Cloud Computing Architecture

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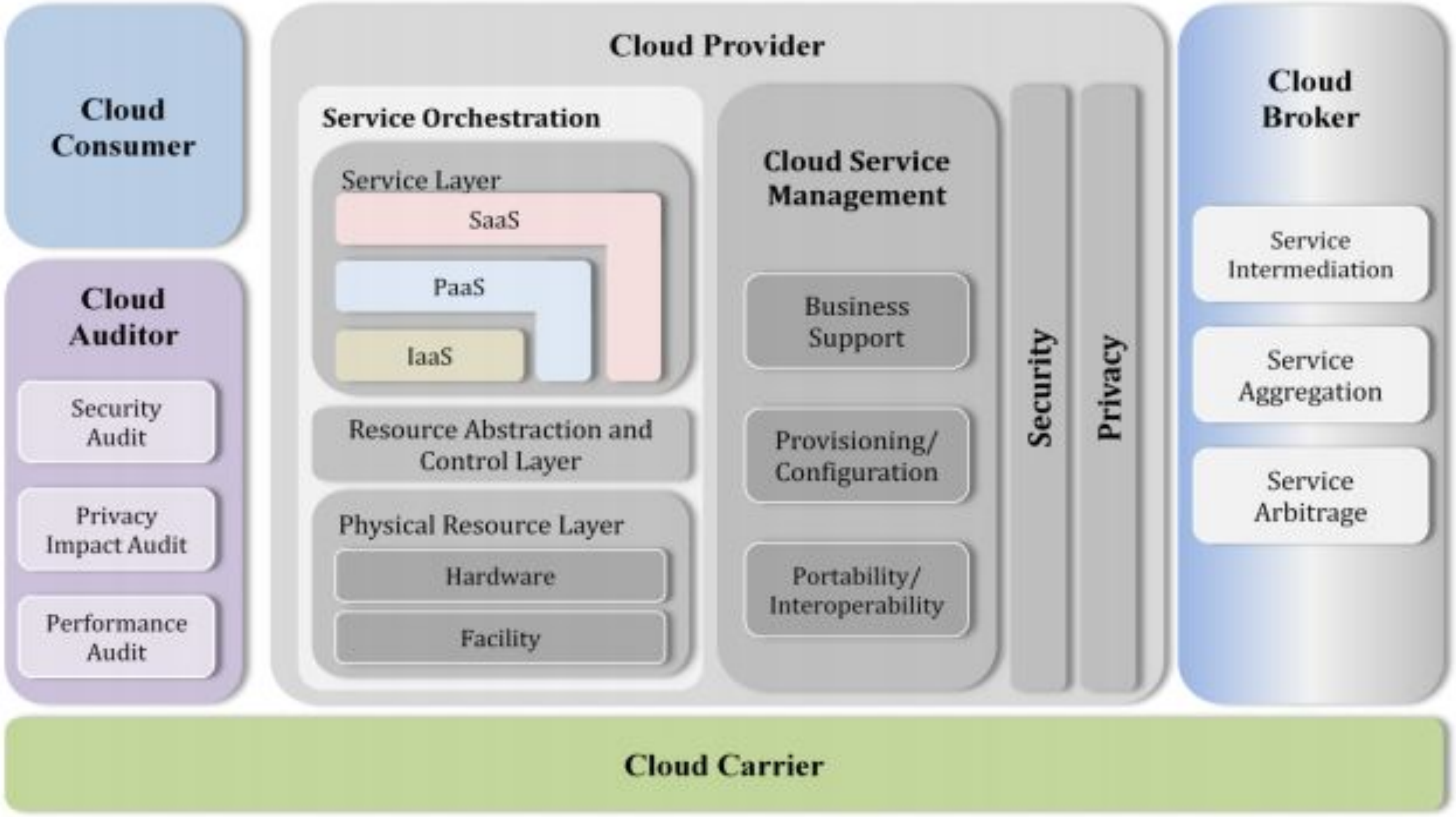


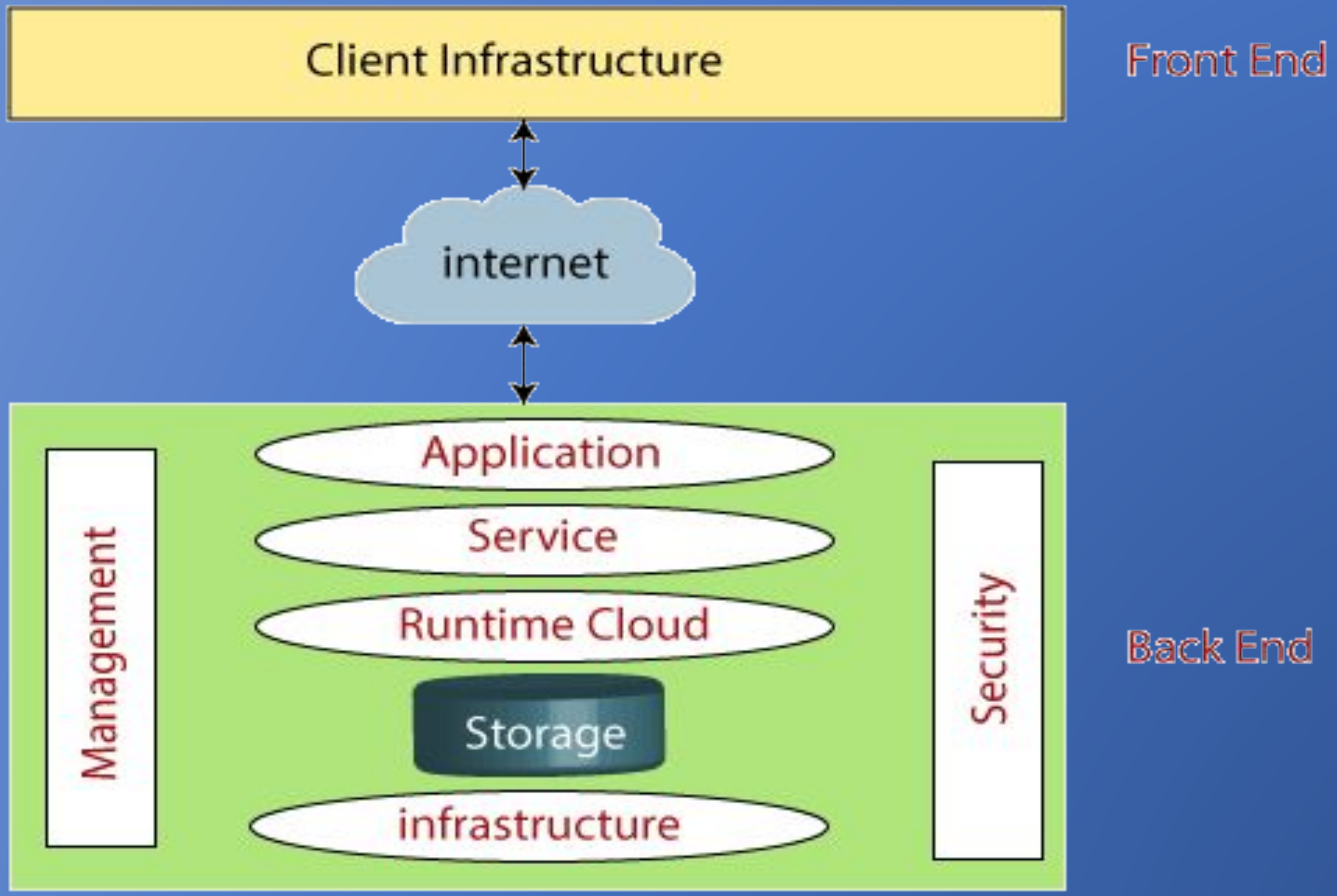
Figure 1: The Conceptual Reference Model

- As we know, cloud computing technology is used by both small and large organizations to **store the information** in cloud and **access** it from anywhere at anytime using the internet connection.
- Cloud computing architecture is a combination of **service-oriented architecture** and **event-driven architecture**.

- SOA, or **service-oriented architecture**, defines a way to make software components reusable via **service** interfaces. These interfaces utilize common communication standards in such a way that they can be rapidly incorporated into new applications without having to perform deep integration each time.
- **Event-driven architecture (EDA)** is a software architecture paradigm promoting the production, detection, consumption of, and reaction to events.

- Cloud computing architecture is divided into the following two parts -
- Front End
- Back End

Architecture of Cloud Computing



Front End

- The front end is used by the client. It contains client-side interfaces and applications that are required to access the cloud computing platforms. The front end includes web servers (including Chrome, Firefox, internet explorer, etc.), thin & fat clients, tablets, and mobile devices.

Back End

- The back end is used by the service provider. It manages all the resources that are required to provide cloud computing services. It includes a huge amount of data storage, security mechanism, virtual machines, deploying models, servers, traffic control mechanisms, etc.

Components of Cloud Computing Architecture

- There are the following components of cloud computing architecture -
- **1. Client Infrastructure**
- Client Infrastructure is a Front end component. It provides GUI (Graphical User Interface) to interact with the cloud.
- **2. Application**
- The application may be any software or platform that a client wants to access.
- **3. Service**
- A Cloud Services manages that which type of service you access according to the client’s requirement. i.e. SaaS, PaaS, IaaS

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- **4. Runtime Cloud**
- Runtime Cloud provides the **execution and runtime environment** to the virtual machines.
- **5. Storage**
- Storage is one of the most important components of cloud computing. It provides a huge amount of storage capacity in the cloud to store and manage data.
- **6. Infrastructure**
- It provides services on the **host level**, **application level**, and **network level**. Cloud infrastructure includes hardware and software components such as servers, storage, network devices, virtualization software, and other storage resources that are needed to support the cloud computing model.

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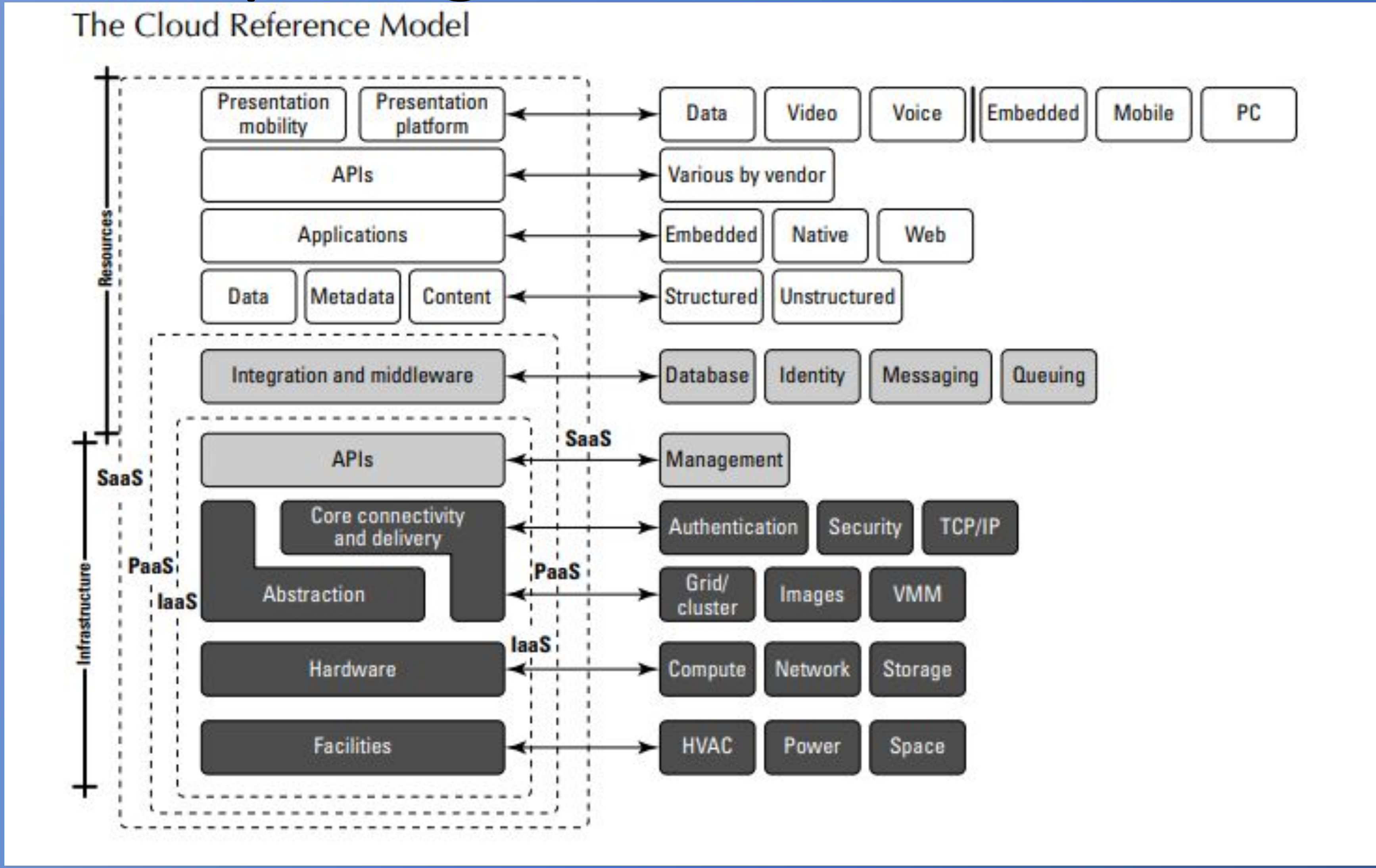
- **7. Management**
- Management is used to manage components such as application, service, runtime cloud, storage, infrastructure, and other security issues in the backend and establish coordination between them.
- **8. Security**
- Security is an in-built back end component of cloud computing. It implements a security mechanism in the back end.
- **9. Internet**
- The Internet is medium through which front end and back end can interact and communicate with each other.

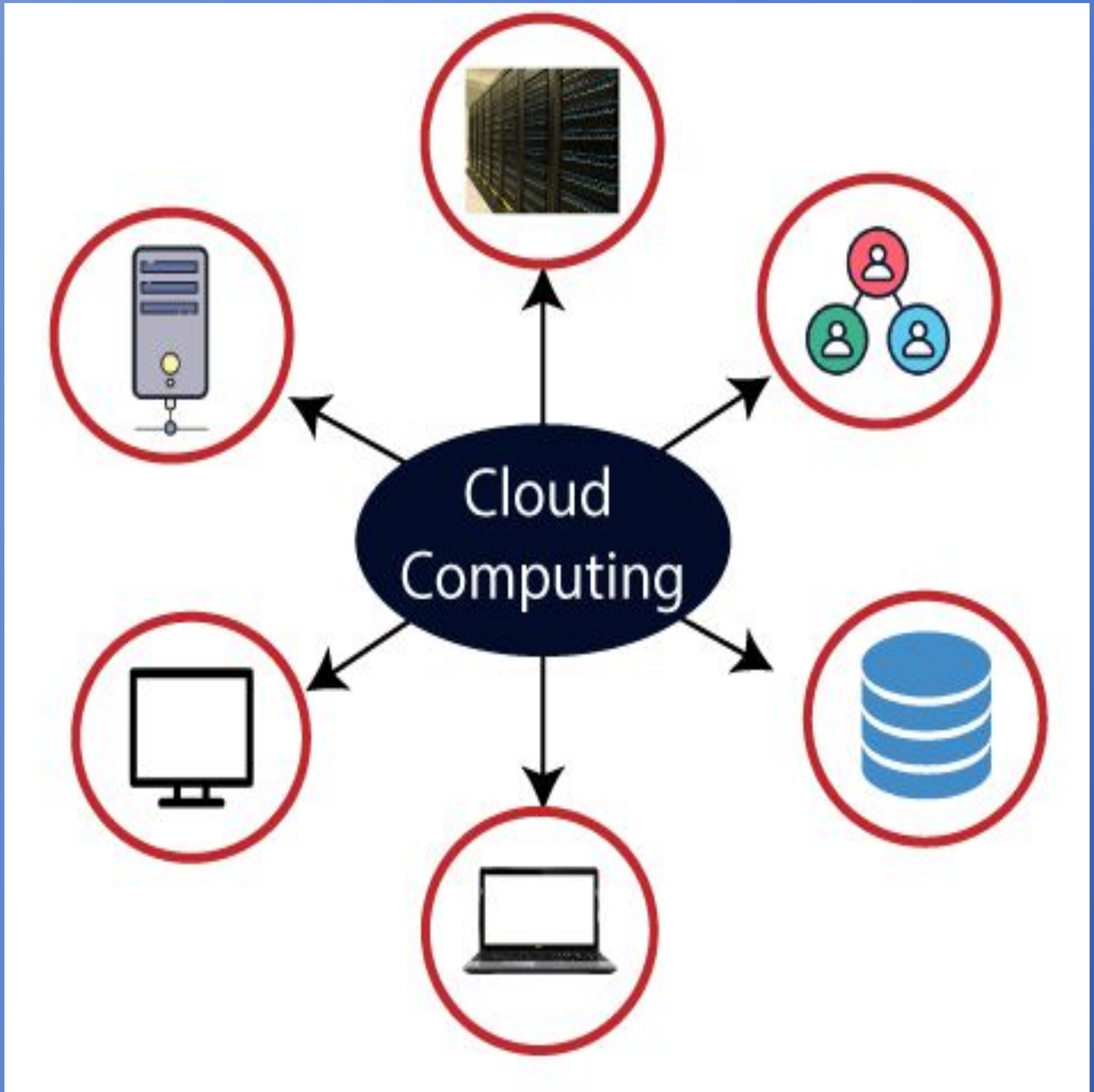
Cloud Computing Stack



Difference between Cloud Computing and Grid Computing

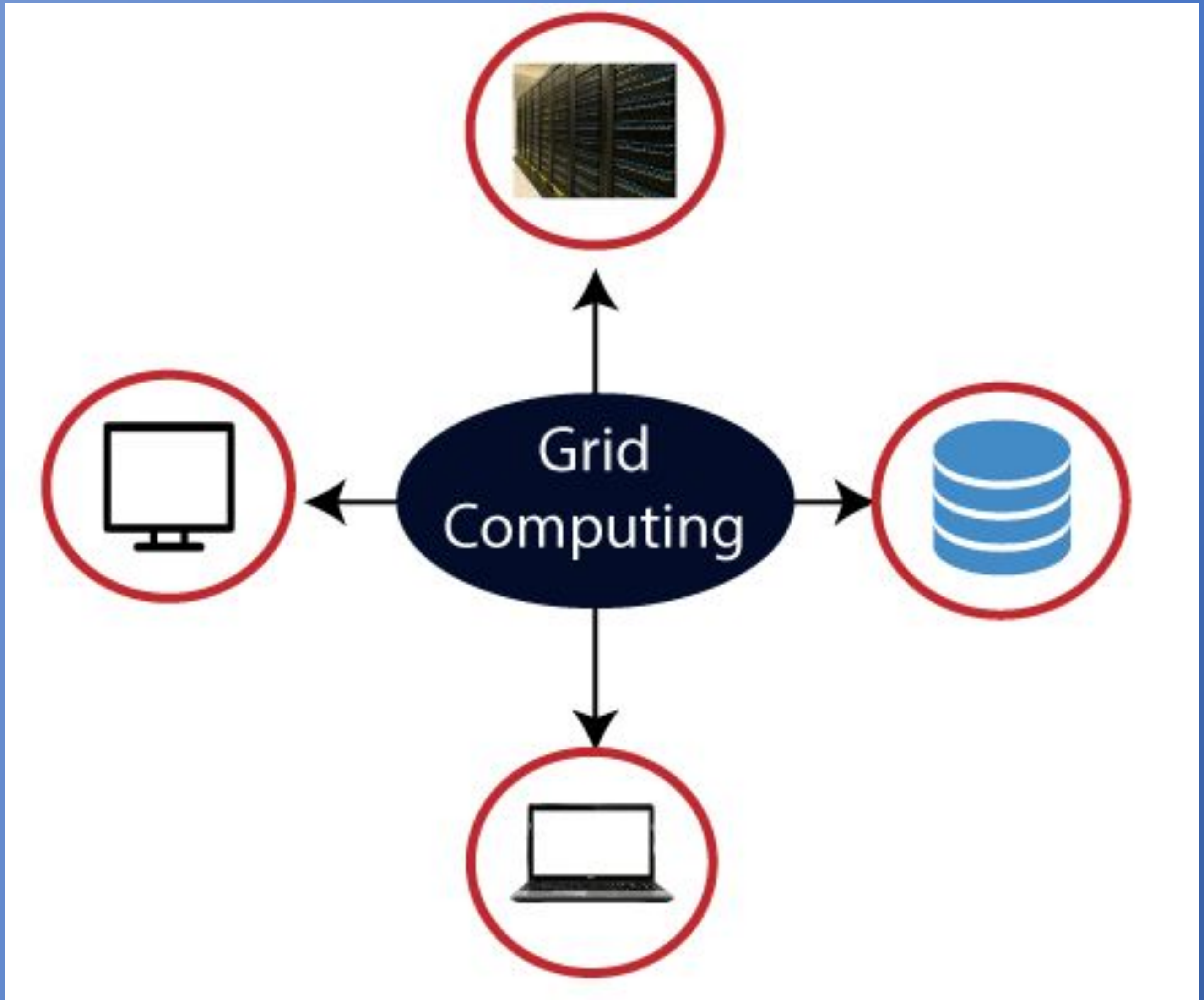
Cloud Computing

- Cloud computing uses a **client-server** architecture to deliver computing resources such as servers, storage, databases, and software over the cloud (Internet) with pay-as-you-go pricing.
- Cloud computing becomes a very popular option for organizations by providing various advantages, including cost-saving, increased productivity, efficiency, performance, data back-ups, disaster recovery, and security.


Cloud
Computing

Grid Computing

- Grid computing is also called as "**distributed computing**." It links multiple computing resources (PC's, workstations, servers, and storage elements) together and provides a mechanism to access them.
- The main advantages of grid computing are that it increases user productivity by providing transparent access to resources, and work can be completed more quickly.


Grid
Computing

Difference between cloud computing and grid computing.

Cloud Computing	Grid Computing
Cloud Computing follows client-server computing architecture.	Grid computing follows a distributed computing architecture.
Scalability is high.	Scalability is normal.
Cloud Computing is more flexible than grid computing.	Grid Computing is less flexible than cloud computing.
Cloud operates as a centralized management system.	Grid operates as a decentralized management system.
In cloud computing, cloud servers are owned by infrastructure providers.	In Grid computing, grids are owned and managed by the organization.
Cloud computing uses services like Iaas, PaaS, and SaaS.	Grid computing uses systems like distributed computing, distributed information, and distributed pervasive.
Cloud Computing is Service-oriented.	Grid Computing is Application-oriented.
It is accessible through standard web protocols.	It is accessible through grid middleware.

Cloud Computing services at different levels

- Cloud services are services available via a remote cloud computing server rather than an on-site server. These scalable solutions are managed by a third party and provide users with access to computing services such as analytics or networking via the internet.
- Cloud services offer powerful benefits for the enterprise, from greater productivity and enhanced efficiency to significant cost reductions and simplified IT management. Enterprise cloud computing can also enable the mobile services that employees increasingly use when accessing corporate data and applications.

Cloud services examples

- The benefits of cloud services depend on the industry. Many enterprises may use the cloud in the following applications:
- **Managing spikes with scalability**
- One of the main advantages of cloud services is their scalability, meaning enterprises can increase demand based on business need without adversely affecting performance. This is particularly helpful for enterprises whose usage may experience peaks and troughs.
- Online video streaming services, for example, may experience large surges in user volumes, which could place additional strain on servers. By using cloud services, these companies do not have to place this stress on their in-house servers, thereby allowing for expanding customer bases without investing in infrastructure.

- **Customer relationship management**
- Users can remotely manage their customer databases and update records using Software as a Service models. Several users can make changes to records at the same time, while keeping data secure and accessing it easily via a web browser.
- **Backup and recovery**
- Enterprises can save significant costs on building infrastructure and maintenance by moving data storage to the cloud. A third-party cloud service provider is responsible for the data, and also ensures security plus compliance and legal matters. Cloud backup increases flexibility with on-demand backup and larger storage capability. Data can also be restored faster as it is stored over a network rather than in one physical location.

- **Big data analytics**
- Data scientists may access any organization data for analysis using cloud computing. This is essential for making predictions and forecasting potential problems. Cloud solutions allow users to manage large amounts of data remotely with open source dig data tools.
- Enterprises may also turn to cloud services for:
- Communication, from email calendars to messenger services and chatbots
- Remotely creating and updating documents such as word processing
- Application development for web and mobile
- Test and development for launching apps
- Social networking, for handling large volumes of data

Benefits of cloud services

- Enterprises can reap the benefits of better efficiency with cloud services, which allow for:
- **Higher Speeds.** An intelligent software like the Akamai Intelligent Platform accelerates cloud services by overcoming problems such as unreliable networks, congestion, inefficient protocols and malicious attacks. Patented algorithms map users to the most optimal servers, shape content for the most efficient delivery and route traffic along the fastest paths.

- **Better Security.** Akamai cloud security solutions are built with the intelligence gathered from delivering 15 to 30% of the world's web interactions every day. Our security experts continually analyze data from hundreds of millions of unique IP addresses and our distributed architecture deflects, absorbs and filters malicious requests close to the attack source.
- **Flexible Scaling.** The scale and capacity of our Intelligent Platform enable cloud services to keep pace with the increasing volume of web traffic, proliferation of devices, complexity of interactions and growth of cyber threats. Our technology for content delivery networks has helped us deliver streaming video for many of the world's largest live events and to serve peak traffic conditions during heavy shopping seasons.

Role of Networks in Cloud computing

- In the center of the cloud delivery and consumption model is the network. The network serves as the linkage between the end users consuming cloud services and the provider's data centers providing the cloud services.
- In addition, in large-scale cloud data centers, tens of thousands of compute and storage nodes are connected by a data center network to deliver a single-purpose cloud service.

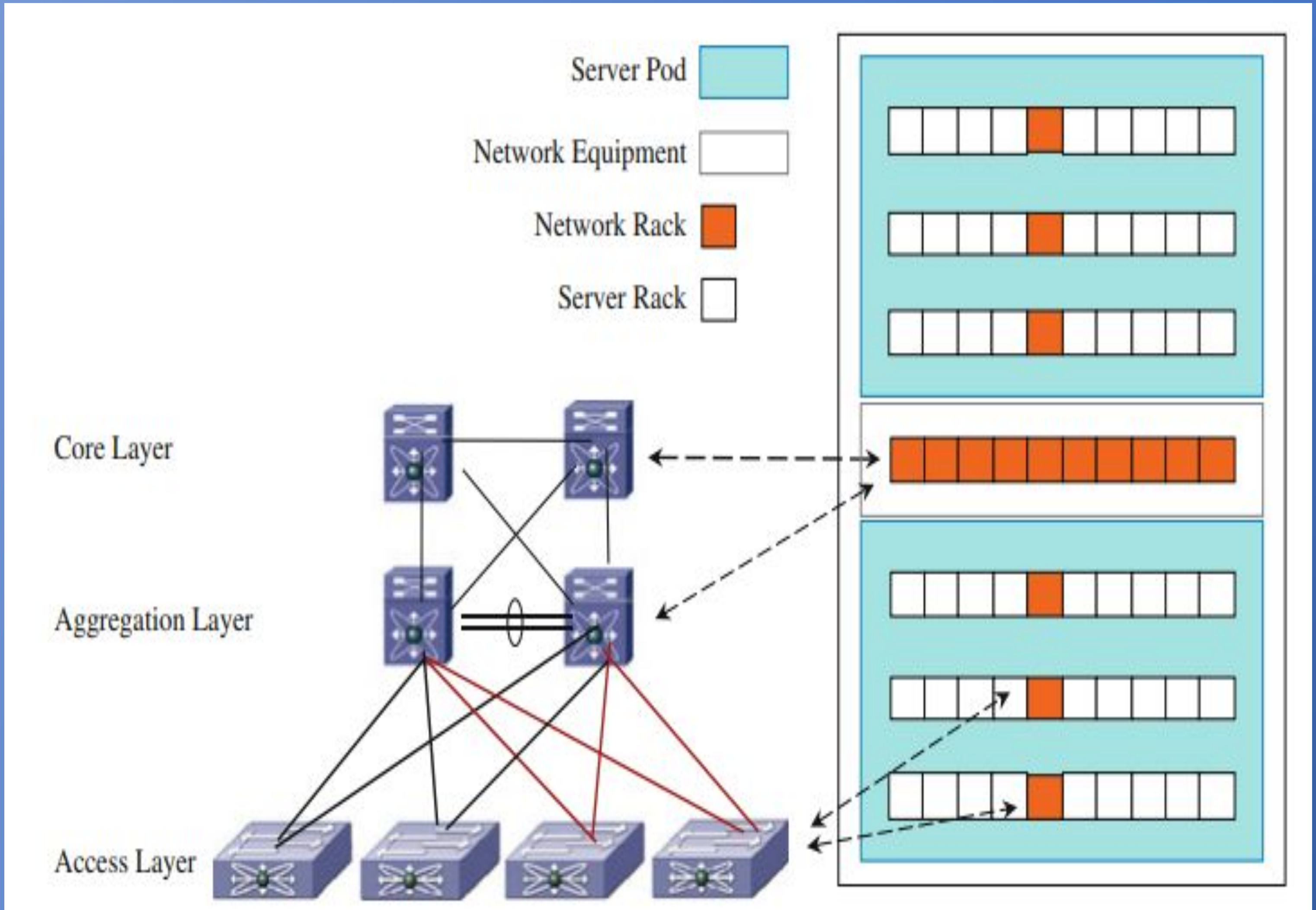
- How do network architectures affect cloud computing?
- How will network architecture evolve to better support cloud computing and cloud-based service delivery?
- What is the network’s role in security, reliability, performance, and scalability of cloud computing?
- Should the network be a dumb transport pipe or an intelligent stack that is cloud workload aware?

An Overview of Network Architectures for Clouds

- There are three principal areas in which the network architecture is of importance to cloud computing:
- (1) a data center network that interconnects the infrastructure resources (e.g. servers and storage devices) within a cloud service data center,
- (2) a data center interconnect network that connects multiple data centers in a private, public, or hybrid cloud to supporting the cloud services,
- (3) the public Internet that connect end users to the public cloud provider's data centers.
- The last area has mostly to do with today's telecommunications network infrastructure, and is a complex topic by itself from the architectural, regulatory, operational and regional perspectives. It is beyond the scope of this subject.

Data Center Network

- Cloud providers offer scalable cloud services via massive data centers. In such massive-scale data centers, Data Center Network (DCN) is constructed to connect tens, sometimes hundreds, of thousands of serves to deliver massively scalable cloud services to the public. Hierarchical network design is the most common architecture used in data center networks.



Server Pod
Network Equipment
Network Rack
Server Rack
Core Layer
Aggregation Layer
Access Layer

- The access layer of a data center network provides connectivity for server resource pool residing in the data center.
- Design of the access layer is heavily influenced by the decision criteria such as server density, form factor, and server virtualization that can result in higher interface count requirements.
- The commonly used approaches for data center access layer connectivity are
  - end-of-row (EoR) switch,
  - top-of-rack (ToR) switch,
  - and integrated switch (typically in the form of blade switches inside a modular blade server chassis).
- Another form of the integrated switch is the embedded software switch in a server end point.
- Each design approach has pros and cons, and is dictated by server hardware and application requirements.

- The *aggregation layer* of the data center provides a consolidation point where access layer switches are connected providing connectivity between servers for multi-tier applications, as well as connectivity across the core of the network to the clients residing within the campus, WAN, or Internet.
- The access switches are connected to the aggregation layer using 802.1Q VLAN trunks to provide the capability of connecting servers belonging to different VLANs and IP subnets to the same physical switch.
- The primary function of the *core layer* in a data center network is to provide highly available, high performance Layer-3 switching for IP traffic between the data center and the Telco’s Internet edge and backbone.

XaaS (Anything as a Service)

- “Anything as a service” (XaaS) describes a general category of services related to cloud computing and remote access. It recognizes the vast number of products, tools, and technologies that are now delivered to users as a service over the internet. Essentially, any IT function can be transformed into a service for enterprise consumption. The service is paid for in a flexible consumption model rather than as an upfront purchase or license.

- **Examples of XaaS**
- Because XaaS stands for "anything as a service," the list of examples is endless. Many kinds of IT resources or services are now delivered this way. Broadly speaking, there are three categories of cloud computing models: software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS). Outside these categories, there are other examples such as disaster recovery as a service (DRaaS), communications as a service (CaaS), network as a service (NaaS), database as a service (DBaaS), storage as a service (StaaS), desktop as a service (DaaS), and monitoring as a service (MaaS). Other emerging industry examples include marketing as a service and healthcare as a service.

What are the benefits of XaaS?

- There are several benefits of XaaS: improving the expense model, speeding new apps and business processes, and shifting IT resources to higher-value projects.
- **Improving the expense model.** With XaaS, businesses can cut costs by purchasing services from providers on a subscription basis. Before XaaS and cloud services, businesses had to buy individual products—software, hardware, servers, security, infrastructure—install them on site, and then link everything together to create networks. Now, with XaaS, businesses simply buy what they need, and pay as they go. Previous capital expenses now become operating expenses.

- **Speeding new apps and business processes.** This model allows businesses to quickly adapt to changing market conditions with new apps or solutions. Using multitenant approaches, cloud services can provide much-needed flexibility. Resource pooling and rapid elasticity support mean that business leaders can simply add or subtract services as needed. A company can quickly access new technologies, scaling infrastructure automatically when users need innovative resources.

- **Shifting IT resources to higher-value projects.** Increasingly, IT organizations are turning to an XaaS delivery model to streamline operations and free up resources for innovation. They are also using the benefits of XaaS to transform digitally and become more agile. In a recent survey by Deloitte, 71% of companies report that XaaS now constitutes more than half of their company's enterprise IT.

What are the disadvantages of XaaS?

- XaaS has some potential drawbacks: possible downtime, performance issues, and complexity.
- **Possible downtime.** The internet sometimes breaks, and when it does, your XaaS provider might have problems as well. With XaaS, there can be issues of internet reliability, resilience, provisioning and managing the infrastructure resources . If XaaS servers go down, users won’t be able to use them. XaaS providers can guarantee services through SLAs.

- **Performance issues.** As XaaS becomes more popular, bandwidth, latency, data storage, and retrieval times can suffer . If too many customers use the same resources, the system can slow down. Apps running in virtualized environments can also face impacts. In these complex environments, there can be integration issues, including the ongoing management and security of multiple cloud services.

- **Complexity impacts.** Pushing technology to XaaS can relieve IT staff of day-to-day operational headaches; however, if something does go wrong, it might be harder to troubleshoot. The internal IT staff still needs to stay current on the new technology. Costs for maintaining high-performing, robust networks can increase—although the overall cost savings of XaaS models are usually much greater. Nonetheless, some companies want to retain visibility into their XaaS service provider’s environment and infrastructure. In addition, an XaaS provider that gets acquired, discontinues a service, or alters its roadmap can have a profound impact on XaaS users.

NetApp and XaaS

- NetApp provides several XaaS options, including IaaS, IT as a service (ITaaS), SaaS, and PaaS.
- **IaaS.** When you differentiate your hosted and managed infrastructure services, you can increase service and platform revenue, improve customer satisfaction, and turn IaaS into a profit center. You can also take advantage of new opportunities to differentiate and expand services and platform revenue, including delivering more performance and predictability from your IaaS services. Plus, NetApp® technology can enable you to offer a competitive advantage to your customers and reduce time to market for deploying IaaS solutions.

- **ITaaS.** When your data center is in a private cloud, it takes advantage of cloud features to deliver ITaaS to internal business users. A private cloud offers characteristics similar to the public cloud but is designed for use by a single organization. These characteristics include:
- Catalog-based, on-demand service delivery
- Automated scalability and service elasticity
- Multitenancy with shared resource pools
- Metering with utility-style operating expense models
- Software-defined, centrally managed infrastructure
- Self-service lifecycle management of services

- **StaaS(**storage as a service (StaaS)**).** NetApp facilitates private storage as a service in a pay-as-you-go model by partnering with various vendors, including Arrow Electronics, HPE ASE, BriteSky, DARZ, DataLink, Faction, Forsythe, Node4, Proact, Solvinity, Synoptek, and 1901 Group. NetApp also seamlessly integrates with all major cloud service providers including AWS, Google Cloud, IBM Cloud, and Microsoft Azure.

- **PaaS.** NetApp PaaS solutions help simplify a customer’s application development cycle. Our storage technologies support PaaS platforms to:
- Reduce application development complexity.
- Provide high-availability infrastructure.
- Support native multitenancy.
- Deliver web scale storage.

PaaS services built on NetApp technology enable your enterprise to adopt hybrid hosting services—and accelerate your application-deployment time.