

The Cloud Computing: A Review Paper

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Abstract

Cloud computing has transformed the way organizations approach IT infrastructure and service delivery by enabling on-demand access to computing resources over the internet. Rather than investing heavily in physical servers, storage and networking up front, businesses can adopt a pay-as-you-go model that shifts the major expense from capital expenditure (CapEx) to operational expenditure (OpEx). This change not only reduces upfront cost and financial risk, but also enables more flexible budgeting and allocation of resources.

One of the most important benefits is scalability and elasticity: organizations can rapidly scale resources up or down in response to demand fluctuations such as seasonal peaks, sudden project-bursts or variable workload patterns without having to over-provision infrastructure in advance. This sensitivity to demand leads to more efficient resource utilization and better cost management. At the same time, cloud platforms enhance agility: new services or applications can be deployed quickly because the underlying infrastructure is already available, allowing businesses to test ideas, iterate faster and accelerate time-to-market. Cloud computing also opens the door to advanced technologies that might otherwise be out of reach such as artificial intelligence (AI), machine learning (ML), predictive analytics and large-scale data processing. Because cloud providers offer powerful compute, storage and analytics platforms, organizations can leverage these capabilities without large upfront hardware investments. This contributes to innovation and strategic differentiation. Accessibility and collaboration are further improved: cloud-based tools and services make it easier for users and teams to access applications and data anytime, anywhere, and from multiple devices, which supports remote work, cross-location projects and flexible operations. Security, disaster recovery and business continuity are additional advantages. Many cloud providers offer robust infrastructure with redundancy, backup, and disaster-recovery solutions built-in. This means that organizations can improve their resilience to hardware failures, site outages or data loss without bearing all the costs themselves. Moreover, cloud providers typically maintain dedicated security expertise and compliance capabilities, which can strengthen an organization's security posture although responsibility for configuration and governance remains shared. Finally, cloud computing also contributes to sustainability efforts: by leveraging shared infrastructure, optimizing energy usage and reducing the footprint of individual data centers, organizations can align their IT operations with environmental goals and corporate social responsibility.

Keywords: *Cloud Computing, Cloud Security, Hybrid Cloud, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Private Cloud, Public Cloud, Software as a Service (SaaS).*

Introduction

Just as real clouds consist of clusters of water molecules, the term “cloud” in cloud computing represents a networked collection of computing resources. In this model, users access computing services on demand rather than relying on dedicated physical infrastructure. The formal definition offered by the National Institute of Standards and Technology describes cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (such as networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or provider interaction.

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Instead of organizations or individuals setting up and maintaining their own hardware, they typically rely on third-party providers that deliver cloud services over the internet, allowing them to pay only for what they use. This pay-as-you-go pricing model is central to the value proposition of cloud computing.

A key advantage of cloud computing is workload distribution: heavy computational or storage tasks are handled by the cloud provider's infrastructure rather than local machines. The cloud network thus manages computing loads, reduces the burden on end-devices and ensures efficient application performance.

This arrangement minimizes the need for extensive hardware or local software installations on the user's end. Access to these cloud-based services typically requires only a web browser (for example, Google Chrome) or a thin client, since the bulk of processing and storage is handled remotely. This makes it possible for users to engage with sophisticated applications and services without owning or maintaining the underlying infrastructure.

The key features of Cloud Computing:

- I.I Resource Pooling and Elasticity
- I.II Self-Service and On-Demand Services
- I.III Pricing
- I.IV Quality of Service

Cloud computing provides three primary service models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

In the SaaS model, the cloud provider delivers fully-developed applications over the internet, managing underlying infrastructure, operating systems, and updates. Users simply access the software via a browser or mobile app without worrying about installation or maintenance.

PaaS provides an environment for building, testing, deploying, and managing applications—developers focus on application logic while the provider handles infrastructure, runtime, operating system, and middleware.

IaaS offers virtualized computing resources—such as servers, storage, and networking—on demand. Users retain control over operating systems, middleware, applications and data, while the provider manages the underlying hardware.

Some common examples of cloud-based applications in daily life include social media platforms, video-sharing services, file-hosting solutions and web-mail systems—these make use of the SaaS model by giving users access to services over the internet without needing to host or manage infrastructure.

Cloud computing is widely adopted across enterprises because of its scalability (resources can grow or shrink with demand), flexibility (various service models and deployment options), agility (rapid provisioning and delivery of services) and simplicity (reduced administrative overhead for infrastructure). These benefits contribute significantly to its growing popularity across diverse industries.

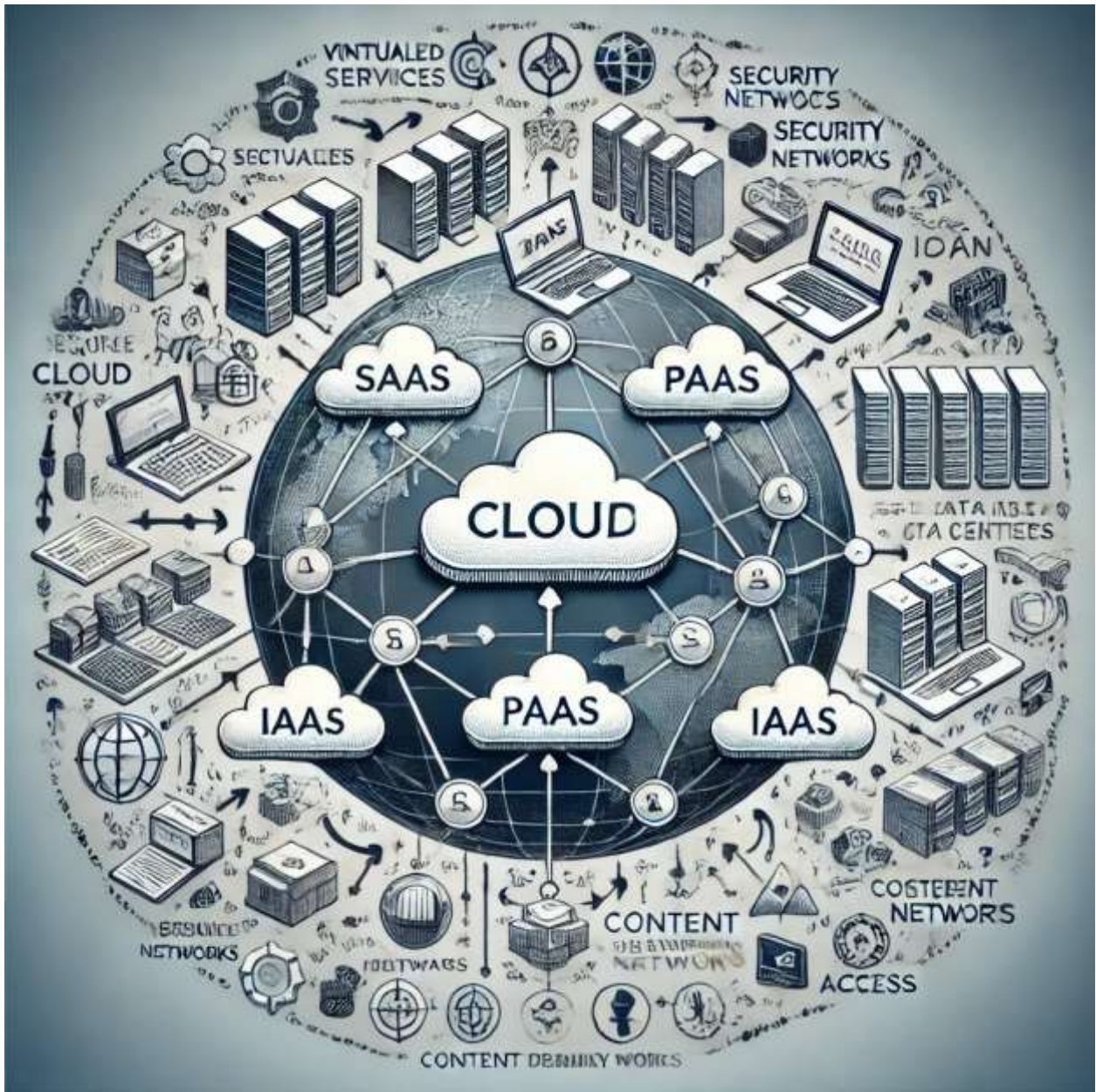


Fig 1: Network of Cloud

Evolution of Cloud Computing

Cloud computing's evolution is a testament to decades of technological innovation and visionary thinking. The concept of delivering computing resources as a utility was first proposed by John McCarthy, a prominent computer scientist, in 1961 during a speech at MIT's centennial celebration. He suggested that computing could be organized as a public utility, similar to the telephone system, allowing users to access computing power on demand.

Fast forward to 1999, Salesforce revolutionized the software industry by introducing the idea of delivering software applications over the internet. Founded by Marc Benioff, Salesforce launched its cloud-based CRM platform, allowing businesses to access and manage customer relationships without the need for on-premises software installations. This shift marked the beginning of the Software as a Service (SaaS) model, where applications are hosted in the cloud and accessed via the internet.

In 2002, Amazon took a significant step towards realizing McCarthy's vision by launching Amazon Web Services (AWS). Initially offering simple storage and computational power, AWS evolved into a comprehensive cloud platform that provides a wide range of services, including computing power, storage, and databases, all accessible over the internet. This move not only transformed Amazon's

business model but also laid the foundation for the Infrastructure as a Service (IaaS) model, where users can rent computing resources on-demand.

By 2009, major technology companies like Google, Microsoft, HP, and Oracle recognized the potential of cloud computing and entered the market. These companies introduced various cloud services, further accelerating the adoption of cloud technologies across industries. Google's cloud offerings, for instance, provided scalable infrastructure and tools for developers, while Microsoft's Azure platform offered a comprehensive suite of cloud services for enterprises.

Today, cloud computing has become an integral part of daily life. Services like Google Photos, Google Drive, and iCloud allow users to store, access, and share data seamlessly across devices. These platforms exemplify the SaaS model, providing users with convenient access to applications and data without the need for local installations.

Looking ahead, cloud computing is poised to remain a cornerstone of IT infrastructure. Its scalability, flexibility, and cost-effectiveness make it an essential component for businesses and individuals alike. As technology continues to advance, the cloud will likely evolve to support emerging trends such as artificial intelligence, machine learning, and the Internet of Things, further shaping the future of technology.

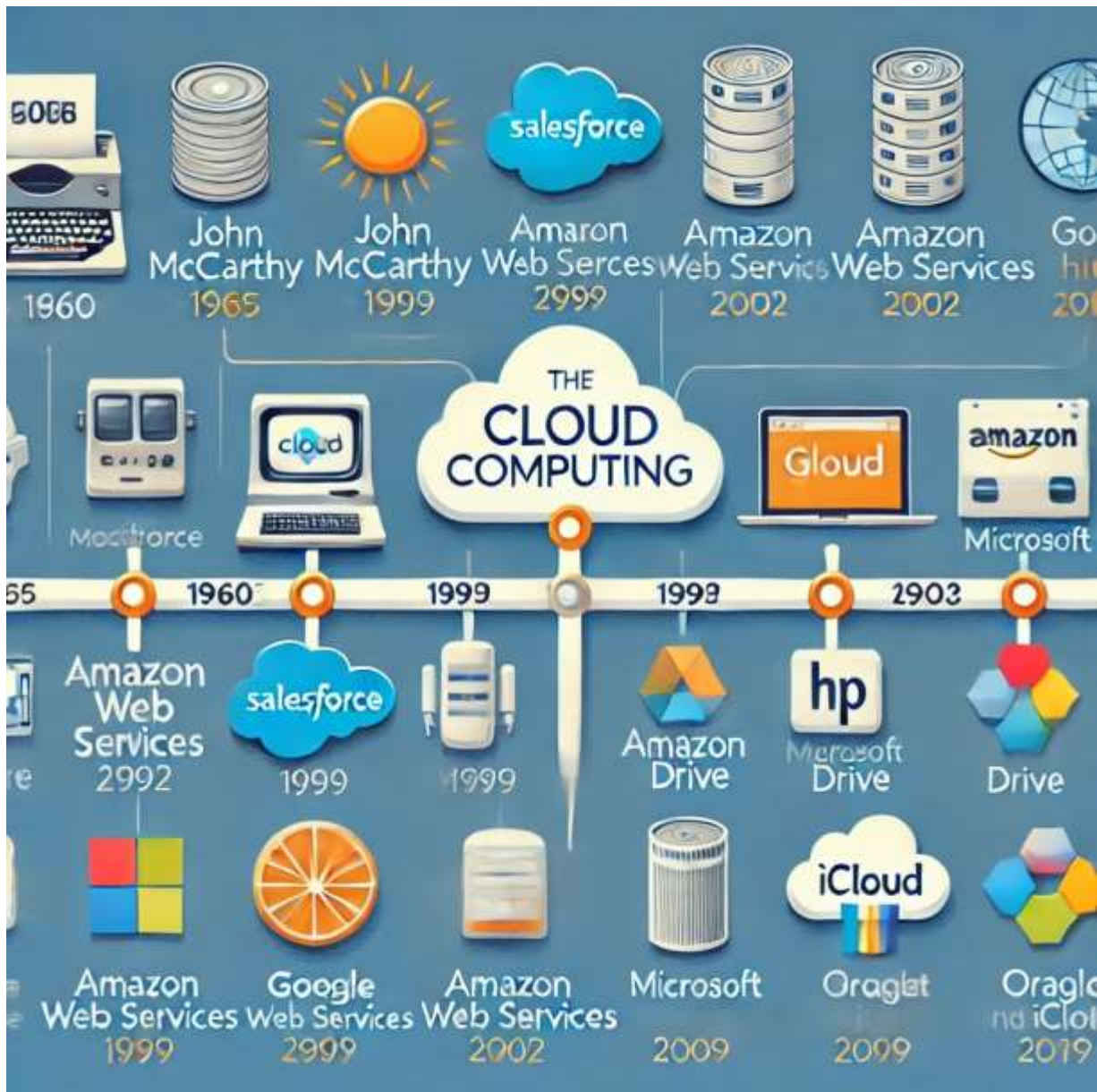


Fig 2 Evolution of Cloud Computing

Components of Cloud Computing

Cloud computing has three basic components as follows:

Client Computers:

Client computers serve as the interface through which end users interact with cloud services. These devices can range from traditional desktop computers and laptops to mobile devices such as smartphones and tablets.

The client-side platform includes the hardware and software that allow users to access cloud applications and data. Users typically interact with the cloud via web browsers, mobile applications, or specialized client software. The client device communicates with cloud services over the internet, sending requests and receiving responses. This setup enables users to access cloud-based resources from virtually anywhere, provided they have an internet connection.

Distributed Servers:

Distributed servers form the backbone of cloud computing infrastructure. These servers are strategically located in various geographic regions and are interconnected to function as a cohesive system.

By distributing workloads across multiple servers, cloud providers can enhance performance, reliability, and scalability. This distribution ensures that if one server experiences issues, others can take over the load, minimizing service disruptions.

Additionally, distributing servers allows for efficient load balancing, where tasks are allocated based on server capacity and current load, optimizing resource utilization. This architecture is fundamental to the cloud's ability to provide on-demand, scalable services.

Data Centers:

Data centers are physical facilities that house the servers and other critical components of cloud infrastructure.

They are equipped with the necessary hardware, such as servers, storage devices, and networking equipment, to support cloud services. Beyond hardware, data centers are designed with robust power supplies, cooling systems, and security measures to ensure continuous operation and data protection.

Cloud providers often operate multiple data centers across different regions to enhance redundancy and meet compliance requirements. These data centers are interconnected to form a global network, enabling cloud providers to offer services with high availability and low latency to users worldwide.

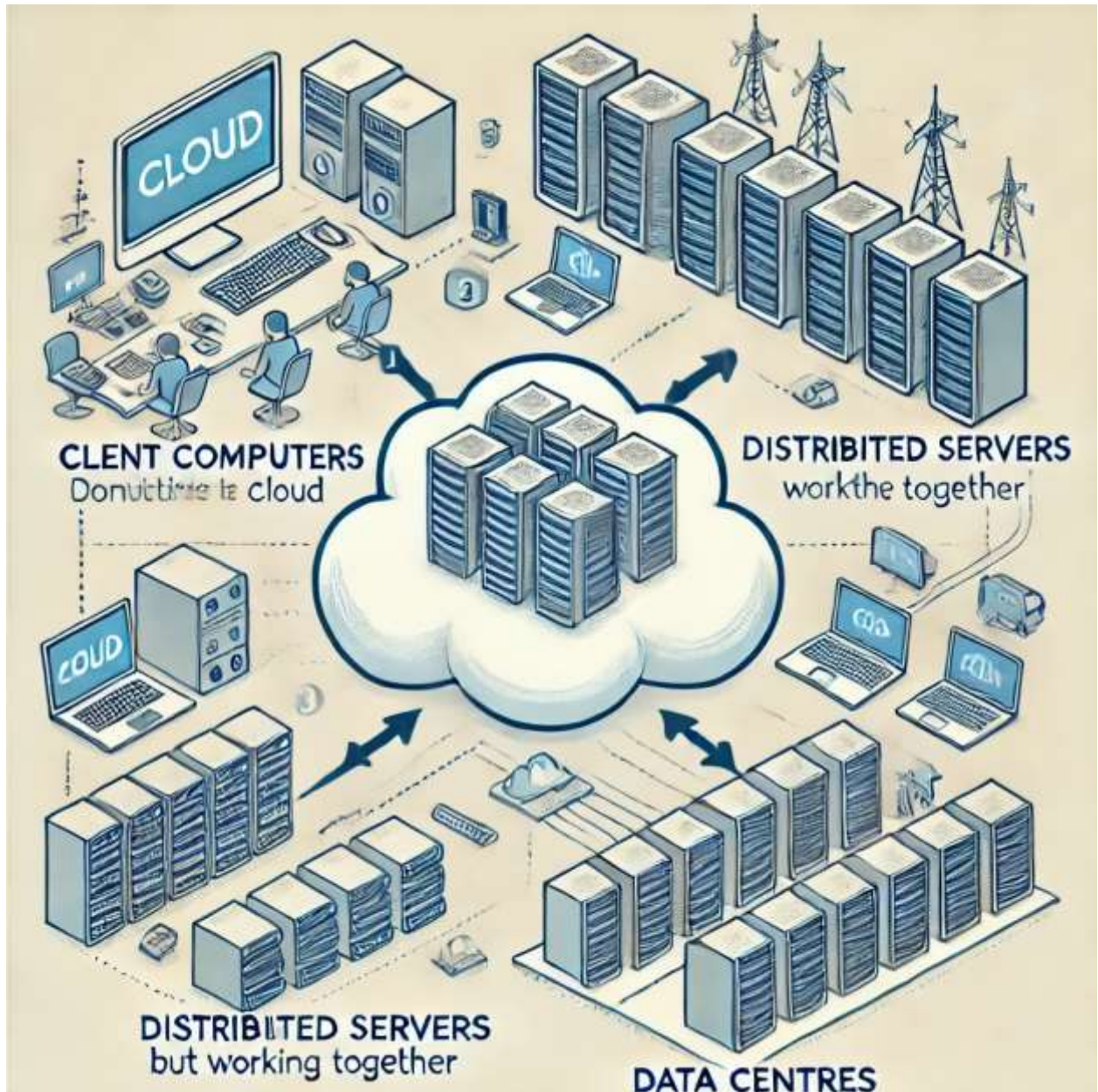


Fig 3 Components

Services of Cloud Computing

IV.1 Software as a Service (SaaS):

Software as a Service (SaaS) is a cloud-based software delivery model where applications are hosted by a third-party provider and made available to users over the internet. This model eliminates the need for users to install, manage, or maintain software locally on their devices.

Instead, users can access the software through a web browser or application, paying a subscription fee for the service. The provider handles all aspects of the software, including updates, security, and infrastructure maintenance.

The primary advantage of SaaS is its convenience and cost-effectiveness. Users can access the software from any device with an internet connection, facilitating remote work and collaboration. Additionally, the subscription model often reduces upfront costs and ensures that users always have access to the latest features and security updates.

Platform as a Service (PaaS):

Platform as a Service (PaaS) provides a cloud-based environment that allows developers to build, deploy, and manage applications without the complexity of maintaining the underlying infrastructure.

PaaS offerings typically include development tools, operating systems, databases, and middleware, all hosted and managed by the provider. This model enables developers to focus on writing code and developing functionality, rather than dealing with hardware and software configurations.

Examples of PaaS include Google App Engine, Microsoft Azure App Service, and Heroku. These platforms support various programming languages and frameworks, offering scalability and flexibility for application development. By abstracting the infrastructure layer, PaaS accelerates the development process and allows for rapid deployment and scaling of applications.

Infrastructure as a Service (IaaS):

Infrastructure as a Service (IaaS) is a cloud computing model that provides virtualized computing resources over the internet.

IaaS offers fundamental infrastructure services such as virtual machines, storage, networking, and operating systems on a pay-as-you-go basis. Users have control over the operating systems, applications, and data, but the provider manages the physical hardware and infrastructure.

IaaS is ideal for businesses that require scalable and flexible computing resources without the capital expense of purchasing and maintaining physical hardware. Providers like Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform offer IaaS solutions that support a wide range of applications, from simple websites to complex enterprise systems. The ability to scale resources up or down based on demand makes IaaS a cost-effective and efficient solution for many organizations.

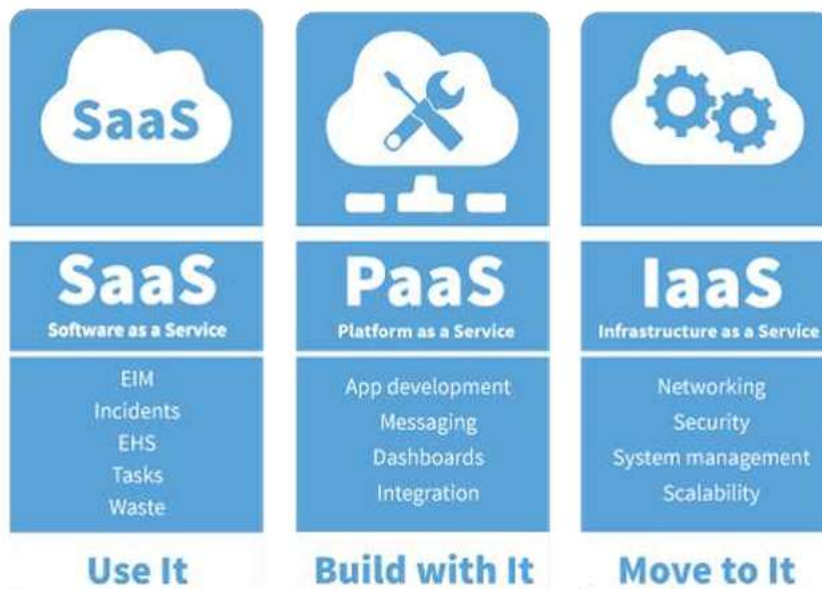


Fig 4 Cloud Computing Services

Types of Cloud Computing

Public Cloud

The public cloud is a cloud computing model where computing resources such as servers, storage, and networking are owned and operated by third-party providers and made available to users over the internet. These resources are shared among multiple customers, allowing users to access and use them on a pay-as-you-go basis. Public cloud services are typically hosted in the provider's data centers and are accessible to any user who subscribes to the service.

The primary advantages of the public cloud include cost-effectiveness, scalability, and flexibility. Since the infrastructure is shared among multiple users, the costs are distributed, making it more affordable for individual users and small businesses. Additionally, public cloud services can scale resources up or down based on demand, providing flexibility to meet changing needs. Examples of public cloud services include Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform.

Private Cloud:

A private cloud is a cloud computing environment that is used exclusively by a single organization. Unlike the public cloud, where resources are shared among multiple users, a private cloud provides dedicated resources to a single organization, offering greater control and security. Private clouds can be hosted on-premises within the organization's own data center or by a third-party provider.

The primary benefits of a private cloud include enhanced security, customization, and compliance.

Organizations can implement stricter security measures and tailor the infrastructure to meet specific business needs and regulatory requirements. Private clouds are often used by large enterprises and organizations that handle sensitive data or have specific compliance requirements. Examples of private cloud solutions include VMware vSphere and OpenStack.

Hybrid Cloud:

A hybrid cloud is a cloud computing environment that combines elements of both public and private clouds, allowing data and applications to be shared between them. This model enables organizations to take advantage of the scalability and cost-effectiveness of the public cloud while maintaining control over critical workloads in a private cloud.

The hybrid cloud approach offers flexibility and optimization of existing infrastructure. Organizations can keep sensitive data and critical applications in the private cloud, while leveraging the public cloud for less-sensitive workloads and to handle peak demands. This model is particularly beneficial for businesses that require a balance between control, security, and scalability. Examples of hybrid cloud solutions include Microsoft Azure Stack and AWS Outposts.

Benefits of Cloud Computing

Cost Saving

Cloud computing offers significant cost advantages by eliminating the need for businesses to invest in and maintain physical infrastructure. Instead of purchasing servers, storage devices, and networking equipment, organizations can access these resources on a pay-as-you-go basis through cloud service providers.

This model transforms capital expenditures into operational expenses, allowing businesses to scale their IT resources according to demand without incurring large upfront costs. Additionally, cloud providers often handle maintenance, updates, and security, reducing the need for in-house IT staff and further lowering operational costs.

Flexibility and Scalability

Cloud computing provides unparalleled flexibility and scalability, enabling businesses to quickly adjust their IT resources in response to changing demands. Whether experiencing seasonal traffic spikes, unexpected growth, or fluctuating workloads, organizations can scale their computing resources up or down without the delays associated with traditional hardware provisioning.

This dynamic scalability ensures that businesses can maintain optimal performance and efficiency, adapting swiftly to market changes and operational needs. Moreover, cloud platforms often offer auto scaling capabilities, automatically adjusting resources to match real-time demand, which helps in managing costs effectively.

Enhanced Security:

Contrary to some misconceptions, cloud computing can enhance data security through advanced technologies and practices implemented by reputable cloud service providers.

These providers invest in robust security measures, including data encryption during transmission and storage, strong access controls, and comprehensive key management systems. By leveraging the expertise and resources of cloud providers, businesses can benefit from security protocols that may be more sophisticated than those achievable with on-premises solutions.

Additionally, cloud services often include features for data backup and disaster recovery, further safeguarding against data loss and ensuring business continuity.

Conclusion

In this review paper, I described in short the introduction, evolution, types and components of cloud computing and also different approaches of cloud computing and some of its advantages.

This review has provided an overview of cloud computing, covering its introduction, evolution, core components, deployment models, service models, and key advantages. As we've seen, cloud computing has become an integral part of modern technology infrastructure, offering scalable, flexible, and cost-effective solutions for businesses and individuals alike.

The application of cloud computing continues to expand across various industries. According to recent statistics, over 90% of companies worldwide utilize cloud services, with a significant portion of their workloads hosted in the cloud. This widespread adoption underscores the transformative impact of cloud computing on business operations and society.

In conclusion, cloud computing is not just a technological advancement but a catalyst for innovation and efficiency in the digital age. Its ongoing evolution promises to further shape the future of technology, driving progress across industries and enhancing the way we live and work.

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