CE 644 Cloud Computing and Applications

Cloud Computing Architecture

- **Architecture** is the hierarchical view of describing a technology.
- This usually includes the components over which the **existing technology is built** and the **components that are dependent on the technology.**
- **Anatomy** describes the **core structure of the cloud.**

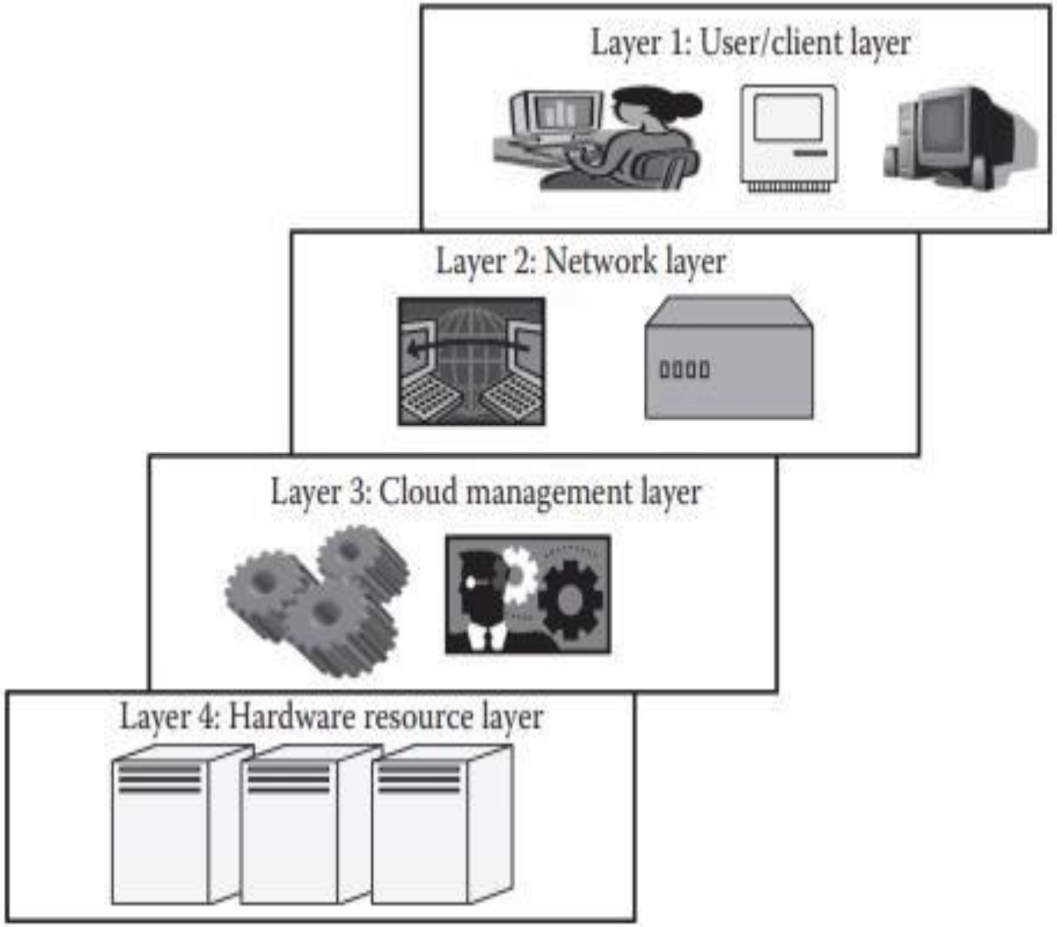

Layer 1: User/client layer
Layer 2: Network layer
Layer 3: Cloud management layer
Layer 4: Hardware resource layer

FIGURE 3.1
Cloud architecture.

Cloud Architecture

- The cloud also has an architecture that **describes its working mechanism**. It includes the **dependencies** on which it works and the **components** that work over it.
- The cloud is a recent technology that is completely dependent on the Internet for its functioning.
- The cloud architecture can be divided into **four layer**s based on the **access of the cloud by the user.**

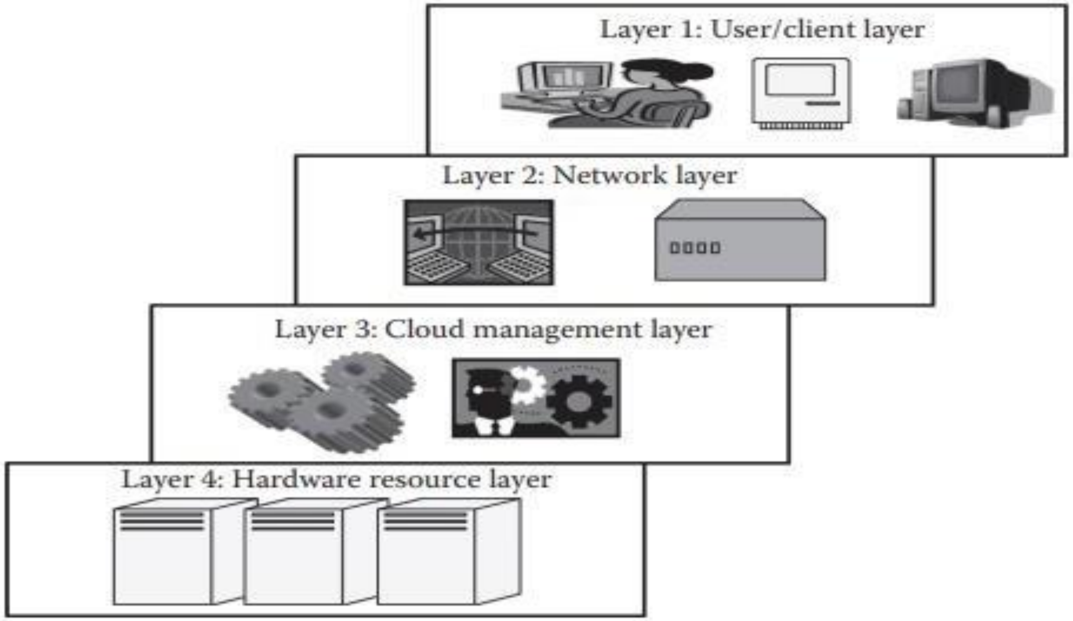

Layer 1: User/client layer
Layer 2: Network layer
Layer 3: Cloud management layer
Layer 4: Hardware resource layer

FIGURE 3.1
Cloud architecture.

Layer 1 (User/Client Layer)

- This layer is the **lowest layer** in the cloud architecture.
- All the **users or client** belong to this layer.
- This is the place where the **client/user initiates the connection** to the cloud.
- The client can be any device such as a **thin client, thick client, or mobile or any handheld device** that would support basic functionalities to access a web application.
- The **thin client** here refers to a device that is completely dependent on some other system for its complete functionality. In simple terms, they have very **low processing capability**. Similarly, **thick clients** are general computers that have **adequate processing capability**. They have sufficient capability for independent work.
- Usually, a cloud application can be accessed in the same way as a web application. But internally, the properties of cloud applications are significantly different. **Thus, this layer consists of client devices.**

Layer 2 (Network Layer)

- This layer allows the users **to connect to the cloud**.
- The whole cloud infrastructure is **dependent** on this connection where **the services are offered to the customers**.
- This is primarily the **Internet** in the case of a **public cloud**.
- In the case of a private cloud, the connectivity may be provided by a **local area network (LAN).** Even in this case, the cloud completely depends on the network that is used.
- This layer **does not come under the purview of service-level agreements (SLAs)**, that is, SLAs do not take into account the Internet connection between the user and cloud for quality of service (QoS).

Layer 3 (Cloud Management Layer)

- This layer consists of **software's that are used in managing the cloud**.
- The software's can be a **cloud operating system** (OS), a software that acts as **an interface between the data center** (actual resources) **and the user**, or a **management software** that allows managing resources.
- These software's usually allow **resource management** (scheduling, provisioning, etc.), **optimization** (server consolidation, storage workload consolidation), and **internal cloud governance**.
- This layer **comes under the purview of SLAs**, that is, the operations taking place in this layer would affect the SLAs that are being decided upon between the users and the service providers.
- Any delay in processing or any discrepancy in service provisioning may lead to an SLA violation.
- Popular service providers are **Amazon Web Services (AWS) and Microsoft Azure** for public cloud. Similarly, **OpenStack and Eucalyptus** allow private cloud creation, deployment, and management.

Layer 4 (Hardware Resource Layer)

- Layer 4 consists of **provisions for actual hardware resources.**
- Usually, in the case of a **public cloud**, a **data center** is used in the back end. Similarly, in a **private cloud**, it can be a **data center, which is a huge collection of hardware resources interconnected to each other that is present in a specific location or a high configuration system.**
- This layer **comes under the purview of SLAs**. This is the most important layer that governs the SLAs.
- Hence, the data center consists of a **high-speed network connection and a highly efficient algorithm to transfer the data from the data center to the manager**.
- There can be a number of data centers for a cloud, and similarly, a number of clouds can share a data center. Thus, this is the architecture of a cloud.

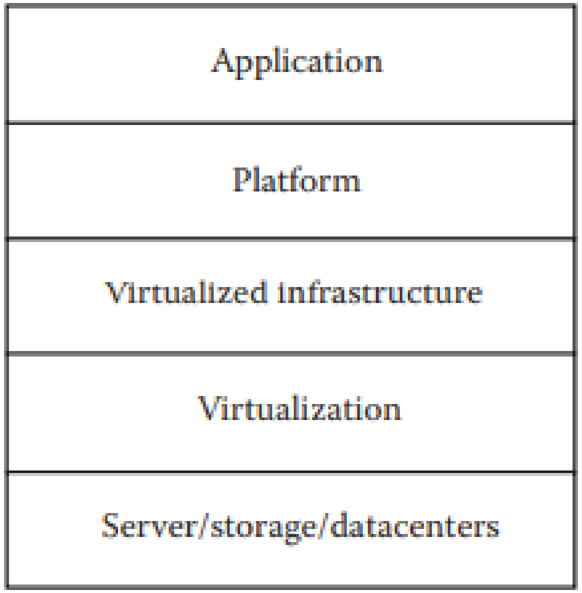
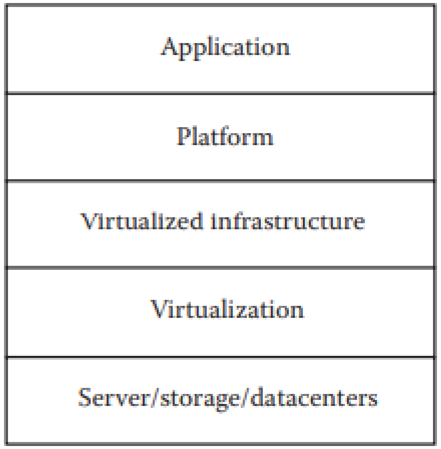


FIGURE 3.2
Cloud structure.

Anatomy of the Cloud

- Cloud anatomy can be simply defined as the **structure of the cloud**.
- Cloud anatomy **cannot be considered the same as cloud architecture**. It may **not include any dependency on which or over which the technology works**, whereas architecture wholly defines and describes the technology over which it is working.



Application

Platform

Virtualized infrastructure

Virtualization

Server/storage/datacenters

FIGURE 3.2
Cloud structure.

- Figure depicts the most standard anatomy that is the base for the cloud

- There are basically five components of the cloud:

1. Application: The upper layer is the application layer. In this layer, any **applications are executed**.
2. Platform: This component consists of **platforms that are responsible for the execution of the application**. This platform is between the infrastructure and the application.
3. Infrastructure: The infrastructure consists of **resources over which the other components work**. This provides computational capability to the user.
4. Virtualization: Virtualization is the process of **making logical components of resources over the existing physical resources.** The logical components are isolated and independent, which form the infrastructure.
5. Physical hardware: The **physical hardware is provided by server and storage units.**

NETWORK CONNECTIVITY IN CC

- Cloud computing is a technique of resource sharing where servers, storage, and other computing infrastructure in multiple locations are connected by networks.
- In the cloud, when an application is submitted for its execution, needy and suitable resources are allocated from this collection of resources; as these resources are connected via the Internet, the users get their required
- results.
- For many cloud computing applications, network performance will be the key issue to cloud computing performance.

1. Public Cloud Access Networking

Definition: Public clouds are accessed over the **Internet**. Customers connect to cloud resources owned and managed by third-party providers (e.g., AWS, Azure).

Key Points:

•**Connectivity**: Usually via the Internet, but some providers offer Virtual Private Networks (VPNs) for secure access.

•**Security Measures**: To ensure data safety, encrypted tunnels (e.g., HTTPS or VPNs) are used, creating secure pipelines for data transmission.

•**Performance Impact**: Encrypting data adds **overhead**, which can cause **delays** or impact overall network performance due to encryption and decryption processes.

2. Private Cloud Access Networking

Definition: Private clouds are part of an organization's **internal network**, with access controlled locally. They are used exclusively by the organization.

Key Points:

- **Connectivity**: May include an **Internet VPN** or a dedicated **VPN service** from a network operator, depending on the organization’s setup.

- **Localized Control**: All networking is **internal** to the organization, providing better control over security and performance.

- **Usage**: Suited for sensitive data and applications requiring higher security and compliance

3. Intra-Cloud Networking for Public Cloud Access

Definition: Refers to the internal communication between geographically distributed resources within a public cloud provider's infrastructure.

Key Points:

- **Connectivity**: The provider’s resources (data centers, servers, etc.) are located in **different regions** but are connected via the Internet to offer seamless service to the customer.

- **Customer Impact**: Customers rely on this **backend connectivity** to access and use resources assigned to their applications.

4. Private Intra-Cloud Networking

Definition: Refers to networking within a **private cloud**, specifically the interconnection between the organization’s own **data centers** or systems.

Key Points:

•**Connectivity**: Supported by the organization’s **local infrastructure**, such as dedicated data center links.

•**Usage**: Used for internal workloads that require high security, low latency, and consistent performance.

- NEW FACETS IN PRIVATE NETWORK

1. Conventional Private Networks

Traditional Design networks were originally designed for on-premises applications, meaning applications that are hosted and run entirely within an organization's physical infrastructure (corporate servers, local data centers).

prioritize Internet security, ensuring that external threats are minimized by implementing strong firewalls, intrusion detection systems, and limited external exposure.

2. Path for Internet Traffic

There is Shift in Routing Strategies in modern private networks, Unlike traditional networks where traffic had to pass through a central data center for security checks, newer architectures allow for direct traffic routing.

beneficial in scenarios where organizations leverage cloud-based applications or need low-latency access to Internet resources.

3. Widely Distributed Internet Gateway Infrastructure

Instead of relying on a single or centralized internet gateway, private networks now deploy distributed internet gateways across multiple geographic locations.

Faster access to the Internet, Lower latency, Enhanced redundancy and fault tolerance.

Applications on the Cloud

- The power of a computer is realized through the applications.

1. A stand-alone application- self-contained programs installed on a single device, operating independently without requiring internet connectivity (desktop software)
2. Web applications- run on web browsers, requiring internet access, and offer cross-platform compatibility without the need for installation (online banking).
3. Cloud applications- leverage cloud infrastructure for storage, processing, and accessibility, providing scalability and remote access from any connected device (Google Drive).

Dis-adv of Web applications

- The web application is **not elastic and cannot handle very heavy loads**, that is, it cannot serve highly varying loads.
- The web application is **not multitenant**.
- The web application **does not provide a quantitative measurement of the services** that are given to the users, though they can monitor the user.
- The web applications are usually in **one particular platform**.
- The web applications are not provided on a **pay-as-you-go basis**; thus, a particular service is given to the user for permanent or trial use and usually the timings of user access cannot be monitored.

Features of cloud

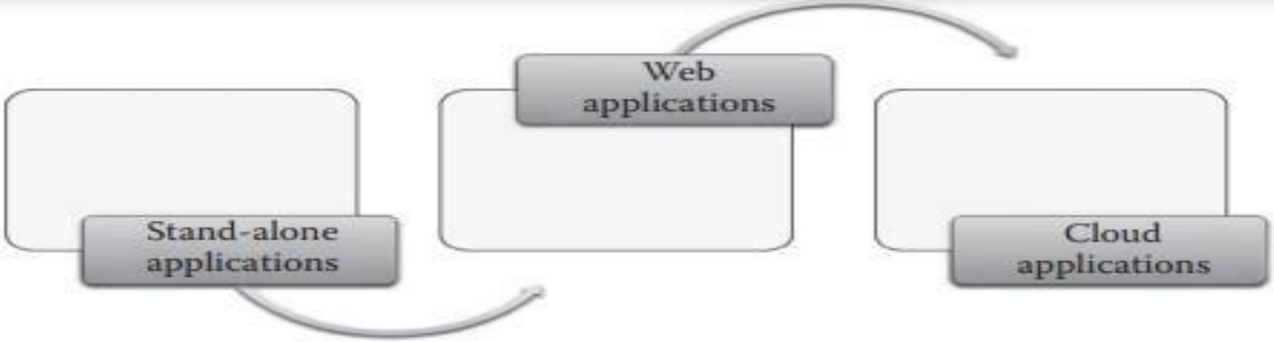


FIGURE 3.3
Computer application evolution.

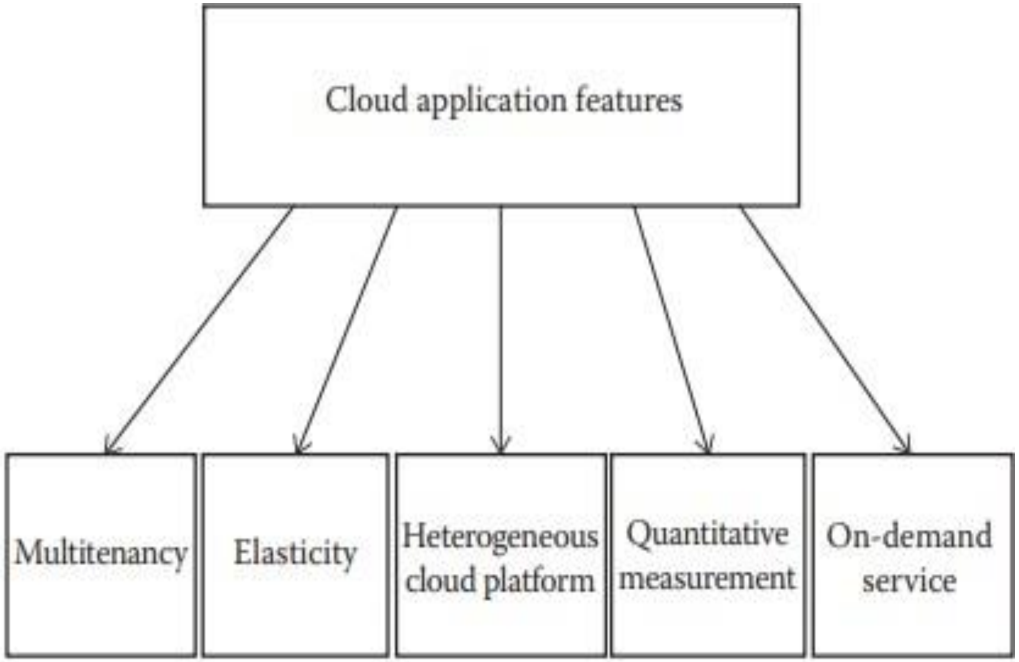
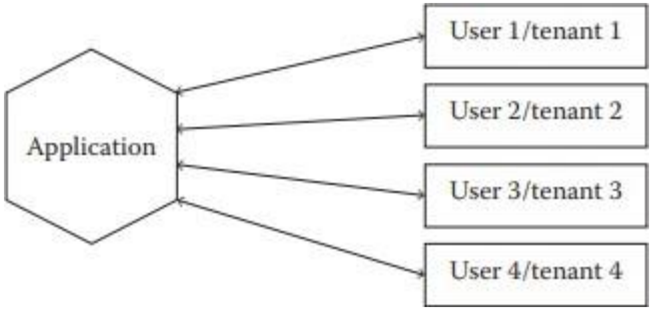


FIGURE 3.4
Features of cloud.

1. Multitenancy: Multitenancy is one of the important properties of cloud in which the software can be shared by different users with full independence.



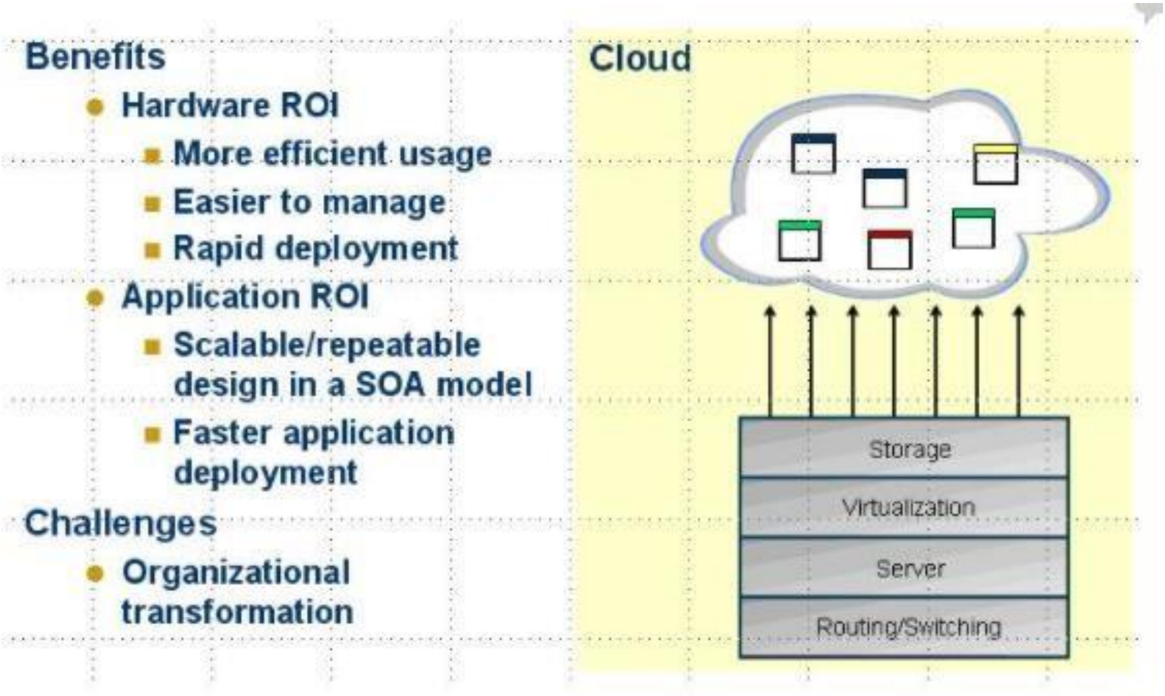
1. Elasticity: Elasticity can be defined as the degree to which a system is able to adapt to workload changes by provisioning and deprovisioning resources in an autonomic manner such that at each point in time, the available resources match the current demand as closely as possible

3. Heterogeneous cloud platform: The cloud platform supports heterogeneity, wherein any type of application can be deployed in the cloud. Because of this property, the cloud is flexible for the developers, which facilitates deployment.

4. Quantitative measurement: The services provided can be quantitatively measured. The user is usually offered services based on certain charges. Here, the application or resources are given as a utility on a pay-per-use basis. Thus, the use can be monitored and measured.

5. On-demand service: The cloud applications offer service to the user, on demand, that is, whenever the user requires it. The cloud service would allow the users to access web applications usually without any restrictions on time, duration, and type of device used.

Benefits and challenges of cloud architecture.



Benefits

- Hardware ROI
  - More efficient usage
  - Easier to manage
  - Rapid deployment
- Application ROI
  - Scalable/repeatable design in a SOA model
  - Faster application deployment

Challenges

- Organizational transformation

- https://www.youtube.com/watch?v=YHXFWMAHW2Y