Unit 1st

[TCS 074 - Cloud Computing]

Introduction: From Distributed Computing to Cloud Computing

Distributed Computing Overview:

Distributed computing is a computing model in which multiple interconnected computers work together to complete complex tasks. In a distributed system, tasks are divided across multiple systems (nodes) connected through a network. The main advantage of distributed computing was the ability to process large datasets by sharing workloads among multiple machines, making it efficient for complex calculations, big data analysis, and scientific simulations.

For example:

SETI@home Project: One of the earliest large-scale distributed computing projects, SETI@home, allowed volunteers to use their computers to analyze radio signals from space in search of extraterrestrial intelligence. By distributing the workload across thousands of volunteer computers, SETI achieved greater computational power than was possible with a single machine.

The Shift to Cloud Computing:

The transition to cloud computing began as organizations realized the limitations of traditional distributed computing, particularly the high infrastructure and maintenance costs. Cloud computing transformed this model by offering resources on demand over the internet, creating a centralized system where resources are available when needed. Instead of setting up and maintaining complex networks, companies now use cloud providers for their infrastructure, focusing on innovation and scalability without the need for physical servers.

Cloud computing simplified resource management, enabling businesses to reduce costs, scale easily, and deploy applications rapidly.This shift has profoundly impacted organizations of all sizes, allowing them to access enterprise-grade IT resources without a substantial investment in physical hardware.

Principles and Characteristics of Cloud Computing

Cloud computing has key characteristics that set it apart from traditional IT infrastructure:

On-Demand Self-Service: Users can access resources (like storage, processing power, and applications) as needed through a web portal or API, eliminating the need for manual provisioning. For instance, when a business anticipates a sudden surge in website traffic, it can quickly allocate more computing resources via cloud services, accommodating traffic spikes without delay.

Broad Network Access: Resources are accessible from anywhere with an internet

connection, ensuring flexibility and enabling remote work. For example, Google Drive allows users to access and share files across devices—phones, tablets, or computers—from any location with internet access.

Resource Pooling: Cloud providers use a multi-tenant model, dynamically assigning and reallocating resources across multiple users. This model ensures efficiency and scalability, as resources are pooled to meet varying demands. For example, Amazon Web Services (AWS) serves millions of clients worldwide by pooling massive data center resources.

Rapid Elasticity: Resources can be quickly scaled up or down, often automatically, in response to demand changes. E-commerce companies like Shopify rely on cloud elasticity during peak seasons (like Black Friday) to accommodate traffic surges without risking downtime.

Measured Service: Cloud providers use a pay-as-you-go model, where users are billed based on resource consumption. For instance, Netflix's infrastructure on AWS is highly variable in terms of demand, so AWS tracks and bills Netflix based on its usage, making costs predictable and aligned with actual use.

Types of Cloud Service Models: IaaS, PaaS, SaaS

Cloud computing is provided through different service models, each catering to distinct business needs:

Infrastructure as a Service (IaaS):

Definition: IaaS offers foundational computing resources—such as virtual machines, storage, and networks—over the internet. Users control operating systems, storage, and deployed applications but don't need to manage physical hardware.

Advantages: IaaS is ideal for businesses needing a high level of control over their environment and who want to avoid investing in costly on-premises hardware.

Real-Life Example:
Amazon Web Services (AWS): AWS provides virtual machines (EC2), storage solutions (S3), and networking tools, enabling companies like Airbnb to scale infrastructure as needed without managing physical servers. AWS also supports high-performance computing for tasks like big data processing, backup, and recovery.

Platform as a Service (PaaS):

Definition: PaaS delivers a platform with tools and environments that developers can use to build, test, and deploy applications. The provider manages infrastructure, allowing developers to focus on coding and application functionality.

Advantages: PaaS simplifies development by removing infrastructure management from the equation, offering pre-built environments that speed up the development cycle.

Real-Life Example:

Google App Engine: Google App Engine enables developers to build and host applications using Google's infrastructure. Snap, the company behind Snapchat, uses Google App Engine to scale application resources automatically based on user demand, allowing Snapchat to support millions of active users without managing servers.

Software as a Service (SaaS):

Definition: SaaS delivers fully functional software applications accessible over the internet. Users interact with the application but don't manage or control the underlying infrastructure.

Advantages: SaaS eliminates the need for software installation, maintenance, and updates on local devices, reducing IT overhead and allowing users to access applications from anywhere.

Real-Life Example:
Salesforce: As a leading CRM solution, Salesforce allows organizations to manage customer relationships and sales processes via a web interface. By operating in the cloud, Salesforce allows teams to access customer data remotely, enhancing productivity and collaboration across global sales teams.

Difference between IAAS, PAAS and SAAS

Basis Of	IAAS	PAAS	SAAS
Stands for	Infrastructure as a service.	Platform as a service.	Software as a service.
Uses	IAAS is used by network architects.	PAAS is used by developers.	SAAS is used by the end user.
Access	IAAS gives access to the resources like virtual machines and virtual storage.	PAAS gives access to run time environment to deployment and development tools for application.	SAAS gives access to the end user.
Model	It is a service model that provides virtualized computing resources over the internet.	It is a cloud computing model that delivers tools that are used for the development of applications.	It is a service model in cloud computing that hosts software to make it available to clients.
Technical understanding.	It requires technical knowledge.	Some knowledge is required for the basic setup.	There is no requirement about technicalities company handles

Basis Of	IAAS	PAAS	SAAS
			everything.
Popularity	It is popular among developers and researchers.	It is popular among developers who focus on the development of apps and scripts.	It is popular among consumers and companies, such as file sharing, email, and networking.
Percentage rise	It has around a 12% increment.	It has around 32% increment.	It has about a 27 % rise in the cloud computing model.
Usage	Used by the skilled developer to develop unique applications.	Used by mid-level developers to build applications.	Used among the users of entertainment.
Cloud services.	Amazon Web Services, sun, vCloud Express.	Facebook, and Google search engine.	MS Office web, Facebook and Google Apps.
Enterprise services.	AWS virtual private cloud.	Microsoft Azure.	IBM cloud analysis.
Outsourced cloud services.	Salesforce	Force.com, Gigaspaces.	AWS, Terremark
User Controls	Operating System, Runtime, Middleware, and Application data	Data of the application	Nothing
Others	It is highly scalable and flexible.	It is highly scalable to suit the different businesses according to resources.	It is highly scalable to suit the small, mid and enterprise level business

Advantages of IaaS

- The resources can be deployed by the provider to a customer's environment at any given time.
- Its ability to offer the users to scale the business based on their requirements.
- The provider has various options when deploying resources including virtual machines, applications, storage, and networks.
- It has the potential to handle an immense number of users.
- It is easy to expand and saves a lot of money. Companies can afford the huge costs associated with the implementation of advanced technologies.
- Cloud provides the architecture.
- Enhanced scalability and quite flexible.
- Dynamic workloads are supported.

Disadvantages of IaaS

- Security issues are there.
- Service and Network delays are quite a issue in IaaS.

When to Use IaaS

Choosing Infrastructure as a Service (IaaS) sets businesses up for future success, irrespective of their size. With IaaS, one can easily adjust their resources as your business grows or changes, all without dealing with physical hardware. This means one have to only pay for what they need, keeping costs in check. Plus, they have total control over their setup, allowing them to customize it to fit your needs and keep up with industry standards. If they run into any issues, they can count on support from their provider to help out. And with IaaS, they are always up-to-date with the latest tech advancements, keeping them competitive in the market. So, by using IaaS, businesses can stay flexible, save money, and keep up with the times, paving the way for future innovation and success.

Advantages of PaaS

- Programmers need not worry about what specific database or language the application has been programmed in.
- It offers developers the to build applications without the overhead of the underlying operating system or infrastructure.
- Provides the freedom to developers to focus on the application's design while the platform takes care of the language and the database.
- It is flexible and portable.
- It is quite affordable.
- It manages application development phases in the cloud very efficiently.

Disadvantages of PaaS

- Data is not secure and is at big risk.
- As data is stored both in local storage and cloud, there are high chances of data mismatch while integrating the data.

When to Use PaaS

PaaS is ideal when developers prioritize cost-effectiveness and efficiency in creating unique applications. By unloading tasks like software updates and security patches, PaaS enables developers to focus on the creative aspects of app development, such as designing, testing, and deploying. Use PaaS when you want to streamline development, reduce time spent on maintenance, and maximize focus on innovation.

Advantages of SaaS

- It is a cloud computing service category providing a wide range of hosted capabilities and services. These can be used to build and deploy web-based software applications.
- It provides a lower cost of ownership than on-premises software. The reason is it does not require the purchase or installation of hardware or licenses.
- It can be easily accessed through a browser along a thin client.
- No cost is required for initial setup.
- Low maintenance costs.
- Installation time is less, so time is managed properly.

Disadvantages of SaaS

- Low performance.
- It has limited customization options.
- It has security and data concerns.

When to Use SaaS
SaaS Platform are ideal when you want applications to work smoothly without needing much effort from you. It's great for businesses that want quick access to tools like email, project management, or customer relationship management (CRM) software.

Service-Oriented Computing and the Cloud Environment

Understanding Service-Oriented Computing (SOC)
Service-oriented computing (SOC) is an architectural model that emphasizes the creation of reusable services for building applications. SOC is based on principles like interoperability, reusability, and modularity, which enable efficient and scalable software development.

Key SOC Characteristics:

Interoperability: Services can work together regardless of their origin or platform. For example, many services use REST APIs, allowing different systems to communicate seamlessly, making SOC ideal for complex, multi-application environments.

Reusability: Services are designed to be reused across multiple applications, reducing the need to write new code. For instance, a payment gateway service could be used by multiple e-commerce websites within the same organization.

Modularity: SOC encourages breaking down software into modular components, each performing a specific function. This approach simplifies development and makes it easier to update or replace individual services without affecting the whole application.

SOC and Cloud Computing

Cloud computing is particularly well-suited for SOC due to the flexible, scalable, and accessible nature of cloud environments. Service-oriented applications can be hosted on cloud platforms, allowing for modular, efficient, and high-performance computing.

Benefits of SOC in the Cloud:

Scalability: SOC applications on the cloud can handle increased loads by allocating more resources during high-demand periods. For example, Netflix uses microservices (an implementation of SOC) in combination with AWS to manage millions of streaming requests daily.

Cost Efficiency: By deploying modular services on a cloud platform, organizations can allocate and pay for resources based on actual usage, saving costs.
- **Simplified Development**: Cloud providers offer development tools and environments (like AWS Lambda for serverless computing) that allow developers to build and manage services without setting up infrastructure.

Real-Life Example:
Netflix: Netflix adopted a microservices architecture (an implementation of SOC) to handle the demands of millions of users streaming content daily. AWS provides the necessary cloud infrastructure, allowing Netflix to scale each microservice independently and handle peak demand efficiently.

Benefits and Challenges of Cloud Computing

Benefits of Cloud Computing

Cost Savings: Cloud computing eliminates the need for large capital investments in IT infrastructure, as users can pay for resources as they need them. For example, startups can use IaaS to access powerful computing resources without purchasing expensive servers.

Scalability and Flexibility: Cloud resources can be scaled up or down based on demand, making it suitable for applications with fluctuating workloads. For instance, retailers like Walmart use cloud computing to scale their infrastructure during peak shopping periods, such as holidays, without purchasing permanent hardware.

Disaster Recovery and Backup: Cloud providers offer reliable disaster recovery and backup options, ensuring data security and business continuity. Dropbox, for instance, provides cloud-based storage solutions that enable users to back up files and recover them easily in case of hardware failure.

Challenges of Cloud Computing

Security and Privacy: Storing data on third-party servers can introduce security risks. Many companies invest in encryption, authentication, and other security measures to ensure data integrity. Healthcare companies, for instance, must follow stringent data security standards (like HIPAA in the U.S.) when using cloud services to store patient data.

Compliance: Cloud computing can pose challenges for organizations with strict data regulations. Financial institutions, for instance, may need to ensure data storage

complies with laws like GDPR (for EU citizens' data) and CCPA (for California residents' data).

Dependency on Internet Connectivity: Cloud services depend on internet access, which may not be reliable in some areas. In remote locations, limited internet connectivity can restrict access to cloud resources, making local infrastructure a preferable option for critical operations.

Conclusion of UNIT 1st:

Cloud computing represents a paradigm shift from traditional, on-premises IT infrastructure to highly scalable, flexible, and accessible resources available on demand. This evolution has allowed organizations to focus on growth and innovation without investing heavily in physical infrastructure.

By adopting cloud computing, companies have gained unprecedented flexibility, scalability, and efficiency, allowing them to adapt to changing business needs. Cloud service models (IaaS, PaaS, SaaS) offer varying levels of control and simplicity, enabling businesses of all sizes to select the best solution for their unique needs. Furthermore, combining cloud computing with service-oriented computing has led to modular, reusable, and high-performance applications, driving the efficiency and agility of modern businesses.

Through real-world examples like Netflix, Amazon, Salesforce, and Google, the practical benefits of cloud computing are evident in everyday services that millions of people rely on worldwide.

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