Cloud Computing (CS60118)

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Cloud Architecture & Components

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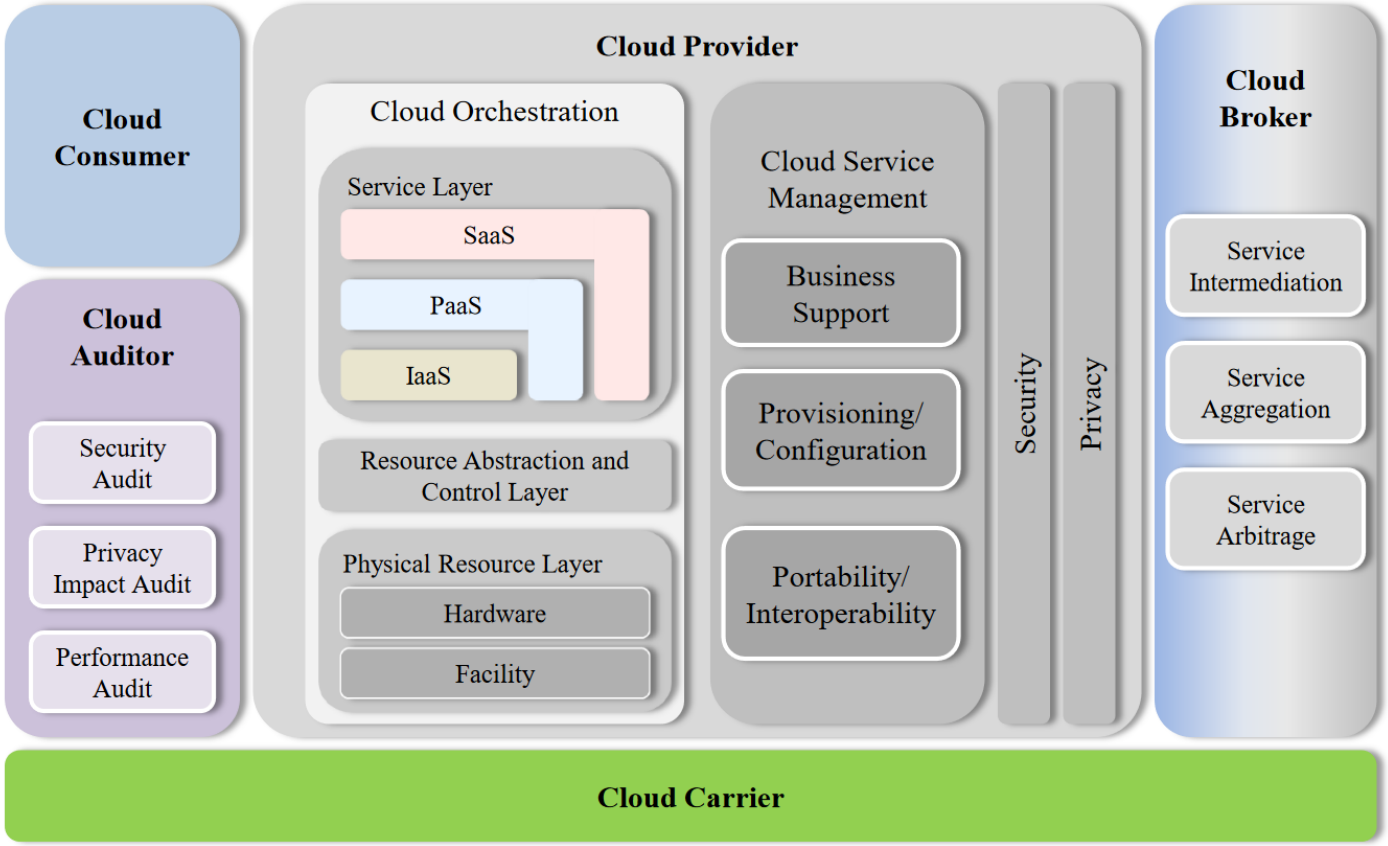
Contents

- The NIST cloud reference architecture
- Components of Cloud Architecture
- Anything/Everything as a Service (XaaS)
  - IaaS
  - PaaS
  - SaaS
- Microservices

Cloud Computing: The Architecture

- Multiple components
- Broad classification
  - Front end
  - Back end
- Front end takes care of the connection with the end-user or the clients
- Back end is used by the service provider for managing the services and infrastructure.

NIST Architecture



Source: R. B. Bohn, J. Messina, F. Liu, J. Tong and J. Mao, "NIST Cloud Computing Reference Architecture," 2011 IEEE World Congress on Services, Washington, DC, 2011, pp. 594-596, doi: 10.1109/SERVICES.2011.105.

NIST Architecture

The **National Institute of Standards and Technology's** definition of cloud computing identifies "five essential characteristics":

➢ ***On-demand self-service***

A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

➢ ***Broad network access***

Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

Source: R. B. Bohn, J. Messina, F. Liu, J. Tong and J. Mao, "NIST Cloud Computing Reference Architecture," 2011 IEEE World Congress on Services, Washington, DC, 2011, pp. 594-596, doi: 10.1109/SERVICES.2011.105.

NIST Architecture

➢ ***Resource pooling***

The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.

➢ ***Rapid elasticity***

Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear unlimited and can be appropriated in any quantity at any time.

Source: R. B. Bohn, J. Messina, F. Liu, J. Tong and J. Mao, "NIST Cloud Computing Reference Architecture," 2011 IEEE World Congress on Services, Washington, DC, 2011, pp. 594-596, doi: 10.1109/SERVICES.2011.105.

NIST Architecture

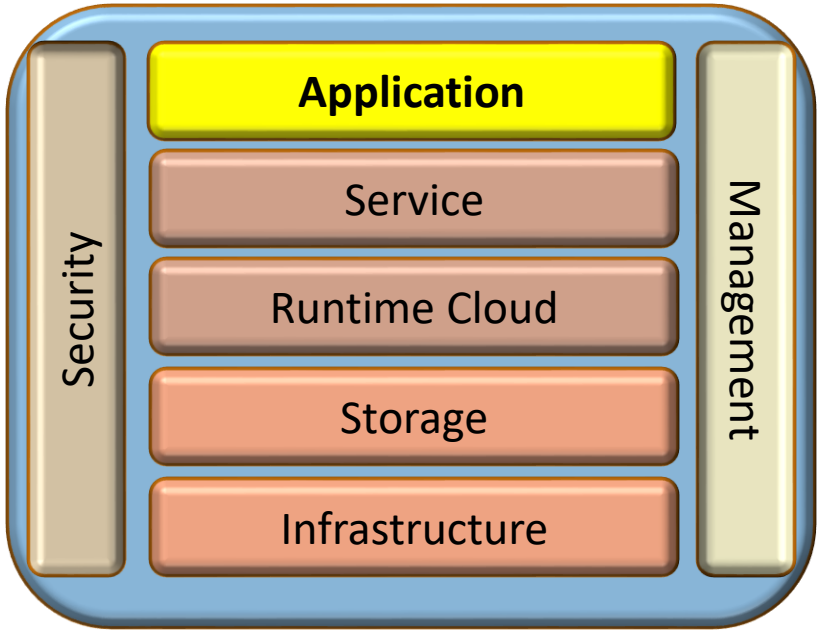
- ***Measured service***

Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

Source: R. B. Bohn, J. Messina, F. Liu, J. Tong and J. Mao, "NIST Cloud Computing Reference Architecture," 2011 IEEE World Congress on Services, Washington, DC, 2011, pp. 594-596, doi: 10.1109/SERVICES.2011.105.

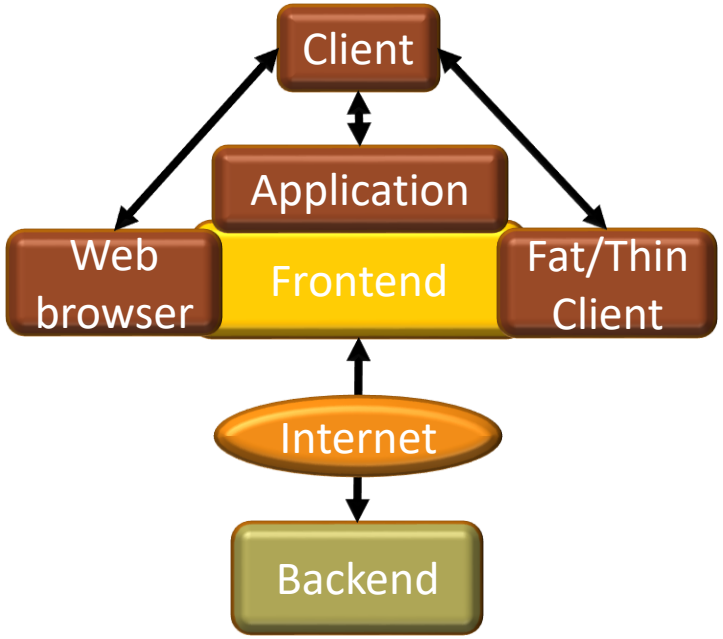
Components

- Backend



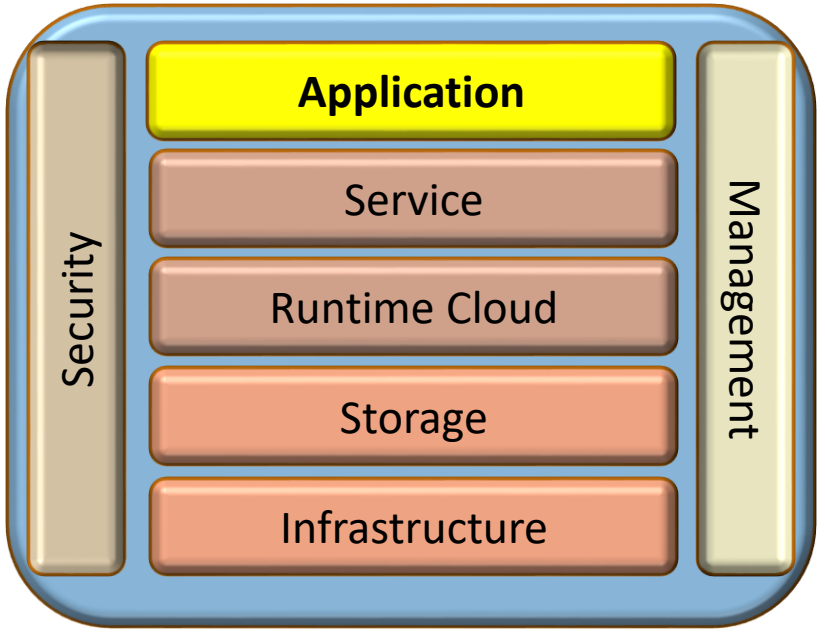
Backend

- Frontend



Backend: Components

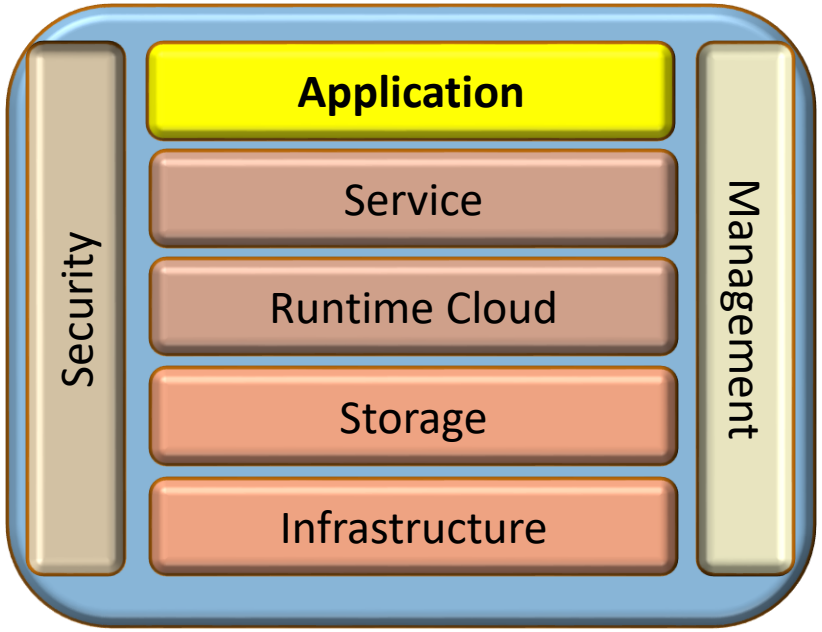
- Application
- Storage
- Service
- Runtime Cloud
- Management
- Security
- Infrastructure



Backend

Application

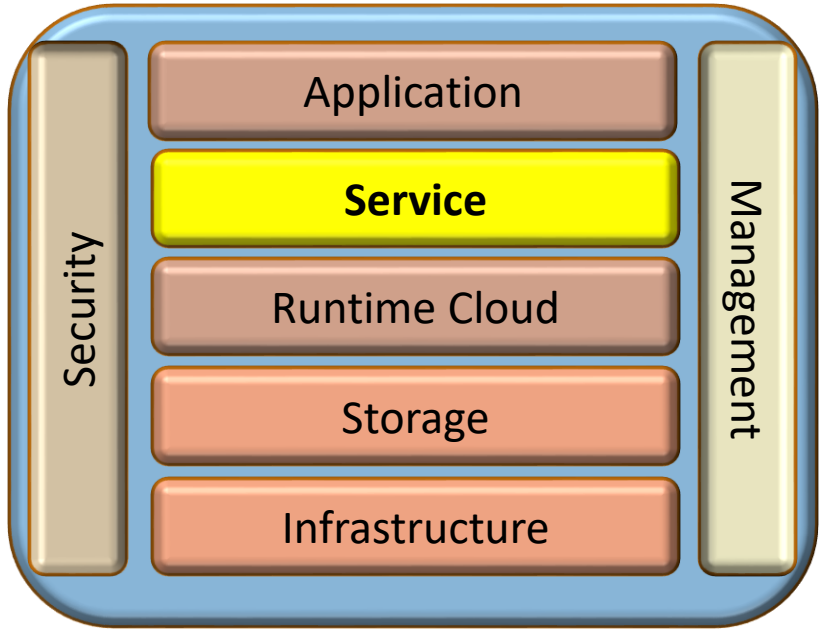
- User Interface for the backend
- Used by the client to interact with the backend services, databases, and manage the client's requests.
- It may be any kind of software that the client wants to access.



Backend

Service

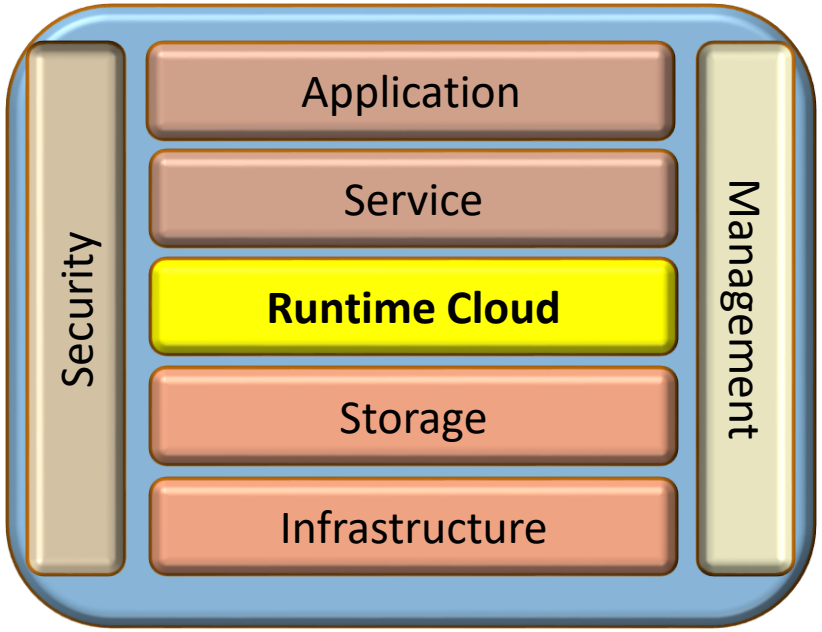
- Services consists of different type of service that has to accessed as per the requirement of the client.
- The services are primarily classified as-
  - Platform as a Service
  - Software as a Service
  - Infrastructure as a Service



Backend

Runtime Cloud

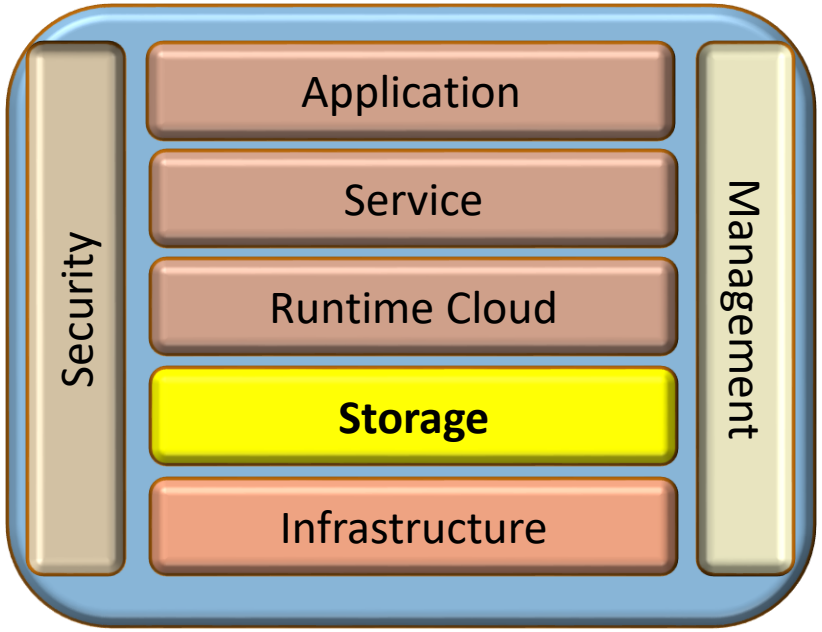
- Manages the execution of programs in virtual machines
- Manages runtime environment and instances of virtual machines



Backend

Storage

- Provides large storage capacity for client data
- Enables complex data analytics
- Supports computationally intensive tasks

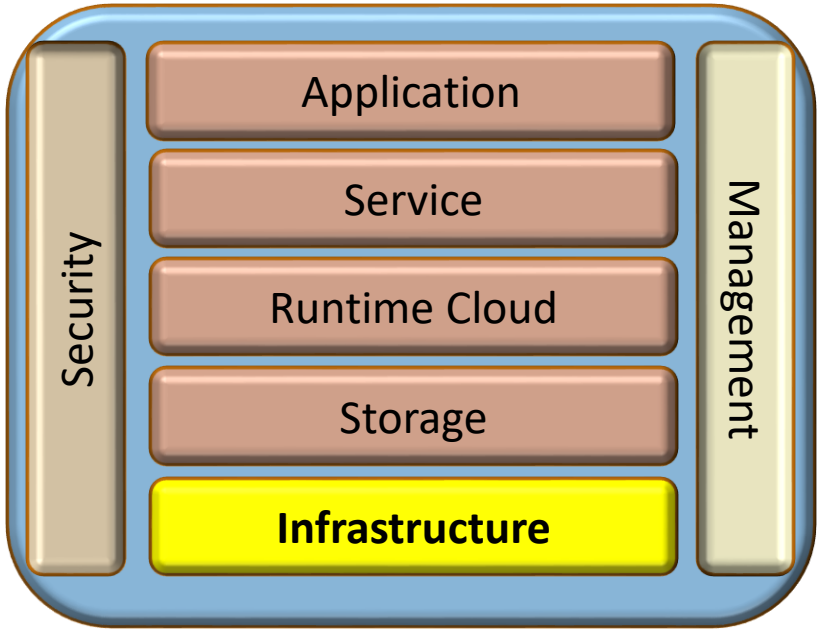


Backend

Infrastructure

- Responsible for providing services at 3 different levels-
  - Host level
  - Application level
  - Network level

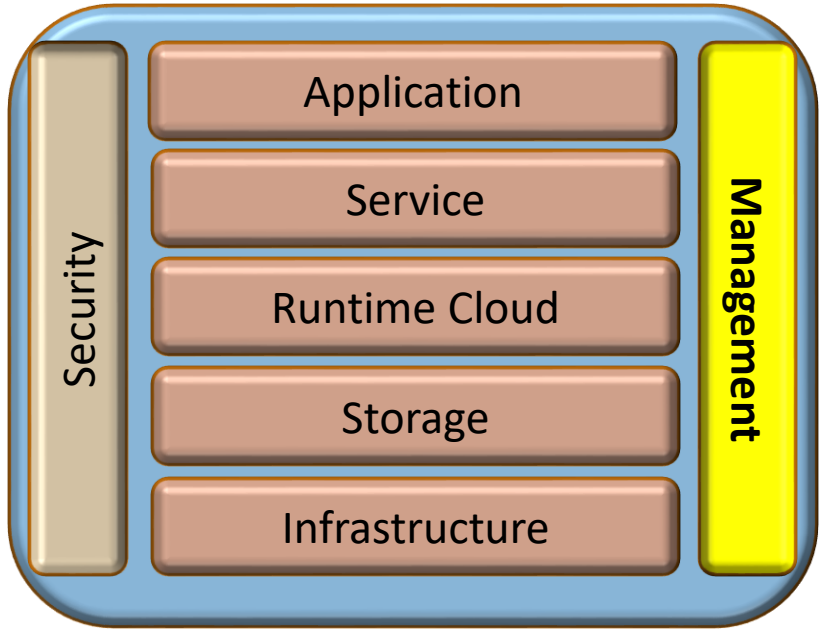
- Infrastructure consists of-
  - Software components such as virtualization software
  - Hardware components such as network devices, servers, and storage facilities



Backend

Management

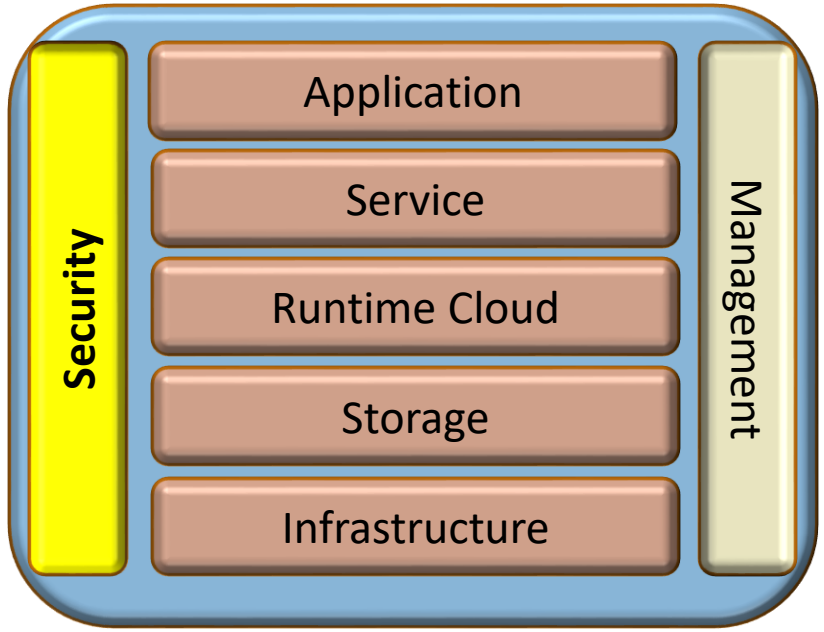
- Coordinates between different components of the backend
- Manages the cloud environment
- Manages the resources in the backend and orchestrate the workflow
- Manages workload distribution
- Implement security



Backend

Security

- This is a dedicated inbuilt component of the cloud backend
- Set of policies, rules, applications, and control mechanisms to enhance the privacy and security of the cloud infrastructure and services.



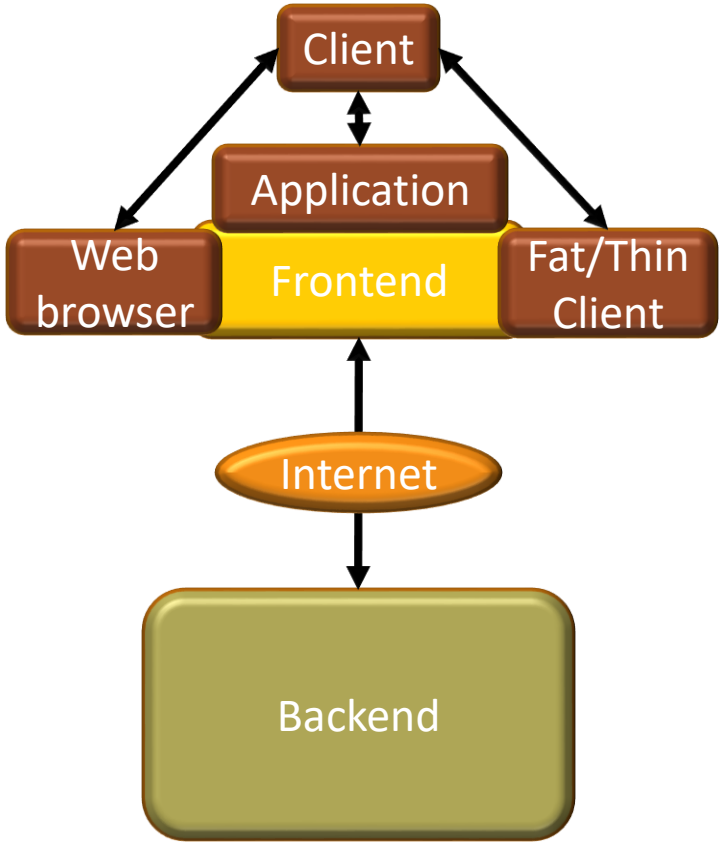
Backend

Front end: Components

- User Application
- User Interface
- Web Servers
- Thin Client
- Fat Client

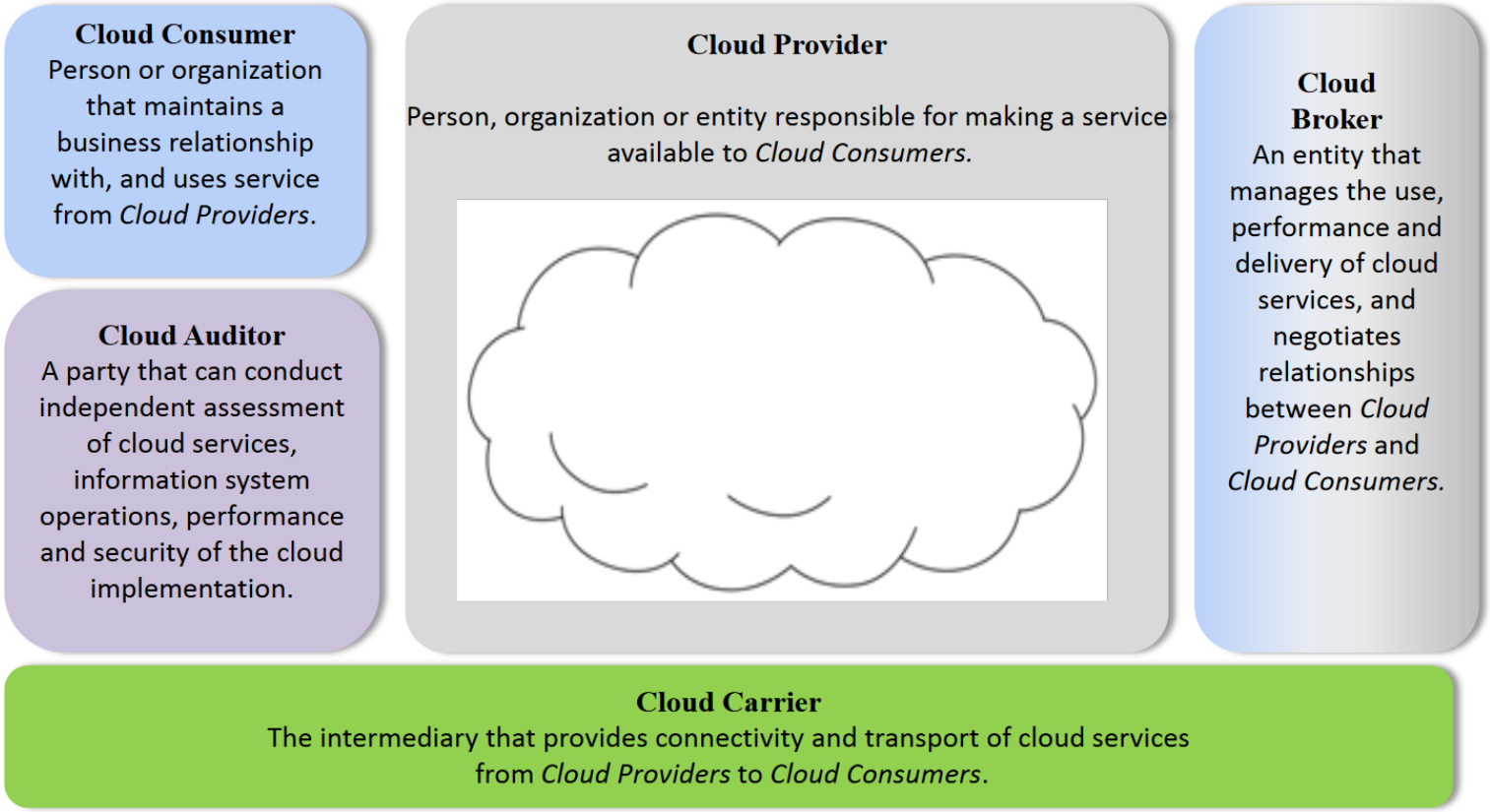
Front end

- User interface
- Client side web applications
- Web browsers
- Web servers



Cloud Actors

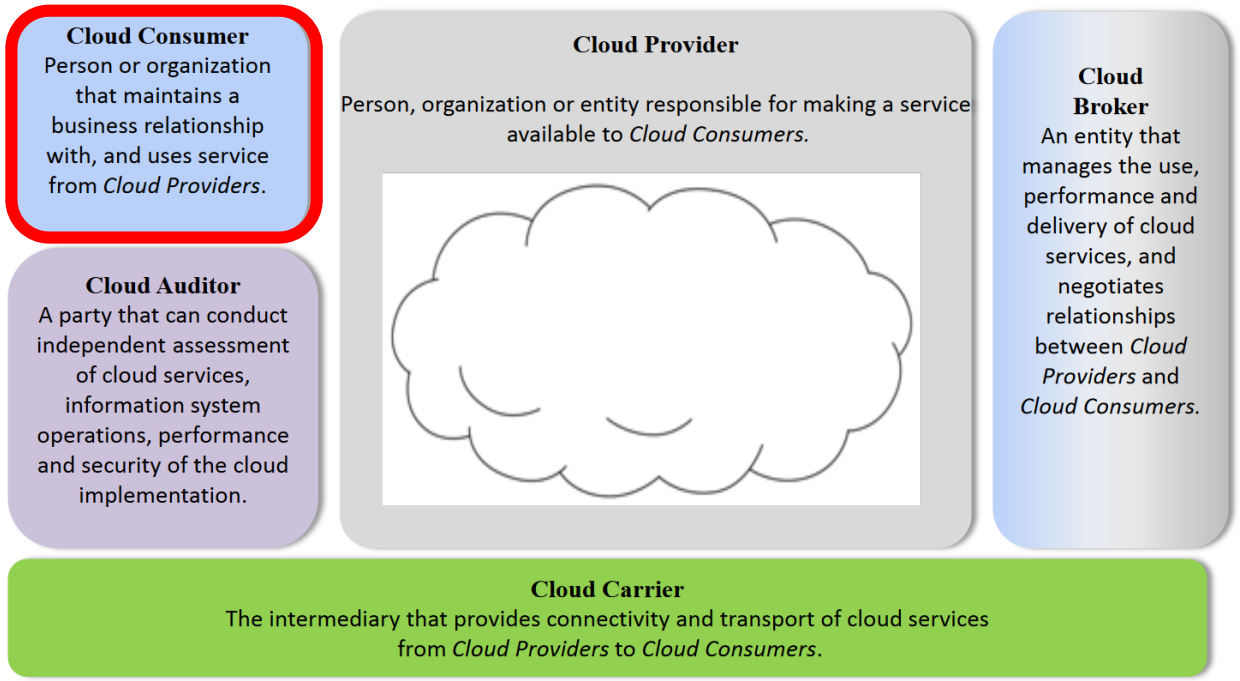
- Cloud Consumer
- Cloud Auditor
- Cloud Provider
- Cloud Broker
- Cloud Carrier



Source:

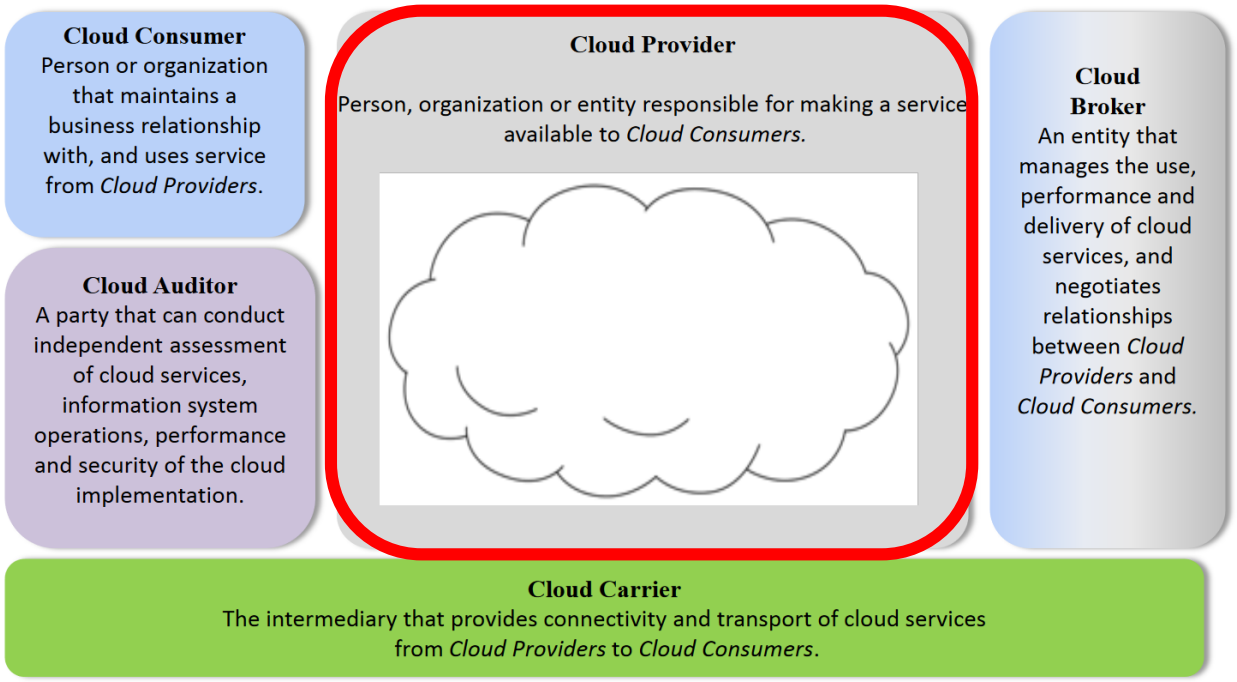
Cloud Consumer

- Primary stakeholder in the cloud computing services
- It may represent a person or an organization
- A cloud consumer uses the services of the cloud



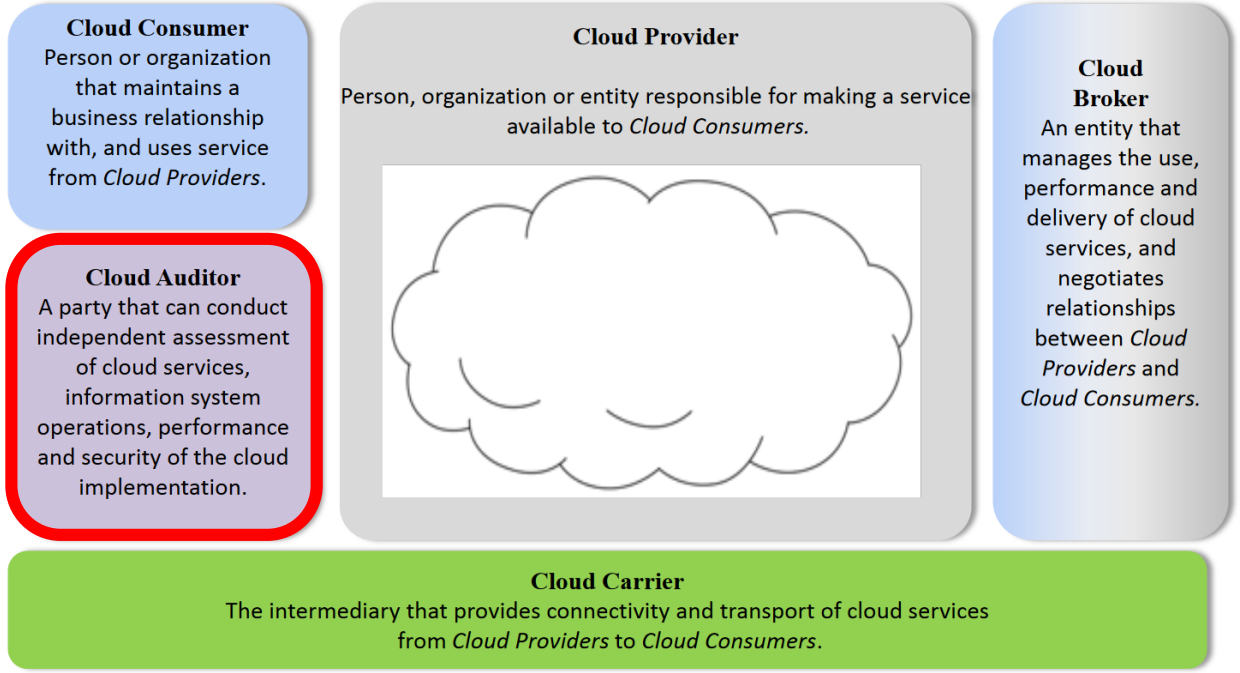
Cloud provider

- Provides cloud services to individuals or organizations
- Provides provide rented and provider-managed virtual hardware, software, infrastructure and other related services



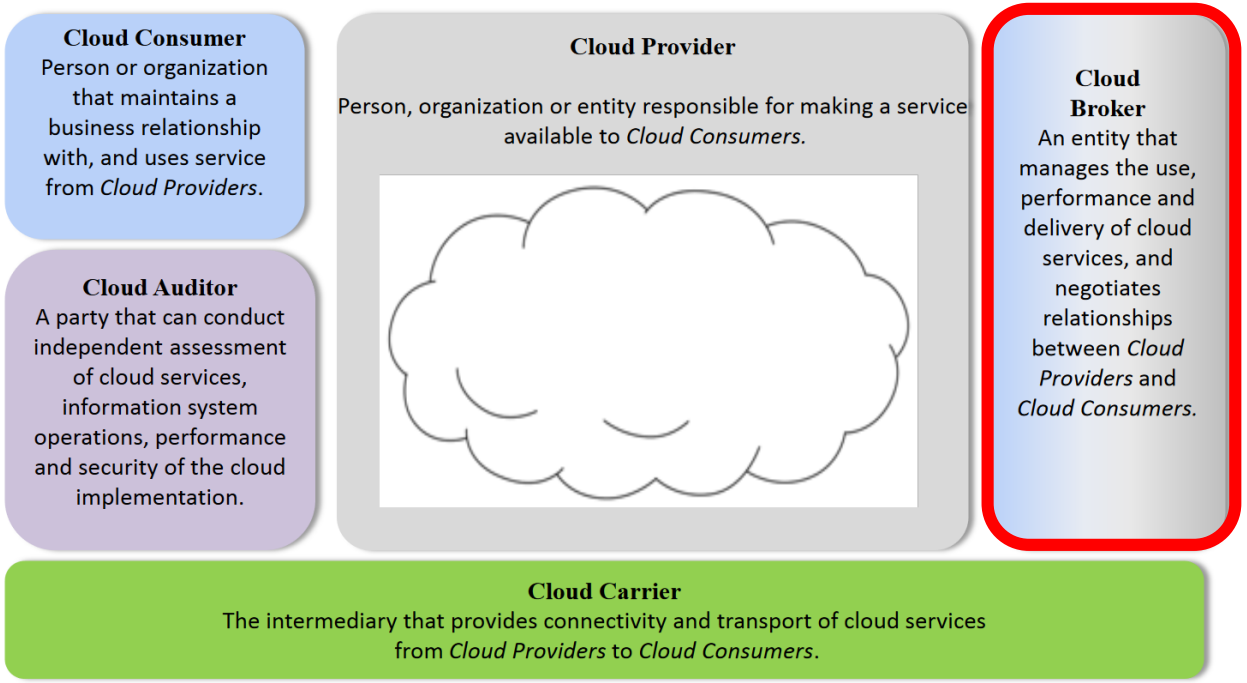
Cloud Auditor

- Examines the services provided by the Cloud provider
- Provides an independent opinion about the services and verify conformance with the standards
- Evaluate services such as security, performance, and privacy



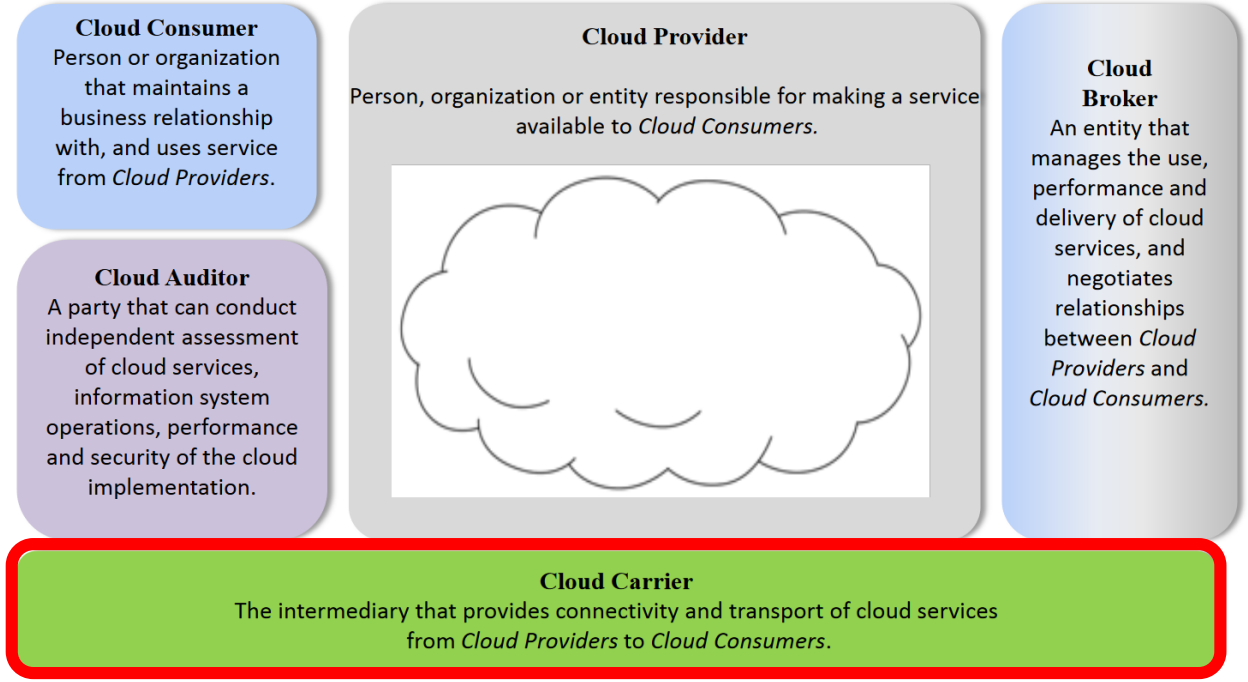
Cloud Broker

- Manages the use, performance and delivery of cloud services
- Negotiates relationships between cloud providers and cloud consumers
- Three categories of services provided by the cloud broker-
  - Aggregation
  - Arbitrage
  - Intermediation



Cloud Carrier

- Connects cloud services to the telecommunication provider
- Carrier clouds integrate some of the components and features found in telecom networks such as wide area networks (WAN), virtual private networks (VPN), open APIs and dynamic resource allocation.



Cloud Service Models (XaaS)

- XaaS stands for “Anything-as-a-Service” or “Everything-as-a-Service”
- Combination of Service Oriented Architecture and Cloud computing
- XaaS refers to different services provided over the Internet instead of performing it on the local machine or on-site.

Primary Cloud Service Models

- Infrastructure as a Service
- Platform as a Service
- Software as a Service

Provider Type	Major Activities
SaaS	Installs, manages, maintains and supports the software application on a cloud infrastructure.
PaaS	Provisions and manages cloud infrastructure and middleware for the platform consumers; provides development, deployment and administration tools to platform consumers.
IaaS	Provisions and manages the physical processing, storage, networking and the hosting environment and cloud infrastructure for IaaS consumers.

Source:

Infrastructure as a Service

- Services that provide high-level APIs used to abstract various low-level details of underlying network infrastructure like physical computing resources, location, data partitioning, scaling, security, backup

- According to NIST's definition of IaaS is

  where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

Infrastructure as a Service

Business aspects of IaaS:

- Economical web hosting services
- Supports application and web servers and manage networking resources
- Increased performance on computing
- Assists in big data analysis
- Maintains huge storage, backup, and recovery

Infrastructure as a Service

Example of IaaS:

- Google Cloud Platform
- Amazon's AWS
- Microsoft Azure

Platform as a Service

- NIST defines PaaS as

  The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

- Gives customers the ability to use a provider's physical hardware remotely

- Clients may utilize a provider's virtual servers, storage databases and networks on pay-per-use basis.

Platform as a Service

Business aspects of PaaS:

- Stands as a platform for the development and customization of cloud-based applications.

- PaaS tools allow you to investigate and mine their information thus finding deeper insights to deliver better outcomes.

- Offers services for enhanced protection, workflow, directory, and scheduling.

Platform as a Service

Examples of PaaS:

- Google App Engine
- Heroku

Software as a Service

- Provides on-demand access and use of cloud-based software without the need for physical, on-site equipment, platforms or installed software applications.
- As per the definition of SaaS by NIST-

  The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

Software as a Service

Business aspects of SaaS:

- Shows simple accessibility for complex applications
- Allows using client software in a free manner
- Mobilize workforce
- Accessibility for application information from any location

Software as a Service

Examples of SaaS:

- OneDrive
- DropBox
- Office 365

Other Cloud Service Models

- Security as a Service (SECaaS)
- Database as a Service (DaaS)
- Business Process as a Service (BPaaS)
- Identity as a Service (IDaaS)
- Backup as a Service (BaaS)
- Communications, content, and computing as a Service (CaaS)
- Storage as a Service (another SaaS)

Requirements

- Requirements of Cloud Service Provider:
  - Increase productivity
  - Increase end-user satisfaction
  - Increase innovation
  - Increase agility

Microservices

- It is a variant of the Service-oriented Architecture
- It arranges an application as a collection of loosely coupled services
- Microservices use lightweight protocols

Microservices

Characteristics:

- Services in a microservice architecture (MSA) are often processes that communicate over a network to fulfil a goal using technology-agnostic protocols such as HTTP
- Services are organized around business capabilities
- Services can be implemented using different programming languages, databases, hardware and software environment, depending on what fits best

Microservices

Characteristics:

- Services are small in size, messaging-enabled, bounded by contexts, autonomously developed, independently deployable, decentralized and built and released with automated processes

- Lends itself to a continuous delivery software development process. A change to a small part of the application only requires rebuilding and redeploying only one or a small number of services

- Adheres to principles such as fine-grained interfaces (to independently deployable services), business-driven development (e.g. domain-driven design)

Microservices

Benefits:

- **Scalability:**

  Since microservices are implemented and deployed independently of each other, i.e. they run within independent processes, they can be monitored and scaled independently

- **Distributed development:**

  It parallelizes development by enabling small autonomous teams to develop, deploy and scale their respective services independently. It also allows the architecture of an individual service to emerge through continuous refactoring. Microservice-based architectures facilitate continuous integration, continuous delivery and deployment.

Microservices

Benefits:

- **Modularity:**

  This makes the application easier to understand, develop, test, and become more resilient to architecture erosion. This benefit is often argued in comparison to the complexity of monolithic architectures

- **Integration of heterogeneous and legacy systems:**

  Microservices is considered as a viable mean for modernizing existing monolithic software application. There are experience reports of several companies who have successfully replaced (parts of) their existing software by microservices, or are in the process of doing so. The process for Software modernization of legacy applications is done using an incremental approach.

References

- R. B. Bohn, J. Messina, F. Liu, J. Tong and J. Mao, "NIST Cloud Computing Reference Architecture," 2011 IEEE World Congress on Services, Washington, DC, 2011, pp. 594-596, doi: 10.1109/SERVICES.2011.105.
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- https://www.elprocus.com/cloud-computing-technology/
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Thank You!