TCS 451
Virtualization and Cloud Computing

Unit – I

Introduction to Cloud Computing

Why Cloud Computing (CC)? Different Perspectives on CC, Different Stakeholders in CC, Total cost of ownership (TCO) of on-premises IT, Cloud Computing Taxonomy, Characteristics of cloud computing, Characteristics of cloud computing as per NIST, Cloud Definitions Cloud Computing at a Glance, Vision of Cloud Computing, Cloud Computing Reference Model, Challenges Ahead, Historical Developments, Distributed Systems, Virtualization, Web 2.0, Service-Oriented Computing, Utility-Oriented Computing, Building Cloud Computing Environments, Application Development, Infrastructure and System Development, Computing Platforms and Technologies, Amazon Web Services (AWS), Google AppEngine, Microsoft Azure, Hadoop, Force.com and Salesforce.com

Why Cloud Computing (CC)?

- Cloud computing is the delivery of different services through the Internet. These resources include tools and applications like data storage, servers, databases, networking, and software.

- Cloud computing is a popular option for people and businesses for a number of reasons including cost savings, increased productivity, speed and efficiency, performance, and security.

Different Perspectives on CC

- Cloud computing is named as such because the information being accessed is found remotely in the cloud or a virtual space. Companies that provide cloud services enable users to store files and applications on remote servers and then access all the data via the Internet.

- Businesses can employ cloud computing in different ways. Some users maintain all apps and data on the cloud, while others use a hybrid model, keeping certain apps and data on private servers and others on the cloud.

When it comes to providing services, the big players in the corporate computing sphere include:

- Google Cloud

- Amazon Web Services (AWS)

- Microsoft Azure

- IBM Cloud

- Alibaba Cloud

Different Stakeholders in CC

NIST Cloud Computing reference architecture defines five major performers:

• Cloud Provider

• Cloud Carrier

• Cloud Broker

• Cloud Auditor

• Cloud Consumer

National Institute of Standards and Technology (NIST)

- The National Institute of Standards and Technology (NIST) is a physical sciences laboratory and non-regulatory agency of the United States Department of Commerce.

- Its mission is to promote American innovation and industrial competitiveness.

- NIST's activities are organized into laboratory programs that include nanoscale science and technology, engineering, information technology, neutron research, material measurement, and physical measurement.

- From 1901 to 1988, the agency was named the National Bureau of Standards

Cloud Service Providers

- **IaaS Providers:** In this model, the cloud service providers offer infrastructure components that would exist in an on-premises data center. These components consist of servers, networking, and storage as well as the virtualization layer.

- **PaaS Providers:** In Platform as a Service (PaaS), vendors offer cloud infrastructure and services that can access to perform many functions. In PaaS, services and products are mostly utilized in software development. PaaS providers offer more services than IaaS providers. PaaS providers provide operating system and middleware along with application stack, to the underlying infrastructure.

- **SaaS Providers:** In Software as a Service (SaaS), vendors provide a wide sequence of business technologies, such as Human resources management (HRM) software, customer relationship management (CRM) software, all of which the SaaS vendor hosts and provides services through the internet.

Cloud Carrier

- The mediator who provides offers connectivity and transport of cloud services within cloud service providers and cloud consumers.

- It allows access to the services of the cloud through Internet networks, telecommunication, and other access devices.

- Network and telecom carriers or a transport agent can provide distribution.

- A consistent level of services is provided when cloud providers set up Service Level Agreements (SLA) with a cloud carrier. In general, Carrier may be required to offer dedicated and encrypted connections.

Cloud Broker

An organization or a unit that manages the performance, use, and delivery of cloud services by enhancing specific capability and offers value-added services to cloud consumers. It combines and integrates various services into one or more new services. They provide service arbitrage which allows flexibility and opportunistic choices. There are major three services offered by a cloud broker:

• Service Intermediation.

• Service Aggregation.

• Service Arbitrage.

Cloud Auditor

An entity that can conduct independent assessment of cloud services, security, performance, and information system operations of the cloud implementations. The services that are provided by Cloud Service Providers (CSP) can be evaluated by service auditors in terms of privacy impact, security control, and performance, etc. Cloud Auditor can make an assessment of the security controls in the information system to determine the extent to which the controls are implemented correctly, operating as planned and constructing the desired outcome with respect to meeting the security necessities for the system. There are three major roles of Cloud Auditor which are mentioned below:

- Security Audit.

- Privacy Impact Audit.

- Performance Audit.

Cloud Consumer

- A cloud consumer is the end-user who browses or utilizes the services provided by Cloud Service Providers (CSP), sets up service contracts with the cloud provider.

- The cloud consumer pays peruse of the service provisioned. Measured services utilized by the consumer.

- In this, a set of organizations having mutual regulatory constraints performs a security and risk assessment for each use case of Cloud migrations and deployments.

Total cost of ownership (TCO)

- The Total Cost of Ownership (TCO) for enterprise software is the sum of all direct and indirect costs incurred by that software, and is a critical part of the ROI calculation.

- The total cost of ownership (TCO) is used to calculate the total cost of purchasing and operating a technology product or service over its useful life. The TCO is important for evaluating technology costs that aren't always reflected in upfront pricing.
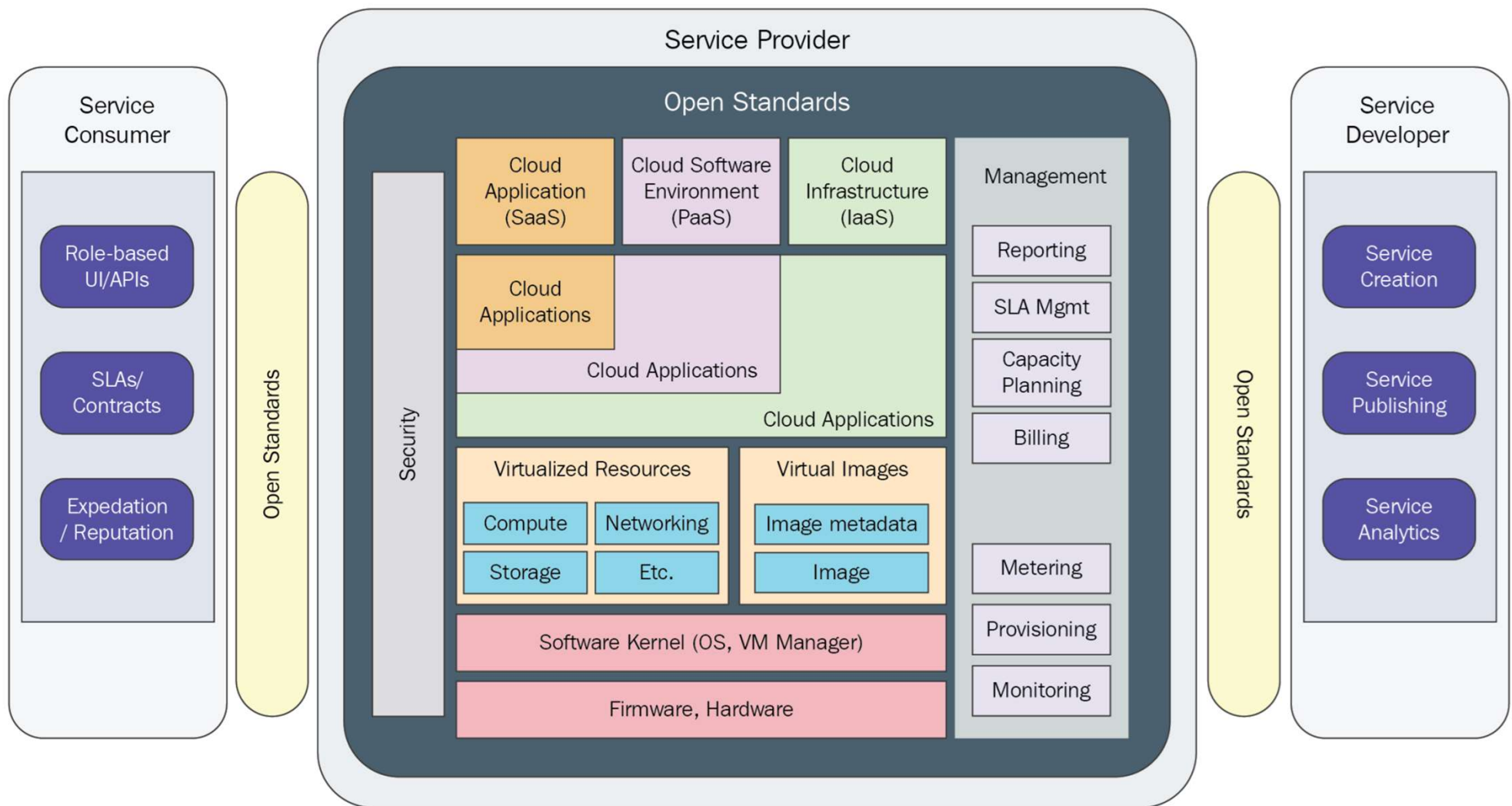
Cloud Computing Taxonomy

Characteristics of cloud computing

- On-demand self-services: The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.

- Broad network access: The Computing services are generally provided over standard networks and heterogeneous devices.

- Rapid elasticity: The Computing services should have IT resources that are able to scale out and in quickly and on as needed basis. Whenever the user require services it is provided to him and it is scale out as soon as its requirement gets over.

- Resource pooling: The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.

- Measured service: The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource

Vision of Cloud Computing

- Cloud computing provides the facility to provision virtual hardware, runtime environment and services to a person having money.

- These all things can be used as long as they are needed by the user.

- The whole collection of computing system is transformed into collection of utilities, which can be provisioned and composed together to deploy systems in hours rather than days, with no maintenance cost.

- The long term vision of a cloud computing is that IT services are traded as utilities in an open market without technological and legal barriers.

Cloud Computing Reference Model
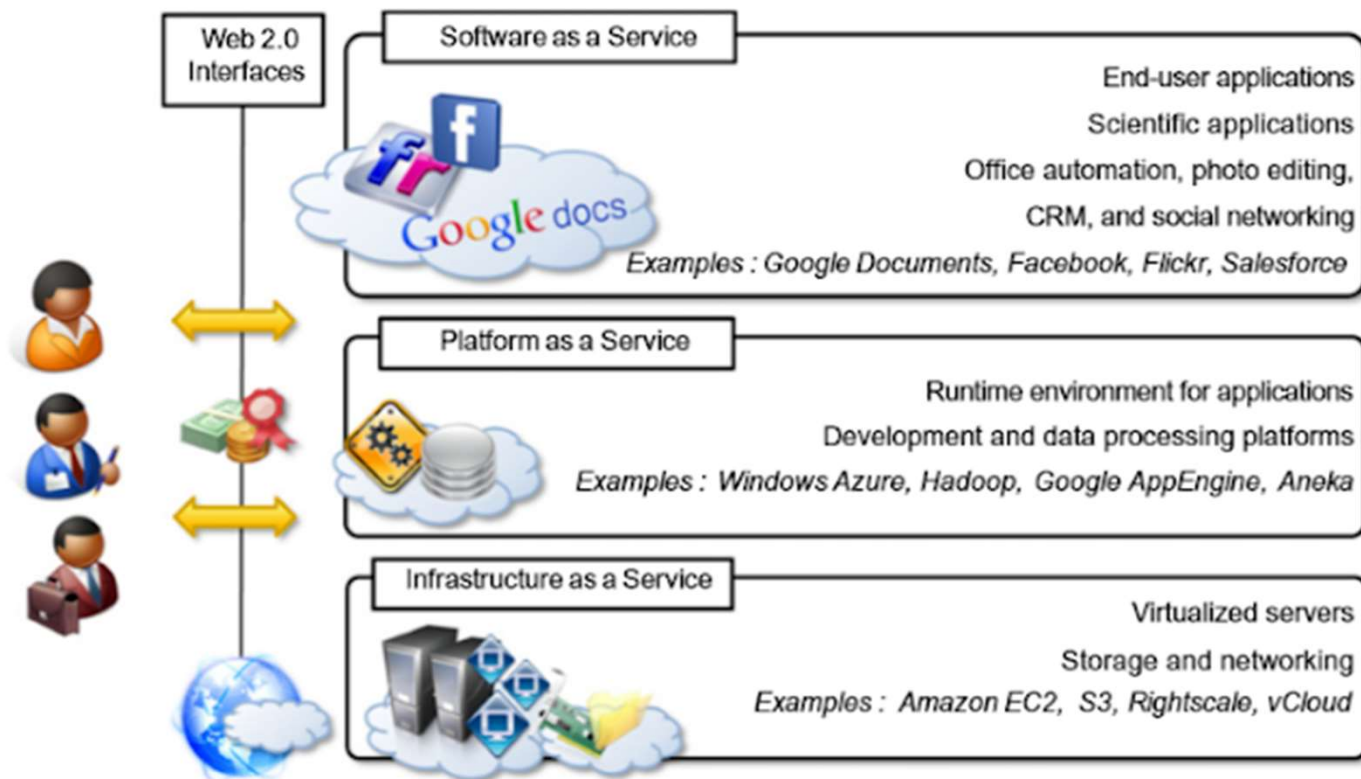
Cloud Computing Challenges

- Security and Privacy: Security and Privacy of information is the biggest challenge to cloud computing. Security and privacy issues can be overcome by employing encryption, security hardware and security applications.

- Portability: This is another challenge to cloud computing that applications should easily be migrated from one cloud provider to another. There must not be vendor lock-in. However, it is not yet made possible because each of the cloud provider uses different standard languages for their platforms.

- Interoperability: It means the application on one platform should be able to incorporate services from the other platforms. It is made possible via web services, but developing such web services is very complex.

- Computing Performance: Data intensive applications on cloud requires high network bandwidth, which results in high cost. Low bandwidth does not meet the desired computing performance of cloud application.

- Reliability and Availability: It is necessary for cloud systems to be reliable and robust because most of the businesses are now becoming dependent on services provided by third-party.

Evolution of Cloud Computing

Evolution of Cloud Computing
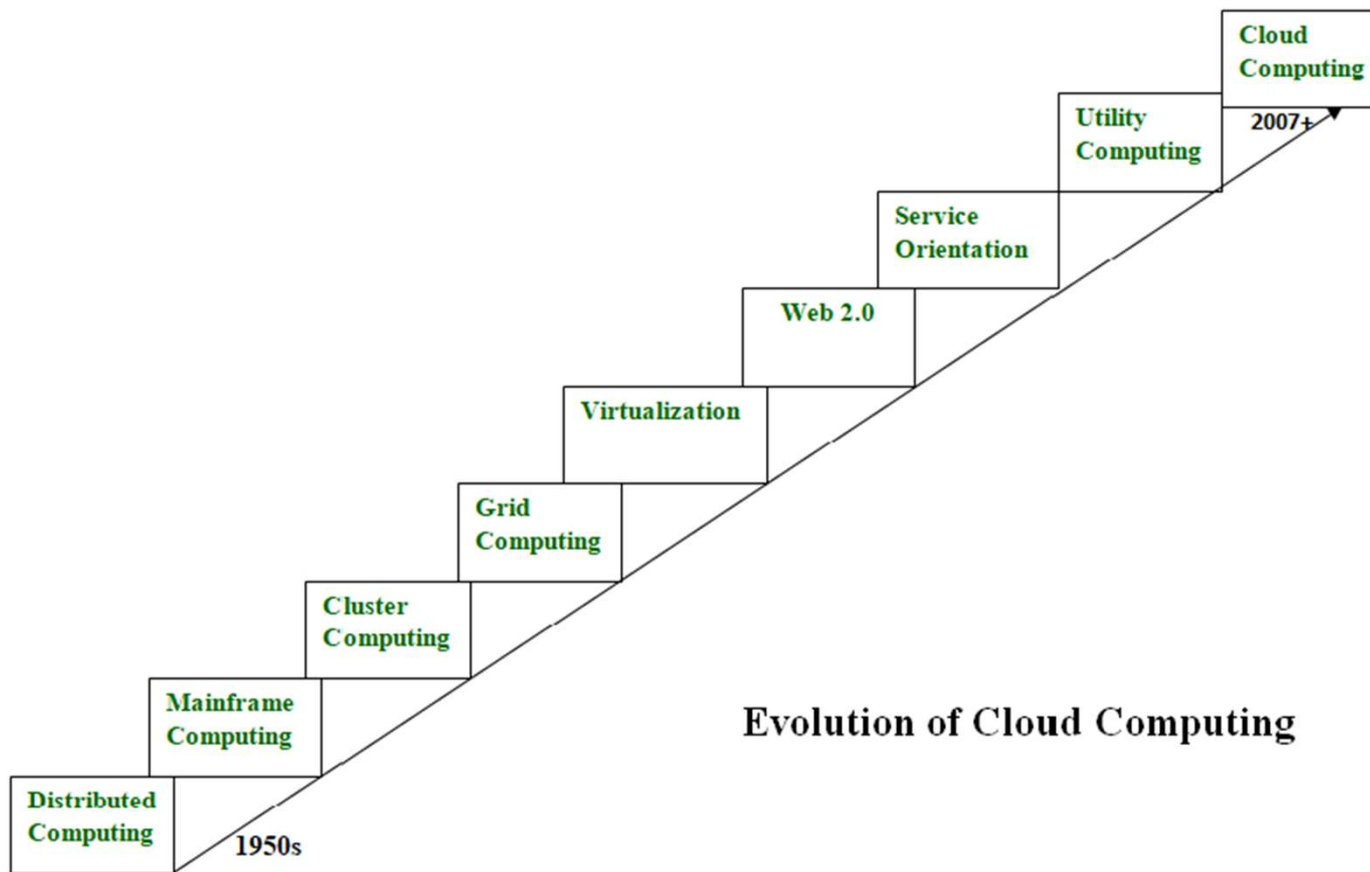
Distributed Systems

- It is a composition of multiple independent systems but all of them are depicted as a single entity to the users.

- The purpose of distributed systems is to share resources and also use them effectively and efficiently.

- Distributed systems possess characteristics such as scalability, concurrency, continuous availability, heterogeneity, and independence in failures.

- But the main problem with this system was that all the systems were required to be present at the same geographical location.

- Thus to solve this problem, distributed computing led to three more types of computing and they were-Mainframe computing, cluster computing, and grid computing.

Mainframe computing

- Mainframes which first came into existence in 1951 are highly powerful and reliable computing machines.

- These are responsible for handling large data such as massive input-output operations.

- Even today these are used for bulk processing tasks such as online transactions etc.

- These systems have almost no downtime with high fault tolerance. After distributed computing, these increased the processing capabilities of the system.

- But these were very expensive. To reduce this cost, cluster computing came as an alternative to mainframe technology.

Cluster computing

- In 1980s, cluster computing came as an alternative to mainframe computing.
- Each machine in the cluster was connected to each other by a network with high bandwidth.
- These were way cheaper than those mainframe systems.
- These were equally capable of high computations.
- Also, new nodes could easily be added to the cluster if it was required.
- Thus, the problem of the cost was solved to some extent but the problem related to geographical restrictions still pertained.
- To solve this, the concept of grid computing was introduced.

Grid computing

- In 1990s, the concept of grid computing was introduced.
- It means that different systems were placed at entirely different geographical locations and these all were connected via the internet.
- These systems belonged to different organizations and thus the grid consisted of heterogeneous nodes.
- Although it solved some problems but new problems emerged as the distance between the nodes increased.
- The main problem which was encountered was the low availability of high bandwidth connectivity and with it other network associated issues.
- Thus. cloud computing is often referred to as "Successor of grid computing".

Virtualization

- It was introduced nearly 40 years back.
- It refers to the process of creating a virtual layer over the hardware which allows the user to run multiple instances simultaneously on the hardware.
- It is a key technology used in cloud computing.
- It is the base on which major cloud computing services such as Amazon EC2, VMware vCloud, etc work on.
- Hardware virtualization is still one of the most common types of virtualization.

Web 2.0

- It is the interface through which the cloud computing services interact with the clients.

- It is because of Web 2.0 that we have interactive and dynamic web pages. It also increases flexibility among web pages.

- Popular examples of web 2.0 include Google Maps, Facebook, Twitter, etc. Needless to say, social media is possible because of this technology only.

- In gained major popularity in 2004.

Service orientation

- It acts as a reference model for cloud computing.
- It supports low-cost, flexible, and evolvable applications.
- Two important concepts were introduced in this computing model.
- These were Quality of Service (QoS) which also includes the SLA (Service Level Agreement) and Software as a Service (SaaS).

Utility computing

It is a computing model that defines service provisioning techniques for services such as compute services along with other major services such as storage, infrastructure, etc which are provisioned on a pay-per-use basis.

Cloud Computing Platforms and Technologies

- Amazon Web Services (AWS) : AWS provides different wide-ranging clouds IaaS services, which ranges from virtual compute, storage, and networking to complete computing stacks. AWS is well known for its storage and compute on demand services, named as Elastic Compute Cloud (EC2) and Simple Storage Service (S3).

- Google AppEngine : Google AppEngine is a scalable runtime environment frequently dedicated to executing web applications. These utilize benefits of the large computing infrastructure of Google to dynamically scale as per the demand. AppEngine offers both a secure execution environment and a collection of which simplifies the development if scalable and high-performance Web applications.

- Microsoft Azure: Microsoft Azure is a Cloud operating system and a platform in which user can develop the applications in the cloud. Generally, a scalable runtime environment for web applications and distributed applications is provided. Application in Azure are organized around the fact of roles, which identify a distribution unit for applications and express the application's logic.

- Hadoop : Apache Hadoop is an open source framework that is appropriate for processing large data sets on commodity hardware. Hadoop is an implementation of MapReduce, an application programming model which is developed by Google. This model provides two fundamental operations for data processing: map and reduce.

- Force.com and Salesforce.com : Force.com is a Cloud computing platform at which user can develop social enterprise applications. The platform is the basis of SalesForce.com – a Software-as-a-Service solution for customer relationship management. Force.com allows creating applications by composing ready-to-use blocks: a complete set of components supporting all the activities of an enterprise are available.

- There are 4 main types of cloud computing: private clouds, public clouds, hybrid clouds, and multiclouds/Community Cloud.

- There are also 3 main types of cloud computing services: Infrastructure-as-a-Service (IaaS), Platforms-as-a-Service (PaaS), and Software-as-a-Service (SaaS).

- Public clouds are cloud environments typically created from IT infrastructure not owned by the end user. Some of the largest public cloud providers include Alibaba Cloud, Amazon Web Services (AWS), Google Cloud, IBM Cloud, and Microsoft Azure.

- Private clouds are loosely defined as cloud environments solely dedicated to a single end user or group, where the environment usually runs behind that user or group's firewall. All clouds become private clouds when the underlying IT infrastructure is dedicated to a single customer with completely isolated access.

- A hybrid cloud is a seemingly single IT environment created from multiple environments connected through local area networks (LANs), wide area networks (WANs), virtual private networks (VPNs), and/or APIs.

- The characteristics of hybrid clouds are complex and the requirements can differ, depending on whom you ask. For example, a hybrid cloud may need to include:

- At least 1 private cloud and at least 1 public cloud

- 2 or more private clouds

- 2 or more public clouds

- A bare-metal or virtual environment connected to at least 1 public cloud or private cloud

- Multiclouds are a cloud approach made up of more than 1 cloud service, from more than 1 cloud vendor—public or private. All hybrid clouds are multiclouds, but not all multiclouds are hybrid clouds. Multiclouds become hybrid clouds when multiple clouds are connected by some form of integration or orchestration.

- A community cloud in computing is a collaborative effort in which infrastructure is shared between several organizations from a specific community with common concerns, whether managed internally or by a third-party and hosted internally or externally.
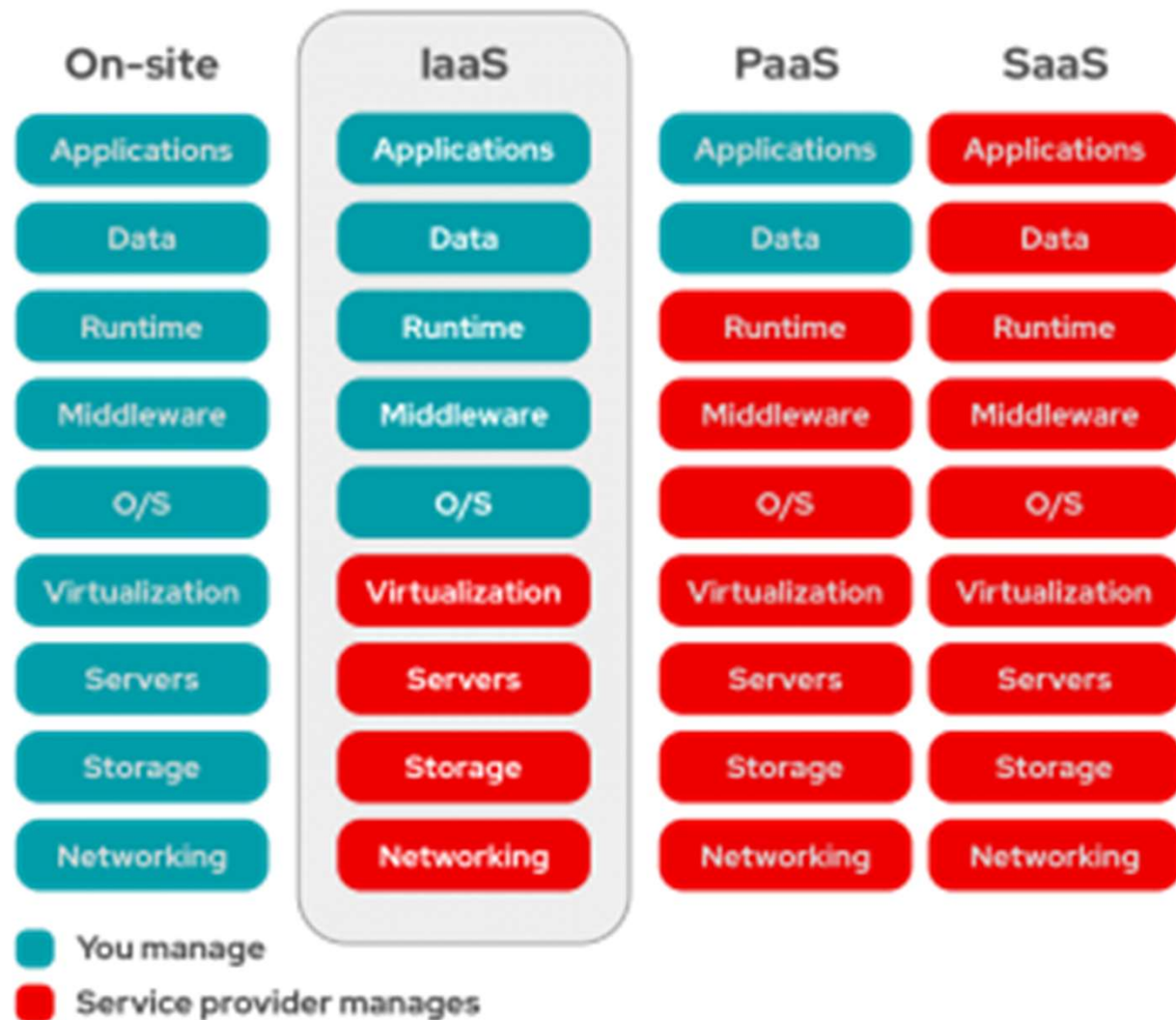
The Azure Roadmap

Fundamentals   **Associate**

AZ-900
Fundamentals

Administrator
- AZ-103

Data Scientist
DP-100

Developer
- AZ-203

Data Engineer
- DP-200
- DP-201

AI Engineer
- A1-100

Security
- AZ-500

Expert

Solutions Architect Expert
- AZ-300
- AZ-301

DevOps Engineer Expert
- AZ-400

Specialty

Azure for SAP Workloads
- AZ-120

IoT Developer
- AZ-220

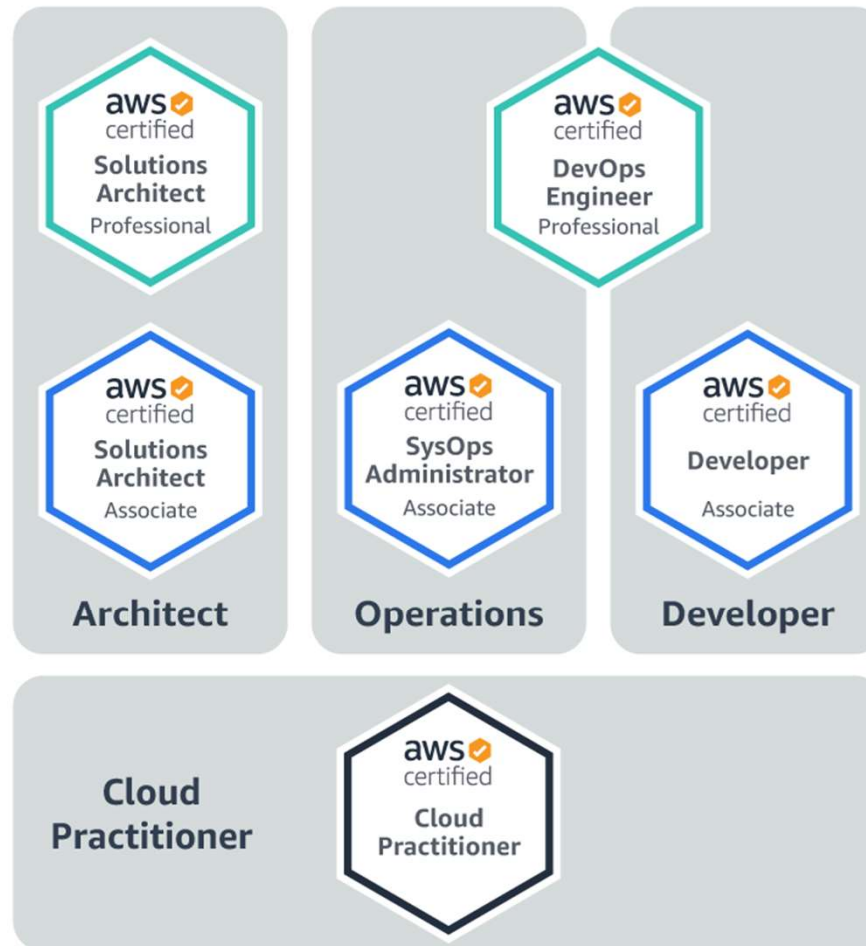# Available AWS Certifications

Professional

Two years of comprehensive experience designing, operating, and troubleshooting solutions using the AWS Cloud

Associate

One year of experience solving problems and implementing solutions using the AWS Cloud

Foundational

Six months of fundamental AWS Cloud and industry knowledge

Specialty

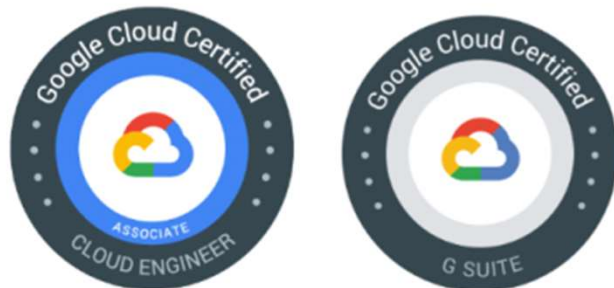Technical AWS Cloud experience in the Specialty domain as specified in the **exam guide**

Architect

aws certified
Solutions Architect
Professional

aws certified
Solutions Architect
Associate

Operations

aws certified
DevOps Engineer
Professional

aws certified
SysOps Administrator
Associate

Developer

aws certified
Developer
Associate

Cloud Practitioner

aws certified
Cloud Practitioner

aws certified
Advanced Networking
Specialty

aws certified
Big Data
Specialty

aws certified
Security
Specialty

aws certified
Machine Learning
Specialty

aws certified
Alexa Skill Builder
Specialty

Specialization

Google Cloud Certified — PROFESSIONAL — DATA ENGINEER

Google Cloud Certified — PROFESSIONAL — CLOUD NETWORK ENGINEER

Google Cloud Certified — PROFESSIONAL — CLOUD DEVELOPER

Google Cloud Certified — PROFESSIONAL — CLOUD SECURITY ENGINEER

Architect

Google Cloud Certified — PROFESSIONAL — CLOUD ARCHITECT

Foundation

Google Cloud Certified — ASSOCIATE — CLOUD ENGINEER

Google Cloud Certified — G SUITE

Google Cloud

DEVELOPER'S CHEAT SHEET

v2018.12.19
Created by the Google Developer Relations Team
Maintained at https://github.com/gregsramblings/google-cloud-4-words

Feedback? 🐦 @gregsramblings

COMPUTE PRODUCTS

Compute Engine	Virtual Machines, Disks, Network
App Engine	Managed App Platform
Kubernetes Engine	Managed Kubernetes/Containers
Cloud Functions	Event-driven serverless functions

STORAGE PRODUCTS

Cloud Storage	Object Storage and Serving
Nearline	Archival Occasional Access Storage
Coldline	Archival Rare Access Storage
Persistent Disk	VM-attached Disks
Cloud Filestore	Managed NFS Server

DATABASES PRODUCTS

Cloud Bigtable	Petabyte-scale, low-latency nonrelational
Cloud Datastore	Horizontally Scalable Document DB
Cloud Firestore	Strongly-consistent Serverless Document DB
Cloud Memorystore	Managed Redis
Cloud Spanner	Horizontally Scalable Relational DB
Cloud SQL	Managed MySQL and PostgreSQL

DATA AND ANALYTICS PRODUCTS

Cloud Composer	Managed Workflow Orchestration Service
Cloud Dataflow	Stream/batch data processing
Cloud Datalab	Managed Jupyter Notebook
Cloud Dataprep	Visual data wrangling
Cloud Dataproc	Managed Spark and Hadoop
Cloud Pub/Sub	Global Real-time Messaging
Google BigQuery	Data Warehouse/Analytics
Google Data Studio	Collaborative Data Exploration/Dashboarding
Google Genomics	Managed Genomics Platform

AI AND MACHINE LEARNING PRODUCTS

Cloud AutoML Natural Language	Custom text classification models
Cloud AutoML Translate	Custom domain-specific translation
Cloud AutoML Vision	Custom image classification models
Cloud Job Discovery	Job Search with ML
Cloud Deep Learning VM Image	Preconfigured VMs for deep learning
Cloud Machine Learning Engine	Managed Platform for ML
Cloud Natural Language	Text Parsing and Analysis
Cloud Speech-To-Text	Convert Audio to Text
Cloud Text-To-Speech	Convert Text to Audio

AI AND MACHINE LEARNING PRODUCTS (CONT.)

Cloud TPU	Specialized Hardware for ML
Cloud Translation API	Language Detection and Translation
Cloud Video Intelligence	Scene-level Video Annotation
Cloud Vision API	Image Recognition and Classification
Dialogflow Enterprise Edition	Create Conversational Interfaces

NETWORKING PRODUCTS

Carrier Peering	Peer through a carrier
Direct Peering	Peer with GCP
Dedicated Interconnect	Dedicated private network connection
Partner Interconnect	Connect on-premises network to VPC
Cloud Armor	DDoS Protection and WAF
Cloud CDN	Content Delivery Network
Cloud DNS	Programmable DNS Serving
Cloud Load Balancing	Multi-region Load Distribution
Cloud NAT	Network Address Translation Service
IPsec VPN	Virtual private network connection
Network Service Tiers	Price vs Performance Tiering
Network Telemetry	Network Telemetry Service
Virtual Private Cloud	Software Defined Networking

INTERNET OF THINGS PRODUCTS

Cloud IoT Core	Device Management and ingest data

IDENTITY AND SECURITY PRODUCTS

Access Transparency	Audit Cloud Provider Access
Binary Authorization	Kubernetes Deploy-time Security
Cloud Data Loss Prevention API	Classify, Redact Sensitive Data
Cloud HSM	Hardware Security Module Service
Cloud IAM	Resource Access Control
Cloud Identity	Manage Users, Devices & Apps
Cloud Identity-Aware Proxy	Identity-based App Signin
Cloud Key Management Service	Hosted Key Management Service
Cloud Resource Manager	Cloud Project Metadata Management
Cloud Security Command Center	Asset inventory, discovery, search, management
Cloud Security Scanner	App Engine Security Scanner
Security Key Enforcement	Two-step Key Verification
Shielded VMs	Hardened VMs
Titan Security Key	Two-factor Authentication (2FA) Device

MANAGEMENT TOOLS PRODUCTS

Cloud APIs	APIs for Cloud Services
Cloud Billing	Billing and Cost Management Tools
Cloud Billing API	Programmatically Manage GCP Billing
Cloud Console	Web-based Management Console
Cloud Deployment Manager	Templated Infrastructure Deployment
Cloud Mobile App	iOS/Android GCP Manager App
Cloud Shell	Browser-based Terminal/CLI
Stackdriver Debugger	Live Production Debugging
Stackdriver Error Reporting	App Error Reporting
Stackdriver Logging	Centralized Logging
Stackdriver Monitoring	Infrastructure and Application Monitoring
Stackdriver Profiler	CPU and heap profiling
Stackdriver Transparent SLIs	Monitor GCP Services
Stackdriver Trace	App Performance Insights

DEVELOPER TOOLS

Cloud SDK	CLI for GCP
Cloud Build	Continuous integration/delivery platform
Cloud Source Repositories	Hosted Private Git Repos

DEVELOPER TOOLS (CONT.)

Cloud Scheduler	Managed cron job service
Cloud Tools for IntelliJ	IntelliJ GCP Tools
Cloud Tools for PowerShell	PowerShell GCP Tools
Cloud Tools for Visual Studio	Visual Studio GCP Tools
Cloud Tools for Eclipse	Eclipse GCP Tools
Container Registry	Private Container Registry/Storage
Gradle App Engine Plugin	Gradle App Engine Plugin
Maven App Engine Plugin	Maven App Engine Plugin

MIGRATION (TO GCP)

Google Transfer Appliance	Rentable Data Transport Box
Cloud Storage Transfer Service	Cloud to Cloud Transfers
BigQuery Data Transfer Service	Bulk Import Analytics Data
Velostrata	Lift-and-shift VM Migration

API PLATFORM AND ECOSYSTEMS

API Analytics	API Metrics
API Monetization	Monetize APIs
Apigee API Platform	Develop, secure, monitor APIs
Apigee Sense	API protection from attacks
Cloud Endpoints	Cloud API Gateway
Cloud Healthcare API	Healthcare System GCP Interoperability
Developer Portal	API Management Portal
GCP Marketplace	Partner & Open Source Marketplace

GOOGLE MAPS PLATFORM

Directions API	Get Directions Between Locations
Distance Matrix API	Calculate Travel Times
Geocoding API	Convert Address to/from Coordinates
Geolocation API	Derive Location Without GPS
Maps Embed API	Web Embedded Maps
Maps JavaScript API	Dynamic Web Maps
Maps SDK for Android	Maps SDK for Android
Maps SDK for iOS	Maps SDK for iOS
Maps Static API	Web Static Maps
Maps Unity SDK	Unity SDK for Games
Maps URLs	URL Scheme for Maps
Places API	Metadata About Places (REST)
Places Library, Maps JS API	Metadata About Places (JavaScript)
Places SDK for Android	Places SDK for Android
Places SDK for iOS	Places SDK for iOS
Roads API	Metadata About Roads
Street View API	Street View API
Time Zone API	Convert Coordinates to Timezone

G SUITE PLATFORM

App Maker	Assistive App Building
Apps Script	Extend and Automate Everything
Editor Add-ons	Extend Docs, Sheets, Slides
Gmail Add-ons	Contextual Apps in Gmail
Hangouts Chat Bots	Conversational Bots in Chat
Calendar API	Create and Manage Calendars
Classroom API	Provision and Manage Classrooms
Drive API	Read and Write Files
Gmail API	Enhance Gmail and Inbox
Sheets API	Read and Write Spreadsheets
Slides API	Create and Edit Presentations
Drive Picker	Drive File Selection Widget
Admin SDK	Managed G Suite Resources
Email Markup	Interactive Email using Schema.org
G Suite Marketplace	Storefront for Integrated Applications
Other G Suite APIs/SDKs	Contacts, Google+, Tasks, Vault.

MOBILE PRODUCTS (FIREBASE)

Cloud Firestore	Document Store and Sync
Cloud Functions for Firebase	Event-driven Serverless Applications
Cloud Storage for Firebase	Object Storage and Serving
Crashlytics	Crash Reporting and Analytics
Firebase A/B Testing	Create A/B Test Experiments
Firebase App Indexing	App / Google Search Integration
Firebase Authentication	Drop-in Authentication
Firebase Cloud Messaging	Send Device Notifications
Firebase Dynamic Links	Link to App Content
Firebase Hosting	Web Hosting with CDN/SSL
Firebase In-App Messaging	Send Contextual Messages In-App
Firebase Performance Monitoring	App Performance Monitoring
Firebase Predictions	Predict User Targetting
Firebase Realtime Database	Real-time Data Synchronization
Firebase Remote Config	Remotely Configure Installed Apps
Firebase Test Lab	Mobile testing device farm
Google Analytics for Firebase	Mobile App Analytics
ML Kit for Firebase	ML APIs for Mobile

GCP FOUNDATIONAL OPEN SOURCE PROJECTS

Apache Beam	Batch/Streaming Data Processing
gRPC	RPC Framework
gVisor	Secure Container Runtime
Istio	Connect and Secure Services
Knative	Serverless framework for Kubernetes
Kubeflow	ML Toolkit for Kubernetes
Kubernetes	Management of containerized applications
OpenCensus	Cloud Native Observability Framework
TensorFlow	ML Framework

ADDITIONAL RESOURCES

Google Cloud Home Page	https://cloud.google.com
Google Cloud Blog	https://cloud.google.com/blog
GCP Medium Publication	https://medium.com/google-cloud
Apigee Blog	https://apigee.com/about/blog
Firebase Blog	https://firebase.googleblog.com
G Suite Developers Blog	https://gsuite-developers.googleblog.com
Google Cloud Certifications	https://cloud.google.com/certification
Google Cloud System Status	https://status.cloud.google.com
Google Cloud Training	https://cloud.google.com/training
Google Developers Blog	https://developers.googleblog.com
Google Maps Platform Blog	https://mapsplatform.googleblog.com
Google Open Source Blog	https://opensource.googleblog.com
Google Security Blog	https://security.googleblog.com
Kaggle Home Page	https://www.kaggle.com
Kubernetes Blog	https://kubernetes.io/blog
Regions and Network Map	https://cloud.google.com/about/locations

Top-paying certifications:

1. Google Certified Professional Data Engineer — $171,749
2. Google Certified Professional Cloud Architect — $169,029
3. AWS Certified Solutions Architect - Associate — $159,033
4. CRISC - Certified in Risk and Information Systems Control — $151,995
5. CISSP - Certified Information Systems Security Professional — $151,853
6. CISM – Certified Information Security Manager — $149,246
7. PMP® - Project Management Professional — $148,906
8. NCP-MCI - Nutanix Certified Professional - Multicloud Infrastructure — $142,810
9. CISA - Certified Information Systems Auditor — $134,460
10. VCP-DVC - VMware Certified Professional - Data Center Virtualization 2020 — $132,947
11. MCSE: Windows Server — $125,980
12. Microsoft Certified: Azure Administrator Associate — $121,420
13. CCNP Enterprise - Cisco Certified Network Professional - Enterprise — $118,911
14. CCA-V - Citrix Certified Associate - Virtualization — $115,308
15. CompTIA Security+ — $110,974

Source: 15 Highest-Paying IT Certifications in 2021 | Global Knowledge

Assignment 1

- Evaluate Cloud Computing with different Perspectives using suitable case study.

- Evaluate Total cost of ownership (TCO) with suitable case study.

- Evaluate Characteristics of cloud computing as per NIST with suitable examples.

- Analyze Cloud Computing Reference Model with suitable diagram.

- Evaluate Distributed Systems, Virtualization, Web 2.0, Service-Oriented Computing, and Utility-Oriented Computing.

- Evaluate Amazon Web Services (AWS), Google AppEngine, Microsoft Azure, Hadoop, Force.com and Salesforce.com.

Submission link: https://forms.gle/f8vGUapeDMowSL7n9

Presentation I (Choose any one topic)

- Case study on Distributed Systems,
- Case study on Virtualization,
- Case study on Web 2.0,
- Case study on Service-Oriented Computing,
- Case study on Utility-Oriented Computing,
- Case study on Amazon Web Services (AWS),
- Case study on Google AppEngine,
- Case study on Microsoft Azure,
- Case study on Hadoop,
- Case study on Force.com
- Case study on Salesforce.com

Submission link: https://forms.gle/f8vGUapeDMowSL7n9

Lab 1

To install a GCC compiler in the ubuntu virtual machine using VMware and execute a sample program.

- Submission link: https://forms.gle/f8vGUapeDMowSL7n9