

CLOUD COMPUTING

Unit I — Introduction to Cloud Computing

Topics Covered (09 Hours)

Cloud Fundamentals: Definition & Historical Evolution
The Importance & Strategic Value of Cloud Computing
Advantages & Disadvantages (Trade-offs & Constraints)
NIST Core Characteristics of Cloud Computing Services
Cloud Categories: Private vs. Public Cloud Systems
Service Models: Infrastructure as a Service (IaaS)
Service Models: Platform as a Service (PaaS)
Service Models: Software as a Service (SaaS)
Core Cloud Infrastructure & Architectural Layers
Distributed Data Storage & Data Management Systems
Deployment Models: Public, Private, Hybrid, and Community

*Compiled in a simple, easy-to-understand, book style format
for students of Computer Science and Engineering*

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1.1 Cloud Fundamentals & Characteristics

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 a pay-as-you-go pricing model. Instead of buying, owning, and maintaining physical data centers and servers, organizations can access technology services on an as-needed basis from cloud providers like Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP).

NIST (National Institute of Standards and Technology) Definition

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Core Characteristics of Cloud Computing

The NIST model lists five essential characteristics that define a true cloud computing service:

- **1. On-Demand Self-Service:** A consumer can unilaterally provision computing capabilities (such as server time and network storage) automatically, without requiring human interaction with the service provider.
- **2. Broad Network Access:** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).
- **3. Resource Pooling:** The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.
- **4. Rapid Elasticity:** Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited.
- **5. Measured Service:** Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts).

Advantages and Disadvantages

- **Advantages:** Trade Capital Expense (CapEx) for Variable Expense (OpEx); Benefit from massive economies of scale; Stop guessing capacity needs; Increase speed and agility; Stop spending money running and maintaining data centers; Go global in minutes.
- **Disadvantages:** Dependence on internet connectivity (downtime risks); Potential security and privacy vulnerabilities on shared infrastructure; Limited control over underlying hardware; Vendor lock-in (difficulty migrating applications and data to another provider).

1.2 Cloud Service Models: IaaS, PaaS, SaaS

Cloud computing services are organized into three primary models, representing different levels of control and management responsibility.

Detailed Service Models Analysis

- **Infrastructure as a Service (IaaS):** Contains the basic building blocks for cloud IT. It provides access to networking features, computers (virtual or dedicated hardware), and data storage space. It offers the highest level of flexibility and management control over your IT resources. The customer is responsible for managing the operating system, middleware, runtimes, applications, and data. (Examples: Amazon EC2, Azure VMs, Google Compute Engine).
- **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. The provider manages the OS, middleware, and runtime. (Examples: AWS Elastic Beanstalk, Heroku, Google App Engine).
- **Software as a Service (SaaS):** Provides you with a complete product that is run and managed by the service provider. In most cases, people referring to SaaS are referring to end-user applications. With a SaaS offering, you don't 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 software. (Examples: Google Workspace, Microsoft 365, Salesforce).

Summary of Shared Responsibility

Responsibility Layer	On-Premises	IaaS (Infrastructure)	PaaS (Platform)	SaaS (Software)
Applications & Data	Customer	Customer	Customer	Provider
Runtime & Middleware	Customer	Customer	Provider	Provider
Operating System	Customer	Customer	Provider	Provider
Virtualization & Hypervisor	Customer	Provider	Provider	Provider
Server, Storage, Network	Customer	Provider	Provider	Provider

1.3 Deployment Models & Distributed Storage

We deploy cloud architectures using different hosting configurations, supported by distributed data management.

Cloud Deployment Models

- **Public Cloud:** Owned and operated by a third-party cloud service provider, which delivers computing resources over the Internet. Multiple tenants share the same physical hardware.
- **Private Cloud:** Cloud infrastructure operated solely for a single organization. It can be managed by the organization itself or a third party, and hosted on-premises or off-premises.
- **Hybrid Cloud:** Connects public and private clouds, allowing data and applications to be shared between them. This gives businesses greater flexibility and optimization of their infrastructure.
- **Community Cloud:** Shared by several organizations with common concerns (e.g., security requirements, compliance standards).

Distributed Cloud Storage

Cloud storage relies on distributed data storage architectures to ensure high availability, durability, and scalability. Instead of saving data to a single hard drive, distributed systems break files into blocks, replicate them across multiple disks and servers located in different power zones, and manage metadata to reconstruct files instantly. This prevents data loss even if entire server racks fail.

Unit Summary

This unit introduced the foundations and service models of Cloud Computing.

- Cloud Computing is the on-demand delivery of IT resources over the internet.
- NIST defines five characteristics: self-service, broad access, pooling, elasticity, and measured services.
- Service models include IaaS (raw infrastructure), PaaS (runtimes), and SaaS (complete applications).
- Deployment choices are Public (multi-tenant), Private (single-tenant), Hybrid, and Community clouds.
- Distributed storage uses data replication and redundancy across servers to prevent data loss.

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