created>2004-03-01</created>
    <authors>Various</authors>
    <subjects>
        <subject>English wit and humor -- Periodicals</subject>
        <subject>AP</subject>
    </subjects>
    <title>Punch, or the London Charivari, Volume 156, April 2, 1919</title>
    <id>etext11617</id>
</book>
```

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Code Snippet 9 demonstrates how to create a Selective XML index on the **BookDetails** column in the **BooksBilling** table.

Code Snippet 9:

```
USE CUST_DB
CREATE SELECTIVE XML INDEX SXI_index
ON BooksBilling(BookDetails)
FOR
(
    pathTitle = '/book/title/text()' AS XQUERY 'xs:string',
    pathAuthors = '/book/authors' AS XQUERY 'node()',
    pathId = '/book/id' AS SQL NVARCHAR(100)
)
GO
```

Note - SELECTIVE XML INDEX will work only in enterprise edition of SQL Server 2012.

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PROFESSIONAL**



11.2.14 Modifying an XML Index

An XML index, primary or secondary, can be modified using the ALTER INDEX statement.

Syntax:

```
ALTER INDEX<xml_index_name> ON<table_name> REBUILD
```

where,

xml_index_name: specifies the name of the XML index.

Code Snippet 10 rebuilds the primary XML index **PXML_DocumentStore** created on the **XMLDocument** table.

Code Snippet 10:

```
ALTER INDEX PXML_DocumentStore ON XMLDocument REBUILD
```

11.2.15 Removing an XML Index

Following is the syntax to remove an XML index using the DROP INDEX statement.

Syntax:

```
DROP INDEX<xml_index_name> ON<table_name>
```

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Code Snippet 11 removes the primary XML index **PXML_DocumentStore** created on the **XMLDocument** table.

Code Snippet 11:

```
DROP INDEX PXML_DocumentStore ON XMLDocument
```

11.3 Allocation Units

A heap or a clustered index structure contains data pages in one or more allocation units. An allocation unit is a collection of pages and is used to manage data based on their page type. The types of allocation units that are used to manage data in tables and indexes are as follows:

→ **IN_ROW_DATA**

It is used to manage data or index rows that contain all types of data except large object (LOB) data.

→ **LOB_DATA**

It is used to manage large object data, which is stored in one or more of the following data types: varbinary(max), varchar(max), and xml.

→ **ROW_OVERFLOW_DATA**

It is used to manage data of variable length, which is stored in varchar, nvarchar, varbinary, or sql_variant columns.

*Action may not always bring happiness,
but there is no happiness without
action.*

Figure 11.18 shows the allocation units.

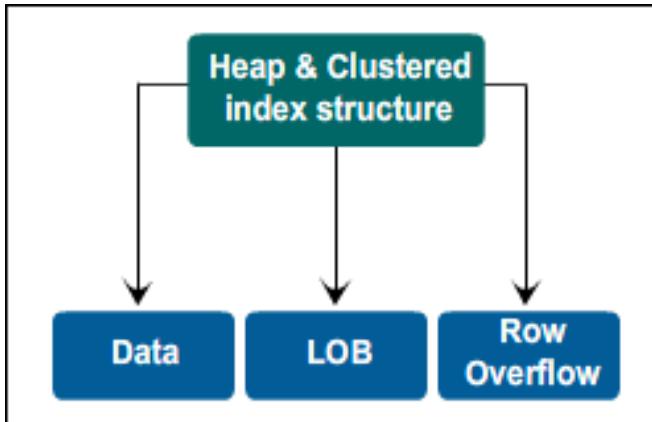


Figure 11.18: Allocation Units

Note - A heap can have only one allocation unit of each type in a particular partition of a table.

11.4 Partitioning

Partitioning divides data into subsets. This makes large tables or indexes more manageable. Partitioning enables you to access data quickly and efficiently. Maintenance operations on subsets of data are performed more efficiently because they target only the required subset of data instead of the entire table.

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By default, a table or an index has only one partition that contains all the data or index pages. When a table or index uses multiple partitions, the data is partitioned horizontally into groups of rows as shown in figure 11.19.

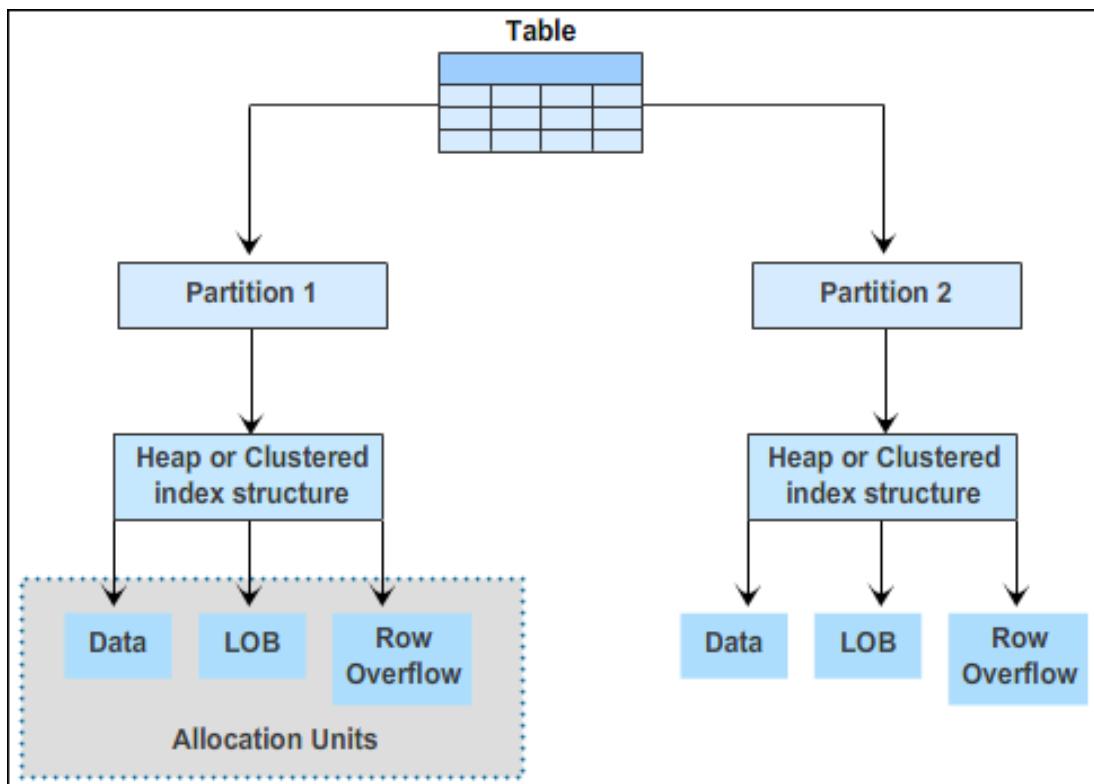


Figure 11.19: Partitioning



11.4.1 The sys.partitions View

The `sys.partitions` view is a system view that contains the complete information about the different partitions of all the tables and indexes in the database.

Table 11.2 shows the different columns of the `sys.partitions` view along with their data types and descriptions:

Column Name	Data Type	Description
<code>partition_id</code>	<code>bigint</code>	Contains the id of the partition and is unique within a database.
<code>object_id</code>	<code>int</code>	Contains the id of the object to which the partition belongs.
<code>index_id</code>	<code>int</code>	Contains the id of the index to which the partition belongs.
<code>partition_number</code>	<code>int</code>	Contains the partition number within the index or heap.
<code>hobt_id</code>	<code>bigint</code>	Contains the id of the data heap or B-Tree that contains the rows for the partition.
<code>rows</code>	<code>bigint</code>	States the approximate number of rows in the partition.

Table 11.2: Columns of `sys.partitions` View and Data Types

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11.4.2 The index_id Column

The `index_id` column contains the id of the index to which the partition belongs. The `sys.partitions` catalog view returns a row for each partition in a table or index. The values of `index_id` column are unique within the table in which the partition is created. The data type of the `index_id` column is `int`.

Following are the various values of the `index_id` column:

- The `index_id` value for a heap is 0.
- The `index_id` value for a clustered index is 1.
- The `index_id` value for a nonclustered index is greater than 1.
- The `index_id` value for large objects is greater than 250.

First say to yourself what you would be; and then do what you have to do.

Figure 11.20 shows the index_id column in the sys.partitions view.

	partition_id	object_id	index_id	partition_number	hobt_id	rows
1	196608	3	1	1	196608	1779
2	327680	5	1	1	327680	332
3	458752	7	1	1	458752	379
4	524288	8	0	1	524288	2
5	281474977103872	6	1	1	281474977103872	0
6	281474977300480	9	1	1	281474977300480	0
7	281474977824768	17	1	1	281474977824768	0
8	281474977890304	18	1	1	281474977890304	0
9	281474977955840	19	1	1	281474977955840	0
10	281474978021376	20	1	1	281474978021376	2

Figure 11.20: Index_id Column

11.5 Finding Rows

SQL Server uses catalog views to find rows when an index is not created on a table. It uses the sys.indexes view to find the IAM page. This IAM page contains a list of all pages of a specific table through which SQL Server can read all data pages.

When the sys.indexes view is used, the query optimizer checks all rows in a table and extracts only those rows that are referenced in the query as shown in figure 11.21. This scan generates many I/O operations and utilizes many resources.

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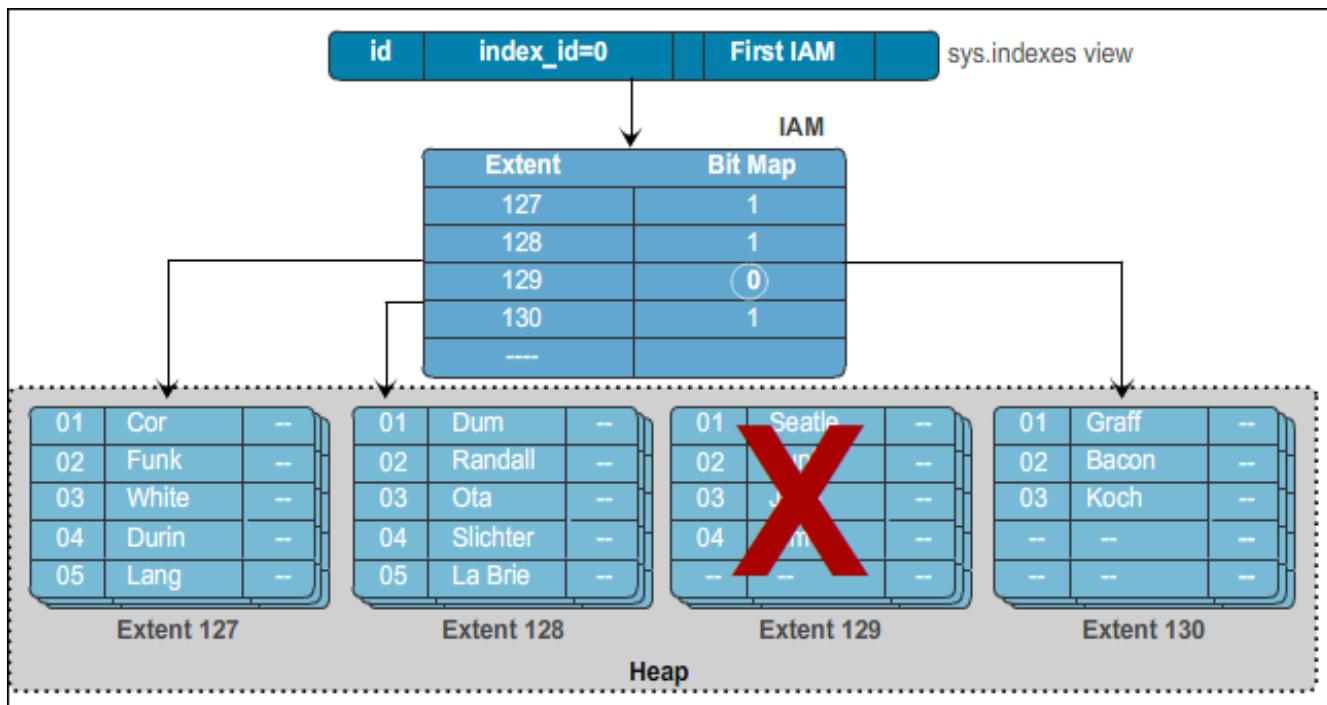


Figure 11.21: Finding Rows without Indexes



Code Snippet 12 demonstrates how to create a table **Employee_Details** without an index.

Code Snippet 12:

```
USE CUST_DB
CREATE TABLE Employee_Details
(
    EmpID int not null,
    FirstName varchar(20) not null,
    LastName varchar(20) not null,
    DateofBirth datetime not null,
    Gender varchar(6) not null,
    City varchar(30) not null,
)
GO
```

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Assume that multiple records are inserted in the table, `Employee_Details`. The `SELECT` statement is used to search for records having the `FirstName` as John.

Since there is no index associated with the `FirstName` column, SQL Server will perform a full table scan.

11.5.1 Finding Rows with Nonclustered Index

A nonclustered index is similar to a book index; the data and the index are stored in different places. The pointers in the leaf level of the index point to the storage location of the data in the underlying table. The nonclustered index is used to search for exact-match queries. This is because the index contains entries describing the exact location of the data in the table.

For finding rows using nonclustered indexes, a `SELECT` statement is used with the nonclustered index column specified in the `WHERE` clause.

Learning how to learn is life's most important skill.

Figure 11.22 shows the process of finding rows with nonclustered index.

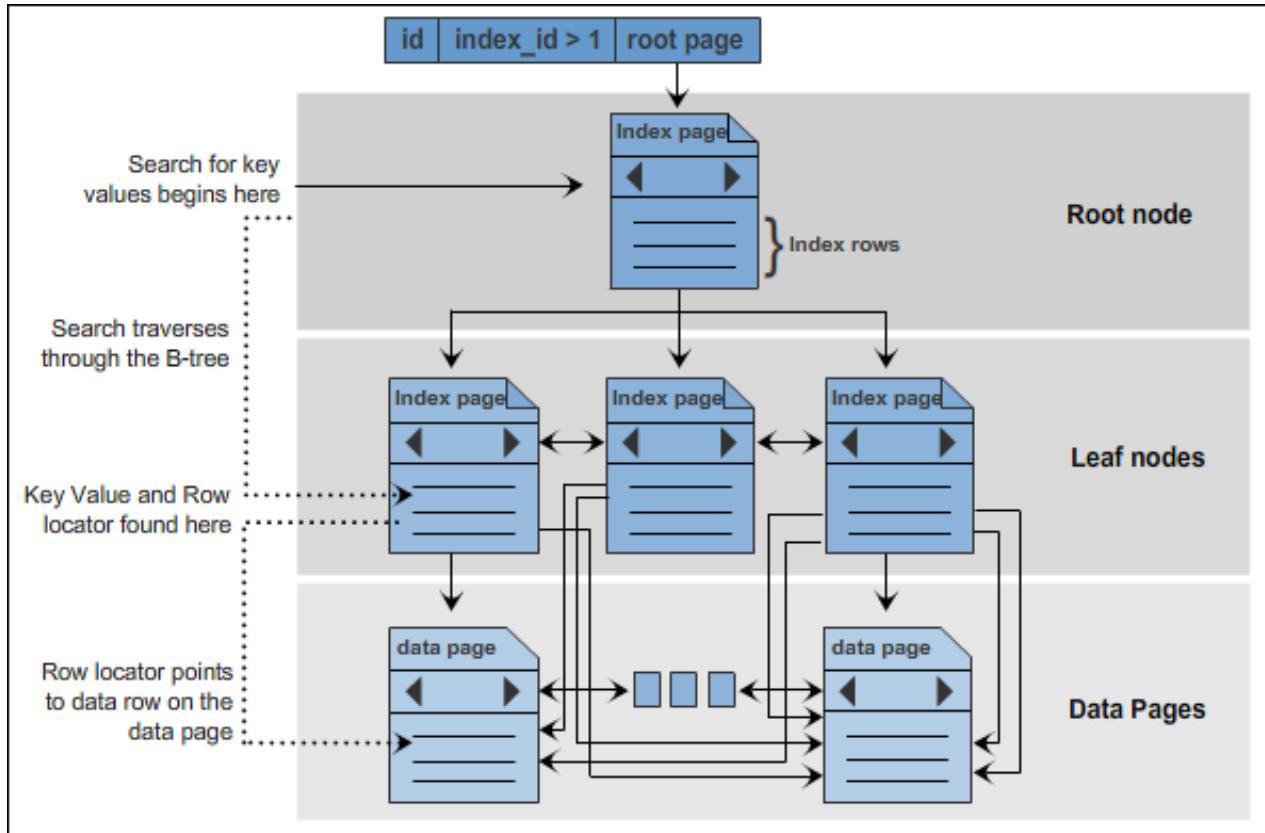


Figure 11.22: Finding Rows with Nonclustered Index

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Code Snippet 13 demonstrates how to create a nonclustered index **IX_EmployeeCity** on the **City** column of the **Employee_Details** table.

Code Snippet 13:

```
USE CUST_DB  
CREATE NONCLUSTERED INDEX IX_EmployeeCity ON Employee_Details(City);  
GO
```

Assume that multiple records are inserted in the table, **Employee_Details**. The **SELECT** statement is used to search for records of employees from city, Boston as shown in Code Snippet 14.

Code Snippet 14:

```
USE CUST_DB  
SELECT EmpID, FirstName, LastName, City FROM Employee_Details WHERE City='Boston'  
GO
```

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BLOGS

MULTIPLE EXPERTS | MULTIPLE TOPICS

Since there is a nonclustered index associated with `City` column, SQL Server will use the `IX_EmployeeCity` index to extract the records as shown in figure 11.23.

	EmpID	FirstName	LastName	City
1	101	Andrew	Waller	Boston
2	103	Sophia	broderich	Boston

Figure 11.23: IX_EmployeeCity Index

Note - In a table having a nonclustered index, there is no specific storage order of the data. Data is retrieved directly from its physical location.

11.5.2 Finding Rows in a Clustered Index

Clustered indexes store the data rows in the table based on their key values. This data is stored in a sorted manner. If the clustered key value is small, more number of index rows can be placed on an index page. This decreases the number of levels in the index B-Tree that must be traversed to reach the data rows producing faster query results. This minimizes I/O overhead.

For finding rows using clustered indexes, a `SELECT` statement is used with the clustered index column specified in the `WHERE` clause.

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Figure 11.24 shows the process of finding rows with clustered index.

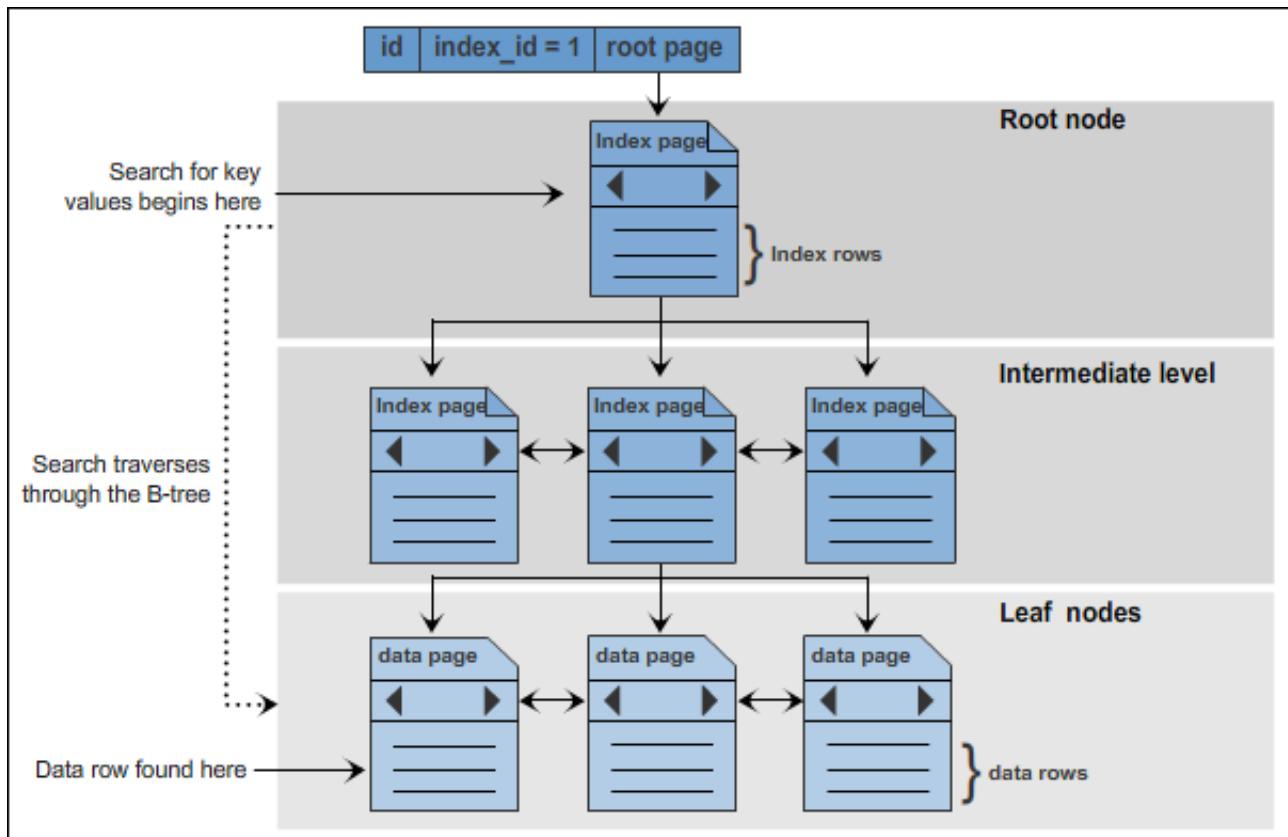


Figure 11.24: Finding Rows with Clustered Index

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

Code Snippet 15 demonstrates how to create a clustered index **IX_EmployeeID** on the **EmpID** column of the **Employee_Details** table.

Code Snippet 15:

```
USE CUST_DB  
CREATE UNIQUE CLUSTERED INDEX IX_EmployeeID ON Employee_Details (EmpID);  
GO
```

Assume that multiple records are inserted in the table, **Employee_Details**. The SELECT statement is used to search for records of employees having **EmpID** between 102 and 105 as shown in Code Snippet 16.

Code Snippet 16:

```
USE CUST_DB  
SELECT EmpID, FirstName, LastName, City FROM Employee_Details WHERE EmpID >= 102  
AND EmpID <= 105;  
GO
```

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Since there is a clustered index associated with the `EmpID` column, SQL Server will use the `IX_EmployeeID` index to extract the records as shown in figure 11.25.

	EmpID	FirstName	LastName	City
1	102	AJ	Stiles	Liverpool
2	103	Sophia	broderich	Boston
3	104	Shawn	roderichs	Texas

Figure 11.25: IX_EmployeeID Index

11.5.3 Creating Unique Indexes

A unique index can be created on a column that does not have any duplicate values. Also, once a unique index is created, duplicate values will not be accepted in the column. Hence, unique indexes should be created only on columns where uniqueness of values is a key characteristic. A unique index ensures entity integrity in a table.

If a table definition has a `PRIMARY KEY` or a column with a `UNIQUE` constraint, SQL Server automatically creates a unique index when you execute the `CREATE TABLE` statement as shown in figure 11.26.



Unique index can be created using either the CREATE UNIQUE INDEX statement or using SSMS.

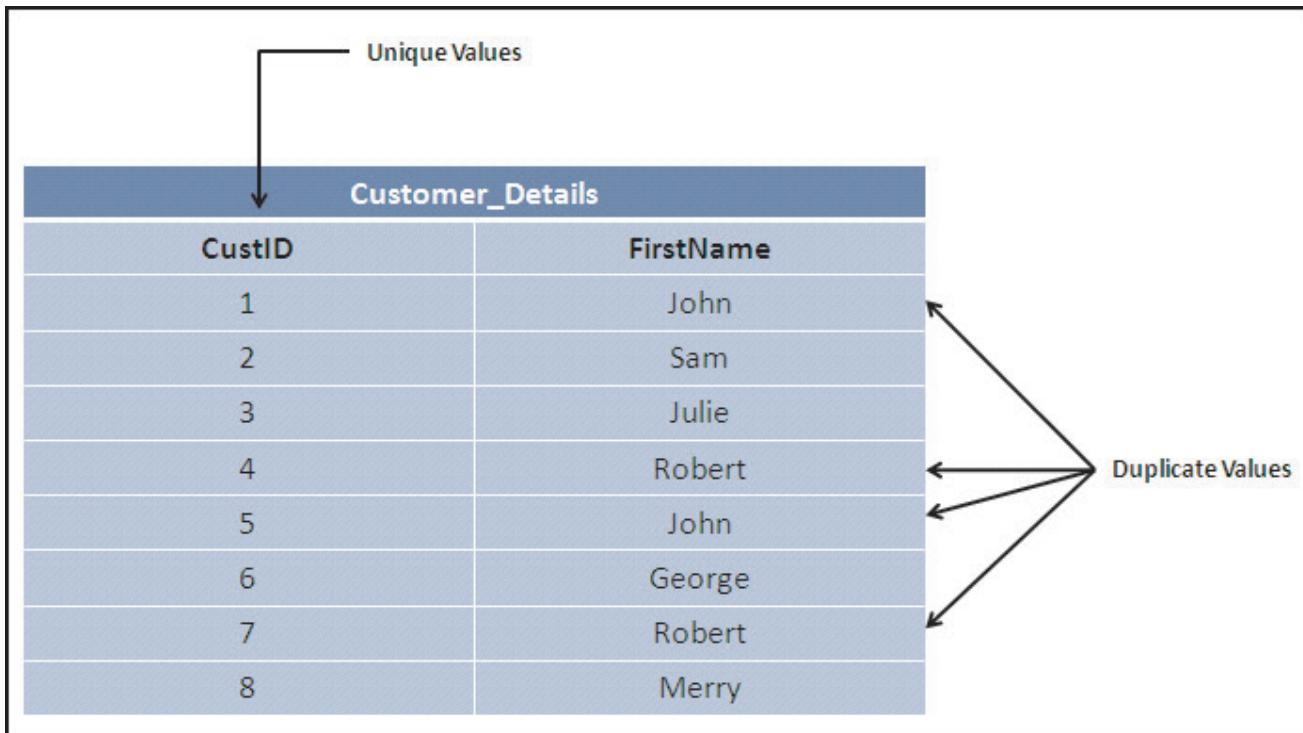


Figure 11.26: Creating Unique Indexes

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Following syntax is used to create a unique index.

Syntax:

```
CREATE UNIQUE INDEX <index_name> ON <table_name> (<column_name>)
```

where,

`column_name`: specifies the name of the column on which the index is to be created.

`UNIQUE`: specifies that no duplicate values are allowed in the column.

Code Snippet 17 creates a unique index on the `CustID` column in the `Customer_Details` table.

Code Snippet 17:

```
CREATE UNIQUE INDEX IX_CustID ON Customer_Details (CustID)
```

11.5.4 Creating Computed Columns

A computed column is a virtual column in a table whose value is calculated at run-time. The values in the column are not stored in the table but are computed based on the expression that defines the column. The expression consists of a non-computed column name associated with a constant, a function, or a variable using arithmetical or logical operators.

To learn, you must want to be taught.

A computed column can be created using the CREATE TABLE or ALTER TABLE statements as shown in figure 11.27.

Length	Breadth	Area
34	10	340
20	20	400
33.4	12	400.8
12	7	84

Computed column
($A=L*B$)

Figure 11.27: Creating Computed Columns

Following syntax is used to create a computed column.

Syntax:

```
CREATE TABLE <table_name> ([<column_name> AS <computed_column_expression>] )
```

where,

`table_name`: Specifies the name of the table.

`column_name AS computed_column_expression`: Specifies the name of the computed column as well as the expression that defines the values in the column.

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Code Snippet 18 creates a computed column **Area** whose values are calculated from the values entered in the **Length** and **Breadth** fields.

Code Snippet 18:

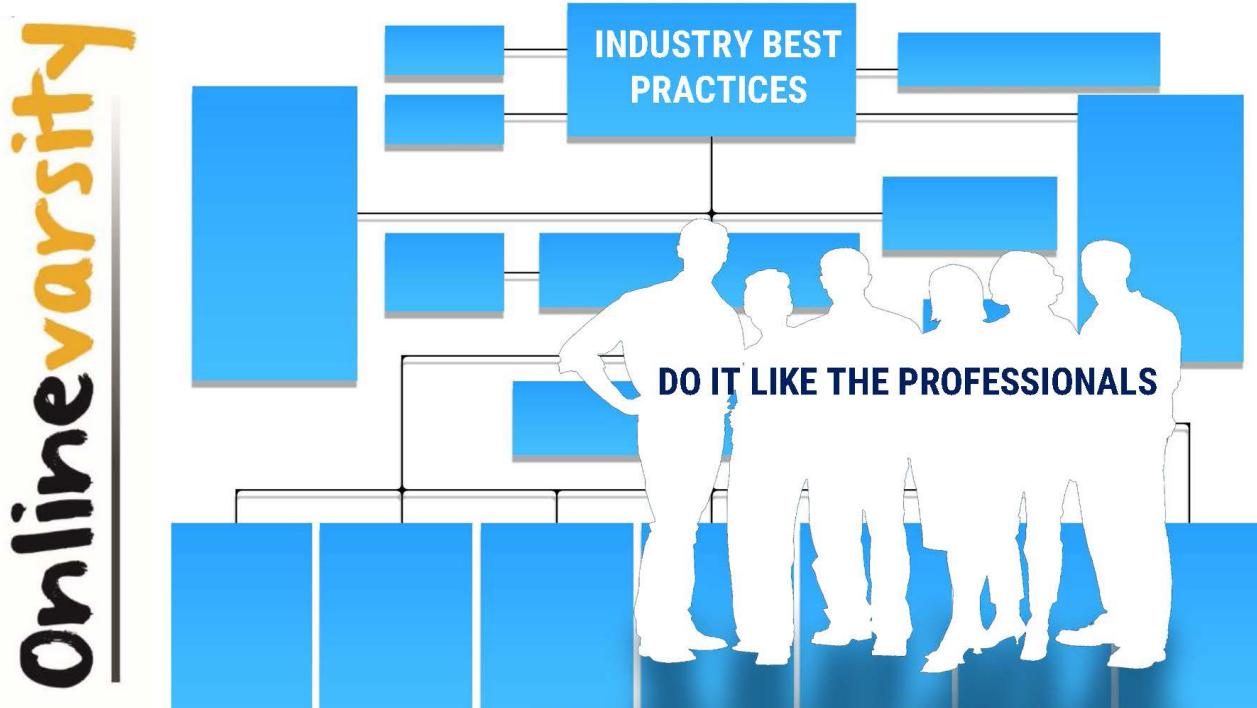
```
USE SampleDB  
CREATE TABLE Calc_Area (Length int, Breadth int, Area AS Length*Breadth)  
GO
```

Note - A computed column cannot be used as a part of any PRIMARY KEY, UNIQUE KEY, FOREIGN KEY, or CHECK constraint definition.

11.5.5 Creating Index on Computed Columns

An index can be created on a computed column if the column is marked **PERSISTED**. This ensures that the Database Engine stores computed values in the table. These values are updated when any other columns on which the computed column depends are updated.

The database engine uses this persisted value when it creates an index on the column.



An index is created on the computed column using the CREATE INDEX statement as shown in figure 11.28.

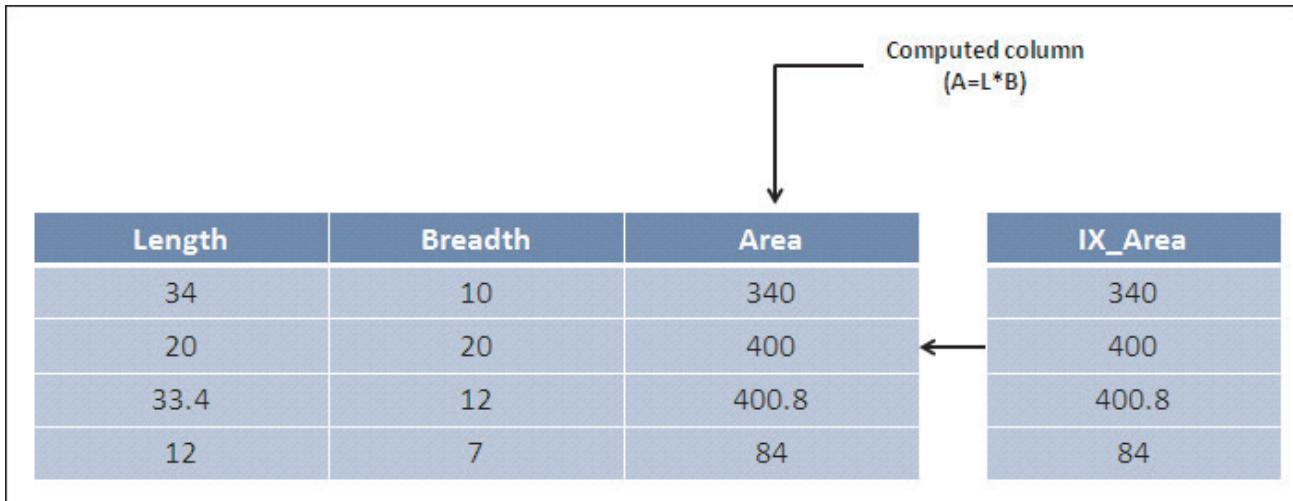


Figure 11.28: Creating Index on Computed Columns

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Following syntax creates an index on a computed column.

Syntax:

```
CREATE INDEX <index_name> ON <table_name> (<computed_column_name>)
```

where,

`computed_column_name` specifies the name of the computed column.

Code Snippet 19 creates an index `IX_Area` on the computed column `Area`.

Code Snippet 19:

```
USE SampleDB  
CREATE INDEX IX_Area ON Calc_Area (Area) ;  
GO
```

11.6 Cursors

A database object that is used to retrieve data as one row at a time, from a resultset is called as cursors. Cursors are used instead of the Transact-SQL commands that operate on all the rows at one time in the resultset. Cursors are used when records in a database table need to be updated one row at a time.

Democritus said, words are but the shadows of actions.

Types of Cursors

- **Static Cursors** – These cursors help to populate the resultset when the cursor is created and the query result is cached. This is the slowest of all the cursors. This cursor can move/scroll in both backward and forward directions. Also, the static cursor cannot be updated or deleted.
- **Dynamic Cursors** – These cursors allow you to view the procedures of insertion, updation, and deletion when the cursor is open. This is one of the most sensitive cursor and is scrollable.
- **Forward Only Cursors** - These cursors also support updation and deletion of data. This is the fastest cursor though it does not support backward scrolling. The three types of forward cursors are FORWARD _ ONLY KEYSET, FORWARD _ ONLY STATIC, and FAST _ FORWARD.
- **Keyset Driven Cursors** - These cursors create a set of unique identifiers as keys in a keyset that are used to control the cursor. This is also a sensitive cursor that can update and delete data. The keyset is dependent on all the rows that qualify the SELECT statement at the time of opening the cursor.

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Following is the syntax to declare a cursor.

Syntax:

```
DECLARE cursor_name CURSOR [ LOCAL | GLOBAL ]  
[ FORWARD_ONLY | SCROLL ]  
[ STATIC | KEYSET | DYNAMIC | FAST_FORWARD ]  
[ READ_ONLY | SCROLL_LOCKS | OPTIMISTIC ]  
[ TYPE_WARNING ]  
FOR select_statement  
[ FOR UPDATE [ OF column_name [ ,...n ] ] ]  
[ ; ]
```



where,

`cursor_name`: is the name of the cursor defined, `cursor_name` must comply to the rules for identifiers.

`LOCAL`: specifies that the cursor can be used locally to the batch, stored procedure, or trigger in which the cursor was created.

`GLOBAL`: specifies that the cursor can be used globally to the connection.

`FORWARD_ONLY`: specifies that the cursor can only be scrolled from the first to the last row.

`STATIC`: defines a cursor that makes a temporary copy of the data to be used by the cursor.

`KEYSET`: specifies that the membership and order of rows in the cursor are fixed when the cursor is opened.

`DYNAMIC`: defines a cursor that reflects all data changes made to the rows in its resultset as you scroll around the cursor.

`FAST_FORWARD`: specifies a `FORWARD_ONLY`, `READ_ONLY` cursor with performance optimizations enabled.

`READ_ONLY`: prevents updates made through this cursor.

`SCROLL_LOCKS`: specifies that positioned updates or deletes made through the cursor are guaranteed to succeed.

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Code Snippet 20 creates an **Employee** table in **SampleDB** database.

Code Snippet 20:

```
USE SampleDB
CREATE TABLE Employee
(
    EmpID int PRIMARY KEY,
    EmpName varchar (50) NOT NULL,
    Salary int NOT NULL,
    Address varchar (200) NOT NULL,
)
GO
INSERT INTO Employee(EmpID,EmpName,Salary,Address)
VALUES(1,'Derek',12000,'Housten')
INSERT INTO Employee(EmpID,EmpName,Salary,Address)
VALUES(2,'David',25000,'Texas')
INSERT INTO Employee(EmpID,EmpName,Salary,Address) VALUES(3,'Alan',22000,'New York')
INSERT INTO Employee(EmpID,EmpName,Salary,Address)
VALUES(4,'Mathew',22000,'las Vegas')
INSERT INTO Employee(EmpID,EmpName,Salary,Address)
VALUES(5,'Joseph',28000,'Chicago')
GO
SELECT * FROM Employee
```

*Nothing is a waste of time if you use
the experience wisely.*

Figure 11.29 shows the output of the code.

	EmpId	FirstName	Salary	City
1	1	Derek	12000	Houston
2	2	David	25000	Texas
3	3	Alan	22000	New York
4	4	Mathew	22000	Las Vegas
5	5	Joseph	28000	Chicago

Figure 11.29: Employee Table Created in SampleDB Database

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Code Snippet 21 demonstrates how to declare a cursor on **Employee** table.

Code Snippet 21:

```
USE SampleDB
SET NOCOUNT ON
DECLARE @Id int
DECLARE @name varchar(50)
DECLARE @salary int
/* A cursor is declared by defining the SQL statement that returns a resultset.*/
DECLARE cur_emp CURSOR
STATIC FOR
SELECT EmpID, EmpName, Salary from Employee
/* A Cursor is opened and populated by executing the SQL statement defined by the
cursor.*/
OPEN cur_emp
IF @@CURSOR_ROWS > 0
BEGIN
/* Rows are fetched from the cursor one by one or in a block to do data manipulation*/
FETCH NEXT FROM cur_emp INTO @Id, @name, @salary
WHILE @@Fetch_Status = 0
BEGIN
PRINT 'ID : '+convert(varchar(20),@Id)+', Name : '+@name+', Salary :
'+convert(varchar(20),@salary)

FETCH NEXT FROM cur_emp INTO @Id, @name, @salary
END
END
--close the cursor explicitly
CLOSE cur_emp
/*Delete the cursor definition and release all the system resources associated with
the cursor*/
DEALLOCATE cur_emp
SET NOCOUNT OFF
```

Figure 11.30 shows the output of the code.

```
ID : 1, Name : Derek, Salary : 12000
ID : 2, Name : David, Salary : 25000
ID : 3, Name : Alan, Salary : 22000
ID : 4, Name : Mathew, Salary : 22000
ID : 5, Name : Joseph, Salary : 28000
```

Figure 11.30: Cursor Created on Employee Table

In the code, the details are retrieved one row at a time. This procedure will help in retrieving large databases sequentially.

First, a cursor is declared by defining the SQL statement that returns a resultset. Then, it is opened and populated by executing the SQL statement defined by the cursor. Rows are then fetched from the cursor one by one or in a block to perform data manipulation.

The cursor is then closed and finally, the cursor definition is deleted and all the system resources associated with the cursor are released.

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11.7 Check Your Progress

1. Which of the following is the correct code to define an index?

(A)	USE CUST_DB CREATE INDEX IX_CountryCustomer_Details(Country); GO	(C)	USE CUST_DB CREATE INDEX IX_CountryWithCustomer_Details(Country); GO
(B)	USE CUST_DB CREATE INDEX IX_CountryFROMCustomer_Details(Country); GO	(D)	USE CUST_DB CREATE INDEX IX_CountryONCustomer_Details(Country); GO

2. SQL Server 2012 stores data in storage units known as _____.

(A)	data pages	(C)	records
(B)	forms	(D)	columns

3. Which of the following code moves the data in the resulting **Supplier _ Details** table to the default location?

(A)	DROP INDEX IX_SuppID ON Supplier_Details	(C)	DROP INDEX IX_SuppID ON Supplier_Details WITH (MOVE TO 'default')
(B)	MOVE INDEX IX_SuppID ON Supplier_Details WITH ('default')	(D)	DELETE INDEX IX_SuppID ON Supplier_Details WITH ('default')

4. Which of the following code is used to create a clustered INDEX on **CustID** in **Customer _ Details** table?

(A)	USE CUST_DB CREATE CLUSTERED INDEX Customer_Details(CustID) GO	(C)	USE CUST_DB CREATE INDEX Customer_Details ON IX_CustID GO
(B)	USE CUST_DB CREATE INDEX IX_CustID ON Customer_Details GO	(D)	USE CUST_DB CREATE CLUSTERED INDEX IX_CustID ON Customer_Details(CustID) GO

5. A clustered index can be created on a table using a column without _____ values.

(A)	similar	(C)	transparent
(B)	duplicate	(D)	any

11.7.1 Answers

1.	D
2.	A
3.	C
4.	D
5.	B

Summary

- Indexes increase the speed of the querying process by providing quick access to rows or columns in a data table.
- SQL Server 2012 stores data in storage units known as data pages.
- All input and output operations in a database are performed at the page level.
- SQL Server uses catalog views to find rows when an index is not created on a table.
- A clustered index causes records to be physically stored in a sorted or sequential order.
- A nonclustered index is defined on a table that has data either in a clustered structure or a heap.
- XML indexes can speed up queries on tables that have XML data.
- Column Store Index enhances performance of data warehouse queries extensively.



- Houston State Library is one of the renowned libraries in Houston, Texas. The library has a stock of around 10,00000 books of different genres. The library issues books to the students of the college nearby. With the inflow of students coming to the library growing exponentially, Houston State Library has decided to automate the entire process of issuing books to the students. The library has increased the quantity of each book by 10 copies, depending upon the demand made by the students.

- Create a database named **HoustonStateLibrary** to store the details of books in the Library.
- Create a table named **BooksMaster** to store the details of the books in the library as shown in table 11.3.

Field Name	Data Type	Key Field	Description
BookCode	varchar(50)	Primary Key	Stores book code of the book
Title	varchar(max)		Stores the book title
ISBN	varchar(50)		Stores the ISBN of the book
Author	char(30)		Stores author name of the book
Price	money		Stores price of the book
Publisher	char(30)		Stores publisher name of the book
NumPages	numeric(10,0)		Stores number of pages in the book

Table 11.3: BooksMaster Table

- Create a clustered index named **IX _ Title** on the **Title** column in the **BooksMaster** table.
- Create a table **BooksMaster1** having field names **BookCode**, **Title**, and **Book Details**. Specify the data type for **BookDetails** as **xml**. Create an XML document with details of **ISBN**, **Author**, **Price**, **Publisher**, and **NumPages**.
- The library wants to retrieve the publisher name of the company which prints a specific author's book. Create a primary XML index **PXML _ Books** on the **BookCode** column of the **BooksMaster** table.

Session - 12

Triggers

Welcome to the Session, **Triggers**.

This session explains the triggers and different types of triggers. The session also describes the procedure to create and alter DML triggers, nested triggers, update functions, handling multiple rows in a session, and performance implication of triggers.

In this Session, you will learn to:

- Explain triggers
- Explain the different types of triggers
- Explain the procedure to create DML triggers
- Explain the procedure to alter DML triggers
- Describe nested triggers
- Describe update functions
- Explain the handling of multiple rows in a session
- Explain the performance implication of triggers

12.1 Introduction

A trigger is a stored procedure that is executed when an attempt is made to modify data in a table protected by the trigger. Unlike standard system stored procedures, triggers cannot be executed directly, nor do they pass or receive parameters. Triggers are defined on specific tables and these tables are referred to as trigger tables.

If a trigger is defined on the INSERT, UPDATE, or DELETE action on a table, it fires automatically when these actions are attempted. This automatic execution of the trigger cannot be circumvented. In SQL Server 2012, triggers are created using the CREATE TRIGGER statement.



Figure 12.1 displays an example of triggers.

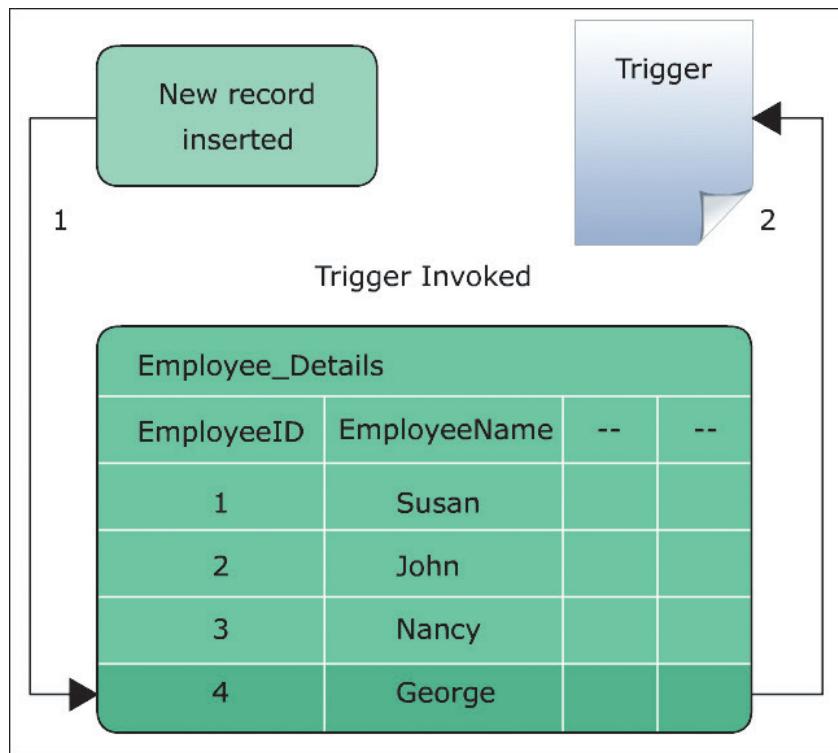


Figure 12.1: Triggers

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12.2 Uses of Triggers

Triggers can contain complex processing logic and are generally used for maintaining low-level data integrity. The primary uses of triggers can be classified as follows:

→ Cascading changes through related tables

Users can use a trigger to cascade changes through related tables. For example, consider a table `Salary_Details` having a `FOREIGN KEY, EmpID` referencing the `PRIMARY KEY, EmpID` of the `Employee_Details` table. If an update or a delete event occurs in the `Employee_Details` table, an update or delete trigger can be defined to cascade these changes to the `Salary_Details` table.

→ Enforcing more complex data integrity than CHECK constraints

Unlike `CHECK` constraints, triggers can reference the columns in other tables. This feature can be used to apply complex data integrity checks. Data integrity can be enforced by:

- Checking constraints before cascading updates or deletes.
- Creating multi-row triggers for actions executed on multiple rows.
- Enforcing referential integrity between databases.

Learning how to learn is life's most important skill.

→ Defining custom error messages

Custom error messages are used for providing more suitable or detailed explanations in certain error situations. Triggers can be used to invoke such predefined custom error messages when the relevant error conditions occur.

→ Maintaining denormalized data

Low-level data integrity can be maintained in denormalized database environments using triggers. Denormalized data generally refers to redundant or derived data. Here, triggers are used for checks that do not require exact matches. For example, if the value of the year is to be checked against complete dates, a trigger can be used to perform the check.

→ Comparing before and after states of data being modified

Triggers provide the option to reference changes that are made to data by `INSERT`, `UPDATE`, and `DELETE` statements. This allows users to reference the affected rows when modifications are carried out through triggers.

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12.3 Types of Triggers

A trigger can be set to automatically execute an action when a language event occurs in a table or a view. Language events can be classified as DML events and DDL events. Triggers associated with DML events are known as DML triggers, whereas triggers associated with DDL events are known as DDL triggers.

Triggers in SQL Server 2012 can be classified into three basic types:

→ **DML Triggers**

DML triggers execute when data is inserted, modified, or deleted in a table or a view using the INSERT, UPDATE, or DELETE statements.

→ **DDL Triggers**

DDL triggers execute when a table or a view is created, modified, or deleted using the CREATE, ALTER, or DROP statements.

→ **Logon Triggers**

Logon triggers execute stored procedures when a session is established with a LOGON event. These triggers are invoked after the login authentication is complete and before the actual session is established. Logon triggers control server sessions by restricting invalid logins or limiting the number of sessions.



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12.4 DDL Triggers versus DML Triggers

DDL and DML triggers have different uses and are executed with different database events. Table 12.1 displays the differences between DDL and DML triggers.

DDL Triggers	DML Triggers
DDL triggers execute stored procedures on CREATE, ALTER, and DROP statements.	DML triggers execute on INSERT, UPDATE, and DELETE statements.
DDL triggers are used to check and control database operations.	DML triggers are used to enforce business rules when data is modified in tables or views.
DDL triggers operate only after the table or a view is modified.	DML triggers execute either while modifying the data or after the data is modified.
DDL triggers are defined at either the database or the server level.	DML triggers are defined at the database level.

Table 12.1: Differences between DDL and DML Triggers

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12.5 Creating DML Triggers

DML triggers are executed when DML events occur in tables or views. These DML events include the INSERT, UPDATE, and DELETE statements. DML triggers can execute either on completion of the DML events or in place of the DML events.

DML triggers enforce referential integrity by cascading changes to related tables when a row is modified. DML triggers can perform multiple actions for each modification statement.

DML triggers are of three main types:

- ➔ INSERT trigger
- ➔ UPDATE trigger
- ➔ DELETE trigger

Who dares to teach must never cease to learn.

Figure 12.2 displays the types of DML triggers.

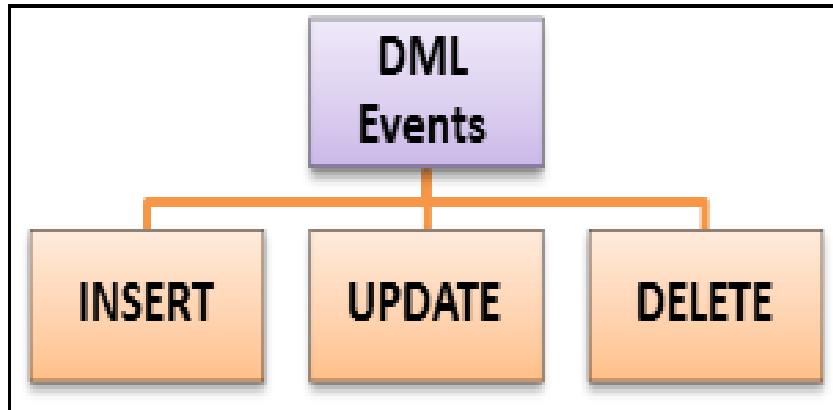


Figure 12.2: DML Triggers

12.5.1 Introduction to Inserted and Deleted Tables

The SQL statements in DML triggers use two special types of tables to modify data in the database. When the data is inserted, updated, or deleted, SQL Server 2012 creates and manages these tables automatically.

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The tables temporarily store the original as well as the modified data. These tables are as follows:

→ **Inserted Table**

The `Inserted` table contains copies of records that are modified with the `INSERT` and `UPDATE` operations on the trigger table. Trigger table is the table on which the trigger is defined. The `INSERT` and `UPDATE` operations insert new records into the `Inserted` and `Trigger` tables.

→ **Deleted Table**

The `Deleted` table contains copies of records that are modified with the `DELETE` and `UPDATE` operations on the trigger table. Trigger table is the table on which the trigger is defined. These operations delete the records from the trigger table and insert them in the `Deleted` table.

Note - The `Inserted` and `Deleted` tables do not physically remain present in the database. They are created and dropped whenever any triggering events occur.

12.5.2 Insert Triggers

An `INSERT` trigger is executed when a new record is inserted in a table. The `INSERT` trigger ensures that the value being entered conforms to the constraints defined on that table.

When a user inserts a record in the table, the `INSERT` trigger saves a copy of that record in the `Inserted` table. It then checks whether the new value in the `Inserted` table conforms to the specified constraints.

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If the record is valid, the `INSERT` trigger inserts the row in the trigger table otherwise, it displays an error message.

An `INSERT` trigger is created using the `INSERT` keyword in the `CREATE TRIGGER` and `ALTER TRIGGER` statements.

Following is the syntax for creating an `INSERT` trigger.

Syntax:

```
CREATE TRIGGER [schema_name.] trigger_name
ON [schema_name.] table_name
[WITH ENCRYPTION]
{ FOR INSERT }
AS
[IF UPDATE (column_name) ...]
[{AND | OR} UPDATE (column_name) ...]
<sql_statements>
```

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where,

`schema_name`: specifies the name of the schema to which the table/trigger belongs.

`trigger_name`: specifies the name of the trigger.

`table_name`: specifies the table on which the DML trigger is created.

`WITH ENCRYPTION`: encrypts the text of the `CREATE TRIGGER` statement.

`FOR`: specifies that the DML trigger executes after the modification operations are complete.

`INSERT`: specifies that this DML trigger will be invoked by insert operations.

`UPDATE`: Returns a Boolean value that indicates whether an `INSERT` or `UPDATE` attempt was made on a specified column.

`column_name`: Is the name of the column to test for the `UPDATE` action.

`AND`: Combines two Boolean expressions and returns `TRUE` when both expressions are `TRUE`.

`OR`: Combines two Boolean expressions and returns `TRUE` if at least one expression is `TRUE`.

`sql_statement`: specifies the SQL statements that are executed in the DML trigger.

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

Code Snippet 1 creates an `INSERT` trigger on a table named `Account_Transactions`. When a new record is inserted, and if the withdrawal amount exceeds `80000`, the insert trigger displays an error message and rolls back the transaction using the `ROLLBACK TRANSACTION` statement.

A transaction is a set of one or more statements that is treated as a single unit of work. A transaction can succeed or fail as a whole, therefore, all the statements within it succeed or fail together. The `ROLLBACK TRANSACTION` statement cancels or rolls back a transaction.

Code Snippet 1:

```
CREATE TRIGGER CheckWithdrawal_Amount
ON Account_Transactions
FOR INSERT
AS
IF (SELECT Withdrawal From inserted) > 80000
BEGIN
PRINT 'Withdrawal amount cannot exceed 80000'
ROLLBACK TRANSACTION
END
```

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Code Snippet 2 inserts a record where the `Withdrawal` amount exceeds 80000. This causes the `INSERT` trigger to display an error message and roll back the transaction.

Code Snippet 2:

```
INSERT INTO Account_Transactions
(TransactionID, EmployeeID, CustomerID, TransactionTypeID, TransactionDate,
TransactionNumber, Deposit, Withdrawal)
VALUES
(1008, 'E08', 'C08', 'T08', '05/02/12', 'TN08', 300000, 90000)
```

Following error message is displayed as specified by the `PRINT` statement:

Withdrawal amount cannot exceed 80000.

12.5.3 Update Triggers

The `UPDATE` trigger copies the original record in the `Deleted` table and the new record into the `Inserted` table when a record is updated. It then evaluates the new record to determine if the values conform to the constraints specified in the trigger table.

If the new values are valid, the record from the `Inserted` table is copied to the trigger table. However, if the new values are invalid, an error message is displayed. Also, the original record is copied from the `Deleted` table back into the trigger table.



An UPDATE trigger is created using the UPDATE keyword in the CREATE TRIGGER and ALTER TRIGGER statements. Following is the syntax for creating an UPDATE trigger at the table-level.

Syntax:

```
CREATE TRIGGER [schema_name.] trigger_name
ON [schema_name.] table_name
[WITH ENCRYPTION]
{FOR UPDATE}
AS
[IF UPDATE (column_name) ...]
[ {AND | OR} UPDATE (column_name) ... ]
<sql_statements>
```

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where,

FOR UPDATE: specifies that this DML trigger will be invoked after the update operations.

Code Snippet 3 creates an UPDATE trigger at the table level on the **EmployeeDetails** table. When a record is modified, the UPDATE trigger is activated. It checks whether the date of birth is greater than today's date. It displays an error message for invalid values and rolls back the modification operation using the ROLLBACK TRANSACTION statement.

Code Snippet 3:

```
CREATE TRIGGER CheckBirthDate
ON EmployeeDetails
FOR UPDATE
AS
IF (SELECT BirthDate From inserted) > getDate()
BEGIN
PRINT 'Date of birth cannot be greater than today's date'
ROLLBACK
END
```

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

Code Snippet 4 updates a record where an invalid date of birth is specified. This causes the update trigger to display the error message and roll back the transaction.

Code Snippet 4:

```
UPDATE EmployeeDetails  
SET BirthDate='2015/06/02'  
WHERE EmployeeID='E06'
```

Following error message is displayed as specified by the PRINT statement:

Date of birth cannot be greater than today's date.

→ Creating Update Triggers

The UPDATE triggers are created either at the column level or at the table level. The triggers at the column level execute when updates are made in the specified column. The triggers at the table level execute when updates are made anywhere in the entire table.

For creating an UPDATE trigger at the column level, the UPDATE () function is used to specify the column.

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Code Snippet 5 creates an UPDATE trigger at the column level on the `EmployeeID` column of `EmployeeDetails` table. When the `EmployeeID` is modified, the UPDATE trigger is activated and an error message is displayed. The modification operation is rolled back using the `ROLLBACK TRANSACTION` statement.

Code Snippet 5:

```
CREATE TRIGGER Check_EmployeeID
ON EmployeeDetails
FOR UPDATE
AS
IF UPDATE (EmployeeID)
BEGIN
PRINT 'You cannot modify the ID of an employee'
ROLLBACK TRANSACTION
END
```

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Code Snippet 6 updates a record where the value in the `EmployeeID` column is being modified. This causes the update trigger to fire. The update trigger displays an error message and rolls back the transaction.

Code Snippet 6:

```
UPDATE EmployeeDetails  
SET EmployeeID='E12'  
WHERE EmployeeID='E04'
```

12.5.4 Delete Triggers

The `DELETE` trigger can be created to restrict a user from deleting a particular record in a table. Following will happen if the user tries to delete the record:

- The record is deleted from the trigger table and inserted in the `Deleted` table.
- It is checked for constraints against deletion.
- If there is a constraint on the record to prevent deletion, the `DELETE` trigger displays an error message.
- The deleted record stored in the `Deleted` table is copied back to the trigger table.

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A DELETE trigger is created using the DELETE keyword in the CREATE TRIGGER statement. Following is the syntax for creating a DELETE trigger.

Syntax:

```
CREATE TRIGGER<trigger_name>
ON <table_name>
[WITH ENCRYPTION]
FOR DELETE
AS <sql_statement>
```

where,

DELETE: specifies that this DML trigger will be invoked by delete operations.

To avoid criticism, do nothing, say nothing, be nothing.

Code Snippet 7 creates a DELETE trigger on the **Account_Transactions** table. If a record of a **TransactionID** is deleted, the DELETE trigger is activated and an error message is displayed. The delete operation is rolled back using the ROLLBACK TRANSACTION statement.

Code Snippet 7:

```
CREATE TRIGGER CheckTransactions
ON Account_Transactions
FOR DELETE
AS
IF 'T01' IN (SELECT TransactionID FROM deleted)
BEGIN
PRINT 'Users cannot delete the transactions.'
ROLLBACK TRANSACTION
END
```

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Code Snippet 8 attempts to delete records from the **Account_Transactions** table where **Deposit** is 50000.

Code Snippet 8:

```
DELETE FROM Account_Transactions
WHERE Deposit=50000
```

The error message is displayed as specified by the **PRINT** statement.

Users cannot delete the transactions.

12.6 AFTER Triggers

An AFTER trigger is executed on completion of **INSERT**, **UPDATE**, or **DELETE** operations. AFTER triggers can be created only on tables. A table can have multiple AFTER triggers defined for each **INSERT**, **UPDATE**, and **DELETE** operation. If multiple AFTER triggers are created on the same table, the user must define the order in which the triggers must be executed. An AFTER trigger is executed when the constraint check in the table is completed. Also, the trigger is executed after the **Inserted** and **Deleted** tables are created.



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Figure 12.3 displays the types of AFTER triggers.

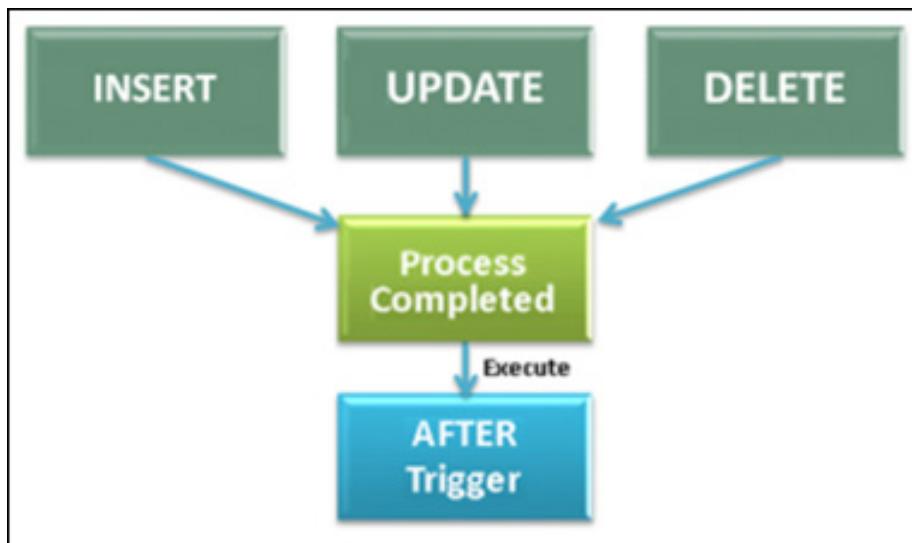


Figure 12.3: AFTER Triggers

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Following is the syntax for creating an AFTER trigger.

Syntax:

```
CREATE TRIGGER <trigger_name>
ON <table_name>
[WITH ENCRYPTION]
{ FOR | AFTER }
{ [ INSERT ] [ , ] [ UPDATE ] [ , ] [ DELETE ] }
AS <sql_statement>
```

where,

FOR | AFTER: specifies that the DML trigger executes after the modification operations are complete.

{ [INSERT] [,] [UPDATE] [,] [DELETE] }: specifies the operations that invoke the DML trigger.

Learning is not compulsory, but neither is survival.

Code Snippet 9 creates an AFTER DELETE trigger on the **EmployeeDetails** table. If any employee record is deleted from the table, the AFTER DELETE trigger activates. The trigger displays the number of employee records deleted from the table.

Code Snippet 9:

```
CREATE TRIGGER Employee_Deletion
ON EmployeeDetails
AFTER DELETE
AS
BEGIN
DECLARE @num nchar;
SELECT @num=COUNT(*) FROM deleted
PRINT 'No. of employees deleted= ' + @num
END
```

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Code Snippet 10 deletes a record from the `EmployeeDetails` table.

Code Snippet 10:

```
DELETE FROM EmployeeDetails WHERE EmployeeID='E07'
```

Following error message is displayed:

No. of employees deleted = 0

12.7 INSTEAD OF Triggers

An INSTEAD OF trigger is executed in place of the INSERT, UPDATE, or DELETE operations. INSTEAD OF triggers can be created on tables as well as views. A table or a view can have only one INSTEAD OF trigger defined for each INSERT, UPDATE, and DELETE operation.

The INSTEAD OF triggers are executed before constraint checks are performed on the table. These triggers are executed after the creation of the Inserted and Deleted tables. The INSTEAD OF triggers increase the variety of types of updates that the user can perform against the view.



Figure 12.4 displays an example of INSTEAD OF triggers.

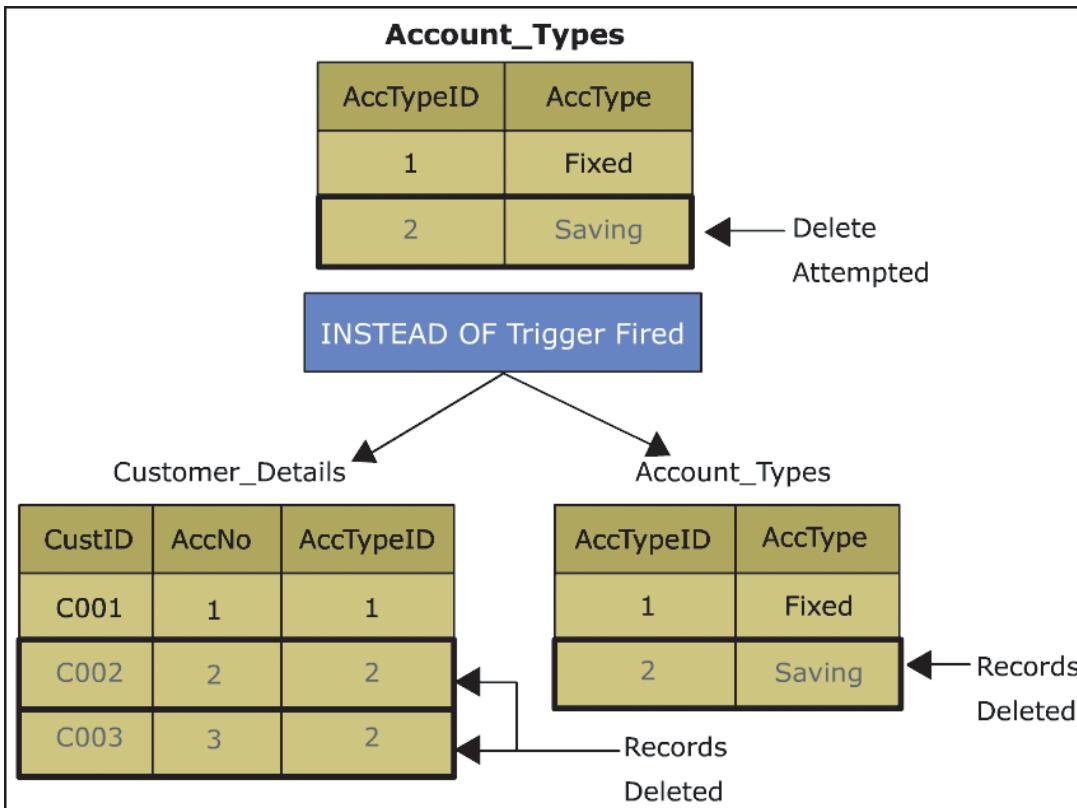


Figure 12.4: INSTEAD OF Triggers

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In the example shown in figure 12.4, an INSTEAD OF DELETE trigger on the **Account_Types** table is created. If any record in the **Account_Types** table is deleted, the corresponding records in the **Customer_Details** table will also be removed. Thus, instead of working only on one table, here, the trigger ensures that the delete operation is performed on both the tables.

Note - Users cannot create INSTEAD OF triggers for delete or update operations on tables that have the ON DELETE cascade and ON UPDATE cascade options selected.

Following is the syntax for creating an INSTEAD OF trigger.

Syntax:

```
CREATE TRIGGER <trigger_name>
ON { <table_name> | <view_name> }
{ FOR | AFTER | INSTEAD OF }
{ [ INSERT ] [ , ] [ UPDATE ] [ , ] [ DELETE ] }
AS <sql_statement>
```

where,

`view_name`: specifies the view on which the DML trigger is created.

`INSTEAD OF`: specifies that the DML trigger executes in place of the modification operations. These triggers are not defined on updatable views using `WITH CHECK OPTION`.

A wise man learns from the mistakes of others, a fool by his own.

Code Snippet 11 creates an INSTEAD OF DELETE trigger on the **Account_Transactions** table. If any record in the **Account_Transactions** table is deleted, the corresponding records in the **EmployeeDetails** table will be removed.

Code Snippet 11:

```
CREATE TRIGGER Delete_AccType
ON Account_Transactions
INSTEAD OF DELETE
AS
BEGIN
DELETE FROM EmployeeDetails WHERE EmployeeID IN
(SELECT TransactionTypeID FROM deleted)
DELETE FROM Account_Transactions WHERE TransactionTypeID IN
(SELECT TransactionTypeID FROM deleted)
END
```

12.7.1 Using INSTEAD OF Triggers with Views

INSTEAD OF triggers can be specified on tables as well as views. This trigger executes instead of the original triggering action. INSTEAD OF triggers provide a wider range and types of updates that the user can perform against a view. Each table or view is limited to only one INSTEAD OF trigger for each triggering action (INSERT, UPDATE, or DELETE).

Users cannot create an INSTEAD OF trigger on views that have the WITH CHECK OPTION clause defined.

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Figure 12.5 displays an example of using INSTEAD OF triggers with views.

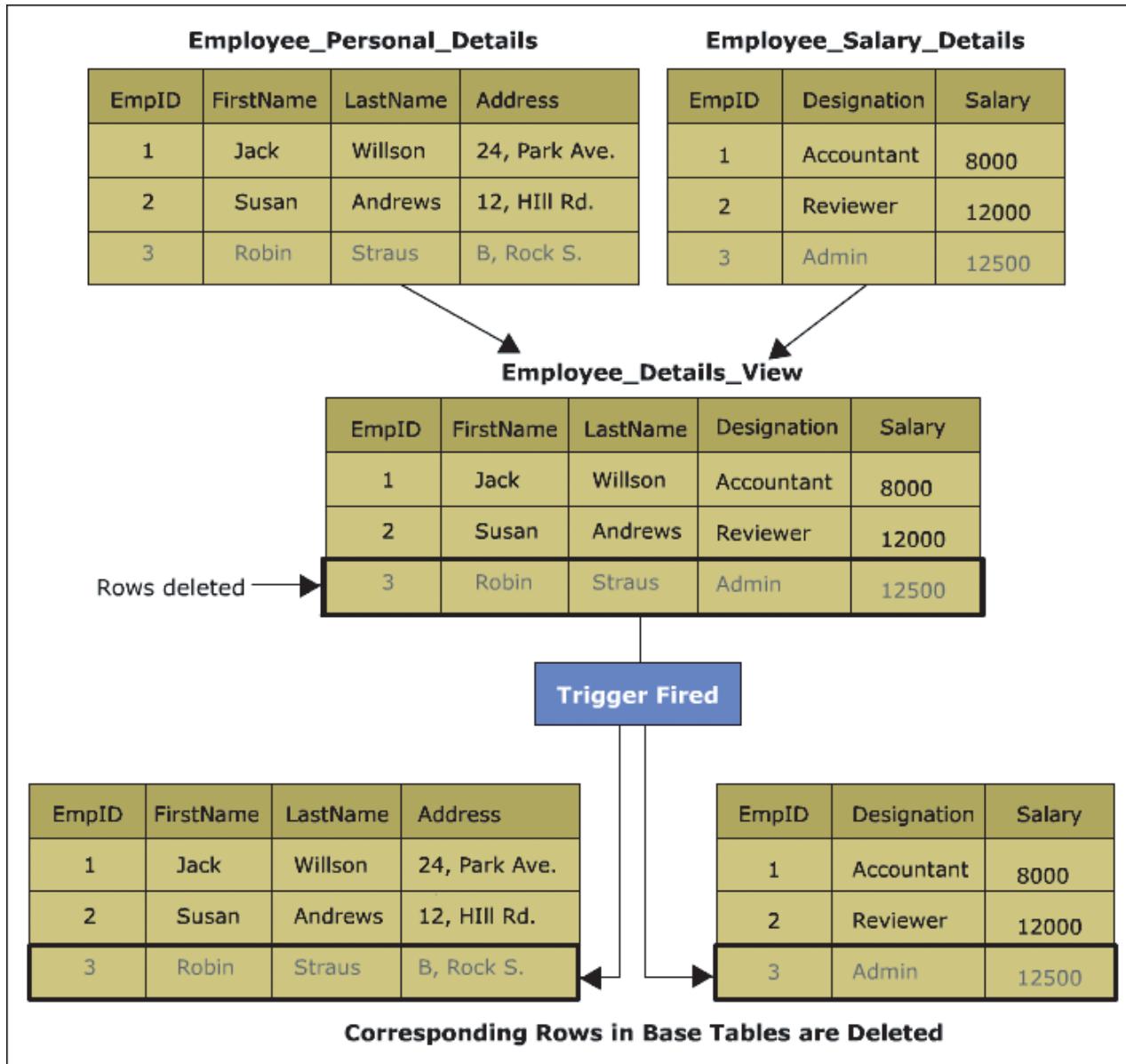


Figure 12.5: Using INSTEAD OF Triggers with Views

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BLOGS

MULTIPLE EXPERTS | MULTIPLE TOPICS

Code Snippet 12 creates a table named **Employee_Personal_Details**.

Code Snippet 12:

```
CREATE TABLE Employee_Personal_Details
(
    EmpID int NOT NULL,
    FirstName varchar (30) NOT NULL,
    LastName varchar (30) NOT NULL,
    Address varchar (30)
)
```

Code Snippet 13 creates a table named **Employee_Salary_Details**.

Code Snippet 13:

```
CREATE TABLE Employee_Salary_Details
(
    EmpID int NOT NULL,
    Designation varchar (30),
    Salary int NOT NULL
)
```

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Code Snippet 14 creates a view `Employee_Details_View` using columns from the `Employee_Personal_Details` and `Employee_Salary_Details` tables by joining the two tables on the `EmpID` column.

Code Snippet 14:

```
CREATE VIEW Employee_Details_View  
AS  
SELECT e1.EmpID, FirstName, LastName, Designation, Salary  
FROM Employee_Personal_Details e1  
JOIN Employee_Salary_Details e2  
ON e1.EmpID = e2.EmpID
```

You must do the things you think you cannot do.

Code Snippet 15 creates an INSTEAD OF DELETE trigger **Delete_Employees** on the view **Employee_Details_View**. When a row is deleted from the view, the trigger is activated. It deletes the corresponding records from the base tables of the view, namely, **Employee_Personal_Details** and **Employee_Salary_Details**.

Code Snippet 15:

```
CREATE TRIGGER Delete_Employees
ON Employee_Details_View
INSTEAD OF DELETE
AS
BEGIN
DELETE FROM Employee_Salary_Details WHERE EmpID IN
(SELECT EmpID FROM deleted)
DELETE FROM Employee_Personal_Details WHERE EmpID IN
(SELECT EmpID FROM deleted)
```

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Code Snippet 16 deletes a row from the view `Employee_Details_View` where `EmpID='2'`.

Code Snippet 16:

```
DELETE FROM Employee_Details_View WHERE EmpID='3'
```

12.8 Working with DML Triggers

SQL Server 2012 allows users to create multiple AFTER triggers for each triggering action (such as UPDATE, INSERT, and DELETE) on a table. However, the user can create only one INSTEAD OF trigger for each triggering action on a table.

When users have multiple AFTER triggers on a triggering action, all of these triggers must have a different name. An AFTER trigger can include a number of SQL statements that perform different functions.

The image shows a person in a dark suit jacket holding a white tablet. The tablet screen displays a 6x8 grid of 48 small, square profile pictures of various people's faces. To the left of the tablet, there is promotional text for 'Onlinevarsity'.

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GROUPS

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Figure 12.6 displays the types of DML Triggers.

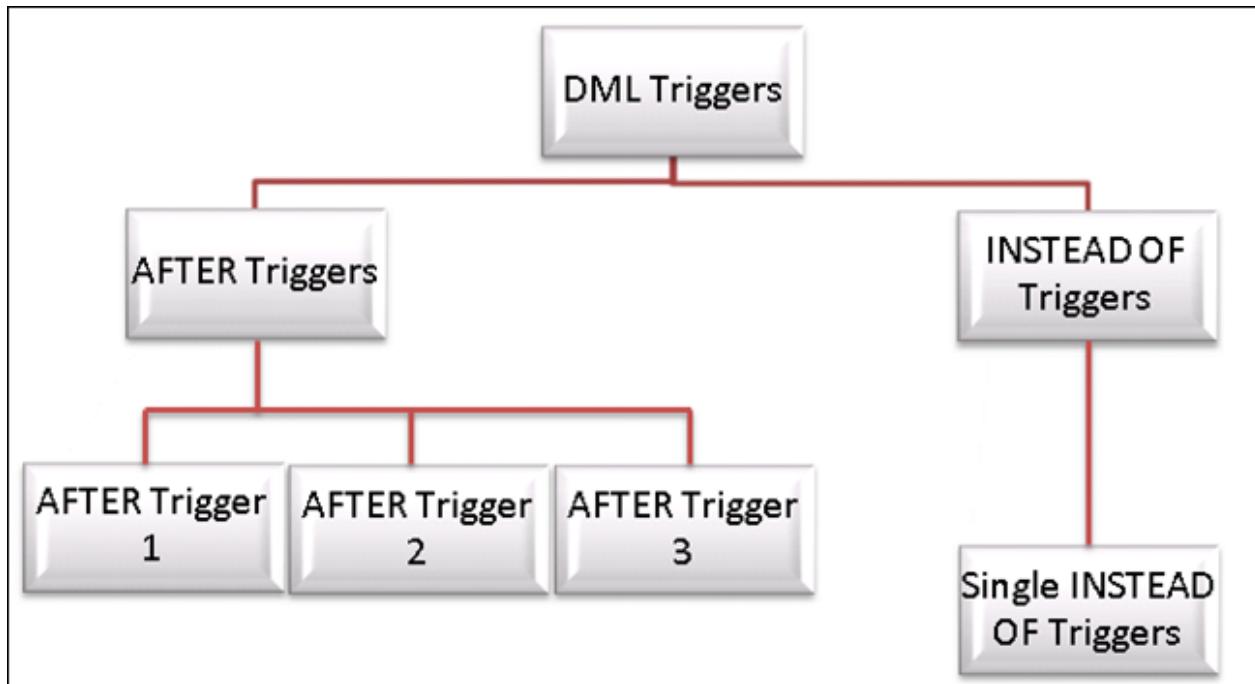


Figure 12.6: Types of DML Triggers

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Note - A single AFTER trigger can be invoked by more than one triggering action.

→ **Execution Order of DML Triggers**

SQL Server 2012 allows users to specify which AFTER trigger is to be executed first and which is to be executed last. All AFTER triggers invoked between the first and last triggers have no definite order of execution.

All the triggering actions have a first and last trigger defined for them. However, no two triggering actions on a table can have the same first and last triggers.

Users can use the `sp_settriggerorder` stored procedure to define the order of DML AFTER triggers.

*Woe to him who teaches men faster
than they can learn.*

Figure 12.7 displays the execution order of DML Triggers.

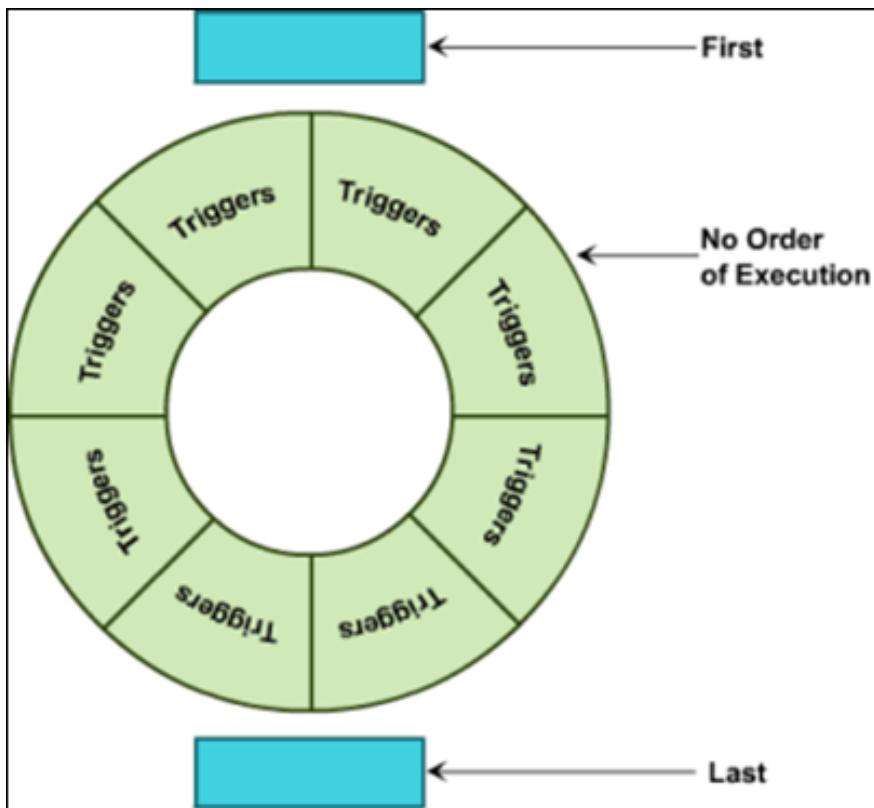


Figure 12.7: Execution Order of DML Triggers

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Following is the syntax for specifying execution order of multiple AFTER DML triggers.

Syntax:

```
sp_settriggerorder [ @triggername = ] ' [ triggerschema.] triggername '
, [ @order = ] 'value'
, [ @stmttype = ] 'statement_type'
```

where,

[triggerschema.] triggername: is the name of the DML or DDL trigger and the schema to which it belongs and whose order needs to be specified.

value: specifies the execution order of the trigger as FIRST, LAST, or NONE. If FIRST is specified, then the trigger is fired first. If LAST is specified, the trigger is fired last. If NONE is specified, the order of the firing of the trigger is undefined.

statement_type: specifies the type of SQL statement (INSERT, UPDATE, or DELETE) that invokes the DML trigger.

Code Snippet 17 first executes the **Employee_Deletion** trigger defined on the table when the DELETE operation is performed on the **Withdrawal** column of the table.

Code Snippet 17:

```
EXEC sp_settriggerorder @triggername = 'Employee_Deletion ', @order =
'FIRST', @stmttype = 'DELETE'
```



12.8.1 Viewing Definitions of DML Triggers

A trigger definition includes the trigger name, the table on which the trigger is created, the triggering actions, and the SQL statements that are executed. SQL Server 2012 provides `sp_helptext` stored procedure to retrieve the trigger definitions.

The DML trigger name must be specified as the parameter when executing `sp_helptext`. Figure 12.8 displays the definitions of DML triggers.

Note - Trigger definition cannot be viewed if the definition is encrypted.

Following is the syntax for viewing a DML trigger.

Syntax:

```
sp_helptext '<DML_trigger_name>'
```

where,

`DML_trigger_name`: specifies the name of the DML trigger whose definitions are to be displayed.

Code Snippet 18 displays the definitions of the trigger, `Employee_Deletion`, created on the table.

Code Snippet 18:

```
sp_helptext 'Employee_Deletion'
```

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12.8.2 Modifying Definitions of DML Triggers

Trigger parameters are defined at the time of creating a trigger. These parameters include the type of triggering action that invokes the trigger and the SQL statements that are executed.

If the user wants to modify any of these parameters for a DML trigger, a user can do so in any one of two ways:

- ➔ Drop and re-create the trigger with the new parameters.
- ➔ Change the parameters using the ALTER TRIGGER statement.

If the object referencing a DML trigger is renamed, the trigger must be modified to reflect the change in object name.

Note - A DML trigger can be encrypted to hide its definition.

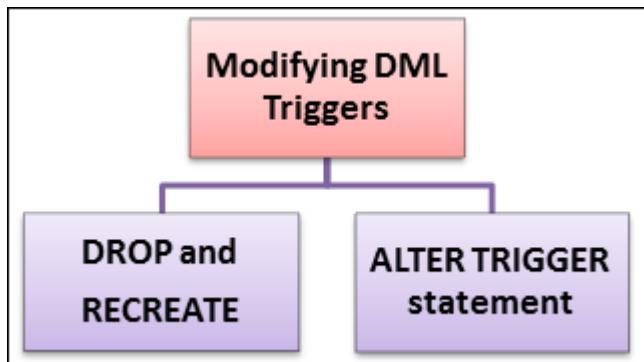


Figure 12.8: Modifying DML Triggers

*Real generosity towards the future lies
in giving all to the present.*

Following is the syntax for modifying a DML trigger.

Syntax:

```
ALTER TRIGGER <trigger_name>
ON { <table_name> | <view_name> }
[WITH ENCRYPTION]
{ FOR | AFTER | INSTEAD OF }
{ [ INSERT ] [ , ] [ UPDATE ] [ , ] [ DELETE ] }
AS <sql_statement>
```

where,

WITH ENCRYPTION: specifies that the DML trigger definitions are not displayed.

FOR | AFTER: specifies that the DML trigger executes after the modification operations are complete.

INSTEAD OF: specifies that the DML trigger executes in place of the modification operations.

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Code Snippet 19 alters the **CheckEmployeeID** trigger created on the **EmployeeDetails** table using the WITH ENCRYPTION option.

Code Snippet 19:

```
ALTER TRIGGER CheckEmployeeID
ON EmployeeDetails
WITH ENCRYPTION
FOR INSERT
AS
IF 'E01' IN (SELECT EmployeeID FROM inserted)
BEGIN
PRINT 'User cannot insert the customers of Austria'
ROLLBACK TRANSACTION
END
```

Now, if the user tries to view the definition of the **CheckEmployeeID** trigger using the **sp_helptext** stored procedure, the following error message is displayed:

The text for object CheckEmployeeID is encrypted.



12.8.3 Dropping DML Triggers

SQL Server 2012 provides the option of dropping a DML trigger created on a table if the trigger is no longer required. The trigger can be dropped using the `DROP TRIGGER` statement. Multiple triggers can also be dropped using a single drop trigger statement.

When a table is dropped, all the triggers defined on that table are also dropped.

Figure 12.9 depicts the concept of dropped DML triggers.

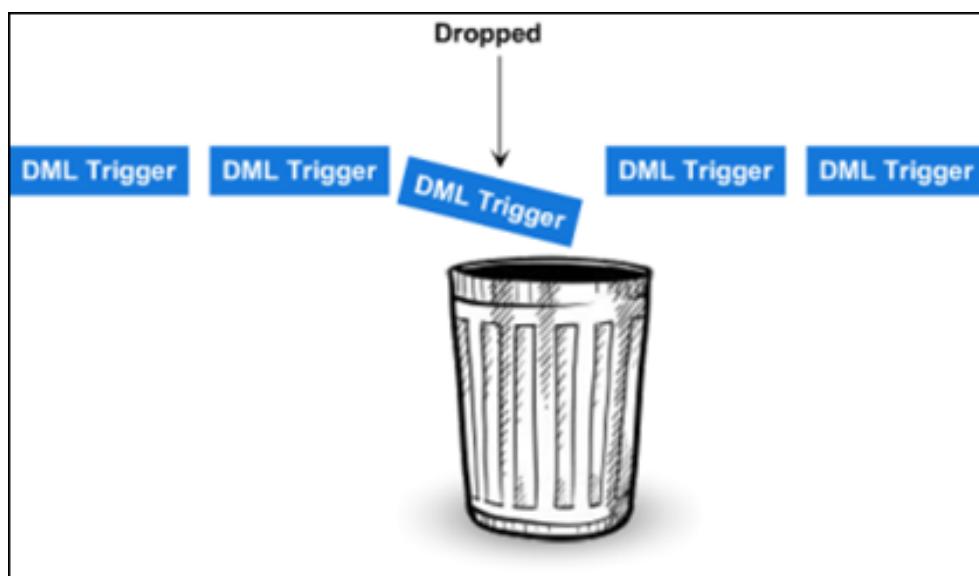


Figure 12.9: Dropping DML Triggers

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Note - When the DML trigger is deleted from the table, the information about the trigger is also removed from the catalog views.

Following is the syntax for dropping DML triggers.

Syntax:

```
DROP TRIGGER <DML_trigger_name> [ ,...n ]
```

where,

DML_trigger_name: specifies the name of the DML trigger to be dropped.

[,...n]: specifies that multiple DML triggers can be dropped.

Code Snippet 20 drops the `CheckEmployeeID` trigger created on the `EmployeeDetails` table.

Code Snippet 20:

```
DROP TRIGGER CheckEmployeeID
```

Knowledge is not enough; we must apply. Willing is not enough; we must do.

12.9 DDL Triggers

A Data Definition Language (DDL) triggers execute stored procedures when DDL events such as CREATE, ALTER, and DROP statements occur in the database or the server. DDL triggers can operate only on completion of the DDL events.

DDL triggers can be used to prevent modifications in the database schema. A schema is a collection of objects such as tables, views, and so forth in a database.

DDL triggers can invoke an event or display a message based on the modifications attempted on the schema. DDL triggers are defined either at the database level or at the server level. Figure 12.10 displays the types of DDL triggers.

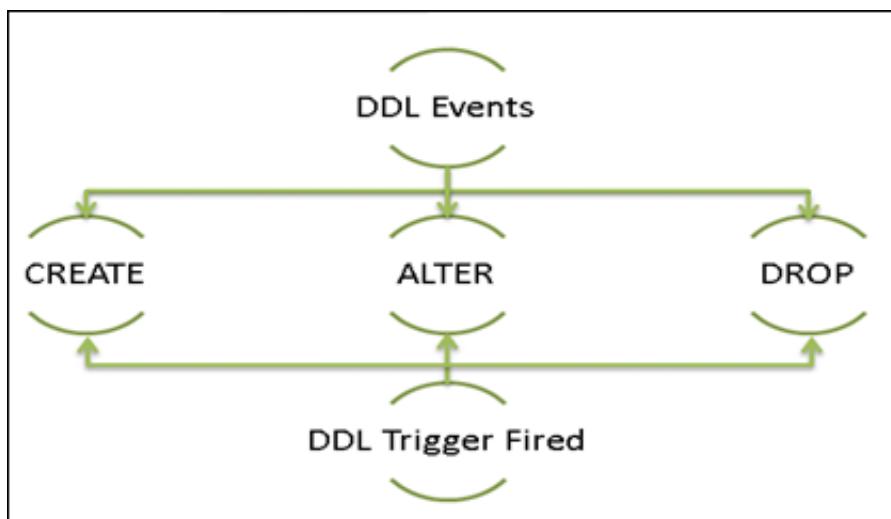


Figure 12.10: DDL Triggers

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Following is the syntax for creating DDL triggers.

Syntax:

```
CREATE TRIGGER<trigger_name>
ON { ALL SERVER | DATABASE }
[WITH ENCRYPTION]
{ FOR | AFTER } { <event_type> }
AS<sql_statement>
```

where,

ALL SERVER: specifies that the DDL trigger executes when DDL events occur in the current server.

DATABASE: specifies that the DDL trigger executes when DDL events occur in the current database.

event_type: specifies the name of the DDL event that invokes the DDL trigger.



Code Snippet 21 creates a DDL trigger for dropping and altering a table.

Code Snippet 21:

```
CREATE TRIGGER Secure
ON DATABASE
FOR DROP_TABLE, ALTER_TABLE
AS
PRINT 'You must disable Trigger "Secure" to drop or alter tables!'
ROLLBACK;
```

In this code, the DDL trigger is created for `DROP TABLE` and `ALTER TABLE` statements.

12.9.1 Scope of DDL Triggers

DDL triggers are invoked by SQL statements executed either in the current database or on the current server. For example, a DDL trigger created for a `CREATE TABLE` statement executes on the `CREATE TABLE` event in the database. A DDL trigger created for a `CREATE LOGIN` statement executes on the `CREATE LOGIN` event in the server.

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The scope of the DDL trigger depends on whether the trigger executes for database events or server events. Accordingly, the DDL triggers are classified into two types, which are as follows:

→ **Database-Sscoped DDL Triggers**

Database-scoped DDL triggers are invoked by the events that modify the database schema. These triggers are stored in the database and execute on DDL events, except those related to temporary tables.

→ **Server-Sscoped DDL Triggers**

Server-scoped DDL triggers are invoked by DDL events at the server level. These triggers are stored in the `master` database.

*Don't just learn the tricks of the trade,
learn the trade.*

Figure 12.11 displays the scope of DDL triggers.

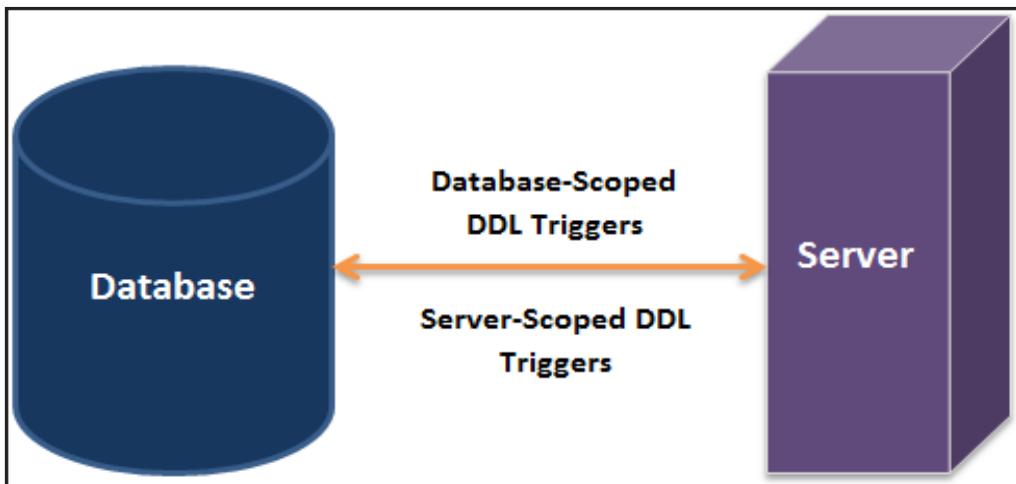


Figure 12.11: Scope of DDL Triggers

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12.10 Nested Triggers

Both DDL and DML triggers are nested when a trigger implements an action that initiates another trigger. DDL and DML triggers can be nested up to 32 levels. Suppose if a trigger modifies a table on which there is another trigger, the second trigger is initiated, which then calls a third trigger, and so on.

If the nested triggers are allowed, then the triggers in the sequence start an infinite loop. This will exceed the nesting level and the trigger will terminate.

Nested triggers can be used to perform the functions such as storing the backup of the rows that are affected by the previous actions.

A Transact-SQL trigger executes the managed code through referencing a CLR routine, aggregate, or type, that references the counts as one level against the 32-level nesting limit. Methods which are invoked from within managed code are not counted against this limit.

Users can disable nested triggers, by setting the nested triggers option of `sp_configure` to 0 or off. The default configuration is allowed for nested triggers. If nested trigger option is off, then the recursive trigger is disabled, irrespective of the recursive triggers setting that is set by using the `ALTER DATABASE`.



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Code Snippet 22 creates an AFTER DELETE trigger named **Employee_Deletion** on the **Employee_Personal_Details** table.

Code Snippet 22:

```
CREATE TRIGGER Employee_Deletion
ON Employee_Personal_Details
AFTER DELETE
AS
BEGIN
PRINT 'Deletion will affect Employee_Salary_Details table'
DELETE FROM Employee_Salary_Details WHERE EmpID IN
(SELECT EmpID FROM deleted)
END
```

When a record is deleted from the **Employee_Personal_Details** table, the **Employee_Deletion** trigger is activated and a message is displayed. Also, the record of the employee is deleted from the **Employee_Salary_Details** table.

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Code Snippet 23 creates an AFTER DELETE trigger **Deletion_Confirmation** on the **Employee_Salary_Details** table.

Code Snippet 23:

```
CREATE TRIGGER Deletion_Confirmation
ON Employee_Salary_Details
AFTER DELETE
AS
BEGIN
PRINT 'Employee details successfully deleted from Employee_Salary_Details table'
END
DELETE FROM Employee_Personal_Details WHERE EmpID=1
```

When a record is deleted from the **Employee_Salary_Details** table, the **Deletion_Confirmation** trigger is activated. This trigger prints the confirmation message of the record being deleted.

Thus, the **Employee_Deletion** and the **Deletion_Confirmation** triggers are seen to be nested.

Practice is the best of all instructors.

12.11 UPDATE()

UPDATE () function returns a Boolean value that specifies whether an UPDATE or INSERT action was performed on a specific view or column of a table.

UPDATE () function can be used anywhere inside the body of a Transact-SQL UPDATE or INSERT trigger to test whether the trigger should execute some actions.

Following is the syntax for UPDATE () .

Syntax:

```
UPDATE (column)
```

where,

column: is the name of the column to test for either an INSERT or UPDATE action.

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Code Snippet 24 creates a trigger **Accounting** on the **Account_Transactions** table to update the columns **TransactionID** OR **EmployeeID**.

Code Snippet 24:

```
CREATE TRIGGER Accounting
ON Account_Transactions
AFTER UPDATE
AS
IF ( UPDATE (TransactionID) OR UPDATE (EmployeeID) )
BEGIN
RAISERROR (50009, 16, 10)
END;
GO
```

12.12 Handling of Multiple Rows in a Session

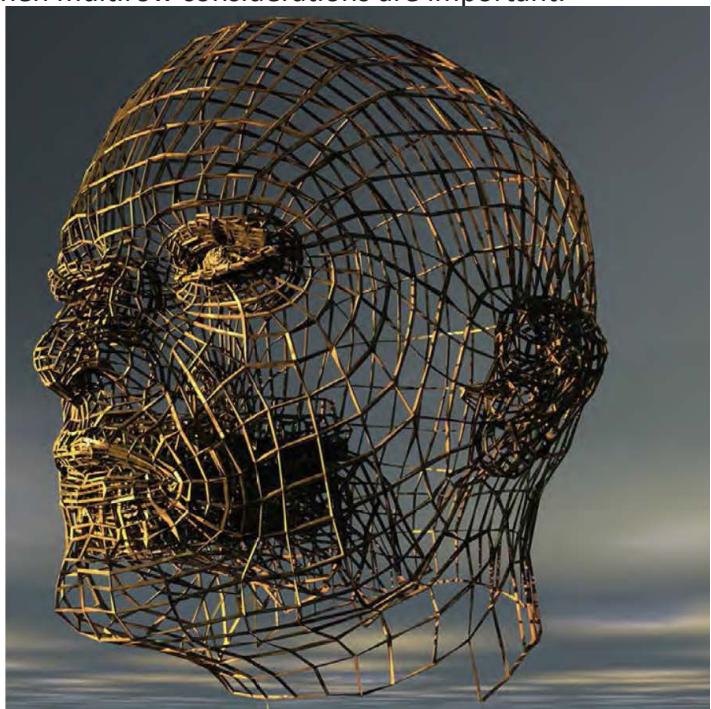
When a user writes the code for a DML trigger, then the statement that causes the trigger to fire will be single statement. This single statement will affect multiple rows of data, instead of a single row. This is a common behavior for **DELETE** and **UPDATE** triggers as these statements often affect multiple rows. The behavior for **INSERT** triggers is less common as the basic **INSERT** statement adds only one row.

When the functionality of a DML trigger involves automatically recalculating summary values of one table and storing the result in another table, then multirow considerations are important.

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Code Snippet 25 stores a running total for a single-row insert.

Code Snippet 25:

```
USE AdventureWorks2012;
GO
CREATE TRIGGER PODetails
ON Purchasing.PurchaseOrderDetail
AFTER INSERT AS
    UPDATE PurchaseOrderHeader
    SET SubTotal = SubTotal + LineTotal
    FROM inserted
    WHERE PurchaseOrderHeader.PurchaseOrderID = inserted.PurchaseOrderID;
```

In this code, the subtotal is calculated and stored for a single-row insert operation.

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Code Snippet 26 stores a running total for a multi-row or single-row insert.

Code Snippet 26:

```
USE AdventureWorks2012;
GO
CREATE TRIGGER PODetailsMultiple
ON Purchasing.PurchaseOrderDetail
AFTER INSERT AS
    UPDATE Purchasing.PurchaseOrderHeader
    SET SubTotal = SubTotal +
        (SELECT SUM(LineTotal)
        FROM inserted
        WHERE PurchaseOrderHeader.PurchaseOrderID
        = inserted.PurchaseOrderID)
    WHERE PurchaseOrderHeader.PurchaseOrderID IN
        (SELECT PurchaseOrderID FROM inserted);
```

In this code, the subtotal is calculated and stored for a multi-row or single-row insert operation.

It is hard to fail, but it is worse never to have tried to succeed.

12.13 Performance Implication of Triggers

In reality, triggers do not carry overheads, rather they are quite responsive. However, many performance issues can occur because of the logic present inside the trigger. Suppose a trigger creates a cursor and loops through many rows, then there will be a slowdown in the process.

Similarly, consider that the trigger executes various SQL statements against other tables separate from the `Inserted` and `Deleted` tables. This will again result in the slowdown of the speed of the SQL statements that are within the trigger.

A good rule will be to keep the logic simple within the triggers and avoid using cursors while executing statements against another table and different tasks that cause performance slowdown.

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12.14 Check Your Progress

1. Which of these statements about triggers in SQL Server 2012 are true?

a.	Triggers retrieve information from tables of the same as well as other databases.	c.	DML triggers execute on INSERT, UPDATE, and DELETE statements.
b.	DDL triggers operate only after a table or a view is modified.	d.	DDL triggers execute either while modifying the data or after the data is modified.

(A)	a, b, c	(C)	a, b ,d
(B)	b, c, d	(D)	a, c, d

2. Match the types of DML triggers in SQL Server 2012 against their corresponding descriptions.

	Description		DML Trigger
a.	Executes when users replace an existing record with a new value.	1.	INSERT
b.	Executes on completion of the modification operations.	2.	UPDATE
c.	Executes in place of the modification operations.	3.	DELETE
d.	Executes when users add a record on a table.	4.	AFTER
e.	Executes when users remove a record from a table.	5.	INSTEAD OF

(A)	a-1, b-4, c-2, d-3, e-5	(C)	a-2, b-4, c-3, d-5, e-1
(B)	a-2, b-4, c-5, d-1, e-3	(D)	a-1, b-2, c-3, d-4, e-5

3. Which of these statements about DML triggers in SQL Server 2012 are true?

a.	DML triggers can perform multiple actions for each modification statement.	c.	UPDATE triggers do not use the Deleted table to update records in a table.
b.	The Inserted and Deleted tables are created by SQL Server 2012 when a new table is created in the database.	d.	Deleted triggers do not use the Inserted table to delete records from a table.

(A)	a, b	(C)	a, d
(B)	c, d	(D)	b, d

4. Which of these statements about the working with DML triggers of SQL Server 2012 are true?

a.	Each triggering action cannot have multiple AFTER triggers.	c.	DML trigger definition can be modified by dropping and recreating the trigger.
b.	Two triggering actions on a table can have the same first and last triggers.	d.	DML trigger definition can be viewed using the sp_helptext stored procedure.

(A)	a, c	(C)	b, d
(B)	b, c	(D)	c, d

5. _____ triggers can be used to perform the functions such as storing the backup of the rows that are affected by the previous actions.

(A)	Nested	(C)	DDL
(B)	DML	(D)	INSTEAD OF

12.14.1 Answers

1.	A
2.	B
3.	C
4.	D
5.	A



Summary

- A trigger is a stored procedure that is executed when an attempt is made to modify data in a table that is protected by the trigger.
- Logon triggers execute stored procedures when a session is established with a LOGON event.
- DML triggers are executed when DML events occur in tables or views.
- The INSERT trigger is executed when a new record is inserted in a table.
- The UPDATE trigger copies the original record in the Deleted table and the new record into the Inserted table when a record is updated.
- The DELETE trigger can be created to restrict a user from deleting a particular record in a table.
- The AFTER trigger is executed on completion of INSERT, UPDATE, or DELETE operations.



Try It Yourself

1. **Galaxy Airlines** is a newly launched airline service that operates flights to and from various cities all over Europe. The company maintains the data pertaining to day-to-day transactions regarding flight services in SQL Server 2012 databases. To enable efficient and faster performance, **Galaxy Airlines** has decided to incorporate use of triggers in their database applications. The detailed list of operations to be performed are listed as follows:
 - a. Create the following tables in **GalaxyAirlines** database. Table 12.2 lists the **Flight** table.

Field Name	Data Type	Key Field	Description
Aircraft_code	varchar(10)	Primary key	Stores aircraft code
Type	varchar(6)		Describes the type of aircraft
Source	varchar(20)		Stores the name of the city from where the aircraft will depart
Destination	varchar(20)		Stores the name of the city where the aircraft will arrive
Dep_time	varchar(10)		Stores departure time
Journey_hrs	int		Stores journey hours

Table 12.2: Flight Table

Table 12.3 lists the **Flight_Details** table.

Field Name	Data Type	Key Field	Description
Class_Code	varchar(10)	Primary key	Stores the class, whether first, business or economy
Aircraft_code	varchar(10)	Foreign key	Stores aircraft code
Fare	money		Stores the fare amount
Seats	int		Stores total number of seats on the flight

Table 12.3: Flight_Details Table

- b. Write statements to create a trigger **trgCheckSeats** that will activate whenever a new row is being inserted into the **Flight_Details** table. The maximum limit of seats that a flight can contain is **150**. The trigger should check for the value of seats being inserted. If it is more than 150, the INSERT operation is not allowed to succeed.

Try It Yourself

- c. Insert at least five records in each table.
- d. Write statements to create a trigger **UpdateValid** that will activate whenever a row is being updated in the **Flight_Details** table. The trigger should determine if the Seats column is present in the list of columns being updated. If yes, the UPDATE operation should not succeed because the Seats column is defined as a constant and cannot be changed.
- e. Write statements to create a DDL trigger **ProhibitDelete** that will activate whenever a user is trying to delete a table from the **Galaxy Airlines** database. The trigger must not allow a user to perform deletes and must display a message "You are not allowed to delete tables in this database".

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Session - 13

Programming Transact-SQL

Welcome to the Session, **Programming Transact-SQL**.

This session introduces programming with Transact-SQL and describes various Transact-SQL programming elements. The session also describes program flow statements, Transact-SQL functions, and so on. The session further explains the procedure to create and alter user-defined functions, and create windows using the OVER and window functions.

In this Session, you will learn to:

- Describe an overview of Transact-SQL programming
- Describe the Transact-SQL programming elements
- Describe program flow statements
- Describe various Transact-SQL functions
- Explain the procedure to create and alter user-defined functions (UDFs)
- Explain creation of windows with OVER
- Describe window functions

13.1 Introduction

Transact-SQL programming is a procedural language extension to SQL. Transact-SQL programming is extended by adding the subroutines and programming structures similar to high-level languages. Like high-level languages, Transact-SQL programming also has rules and syntax that control and enable programming statements to work together. Users can control the flow of programs by using conditional statements such as IF and loops such as WHILE.

13.2 Transact-SQL Programming Elements

Transact-SQL programming elements enable to perform various operations that cannot be done in a single statement. Users can group several Transact-SQL statements together by using one of the following ways:

→ **Batches**

A batch is a collection of one or more Transact-SQL statements that are sent as one unit from an application to the server.

→ **Stored Procedures**

A stored procedure is a collection of Transact-SQL statements that are precompiled and predefined on the server.

*The future depends on what we do in
the present.*

→ Triggers

A trigger is a special type of stored procedure that is executed when the user performs an event such as an `INSERT`, `DELETE`, or `UPDATE` operation on a table.

→ Scripts

A script is a chain of Transact-SQL statements stored in a file that is used as input to the SSMS code editor or `sqlcmd` utility.

Following features enable users to work with Transact-SQL statements:

→ Variables

A variable allows a user to store data that can be used as input in a Transact-SQL statement.

→ Control-of-flow

Control-of-flow is used for including conditional constructs in Transact-SQL.

→ Error Handling

Error handling is a mechanism that is used for handling errors and provides information to the users about the error occurred.

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13.2.1 Transact-SQL Batches

A Transact-SQL batch is a group of one or more Transact-SQL statements sent to the server as one unit from an application for execution. SQL Server compiles the batch SQL statements into a single executable unit, also called as an execution plan. In the execution plan, the SQL statements are executed one by one. A Transact-SQL batch statement should be terminated with a semicolon. This condition is not mandatory, but the facility to end a statement without a semicolon is deprecated and may be removed in the new versions of SQL Server in the future. Hence, it is recommended to use semicolons to terminate batches.

A compile error such as syntax error restricts the compilation of the execution plan. So, if a compile-time error occurs, no statements in the batch are executed.

A run-time error such as a constraint violation or an arithmetic overflow has one of the following effects:

- Most of the run-time errors stop the current statement and the statements that follow in the batch.
- A specific run-time error such as a constraint violation stops only the existing statement and the remaining statements in the batch are executed.

The SQL statements that execute before the run-time error is encountered are unaffected. The only exception is when the batch is in a transaction and the error results in the transaction being rolled back.



For example, suppose there are 10 statements in a batch and the sixth statement has a syntax error, then the remaining statements in the batch will not execute. If the batch is compiled and the third statement fails to run, then, the results of the first two statements remains unaffected as it is already executed.

Following rules are applied to use batches:

1. CREATE FUNCTION, CREATE DEFAULT, CREATE RULE, CREATE TRIGGER, CREATE PROCEDURE, CREATE VIEW, and CREATE SCHEMA statements cannot be jointly used with other statements in a batch. The CREATE SQL statement starts the batch and all other statements that are inside the batch will be considered as a part of the CREATE statement definition.
2. No changes are made in the table and the new columns reference the same batch.
3. If the first statement in a batch has the EXECUTE statement, then, the EXECUTE keyword is not required. It is required only when the EXECUTE statement does not exist in the first statement in the batch.

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Code Snippet 1 creates a view in a batch.

Code Snippet 1:

```
USE AdventureWorks2012;
GO
CREATE VIEW dbo.vProduct
AS
SELECT ProductNumber, Name
FROM Product;
GO
SELECT *
FROM dbo.vProduct;
GO
```

In this code snippet, a view is created in a batch. The `CREATE VIEW` is the only statement in the batch, the `GO` commands are essential to separate the `CREATE VIEW` statement from the `SELECT` and `USE` statements. This was a simple example to demonstrate the use of a batch. In the real-world, a large number of statements may be used within a single batch. It is also possible to combine two or more batches within a transaction.

*Action may not always bring happiness,
but there is no happiness without
action.*

Code Snippet 2 shows an example of this.

Code Snippet 2:

```
BEGIN TRANSACTION
GO
USE AdventureWorks2012;
GO
CREATE TABLE Company
(
Id_Num int IDENTITY(100, 5),
Company_Name nvarchar(100)
)
GO
INSERT Company (Company_Name)
VALUES (N'A Bike Store')
INSERT Company (Company_Name)
VALUES (N'Progressive Sports')
INSERT Company (Company_Name)
VALUES (N'Modular Cycle Systems')
INSERT Company (Company_Name)
VALUES (N'Advanced Bike Components')
INSERT Company (Company_Name)
VALUES (N'Metropolitan Sports Supply')
INSERT Company (Company_Name)
VALUES (N'Aerobic Exercise Company')
INSERT Company (Company_Name)
VALUES (N'Associated Bikes')
INSERT Company (Company_Name)
VALUES (N'Exemplary Cycles')
GO
SELECT Id_Num, Company_Name
FROM dbo. Company
ORDER BY Company_Name ASC;
GO
COMMIT;
GO
```

In this code snippet, several batches are combined into one transaction. The `BEGIN TRANSACTION` and `COMMIT` statements enclose the transaction statements. The `CREATE TABLE`, `BEGIN TRANSACTION`, `SELECT`, `COMMIT`, and `USE` statements are in single-statement batches. The `INSERT` statements are all included in one batch.

13.2.2 Transact-SQL Variables

Variables allow users to store data for using as input in a Transact-SQL statement. For example, users can create a query that requires various types of data values specified in the `WHERE` clause each time the query is executed. Here, the users can use variables in the `WHERE` clause, and write the logic to store the variables with the appropriate data.

SQL Server provides the following statements to set and declare local variables.

→ **DECLARE**

Variables are declared with the `DECLARE` statement in the body of a batch. These variables are assigned values by using the `SELECT` or `SET` statement. The variables are initialized with `NULL` values if the user has not provided a value at the time of the declaration.



Following is the basic syntax to declare a local variable.

Syntax:

```
DECLARE {{ @local_variable [AS] data_type } | [=value] }
```

where,

`@local_variable`: specifies the name of the variables and begins with `@` sign.

`data_type`: specifies the data type. A variable cannot be of `image`, `text`, or `ntext` data type.

`=value`: Assigns an inline value to a variable. The value can be an expression or a constant value. The value should match with the variable declaration type or it should be implicitly converted to that type.

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Code Snippet 3 uses a local variable to retrieve contact information for the last names starting with Man.

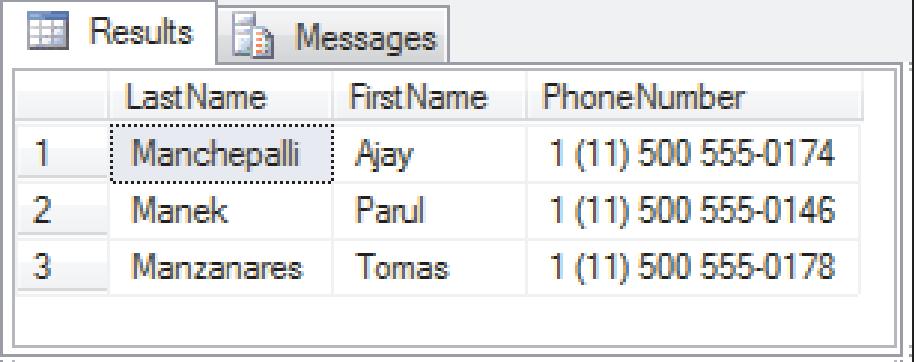
Code Snippet 3:

```
USE AdventureWorks2012;
GO
DECLARE @find varchar(30) = 'Man%';
SELECT p.LastName, p.FirstName, ph.PhoneNumber
FROM Person.Person AS p
JOIN Person.PersonPhone AS ph ON p.BusinessEntityID = ph.BusinessEntityID
WHERE LastName LIKE @find;
```

In this code snippet, a local variable named @find is used to store the search criteria, which will be then, used to retrieve the contact information. Here, the criteria include all last names beginning with Man.

First say to yourself what you would be; and then do what you have to do.

Figure 13.1 displays the output.



The screenshot shows the SSMS interface with the 'Results' tab selected. The results grid displays three rows of data with columns: Last Name, First Name, and Phone Number. The data is as follows:

	Last Name	First Name	Phone Number
1	Manchepalli	Ajay	1 (11) 500 555-0174
2	Manek	Parul	1 (11) 500 555-0146
3	Manzanares	Tomas	1 (11) 500 555-0178

Figure 13.1: Contact Information

→ SET

The `SET` statement sets the local variable created by the `DECLARE` statement to the specified value.

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Following is the basic syntax to set a local variable.

Syntax:

```
SET
{ @local_variable = { expression }
}
|
{ @local_variable
{ += | -= | *= | /= | %= | &= | ^= | |= } expression
}
```

where,

`@local_variable`: specifies the name of the variable and begins with `@` sign.

`=`: Assigns the value on the right-hand side to the variable on the left-hand side.

`{ = | += | -= | *= | /= | %= | &= | ^= | |= }`: specifies the compound assignment operators. They are as follows:

`+=` Add and then, assign

`-=` Subtract and then, assign

`*=` Multiply and then, assign

`/=` Divide and then, assign

`%=` Modulo and then, assign

`&=` Bitwise AND and then, assign

`^=` Bitwise XOR and then, assign

`|=` Bitwise OR and then, assign

`expression`: specifies any valid expression which can even include a scalar subquery.

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WORKING
PROFESSIONAL**



Code Snippet 4 demonstrates the use of `SET` to assign a string value to a variable.

Code Snippet 4:

```
DECLARE @myvar char (20);
SET @myvar = 'This is a test';
```

In this code snippet, the `@myvar` variable is assigned a string value.

→ SELECT

The `SELECT` statement indicates that the specified local variable that was created using `DECLARE` should be set to the given expression.

Following is the syntax of the `SELECT` statement.

Syntax:

```
SELECT { @local_variable { = | += | -= | *= | /= | %= | &= | ^= | |= } expression } [ ,...n ] [ ; ]
```

where,

`@local_variable`: specifies the local variable to which a value will be assigned.

`=`: Assigns the value on the right-hand side to the variable on the left-hand side.

`{ = | += | -= | *= | /= | %= | &= | ^= | |= }`: specifies the compound assignment operators.

`expression`: specifies any valid expression which can even include a scalar subquery.

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Code Snippet 5 shows how to use SELECT to return a single value.

Code Snippet 5:

```
USE AdventureWorks2012 ;
GO
DECLARE @var1 nvarchar(30) ;
SELECT @var1 = 'Unnamed Company' ;

SELECT @var1 = Name
FROM Sales.Store
WHERE BusinessEntityID = 10;

SELECT @var1 AS 'Company Name';
```

In this code snippet, the variable @var1 is assigned Unnamed Company as its value.

The query against the Store table will return zero rows as the value specified for the BusinessEntityID does not exist in the table. The variable will then, retain the Unnamed Company value and will be displayed with the heading Company Name. Figure 13.2 displays the output.

	Company Name
1	Unnamed Company

Figure 13.2: Generic Name

Learning how to learn is life's most important skill.

Though both the SET and SELECT statements look similar, they are not. Here are a few differences between the two:

- It is possible to assign only one variable at a time using SET. However, using SELECT you can make multiple assignments at once.
- SET can only assign a scalar value when assigning from a query. It raises an error and does not work if the query returns multiple values/rows. However, SELECT assigns one of the returned values to the variable and the user will not even know that multiple values were returned.

Note - To assign variables, it is recommended to use `SET @local_variable` instead of `SELECT @local_variable`.

13.3 Synonyms

Synonyms are database objects that serve the following purposes:

- They offer another name for a different database object, also called as the base object, which may exist on a remote or local server.
- They present a layer of abstraction that guards a client application from the modifications made to the location and the name of the base object.

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For example, consider that the `Department` table of `AdventureWorks2012` is located on the first server named `Server1`. To reference this table from the second server, `Server2`, a client application would have to use the four-part name `Server1.AdventureWorks2012.Person.Department`. If the location of the table was modified, for example, to another server, the client application would have to be rectified to reflect that change. To address both these issues, users can create a synonym, `DeptEmpTable`, on `Server2` for the `Department` table on `Server1`. Now, the client application only has to use the single name, `DeptEmpTable`, to refer to the `Employee` table.

Similarly, if the location of the `Department` table changes, users have to modify the synonym, `DeptEmpTable`, to point to the new location of the `Department` table. Since there is no `ALTER SYNONYM` statement, you first have to drop the synonym, `DeptEmpTable`, and then, re-create the synonym with the same name, but point the synonym to the new location of `Department`.

Note - A synonym is a part of schema, and similar to other schema objects, the synonym name must be unique.

Table 13.1 lists the database objects for which the users can create synonyms.

Database Objects
Extended stored procedure
SQL table-valued function
SQL stored procedure
Table(User-defined)
Replication-filter-procedure
SQL scalar function
SQL inline-tabled-valued function
View

Table 13.1: Database Objects



→ Synonyms and Schemas

Suppose users want to create a synonym and have a default schema that is not owned by them. In such a case, they can qualify the synonym name with the schema name that they actually own. Consider for example that a user owns a schema **Resources**, but **Materials** is the user's default schema. If this user wants to create a synonym, he/she must prefix the name of the synonym with the schema **Resources**.

→ Granting Permissions on Synonyms

Only members of the roles `db_owner` or `db_ddladmin` or synonym owners are allowed to grant permissions on a synonym. Users can deny, grant, or revoke all or any of the permissions on a synonym. Table 13.2 displays the list of permissions that are applied on a synonym.

Permissions
DELETE
INSERT
TAKE OWNERSHIP
VIEW DEFINITION
CONTROL
EXECUTE
SELECT
UPDATE

Table 13.2: Permissions

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→ Working with Synonyms

Users can work with synonyms in SQL Server 2012 using either Transact-SQL or SSMS.

To create a synonym using SSMS, perform the following steps:

1. In **Object Explorer**, expand the database where you want to create a new synonym.
2. Select the **Synonyms** folder, right-click it and then, click **New Synonym...** as shown in figure 13.3.

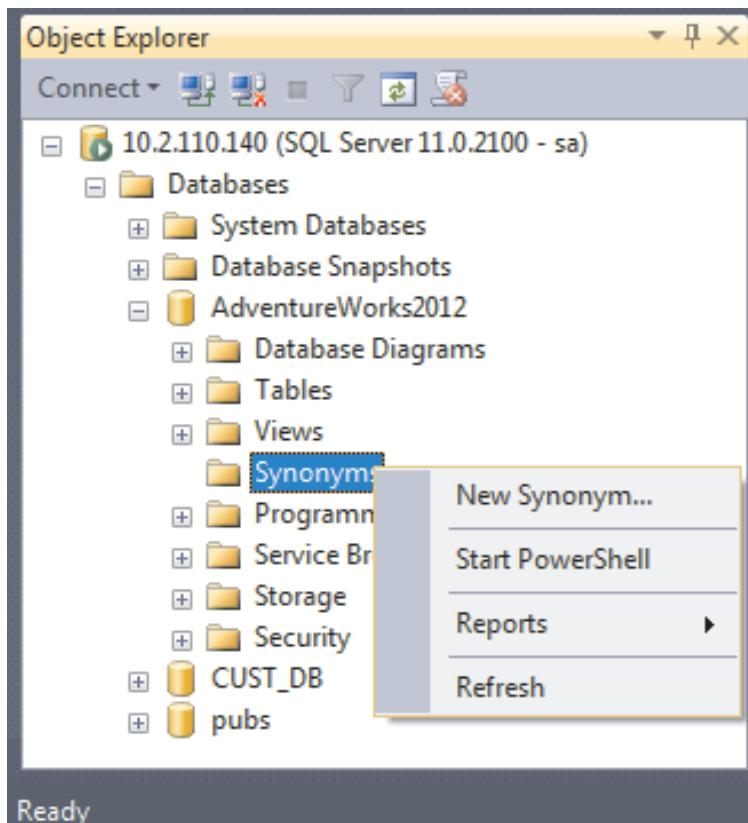


Figure 13.3: Creating a New Synonym

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

3. In the **New Synonym** dialog box, provide the information as shown in figure 13.4.

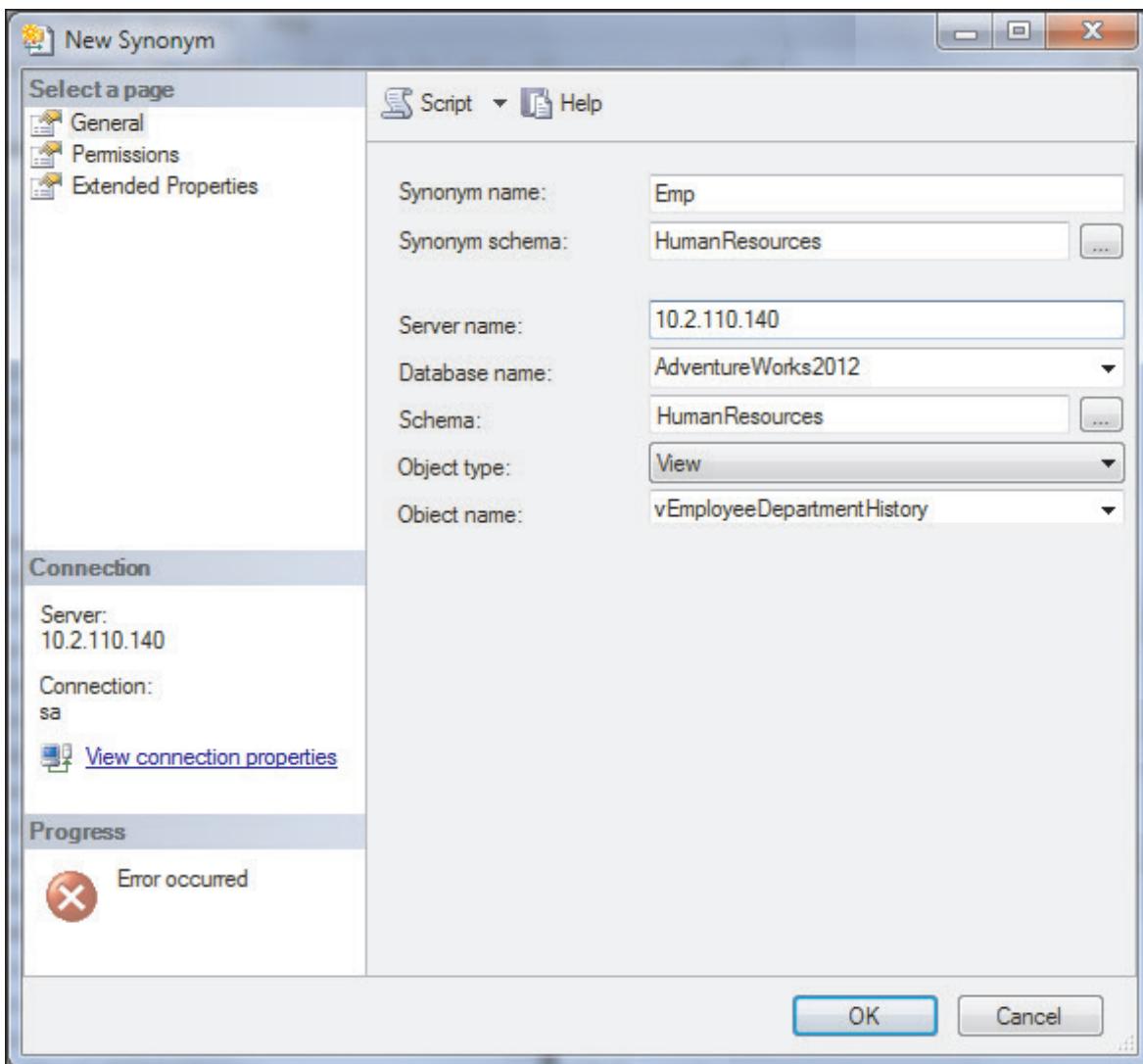


Figure 13.4: Adding Details in the New Synonym Dialog Box

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where,

Synonym name: is the new name for the object. Here, `Emp` is the name.

Synonym schema: is the new name for the schema object. Here, the same schema name `HumanResources` is used for the synonym and the object type.

Server name: is the name of the server to be connected. Here, the server name is specified as `10.2.110.140`.

Database name: is the database name to connect the object. Here, `AdventureWorks2012` is the database name.

Schema: is the schema that owns the object.

Object type and **Object name:** is the object type and name respectively. Here, the object type selected is `view` and the object name that refers the synonym is `vEmployeeDepartmentHistory`.

To create a synonym using Transact-SQL, perform the following steps:

1. Connect to the Database Engine.
2. Click **New Query** in the Standard bar.
3. Write the query to create the synonym in the query window.



Following is the syntax to create a synonym.

Syntax:

```
CREATE SYNONYM [ schema_name_1. ] synonym_name FOR <object>

<object> ::=

{
    [ server_name. [ database_name ] . [ schema_name_2 ] . | database_name . [
        schema_name_2 ] . | schema_name_2. ] object_name
}
```

where,

`schema_name_1`: states that the schema in which the synonym is created.

`synonym_name`: specifies the new synonym name.

`server_name`: specifies the server name where the base object is located.

`database_name`: specifies the database name where the base object is located.

`schema_name_2`: specifies the schema name of the base object.

`object_name`: specifies the base object name, which is referenced by the synonym.

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Code Snippet 6 creates a synonym from an existing table.

Code Snippet 6:

```
USE tempdb;
GO
CREATE SYNONYM MyAddressType
FOR AdventureWorks2012.Person.AddressType;
GO
```

In this code snippet, a synonym is created from an existing table present in the AdventureWorks2012 database.

4. Click **Execute** on the toolbar to complete creation of the synonym.

To learn, you must want to be taught.

13.4 Program Flow Statements

There are different types of program flow statements and functions supported by Transact-SQL. Some of these are as follows:

→ Transact-SQL Control-of-Flow language

Control-of-flow language determines the execution flow of Transact-SQL statements, statement blocks, user-defined functions, and stored procedures.

By default, Transact-SQL statements are executed sequentially, in the order they occur. Control-of-flow language elements allow statements to be executed in a particular order, to be related to each other, and made interdependent using constructs similar to programming languages.

Table 13.3 lists some of the Transact-SQL control-of-flow language keywords.

Control-Of-Flow Language Keywords
RETURN
THROW
TRY....CATCH
WAITFOR
WHILE
BEGIN....END
BREAK
CONTINUE
GOTO label
IF...ELSE

Table 13.3: Keywords

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→ **BEGIN....END**

The BEGIN...END statements surround a series of Transact-SQL statements so that a group of Transact-SQL statements is executed.

Following is the basic syntax for the BEGIN and END statement.

Syntax:

```
BEGIN
{
    sql_statement | statement_block
}
END
```

where,

{ sql_statement| statement_block }: Is any valid Transact-SQL statement that is defined using a statement block.



Code Snippet 7 shows the use of BEGIN and END statements.

Code Snippet 7:

```
USE AdventureWorks2012;
GO
BEGIN TRANSACTION;
GO
IF @@TRANCOUNT = 0
BEGIN
    SELECT FirstName, MiddleName
    FROM Person.Person WHERE LastName = 'Andy';
    ROLLBACK TRANSACTION;
    PRINT N'Rolling back the transaction two times would cause an error.';
END;
ROLLBACK TRANSACTION;
PRINT N'Rolled back the transaction.';
GO
```

In this code snippet, BEGIN and END statements describe a sequence of Transact-SQL statements that are executed together. Suppose the BEGIN and END are not included, then, the ROLLBACK TRANSACTION statements will execute and both the PRINT messages will be displayed.

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→ IF...ELSE

The IF...ELSE statement enforces a condition on the execution of a Transact-SQL statement. The Transact-SQL statement is followed with the IF keyword and the condition executes only if the condition is satisfied and returns TRUE. The ELSE keyword is an optional Transact-SQL statement that executes only when the IF condition is not satisfied and returns FALSE.

Following is the syntax for the IF...ELSE statement.

Syntax:

```
IF Boolean_expression  
{ sql_statement | statement_block }  
[ ELSE  
{ sql_statement | statement_block } ]
```

where,

Boolean_expression: specifies the expression that returns TRUE or FALSE value.

{ sql_statement | statement_block }: Is any Transact-SQL statement or statement grouping that is defined by using a statement block. If a statement block is not used, the IF or ELSE condition can affect the performance of only one Transact-SQL statement. In order to define the statement block, the BEGIN and END keywords are used.

Democritus said, words are but the shadows of actions.

Code Snippet 8 shows the use of IF...ELSE statements.

Code Snippet 8:

```
USE AdventureWorks2012
GO
DECLARE @ListPrice money;
SET @ListPrice = (SELECT MAX(p.ListPrice)
    FROM Production.Product AS p
    JOIN Production.ProductSubcategory AS s
    ON p.ProductSubcategoryID = s.ProductSubcategoryID
    WHERE s.[Name] = 'Mountain Bikes' );
PRINT @ListPrice
IF @ListPrice < 3000
    PRINT 'All the products in this category can be purchased for an amount less
than 3000'
ELSE
    PRINT 'The prices for some products in this category exceed 3000'
```

In this code snippet, the IF...ELSE statement is used to form a conditional statement. First, a variable `@ListPrice` is defined and a query is created to return the maximum list price of the product category Mountain Bikes. Then, this price is compared with a value of 3000 to determine if products can be purchased for an amount less than 3000. If yes, an appropriate message is printed using the first `PRINT` statement. If not, then the second `PRINT` statement executes.

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→ WHILE

The WHILE statement specifies a condition for the repetitive execution of the statement block. The statements are executed repetitively as long as the specified condition is true. The execution of statements in the WHILE loop can be controlled by using the BREAK and CONTINUE keywords.

Following is the syntax for the WHILE statement.

Syntax:

```
WHILE Boolean_expression
  { sql_statement | statement_block | BREAK | CONTINUE }
```

where,

Boolean_expression: specifies the expression that returns TRUE or FALSE values.

{sql_statement | statement_block}: Is any Transact-SQL statement that defines the statement block.

BREAK: Results in an exit from the innermost WHILE loop. Every statement that appears after the END keyword, that marks the end of the loop, is executed.

CONTINUE: Results in the WHILE loop being restarted. The statements after the CONTINUE keyword within the body of the loop are not executed.



Code Snippet 9 shows the use of WHILE statement.

Code Snippet 9:

```
DECLARE @flag int  
SET @flag = 10  
WHILE (@flag <=95)  
BEGIN  
    IF @flag%2 =0  
        PRINT @flag  
    SET @flag = @flag + 1  
    CONTINUE;  
END  
GO
```

Using this code snippet, all the even numbers beginning from 10 until 95 are displayed. This is achieved using a WHILE loop along with an IF statement.

Similarly, a WHILE loop can also be used with queries and other Transact-SQL statements.

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13.5 Transact-SQL Functions

The Transact-SQL functions that are commonly used are as follows:

→ Deterministic and non-deterministic functions

User-defined functions possess properties that define the capability of the SQL Server Database Engine. The Database engine is used to index the result of a function through either computed columns that the function calls or the indexed views that reference the functions. One such property is the determinism of a function.

Deterministic functions return the same result every time they are called with a definite set of input values and specify the same state of the database. Non-deterministic functions return different results every time they are called with specified set of input values even though the database that is accessed remains the same.

For example, if a user calls the `DAY()` function on a particular column, it always returns the numerical day for the date parameter passed in. However, if the user calls the `DATENAME()` function, the output cannot be predicted since it may be different each time, depending on what part of the date is passed as input. Thus, here, `DAY()` is a deterministic function, while `DATENAME()` is a non-deterministic function. Similarly, `RAND` (without any seed), `@@TIMETICKS`, `@@CONNECTIONS`, and `GETDATE()` are non-deterministic.

Users cannot influence the determinism of built-in functions. Every built-in function is deterministic or non-deterministic depending on how the function is implemented by SQL Server.

*Nothing is a waste of time if you use
the experience wisely.*

Table 13.4 lists some of the deterministic and non-deterministic built-in functions.

Deterministic Built-in Functions	Non-Deterministic Built-in Functions
POWER	@@TOTAL_WRITE
ROUND	CURRENT_TIMESTAMP
RADIANS	GETDATE
EXP	GETUTCDATE
FLOOR	GET_TRANSMISSION_STATUS
SQUARE	NEWID
SQRT	NEWSEQUENTIALID
LOG	@@CONNECTIONS
YEAR	@@CPU_BUSY
ABS	@@DBTS
ASIN	@@IDLE
ACOS	@@IOBUSY
SIGN	@@PACK_RECEIVED
SIN	@@PACK_SENT

Table 13.4: Deterministic and Non-deterministic Built-in Functions

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There are also some functions that are not always deterministic but you can use them in indexed views if they are given in a deterministic manner. Table 13.5 lists some of these functions.

Function	Description
CONVERT	Is deterministic only if one of these conditions exists: <ul style="list-style-type: none"> ➔ Has an sql_variant source type. ➔ Has an sql_variant target type and source type is non-deterministic. ➔ Has its source or target type as smalldatetime or datetime, has the other source or target type as a character string, and has a non-deterministic style specified. The style parameter must be a constant to be deterministic.
CAST	Is deterministic only if it is used with smalldatetime, sql_variant, or datetime.
ISDATE	Is deterministic unless used with the CONVERT function, the CONVERT style parameter is specified, and style is not equal to 0, 100, 9, or 109.
CHECKSUM	Is deterministic, with the exception of CHECKSUM(*)..

Table 13.5: Deterministic Functions



→ Calling Extended Stored Procedures from Functions

Functions calling extended stored procedures are non-deterministic because the extended stored procedures may result in side effects on the database. Changes made to the global state of a database such as a change to an external resource, or updates to a table, file, or a network are called side effects. For example, sending an e-mail, or deleting a file can cause side effects. While executing an extended stored procedure from a user-defined function, the user cannot assure that it will return a consistent resultset.

Therefore, the user-defined functions that create side effects on the database are not recommended.

→ Scalar-valued Functions

A Scalar-valued Function (SVF) always returns an int, bit, or string value. The data type returned from and the input parameters of SVF can be of any data type except text, ntext, image, cursor, and timestamp.

An inline scalar function has a single statement and no function body. A multi-statement scalar function encloses the function body in a BEGIN...END block.

→ Table-valued Functions

Table-valued functions are user-defined functions that return a table. Similar to an inline scalar function, an inline table-valued function has a single statement and no function body.

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Code Snippet 10 shows the creation of a table-valued function.

Code Snippet 10:

```
USE AdventureWorks2012;
GO
IF OBJECT_ID (N'Sales.ufn_CustDates', N'IF') IS NOT NULL
    DROP FUNCTION Sales.ufn_ufn_CustDates;
GO
CREATE FUNCTION Sales.ufn_CustDates ()
RETURNS TABLE
AS
RETURN
(
    SELECT A.CustomerID, B.DueDate, B.ShipDate
    FROM Sales.Customer A
    LEFT OUTER JOIN
        Sales.SalesOrderHeader B
    ON
        A.CustomerID = B.CustomerID AND YEAR(B.DueDate) < 2012
);
```

Learning how to learn is life's most important skill.

Here, an inline table-valued function defines a left outer join between the tables Sales.Customer and Sales.SalesOrderHeader.

The tables are joined based on customer ids. In this case, all records from the left table and only matching records from the right table are returned. The resultant table is then returned from the table-valued function.

The function is invoked as shown in Code Snippet 11.

Code Snippet 11:

```
SELECT * FROM Sales.ufn_CustDates();
```

The result will be the outcome of the join represented in a tabular format.

13.6 Altering User-defined Functions

Users can modify the user-defined functions in SQL Server 2012 by using the Transact-SQL or SSMS. Changing the user-defined functions does not modify the functions permissions, nor will it affect any stored procedures, triggers, or functions.

→ Limitations and Restrictions

The ALTER FUNCTION does not allow the users to perform the following actions:

- Modify a scalar-valued function to a table-valued function.
- Modify an inline function to a multi-statement function.
- Modify a Transact-SQL to a CLR function.

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→ Permissions

The ALTER permission is required on the schema or the function. If the function specifies a user-defined type, then it requires the EXECUTE permission on the type.

→ Modifying a User-defined function using SSMS

Users can also modify user-defined functions using SSMS.

To modify the user-defined function using SSMS, perform the following steps:

1. Click the plus (+) symbol beside the database that contains the function to be modified.
2. Click the plus (+) symbol next to the Programmability folder.
3. Click the plus (+) symbol next to the folder, which contains the function to be modified. There are three folder types as follows:
 - Table-valued Functions
 - Scalar-valued Functions
 - Aggregate Functions
 - System Functions
4. Right-click the function to be modified and then, select **Modify**. The code for the function appears in a query editor window.
5. In the query editor window, make the required changes to the `ALTER FUNCTION` statement body.
6. Click **Execute** on the toolbar to execute the `ALTER FUNCTION` statement.



→ Modifying a User-defined function using Transact-SQL

To modify the user-defined function using Transact-SQL, perform the following steps:

- In the **Object Explorer**, connect to the Database Engine instance.
- On the **Standard bar**, click **New Query**.
- Type the `ALTER FUNCTION` code in the **Query Editor**.
- Click **Execute** on the toolbar to execute the `ALTER FUNCTION` statement.

Code Snippet 12 demonstrates modifying a table-valued function.

Code Snippet 12:

```
USE [AdventureWorks2012]
GO
ALTER FUNCTION [dbo].[ufnGetAccountingEndDate] ()
RETURNS [datetime]
AS
BEGIN
    RETURN DATEADD(millisecond, -2, CONVERT(datetime, '20040701', 112));
END;
```

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13.7 Creation of Windows with OVER

A window function is a function that applies to a collection of rows. The word 'window' is used to refer to the collection of rows that the function works on.

In Transact-SQL, the `OVER` clause is used to define a window within a query resultset. Using windows and the `OVER` clause with functions provides several advantages. For instance, they help to calculate aggregated values. They also enable row numbers in a resultset to be generated easily.

13.7.1 Windowing Components

The three core components of creating windows with the `OVER` clause are as follows:

→ Partitioning

Partitioning is a feature that limits the window of the recent calculation to only those rows from the resultset that contains the same values in the partition columns as in the existing row. It uses the `PARTITION BY` clause.

Who dares to teach must never cease to learn.

Code Snippet 13 demonstrates use of the PARTITION BY and OVER clauses with aggregate functions. Here, using the OVER clause proves to be better efficient than using subqueries to calculate the aggregate values.

Code Snippet 13:

```
USE AdventureWorks2012;
GO
SELECT SalesOrderID, ProductID, OrderQty
    , SUM(OrderQty) OVER(PARTITION BY SalesOrderID) AS Total
    , MAX(OrderQty) OVER(PARTITION BY SalesOrderID) AS MaxOrderQty
FROM Sales.SalesOrderDetail
WHERE ProductId IN(776, 773);
GO
```

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The output of the code is shown in figure 13.5.

	SalesOrderID	ProductID	OrderQty	Total	MaxOrderQty
1	43659	776	1	3	2
2	43659	773	2	3	2
3	43661	776	4	6	4
4	43661	773	2	6	4
5	43664	773	1	1	1
6	43665	773	1	2	1
7	43665	776	1	2	1
8	43667	773	1	1	1
9	43670	773	2	3	2
10	43670	776	1	3	2
11	43672	776	2	2	2

Figure 13.5: Partitioning with OVER Clause



→ Ordering

The ordering element defines the ordering for calculation in the partition. In a standard SQL ordering element all functions are supported. Earlier, SQL Server had no support for the ordering elements with aggregate functions as it only supported partitioning. In SQL Server 2012, there is a support for the ordering element with aggregate functions. The ordering element has different meaning to some extent for different function categories. With ranking functions, ordering is spontaneous.

Code Snippet 14 demonstrates an example of the ordering element.

Code Snippet 14:

```
SELECT CustomerID, StoreID,  
RANK () OVER (ORDER BY StoreID DESC) AS Rnk_All,  
RANK () OVER (PARTITION BY PersonID  
ORDER BY CustomerID DESC) AS Rnk_Cust  
FROM Sales.Customer;
```

This code snippet makes use of the `RANK()` function which returns the rank of each row in the partition of a resultset. The rank of a row is determined by adding 1 to the number of ranks that come before the specified row. For example, while using descending ordering, the `RANK()` function returns one more than the number of rows in the respective partition that has a greater ordering value than the specified one.

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Figure 13.6 displays the output of Code Snippet 14.

	CustomerID	StoreID	Rnk_All	Rnk_Cust
1	701	844	813	1
2	700	1030	633	2
3	699	842	815	3
4	698	640	1009	4
5	697	1032	631	5
6	696	840	817	6
7	695	638	1011	7
8	694	1034	629	8
9	693	838	819	9
10	692	802	855	10
11	691	1036	627	11

Figure 13.6: Ordering

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

Code Snippet 15 displays a query with two RANK calculations and the ORDER BY clause.

Code Snippet 15:

```
SELECT TerritoryID, Name, SalesYTD,  
RANK () OVER (ORDER BY SalesYTD DESC) AS Rnk_One,  
RANK () OVER (PARTITION BY TerritoryID  
ORDER BY SalesYTD DESC) AS Rnk_Two  
FROM Sales.SalesTerritory;
```

This code snippet makes use of the RANK () function which returns the rank of each row in the partition of a resultset. In general, the rank of a row is determined by adding 1 to the number of ranks that come before the specified row. Here in this code, the first RANK () function generates the attribute Rnk_One that depends on the default partitioning, and the second RANK function generates Rnk_Two that uses explicit partitioning by TerritoryID.

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Figure 13.7 displays the partitions defined for a sample of three results of calculations in the query: one Rnk_One value and two Rnk_Two value.

TerritoryID	Name	SalesYTD	Rnk_One	Rnk_Two
1	Northwest	7887186.7882	2	1
2	Northeast	2402176.8476	10	1
3	Central	3072175.118	8	1
4	Southwest	10510853.8739	1	1
5	Southeast	2538667.2515	9	1
6	Canada	6771829.1376	3	1
7	France	4772398.3078	6	1
8	Germany	3805202.3478	7	1
9	Australia	5977814.9154	4	1
10	United Kingdom	5012905.3656	5	1

Figure 13.7: Partitioning and Ranking



→ Framing

Framing is a feature that enables you to specify a further division of rows within a window partition. This is done by assigning upper and lower boundaries for the window frame that presents rows to the window function. In simple terms, a frame is similar to a moving window over the data that starts and ends at specified positions. Window frames can be defined using the `ROW` or `RANGE` subclauses and providing starting and ending boundaries.

Code Snippet 16 displays a query against the `ProductInventory`, calculating the running total quantity for each product and location.

Code Snippet 16:

```
SELECT ProductID, Shelf, Quantity,  
SUM(Quantity) OVER (PARTITION BY ProductID  
ORDER BY LocationID  
ROWS BETWEEN UNBOUNDED PRECEDING  
AND CURRENT ROW) AS RunQty  
FROM Production.ProductInventory;
```

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In this code snippet, the window function applies the `SUM` aggregate to the attribute `Quantity`, partitions the window by `ProductID`, orders the partition rows by `LocationID`, and frames the partition rows depending on the given ordering between unbounded preceding (no low boundary point) and the current row. In other words, the result will be the sum of all prior rows in the frame, including the current row. Figure 13.8 displays the output of Code Snippet 16.

	ProductID	Shelf	Quantity	RunQty
1	1	A	408	408
2	1	B	324	732
3	1	A	353	1085
4	2	A	427	427
5	2	B	318	745
6	2	A	364	1109
7	3	A	585	585
8	3	B	443	1028
9	3	A	324	1352
10	4	A	512	512
11	4	B	422	934

Figure 13.8: Framing

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

13.8 Window Functions

Some of the different types of window functions are as follows:

→ Ranking functions

These functions return a rank value for each row in a partition. Based on the function that is used, many rows will return the same value as the other rows. Ranking functions are non-deterministic.

Table 13.6 lists various ranking functions.

Ranking Functions	Description
NTILE	Spreads rows in an ordered partition into a given number of groups, beginning at 1. For each row, the function returns the number of the group to which the row belongs.
ROW NUMBER	Retrieves the sequential number of a row in a partition of a resultset, starting at 1 for the first row in each partition.
DENSE RANK	Returns the rank of rows within the partition of a resultset, without any gaps in the ranking. The rank of a row is one plus the number of distinct ranks that come before the row in question.

Table 13.6: Ranking Functions

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Code Snippet 17 demonstrates the use of ranking functions.

Code Snippet 17:

```
USE AdventureWorks2012;
GO
SELECT p.FirstName, p.LastName
    ,ROW_NUMBER() OVER (ORDER BY a.PostalCode) AS 'Row Number'
    ,NTILE(4) OVER (ORDER BY a.PostalCode) AS 'NTILE'
    ,s.SalesYTD, a.PostalCode
FROM Sales.SalesPerson AS s
INNER JOIN Person.Person AS p
    ON s.BusinessEntityID=p.BusinessEntityID
INNER JOIN Person.Address AS a
    ON a.AddressID=p.BusinessEntityID
WHERE TerritoryID IS NOT NULL
    AND SalesYTD <> 0;
```

The NTILE() function breaks a given input collection into N equal sized logical groups. To determine how many rows belong in each group, SQL Server has to determine the total number of rows in the input collection. The OVER clause decides the order of the rows when they have been divided into groups. It is possible to perform the grouping in one order and return the resultset in another order.



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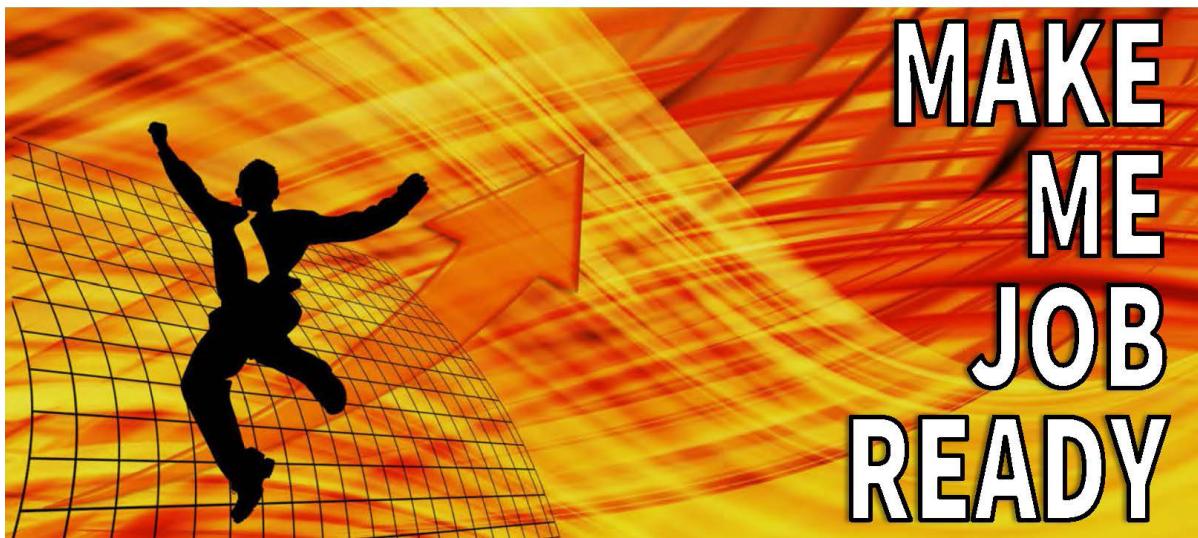


Figure 13.9 displays the output of Code Snippet 17.

	FirstName	LastName	Row Number	NTILE	SalesYTD	PostalCode
1	Michael	Blythe	1	1	3763178.1787	98027
2	Linda	Mitchell	2	1	4251368.5497	98027
3	Jillian	Carson	3	1	3189418.3662	98027
4	Garett	Vargas	4	1	1453719.4653	98027
5	Tsvi	Reiter	5	2	2315185.611	98027
6	Pamela	Ansman-Wolfe	6	2	1352577.1325	98027
7	Shu	Ito	7	2	2458535.6169	98055
8	José	Saraiva	8	2	2604540.7172	98055
9	David	Campbell	9	3	1573012.9383	98055
10	Tete	Mensa-Annan	10	3	1576562.1966	98055
11	Lynn	Tsoflias	11	3	1421810.9242	98055

Figure 13.9: Output of Code Snippet 17

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→ OFFSET functions

The different types of offset functions are as follows:

- **SWITCHOFFSET**

This function returns a DATETIMEOFFSET value that is modified from the stored time zone offset to a specific new time zone offset.

Following is the syntax for the SWITCHOFFSET function.

Syntax:

```
SWITCHOFFSET ( DATETIMEOFFSET, time_zone )
```

where,

DATETIMEOFFSET: is an expression that is resolved to a datetimeoffset (n) value.

time_zone: specifies the character string in the format [+|-]TZH:TZM or a signed integer (of minutes) which represents the time zone offset, and is assumed to be daylight-saving aware and adjusted.

To avoid criticism, do nothing, say nothing, be nothing.

Code Snippet 18 displays the use of SWITCHOFFSET function.

Code Snippet 18:

```
CREATE TABLE Test
(
ColDatetimeoffset datetimeoffset
);
GO
INSERT INTO Test
VALUES ('1998-09-20 7:45:50.71345 -5:00');
GO
SELECT SWITCHOFFSET (ColDatetimeoffset, '-08:00')
FROM Test;
GO
--Returns: 1998-09-20 04:45:50.7134500 -08:00
SELECT ColDatetimeoffset
FROM Test;
```

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Figure 13.10 displays the output of Code Snippet 18.

(No column name)	
1	1998-09-20 04:45:50.7134500 -08:00
ColDatetimeoffset	
1	1998-09-20 07:45:50.7134500 -05:00

Figure 13.10: Use of SWITCHOFFSET Function

→ DATETIMEOFFSETFROMPARTS

This function returns a datetimeoffset value for the specified date and time with specified precision and offset.

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Following is the syntax for DATETIMEOFFSETFROMPARTS.

Syntax:

```
DATETIMEOFFSETFROMPARTS ( year, month, day, hour,  
minute, seconds, fractions, hour_offset,  
minute_offset, precision )
```

where,

year: specifies the integer expression for a year.

month: specifies the integer expression for a month.

day: specifies the integer expression for a day.

hour: specifies the integer expression for an hour.

minute: specifies the integer expression for a minute.

seconds: specifies the integer expression for a day.

fractions: specifies the integer expression for fractions.

hour_offset: specifies the integer expression for the hour portion of the time zone offset.

minute_offset: specifies the integer expression for the minute portion of the time zone offset.

precision: specifies the integer literal precision of the datetimeoffset value to be returned.

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Code Snippet 19 displays the use of DATETIMEOFFSETFROMPARTS function.

Code Snippet 19:

```
SELECT DATETIMEOFFSETFROMPARTS ( 2010, 12, 31, 14, 23, 23, 0, 12, 0,  
7 )  
AS Result;
```

The code displays a datetimeoffset value for the given date and time with the specified precision and offset.

Figure 13.11 displays the output of Code Snippet 19.

Result	
1	2010-12-31 14:23:23.0000000 +12:00

Figure 13.11: Use of DATETIMEOFFSETFROMPARTS Function

Learning is not compulsory, but neither is survival.

→ SYSDATETIMEOFFSET

These functions returns `datetimeoffset(7)` value which contains the date and time of the computer on which the instance of SQL Server is running.

Following is the syntax for SYSDATETIMEOFFSET.

Syntax:

```
SYSDATETIMEOFFSET ()
```

Code Snippet 20 displays the different formats used by the date and time functions.

Code Snippet 20:

```
SELECT SYSDATETIME () AS SYSDATETIME  
      , SYSDATETIMEOFFSET () AS SYSDATETIMEOFFSET  
      , SYSUTCDATETIME () AS SYSUTCDATETIME
```

Figure 13.12 displays the use of SYSDATETIMEOFFSET function.

	SYSDATETIME	SYSDATETIMEOFFSET	SYSUTCDATETIME
1	2013-02-08 16:08:16.6565247	2013-02-08 16:08:16.6565247 +05:30	2013-02-08 10:38:16.6565247

Figure 13.12: Use of SYSDATETIMEOFFSET Function

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→ Analytic Functions

SQL Server 2012 supports several analytic functions. These functions compute aggregate value based on a group of rows. Analytic functions compute running totals, moving averages, or top-N results within a group.

Table 13.7 lists some of the analytic functions.

Function	Description
LEAD	Provides access to data from a subsequent row in the same resultset without using a self-join.
LAST_VALUE	Retrieves the last value in an ordered set of values.
LAG	Provides access to data from a previous row in the same resultset without using a self-join.
FIRST_VALUE	Retrieves the first value in an ordered set of values.
CUME_DIST	Computes the cumulative distribution of a value in a group of values.
PERCENTILE_CONT	Computes a percentile based on a continuous distribution of the column value in SQL.
PERCENTILE_DISC	Calculates a particular percentile for sorted values in an entire rowset or within distinct partitions of a rowset.

Table 13.7: Analytic Functions



Code Snippet 21 demonstrates the use of `LEAD()` function.

Code Snippet 21:

```
USE AdventureWorks2012;
GO
SELECT BusinessEntityID, YEAR(QuotaDate) AS QuotaYear, SalesQuota AS
NewQuota,
    LEAD(SalesQuota, 1, 0) OVER (ORDER BY YEAR(QuotaDate)) AS FutureQuota
FROM Sales.SalesPersonQuotaHistory
WHERE BusinessEntityID=275 and YEAR(QuotaDate) IN ('2007','2008');
```

In this code snippet, the `LEAD()` function is used to return the difference in the sales quotas for a particular employee over the subsequent years.

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Code Snippet 22 demonstrates the use of FIRST_VALUE () function.

Code Snippet 22:

```
USE AdventureWorks2012;
GO
SELECT Name, ListPrice,
       FIRST_VALUE (Name) OVER (ORDER BY ListPrice ASC) AS LessExpensive
FROM Production.Product
WHERE ProductSubcategoryID = 37
```

In this code snippet, the FIRST_VALUE () function compares products in the product category 37 and returns the product name that is less expensive.

A wise man learns from the mistakes of others, a fool by his own.

13.9 Check Your Progress

1. Which of the following is not a feature that controls the use of multiple Transact-SQL statements at one time?

(A)	Scripts	(C)	Control-of-flow
(B)	Error Handling	(D)	Variables

2. Which of the following are used to set and declare local variables provided by SQL Server?

a.	DECLARE
b.	SET
c.	DELETE
d.	INSERT

(A)	a, d	(C)	a, b
(B)	b, c	(D)	c, d

3. Which of the following is not a permission that is applied on a synonym?

(A)	GRANT	(C)	DELETE
(B)	CONTROL	(D)	UPDATE

4. Which of the following code uses a local variable to retrieve contact information for the last names starting with Per?

(A)	<pre>USE AdventureWorks2012; GO DECLARE @find varchar(30); DECLARE @find varchar(30) = 'Per%'; SET @find = 'Per%'; SELECT p.LastName, p.FirstName, ph.PhoneNumber FROM Person.Customer AS p JOIN Person.Phone AS ph ON p.BusinessEntityID=ph.BusinessEntityID WHERE LastName LIKE @find;</pre>
(B)	<pre>USE AdventureWorks2012; GO DECLARE find varchar(30); DECLARE find varchar(30) = 'Per%'; SET find = 'Per%'; SELECT p.LastName, p.FirstName, ph.PhoneNumber FROM Person.Customer AS p JOIN Person.Phone AS ph ON p.BusinessEntityID=ph.BusinessEntityID WHERE LastName LIKE find;</pre>
(C)	<pre>USE AdventureWorks2012; GO @find varchar(30); @find varchar(30) = 'Per%'; SET @find = 'Per%'; SELECT p.LastName, p.FirstName, ph.PhoneNumber FROM Person.Customer AS p JOIN Person.Phone AS ph ON p.BusinessEntityID=ph.BusinessEntityID WHERE LastName LIKE @find;</pre>

(D)

```
USE AdventureWorks2012;
GO
SET @find varchar(30);
SET @find varchar(30) = 'Per%';
SET @find = 'Per';
SELECT p.LastName, p.FirstName, ph.PhoneNumber
FROM Person.Customer AS p
JOIN Person.Phone AS ph ON p.BusinessEntityID=ph.BusinessEntityID
WHERE LastName LIKE @find;
```

5. Which of the following is not a non-deterministic function?

(A)	@@PACK_SENT	(C)	@@DBTS
(B)	@@IOBUSY	(D)	IDLE

13.9.1 Answers

1.	A
2.	C
3.	A
4.	A
5.	D



Summary

- Transact-SQL provides basic programming elements such as variables, control-of-flow elements, conditional, and loop constructs.
- A batch is a collection of one or more Transact-SQL statements that are sent as one unit from an application to the server.
- Variables allow users to store data for using as input in other Transact-SQL statements.
- Synonyms provide a way to have an alias for a database object that may exist on a remote or local server.
- Deterministic functions each time return the same result every time they are called with a definite set of input values and specify the same state of the database.
- Non-deterministic functions return different results every time they are called with specified set of input values even though the database that is accessed remains the same.
- A window function is a function that applies to a collection of rows.



1. Zen Technologies is a leading company in textiles located in California. The management of the company wants to give a loyalty award to all employees completing tenure of five years in the organization. Using the same **Employee** table, create a Transact-SQL batch to return **EmployeeID**, **FirstName**, **Department**, and **HireDate** of all such employees. Assume that the management gives a twenty five percent salary increment to everybody completing one year in the organization. The chairman of the organization wants to participate in a national salary survey.

Write a batch to determine the total salary paid to a department which employs more than one employee. The management wants to find out which department has hired the largest number of employees in the last five years.

Hints:

- Use the DATETIMEOFFSETFROMPARTS function.

Session - 14

Transactions

Welcome to the Session, **Transactions**.

This session explains the types of transactions and the procedure to implement these transactions. It also describes the process to control and mark a transaction, and lists the differences between the implicit and explicit transactions. It also further explains the isolation levels, scope, different types of locks, and transaction management.

In this Session, you will learn to:

- Define and describe transactions
- Explain the procedure to implement transactions
- Explain the process of controlling transactions
- Explain the steps to mark a transaction
- Distinguish between implicit and explicit transactions
- Explain isolation levels
- Explain the scope and different types of locks
- Explain transaction management

14.1 Introduction

A transaction is a single unit of work. A transaction is successful only when all data modifications that are made in a transaction are committed and are saved in the database permanently. If the transaction is rolled back or cancelled, then it means that the transaction has encountered errors and there are no changes made to the contents of the database. Hence, a transaction can be either committed or rolled back.

14.2 Need for Transactions

There are many circumstances where the users need to make many changes to the data in more than one database tables. In many cases, the data will be inconsistent that executes the individual commands. Suppose if the first statement executes correctly but the other statements fail then the data remains in an incorrect state.

For example, a good scenario will be the funds transfer activity in a banking system. The transfer of funds will need an `INSERT` and two `UPDATE` statements. First, the user has to increase the balance of the destination account and then, decrease the balance of the source account. The user has to check that the transactions are committed and whether the same changes are made to the source account and the destination account.



→ Defining Transactions

A logical unit of work must exhibit four properties, called the atomicity, consistency, isolation, and durability (ACID) properties, to qualify as a transaction.

- **Atomicity:** If the transaction has many operations then all should be committed. If any of the operation in the group fails then it should be rolled back.
- **Consistency:** The sequence of operations must be consistent.
- **Isolation:** The operations that are performed must be isolated from the other operations on the same server or on the same database.
- **Durability:** The operations that are performed on the database must be saved and stored in the database permanently.

→ Implementing Transactions

SQL Server supports transactions in several modes. Some of these modes are as follows:

- **Autocommit Transactions:** Every single-line statement is automatically committed as soon as it completes. In this mode, one does not need to write any specific statements to start and end the transactions. It is the default mode for SQL Server Database Engine.
- **Explicit Transactions:** Every transaction explicitly starts with the BEGIN TRANSACTION statement and ends with a ROLLBACK or COMMIT transaction.

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- **Implicit Transactions:** A new transaction is automatically started when the earlier transaction completes and every transaction is explicitly completed by using the ROLLBACK or COMMIT statement.
- **Batch-scoped Transactions:** These transactions are related to Multiple Active Result Sets (MARS). Any implicit or explicit transaction that starts in a MARS session is a batch-scoped transaction. A batch-scoped transaction that is rolled back when a batch completes automatically is rolled back by SQL Server.

→ Transactions Extending Batches

The transaction statements identify the block of code that should either fail or succeed and provide the facility where the database engine can undo or roll back the operations. The errors that encounter during the execution of simple batch have the possibility of partial success, which is not a desired result. This also led to inconsistencies in the tables and databases. To overcome this, users can add code to identify the batch as a transaction and place the batch between the BEGIN TRANSACTION and COMMIT TRANSACTION. Users can add error-handling code to roll back the transaction in case of errors. The error-handling code will undo the partial changes that were made before the error had occurred. This way, inconsistencies in the tables and databases can be prevented.

You must do the things you think you cannot do.

14.3 Controlling Transactions

Transactions can be controlled through applications by specifying the beginning and ending of a transaction. This is done by using the database API functions or Transact-SQL statements.

Transactions are managed at the connection level, by default. When a transaction is started on a connection, all Transact-SQL statements are executed on the same connection and are a part of the connection until the transaction ends.

14.3.1 Starting and Ending Transactions Using Transact-SQL

One of the ways users can start and end transactions is by using Transact-SQL statements. Users can start a transaction in SQL Server in the implicit or explicit modes. Explicit transaction mode starts a transaction by using a `BEGIN TRANSACTION` statement. Users can end a transaction using the `ROLLBACK` or `COMMIT` statements.

Following are some of the types of transaction statements:

→ BEGIN TRANSACTION

The `BEGIN TRANSACTION` statement marks the beginning point of an explicit or local transaction.

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Following is the syntax for the BEGIN TRANSACTION statement.

Syntax:

```
BEGIN { TRAN | TRANSACTION }
    [ { transaction_name | @tran_name_variable }
        [ WITH MARK [ 'description' ] ]
    ]
[ ; ]
```

where,

`transaction_name`: specifies the name that is assigned to the transaction. It should follow the rules for identifiers and limit the identifiers that are 32 characters long.

`@tran_name_variable`: specifies the name of a user-defined variable that contains a valid transaction name.

`WITH MARK['description']`: specifies the transaction that is marked in the log. The description string defines the mark.

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Code Snippet 1 shows how to create and begin a transaction.

Code Snippet 1:

```
USE AdventureWorks2012;
GO
DECLARE @TranName VARCHAR(30);
SELECT @TranName = 'FirstTransaction';
BEGIN TRANSACTION @TranName;
DELETE FROM HumanResources.JobCandidate
WHERE JobCandidateID = 13;
```

In this code snippet, a transaction name is declared using a variable with value **FirstTransaction**. A new transaction with this name is then created having a `DELETE` statement. As the transaction comprises a single-line statement, it is implicitly committed.

→ **COMMIT TRANSACTION**

The `COMMIT TRANSACTION` statement marks an end of a successful implicit or explicit transaction. If the `@@TRANCOUNT` is 1, then, `COMMIT TRANSACTION` performs all data modifications performed on the database and becomes a permanent part of the database. Further, it releases the resources held by the transaction and decrements `@@TRANCOUNT` by 0. If `@@TRANCOUNT` is greater than 1, then the `COMMIT TRANSACTION` decrements the `@@TRANCOUNT` by 1 and keeps the transaction in active state.

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Following is the syntax for the COMMIT TRANSACTION statement.

Syntax:

```
COMMIT { TRAN | TRANSACTION } [ transaction_name | @tran_name_variable
] ]
[ ; ]
```

where,

transaction_name: specifies the name that is assigned by the previous BEGIN TRANSACTION statement. It should follow the rules for identifiers and do not allow identifiers that are 32 characters long.

@tran_name_variable: specifies the name of a user-defined variable that contains a valid transaction name. The variable can be declared as char, varchar, nchar, or nvarchar data type. If more than 32 characters are passed to the variable, then only 32 characters are used and the remaining characters will be truncated.

Code Snippet 2 shows how to commit a transaction in the HumanResources.JobCandidate table of AdventureWorks2012 database.

Code Snippet 2:

```
BEGIN TRANSACTION;
GO
DELETE FROM HumanResources.JobCandidate
WHERE JobCandidateID = 11;
GO
COMMIT TRANSACTION;
GO
```

*Woe to him who teaches men faster
than they can learn.*

This code snippet defines a transaction that will delete a job candidate record having `JobCandidateID` as 11.

→ COMMIT WORK

The `COMMIT WORK` statement marks the end of a transaction.

Following is the syntax for the `COMMIT WORK` statement.

Syntax:

```
COMMIT [ WORK ]  
[ ; ]
```

`COMMIT TRANSACTION` and `COMMIT WORK` are identical except for the fact that `COMMIT TRANSACTION` accepts a user-defined transaction name.

→ Marking a Transaction

Code Snippet 3 shows how to mark a transaction in the `HumanResources.JobCandidate` table of `AdventureWorks2012` database.

Code Snippet 3:

```
BEGIN TRANSACTION DeleteCandidate  
    WITH MARK N'Deleting a Job Candidate';  
GO  
DELETE FROM HumanResources.JobCandidate  
    WHERE JobCandidateID = 11;  
GO  
COMMIT TRANSACTION DeleteCandidate;
```

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In this code snippet, a transaction named `DeleteCandidate` is created and marked in the log.

→ ROLLBACK TRANSACTION

This transaction rolls back or cancels an implicit or explicit transaction to the starting point of the transaction, or to a savepoint in a transaction. A savepoint is a mechanism to roll back some parts of transactions. The `ROLLBACK TRANSACTION` is used to delete all data modifications made from the beginning of the transaction or to a savepoint. It also releases the resources held by the transaction.

Following is the syntax for the `ROLLBACK TRANSACTION` statement.

Syntax:

```
ROLLBACK { TRAN | TRANSACTION }
    [ transaction_name | @tran_name_variable
    | savepoint_name | @savepoint_variable ]
[ ; ]
```

where,

`transaction_name`: specifies the name that is assigned to the `BEGIN TRANSACTION` statement. It should confirm the rules for identifiers and do not allow identifiers that are 32 characters long.

`@tran_name_variable`: specifies the name of a user-defined variable that contains a valid `transaction_name`. The variable can be declared as `char`, `varchar`, `nchar`, or `nvarchar` data type.

`savepoint_name`: specifies the `savepoint_name` from a `SAVE TRANSACTION` statement. Use `savepoint_name` only when a conditional roll back affects a part of a transaction.

`@savepoint_variable`: specifies the name of `savepoint` variable that contain a valid `savepoint` name. The variable can be declared as `char`, `varchar`, `nchar`, or `nvarchar` data type.



Consider an example that demonstrates the use of ROLLBACK. Assume that a database named **Sterling** has been created. A table named **ValueTable** is created in this database as shown in Code Snippet 4.

Code Snippet 4:

```
USE Sterling;
GO
CREATE TABLE ValueTable ([value] char)
GO
```

Code Snippet 5 creates a transaction that inserts two records into **ValueTable**. Then, it rolls back the transaction and again inserts one record into **ValueTable**. When a **SELECT** statement is used to query the table, you will see that only a single record with value **C** is displayed. This is because the earlier **INSERT** operations have been rolled back or cancelled.

Code Snippet 5:

```
BEGIN TRANSACTION
    INSERT INTO ValueTable VALUES('A');
    INSERT INTO ValueTable VALUES('B');
GO
ROLLBACK TRANSACTION
INSERT INTO ValueTable VALUES('C');
SELECT [value] FROM ValueTable;
```

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→ ROLLBACK WORK

This statement rolls back a user-specified transaction to the beginning of the transaction.

Following is the syntax for the ROLLBACK WORK statement.

Syntax:

```
ROLLBACK [ WORK ]  
[ ; ]
```

The keyword WORK is optional and is rarely used.

Figure 14.1 displays the working of transactions.

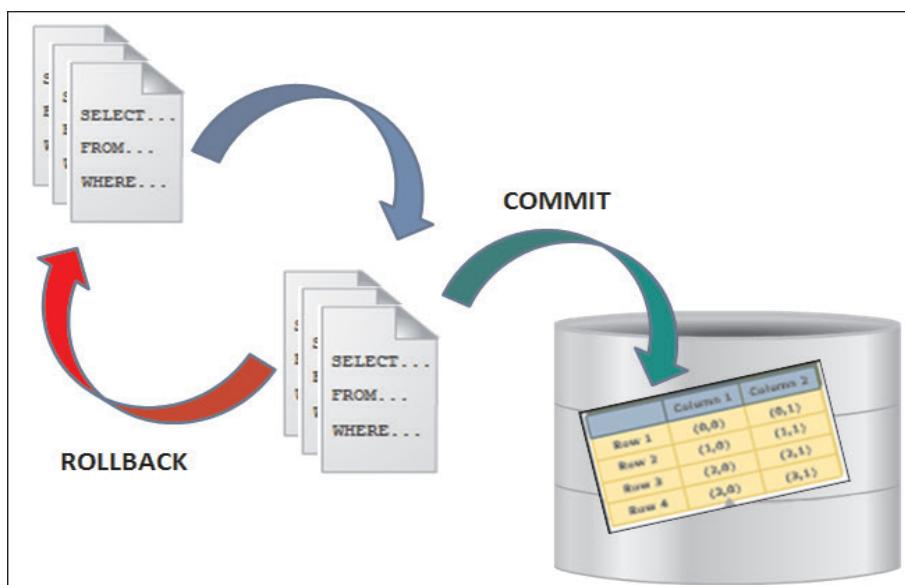


Figure 14.1: Working of Transactions

*Real generosity towards the future lies
in giving all to the present.*

→ SAVE TRANSACTION

The SAVE TRANSACTION statement sets a savepoint within a transaction. Following is the syntax for the SAVE TRANSACTION statement.

Syntax:

```
SAVE { TRAN | TRANSACTION } { savepoint_name | @savepoint_variable }
[ ; ]
```

where,

`savepoint_name`: specifies the `savepoint_name` assigned. These names conform to the rules of identifiers and are restricted to 32 characters.

`@savepoint_variable`: specifies the name of a user-defined variable that contain a valid savepoint name. The variable can be declared as `char`, `varchar`, `nchar`, or `nvarchar` data type. More than 32 characters are allowed to pass to the variables but only the first 32 characters are used.

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Code Snippet 6 shows how to use a savepoint transaction.

Code Snippet 6:

```
CREATE PROCEDURE SaveTranExample
    @InputCandidateID INT
AS
    DECLARE @TranCounter INT;
    SET @TranCounter = @@TRANCOUNT;
    IF @TranCounter > 0
        SAVE TRANSACTION ProcedureSave;
    ELSE
        BEGIN TRANSACTION;
        DELETE HumanResources.JobCandidate
            WHERE JobCandidateID = @InputCandidateID;
        IF @TranCounter = 0
            COMMIT TRANSACTION;
        IF @TranCounter = 1
            ROLLBACK TRANSACTION ProcedureSave;
GO
```

In this code snippet, a savepoint transaction is created within a stored procedure. This will then be used to roll back only the changes made by the stored procedure if an active transaction has started before the stored procedure executes.



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14.4 The @@TRANCOUNT

The @@TRANCOUNT system function returns a number of BEGIN TRANSACTION statements that occur in the current connection. Figure 14.2 displays an example of using @@TRANCOUNT.

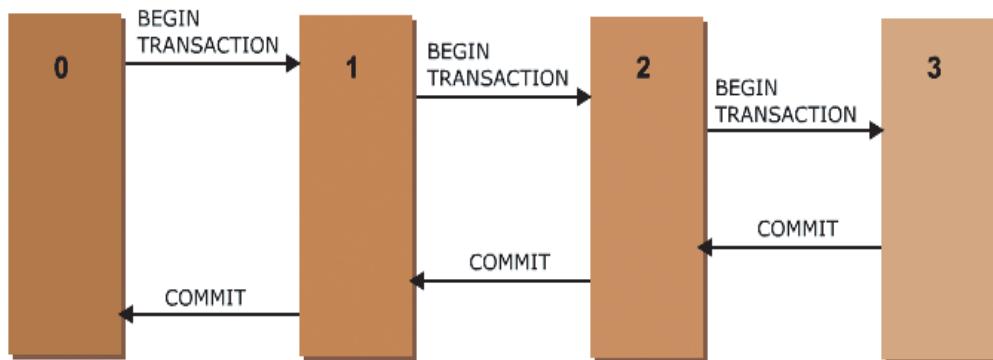


Figure 14.2: @@TRANCOUNT

Following is the syntax for the @@TRANCOUNT statement.

Syntax:

```
@@TRANCOUNT
```

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Code Snippet 7 shows the effect that nested BEGIN and COMMIT statements have on the @@TRANCOUNT variable.

Code Snippet 7:

```
PRINT @@TRANCOUNT
BEGIN TRAN
    PRINT @@TRANCOUNT
    BEGIN TRAN
        PRINT @@TRANCOUNT
    COMMIT
    PRINT @@TRANCOUNT
    COMMIT
PRINT @@TRANCOUNT
```

This code snippet displays the number of times the BEGIN TRAN and COMMIT statement execute in the current connection.

Figure 14.3 displays the output of Code Snippet 7.

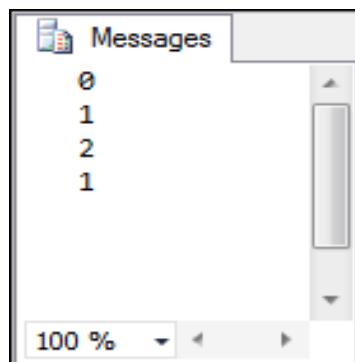


Figure 14.3: Output of Code Snippet 7

Knowledge is not enough; we must apply. Willing is not enough; we must do.

ode Snippet 8 shows the effect that nested BEGIN and ROLLBACK statements have on the @@TRANCOUNT variable.

Code Snippet 8:

```
PRINT @@TRANCOUNT
BEGIN TRAN
    PRINT @@TRANCOUNT
    BEGIN TRAN
        PRINT @@TRANCOUNT
ROLLBACK
PRINT @@TRANCOUNT
```

In this case, the code snippet displays the number of times the BEGIN and ROLLBACK statements execute in the current connection.

Figure 14.4 displays the output of Code Snippet 8.

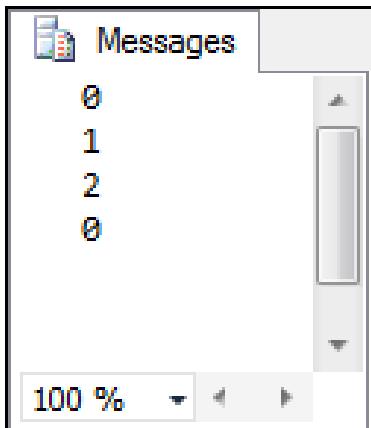


Figure 14.4: Output of Code Snippet 8

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14.5 Marking a Transaction

Users can use transaction marks to recover the related updates made to two or more related databases. Though this recovery loses every transaction that is committed after the mark was used as the recovery point. Marking a transaction is useful only when the user is willing to lose recently committed transactions or is testing related databases. Marking related transactions on a routine basis in every single related database creates a sequence of common recovery points in a database. The transaction marks are incorporated in log backups and are also recorded in the transaction log. In case of any disaster, user can restore each of the databases to the same transaction mark in order to recover them to a consistent point.

→ Concerns for Using Marked Transactions

Consider the following situations before inserting the named marks in the transaction:

- As the transaction mark consume log space, use them only for transactions that play an important role in the database recovery strategy.
- When the marked transaction is committed, then a row is inserted in the `logmarkhistory` table in `msdb`.
- If a marked transaction spans over multiple databases on different servers or on the same database server, the marks must be logged in the records of all affected databases.

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14.5.1 Create Marked Transactions

For creating a marked transaction, users can use the BEGIN TRANSACTION statement and the WITH MARK [description] clause. The optional description is a textual description of the mark. A mark name for the transaction is reused and required. The transaction log records the mark description, name, user, database, datetime information, and the Log Sequence Number (LSN). The datetime information is used with the mark name for unique identification of the mark.

For creating a marked transaction in a set of databases, the following steps are required:

1. Name the transaction in the BEGIN TRAN statement and use the WITH MARK clause.
2. Execute an update against all of the databases in the set.

Code Snippet 9 shows to update the ListPrice in the Product table of the AdventureWorks2012 database.

Code Snippet 9:

```
USE AdventureWorks2012
GO
BEGIN TRANSACTION ListPriceUpdate
    WITH MARK 'UPDATE Product list prices';
GO

UPDATE Production.Product
    SET ListPrice = ListPrice * 1.20
    WHERE ProductNumber LIKE 'BK-%';
GO

COMMIT TRANSACTION ListPriceUpdate;
GO
```

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Code Snippet 10 shows how to restore a transaction log. It assumes that a backup named AdventureWorksBackups has been created.

Code Snippet 10:

```
USE AdventureWorks2012
GO
BEGIN TRANSACTION ListPriceUpdate
    WITH MARK 'UPDATE Product list prices';
GO

UPDATE Production.Product
    SET ListPrice = ListPrice * 1.20
    WHERE ProductNumber LIKE 'BK-%';
GO

COMMIT TRANSACTION ListPriceUpdate;
GO
```

*Don't just learn the tricks of the trade,
learn the trade.*

14.6 Differences Between Implicit and Explicit Transactions

Table 14.1 list the differences between implicit and explicit transactions.

Implicit	Explicit
These transactions are maintained by SQL Server for each and every DML and DDL statements	These transactions are defined by programmers
These DML and DDL statements execute under the implicit transactions	DML statements are included to execute as a unit
SQL Server will roll back the entire statement	SELECT Statements are not included as they do not modify data

Table 14.1 Differences Between Implicit and Explicit Transactions

14.7 Isolation Levels

Transactions identify the isolation levels that define the degree to which one transaction must be isolated from the data modifications or resource that are made by the other transactions. Isolation levels are defined in terms of which the concurrency side effects such as dirty reads are allowed. When one transaction changes a value and a second transaction reads the same value before the original change has been committed or rolled back, it is called as a dirty read.

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Transaction isolation levels control the following:

- When data is read, are there any locks taken and what types of locks are requested?
- How much amount of time the read locks are held?
- If a read operation that is referencing a row modified by some other transaction is:
 - Blocking until the exclusive lock on the row is free
 - Retrieving the committed version of the row that exists at the time when the transaction or statement started.
 - Reading the uncommitted data modification.

While choosing a transaction isolation level, those locks that prevent data modification are not affected. A transaction acquires an exclusive lock every time on each data that it modifies. Then, it holds that lock until the transaction is completed, irrespective of the isolation level that is set for that transaction.

Transaction isolation levels mainly describe the protection levels from the special effects of changes made by other transactions for read operations. A lower isolation level increases the capability of several users to access data at the same time. However, it increases the number of concurrency effects such as dirty reads or lost updates that users might come across. On the other hand, a higher isolation level decreases the types of concurrency effects which user may encounter. This requires additional system resources and increases the chance of one transaction blocking another transaction.



Selecting a suitable isolation level is based on the data integrity requirements of the application as compared to the overheads of each isolation level. The higher isolation level, serializable, assures that a transaction will recover the same data each time it repeats the read operation. Then, it does this by performing a level of locking that is expected to influence other users in a multi-user system. The lower isolation level, read uncommitted, retrieves data that is modified, and is not committed by other transactions. All concurrency side effects occur in read uncommitted, however, there is no read versioning or locking, hence, the overhead is minimized.

Table 14.2 lists the concurrency effects that are allowed by the different isolation levels.

Isolation Level	Dirty Read	NonRepeatable Read
Read committed	No	Yes
Read uncommitted	Yes	No
Snapshot	No	No
Repeatable Read	No	No
Serializable	No	No

Table 14.2: Isolation Levels

Transactions need to execute at an isolation level of at least repeatable read that prevents lost updates occurring when two transactions each retrieve the same row, and then updates the row that is dependent on the originally retrieved rows.

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14.8 Scope and Different Types of Locks

The SQL Server Database Engine locks the resources that use different lock modes, which determine the resources that are accessible to concurrent transactions.

Table 14.3 lists the resource lock modes used by the Database Engine.

Lock Mode	Description
Update	Is used on resources that are to be updated.
Shared	Is used for read operations that do not change data such as SELECT statement.
Intent	Is used to establish a hierarchy of locks.
Exclusive	Is used for INSERT, UPDATE, or DELETE data-modification operations.
BULK UPDATE	Is used while copying bulk data into the table.
Schema	Is used when the operation is dependent on the table schema.

Table 14.3: Lock Modes

Practice is the best of all instructors.

The different types of locks are as follows:

→ **Update Locks**

These locks avoid common forms of deadlock. In a serializable transaction, the transaction will read data, acquire a shared lock on the row or a page, and modify the data that requires lock conversion to an exclusive lock. When two transactions acquire a shared lock on a resource and try to update data simultaneously, the same transaction attempts the lock conversion to an exclusive lock. The shared mode to exclusive lock conversion should wait as the exclusive lock for one transaction is not compatible with shared mode lock of the other transaction a lock wait occurs. Similarly, the second transaction tries to acquire an exclusive lock for update. As both the transactions are converting to exclusive locks and each waits for the other transaction to release its shared lock mode, a deadlock occurs.

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Figure 14.5 depicts the concept of such a deadlock.

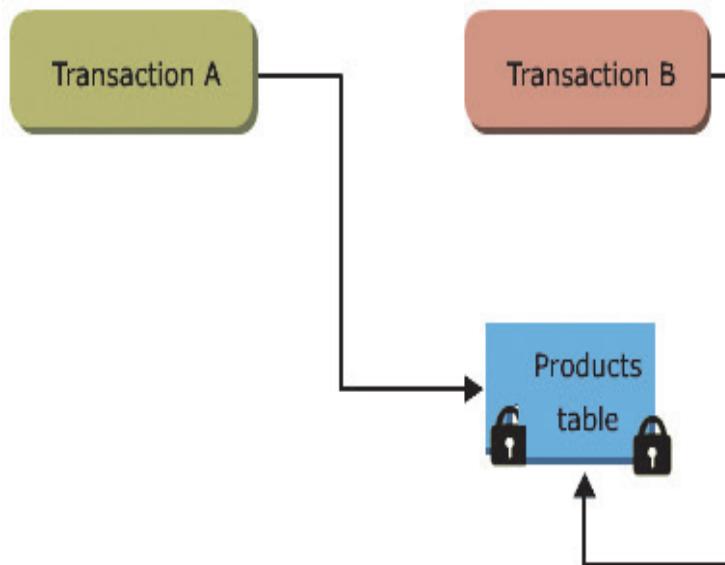


Figure 14.5: Deadlock

To avoid this deadlock, update locks are used. Only one transaction can obtain an update lock to a resource at a time. When a transaction modifies a resource, then the update lock is converted to an exclusive lock.

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→ Shared Locks

These locks allow parallel transactions to read a resource under pessimistic concurrency control. Transactions can change the data while shared locks exist on the resource. Shared locks are released on a resource once the read operation is completed, except the isolation level is set to repeatable read or higher.

→ Exclusive Locks

These locks prevent access to resources by concurrent transactions. By using an exclusive lock, no other transaction can change data and read operations take place only through the read uncommitted isolation level or NOLOCK hint. DML statements such as INSERT, DELETE, and UPDATE combine modification and read operations. These statements first perform a read operation to get data before modifying the statements. DML statements usually request both exclusive and shared locks. For example, if the user wants to use an UPDATE statement that modifies the row in one table that is dependent on a join with other table. Therefore, the update statements request shared lock on the rows that reads from the join table and request exclusive locks on the modified rows.

→ Intent Locks

The Database Engine uses intent locks for protecting and places an exclusive or shared lock on the resource that is at a lower level in the lock hierarchy. The name intent locks is given because they are acquired before a lock at the low level and hence, indicate intent to place locks at low level. An intent lock is useful for two purposes:

- To prevent other transactions from changing the higher-level resource in a way that will invalidate the lock at the lower-level.
- To improve the efficiency of the Database Engine for identifying the lock conflicts those are at the higher level of granularity.

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For example, a shared intent locks are requested at the table level before requesting the shared locks on rows or pages within the table. Setting the intent lock at the table level protects other transaction from subsequently acquiring an exclusive lock on the table containing pages. Intent locks also contain Intent Exclusive (IX), Intent Shared (IS), and Shared with Intent Exclusive (SIX). Table 14.4 lists the lock modes in Intent locks.

Lock Mode	Description
Intent shared (IS)	Protects the requested shared lock on some resources that are lower in the hierarchy.
Intent exclusive (IX)	Protects the requested exclusive lock on some resources lower in the hierarchy. IX is a superset of IS, that protects requesting shared locks on lower level resources.
Shared with Intent Exclusive (SIX)	Protects the requested shared lock on all resources lower in the hierarchy and intent exclusive locks on some of the lower level resources. Concurrent IS locks are allowed at the top-level resource.
Intent Update (IU)	Protects the requested update locks on all resources lower in the hierarchy. IU locks are used only on page resources. IU locks are converted to IX locks if an update operation takes place.
Shared intent update (SIU)	Provides the combination of S and IU locks, as a result of acquiring these locks separately and simultaneously holding both locks.
Update intent exclusive (UIX)	Provides the combination of U and IX locks, as a result of acquiring these locks separately and simultaneously holding both locks.

Table 14.4: Lock Modes in Intent Locks

It is hard to fail, but it is worse never to have tried to succeed.

→ Bulk Update locks

Bulk update locks are used by the database engine. These locks are used when a large amount of data is copied into a table (bulk copy operations) and either the table lock on bulk load option is set or the TABLOCK hint is specified using the sp_tableoption.

These locks allow multiple threads to load bulk data continuously in the same table however, preventing other processes that are not bulk loading data from accessing the table.

→ Schema Locks

Schema modification locks are used by Database Engine while performing a table DDL operation such as dropping a table or a column. Schema locks prevent concurrent access to the table, which means a schema lock blocks all external operations until the lock releases.

Some DML operations such as truncating a table use the Schema lock to prevent access to affected tables by concurrent operations.

Schema stability locks are used by the database engine while compiling and executing the queries. These stability locks do not block any of the transaction locks including the exclusive locks. Hence, the transactions that include X locks on the table continue to execute during the query compilation. Though, the concurrent DML and DDL operations that acquire the Schema modification locks do not perform on the tables.

→ Key-Range Locks

These types of locks protect a collection of rows that are implicitly present in a recordset which is being read by a Transact-SQL statement while using the serializable transaction isolation level. Key-range locks prevent phantom reads. By protecting the range of keys between rows, they also prevent the phantom deletions or insertions in the recordset that accesses a transaction.

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14.9 Transaction Management

Every single statement that is executed is, by default, transactional in SQL Server. If a single SQL statement is issued, then, an implicit transaction is started. It means the statement will start and complete implicitly. When the users use explicit BEGIN TRAN/COMMIT TRAN commands, they can group them together as an explicit transaction. These statements will either succeed or fail. SQL Server implements several transaction isolation levels that ensure the ACID properties of these transactions. In reality, it means that it uses locks to facilitate transactional access to shared database resources and also, prevent the interference between the transactions.

14.10 Transaction Log

Each SQL Server database has a transaction log, which records all transactions and the database modifications made by every transaction. The transaction log should be truncated regularly to keep it from filling up. Monitoring log size is important as there may be some factors that delay the log truncation.

Transaction log is a critical component of the database and if a system failure occurs, the transaction log will be required to bring the database to a consistent data. The transaction log should not be moved or deleted until users understand the consequences of doing it. The operations supported by the transaction log are as follows:

- Individual transactions recovery
- Incomplete transactions recovery when SQL Server starts
- Transactional replication support
- Disaster recovery solutions and high availability support
- Roll back a file, restored database, filegroup, or page forward to the point of failure



→ Truncating a Transaction Log

Truncating a log frees the space in the log file for reusing the transaction log. Truncation of logs starts automatically after the following events:

- In a simple recovery model after the checkpoint.
- In a bulk-logged recovery model or full recovery model, if the checkpoint is occurred ever since the last backup, truncation occurs after a log backup.

There are factors that delay a log truncation. When the log records remain active for a long time, transaction log truncation is late and the transaction log fills up. Log truncations are delayed due to many reasons. Users can also discover if anything prevents the log truncation by querying the `log_reuse_wait_desc` and `log_reuse_wait` columns of the `sys.databases` catalog view.

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Table 14.5 lists the values of some of these columns.

Log_reuse_wait mode	value	Log_reuse_wait value	desc	Description
0	NOTHING			Specifies that at present, there are more than one reusable virtual log file.
1	CHECKPOINT			Specifies that there is no checkpoint occurred since the last log truncation, or the head of the log has not moved beyond a virtual log file.
2	LOG_BACKUP			Specifies a log backup that is required before the transaction log truncates.
3	ACTIVE_BACKUP_OR_RESTORE			Specifies that the data backup or a restore is in progress.
4	ACTIVE_TRANSACTION			Specifies that a transaction is active.
5	DATABASE_MIRRORING			Specifies that the database mirroring is paused, or under high-performance mode, the mirror database is significantly behind the principal database.

Table 14.5: Values of log_reuse_wait_desc and log_reuse_wait Columns

The future depends on what we do in the present.

14.11 Check Your Progress

1. Which of the following types of transaction is related to Multiple Active Result Sets?

(A)	Autocommit	(C)	Implicit
(B)	Explicit	(D)	Batch-scoped

2. _____ marks the beginning point of an explicit or local transaction.

(A)	ROLLBACK TRANSACTION	(C)	COMMIT WORK
(B)	BEGIN TRANSACTION	(D)	COMMIT TRANSACTION

3. Identify the function that returns a number of BEGIN TRANSACTION statements that occur in the current connection.

(A)	@@TRANCOUNTER	(C)	@@TRANCOUNT
(B)	@@ERRORMESSAGE	(D)	@@ERROR

4. Which of the following is not the concurrency effect allowed by the different isolation levels?

(A)	Read committed	(C)	Repeatable Read
(B)	Snapshot	(D)	COMMIT

5. Match the types of resource lock modes in SQL Server 2012 against their corresponding descriptions.

	Description		Lock Modes
a.	Is used on resources that are to be updated.	1.	Schema
b.	Is used for read operations that do not change data such as SELECT statement.	2.	Exclusive
c.	Is used to establish a hierarchy of locks.	3.	Intent
d.	Is used for INSERT, UPDATE, or DELETE data-modification operations.	4.	Shared
e.	Is used when the operation is dependent on the table schema.	5.	Update

(A)	a-1, b-4, c-2, d-3, e-5	(C)	a-2, b-4, c-3, d-5, e-1
(B)	a-5, b-4, c-3, d-2, e-1	(D)	a-1, b-2, c-3, d-4, e-5

Summary

2.	B
→ 3.	A transaction is a sequence of operations that works as a single unit.
→ 4.	Transactions can be controlled by an application by specifying a beginning and an ending.
→ 5.	BEGIN TRANSACTION marks the beginning point of an explicit or local transaction.

- COMMIT TRANSACTION marks an end of a successful implicit or explicit transaction.
- ROLLBACK with an optional keyword WORK rolls back a user-specified transaction to the beginning of the transaction.
- @@TRANCOUNT is a system function that returns a number of BEGIN TRANSACTION statements that occur in the current connection.
- Isolation levels are provided by the transaction to describe the extent to which a single transaction needs to be isolated from changes made by other transactions.
- The SQL Server Database Engine locks the resources using different lock modes, which determine the resources that are accessible to concurrent transactions.



Try It Yourself

- Zamora Electronics Ltd. employs more than 500 workers in its units. Some of these are at junior level while some are at senior level depending upon their expertise and years of experience. Each employee is given annual leave based on the designation. The management at Zamora Electronics Ltd. is planning to computerize their human resources department and all the data pertaining to employees will now be stored in an SQL Server 2012 database. The company has made some changes in the leave policy of the employees and wants to update the same in their tables. Assume that you are the database administrator and that you are assigned the following tasks:
 - Create a transaction to update the records in the table as per the new leave policy.
 - Check if the transactions are updated in the appropriate table.
 - Check if the transactions are not updated. Then, ensure that they are rolled back with the appropriate error messages.

Table 14.6 lists the **EmployeeDetails** table.

Field Name	Data Type	Key Field	Description
Employee_Id	varchar(5)	Primary Key	Stores employee identification number
FirstName	varchar(30)		Stores first name of the employee
LastName	varchar(30)		Stores last name of the employee
Address	varchar(60)		Stores address of the employee
PhoneNumber	varchar(20)		Phone number of the employee, it could be landline or mobile
Department_Id	varchar(4)		Stores department id of the department to which the employee belongs
Designation	varchar(30)		Stores designation or job role of the employee
Salary	money		Stores salary of the employee
Join_date	datetime		Stores date of joining for the employee
Performance_Rating	int		Stores rating of the employee

Table 14.6: EmployeeDetails Table

Session - 15

Error Handling

Welcome to the Session, **Error Handling**.

This session introduces error-handling techniques in SQL Server and describes the use of TRY-CATCH blocks. Various system functions and statements that can help display error information are also covered in the session.

In this Session, you will learn to:

- Explain the various types of errors
- Explain error handling and the implementation
- Describe the TRY-CATCH block
- Explain the procedure to display error information
- Describe the @@ERROR and RAISERROR statements
- Explain the use of ERROR_STATE, ERROR_SEVERITY, and ERROR_PROCEDURE
- Explain the use of ERROR_NUMBER, ERROR_MESSAGE, and ERROR_LINE
- Describe the THROW statement

15.1 Introduction

Error handling in SQL Server has become easy through a number of different techniques. SQL Server has introduced options that can help you to handle errors efficiently. Often, it is not possible to capture errors that occur at the user's end. SQL Server provides the TRY...CATCH statement that helps to handle errors effectively at the back end. There are also a number of system functions that print error related information, which can help fix errors easily.

15.2 Types of Errors

As a Transact-SQL programmer, one must be aware of the various types of errors that can occur while working with SQL Server statements. The first step one can perform is to identify the type of the error and then determine how to handle or overcome it.

Some of the types of errors are as follows:

→ Syntax Errors

Syntax errors are the errors that occur when code cannot be parsed by SQL Server. Such errors are detected by SQL Server before beginning the execution process of a Transact-SQL block or stored procedure.



Some scenarios where syntax errors occur are as follows:

- If a user is typing an operator or a keyword is used in a wrong way, the code editor will display the tooltip showing the error. Figure 15.1 displays an example of syntax error.

The screenshot shows a SQL query window titled 'SQLQuery1.sql - 10....160.master (sa (51))*'. The query is:1 USE AdventureWorks2012;
2 GO
3
4 DECLARE @Number SET;
5 GOA tooltip box appears over the word 'SET' in line 4, containing the text 'Incorrect syntax near 'SET''. The status bar at the bottom shows 'Connected. (1/1)' and connection details: '10.2.110.160 (11.0 RTM) | sa (51) | master | 00:00:00 | 0 rows'.

Figure 15.1: Syntax Error

In figure 15.1, the `SET` operator is wrongly used in the Transact-SQL statement, hence a syntax error will be raised.

- If a user types a keyword or an operator wrongly because the user does not remember the valid usage, the code editor will appropriately indicate it.

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Figure 15.2 displays an example.

The screenshot shows a SQL query window titled 'SQLQuery1.sql - 10...160.master (sa (51))'. The code entered is:

```
1 US AdventureWorks2012;
2 Could not find stored procedure 'US'.
```

An error message 'Could not find stored procedure 'US''. The status bar at the bottom shows 'Connected. (1/1)' and '10.2.110.160 (11.0 RTM) | sa (51) | master | 00:00:00 | 0 rows'.

Figure 15.2: Wrong Keyword Error

- If the user forgets to type something that is required, the code editor will display an error once the user executes that statement.

Syntax errors are easily identified as the code editor points them out. Therefore, these errors can be easily fixed. However, if users use a command-based application such as `sqlcmd`, the error is shown only after the code is executed.

→ Run-time Errors

Run-time errors are errors that occur when the application tries to perform an action that is supported neither by SQL Server nor by the operating system. Run-time errors are sometimes difficult to fix as they are not clearly identified or are external to the database.

*Action may not always bring happiness,
but there is no happiness without
action.*

Some instances where run-time errors can occur are as follows:

- Performing a calculation such as division by 0
- Trying to execute code that is not defined clearly

Figure 15.3 shows the divide by zero error.

The screenshot shows a SQL query window titled 'SQLQuery1.sql - 10....Works2012 (sa (51))*'. The query is:USE AdventureWorks2012;
GO
DECLARE @Number1 int;
SET @NUmber1 = 217/0
GOA message window titled 'Messages' displays the error: 'Msg 8134, Level 16, State 1, Line 2 Divide by zero error encountered.' The status bar at the bottom shows 'Q... | 10.2.110.160 (11.0 RTM) | sa (51) | AdventureWorks2012 | 00:00:00 | 0 rows'.

Figure 15.3: Divide by Zero Error

Here, the code editor will not show any error before execution because there is no syntax error.

- Using a stored procedure, or a function, or a trigger that is unavailable
- Trying to perform an action that an object or a variable cannot handle
- Attempting to access or use computer memory that is insufficient

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Figure 15.4 displays an example that tries to store a value in the variable that does not meet the specified range. In such a case, an arithmetic overflow error occurs.

The screenshot shows a SQL query window titled 'SQLQuery1.sql - 10....Works2012 (sa (51))*'. The query is:1 USE AdventureWorks2012;
2 GO
3 DECLARE @Number1 tinyint;
4 SET @Number1 = 2268
5 GOA message window titled 'Messages' displays the error: 'Msg 220, Level 16, State 2, Line 2 Arithmetic overflow error for data type tinyint, value = 2268.' Below the message window, the status bar shows 'Quer... | 10.2.110.160 (11.0 RTM) | sa (51) | AdventureWorks2012 | 00:00:00 | 0 rows'.

Figure 15.4: Arithmetic Overflow Error

- Trying to perform an action on incompatible types
- Using wrongly conditional statements



15.3 Implementing Error Handling

While developing any application, one of the most important things that users need to take care of is error handling. In the same way, users also have to take care of handling exception and errors while designing the database. Various error handling mechanisms can be used. Some of them are as follows:

- When executing some DML statements such as `INSERT`, `DELETE`, and `UPDATE`, users can handle errors to ensure correct output.
- When a transaction fails and the user needs to roll back the transaction, an appropriate error message can be displayed.
- When working with cursors in SQL Server, users can handle errors to ensure correct results.

15.4 TRY...CATCH

`TRY...CATCH` statements are used to implement exception handling in Transact-SQL. One or more Transact-SQL statements can be enclosed within a `TRY` block. If an error occurs in the `TRY` block, the control is passed to the `CATCH` block that may contain one or more statements.

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Figure 15.5 illustrates the TRY...CATCH logic.

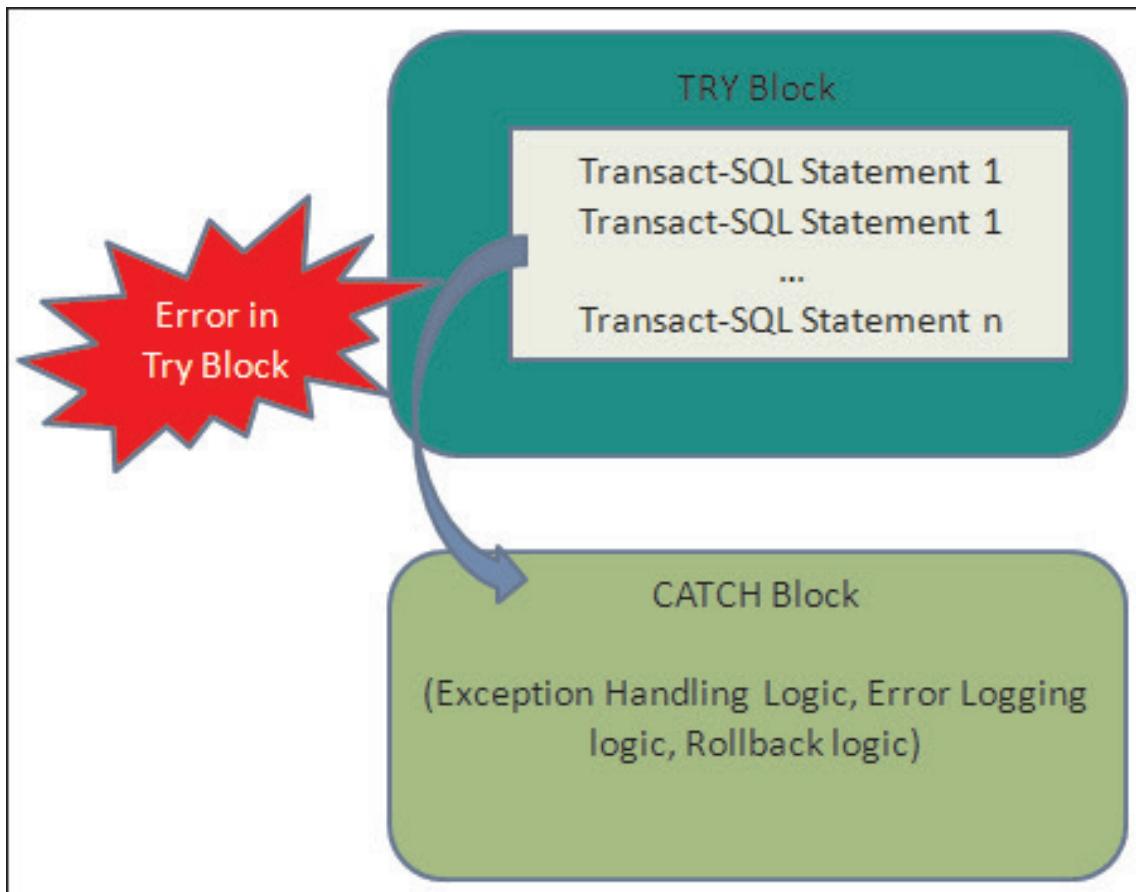


Figure 15.5: TRY...CATCH Logic

First say to yourself what you would be; and then do what you have to do.

Following is the syntax for the TRY...CATCH statements.

Syntax:

```
BEGIN TRY  
    { sql_statement | statement_block }  
END TRY  
  
BEGIN CATCH  
    [ { sql_statement | statement_block } ]  
END CATCH  
[ ; ]
```

where,

`sql_statement`: specifies any Transact-SQL statement.

`statement_block`: specifies the group of Transact-SQL statements in a BEGIN...END block.

A TRY...CATCH construct will catch all run-time errors that have severity higher than 10 and that do not close the database connection. A TRY block is followed by a related CATCH block. A TRY...CATCH block cannot span multiple batches or multiple blocks of Transact-SQL statements.

If there are no errors in the TRY block, after the last statement in the TRY block has executed, control is passed to the next statement following the END CATCH statement. If there is an error in the TRY block, control is passed to the first statement inside the CATCH block. If END CATCH is the last statement in a trigger or a stored procedure, control is passed back to the calling block.

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Code Snippet 1 demonstrates a simple example of TRY...CATCH statements.

Code Snippet 1:

```
BEGIN TRY
    DECLARE @num int;
    SELECT @num=217/0;
END TRY
BEGIN CATCH
    PRINT 'Error occurred, unable to divide by 0'
END CATCH;
```

In this code, an attempt is made to divide a number by zero. This will cause an error, hence, the TRY...CATCH statement is used here to handle the error.

Both TRY and CATCH blocks can contain nested TRY...CATCH constructs. For example, a CATCH block can have an embedded TRY...CATCH construct to handle errors faced by the CATCH code. Errors that are encountered in a CATCH block are treated just like errors that are generated elsewhere. If the CATCH block encloses a nested TRY...CATCH construct, any error in the nested TRY block passes the control to the nested CATCH block. If there is no nested TRY...CATCH construct the error is passed back to the caller.

TRY...CATCH constructs can also catch unhandled errors from triggers or stored procedures that execute through the code in TRY block. However, as an alternative approach, triggers or stored procedures can also enclose their own TRY...CATCH constructs to handle errors generated through their code.

GOTO statements can be used to jump to a label inside the same TRY...CATCH block or to leave the TRY...CATCH block. The TRY...CATCH construct should not be used in a user-defined function.



15.5 Error Information

It is a good practice to display error information along with the error, so that it can help to solve the error quickly and efficiently.

To achieve this, system functions need to be used in the `CATCH` block to find information about the error that initiated the `CATCH` block to execute.

The system functions are as follows:

- `ERROR _ NUMBER()`: returns the number of error.
- `ERROR _ SEVERITY()`: returns the severity.
- `ERROR _ STATE()`: returns state number of the error.
- `ERROR _ PROCEDURE()`: returns the name of the trigger or stored procedure where the error occurred.
- `ERROR _ LINE()`: returns the line number that caused the error.
- `ERROR _ MESSAGE()`: returns the complete text of the error. The text contains the value supplied for the parameters such as object names, length, or times.

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The functions return `NULL` when they are called outside the scope of the `CATCH` block.

→ **Using TRY...CATCH with error information**

Code Snippet 2 demonstrates a simple example displaying error information.

Code Snippet 2:

```
USE AdventureWorks2012;
GO
BEGIN TRY
    SELECT 217/0;
END TRY
BEGIN CATCH
    SELECT
        ERROR_NUMBER() AS ErrorNumber,
        ERROR_SEVERITY() AS ErrorSeverity,
        ERROR_LINE() AS ErrorLine,
        ERROR_MESSAGE() AS ErrorMessage;
END CATCH;
GO
```

Learning how to learn is life's most important skill.

In this code, the SELECT statement will cause a divide-by-zero error that is handled using the TRY...CATCH statement. The error causes the execution to jump to the associated CATCH block within which the error information will be displayed.

Figure 15.6 displays the result of the error information. The first resultset is blank because the statement fails.

(No column name)				
	ErrorNumber	ErrorSeverity	ErrorLine	ErrorMessage
1	8134	16	2	Divide by zero error encountered.

Figure 15.6: Error Information

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Code Snippet 3 demonstrates a stored procedure that contains error-handling functions.

Code Snippet 3:

```
USE AdventureWorks2012;
GO
IF OBJECT_ID ( 'sp_ErrorInfo', 'P' ) IS NOT NULL
DROP PROCEDURE sp_ErrorInfo;
GO
CREATE PROCEDURE sp_ErrorInfo
AS
SELECT
    ERROR_NUMBER() AS ErrorNumber,
    ERROR_SEVERITY() AS ErrorSeverity,
    ERROR_STATE() AS ErrorState,
    ERROR_PROCEDURE() AS ErrorProcedure,
    ERROR_LINE() AS ErrorLine,
    ERROR_MESSAGE() AS ErrorMessage;
GO
BEGIN TRY
    SELECT 217/0;
END TRY
BEGIN CATCH
    EXECUTE sp_ErrorInfo;
END CATCH;
```

Onlinevarsity



In this code, when an error occurs, the CATCH block of the TRY...CATCH construct is called and the error information is returned.

→ Using TRY...CATCH with Transaction

Code Snippet 4 demonstrates a TRY...CATCH block that works inside a transaction.

Code Snippet 4:

```
USE AdventureWorks2012;
GO
BEGIN TRANSACTION;
BEGIN TRY
    DELETE FROM Production.Product
    WHERE ProductID = 980;
END TRY
BEGIN CATCH
    SELECT
        ERROR_SEVERITY() AS ErrorSeverity
        ,ERROR_NUMBER() AS ErrorNumber
        ,ERROR_PROCEDURE() AS ErrorProcedure
        ,ERROR_STATE() AS ErrorState
        ,ERROR_MESSAGE() AS ErrorMessage
        ,ERROR_LINE() AS ErrorLine;
    IF @@TRANCOUNT > 0
        ROLLBACK TRANSACTION;
END CATCH;
IF @@TRANCOUNT > 0
    COMMIT TRANSACTION;
GO
```

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In this code, the TRY...CATCH block works within the transaction. The statement inside the TRY block generates a constraint violation error as follows:

The DELETE statement is conflicted with the REFERENCE constraint "FK_BillOfMaterials_Product_ProductAssemblyID". The conflict occurred in database "AdventureWorks2012", table "Production.BillOfMaterials", column 'ProductAssemblyID'.

→ Uncommittable Transactions

If an error is generated in a TRY block, it causes the state of the current transaction to be invalid and the transaction is considered as an uncommitted transaction. An uncommittable transaction performs only ROLLBACK TRANSACTION or read operations. The transaction does not execute any Transact-SQL statement that performs a COMMIT TRANSACTION or a write operation.

The XACT_STATE function returns -1 if the transaction has been classified as an uncommittable transaction. When a batch is completed, the Database Engine rolls back any uncommittable transactions. If no error messages are sent when the transaction enters the uncommittable state on completing the batch, then the error messages are sent to the client. This specifies that an uncommittable transaction is detected and rolled back.

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

15.6 The @@ERROR

The @@ERROR function returns the error number for the last Transact-SQL statement executed.

Following is the syntax for the @@ERROR function.

Syntax:

```
@@ERROR
```

The @@ERROR system function returns a value of the integer type. This function returns 0, if the previous Transact-SQL statement encountered no errors. It also returns an error number only if the previous statements encounter an error. If an error is among the list of errors in the sys.messages catalog view includes the value from the sys.messages.messages_id column for that error. Users can view the text associated with an @@ERROR error number in the sys.messages catalog view.

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Code Snippet 5 demonstrates how to use @@ERROR to check for a constraint violation.

Code Snippet 5:

```
USE AdventureWorks2012;
GO
BEGIN TRY
    UPDATE HumanResources.EmployeePayHistory
        SET PayFrequency = 4
        WHERE BusinessEntityID = 1;
END TRY
BEGIN CATCH
    IF @@ERROR = 547
        PRINT N'Check constraint violation has occurred.';
END CATCH
```

In this code, @@ERROR is used to check for a check constraint violation (which has error number 547) in an UPDATE statement.

It displays the following error message:

Check constraint violation has occurred.

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15.7 RAISERROR

The RAISERROR statement starts the error processing for a session and displays an error message. RAISERROR can reference a user-defined message stored in the sys.messages catalog view or build dynamic error messages at run-time. The message is returned as a server error message to the calling application or to the associated CATCH block of a TRY...CATCH construct.

Following is the syntax for the RAISERROR statement.

Syntax:

```
RAISERROR ( { msg_id | msg_str | @local_variable }  
    { ,severity ,state }  
    [ ,argument [ ,...n ] ] )  
    [ WITH option [ ,...n ] ]
```

where,

msg_id: specifies the user-defined error message number that is stored in the sys.messages catalog view using the sp_addmessage.

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`msg_str`: Specifies the user-defined messages with formatting. `msg_str` is a string of characters with optional embedded conversion specifications. A conversion specification has the following format:

`% [[flag] [width] [. precision] [{h | l}]] type`

The parameters that can be used in `msg_str` are as follows:

`{h | l} type`: Specifies the use of character types `d`, `i`, `o`, `s`, `x`, `X`, or `u`, and creates `shortint(h)` or `longint(l)` values.

Following are some of the type specifications:

`d` or `i`: Specifies the signed integer

`o`: Specifies the unsigned octal

`x` or `X`: Specifies the unsigned hexadecimal

`flag`: Specifies the code that determines the spacing and justification of the substituted value. This can include symbols such as `-` (minus) and `+` (plus) to specify left-justification or to indicate the value is a signed type respectively.

`precision`: Specifies the maximum number of characters taken from the argument value for string values. For example, if a string has five characters and the precision is 2, only the first two characters of the string value are used.

`width`: Specifies an integer that defines the minimum width for the field in which the argument value is placed.

To learn, you must want to be taught.

`@local_variable`: Specifies a variable of any valid character data type that contains string formatted in the same way as `msg_str`.

`severity`: Severity levels from 0 through 18 are specified by any user. Severity levels from 19 through 25 are specified by members of the `sysadmin` fixed server role or users with `ALTER TRACE` permissions. Severity levels from 19 through 25 uses the `WITH LOG` option is required.

`option`: Specifies the custom option for the error.

Table 15.1 lists the values for the custom options.

Value	Description
LOG	Records the error in the error log and the application log for the instance of the Microsoft SQL Server Database Engine.
NOWAIT	Sends message directly to the client
SETERROR	Sets the <code>ERROR_NUMBER</code> and <code>@@ERROR</code> values to <code>msg_id</code> or 5000 irrespective of the severity level.

Table 15.1: Type Specification Values

When `RAISERROR` executes with a severity of 11 or higher in a `TRY` block, it will transfer the control to the associated `CATCH` block.

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Following errors are returned back to the caller if RAISERROR executes:

- Out of scope of any TRY block
- Having severity of 10 or lower in TRY block
- Having severity of 20 or higher that terminates the database connection

A CATCH block can use the RAISERROR statement to rethrow the error that has invoked the CATCH block. For this, it will need to know the original error information which can be obtained through the ERROR_NUMBER and the ERROR_MESSAGE system functions.

By default, the @@ERROR is set to 0 for messages that have a severity from 1 through 10.

Code Snippet 6 demonstrates how to build a RAISERROR statement to display a customized error statement.

Code Snippet 6:

```
RAISERROR (N'This is an error message %s %d.',
           10, 1, N'serial number', 23);
GO
```



In this code, the RAISERROR statements takes the first argument of N'serial number' changes the first conversion specification of %s, and the second argument of 23 changes the second conversion of %d. The code snippet displays the 'This is error message serial number 23'. Code Snippet 7 demonstrates how to use RAISERROR statement to return the same string.

Code Snippet 7:

```
RAISERROR (N'%*.*s', 10, 1, 7, 3, N'Helloworld');
GO
RAISERROR (N'%7.3s', 10, 1, N'Helloworld');
GO
```

In this code, the RAISERROR statements return the same string, **Hell**. The first statement specifies the width and the precision values and the second statement specifies the conversion specification.

Users can also return error information from a CATCH block.

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Code Snippet 8 demonstrates how to use RAISERROR statement inside the TRY block.

Code Snippet 8:

```
BEGIN TRY
    RAISERROR ('Raises Error in the TRY block.', 16, 1);
END TRY

BEGIN CATCH
    DECLARE @ErrorMessage NVARCHAR(4000);
    DECLARE @ErrorSeverity INT;
    DECLARE @ErrorState INT;
    SELECT
        @ErrorMessage = ERROR_MESSAGE(),
        @ErrorSeverity = ERROR_SEVERITY(),
        @ErrorState = ERROR_STATE();
    RAISERROR (@ErrorMessage, @ErrorSeverity, @ErrorState);
END CATCH;
```

In this code, the RAISERROR statement used inside the TRY block has severity 16, which causes the execution to jump to the associated CATCH block.

RAISERROR is then used inside the CATCH block to return the error information about the original error.

Democritus said, words are but the shadows of actions.

15.8 ERROR_STATE

The `ERROR_STATE` system function returns the state number of the error that causes the `CATCH` block of a `TRY...CATCH` construct to execute. Following is the syntax for the `ERROR_STATE` system function.

Syntax:

```
ERROR_STATE ( )
```

When called in a `CATCH` block, it returns the state number of the error message that caused the `CATCH` block to be run. This returns a `NULL` when it is called outside the scope of a `CATCH` block.

There are specific error messages that are raised at various points in the code for the SQL Server Database Engine. For example, an error 1105 is raised for several different conditions. Each specific condition that raises error assigns the unique state code.

`ERROR_STATE` is called from anywhere within the scope of a `CATCH` block. `ERROR_STATE` returns the error state regardless of how many times it is executed or whether it is executed within the scope of the `CATCH` block. This is in comparison with the functions such as `@@ERROR` that only returns the error number in the statement directly after the one that caused error, or in the first statement of a `CATCH` block.

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Users can use the `ERROR_STATE` in a `CATCH` block. Code Snippet 9 demonstrates how to use `ERROR_STATE` statement inside the `TRY` block.

Code Snippet 9:

```
BEGIN TRY
    SELECT 217/0;
END TRY
BEGIN CATCH
    SELECT ERROR_STATE() AS ErrorState;
END CATCH;
GO
```

In this code, the `SELECT` statement generates a divide-by-zero error. The `CATCH` statement will then return the state of the error. The `ERROR_STATE` is displayed as 1.



15.9 ERROR_SEVERITY

The `ERROR_SEVERITY` function returns the severity of the error that causes the `CATCH` block of a `TRY...CATCH` construct to be executed.

Following is the syntax for `ERROR_SEVERITY`.

Syntax:

```
ERROR_SEVERITY ( )
```

It returns a `NULL` value if called outside the scope of the `CATCH` block. `ERROR_SEVERITY` can be called anywhere within the scope of a `CATCH` block. In nested `CATCH` blocks, `ERROR_SEVERITY` will return the error severity that is specific to the scope of the `CATCH` block where it is referenced. Users can use the `ERROR_SEVERITY` function in a `CATCH` block.

Code Snippet 10 shows how to display the severity of the error.

Code Snippet 10:

```
BEGIN TRY
    SELECT 217/0;
BEGIN CATCH
    SELECT ERROR_SEVERITY() AS ErrorSeverity;
END CATCH;
GO
END TRY
```

In this code, an attempt to divide by zero generates the error and causes the `CATCH` block to display the severity error as 16.

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15.10 ERROR_PROCEDURE

The `ERROR_PROCEDURE` function returns the trigger or a stored procedure name where the error has occurred that has caused the `CATCH` block of a `TRY...CATCH` construct to be executed. Following is the syntax of the `ERROR_PROCEDURE`.

Syntax:

```
ERROR_PROCEDURE ( )
```

It returns the `nvarchar` data type. When the function is called in a `CATCH` block, it will return the name of the stored procedure where the error occurred. The function returns a `NULL` value if the error has not occurred within a trigger or a stored procedure. `ERROR_PROCEDURE` can be called from anywhere in the scope of a `CATCH` block. The function also returns `NULL` if this function is called outside the scope of a `CATCH` block.

In nested `CATCH` blocks, the `ERROR_PROCEDURE` returns the trigger or stored procedure name specific to the scope of the `CATCH` block where it is referenced.

*Nothing is a waste of time if you use
the experience wisely.*

Code Snippet 11 shows the use of the ERROR_PROCEDURE function.

Code Snippet 11:

```
USE AdventureWorks2012;
GO
IF OBJECT_ID ('usp_Example', 'P') IS NOT NULL
DROP PROCEDURE usp_Example;
GO
CREATE PROCEDURE usp_Example
AS
SELECT 217/0;
GO
BEGIN TRY
EXECUTE usp_Example;
END TRY
BEGIN CATCH
SELECT ERROR_PROCEDURE () AS ErrorProcedure;
END CATCH;
GO
```

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In this code, the stored procedure `usp_Example` generates a divide-by-zero error. The `ERROR_PROCEDURE` function accordingly returns the name of this stored procedure where the error has occurred.

Code Snippet 12 demonstrates the use of `ERROR_PROCEDURE` function along with other functions.

Code Snippet 12:

```
USE AdventureWorks2012;
GO
IF OBJECT_ID ('usp_Example', 'P') IS NOT NULL
DROP PROCEDURE usp_Example;
GO
CREATE PROCEDURE usp_Example
AS
SELECT 217/0;
GO
BEGIN TRY
EXECUTE usp_Example;
END TRY
BEGIN CATCH
SELECT
    ERROR_NUMBER() AS ErrorNumber,
    ERROR_SEVERITY() AS ErrorSeverity,
    ERROR_STATE() AS ErrorState,
    ERROR_PROCEDURE() AS ErrorProcedure,
    ERROR_MESSAGE() AS ErrorMessage,
    ERROR_LINE() AS ErrorLine;
END CATCH;
GO
```

This code makes use of several error handling system functions that can help to detect and rectify an error easily.

15.11 ERROR_NUMBER

The `ERROR_NUMBER` system function when called in a `CATCH` block returns the error number of the error that causes the `CATCH` block of a `TRY...CATCH` construct to be executed. Following is the syntax of `ERROR_NUMBER`.

Syntax:

```
ERROR_NUMBER ( )
```

The function can be called from anywhere inside the scope of a `CATCH` block. The function will return `NULL` when it is called out of the scope of a `CATCH` block.

`ERROR_NUMBER` returns the error number irrespective of how many times it executes or whether it executes within the scope of a `CATCH` block. This is different than the `@@ERROR` which only returns the error number in the statement immediately after the one that causes error, or the first statement of the `CATCH` block.

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Code Snippet 13 demonstrates the use of `ERROR_NUMBER` in a `CATCH` block.

Code Snippet 13:

```
BEGIN TRY  
    SELECT 217/0;  
END TRY  
  
BEGIN CATCH  
    SELECT ERROR_NUMBER() AS ErrorNumber;  
END CATCH;  
  
GO
```

As a result of this code, the error number is displayed when the attempted division by zero occurs.

15.12 `ERROR_MESSAGE`

The `ERROR_MESSAGE` function returns the text message of the error that causes the `CATCH` block of a `TRY...CATCH` construct to execute.

Following is the syntax of `ERROR_MESSAGE`.

Syntax:

```
ERROR_MESSAGE ( )
```

Learning how to learn is life's most important skill.

When the `ERROR_MESSAGE` function is called in the `CATCH` block, it returns the full text of the error message that causes the `CATCH` block to execute. The text includes the values that are supplied for any parameter that can be substituted such as object names, times, or lengths. It also returns `NULL` if it is called outside the scope of a `CATCH` block.

Code Snippet 14 demonstrates the use of `ERROR_MESSAGE` in a `CATCH` block.

Code Snippet 14:

```
BEGIN TRY  
    SELECT 217/0;  
END TRY  
  
BEGIN CATCH  
    SELECT ERROR_MESSAGE () AS ErrorMessage;  
END CATCH;  
  
GO
```

In this code, similar to other examples, the `SELECT` statement generates a divide-by-zero error. The `CATCH` block displays the error message.

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15.13 ERROR_LINE

The `ERROR_LINE` function returns the line number at which the error occurred in the `TRY...CATCH` block.

Following is the syntax of `ERROR_LINE`.

Syntax:

```
ERROR_LINE()
```

When this function is called in the `CATCH` block, it returns the line number where the error has occurred. If the error has occurred within a trigger or a stored procedure, it returns the line number in that trigger or stored procedure. Similar to other functions, this function returns a `NULL` if it is called outside the scope of a `CATCH` block.

Code Snippet 15 demonstrates the use of `ERROR_LINE` in a `CATCH` block.

Code Snippet 15:

```
BEGIN TRY
    SELECT 217/0;
END TRY
BEGIN CATCH
    SELECT ERROR_LINE() AS ErrorLine;
END CATCH;
GO
```

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As a result of this code, the line number at which the error has occurred will be displayed.

15.14 Errors Unaffected by the TRY...CATCH Construct

The TRY...CATCH construct does not trap the following conditions:

- Informational messages or Warnings having a severity of 10 or lower
- An error that has a severity of 20 or higher that stops the SQL Server Database Engine task processing for the session. If errors occur that have severity of 20 or higher and the database connection is not interrupted, the TRY...CATCH will handle the error
- Attentions such as broken client connection or client-interrupted requests
- When the session ends because of the KILL statements used by the system administrator

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Following types of errors are not handled by a CATCH block that occur at the same execution level as that of the TRY...CATCH construct:

- Compile errors such as syntax errors that restrict a batch from running
- Errors that arise in the statement-level recompilation such as object name resolution errors occurring after compiling due to deferred name resolution.

Code Snippet 16 demonstrates how an object name resolution error is generated by the SELECT statement.

Code Snippet 16:

```
USE AdventureWorks2012;
GO
BEGIN TRY
    SELECT * FROM Nonexistent;
END TRY
BEGIN CATCH
    SELECT
        ERROR_NUMBER() AS ErrorNumber,
        ERROR_MESSAGE() AS ErrorMessage;
END CATCH
```

Who dares to teach must never cease to learn.

This code will cause the object name resolution error in the SELECT statement. It will not be caught by the TRY...CATCH construct.

Running a similar SELECT statement inside a stored procedure causes the error to occur at a level lower than the TRY block. The error is handled by the TRY...CATCH construct.

Code Snippet 17 demonstrates how the error message is displayed in such a case.

Code Snippet 17:

```
IF OBJECT_ID ( N'sp_Example', N'P' ) IS NOT NULL
DROP PROCEDURE sp_Example;
GO
CREATE PROCEDURE sp_Example
AS
SELECT * FROMNonexistent;
GO
BEGIN TRY
EXECUTE sp_Example;
END TRY
BEGIN CATCH
SELECT
ERROR_NUMBER() AS ErrorNumber,
ERROR_MESSAGE() AS ErrorMessage;
END CATCH;
```

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15.15 THROW

The THROW statement raises an exception and transfers control of the execution to a CATCH block of a TRY...CATCH construct.

Following is the syntax of the THROW statement.

Syntax:

```
THROW [ { error_number | @local_variable },
        { message | @local_variable },
        { state | @local_variable }
    ] [ ; ]
```

where,

error_number: specifies a constant or variable that represents the error_number as int.

message: specifies a variable or string that defines the exception message as nvarchar (2048).

State: specifies a variable or a constant between 0 and 255 that specifies the state to associate with state of message as tinyint.



Code Snippet 18 demonstrates the use of THROW statement to raise an exception again.

Code Snippet 18:

```
USE tempdb;
GO
CREATE TABLE dbo.TestRethrow
(
    ID INT PRIMARY KEY
);
BEGIN TRY
    INSERT dbo.TestRethrow(ID) VALUES(1);
    INSERT dbo.TestRethrow(ID) VALUES(1);
END TRY
BEGIN CATCH
    PRINT 'In catch block.';
    THROW;
END CATCH;
```

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In this code, the `THROW` statement is used to raise once again the exception that had last occurred.

The outcome of the code will be as follows:

```
(1 row(s) affected)
```

```
(0 row(s) affected)
```

In catch block.

```
Msg 2627, Level 14, State 1, Line 6
```

```
Violation of PRIMARY KEY constraint 'PK__TestReth__3214EC27AAB15FEE'.  
Cannot insert duplicate key in object 'dbo.TestRethrow'. The duplicate  
key value is (1).
```

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

15.16 Check Your Progress

1. _____ occur only if the user writes code that cannot be parsed by SQL Server, such as a wrong keyword or an incomplete statement.

(A)	Syntax Errors	(C)	Logical Errors
(B)	Run-time Errors	(D)	Error Log

2. Which of the following constructs can catch unhandled errors from triggers or stored procedures?

(A)	IF-ELSE	(C)	RAISERROR
(B)	TRY...CATCH	(D)	@@ERROR

3. Which of the following functions returns the error number for the last Transact-SQL statement executed?

(A)	ERROR_LINE	(C)	@@ERROR
(B)	RAISERROR	(D)	@@ERROR_NUMBER

4. Which of these functions returns the severity of the error that causes the CATCH block of a TRY...CATCH construct to be executed?

(A)	ERROR_LINE	(C)	ERROR_PROCEDURE
(B)	ERROR_NUMBER	(D)	ERROR_SEVERITY

5. The _____ statement raises an exception and transmits the execution to a CATCH block of a TRY...CATCH construct in SQL Server 2012.

(A)	BEGIN	(C)	THROW
(B)	END	(D)	ERROR

15.16.1 Answers

1.	A
2.	B
3.	C
4.	D
5.	C



Summary

- Syntax errors are the errors that occur when code cannot be parsed by SQL Server.
- Run-time errors occur when the application tries to perform an action that is supported neither by Microsoft SQL Server nor by the operating system.
- TRY...CATCH statements are used to handle exceptions in Transact-SQL.
- TRY...CATCH constructs can also catch unhandled errors from triggers or stored procedures that execute through the code in a TRY block.
- GOTO statements can be used to jump to a label inside the same TRY...CATCH block or to leave a TRY...CATCH block.
- Various system functions are available in Transact-SQL to print error information about the error that occurred.
- The RAISERROR statement is used to start the error processing for a session and displays an error message.



1. For the transactions created in the Try It Yourself of Session 10 and 15, add error-handling statements to take care of the errors.
2. Acme Technologies Private Limited is a leading software company located at New York. The company has achieved many awards as the best dealer in the development of software technologies. The company has received many new projects on mobile and Web development. At present, they are working on a database project for Payroll Management System in SQL Server 2012.

They have created the database on Payroll management system for the employees. While creating the tables, they receive different types of errors. Assume that you are the database administrator of Acme Technologies and the Technical head has assigned you the task of rectifying the errors. Perform the following steps:

- a. Write error-handling statements using the TRY...CATCH construct for both normal statements as well as stored procedures.
- b. Display the error information using the following:
 - ◆ ERROR_NUMBER
 - ◆ ERROR_MESSAGE
 - ◆ ERROR_LINE

Session - 16

Introduction to SQL Server 2016

Welcome to the Session, **Introduction to SQL Server 2016**.

This session provides an overview of SQL Server 2016. It also explains the new features of SQL Server 2016. There is brief discussion about evolution of SQL Server. Finally, the session lists and describes the different editions and versions of SQL Server.

In this Session, you will learn to:

- Describe an overview of SQL Server 2016
- Outline the new features of SQL Server 2016
- List and describe the different editions of SQL Server 2016

16.1 Introduction to SQL Server 2016

SQL Server 2016 is the latest version of Microsoft's flagship database product, SQL Server.

SQL Server 2016 has brought a revolutionary change in areas such as speedy transactions, higher security, more profound insights, and the latest hybrid cloud. It enhances mission-essential capabilities of in-memory operations.

AlwaysOn is a feature that ensures the database server is available all the time. This feature was first introduced in SQL Server 2012 and is improved in this release of SQL Server 2016.

SQL Server 2016 brings with its features such as enhanced Business Intelligence tools that enable the businesses for better data analytics. It also supports data backup on cloud.

16.1.1 What is New in SQL Server 2016?

The new features of SQL Server 2016 are as follows:

Enhanced In-Memory: This feature provides enhanced in-memory functionality for Online Transaction Processing (OLTP) operations. It can provide up to 30x times speedy operation on transaction data, and up to 100x times speedier real-time analytics, and database queries in comparison with conventional disk-based relational databases.

Always Encrypted: Always Encrypted feature is newly introduced in SQL Server 2016 and provides enhanced data security. This feature provides data security whether the data is in use or not and both in the same machine and on cloud. Developers need not change their application after implementing Always Encrypted security feature.



Advanced Analytics: Advanced analytics feature is another powerful new offering in SQL Server 2016. This provides a boost in the performance of analytics algorithms that are generated and implemented on a transactional database.

Rich Visualizations: Rich Visualization is another feature that makes it attractive for the end-user to use this application for business intelligence on a wide variety of mobile devices.

PolyBase Technology: Many other methods of data warehousing has evolved such as Hadoop and other noSQL methodologies. It is not always feasible to build separate application for them. PolyBase technology is a feature, which uses Transact SQL for querying and enables the users to access data from Hadoop and such noSQL data storages. This simplifies relational and non-relational data management.

Stretch Database: SQL Server 2016 also offers a new Stretch Database technology. This technology enables both warm and cold data to be stretched dynamically to Microsoft Azure. Warm data refers to data that is frequently accessed over a fast means of storage whereas cold data refers to rarely accessed data stored on the slowest storage that an organization has.

AlwaysOn: AlwaysOn feature provides effective disaster recovery and assured availability of data in the database server.

Consistent Experience: Using Microsoft SQL Server 2016 ensures that you and your customers will always have a consistent experience across on-premise and cloud environments. This can enable hybrid environments to operate smoothly.

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16.1.2 Evolution of SQL Server 2016

Microsoft SQL Server has come a long way since the year 2000. The journey of the flagship database product by Microsoft from 2000 to the present is pictorially depicted in figure 16.1.

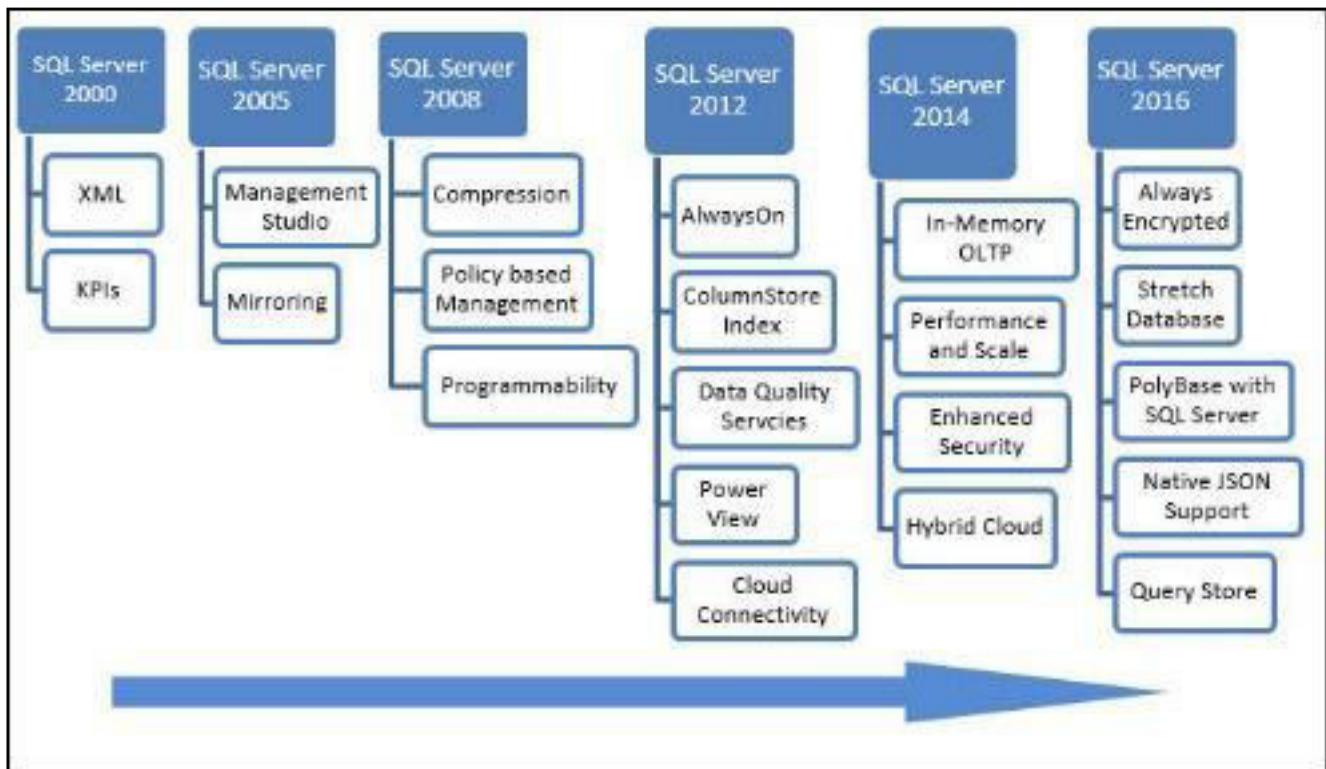


Figure 16.1: Evolution of SQL Server 2016

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

16.1.3 Mission-Critical Performance

SQL Server 2016 is the database for mission-critical performance. The mission-critical performance of SQL Server 2016 is measured basically in terms of four parameters namely Performance, Availability, Scalability, and Security. Features such as In-Memory OLTP enhancements, AlwaysOn, and Always Encrypted enable SQL Server 2016 to achieve mission-critical performance.

Performance

Mission-critical performance is achieved through features such as:

- **Operational Analytics:** Operational Analytics is the ability to do business analytics in real time. This in turn will help in quick business decisions. The combination of In-Memory OLTP and In-Memory analytics in SQL Server enables the real-time Operational Analytics.
- **In-Memory OLTP improvements:** Better Transact-SQL capabilities, support for memory-optimized tables, increased data size in terms of terabytes, and support for more CPUs that are concurrent.
- **Query Data Store:** Optimized query plans with complete execution history.
- **Native JSON:** Support for exporting relational data to JSON format and storing JSON data in relational format.
- **Temporal Tables:** Temporal tables are an additional new feature in SQL Server 2016 and enable automatic history tracking of data in a table.

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Higher Availability

As of today, the world is becoming increasingly online. Thus, maintaining availability and streamlining maintenance operations for your mission-critical applications is a crucial task.

Increased availability is achieved through enhanced AlwaysOn feature as follows:

- Up to three synchronous reproductions for auto fail-over across domain names
- Round-robin method of load balancing of replicas
- SQL Server Integration Services (SSIS) and Distributed Transaction Coordinator (DTC) support
- Depending on the database health and support for automated failover

Improved Scalability

Improved Scalability is achieved through:

- **Enhanced Database Caching:** Automatic and multiple TempDB files per instance provide database caching.



Security

Apart from Always Encrypted, there are some other security upgrades such as:

- **Row Level Security:** Providing fine-tuned access-control to rows of table, depending on the accessibility rights defined for that particular user.
- **Information Masking:** Real-time information hiding to avoid unauthorized access

16.1.4 Deeper Insights across Data

SQL Server 2016 allows more flexibility in terms of data portability. This feature is explained in detail as follows:

Access Any Data

The user can use simple Transact-SQL to query both non-relational and relational data. Native JSON support enables the user to manage data more efficiently. Access to any type of data is made possible through some features described as follows:

- **PolyBase:** Ability to fetch data from any data storage such as Hadoop using Transact-SQL.
- **Power Query for Analytics and Reporting:** Fetch data from innumerable data sources and store into reports and data models.
- **Improved SQL Server Integration Services (SSIS):** Backward compatibility with earlier versions of SSIS and Power Query Support.

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Scale and Manage

SQL Server 2016 has efficient scalability and better data management tools. Some of the features are as follows:

- **Enterprise-grade Analysis Services:** Scalability and increased functionality for Analysis Solutions.
- **SQL Server Data Tools (SSDT) in Visual Studio 2015:** SSDT is a tool in Visual Studio 2015, enabling the user to build efficient analytics solutions.
- **Enhanced Master Data Services (MDS):** This is achieved through an Excel add-in, providing transaction log archiving, entity reusability across models, and more carefully defined security roles.

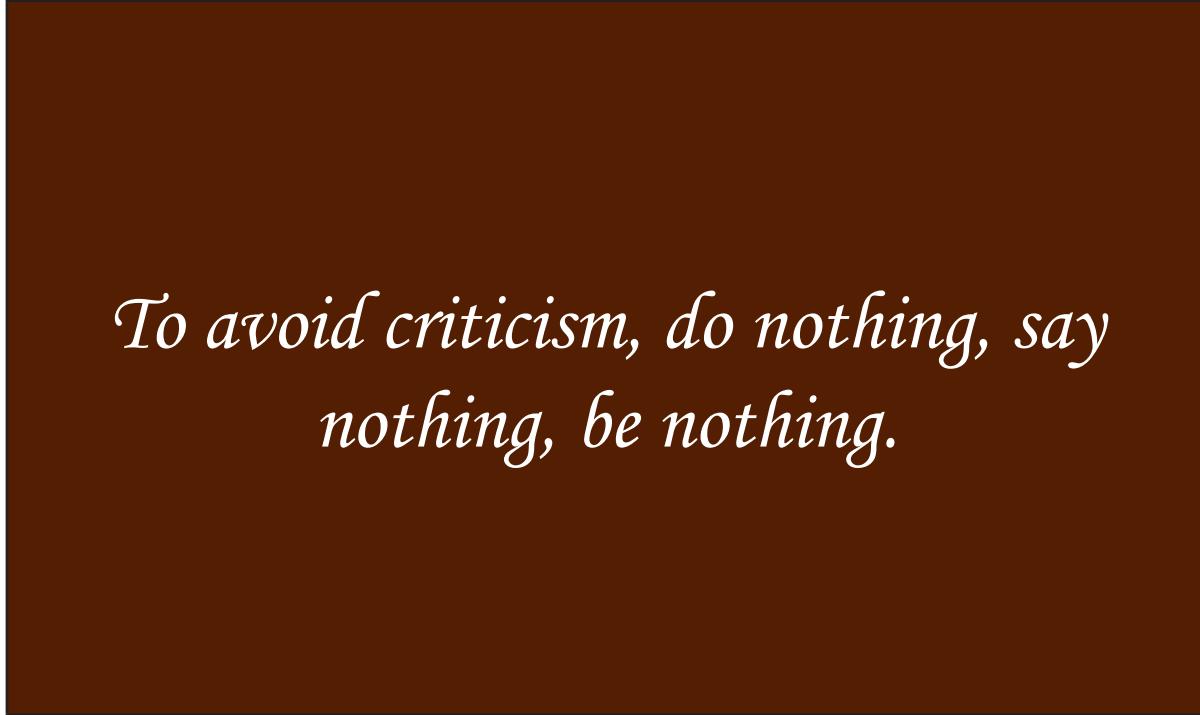
Powerful Insights on any Device

SQL Server 2016 provides native apps for Power BI for Android, Windows, and iOS, thus, enabling rich visualizations on any devices, including mobiles. This is achieved with the features such as:

- **Mobile Business Intelligence (BI):** Provide rich visualizations.
- **Query for Reporting and Analytics:** Supports reporting and analytics.

Built -in Advanced Analytics at Massive Scale

SQL Server 2016 enables R algorithms to be directly executed on SQL Server through advanced analytics.



To avoid criticism, do nothing, say nothing, be nothing.

R is a widely popular open-source programming language used for advanced analytics, data exploration, and machine learning. SQL Server R Services integrates a unique R distribution into the SQL Server platform. This enables you to execute R programs in a SQL Server database and reuse the same code in another platform, such as Hadoop. Using R Services, you can create intelligent and predictive applications that can be deployed easily.

16.1.5 Hyper Scale Cloud

SQL Server 2016 provides Hyper Scale Cloud. The architecture of SQL Server 2016 enables the user to work smoothly with the cloud in a hybrid environment, in which data and services reside in different locations. The term hyper scale refers to the ability of the database server to scale itself appropriately with the increasing demand, at the same time providing high performance. This is achieved through the following features:

- **Breakthrough Hybrid Situations:** The Microsoft hybrid cloud technology offers a consistent set of tools and processes between cloud-based environments and on-premises, which in turn allows SQL Server and Microsoft Azure work better together.
Features supported are Always Encrypted, Stretch Database, faster hybrid backups and high availability, and disaster recovery solutions to back up and restore on-premises databases to Microsoft Azure and place SQL Server AlwaysOn secondaries in Azure.
- **Ease:** Migration from SQL Server to any hybrid scenario and Microsoft Azure is easier.
- **Uniformity:** The Microsoft Azure Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) and SQL Server inter-operability is consistent.

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16.2 Various Editions of SQL Server 2016

SQL Server 2016 will be available to users in four main editions: Enterprise, Standard, Express and Developer, besides the Web edition. Among these, the Express edition will be the most basic with few essential features.

Table 16.1 summarizes these editions in brief.

SQL Server Edition	Description
Enterprise	Delivers comprehensive high-end datacenter capabilities with super fast performance, unlimited virtualization, and end-to-end business intelligence.
Standard	Delivers basic data management and business intelligence database for medium to small-scale organizations to run their applications and supports tools for on-premise and cloud.
Web	Provides scalability, affordability, and manageability capabilities and delivers a low total-cost-of-ownership option for companies that are into Web hosting.
Developer	Delivers all the functionality of Enterprise edition to developers but is not intended to be used as a production server. Ideal for development and testing environments.

Table 16.1: SQL Server 2016 Editions

Many of the advanced features of SQL Server 2016, such as In-Memory Column store, AlwaysOn failover clusters, In-Memory OLTP, Always Encrypted, and Polybase are not available in Express Edition. To avail all the advanced features, it is recommended to choose the Enterprise Edition.



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16.3 Check Your Progress

1. Mission-critical performance of SQL Server 2016 is measured in terms of:

(A)	Performance	(C)	calability and Security
(B)	Availability	(D)	Reliability

2. The popular open-source programming language used for advanced analytics, data exploration, and machine learning is _____.

(A)	C	(C)	R
(B)	C++	(D)	Java

3. Always Encrypted features assures:

(A)	Data security	(C)	Data transfer
(B)	Database backup	(D)	None of these

4. Which of these features provides the ability to fetch data from any data storage such as Hadoop using Transact-SQL?

(A)	PolyBase	(C)	JSON
(B)	R	(D)	Stretch Database

16.3.1 Answers

1.	C
2.	C
3.	A
4.	A



Summary

- Microsoft SQL Server 2016 has some great features enabling the user to create better scalable, high performance, and more secure applications making use of the hybrid cloud whenever required.
- Some of the specific new features in SQL Server 2016 include Stretch Database, Always Encrypted, Native JSON support, and PolyBase.
- Although certain features such as In-Memory OLTP were present in earlier versions, SQL Server 2016 has enhanced these features.
- SQL Server 2016 editions will be available in four main editions: Enterprise, Standard, Express, and Developer.
- The Express Edition is free and offers basic features to independent software developers and hobbyists. However, it does not support many of the advanced new features introduced in SQL Server 2016.
- The Enterprise Edition is the premium edition and supports all the basic and advanced features.

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Session - 17

New Features of SQL Server 2016

Welcome to the Session, **New Features of SQL Server 2016**.

This session explains the new features of SQL Server 2016 and how SQL Server 2016 supports Real-time Operational Analytics and its configuration. It also explains support for JSON (the lightweight data exchange tool), AlwaysOn (the high availability and disaster recovery tool), and describes enhancements to In-Memory, the OLTP technology, and also support for in-database analytics.

In this Session, you will learn to:

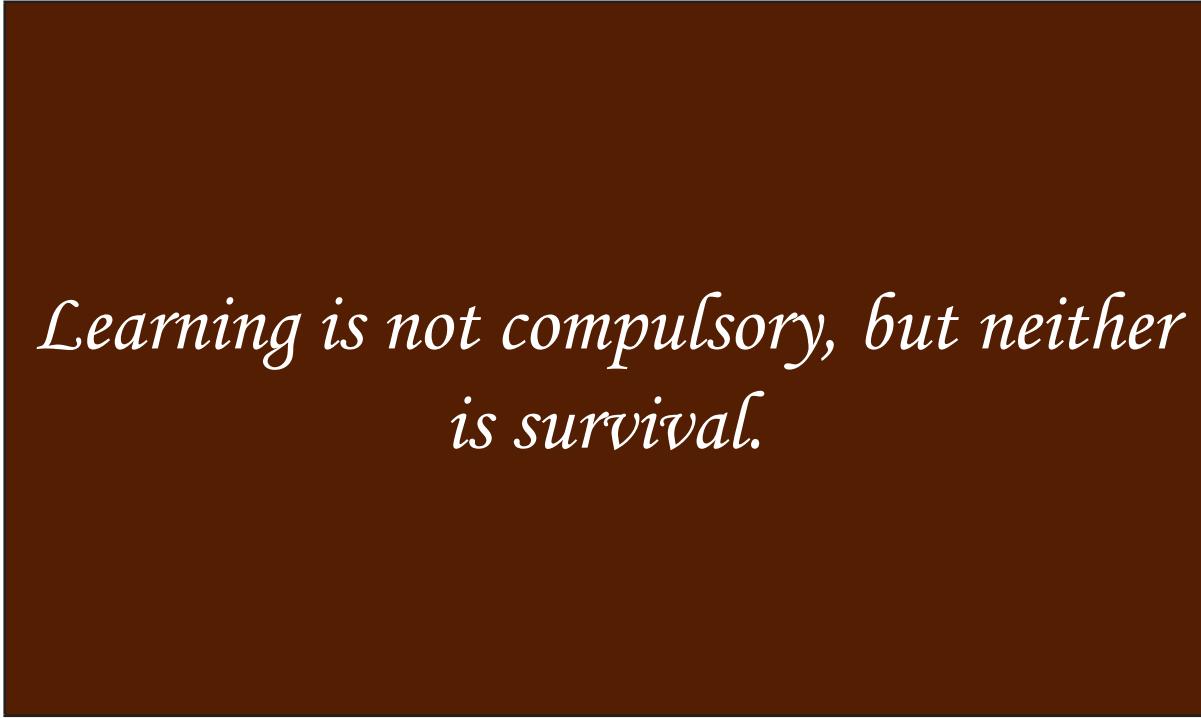
- ➔ List new features of SQL Server 2016
- ➔ Explain Real-time Operational Analytics
- ➔ Describe native JSON support
- ➔ Explain AlwaysOn feature
- ➔ Describe the enhancements made to In-Memory OLTP (Hekaton)
- ➔ Explain support for in-database analytics with R integration

17.1 New Features of SQL Server 2016

Users of SQL Server 2016 can make best use of the features offered by SQL Server 2016, for analytics, data visualization, and data security.

Following are some of the new features of SQL Server 2016:

- ➔ Always Encrypted
- ➔ Stretch Database
- ➔ Real-time Operational Analytics
- ➔ PolyBase with SQL Server
- ➔ Native JSON Support
- ➔ Support for in-database analytics with R-integration
- ➔ Query Store
- ➔ Dynamic Data Masking



Learning is not compulsory, but neither is survival.

Following are some of the enhancements in SQL Server 2016:

- Enhancements to AlwaysOn
- Enhancements to In-Memory OLTP
- Enhancements in Transact SQL
- Row level Security enhancements

17.2 Real-time Operational Analytics

Data and analytics help businesses to take decisions more efficiently. The evolution of social media and Internet of Things (IOT) has contributed to enormous growth of data and the challenges associated with it to manage huge data sets. Businesses used Power Pivot as one of the tools to access such huge data sets. However, it proves to be inadequate for some of the needs.

As the number of queries increase when more employees have access to the data sets, queries also tend to become ad-hoc rather than simple, this degrades analytics query performance. SQL Server 2016 takes care of these challenges with the improvements to In-Memory analytics, which provides considerable data compression. In addition, the query performance is boosted 100x faster.

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17.2.1 Conventional Methods of Data Modeling

The conventional methods of data modeling are as follows:

- Multidimensional Online Analytical Processing (MOLAP) with pre-collected data
- Tabular model with data in the database with regular Extract, Transform, and Load (ETL)



Figure 17.1 depicts a typical deployment wherein SQL Server is used for relational Data Warehouse and SQL Server Analysis Services (SSAS) for data modeling.

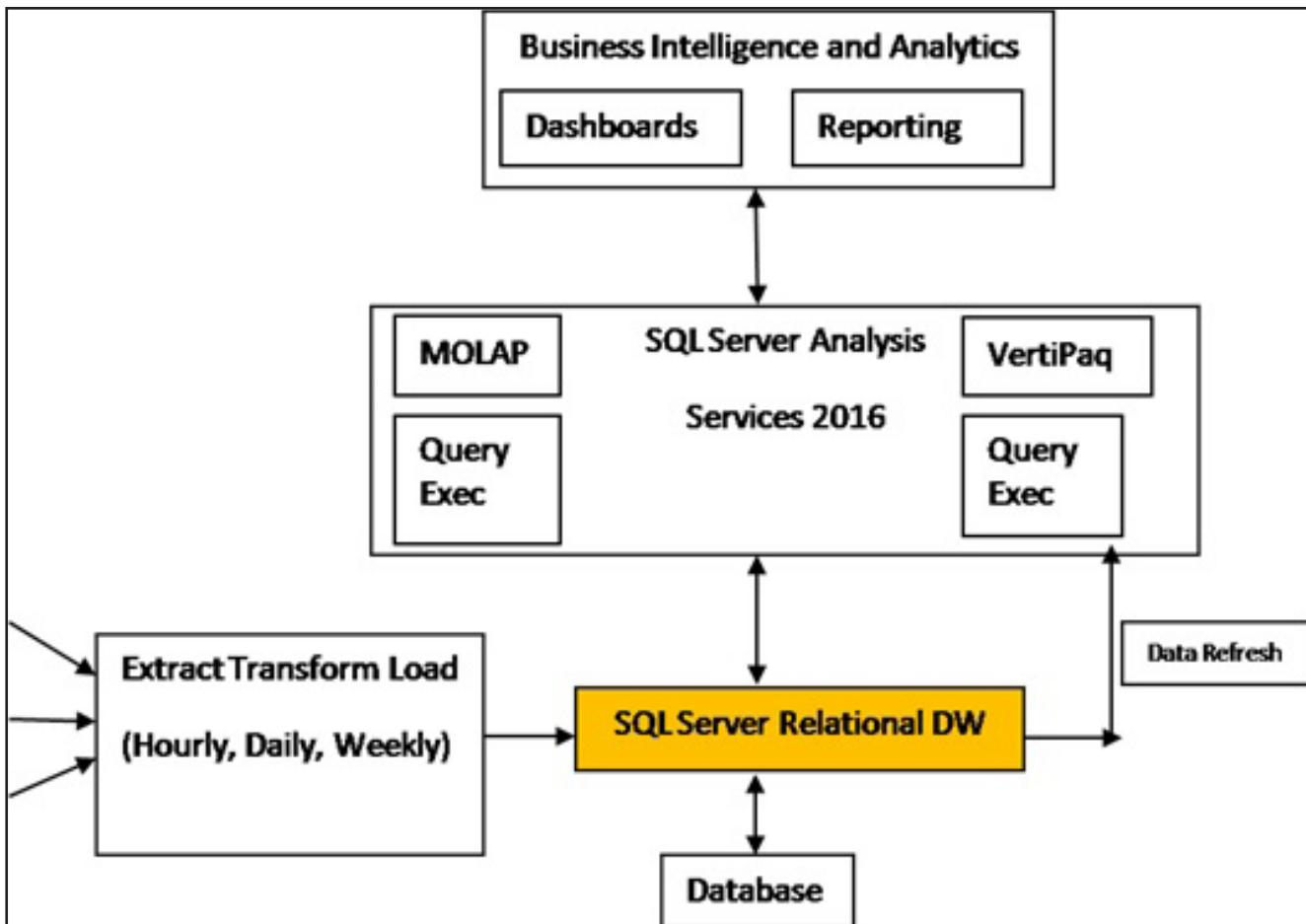


Figure 17.1: SQL Server Relational Data Warehouse and SSAS for Data Modeling

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The yellow box represents the analytical queries run inside SSAS for both MOLAP and Tabular models. With this approach, even with slow data sources, customers can gain the best analytical performance.

Following are some challenges in this method:

- **Cube Processing:** This means that periodic refreshing and aggregation of data is required.
- **Data Latency:** This means that the latest data fetched is from previous refresh cycle, which is highly unacceptable. Many businesses require analytics to be run right after data loading so that results are in real time.
- **Very Large Database Support:** Loading data to separate Business Intelligence (BI) servers may not always be a feasible solution, because of time and resource constraints, when it comes to voluminous data sources.

Clustered Columnstore Index (CCI), a feature provided with In-Memory Analytics, addresses some of these drawbacks. CCIs store data in each column independently, that is in columnar format, as shown in figure 17.2.

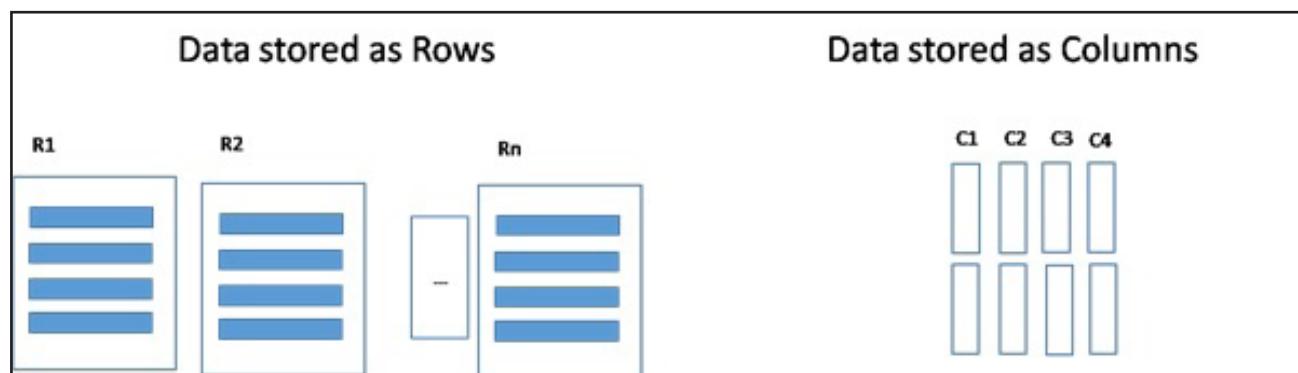


Figure 17.2: Storage of Data as Rows and as Columns

Learning is not compulsory, but neither is survival.

The main advantages of columnar data storage are as follows:

- Columnar values are stored together which can be compressed, ideally to 10x. This considerably reduces storage and proportionately decreases Input Output (IO)/Memory usage, thus, enhancing analytics query performance.
- The columns fetched to memory are those referenced in the query. This reduces both IO and memory requirements, thus, enhancing analytics query performance.

For efficient execution of queries on CCI, SQL Server executes them in a special batch mode, processing a group of rows together. For example, when aggregating the total expenses for a given period, SQL Server can aggregate a set of 1000 values collectively, in place of one single value at a time.

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17.2.2 Recommended Configuration

Columnstore indexes eliminate the need to pre-collect data for report queries enabling configuration, as depicted in figure 17.3.

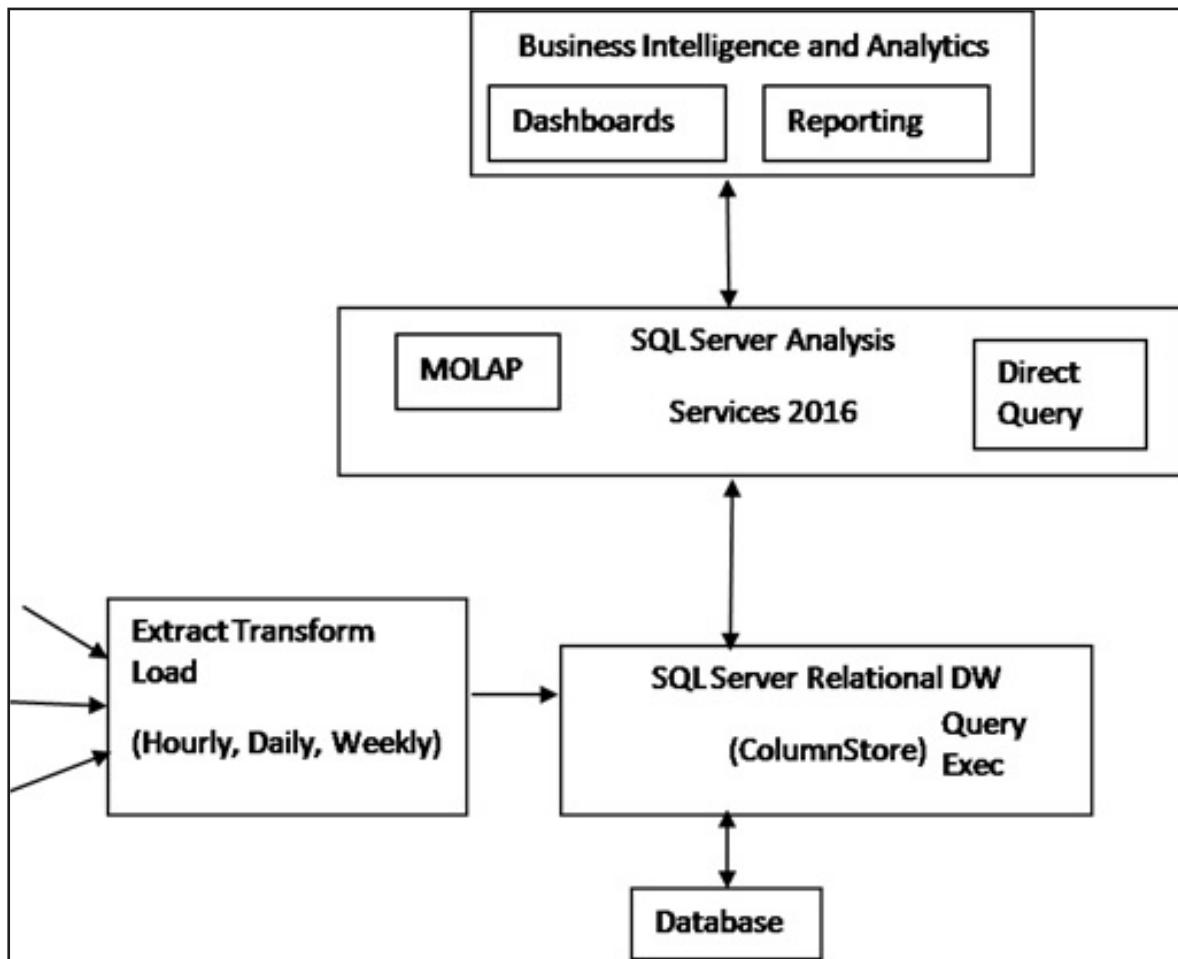


Figure 17.3: Using Columnstore Index



The need to pre-collect data for many workloads is eliminated with the configuration of Analysis services, using Relational Online Analytical Processing (ROLAP) Multidimensional or DirectQueryMode (Tabular). This configuration directly sends the query to SQL Server with data as CCI. This remarkably reduces storage requirements and achieves 10x data compression and 100x speedy analytics query processing. In comparison with SQL Server 2014, SSAS Tabular (DirectQuery) mode improves in SQL Server 2016, thus, generating better queries.

17.2.3 Migrating Workload to use Columnstore Index

For using columnstore index to migrate workload, execute the following command, dropping the existing columnstore index if it exists. Also, with columnstore indexes, users may not need some of the other indexes so they can consider dropping them.

Example 1:

```
CREATE CLUSTERED COLUMNSTORE INDEX <Index-Name> ON <Table> WITH (DROP_
EXISTING=ON)
```

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17.2.4 Changes in Operational Analytics in SQL Server 2016

The term Operational Workload means the criticality of business transactions in a business. For example, for a credit cards company, a reliable transaction system is critical for its customers. Any slowdown or downtime of database server on which the transaction is dependent will have a major impact on the company's business. Hence, it is very important that such transaction system is highly scalable and should be designed and configured for high availability. The analytics part plays another major role in such transaction systems.

Optimizing/isolating operational and analytics workloads is one approach. Data Warehouse can be set up on a different machine, which uses In-Memory technology.

Some of the drawbacks with this approach are as follows:

- **Complexity:** Migration of operational data might be complex. For instance, it is quite difficult to track changes since the last ETL operation.
- **Cost:** Overheads with respect to creation, maintenance, licensing, and costs involved in setting up a separate Data Warehouse server.

A wise man learns from the mistakes of others, a fool by his own.

Real-Time Operational Analytics enables users to run analytics queries directly on operational workload using columnstore indexes. One possible configuration to run Analytics queries is shown in figure 17.4. However, user can try different configurations as per his/her requirement.

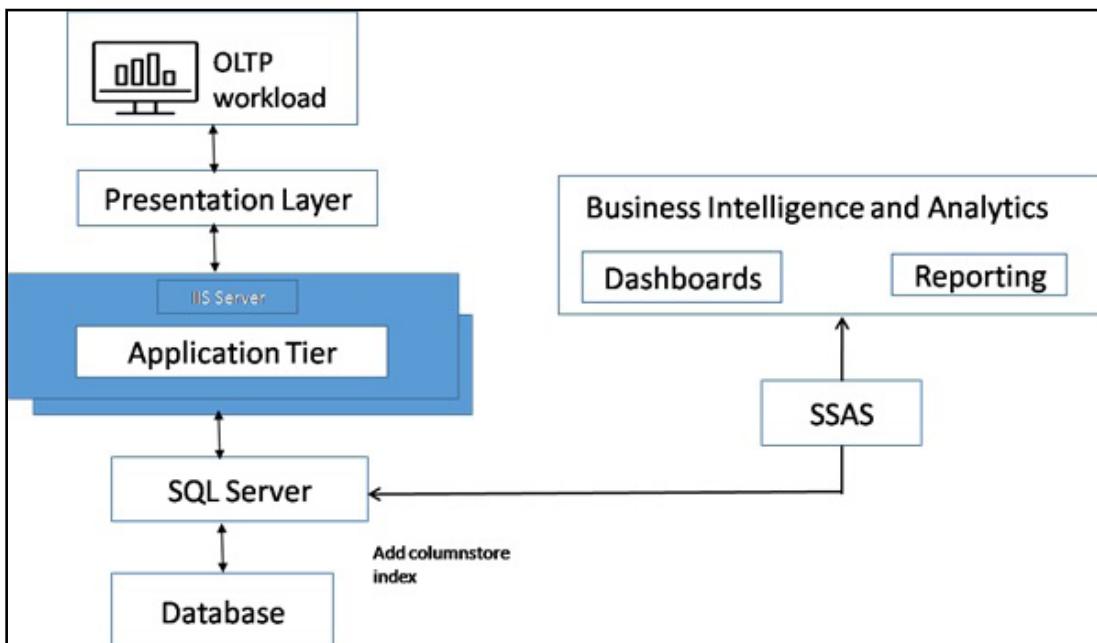


Figure 17.4: Configuration to run Analytics Queries on Operational Workload

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Steps to perform real-time operational analytics are as follows:

- First step is to identify the table(s) and the columns required to run analytics.
- Second step is to create columnstore indexes for those tables.
- Third step is to set up Analytics framework to fetch data directly from Operational Workload.

A standard configuration might not suit all workloads. For analytics of data, which has to be aggregated from multiple sources, a separate Data Warehouse is essential.

Real-time analytics on operational schema is achieved through updateable NonClustered Columnstore Index (NCCI), a feature available in SQL Server 2016.

Users can create an NCCI on table(s) on which analytics has to be performed, without having to change the existing OLTP. The OLTP can continue using existing btree indexes, while the SQL Server query optimizer automatically selects NCCI for analytics queries. Most of the times, a single NCCI index can replace all the other OLTP workload indexes or btree indexes, if any. This also increases throughput.



A table with NCCI is shown in figure 17.5.

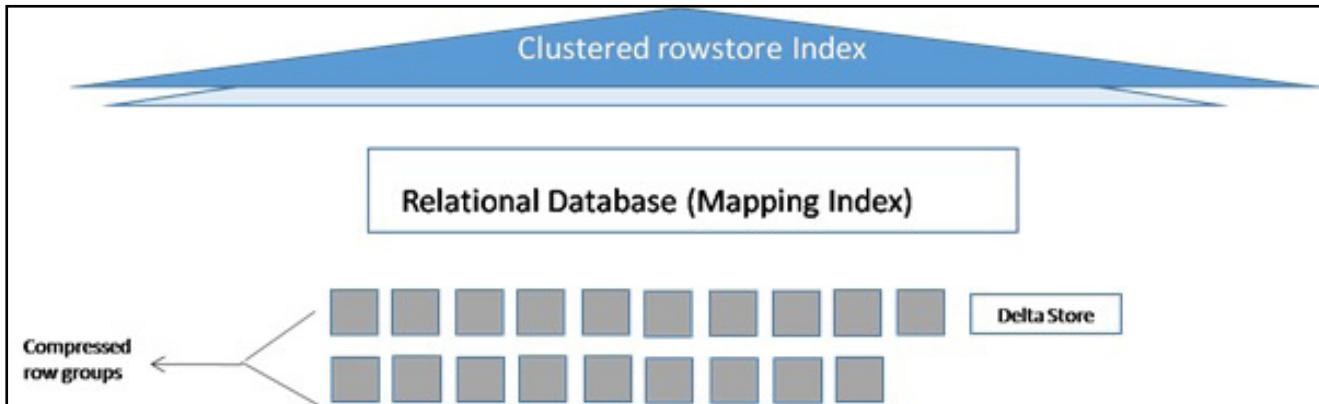


Figure 17.5: Table with NCCI

This configuration also poses some challenges.

A major challenge is about the performance of analytics queries when the database is optimized for OLTP.

Since, the schema for OLTP databases is normalized largely and normalization might involve complex joins between many tables, using the same OLTP database might lead to very poor performance.

One solution to this could be the use of NCCI, which can execute many analytics queries in few second. A dedicated Data Warehouse could improve the performance of analytics query.

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The customer decides which of the following actions to take:

- Perform real-time operational analytics and at the same time maintain a dedicated Data Warehouse for critical analytics.
- Deploy NCCI in production, thus, totally avoiding the dedicated Data Warehouse.

Overall, it is a trade-off between real-time operational analytics and its impact on operational workload.

Some of the options provided by the SQL Server 2016, to reduce the impact on operational workload are as follows:

→ **Filtered Columnstore Index**

When DML is applied on the data, it is said to be 'hot', which then transits to a 'warm' or 'cold' state. For example, the order placed by customers in an online retail shop is 'hot' as long as it is being processed. Once the order is shipped, it transits to 'cold' state. This means that SQL Server need not maintain the columnstore on the 'hot' data. However, SQL Server generates query plan to fetch rows from both columnstore index and the filtered ones.



You must do the things you think you cannot do.

The syntax to create a columnstore index is as follows:

Example 2:

```
CREATE NONCLUSTERED COLUMNSTORE INDEX <index-name> ON P-Orders (<list of  
columns> WHERE ORDER_STATUS='SHIPPED'
```

→ **Compression Delay**

SQL Server provides Compression Delay option, enabling users to set a 'time-limit', for the 'hot' data, after which the row(s) are marked for compression.

→ **Offloading Analytics Queries to Readable Secondary**

Most of the operational workloads are configured using AlwaysOn, as they are mission-critical and availability should be high. To reduce the impact on primary replica, they can be offloaded to a readable secondary.

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This is illustrated in figure 17.6.

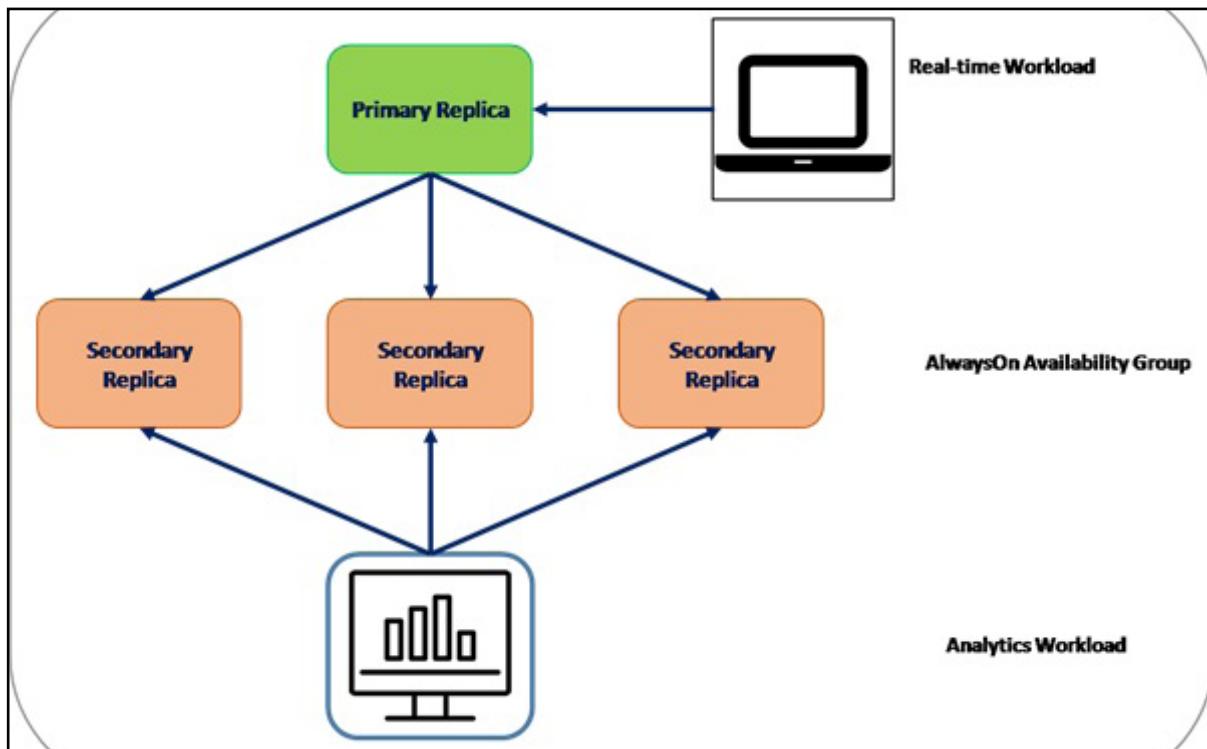


Figure 17.6: Offloading Analytics Queries

To summarize, SQL Server 2016 supports real-time operational analytics for both memory-optimized and disk based tables. With the combination of columnstore index and memory optimization, users can get best of analytics query and OLTP performance.



17.3 Native JSON Support

JavaScript Object Notation (JSON) is a subset of JavaScript programming language. It is language-independent, lightweight, and provides a human readable text data exchange format.

In earlier versions of SQL Server, developers had to put in a lot of efforts to implement the storing, managing, and parsing of JSON data. SQL Server 2016 has built-in support for JSON data, thus, helping developers to concentrate on application logic than having to write functions to parse JSON data.

However, support for XML as a media for data interchange, which was first introduced in SQL Server 2005, still continues due to the native advantages that XML provides.

17.3.1 JSON Data Processing in SQL Server

The tabular data from relational tables can be converted to JSON format. The JSON data can also be converted into tabular format for various tasks, such as joining with other relational tables, reporting, and so on.

SQL Server 2016 supports JSON data with its NVARCHAR data type. This is in contrast to native XML support, which has XML data type to store XML data. The NVARCHAR data type provides more flexibility, in the sense that JSON data can be stored in all databases that support NVARCHAR data type. Regular indexes work well with JSON data.

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17.3.2 Exporting Tabular Data as JSON Data

Following are the clauses to export tabular data as JSON data:

→ **The FOR JSON [AUTO|PATH] clause**

SQL Server 2016 provides the `FOR JSON [AUTO | PATH]` clause. Use this clause in SQL queries to fetch data in JSON format.

→ **The FOR JSON AUTO clause**

When this clause is used, SQL Server 2016 automatically formats the nested JSON sub arrays of query result, depending on column order and table hierarchy.

Let us look at an example that illustrates the use of `FOR JSON` clause.

*Woe to him who teaches men faster
than they can learn.*

To begin with, create a table 'Employees' and insert a few rows as shown in Code Snippet 1.

Code Snippet 1:

```
CREATE TABLE Employees (
    ID INT IDENTITY (1, 1) NOT NULL,
    FirstName VARCHAR (255),
    LastName VARCHAR (255),
    Grade INT,
    Age DECIMAL (3, 1)
)

INSERT INTO Employees (FirstName, LastName, Grade, Age)
SELECT 'Mark', 'Thomas', 2, 45
UNION ALL
SELECT 'Salmon', 'John', 1, 56
UNION ALL
SELECT 'Kirsten', 'Powell', 3, 28
```

Upon executing these statements, the table will be successfully created and the records will be inserted into it.

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Now, create an SQL query to retrieve the table data and insert the `FOR JSON AUTO` clause at the end of the query as shown in Code Snippet 2.

Code Snippet 2:

```
SELECT ID, FirstName, LastName, Grade, Age
FROM Employees
FOR JSON AUTO
```

In this command, SQL Server obtains the result of the query and formats it in the output as a JSON document. Then, this is returned to the client. The query and its outcome in the SQL Server Management Studio window are shown in figure 17.7.



Figure 17.7: FOR JSON AUTO Clause and the Result

The JSON output formatted by SQL Server does not include tabs or whitespaces for apparent reasons. However, users can format the output manually to make it more readable.

With the `FOR JSON AUTO` clause, SQL Server automatically formats the JSON output based on the query structure (that is, the order of the columns in the `SELECT` list and their source table).



Copy the JSON data shown in figure 17.7 to a text editor such as Notepad and format it. The output is viewed as shown in figure 17.8.

```
[  
  {  
    "ID": 1,  
    "FirstName": "Mark",  
    "LastName": "Thomas",  
    "Grade": 2,  
    "Age": 45  
  },  
  {  
    "ID": 2,  
    "FirstName": "Salmon",  
    "LastName": "John",  
    "Grade": 1,  
    "Age": 56  
  },  
  {  
    "ID": 3,  
    "FirstName": "Kirsten",  
    "LastName": "Powell",  
    "Grade": 3,  
    "Age": 28  
  }  
]
```

Figure 17.8: Formatted Output

In ideal situations, the `FOR JSON AUTO` clause should suffice. However, it might not work for some specific scenarios, when users would prefer to have more control on how JSON data is nested or generated. Then, the `FOR JSON PATH` clause gives users complete control to state the output format of the JSON data. Users can create wrapper objects and nest complex properties.

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If there are two or more tables in a query, by default, it returns a flat result. Each column in the query result then becomes the property of the JSON object.

For nested results, the user can also use dot-separated column names. An example of using FOR JSON PATH is shown in Code Snippet 3.

Code Snippet 3:

```
SELECT ID, FirstName AS "EmployeeName.FirstName",
LastName AS "EmployeeName.LastName", Age FROM Employees
FOR JSON PATH
```

The result of Code Snippet 3 can be seen in figure 17.9.

The screenshot shows the SQL Editor window with the following code:

```
SELECT
    ID,
    FirstName AS "EmployeeName.FirstName",
    LastName AS "EmployeeName.LastName",
    Age
FROM Employees
FOR JSON PATH
```

The Results tab displays the output:

	JSON_F52E2B61-18A1-11d1-B105-00805F49916B
1	[{"ID":1,"EmployeeName":{"FirstName":"Mark","LastName":"Brown","Age":25}}]

Figure 17.9: FOR JSON PATH and the Result

*Real generosity towards the future lies
in giving all to the present.*

After formatting the JSON in figure 17.9, the output can be viewed as shown in figure 17.10.

```
[  
  {  
    "ID": 1,  
    "EmployeeName": {  
      "FirstName": "Mark",  
      "LastName": "Thomas"  
    },  
    "Age": 45  
  },  
  {  
    "ID": 2,  
    "EmployeeName": {  
      "FirstName": "Salmon",  
      "LastName": "John"  
    },  
    "Age": 56  
  },  
  {  
    "ID": 3,  
    "EmployeeName": {  
      "FirstName": "Kirsten",  
      "LastName": "Powell"  
    },  
    "Age": 28  
  }  
]
```

Figure 17.10: Formatted Output

The output of querying for JSON data does not include a root element by default. Hence, adding the `FOR JSON AUTO` or `FOR JSON PATH` clause to the `ROOT` keyword can result in a single, top-level element with the JSON output.

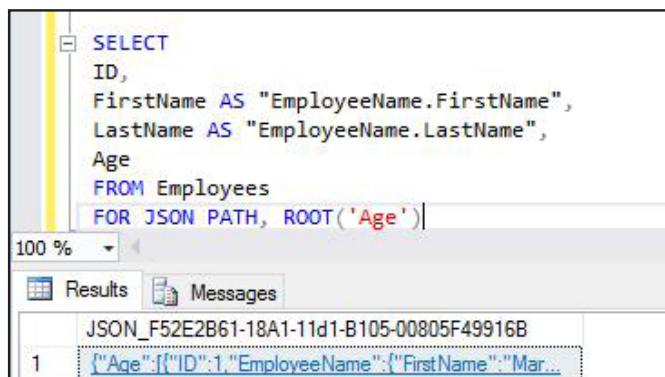
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An example query is shown in Code Snippet 4.

Code Snippet 4:

```
SELECT
    ID,
    FirstName AS "EmployeeName.FirstName",
    LastName AS "EmployeeName.LastName",
    Age
FROM Employees
FOR JSON PATH, ROOT ('Age')
```

Figure 17.11 shows the query and the result.



The screenshot shows the SQL Server Management Studio interface. In the top pane, a query window displays the following T-SQL code:

```
SELECT
    ID,
    FirstName AS "EmployeeName.FirstName",
    LastName AS "EmployeeName.LastName",
    Age
FROM Employees
FOR JSON PATH, ROOT ('Age')
```

In the bottom pane, the 'Results' tab is selected, showing the output of the query:

	JSON_F52E2B61-18A1-11d1-B105-00805F49916B
1	{"Age": [{"ID": 1, "EmployeeName": {"FirstName": "Mar..."}]}

Figure 17.11: For JSON PATH, ROOT, and the Result

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THE TECHNOLOGIES OF TOMORROW



Format the JSON in a text editor to produce the outcome as shown in figure 17.12.

```
{  
    "Age": [  
        {  
            "ID": 1,  
            "EmployeeName": {  
                "FirstName": "Mark",  
                "LastName": "Thomas"  
            },  
            "Age": 45  
        },  
        {  
            "ID": 2,  
            "EmployeeName": {  
                "FirstName": "Salmon",  
                "LastName": "John"  
            },  
            "Age": 56  
        },  
        {  
            "ID": 3,  
            "EmployeeName": {  
                "FirstName": "Kirsten",  
                "LastName": "Powell"  
            },  
            "Age": 28  
        }  
    ]  
}
```

Figure 17.12: Formatted JSON Output

The output does not include the null values by default. To add null values (as JSON properties) in the JSON output, the user can also use the `INCLUDE_NULL_VALUES` keyword, with either the `FOR JSON PATH` or the `FOR JSON AUTO` clause.

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17.4 AlwaysOn

SQL Server 2016 includes AlwaysOn, a feature that provides a substitute for data mirroring. This feature was first introduced in SQL Server 2012. It provides high-availability and disaster recovery solutions for mission-critical applications.

A crucial term to understand in this context is failover. Failover is a backup mechanism or process in which the functions of a system component are handled by secondary components whenever the primary component becomes unavailable. These primary components may include a processor, network, database, and so on. Failover is a crucial and integral part of mission-critical systems that are expected to always available with almost zero downtime. The procedure of failover should be as seamless as possible to the end user.

Availability databases are a set of user databases that can failover together. Each availability database has one read-write copy called the primary database and between one to eight read-only copies called as secondary databases maintained by the availability group. An Availability group supports failover environment for these databases.

An availability replica hosts each set of Availability database. Following are the two types of availability replica:

- ➔ Primary replica for the primary databases
- ➔ Between one to eight secondary replicas for a set of secondary databases

Knowledge is not enough; we must apply. Willing is not enough; we must do.

The primary databases can be accessed by the clients for read-write connections and this is achieved through the primary replica. The transaction logs associated with each primary database is sent to every secondary database by the primary replica. These transaction logs, in turn, are cached by the secondary replica and then associated with the secondary database. Thus, independent of the other databases, data synchronization takes place across the primary database and each associated secondary database.

A Windows Server Failover Clustering (WSFC) cluster is required for the deployment of AlwaysOn Availability group. In any availability group, each availability group must be resident on a different node but on the same WSFC. Only at the time of migration to another WSFC cluster, an availability group can straddle two clusters.

Every availability group should have one WSFC group, to keep track of the group and to analyze the primary replica.

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Figure 17.13 illustrates an Availability group with one primary replica and four secondary replicas.

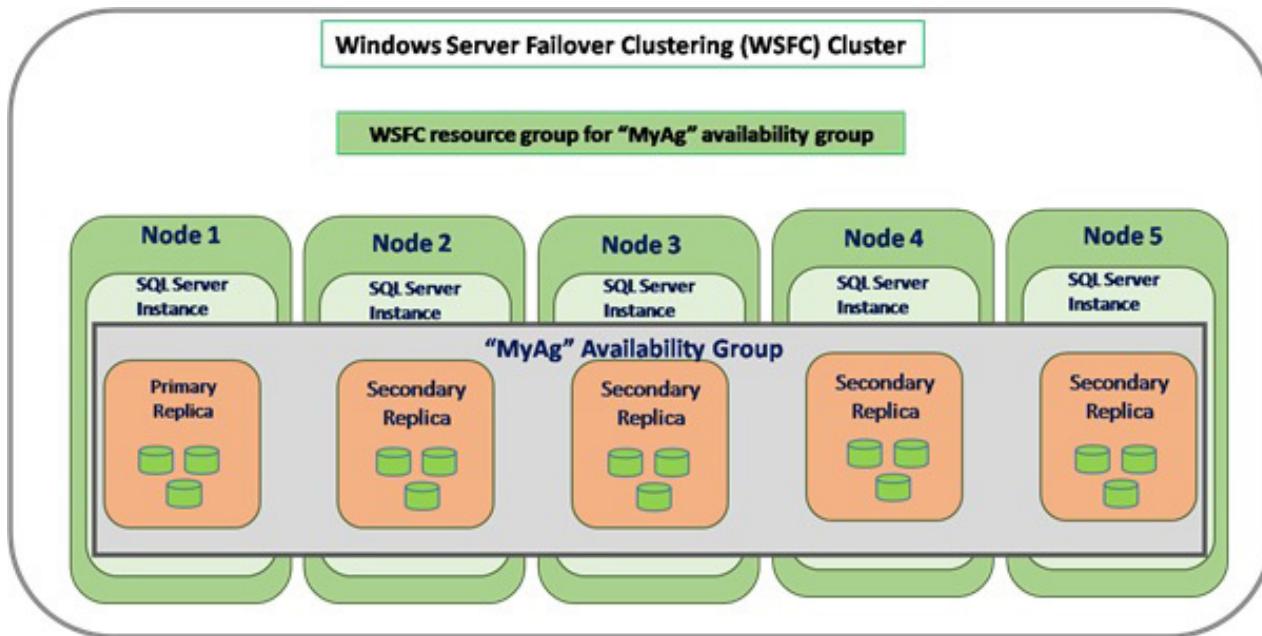


Figure 17.13: Availability Group

17.4.1 Availability Databases

The database should be online, read-write database, residing on the server instance that has the primary replica to be added to an availability group. This becomes the primary database and can be accessed by clients. Secondary databases are created, after restoring the backups of the new primary database (for this, use RESTORE WITH NORECOVERY command) on the server instance hosting secondary replica.



17.4.2 Availability Replicas

Availability Replicas are a set of two or more failover patterns, defined by each availability group.

Different instances of SQL Server on separate nodes of WSFC cluster, should host the availability replicas for each availability group. For AlwaysOn, one should enable each of these server instances.

A role is assigned for each Availability replica. It could either be a primary role or a secondary role. Primary role is assigned to a primary replica, which hosts read-write or primary databases. Secondary role is assigned to a secondary replica, which hosts read-only or secondary databases.

Organizations can add secondary replicas in an Azure Virtual Machine through the wizard Add Azure. This is possible through SQL Server’s Always On support to Azure. This replica can be used for backup operations, disaster recovery, and reporting. Further, this can decrease the expenses as it removes spending of additional hardware just for Always On secondary replicas.

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17.4.3 Availability Modes

An availability replica has a property called availability mode. Following are the two availability modes:

→ **Asynchronous-commit mode**

In this mode, the transaction latency on secondary databases is reduced, but there might be some data loss as the secondary databases are not in sync with primary database. Asynchronous-commit replica uses this mode.

→ **Synchronous-commit mode**

In this mode, committed transaction is completely protected as the secondary and primary databases are always synchronized. However, this leads to increase in transaction latency. Synchronous-commit replica uses this mode.

17.4.4 Types of Failover

There are two replicas of the SQL Server database namely, primary replica and secondary replica. Whenever a failover occurs, the secondary replica changes to primary replica. Client application can then start using this new primary replica, which has the databases. Once the original primary replica becomes available again, it changes to secondary replica, thus, synchronizing data again.

*Don't just learn the tricks of the trade,
learn the trade.*

There are three types of failovers namely, automatic, manual, and forced. The availability mode of the secondary replica determines which failover type it supports from following given options:

→ **Synchronous-commit mode**

This mode supports two failover types namely, automatic failover and planned manual failover.

→ **Planned manual failover (without data loss)**

A failover command issued by the database administrator results in manual failover. This causes the secondary replica to change to primary replica and vice versa. For a manual failover, it is essential that the secondary replica is synchronized and the primary and secondary replicas must be running under synchronous-commit mode only.

→ **Automatic failover (without data loss)**

Any failure causing the secondary replica to change to primary replica results in automatic failure. Once the original primary replica becomes available, it changes to secondary replica. For this type of failover, the failover type should be set to automatic and both the primary and secondary replica must be running under synchronous-commit mode. It is essential that the secondary replica is synchronized.

→ **Asynchronous-commit mode**

This mode supports only forced manual failover. There might be data loss in this type. This type of failover is said to be a manual failover as it can be started manually only. When the secondary replica is not in synchronization with the primary replica, the only failover type that can occur is forced failover. This is the option for disaster recovery.

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17.4.5 Client Connections

The user can create an availability group listener to enable the client connectivity to the primary replica, belonging to a specific availability group. An availability group listener contains the resource group that is associated with a specific availability group to route client connections to the proper availability replica.

17.4.6 Active Secondary Replicas

Active secondary replicas are supported by AlwaysOn availability groups.

The functionalities provided by Active secondary replicas are as follows:

→ **Backup operations on secondary replicas**

The availability group can be configured to specify its own choices for the backup operation. SQL Server does not have any role in this. The availability group for each database, which might contain the script or the logic written in the jobs, determines the actual function to be performed at the time of backup.

→ **Readable secondary replicas**

The user can configure the availability replica to have read-only permissions to local databases, when it is acting as the secondary replica. Similarly, the user can configure availability replica to have read-write permissions to local databases when it is acting as the primary replica. This will avoid unnecessary read-only workloads to run on the primary replica.

SQL Server can direct read-intensive connection requests to an availability group containing an availability group listener. It can do this with the help of one or more read-only secondary replicas, if one exists.



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17.4.7 Session-Timeout Period

The availability-replica has Session-Timeout. This property determines the duration till which another availability replica can be inactive before closing the connection. The primary and secondary replicas ping each other to indicate their active state. During the timeout period, a ping received from another replica signals that the connection is active and that there is communication between server instances. The session-timeout is reset once the ping is received.

The session-timeout property ensures that no two replicas wait for each other indefinitely. The replica times out if a ping is not received from the other replica within the session time out period.

The timeout replica is then put in DISCONNECTED state and its connection closed.

The session-timeout has a default value of 10 seconds. This can be configured by the user. The minimum value should be 5 seconds, although the recommended value is 10 seconds or more.

17.4.8 Automatic Page Repair

Automatic page repair of corrupted pages residing on a local database is taken care of by the availability replica. The primary replica provides a fresh copy of the page if the secondary replica is unable to read the corrupted page. On the other hand, the page obtained from the first response by all the secondary replicas obtained, if the primary replica is unable to read the corrupted page. The corrupt page is replaced with the fresh copy provided the request succeeds.

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17.5 Enhanced Features in SQL Server 2016

In addition to new features, SQL Server 2016 also introduces enhancements to several existing features.

17.5.1 Enhanced AlwaysOn

Major improvements are made in AlwaysOn in terms of scalability and manageability. Scalability is achieved through load balancing readable secondaries. Load balancing can be done by defining one or more groups of secondaries which are readable. Group members will connect in a round-robin manner.

Support for Distributed Transaction Coordinator (DTC) enrolled transactions for Availability Group (AG) databases enhances manageability. DTC will be viewing the same resource on the new primary as it is tied to the database than an instance, thus, resolving transaction outcomes.

Database level health monitoring is another refinement. In SQL Server 2014, only instance health is monitored by AG health, and hence, failover will not be triggered even when the database is corrupt or offline. However, SQL Server 2016 provides options to monitor even the database health through AG health.

17.5.2 Enhanced Online Operations

While performing TRUNCATE or ALTER operations on tables, SQL Server 2016 provides 100 percent uptime, which enhances online database operations.

Practice is the best of all instructors.

17.5.3 Scalability

Scalability is improved to a great extent with the improvement in interaction between Windows Server and SQL Server. Physical processing can be scaled up to 640 logical processors and virtual machines can be scaled up to 64 logical processors. Resource optimization takes place by proper storage space utilization and network virtualization by SQL Server. To minimize surface area of attack, SQL Server can run on core Windows Server.

17.5.4 Hardware Acceleration for TDE Encryption/Decryption

To enable faster encryption/decryption of data for TDE that uses the hardware, SQL Server 2016 implements the next generation cryptography (CNG) Application Program Interface (API) by Microsoft. This API makes best use of specialized instructions of microprocessors such as AES-NI by INTEL. The Advanced Encryption Standard (AES) implementation in INTEL draws attention by 3 to 10 times performance enhancement compared to pure software implementation.

17.5.5 Buffer Pool Extension

Devices such as Solid-State Drives (SSDs) which are non-volatile are used to decrease pressure on SQL Server memory, thus, avoiding data loss and enhancing query performance. The configuration for this one is easy to achieve.

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17.5.6 In-Memory OLTP (Hekaton) and Optimization Enhancements

Hekaton is the code name given to In-Memory OLTP. This feature was introduced in SQL Server 2014. At the time when SQL Server originated, main memory was highly expensive, thus, forcing the data to reside on the disk. The data was read into memory only for processing and later written back to disk. This resulted in lot of I/O (Input/Output) operations. However, over a period of time the scenario has changed completely. Memory prices have become much cheaper and more affordable.

The OLTP release in SQL Server 2014 has provided its users up to 40 fold efficiency. In-Memory OLTP was first introduced with SQL Server 2014; now, SQL Server 2016 offers several improvements.



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Key changes to In-Memory OLTP are as follows:

- Enhanced In-Memory performance
- Maximum memory for memory-optimized tables
- Collation
- Schema and data changes
- More Transact-SQL features supported
- Parallel Plans
- Transparent data encryption
- AlwaysOn
- Number of sockets

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17.6 Check Your Progress

1. SQL Server 2016 performs real-time analytics with the introduction of:

(A)	Updateable Nonclustered Columnstore Index (NCCI)	(C)	OLTP
(B)	Clustered Columnstore Index (CCI) columnstore	(D)	Row data security

2. SQL Server 2016 has native support for _____.

(A)	XML	(C)	HTML
(B)	JSON	(D)	DHTML

3. JSON is a text data exchange format which is:

(A)	Heavy weight	(C)	Language dependent
(B)	Lightweight	(D)	Data type

4. The AlwaysOn feature provides:

(A)	Data management	(C)	High availability and disaster recovery
(B)	Data exchange	(D)	Availability replica

5. The recommended Session-Timeout period for SQL Server 2016 is:

(A)	10 seconds	(C)	4 seconds
(B)	8 seconds	(D)	18 seconds

6. Which of these are the two types of availability replicas?

(A)	Primary replica and secondary replica	(C)	Basic replica and substitute replica
(B)	Replica one and replica two	(D)	Replica A and Replica B

7. The code name for InMemory OLTP is:

(A)	Project Yukon	(C)	CTP2
(B)	Project Hekaton	(D)	CTP3

17.6.1 Answers

1.	A
2.	B
3.	B
4.	C
5.	A
6.	A
7.	B



Summary

- SQL Server 2016 has introduced several powerful new features, such as Real-time operational analytics, native JSON support, Stretch database, Always Encrypted, and so on.
- SQL Server 2016 also brings in improvements to existing features, such as enhancements to AlwaysOn and In-Memory processing.
- Real-time Operational Analytics enables users to run analytics queries directly on operational workload.
- SQL Server 2016 provides native support for JSON, which helps the developer concentrate on application logic, than having to write functions to parse JSON data.
- SQL Server 2016 provides enhanced AlwaysOn, a substitute for data mirroring, which provides high-availability and disaster recovery solution for mission-critical applications.
- SQL Server 2016 also provides In-Memory OLTP (Hekaton) and optimization enhancements.

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INDUSTRY BEST PRACTICES

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Session - 18

Enhancements in SQL Server 2016

Welcome to the Session, **Enhancements in SQL Server 2016**.

This session covers some of the enhancements made in SQL Server 2016. These include configuring tempdb database during installation, comparing two execution plans, and creating temporal tables that enables system-versioning on tables.

In this Session, you will learn to:

- Describe the importance of configuring tempdb database files
- Describe how to configure tempdb during installation of an instance of SQL Server 2016
- Outline the allocation and autogrowth of tempdb files in SQL Server 2016
- List the differences between the two execution plans
- Explain how to enable system-versioning on tables

18.1 Configuring tempdb Database

Earlier versions of SQL Server, including SQL Server 2014, allowed the creation of multiple tempdb data files manually, after installation of the SQL Server instance. SQL Server 2016 allows you to configure the tempdb database during the installation of the SQL Server instance.

18.1.1 Use of tempdb Database

All users connected to a SQL Server instance have access to tempdb, which is a system database. The primary use of the tempdb is to store local and global temporary tables, temporary procedures, table variables, and cursors.

This database is also used during the creation or re-build of an index, if the 'SORT_IN_TEMPDB' option is applied. The database engine in SQL Server uses the tempdb database to store the intermediate sort results during the indexing process. Sometimes, multiple tempdb database files are configured.

18.1.2 Importance of tempdb Configuration

It is important to configure the tempdb database files to the correct size to ensure that the system performance is not impacted. For example, defining the tempdb to a size that is smaller than required would require the system processor to autogrow the tempdb to the required size each time the SQL Server instance is started. This reduces performance.

It is hard to fail, but it is worse never to have tried to succeed.

Furthermore, it is essential to configure multiple tempdb database files with the same size. Each time a ‘write’ is made, SQL decides the file for it by using the proportional fill method. This method is used to ensure that writes are evenly distributed across a set of data files. SQL Server chooses the file with a higher percentage of free space for a write. Therefore, if there were four files, then SQL Server performs a round-robin process through them, by selecting each of them as the write-target turn by turn. SQL Server then ensures that the writes are evenly distributed, thereby evenly filling up the four files. Thus, no single file gets loaded with writes. However, if the four files were not equal-sized and one of the files was significantly larger than the others, then SQL Server would choose that file for every write, as it would find the percentage of free space higher in that file. This would mean that only one file would be chosen and even distribution of writes would not happen. Essentially, this would defeat the purpose of having four files, which is to avoid an overload resulting in poor performance. Ideally, it is required that the files are sized and grow in an even manner.

Therefore, the proper configuration of the tempdb database has a major impact on the performance of SQL Server.

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18.1.3 Enhancements to tempdb Configuration

During SQL Server 2016 installation, the following features relevant to tempdb configuration are included:

- ➔ The setup process, by default, adds as many tempdb files as the CPU Count, with a maximum of eight files.
- ➔ It is possible to specify:
 - The number of tempdb database files
 - Initial size of the files, autogrowth, and directory placement
 - Initial size of the log files, autogrowth, and directory placement
 - Multiple volumes or directories for the tempdb database files
- ➔ All tempdb files grow at the same time and the need for Trace flags 1117 and 1118 is eliminated.



18.1.4 tempdb Setup

Let us understand the tempdb Setup in SQL Server 2016. The number of files, initial size, and autogrowth size are configured by default in the tempdb tab. Microsoft detects the number of CPU cores available and configures these during the setup process. If the number of CPU cores is less than or equal to eight, then the number of tempdb files configured is equal to the number of CPU cores. However, if the number of CPU cores is greater than eight, then the number of tempdb files configured is only eight. Having multiple tempdb files overcomes the 'Latch Contention' problem, which usually occurs when only one tempdb file is allocated.

Table 18.1 illustrates the number of tempdb files configured based on the number of CPU cores available.

Number of Available CPU Cores	Number of tempdb Data Files
2	2
4	4
8	8
32	8

Table 18.1: Available CPU Cores and Allotted Temp DB Data Files

Furthermore, providing multiple data directories during the setup enables allocation of the files in a round-robin fashion between the folders.

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18.1.5 Handling of Allocations and Autogrowth

In versions of SQL Server prior to 2016, it was necessary to use Trace 1117 and 1118 flags to define allocation of pages in databases and handling of Autogrowth across multiple data files. Earlier, data pages for temp tables were allocated to Mixed Extents. Mixed Extents were 64 KB in size and were shared across multiple database objects such as tables and indexes. The database object's first eight pages were always allocated to a Mixed Extent. Subsequent pages, starting with page 9 were allocated to a Uniform Extent, which was also 64 KB in size. This ensured that the size of small database objects remained small. When a Uniform Extent was allocated to a database object, the object size itself immediately grew by 64 KB. When the Trace Flag 1118 was enabled for the entire SQL Server instance, Mixed Extents were ignored and database objects were only allocated to Uniform Extents. This reduced Latch Contention problems on the Shared Global Allocation Map (SGAM) page that managed the Mixed Extents.

In SQL Server 2016, there is no need of enabling any Trace Flag. Temp table pages are always allocated to Uniform Extents and Mixed Extents are not used, even without the usage of any Trace Flag. However, allocations other than temp tables do use Mixed Extents.

*The future depends on what we do in
the present.*

Code Snippet 1 demonstrates how five allocated pages in a temp table are made directly to a Uniform Extent without using Mixed Extents.

Code Snippet 1:

```
USE tempdb
GO
CREATE TABLE #SampleTable
(
    tempColumn1 INT IDENTITY(1, 1) PRIMARY KEY NOT NULL,
    tempColumn2 CHAR(4000) NOT NULL
)
GO
-- Insert five records, this allocates five pages in tempdb
INSERT INTO #SampleTable VALUES (REPLICATE('a', 4000))
GO 5
-- Enable DBCC trace flag 3604
DBCC TRACEON(3604)
GO
-- Retrieve the temp table name from sys.tables
SELECT name FROM sys.tables
WHERE name LIKE '#SampleTable%'
GO
```

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In Code Snippet 1, five records are inserted into the table. This will result in five pages being allocated in the tempdb. The pages are allocated to a uniform extent directly and not to a mixed extent.

Note that # is used before SampleTable in Code Snippet 1 to indicate that it is a temporary table.

At this stage, after execution, copy the table name from the Results window and then paste it into Code Snippet 2, replacing <table name>. Then execute the code.

Code Snippet 2:

```
DBCC IND(tempdb, [ <table name> ] -1)
-- Then, execute the command with GO
GO
-- Dump the IAM page of the table retrieved by
-- DBCC IND previously
-- No pages are allocated in Mixed Extents, a complete Uniform
-- Extent is allocated.
DBCC PAGE (tempdb, 5, 33, 1)
GO
-- Clean up by dropping the table
DROP TABLE #SampleTable
GO
```



The first few lines of Code Snippet 2 retrieve the first data page for the specified table by using the columns PageFID and PagePID with DBCC IND. Then, you verify that no pages are allocated in mixed extent and finally, drop the temp table.

18.2 Comparing Execution Plans

In SQL Server 2016, it is possible to compare execution plans. Comparing execution plans is a useful feature in the following scenarios:

- One wants to test differences when few changes are made to an execution plan
- One wants to troubleshoot a problem in production environment, which had not occurred earlier in the test environment

Manual comparison between the two environments in two windows, which is the existing solution, is quite tedious. Hence, the comparison feature in SQL Server 2016 enables to quickly highlight the differences.

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Following example illustrates and helps to understand how execution plans can be compared in SQL Server 2016.

1. Create a table, Employee. Code Snippet 3 creates the table Employee, with 500,000 records. The code also retrieves the top 500000 records.

Code Snippet 3:

```
CREATE DATABASE SampleCompareExec
GO
USE SampleCompareExec
GO
CREATE TABLE dbo.Employee (
    Id INT IDENTITY (1, 1) NOT NULL PRIMARY KEY,
    EmpName NVARCHAR (50), MobileNumber NVARCHAR (20),
    StartDate DATETIME, ChangeDate DATETIME)
GO
INSERT INTO dbo.Employee (EmpName, MobileNumber,
    StartDate, ChangeDate)
SELECT TOP 500000 NEWID (),
    100000000 - ROW_NUMBER () OVER (ORDER BY SC1.object_id),
    GETDATE (), GETDATE ()
FROM SYS.all_columns SC1
CROSS JOIN SYS.all_columns SC2
```

*Action may not always bring happiness,
but there is no happiness without
action.*

2. In the SSMS window, enable the actual execution plan (Query → Include Actual Execution Plan or CTRL + M). Then, execute a query to retrieve a phone number. Code Snippet 4 executes a query to retrieve records with phone number '85962000'.

Code Snippet 4:

```
SELECT *
FROM dbo.Employee WITH (NOLOCK)
WHERE MobileNumber = '85962000'
```

Figure 18.1 shows the resulting execution plan.

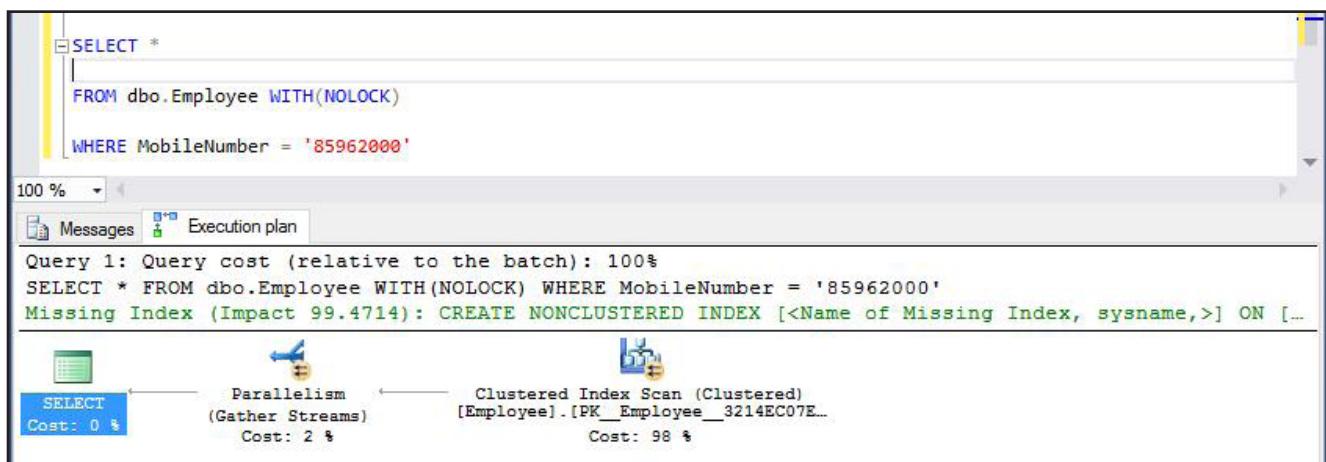


Figure 18.1: Execution Plan of Query Before Indexing

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3. Save the execution plan as FirstExecutionPlan.sqlplan.
4. Index the database on the column MobileNumber. Code Snippet 5 adds the index.

Code Snippet 5:

```
CREATE INDEX IX_Employee_MobileNumber
ON dbo.Employee (MobileNumber)
```

5. Select the actual execution plan option and then re-execute the query on MobileNumber using the earlier Code Snippet 4. Save the execution plan as SecondExecutionPlan.sqlplan. The result is shown in figure 18.2.

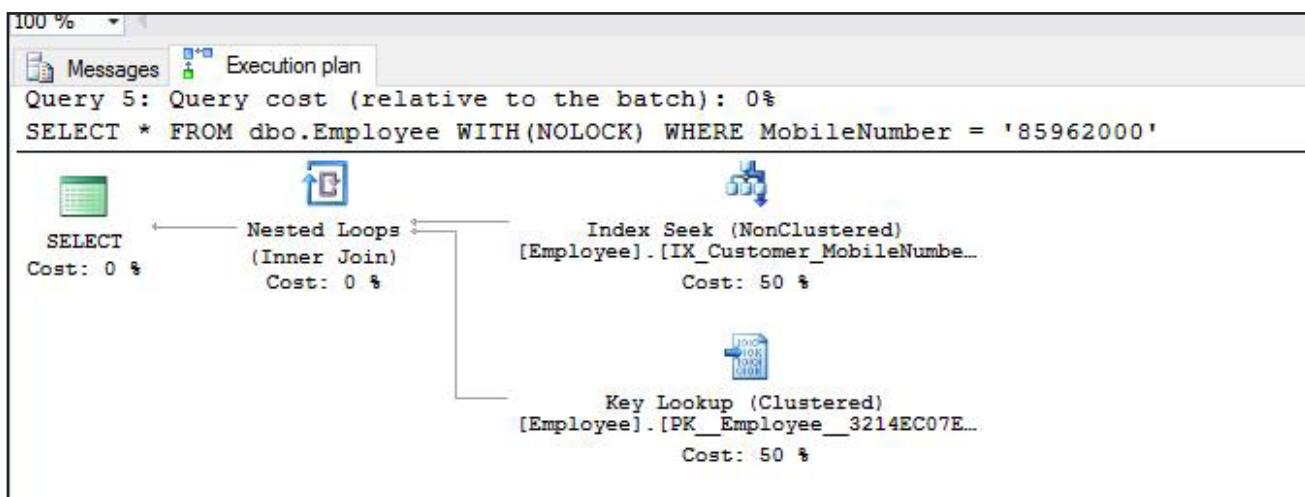


Figure 18.2: Execution Plan of Query After Indexing

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6. In SSMS, open the saved FirstExecutionPlan.sqlplan and right-click the tab. The Compare Showplan option is available as shown in figure 18.3.

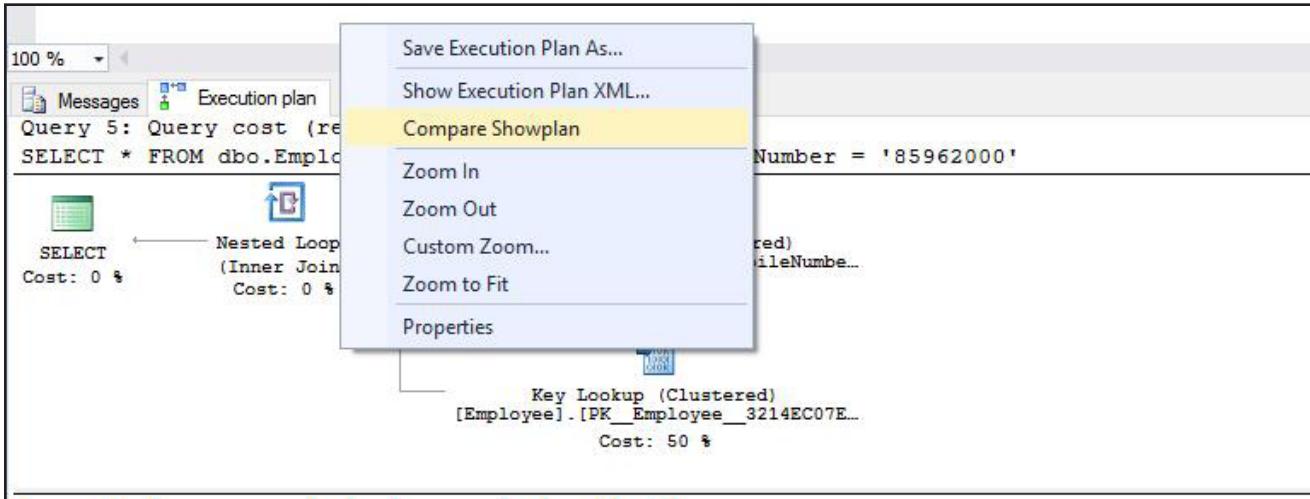


Figure 18.3: Compare Showplan Option

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7. Select Compare Showplan and open the previously saved SecondExecutionPlan.sqlplan. The Showplan Comparison tab opens showing the compared execution plans. Figure 18.4 shows the resultant Showplan Comparison tab.

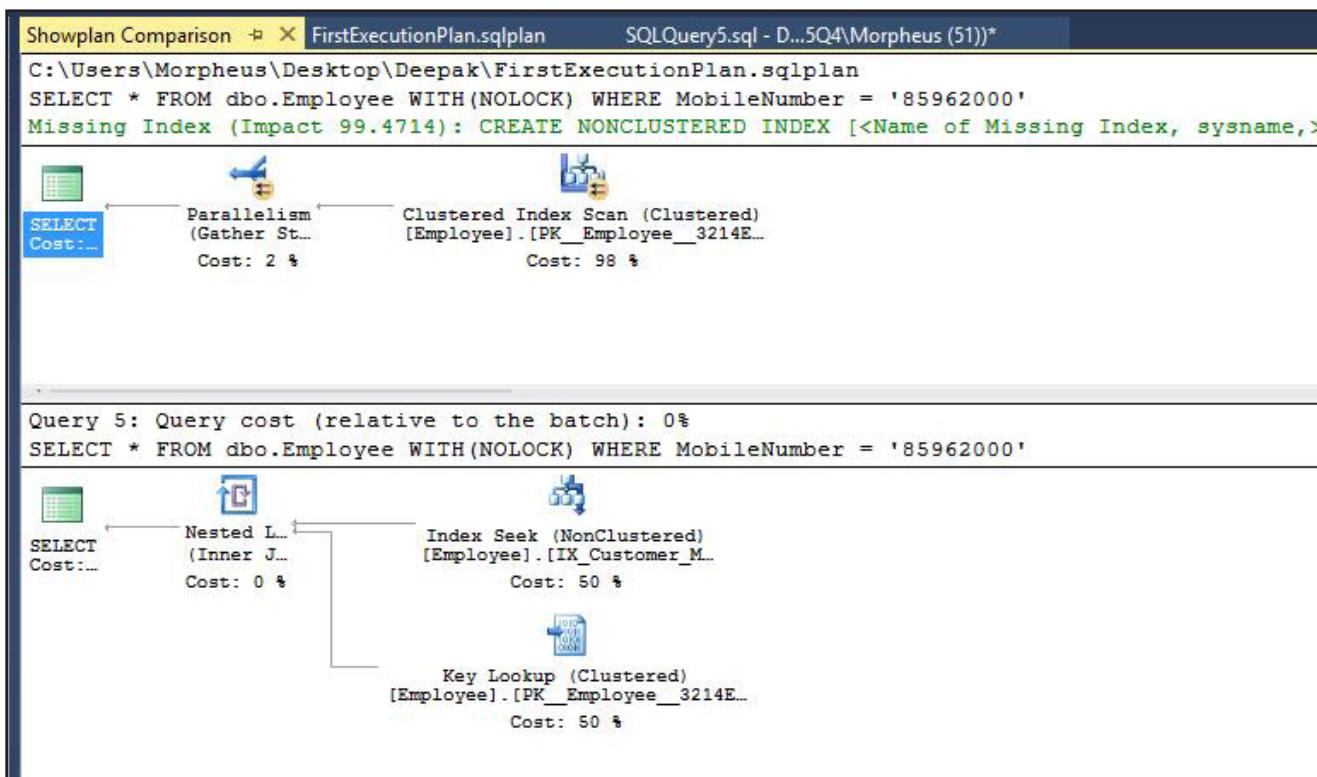


Figure 18.4: ShowPlan Comparison of FirstExecutionPlan and SecondExecutionPlan

First say to yourself what you would be; and then do what you have to do.

8. On the ShowPlan Comparison tab, select the node Clustered Index Scan from the FirstExecutionPlan and then select the node Index Seek from SecondExecutionPlan.
9. Right-click any of the nodes and then select the menu option Properties. Various properties of the two nodes are displayed side-by-side in the Properties window, allowing easy comparison. Figure 18.5 shows the comparison of nodes in the Properties window.

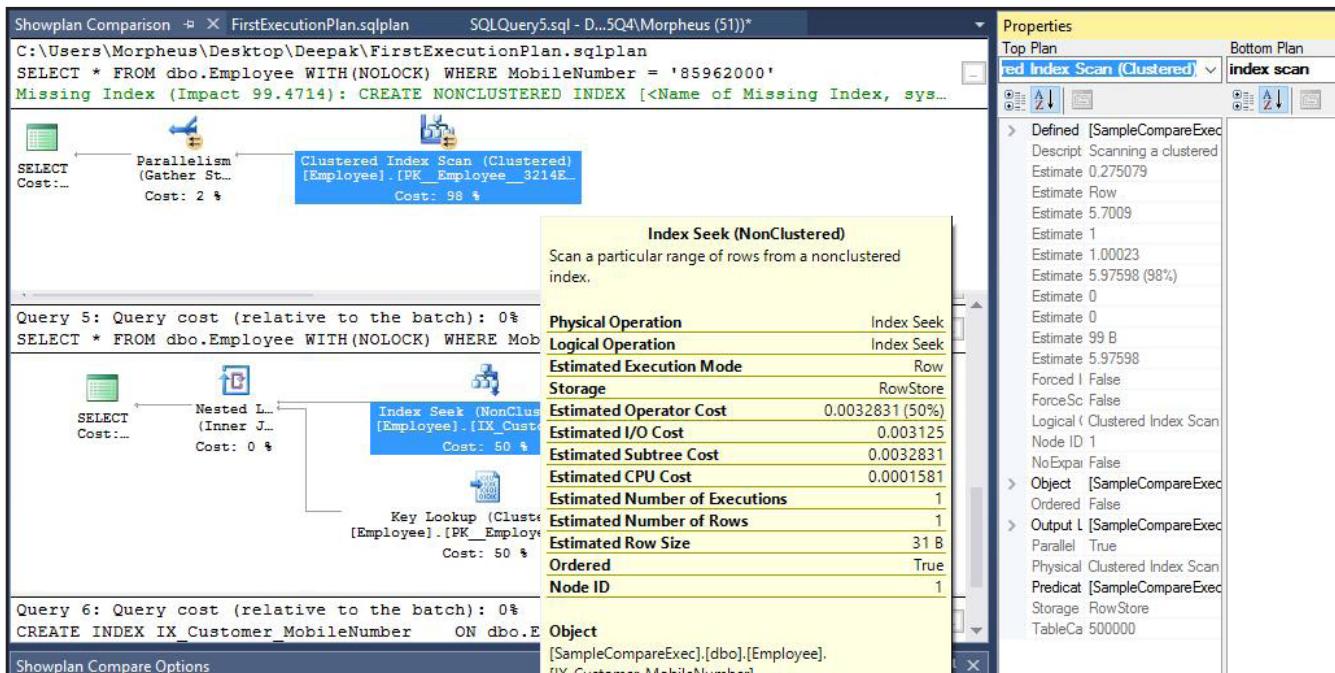


Figure 18.5: Comparison of Nodes in Properties Window

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Note that you can view the execution plans either side-by-side or one below the other. To change the views of the execution plans, right-click and select the Toggle Splitter Orientation option and then select Side-by-Side or Top-and-Bottom view.

Colored Highlights for Comparison

When two execution plans are compared and the common nodes in them have no changes, they are highlighted with the same color. For example, execute the query to retrieve phone records, but with the inclusion of the `TOP` clause. Code Snippet 6 executes the query with the `TOP` clause.

Code Snippet 6:

```
SELECT TOP 1 *
FROM dbo.Employee WITH (NOLOCK)
WHERE MobileNumber = '85962000'
```

Save the execution plan as `ThirdExecutionPlan.sqlplan`.



Figure 18.6 shows the execution plan of this code.

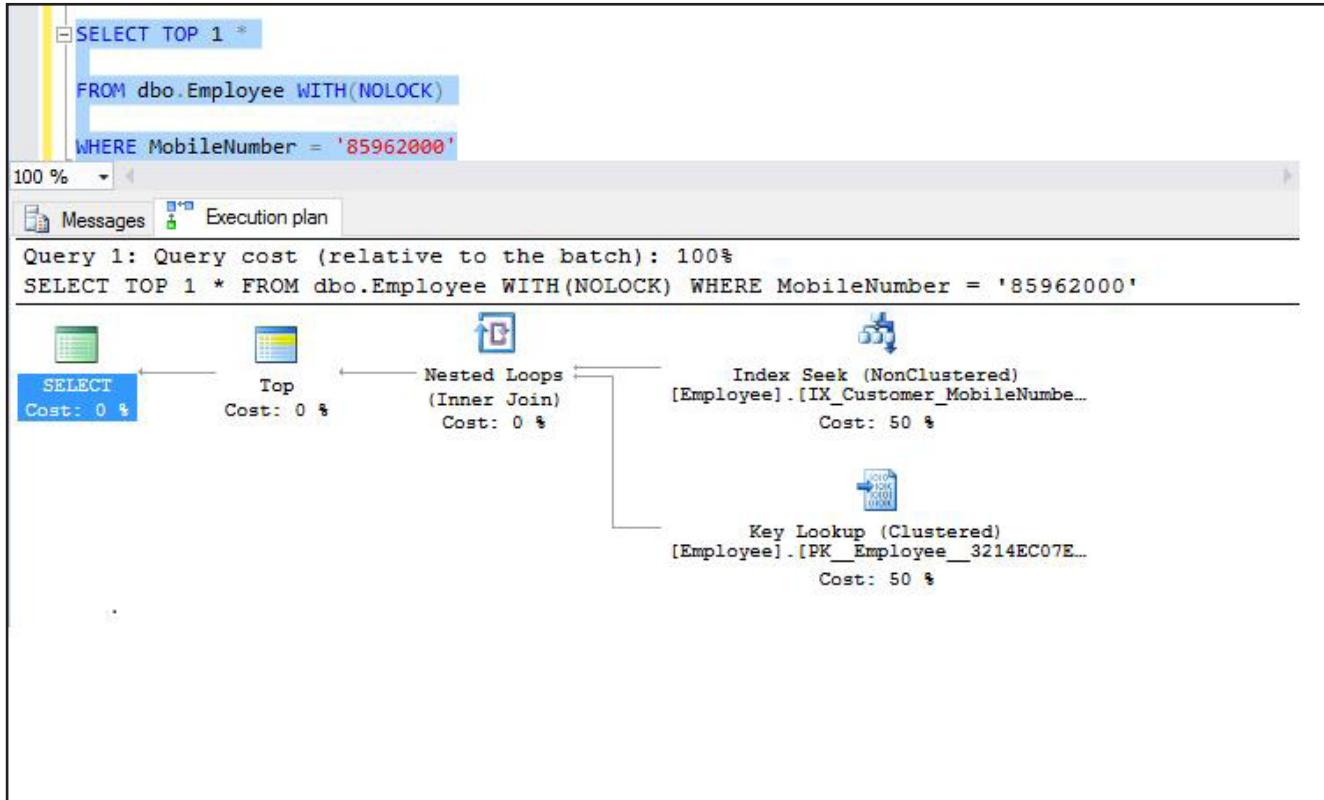


Figure 18.6: Execution Plan of Query with TOP Clause

Open the previously saved SecondExecutionPlan.sqlplan and the ThirdExecutionPlan.sqlplan and compare using the ShowPlan Comparison option. The comparison of the two plans is shown with the nodes being color-highlighted. If there are no changes, the common nodes appear in the same color. A node that is not common is not colored. Also, a common node, when selected in one plan, is automatically selected in the second plan, as well.

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Figure 18.7 shows the color-highlights of the common nodes, and the non-common node, Top that is not colored.

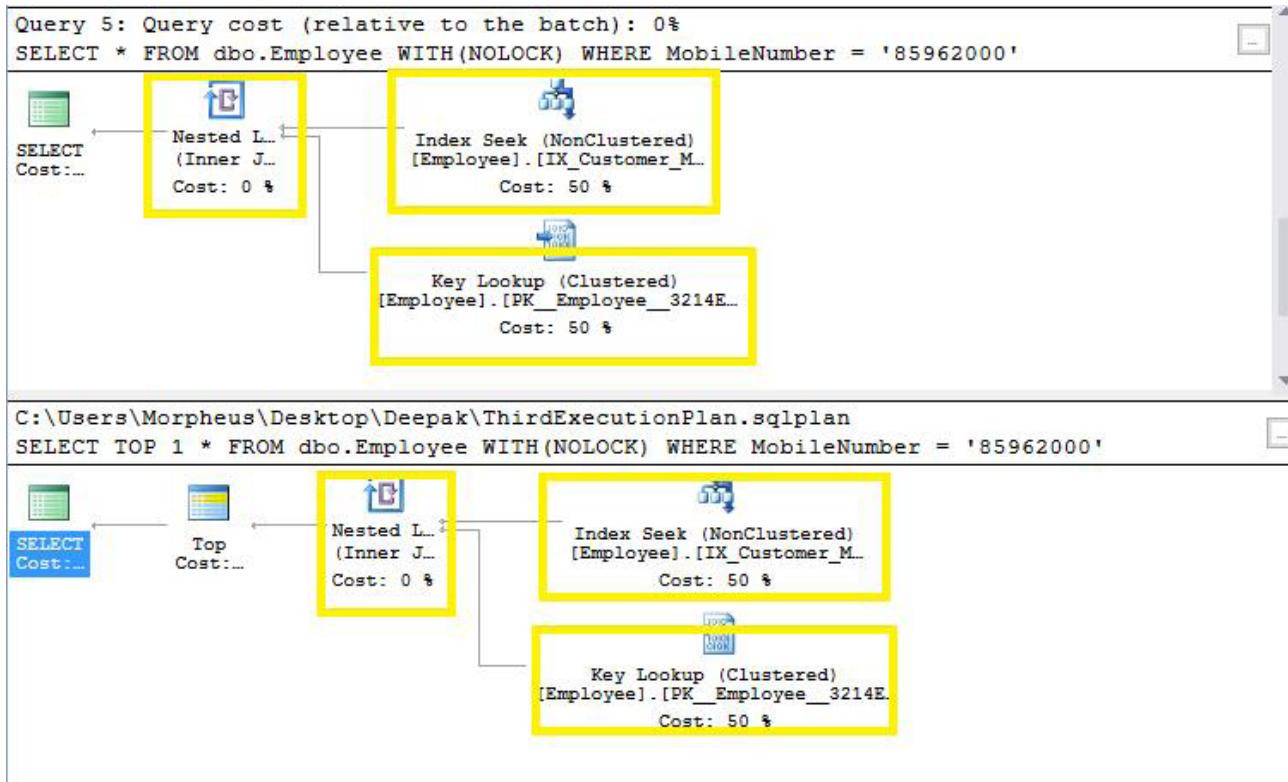


Figure 18.7: Color Highlights of Comparing SecondExecutionPlan and ThirdExecutionPlan

18.3 Temporal Tables and Setting Versioning of Tables

Versions of SQL Server previous to 2016 did not support retrieval of different versions of data in tables. It was only possible to retrieve the current version of data held in a table and not older versions. SQL Server 2016 provides the facility to retrieve different versions of data in tables.

Learning how to learn is life's most important skill.

Figure 18.8 shows a System-versioned table.

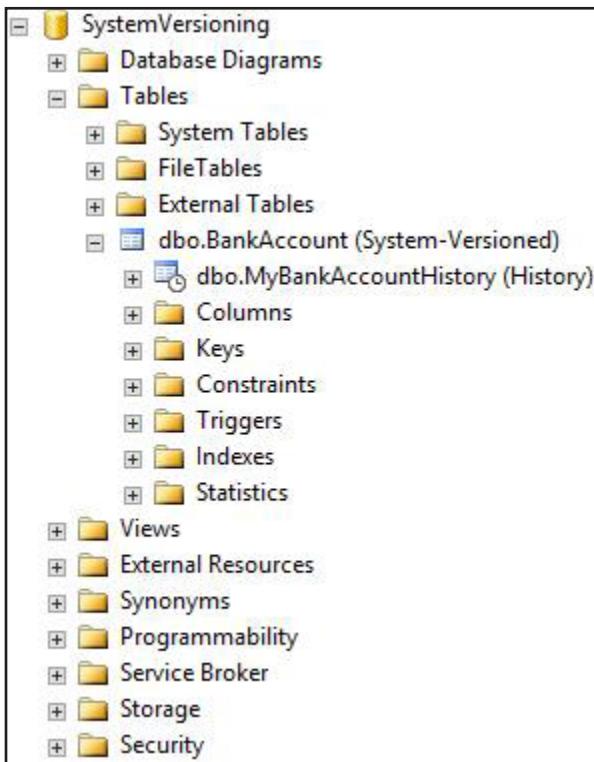


Figure 18.8: System-versioned Table

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18.3.1 Temporal Tables

In SQL Server 2016, a table called temporal table (or history table), linked to the base table, holds older versions of rows. When the base table is updated, the old row version is moved to the temporal table. This is illustrated in figure 18.9.

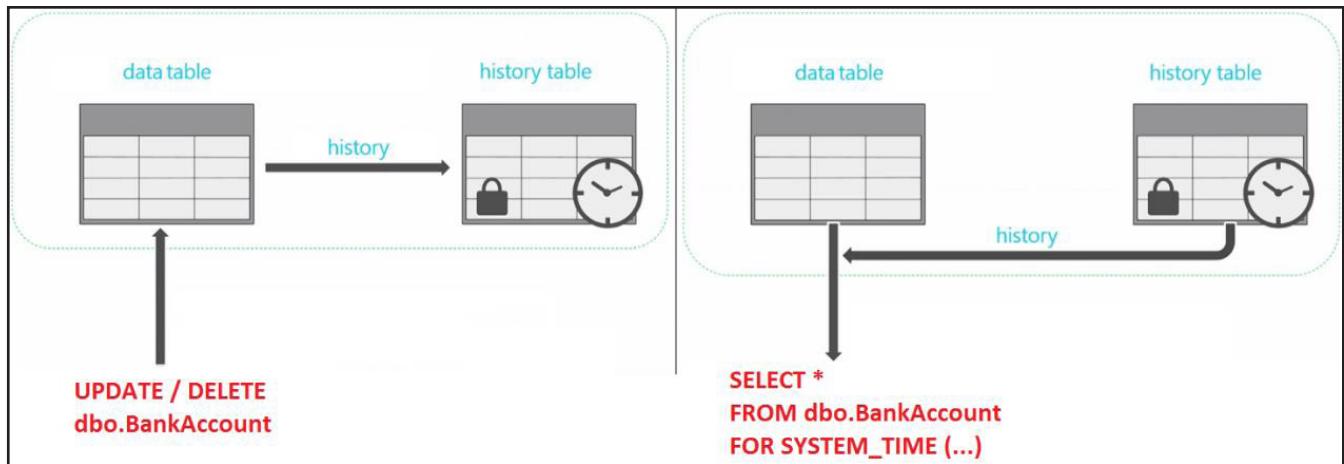


Figure 18.9: Data Inserts to History Table



18.3.2 Use of Temporal Tables

It is useful to have temporal tables and be able to retrieve data in different versions. Following are some of the uses:

- Audit data changes
- Analyze data to make business decisions
- Understand trends
- Correct accidentally changed data
- Revert to proper data in case of error occurrences

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18.3.3 Retrieving Versions of Data

Different versions of a record can be retrieved by enabling a table to be 'system-versioned'. The working of time-specific data retrieval can be better understood by going through the following example of Bank account transaction:

1. Create a table, BankAccount as shown in Code Snippet 7.

Code Snippet 7:

```
CREATE TABLE dbo.BankAccount  
(PrimaryAccountNumber INT CONSTRAINT PK_BankAccount_TransactionID  
PRIMARY KEY, CurrentAccountBalance FLOAT)
```

2. To make a table 'system-versioned', add two datetime2 columns to the table as shown in Code Snippet 8. These are used by SQL Server to store the 'From-date' and 'To-date' of the record. Including the keyword 'PERIOD FOR SYSTEM_TIME' indicates to SQL Server that when querying for data, the datetime2 columns should be used. Thus, data in a time-frame can be retrieved.

Code Snippet 8:

```
ALTER TABLE dbo.BankAccount  
ADD ValidFrom datetime2 GENERATED ALWAYS AS ROW START HIDDEN NOT NULL,  
ValidTo datetime2 GENERATED ALWAYS AS ROW END HIDDEN NOT NULL,  
PERIOD FOR SYSTEM_TIME (ValidFrom, ValidTo);
```

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

Note that using the HIDDEN keyword hides the two newly added columns in the original table so that no error occurs in the database code execution.

3. Now, enable the system-versioning on the table as shown in Code Snippet 9.

Code Snippet 9:

```
ALTER TABLE dbo.BankAccount  
SET (SYSTEM_VERSIONING = ON (HISTORY_TABLE = dbo.BankAccountPast));
```

4. Enable the execution plan in the SSMS so that the capture of data changes and recording of history can be viewed.
5. Insert a record in the table. Code Snippet 10 inserts a record in the table.

Code Snippet 10:

```
INSERT INTO dbo.BankAccount  
(PrimaryAccountNumber, CurrentAccountBalance)  
VALUES  
(2147482647, 10100)
```

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Figure 18.10 shows the Clustered Index Insert in the execution plan.

```

Messages Execution plan
T-SQL
CREATE TABLE
Cost: 0 %

Query 2: Query cost (relative to the batch): 100%
INSERT INTO dbo.BankAccount VALUES (2147483247, 10100)

T-SQL
Clustered Index Insert
INSERT [BankAccount].[PK_BankAccount_Trans...
Cost: 100 %

```

Figure 18.10: Clustered Index Insert

- Now, update the bank account balance as shown in Code Snippet 11.

Code Snippet 11:

```

UPDATE dbo.BankAccount
SET CurrentAccountBalance = CurrentAccountBalance - 2500
WAITFOR DELAY '00:01:00'
UPDATE dbo.BankAccount
SET CurrentAccountBalance = CurrentAccountBalance + 1000

```

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Enhancements in SQL Server 2016

Figure 18.11 shows the execution plan of the update. Observe the additional DML command and an additional Clustered Index Insert. This is the insertion in the history table by SQL Server. This requires no user interaction and the historical data is stored automatically.

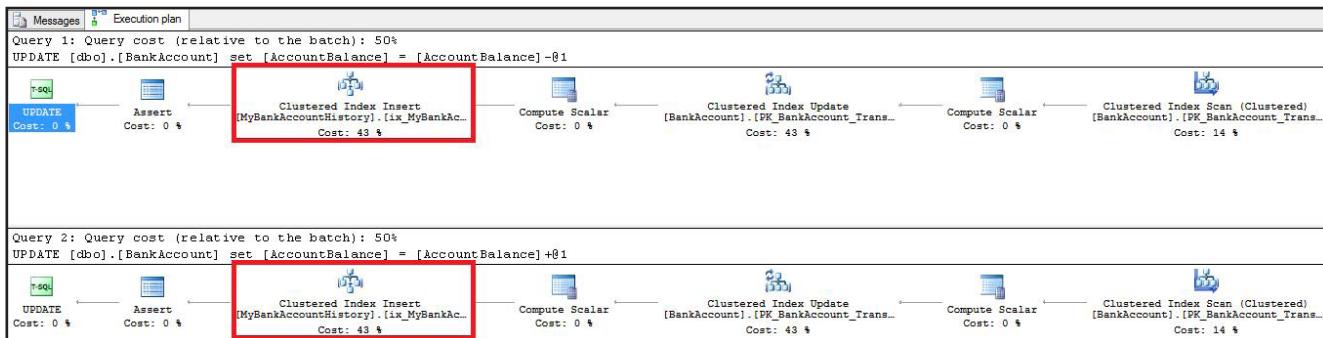


Figure 18.11: Clustered Index Insert to History Table

Suppose, the following changes were made to the data at different times on 09/07/2016:

- 6:25 – No data available
- 6:26 – Insert 10.000
- 6:27 – Update -2.500
- 6:28 – Update +1.000
- 6:29 – No data changes

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7. To retrieve data at each of these times, include the clause 'FOR SYSTEM_TIME' in the query as shown in Code Snippet 12.

Code Snippet 12:

```
SELECT * FROM dbo.BankAccount FOR SYSTEM_TIME AS OF '2016-07-04 06:25:00'
--No data available

SELECT * FROM dbo.BankAccount FOR SYSTEM_TIME AS OF '2016-07-04 06:26:00'
--First insert

SELECT * FROM dbo.BankAccount FOR SYSTEM_TIME AS OF '2016-07-04 06:27:00'
--First update

SELECT * FROM dbo.BankAccount FOR SYSTEM_TIME AS OF '2016-07-04 06:28:00'
--Second update

SELECT * FROM dbo.BankAccount FOR SYSTEM_TIME AS OF '2016-07-04 06:29:00'
--No other changes
```

18.3.4 Querying Time-Specific Data

Code Snippets 13 to 16 shows how you can query time-specific data.

Code Snippet 13:

```
DECLARE @DateTimeInHistory DATETIME2
SET @DateTime History = '2016-07-04 06:28:00'
SELECT * FROM dbo.BankAccount FOR SYSTEM_TIME AS OF @DateTimeInHistory
```

To learn, you must want to be taught.

Code Snippet 14:

```
SELECT PrimaryAccountNumber, CurrentAccountBalance, ValidFrom, ValidTo
FROM dbo.BankAccount
FOR SYSTEM_TIME FROM '2016-07-04 06:26:00' TO '2016-07-04 06:28:00'
```

Code Snippet 15:

```
SELECT PrimaryAccountNumber, CurrentAccountBalance, ValidFrom, ValidTo
FROM dbo.BankAccount
FOR SYSTEM_TIME BETWEEN '2016-07-04 06:26:00' AND '2016-07-04 06:28:00'
```

Code Snippet 16:

```
SELECT PrimaryAccountNumber, CurrentAccountBalance, ValidFrom, ValidTo
FROM dbo.BankAccount
FOR SYSTEM_TIME CONTAINED IN ('2016-07-04 06:26:00', '2016-07-04 06:28:00')
```

18.3.5 Schema Changes on Temporal Tables

In order to handle schema changes, such as addition of a column, system-versioning must first be disabled on the table. Then, the same change must be made to the temporal table or history table. Next, system-versioning must be enabled again.

Disabling system-versioning for a short period means some historical data loss. To handle this, the database might be changed to a 'single-user' mode, which would prevent other users from making any changes. However, this is not a very feasible solution in a production environment. Disabling the system-versioning would not result in removal of historical data.

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Code Snippet 17 shows how making a change to the schema without disabling system-versioning would result in an error. Figure 18.12 shows the outcome of the code.

Code Snippet 17:

```
ALTER TABLE dbo.BankAccount ADD NewColumn VARCHAR(10)
```

Messages
Msg 13550, Level 16, State 1, Line 33
Add column operation failed on table 'SystemVersioning.dbo.BankAccount' because it is not supported operation on system-versioned temporal tables.

Figure 18.12: Error Due to Enabled System-Versioning

Code Snippet 18 shows how disabling system-versioning but not making the same change to the temporal table would result in an error. Figure 18.13 shows the outcome of the code.

Code Snippet 18:

```
ALTER TABLE dbo.BankAccount SET (SYSTEM_VERSIONING=OFF)
GO
ALTER TABLE dbo.BankAccount ADD NewColumn VARCHAR(10)
GO
ALTER TABLE dbo.BankAccount
SET (SYSTEM_VERSIONING=ON (HISTORY_TABLE = dbo.BankAccountPast))
GO
```

Messages
Msg 13523, Level 16, State 1, Line 44
Setting SYSTEM_VERSIONING to ON failed because table 'SystemVersioning.dbo.BankAccount' has 5 columns and table 'SystemVersioning.dbo.MyBankAccountHistory' has 4 columns.

Figure 18.13: Error Due to Schema Differences in Temporal Table



Code Snippet 19 adds the same schema to the Temporal or history table.

Code Snippet 19:

```
ALTER TABLE dbo.BankAccountPast  
ADD NewColumn VARCHAR(10)  
GO  
ALTER TABLE dbo.BankAccount  
SET (SYSTEM_VERSIONING = ON (HISTORY_TABLE = dbo.BankAccountPast))  
GO
```

18.3.6 Indexing on Temporal Tables

Temporal tables can also be indexed in the same way as normal tables. This ensures that when queries are run on the temporal tables for time-specific data, the performance is not affected. Code Snippet 20 indexes a temporal table.

Code Snippet 20:

```
CREATE NONCLUSTERED INDEX IX_MyPastData  
ON dbo.BankAccountPast (PrimaryAccountNumber, CurrentAccountBalance)
```

18.3.7 Cleaning Up Temporal Tables

If data on temporal tables need to be removed at any time, it can only be done by executing a simple query that would go through the temporal tables and delete the records. This could be scheduled in a SQL Server Agent job. There is no readily available Cleanup Process available at present.

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18.4 Check Your Progress

1. Which clause among the following is used to retrieve data at a specific point in time?

(A) FOR SYSTEM_TIME AS OF	(C) FOR SYSTEM_TIME BETWEEN
(B) FOR SYSTEM_TIME FROM	(D) FOR SYSTEM_TIME CONTAINED IN

2. If the number of available CPU cores is 32, what would be the number of tempdb database files by default?

(A) 2	(C) 32
(B) 8	(D) 4

3. Select the correct order of the following steps from the options provided:

(1) Insert a new column in a System-Versioned' table	(3) Disable system-versioning on table
(2) Insert a new column in a temporal table	(4) Enable system-versioning on table

(A) (1,2,3,4)	(C) (3,1,2,4)
(B) (2,1,3,4)	(D) (2,3,1,4)

4. Which of the following are uses of storing historical data? Choose all the correct options.

(A) Calculate trends for business decisions	(C) Overcome accidental data changes
(B) Troubleshoot errors in production environment	(D) Overcome performance issues

5. Select the correct option: Allocating a database object to a uniform extent.

(A) Grows the database object size by 64 KB	(C) Does not make any change to the size of the database object
(B) Reduces the database object size by 8 KB	(D) Grows the database object size by 8 KB

18.4.1 Answers

1.	a
2.	c
3.	c
4.	a and c
5.	a



- ➔ Enhancements in SQL Server 2016 include:
 - Configuring tempdb databases during setup: Accurate sizing of tempdb is important for optimal system performance. SQL Server 2016 simplifies this process with default allocation of the number of tempdb files as well as their initial sizes.
 - Comparing two execution plans: SQL Server 2016 provisions easy comparison of changes in execution plans and their impact with easy-to-analyze highlights.
 - Retrieving time-specific versions of data through temporal or history tables: SQL Server 2016 enables to store table data in different versions helps in case of a need to roll-back to a previous version.
- ➔ SQL Server 2016 also eliminates the need to use Trace Flags 1117 and 1118.
- ➔ Comparing two execution plans proves useful to troubleshoot errors in production environment.
- ➔ Time-specific data retrieval that is made possible in SQL Server 2016 is also very useful to analyze data for business decisions.

Session - 19

Security Upgrades and Working with JSON

Welcome to the Session, **Security Upgrades and Working with JSON.**

This session focuses on the security enhancements and its implementation methodologies, such as Always Encrypted and Dynamic Data Masking. This session also describes about converting JSON to rowset data with the help of the OPENJSON function.

In this Session, you will learn to:

- ➔ Explain how to use SQL Server features to protect data at rest and in motion
- ➔ Describe security enhancements in SQL Server 2016
- ➔ Explain how to work with JSON data

19.1 Introduction

The enhanced security features and data conversion from JSON to rowsets are some of the many attractive features of SQL Server 2016 that will be explored in this session.

19.2 Security Enhancements of SQL Server 2016

Always Encrypted, Dynamic Data Mask, Transparent Data Encryption, and Row-Level security provide security in SQL Server 2016.

19.2.1 Always Encrypted

Credit card numbers or national identification numbers are common examples of sensitive data stored in SQL Server databases or Azure databases. Always Encrypted is a feature that protects crucial data by encrypting the same inside the client applications. The encrypted keys are hidden from SQL database. Hence, there is always a separation between data managers who manage data but have no access to it and data owners who can view the data. This reduces the burden on the part of Database Administrators (DBAs) with respect to security clearance. This feature enables organizations to perform data encryption, whether the data is in use or not in use.

Democritus said, words are but the shadows of actions.

Types of Encryption

Following are the two types of encryption supported by Always Encrypted:

- **Randomized Encryption:** This type of encryption is more secure. However, as the name suggests, it encrypts the data in a randomized manner. Nevertheless, table joins, indexing, grouping, and equality searches on encrypted columns are not possible.
- **Deterministic Encryption:** In this type of encryption, same encrypted value is generated for any specific plain text value. This means that unauthorized users can guess some details about encrypted data by inspecting encrypted column patterns. Small set of possible encrypted values, such as True/False widens the weakness. However, this method also enables table joins, filtering by equality, and grouping.

Always Encrypted Keys

Following are the two types of keys used by Always Encrypted:

- **Column Encryption Keys:** Sensitive data stored in database is encrypted with these types of keys. A single column key can encrypt all data in one column. The database in system catalog view stores the encrypted values of column encryption keys. It is advisable to store column encryption keys in a trusted location for backup.
- **Column Master Keys:** Master keys protect column encryption keys. The database in system catalog views stores information about column master keys. It is advisable to store column master keys in a trusted key store.

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Getting Started with Always Encrypted

Following is the step-by-step procedure to encrypt a database with Always Encrypted:

1. Expand database in SQL Server Management Studio (SSMS), expand Security, and then create Column Master Key. 'Always Encrypted Keys' item can be seen as shown in figure 19.1:

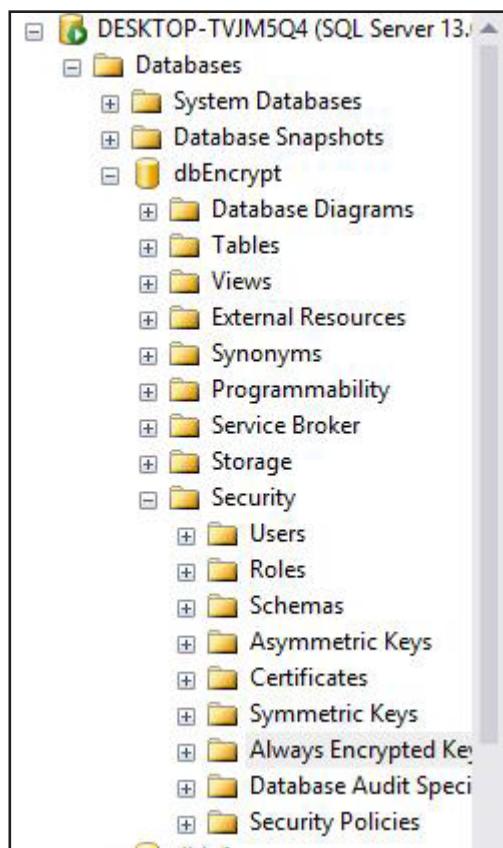


Figure 19.1: Always Encrypted Keys in SSMS



Security Upgrades and Working with JSON

2. Expand 'Always Encrypted Keys' option that, in turn, gives more options as shown in figure 19.2:



Figure 19.2: Expand Always Encrypted Keys

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3. To create a Column Master Key, click the 'Column Master Keys' item, which displays options as shown in figure 19.3:

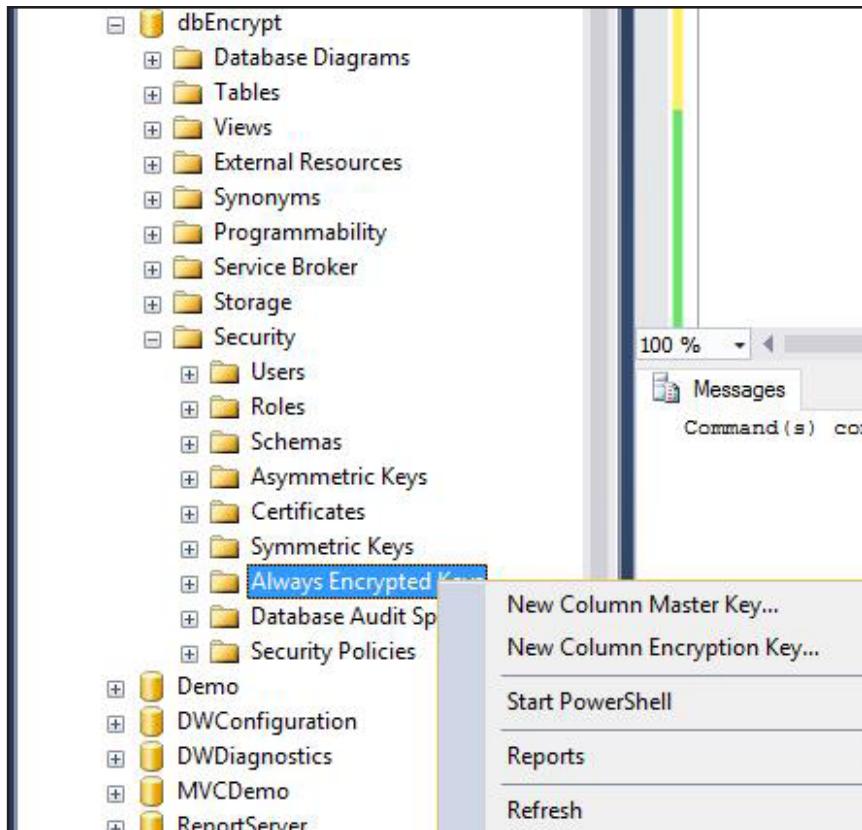


Figure 19.3: New Column Master Key

*Nothing is a waste of time if you use
the experience wisely.*

Security Upgrades and Working with JSON

4. Click the 'New Column Master Key' item in the drop-down list to display the screen as shown in figure 19.4:

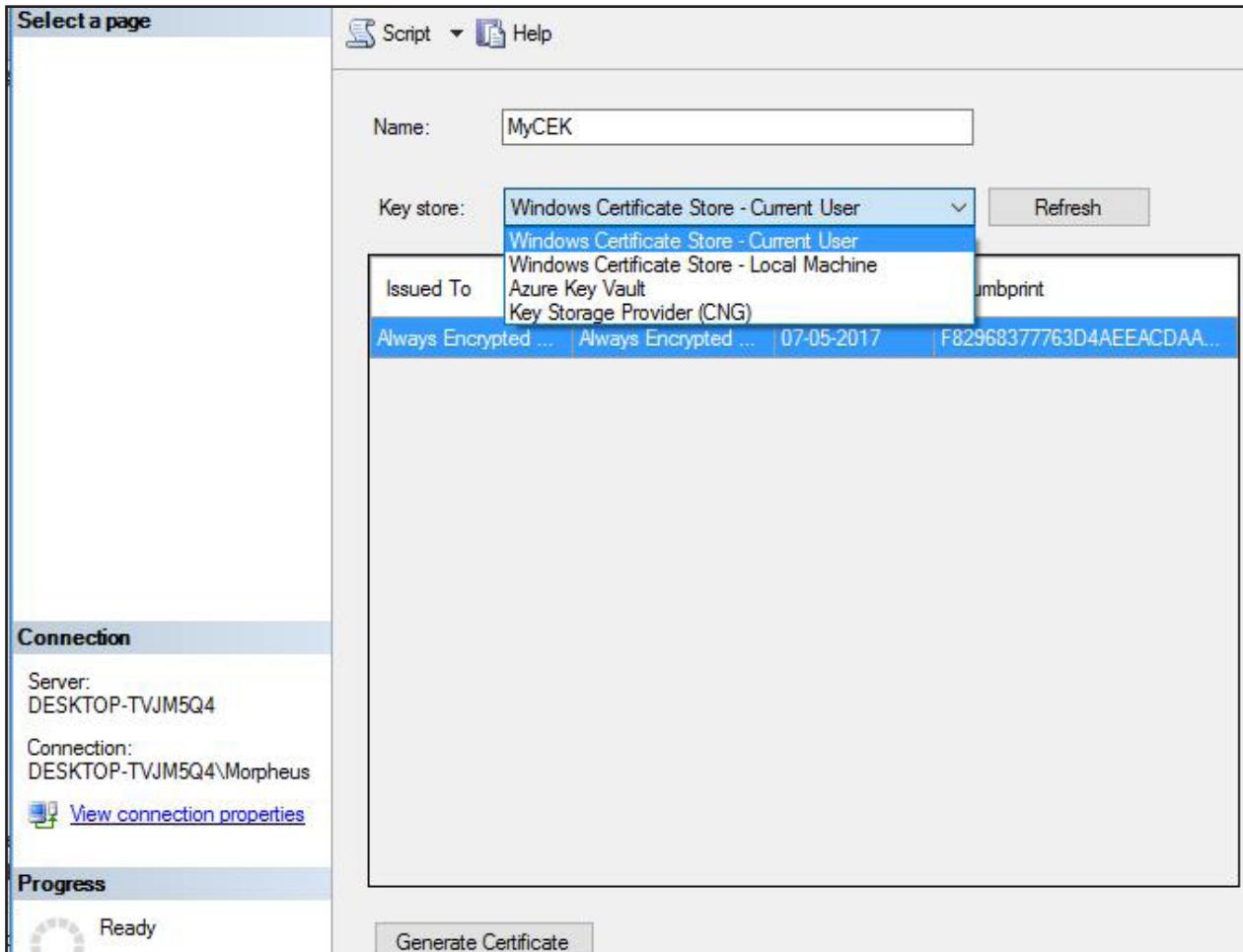


Figure 19.4: Name and Keystore

In figure 19.4, a 'Name' and a 'Key store' location can be seen for creating a New Column Master Key.

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5. In the Name section, enter name for Column Master Key. Expand the 'Key store' drop-down box to see the different key store options, and then, click the 'Generate Certificate' button.

A screen appears as shown in figure 19.5:

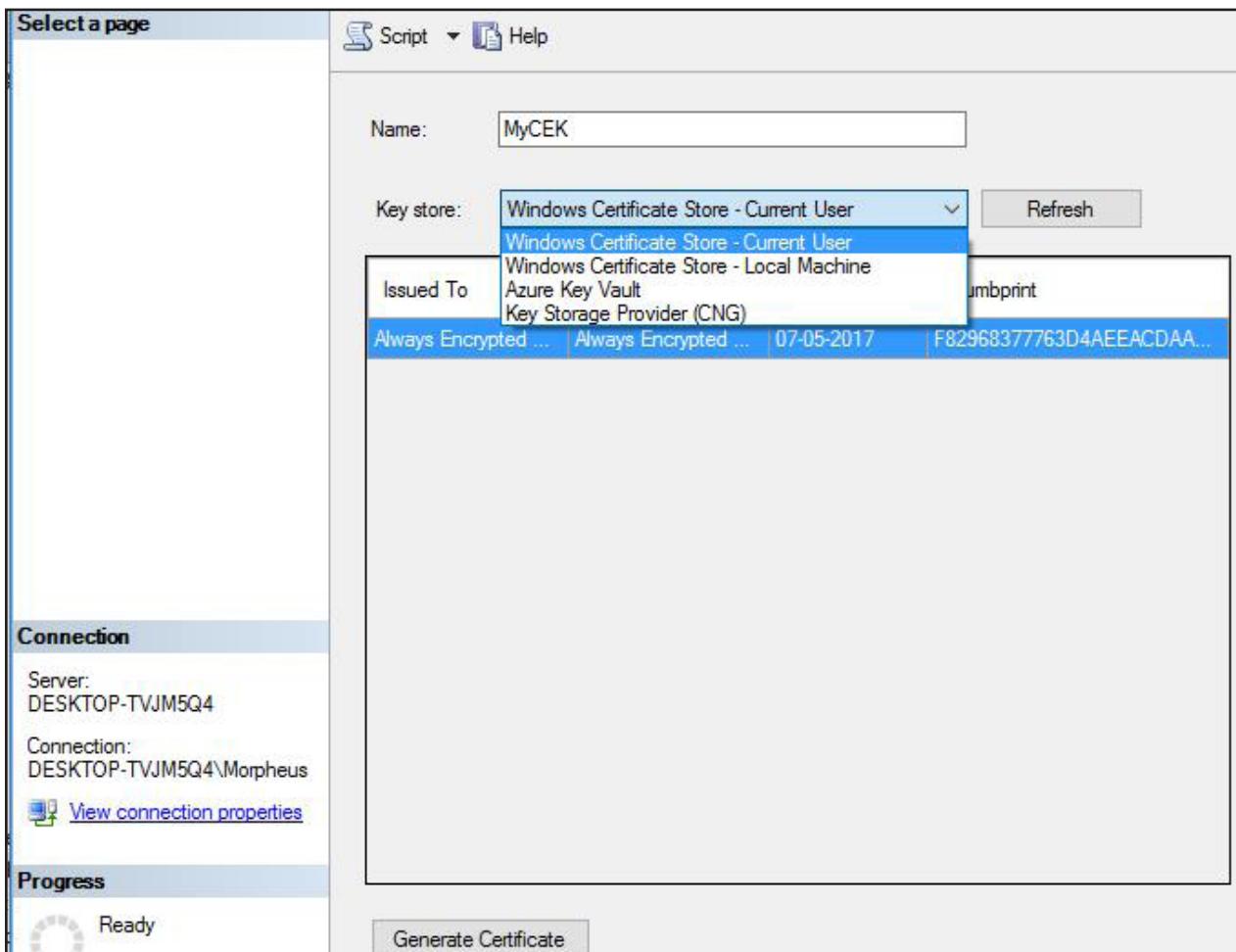


Figure 19.5: Generate Certificate

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6. The encrypted master key 'MyCEK' has been created. A column encryption key can be created now. Right-click the 'Column Encryption Key' item in the object explorer and then select the 'New Column Encryption Key' item as shown in figure 19.6.

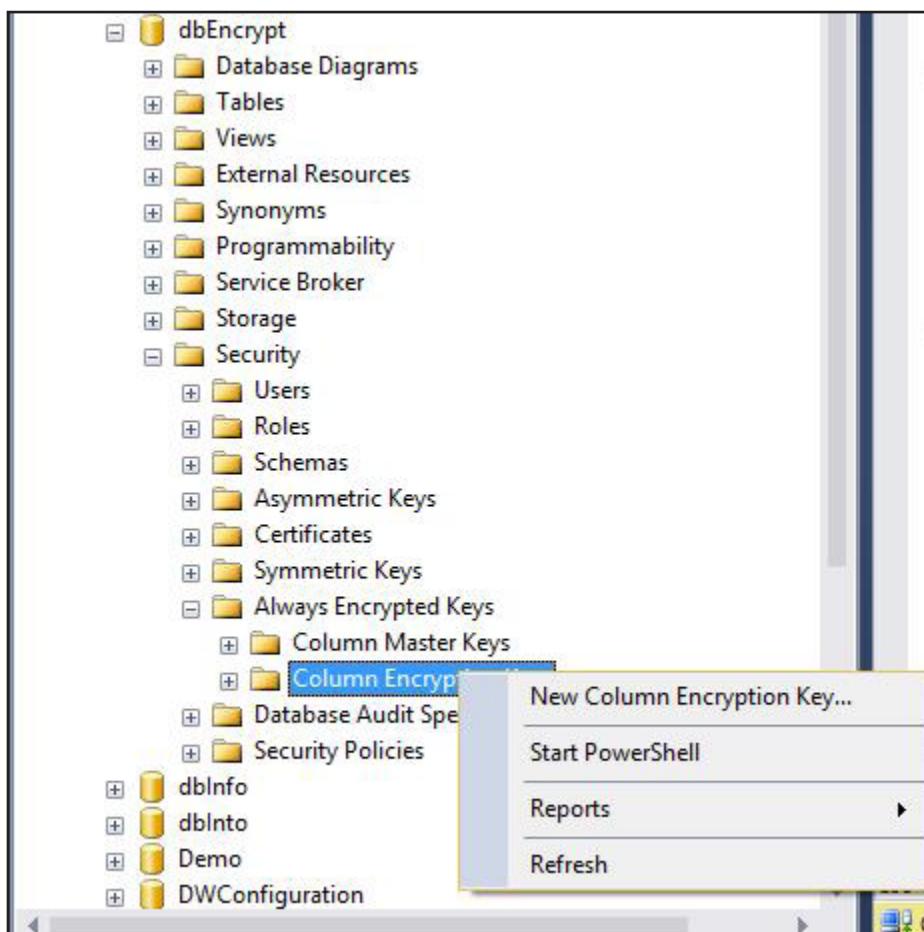


Figure 19.6: New Column Encryption Key

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Then the 'New Column Encryption Key' window is displayed as shown in figure 19.7:

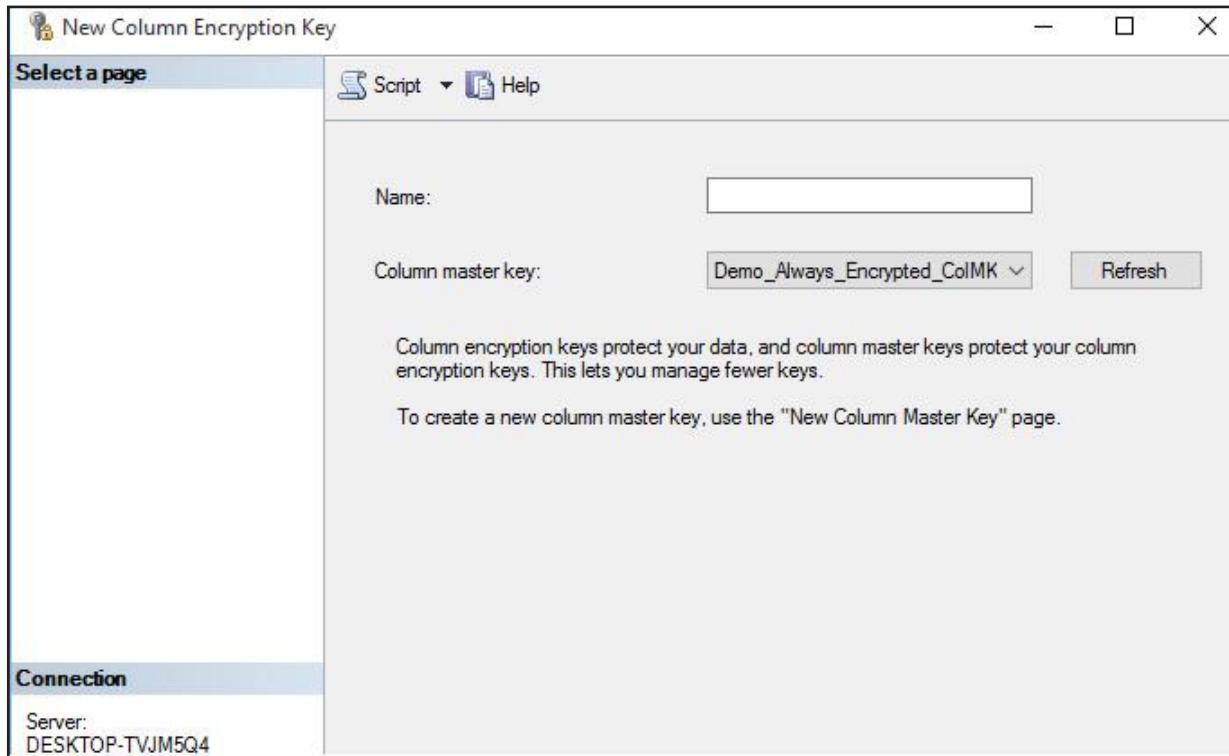


Figure 19.7: New Column Encryption Key Window

Learning how to learn is life's most important skill.

7. Enter the name of new 'Column Encryption Key', which is 'Demo_Always_Encrypted_CEK'. Select the 'Column Master Key' from the drop-down menu. After identifying the name and master key, press OK to create column encryption key.
8. Create a new database one or more tables with columns to be encrypted as shown in Code Snippet 1:

Code Snippet 1:

```

CREATE DATABASE dbEncrypt
USE dbEncrypt
CREATE TABLE Employees
(
    EmpName nvarchar(60),
    COLLATE Latin1_General_BIN2 ENCRYPTEDWITH (COLUMN_ENCRYPTION_KEY
        Demo_Always_Encrypted_ColMKey,
        ENCRYPTION_TYPE = RANDOMIZED,
        ALGORITHM = 'AEAD_AES_256_CBC_HMAC_SHA_256'),
    UID varchar(11)
    COLLATE Latin1_General_BIN2 ENCRYPTEDWITH (COLUMN_ENCRYPTION_KEY = Demo_
        Always_Encrypted_ColMKey,
        ENCRYPTION_TYPE = DETERMINISTIC,
        ALGORITHM = 'AEAD_AES_256_CBC_HMAC_SHA_256'),
    Age int NULL
);
GO

```

Thus, the Always Encrypted feature can be used in this manner.

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19.2.2 Transparent Data Encryption (TDE)

Inactive data or data that is not in use is referred as to **data at rest**. This data is stored in digital form, such as data warehouses, databases, archives, spreadsheets, mobile devices, and so on. The other two states of digital data are **data in use** and **data in transit**.

Vulnerabilities of Data at Rest

Data at rest poses security issues to government agencies, businesses, and other institutions. Security protocols are used to protect data at rest, in case it is lost from access by unauthorized people. The more the duration of data at rest, the higher the chances of its access by unauthorized individuals.

Transparent Data Encryption (TDE) is a technique used to encrypt SQL Server and Azure SQL database data files. This is called encrypting data at rest. Various preventive measures can be taken to assure that the database is secure. For example, encryption of confidential assets, providing a firewall around the database servers, secure system design and so on. In a situation where in the physical media such as backup tapes or disk drives themselves can be stolen, a hostile user can easily browse the data by attaching or restoring the data in the database. Hence, it is essential to encrypt the sensitive data in the database and to certify the encryption keys used for data encryption.

TDE accomplishes real-time I/O encrypting and decrypting of the log and data files. The database boot record stores the Database Encryption Key (DEK), used by encryption. This helps during recovery. The master database in the server stores the symmetric DEK that is secured with a certificate. Extensible Key Management (EKM) module protects the asymmetric DEK. The data and log files are known as data at rest and TDE protects this data. The Advanced Encryption Standard (AES) and Triple Data Encryption standard (3DES) algorithms can be used for data encryption without the software developers having to change the existing applications.

Oracle and Microsoft have adapted TDE technology to encrypt database files, which provides file level encryption. The security issue raised by data at rest is solved with TDE. It encrypts databases on both hard drive and backup media. However, the data in transit or data in use is not protected by TDE.



19.2.3 Dynamic Data Masking

Dynamic data masking, as shown with an example in figure 19.8, masks sensitive data, thus, preventing it from unauthorized access.

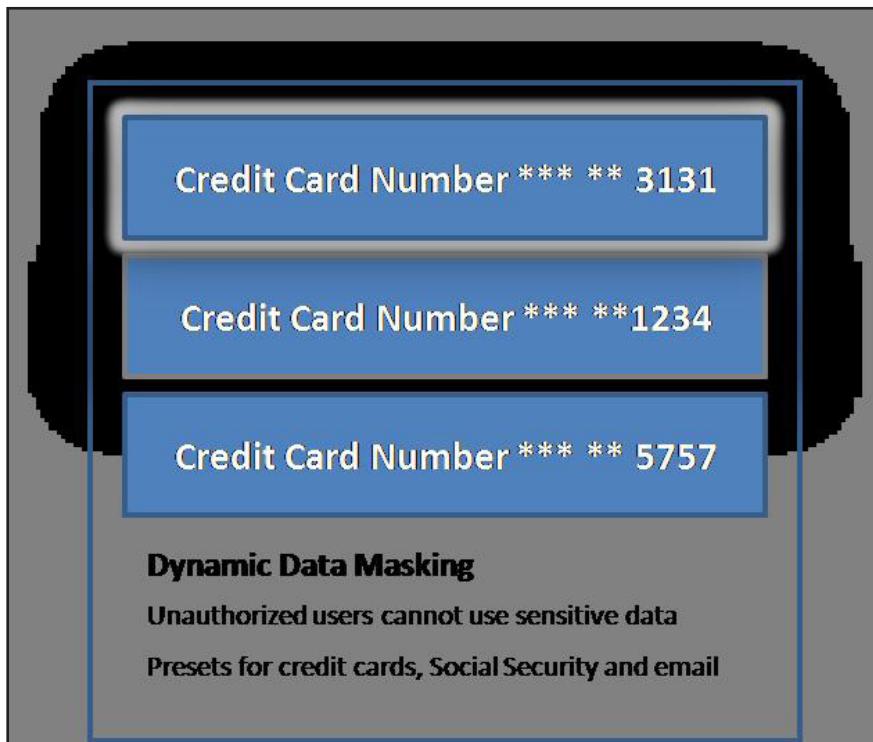


Figure 19.8: Dynamic Data Masking

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Customers can decide on the quantity of data to be revealed without much affecting the application layer. This data protection tool hides the query result set that is sensitive, at the same time keeping the database unchanged. Sensitive data can be masked without modifying existing queries. Nevertheless, dynamic data masking does not block the database users to have direct access to the database and run comprehensive queries, which gives parts of sensitive data. It is suggested to use dynamic data masking in co-ordination with other security features such as auditing, encryption, and row-level security to safeguard the sensitive data in the database.

Defining a Dynamic Data Mask

The data in a specific column can be protected by defining a mask rule on that column.

Who dares to teach must never cease to learn.

Security Upgrades and Working with JSON

Four types of masks are shown in table 19.1 as follows.

Function	Description	Examples
Default	<p>This enables complete masking depending on the field data types.</p> <p>String data type : use XXXX</p>	<p>Column definition syntax:</p> <pre>Phone varchar(18) MASKED WITH (FUNCTION = 'default()') NULL</pre>
	<p>If the length of the field is less than four characters, use fewer Xs.</p> <p>Supported string data types: nchar, nvarchar.</p> <p>Numeric data type: use zero value.</p> <p>Numeric data types are as follows: bigint, bit, decimal, int, money, numeric, smallint, smallmoney, tinyint, float, and real.</p> <p>Binary data type: use single ASCII byte value zero.</p> <p>Binary data types are: binary, varbinary, and image.</p>	<p>Alter column syntax:</p> <pre>ALTER COLUMN Gendr ADD MASKED WITH (FUNCTION = 'default()')</pre>
E-mail	<p>This method reveals only the first letter of a specific e-mail address and the constant suffix '.com'. After masking, the e-mail address will be in the form: aXXX@XXXX.com</p>	<p>Definition Syntax:</p> <pre>Email varchar(50) MASKED WITH (FUNCTION = 'email()') NULL</pre> <p>Alter Syntax:</p> <pre>ALTER COLUMN Email ADD MASKED WITH (FUNCTION = 'email()')</pre>

Function	Description	Examples
Custom String	This method reveals only the first and last letters and adds a custom padding string in the middle. After masking, the string will be in the form: prefix,[padding],suffix	<p>Definition syntax:</p> <pre>LNM varchar(50) MASKED WITH (FUNCTION = 'partial(prefix,[padding],suffix)')</pre> <p>NULL</p> <p>Alter syntax:</p> <pre>ALTER COLUMN [Phone Number] ADD MASKED WITH (FUNCTION = 'partial(1,'XXXXXXXXX',0)')</pre> <p>Additional examples:</p> <pre>ALTER COLUMN [Phone Number] ADD MASKED WITH (FUNCTION = 'partial(5,'XXXXXXXX',0)')</pre> <pre>ALTER COLUMN [UID] ADD MASKED WITH(FUNCTION = 'partial (0,'XXX-XX-',8)')</pre>
Random	This method masks the values of any numeric data type with random values within a particular range.	<p>Definition syntax:</p> <pre>PrimaryAcc_Number bigint MASKED WITH (FUNCTION = 'random([start range],[end range])')</pre> <p>Alter syntax:</p> <pre>ALTER COLUMN [StartMnth] ADD MASKED WITH (FUNCTION = 'random(2, 10)')</pre>

Table 19.1: Types of Masks



Permissions

The standard CREATE TABLE and ALTER permissions on schema are enough to create a table with dynamic data mask. ALTER ANY MASK and ALTER permission at table level are needed to add, replace, or remove the mask of a column. ALTER ANY MASK permission can be granted to a security officer.

Use Cases

Update on a column is possible even with masking enabled on that column. Hence, the users can update the data provided they have write permissions, even when masked data is obtained after querying the masked column. Copying data from masked column using SQL commands SELECT INTO or INSERT INTO will result in masked data in the copied table also.

Querying for Masked Columns

Table-columns, which have masking function applied to them can be queried using the sys.masked_columns view, which in turn is inherited from the sys.columns view.

The sys.masked_columns view returns all the columns in the view sys.columns and the column is_masked. It specifies whether the column is masked. The masking_function column specifies the masking function defined if the column is masked. Code Snippet 2 shows an example for querying on masked columns.

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Code Snippet 2:

```
SELECT m.name, tbl.name AS table_name, m.is_masked, m.masking_function
FROM sys.masked_columns AS m
JOIN sys.tables AS tbl
ON m.[object_id] = tbl.[object_id]
WHERE is_masked = 1;
```

Limitations and Restrictions

Following column types cannot have a masking rule defined on them:

- Encrypted columns
 - FILESTREAM (For storing Microsoft Word documents)
 - COLUMN_SET or a sparse column that is part of a column set (Untyped XML representation that combines all columns of a table into structured output)
 - Computed column
- Note** - The masked data will be returned by the computed column if the computed column is dependent on a masked column.
- FULLTEXT index key cannot be defined for a column with data masking

The real voyage of discovery consists not seeking in new lands, but seeing things with new eyes.

Security Upgrades and Working with JSON

The deprecated READTEXT, UPDATETEXT, and WRITETEXT statements will not properly function on a column with Dynamic Data Mask, for users who do not have UNMASK permission.

Creating a Dynamic Data Mask

Code Snippet 3 shows how to create a dynamic data mask.

Code Snippet 3:

```
CREATE TABLE NewGroup  
    (UID int IDENTITY PRIMARY KEY,  
     FNM varchar(100) MASKEDWITH (FUNCTION= 'partial(1,'XXXXXXXX',0)' )  
     NULL,  
     FatherName varchar(100) NOT NULL,  
     Mobile varchar(12) MASKEDWITH (FUNCTION= 'default()' ) NULL,  
     PersonalEmail varchar(100) MASKEDWITH (FUNCTION= 'email()' ) NULL);  
  
INSERT NewGroup (FNM, FatherName, Mobile, PersonalEmail) VALUES  
    ('Johnson', 'Flanagan', '12345688', 'JohnnsonFlan@yahoo.com'),  
    ('Rossell', 'Geller', '76543218', 'RossGeller@hotmail.com'),  
    ('Brook', 'Darwin', '88956585', 'Brookdarwin@gmail.com');  
  
SELECT * FROM NewGroup;
```

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Code Snippet 4 shows how to create a new user and to grant SELECT permission on the table.

Code Snippet 4:

```
CREATE USER DemoUser WITHOUT LOGIN;
GRANT SELECT ON NewGroup TO DemoUser;
EXECUTE AS USER = 'DemoUser';
SELECT * FROM NewGroup;
REVERT;
The data is changed from:
1 John Flanagan 12345688 Johnson@yahoo.com
```

The data is changed from:

```
1 John Flanagan 12345688 Johnson@yahoo.com
```

To:

```
1 JXXXXXXXXX Flanagan xxxx JXXXX@XXXX.com
```

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Adding or Editing a Mask on an Existing Column

ALTER TABLE command can be used to add a mask to the column already existing in the table or to modify the column mask. A masking function is added to the FatherName column as shown in Code Snippet 5.

Code Snippet 5:

```
ALTER TABLE NewGroup  
ALTER COLUMN FatherName ADD MASKED WITH (FUNCTION = 'partial(2, 'XXX', 0)' );
```

Code Snippet 6 modifies the masking function on column FatherName.

Code Snippet 6:

```
ALTER TABLE NewGroup  
ALTER COLUMN FatherName varchar(100) MASKED WITH (FUNCTION = 'default()' );
```

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Granting Permissions to View Unmasked Data

The user named `DemoUser` can see the unmasked data when `UNMASK` permission is granted. Code Snippet 7 shows how to do that.

Code Snippet 7:

```
GRANT UNMASK TO DemoUser;  
  
EXECUTE AS USER = 'DemoUser';  
  
SELECT * FROM NewGroup;  
  
REVERT;  
  
--REMOVING the UNMASK permission  
  
REVOKE UNMASK TO DemoUser;
```

Dropping a Dynamic Data Mask

The mask on the `FatherName` column created earlier in Code Snippet 7 can be removed as shown in Code Snippet 8.

Code Snippet 8:

```
ALTER TABLE NewGroup  
  
ALTER COLUMN FatherName DROP MASKED;
```

Learn all you can from the mistakes of others, you won't have time to make them all yourself.

19.2.4 Row-Level Security

Stored procedures or table value functions can be simulated to apply security rules on per row basis.

Later, it can be ensured that those rules are not bypassed.

Implementation

A special inline table valued function is used to implement row-level security. Depending on the permission given to the user to access the row, this function returns either a single row with 1 as the value or no results. This can be implemented as demonstrated in Code Snippet 9.

Code Snippet 9:

```
CREATE SCHEMA Security;
GO
CREATE FUNCTION Security.fn_securityinterim(@depmanager AS sysname)
RETURNS TABLE
WITH SCHEMABINDING
AS
RETURN SELECT 1 AS fn_securityinterim_result
WHERE @depmanager = USER_NAME() OR USER_NAME() = 'Supervisor';
```

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Code Snippet 9 implies that the present user must be the department manager or supervisor associated with the record. Even though the function cannot directly access the row, required columns can be passed as parameters. Code Snippet 10 demonstrates this.

Code Snippet 10:

```
CREATE TABLE Departments
(
    depID int,
    DepartmentRep sysname,
    Products varchar(10),
    Qty int
);

CREATE SECURITY POLICY DepartmentFilter
    ADD FILTER PREDICATE
        Security.fn_securityinterim (depmanager) ON
        dbo.Depments
    WITH (STATE = ON)
```



Practical Effects

Row-Level security users will not be able to view the rows for which they do not have permission. This works the same way as the where clause with SQL query and because of this there are certain restrictions. A Full Text Search to the column can leak the data.

To view the statistics on a secured column, the user should belong to one of the following roles:

- Table owner
- Member of sysadmin fixed server role
- db_ddladmin fixed database role
- db_owner fixed database role

This is done to reduce the risk of information leakage.

Middle Tier Applications

When one database account is shared across many users in a middle tier application, further steps are needed. Whenever a middle tier application opens a connection to the database, the recommended configuration is to set the CONTEXT_INFO value to application specific user id. The security function can then reference the value of CONTEXT_INFO.

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An example is shown in Code Snippet 11. An assumption is made in this approach that the user cannot change their CONTEXT_INFO as per their wish.

Code Snippet 11:

```
CREATE SCHEMA Security;
GO
CREATE FUNCTION Security.fn_securityinterim(@UserId int)
RETURNS TABLE
WITH SCHEMABINDING
AS
RETURN SELECT 1 AS fn_securityinterim_result
WHERE
DATABASE_PRINCIPAL_ID() = DATABASE_PRINCIPAL_ID('AppUser')
AND CAST(SESSION_CONTEXT(N'UserId') AS int) = @UserId;
GO
CREATE SECURITY POLICY Security.DepartmentsFilter
ADD FILTER PREDICATE Security.fn_securityinterim (depId)
ON dbo.Departments1
WITH (STATE = ON);
```

To avoid criticism, do nothing, say nothing, be nothing.

19.2.5 Opening JSON with OPENJSON ()

JSON is an open standard that is used to send out data between Web application and a server. This format uses text to transmit data objects in the form of attribute-value pairs. JSON is used as a substitute to XML.

A built-in Table-valued Function (TVF) named OPENJSON does the following:

- Locate an array of JSON objects
- Seeks into some JSON text
- Iterate through array elements
- Outputs one row for each array element

OPENJSON will transform the JSON text generated with `FOR JSON` clause back to relational form. Following are the types of OPENJSON TVF:

- **OPENJSON with predefined result:** The user can define schema for the table to be returned and the mapping rules specifying the properties to be mapped to the returned columns.
- **OPENJSON without return schema:** Here the output will be as key-value pairs.

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OPENJSON enables returning properties as relational table and parsing JSON text. If the schema of results is not defined then the default schema will be used. OPENJSON provides a rowset on JSON document. Hence, Transact-SQL statements can use OPENJSON to provide rowsets, such as view, table, or the function OPENROWSET itself.

The usage of OPENJSON is shown in Code Snippet 12.

Code Snippet 12:

```
SELECT * FROM OPENJSON('['Antwerp', 'Bristol',
'LongIsland','NewMexico','Laos'])'
GO
```

JSON text will be parsed by OPENJSON, and one row with an index and a corresponding value will be produced for each array element. Whenever there is an object in JSON expression, the first level properties in the form of (key, value) pair will be returned. A complex JSON text is shown in Code Snippet 13.

Code Snippet 13:

```
DECLARE @JSON NVARCHAR (4000)
SET @JSON = N'
{
  "uid": 1,
  "cost": 50,
  "color": "Grey",
  "character": "school",
  "tags": ["magic", "primary"]
}
SELECT * FROM OPENJSON (@JSON) AS MyJSON;
SELECT * FROM OPENJSON (@JSON, N' $ .tags')
```



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OPENXML is used as the framework for OPENJSON too Even though the usage looks identical, there are elemental differences as shown in table 19.2.

OPENJSON	OPENXML
Accepts text input Drawback: When two identical JSON text are passed to different OPENJSON calls, they will be parsed each time.	Accepts handle
Return row with (key, value) schema	Parses entire XML tree without distinct schema. Returns a flat table with all nodes.

Table 19.2: Difference Between OPENJSON and OPENXML

19.2.6 Converting JSON to Rowset Data Using the OPENJSON Function

The OPENJSON rowset function is used to convert the data to relational format. This function returns following three values:

- **Key:** Key is either the index of an array element or property name within the object.
- **Value:** Value specifies the array element value or the value of the property within the object.

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Security Upgrades and Working with JSON

- **Type:** It refers to the data type of the value. This is depicted numerically, as described in table 19.3.

Numeric Value	Data Type
0	null
1	string
2	int
3	True or false
4	array
5	object

Table 19.3: Numerical Depiction of Data Type

Learning is not compulsory, but neither is survival.

Security Upgrades and Working with JSON

The user can allocate JSON snippet to a variable and then, use OPENJSON function to call the variable as shown in Code Snippet 14.

Code Snippet 14:

```
DECLARE @JSON NVARCHAR (MAX) = N'  
{  
    'InitialName': null,  
    'MaidenName': 'Dawson ',  
    'UID': 9988776655,  
    'Current': false,  
    'Skills': ['DevOps', 'Python', 'Perl'],  
    'Region': { 'Country': 'USA', 'Territory': 'North America' }  
};  
  
SELECT * FROM OPENJSON (@json);
```

The JSON snippet consists of a single object with a property for each data type. The SELECT statement utilizes OPENJSON function with the FROM clause to fetch JSON data as rowset.

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This is shown in table 19.4.

Key	Value	Type
InitialName	null	0
MaidenName	Dawson	1
UID	9988776655	2
Current	False	3
Skills	['DevOps','Python','Perl']	4
Location	{'Country':'USA','Territory':'North America'}	5

Table 19.4: Value and Type

In table 19.4, 'type' column signifies the data type for each value. The 'key' skills is an array that consists of all array elements in the result set. The 'key' location is an object that consists of all the object properties.

Whenever only the 'key' and 'value' columns are to be returned, only those columns should be specified in the SELECT list as shown in Code Snippet 15.

Code Snippet 15:

```
SELECT [key], value FROM OPENJSON (@json)
```



Security Upgrades and Working with JSON

It is important to delimit the 'key' column since this is also a Transact SQL reserved keyword. The result of Code Snippet 15 includes only two columns as shown in table 19.5.

Key	Value
InitialName	NULL
MaidenName	Dawson
UID	9988776655
Current	False
Skills	['Dev','QA','PM']
Location	{'Country':'Canada','Territory':'North America'}

Table 19.5: Keys and Values Columns

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Code Snippet 16 shows a more complex JSON snippet.

Code Snippet 16:

```
{  
  'Programmers': [  
    {  
      'Name': {  
        'Initial': 'Tyson',  
        'Middle': 'Leking',  
        'Maiden': 'Dawson'  
      },  
      'PII': {  
        'DOB': '1981-03-11',  
        'UID': '245797968'  
      },  
      'LoginID': 'adventure-works\\Tyson0'  
    },  
    {  
      'Name': {  
        'Initial': 'Robert',  
        'Middle': null,  
        'Maiden': 'Tyrell'  
      },  
      'PII': {  
        'DOB': '1984-11-02',  
        'UID': '509647176'  
      },  
      'LoginID': 'adventure-works\\robert0'  
    }  
  ]  
}
```

A wise man learns from the mistakes of others, a fool by his own.

Security Upgrades and Working with JSON

The JSON output format rendered by the database engine will be in a much less readable form than shown in Code Snippet 16. The JSON can be assigned to a variable so that it can be much simpler to work with. Code Snippet 17 shows one such example.

Code Snippet 17:

```
DECLARE @json NVARCHAR (MAX) =
N' { 'Programmers': [ { 'Name': { 'Initial': 'Tyson', 'Middle': 'Leking', 'M
'Maiden': 'Dawson' }, 'PII': { 'DOB': '1981-03-1 1', 'UID': '245797968' }, 'LoginID':
'adventure-works\\tyson0' }, { 'Name': { 'Initial': 'Robert', 'Middle': null,
'Maiden': 'Tyrell' }, 'PII': { 'DOB': '1984-11-02', 'UID': '509647176' }
,'LoginID': 'adventure-works\\robert0' } ] }';
```

This variable definition can be used for other example code snippets. This definition also avoids all the white spaces obtained when results are run through a parser.

Code snippet 18 shows usage of OPENJSON function to convert the JSON in the variable.

Code Snippet 18:

```
SELECT [key], value
FROM OPENJSON (@json);
```

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Code Snippet 18 uses the most basic OPENJSON without any defined parameters. Hence, the SELECT statement returns a single row for Programmers array as shown in table 19.6.

Key	Value
programmers	[{ 'Name': { 'Initial': 'Tyson', 'Middle': 'Leking', 'Maiden': 'Dawson' }, 'PII': { 'DOB': '1981-03-11', 'UID': '245797968' }, 'LoginID': 'adventure-works\\tyson0' }, { 'Name': { 'Initial': 'Robert', 'Middle': null, 'Maiden': 'Tyrell' }, 'PII': { 'DOB': '1984-11-02', 'UID': '509647176' }, 'LoginID': 'adventure-works\\robert0' }]

Table 19.6: Content of Programmers Array in JSON Format

Passing a second parameter to the OPENJSON function will provide better control on the result. That parameter is a JSON path instructing database engine on parsing the data as shown in Code Snippet 19.

Code Snippet 19:

```
SELECT [key], value
FROM OPENJSON (@json, '$.Programmers');
```

A JSON path starts dollar sign (\$) to represent the item as is in the current context. Later specify one or more period separated elements, as they appear hierarchically in JSON snippet. The path signifies only the root element that is `Programmers`, in this example.

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The result is shown in table 19.7.

Key	Value
0	[{"Name": {"Initial": "Tyson", "Middle": "Leking", "Maiden": "Lawson"}, "PII": {"DOB": "1981-03-11", "UID": "245797968"}, "LoginID": "adventure-works\\tyson0"}, {"Name": {"Initial": "Robert", "Middle": null, "Maiden": "Tyrell"}, "PII": {"DOB": "1984-11-02", "UID": "509647176"}, "LoginID": "adventure-works\\robert0"}]
1	{"Name": {"Initial": "Robert", "Middle": null, "Maiden": "Tyrell"}, "PII": {"DOB": "1984-11-02", "UID": "509647176"}, "LoginID": "adventure-works\\robert0"}

Table 19.7: Resulting Values for Specified Keys

A row is obtained for each element in the `Programmers` array. The hierarchy has to be spilt first to break down the results even further. An array element can be referenced with the index of the element and the index count of the array element starts with 0. Code Snippet 20 shows how to retrieve the first element of `Programmers` array.

Code Snippet 20:

```
SELECT [key], value
FROM OPENJSON (@json, '$.Programmers[0]');
```

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The result returned by `SELECT` statement in Code Snippet 20 is shown in table 19.8. The first element is a JSON object with three properties.

Key	Value
Name	{ 'InitialName': 'Tyson', 'Middle': 'Leking', 'Maiden': 'Dawson' }
PII	{ 'DOB': '1981-03-11', 'UID': '245797968' }
LoginID	adventure-works\tyson0

Table 19.8: Result of `SELECT` Statement

The entire content of the first two objects are returned. By specifying the object name in the `SELECT` query, only one among those objects can be returned as shown in Code Snippet 21.

Code Snippet 21:

```
SELECT [key], value
FROM OPENJSON (@json, '$.Programmers[0].Name');
```

This `SELECT` statement returns only three properties in the object Name as shown in table 19.9.

Key	Value
InitialName	Tyson
Middle	Leking
Maiden	Dawson

Table 19.9: Three Properties in Object Name

You must do the things you think you cannot do.

Security Upgrades and Working with JSON

All the OPENJSON examples discussed so far have used the already existing default schema for returning data as rowset. However, with this approach, there are a few limitations, as to how ably the results or JSON output can be handled. Hence, OPENJSON also enables the user to use the WITH clause to SELECT statement to specify an explicit schema. In Code Snippet 22, the schema flattens our data, so that each programmer detail can be seen.

Create column definitions that have new name, data type, and a path reference for more readable column names as shown in Code Snippet 22.

Code Snippet 22:

```
SELECT *
FROM OPENJSON (@json, '$.Programmers')
WITH (InitialName NVARCHAR (25) '$.Name.Frst',
      MiddleName NVARCHAR (25) '$.Name.Middle',
      MaidenName NVARCHAR (25) '$.Name.Maiden',
      UID INT '$.PII.UID');
```

The Programmers array need not be referenced for the path as it is taken care of by OPENJSON function itself. However, the dollar sign should be specified to show the current context. This is followed by Name or PII object name and then, property name. The result returned by the SELECT statement is shown in table 19.10.

First Name	Middle Name	Maiden Name	UID
Tyson	Leking	Dawson	245797968
Robert	NULL	Tyrell	509647176

Table 19.10: Result of Use of Array

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19.3 Check Your Progress

1. Sensitive data such as credit card number can be protected with the feature _____.

(A)	Always Encrypted	(C)	TDE
(B)	JSON	(D)	Row-Level security

2. Data at Rest refers to _____.

(A)	Inactive data stored in any digital form	(C)	Data that is taking rest
(B)	Active data	(D)	Data being processed by a computer

3. Security features in SQL Server 2016 is implemented through _____.

(A)	Always Encrypted	(C)	Dynamic data masking
(B)	TDE	(D)	Always Encrypted, TDE, and Dynamic data masking

4. In middle tier applications, one database account is _____.

(A)	Shared by many users	(C)	Accessed by two users
(B)	Accessed by single user	(D)	Shared by many users and accessed by single user

5. The Row-Level security feature behaves in a similar manner as _____.

(A)	WHERE clause is used in a SELECT statement	(C)	INSERT statement
(B)	Plain SELECT statement	(D)	SELECT INTO statement

6. The OPENJSON converts data to _____.

(A)	Relational format	(C)	Plain text
(B)	Non-relational format	(D)	Binary format

19.3.1 Answers

1.	a
2.	a
3.	d
4.	a
5.	a
6.	a



- Security features are implemented in SQL Server 2016 with Always Encrypted, Dynamic Data Mask, Transparent Data Encryption, and Row-Level security.
- Always Encrypted feature protects sensitive data by encrypting the same inside the client applications. The encrypted keys are hidden from SQL database.
- Randomized encryption and deterministic encryption are the two types of encryption supported by Always Encrypted.
- The TDE technology encrypts database files, providing file level encryption. The security issue raised by data at rest is solved with TDE. It encrypts databases on backup media and hard drive.
- Dynamic data masking masks the data thus, preventing it from unauthorized access.
- Row-Level security ensures that the stored procedures or table value functions can be simulated to apply security rules on per row basis.
- JSON is an open standard that is used to exchange data between Web application and a server.
- The built-in OPENJSON rowset function converts the data to relational format.

Session - 20

PolyBase, Query Store, and Stretch Database

Welcome to the Session, **PolyBase, Query Store, and Stretch Database.**

This session introduces some new additions of SQL Server 2016 such as PolyBase, Stretch Database, and Query Store features.

In this Session, you will learn to:

- Describe PolyBase
- Explain features and advantages of PolyBase
- Define and describe Query Store
- Explain how to dynamically stretch warm and cold transactional data from SQL Server to Azure
- Describe how to tune workload performance with Query Store

20.1 Understanding PolyBase

As data is increasingly being stored in cost-effective, distributed databases such as Hadoop, the need to access this data and work with it is vital. Consequently, there is a requirement for applications that are built to work over such systems, as well as for skills to connect and work with this data.

PolyBase feature in SQL Server helps to connect to big data stored in Hadoop or Azure Blob Storage. It acts as a connector from SQL Server to Hadoop or Azure Blob Storage. SQL Server contains relational data and Hadoop or any external data sources contain non-relational data. Analysis of both types of data is ideally required for business decisions. PolyBase enables relational data in SQL Server and non-relational data in Hadoop to be combined. It also allows queries to be run on the Hadoop data by using simple Transact-SQL commands. Although, previously the PolyBase feature existed as part of Microsoft Analytics platform in SQL Server Parallel Data Warehouse, it is now a built-in feature with SQL Server 2016. This enhancement eliminates the need for any data importing tools and also for a working knowledge of Java, MapReduce, Hive, and other such concepts required to work with data on Hadoop.

PolyBase enables the following:

- Easy access to big data on Hadoop and Azure Blob Storage
- Easy querying of data on Hadoop and Azure Blob Storage, similar to handling traditional database tables by usage of simple Transact-SQL



- Easy import and export of data between SQL Server and Hadoop or Azure Blob Storage
- Use of SQL Server features, such as column store and Business Intelligence tools on the data for generating reports
- Processing of data on Hadoop or where the data resides, thereby, eliminating the need to import the data to SQL Server
- Integration of data from different systems, thereby, eliminating the need to customize any existing applications
- Incorporation of the external data into the database schema, thereby, keeping operations transparent to end users and querying applications

20.1.1 PolyBase Architecture

The architecture of PolyBase has some similarities to the Hadoop architecture. This is because the purpose of PolyBase is interaction with Hadoop data.

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Following are two main components of the PolyBase architecture:

- **Control Node:** Hadoop has a Name Node or job tracker. Similarly, PolyBase has one Control Node. This is nothing but the SQL Server instance. This is configured to run the **PolyBase Engine Service**. Client applications across the cluster contact the Control Node, which performs the tasks of parsing Transact-SQL queries, building query plans and running them optimally, managing parallel queries, and passing the results back to the applications.
- **Compute Node:** Just as Hadoop has the Data Node or task tracker, PolyBase has the Compute Nodes. There can be one or many Compute Nodes and these serve to bring the data temporarily to the SQL Server and handle the queries. Thus, it runs the PolyBase Data Movement Service. In case of parallel execution, the load is shared by Compute Nodes and is controlled by the Control Node.

When PolyBase is deployed in single-server architecture, Control Node also functions as Compute Node. In a multi-cluster deployment, because of the large resource requirements for computation and storage, it is possible to have PolyBase run by only one SQL Server instance per machine.

*Woe to him who teaches men faster
than they can learn.*

Figure 20.1 illustrates the PolyBase architecture.

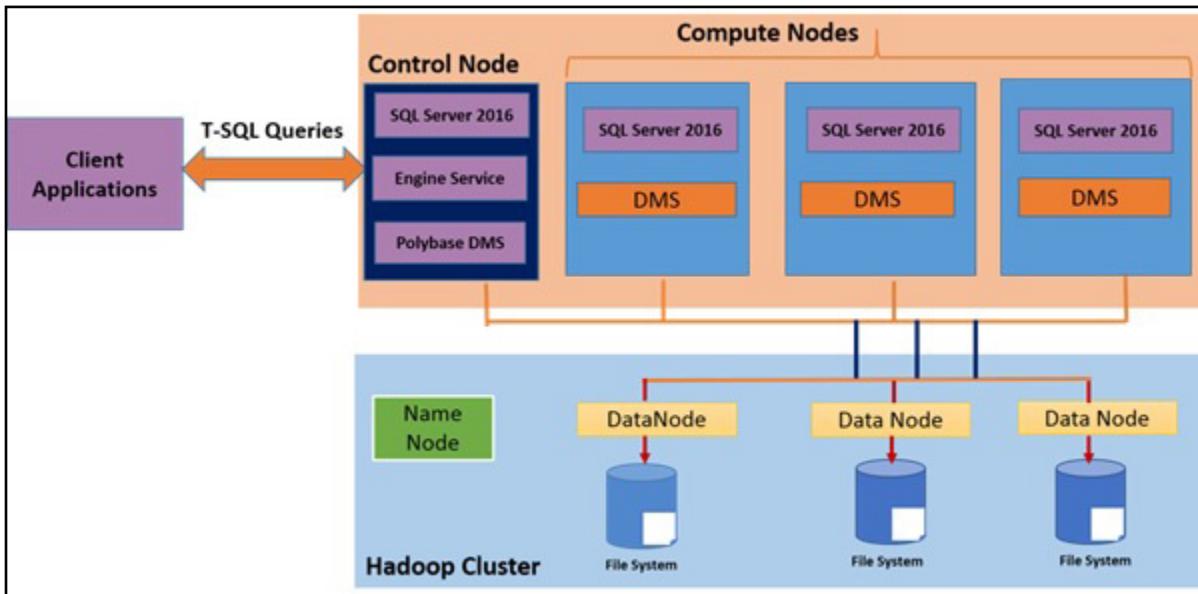


Figure 20.1: PolyBase Architecture

20.1.2 Installing and Setting up PolyBase Through SQL Server 2016

Following are the steps to install and set up PolyBase:

1. During SQL Server set up process, on **Feature Selection** screen, select **PolyBase Query Service for External Data**. Figure 20.2 shows the prerequisites listed on the screen.

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PolyBase, Query Store, and Stretch Database

Note that Oracle Java SE Runtime Environment (JRE) 7.51 (x64) or higher is a requirement for PolyBase installation. Therefore, before starting the SQL Server 2016 installation, be sure to install JRE. This is required because PolyBase needs to interact with Hadoop or any other external data source. PolyBase installation will fail if JRE is not previously installed. JRE can be downloaded from Oracle Website.

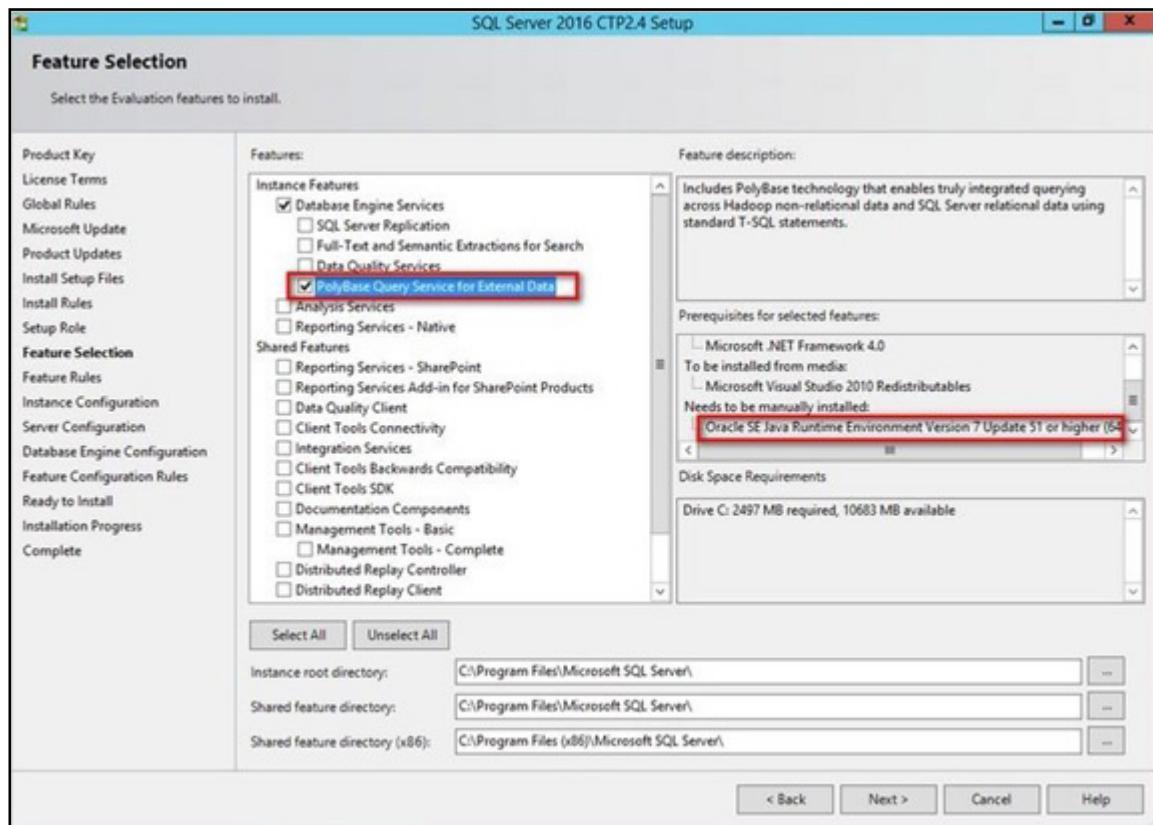


Figure 20.2: Prerequisites to PolyBase Feature



Figure 20.3 screen displays the message stating that JRE is not installed.

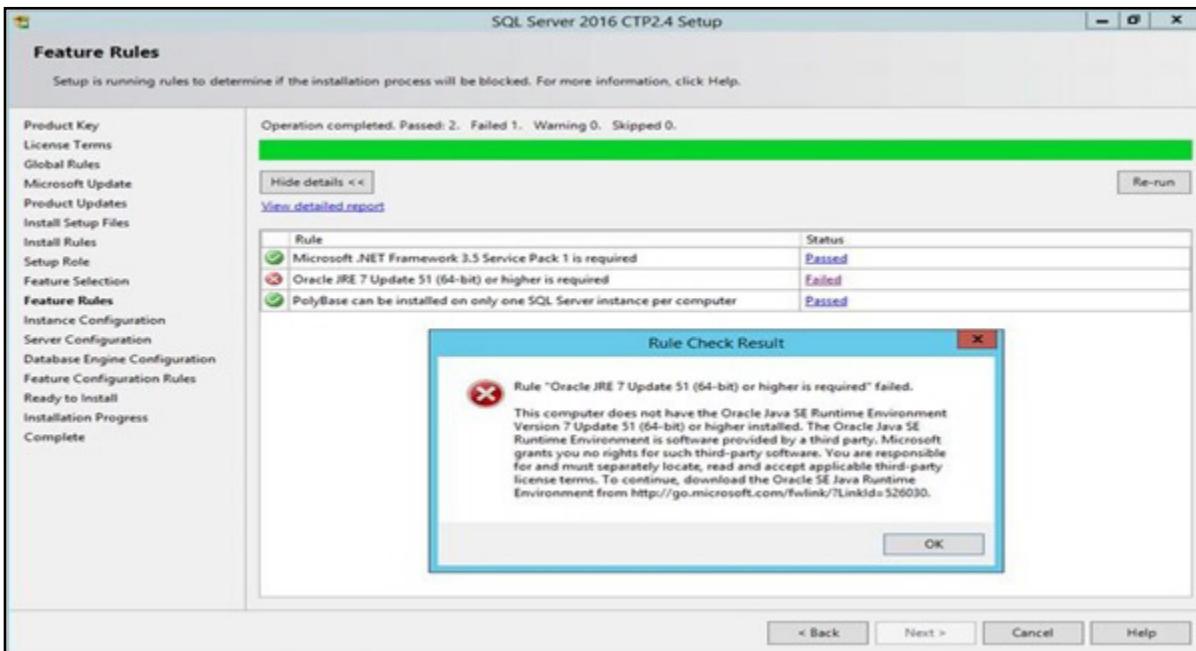
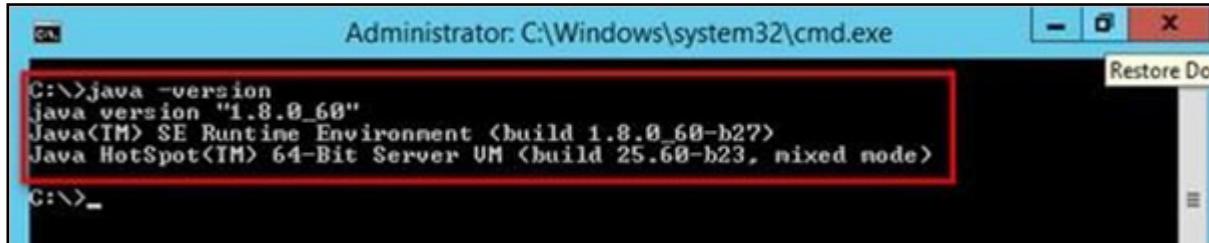


Figure 20.3: JRE Requirement Check

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Once the JRE installation is complete, check that it is working properly by typing the command **C:\>java -version**. This displays version of JRE installed as shown in figure 20.4.



The screenshot shows a Windows Command Prompt window titled "Administrator: C:\Windows\system32\cmd.exe". The window contains the following text:
C:\>java -version
java version "1.8.0_60"
Java(TM) SE Runtime Environment (build 1.8.0_60-b27)
Java HotSpot(TM) 64-Bit Server VM (build 25.60-b23, mixed mode)

Figure 20.4: JRE Version

If JRE is installed properly, a confirmation is displayed on **Feature Rules** screen and installation can be continued.

*Real generosity towards the future lies
in giving all to the present.*

Figure 20.5 shows how setup checks and confirms that the JRE requirement is satisfied.

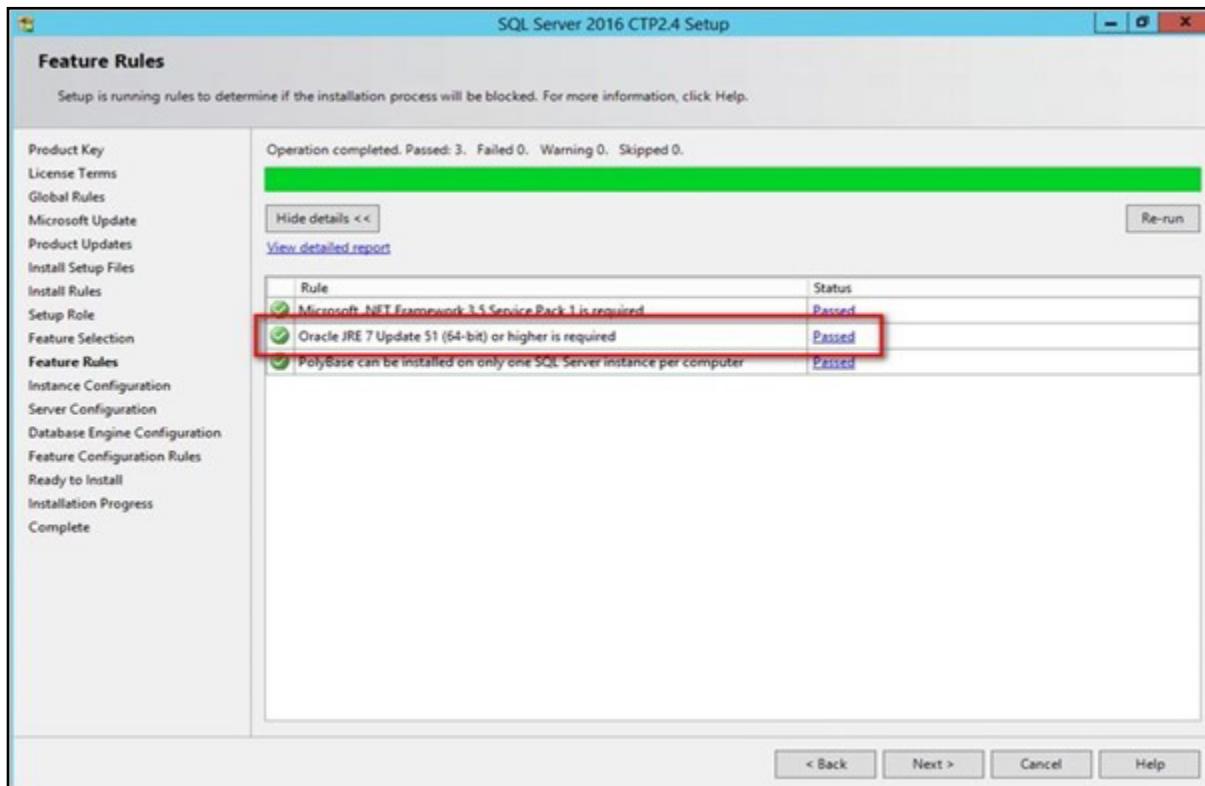


Figure 20.5: Verification of JRE Installation

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Note that for each machine, only one SQL Server instance can be installed. During the installation process, following are added:

- **Databases:** DWDiagnostics, DWConfiguration, and DWQueue
- **Services:** SQL Server PolyBase Engine Service and SQL Server PolyBase Data Movement Service

On the **Server Configuration** dialog box, under the **Service Accounts** tab, the PolyBase Engine Service and the PolyBase Data Movement Service are listed. Figure 20.6 shows the list of services. Service accounts for both must be provided.



Note that in both single-server and multi-cluster deployment, Control Node also acts as Compute Node.

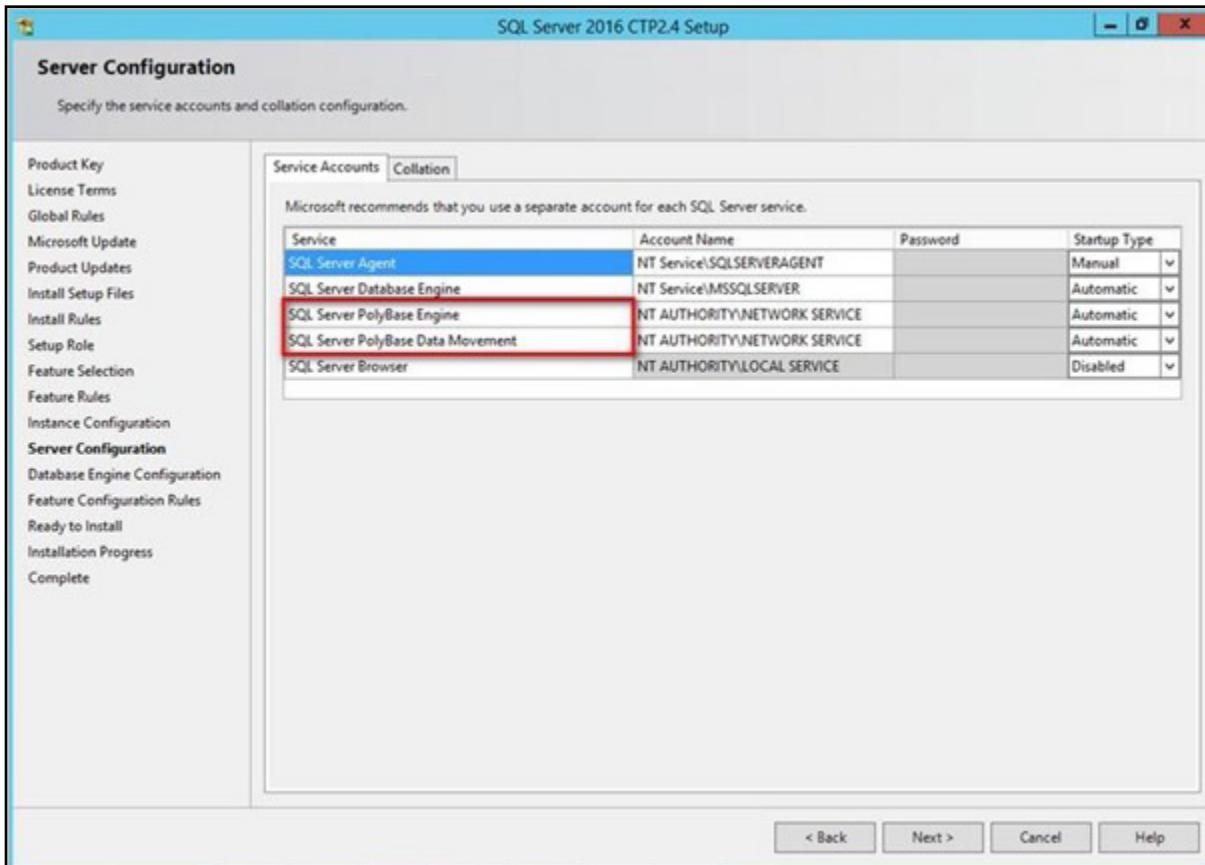


Figure 20.6: PolyBase Engine and Data Movement Service

Once SQL Server installation is complete with the PolyBase feature, PolyBase must be configured to interact with external data sources. Note that in SQL Server 2016, PolyBase can interact with the Cloudera and Hortonworks versions of Hadoop and also with Azure Blob Storage.

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2. To set up PolyBase interaction with any of the supported external data sources, the system procedure `sp_configure` must be run. Code Snippet 1 is an example of executing `sp_configure` procedure, where PolyBase is configured to interact with Hadoop. The value '5' is Hadoop connectivity parameter.

Code Snippet 1:

```
EXEC sp_configure , hadoop connectivity, 5;
GO
RECONFIGURE;
GO
```

The Hadoop connectivity parameter specifies the type of Hadoop data source for all connections from PolyBase to Hadoop clusters or Windows Azure Storage Blob (WASB). This setting creates an external data source for an external table.

Following is a list of Hadoop connectivity parameters that can be specified and what each parameter stands for:

- **Option 0:** Disable Hadoop connectivity
- **Option 1:** Hortonworks HDP 1.3 on Windows Server
- **Option 1:** Azure blob storage (WASB[S])
- **Option 2:** Hortonworks HDP 1.3 on Linux
- **Option 3:** Cloudera CDH 4.3 on Linux
- **Option 4:** Hortonworks HDP 2.0 on Windows Server
- **Option 4:** Azure blob storage (WASB[S])

Knowledge is not enough; we must apply. Willing is not enough; we must do.

- **Option 5:** Hortonworks HDP 2.0 on Linux
- **Option 6:** Cloudera 5.1, 5.2, 5.3, 5.4, and 5.5 on Linux
- **Option 7:** Hortonworks 2.1, 2.2, and 2.3 on Linux
- **Option 7:** Hortonworks 2.1, 2.2, and 2.3 on Windows Server
- **Option 7:** Azure blob storage (WASB[S])

One setting can be in effect at a time. Options 1, 4, and 7 allow multiple types of external data sources to be created and can be used across all sessions on the server.

The user accessing Hadoop must be added to the PolyBase configuration file. To access this file, navigate to the instance:

C:\Program Files\Microsoft SQL

Server\MSSQL13.MSSQLSERVER\MSSQL\Binn\Polybase\Settings\

Hadoop.config

Then access the sub-directory Binn\Polybase\Settings.

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3. Create a data source object that defines the connection to the external data source by using the statement: **CREATE EXTERNAL DATA SOURCE** as shown in Code Snippet 2.

Code Snippet 2:

```
CREATE EXTERNAL DATA SOURCE HDP
WITH
(
  TYPE='HADOOP'
  LOCATION='hdfs://sandbox.hortonworks.com:8020';
)
```

4. Define a file format object to specify the format of external data by using the statement: **CREATE EXTERNAL FILE FORMAT**. PolyBase supports the delimited text, Hive RCFile, and Hive ORC formats. Code Snippet 3 shows how the external file format is specified.

Code Snippet 3:

```
CREATE EXTERNAL FILE FORMAT TSV
WITH
(
  FORMAT_TYPE = DELIMITEDTEXT,
  FORMAT_OPTIONS (
    FIELD_TERMINATOR = , \t ,
    DATE_FORMAT = , MM/dd/yyyy'
  )
)
```



5. Create external tables using the **CREATE EXTERNAL TABLE** statement to facilitate a schema-based structure that makes referencing the external data as easy as referencing relational tables as shown in Code Snippet 4.

Code Snippet 4:

```
CREATE EXTERNAL TABLE sample_07
(
    code nvarchar(255),
    description nvarchar(255),
    total_emp int,
    salary nvarchar(255)
)
WITH
(
    LOCATION = '/apps/hive/warehouse/sample_07',
    DATA_SOURCE = HDP2,
    FILE_FORMAT = TSV,
    REJECT_TYPE = value,
    REJECT_VALUE = 0
)
```

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6. View the database in the SQL Server Management Studio (SSMS). A new folder **External Resources** is created under the databases folder. The data sources and file formats are listed under this folder. Another new folder **External Tables**, containing the defined external tables, is created under the **Tables** folder. Figure 20.7 shows the **External Tables** folder.

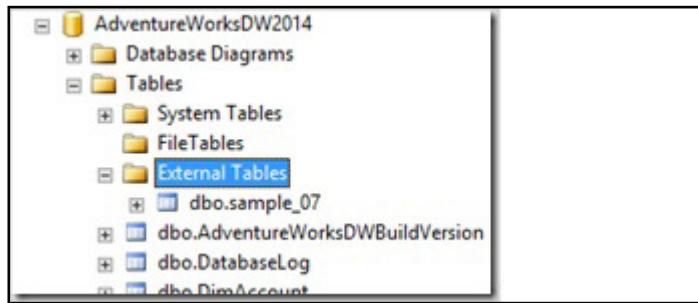


Figure 20.7: New Folders - External Tables Folder

Now, the external table can easily be queried just like any other table using standard query statements. For example, `SELECT * from SAMPLE_07` selects the records from the external table `Sample_07`.

*Don't just learn the tricks of the trade,
learn the trade.*

Figure 20.8 shows the retrieved records.

	code	description	total_emp	salary
1	00-0000	All Occupations	134354250	40690
2	11-0000	Management occupations	6003930	96150
3	11-1011	Chief executives	299160	151370
4	11-1021	General and operations managers	1655410	103780
5	11-1031	Legislators	61110	33880
6	11-2011	Advertising and promotions managers	36300	91100
7	11-2021	Marketing managers	165240	113400
8	11-2022	Sales managers	322170	106790
9	11-2021	Public-relations managers	47210	97170

Figure 20.8: Querying External Tables

Once tables are created, one can perform the following operations with PolyBase:

- Define query optimization with the CREATE STATISTICS statement
- Use Dynamic Management Views (DMVs) provided to troubleshoot any PolyBase queries
- Retrieve information about the external data sources using catalog views
- Conduct analytics and generate reports by providing the data to Microsoft BI tools, (Power Pivot and Power Query) or third-party BI tools (Tableau and Cognos)

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20.2 Query Store

The Query Store feature in SQL Server 2016 Database Engine is a built-in tool for better performance tuning. This feature helps in performance tuning by doing the following:

- Maintaining a complete history of execution plans of all queries including all the changes to the plans
- Monitoring and storing the performance information of each execution plan over a period
- Analyzing the information regarding query execution times, memory consumption, and so on
- Enabling information retrieval even after server-restarts by storing it on disk rather than in cache
- Providing access to the information through DMVs, thus enabling generation of custom reports and triggering of alerts
- Identifying and alerting about the plans causing performance issues
- Facilitating a quick 'roll-back' to any old plan, if required, to solve performance issues



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20.2.1 Query Store Architecture

Each query compilation or execution by SQL Server sends a message to the Query store. Figure 20.9 illustrates the connection to the Query Store.

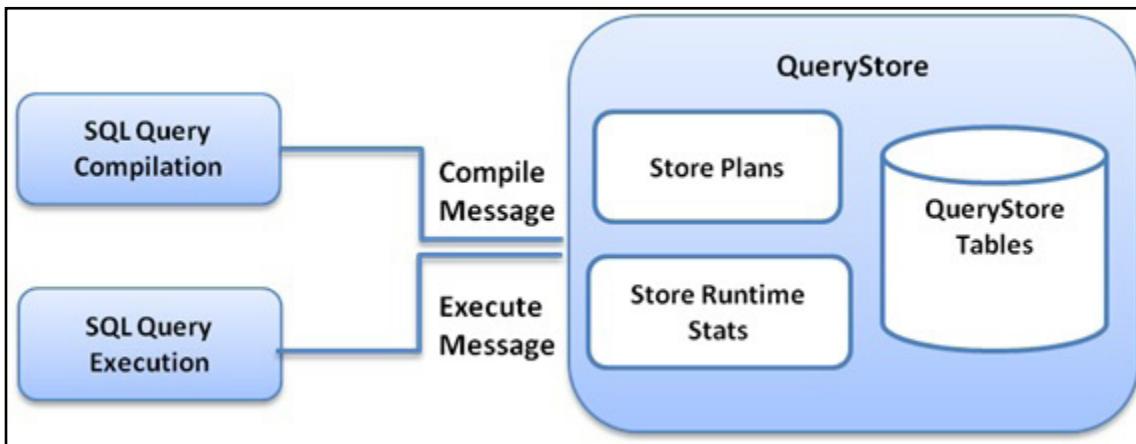


Figure 20.9: SQL Server Messages to Query Store

The information about the compilation and execution is first stored in cache and then stored to the disk. The duration of keeping the information in the cache and the time when it is stored on the disk is determined by the INTERVAL_LENGTH_MINUTES parameter and the DATA_FLUSH_INTERVAL_SECONDS parameter, respectively. These parameters should be specified when Query Store is enabled and configured. Sometimes, if there is an overload in the cache, the information is written to the disk and then the cache is cleared.

Note that information on both the cache and the disk can be accessed by running the `sys.query_store_runtime_stats` catalog.

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20.2.2 Enabling Query Store

The Query Store feature needs to be enabled for new databases. To do this, right-click the database on the **Object Explorer** and on the **Database Properties** dialog box, select the **Query Store** page and then in the **Enable** box, select **True**. Figure 20.10 shows the **Query Store** page in the **Database Properties** dialog box.

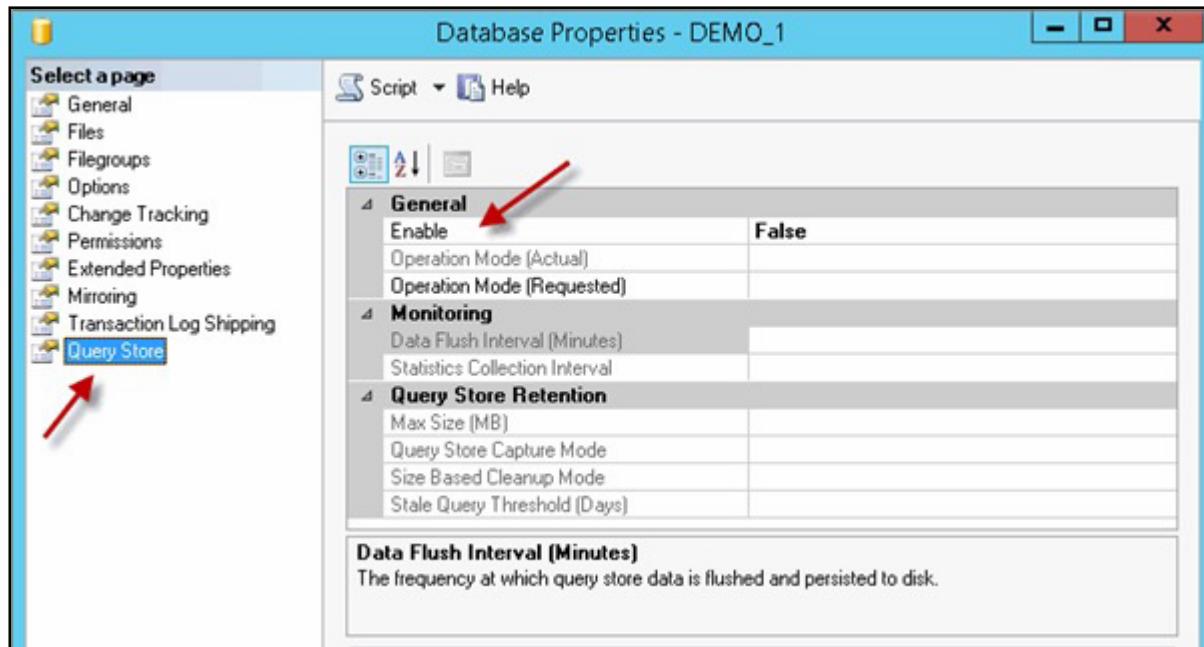


Figure 20.10: Enable Query Store

Alternatively, the feature can be enabled using a Transact-SQL statement as shown in Code Snippet 5.

Code Snippet 5:

```
ALTER DATABASE [DEMO] SET QUERY_STORE = ON
GO
```

Practice is the best of all instructors.

When Query Store is enabled, the SSMS displays the Query Store container for the database. Information about the queries and execution plans can be viewed either by right-clicking the Query Store container or expanding the Query Store container and then selecting from the listed options.

Figure 20.11 shows the Query Store container for the database. Figure 20.12 shows options displayed after right-clicking the Query Store container and figure 20.13 shows the options on expanding the Query Store container. The options provide information about the queries and execution plans to help with performance tuning.

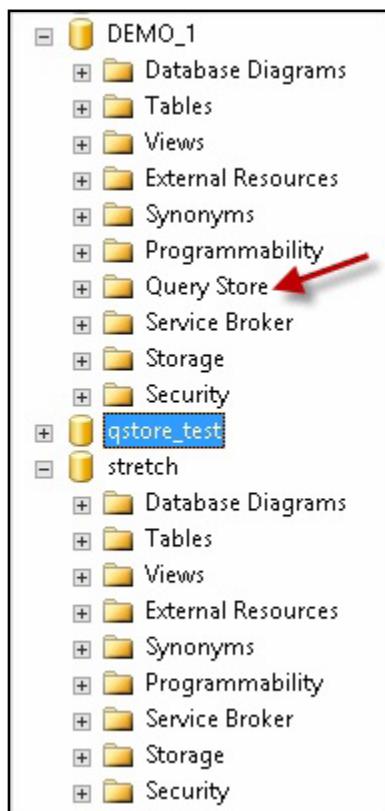


Figure 20.11: Query Store Container

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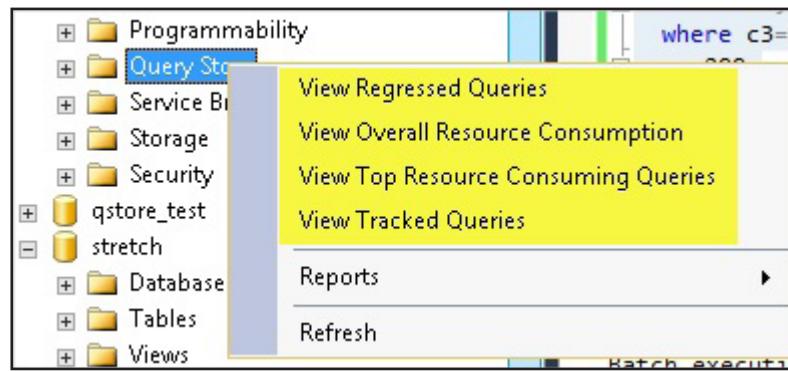


Figure 20.12: Query Store Options on Right-Click

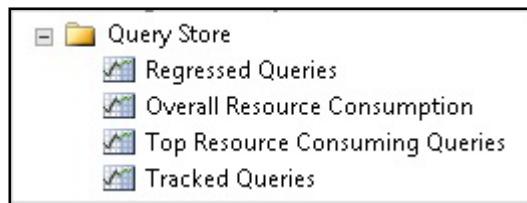


Figure 20.13: Query Store Options on SSMS Pane

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20.2.3 Configuring Query Store

Once the Query Store feature is enabled, other parameters for **Monitoring** and **Query Store Retention** can be configured. Figure 20.14 shows the parameters that can be configured.

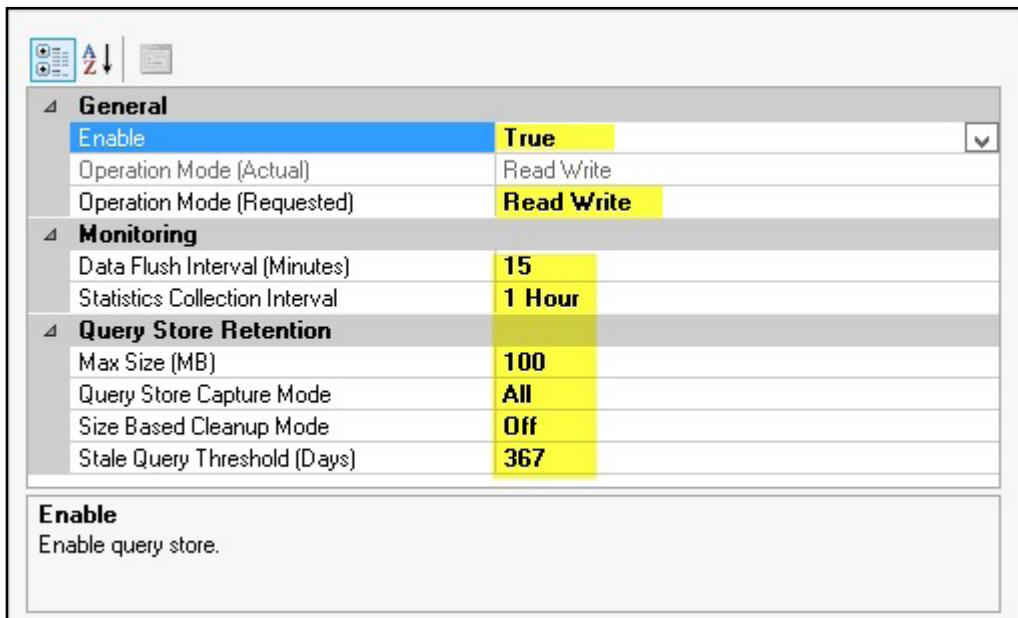
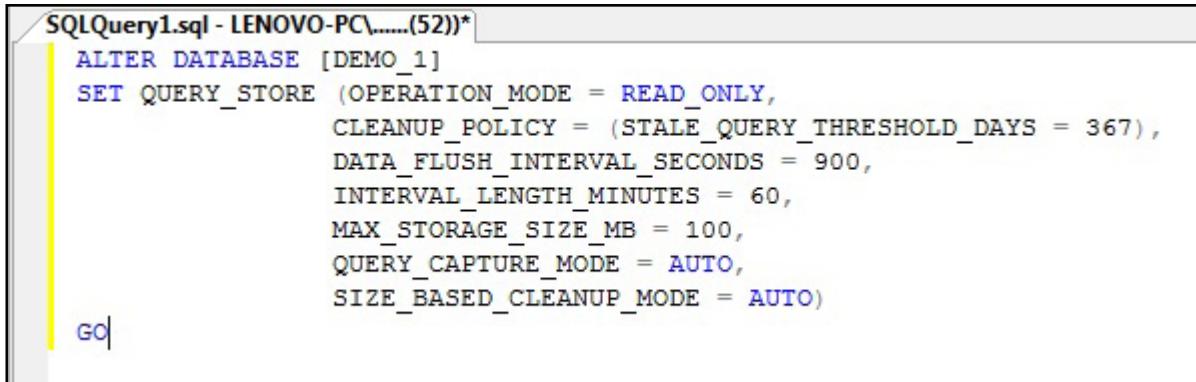


Figure 20.14: Configure Query Store Using SSMS

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Alternatively, Transact-SQL statements can be used. Figure 20.15 shows the Transact-SQL statements to configure the Query Store parameters.



```
SQLQuery1.sql - LENOVO-PC\.....(52)*
ALTER DATABASE [DEMO_1]
SET QUERY_STORE (OPERATION_MODE = READ_ONLY,
CLEANUP_POLICY = (STALE_QUERY_THRESHOLD_DAYS = 367),
DATA_FLUSH_INTERVAL_SECONDS = 900,
INTERVAL_LENGTH_MINUTES = 60,
MAX_STORAGE_SIZE_MB = 100,
QUERY_CAPTURE_MODE = AUTO,
SIZE_BASED_CLEANUP_MODE = AUTO)
GO
```

Figure 20.15: Configure Query Store Using Transact-SQL

In the code shown in figure 20.15,

- CLEANUP_POLICY = STALE_QUERY_THRESHOLD_DAYS = 367 specifies that the number of days to retain data in the query store is 367.
- DATA_FLUSH_INTERVAL_SECONDS specifies that data in the query store is flushed to disk at an interval of 900 seconds.
- MAX_STORAGE_SIZE_MB specifies that the maximum size of the query store is 100 MB. Once this size is reached, the query store stops collecting new data and the state changes from read-write to read-only.

It is hard to fail, but it is worse never to have tried to succeed.

- INTERVAL_LENGTH_MINUTES specifies the time interval at which the execution statistics data is saved to the query store.
- SIZE_BASED_CLEANUP_MODE specifies whether the cleanup process is automatically activated when total amount of data is almost reaching the maximum size.
- QUERY_CAPTURE_MODE specifies whether all queries are captured automatically or only some queries are captured based on execution count and resource consumption, or if only current queries are captured.
- Additionally, MAX_PLANS_PER_QUERY can also be given in a query. It specifies the maximum number of plans maintained for each query.

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20.2.4 Query Store System Objects

New system procedures and catalog views related to Query Store can be found in SQL Server 2016. Code Snippet 6 is used to retrieve these procedures and views.

Code Snippet 6:

```
SELECT name, type_desc FROM sys.all_objects
WHERE name LIKE '%query_Store%' or name='query_context_settings'
```

Figure 20.16 displays the list.

	name	type_desc
1	database_query_store_options	VIEW
2	query_context_settings	VIEW
3	query_store_plan	VIEW
4	query_store_query	VIEW
5	query_store_query_text	VIEW
6	query_store_runtime_stats	VIEW
7	query_store_runtime_stats_interval	VIEW
8	sp_query_store_flush_db	EXTENDED_STORED_PROCEDURE
9	sp_query_store_force_plan	EXTENDED_STORED_PROCEDURE
10	sp_query_store_remove_plan	EXTENDED_STORED_PROCEDURE
11	sp_query_store_remove_query	EXTENDED_STORED_PROCEDURE
12	sp_query_store_reset_exec_stats	EXTENDED_STORED_PROCEDURE
13	sp_query_store_unforce_plan	EXTENDED_STORED_PROCEDURE

Figure 20.16: System-Stored Procedures and Catalog Views



20.2.5 Performance Tuning with Query Store

Performance of queries may deteriorate over time as a database grows. To analyze what is causing the performance issue is a challenging and time-consuming task that is made easy with the Query Store feature. The Query Store feature maintains all the information about queries over time and aids in quick resolution of issues. As mentioned before, it also enables to 'roll-back' to query plans from history.

Following are few examples of application scenarios, where performance-tuning solutions can be provided reactively or proactively by using the Query Store feature:

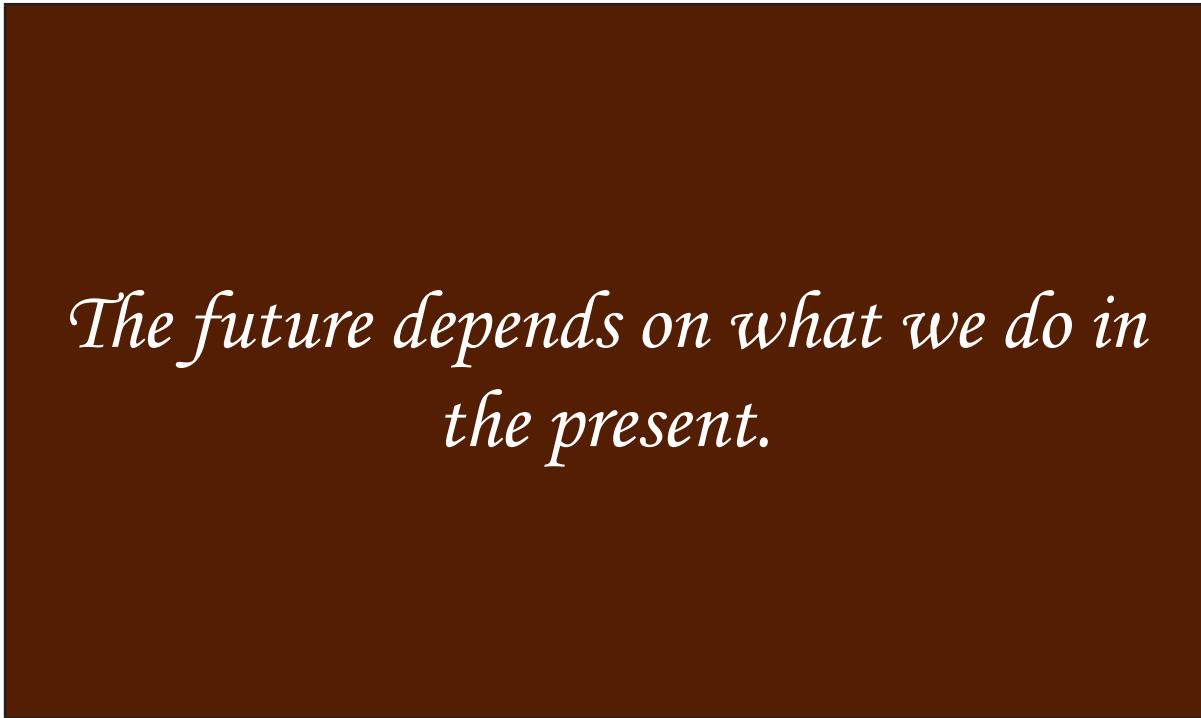
- If any recent plan changes have caused poorer performance, Query Store can be used to quickly identify the issue and if required revert to a previous plan.
- If any queries are consuming the most of system resources, such as CPU, memory or IO, they can be identified and accordingly changed to ensure optimal usage.
- When changes to applications or platforms are planned, Query Store can be used to compare performance before and after change implementation. These changes may include installing new versions of applications, installing new hardware, compatibility level upgrades to the database, and adding or modifying indexes.
- When upgrades are planned for Query Optimizer, performance of queries can be recorded before upgradation and fixed during upgradation.
- When there is a need to optimize resources, queries with a lower frequency of execution can be identified and allocation of resources to them can be proactively handled.

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20.3 Stretch Database

Stretch Database is a new feature built into SQL Server 2016 that facilitates storage of a part of a database in the cloud. When there is a need to retain data for a longer time, Stretch Database feature enables secure migration of tables and data to the cloud. This is an economical solution for long-term data storage. Moreover, applications can still query the data in the same way as before. Enabling Stretch Database feature makes it possible to do the following:

- Move archived data as well as current data to the cloud securely by using the encryption features
- Access and query the data on the cloud at any time, without any changes to existing applications or queries
- Reduce storage needs of on-premise data by using the vast storage capacity of the cloud
- Reduce processing burden on the on-premise data by running the processes on the cloud in a way that is transparent to the applications



The future depends on what we do in the present.

20.3.1 Stretch Database Architecture

A secure linked server definition is created in the on-premise SQL Server when the Stretch Database feature is enabled on a database. This establishes a connection to the remote or cloud database. When Stretch Database is enabled on a table, the resources on cloud are prepared and if migration is enabled, eligible data is migrated to the cloud database. Figure 20.17 illustrates the Stretch Database Architecture.

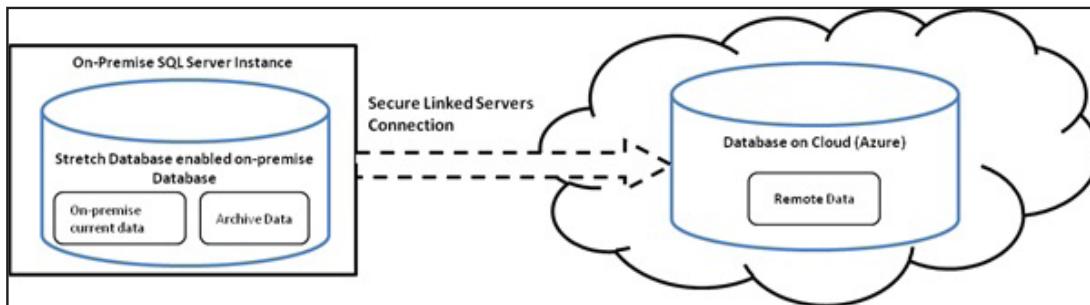


Figure 20.17: Stretch Database Architecture

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20.3.2 Setting up Stretch Database

Before configuring the Stretch Database feature, you need to have an Azure account.

Following are the steps to set up Stretch Database:

1. Enable Stretch Database on the SQL Server instance as shown in Code Snippet 7.

Code Snippet 7:

```
EXEC sys.sp_configure N'remote data archive', '1';
RECONFIGURE;
GO
```

2. Select the database and the table that needs to be stretched.



Consider that you have created a sample database and table. This table will be stretched to the Azure cloud. Code Snippet 8 creates a table StretchSampleTable on the StretchDemo database.

Code Snippet 8:

```
USE [StretchDemo];
GO
CREATE TABLE dbo.StretchSampleTable
(
    FNM VARCHAR(50),
    LNM VARCHAR(50)
);
GO
```

Insert sample records into the table as shown in Code Snippet 9, where sample data is inserted into the StretchSampleTable.

Code Snippet 9:

```
USE [StretchDemo];
GO
INSERT INTO dbo.StretchSampleTable (FNM, LNM)
VALUES('Pamella', 'Whee'), ('Kimon', 'Turing'), ('Joannie', 'Whitt'),
      ('Amelie', 'Janese'), ('Toni', 'Gregory'), ('Tedd', 'Walt');
GO
```

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3. On the Object Explorer, right-click the StretchDemo database, select **Tasks** and then select the **Enable Database for Stretch** option. Figure 20.18 shows the Enable Database for Stretch option.

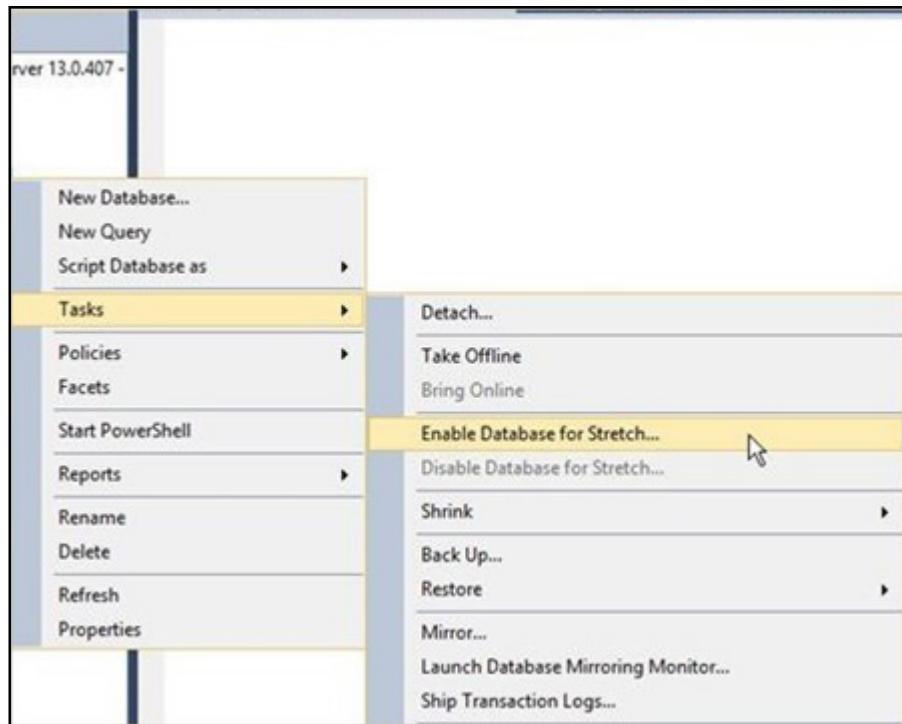


Figure 20.18: Enabling Database for Stretch

*Action may not always bring happiness,
but there is no happiness without
action.*

The **Enable Database for Stretch** wizard opens.

1. On the wizard, sign in to the Microsoft Azure account and then specify the Azure location, as well as the server access credentials. It is recommended to save access credentials.
2. Click **Finish** on the wizard to verify the choices made and to complete enabling the database for Stretch. A secure linked server definition between the local database and the remote database on Azure is now established.
3. To stretch the table to Azure, remote data archive needs to be enabled on the table. Code Snippet 10 enables remote data archive on the table.

Code Snippet 10:

```
USE [StretchDemo] ;  
GO  
ALTER TABLE [StretchSampleTable]  
ENABLE REMOTE_DATA_ARCHIVE WITH (MIGRATION_STATE = ON) ;  
GO
```

4. To confirm and monitor data migration to the Azure database, query the DMV `sys.dm_db_rda_migration_status`. This displays in addition to other details, the number of migrated rows for the tables.

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20.3.3 Stretch Database Limitations

Stretch database does not support following types of tables:

- Tables that are replicated
- Memory-optimized tables
- Tables that contain FILESTREAM data
- Tables that use 'Change Tracking' or 'Change Data'
- Tables with columns that are Always Encrypted data
- Tables with data-types, such as XML, filestream, and sql_variant

It also does not support the following features:

- Foreign key constraints on a table
- ColumnStore Indexes and full-text indexes

Also note that on Stretch Database enabled tables, UPDATE statements and DELETE statements will not work. The CREATE INDEX and ALTER INDEX operations also will not work.

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TIPS & TRICKS

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20.4 Check Your Progress

1. Which of the following are added during installation of PolyBase through SQL Server 2016?

(A)	SQL Server PolyBase Engine	(C)	SQL Server Data Movement Service
(B)	DWQueue	(D)	All of these

2. Which of the following actions are necessary for data migration from a database table to an Azure database through SQL Server?

(A)	Stretch Database must be enabled on the Server instance	(C)	Stretch Database must be enabled on the table
(B)	Stretch Database must be enabled on the database	(D)	Stretch Database must be enabled on the Server instance, database and on the table

3. Which of the following are not supported by Stretch Database?

(A)	Migration of current data to cloud	(C)	Filestream column type
(B)	Querying data on cloud	(D)	Viewing migration status

4. Which of the following is not a function of Query Store?

(A)	Seamless integration with external data store such as Hadoop	(C)	Identify queries with degraded performance
(B)	Store history of query plans in the system	(D)	Force older execution plans when required

5. Which of the following statements are incorrect?

(A)	PolyBase can be installed on only one SQL Server instance per machine	(C)	CREATE EXTERNAL DATA SOURCE statement is necessary to define a connection to Hadoop file from SQL Server
(B)	PolyBase supports Cloudera and Hortonworks flavors of Hadoop	(D)	Delimited Text is not a format of data supported by PolyBase

20.4.1 Answers

1.	d
2.	d
3.	c
4.	a
5.	d



Summary

- The PolyBase feature provides seamless integration with external data sources, such as Hadoop or Azure Blob Storage.
- PolyBase eliminates the need to specialized skills on Hadoop internals by enabling query-runs on external data sources with simple Transact-SQL commands.
- Query Store is a built-in tool to improve performance by maintaining historical information of every query and execution plan.
- Query Store tracks the performance of queries and triggers alerts on poorly performing plans.
- Stretch Database in SQL Server 2016 enables stretching some part of a database to the Azure cloud, thereby, lowering long-term storage costs as well as maintenance efforts.
- With Stretch Database, archive data as well as any current data can be migrated to the cloud securely and also accessed as easily as accessing local data at any time.

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Session - 21

Improved Performance Tools and Transact-SQL Enhancements

Welcome to the Session, **Improved Performance Tools and Transact-SQL Enhancements**.

This session covers the further enhancements to SQL Server 2016 including improvements to In-Memory OLTP and tools to monitor and tune performance. The session also explores enhancements to Transact-SQL.

In this Session, you will learn to:

- ➔ Explain how to start and use Database Engine Tuning Advisor in SQL Server 2016
- ➔ Explain the set of tools for monitoring events in SQL Server 2016 and for tuning the physical database design
- ➔ Outline the enhancements in Transact-SQL

21.1 In-Memory OLTP Enhancements

Earlier versions of SQL Server used to store data on disk and would bring it to memory when queries had to be run. The idea behind this architecture was to reduce memory requirement since it was quite expensive. However, over time, the cost of buying servers with more memory has drastically reduced. Thus, SQL Server 2014 brought in the In-Memory OLTP feature, also called Hekaton that would allow tables to be stored in main memory, otherwise known as memory-optimized tables. This resulted in faster OLTP because access to the tables that were now present within the internal memory became much quicker.

A memory-optimized table is a table where SQL Server will always store within memory the entire table as well as its indexes. This means that when accessing in-memory data structures, user processes will always find the required data in-memory, thus speeding up the process.

Hekaton also enables to design new data structures from scratch to leverage terabytes of available memory and high numbers of processing cores.

The Hekaton feature came with a new, separate database engine that worked alongside the SQL Server engine, which enabled direct access to the memory-optimized tables. This significantly improved performance for OLTP.

First say to yourself what you would be; and then do what you have to do.

However, this feature in SQL Server 2014 had some limitations, which are now overcome in SQL Server 2016. For the limitations in SQL Server 2014, the solutions in SQL Server 2016 are listed in table 21.1.

SQL Server 2014 Limitation	SQL Server 2016 Enhancement
Total size of memory-optimized tables could not exceed 256 GB of memory	Memory-optimized tables can be up to 2 TB
Could not handle multi-socket servers	Supports four-socket machines
To scan for changes in memory-optimized tables, single offline checkpoint thread was used, causing issues with large number of transactions	Uses multiple threads to track changes and thus, boosts performance
The query optimizer did not support parallel queries on memory-optimized tables	Query optimizer supports parallel queries with operations using hash index
Could not handle garbage collection with large volume of data	Has an improved garbage collection algorithms to handle removal of unnecessary data
Used filestream technology to indirectly allocate and manage files	The In-Memory OLTP engine directly controls the files and handles operations, such as creation and dropping of files
Needed configuration of Management Data Warehouse (MDW) to generate In-Memory OLTP reports	Reports can be generated through the SSMS
Did not support Transparent Data Encryption (TDE) and Multiple Active Result Sets (MARS)	Supports TDE and MARS

Table 21.1: In-Memory OLTP Enhancements in SQL Server 2016

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21.1.1 Non-BIN2 Collation

In addition to the enhancements listed in table 21.1, SQL Server 2016 does not require BIN2 collation on index key columns in memory-optimized tables. This is in contrast to SQL Server 2014. When a non-BIN2 collation was used in a memory-optimized table, SQL Server 2014 triggered the error – ‘The feature ‘non-bin2 collation’ is not supported with indexes on memory-optimized tables’.

Code Snippet 1 shows how a memory-optimized table works well with a non-BIN2 collation. Note that memory-optimized tables cannot be created in system databases. Also, to create memory-optimized tables, the database must have a `MEMORY_OPTIMIZED_FILEGROUP` that is online and has at least one container. Hence,



Code Snippet 1 begins with creating a database and a filegroup that is memory-optimized and then proceeds to create the table.

Code Snippet 1:

```
CREATE DATABASE MUSIC_INVENTORY
GO

ALTER DATABASE MUSIC_INVENTORY ADD FILEGROUP MUSIC_INVENTORY_mod CONTAINS
MEMORY_OPTIMIZED_DATA

ALTER DATABASE MUSIC_INVENTORY ADD FILE (name='MUSIC_INVENTORY_mod1',
filename='d:\MUSIC_INVENTORY_mod1') TO FILEGROUP MUSIC_INVENTORY_mod

ALTER DATABASE MUSIC_INVENTORY SET MEMORY_OPTIMIZED_ELEVATE_TO_SNAPSHOT=ON
GO

USE MUSIC_INVENTORY
CREATE TABLE NewOrdrs
(
[Uid] int identity(1,1) NOT NULL,
[custname] nvarchar(10) NOT NULL,
[OdrSummary] varchar(50) COLLATE FRENCH_CI_AS NOT NULL -- Non Bin2 -- Collation
PRIMARY KEY NONCLUSTERED HASH (Uid) WITH (BUCKET_COUNT=2048))
WITH (MEMORY_OPTIMIZED=ON, DURABILITY = SCHEMA_AND_DATA)
```

In Code Snippet 1, the clause `MEMORY_OPTIMIZED=ON` makes the `NewOrdrs` a memory-optimized table. `OdrSummary` does not use `_BIN2` with the `COLLATE` clause, which indicates that it is non-BIN2 index key.

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21.1.2 ALTER TABLE on Memory-optimized Tables

A memory-optimized table could not be altered in SQL Server 2014. The table had to be dropped and re-created. SQL Server 2016 overcomes this limitation by supporting ALTER TABLE statement to make changes to index and schema.

Note that ALTER TABLE is an offline operation and at least two times the table space is required to run it. The table would be temporarily unavailable to any other operation trying to use it until the alteration is completed.

Code Snippet 2 shows how the ALTER TABLE statement is used to modify the BUCKET_COUNT on an existing index.

Tip - To get the index name, right-click in the Object Explorer under Indexes node of NewOrdrs and copy the index name.

Code Snippet 2:

```
ALTER TABLE NewOrdrs  
ALTER INDEX [PK__NewOrdr__4114F56EB17AF7D7] REBUILD WITH (BUCKET_COUNT=2048)
```

In Code Snippet 2, the index on table NewOrdrs is modified to change the BUCKET_COUNT to 2048.

Learning how to learn is life's most important skill.

Code Snippet 3 will verify the change to BUCKET_COUNT.

Code Snippet 3:

```
SELECT index_id, name, BUCKET_COUNT  
FROM sys.hash_indexes  
WHERE object_id=object_id('dbo.NewOrdrs')
```

A new column and index can also be added to a table as shown in Code Snippet 4.

Code Snippet 4:

```
ALTER TABLE NewOrdrs  
ADD [Customername] Int NULL  
ALTER TABLE NewOrdrs  
ADD index IX_Custname nonclustered ([Customername])
```

In Code Snippet 4, a new index IX_Custname is added to the existing table NewOrdrs.

Code Snippet 5 verifies the new index.

Code Snippet 5:

```
SELECT index_id, name, type_desc  
FROM sys.indexes  
WHERE object_id=object_id('dbo.NewOrdrs')
```

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Code Snippet 6 adds multiple columns and indexes.

Code Snippet 6:

```
ALTER TABLE dbo.NewOrdrs  
ADD DestinationId int NOT NULL DEFAULT 1 WITH VALUES,  
Destination varchar(200) NOT NULL DEFAULT 1 WITH VALUES,  
INDEX IX_DestinationId (DestinationId)
```

Code Snippet 7 drops an index on a memory-optimized table.

Code Snippet 7:

```
ALTER table NewOrdrs  
DROP INDEX IX_DestinationId
```



21.2 Performance Monitoring and Tuning Tools

In order to improve and tune performance quickly, it is important to be able to identify and work to rectify the underlying issues. For this, it is essential to have an easy way of collecting and analyzing performance data. SQL Server 2016 supports easy analysis by providing tools that monitor events and capture information that subsequently aid to resolve issues. Table 21.2 lists the tools available for performance tuning in SQL Server 2016.

The tool should be chosen based on the tuning requirements as well as the monitoring requirements.

Tool	Description
SQL Server Profiler	This tool helps to monitor server activity for events such as deadlocks, logins, and fatal errors. The data on monitored events can be stored in a table and analyzed later. All the events from a single computer can also be replayed so that the exact issue can be identified.
SQL Server Distributed Replay	This tool is useful to assess how future SQL Server upgrades will impact the current system. On an upgraded test environment, it can replay the events to investigate the captured trace so that possible performance issues after the upgrades can be noted. It functions like SQL Server Profiler but it can replay captured events from multiple computers and is effective especially in simulation of mission-critical environments.
Monitor Resource Usage (System Monitor)	This tool is useful to monitor how resources are used by server processes. It uses system-defined counter to capture server performance and user-defined counters to capture event information. It allows setting thresholds on counters and triggering alerts as required. It can also monitor SQL Server and Windows operating system simultaneously to understand any interrelated issues.
Open Activity Monitor SSMS	This tool is available in SSMS and can be used to monitor processes on the SQL Server and report information about user activity, any blocked processes, and locks.
Live Query Statistics	This tool helps to troubleshoot performance issues of queries by generating statistical information about on-going queries. Real-time query statistics can be viewed using the SSMS.

Tool	Description
SQL Trace	<p>There are in-built Transact-SQL procedures that create traces on a SQL Server Database engine. These can be run from the applications directly without the need to use the SQL Server Profiler. The procedures are:</p> <ul style="list-style-type: none"> ➔ <code>sp_trace_create</code> ➔ <code>sp_trace_generateevent</code> ➔ <code>sp_trace_setevent</code> ➔ <code>sp_trace_setfilter</code> ➔ <code>sp_trace_setstatus</code>
Error Logs	Error log information is useful to debug server problems. These give information about Windows Server and OS events and also about events occurring in SQL Server and full-text searches.
System Stored Procedures (Transact-SQL)	<p>More system stored Transact-SQL procedures help with monitoring such as the following:</p> <ul style="list-style-type: none"> ➔ <code>sp_who</code>: Used to gain information about users and processes. It can provide information about the on-going statement and report if it is blocked ➔ <code>sp_lock</code>: Used to gain information about locks such as object ID, index ID, type of lock, and type or resource on which the lock is applied ➔ <code>sp_spaceused</code>: Used to gain information about the amount of disk space used by tables or by database ➔ <code>sp_monitor</code>: Used to retrieve information about CPU usage, I/O usage, and idle-time between executions of two <code>sp_monitor</code> statements.
Database Console Command (DBCC)	These are Transact-SQL statements that enable viewing of statistical information of performance and the logical and physical consistency of a database.

Tool	Description
Built-in Functions (Transact-SQL)	<p>SQL Server has in-built counters that record information since the server was started. Some of them are as follows:</p> <ul style="list-style-type: none"> ➔ @@CPU _ BUSY stores the amount of time the CPU has been executing SQL Server code ➔ @@CONNECTIONS stores the number of SQL Server connections or attempted connections ➔ @@PACKET _ ERRORS stores the number of network packets occurring on SQL Server connections
Database Engine Tuning Advisor (DTA)	This tool is helpful in scrutinizing the Transact-SQL statements running on databases. This helps to evaluate the performance and accordingly tune the database. It also recommends solutions such as to add, remove, or modify indexes so that performance can be improved.

Table 21.2: SQL Server Performance Tuning Tools

Note that the tool selection is based on the required type of event or activity.

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Table 21.3 lists the events or activities and the tools that can be used for them.

Event or Activity	Applicable Tools
Trend Analysis	SQL Server Profiler and System Monitor
Replaying captured events	SQL Server Profiler (from single computer) and Distributed Replay (from multiple computers)
Ad hoc monitoring	SQL Server Profiler, Activity monitor, Transact –SQL, and Error Logs
Generating alerts	System monitor
Graphical interface	SQL Server Profiler, System Monitor, Activity Monitor, and Error Logs
Usage from applications	SQL Server Profiler system-stored procedures

Table 21.3: Activities and Applicable Tools

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MULTIPLE EXPERTS | MULTIPLE TOPICS

21.2.1 DTA

As listed in table 21.2, DTA is one of the SQL Server performance tuning tools. It helps to tune the physical design structures of a database system which include indexes, clustered indexes, indexed views, and partitions. This tool can go through every Transact-SQL statement on a database and then, provide the following:

- Analysis of current queries or a set of Transact-SQL queries
- Recommendations about optimal indexes and partitions that will improve performance
- Analysis of any proposed changes to indexes or queries
- Transact-SQL scripts that can implement the recommendations
- Generation of statistics

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Following are the steps to use DTA for analysis and recommendations:

1. On the query window, in SSMS, right-click and select the option **Analyze Query in Database Engine Tuning Advisor** as shown in figure 21.1. Alternatively, click **Tools** and then, click **Database Engine Tuning Advisor**.

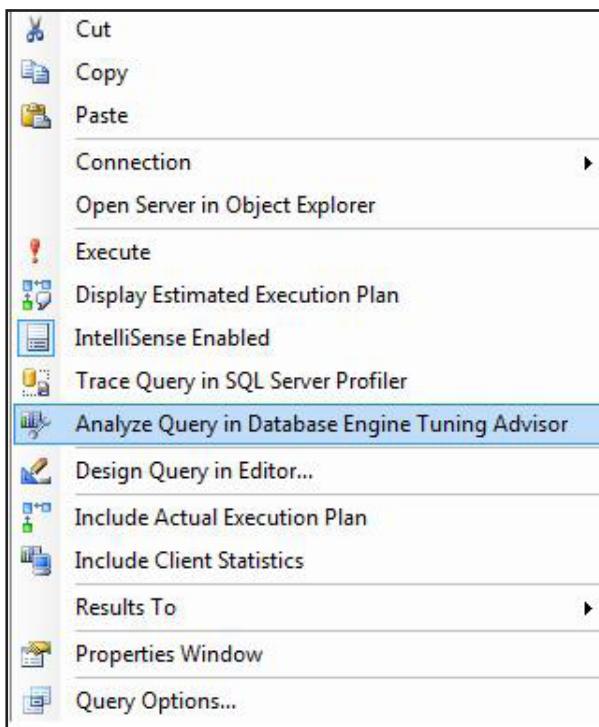


Figure 21.1: Analyze Query with DTA Option

*A little learning is a dangerous thing,
but a lot of ignorance is just as bad.*

2. Select an option to tune as shown in figure 21.2.

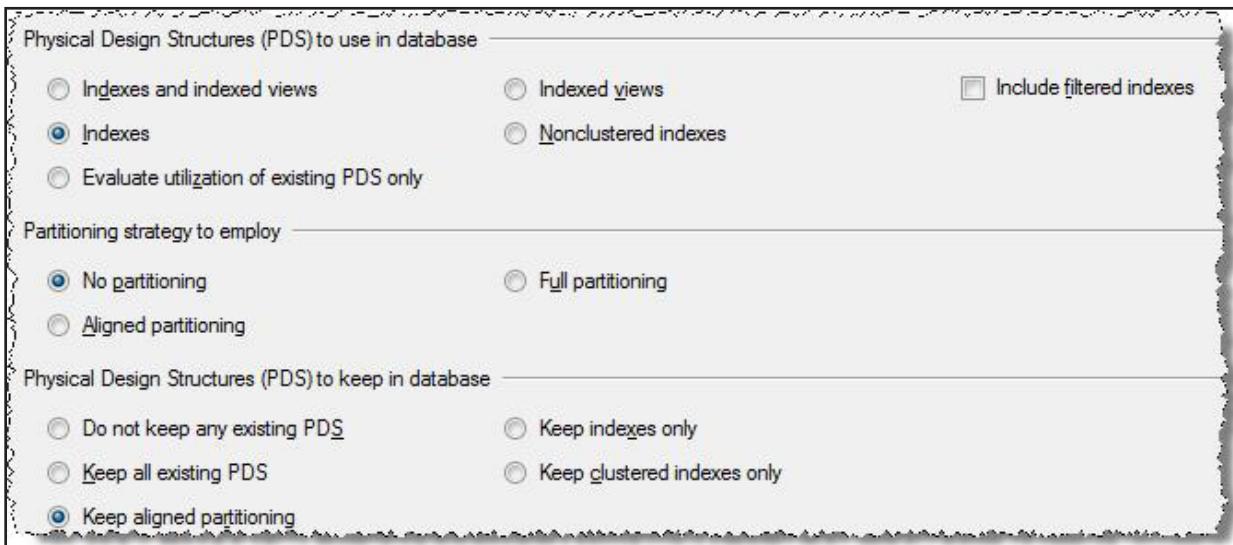


Figure 21.2: Options for Tuning

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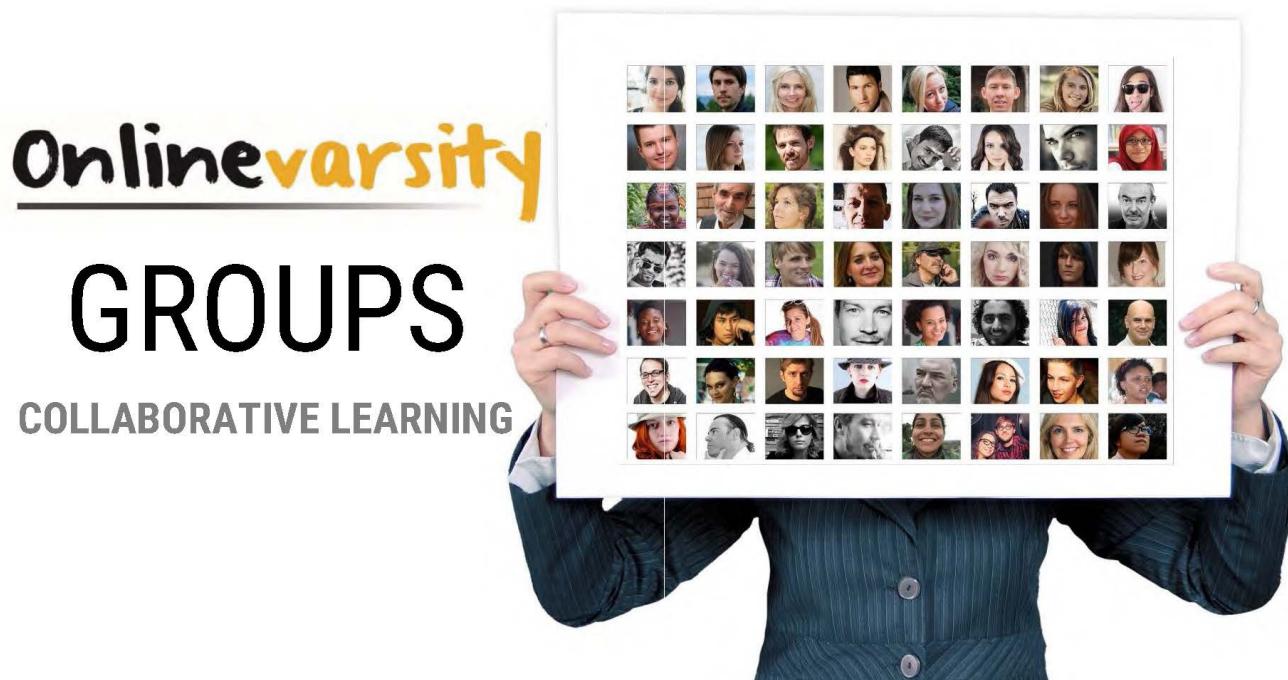
The DTA recommendations are shown in figure 21.3.

General	Tuning Options	Progress	Recommendations	Reports
Estimated improvement: 97%				
Partition Recommendations				
Index Recommendations				
<input checked="" type="checkbox"/> Database Name	Object Name	Recommendation	Target of Recommendation	D
<input checked="" type="checkbox"/> AdventureWorksDW	[dbo].[DimProduct]	create	_dta_index_DimProduct_14_117575457_K11_1_3	

Figure 21.3: DTA Recommendations

Note that to use DTA functionality in software programs and scripts, the command-line utility program dta.exe can be used.

Also, note that the DTA uses msdb database to store tuning session data. It is recommended to incorporate the backup strategy for this database to ensure that the tuning session data is not lost.



21.2.2 Third-party Tools for Performance Tuning

To generate performance data that is much more detailed than that generated by the built-in tools in SQL Server, there are some tools by third-party vendors. Some of these tools and their features are listed in table 21.4.

Third-party Tool	Features
DB Performance Center XE by Embarcadero	<ul style="list-style-type: none"> → Provides round-the-clock monitoring of databases to provide information about memory, I/O contention, space, network, objects, and users → Capable of monitoring mixed database environment → Automatically captures SQL Sessions and provisions → Generates real-time performance metrics, brief as well as detailed reports → Facilitates creation of customized reports and their export to any desired formats
SQL Suite by SQL Solutions	<ul style="list-style-type: none"> → Provides tools Trace Analyzer, Deadlock Detector, Ultimate Debugger, and Heartbeat that help with troubleshooting → The Trace Analyzer locates code that is causing performance issues and provides resolutions → With the analyzer, it can trace time-consuming procedures and procedures using high resources
SQL Server Monitor by NetIQ	<ul style="list-style-type: none"> → Monitors and analyzes performance at statement level → Triggers alerts to customized threshold levels and automatically provides resolutions → Stores real-time monitoring and performance data → Provides high-level fault management
Heroix Longitude by Heroix	<ul style="list-style-type: none"> → Measures metrics, such as disk I/O, lock wait times, available memory, processor threads, page rates, number of user connections, and latency in transactions → Is an agent-less metrics monitoring solution and supports SQL Server 7, 2000, 2005, and 2008

Third-party Tool	Features
Zero Impact SQL Monitor by SQL Power Tools	<ul style="list-style-type: none"> ➔ Captures all end-user SQL without any middleware, proxies, or connections to database ➔ Provides trend analysis and real-time monitoring of response times and real-time user analysis

Table 21.4: Third-party Performance Tuning Tools

21.3 Transact-SQL Enhancements

SQL Server 2016 provides following Transact-SQL enhancements:

- ➔ It is possible to alter memory-optimized tables with the `ALTER INDEX` clause.
- ➔ `ALTER TABLE` statement can use `WITH (ONLINE = ON | OFF)` clause and alter many columns while the table remains online.
- ➔ Foreign keys, check constraints, unique constraints, outer joins, and operators, such as `UNION[ALL]`, `DISTINCT`, `IN`, and `EXISTS` are supported.
- ➔ DML triggers and LOB data types are supported on memory-optimized tables.

To learn, you must want to be taught.

- Nullable columns can be indexed.
- Non-BIN2 collations can be used on memory-optimized tables.
- The `sp_recompile` system-stored procedure can be run with natively compiled procedures.
- In natively compiled procedures, subqueries and nested native procedure calls are supported.
- Natively compiled scalar User Defined Functions (UDFs) can be used in the same way as built-in scalar functions and can also be altered or dropped after their creation.

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- With the TRUNCATE _ TABLE WITH PARTITION clause specific partitions on large partitioned tables can be truncated, which simplifies and speeds up maintenance on such tables. Code Snippet 8 shows the syntax of this clause.

Code Snippet 8:

```
TRUNCATE TABLE [database] . [schema] . [table] WITH (PARTITIONS [partition number expression] | [range] );
```

where,

Partitions argument can be:

- number of a partition { Example: (PARTITIONS (8)) }
- comma separated list of partitions numbers: {Example: (PARTITIONS (1,2,3,4))}
- a range with the keyword TO {Example: (PARTITIONS (1 TO 4))}
- a combination of the two second and third Partitions argument {Example: (PARTITIONS (1,2 TO 4))}

For example,

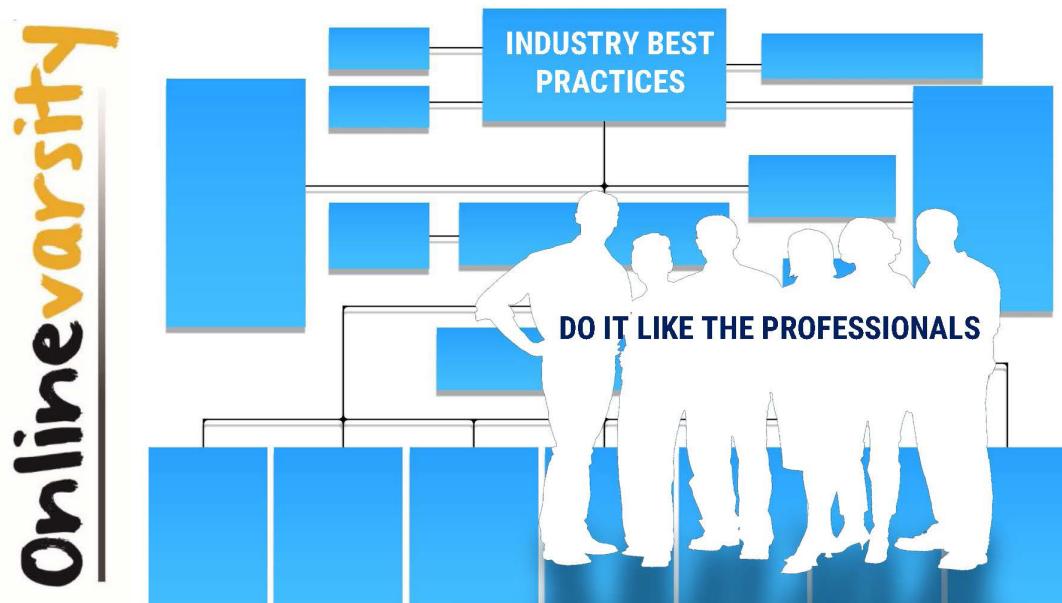
```
TRUNCATE TABLE dbo.SampleTbl WITH (PARTITIONS (1, 4 TO 8));
```

- Provisions to check for the existence of a table before dropping it by using a simple DROP TABLE IF EXISTS statement. Code Snippet 9 shows how the DROP IF statement is used.

Code Snippet 9:

```
DROP TABLE IF EXISTS [dbo] . [SampleTbl];
```

where, SampleTbl is the table to be dropped.



The DROP IF statement can also be used with columns, views, indexes, databases, users, and so on.

- Scripts in R language, which is used for data science and advanced analytics are supported with the stored procedure `sp_execute_external_script`.
- Temporal tables can be queried to retrieve historical row data.
- FOR JSON clause can be used to convert tabular data.
- Dynamic Data Masking is supported.
- Addition of spool operators to query plan can be prevented using `NO_PERFORMANCE_SPOOL` query hint.
- The `MAXDOP` option can be added to `DBCC CHECKTABLE`, `DBCC CHECKDB`, and `DBCC CHECKFILEGROUP` to control the degree of parallelism.
- `sp_set_session_context`, the `SESSION_CONTEXT` function and the `CURRENT_TRANSACTION_ID` function can be used to manage session context.

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21.4 Check Your Progress

1. Which of the following are Transact-SQL enhancements to SQL Server 2016?

(A)	DROP IF EXISTS sentence	(C)	ALTER TABLE on memory-optimized tables
(B)	FOR JSON clause	(D)	FOR XML clause

2. Which of the following is a tool in SQL Server to replay captured events from multiple computers?

(A)	SQL Server Profiler	(C)	SQL Server Distributed Replay
(B)	DTA	(D)	SQL Server Monitor

3. Match the options in Column A to the correct options in Column B?

(1)	To use DTA functionality in software programs and scripts	(A)	Requires at least two times the table space
(2)	Non-BIN2 Collation	(B)	Provide historical row data
(3)	Temporal tables	(C)	index key columns in memory-optimized tables
(4)	ALTER TABLE	(D)	Use dta.exe

4. To truncate a table EmployeeInfo at a specific partition 8, which of the following statements is correct?

(A)	TRUNCATE TABLE dbo.EmployeeInfo WITH (PARTITIONS (2,4 TO 8))	(C)	TRUNCATE TABLE dbo.EmployeeInfo WITH (PARTITIONS (8,9))
(B)	TRUNCATE TABLE dbo.EmployeeInfo WITH (PARTITIONS (8))	(D)	TRUNCATE TABLE dbo.EmployeeInfo WITH (PARTITIONS (2,4 TO 8)), TRUNCATE TABLE dbo.EmployeeInfo WITH (PARTITIONS (8)), TRUNCATE TABLE dbo.EmployeeInfo WITH (PARTITIONS (8,9))

5. Which of the following is an in-built SQL Server counter that records information since the server was first started?

(A)	@@CPU_BUSY	(C)	@@PACKET_ERRORS
(B)	@@CONNECTIONS	(D)	@@CPU_BUSY, @@CONNECTIONS, @@PACKET_ERRORS

21.4.1 Answers

1.	a, b, and c
2.	c
3.	1 – d, 2 – c, 3 – b, and 4 – a
4.	b
5.	d



Summary

- In-Memory OLTP in SQL Server 2016 is enhanced to overcome limitations in SQL Server 2014.
- SQL Server 2016 has increased memory for memory-optimized tables, improved garbage collection algorithms, and provides better scalability and performance.
- Non-BIN2 collation on index columns and altering of the table after initial creation is also supported for memory-optimized tables.
- Tools such as SQL Server Profiler, SQL Server Distributed Replay, and Data Engine Tuning Advisor are provided by SQL Server 2016 for tuning performance.
- DTA is an important tool that goes through every statement tracking, identifying, and recommending appropriate solutions to improve performance.
- Third-party tools such as DB Performance Center XE, SQL Server Monitor, and Zero Impact SQL Monitor also help to gain more detailed information and analysis of performance metrics.
- Several Transact-SQL enhancements are included in SQL Server 2016. Some important ones are support of foreign keys, check constraints, TRUNCATE_TABLE WITH PARTITION clause, and DROP IF EXISTS sentence.

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