# CLOUD COMPUTING
# (Undergraduate Course)

# Chapter 2 – Basic Concepts and Models

Presenter: **Dr. Nguyen Dinh Long**

Email: dinhlonghcmut@gmail.com

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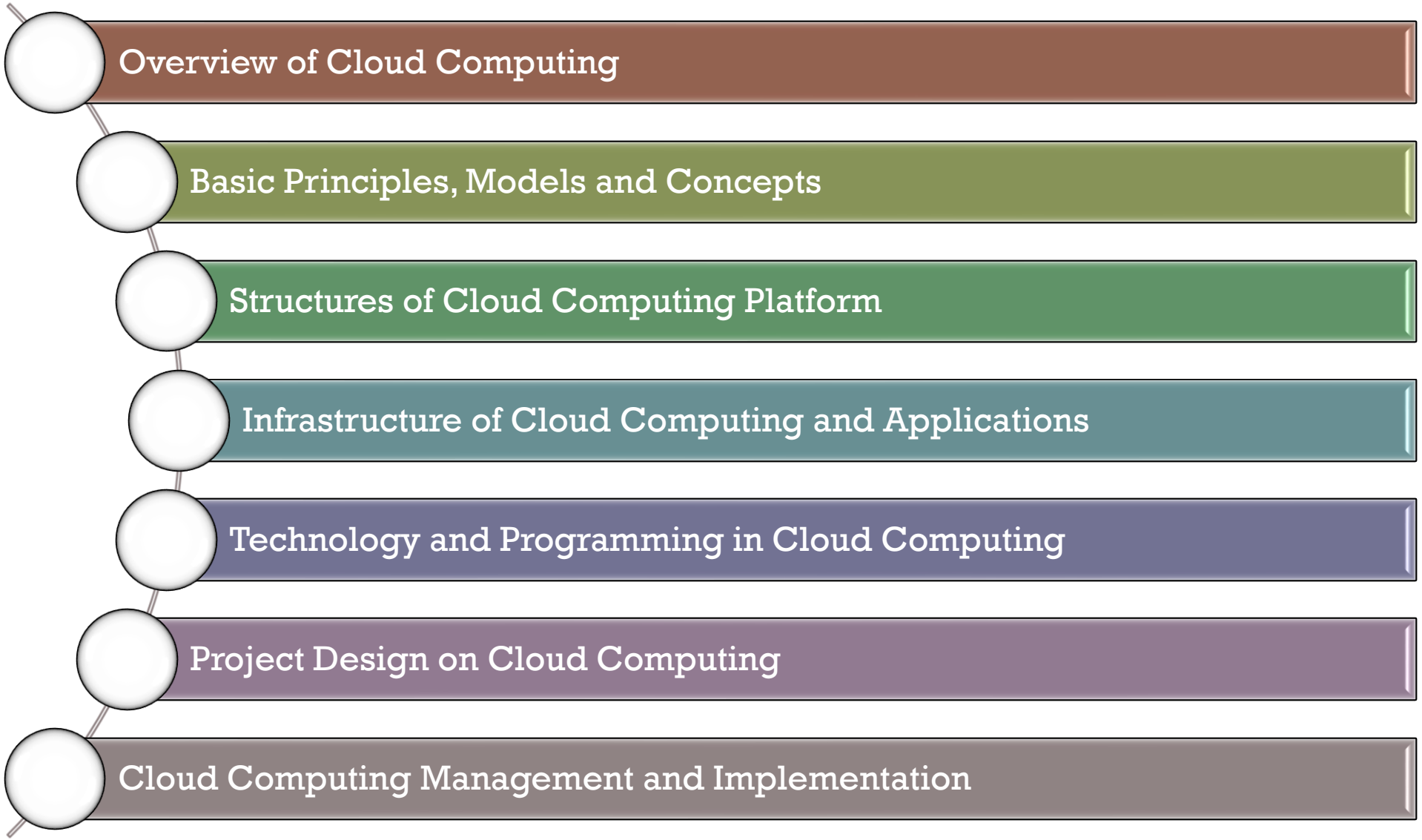
# Outline


Overview of Cloud Computing
Basic Principles, Models and Concepts
Structures of Cloud Computing Platform
Infrastructure of Cloud Computing and Applications
Technology and Programming in Cloud Computing
Project Design on Cloud Computing
Cloud Computing Management and Implementation

# References

Main:


- Thomas Erl, Zaigham Mahmood, and Ricardo Puttini. 2013. *Cloud Computing Concepts, Technology & Architecture*. Prentice Hall.
- Michael J. Kavis. 2014. *Architecting the Cloud: Design Decisions for Cloud Computing Service Models*. Wiley
- Arshdeep Bahga, and Vijay Madisetti. 2013. *Cloud Computing: A Hands-On Approach*. CreateSpace Independent Publishing Platform


More:


- Rajkuma Buyya, Jame Broberg and Andrzej Goscinski. 2011. *Cloud Computing –Principles and paradigms*, Wiley
- Nick Antonopoulos, and Lee Gillam. 2010. *Cloud Computing - Principles, Systems and Applications*, Springer-Verlag London Limited.


- Slides here are modified from several sources in Universities and Internet.

# Content of Chapter 2

1. Basic concepts, Principle components

2. Structures of cloud
   Cloud computing, cloud services, cloud app …

3. Characteristics of cloud computing

4. Cloud computing services

5. Some cloud computing platforms and analysis

6. Applications of cloud computing

# What is Cloud computing?

**Linh hoạt lưu trữ**

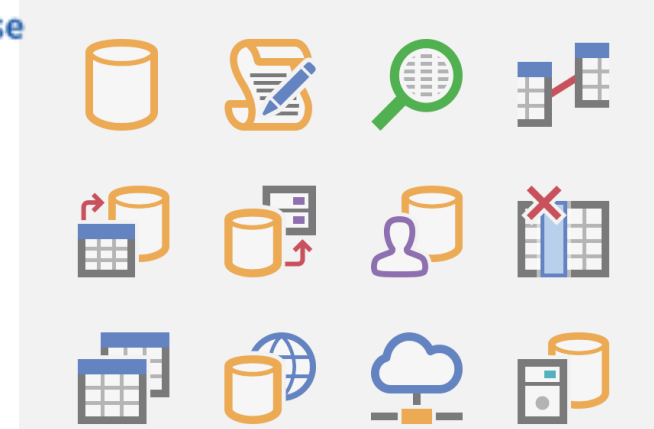
**Đa ứng dụng, phương tiện**

**Đa tương tác**
**Low coding**

**Máy chủ ảo**
(serverless computing)




**Cơ sở dữ liệu trực tuyến**



# What is Cloud computing?

- What do you think?

- *"**Cloud computing** is an information technology (IT) paradigm that enables ubiquitous access to shared pools of configurable system resources and higher-level services that can be rapidly provisioned with minimal management effort, often over the Internet. Cloud computing relies on sharing of resources to achieve coherence and economies of scale, similar to a public utility."*

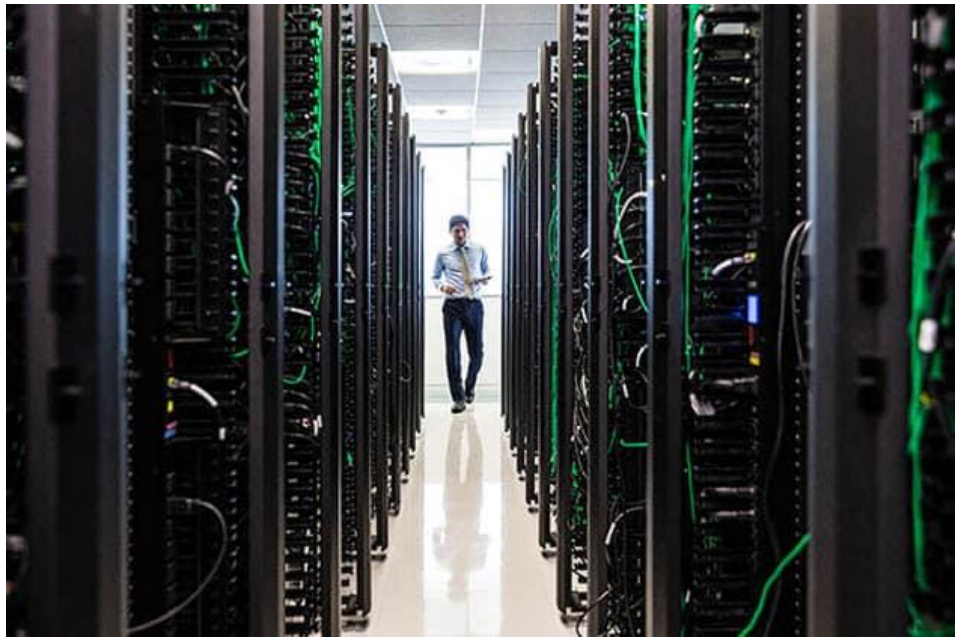
https://en.wikipedia.org/wiki/Cloud_computing

# What is Cloud computing?

- **… Data center …**

- A data center is a facility made up of networked computers, storage systems, and computing infrastructure that businesses and other organizations use to organize, process, store large amounts of data.
- A business typically relies heavily on applications, services, and data within a data center, making it a focal point and critical asset for everyday operations.
- Enterprise data centers increasingly incorporate cloud computing resources and facilities to secure and protect in-house, onsite resources.
- The key components of a data center design include routers, switches, firewalls, storage systems, servers, and application-delivery controllers.

*As enterprises increasingly turn to cloud computing, the boundaries between cloud providers' data centers and enterprise data centers become less clear*.



# What is Cloud computing?

- **… Data center vs Cloud computing …**

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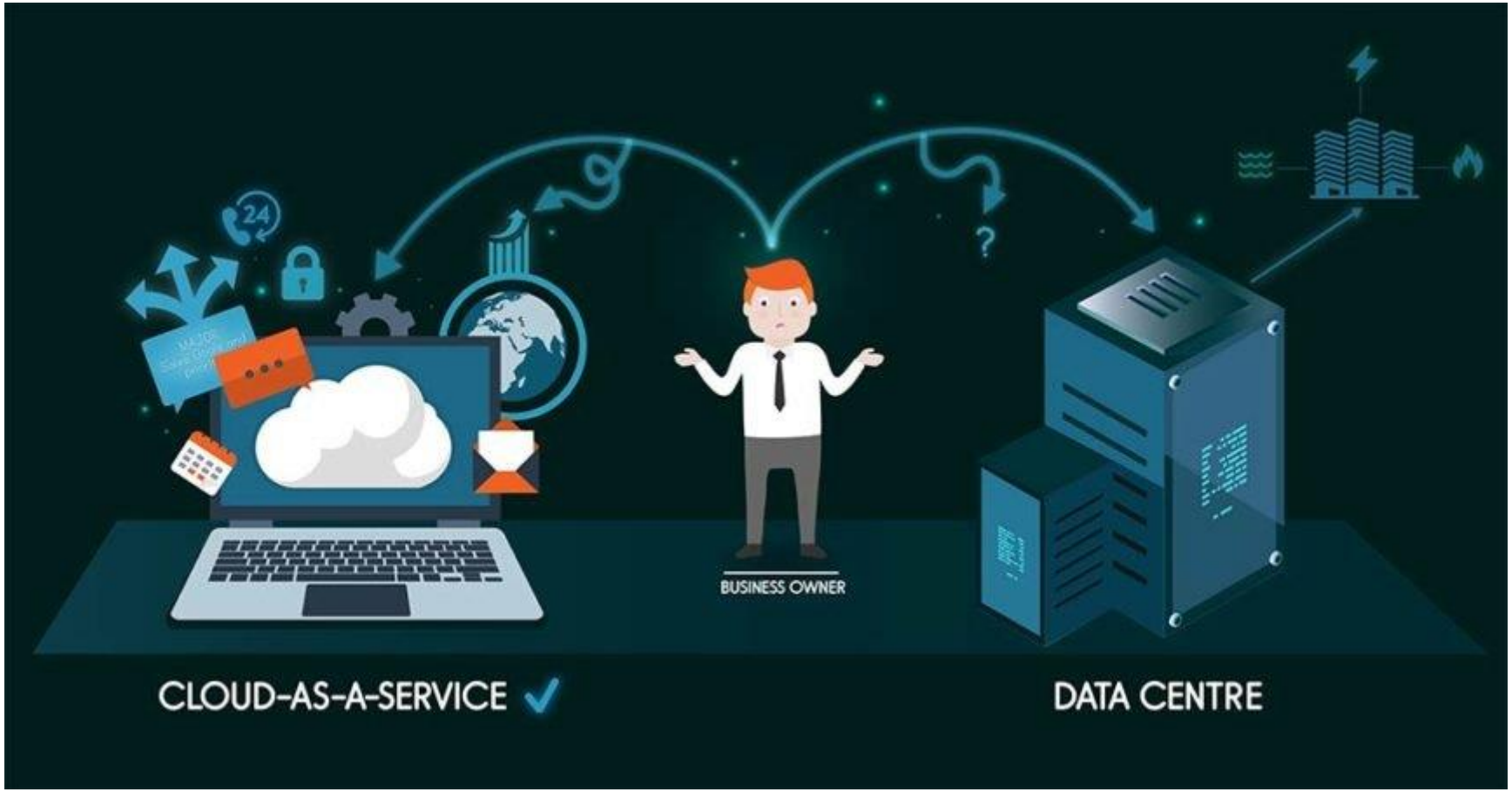


# What is Cloud computing?

- **Server (Compact)**

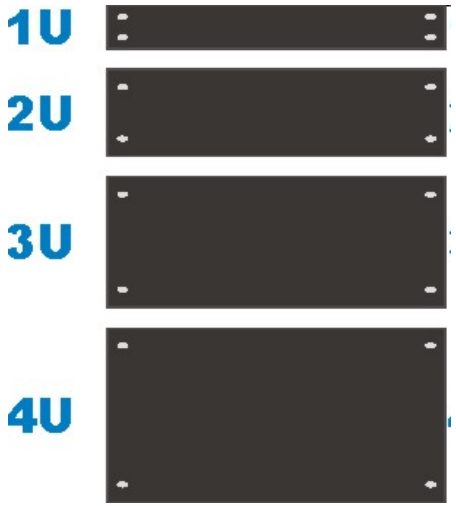
- **Server (large-scale installations)**

# What is Cloud computing?

- **Rack units**

**A single rack can hold up to 42 1U servers**

1 rack ~ 42U – 47U
1U ~ one/two processors GHz,
4GB Ram, 60GB HDD/SSD
2 network ports

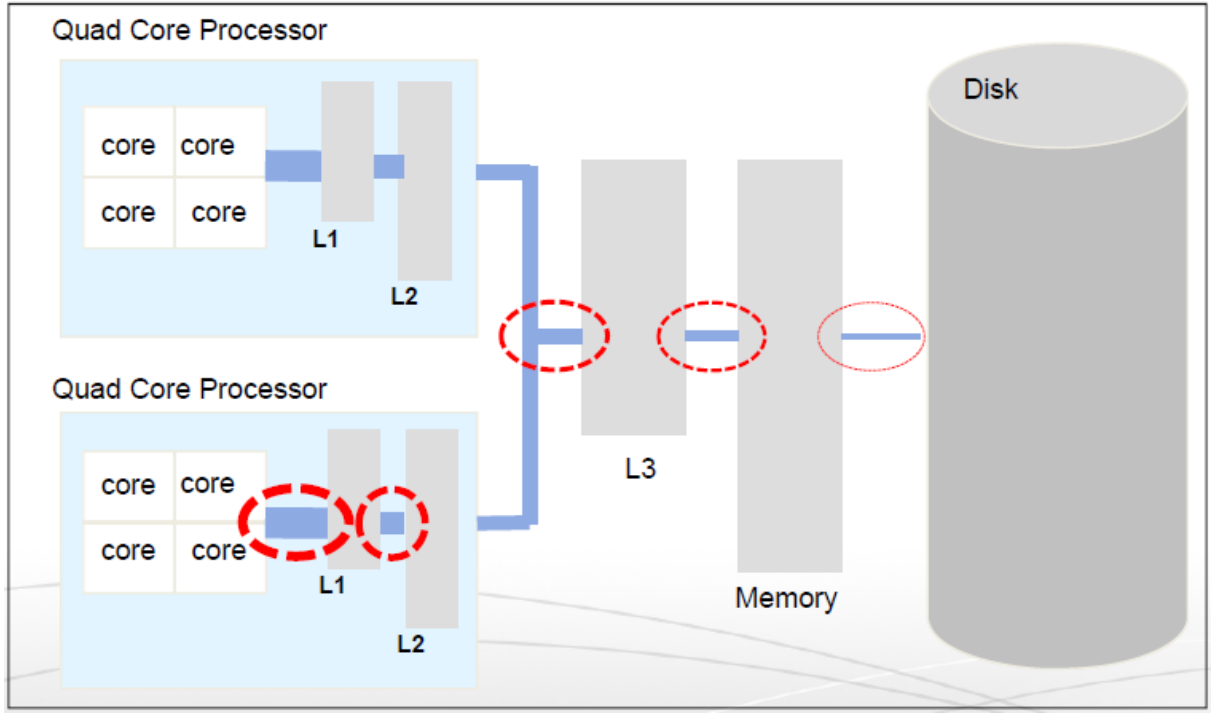



# What is Cloud computing?

- **Blades and Blade Enclosures**

A blade enclosure holds multiple blade servers and provides power

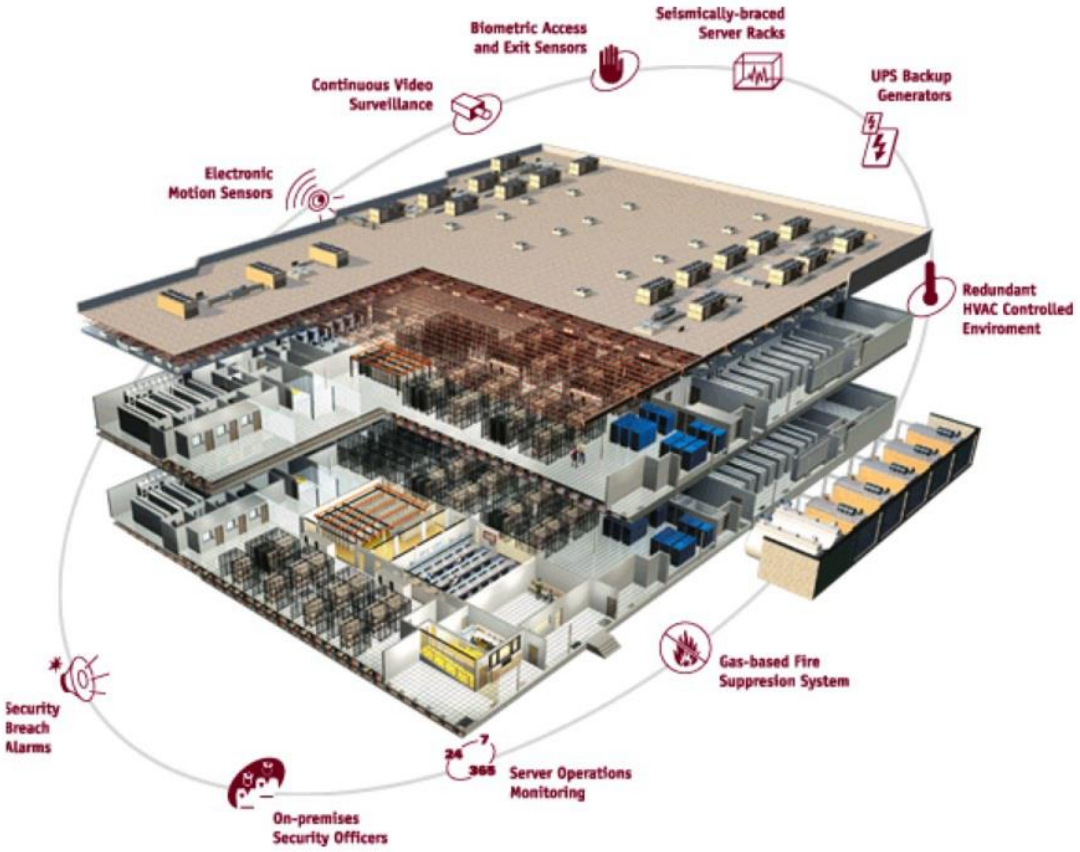
- **Blade Performance**



# What is Cloud computing?

- **Data center:**

A data center is a facility used to house computer systems and associated components



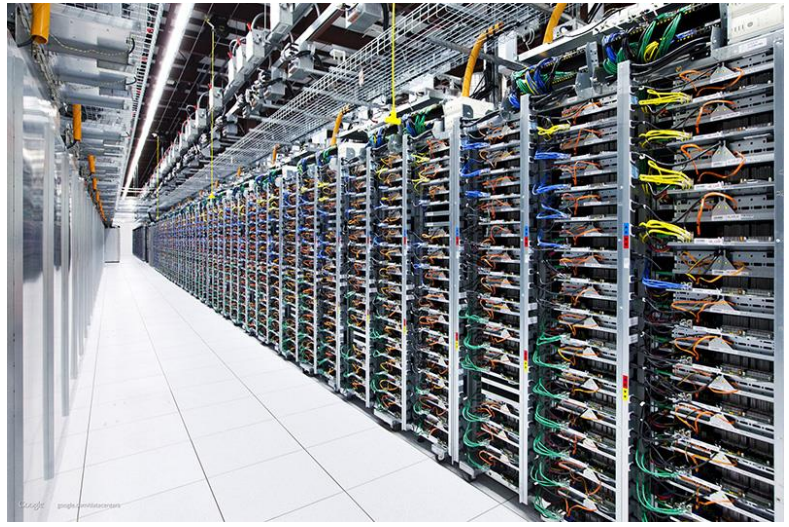

**Data Center Components**

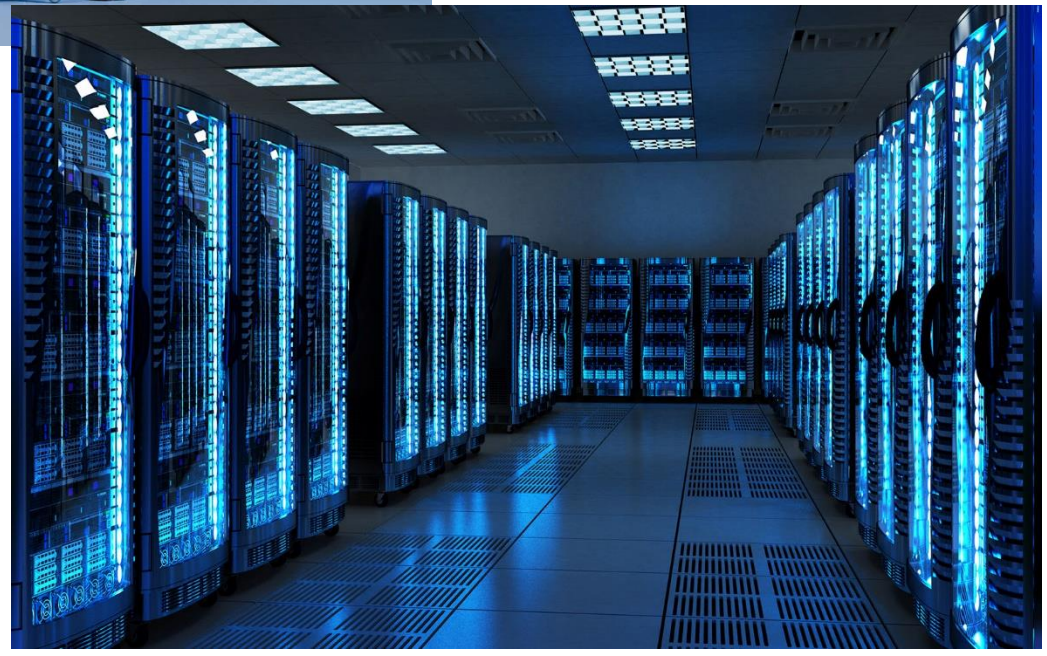
- ❑ Air conditioning
  - Keep all components in the manufacturer's recommended temperature range
- ❑ Redundant Power
  - UPS/Generators
  - Multiple power feeds
- ❑ Fire protection
- ❑ Physical security
  - CCTV/Access Control
- ❑ Monitoring Systems
- ❑ Connectivity
  - Multiple ISPs/Leased Lines

# What is Cloud computing?

- **Data center:**

A data center is a facility used to house computer systems and associated components





# Largest Data Centers

- **Rank 10: CoreSite Reston VA3 (100% Renewable Energy)**

Area: 940,000 square feet

Location: Northern Virginia, United States

There are three facilities in CoreSite's Reston data center: VA1, VA2, and VA3. The last is the largest one with a total square feet area of more than 940,000. It provides access to almost all cloud, network, and managed service providers.

12 MW power

280 customers

40 cloud providers

170 enterprises

70 network providers

# Largest Data Centers

- **Rank 09: Tulip Data Center ($ 200 million USD)**

Area: 970,000 square feet

Location: Bengaluru, India

The facility is backed by 100 MW of power and has the capacity to house 12,000 racks. Integrated building management systems controls all crucial components of the building, including power, air-conditioning, and security. Being the most energy-efficient and most ‘green’ datacenter in India, the facility saves up to 35 MW of power at full capacity.

# Largest Data Centers

- **Rank 08: QTS: Atlanta Metro ($127 million USD market value)**

Area: 990,000 square feet

Location: Atlanta, United States

QTS Atlanta Metro facility has its own on-site Georgia Power substation and direct fiber access to various carrier alternatives. It offers a wide range of services, including colocation, custom data center, and cloud services.

The building has 46 generators support and 24 independent UPS systems. Electrical redundancy is achieved through 2 feeds from separate substations, which power 3 on-site 40MVA transformers (120MVA).

# Largest Data Centers

- **Rank 07: Utah Data Center ($1.5 billion USD)**

Area: 1,000,000 square feet

Location: Utah, United States

900,000 square feet of area is used for technical support and administrative space. The remaining 100,000 square feet facility houses a mission-critical Tier III data center. The entire project (large twenty-building complex) costs $1.5 billion.

The data center is powered by the parallel Cray XC30 supercomputer that can handle workloads of over 100 petaflops (100,000 trillion operations per second).

# Largest Data Centers

- **Rank 06: Lakeside Technology Center (100% Renewable Energy)**

Area: 1,100,000 square feet

Location: Chicago, United States

Digital Reality, an investment trust, operates over 280 data center facilities totaling 35 million rentable square feet across the world. Its most impressive site, Lakeside Technology Center, is located at 350 East Cermak Road in Chicago.

In 2005, Digital Realty bought the building for $140 million. Today, it houses different types of data centers for financial firms. It includes 4 fiber vaults and 3 electric power feeds that provide the building with over 100 megawatts of power.

One of the unique features of this building is its cooling system, which is built using an 8.5 million gallon tank of a refrigerated brine-like liquid. This large tank serves as thermal energy storage, which further reduces costs by running chillers during off-peak hours.

# Largest Data Centers

- **Rank 05: Apple's Mesa Data Center ($ 800 million USD)**

Area: 1,300,000 square feet

Location: Arizona, United States

Mesa Datacenter was originally developed by Tempe-based First Solar Inc. In 2018, Apple revealed that it would spend $2 billion over the next decade to continue to improve the facility. However, the company, known for its secrecy, wouldn't share details about what happens inside the data center, citing security concerns.

To power the datacenter with green energy, Apple constructed a 300-acre solar power plant in Florence, Arizona. It has a 50 MW capacity, which is enough to power about 12,500 homes. It doesn't make the datacenter 100% green but does offset the power consumption in Mesa.

# Largest Data Centers

- **Rank 04: CWL1 Data Centre (100% Renewable Energy)**

Area: 1,450,000 square feet

Location: Newport, Wales

CWL1 is the largest data center in Europe. It has several dedicated offices and workspaces customizable as per customers' needs. There are plenty of meeting spaces and conference rooms throughout the campus.

CWL1 is currently among the most efficient data centers in the UK, with low power usage effectiveness (PUE). It has a direct 400 kV SuperGrid connection, highly resilient generators, and UPS systems.

# Largest Data Centers

- **Rank 03: The Citadel Campus (100% Renewable Energy)**

Area: 7,750,015 square feet

Location: Nevada, United States

The campus space is designed to exceed Tier IV standards. Its fiber network delivers 9-ms latency to San Diego and Los Angeles, with a 7-ms connection to TAHOE RENO 1 data center in The Citadel Campus.

650 MW of power using 100% renewable energy.

# Largest Data Centers

- **Rank 02: China Mobile ($ 2.1 billion USD)**

Area: 7,750,015 square feet

Location: Hohhot, China

China Mobile data center is located in the Inner Mongolia Information Park, Hohhot. With a service capacity of over 40,000 racks in a building of 720,000 square meters, it is one of the world's biggest cloud computing data centers.

The entire facility is built on 106 hectares with an initial investment of $1.92 billion. It serves as a centralized operation support system, which provides enterprise services, concentrated network management, and R&D for new technologies such as cloud computing and 5G.

# Largest Data Centers

- **Rank 01: China Telecom Data Center ($ 3 billion USD)**

Area: 10,763,910 square feet

Location: Hohhot, China

China Telecom has the largest internet data center in the world, and it has secured over 50% market share in the Chinese data center market. It has an extensive global network of over 400 data centers located in prime regions in Mainland China and overseas markets.

The company has established ‘green’ data center policies to minimize energy consumption. It has also laid emphasis on rainwater collection to reduce domestic water consumption.

# What is Cloud computing?

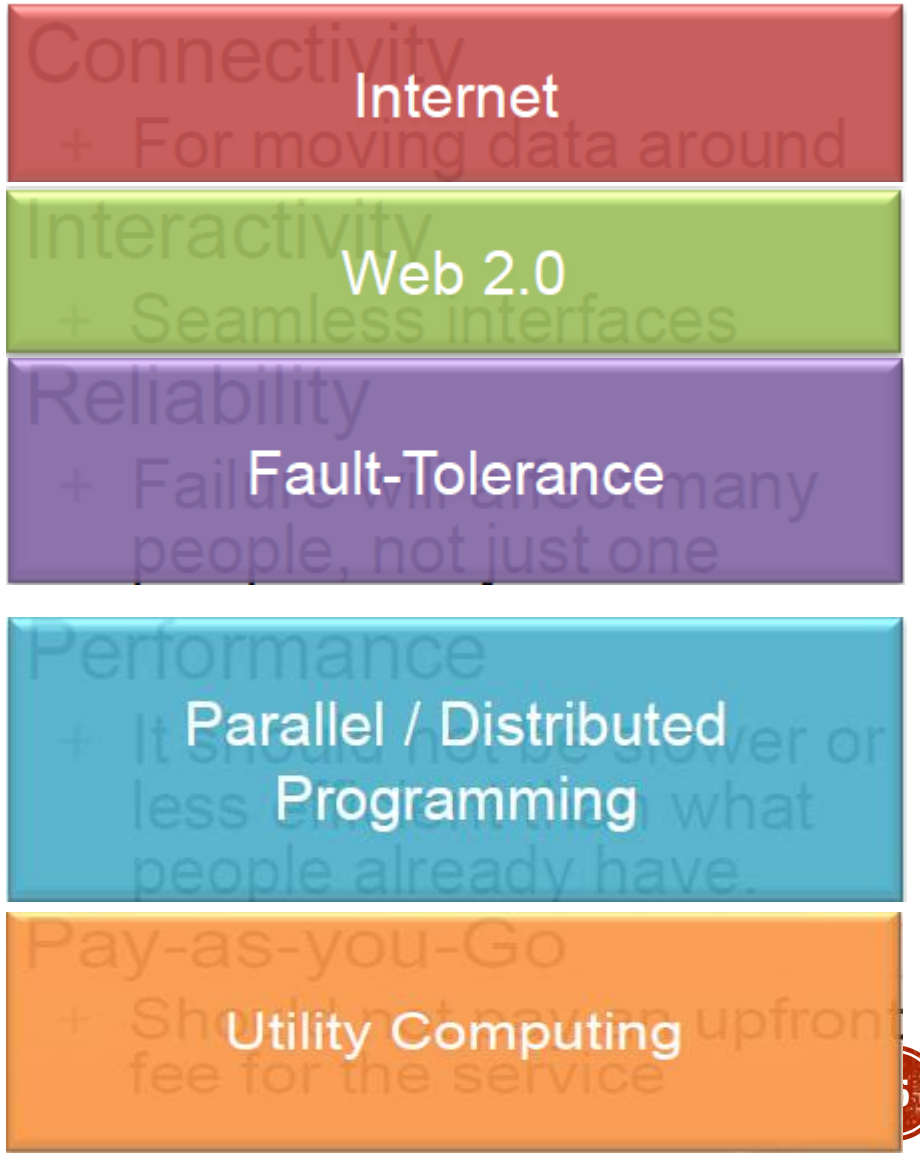
- **A Cloud is …**

**A data center hardware and software that the vendors use to offer the computing resources and services**

**“Cloud Computing is the transformation of IT from a product to a service”**

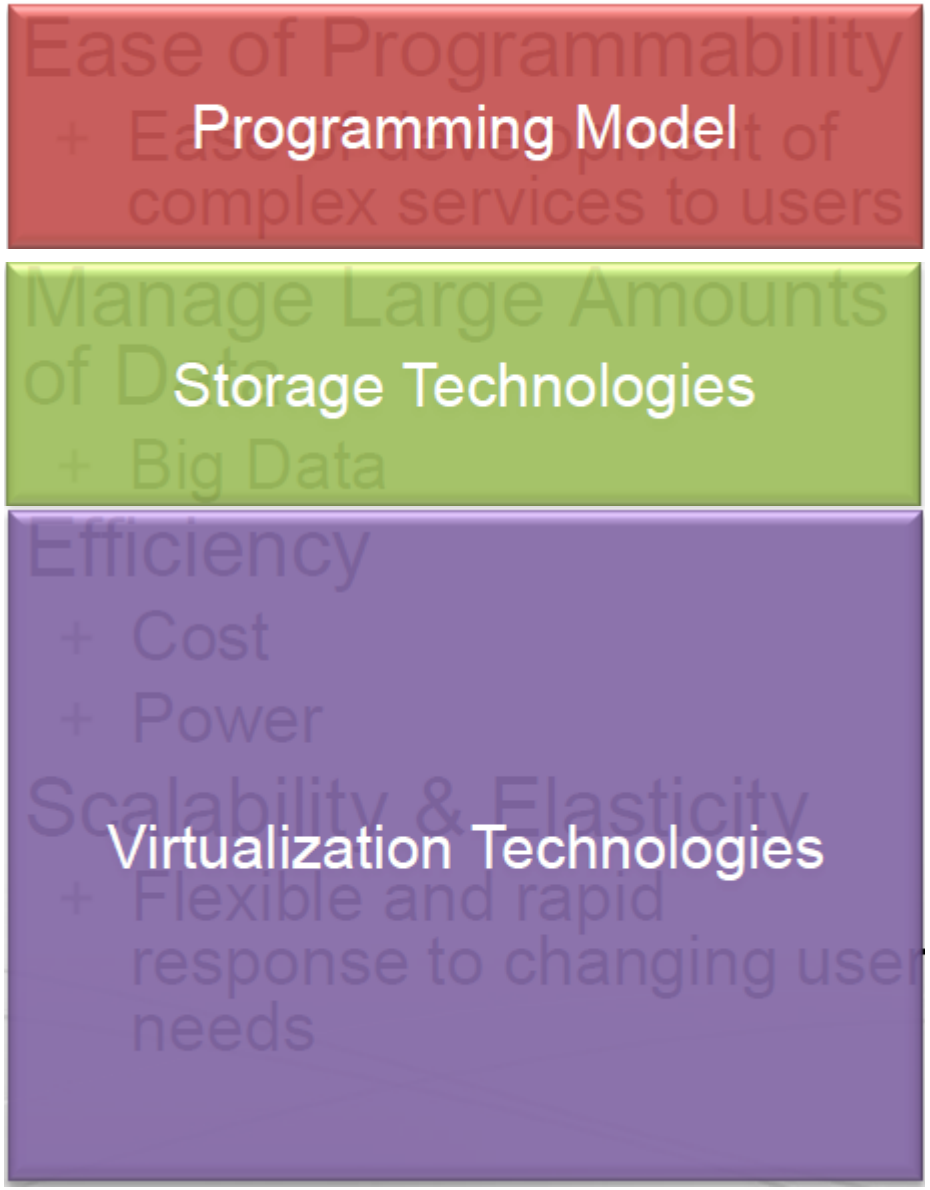

# Technology in Cloud computing

- **Requirements to Transform IT to a Service:**
  - Connectivity
    - For moving data around
  - Interactivity
    - Seamless interfaces
  - Reliability
    - Failure will affect many people, not just one
  - Performance
    - It should not be slower or less efficient than what people already have
  - Pay-as-you-Go
    - Should not pay an upfront fee for the service



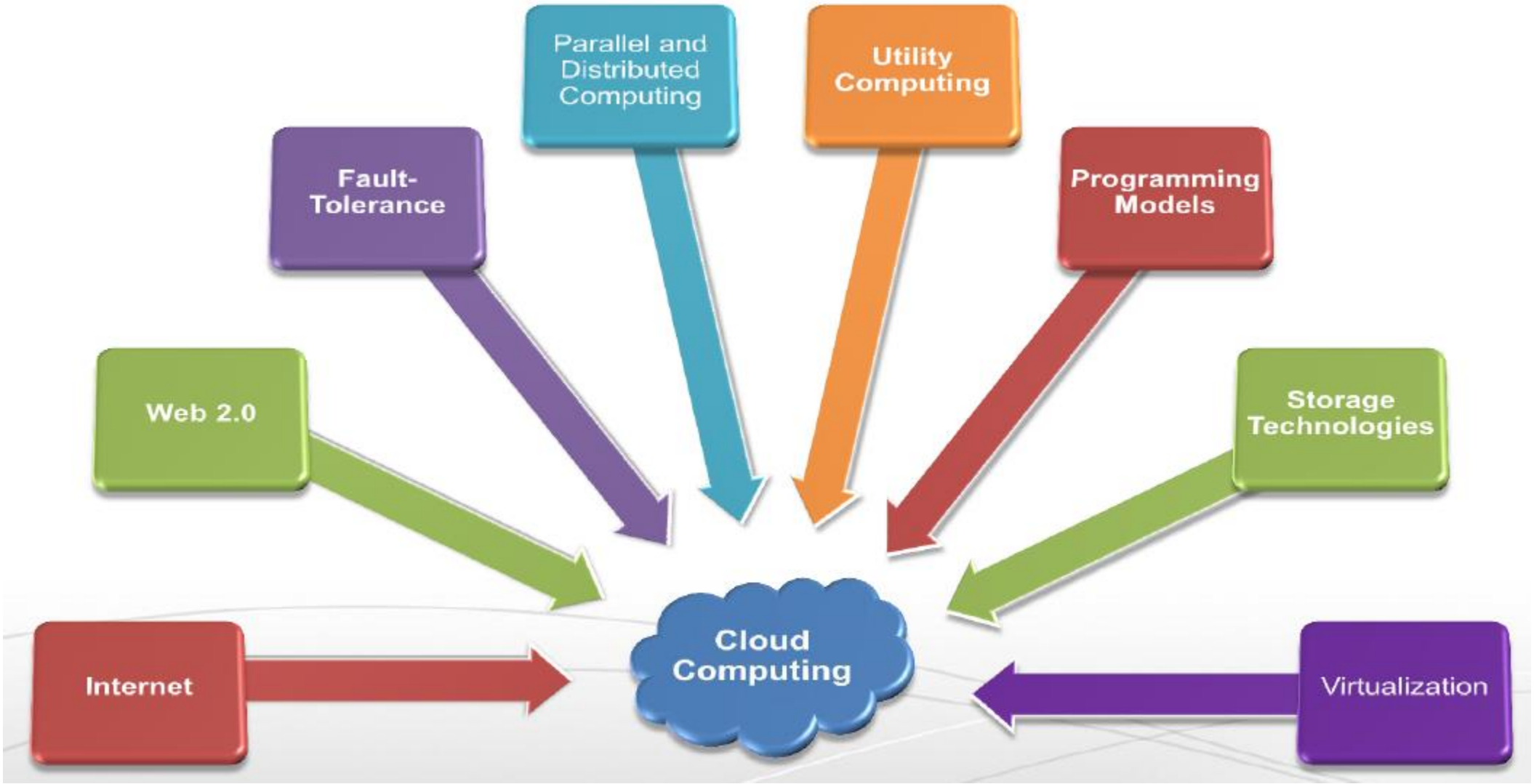
# Technology in Cloud computing

- **Requirements to Transform IT to a Service:**
  - Ease of Programmability
    - Ease of development of complex services to users
  - Manage Large Amounts of Data
    - Big Data
  - Efficiency
    - Cost
    - Power
  - Scalability & Elasticity
    - Flexible and rapid response to changing user needs

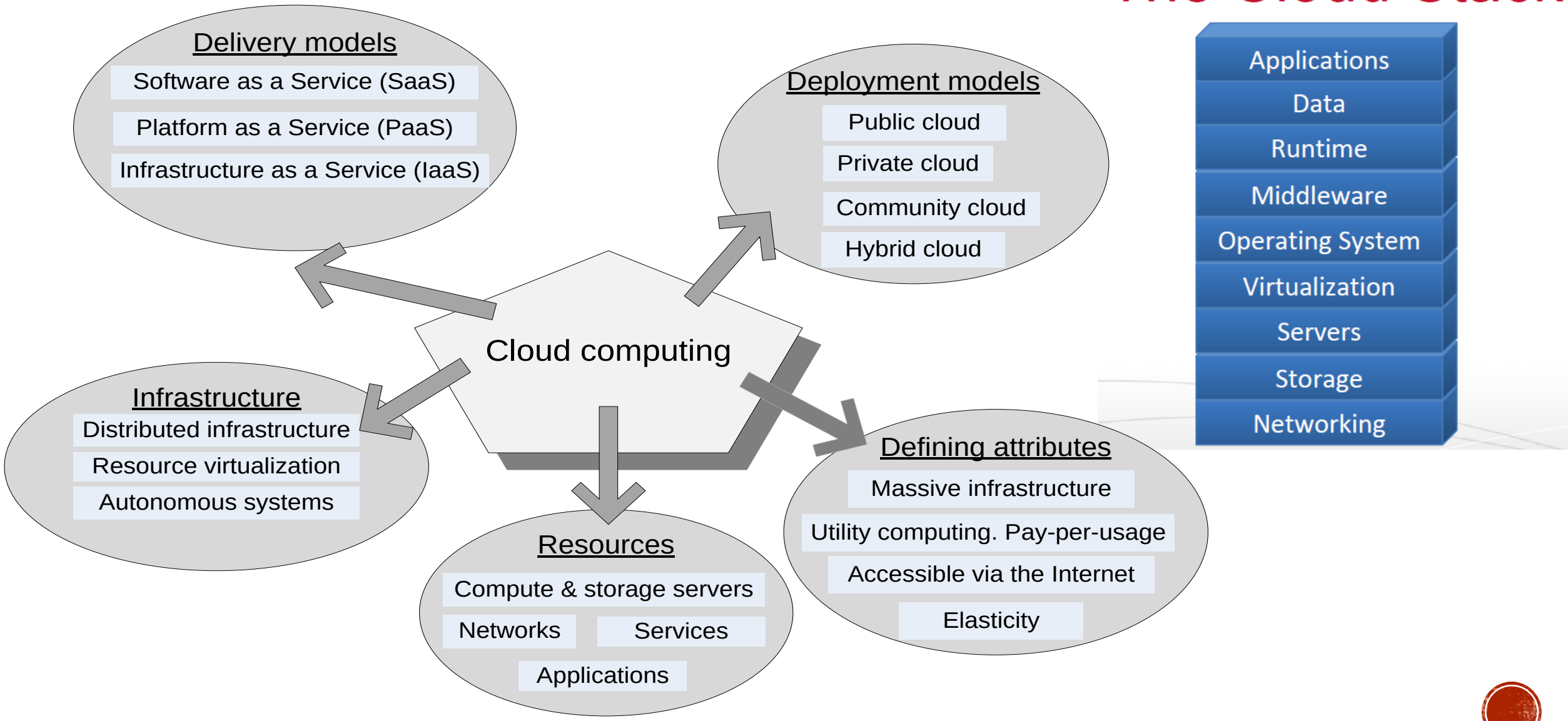


# Technology in Cloud computing

- Combine the Enabling Technologies…



# BASIC CONCEPTS AND PRINCIPLE COMPONENTS



# Basic concepts and Principle components

- **Roles:**

Organizations and humans can assume different types of pre-defined roles depending on how they relate to and/or interact with a cloud and its hosted IT resources. Each of the upcoming roles participates in and carries out responsibilities in relation to cloud-based activity.

The following sections define these roles and identify their main interactions:

- Cloud Provider
- Cloud Consumer
- Cloud Service Owner
- Cloud administrator

# Basic concepts and Principle components

- **Roles - Cloud Provider:**

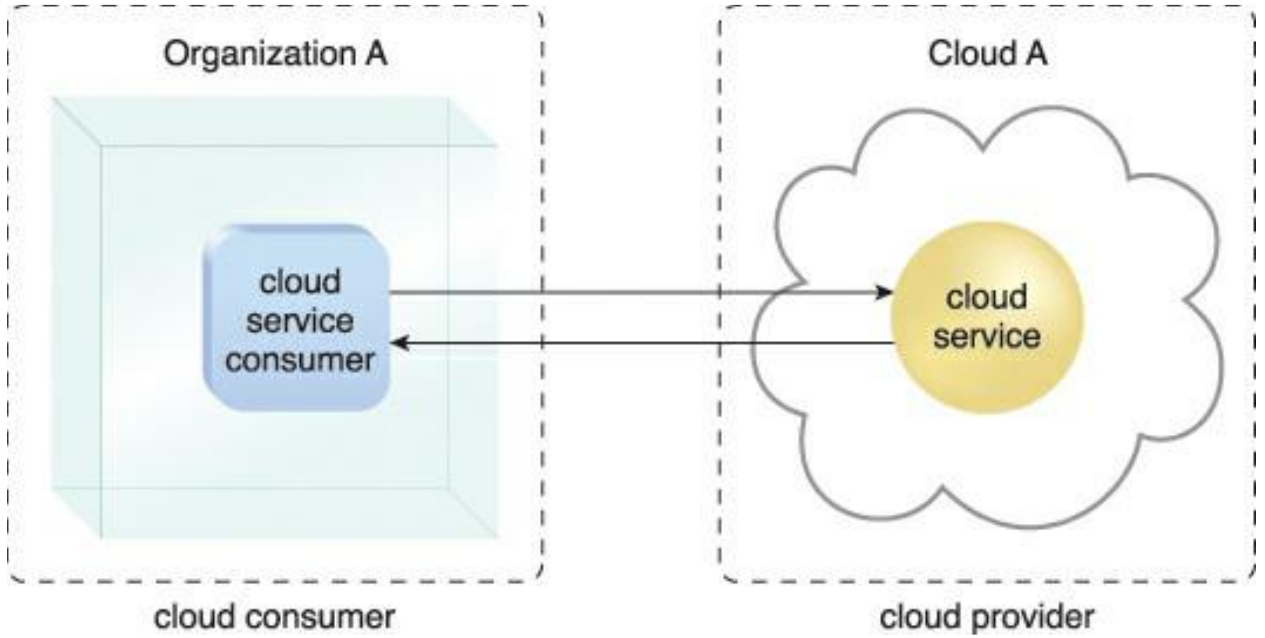
- The organization that provides cloud-based IT resources is the cloud provider. When assuming the role of cloud provider, an organization is responsible for making cloud services available to cloud consumers, as per agreed upon SLA guarantees. The cloud provider is further tasked with any required management and administrative duties to ensure the on-going operation of the overall cloud infrastructure.
- Cloud providers normally own the IT resources that are made available for lease by cloud consumers; however, some cloud providers also “resell” IT resources leased from other cloud providers.

# Basic concepts and Principle components

## Roles - Cloud Consumer:

- A cloud consumer is an organization (or a human) that has a formal contract or arrangement with a cloud provider to use IT resources made available by the cloud provider. Specifically, the cloud consumer uses a cloud service consumer to access a cloud service.
- The former is usually used to label software programs or applications that programmatically interface with a cloud service's technical contract or API.

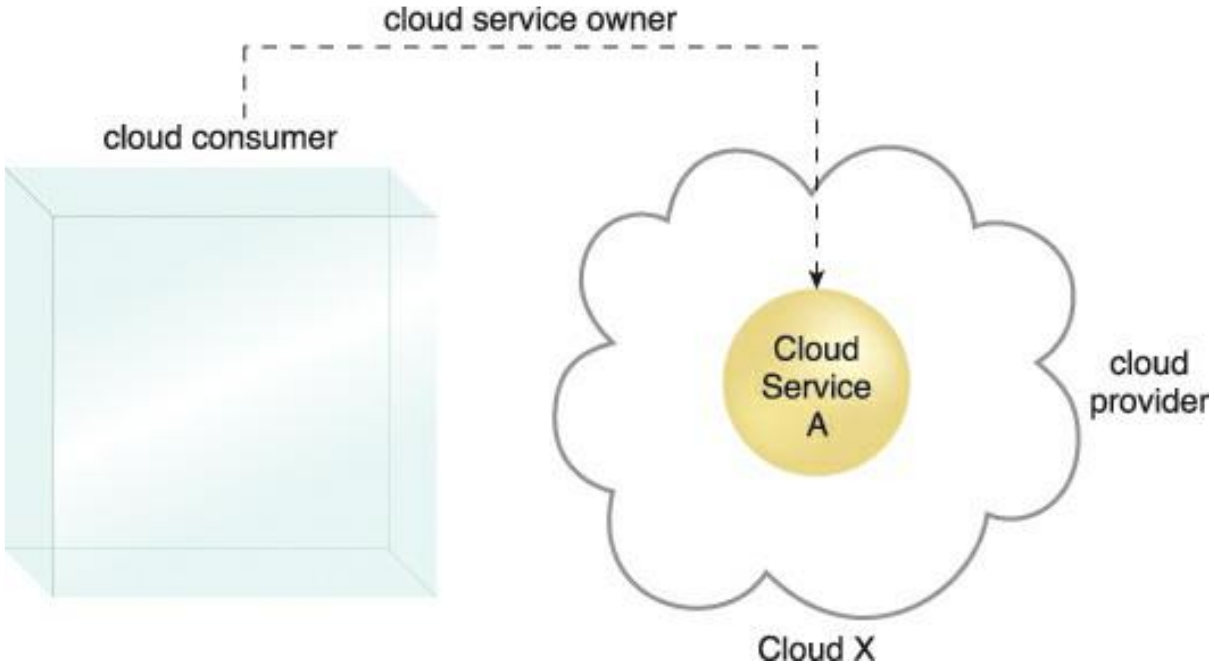
**API** is more broad in that it can be used to label an organization, an individual accessing a user-interface, or a software program that assumes the role of cloud consumer when interacting with a cloud, a cloud-based IT resource, or a cloud provider.

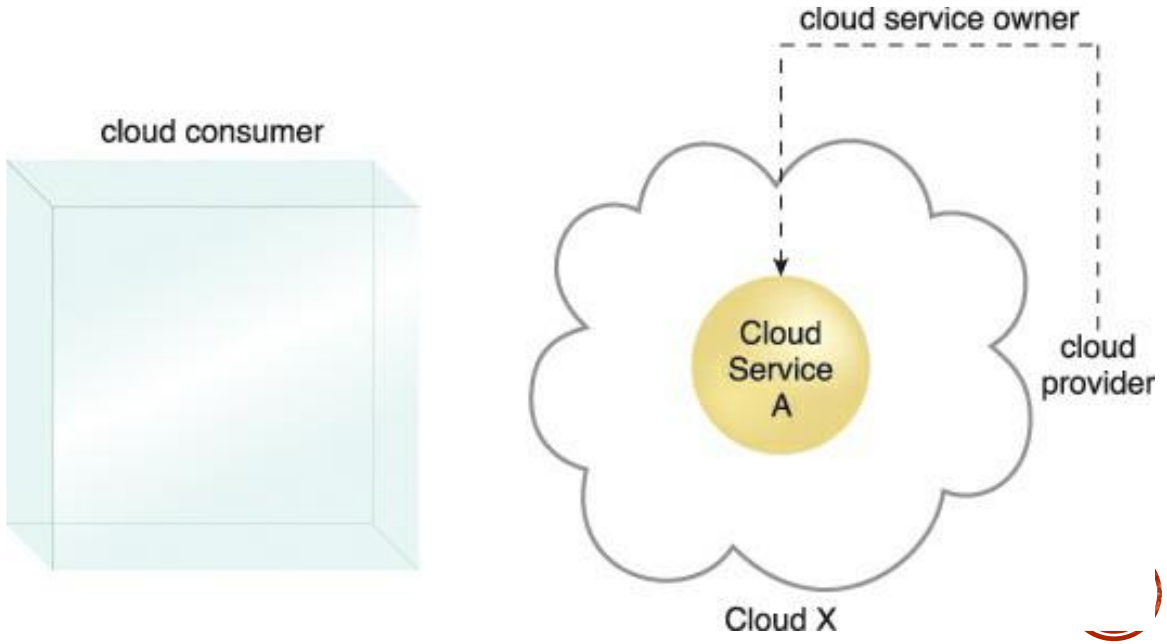


# Basic concepts and Principle components

## Roles - Cloud Service Owner:

- The person or organization that legally owns a cloud service is called a cloud service owner. The cloud service owner can be the cloud consumer, or the cloud provider that owns the cloud within which the cloud service resides.
- Note that a cloud consumer that owns a cloud service hosted by a third-party cloud does not necessarily need to be the user (or consumer) of the cloud service. Several cloud consumer organizations develop and deploy cloud services in clouds owned by other parties for the purpose of making the cloud services available to the general public.

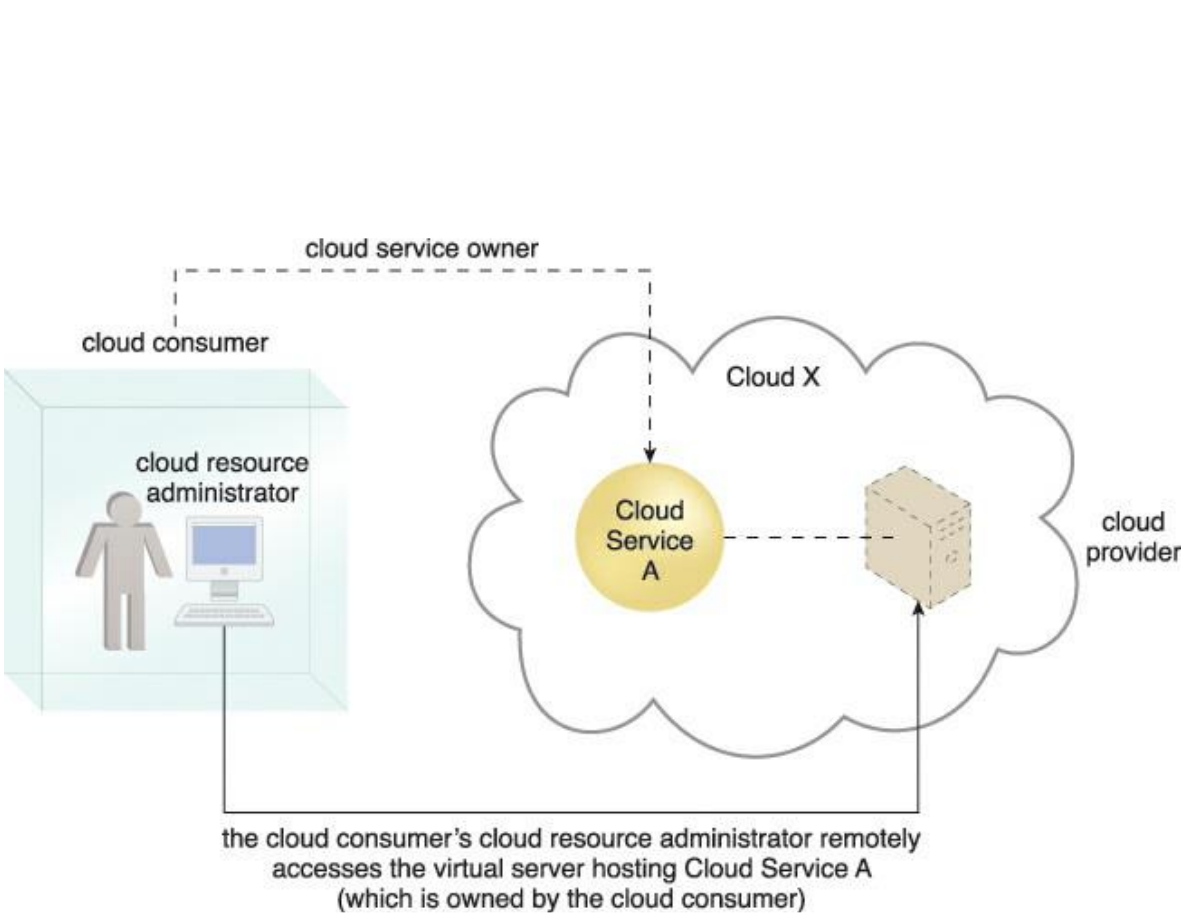


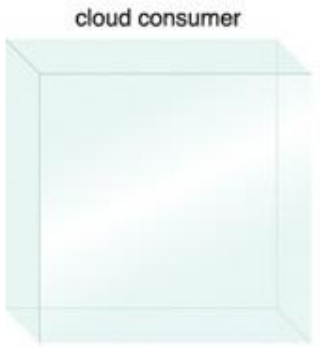



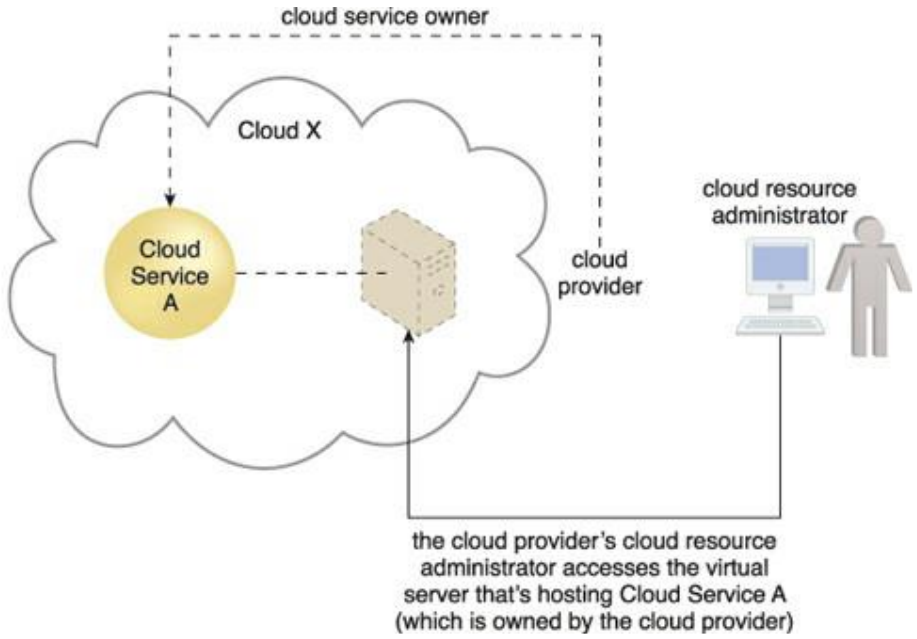
# Basic concepts and Principle components

## Roles - Cloud Resource Administrator:

- A cloud resource administrator is the person or organization responsible for administering a cloud-based IT resource (including cloud services). The cloud resource administrator can be (or belong to) the cloud consumer or cloud provider of the cloud within which the cloud service resides. Alternatively, it can be (or belong to) a third-party organization contracted to administer the cloud-based IT resource.



# Basic concepts and Principle components

- **Addition Roles:**

- *Cloud Auditor* – A third-party (often accredited) that conducts independent assessments of cloud environments assumes the role of the cloud auditor. The typical responsibilities associated with this role include the evaluation of security controls, privacy impacts, and performance. The main purpose of the cloud auditor role is to provide an unbiased assessment (and possible endorsement) of a cloud environment to help strengthen the trust relationship between cloud consumers and cloud providers.

- *Cloud Broker* – This role is assumed by a party that assumes the responsibility of managing and negotiating the usage of cloud services between cloud consumers and cloud providers. Mediation services provided by cloud brokers include service intermediation, aggregation, and arbitrage.

- *Cloud Carrier* – The party responsible for providing the wire-level connectivity between cloud consumers and cloud providers assumes the role of the cloud carrier. This role is often assumed by network and telecommunication providers

# Cloud characteristics

- An IT environment requires a specific set of characteristics to enable the remote provisioning of scalable and measured IT resources in an effective manner. These characteristics need to exist to a meaningful extent for the IT environment to be considered an effective cloud.

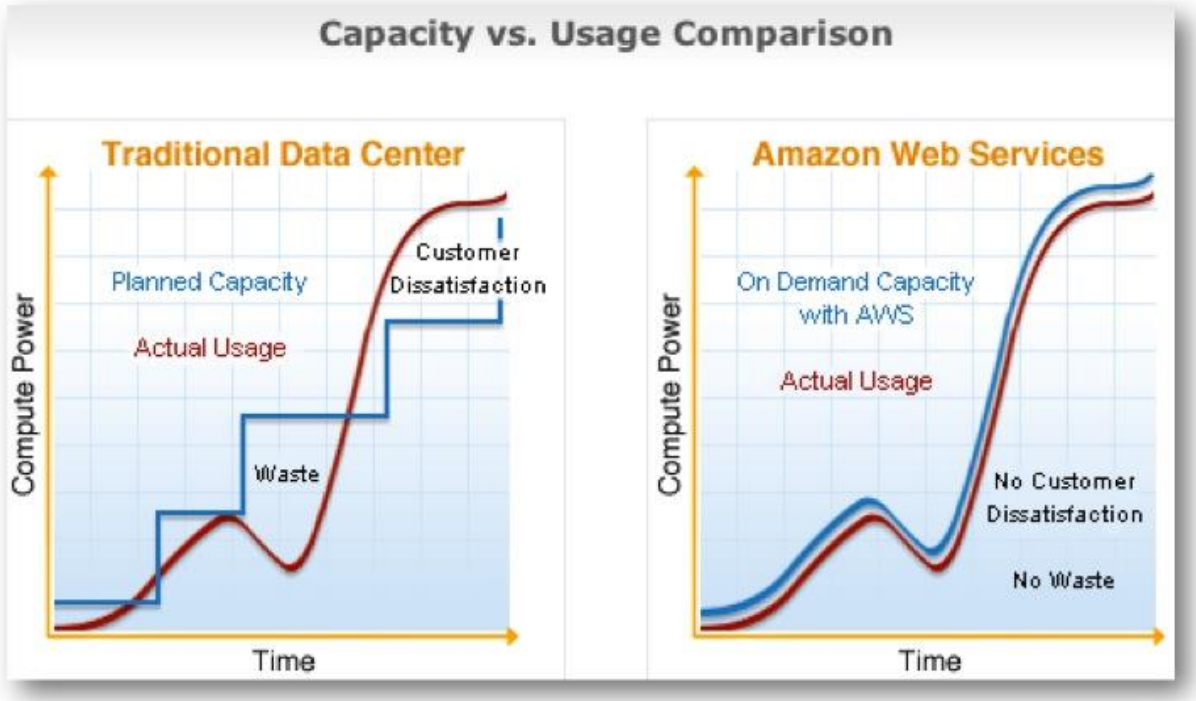
- The following six specific characteristics are common to the majority of cloud environments:
  - On-demand usage
  - Ubiquitous access
  - Multitenancy (and resource pooling)
  - Elasticity
  - Measured usage
  - Resiliency

Cloud providers and cloud consumers can assess these characteristics individually and collectively to measure the value offering of a given cloud platform. Although cloud-based services and IT resources will inherit and exhibit individual characteristics to varying extents, usually the greater the degree to which they are supported and utilized, the greater the resulting value proposition

# Cloud characteristics

## On-demand usage:

- A cloud consumer can unilaterally access cloud-based IT resources giving the cloud consumer the freedom to self-provision these IT resources. Once configured, usage of the self-provisioned IT resources can be automated, requiring no further human involvement by the cloud consumer or cloud provider. This results in an on-demand usage environment. Also known as “on-demand self-service usage,” this characteristic enables the service-based and usage-driven features found in mainstream clouds.



# Cloud characteristics

- **On-demand usage:**

**Example:**

Xem xét một công ty lưu trữ dữ liệu xây dựng trung tâm quản lý dữ liệu của họ. Thống kê cho thấy dung lượng dữ liệu của công ty tăng liên tục mỗi tháng và trong 5 năm, giả sử rằng dung lượng trong 1 năm thì giữ nguyên trong suốt năm tính từ tháng đầu tiên của năm, và năm kế tiếp dung lượng lại tăng lên gấp 3 lần so với năm trước đó.

Giả sử năm đầu tiên dung lượng công ty lưu trữ là: 1.5 TB

Chi phí để lưu trữ 1GB dữ liệu:

$0.02/GB/month (thuê cloud service), $0.025/GB/month (phần cứng hardware tự lưu trữ, bỏ qua chi phí khác)

Việc lưu trữ được ước tính theo 3 phương thức:

1. Mua phần cứng một lần duy nhất ngay từ đầu

2. Ước lượng độ tăng trưởng dung lượng và mua phần cứng bổ sung phù hợp để lưu trữ

(giả sử 1 đơn vị phần cứng cố định lưu trữ được 4TB/unit)

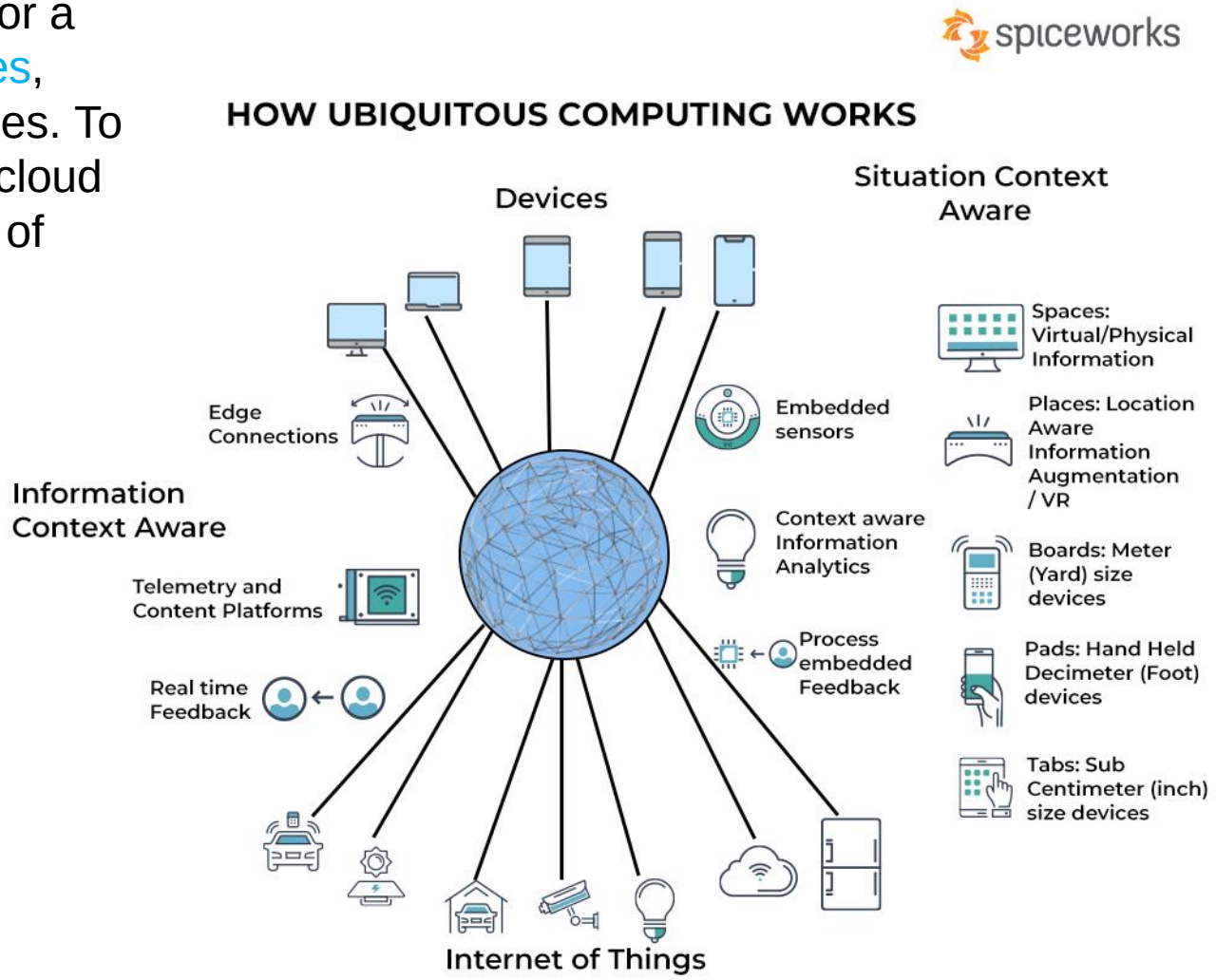
3. Thuê dịch vụ cloud sử dụng optimized on-demand usage

So sánh chi phí đầu tư trong 3 phương thức.

# Cloud characteristics

## ❑ Ubiquitous access:

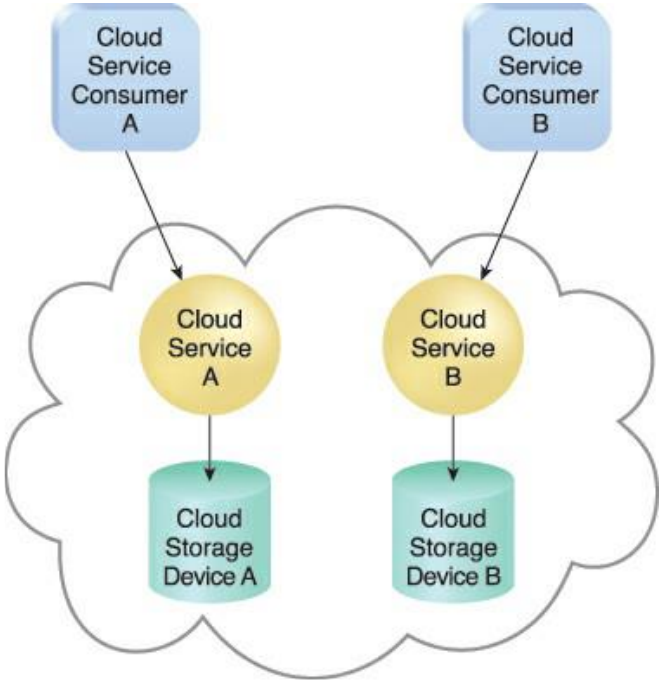
- Ubiquitous access represents the ability for a cloud service to be widely accessible. Establishing ubiquitous access for a cloud service can require support for a range of devices, transport protocols, interfaces, and security technologies. To enable this level of access generally requires that the cloud service architecture be tailored to the particular needs of different cloud service consumers.

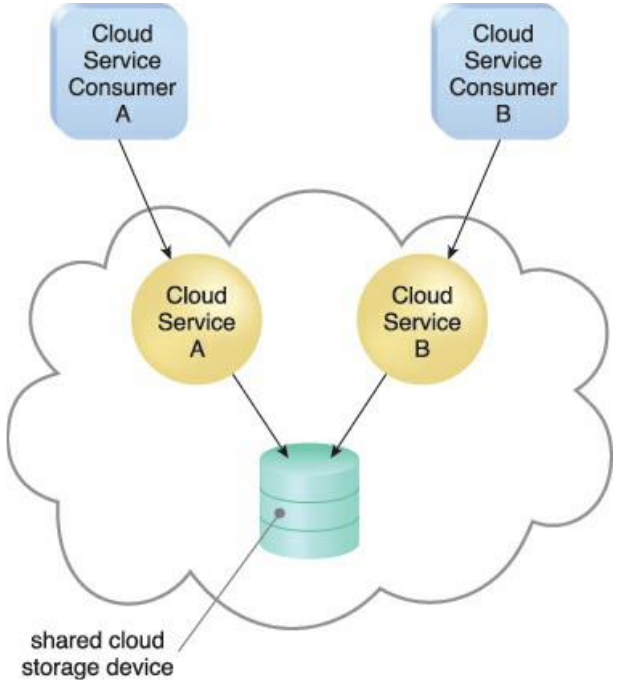


# Cloud characteristics

## Multitenancy (and resource pooling):

- The characteristic of a software program that enables an instance of the program to serve different consumers (tenants). A cloud provider pools its IT resources to serve multiple cloud service consumers by using multitenancy models that frequently rely on the use of virtualization technologies. IT resources can be dynamically assigned and reassigned, according to cloud service consumer demands.
- Resource pooling allows cloud providers to pool large-scale IT resources to serve multiple cloud consumers. Different physical and virtual IT resources are dynamically assigned and reassigned according to cloud consumer demand, typically followed by execution through statistical multiplexing.

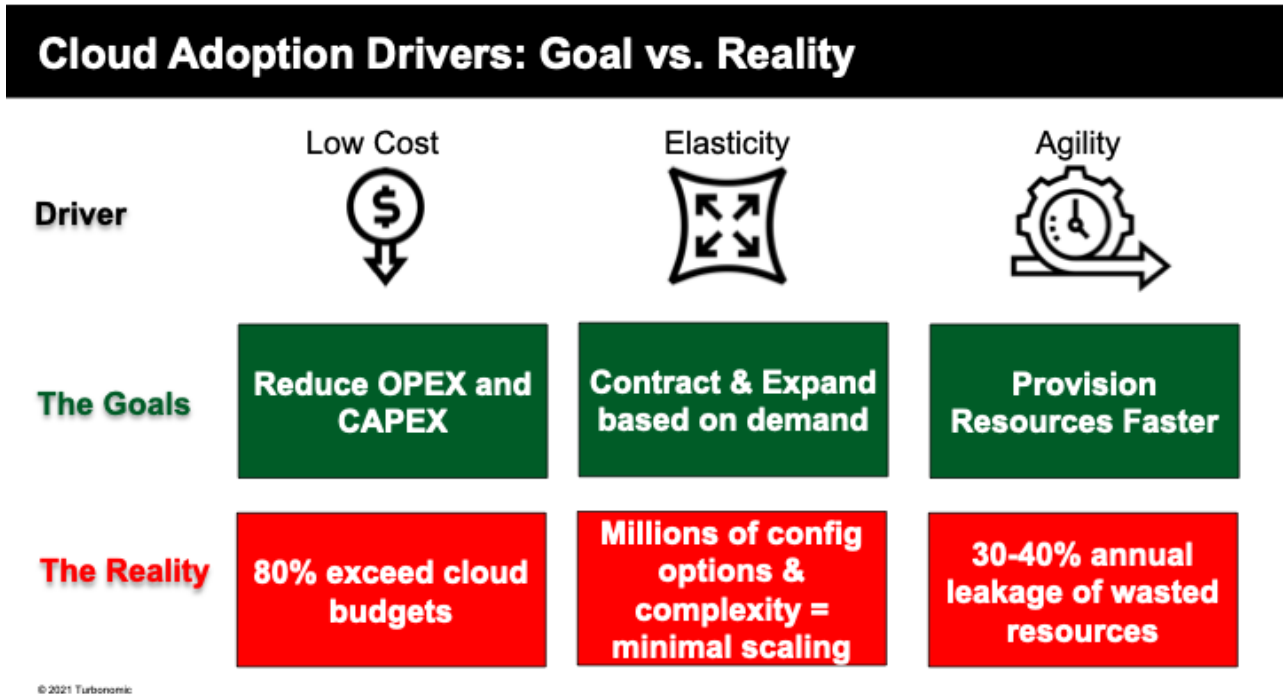


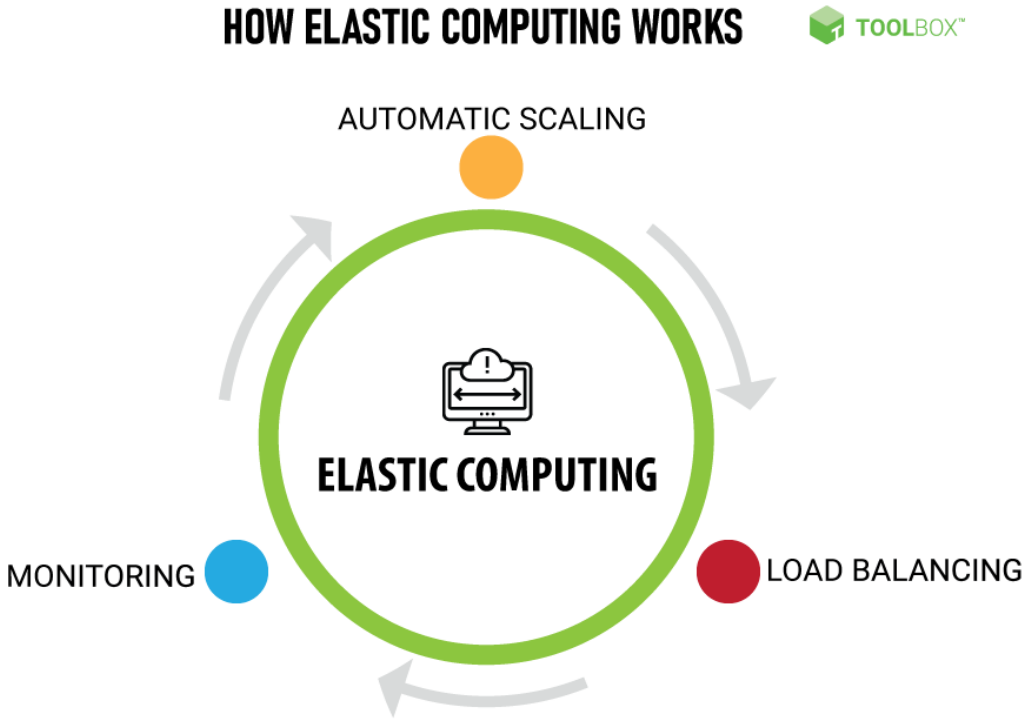



# Cloud characteristics

## ❑ Elasticity:

- Elasticity is the automated ability of a cloud to transparently scale IT resources, as required in response to runtime conditions or as pre-determined by the cloud consumer or cloud provider. Elasticity is often considered a core justification for the adoption of cloud computing, primarily due to the fact that it is closely associated with the Reduced Investment and Proportional Costs benefit. Cloud providers with vast IT resources can offer the greatest range of elasticity.



# Cloud characteristics

- **Elasticity:**

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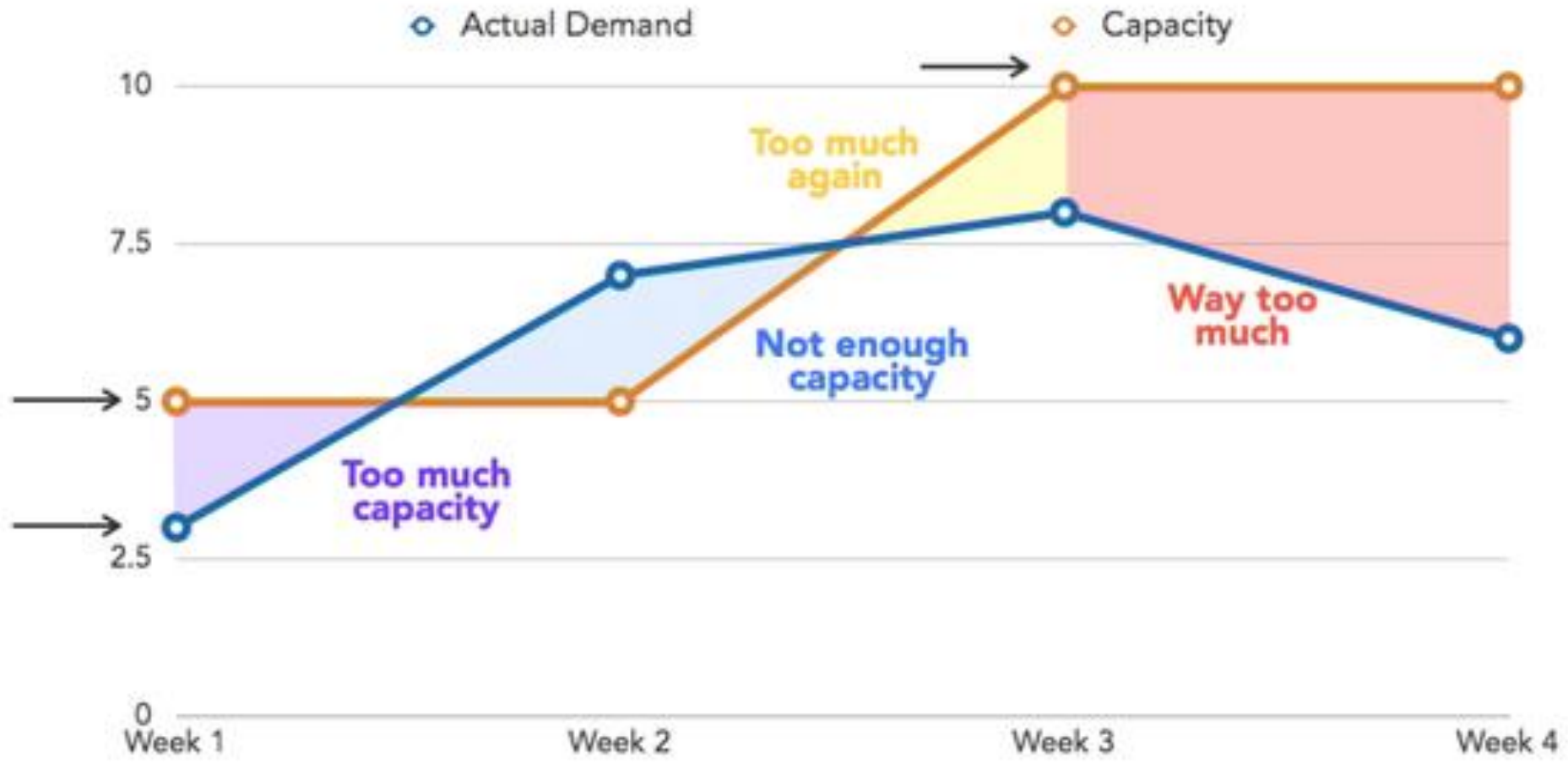
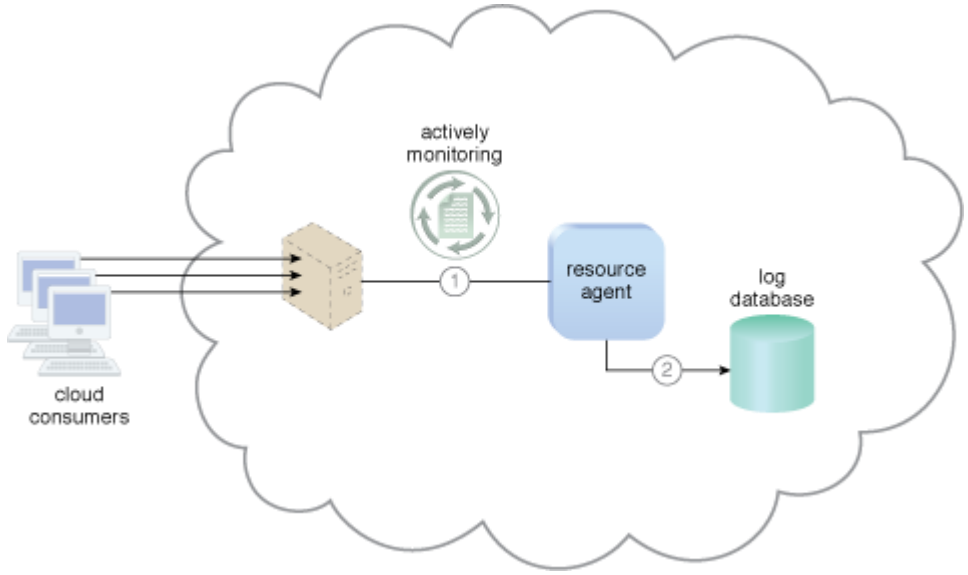
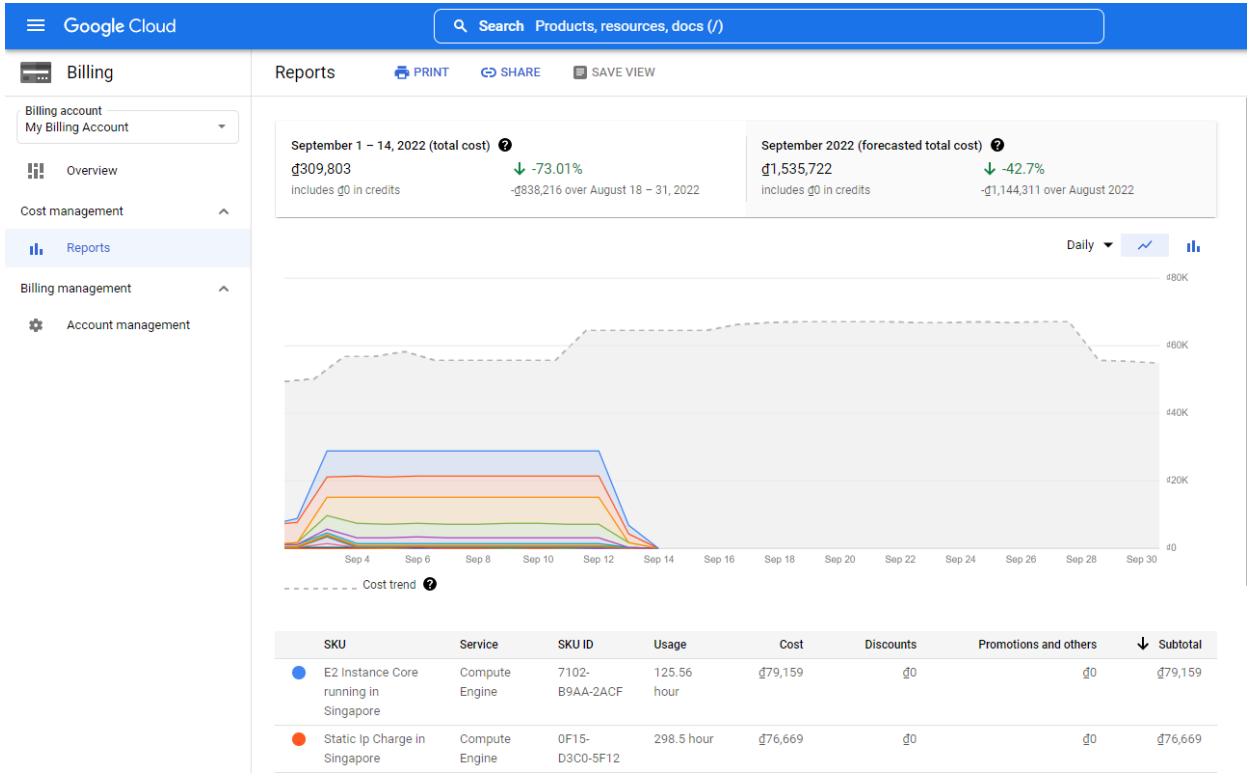


# Cloud characteristics

- **Measured usage:**

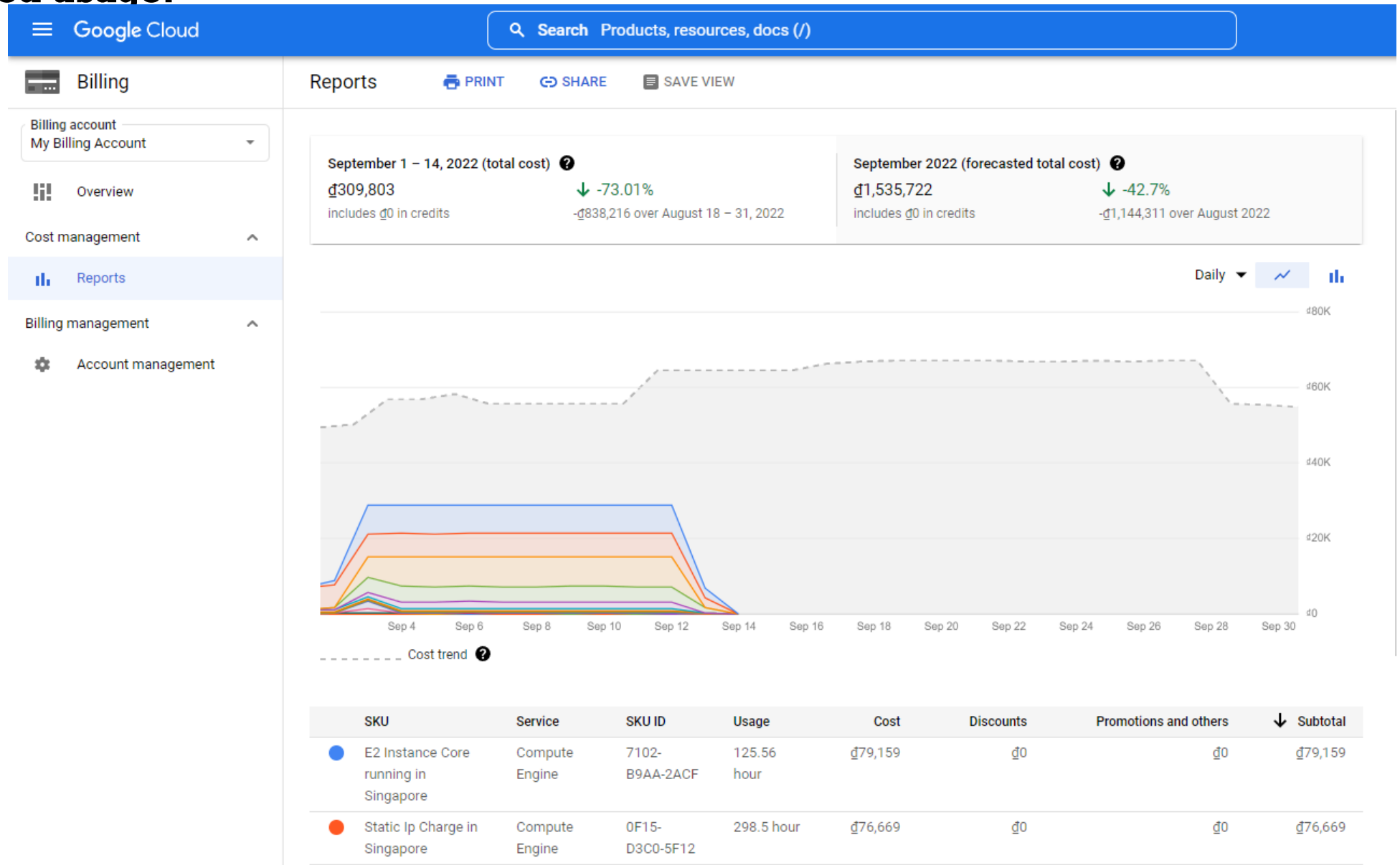
- The measured usage characteristic represents the ability of a cloud platform to keep track of the usage of its IT resources, primarily by cloud consumers. Cloud provider can charge a cloud consumer only for the IT resources actually used and/or for the timeframe during which access to the IT resources was granted.
- Measured usage is not limited to tracking statistics for billing purposes. It also encompasses the general monitoring of IT resources and related usage reporting (for both cloud provider and cloud consumers).



# Cloud characteristics

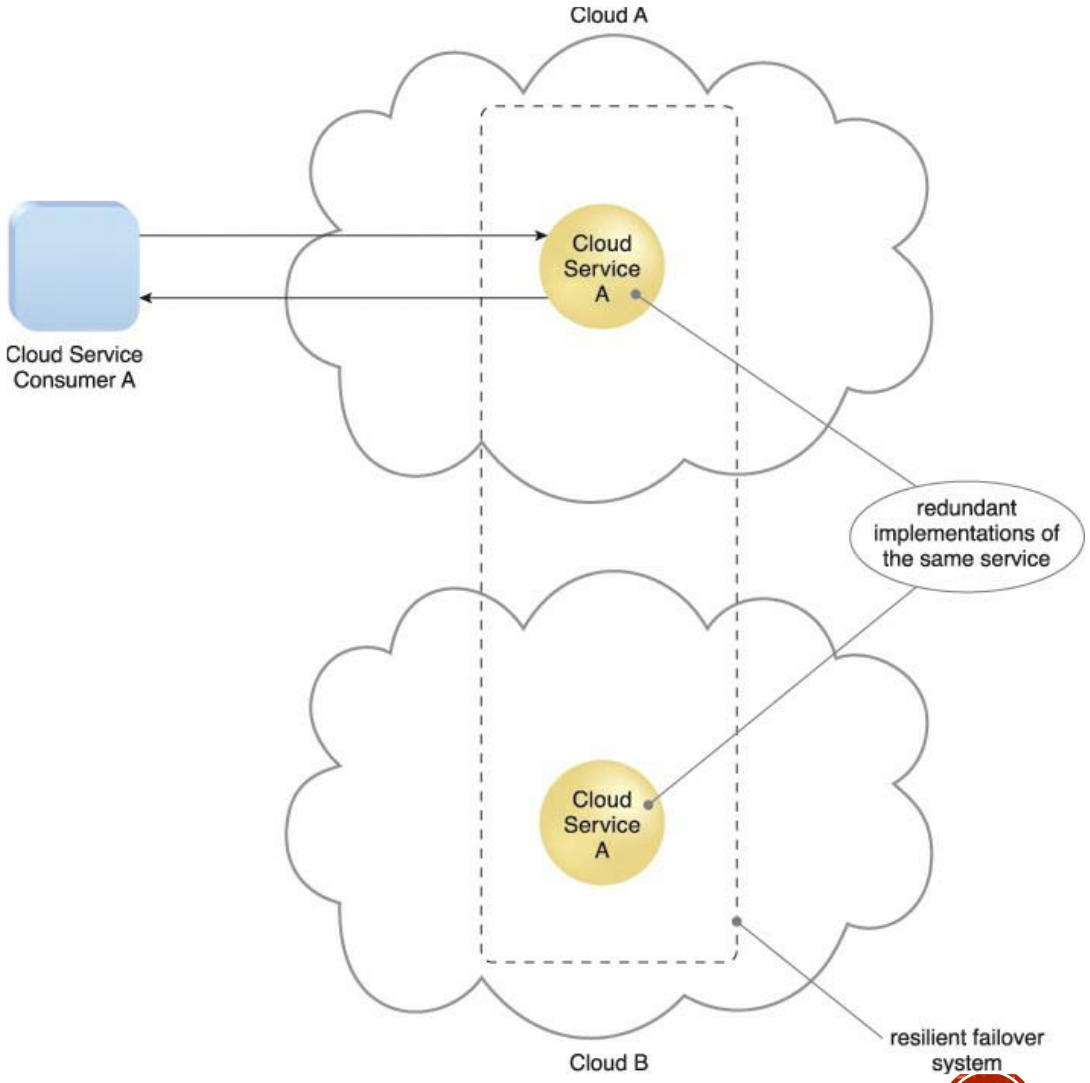
- **Measured usage:**



# Cloud characteristics

## Resiliency:

- Resilient computing is a form of failover that distributes redundant implementations of IT resources across physical locations.
- IT resources can be pre-configured so that if one becomes deficient, processing is automatically handed over to another redundant implementation.
- The characteristic of resiliency can refer to redundant IT resources within the same cloud (but in different physical locations) or across multiple clouds.
- Cloud consumers can increase both the reliability and availability of their applications by leveraging the resiliency of cloud-based IT resources.



# Cloud computing service delivery

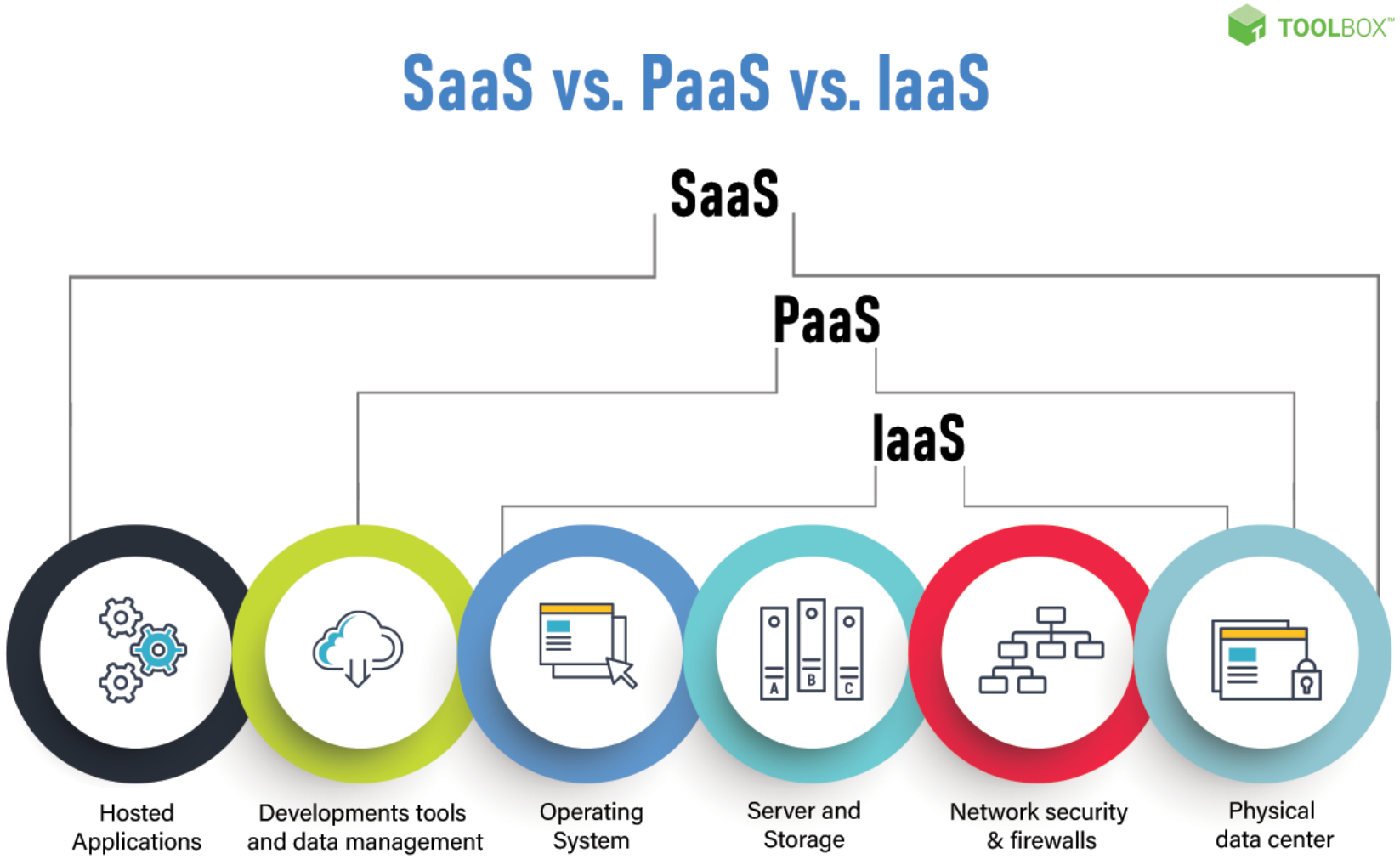
- Cloud service delivery represent a specific, pre-packaged combination of IT resources offered by a cloud provider.

- Three common cloud delivery models have become widely established and formalized:
  - Infrastructure-as-a-Service (IaaS)
  - Platform-as-a-Service (PaaS)
  - Software-as-a-Service (SaaS)

- Many specialized variations of the three base cloud delivery models have emerged, each comprised of a distinct combination of IT resources.
  - Storage-as-a-Service
  - Database-as-a-Service
  - Security-as-a-Service
  - Communication-as-a-Service
  - Integration-as-a-Service
  - Testing-as-a-Service
  - Process-as-a-Service

# Cloud computing service delivery

- Cloud service delivery represent a specific, pre-packaged combination of IT resources offered by a cloud provider.



# Cloud computing service delivery

- **Infrastructure-as-a-Service (IaaS):**

- Infrastructure is compute resources, CPU, VMs, storage, …

- 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, storage, computing hardware, operating systems, virtual instances, load balancing, Internet access, and bandwidth provisioning.

Example: Amazon EC2

# Cloud computing service delivery

- **Infrastructure-as-a-Service (IaaS):**

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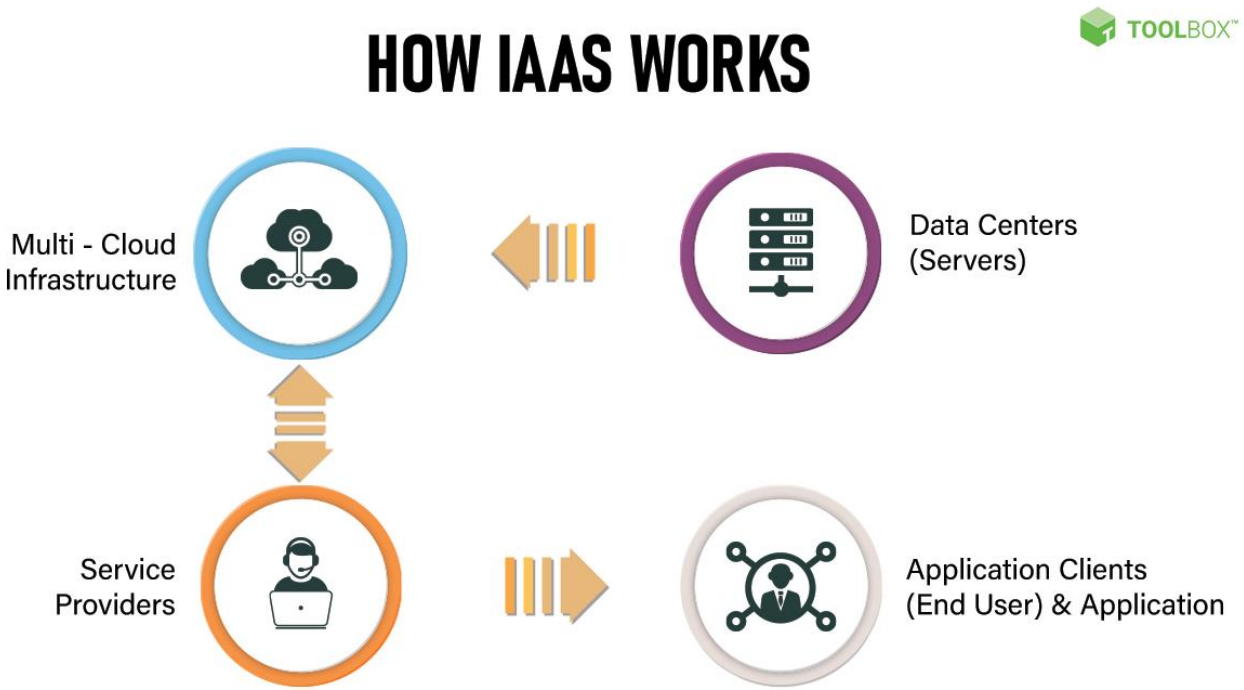


# Cloud computing service delivery

- **Infrastructure-as-a-Service (IaaS):**

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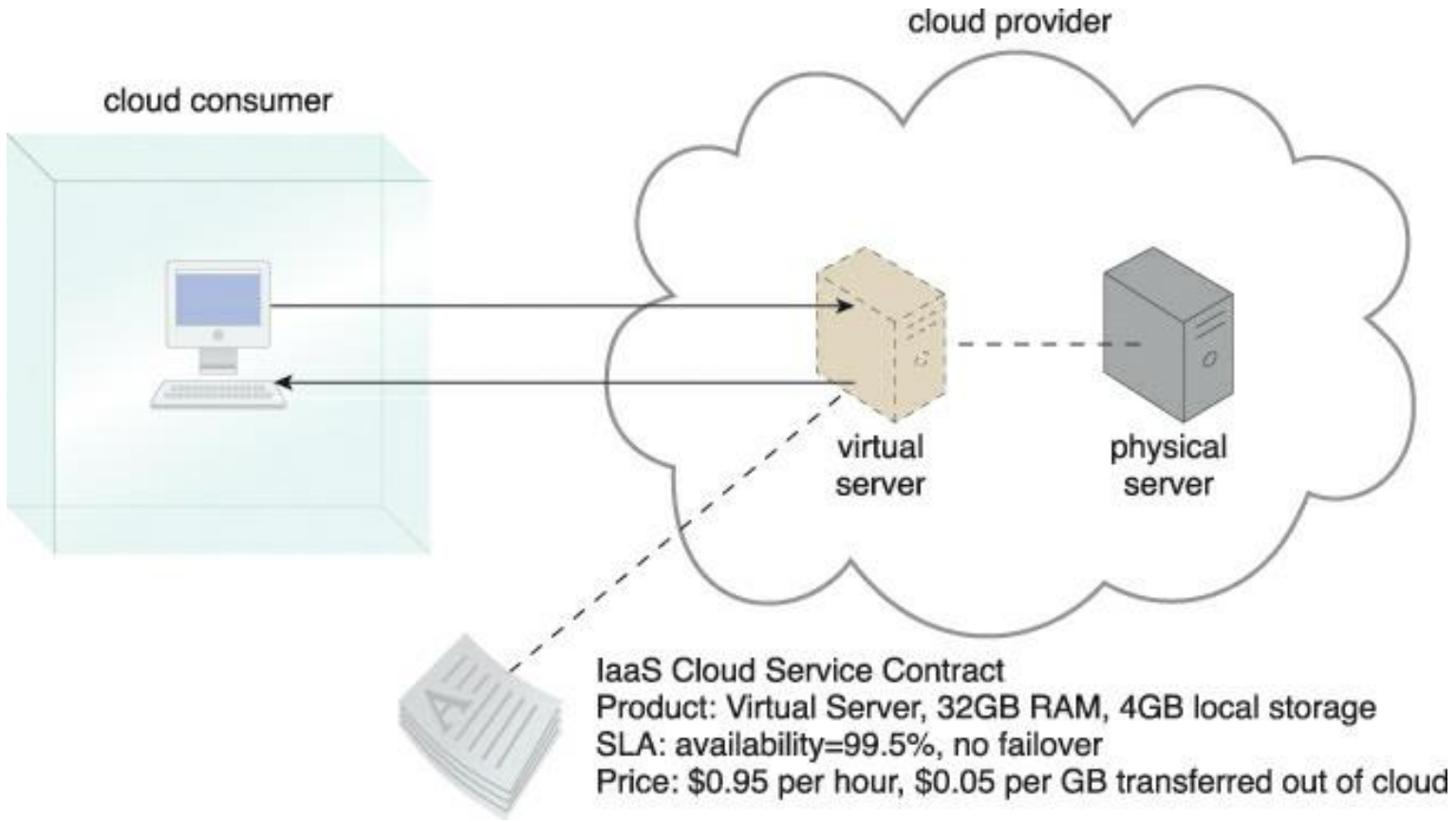

# Cloud computing service delivery

## ❑ 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 customised to improve the performance of the application.

Examples: Google App Engine, Windows Azure

# Cloud computing service delivery

- **Platform-as-a-Service (PaaS):**

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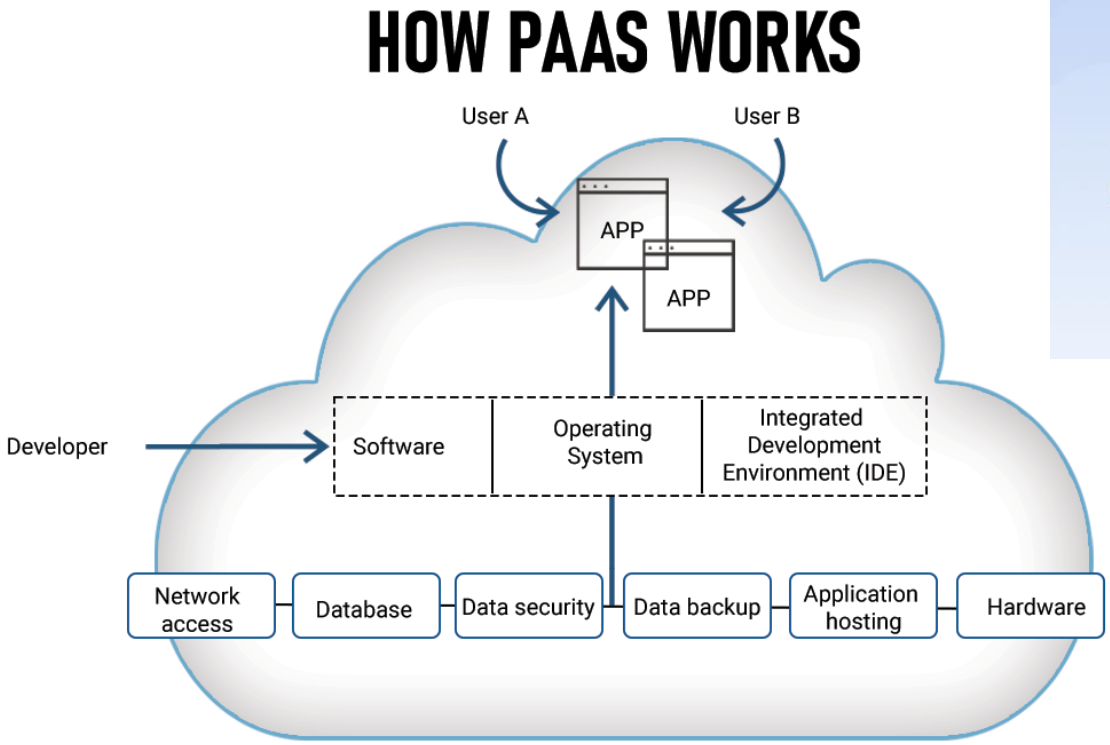


# Cloud computing service delivery

- **Platform-as-a-Service (PaaS):**

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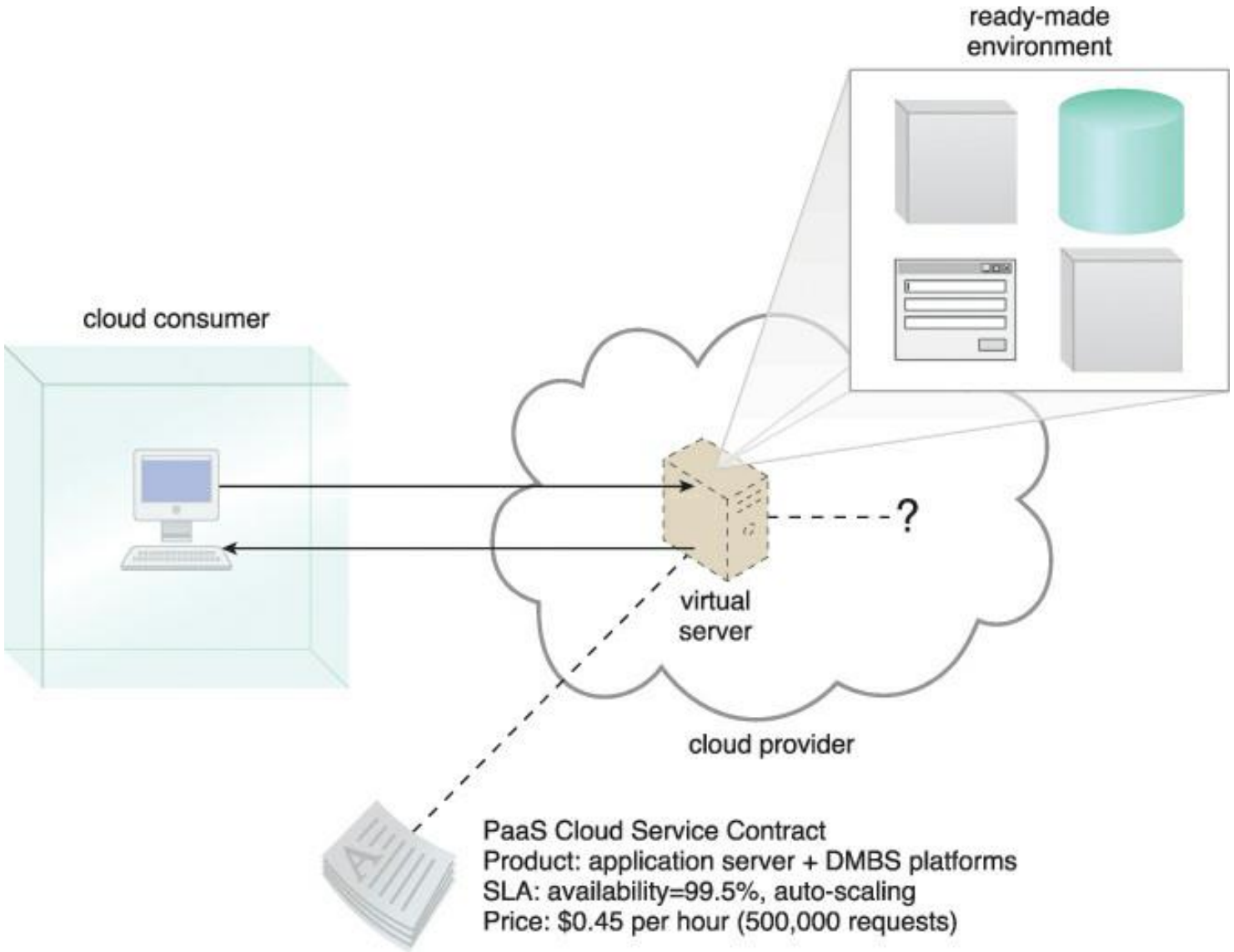

# Cloud computing service delivery

- **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, communications, digital signature, customer relationship management (CRM), desktop software, financial management, geo-spatial, and search.

- Not suitable for real-time applications or for those where data is not allowed to be hosted externally.

Examples: Gmail, Salesforce

# Cloud computing service delivery

- **Software-as-a-Service (SaaS):**

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# Cloud computing service delivery

- **Software-as-a-Service (SaaS):**

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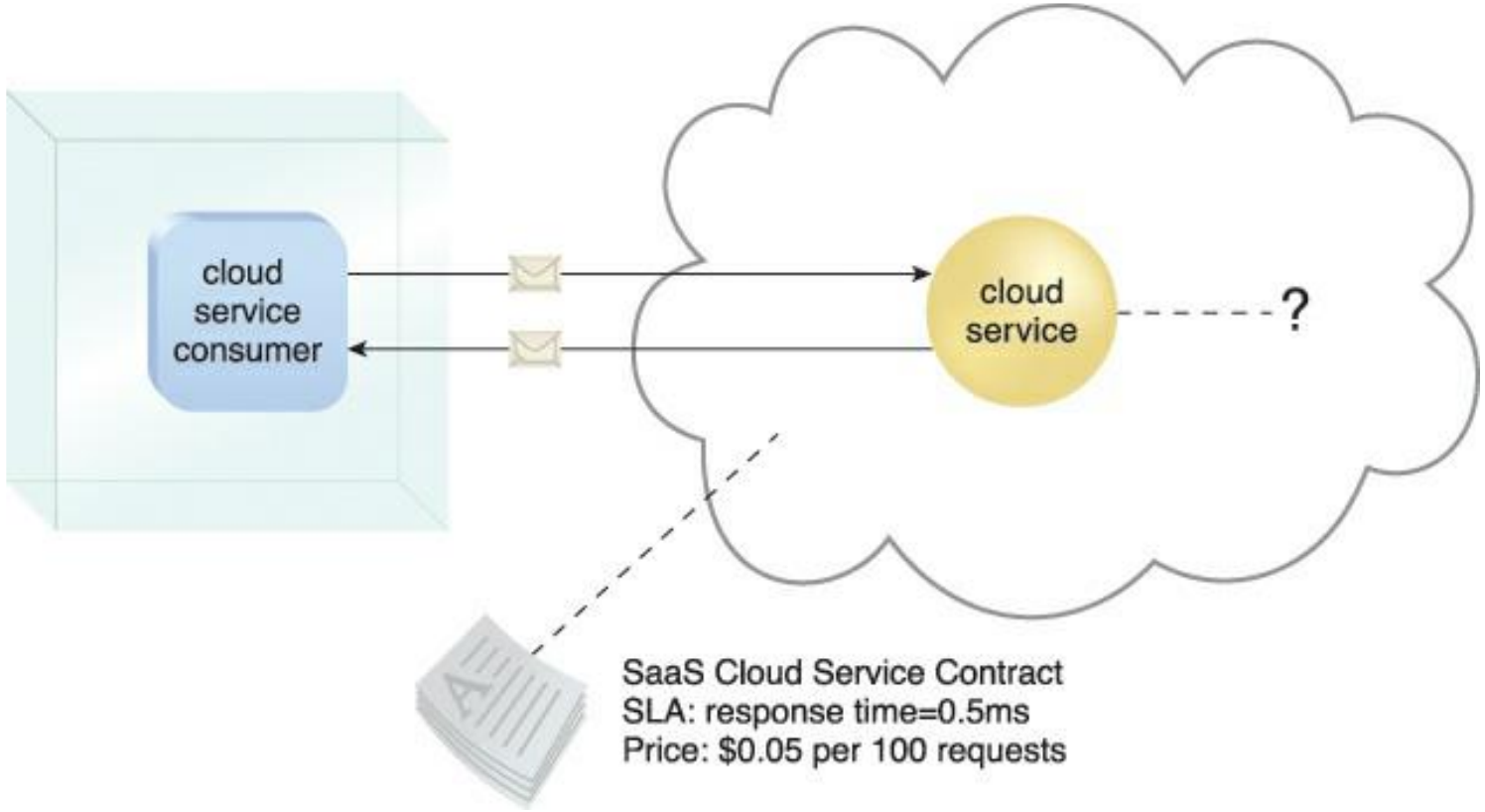


# Cloud computing services

**The Three delivery models of Cloud Computing**

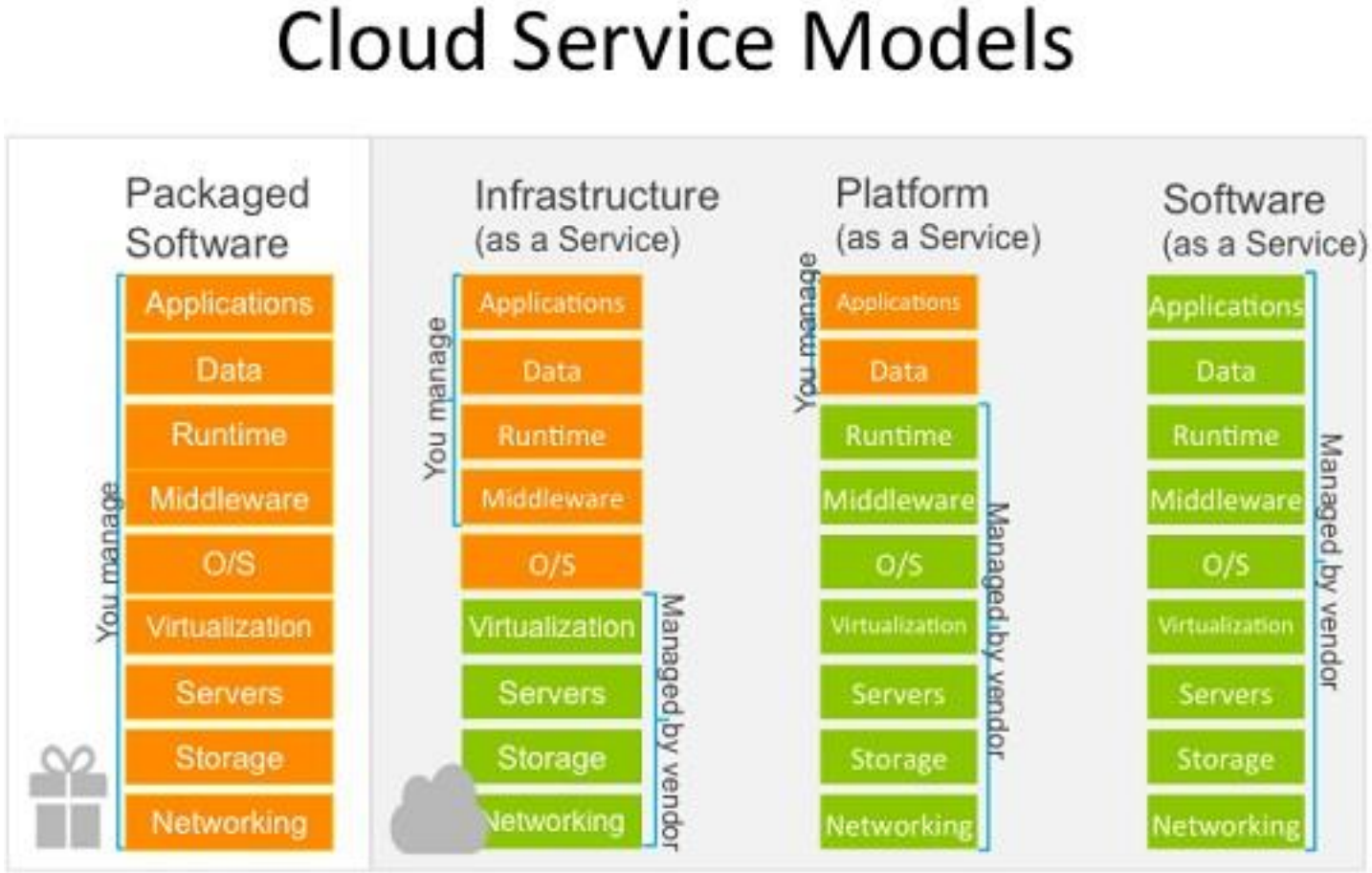
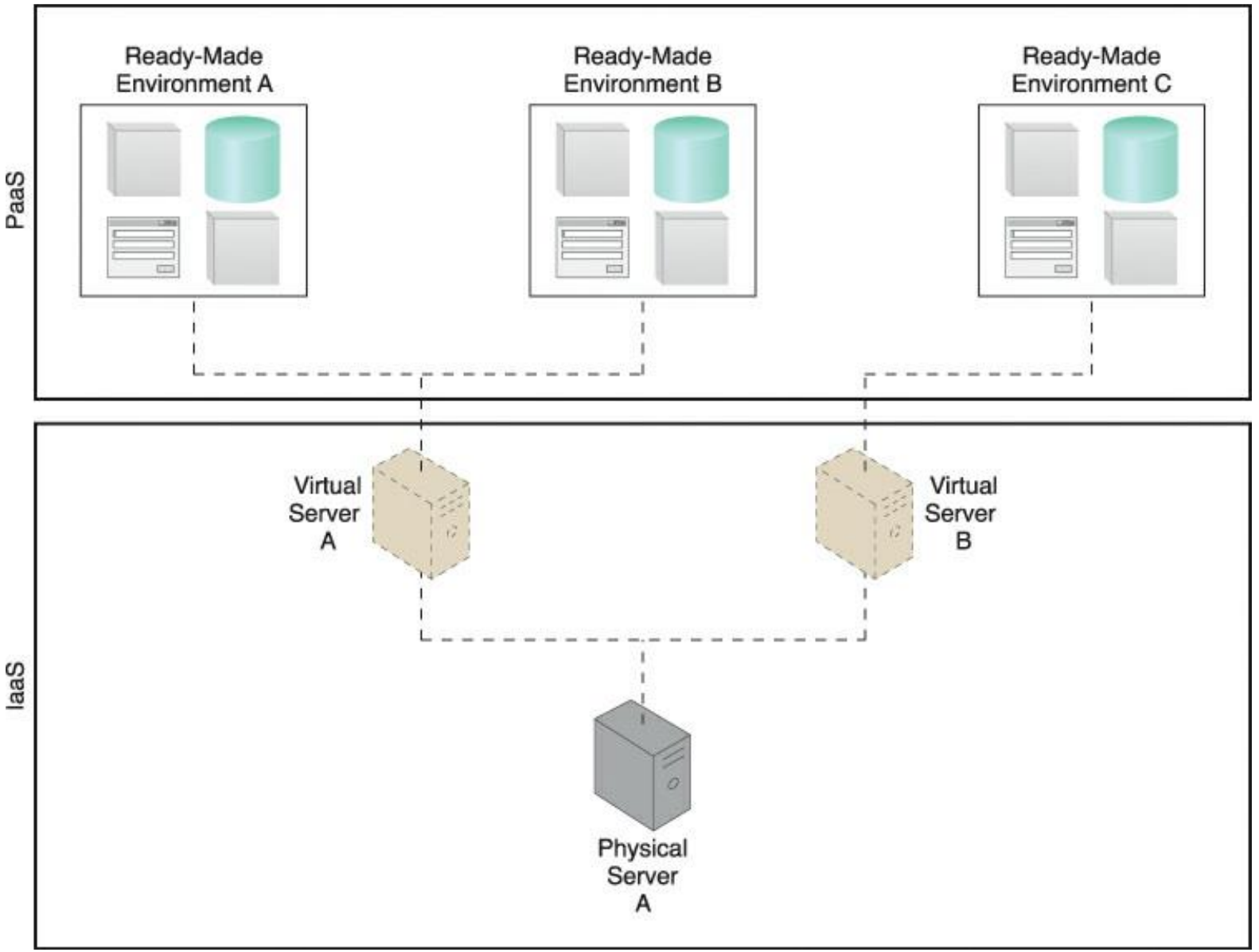




**Figure 1.** **Source: Microsoft Azure**

# Combining Cloud Service Delivery

- **IaaS + PaaS:**



# Combining Cloud Service Delivery

- **IaaS + PaaS + SaaS:**

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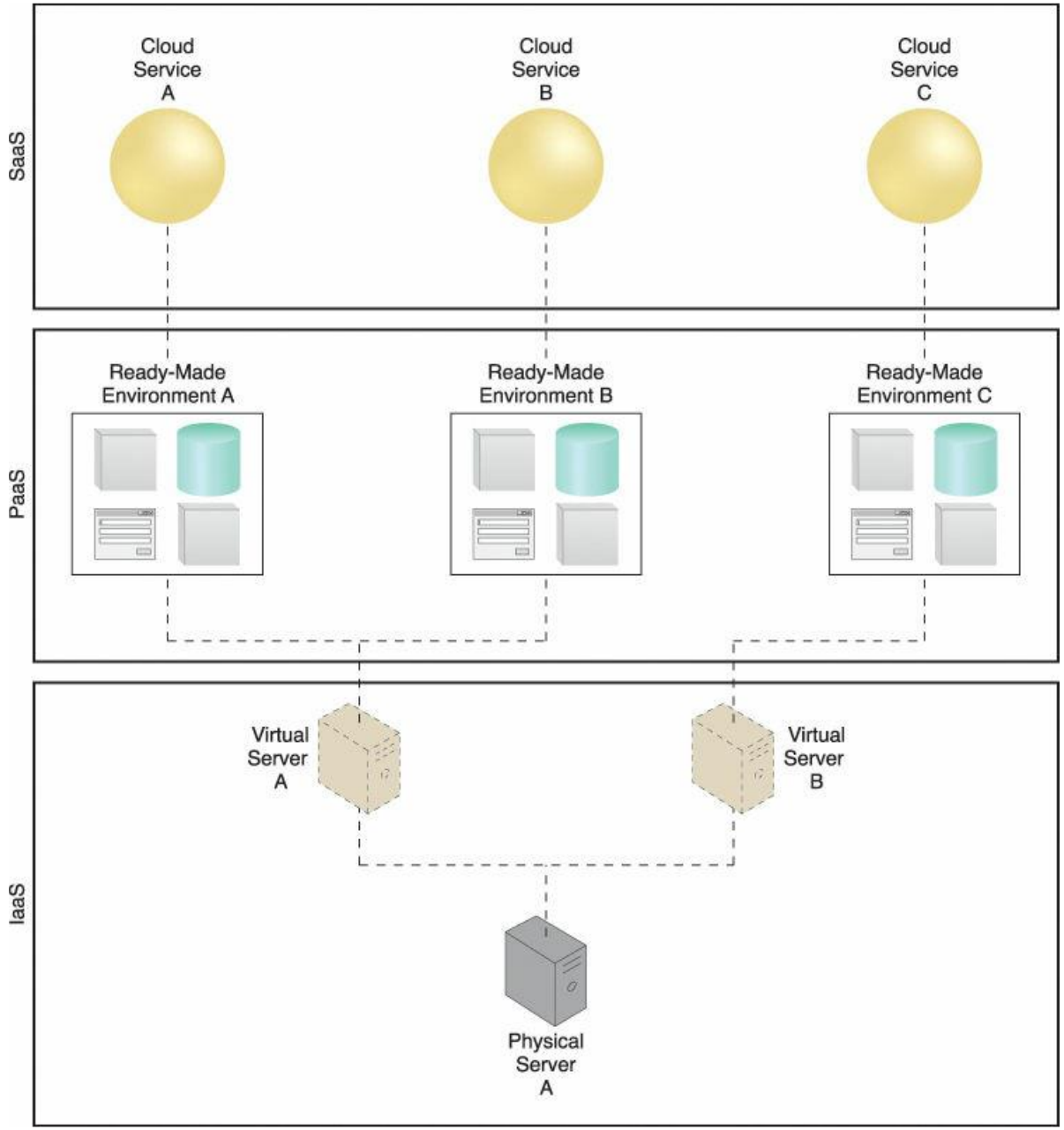


# Cloud computing services

## Cloud activities:

- Service management and provisioning including:
  - Virtualization.
  - Service provisioning.
  - Call center.
  - Operations management.
  - Systems management.
  - QoS management.
  - Billing and accounting, asset management.
  - SLA management.
  - Technical support and backups

# Cloud computing services

- **Cloud activities:**

- Security management including:
  - ID and authentication.
  - Certification and accreditation.
  - Intrusion prevention.
  - Intrusion detection.
  - Virus protection.
  - Cryptography.
  - Physical security, incident response.
  - Access control, audit and trails, and firewalls

# Cloud computing services

- **Cloud activities:**

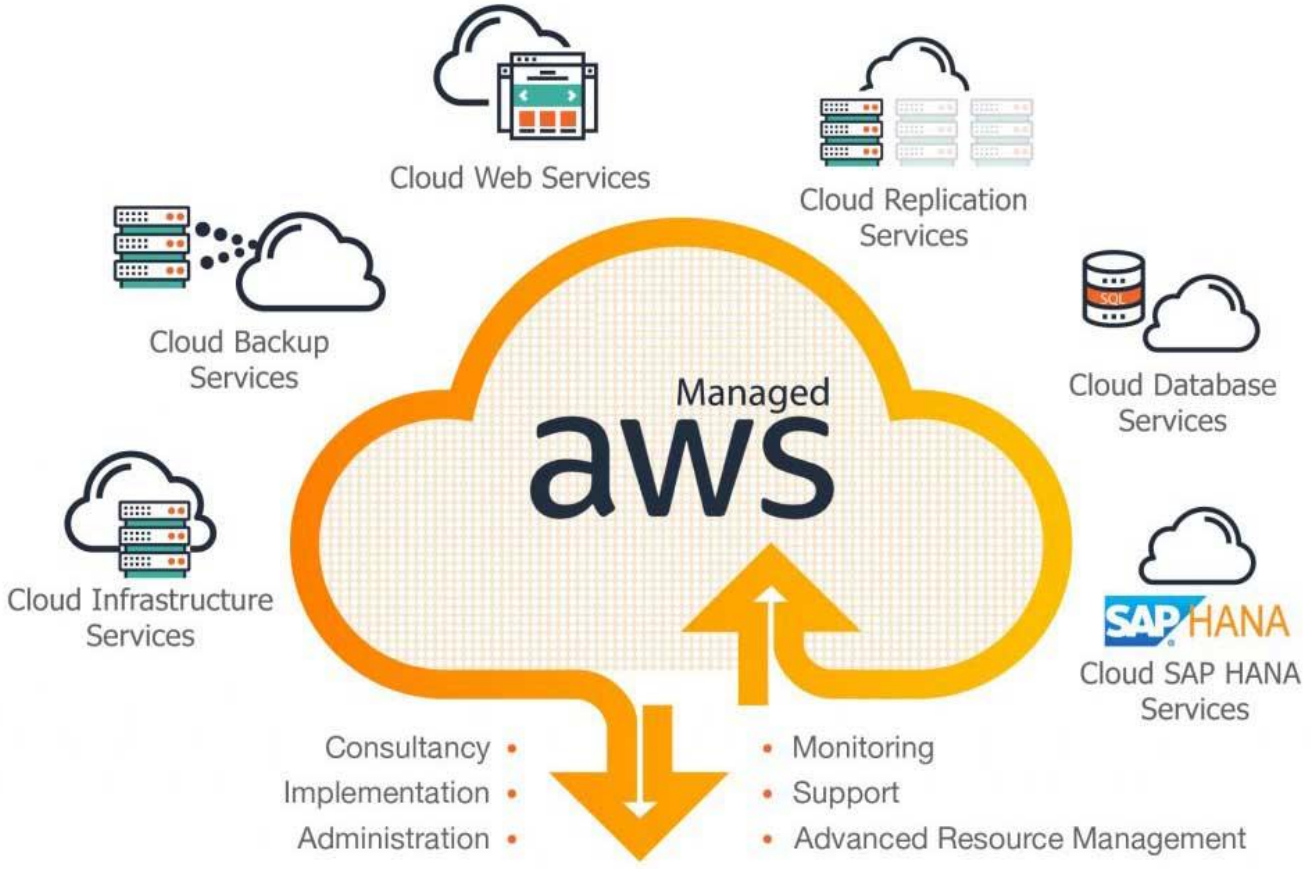
- Customer services such as:
  - Customer assistance and on-line help.
  - Subscriptions.
  - Business intelligence.
  - Reporting.
  - Customer preferences.
  - Personalization.

- Integration services including:
  - Data management.
  - Development.

# Cloud computing platforms and Analysis

## Amazon Web Services

- Amazon Web Services, Inc. is a subsidiary of Amazon that provides on-demand cloud computing platforms and APIs to individuals, companies, and governments, on a metered pay-as-you-go basis. These cloud computing web services provide distributed computing processing capacity and software tools via AWS server farms.

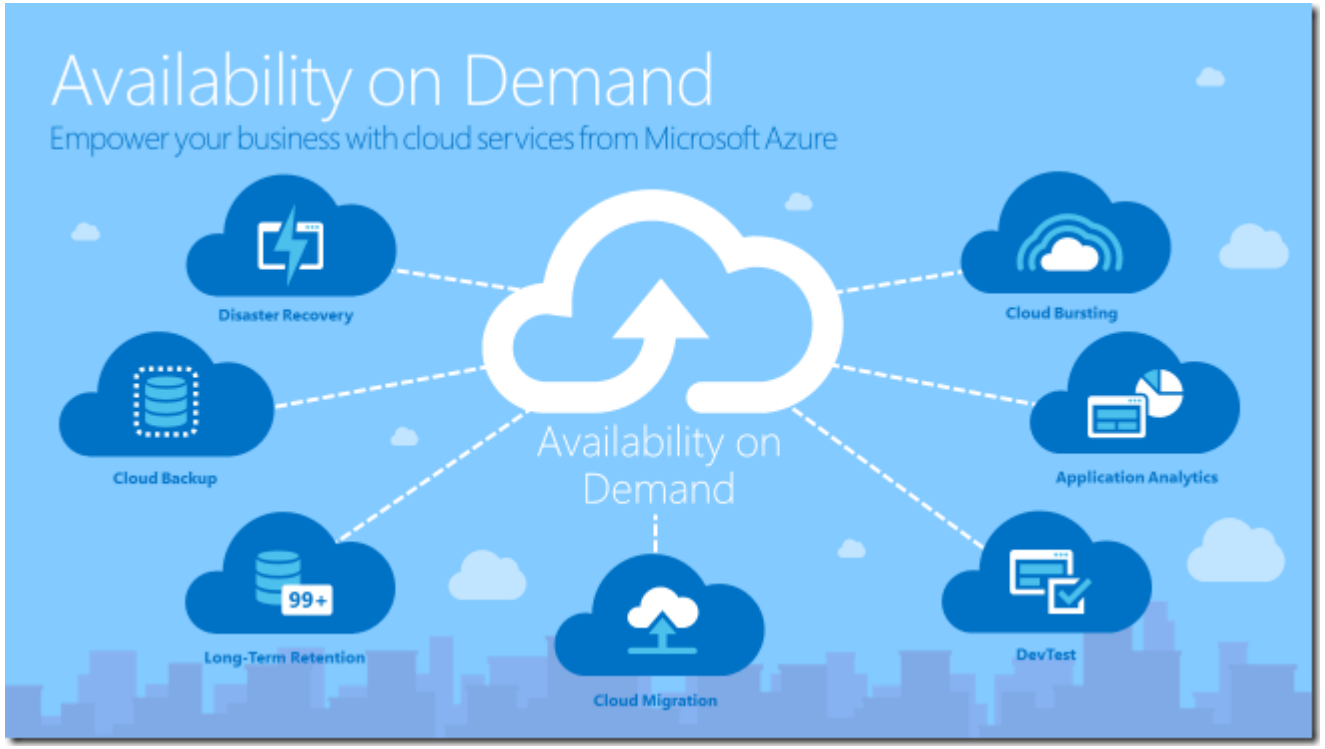



Revenue: 62 billion USD (2021)
Headquarters: Seattle, Washington, US
CEO: Adam Selipsky (May 17, 2021–)
Founder: Amazon.com
Founded: March 3, 2006

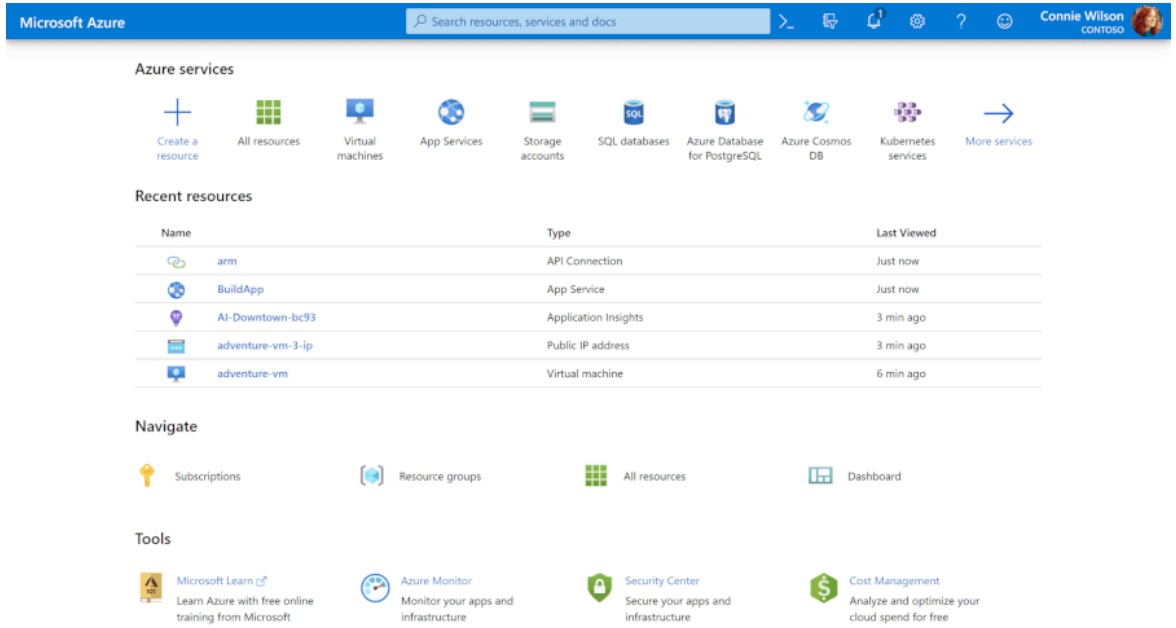
# Cloud computing platforms and Analysis

## Microsoft Azure: Cloud Computing Services

Microsoft Azure, often referred to as Azure, is a cloud computing service operated by Microsoft for application management via Microsoft-managed data centers.




Developer: Microsoft Corporation
Original author: Microsoft Corporation
Revenue: more than $60 billion (2021)
CEO: Ranjit Gupta

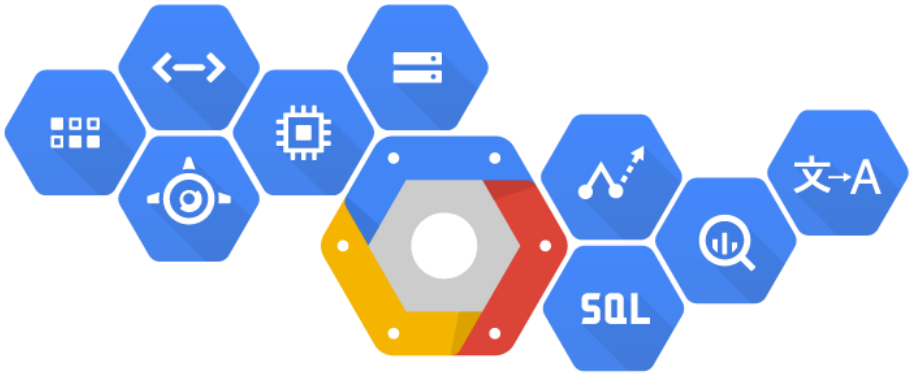


# Cloud computing platforms and Analysis

## Google Cloud: Cloud Computing Services

Google Cloud Platform, offered by Google, is a suite of cloud computing services that runs on the same infrastructure that Google uses internally for its end-user products, such as Google Search, Gmail, Google Drive, and YouTube.

Original author: Google
Developer: Google
CEO: Thomas Kurian
Revenue: 19 billion USD (2021)

# Applications of Cloud computing

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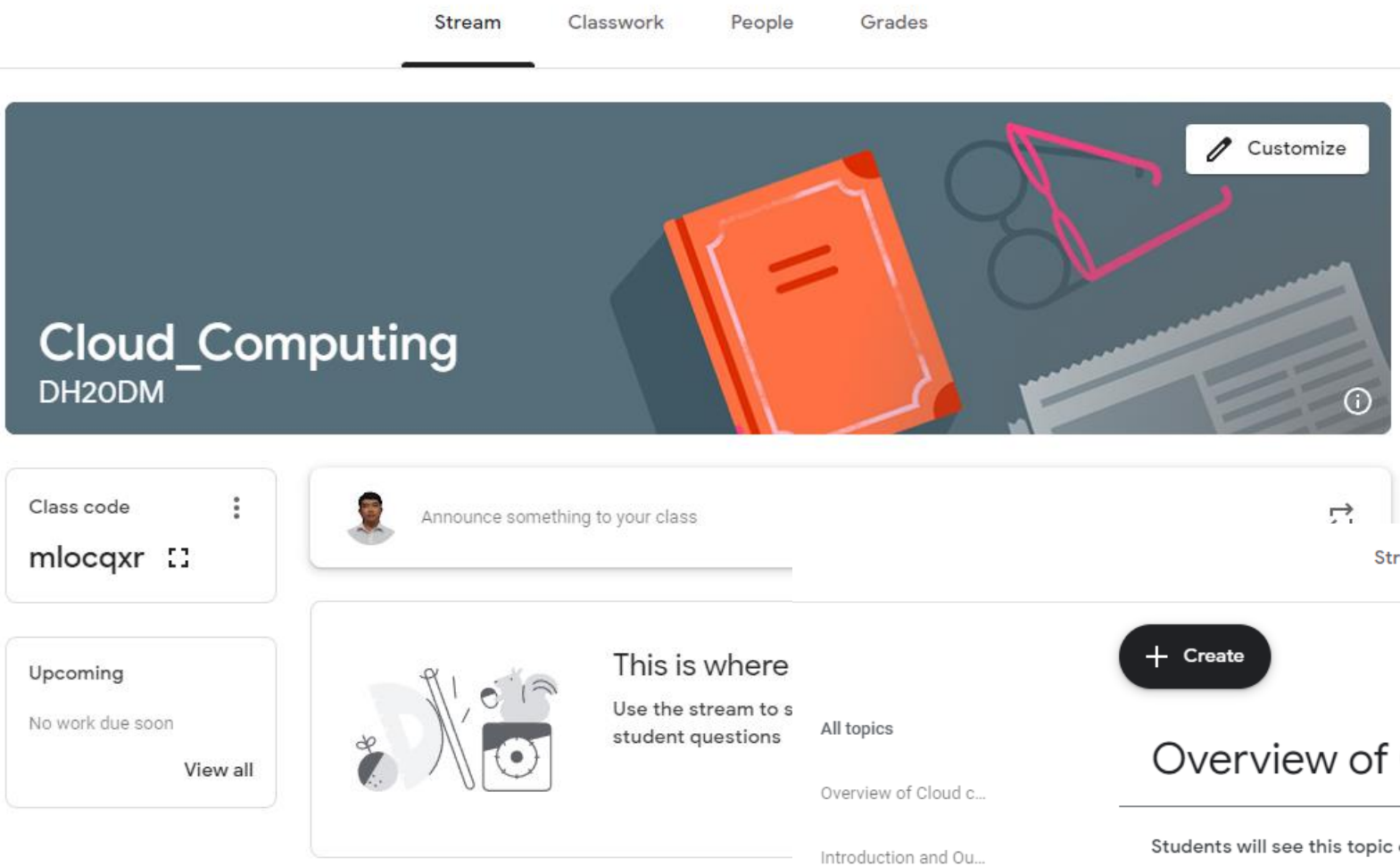

# Applications of Cloud computing

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**High Growth Applications**

Startup Businesses

2001

friendster®

Could not keep up with the growth of their number of users.

vs.

2006

facebook

Growing exponentially

What do you do when your startup gains traction?

Can you grow quick enough?

# Applications of Cloud computing

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Website went down on 9/11/2001 due to traffic

February 14th – Busiest Day of the Year

US Holiday Season

Website crashed within 10 minutes of the free trouser promotion during Superbowl 2010

Even if you design your website infrastructure to handle peak loads, wont it be idle during other times?

Aperiodic Bursting Applications


Seasonal Businesses

# Applications of Cloud computing

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On-Off Applications


Research Computing

Researchers running large-scale scientific simulation using 1000s of computers.

Modern Drug Discovery

- Data-intensive simulation and tests to discover new compounds
- Large compute power required for simulation jobs
- Time to market is crucial

Why not rent computer time to run these simulations?

# Applications of Cloud computing

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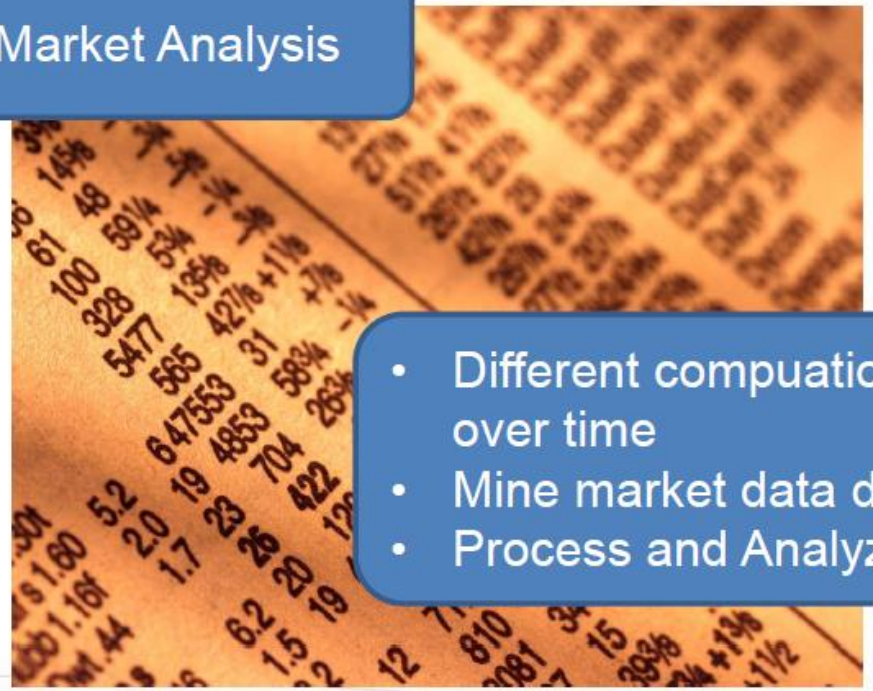
Sock Market Analysis



- Different compuational requirements over time
- Mine market data during the day.
- Process and Analyze at night.

Periodic Applications

Changing computational patterns over time

Dynamic and Flexible infrastructure can reduce costs and improve performance.