DS684
Cloud Computing
Week 02

Regarding Labs and Assignments

- Class participation means more than Zoom attendance. You must actively participate in the discussion and labs, and answer questions.

- Must hit Submit button, otherwise no grade
- If you need extension in time, must send written request (***email***). Otherwise no grade and no makeup. Requests sent over Zoom chat do not count.
- For any technical difficulty (installation, Azure access, etc), you must send written explanation (***email***) before the deadline. Otherwise no grade and no makeup.

Agenda

- Virtual Machine
  - What is a virtual machine
  - Virtual Machine Demo
  - Images
- Azure Virtual Network
  - Demo
- Lab: Provision a VM
- Abstraction of Compute
  - Serverless
    - Container
    - Function as a Service
  - Application Programming Interface (API)

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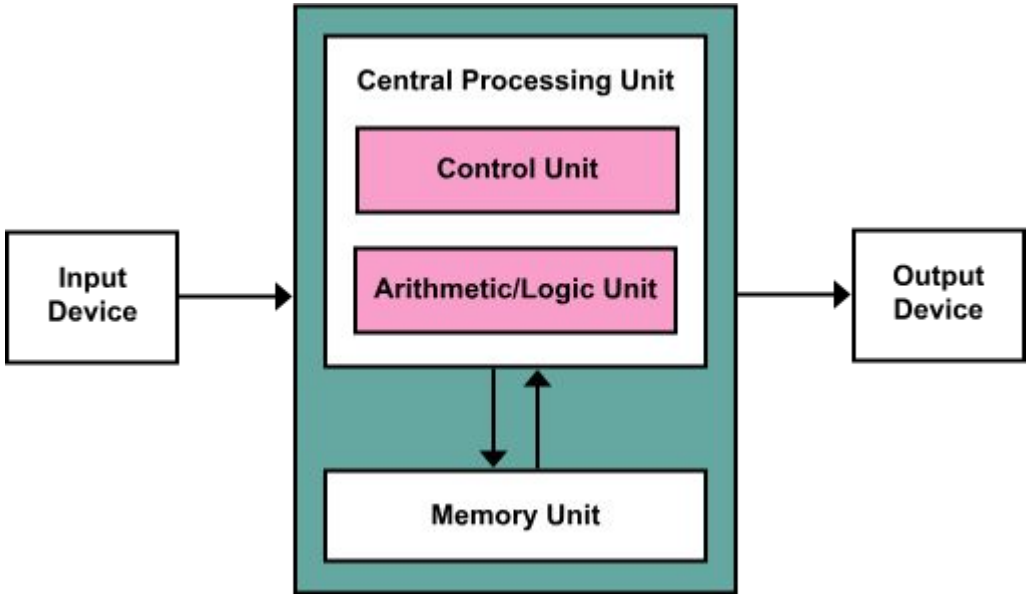
Understanding Compute

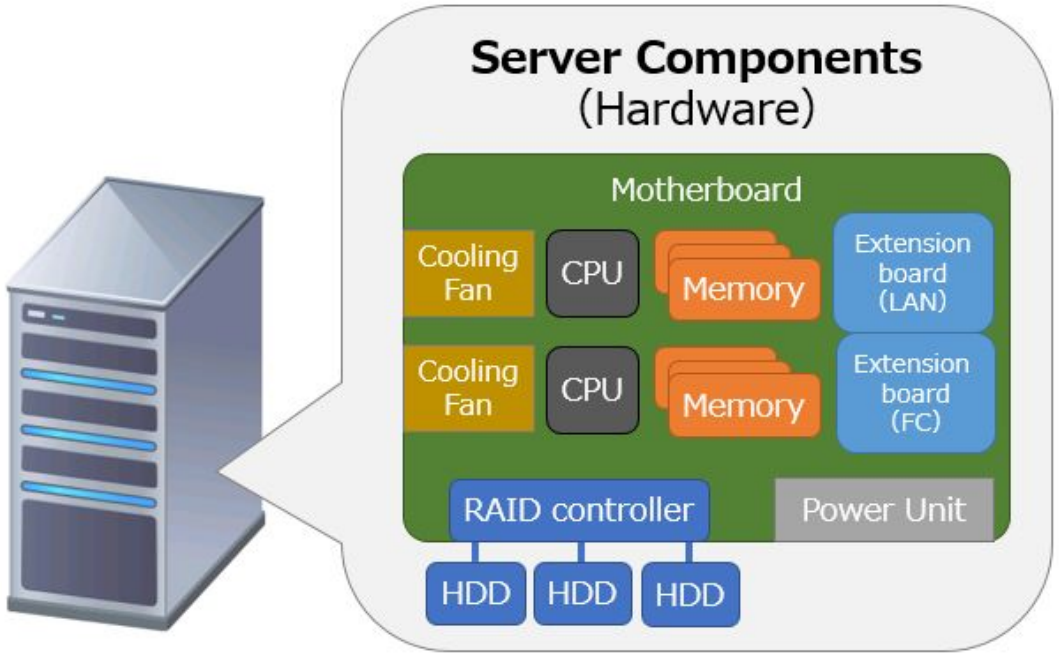
Compute resources: servers.

Von Neumann computer architecture =====>



Traditional Server

- Hardware
  - CPU
  - Memory
  - Hard disk
  - Input/output
- Software
  - Operating System
  - Application
  - Data



Virtualization

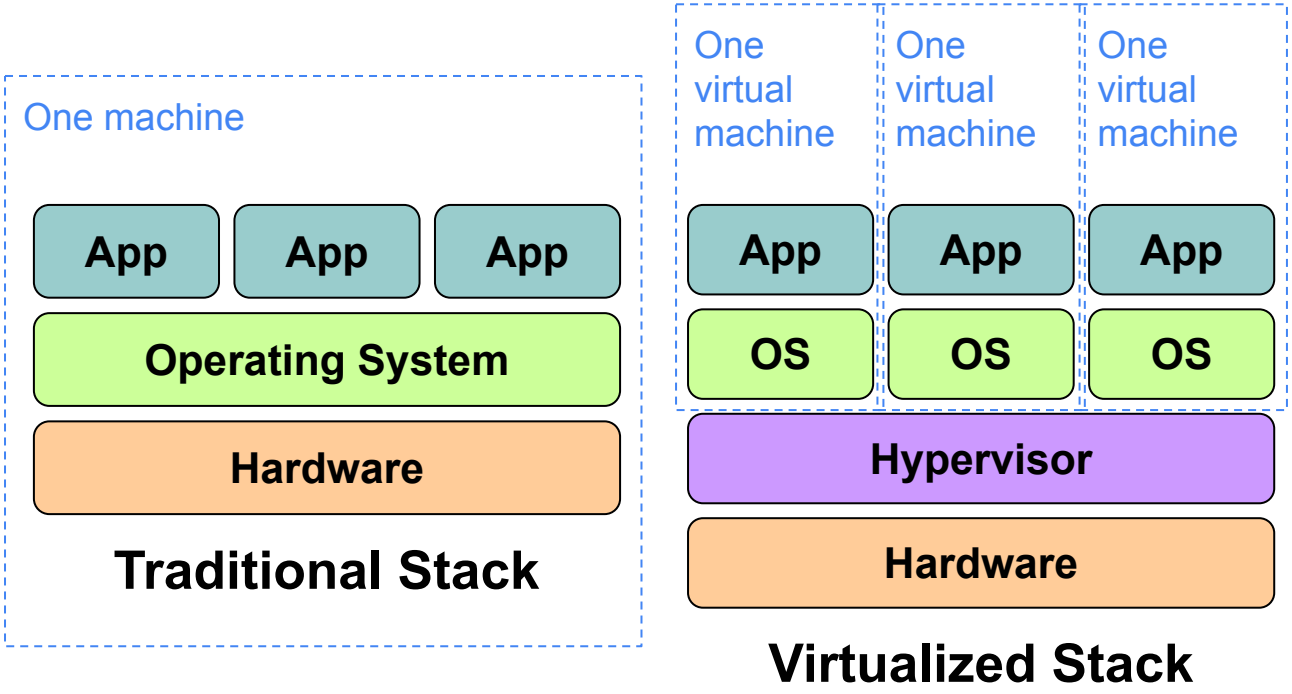
- Servers can have much more power than a single workload
  - It is possible to run multiple environments on the same hardware
- Hyperviser
  - A powerful physical host machine
  - Hosts and emulates machines/computers/servers, and allows management of these emulated machines/computers/servers
  - The emulated machines/computers/servers are called “virtual machines”

Virtualization

- Virtual machine:
  - Abstraction of a physical host machine,
  - An abstraction of an execution environment that can be made dynamically available to authorized clients by using well-defined protocols,
  - Resource quota (e.g. CPU, memory share),
  - Software configuration (e.g. O/S, provided services).

Virtualization

- Hardware
  - CPU
  - Memory
  - Hard disk
  - Input/output
- Software
  - OS
  - Application
  - Data



Azure Virtual Machine

- Virtualized computing resource offered by Microsoft Azure
- Virtualized instances of Windows or Linux servers that run in the cloud
- Provisioned with predetermined CPU, memory, hard disk, OS, and other settings

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Azure Virtual Machine

Information needed to create a virtual machine:

- Subscription and resource group
- Region and availability zone
- Virtual network
- CPU and memory: instance family
- Hard disk
  - Initial setup: OS, drivers, applications
  - Modifications to the disk: new installations, updates, configurations

Azure Virtual Machine

DEMO:

Provisioning an Azure virtual machine

Virtual machine state: Started, Stopped, Deleted

- Cost saving measures

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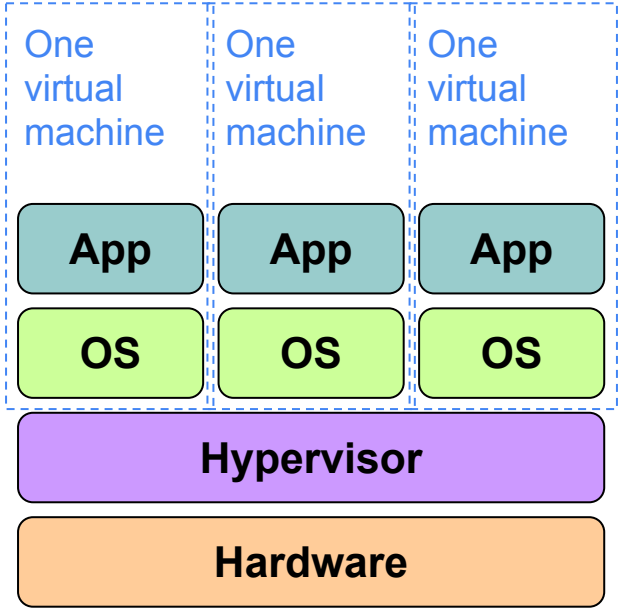
Persisting a Virtual Machine

- What is needed to keep the functionality of a Virtual Machine after it is shut down
  - Will not impact VM functionality
    - CPU
    - Memory
    - Hard disk type and size
    - Input/output
  - Will impact VM functionality
    - OS
    - Application
    - Data
- Save to hard disk (snapshot) for restoration



Virtualized Stack

Azure Image

- Pre-configured virtual hard disk (VHD) that contains an operating system, application, data, and/or other software.
- Azure images are used as a template to create new virtual machines (VMs) in the Azure cloud environment.
- Can be created from a Virtual machine that is in STOPPED state
- Image can be shared with other users

Azure Image

Azure Image Gallery vs Managed Image

- Image Gallery
- Managed Image

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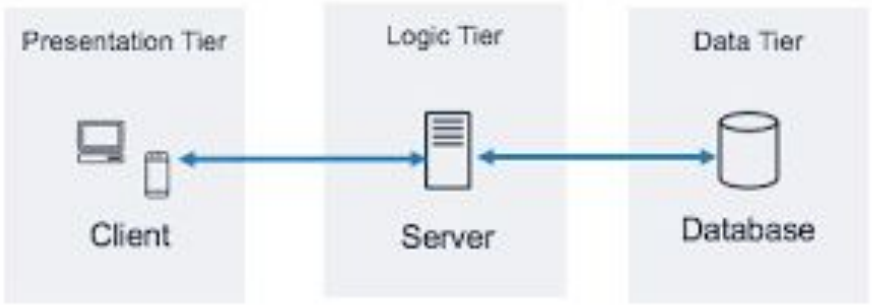
Application Architecture

In a simplest example, application (Jupyter Notebook) and database (PostgreSQL) are hosted on one machine.

3 tier architecture:

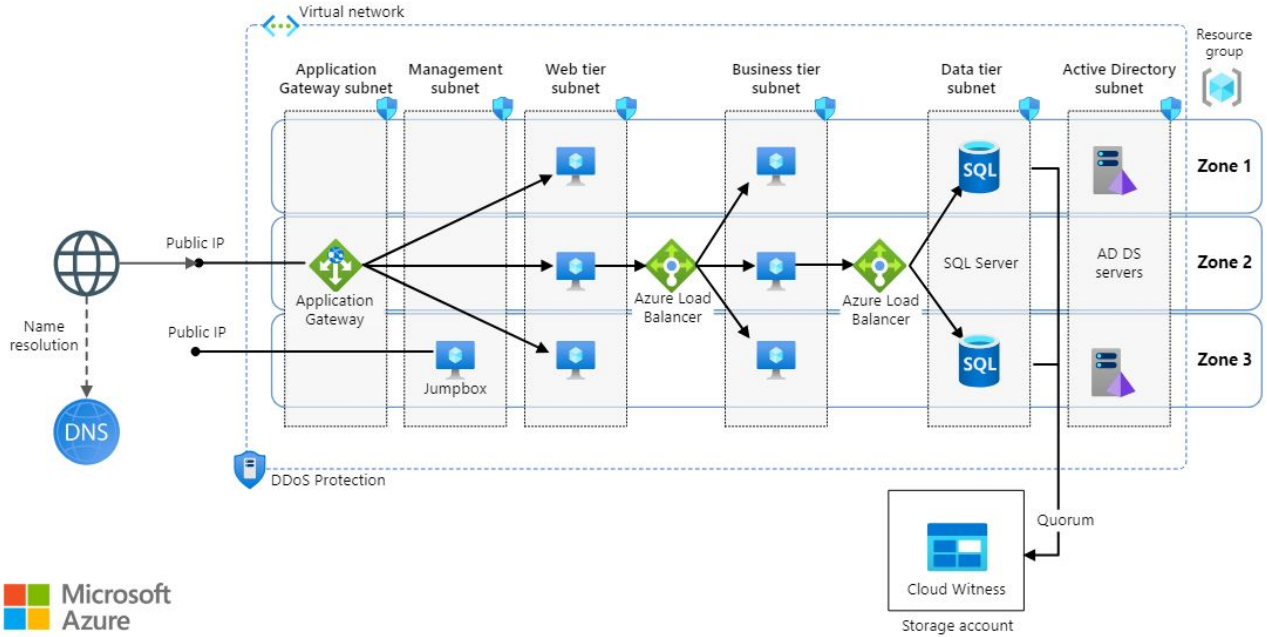
- Separation of duty
- Flexibility and scalability



Three-tier Azure architecture

Application Architecture

In reality, a production system can host hundreds even thousands of machines:



Application Architecture

All these machines exist in Azure data centers, and they must be able to:

- communicate to other machines in the same workload, while
- hide securely from outside machines, including other tenants' machines in Azure

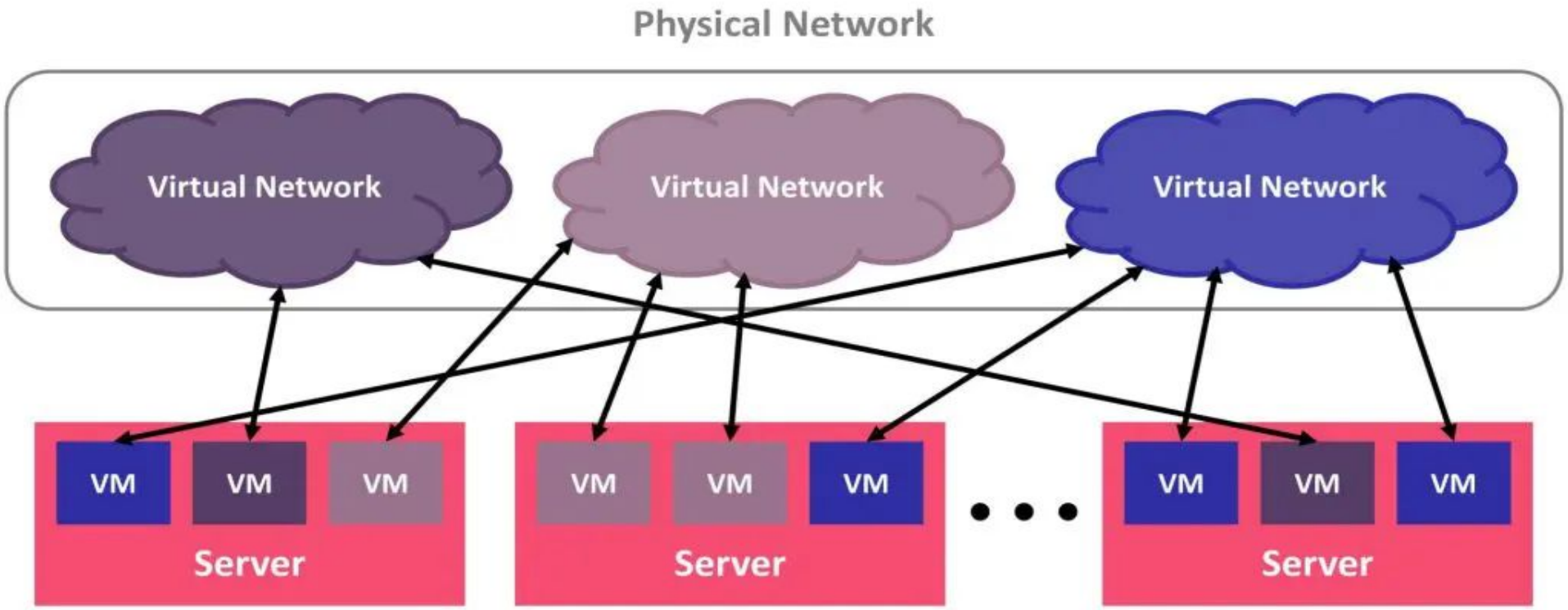
Azure Virtual Network

Azure Virtual Network is a service that provides the fundamental building block of private network, i.e., the secured private connectivities between virtual machines, in your Azure environment.

Virtualization of network

- One level higher than the physical network (“software tunnels” in the data center network)

Azure Virtual Network

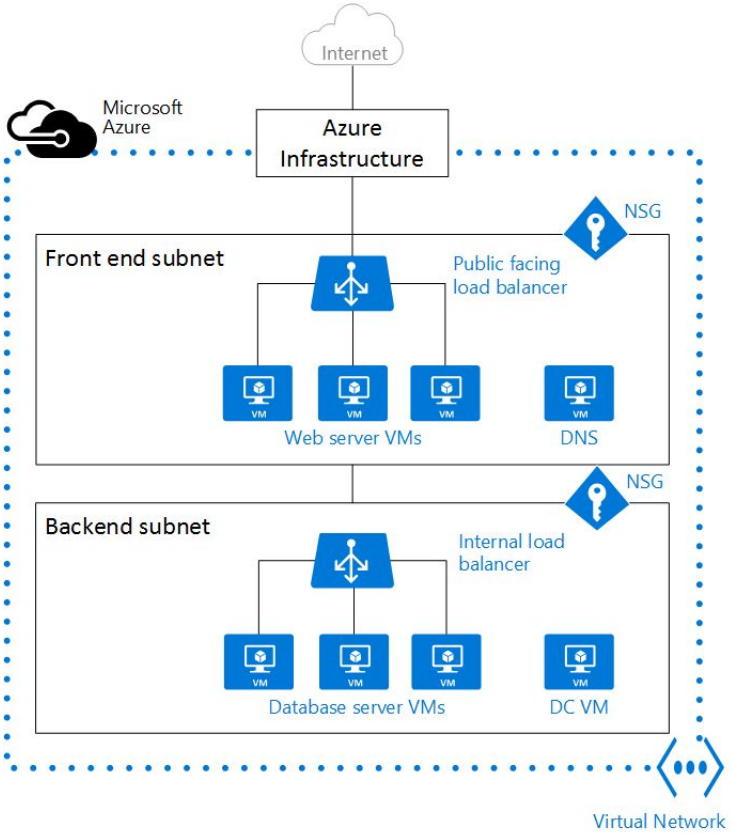


Azure Virtual Network

In a typical Virtual Network:

- Traffic inside Virtual Network is allowed
- Some VMs are allowed to have Internet access, some are not.
- Some VMs are used for special purpose (firewall, Bastion) and requires special network rules

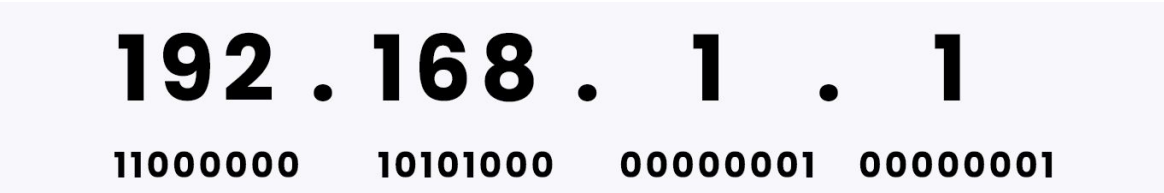
Divide the virtual network into subnets: public subnet vs private subnet



IP Address

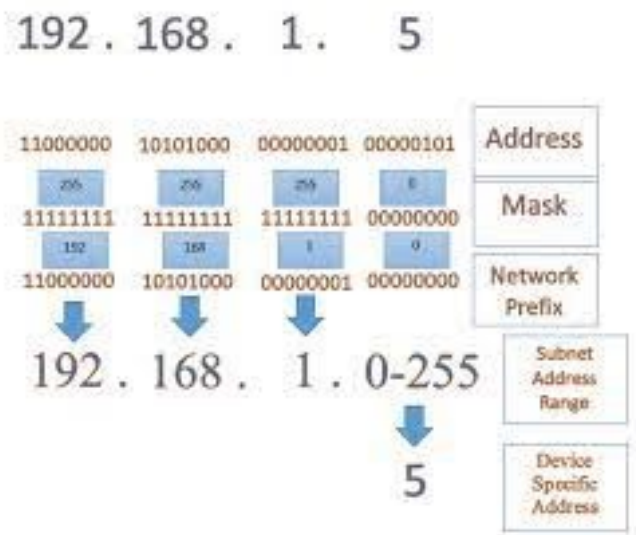
- Address of internet
  - Each network exposure interface should have one IP address

    xxx.xxx.xxx.xxx
- Each VM has its own IP address



IP Address Network Masks

- Each network's IP addresses are assigned in blocks, which includes each Azure Virtual Network and all subnets in it.
- Each virtual network/subnet has its own IP address range. VMs in a virtual network/subnet can only use the IP addresses within that range.



IP Address Range

The standard way to assign IP address to network: IP address range + CIDR

CIDR Block

CIDR is the size of network

/n means the first n bits are the network address, the rests are internal addresses.

CIDR Block

CIDR Block Size	Exponential Notation	Number of Addresses
/24	2^8	256
/23	2^9	512
/22	2^{10}	1,024
/21	2^{11}	2,048
/20	2^{12}	4,096
/19	2^{13}	8,192
/18	2^{14}	16,384
/17	2^{15}	32,768
/16	2^{16}	65,536

Azure Virtual Network Security Group

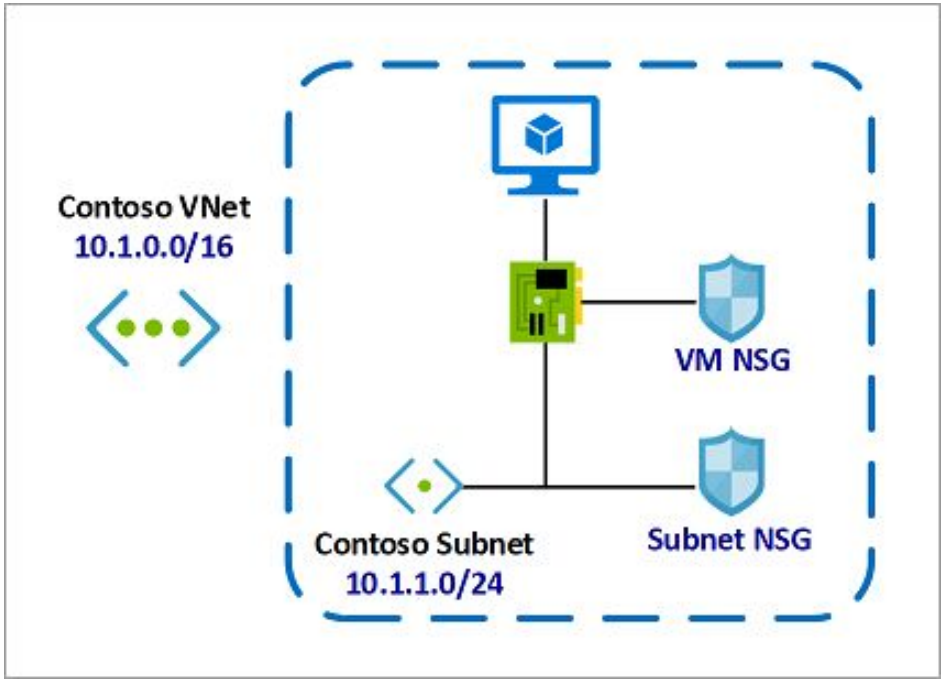
Firewall for virtual machines and services

- Based on ports
- Based on IP, tags, application security groups

A network security group contains security rules that allow or deny inbound network traffic to, or outbound network traffic from, several types of Azure resources.

Azure Virtual Network Security Group

Security group can be applied to both subnets and virtual machines.



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Demo of Azure Network

- Virtual Network
  - IP address
- Subnet
  - Public/private
- Network Security Group

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Demo and Lab

Instructor will demonstrate the provisioning of a VM and the sharing of an image, and termination of VM

Lab: Provision a virtual machine and shut it down

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Abstraction of Compute

What is Compute:

- A metal box with some copper wires inside
- A combination of CPU and memory
  - Virtualization
  - Still concerned about the physical details about CPU and memory
- A black box that can generate output when prompted with inputs
  - The physical details are not important any more

Types of Compute Abstraction

- Remove the physical dependencies and constraints: Serverless
  - Container
  - Function as a service
- Only keep the output: Application programming interface (API)

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Serverless Computing

Azure definition of serverless

Serverless computing enables developers to build applications faster by eliminating the need for them to manage infrastructure. With serverless applications, the cloud service provider automatically provisions, scales, and manages the infrastructure required to run the code.

servers are still running the code. The serverless name comes from the fact that the tasks associated with infrastructure provisioning and management are invisible to the developer.

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Introduction to Container

- Applications nowadays must be able to run on multiple platforms (operating systems): Windows, Linux, iOS, etc
- Migrating between platforms is painful
- What applications want from OS are indeed pretty similar: file, memory, configuration storage
- A further virtualization: Container layer to simulate the functionalities of different OS

Advantage of Containerization

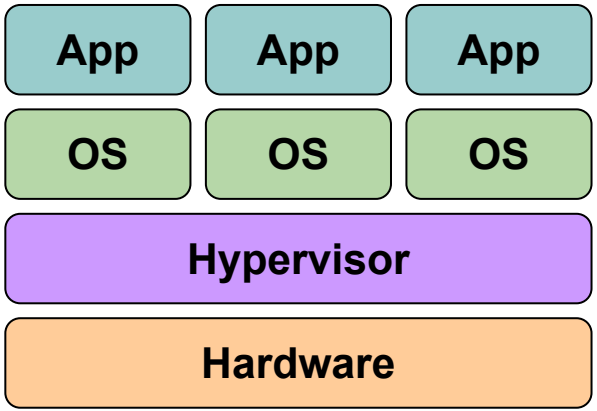
Many functionalities are similar across different OS and their toolsets. Container layer provides a common interface to these functionalities, while the applications can keep their own configurations in the container.

- Portability.
- Efficiency.
- Agility.
- Faster delivery

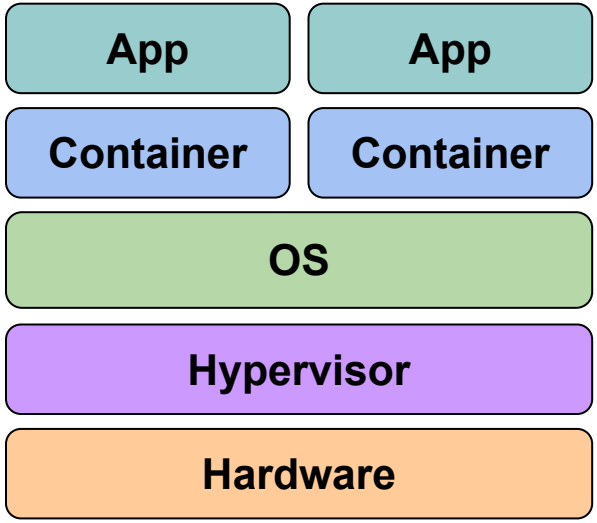
Container makes users focusing on ***applications***.

Introduction to Container

Each application has its own container space (pseudo OS environment), in which it can have its own configurations.



Virtualized Stack



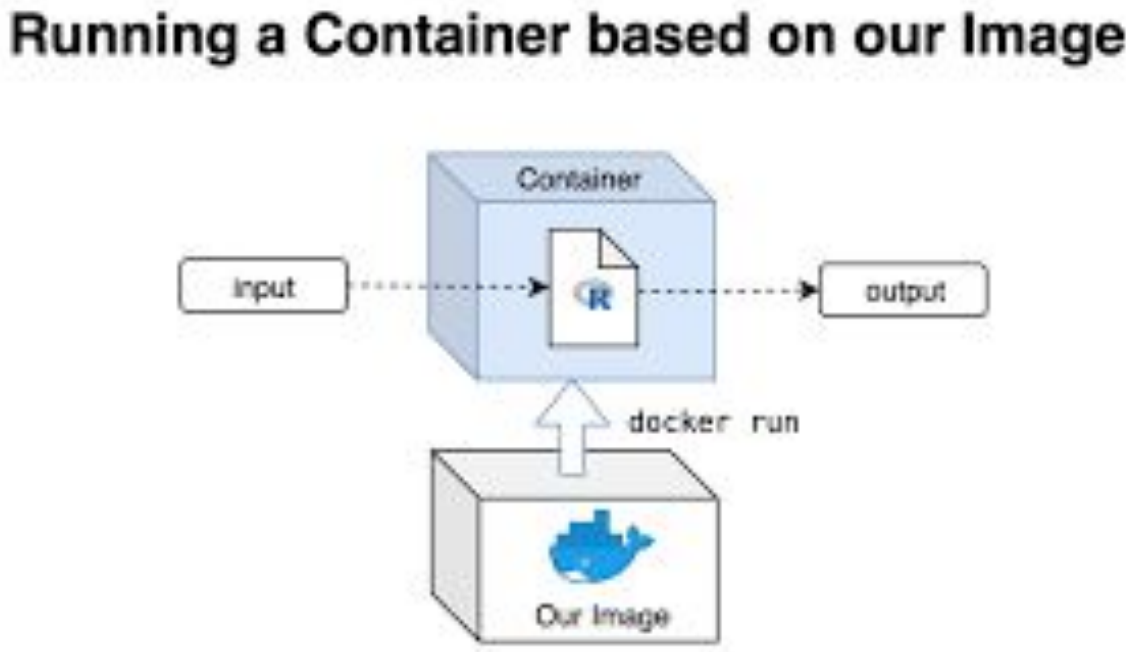
Container Stack

Container Image

Each application is packaged into an “image”, which has

- Pseudo OS (a layer of interface that simulates OS behavior but indeed pass the requests to the container layer)
- Libraries/runtime/supporting framework
- Application code/executable
- Application configuration information

Running a Container Image



Running Container in Azure

If you want to	Use this
Build, store, secure, and replicate container images and artifacts	Azure Container Registry
Launch containers with hypervisor isolation	Azure Container Instances
Migrate legacy application as-is to the cloud	Azure App Service
Run containerized web apps on Windows and Linux	Web App for Containers
Deploy and operate always-on, scalable, distributed apps	Azure Service Fabric
Build and deploy modern apps and microservices using serverless containers	Azure Container Apps
Execute event-driven, serverless code with an end-to-end development experience	Azure Functions
Deploy and scale containers on managed Kubernetes	Azure Kubernetes Service (AKS)

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Function as a Service

Function as a Service (FaaS): A platform allowing customers to develop, run, and manage application functionalities without the complexity of building and maintaining the infrastructure

Event-driven, serverless compute platform that helps you develop more efficiently using the programming language of your choice

Event Driven

Instead of invoked manually, Azure Functions can be triggered by an external event, such as:

- a blob is added to a specified container
- an event grid receives a new event
- an event hub receives a new event
- an HTTP request
- a specified schedule (date/time)
- etc.

Azure Cloud Function Demo

1. Create a Cloud Function App (a container for functions)
2. Create a function

   HTTP trigger: A function that will be run whenever a HTTP URL is requested

3. Provision the function by adding code
4. Test with trigger

We don’t care about the OS or language or hard disk. We only care about the output.

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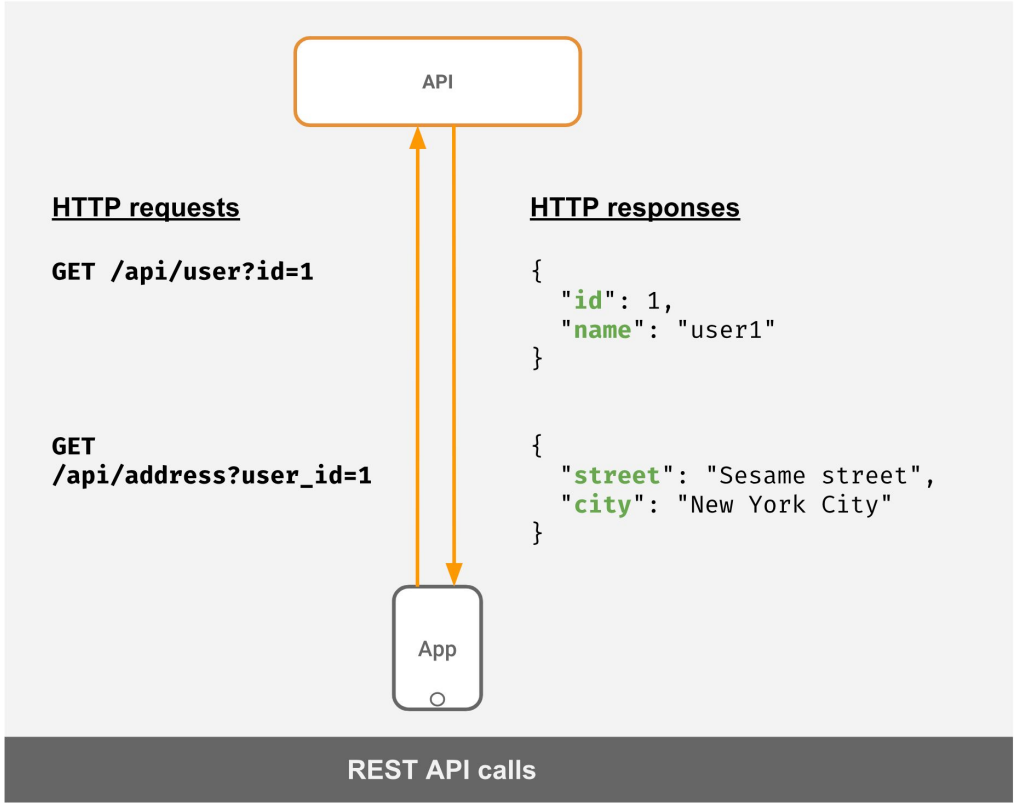
Application Programming Interface (API)

A set of rules that define how applications or devices can connect to and communicate with each other

- Endpoint (Address): usually an URL
- Method: GET, POST, etc.
- Input: usually JSON
- Output: usually JSON

API Example (GET)



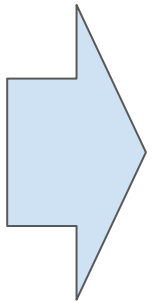
API Example (POST)

https://example.com/api/v1/users

POST

content-type: application/json
accept: application/json
authorization: Bearer eyJhbGciOi.....ssw5c

```
{
  "name": "Juan",
  "job": "author"
}
```

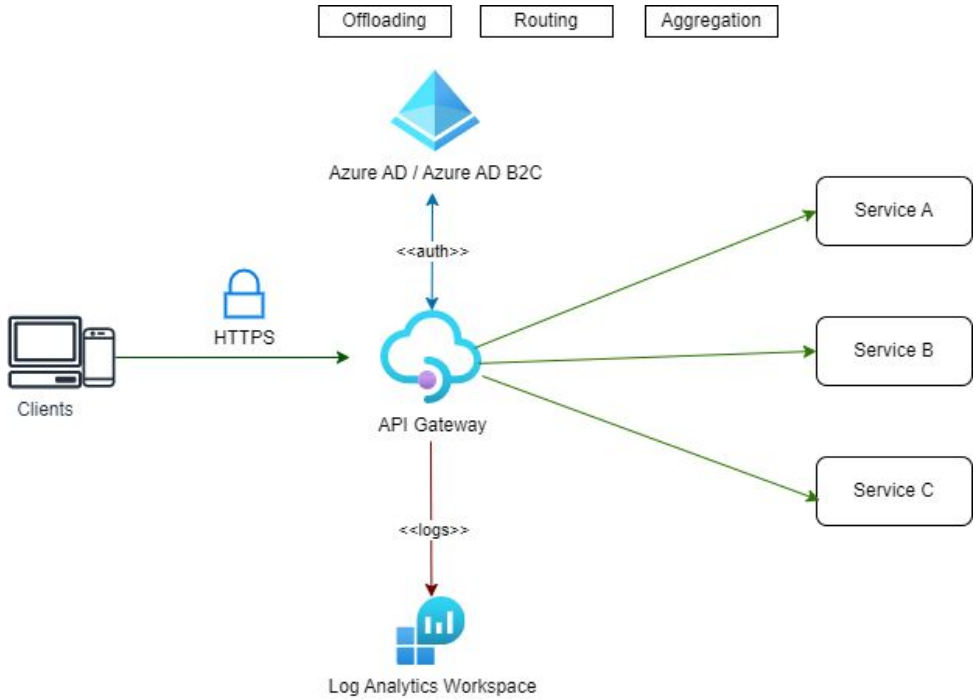


```
{
  "message": "Hello world!"
}
```

Advantages of API based Architecture

- Loosely coupled.
- Easy to maintain and upgrade.
- Flexible
- Wide adoption

Azure API Management Portal



More Event Driven

Azure Function’s HTTP Triggering Event is a one-source-to-one-target mapping. Sometimes, you may want a centralized way of event management

Azure has three event management systems

- Event grid
- Event hubs
- Service bus

Azure Storage Account has its own Blob Event mechanism

More Event Driven

Service	Purpose	Type	When to use
Event Grid	Reactive programming	Event distribution (discrete)	React to status changes
Event Hubs	Big data pipeline	Event streaming (series)	Telemetry and distributed data streaming
Service Bus	High-value enterprise messaging	Message	Order processing and financial transactions

Assignment