CLOUD COMPUTING
(Undergraduate Course)

Chapter 3 – Structure of Cloud Computing Platform

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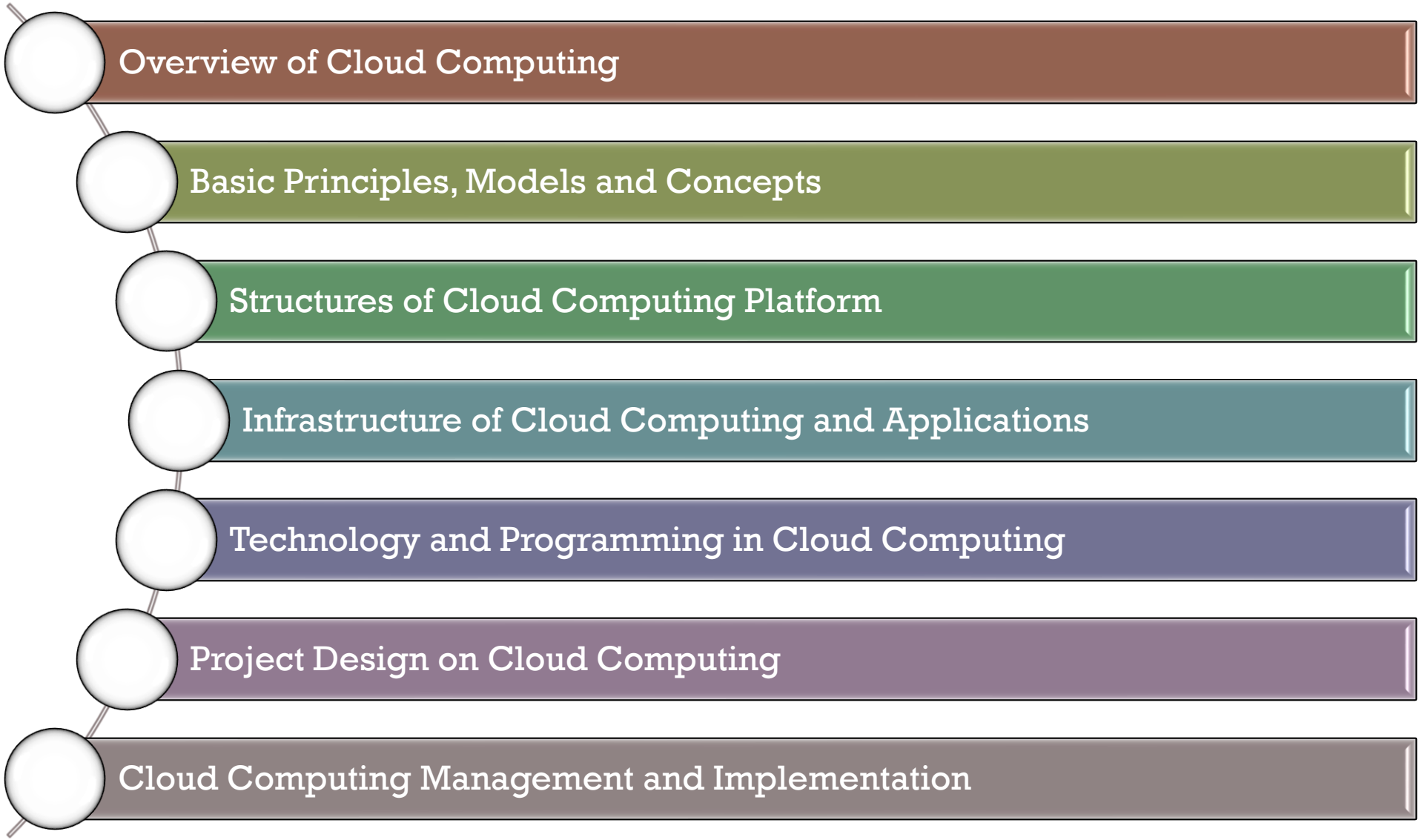
Outline


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:

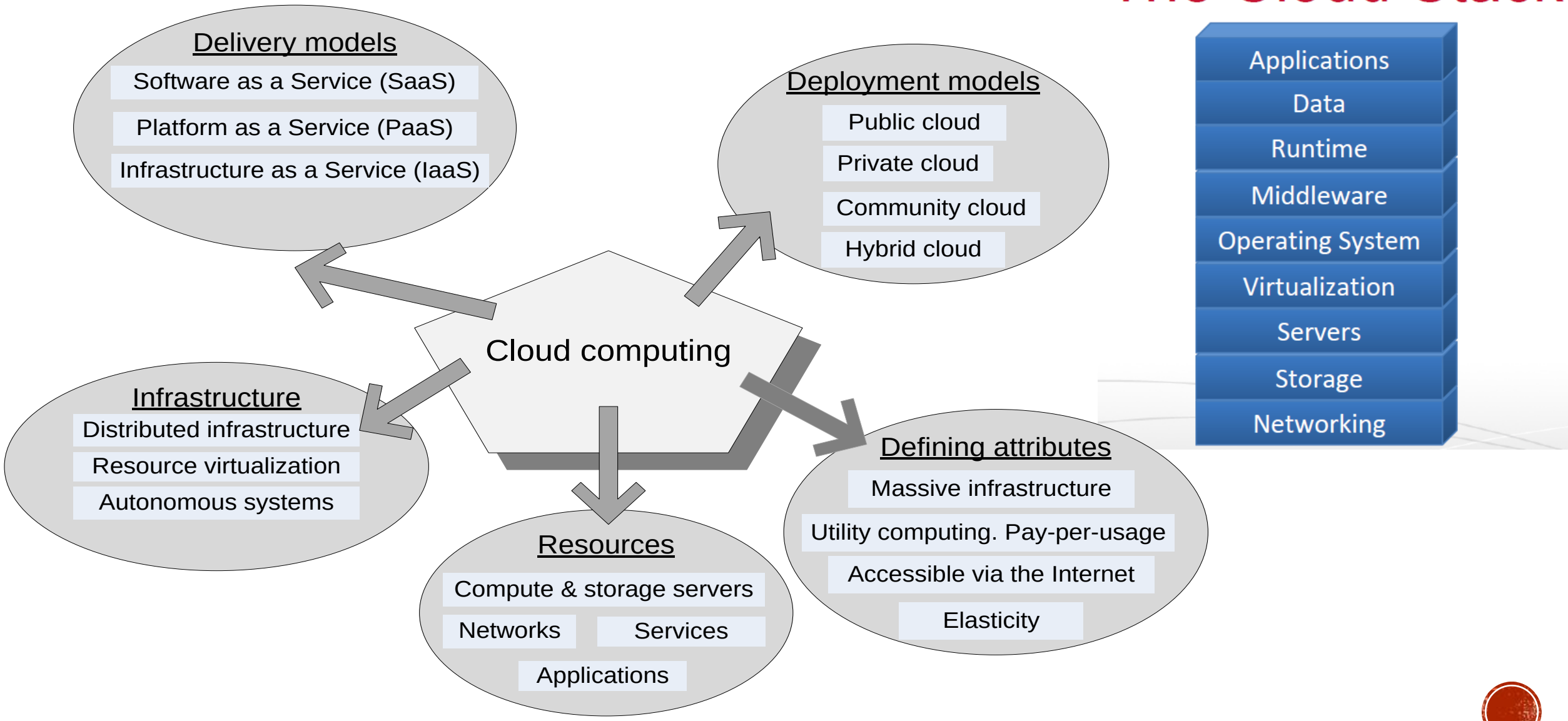
- Rajkuma Buyya, Jame Broberg and Andrzej Goscinski. 2011. *Cloud Computing –Principles and paradigms*, Wiley
- Nick Antonopoulos, and Lee Gillam. 2010. *Cloud Computing - Principles, Systems and Applications*, Springer-Verlag London Limited.

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

Content of Chapter 3

1. Physical layer
   Network, Storage, Server on cloud
2. Virtualization layer
3. Operation systems, Middleware, Runtime layers
4. Data layers
5. Applications layer

BASIC CONCEPTS AND PRINCIPLE COMPONENTS



What is Cloud computing?

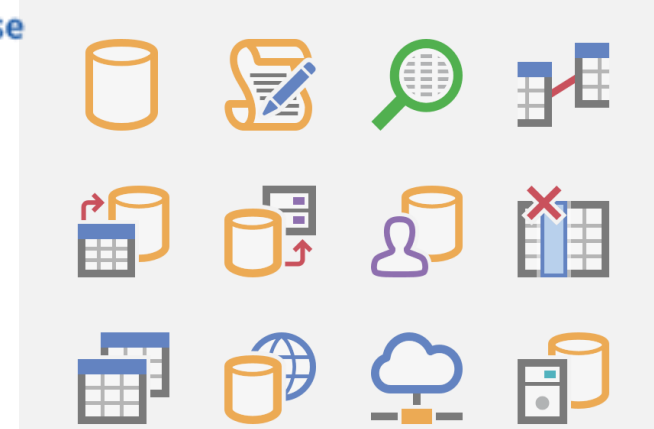
Linh hoạt lưu trữ

Đa ứng dụng, phương tiện

Đa tương tác
Low coding

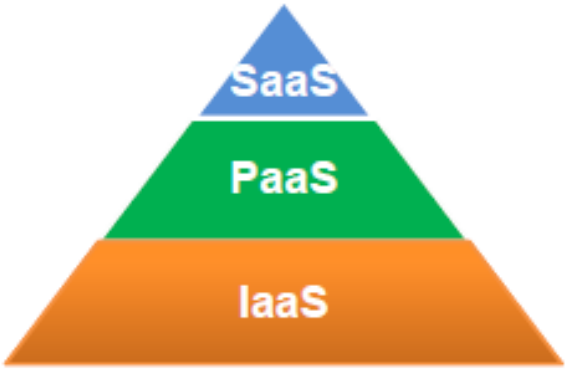
Máy chủ ảo
(serverless computing)

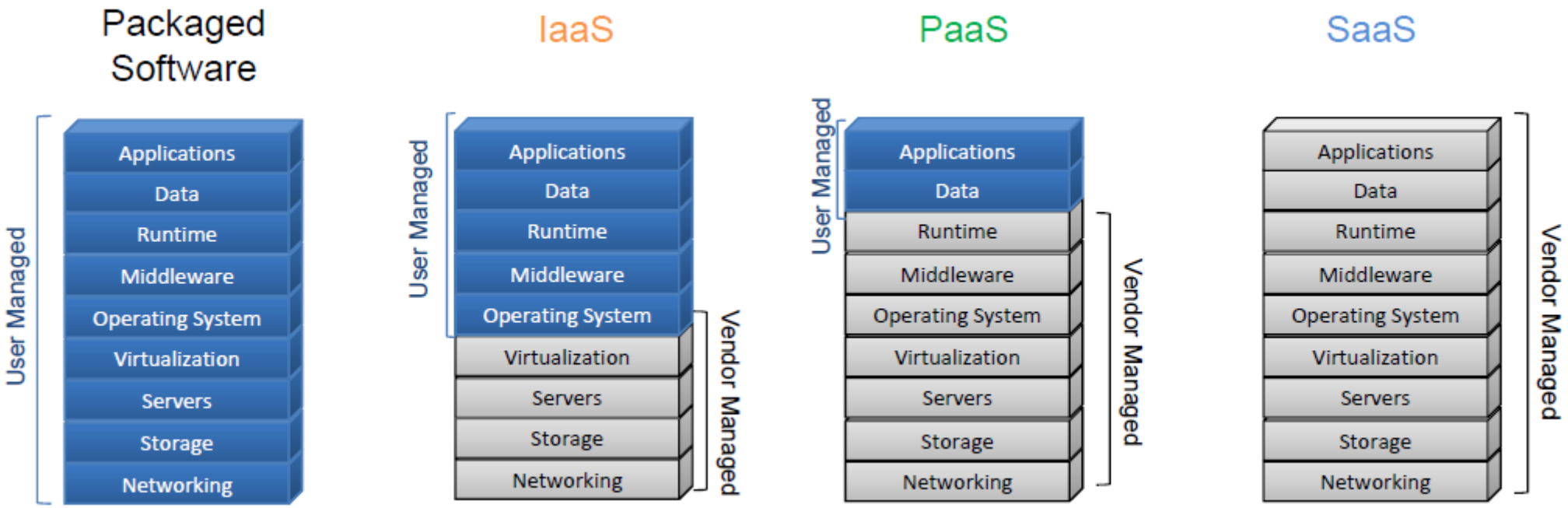
Cơ sở dữ liệu trực tuyến



Structure of Cloud computing

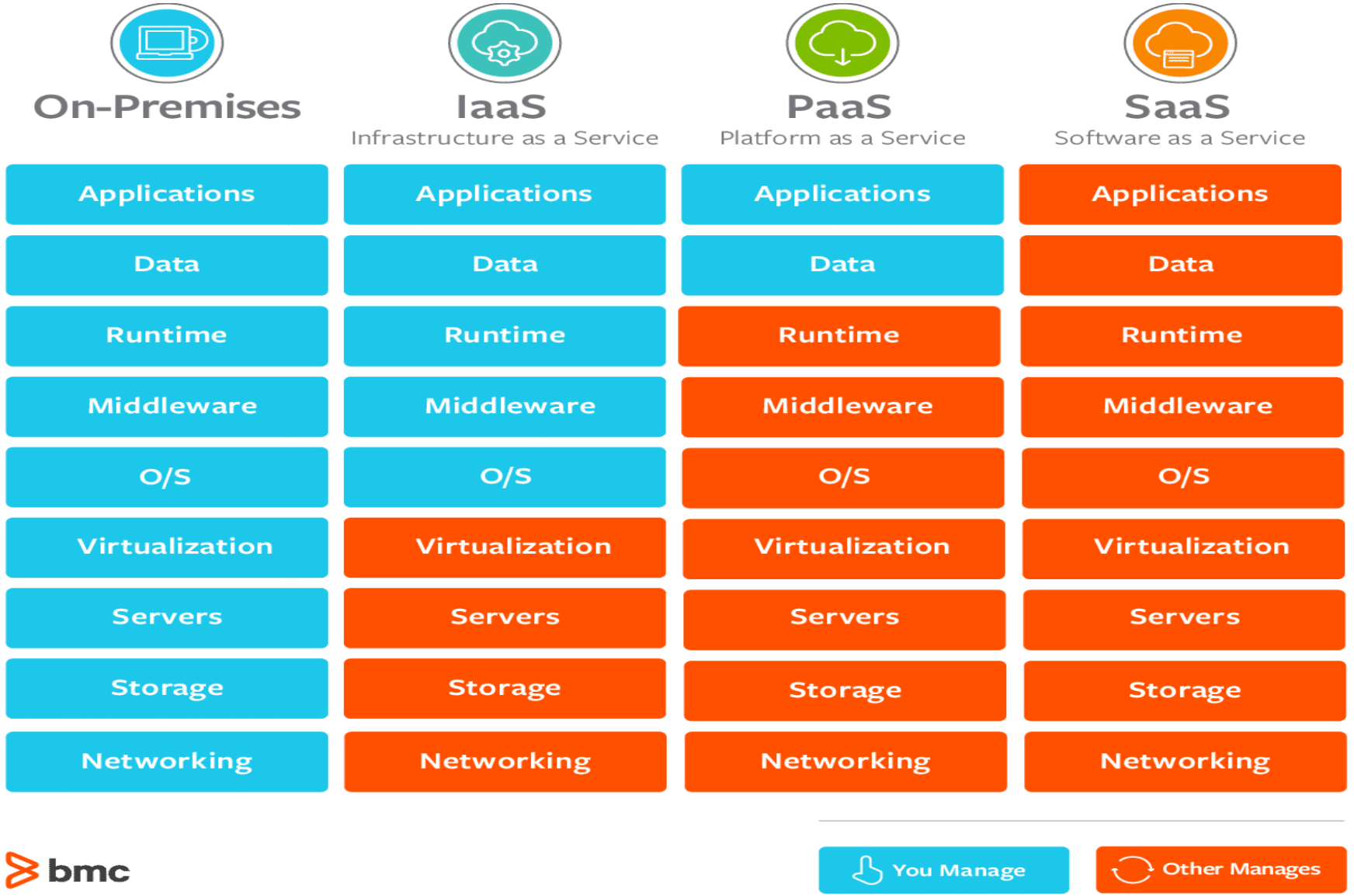
- Cloud Service Layers …





Structure of Cloud computing

- Cloud Service Layers …



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Structure of Cloud computing

- **Example: Qloud stack**

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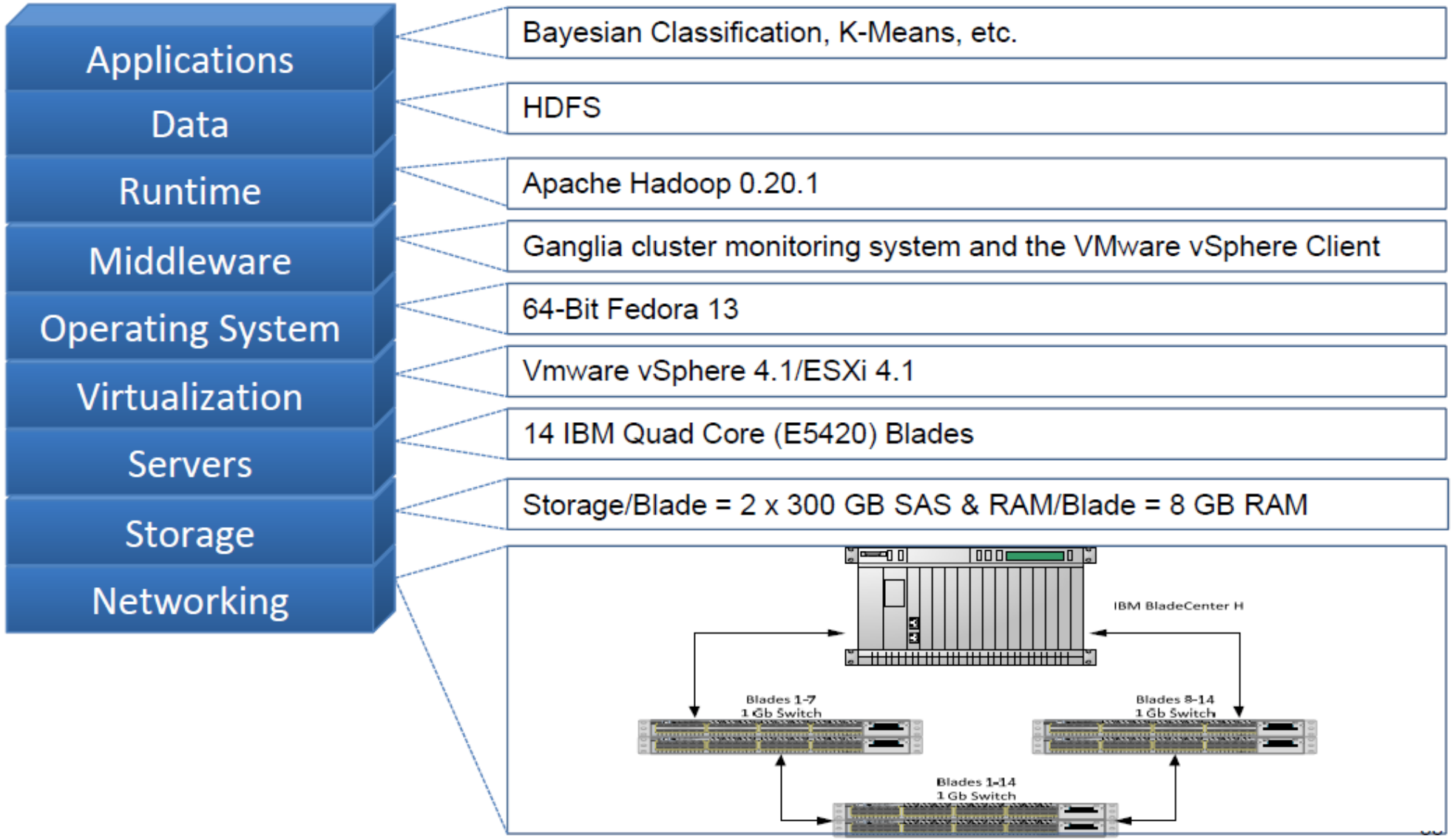

Structure of Cloud computing

Physical components (Servers – Storage - Networking):

- All clouds must be connected to a network. This inevitable requirement forms an inherent dependency on internetworking.

- Internetworks, or the Internet, allow for the remote provisioning of IT resources and are directly supportive of ubiquitous network access.
- Cloud consumers have the option of accessing the cloud using only private and dedicated network links in LANs, although most clouds are Internet-enabled.

- Physical Network
  - IP packets are transmitted through underlying physical networks that connect adjacent nodes, such as Ethernet, ATM network, and the mobile networks (3G, 4G, 5G).

  - Physical networks comprise a data link layer that controls data transfer between neighboring nodes, and a physical layer that transmits data bits through both wired and wireless media.

Structure of Cloud computing

Physical components (Servers – Storage - Networking):

Computing Hardware

Much of the heavy processing in data centers is often executed by standardized commodity servers that have substantial computing power and storage capacity. Several computing hardware technologies are integrated into these modular servers, such as:

- rackmount server design composed of standardized racks with interconnects for power, network, and internal cooling
- support for different hardware processing architectures, such as x86-32bits, x86-64, ...
- a power-efficient multi-core CPU architecture, hundreds of processing cores in a space as a single unit of standardized racks
- redundant and hot-swappable components, such as hard disks, power supplies, network interfaces, and storage controller cards

Structure of Cloud computing

❑ Physical components (Servers – Storage - Networking):

❑ Storage Hardware

Data centers have specialized storage systems that maintain enormous amounts of digital information in order to fulfill considerable storage capacity needs. These storage systems are containers housing numerous hard disks as arrays.

- Hard Disk Arrays – These arrays inherently divide and replicate data among multiple physical drives, and increase performance and redundancy by including spare disks.
- I/O Caching – performed through hard disk array controllers, which enhance disk access times and performance.
- Hot-Swappable Hard Disks – These can be safely removed from arrays without requiring prior powering down.
- Storage Virtualization – This is realized through the use of virtualized hard disks and storage sharing.
- Fast Data Replication Mechanisms – These include snapshotting, which is saving a virtual machine's memory into a hypervisor-readable file for future reloading, and volume cloning.

- Networked storage devices categories:
  - Storage Area Network (SAN) – Physical data storage media are connected through a dedicated network and provide block-level data storage access using industry standard protocols, such as the Small Computer System Interface (SCSI).
  - Network-Attached Storage (NAS) – Hard drive arrays are contained and managed by this dedicated device, which connects through a network and facilitates access to data using file-centric data access protocols like the Network File System (NFS) or Server Message Block (SMB).

Structure of Cloud computing

❑ Physical components (Servers – Storage - Networking):

❑ Network Hardware

Data centers require extensive network hardware in order to enable multiple levels of connectivity.
For a simplified version of networking infrastructure, the data center is broken down into five network subsystems.

- Carrier and External Networks Interconnection

A subsystem related to the internetworking infrastructure, this interconnection is usually comprised of backbone routers.

- Web-Tier Load Balancing and Acceleration

This subsystem comprises Web acceleration devices.

- LAN Fabric

the internal LAN and provides high-performance and redundant connectivity for all of the data center's network-enabled IT resources.

- SAN Fabric

implementation of storage area networks (SANs) that provide connectivity between servers and storage systems.

- NAS Gateways

supplies attachment points for NAS-based storage devices and implements protocol conversion hardware.

Structure of Cloud computing

- **Cloud platform at CMU-Q:**

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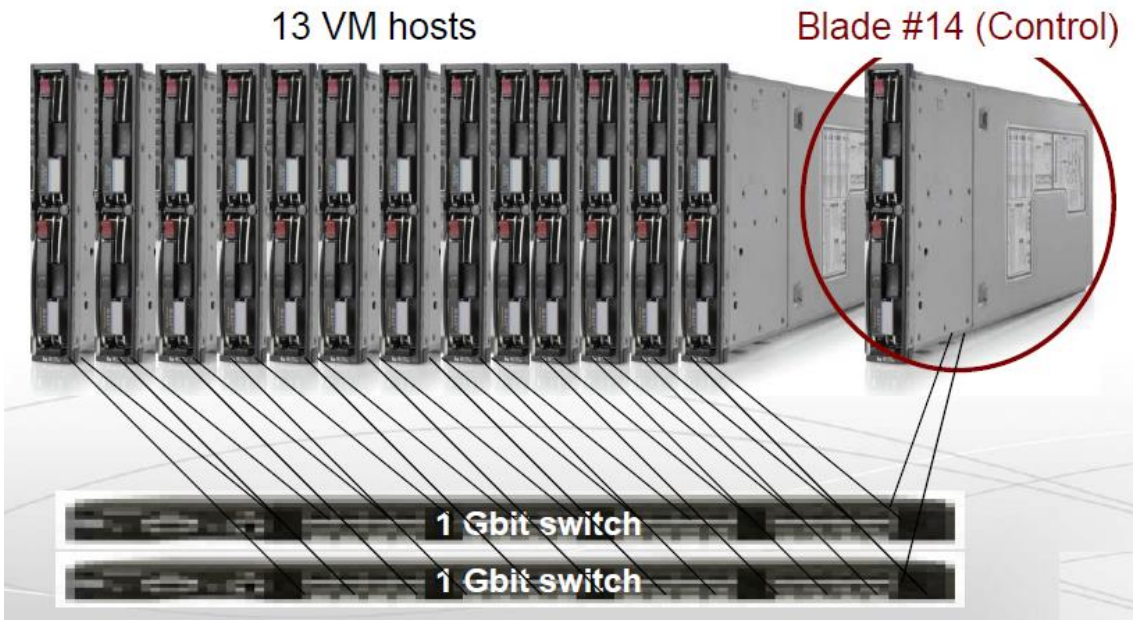
Total Installed Capacity:
20 Servers
240 Cores, 960 GB Memory,
18 TB local storage, 20 TB
SAN Storage
VMWare vSphere 4.x
Virtualization Environment



Structure of Cloud computing

Physical components (Servers – Storage - Networking):

- Network Bandwidth and Latency Issues

- In addition to being affected by the bandwidth of the data link, end-to-end bandwidth is determined by the transmission capacity of the shared data links that connect intermediary nodes. This type of bandwidth is constantly increasing, as Web acceleration technologies, such as dynamic caching, compression, and pre-fetching, continue to improve end-user connectivity.

- Latency (time delay) is the amount of time it takes a packet to travel from one data node to another. Latency increases with every intermediary node on the data packet's path. Transmission queues in the network infrastructure can result in heavy load conditions that also increase network latency. Networks are dependent on traffic conditions in shared nodes, making Internet latency highly variable and often unpredictable.

- Packet networks with "best effort" quality-of-service (QoS) typically transmit packets on a first-come/first-serve basis. Data flows that use congested network paths suffer service-level degradation in the form of bandwidth reduction, latency increase, or packet loss when traffic is not prioritized.

- The nature of packet switching allows data packets to choose routes dynamically as they travel through the Internet's network infrastructure.
- IT solutions need to be assessed against business requirements that are affected by network bandwidth and latency, which are inherent to cloud interconnection. Bandwidth is critical for applications that require substantial amounts of data to be transferred to and from the cloud, while latency is critical for applications.

Structure of Cloud computing

- **Physical components (Servers – Storage - Networking):**

- Network Bandwidth and Latency Issues

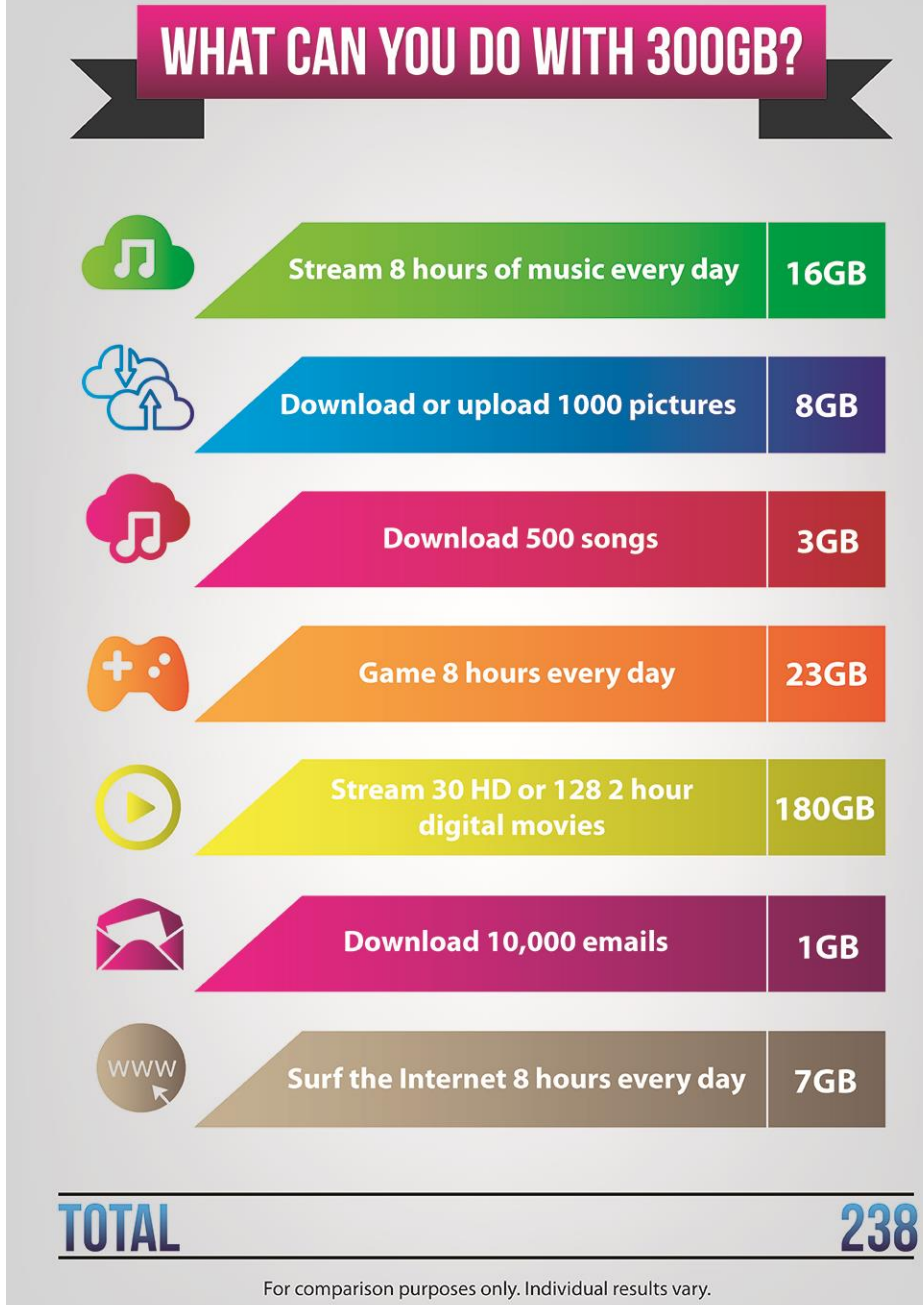
Choose the right plan for you.

STARTER 100 PLUS	STREAMER & GAMER 200 PLUS	TURBO 300 PLUS	GIGAONE PLUS
Download: up to 100Mbps	Download: up to 200Mbps	Download: up to 300Mbps	Download: up to 1,000Mbps
Upload: up to 10Mbps	Upload: up to 20Mbps	Upload: up to 30Mbps	Upload: up to 50Mbps
Data: 300GB*	Data: 600GB*	Data: 900GB*	Data: 1200GB*
Self-Install: Yes	Self-Install: Yes	Self-Install: Yes	
$45/MO	$65/MO	$80/MO	$125/MO
for the first 3 months $55/mo after trial offer.			
View Details	View Details	View Details	View Details
Offer ends 01/02/2020 *$10 charge for each add'l 100GB; Up to $50/mo.	*$10 charge for each add'l 100GB; Up to $50/mo.	*$10 charge for each add'l 100GB; Up to $50/mo.	*$10 charge for each add'l 100GB; Up to $50/mo.

Structure of Cloud computing

- **Physical components (Servers – Storage - Networking):**

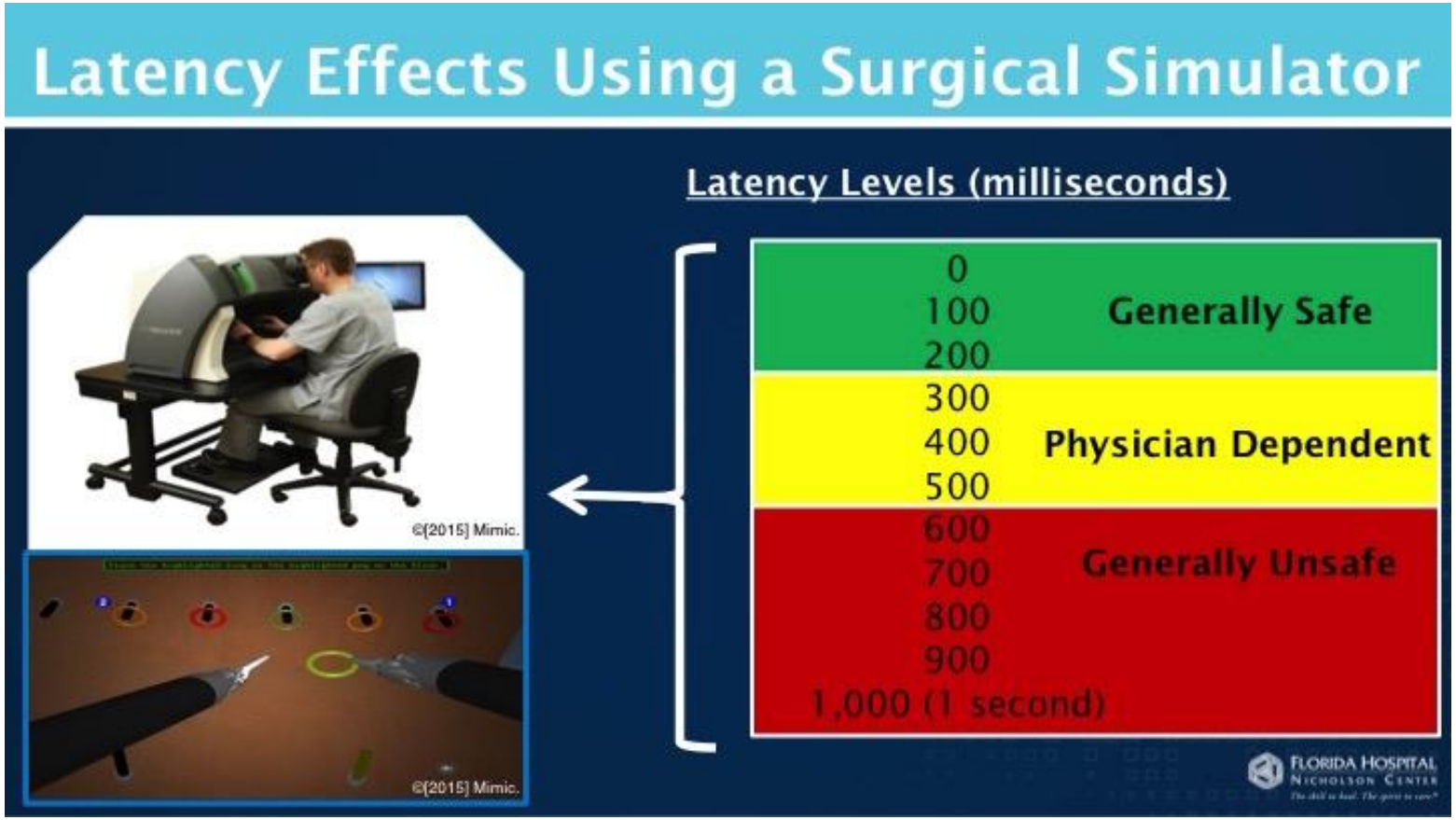
- Network Bandwidth and Latency Issues



Structure of Cloud computing

- **Physical components (Servers – Storage - Networking):**

- Network Bandwidth and Latency Issues

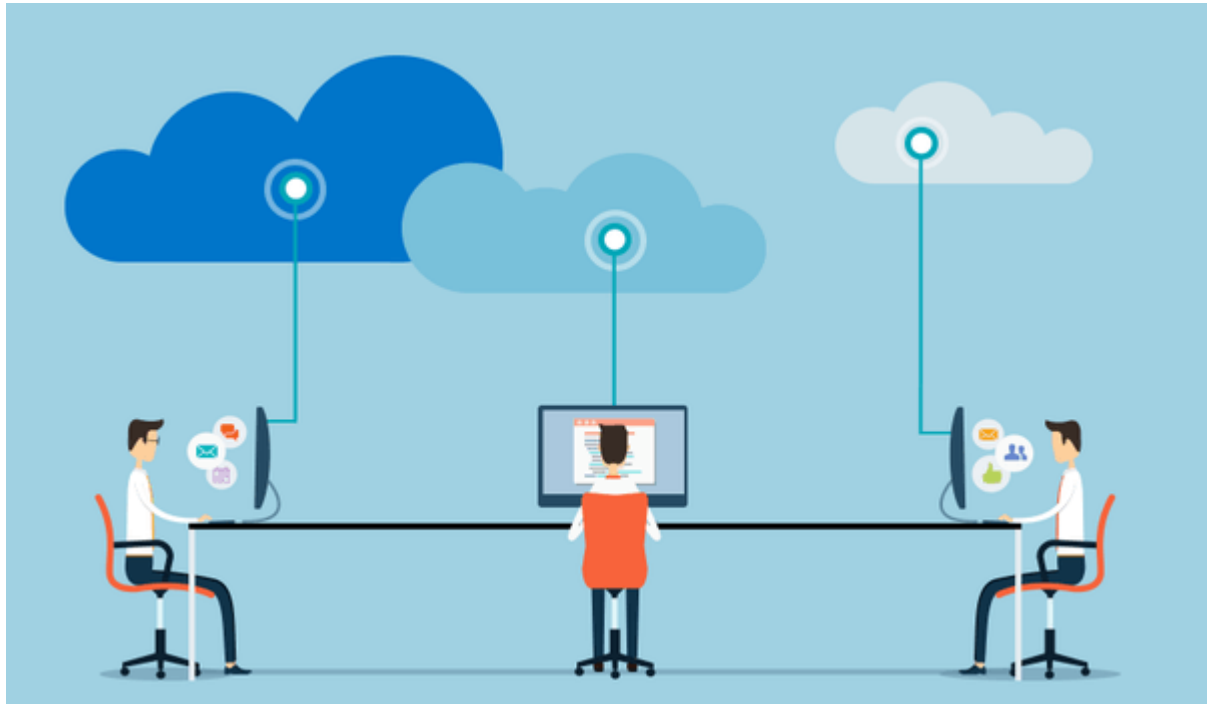


Structure of Cloud computing

- **Physical components (Servers – Storage - Networking):**

- "Đám mây" (cloud) là lối nói ẩn dụ chỉ liên kết mạng giữa các máy tính. Thông tin và dữ liệu ở đây đều được trao đổi thông qua "cloud". Để sử dụng tài nguyên, người dùng ở các thiết bị phải liên kết với "Cloud". "Cloud" giờ đây cho phép người dùng lấy dữ liệu hoặc lưu trữ ngay trên nó. Khác với truyền thống – phải tải dữ liệu về một server vật lý.

- Cloud Server ra đời để giải quyết được nhiều vấn đề về chi phí, bảo hành và uptime cho các doanh nghiệp. Đặc biệt dành cho những người muốn phát triển kinh doanh dựa trên nền tảng internet.



Structure of Cloud computing

❑ Physical components (Servers – Storage - Networking):

❑ Public Cloud Server

Cloud Server là máy ảo mà nhà cung cấp sẽ Public Cloud Host trên cơ sở hạ tầng của mình. Sau đó, họ cung cấp cho bạn bằng cách sử dụng giao diện trên Web hoặc dùng bảng điều khiển.

Mô hình này có tên gọi Infrastructure As Aa Service (IaaS) và nó được nhiều người dùng biết đến. Một số ví dụ phổ biến về máy chỉ ảo gồm Azure, Amazon Elastic Compute Cloud và Google Compute Engine.

❑ Private Cloud Server

Máy chủ áo cũng có thể là một phiên bản máy tính trong Private Cloud tại chỗ. Đối với trường hợp này, doanh nghiệp bạn sẽ phân phối máy chủ ảo cho người dùng nội bộ. Bạn có thể cấp cho người dùng mạng cục bộ hoặc cả người dùng bên ngoài Internet.

Sự khác biệt giữa 2 loại máy chủ ảo này là Private tồn tại trong cơ sở hạ tầng riêng của tổ chức. Còn với máy chủ ảo Public thì nó sẽ được sở hữu và vận hành ở bên ngoài tổ chức.

❑ Hybrid Cloud Server

Structure of Cloud computing

- **Physical components (Servers – Storage - Networking):**

- Những thông số cần biết khi thuê Cloud Server là gì?

  - CPU (Central Prossesing Unit)
  - RAM (Random Access Memory)
  - Storage (Bộ nhớ)
  - Uptime (Thời gian hoạt động)
  - Hỗ trợ kỹ thuật

Structure of Cloud computing

- **Virtualization layer:**

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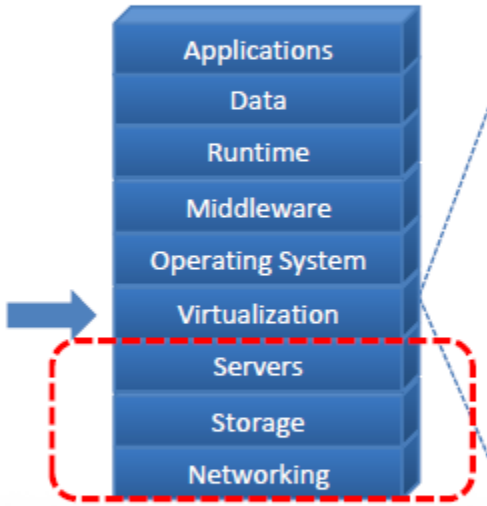


- Key Component
- Resource Virtualization
- Amazon EC2 is based on the Xen virtualization platform

Structure of Cloud computing

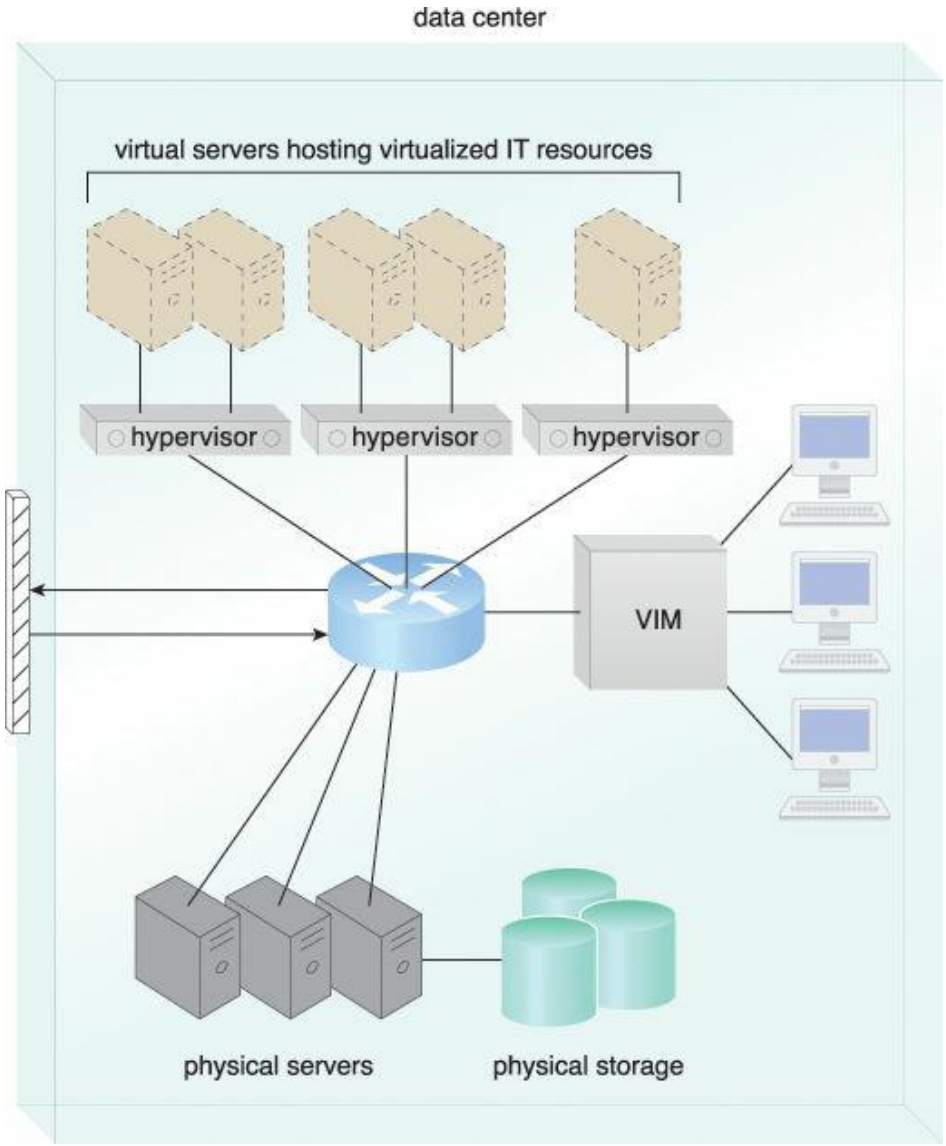
❑ Virtualization layer:

❑ Data centers consist of both physical and virtualized IT resources.
The physical IT resource layer refers to the facility infrastructure that houses computing/networking systems and equipment, together with hardware systems and their operating systems.

❑ The resource abstraction and control of the virtualization layer is comprised of operational and management tools that are often based on virtualization platforms that abstract the physical computing and networking IT resources as virtualized components that are easier to allocate, operate, release, monitor, and control.

Most types of IT resources can be virtualized, including:

- Servers – A physical server can be abstracted into a virtual server.
- Storage – A physical storage device can be abstracted into a virtual storage device or a virtual disk.
- Network – Physical routers and switches can be abstracted into logical network fabrics, such as VLANs.
- Power – A physical UPS and power distribution units can be abstracted into what are commonly referred to as virtual UPSs.



Structure of Cloud computing

- **Operating System layer (based Virtualization):**

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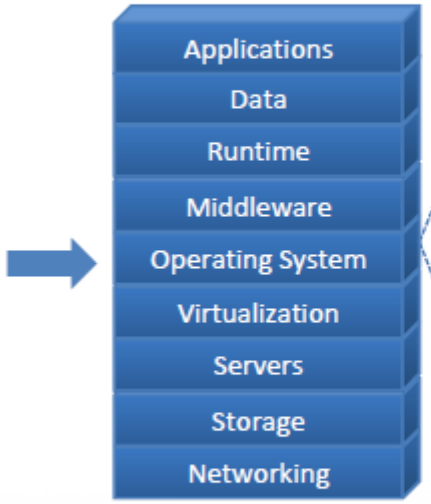


- Standard Operating Systems used in Personal Computing
- Packaged with libraries and software for quick deployment and provisioning
- E.g., Amazon Machine Images (AMI) contain OS as well as required software packages as a “snapshot” for instant deployment

Structure of Cloud computing

❑ Operating System layer (based Virtualization):

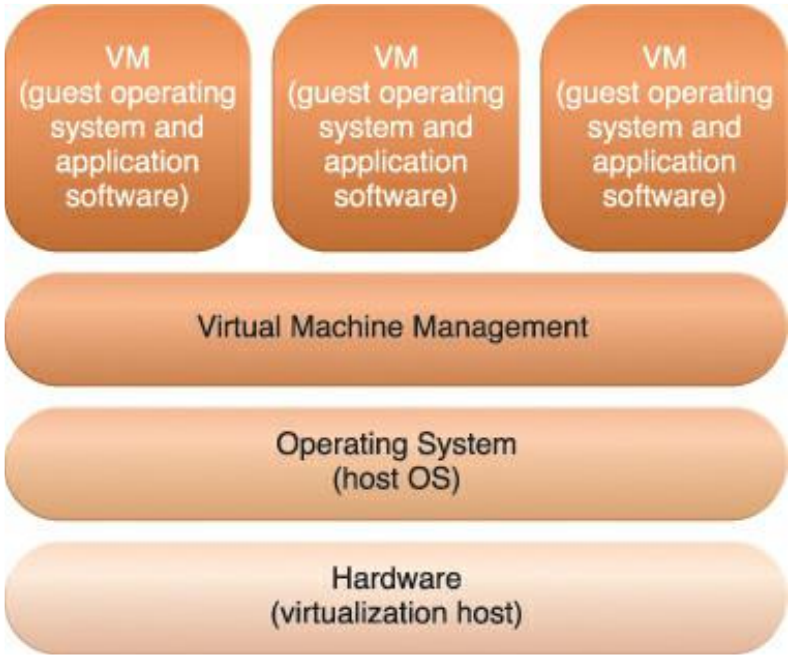
❑ Operating system is the installation of virtualization software in a pre-existing operating system, which is called the host operating system.

Virtualization software translates hardware IT resources for operation into virtualized IT resources that are compatible with a range of operating systems.

- Backup and Recovery
- Integration to Directory Services
- Security Management

❑ Operating system-based virtualization can introduce demands and issues related to performance overhead:

- Host operating system consumes CPU, memory, and other hardware IT resources.
- Hardware-related calls from guest operating systems need to traverse several layers to and from the hardware, which decreases overall performance.
- Licenses are usually required for host operating systems, in addition to individual licenses for each of their guest operating systems.



Structure of Cloud computing

- **Middleware layer:**

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Structure of Cloud computing

- **Middleware layer:**

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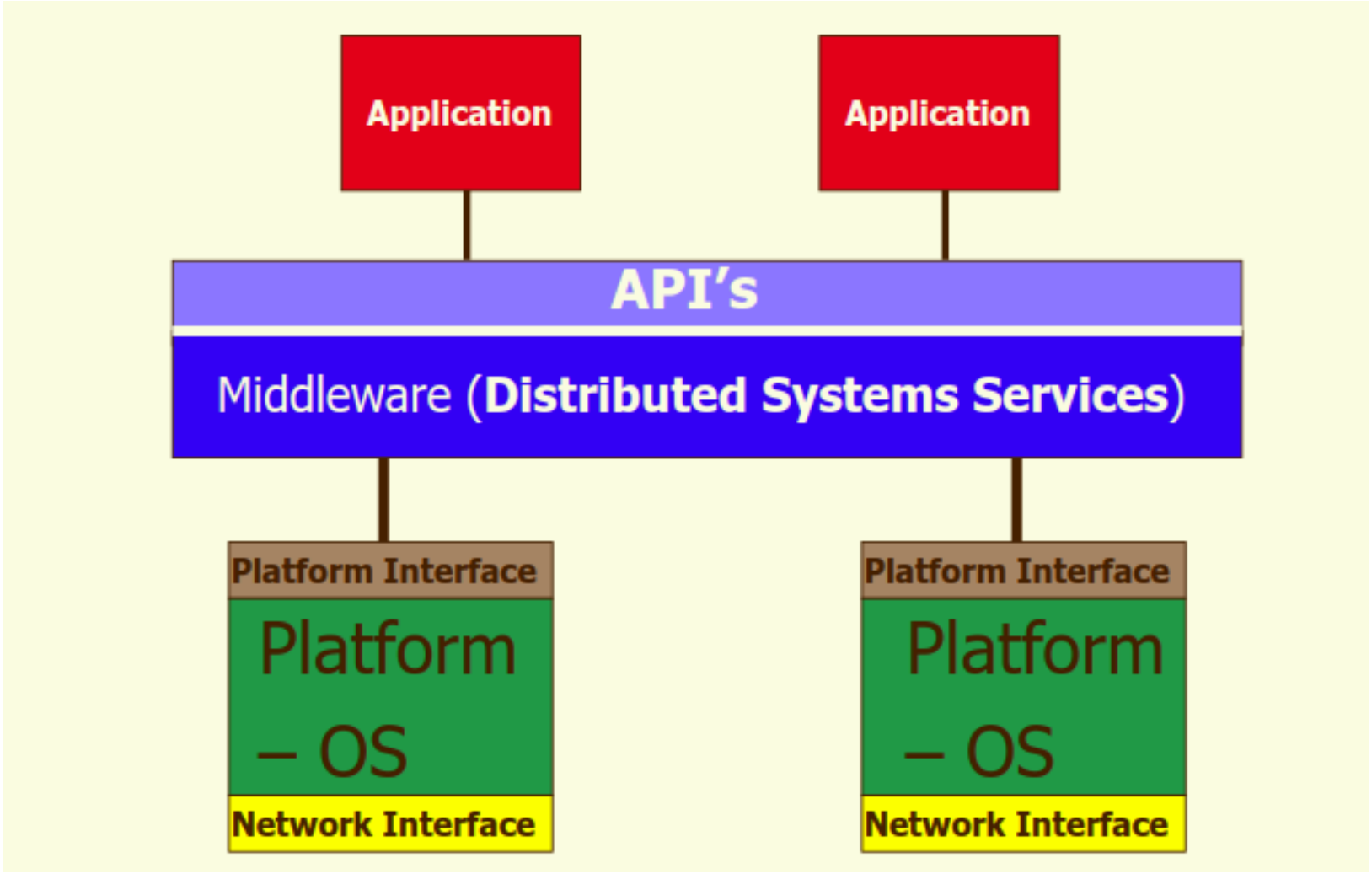

Structure of Cloud computing

- **Runtime Environment layer:**

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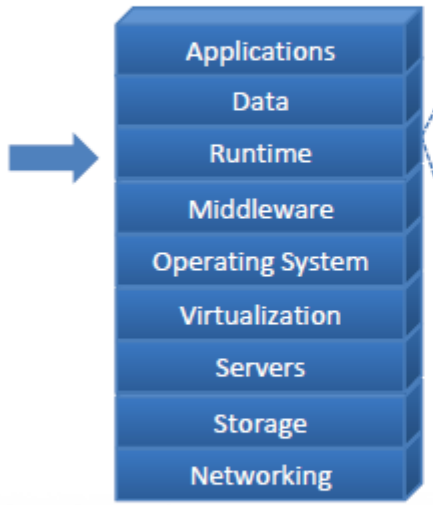
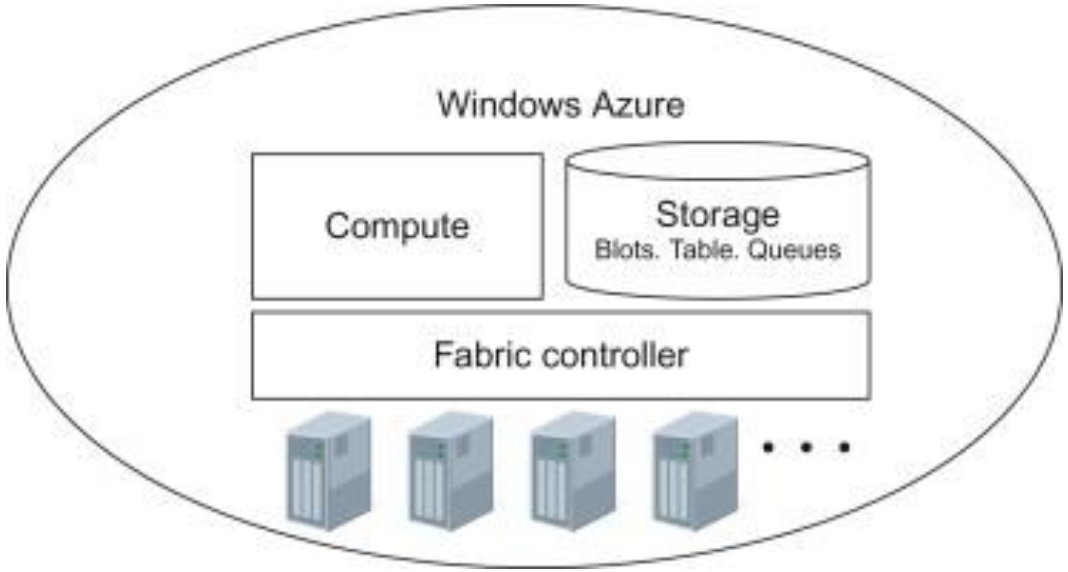


- Runtime platforms to support cloud programming models
- E.g., MPI, MapReduce, Pregel etc.

Structure of Cloud computing

Runtime Environment layer:

- To keep your functions up-to-date and secure, we occasionally need you to update your functions and re-deploy them to use a supported runtime.
- Runtimes on Cloud Functions include an operating system, software required to execute and/or compile code written for a specific programming language, and software to support your functions.



The Runtime Configurator feature lets you define and store data as a hierarchy of key value pairs in Google Cloud Platform. You can use these key value pairs as a way to:

- Dynamically configure services
- Communicate service states
- Send notification of changes to data
- Share information between multiple tiers of services

Structure of Cloud computing

- **Data layer:**

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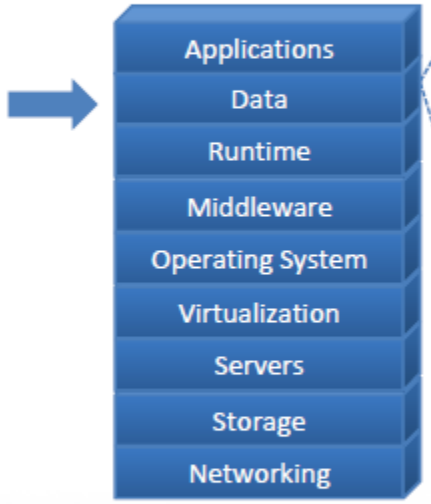


- Data Management
- New generation cloud-specific databases and management systems
- E.g., Hbase, Cassandra, Hive, Pig etc.

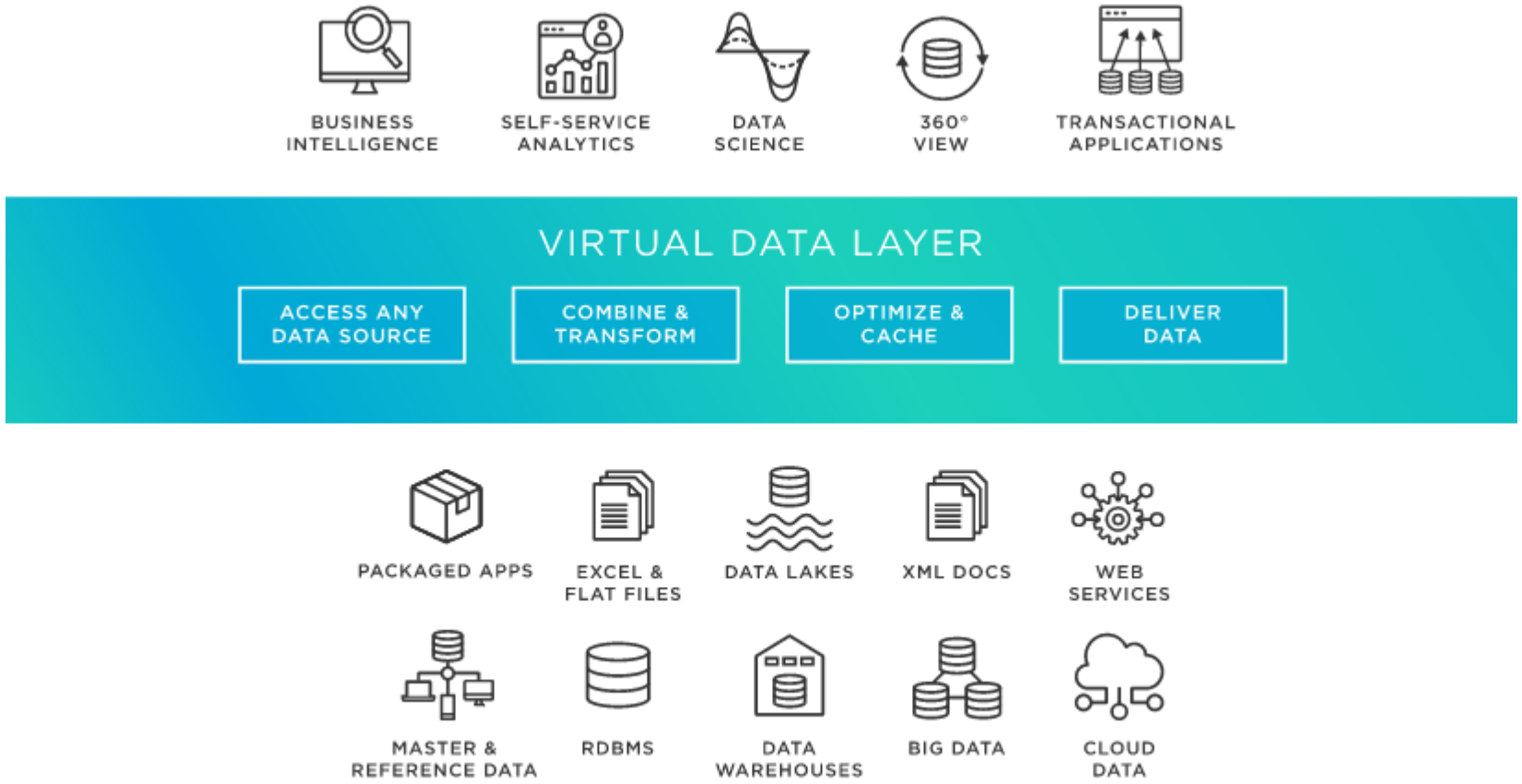
Structure of Cloud computing

❑ Data layer (virtual data):

❑ A virtual data layer is one virtual place to go for all your data.

It combines all of a company's diverse, distributed data sources, whether on-premises or in the cloud, and enables centralized access to data anytime, anywhere.

Data-driven organizations deploy a virtual data layer to access, combine, and provision all of its enterprise data to meet business requirements.



Structure of Cloud computing

Data layer (virtual data):

Employing a virtual data layer means providing data that is:

- Agile and Flexible: A virtual data layer allows organizations to access, transform, and deliver data from distributed data sources, including traditional enterprise, big data, cloud, and IoT at a fraction of the time, cost, and rigidity of traditional physical warehousing and ETL.
- Immediately Available: Organizations can get data up-to-the-minute and deliver it to analytics and applications whenever it's needed.
- Governed and Secure: With a virtual data layer, organizations can ensure data is consistent, high quality, and under control with all the governance and fine-grained data security required.
- Business-friendly: Virtual data layers transform native IT structures and syntax into easy-to-understand, IT-curated data services that are easy to find and use via a self-service business directory.
- Enterprise Grade: A modern virtual data layer allows organizations to support multiple lines of business, hundreds of projects, and thousands of users with consistent, trustworthy data.

Structure of Cloud computing

Data layer (virtual data):

Benefits of a Virtual Data Layer

- One Place for All Your Data: A virtual data layer centralizes your data, creating a single place to access all your data, including both data stored on-premises and in the cloud, with semantic consistency.
- Business-friendly Views: With a virtual data layer, organizations can easily create business-friendly, self-service views of their data. This is done by eliminating the traditionally complex data integration technologies, formats, protocols, and locations so that the data becomes more approachable and user friendly.
- Current, Up-to-date Data: A virtual data layer allows you to get the most current data on demand anytime in any format necessary for any business use case. Businesses no longer need to wait for a nightly batch run to refresh their datasets.
- Decreased Data Replication: By eliminating unnecessary data replication with a virtual data layer, organizations can increase agility, mitigate risk, and reduce costs.
- Faster Data Fulfillment: Virtual data layers enable accelerated provisioning of new datasets, allowing organizations to keep pace with their ever-changing data requirements.
- Centralized Security and Controls: With one place for all your data, enforcing security and managing data controls for every user across all your datasets becomes much easier.

Structure of Cloud computing

- **Data layer (virtual data):**

- A virtual data layer can be leveraged by organizations across various applications:

Financial Services: A virtual data layer can help financial companies manage fixed income risk, improve trading reconciliation, accelerate new client onboarding, address mortgage data complexity, enrich cash management clients, and empower data democracy.

Communications and Technology: Communications and technology companies can use a virtual data layer to differentiate market research services, increase revenue per customer, create a virtual customer data lake, enable leading edge innovation, implement a real-time operational data store for billing and marketing, optimize customer care, manage customer entitlements, and improve customer insights.

Manufacturing: A virtual data layer for manufacturers means global supply chain optimization, optimizing factories and logistics, improving IT asset utilization, and differentiating via digitization.

Healthcare: In healthcare, a virtual data layer can enable new product innovation, accelerated merger and acquisition synergies, efficient claims analysis, and improved patient care.

Energy: Energy companies can utilize a virtual data layer to optimize upstream production, manage wells and repairs, perform offshore platform data analytics, optimize cross-refinery processes, and ensure master data quality.

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Structure of Cloud computing

- **Application layer:**

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- Cloud applications can range from Web applications to scientific computational jobs

Structure of Cloud computing

- **Application layer:**

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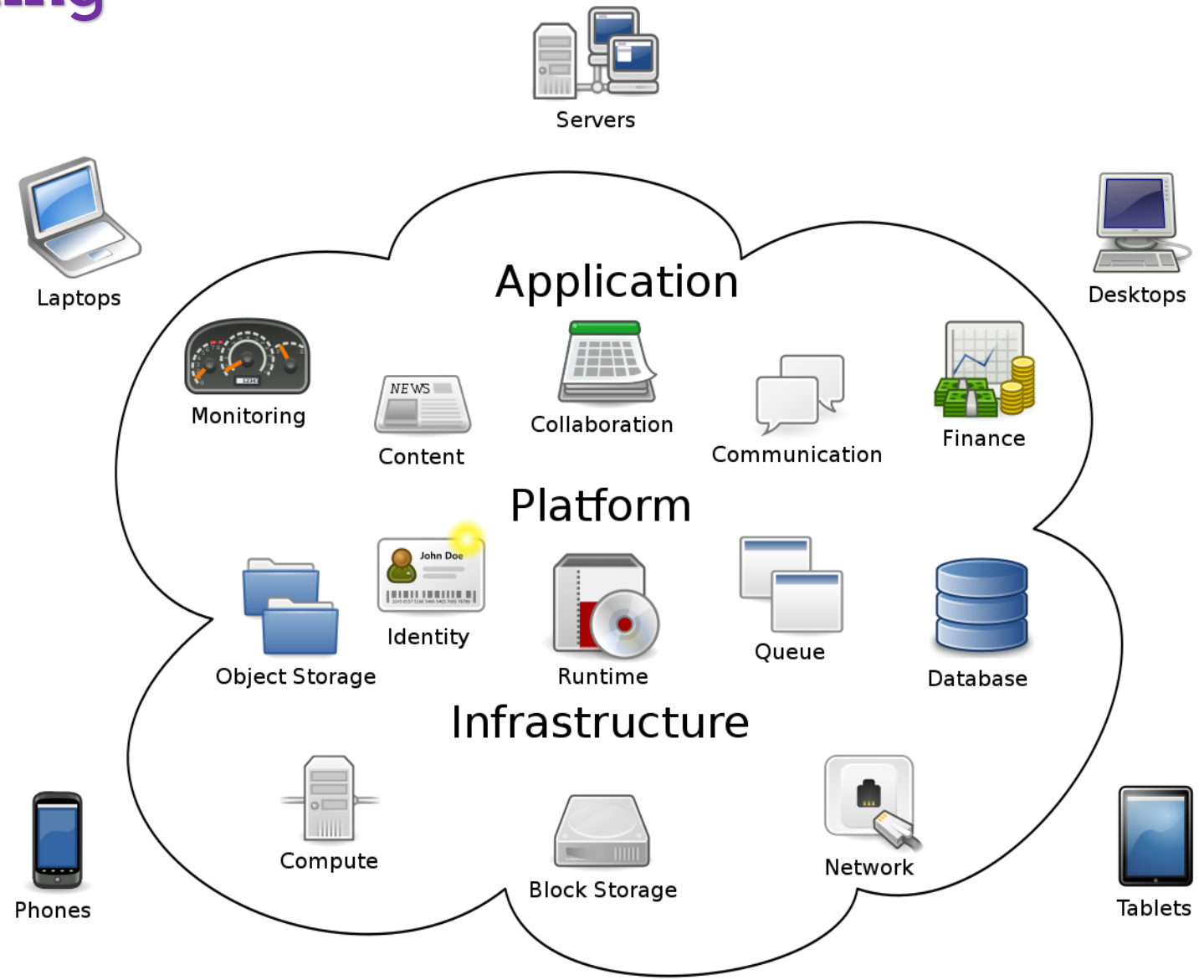

Structure of Cloud computing

❑ Application layer:

Due to cloud computing's fundamental reliance on internetworking, Web browser universality, and the ease of Web-based service development,
Web technology is generally used as both the implementation medium and the management interface for cloud services.

❑ The World Wide Web is a system of interlinked IT resources that are accessed through the Internet.
The two basic components of the Web are the Web browser client and the Web server.
... proxies, caching services, gateways, and load balancers, scalability and security ...
These additional components reside in a layered architecture that is positioned between the client and the server.

❑ Three fundamental elements comprise the technology architecture of the Web:

- Uniform Resource Locator (URL) – A standard syntax used for creating identifiers that point to Web-based resources, the URL is often structured using a logical network location.

- Hypertext Transfer Protocol (HTTP) – This is the primary communications protocol used to exchange content and data throughout the World Wide Web. URLs are typically transmitted via HTTP.

- Markup Languages (HTML, XML) – Markup languages provide a lightweight means of expressing Web-centric data and metadata. The two primary markup languages are HTML (which is used to express the presentation of Web pages) and XML (which allows for the definition of vocabularies used to associate meaning to Web-based data via metadata).

Structure of Cloud computing

- **Application layer:**

- **Web Applications:**

A distributed application that uses Web-based technologies (and generally relies on Web browsers for the presentation of user-interfaces) is typically considered a Web application.
These applications can be found in all kinds of cloud-based environments due to their high accessibility.