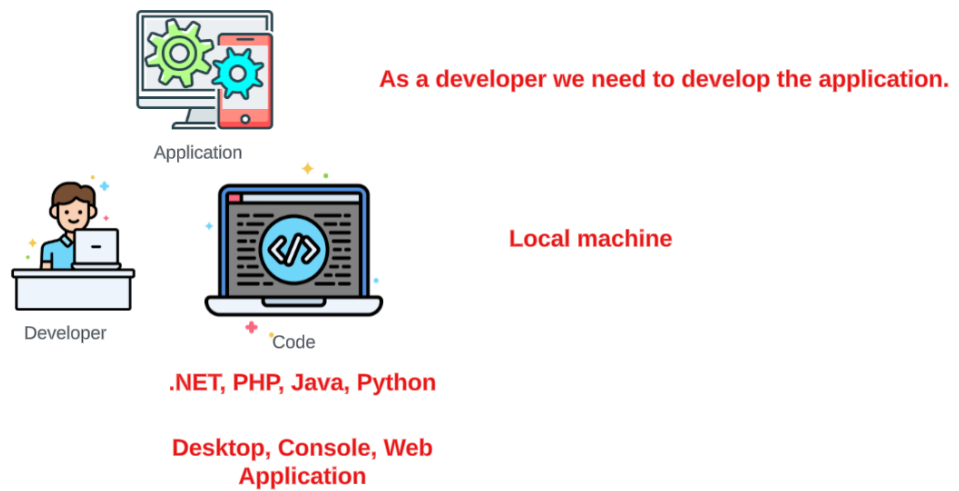


Introduction

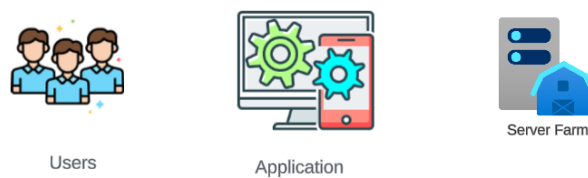
Development and using Azure services

Developing applications

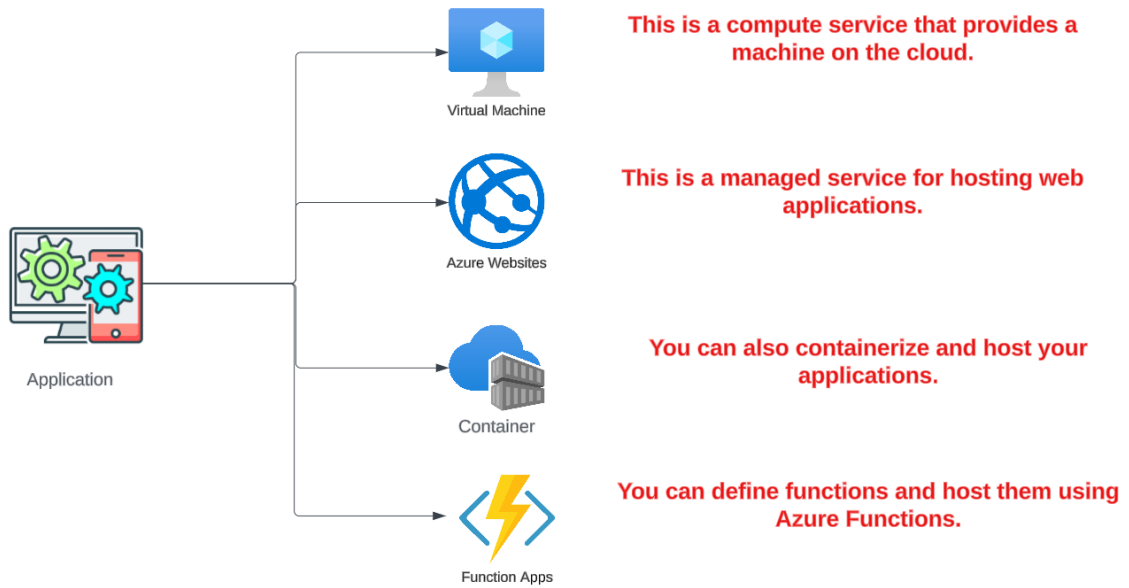
Develop Azure Compute Solutions - Containers, Functions and Web Apps



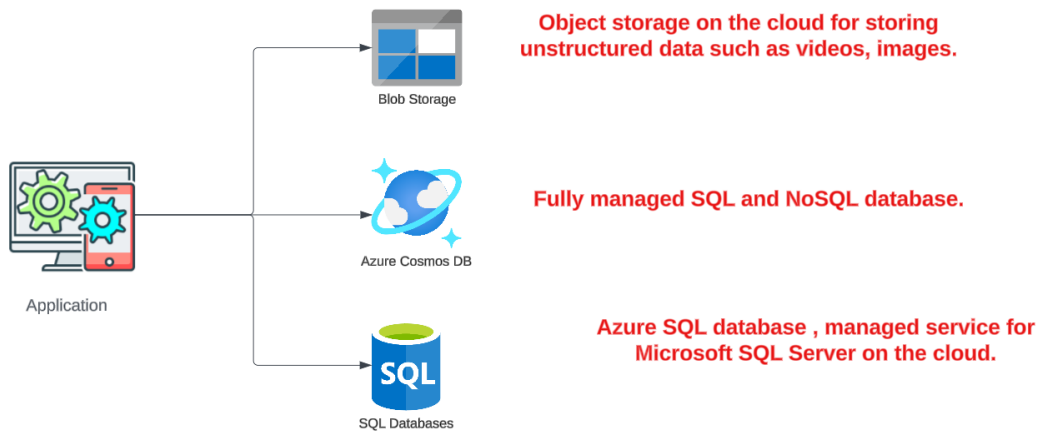
Deployment of the application



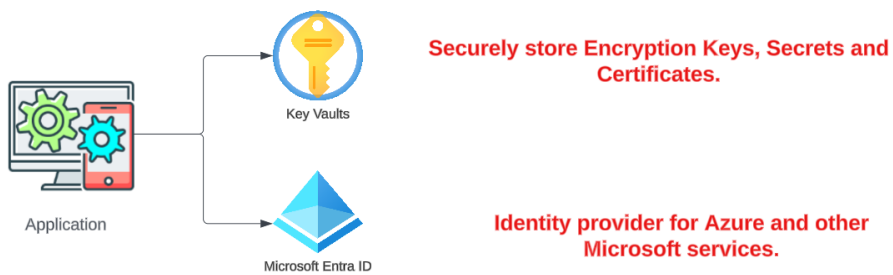
Your application needs to be deployed onto some sort of compute infrastructure.



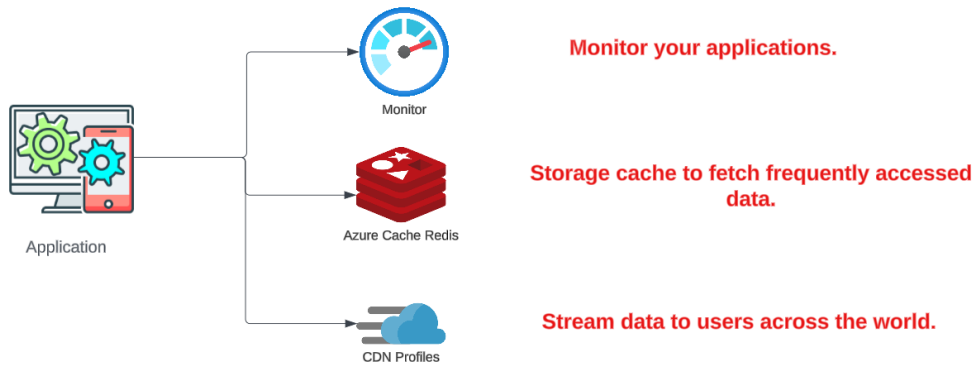
Develop for Azure Storage



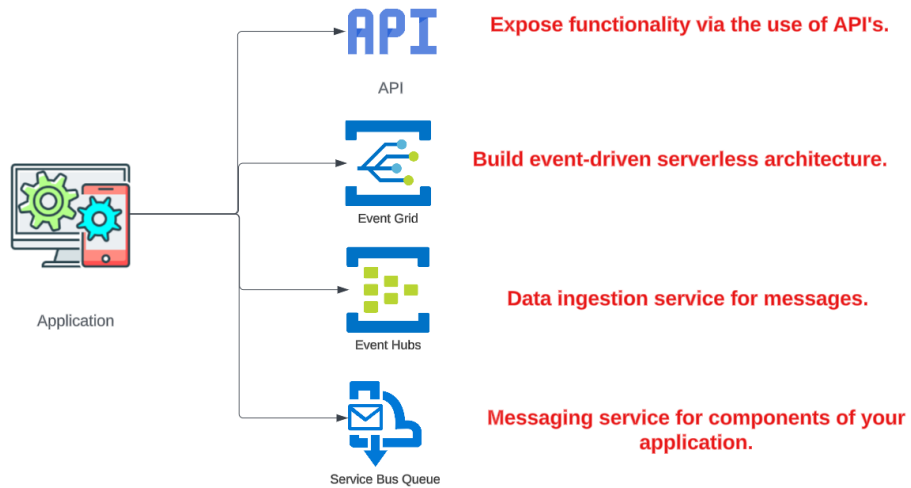
Implement Azure security



Monitor, Troubleshoot and optimize Azure solutions



Connect and Consume Azure Services and third-party services



Develop Azure compute solutions - Azure Virtual Machines

What are we going to do

ASP.NET Core 8

PHP



Application



Code

We will look at simple applications.

We will deploy these applications onto Virtual Machines.

We will use Visual Studio Code as our development tool.

What goes into deploying a virtual machine

What is the Azure Virtual Machine service

Generally what does a company need in order to host an application and make it available to users.

Buy physical servers

Buy storage

Setup a network



All of this costs money, there is an initial investment that the company needs to undertake.

Large companies will normally setup data centers. These centers contain a number of servers, storage devices, racks, cooling devices etc.

All of this is an investment from the company.

The first service we are going to look into is the Azure Virtual Machine service.



This is a compute service that allows you to host virtual machines on the Azure cloud network.

What is involved in the deployment of a virtual machine.



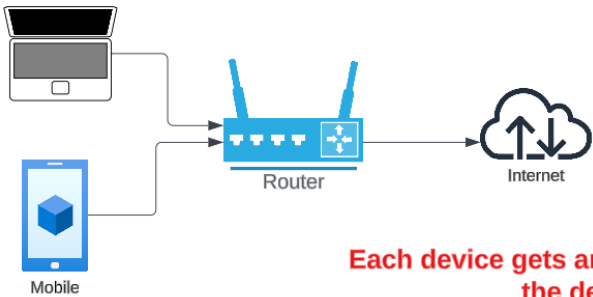
What is the size of virtual machine - number of vCPU's, RAM

What is the number and size of the disks you want allocated for the virtual machine.

What is the underlying operating system - Ubuntu, Windows Server.

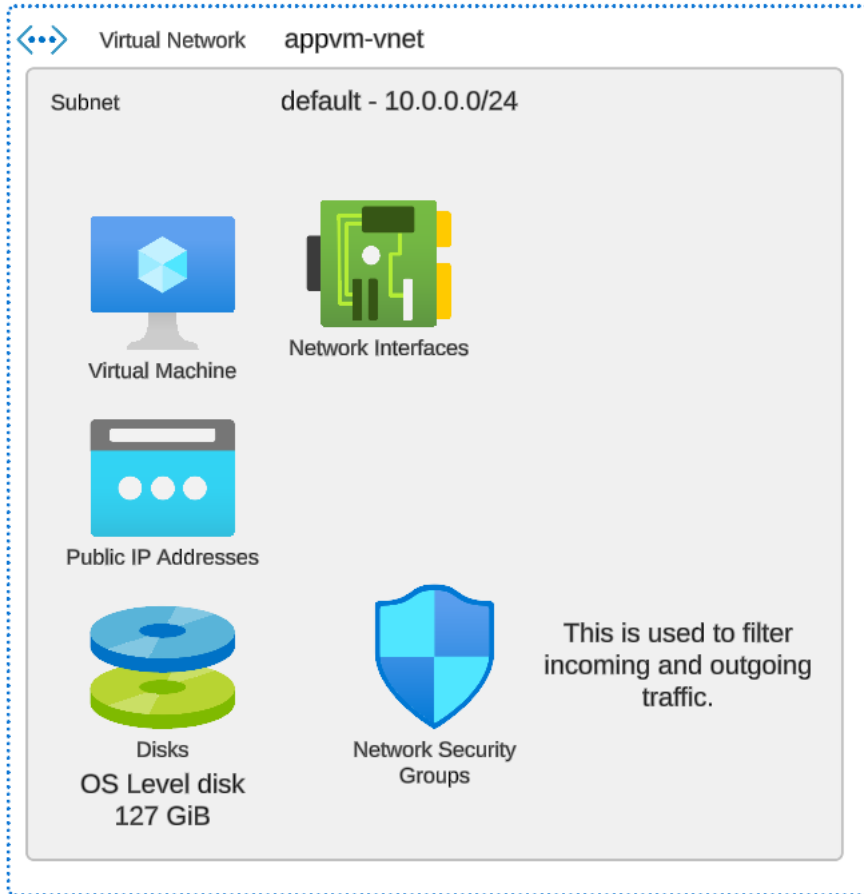


The network details for the virtual machine.

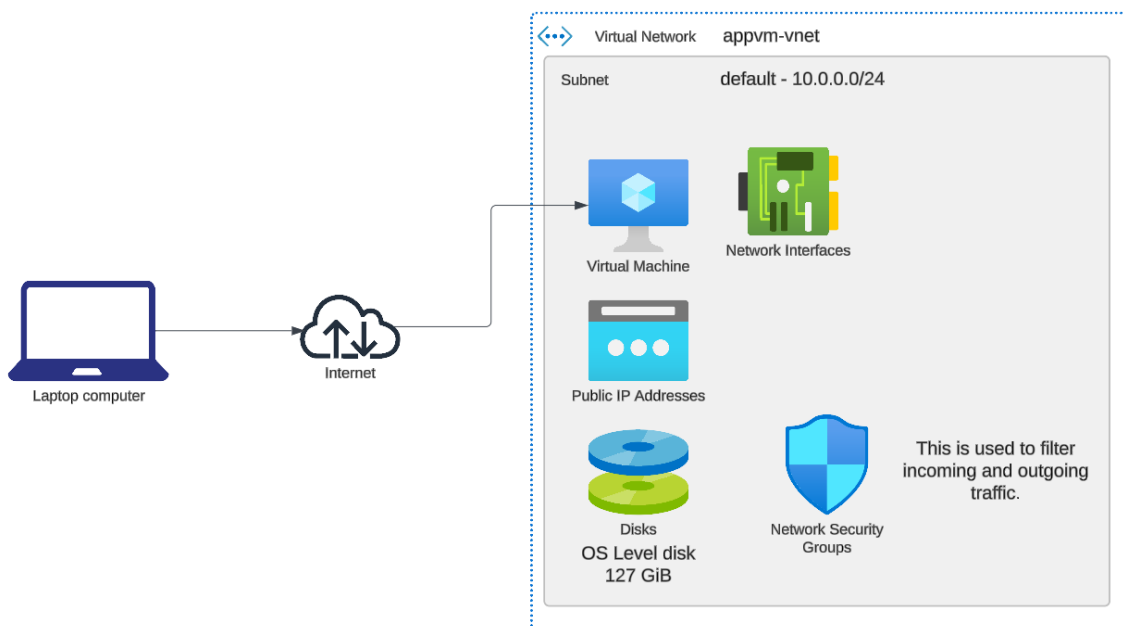


Each device gets an IP address. This helps to identify the device on the network.

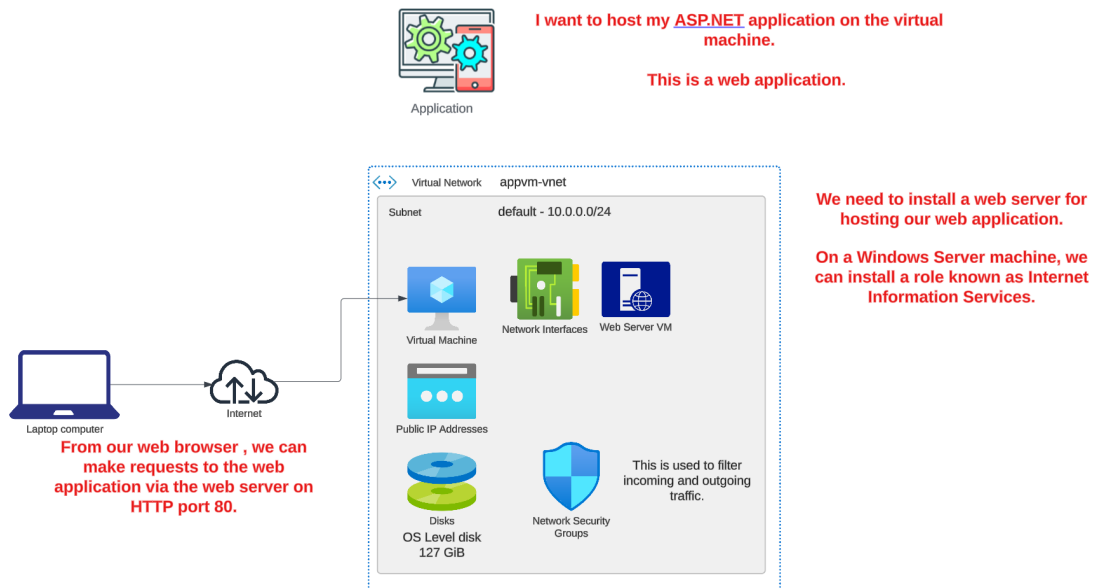
A network allows devices to communicate with each other.



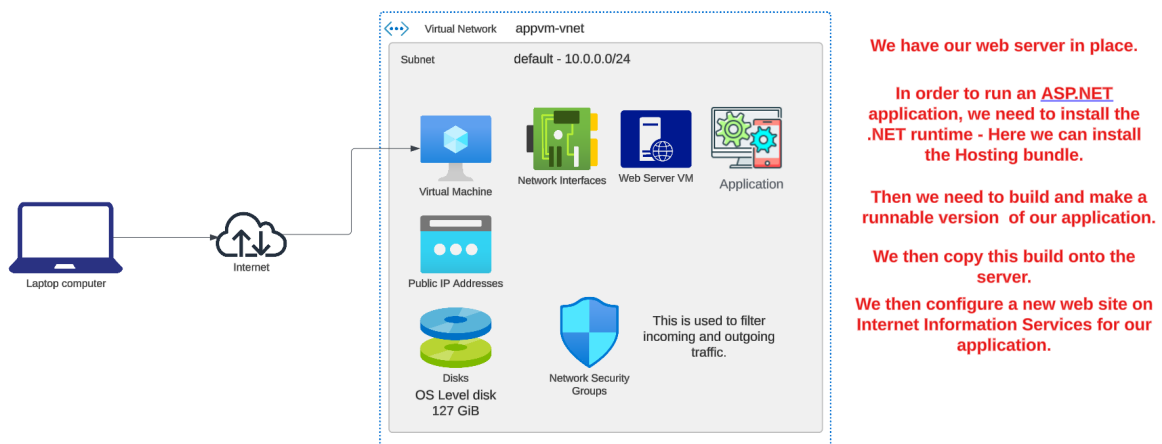
Lab - Connecting to the Virtual Machine



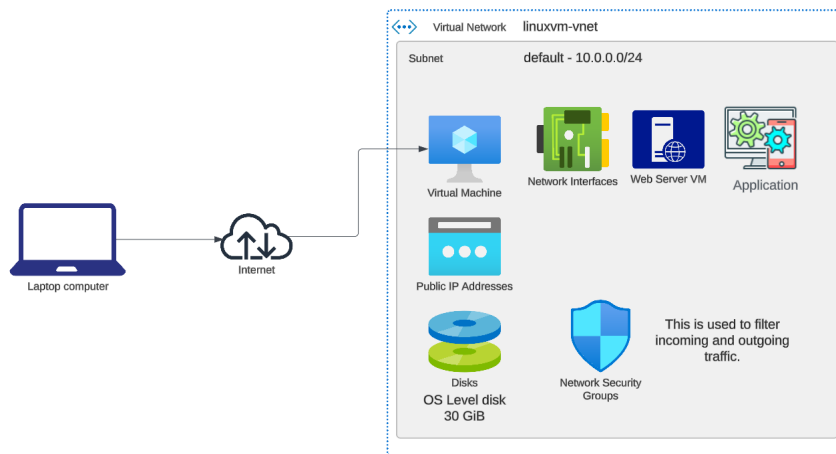
Lab - Installing Internet Information Services



Lab - Publishing our application onto the machine



Lab - Deploying a web server onto the virtual machine



We need to have a web server in place.

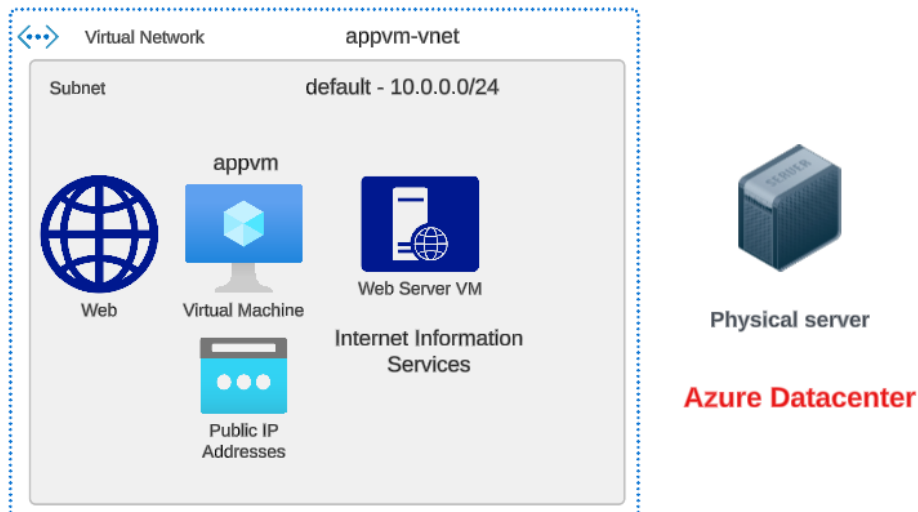
On the Linux machine, we will install the Apache Web server.

We will then use a tool to copy the files from our local system, our application onto the server.

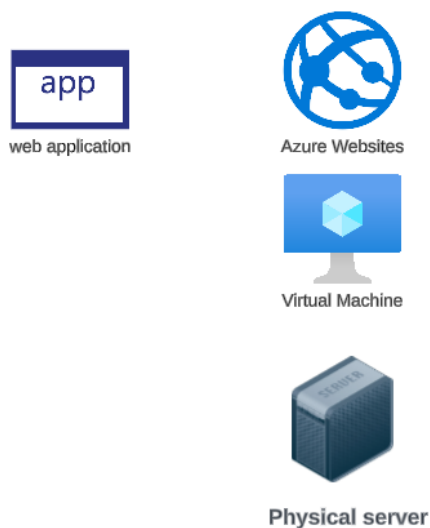
Develop Azure compute solutions - Azure Web Apps

Introduction onto Azure Web Apps

We understand the concept wherein we can host web applications on Azure virtual machines



Azure Web App Service



This is a managed service. Here the virtual machine and physical infrastructure is managed for you.

There is support for web applications based on .NET, Java, Node.js, PHP, Python.

Here the patching of the framework and the operating system is managed by the service.

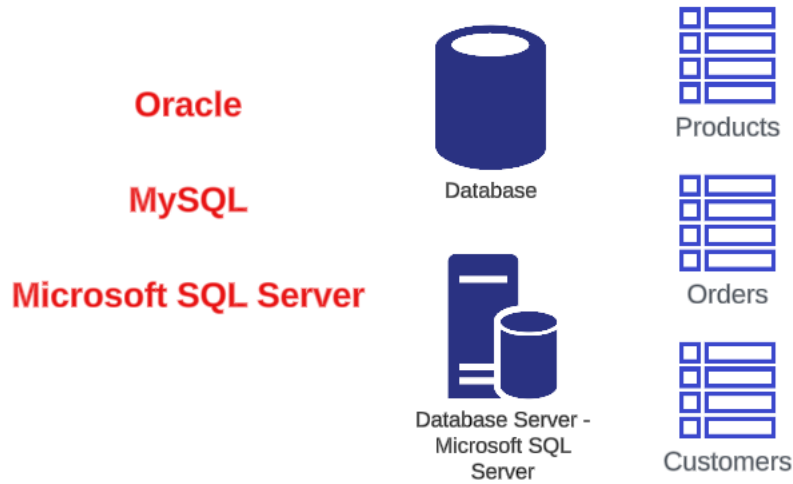
You also get other features such as High Availability.

If you have a web application that fits the framework and you don't want to manage the virtual machines, then you can opt for the Azure Web App service.

But if you need to host a custom application that needs to be installed, then you would probably need to use the Azure virtual machine service.

Lab - Azure SQL Database

Azure SQL Database



We need to install the database software on some sort of compute hardware.



We can install the database engine on a virtual machine.

Database administrator responsibilities

1. Uptime of the database server
2. Database backups and restore
3. Patch installation at the operating system and database engine level.



If the company does not want the burden of managing the underlying infrastructure, they can opt to use the Azure SQL Database service.



Virtual Machine



SQL Servers

Here the underlying server is managed for you. The database software will be in place. It also has features such as backup/restore and several other features.



SQL Databases

You can simply start hosting your databases. The Azure SQL database is the cloud version of Microsoft SQL Server.

Building an Application that connects to the SQL database

Our application hosted on an Azure Web App.



Application



SQL Database

Connects to a database hosted via the Azure SQL database service.

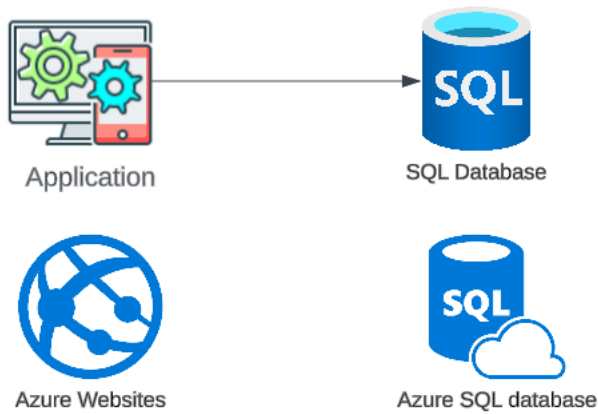


Azure Websites



Azure SQL database

What does it mean to upgrade our App Service Plan



When we create an Azure Web App, we also need to have an App Service Plan in place.

The App Service Plan decides on the features and hardware specifications available to the Azure Web App.

Web App.

Hardware view Feature view Showing 23 App Service pricing plans

Name	ACU/vCPU	vCPU	Memory (GB)	Remote Storage (GB)	Cost per hour (instance)	Cost per month (instance)
Dev/Test (For less demanding workloads)						
<input type="checkbox"/> Free F1	60 minutes/day...	N/A	1	1	Free	Free
Shared D1	240 minutes/da...	N/A	1	1	0.013 USD	9.49 USD
<input checked="" type="checkbox"/> Basic B1	100	1	1.75	10	0.075 USD	54.75 USD
Basic B2	100	2	3.5	10	0.15 USD	109.50 USD
Basic B3	100	4	7	10	0.30 USD	219.00 USD
Production (For most production workloads)						
Standard S1	100	1	1.75	50	0.10 USD	73.00 USD
Premium v3 P0V3	195*	1	4	250	0.209 USD	152.205 USD
Premium v3 P1V3	195	2	8	250	0.328 USD	239.44 USD



Application



Azure Websites



Virtual Machine

In the end the Azure Web App needs to be hosted on some sort of compute infrastructure which has CPU and Memory.

The underlying machine will be based on a desired operating system and it will have the underlying web server configured.

Hardware view Feature view

Showing 23 App Service pricing plans

Name	Custom domain	Auto Scale	Daily backups	Staging slots	Cost per hour (instance)	Cost per month (instance)
<input type="checkbox"/> Dev/Test (For less demanding workloads)						
Free F1	-	N/A	N/A	N/A	Free	Free
Shared D1	-	N/A	N/A	N/A	0.013 USD	9.49 USD
<input checked="" type="checkbox"/> Basic B1	✓	Manual	N/A	N/A	0.075 USD	54.75 USD
Basic B2	✓	Manual	N/A	N/A	0.15 USD	109.50 USD
Basic B3	✓	Manual	N/A	N/A	0.30 USD	219.00 USD
<input type="checkbox"/> Production (For most production workloads)						
Standard S1	✓	Rules	10	5	0.10 USD	73.00 USD
Premium v3 P0V3	✓	Rules	50	20	0.209 USD	152.205 USD
Premium v3 P1V3	✓	Rules, Elastic	50	20	0.328 USD	239.44 USD
Premium v3 P2V3	✓	Rules, Elastic	50	20	0.656 USD	478.88 USD
Premium v3 P3V3	✓	Rules, Elastic	50	20	1.312 USD	957.76 USD
Premium v3 P1mv3	✓	Rules	50	20	0.362 USD	263.968 USD

AutoScaling for your Azure Web App



Application

With the Basic App Service Plan or higher, you have dedicated machines that can be used to host your web apps.



Azure Websites



Virtual Machine



Virtual Machine



Virtual Machine

For the Basic App Service Plan, you can have a maximum of 3 machines running your Azure Web Apps.



Application



Application



Application



Application



Azure Websites



Azure Websites



Azure Websites



Azure Websites



App Service Plan



Virtual Machine



Virtual Machine



Virtual Machine

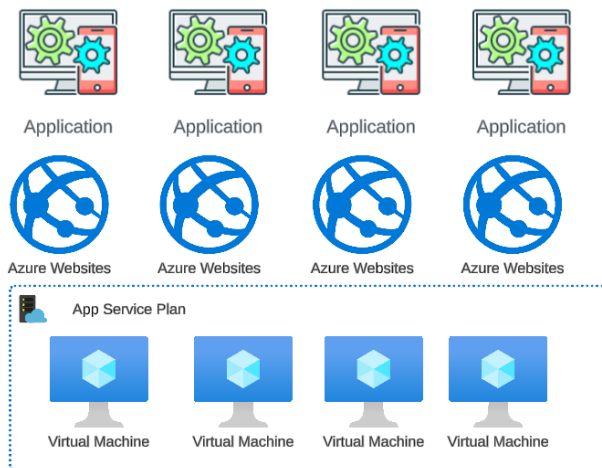
You can define multiple Azure Web Apps that can share the same App Service Plan.

With the Basic App Service Plan, you can manually scale out and scale in the number of machines running as part of your infrastructure - Remember costing of the machines are important.

With the Standard App service plan and higher, you can also configure autoscaling based on rules.

With the Premium App service plan and higher you can configure automatic scaling.

Example - Standard App Service Plan



Here we can have a maximum of 10 machines running as part of our infrastructure.

But instead of manually scaling out or scaling in, we can set rules to autoscale based on conditions.

For example, if the CPU threshold goes beyond 70%, then scale our infrastructure out by one machine. If the CPU threshold goes down, then scale down by one machine.

Deployment Slots



We have deployed our application



We now have a newer version of the application.

Now before we actually deploy the newer version of the application, we would ideally first want to test the application. At one phase, with a set of business users.



1. Create a new Azure Web App
2. Deploy the newer application
3. Test the application
4. Publish the application after successful testing to the primary Azure Web App

In Azure Web Apps , we can make use of deployment slots.



This feature is available with the Standard, Premium and Isolated App Service Plan.



Create a new slot and publish the newer version of the application to the slot.



Each slot is a live web application with its own host name.



Azure Websites



Production - Web Slots



Staging - Web Slots



Application v1



Application

Then at any point in time, you can swap the slots. So that the newer version of the application runs as part of the production slot.

This helps in first testing of the application in the staging slot and then swapping the slots at any point in time.

It also helps in recovery from failure. If the swap succeeds, but the newer version of the application is not working, you can easily swap back at any point in time.

Publishing code from a git-based repository



Normally you will have a set of developers working on an application.

During the lifecycle of the application, you can have many changes to the application itself.

For this we need to be able to maintain different versions of our application.

For this we can make use of Git which is a popular version-control software.



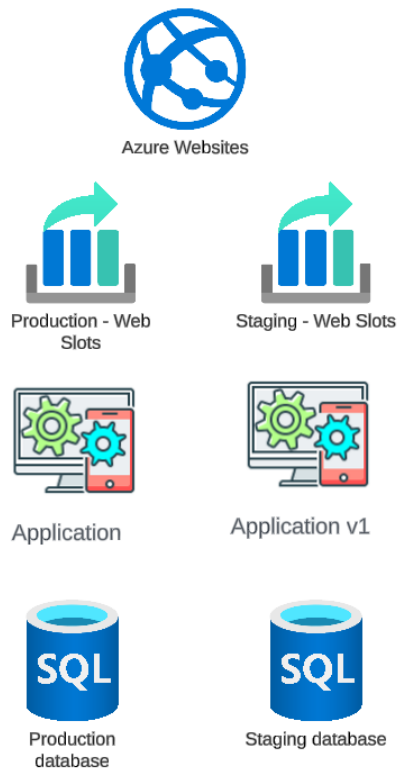
Git repository

We can also maintain the versions in an online repository on the Internet via the use of GitHub.



GitHub

Deployment slots with databases



The Staging database might just have a subset of the data from the production database.

The application version change could have or not have changes at the database level.

If there are also changes at the database level, then first we need to create a script for the database level changes.

Have a backup of the database in place.

Define a time for the entire change to take place

- 1. Swap the slots for the Azure Web App**
- 2. Apply the database changes via the use of the database scripts.**

Azure App Config



Application



Azure Websites



This is a central service that allows you to store application settings and feature flags.



Application



Virtual Machine

Here configuration data can be stored as key-value pairs.

Develop Azure compute solutions - Azure Functions

What are Azure Function Apps



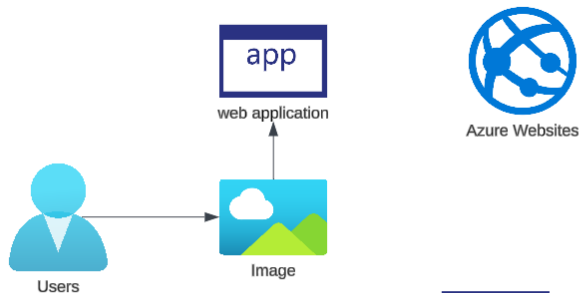
Function Apps

This is a serverless solution where the infrastructure is managed for you.

Here the underlying compute is managed for you.

What's the purpose of using Azure Functions?

There are different use cases , let's look at a use case.



An application is hosted on an Azure Web App. The application allows users to upload images.

The application is responsible for processing the image and storing the image.



The code base would have different modules for different functionality.



Upload images

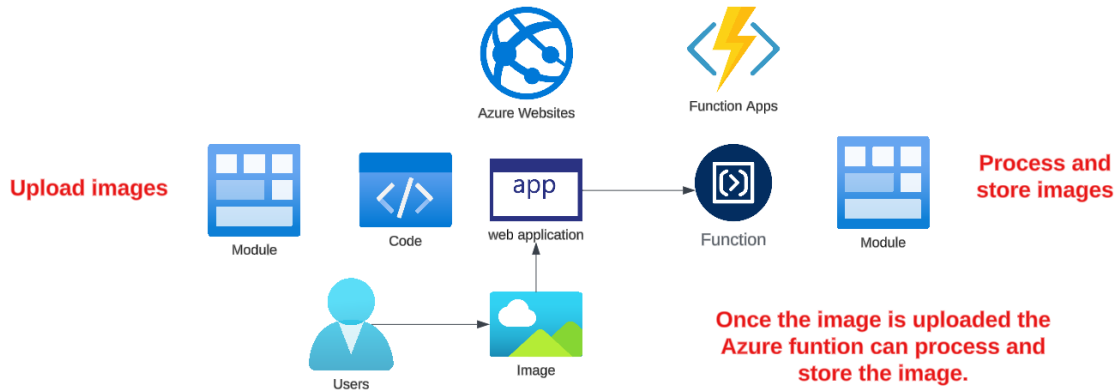


Process and store images

The module for processing and storing the images can be in the same code base as the application.

But maybe this code module needs to be reused by other applications.

We can therefore look towards hosting that code module in Azure Functions.

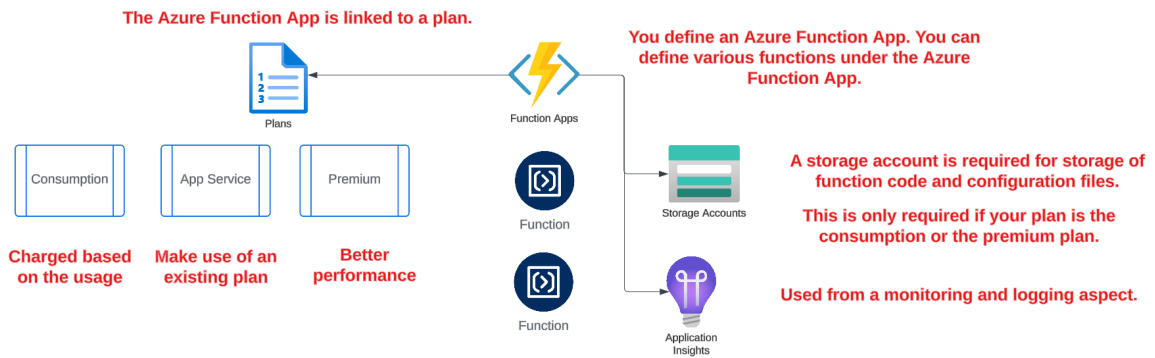


Some of the core advantages

Other applications can invoke the same Azure Function. Its now like a shared service.

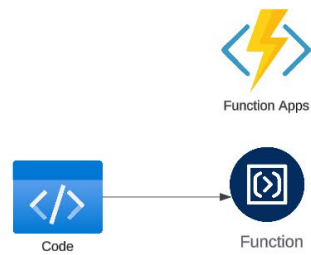
We can update and maintain the code base for Processing and storing images seperately.

Our web application can make full use of the capacity of the Azure App Service Plan just for the web application needs.



The Functions have support for languages - C#, Java, JavaScript, Python, PowerShell.

Lab - Creating a function in the portal



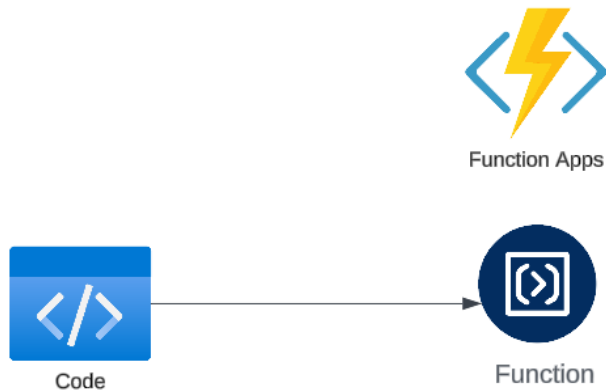
When you define a function, you specify a trigger for the function. How would the function get invoked.

Initially we will select an HTTP trigger.

```
1 module.exports = async function (context, req) {
2     context.log('JavaScript HTTP trigger function processed a request.');
```

```
3
4     const name = (req.query.name || (req.body && req.body.name));
5     const responseMessage = name
6     ? "Hello, " + name + ". This HTTP triggered function executed successfully."
7     : "This HTTP triggered function executed successfully. Pass a name in the query string or in the request body for a personalized response.";
```

```
8
9     context.res = {
10         // status: 200, /* Defaults to 200 */
11         body: responseMessage
12     };
13 }
```



Here our function is based on an HTTP trigger. With the HTTP protocol a request is sent onto a destination and a response is sent back.

When sending an HTTP request, there is a method associated with the request. This helps to establish what is the type of request that is being sent across.

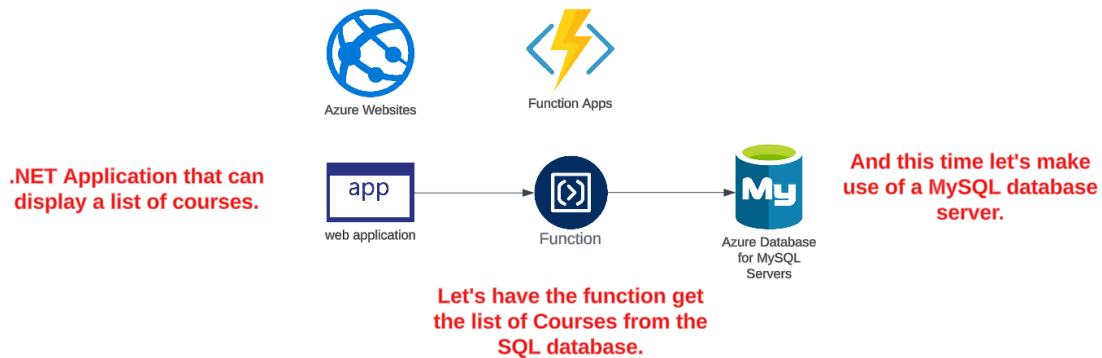
GET Method - This is used to request data.

With the GET request you can pass in query string parameters.

POST Method - This is used to send data to create or update a resource.

Here you can pass data in the body of the request.

What's the game plan

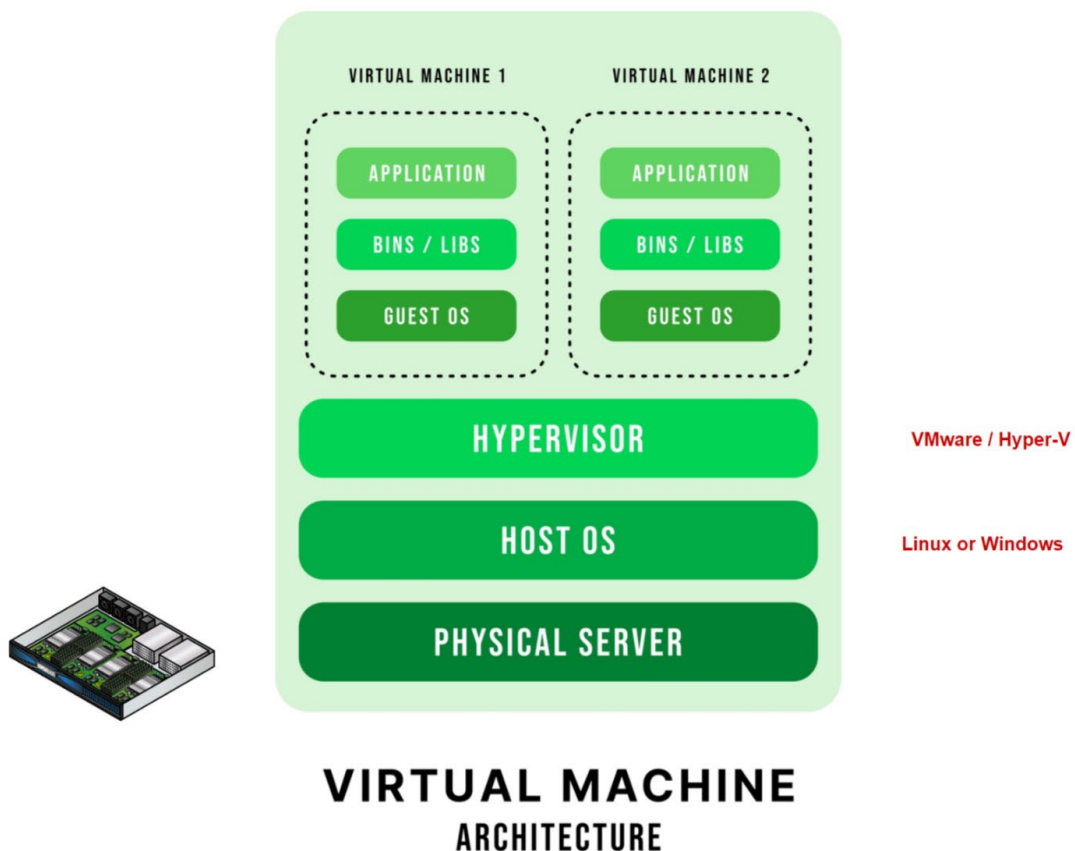


What are the steps we are going to perform

1. Create an Azure database for MySQL - Ensure that we have the Course table and data in place.
2. Then let's create an Azure Function that can get the course details.
3. Finally let's have an Azure Web app calling the Azure Function to get the Course details.

Develop Azure compute solutions – Containers

What is the need for containers



Each virtual machine can make use of resources such as CPU/Memory from the underlying physical server.

Each virtual machine is isolated from each other.



Containers

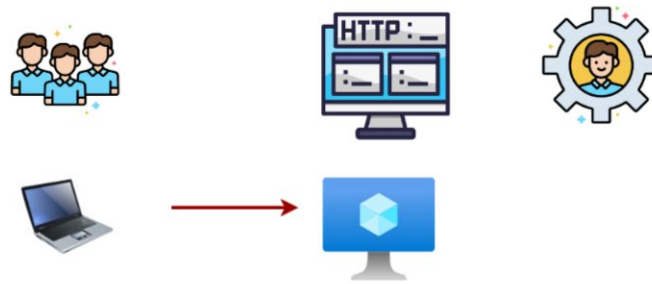


Having virtual machines was a big breakthrough

Companies could host multiple virtual machines on a physical server and make use of the server.

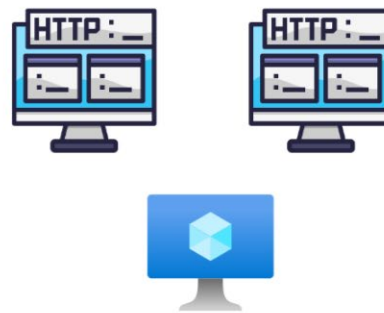
But then there were issues when it came to deploying applications.

Developers develop the application on their machines



When the application is deployed to a virtual machine it does not work as intended.

This could be because of differences in machine software configuration, libraries not present etc.



You have 2 applications on the same machine.

One application update requires a library/component to be installed.

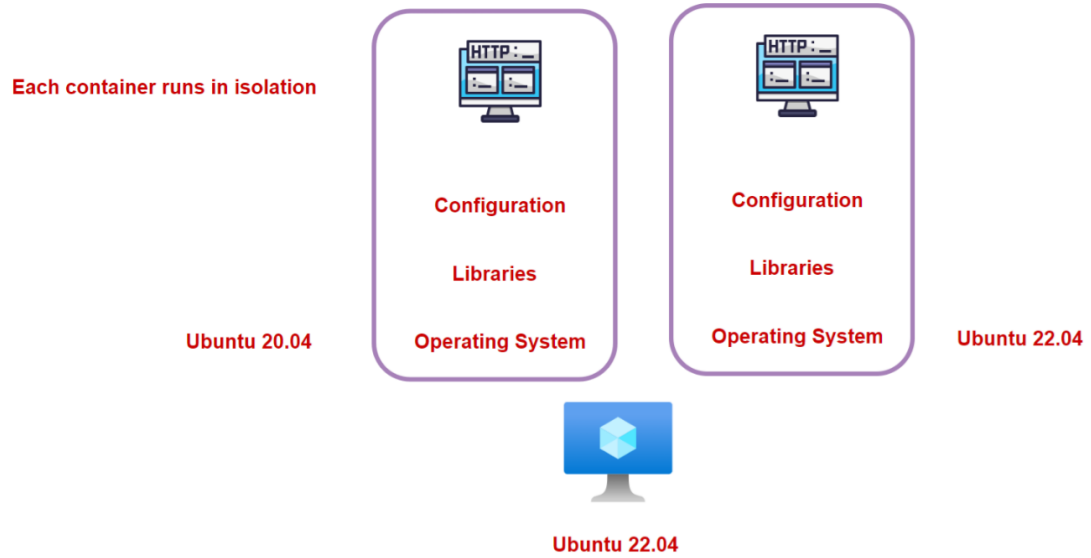
This causes the other application to stop working.

Welcome to containers

This is a unit of software that packages up all the code and dependencies that are required for the application to run.

CONTAINER ARCHITECTURE

The underlying container will have a light-weight operating system, the application, libraries etc.



Running a simple container

Running a simple container



Virtual Machine

Host a web server on a Linux-based machine

We can install the Apache web server and then host our application.



Apache web server



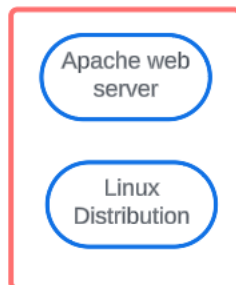
Web server



Virtual Machine



Docker Image

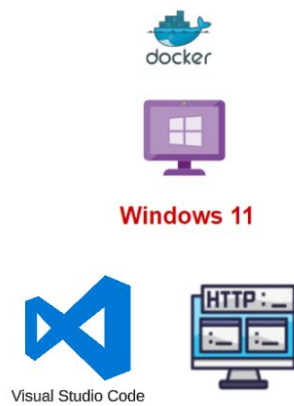


Apache web server within a container



Windows 11

Containerizing an application



1. Create a simple ASP.NET Application in Visual Studio Code
2. Build the application
3. Create a Docker image



Remember for .NET , we can publish the build of the project.

We first want to have the runnable version of our application in place.

The screenshot shows the Visual Studio Code interface. The left sidebar contains the Solution Explorer with the project structure for 'learningapp'. The main editor shows the 'Index.cshtml' file with the following code:

```
1 @page
2 @model IndexModel
3 @{
4     ViewData["Title"] = "Home page";
5 }
6
7 <div class="text-center">
8     <h1 class="display-4">Running this application within a container</h1>
9     <p>Learn about <a href="https://learn.microsoft.com/aspnet/core">building a containerized application</a>
10 </div>
11
```

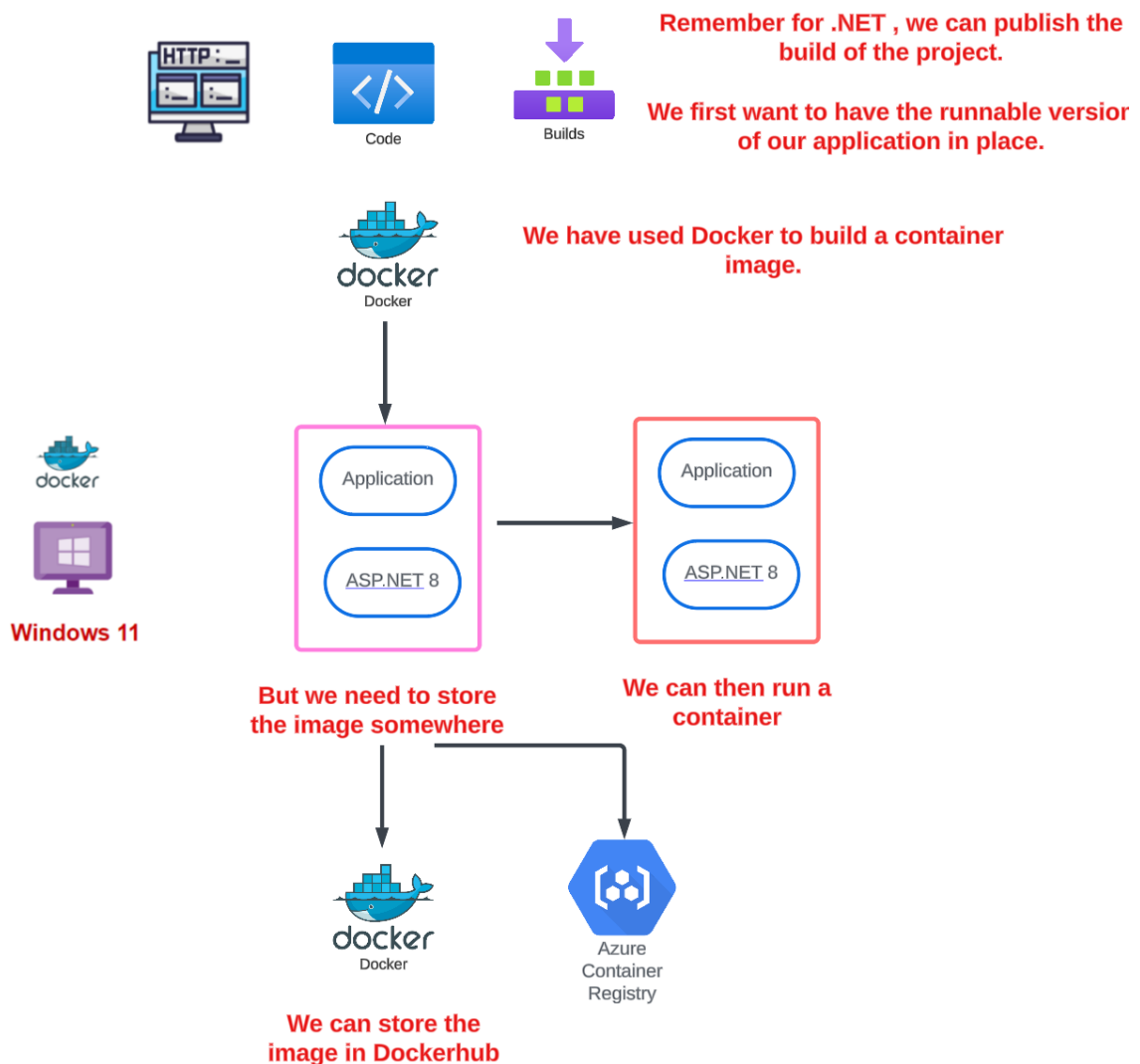
The bottom panel shows the Terminal with the following commands and output:

```
PS C:\tmp7> cd learningapp
PS C:\tmp7\learningapp> dotnet publish -c Release -o ./bin/Publish
MSBuild version 17.8.3+195e7f5a3 for .NET
Determining projects to restore...
All projects are up-to-date for restore.
learningapp -> C:\tmp7\learningapp\bin\Release\net8.0\learningapp.dll
learningapp -> C:\tmp7\learningapp\bin\Publish\
PS C:\tmp7\learningapp>
```

We will then create a file known as a Dockerfile and place it in the folder that has our runnable code.

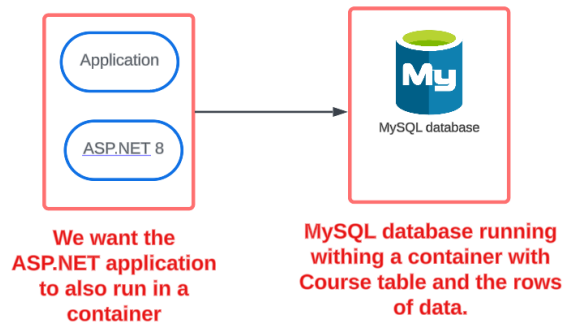
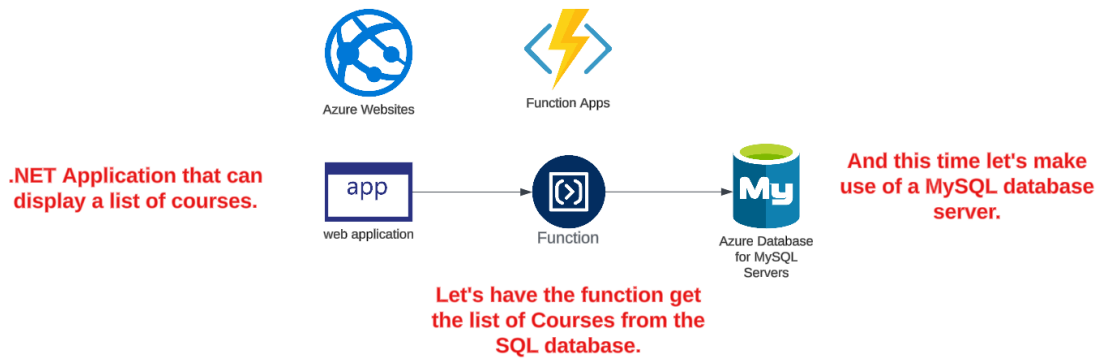
Docker can use the Dockerfile instructions to build a Docker image.

The need for a registry



What's our next game plan

We performed an implementation when it came to Azure Functions



The ASP.NET web application will fetch information from the MySQL database running in its container.

Let's make use of Azure Container Instances. But we can now run these containers as a group.

Step 1 : Let's see how to first run a MySQL database in a container.

Step 2 : Let's create our own image that will have a table and data already present when the container launches.

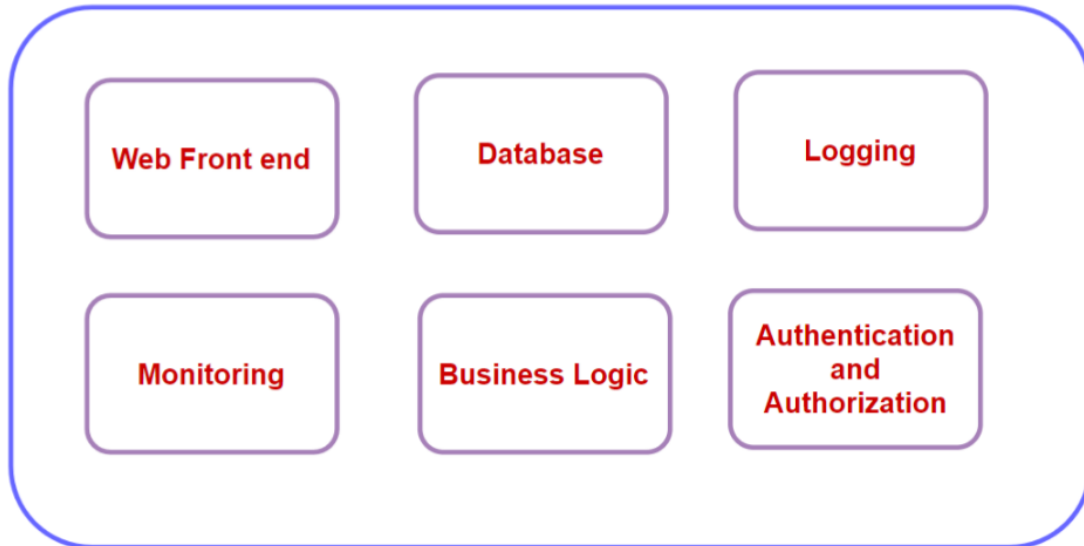
Step3 : Let's see our web application connecting to the database running in the container.

Step 4 : Let's containerize our web application.

Step 5 : Let's run them as part of a container group.

What is Azure Kubernetes

Applications can be built around multiple containers.



And when a company develops multiple container-based applications, things can become complicated.

Companies can then look towards using Orchestration tools.



A popular tool when it comes to container-orchestration is Kubernetes.

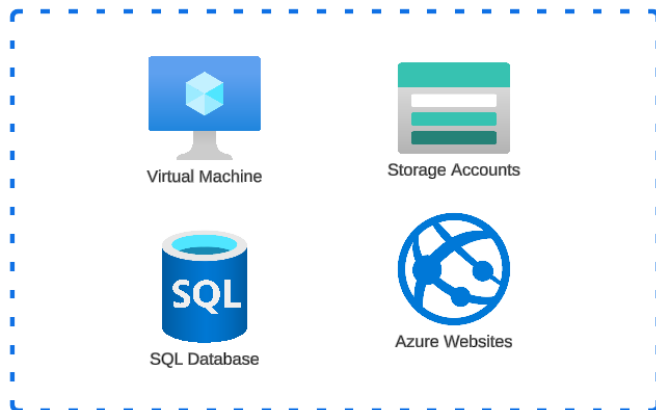
It's an open source platform that is used for managing your containerized workloads and services.

Features provided

- 1. It can restart containers if they fail**
- 2. You can load balance traffic across your containers.**
- 3. You can dictate the state of the services that need to run.**
- 4. You can mount different storage systems when it comes to persistence of data.**
- 5. You can scale up your services whenever required.**

Develop Azure compute solutions - Other tools

What are ARM templates



Test Environment

We need to rebuild the Test environment everytime a new testing cycle starts.

We want to have a repeatable and reliable way to build the resources everytime.



We can build an ARM (Azure Resource Manager) template that has the resources defined.

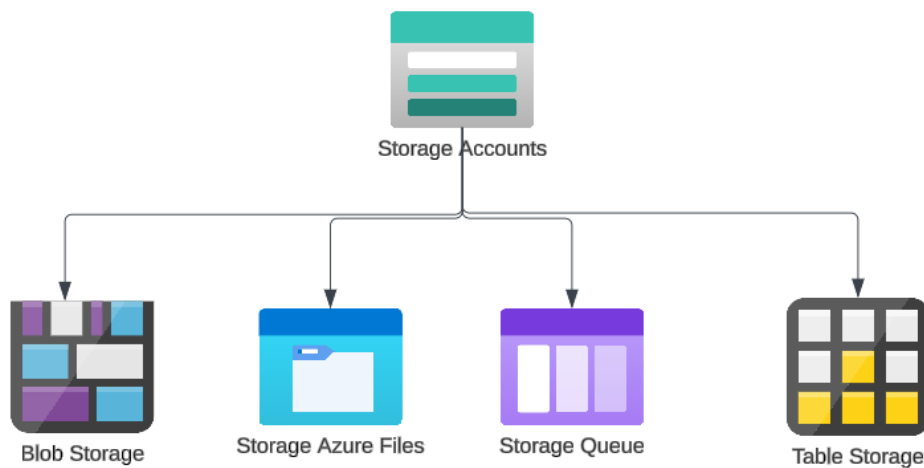
We then submit the template to Azure and the resources will be deployed accordingly.

This is also known as Infrastructure as code.

Develop for Azure Storage - Azure Storage Accounts

What are Azure Storage Accounts

Azure Storage Accounts - This is storage on the Azure cloud for your blob objects, files, queues and tables.



Azure Storage Accounts provides 4 services.



Blob Storage

This is used for storing a large amount of unstructured data. Suitable for storing images, documents, video and audio files.



Virtual Machine



Blob Storage

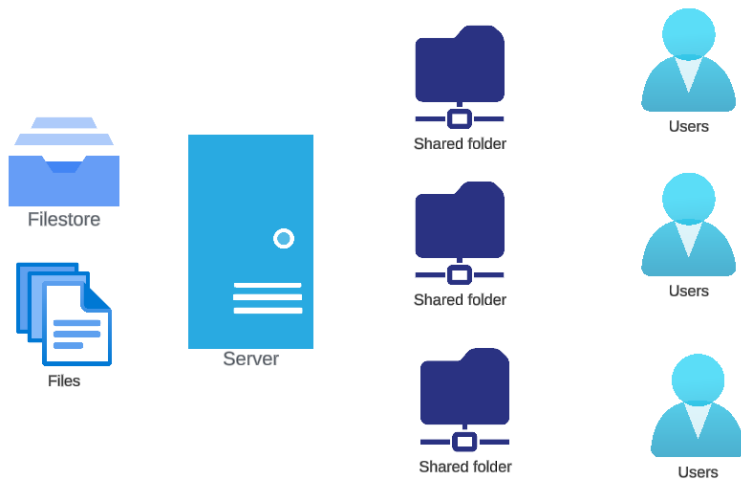


Web



Audio

The video and audio files could be stored in an Azure storage account.

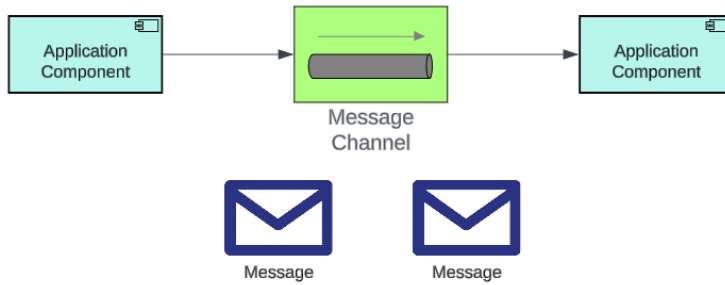


Here you need to maintain the file server and ensure enough storage is in place.



Instead you can create file shares using the Azure File share service. Here the storage is managed for you.

If messages need to be shared across multiple application components. Here you need to have the message software and maintain it.



Instead we can make use of the Queue service which provides the basic messaging service.



If an application needs to store data (non-relational structured data), like let's say data about users.

Azure Storage Accounts - Different authorization techniques



Storage Accounts

Let's say you are using an Azure Storage account to store images via the use of the Blob service.



Blob Storage



Image

One way to give access is to enable anonymous access. But this gives access to the Blobs at the container level.

Another broader way of giving access is via the use of Access Keys.


This gives access to all services in the storage account.

🕒 Set rotation reminder 🔄 Refresh 🗨️ Give feedback

Access keys authenticate your applications' requests to this storage account. Keep your keys in a secure location like Azure Key Vault, and replace them often with new keys. The two keys allow you to replace one while still using the other.

Remember to update the keys with any Azure resources and apps that use this storage account.
[Learn more about managing storage account access keys](#)

Storage account name

appstore4434434 


key1  Rotate key

Last rotated: 4/25/2024 (0 days ago)

Key

PN5HdpUFsovnw3l05S0s4OqnpfFzxYf6Am+eW5bSElbPrFEqvoBvx7e1alzAorkWX...  Hide


Connection string

DefaultEndpointsProtocol=https;AccountName=appstore4434434;AccountKey=P...  Hide

key2  Rotate key

Last rotated: 4/25/2024 (0 days ago)

Key

2E3Au5x3etGqNVQWr95vbcxjibDFNTuLxZWQOBhYwl/2od7FBikXqs87UEWoCKGa...  Hide

Connection string

DefaultEndpointsProtocol=https;AccountName=appstore4434434;AccountKey=2...  Hide

Another way of granting access is via the use of Shared Access Signatures.

Another way of granting access is via the use of Shared Access Signatures.

Here you can put more restrictions on the access - You can also grant time limited access.

Storage Accounts - Access Tiers



Storage Accounts

A company can look towards millions of objects in an Azure Storage Account.



Blob Storage



Storage Container



Files

Data storage prices pay-as-you-go	Premium	Hot	Cool	Cold	Archive
First 50 terabyte (TB) / month	\$0.15 per GB	\$0.018 per GB	\$0.01 per GB	\$0.0036 per GB	\$0.00099 per GB
Next 450 TB / month	\$0.15 per GB	\$0.0173 per GB	\$0.01 per GB	\$0.0036 per GB	\$0.00099 per GB
Over 500 TB / month	\$0.15 per GB	\$0.0166 per GB	\$0.01 per GB	\$0.0036 per GB	\$0.00099 per GB

A company would want to monitor their storage costs.

An this can especially be the case if objects are not being used.



Storage Accounts



Blob Storage



Image



Image

A thousand images have been uploaded on a particular day. During the first week the images are being used regularly.

But after a week the images are not being accessed. Should be still pay the same when it comes to storage costs.

We can use Access tiers to help in this regard.

Hot

This is the default tier for objects. Here this is optimized for objects that are accessed frequently.

Cool

This is ideal for objects that are infrequently accessed. An object can be set to the Cool Access tier. Here the object needs to be stored for a minimum of 30 days.

Here the storage costs are lower when compared with the Hot access tier, but the access costs are higher.

Cold

This is ideal for objects that are rarely accessed or modified, but you still need access to them. An object can be set to the Cool Access tier. Here the object needs to be stored for a minimum of 90 days.

Here the storage costs are lower when compared with the Cool access tier, but the access costs are higher.

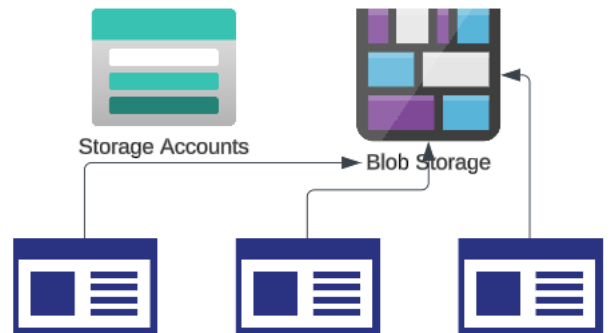
Archive

This is ideal for objects that are rarely accessed. And if you need to access them, you don't mind waiting for the data to be restored first.

Here the data needs to be stored for a minimum of 180 days.

Concurrency in Azure Blobs

You can have multiple application instances, different users who are accessing blob storage.



User A has retrieved ObjectA



User B has also retrieved the same object



User A has made a change onto the object



User B also wants to make a change to the object. But User B does not know that a change to the object has occurred since the read request was made to the object.

Optimistic concurrency - Here both users must be able to make their changes. At the same time they must be made aware that changes were made since the object was last read.

Here they can make use of the ETag header value.



When a request is made for an object in the blob service, they get an ETag value in the header as part of the HTTP response.

The application makes a note of this ETag header value. When an update operation is made to the object, an If-Match condition is used that compares the current ETag value and the ETag value of the object in the storage account.

Because if the object was updated by another user, the ETag value would change. Hence if the object was changed , when User B tries to submit the request for their changes, they would receive a response that would indicate that the object has already been updated by someone else.

Pessimistic concurrency - Here a user puts a lock on the object being updated. This is so that no one else can update the object.

In Azure Blob service, you can create a lease for an object. When you create a lease , no one else can update the object.

You can create a finite lease for a period of time or create an infinite lease. You can also remove the lease at any point in time.

Develop for Azure Storage - Azure Cosmos DB

What is Azure Cosmos DB



SQL Databases

ID	Name	Description
C01	AZ-104 Azure Administrator	Azure Administration
C02	AZ-204 Azure Developer	Azure Development

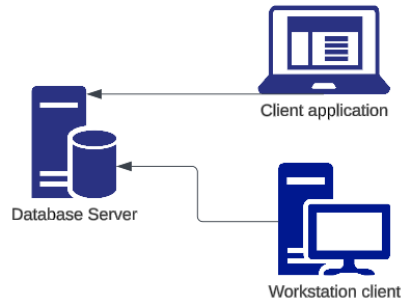
Course

ID	Name	CourseID
S01	Mark	C01
S02	James	C02

Student

What is NoSQL

Familiar with SQL-based database engines - Oracle , MySQL, Microsoft SQL Server



Applications, users connect to the database hosted on the database server.

There were issues when it came to traditional SQL database engines.

Ability to store large amounts of data - These were meant to be transactional systems and not able to manage large amounts of data.

Tables in the databases needed to have a predefined schema. But in today's world , data comes in all sizes, shapes and form.

Needed to have a more flexible way of storing data.

There were many NoSQL-based data stores developed for this purpose - MongoDB , Cassandra.



Azure Cosmos DB

Azure Cosmos DB is a fully managed NoSQL, relational and vector database.

You get fast access to your data.

Different API's

NoSQL

Data is stored in document format.

You can query for items using Structured Query Language (SQL)

MongoDB

Here documents are stored in BSON

PostgreSQL

Managed open source relational database with better performance.

Apache Cassandra

Here data is stored in a column-oriented schema.

Gremlin

This allows you to store graph-based databases.

Table

Store data in the form of key/value pairs.

Azure Cosmos DB Architecture



Azure Cosmos DB

NoSQL

Data is stored in document format.

You can query for items using Structured Query Language (SQL)

<https://learn.microsoft.com/en-us/azure/cosmos-db/resource-model>

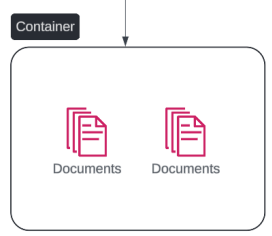
Azure Cosmos DB entity	API for NoSQL	API for Apache Cassandra	API for MongoDB	API for Apache Gremlin	API for Table
Azure Cosmos DB database	Database	Keyspace	Database	Database	Not applicable



A database is a group of containers.

<https://learn.microsoft.com/en-us/azure/cosmos-db/resource-model>

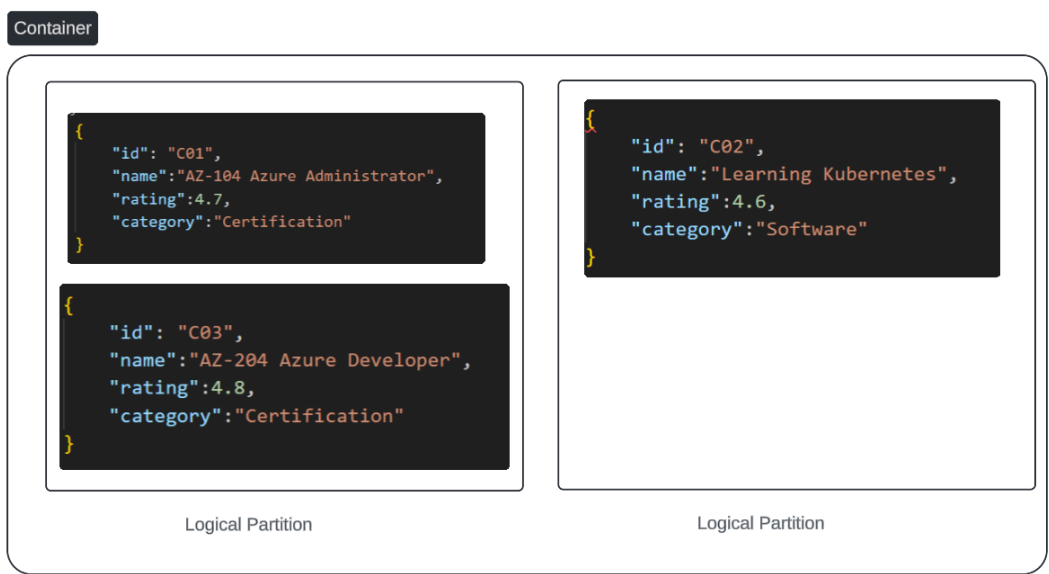
Azure Cosmos DB entity	API for NoSQL	API for Cassandra	API for MongoDB	API for Gremlin	API for Table
Azure Cosmos DB container	Container	Table	Collection	Graph	Table



The data is stored in a container.

The items in a container are split into different logical partitions.

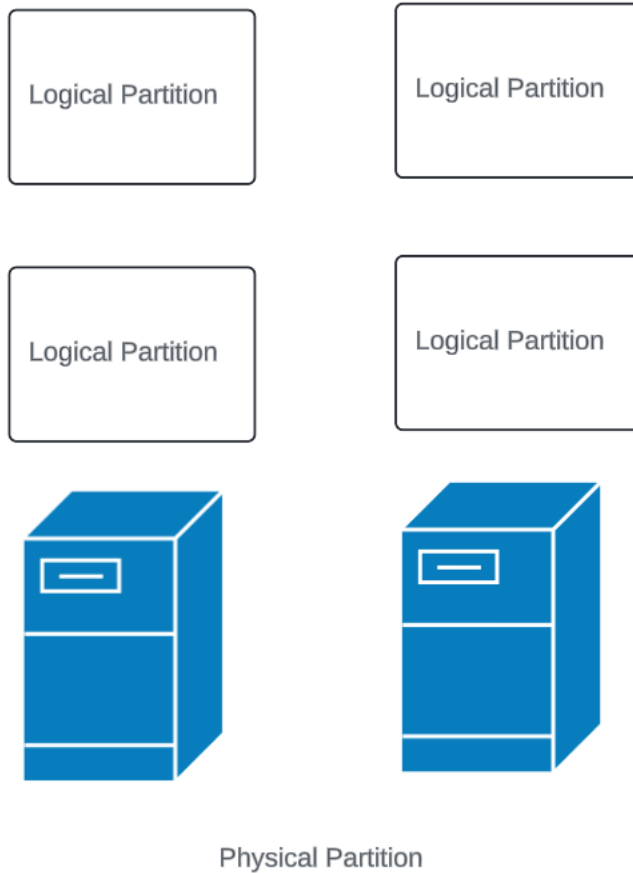
The logical partition for the item depends on the partition key set for the container.



Here the category has been set as the partition key for the container.

Each item also has an id that is unique within a logical partition. The partition key along with the item ID helps to uniquely identify the item in the container.

You can have multiple logical partitions in a container. Each partition can store up to 20 GB of data. It's good to choose a partition key that helps to distribute data across many logical partitions.



Your logical partitions are split across multiple physical partitions.

The number of physical partitions depends on the throughput set for the container.

The cost of all database operations is deemed via the use of Request units.



CPU

Memory

IOPS

In Azure Cosmos DB, all of this is taken as a blended measure known as Request Units.

A read operation of a 1-KB item takes one request unit.

Change Feed

Change feed

This feature gives a persistent record of changes that occur in the container. This is in the order in which the changes occur.

The output is a sorted list of documents that were changed.



The change feed can trigger an Azure Function.

Monitored container - This is the container being monitored for changes.

Lease container - Here the container maintains state across multiple Azure Function instances.

You can also implement the change feed processor

Compute Instance - This hosts the change feed processor that listens for changes.

Delegate - This is the code that decides what to do with the change processor feeds.

Consistency Levels



Latency

Throughput

Strong

Here the reads are guaranteed to return the most recent committed version of an item.



Azure Cosmos DB
West US



Azure Cosmos DB
West US 3



Azure Cosmos DB
West Central US



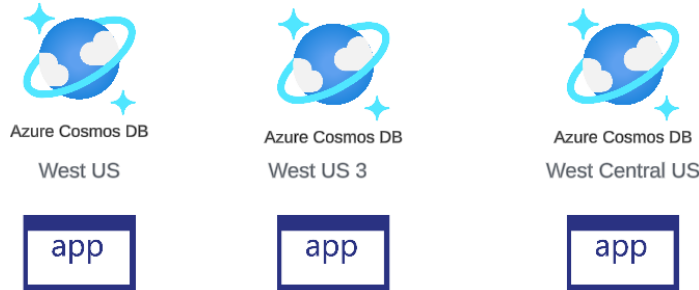
```
{ "id" : "C01", "category": "Certification", "name" :  
  "AZ-204 Azure Developer", "rating" : 4.7}
```

```
{ "id" : "C01", "category": "Certification", "name" :  
  "AZ-204 Azure Developer", "rating" : 4.8}
```

A change is made to the rating by the application running in the West US location. All other locations when they make a read operation to the same item, they will only get the result when the rating has been updated for the item to all locations.

Bounded staleness

Here the reads might lag behind the writes by at most "K" versions of an item or "T" time interval.



```
{ "id" : "C01", "category": "Certification" , "name" :  
  "AZ-204 Azure Developer", "rating" : 4.7}
```

```
{ "id" : "C01", "category": "Certification" , "name" :  
  "AZ-204 Azure Developer", "rating" : 4.8}
```

Here the application in the other regions, when they make a read request to an updated item, they need to get a response based on a maximum delay or either k versions behind or a time delay.

Session

Here within a single client session, the reads are guaranteed to honor the consistent-prefix, monotonic reads and writes, read-your-writes and write-follows-read guarantees

Consistent prefix

Here different regions might see different versions or updates of the item, but they will never see an out of order write.

Eventual

Here clients in other regions might see older versions of an item, eventually the item will be of the most recent update.

Further Concepts

Azure Container Instances and file shares

Normally when it comes to a container, the data within the container only stays for the lifetime of the container.



Container Instances

Let's say you have a database that needs to persist data, you need to extend the functionality of the container to connect to a volume for storage of data.



Container Instances



Storage Accounts



Storage Azure Files

For Azure Container Instances, you can make use of Azure File shares for storage of data.

Azure Functions - Blob Storage Trigger

Azure Functions



Function Apps

We created Functions based on the HTTP Trigger

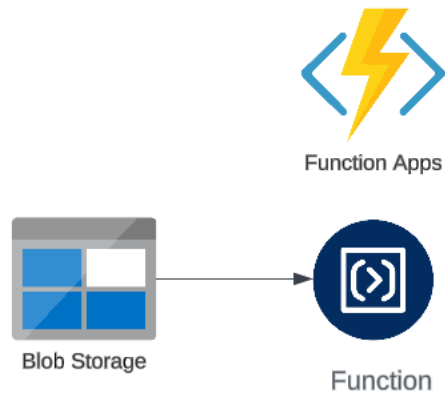
A function can only have one type of trigger

Here data sent with the trigger request - in the payload of the request.



Function

There are different types of triggers available.



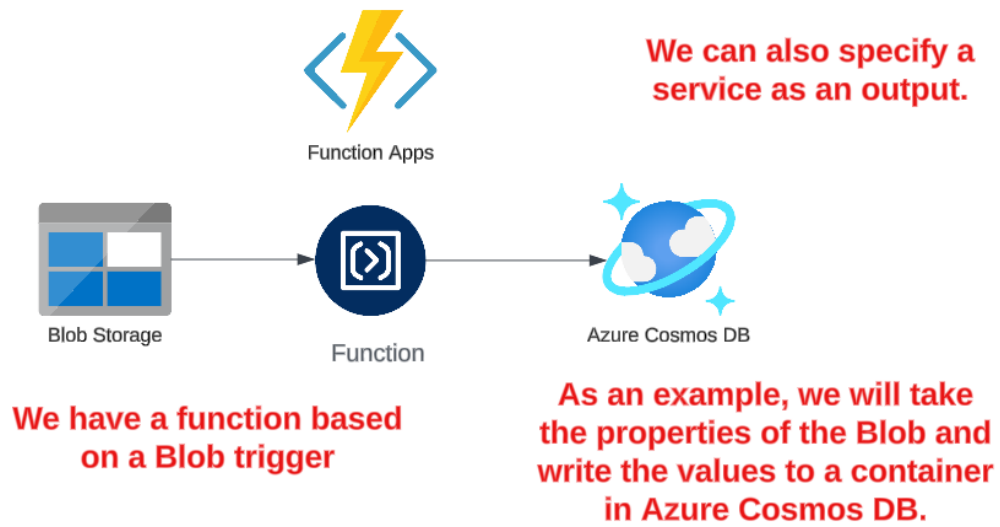
Whenever there are changes to the Blob's in the container, you can invoke an Azure Function.

What are we going to do initially

We will use Azure Blob service locally. For this we can make use of the Azurite Emulator that helps to emulate the service on the local machine.

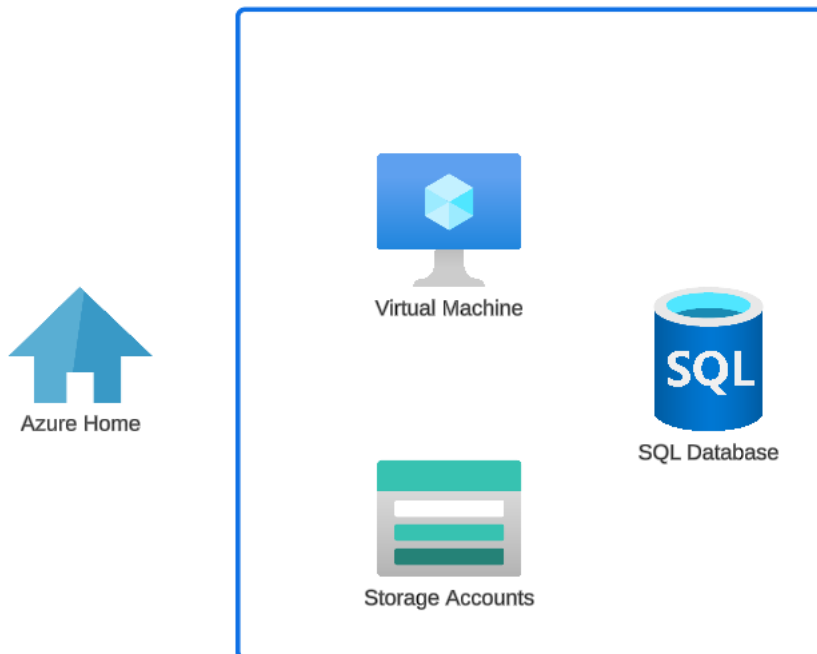


Lab - Azure Function - Azure Cosmos DB output



Implement Azure security

What is Microsoft Entra ID



So far we have been working with Azure resources with our Azure Admin Account.

But in an organization, you want to have users who can access and manage resources.

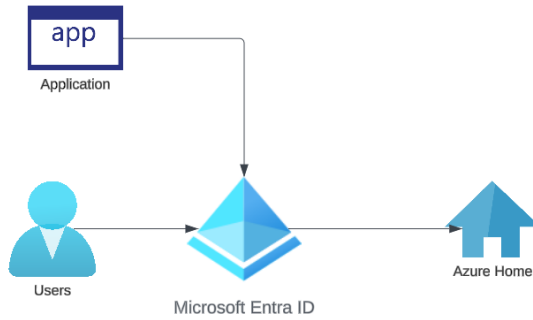
Who has permission to create resources. Who has permission to access resources.

We need to create users and be able to assign permissions.



Microsoft Entra ID - This is a cloud-based identity and access management service. This identity service can be used for Azure, Microsoft 365 and even other Software-as-a-service applications.

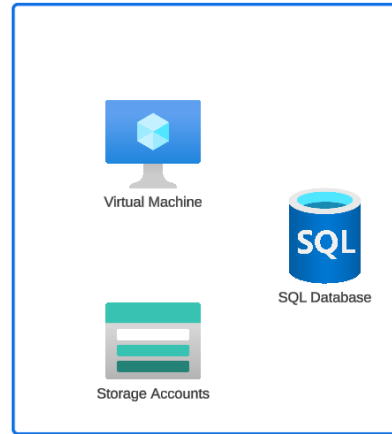
Even Applications can be linked to identities and be given access accordingly.



You can define users in Microsoft Entra ID.

Authentication - Here the identity of the users are verified.

Authorization - Here the permissions are checked for the users.



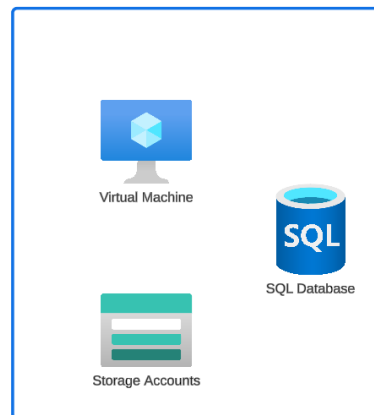
Lab - Role-based access control



You can define users in Microsoft Entra ID.

Authentication - Here the identity of the users are verified.

Authorization - Here the permissions are checked for the users.



Role-based access control

Role

We can assign different roles to a user.

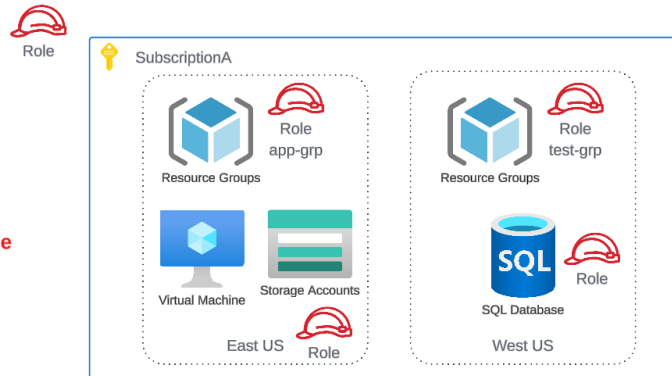
There are many in-built roles.

You can also define your own custom roles.

You can assign a role at the subscription level.

You can assign a role at the resource group level.

You can assign a role at the resource level.



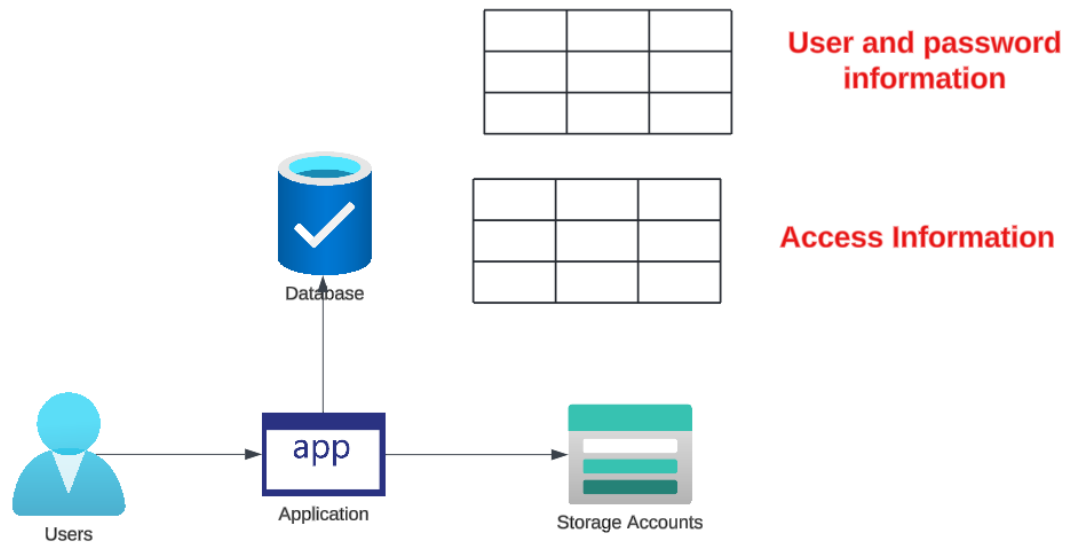
Owner Role
Here the user would have complete access and be able to manage the resources. The user can also delegate access to other users.

Contributor Role
Here the user would have complete access and be able to manage the resources.

User Access Administrator Role
Here the user would be able to delegate access to other users.

Reader Role
Here the user would be just be able to read the properties for the resources.

Introduction to Application Objects

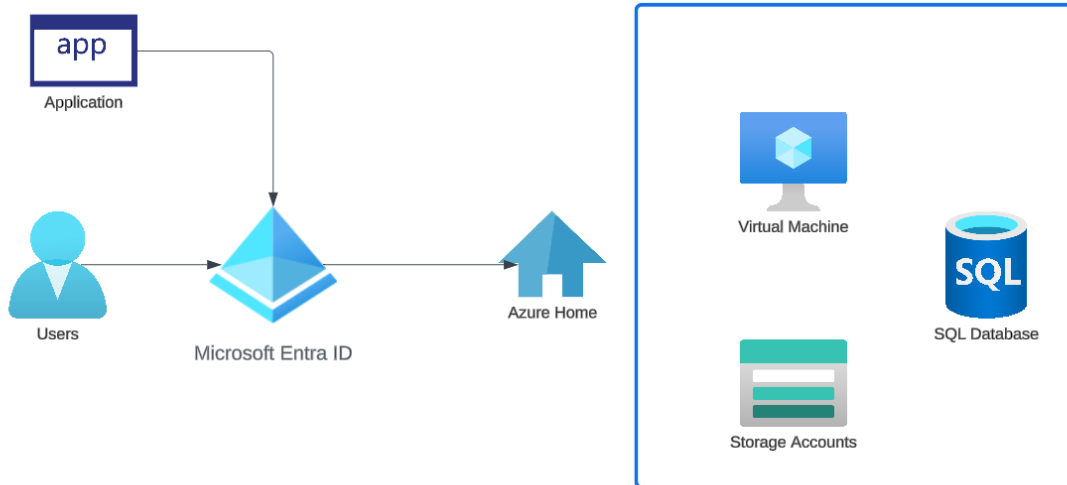


Consider an application that needs to authenticate users and authorize them to use resources on Azure.

The application would need to maintain a data store that has information for the different users and their access permissions.

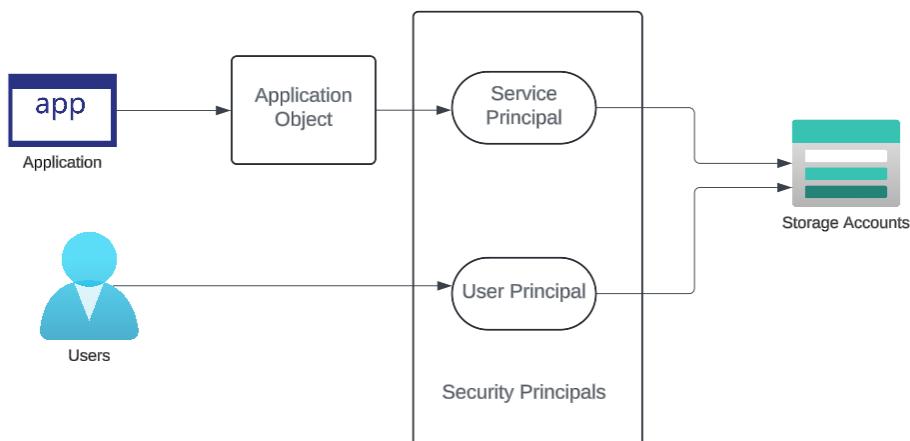
The company maintaining the application would need to maintain the database of credentials, their security and the required protocols used to authenticate and authorize users.

Instead we can make use of Microsoft Entra ID as the authentication and authorization provider. We delegate these tasks to Microsoft Entra ID.



In order for the Application to use Microsoft Entra ID, it needs to be registered in Entra ID. This is done by creating an Application Object.

In order for the Application to use Microsoft Entra ID, it needs to be registered in Entra ID. This is done by creating an Application Object.



The Application Object is associated with a service principal. This principal is then given permissions to access resources.

Lab - Application Object - Blob objects

Revisit the program that was used to download a blob from a storage account in .NET

```
using Azure.Storage.Blobs;

string connectionString="DefaultEndpointsProtocol=https;AccountName=appstore4554646;AccountKey=kSDxUAJ/sBqu9GdBofHe

BlobServiceClient blobServiceClient=new BlobServiceClient(connectionString);

string containerName="scripts";
string fileName="01.sql";
string path=@"C:\tmp4\01.sql";

BlobContainerClient blobContainerClient=blobServiceClient.GetBlobContainerClient(containerName);
BlobClient blobClient=blobContainerClient.GetBlobClient(fileName);

await blobClient.DownloadToAsync(path);

Console.WriteLine("Download operation is complete");
```

At that point we used connection strings to connect to the storage account.

We now want to make use of an Application Object.



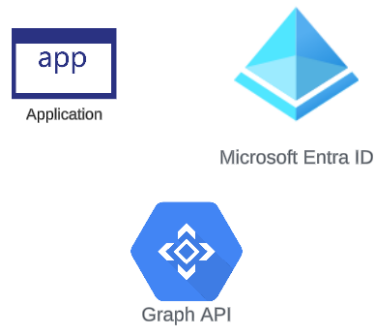
Microsoft Entra ID

In Microsoft Entra ID, we will first create an Application Object.

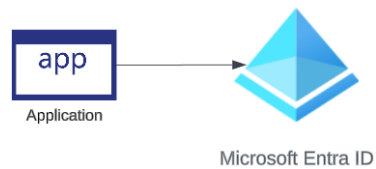
We will give permissions for the Application Object to access our Storage Account - We will provide Role-based access to the service principal attached to the Application Ob

Then in our .NET code , we will make the required changes to make use of the Application Object instead of the connection string.

Lab - Getting user and group information - Application Configuration



This exposes API's that can be used to get information on let's say users and groups in your tenant/directory.



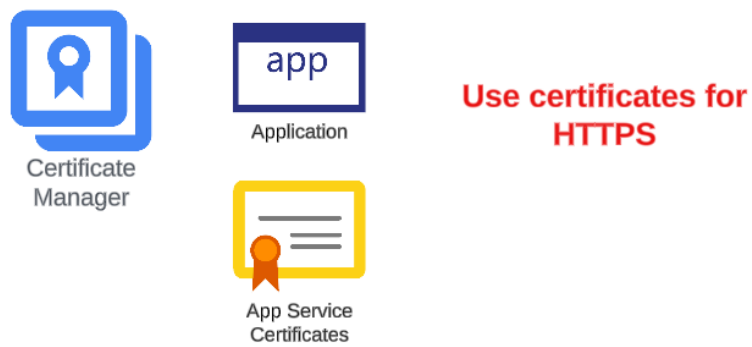
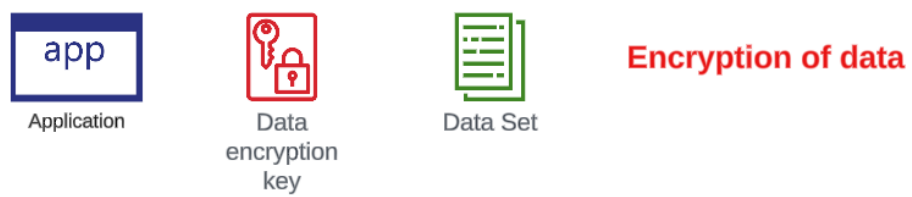
First our application needs to make a call to Microsoft Entra ID to get an access token.

The access token will be based on the Application Object and the permissions it has.

The access token can then be used against the Graph API.

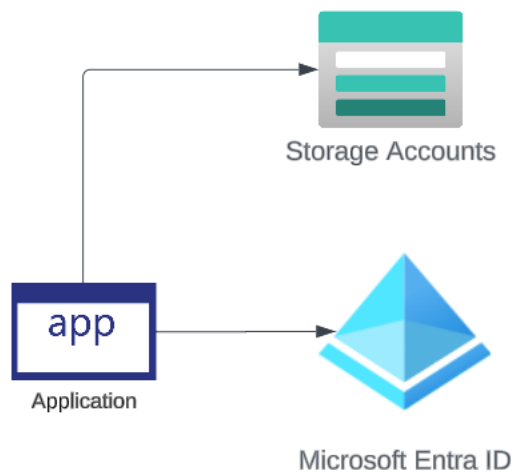
Azure Key Vault

Azure Key Vault



The Azure Key vault is a managed service that can be used to store secrets, encryption keys and certificates.

Managed Identities

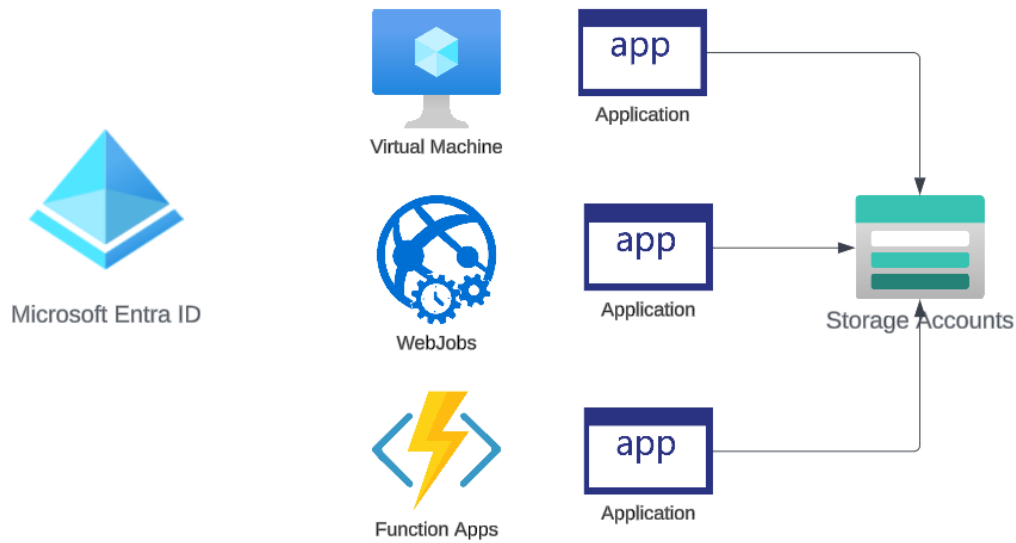


Application uses an Application Object to access an Azure Storage account

The application with the help of the in-built classes would get the required access tokens to access the storage account.

Even though we now make use of RBAC, we still need to embed the credentials of the Application Object in our code.

You can make use of Managed Identities. This gives a way for applications to authenticate to Azure resources without the need of embedding credentials.



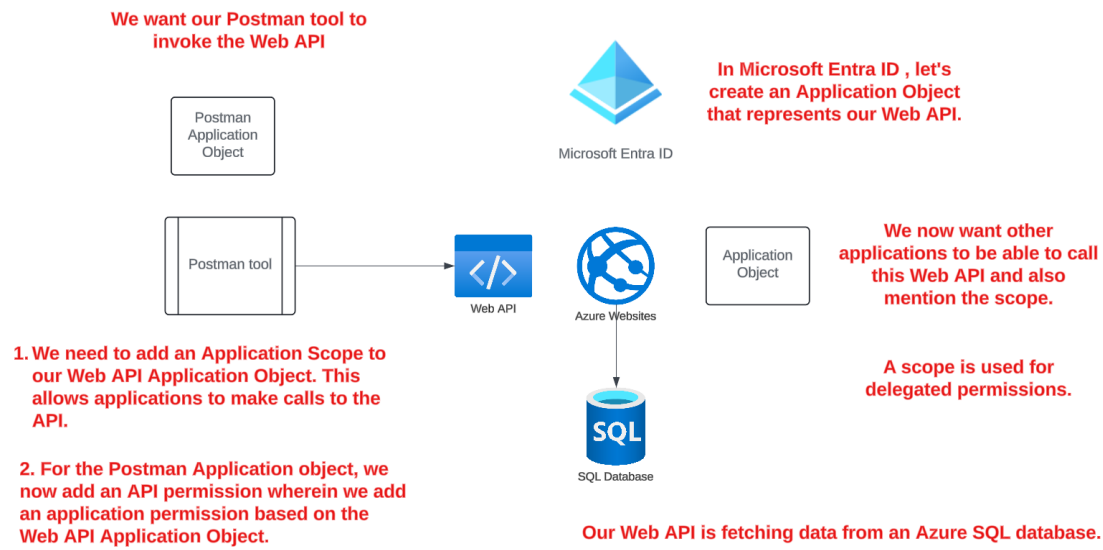
Your application could be hosted on a service that supports managed identities.

The managed identity for the resource can be registered in Microsoft Entra ID. This would create a service principal for that resource.

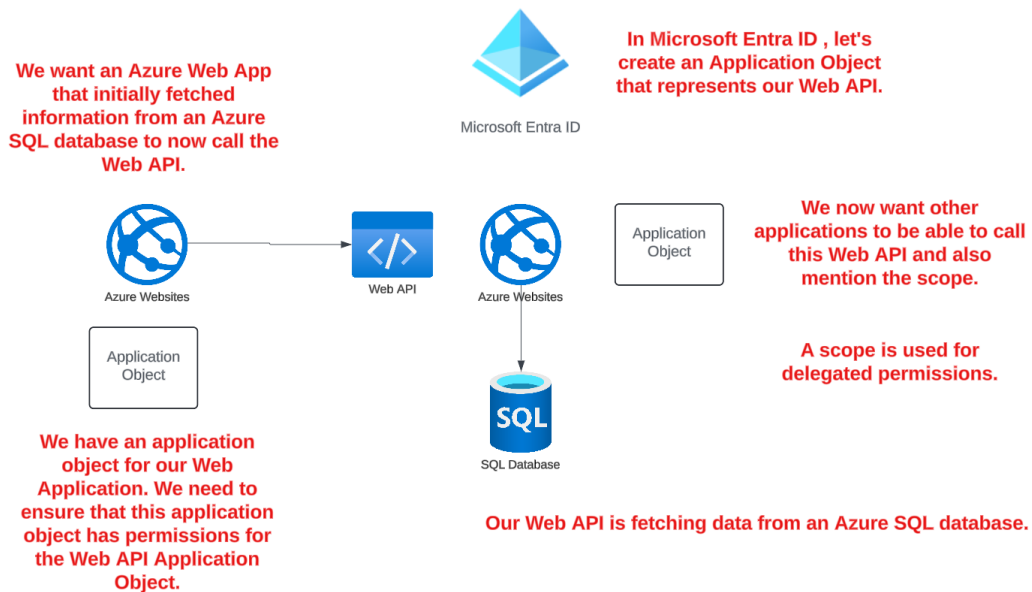
You can then provide RBAC access for that service principal onto the resource. And in your code you don't embed any sort of credentials.

We will look into an example of having an application hosted on a Virtual Machine that is accessing the blob service.

Lab - Calling our protected Web API from POSTMAN

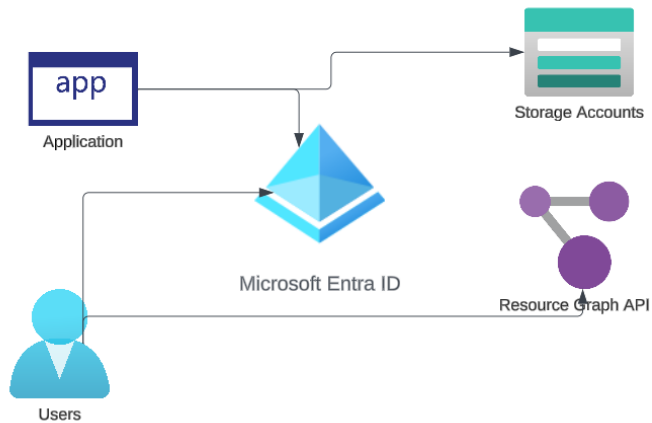


Lab - Invoking the Web API from a Web App



Implement Azure security - Authentication and Authorization

Authentication and Authorization

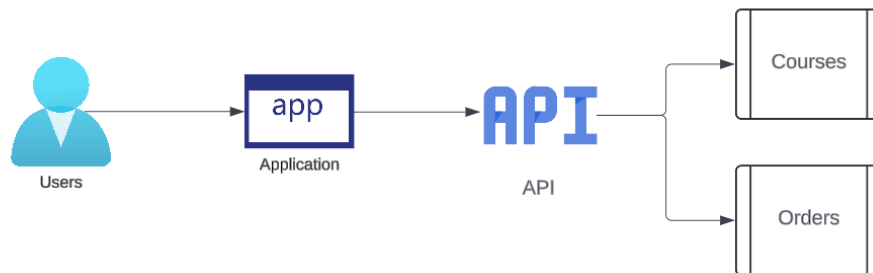


We know that Microsoft Entra ID is an identity provider.

Here users and application can be authorized to use API's and Azure resources.

Authentication - This is the process of verifying a user.

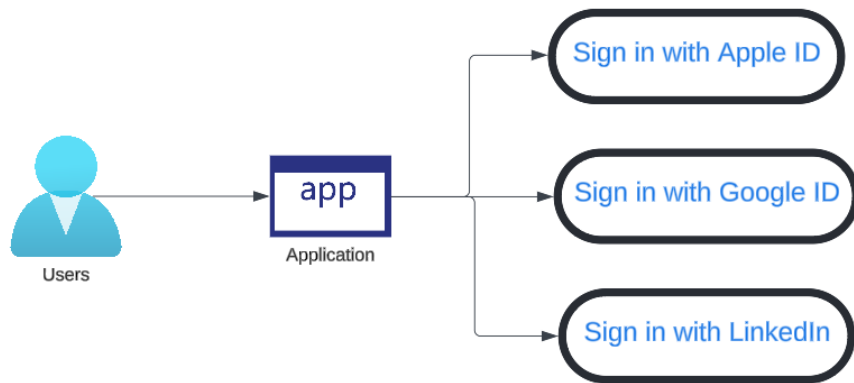
Authorization - This is the process of giving access to a resource.



Let's say you have an online course platform that is provided via a web application.

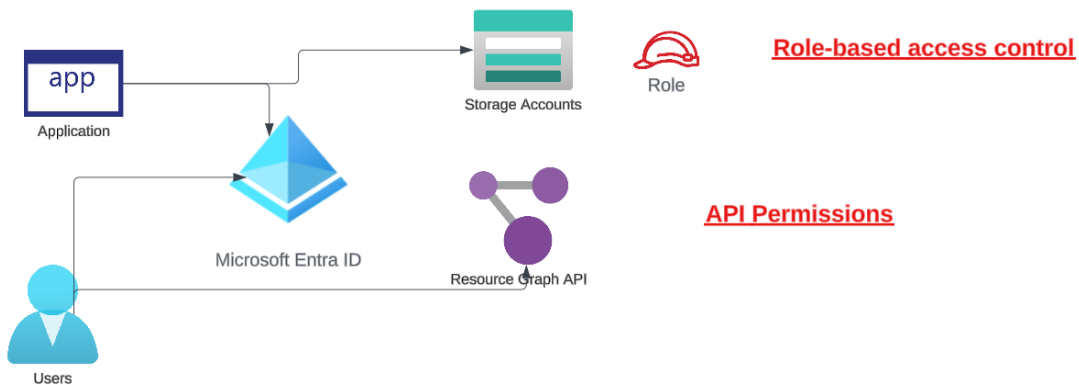
Users first need to authenticate to the platform by entering their user name and password.

The application would need to maintain the authentication modules, update them when latest changes are made to the authentication protocol and then also maintain the user database.



Applications might now offload the authentication to other providers.

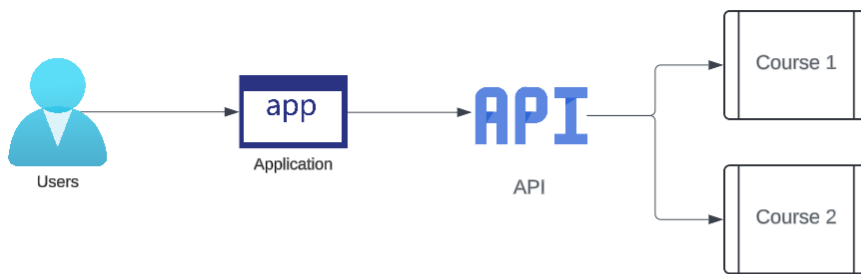
In a similar way, Microsoft Entra ID is an identity provider.



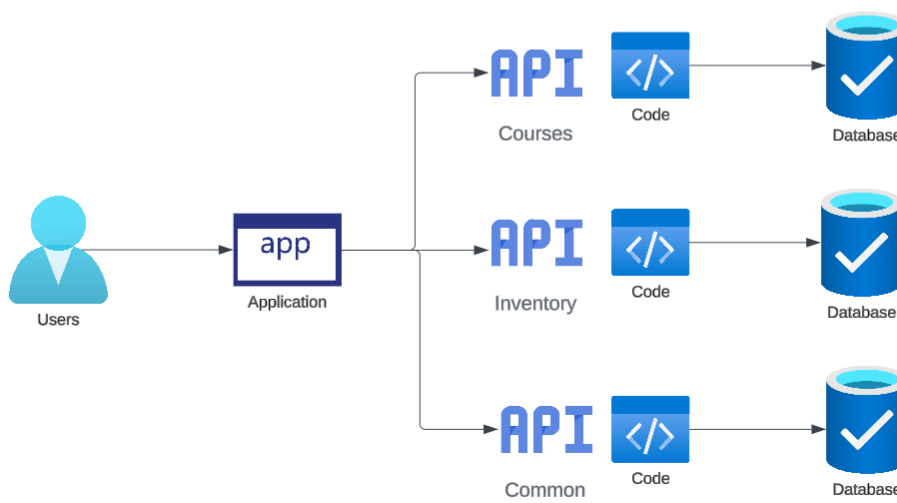
Then you can be authorized to use resources.

API's and Authorization

Quick understanding of API's



Application Programming Interface



Now let's say that a user has logged onto the application via the user name and password.

By default a user in the system will not get access to all API's. Maybe the user cannot see the Inventory.

Hence the user needs to be granted access to the Inventory API.

You can have a different data store for storing the resource permissions - Note this is already a part of Microsoft Entra ID.

Now when the user tries to access an API, how does the flow work.



User has logged into the application.

The user now wants to access the courses.

The web application needs to call the Courses API to get the information on Courses.

The web application needs to use the permissions that has been granted to the user and then make a call to the Courses API.

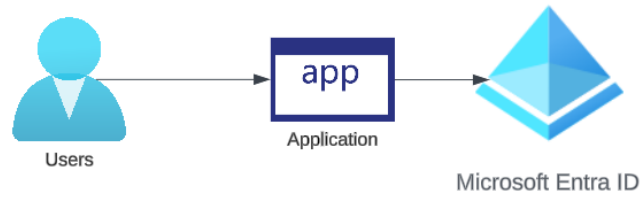
The web application will generate an access token that will have the required permissions embedded and then send it across to the Courses API.

The Courses Web API will validate the token , and if the user does have permissions, then the information will be sent back to the application/user.

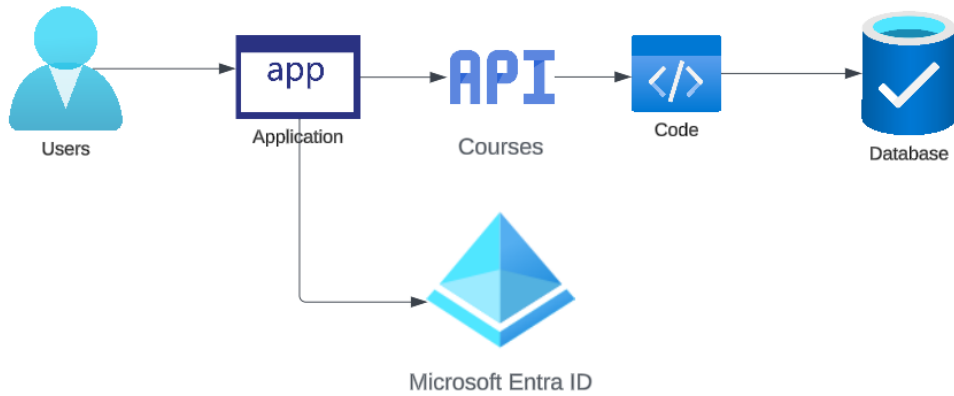
Using access tokens are secure. They are short lived in nature. The token lifetime could be between 60 - 90 minutes. Then after that if access is required, then a new access token needs to be generated or the lifetime of the existing access token needs to be extended.

There are generic formats for access tokens, but the format used by applications can vary.

The advantage of using Microsoft Entra ID is that it can manage the authentication and authorization for you.



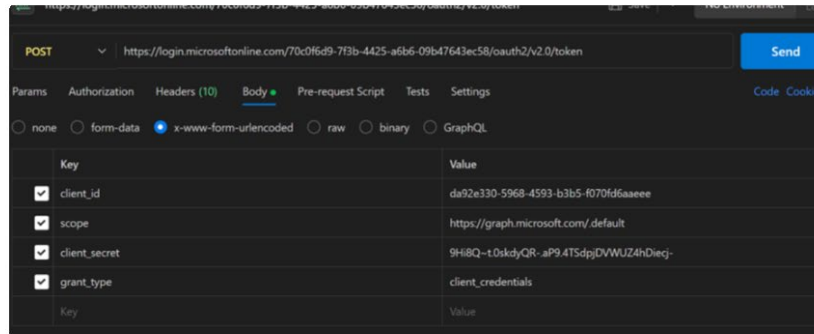
So first Microsoft Entra ID can perform the authentication for you.



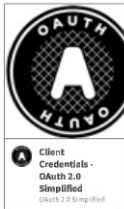
The application can also request Microsoft Entra ID for the access token for the user who wants to get access to a resource - Web API.

OAuth2 - Grant type - Client Credentials

OAuth - Standard when it comes to authorization - It just provides the flow of how authorization should work.



When trying to access the Graph API, we first sent a request to get an access token, a bearer token was returned.



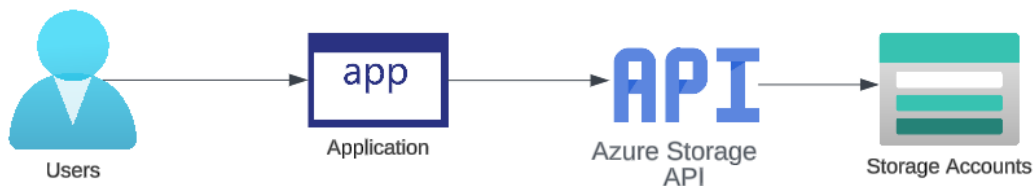
Here the grant_type was mentioned as client_credentials.

This is a type when it comes to OAuth. This is used by applications that need to get an access token outside of the context of a user.

OAuth2 - Grant type - Authorization Code

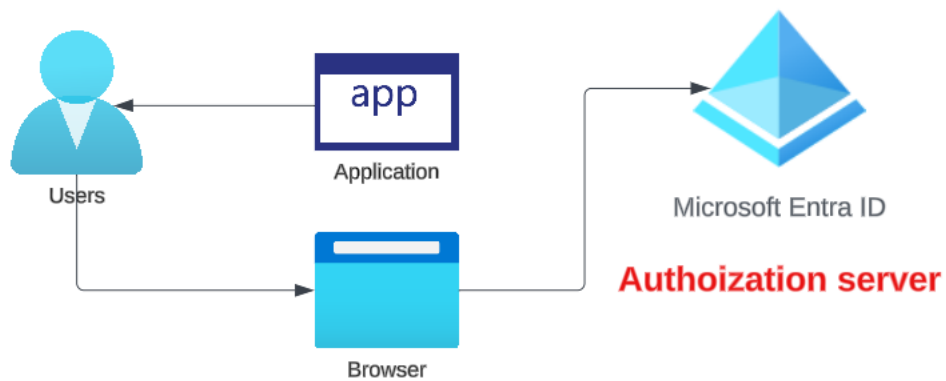
OAuth - Authorization Code

Let's say that a user logged into an application needs to access a blob in an Azure storage account.



The application will make a request to the storage API.

But let's understand the entire authorization flow taking Microsoft Entra ID as the identity provider.

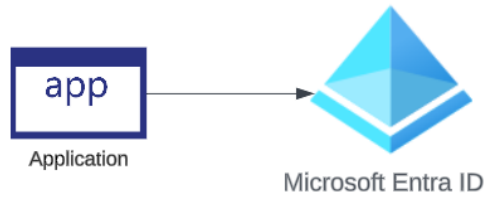


The first step in the flow is to get an authorization code.

The application will open up the browser and the user will be directed to the Authorization server. The request will have the scope of what resources are being requested by the user.

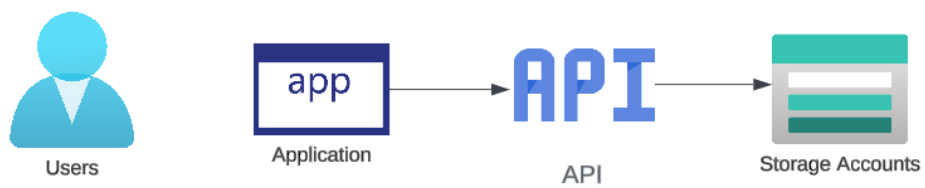
A code will be sent in the response back. There needs to be a redirect URI in place so that the Authorization server can send the code back to the web application.

The web application now formulates a backend POST request to exchange the code for an Access token.



Here Microsoft Entra ID will send the access token which will have the required permissions.

Here we have an entire 2 step process which is more secure.

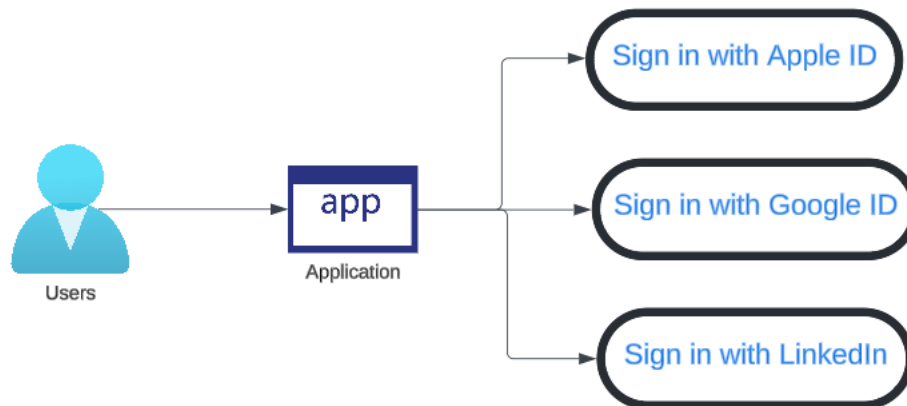


The application can now use the access token to request access to the storage API for the user.

Open ID Connect

OpenID Connect (OIDC)

Now OAuth is used for authorization. OIDC is an extension to OAuth which also sets how authentication take place.



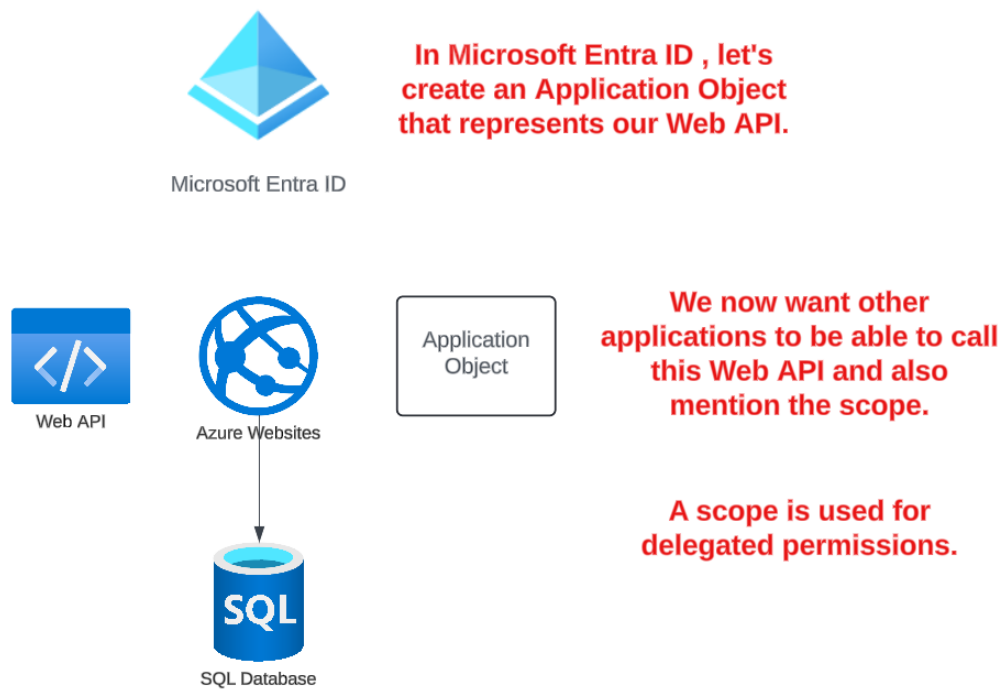
How an application can make use of third-party providers for authentication. These now come under the category of an OIDC provider.

So now the application, the relying party directs the user to an OIDC provider for authentication.

The OIDC provider is now responsible for authenticating the user.

The OIDC provider returns an ID token - The ID token can have the details of the user like the ID, email address etc.

Lab - Protecting our Web API - Application Registration



Our Web API is fetching data from an Azure SQL database.

Monitor, troubleshoot, and optimize Azure solutions

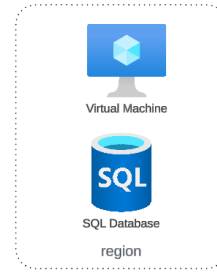
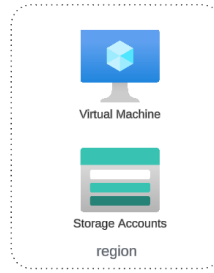
Quick look at the Azure Monitor service

This service allows you to collect data for your resources in Azure and your on-premises resources as well.



Monitor

You can analyze and work on the analyzed data.



Metrics

You can look at the metrics collected for various resources



Alerts

Alerts can be generated if metrics for resources go beyond a particular threshold.



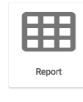
Log Analytics Workspaces

You can also collect logs for various resources.



Insights

You can get insights when it comes to resources such as Virtual Machines



Report

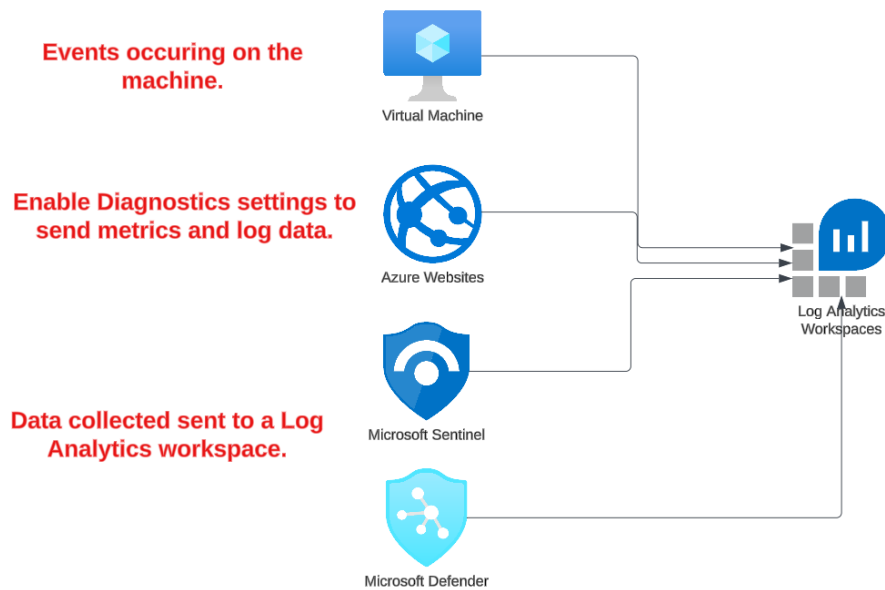
You can get reports and even Visualize the data.

What is a Log Analytics Workspace



This is an environment that can be used to collect log data.

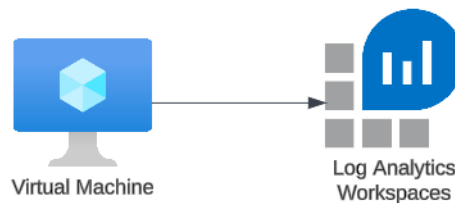
A single workspace can be used for the collection of data.





Within the Log Analytics workspace, the data is collected into tables that have rows of data.

You are charged for the data that is ingested into the workspace and for how long you plan to retain the data.



You can have multiple virtual machines that send data to a Log Analytics workspace.

For collecting data from Azure virtual machines , we need to define a data collection rule.

In the rule, we can define the source when it comes to what is the data we need to collect. And then define where to deliver the content to.

What is Application Insights

Collecting telemetry data



Application

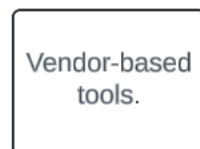


Virtual Machine

An application could be hosted on any compute infrastructure.

You would want to collect telemetry data about the application and possibly for the underlying infrastructure as well.

Telemetry data - Metrics , Logging, Tracing.



Application

There are vendors who provide tools for Application Performance Management.

This helps to provide an overview on how your application behaves when users are accessing the application.

You might need to instrument your application to get more data about it. Here you need to embed some code into your application code.



This is a feature of Azure Monitor that allows you to monitor your live web applications. You can get various aspects into the performance and reliability of your application.

Application Insights – Profiler

Live Metrics - QuickPulse

Here you can look at metrics and performance in real time.

If you are conducting any tests for your application like load tests you can look at the real live metrics.

If you have deployed new application fixes, you can view the performance and failure counts.

if you have deployed new application fixes, you can view the performance and failure counts.

|| Pause
↶ Reset
📖 Learn more
👤 View in Logs
🗨 Feedback



Profiler

Profiler

You can get performance traces for your application in a production-based environment.

Application Insights Profiler

Profile now Triggers Refresh Troubleshoot profiler

Recent Sessions

Timespan : Last 24 Hours Role Name == All Triggered By == All Role Instance == All

Recent profiling sessions

(Click on a row to open traces)

Triggered By Role Name Role Instance

No application has reported a profiling session. Try use 'Profile now' to trigger one.

You can run the Profiler on demand.

Or run it based on a trigger.

Trigger Settings

CPU Memory Sampling

Learn more

CPU Trigger

on off

CPU Threshold (%)

80

Duration

Time : 120 Seconds

Cooldown

Time : 4 hrs

CPU Memory Sampling

Learn more

Memory Trigger

on off

Memory Threshold (%)

80

Duration

Time : 120 Seconds

Cooldown

Time : 4 hrs

Trigger Settings

CPU Memory Sampling

Learn more

Sampling

on off

Sample rate

Normal High Max

Duration

Time : 120 Seconds

If your application is part of an App Service Plan, it needs to be part of the Basic App Service Plan or higher.

The Always On setting is enabled.

The Profiler is enabled for the Application Insights configuration in the Azure Web App.

Snapshot Debugger

Here you can get a snapshot of an exception when it occurs in your .NET application.

Here you can see the values of the variables and source code at that point in time.

For an Azure Web App, the App Service Plan needs to be basic or higher.

Enable the Snapshot Debugger when using Application Insights with Azure Web Apps.

Azure Cache for Redis

Azure Redis Cache - This provides an in-memory data store based on Redis software.



Consider a simple web application that works off a data store based on a SQL-database.

How does the flow work

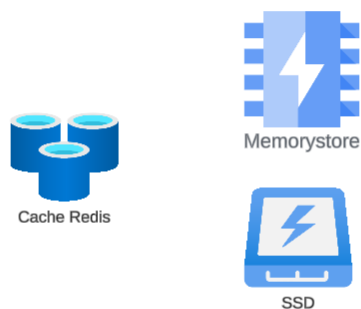
1. The browser sends a request to the web application to fetch products for an ecommerce application.
2. The application sends a SQL query to the database.
3. The database gets the data from a set of tables on the disk.
4. The database sends the response back to the web application.
5. The web application sends the response back to the client.

Disk operations on the database does take time. There could be many times wherein users are requesting for the same set of information every time.

Maybe there is a sale on the ecommerce site - Common products on sale. Every user requests for the page and the request pipeline is always the same.



This is an in-memory database that gives you fast access to data. So at the data layer its trying to reduce the time.



Here Redis stores data in memory and on fast access disks. This memory-based infrastructure is still relatively expensive , so it becomes difficult for a normal database to store all data on such disks.



SQL Database

Disks



SQL Servers

Normally a server also has RAM for In-Memory operations. The database would normally load the data from the disk onto memory and then perform operations on it.



Memorystore

But the RAM memory would be a small portion when compared to the actual disk size.

But the Redis cache software is built on the aspect that it stores data on fast memory.

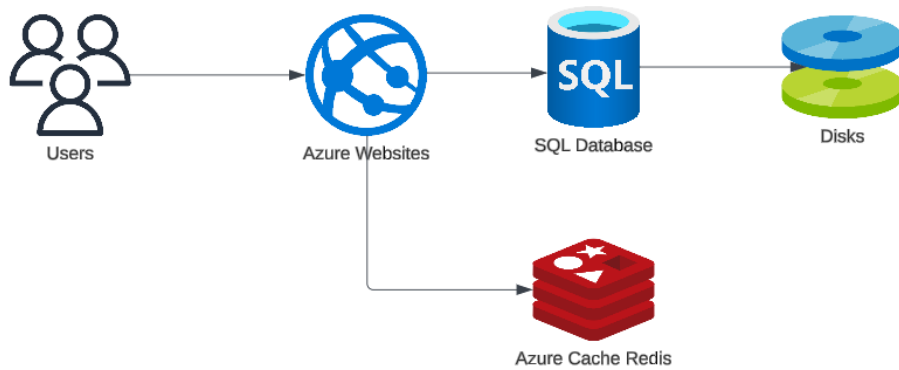


Azure Cache Redis

Azure Cache for Redis is just a managed service for the Redis software.

Redis Cache key eviction

Now the application can save frequently accessed items in the cache.



Normally a cache is good if items are not frequently changed.

But items in the cache at some point in time will need a refresh or a change.

Ecommerce site - There is a change for the items for sale on a daily basis.

So the key that stores the item list can be refreshed on a daily basis.

In the cache you can change the value of a key or you can delete a key that is no longer required.

You can also set eviction rules. This helps to manage keys in the Redis database in an automated way.

Different ways of using Redis Cache

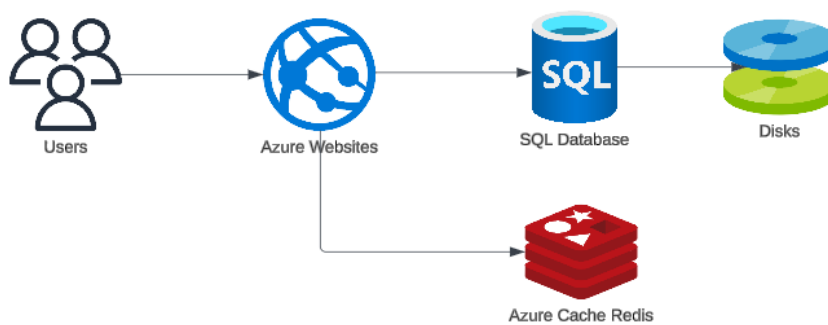
Redis can be used to cache an entire HTTP response



Frequent responses are cached and then those responses are sent to users instead of formulating the entire response again.



Redis can be used as a session store.



Azure Cache can used to store frequently accessed data sets.

Azure Redis High Availability

Ways to increase the overall availability of data in Azure Redis Cache



Azure Cache Redis

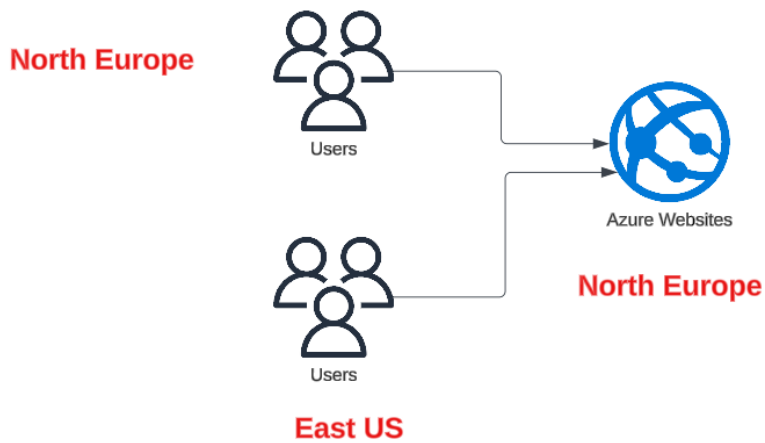
Since the data is stored in-memory, if anything happens to the server hosting Redis, it will impact your data.

You can persist your data, this is available in higher plans for Azure Redis.

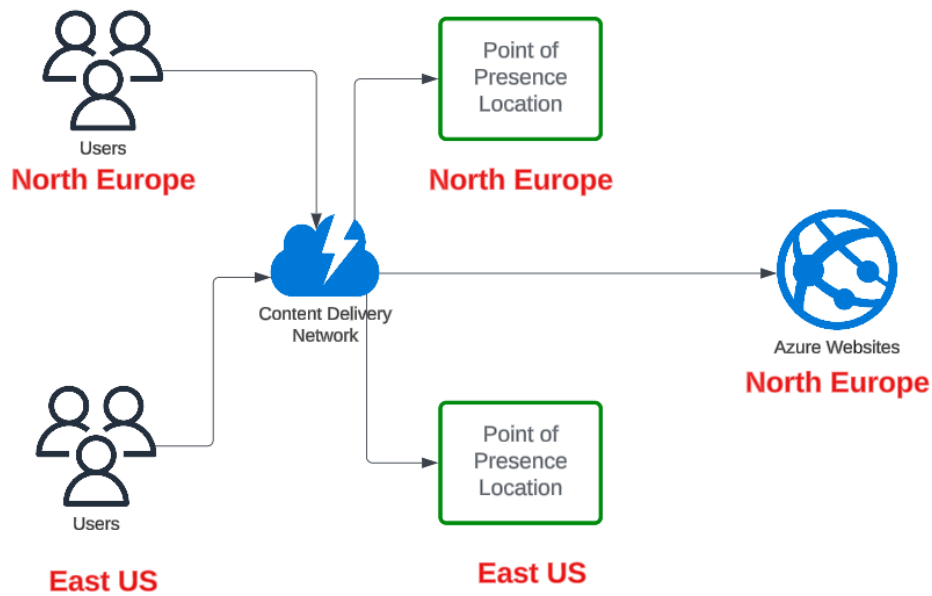
What is Azure Content Delivery Network

Azure Content Delivery Network

This helps to distribute network content across the world.



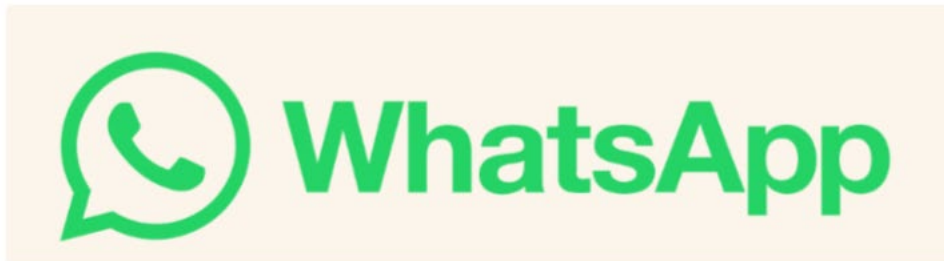
Would users across the world get the same experience when accessing the web application.



Connect to and consume Azure services and third-party services

Using a messaging service

The need of a messaging service.



Users



Users

Users can send and receive messages on the platform.

The message has various details - The body of the message, the sender , receiver etc.



Application



Module



Module

Similarly for an application you might need to enable for different modules to send messages to each other.

You might want to trigger events or receives events/messages from external systems.



Storage Queue

Here you can make use of simple queues.



Service Bus Queue

Enterprise messaging platform.



Event Hubs

Here you can ingest data in real time.

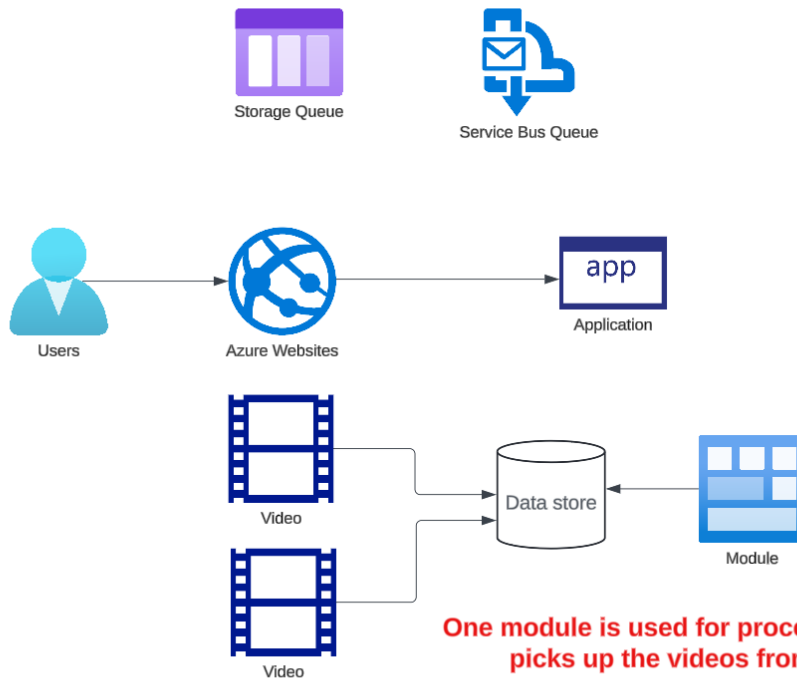


Event Grid

Build event driven applications.

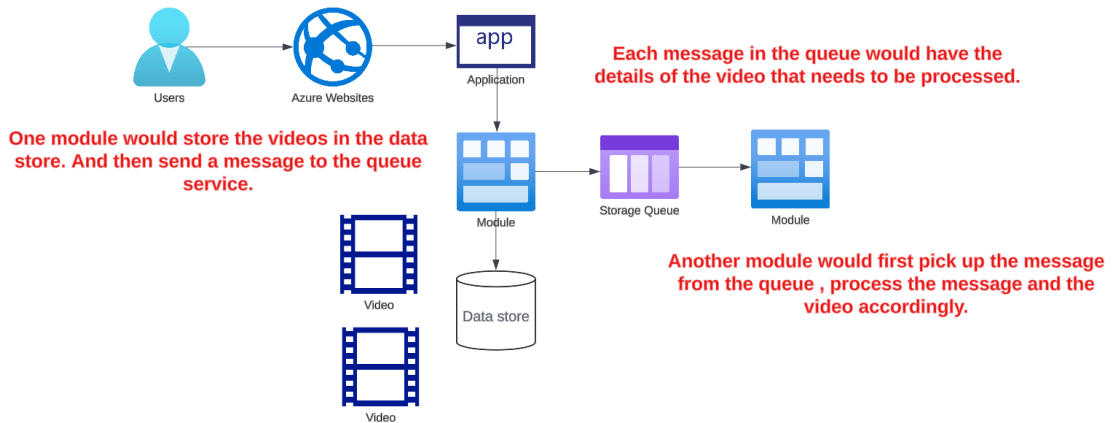
The purpose of the queue service

Using a queue service to decouple components of an application.



One module is used for processing the videos. It picks up the videos from a data store.

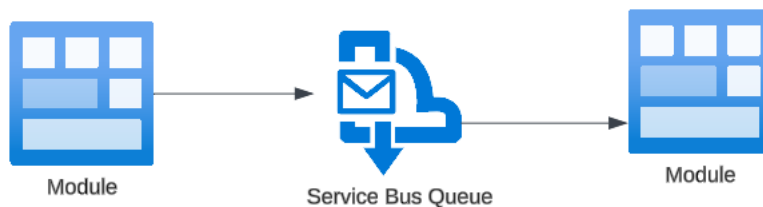
What happens if the module crashes.



What is Azure Service Bus

Azure Service Bus

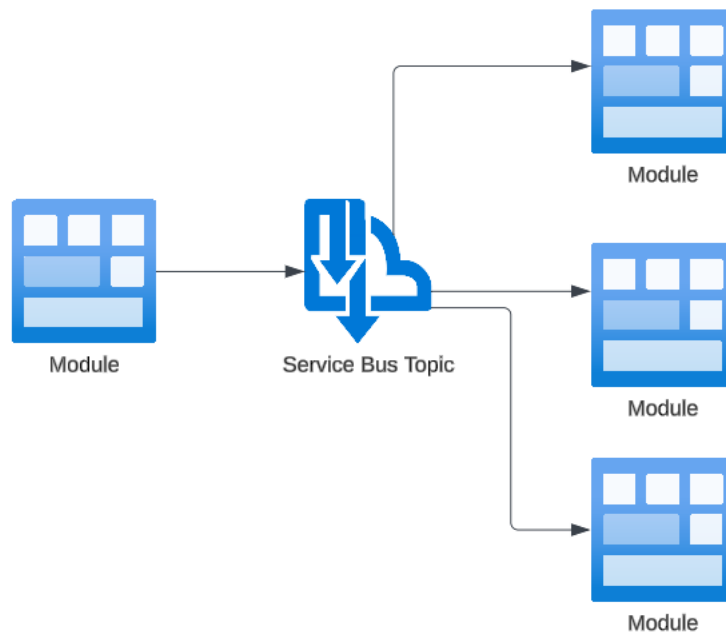
Fully managed enterprise message broker



You can publish messages to the queue.

You can then have modules that poll the queue for messages. The receiving module then needs to process and remove the messages accordingly.

Here the entire underlying infrastructure is managed for you. Its highly available in nature.

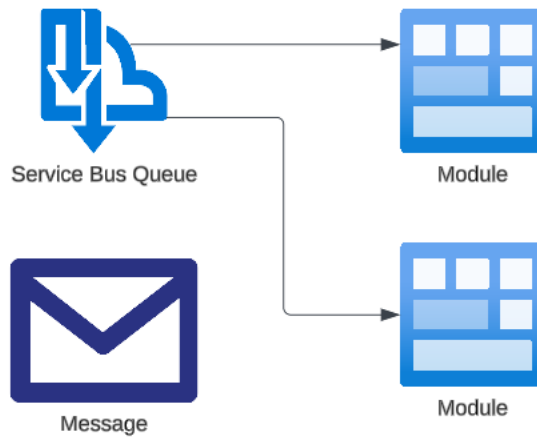


Here the sender module publishes messages to the topic.

You can have multiple subscribers that subscribe to a topic.

All subscribers would receive a copy of the message. They can also have filters in place to decide on what messages to receive.

Azure Service Bus queue - Message lock duration



Normally you configure multiple receivers to process messages.

So when one receiver receives the message, you need to ensure that no other receivers can receive the same message.

The message will be locked for a specific duration of time.

During this lock time, the initial receiver needs to process the message and then delete the message accordingly.

Here the messages are first received in the PeekLock mode.

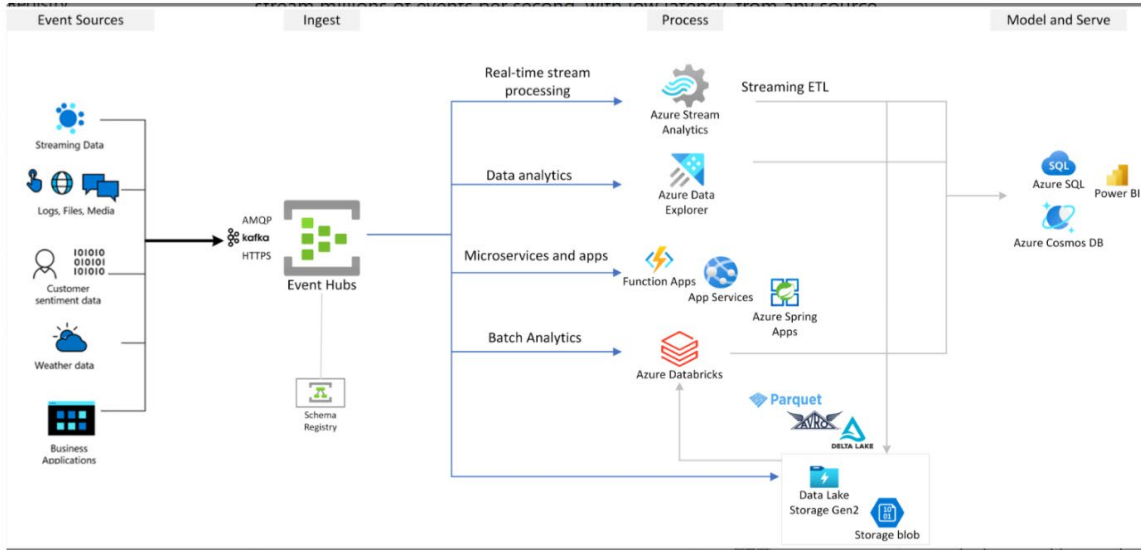
In the ReceiveAndDelete mode the messages are automatically deleted from the queue. But the downside here is that there is a dependency that the receiver would have already processed the messages.

What are Azure Event Hubs

Azure Event Hubs

This is a data streaming service that can stream millions of events per second.

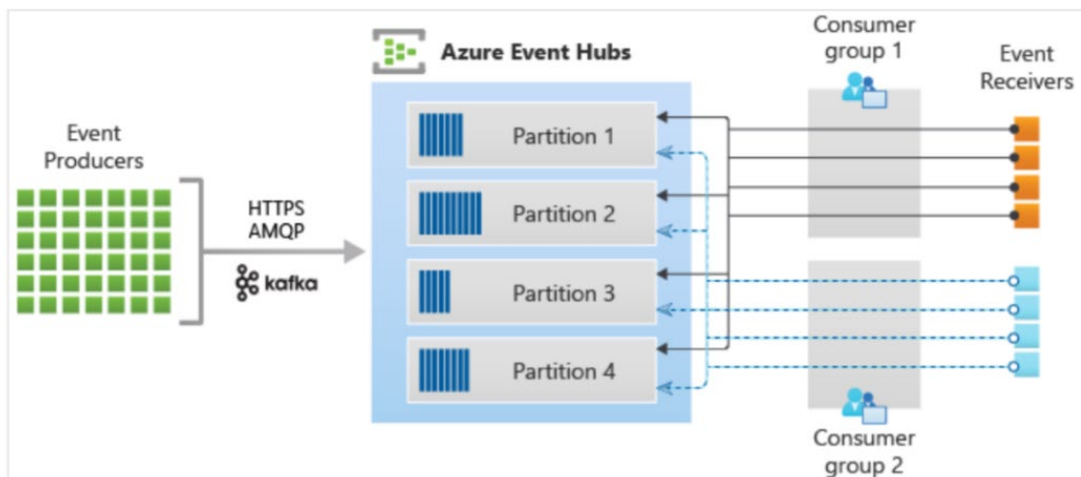
This can be from any source or destination.



Reference -

<https://learn.microsoft.com/en-us/azure/event-hubs/event-hubs-about>

Event Hubs Architecture



Reference -

<https://learn.microsoft.com/en-us/azure/event-hubs/event-hubs-features>

Event Hub namespace - This is a container for multiple Event Hubs.

As event data comes in, they are stored across multiple partitions.

Each Event can have the body of the event. Any user-defined properties. Metadata - offset in the partition, stream sequence number.

Having multiple partitions helps to increase the overall throughput of the system.

Each partition generally can sustain 1 MB/s throughput.

You can also use a partition key in your data events to map the events to a specific partition.

Event Publisher - This sends data to the Event hub.

Event Retention - Standard - 7 days, Premium , Dedicated - 90 days maximum.

Event Consumer- These consumes the events from Event Hub.

Consumer Group - This is a logical grouping of consumers that read data from the event hub.

Throughput capacity of the Event Hub is controlled via the number of throughput units you assign. These are prepurchased but billed per hour.

Ingress - 1 MB per second or 1000 events per second

Egress - 2 MB per second or 4096 events per second

So let's understand some concepts



The consumer application needs to keep on running to process events in real time from the Event Hub

After consuming the events do the events get deleted?

Well No. Because Azure Event Hubs serves a different purpose

Maybe another type of consumer needs to read the events again for another requirement.

Does that mean Azure Event Hubs will keep the messages indefinitely?

Again No. There is a message retention. This means this is not treated as a permanent data store.

not treated as a permanent data store.

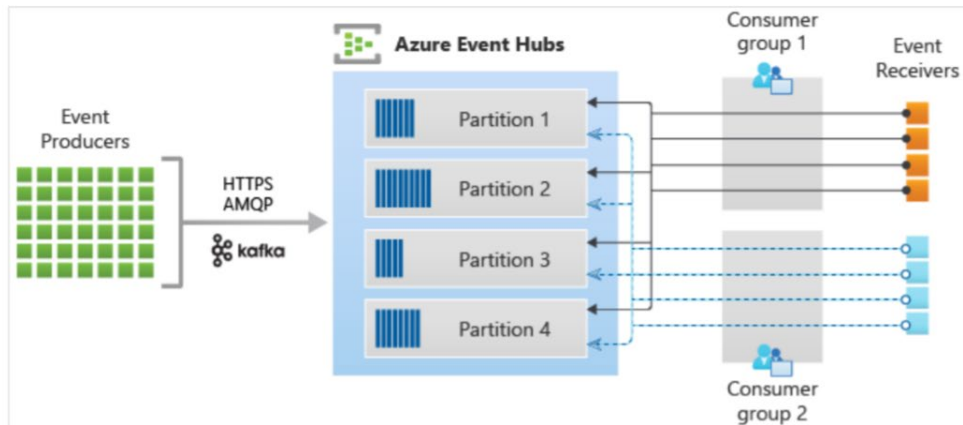


Did you notice that after running the consumer program again, it is reading all of the events again from the beginning.

Your program needs to keep track of events being read.

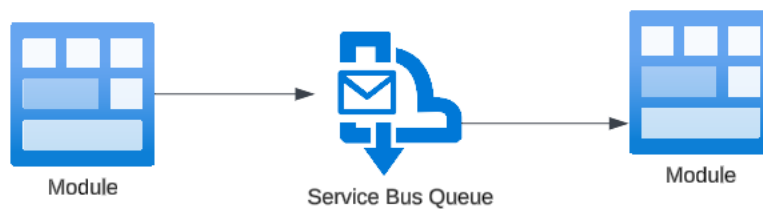
Comparison with Azure Service Bus

This can be from any source or destination.



Azure Service Bus

Fully managed enterprise message broker



You can publish messages to the queue.

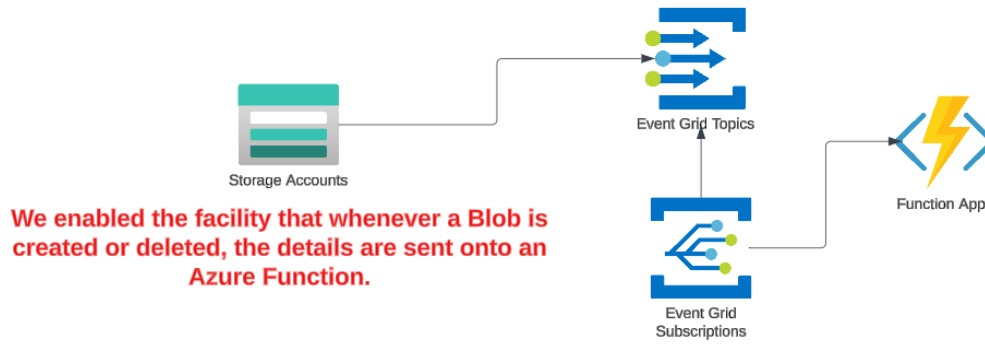
You can then have modules that poll the queue for messages. The receiving module then needs to process and remove the messages accordingly.

Debugging Azure Event Grid locally

Here the events are sent onto an Event Grid Topic.

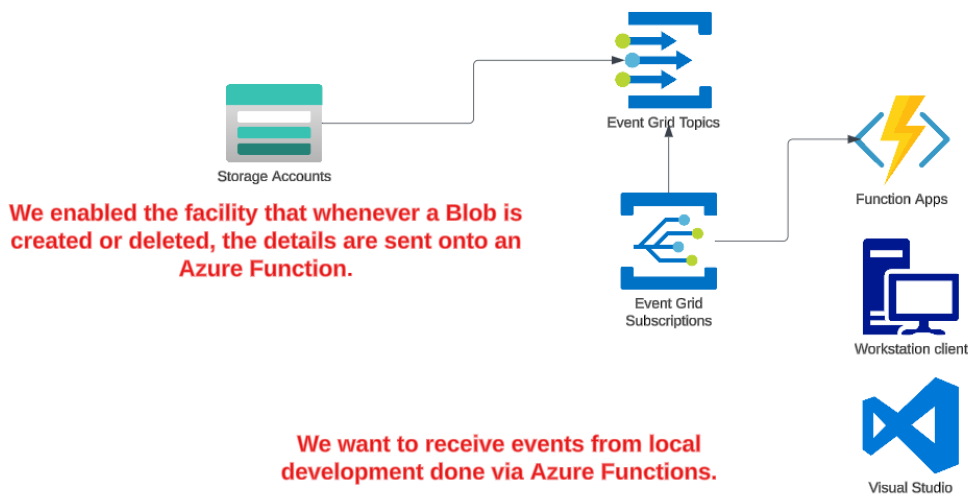
System Topic - Events from Azure services.

Custom Topic - Here you can publish your own Application-based events.



We enabled the facility that whenever a Blob is created or deleted, the details are sent onto an Azure Function.

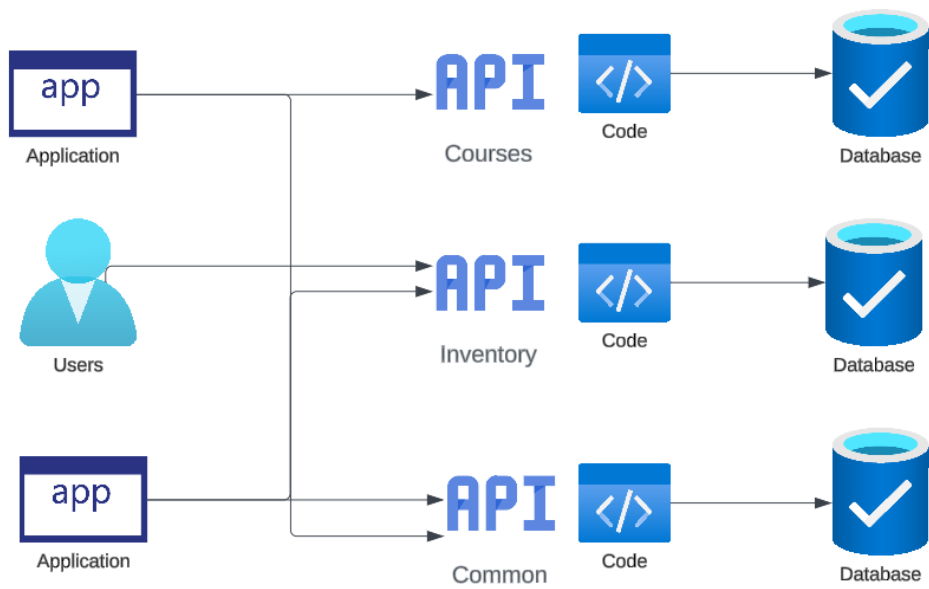
We then subscribed to the topic and placed the Azure Function as an endpoint.



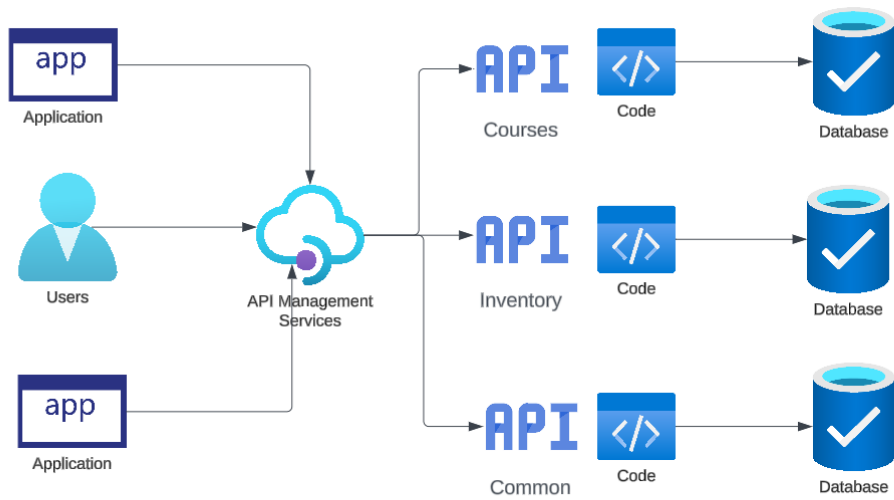
We enabled the facility that whenever a Blob is created or deleted, the details are sent onto an Azure Function.

We want to receive events from local development done via Azure Functions.

What is the API Management service



You could have applications and users all calling API's.



With Azure API Management, you get an API Gateway. All requests to the API's can flow via the API Gateway.

Security - Validate API keys or JWT tokens.

Cache responses

You can enforce usage quotas and rate limits.