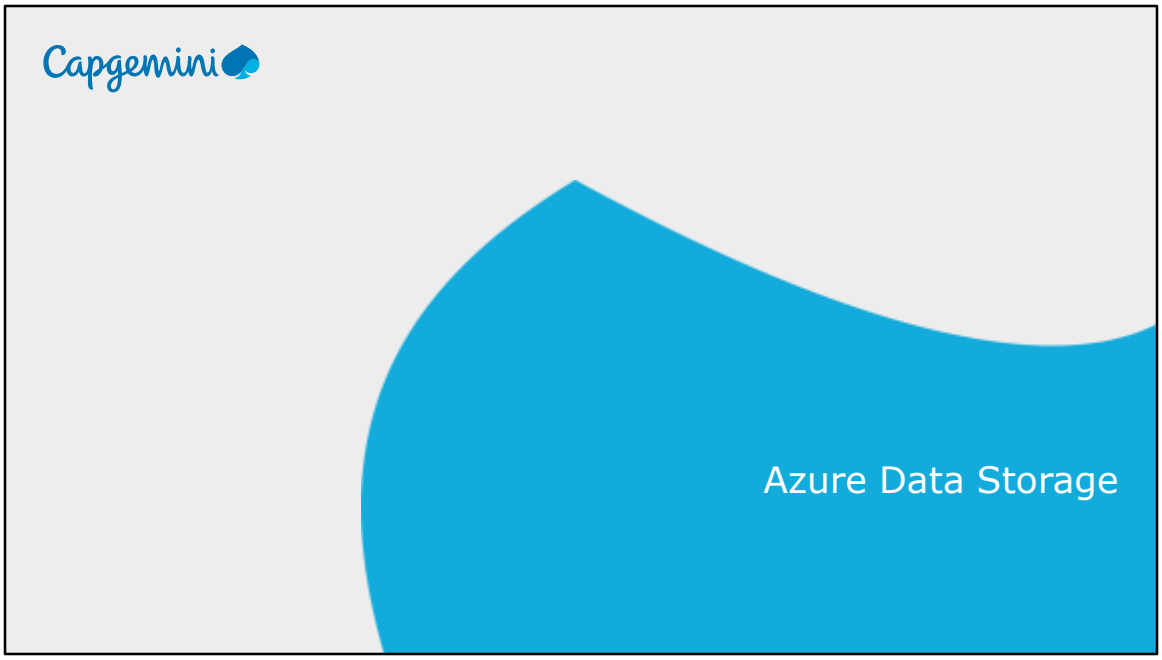
Capgemini
Azure Data Storage

Lesson Objectives

At the end of this module you will be able to:

- ✓ Store and retrieve data from Azure Relational databases like SQL database, MySQL
- ✓ Understand the fundamentals of NoSQL
- ✓ Store and retrieve data from Cosmos DB using Multi Model Api
- ✓ Store and retrieve data from Azure Storage

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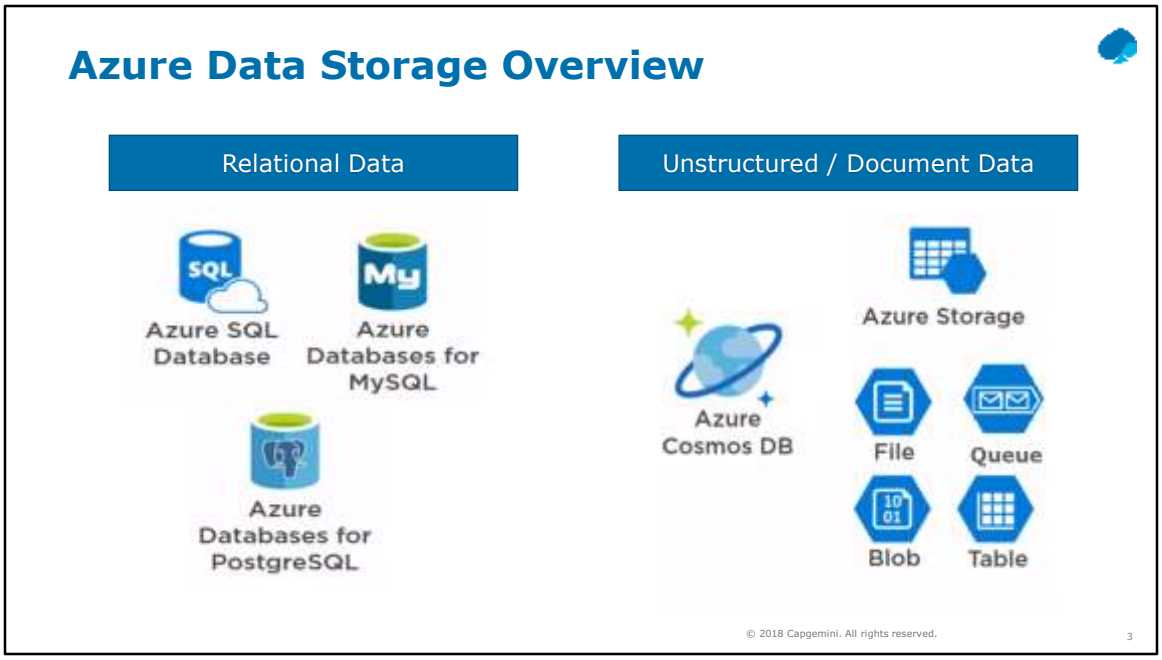

Database as a Service is a public cloud offering defined by 3 fundamental characteristics.

1. The service provider owns and manages the database software, common administration tasks like backups and high availability, the operating system, hypervisors, and bare metal hardware
2. The service users pay according to their usage of the service. There is no upfront expense or contract lock-in unless the user wants it.
3. Users can scale up or down on demand and also create and destroy environments on demand with no provider intervention.

Azure Relational Data Overview

Azure SQL Database is a relational database-as-a service using the Microsoft SQL Server Engine. SQL Database is a high-performance, reliable, and secure database. Data-driven applications and websites can be built in the programming language of choice, without needing to manage infrastructure

Azure Database for MySQL is a relational database service based on the open source MySQL Server engine. It is a fully managed database as a service offering capable of handing mission-critical workload with predictable performance and dynamic scalability.

Azure Database for PostgreSQL is a relational database service based on the open source Postgres database engine. It is a fully managed database as a service offering capable of handling mission-critical workloads with predictable performance, security, high availability, and dynamic scalability

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Develop applications with Azure Database for MySQL & PostgreSQL leveraging the open source tools and platform of your choice

Azure SQL Database

- Azure SQL Database is a relational database service in the cloud based on the market leading Microsoft SQL Server engine, with mission critical capabilities. SQL database delivers predictable performance, scalability with no down time, business continuity and data protection.

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Billing model
The service is paid by the hour. The hourly rate is based on the highest service tier selected during that hour.
The service tier determines the size, performance, features and recovery characteristics of the database

Database Transaction Unit
A DTU is a unit of measure of the resources that are guaranteed to be available to an Azure SQL database at a specific performance level.

Azure SQL Database (PaaS) vs (IaaS)

Azure SQL Database	SQL server on Azure VMs
Azure SQL database is optimized for software as a service (SaaS) app development.	SQL server on Azure virtual machines is optimized for migrating existing SQL server application
SQL License is included in pay as you go price	Either use pay as you go for a SQL server license or use an existing license
No management of underlying operating system and configuration settings	Customized environment with full administrative rights
Near to zero administrative effort	Administration effort will be needed
Total cost of application = Highly minimized administration costs + software development costs + SQL Database service costs	Total cost of application = Highly minimized software development cost + administration costs + SQL Server and Windows Server licensing costs + Azure Storage costs

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Azure SQL Purchasing Models

- Azure SQL Database delivers dynamically scalable performance within two different purchasing models
  - DTU-based purchasing model
    - Basic, Standard and Premium Tiers
  - vCore-based purchasing model (preview).
    - General Purpose and Business Critical
- We can move from a lower tier to a higher one and vice versa at any point in time.
- Performance is measured in Database Transaction Units (DTUs).

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Database Transaction Unit
A DTU is a unit of measure of the resources that are guaranteed to be available to an Azure SQL database at a specific performance level.

For a single database, use service tiers to increase or decrease the performance.

Basic: Good for small database that doesn't have multiple concurrent requests. Performance predictability is at hour by hour.

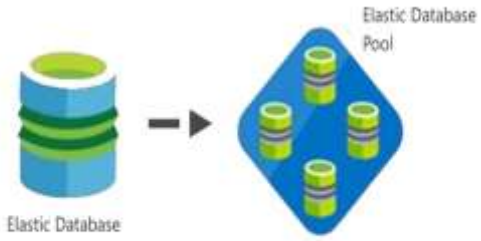
Standard: Ideal for databases that have multiple concurrent requests like web applications. Performance predictability is at minute by minute.

Premium: The Premium service tier provides predictable performance, second over second, for each Premium database.

Billing model
The service is billed by the hour, based on the service tier of the database.

Elastic Database Pool

- Pools are well suited for a large number of databases with a pattern of low average utilization with relatively infrequent utilization spikes.
- The more databases you can add to a pool the greater your savings become.



Predictable model for deploying large numbers of databases

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- Elastic pools are pools of databases where you can allocate performance at pool level and pay for the collective performance rather the individual database.

- In SQL database, the relative measure of database's ability to handle resource demands is expressed in Database Transaction Units (DTUs) for single databases and elastic DTUs for elastic databases in an elastic pool.

- A pool is given a set number of eDTUs, for a set price. Within the pool, individual
- databases are given the flexibility to auto-scale within set parameters.

- Additional eDTUs can be added to an existing pool without any database downtime. Databases can be added & removed from the pool.

- With in the pool, management tasks are simplified by running scripts in elastic jobs. An elastic job allows you to execute T-SQL scripts that span multiple databases.

Azure SQL Database Security

Connection Security	Firewall rules can be used by both server and database to reject connection attempts from IP addresses that have not been explicitly whitelisted. Also, all connections to Azure SQL Database requires encryption at all times while data is in transit to and from database.
Authentication	Supports two types of authentication. SQL Authentication, which uses a username and password. Azure Active Directory Authentication which uses identities managed by Azure Active Directory.
Authorization	Authorization can be achieved by using Database roles, granular permission, row level security, data masking etc.
Encryption	Data can be protected at rest using Transparent Data Encryption. Even a cell-level encryption can be applied
Auditing	SQL Database Auditing allows you to record events in your database to an audit log in your Azure Storage account

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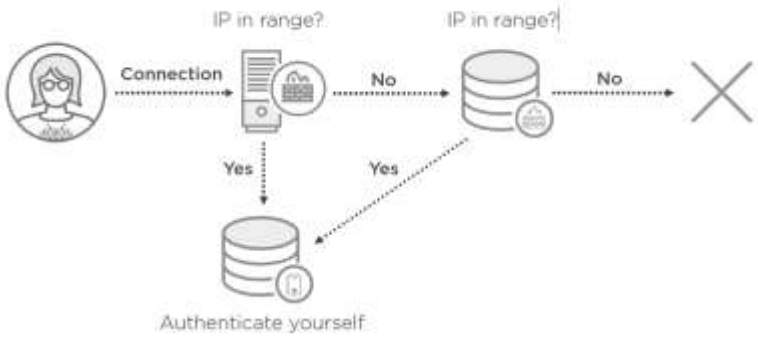
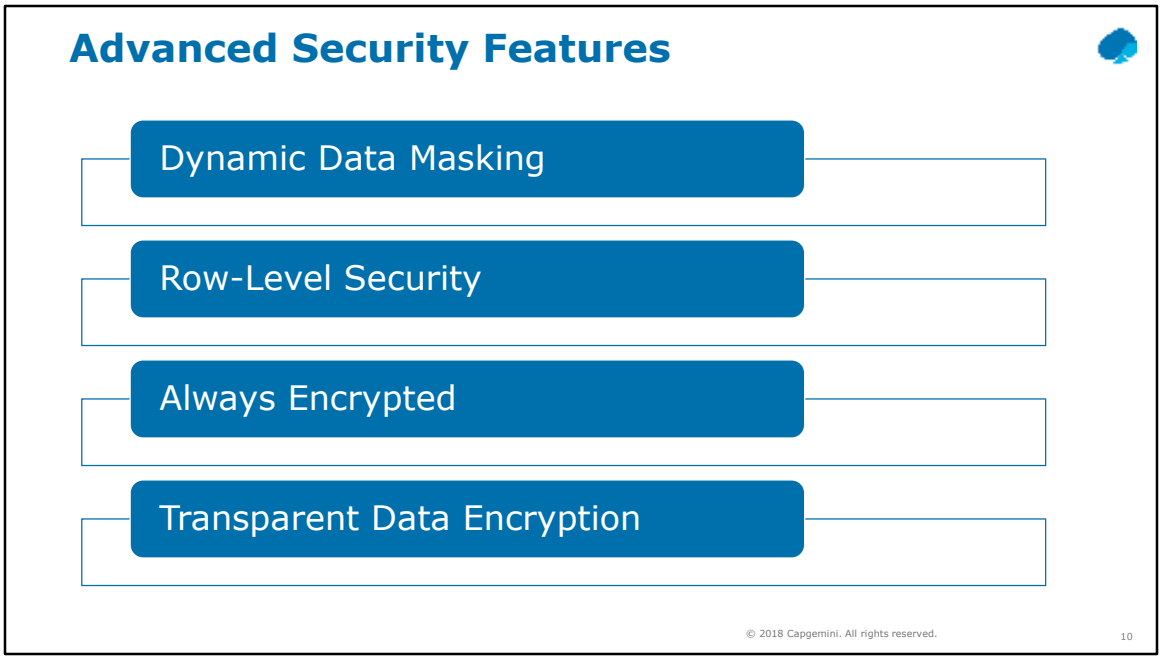
Firewall Settings

- Use database-level firewall rules to enhance security and to make your database more portable
- Use server-level firewall rules for administrators and when you have many databases that have the same access requirements

Authentication

SQL Authentication	Azure AD Authentication
Individual accounts only	Individual and group accounts
Multi-server access requires multiple users	One identity can be granted access to multiple servers
No built-in password expiration	Password expiration follows the AAD policy





Dynamic Data Masking

- Can limit access to sensitive data by controlling how data appears
- Masking rules can be defined on particular columns

Row-level Security

- Restrict row-level access based on a user's identity
- Access restriction logic is located in database tier

Always Encrypted

- Encrypt data inside client applications and not reveal encryption keys to Database Engine
- Ensure sensitive data never appears as plaintext inside the system
- Only systems that have access to keys can access plaintext data
- Encryption keys are stored in Azure Key Vault

Transparent Data Encryption

- Real-time encryption and decryption of database, backups, and transaction log files at rest
- Encrypts storage using a symmetric key
- Azure SQL Database does not support Azure Key Vault integration with TDE

Scalability

- Azure SQL Database is a flexible Platform as a service database that can be easily scaled to fit your needs.
- Azure SQL Database supports two types of scaling:
  - Vertical scaling: where you can scale up or down the database by adding more compute power.
  - Horizontal scaling: where you can add more databases and to shard your data into multiple database nodes.

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You can add more compute or storage to satisfy your performance requirements without waiting for new hardware or migrating data to more powerful machines. Azure enables you to change performance characteristics of your database on the fly and assign more resources when needed or release the resources when they are not needed in order to decrease the cost.

Sharding is technique to distribute large amounts of identically structured data across a number of independent databases. This type of technique is popular with cloud developers creating Software as a Service (SSAS) offerings for end customers or business.

Single tenant sharding pattern
For each tenant, a separate database will becreated. Each database will be associated with a specific tenant ID value and it is application responsibility

Multi-tenant sharding pattern
In this pattern, rows in the database table are all designed to carry a key identifying the tenant ID or sharding key.

Geo Replication

- Geo-replication is a type of data storage replication in which the same data is stored on servers in multiple distant physical locations
- Geo-replication typically works in this fashion: data is created or updated in a primary location and then asynchronously replicated to a secondary location so that the same data exists (and is backed up) in both locations. Ideally, these locations remain completely independent of each other, with no need to communicate with one another beyond data transfer.

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Available in Basic, Standard, and Premium tiers
Provides a readable replica database (secondary) in a different region
Can replicate to any size within performance tier
Estimated Recovery Time (ERT) < 30s with a Recovery Point Objective (RPO) < 1h

Backups & Recovery

- Azure SQL Database offers service managed backups and restores.
  - Backups happen automatically as part of the service.
  - Backups are Geo-Replicated
  - Backup retention depends on service tier.
- Restores can be done to the logical server hosting the database or to another region.

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Database backups

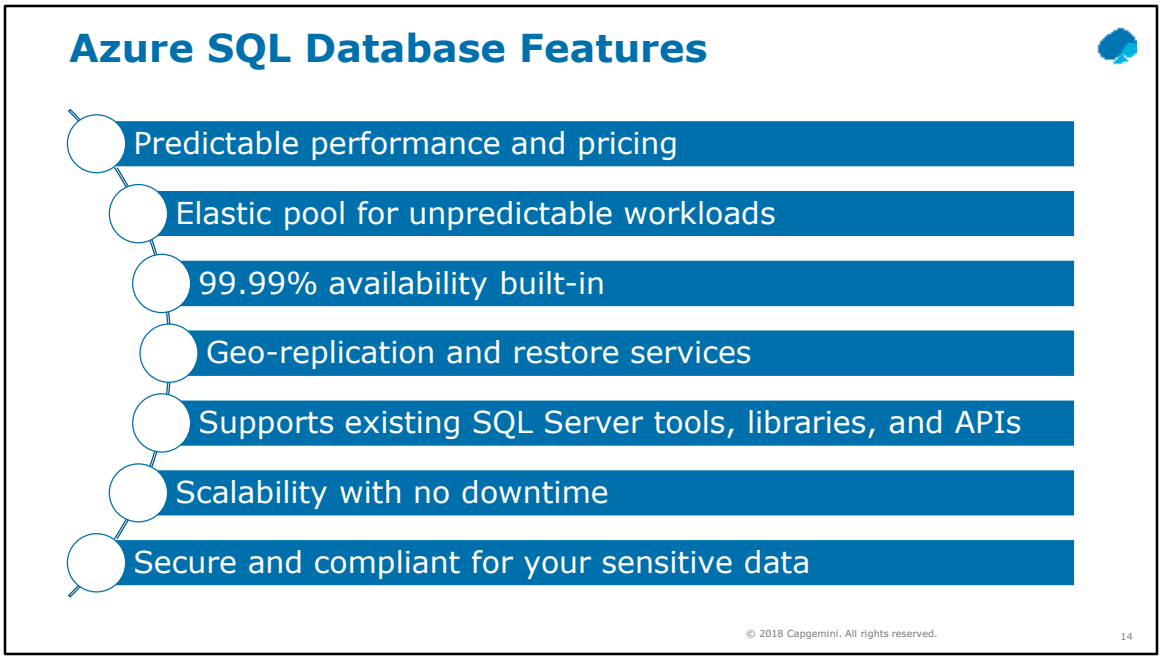
SQL Database automatically performs a combination of full database backups weekly, differential database backups hourly, and transaction log backups every five minutes to protect your business from data loss. These backups are stored in locally redundant storage for 35 days for databases in the Standard and Premium service tiers and seven days for databases in the Basic service tier. In most cases recovery time of less than 12 hours.

Active Geo-Replication

This is to configure the database to have up to four readable secondary databases in the regions of your choice. These databases are kept synchronized with the primary database using an asynchronous replication mechanism. You can quickly promote one of these secondary databases into primary in the event of unexpected failure.

Restore the database

Use the automated backups to recover a copy of data. Once a copy is recovered, either replace the original database with the restored database or copy the needed data from restored data into the original database. If database uses active geo-replication, later is recommended.



Database Transaction Unit

A DTU is a unit of measure of the resources that are guaranteed to be available to an Azure SQL database at a specific performance level.

SQL Data Warehouse

- Azure SQL Data Warehouse is a massively parallel processing (MPP) cloud-based, scale-out, relational database capable of processing massive volumes of data
- Azure SQL Database is optimized for doing CRUD operations where as Azure SQL Data Warehouse is optimized for performing data analytics tasks.
- SQL DW has 12 different pricing tiers and uses Data Warehouse Units (DWU) to specify the performance level

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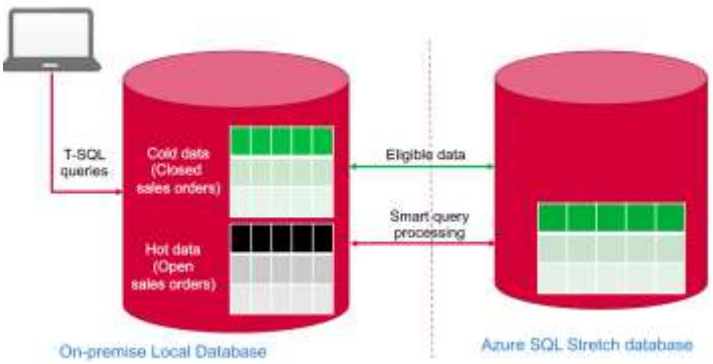
Massively parallel processing architecture – In this architecture, requests are received by the control node, optimized and passed on to the compute nodes to do work in parallel. SQL data warehouse stores the data in Premium locally redundant storage, and linked to compute nodes for query extraction.

Azure SQL Database is optimized for doing CRUD operations (Create, Read, Update and Delete) that you typically perform from an application. This is also called OLTP (Online Transaction Processing). This is reflected by the functionality that it offers, which is typically used when you are building applications. Azure SQL Database also scales for OLTP, as different pricing tiers typically scale to give you more query throughput and not so much data (the current maximum is 1TB, and in some regions 4TB).

Azure SQL Data Warehouse is optimized for performing data analytics tasks, and working with large amounts of data. This is also called OLAP (Online Analytical Processing). Data Warehouse is optimized for OLAP because it is built on top of the MPP (Massive Parallel Processing) architecture, and because it can hold massive amounts of data (currently the maximum is around 1PB) – much more than Azure SQL Database can store in one instance.

SQL Server Stretch Database

- Stretch Database migrates your cold data transparently and securely to the Microsoft Azure Cloud.



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How Stretch Database work

Enable Stretch Database for a SQL server instance at a database or table level. Once enabled, Stretch database will start migrating the cold data into the cloud

- If you store cold data into a separate table then you can migrate entire table
- If your table contains both hot and cold data, you can specify a filter function to select rows to migrate.

Existing queries will not be impacted because SQL server provides seamless access to both onsite and cloud data. If query includes cold data, you might experience latency because of remote data retrieval.

You can pause data migration at any point of time to troubleshoot problems.

Stretch Database are best suited for transaction databases with large amounts of cold data typically stored in small tables

Azure Database for MySQL

- MySQL in the Cloud
- Relational Database
- Managed and Scalable
- Highly available (99.99%) and redundant
- Works well with LAMP Stack
  - Linux, Apache, MySQL and PHP
- Use it with tools for MySQL
  - MySQL Workbench and SQLyog

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Azure Database for PostgreSQL

- PostgreSQL in the Cloud
- Relational Database
- Managed and Scalable
- Highly available (99.99%) and redundant
- Write functions in several languages
  - Use PostgreSQL extensions
- Use it with tools for PostgreSQL

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NoSQL Introduction

- Modern application produces huge volumes of data which is un-structured, semi-structured and un-predictable
- RDBMS is designed to maintain structured data up to certain limit
- NoSQL is a Non-relational database management system.
- NoSQL stands for **N**ot **O**nly **SQL**

NoSQL Databases

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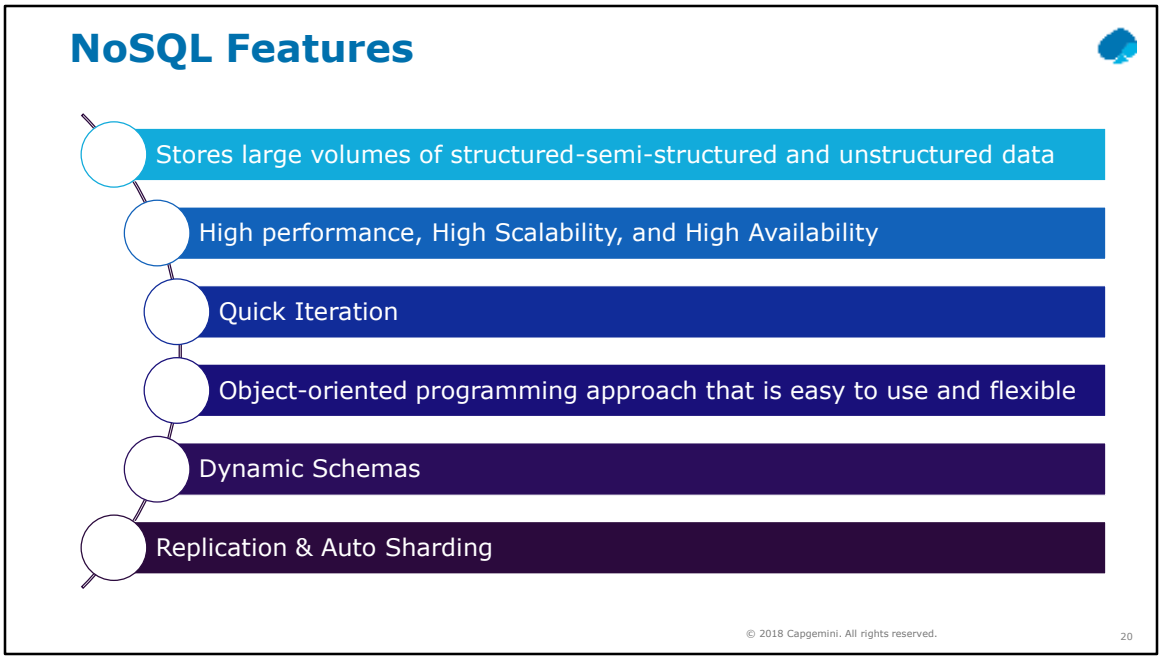

Distributed
Replicas ensure high throughput/availability, and low latency

Scale-out
Horizontal partitioning enables virtually limitless storage and throughput

Schema-free
Supports Document, table, graph, and columnar data models

NoSQL Databases

Key-Value Stores

Redis, Dynamo, Riak

Column-oriented

BigTable, Cassandra, Simple DB, HBase

Graph

OrientDB, Neo4j, Titan

Document-oriented

MongoDB, CouchDB, Cosmos DB

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Introduction to Cosmos DB

- Evolution of DocumentDB
- Multi-model / Multi-API
- Virtually unlimited scale
- Turnkey global distribution

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Evolution of DocumentDB
Scalable NoSQL document database Low latency (single-digit millisecond)

Multi-model / Multi-API
No longer exclusively a document database Also supports tables, graph, and columnar

Virtually unlimited scale
Scale storage with server-side partitioning Scale throughput with variable request units

Turnkey global distribution
Point-and-click control over where your data gets geo-replicated

Cosmos DB Emulator

- Emulate Cosmos DB in a local development environment
  - Supports identical functionality as Azure Cosmos DB in the cloud
- No need for:
  - Azure subscription
  - Cosmos DB account
  - Internet connection
- Develop and test locally
  - Incur no costs
  - Deploy to the cloud when ready

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Evolution of DocumentDB
Scalable NoSQL document database Low latency (single-digit millisecond)

Multi-model / Multi-API
No longer exclusively a document database Also supports tables, graph, and columnar

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Scale storage with server-side partitioning Scale throughput with variable request units

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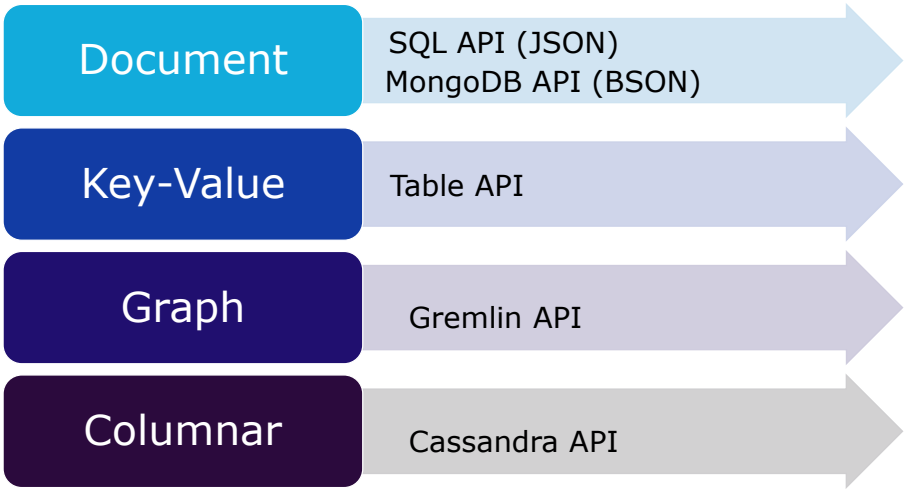
Point-and-click control over where your data gets geo-replicated

Multiple APIs and Data Models



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Azure Storage

- A basic building block in any application is data storage.
- Azure Storage provides multiple options for storing data, like files or rows of data.
- Azure Storage provides storage for data objects that is highly available, secure, durable, massively scalable, and redundant.
- All access to data objects in Azure Storage happens through a storage account.

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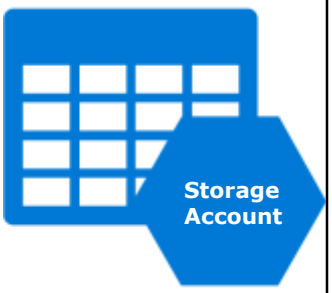
Azure Storage Account

- An Azure Storage account provides a unique namespace in the cloud to store and access your data objects in Azure Storage
- A storage account contains any blobs, files, queues, tables, and disks that you create under that account, which can be accessed through the endpoint created for the storage account.
- Configurations like geographic regions, data encryption and authentication can be carried out here.



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Storage Account name should be unique across all existing storage account names in azure

Replication Options

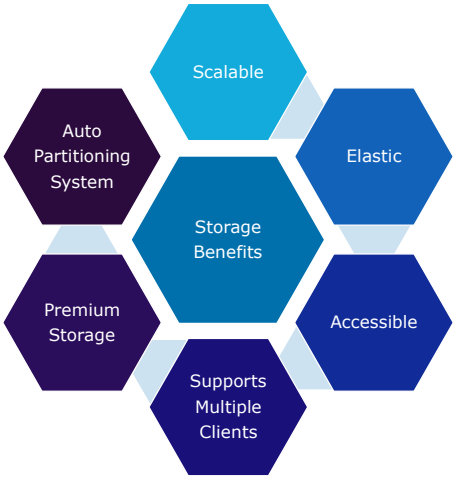
Locally Redundant Storage (LRS) : 3 copies within single data center for Premium Storage

Zone Redundant Storage (ZRS) : 3 copies across 2-3 data centers. Block blobs only; available only during SA creation

Geo Redundant Storage (GRS) : 3 copies in primary region and 3 copies in secondary region

Read-Access Geo- Redundant Storage (RAGRS) : RO access to secondary region data

Azure Storage Benefits



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Scalable
We can store and process huge amount of data which supports Bigdata scenarios

Elastic
It supports applications which targets large audience and scale those applications as needed

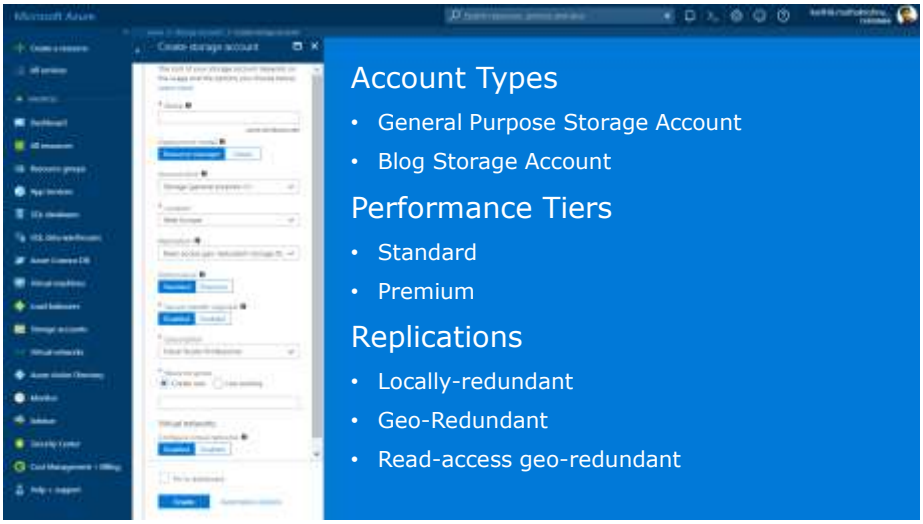
Accessible
It is accessible anywhere in the world and also for any type of application like web, desktop, mobile devices which run in the Cloud / On-Premises

Supports Multiple clients
It supports different OS and Programming languages.

Premium Storage
Delivers high performance, low latency disk support for I/O intensive workload

Autopartitioning System
Automatically load balance the data based on traffic, it will automatically allocates the resource to meet the demand of requests

Creating Azure Storage Account



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General Purpose Storage Account : Gives the access to Azure Storage services such as Tables, Queues, Files, Blobs and Azure virtual machine disks under a single account.

Blob Storage Accounts: It is a specialized storage account for storing unstructured data as blobs (objects) in Azure Storage. For applications requiring only block or append blob storage, Microsoft recommend using Blob storage accounts

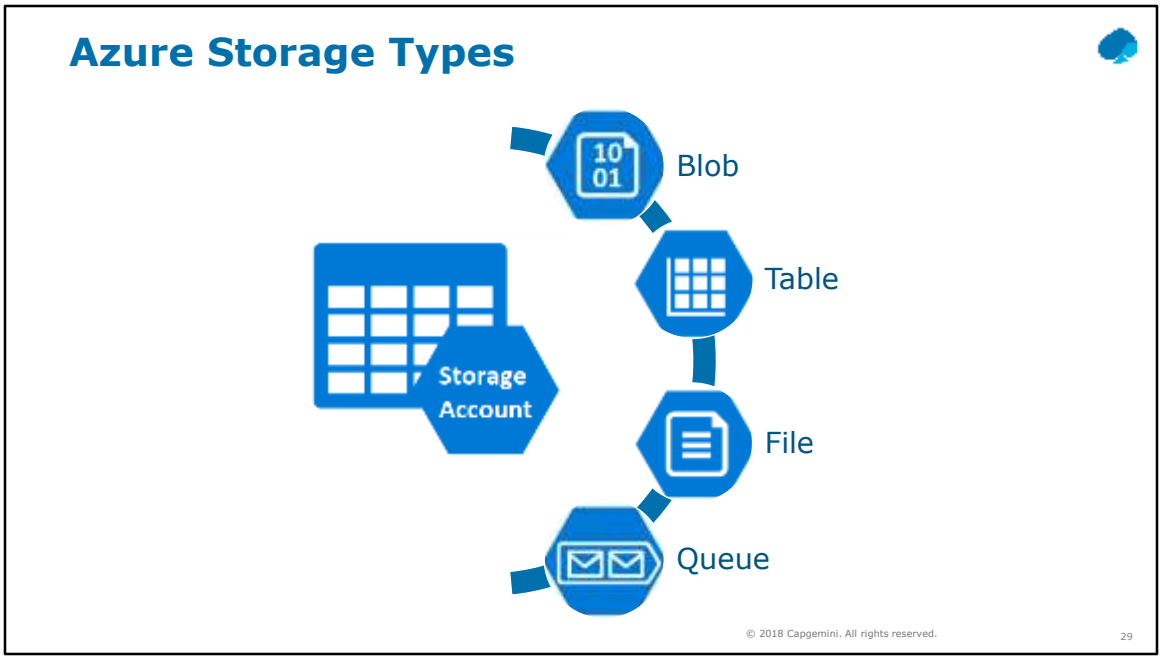
Standard Tier: A standard storage performance tier which allows you to store Tables, Queues, Files, Blobs and Azure virtual machine disks.

Premium Tier: A premium storage performance tier which currently only supports Azure virtual machine disks.

Locally-redundant: Data replicated 3 times within the storage unit which is hosted in a data center where the account is located.

Geo-Redundant: Data gets replicates into secondary region and updates in both primary and secondary region and reads from secondary region if failover happens.

Read-access geo-redundant: Same as **Geo-Redundant** but provides read only access to the data in secondary location



Every object that you store in Azure Storage has a unique URL address. The storage account name forms the subdomain of that address. The combination of subdomain and domain name, which is specific to each service, forms an endpoint for your storage account.

For example, if your storage account is named **mystorageaccount**, then the default endpoints for your storage account are:

Blob service: http://mystorageaccount.blob.core.windows.net

Table service: http://mystorageaccount.table.core.windows.net

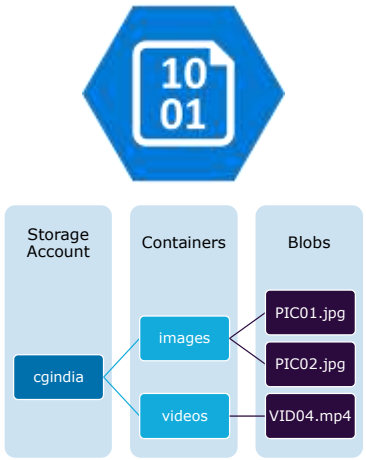
Queue service: http://mystorageaccount.queue.core.windows.net

File service: http://mystorageaccount.file.core.windows.net

Note : A Blob storage account only exposes the Blob service endpoint and it can map custom domain to the service endpoints

Azure Blob Storage

- Azure Blob(Binary Large Objects) storage can be used for storing large amounts of unstructured data such as documents, images, videos etc.
- Every blob is placed in a container
  - Security policies can be assigned to containers which will be cascaded to all objects under that container
  - Storage account can contain unlimited number of containers and each container can contain unlimited number of blobs up to the storage account size limit of 500 TB



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Naming Conventions :

A container name must be a valid DNS name, conforming to the following naming rules:

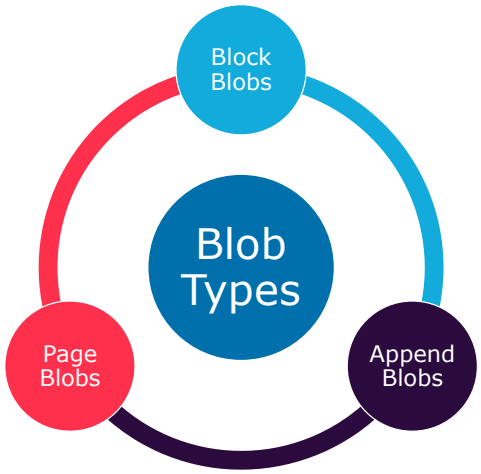
- Container names must start with a letter or number, and can contain only letters, numbers, and the dash (-) character.
- Every dash (-) character must be immediately preceded and followed by a letter or number; consecutive dashes are not permitted in container names.
- All letters in a container name must be lowercase.
- Container names must be from 3 through 63 characters long.

A blob name must conforming to the following naming rules:

- A blob name can contain any combination of characters.
- A blob name must be at least one character long and cannot be more than 1,024 characters long.
- Blob names are case-sensitive.
- Reserved URL characters must be properly escaped.
- The number of path segments comprising the blob name cannot exceed 254. A path segment is the string between consecutive delimiter characters (e.g., the forward slash '/') that corresponds to the name of a virtual directory.

Azure Blob Types

- Blob storage offers three types of blobs
  - **Block blobs** : Documents, media files and back up can be stored. Optimized for streaming and storing
  - **Append blobs** : Similar to block blobs but optimized for append operations. For instance storing logs
  - **Page blobs** : Optimized for representing IaaS disks and supports random writes
- Blob storage account supports only block and append blobs.



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Page blobs :

Page Blobs are a collection of 512-byte pages

- Optimized for Random Access and Frequent Updates
- Used as persistent disks for VMs in Azure.
- Highly performant, durable and reliable
- Can grow and shrink in size by adding or removing pages

Modifications of a page blob can overwrite one or more pages.

- Changes are in-place and immediately committed.

A page blob can be no larger than 1 TB.

A Virtual Machine network attached IaaS disk is a VHD(Virtual Hard Disk) stored as a page blob

Block Blobs :

Block Blobs are comprised of a series of blocks

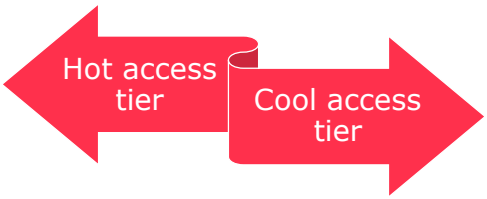
- Blocks can be uploaded in parallel sets to speed up the ingress of a large file.
- MD5 hash can be used to verify that each block is uploaded successfully and retry failed blocks.
- Progress of block upload can be tracked.
- While uploading, the blob is considered uncommitted.

Block Blobs can be no larger than 200 GB.

Note: Choice of blob type will affect the performance and scalability of your solution

Blob Storage - Access Tiers

- Blob storage accounts expose the Access Tier attribute which can be specified during account creation and modified later as needed.
  - **Hot access tier** which indicates that the objects in the storage account will be more frequently accessed. This allows you to store data at a lower access cost.
  - **Cool access tier** which indicates that the objects in the storage account will be less frequently accessed. This allows you to store data at a lower data storage cost.



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If there is a change in the usage pattern of your data, you can also switch between these access tiers at any time. Changing the access tier may result in additional charges. Refer Pricing and billing for Blob storage accounts for more details.

Azure File Storage

- Azure File Storage provides fully managed file shares in the cloud using SMB(Server Message Block) 3.0 protocol in a secured and reliable manner
- Applications running in Azure VMs or cloud services can mount a file storage share to access file data
- File share data can be accessed via Azure Portal, File Explorer, CLI and REST APIs
- Helps legacy applications that rely on file share can be migrated on Azure with no code changes.

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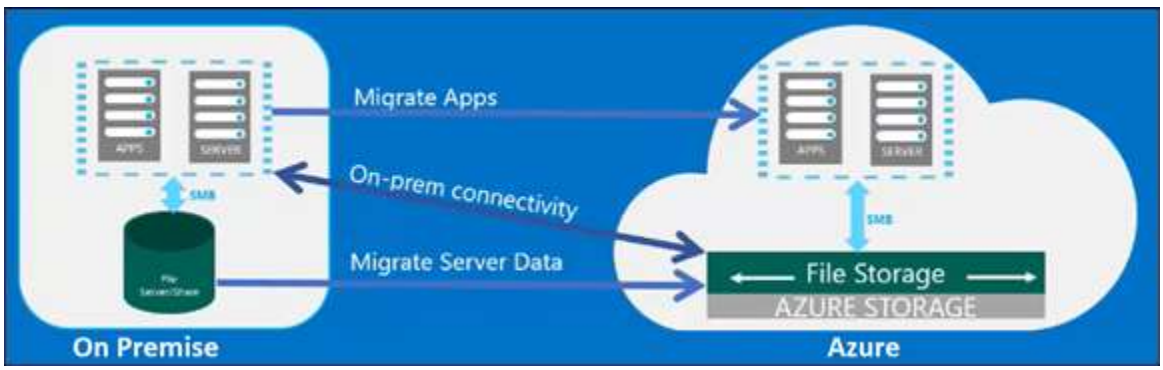
A file storage share is SMB file share in Azure. All directories and files must be created in parent share. 5TB upper limit on file share

URL Format :

https://<storageaccount>.file.core.windows.net/<share>/<directory>/<file>



Azure Table Storage

- Table storage is a service that stores structures NoSQL data in the cloud.
- It is a key/attribute store with schema less design.
- It is much faster & cheaper compared to traditional SQL Databases
- Table storage is best suited to store flexible datasets such as user data, address data, device information etc.

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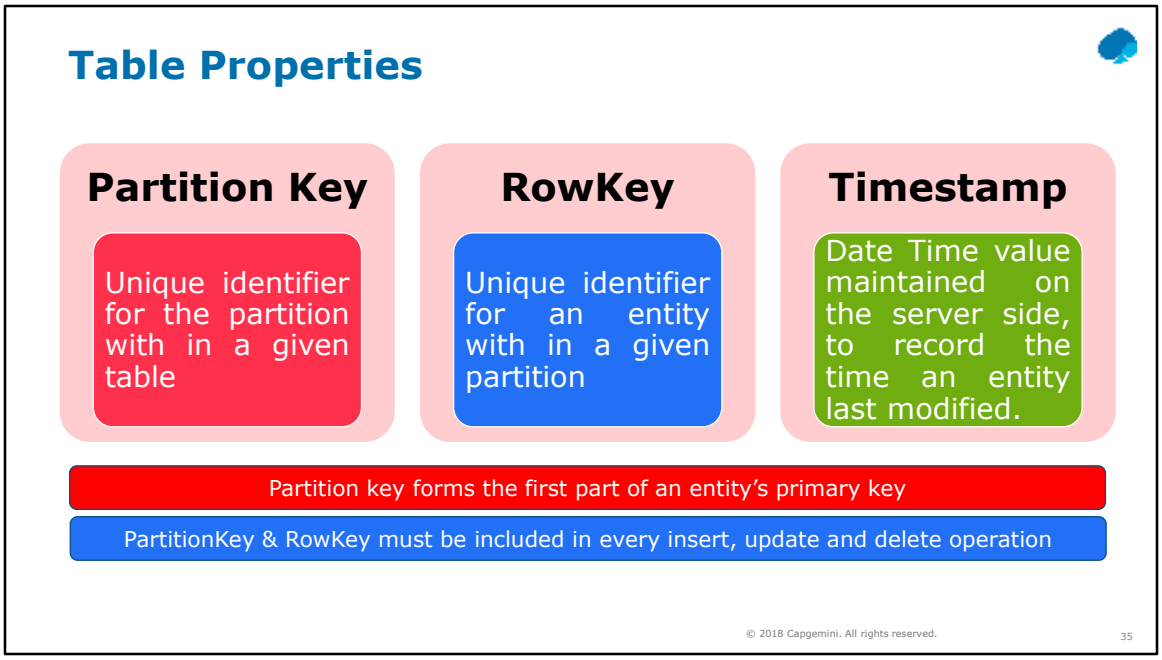
- Table is a collection of entities.
- Table don't enforce a schema on entities which means a single table can contain entities with different properties
- Entity is a set of properties similar to database row. It can be up to 1 MB of size.
- Properties is a name-value pair. Each entity can be up to 252 properties

URL Format :

http://<storageaccount>.table.core.windows.net/<table>



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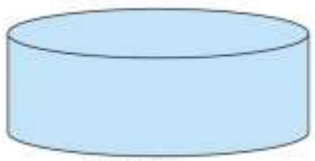
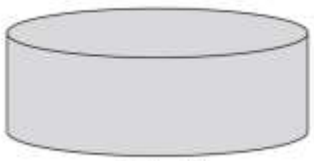
URL Format :

http://<storageaccount>.table.core.windows.net/<table>

Table Partitions

	Partition Key	Row Key	Country	Location	
A	Sogeti	SG1234	India	Bangalore	
	Sogeti	SG1234	France	Paris	
	Apps NA	NA1234	India	Mumbai	B
A	I&D	ID1234	India	Chennai	





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The account name, table name and partitionkey together identify the partition with in the storage service where as the table services stores the entity

Azure Queue

- Azure Queue storage is a service for storing large number of messages in the cloud that can be accessed from anywhere in the world using HTTP and HTTPS.
- A queue contains set of messages.
- Queue name must be in lowercase
- A single queue message can be up to 64KB in size.
- A message can remain in the queue for maximum time of 7 days.

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URL Format :

http://<storageaccount>.queue.core.windows.net/<queue>

Note

When message retrieved from the queue, it stays invisible for 30 seconds. Message need to deleted explicitly from the queue to avoid getting picked up by another application

Azure Redis Cache

- Azure Redis Cache is a distributed, managed cache that helps you build highly scalable and responsive applications by providing super-fast access to your data.
- Azure Redis Cache gives access to secure, dedicated Redis cache, managed by Microsoft. A cache created using Azure Redis Cache is accessible from any application within Microsoft Azure

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Microsoft Azure Redis Cache is available in the following tiers:

Basic
Single node. Multiple sizes up to 53 GB.

Standard:
Two-node Primary/Replica. Multiple sizes up to 53 GB. 99.9% SLA.

Premium:
Two-node Primary/Replica with up to 10 shards. Multiple sizes from 6 GB to 530 GB

A cache end point will look like this <cachename>.redis.cache.windows.net

Azure Data Factory

- Data factory is a cloud based data integration service that orchestrates and automates the movement and transformation of date.
- This service can ingest data from various data stores, transform/process the data, and publish the result data to data stores.
- Using Azure Data factory, we can
  - Ingest the data from different data sources
  - Prepare the data
  - Transform & Analyze
  - Publish the data for consumption

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Summary

- Azure SQL database is scalable database platform as a service that enables you to easily increase or remove resources in your database, offload queries to secondary nodes or implement full sharding solution.
- Blob storage is used to store Unstructured file data
- Table storage is used to NoSQL semi-structured data
- Queue storage is used by developers to Publish / subscribe messaging data between the applications
- File Storage is used by system administrators for SMB file shares

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