KLE Technological University
Creating Value
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KLE TECH.

Master of Computer Applications

Chapter 1
Introduction to Cloud Computing

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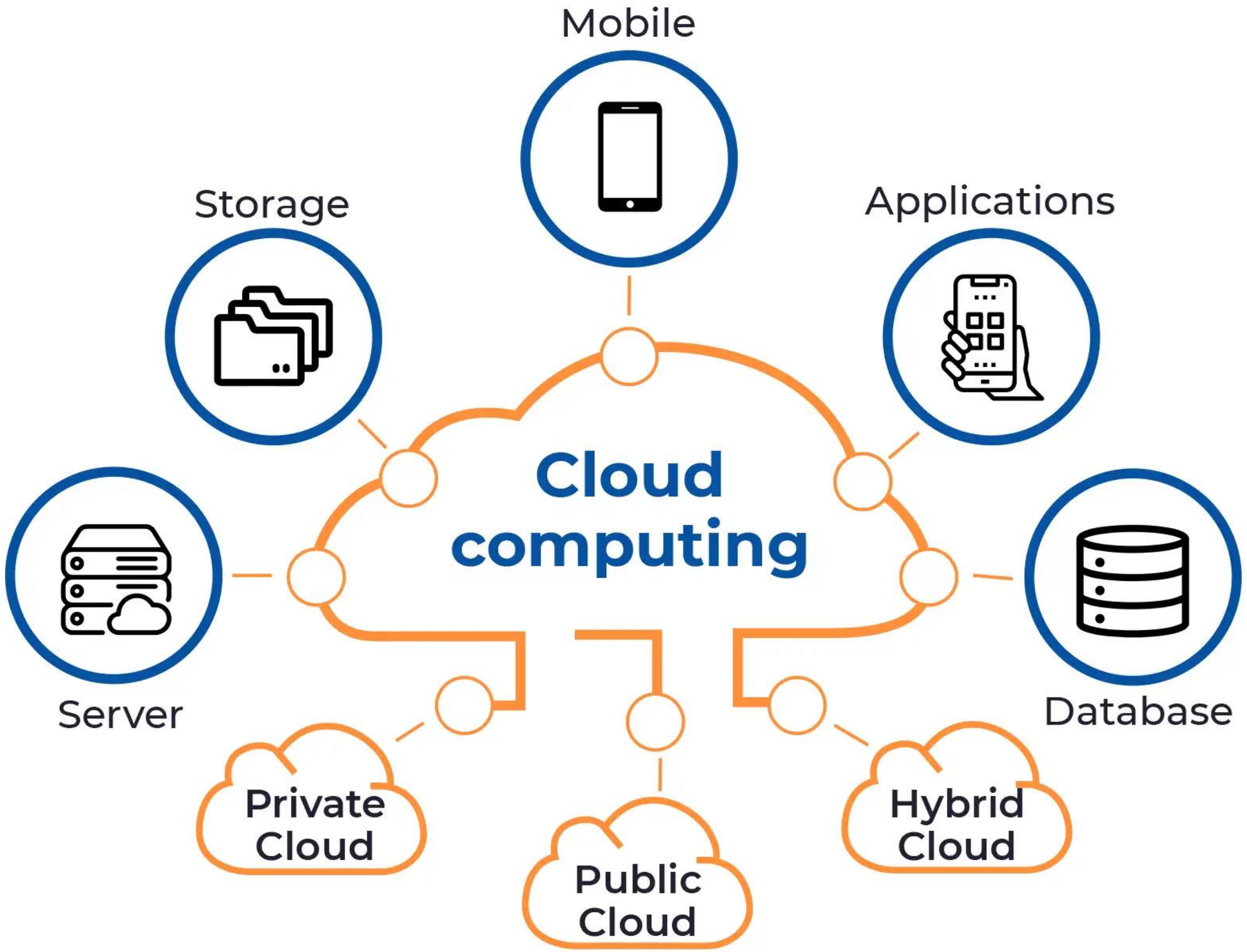
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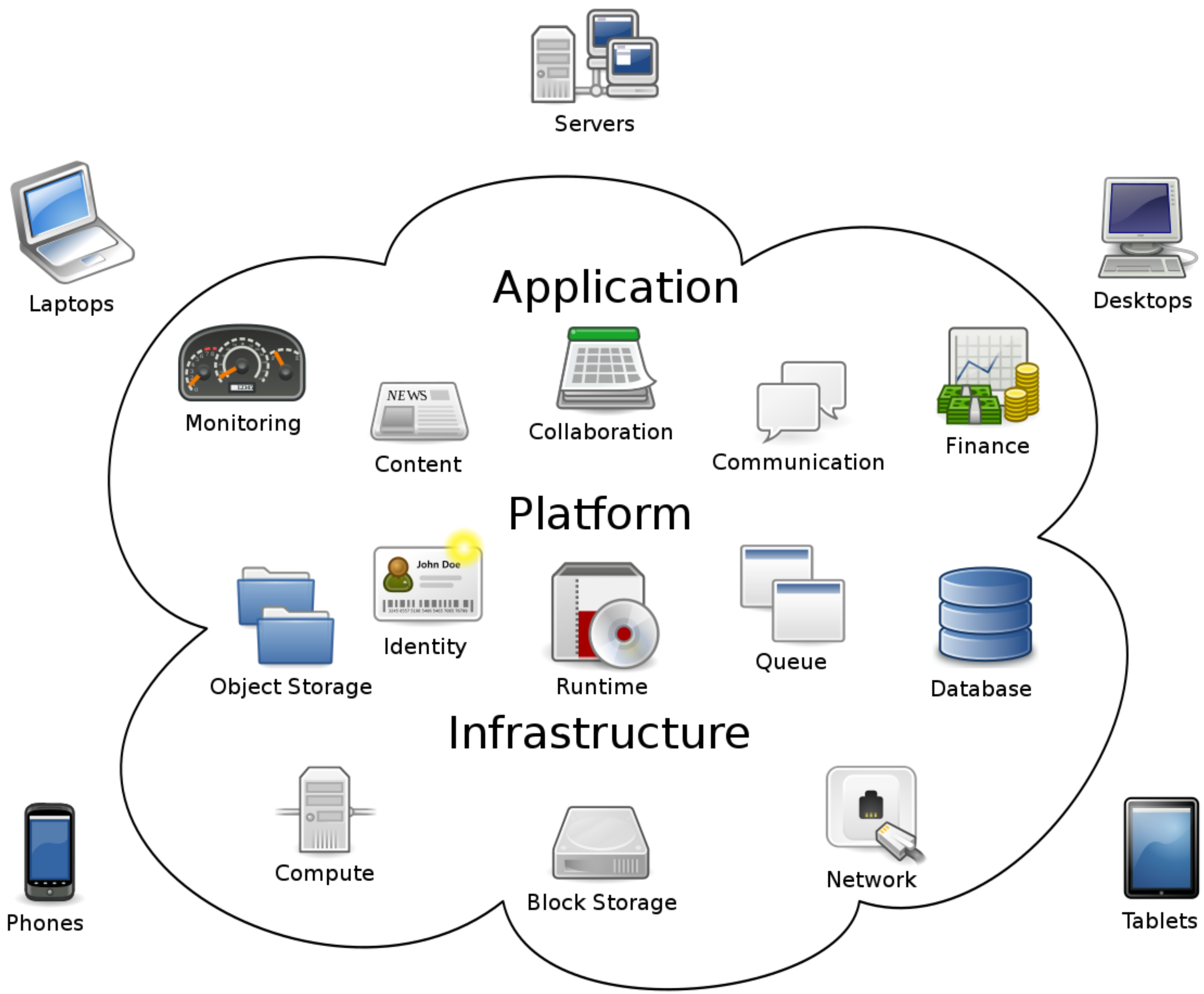
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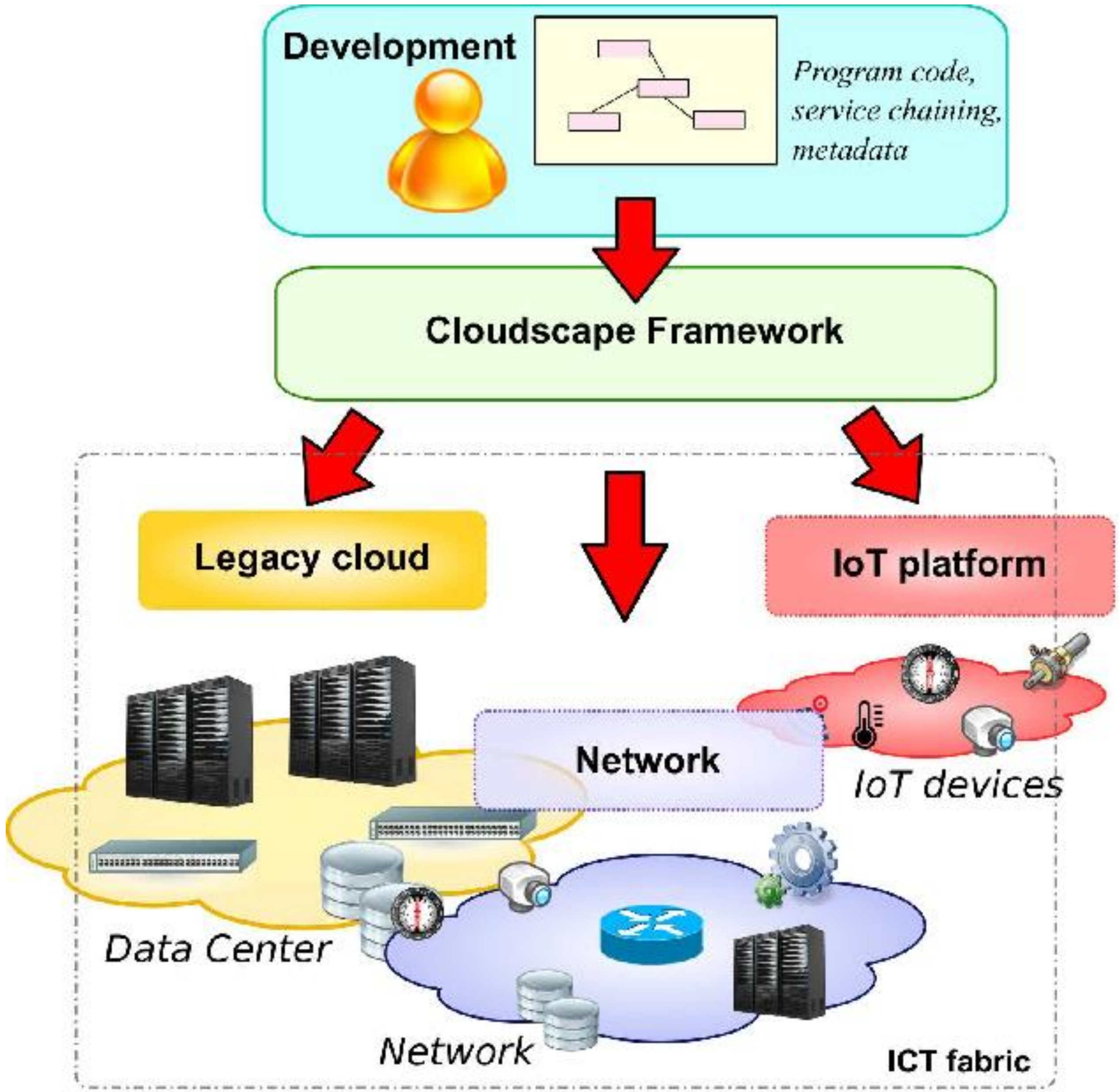
Network-centric computing



Network-centric computing

- Information processing can be **done more efficiently on large farms of computing and storage systems accessible via the Internet**
- “Distributed environments where **applications and data are exchanged** among peers across a network on as as-needed basis.”

The key features of network-centric computing

Distributed processing:

- The computing tasks are distributed across multiple devices and servers connected through a network, allowing for parallel processing and improved performance.

Resource sharing:

- Network-centric computing enables the sharing of computing resources, such as processing power, storage, and software applications, among multiple users and devices.
- This leads to efficient resource utilization and cost savings.

Centralized management:

- Network-centric computing often involves centralized management of computing resources, which simplifies administration, improves security, and allows for efficient resource allocation and monitoring

The key features of network-centric computing

Collaboration and communication:

- The network infrastructure facilitates real-time communication and collaboration between users and devices.
- It enables sharing of data, files, and information, as well as enables collaborative work on shared documents or projects

Scalability and flexibility:

- Network-centric computing allows for easy scalability of computing resources by adding or removing devices from the network.
- It also provides flexibility in accessing and managing resources based on user requirements.

Network-centric computing

- Network-centric computing has been instrumental in the development of various technologies and applications, such as cloud computing, distributed computing, grid computing, and the Internet of Things (IoT).
- It has enabled the seamless integration of devices, services, and data across networks, leading to increased productivity, collaboration, and innovation in various fields, including business, research, and entertainment.

Network-centric computing- Examples

- **Grid computing**
  - initiated by the National Labs in the early 1990s; targeted primarily at scientific computing.
  - A collection of distributed computing resources available over a local or wide are network, that appears to an end user or application as one large virtual computing system
  - Grid computing is **a computing infrastructure that combines computer resources spread over different geographical locations to achieve a common goal**.

Difference between Grid Computing and Cloud Computing

Grid Computing VS Cloud Computing

Criteria	Grid Computing	Cloud Computing
User Management	Decentralised management	Centralised management
Dependancy	Other computer picks up the work whenever the computer stops	Totally dependent on internet
Operation	Operates within a corporate network	Can also operate through the internet
Accessibility	Through Grid middleware	Through standard Web protocols
Domains	Multiple Domains	Single Domain
Scalability	Normal	High
Architecture	Distributed computing architecture	Client-server architecture
Virtualization	Data and computing resources	Hardware and software platforms
Computation	Maximum computing	On-demand
Application Type	Batch	Interactive

Network-centric computing - Examples

- Utility computing
  - initiated in 2005-2006 by IT companies and targeted at enterprise computing
  - Utility computing is a service provisioning model where a provider makes computing resources, infrastructure management and technical services available to customers as they need them.
  - The provider then charges the customer for the amount of services they use rather than a flat-rate fee

Network-centric computing - Example

Utility computing

- The focus of utility computing is on the business model for providing computing services; it often requires a cloud-like infrastructure.
- Cloud computing is a path to utility computing embraced by major IT companies including: Amazon, HP, IBM, Microsoft, Oracle, and others.

Network-centric computing - Example

Cloud Computing	Utility Computing
Cloud Computing also works like utility computing, you pay only for what you use but Cloud Computing might be cheaper, as such, Cloud based app can be up and running in days or weeks.	Utility computing refers to the ability to charge the offered services, and charge customers for exact usage
In cloud computing, provider is in complete control of cloud computing services and infrastructure	Utility computing users want to be in control of the geographical location of the infrastructure
Cloud computing is great and easy to use when the selection infrastructure and performance is not critical	Utility computing is more favorable when performance and selection infrastructure is critical
Cloud computing is a good choice for high resource demanding	Utility computing is a good choice for less resource demanding
Cloud computing refers to the underlying IT architecture	Utility computing refers to a business model

Network-centric content

- Content: any type or volume of media, be it static or dynamic, monolithic or modular, live or stored, produced by aggregation, or mixed.
- The “Future Internet” will be content-centric.
- The creation and consumption of audio and visual content is likely to transform the Internet to support increased quality in terms of resolution, frame rate, color depth, stereoscopic information.

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Network Centric Content.

- Network-centric content refers to digital content that is specifically designed or optimized for distribution and consumption over computer networks.
- It encompasses various forms of media and applications that rely on network connectivity to be accessed and utilized. Here are some examples of network-centric content:

Examples – Network Centric Content

- **Streaming Media:** Services like Netflix, YouTube, and Spotify deliver video and audio content over the internet, allowing users to stream movies, TV shows, music, and podcasts directly to their devices.
- **Online Gaming:** Multiplayer online games, such as Fortnite, World of Warcraft, or Call of Duty, rely on network connectivity to enable players to compete or collaborate with others in real-time.
- **Web-based Applications**: Many web applications, such as Google Docs, Trello, or Slack, are designed to be accessed and used through web browsers, leveraging network connectivity for real-time collaboration and data synchronization.

Examples – Network Centric Content

- **Social Media Platforms**: Platforms like Facebook, Instagram, and Twitter facilitate the sharing and consumption of user-generated content, including photos, videos, and text posts, across networks.
- **Social Media Platforms**: Platforms like Facebook, Instagram, and Twitter facilitate the sharing and consumption of user-generated content, including photos, videos, and text posts, across networks.
- **Cloud Storage and File Sharing:** Services like Dropbox, Google Drive, and Microsoft OneDrive allow users to store their files in the cloud and access them from anywhere with network connectivity, enabling easy sharing and collaboration.

Examples – Network Centric Content

- **Video Conferencing and VoIP:** Tools like Zoom, Microsoft Teams, and Skype enable real-time audio and video communication over networks, supporting remote meetings, conferences, and virtual collaboration.
- **News and Media Websites:** Online news outlets and media platforms provide articles, videos, and other multimedia content that can be accessed and consumed through web browsers or dedicated applications.
- **E-commerce and Online Shopping:** Websites and apps like Amazon, eBay, and Alibaba enable users to browse, purchase, and sell products online, leveraging network connectivity for transactions and order fulfillment.

Network-centric computing and content

- **Data-intensive:** large scale simulations in science and engineering require large volumes of data. Multimedia streaming transfers large volume of data.
- **Network-intensive:** transferring large volumes of data requires high bandwidth networks.
- The systems are accessed using *thin clients* running on systems with limited resources, e.g., wireless devices such as smart phones and tablets.

Peer-to-Peer Systems

Peer-to-peer (P2P) systems are

- Decentralized computer networks where participants, called peers, communicate and collaborate directly with each other without the need for a central server or authority.
- In a P2P system, each peer acts as both a client and a server, sharing resources and contributing to the network's functionality.

Examples of peer-to-peer systems

BitTorrent:

- BitTorrent is a popular P2P file sharing protocol used for distributing large files across the internet.
- It allows users to download and upload files simultaneously by connecting to multiple peers who have portions of the desired file.

Bitcoin:

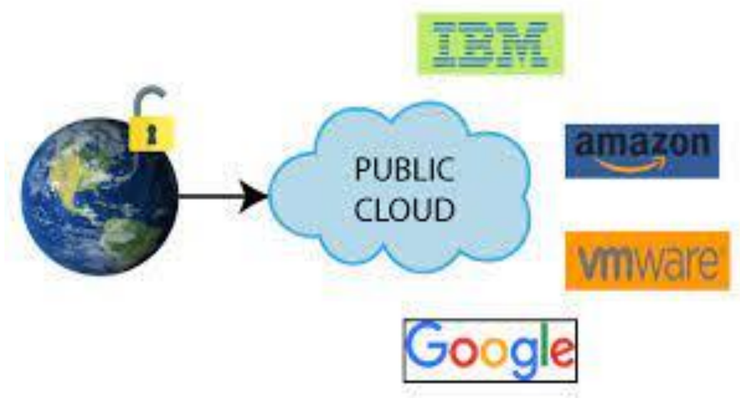
- Bitcoin is a decentralized cryptocurrency that operates on a P2P network.
- It enables users to perform transactions directly with each other, without the need for intermediaries like banks.

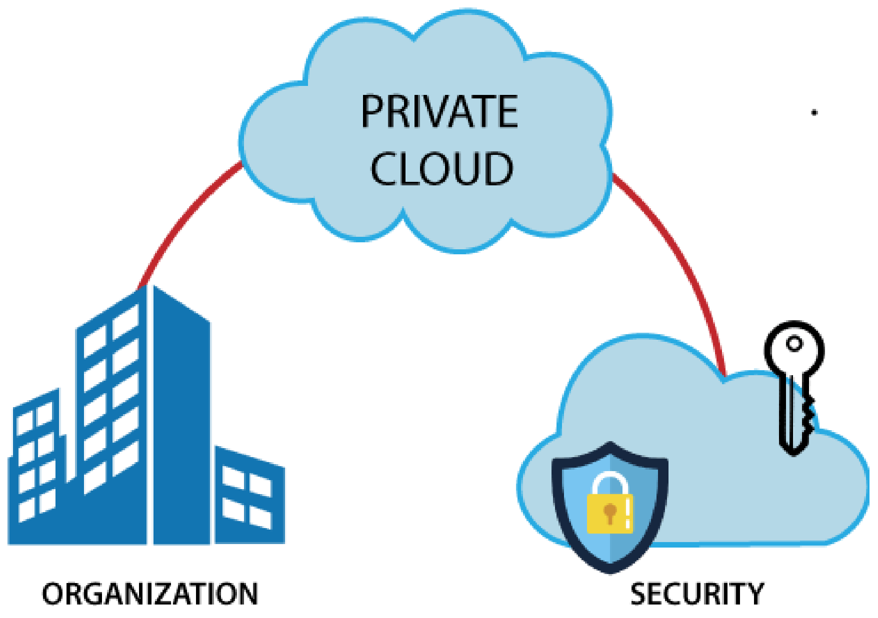
Cloud computing

- Uses Internet technologies to offer scalable and elastic services.
- The term “elastic computing” refers to the ability of *dynamically acquiring computing resources* and supporting a variable workload.
- The resources used for these services can be metered and
- the *users can be charged only for the resources they used*.
- The maintenance and security are ensured by service providers.
- The service providers can operate more efficiently due to specialization and centralization.

Types of clouds

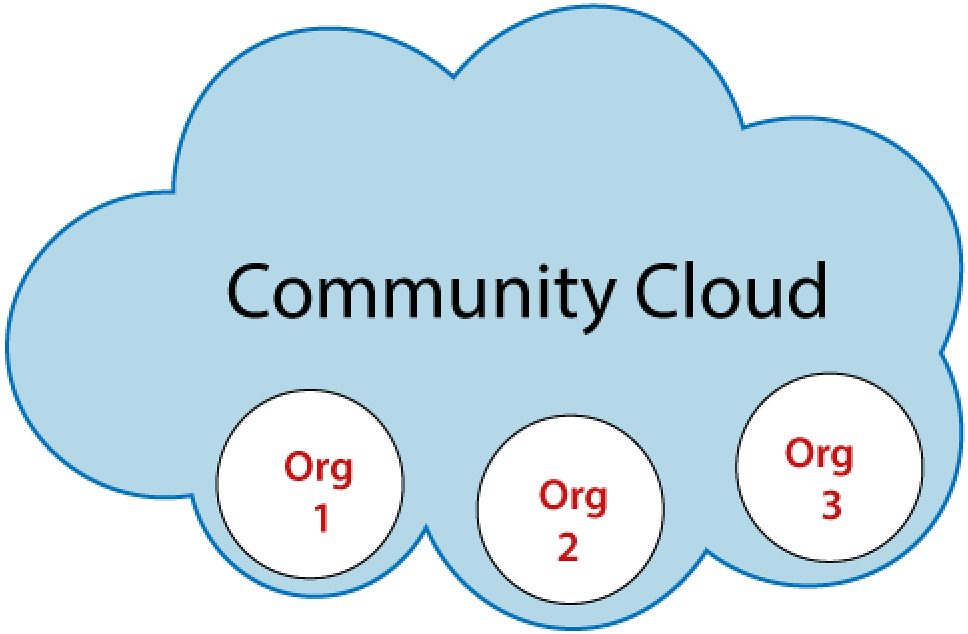
- **Public Cloud** - the infrastructure is made available to the general public or a large industry group and is owned by the organization selling cloud services.
- **Private Cloud –** the infrastructure is operated solely for an organization.



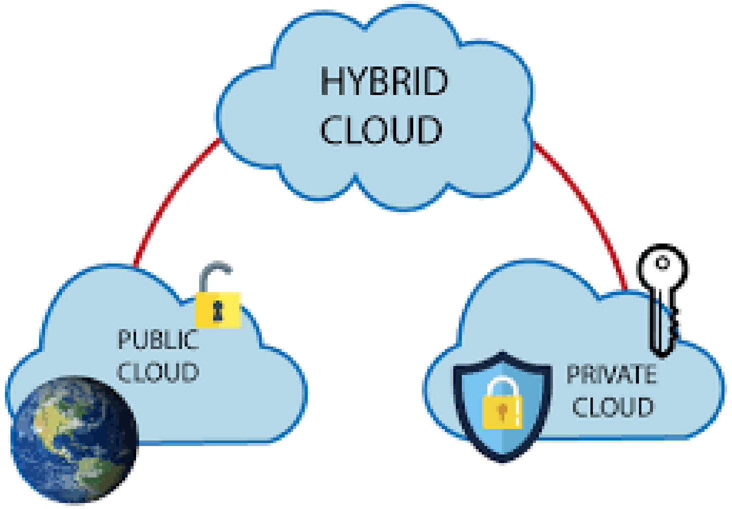


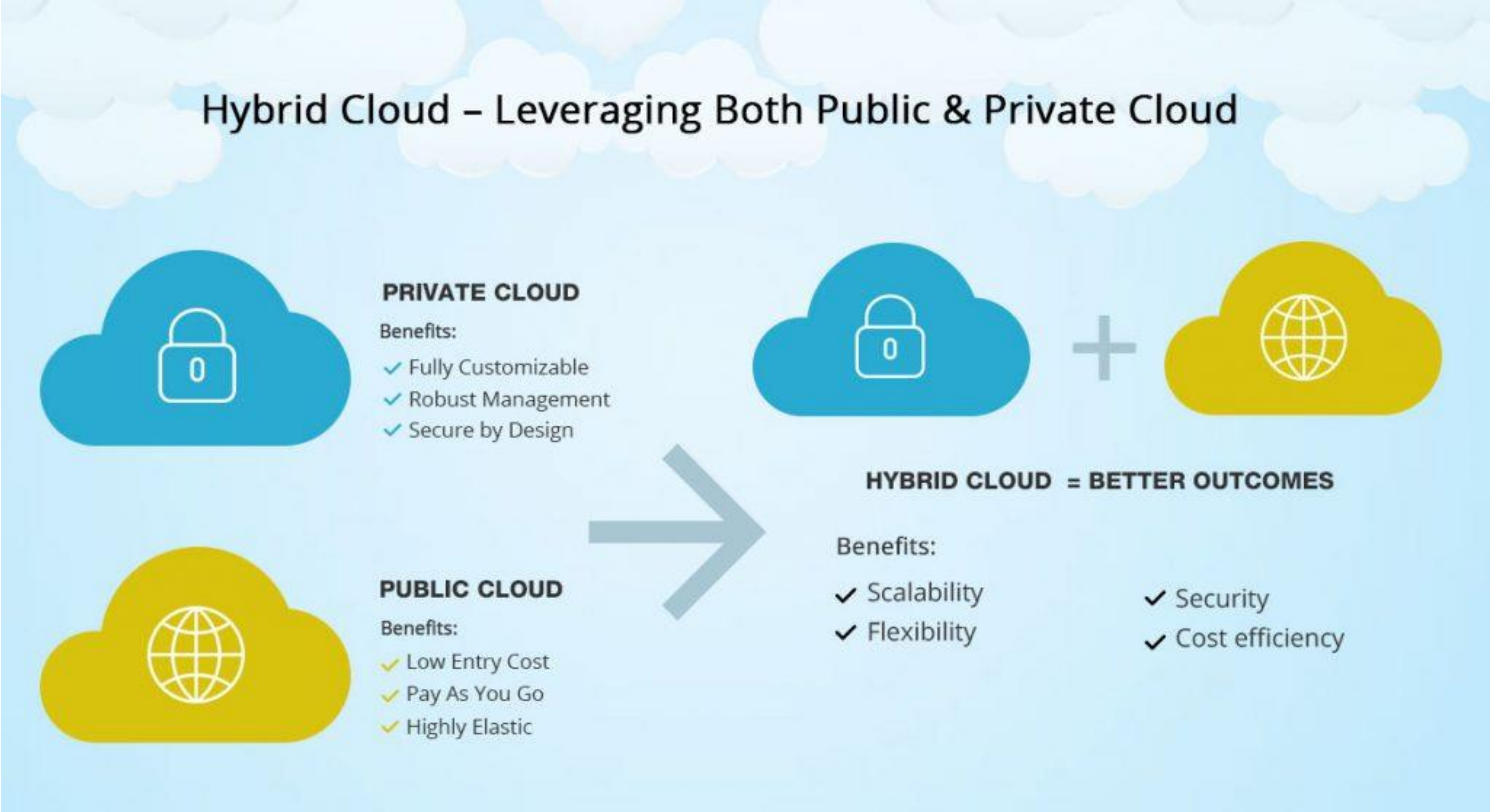
Types of clouds

- **Community Cloud** - the infrastructure is shared by several organizations and supports a community that has shared concerns.



- **Hybrid Cloud** - composition of two or more clouds (public, private, or community) as unique entities but bound by standardized technology that enables data and application portability




Hybrid Cloud – Leveraging Both Public & Private Cloud
PRIVATE CLOUD
Benefits:
Fully Customizable
Robust Management
Secure by Design
PUBLIC CLOUD
Benefits:
Low Entry Cost
Pay As You Go
Highly Elastic
HYBRID CLOUD = BETTER OUTCOMES
Benefits:
Scalability
Flexibility
Security
Cost efficiency

The “good” about cloud computing

- Resources, such as CPU cycles, storage, network bandwidth, are shared.
- When multiple applications share a system, their peak demands for resources are not synchronized thus, *multiplexing leads to a higher resource utilization*.
- Resources can be aggregated to support data-intensive applications.
- Data sharing facilitates collaborative activities.
- Many applications require multiple types of analysis of shared data sets and multiple decisions carried out by groups scattered around the globe.

Why cloud computing could be successful when other paradigms have failed?

- It is in a better position to exploit recent advances in software, networking, storage, and processor technologies promoted by the same companies who provide cloud services.
- It is focused on enterprise computing; its adoption by industrial organizations, financial institutions, government, and so on could have a huge impact on the economy.

Why cloud computing could be successful when other paradigms have failed?

- A cloud consists of a homogeneous set of hardware and software resources.
- The resources are in a single administrative domain (AD).
- Security, resource management, fault-tolerance, and quality of service are less challenging than in a heterogeneous environment with resources in multiple administrative domain(Ads).

Benefits Offered by Cloud computing

- **Scalability:** Users can easily scale up or down their computing resources based on their needs, allowing for flexibility and cost optimization.
- **Cost Savings:** Cloud computing eliminates the need for upfront investments in infrastructure and hardware.
- Users only pay for the resources they consume, shifting from a capital expenditure (CapEx) model to an operational expenditure (OpEx) model.

Benefits Offered by Cloud computing

Accessibility:

- Cloud services can be accessed from anywhere with an internet connection, enabling remote access, collaboration, and increased mobility.

Reliability and Availability:

- Cloud service providers often offer robust infrastructure and redundancy measures, ensuring high availability and reliability of services.

Agility and Innovation:

- Cloud computing enables rapid deployment of applications and services, facilitating faster time-to-market and fostering innovation.

Use of Cloud Computing in various domains

- Cloud computing is used in various domains, including business applications, data storage and backup, software development and testing, artificial intelligence, Internet of Things (IoT), and more.
- Major cloud service providers, such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP), offer a wide range of cloud services and solutions to cater to diverse user requirements.

Delivery Models in Cloud Computing

- Cloud computing offers different delivery models that define the level of control and responsibility users have over their computing resources and services.
- The three primary delivery models in cloud computing are
  - Software as a Service (SaaS),
  - Platform as a Service (PaaS), and
  - Infrastructure as a Service (IaaS)

Software as a Service (SaaS),

Software as a Service (SaaS),

- SaaS is a cloud delivery model where users access and use software applications hosted by a cloud service provider over the internet.
- With SaaS, users do not need to manage or control the underlying infrastructure, including hardware, operating systems, or application maintenance.
- They can simply use the software through a web browser or a dedicated application.
- Example: Salesforce, Google Workspace (formerly G Suite), Microsoft Office 365, and Dropbox.

Software as a Service (SaaS),

- Applications are supplied by the service provider.
- The user does not manage or control the underlying cloud infrastructure or individual application capabilities.
- Services offered include:
- Enterprise services such as: workflow management, group-ware and collaborative, supply chain, communications, digital signature, customer relationship management (CRM), desktop software, financial management, geo-spatial, and search.
- Web 2.0 applications such as: metadata management, social networking, blogs, wiki services, and portal services.

Platform as a Service (PaaS)

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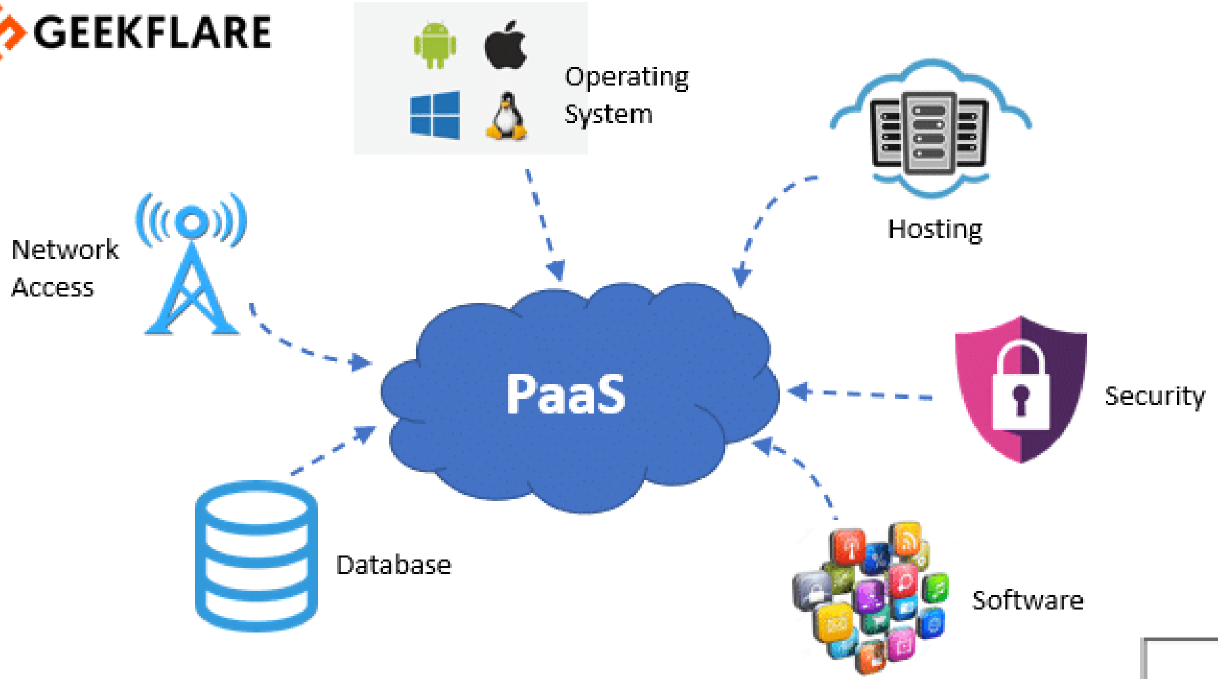
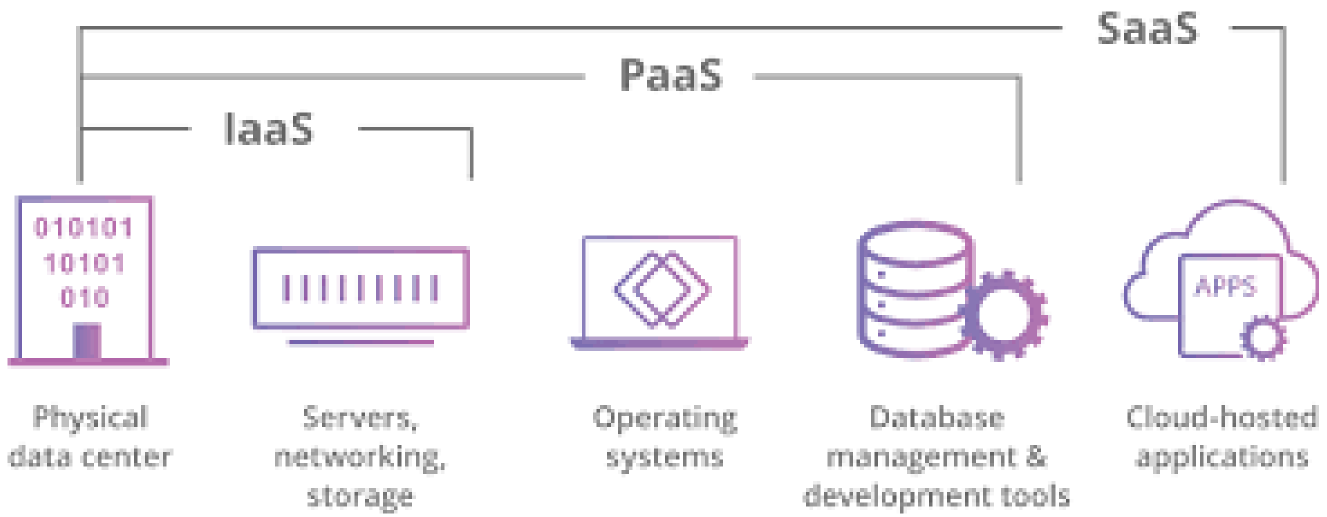
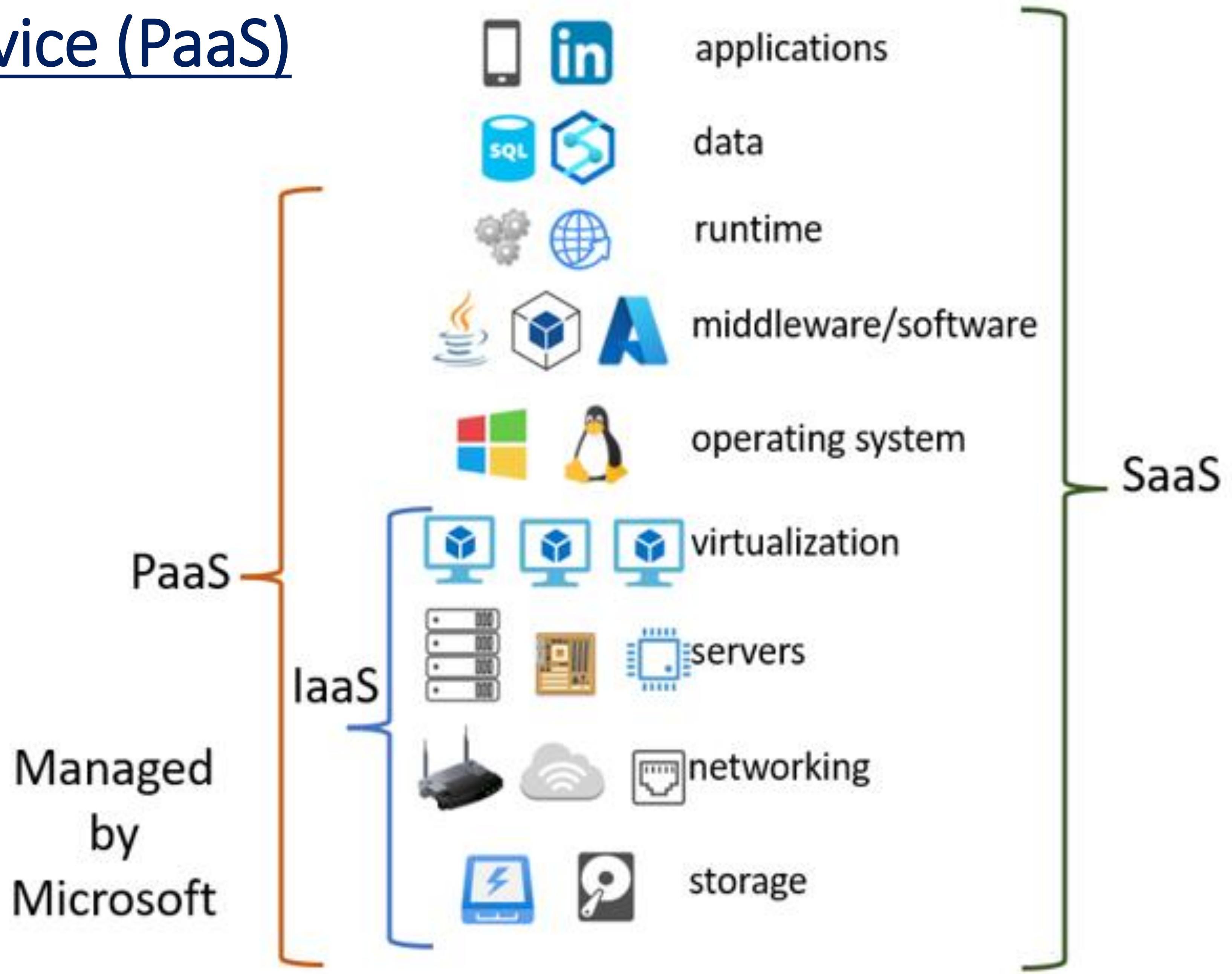




Platform as a Service (PaaS)



Platform as a Service (PaaS)

- **PaaS provides a platform and environment for users** to develop, deploy, and manage applications without the need to manage the underlying infrastructure.
- **PaaS typically includes tools**, programming languages, libraries, and frameworks to support the development and deployment of applications.
- Users have control over their applications and data, but the underlying infrastructure and operating system are managed by the cloud service provider.
- **Example:** Heroku, Google App Engine, Microsoft Azure App Service, and AWS Elastic Beanstalk.

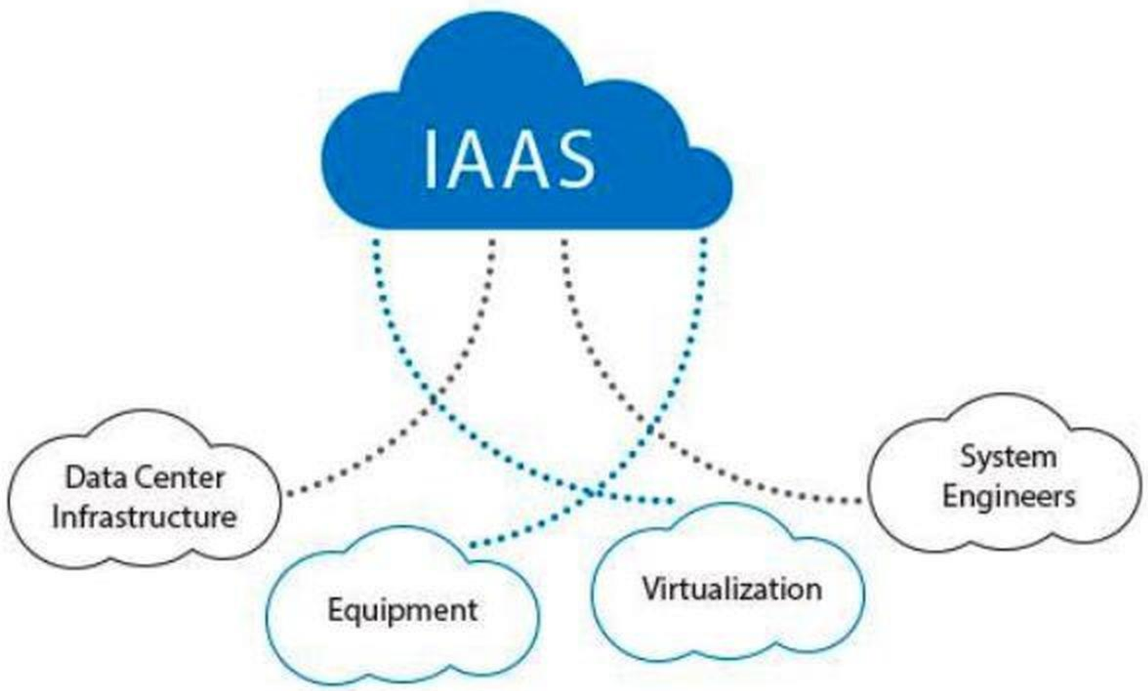
Platform as a Service (PaaS)

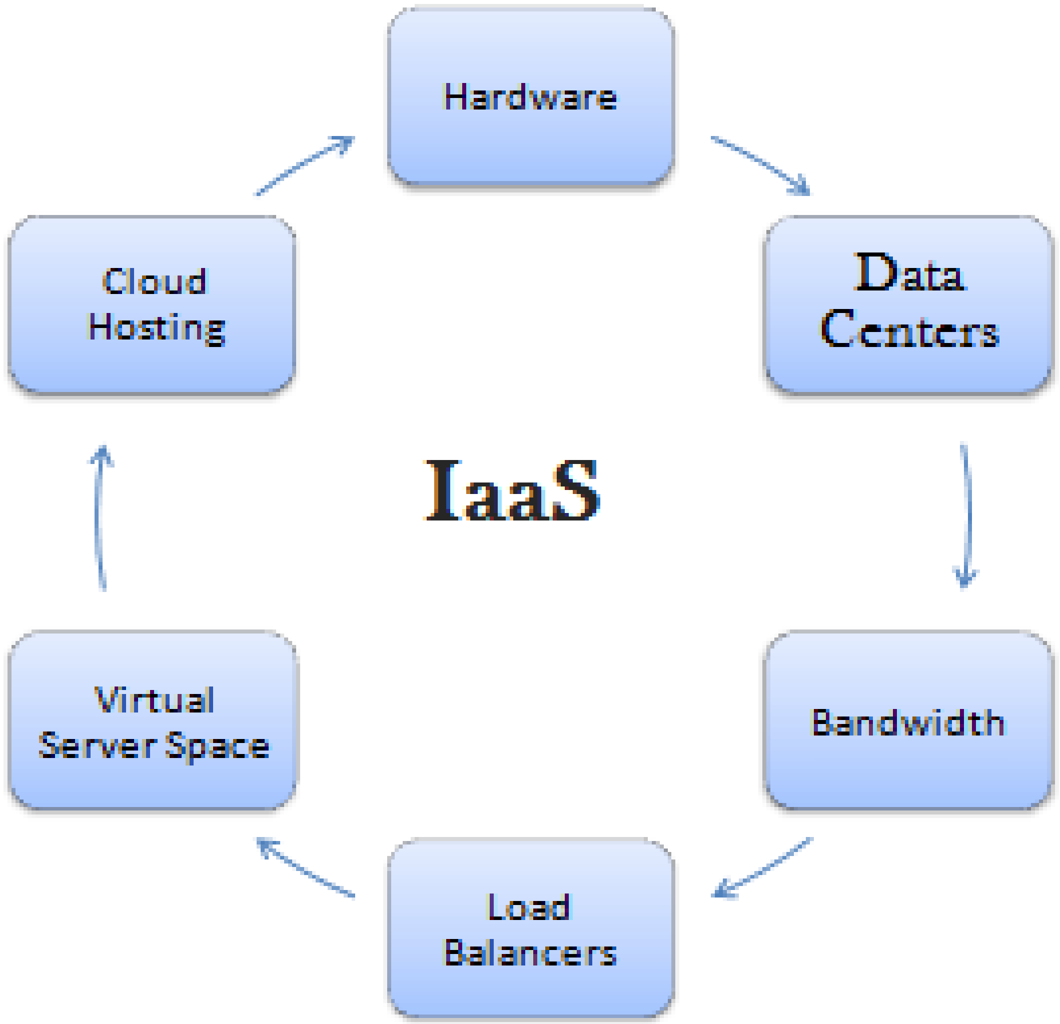
- Allows a cloud user to deploy consumer-created or acquired applications using programming languages and tools supported by the service provider.
- **The user:**
  - Has control over the deployed applications and, possibly, application hosting environment configurations.
  - Does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage.
- **Not particularly useful when:**
  - The application must be portable.
  - Proprietary programming languages are used.
  - The hardware and software must be customized to improve the performance of the application.

Infrastructure as a Service (IaaS)

- IaaS is a cloud delivery model that **provides users with virtualized computing resources over the internet**.
- It offers virtual machines, storage, and networking capabilities, allowing users to have more control and flexibility over their infrastructure.
- **Users are responsible** for managing their applications, data, and operating systems, while the cloud service provider manages the physical infrastructure.
- **Example:** Amazon EC2, Microsoft Azure Virtual Machines, Google Compute Engine, and IBM Cloud Virtual Servers.

Infrastructure as a Service (IaaS)





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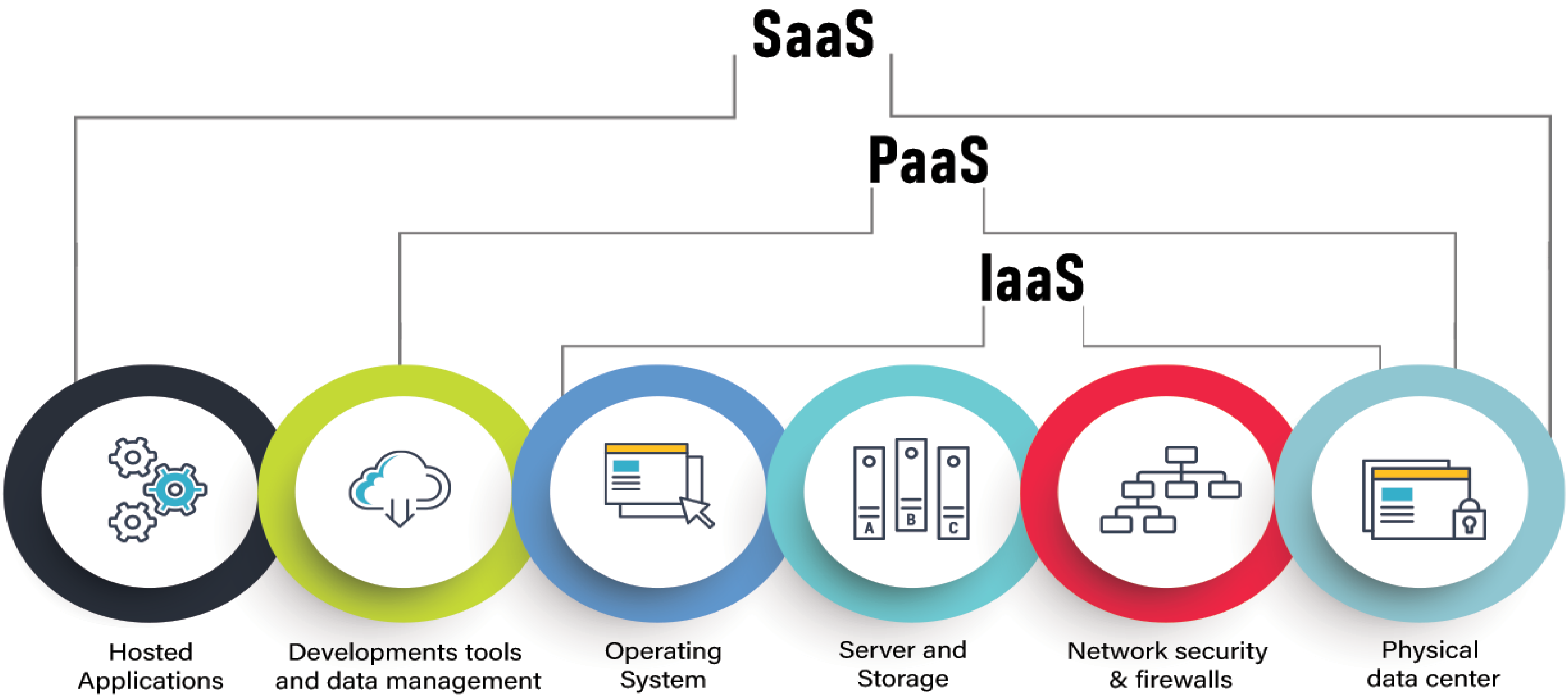
- **Users are responsible** for managing their applications, data, and operating systems, while the cloud service provider manages the physical infrastructure.
- **Example:** Amazon EC2, Microsoft Azure Virtual Machines, Google Compute Engine, and IBM Cloud Virtual Servers.

Infrastructure as a Service (IaaS)

- The user is able to deploy and run arbitrary software, which can include operating systems and applications.
- The user does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of some networking components, e.g., host firewalls.
- **Services offered by this delivery model include:**
  - server hosting, Web servers, storage, computing hardware,
  - operating systems, virtual instances, load balancing, Internet access, and bandwidth provisioning.

SaaS vs. PaaS vs. IaaS



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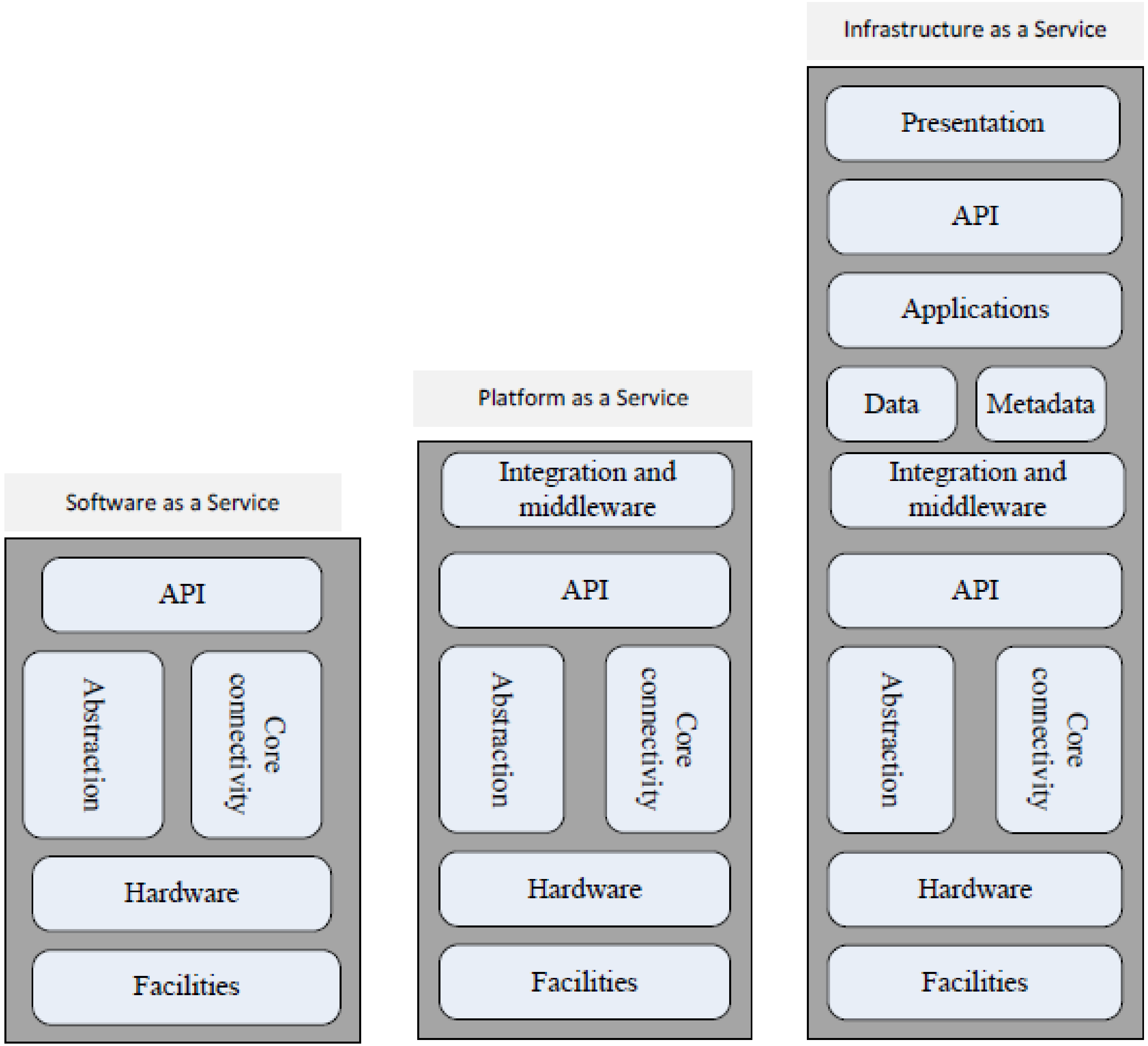
Software as a Service
API
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Core connectivity
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Platform as a Service
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API
Abstraction
Core connectivity
Hardware
Facilities
Infrastructure as a Service
Presentation
API
Applications
Data
Metadata
Integration and middleware
API
Abstraction
Core connectivity
Hardware
Facilities

Ethical Issues in Cloud Computing

- Cloud computing presents several ethical issues that need to be considered and addressed.
- Here are some of the key ethical concerns related to cloud computing:

Data Privacy:

- Cloud service providers store and process vast amounts of user data.
- Data privacy becomes a critical concern, as users need assurance that their personal information and sensitive data are protected and not accessed without their consent.
- Issues such as unauthorized data access, data breaches, and the use of personal data for advertising or profiling purposes can raise ethical questions.

Ethical Issues in Cloud Computing

Data Security:

- Cloud computing introduces new security challenges, as sensitive data is stored and processed outside the user's direct control.
- Concerns include data breaches, hacking attempts, and unauthorized access to confidential information.
- Cloud service providers must ensure robust security measures and encryption techniques to safeguard user data from unauthorized access or exploitation.

Ethical Issues in Cloud Computing

Paradigm shift with implications on computing ethics:

- The control is relinquished to third party services.
- The data is stored on multiple sites administered by several organizations.
- Multiple services interoperate across the network.

Implications

- Unauthorized access.
- Data corruption.
- Infrastructure failure, and service unavailability

Cloud Vulnerabilities

- Cloud computing introduces unique vulnerabilities that can **pose risks to the security and integrity of data and systems**.
- Here are some common cloud vulnerabilities:

Inadequate Authentication and Access Controls:

- **Weak authentication mechanisms** or improper access controls can lead to unauthorized access to cloud resources.
- **Insufficiently protected credentials,** weak passwords, and **misconfigured access controls** can allow attackers to gain unauthorized access to sensitive data or manipulate cloud resources.

Cloud Vulnerabilities

Data Breaches:

- Cloud environments may be susceptible to data breaches, where unauthorized individuals gain access to sensitive information.
- Breaches can occur due to vulnerabilities in cloud infrastructure, misconfigurations, insider threats, or attacks targeting weakly secured cloud interfaces and APIs.

Insecure APIs:

- Application Programming Interfaces (APIs) provide a means for interaction between cloud services and client applications.
- Insecure APIs can be targeted by attackers to gain unauthorized access, manipulate data, or exploit vulnerabilities in cloud systems.

Cloud Vulnerabilities

Insufficient Data Protection:

- Data stored in the cloud can be exposed to risks if adequate data protection measures are not in place.
- Lack of encryption, improper data segregation, or weak security controls can lead to data leakage or unauthorized disclosure.

Shared Technology Vulnerabilities:

- Cloud environments often share resources and infrastructure among multiple users or tenants.
- Vulnerabilities in shared technologies, such as hypervisors or underlying hardware, can be exploited to gain unauthorized access or perform attacks on other cloud tenants.

Cloud Vulnerabilities

Insider Threats:

- Insider threats involve malicious actions or negligence by individuals with authorized access to the cloud environment.
- This can include cloud service provider employees, contractors, or even compromised user accounts with elevated privileges.

Lack of Data Backup and Recovery:

- Inadequate data backup and recovery strategies can result in data loss or prolonged downtime in the event of system failures, natural disasters, or human errors.
- Without proper backup measures, recovery of data and services can be challenging or impossible.

Major Challenges Faced by Cloud Computing

Cloud computing faces several significant challenges that need to be addressed to ensure its successful adoption and operation. Here are some of the major challenges faced by cloud computing:

- **Security and Privacy:**
- Security is a top concern in cloud computing.
- Protecting sensitive data, ensuring secure access controls, and safeguarding against unauthorized access or data breaches are critical challenges.
- Cloud providers must implement robust security measures, encryption, and access controls to address these concerns.
- Data privacy is also a challenge, as users need assurance that their personal information is handled and stored in compliance with privacy regulations.

Major Challenges Faced by Cloud Computing

Compliance and Legal Issues:

- Cloud computing operates across multiple jurisdictions, and compliance with various legal and regulatory requirements can be challenging.
- Organizations need to ensure that their cloud deployments comply with industry-specific regulations, data protection laws, and other relevant legal frameworks.

Service Reliability and Downtime:

- Cloud service availability and reliability are crucial for businesses.
- Downtime or service disruptions can have significant financial and operational implications. Cloud providers must implement redundancy measures, disaster recovery plans, and high availability architectures to minimize downtime and ensure reliable service delivery.

Major Challenges Faced by Cloud Computing

Performance and Latency:

- The performance of cloud-based applications can be affected by factors such as network latency, bandwidth limitations, and resource contention.
- Proper workload management, performance monitoring, and optimization strategies are needed to address these challenges.

Data Transfer and Bandwidth Costs:

- Transferring large volumes of data to and from the cloud can be time-consuming and expensive, especially when considering bandwidth costs and data transfer fees imposed by cloud providers.
- Managing data transfer costs and optimizing data transfer processes are essential for organizations that deal with significant data volumes

Thank You