Week 2 Amazon Web Services Introduction

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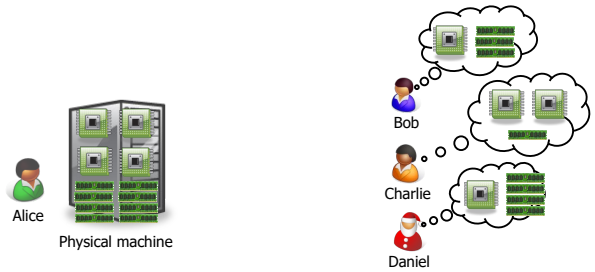
Overview

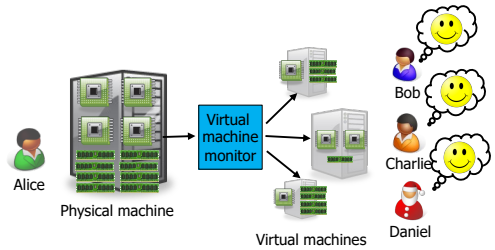
- Brief introduction to virtualization
- AWS introduction

Virtualization: the core technique of cloud computing



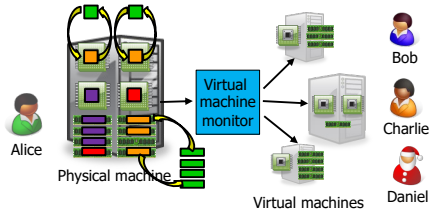
- Suppose Alice has a machine with 16 CPUs and 64 GB of memory. There are three customers:
  - Bob wants a machine with 8 CPUs and 32 GB of memory
  - Charlie wants a machine with 8 CPUs and 32 GB of memory
  - Daniel wants a machine with 4 CPUs and 8 GB of memory
- What should Alice do?

Virtualization: the core technique of cloud computing



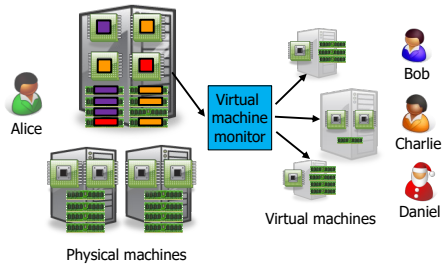
- Alice installs a virtual machine monitor (VMM) and provides each customer a guest OS/virtual machine (VM) with the requested resources
  - Bob is assigned with 8 vCPU and 32 GB of guest physical memory
  - Charlie is assigned with 8 vCPUs and 32 GB of guest physical memory
  - Daniel is assigned with 4 CPUs and 8 GB of guest physical memory
  - From each customer's perspective, it appears as if they owned the physical machine all by themselves (indicating VM isolation)
- Obviously, more resources are provided by virtualization.

Time sharing



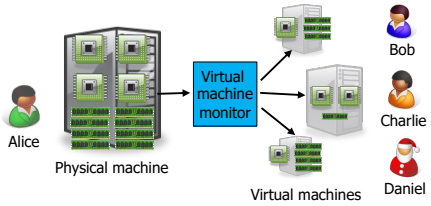
- VMs time-share existing hardware resources (a time-multiplexed manner)
- What if Alice serves more customers?

VM live migration



- What if the machine needs to be shut down for maintenance?
  - Alice can migrate the running VMs to different physical machines without interrupting any customers.

VM isolation

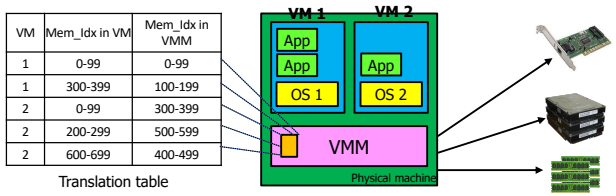


- One customer cannot access data of another customer

The benefits of virtualization

- Flexible to cloud providers, who
  - can generate VMs with different resource capabilities
  - can migrate VMs if necessary (e.g., for maintenance)
  - can increase load by overcommitting resources
- Secure to VMs
  - One VM cannot access another without permission
- Convenient to customers
  - Complete control over the virtual 'hardware' (can install their own operating systems, applications, ...)
- **But there might be performance impacts**
  - Load changes in one VM may affect the performance of another VM on the same physical machine

How is virtualization implemented?



VM	Mem_Idx in VM	Mem_Idx in VMM
1	0-99	0-99
1	300-399	100-199
2	0-99	300-399
2	200-299	500-599
2	600-699	400-499

Translation table

- Resources (CPU, memory, and I/O devices) are virtualized
  - VMM ("Hypervisor") has translation tables that map virtual resources to physical resources
  - Example: VM 1 accesses memory cell #300; VMM maps this to memory cell #100.

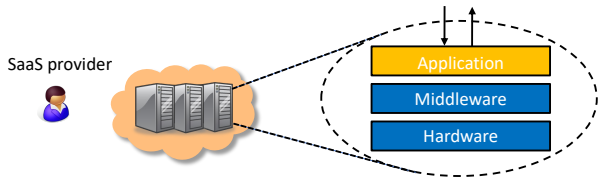
Amazon: the pioneer

- Jul 2002: Amazon Web Services launched
- Mar 2006: Amazon S3 (Simple Storage Service) launched
  - Proposed the 'pay-per-use' business model, which is now the standard in cloud computing
- Aug 2006: Amazon EC2 (Elastic Compute Cloud) launched
- Nov 2009: Microsoft Azure Beta launched
  - Microsoft's online services are gradually transitioning to Azure
- Dec 2013: Google Compute Engine launched

What services does a cloud provide?

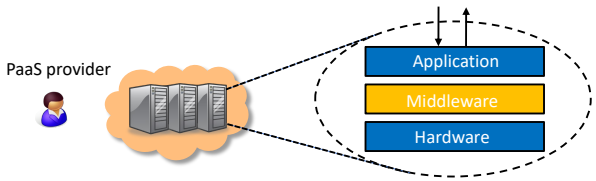
- Three common types of cloud services:
  - Software as a service (SaaS)
    - Analogy: Restaurant. Prepares & Serves an entire meal...
  - Platform as a service (PaaS)
    - Analogy: Take-out food. Prepares meal, but does not serve it.
  - Infrastructure as a service (IaaS)
    - Analogy: Grocery store. Provides raw ingredients.
- Other xaaS (anything as a service) types have been defined, but are less common
  - Desktop, Backend,, Network, Monitoring, ...

Software as a Service (SaaS)



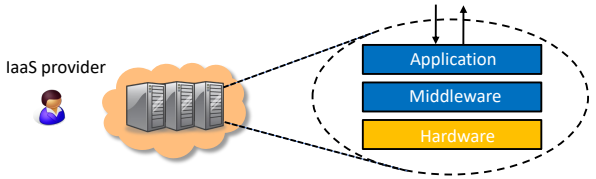
- Cloud provides an entire application
  - Email, Drive, Doc, Slides,...
  - Example: Google Workspace

Platform as a Service (PaaS)



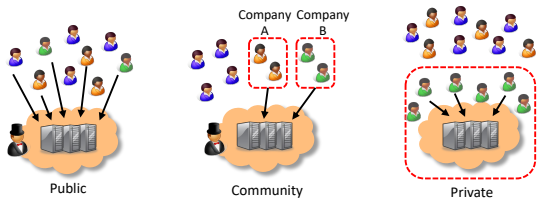
- Cloud provides middleware
  - Common Language Runtime environment
  - Example: Heroku

Infrastructure as a Service (IaaS)



- Cloud provides hardware resources
  - Virtual Machines, Virtual Memory, Virtual Disk,...
  - Examples: AWS (Amazon Web Services)

Public/community/Private clouds



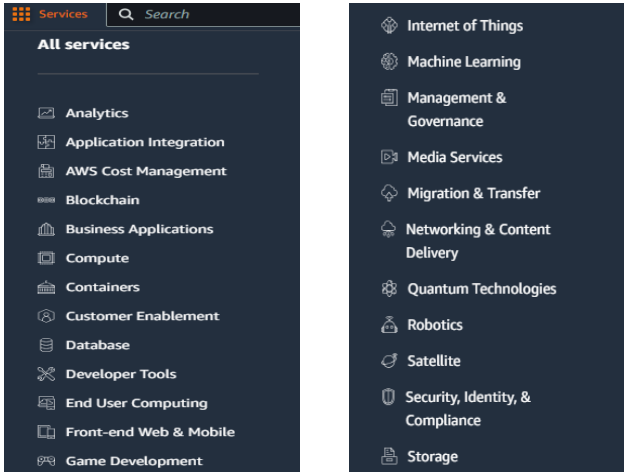
- Targeting different customers:
  - Public cloud: open to general public.
    - ➢Example: AWS, Microsoft Azure, Google Compute Engine
  - Community cloud: shared by multiple organizations with common interests and requirements.
    - ➢Example: Healthcare Sectors
  - Private cloud: exclusively used by a single organization.
    - ➢Example: Google's internal datacenter

Practice Questions

- [7 marks] Q1: What is service (XaaS) cloud computing? Describe the different categories of XaaS cloud computing can provide with specific examples of each service.

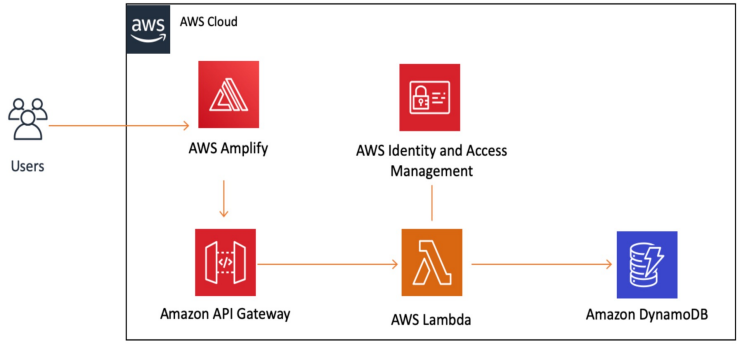
- [1 mark] Cloud computing offers a range of services, referred to as "XaaS," which stands for "Anything as a Service."
- [2 marks] Infrastructure as a Service that provides virtualized computing resources. An example is AWS.
- [2 marks] Platform as a Service that provides a runtime environment for developers to build, deploy, and manage applications. An examples is Google App Engine or Heroku.
- [2 marks] Software as a Service that delivers fully functional software applications. An example is Microsoft 365 office or Google workplace.

AWS: the leading cloud providing a wide range of services



AWS: the leading cloud providing a wide range of services

- The services satisfy different needs of customers:
  - Allowing us to design, deploy, and manage applications on the cloud, so-called application architecture.
  - e.g., build a web application



What is an application architecture?

- It is the structural design and organization of a software application.

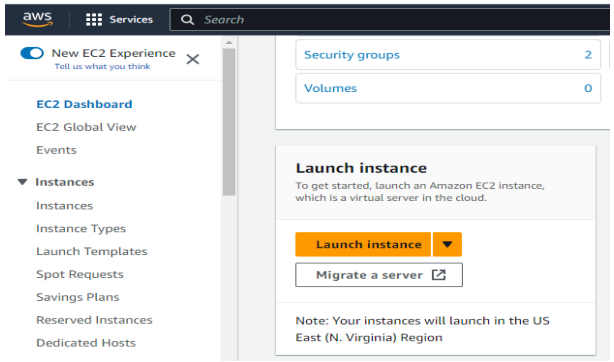
- Main types of application architectures
  - Monolithic architecture: combines the frontend, backend, and database functionalities into a single application.
    - e.g., wordpress: a content management system (CMS)
  - Client/Server architecture: an application is split into two main components: the client, which handles the user requests, and the server, which handles the processing of requests and data storage.
    - e.g., gmail
  - Three-tier architecture: a presentation tier (frontend), application logic tier (backend), and a database tier (backend).
    - e.g., Shopify: an e-commerce platform.
  - Cloud-based serverless architecture: known as Function-as-a-Service, which is a cloud computing model where the cloud provider provisions, maintain and scale applications.
    - e.g., AWS Lambda

Deploying application architecture

- When an architecture is ready, it can be deployed onto AWS via different services:
  - Elastic Compute Cloud (EC2): an EC2 instance is a virtual machine that runs a Windows or Linux server. It is essentially running on Virtual Machine Monitor (VMM).
  - Elastic Container Service (ECS): a customized environment provided by an EC2 instance.

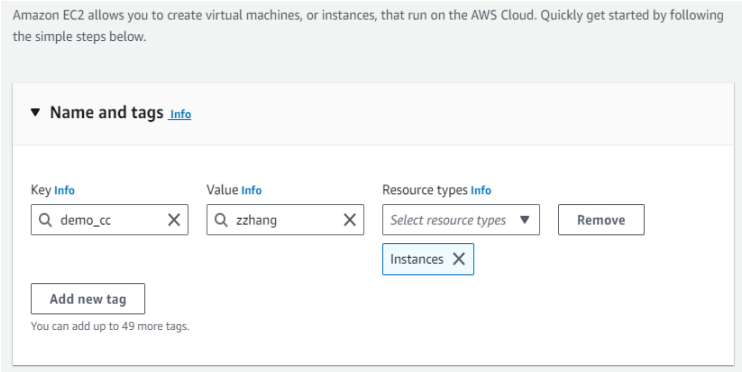
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - Sign in to the AWS Management Console:
    - https://aws.amazon.com/ or https://489389878001.signin.aws.amazon.com/console
  - Navigate to EC2 Dashboard and Click “Launch instance”



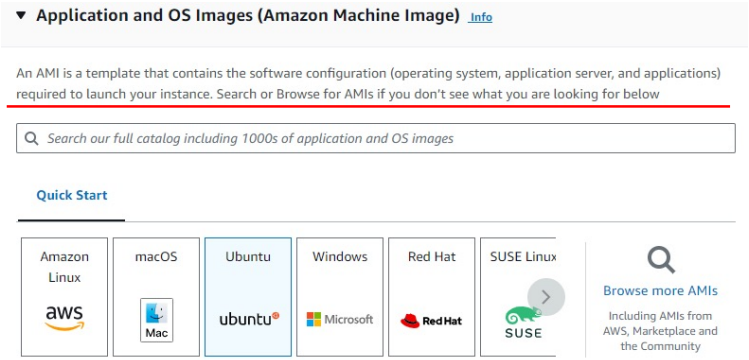
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Name and tags”: In this step, we can add names and tags to our instance. Tags are key-value pairs that help identify and categorize instances for better management, e.g., Key: demo_cloudcompute, Value: MyEC2Instance. We can click the "Add new tag" button to add multiple tags as needed.



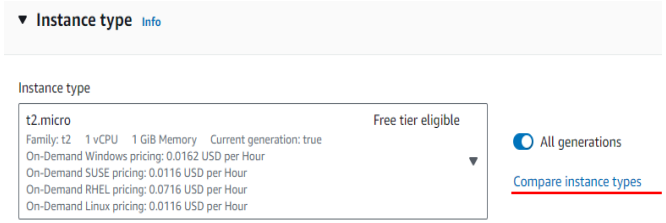
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Application and OS Images (Amazon Machine Image)”: In this step, we select an AMI that suits our requirements. We can choose from various operating systems and pre-configured applications. The definition of an AMI is as follows:



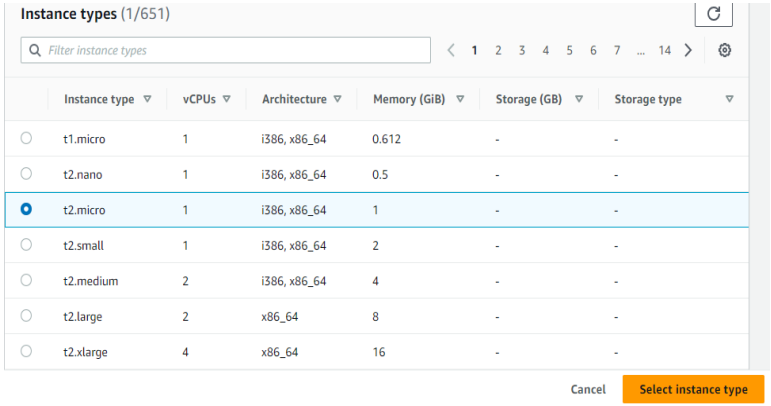
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Instance type”: In this step, we select an appropriate instance type that meets our computing, memory, networking or storage needs.



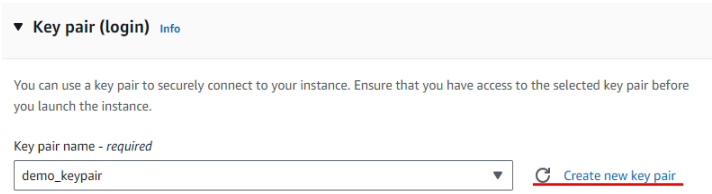
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Instance type”
    What does Architecture mean?



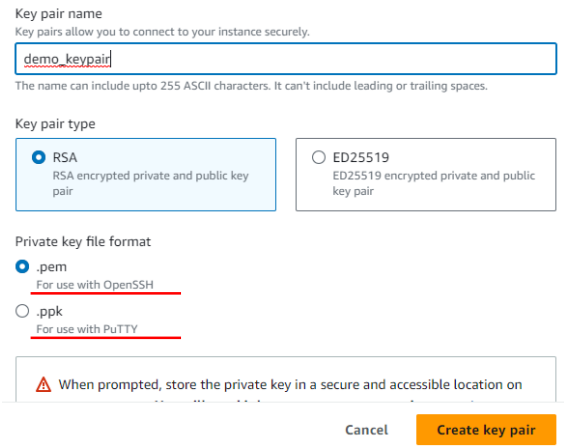
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Key pair (login)”: In this step, we can select/create a key pair (SSH key) for secure access to our first instance. If we currently don't have a key pair, we can create one.



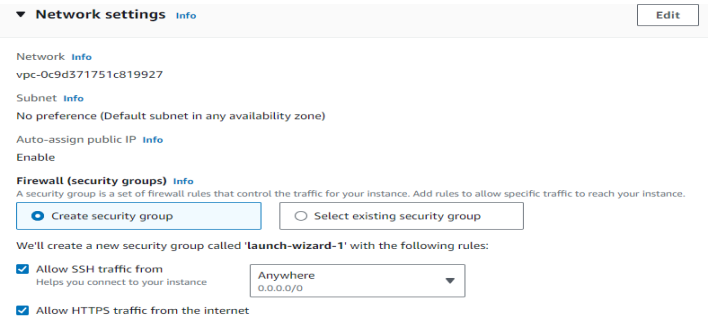
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Key pair (login)”:



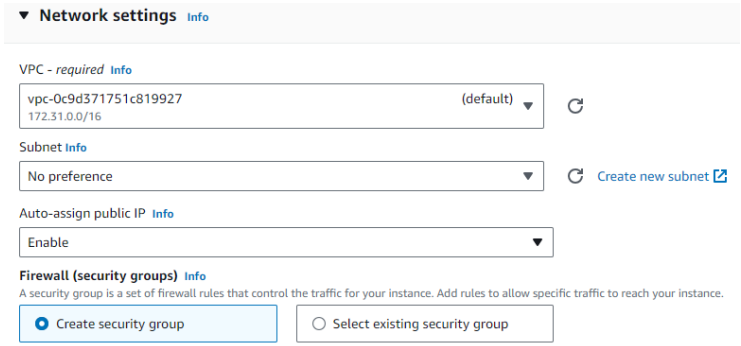
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
- “Network settings”: In this step, we configure the network based on the application of our instance, e.g., connect to the instance via SSH or RDP, create security group, etc.



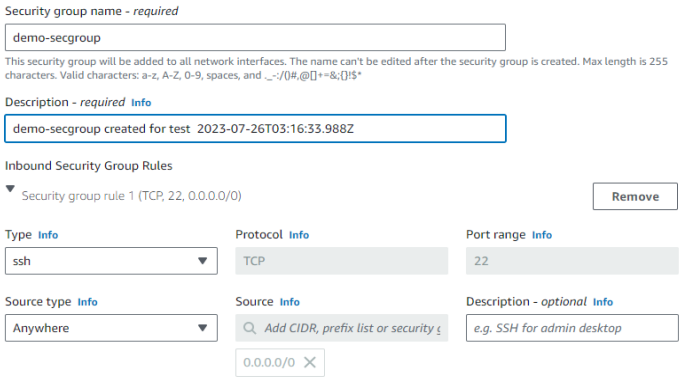
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - "Network settings"



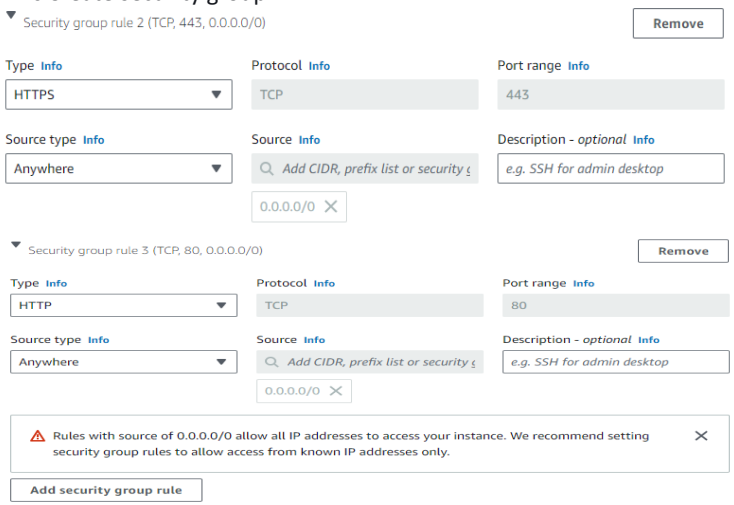
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - "Network settings"
    - Create security group: a security group is a set of firewall rules that control the network traffic for our instance. We can add rules to allow specific traffic to reach our instance.



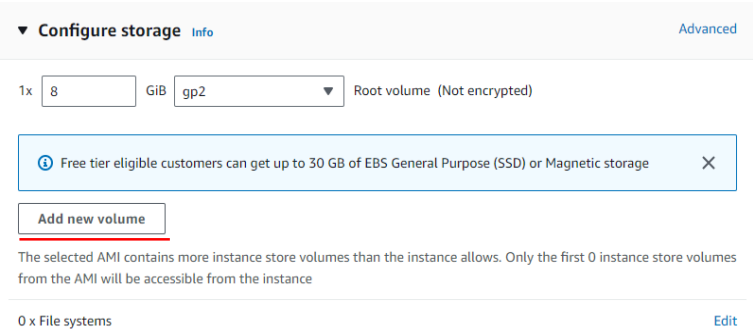
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - "Network settings"
    - Create security group



AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - "Configure storage": In this step, we specify storage volume for our instance. By default, one Elastic Block Store (EBS) volume is attached to the instance. We can add more EBS volumes if needed.



AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Configure storage”

- What is EBS about?
  - provides block level storage volumes for use with EC2 instances.
  - EBS storage is allocated in **volumes.** A volume is a 'virtual disk' (size from 1GB to 1TB)
  - Can be attached to any instance in the same Availability Zone
  - We pay for what we use with EBS.

AWS EC2

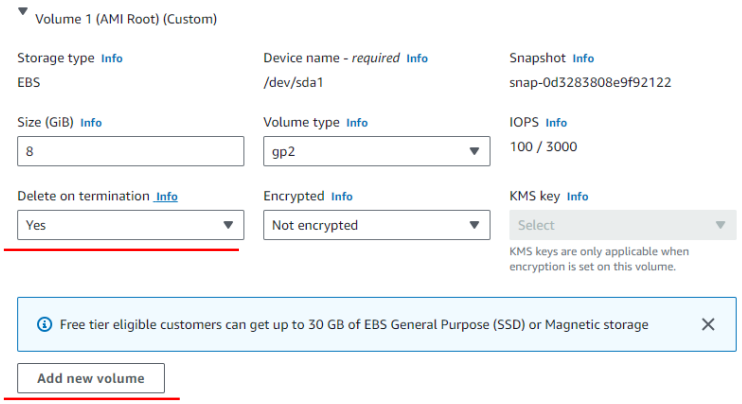
- Steps of creating, configuring and launching an EC2 instance :
  - “Configure storage”

EBS features

- **Persistent Storage:** EBS volumes persist independently from EC2 instances, indicating that when an instance is terminated, the data stored on the attached EBS volume CAN be retained.
- **High durability and availability:** EBS replicates volumes data across multiple physical servers within the same availability zone to prevent the loss of data from hardware failures.
- **Snapshots**: allows users to create point-in-time snapshots of their volumes. These snapshots serve as backups and can be used to restore volumes to a previous state.
- **Elastic volumes** : allows users to dynamically adapt their volumes when the needs of their applications change.

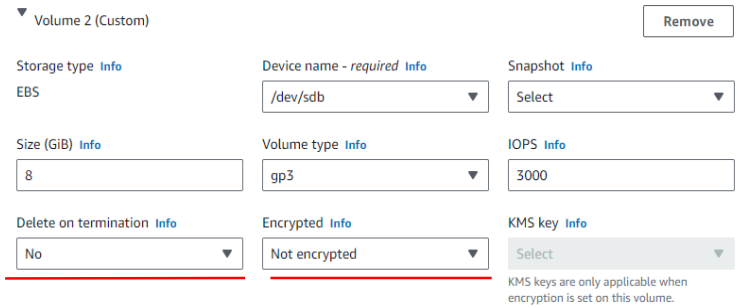
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Configure storage”
    - EBS setting



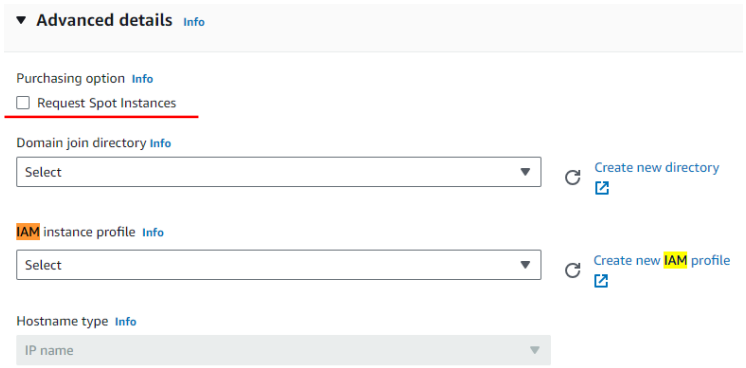
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Configure storage”
    - EBS setting



AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - "Advanced details"



AWS EC2

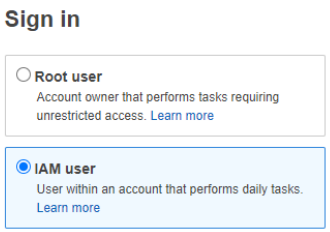
- Steps of creating, configuring and launching an EC2 instance :
  - "Advanced details"
    - Instance purchasing options

Amazon EC2 provides the following purchasing options to enable you to optimize your costs based on your needs:

- **On-Demand Instances** – Pay, by the second, for the instances that you launch.
- **Savings Plans** – Reduce your Amazon EC2 costs by making a commitment to a consistent amount of usage, in USD per hour, for a term of 1 or 3 years.
- **Reserved Instances** – Reduce your Amazon EC2 costs by making a commitment to a consistent instance configuration, including instance type and Region, for a term of 1 or 3 years.
- **Spot Instances** – Request unused EC2 instances, which can reduce your Amazon EC2 costs significantly.
- **Dedicated Hosts** – Pay for a physical host that is fully dedicated to running your instances, and bring your existing per-socket, per-core, or per-VM software licenses to reduce costs.
- **Dedicated Instances** – Pay, by the hour, for instances that run on single-tenant hardware.
- **Capacity Reservations** – Reserve capacity for your EC2 instances in a specific Availability Zone for any duration.

AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - "Advanced details"
    - Identity and Access Management (IAM) : It is a service that allows us to manage users, groups, and permissions to securely control access to AWS resources, e.g., root user and IAM user (according to the principle of least privilege).



What is the principle of least privilege?

AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - "Advanced details"
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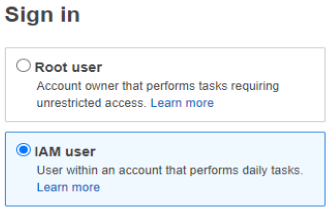


What is the principle of least privilege?

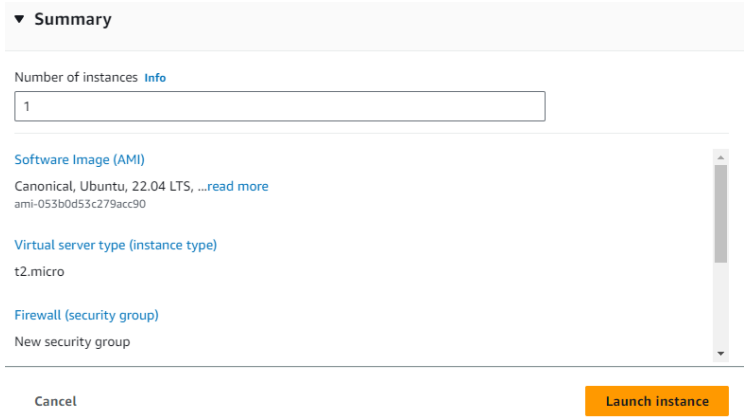
A user only has those privileges which are essentially vital to perform their intended operations. Thus, root user in AWS can be regarded as the system administer in a local OS. IAM user is a normal user in the OS.

AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Advanced details”

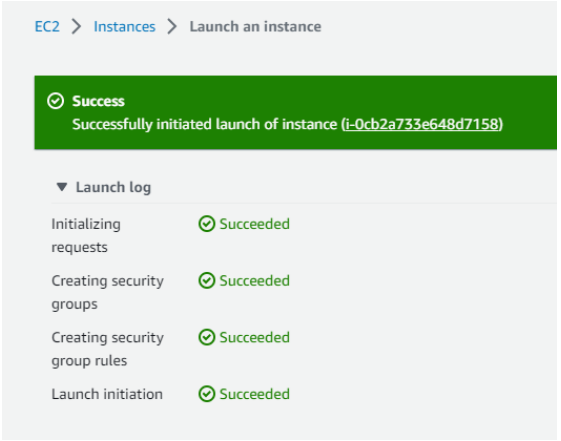
AWS EC2

- Steps of creating, configuring and launching an EC2 instance :
  - “Review and Launch”



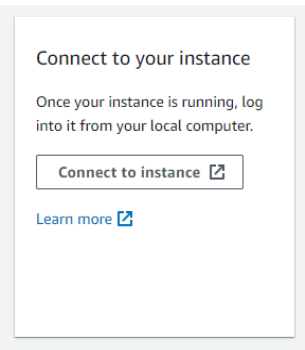
AWS EC2

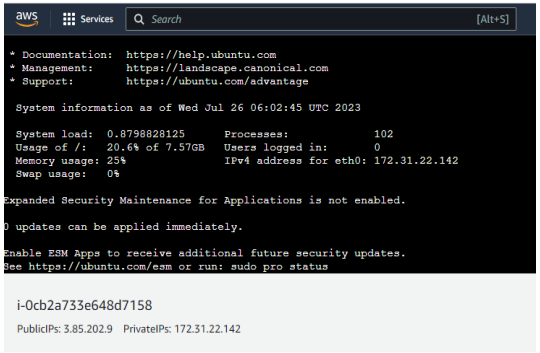
- Steps of creating, configuring and launching an EC2 instance :
  - “Review and Launch”



AWS EC2

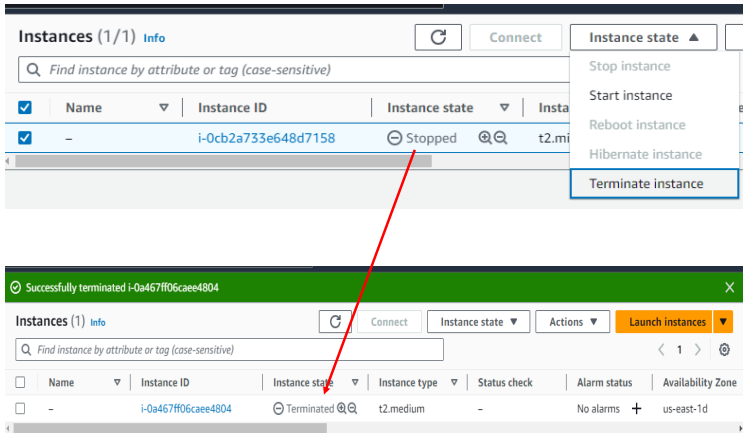
- Connecting to an EC2 instance :





AWS EC2

- Terminating an EC2 instance :



Demo

- Create, configure and launch an instance
- Connect to an instance
- Terminate an instance

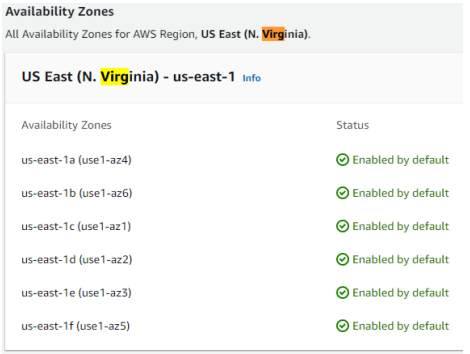
Geographical location of an instance

- AWS region:
  - There are many different geographical locations for AWS data centers around the world, known as “AWS Regions”, identified by names such as “us-west-2” (US West-Oregon).

US East (N. Virginia)	us-east-1
US East (Ohio)	us-east-2
US West (N. California)	us-west-1
US West (Oregon)	us-west-2
Asia Pacific (Mumbai)	ap-south-1
Asia Pacific (Osaka)	ap-northeast-3
Asia Pacific (Seoul)	ap-northeast-2
Asia Pacific (Singapore)	ap-southeast-1
Asia Pacific (Sydney)	ap-southeast-2
Asia Pacific (Tokyo)	ap-northeast-1

Geographical location of an instance

- Availability zone:
  - Each region is further divided into multiple availability zones, which are identified by additional letters such as “us-west-2a” and “us-west-2b”.
  - Each zone represents a separate data center in different physical locations within a region.
  - Each zone within a region is networked with low-latency connections



Practice Questions

- [10 marks] Q2: Describe the steps which you would take on AWS and the decisions that would need to be made to create, configure and launch an EC2 Instance.

- [1 mark] Sign in to the AWS management console
- [1 mark] Navigate to EC2 Dashboard and click “Launch instance”
- [1 mark] Select/Create names and tags
- [2 marks] Select AMI and Instance type
- [1 mark] Select/Create Key pair for login
- [3 marks] Configure network settings, storage and more advanced details (e.g., specify some self-defined behaviors)
- [1 mark] Review and launch

Practice Questions

- [7 marks] Q3: Describe EBS and what features it offers.

- [1 mark] A brief introduction to EBS.
- [2 marks] One feature and its brief description.
- [2 marks] One feature and its brief description.
- [2 marks] One feature and its brief description.