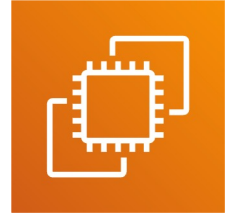


Amazon EC2 – Basics



Amazon EC2

- EC2 is one of the most popular of AWS' offerings
- EC2 = Elastic Compute Cloud = Infrastructure as a Service
- It mainly consists in the capability of :
 - Renting virtual machines (EC2)
 - Storing data on virtual drives (EBS)
 - Distributing load across machines (ELB)
 - Scaling the services using an auto-scaling group (ASG)
- Knowing EC2 is fundamental to understand how the Cloud works

EC2 sizing & configuration options

- Operating System (**OS**): Linux, Windows or Mac OS
- How much compute power & cores (**CPU**)
- How much random-access memory (**RAM**)
- How much storage space:
 - Network-attached (**EBS & EFS**)
 - hardware (**EC2 Instance Store**)
- Network card: speed of the card, Public IP address
- Firewall rules: **security group**
- Bootstrap script (configure at first launch): EC2 User Data

EC2 User Data

- It is possible to bootstrap our instances using an [EC2 User data](#) script.
- [bootstrapping](#) means launching commands when a machine starts
- That script is [only run once](#) at the instance [first start](#)
- EC2 user data is used to automate boot tasks such as:
 - Installing updates
 - Installing software
 - Downloading common files from the internet
 - Anything you can think of
- The EC2 User Data Script runs with the root user

Hands-On: Launching an EC2 Instance running Linux

- We'll be launching our first virtual server using the AWS Console
- We'll get a first high-level approach to the various parameters
- We'll see that our web server is launched using EC2 user data
- We'll learn how to start / stop / terminate our instance.

EC2 Instance Types - Overview

- You can use different types of EC2 instances that are optimised for different use cases (<https://aws.amazon.com/ec2/instance-types/>)
- AWS has the following naming convention:

m5.2xlarge

- m: instance class
- 5: generation (AWS improves them over time)
- 2xlarge: size within the instance class

General Purpose

Compute Optimized

Memory Optimized

Accelerated Computing

Storage Optimized

HPC Optimized

Instance Features

Measuring Instance
Performance

EC2 Instance Types – General Purpose

- Great for a diversity of workloads such as web servers or code repositories
- Balance between:
 - Compute
 - Memory
 - Networking
- In the course, we will be using the t2.micro which is a General Purpose EC2 instance

General Purpose

General purpose instances provide a balance of compute, memory and networking resources, and can be used for a variety of diverse workloads. These instances are ideal for applications that use these resources in equal proportions such as web servers and code repositories.

Mac	T4g	T3	T3a	T2	M6g	M5	M5a	M5n	M5zn	M4	A1
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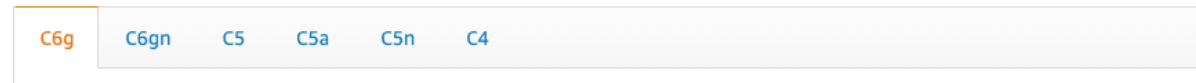
** this list will evolve over time, please check the AWS website for the latest information*

EC2 Instance Types – Compute Optimized

- Great for compute-intensive tasks that require high performance processors:
 - Batch processing workloads
 - Media transcoding
 - High performance web servers
 - High performance computing (HPC)
 - Scientific modeling & machine learning
 - Dedicated gaming servers

Compute Optimized

Compute Optimized instances are ideal for compute bound applications that benefit from high performance processors. Instances belonging to this family are well suited for batch processing workloads, media transcoding, high performance web servers, high performance computing (HPC), scientific modeling, dedicated gaming servers and ad server engines, machine learning inference and other compute intensive applications.



** this list will evolve over time, please check the AWS website for the latest information*

EC2 Instance Types – Memory Optimized

- Fast performance for workloads that process large data sets in memory
- Use cases:
 - High performance, relational/non-relational databases
 - Distributed web scale cache stores
 - In-memory databases optimized for BI (business intelligence)
 - Applications performing real-time processing of big unstructured data

Memory Optimized

Memory optimized instances are designed to deliver fast performance for workloads that process large data sets in memory.

R6g	R5	R5a	R5b	R5n	R4	X1e	X1	High Memory	z1d
-----	----	-----	-----	-----	----	-----	----	-------------	-----

** this list will evolve over time, please check the AWS website for the latest information*

EC2 Instance Types – Storage Optimized

- Great for storage-intensive tasks that require high, sequential read and write access to large data sets on local storage
- Use cases:
 - High frequency online transaction processing (OLTP) systems
 - Relational & NoSQL databases
 - Cache for in-memory databases (for example, Redis)
 - Data warehousing applications
 - Distributed file systems

Storage Optimized

Storage optimized instances are designed for workloads that require high, sequential read and write access to very large data sets on local storage. They are optimized to deliver tens of thousands of low-latency, random I/O operations per second (IOPS) to applications.

I3	I3en	D2	D3	D3en	H1
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** this list will evolve over time, please check the AWS website for the latest information*

EC2 Instance Types: example

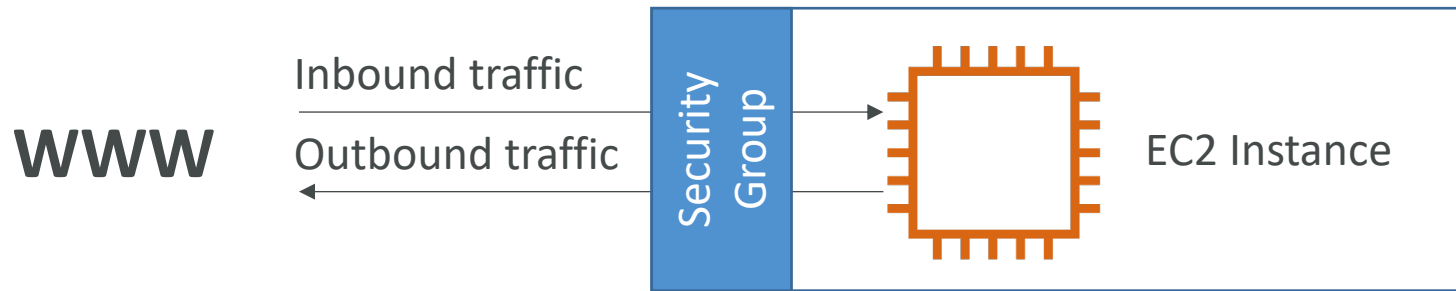
Instance	vCPU	Mem (GiB)	Storage	Network Performance	EBS Bandwidth (Mbps)
t2.micro	1	1	EBS-Only	Low to Moderate	
t2.xlarge	4	16	EBS-Only	Moderate	
c5d.4xlarge	16	32	1 x 400 NVMe SSD	Up to 10 Gbps	4,750
r5.16xlarge	64	512	EBS Only	20 Gbps	13,600
m5.8xlarge	32	128	EBS Only	10 Gbps	6,800

t2.micro is part of the AWS free tier (up to 750 hours per month)

Great website: <https://instances.vantage.sh>

Introduction to Security Groups

- Security Groups are the fundamental of network security in AWS
- They control how traffic is allowed into or out of our EC2 Instances.



- Security groups only contain **allow** rules
- Security groups rules can reference by IP or by security group

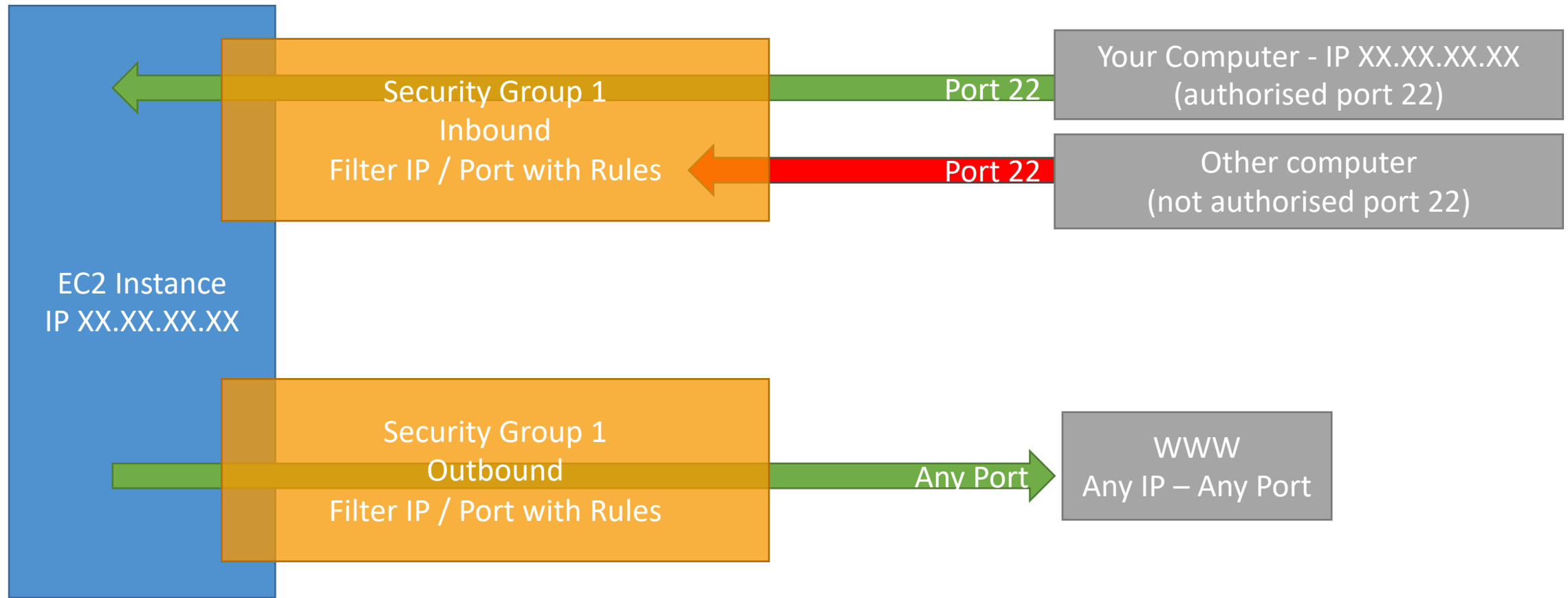
Security Groups

Deeper Dive

- Security groups are acting as a “firewall” on EC2 instances
- They regulate:
 - Access to Ports
 - Authorised IP ranges – IPv4 and IPv6
 - Control of inbound network (from other to the instance)
 - Control of outbound network (from the instance to other)

Type ⓘ	Protocol ⓘ	Port Range ⓘ	Source ⓘ	Description ⓘ
HTTP	TCP	80	0.0.0.0/0	test http page
SSH	TCP	22	122.149.196.85/32	
Custom TCP Rule	TCP	4567	0.0.0.0/0	java app

Security Groups Diagram



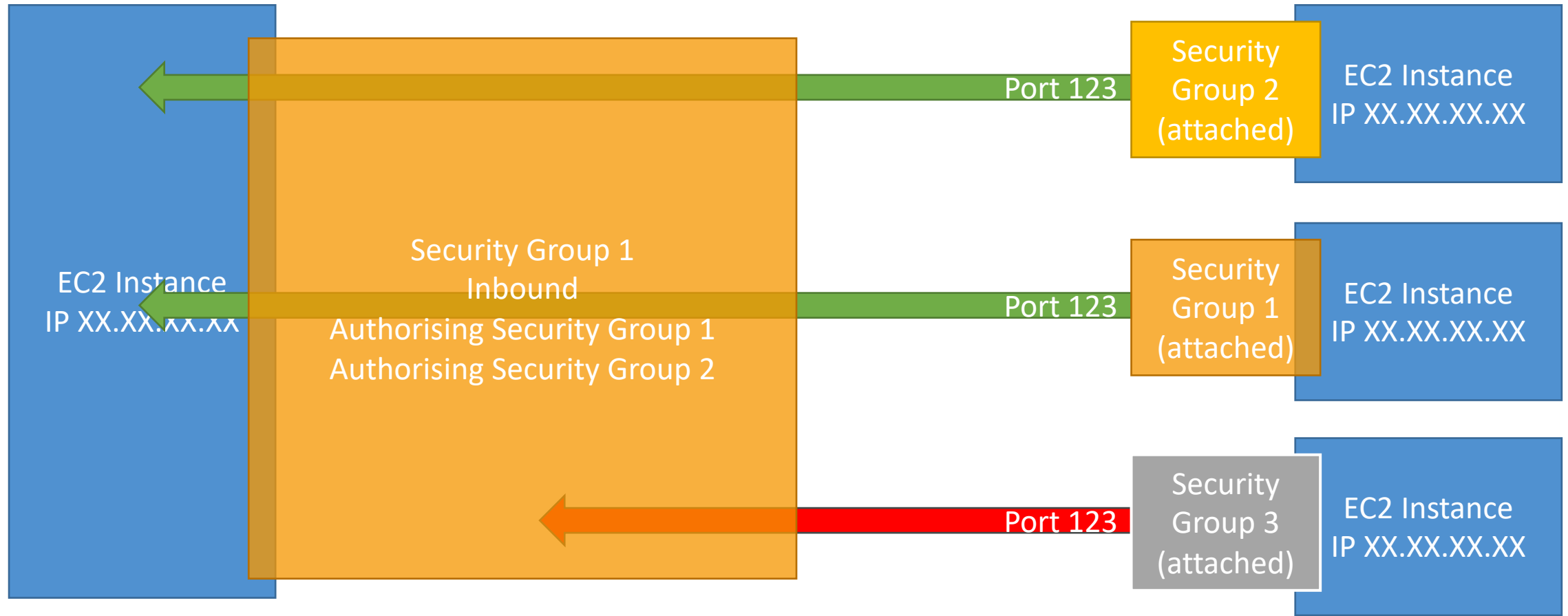
Security Groups

Good to know

- Can be attached to multiple instances
- Locked down to a region / VPC combination
- Does live “outside” the EC2 – if traffic is blocked the EC2 instance won’t see it
- It’s good to maintain one separate security group for SSH access
- If your application is not accessible (time out), then it’s a security group issue
- If your application gives a “connection refused” error, then it’s an application error or it’s not launched
- All inbound traffic is **blocked** by default
- All outbound traffic is **authorised** by default

Referencing other security groups

Diagram



Classic Ports to know

- 22 = SSH (Secure Shell) - log into a Linux instance
- 21 = FTP (File Transfer Protocol) – upload files into a file share
- 22 = SFTP (Secure File Transfer Protocol) – upload files using SSH
- 80 = HTTP – access unsecured websites
- 443 = HTTPS – access secured websites
- 3389 = RDP (Remote Desktop Protocol) – log into a Windows instance

SSH Summary Table

	SSH	Putty	EC2 Instance Connect
Mac	✓		✓
Linux	✓		✓
Windows < 10		✓	✓
Windows >= 10	✓	✓	✓

Which Lectures to watch

- Mac / Linux:
 - SSH on Mac/Linux lecture
- Windows:
 - Putty Lecture
 - If Windows 10: SSH on Windows 10 lecture
- All:
 - EC2 Instance Connect lecture

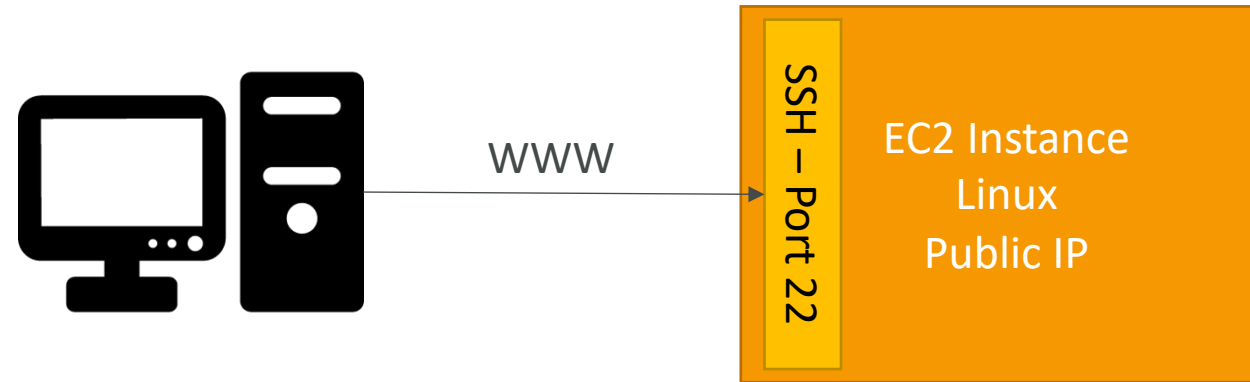
SSH troubleshooting

- Students have the most problems with SSH
- If things don't work...
 1. Re-watch the lecture. You may have missed something
 2. Read the troubleshooting guide
 3. Try EC2 Instance Connect
- If one method works (SSH, Putty or EC2 Instance Connect) you're good
- If no method works, that's okay, the course won't use SSH much

How to SSH into your EC2 Instance

Linux / Mac OS X

- We'll learn how to SSH into your EC2 instance using [Linux / Mac](#)
- SSH is one of the most important function. It allows you to control a remote machine, all using the command line.

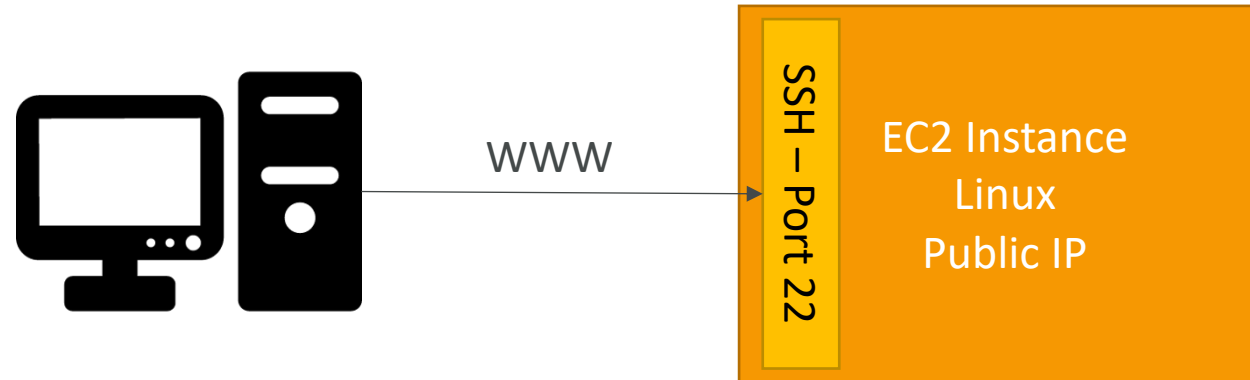


- We will see how we can configure OpenSSH `~/.ssh/config` to facilitate the SSH into our EC2 instances

How to SSH into your EC2 Instance

Windows

- We'll learn how to SSH into your EC2 instance using [Windows](#)
- SSH is one of the most important function. It allows you to control a remote machine, all using the command line.



- We will configure all the required parameters necessary for doing SSH on Windows using the free tool [Putty](#).

EC2 Instance Connect

- Connect to your EC2 instance within your browser
- No need to use your key file that was downloaded
- The “magic” is that a temporary key is uploaded onto EC2 by AWS
- Works only out-of-the-box with Amazon Linux 2
- Need to make sure the port 22 is still opened!

EC2 Instances Purchasing Options

- **On-Demand Instances** – short workload, predictable pricing, pay by second
- **Reserved (1 & 3 years)**
 - **Reserved Instances** – long workloads
 - **Convertible Reserved Instances** – long workloads with flexible instances
- **Savings Plans (1 & 3 years)** – commitment to an amount of usage, long workload
- **Spot Instances** – short workloads, cheap, can lose instances (less reliable)
- **Dedicated Hosts** – book an entire physical server, control instance placement
- **Dedicated Instances** – no other customers will share your hardware
- **Capacity Reservations** – reserve capacity in a specific AZ for any duration

EC2 On Demand

- Pay for what you use:
 - Linux or Windows - billing per second, after the first minute
 - All other operating systems - billing per hour
- Has the highest cost but no upfront payment
- No long-term commitment
- Recommended for **short-term** and **un-interrupted workloads**, where you can't predict how the application will behave

EC2 Reserved Instances

- Up to 72% discount compared to On-demand
- You reserve a specific instance attributes (Instance Type, Region, Tenancy, OS)
- Reservation Period – 1 year (+discount) or 3 years (+++discount)
- Payment Options – No Upfront (+), Partial Upfront (++), All Upfront (+++)
- Reserved Instance's Scope – Regional or Zonal (reserve capacity in an AZ)
- Recommended for steady-state usage applications (think database)
- You can buy and sell in the Reserved Instance Marketplace
- Convertible Reserved Instance
 - Can change the EC2 instance type, instance family, OS, scope and tenancy
 - Up to 66% discount

Note: the % discounts are different from the video as AWS change them over time – the exact numbers are not needed for the exam. This is just for illustrative purposes 😊

EC2 Savings Plans

- Get a discount based on long-term usage (up to 72% - same as RIs)
- Commit to a certain type of usage (\$10/hour for 1 or 3 years)
- Usage beyond EC2 Savings Plans is billed at the On-Demand price
- Locked to a specific instance family & AWS region (e.g., M5 in us-east-1)
- Flexible across:
 - Instance Size (e.g., m5.xlarge, m5.2xlarge)
 - OS (e.g., Linux, Windows)
 - Tenancy (Host, Dedicated, Default)



EC2 Spot Instances

- Can get a **discount of up to 90%** compared to On-demand
- Instances that you can “lose” at any point of time if your max price is less than the current spot price
- The **MOST cost-efficient** instances in AWS
- Useful for workloads that are resilient to failure
 - Batch jobs
 - Data analysis
 - Image processing
 - Any **distributed** workloads
 - Workloads with a flexible start and end time
- Not suitable for critical jobs or databases

EC2 Dedicated Hosts

- A physical server with EC2 instance capacity fully dedicated to your use
- Allows you address **compliance requirements** and **use your existing server-bound software licenses** (per-socket, per-core, per-VM software licenses)
- Purchasing Options:
 - **On-demand** – pay per second for active Dedicated Host
 - **Reserved** - 1 or 3 years (No Upfront, Partial Upfront, All Upfront)
- The most expensive option
- Useful for software that have complicated licensing model (BYOL – Bring Your Own License)
- Or for companies that have strong regulatory or compliance needs

EC2 Dedicated Instances

- Instances run on hardware that's dedicated to you
- May share hardware with other instances in same account
- No control over instance placement (can move hardware after Stop / Start)

Characteristic	Dedicated Instances	Dedicated Hosts
Enables the use of dedicated physical servers	X	X
Per instance billing (subject to a \$2 per region fee)	X	
Per host billing		X
Visibility of sockets, cores, host ID		X
Affinity between a host and instance		X
Targeted instance placement		X
Automatic instance placement	X	X
Add capacity using an allocation request		X

EC2 Capacity Reservations

- Reserve **On-Demand** instances capacity in a specific AZ for any duration
- You always have access to EC2 capacity when you need it
- **No time commitment** (create/cancel anytime), **no billing discounts**
- Combine with Regional Reserved Instances and Savings Plans to benefit from billing discounts
- You're charged at On-Demand rate whether you run instances or not
- Suitable for short-term, uninterrupted workloads that needs to be in a specific AZ

Which purchasing option is right for me?



- **On demand:** coming and staying in resort whenever we like, we pay the full price
- **Reserved:** like planning ahead and if we plan to stay for a long time, we may get a good discount.
- **Savings Plans:** pay a certain amount per hour for certain period and stay in any room type (e.g., King, Suite, Sea View, ...)
- **Spot instances:** the hotel allows people to bid for the empty rooms and the highest bidder keeps the rooms. You can get kicked out at any time
- **Dedicated Hosts:** We book an entire building of the resort
- **Capacity Reservations:** you book a room for a period with full price even you don't stay in it

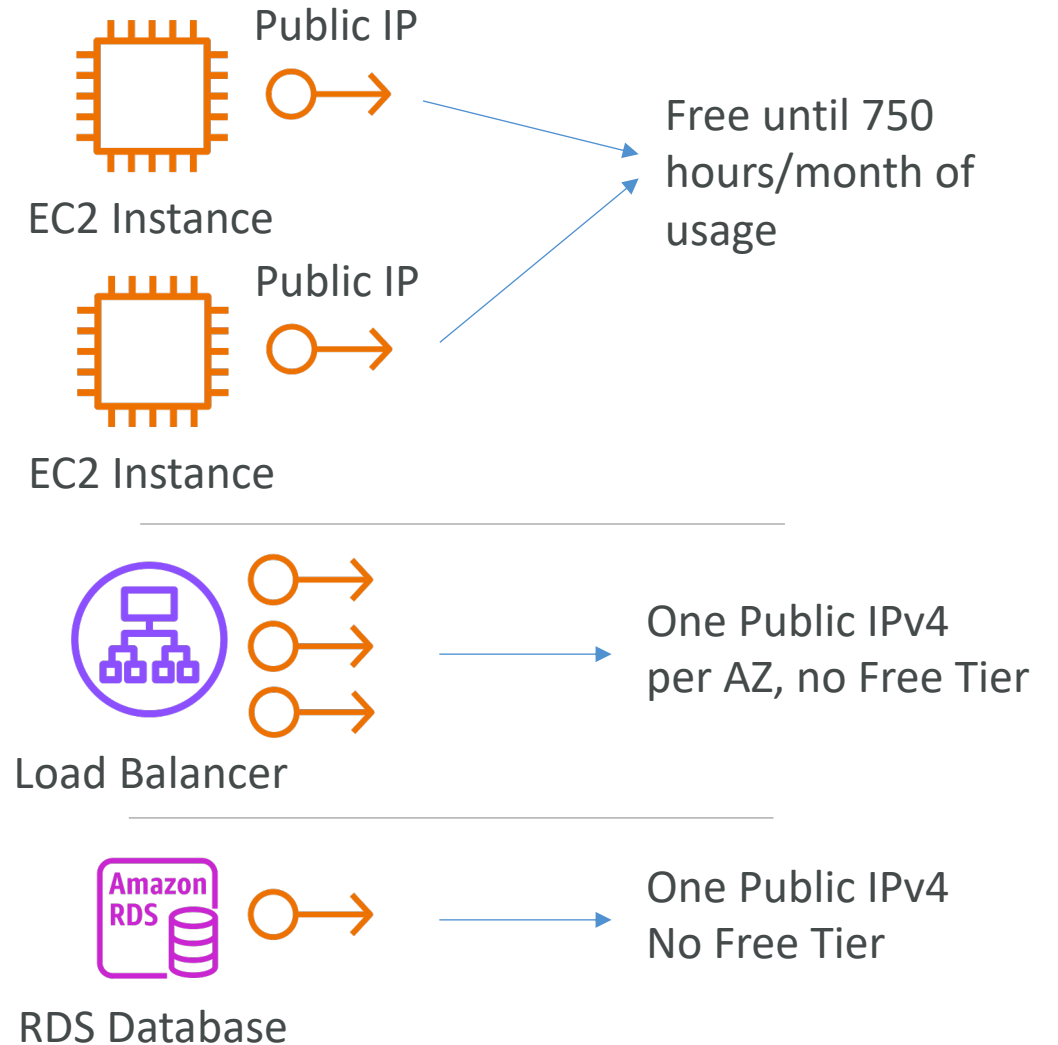
Price Comparison

Example – m4.large – us-east-1

Price Type	Price (per hour)
On-Demand	\$0.10
Spot Instance (Spot Price)	\$0.038 - \$0.039 (up to 61% off)
Reserved Instance (1 year)	\$0.062 (No Upfront) - \$0.058 (All Upfront)
Reserved Instance (3 years)	\$0.043 (No Upfront) - \$0.037 (All Upfront)
EC2 Savings Plan (1 year)	\$0.062 (No Upfront) - \$0.058 (All Upfront)
Reserved Convertible Instance (1 year)	\$0.071 (No Upfront) - \$0.066 (All Upfront)
Dedicated Host	On-Demand Price
Dedicated Host Reservation	Up to 70% off
Capacity Reservations	On-Demand Price

AWS charges for IPv4 addresses

- Starting February 1st 2024, there's a charge for all Public IPv4 created in your account
- \$0.005 per hour of Public IPv4 (~ \$3.6 per month)
- For new accounts in AWS, you have a free tier for the **EC2 service**: 750 hours of Public IPv4 per month for the first 12 months
- For all other services there is no free tier



AWS charges for IPv4 addresses

- What about IPv6?

- Unfortunately, many Internet Service Provider (ISP) around the world don't support IPv6, so the course would not work for some of you
- You can test IPv6 by going to <https://test-ipv6.com/>
- If you use IPv6 in this course, you're on your own (security groups, networking...) but you can do it!

- How to troubleshoot charges?

- Go into your AWS Bill
- Look into the AWS Public IP Insights service
- Nice article here:
https://repost.aws/articles/ARknH_OR0cTvqoTfjrVGaB8A/why-am-i-seeing-charges-for-public-ipv4-addresses-when-i-am-under-the-aws-free-tier

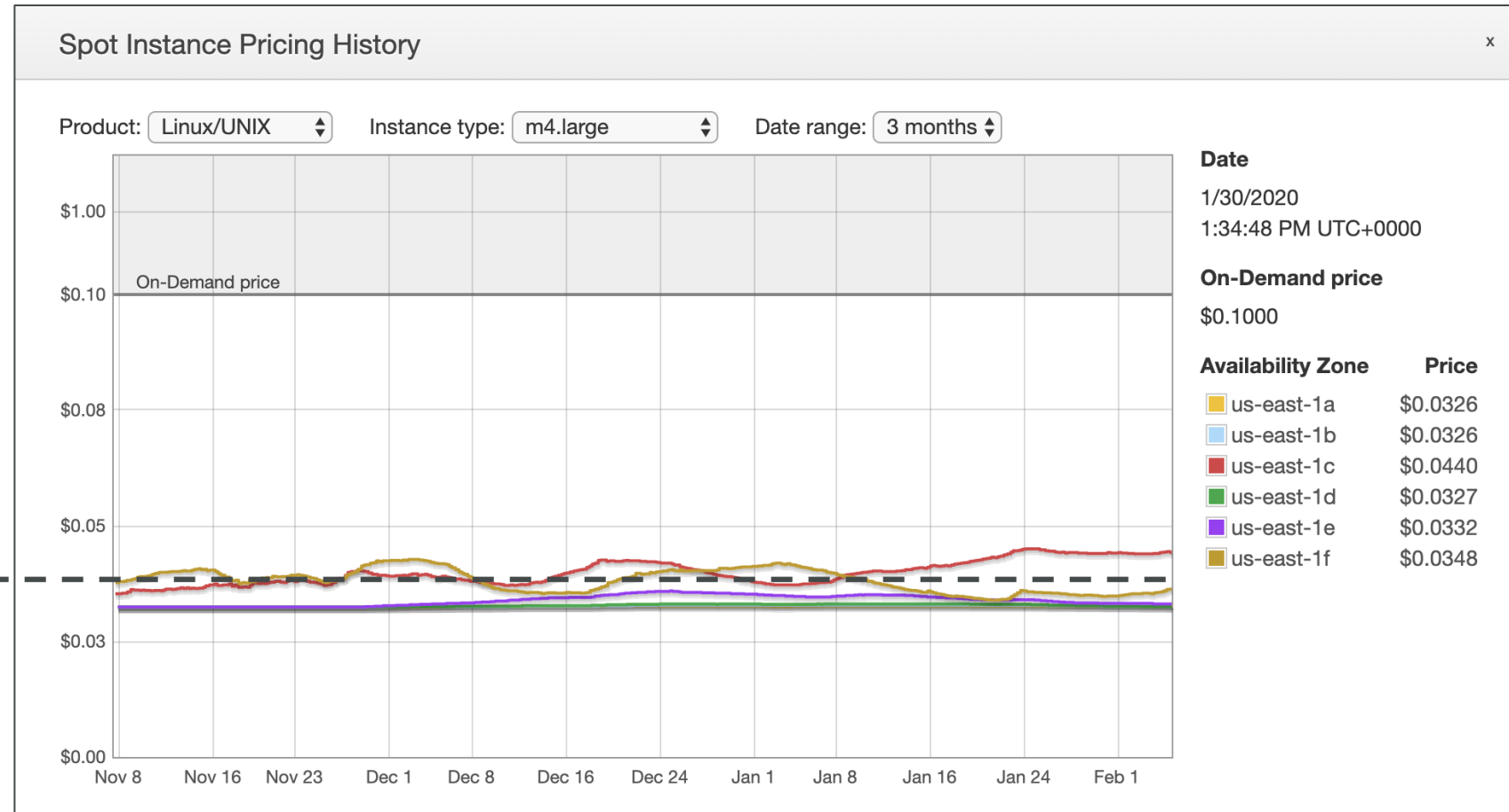


EC2 Spot Instance Requests

- Can get a discount of up to 90% compared to On-demand
- Define **max spot price** and get the instance while **current spot price** < max
 - The hourly spot price varies based on offer and capacity
 - If the current spot price > your max price you can choose to **stop** or **terminate** your instance with a 2 minutes grace period.
- Other strategy: **Spot Block**
 - “block” spot instance during a specified time frame (1 to 6 hours) without interruptions
 - In rare situations, the instance may be reclaimed
- Used for batch jobs, data analysis, or workloads that are resilient to failures.
- Not great for critical jobs or databases

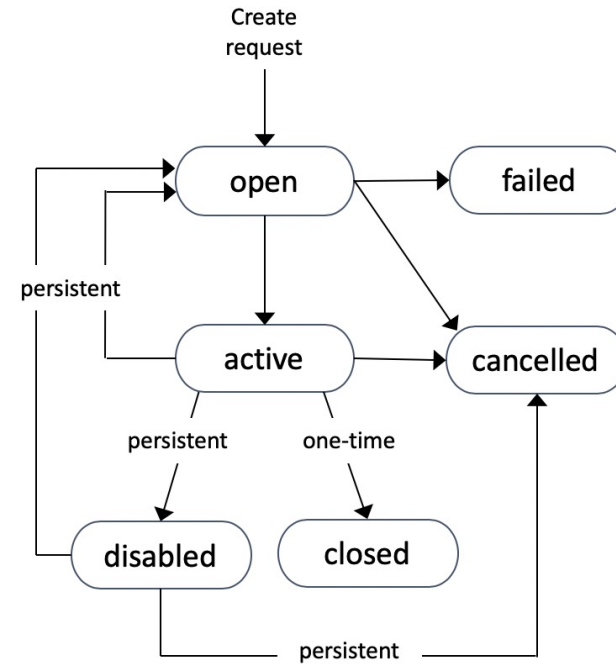
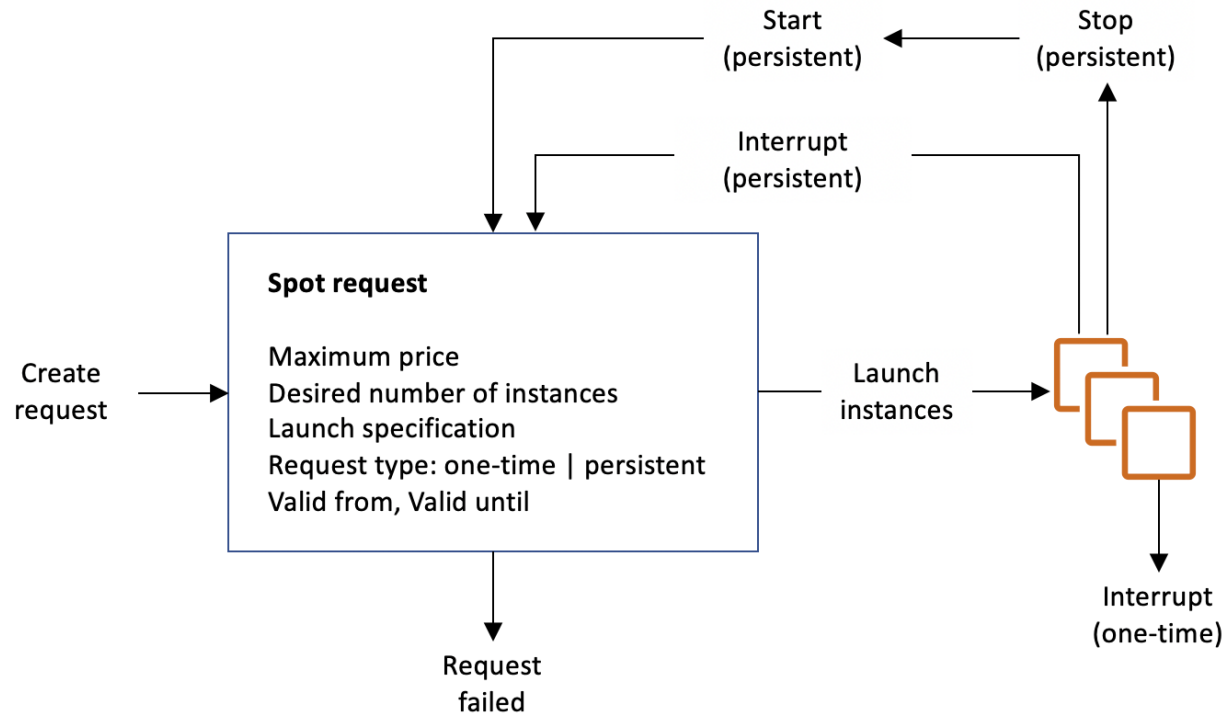
EC2 Spot Instances Pricing

User-defined max price



<https://console.aws.amazon.com/ec2sp/v1/spot/home?region=us-east-1#>

How to terminate Spot Instances?



You can only cancel Spot Instance requests that are **open, active, or disabled**.
Cancelling a Spot Request does not terminate instances
You must first cancel a Spot Request, and then terminate the associated Spot Instances

Spot Fleets

- Spot Fleets = set of Spot Instances + (optional) On-Demand Instances
- The Spot Fleet will try to meet the target capacity with price constraints
 - Define possible launch pools: instance type (m5.large), OS, Availability Zone
 - Can have multiple launch pools, so that the fleet can choose
 - Spot Fleet stops launching instances when reaching capacity or max cost
- Strategies to allocate Spot Instances:
 - **lowestPrice**: from the pool with the lowest price (cost optimization, short workload)
 - **diversified**: distributed across all pools (great for availability, long workloads)
 - **capacityOptimized**: pool with the optimal capacity for the number of instances
 - **priceCapacityOptimized (recommended)**: pools with highest capacity available, then select the pool with the lowest price (best choice for most workloads)
- Spot Fleets allow us to automatically request Spot Instances with the lowest price