

# The BigTable

# Motivation

**Highly available distributed storage for structured data**

Ex:

- URLs: content, metadata, links, anchors, page rank
- User data: preferences, account info, recent queries
- Geography: roads, satellite images, points of interest, annotations

**Large scale**

- Petabytes of data across thousands of servers
- Billions of URLs with many versions per page
- Hundreds of millions of users
- Thousands of queries per second
- 100TB+ satellite image data

# What is Bigtable?

- Distributed storage system
- Designed for structured data
- Designed to scale to thousands of servers
- Designed to store up to several hundred terabytes
- To scale, Bigtable has a limited set of features

# Different Types of Data

- Structured data
  - All data conforms to a schema
    - Ex: business data
- Semistructured data
  - Some structure in the data but implicit and irregular
  - Ex: resume, ads
- Unstructured data
  - No structure in data
  - Ex: text, sound, video, images

# What is Bigtable?

- Bigtable *cluster* – set of processes that runs Bigtable software
  - Each process serves a set of tables
  - Tables:
    - Sparse, Distributed, Persistent, Multi-dimensional Sorted map – indexed by three dimensions:
      - row: string
      - column: string
      - timestamp: int64
  - Each value in the map is an un-interpreted array of bytes

# What is Bigtable?

"A BigTable is a sparse, distributed, persistent multidimensional sorted map"

- (row:string, column:string, time:int64) → cell content

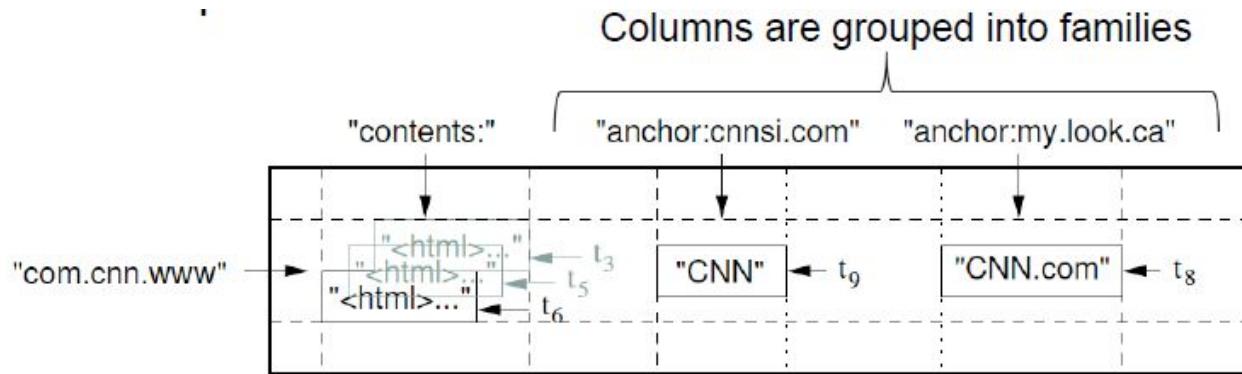
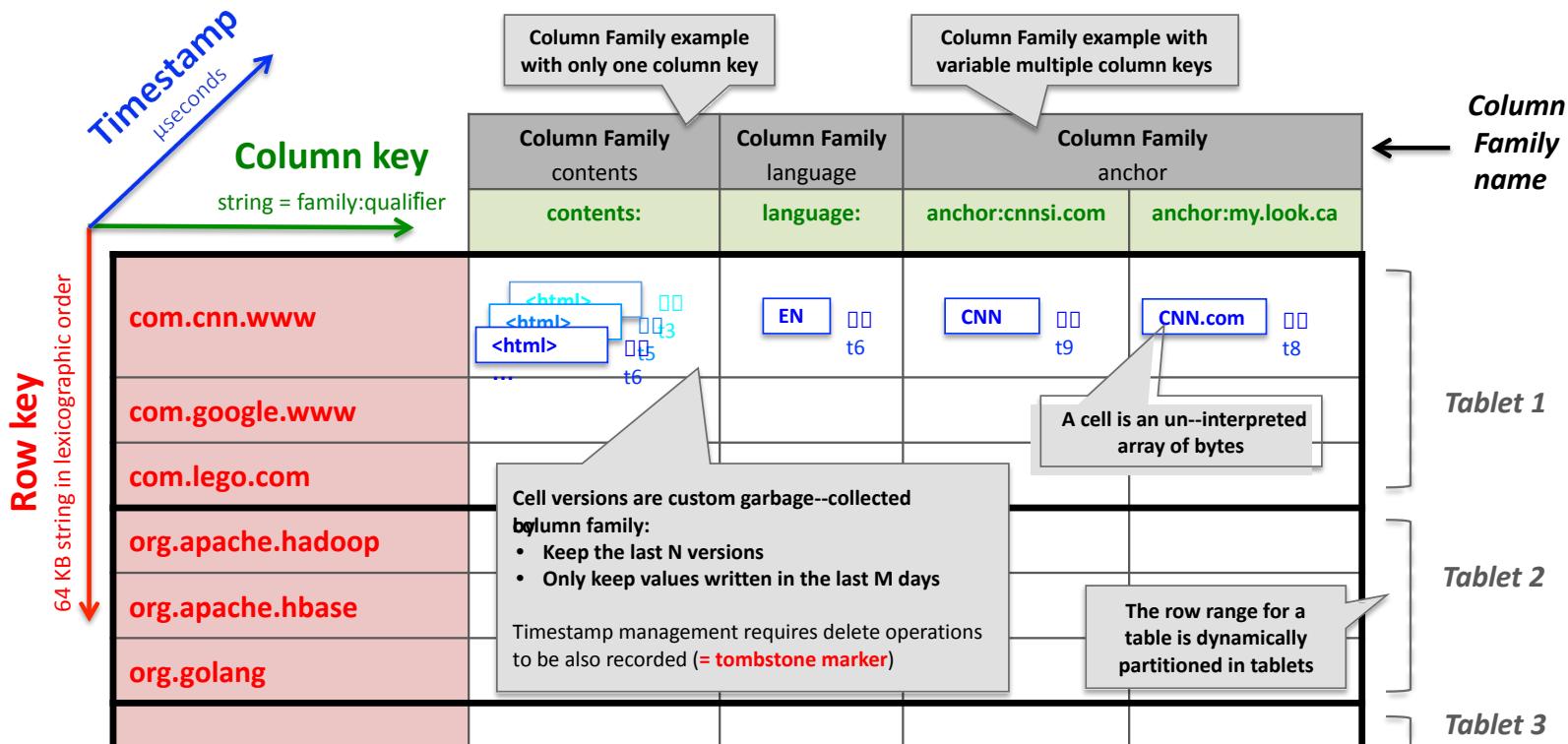


Fig: A slice of an example table (consider name *Webtable*) storing web pages

# Big Table - Data model



# Big Table - Rows

Rows – kept ordered by row key ; choice of row key important

- Select row key to get good locality of data access (i.e. reverse hostname)
- Small row ranges → small # machines to access
- Rows with consecutive keys grouped into *tablets*
- Partitioning is fixed (in contrast with RDBMS)
- # rows in a table is unbounded
- Tablets are unit of distribution and load balancing
- Row is unit of transactional consistency
- Row read/writes are serializable
- No transactions across rows

# Big Table - Tablets

- Table - partitioned dynamically by rows into tablets
- Tablet = range of contiguous rows
  - Unit of distribution and load balancing
  - Nearby rows will usually be served by same server
  - Accessing nearby rows requires communication with small # of servers
  - Usually, 100-200 MB per tablet
- Users can control related rows to be in same tablet by row keys
  - E.g., store [maps.google.com/index.html](http://maps.google.com/index.html) under key com.google.maps/index.html

# Big Table - Columns

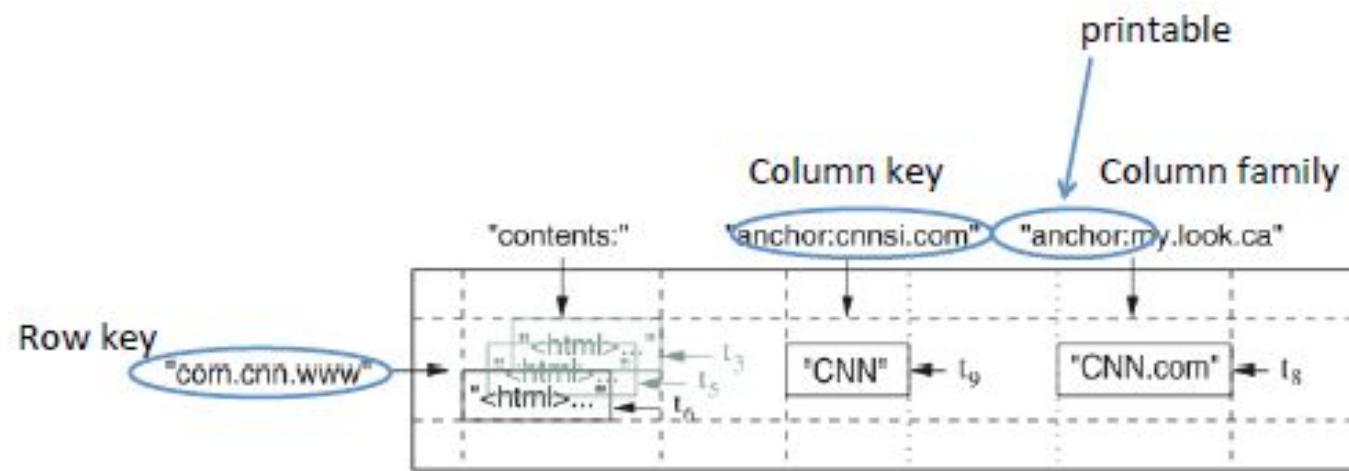
Columns grouped into Column Families

- Data stored in column families - usually of the same type (compressed together)
- Number of column families intended to be small (unlimited rows, cols)
- Keeps shared meta-data small
- Column families must be created explicitly
- Column key is family:qualifier
- Column family is unit of access control

Example column families:

- “language”:language\_id
  - “anchor”:referring\_site
    - Example: <a href="http://www.w3.org/">CERN</a> appearing in www.berkeley.edu
- 
- The diagram illustrates a cell structure. A large rectangular box labeled "Cell content" contains the text "<a href="http://www.w3.org/">CERN</a> appearing in www.berkeley.edu". Two arrows point from the text within this box to two smaller rectangular boxes below it. One arrow points from "http://www.w3.org/" to a box labeled "Referring site". Another arrow points from "www.berkeley.edu" to the same "Referring site" box.

# Big Table – Row and Column Keys



# Big Table – Another Example

row keys      column family      column family      column family

“language:”      “contents:”      anchor:cnnsi.com      anchor:mylook.ca

Sorted rows ↓

	EN	<!DOCTYPE html PUBLIC...		
com.aaa	EN	<!DOCTYPE html PUBLIC...		
com.cnn.www	EN	<!DOCTYPE HTML PUBLIC...	“CNN”	“CNN.com”
com.cnn.www/TECH	EN	<!DOCTYPE HTML>...		
com.weather	EN	<!DOCTYPE HTML>...		

# Big Table - Timestamps

Multiple versions of the data in a cell - indexed by timestamp

- Timestamps - assigned implicitly by Bigtable or explicitly by clients
- Bigtable stores in decreasing timestamp order (most recent version read first)
- Garbage collection options:
  - Keep last N versions
  - Keep last D days of data
- Webtable example: Timestamps are Times pages were crawled

Row Key	Time Stamp	ColumnFamily contents	ColumnFamily anchor	ColumnFamily people
"com.cnn.www"	t9		anchor:cnnsi.com = "CNN"	
"com.cnn.www"	t8		anchor:my.look.ca = "CNN.com"	
"com.cnn.www"	t6	contents:html = "<html>..."		
"com.cnn.www"	t5	contents:html = "<html>..."		
"com.cnn.www"	t3	contents:html = "<html>..."		
"com.example.www"	t5	contents:html = "<html>..."		people:author = "John Doe"

# Big Table - API

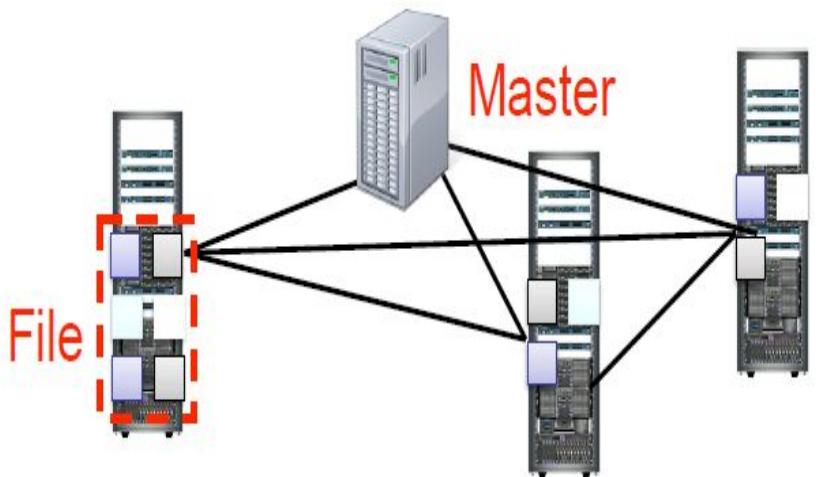
- **Data definition**
  - Creating/deleting tables or column families
  - Changing access control rights
- **Data manipulation**
  - Writing or deleting values
  - Looking up values from individual rows
  - Iterate over subset of data in the table
- Bigtable can serve as input to or output from MapReduce

# Big Table – Building Blocks

- **Google File System**
  - To Store log and data files
- **Google SSTable**
  - Used internally to store data in Bigtable
- **Chubby**
  - Paxos based system for consensus in network of unreliable processors
  - Provides a namespace to store Directories and small files
  - Each Dir or file can be used as a lock and every access is atomic
  - Chubby Unavailable Bigtable Unavailable

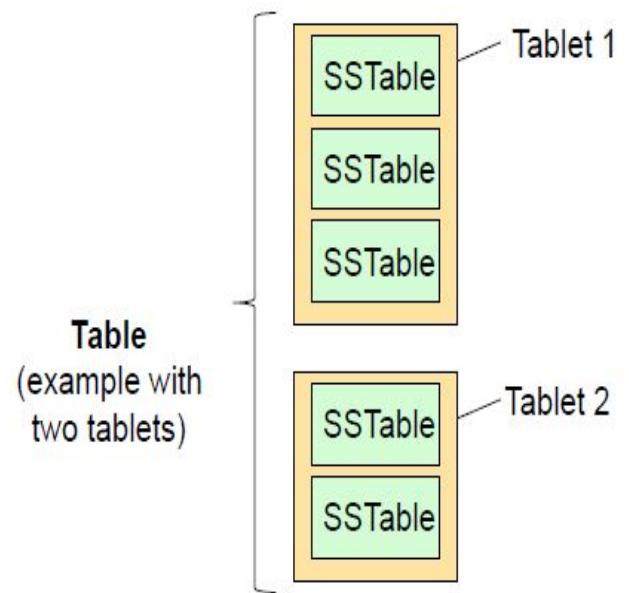
# Google File System

- File = A series of chunks
  - Size of a chunk  $\geq$  64MB
  - Append & read only
- Fault-tolerance
  - Chunks are distributed
  - Chunks are replicated
- Master node
  - Decides chunk placement
  - Decides replica placement
  - Tells clients where to find data
- GFS stores log and data files
  - **metadata** = METADATA tablets (store tablets location)
  - **data** = SSTables collection by tablet
  - **log** = Tabletlogs



# A Table in Big Table

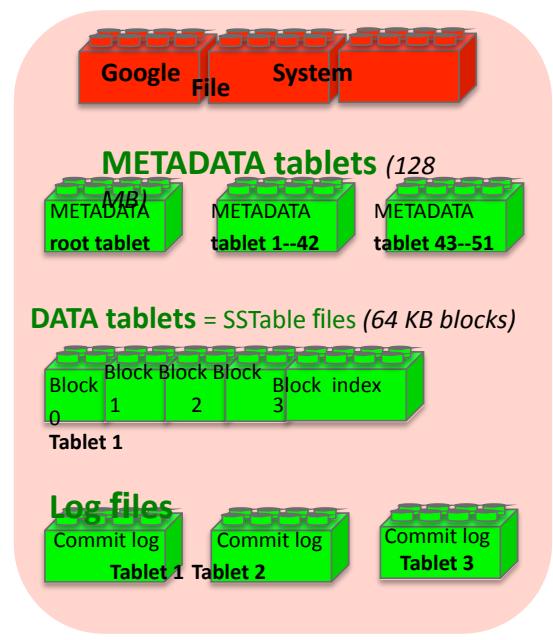
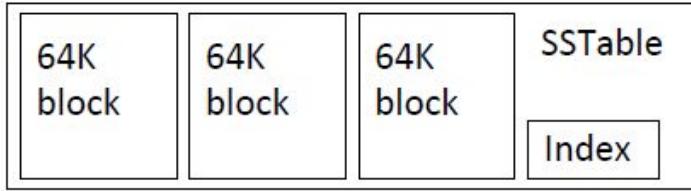
- A table consists of a set of tablets
- Each tablet comprises one or more SSTables
- Tablets are stored in GFS
- Tablet servers load data into memory
- Reads are served from memory
- Tables are range partitioned



# Google SSTable

Google SSTable file format ( Sorted String Table )

- Used to store table data in GFS
  - Persistent, ordered, immutable, sorted file of key-value pairs
- Chunks of data plus an index
- Index of block ranges, not values
  - Index loaded into memory when SSTable is opened
  - Lookup is a single disk seek
- Client can map SSTable into mem



# Google SSTable File Format

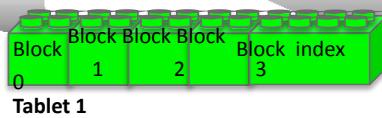
Google SSTable file format ( Sorted String Table )

• Contains a sequence of 64 KB Blocks (*size configurable*)

- Optionally, Blocks can be completely mapped into memory
- **Block index stored at the end of the file**
  - Used to locate blocks
  - Index loaded in memory when the SSTable is opened
  - Lookup with a single seek
    1. Find the appropriate block by performing a binary search in the in--memory index
    2. Reading the appropriate block from disk

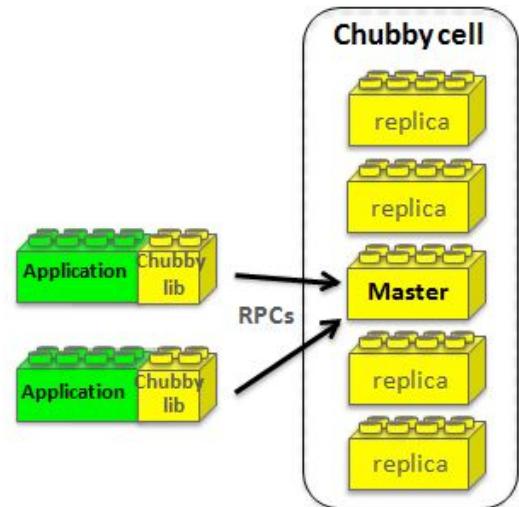
rowkey 1	col key	timestamp	value
	col key	timestamp	value
rowkey 2	col key	timestamp	value
	col key	timestamp	value
rowkey 3	col key	timestamp	value

Block 0		Block 1		Block 2		Block 3	
File offset							
First row	rowkey 1	First row	rowkey 4	First row	rowkey 10	First row	rowkey 15
Last row	rowkey 3	Last row	rowkey 9	Last row	rowkey 14	Last row	rowkey 18



# Google Chubby

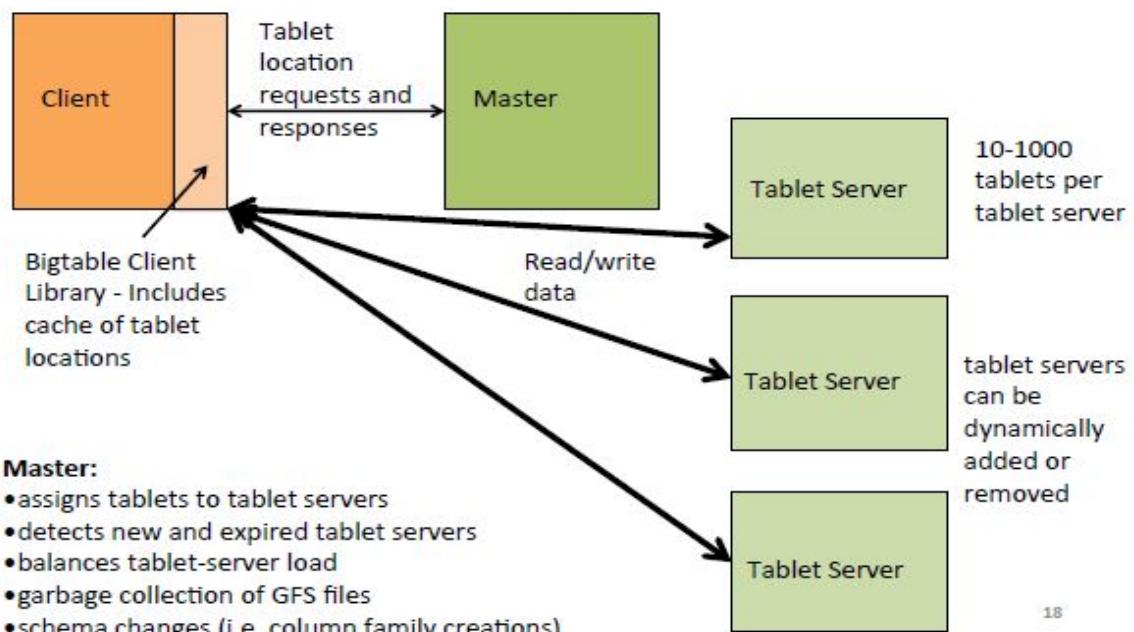
- Highly-available & persistent distributed lock (lease) service
- Five active replicas; one elected as master to serve requests
- Majority must be running
- Paxos used to keep replicas consistent
- Namespace of files & directories
- Each file or directory can be used as a lock
- Chubby is used to:
  - Ensure there is only one active master
  - Store bootstrap location of BigTable data
  - Discover tablet servers
  - Store BigTable schema information
  - Store access control lists



# Big Table – Implementation

- Three components
  - A Library that is linked to every client
  - One master server:
    - Responsible for assigning tablets to Tablet Servers
  - Many Tablet servers:
    - Dynamically added and removed from a cluster to accommodate changes in workloads

# Big Table – Implementation



# Big Table – Table startup and growth

- A table starts off with just one tablet
- As the table grows, it is split into multiple tablets.
- By default, a table is split at around 100 to 200 MB
- Locating rows within a BigTable is managed in a three-level hierarchy
- The root (top-level) tablet stores the location of all Metadata tablets in a special Metadata tablet
- Each Metadata table contains the location of user data tablets
- This table is keyed by node IDs and each row identifies a tablet's table ID and end row
- For efficiency, the client library caches tablet locations

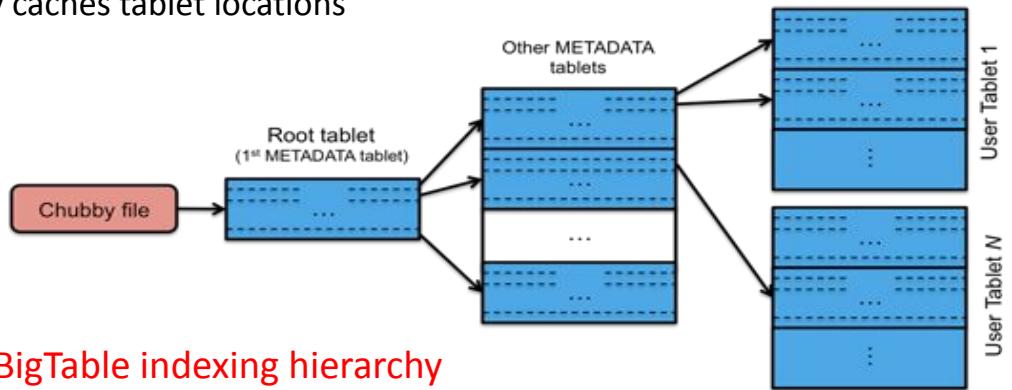


Figure: BigTable indexing hierarchy

# Big Table – Tablet assignment

- A tablet is assigned to one tablet server at a time
- Chubby keeps track of tablet servers
- When a tablet server starts, it creates and acquires an exclusive lock on a uniquely-named file in a *Chubby servers* directory
- Master monitors this directory to discover new tablet servers
- When the master starts, it:
  - grabs a unique master lock in Chubby (to prevent multiple masters from starting)
  - scans the servers directory in Chubby to find live tablet servers
  - communicates with each tablet server to discover what tablets are assigned to each server
  - scans the Metadata table to learn the full set of tablets
  - builds a set of unassigned tablet servers, which are eligible for tablet assignment

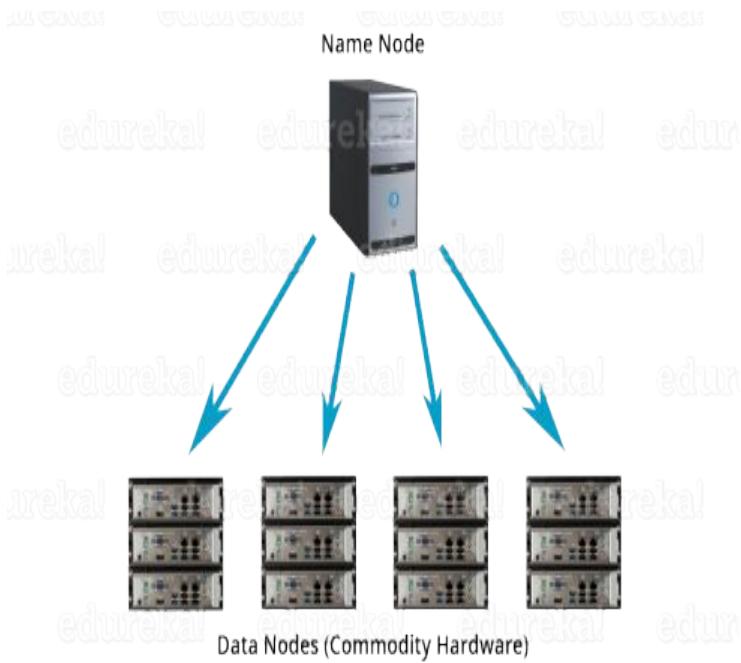
# HDFS

# HDFS - Introduction

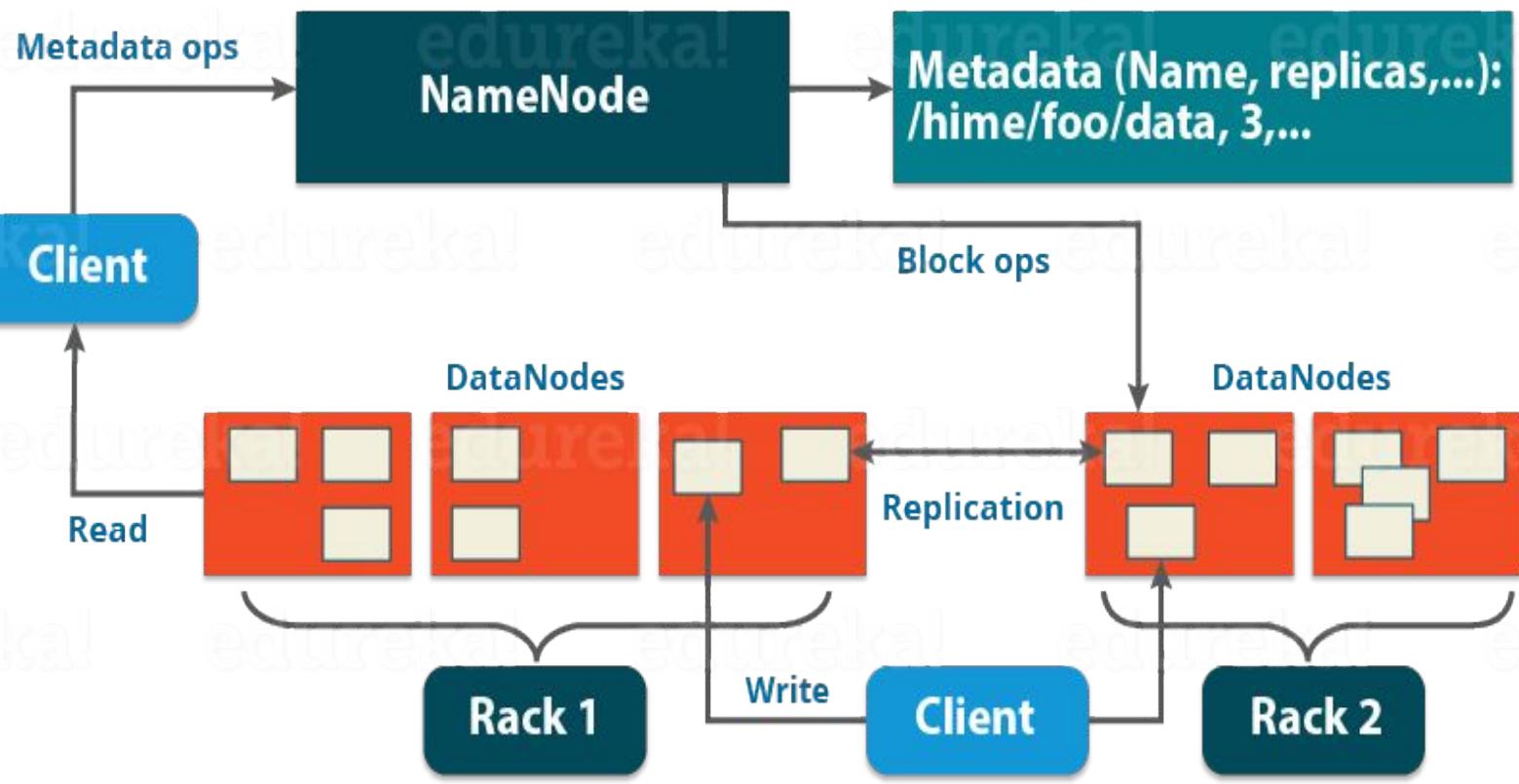
- is based on the Google File System (GFS)
- written completely in Java language
- Google provided only a white paper, without any implementation
- around 90 % of the GFS architecture - implemented in the form of HDFS
- was originally built and developed as a storage infrastructure for the Apache Nutch web search engine project
- was initially known as the *Nutch Distributed File System (NDFS)*

# Apache HDFS or Hadoop Distributed File System

- is a block-structured file system
- each file - divided into blocks of a pre-determined size
- blocks - stored across a cluster of one or several machines
- follows a *Master/Slave Architecture*
- a cluster comprises of
  - a single NameNode (Master node)
  - all the other nodes are DataNodes (Slave nodes)



## HDFS Architecture



# HDFS – Basic Design

- **Divide user data into blocks**
- Blocks are big! [64, 128] MB
- Avoids problems related to metadata management
- **Replicate blocks across the local disks of nodes in the cluster**
- Replication - handled by storage nodes themselves (similar to chain replication) and follows distance rules
- **Master-Slave architecture**
- **NameNode:** master maintains the namespace (metadata, file to block mapping, location of blocks) and maintains overall **health** of the file system
- **DataNode:** slaves – manage data blocks

# NameNode - Functions

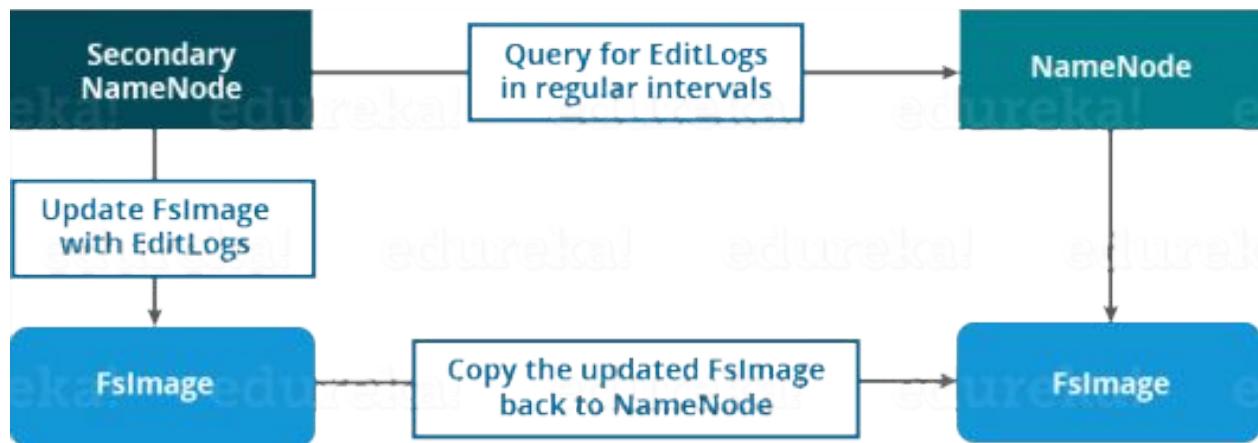
- is the master daemon - maintains and manages the DataNodes (slave nodes)
- records metadata – as two files:
  - **FsImage:** It contains the complete state of the file system namespace since the start of the NameNode
  - **EditLogs:** It contains all the recent modifications made to the file system with respect to the most recent FsImage
- regularly receives a Heartbeat and a Block report from all the DataNodes in the cluster to ensure that the DataNodes are alive
- keeps a record of all the blocks in HDFS + nodes of these blocks

# DataNode - Functions

- is a slave node in HDFS
- is a commodity hardware - non-expensive system which is not of high quality or high-availability
- is a block server - stores the data in the local file ext3 or ext4
- actual data - stored on DataNodes
- perform low-level read and write requests from the file system's clients
- send heartbeats to the NameNode periodically to report the overall health of HDFS ( by default, this frequency is set to 3 seconds)

# Secondary NameNode - Functions

- constantly reads all the file systems and metadata from the RAM of the NameNode and writes it into the hard disk or the file system
- combines EditLogs with FsImage from the NameNode
- Downloads EditLogs from NameNode at regular intervals - applies to FsImage
- new FsImage - copied back to the NameNode – used the NameNode restarts
- performs regular checkpoints in HDFS □ also called ***CheckpointNode***



# HDFS – I/O

- **A typical read from a client involves:**

- Contact the NameNode to determine where the actual data is stored
- NameNode replies with block identifiers and locations (*i.e.*, which DataNode)

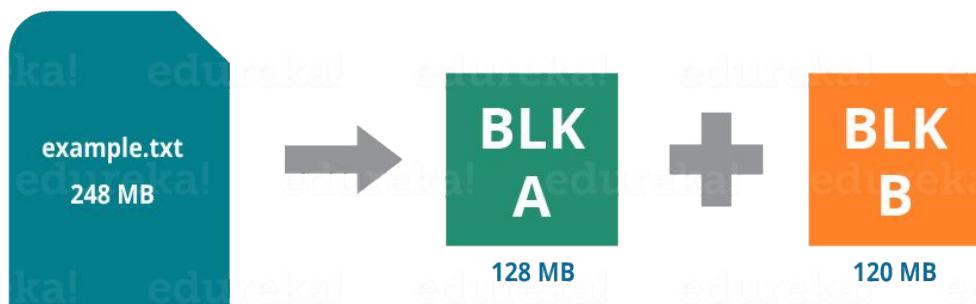
- Contact the DataNode to fetch data

- **A typical write from a client involves:**

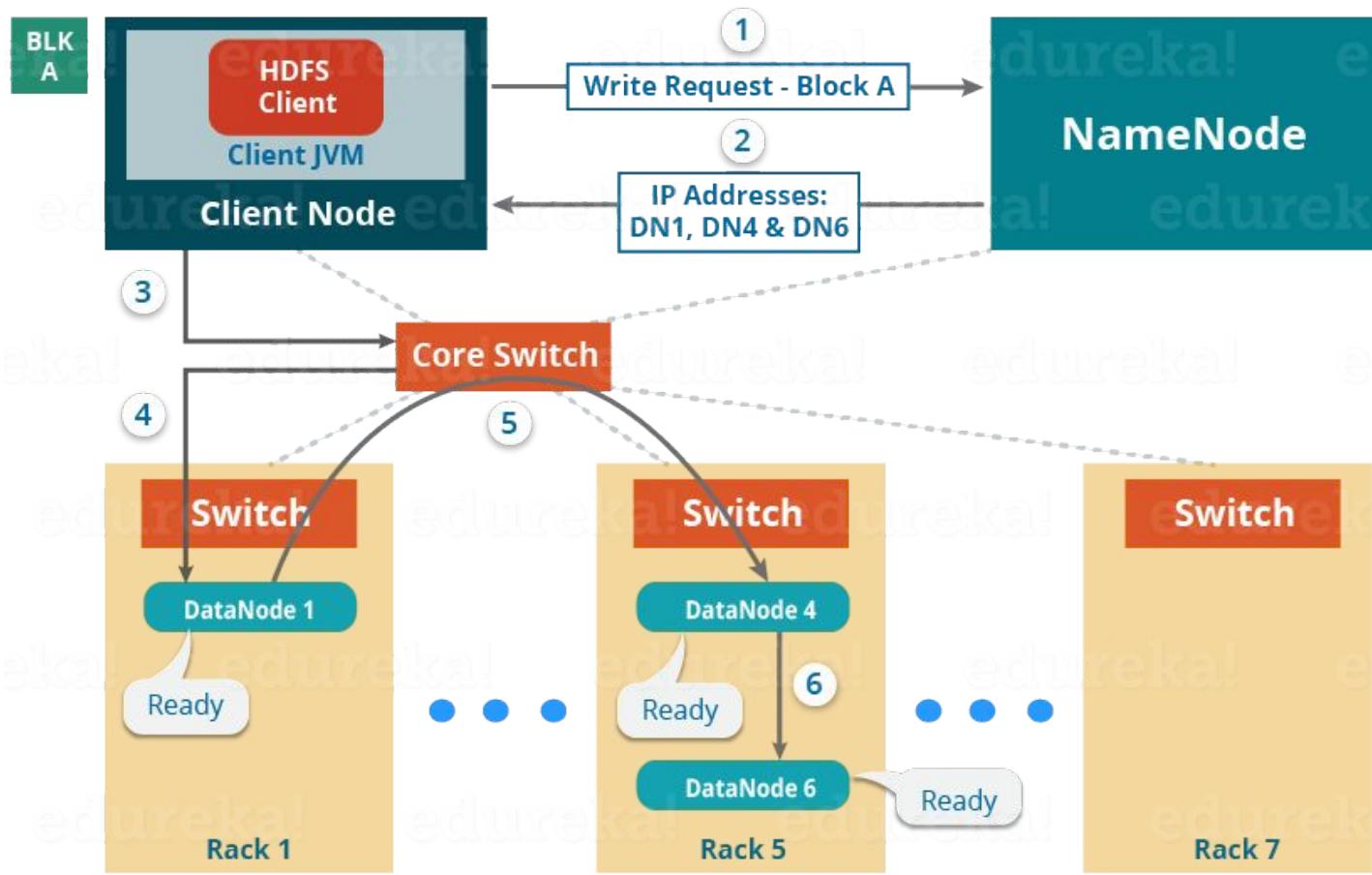
- Contact the NameNode to update the namespace and verify permissions
- NameNode allocates a new block on a suitable DataNode
- Directly stream to the selected DataNode
- Currently, HDFS files are **immutable**
- **Data is never moved through the NameNode**
- Hence, there is no bottleneck

# HDFS Read/ Write Architecture

- follows ***Write Once – Read Many Philosophy***
- can't edit files already stored; but can append new data by re-opening the file
- **HDFS Write Architecture:**
  - **Ex:** If a HDFS client wants to write a file named “example.txt” of size 248 MB

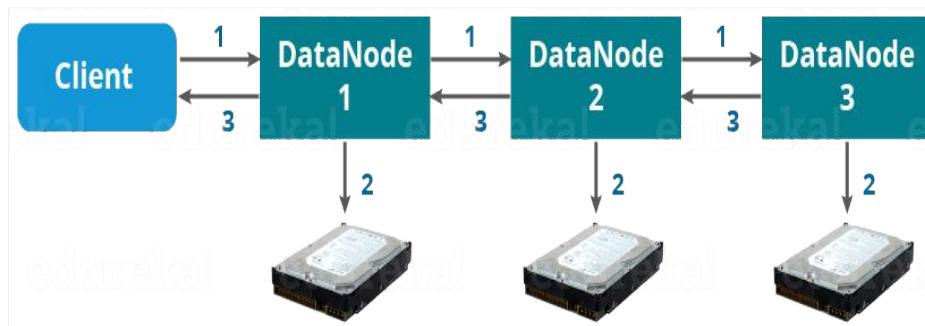


## Setting up HDFS - Write Pipeline



# HDFS Write Protocol

- HDFS client – forwards Write Request against 2 blocks, A & B to the NameNode
- NameNode – grants write permission + the IP addresses of the DataNodes
- For each block – NameNode provides a list of (3) IP addresses of DataNodes (replication factor is set to default i.e. 3.)
- Suppose, the NameNode provided following lists of IP addresses to the client:
  - For Block A, list A = {IP of DataNode 1, IP of DataNode 4, IP of DataNode 6}
  - For Block B, set B = {IP of DataNode 3, IP of DataNode 7, IP of DataNode 9}



# HDFS Write – Data Copy

- The whole data copy process will happen in three stages:
  - Set up of Pipeline
  - Data streaming and replication
  - Shutdown of Pipeline (Acknowledgement stage)

# Stage-1: Pipeline creation

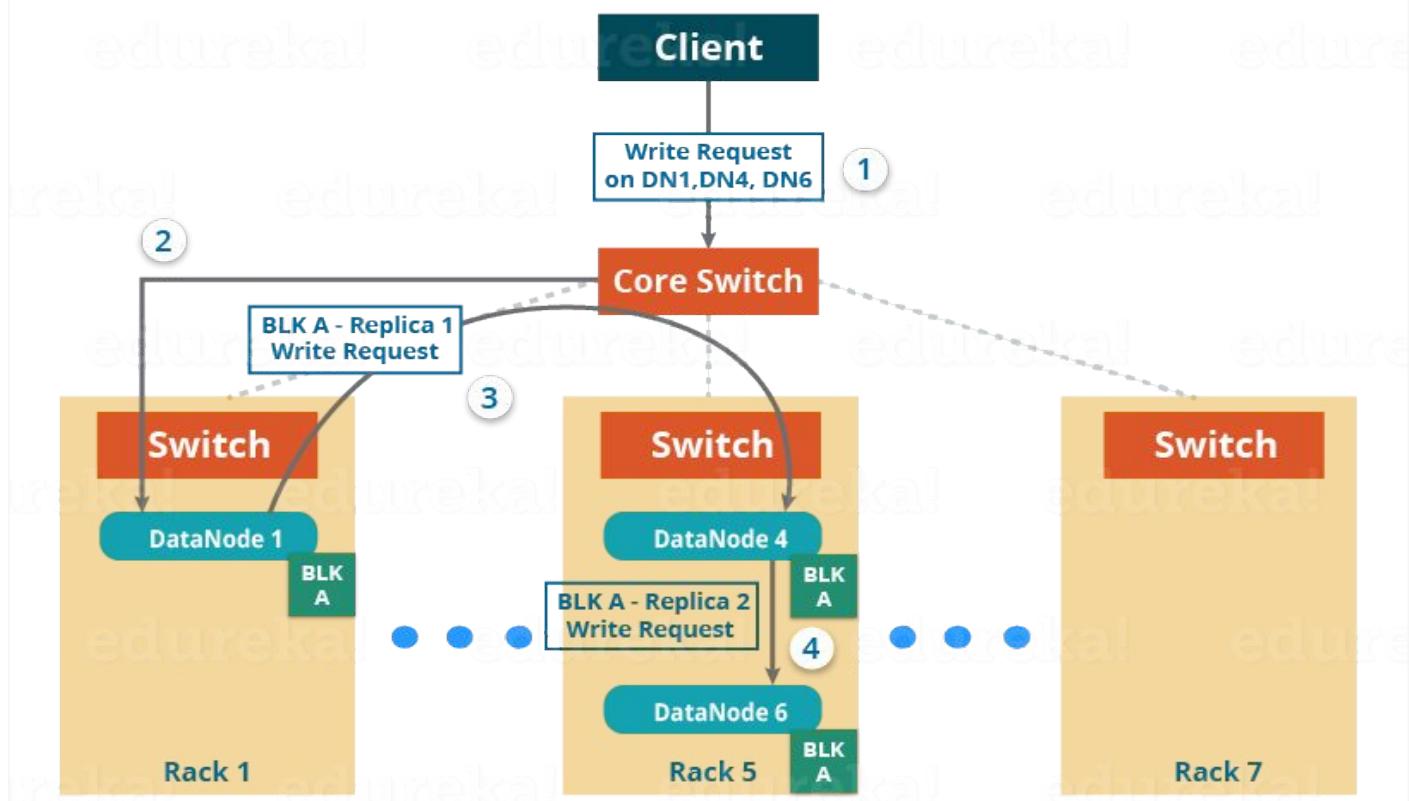
- **Client**
- chooses the first DataNode in the list (DataNode IPs for Block A) which is DataNode 1 and will establish a TCP/IP connection
- informs it to be ready to receive the block
- also provides the IPs of next two DataNodes (4 and 6) to the DataNode 1 where the block is supposed to be replicated
- **DataNode 1**
- will connect to DataNode 4 and inform it to be ready to receive the block
- Gives the IP of DataNode 6
- **DataNode 4**
- will tell DataNode 6 to be ready for receiving the data

# **Stage-1: Pipeline creation**

- Next, the acknowledgement of readiness will follow the reverse sequence, i.e.
- From the DataNode 6 to 4 and then to 1
- At last DataNode 1 will inform the client that all the DataNodes are ready
- Pipeline - formed between the client, DataNodes 1, 4 and 6
- Now pipeline set up is complete and the client will finally begin the data copy or streaming process

# Stage-2: Data Streaming

HDFS - Write Pipeline

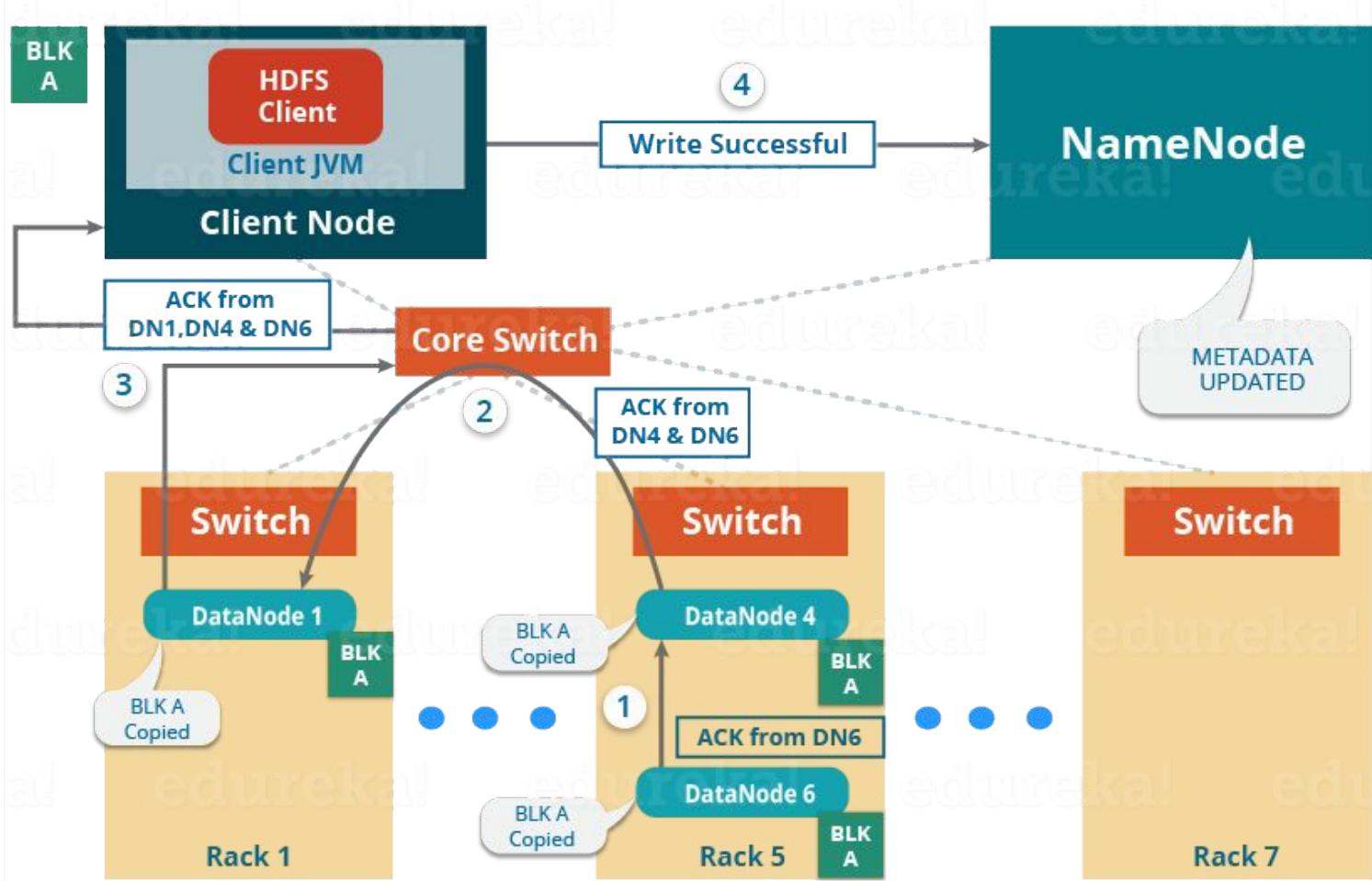


# Stage-2: Data Streaming

- Replication - steps
- Once the block has been written to DataNode 1 by the client, DataNode 1 will connect to DataNode 4.
- Then, DataNode 1 will push the block in the pipeline and data will be copied to DataNode 4.
- Again, DataNode 4 will connect to DataNode 6 and will copy the last replica of the block.

# Stage-3: Acknowledgement

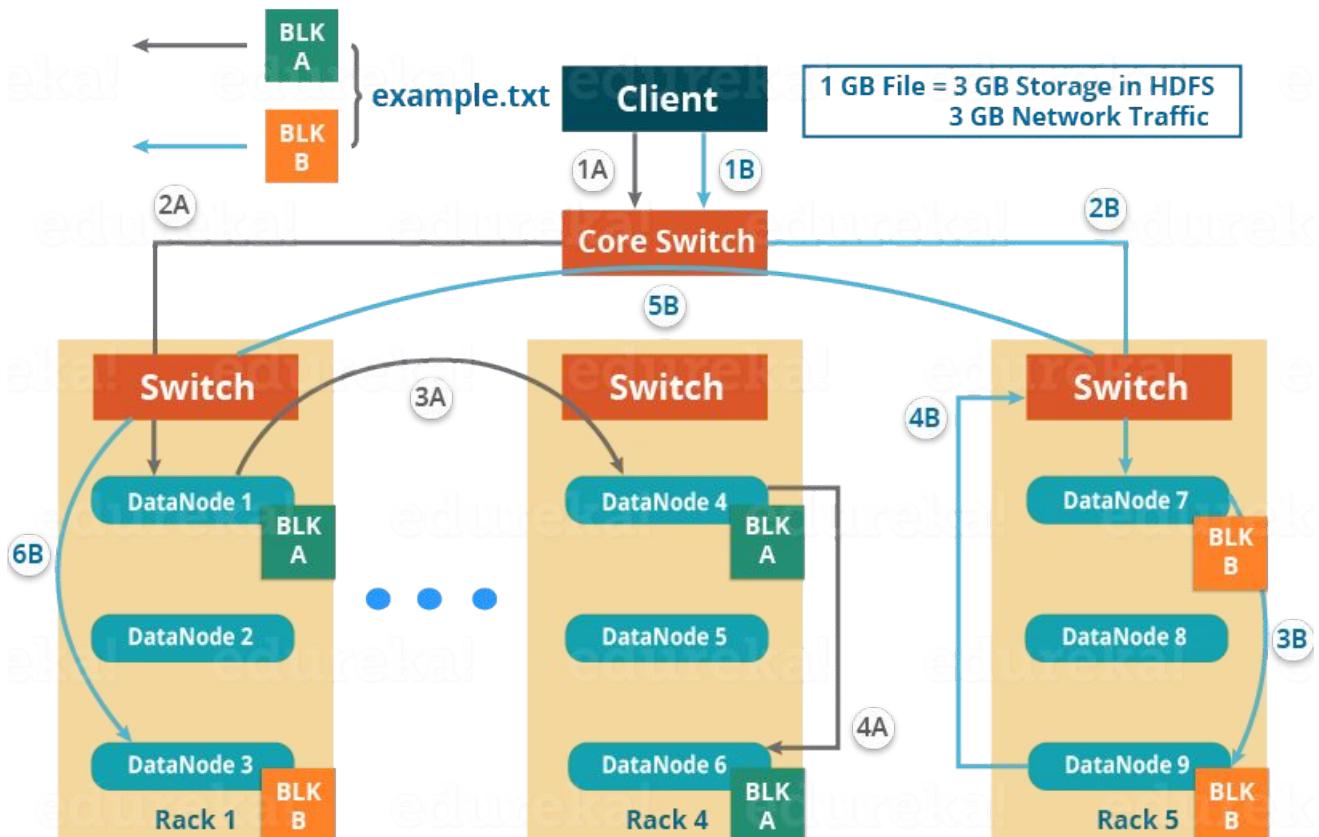
## Acknowledgement in HDFS - Write



# Stage-3: Acknowledgement

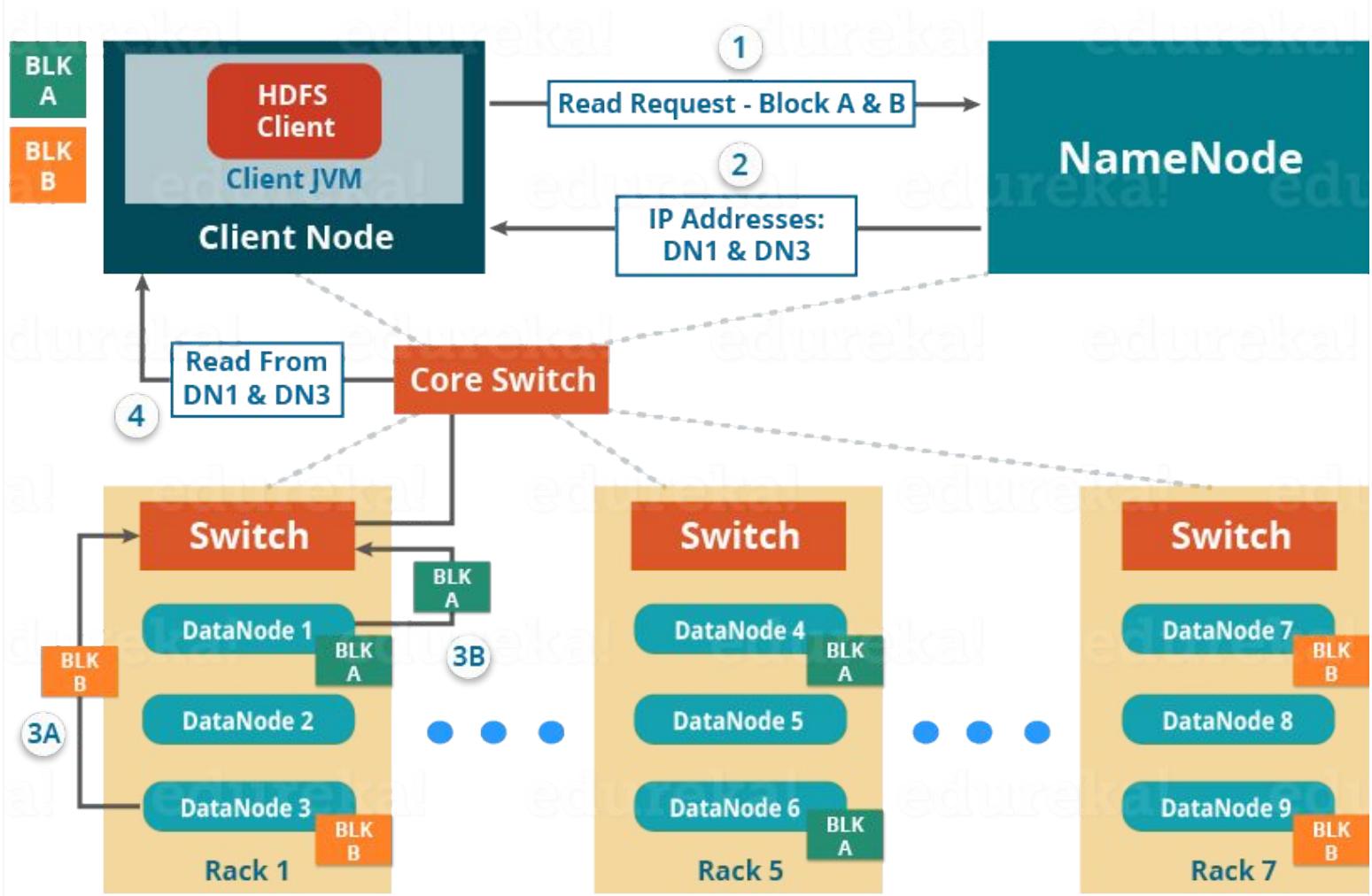
- Acknowledgement – in **the reverse sequence** i.e. from DataNode 6 to 4 and then to 1
- Finally, the DataNode 1 will push three acknowledgements (including its own) into the pipeline and send it to the client
- The client will inform NameNode that data has been written successfully
- The NameNode will update its metadata and the client will **shut down** the pipeline
- Similarly, Block B will also be copied into the DataNodes in parallel with Block A  
So, the following things are to be noticed here:
  - The client will copy Block A and Block B to the first DataNode **simultaneously**
  - Therefore, two pipelines will be formed for each of the block and all the processes will happen in parallel in these two pipelines
  - The client writes the block into the first DataNode and then the DataNodes will be replicating the block sequentially

# HDFS Multi - Block Write Pipeline



- Two pipelines formed for each block (A and B)
- Flow of operations taking place for each block in their respective pipelines:
- For Block A: 1A -> 2A -> 3A -> 4A
- For Block B: 1B -> 2B -> 3B -> 4B -> 5B -> 6B

# HDFS - Read Architecture



# HDFS Read - Protocol

- Client – requests NameNode for the block metadata for the file “example.txt”
- NameNode - returns the list of DataNodes where each block (A and B) are stored
- Client - connects to the DataNodes where the blocks are stored
- Client – reads data parallel from the DataNodes (Block A from DataNode 1 and Block B from DataNode 3)
- Once the client gets all the required file blocks, it combines the blocks to form a file

**Note:**

- While serving read request of the client, HDFS selects the replica which is closest to the client - this reduces the read latency and the bandwidth consumption
- Hence, that replica is selected which resides on the same rack as the reader node, if possible

# Google Cloud Bigtable

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# AGENDA

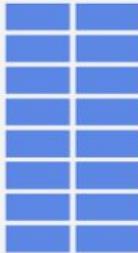
- ❑ INTRODUCTION
- ❑ BIGTABLE ARCHITECTURE
- ❑ BIGTABLE STORAGE MODEL
- ❑ EXAMPLE
- ❑ USE CASES
- ❑ PROS AND CONS OF BIGTABLE
- ❑ DEMO
- ❑ CONCLUSION
- ❑ REFERENCES

# INTRODUCTION

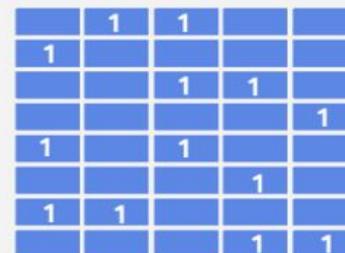
- ❑ Cloud Bigtable is a sparsely populated table that can scale to billions of rows and thousands of columns, enabling you to store terabytes or even petabytes of data.
- ❑ A single value in each row is indexed this value is known as the row key.
- ❑ Bigtable is ideal for storing very large amounts of single-keyed data with very low latency.
- ❑ It supports high read and write throughput at low latency, and it is an ideal data source for MapReduce operations.

# TYPES OF NoSql DATABASE

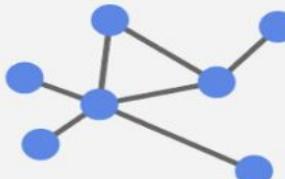
Key Value



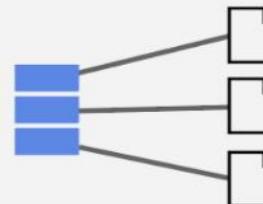
Column Based



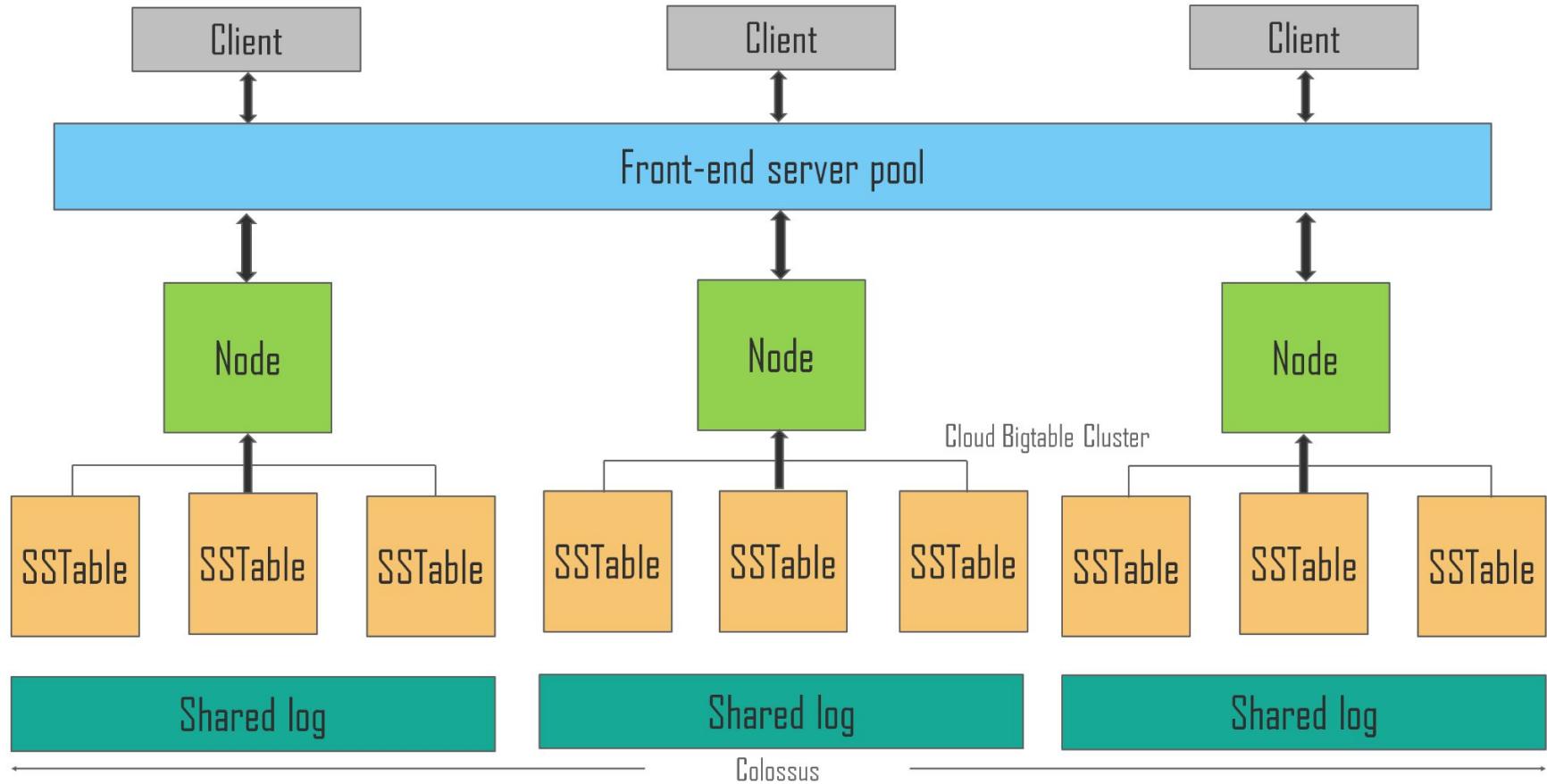
Graph DB



Document



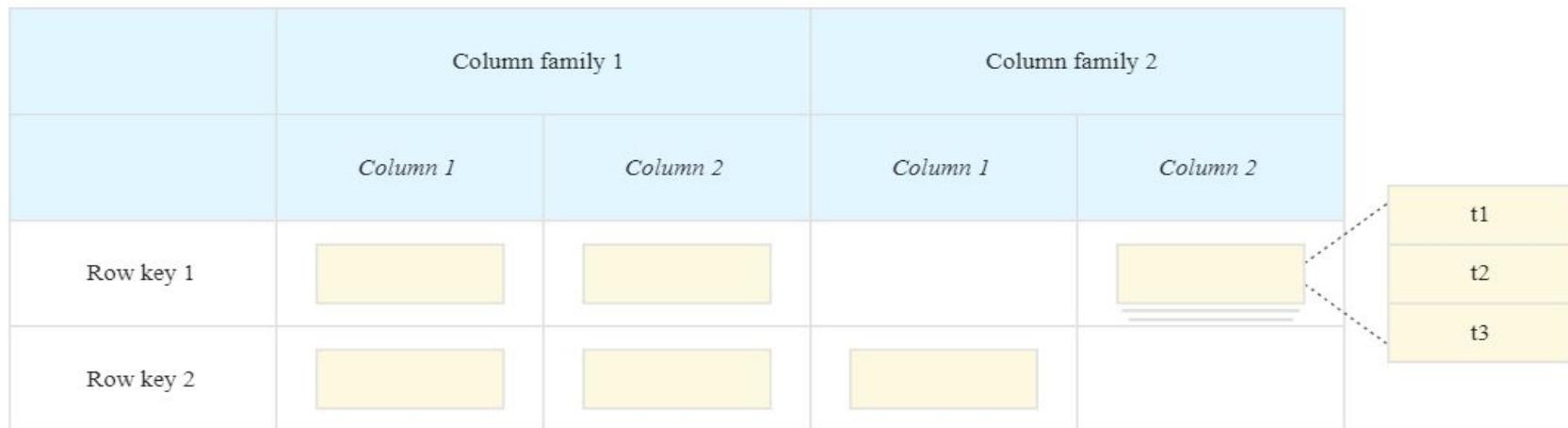
# BIGTABLE ARCHITECTURE



# BIGTABLE STORAGE MODEL

- ❑ Bigtable stores data in massively scalable tables, each of which is a sorted key/value map.
- ❑ The table is composed of rows, each of which typically describes a single entity, and columns, which contain individual values for each row.

	Column family 1		Column family 2	
	<i>Column 1</i>	<i>Column 2</i>	<i>Column 1</i>	<i>Column 2</i>
Row key 1				
Row key 2				



## EXAMPLE

A social network for United States presidents. Each president can follow posts from other presidents.  
The following shows a Bigtable table that tracks who each president is following

"follows" column family

Row Key	follows			
	gwashington	jadams	tjefferson	wmckinley
wmckinley			1	
gwashington		1		
tjefferson	1	1		1
jadams	1		1	

Multiple versions

## **PROS OF BIGTABLE**

- Simple Administration
- Scalability
- Integrate with HBase
- Empty cells take no spaces
- Well- Designed Architecture

## **CONS OF BIGTABLE**

- No Easy way to Query
- Not portable outside of Cloud
- Lack of Docs and Samples
- Lack of Data Consistency
- Hard Adaptation from RDBMS

# USE CASES

Bigtable used to store and query all of the following types of data:

- Time-series data
- Marketing data
- Financial data
- Internet of Things data
- Graph data

# Demo - Using Hbase

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## **Connect HBase shell to a Cloud Bigtable instance, to perform basic administrative tasks, read and write data to a table**

- ❑ Create a Cloud Bigtable instance
- ❑ Connect to the instance
- ❑ Read and Write data

- ❑ Create a table named my-table, with one column family named cf1:

```
create 'my-table', 'cf1'
```

- ❑ List your tables:

```
list
```

- ❑ Put the value test-value in the row r1, using the column family cf1 and the column qualifier c1:

```
put 'my-table', 'r1', 'cf1:c1', 'test-value'
```

- ❑ Use the scan command to scan the table and read the data you added:

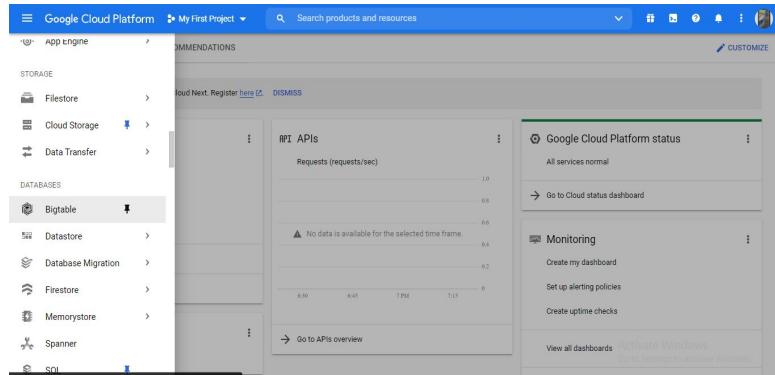
```
scan 'my-table'
```

- ❑ Delete the table my-table:

```
disable 'my-table'
```

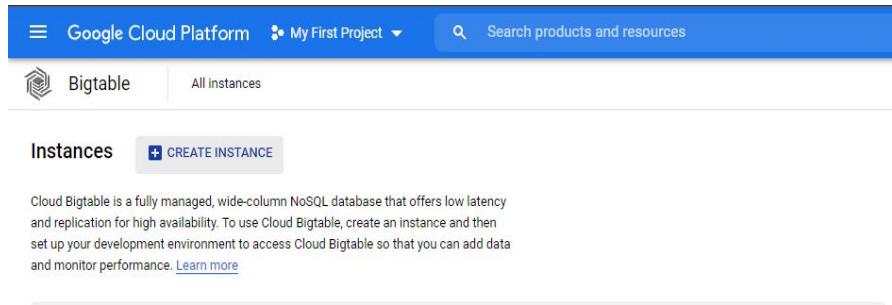
```
drop 'my-table'
```

# Select Bigtable



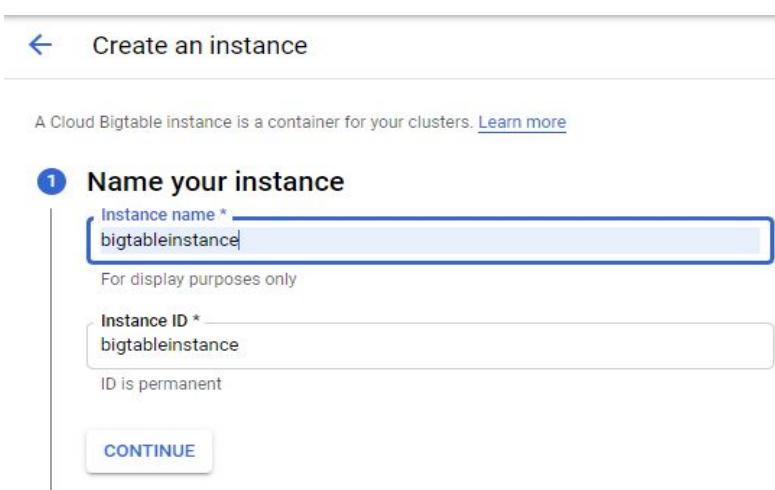
The screenshot shows the Google Cloud Platform dashboard for a project named "My First Project". The left sidebar lists various services: App Engine, Filestore, Cloud Storage, Data Transfer, Databases (Bigtable, Firestore, Memorystore, Spanner), and Compute (Cloud Functions). The main content area displays the "Bigtable" section under "Databases". It includes a chart titled "API APIs Requests (requests/sec)" with a note "No data is available for the selected time frame". To the right is a "Google Cloud Platform status" card showing "All services normal" and links to "Go to Cloud status dashboard" and "Monitoring".

# Create instance



The screenshot shows the "Create instance" page for Cloud Bigtable. The top navigation bar is "My First Project". The main header is "Bigtable" with a "CREATE INSTANCE" button. Below it is a brief description: "Cloud Bigtable is a fully managed, wide-column NoSQL database that offers low latency and replication for high availability. To use Cloud Bigtable, create an instance and then set up your development environment to access Cloud Bigtable so that you can add data and monitor performance." A "Learn more" link is present.

## Create an instance



A Cloud Bigtable instance is a container for your clusters. [Learn more](#)

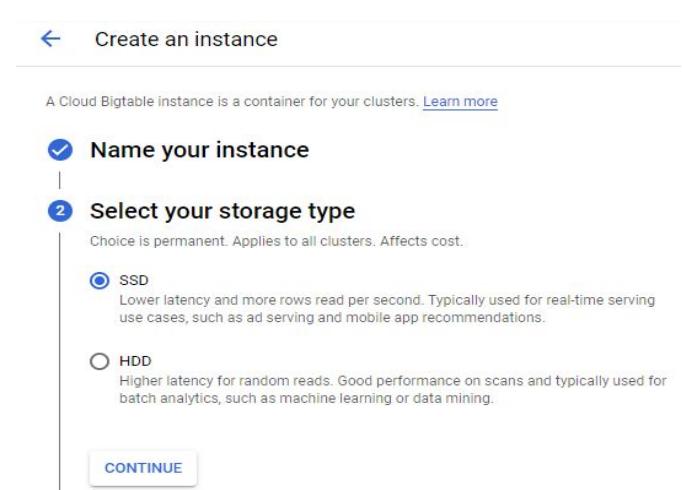
**1 Name your instance**

Instance name \*  For display purposes only

Instance ID \*  ID is permanent

**CONTINUE**

This part of the interface shows the first step of creating a Cloud Bigtable instance. It asks for the instance name ("bigtableinstance") and instance ID ("bigtableinstance"). Both fields have a note indicating they are for display purposes only and permanent respectively. A "CONTINUE" button is at the bottom.



A Cloud Bigtable instance is a container for your clusters. [Learn more](#)

**1 Name your instance**

**2 Select your storage type**

Choice is permanent. Applies to all clusters. Affects cost.

SSD Lower latency and more rows read per second. Typically used for real-time serving use cases, such as ad serving and mobile app recommendations.

HDD Higher latency for random reads. Good performance on scans and typically used for batch analytics, such as machine learning or data mining.

**CONTINUE**

This part of the interface shows the second step of creating a Cloud Bigtable instance. It asks to "Name your instance" (which is completed) and "Select your storage type". The "SSD" option is selected. Both steps include notes about permanence and cost. A "CONTINUE" button is at the bottom.

[←](#) Create an instance

## ✓ Select your storage type

### 3 Configure your first cluster

A cluster handles application requests for an instance. It contains nodes which determine your cluster's performance and storage limit.

Additional clusters can be added at any time.

#### Select a cluster ID

ID is permanent

Cluster ID \*

bigtableinstance-c1

#### Select a location

Choice is permanent. Determines where cluster data is stored. To reduce latency and increase throughput, store your data near the services that need it. [Learn more](#)

Region \*

asia-south2 (Delhi)

Zone \*

asia-south2-c

#### Allocate nodes

Node count can be updated at any time to meet your cluster's need for data throughput, storage, and rows read per second. For better instance performance, keep your cluster's CPU utilization under the recommended threshold for your [app profile routing policy](#). [Contact us](#) if you need to increase your node quota. [Learn more](#)

Nodes \*

1

▼ SHOW ENCRYPTION OPTIONS

▼ SHOW ADVANCED OPTIONS

CREATE

CANCEL

## Instance created

		Filter instances	?	☰			
<input type="checkbox"/>	<input checked="" type="radio"/>	Instance ID	Instance name ↑	Application profiles	Zones	Nodes <span>?</span>	Storage utilization <span>?</span>
<input type="checkbox"/>	<input checked="" type="radio"/>	bigtableinstance	bigtableinstance	default <a href="#">Add</a>	asia-south2-c <a href="#">Add</a>	1	<div style="width: 100%;"><div style="width: 100%;"></div></div>

## Open shell

Clone the repository that contains the HBase shell files, then change to the directory for the HBase shell:

```
git clone https://github.com/GoogleCloudPlatform/cloud-bigtable-examples.git  
cd cloud-bigtable-examples/quickstart
```

Start the HBase shell:

```
./quickstart.sh
```

## Table created

```
hbase(main):002:0> create 'Table-1', 'cf1'  
0 row(s) in 4.5050 seconds  
  
=> Hbase::Table - Table-1
```

## Listing the table

```
hbase(main):003:0> list  
TABLE  
Table-1  
1 row(s) in 0.2070 seconds  
  
=> ["Table-1"]
```

## Entering data's into table

```
hbase(main):004:0> put 'Table-1', 'r1', 'cf1:c1', 'Coimbatore'  
2021-10-07 14:17:01,482 INFO  [Credentials-Refresh-1] io.OAuthCredentialsCache: Refreshing the OAuth token  
0 row(s) in 0.7140 seconds  
  
hbase(main):005:0> put 'Table-1', 'r1', 'cf1:c2', 'Trichy'  
2021-10-07 14:17:56,718 INFO  [Credentials-Refresh-1] io.OAuthCredentialsCache: Refreshing the OAuth token  
0 row(s) in 0.5140 seconds  
  
hbase(main):006:0> put 'Table-1', 'r2', 'cf1:c1', 'Erode'  
2021-10-07 14:18:13,211 INFO  [Credentials-Refresh-1] io.OAuthCredentialsCache: Refreshing the OAuth token  
0 row(s) in 0.4750 seconds  
  
hbase(main):007:0> put 'Table-1', 'r2', 'cf1:c2', 'Salem'  
0 row(s) in 0.5480 seconds
```

## Display table

```
hbase(main):008:0> scan 'Table-1'
ROW                                     COLUMN+CELL
  r1                                      column=cf1:c1, timestamp=1633616221466, value=Coimbatore
  r1                                      column=cf1:c2, timestamp=1633616276717, value=Trichy
  r2                                      column=cf1:c1, timestamp=1633616293211, value=Erode
  r2                                      column=cf1:c2, timestamp=1633616309615, value=Salem
2 row(s) in 0.3290 seconds
```

## Deleting the table

```
hbase(main):009:0> disable 'Table-1'
2021-10-07 14:21:27,463 WARN  [org.jruby.Main.main()] hbase1_x.BigtableAdmin: Table Table-1 was disabled in memory only.
0 row(s) in 0.4060 seconds

hbase(main):010:0> drop 'Table-1'
0 row(s) in 0.5560 seconds
```

## CONCLUSION

- ❑ Bigtable has achieved its goals of high performance, data availability and scalability.
- ❑ It has been successfully deployed in real apps (Personalized Search, Orkut, Google Maps).
- ❑ Significant advantages of building own storage system like flexibility in designing data model, control over implementation and other infrastructure on which Bigtable relies on.

# MCQ'S

1. HBase is a distributed \_\_\_\_\_ database built on top of the Hadoop file system.

- a) Column-oriented
- b) Row-oriented
- c) Tuple-oriented
- d) None of the mentioned

2. Apache HBase is a non-relational database modeled after Google's \_\_\_\_\_

- a) BigTop
- b) Bigtable
- c) Scanner
- d) FoundationDB

3. Columns in HBase are organized to

- a) Column group
- b) Column families
- c) Column list
- d) Column base

4. Cloud Bigtable provides a NOSQL based managed service option. which one of the following is valid use case for this service ?

- a) An object store
- b) A data warehouse
- c) A transactional database of a bank
- d) **A backend for the IoT system**

5. Each table in NoSQL database such as Cloud Bigtable has a single schema that is enforced by the database engine itself.

- a) True
- b) False**

6. Some developers think of Cloud Bigtable as a persistent hash table . What does that mean?

- a) Each item in the database can be sparsely populated and is looked up with a single key.**
- b) Each item in the database consists of exactly the same fields and can be looked up based on a variety of keys.

7. Manufactured device with sensors and need to stream huge amounts of data from these devices to a storage option in the cloud. which Google Cloud Platform storage option is the best choice for this application?

a) Cloud Datastore

b) BigQuery

**c) Cloud Bigtable**

d) Cloud Spanner

8. Hbase creates a new version of a record during

a) Creation of a record

b) Modification of a record

c) Deletion of a record

**d) All the above**

# REFERENCES

<https://youtu.be/JpWLvQK95IE>

<https://cloud.google.com/bigtable/docs/overview>

<https://www.slideshare.net/cstcolloquium/google-bigtable-56386019>

<https://networkingfunda.com/storage-in-the-cloud-quiz-answers-2021/>

<https://cloud.google.com/bigtable/docs/quickstart-hbase>

<https://medium.com/google-cloud/getting-started-with-bigtable-on-gcp-adfb896e0b26>

<https://livebook.manning.com/book/google-cloud-platform-in-action/chapter-7/224>

# THANK YOU

---

# Google app engine

— 20mx201 & 20mx217 —

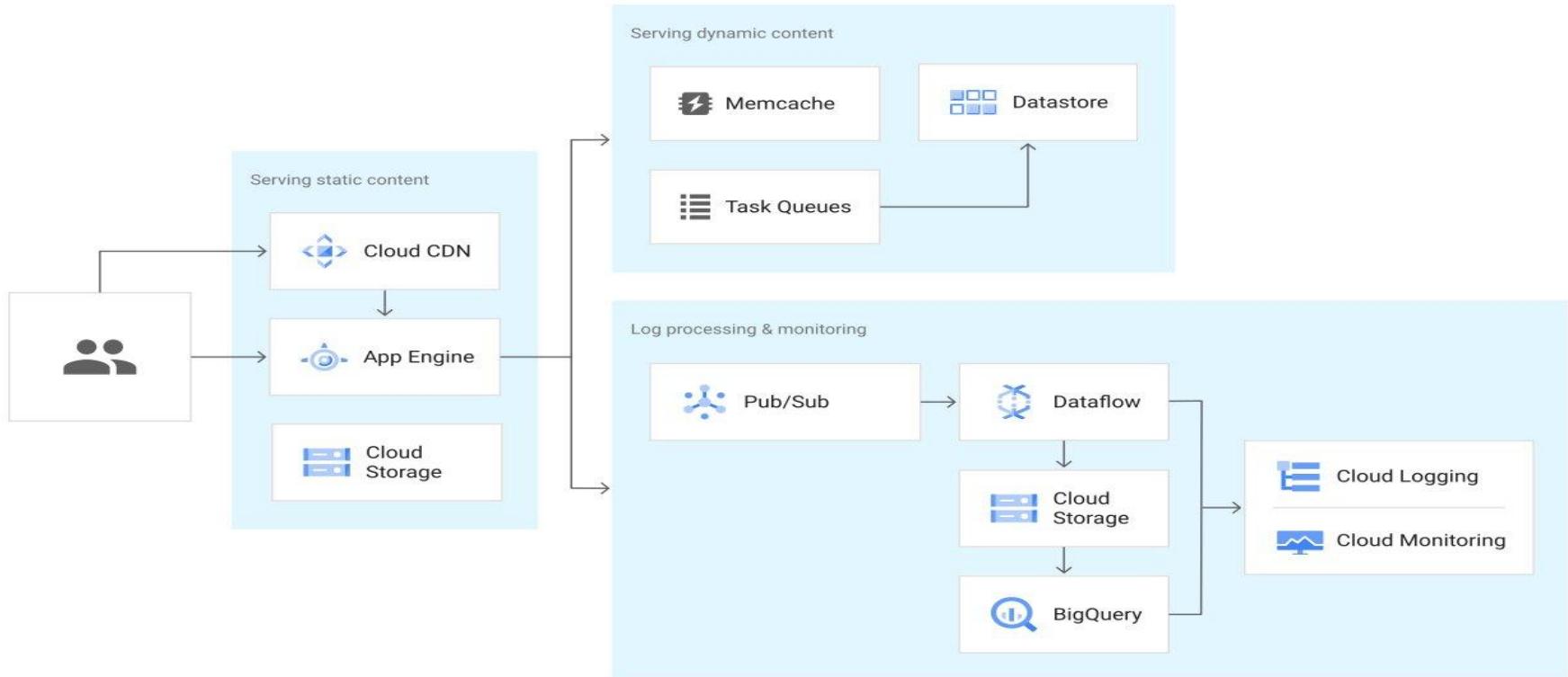
# **Google App Engine :**

- Google App Engine is a cloud computing platform as a service for developing and hosting web applications in Google-managed data centers.
- Applications are sandboxed and run across multiple servers.
- App Engine automatically allocates more resources for the web application to handle the additional demand.

# **Key Features:**

- Popular programming languages
- Open and Flexible
- Full managed
- Power application diagnostics
- Application versioning
- Traffic splitting
- Application security
- Service Ecosystem

# Use Case (Modern Web Application):



# MCQs

1. What kind of environment would a Go application be tested in?

ans : A sandboxed environment

2. If you want to develop your app using Java, what is necessary before starting?

ans : App Engine Java software development kit

3. What two programming languages do App Engine's tools use?

ans: Python and Java

4. What is Google App Engine for?

ans: Google App Engine is for running web applications on Google's infrastructure

# MCQs

5. When Java programming for App Engine, what a preferred development kit?

ans : Eclipse

6. Does the Python runtime environment include a Python interpreter?

ans : Yes

7. Why does Python in App Engine use the native JSON library?

ans : It is much faster than simplejson.

8. What scalable technologies is App Engine based off of?

ans : BigTable and GFS

# MCQs

9. What two programming languages do App Engine's tools use?

ans : Python and Java

10. App Engine does not support certificate type:

ans : DigiCert Extended Validation Multi-Domain Certificate (EV MD)

---

# Google app engine Demo

— 20mx217 & 20mx201 —

---

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[Sole-tenant nodes](#)

Help meet compliance, licensing, and management needs by keeping your instances physically separated with dedicated hardware.

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## App Engine

## Documentation

Choose an environment

## Standard environment

About the standard environment

Standard environment runtimes

Long-term support for legacy runtimes

Go

Java

Node.js

PHP

Python

Ruby

## Flexible environment

About the flexible environment

Known issues



App Engine &gt; Documentation

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App Engine is a fully managed, serverless platform for developing and hosting web applications at scale. You can choose from several popular languages, libraries, and frameworks to develop your apps, and then let App Engine take care of provisioning servers and scaling your app instances based on demand.

Pick a language to learn more.

Go

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PHP

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Java

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Node.js

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.NET

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with large amounts of data. Your application runs within its own secure, reliable environment that is independent of the hardware, operating system, or physical location of the server. [Learn more](#)

## Google App Engine Python 3 Standard Environment documentation

- [Overview](#)
- [Training and tutorials](#)
- [Use cases](#)
- [Code samples](#)
- [Videos](#)

### Guides

**Quickstart**

- [Setting Up your Development Environment](#)
- [Writing a Basic Web Service](#)
- [Testing and Deploying Your Application](#)
- [Creating Your Google Cloud Project](#)
- [Installing the Cloud Client Libraries for Python 3](#)

### Reference

- [app.yaml Configuration File](#)
- [Scheduling Jobs with cron.yaml](#)
- [Request Headers and Responses](#)
- [Dispatch.yaml Configuration File](#)
- [Configuring Datastore Indexes with index.yaml](#)

### Resources

- [Python 3 release notes](#)
- [Choosing a serverless option](#)
- [Pricing](#)
- [Quotas and limits](#)
- [Managing costs](#)
- [Troubleshooting](#)
- [Activating Windows](#)  
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Google Cloud Platform Select a project ▾

X Search

Filter by Project Any

Type

- API
- Marketplace Solution
- Project
- Folder
- Organization

App Engine Version

Backend bucket

Search bar: app

PRODUCTION PAGES

- ⚙️ App Engine
- ⚙️ Application Settings App Engine
- ⚙️ Applications Kubernetes Engine
- ⚙️ Cron jobs App Engine

DOCUMENTATION & TUTORIALS

- 🎓 App Engine Quickstart for Go Interactive Tutorial
- 🎓 App Engine Quickstart for Java Interactive Tutorial
- 🎓 App Engine Quickstart for Node.js Interactive Tutorial

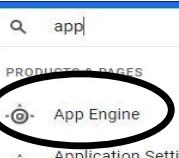
App

Type: RESOURCES

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App Engine default service account

Type: Service Account





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≡ Google Cloud Platform demo app

X ? ⓘ HIDE INFO PANEL LEARN

App Engine

Dashboard

HIDE INFO PANEL

LEARN

Dashboard

Services

Release Notes

CI

CLOUD SHELL

Terminal

(buoyant-keel-326013) +

Welcome to Cloud Shell! Type "help" to get started.  
Your Cloud Platform project in this session is set to **buoyant-keel-326013**.  
Use "gcloud config set project [PROJECT\_ID]" to change to a different project.  
sanjaykumar442000@cloudshell:~ (buoyant-keel-326013)\$ git clone https://github.com/GoogleCloudPlatform/python-docs-samples

Version 20210...

Today

7:15 PM Completed: Create App Engi... sanjaykumar442000@gmail...

7:11 PM Completed: Create App Engine version

Open Editor



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Google Cloud Platform demo app



CLOUD SHELL  
Editor

File Edit Selection View Go Run Terminal Help



EXPLORER: SANJAYKUM...



main.py x

```
1 # Copyright 2015 Google Inc. All Rights Reserved.
2 #
3 # Licensed under the Apache License, Version 2.0 (the "License");
4 # you may not use this file except in compliance with the License.
5 # You may obtain a copy of the License at
6 #
7 #     http://www.apache.org/licenses/LICENSE-2.0
8 #
9 # Unless required by applicable law or agreed to in writing, software
10 # distributed under the License is distributed on an "AS IS" BASIS,
11 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
12 # See the License for the specific language governing permissions and
13 # limitations under the License.
14
15 # [START gae_flex_quickstart]
16 import logging
17
18 from flask import Flask
19
20
21 app = Flask( name )
```



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P master 0 0 0 ▲ 0 Cloud Code minikube

Ln 1, Col 1 LF UTF-8 Spaces: 4 Python



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🔍 app

CLOUD SHELL  
Terminal

① (buoyant-keel-326013) ✎ +

Open Editor

Activate Cloud Shell

Close Reconnect

⚠ The connection to your Google Cloud Shell was lost.

```
remote: Enumerating objects: 56260, done.
remote: Counting objects: 100% (29/29), done.
remote: Compressing objects: 100% (26/26), done.
remote: Total 56260 (delta 12), reused 3 (delta 0), pack-reused 56231
Receiving objects: 100% (56260/56260), 75.54 MiB | 17.26 MiB/s, done.
Resolving deltas: 100% (31834/31834), done.
sanjaykumar442000@cloudshell:~ (buoyant-keel-326013)$ ls
python-docs-samples README-cloudshell.txt
sanjaykumar442000@cloudshell:~ (buoyant-keel-326013)$ cd python-docs-sample/appengine/
-bash: cd: python-docs-sample/appengine/: No such file or directory
sanjaykumar442000@cloudshell:~ (buoyant-keel-326013)$ cd python-docs-samples/appengine/
sanjaykumar442000@cloudshell:~/python-docs-samples/appengine (buoyant-keel-326013)$ ls
flexible standard standard_python3
sanjaykumar442000@cloudshell:~/python-docs-samples/appengine (buoyant-keel-326013)$ cd flexible/hello_world
sanjaykumar442000@cloudshell:~/python-docs-samples/appengine/flexible/hello_world (buoyant-keel-326013)$ gcloud app deploy
You are creating an app for project [buoyant-keel-326013].
WARNING: Creating an App Engine application for a project is irreversible and the region
cannot be changed. More information about regions is at
<https://cloud.google.com/appengine/docs/locations>.
```

Please choose the region where you want your App Engine application located:

- [1] asia-east1 (supports standard and flexible)
- [2] asia-east2 (supports standard and flexible and search\_api)
- [3] asia-northeast1 (supports standard and flexible and search\_api)
- [4] asia-northeast2 (supports standard and flexible and search\_api)
- [5] asia-northeast3 (supports standard and flexible and search\_api)

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CLOUD SHELL  
Terminal

(buoyant-keel-326013) X + ▾

[Open Editor](#)

Activate Cloud Shell

[Close](#) [Reconnect](#)

⚠ The connection to your Google Cloud Shell was lost.

```
9ccde33985aa: Layer already exists
10f01022707f: Layer already exists
Seeale554763: Layer already exists
f61ae728b1cd: Pushed
6284f83d9066: Pushed
4e38e67e5f18: Layer already exists
4cdce7a98dae: Pushed
755297441977: Layer already exists
abef388ed842: Layer already exists
3004090ba2bb: Layer already exists
a4d785993cc3: Pushed
84ff92691f90: Layer already exists
2f0c6ca9a77d: Layer already exists
15fbcc790c7cd: Layer already exists
latest: digest: sha256:36492663e34a014d30fd9249cefeba6b5753ed81a1a83cf7aa864deeb8465c96 size: 3669
DONE
```

Updating service [default] (this may take several minutes)...done.

Setting traffic split for service [default]...done.

Deployed service [default] to [<https://buoyant-keel-326013.firebaseioapp.com>]

You can stream logs from the command line by running:

```
$ gcloud app logs tail -s default
```

To view your application in the web browser run:

```
$ gcloud app browse
sanjaykumar442000@cloudshell:~/python-docs-samples/appengine/flexible/hello_world (buoyant-keel-326013)$ ^C
sanjaykumar442000@cloudshell:~/python-docs-samples/appengine/flexible/hello_world (buoyant-keel-326013)$
```

[Activate Windows](#)

Go to Settings to activate Windows.

Hello World!

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---

---

# **Overview of Amazon Web Services**

## **AWS Whitepaper**



## **Overview of Amazon Web Services: AWS Whitepaper**

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# Overview of Amazon Web Services

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## Abstract

Amazon Web Services offers a broad set of global cloud-based products including compute, storage, databases, analytics, networking, mobile, developer tools, management tools, IoT, security, and enterprise applications: on-demand, available in seconds, with pay-as-you-go pricing. From data warehousing to deployment tools, directories to content delivery, over 200 AWS services are available. New services can be provisioned quickly, without the upfront capital expense. This allows enterprises, start-ups, small and medium-sized businesses, and customers in the public sector to access the building blocks they need to respond quickly to changing business requirements. This whitepaper provides you with an overview of the benefits of the AWS Cloud and introduces you to the services that make up the platform.

## Introduction

In 2006, Amazon Web Services (AWS) began offering IT infrastructure services to businesses as web services—now commonly known as cloud computing. One of the key benefits of cloud computing is the opportunity to replace upfront capital infrastructure expenses with low variable costs that scale with your business. With the cloud, businesses no longer need to plan for and procure servers and other IT infrastructure weeks or months in advance. Instead, they can instantly spin up hundreds or thousands of servers in minutes and deliver results faster.

Today, AWS provides a highly reliable, scalable, low-cost infrastructure platform in the cloud that powers hundreds of thousands of businesses in 190 countries around the world.

# What Is Cloud Computing?

Cloud computing is the on-demand delivery of compute power, database, storage, applications, and other IT resources through a cloud services platform via the Internet with pay-as-you-go pricing. Whether you are running applications that share photos to millions of mobile users or you're supporting the critical operations of your business, a cloud services platform provides rapid access to flexible and low-cost IT resources. With cloud computing, you don't need to make large upfront investments in hardware and spend a lot of time on the heavy lifting of managing that hardware. Instead, you can provision exactly the right type and size of computing resources you need to power your newest bright idea or operate your IT department. You can access as many resources as you need, almost instantly, and only pay for what you use.

Cloud computing provides a simple way to access servers, storage, databases and a broad set of application services over the Internet. A cloud services platform such as Amazon Web Services owns and maintains the network-connected hardware required for these application services, while you provision and use what you need via a web application.

# Six Advantages of Cloud Computing

- **Trade capital expense for variable expense** – Instead of having to invest heavily in data centers and servers before you know how you're going to use them, you can pay only when you consume computing resources, and pay only for how much you consume.
- **Benefit from massive economies of scale** – By using cloud computing, you can achieve a lower variable cost than you can get on your own. Because usage from hundreds of thousands of customers is aggregated in the cloud, providers such as AWS can achieve higher economies of scale, which translates into lower pay as-you-go prices.
- **Stop guessing capacity** – Eliminate guessing on your infrastructure capacity needs. When you make a capacity decision prior to deploying an application, you often end up either sitting on expensive idle resources or dealing with limited capacity. With cloud computing, these problems go away. You can access as much or as little capacity as you need, and scale up and down as required with only a few minutes' notice.
- **Increase speed and agility** – In a cloud computing environment, new IT resources are only a click away, which means that you reduce the time to make those resources available to your developers from weeks to just minutes. This results in a dramatic increase in agility for the organization, since the cost and time it takes to experiment and develop is significantly lower.
- **Stop spending money running and maintaining data centers** – Focus on projects that differentiate your business, not the infrastructure. Cloud computing lets you focus on your own customers, rather than on the heavy lifting of racking, stacking, and powering servers.
- **Go global in minutes** – Easily deploy your application in multiple regions around the world with just a few clicks. This means you can provide lower latency and a better experience for your customers at minimal cost.

# Types of Cloud Computing

Cloud computing provides developers and IT departments with the ability to focus on what matters most and avoid undifferentiated work such as procurement, maintenance, and capacity planning. As cloud computing has grown in popularity, several different models and deployment strategies have emerged to help meet specific needs of different users. Each type of cloud service and deployment method provides you with different levels of control, flexibility, and management. Understanding the differences between Infrastructure as a Service, Platform as a Service, and Software as a Service, as well as what deployment strategies you can use, can help you decide what set of services is right for your needs.

## Cloud Computing Models

### Infrastructure as a Service (IaaS)

Infrastructure as a Service (IaaS) contains the basic building blocks for cloud IT and typically provides access to networking features, computers (virtual or on dedicated hardware), and data storage space. IaaS provides you with the highest level of flexibility and management control over your IT resources and is most similar to existing IT resources that many IT departments and developers are familiar with today.

### Platform as a Service (PaaS)

Platform as a Service (PaaS) removes the need for your organization to manage the underlying infrastructure (usually hardware and operating systems) and allows you to focus on the deployment and management of your applications. This helps you be more efficient as you don't need to worry about resource procurement, capacity planning, software maintenance, patching, or any of the other undifferentiated heavy lifting involved in running your application.

### Software as a Service (SaaS)

Software as a Service (SaaS) provides you with a completed product that is run and managed by the service provider. In most cases, people referring to Software as a Service are referring to end-user applications. With a SaaS offering you do not have to think about how the service is maintained or how the underlying infrastructure is managed; you only need to think about how you will use that particular piece of software. A common example of a SaaS application is web-based email which you can use to send and receive email without having to manage feature additions to the email product or maintain the servers and operating systems that the email program is running on.

## Cloud Computing Deployment Models

### Cloud

A cloud-based application is fully deployed in the cloud and all parts of the application run in the cloud. Applications in the cloud have either been created in the cloud or have been migrated from an existing infrastructure to take advantage of the [benefits of cloud computing](#). Cloud-based applications can be built on low-level infrastructure pieces or can use higher level services that provide abstraction from the management, architecting, and scaling requirements of core infrastructure.

## Hybrid

A hybrid deployment is a way to connect infrastructure and applications between cloud-based resources and existing resources that are not located in the cloud. The most common method of hybrid deployment is between the cloud and existing on-premises infrastructure to extend, and grow, an organization's infrastructure into the cloud while connecting cloud resources to the internal system. For more information on how AWS can help you with your hybrid deployment, visit our [Hybrid Cloud with AWS](#) page.

## On-premises

The deployment of resources on-premises, using virtualization and resource management tools, is sometimes called the “private cloud.” On-premises deployment doesn’t provide many of the benefits of cloud computing but is sometimes sought for its ability to provide dedicated resources. In most cases this deployment model is the same as legacy IT infrastructure while using application management and virtualization technologies to try and increase resource utilization. For more information on how AWS can help, see [Use case: Cloud services on-premises](#).

# Global Infrastructure

AWS serves over a million active customers in more than 240 countries and territories. We are steadily expanding global infrastructure to help our customers achieve lower latency and higher throughput, and to ensure that their data resides only in the AWS Region they specify. As our customers grow their businesses, AWS will continue to provide infrastructure that meets their global requirements.

The AWS Cloud infrastructure is built around AWS Regions and Availability Zones. An AWS Region is a physical location in the world where we have multiple Availability Zones. Availability Zones consist of one or more discrete data centers, each with redundant power, networking, and connectivity, housed in separate facilities. These Availability Zones offer you the ability to operate production applications and databases that are more highly available, fault tolerant, and scalable than would be possible from a single data center. The AWS Cloud operates in 80 Availability Zones within 25 geographic Regions around the world, with announced plans for more Availability Zones and Regions. For more information on the AWS Cloud Availability Zones and AWS Regions, see [AWS Global Infrastructure](#).

Each Amazon Region is designed to be completely isolated from the other Amazon Regions. This achieves the greatest possible fault tolerance and stability. Each Availability Zone is isolated, but the Availability Zones in a Region are connected through low-latency links. AWS provides you with the flexibility to place instances and store data within multiple geographic regions as well as across multiple Availability Zones within each AWS Region. Each Availability Zone is designed as an independent failure zone. This means that Availability Zones are physically separated within a typical metropolitan region and are located in lower risk flood plains (specific flood zone categorization varies by AWS Region). In addition to discrete uninterruptible power supply (UPS) and onsite backup generation facilities, data centers located in different Availability Zones are designed to be supplied by independent substations to reduce the risk of an event on the power grid impacting more than one Availability Zone. Availability Zones are all redundantly connected to multiple tier-1 transit providers.

# Security and Compliance

## Security

[Cloud security](#) at AWS is the highest priority. As an AWS customer, you will benefit from a data center and network architecture built to meet the requirements of the most security-sensitive organizations. Security in the cloud is much like security in your on-premises data centers—only without the costs of maintaining facilities and hardware. In the cloud, you don't have to manage physical servers or storage devices. Instead, you use software-based security tools to monitor and protect the flow of information into and out of your cloud resources.

An advantage of the AWS Cloud is that it allows you to scale and innovate, while maintaining a secure environment and paying only for the services you use. This means that you can have the security you need at a lower cost than in an on-premises environment.

As an AWS customer you inherit all the best practices of AWS policies, architecture, and operational processes built to satisfy the requirements of our most security-sensitive customers. Get the flexibility and agility you need in security controls.

The AWS Cloud enables a shared responsibility model. While AWS manages security **of** the cloud, you are responsible for security **in** the cloud. This means that you retain control of the security you choose to implement to protect your own content, platform, applications, systems, and networks no differently than you would in an on-site data center.

AWS provides you with guidance and expertise through online resources, personnel, and partners. AWS provides you with advisories for current issues, plus you have the opportunity to work with AWS when you encounter security issues.

You get access to hundreds of tools and features to help you to meet your security objectives. AWS provides security-specific tools and features across network security, configuration management, access control, and data encryption.

Finally, AWS environments are continuously audited, with certifications from accreditation bodies across geographies and verticals. In the AWS environment, you can take advantage of automated tools for asset inventory and privileged access reporting.

## Benefits of AWS Security

- **Keep Your Data Safe:** The AWS infrastructure puts strong safeguards in place to help protect your privacy. All data is stored in highly secure AWS data centers.
- **Meet Compliance Requirements:** AWS manages dozens of compliance programs in its infrastructure. This means that segments of your compliance have already been completed.
- **Save Money:** Cut costs by using AWS data centers. Maintain the highest standard of security without having to manage your own facility
- **Scale Quickly:** Security scales with your AWS Cloud usage. No matter the size of your business, the AWS infrastructure is designed to keep your data safe.

## Compliance

[AWS Cloud Compliance](#) enables you to understand the robust controls in place at AWS to maintain security and data protection in the cloud. As systems are built on top of AWS Cloud infrastructure,

compliance responsibilities will be shared. By tying together governance-focused, audit-friendly service features with applicable compliance or audit standards, AWS Compliance enablers build on traditional programs. This helps customers to establish and operate in an AWS security control environment.

The IT infrastructure that AWS provides to its customers is designed and managed in alignment with best security practices and a variety of IT security standards. The following is a partial list of assurance programs with which AWS complies:

- SOC 1/ISAE 3402, SOC 2, SOC 3
- FISMA, DIACAP, and FedRAMP
- PCI DSS Level 1
- ISO 9001, ISO 27001, ISO 27017, ISO 27018

AWS provides customers a wide range of information on its IT control environment in whitepapers, reports, certifications, accreditations, and other third-party attestations. More information is available in the [Risk and Compliance whitepaper](#) and the [AWS Security Center](#).

# Amazon Web Services Cloud

## Topics

- [AWS Management Console \(p. 9\)](#)
- [AWS Command Line Interface \(p. 9\)](#)
- [Software Development Kits \(p. 10\)](#)
- [Analytics \(p. 10\)](#)
- [Application Integration \(p. 14\)](#)
- [AR and VR \(p. 16\)](#)
- [Blockchain \(p. 17\)](#)
- [Business Applications \(p. 17\)](#)
- [Cloud Financial Management \(p. 19\)](#)
- [Compute Services \(p. 20\)](#)
- [Contact Center \(p. 24\)](#)
- [Containers \(p. 25\)](#)
- [Database \(p. 26\)](#)
- [Developer Tools \(p. 29\)](#)
- [End User Computing \(p. 31\)](#)
- [Front-End Web & Mobile Services \(p. 32\)](#)
- [Game Tech \(p. 34\)](#)
- [Internet of Things \(IoT\) \(p. 34\)](#)
- [Machine Learning \(p. 39\)](#)
- [Management and Governance \(p. 48\)](#)
- [Media Services \(p. 54\)](#)
- [Migration and Transfer \(p. 57\)](#)
- [Networking and Content Delivery \(p. 60\)](#)
- [Quantum Technologies \(p. 64\)](#)
- [Robotics \(p. 64\)](#)
- [Satellite \(p. 65\)](#)
- [Security, Identity, and Compliance \(p. 65\)](#)
- [Storage \(p. 72\)](#)

## AWS Management Console

Access and manage Amazon Web Services through the [AWS Management Console](#), a simple and intuitive user interface. You can also use the [AWS Console Mobile Application](#) to quickly view resources on the go.

## AWS Command Line Interface

The [AWS Command Line Interface \(CLI\)](#) is a unified tool to manage your AWS services. With just one tool to download and configure, you can control multiple AWS services from the command line and automate them through scripts.

# Software Development Kits

Our [Software Development Kits \(SDKs\)](#) simplify using AWS services in your applications with an Application Program Interface (API) tailored to your programming language or platform.

## Analytics

### Topics

- [Amazon Athena \(p. 10\)](#)
- [Amazon CloudSearch \(p. 10\)](#)
- [Amazon Elasticsearch Service \(p. 11\)](#)
- [Amazon EMR \(p. 11\)](#)
- [Amazon FinSpace \(p. 11\)](#)
- [Amazon Kinesis \(p. 11\)](#)
- [Amazon Kinesis Data Firehose \(p. 12\)](#)
- [Amazon Kinesis Data Analytics \(p. 12\)](#)
- [Amazon Kinesis Data Streams \(p. 12\)](#)
- [Amazon Kinesis Video Streams \(p. 12\)](#)
- [Amazon Redshift \(p. 12\)](#)
- [Amazon QuickSight \(p. 13\)](#)
- [AWS Data Exchange \(p. 13\)](#)
- [AWS Data Pipeline \(p. 13\)](#)
- [AWS Glue \(p. 13\)](#)
- [AWS Lake Formation \(p. 14\)](#)
- [Amazon Managed Streaming for Apache Kafka \(Amazon MSK\) \(p. 14\)](#)

## Amazon Athena

[Amazon Athena](#) is an interactive query service that makes it easy to analyze data in Amazon S3 using standard SQL. Athena is serverless, so there is no infrastructure to manage, and you pay only for the queries that you run.

Athena is easy to use. Simply point to your data in Amazon S3, define the schema, and start querying using standard SQL. Most results are delivered within seconds. With Athena, there's no need for complex extract, transform, and load (ETL) jobs to prepare your data for analysis. This makes it easy for anyone with SQL skills to quickly analyze large-scale datasets.

Athena is out-of-the-box integrated with AWS Glue Data Catalog, allowing you to create a unified metadata repository across various services, crawl data sources to discover schemas and populate your Catalog with new and modified table and partition definitions, and maintain schema versioning.

## Amazon CloudSearch

[Amazon CloudSearch](#) is a managed service in the AWS Cloud that makes it simple and cost-effective to set up, manage, and scale a search solution for your website or application. Amazon CloudSearch

supports 34 languages and popular search features such as highlighting, autocomplete, and geospatial search.

## Amazon Elasticsearch Service

[Amazon Elasticsearch Service](#) makes it easy to deploy, secure, operate, and scale Elasticsearch to search, analyze, and visualize data in real-time. With Amazon Elasticsearch Service, you get easy-to-use APIs and real-time analytics capabilities to power use-cases such as log analytics, full-text search, application monitoring, and clickstream analytics, with enterprise-grade availability, scalability, and security. The service offers integrations with open-source tools like Kibana and Logstash for data ingestion and visualization. It also integrates seamlessly with other AWS services such as [Amazon Virtual Private Cloud \(Amazon VPC\)](#), [AWS Key Management Service \(AWS KMS\)](#), [Amazon Kinesis Data Firehose](#), [AWS Lambda](#), [AWS Identity and Access Management \(IAM\)](#), [Amazon Cognito](#), and [Amazon CloudWatch](#), so that you can go from raw data to actionable insights quickly.

## Amazon EMR

[Amazon EMR](#) is the industry-leading cloud big data platform for processing vast amounts of data using open source tools such as [Apache Spark](#), [Apache Hive](#), [Apache HBase](#), [Apache Flink](#), [Apache Hudi](#), and [Presto](#). Amazon EMR makes it easy to set up, operate, and scale your big data environments by automating time-consuming tasks like provisioning capacity and tuning clusters. With EMR you can run petabyte-scale analysis at [less than half of the cost](#) of traditional on-premises solutions and [over 3x faster](#) than standard Apache Spark. You can run workloads on Amazon EC2 instances, on Amazon Elastic Kubernetes Service (EKS) clusters, or on-premises using EMR on AWS Outposts.

## Amazon FinSpace

[Amazon FinSpace](#) is a data management and analytics service purpose-built for the financial services industry (FSI). FinSpace reduces the time you spend finding and preparing petabytes of financial data to be ready for analysis from months to minutes.

Financial services organizations analyze data from internal data stores like portfolio, actuarial, and risk management systems as well as petabytes of data from third-party data feeds, such as historical securities prices from stock exchanges. It can take months to find the right data, get permissions to access the data in a compliant way, and prepare it for analysis.

FinSpace removes the heavy lifting of building and maintaining a data management system for financial analytics. With FinSpace, you collect data and catalog it by relevant business concepts such as asset class, risk classification, or geographic region. FinSpace makes it easy to discover and share data across your organization in accordance with your compliance requirements. You define your data access policies in one place and FinSpace enforces them while keeping audit logs to allow for compliance and activity reporting. FinSpace also includes a library of 100+ functions, like time bars and Bollinger bands, for you to prepare data for analysis.

## Amazon Kinesis

[Amazon Kinesis](#) makes it easy to collect, process, and analyze real-time, streaming data so you can get timely insights and react quickly to new information. Amazon Kinesis offers key capabilities to cost-effectively process streaming data at any scale, along with the flexibility to choose the tools that best suit the requirements of your application. With Amazon Kinesis, you can ingest real-time data such as video, audio, application logs, website clickstreams, and IoT telemetry data for machine learning, analytics, and other applications. Amazon Kinesis enables you to process and analyze data as it arrives and respond instantly instead of having to wait until all your data is collected before the processing can begin.

Amazon Kinesis currently offers four services: Kinesis Data Firehose, Kinesis Data Analytics, Kinesis Data Streams, and Kinesis Video Streams.

## Amazon Kinesis Data Firehose

[Amazon Kinesis Data Firehose](#) is the easiest way to reliably load streaming data into data stores and analytics tools. It can capture, transform, and load streaming data into Amazon S3, Amazon Redshift, Amazon Elasticsearch Service, and Splunk, enabling near real-time analytics with existing business intelligence tools and dashboards you're already using today. It is a fully managed service that automatically scales to match the throughput of your data and requires no ongoing administration. It can also batch, compress, transform, and encrypt the data before loading it, minimizing the amount of storage used at the destination and increasing security.

You can easily create a Firehose delivery stream from the AWS Management Console, configure it with a few clicks, and start sending data to the stream from hundreds of thousands of data sources to be loaded continuously to AWS—all in just a few minutes. You can also configure your delivery stream to automatically convert the incoming data to columnar formats like Apache Parquet and Apache ORC, before the data is delivered to Amazon S3, for cost-effective storage and analytics.

## Amazon Kinesis Data Analytics

[Amazon Kinesis Data Analytics](#) is the easiest way to analyze streaming data, gain actionable insights, and respond to your business and customer needs in real time. Amazon Kinesis Data Analytics reduces the complexity of building, managing, and integrating streaming applications with other AWS services. SQL users can easily query streaming data or build entire streaming applications using templates and an interactive SQL editor. Java developers can quickly build sophisticated streaming applications using open source Java libraries and AWS integrations to transform and analyze data in real-time.

Amazon Kinesis Data Analytics takes care of everything required to run your queries continuously and scales automatically to match the volume and throughput rate of your incoming data.

## Amazon Kinesis Data Streams

[Amazon Kinesis Data Streams](#) is a massively scalable and durable real-time data streaming service. KDS can continuously capture gigabytes of data per second from hundreds of thousands of sources such as website clickstreams, database event streams, financial transactions, social media feeds, IT logs, and location-tracking events. The data collected is available in milliseconds to enable real-time analytics use cases such as real-time dashboards, real-time anomaly detection, dynamic pricing, and more.

## Amazon Kinesis Video Streams

[Amazon Kinesis Video Streams](#) makes it easy to securely stream video from connected devices to AWS for analytics, machine learning (ML), playback, and other processing. Kinesis Video Streams automatically provisions and elastically scales all the infrastructure needed to ingest streaming video data from millions of devices. It also durably stores, encrypts, and indexes video data in your streams, and allows you to access your data through easy-to-use APIs. Kinesis Video Streams enables you to playback video for live and on-demand viewing, and quickly build applications that take advantage of computer vision and video analytics through integration with Amazon Rekognition Video, and libraries for ML frameworks such as Apache MxNet, TensorFlow, and OpenCV.

## Amazon Redshift

[Amazon Redshift](#) is the most widely used cloud data warehouse. It makes it fast, simple and cost-effective to analyze all your data using standard SQL and your existing Business Intelligence (BI) tools.

It allows you to run complex analytic queries against terabytes to petabytes of structured and semi-structured data, using sophisticated query optimization, columnar storage on high-performance storage, and massively parallel query execution. Most results come back in seconds. You can start small for just \$0.25 per hour with no commitments and scale out to petabytes of data for \$1,000 per terabyte per year, less than a tenth the cost of traditional on-premises solutions.

## Amazon QuickSight

[Amazon QuickSight](#) is a fast, cloud-powered business intelligence (BI) service that makes it easy for you to deliver insights to everyone in your organization. QuickSight lets you create and publish interactive dashboards that can be accessed from browsers or mobile devices. You can embed dashboards into your applications, providing your customers with powerful self-service analytics. QuickSight easily scales to tens of thousands of users without any software to install, servers to deploy, or infrastructure to manage.

## AWS Data Exchange

[AWS Data Exchange](#) makes it easy to find, subscribe to, and use third-party data in the cloud. Qualified data providers include category-leading brands such as Reuters, who curate data from over 2.2 million unique news stories per year in multiple languages; Change Healthcare, who process and anonymize more than 14 billion healthcare transactions and \$1 trillion in claims annually; Dun & Bradstreet, who maintain a database of more than 330 million global business records; and Foursquare, whose location data is derived from 220 million unique consumers and includes more than 60 million global commercial venues.

Once subscribed to a data product, you can use the AWS Data Exchange API to load data directly into [Amazon S3](#) and then analyze it with a wide variety of AWS [analytics](#) and [machine learning](#) services. For example, property insurers can subscribe to data to analyze historical weather patterns to calibrate insurance coverage requirements in different geographies; restaurants can subscribe to population and location data to identify optimal regions for expansion; academic researchers can conduct studies on climate change by subscribing to data on carbon dioxide emissions; and healthcare professionals can subscribe to aggregated data from historical clinical trials to accelerate their research activities.

For data providers, AWS Data Exchange makes it easy to reach the millions of AWS customers migrating to the cloud by removing the need to build and maintain infrastructure for data storage, delivery, billing, and entitling.

## AWS Data Pipeline

[AWS Data Pipeline](#) is a web service that helps you reliably process and move data between different AWS compute and storage services, as well as on-premises data sources, at specified intervals. With AWS Data Pipeline, you can regularly access your data where it's stored, transform and process it at scale, and efficiently transfer the results to AWS services such as [Amazon S3 \(p. 74\)](#), [Amazon RDS \(p. 28\)](#), [Amazon DynamoDB \(p. 26\)](#), and [Amazon EMR \(p. 11\)](#).

AWS Data Pipeline helps you easily create complex data processing workloads that are fault tolerant, repeatable, and highly available. You don't have to worry about ensuring resource availability, managing inter-task dependencies, retrying transient failures or timeouts in individual tasks, or creating a failure notification system. AWS Data Pipeline also allows you to move and process data that was previously locked up in on-premises data silos.

## AWS Glue

[AWS Glue](#) is a fully managed extract, transform, and load (ETL) service that makes it easy for customers to prepare and load their data for analytics. You can create and run an ETL job with a few clicks in the

AWS Management Console. You simply point AWS Glue to your data stored on AWS, and AWS Glue discovers your data and stores the associated metadata (e.g. table definition and schema) in the AWS Glue Data Catalog. Once cataloged, your data is immediately searchable, queryable, and available for ETL.

## AWS Lake Formation

[AWS Lake Formation](#) is a service that makes it easy to set up a secure data lake in days. A data lake is a centralized, curated, and secured repository that stores all your data, both in its original form and prepared for analysis. A data lake enables you to break down data silos and combine different types of analytics to gain insights and guide better business decisions.

However, setting up and managing data lakes today involves a lot of manual, complicated, and time-consuming tasks. This work includes loading data from diverse sources, monitoring those data flows, setting up partitions, turning on encryption and managing keys, defining transformation jobs and monitoring their operation, re-organizing data into a columnar format, configuring access control settings, deduplicating redundant data, matching linked records, granting access to data sets, and auditing access over time.

Creating a data lake with Lake Formation is as simple as defining where your data resides and what data access and security policies you want to apply. Lake Formation then collects and catalogs data from databases and object storage, moves the data into your new Amazon S3 data lake, cleans and classifies data using machine learning algorithms, and secures access to your sensitive data. Your users can then access a centralized catalog of data which describes available data sets and their appropriate usage. Your users then leverage these data sets with their choice of analytics and machine learning services, like Amazon EMR for Apache Spark, Amazon Redshift, Amazon Athena, SageMaker, and Amazon QuickSight.

## Amazon Managed Streaming for Apache Kafka (Amazon MSK)

[Amazon Managed Streaming for Apache Kafka \(Amazon MSK\)](#) is a fully managed service that makes it easy for you to build and run applications that use [Apache Kafka](#) to process streaming data. Apache Kafka is an open-source platform for building real-time streaming data pipelines and applications. With Amazon MSK, you can use Apache Kafka APIs to populate data lakes, stream changes to and from databases, and power machine learning and analytics applications.

Apache Kafka clusters are challenging to setup, scale, and manage in production. When you run Apache Kafka on your own, you need to provision servers, configure Apache Kafka manually, replace servers when they fail, orchestrate server patches and upgrades, architect the cluster for high availability, ensure data is durably stored and secured, setup monitoring and alarms, and carefully plan scaling events to support load changes. Amazon MSK makes it easy for you to build and run production applications on Apache Kafka without needing Apache Kafka infrastructure management expertise. That means you spend less time managing infrastructure and more time building applications.

With a few clicks in the [Amazon MSK console](#) you can create highly available Apache Kafka clusters with settings and configuration based on Apache Kafka's deployment best practices. Amazon MSK automatically provisions and runs your Apache Kafka clusters. Amazon MSK continuously monitors cluster health and automatically replaces unhealthy nodes with no downtime to your application. In addition, Amazon MSK secures your Apache Kafka cluster by encrypting data at rest.

## Application Integration

### Topics

- [AWS Step Functions \(p. 15\)](#)
- [Amazon AppFlow \(p. 15\)](#)
- [Amazon EventBridge \(p. 15\)](#)
- [Amazon Managed Workflows for Apache Airflow \(MWAA\) \(p. 15\)](#)
- [Amazon MQ \(p. 16\)](#)
- [Amazon Simple Notification Service \(p. 16\)](#)
- [Amazon Simple Queue Service \(p. 16\)](#)
- [Amazon Simple Workflow Service \(p. 16\)](#)

## AWS Step Functions

[AWS Step Functions](#) is a fully managed service that makes it easy to coordinate the components of distributed applications and microservices using visual workflows. Building applications from individual components that each perform a discrete function lets you scale easily and change applications quickly. Step Functions is a reliable way to coordinate components and step through the functions of your application. Step Functions provides a graphical console to arrange and visualize the components of your application as a series of steps. This makes it simple to build and run multi-step applications. Step Functions automatically triggers and tracks each step, and retries when there are errors, so your application runs in order and as expected. Step Functions logs the state of each step, so when things do go wrong, you can diagnose and debug problems quickly. You can change and add steps without even writing code, so you can easily evolve your application and innovate faster.

## Amazon AppFlow

[Amazon AppFlow](#) is a fully managed integration service that enables you to securely transfer data between Software-as-a-Service (SaaS) applications like Salesforce, Zendesk, Slack, and ServiceNow, and AWS services like Amazon S3 and Amazon Redshift, in just a few clicks. With Amazon AppFlow, you can run data flows at enterprise scale at the frequency you choose - on a schedule, in response to a business event, or on demand. You can configure data transformation capabilities like filtering and validation to generate rich, ready-to-use data as part of the flow itself, without additional steps. Amazon AppFlow automatically encrypts data in motion, and allows users to restrict data from flowing over the public Internet for SaaS applications that are integrated with AWS PrivateLink, reducing exposure to security threats.

## Amazon EventBridge

[Amazon EventBridge](#) is a serverless event bus that makes it easier to build event-driven applications at scale using events generated from your applications, integrated Software-as-a-Service (SaaS) applications, and AWS services. EventBridge delivers a stream of real-time data from event sources such as Zendesk or Shopify to targets like AWS Lambda and other SaaS applications. You can set up routing rules to determine where to send your data to build application architectures that react in real-time to your data sources with event publisher and consumer completely decoupled.

## Amazon Managed Workflows for Apache Airflow (MWAA)

[Amazon Managed Workflows for Apache Airflow \(MWAA\)](#) is a managed orchestration service for [Apache Airflow](#) that makes it easier to set up and operate end-to-end data pipelines in the cloud at scale. Apache Airflow is an open-source tool used to programmatically author, schedule, and monitor sequences of

processes and tasks referred to as “workflows.” With Managed Workflows, you can use Airflow and Python to create workflows without having to manage the underlying infrastructure for scalability, availability, and security. Managed Workflows automatically scales its workflow execution capacity to meet your needs, and is integrated with AWS security services to help provide you with fast and secure access to data.

## Amazon MQ

[Amazon MQ](#) is a managed message broker service for [Apache ActiveMQ](#) and [RabbitMQ](#) that makes it easy to set up and operate message brokers in the cloud. Message brokers allow different software systems—often using different programming languages, and on different platforms—to communicate and exchange information. Amazon MQ reduces your operational load by managing the provisioning, setup, and maintenance of ActiveMQ and [RabbitMQ](#), popular open-source message brokers. Connecting your current applications to Amazon MQ is easy because it uses industry-standard APIs and protocols for messaging, including JMS, NMS, AMQP, STOMP, MQTT, and WebSocket. Using standards means that in most cases, there’s no need to rewrite any messaging code when you migrate to AWS.

## Amazon Simple Notification Service

[Amazon Simple Notification Service \(Amazon SNS\)](#) is a highly available, durable, secure, fully managed pub/sub messaging service that enables you to decouple microservices, distributed systems, and serverless applications. Amazon SNS provides topics for high-throughput, push-based, many-to-many messaging. Using Amazon SNS topics, your publisher systems can fan out messages to a large number of subscriber endpoints for parallel processing, including Amazon SQS queues, AWS Lambda functions, and HTTP/S webhooks. Additionally, SNS can be used to fan out notifications to end users using mobile push, SMS, and email.

## Amazon Simple Queue Service

[Amazon Simple Queue Service \(Amazon SQS\)](#) is a fully managed message queuing service that enables you to decouple and scale microservices, distributed systems, and serverless applications. SQS eliminates the complexity and overhead associated with managing and operating message oriented middleware, and empowers developers to focus on differentiating work. Using SQS, you can send, store, and receive messages between software components at any volume, without losing messages or requiring other services to be available. Get started with SQS in minutes using the AWS console, Command Line Interface or SDK of your choice, and three simple commands.

SQS offers two types of message queues. Standard queues offer maximum throughput, best-effort ordering, and at-least-once delivery. SQS FIFO queues are designed to guarantee that messages are processed exactly once, in the exact order that they are sent.

## Amazon Simple Workflow Service

[Amazon Simple Workflow Service \(Amazon SWF\)](#) helps developers build, run, and scale background jobs that have parallel or sequential steps. You can think of Amazon SWF as a fully-managed state tracker and task coordinator in the cloud. If your application’s steps take more than 500 milliseconds to complete, you need to track the state of processing. If you need to recover or retry if a task fails, Amazon SWF can help you.

# AR and VR

## Topics

- [Amazon Sumerian \(p. 17\)](#)

## Amazon Sumerian

**Amazon Sumerian** lets you create and run virtual reality (VR), augmented reality (AR), and 3D applications quickly and easily without requiring any specialized programming or 3D graphics expertise. With Sumerian, you can build highly immersive and interactive scenes that run on popular hardware such as Oculus Go, Oculus Rift, HTC Vive, HTC Vive Pro, Google Daydream, and Lenovo Mirage as well as Android and iOS mobile devices. For example, you can build a virtual classroom that lets you train new employees around the world, or you can build a virtual environment that enables people to tour a building remotely. Sumerian makes it easy to create all the building blocks needed to build highly immersive and interactive 3D experiences including adding objects (e.g. characters, furniture, and landscape), and designing, animating, and scripting environments. Sumerian does not require specialized expertise and you can design scenes directly from your browser.

## Blockchain

### Topics

- [Amazon Managed Blockchain \(p. 17\)](#)

## Amazon Managed Blockchain

**Amazon Managed Blockchain** is a fully managed service that makes it easy to create and manage scalable blockchain networks using the popular open source frameworks Hyperledger Fabric and Ethereum.

Blockchain makes it possible to build applications where multiple parties can execute transactions without the need for a trusted, central authority. Today, building a scalable blockchain network with existing technologies is complex to set up and hard to manage. To create a blockchain network, each network member needs to manually provision hardware, install software, create and manage certificates for access control, and configure networking components. Once the blockchain network is running, you need to continuously monitor the infrastructure and adapt to changes, such as an increase in transaction requests, or new members joining or leaving the network.

Amazon Managed Blockchain is a fully managed service that allows you to set up and manage a scalable blockchain network with just a few clicks. Amazon Managed Blockchain eliminates the overhead required to create the network, and automatically scales to meet the demands of thousands of applications running millions of transactions. Once your network is up and running, Managed Blockchain makes it easy to manage and maintain your blockchain network. It manages your certificates, lets you easily invite new members to join the network, and tracks operational metrics such as usage of compute, memory, and storage resources. In addition, Managed Blockchain can replicate an immutable copy of your blockchain network activity into Amazon Quantum Ledger Database (QLDB), a fully managed ledger database. This allows you to easily analyze the network activity outside the network and gain insights into trends.

## Business Applications

### Topics

- [Alexa for Business \(p. 18\)](#)
- [Amazon Chime \(p. 18\)](#)

- [Amazon SES \(p. 18\)](#)
- [Amazon WorkDocs \(p. 18\)](#)
- [Amazon WorkMail \(p. 18\)](#)

## Alexa for Business

[Alexa for Business](#) is a service that enables organizations and employees to use Alexa to get more work done. With Alexa for Business, employees can use Alexa as their intelligent assistant to be more productive in meeting rooms, at their desks, and even with the Alexa devices they already have at home.

## Amazon Chime

[Amazon Chime](#) is a communications service that transforms online meetings with a secure, easy-to-use application that you can trust. Amazon Chime works seamlessly across your devices so that you can stay connected. You can use Amazon Chime for online meetings, video conferencing, calls, chat, and to share content, both inside and outside your organization.

Amazon Chime works with Alexa for Business, which means you can use Alexa to start your meetings with your voice. Alexa can start your video meetings in large conference rooms, and automatically dial into online meetings in smaller huddle rooms and from your desk.

## Amazon SES

[Amazon Simple Email Service \(Amazon SES\)](#) is a cost-effective, flexible, and scalable email service that enables developers to send mail from within any application. You can configure Amazon SES quickly to support several email use cases, including transactional, marketing, or mass email communications. Amazon SES's flexible IP deployment and email authentication options help drive higher deliverability and protect sender reputation, while sending analytics measure the impact of each email. With Amazon SES, you can send email securely, globally, and at scale.

## Amazon WorkDocs

[Amazon WorkDocs](#) is a fully managed, secure enterprise storage and sharing service with strong administrative controls and feedback capabilities that improve user productivity.

Users can comment on files, send them to others for feedback, and upload new versions without having to resort to emailing multiple versions of their files as attachments. Users can take advantage of these capabilities wherever they are, using the device of their choice, including PCs, Macs, tablets, and phones. Amazon WorkDocs offers IT administrators the option of integrating with existing corporate directories, flexible sharing policies and control of the location where data is stored. You can get started using Amazon WorkDocs with a 30-day free trial providing 1 TB of storage per user for up to 50 users.

## Amazon WorkMail

[Amazon WorkMail](#) is a secure, managed business email and calendar service with support for existing desktop and mobile email client applications. Amazon WorkMail gives users the ability to seamlessly access their email, contacts, and calendars using the client application of their choice, including Microsoft Outlook, native iOS and Android email applications, any client application supporting the IMAP protocol, or directly through a web browser. You can integrate Amazon WorkMail with your existing corporate directory, use email journaling to meet compliance requirements, and control both the keys that encrypt your data and the location in which your data is stored. You can also set up interoperability with Microsoft Exchange Server, and programmatically manage users, groups, and resources using the Amazon WorkMail SDK.

# Cloud Financial Management

## Topics

- [AWS Application Cost Profiler \(p. 19\)](#)
- [AWS Cost Explorer \(p. 19\)](#)
- [AWS Budgets \(p. 19\)](#)
- [AWS Cost & Usage Report \(p. 19\)](#)
- [Reserved Instance \(RI\) Reporting \(p. 20\)](#)
- [Savings Plans \(p. 20\)](#)

## AWS Application Cost Profiler

[AWS Application Cost Profiler](#) provides you the ability to track the consumption of shared AWS resources used by software applications and report granular cost breakdown across tenant base. You can achieve economies of scale with the shared infrastructure model, while still maintaining a clear line of sight to detailed resource consumption information across multiple dimensions.

With the proportionate cost insights of shared AWS resources, organizations running applications can establish the data foundation for accurate cost allocation model, and ISV selling applications can better understand your profitability and customize pricing strategies for your end customers.

## AWS Cost Explorer

[AWS Cost Explorer](#) has an easy-to-use interface that lets you visualize, understand, and manage your AWS costs and usage over time. Get started quickly by creating custom reports (including charts and tabular data) that analyze cost and usage data, both at a high level (e.g., total costs and usage across all accounts) and for highly-specific requests (e.g., m2.2xlarge costs within account Y that are tagged "project: secretProject").

## AWS Budgets

[AWS Budgets](#) gives you the ability to set custom budgets that alert you when your costs or usage exceed (or are forecasted to exceed) your budgeted amount. You can also use AWS Budgets to set RI utilization or coverage targets and receive alerts when your utilization drops below the threshold you define. RI alerts support Amazon EC2, Amazon RDS, Amazon Redshift, and Amazon ElastiCache reservations.

Budgets can be tracked at the monthly, quarterly, or yearly level, and you can customize the start and end dates. You can further refine your budget to track costs associated with multiple dimensions, such as AWS service, linked account, tag, and others. Budget alerts can be sent via email and/or Amazon Simple Notification Service (SNS) topic.

Budgets can be created and tracked from the AWS Budgets dashboard or via the Budgets API.

## AWS Cost & Usage Report

The [AWS Cost & Usage Report](#) is a single location for accessing comprehensive information about your AWS costs and usage.

The AWS Cost & Usage Report lists AWS usage for each service category used by an account and its IAM users in hourly or daily line items, as well as any tags that you have activated for cost allocation purposes. You can also customize the AWS Cost & Usage Report to aggregate your usage data to the daily or monthly level.

## Reserved Instance (RI) Reporting

AWS provides a number of RI-specific cost management solutions out-of-the-box to help you better understand and manage your RIs. Using the [RI Utilization and Coverage reports](#) available in AWS Cost Explorer, you can visualize your RI data at an aggregate level or inspect a particular RI subscription. To access the most detailed RI information available, you can leverage the AWS Cost & Usage Report. You can also set a custom RI utilization target via AWS Budgets and receive alerts when your utilization drops below the threshold you define.

## Savings Plans

[Savings Plans](#) is a flexible pricing model offering lower prices compared to On-Demand pricing, in exchange for a specific usage commitment (measured in \$/hour) for a one or three-year period. AWS offers three types of Savings Plans – Compute Savings Plans, EC2 Instance Savings Plans, and Amazon SageMaker Savings Plans. Compute Savings Plans apply to usage across Amazon EC2, AWS Lambda, and AWS Fargate. The EC2 Instance Savings Plans apply to EC2 usage, and Amazon SageMaker Savings Plans apply to Amazon SageMaker usage. You can easily sign up a 1- or 3-year term Savings Plans in AWS Cost Explorer and manage your plans by taking advantage of recommendations, performance reporting, and budget alerts.

## Compute Services

### Topics

- [Amazon EC2 \(p. 20\)](#)
- [Amazon EC2 Auto Scaling \(p. 21\)](#)
- [Amazon EC2 Image Builder \(p. 21\)](#)
- [Amazon Lightsail \(p. 22\)](#)
- [AWS App Runner \(p. 22\)](#)
- [AWS Batch \(p. 22\)](#)
- [AWS Elastic Beanstalk \(p. 22\)](#)
- [AWS Fargate \(p. 22\)](#)
- [AWS Lambda \(p. 23\)](#)
- [AWS Serverless Application Repository \(p. 23\)](#)
- [AWS Outposts \(p. 23\)](#)
- [AWS Wavelength \(p. 23\)](#)
- [VMware Cloud on AWS \(p. 24\)](#)

## Amazon EC2

[Amazon Elastic Compute Cloud \(Amazon EC2\)](#) is a web service that provides secure, resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers.

The simple web interface of Amazon EC2 allows you to obtain and configure capacity with minimal friction. It provides you with complete control of your computing resources and lets you run on Amazon's proven computing environment. Amazon EC2 reduces the time required to obtain and boot new server instances (called Amazon EC2 instances) to minutes, allowing you to quickly scale capacity, both up and down, as your computing requirements change. Amazon EC2 changes the economics of computing by allowing you to pay only for capacity that you actually use. Amazon EC2 provides developers and system administrators the tools to build failure resilient applications and isolate themselves from common failure scenarios.

## Instance Types

Amazon EC2 passes on to you the financial benefits of Amazon's scale. You pay a very low rate for the compute capacity you actually consume. See [Amazon EC2 Instance Purchasing Options](#) for a more detailed description.

- **On-Demand Instances**—With On-Demand instances, you pay for compute capacity by the hour or the second depending on which instances you run. No longer-term commitments or upfront payments are needed. You can increase or decrease your compute capacity depending on the demands of your application and only pay the specified per hourly rates for the instance you use. On-Demand instances are recommended for:
  - Users that prefer the low cost and flexibility of Amazon EC2 without any up-front payment or long-term commitment
  - Applications with short-term, spiky, or unpredictable workloads that cannot be interrupted
  - Applications being developed or tested on Amazon EC2 for the first time
- **Spot Instances**—[Spot Instances](#) are available at up to a 90% discount compared to On-Demand prices and let you take advantage of unused Amazon EC2 capacity in the AWS Cloud. You can significantly reduce the cost of running your applications, grow your application's compute capacity and throughput for the same budget, and enable new types of cloud computing applications. Spot instances are recommended for:
  - Applications that have flexible start and end times
  - Applications that are only feasible at very low compute prices
  - Users with urgent computing needs for large amounts of additional capacity
- **Reserved Instances**—[Reserved Instances](#) provide you with a significant discount (up to 72%) compared to On-Demand instance pricing. You have the flexibility to change families, operating system types, and tenancies while benefitting from Reserved Instance pricing when you use Convertible Reserved Instances.
- **Savings Plans**—[Savings Plans](#) are a flexible pricing model that offer low prices on EC2 and Fargate usage, in exchange for a commitment to a consistent amount of usage (measured in \$/hour) for a 1 or 3 year term.
- **Dedicated Hosts**—A [Dedicated Host](#) is a physical EC2 server dedicated for your use. Dedicated Hosts can help you reduce costs by allowing you to use your existing server-bound software licenses, including Windows Server, SQL Server, and SUSE Linux Enterprise Server (subject to your license terms), and can also help you meet compliance requirements.

## Amazon EC2 Auto Scaling

[Amazon EC2 Auto Scaling](#) helps you maintain application availability and allows you to automatically add or remove EC2 instances according to conditions you define. You can use the fleet management features of Amazon EC2 Auto Scaling to maintain the health and availability of your fleet. You can also use the dynamic and predictive scaling features of Amazon EC2 Auto Scaling to add or remove EC2 instances. Dynamic scaling responds to changing demand and predictive scaling automatically schedules the right number of EC2 instances based on predicted demand. Dynamic scaling and predictive scaling can be used together to scale faster.

## Amazon EC2 Image Builder

[EC2 Image Builder](#) simplifies the building, testing, and deployment of Virtual Machine and container images for use on AWS or on-premises.

Keeping Virtual Machine and container images up-to-date can be time consuming, resource intensive, and error-prone. Currently, customers either manually update and snapshot VMs or have teams that build automation scripts to maintain images.

Image Builder significantly reduces the effort of keeping images up-to-date and secure by providing a simple graphical interface, built-in automation, and AWS-provided security settings. With Image Builder, there are no manual steps for updating an image nor do you have to build your own automation pipeline.

Image Builder is offered at no cost, other than the cost of the underlying AWS resources used to create, store, and share the images.

## Amazon Lightsail

[Amazon Lightsail](#) is designed to be the easiest way to launch and manage a virtual private server with AWS. Lightsail plans include everything you need to jumpstart your project – a virtual machine, SSD-based storage, data transfer, DNS management, and a static IP address – for a low, predictable price.

## AWS App Runner

[AWS App Runner](#) is a fully managed service that makes it easy for developers to quickly deploy containerized web applications and APIs, at scale and with no prior infrastructure experience required. Start with your source code or a container image. App Runner automatically builds and deploys the web application and load balances traffic with encryption. App Runner also scales up or down automatically to meet your traffic needs. With App Runner, rather than thinking about servers or scaling, you have more time to focus on your applications.

## AWS Batch

[AWS Batch](#) enables developers, scientists, and engineers to easily and efficiently run hundreds of thousands of batch computing jobs on AWS. AWS Batch dynamically provisions the optimal quantity and type of compute resources (e.g., CPU or memory-optimized instances) based on the volume and specific resource requirements of the batch jobs submitted. With AWS Batch, there is no need to install and manage batch computing software or server clusters that you use to run your jobs, allowing you to focus on analyzing results and solving problems. AWS Batch plans, schedules, and runs your batch computing workloads across the full range of AWS compute services and features, such as Amazon EC2 and Spot Instances.

## AWS Elastic Beanstalk

[AWS Elastic Beanstalk](#) is an easy-to-use service for deploying and scaling web applications and services developed with Java, .NET, PHP, Node.js, Python, Ruby, Go, and Docker on familiar servers such as Apache, Nginx, Passenger, and Internet Information Services (IIS).

You can simply upload your code, and AWS Elastic Beanstalk automatically handles the deployment, from capacity provisioning, load balancing, and auto scaling to application health monitoring. At the same time, you retain full control over the AWS resources powering your application and can access the underlying resources at any time.

## AWS Fargate

[AWS Fargate](#) is a compute engine for Amazon ECS that allows you to run [containers](#) without having to manage servers or clusters. With AWS Fargate, you no longer have to provision, configure, and scale clusters of virtual machines to run containers. This removes the need to choose server types, decide when to scale your clusters, or optimize cluster packing. AWS Fargate removes the need for you to interact with or think about servers or clusters. Fargate lets you focus on designing and building your applications instead of managing the infrastructure that runs them.

Amazon ECS has two modes: Fargate launch type and EC2 launch type. With Fargate launch type, all you have to do is package your application in containers, specify the CPU and memory requirements,

define networking and IAM policies, and launch the application. EC2 launch type allows you to have server-level, more granular control over the infrastructure that runs your container applications. With EC2 launch type, you can use Amazon ECS to manage a cluster of servers and schedule placement of containers on the servers. Amazon ECS keeps track of all the CPU, memory and other resources in your cluster, and also finds the best server for a container to run on based on your specified resource requirements. You are responsible for provisioning, patching, and scaling clusters of servers. You can decide which type of server to use, which applications and how many containers to run in a cluster to optimize utilization, and when you should add or remove servers from a cluster. EC2 launch type gives you more control of your server clusters and provides a broader range of customization options, which might be required to support some specific applications or possible compliance and government requirements.

## AWS Lambda

[AWS Lambda](#) lets you run code without provisioning or managing servers. You pay only for the compute time you consume—there is no charge when your code is not running. With Lambda, you can run code for virtually any type of application or backend service—all with zero administration. Just upload your code, and Lambda takes care of everything required to run and scale your code with high availability. You can set up your code to automatically trigger from other AWS services, or you can call it directly from any web or mobile app.

## AWS Serverless Application Repository

The [AWS Serverless Application Repository](#) enables you to quickly deploy code samples, components, and complete applications for common use cases such as web and mobile back-ends, event and data processing, logging, monitoring, IoT, and more. Each application is packaged with an [AWS Serverless Application Model \(SAM\)](#) template that defines the AWS resources used. Publicly shared applications also include a link to the application's source code. There is no additional charge to use the Serverless Application Repository - you only pay for the AWS resources used in the applications you deploy.

You can also use the Serverless Application Repository to publish your own applications and share them within your team, across your organization, or with the community at large. To share an application you've built, [publish it to the AWS Serverless Application Repository](#).

## AWS Outposts

[AWS Outposts](#) bring native AWS services, infrastructure, and operating models to virtually any data center, co-location space, or on-premises facility. You can use the same APIs, the same tools, the same hardware, and the same functionality across on-premises and the cloud to deliver a truly consistent hybrid experience. Outposts can be used to support workloads that need to remain on-premises due to low latency or local data processing needs.

AWS Outposts come in two variants: 1) VMware Cloud on AWS Outposts allows you to use the same VMware control plane and APIs you use to run your infrastructure, 2) AWS native variant of AWS Outposts allows you to use the same exact APIs and control plane you use to run in the AWS cloud, but on-premises.

AWS Outposts infrastructure is fully managed, maintained, and supported by AWS to deliver access to the latest AWS services. Getting started is easy, you simply log into the AWS Management Console to order your Outposts servers, choosing from a wide range of compute and storage options. You can order one or more servers, or quarter, half, and full rack units.

## AWS Wavelength

[AWS Wavelength](#) is an AWS Infrastructure offering optimized for mobile edge computing applications. Wavelength Zones are AWS infrastructure deployments that embed AWS compute and storage

services within communications service providers' (CSP) datacenters at the edge of the 5G network, so application traffic from 5G devices can reach application servers running in Wavelength Zones without leaving the telecommunications network. This avoids the latency that would result from application traffic having to traverse multiple hops across the Internet to reach their destination, enabling customers to take full advantage of the latency and bandwidth benefits offered by modern 5G networks.

## VMware Cloud on AWS

[VMware Cloud on AWS](#) is an integrated cloud offering jointly developed by AWS and VMware delivering a highly scalable, secure and innovative service that allows organizations to seamlessly migrate and extend their on-premises VMware vSphere-based environments to the AWS Cloud running on next-generation Amazon Elastic Compute Cloud (Amazon EC2) bare metal infrastructure. VMware Cloud on AWS is ideal for enterprise IT infrastructure and operations organizations looking to migrate their on-premises vSphere-based workloads to the public cloud, consolidate and extend their data center capacities, and optimize, simplify and modernize their disaster recovery solutions. VMware Cloud on AWS is delivered, sold, and supported globally by VMware and its partners with availability in the following AWS Regions: AWS Europe (Stockholm), AWS US East (Northern Virginia), AWS US East (Ohio), AWS US West (Northern California), AWS US West (Oregon), AWS Canada (Central), AWS Europe (Frankfurt), AWS Europe (Ireland), AWS Europe (London), AWS Europe (Paris), AWS Europe (Milan), AWS Asia Pacific (Singapore), AWS Asia Pacific (Sydney), AWS Asia Pacific (Tokyo), AWS Asia Pacific (Mumbai) Region, AWS South America (Sao Paulo), AWS Asia Pacific (Seoul), and AWS GovCloud (US West). With each release, VMware Cloud on AWS availability will expand into additional global regions.

VMware Cloud on AWS brings the broad, diverse and rich innovations of AWS services natively to the enterprise applications running on VMware's compute, storage and network virtualization platforms. This allows organizations to easily and rapidly add new innovations to their enterprise applications by natively integrating AWS infrastructure and platform capabilities such as AWS Lambda, Amazon Simple Queue Service (SQS), Amazon S3, Elastic Load Balancing, Amazon RDS, Amazon DynamoDB, Amazon Kinesis, and Amazon Redshift, among many others.

With VMware Cloud on AWS, organizations can simplify their Hybrid IT operations by using the same VMware Cloud Foundation technologies including vSphere, vSAN, NSX, and vCenter Server across their on-premises data centers and on the AWS Cloud without having to purchase any new or custom hardware, rewrite applications, or modify their operating models. The service automatically provisions infrastructure and provides full VM compatibility and workload portability between your on-premises environments and the AWS Cloud. With VMware Cloud on AWS, you can leverage AWS's breadth of services, including compute, databases, analytics, Internet of Things (IoT), security, mobile, deployment, application services, and more.

## Contact Center

### Topics

- [Amazon Connect \(p. 24\)](#)

## Amazon Connect

[Amazon Connect](#) is a self-service, omnichannel cloud contact center service that makes it easy for any business to deliver better customer service at lower cost. Amazon Connect is based on the same contact center technology used by Amazon customer service associates around the world to power millions of customer conversations. The self-service graphical interface in Amazon Connect makes it easy for non-technical users to design contact flows, manage agents, and track performance metrics – no specialized skills required. There are no up-front payments or long-term commitments and no infrastructure to manage with Amazon Connect; customers pay by the minute for Amazon Connect usage plus any associated telephony services.

# Containers

## Topics

- [Amazon Elastic Container Registry \(p. 25\)](#)
- [Amazon Elastic Container Service \(p. 25\)](#)
- [Amazon Elastic Kubernetes Service \(p. 25\)](#)
- [AWS App2Container \(p. 25\)](#)
- [Red Hat OpenShift Service on AWS \(p. 26\)](#)

## Amazon Elastic Container Registry

[Amazon Elastic Container Registry \(ECR\)](#) is a fully-managed Docker container registry that makes it easy for developers to store, manage, and deploy Docker container images. Amazon ECR is integrated with [Amazon Elastic Container Service \(Amazon ECS\)](#), simplifying your development to production workflow. Amazon ECR eliminates the need to operate your own container repositories or worry about scaling the underlying infrastructure. Amazon ECR hosts your images in a highly available and scalable architecture, allowing you to reliably deploy containers for your applications. Integration with [AWS Identity and Access Management \(IAM\) \(p. 69\)](#) provides resource-level control of each repository. With Amazon ECR, there are no upfront fees or commitments. You pay only for the amount of data you store in your repositories and data transferred to the Internet.

## Amazon Elastic Container Service

[Amazon Elastic Container Service \(Amazon ECS\)](#) is a highly scalable, high-performance container orchestration service that supports Docker containers and allows you to easily run and scale containerized applications on AWS. Amazon ECS eliminates the need for you to install and operate your own container orchestration software, manage and scale a cluster of virtual machines, or schedule containers on those virtual machines.

With simple API calls, you can launch and stop Docker-enabled applications, query the complete state of your application, and access many familiar features such as IAM roles, security groups, load balancers, Amazon CloudWatch Events, AWS CloudFormation templates, and AWS CloudTrail logs.

## Amazon Elastic Kubernetes Service

[Amazon Elastic Kubernetes Service \(Amazon EKS\)](#) makes it easy to deploy, manage, and scale containerized applications using Kubernetes on AWS.

Amazon EKS runs the Kubernetes management infrastructure for you across multiple AWS availability zones to eliminate a single point of failure. Amazon EKS is certified Kubernetes conformant so you can use existing tooling and plugins from partners and the Kubernetes community. Applications running on any standard Kubernetes environment are fully compatible and can be easily migrated to Amazon EKS.

## AWS App2Container

[AWS App2Container \(A2C\)](#) is a command-line tool for modernizing .NET and Java applications into containerized applications. A2C analyzes and builds an inventory of all applications running in virtual machines, on-premises or in the cloud. You simply select the application you want to containerize, and A2C packages the application artifact and identified dependencies into container images, configures the network ports, and generates the ECS task and Kubernetes pod definitions. A2C provisions, through CloudFormation, the cloud infrastructure and CI/CD pipelines required to deploy the containerized .NET

or Java application into production. With A2C, you can easily modernize your existing applications and standardize the deployment and operations through containers.

## Red Hat OpenShift Service on AWS

[Red Hat OpenShift Service on AWS \(ROSA\)](#) provides an integrated experience to use OpenShift. If you are already familiar with OpenShift, you can accelerate your application development process by leveraging familiar OpenShift APIs and tools for deployments on AWS. With ROSA, you can use the wide range of AWS compute, database, analytics, machine learning, networking, mobile, and other services to build secure and scalable applications faster. ROSA comes with pay-as-you-go hourly and annual billing, a 99.95% SLA, and joint support from AWS and Red Hat.

ROSA makes it easier for you to focus on deploying applications and accelerating innovation by moving the cluster lifecycle management to Red Hat and AWS. With ROSA, you can run containerized applications with your existing OpenShift workflows and reduce the complexity of management.

# Database

## Topics

- [Amazon Aurora \(p. 26\)](#)
- [Amazon DynamoDB \(p. 26\)](#)
- [Amazon ElastiCache \(p. 27\)](#)
- [Amazon Keyspaces \(for Apache Cassandra\) \(p. 27\)](#)
- [Amazon Neptune \(p. 27\)](#)
- [Amazon Relational Database Service \(p. 28\)](#)
- [Amazon RDS on VMware \(p. 28\)](#)
- [Amazon Quantum Ledger Database \(QLDB\) \(p. 28\)](#)
- [Amazon Timestream \(p. 29\)](#)
- [Amazon DocumentDB \(with MongoDB compatibility\) \(p. 29\)](#)

## Amazon Aurora

[Amazon Aurora](#) is a MySQL and PostgreSQL compatible relational database engine that combines the speed and availability of high-end commercial databases with the simplicity and cost-effectiveness of open source databases.

Amazon Aurora is up to five times faster than standard MySQL databases and three times faster than standard PostgreSQL databases. It provides the security, availability, and reliability of commercial databases at 1/10th the cost. Amazon Aurora is fully managed by Amazon Relational Database Service (Amazon RDS), which automates time-consuming administration tasks like hardware provisioning, database setup, patching, and backups.

Amazon Aurora features a distributed, fault-tolerant, self-healing storage system that auto-scales up to 128TB per database instance. It delivers high performance and availability with up to 15 low-latency read replicas, point-in-time recovery, continuous backup to Amazon S3, and replication across three Availability Zones (AZs).

## Amazon DynamoDB

[Amazon DynamoDB](#) is a key-value and document database that delivers single-digit millisecond performance at any scale. It's a fully managed, multiregion, multimaster database with built-in security,

backup and restore, and in-memory caching for internet-scale applications. DynamoDB can handle more than 10 trillion requests per day and support peaks of more than 20 million requests per second.

Many of the world's fastest growing businesses such as Lyft, Airbnb, and Redfin as well as enterprises such as Samsung, Toyota, and Capital One depend on the scale and performance of DynamoDB to support their mission-critical workloads.

Hundreds of thousands of AWS customers have chosen DynamoDB as their key-value and document database for mobile, web, gaming, ad tech, IoT, and other applications that need low-latency data access at any scale. Create a new table for your application and let DynamoDB handle the rest.

## Amazon ElastiCache

[Amazon ElastiCache](#) is a web service that makes it easy to deploy, operate, and scale an in-memory cache in the cloud. The service improves the performance of web applications by allowing you to retrieve information from fast, managed, in-memory caches, instead of relying entirely on slower disk-based databases.

Amazon ElastiCache supports two open-source in-memory caching engines:

- [Redis](#) - a fast, open-source, in-memory key-value data store for use as a database, cache, message broker, and queue. [Amazon ElastiCache for Redis](#) is a Redis-compatible in-memory service that delivers the ease-of-use and power of Redis along with the availability, reliability, and performance suitable for the most demanding applications. Both single-node and up to 15-shard clusters are available, enabling scalability to up to 3.55 TiB of in-memory data. ElastiCache for Redis is fully managed, scalable, and secure. This makes it an ideal candidate to power high-performance use cases such as web, mobile apps, gaming, ad-tech, and IoT.
- [Memcached](#) - a widely adopted memory object caching system. [ElastiCache for Memcached](#) is protocol compliant with Memcached, so popular tools that you use today with existing Memcached environments will work seamlessly with the service.

## Amazon Keyspaces (for Apache Cassandra)

[Amazon Keyspaces \(for Apache Cassandra\)](#) is a scalable, highly available, and managed Apache Cassandra-compatible database service. With Amazon Keyspaces, you can run your Cassandra workloads on AWS using the same Cassandra application code and developer tools that you use today. You don't have to provision, patch, or manage servers, and you don't have to install, maintain, or operate software. Amazon Keyspaces is serverless, so you pay for only the resources you use and the service can automatically scale tables up and down in response to application traffic. You can build applications that serve thousands of requests per second with virtually unlimited throughput and storage. Data is encrypted by default and Amazon Keyspaces enables you to back up your table data continuously using point-in-time recovery. Amazon Keyspaces gives you the performance, elasticity, and enterprise features you need to operate business-critical Cassandra workloads at scale.

## Amazon Neptune

[Amazon Neptune](#) is a fast, reliable, fully-managed graph database service that makes it easy to build and run applications that work with highly connected datasets. The core of Amazon Neptune is a purpose-built, high-performance graph database engine optimized for storing billions of relationships and querying the graph with milliseconds latency. Amazon Neptune supports popular graph models Property Graph and W3C's RDF, and their respective query languages Apache TinkerPop Gremlin and SPARQL, allowing you to easily build queries that efficiently navigate highly connected datasets. Neptune powers graph use cases such as recommendation engines, fraud detection, knowledge graphs, drug discovery, and network security.

Amazon Neptune is highly available, with read replicas, point-in-time recovery, continuous backup to Amazon S3, and replication across Availability Zones. Neptune is secure with support for encryption at rest. Neptune is fully-managed, so you no longer need to worry about database management tasks such as hardware provisioning, software patching, setup, configuration, or backups.

## Amazon Relational Database Service

[Amazon Relational Database Service \(Amazon RDS\)](#) makes it easy to set up, operate, and scale a relational database in the cloud. It provides cost-efficient and resizable capacity while automating time-consuming administration tasks such as hardware provisioning, database setup, patching and backups. It frees you to focus on your applications so you can give them the fast performance, high availability, security and compatibility they need.

Amazon RDS is available on several database instance types - optimized for memory, performance or I/O - and provides you with six familiar database engines to choose from, including [Amazon Aurora](#), [PostgreSQL](#), [MySQL](#), [MariaDB](#), [Oracle Database](#), and [SQL Server](#). You can use the [AWS Database Migration Service](#) to easily migrate or replicate your existing databases to Amazon RDS.

## Amazon RDS on VMware

[Amazon Relational Database Service \(Amazon RDS\)](#) on VMware lets you deploy managed databases in on-premises VMware environments using the Amazon RDS technology enjoyed by hundreds of thousands of AWS customers. Amazon RDS provides cost-efficient and resizable capacity while automating time-consuming administration tasks including hardware provisioning, database setup, patching, and backups, freeing you to focus on your applications. RDS on VMware brings these same benefits to your on-premises deployments, making it easy to set up, operate, and scale databases in VMware vSphere private data centers, or to migrate them to AWS.

Amazon RDS on VMware allows you to utilize the same simple interface for managing databases in on-premises VMware environments as you would use in AWS. You can easily replicate RDS on VMware databases to RDS instances in AWS, enabling low-cost hybrid deployments for disaster recovery, read replica bursting, and optional long-term backup retention in Amazon Simple Storage Service (Amazon S3).

## Amazon Quantum Ledger Database (QLDB)

[Amazon QLDB](#) is a fully managed ledger database that provides a transparent, immutable, and cryptographically verifiable transaction log owned by a central trusted authority. Amazon QLDB tracks each and every application data change and maintains a complete and verifiable history of changes over time.

Ledgers are typically used to record a history of economic and financial activity in an organization. Many organizations build applications with ledger-like functionality because they want to maintain an accurate history of their applications' data, for example, tracking the history of credits and debits in banking transactions, verifying the data lineage of an insurance claim, or tracing movement of an item in a supply chain network. Ledger applications are often implemented using custom audit tables or audit trails created in relational databases. However, building audit functionality with relational databases is time-consuming and prone to human error. It requires custom development, and since relational databases are not inherently immutable, any unintended changes to the data are hard to track and verify. Alternatively, blockchain frameworks, such as Hyperledger Fabric and Ethereum, can also be used as a ledger. However, this adds complexity as you need to set-up an entire blockchain network with multiple nodes, manage its infrastructure, and require the nodes to validate each transaction before it can be added to the ledger.

Amazon QLDB is a new class of database that eliminates the need to engage in the complex development effort of building your own ledger-like applications. With QLDB, your data's change history is immutable – it cannot be altered or deleted – and using cryptography, you can easily verify

that there have been no unintended modifications to your application's data. QLDB uses an immutable transactional log, known as a journal, that tracks each application data change and maintains a complete and verifiable history of changes over time. QLDB is easy to use because it provides developers with a familiar SQL-like API, a flexible document data model, and full support for transactions. QLDB is also serverless, so it automatically scales to support the demands of your application. There are no servers to manage and no read or write limits to configure. With QLDB, you only pay for what you use.

## Amazon Timestream

[Amazon Timestream](#) is a fast, scalable, fully managed time series database service for IoT and operational applications that makes it easy to store and analyze trillions of events per day at 1/10th the cost of relational databases. Driven by the rise of IoT devices, IT systems, and smart industrial machines, time-series data — data that measures how things change over time — is one of the fastest growing data types. Time-series data has specific characteristics such as typically arriving in time order form, data is append-only, and queries are always over a time interval. While relational databases can store this data, they are inefficient at processing this data as they lack optimizations such as storing and retrieving data by time intervals. Timestream is a purpose-built time series database that efficiently stores and processes this data by time intervals. With Timestream, you can easily store and analyze log data for DevOps, sensor data for IoT applications, and industrial telemetry data for equipment maintenance. As your data grows over time, Timestream's adaptive query processing engine understands its location and format, making your data simpler and faster to analyze. Timestream also automates rollups, retention, tiering, and compression of data, so you can manage your data at the lowest possible cost. Timestream is serverless, so there are no servers to manage. It manages time-consuming tasks such as server provisioning, software patching, setup, configuration, or data retention and tiering, freeing you to focus on building your applications.

## Amazon DocumentDB (with MongoDB compatibility)

[Amazon DocumentDB \(with MongoDB compatibility\)](#) is a fast, scalable, highly available, and fully managed document database service that supports MongoDB workloads.

Amazon DocumentDB (with MongoDB compatibility) is designed from the ground-up to give you the performance, scalability, and availability you need when operating mission-critical MongoDB workloads at scale. Amazon DocumentDB (with MongoDB compatibility) implements the Apache 2.0 open source MongoDB 3.6 and 4.0 APIs by emulating the responses that a MongoDB client expects from a MongoDB server, allowing you to use your existing MongoDB drivers and tools with Amazon DocumentDB (with MongoDB compatibility).

## Developer Tools

### Amazon Corretto

[Amazon Corretto](#) is a no-cost, multiplatform, production-ready distribution of the Open Java Development Kit (OpenJDK). Corretto comes with long-term support that will include performance enhancements and security fixes. Amazon runs Corretto internally on thousands of production services and Corretto is certified as compatible with the Java SE standard. With Corretto, you can develop and run Java applications on popular operating systems, including Amazon Linux 2, Windows, and macOS.

### AWS Cloud9

[AWS Cloud9](#) is a cloud-based integrated development environment (IDE) that lets you write, run, and debug your code with just a browser. It includes a code editor, debugger, and terminal. Cloud9 comes prepackaged with essential tools for popular programming languages, including JavaScript, Python, PHP,

and more, so you don't need to install files or configure your development machine to start new projects. Since your Cloud9 IDE is cloud-based, you can work on your projects from your office, home, or anywhere using an internet-connected machine. Cloud9 also provides a seamless experience for developing serverless applications enabling you to easily define resources, debug, and switch between local and remote execution of serverless applications. With Cloud9, you can quickly share your development environment with your team, enabling you to pair program and track each other's inputs in real time.

## AWS CloudShell

[AWS CloudShell](#) is a browser-based shell that makes it easy to securely manage, explore, and interact with your AWS resources. CloudShell is pre-authenticated with your console credentials. Common development and operations tools are pre-installed, so no local installation or configuration is required. With CloudShell, you can quickly run scripts with the AWS Command Line Interface (AWS CLI), experiment with AWS service APIs using the AWS SDKs, or use a range of other tools to be productive. You can use CloudShell right from your browser and at no additional cost.

## AWS CodeArtifact

[AWS CodeArtifact](#) is a fully managed artifact repository service that makes it easy for organizations of any size to securely store, publish, and share software packages used in their software development process. CodeArtifact can be configured to automatically fetch software packages and dependencies from public artifact repositories so developers have access to the latest versions. CodeArtifact works with commonly used package managers and build tools like Maven, Gradle, npm, yarn, twine, pip, and NuGet making it easy to integrate into existing development workflows.

## AWS CodeBuild

[AWS CodeBuild](#) is a fully managed build service that compiles source code, runs tests, and produces software packages that are ready to deploy. With CodeBuild, you don't need to provision, manage, and scale your own build servers. CodeBuild scales continuously and processes multiple builds concurrently, so your builds are not left waiting in a queue. You can get started quickly by using prepackaged build environments, or you can create custom build environments that use your own build tools.

## AWS CodeCommit

[AWS CodeCommit](#) is a fully managed source control service that makes it easy for companies to host secure and highly scalable private Git repositories. AWS CodeCommit eliminates the need to operate your own source control system or worry about scaling its infrastructure. You can use AWS CodeCommit to securely store anything from source code to binaries, and it works seamlessly with your existing Git tools.

## AWS CodeDeploy

[AWS CodeDeploy](#) is a service that automates code deployments to any instance, including EC2 instances and instances running on premises. CodeDeploy makes it easier for you to rapidly release new features, helps you avoid downtime during application deployment, and handles the complexity of updating your applications. You can use CodeDeploy to automate software deployments, eliminating the need for error-prone manual operations. The service scales with your infrastructure so you can easily deploy to one instance or thousands.

## AWS CodePipeline

[AWS CodePipeline](#) is a fully managed continuous delivery service that helps you automate your release pipelines for fast and reliable application and infrastructure updates. CodePipeline automates the build,

test, and deploy phases of your release process every time there is a code change, based on the release model you define. This enables you to rapidly and reliably deliver features and updates. You can easily integrate CodePipeline with third-party services such as GitHub or with your own custom plugin. With AWS CodePipeline, you only pay for what you use. There are no upfront fees or long-term commitments.

## AWS CodeStar

[AWS CodeStar](#) enables you to quickly develop, build, and deploy applications on AWS. AWS CodeStar provides a unified user interface, enabling you to easily manage your software development activities in one place. With AWS CodeStar, you can set up your entire continuous delivery toolchain in minutes, allowing you to start releasing code faster. AWS CodeStar makes it easy for your whole team to work together securely, allowing you to easily manage access and add owners, contributors, and viewers to your projects. Each AWS CodeStar project comes with a project management dashboard, including an integrated issue tracking capability powered by Atlassian JIRA Software. With the AWS CodeStar project dashboard, you can easily track progress across your entire software development process, from your backlog of work items to teams' recent code deployments. For more information, see [AWS CodeStar features](#).

## AWS Fault Injection Simulator

[AWS Fault Injection Simulator](#) is a fully managed service for running fault injection experiments on AWS that makes it easier to improve an application's performance, observability, and resiliency. Fault injection experiments are used in chaos engineering, which is the practice of stressing an application in testing or production environments by creating disruptive events, such as sudden increase in CPU or memory consumption, observing how the system responds, and implementing improvements. Fault injection experiment helps teams create the real-world conditions needed to uncover the hidden bugs, monitoring blind spots, and performance bottlenecks that are difficult to find in distributed systems.

Fault Injection Simulator simplifies the process of setting up and running controlled fault injection experiments across a range of AWS services so teams can build confidence in their application behavior. With Fault Injection Simulator, teams can quickly set up experiments using pre-built templates that generate the desired disruptions. Fault Injection Simulator provides the controls and guardrails that teams need to run experiments in production, such as automatically rolling back or stopping the experiment if specific conditions are met. With a few clicks in the console, teams can run complex scenarios with common distributed system failures happening in parallel or building sequentially over time, enabling them to create the real world conditions necessary to find hidden weaknesses.

## AWS X-Ray

[AWS X-Ray](#) helps developers analyze and debug distributed applications in production or under development, such as those built using a microservices architecture. With X-Ray, you can understand how your application and its underlying services are performing so you can identify and troubleshoot the root cause of performance issues and errors. X-Ray provides an end-to-end view of requests as they travel through your application, and shows a map of your application's underlying components. You can use X-Ray to analyze both applications in development and in production, from simple three-tier applications to complex microservices applications consisting of thousands of services.

# End User Computing

## Topics

- [Amazon AppStream 2.0 \(p. 32\)](#)
- [Amazon WorkSpaces \(p. 32\)](#)

- [Amazon WorkLink \(p. 32\)](#)

## Amazon AppStream 2.0

**Amazon AppStream 2.0** is a fully managed application streaming service. You centrally manage your desktop applications on AppStream 2.0 and securely deliver them to any computer. You can easily scale to any number of users across the globe without acquiring, provisioning, and operating hardware or infrastructure. AppStream 2.0 is built on AWS, so you benefit from a data center and network architecture designed for the most security-sensitive organizations. Each user has a fluid and responsive experience with your applications, including GPU-intensive [3D design and engineering](#) ones, because your applications run on virtual machines (VMs) optimized for specific use cases and each streaming session automatically adjusts to network conditions.

Enterprises can use AppStream 2.0 to simplify application delivery and complete their migration to the cloud. Educational institutions can provide every student access to the applications they need for class on any computer. Software vendors can use AppStream 2.0 to deliver trials, demos, and training for their applications with no downloads or installations. They can also develop a full software-as-a-service (SaaS) solution without rewriting their application.

## Amazon WorkSpaces

**Amazon WorkSpaces** is a fully managed, secure cloud desktop service. You can use WorkSpaces to provision either Windows or Linux desktops in just a few minutes and quickly scale to provide thousands of desktops to workers across the globe. You can pay either monthly or hourly, just for the WorkSpaces you launch, which helps you save money when compared to traditional desktops and on-premises VDI solutions. WorkSpaces helps you eliminate the complexity in managing hardware inventory, OS versions and patches, and Virtual Desktop Infrastructure (VDI), which helps simplify your desktop delivery strategy. With WorkSpaces, your users get a fast, responsive desktop of their choice that they can access anywhere, anytime, from any supported device.

## Amazon WorkLink

**Amazon WorkLink** is a fully managed service that lets you provide your employees with secure, easy access to your internal corporate websites and web apps using their mobile phones. Traditional solutions such as Virtual Private Networks (VPNs) and device management software are inconvenient to use on the go, and often require the use of custom browsers that have a poor user experience. As a result, employees often forgo using them altogether.

With Amazon WorkLink, employees can access internal web content as easily as they access any public website, without the hassle of connecting to their corporate network. When a user accesses an internal website, the page is first rendered in a browser running in a secure container in AWS. Amazon WorkLink then sends the contents of that page to employee phones as vector graphics while preserving the functionality and interactivity of the page. This approach is more secure than traditional solutions because internal content is never stored or cached by the browser on employee phones, and employee devices never connect directly to your corporate network.

With Amazon WorkLink, there are no minimum fees or long-term commitments. You pay only for users that connect to the service each month, and there is no additional charge for bandwidth consumption.

## Front-End Web & Mobile Services

### Topics

- [Amazon Location Service \(p. 33\)](#)

- [Amazon Pinpoint \(p. 33\)](#)
- [AWS Amplify \(p. 33\)](#)
- [AWS Device Farm \(p. 34\)](#)
- [AWS AppSync \(p. 34\)](#)

## Amazon Location Service

[Amazon Location Service](#) makes it easy for developers to add location functionality to applications without compromising data security and user privacy.

Location data is a vital ingredient in today's applications, enabling capabilities ranging from asset tracking to location-based marketing. However, developers face significant barriers when integrating location functionality into their applications. This includes cost, privacy and security compromises, and tedious and slow integration work.

Amazon Location Service provides affordable data, tracking and geofencing capabilities, and native integrations with AWS services, so you can create sophisticated location-enabled applications quickly, without the high cost of custom development. You retain control of your location data with Amazon Location, and you can combine proprietary data with data from the service. Amazon Location provides cost-effective location-based services (LBS) using high-quality data from global, trusted providers Esri and HERE.

## Amazon Pinpoint

[Amazon Pinpoint](#) makes it easy to send targeted messages to your customers through multiple engagement channels. Examples of targeted campaigns are promotional alerts and customer retention campaigns, and transactional messages are messages such as order confirmations and password reset messages.

You can integrate Amazon Pinpoint into your mobile and web apps to capture usage data to provide you with insight into how customers interact with your apps. Amazon Pinpoint also tracks the ways that your customers respond to the messages you send—for example, by showing you the number of messages that were delivered, opened, or clicked.

You can develop custom audience segments and send them pre-scheduled targeted campaigns via email, SMS, and push notifications. Targeted campaigns are useful for sending promotional or educational content to re-engage and retain your users.

You can send transactional messages using the console or the Amazon Pinpoint REST API. Transactional campaigns can be sent via email, SMS, push notifications, and voice messages. You can also use the API to build custom applications that deliver campaign and transactional messages.

## AWS Amplify

[AWS Amplify](#) makes it easy to create, configure, and implement scalable mobile applications powered by AWS. Amplify seamlessly provisions and manages your mobile backend and provides a simple framework to easily integrate your backend with your iOS, Android, Web, and React Native frontends. Amplify also automates the application release process of both your frontend and backend allowing you to deliver features faster.

Mobile applications require cloud services for actions that can't be done directly on the device, such as offline data synchronization, storage, or data sharing across multiple users. You often have to configure, set up, and manage multiple services to power the backend. You also have to integrate each of those services into your application by writing multiple lines of code. However, as the number of application

features grow, your code and release process becomes more complex and managing the backend requires more time.

Amplify provisions and manages backends for your mobile applications. You just select the capabilities you need such as authentication, analytics, or offline data sync and Amplify will automatically provision and manage the AWS service that powers each of the capabilities. You can then integrate those capabilities into your application through the Amplify libraries and UI components.

## AWS Device Farm

[AWS Device Farm](#) is an app testing service that lets you test and interact with your Android, iOS, and web apps on many devices at once, or reproduce issues on a device in real time. View video, screenshots, logs, and performance data to pinpoint and fix issues before shipping your app.

## AWS AppSync

[AWS AppSync](#) is a serverless back-end for mobile, web, and enterprise applications.

AWS AppSync makes it easy to build data driven mobile and web applications by handling securely all the application data management tasks like online and offline data access, data synchronization, and data manipulation across multiple data sources. AWS AppSync uses GraphQL, an API query language designed to build client applications by providing an intuitive and flexible syntax for describing their data requirement.

# Game Tech

## Topics

- [Amazon GameLift \(p. 34\)](#)
- [Amazon Lumberyard \(p. 34\)](#)

## Amazon GameLift

[Amazon GameLift](#) is a managed service for deploying, operating, and scaling dedicated game servers for session-based multiplayer games. Amazon GameLift makes it easy to manage server infrastructure, scale capacity to lower latency and cost, match players into available game sessions, and defend from distributed denial-of-service (DDoS) attacks. You pay for the compute resources and bandwidth your games actually use, without monthly or annual contracts.

## Amazon Lumberyard

[Amazon Lumberyard](#) is a free, cross-platform, 3D game engine for you to create the highest-quality games, connect your games to the vast compute and storage of the AWS Cloud, and engage fans on Twitch. By starting game projects with Lumberyard, you can spend more of your time creating great gameplay and building communities of fans, and less time on the undifferentiated heavy lifting of building a game engine and managing server infrastructure.

# Internet of Things (IoT)

## Topics

- [AWS IoT 1-Click \(p. 35\)](#)
- [AWS IoT Analytics \(p. 35\)](#)
- [AWS IoT Button \(p. 36\)](#)
- [AWS IoT Core \(p. 36\)](#)
- [AWS IoT Device Defender \(p. 36\)](#)
- [AWS IoT Device Management \(p. 37\)](#)
- [AWS IoT Events \(p. 37\)](#)
- [AWS IoT Greengrass \(p. 37\)](#)
- [AWS IoT SiteWise \(p. 37\)](#)
- [AWS IoT Things Graph \(p. 38\)](#)
- [AWS Partner Device Catalog \(p. 38\)](#)
- [FreeRTOS \(p. 38\)](#)

## AWS IoT 1-Click

[AWS IoT 1-Click](#) is a service that enables simple devices to trigger AWS Lambda functions that can execute an action. AWS IoT 1-Click supported devices enable you to easily perform actions such as notifying technical support, tracking assets, and replenishing goods or services. AWS IoT 1-Click supported devices are ready for use right out of the box and eliminate the need for writing your own firmware or configuring them for secure connectivity. AWS IoT 1-Click supported devices can be easily managed. You can easily create device groups and associate them with a Lambda function that runs your desired action when triggered. You can also track device health and activity with the pre-built reports.

## AWS IoT Analytics

[AWS IoT Analytics](#) is a fully-managed service that makes it easy to run and operationalize sophisticated analytics on massive volumes of IoT data without having to worry about the cost and complexity typically required to build an IoT analytics platform. It is the easiest way to run analytics on IoT data and get insights to make better and more accurate decisions for IoT applications and machine learning use cases.

IoT data is highly unstructured which makes it difficult to analyze with traditional analytics and business intelligence tools that are designed to process structured data. IoT data comes from devices that often record fairly noisy processes (such as temperature, motion, or sound). The data from these devices can frequently have significant gaps, corrupted messages, and false readings that must be cleaned up before analysis can occur. Also, IoT data is often only meaningful in the context of additional, third party data inputs. For example, to help farmers determine when to water their crops, vineyard irrigation systems often enrich moisture sensor data with rainfall data from the vineyard, allowing for more efficient water usage while maximizing harvest yield.

AWS IoT Analytics automates each of the difficult steps that are required to analyze data from IoT devices. AWS IoT Analytics filters, transforms, and enriches IoT data before storing it in a time-series data store for analysis. You can setup the service to collect only the data you need from your devices, apply mathematical transforms to process the data, and enrich the data with device-specific metadata such as device type and location before storing the processed data. Then, you can analyze your data by running ad hoc or scheduled queries using the built-in SQL query engine, or perform more complex analytics and machine learning inference. AWS IoT Analytics makes it easy to get started with machine learning by including pre-built models for common IoT use cases.

You can also use your own custom analysis, packaged in a container, to execute on AWS IoT Analytics. AWS IoT Analytics automates the execution of your custom analyses created in Jupyter Notebook or your own tools (such as Matlab, Octave, etc.) to be executed on your schedule.

AWS IoT Analytics is a fully managed service that operationalizes analyses and scales automatically to support up to petabytes of IoT data. With AWS IoT Analytics, you can analyze data from millions of devices and build fast, responsive IoT applications without managing hardware or infrastructure.

## AWS IoT Button

The [AWS IoT Button](#) is a programmable button based on the Amazon Dash Button hardware. This simple Wi-Fi device is easy to configure, and it's designed for developers to get started with AWS IoT Core, AWS Lambda, Amazon DynamoDB, Amazon SNS, and many other Amazon Web Services without writing device-specific code.

You can code the button's logic in the cloud to configure button clicks to count or track items, call or alert someone, start or stop something, order services, or even provide feedback. For example, you can click the button to unlock or start a car, open your garage door, call a cab, call your spouse or a customer service representative, track the use of common household chores, medications or products, or remotely control your home appliances.

The button can be used as a remote control for Netflix, a switch for your Philips Hue light bulb, a check-in/check-out device for Airbnb guests, or a way to order your favorite pizza for delivery. You can integrate it with third-party APIs like Twitter, Facebook, Twilio, Slack or even your own company's applications. Connect it to things we haven't even thought of yet.

## AWS IoT Core

[AWS IoT Core](#) is a managed cloud service that lets connected devices easily and securely interact with cloud applications and other devices. AWS IoT Core can support billions of devices and trillions of messages, and can process and route those messages to AWS endpoints and to other devices reliably and securely. With AWS IoT Core, your applications can keep track of and communicate with all your devices, all the time, even when they aren't connected.

AWS IoT Core makes it easy to use AWS services like AWS Lambda, Amazon Kinesis, Amazon S3, Amazon SageMaker, Amazon DynamoDB, Amazon CloudWatch, AWS CloudTrail, and Amazon QuickSight to build Internet of Things (IoT) applications that gather, process, analyze and act on data generated by connected devices, without having to manage any infrastructure.

## AWS IoT Device Defender

[AWS IoT Device Defender](#) is a fully managed service that helps you secure your fleet of IoT devices. AWS IoT Device Defender continuously audits your IoT configurations to make sure that they aren't deviating from security best practices. A configuration is a set of technical controls you set to help keep information secure when devices are communicating with each other and the cloud. AWS IoT Device Defender makes it easy to maintain and enforce IoT configurations, such as ensuring device identity, authenticating and authorizing devices, and encrypting device data. AWS IoT Device Defender continuously audits the IoT configurations on your devices against a set of predefined security best practices. AWS IoT Device Defender sends an alert if there are any gaps in your IoT configuration that might create a security risk, such as identity certificates being shared across multiple devices or a device with a revoked identity certificate trying to connect to [AWS IoT Core](#).

AWS IoT Device Defender also lets you continuously monitor security metrics from devices and AWS IoT Core for deviations from what you have defined as appropriate behavior for each device. If something doesn't look right, AWS IoT Device Defender sends out an alert so you can take action to remediate the issue. For example, traffic spikes in outbound traffic might indicate that a device is participating in a DDoS attack. [AWS IoT Greengrass](#) and [FreeRTOS](#) automatically integrate with AWS IoT Device Defender to provide security metrics from the devices for evaluation.

AWS IoT Device Defender can send alerts to the AWS IoT Console, Amazon CloudWatch, and Amazon SNS. If you determine that you need to take an action based on an alert, you can use [AWS IoT Device Management](#) to take mitigating actions such as pushing security fixes.

## AWS IoT Device Management

As many IoT deployments consist of hundreds of thousands to millions of devices, it is essential to track, monitor, and manage connected device fleets. You need to ensure your IoT devices work properly and securely after they have been deployed. You also need to secure access to your devices, monitor health, detect and remotely troubleshoot problems, and manage software and firmware updates.

[AWS IoT Device Management](#) makes it easy to securely onboard, organize, monitor, and remotely manage IoT devices at scale. With AWS IoT Device Management, you can register your connected devices individually or in bulk, and easily manage permissions so that devices remain secure. You can also organize your devices, monitor and troubleshoot device functionality, query the state of any IoT device in your fleet, and send firmware updates over-the-air (OTA). AWS IoT Device Management is agnostic to device type and OS, so you can manage devices from constrained microcontrollers to connected cars all with the same service. AWS IoT Device Management allows you to scale your fleets and reduce the cost and effort of managing large and diverse IoT device deployments.

## AWS IoT Events

[AWS IoT Events](#) is a fully managed IoT service that makes it easy to detect and respond to events from IoT sensors and applications. Events are patterns of data identifying more complicated circumstances than expected, such as changes in equipment when a belt is stuck or connected motion detectors using movement signals to activate lights and security cameras. To detect events before AWS IoT Events, you had to build costly, custom applications to collect data, apply decision logic to detect an event, and then trigger another application to react to the event. Using AWS IoT Events, it's simple to detect events across thousands of IoT sensors sending different telemetry data, such as temperature from a freezer, humidity from respiratory equipment, and belt speed on a motor, and hundreds of equipment management applications. You simply select the relevant data sources to ingest, define the logic for each event using simple 'if-then-else' statements, and select the alert or custom action to trigger when an event occurs. AWS IoT Events continuously monitors data from multiple IoT sensors and applications, and it integrates with other services, such as AWS IoT Core and AWS IoT Analytics, to enable early detection and unique insights into events. AWS IoT Events automatically triggers alerts and actions in response to events based on the logic you define. This helps resolve issues quickly, reduce maintenance costs, and increase operational efficiency.

## AWS IoT Greengrass

[AWS IoT Greengrass](#) seamlessly extends AWS to devices so they can act locally on the data they generate, while still using the cloud for management, analytics, and durable storage. With AWS IoT Greengrass, connected devices can run [AWS Lambda](#) functions, execute predictions based on machine learning models, keep device data in sync, and communicate with other devices securely – even when not connected to the Internet.

With AWS IoT Greengrass, you can use familiar languages and programming models to create and test your device software in the cloud, and then deploy it to your devices. AWS IoT Greengrass can be programmed to filter device data and only transmit necessary information back to the cloud. You can also connect to third-party applications, on-premises software, and AWS services out-of-the-box with AWS IoT Greengrass Connectors. Connectors also jumpstart device onboarding with pre-built protocol adapter integrations and allow you to streamline authentication via integration with AWS Secrets Manager.

## AWS IoT SiteWise

[AWS IoT SiteWise](#) is a managed service that makes it easy to collect, store, organize and monitor data from industrial equipment at scale to help you make better, data-driven decisions. You can use AWS IoT SiteWise to monitor operations across facilities, quickly compute common industrial performance

metrics, and create applications that analyze industrial equipment data to prevent costly equipment issues and reduce gaps in production. This allows you to collect data consistently across devices, identify issues with remote monitoring more quickly, and improve multi-site processes with centralized data.

Today, getting performance metrics from industrial equipment is challenging because data is often locked into proprietary on-premises data stores and typically requires specialized expertise to retrieve and place in a format that is useful for analysis. AWS IoT SiteWise simplifies this process by providing software running on a gateway that resides in your facilities and automates the process of collecting and organizing industrial equipment data. This gateway securely connects to your on-premises data servers, collects data, and sends the data to the AWS Cloud. AWS IoT SiteWise also provides interfaces for collecting data from modern industrial applications through MQTT messages or APIs.

You can use AWS IoT SiteWise to model your physical assets, processes and facilities, quickly compute common industrial performance metrics, and create fully managed web applications to help analyze industrial equipment data, reduce costs and make faster decisions. With AWS IoT SiteWise, you can focus on understanding and optimizing your operations, rather than building costly in-house data collection and management applications.

## AWS IoT Things Graph

[AWS IoT Things Graph](#) is a service that makes it easy to visually connect different devices and web services to build IoT applications.

IoT applications are being built today using a variety of devices and web services to automate tasks for a wide range of use cases, such as smart homes, industrial automation, and energy management. Because there aren't any widely adopted standards, it's difficult today for developers to get devices from multiple manufacturers to connect to each other as well as with web services. This forces developers to write lots of code to wire together all of the devices and web services they need for their IoT application. AWS IoT Things Graph provides a visual drag-and-drop interface for connecting and coordinating devices and web services, so you can build IoT applications quickly. For example, in a commercial agriculture application, you can define interactions between humidity, temperature, and sprinkler sensors with weather data services in the cloud to automate watering. You represent devices and services using pre-built reusable components, called models, that hide low-level details, such as protocols and interfaces, and are easy to integrate to create sophisticated workflows.

You can get started with AWS IoT Things Graph using these pre-built models for popular device types, such as switches and programmable logic controllers (PLCs), or create your own custom model using a GraphQL-based schema modeling language, and deploy your IoT application to AWS IoT Greengrass-enabled devices such as cameras, cable set-top boxes, or robotic arms in just a few clicks. IoT Greengrass is software that provides local compute and secure cloud connectivity so devices can respond quickly to local events even without internet connectivity, and runs on a huge range of devices from a Raspberry Pi to a server-level appliance. IoT Things Graph applications run on IoT Greengrass-enabled devices.

## AWS Partner Device Catalog

The [AWS Partner Device Catalog](#) helps you find devices and hardware to help you explore, build, and go to market with your IoT solutions. Search for and find hardware that works with AWS, including development kits and embedded systems to build new devices, as well as off-the-shelf-devices such as gateways, edge servers, sensors, and cameras for immediate IoT project integration. The choice of AWS enabled hardware from our curated catalog of devices from APN partners can help make the rollout of your IoT projects easier. All devices listed in the AWS Partner Device Catalog are also available for purchase from our partners to get you started quickly.

## FreeRTOS

[FreeRTOS](#) is an operating system for microcontrollers that makes small, low-power edge devices easy to program, deploy, secure, connect, and manage. FreeRTOS extends the FreeRTOS kernel, a popular

open source operating system for microcontrollers, with software libraries that make it easy to securely connect your small, low-power devices to AWS cloud services like [AWS IoT Core](#) or to more powerful edge devices running [AWS IoT Greengrass](#).

A microcontroller (MCU) is a single chip containing a simple processor that can be found in many devices, including appliances, sensors, fitness trackers, industrial automation, and automobiles. Many of these small devices could benefit from connecting to the cloud or locally to other devices. For example, smart electricity meters need to connect to the cloud to report on usage, and building security systems need to communicate locally so that a door will unlock when you badge in. Microcontrollers have limited compute power and memory capacity and typically perform simple, functional tasks. Microcontrollers frequently run operating systems that do not have built-in functionality to connect to local networks or the cloud, making IoT applications a challenge. FreeRTOS helps solve this problem by providing both the core operating system (to run the edge device) as well as software libraries that make it easy to securely connect to the cloud (or other edge devices) so you can collect data from them for IoT applications and take action.

## Machine Learning

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## Amazon Augmented AI

[Amazon Augmented AI \(Amazon A2I\)](#) is a machine learning service which makes it easy to build the workflows required for human review. Amazon A2I brings human review to all developers, removing the undifferentiated heavy lifting associated with building human review systems or managing large numbers of human reviewers whether it runs on AWS or not.

## Amazon CodeGuru

[Amazon CodeGuru](#) is a developer tool that provides intelligent recommendations to improve code quality and identify an application's most expensive lines of code. Integrate CodeGuru into your existing software development workflow to automate code reviews during application development and continuously monitor application's performance in production and provide recommendations and visual clues on how to improve code quality, application performance, and reduce overall cost.

CodeGuru Reviewer uses machine learning and automated reasoning to identify critical issues, security vulnerabilities, and hard-to-find bugs during application development and provides recommendations to improve code quality.

CodeGuru Profiler helps developers find an application's most expensive lines of code by helping them understand the runtime behavior of their applications, identify and remove code inefficiencies, improve performance, and significantly decrease compute costs.

## Amazon Comprehend

[Amazon Comprehend](#) is a natural language processing (NLP) service that uses machine learning to find insights and relationships in text. No machine learning experience required.

There is a treasure trove of potential sitting in your unstructured data. Customer emails, support tickets, product reviews, social media, even advertising copy represents insights into customer sentiment that can be put to work for your business. The question is how to get at it? As it turns out, Machine learning is particularly good at accurately identifying specific items of interest inside vast swathes of text (such as finding company names in analyst reports), and can learn the sentiment hidden inside language (identifying negative reviews, or positive customer interactions with customer service agents), at almost limitless scale.

Amazon Comprehend uses machine learning to help you uncover the insights and relationships in your unstructured data. The service identifies the language of the text; extracts key phrases, places, people, brands, or events; understands how positive or negative the text is; analyzes text using tokenization and parts of speech; and automatically organizes a collection of text files by topic. You can also use AutoML capabilities in Amazon Comprehend to build a custom set of entities or text classification models that are tailored uniquely to your organization's needs.

For extracting complex medical information from unstructured text, you can use [Amazon Comprehend Medical](#). The service can identify medical information, such as medical conditions, medications, dosages, strengths, and frequencies from a variety of sources like doctor's notes, clinical trial reports, and patient health records. Amazon Comprehend Medical also identifies the relationship among the extracted medication and test, treatment and procedure information for easier analysis. For example, the service identifies a particular dosage, strength, and frequency related to a specific medication from unstructured clinical notes.

## Amazon DevOps Guru

[Amazon DevOps Guru](#) is a Machine Learning (ML) powered service that makes it easy to improve an application's operational performance and availability. DevOps Guru detects behaviors that deviate from normal operating patterns so you can identify operational issues long before they impact your customers.

DevOps Guru uses machine learning models informed by years of Amazon.com and AWS operational excellence to identify anomalous application behavior (e.g. increased latency, error rates, resource constraints, etc.) and surface critical issues that could cause potential outages or service disruptions. When DevOps Guru identifies a critical issue, it automatically sends an alert and provides a summary of related anomalies, the likely root cause, and context about when and where the issue occurred. When possible DevOps Guru, also provides recommendations on how to remediate the issue.

DevOps Guru automatically ingests operational data from your AWS applications and provides a single dashboard to visualize issues in your operational data. You can get started with DevOps Guru by selecting coverage from your CloudFormation stacks or your AWS account to improve application availability and reliability with no manual setup or machine learning expertise.

## Amazon Elastic Inference

[Amazon Elastic Inference](#) allows you to attach low-cost GPU-powered acceleration to Amazon EC2 and Amazon SageMaker instances to reduce the cost of running deep learning inference by up to 75%. Amazon Elastic Inference supports TensorFlow, Apache MXNet, PyTorch, and ONNX models.

In most deep learning applications, making predictions using a trained model—a process called inference—can drive as much as 90% of the compute costs of the application due to two factors. First, standalone GPU instances are designed for model training and are typically oversized for inference. While training jobs batch process hundreds of data samples in parallel, most inference happens on a single input in real time that consumes only a small amount of GPU compute. Even at peak load, a GPU's compute capacity may not be fully utilized, which is wasteful and costly. Second, different models need different amounts of GPU, CPU, and memory resources. Selecting a GPU instance type that is big enough to satisfy the requirements of the least used resource often results in under-utilization of the other resources and high costs.

Amazon Elastic Inference solves these problems by allowing you to attach just the right amount of GPU-powered inference acceleration to any EC2 or SageMaker instance type with no code changes. With Amazon Elastic Inference, you can now choose the instance type that is best suited to the overall CPU and memory needs of your application, and then separately configure the amount of inference acceleration that you need to use resources efficiently and to reduce the cost of running inference.

## Amazon Forecast

[Amazon Forecast](#) is a fully managed service that uses machine learning to deliver highly accurate forecasts.

Companies today use everything from simple spreadsheets to complex financial planning software to attempt to accurately forecast future business outcomes such as product demand, resource needs, or financial performance. These tools build forecasts by looking at a historical series of data, which is called time series data. For example, such tools may try to predict the future sales of a raincoat by looking only at its previous sales data with the underlying assumption that the future is determined by the past. This approach can struggle to produce accurate forecasts for large sets of data that have irregular trends. Also, it fails to easily combine data series that change over time (such as price, discounts, web traffic, and number of employees) with relevant independent variables like product features and store locations.

Based on the same technology used at Amazon.com, Amazon Forecast uses machine learning to combine time series data with additional variables to build forecasts. Amazon Forecast requires no machine learning experience to get started. You only need to provide historical data, plus any additional data that you believe may impact your forecasts. For example, the demand for a particular color of a shirt may change with the seasons and store location. This complex relationship is hard to determine on its own, but machine learning is ideally suited to recognize it. Once you provide your data, Amazon Forecast will automatically examine it, identify what is meaningful, and produce a forecasting model capable of making predictions that are up to 50% more accurate than looking at time series data alone.

Amazon Forecast is a fully managed service, so there are no servers to provision, and no machine learning models to build, train, or deploy. You pay only for what you use, and there are no minimum fees and no upfront commitments.

## Amazon Fraud Detector

[Amazon Fraud Detector](#) is a fully managed service that uses machine learning (ML) and more than 20 years of fraud detection expertise from Amazon, to identify potentially fraudulent activity so customers can catch more online fraud faster. Amazon Fraud Detector automates the time consuming and expensive steps to build, train, and deploy an ML model for fraud detection, making it easier for customers to leverage the technology. Amazon Fraud Detector customizes each model it creates to a customer's own dataset, making the accuracy of models higher than current one-size fits all ML solutions. And, because you pay only for what you use, you avoid large upfront expenses.

## Amazon HealthLake

[Amazon HealthLake](#) is a HIPAA-eligible service that healthcare providers, health insurance companies, and pharmaceutical companies can use to store, transform, query, and analyze large-scale health data.

Health data is frequently incomplete and inconsistent. It's also often unstructured, with information contained in clinical notes, lab reports, insurance claims, medical images, recorded conversations, and time-series data (for example, heart ECG or brain EEG traces).

Healthcare providers can use HealthLake to store, transform, query, and analyze data in the AWS Cloud. Using the HealthLake integrated medical natural language processing (NLP) capabilities, you can analyze unstructured clinical text from diverse sources. HealthLake transforms unstructured data using natural language processing models, and provides powerful query and search capabilities. You can use HealthLake to organize, index, and structure patient information in a secure, compliant, and auditable manner.

## Amazon Kendra

[Amazon Kendra](#) is an intelligent search service powered by machine learning. Kendra reimagines enterprise search for your websites and applications so your employees and customers can easily find the content they are looking for, even when it's scattered across multiple locations and content repositories within your organization.

Using Amazon Kendra, you can stop searching through troves of unstructured data and discover the right answers to your questions, when you need them. Amazon Kendra is a fully managed service, so there are no servers to provision, and no machine learning models to build, train, or deploy.

## Amazon Lex

[Amazon Lex](#) is a service for building conversational interfaces into any application using voice and text. Lex provides the advanced deep learning functionalities of automatic speech recognition (ASR) for converting speech to text, and natural language understanding (NLU) to recognize the intent of the text, to enable you to build applications with highly engaging user experiences and lifelike conversational interactions. With Amazon Lex, the same deep learning technologies that power Amazon Alexa are now available to any developer, enabling you to quickly and easily build sophisticated, natural language, conversational bots ("chatbots").

Speech recognition and natural language understanding are some of the most challenging problems to solve in computer science, requiring sophisticated deep learning algorithms to be trained on massive amounts of data and infrastructure. Amazon Lex democratizes these deep learning technologies by putting the power of Alexa within reach of all developers. Harnessing these technologies, Amazon Lex enables you to define entirely new categories of products made possible through conversational interfaces.

## Amazon Lookout for Equipment

[Amazon Lookout for Equipment](#) analyzes the data from the sensors on your equipment (e.g. pressure in a generator, flow rate of a compressor, revolutions per minute of fans), to automatically train a machine learning model based on just your data, for your equipment – with no ML expertise required. Lookout for Equipment uses your unique ML model to analyze incoming sensor data in real-time and accurately identify early warning signs that could lead to machine failures. This means you can detect equipment abnormalities with speed and precision, quickly diagnose issues, take action to reduce expensive downtime, and reduce false alerts.

## Amazon Lookout for Metrics

[Amazon Lookout for Metrics](#) uses machine learning (ML) to automatically detect and diagnose anomalies (i.e. outliers from the norm) in business and operational data, such as a sudden dip in sales revenue or customer acquisition rates. In a couple of clicks, you can connect Amazon Lookout for Metrics to popular data stores like Amazon S3, Amazon Redshift, and Amazon Relational Database Service (RDS), as well as third-party SaaS applications, such as Salesforce, ServiceNow, Zendesk, and Marketo, and start monitoring metrics that are important to your business. Amazon Lookout for Metrics automatically inspects and prepares the data from these sources to detect anomalies with greater speed and accuracy than traditional methods used for anomaly detection. You can also provide feedback on detected anomalies to tune the results and improve accuracy over time. Amazon Lookout for Metrics makes it easy to diagnose detected anomalies by grouping together anomalies that are related to the same event and sending an alert that includes a summary of the potential root cause. It also ranks anomalies in order of severity so that you can prioritize your attention to what matters the most to your business.

## Amazon Lookout for Vision

[Amazon Lookout for Vision](#) is a machine learning (ML) service that spots defects and anomalies in visual representations using computer vision (CV). With Amazon Lookout for Vision, manufacturing companies can increase quality and reduce operational costs by quickly identifying differences in images of objects at scale. For example, Amazon Lookout for Vision can be used to identify missing components in products, damage to vehicles or structures, irregularities in production lines, minuscule defects in silicon wafers, and other similar problems. Amazon Lookout for Vision uses ML to see and understand images from any camera as a person would, but with an even higher degree of accuracy and at a much larger scale. Amazon Lookout for Vision allows customers to eliminate the need for costly and inconsistent manual inspection, while improving quality control, defect and damage assessment, and compliance. In minutes, you can begin using Amazon Lookout for Vision to automate inspection of images and objects—with no machine learning expertise required.

## Amazon Monitron

[Amazon Monitron](#) is an end-to-end system that uses machine learning (ML) to detect abnormal behavior in industrial machinery, enabling you to implement predictive maintenance and reduce unplanned downtime.

Installing sensors and the necessary infrastructure for data connectivity, storage, analytics, and alerting are foundational elements for enabling predictive maintenance. However, in order to make it work, companies have historically needed skilled technicians and data scientists to piece together a complex solution from scratch. This included identifying and procuring the right type of sensors for their use cases and connecting them together with an IoT gateway (a device that aggregates and transmits data). As a result, few companies have been able to successfully implement predictive maintenance.

Amazon Monitron includes sensors to capture vibration and temperature data from equipment, a gateway device to securely transfer data to AWS, the Amazon Monitron service that analyzes the data for abnormal machine patterns using machine learning, and a companion mobile app to set up the devices

and receive reports on operating behavior and alerts to potential failures in your machinery. You can start monitoring equipment health in minutes without any development work or ML experience required, and enable predictive maintenance with the same technology used to monitor equipment in Amazon Fulfillment Centers.

## Amazon Personalize

[Amazon Personalize](#) is a machine learning service that makes it easy for developers to create individualized recommendations for customers using their applications.

Machine learning is being increasingly used to improve customer engagement by powering personalized product and content recommendations, tailored search results, and targeted marketing promotions. However, developing the machine-learning capabilities necessary to produce these sophisticated recommendation systems has been beyond the reach of most organizations today due to the complexity of developing machine learning functionality. Amazon Personalize allows developers with no prior machine learning experience to easily build sophisticated personalization capabilities into their applications, using machine learning technology perfected from years of use on Amazon.com.

With Amazon Personalize, you provide an activity stream from your application – page views, signups, purchases, and so forth – as well as an inventory of the items you want to recommend, such as articles, products, videos, or music. You can also choose to provide Amazon Personalize with additional demographic information from your users such as age, or geographic location. Amazon Personalize will process and examine the data, identify what is meaningful, select the right algorithms, and train and optimize a personalization model that is customized for your data.

All data analyzed by Amazon Personalize is kept private and secure, and only used for your customized recommendations. You can start serving your personalized predictions via a simple API call from inside the virtual private cloud that the service maintains. You pay only for what you use, and there are no minimum fees and no upfront commitments.

Amazon Personalize is like having your own Amazon.com machine learning personalization team at your disposal, 24 hours a day.

## Amazon Polly

[Amazon Polly](#) is a service that turns text into lifelike speech. Polly lets you create applications that talk, enabling you to build entirely new categories of speech-enabled products. Polly is an Amazon artificial intelligence (AI) service that uses advanced deep learning technologies to synthesize speech that sounds like a human voice. Polly includes a wide selection of lifelike voices spread across dozens of languages, so you can select the ideal voice and build speech-enabled applications that work in many different countries.

Amazon Polly delivers the consistently fast response times required to support real-time, interactive dialog. You can cache and save Polly's speech audio to replay offline or redistribute. And Polly is easy to use. You simply send the text you want converted into speech to the Polly API, and Polly immediately returns the audio stream to your application so your application can play it directly or store it in a standard audio file format, such as MP3.

With Polly, you only pay for the number of characters you convert to speech, and you can save and replay Polly's generated speech. Polly's low cost per character converted, and lack of restrictions on storage and reuse of voice output, make it a cost-effective way to enable Text-to-Speech everywhere.

## Amazon Rekognition

[Amazon Rekognition](#) makes it easy to add image and video analysis to your applications using proven, highly scalable, deep learning technology that requires no machine learning expertise to use. With

Amazon Rekognition, you can identify objects, people, text, scenes, and activities in images and videos, as well as detect any inappropriate content. Amazon Rekognition also provides highly accurate facial analysis and facial search capabilities that you can use to detect, analyze, and compare faces for a wide variety of user verification, people counting, and public safety use cases.

With Amazon Rekognition Custom Labels, you can identify the objects and scenes in images that are specific to your business needs. For example, you can build a model to classify specific machine parts on your assembly line or to detect unhealthy plants. Amazon Rekognition Custom Labels takes care of the heavy lifting of model development for you, so no machine learning experience is required. You simply need to supply images of objects or scenes you want to identify, and the service handles the rest.

## Amazon SageMaker

[Amazon SageMaker](#) is a fully-managed service that enables developers and data scientists to quickly and easily build, train, and deploy machine learning models at any scale. SageMaker removes all the barriers that typically slow down developers who want to use machine learning.

Machine learning often feels a lot harder than it should be to most developers because the process to build and train models, and then deploy them into production is too complicated and too slow. First, you need to collect and prepare your training data to discover which elements of your data set are important. Then, you need to select which algorithm and framework you'll use. After deciding on your approach, you need to teach the model how to make predictions by training, which requires a lot of compute. Then, you need to tune the model so it delivers the best possible predictions, which is often a tedious and manual effort. After you've developed a fully trained model, you need to integrate the model with your application and deploy this application on infrastructure that will scale. All of this takes a lot of specialized expertise, access to large amounts of compute and storage, and a lot of time to experiment and optimize every part of the process. In the end, it's not a surprise that the whole thing feels out of reach for most developers.

SageMaker removes the complexity that holds back developer success with each of these steps. SageMaker includes modules that can be used together or independently to build, train, and deploy your machine learning models.

## Amazon SageMaker Ground Truth

[Amazon SageMaker Ground Truth](#) helps you build highly accurate training datasets for machine learning quickly. SageMaker Ground Truth offers easy access to public and private human labelers and provides them with built-in workflows and interfaces for common labeling tasks. Additionally, SageMaker Ground Truth can lower your labeling costs by up to 70% using automatic labeling, which works by training Ground Truth from data labeled by humans so that the service learns to label data independently.

Successful machine learning models are built on the shoulders of large volumes of high-quality training data. But, the process to create the training data necessary to build these models is often expensive, complicated, and time-consuming. The majority of models created today require a human to manually label data in a way that allows the model to learn how to make correct decisions. For example, building a computer vision system that is reliable enough to identify objects - such as traffic lights, stop signs, and pedestrians - requires thousands of hours of video recordings that consist of hundreds of millions of video frames. Each one of these frames needs all of the important elements like the road, other cars, and signage to be labeled by a human before any work can begin on the model you want to develop.

Amazon SageMaker Ground Truth significantly reduces the time and effort required to create datasets for training to reduce costs. These savings are achieved by using machine learning to automatically label data. The model is able to get progressively better over time by continuously learning from labels created by human labelers.

Where the labeling model has high confidence in its results based on what it has learned so far, it will automatically apply labels to the raw data. Where the labeling model has lower confidence in its results,

it will pass the data to humans to do the labeling. The human-generated labels are provided back to the labeling model for it to learn from and improve. Over time, SageMaker Ground Truth can label more and more data automatically and substantially speed up the creation of training datasets.

## Amazon Textract

[Amazon Textract](#) is a service that automatically extracts text and data from scanned documents. Amazon Textract goes beyond simple optical character recognition (OCR) to also identify the contents of fields in forms and information stored in tables.

Many companies today extract data from documents and forms through manual data entry that's slow and expensive or through simple optical character recognition (OCR) software that is difficult to customize. Rules and workflows for each document and form often need to be hard-coded and updated with each change to the form or when dealing with multiple forms. If the form deviates from the rules, the output is often scrambled and unusable.

Amazon Textract overcomes these challenges by using machine learning to instantly "read" virtually any type of document to accurately extract text and data without the need for any manual effort or custom code. With Textract you can quickly automate document workflows, enabling you to process millions of document pages in hours. Once the information is captured, you can take action on it within your business applications to initiate next steps for a loan application or medical claims processing. Additionally, you can create smart search indexes, build automated approval workflows, and better maintain compliance with document archival rules by flagging data that may require redaction.

## Amazon Transcribe

[Amazon Transcribe](#) is an automatic speech recognition (ASR) service that makes it easy for developers to add speech-to-text capability to their applications. Using the Amazon Transcribe API, you can analyze audio files stored in Amazon S3 and have the service return a text file of the transcribed speech. You can also send a live audio stream to Amazon Transcribe and receive a stream of transcripts in real time.

Amazon Transcribe can be used for lots of common applications, including the transcription of customer service calls and generating subtitles on audio and video content. The service can transcribe audio files stored in common formats, like WAV and MP3, with time stamps for every word so that you can easily locate the audio in the original source by searching for the text. Amazon Transcribe is continually learning and improving to keep pace with the evolution of language.

## Amazon Translate

[Amazon Translate](#) is a neural machine translation service that delivers fast, high-quality, and affordable language translation. Neural machine translation is a form of language translation automation that uses deep learning models to deliver more accurate and more natural sounding translation than traditional statistical and rule-based translation algorithms. Amazon Translate allows you to localize content - such as websites and applications - for international users, and to easily translate large volumes of text efficiently.

## Apache MXNet on AWS

[Apache MXNet on AWS](#) is a fast and scalable training and inference framework with an easy-to-use, concise API for machine learning.

MXNet includes the [Gluon](#) interface that allows developers of all skill levels to get started with deep learning on the cloud, on edge devices, and on mobile apps. In just a few lines of Gluon code, you can build linear regression, convolutional networks and recurrent LSTMs for object detection, speech recognition, recommendation, and personalization.

You can get started with MxNet on AWS with a fully-managed experience using [SageMaker](#), a platform to build, train, and deploy machine learning models at scale. Or, you can use the [AWS Deep Learning AMIs](#) to build custom environments and workflows with MxNet as well as other frameworks including [TensorFlow](#), PyTorch, Chainer, Keras, Caffe, Caffe2, and Microsoft Cognitive Toolkit.

## AWS Deep Learning AMIs

The [AWS Deep Learning AMIs](#) provide machine learning practitioners and researchers with the infrastructure and tools to accelerate deep learning in the cloud, at any scale. You can quickly launch Amazon EC2 instances pre-installed with popular deep learning frameworks such as Apache MXNet and Gluon, TensorFlow, Microsoft Cognitive Toolkit, Caffe, Caffe2, Theano, Torch, PyTorch, Chainer, and Keras to train sophisticated, custom AI models, experiment with new algorithms, or to learn new skills and techniques.

## AWS DeepComposer

[AWS DeepComposer](#) is the world's first musical keyboard powered by machine learning to enable developers of all skill levels to learn Generative AI while creating original music outputs. DeepComposer consists of a USB keyboard that connects to the developer's computer, and the DeepComposer service, accessed through the AWS Management Console. DeepComposer includes tutorials, sample code, and training data that can be used to start building generative models.

## AWS DeepLens

[AWS DeepLens](#) helps put deep learning in the hands of developers, literally, with a fully programmable video camera, tutorials, code, and pre-trained models designed to expand deep learning skills.

## AWS DeepRacer

[AWS DeepRacer](#) is a 1/18th scale race car which gives you an interesting and fun way to get started with reinforcement learning (RL). RL is an advanced machine learning (ML) technique which takes a very different approach to training models than other machine learning methods. Its super power is that it learns very complex behaviors without requiring any labeled training data, and can make short term decisions while optimizing for a longer term goal.

With AWS DeepRacer, you now have a way to get hands-on with RL, experiment, and learn through autonomous driving. You can get started with the virtual car and tracks in the cloud-based 3D racing simulator, and for a real-world experience, you can deploy your trained models onto AWS DeepRacer and race your friends, or take part in the global AWS DeepRacer League. Developers, the race is on.

## AWS Inferentia

[AWS Inferentia](#) is a machine learning inference chip designed to deliver high performance at low cost. AWS Inferentia will support the TensorFlow, Apache MXNet, and PyTorch deep learning frameworks, as well as models that use the ONNX format.

Making predictions using a trained machine learning model—a process called inference—can drive as much as 90% of the compute costs of the application. Using [Amazon Elastic Inference](#), developers can reduce inference costs by up to 75% by attaching GPU-powered inference acceleration to Amazon EC2 and SageMaker instances. However, some inference workloads require an entire GPU or have extremely low latency requirements. Solving this challenge at low cost requires a dedicated inference chip.

AWS Inferentia provides high throughput, low latency inference performance at an extremely low cost. Each chip provides hundreds of TOPS (tera operations per second) of inference throughput to allow complex models to make fast predictions. For even more performance, multiple AWS Inferentia chips can

be used together to drive thousands of TOPS of throughput. AWS Inferentia will be available for use with SageMaker, Amazon EC2, and Amazon Elastic Inference.

## TensorFlow on AWS

TensorFlow enables developers to quickly and easily get started with [deep learning](#) in the cloud. The framework has broad support in the industry and has become a popular choice for deep learning research and application development, particularly in areas such as computer vision, natural language understanding and speech translation.

You can get started on AWS with a fully-managed TensorFlow experience with [SageMaker](#), a platform to build, train, and deploy machine learning models at scale. Or, you can use the [AWS Deep Learning AMIs](#) to build custom environments and workflows with TensorFlow and other popular frameworks including [Apache MXNet](#), PyTorch, Caffe, Caffe2, Chainer, Gluon, Keras, and Microsoft Cognitive Toolkit.

# Management and Governance

## Topics

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## Amazon CloudWatch

[Amazon CloudWatch](#) is a monitoring and management service built for developers, system operators, site reliability engineers (SRE), and IT managers. CloudWatch provides you with data and actionable insights to monitor your applications, understand and respond to system-wide performance changes, optimize resource utilization, and get a unified view of operational health. CloudWatch collects monitoring and operational data in the form of logs, metrics, and events, providing you with a unified view of AWS resources, applications and services that run on AWS, and on-premises servers. You can use CloudWatch to set high resolution alarms, visualize logs and metrics side by side, take automated

actions, troubleshoot issues, and discover insights to optimize your applications, and ensure they are running smoothly.

## AWS Auto Scaling

[AWS Auto Scaling](#) monitors your applications and automatically adjusts capacity to maintain steady, predictable performance at the lowest possible cost. Using AWS Auto Scaling, it's easy to setup application scaling for multiple resources across multiple services in minutes. The service provides a simple, powerful user interface that lets you build scaling plans for resources including [Amazon EC2](#) instances and Spot Fleets, [Amazon ECS](#) tasks, [Amazon DynamoDB](#) tables and indexes, and [Amazon Aurora](#) Replicas. AWS Auto Scaling makes scaling simple with recommendations that allow you to optimize performance, costs, or balance between them. If you're already using [Amazon EC2 Auto Scaling](#) to dynamically scale your Amazon EC2 instances, you can now combine it with AWS Auto Scaling to scale additional resources for other AWS services. With AWS Auto Scaling, your applications always have the right resources at the right time.

## AWS Chatbot

[AWS Chatbot](#) is an interactive agent that makes it easy to monitor and interact with your AWS resources in your [Slack](#) channels and [Amazon Chime](#) chat rooms. With AWS Chatbot you can receive alerts, run commands to return diagnostic information, invoke AWS Lambda functions, and create AWS support cases.

AWS Chatbot manages the integration between AWS services and your Slack channels or Amazon Chime chat rooms helping you to get started with ChatOps fast. With just a few clicks you can start receiving notifications and issuing commands in your chosen channels or chat rooms, so your team doesn't have to switch contexts to collaborate. AWS Chatbot makes it easier for your team to stay updated, collaborate, and respond faster to operational events, security findings, CI/CD workflows, budget, and other alerts for applications running in your AWS accounts.

## AWS Compute Optimizer

[AWS Compute Optimizer](#) recommends optimal AWS resources for your workloads to reduce costs and improve performance by using machine learning to analyze historical utilization metrics. Over-provisioning resources can lead to unnecessary infrastructure cost, and under-provisioning resources can lead to poor application performance. Compute Optimizer helps you choose optimal configurations for three types of AWS resources: Amazon EC2 instances, Amazon EBS volumes, and AWS Lambda functions, based on your utilization data.

By applying the knowledge drawn from Amazon's own experience running diverse workloads in the cloud, Compute Optimizer identifies workload patterns and recommends optimal AWS resources. Compute Optimizer analyzes the configuration and resource utilization of your workload to identify dozens of defining characteristics, for example, if a workload is CPU-intensive, if it exhibits a daily pattern, or if a workload accesses local storage frequently. The service processes these characteristics and identifies the hardware resource required by the workload. Compute Optimizer infers how the workload would have performed on various hardware platforms (e.g. Amazon EC2 instance types) or using different configurations (e.g. Amazon EBS volume IOPS settings, and AWS Lambda function memory sizes) to offer recommendations.

Compute Optimizer is available to you at no additional charge. To get started, you can opt in to the service in the AWS Compute Optimizer Console.

## AWS Control Tower

[AWS Control Tower](#) automates the set-up of a baseline environment, or landing zone, that is a secure, well-architected multi-account AWS environment. The configuration of the landing zone is based on

best practices that have been established by working with thousands of enterprise customers to create a secure environment that makes it easier to govern AWS workloads with rules for security, operations, and compliance.

As enterprises migrate to AWS, they typically have a large number of applications and distributed teams. They often want to create multiple accounts to allow their teams to work independently, while still maintaining a consistent level of security and compliance. In addition, they use AWS's management and security services, like AWS Organizations, AWS Service Catalog and AWS Config, that provide very granular controls over their workloads. They want to maintain this control, but they also want a way to centrally govern and enforce the best use of AWS services across all the accounts in their environment.

Control Tower automates the set-up of their landing zone and configures AWS management and security services based on established best practices in a secure, compliant, multi-account environment. Distributed teams are able to provision new AWS accounts quickly, while central teams have the peace of mind knowing that new accounts are aligned with centrally established, company-wide compliance policies. This gives you control over your environment, without sacrificing the speed and agility AWS provides your development teams.

## AWS CloudFormation

[AWS CloudFormation](#) gives developers and systems administrators an easy way to create and manage a collection of related AWS resources, provisioning and updating them in an orderly and predictable fashion.

You can use the AWS CloudFormation [sample templates](#) or create your own templates to describe your AWS resources, and any associated dependencies or runtime parameters, required to run your application. You don't need to figure out the order for provisioning AWS services or the subtleties of making those dependencies work. CloudFormation takes care of this for you. After the AWS resources are deployed, you can modify and update them in a controlled and predictable way, in effect applying version control to your AWS infrastructure the same way you do with your software. You can also visualize your templates as diagrams and edit them using a drag-and-drop interface with the [AWS CloudFormation Designer](#).

## AWS CloudTrail

[AWS CloudTrail](#) is a web service that records AWS API calls for your account and delivers log files to you. The recorded information includes the identity of the API caller, the time of the API call, the source IP address of the API caller, the request parameters, and the response elements returned by the AWS service.

With CloudTrail, you can get a history of AWS API calls for your account, including API calls made using the AWS Management Console, AWS SDKs, command line tools, and higher-level AWS services (such as [AWS CloudFormation \(p. 50\)](#)). The AWS API call history produced by CloudTrail enables security analysis, resource change tracking, and compliance auditing.

## AWS Config

[AWS Config](#) is a fully managed service that provides you with an AWS resource inventory, configuration history, and configuration change notifications to enable security and governance. The Config Rules feature enables you to create rules that automatically check the configuration of AWS resources recorded by AWS Config.

With AWS Config, you can discover existing and deleted AWS resources, determine your overall compliance against rules, and dive into configuration details of a resource at any point in time. These capabilities enable compliance auditing, security analysis, resource change tracking, and troubleshooting.

## AWS Launch Wizard

[AWS Launch Wizard](#) offers a guided way of sizing, configuring, and deploying AWS resources for third party applications, such as Microsoft SQL Server Always On and HANA based SAP systems, without the need to manually identify and provision individual AWS resources. To start, you input your application requirements, including performance, number of nodes, and connectivity on the service console. Launch Wizard then identifies the right AWS resources, such as EC2 instances and EBS volumes, to deploy and run your application. Launch Wizard provides an estimated cost of deployment, and lets you modify your resources to instantly view an updated cost assessment. Once you approve the AWS resources, Launch Wizard automatically provisions and configures the selected resources to create a fully-functioning, production-ready application.

AWS Launch Wizard also creates [CloudFormation templates](#) that can serve as a baseline to accelerate subsequent deployments. Launch Wizard is available to you at no additional charge. You only pay for the AWS resources that are provisioned for running your solution.

## AWS Organizations

[AWS Organizations](#) helps you centrally manage and govern your environment as you grow and scale your AWS resources. Using AWS Organizations, you can programmatically create new AWS accounts and allocate resources, group accounts to organize your workflows, apply policies to accounts or groups for governance, and simplify billing by using a single payment method for all of your accounts.

In addition, AWS Organizations is integrated with other AWS services so you can define central configurations, security mechanisms, audit requirements, and resource sharing across accounts in your organization. AWS Organizations is available to all AWS customers at no additional charge.

## AWS OpsWorks

[AWS OpsWorks](#) is a configuration management service that provides managed instances of Chef and Puppet. Chef and Puppet are automation platforms that allow you to use code to automate the configurations of your servers. OpsWorks lets you use Chef and Puppet to automate how servers are configured, deployed, and managed across your [Amazon EC2](#) instances or on-premises compute environments. OpsWorks has three offerings, [AWS OpsWorks for Chef Automate](#), [AWS OpsWorks for Puppet Enterprise](#), and [AWS OpsWorks Stacks](#).

## AWS Proton

[AWS Proton](#) is the first fully managed delivery service for container and serverless applications. Platform engineering teams can use AWS Proton to connect and coordinate all the different tools needed for infrastructure provisioning, code deployments, monitoring, and updates.

Maintaining hundreds – or sometimes thousands – of microservices with constantly changing infrastructure resources and continuous integration/continuous delivery (CI/CD) configurations is a nearly impossible task for even the most capable platform teams.

AWS Proton solves this by giving platform teams the tools they need to manage this complexity and enforce consistent standards, while making it easy for developers to deploy their code using containers and serverless technologies.

## AWS Service Catalog

[AWS Service Catalog](#) allows organizations to create and manage catalogs of IT services that are approved for use on AWS. These IT services can include everything from virtual machine images, servers, software, and databases to complete multi-tier application architectures. AWS Service Catalog allows you to

centrally manage commonly deployed IT services and helps you achieve consistent governance and meet your compliance requirements, while enabling users to quickly deploy only the approved IT services they need.

## AWS Systems Manager

[AWS Systems Manager](#) gives you visibility and control of your infrastructure on AWS. Systems Manager provides a unified user interface so you can view operational data from multiple AWS services and allows you to automate operational tasks across your AWS resources. With Systems Manager, you can group resources, like [Amazon EC2](#) instances, [Amazon S3](#) buckets, or [Amazon RDS](#) instances, by application, view operational data for monitoring and troubleshooting, and take action on your groups of resources. Systems Manager simplifies resource and application management, shortens the time to detect and resolve operational problems, and makes it easy to operate and manage your infrastructure securely at scale.

AWS Systems Manager contains the following tools:

- **Resource groups:** Lets you create a logical group of resources associated with a particular workload such as different layers of an application stack, or production versus development environments. For example, you can group different layers of an application, such as the frontend web layer and the backend data layer. Resource groups can be created, updated, or removed programmatically through the API.
- **Insights Dashboard:** Displays operational data that the AWS Systems Manager automatically aggregates for each resource group. Systems Manager eliminates the need for you to navigate across multiple AWS consoles to view your operational data. With Systems Manager you can view API call logs from [AWS CloudTrail](#), resource configuration changes from [AWS Config](#), software inventory, and patch compliance status by resource group. You can also easily integrate your [Amazon CloudWatch Dashboards](#), [AWS Trusted Advisor](#) notifications, and [AWS Personal Health Dashboard](#) performance and availability alerts into your Systems Manager dashboard. Systems Manager centralizes all relevant operational data, so you can have a clear view of your infrastructure compliance and performance.
- **Run Command:** Provides a simple way of automating common administrative tasks like remotely executing shell scripts or PowerShell commands, installing software updates, or making changes to the configuration of OS, software, EC2 and instances and servers in your on-premises data center.
- **State Manager:** Helps you define and maintain consistent OS configurations such as firewall settings and anti-malware definitions to comply with your policies. You can monitor the configuration of a large set of instances, specify a configuration policy for the instances, and automatically apply updates or configuration changes.
- **Inventory:** Helps you collect and query configuration and inventory information about your instances and the software installed on them. You can gather details about your instances such as installed applications, DHCP settings, agent detail, and custom items. You can run queries to track and audit your system configurations.
- **Maintenance Window:** Lets you define a recurring window of time to run administrative and maintenance tasks across your instances. This ensures that installing patches and updates, or making other configuration changes does not disrupt business-critical operations. This helps improve your application availability.
- **Patch Manager:** Helps you select and deploy operating system and software patches automatically across large groups of instances. You can define a maintenance window so that patches are applied only during set times that fit your needs. These capabilities help ensure that your software is always up to date and meets your compliance policies.
- **Automation:** Simplifies common maintenance and deployment tasks, such as updating Amazon Machine Images (AMIs). Use the Automation feature to apply patches, update drivers and agents, or bake applications into your AMI using a streamlined, repeatable, and auditable process.
- **Parameter Store:** Provides an encrypted location to store important administrative information such as passwords and database strings. The Parameter Store integrates with AWS KMS to make it easy to encrypt the information you keep in the Parameter Store.

- **Distributor:** Helps you securely distribute and install software packages, such as software agents. Systems Manager Distributor allows you to centrally store and systematically distribute software packages while you maintain control over versioning. You can use Distributor to create and distribute software packages and then install them using Systems Manager Run Command and State Manager. Distributor can also use AWS Identity and Access Management (IAM) policies to control who can create or update packages in your account. You can use the existing IAM policy support for Systems Manager Run Command and State Manager to define who can install packages on your hosts.
- **Session Manager:** Provides a browser-based interactive shell and CLI for managing Windows and Linux EC2 instances, without the need to open inbound ports, manage SSH keys, or use bastion hosts. Administrators can grant and revoke access to instances through a central location by using [AWS Identity and Access Management \(IAM\)](#) policies. This allows you to control which users can access each instance, including the option to provide non-root access to specified users. Once access is provided, you can audit which user accessed an instance and log each command to [Amazon S3](#) or [Amazon CloudWatch Logs](#) using [AWS CloudTrail](#).

## AWS Trusted Advisor

[AWS Trusted Advisor](#) is an online resource to help you reduce cost, increase performance, and improve security by optimizing your AWS environment. Trusted Advisor provides real-time guidance to help you provision your resources following AWS best practices.

## AWS Personal Health Dashboard

[AWS Personal Health Dashboard](#) provides alerts and remediation guidance when AWS is experiencing events that might affect you. While the Service Health Dashboard displays the general status of AWS services, Personal Health Dashboard gives you a personalized view into the performance and availability of the AWS services underlying your AWS resources. The dashboard displays relevant and timely information to help you manage events in progress, and provides proactive notification to help you plan for scheduled activities. With Personal Health Dashboard, alerts are automatically triggered by changes in the health of AWS resources, giving you event visibility and guidance to help quickly diagnose and resolve issues.

## AWS Managed Services

[AWS Managed Services](#) provides ongoing management of your AWS infrastructure so you can focus on your applications. By implementing best practices to maintain your infrastructure, AWS Managed Services helps to reduce your operational overhead and risk. AWS Managed Services automates common activities such as change requests, monitoring, patch management, security, and backup services, and provides full-lifecycle services to provision, run, and support your infrastructure. Our rigor and controls help to enforce your corporate and security infrastructure policies, and enables you to develop solutions and applications using your preferred development approach. AWS Managed Services improves agility, reduces cost, and unburdens you from infrastructure operations so you can direct resources toward differentiating your business.

## AWS Console Mobile Application

The [AWS Console Mobile Application](#) lets customers view and manage a select set of resources to support incident response while on-the-go.

The Console Mobile Application allows AWS customers to monitor resources through a dedicated dashboard and view configuration details, metrics, and alarms for select AWS services. The Dashboard provides permitted users with a single view a resource's status, with real-time data on Amazon CloudWatch, Personal Health Dashboard, and AWS Billing and Cost Management. Customers can view ongoing issues and follow through to the relevant CloudWatch alarm screen for a detailed view with

graphs and configuration options. In addition, customers can check on the status of specific AWS services, view detailed resource screens, and perform select actions.

## AWS License Manager

[AWS License Manager](#) makes it easier to manage licenses in AWS and on-premises servers from software vendors such as Microsoft, SAP, Oracle, and IBM. AWS License Manager lets administrators create customized licensing rules that emulate the terms of their licensing agreements, and then enforces these rules when an instance of Amazon EC2 gets launched. Administrators can use these rules to limit licensing violations, such as using more licenses than an agreement stipulates or reassigning licenses to different servers on a short-term basis. The rules in AWS License Manager enable you to limit a licensing breach by physically stopping the instance from launching or by notifying administrators about the infringement. Administrators gain control and visibility of all their licenses with the AWS License Manager dashboard and reduce the risk of non-compliance, misreporting, and additional costs due to licensing overages.

AWS License Manager integrates with AWS services to simplify the management of licenses across multiple AWS accounts, IT catalogs, and on-premises, through a single AWS account. License administrators can add rules in [AWS Service Catalog](#), which allows them to create and manage catalogs of IT services that are approved for use on all their AWS accounts. Through seamless integration with [AWS Systems Manager](#) and [AWS Organizations](#), administrators can manage licenses across all the AWS accounts in an organization and on-premises environments. [AWS Marketplace](#) buyers can also use AWS License Manager to track bring your own license (BYOL) software obtained from the Marketplace and keep a consolidated view of all their licenses.

## AWS Well-Architected Tool

The [AWS Well-Architected Tool](#) helps you review the state of your workloads and compares them to the latest AWS architectural best practices. The tool is based on the [AWS Well-Architected Framework](#), developed to help cloud architects build secure, high-performing, resilient, and efficient application infrastructure. This Framework provides a consistent approach for customers and partners to evaluate architectures, has been used in tens of thousands of workload reviews conducted by the AWS solutions architecture team, and provides guidance to help implement designs that scale with application needs over time.

To use this free tool, available in the AWS Management Console, just define your workload and answer a set of questions regarding operational excellence, security, reliability, performance efficiency, and cost optimization. The AWS Well-Architected Tool then provides a plan on how to architect for the cloud using established best practices.

## Media Services

### Topics

- [Amazon Elastic Transcoder \(p. 55\)](#)
- [Amazon Interactive Video Service \(p. 55\)](#)
- [Amazon Nimble Studio \(p. 55\)](#)
- [AWS Elemental Appliances & Software \(p. 55\)](#)
- [AWS Elemental MediaConnect \(p. 55\)](#)
- [AWS Elemental MediaConvert \(p. 56\)](#)
- [AWS Elemental MediaLive \(p. 56\)](#)
- [AWS Elemental MediaPackage \(p. 56\)](#)
- [AWS Elemental MediaStore \(p. 56\)](#)

- [AWS Elemental MediaTailor \(p. 56\)](#)

## Amazon Elastic Transcoder

[Amazon Elastic Transcoder](#) is media transcoding in the cloud. It is designed to be a highly scalable, easy-to-use, and cost-effective way for developers and businesses to convert (or transcode) media files from their source format into versions that will play back on devices like smartphones, tablets, and PCs.

## Amazon Interactive Video Service

[Amazon Interactive Video Service \(Amazon IVS\)](#) is a managed live streaming solution that is quick and easy to set up, and ideal for creating interactive video experiences. Send your live streams to Amazon IVS using streaming software and the service does everything you need to make low-latency live video available to any viewer around the world, letting you focus on building interactive experiences alongside the live video. You can easily customize and enhance the audience experience through the Amazon IVS player SDK and timed metadata APIs, allowing you to build a more valuable relationship with your viewers on your own websites and applications.

## Amazon Nimble Studio

[Amazon Nimble Studio](#) empowers creative studios to produce visual effects, animation, and interactive content entirely in the cloud, from storyboard sketch to final deliverable. Rapidly onboard and collaborate with artists globally and create content faster with access to virtual workstations, high-speed storage, and scalable rendering across AWS's global infrastructure.

## AWS Elemental Appliances & Software

[AWS Elemental Appliances and Software](#) solutions bring advanced video processing and delivery technologies into your data center, co-location space, or on-premises facility. You can deploy AWS Elemental Appliances and Software to encode, package, and deliver video assets on-premises and seamlessly connect with cloud-based video infrastructure. Designed for easy integration with AWS Cloud media solutions, AWS Elemental Appliances and Software support video workloads that need to remain on-premises to accommodate physical camera and router interfaces, managed network delivery, or network bandwidth constraints.

AWS Elemental Live, Server, and Conductor come in two variants: ready-to-deploy appliances, or AWS-licensed software that you install on your own hardware. AWS Elemental Link is a compact hardware device that sends live video to the cloud for encoding and delivery to viewers.

## AWS Elemental MediaConnect

[AWS Elemental MediaConnect](#) is a high-quality transport service for live video. Today, broadcasters and content owners rely on satellite networks or fiber connections to send their high-value content into the cloud or to transmit it to partners for distribution. Both satellite and fiber approaches are expensive, require long lead times to set up, and lack the flexibility to adapt to changing requirements. To be more nimble, some customers have tried to use solutions that transmit live video on top of IP infrastructure, but have struggled with reliability and security.

Now you can get the reliability and security of satellite and fiber combined with the flexibility, agility, and economics of IP-based networks using AWS Elemental MediaConnect. MediaConnect enables you to build mission-critical live video workflows in a fraction of the time and cost of satellite or fiber services. You can use MediaConnect to ingest live video from a remote event site (like a stadium), share video with a partner (like a cable TV distributor), or replicate a video stream for processing (like an over-the-

top service). MediaConnect combines reliable video transport, highly secure stream sharing, and real-time network traffic and video monitoring that allow you to focus on your content, not your transport infrastructure.

## AWS Elemental MediaConvert

[AWS Elemental MediaConvert](#) is a file-based video transcoding service with broadcast-grade features. It allows you to easily create video-on-demand (VOD) content for broadcast and multiscreen delivery at scale. The service combines advanced video and audio capabilities with a simple web services interface and pay-as-you-go pricing. With AWS Elemental MediaConvert, you can focus on delivering compelling media experiences without having to worry about the complexity of building and operating your own video processing infrastructure.

## AWS Elemental MediaLive

[AWS Elemental MediaLive](#) is a broadcast-grade live video processing service. It lets you create high-quality video streams for delivery to broadcast televisions and internet-connected multiscreen devices, like connected TVs, tablets, smart phones, and set-top boxes. The service works by encoding your live video streams in real-time, taking a larger-sized live video source and compressing it into smaller versions for distribution to your viewers. With AWS Elemental MediaLive, you can easily set up streams for both live events and 24x7 channels with advanced broadcasting features, high availability, and pay-as-you-go pricing. AWS Elemental MediaLive lets you focus on creating compelling live video experiences for your viewers without the complexity of building and operating broadcast-grade video processing infrastructure.

## AWS Elemental MediaPackage

[AWS Elemental MediaPackage](#) reliably prepares and protects your video for delivery over the Internet. From a single video input, AWS Elemental MediaPackage creates video streams formatted to play on connected TVs, mobile phones, computers, tablets, and game consoles. It makes it easy to implement popular video features for viewers (start-over, pause, rewind, etc.), like those commonly found on DVRs. AWS Elemental MediaPackage can also protect your content using Digital Rights Management (DRM). AWS Elemental MediaPackage scales automatically in response to load, so your viewers will always get a great experience without you having to accurately predict in advance the capacity you'll need.

## AWS Elemental MediaStore

[AWS Elemental MediaStore](#) is an AWS storage service optimized for media. It gives you the performance, consistency, and low latency required to deliver live streaming video content. AWS Elemental MediaStore acts as the origin store in your video workflow. Its high performance capabilities meet the needs of the most demanding media delivery workloads, combined with long-term, cost-effective storage.

## AWS Elemental MediaTailor

[AWS Elemental MediaTailor](#) lets video providers insert individually targeted advertising into their video streams without sacrificing broadcast-level quality-of-service. With AWS Elemental MediaTailor, viewers of your live or on-demand video each receive a stream that combines your content with ads personalized to them. But unlike other personalized ad solutions, with AWS Elemental MediaTailor your entire stream – video and ads – is delivered with broadcast-grade video quality to improve the experience for your viewers. AWS Elemental MediaTailor delivers automated reporting based on both client and server-side ad delivery metrics, making it easy to accurately measure ad impressions and viewer behavior. You can easily monetize unexpected high-demand viewing events with no up-front costs using AWS Elemental MediaTailor. It also improves ad delivery rates, helping you make more money from every video, and it works with a wider variety of content delivery networks, ad decision servers, and client devices.

See also [Amazon Kinesis Video Streams \(p. 12\)](#)

## Migration and Transfer

### Topics

- [AWS Application Migration Service \(p. 57\)](#)
- [AWS Migration Hub \(p. 57\)](#)
- [AWS Application Discovery Service \(p. 57\)](#)
- [AWS Database Migration Service \(p. 58\)](#)
- [AWS Server Migration Service \(p. 58\)](#)
- [AWS Snow Family \(p. 58\)](#)
- [AWS DataSync \(p. 59\)](#)
- [AWS Transfer Family \(p. 59\)](#)

## AWS Application Migration Service

[AWS Application Migration Service \(AWS MGN\)](#) allows you to quickly realize the benefits of migrating applications to the cloud without changes and with minimal downtime.

AWS Application Migration Service minimizes time-intensive, error-prone manual processes by automatically converting your source servers from physical, virtual, or cloud infrastructure to run natively on AWS. It further simplifies your migration by enabling you to use the same automated process for a wide range of applications.

And by launching non-disruptive tests before migrating, you can be confident that your most critical applications such as SAP, Oracle, and SQL Server will work seamlessly on AWS.

## AWS Migration Hub

[AWS Migration Hub](#) provides a single location to track the progress of application migrations across multiple AWS and partner solutions. Using Migration Hub allows you to choose the AWS and partner migration tools that best fit your needs, while providing visibility into the status of migrations across your portfolio of applications. Migration Hub also provides key metrics and progress for individual applications, regardless of which tools are being used to migrate them. For example, you might use AWS Database Migration Service, AWS Server Migration Service, and partner migration tools such as ATADATA ATAmotion, CloudEndure Live Migration, or RiverMeadow Server Migration SaaS to migrate an application comprised of a database, virtualized web servers, and a bare metal server. Using Migration Hub, you can view the migration progress of all the resources in the application. This allows you to quickly get progress updates across all of your migrations, easily identify and troubleshoot any issues, and reduce the overall time and effort spent on your migration projects.

## AWS Application Discovery Service

[AWS Application Discovery Service](#) helps enterprise customers plan migration projects by gathering information about their on-premises data centers.

Planning data center migrations can involve thousands of workloads that are often deeply interdependent. Server utilization data and dependency mapping are important early first steps in the migration process. AWS Application Discovery Service collects and presents configuration, usage, and behavior data from your servers to help you better understand your workloads.

The collected data is retained in encrypted format in an AWS Application Discovery Service data store. You can export this data as a CSV file and use it to estimate the Total Cost of Ownership (TCO) of running on AWS and to plan your migration to AWS. In addition, this data is also available in AWS Migration Hub, where you can migrate the discovered servers and track their progress as they get migrated to AWS.

## AWS Database Migration Service

[AWS Database Migration Service](#) helps you migrate databases to AWS easily and securely. The source database remains fully operational during the migration, minimizing downtime to applications that rely on the database. The AWS Database Migration Service can migrate your data to and from most widely used commercial and open-source databases. The service supports homogeneous migrations such as Oracle to Oracle, as well as heterogeneous migrations between different database platforms, such as Oracle to Amazon Aurora or Microsoft SQL Server to MySQL. It also allows you to stream data to Amazon Redshift from any of the supported sources including Amazon Aurora, PostgreSQL, MySQL, MariaDB, Oracle, SAP ASE, and SQL Server, enabling consolidation and easy analysis of data in the petabyte-scale data warehouse. AWS Database Migration Service can also be used for continuous data replication with high availability.

## AWS Server Migration Service

[AWS Server Migration Service \(SMS\)](#) is an agentless service which makes it easier and faster for you to migrate thousands of on-premises workloads to AWS. AWS SMS allows you to automate, schedule, and track incremental replications of live server volumes, making it easier for you to coordinate large-scale server migrations.

## AWS Snow Family

The [AWS Snow Family](#) helps customers that need to run operations in austere, non-data center environments, and in locations where there's lack of consistent network connectivity. The Snow Family comprises AWS Snowcone, AWS Snowball, and AWS Snowmobile and offers a number of physical devices and capacity points, most with built-in computing capabilities. These services help physically transport up to exabytes of data into and out of AWS. Snow Family devices are owned and managed by AWS and integrate with AWS security, monitoring, storage management, and computing capabilities.

### AWS Snowcone

[AWS Snowcone](#) is the smallest member of the AWS Snow Family of edge computing edge storage, and data transfer devices, weighing in at 4.5 pounds (2.1 kg) with 8 terabytes of usable storage. Snowcone is ruggedized, secure, and purpose-built for use outside of a traditional data center. Its small form factor makes it a perfect fit for tight spaces or where portability is a necessity and network connectivity is unreliable. You can use Snowcone in backpacks on first responders, or for IoT, vehicular, and drone use cases. You can execute compute applications at the edge, and you can ship the device with data to AWS for offline data transfer, or you can transfer data online with AWS DataSync from edge locations.

Like AWS Snowball, Snowcone has multiple layers of security and encryption. You can use either of these services to run edge computing workloads, or to collect, process, and transfer data to AWS. Snowcone is designed for data migration needs up to 8 terabytes per device and from space-constrained environments where AWS Snowball devices will not fit.

### AWS Snowball

[AWS Snowball](#) is an edge computing, data migration, and edge storage device that comes in two options. Snowball Edge Storage Optimized devices provide both block storage and Amazon S3-compatible object

storage, and 40 vCPUs. They are well suited for local storage and large scale-data transfer. Snowball Edge Compute Optimized devices provide 52 vCPUs, block and object storage, and an optional GPU for use cases like advanced machine learning and full motion video analysis in disconnected environments. You can use these devices for data collection, machine learning and processing, and storage in environments with intermittent connectivity (like manufacturing, industrial, and transportation) or in extremely remote locations (like military or maritime operations) before shipping them back to AWS. These devices may also be rack mounted and clustered together to build larger temporary installations.

Snowball supports specific Amazon EC2 instance types and AWS Lambda functions, so you can develop and test in the AWS Cloud, then deploy applications on devices in remote locations to collect, pre-process, and ship the data to AWS. Common use cases include data migrati

## AWS Snowmobile

[AWS Snowmobile](#) is an exabyte-scale data transfer service used to move extremely large amounts of data to AWS. You can transfer up to 100 PB per Snowmobile, a 45-foot long ruggedized shipping container, pulled by a semi-trailer truck. Snowmobile makes it easy to move massive volumes of data to the cloud, including video libraries, image repositories, or even a complete data center migration. Transferring data with Snowmobile is secure, fast, and cost effective.

After an initial assessment, a Snowmobile will be transported to your data center, and AWS personnel will configure it for you so it can be accessed as a network storage target. When your Snowmobile is on site, AWS personnel will work with your team to connect a removable, high-speed network switch from the Snowmobile to your local network. Then you can begin your high-speed data transfer from any number of sources within your data center to the Snowmobile. After your data is loaded, the Snowmobile is driven back to AWS where your data is imported into Amazon S3 or S3 Glacier.

AWS Snowmobile uses multiple layers of security designed to protect your data including dedicated security personnel, GPS tracking, alarm monitoring, 24/7 video surveillance, and an optional escort security vehicle while in transit. All data is encrypted with 256-bit encryption keys managed through [AWS KMS \(p. 70\)](#) and designed to ensure both security and full chain of custody of your data.

## AWS DataSync

[AWS DataSync](#) is a data transfer service that makes it easy for you to automate moving data between on-premises storage and Amazon S3 or Amazon Elastic File System (Amazon EFS). DataSync automatically handles many of the tasks related to data transfers that can slow down migrations or burden your IT operations, including running your own instances, handling encryption, managing scripts, network optimization, and data integrity validation. You can use DataSync to transfer data at speeds up to 10 times faster than open-source tools. DataSync uses an on-premises software agent to connect to your existing storage or file systems using the Network File System (NFS) protocol, so you don't have write scripts or modify your applications to work with AWS APIs. You can use DataSync to copy data over AWS Direct Connect or internet links to AWS. The service enables one-time data migrations, recurring data processing workflows, and automated replication for data protection and recovery. Getting started with DataSync is easy: Deploy the DataSync agent on premises, connect it to a file system or storage array, select Amazon EFS or S3 as your AWS storage, and start moving data. You pay only for the data you copy.

## AWS Transfer Family

[AWS Transfer Family](#) provides fully managed support for file transfers directly into and out of Amazon S3 or Amazon EFS. With support for Secure File Transfer Protocol (SFTP), File Transfer Protocol over SSL (FTPS), and File Transfer Protocol (FTP), the AWS Transfer Family helps you seamlessly migrate your file transfer workflows to AWS by integrating with existing authentication systems, and providing DNS routing with Amazon Route 53 so nothing changes for your customers and partners, or their applications. With your data in Amazon S3 or Amazon EFS, you can use it with AWS services for

processing, analytics, machine learning, archiving, as well as home directories and developer tools. Getting started with the AWS Transfer Family is easy; there is no infrastructure to buy and set up.

## Networking and Content Delivery

### Topics

- [Amazon API Gateway \(p. 60\)](#)
- [Amazon CloudFront \(p. 60\)](#)
- [Amazon Route 53 \(p. 60\)](#)
- [Amazon VPC \(p. 61\)](#)
- [AWS App Mesh \(p. 61\)](#)
- [AWS Cloud Map \(p. 62\)](#)
- [AWS Direct Connect \(p. 62\)](#)
- [AWS Global Accelerator \(p. 62\)](#)
- [AWS PrivateLink \(p. 63\)](#)
- [AWS Transit Gateway \(p. 63\)](#)
- [AWS VPN \(p. 63\)](#)
- [Elastic Load Balancing \(p. 63\)](#)

## Amazon API Gateway

[Amazon API Gateway](#) is a fully managed service that makes it easy for developers to create, publish, maintain, monitor, and secure APIs at any scale. With a few clicks in the AWS Management Console, you can create an API that acts as a “front door” for applications to access data, business logic, or functionality from your back-end services, such as workloads running on Amazon EC2, code running on AWS Lambda, or any web application. Amazon API Gateway handles all the tasks involved in accepting and processing up to hundreds of thousands of concurrent API calls, including traffic management, authorization and access control, monitoring, and API version management.

## Amazon CloudFront

[Amazon CloudFront](#) is a fast content delivery network (CDN) service that securely delivers data, videos, applications, and APIs to customers globally with low latency, high transfer speeds, all within a developer-friendly environment. CloudFront is integrated with AWS – both physical locations that are directly connected to the AWS global infrastructure, as well as other AWS services. CloudFront works seamlessly with services including AWS Shield for DDoS mitigation, Amazon S3, Elastic Load Balancing or Amazon EC2 as origins for your applications, and Lambda@Edge to run custom code closer to customers' users and to customize the user experience.

You can get started with the Content Delivery Network in minutes, using the same AWS tools that you're already familiar with: APIs, AWS Management Console, AWS CloudFormation, CLIs, and SDKs. Amazon's CDN offers a simple, pay-as-you-go pricing model with no upfront fees or required long-term contracts, and support for the CDN is included in your existing AWS Support subscription.

## Amazon Route 53

[Amazon Route 53](#) is a highly available and scalable cloud Domain Name System (DNS) web service. It is designed to give developers and businesses an extremely reliable and cost-effective way to route end

users to Internet applications by translating human readable names, such as `www.example.com`, into the numeric IP addresses, such as `192.0.2.1`, that computers use to connect to each other. Amazon Route 53 is fully compliant with IPv6 as well.

Amazon Route 53 effectively connects user requests to infrastructure running in AWS—such as EC2 instances, Elastic Load Balancing load balancers, or Amazon S3 buckets—and can also be used to route users to infrastructure outside of AWS. You can use Amazon Route 53 to configure DNS health checks to route traffic to healthy endpoints or to independently monitor the health of your application and its endpoints. Amazon Route 53 traffic flow makes it easy for you to manage traffic globally through a variety of routing types, including latency-based routing, Geo DNS, and weighted round robin—all of which can be combined with DNS Failover in order to enable a variety of low-latency, fault-tolerant architectures. Using Amazon Route 53 traffic flow's simple visual editor, you can easily manage how your end users are routed to your application's endpoints—whether in a single AWS Region or distributed around the globe. Amazon Route 53 also offers Domain Name Registration—you can purchase and manage domain names such as `example.com` and Amazon Route 53 will automatically configure DNS settings for your domains.

## Amazon VPC

[Amazon Virtual Private Cloud \(Amazon VPC\)](#) lets you provision a logically isolated section of the AWS Cloud where you can launch AWS resources in a virtual network that you define. You have complete control over your virtual networking environment, including selection of your own IP address range, creation of subnets, and configuration of route tables and network gateways. You can use both IPv4 and IPv6 in your VPC for secure and easy access to resources and applications.

You can easily customize the network configuration for your VPC. For example, you can create a public-facing subnet for your web servers that has access to the Internet, and place your backend systems, such as databases or application servers, in a private-facing subnet with no Internet access. You can leverage multiple layers of security (including security groups and network access control lists) to help control access to EC2 instances in each subnet.

Additionally, you can create a hardware virtual private network (VPN) connection between your corporate data center and your VPC and leverage the AWS Cloud as an extension of your corporate data center.

## AWS App Mesh

[AWS App Mesh](#) makes it easy to monitor and control [microservices](#) running on AWS. App Mesh standardizes how your microservices communicate, giving you end-to-end visibility and helping to ensure high-availability for your applications.

Modern applications are often composed of multiple microservices that each perform a specific function. This architecture helps to increase the availability and scalability of the application by allowing each component to scale independently based on demand, and automatically degrading functionality when a component fails instead of going offline. Each microservice interacts with all the other microservices through an API. As the number of microservices grows within an application, it becomes increasingly difficult to pinpoint the exact location of errors, re-route traffic after failures, and safely deploy code changes. Previously, this has required you to build monitoring and control logic directly into your code and redeploy your microservices every time there are changes.

AWS App Mesh makes it easy to run microservices by providing consistent visibility and network traffic controls for every microservice in an application. App Mesh removes the need to update application code to change how monitoring data is collected or traffic is routed between microservices. App Mesh configures each microservice to export monitoring data and implements consistent communications control logic across your application. This makes it easy to quickly pinpoint the exact location of errors and automatically re-route network traffic when there are failures or when code changes need to be deployed.

You can use App Mesh with [Amazon ECS](#) and [Amazon EKS](#) to better run containerized microservices at scale. App Mesh uses the open source [Envoy proxy](#), making it compatible with a wide range of AWS partner and open source tools for monitoring microservices.

## AWS Cloud Map

[AWS Cloud Map](#) is a cloud resource discovery service. With Cloud Map, you can define custom names for your application resources, and it maintains the updated location of these dynamically changing resources. This increases your application availability because your web service always discovers the most up-to-date locations of its resources.

Modern applications are typically composed of multiple services that are accessible over an API and perform a specific function. Each service interacts with a variety of other resources such as databases, queues, object stores, and customer-defined microservices, and they also need to be able to find the location of all the infrastructure resources on which it depends, in order to function. You typically manually manage all these resource names and their locations within the application code. However, manual resource management becomes time consuming and error-prone as the number of dependent infrastructure resources increases or the number of microservices dynamically scale up and down based on traffic. You can also use third-party service discovery products, but this requires installing and managing additional software and infrastructure.

Cloud Map allows you to register any application resources such as databases, queues, microservices, and other cloud resources with custom names. Cloud Map then constantly checks the health of resources to make sure the location is up-to-date. The application can then query the registry for the location of the resources needed based on the application version and deployment environment.

## AWS Direct Connect

[AWS Direct Connect](#) makes it easy to establish a dedicated network connection from your premises to AWS. Using AWS Direct Connect, you can establish private connectivity between AWS and your data center, office, or co-location environment, which in many cases can reduce your network costs, increase bandwidth throughput, and provide a more consistent network experience than Internet-based connections.

AWS Direct Connect lets you establish a dedicated network connection between your network and one of the AWS Direct Connect locations. Using industry standard 802.1Q virtual LANS (VLANs), this dedicated connection can be partitioned into multiple virtual interfaces. This allows you to use the same connection to access public resources, such as objects stored in Amazon S3 using public IP address space, and private resources such as EC2 instances running within a VPC using private IP address space, while maintaining network separation between the public and private environments. Virtual interfaces can be reconfigured at any time to meet your changing needs.

## AWS Global Accelerator

[AWS Global Accelerator](#) is a networking service that improves the availability and performance of the applications that you offer to your global users.

Today, if you deliver applications to your global users over the public internet, your users might face inconsistent availability and performance as they traverse through multiple public networks to reach your application. These public networks are often congested and each hop can introduce availability and performance risk. AWS Global Accelerator uses the highly available and congestion-free AWS global network to direct internet traffic from your users to your applications on AWS, making your users' experience more consistent.

To improve the availability of your application, you must monitor the health of your application endpoints and route traffic only to healthy endpoints. AWS Global Accelerator improves application

availability by continuously monitoring the health of your application endpoints and routing traffic to the closest healthy endpoints.

AWS Global Accelerator also makes it easier to manage your global applications by providing static IP addresses that act as a fixed entry point to your application hosted on AWS which eliminates the complexity of managing specific IP addresses for different AWS Regions and Availability Zones. AWS Global Accelerator is easy to set up, configure and manage.

## AWS PrivateLink

[AWS PrivateLink](#) simplifies the security of data shared with cloud-based applications by eliminating the exposure of data to the public Internet. AWS PrivateLink provides private connectivity between VPCs, AWS services, and on-premises applications, securely on the Amazon network. AWS PrivateLink makes it easy to connect services across different accounts and VPCs to significantly simplify the network architecture.

## AWS Transit Gateway

[AWS Transit Gateway](#) is a service that enables customers to connect their Amazon Virtual Private Clouds (VPCs) and their on-premises networks to a single gateway. As you grow the number of workloads running on AWS, you need to be able to scale your networks across multiple accounts and Amazon VPCs to keep up with the growth. Today, you can connect pairs of Amazon VPCs using peering. However, managing point-to-point connectivity across many Amazon VPCs, without the ability to centrally manage the connectivity policies, can be operationally costly and cumbersome. For on-premises connectivity, you need to attach your AWS VPN to each individual Amazon VPC. This solution can be time consuming to build and hard to manage when the number of VPCs grows into the hundreds.

With AWS Transit Gateway, you only have to create and manage a single connection from the central gateway in to each Amazon VPC, on-premises data center, or remote office across your network. Transit Gateway acts as a hub that controls how traffic is routed among all the connected networks which act like spokes. This hub and spoke model significantly simplifies management and reduces operational costs because each network only has to connect to the Transit Gateway and not to every other network. Any new VPC is simply connected to the Transit Gateway and is then automatically available to every other network that is connected to the Transit Gateway. This ease of connectivity makes it easy to scale your network as you grow.

## AWS VPN

[AWS Virtual Private Network](#) solutions establish secure connections between your on-premises networks, remote offices, client devices, and the AWS global network. AWS VPN is comprised of two services: AWS Site-to-Site VPN and AWS Client VPN. Each service provides a highly-available, managed, and elastic cloud VPN solution to protect your network traffic.

AWS Site-to-Site VPN creates encrypted tunnels between your network and your Amazon Virtual Private Clouds or AWS Transit Gateways. For managing remote access, AWS Client VPN connects your users to AWS or on-premises resources using a VPN software client.

## Elastic Load Balancing

[Elastic Load Balancing \(ELB\)](#) automatically distributes incoming application traffic across multiple targets, such as Amazon EC2 instances, containers, and IP addresses. It can handle the varying load of your application traffic in a single Availability Zone or across multiple Availability Zones. Elastic Load Balancing offers four types of load balancers that all feature the high availability, automatic scaling, and robust security necessary to make your applications fault tolerant.

- [Application Load Balancer](#) is best suited for load balancing of HTTP and HTTPS traffic and provides advanced request routing targeted at the delivery of modern application architectures, including

microservices and containers. Operating at the individual request level (Layer 7), Application Load Balancer routes traffic to targets within Amazon Virtual Private Cloud (Amazon VPC) based on the content of the request.

- [Network Load Balancer](#) is best suited for load balancing of TCP traffic where extreme performance is required. Operating at the connection level (Layer 4), Network Load Balancer routes traffic to targets within Amazon Virtual Private Cloud (Amazon VPC) and is capable of handling millions of requests per second while maintaining ultra-low latencies. Network Load Balancer is also optimized to handle sudden and volatile traffic patterns.
- [Gateway Load Balancer](#) makes it easy to deploy, scale, and run third-party virtual networking appliances. Providing load balancing and auto scaling for fleets of third-party appliances, Gateway Load Balancer is transparent to the source and destination of traffic. This capability makes it well suited for working with third-party appliances for security, network analytics, and other use cases.
- [Classic Load Balancer](#) provides basic load balancing across multiple Amazon EC2 instances and operates at both the request level and connection level. Classic Load Balancer is intended for applications that were built within the EC2-Classic network.

## Quantum Technologies

### Amazon Braket

[Amazon Braket](#) is a fully managed quantum computing service that helps researchers and developers get started with the technology to accelerate research and discovery. Amazon Braket provides a development environment for you to explore and build quantum algorithms, test them on quantum circuit simulators, and run them on different quantum hardware technologies.

Quantum computing has the potential to solve computational problems that are beyond the reach of classical computers by harnessing the laws of quantum mechanics to process information in new ways. This approach to computing could transform areas such as chemical engineering, material science, drug discovery, financial portfolio optimization, and machine learning. But defining those problems and programming quantum computers to solve them requires new skills, which are difficult to acquire without easy access to quantum computing hardware.

Amazon Braket overcomes these challenges so you can explore quantum computing. With Amazon Braket you can design and build your own quantum algorithms from scratch or choose from a set of pre-built algorithms. Once you have built your algorithm, Amazon Braket provides a choice of simulators to test, troubleshoot and run your algorithms. When you are ready, you can run your algorithm on your choice of different quantum computers, including quantum annealers from D-Wave, and gate-based computers from Rigetti and IonQ. With Amazon Braket you can now evaluate the potential of quantum computing for your organization, and build expertise.

## Robotics

### AWS RoboMaker

[AWS RoboMaker](#) is a service that makes it easy to develop, test, and deploy intelligent robotics applications at scale. RoboMaker extends the most widely used open-source robotics software framework, Robot Operating System (ROS), with connectivity to cloud services. This includes AWS machine learning services, monitoring services, and analytics services that enable a robot to stream data, navigate, communicate, comprehend, and learn. RoboMaker provides a robotics development environment for application development, a robotics simulation service to accelerate application testing, and a robotics fleet management service for remote application deployment, update, and management.

Robots are machines that sense, compute, and take action. Robots need instructions to accomplish tasks, and these instructions come in the form of applications that developers code to determine how the robot will behave. Receiving and processing sensor data, controlling actuators for movement, and performing a specific task are all functions that are typically automated by these intelligent robotics applications. Intelligent robots are being increasingly used in warehouses to distribute inventory, in homes to carry out tedious housework, and in retail stores to provide customer service. Robotics applications use machine learning in order to perform more complex tasks like recognizing an object or face, having a conversation with a person, following a spoken command, or navigating autonomously. Until now, developing, testing, and deploying intelligent robotics applications was difficult and time consuming. Building intelligent robotics functionality using machine learning is complex and requires specialized skills. Setting up a development environment can take each developer days and building a realistic simulation system to test an application can take months due to the underlying infrastructure needed. Once an application has been developed and tested, a developer needs to build a deployment system to deploy the application into the robot and later update the application while the robot is in use.

AWS RoboMaker provides you with the tools to make building intelligent robotics applications more accessible, a fully managed simulation service for quick and easy testing, and a deployment service for lifecycle management. AWS RoboMaker removes the heavy lifting from each step of robotics development so you can focus on creating innovative robotics applications.

## Satellite

### AWS Ground Station

**AWS Ground Station** is a fully managed service that lets you control satellite communications, downlink and process satellite data, and scale your satellite operations quickly, easily and cost-effectively without having to worry about building or managing your own ground station infrastructure. Satellites are used for a wide variety of use cases, including weather forecasting, surface imaging, communications, and video broadcasts. Ground stations are at the core of global satellite networks, which are facilities that provide communications between the ground and the satellites by using antennas to receive data and control systems to send radio signals to command and control the satellite. Today, you must either build your own ground stations and antennas, or obtain long-term leases with ground station providers, often in multiple countries to provide enough opportunities to contact the satellites as they orbit the globe. Once all this data is downloaded, you need servers, storage, and networking in close proximity to the antennas to process, store, and transport the data from the satellites.

AWS Ground Station eliminates these problems by delivering a global Ground Station as a Service. We provide direct access to AWS services and the AWS Global Infrastructure including our low-latency global fiber network right where your data is downloaded into our AWS Ground Station. This enables you to easily control satellite communications, quickly ingest and process your satellite data, and rapidly integrate that data with your applications and other services running in the AWS Cloud. For example, you can use Amazon S3 to store the downloaded data, Amazon Kinesis Data Streams for managing data ingestion from satellites, SageMaker for building custom machine learning applications that apply to your data sets, and Amazon EC2 to command and download data from satellites. AWS Ground Station can help you save up to 80% on the cost of your ground station operations by allowing you to pay only for the actual antenna time used, and relying on our global footprint of ground stations to download data when and where you need it, instead of building and operating your own global ground station infrastructure. There are no long-term commitments, and you gain the ability to rapidly scale your satellite communications on-demand when your business needs it.

## Security, Identity, and Compliance

### Topics

- [Amazon Cognito \(p. 66\)](#)
- [Amazon Cloud Directory \(p. 66\)](#)
- [Amazon Detective \(p. 67\)](#)
- [Amazon GuardDuty \(p. 67\)](#)
- [Amazon Inspector \(p. 67\)](#)
- [Amazon Macie \(p. 68\)](#)
- [AWS Artifact \(p. 68\)](#)
- [AWS Audit Manager \(p. 68\)](#)
- [AWS Certificate Manager \(p. 68\)](#)
- [AWS CloudHSM \(p. 69\)](#)
- [AWS Directory Service \(p. 69\)](#)
- [AWS Firewall Manager \(p. 69\)](#)
- [AWS Identity and Access Management \(p. 69\)](#)
- [AWS Key Management Service \(p. 70\)](#)
- [AWS Network Firewall \(p. 70\)](#)
- [AWS Resource Access Manager \(p. 70\)](#)
- [AWS Secrets Manager \(p. 71\)](#)
- [AWS Security Hub \(p. 71\)](#)
- [AWS Shield \(p. 71\)](#)
- [AWS Single Sign-On \(p. 72\)](#)
- [AWS WAF \(p. 72\)](#)

## Amazon Cognito

[Amazon Cognito](#) lets you add user sign-up, sign-in, and access control to your web and mobile apps quickly and easily. With Amazon Cognito, you also have the option to authenticate users through social identity providers such as Facebook, Twitter, or Amazon, with SAML identity solutions, or by using your own identity system. In addition, Amazon Cognito enables you to save data locally on users' devices, allowing your applications to work even when the devices are offline. You can then synchronize data across users' devices so that their app experience remains consistent regardless of the device they use.

With Amazon Cognito, you can focus on creating great app experiences instead of worrying about building, securing, and scaling a solution to handle user management, authentication, and sync across devices.

## Amazon Cloud Directory

[Amazon Cloud Directory](#) enables you to build flexible, cloud-native directories for organizing hierarchies of data along multiple dimensions. With Cloud Directory, you can create directories for a variety of use cases, such as organizational charts, course catalogs, and device registries. While traditional directory solutions, such as Active Directory Lightweight Directory Services (AD LDS) and other LDAP-based directories, limit you to a single hierarchy, Cloud Directory offers you the flexibility to create directories with hierarchies that span multiple dimensions. For example, you can create an organizational chart that can be navigated through separate hierarchies for reporting structure, location, and cost center.

Amazon Cloud Directory automatically scales to hundreds of millions of objects and provides an extensible schema that can be shared with multiple applications. As a fully-managed service, Cloud Directory eliminates time-consuming and expensive administrative tasks, such as scaling infrastructure

and managing servers. You simply define the schema, create a directory, and then populate your directory by making calls to the [Cloud Directory API](#).

## Amazon Detective

[Amazon Detective](#) makes it easy to analyze, investigate, and quickly identify the root cause of potential security issues or suspicious activities. Amazon Detective automatically collects log data from your AWS resources and uses machine learning, statistical analysis, and graph theory to build a linked set of data that enables you to easily conduct faster and more efficient security investigations.

AWS security services like Amazon GuardDuty, Amazon Macie, and AWS Security Hub as well as partner security products can be used to identify potential security issues, or findings. These services are really helpful in alerting you when something is wrong and pointing out where to go to fix it. But sometimes there might be a security finding where you need to dig a lot deeper and analyze more information to isolate the root cause and take action. Determining the root cause of security findings can be a complex process that often involves collecting and combining logs from many separate data sources, using extract, transform, and load (ETL) tools or custom scripting to organize the data, and then security analysts having to analyze the data and conduct lengthy investigations.

Amazon Detective simplifies this process by enabling your security teams to easily investigate and quickly get to the root cause of a finding. Amazon Detective can analyze trillions of events from multiple data sources such as Virtual Private Cloud (VPC) Flow Logs, AWS CloudTrail, and Amazon GuardDuty, and automatically creates a unified, interactive view of your resources, users, and the interactions between them over time. With this unified view, you can visualize all the details and context in one place to identify the underlying reasons for the findings, drill down into relevant historical activities, and quickly determine the root cause.

You can get started with Amazon Detective in just a few clicks in the AWS Console. There is no software to deploy, or data sources to enable and maintain.

## Amazon GuardDuty

[Amazon GuardDuty](#) is a threat detection service that continuously monitors for malicious or unauthorized behavior to help you protect your AWS accounts and workloads. It monitors for activity such as unusual API calls or potentially unauthorized deployments that indicate a possible account compromise. GuardDuty also detects potentially compromised instances or reconnaissance by attackers.

Enabled with a few clicks in the AWS Management Console, Amazon GuardDuty can immediately begin analyzing billions of events across your AWS accounts for signs of risk. GuardDuty identifies suspected attackers through integrated threat intelligence feeds and uses machine learning to detect anomalies in account and workload activity. When a potential threat is detected, the service delivers a detailed security alert to the GuardDuty console and Amazon CloudWatch Events. This makes alerts actionable and easy to integrate into existing event management and workflow systems.

Amazon GuardDuty is cost effective and easy. It does not require you to deploy and maintain software or security infrastructure, meaning it can be enabled quickly with no risk of negatively impacting existing application workloads. There are no upfront costs with GuardDuty, no software to deploy, and no threat intelligence feeds required. Customers pay for the events analyzed by GuardDuty and there is a 30-day free trial available for every new account to the service.

## Amazon Inspector

[Amazon Inspector](#) is an automated security assessment service that helps improve the security and compliance of applications deployed on AWS. Amazon Inspector automatically assesses applications for exposure, vulnerabilities, and deviations from best practices. After performing an assessment, Amazon Inspector produces a detailed list of security findings prioritized by level of severity. These findings

can be reviewed directly or as part of detailed assessment reports which are available via the Amazon Inspector console or API.

Amazon Inspector security assessments help you check for unintended network accessibility of your Amazon EC2 instances and for vulnerabilities on those EC2 instances. Amazon Inspector assessments are offered to you as pre-defined rules packages mapped to common security best practices and vulnerability definitions. Examples of built-in rules include checking for access to your EC2 instances from the internet, remote root login being enabled, or vulnerable software versions installed. These rules are regularly updated by AWS security researchers.

## Amazon Macie

[Amazon Macie](#) is a security service that uses machine learning to automatically discover, classify, and protect sensitive data in AWS. Amazon Macie recognizes sensitive data such as personally identifiable information (PII) or intellectual property, and provides you with dashboards and alerts that give visibility into how this data is being accessed or moved. The fully managed service continuously monitors data access activity for anomalies, and generates detailed alerts when it detects risk of unauthorized access or inadvertent data leaks.

## AWS Artifact

[AWS Artifact](#) is your go-to, central resource for compliance-related information that matters to you. It provides on-demand access to AWS' security and compliance reports and select online agreements. Reports available in AWS Artifact include our Service Organization Control (SOC) reports, Payment Card Industry (PCI) reports, and certifications from accreditation bodies across geographies and compliance verticals that validate the implementation and operating effectiveness of AWS security controls. Agreements available in AWS Artifact include the Business Associate Addendum (BAA) and the Nondisclosure Agreement (NDA).

## AWS Audit Manager

[AWS Audit Manager](#) helps you continuously audit your AWS usage to simplify how you assess risk and compliance with regulations and industry standards. Audit Manager automates evidence collection to reduce the “all hands on deck” manual effort that often happens for audits and enable you to scale your audit capability in the cloud as your business grows. With Audit Manager, it is easy to assess if your policies, procedures, and activities – also known as controls – are operating effectively. When it is time for an audit, AWS Audit Manager helps you manage stakeholder reviews of your controls and enables you to build audit-ready reports with much less manual effort.

AWS Audit Manager's prebuilt frameworks help translate evidence from cloud services into auditor-friendly reports by mapping your AWS resources to the requirements in industry standards or regulations, such as CIS AWS Foundations Benchmark, the General Data Protection Regulation (GDPR), and the Payment Card Industry Data Security Standard (PCI DSS). You can also fully customize a framework and its controls for your unique business requirements. Based on the framework you select, Audit Manager launches an assessment that continuously collects and organizes relevant evidence from your AWS accounts and resources, such as resource configuration snapshots, user activity, and compliance check results.

You can get started quickly in the AWS Management Console. Just select a prebuilt framework to launch an assessment and begin automatically collecting and organizing evidence.

## AWS Certificate Manager

[AWS Certificate Manager](#) is a service that lets you easily provision, manage, and deploy Secure Sockets Layer/Transport Layer Security (SSL/TLS) certificates for use with AWS services and your internal

connected resources. SSL/TLS certificates are used to secure network communications and establish the identity of websites over the Internet as well as resources on private networks. AWS Certificate Manager removes the time-consuming manual process of purchasing, uploading, and renewing SSL/TLS certificates.

With AWS Certificate Manager, you can quickly request a certificate, deploy it on ACM-integrated AWS resources, such as Elastic Load Balancing, Amazon CloudFront distributions, and APIs on API Gateway, and let AWS Certificate Manager handle certificate renewals. It also enables you to create private certificates for your internal resources and manage the certificate lifecycle centrally. Public and private certificates provisioned through AWS Certificate Manager for use with ACM-integrated services are free. You pay only for the AWS resources you create to run your application. With AWS Certificate Manager Private Certificate Authority, you pay monthly for the operation of the private CA and for the private certificates you issue.

## AWS CloudHSM

The [AWS CloudHSM](#) is a cloud-based hardware security module (HSM) that enables you to easily generate and use your own encryption keys on the AWS Cloud. With CloudHSM, you can manage your own encryption keys using FIPS 140-2 Level 3 validated HSMs. CloudHSM offers you the flexibility to integrate with your applications using industry-standard APIs, such as PKCS#11, Java Cryptography Extensions (JCE), and Microsoft CryptoNG (CNG) libraries.

CloudHSM is standards-compliant and enables you to export all of your keys to most other commercially-available HSMs, subject to your configurations. It is a fully-managed service that automates time-consuming administrative tasks for you, such as hardware provisioning, software patching, high-availability, and backups. CloudHSM also enables you to scale quickly by adding and removing HSM capacity on-demand, with no up-front costs.

## AWS Directory Service

[AWS Directory Service](#) for Microsoft Active Directory, also known as AWS Managed Microsoft AD, enables your directory-aware workloads and AWS resources to use managed Active Directory in the AWS Cloud. AWS Managed Microsoft AD is built on actual Microsoft Active Directory and does not require you to synchronize or replicate data from your existing Active Directory to the cloud. You can use standard Active Directory administration tools and take advantage of built-in Active Directory features such as Group Policy and single sign-on (SSO). With AWS Managed Microsoft AD, you can easily join [Amazon EC2](#) and [Amazon RDS for SQL Server](#) instances to a domain, and use [AWS Enterprise IT applications](#) such as [Amazon WorkSpaces](#) with Active Directory users and groups.

## AWS Firewall Manager

[AWS Firewall Manager](#) is a security management service that makes it easier to centrally configure and manage AWS WAF rules across your accounts and applications. Using Firewall Manager, you can easily roll out AWS WAF rules for your Application Load Balancers and Amazon CloudFront distributions across accounts in [AWS Organizations](#). As new applications are created, Firewall Manager also makes it easy to bring new applications and resources into compliance with a common set of security rules from day one. Now you have a single service to build firewall rules, create security policies, and enforce them in a consistent, hierarchical manner across your entire Application Load Balancers and Amazon CloudFront infrastructure.

## AWS Identity and Access Management

[AWS Identity and Access Management \(IAM\)](#) enables you to securely control access to AWS services and resources for your users. Using IAM, you can create and manage AWS users and groups, and use permissions to allow and deny their access to AWS resources. IAM allows you to do the following:

- **Manage IAM users** and their **access**: You can create users in IAM, assign them individual security credentials (access keys, passwords, and **multi-factor authentication** devices), or request temporary security credentials to provide users access to AWS services and resources. You can manage permissions in order to control which operations a user can perform.
- **Manage IAM roles** and their **permissions**: You can create roles in IAM and manage permissions to control which operations can be performed by the entity, or AWS service, that assumes the role. You can also define which entity is allowed to assume the role.
- **Manage federated users** and their **permissions**: You can enable identity federation to allow existing identities (users, groups, and roles) in your enterprise to access the AWS Management Console, call AWS APIs, and access resources, without the need to create an IAM user for each identity.

## AWS Key Management Service

**AWS Key Management Service (KMS)** makes it easy for you to create and manage keys and control the use of encryption across a wide range of AWS services and in your applications. AWS KMS is a secure and resilient service that uses FIPS 140-2 validated hardware security modules to protect your keys. AWS KMS is integrated with AWS CloudTrail to provide you with logs of all key usage to help meet your regulatory and compliance needs.

## AWS Network Firewall

**AWS Network Firewall** is a managed service that makes it easy to deploy essential network protections for all of your Amazon Virtual Private Clouds (VPCs). The service can be setup with just a few clicks and scales automatically with your network traffic, so you don't have to worry about deploying and managing any infrastructure. AWS Network Firewall's flexible rules engine lets you define firewall rules that give you fine-grained control over network traffic, such as blocking outbound Server Message Block (SMB) requests to prevent the spread of malicious activity. You can also import rules you've already written in common open source rule formats as well as enable integrations with managed intelligence feeds sourced by AWS partners. AWS Network Firewall works together with AWS Firewall Manager so you can build policies based on AWS Network Firewall rules and then centrally apply those policies across your VPCs and accounts.

AWS Network Firewall includes features that provide protections from common network threats. AWS Network Firewall's stateful firewall can incorporate context from traffic flows, like tracking connections and protocol identification, to enforce policies such as preventing your VPCs from accessing domains using an unauthorized protocol. AWS Network Firewall's intrusion prevention system (IPS) provides active traffic flow inspection so you can identify and block vulnerability exploits using signature-based detection. AWS Network Firewall also offers web filtering that can stop traffic to known bad URLs and monitor fully qualified domain names.

It's easy to get started with AWS Network Firewall by visiting the [Amazon VPC Console](#) to create or import your firewall rules, group them into policies, and apply them to the VPCs you want to protect. AWS Network Firewall pricing is based on the number of firewalls deployed and the amount of traffic inspected. There are no upfront commitments and you pay only for what you use.

## AWS Resource Access Manager

**AWS Resource Access Manager (RAM)** helps you securely share your resources across AWS accounts, within your organization or organizational units (OUS) in AWS Organizations, and with IAM roles and IAM users for supported resource types. You can use AWS RAM to share transit gateways, subnets, AWS License Manager license configurations, Amazon Route 53 Resolver rules, and more [resource types](#).

Many organizations use multiple accounts to create administrative or billing isolation, and to limit the impact of errors. With AWS RAM, you don't need to create duplicate resources in multiple AWS accounts.

This reduces the operational overhead of managing resources in every account that you own. Instead, in your multi-account environment, you can create a resource once, and use AWS RAM to share that resource across accounts by creating a resource share. When you create a resource share, you select the resources to share, choose an AWS RAM managed permission per resource type, and specify whom you want to have access to the resources. AWS RAM is available to you at no additional charge.

## AWS Secrets Manager

[AWS Secrets Manager](#) helps you protect secrets needed to access your applications, services, and IT resources. The service enables you to easily rotate, manage, and retrieve database credentials, API keys, and other secrets throughout their lifecycle. Users and applications retrieve secrets with a call to Secrets Manager APIs, eliminating the need to hardcode sensitive information in plain text. Secrets Manager offers secret rotation with built-in integration for Amazon RDS for MySQL, PostgreSQL, and Amazon Aurora. Also, the service is extensible to other types of secrets, including API keys and OAuth tokens. In addition, Secrets Manager enables you to control access to secrets using fine-grained permissions and audit secret rotation centrally for resources in the AWS Cloud, third-party services, and on-premises.

## AWS Security Hub

[AWS Security Hub](#) gives you a comprehensive view of your high-priority security alerts and compliance status across AWS accounts. There are a range of powerful security tools at your disposal, from firewalls and endpoint protection to vulnerability and compliance scanners. But oftentimes this leaves your team switching back-and-forth between these tools to deal with hundreds, and sometimes thousands, of security alerts every day. With Security Hub, you now have a single place that aggregates, organizes, and prioritizes your security alerts, or findings, from multiple AWS services, such as Amazon GuardDuty, Amazon Inspector, and Amazon Macie, as well as from AWS Partner solutions. Your findings are visually summarized on integrated dashboards with actionable graphs and tables. You can also continuously monitor your environment using automated compliance checks based on the AWS best practices and industry standards your organization follows. Get started with AWS Security Hub just a few clicks in the Management Console and once enabled, Security Hub will begin aggregating and prioritizing findings.

## AWS Shield

[AWS Shield](#) is a managed Distributed Denial of Service (DDoS) protection service that safeguards web applications running on AWS. AWS Shield provides you with always-on detection and automatic inline mitigations that minimize application downtime and latency, so there is no need to engage AWS Support to benefit from DDoS protection. There are two tiers of AWS Shield: Standard and Advanced.

All AWS customers benefit from the automatic protections of AWS Shield Standard, at no additional charge. AWS Shield Standard defends against most common, frequently occurring network and transport layer DDoS attacks that target your website or applications. When you use AWS Shield Standard with [Amazon CloudFront](#) and [Amazon Route 53](#), you receive comprehensive availability protection against all known infrastructure (Layer 3 and 4) attacks.

For higher levels of protection against attacks targeting your applications running on Amazon Elastic Compute Cloud (Amazon EC2), Elastic Load Balancing (ELB), Amazon CloudFront, and Amazon Route 53 resources, you can subscribe to AWS Shield Advanced. In addition to the network and transport layer protections that come with Standard, AWS Shield Advanced provides additional detection and mitigation against large and sophisticated DDoS attacks, near real-time visibility into attacks, and integration with AWS WAF, a web application firewall. AWS Shield Advanced also gives you 24x7 access to the AWS DDoS Response Team (DRT) and protection against DDoS related spikes in your Amazon Elastic Compute Cloud (Amazon EC2), Elastic Load Balancing (ELB), Amazon CloudFront, and Amazon Route 53 charges.

AWS Shield Advanced is available globally on all Amazon CloudFront and Amazon Route 53 edge locations. You can protect your web applications hosted anywhere in the world by deploying Amazon CloudFront in front of your application. Your origin servers can be Amazon S3, Amazon Elastic Compute

Cloud (Amazon EC2), Elastic Load Balancing (ELB), or a custom server outside of AWS. You can also enable AWS Shield Advanced directly on an Elastic IP or Elastic Load Balancing (ELB) in the following AWS Regions: Northern Virginia, Ohio, Oregon, Northern California, Montreal, São Paulo, Ireland, Frankfurt, London, Paris, Stockholm, Singapore, Tokyo, Sydney, Seoul, and Mumbai.

## AWS Single Sign-On

**AWS Single Sign-On (SSO)** is a cloud SSO service that makes it easy to centrally manage SSO access to multiple AWS accounts and business applications. With just a few clicks, you can enable a highly available SSO service without the upfront investment and on-going maintenance costs of operating your own SSO infrastructure. With AWS SSO, you can easily manage SSO access and user permissions to all of your accounts in [AWS Organizations](#) centrally. AWS SSO also includes built-in SAML integrations to many business applications, such as Salesforce, Box, and Microsoft Office 365. Further, by using the AWS SSO application configuration wizard, you can create [Security Assertion Markup Language](#) (SAML) 2.0 integrations and extend SSO access to any of your SAML-enabled applications. Your users simply sign in to a user portal with credentials they configure in AWS SSO or using their existing corporate credentials to access all their assigned accounts and applications from one place.

## AWS WAF

**AWS WAF** is a web application firewall that helps protect your web applications from common web exploits that could affect application availability, compromise security, or consume excessive resources. AWS WAF gives you control over which traffic to allow or block to your web application by defining customizable web security rules. You can use AWS WAF to create custom rules that block common attack patterns, such as SQL injection or cross-site scripting, and rules that are designed for your specific application. New rules can be deployed within minutes, letting you respond quickly to changing traffic patterns. Also, AWS WAF includes a full-featured API that you can use to automate the creation, deployment, and maintenance of web security rules.

# Storage

## Topics

- [Amazon Elastic Block Store \(p. 72\)](#)
- [Amazon Elastic File System \(p. 73\)](#)
- [Amazon FSx for Lustre \(p. 73\)](#)
- [Amazon FSx for Windows File Server \(p. 73\)](#)
- [Amazon Simple Storage Service \(p. 74\)](#)
- [Amazon S3 Glacier \(p. 74\)](#)
- [AWS Backup \(p. 74\)](#)
- [AWS Storage Gateway \(p. 74\)](#)

## Amazon Elastic Block Store

**Amazon Elastic Block Store (Amazon EBS)** provides persistent block storage volumes for use with Amazon EC2 instances in the AWS Cloud. Each Amazon EBS volume is automatically replicated within its Availability Zone to protect you from component failure, offering high availability and durability. Amazon EBS volumes offer the consistent and low-latency performance needed to run your workloads. With Amazon EBS, you can scale your usage up or down within minutes—all while paying a low price for only what you provision.

## Amazon Elastic File System

[Amazon Elastic File System \(Amazon EFS\)](#) provides a simple, scalable, elastic file system for Linux-based workloads for use with AWS Cloud services and on-premises resources. It is built to scale on demand to petabytes without disrupting applications, growing and shrinking automatically as you add and remove files, so your applications have the storage they need – when they need it. It is designed to provide massively parallel shared access to thousands of Amazon EC2 instances, enabling your applications to achieve high levels of aggregate throughput and IOPS with consistent low latencies. Amazon EFS is a fully managed service that requires no changes to your existing applications and tools, providing access through a standard file system interface for seamless integration. Amazon EFS is a regional service storing data within and across multiple Availability Zones (AZs) for high availability and durability. You can access your file systems across AZs and AWS Regions and share files between thousands of Amazon EC2 instances and on-premises servers via AWS Direct Connect or AWS VPN.

Amazon EFS is well suited to support a broad spectrum of use cases from highly parallelized, scale-out workloads that require the highest possible throughput to single-threaded, latency-sensitive workloads. Use cases such as lift-and-shift enterprise applications, big data analytics, web serving and content management, application development and testing, media and entertainment workflows, database backups, and container storage.

## Amazon FSx for Lustre

[Amazon FSx for Lustre](#) is a fully managed file system that is optimized for compute-intensive workloads, such as high performance computing, machine learning, and media data processing workflows. Many of these applications require the high-performance and low latencies of scale-out, parallel file systems. Operating these file systems typically requires specialized expertise and administrative overhead, requiring you to provision storage servers and tune complex performance parameters. With Amazon FSx, you can launch and run a Lustre file system that can process massive data sets at up to hundreds of gigabytes per second of throughput, millions of IOPS, and sub-millisecond latencies.

Amazon FSx for Lustre is seamlessly integrated with Amazon S3, making it easy to link your long-term data sets with your high performance file systems to run compute-intensive workloads. You can automatically copy data from S3 to FSx for Lustre, run your workloads, and then write results back to S3. FSx for Lustre also enables you to burst your compute-intensive workloads from on-premises to AWS by allowing you to access your FSx file system over Amazon Direct Connect or VPN. FSx for Lustre helps you cost-optimize your storage for compute-intensive workloads: It provides cheap and performant non-replicated storage for processing data, with your long-term data stored durably in Amazon S3 or other low-cost data stores. With Amazon FSx, you pay for only the resources you use. There are no minimum commitments, upfront hardware or software costs, or additional fees.

## Amazon FSx for Windows File Server

[Amazon FSx for Windows File Server](#) provides a fully managed native Microsoft Windows file system so you can easily move your Windows-based applications that require file storage to AWS. Built on Windows Server, Amazon FSx provides shared file storage with the compatibility and features that your Windows-based applications rely on, including full support for the SMB protocol and Windows NTFS, Active Directory (AD) integration, and Distributed File System (DFS). Amazon FSx uses SSD storage to provide the fast performance your Windows applications and users expect, with high levels of throughput and IOPS, and consistent sub-millisecond latencies. This compatibility and performance is particularly important when moving workloads that require Windows shared file storage, like CRM, ERP, and .NET applications, as well as home directories.

With Amazon FSx, you can launch highly durable and available Windows file systems that can be accessed from up to thousands of compute instances using the industry-standard SMB protocol. Amazon FSx eliminates the typical administrative overhead of managing Windows file servers. You pay for only the resources used, with no upfront costs, minimum commitments, or additional fees.

## Amazon Simple Storage Service

[Amazon Simple Storage Service \(Amazon S3\)](#) is an object storage service that offers industry-leading scalability, data availability, security, and performance. This means customers of all sizes and industries can use it to store and protect any amount of data for a range of use cases, such as websites, mobile applications, backup and restore, archive, enterprise applications, IoT devices, and big data analytics. Amazon S3 provides easy-to-use management features so you can organize your data and configure finely-tuned access controls to meet your specific business, organizational, and compliance requirements. Amazon S3 is designed for 99.999999999% (11 9's) of durability, and stores data for millions of applications for companies all around the world.

## Amazon S3 Glacier

[Amazon S3 Glacier](#) is a secure, durable, and extremely low-cost storage service for data archiving and long-term backup. It is designed to deliver 99.999999999% durability, and provides comprehensive security and compliance capabilities that can help meet even the most stringent regulatory requirements. Amazon S3 Glacier provides query-in-place functionality, allowing you to run powerful analytics directly on your archive data at rest. You can store data for as little as \$1 per terabyte per month, a significant savings compared to on-premises solutions. To keep costs low yet suitable for varying retrieval needs, Amazon S3 Glacier provides three options for access to archives, from a few minutes to several hours, and S3 Glacier Deep Archive provides two access options ranging from 12 to 48 hours.

## AWS Backup

[AWS Backup](#) enables you to centralize and automate data protection across AWS services. AWS Backup offers a cost-effective, fully managed, policy-based service that further simplifies data protection at scale. AWS Backup also helps you support your regulatory compliance or business policies for data protection. Together with AWS Organizations, AWS Backup enables you to centrally deploy data protection policies to configure, manage, and govern your backup activity across your organization's AWS accounts and resources, including Amazon Elastic Compute Cloud (Amazon EC2) instances, Amazon Elastic Block Store (Amazon EBS) volumes, Amazon Relational Database Service (Amazon RDS) databases (including Amazon Aurora clusters), Amazon DynamoDB tables, Amazon Elastic File System (Amazon EFS) file systems, Amazon FSx for Lustre file systems, Amazon FSx for Windows File Server file systems, and AWS Storage Gateway volumes.

## AWS Storage Gateway

The [AWS Storage Gateway](#) is a hybrid storage service that enables your on-premises applications to seamlessly use AWS cloud storage. You can use the service for backup and archiving, disaster recovery, cloud data processing, storage tiering, and migration. Your applications connect to the service through a virtual machine or hardware gateway appliance using standard storage protocols, such as NFS, SMB and iSCSI. The gateway connects to AWS storage services, such as Amazon S3, S3 Glacier, and Amazon EBS, providing storage for files, volumes, and virtual tapes in AWS. The service includes a highly-optimized data transfer mechanism, with bandwidth management, automated network resilience, and efficient data transfer, along with a local cache for low-latency on-premises access to your most active data.

# Next Steps

Reinvent how you work with IT by signing up for the [AWS Free Tier](#), which enables you to gain hands-on experience with a broad selection of AWS products and services. Within the AWS Free Tier, you can test workloads and run applications to learn more and build the right solution for your organization. You can also [contact AWS Sales and Business Development](#).

By [signing up for AWS](#), you have access to Amazon's cloud computing services. Note: The sign-up process requires a credit card, which will not be charged until you start using services. There are no long-term commitments and you can stop using AWS at any time.

To help familiarize you with AWS, view [these short videos](#) that cover topics like creating an account, launching a virtual server, storing media and more. Learn about the breadth and depth of AWS on our general [AWS Channel](#) and [AWS Online Tech Talks](#). Get hands on experience from our [self-paced labs](#).

# Conclusion

AWS provides building blocks that you can assemble quickly to support virtually any workload. With AWS, you'll find a complete set of highly available services that are designed to work together to build sophisticated scalable applications.

You have access to highly durable storage, low-cost compute, high-performance databases, management tools, and more. All this is available without up-front cost, and you pay for only what you use. These services help organizations move faster, lower IT costs, and scale. AWS is trusted by the largest enterprises and the hottest start-ups to power a wide variety of workloads, including web and mobile applications, game development, data processing and warehousing, storage, archive, and many others.

# Resources

- [AWS Architecture Center](#)
- [AWS Whitepapers](#)
- [AWS Architecture Monthly](#)
- [AWS Architecture Blog](#)
- [This Is My Architecture videos](#)
- [AWS Documentation](#)

# Document Details

## Contributors

The following individuals and organizations contributed to this document:

- Sajee Mathew, AWS Principal Solutions Architect

## Document Revisions

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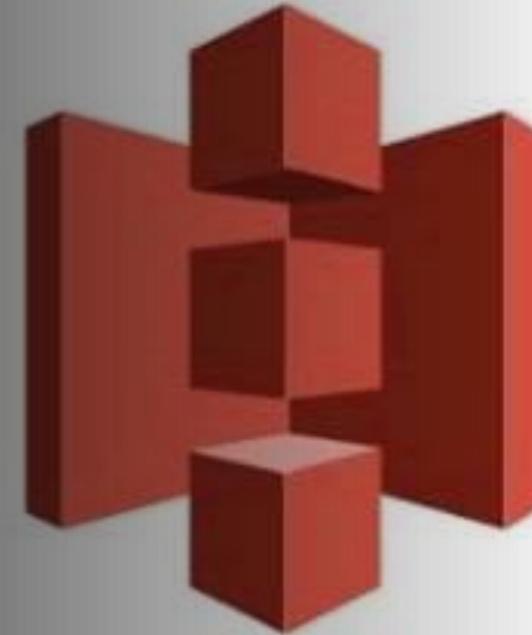
update-history-change	update-history-description	update-history-date
<a href="#">Whitepaper updated (p. 77)</a>	Added new services and updated information throughout.	August 5, 2021
<a href="#">Minor update (p. 77)</a>	Minor text updates to improve accuracy and fix links.	April 12, 2021
<a href="#">Minor update (p. 77)</a>	Minor text updates to improve accuracy.	November 20, 2020
<a href="#">Minor update (p. 77)</a>	Fixed incorrect link.	November 19, 2020
<a href="#">Minor update (p. 77)</a>	Fixed incorrect link.	August 11, 2020
<a href="#">Minor update (p. 77)</a>	Fixed incorrect link.	July 17, 2020
<a href="#">Minor updates (p. 77)</a>	Minor text updates to improve accuracy.	January 1, 2020
<a href="#">Minor updates (p. 77)</a>	Minor text updates to improve accuracy.	October 1, 2019
<a href="#">Whitepaper updated (p. 77)</a>	Added new services and updated information throughout.	December 1, 2018
<a href="#">Whitepaper updated (p. 77)</a>	Added new services and updated information throughout.	April 1, 2017
<a href="#">Initial publication (p. 77)</a>	Overview of Amazon Web Services published.	January 1, 2014

# AWS glossary

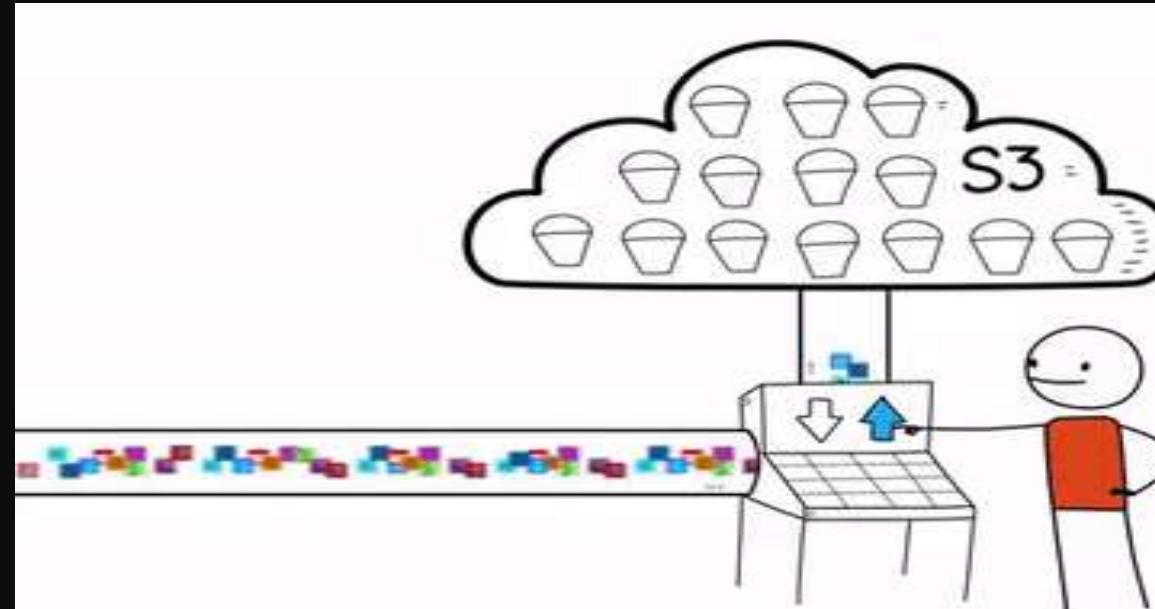
For the latest AWS terminology, see the [AWS glossary](#) in the *AWS General Reference*.

# AWS S3

Deepika K(20mx108)



Amazon S3



# AGENDA:



What is S3?



Concepts



Benefits



Demo

# S3



## Simple Storage Service



Object storage built to store and retrieve any amount of data from anywhere



The files which are stored in S3 can be from 0 Bytes to 5 TB

S3



Files are stored in Bucket



S3 is a universal namespace

# S3 Concepts

---

BUCKET

---

OBJECT

---

KEY

---

REGION

---

VERSIONING

# Bucket

- A bucket is a container for objects stored in Amazon S3
- An object consists of data, key , and metadata
- A bucket is used to store objects
- When data is added to a bucket, Amazon S3 creates a unique version ID and allocates it to the object

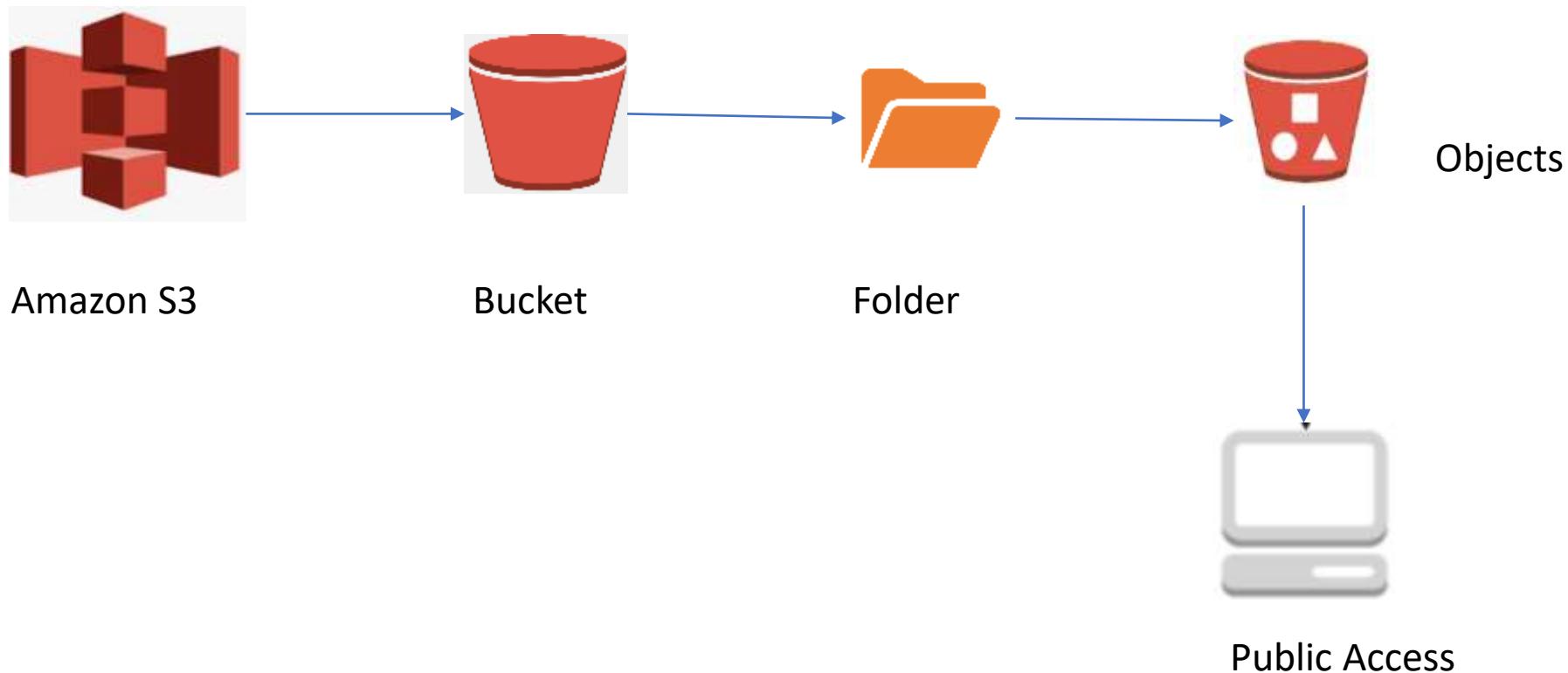
# Object

- An object is uniquely identified within a bucket by a key and a version ID
- Objects consist of object data and metadata
- The metadata is a set of name-value pairs that describe the object

# Key

- An *object key* is the unique identifier for an object within a bucket
- Every object in a bucket has exactly one key
- The combination of a bucket, object key, and optionally, version ID uniquely identify each object

# Flow Diagram:



# S3 Storage Class

- S3 Standard
- S3 Intelligent-Tiering
- S3 Standard-Infrequent Access
- S3 One Zone-Infrequent Access
- Amazon S3 Glacier
- Amazon S3 Glacier Deep Archive
- S3 Outposts storage

# Performance Chart:

	S3 Standard	S3 Intelligent-Tiering*	S3 Standard-IA	S3 One Zone- IA+	S3 Glacier	S3 Glacier Deep Archive
Designed for durability	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)
Designed for availability	99.99%	99.9%	99.9%	99.5%	99.99%	99.99%
Availability Zones	≥3	≥3	≥3	1	≥3	≥3
Minimum capacity charge per object	N/A	N/A	128KB	128KB	40KB	40KB
Minimum storage duration charge	N/A	N/A	30 days	30 days	90 days	180 days
Retrieval charge	N/A	N/A	per GB retrieved	per GB retrieved	per GB retrieved	per GB retrieved
First byte latency	milliseconds	milliseconds	milliseconds	milliseconds	select minutes or hours	select hours

# Benefits

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Simple to Use



Enhances Security



Reliable and Durable Data Storage



Integration



Scalability

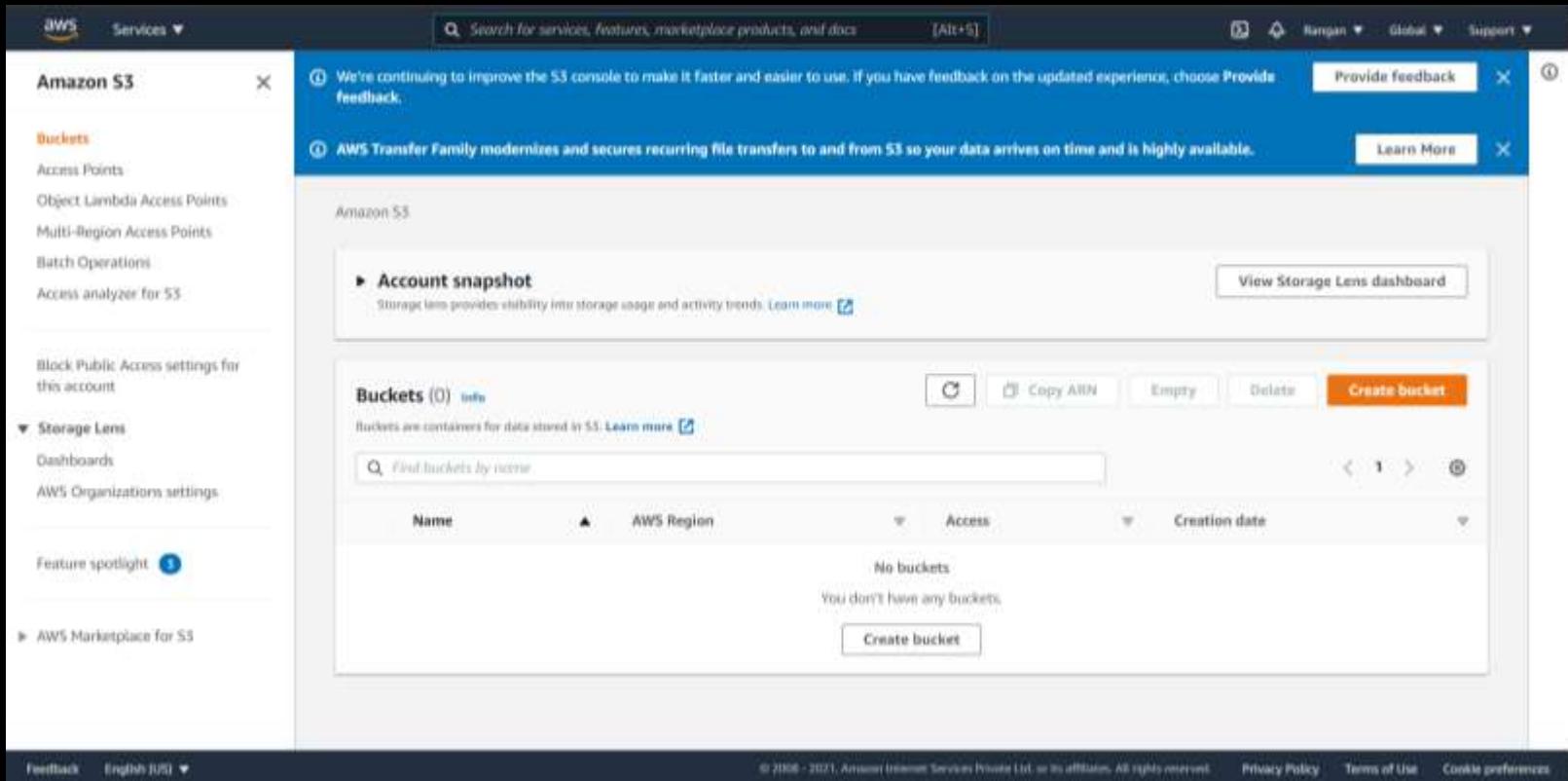


Migration of Data from Cloud

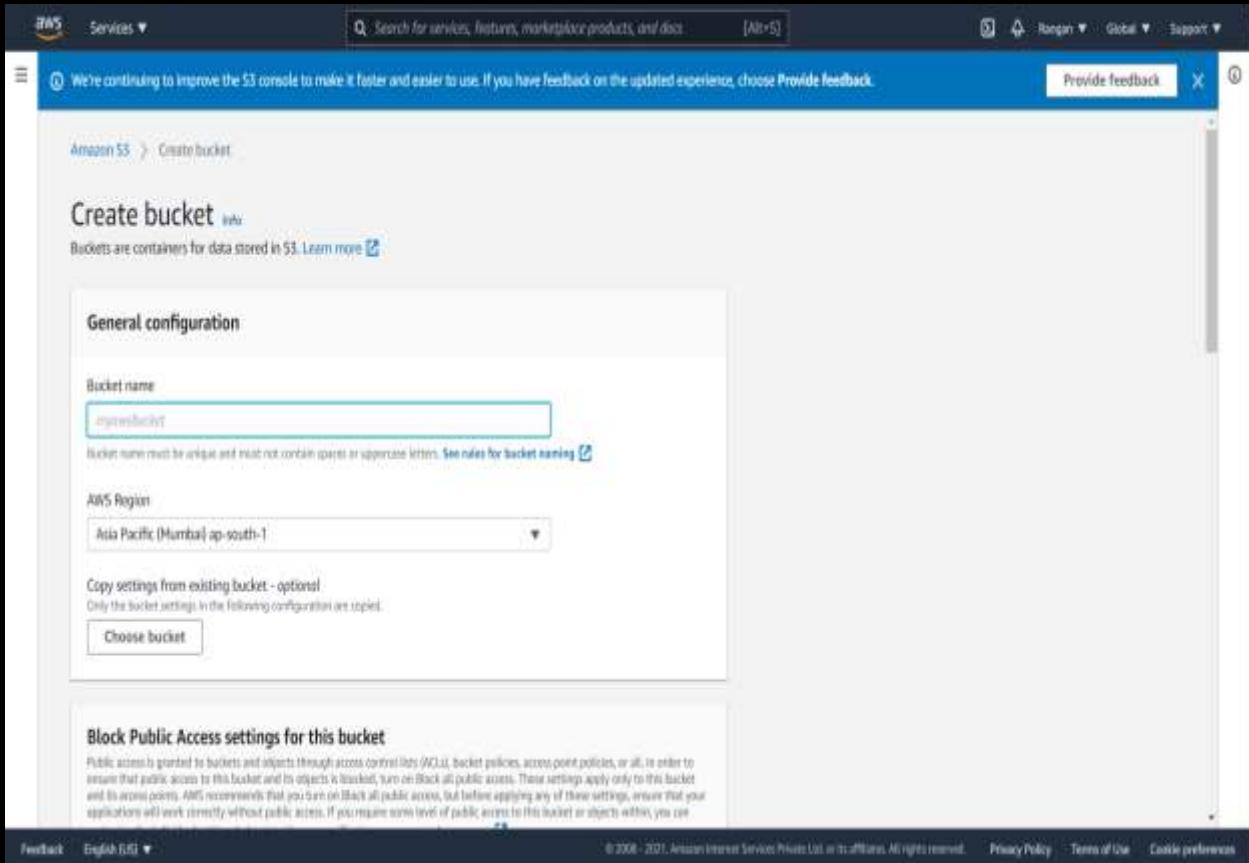
# DEMO

---

# SCREENSHOTS:



# SCREENSHOTS:



# SCREENSHOTS:

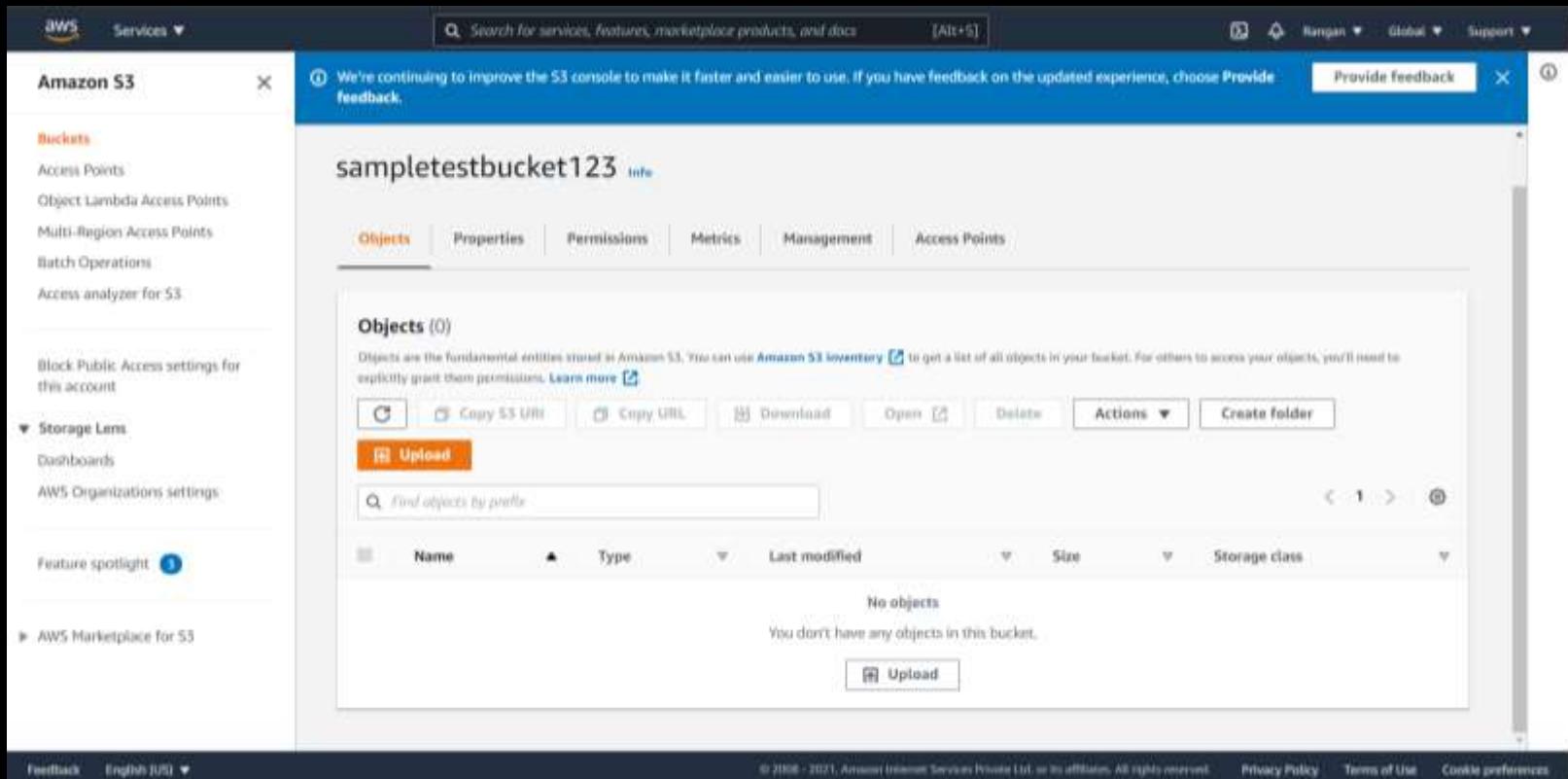
The screenshot shows the AWS S3 console interface. On the left, there's a sidebar with options like Buckets, Access Points, Object Lambda Access Points, Multi-Region Access Points, Batch Operations, and Access analyzer for S3. Below that are sections for Block Public Access settings and Storage Lens (Dashboards and AWS Organizations settings). A Feature spotlight section is also present. At the bottom of the sidebar are links for Feedback, English (US), and other language options.

The main content area has a success message: "Successfully created bucket 'sampletestbucket123'. To upload files and folders, or to configure additional bucket settings choose View details." It also features an advertisement for AWS Transfer Family. Below these messages is an "Account snapshot" section with a link to the Storage Lens dashboard.

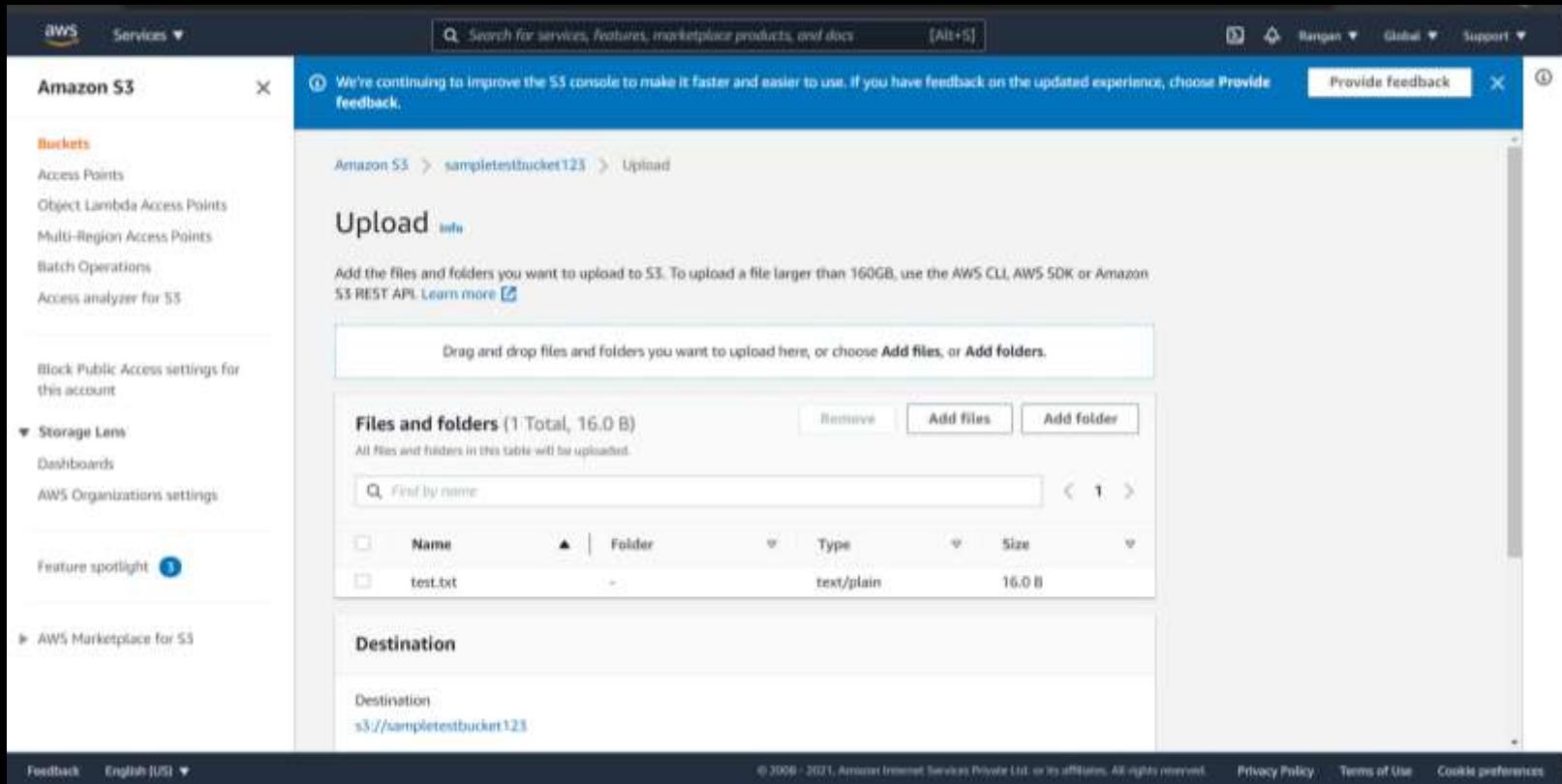
The central part of the screen displays a table titled "Buckets (1)". The table has columns for Name, AWS Region, Access, and Creation date. One row is shown, detailing a bucket named "sampletestbucket123" located in the "Asia Pacific (Mumbai) ap-south-1" region, with access set to "Bucket and objects not public" and created on "September 30, 2021, 16:12:22 (UTC+05:30)". Action buttons for Copy ARN, Empty, Delete, and Create Bucket are available for each row.

At the bottom of the page, there are footer links for Feedback, English (US), Privacy Policy, Terms of Use, and Cookie preferences, along with copyright information: "© 2006 – 2021, Amazon Internet Services Private Ltd. or its affiliates. All rights reserved."

# SCREENSHOTS:



# SCREENSHOTS:



# SCREENSHOTS:

The screenshot shows the AWS S3 console interface. On the left, there's a sidebar with navigation links like 'Buckets', 'Access Points', 'Object Lambda Access Points', etc. The main area displays the properties of an object named 'test.txt'. The 'Properties' tab is selected, showing details such as Owner, AWS Region (Asia Pacific (Mumbai) ap-south-1), Last modified (September 30, 2021, 16:18:04 (UTC+05:30)), Size (16.0 B), Type (txt), Key (test.txt), S3 URL (s3://sampletestbucket123/test.txt), Amazon Resource Name (ARN) (arn:aws:s3:::sampletestbucket123/test.txt), Entity tag (Etag) (c3a4f5cc30bb86884198f033a101dac2), and Object URL (https://sampletestbucket123.s3.ap-south-1.amazonaws.com/test.txt). There are also buttons for 'Copy S3 URI', 'Download', 'Open', and 'Object actions'.

We're continuing to improve the S3 console to make it faster and easier to use. If you have feedback on the updated experience, choose Provide feedback.

Provide feedback

Properties Permissions Versions

Object overview

Owner	S3 URL
AWS Region	s3://sampletestbucket123/test.txt
Asia Pacific (Mumbai) ap-south-1	Amazon Resource Name (ARN)
Last modified	arn:aws:s3:::sampletestbucket123/test.txt
September 30, 2021, 16:18:04 (UTC+05:30)	Entity tag (Etag)
Size	c3a4f5cc30bb86884198f033a101dac2
Type	Object URL
txt	https://sampletestbucket123.s3.ap-south-1.amazonaws.com/test.txt
Key	
test.txt	

# SCREENSHOTS:

The screenshot shows the AWS S3 console interface. At the top, there is a blue header bar with the AWS logo, a search bar, and navigation links for 'Ranger', 'Global', and 'Support'. A green success message box displays the text: 'Upload succeeded' and 'View details below.' Below this, a note states: 'The information below will no longer be available after you navigate away from this page.' The main content area is titled 'Summary' and shows the destination as 's3://sampletestbucket123'. It indicates 'Succeeded' with '1 file, 16.0 B (100.00%)' and 'Failed' with '0 files, 0 B (0%)'. There are two tabs at the bottom: 'Files and folders' (which is selected) and 'Configuration'. The 'Files and folders' section shows a table with one item: 'test.txt' (Type: text/plain, Size: 16.0 B, Status: Succeeded). A search bar labeled 'Find by name' is also present.

# References:

- <https://aws.amazon.com/s3/?nc=sn&loc=0>
- <https://docs.aws.amazon.com/AmazonS3/latest/userguide>Welcome.html#CoreConcepts>
- <https://www.linkeit.com/blog/what-is-amazon-s3-and-its-benefits>
- <https://searchaws.techtarget.com/quiz/Test-your-knowledge-Amazon-Simple-Storage-Service-quiz?q0=0&q1=1&q2=3&q3=4&q4=2&q5=3&q6=1&q7=1&q8=0&q9=1>

# MCQ

1)Amazon S3 is which type of storage service?

- A)Object
- B)Block
- C)Simple
- D)Secure

2)Which AWS storage service assists S3 with transferring data?

- A)CloudFront
- B)**AWS Import/Export**
- C>DynamoDB
- D>ElastiCache

# MCQ

3) Object storage systems store files in a flat organization of containers called what?

- A) Baskets
- B) Brackets
- C) Clusters
- D) **Buckets**

4) Amazon S3 offers encryption services for which types of data?

- A) data in flight
- B) data at relax
- C) data at rest
- D) data in motion
- E) **a and c**
- F) b and d

# MCQ

5)Amazon S3 has how many pricing components?

- A)4
- B)5
- C)**3**
- D)2

6)What does RRS stand for when referring to the storage option in Amazon S3 that offers a lower level of durability at a lower storage cost?

- A)Reduced Reaction Storage
- B)Redundant Research Storage
- C)Regulatory Resources Storage
- D)**Reduced Redundancy Storage**

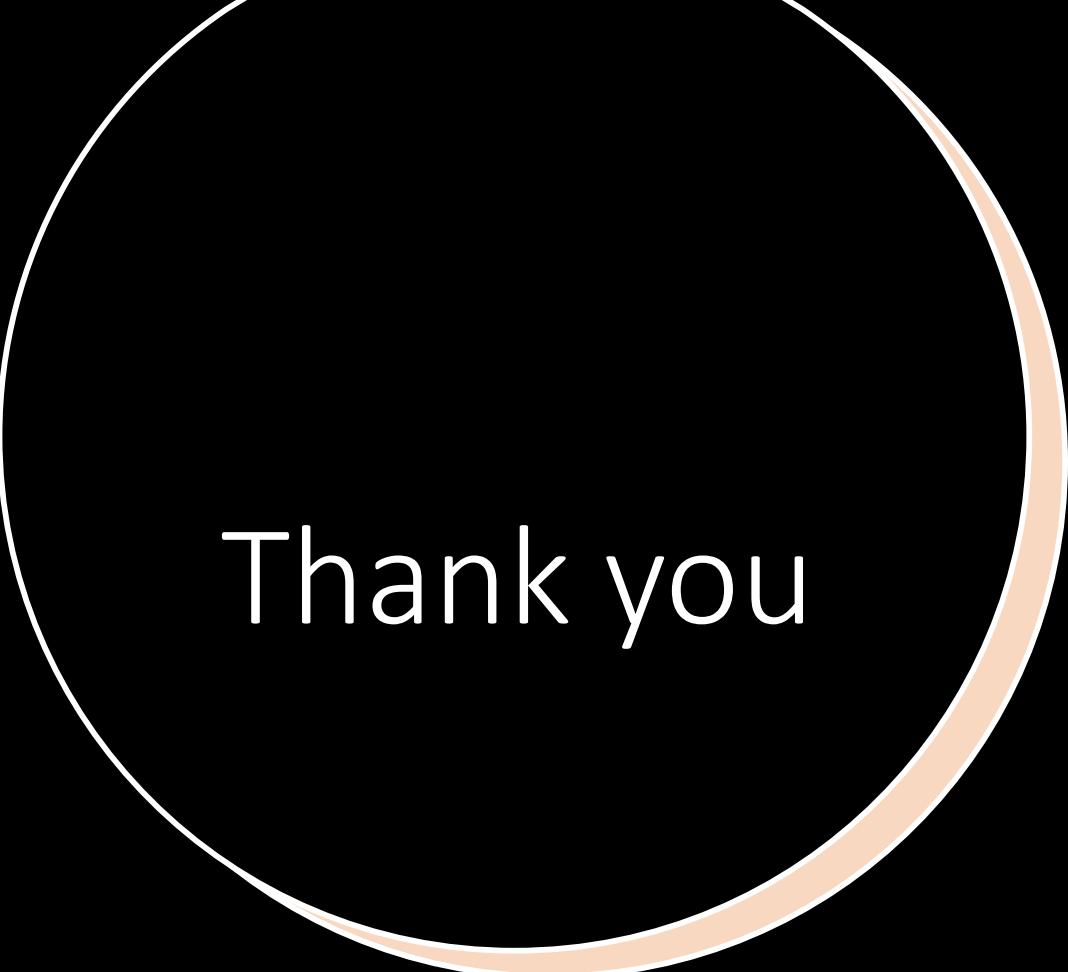
# MCQ

7)True or False. S3 objects are only accessible from the region they were created in.

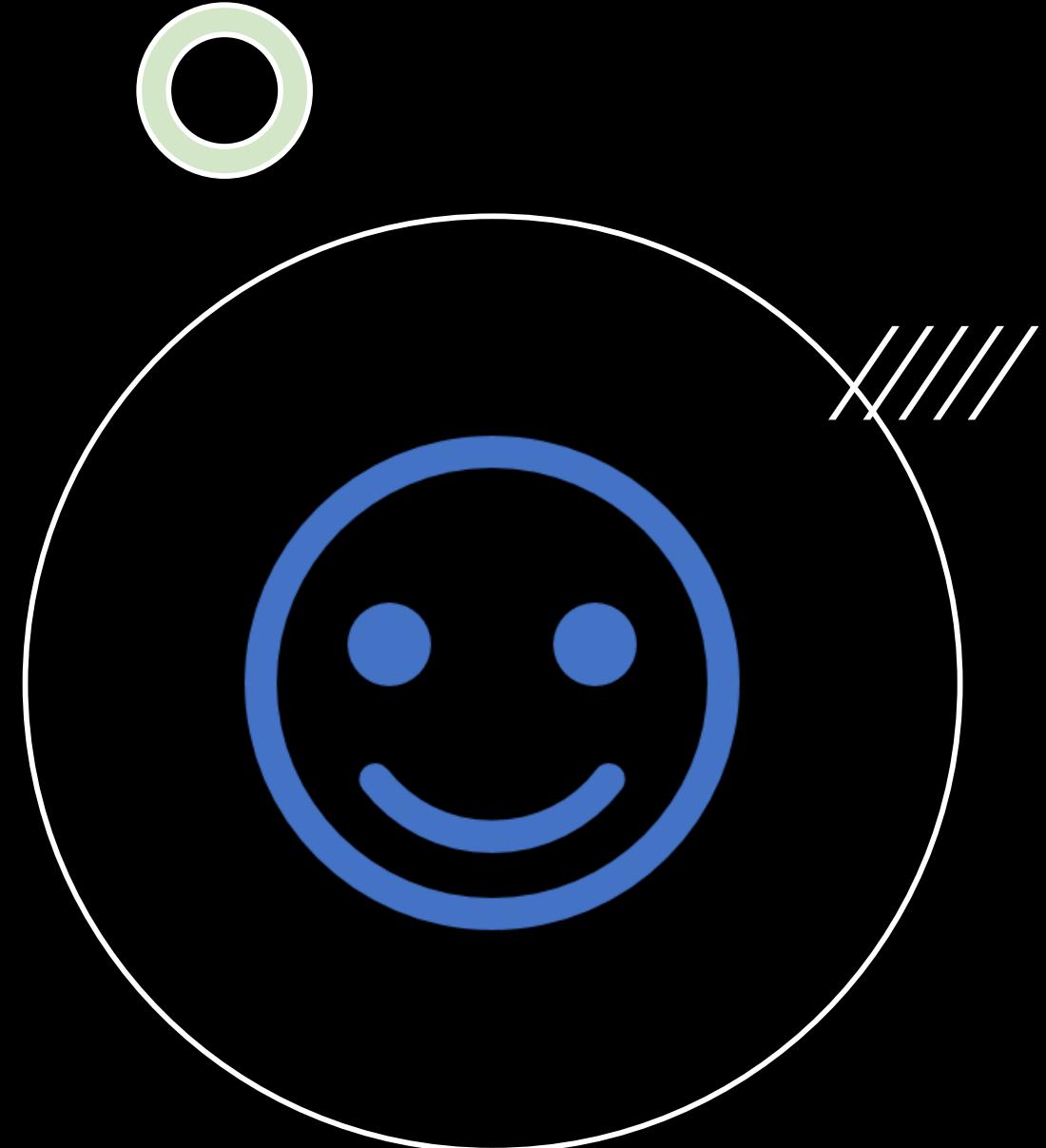
- True
- False

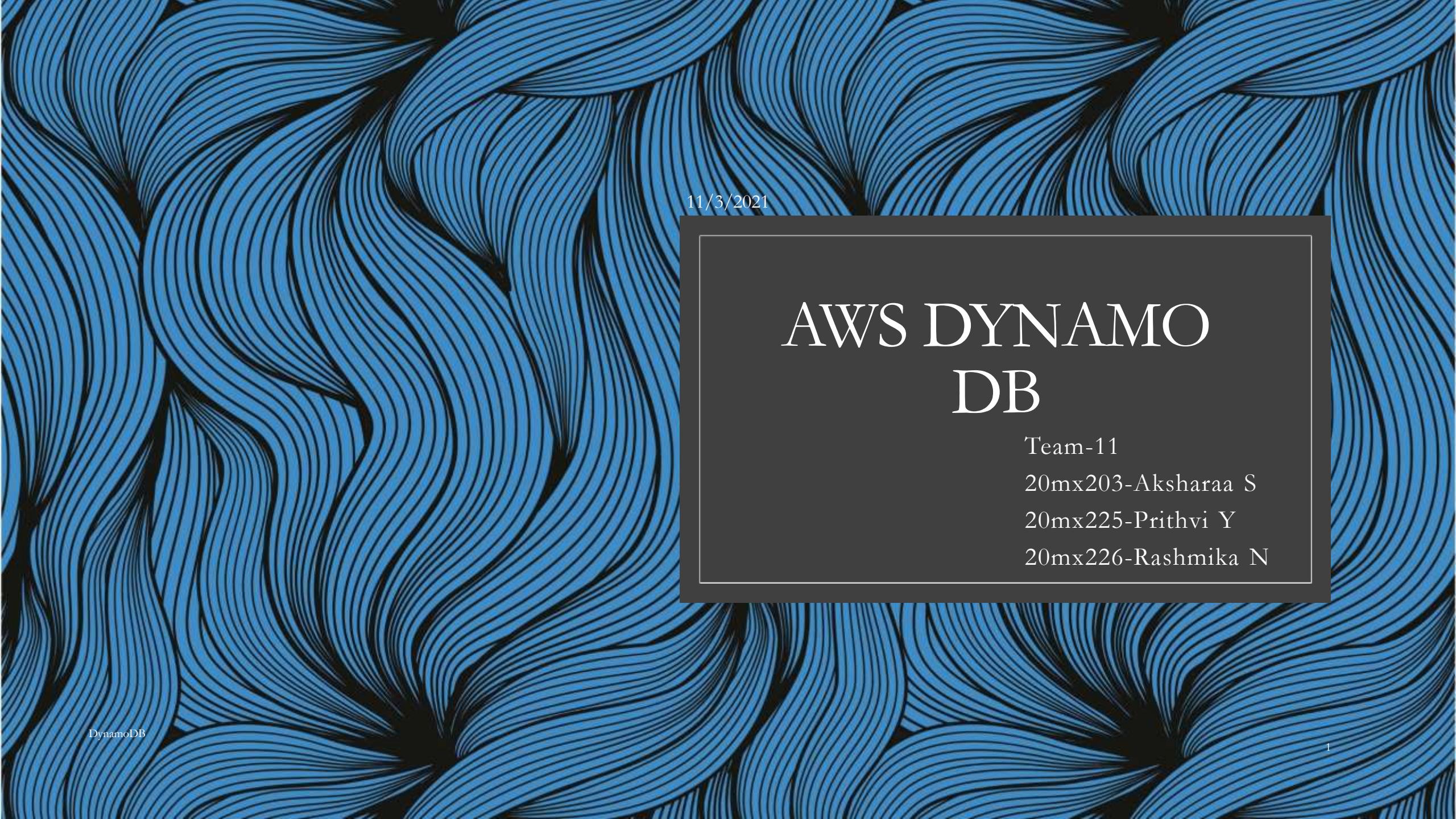
8)Why is a bucket policy necessary?

- To allow bucket access to multiple users.
- To grant or deny accounts to read and upload files in your bucket.
- To approve or deny users the option to add or remove buckets.
- All of the above



Thank you





A presentation slide with a dark grey rectangular overlay in the center. The background features a repeating pattern of blue and black wavy lines.

11/3/2021

# AWS DYNAMO DB

Team-11

20mx203-Aksharaa S

20mx225-Prithvi Y

20mx226-Rashmika N

# AGENDA

- Introduction
- Features
- Components
- How it works
- DynamoDB vs RDS
- Advantage & Disadvantage
- Demo

# Introduction

- DynamoDB is a speedy and flexible NoSQL database service offered by AWS (Amazon Web Service).
- Delivers single-digit millisecond performance at any scale.
- Perfect for mobile apps, web apps, IoT devices, and gaming.



# Companies & Enterprises

- Netflix
- Lyft
- Airbnb
- Redfin
- Samsung
- Toyota
- Capital One

# Features

- Performance at Scale
- No server to manage
- Security
- Backup

# Components



## TABLE:

- DynamoDB stores data in tables.
- A table is a collection of data.

## ITEMS:

- Each table contains zero or more items.
- An item is a group of attributes that is uniquely identifiable among all of the other items.

## ATTRIBUTES:

- Each item is composed of one or more attributes.
- An attribute is a fundamental data element

# How it works

- Create table
  - Read capacity unit
  - Write Capacity Unit
- Add records/Items
- Scan Table
- Query Table

# Dynamo Db vs RDS

FEATURES	RDS	DYNAMO DB
Type of database	Relational database	Key-value
Defining	Relational data model, complex queries, joins	Unorganized data models. Used for transactions
Performance	Automatically optimized	Depends on storage optimization
Scaling	Relatively easy to scale	Scales seamlessly
Storage	64TB	Unlimited storage
Pricing	Generally cheaper than others.	Pay per use model

# Advantage

- Fast, Consistent Performance
- Highly scalable
- Data replication
- Easy administration

# Disadvantage

- Attributes values cannot be null
- Table joins
- Hard to predict the costs

# Dynamo DB in future

- More Infrastructure
- More Data
- More security
- More Competition

11/3/2021

# DEMO

# TASK 1: CREATE A NEW TABLE

The screenshot shows the Amazon DynamoDB console interface. On the left, there's a navigation sidebar with options like 'Dashboard', 'Tables', 'Items', 'PartiQL editor', 'Backups', 'Exports to S3', and 'Reserved capacity'. Below that is a 'DAX' section with 'Clusters', 'Subnet groups', 'Parameter groups', and 'Events'. At the bottom of the sidebar are links for 'Tell us what you think' and 'Return to the previous console experience'. The main content area features a large 'Amazon DynamoDB' logo with the tagline 'A fast and flexible NoSQL database service for any scale'. Below the tagline, it says 'DynamoDB is a fully managed, key-value, and document database that delivers single-digit-millisecond performance at any scale.' To the right, there's a 'Get started' section with a 'Create table' button, which is circled in red. Further down is a 'Pricing' section with a link to learn more about pricing. At the very bottom, there's a footer with links for 'Feedback', 'English (US)', 'Privacy Policy', 'Terms of Use', and 'Cookie preferences', along with system status icons.

[Create](#) [Import](#) [Export](#) [DynamoDB](#) [Index](#) [Help](#)

Search for services, features, marketplace products, and docs [Alt+S]

awsstudent @ 0229-4111-0102 Oregon Support

**Create table**

**Table details** [Info](#)

DynamoDB is a schemaless database that requires only a table name and a primary key when you create the table.

**Table name:**  This will be used to identify your table.

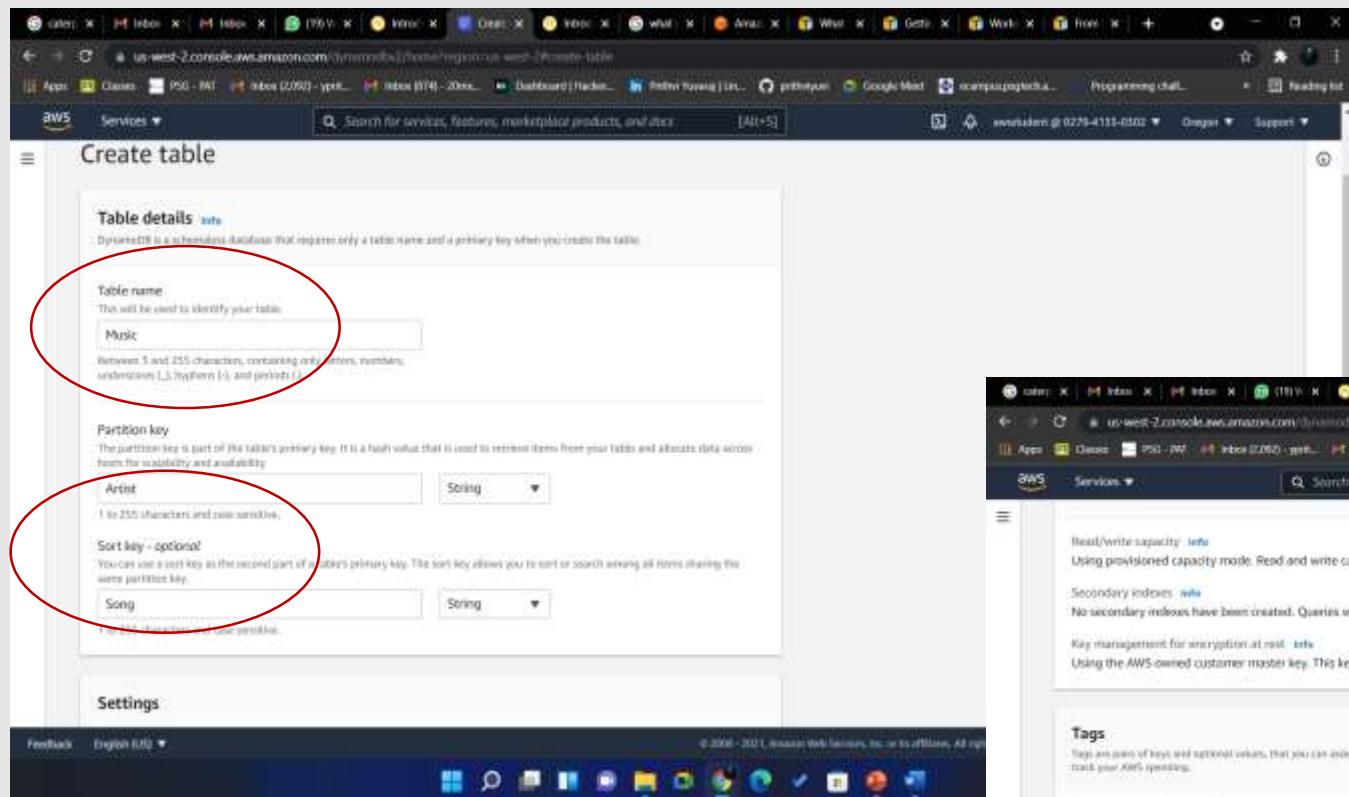
**Partition key:**  String Between 5 and 255 characters, containing only letters, numbers, underscores (\_), hyphens (-), and periods (.)

**Sort key - optional:**  String Between 5 and 255 characters and can't start with a colon (:).

**Settings:**

Feedback English (US) [Info](#)

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[Create](#) [Import](#) [Export](#) [DynamoDB](#) [Index](#) [Help](#)

Search for services, features, marketplace products, and docs [Alt+S]

awsstudent @ 9279-4111-0102 Oregon Support

**Create table**

**Read/write capacity** [Info](#)  
Using provisioned capacity mode. Read and write capacity are set to 5 units each.

**Secondary indexes** [Info](#)  
No secondary indexes have been created. Queries will be run by using the table's partition key and sort key only.

**Key management for encryption at rest** [Info](#)  
Using the AWS-owned customer master key. This key is managed by DynamoDB at no extra cost.

**Tags:**  
Tags are pairs of keys and optional values that you can assign to AWS resources. You can use tags to control access to your resources or track your AWS spending.

No tags are associated with this resource.

[Add new tag](#)  
You can add 50 more tags.

This table will be created with auto scaling disabled. You do not have permissions to create auto scaling.

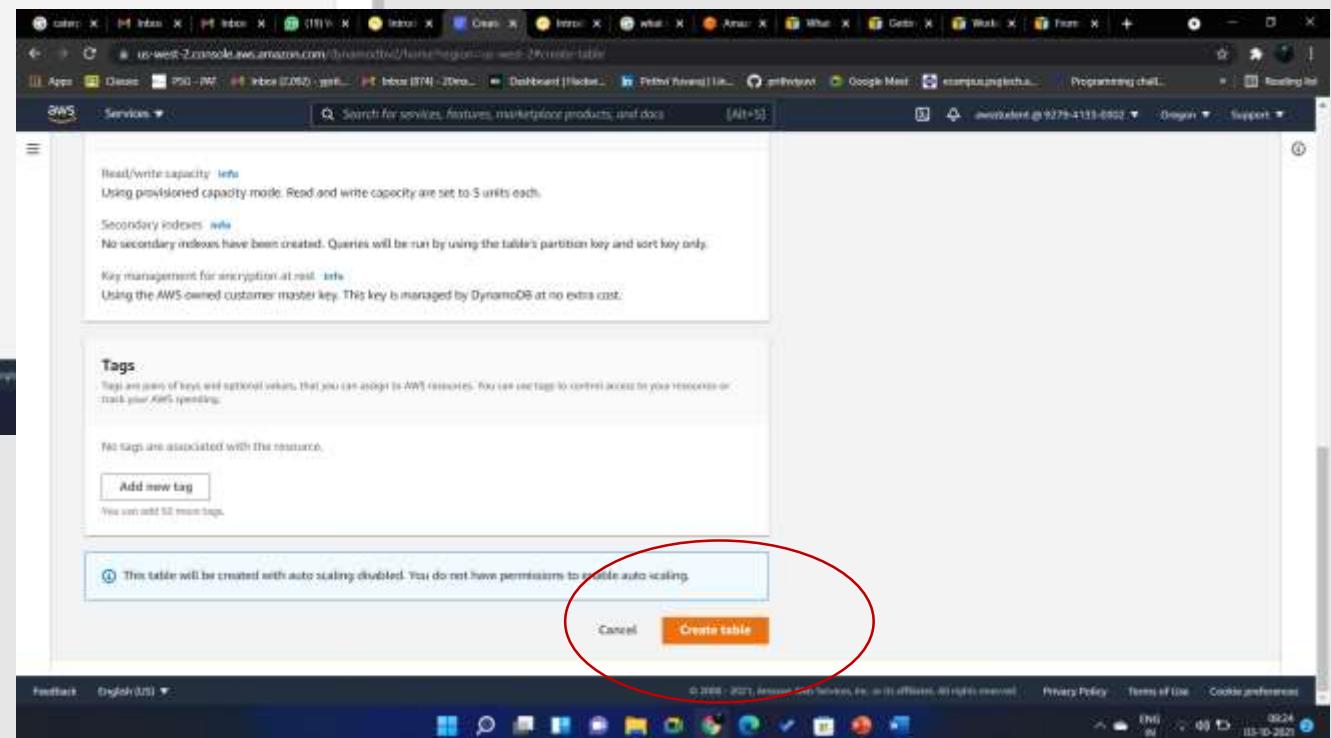
[Cancel](#) [Create table](#)

Feedback English (US) [Info](#)

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Privacy Policy Terms of Use Cookies preferences

11:30 AM 11/3/2021



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us-west-2.console.aws.amazon.com/dynamodbv2/home?region=us-west-2#tables

Apps Classes PSG - PAT Inbox (2,092) - yprit... Inbox (874) - 20m... Dashboard | Hacker... Prithvi Yuvraj | Lin... prithviyuv... Google Meet ecampus.psgtech.a... Programming chall... Reading list

aws Services Search for services, features, marketplace products, and docs [Alt+S]

DynamoDB X

The new DynamoDB console is now complete, and becomes your default experience  
Following the preview phase in which we analyzed and incorporated your feedback, we have completed the new DynamoDB console, making it even easier for you to manage your data and resources. Let us know what you think. You can still choose to return to the previous console from the navigation pane.

Creating the Music table. It will be available for use shortly.

Dashboard

Tables New

Items New

PartiQL editor New

Backups

Exports to S3 New

Reserved capacity

DAX

Clusters

Subnet groups

Parameter groups

Events

Tell us what you think

Return to the previous console experience

DynamoDB > Tables

Tables (1) Info

Find tables by table name Any table tag

Actions Delete Create table

< 1 > @

Name	Status	Partition key	Sort key	Indexes	Read capacity mode	Write capacity mode
Music	Creating	Artist (String)	Song (String)	0	Provisioned (5)	Provisioned (5)

Feedback English (US) ▾ © 2008 - 2021, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use Cookie preferences

8:24 03-10-2021 ENG IN

# TASK 2:ADD DATA

The screenshot shows the AWS DynamoDB Items page. On the left, a sidebar menu is visible with options like Dashboard, Tables, Items (which is highlighted with a red oval), New, Partition editor, Backups, Exports to S3, and Reserved capacity. Below this is a DAX section with Clusters, Subnet groups, Parameter groups, and Events. At the bottom of the sidebar, there are links for Feedback, English (US), Privacy Policy, Terms of Use, and Cookie preferences.

The main content area displays a table titled "Tables (1)". A single table named "Music" is listed, indicated by a blue selection bar. To the right of the table list, there is a section titled "Music" with a sub-section "Items returned (0)". Below this, a search bar says "Find items". On the far right of the "Items returned" section, there are "Actions" and "Create item" buttons, with the "Create item" button also highlighted with a red oval.

At the bottom of the page, a footer bar includes links for ENG, IN, 08:25, 03-10-2021, and a date/time indicator.

The new DynamoDB console is now complete, and becomes your default experience

Following the preview phase in which we analyzed and incorporated your feedback, we have completed the new DynamoDB console, making it even easier for you to manage your data and resources. Let us know what you think. You can still choose to return to the previous console from the navigation pane.

DynamoDB > Items: Music > Item editor

## Create item

Form JSON

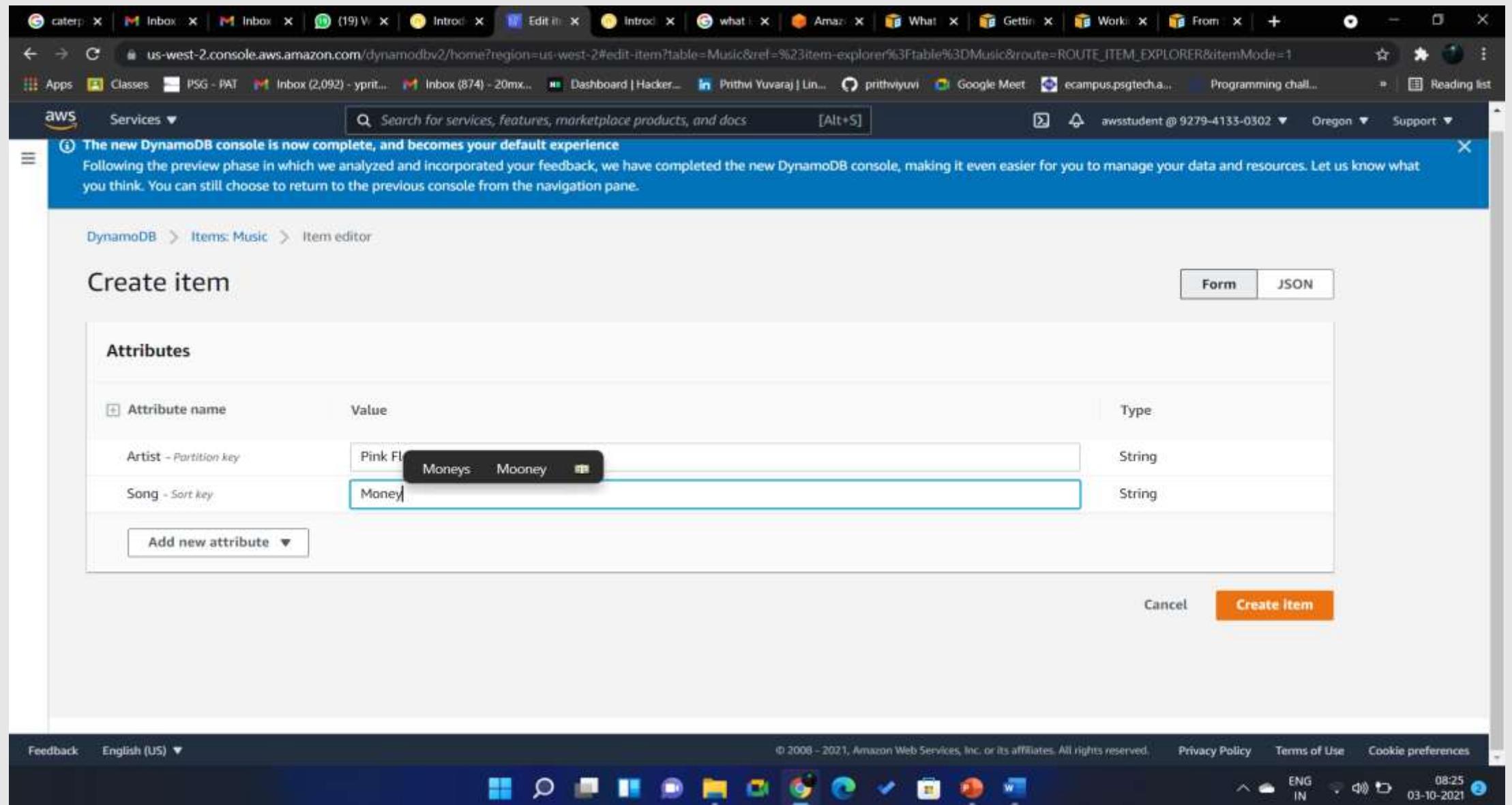
### Attributes

Attribute name	Value	Type
Artist - Partition key	Pink Fl... Moneys Mooney	String
Song - Sort key	Money	String

Add new attribute ▾

Cancel Create item

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# ADD NEW ATTRIBUTE

The new DynamoDB console is now complete, and becomes your default experience.

Following the preview phase in which we analyzed and incorporated your feedback, we have completed the new DynamoDB console, making it even easier for you to manage your data and resources. Let us know what you think. You can still choose to return to the previous console from the navigation pane.

DynamoDB > Items > Item editor

Create item

Attributes

Attribute name	Type	Value
Artist - Person	String	Pink Floyd
Song - String	String	Money
Album	String	The Dark Side of the Moon

Add new attribute

Cancel Create item

DynamoDB > Items > Item editor

Create item

Attributes

Attribute name	Type	Value
Artist - Person	String	Pink Floyd
Song - String	String	Money
Album	String	The Dark Side of the Moon

Add new attribute

Cancel Create item

The new DynamoDB console is now complete, incorporating your feedback. Following the preview phase in which we analyzed and incorporated your feedback, we have completed the new DynamoDB console, making it even easier for you to manage your data and resources. Let us know what you think! You can still choose to return to the previous console from the navigation pane.

The item has been saved successfully.

DynamoDB > items/Music > Item editor

Item

String

Number

Boolean

Binary

Null

String set

Number set

Binary set

List

Map

Add new attribute

Value

Type

Pink Floyd

New String

Money

New String

The Dark Side of the Moon

String Remove

Cancel Save changes



you think! You can still choose to return to the previous console from the navigation pane.

The item has been saved successfully.

DynamoDB > items/Music > Item editor

Item editor

Attributes

Attribute name	Value	Type
Artist - Partition key	Pink Floyd	String
Song - Sort key	Money	String
Album	The Dark Side of the Moon	String
Year	1973	Number

Add new attribute

Cancel Save changes

The item has been saved successfully.

DynamoDB

Dashboard

Tables

Items **New**

Partitions **New**

Backups

Exports to S3 **New**

Reserved capacity

DAX

Clusters

Subset groups

Parameter groups

Events

Tell us what you think

Return to the previous console experience

Feedback English (US) \*

Autopreview

Tables (1)

Music

Items returned (1)

Artist Song Album Year

Pink Floyd Money The Dark Si... 1973

This screenshot shows the AWS DynamoDB Items page. A green success message at the top right says "The item has been saved successfully." On the left, there's a sidebar with various navigation options like Dashboard, Tables, and DAX. The main area shows a table named "Music" with one item: "Pink Floyd" with the song "Money" from the album "The Dark Side of the Moon" in 1973. There's also an "Autopreview" button and a "View table details" link.

The item has been saved successfully.

DynamoDB > Home Music > Item editor

Create item

Form JSON

Attributes

Attribute name	Value	Type
ARTIST - Partition key	John Lennon	String
Song - Sort key	Imagine	String
Album	Imagine	String
Year	1971	Number
Genre	Soft rock	String

Add new attribute

Cancel Create item

Feedback English (US) \*

Autopreview

This screenshot shows the AWS DynamoDB Item editor. A green success message at the top right says "The item has been saved successfully." The main area is titled "Create item" and shows a table of attributes for a new item. The attributes listed are ARTIST (Partition key), Song (Sort key), Album, Year, and Genre. The values are set to John Lennon, Imagine, Imagine, 1971, and Soft rock respectively. There are "Add new attribute" and "Create item" buttons at the bottom. The interface includes tabs for "Form" and "JSON".

Edit item | Amazon DynamoDB

http://eu-west-2.console.aws.amazon.com/dynamodb/item/edit?&region=eu-west-2&tab=Edit&table=Music&id=1&versionId=1&index=0&format=JSON&formatVersion=2

App Classes PSG - 90% Info 0.050 - 9ms Home (816 - 29ms) Dashboard | Metrics Print Preview Google Meet Zoom US East Region Preferences Help Reading list

DynamoDB Items Editor

Create item

Form JSON

**Attributes**

Attribute name	Value	Type
Artist	Psy	String
Song	Gangnam Style	String
Album	Psy 6 (Six Rules), Part 1	String
Year	2011	Number
LengthInSeconds	0	Number

Add new attribute

Home | Amazon DynamoDB

The item has been saved successfully.

DynamoDB Items

Tables (1)

Tag: my-table-tag

View table details

Items returned (3)

Actions Create item

View items

Artist	Song	Album	Genre	LengthInSeconds	Year
Pink Floyd	Honey	The Dark Si...	Rock	0	1973
Psy	Gangnam S...	Psy 6 (Six R...	Pop	0	2011
John Lennon	Imagine	Imagine	Soft rock	0	1971

Tell us what you think

Return to the previous console experience

<https://eu-west-2.console.aws.amazon.com/dynamodb/home?region=eu-west-2>

0.000 - 2021. Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use Create preferences

# TASK 3: MODIFY AN EXISTING ITEM

The screenshot shows the AWS DynamoDB console interface. On the left, the navigation pane includes 'Dashboard', 'Tables (1)', 'Items (New)', 'Partition editor (New)', 'Backups', 'Exports to S3 (New)', and 'Reserved capacity'. Under 'Tables (1)', the 'Music' table is selected. The main area displays the 'Items returned (5)' table with columns: Artist, Song, Album, Genre, LengthSeconds, and Year. Three items are listed: 'Pink Floyd', 'Pig', and 'John Lennon'. The 'Pig' item is currently selected. To the right, the 'Item editor' dialog is open, showing the attributes for the selected item:

Attribute name	Type	Value
Artist - Partition key	String	Pig
Song - Sort key	String	Gangnam Style
Album	String	Piggyback Rules Part 1
LengthSeconds	Number	0
Year	Number	2012

A red oval highlights the 'Save changes' button at the bottom right of the editor.

The screenshot shows the AWS DynamoDB Items Explorer interface. A green success message at the top states "The item has been saved successfully." The left sidebar includes links for Dashboard, Tables, Items (selected), PartiQL editor, Backups, Exports to S3, and Reserved capacity. Under DAX, there are links for Clusters, Subnet groups, Parameter groups, and Events. A "Tell us what you think" link is also present. The main content area shows a "Tables (1)" section with a "Music" table selected. The "Items returned (3)" section displays three items:

	Artist	Song	Album	Genre	LengthS...	Year
<input type="checkbox"/>	Pink Floyd	Money	The Dark Si...			1973
<input type="checkbox"/>	Psy	Gangnam S...	Psy 6 (Six R...		0	2012
<input type="checkbox"/>	John Lennon	Imagine	Imagine	Soft rock		1971

At the bottom, there are links for Feedback, English (US), Privacy Policy, Terms of Use, and Cookie preferences. The status bar shows the date as 03-10-2021 and time as 08:33.

# TASK 4: QUERY THE TABLE

The screenshot shows the AWS DynamoDB Items Explorer interface. On the left, the navigation pane includes links for Dashboard, Tables (with 'Items' selected), PartiQL editor, Backups, Exports to S3, and Reserved capacity. Below that is the DAX section with Clusters, Subnet groups, Parameter groups, and Events. A feedback link is also present.

The main area displays the 'Tables (1)' section, where 'Music' is selected. The 'Query' tab is active. The query parameters are set to find the 'Music' table, using 'Artist (Partition key)' as 'Pink Floyd' and 'Song (Sort key)' as 'Money'. The 'Equal to' dropdown is set to 'Money'. A 'Sort descending' checkbox is unchecked. The 'Run' button is visible.

Below the query form, two status messages are shown: 'Completed' with 'Read capacity units consumed: 0.5' and another 'Completed' message with the same consumption. The 'Items returned (0)' section is empty.

At the bottom, a table titled 'Items returned (1)' shows one item: 'Artist': 'Pink Floyd', 'Song': 'Money', 'Album': 'The Dark Si...', and 'Year': '1973'. There are 'Actions' and 'Create item' buttons above the table, and a search bar below it.

# SCAN THE TABLE

The screenshot shows the AWS DynamoDB Items Explorer interface. On the left, the navigation pane includes links for Dashboard, Tables, Items (New), PartiQL editor, Backups, Exports to S3, Reserved capacity, DAX, Clusters, Subnet groups, Parameter groups, and Events. A feedback section at the bottom asks for user input.

In the center, the 'Tables (1)' section shows a single table named 'Music'. The 'Scan' tab is selected under the 'Table or index' dropdown. A filter is applied with the attribute name 'Year' set to 'Number' and 'Equal to' '1971'. The 'Run' button is highlighted with a red oval.

The results section shows 'Items returned (0)' initially, then transitions to 'Items returned (1)'. The single item listed is:

Artist	Song	Album	Genre	Year
John Lennon	Imagine	Imagine	Soft Rock	1971

At the bottom right, there are links for Actions, Create item, and a page number indicator (1 of 1).

# TASK 5: DELETE THE TABLE

The screenshot shows the Amazon DynamoDB console interface. On the left, there's a sidebar with options like Dashboard, Tables (which is selected and highlighted in orange), Items, PartiQL editor, Backups, Exports to S3, and Reserved capacity. Below that is a section for DAX with Clusters, Subnet groups, Parameter groups, and Events. At the bottom of the sidebar, there are links for 'Tell us what you think' and 'Return to the previous console experience'.

The main content area shows a success message: "The new DynamoDB console is now complete, and becomes your default experience" and "The item has been saved successfully." Below this, the "Tables (1) Info" section displays a table with one item: "Music". The table columns are Name, Status, Partition key, Sort key, Indexes, Read capacity mode, and Write capacity mode. The "Music" row has a checked checkbox under "Name", "Active" under "Status", "Artist (String)" under "Partition key", "Song (String)" under "Sort key", 0 under "Indexes", "Provisioned (5)" under "Read capacity mode", and "Provisioned (5)" under "Write capacity mode".

At the top right of the main content area, there are buttons for Actions (with a dropdown arrow), Delete (which is circled in red), and Create table. There are also navigation controls for pages 1 and 2, and a refresh icon.

At the very bottom of the screen, there's a taskbar with various icons for Windows applications like File Explorer, Task View, and Control Panel. The system tray shows the date and time as 03-10-2021 08:43, and it includes icons for battery level, signal strength, and network status.

List tables | Amazon DynamoDB

us-west-2.console.aws.amazon.com/dynamodbv2/home?region=us-west-2#tables

aws Services Search for services, features, marketplace products, and docs [Alt+S]

DynamoDB Dashboard Tables Items New PartiQL editor Backups Exports to S3 Reserved capacity DAX Clusters Subnet groups Parameter groups Events Tell us what you think Return to the previous console experience

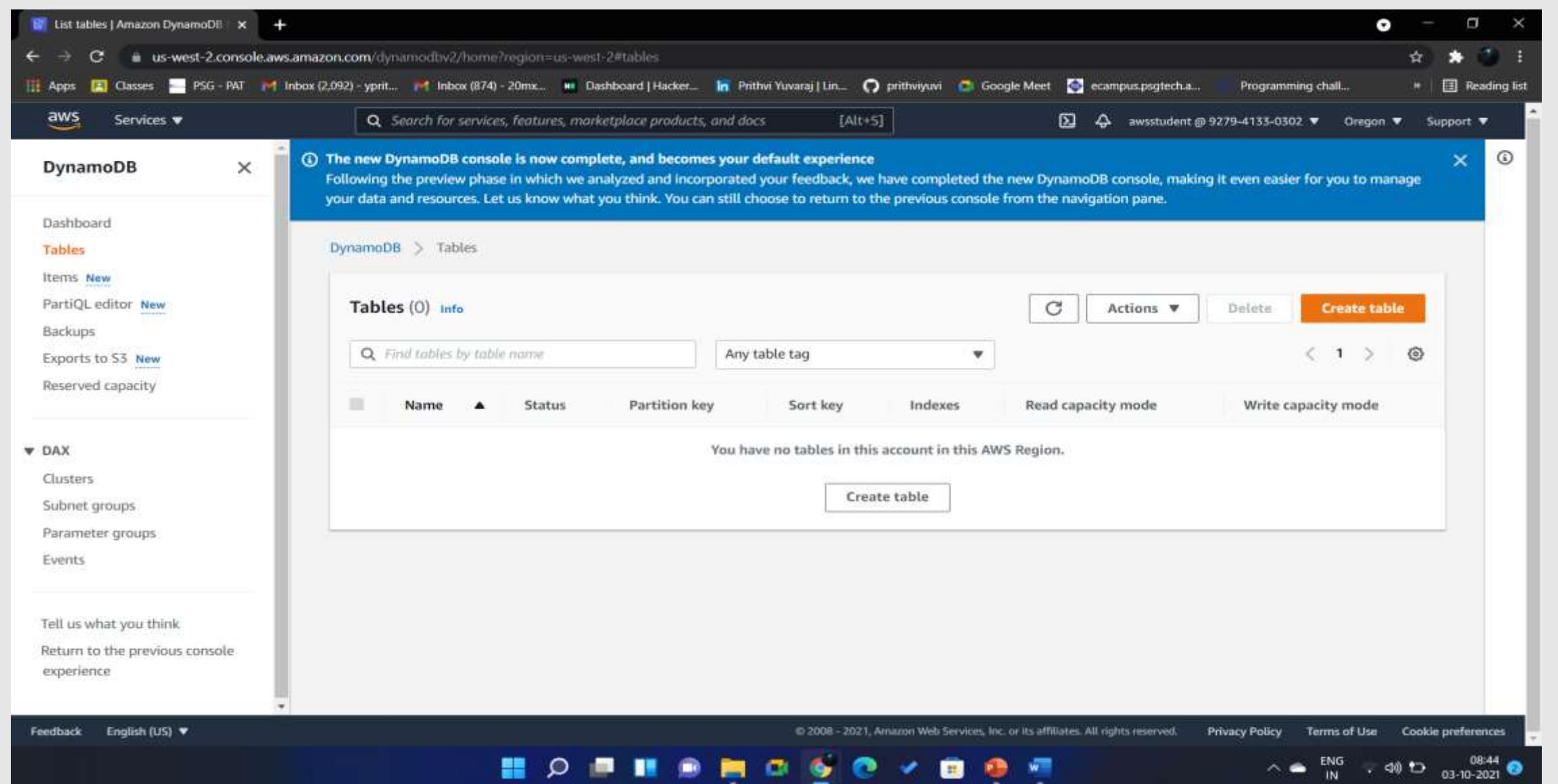
The new DynamoDB console is now complete, and becomes your default experience  
Following the preview phase in which we analyzed and incorporated your feedback, we have completed the new DynamoDB console, making it even easier for you to manage your data and resources. Let us know what you think. You can still choose to return to the previous console from the navigation pane.

DynamoDB > Tables

Tables (0) Info Find tables by table name Any table tag Create table

Name	Status	Partition key	Sort key	Indexes	Read capacity mode	Write capacity mode
You have no tables in this account in this AWS Region.						
Create table						

Feedback English (US) © 2008 - 2021, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use Cookie preferences ENG IN 08:44 03-10-2021



# MCQ :

- 1. Amazon DynamoDB is a fully managed proprietary?
  - A. Centralised database
  - B. Commercial database
  - C. **NoSQL database**
  - D. Relational database
- 2. How many types of primary keys does DynamoDB supports?
  - A. **2**
  - B. 3
  - C. 4
  - D. 5
- 3. Which index has the same partition key as the base table, but a different sort key?
  - A. Global secondary index
  - B. **Local secondary index**
  - C. Both A and B
  - D. None of the above

- 4. How many attributes does DynamoDB allows?
  - A. 5
  - B. 10
  - C. 15
  - D. **20**
- 5.DynamoDB offers \_\_\_\_\_ low-level actions for data reading.
  - A. 1
  - B. 2
  - C. 3
  - D. **4**
- 6. DynamoDB uses eventually consistent and strongly consistent reads to support dynamic application needs.
  - A. **TRUE**
  - B. **FALSE**
  - C. Can be true or false
  - D. Cannot say
- 7.DynamoDB does not supports Null values.
  - A. **TRUE**
  - B. **FALSE**
  - C. Can be true or false
  - D. Cannot say

- 8. Which of the following are benefits of using Amazon DynamoDB?
  - A. It is scalable
  - B. It provides the users high throughput at very low latency.
  - C. It is durable and highly available
  - D. **All of the above**
- 9. Does DynamoDB support in-place atomic updates?
  - A. **TRUE**
  - B. **FALSE**
  - C. Can be true or false
  - D. Cannot say
- 10. How many types of secondary indexes does DynamoDB supports?
  - A. **2**
  - B. 3
  - C. 4
  - D. 5

# References

- <https://docs.aws.amazon.com/index.html>
- <https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/Introduction.html>
- <https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/HowItWorks.html>

# THANK YOU :)

# Usage demo of EC2



Chandeesh S - 20mx107

Srivijayram N B - 20mx221

Swathi shri K - 20mx223

# Services provided by AWS

- Amazon EC2
- Amazon Simple Storage Service (S3)
- Amazon Aurora
- Amazon Dynamo
- Amazon RDS
- AWS Lambda
- Amazon VPC
- Amazon Lightsail
- Amazon SageMaker



- Regions
- Coming Soon

# History

- Amazon announced a limited public beta test of EC2 on August 25, 2006.
- Amazon added three new features on March 27, 2008 static IP addresses, availability zones, and user selectable kernels.
- On August 20, 2008, Amazon added [Elastic Block Store \(EBS\)](#)
- Amazon EC2 went into full production when it dropped the beta label on October 23, 2008.
- And announced plans for [load balancing](#), [autoscaling](#), and cloud monitoring services.

# Amazon EC2

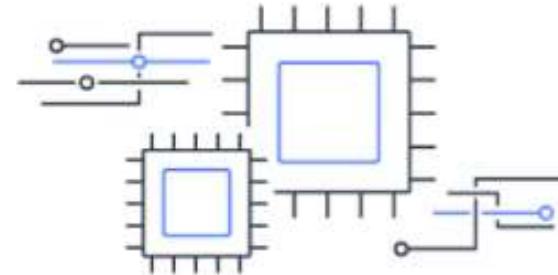
- Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides secure, resizable compute capacity in the cloud.
- It is designed to make web-scale cloud computing easier for developers.
- Amazon EC2 offers the broadest and deepest compute platform with choice of processor, storage, networking, operating system, and purchase model.
- EC2 offers many options that enable you to build and run virtually any application.

# Building Blocks - EC2

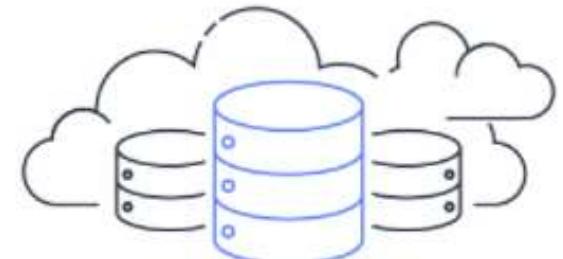
Faster innovation and increased security  
with AWS Nitro System



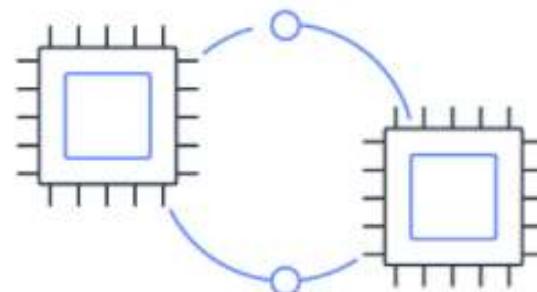
Choice of processors



High performance storage



Enhanced networking



Choice of purchasing model



**NETFLIX**



CATHAY PACIFIC



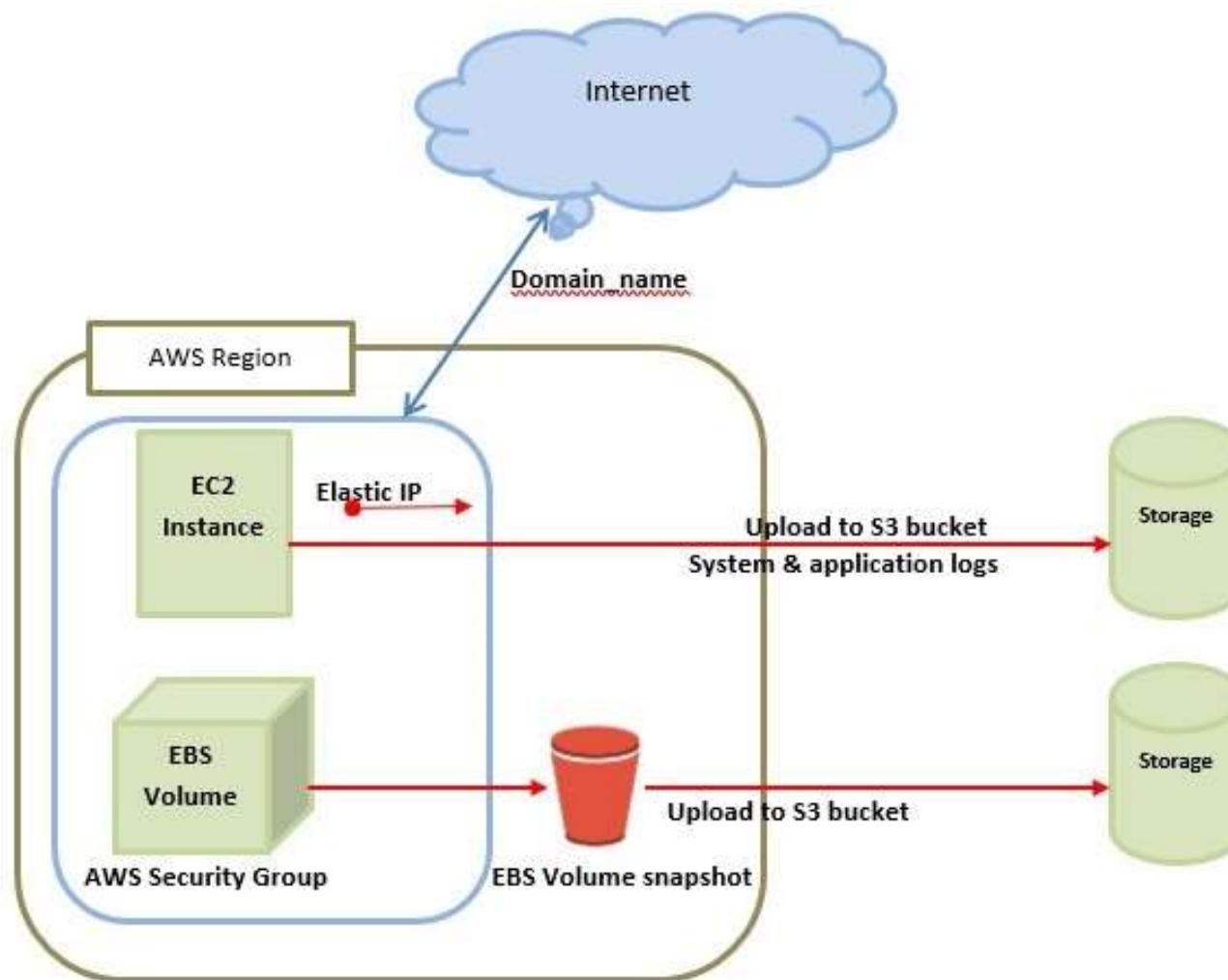
# Features of Amazon EC2

- Reliable
- Secure
- Flexible tools
- Inexpensive

# Use Cases

- Hosting environments
- Backup and disaster recovery
- High-performing computing
- Development & test environment
- Banking and financial sectors

# Architecture



# Steps for creating Instance

- Select a pre-configured, templated Amazon Machine Image (AMI)
- Configure security and network access on Amazon EC2 instance
- Choose which instance type(s)
- Determine whether you want to run in multiple locations
- Pay only for the resources that you actually consume

# **Demo**

# MCQ

1) What does Amazon EC2 stand for?

1. Elastic Computer Cloud.
2. Elastic Computer Center
- 3. *Elastic Compute Cloud.***
4. Extended Compute Cloud.

2) What does the following CLI command do? aws ec2 run-instances --image-id ami-e3a5408a --count 20 --instance-type t1.micro --security-groups appserver

1. It fails silently because there is no run-instances command.
2. It changes the AMI of all the running instances that belong to the appserver security group
3. It returns a syntax error, because the option image-id does not exist.
- 4. *Starts 20 EC2 micro instances as members of the appserver security group***

3) In Amazon EC2, Pricing is \_\_\_\_\_ consumed for each instance type.

- 1. *per instance-hour***
2. per instance-minute
3. per instance-second
4. per instance-day

4) A \_\_\_\_\_ in VPC contains a set of rules, called routes, that are used to determine where network traffic is directed.

1. Gateway table
2. Switch
3. Router
4. **Route table**

5) How can I launch an EC2 instance with an IAM role? Choose the most correct answer from the below options:

1. Only using the AWS Management Console
2. Only using EC2 command line interfaces (CLIs)
3. **Using the AWS Management Console or by using both the IAM and the EC2 command line interfaces (CLIs)**
4. Only using the IAM command line interfaces (CLIs)

6) Can Amazon EC2 have an Amazon Resource Name (ARN)?

1. No, because EC2 is unrelated to ARN
2. No, because you can't specify a particular Amazon EC2 resource in an IAM policy
3. **Yes**
4. Yes, just for certain kind of EC2 instances

7) \_\_\_\_\_ in VPC support Allow rules only

1. Availability Zones
2. Geo Redundant Servers
3. Network ACLs
4. **Security groups**

8) With regard to AWS what does ARN stand for?

1. Amazon Reesource Namespace
2. Amazon Resource Nametag
3. Amazon Resource Number
4. ***Amazon Resource Name***

9) Is it possible to move an EC2 instance from one Security Group to another?

1. No. The security group is set for every specific AMI, and can never be changed.
2. ***except for EC2-classic***
3. Yes, but you will need to reload the Security Group configuration for that EC2 instance.
4. Yes, but it will take up to 30 minutes for the new configuration to take effect.

10) What's an ECU?

1. ***Elastic Compute Unit.***
2. Extended Cluster User.
3. None of these.
4. Elastic Computer Usage.

# References

<https://aws.amazon.com/ec2/>

[https://en.wikipedia.org/wiki/Amazon\\_Elastic\\_Compute\\_Cloud](https://en.wikipedia.org/wiki/Amazon_Elastic_Compute_Cloud)

<https://k21academy.com/amazon-web-services/aws-devops/aws-ec2-instance/>

<https://medhahosting.com/amazon-ec2-instance-creation/>

**THANK YOU**

# **CREATING AND DEPLOYING WEBSITE IN CLOUD PLATFORM**

By

20MX103 - ASMATH HASEENA S

20MX109 - DHARSHINI PRIYA P

20mx215 - NEVESH S

# AGENDA

- INTRODUCTION
- PLATFORM CHOSEN
- DEMO
- CONCLUSION

# INTRODUCTION

- Cloud storage is a model of computer data storage in which the digital data is stored in logical pools, said to be on "the cloud"
- Users can remotely upload their content, store them and retrieve the data as and when required.
- Cloud platform is typically owned and managed by a hosting company.

# PLATFORM CHOSEN

- BUBLUP CLOUD STORAGE
- WIX CLOUD STORAGE



# BUBLUP CLOUD STORAGE

- Founded by Alain Cohen, Marc Cohen on 2014
- Headquarters located in Washington DC Metro Area, East Coast, Southern US
- Pronounced Bubble-up is reimagining the cloud, one of the mainstays of modern computing, by reinventing not just the technology that powers the cloud, but how we use it in our daily lives.



# BUBLUP CLOUD STORAGE

- Bublup helps to store, organize, and share critical content within a centralized repository
- Professionals can utilize the drag-and-drop functionality to import documents, images, videos, links, and web pages to the platform
- Invite team members to collaborate on content



# WIX CLOUD STORAGE

- An Israeli software company, providing cloud-based web development services.
- Headquarters and other offices in Israel, Wix also has offices in Brazil, Canada, Germany, India, Ireland, Lithuania, the United States, and Ukraine.
- Allows users to create HTML5 websites and mobile sites through the use of online drag and drop tools.

## STOR

- Wix is a website builder
- Easy-to-use tool that lets you quickly create an online presence via drag-and-drop interface—no coding or FTP knowledge is required.
- All you need is an email address to get started with Wix web hosting.



WIX.COM

# REFERENCES

<https://www.getapp.com/collaboration-software/cloud-storage/>

<https://www.bublup.com/>

<https://www.wix.com/free/web-hosting>

# THANK YOU

# MCQ

1. How many categories of storage devices broadly exist in cloud?
  - a) 1
  - b) 2**
  - c) 3
  - d) None of the mentioned
  
2. The addition of a software package on top of a cloud storage volume makes most cloud storage offerings conform to a \_\_\_\_\_ as a Service model.  
**a) Software**  
b) Platform  
c) Analytics  
d) None of the mentioned
  
3. Which of the following system does not provision storage to most users?  
**b) IaaS**  
a) PaaS  
c) CaaS  
d) SaaS

4. Cloud storage data usage in the year 2020 is estimated to be \_\_\_\_\_ percent resident by IDC.

- a) 10
- b) 15
- c) 20
- d) None of the mentioned

5. Which of the following impose additional overhead on clients and offer faster transfer?

- a) Block storage
- b) File Storage
- c) File Server
- d) All of the mentioned

6. Which of the following storage devices exposes its storage to clients as Raw storage that can be partitioned to create volumes?

- a) block
- b) file
- c) disk
- d) all of the mentioned

7. Which of the following is storage data interchange interface for stored data objects?

- a) OCC
- b) OCCI
- c) OCMI
- d) All of the mentioned

8. \_\_\_\_\_ data represents more than 50 percent of the data created every day.

- a) Shadow
- b) Light
- c) Dark
- d) All of the mentioned

9. Which one of the following is Cloud Platform by Amazon?

- a) Azure
- b) AWS
- c) Cloudera
- d) All of the mentioned

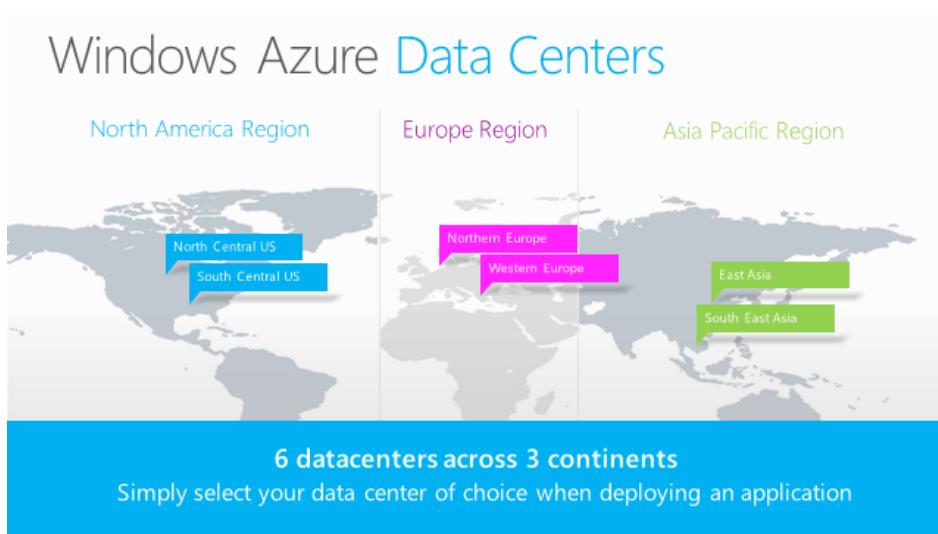
10. Cloud computing is a kind of abstraction which is based on the notion of combining physical resources and represents them as \_\_\_\_\_ resources to users.

- a) Real
- b) Cloud
- c) Virtual
- d) none of the mentioned

## An Introduction to Windows Azure

- Windows Azure is a cloud computing platform developed by Microsoft that can be used to build and host online Web applications through Microsoft data centers. Management of the scalable Web applications is also performed at Microsoft's data centers.
- Windows Azure was originally codenamed "Red Dog" and was initially called "Windows Cloud" when it first launched in October 2008.
- Windows Azure is the Microsoft cloud computing platform which enables developers to quickly develop, deploy, and manage their applications hosted in a Microsoft data center.
- As a PAAS provider, Windows Azure not only takes care of the infrastructure, but will also help to manage higher level components including operating systems, runtimes, and middleware.

### Windows Azure Data Centers



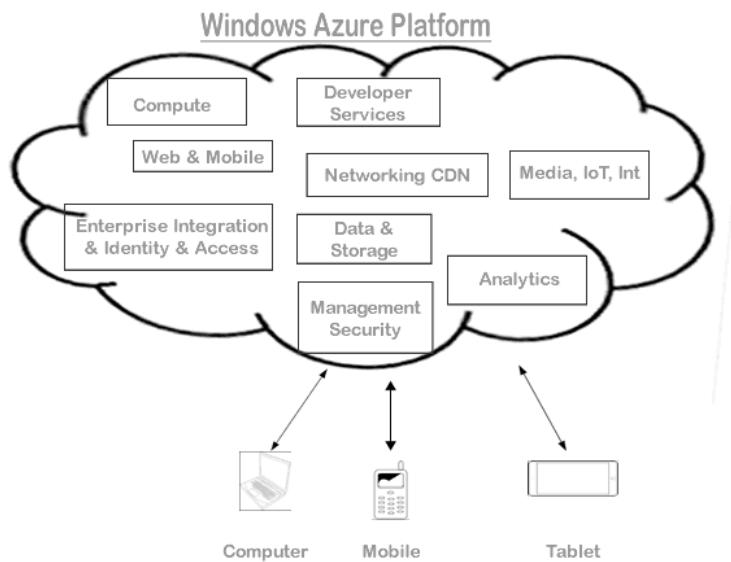
Microsoft has invested heavily in Windows Azure over the past few years. Six data centers across three continents have been developed to serve millions of customers. They have been built with an optimized power efficiency mechanism, self-cooling containers, and hardware homogeneity, which differentiates them from other data centers.

The data centers are located in the following cities:

- US North Central – Chicago, IL
- US South Central – San Antonio, TX
- West Europe – Amsterdam
- North Europe – Dublin
- East Asia – Hong Kong
- South-East Asia – Singapore

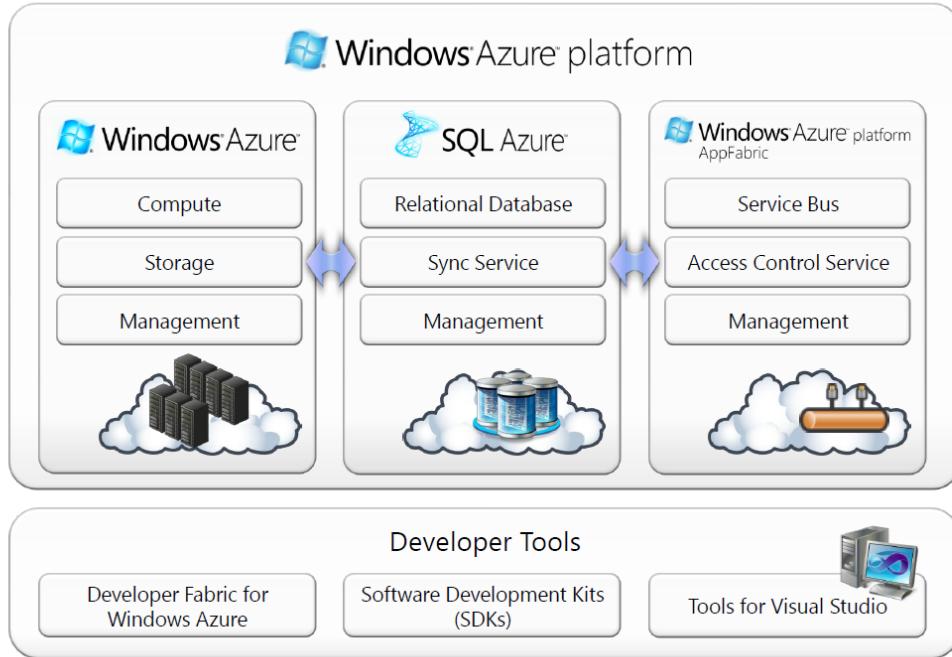


**Windows Azure data centers are vast and intricately sophisticated**



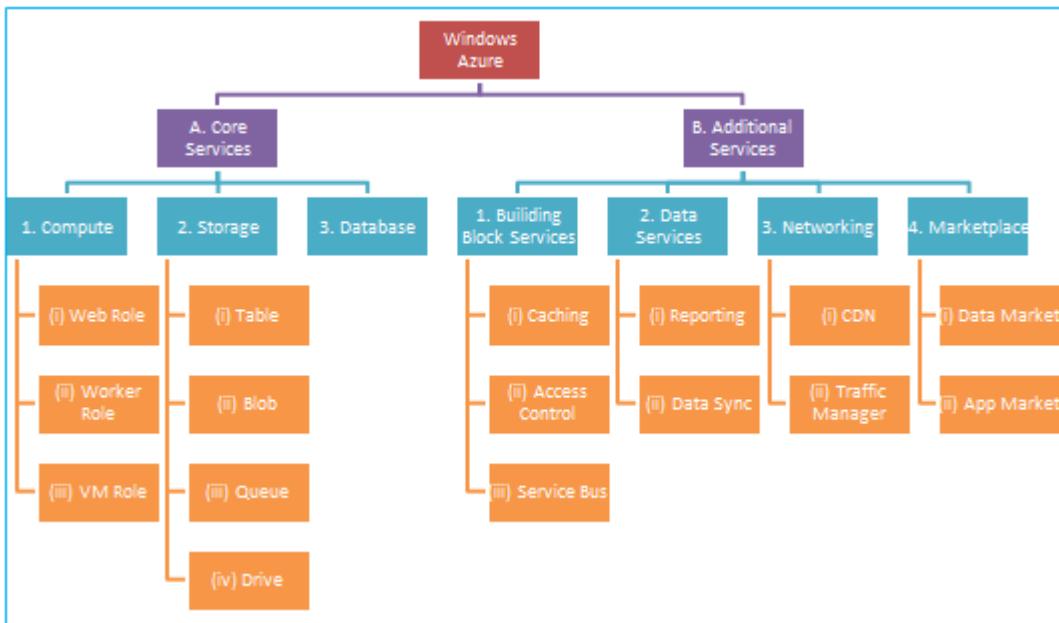
**Windows Azure Services**

Microsoft has previously categorized the Windows Azure Platform into three main components: Windows Azure, SQL Azure, and Windows Azure AppFabric.



However, with the recent launch of the Metro-style [Windows Azure portal](#), there are some slight changes to the branding, but the functionality has remained similar.

The following diagram illustrates the complete suite of Windows Azure services available today.



## The complete suite of Windows Azure services available today

### A. Core Services

#### 1. Compute

The Compute service refers to computation power, usually in the form of provisioned Virtual Machines (VMs).

In Windows Azure, the compute containers are often referred to as 'roles'. At the moment, there are three types of roles:

##### (i) Web Roles

Web Roles offer a predefined environment, set-up to allow developers to easily deploy web applications.

[Web server IIS \(Internet Information Services\)](#) has been preinstalled and preconfigured to readily host web application.

## (ii) Worker Roles

Worker Roles allow the developer to run an application's background processes that do not require user interface interaction.

Worker Roles are perfectly suitable to run processes such as scheduled batch jobs, asynchronous processing, and number crunching jobs.

## (iii) VM Roles

VM Roles enable developers to bring their customized Windows Server 2008 R2 VM to the cloud, and configure it.

VM Roles are suitable for cases where the prerequisite software requires lengthy, manual installation.

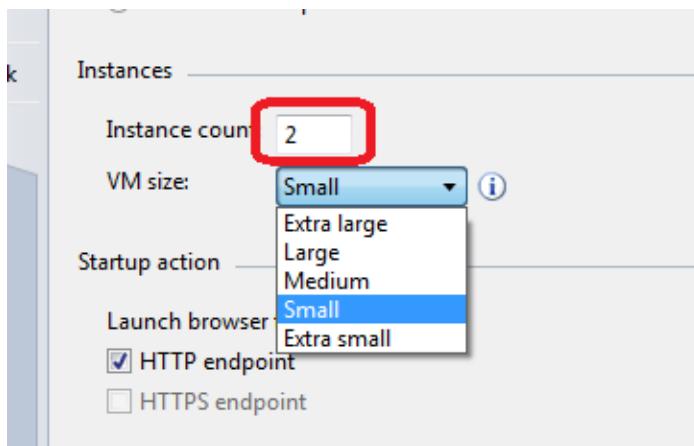
Using VM Roles has one substantial drawback. Unlike Web Roles and Worker Roles, whereby Windows Azure will automatically manage the OS, VM Roles require developers to actively manage the OS.

Apart from 'roles', there are two other essential terms, namely 'VM Size' and 'Instance'.

- **VM Size** denotes the predefined specifications that Windows Azure offers for the provisioned VM. The following diagram shows various Windows Azure VM Sizes.

Extra Small	Small	Medium	Large	X-Large
<b>\$0.04</b> Per service hour	<b>\$0.12</b> Per service hour	<b>\$0.24</b> Per service hour	<b>\$0.48</b> Per service hour	<b>\$0.96</b> Per service hour
<b>1 x 1.0Ghz</b> (low IO)  768 MB memory 20 GB storage (instance storage)	<b>1 x 1.6Ghz</b> (moderate IO)  1.75 GB memory 250 GB storage (instance storage)	<b>2 x 1.6Ghz</b> (high IO)  3.5 GB memory 500 GB storage (instance storage)	<b>4 x 1.6Ghz</b> (high IO)  7.0 GB memory 1000 GB storage (instance storage)	<b>8 x 1.6Ghz</b> (high IO)  14 GB memory 2000 GB (instance storage)

- **Instance** refers to the actual VM that is provisioned. Developers will need to specify how many instances they need after selecting the VM Size.

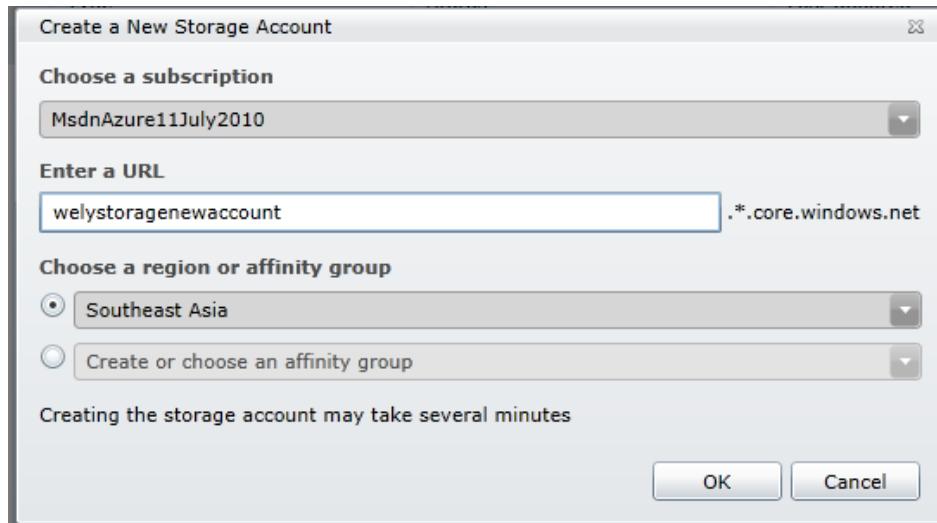


## 2. Storage

Windows Azure Storage is a cloud storage service that comes with the following characteristics:

- Highly available with [99.9% monthly SLA](#)
- Scalable with [automatic load-balanced partitioning](#)
- Data is replicated for resilience and protection with 3 copies within the same data center, and [another 3 copies geo-replicated in another data center](#)
- Accessible through [several libraries](#) including .NET, Java, PHP, Ruby, etc. REST-based API
- [Up to 100TB size limit](#) per storage account
- [Cost effective](#)
  - Storage capacity: \$ 0.14 per GB per month
  - Storage transaction: \$ 0.01 per 10,000 transaction

The first step in using Windows Azure Storage is to create a storage account by specifying storage account name and the region:



There are four types of storage abstraction that are available today:

**(i) BLOB (Binary Large Object) Storage**

Blob Storage provides a highly scalable, durable, and available file system in the cloud.

Blob Storage allows customers to store any file type such as video, audio, photos, or text.

**(ii) Table Storage**

Table Storage provides structured storage that can be used to store non-relational tabular data.

A Table is a set of entities, which contains a set of properties.

An application can manipulate the entities and query over any of the properties stored in a Table.

**(iii) Queue Storage**

Queue Storage is a reliable and persistent messaging delivery that can be used to bridge applications.

Queues are often being used to reliably dispatch asynchronous work.

#### **(iv) Azure Drive**

Azure Drive (aka X-Drive) provides the capability to store durable data by using the existing Windows NTFS APIs.

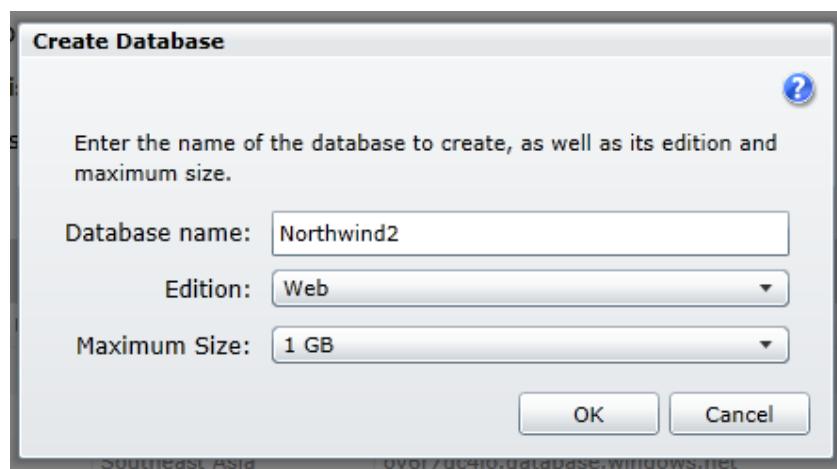
Azure Drive is essentially a [VHD Page Blob](#) mounted as an NTFS drive by a Windows Azure instance.

### **3. Database**

SQL Azure database is a [highly available](#) database service built on existing SQL Server technology.

Developers do not have to setup, install, configure, or manage any of the database infrastructure.

All developers need to do is define the database name, edition, and size. Developers are then ready to bring the objects and data to the cloud:



SQL Azure uses the same T-SQL language and the same tools as SQL Server Management Studio to manage databases.

SQL Azure is likely to lead to a shift in the responsibility of DBAs toward a more logical administration, as SQL Azure handles physical administration. For example, a SQL Azure database will be replicated to three copies to ensure high-availability.

## **Additional Services**

### **1. Building Block Services**

‘Building block services’ were previously branded ‘Windows Azure AppFabric’.

The main objective of building block services is to enable developers to build connected applications.

The three services under this category are:

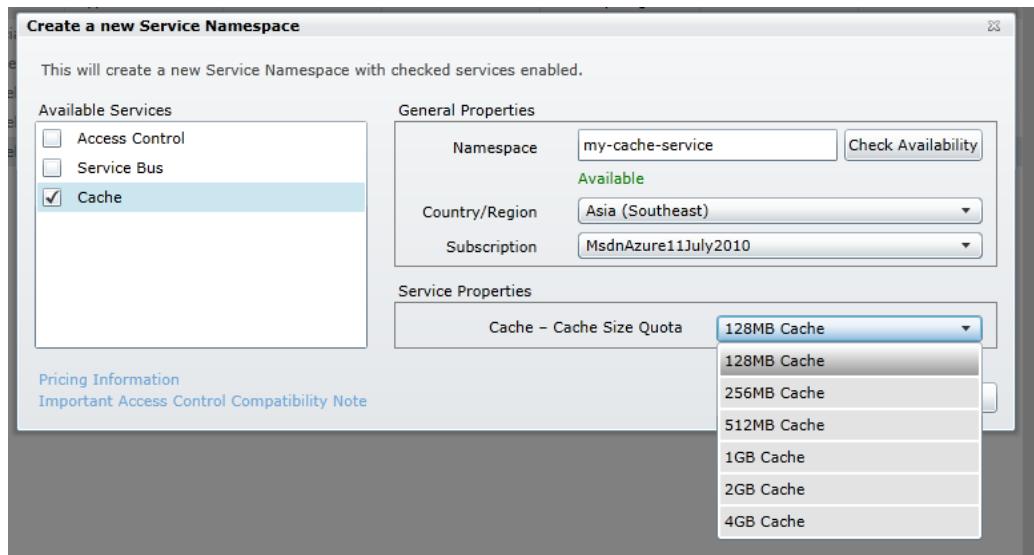
### (i) Caching Service

Generally, accessing RAM is much faster than accessing disk, including storage and databases. For that reason, Microsoft have developed an in-memory and distributed caching service to deliver low latency, high-performance access, namely [Windows Server AppFabric Caching](#).

However, there are some activities, such as installing and managing, and some hardware requirements like investing in clustered servers, which have to be handled by the end-user.

Windows Azure Caching Service is a self-managed, yet distributed, in-memory caching service built on top of the Windows Server AppFabric Caching Service.

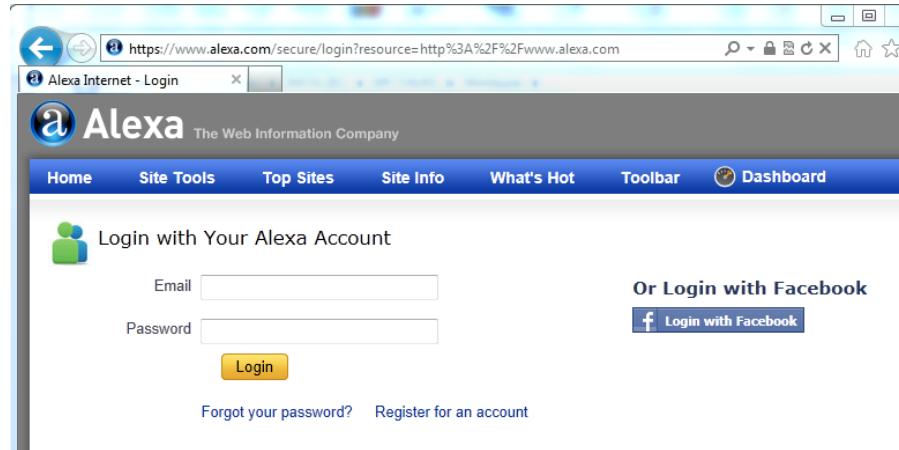
Developers will no longer have to install and manage the Caching Service / Clusters. All they need to do is to create a namespace, specify the region, and define the Cache Size. Everything will get provisioned automatically in just a few minutes.



### Creating new Windows Azure Caching Service

Additionally, Azure Caching Service comes along with a .NET client library and session providers for ASP.NET, which allow the developer to quickly use them in the application.

## (ii) Access Control Service

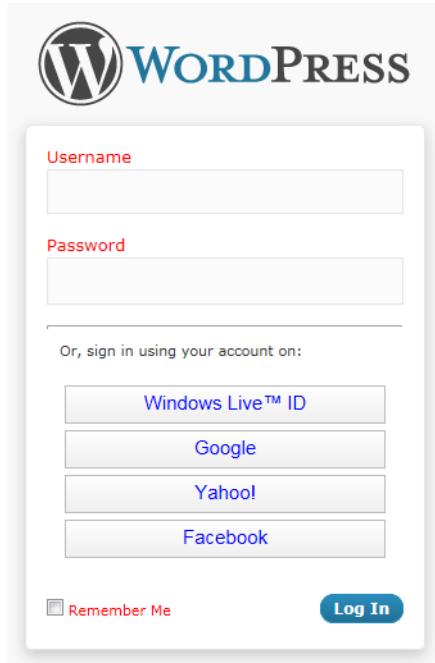


A screenshot of a web browser displaying the Alexa login page. The URL in the address bar is <https://www.alexa.com/secure/login?resource=http%3A%2F%2Fwww.alexa.com>. The page header includes the Alexa logo and navigation links for Home, Site Tools, Top Sites, Site Info, What's Hot, Toolbar, and Dashboard. Below the header, there is a section titled "Login with Your Alexa Account" featuring fields for Email and Password, and a "Login" button. To the right, there is an option to "Or Login with Facebook" with a "Login with Facebook" button. At the bottom of the form, there are links for "Forgot your password?" and "Register for an account".

## Third Party Authentication

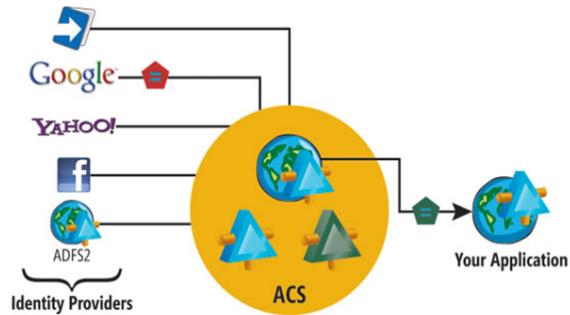
With the trend for federated identity / authentication becoming increasingly popular, many applications have relied on authentication from third party identity providers (IdPs) such as Live ID, Yahoo ID, Google ID, and Facebook.

One of the challenges developers face when dealing with different IdPs is that they use different standard protocols (OAuth, WS-Trust, WS-Federation) and web tokens (SAML 1.1, SAML 2.0, SWT).



### Multiple ID Authentication

Access Control Service (ACS) allows application users to authenticate using multiple IdPs. Instead of dealing with different IdPs individually, developers just need to deal with ACS and let it take care of the rest.



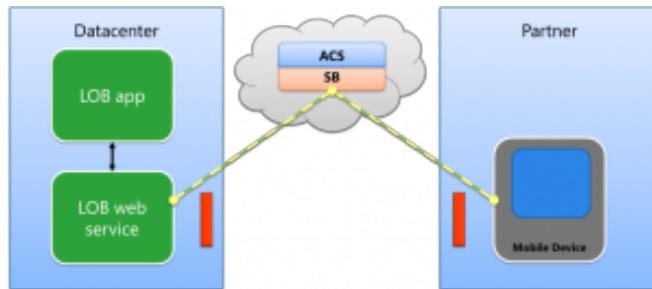
**AppFabric Access Control Services**

### (iii) Service Bus

Windows Azure's Service Bus allows secure messaging and connectivity across multiple network hierarchies.

It enables hybrid model scenarios, such as connecting cloud applications with on-premise systems.

The Service Bus allows applications running on Windows Azure to call back to on-premise applications located behind firewalls and NATs.



**Service Bus Diagram**

Migrating from an on-premise Windows Communication Foundation (WCF) framework to the Service Bus is trivial as they use a similar programming approach.

## 2. Data Services

Data Services consists of SQL Azure Reporting and SQL Azure Data Sync, both of which are still currently available as Community Technology Previews (CTP).

### (i) SQL Azure Reporting

SQL Azure Reporting aims to provide developers with a service similar to that of the [current SQL Server Reporting Service \(SSRS\)](#), with the advantages of being in the cloud.

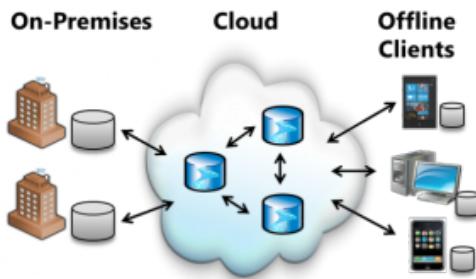
Developers are still able to use familiar tools such as [SQL Server Business Intelligence Development Studio](#).

Migrating on-premise reports is also easy as SQL Azure Reporting is essentially built on top of SSRS architecture.

## (ii) SQL Azure Data Sync

SQL Azure Data Sync is a cloud-based data synchronization service built on top of the [Microsoft Sync Framework](#).

It enables synchronization between a cloud database and another cloud database, or with an on-premise database.



Windows Azure BootCamp material

## 3. Networking

Three networking services are available today:

### (i) Windows Azure CDN

The Content Delivery Network (CDN) caches static content such as video, images, JavaScript, and CSS at the closest node to users.

By doing so, it improves performance and provides the best user experience. There are currently [24 nodes available globally](#).



**Windows Azure CDN Locations**

**(ii) Windows Azure Traffic Manager**

Traffic Manager is designed to enable high performance and high availability of web applications, by providing load-balancing across multiple hosted services in the six available data centers.

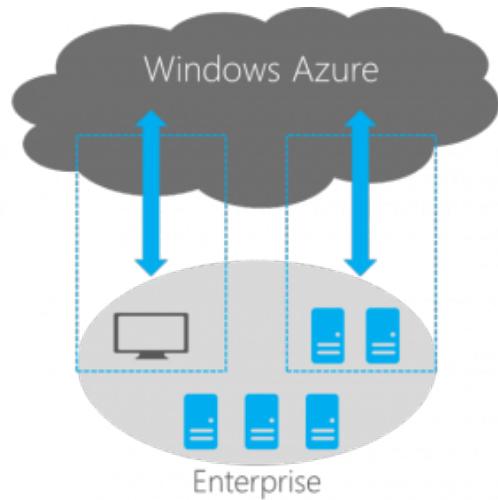
In its current CTP guise, developers can select one of the following rules:

- Performance – detects the location of the user traffic and routes it to the best online hosted service based on network performance.
- Failover – based on an ordered list of hosted services, traffic is routed to the online service highest on the list.
- Round Robin – equally distributes traffic to all hosted services.

**(iii) Windows Azure Connect**

Windows Azure Connect supports secure network connectivity between on-premise resources and the cloud by establishing a virtual network environment between them.

With Windows Azure Connect, cloud applications appear to reside on the same network environment as on-premise applications.



Windows Azure Connect enables scenarios such as:

- Using an on-premise SMTP Server from a cloud application.
- Migrating enterprise apps which require an on-premise SQL Server to Windows Azure.
- Domain-join a cloud application running in Azure to an Active Directory.

#### **4. Windows Azure Marketplace**

Windows Azure Marketplace is a centralized online market where developers are able to easily sell their applications or datasets.

##### **(i) Marketplace for Data**

[Windows Azure Marketplace for Data](#) is an information marketplace allowing ISVs to provide datasets (either free or paid) on any platform, and available to the global market.

For example, [Average House Prices, Borough](#) provides annual and quarterly house prices based on Land Registry data in the UK.

Developers can then subscribe and utilize this dataset to develop their application.

## **(ii) Marketplace for Applications**

[Windows Azure Market Place for Applications](#)s enables developers to publish and sell their applications.

Many, if not all of these applications are SAAS applications built on Windows Azure.

Applications submitted to the Marketplace must meet a set of criteria.

# Introduction

- Aneka is a platform and a framework for developing distributed applications on the top of it.
- It can install on the following OS:
  - Windows
  - Linux
  - Mac OS X

# Introduction

- An installation scenario :
  - Install one Aneka service on a reliable and more powerful machine as the master node.
    - For scheduling ,file, persistence, security services
  - Install and configure as many as slave nodes
    - For computing capabilities.

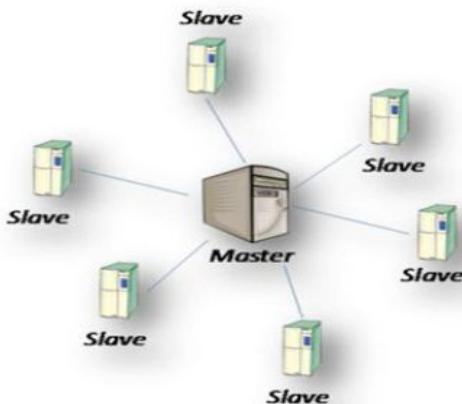
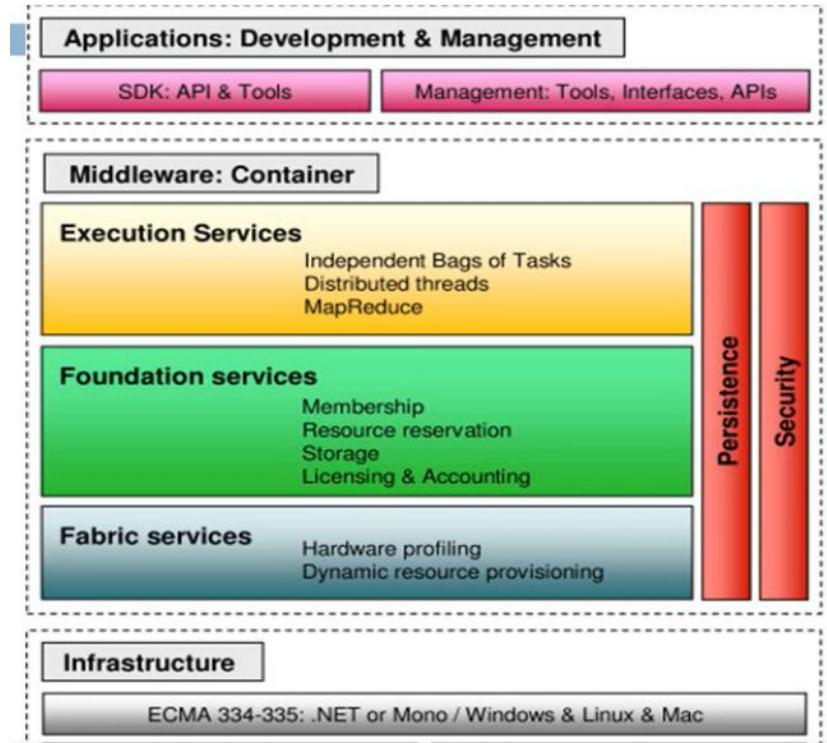


Figure 1: Typical Network Configuration

# Aneka Architecture - Overview



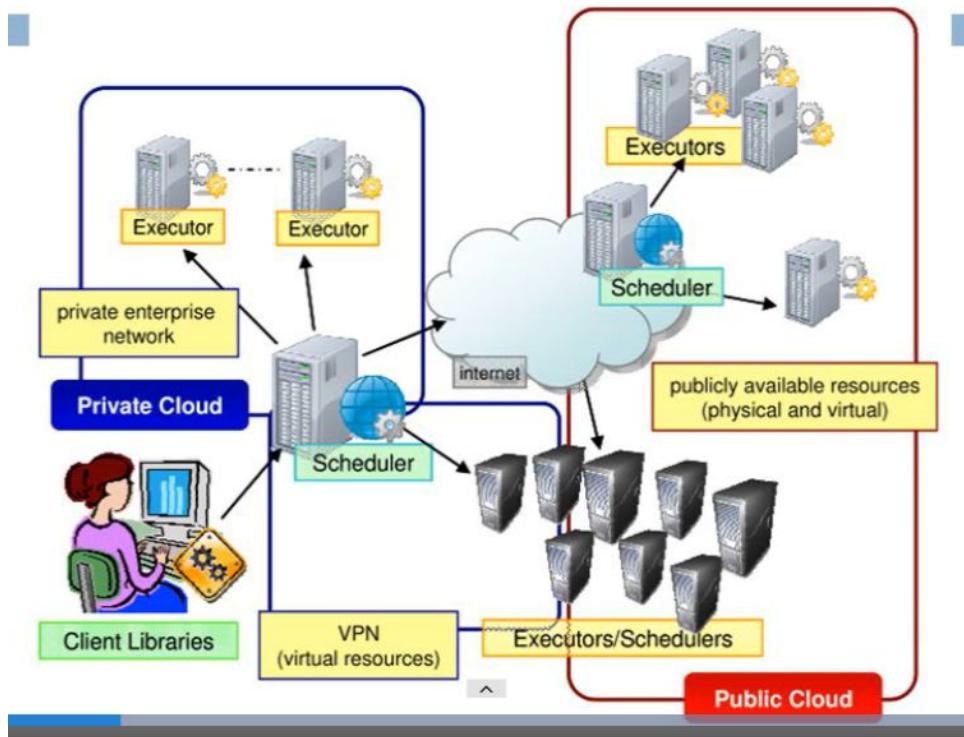
# Aneka Architecture - Overview

- **Middleware: container**
  - Provides **the basic management features of the single node** and leverages all the other operations on the services.
  - Contain fabric, foundation, and execution services.
- At the application level, a set of different components and tools are provided to:
  - 1) simplify the development of applications (SDK);
  - 2) monitoring and managing the Aneka Cloud.

## Aneka Architecture - Features

- The architecture and the implementation of the Container play a key role in supporting these three features:
  - Flexibility
  - Elastic
  - Pay per usage

# Aneka Architecture – Possible Scenario



# Aneka Container - Anatomy

For Container, it is possible to identify four major groups of services:

- Fabric Services
- Foundation Services
- Execution Services
- Transversal Services

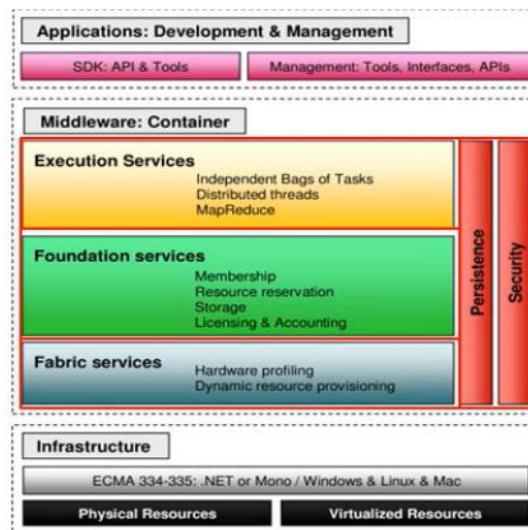


Figure 3. Overview of the Aneka framework.

# Fabric Services

- Fabric services define the lowest level of the software stack representing the Aneka Container.
  - So fabric services directly interface with the hosting resource and are responsible for low level operations.
- Fabric services contain:
  - The resource provisioning subsystem
  - The hardware profiling services

# About Resource Provisioning Services

- Dynamic resource provisioning allows the Aneka Cloud to **elastically scale up and down** according to the requirements of applications.
- Dynamic resource provisioning addresses two different scenarios:
  - physical resource provisioning :
    - simply “borrows” some nodes from other Aneka Clouds.
  - virtual resource provisioning
    - the nodes are dynamically acquired by interacting with **existing virtual machine managers or IaaS implementations** such as Amazon EC2 or Amazon S3.

## About Hardware Profile Services

- Hardware profiling services provide **Performance information and the properties** of the host operating system and hardware.
- The following information is collected
  - Static and dynamic CPU information (CPUs, operating frequency, CPU usage);
  - Static and dynamic memory information (size, available, and used);
  - Static and dynamic storage information (size, available, and used);

# Foundation Services

- Foundation services provides runtime support for execution services and applications, :
  - Directory and Membership;
  - Resource reservation;
  - Storage management;
    - The current release of Aneka provides a storage implementation based on the File Transfer Protocol (FTP) service
  - Licensing, accounting, and pricing;

# Foundation Services – Directory and Membership

- Directory and Membership Services are responsible for setting up and maintaining the information about the services in each nodes.
- These services include:
  - Membership Catalogue:
    - Acts as global directory maintaining the list of available services and their location.
  - Heartbeat Service:
    - Collects the statistic information about the hosting node from the Hardware profiling services and update the Membership Catalogue periodically.
  - Discovery Service:
    - Discovering the available Aneka nodes on the Cloud and providing the required information for adding a node to the Membership Catalogue.

## Foundation Services – Resource Reservation

- Resource reservation aims to support application execution with a specific QoS.
  - It allows users to reserve a collection of nodes **for a given time frame**, and **assign this reservation to a specific application**.
- Reserved nodes only accept jobs that belong to the reservation request that is currently active in given time frame.

# Foundation Services – Licensing, Accounting and Pricing

- The Licensing Service provides the very basic resource controlling feature that protects the system from misuse.
- Restricts the number of resources that can be used for a certain deployment.
  - number of maximum nodes in Aneka.
  - a specific set of services hosted by the container
- Every container that wants to join the Aneka Cloud is subject to verification against the license installed in the system.

# Foundation Services – Licensing, Accounting and Pricing

- The Accounting and Pricing Services are more directly related with billing the user for using the Cloud.(available in the next release of Aneka)
  - Accounting Service keeps track of **applications running, their reservations, and of the users they belong to.**
  - Pricing Service provides flexible pricing strategies that benefit both the users of the Cloud and the service providers.

# Execution Services

- Execution services identify the set of services that are directly involved in the execution of distributed applications in the Aneka Cloud.
- Execution services contains two component:
  - Scheduling Service
    - It is responsible for **coordinating and dispatching** the collection of jobs generated by applications to the compute nodes.
  - Execution Service.
    - It is in charge of **retrieving all the files required for execution, monitoring the execution of the job, and collecting the results.**

## Transversal Services - Persistence

- The persistence layer provides a complete solution for
  - recording the status of the Cloud
    - All the applications running in the Cloud and their status;
    - The topology information of the Cloud and the current execution status;
  - restoring it after a system crash or a partial failure.

## Transversal Services - Security

- The implementation relies on cloud providers.
  - ▣ It is possible to run Aneka on different security infrastructure according to specific requirements of the Cloud.
  - ▣ Third parties can set up their own security providers by implementing the interfaces defined in the Aneka security APIs.

# Application Development

- Aneka provides Software Development Kit (SDK) for developer :
  - A collection of tutorials explain how to develop applications in Aneka
  - A collection of class libraries constituting the *Aneka Application Model*

# Application Model

- Defines the abstractions used by the user to **model their application and the execution logic** of these applications in the Aneka Cloud.
- The current release of Aneka includes three different programming :
  - *Task Programming Model,*
  - *Thread Programming Model,*
  - *MapReduce Programming Model.*

# Task Programming Model

- Task Model is a basic model, it has following feature :
  - Tasks being independent from each other, no order or sequencing
  - Users submit tasks and forget of their existence until they terminate

# Thread Programming Model

- With thread model developer can easily take advantage of the set of compute resources available.
- Aneka will take care of distributing and coordinating the execution of these threads.
- The best option when a preexisting multi-threaded application needs to be ported to a distributed environment for improving its performance.

# Map Reduce Programming Model

- *The map function processes a key/value pair to generate a set of intermediate key/value pairs.*
- The reduce function merges all intermediate values associated with the same intermediate key.
- Useful for data intensive applications.

# Cloud Maintenance and Monitoring

- The Management Studio is a GUI that can :
  - Quick setup of computing clouds;
  - Remote installation and configuration of nodes;
  - Remote control of containers;
  - System load monitoring and tuning.
    - Ex. the CPU and memory load information in each container

## Case Study

- GoFront Group is China's premier and largest nationwide research and manufacturing group of rail electric traction equipment.
- The raw designs of the prototypes are required to be rendered to high quality 3D images using Maya.
- The rendering of a complete set of images from one design require three days.
- Moreover, this process has to be repeated every time a change is applied to the model.

## Case Study (Contd...)

- In order to face this problem, a private Aneka Cloud has been set up by using **the existing desktop computers and servers** available in the IT department of GoFront.
- By using the spare cycles of 30 computers in the department, the time of rendering significantly reduced .

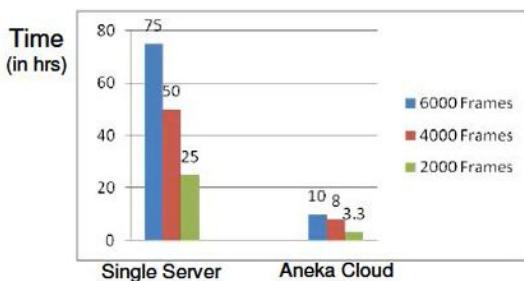


Figure 9. Speed up of the rendering process.

# Conclusion

- The framework is based on an extensible and service oriented architecture.
- And provides a customizable environment that supports different design patterns for distributed applications.

# Aneka Cloud

- Manjrasoft Aneka Cloud and Appliances Aneka ([www.manjrasoft.com/](http://www.manjrasoft.com/)) is a cloud application platform developed by Manjrasoft, based in Melbourne, Australia.
- It is designed to support rapid development and deployment of parallel and distributed applications on private or public clouds.
- It provides a rich set of APIs for transparently exploiting distributed resources and expressing the business logic of applications by using preferred programming abstractions.
- System administrators can leverage a collection of tools to monitor and control the deployed infrastructure.
- It can be deployed on a public cloud such as Amazon EC2 accessible through the Internet to its subscribers, or a private cloud constituted by a set of nodes with restricted access as shown in Figure 1.

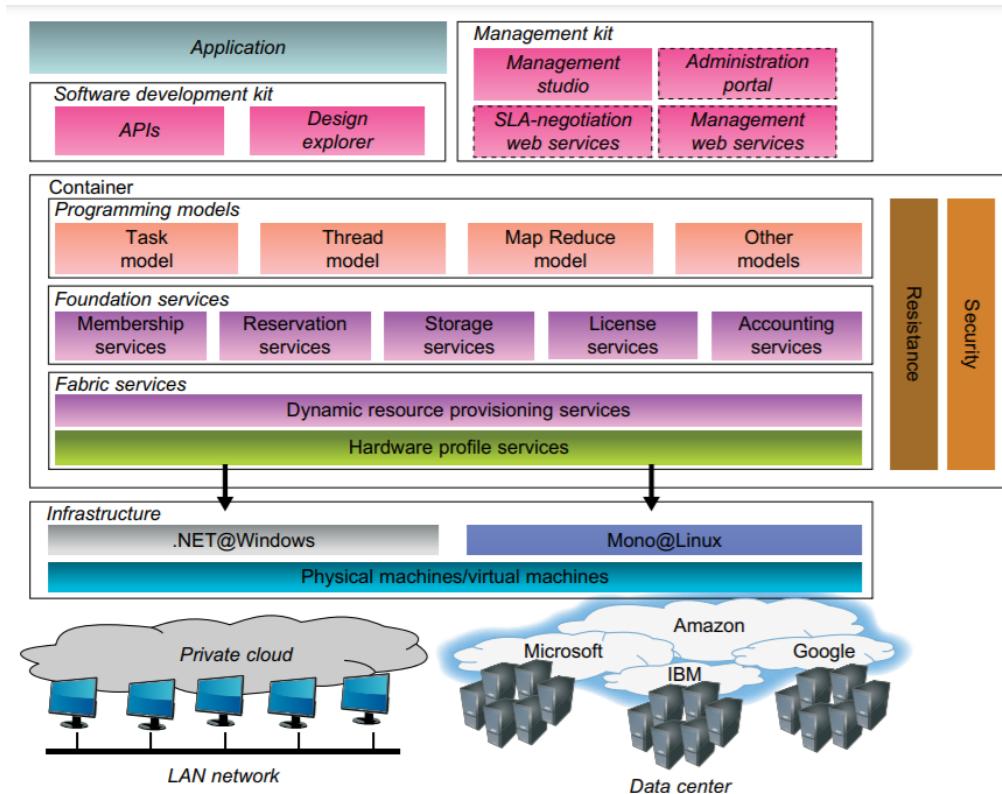


Figure 1: Architecture and Components of Aneka

- Aneka acts as a workload distribution and management platform for accelerating applications in both Linux and Microsoft .NET framework environments.

Some of the key advantages of Aneka over other workload distribution solutions include:

- Support of multiple programming and application environments
- Simultaneous support of multiple runtime environments
- Rapid deployment tools and framework
- Ability to harness multiple virtual and/or physical machines for accelerating application provisioning based on users' Quality of Service/service-level agreement (QoS/SLA) requirements
- Built on top of the Microsoft .NET framework, with support for Linux environments

Aneka offers three types of capabilities which are essential for building, accelerating, and managing clouds and their applications:

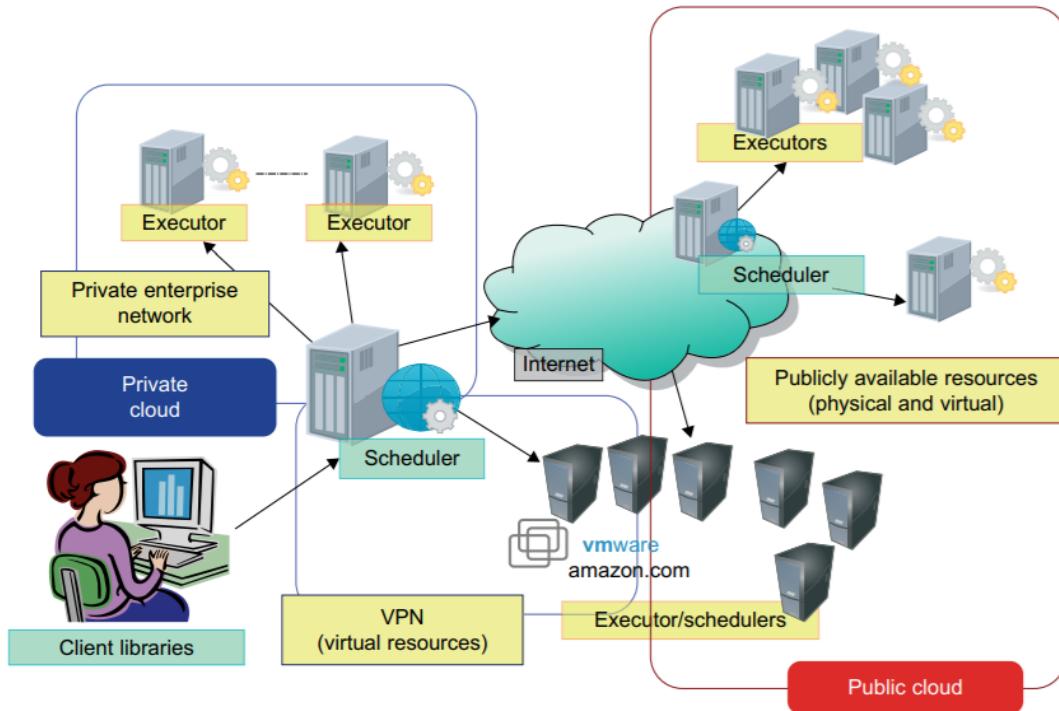
### **1. Build**

- Aneka includes a new SDK which combines APIs and tools to enable users to rapidly develop applications.
- Aneka also allows users to build different runtime environments such as enterprise/private cloud by harnessing compute resources in network or enterprise data centers, Amazon EC2, and hybrid clouds by combining enterprise private clouds managed by Aneka with resources from Amazon EC2 or other enterprise clouds built and managed using XenServer.

### **2. Accelerate**

- Aneka supports rapid development and deployment of applications in multiple runtime environments running different operating systems such as Windows or Linux/UNIX.
- Aneka uses physical machines as much as possible to achieve maximum utilization in local environments.

- Whenever users set QoS parameters such as deadlines, and if the enterprise resources are insufficient to meet the deadline, Aneka supports dynamic leasing of extra capabilities from public clouds such as EC2 to complete the task within the deadline (see Figure 2).



**Figure 2: Aneka using private and public cloud resources**

### 3. Manage

- Management tools and capabilities supported by Aneka include a GUI and APIs to set up, monitor, manage, and maintain remote and global Aneka compute clouds.
- Aneka also has an accounting mechanism and manages priorities and scalability based on SLA/QoS which enables dynamic provisioning.

Here are **three important programming models** supported by Aneka for both cloud and traditional parallel applications:

1. **Thread programming model**, best solution to adopt for leveraging the computing capabilities of multicore nodes in a cloud of computers

2. **Task programming model**, which allows for quickly prototyping and implementing an independent bag of task applications

**3. MapReduce programming model**

- MapReduce is a software framework which supports parallel and distributed computing on large data sets
- This software framework abstracts the data flow of running a parallel program on a distributed computing system by providing users with two interfaces in the form of two functions: Map and Reduce.
- Users can override these two functions to interact with and manipulate the data flow of running their programs.

**Aneka Architecture**

## Applications: Development and Management

### Software Development Kit

API      Tutorials      Samples

### Management Kit

Management Studio      Admin. Portal  
Web Services: SLA and Management

## Middleware: Container

### Foundation Services

Task Model      Thread Model      MapReduce Model      ...

### Foundation Services

Membership      Storage      Resource Reservation  
Accounting      Licensing      ...      ...

Persistence

Security

### Fabric Services

Hardware Profiling      Dynamic Resource Provisioning

### Platform Abstraction Layer (PAL)

## Infrastructure

ECMA 334-335: .NET or Mono/Windows and Linux and Mac

### Physical Resources



### Virtualized Resources



- Aneka as a cloud application platform features a homogeneous distributed runtime environment for applications.
- This environment is built by aggregating together physical and virtual nodes hosting the Aneka container.
- The container is a lightweight layer that interfaces with the hosting environment and manages the services deployed on a node.
- The interaction with the hosting platform is mediated through the ***Platform Abstraction Layer (PAL)***, which hides in its implementation all the heterogeneity of the different operating systems.
- By means of the PAL it is possible to perform all the infrastructure-related tasks, such as performance and system monitoring.
- These activities are vital to ensure the desired QoS for applications.
- The PAL, together with the container, represents the hosting environment of services which implement the core capabilities of the middleware and make it a dynamically composable and extensible system.

The available ***services*** can be aggregated into ***three major categories***:

### Fabric Services

- Fabric services implement the fundamental operations of the infrastructure of the cloud.
- These services include HA and failover for improved reliability, node membership and directory, resource provisioning, performance monitoring, and hardware profiling.

### Foundation Services

- Foundation services constitute the core functionalities of the Aneka middleware.
- They provide a basic set of capabilities that enhance application execution in the cloud.
- These services provide added value to the infrastructure and are of use to system administrators and developers.

- Within this category we can list storage management, resource reservation, reporting, accounting, billing, services monitoring, and licensing.
- Services in this level operate across the range of supported application models.

## **Application Services**

- Application services deal directly with the execution of applications and are in charge of providing the appropriate runtime environment for each application model.
- They leverage foundation and fabric services for several tasks of application execution such as elastic scalability, data transfer, and performance monitoring, accounting, and billing.
- At this level, Aneka expresses its true potential in supporting different application models and distributed programming patterns.
- Each supported application model is managed by a different collection of services that interact with the underlying layers and services to carry out application execution.
- In general, the middleware counterpart of each application model features at least two different services: scheduling and execution.
- In addition, specific models can require additional services or a different type of support.
- Aneka provides support for the most well-known application programming patterns, such as distributed threads, bags of tasks, and MapReduce.
- Additional services can be designed and deployed in the system. This is how the infrastructure is enriched with additional features and capabilities.
- The SDK provides straightforward interfaces and ready-to-use components for rapid service prototyping.
- Deployment and integration of new services is painless and immediate: The container leverages the Spring framework and allows for dynamic integration of new components such as services.



# IBM Cloud Platform

By

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20MX121 SUSHMITHA T

20MX208 JEFFRIN A

# About IBM Cloud

## 01 Platform



IBM cloud platform

## 02 Service



Service availability in  
IBM Cloud console,  
APIs, SDKs, and CLIs

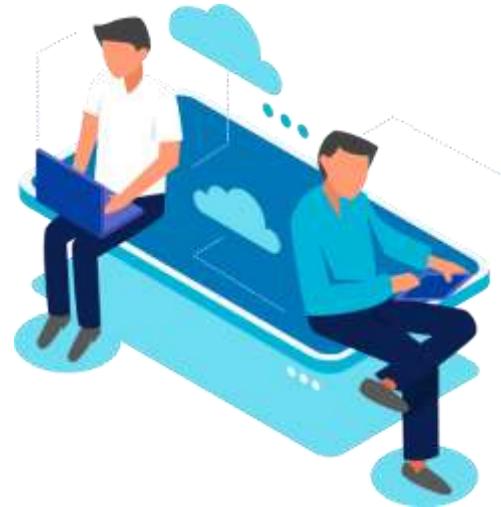
## 03 Prerequisites



IBM Cloud prerequisites

# What is the IBM Cloud platform?

- Combines platform as a service (PaaS) with infrastructure as a service (IaaS) to provide an integrated experience.
- Solution build on IBM Cloud spins up fast and performs reliably in a tested and supported environment.
- Offers the most open and secure public cloud for business





# **Solutions are available in various combinations:**

- With public cloud, made available to you over the public internet.
- Support for multi cloud and hybrid multi cloud solutions is also available.
- A hybrid cloud solution.
  - IBM uses Red Hat OpenShift on IBM Cloud.
- Virtual Private Cloud (VPC).

# Open Source Technologies

01

## Kubernetes

for automating deployment,  
scaling, and management  
of containerized  
applications.

02

## Red Hat OpenShift

full-stack automated  
operations to  
manage hybrid  
cloud, multicloud,

03

## Full Range Computers

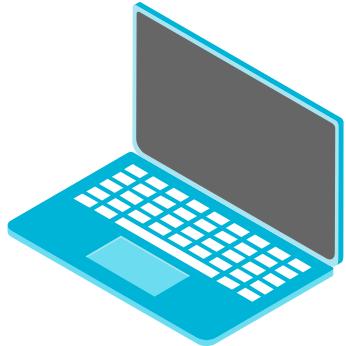
virtual machines,  
containers, bare metal,  
and server less



# IBM Cloud Composed by



# Setting Up the account



User access  
groups

Access  
policies



Go straight to  
the catalog

Resource  
groups



# IBM Cloud Catalog

- Ranging from
  - Containers
  - Compute
  - Security
  - Data
  - AI
- Options for
  - Compute,
  - Storage,
  - Networking,
  - End-to-end developer solutions for app development
  - Testing
  - Deployment
  - Security management services
  - Traditional
  - Open source databases
  - Cloud-native services

# Searching the catalog

- Displayed by default in the catalog.
- Filter the catalog by type to view a specific type of product
- Example, if you want to deploy an analytics instance to
  - Red Hat®
  - OpenShift®

on IBM Cloud™, you can select the **Analytics** category, and filter the results by selecting **Red Hat OpenShift** as the deployment target.

# Pricing and Billing

1

## Account management

maintains the billing relationship with the customer.

3

## Usage reports

return the summary for the account for the specified month.

2

## Usage metering

collected for resource instances that are created by IBM Cloud users.



# Managing security and compliance

- Center offers a single location where you can validate.
- Can use to provide evidence to stakeholders or external auditors.
- Provides security insights.
- <https://cloud.ibm.com/security-compliance/dashboard>



# **Creating and managing resources**

- Provisioning layer that manages the lifecycle of IBM Cloud resources in the account.
- Resource controller uses IBM Cloud Identity and Access Management (IAM) for authentication and authorization.
- Managed by resource groups.
- Associated with your account.
- All IBM Cloud IAM-enabled resources must be created within a resource group

# Monitoring your account

- Activity Tracker service to
  - Monitor the activity of the IBM Cloud account
  - Investigate abnormal activity
  - Comply with regulatory audit requirements.
- Events collected comply with the Cloud Auditing Data Federation (CADF) standard.
- <https://www.ibm.com/in-en/cloud/activity-tracker>

# Viewing status

The screenshot shows the IBM Cloud Status page. The left sidebar has a dark background with white text and icons. It includes links for Status, Planned maintenance, Security bulletins, Announcements, History, and Incident reports. The main content area has a light gray background. At the top, there's a search bar with placeholder text "Search resources and offerings...", a magnifying glass icon, and navigation links for Catalog, Docs, Support, Manage, and user profile. A blue button on the right says "Report outage". Below the header, the word "Status" is displayed in large letters. Underneath it, the text "Last updated: 2021-10-18 9:04 AM • Notifications • RSS Feed" is shown. A search bar with a placeholder "Search" is also present. The main content area is titled "All components" and contains a table with three rows. The table has two columns: "Component" and "Status". Each row shows a component name with a dropdown arrow, a green checkmark icon, and the text "4 Active locations".

Component	Status
Activity Tracker event routing	4 Active locations
Alert Notification	3 Active locations
Analytics Engine	3 Active locations

# Notification preferences

The screenshot shows the IBM Cloud interface with the title "Notification preferences". The left sidebar has a "Notification preferences" section selected. The main content area is titled "Email preferences" and shows a summary of platform-related notifications. It includes sections for "Announcements" and "Details" (Major and Minor events) with toggle switches for "Emails".

IBM Cloud

Search resources and offerings... Catalog Docs Support Manage Niranjanaa M G...

Profile Active sessions Login settings Notification preferences

Email preferences

Platform Resource

Receive notifications and emails about platform-related items across your account, such as lifecycle management and billing and usage.

Announcements

Stay up-to-date with changes to the IBM Cloud platform and products.

Details	Emails
<b>Major</b> Important incidents such as legal notices, service deprecation, or security patches.	<input type="checkbox"/> Off
<b>Minor</b> Informative announcements such as product enhancements.	<input type="checkbox"/> Off

# DEMO



# IBM Cloud Advantages

- Very attractive for organizations
- Flexibility and customization
- Stands out in some other areas,
  - Cutting-edge blockchain offering
  - Watson cognitive computing capabilities
- Already use IBM technology,
  - Power8 servers
  - IBM software



# IBM Bluemix

- Platform as a Service (PaaS)
- Developed by IBM
- Supports several platforms and services
- Provides end-to-end solution for an enterprise application Development
  - Testing
  - Deployment in Production
- Based on Cloud Foundry open technology and runs on SoftLayer infrastructure.
- Supports several programming languages including
  - Java
  - Node.js
  - Go
  - PHP
  - Swift
  - Python
  - Ruby Sinatra
  - Ruby on Rails

# **Bluemix - Apps**

- A boilerplate is a template for an application and its associated runtime environment and predefined services for a specific domain.
- A runtime is the set of resources that is used to run an app.

# **Bluemix - Services**

- Enables to do more with rich,
  - Integrated cloud databases
  - Data & Analytics services
- Provides a wide range of services including experimental services.

# **Bluemix - Infrastructure**

- Provides the highest performing cloud infrastructure available.
- IBM Cloud Data Centers are filled with
  - First class computing
  - Storage
  - Networking gear

# **Bluemix offers 3 types of integrated deployment models.**

- **IBM Bluemix Public**
  - Develop apps and use services that provide ready-to-use functions.
  - Manages all service instances.
- **IBM Bluemix Dedicated**
  - Physically isolated hardware in an IBM SoftLayer data center.
  - Securely connected to both the Bluemix Public environment and your own network.
- **IBM Bluemix Local**
  - Host within your data center.
  - Uses cloud operations as a service to monitor and maintain your environment

**THANK YOU!**

## **20MX31 - Cloud Computing MCQ Questions**

---

**1.Which is not a major cloud computing platform?**

- A. Google 101
- B.Microsoft Azure
- C.IBM Deep blue
- D.Amazon EC2

**Answer: C**

**2.The Private cloud is a \_\_\_\_\_**

- A. standard cloud service offered via the Internet
- B.A cloud service inaccessible to anyone but the cultural elite
- C.cloud architecture maintained within an enterprise data center.
- D.None of the above

**Answer: C**

**3.Which of the following is the most important area of concern in cloud computing?**

- A. Storage
- B.Security
- C.Scalability
- D.None of the above

**Answer: B**

**4.Cloud Services have a \_\_\_\_\_ relationship with their customers.**

- A. One-to-one
- B.One-to-many
- C.Many-to-many
- D.None of the above

**Answer: B**

**5.Which of the following can be identified as a cloud?**

- A. Hadoop
- B.Intranet
- C.Web Applications
- D.None of the above

**Answer: A**

## **20MX31 - Cloud Computing MCQ Questions**

---

**6.Which of the following is related to the service provided by Cloud?**

- A. AaaS
- B. Reliability
- C. Sourcing
- D. Ownership

**Answer: C**

**7.What are the cons of cloud computing?**

- A. Security
- B. Ongoing costs
- C. Restricted or limited flexibility
- D. All of the above

**Answer: D**

**8.Which of the following is the iaas service provider?**

- A. EC1
- B. EC2
- C. EC10
- D. None of the above

**Answer: B**

**9.Which of the following is a type of Service Models?**

- A. Community-as-a-Service
- B. Public-as-a-Service
- C. Platform-as-a-Service
- D. Private -as-a-Service

**Answer: C**

**10.Which is not a characteristic of Cloud Computing?**

- A. Rapid elasticity
- B. Resource pooling
- C. On-demand self-service
- D. Private hardware centers

**Answer: D**

## **Cloud**

Cloud Computing is a computing model, where resources such as computing power, storage, network and software are abstracted and provided as services on the Internet in a remotely accessible fashion.

Billing models for these services are generally similar to the ones adopted for public utilities.

On-demand availability, ease of provisioning, dynamic and virtually infinite scalability are some of the key attributes of Cloud Computing.

An infrastructure setup using the cloud computing model is generally referred to as ‘Cloud’. The following are the broad categories of services available on the ‘Cloud’:

1. Infrastructure As A Services (IAAS)
2. Platform As A Service (PAAS)
3. Software As A Service (SAAS)

This ‘Cloud’ is generally available as service to anyone on the Internet.

However, a variant called ‘Private Cloud’ is increasingly becoming popular for private infrastructure that has some of the attributes of the ‘Cloud’ as mentioned above.

[Amazon Web Services](#) is one of the major players providing IAAS - has 2 popular services – [Elastic Compute Cloud](#)(EC2) and [Simple Storage Service](#)(S3).

These services are available through web services interfaces - the client tools can use EC2 and S3 APIs to communicate with these services.

The popularity of these APIs have encouraged other Cloud products to provide support for them as well.

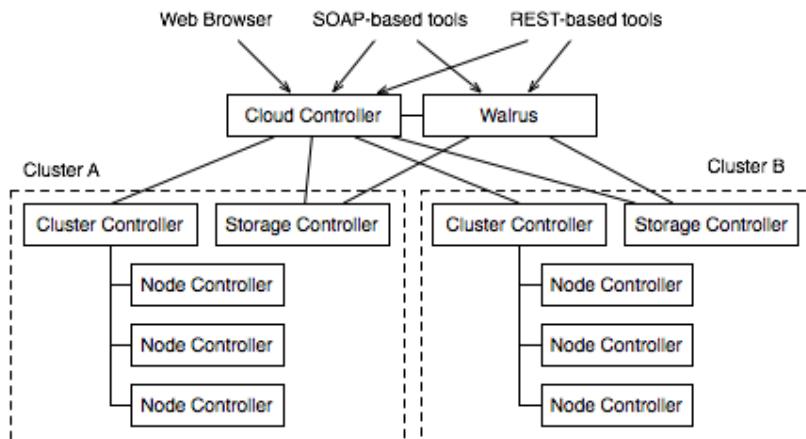
## Eucalyptus

- [Eucalyptus](#) is a software available under GPL that helps in creating and managing a private or even a publicly accessible cloud.
- It provides an EC2 compatible cloud computing platform and S3 compatible cloud storage platform.
- Eucalyptus has become very popular and is seen as one of the key open source cloud platforms.
- Since Eucalyptus makes its services available through EC2/S3 compatible APIs, the client tools written for AWS can be used with Eucalyptus as well.

## Ubuntu Enterprise Cloud (UEC)

- [Ubuntu Enterprise Cloud](#), UEC for short, is a stack of applications from [Canonical](#) included with Ubuntu Server Edition.
- UEC includes Eucalyptus along with a number of other open source software.
- UEC makes it very easy to install and configure the Cloud. Canonical also provides commercial technical support for UEC.

## Components of a Eucalyptus (UEC) based Cloud



*Fundamental Architecture of Eucalyptus*

## Node Controller (NC)

- A UEC node is a VT enabled server capable of running [KVM](#) as the [hypervisor](#).
- UEC automatically installs KVM when the user chooses to install the UEC node.

- The VMs running on the hypervisor and controlled by UEC are called instances.
- Eucalyptus supports other hypervisors like [Xen](#) apart from KVM, but Canonical has chosen KVM as the preferred hypervisor for UEC.
- NC runs on each node and controls the life cycle of instances running on the node.
- NC interacts with the OS and the hypervisor running on the node on one side and the CC on the other side.
- NC queries the Operating System running on the node to discover the node's physical resources – the number of cores, the size of memory, the available disk space and also to learn about the state of VM instances running on the node and propagates this data up to the CC.

***Functions:***

1. Collection of data related to the resource availability and utilization on the Node and reporting the data to CC
2. Instance life cycle management

**Cluster Controller (CC)**

- CC manages one or more Node Controllers and deploys/manages instances on them.
- CC also manages the networking for the instances running on the Nodes under certain types of networking modes of Eucalyptus.
- CC communicates with CLC on one side and NCs on the other side.

***Functions:***

1. To receive requests from CLC to deploy instances
2. To decide which NCs to use for deploying the instances on
3. To control the virtual network available to the instances
4. To collect information about the NCs registered with it and report it to the CLC

**Walrus Storage Controller (WS3)**

WS3 provides a persistent simple storage service using REST and SOAP APIs compatible with S3 APIs.

**Functions:**

1. Storing the machine images
2. Storing snapshots
3. Storing and serving files using S3 API

WS3 should be considered as a simple file storage system.

**Storage Controller (SC)**

SC provides persistent block storage for use by the instances. This is similar to the [Elastic Block Storage \(EBS\)](#) service from AWS.

**Functions:**

1. Creation of persistent EBS devices
2. Providing the block storage over AoE or iSCSI protocol to the instances
3. Allowing creation of snapshots of volumes.

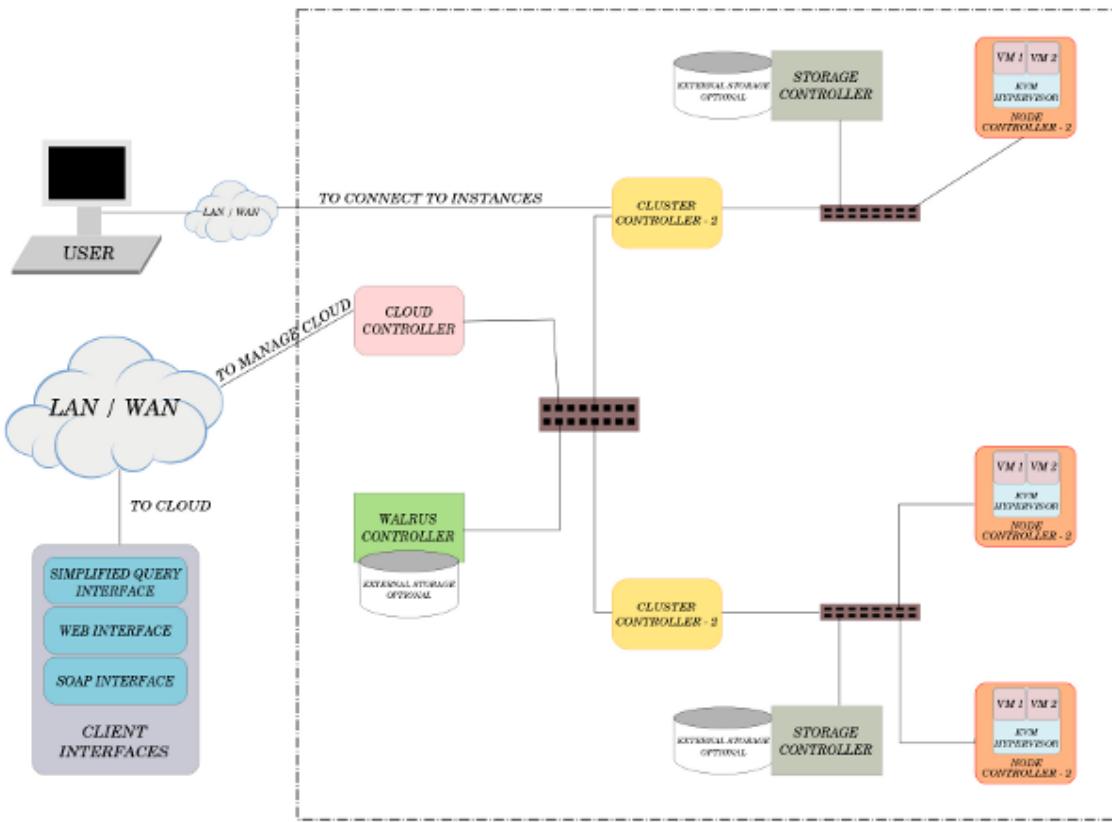
**Cloud Controller (CLC)**

- The Cloud Controller (CLC) is the front end to the entire cloud infrastructure.
- CLC provides an EC2/S3 compliant web services interface to the client tools on one side and interacts with the rest of the components of the Eucalyptus infrastructure on the other side.
- CLC also provides a web interface to the users for managing certain aspects of the UEC infrastructure.

**Functions:**

1. Monitor the availability of resources on various components of the cloud infrastructure, including hypervisor nodes that are used to actually provision the instances and the cluster controllers that manage the hypervisor nodes
2. Resource arbitration – Deciding which clusters will be used for provisioning the instances
3. Monitoring the running instances

In short, CLC has a comprehensive knowledge of the availability and usage of resources in the cloud and the state of the cloud.



# OPENSTACK

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# AGENDA:

- Introduction to OpenStack
- Principles
- Components
- Architecture
- Why OpenStack
- Deployment Models
- Benefits
- Demo

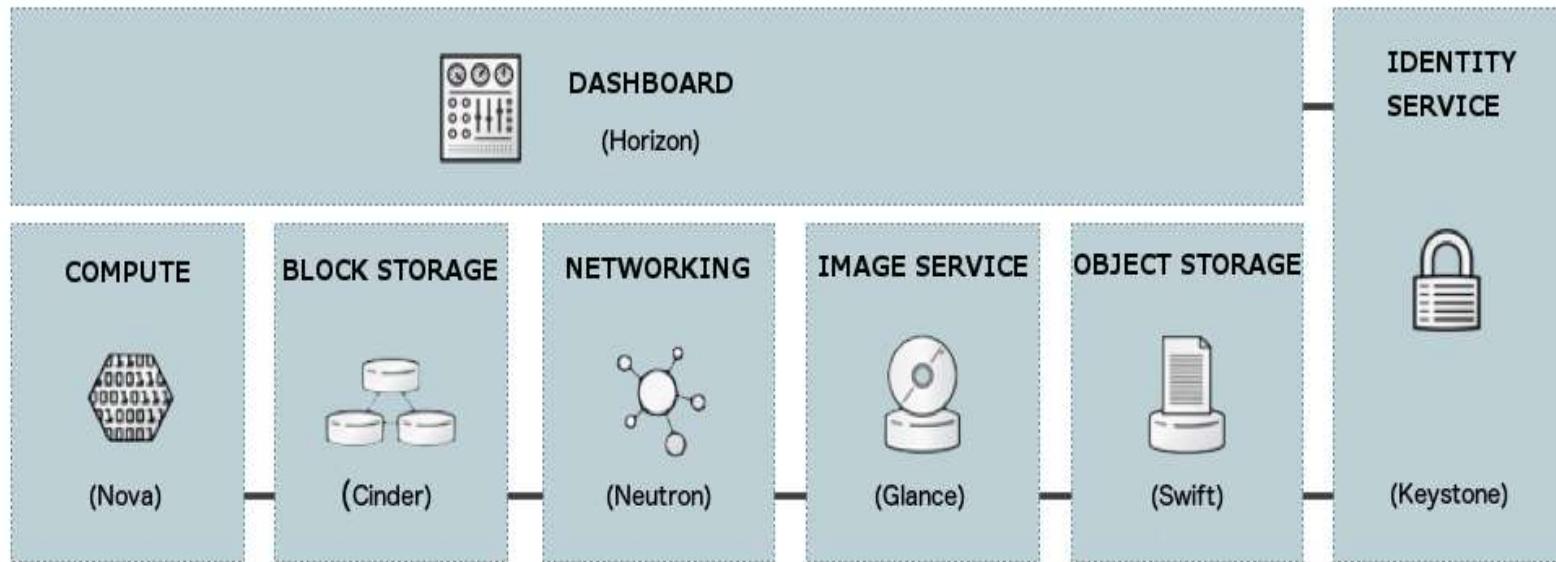
# INTRODUCTION:

- OpenStack is a Cloud OS
- It is an Open-Source & Free Software platform
- This is used as an IaaS for Cloud Computing
- It offers many Cloud-related services
- It manages a lot of virtual machines

# PRINCIPLES:

- Open source
- Open Design
- Open Development
- Open Community

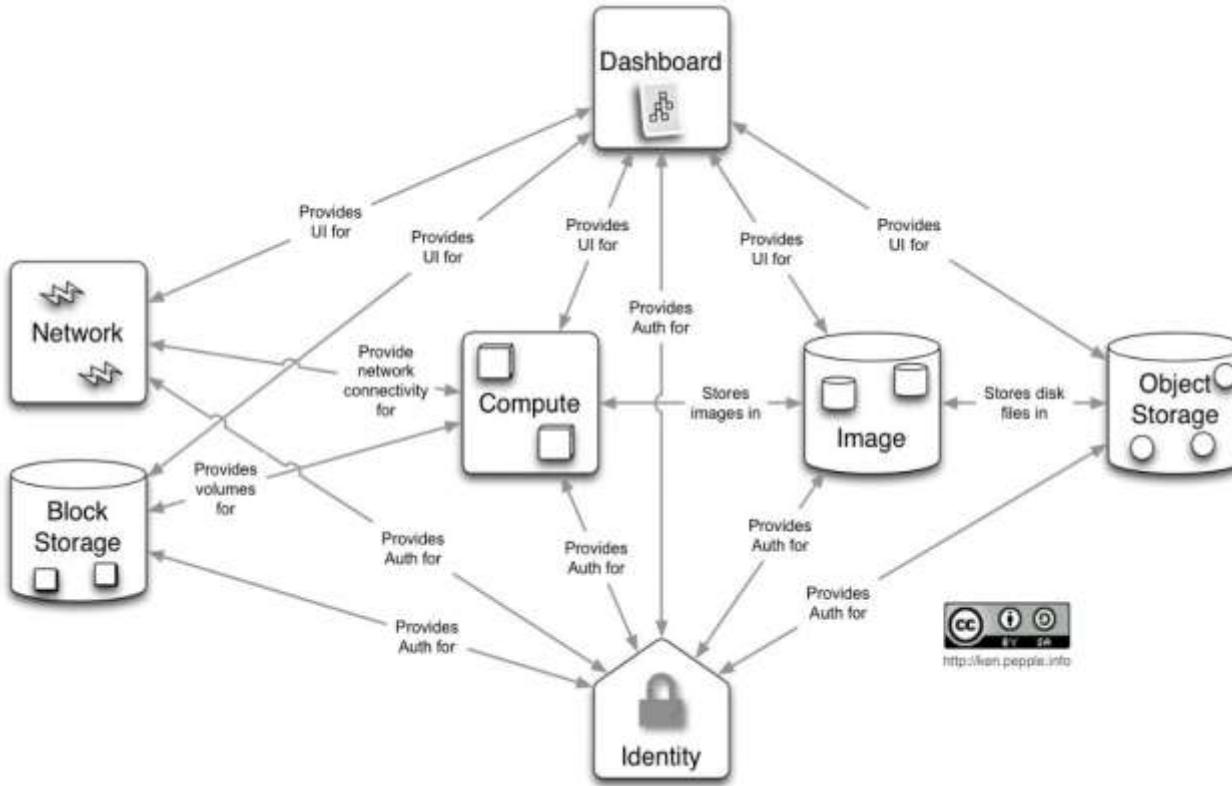
# COMPONENTS:



# ARCHITECTURE:

The basic components that make up the architecture of OpenStack are:

- Nova(Compute)
- Neuran(Networking)
- Glance(Image)
- Swift(Object Storage)
- Cinder(Block Storage)
- Horizon(Dashboard)



http://ivan.pepple.info

# Why OpenStack:

- Gives complete control over cloud computation.
- Customized with the required services to suit the need
- Scaled to any extent possible
- API is made more flexible

# **DEPLOYMENT MODELS:**

- On- Premise Distribution
- OpenStack - based Public Cloud
- Hosted OpenStack Private Cloud
- OpenStack- as- a -Service

## **ON PREMISE DISTRIBUTION**

Download and Install within the internal network

## **OPENSTACK BASED PUBLIC CLOUD**

Provides public Cloud Computing system

## **HOSTED OPENSTACK PRIVATE CLOUD**

Hosts - underlying hardware and the openstack software

## **OPENSTACK AS A SERVICE**

Hosts Openstack Management software as a service

## BENEFITS:

- OpenSource
- Scalability
- Security
- Automation
- Easy to Access Manage
- Services
- Strong Community
- Compatibility

## **Open Source**

OpenStack is the largest open-source platform. It offers the networking, computing, and storage subsystems in a single platform. Some vendors (such as RedHat) have developed and continue to support their own OpenStack distributions.

## **Scalability**

Scalability is the major key component of cloud computing. OpenStack offers better scalability for businesses. Through this feature, it allows enterprises to spin up and spin down servers on-demand.

## **Security**

With OpenStack, your data is always secure - When company owners want to move their IT infrastructure to the cloud, they always fear data loss. But there is no need to think about data loss with OpenStack. It offers the best security feature.

## **Automation**

OpenStack comes with a lot of inbuilt tools that make cloud management much faster and easier. OpenStack provides its own API or Application Program Interface that helps other applications to have full control over the cloud.

## **Easy to Access and Manage**

Command Line Tools - We can access the OpenStack using command-line tools.

Dashboard - OpenStack offers users and administrators to access and manage various aspects of OpenStack using GUI (graphical user interface) based dashboard component.

## **Services**

OpenStack offers a list of services or components such as the Nova, Cinder, Glance, Keystone, Neutron, Ceilometer, Sahara, Manila, Searchlight, Heat, Ironic, Swift, Trove, Horizon, etc.

## **Strong Community**

OpenStack has many experts, developers, and users who love to come together to work on the product of OpenStack and enhance the feature of OpenStack.

## **Compatibility**

Public cloud systems like AWS (Amazon Web Services) are compatible with OpenStack.

# DEMO

# MCQs

1) Which of the following browsers is/are supported by the OpenStack dashboard "Horizon" in the release "Kilo"?

- a)firefox
- b)IE
- c)chrome
- d)b and c
- e)a and c

answer: a and c

2) Which of the following operations is/are performed manually in OpenStack deployment?

- a) physical racking
- b) MAC-to-IP assignment
- c) power configuration
- d)option b and c
- e) option a,b and c

answer: option a,b and c

3) Shared File System storage is managed by which of the following openstack projects?

- a) Nova
- b) Cinder
- c) Manila
- d) Swift

answer: manila

4) Which of the following OpenStack storage types is managed by OpenStack project Nova?

- a) Ephemeral storage
- b) Block Storage
- c) Shared File System Storage
- d) Object Storage

answer: ephemeral storage

5) A Glance database contains which of the following tables?

- a) Image
- b) Image Property
- c) Both a and b
- d) Neither a nor b

answer: both a and b

6) Which of the following OpenStack integrated projects arranges multiple cloud applications for OpenStack?

- a) Ceilometer
- b) Heat
- c) Trove
- d) None of the above

answer: Heat

7) Which of the following statements is/are incorrect about a flavor in openstack?

- a) It is a hardware configuration for a server
- b) It can be used to launch an instance
- c) Size of a virtual server. which can be launched. cannot be defined by a Flavor
- d) Both options a and c are incorrect

answer: Size of a virtual server. which can be launched. cannot be defined by a Flavor

8) How many instances can use persistent volumes at the same time?

- a) One instance only
- b) Two instance only
- c) More than two instances

answer: One instance only

9) While creating a virtual machine on a particular network, which of the following processes communicates with the networking API of OpenStack to plug each virtual network interface card on the virtual machine?

- a) nova-scheduler
- b) nova-compute
- c) nova-neutron
- d) nova-quantum

answer: nova-compute

10) Which of the following projects provides a template-driven service in OpenStack that automates the deployment of compute, networking and storage resources for an application?

- a) Cinder
- b) Trove
- c) Heat
- d) Compute

answer: Heat

# THANK YOU

# Hadoop and MapReduce

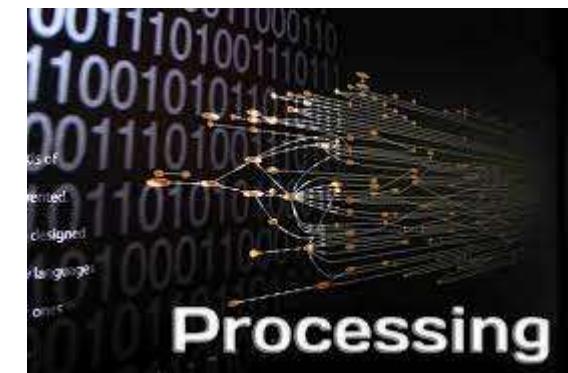
By

Hariharan B 20mx207

Sri Guru Prasath M 20mx220

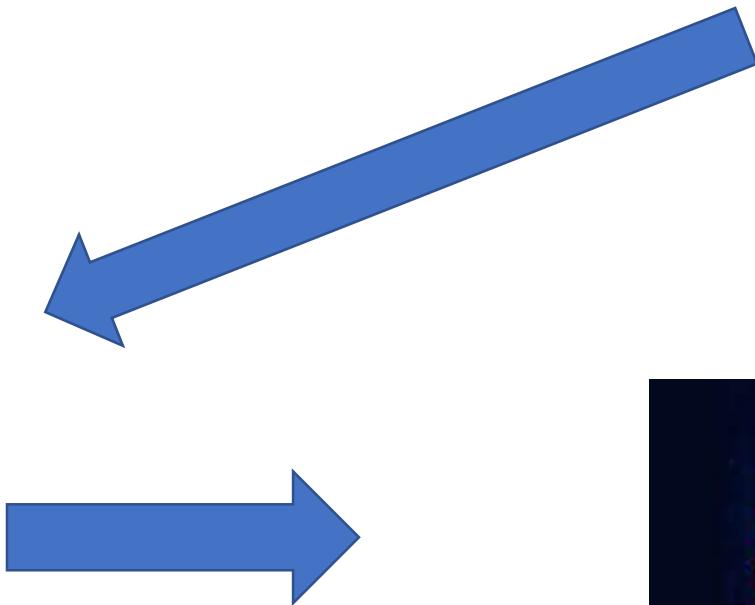


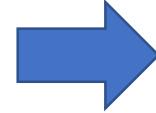
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1	Customer Alpha	North America	100	\$100,000	20%
2	Customer Beta	Europe	150	\$150,000	18%
3	Customer Gamma	Asia Pacific	200	\$200,000	15%
4	Customer Delta	South America	180	\$180,000	17%
5	Customer Epsilon	Africa	120	\$120,000	12%
6	Customer Zeta	Middle East	90	\$90,000	14%
7	Customer Eta	Latin America	140	\$140,000	16%
8	Customer Theta	Oceania	80	\$80,000	13%
9	Customer Iota	Central America	110	\$110,000	19%
10	Customer Kappa	East Asia	160	\$160,000	17%
11	Customer Lambda	West Asia	130	\$130,000	16%
12	Customer Mu	North Africa	105	\$105,000	15%
13	Customer Nu	South Africa	95	\$95,000	14%
14	Customer Xi	East Europe	115	\$115,000	18%
15	Customer Omicron	West Europe	135	\$135,000	17%
16	Customer Pi	Central Europe	100	\$100,000	16%
17	Customer Rho	North America	125	\$125,000	19%
18	Customer Sigma	Europe	145	\$145,000	18%
19	Customer Upsilon	Asia Pacific	170	\$170,000	15%
20	Customer Phi	South America	155	\$155,000	17%
21	Customer Chi	Africa	135	\$135,000	12%
22	Customer Psi	Middle East	105	\$105,000	14%
23	Customer Omega	Latin America	150	\$150,000	16%
24	Customer Epsilon	Oceania	90	\$90,000	13%
25	Customer Zeta	Central America	120	\$120,000	19%
26	Customer Kappa	East Asia	160	\$160,000	17%
27	Customer Lambda	West Asia	130	\$130,000	16%
28	Customer Mu	North Africa	105	\$105,000	15%
29	Customer Nu	South Africa	95	\$95,000	14%
30	Customer Xi	East Europe	115	\$115,000	18%
31	Customer Omicron	West Europe	135	\$135,000	17%
32	Customer Pi	Central Europe	100	\$100,000	16%



**2021**

JANUARY	FEBRUARY	MARCH	APRIL
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
MAY	JUNE	JULY	AUGUST
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SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
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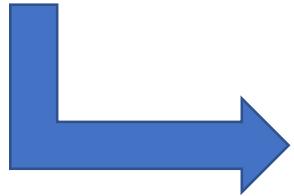




Hadoop consist of three components to specifically work on **BIG DATA**



Storage unit



Hadoop Distributed Files System  
(HDFS)

30

10

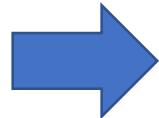
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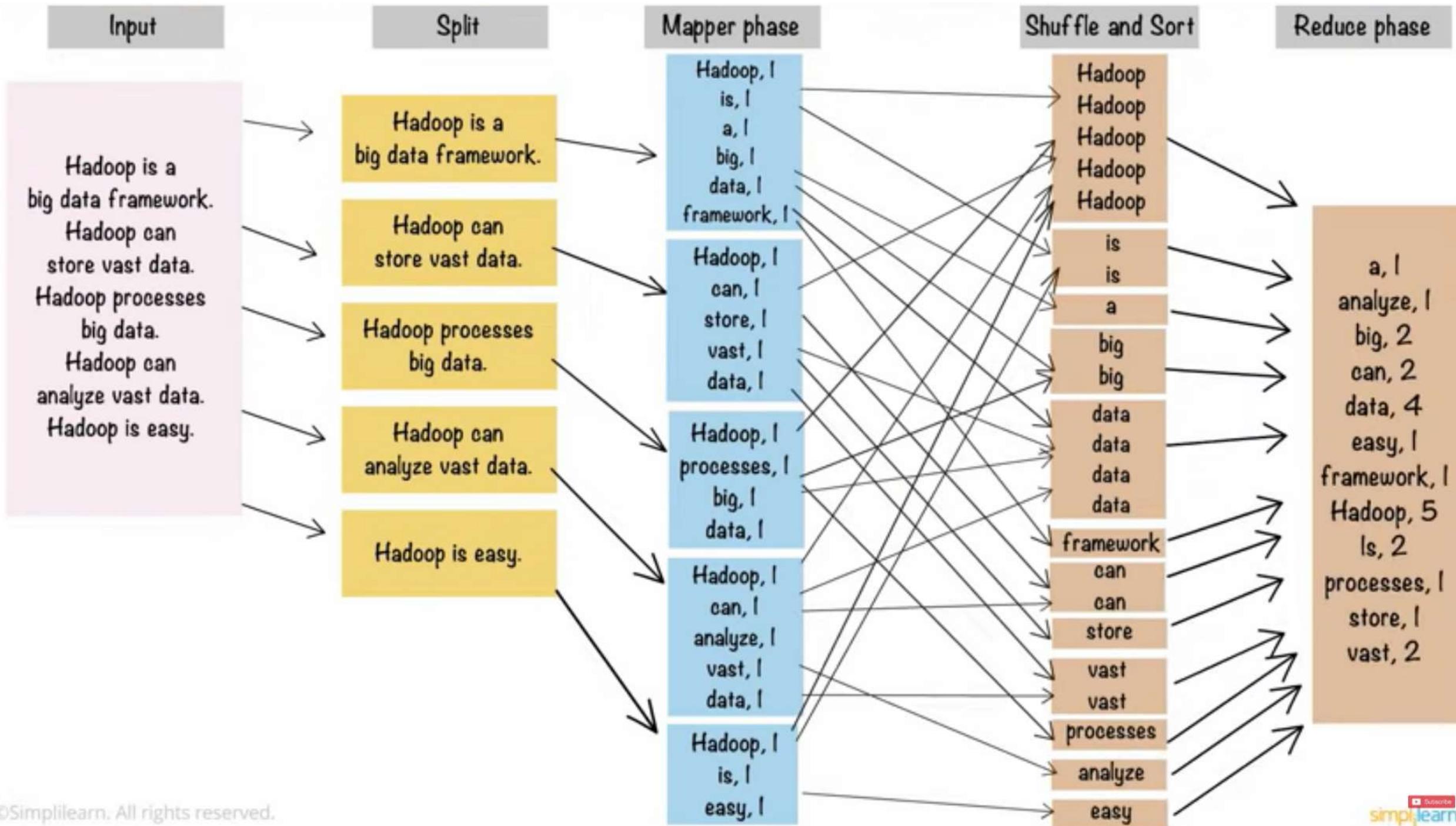
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2

# MapReduce

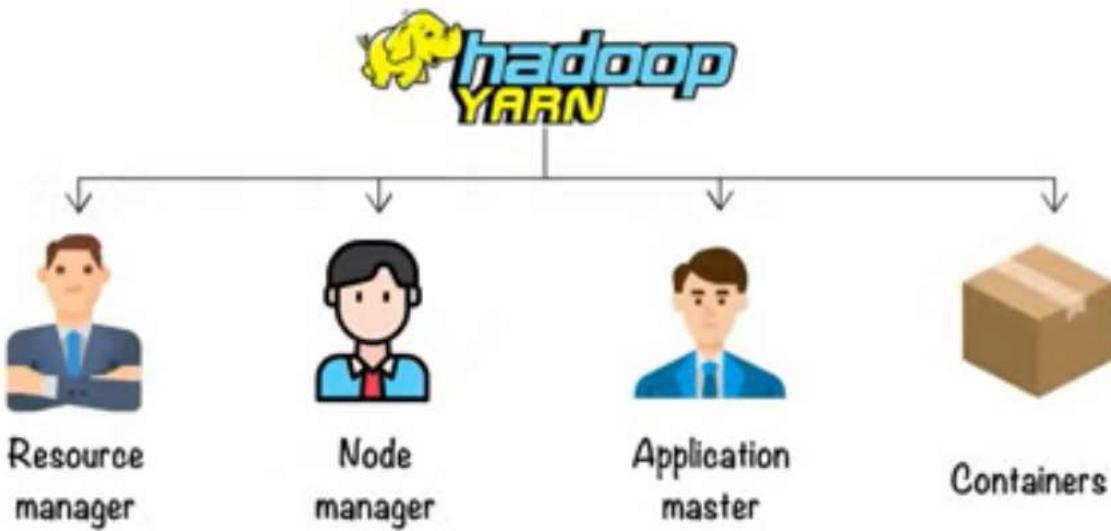
Traditional  
Methods







# Yarn



# Yarn Process



## Multiple Choice Questions

1) What is full form of HDFS?

- A. Hadoop File System
- B. Hadoop Field System
- C. Hadoop File Search
- D. Hadoop Field search

2) Which of the following are the Goals of HDFS?

- A. Fault detection and recovery
- B. Huge datasets
- C. Hardware at data
- D. All of the above

3) The minimum amount of data that HDFS can read or write is called a \_\_\_\_\_.

- A. Datanode
- B. Namenode
- C. Block
- D. None of the above

4) For every node (Commodity hardware/System) in a cluster, there will be a \_\_\_\_\_.

- A. Datanode
- B. Namenode
- C. Block
- D. None of the above

5) Which of the following is not Features Of HDFS?

- A. It is suitable for the distributed storage and processing.
- B. Streaming access to file system data.
- C. HDFS provides file permissions and authentication.
- D. Hadoop does not provides a command interface to interact with HDFS.

6) HDFS is implemented in \_\_\_\_\_ language.

- A. Perl
- B. Python
- C. Java
- D. C

7) The MapReduce algorithm contains two important tasks, namely \_\_\_\_\_.

- A. mapped, reduce
- B. mapping, Reduction
- C. Map, Reduction
- D. Map, Reduce

8) In how many stages the MapReduce program executes?

- A. 2
- B. 3
- C. 4
- D. 5

9) Point out the correct statement.

- A. MapReduce tries to place the data and the compute as close as possible
- B. Map Task in MapReduce is performed using the Mapper() function
- C. Reduce Task in MapReduce is performed using the Map() function
- D. None of the above

10) Although the Hadoop framework is implemented in Java, MapReduce applications need not be written in \_\_\_\_\_

- A. C
- B. C#
- C. Java
- D. None of the above

## TWISTER MAPREDUCE

MapReduce programming model has simplified the implementations of many data parallel applications. The simplicity of the programming model and the quality of services provided by many implementations of MapReduce attract a lot of enthusiasm among parallel computing communities. From the years of experience in applying MapReduce programming model to various scientific applications we identified a set of extensions to the programming model and improvements to its architecture that will expand the applicability of MapReduce to more classes of applications. *Twister* is a lightweight MapReduce runtime we have developed by incorporating these enhancements.

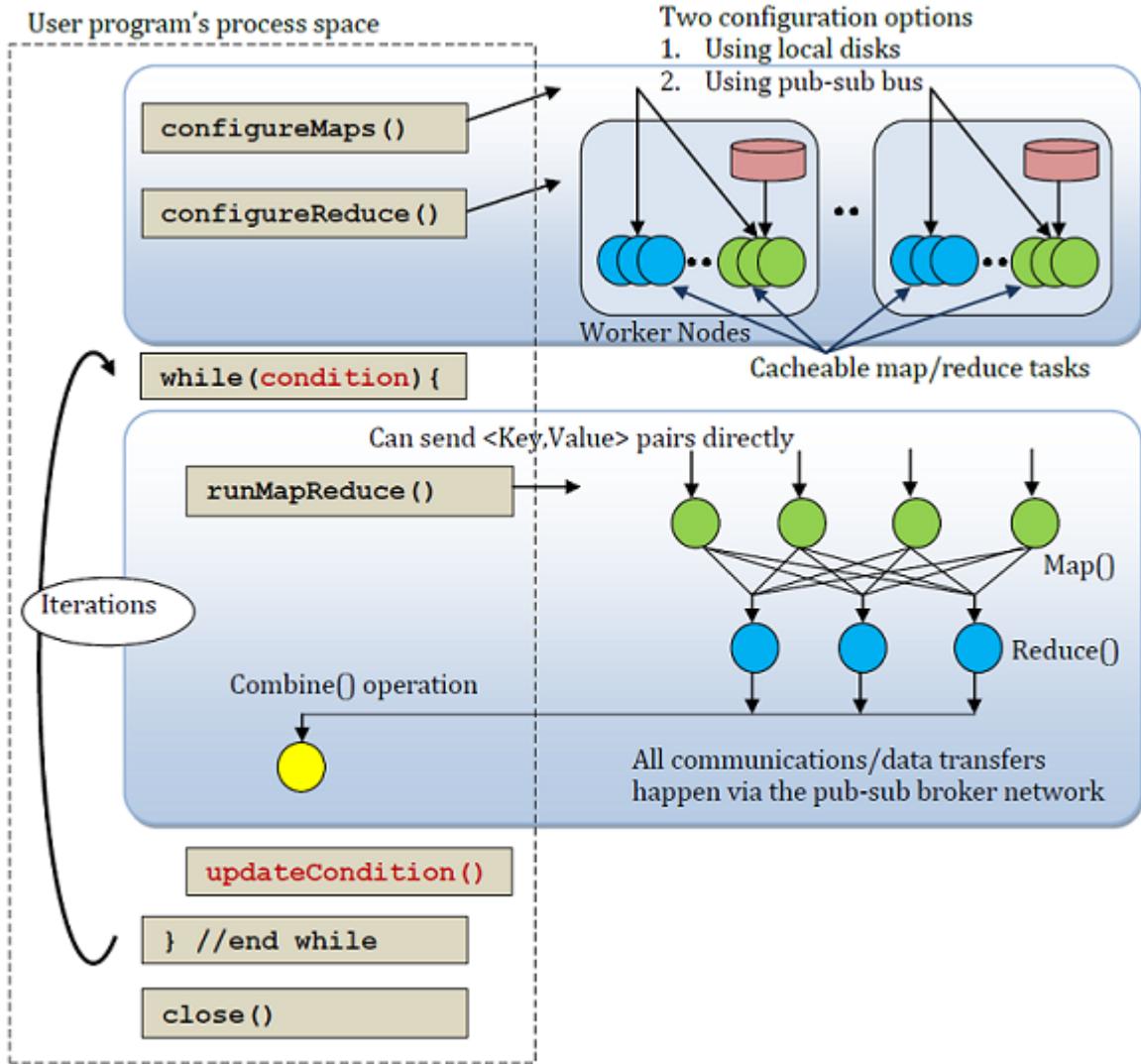
*Twister* provides the following features to support MapReduce computations. (*Twister* is developed as part of [Jaliya Ekanayake's](#) Ph.D. research and is supported by the [S A L S A Team @ IU](#))

- Distinction on static and variable data
- Configurable long running (cacheable) map/reduce tasks
- Pub/sub messaging based communication/data transfers
- Efficient support for Iterative MapReduce computations (extremely faster than [Hadoop](#) or [Dryad/DryadLINQ](#))
- Combine phase to collect all reduce outputs
- Data access via local disks
- Lightweight (~5600 lines of Java code)
- Support for typical MapReduce computations
- Tools to manage data

### New features in **Twister v0.9:**

- Support new broker software ActiveMQ (see [userguide](#))
  - Express Twister environment configuration (see [userguide](#))
  - Automatically recover from faults when FaultTolerance is enabled (see [userguide](#))
  - Partition File can be created inside the client code (see [userguide](#))
- 

## Twister Programming Model



Iterative MapReduce programming model using Twister

## Static vs. Dynamic Data

Many iterative applications we analyzed show a common characteristic of operating on two types of data products. Static data is used in each iteration and remain fixed throughout the computation whereas the variable data is the computed results in each iteration and typically consumed in the next iteration in many expectation maximization (EM) type algorithms.

## Cacheable Mappers/Reducers

Although some of the typical MapReduce computations such as distributed sorting and information retrieval consume very large data sets, many iterative applications we encounter operate on moderately sized data sets which can fit into the distributed memory of the computation clusters. This observation led us to explore the idea of using long running map/reduce tasks similar to the long running parallel processes in many [MPI](#) applications which last throughout the life of the computation. The long running (cacheable) map/reduce tasks allow map/reduce tasks to be configured with static data and use them without loading again and again in each iteration. Current MapReduce implementations such as [Hadoop](#) and [DryadLINQ](#) do not support this

behavior and hence they initiate new map/reduce tasks and load static data in each iteration incurring considerable performance overheads.

### **Supports "side-effect-free" Programming**

By supporting long running map/reduce tasks Twister does not encourage users to store state information in the map/reduce tasks violating the "side-effect-free" nature of the map/reduce computations rather achieving considerable performance gains by caching the static data across map/reduce tasks. The framework does not guarantee the use of same set of map/reduce tasks (objects) throughout the life of the iterative computation.

### **Combine step as a Further Reduction**

Twister also introduce an optional reduction phase named "combine", which is another reduction phase that can be used to combine the results of the reduce phase into a single value. The user program and the combine operation run on a single process space allowing its output directly accessible to the user program. This enables the user to check conditions based on the output of the MapReduce computations.

### **Uses Pub/Sub Messaging**

Twister uses pub/sub messaging for all the communication/data transfer requirements which eliminates the overhead in transferring data via file systems as in [Hadoop](#) or [DryadLINQ](#). The output <Key,Value> pairs produced during the map stage get transferred directly to the reduce stage and the output of the reduce stage get transferred directly to the combined stage via the pub-sub broker network. Currently Twister uses publish-subscribe messaging capabilities of [NaradaBrokering](#) messaging infrastructure, but the framework is extensible to support any other publish-subscribe messaging infrastructure such as [Active MQ](#).

### **Data Access via Local Disks**

We provide two mechanisms to access data in Twister; (i) from the local disk of the computer nodes, (ii) directly from the pub-sub infrastructure. For the simplicity of the implementation, we provide a file based data access mechanism for the map/reduce tasks. Unlike Hadoop, twister does not come with the built in file system. Instead it provides a tool to manage the data across these distributed disks. Apart from the above the use of streaming enables Twister to support features such as directly sending input <Key,Value> pairs for the map stage from the user program and configuring map/reduce stages using the data sent from the user program. The above figure shows the programming model of Twister and how iterative MapReduce computations are executed using it.

### **Fault Tolerance [Working progress]**

Providing fault tolerance support for iterative computations with Twister is currently under development.