

About this Course

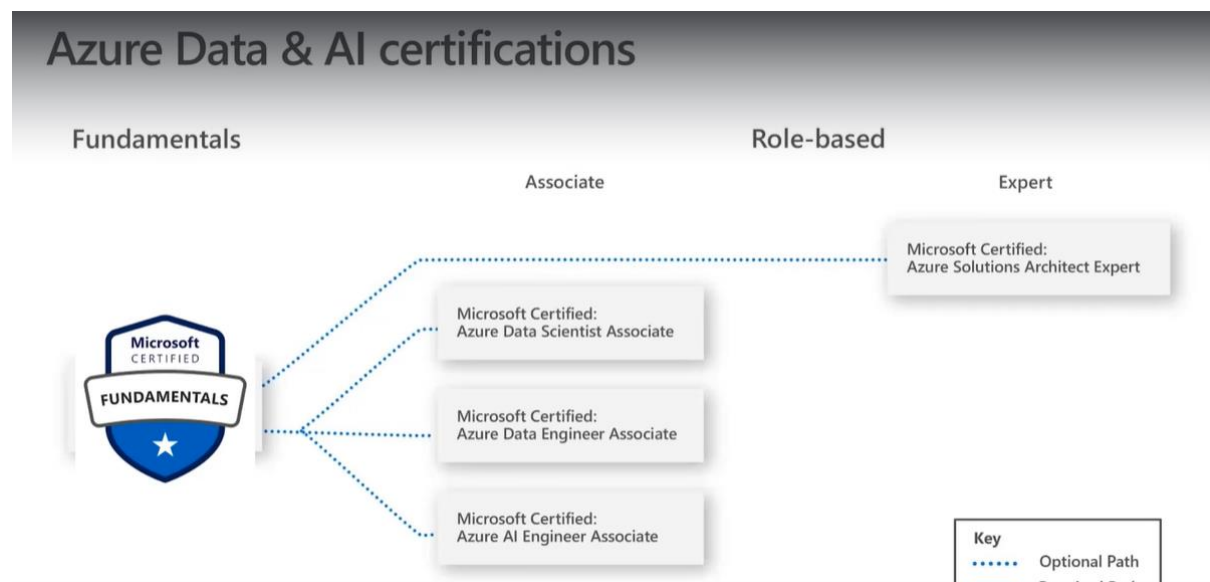
Welcome to this course on *Microsoft Azure Data Fundamentals*!

This course is designed for anyone who wants to learn the fundamentals of database concepts in a cloud environment, get basic skilling in cloud data services, and build their foundational knowledge of cloud data services within Microsoft Azure.

Learning objectives

After completing this course, you will be able to:

- Describe core data concepts in Azure.
- Explain concepts of relational data in Azure.
- Explain concepts of non-relational data in Azure.
- Identify components of a large-scale data warehouse in Azure.



**Can lead to
Azure DBA or
Azure Data
Engineer paths**

**Core Data
Concepts
(25-30%)**

**Relational Data
(20-25%)**

**Non-Relational
Data (15-20%)**

**Data Analytics
(25-30%)**

Course Agenda

This course includes the following modules:

Module 1: Explore fundamentals of data

In this module, you will explore core data concepts and data roles and services.

Module 2: Explore fundamentals of relational data in Azure

In this module, you will explore relational data concepts, and Azure services for relational data.

Module 3: Explore fundamentals of non-relational data in Azure

In this module, you will explore Azure Storage for non-relational data, and the fundamentals of Azure Cosmos DB.

Module 4: Explore fundamentals of data analytics

In this module, you will explore the fundamentals of large-scale data warehousing, streaming and real-time analytics, and data visualization.

Module 1 Explore core data concepts

Introduction

Over the last few decades, the amount of data that systems, applications, and devices have generated has increased significantly. Data is everywhere. Data is available in different structures and formats. Understanding data and exploring it reveals interesting facts, and helps you gain meaningful insights.

In this lesson, you'll learn about how you can organize and process data. You'll learn about relational and non-relational databases, and how data is handled through transactional processing, and through batch and streaming data processing.

Imagine you're a data analyst for a large consumer organization. The organization wants to understand customer buying patterns from supermarkets. The organization has a number of datasets from different sources, such as till information (point of sale), weather data, and holiday data. The organization would like to use Azure technologies to understand and analyze these datasets.

Learning objectives

In this lesson you will:

- Identify how data is defined and stored
- Identify characteristics of relational and non-relational data
- Describe and differentiate data workloads
- Describe and differentiate batch and streaming data

What is data?

Data is a collection of facts such as numbers, descriptions, and observations used to record information. Data structures in which this data is organized often represents *entities* that are important to an organization (such as customers, products, sales orders, and so on). Each entity typically has one or more *attributes*, or characteristics (for example, a customer might have a name, an address, a phone number, and so on).

You can classify data as *structured*, *semi-structured*, or *unstructured*.

Structured data

Structured data is data that adheres to a fixed *schema*, so all of the data has the same fields or properties. Most commonly, the schema for structured data entities is *tabular* - in other words, the data is represented in one or more tables that consist of rows to represent each instance of a data entity, and columns to represent attributes of the entity. For example, the following image shows tabular data representations for *Customer* and *Product* entities.

Customer				
ID	FirstName	LastName	Email	Address
1	Joe	Jones	joe@litware.com	1 Main St.
2	Samir	Nadoy	samir@northwind.com	123 Elm Pl.

Product		
ID	Name	Price
123	Hammer	2.99
162	Screwdriver	3.49
201	Wrench	4.25

Structured data is often stored in a database in which multiple tables can reference one another by using key values in a *relational* model; which we'll explore in more depth later.

Semi-structured data

Semi-structured data is information that has some structure, but which allows for some variation between entity instances. For example, while most customers may have an email address, some might have multiple email addresses, and some might have none at all.

One common format for semi-structured data is *JavaScript Object Notation* (JSON). The example below shows a pair of JSON documents that represent customer information. Each customer document includes address and contact information, but the specific fields vary between customers.

```
// Customer 1
{
  "firstName": "Joe",
  "lastName": "Jones",
  "address":
  {
    "streetAddress": "1 Main St.",
    "city": "New York",
    "state": "NY",
    "postalCode": "10099"
  },
  "contact":
  [
    {
      "type": "home",
```

```

        "number": "555 123-1234"
    },
    {
        "type": "email",
        "address": "joe@litware.com"
    }
]
}

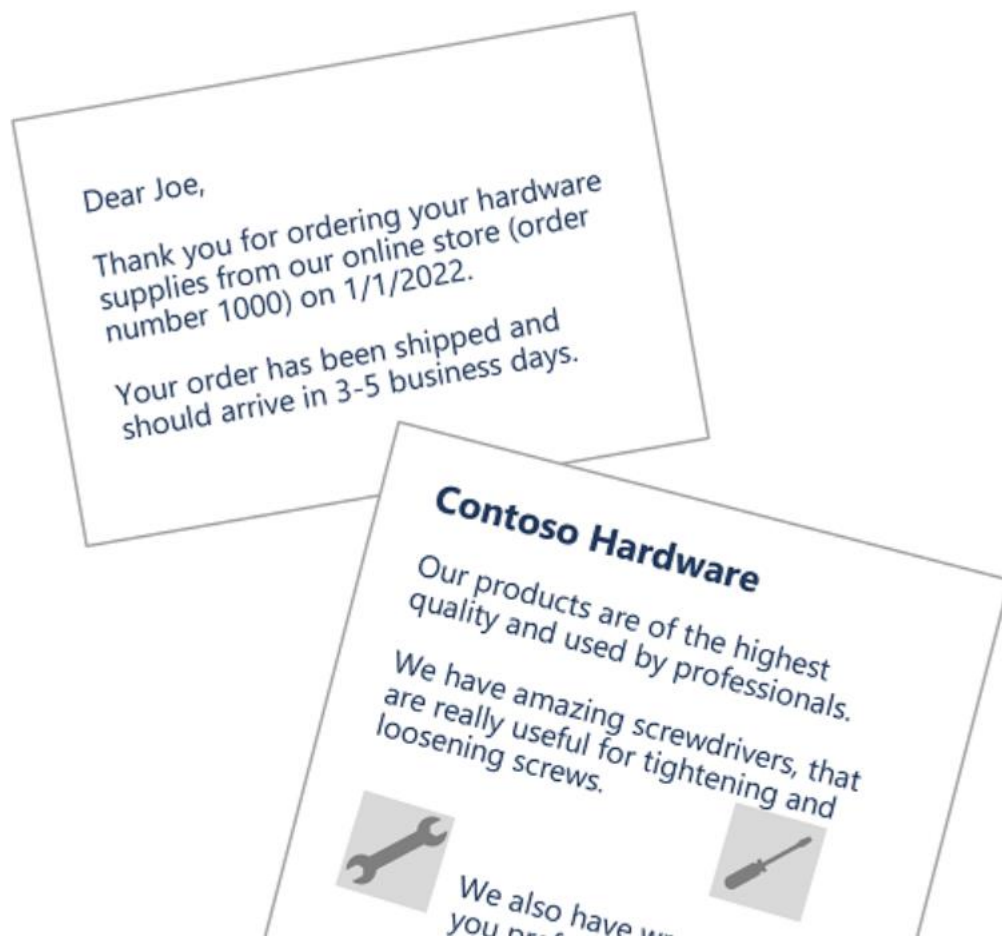
// Customer 2
{
    "firstName": "Samir",
    "lastName": "Nadoy",
    "address":
    {
        "streetAddress": "123 Elm Pl.",
        "unit": "500",
        "city": "Seattle",
        "state": "WA",
        "postalCode": "98999"
    },
    "contact":
    [
        {
            "type": "email",
            "address": "samir@northwind.com"
        }
    ]
}

```

NOTE: JSON is just one of many ways in which semi-structured data can be represented. The point here is not to provide a detailed examination of JSON syntax, but rather to illustrate the flexible nature of semi-structured data representations.

Unstructured data

Not all data is structured or even semi-structured. For example, **documents, images, audio and video data, and binary files** might not have a specific structure. This kind of data is referred to as *unstructured* data.



Data stores

Organizations typically store data in structured, semi-structured, or unstructured format to record details of entities (for example, customers and products), specific events (such as sales transactions), or other information in documents, images, and other formats. The stored data can then be retrieved for analysis and reporting later.

There are two broad categories of data store in common use:

- File stores
- Databases

We'll explore both of these types of data store in subsequent topics.

How is data stored?

The ability to store data in files is a core element of any computing system. Files can be stored in local file systems on the hard disk of your personal computer, and on removable media such as USB drives; but in most organizations, important data files are stored centrally in some kind of shared file storage system. Increasingly, that central storage location is hosted in the cloud, enabling cost-effective, secure, and reliable storage for large volumes of data.

The specific file format used to store data depends on a number of factors, including:

- The type of data being stored (structured, semi-structured, or unstructured).
- The applications and services that will need to read, write, and process the data.
- The need for the data files to be readable by humans, or optimized for efficient storage and processing.

Some common file formats are discussed below.

Delimited text files

Data is often stored in plain text format with specific field delimiters and row terminators. The most common format for delimited data is **comma-separated values** (CSV) in which fields are separated by commas, and rows are terminated by a carriage return / new line. Optionally, the first line may include the field names. Other common formats include tab-separated values (TSV) and space-delimited (in which tabs or spaces are used to separate fields), and fixed-width data in which each field is allocated a fixed number of characters. Delimited text is a good choice for structured data that needs to be accessed by a wide range of applications and services in a human-readable format.

The following example shows customer data in **comma-delimited** format:

```
FirstName,LastName,Email
Joe,Jones,joe@littware.com
Samir,Nadoy,samir@northwind.com
```

JavaScript Object Notation (JSON)

JSON is a ubiquitous format in which a hierarchical document schema is used to define data entities (objects) that have multiple attributes. Each attribute might be an object (or a collection of objects); making **JSON a flexible format that's good for both structured and semi-structured data**.

The following example shows a JSON document containing a collection of customers. Each customer has three attributes (*firstName*, *lastName*, and *contact*), and the *contact* attribute contains a collection of objects that represent one or more contact methods (email or phone). Note that objects are enclosed in braces (`{..}`) and collections are enclosed in square brackets (`[..]`). Attributes are represented by *name:value* pairs and separated by commas (,).

```
{
  "customers":
  [
    {
      "firstName": "Joe",
      "lastName": "Jones",
      "contact":
      [
        {
          "type": "home",
          "number": "555 123-1234"
        }
      ]
    }
  ],
}
```



```

    {
      "type": "email",
      "address": "joe@litware.com"
    }
  ],
  {
    "firstName": "Samir",
    "lastName": "Nadoy",
    "contact": [
      {
        "type": "email",
        "address": "samir@northwind.com"
      }
    ]
  }
]
}

```

Extensible Markup Language (XML)

XML is a human-readable data format that was popular in the 1990s and 2000s. It's largely been superseded by the less verbose JSON format, but there are still some systems that use XML to represent data. XML uses *tags* enclosed in angle-brackets (<./>) to define *elements* and *attributes*, as shown in this example:

```

<Customers>
  <Customer name="Joe" lastName="Jones">
    <ContactDetails>
      <Contact type="home" number="555 123-1234"/>
      <Contact type="email" address="joe@litware.com"/>
    </ContactDetails>
  </Customer>
  <Customer name="Samir" lastName="Nadoy">
    <ContactDetails>
      <Contact type="email" address="samir@northwind.com"/>
    </ContactDetails>
  </Customer>
</Customers>

```

Binary Large Object (BLOB)

Ultimately, all files are stored as binary data (1's and 0's), but in the human-readable formats discussed above, the bytes of binary data are mapped to printable characters (typically though a character encoding scheme such as ASCII or Unicode). Some file formats however, particularly for unstructured data, store the data as raw binary that must be interpreted by applications and rendered. **Common types of data stored as binary include images, video, audio, and application-specific documents.**

When working with data like this, data professionals often refer to the data files as *BLOBs* (**B**inary **L**arge **O**bjects).

Optimized file formats

While human-readable formats for structured and semi-structured data can be useful, they're typically not optimized for storage space or processing. Over time, some specialized file formats that enable compression, indexing, and efficient storage and processing have been developed.

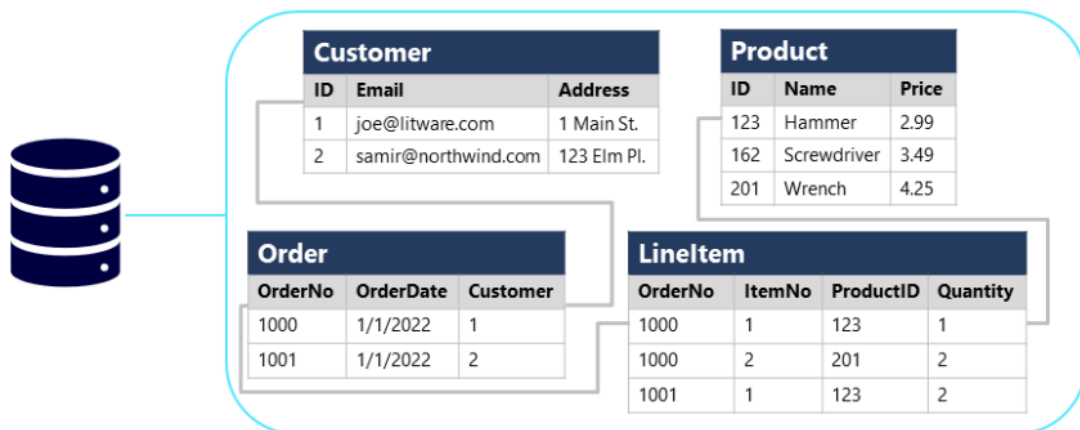
Some common optimized file formats you might see include *Avro*, *ORC*, and *Parquet*:

- *Avro* is a row-based format. It was created by Apache. Each record contains a header that describes the structure of the data in the record. This header is stored as JSON. The data is stored as binary information. An application uses the information in the header to parse the binary data and extract the fields it contains. Avro is a good format for compressing data and minimizing storage and network bandwidth requirements.
- *ORC* (Optimized Row Columnar format) organizes data into columns rather than rows. It was developed by HortonWorks for optimizing read and write operations in Apache Hive (Hive is a data warehouse system that supports fast data summarization and querying over large datasets). An ORC file contains *stripes* of data. Each stripe holds the data for a column or set of columns. A stripe contains an index into the rows in the stripe, the data for each row, and a footer that holds statistical information (count, sum, max, min, and so on) for each column.
- *Parquet* is another columnar data format. It was created by Cloudera and Twitter. A Parquet file contains row groups. Data for each column is stored together in the same row group. Each row group contains one or more chunks of data. A Parquet file includes metadata that describes the set of rows found in each chunk. An application can use this metadata to quickly locate the correct chunk for a given set of rows, and retrieve the data in the specified columns for these rows. Parquet specializes in storing and processing nested data types efficiently. It supports very efficient compression and encoding schemes.

A database is used to define a central system in which data can be stored and queried. In a simplistic sense, the file system on which files are stored is a kind of database; but when we use the term in a professional data context, we usually mean a dedicated system for managing data records rather than files.

Relational databases

Relational databases are commonly used to store and query structured data. The data is stored in tables that represent entities, such as customers, products, or sales orders. Each instance of an entity is assigned a *primary key* that uniquely identifies it; and these keys are used to reference the entity instance in other tables. For example, a customer's primary key can be referenced in a sales order record to indicate which customer placed the order. This use of keys to reference data entities enables a relational database to be *normalized*; which in part means the elimination of duplicate data values so that, for example, the details of an individual customer are stored only once; not for each sales order the customer places. The tables are managed and queried using Structured Query Language (SQL), which is based on an ANSI standard, so it's similar across multiple database systems.



Non-relational databases

Non-relational databases are data management systems that don't apply a relational schema to the data. Non-relational databases are often referred to as NoSQL database, even though some support a variant of the SQL language.

There are four common types of Non-relational database commonly in use.

- **Key-value databases** in which each record consists of a unique key and an associated value, which can be in any format.

Products	
Key	Value
123	"Hammer (\$2.99)"
162	"Screwdriver (\$3.49)"
201	"Wrench (\$4.25)"

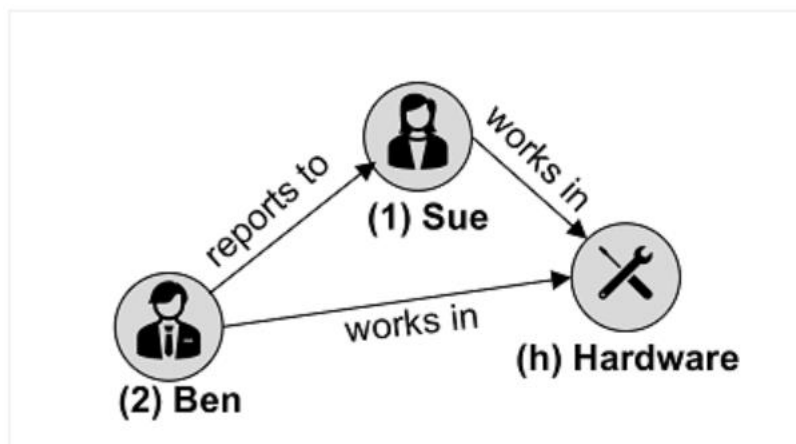
- **Document databases**, which are a specific form of key-value database in which the value is a JSON document (which the system is optimized to parse and query)

Customers	
Key	Document
1	{ "name": "Joe Jones", "email": "joe@litware.com" }
2	{ "name": "Samir Nadoy", "email": "Samir@northwind.com" }

- **Column family databases**, which store tabular data comprising rows and columns, but you can divide the columns into groups known as column-families. Each column family holds a set of columns that are logically related together.

Orders				
Key	Customer		Product	
	Name	Address	Name	Price
1000	Joe Jones	1 Main St.	Hammer	2.99
1001	Samir Nadoy	123 Elm Pl.	Wrench	4.25

- **Graph databases**, which store entities as nodes with links to define relationships between them.



Transactional data workloads

A transactional data processing system is what most people consider the primary function of business computing. A transactional system records *transactions* that encapsulate specific events that the organization wants to track. A transaction could be financial, such as the movement of money between accounts in a banking system, or it might be part of a retail system, tracking payments for goods and services from customers. **Think of a transaction as a small, discrete, unit of work.**

Transactional systems are often high-volume, sometimes handling many millions of transactions in a single day. The data being processed has to be accessible **very quickly**. The work performed by transactional systems is often referred to as Online Transactional Processing (OLTP).



OLTP solutions rely on a database system in which data storage is optimized for both read and write operations in order to support transactional workloads in which data records are created, retrieved, updated, and deleted (often referred to as **CRUD** operations). These operations are applied transactionally, in a way that ensures the **integrity of the data stored in the database**. To accomplish this, OLTP systems enforce transactions that support so-called ACID semantics:

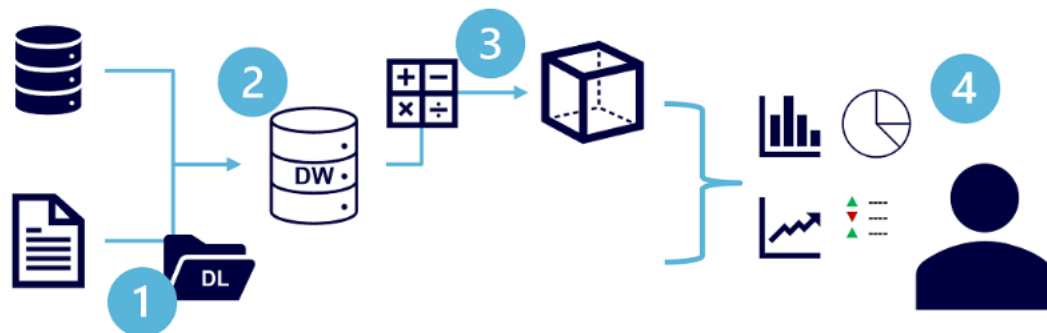
- **Atomicity** – each transaction is treated as a single unit, which succeeds completely or fails completely. For example, a transaction that involved debiting funds from one account and crediting the same amount to another account must complete both actions. If either action can't be completed, then the other action must fail.
- **Consistency** – transactions can only take the data in the database from one valid state to another. To continue the debit and credit example above, the completed state of the transaction must reflect the transfer of funds from one account to the other.
- **Isolation** – concurrent transactions cannot interfere with one another, and must result in a consistent database state. For example, while the transaction to transfer funds from one account to another is in-process, another transaction that checks the balance of these accounts must return consistent results - the balance-checking transaction can't retrieve a value for one account that reflects the balance *before* the transfer, and a value for the other account that reflects the balance *after* the transfer.
- **Durability** – when a transaction has been committed, it will remain committed. After the account transfer transaction has completed, the revised account balances are persisted so that even if the database system were to be switched off, the committed transaction would be reflected when it is switched on again.

OLTP systems are typically used to support live applications that process business data - often referred to as *line of business* (LOB) applications.

Analytical data workloads

Analytical data processing typically uses read-only (or read-*mostly*) systems that store vast volumes of historical data or business metrics. Analytics can be based on a snapshot of the data at a given point in time, or a series of snapshots.

The specific details for an analytical processing system can vary between solutions, but a common architecture for enterprise-scale analytics looks like this:



1. Data files may be stored in a central data lake for analysis.
2. An extract, transform, and load (ETL) process copies data from files and OLTP databases into a data warehouse that is **optimized for read activity**. Commonly, a data warehouse schema is based on *fact* tables that contain numeric values you want to analyze (for example, sales amounts), with related *dimension* tables that represent the entities by which you want to measure them (for example, customer or product),
3. Data in the data warehouse may be aggregated and loaded into an online analytical processing (OLAP) model, or *cube*. Aggregated numeric values (*measures*) from fact tables are calculated for intersections of *dimensions* from dimension tables. For example, sales revenue might be totaled by date, customer, and product.
4. The data in the data lake, data warehouse, and analytical model can be queried to produce reports, visualizations, and dashboards.

Data lakes are common in modern data analytical processing scenarios, where a large volume of file-based data must be collected and analyzed.

Data warehouses are an established way to store data in a relational schema that is optimized for read operations – primarily queries to support reporting and data visualization. The data warehouse schema may require some **denormalization** of data in an OLTP data source (introducing some duplication **to make queries perform faster**).

An OLAP model is an aggregated type of data storage that is optimized for analytical workloads. Data aggregations are across dimensions at different levels, enabling you to *drill up/down* to view aggregations at multiple hierarchical levels; for example to find total sales by region, by city, or for an individual address. Because OLAP data is pre-aggregated, queries to return the summaries it contains can be run quickly.

Different types of user might perform data analytical work at different stages of the overall architecture. For example:

- Data scientists might work directly with data files in a data lake to explore and model data.
- Data Analysts might query tables directly in the data warehouse to produce complex reports and visualizations.
- Business users might consume pre-aggregated data in an analytical model in the form of reports or dashboards.

Summary

Data is at the core of most software applications and solutions. It can be represented in many formats, stored in files and databases, and used to record transactions or to support analysis and reporting.

In this lesson you've learned how to:

Identify common data formats Describe options for storing data in files Describe options for storing data in databases Describe characteristics of transactional data processing solutions Describe characteristics of analytical data processing solutions