

# Module Layout

- Module 1: **Introduction and History of AWS**
- Module 2: **Foundational Services** – Amazon EC2, Amazon VPC, Amazon S3, Amazon EBS
- Module 3: **Security, Identity, and Access Management** - IAM
- Module 4: **Databases** – Amazon DynamoDB, Amazon RDS, Machine Learning
- Module 5: **AWS Elasticity and Management Tools** – Auto Scaling, Elastic Load Balancing, Amazon CloudWatch, and AWS Trusted Advisor
- Module 6: Course Wrap-Up

# Module 1

# Introduction and History of AWS

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# Amazon History



1994: Jeff Bezos incorporated the company.



2005:  
Amazon Publishing was launched.



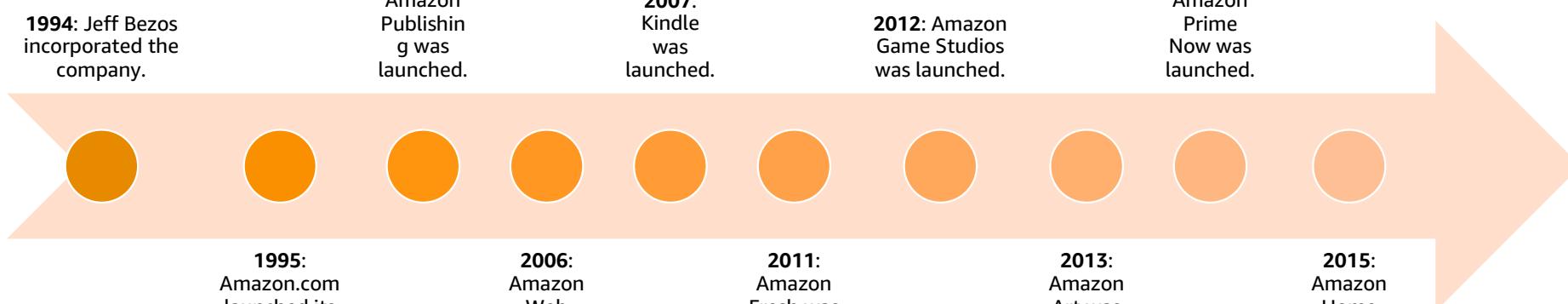
2007:  
Kindle was launched.



2012: Amazon Game Studios was launched.



2014:  
Amazon Prime Now was launched.



1995:  
Amazon.com launched its online bookstore.



2006:  
Amazon Web Services (AWS) was launched.



2011:  
Amazon Fresh was launched.



2013:  
Amazon Art was launched.



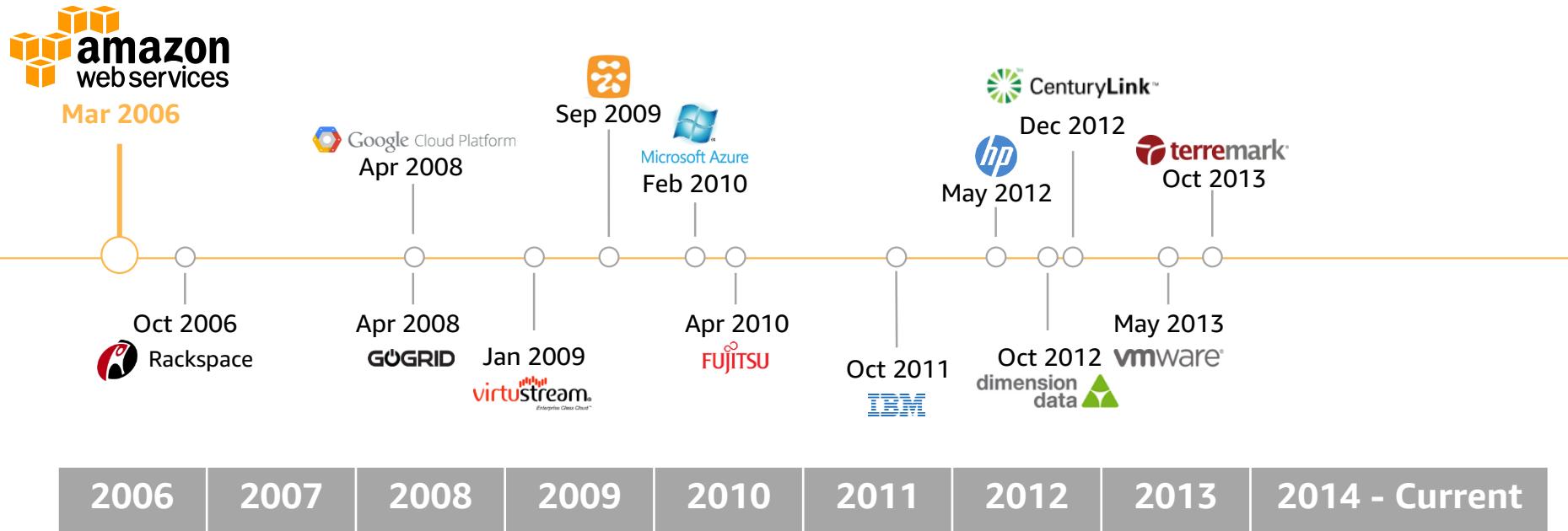
2015:  
Amazon Home Services and Amazon Echo were launched.



# One Amazon – range of services



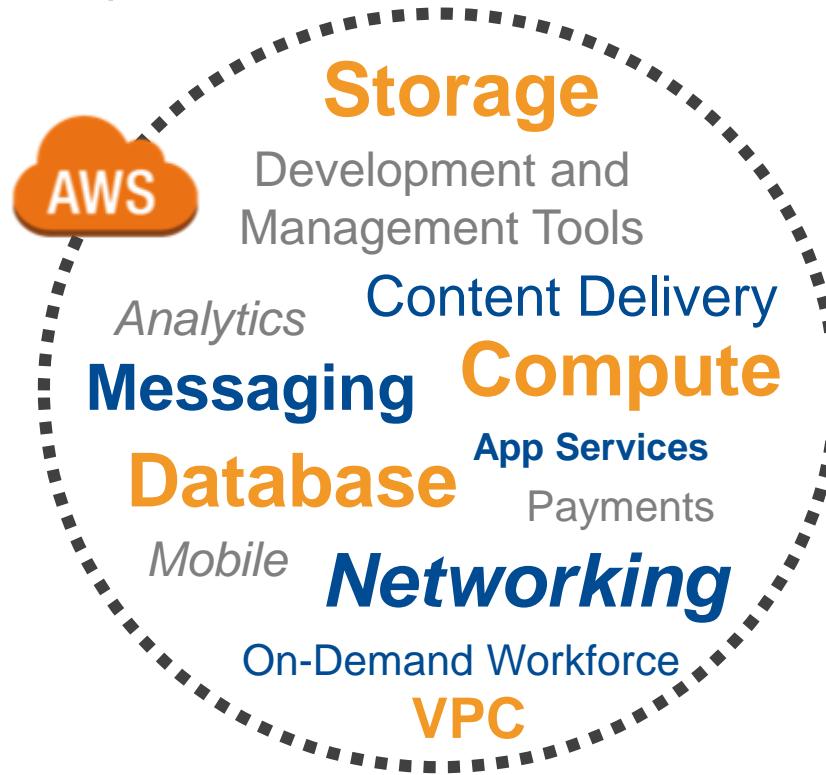
# Amazon Web Services start from 2006



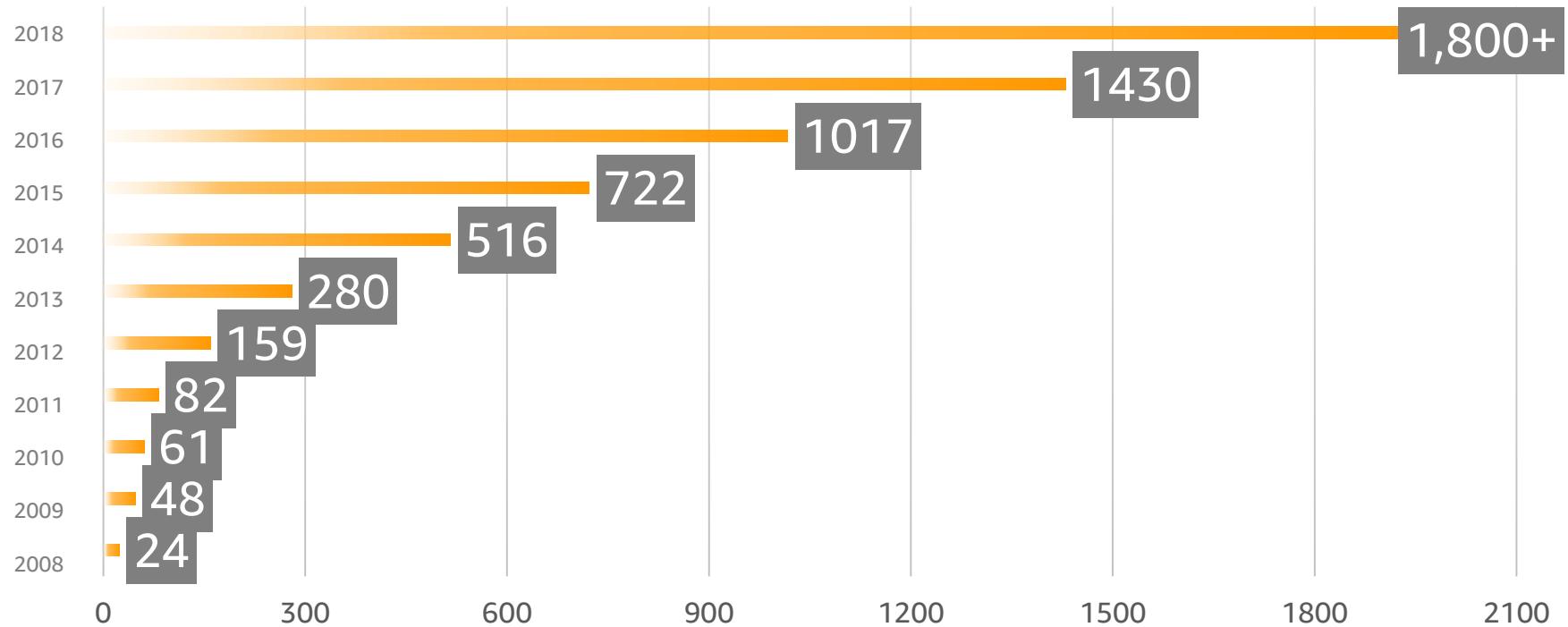
**"There is no compression algorithm for experience."**  
–Andy Jassy, Chief Executive Officer, AWS

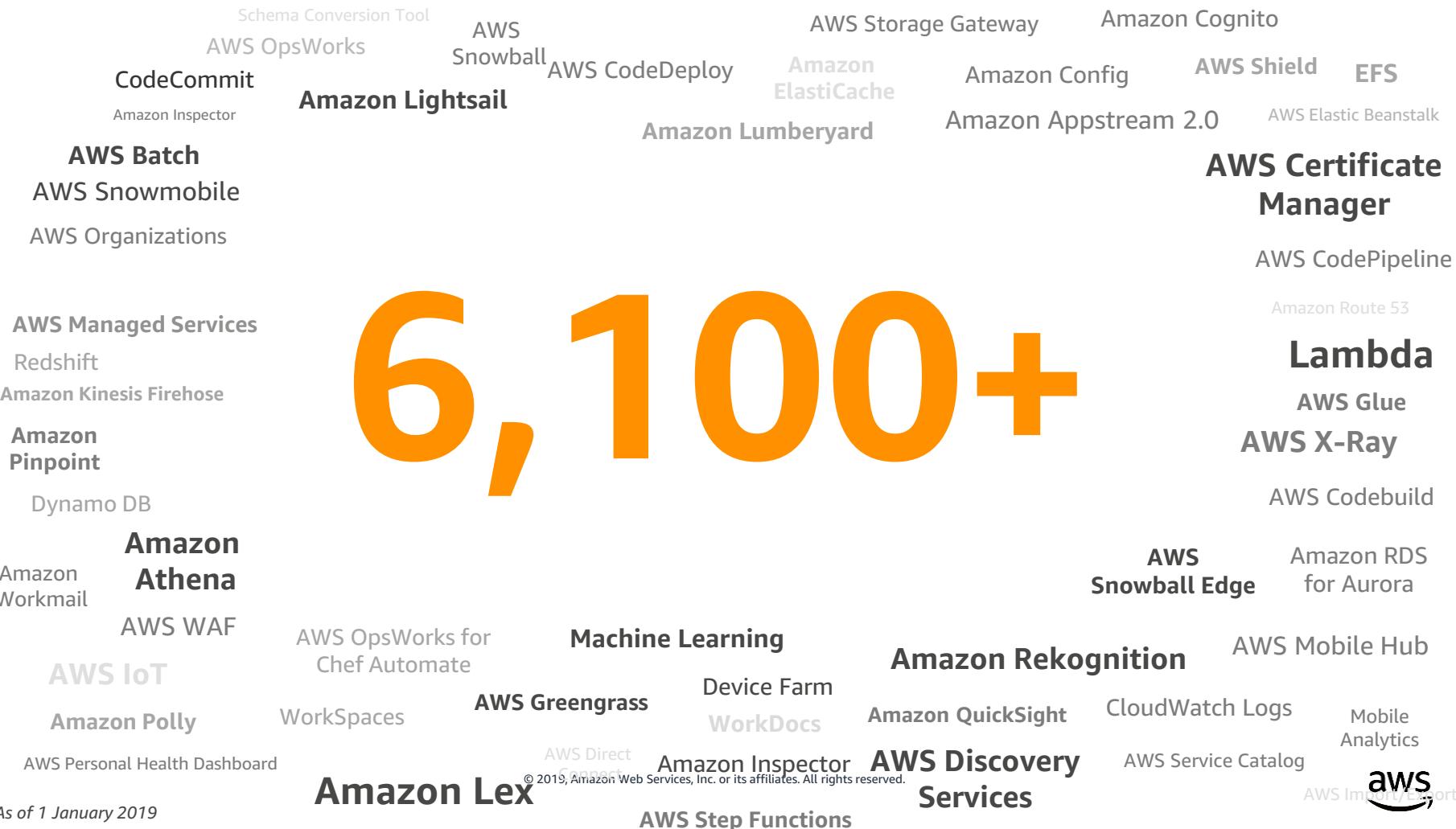
# Amazon Web Service (AWS)

*Enable businesses and developers to use web services to build scalable, sophisticated applications.*



# Rapid Pace of Innovation





\* As of 1 January 2019

# Advantages and Benefits of AWS Cloud Computing



Trade capital expense  
for variable expense.



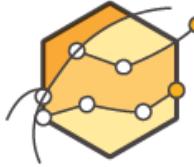
Increase speed and  
agility.



Benefit from massive  
economies of scale.



Stop spending money  
on running and  
maintaining data  
centers.



Stop guessing  
capacity.



Go global in minutes.

# AWS Core Infrastructure and Services



# AWS Cloud Computing

## Applications



Virtual  
Desktops



Collaboration and Sharing

## Platform Services

### Databases

Relational

NoSQL

Caching

### Analytics

Cluster  
Computing

Real-time

Data  
Warehouse

Data  
Workflows

### App Services

Queuing

Orchestration

App Streaming

Transcoding

Email

Search

### Deployment and Management

Containers

Dev/ops Tools

Resource Templates

Usage Tracking

Monitoring and Logs

### Mobile Services

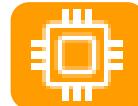
Identity

Sync

Mobile Analytics

Notifications

## Foundation Services



Compute  
(Virtual, Auto-scaling and  
Load Balancing)



Networking



Storage  
(Object, Block and Archive)

## Infrastructure

Regions

Availability Zones



Edge Locations

# AWS Global Infrastructure

## Regions

- Geographic locations
- Consist of **at least two** Availability Zones

## Availability Zones

- Clusters of data centers
- **Isolated from failures** in other Availability Zones

# AWS Global Infrastructure



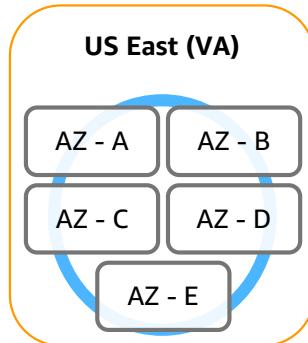
# AWS Global Infrastructure

At least 2 Availability Zones per region.

Examples:

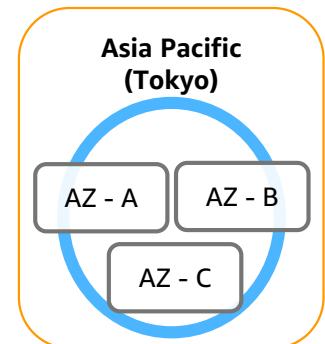
US East (N. Virginia)

- us-east-1a
- us-east-1b
- us-east-1c
- us-east-1d
- us-east-1e



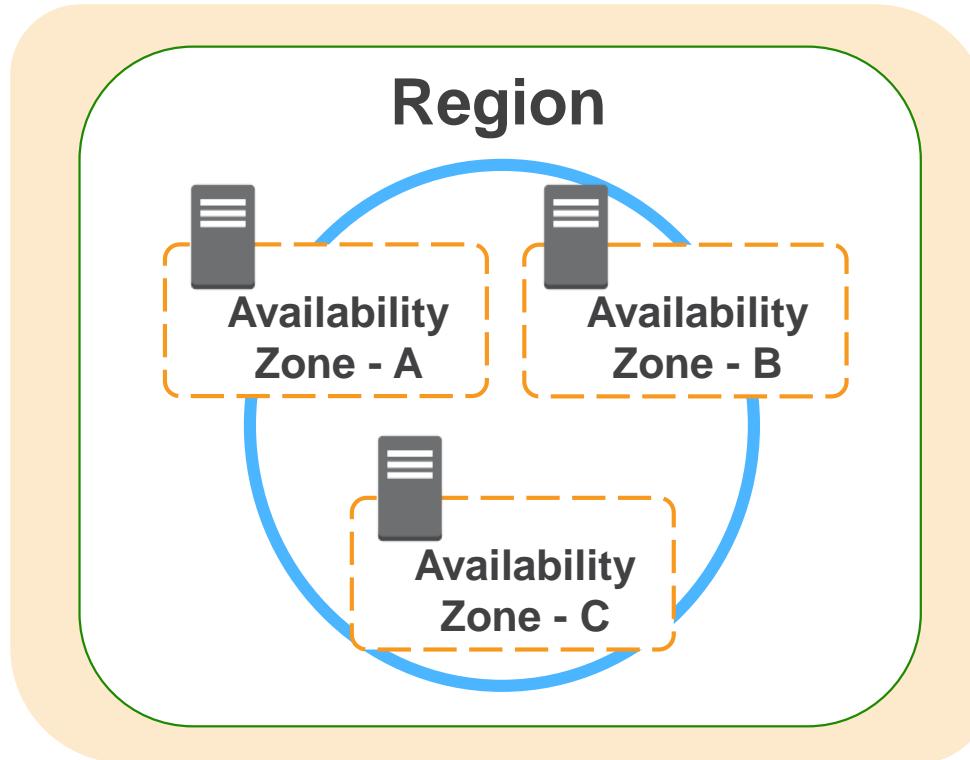
Asia Pacific (Tokyo)

- ap-northeast-1a
- ap-northeast-1b
- ap-northeast-1c



*Note: Conceptual drawing only. The number of Availability Zones (AZ) may vary.*

# High Availability Using Multi-AZ Deployments



# AWS Global Infrastructure

130+ AWS Edge locations - local points of presence  
commonly supporting AWS services like:

- Amazon Route 53 
- Amazon CloudFront 

# Knowledge Check

Q: What is the AWS term for physically distinct groups of **data centers** within a region?

**Availability Zone**

True or False: There are more Regions than Edge locations.

**False**

True or False: AWS owns and maintains the infrastructure required for application services. You provision and use them as needed.

**True**

Q: How do Availability Zones in the same region differ?

**Each Availability Zone is isolated, but the Availability Zones in a region are connected through low-latency links.**

# Module 2

# AWS Foundation Services

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# Module 2 Layout

- Amazon Elastic Compute Cloud (EC2)
  - Amazon ECS
  - Lambda and Serverless architecture
- Amazon Virtual Private Cloud (VPC)
- Amazon Storage Services
  - Amazon Simple Storage Service (S3)
  - Amazon Elastic Block Store (EBS)

# Amazon Elastic Compute Cloud (EC2)

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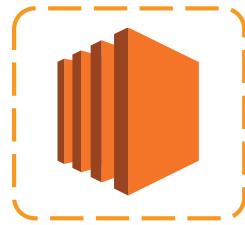
# Amazon Elastic Compute Cloud (EC2)



Amazon  
EC2

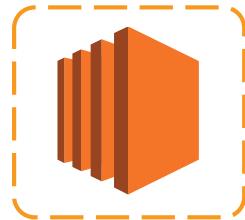
- **Resizable** compute capacity
- Complete control of your computing resources
- **Reduced time required** to obtain and boot new server instances

# Amazon EC2 Facts



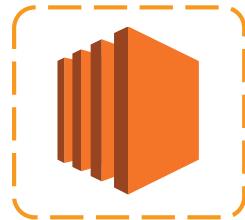
- **Scale capacity** as your computing requirements change
- Pay only for capacity that you actually use
- Choose **Linux** or **Windows**
- Deploy across **AWS Regions** and **Availability Zones** for reliability
- Use **tags** to help manage your Amazon EC2 resources

# Launching an Amazon EC2 Instance via the Management Console



- 1. Determine the AWS Region** in which you want to launch the Amazon EC2 instance.
- 2. Launch** an Amazon EC2 instance from a pre-configured Amazon Machine Image (AMI).
- 3. Choose an instance type** based on CPU, memory, storage, and network requirements.
- 4. Configure** network, IP address, security groups, storage volume, tags, and key pair.

# Amazon Machine Image (AMI) Details



An AMI includes the following:

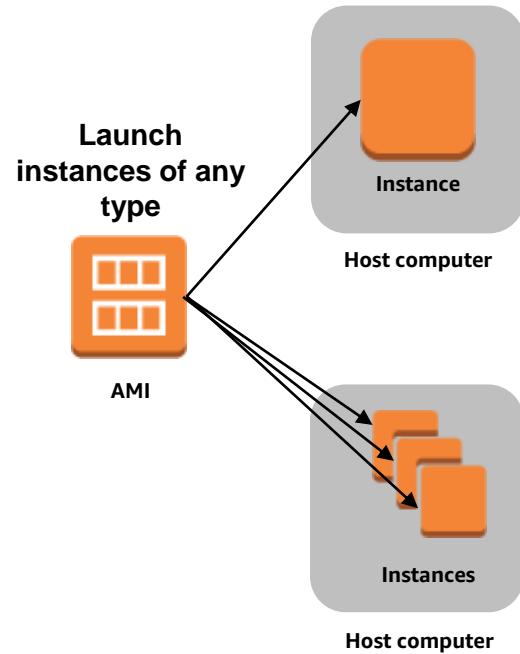
- A template for the **root volume** for the instance (for example, an operating system, an application server, and applications).
- **Launch permissions** that control which AWS accounts can use the AMI to launch instances.
- A block device mapping that specifies the **volumes to attach** to the instance when it is launched.

# Instances and AMIs

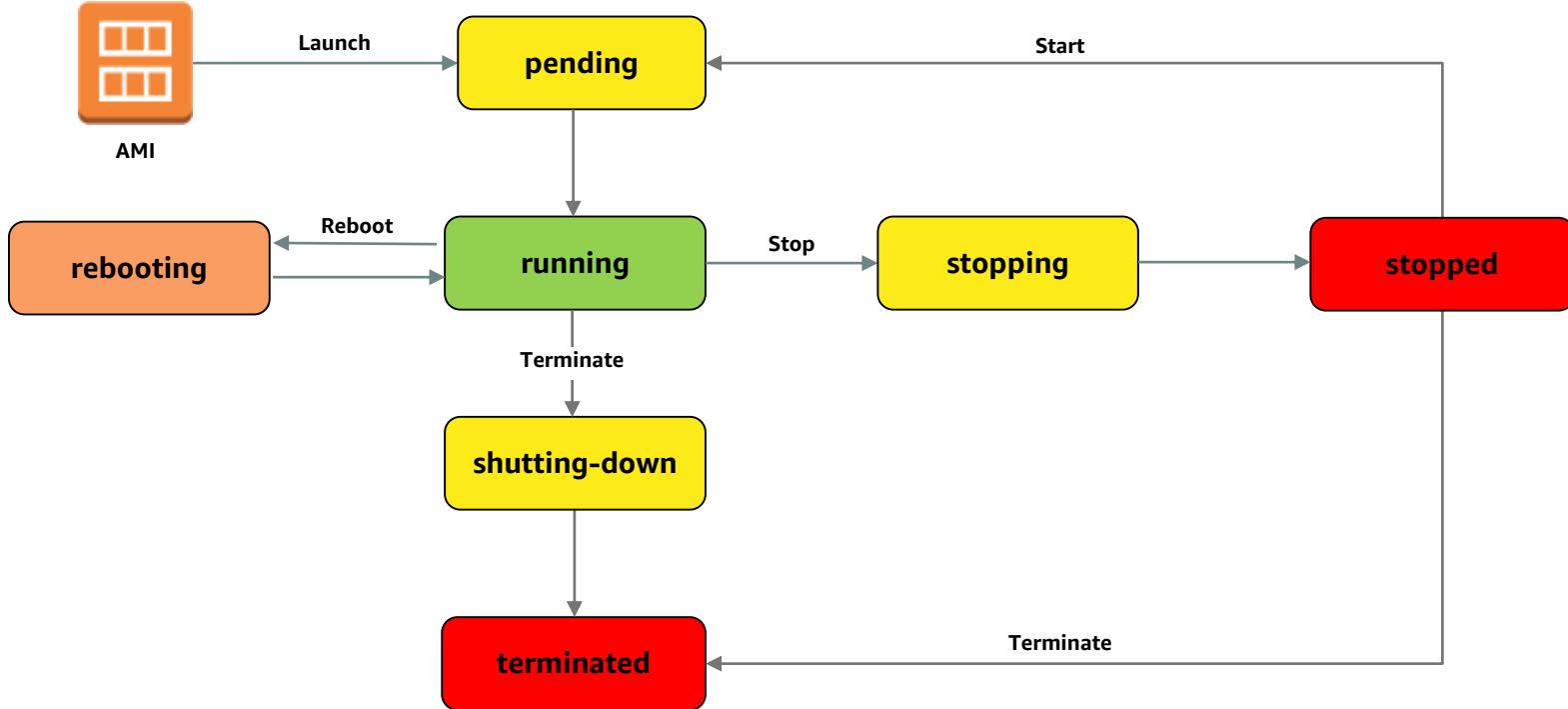
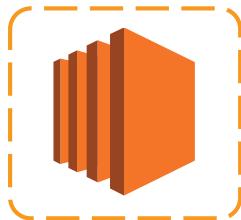


Select an AMI based on:

- Region
- Operating system
- Architecture (32-bit or 64-bit)
- Launch permissions
- Storage for the root device



# Instance Lifecycle



# AWS Marketplace – IT Software Optimized for the Cloud



- Online store to discover, purchase, and deploy IT software on top of the AWS infrastructure.
- Catalog of 4000+ IT software solutions including Paid, BYOL, Open Source, SaaS, and free-to-try options.
- Pre-configured to operate on AWS.
- Software checked by AWS for security and operability.
- Deploys to AWS environment in minutes.
- Flexible, usage-based billing models.
- Software charges billed to AWS account.

Includes [AWS Test Drive](#).

<https://aws.amazon.com/marketplace>

The screenshot shows the AWS Marketplace homepage. At the top, there's a navigation bar with links for 'Sign in or Create a new account', 'Your Account | Help | Sell on AWS Marketplace', and a search bar labeled 'Search AWS Marketplace'. Below the navigation is a main banner with the text 'Production-ready cluster deployments in minutes with AWS Marketplace and AWS CloudFormation' and a link to 'Learn more'. To the right of the banner is a circular diagram illustrating a cluster deployment. The main content area is divided into sections: 'Featured Products' and 'Popular Products'. Under 'Featured Products', there are cards for 'WebSphere Application Server Base Edt...', 'Matillion ETL for Redshift', 'TIBCO Clarity', 'Amazon Linux AMI (HVM / 64-bit)', and 'CentOS 7 (x86\_64) with Updates HVM'. Under 'Popular Products', there are cards for 'SOPHOS Sophos UTM 9', 'SoftNAS Cloud Standard - High-Perform...', 'TIBCO Jaspersoft for AWS with Multi-T...', 'ubuntu 14.04 LTS (HVM)', and 'redhat Red Hat Enterprise Linux (RHEL) 7 (...'. Each card includes a logo, product name, a brief description, and a 'Free Trial' button.



# Choosing the Right Amazon EC2 Instance

AWS uses Intel® Xeon® processors to provide customers with high performance and value. EC2 instance types are optimized for different use cases, workload requirements and come in multiple sizes.

Consider the following when choosing your instances:

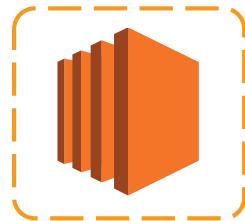
- Core count
- Memory size
- Storage size and type
- Network performance
- CPU technologies

# Current Generation Instances



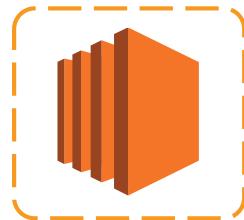
Instance Family	Some Use Cases
General purpose (t3, m5, m4)	<ul style="list-style-type: none"><li>• Low-traffic websites and web applications</li><li>• Small databases and mid-size databases</li></ul>
Compute-optimized (c5, c4)	<ul style="list-style-type: none"><li>• High performance front-end fleets</li><li>• Video-encoding</li></ul>
Memory-optimized (r5, X1)	<ul style="list-style-type: none"><li>• High performance databases</li><li>• Distributed memory caches</li></ul>
Storage-optimized (i3, d2)	<ul style="list-style-type: none"><li>• Data warehousing</li><li>• Log or data-processing applications</li></ul>
GPU instances (g3)	<ul style="list-style-type: none"><li>• 3D application streaming</li><li>• Graphics-intensive workloads</li></ul>
Machine Learning (p3)	<ul style="list-style-type: none"><li>• Optimized for distributed machine learning training</li></ul>

# Instance Metadata



- Is data about your instance.
- Can be used to configure or manage a running instance.

# Retrieving Instance Metadata



To view all categories of instance metadata from within a running instance, use the following URI:

<http://169.254.169.254/latest/meta-data/>

On a Linux instance, you can use:

- \$ curl http://169.254.169.254/latest/meta-data/
- \$ GET http://169.254.169.254/latest/meta-data/

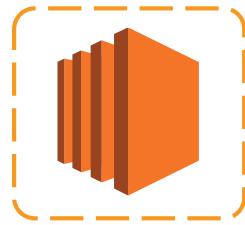
All metadata is returned as text (content type text/plain).



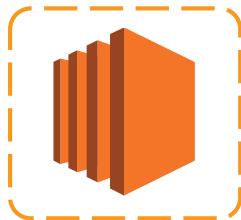
The screenshot shows a browser window with the URL <http://169.254.169.254/latest/meta-data/>. The page displays a list of instance metadata keys:

```
ami-id  
ami-launch-index  
ami-manifest-path  
block-device-mapping/  
hostname  
instance-action  
instance-id  
instance-type  
local-hostname  
local-ipv4  
mac  
metrics/  
network/  
placement/  
profile  
public-hostname  
public-ipv4  
public-keys/  
reservation-id  
security-groups  
services/
```

# Instance User Data



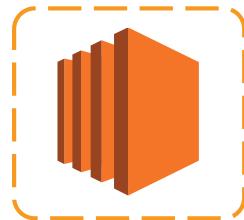
- Can be passed to the instance at launch.
- Can be used to perform common automated configuration tasks.
- Runs scripts after the instance starts.



# Adding User Data

- You can specify user data when launching an instance.
- User data can be:
  - Linux script – executed by **cloud-init**
  - Windows batch or PowerShell scripts – executed by **EC2Config** service
- User data scripts run once per instance ID by default.

# User Data Example Linux



```
#!/bin/sh
```

```
yum -y install httpd  
chkconfig httpd on  
/etc/init.d/httpd start
```

User data shell scripts must start with the `#!` characters and the path to the interpreter you want to read the script.

Install Apache web server  
Enable the web server  
Start the web server

# User Data Example Windows



```
<powershell>
```

```
Import-Module ServerManager
```

Import the Server Manager module for Windows PowerShell.

```
Install-WindowsFeature web-server, web-webserver
```

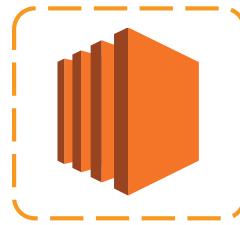
```
Install-WindowsFeature web-mgmt-tools
```

```
</powershell>
```



Install IIS  
Install Web Management Tools

# Retrieving User Data

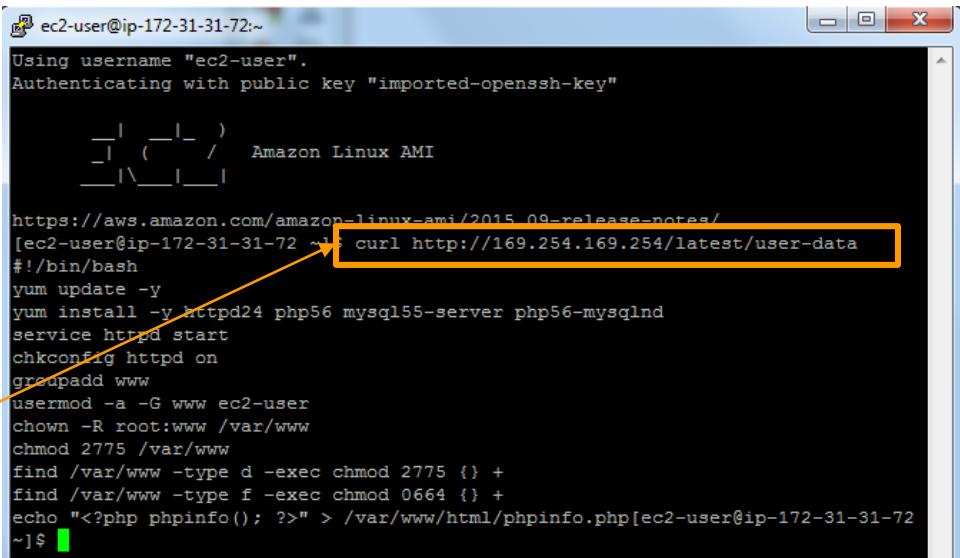


To retrieve user data, use the following URI:

`http://169.254.169.254/latest/user-data`

On a Linux instance, you can use:

```
$ curl http://169.254.169.254/latest/user-data/  
$ GET http://169.254.169.254/latest/user-data/
```



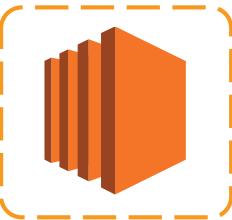
A screenshot of a terminal window titled "ec2-user@ip-172-31-31-72:~". The window shows the following text:

```
Using username "ec2-user".
Authenticating with public key "imported-openssh-key"

[ec2-user@ip-172-31-31-72 ~]$ curl http://169.254.169.254/latest/user-data/
#!/bin/bash
yum update -y
yum install -y httpd24 php56 mysql55-server php56-mysqlnd
service httpd start
chkconfig httpd on
groupadd www
usermod -a -G www ec2-user
chown -R root:www /var/www
chmod 2775 /var/www
find /var/www -type d -exec chmod 2775 {} +
find /var/www -type f -exec chmod 0664 {} +
echo "<?php phpinfo(); ?>" > /var/www/html/phpinfo.php[ec2-user@ip-172-31-31-72
~]$
```

An orange arrow points from the text "\$ curl http://169.254.169.254/latest/user-data/" in the previous code block to the corresponding line in the terminal window.

# Amazon EC2 Purchasing Options



## On-Demand Instances

Pay by the hour.  
Or  
Pay by the Second

## Reserved Instances

Purchase, at a significant discount, instances that are always available

1-year to 3-year terms.

## Scheduled Instances

Purchase instances that are always available on the specified recurring schedule, for a one-year term.

## Spot Instances

Bid on unused instances, which can run as long as they are available and your bid is above the Spot price.

## Dedicated Instances

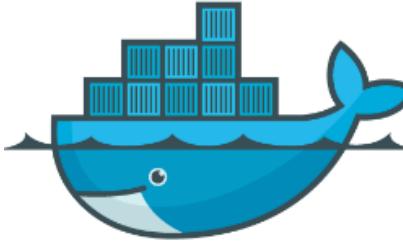
Pay, by the hour, for instances that run on single-tenant hardware.

## Dedicated Hosts

Pay for a physical host that is fully dedicated to running your instances.

# The concept of Container

Just as shipping containers standardized transport of freight goods, software containers aim to standardize the transport of *applications*.



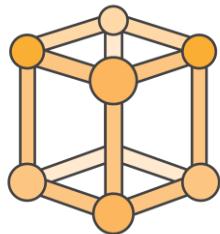
Docker

- Isolated running environment
- Isolated CPU, memory, block I/O and network resource
- Docker image runs in container
- Automatically deploy

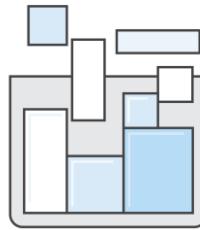
# The challenges for running Container

- Which of the cluster nodes can currently host my container?
- What if my container is unhealthy?
- How do I load-balance?
- Will this plug into my Continuous Delivery pipeline?
- Can I use another scheduler?
- Do I need to add software components?

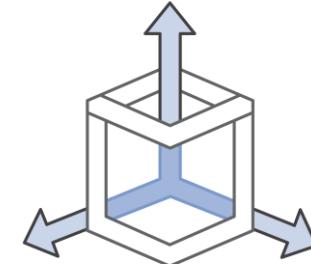
# Amazon Elastic Container Service (ECS)



**Cluster management  
made easy**



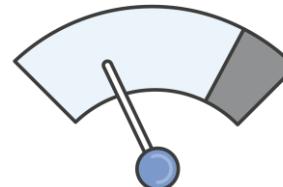
**Flexible scheduling**



**Integrated and  
extensible**

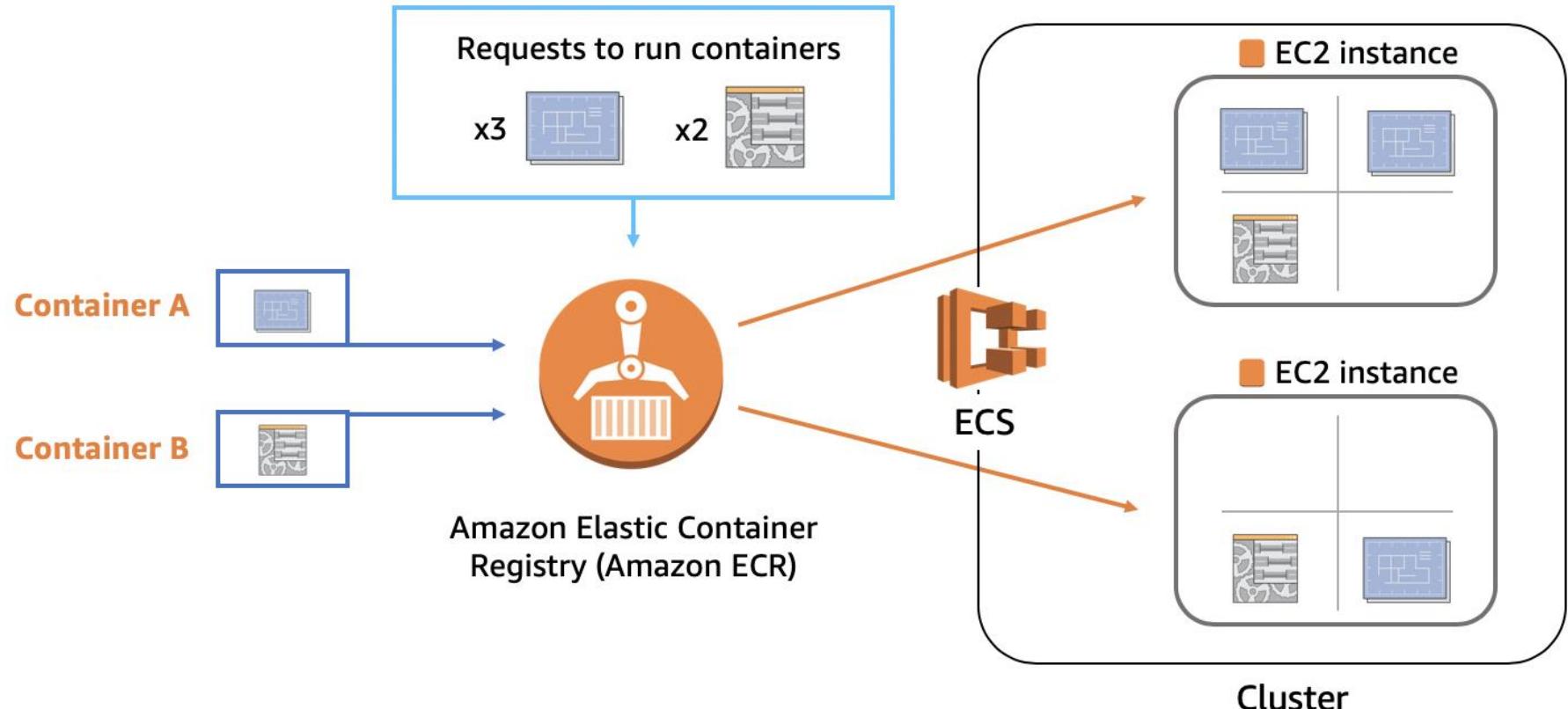


**Security**

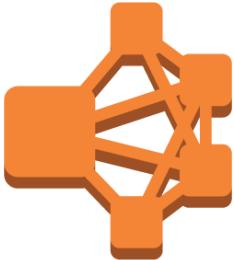


**Performance at  
scale**

# Working With Amazon ECS



# Cluster, Agent and Task Definition



**Cluster**

- Include Docker instance
- Scale with AutoScaling Group



**Agent**

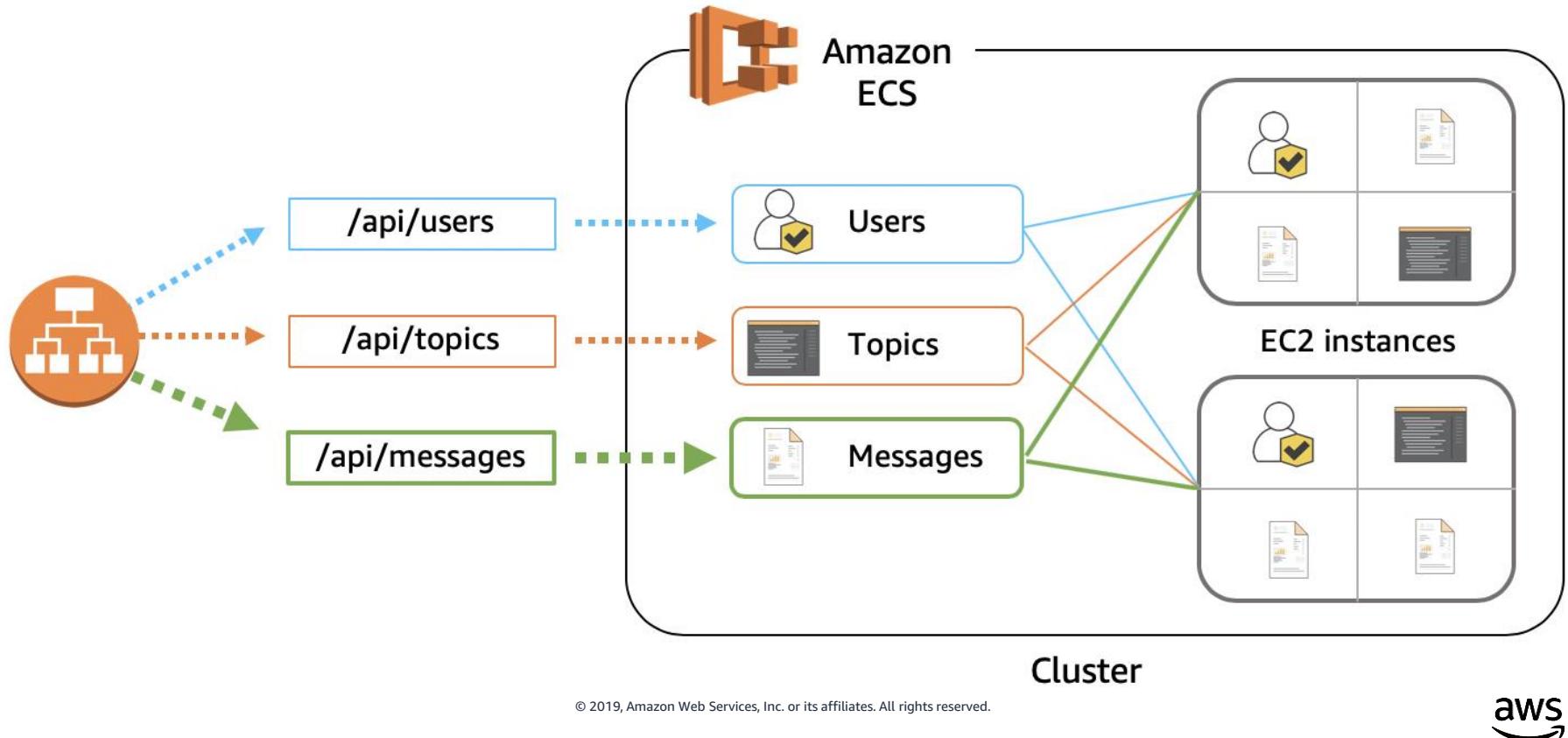
- Runs on Docker instance
- GitHub open source application
- Start or stop Docker on instance

Task Definition

**Task Definition**

- JSON format
- Describe Docker that host application
- Build task on Docker instance

# Amazon ECS Tasks & Services



# AWS Fargate

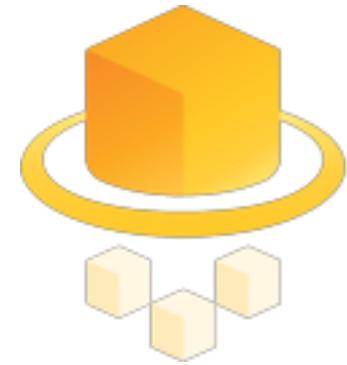
No Clusters to Manage

Seamless Scaling

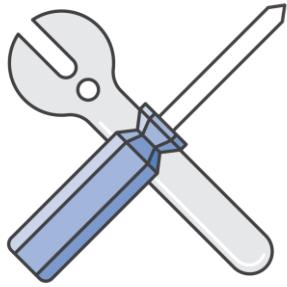
Integrated with Amazon ECS

Flexible configuration options

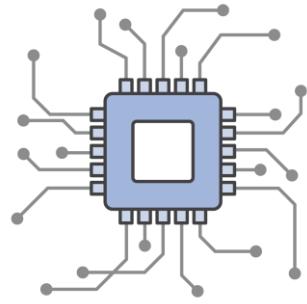
Resource-based pricing



# Using Fargate



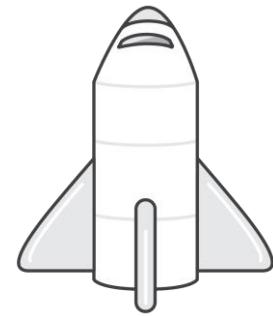
1. Build your container image



2. Specify CPU and memory requirements



3. Define IAM and networking policies



4. Launch

OK, It is truly convenient  
But, do we need server?

AWS Lambda

# AWS Lambda



AWS  
Lambda

Event-driven that trigger **user-defined code**  
**Automate** the resource management  
**Fully management**, need not user interfere  
while running

# AWS Lambda: Connect your application & AWS service

## AWS Lambda: Connective tissue for AWS services



# Networking - Amazon VPC

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# Amazon Virtual Private Cloud (VPC)



Amazon  
VPC

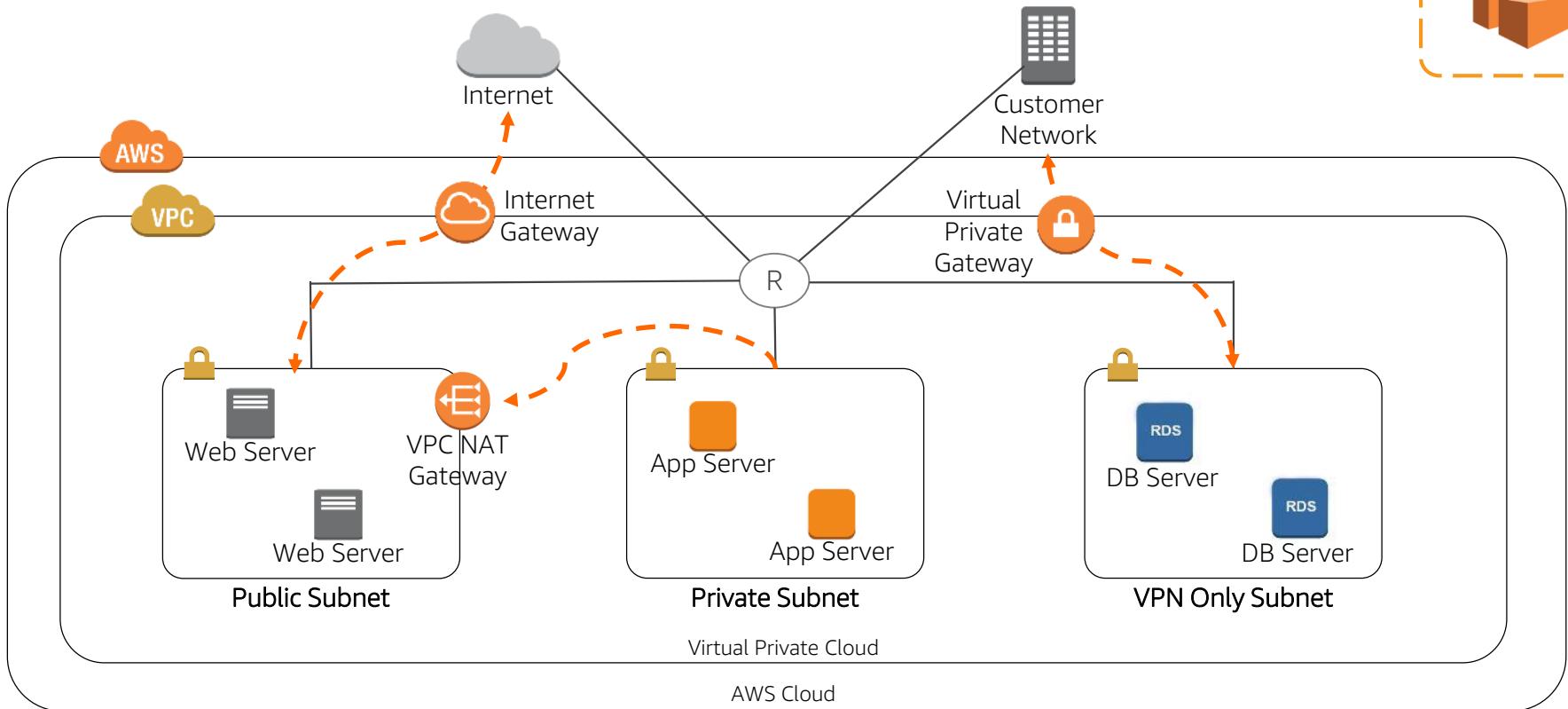
- Provision a **private, isolated virtual network** on the AWS cloud.
- Have complete control over your virtual networking environment.

# VPCs and Subnets



- A **subnet** defines a range of IP addresses in your VPC.
- You can launch AWS resources into a subnet that you select.
- A **private subnet** should be used for resources that won't be accessible over the Internet.
- A **public subnet** should be used for resources that will be accessed over the Internet.
- Each subnet must reside entirely within one Availability Zone and cannot span zones.

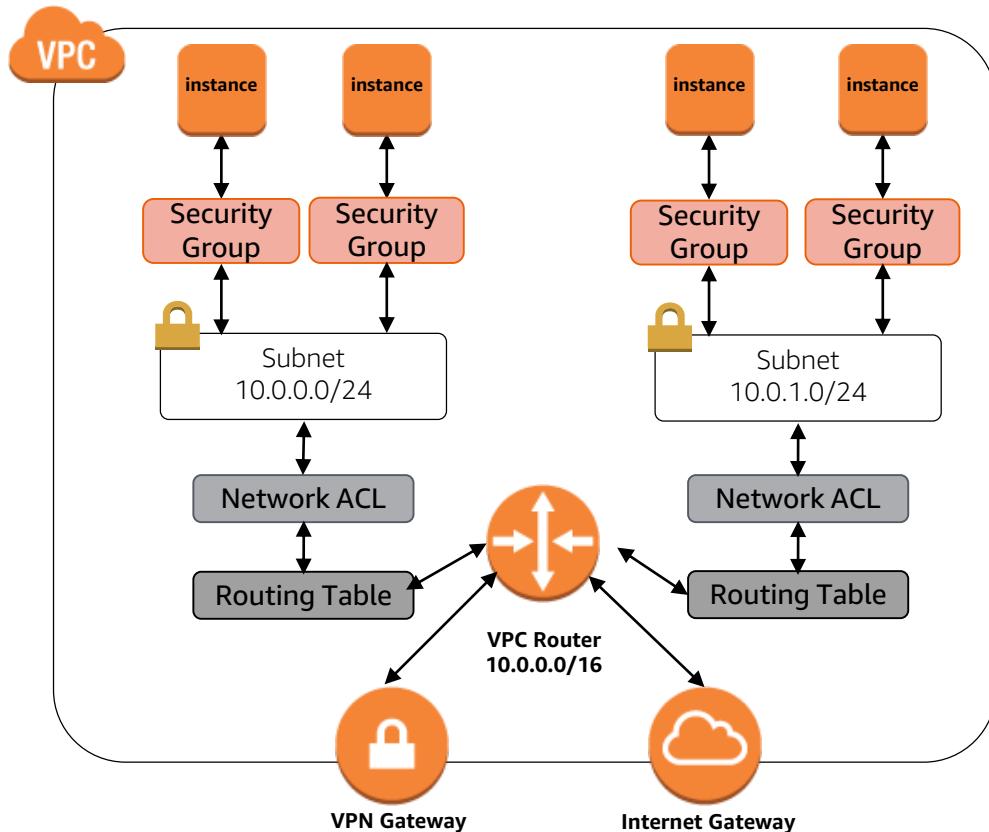
# Amazon VPC Example



# Security in Your VPC



- Security groups
- Network access control lists (ACLs)
- Key Pairs



# VPN Connections



VPN Connectivity option	Description
AWS Hardware VPN	You can create an <b>IPsec</b> hardware VPN connection between your VPC and your remote network.
AWS Direct Connect	AWS Direct Connect provides a <b>dedicated private</b> connection from a remote network to your VPC.
AWS VPN CloudHub	You can create multiple <b>AWS hardware VPN</b> connections via your VPC to enable communications between various remote networks.
Software VPN	You can create a VPN connection to your remote network by using an Amazon EC2 instance in your VPC that's running a <b>software VPN appliance</b> .

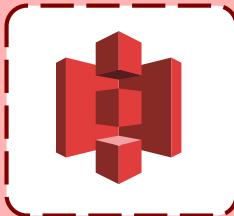
# Storage Service Amazon S3 and Amazon EBS

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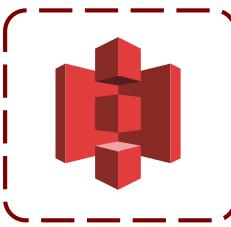
# Amazon Simple Storage Service (S3)



Amazon S3

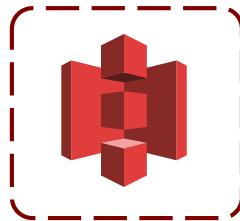
- Storage for the Internet
- Natively online, HTTP access
- Storage that allows you to store and retrieve **any amount of data**, any time, from anywhere on the web
- **Highly scalable**, reliable, fast and durable

# Amazon S3 Facts



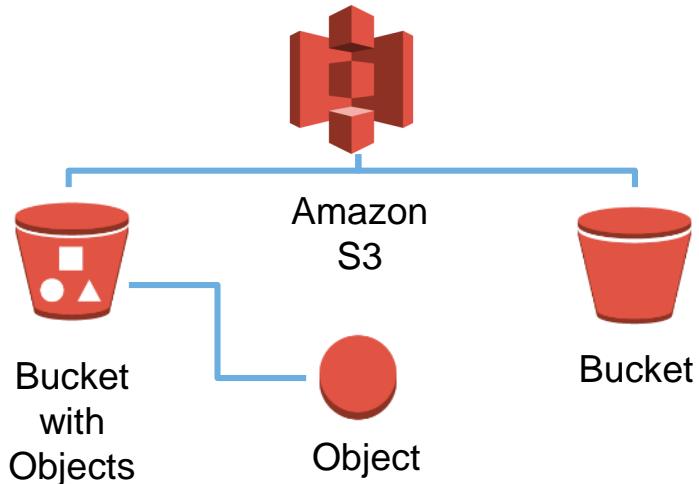
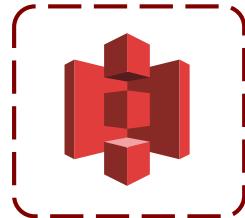
- Can store an **unlimited number of objects** in a bucket
- Objects can be **up to 5 TB**; no bucket size limit
- Designed for **99.99999999%** durability and **99.99%** availability of objects over a given year
- Can use **HTTP/S** endpoints to store and retrieve any amount of data, at any time, from anywhere on the web
- Is highly scalable, reliable, fast, and inexpensive
- Can use optional server-side **encryption** using AWS or customer-managed provided client-side encryption
- Auditing is provided by access logs
- Provides standards-based **REST** and **SOAP** interfaces

# Common Use Scenarios



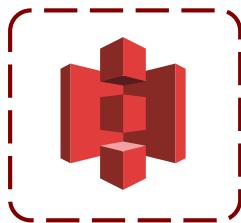
- Storage and backup
- Application file hosting
- Media hosting
- Software delivery
- Store AMIs and snapshots

# Amazon S3 Concepts



- Amazon S3 stores data as objects within **buckets**
- An object is composed of a file and optionally any **metadata** that describes that file
- You can have **up to 100 buckets** in each account
- You can **control access** to the bucket and its objects

# Object Keys



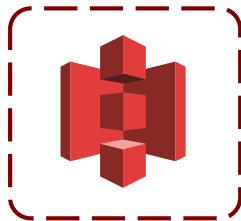
An object key is the unique identifier for an object in a bucket.

<http://doc.s3.amazonaws.com/2006-03-01/AmazonS3.html>

Bucket

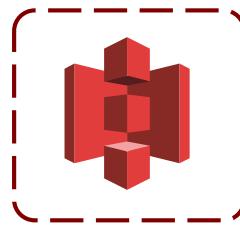
Object/Key

# Amazon S3 Security



- You can **control access** to buckets and objects with:
  - Access Control Lists (ACLs)
  - Bucket policies
  - Identity and Access Management (IAM) policies
- You can upload or download data to Amazon S3 via **SSL** encrypted endpoints.
- You can **encrypt data** using AWS SDKs.

# Amazon S3 Versioning



- Protects from **accidental overwrites and deletes** with no performance penalty.
- Generates a **new version with every upload**.
- Allows easily retrieval of deleted objects or **roll back** to previous versions.
- Three states of an Amazon S3 bucket
  - Un-versioned (default)
  - Versioning-enabled
  - Versioning-suspended

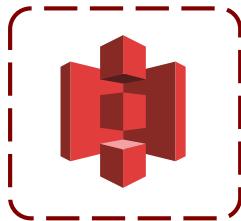


Versioning Enabled

# Amazon S3 Storage Classes

Storage Class	Durability	Availability	Other Considerations
Amazon S3 Standard	99.999999999% %	99.99%	
Amazon S3 Standard - Infrequent Access (IA)	99.999999999% %	99.9%	<ul style="list-style-type: none"><li>• Retrieval fee associated with objects</li><li>• Most suitable for infrequently accessed data</li></ul>
Glacier	99.999999999% %	99.99% (once restored)	<ul style="list-style-type: none"><li>• Not available for real-time access</li><li>• Must restore objects before you can access them</li><li>• Restoring objects can take 3-5 hours</li></ul>

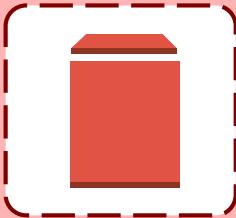
# Amazon S3 Object Lifecycle



**Lifecycle management** defines how Amazon S3 manages objects during their lifetime. Some objects that you store in an Amazon S3 bucket might have a well-defined lifecycle:

- Log files
- Archive documents
- Digital media archives
- Financial and healthcare records
- Raw genomics sequence data
- Long-term database backups
- Data that must be retained for regulatory compliance

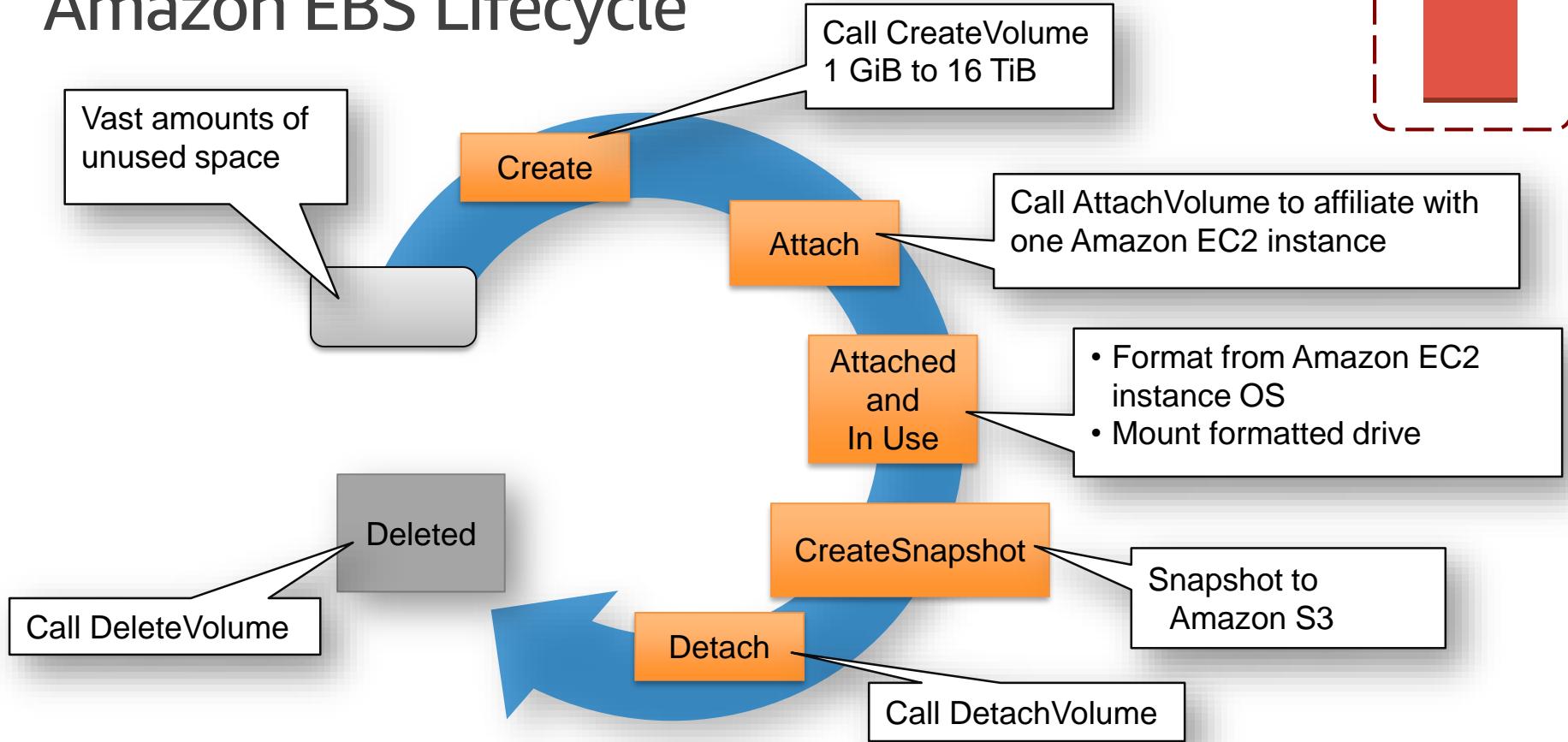
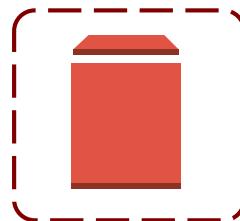
# Amazon Elastic Block Store (EBS)



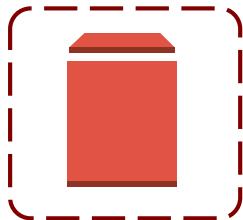
Amazon  
EBS

- **Persistent block level storage** volumes offer consistent and low-latency performance.
- Stored data is automatically replicated within its Availability Zone.
- Snapshots are stored durably in Amazon S3.

# Amazon EBS Lifecycle

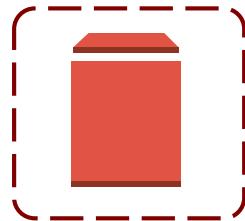


# Amazon EBS Volume Types



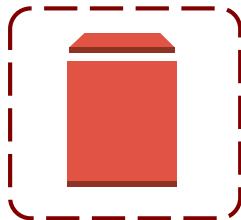
- SSD-backed volumes are
  - Optimized for **transactional** workloads that involve **frequent read/write** operations with **small I/O** size.
  - Dominant in **IOPS** performance.
- HDD-backed volumes are
  - Optimized for **large streaming** workloads.
  - Dominant in **throughput** (measured in MiB/s).

# Amazon EBS Volume Types



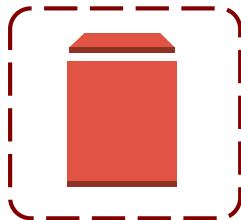
	SSD		HDD	
Volume Type	General Purpose SSD (gp2)	Provisioned IOPS SSD (io1)	Throughput Optimized HDD (st1)	Cold HDD (sc1)
Description	Balances price and performance for a wide variety of <b>transactional</b> loads.	<b>Highest-performance</b> SSD volume designed for <b>mission-critical</b> applications.	<b>Low-cost</b> HDD designed for <b>frequently accessed, throughput-intensive</b> workloads.	<b>Lowest cost</b> HDD designed for less frequently accessed workloads.
Volume Sizes	1 GiB – 16 TiB	4 GiB – 16 TiB	500 GiB – 16 TiB	500 GiB – 16 TiB
Dominant Performance Attribute	IOPS	IOPS	MiB/s	MiB/s

# Amazon EBS Facts



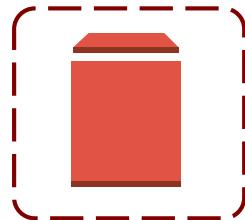
- EBS is recommended when data must be **quickly accessible** and requires **long-term persistence**.
- You can launch your EBS volumes as **encrypted** volumes – data stored at rest on the volume, disk I/O, and snapshots created from the volume are all encrypted.
- You can create **point-in-time snapshots** of EBS volumes, which are persisted to Amazon S3.

# Amazon EBS Use Cases



- **OS:** Use for boot/root volume, secondary volumes
- **Databases:** Scales with your performance needs
- **Enterprise applications:** Provides reliable block storage to run mission-critical applications
- **Business continuity:** Minimize data loss and recovery time by regularly backing up using EBS Snapshots
- **Applications:** Install and persist any application

# Amazon EBS Scope



**Amazon EBS volumes are in a single Availability Zone**

EBS Volume 1



EBS Volume 2



Volume data is replicated across multiple servers in an Availability Zone.

# Amazon EBS and Amazon S3



	Amazon EBS	Amazon S3
Paradigm	Block storage with file system	Object store
Performance	Very fast	Fast
Redundancy	Across multiple servers in an Availability Zone	Across multiple facilities in a Region
Security	EBS Encryption – Data volumes and Snapshots	Encryption
Access from the Internet?	No (1)	Yes (2)
Typical use case	It is a disk drive	Online storage

- (1) Accessible from the Internet if mounted to server and set up as FTP, etc.
- (2) Only with proper credentials, unless ACLs are world-readable

# Amazon EC2 *Instance Storage*

- Is local, complimentary **direct attached block storage**.
- Includes availability, number of disks, and size **based on EC2 instance type**.
- Is optimized for **up to 3M+ Read IOPS**
- Is SSD or magnetic.
- Has **no persistence**.
- **Automatically deletes** data when an EC2 instance stops, fails or is terminated.

# Amazon EBS vs. Amazon EC2 Instance Store

## Amazon EBS

- Data stored on an Amazon EBS volume can persist independently of the life of the instance.
- Storage is **persistent**.

## Amazon EC2 Instance Store

- Data stored on a local instance store persists only as long as the instance is alive.
- Storage is **ephemeral**.

# Reboot vs. Stop vs. Terminate

Characteristic	Reboot	Stop/Start (EBS-backed instances only)	Terminate
Host computer	The instance <b>stays on the same host computer</b> .	The instance runs on a <b>new host computer</b> .	
Public IP address	No change	<b>New address assigned</b>	
Elastic IP addresses (EIP)	EIP remains associated with the instance.	EIP remains associated with the instance.	EIP is <b>disassociated</b> from the instance.
Instance store volumes	Preserved	<b>Erased</b>	<b>Erased</b>
EBS volume	Preserved	Preserved	Boot volume is <b>deleted by default</b> .
Billing	Instance billing hour doesn't change.	You <b>stop incurring charges</b> as soon as state is changed to <i>stopping</i> .	You <b>stop incurring charges</b> as soon as state is changed to <i>shutting-down</i> .

# Module 3

# Security, Identity and Access Management

# AWS Shared Responsibility Model

Customers

Customer Applications & Content

Platform, Applications, Identity, and Access Management

Operating System, Network, and Firewall Configuration

Client-side Data  
Encryption

Server-side Data  
Encryption

Network Traffic  
Protection

Customers are  
responsible for  
security **IN** the cloud

AWS Foundation Services

Compute

Storage

Database

Networking

AWS Global  
Infrastructure

Availability Zones

Regions

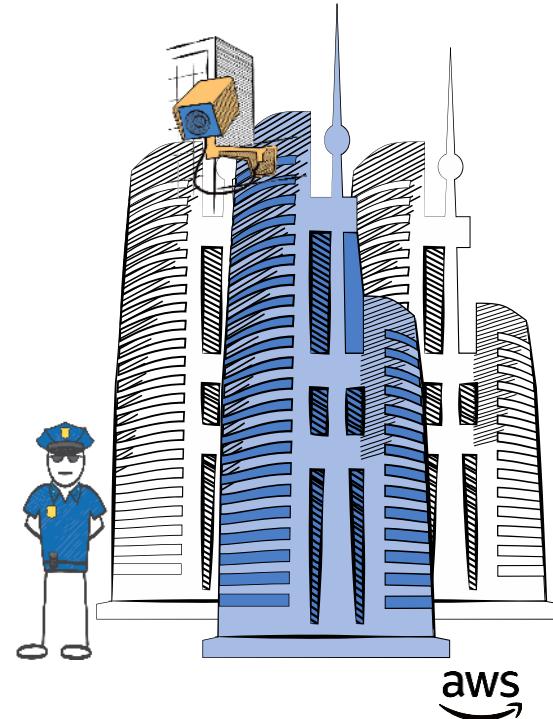
Edge Locations

AWS is responsible  
for the security **OF**  
the cloud



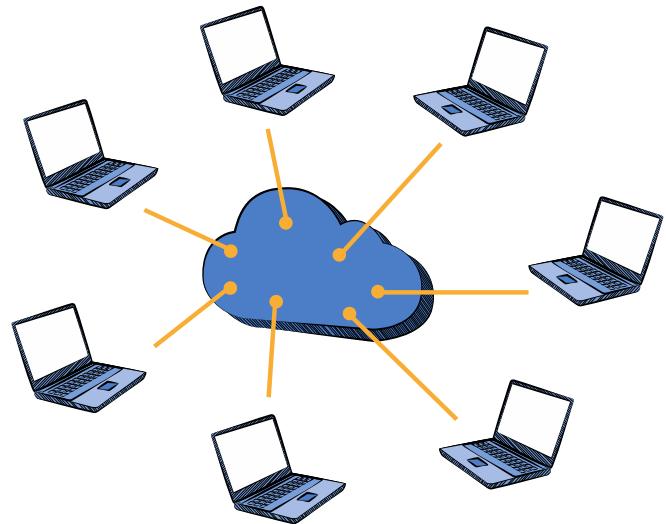
# Physical Security

- 24/7 trained **security staff**
- AWS data centers in **nondescript** and **undisclosed** facilities
- **Two-factor authentication** for authorized staff
- **Authorization** for data center access

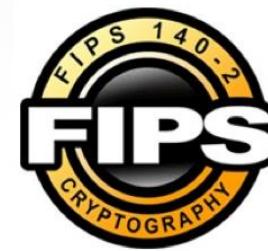


# Hardware, Software, and Network

- Automated **change-control** process
- Bastion servers that **record all access attempts**
- **Firewall** and other **boundary devices**
- AWS **monitoring tools**



# Certifications and Accreditations



ISO 9001, ISO 27001, ISO 27017, ISO 27018, IRAP (Australia), MLPS Level 3 (China),  
MTCS Tier 3 Certification (Singapore) and more ...

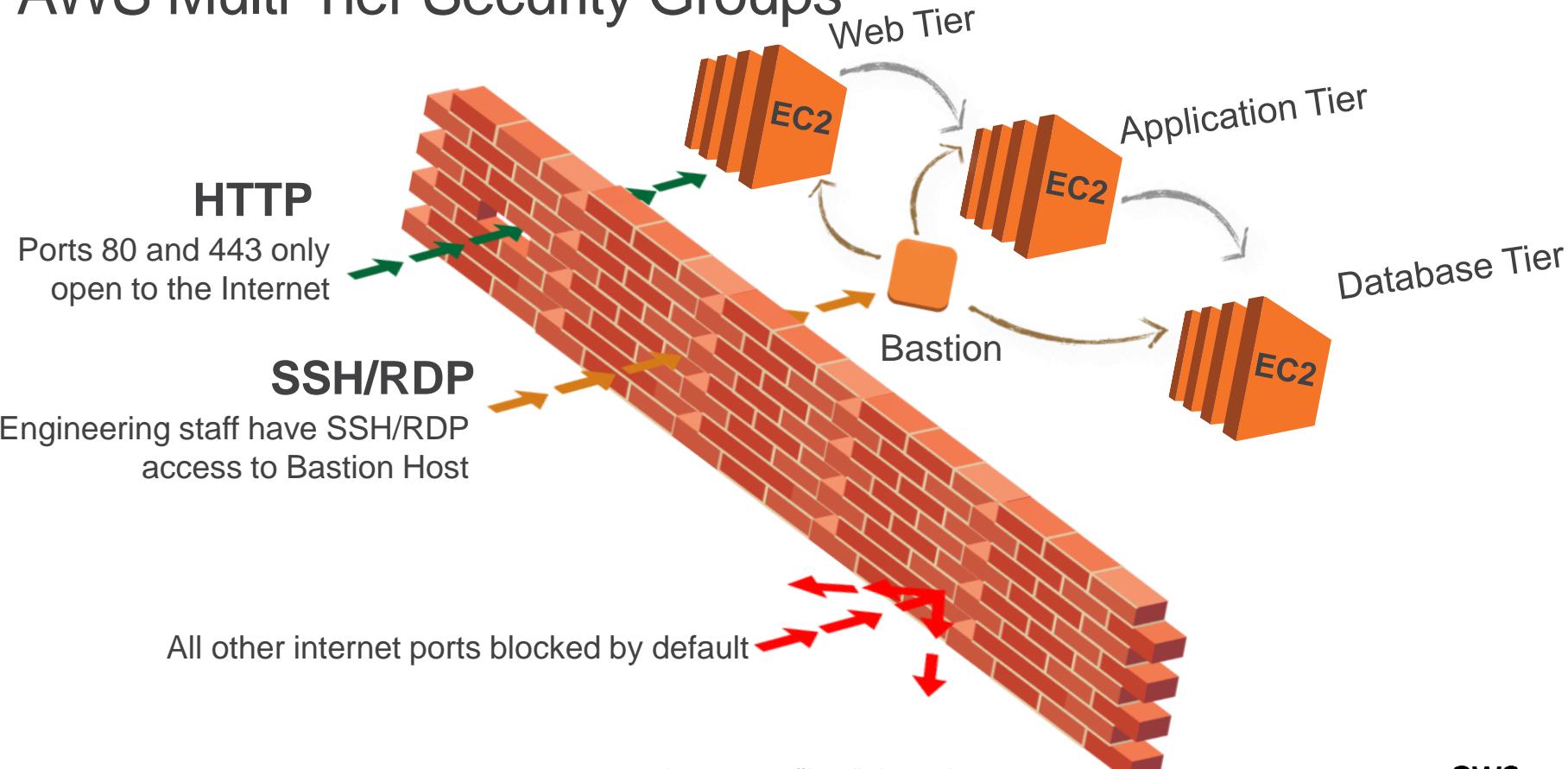
# SSL Endpoints

SSL Endpoints	Security Groups	VPC
<p><b>Secure Transmission</b></p> <p>Use secure endpoints to establish secure communication sessions (HTTPS).</p>	<p><b>Instance Firewalls</b></p> <p>Use security groups to configure firewall rules for instances.</p>	<p><b>Network Control</b></p> <p>Use public and private subnets, NAT, and VPN support in your virtual private cloud to create low-level networking constraints for resource access.</p>

# Security Groups

SSL Endpoints	Security Groups	VPC
<p><b>Secure Transmission</b></p> <p>Use secure endpoints to establish secure communication sessions (HTTPS).</p>	<p><b>Instance Firewalls</b></p> <p>Use security groups to configure firewall rules for instances.</p>	<p><b>Network Control</b></p> <p>Use public and private subnets, NAT, and VPN support in your virtual private cloud to create low-level networking constraints for resource access.</p>

# AWS Multi-Tier Security Groups



# Amazon Virtual Private Cloud (VPC)

SSL Endpoints	Security Groups	VPC
<p><b>Secure Transmission</b></p> <p>Use secure endpoints to establish secure communication sessions (HTTPS).</p>	<p><b>Instance Firewalls</b></p> <p>Use security groups to configure firewall rules for instances.</p>	<p><b>Network Control</b></p> <p>Use public and private subnets, NAT, and VPN support in your virtual private cloud to create low-level networking constraints for resource access.</p>

# AWS Identity and Access Management (IAM)



1

**Manage AWS IAM users  
and their access**

2

**Manage AWS IAM roles  
and their permissions**

3

**Manage federated users  
and their permissions**

## AWS IAM Authentication



- **Authentication**
  - **AWS Management Console**
    - User Name and Password



## IAM User

**Account:** [REDACTED]

**User Name:** [REDACTED]

**Password:** [REDACTED]

MFA users, enter your code on the next screen.



The screenshot shows the AWS Management Console home page. At the top, there's a navigation bar with links for AWS Services, Edit, and Support. Below the navigation bar, the main content area is organized into several sections:

- Amazon Web Services**: A section for managing AWS services.
- Compute**: Includes links for EC2 (Virtual Servers in the Cloud), Lambda (Serverless Functions), and Step Functions (Workflow Events).
- Storage & Content Delivery**: Includes links for S3 (Storage in the Cloud), CloudFront (Content Delivery Network), and Amazon EBS (Fast and Secure SSD EBS).
- Import/Export Snowball**: Large Scale Data Transport.
- Serverless**: Serverless Function Integration.
- Database**: Includes links for RDS (Relational Database Service), DynamoDB (NoSQL Database), Amazon ElastiCache, and Redshift (Fast and Cost-Efficient Data Warehousing).
- Networking**: Includes links for VPC (Virtual Private Cloud), Direct Connect (Private Connection to AWS), and Route 53 (AWS DNS and Domain Name Registration).
- Developer Tools**: Includes links for CodeCommit (Source Code in Private Git Repositories), CodeBuild (Automate Code Deployments), and CodePipeline (Serverless Continuous Delivery).
- Management Tools**: Includes links for CloudWatch Metrics (CloudWatch Metrics and Applications), CloudFormation (Create and Manage Resources with Templates), CloudWatch Metrics (CloudWatch Metrics and Application Metrics), Config (Compliance Inventory and Changes), OpsWorks (Automated Applications with Chef), Service Catalog (Create and Use Standardized Products), Trusted Advisor (Optimize Performance and Security), and Security & Identity.
- Application Services**: Includes links for API Gateway (API Management), AppStream (Low-Latency Application Streaming), CloudWatch Metrics (CloudWatch Metrics and Applications), Elastic Transcoder (Convert Video, Images, and Thumbnails), SES (Email Sending and Receiving Service), SQS (Queue Service), and SWF (Workflow Service for Coordinating Application Components).
- Enterprise Applications**: Includes links for WorkSpaces (Virtual Desktops as a Service), WorkDocs (Collaborative Storage and Sharing Service), and WorkMail (Secure Email and Calendaring Service).
- Internet of Things**: Includes links for AWS IoT (Connect Devices to the Cloud), Device Farm (Test Mobile, Android, and iOS Apps on Real Devices in the Cloud), Mobile Analytics (Collect, Track, and Export App Analytics), and AWS IoT Analytics (Machine Learning Service).
- Resource Groups**: A section for managing resource groups.
- Additional Resources**: Includes links for Getting Started, AWS ConSOLE Mobile App (Available on Amazon Appstore, Google Play, or iTunes), AWS Marketplace, AWS Investor Announcements, and Service Health.
- Footer**: Contains links for AWS Support, AWS News, and AWS Terms of Use.

# AWS IAM Authentication



- **Authentication**
- **AWS CLI or SDK API**
  - Access Key and Secret Key



IAM User



```
Access Key ID: AKIAIOSFODNN7EXAMPLE  
Secret Access Key: wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY
```

## AWS CLI

```
:~ $ aws configure
AWS Access Key ID [*****O22A]:
AWS Secret Access Key [*****4m8i]:
Default region name [ap-southeast-1]:
Default output format [json]:
```

## AWS SDK & API



Java

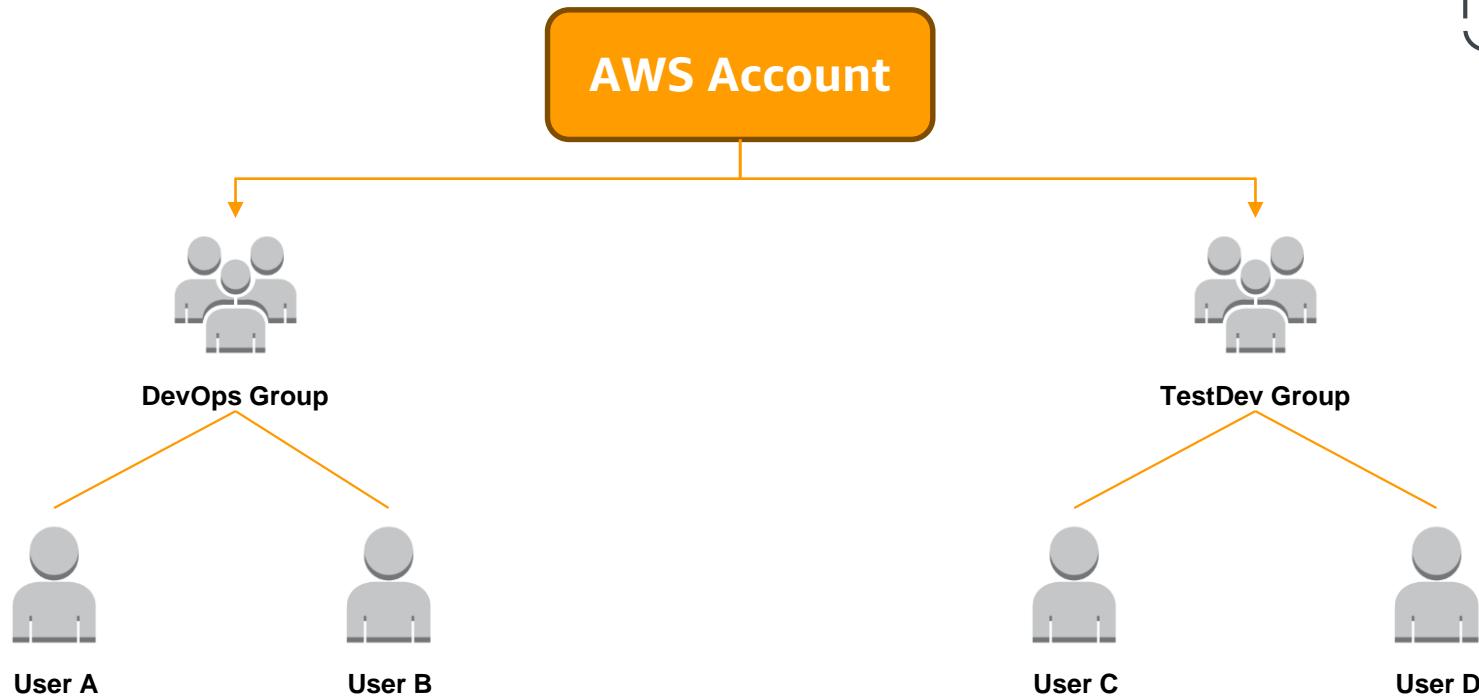


Python



.NET

# AWS IAM User Management - Groups



# AWS IAM Authorization



## Authorization

- Policies:
  - Are JSON documents to describe permissions.
  - Are assigned to users, groups or roles.



IAM User



IAM Group



IAM Roles

# AWS IAM Policy Elements



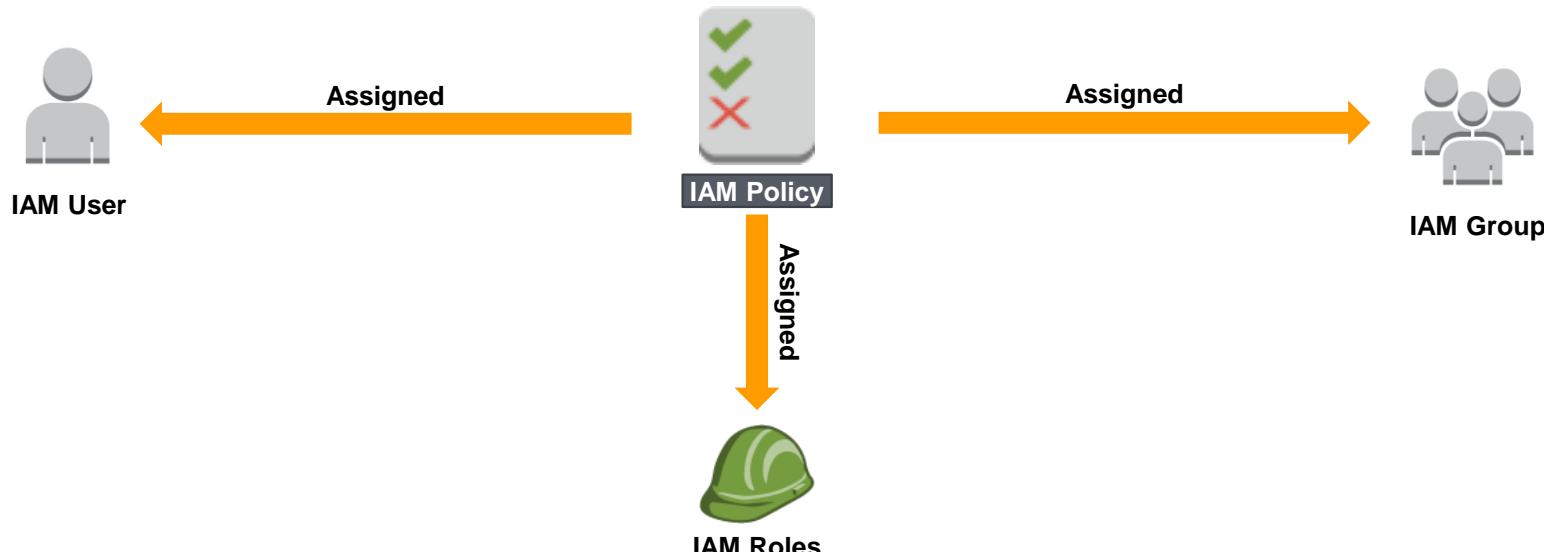
```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Sid": "Stmt1453690971587",  
            "Action": [  
                "ec2:Describe*",  
                "ec2:StartInstances",  
                "ec2:StopInstances"  
            ],  
            "Effect": "Allow",  
            "Resource": "*",  
            "Condition": {  
                "IpAddress": {  
                    "aws:SourceIp": "54.64.34.65/32"  
                }  
            }  
        },  
        {  
            "Sid": "Stmt1453690998327",  
            "Action": [  
                "s3:GetObject*"  
            ],  
            "Effect": "Allow",  
            "Resource": "arn:aws:s3:::example_bucket/*"  
        }  
    ]  
}
```



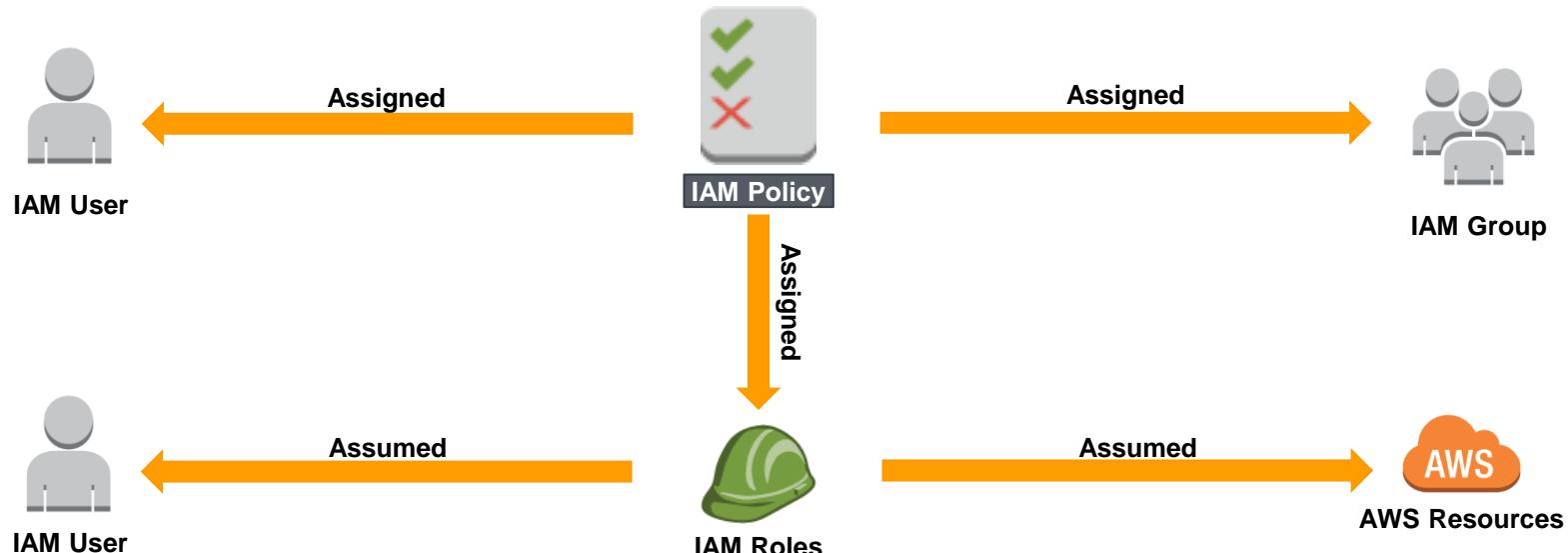
# AWS IAM Policy Assignment



# AWS IAM Policy Assignment



# AWS IAM Policy Assignment



# Example: Application Access to AWS Resources



- Python application hosted on an Amazon EC2 Instance needs to interact with Amazon S3.
- AWS credentials are required:
  - ~~Option 1: Store AWS Credentials on the Amazon EC2 instance.~~
  - Option 2: Securely distribute AWS credentials to AWS Services and Applications.



**IAM Roles**

# AWS IAM Roles - Instance Profiles

Amazon EC2



1  
Create Instance

AWS Services Edit

1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Tag Instance 6. Configure Security Group 7. Review

**Step 3: Configure Instance Details**

Configure the instance to suit your requirements. You can launch multiple instances from the same AMI, request Spot instances to take advantage of the lower pricing, assign an access management role to the instance, and more.

Number of instances: 1 Launch into Auto Scaling Group

Purchasing option: Request Spot instances

Network: vpc-S (172.31.0.0/16) (default) Create new VPC

Subnet: No preference (default subnet in any Availability zone) Create new subnet

Auto-assign Public IP: Use subnet setting (Enable)

Domain join directory: None Create new directory

IAM role: None (dropdown menu open) Create new IAM role

Shutdown behavior: None aws-elasticbeanstalk-ec2-role EMR\_EC2\_DefaultRole PythonInEC2AccessS3

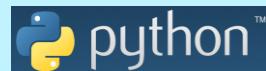
Enable termination protection: None

Monitoring: Enable CloudWatch detailed monitoring Additional charges apply.

Tenancy: Shared - Run a shared hardware instance Additional charges will apply for dedicated tenancy.

Advanced Details

Select IAM Role  
2



App &



3  
**EC2 MetaData Service**

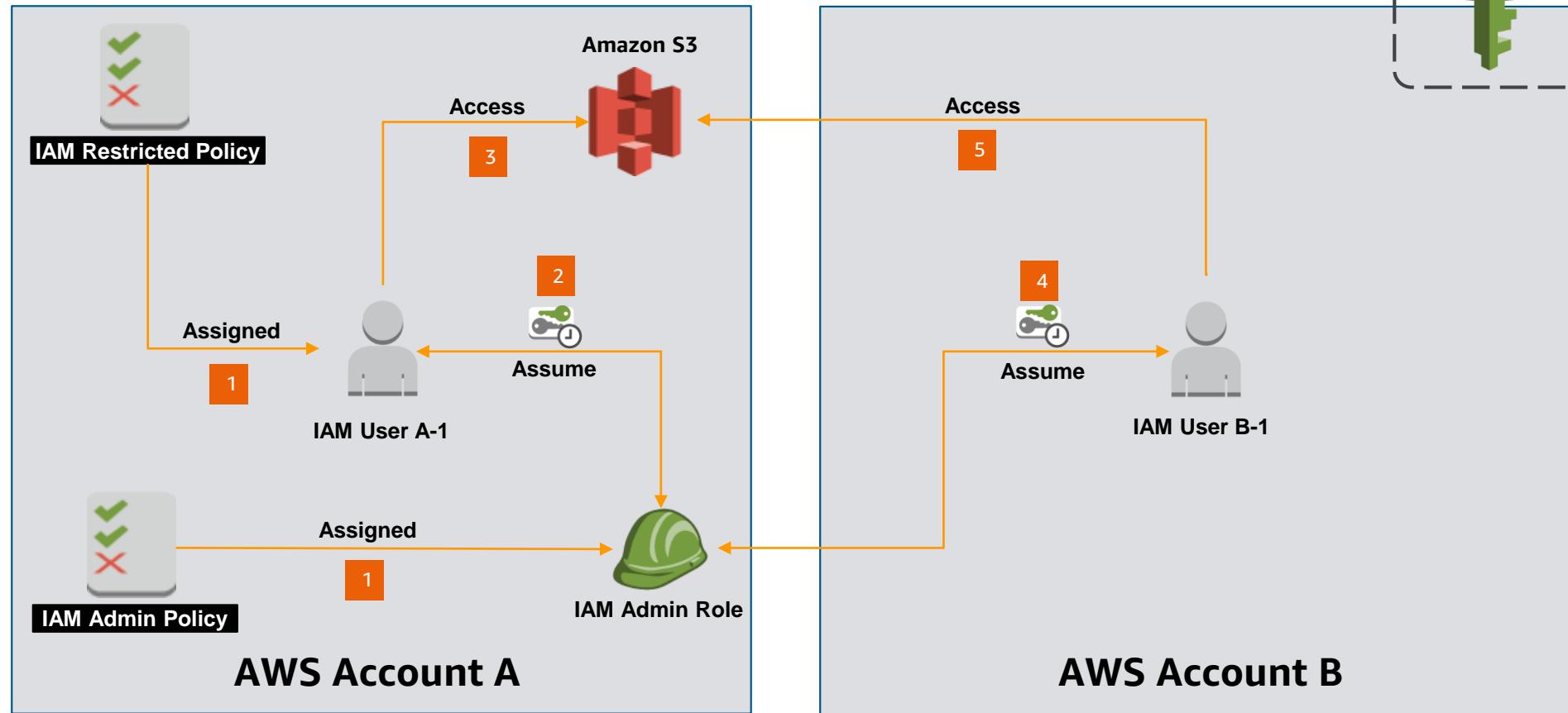
<http://169.254.169.254/latest/meta-data/iam/security-credentials/rolename>

Amazon S3



Application interacts with S3  
4

# AWS IAM Roles – Assume Role



# Application Authentication



# Module 4

# Database

**AWSOME DAY**

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# SQL and NoSQL Databases

	SQL	NoSQL
Data Storage	Rows and Columns	Key-Value
Schemas	Fixed	Dynamic
Querying	Using SQL	Focused on collection of documents
Scalability	Vertical	Horizontal

## SQL

ISBN	Title	Author	Format
9182932465265	Cloud Computing Concepts	Wilson, Joe	Paperback
3142536475869	The Database Guru	Gomez, Maria	eBook

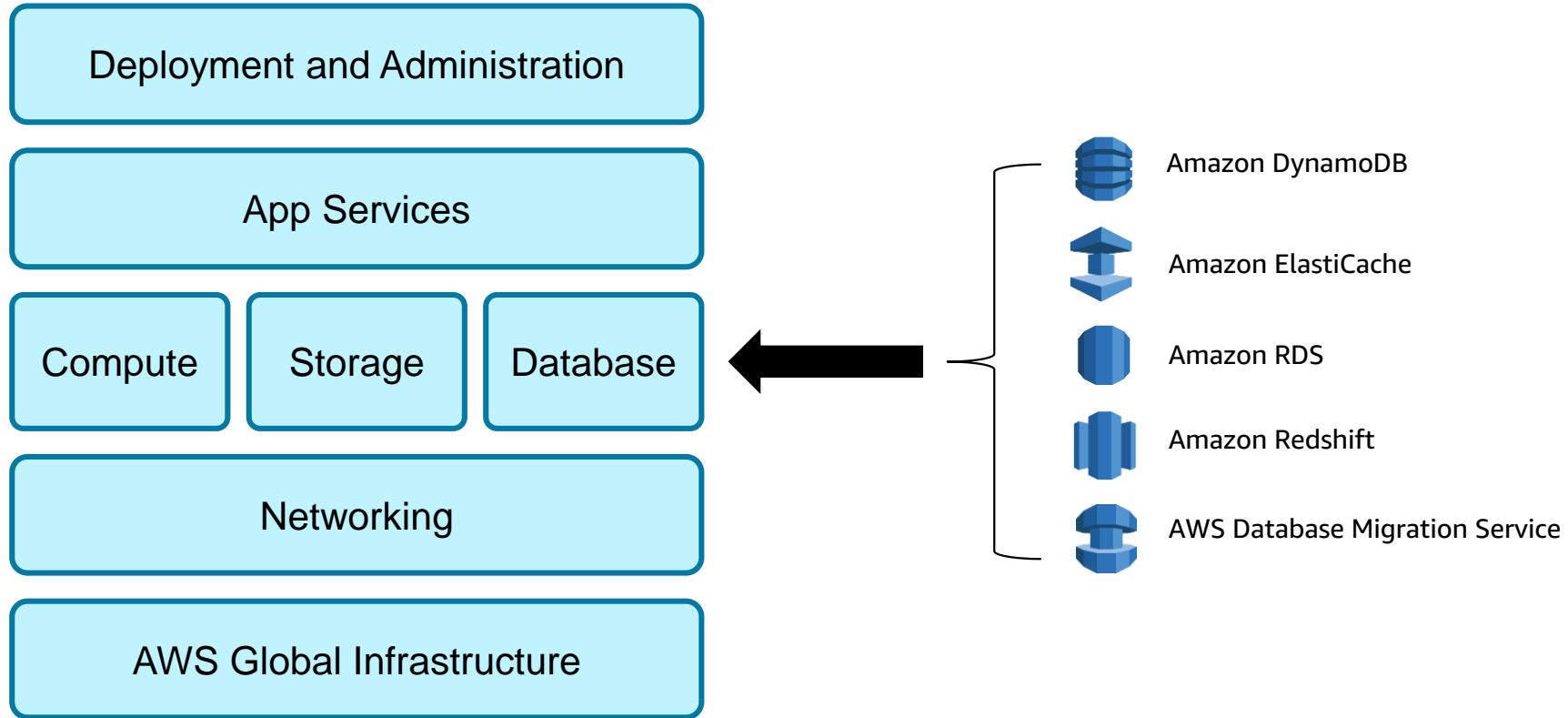
## NoSQL

```
{  
  ISBN: 9182932465265,  
  Title: "Cloud Computing Concepts",  
  Author: "Wilson, Joe",  
  Format: "Paperback"  
}
```

# Data Storage Considerations

- No one size fits all.
- Analyze your data requirements by considering:
  - Data formats
  - Data size
  - Query frequency
  - Data access speed
  - Data retention period

# AWS Managed Database Services



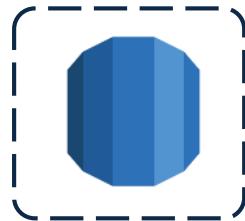
# Amazon Relational Database Service (RDS)



Amazon  
RDS

- Cost-efficient and **resizable capacity**
- Manages time-consuming **database administration** tasks
- Access to the full capabilities of **Amazon Aurora, MySQL, MariaDB, Microsoft SQL Server, Oracle, and PostgreSQL** databases

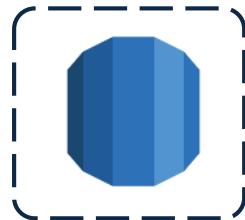
# Amazon RDS



- Simple and **fast to deploy**
- **Manages** common database administrative tasks
- **Compatible** with your applications
- Fast, predictable performance
- Simple and **fast to scale**
- Secure
- Cost-effective



# How Amazon RDS Backups Work



## Automatic Backups:

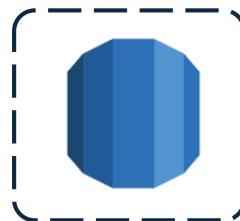
- Restore your database to a point in time.
- Are enabled by default.
- Let you choose a retention period up to 35 days.

## Manual Snapshots:

- Let you build a new database instance from a snapshot.
- Are initiated by the user.
- Persist until the user deletes them.
- Are stored in Amazon S3.



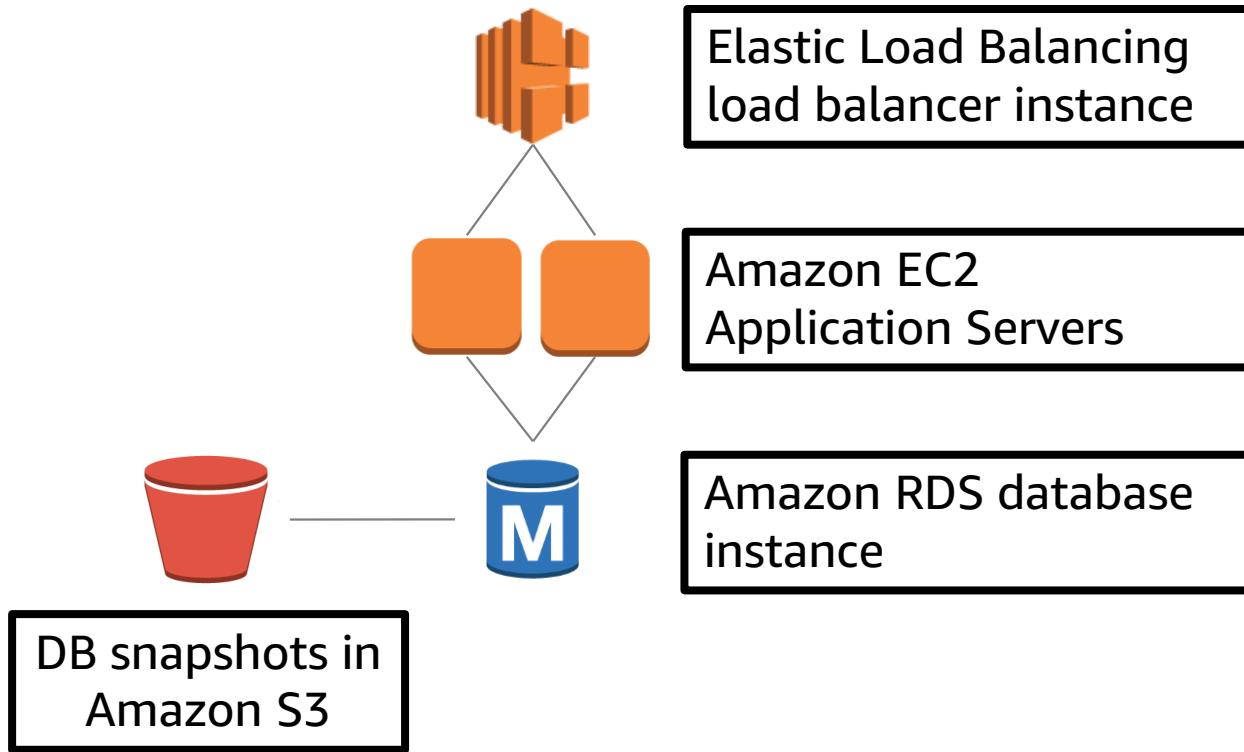
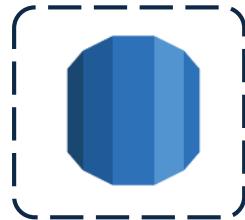
# Cross-Region Snapshots



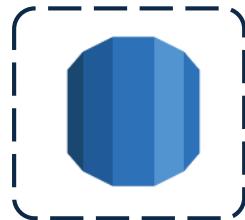
- Are a **copy** of a **database snapshot** stored in a **different AWS Region**.
- Provide a backup for disaster **recovery**.
- Can be used as a **base** for **migration** to a different region.



# A Simple Application Architecture

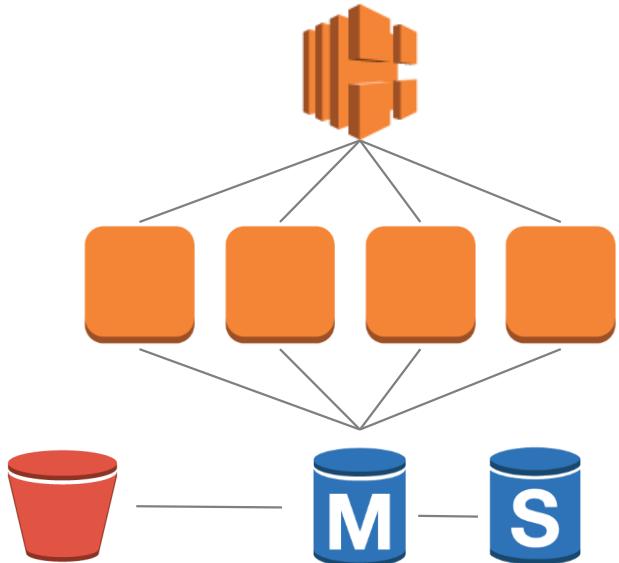
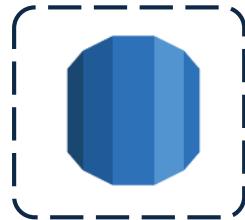


# Multi-AZ RDS Deployment



- With **Multi-AZ** operation, your database is **synchronously replicated to another Availability Zone** in the same AWS Region.
- **Failover** to the standby **automatically** occurs in case of master database failure.
- Planned maintenance is applied first to standby databases.

# A Resilient, Durable Application Architecture



Elastic Load Balancing  
load balancer instance

Application, in Amazon  
EC2 instances

Amazon RDS database instances:  
Master and Multi-AZ standby

DB snapshots in  
Amazon S3

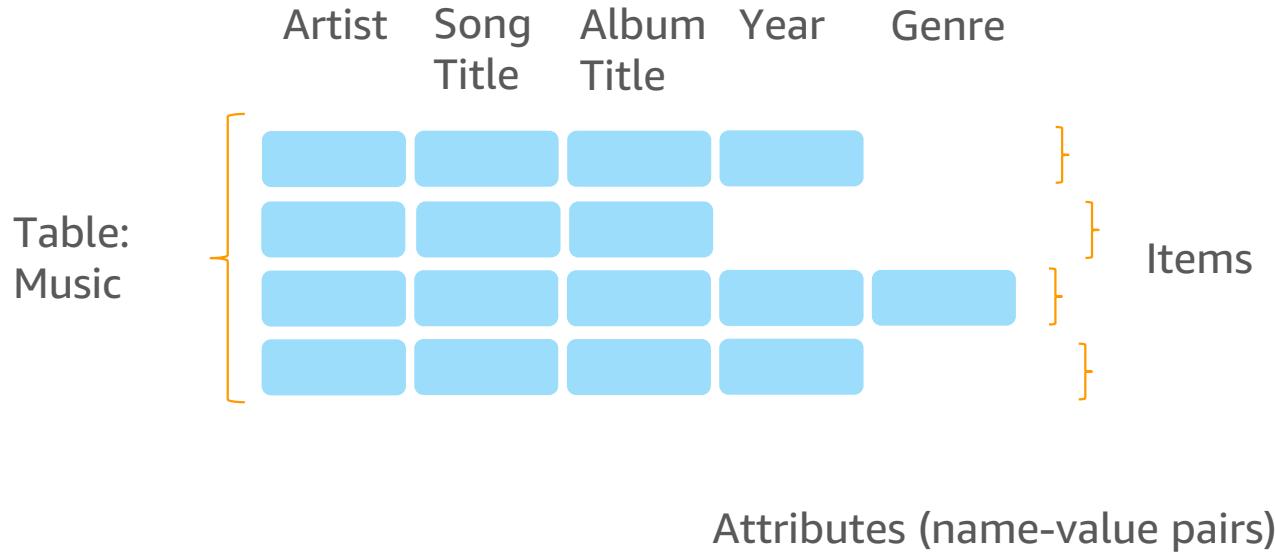
# Amazon DynamoDB



Amazon  
DynamoDB

- Allows you to store any amount of data with **no limits**.
- Provides fast, predictable performance using **SSDs**.
- Allows you to easily provision and change the **request capacity** needed for each table.
- Is a **fully managed, NoSQL** database service.

# DynamoDB Data Model



# Primary Keys

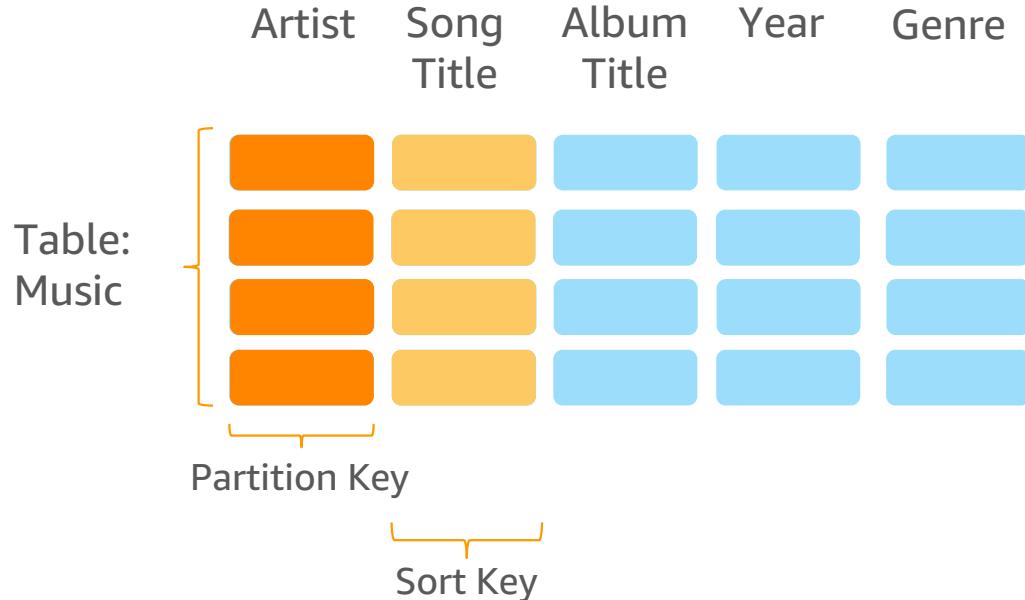
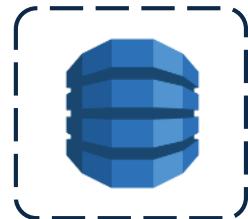


Table *Music*  
Partition Key *Artist*  
Sort Key *Song Title*

(DynamoDB maintains a sorted index for both keys)

# Provisioned Throughput



- You specify how much **provisioned throughput capacity** you need for reads and writes.
- Amazon DynamoDB allocates the necessary machine resources to meet your needs.

# Supported Operations



- **Query:**
  - Query a table using the partition key and an optional sort key filter.
  - If the table has a secondary index, query using its key.
  - It is the **most efficient way to retrieve items** from a table or secondary index.
- **Scan:**
  - You can scan a table or secondary index.
  - Scan reads every item – **slower than querying**.
- You can use conditional expressions in both Query and Scan operations.

# Database Considerations

If You Need	Consider Using
A relational database service with minimal administration	<b>Amazon RDS</b> <ul style="list-style-type: none"><li>• Choice of Amazon Aurora, MySQL, MariaDB, Microsoft SQL Server, Oracle, or PostgreSQL database engines</li><li>• Scale compute and storage</li><li>• Multi-AZ availability</li></ul>
A fast, highly scalable NoSQL database service	<b>Amazon DynamoDB</b> <ul style="list-style-type: none"><li>• Extremely fast performance</li><li>• Seamless scalability and reliability</li><li>• Low cost</li></ul>
A database you can manage on your own	Your choice of <b>AMIs</b> on Amazon EC2 and Amazon EBS that provide scale compute and storage, complete control over instances, and more.



# Amazon Aurora

Fastest-growing AWS service, ever

MySQL and PostgreSQL compatible

---

5X faster than standard MySQL and 3X PostgreSQL

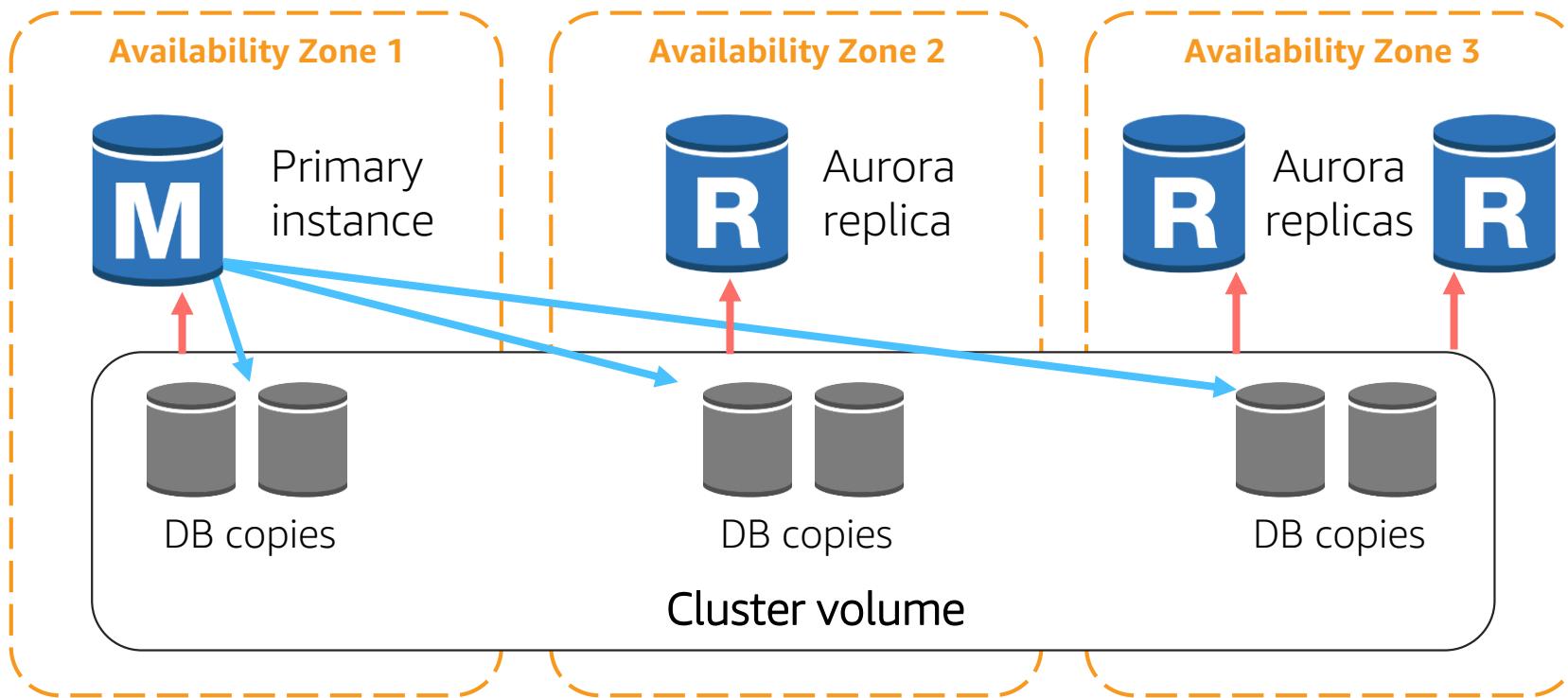
---

Highly available and durable

---

1/10<sup>th</sup> the cost of commercial grade databases

## Each Aurora DB cluster can have up to 15 Aurora replicas



# Aurora Serverless

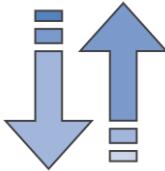


Responds to your application automatically

- Scales capacity
  - Shut down
  - Start up



Pay for number of ACUs used



Good for spiky, unpredictable workloads

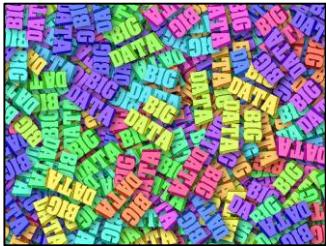
# Big Data

**AWSOME DAY**

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# Overview: Big data



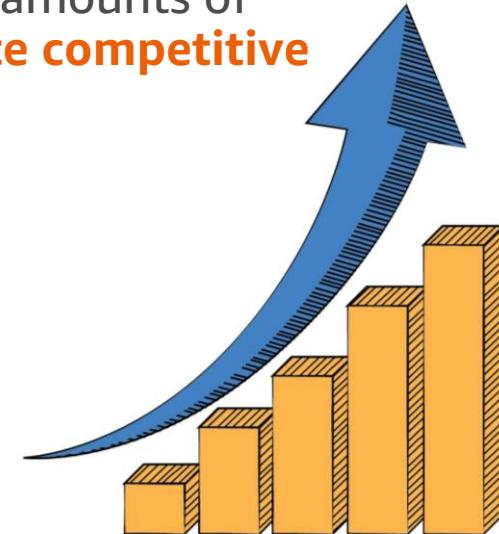
## What is big data?

- The collection and analysis of large amounts of data to **answer questions** and **create competitive advantages**.

**Volume** - Data volume from TB to PB

**Variety** - Multiple source and format (Web log, Social media, E-commerce, Financial service)

**Velocity** - The time from data collection to provide insight



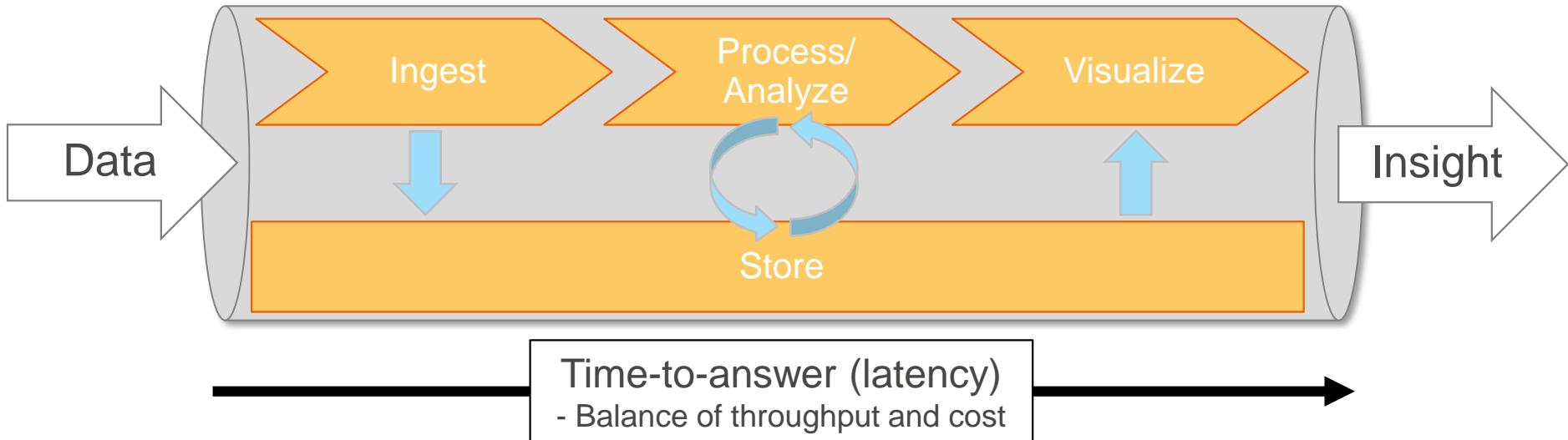
# Big data analytic

The screenshot shows a Yelp business profile for "Sous Beurre Kitchen". The top navigation bar includes the Yelp logo, search bar ("Near San Francisco, CA"), and user options ("Sign Up" and "Log In"). The main content area features the restaurant's name, "Sous Beurre Kitchen", with a "Write a Review" button and photo upload options ("Add Photo", "Share", "Bookmark"). Below this, the restaurant's rating is shown as "98 reviews" with a "Details" link. The category is listed as "\$\$\$ - French". A map shows the location at 2704 24th St, San Francisco, CA 94110, near Potrero Ave & Hampshire St. A large image of a dish, "Bavette Steak Au Poivre w/ sarladaise...", is displayed with a caption from Cherylyn N. A "See all 129 photos" link is also present. On the left, there's a sidebar with the address, phone number (415) 874-9831, and a "Get Directions" button. Below the address, there are two review snippets: one for "Wild Mushroom En Croute" and another for a meal including oysters, apple/brussel sprout salad, cornish game hen, and bavette steak. A "Make a Reservation" form is located at the bottom right.



Generate 1.2TB log file everyday  
Run 250 EMR job, dealing with 30+TB data everyday

# The Big Data "Pipeline"



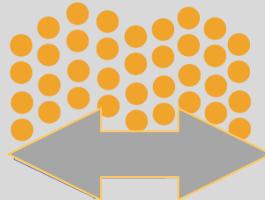
# Types of Data Ingest

Transactional:

Database reads/writes

App server

Web server



Database



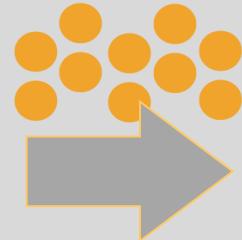
File

Devices

Mobile apps      Browsers  
Game consoles      DVRs  
Sensor/Geo data      IoT

Flume

Log4j



Cloud Storage



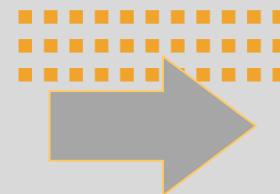
Amazon S3

Stream

Fluentd

Sqoop

Storm



Stream Storage



Amazon  
Kinesis

# Amazon Elastic MapReduce (EMR)



Amazon  
EMR

Fully managed **Hadoop** platform  
**Highly scaled** Cluster  
Simple, low cost to process mega data

# Amazon Kinesis



Amazon  
Kinesis

Collect and process hundreds of terabytes of data per hour

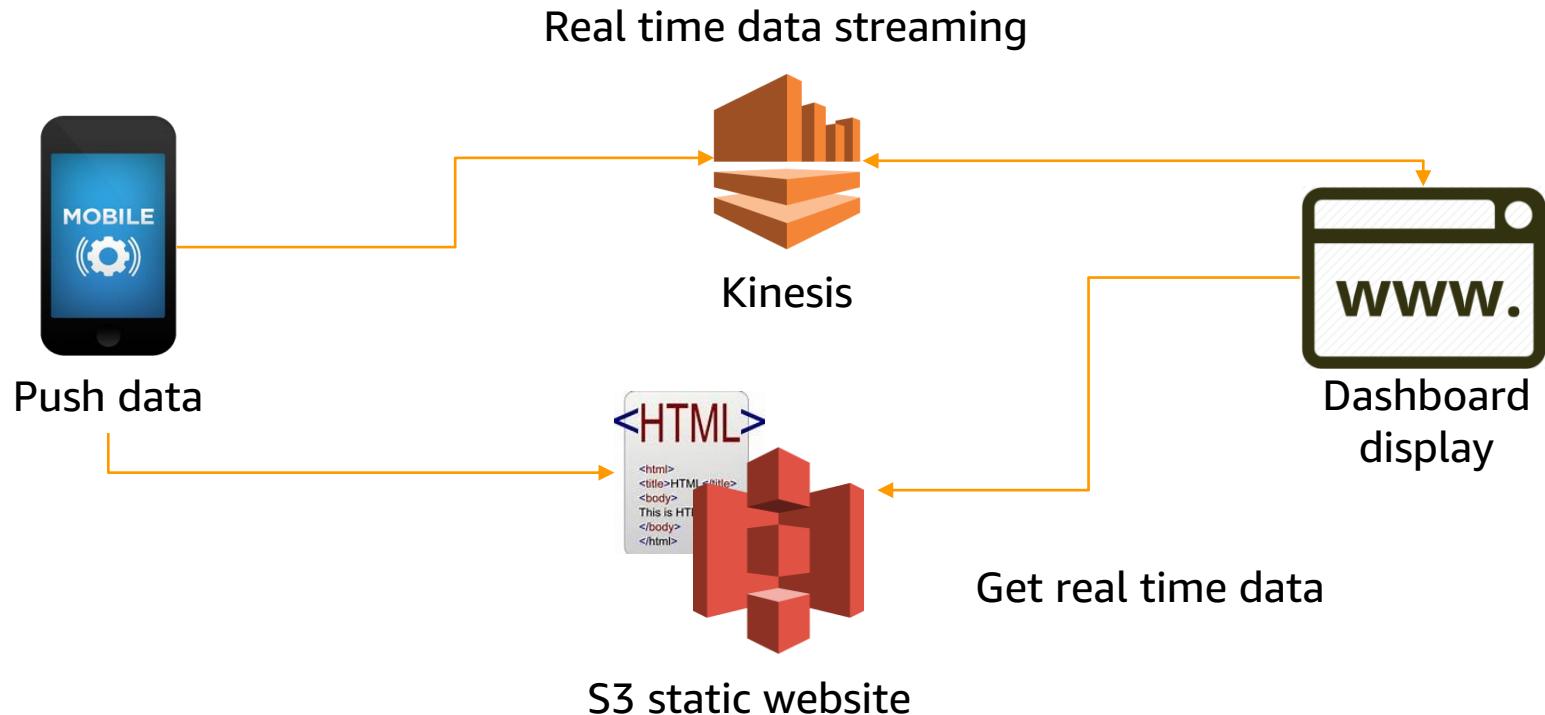
Tens of thousands of data source

Build **real-time** dashboards

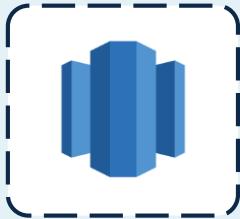
Send data to multiple AWS service

Automatically adjust shard

# Serverless Architecture



# Amazon Redshift



Amazon  
Redshift

Fully managed data warehouse for petabytes of data  
Simplified cluster management  
Significant performance enhancement:

- MPP architecture
- 10G bandwidth
- Columnar based storage
- Local optimized storage

# Machine Learning

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# AWS deep experience differentiates services

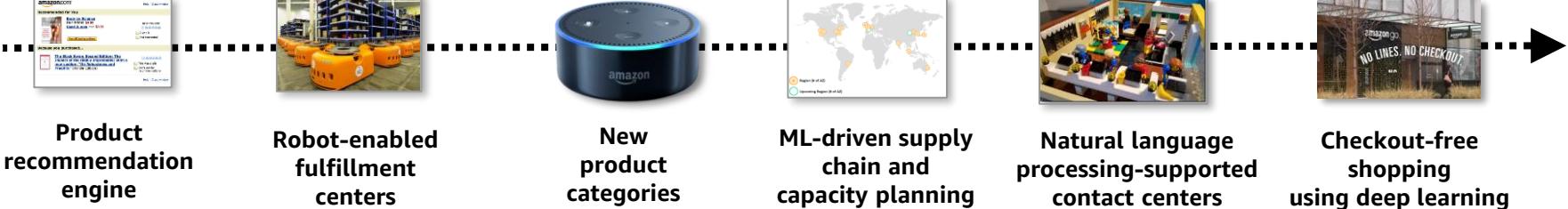


1995

Amazon has invested in AI/ML since our inception, and we share our knowledge and capabilities with our customers



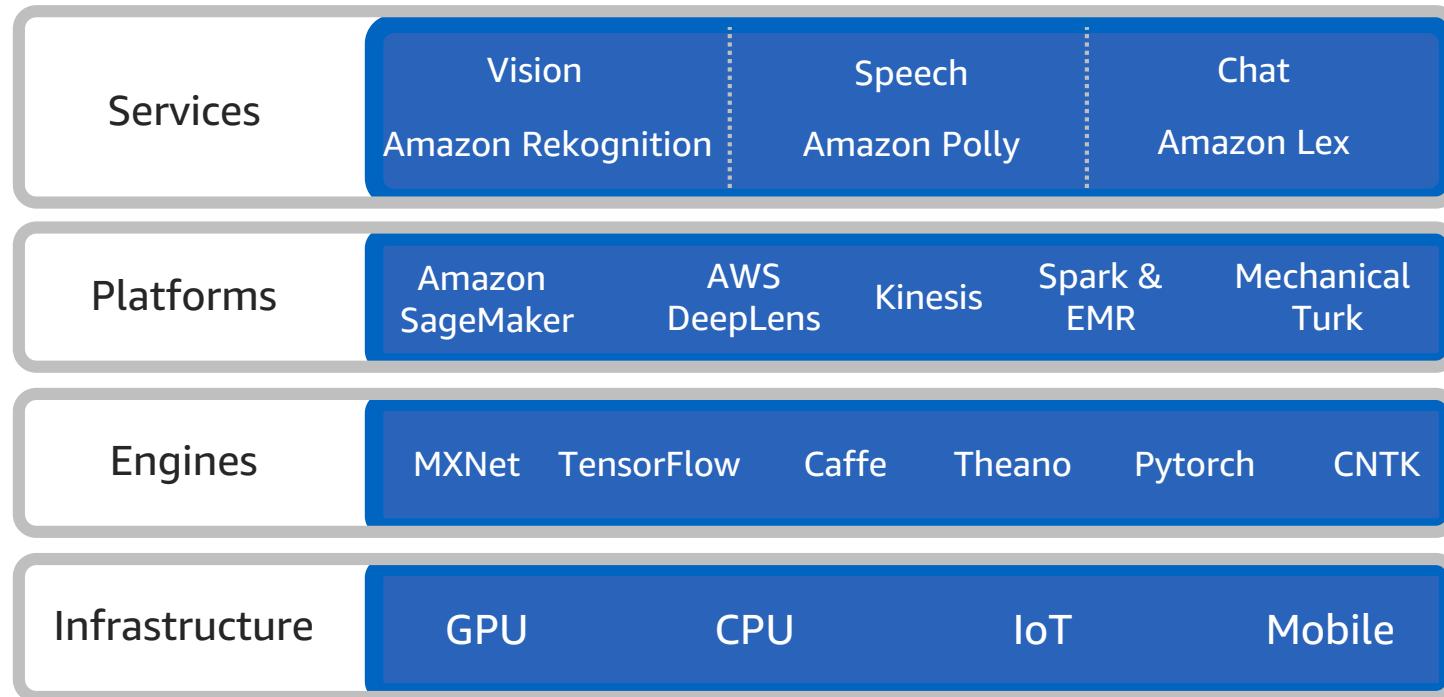
2017



# Our Mission

*Build a Machine Learning platform for every developer and data scientist*

# Machine Learning In The Hands Of Every Developer



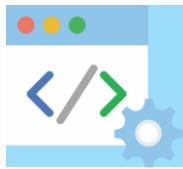


# Amazon SageMaker

A fully **managed service** that provides  
**the quickest and easiest way** for your data scientists and  
developers to get **ML models** from idea **to production**

# SageMaker Component

1



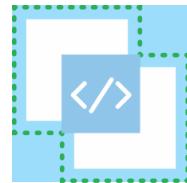
Notebook Instances

2



1P Algorithms

3



ML Training Service

4



ML Hosting Service

# SageMaker – How it works?

## Deploy

Fully-managed hosting at scale

Deployment without engineering effort

Managed notebook instances

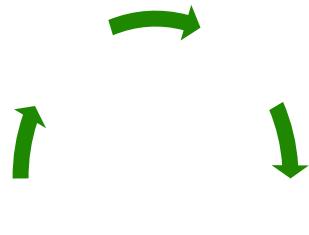
## Build

Highly-optimized ML algorithms

One-click training

## Train

Automatic, built-in model tuning

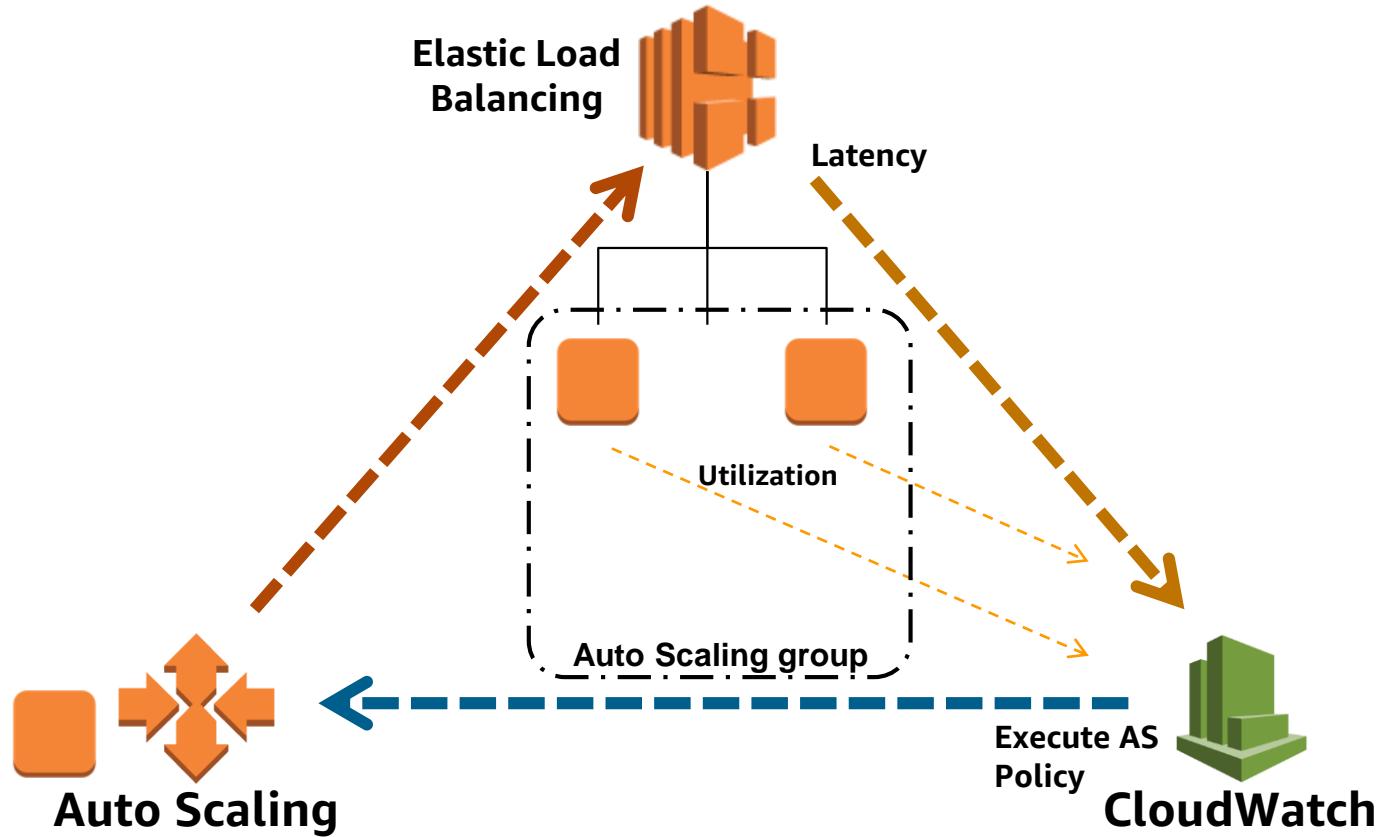


- Zero setup with Managed Notebooks
- Built-in, High Performance Algorithms
- One-click Training
- Automatic Model Tuning (Limited Preview)
- Reduced model training time
- One-Click Deployment
- Pay by the second

# Module 5

# AWS Elasticity and Management Tools

# Triad of Services



# Elastic Load Balancing



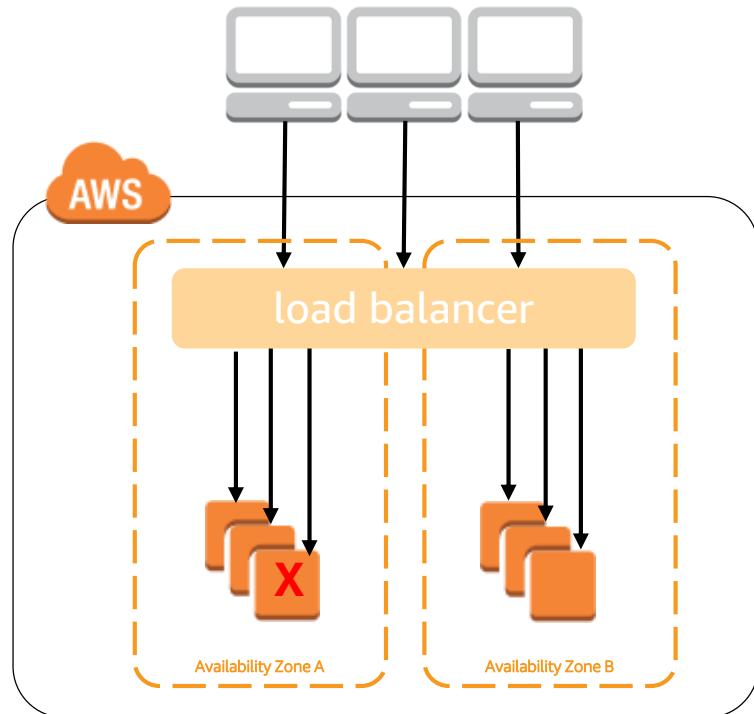
Elastic Load  
Balancing

- **Distributes** traffic across multiple EC2 instances, in multiple Availability Zones
- Supports **health checks** to detect unhealthy Amazon EC2 instances
- Supports the **routing and load balancing** of HTTP, HTTPS, SSL, and TCP traffic to Amazon EC2 instances

# Classic Load Balancer - How It Works



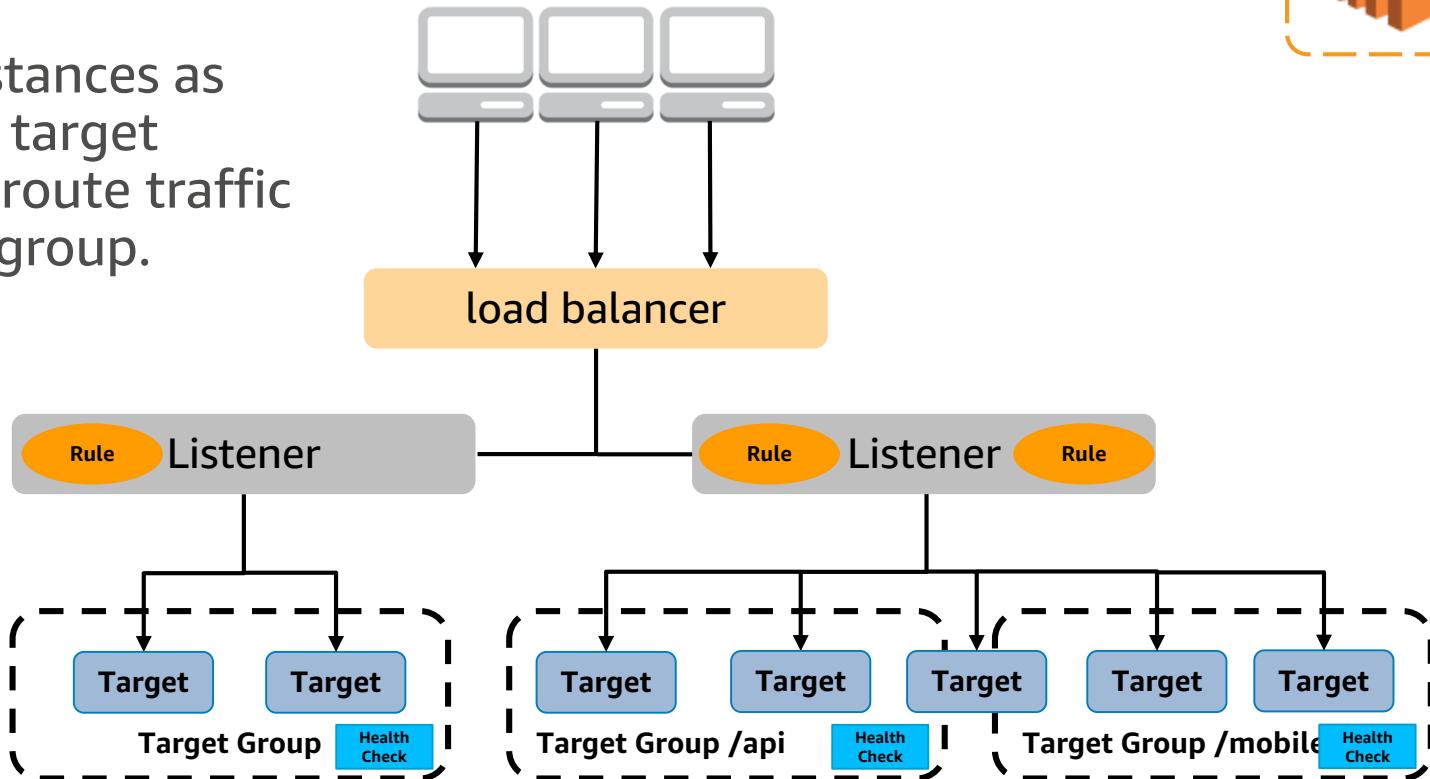
Register instances with your load balancer.



# Application Load Balancer – How It Works



Register instances as targets in a target group, and route traffic to a target group.



# Load Balancer Comparison



**Classic Load Balancer**  
benefits include support for:

- EC2-Classic.
- VPC.
- TCP and SSL listeners.
- Sticky sessions.

**ALB benefits include support for:**

- Path-based routing.
- Routing requests to multiple services on a single EC2 instance.
- Containerized applications.
- Monitoring the health of each service independently.

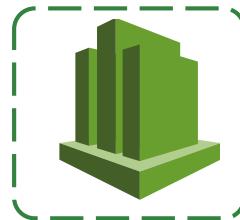
# Amazon CloudWatch



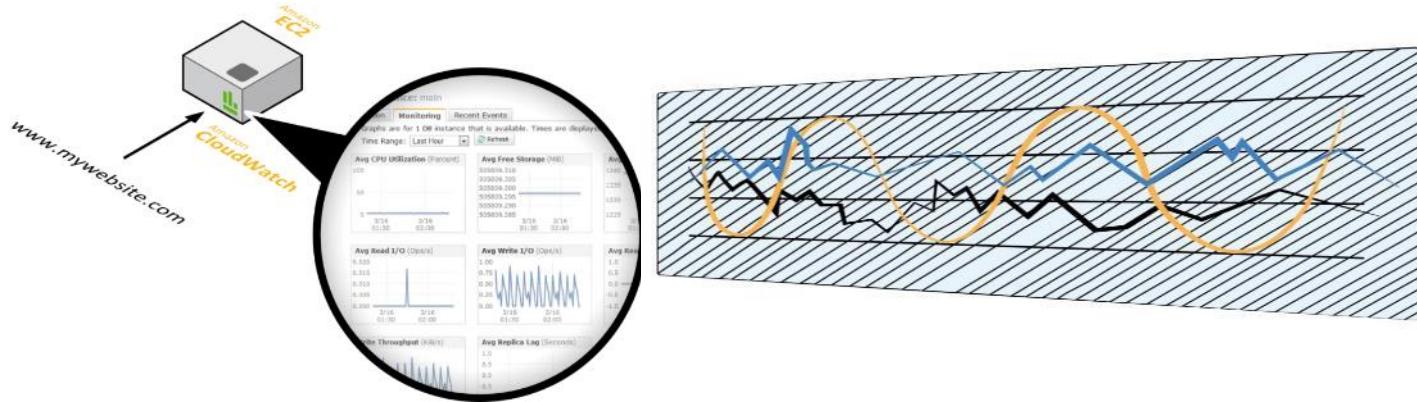
Amazon  
CloudWatch

- **A monitoring service** for AWS cloud resources and the applications you run on AWS
- **Visibility into** resource utilization, operational performance, and overall demand patterns
- **Custom application-specific** metrics of your own
- **Accessible** via AWS Management Console, APIs, SDK, or CLI

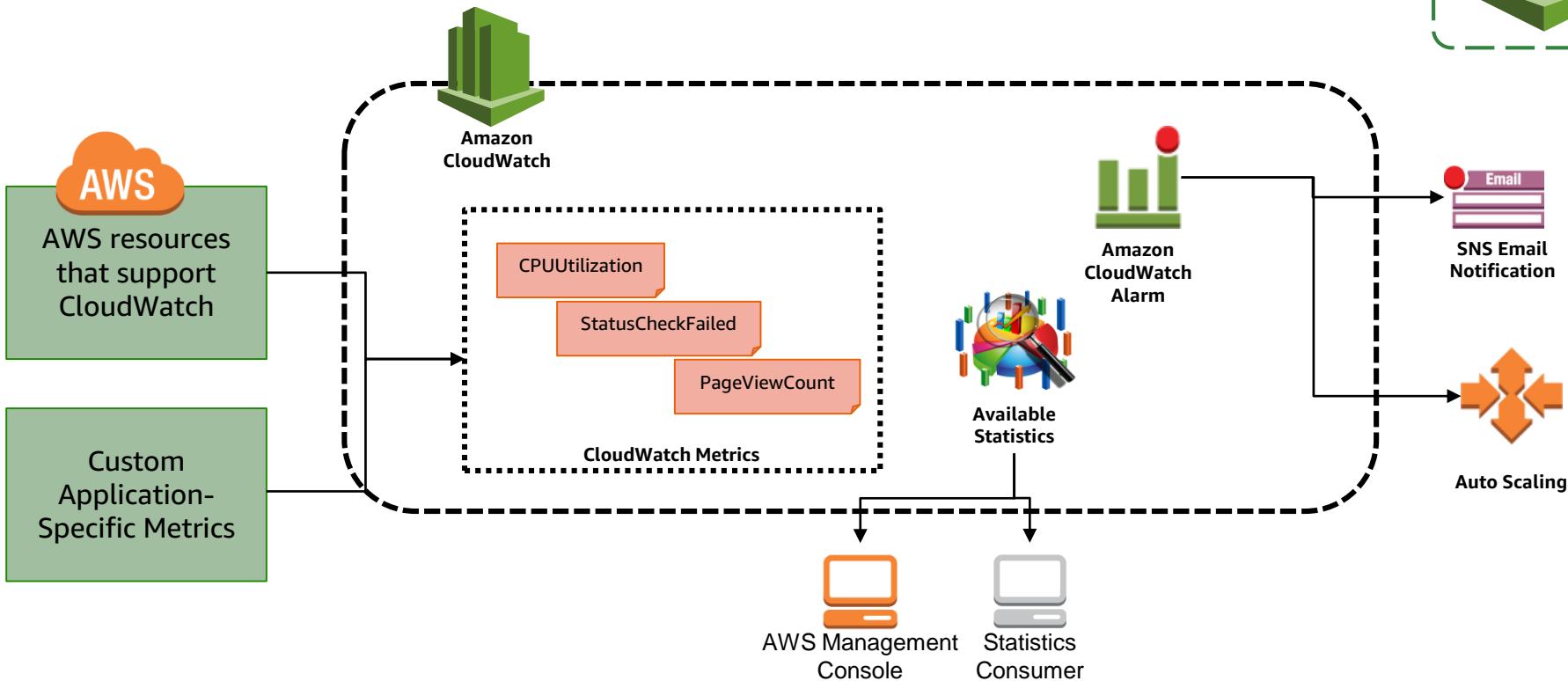
# Amazon CloudWatch Facts



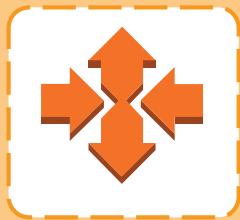
- Monitor other AWS resources
  - View graphics and statistics
- Set Alarms



# Amazon CloudWatch Architecture



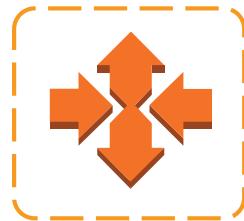
# Auto Scaling



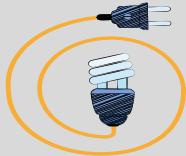
Auto  
Scaling

- **Scale your Amazon EC2 capacity automatically**
- Well-suited for applications that experience **variability in usage**
- Available at no additional charge

# Auto Scaling Benefits



## Better Fault Tolerance



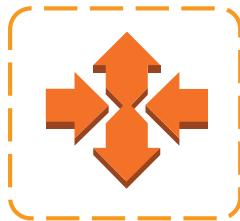
## Better Availability



## Better Cost Management



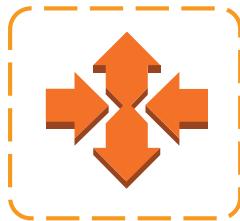
# Launch Configurations



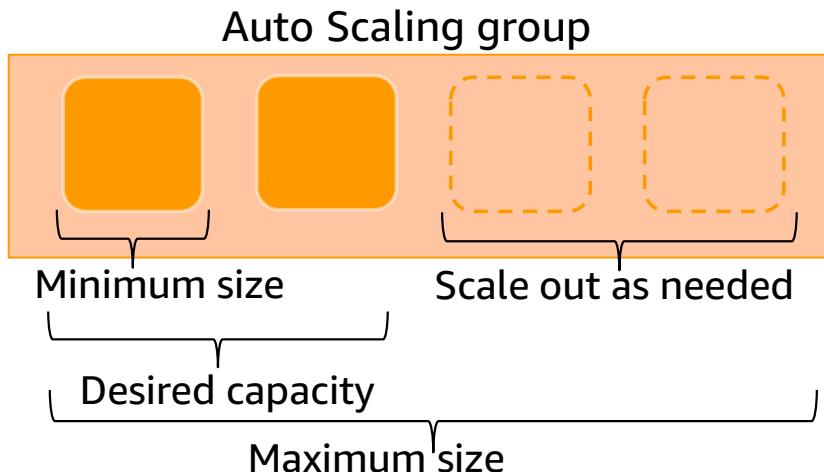
- A **launch configuration** is a template that an Auto Scaling group uses to launch EC2 instances.
- When you create a launch configuration, you can specify:
  - AMI ID
  - Instance type
  - Key pair
  - Security groups
  - Block device mapping
  - User data



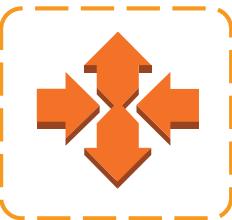
# Auto Scaling Groups



- Contain a collection of EC2 instances that share similar characteristics.
- Instances in an Auto Scaling group are treated as a **logical grouping** for the purpose of instance scaling and management.

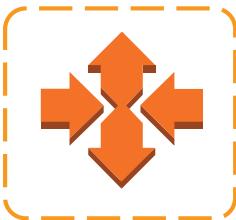
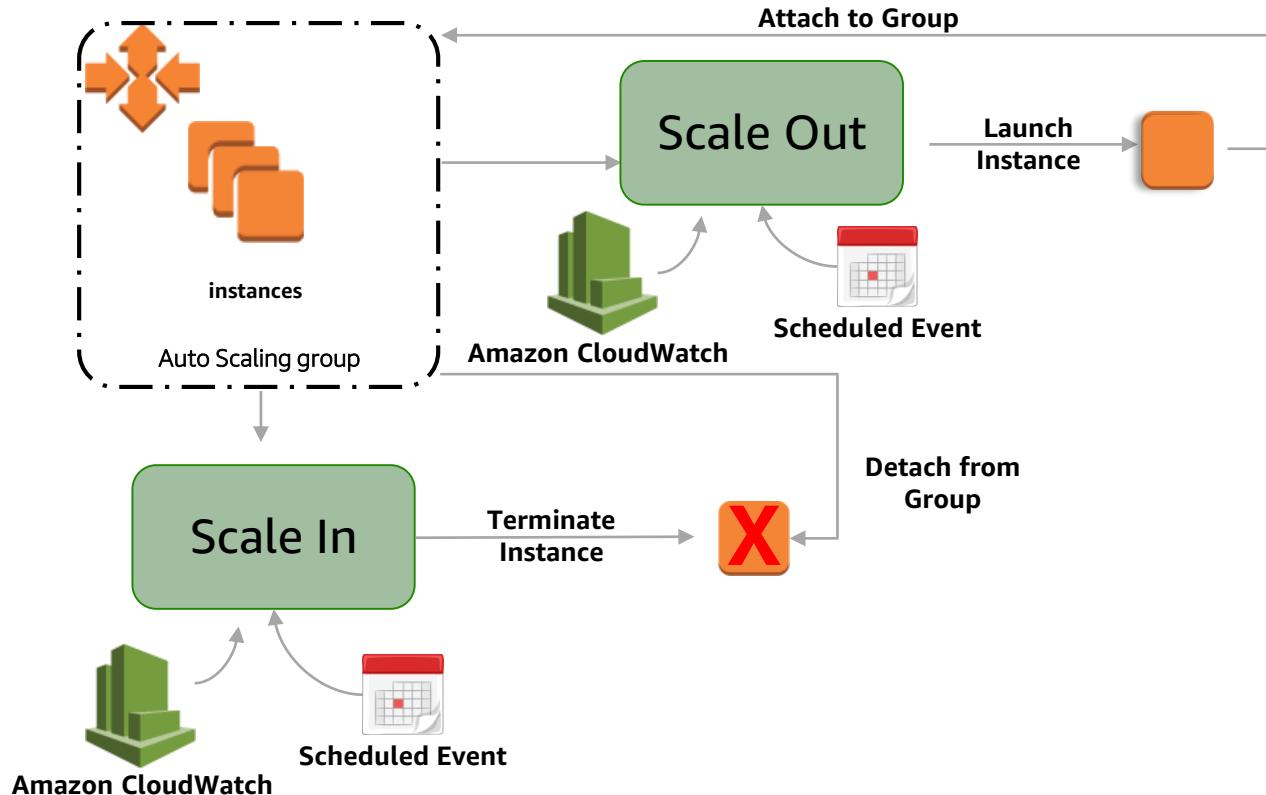


# Dynamic Scaling



- You can create a scaling policy that uses **CloudWatch alarms** to determine:
  - When your Auto Scaling group should **scale out**.
  - When your Auto Scaling group should **scale in**.
- You can use alarms to monitor:
  - Any of the metrics that AWS services send to Amazon CloudWatch.
  - Your own **custom metrics**.

# Auto Scaling Basic Lifecycle



# AWS Trusted Advisor



AWS Trusted  
Advisor

- **Best practice** and recommendation engine.
- Provides AWS customers with performance and security recommendations in four categories:
  - **Cost optimization**
  - **Security**
  - **Fault tolerance**
  - **Performance improvement.**

# Cost Optimization

- Amazon EC2 Reserved Instance Optimization
- Low-utilization Amazon EC2 Instances
- Idle load balancers
- Underutilized Amazon EBS volumes
- Unassociated Elastic IP addresses
- Amazon RDS idle DB instances



Cost Optimization



2 ✓ 4 !

0 ⓘ

0 excluded items



# Security

- Security groups
- AWS IAM use
- Amazon S3 bucket permissions
- MFA on root Account
- AWS IAM password policy
- Amazon RDS security group access risk



Security



4 ✓ 2 ▲

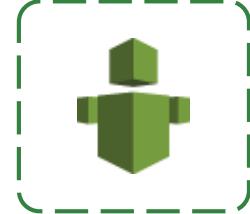
3 !

1 excluded items



# Fault Tolerance

- Amazon EBS Snapshots
- Load balancer optimization
- Auto Scaling Group Resources
- Amazon RDS Multi-AZ
- Amazon Route 53 name server delegations
- ELB connection draining



Fault Tolerance



9 ✓ 2 ▲

2 !

1 excluded items



# Performance Improvement

- High-utilization Amazon EC2 instances
- Service limits
- Large number of rules in EC2 security group
- Over-utilized Amazon EBS magnetic volumes
- Amazon EC2 to EBS throughput optimization
- Amazon CloudFront alternate domain names



Performance



8 0

0

0 excluded items



# Module 6

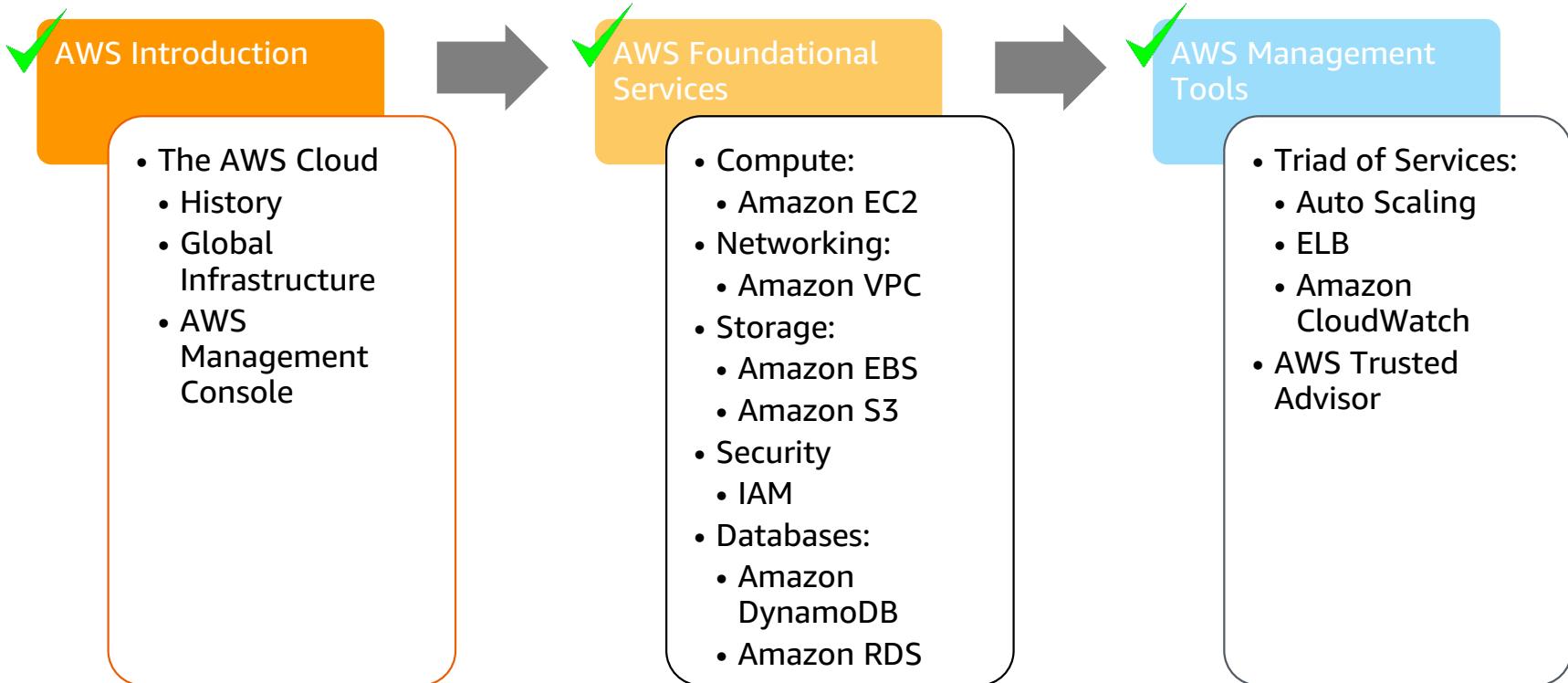
# Course Wrap-Up

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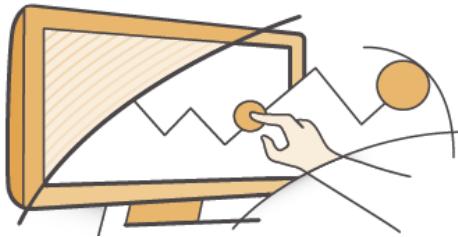


# Learning Path



# Expand Your Cloud Skills with AWS

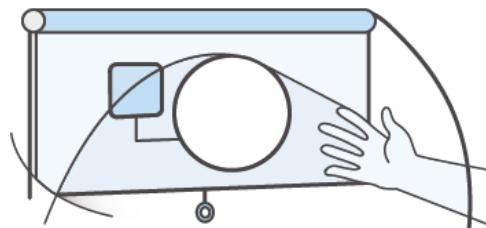
## Online videos and labs



Start working with an AWS service in minutes with free online instructional videos and labs

[aws.amazon.com/training/  
self-paced-labs](https://aws.amazon.com/training/self-paced-labs)

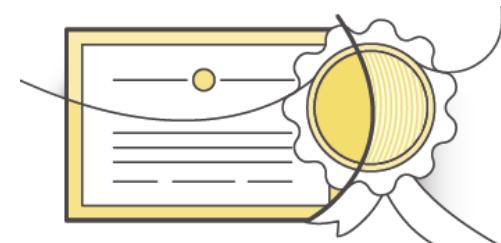
## Instructor-led courses



Learn how to design, deploy, and operate highly available, cost-effective, and secure applications on AWS

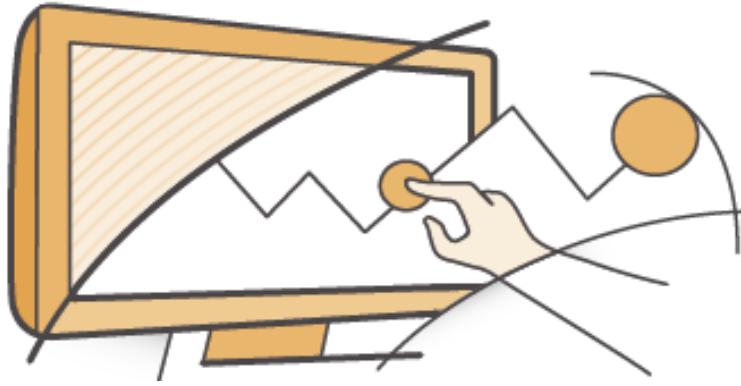
[aws.amazon.com/training](https://aws.amazon.com/training)

## Certification



Validate your proven technical expertise with the AWS platform and gain recognition for your skills

[aws.amazon.com/certification](https://aws.amazon.com/certification/)



# AWS Digital Learning Center

aws training and certification

Find Training    Certification    Support

English ▾    Sign In

Keyword

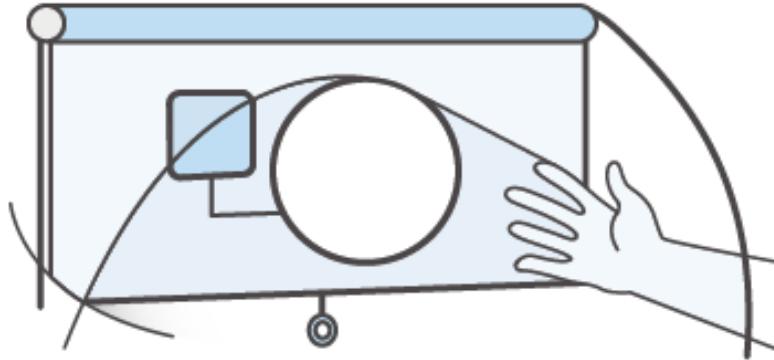
Select the type of training you would like to browse.

**Browse by Role**

-  Cloud Practitioner  
Cloud fundamentals and best practices
-  Architect  
Learn to design highly available systems
-  Developer  
Develop applications for the cloud
-  Operations  
Automate applications, networks and systems

**Browse by Content Domain**

-  See All
-  Introductory
-  Analytics
-  Applications
-  Artificial Intelligence (AI)
-  Business Planning
-  Compute
-  Contact Center
-  Database
-  Developer Tools
-  Internet of Things (IoT)
-  Management Tools
-  Migration
-  Networking & Content Delivery
-  Security, Identity & Compliance
-  Storage



## Instructor-led course

# ILT –Role Based Course

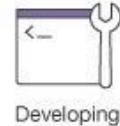
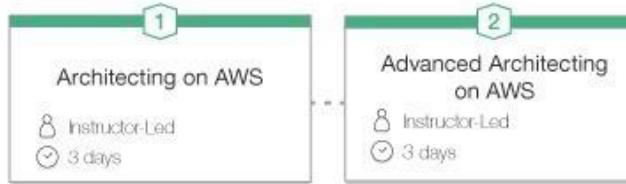
## Foundational



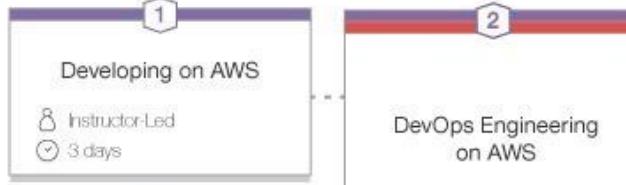
## Role-Based



Architecting



Developing



Operations



# ILT –Skill Based Course

## Specialty



Security

1

AWS Security Fundamentals

Online  
3 hours

2

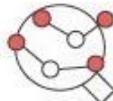
Security Operations on AWS

Instructor-Led  
3 days

3

Data Warehousing on AWS

Instructor-Led  
3 days



Big Data

1

Big Data Technology Fundamentals

Online  
90 minutes

2

Big Data on AWS

Instructor-Led  
3 days

4

Building a Serverless Data Lake

Instructor-Led  
1 day



Artificial Intelligence

1

Introduction to Machine Learning

Online  
40 minutes

2

Deep Learning on AWS

Instructor-Led  
1 day

5

Running Container-Enabled Microservices on AWS

Instructor-Led  
1 day



Migration

6

Secrets to Successful Cloud Transformations

Instructor-Led  
1 day

7

Migrating to AWS

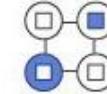
Instructor-Led  
2 days



Data Warehousing



Data Lakes



ECS Microservices



# AWS Certificate



Professional



Associate



Foundational



Cloud Practitioner



Architect

## Role-Based Certifications



Developer



Operations

## Specialty Certifications



Specialty Certification requires  
Cloud Practitioner or  
Associate-level certification

For more information, see [aws.amazon.com/certification.](https://aws.amazon.com/certification/)

# Thank you!

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