ENGENHARIA DE SOFTWARE

41492-ES

Nuno Sá Couto / Rafael Direito

(nuno.sacouto@ua.pt / rafael.neves.direito@ua.pt)

Department of Electronics, Telecommunications and Informatics (DETI)

UNIVERSITY OF AVEIRO (UA), PORTUGAL

2023

Overview

CLOUD COMPUTE

AWS compute services

Amazon Web Services (AWS) offers many compute services. This module will discuss the hig

- Amazon EC2
- Amazon EC2 Auto Scaling
- Amazon Elastic Container Registry (Amazon ECR)
- Amazon Elastic Container Service (Amazon ECS)
- VMware Cloud on AWS
- AWS Elastic Beanstalk
- AWS Lambda
- Amazon Elastic Kubernetes Service (Amazon EKS)
- Amazon Lightsail
- AWS Batch
- AWS Fargate
- AWS Outposts
- AWS Serverless Application Repository

Amazon EC2 overview

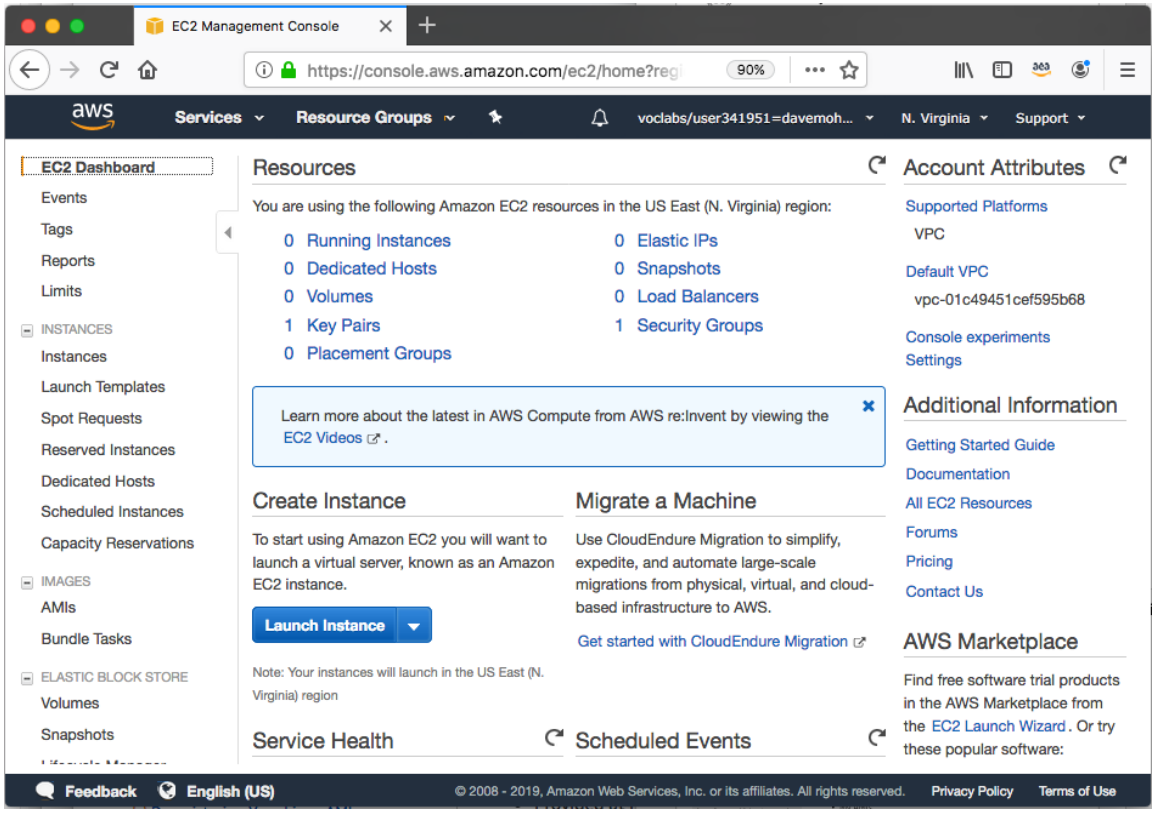
Amazon EC2

- Amazon Elastic Compute Cloud (Amazon EC2)
  - Provides virtual machines—referred to as EC2 instances—in the cloud.
  - Gives you *full control* over the guest operating system (Windows or Linux) on each instance.
- You can launch instances of any size into an Availability Zone anywhere in the world.
  - Launch instances from Amazon Machine Images (AMIs).
  - Launch instances with a few clicks or a line of code, and they are ready in minutes.
- You can control traffic to and from instances.

Launching an Amazon EC2 instance

This section of the module walks through **nine key decisions** to make when you create an EC2 instance by using the AWS Management Console **Launch Instance Wizard**.

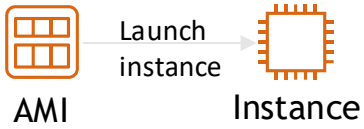
- Along the way, essential Amazon EC2 concepts will be explored.



1. Select an AMI

Choices made using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**

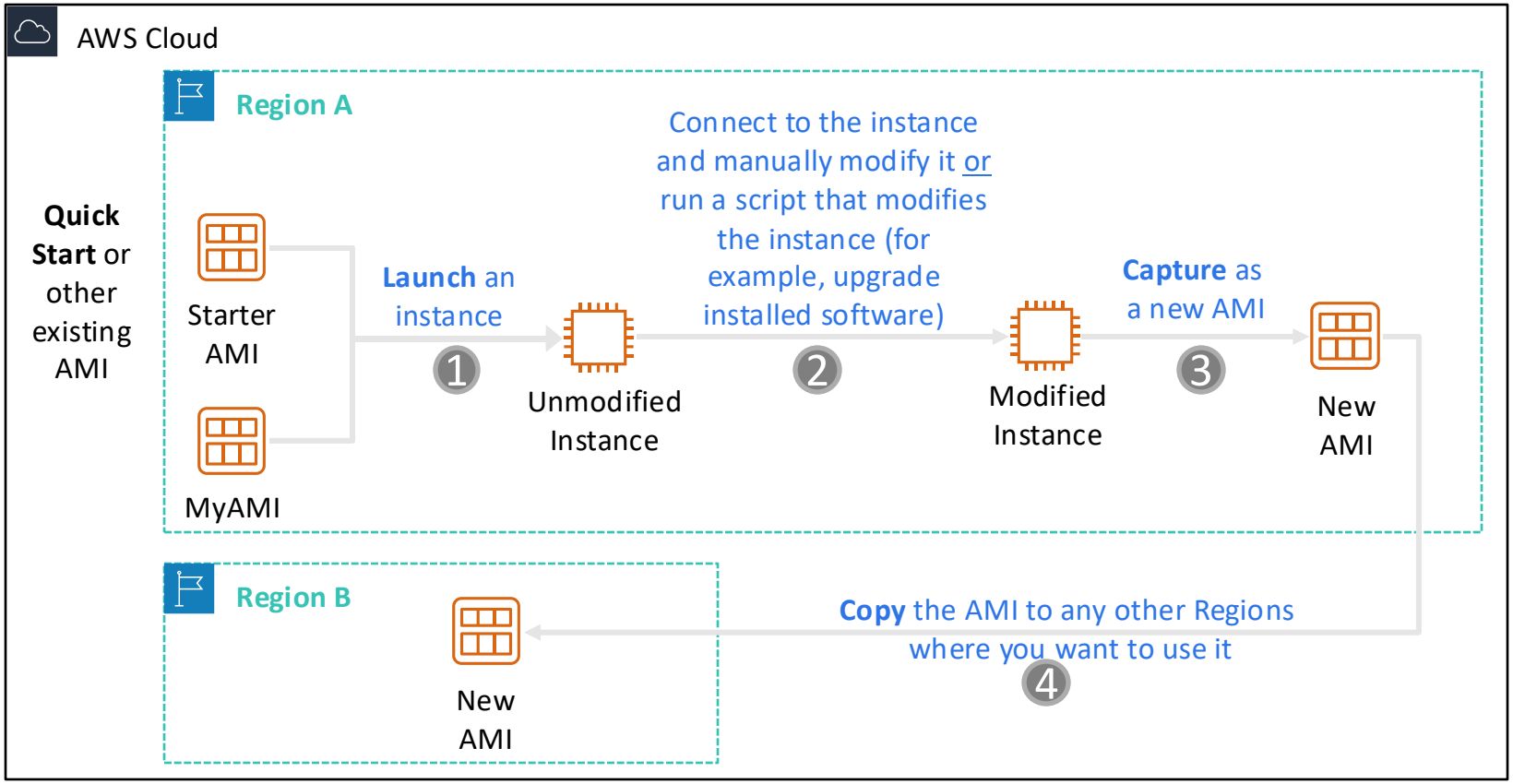


- Amazon Machine Image (AMI)
  - Is a template that is used to create an EC2 instance (which is a virtual machine, or VM, that runs in the AWS Cloud)
  - Contains a Windows or Linux operating system
  - Often also has some software pre-installed
- AMI choices:
  - Quick Start – *Linux and Windows AMIs that are provided by AWS*
  - My AMIs – *Any AMIs that you created*
  - AWS Marketplace – *Pre-configured templates from third p*[illegible]*es*
  - Community AMIs – *AMIs shared by others; use at your own risk*

Creating a new AMI: Example

AMI details

(Optional) Import a virtual machine

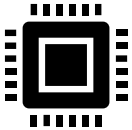


2. Select an instance type

Choices made using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**

- Consider your use case
  - How will the EC2 instance you create be used?
- The instance type that you choose determines –
  - Memory (RAM)
  - Processing power (CPU)
  - Disk space and disk type (Storage)
  - Network performance



- Instance type categories –
  - General purpose
  - Compute optimized
  - Memory optimized
  - Storage optimized
  - Accelerated computing
- Instance types offer *family*, *generation*, and *size*

EC2 instance type naming and sizes

Instance type naming

- Example: t3.large
  - T is the family name
  - 3 is the generation number
  - Large is the size

Example instance sizes

Instance Name	vCPU	Memory (GB)	Storage
t3.nano	2	0.5	EBS-Only
t3.micro	2	1	EBS-Only
t3.small	2	2	EBS-Only
t3.medium	2	4	EBS-Only
t3.large	2	8	EBS-Only
t3.xlarge	4	16	EBS-Only
t3.2xlarge	8	32	EBS-Only

Select instance type: Based on use case

	General Purpose	Compute Optimized	Memory Optimized	Accelerated Computing	Storage Optimized
Instance Types	a1, m4, m5, t2, t3	c4, c5	r4, r5, x1, z1	f1, g3, g4, p2, p3	d2, h1, i3
Use Case	Broad	High performance	In-memory databases	Machine learning	Distributed file systems

Instance types: Networking features

- The network bandwidth (Gbps) varies by instance type.
  - See Amazon EC2 Instance Types to compare.
- To maximize networking and bandwidth performance of your instance type:
  - If you have interdependent instances, launch them into a cluster placement group.
  - Enable enhanced networking.
- Enhanced networking types are supported on most instance types.
  - See the Networking and Storage Features documentation for details.
- Enhanced networking types –
  - Elastic Network Adapter (ENA): Supports network speeds of up to 100 Gbps.
  - Intel 82599 Virtual Function interface: Supports network speeds of up to 10 Gbps.

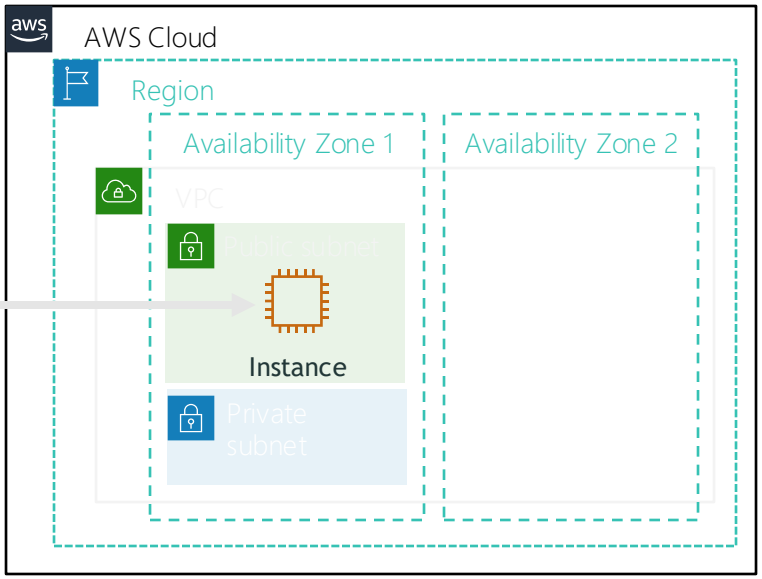
3. Specify network settings

Choices made by using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**

- Where should the instance be deployed?
  - Identify the VPC and optionally the subnet
- Should a public IP address be automatically assigned?
  - To make it internet-accessible

Example: specify to deploy the instance here



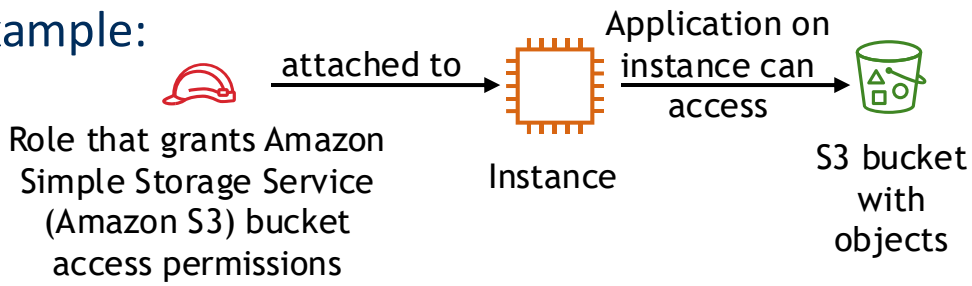
4. Attach IAM role (optional)

Choices made by using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**

- Will software on the EC2 instance need to interact with other AWS services?
  - If yes, attach an appropriate IAM Role.
- An AWS Identity and Access Management (IAM) role that is attached to an EC2 instance is kept in an instance profile.
- You are *not* restricted to attaching a role only at instance launch.
  - You can also attach a role to an instance that already exists.

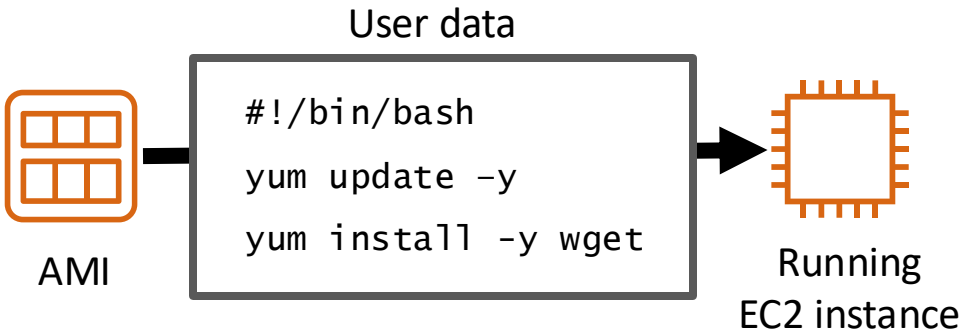
Example:



5. User data script (optional)

Choices made by using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**



- Optionally specify a user data script at instance launch
- Use user data scripts to customize the runtime environment of your instance
  - Script runs the first time the instance starts
- Can be used strategically
  - For example, reduce the number of custom AMIs that you build and maintain

6. Specify storage

Choices made by using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**

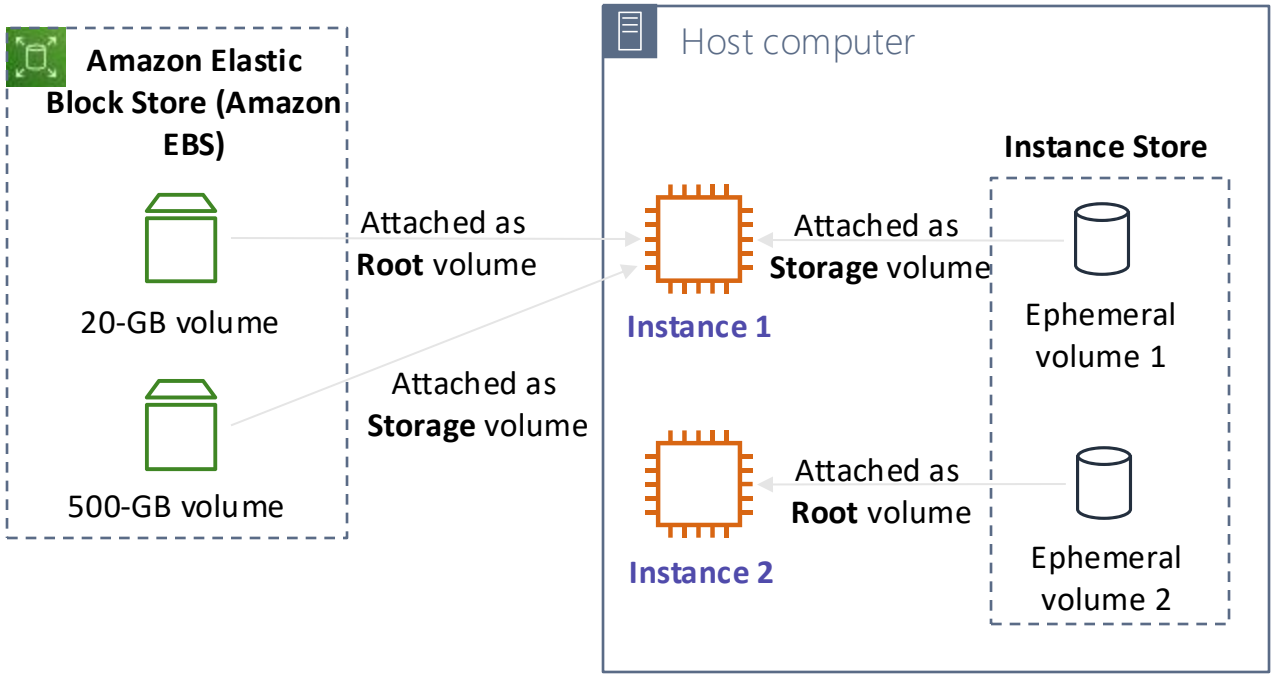
- Configure the root volume
  - Where the guest operating system is installed
- Attach additional storage volumes (optional)
  - AMI might already include more than one volume
- For each volume, specify:
  - The size of the disk (in GB)
  - The volume type
    - Different types of solid state drives (SSDs) and hard disk drives (HDDs) are available
  - If the volume will be deleted when the instance is terminated
  - If encryption should be used

Amazon EC2 storage options

- Amazon Elastic Block Store (Amazon EBS) –
  - Durable, block-level storage volumes.
  - You can stop the instance and start it again, and the data will still be there.
- Amazon EC2 Instance Store –
  - Ephemeral storage is provided on disks that are attached to the host computer where the EC2 instance is running.
  - If the instance stops, data stored here is deleted.
- Other options for storage (not for the root volume) –
  - Mount an Amazon Elastic File System (Amazon EFS) file system.
  - Connect to Amazon Simple Storage Service (Amazon S3).

Example storage options

- Instance 1 characteristics
  - It has an Amazon EBS *root volume* type for the operating system.
  - What will happen if the instance is stopped and then started again?
- Instance 2 characteristics
  - It has an Instance Store *root volume* type for the operating system.
  - What will happen if the instance stops (because of user error or a system malfunction)?



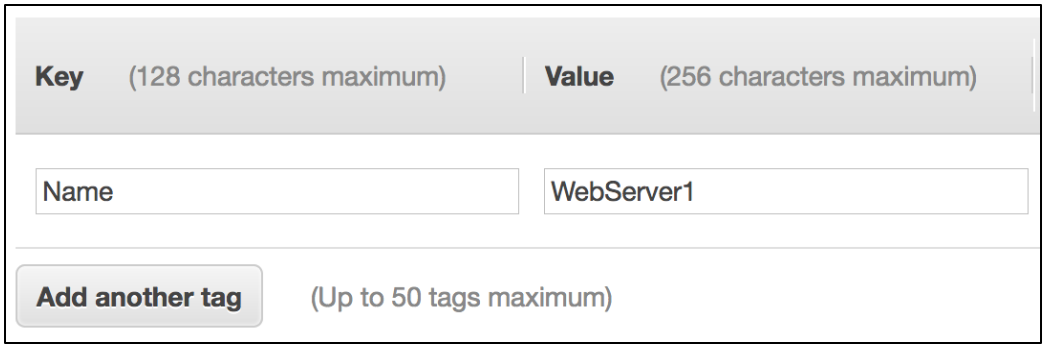
7. Add tags

Choices made by using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**

- A tag is a label that you can assign to an AWS resource.
  - Consists of a *key* and an optional *value*.
- Tagging is how you can attach metadata to an EC2 instance.
- Potential benefits of tagging—Filtering, automation, cost allocation, and access control.

Example:



8. Security group settings

Choices made by using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**

- A security group is a set of firewall rules that control traffic to the instance.
  - It exists *outside* of the instance's guest OS.
- Create rules that specify the source and which ports that network communications can use.
  - Specify the port number and the protocol, such as Transmission Control Protocol (TCP), User Datagram Protocol (UDP), or Internet Control Message Protocol (ICMP).
  - Specify the source (for example, an IP address or another security group) that is allowed to use the rule.

Example rule:

Type	Protocol	Port Range	Source	
SSH	TCP	22	My IP	72.21.198.67/32

9. Identify or create the key pair

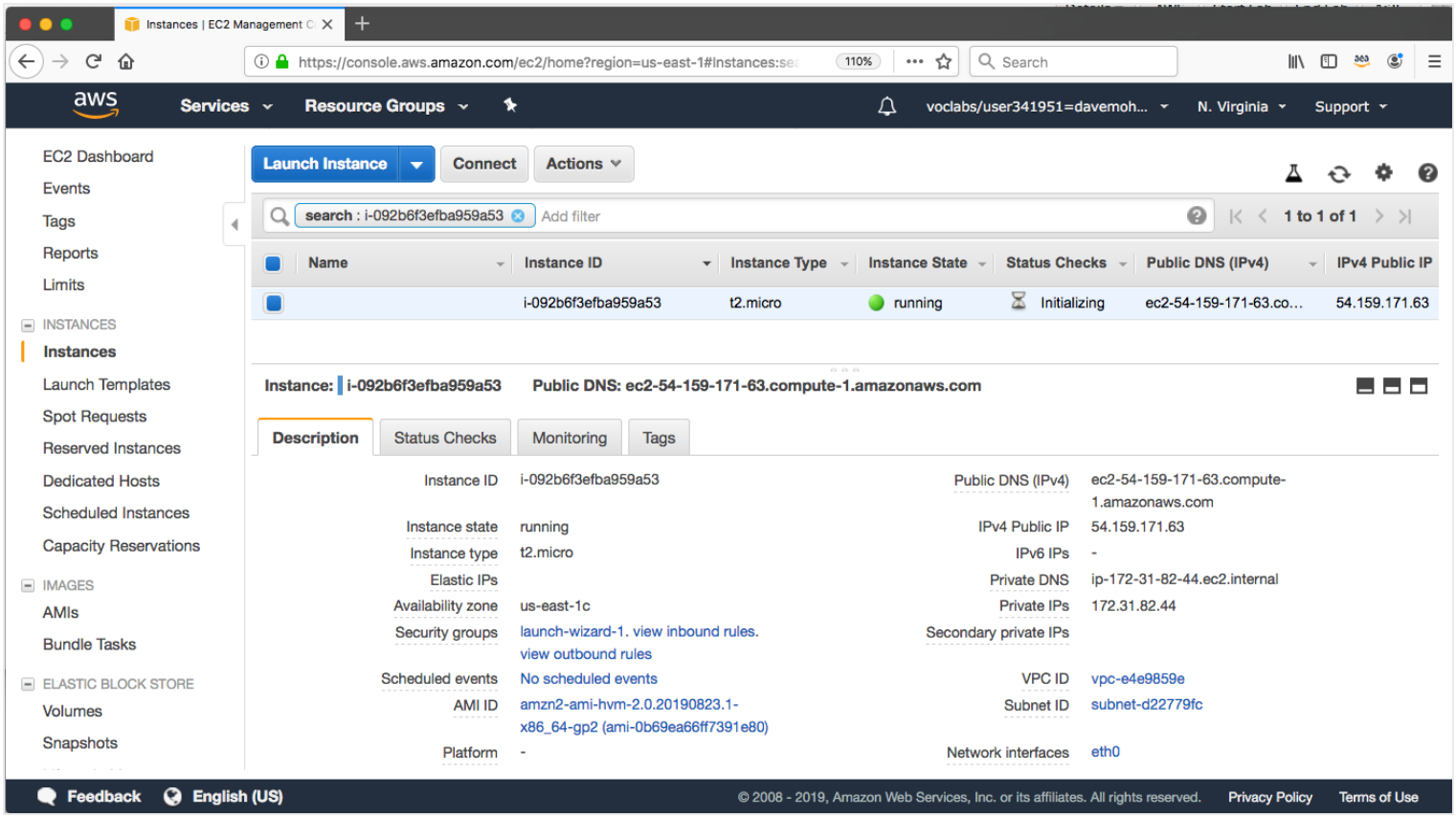
Choices made by using the Launch Instance Wizard:

1. **AMI**
2. **Instance Type**
3. **Network settings**
4. **IAM role**
5. **User data**
6. **Storage options**
7. **Tags**
8. **Security group**
9. **Key pair**

- At instance launch, you specify an existing key pair *or* create a new key pair.
- A key pair consists of –
  - A public key that AWS stores.
  - A private key file that you store.
- It enables secure connections to the instance.
- For **Windows AMIs** –
  - Use the private key to obtain the administrator password that you need to log in to your instance.
- For **Linux AMIs** –
  - Use the private key to use SSH to securely connect to your instance.

mykey.pem

Amazon EC2 console view of a running EC2 instance



Another option: Launch an EC2 instance with the AWS Command Line Interface

- EC2 instances can also be created programmatically.

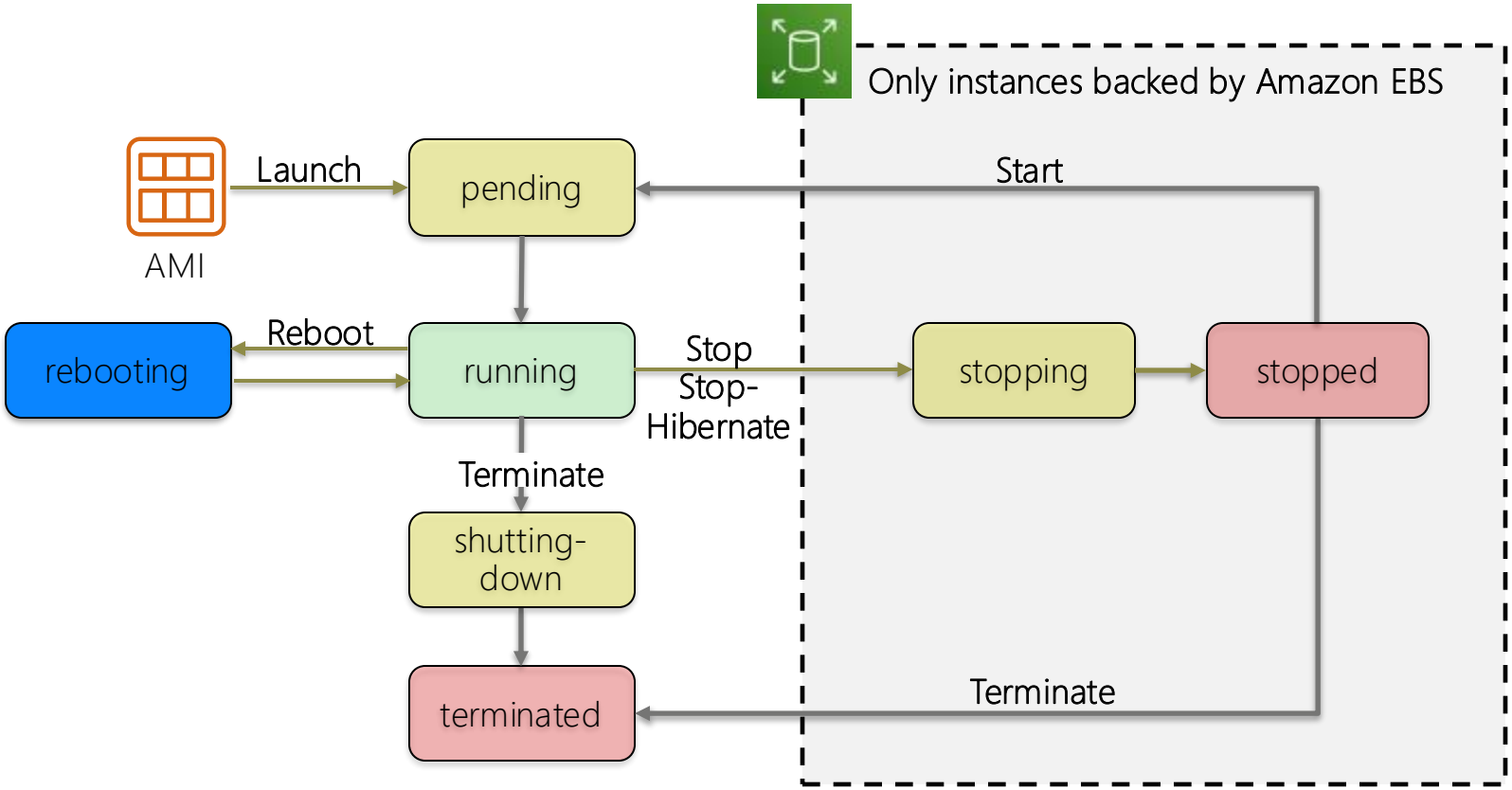
- This example shows how simple the command can be.
  - This command assumes that the key pair and security group already exist.
  - More options could be specified. See the AWS CLI Command Reference for details.

AWS Command Line Interface (AWS CLI)

Example command:

```
aws ec2 run-instances \
--image-id ami-1a2b3c4d \
--count 1 \
--instance-type c3.large \
--key-name MyKeyPair \
--security-groups MySecurityGroup \
--region us-east-1
```

Amazon EC2 instance lifecycle

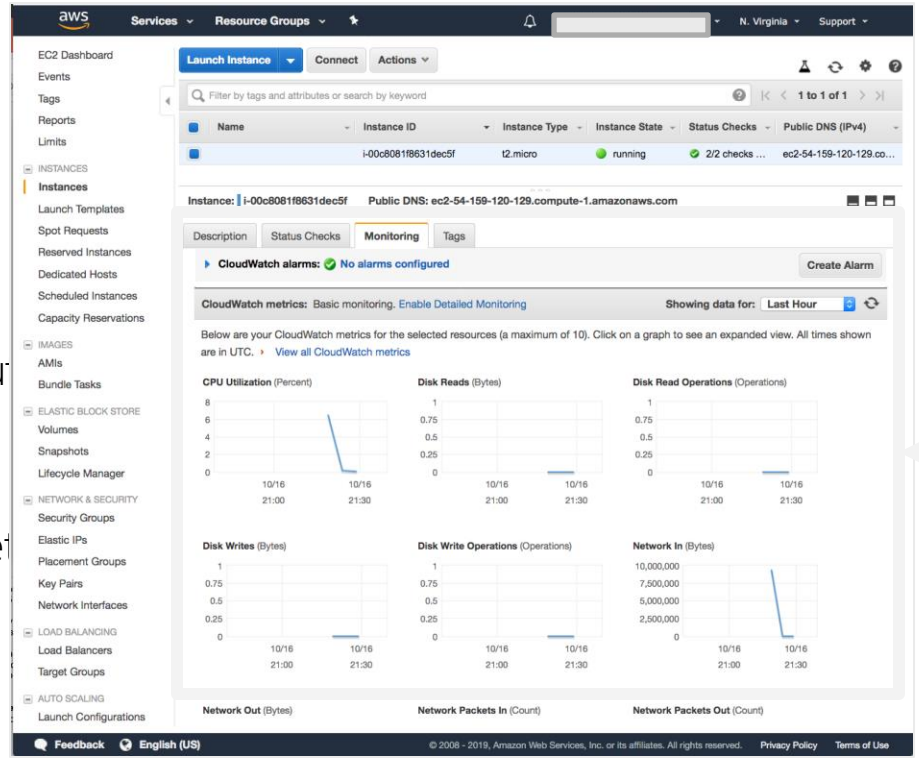


Amazon CloudWatch for monitoring

- Use Amazon CloudWatch to monitor EC2 instances
  - Provides near-real-time metrics
  - Provides charts in the Amazon EC2 console **Monitoring** tab that you can view
  - Maintains 15 months of historical data
- Basic monitoring
  - Default, no additional cost
  - Metric data sent to CloudWatch every 5 minu
- Detailed monitoring
  - Fixed monthly rate for seven pre-selected met
  - Metric data delivered every 1 minute

Amazon CloudWatch

Instance with CloudWatch



Section 2 key takeaways

- Amazon EC2 enables you to run Windows and Linux virtual machines in the cloud.
- You launch EC2 instances from an AMI template into a VPC in your account.
- You can choose from many instance types. Each instance type offers different combinations of CPU, RAM, storage, and networking capabilities.
- You can configure security groups to control access to instances (specify allowed ports and source).
- User data enables you to specify a script to run the first time that an instance launches.
- Only instances that are backed by Amazon EBS can be stopped.
- You can use Amazon CloudWatch to capture and review metrics on EC2 instances.

Amazon EC2 pricing models

On-Demand Instances

- Pay by the hour
- No long-term commitments.
- Eligible for the AWS Free Tier.

Dedicated Hosts

- A physical server with EC2 instance capacity fully dedicated to your use.

Dedicated Instances

- Instances that run in a VPC on hardware that is dedicated to a single customer.

Reserved Instances

- Full, partial, or no upfront payment for instance you reserve.
- Discount on hourly charge for that instance.
- 1-year or 3-year term.

Scheduled Reserved Instances

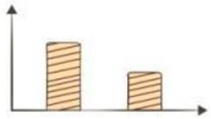
- Purchase a capacity reservation that is always available on a recurring schedule you specify.
- 1-year term.

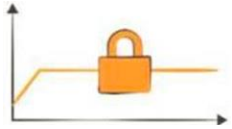
Spot Instances

- Instances run as long as they are available and your bid is above the Spot Instance price.
- They can be interrupted by AWS with a 2-minute notification.
- Interruption options include terminated, stopped or hibernated.
- Prices can be significantly less expensive compared to On-Demand Instances
- Good choice when you have flexibility in when your applications can run.

Per second billing available for On-Demand Instances, Reserved Instances, and Spot Instances that run Amazon Linux or Ubuntu.

Amazon EC2 pricing models: Benefits

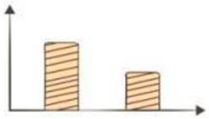





On-Demand Instances	Spot Instances	Reserved Instances	Dedicated Hosts
• Low cost and flexibility	• Large scale, dynamic workload	• Predictability ensures compute capacity is available when needed	• Save money on licensing costs • Help meet compliance and regulatory requirements

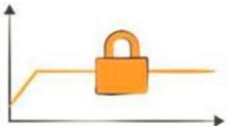
Amazon EC2 pricing models: Use cases

Spiky Workloads



Time-Insensitive Workloads

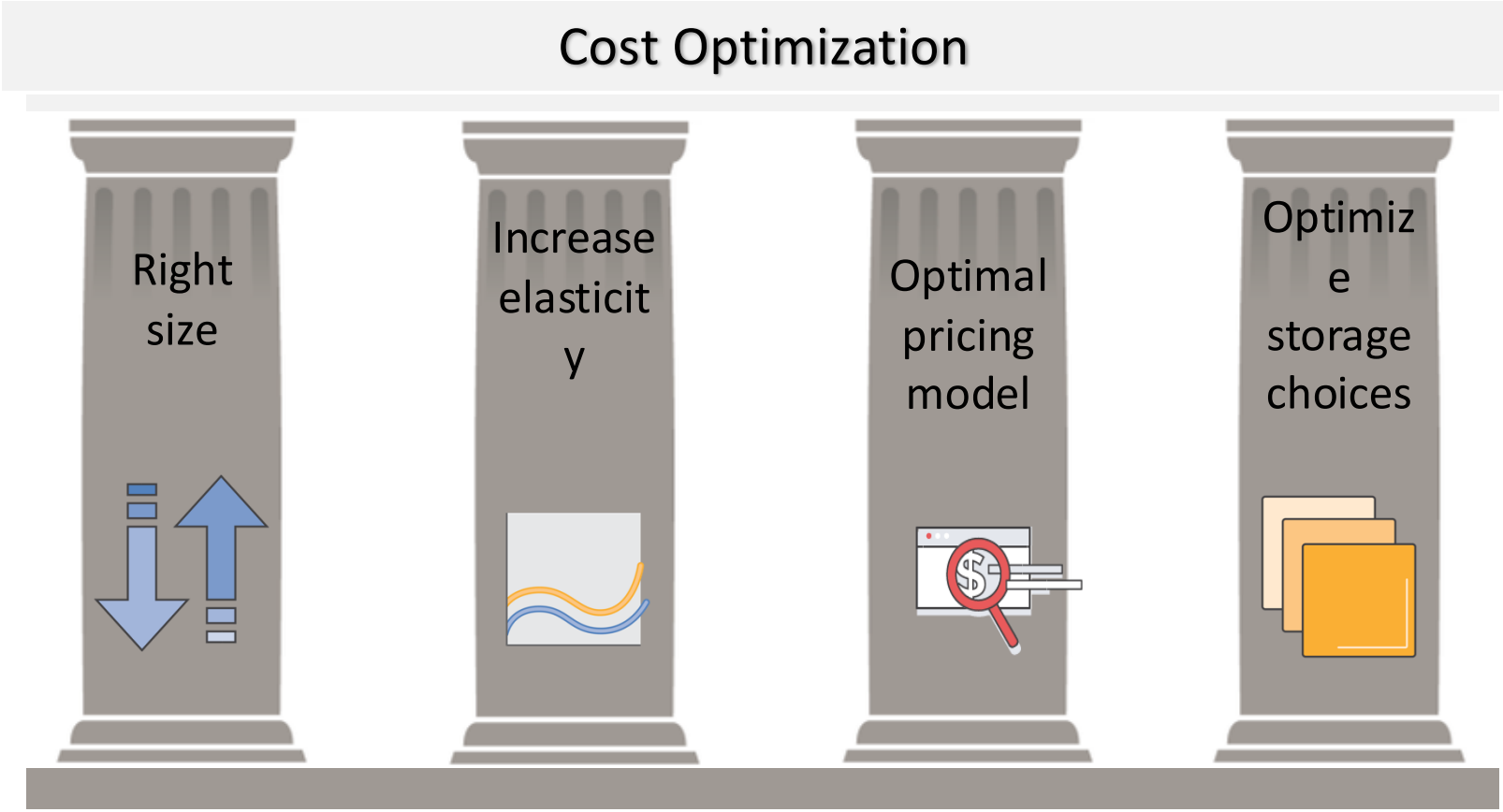
Steady-State Workloads



Highly Sensitive Workloads

On-Demand Instances	Spot Instances	Reserved Instances	Dedicated Hosts
• Short-term, spiky, or unpredictable workloads • Application development or testing	• Applications with flexible start and end times • Applications only feasible at very low compute prices • Users with urgent computing needs for large amounts of additional capacity	• Steady state or predictable usage workloads • Applications that require reserved capacity, including disaster recovery • Users able to make upfront payments to reduce total computing costs even further	• Bring your own license (BYOL) • Compliance and regulatory restrictions • Usage and licensing tracking • Control instance placement

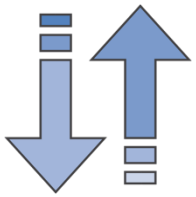
The four pillars of cost optimization



Pillar 1: Right size

Pillars:

1. Right size
2. Increase elasticity
3. Optimal pricing model
4. Optimize storage choices

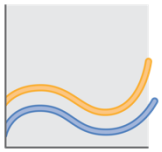


- ✓ Provision instances to match the need
  - CPU, memory, storage, and network throughput
  - Select appropriate instance types for your use
- ✓ Use Amazon CloudWatch metrics
  - How idle are instances? When?
  - Downsize instances
- ✓ Best practice: Right size, then reserve

Pillar 2: Increase elasticity

Pillars:

1. Right-Size
2. Increase Elasticity
3. Optimal pricing model
4. Optimize storage choices



- ✓ Stop or hibernate Amazon EBS-backed instances that are not actively in use
  - Example: non-production development or test instances
- ✓ Use automatic scaling to match needs based on usage
  - Automated and time-based elasticity

Pillar 3: Optimal pricing model

Pillars:

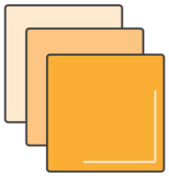
1. Right-Size
2. Increase Elasticity
3. Optimal pricing model
4. Optimize storage choices

- ✓ Leverage the right pricing model for your use case
  - ➢ Consider your usage patterns
- ✓ Optimize and *combine* purchase types
- ✓ Examples:
  - ➢ Use On-Demand Instance and Spot Instances for variable workloads
  - ➢ Use Reserved Instances for predictable workloads
- ✓ Consider serverless solutions (AWS Lambda)

Pillar 4: Optimize storage choices

Pillars:

1. Right-Size
2. Increase Elasticity
3. Optimal pricing model
4. Optimize storage choices



- ✓ Reduce costs while maintaining storage performance and availability
- ✓ Resize EBS volumes
- ✓ Change EBS volume types
  - ✓ Can you meet performance requirements with less expensive storage?
  - ✓ Example: Amazon EBS Throughput Optimized HDD (st1) storage typically costs half as much as the default General Purpose SSD (gp2) storage option.
- ✓ Delete EBS snapshots that are no longer needed
- ✓ Identify the most appropriate destination for specific types of data
  - ✓ Does the application need the instance to reside on Amazon EBS?
  - ✓ Amazon S3 storage options with lifecycle policies can reduce costs

Measure, monitor, and improve

- Cost optimization is an ongoing process.
- Recommendations –
  - Define and enforce cost allocation tagging.
  - Define metrics, set targets, and review regularly.
  - Encourage teams to architect for cost.
  - Assign the responsibility of optimization to an individual or to a team.

Section 3 key takeaways

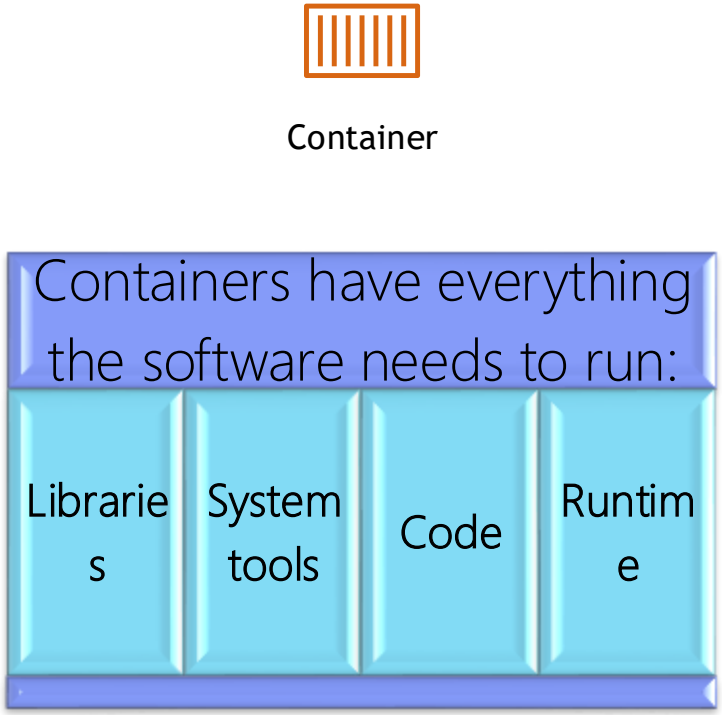
- Amazon EC2 pricing models include On-Demand Instances, Reserved Instances, Spot Instances, Dedicated Instances, and Dedicated Hosts.
- Spot Instances can be interrupted with a 2-minute notification. However, they can offer significant cost savings over On-Demand Instances.
- The four pillars of cost optimization are:
  - Right size
  - Increase elasticity
  - Optimal pricing model
  - Optimize storage choices

Container basics

- Containers are a method of operating system virtualization.
- Benefits –
  - Repeatable.
  - Self-contained environments.
  - Software runs the same in different environments.
    - Developer's laptop, test, production.
  - Faster to launch and stop or terminate than virtual machines

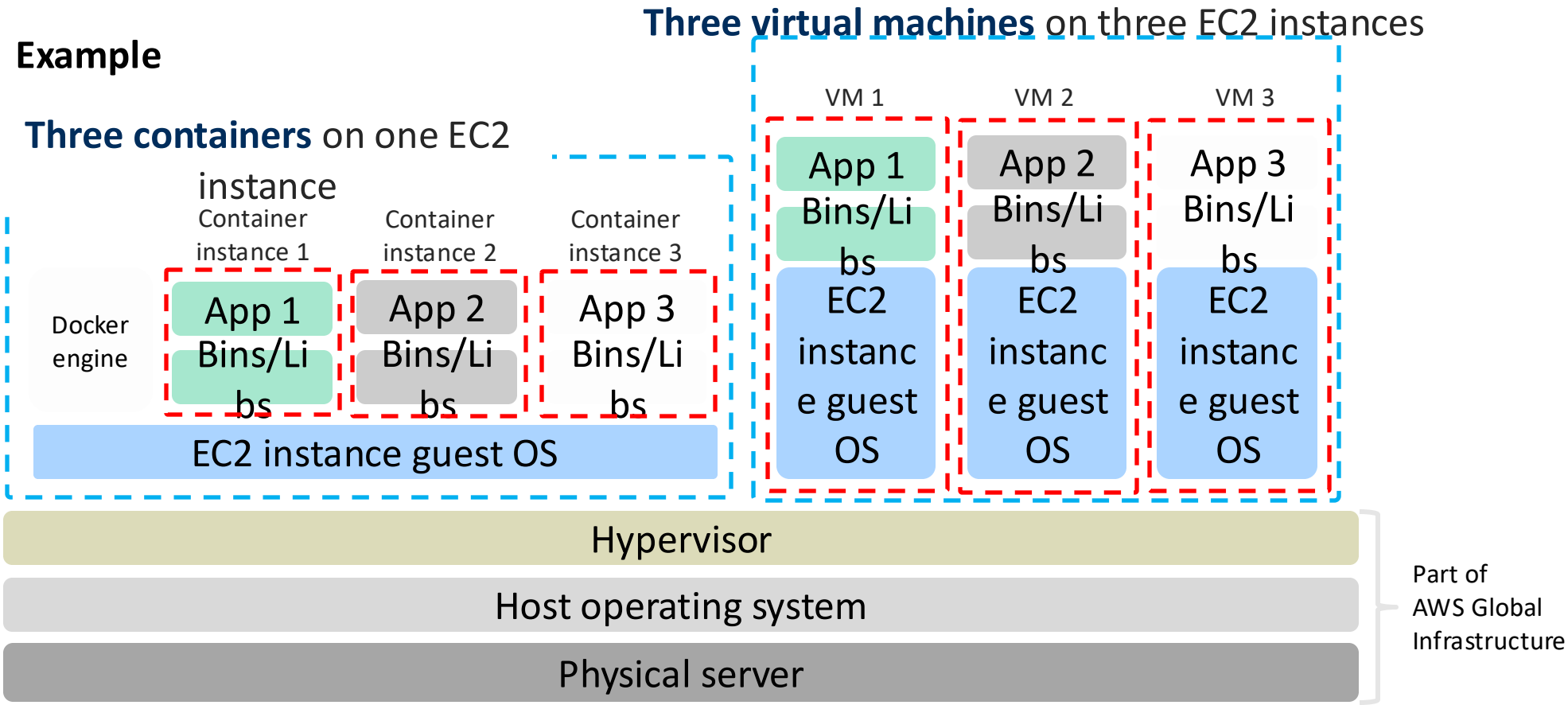
What is Docker?

- Docker is a software platform that enables you to build, test, and deploy applications quickly.
- You run containers on Docker.
  - Containers are created from a template called an *image*.
- A container has everything a software application needs to run.



Containers versus virtual machines

Example



Amazon Elastic Container Service (Amazon ECS)

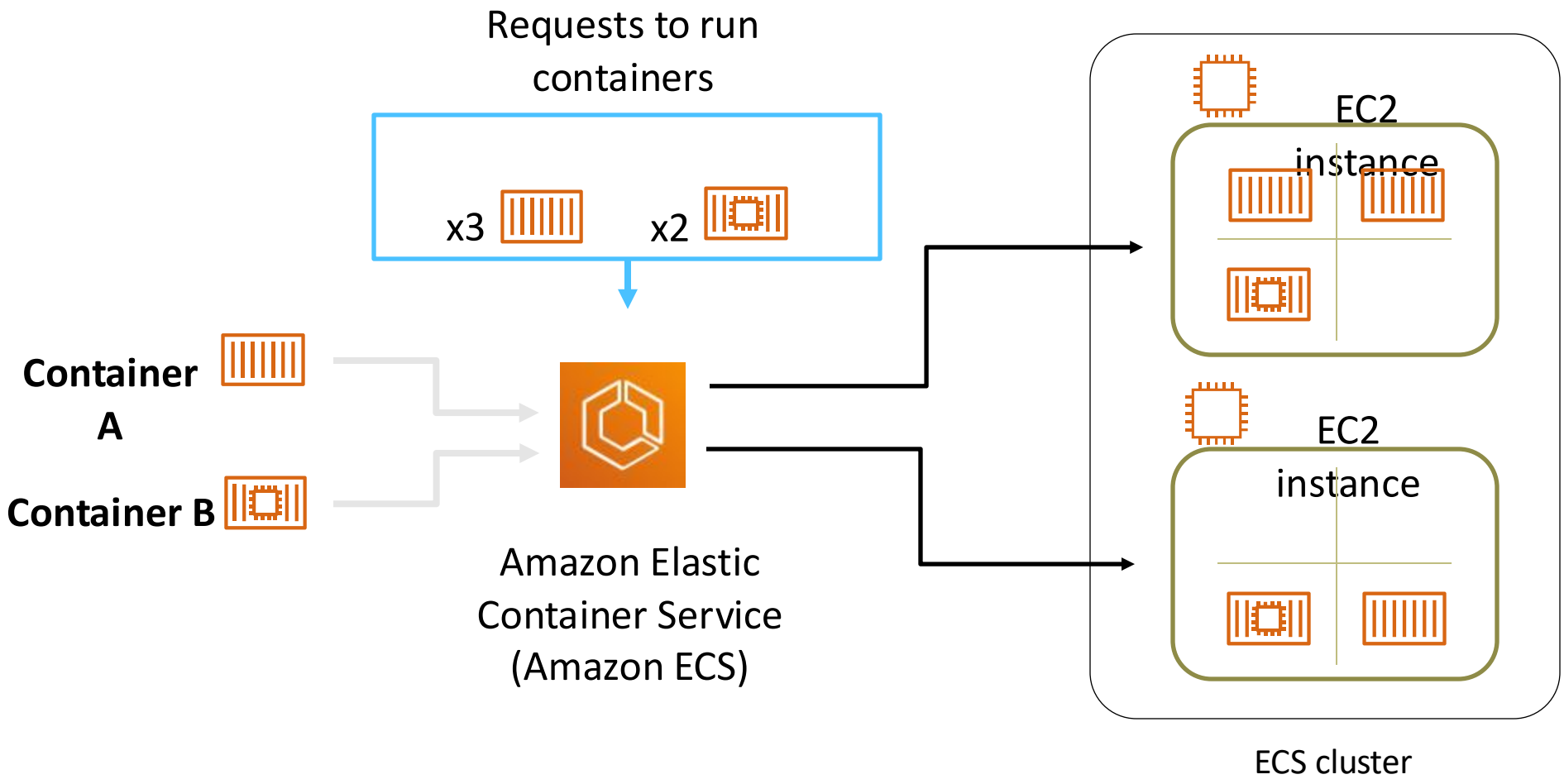
- Amazon Elastic Container Service (Amazon ECS) –
  - A highly scalable, fast, container management service

- Key benefits –
  - Orchestrates the running of Docker containers
  - Maintains and scales the fleet of nodes that run your containers
  - Removes the complexity of standing up the infrastructure

Amazon Elastic Container Service

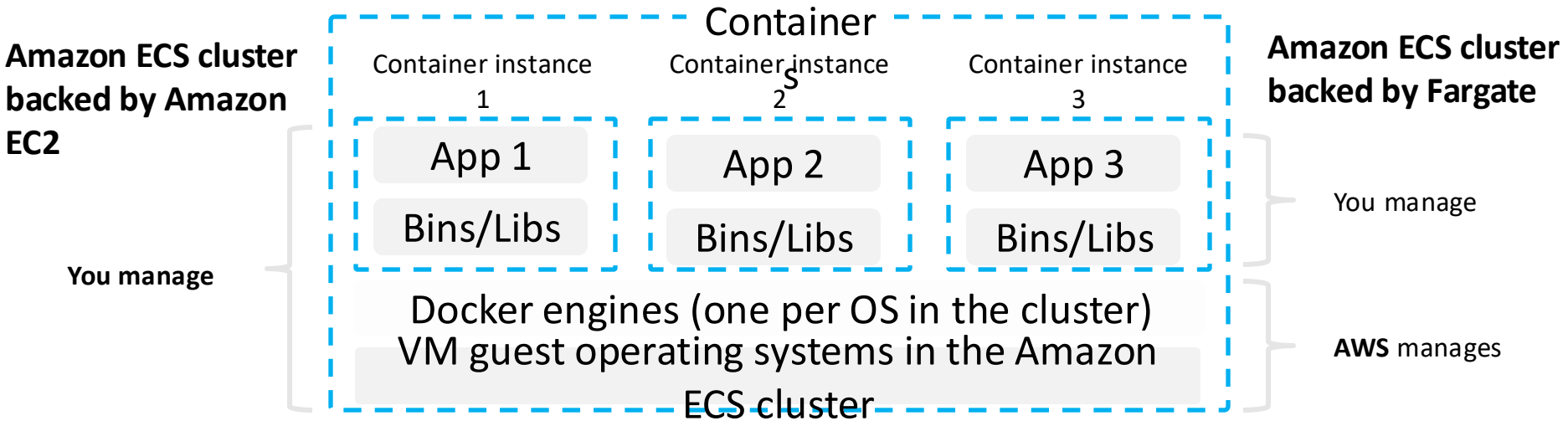
- Integrated with features that are familiar to Amazon EC2 service users –
  - Elastic Load Balancing
  - Amazon EC2 security groups
  - Amazon EBS volumes
  - IAM roles

Amazon ECS orchestrates containers



Amazon ECS cluster options

- **Key question**: Do ***you*** want to manage the Amazon ECS cluster that runs the containers?
  - If **yes**, create an **Amazon ECS cluster backed by Amazon EC2** (provides more granular control over infrastructure)
  - If no, create an Amazon ECS cluster backed by AWS Fargate (easier to maintain, focus on your applications)



What is Kubernetes?

- Kubernetes is open source software for container orchestration.
  - Deploy and manage containerized applications *at scale*.
  - The same toolset can be used on premises and in the cloud.
- Complements Docker.
  - Docker enables you to run multiple containers on a single OS host.
  - Kubernetes orchestrates multiple Docker hosts (nodes).
- Automates –
  - Container provisioning.
  - Networking.
  - Load distribution.
  - Scaling.

Amazon Elastic Kubernetes Service (Amazon EKS)

- Amazon Elastic Kubernetes Service (Amazon EKS)
  - Enables you to run Kubernetes on AWS
  - Certified Kubernetes conformant (supports easy migration)
  - Supports Linux and Windows containers
  - Compatible with Kubernetes community tools and supports popular Kubernetes add-ons

Amazon Elastic Kubernetes Service

- Use Amazon EKS to –
  - Manage clusters of Amazon EC2 compute instances
  - Run containers that are orchestrated by Kubernetes on those instances

Amazon Elastic Container Registry (Amazon ECR)

Amazon ECR is a fully managed Docker container registry that makes it easy for developers to store, manage, and deploy Docker container images.

Amazon Elastic Container Registry

Image Registry

- Amazon ECS integration
- Docker support
- Team collaboration
- Access control
- Third-party integrations

Section 4 key takeaways

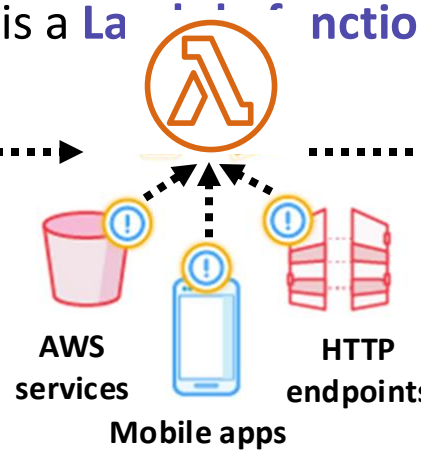
- Containers can hold everything that an application needs to run.
- Docker is a software platform that packages software into containers.
  - A single application can span multiple containers.
- Amazon Elastic Container Service (Amazon ECS) orchestrates the running of Docker containers.
- Kubernetes is open source software for container orchestration.
- Amazon Elastic Kubernetes Service (Amazon EKS) enables you to run Kubernetes on AWS
- Amazon Elastic Container Registry (Amazon ECR) enables you to store, manage, and deploy your Docker containers.

AWS Lambda: Run code without servers

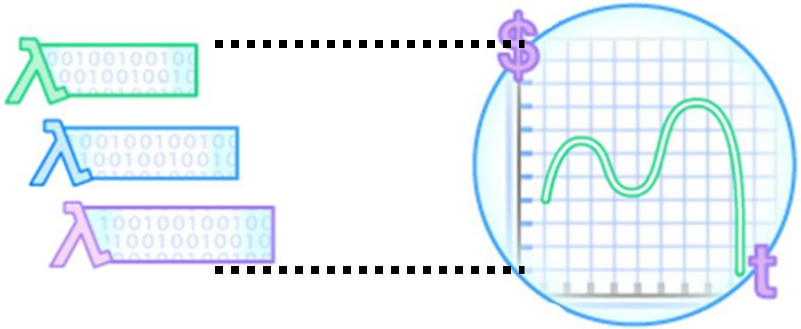
AWS Lambda is a **serverless** compute service.

Upload your code

The code you run is a **La nction**



Run your code on a ***schedule*** *or in response to* ***events***



Your code runs only when it is triggered

Pay only for the compute time that you use

Benefits of Lambda

AWS Lambda

- It supports multiple programming languages
- Completely automated administration
- Built-in fault tolerance
- It supports the orchestration of multiple functions
- Pay-per-use pricing

AWS Lambda event sources

Event sources

- Amazon S3
- Amazon DynamoDB
- Amazon Simple Notification Service (Amazon SNS)
- Amazon Simple Queue Service (Amazon SQS)
- Amazon API Gateway
- Application Load Balancer

Many more…

Configure other AWS services as **event sources** to invoke your function as shown here.

Alternatively, invoke a Lambda function from the Lambda console, AWS SDK, or AWS CLI.

Lambda function

AWS Lambda

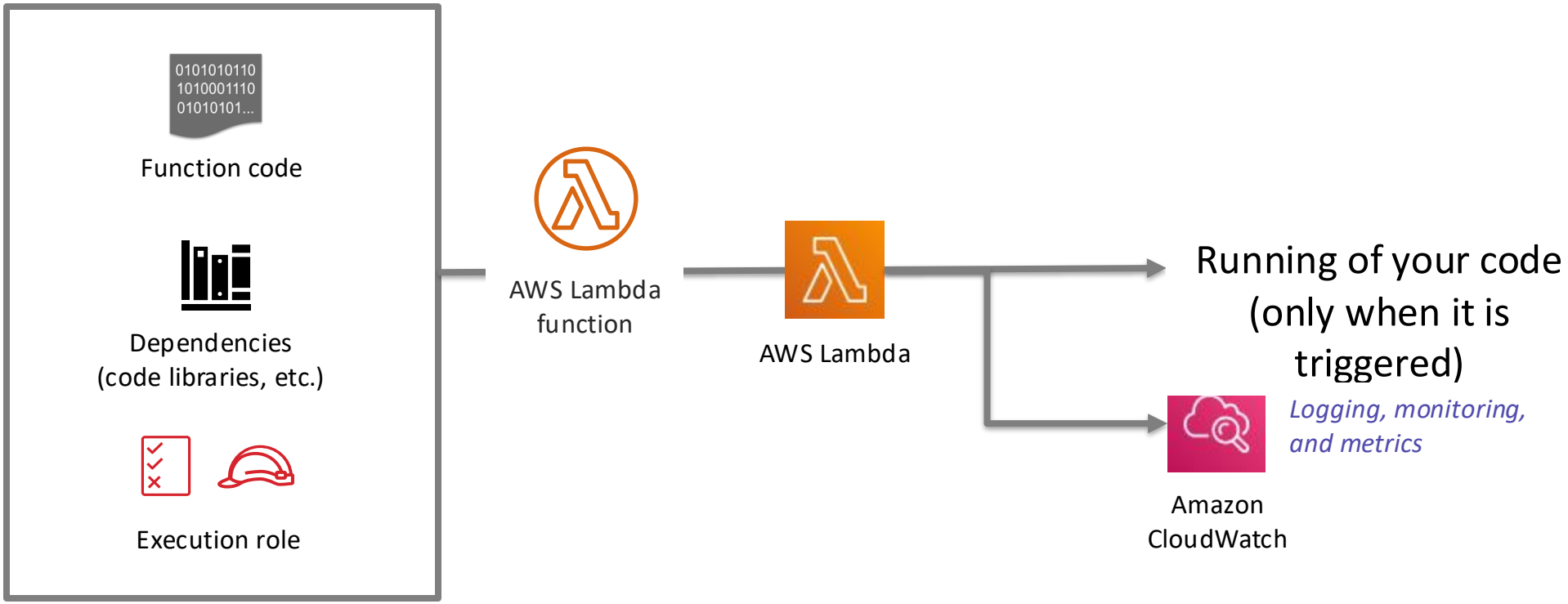
Running of your code (only when triggered)

Logging, monitoring, and metrics

Amazon CloudWatch

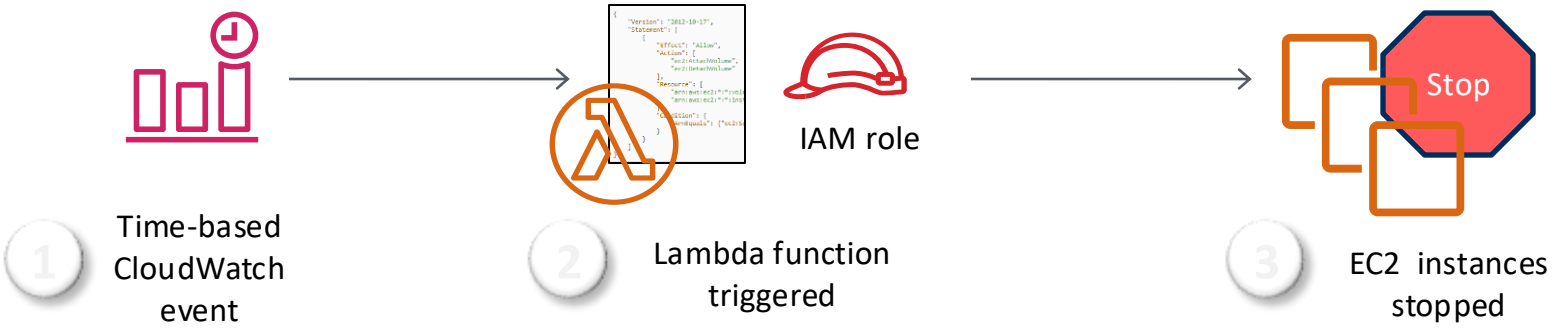
AWS Lambda function configuration

Lambda function configuration

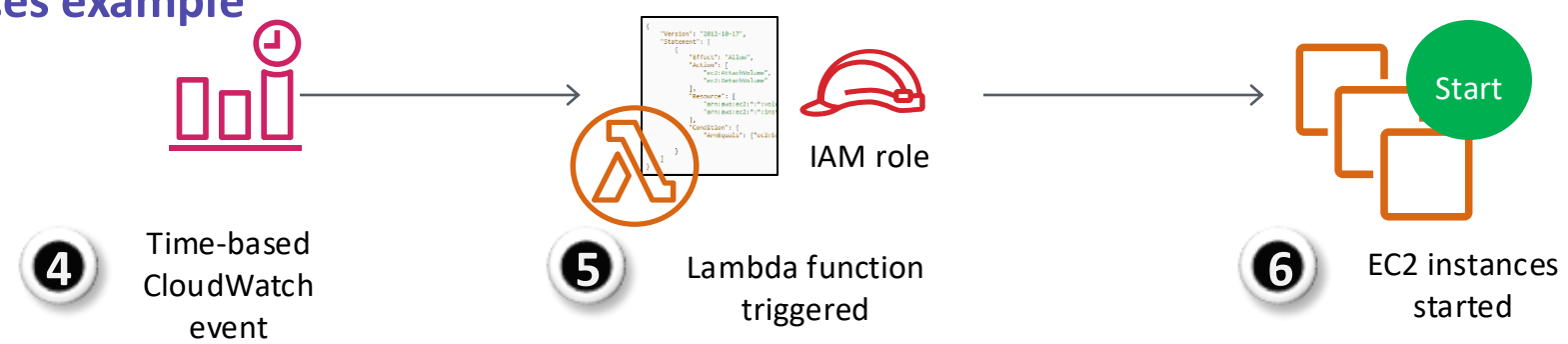


Schedule-based Lambda function example: Start and stop EC2 instances

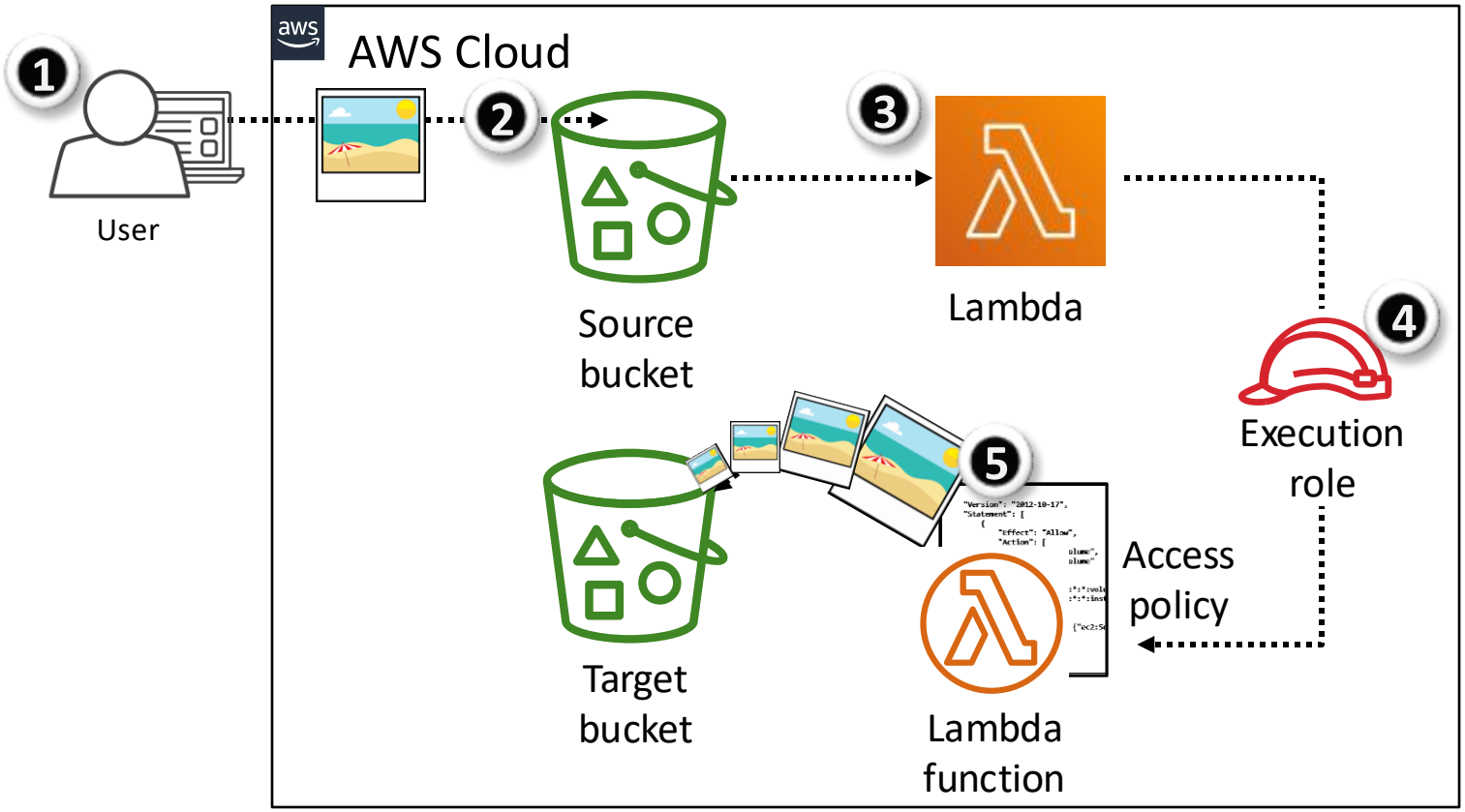
Stop instances example



Start instances example



Event-based Lambda function example: Create thumbnail images



AWS Lambda quotas

Soft limits per Region:

- Concurrent executions = 1,000
- Function and layer storage = 75 GB

Hard limits for individual functions:

- Maximum function memory allocation = 10,240 MB
- Function timeout = 15 minutes
- Deployment package size = 250 MB unzipped, including layers
- Container image code package size = 10 GB

Additional limits also exist. Details are in the AWS Lambda quotas documentation at https://docs.aws.amazon.com/lambda/latest/dg/gettingstarted-limits.html.

Section 5 key takeaways

- Serverless computing enables you to build and run applications and services without provisioning or managing servers.
- AWS Lambda is a serverless compute service that provides built-in fault tolerance and automatic scaling.
- An event source is an AWS service or developer-created application that triggers a Lambda function to run.
- The maximum memory allocation for a single Lambda function is 10,240 MB.
- The maximum run time for a Lambda function is 15 minutes.

Additional resources

- Amazon EC2 Documentation: https://docs.aws.amazon.com/ec2/
- Amazon EC2 Pricing: https://aws.amazon.com/ec2/pricing/
- Amazon ECS Workshop: https://ecsworkshop.com/
- Running Containers on AWS: https://containersonaws.com/
- Amazon EKS Workshop: https://www.eksworkshop.com/
- AWS Lambda Documentation: https://docs.aws.amazon.com/lambda/
- AWS Elastic Beanstalk Documentation: https://docs.aws.amazon.com/elastic-beanstalk/
- Cost Optimization Playbook: https://d1.awsstatic.com/pricing/AWS_CO_Playbook_Final.pdf

OFF TOPIC

IF YOU ARE

NOT BUILDING SW

YOU ARE

NOT LEARNING!