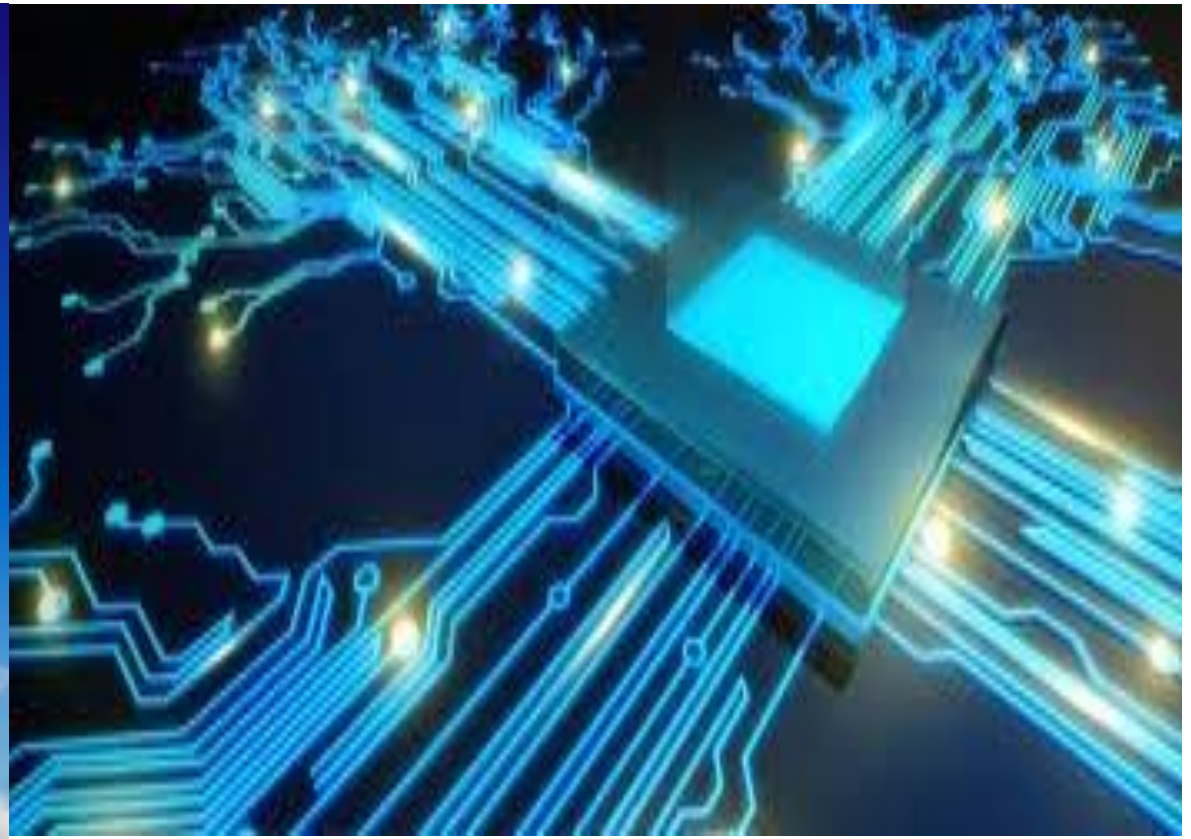


Cloud Computing

MODULE - 1

Contents

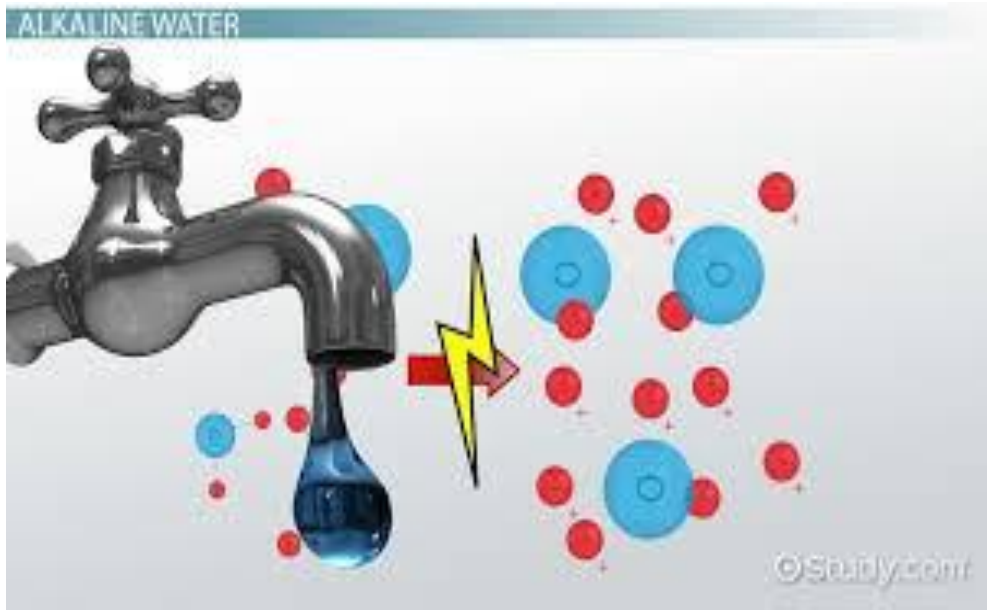
- Course Handout Discussion
- Introduction
- Evolution of cloud computing
- Computing Platforms and Technologies
- Cloud Computing Architecture
- IaaS, PaaS, SaaS,
- Types of Clouds
- Cloud Computing Environments.

Cloud computing

Basic services

- Water
- Electricity
- Telephony

1) Water



Provider

2) Electricity

Provider

Computing

- Computing is being transformed into a model consisting of services that are commoditized and delivered in a manner similar to utilities such as water, electricity, gas, and telephony.

- Cloud computing - turn the vision of “computing utilities "in to a reality.
- computer utilities’
    - like electric and telephone utilities
    - will service individual homes and offices across the country

Example of cloud computation

- Users (consumers) need to pay providers only when they access the computing services.
- consumers

  - no longer need to invest heavily

  - encounter difficulties in building and maintaining complex IT infrastructure.

Cloud Computing

- Users access services based on their requirements without regard to where the services are hosted.
- This model has been referred to as utility computing or, (since 2007), as cloud computing.

Cloud computing

- Cloud computing allows
  - renting infrastructure,
  - runtime environments-IDE
  - and services on a pay- per-use basis.

- This principle provides-several practical applications and then gives different images of cloud computing to different people.

Cloud computing

- One of the most diffuse views of cloud computing can be summarized as follows:
- *I don’t care where my servers are, who manages them, where my documents are stored, or where my applications are hosted.*
- *I just want them always available and access them from any device connected through Internet.*
- *And I am willing to pay for this service for as a long as I need it.*
- The concept expressed above has strong similarities to the way we use other services, such as water and electricity.

cloud computing

- ✖cloud computing turns IT services into utilities.
- ✖a delivery model is made possible by the effective composition of several technologies
- ✖Web 2.0 technologies plays a central role in making cloud computing an attractive opportunity for building computing systems.

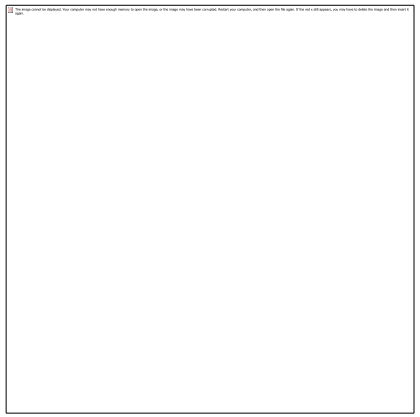
- Service orientation allows cloud computing

  - to deliver its capabilities with familiar abstractions.

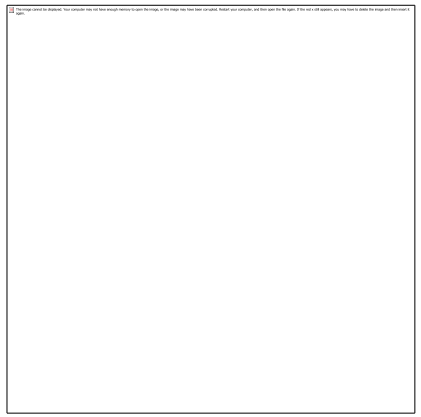
- virtualization allows cloud computing

  - provides the necessary degree of customization, - control, and flexibility for building production and enterprise systems.

Overview



Cloud computing at a glance



Historical Developments

Cloud computing at a glance

Massive transformation – from networks to cloud

- Computing services readily available on demand, just as other utility services
- Pay providers only when you access the computing services
- Consumers no longer need to invest heavily - building and maintaining complex IT infrastructure

Utility computing or, recently (since 2007), as cloud computing

What is cloud computing?

- Paradigm for the dynamic provisioning of computing services
  - supported by state-of-the-art data centers
  - employing virtualization technologies for consolidation and effective utilization of resources
- Cloud computing allows renting infrastructure, runtime environments, and services on a pay-per-use basis

Cloud – one point of view

- I don’t care

  where my servers are,

  who manages them,

  where my documents are stored,

  where my applications are hosted

- I just want them
  - always available and access them from any device connected through Internet

And I am willing to pay for this service for as a long as I need it

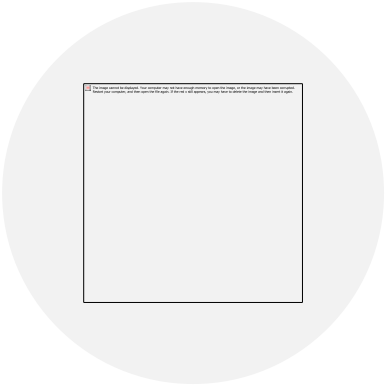
Cloud – Composition of several technologies

Web 2.0 technologies - transformed the Internet into a rich application and service delivery platform

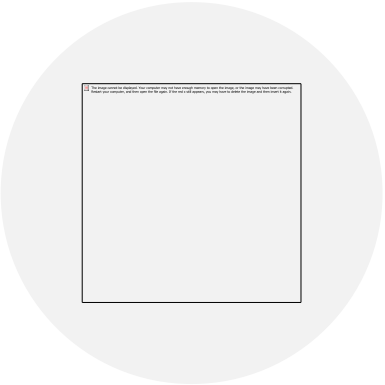
Service orientation - to deliver its capabilities with familiar abstractions

Virtualization - necessary degree of customization, control, and flexibility for building production and enterprise systems

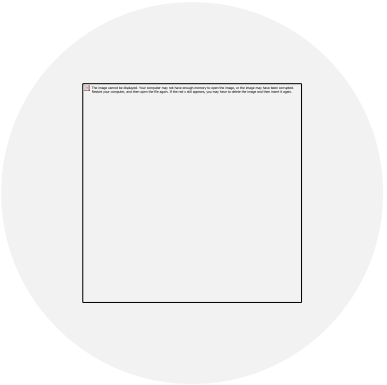
Why is cloud popular?



EXTREMELY FLEXIBLE ENVIRONMENT FOR BUILDING NEW SYSTEMS AND APPLICATIONS



EASY TO INTEGRATE ADDITIONAL CAPACITY OR NEW FEATURES INTO EXISTING SYSTEMS



USE OF DYNAMICALLY PROVISIONED IT RESOURCES – NO NEED TO BUY ADDITIONAL INFRASTRUCTURE AND SOFTWARE

Vision of Cloud

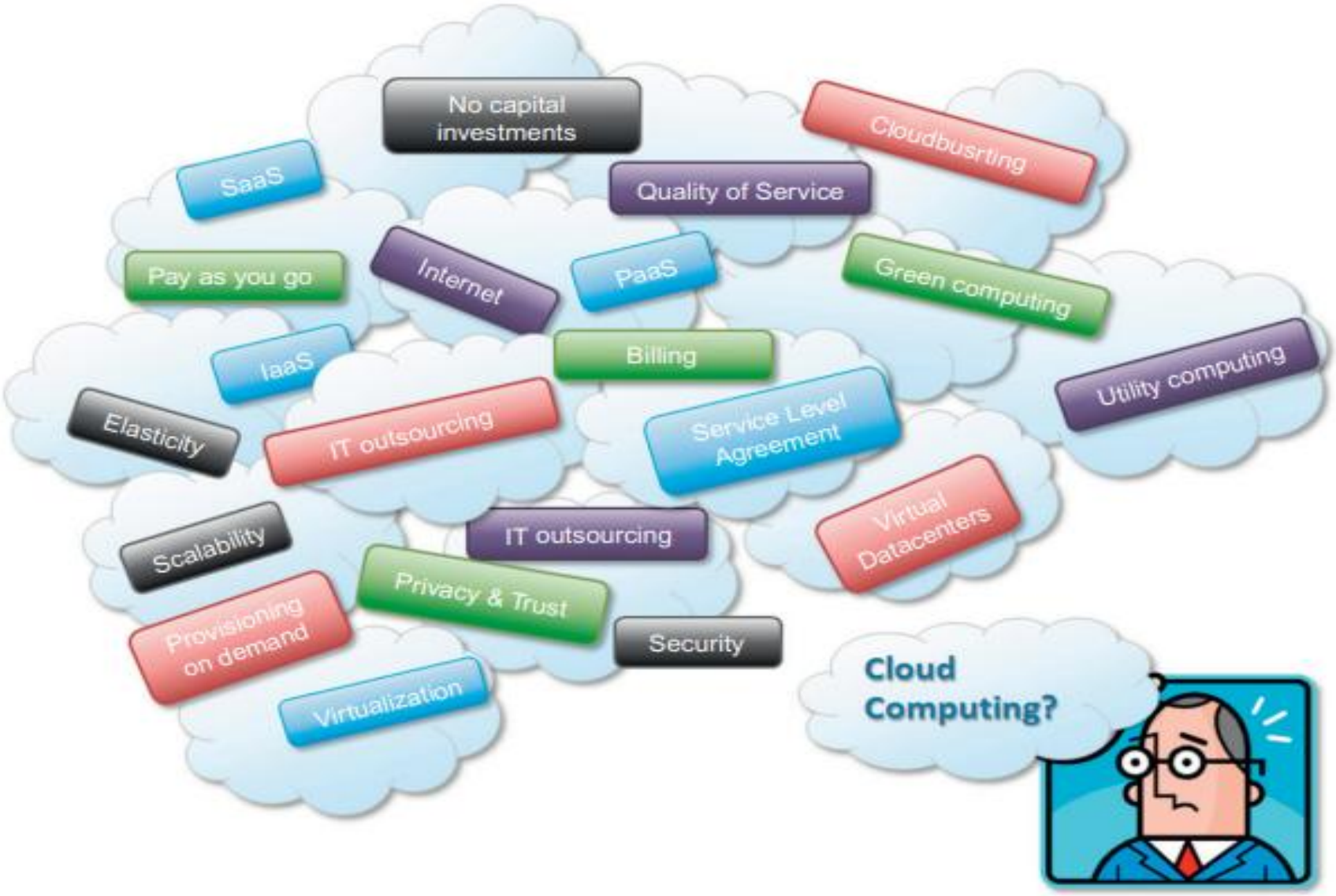
- Anyone with a credit card can provision virtual hardware, runtime environments, and services
- Used as needed, with no up-front commitments
- The entire stack of a computing system is transformed into a collection of utilities
  - composed together to deploy systems in hours and with virtually no maintenance costs

Vision of Cloud

Future – Global cloud marketplace

- Give your needs – automation of discovery process and integration of the cloud services
- Service providers – increase their revenue
- Reduces the barriers between service consumers and providers
- Standards
- Optimize datacenter facilities – greener computing

Defining a Cloud



Defining a Cloud

- Refers to both the applications delivered as services over the Internet and the hardware and system software in the datacenters that provide those services.
- A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Criteria for a cloud service

The service is accessible via a Web browser (nonproprietary) or a Web services application programming interface (API)

Zero capital expenditure is necessary to get started

You pay only for what you use as you use it

Definition (Buyya – utility-oriented)

- A cloud is a type of parallel and distributed system
- consisting of a collection of interconnected and virtualized computers
- that are dynamically provisioned
- and presented as one or more unified computing resources
- based on service-level agreements
  - established through negotiation between the service provider and consumers

What do we get from Cloud?

Large enterprises can offload some of their activities

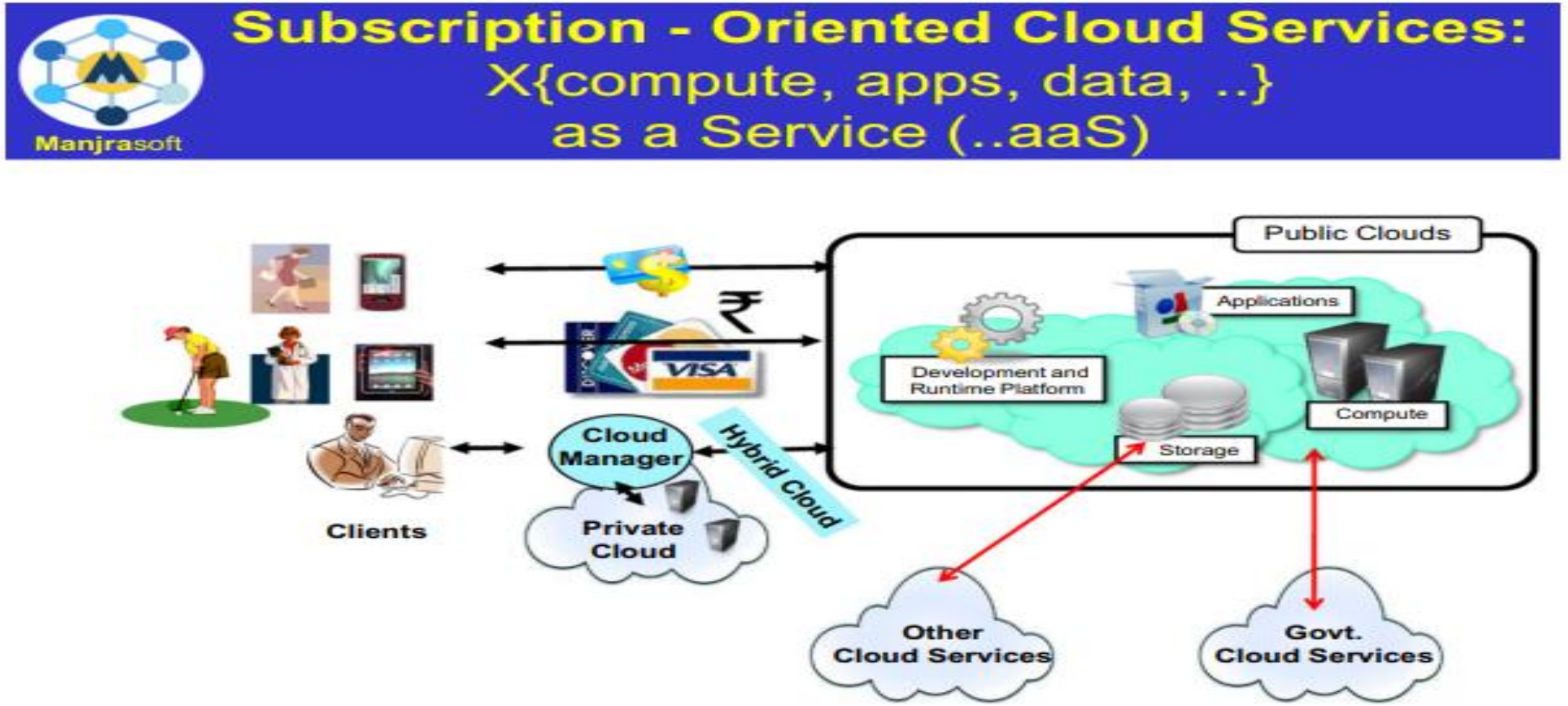
Small enterprises / start-ups translate their ideas into business results more quickly, without excessive up-front costs

System developers can concentrate on the business logic rather than dealing with the complexity of infrastructure management and scalability

End users can have their documents accessible from everywhere and any device

IT Services on Demand

A bird’s-eye view of cloud computing



Historical Developments

5 Core Technologies

Distributed systems

Virtualization

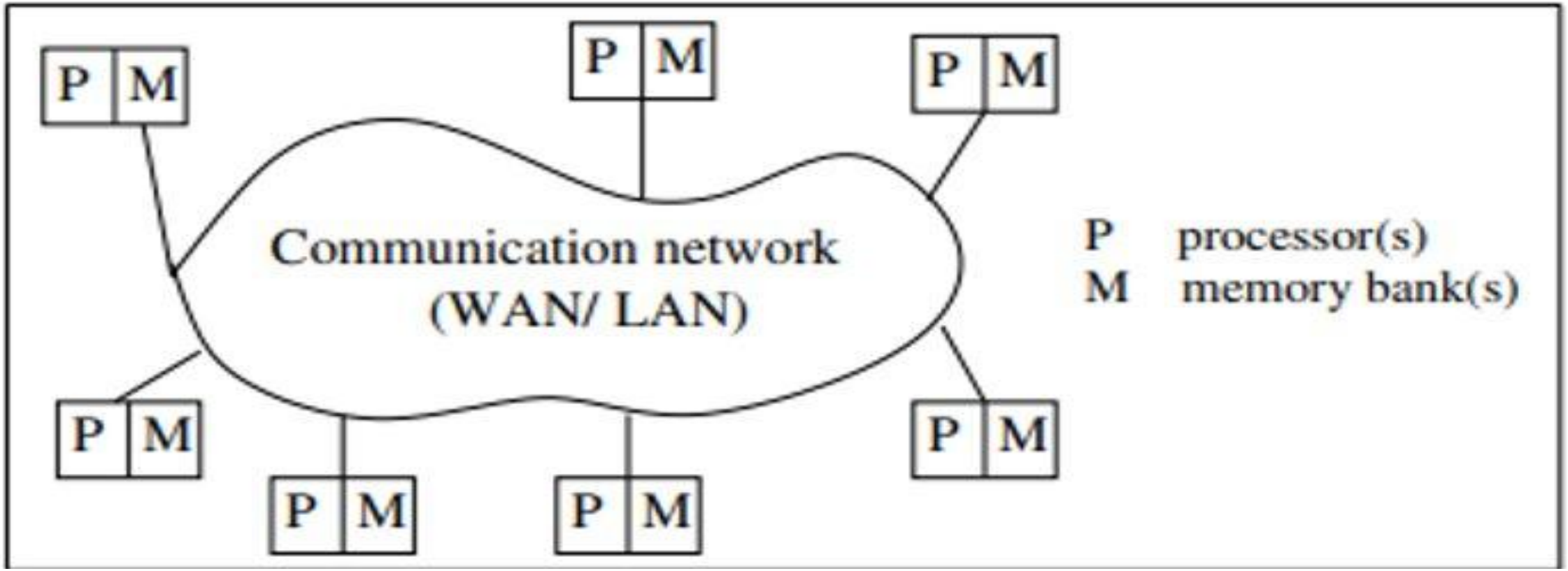
Web 2.0

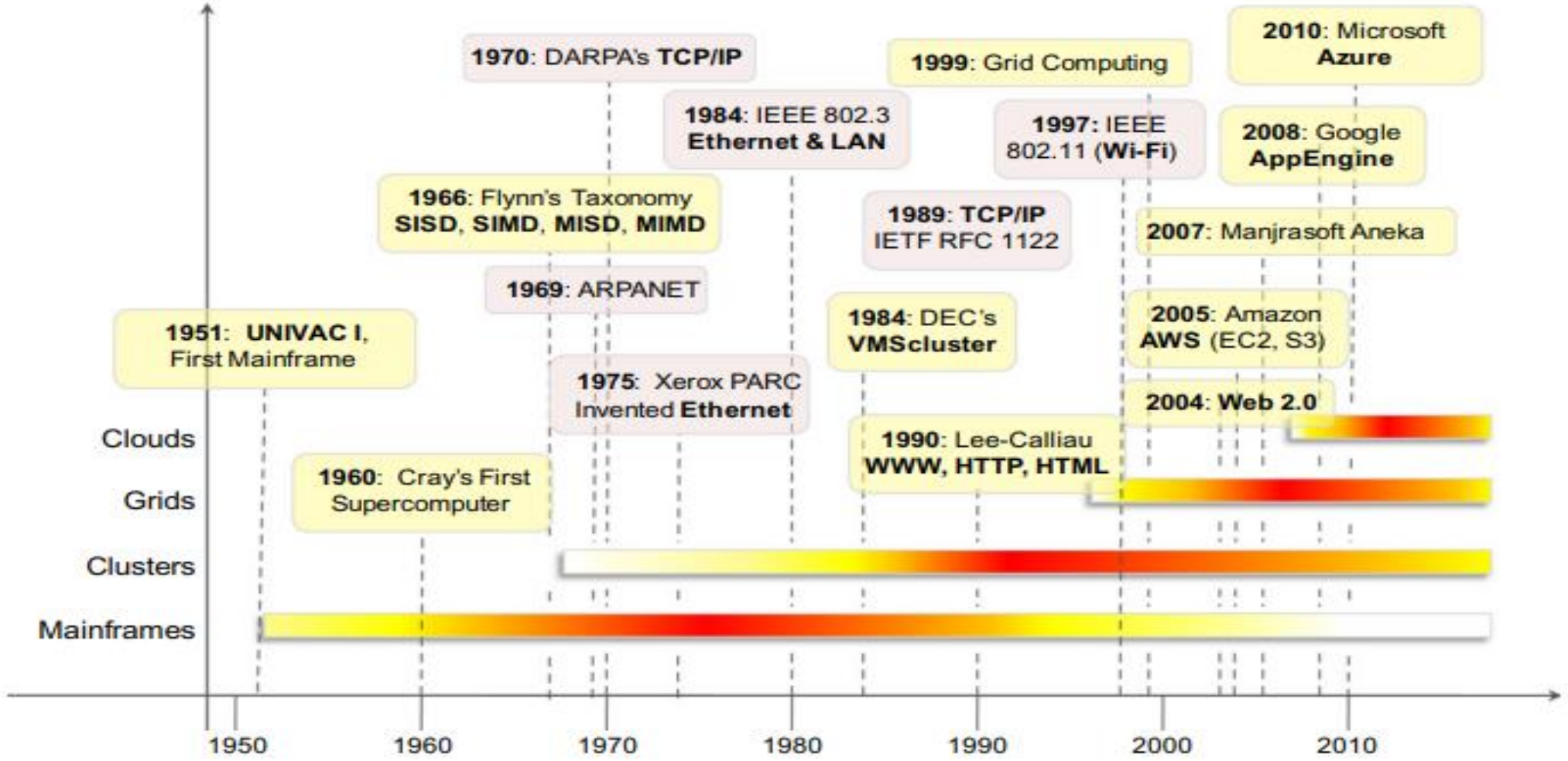
Service oriented computing

Utility-oriented computing

1. Distributed systems

- A distributed system is a collection of independent computers that appears to its users as a single coherent system.





Evolution of Distributed Computing

Major milestones

Mainframe computing

Cluster computing

Grid computing

Mainframes

- Smaller than a super computer
- Large computational facilities leveraging multiple processing units
- Powerful, highly reliable computers specialized for large data movement and massive input/output (I/O) operations.

USE:

- online transactions
- enterprise resource planning
- huge data processing

Mainframes – good and bad

- ✓Good Scalability
- ✓Good memory storage
- ✓Highly reliable
- ✓Transparent fault tolerance
- ✓No interruption while replacing faulty components
- ✓Can run multiple OS

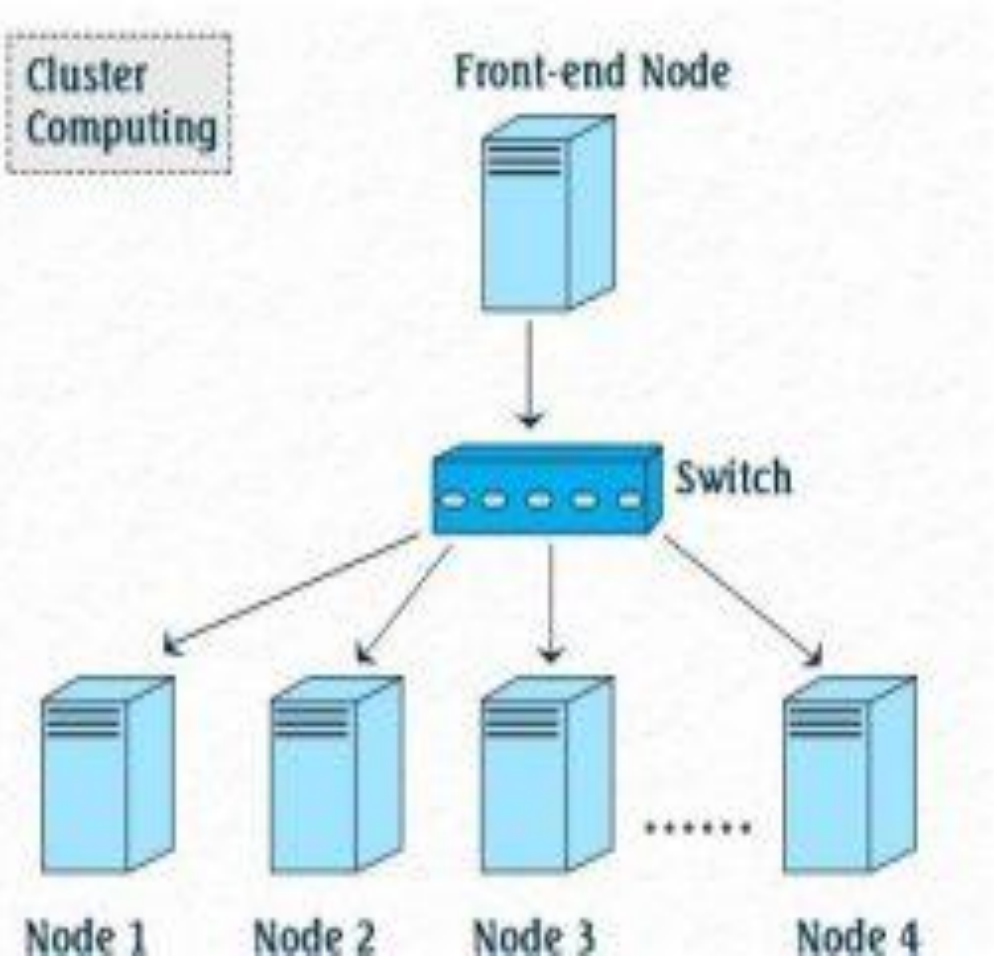
- High cost
- Difficult installation
- Huge physical size
- Environmental issues

Cluster Computing

- Early 1980s
- Low-cost alternative to mainframes and supercomputers
- Increased availability of cheap commodity machines
- Connected by a high-bandwidth network and controlled by specific software tools that manage them as a single system
- 1980s - clusters - standard technology for parallel and high-performance computing
- Could run programs which once required mainframes

Cluster Computing

- Collection of tightly or loosely connected computers (nodes) that work together so that they act as a single entity (transparency)



- **solve complicated problems**
- **faster computational speed**
- **enhanced data integrity**
- **expandability**

Grid Computing

- Early 1990s
- Analogy to the power grid – consume resources
- Aggregate geographically dispersed clusters
  - By means of Internet connections
  - These clusters belonged to different organizations
  - Arrangements were made among them to share the computational power
  - Different from a “large cluster”

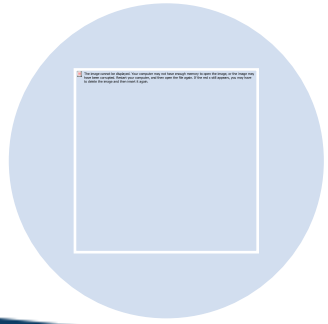
Computing grid - dynamic aggregation of heterogeneous computing nodes, and its scale was nationwide or even worldwide

Why Grid Computing ?

(a) clusters became quite common resources

(b) they were often underutilized

(c) new problems were requiring computational power that went beyond the capability of single clusters



(d) the improvements in networking and the Internet made possible long-distance, high-bandwidth connectivity

GRID COMPUTING
VERSUS
CLOUD COMPUTING

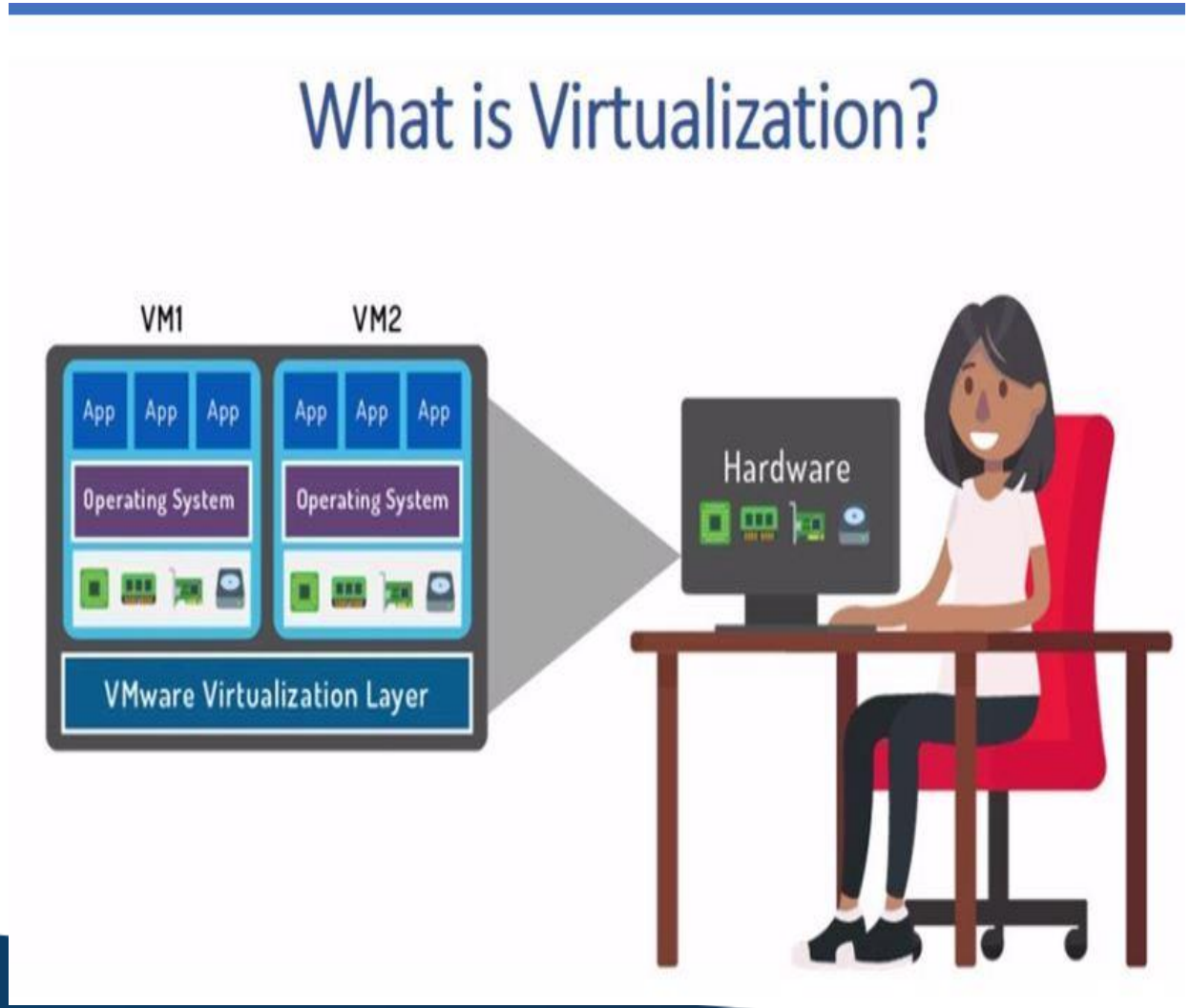
GRID COMPUTING	CLOUD COMPUTING
Use of widely distributed computer resources to reach a common goal	Technology that enables access to shared pools of configurable system resources and higher-level services over the internet
Computing resources are distributed among different devices located in different locations	Computing resources are managed centrally in data centers belonging to the cloud service providers
Task is divided into several independent subtasks, and each machine on the grid is assigned with a subtask	Provides resources according to the requirements
Users can access the data in the grid computing devices via cooperate networks such as internet or a low-speed network	Users can access the resources through the internet
Management is decentralized	Management is centralized
Uses distributed architecture	Uses client-server architecture

COMPARISON OF CLUSTER, GRID AND CLOUDCOMPUTING

	Cluster	Grid	Cloud
Resource Handling	Centralized	Distributed	Both
Loose coupling / Scalable	No	Both	Yes
Reliability/ User friendliness	No	Half	Full
Network type	Private	Private	Public Internet
Virtualization	Half	Half	Yes
Business Model	No	No	Yes
Task Size	Single large	Single large	Small, medium & large
Heterogeneity	No	Yes	Yes
Security	High	Medium / High	Low / Medium
Value Added Service	No	Both	Yes
Cost	Very High	High	Low

2. Virtualization

- Allows creation of different computing environments
  - These environments are called virtual because they simulate the interface that is expected by a guest
  - e.g. Hardware virtualization
- Enables cloud computing solutions to deliver virtual servers on demand, such as Amazon EC2, RightScale, VMware vCloud



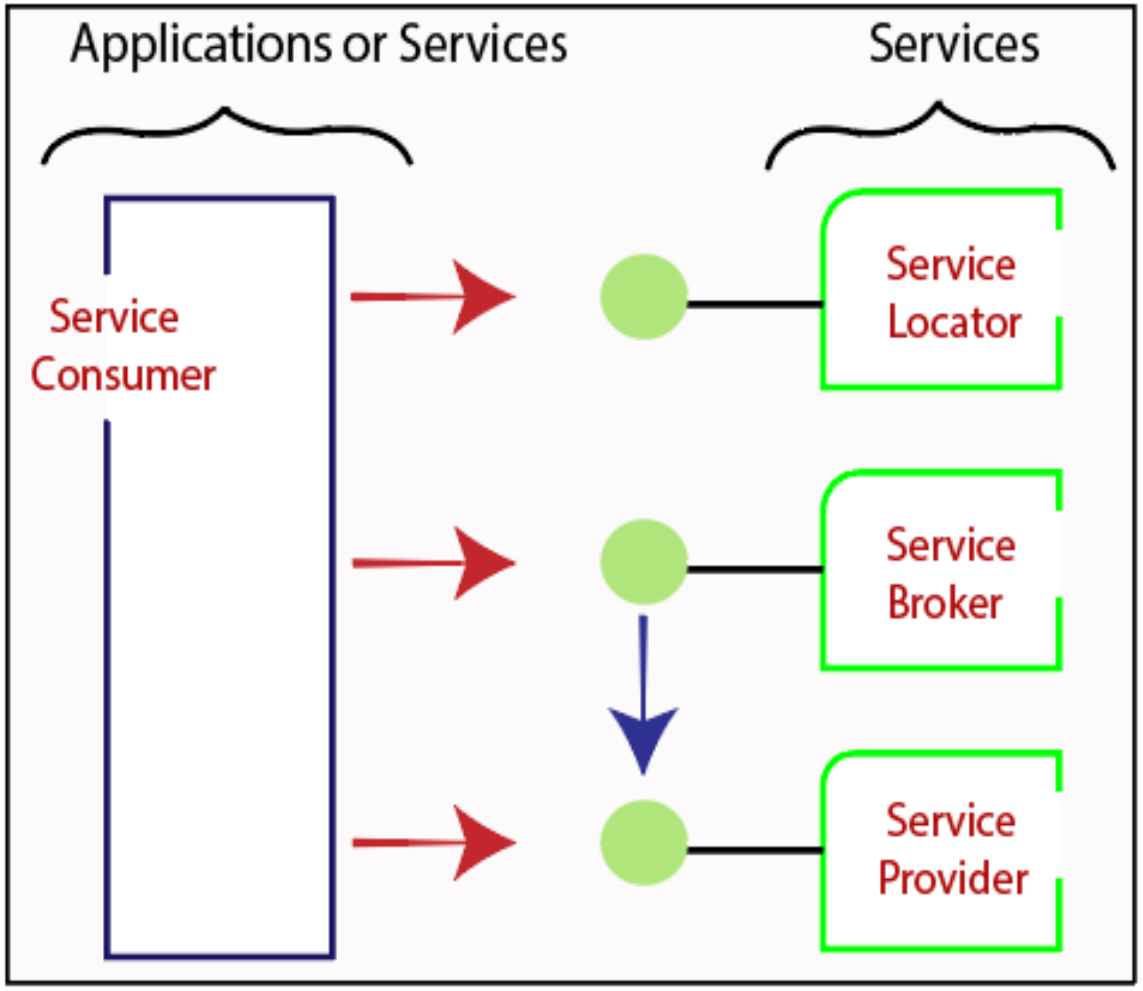
2. Virtualization (Contd.)

- Definition
- Collection of solutions allowing the abstraction of some of the fundamental elements for computing
  - Hardware, runtime environments, storage, and networking

3. Web 2.0

- Refers to websites that have user-generated content, ease of use, participatory culture and interoperability for end users
- A collection of standards and technologies such as XML, Asynchronous JavaScript and XML (AJAX), Web Services, and others
  - brings interactivity and flexibility into Web pages
  - providing enhanced user experience

4. Service-oriented computing



A service oriented architecture (SOA) consists of reusable components or services that can dynamically interoperate.

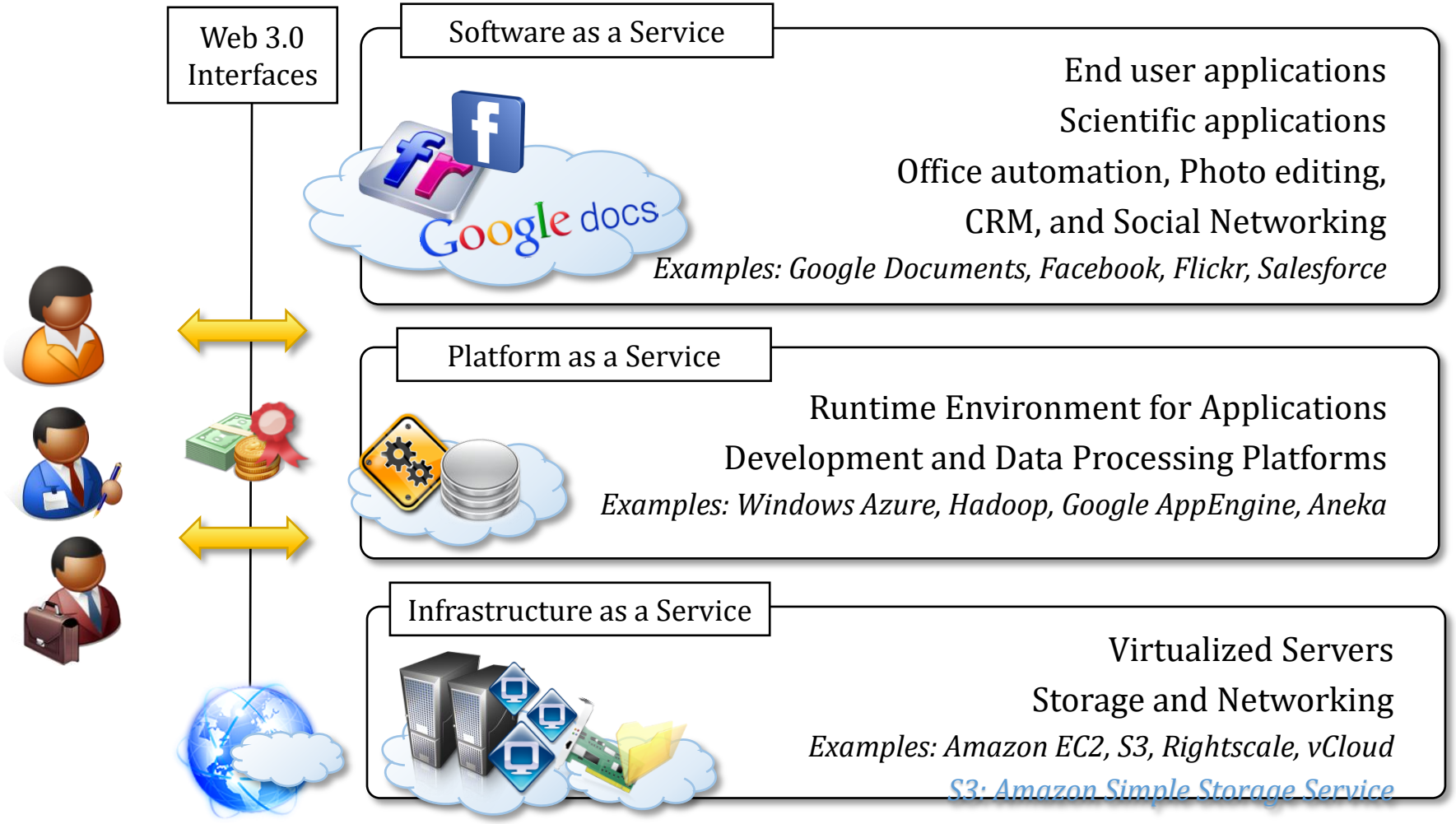
- Instead of building monolithic applications, business processes are implemented by combining services.

- Quickly adapt to changing requirements by re-combining services, without changing the code of the components.

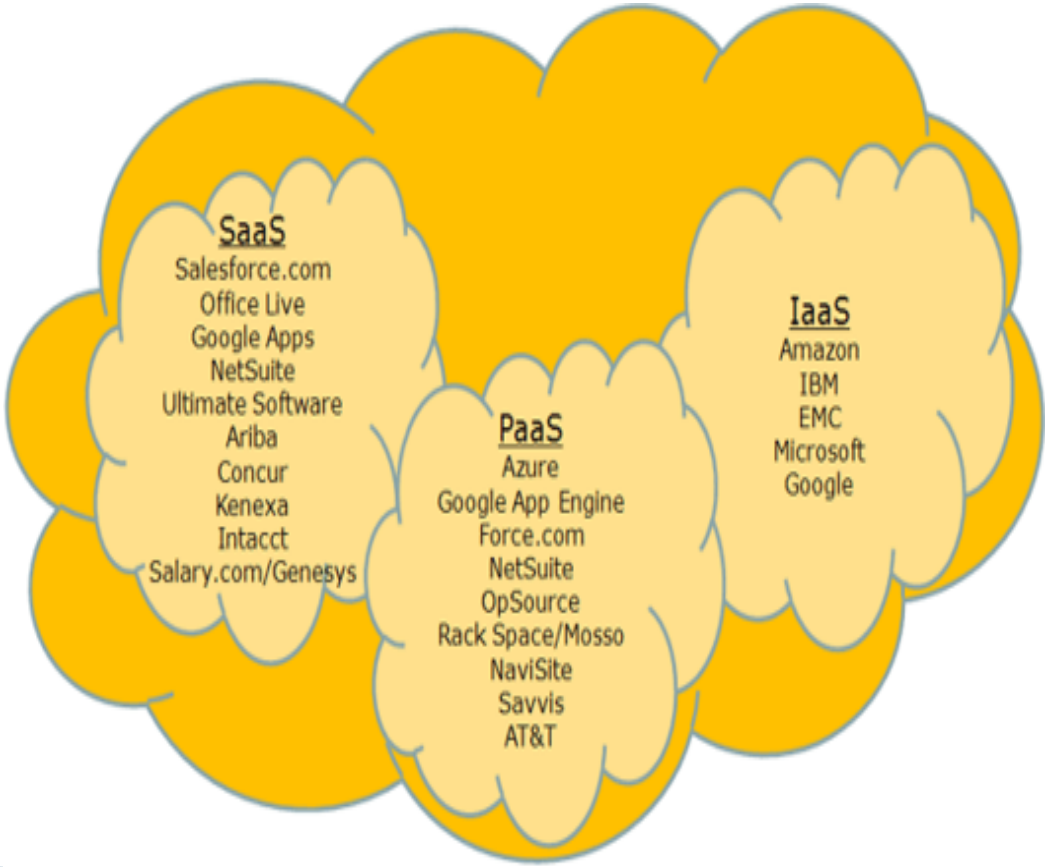
5. Utility-oriented computing

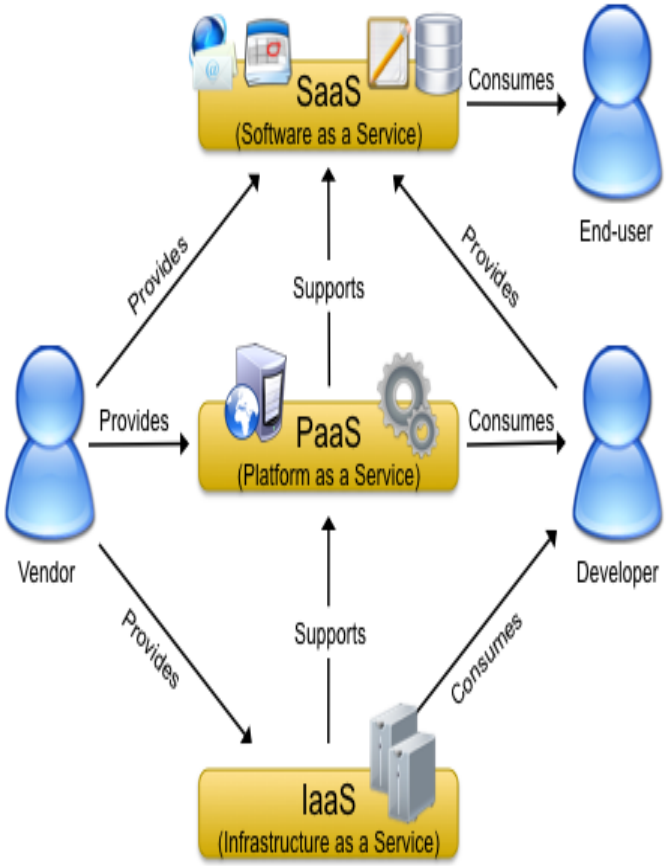
- is a service provisioning model
- providing computing as a utility like natural gas, water, power, and telephone connection
- **computing resources are provided to the customer based on specific demand**
- Examples of such IT services are **computing power, storage or applications.**

Cloud Computing SERVICE Reference Model

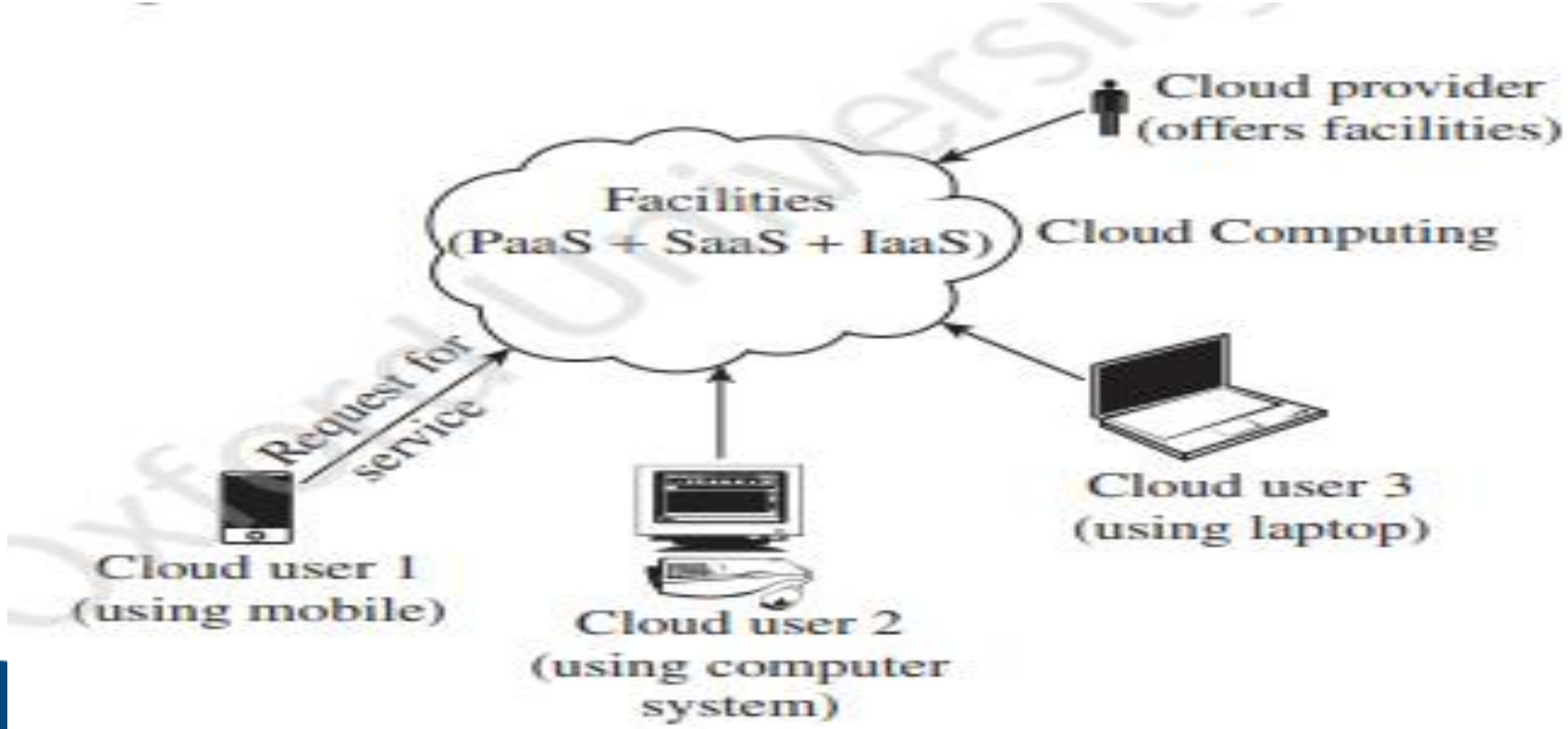


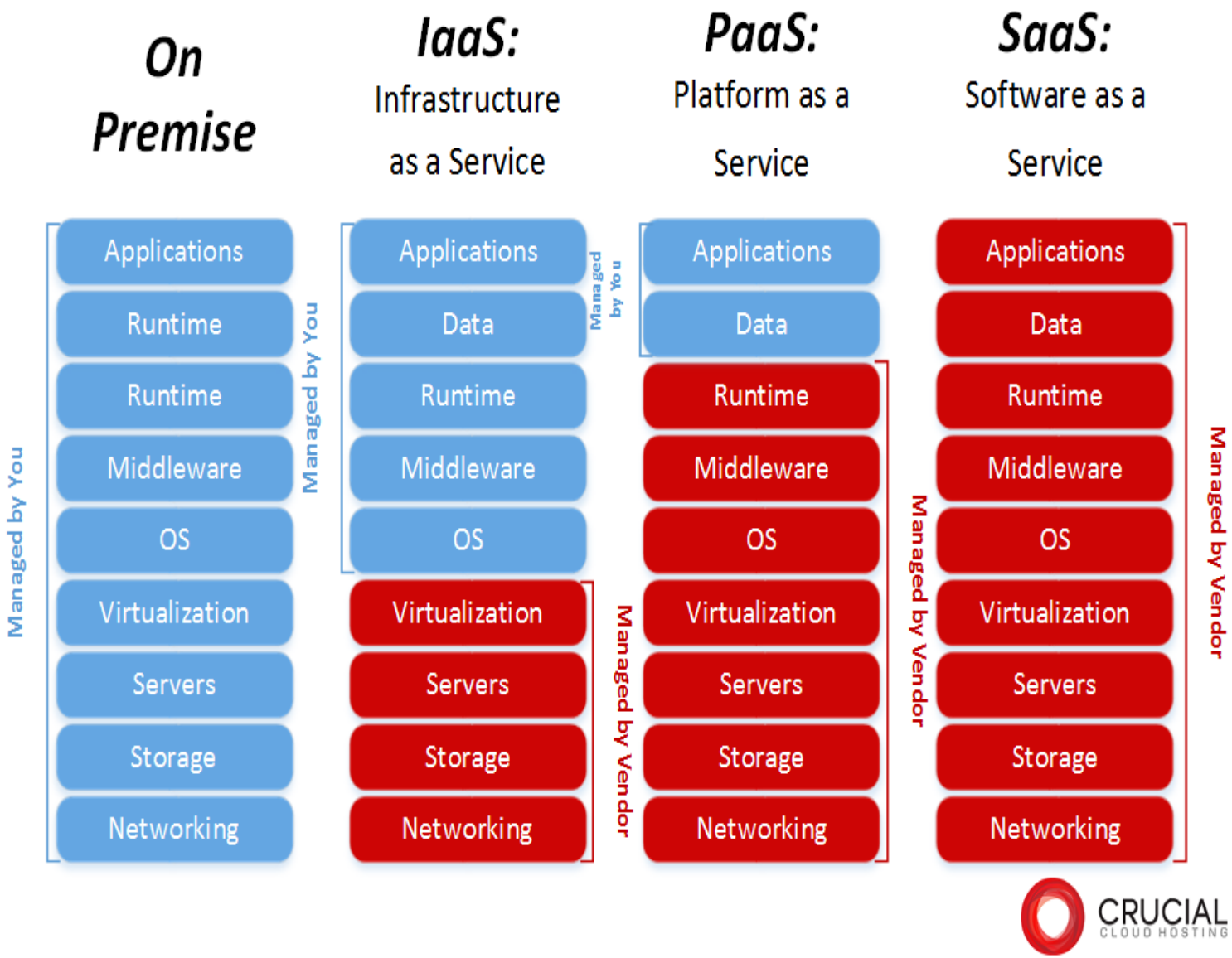
Vendors of SPI Model





Basic Structure of Cloud Computing





Concept of a “Service” in Cloud Computing

In the Cloud scenario, the provider Organization (Microsoft, Oracle, Amazon, Google) offers the following *commodities as services*:

1. Infrastructure (Hardware) -> Storage, Servers, Networking components
2. Platform to run applications -> Runtimes (JRE, CLR), Operating Systems (Windows, Linux), Databases (MySQL, Oracle)
3. Applications -> Gmail, Facebook, CRM, etc.

All these services are offered through Web APIs (Application Programming Interfaces)

Ex: Office 365 suite of applications, Google Drive suite of applications

Types of Services available in cloud computing

- IaaS --- Infrastructure as a Service --- server, memory, CPU processor, storage space, network components, disk space, hard disk
- PaaS---Platform as a Service --- Provides run time environment for developers – visual studio, IDE, WORD , OPERATING SYSTEM, VMWARE
- SaaS – Software as a Service- ALL TYPE OF APPLICATION – FACEBOOK, GMAIL. Google drive, google document,etc
- Stack of cloud computing --- arrangement of services
- SaaS
- PaaS
- IaaS

IaaS- Advantages and Disadvantages

- Advantages of IaaS:

  Cost Saving, On-demand scalability, Have the Flexibility You Need, Focus on business growth, It can also run when the server goes down.

- Disadvantages of IaaS:

  Security, Lack of flexibility, Technical problems, Over Dependency, Upgrade & Maintenance.

PaaS- Advantages

- Advantages of PaaS:

  Time Savings: No need to spend time setting up/maintaining the core stack.

  Speed to Market: Speed up the creation of apps.

  Increase Security: PaaS providers invest heavily in security technology and expertise.

PaaS- Disadvantages

- Disadvantages of PaaS:

Security: All the data of applications are stored inside the provider's cloud database.

Control: Users lack some control over a PaaS solution.

Reliability: PaaS solutions often face reliability concerns.

Compatibility: Not all the components are cloud-enabled.

SaaS- Advantages

- Advantages of SaaS:

Operational Management: No installation, equipment updates or traditional licensing management.

Cost-Effective: There are no upfront hardware costs and flexible payment methods such as pay-as-you-go models.

Scalability: Easily scale a solution to accommodate changing needs. Data Storage: Data is routinely saved in the cloud.

SaaS- Disadvantages

- Disadvantages of SaaS:

Loss of Control: The vendor manages everything, making you dependent upon the vendor's capabilities.

Limited Customization: Most SaaS applications offer little in the way of customization from the vendor.

Slower Speed: SaaS solutions can have more latency than client/server apps.

Cloud Deployment Models

1.Public clouds - most common model

- IT infrastructure is established by a third-party service provider that makes it available to any consumer on a subscription basis
- Advantage: allow users to quickly leverage compute, storage, and application services
- Users' data and applications are deployed on cloud datacenters on the vendor's premises

2. Private clouds - Large organizations that own massive computing

- Infrastructures can still benefit from cloud computing by replicating the cloud IT service delivery model in-house

Cloud Deployment Models – Contd.

3. Hybrid Clouds
   - Whenever private cloud resources are unable to meet users' quality-of-service requirements, hybrid computing systems, partially composed of public cloud resources and privately owned infrastructures, are created to serve the organization's needs

Major deployment models for cloud computing

Public/Internet Clouds

*Third-party, multitenant cloud infrastructure and services

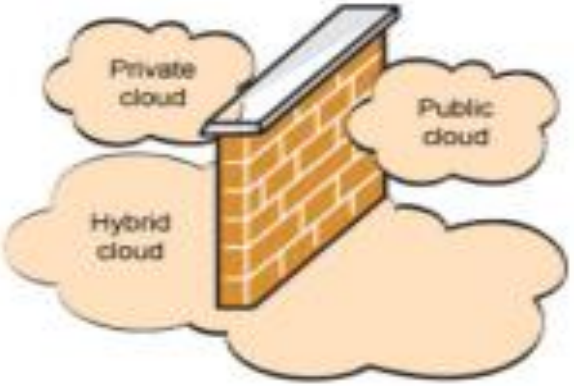
*Available on a subscription basis to all

Private/Enterprise Clouds

*A public cloud model within a company's own datacenter/infrastructure for internal and/or partners' use

Hybrid/Inter Clouds

* Mixed use of private and public clouds; leasing public cloud services when private cloud capacity is insufficient



Characteristics and benefits

- No up-front commitments
- On-demand access
- Nice pricing
- Simplified application acceleration and scalability
- Efficient resource allocation
- Energy efficiency
- Seamless creation and use of third-party services

Cloud computing - challenges

- Technical
- Security
- Legal

Building Cloud Environments

Overview

Application development

Infrastructure and system development

Computing platforms and technologies

Application development

What sort of applications benefit from cloud?

- Dynamically scale on demand

- Classes of applications
  1. Web applications
     - Performance depends on workload generated by varying user demand
     - Rich, complex and interactive

What sort of applications benefit from cloud?

2. Resource-intensive applications
    - Data-intensive or compute-intensive applications
    - Resources are required to complete execution in a reasonable timeframe
    - But not required for a long duration
    - Not interactive, only batch processing
        - e.g. scientific applications

On-demand and dynamic scaling solution

- **How?**

(a) providing methods for renting compute power, storage, and networking

(b) offering runtime environments designed for scalability and dynamic sizing

(c) providing application services that mimic the behavior of desktop applications but that are completely hosted and managed on the provider side

- **Service orientation**
  - allows a simple and seamless integration into existing systems
- Developers access such services via simple Web interfaces

Infrastructure and system Development

Core technologies enabling the provisioning of cloud services

DISTRIBUTED COMPUTING

VIRTUALIZATION

SERVICE ORIENTATION

WEB 2.0

Distributed Systems

- Extreme dynamism of cloud systems
- New nodes and services are provisioned on demand
- Infrastructure-as-a-Service solutions
- Provide the capabilities to add and remove resources
- Platform-as-a-Service solutions
  - embed into their core offering algorithms and rules that control the provisioning process and the lease of resources
- Integration between cloud resources and existing system deployment ???

Web 2.0

- Constitute the interface through which cloud computing services are delivered, managed, and provisioned
- Service orientation is the underlying paradigm
- Cloud - XaaS—Everything-as-a-Service

Virtualization

- Core feature of the infrastructure used by cloud providers

- Virtualization concept is > 40 years old
  - but cloud computing introduces new challenges, especially in the management of virtual environments

Computing platforms and technologies

How to develop cloud applications?

- Leverage
  - Platforms
  - Technologies
  - Frameworks

Amazon web services (AWS)
Google AppEngine
Microsoft Azure
Hadoop
Force.com and Salesforce.com
Manjrasoft Aneka

Amazon web services (AWS)

- **IaaS**
- Platform that offers flexible, reliable, scalable, easy-to-use and, cost-effective cloud computing solutions
- compute and storage-on-demand services
  - Elastic Compute Cloud (EC2) and Simple Storage Service (S3)

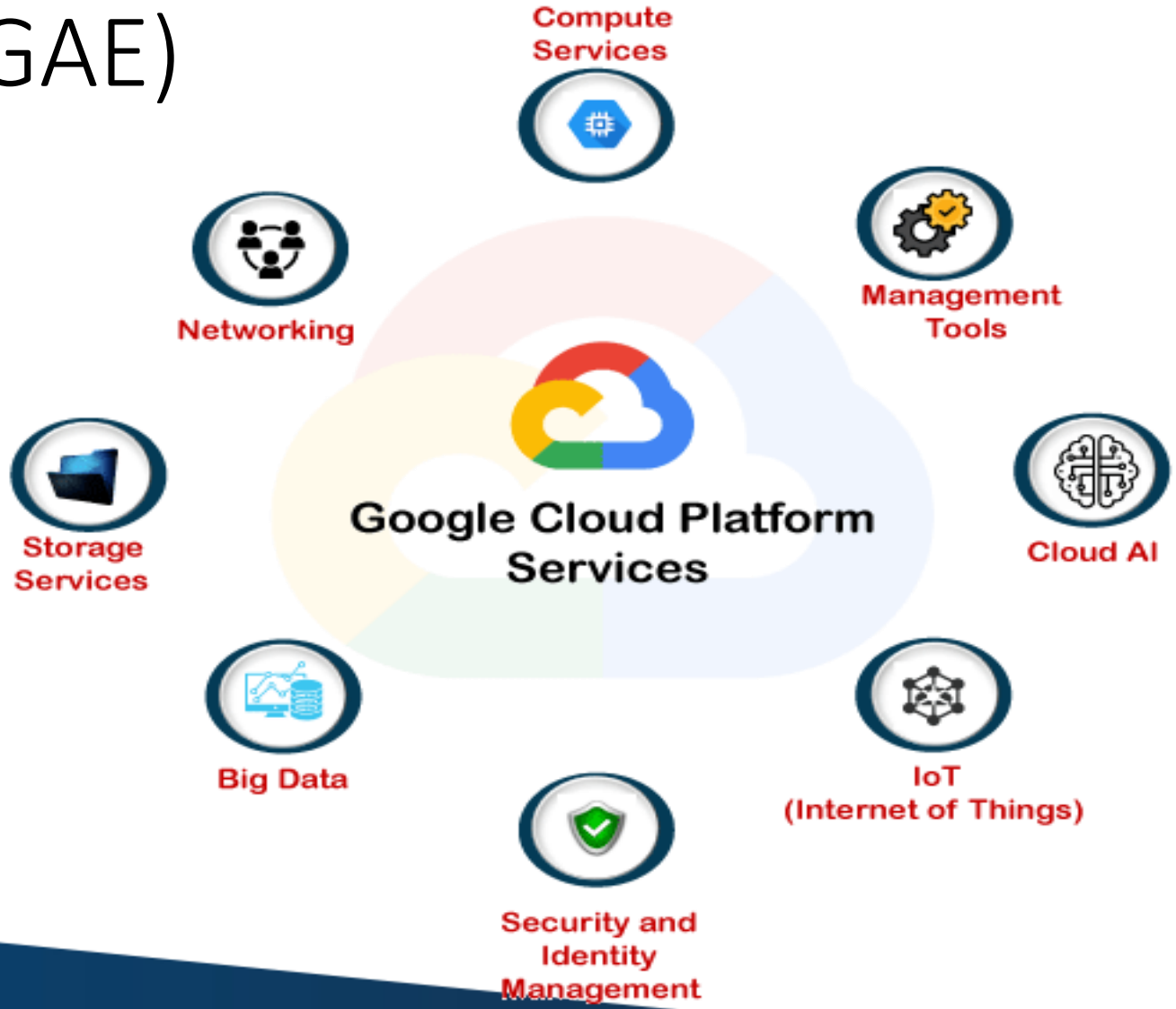
Amazon web services (AWS)

- **Elastic Compute Cloud (EC2)**
- Customizable virtual hardware
- EC2 instances are deployed either by using
  - AWS console, which is a comprehensive Web portal for accessing AWS services
  - Web services API available for several programming languages

- **Simple Storage Service (S3)**
- Delivers persistent storage on demand
- S3 is organized into buckets; these are containers of objects that are stored in binary form and can be enriched with attributes
- Users can store objects of any size, from simple files to entire disk images, and have them accessible from everywhere

Google App Engine (GAE)

- **PaaS**
- Build highly scalable applications on a fully managed serverless platform
- Large computing infrastructure of Google to dynamically scale

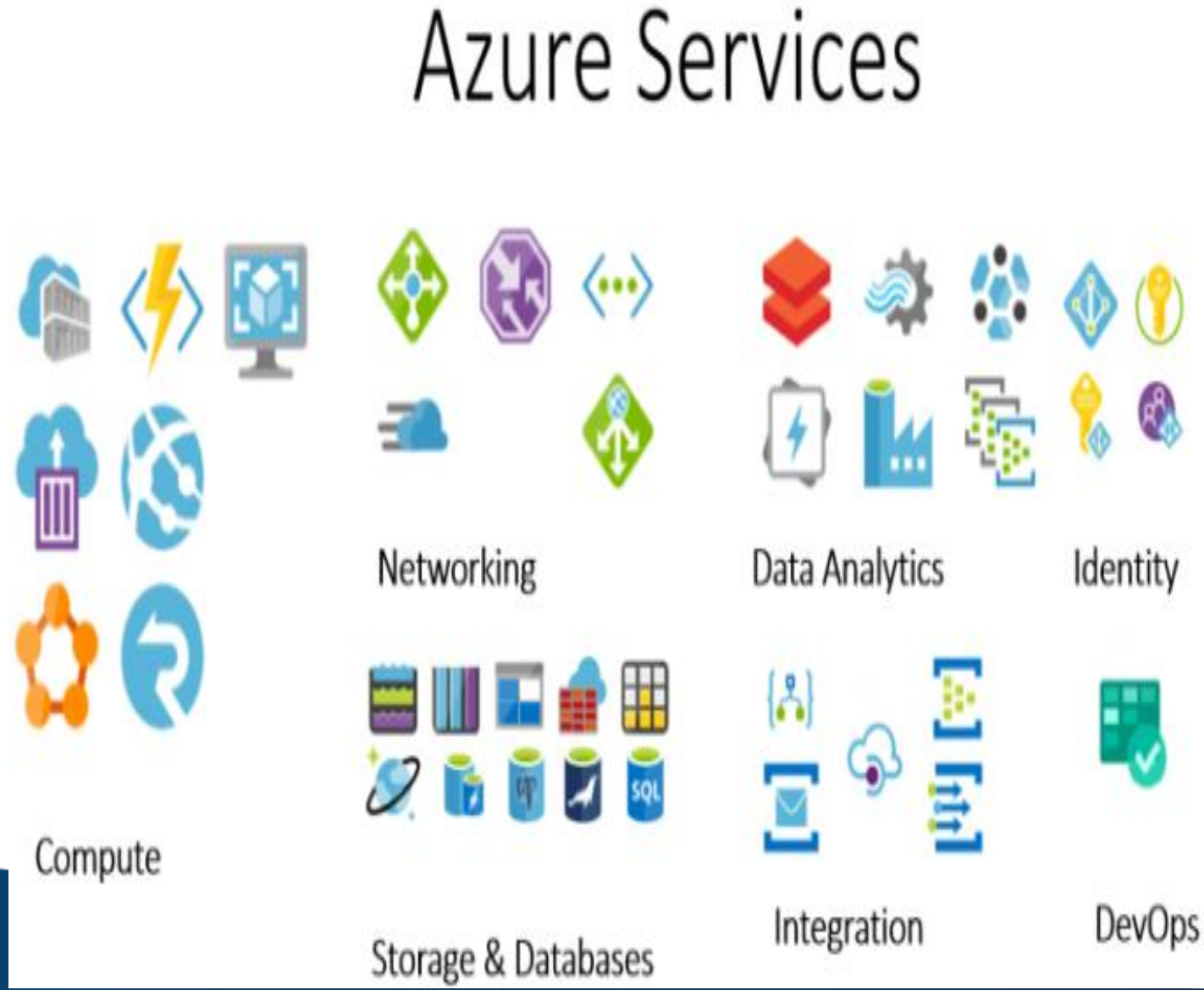


Google AppEngine

- Services include in-memory caching, scalable data store, job queues, messaging, and cron tasks
- GAE requires that applications be written in Java or Python, store data in Google Bigtable and use the Google query language.
- **IaaS similar to EC2**
- Google provides GAE free up to a certain amount of use for the following resources:
  - processor storage
  - API calls
  - concurrent requests

Microsoft Azure

- Provides a scalable runtime environment for Web applications and distributed applications



Microsoft Azure

- Applications in Azure are organized around the concept of roles, which identify a distribution unit for applications and embody the application's logic
- **Three types of role:** Web role, worker role, and virtual machine role

- **Web role** is designed to host a Web application
- **Worker role** is a more generic container of applications and can be used to perform workload processing
- **Virtual machine role** provides a virtual environment in which the computing stack can be fully customized, including the operating systems

Hadoop

- Apache Hadoop is an open-source framework
  - that is suited for processing large data sets on commodity hardware
  - Hadoop is an integral part of the Yahoo! cloud infrastructure
  - Hadoop is an implementation of Map Reduce, an application programming model developed by Google
    - which provides two fundamental operations for data processing: map and reduce

- **Map** - transforms and synthesizes the input data provided by the user
- **Reduce** - aggregates the output obtained by the map operations
- Hadoop provides the runtime environment
- Developers need only provide the input data and specify the map and reduce functions that need to be executed

Force.com and Salesforce.com

- **Force.com** is a cloud computing platform for developing social enterprise applications
  - complete set of components supporting all the activities of an enterprise
  - provides complete support for developing applications - design of the data layout to the definition of business rules and workflows and the definition of the user interface

- The platform is the basis for **SalesForce.com, a Software-as-a-Service** solution for customer relationship management

Manjrasoft Aneka

- Cloud application platform for rapid creation of scalable applications
- Supports a collection of programming abstractions for developing applications and a distributed runtime environment that can be deployed on heterogeneous hardware (clusters, networked desktop computers, and cloud resources)
- Applications are executed on the distributed service-oriented runtime environment, which can dynamically integrate additional resource on demand
- Services manage most of the activities happening at runtime: scheduling, execution, accounting, billing, storage, and quality of service

Review Questions

1. Which are the technologies on which cloud computing relies?
2. Define cloud computing and identify its core features.
3. Briefly summarize the Cloud Computing Reference Model.
4. How is cloud development different from traditional software development?