

# Module I

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## Introduction to Cloud Computing

# Cloud Computing at a Glance

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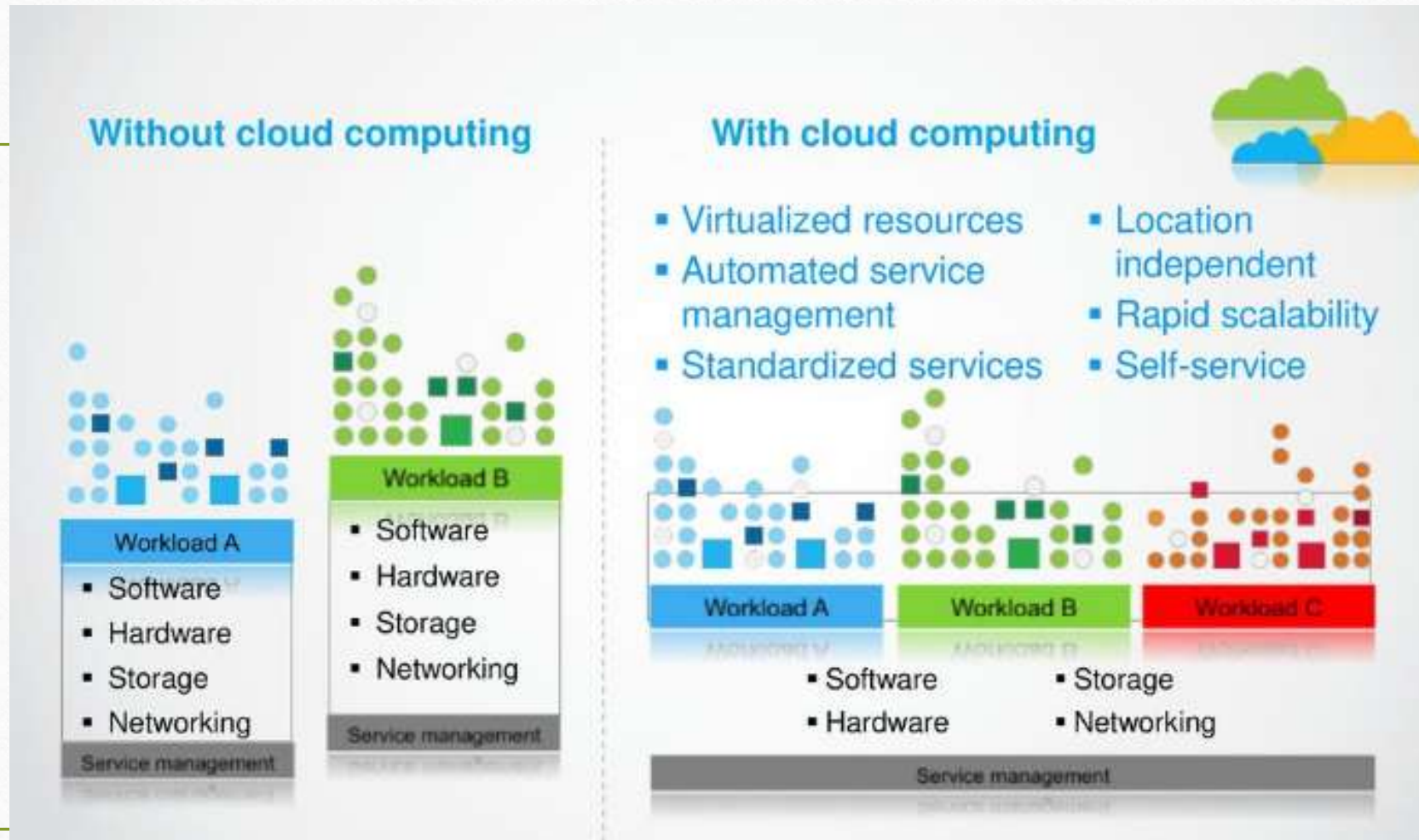
- Cloud computing focuses on the way in which we design computing systems, develop applications, and leverage existing services for building software.
- Computing is being transformed to a model consisting of services that are **commoditized and delivered** in a manner similar to utilities such as water, electricity, gas, and telephony.
- Based on the concept of **dynamic provisioning**.
- Users can **access computing services** based on their requirements regardless of **where they are hosted**.

# Cloud Computing at a Glance

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- Cloud computing is a new 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.
- It allows renting infrastructure, runtime environments, and services on pay-per-use basis.
- Cloud computing turns IT services into **utilities**.
- It has transformed the internet into a rich application and service delivery platform serving different complex needs.

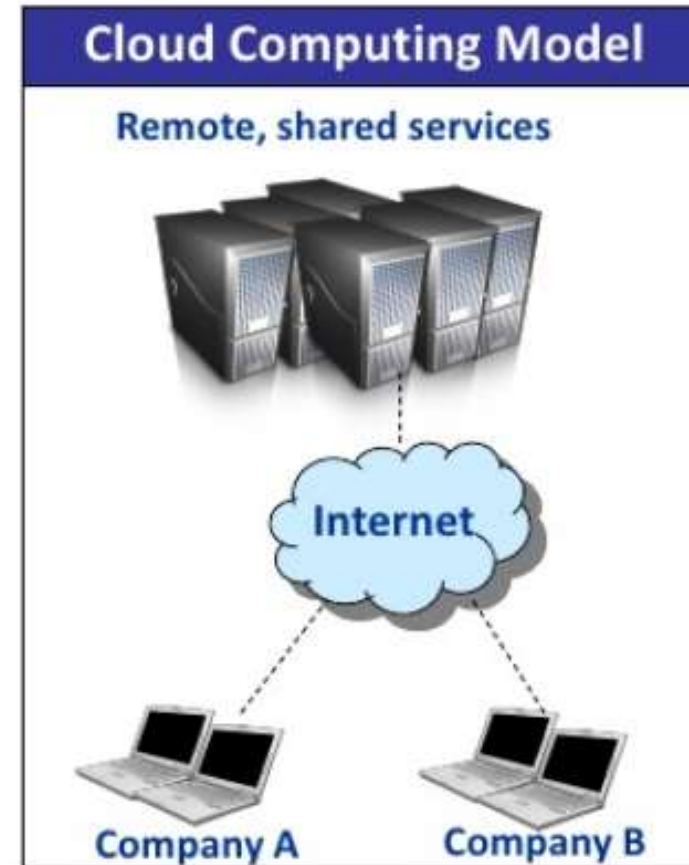
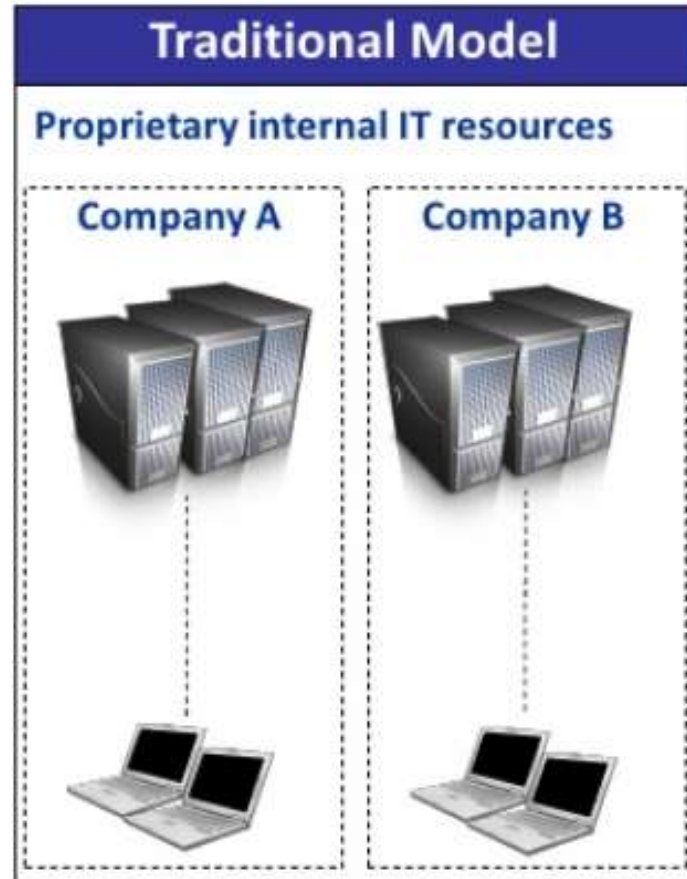
# Classical Computing vs. Cloud Computing







# Classical Computing vs. Cloud Computing



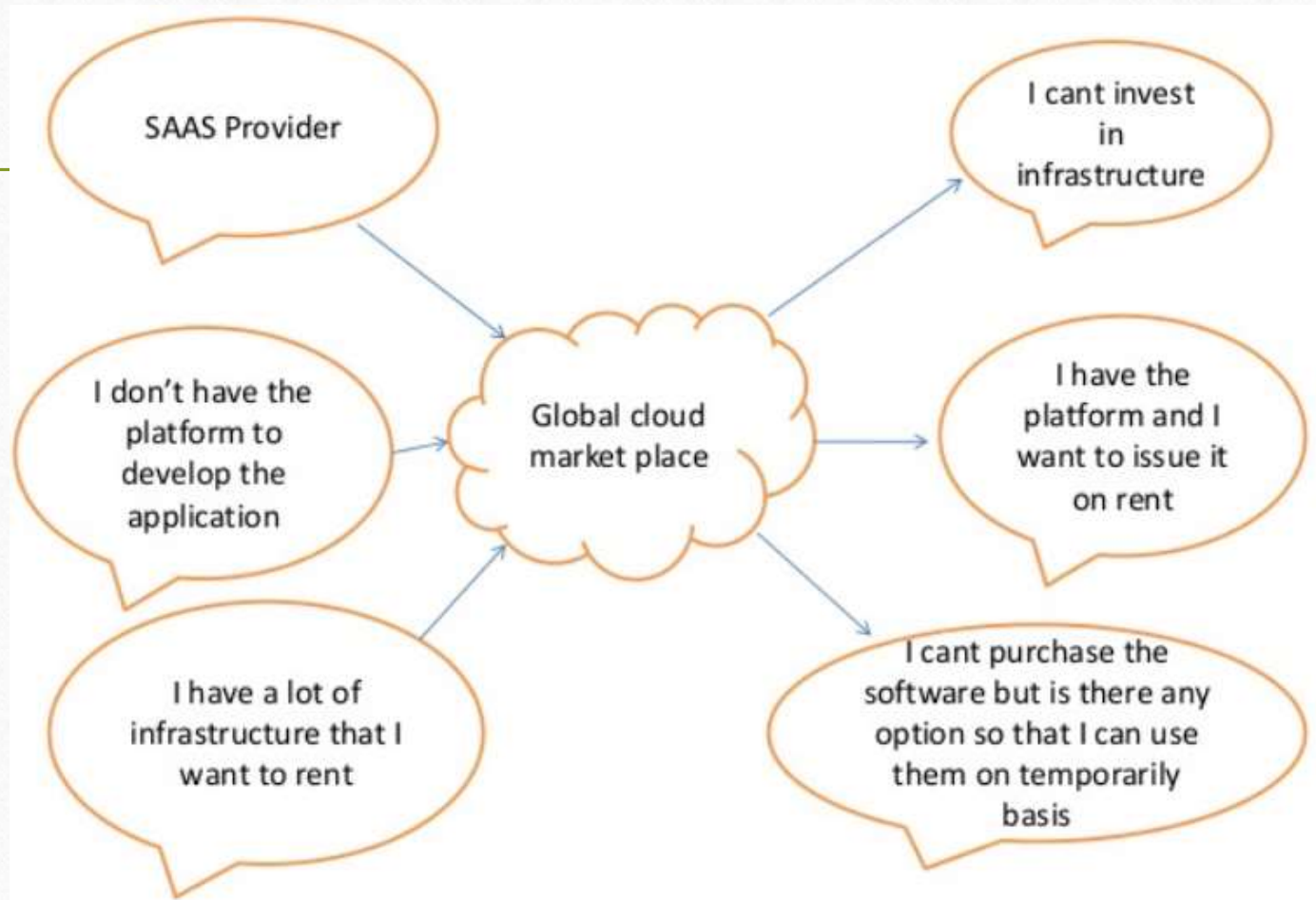
# Classical Computing vs. Cloud Computing

	<b>Traditional IT</b>	<b>Cloud Computing</b>
<b>Delivery Model</b>	Buy assets & build delivery architecture	Buy external service
<b>Interface Model</b>	Internal network or intranet	Via Internet using standard Internet Protocols (IP, HTTP, HTML, etc.)
<b>Business Model</b>	Pay for fixed assets and administrative overhead	Pay directly based on usage or indirectly (e.g., subsidized by advertizing)
<b>Technology Model</b>	Single Tenant	Scalable, Elastic, Dynamic, & Multi-tenant

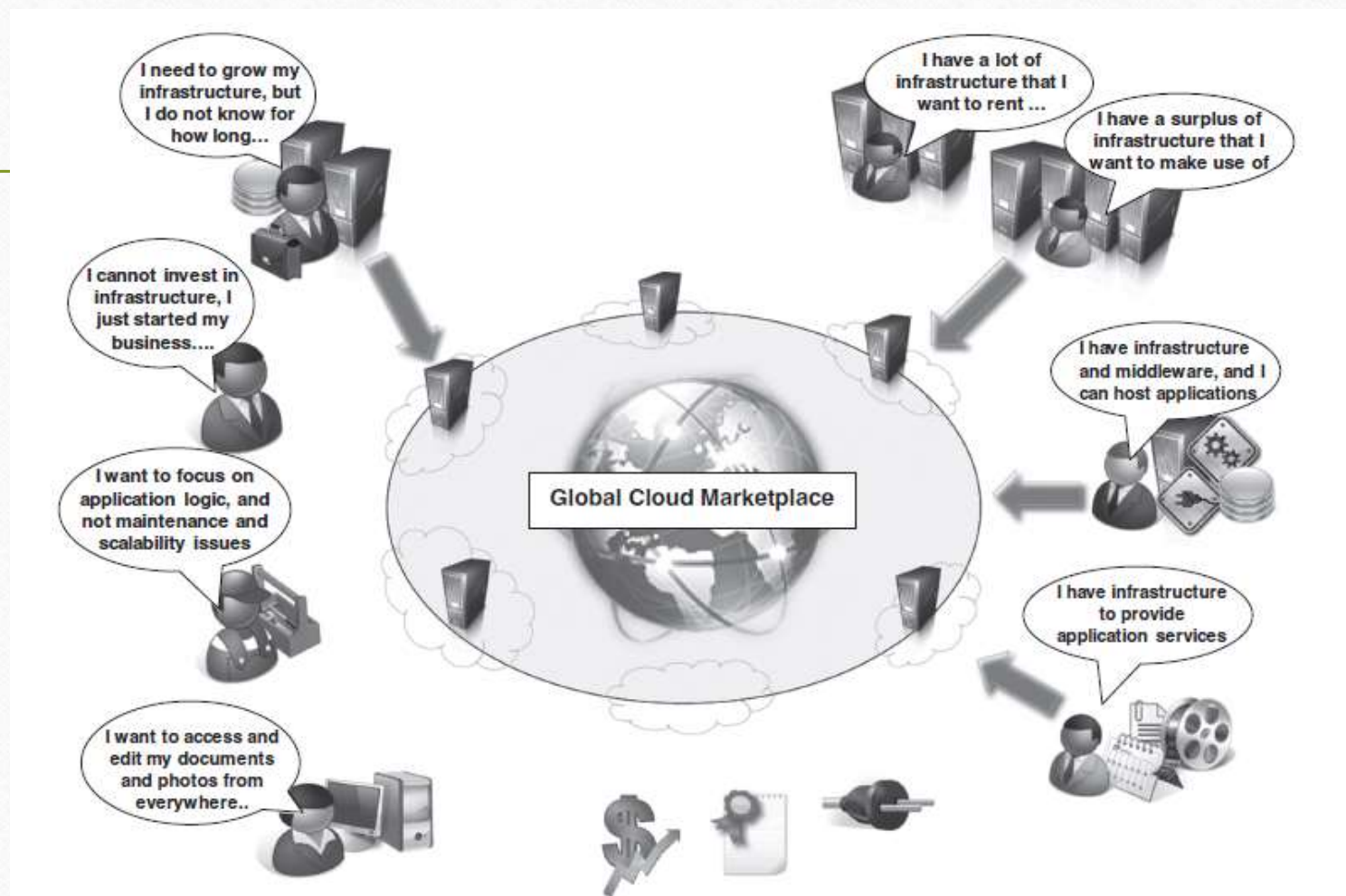
# Classical Computing vs. Cloud Computing

Classical Computing	Cloud Computing
Manually Provisioned	Self Provisioned
Dedicated Hardware	Shared Hardware
Fixed Capacity	Elastic Capacity
Pay-for-Capacity	Pay-for-Use
Capital & Operational Expenses	Operational Expenses
Managed by System Administrator	Managed by API

# Vision of Cloud Computing



# Vision of Cloud Computing



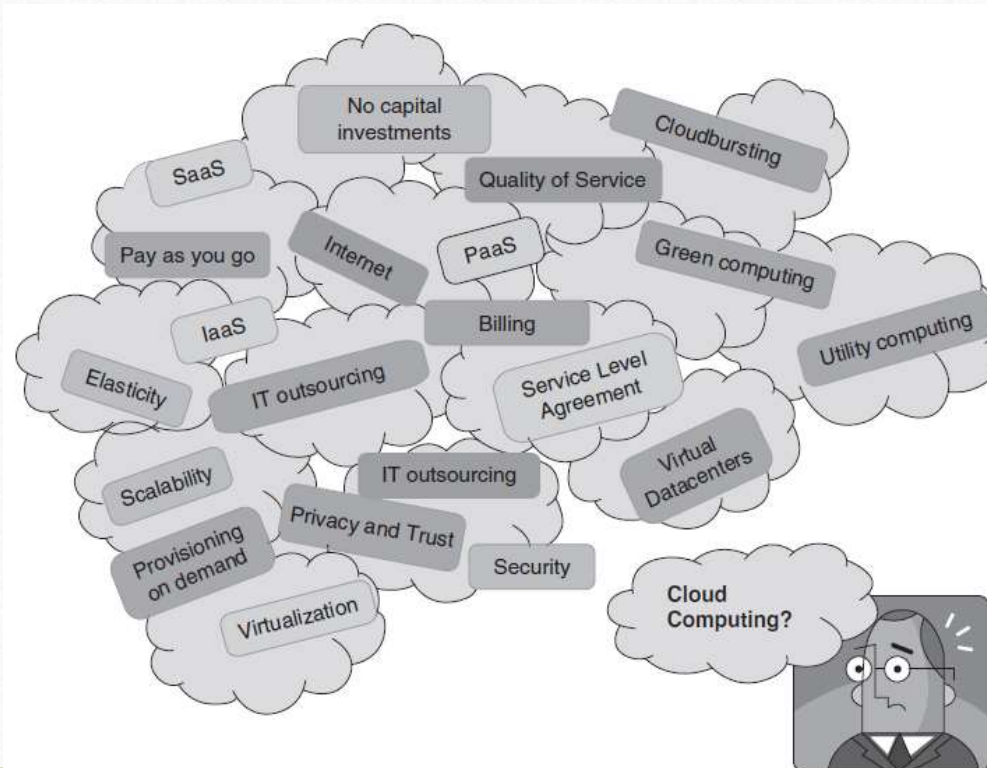
# Vision of Cloud Computing

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- Cloud computing provides the facility to provision virtual hardware, runtime environment and services to a person having money.
- Services can be used as long as needed and no upfront commitments are required.
- The entire stack of a computing system is transformed into a collection of utilities, which can be provisioned and composed together to deploy systems in hours, rather than days, and with virtually no maintenance costs.
- The long term vision of Cloud computing is that IT services are traded as utilities in an open market without technological and legal barriers.

# Defining a Cloud

- Cloud computing has become a **popular buzzword** and it has been widely used to refer to different technologies, services, and concepts.



# Defining a Cloud

*“Cloud computing refers to both the applications delivered as services over the Internet, and the hardware and system software in the datacenters that provide those services.”*

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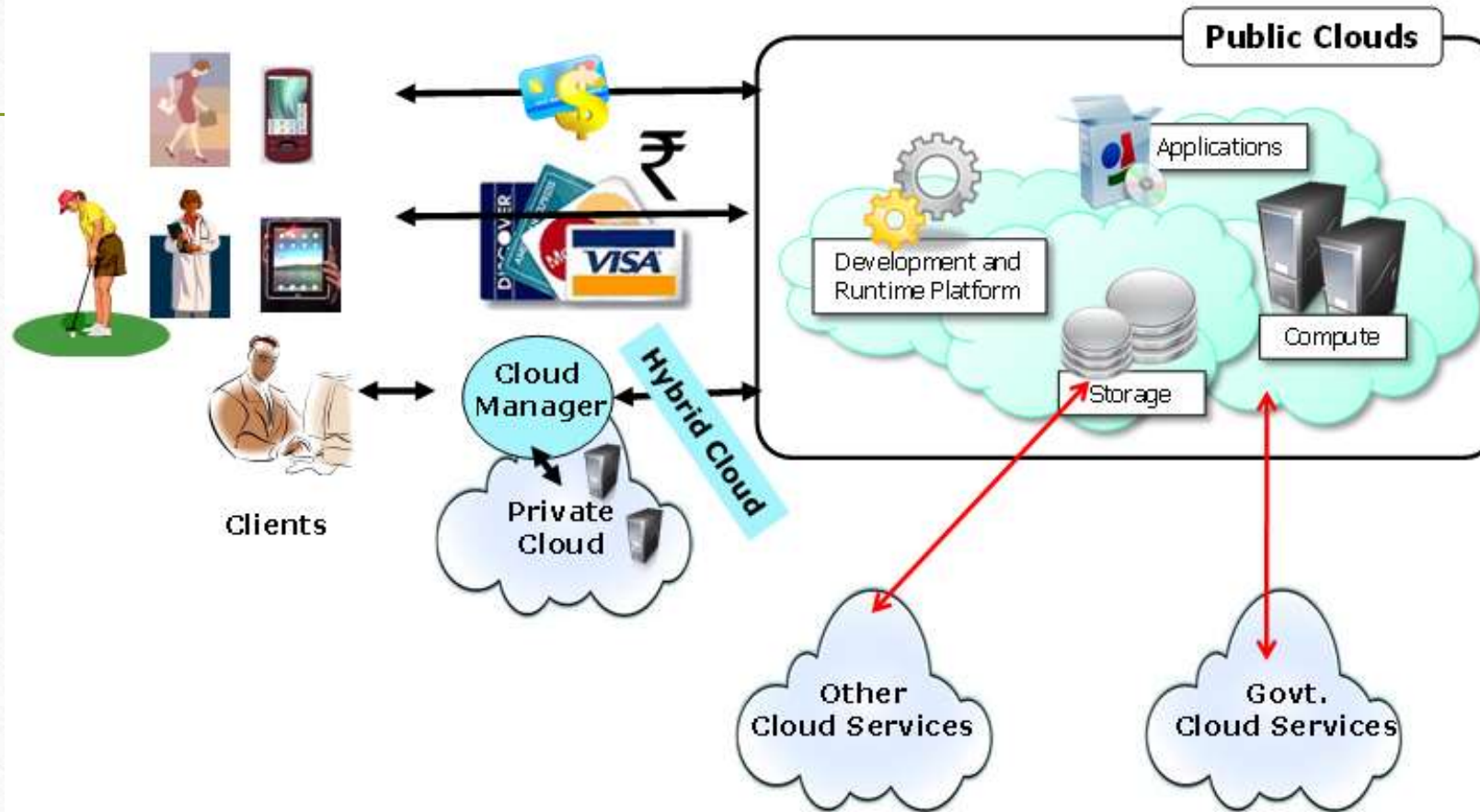
*“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”*

*“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.”*

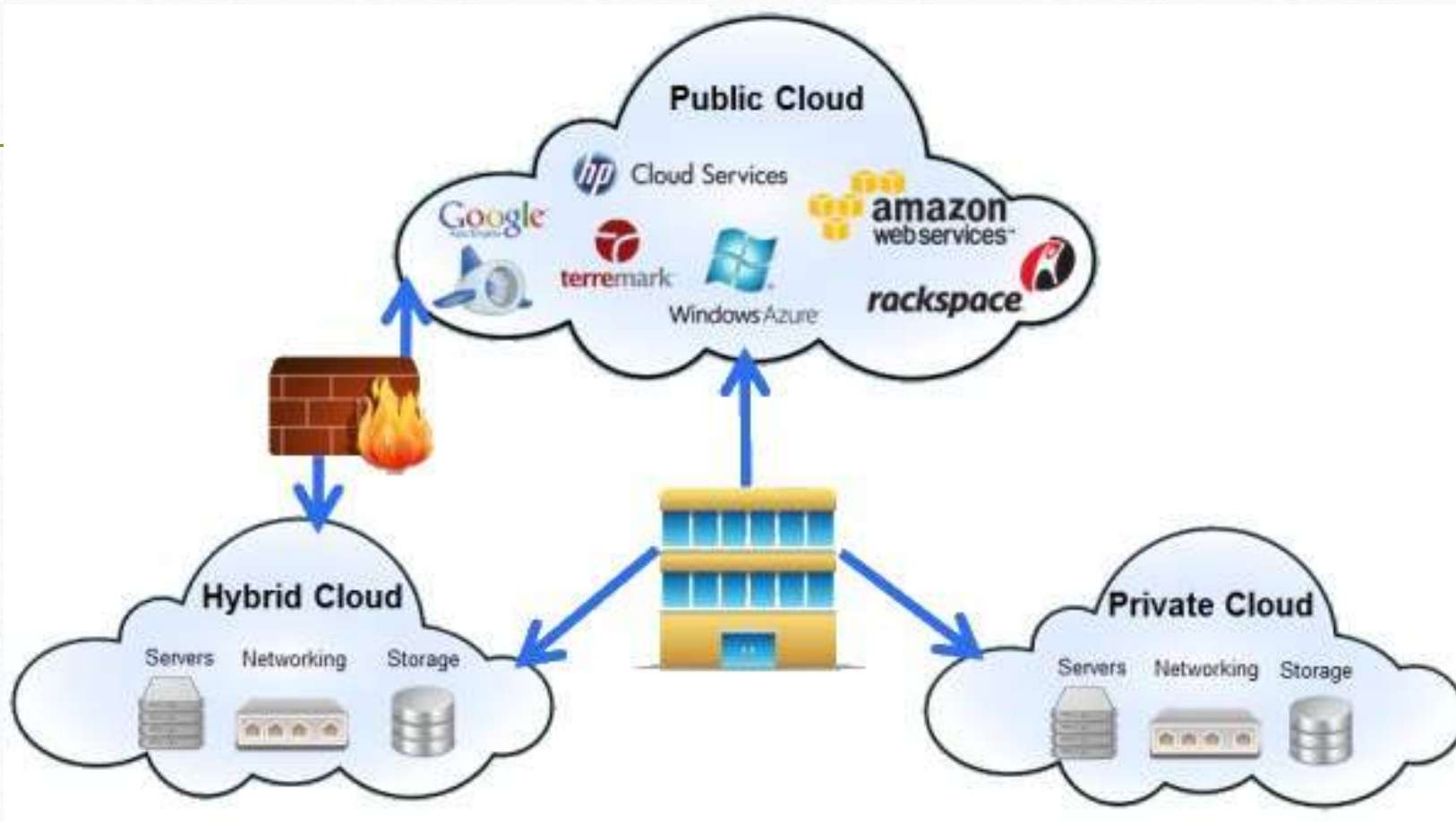
# Cloud Computing : A Closer Look

- Cloud computing is helping enterprises, governments, public and private institutions, as well as research organizations shape more effective and demand-driven computing systems.
- 
- Practical examples of such systems exist across all market segments i.e. :
    - Large enterprises can offload some of their activities to cloud based systems.
    - Small enterprises and start-ups can afford to translate into business results their ideas more quickly without excessive upfront 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 from any device.

# Cloud Computing : A Bird's Eye View



# Cloud Computing Deployment Models



# Cloud Computing Deployment Models



## Public Cloud

- Services are owned and operated by a third party provider.
- The maintenance cost is borne by the service provider.
- Pay-as-you-go model. Thus, the setting and operating cost is less.
- Shared Responsibilities for Security- Provider and Consumer.
- All resources are hosted on cloud providers infra.



## Hybrid Cloud

- Combines both public cloud and on-premises infra/apps .
- Greater flexibility & more deployment options.
- Cloud bursting is also possible.
- Network complexities & compliance issues.
- Can be extremely expensive and difficult to implement.



## Private Cloud

- Cloud Infra used by only one organisation - can be on-premises or off-premises
- Higher security as the resources are not shared.
- Greater flexibility to control the cloud environment.
- Opportunity to control the entire cloud infra stack.
- Implementation is more complex than using a public cloud.

# Cloud Computing Deployment Models



Operated solely  
for a single  
organization

Maybe on  
premise or off  
premise



Shared by several  
entities that have  
a common  
purpose.

Maybe on  
premise or off  
premise

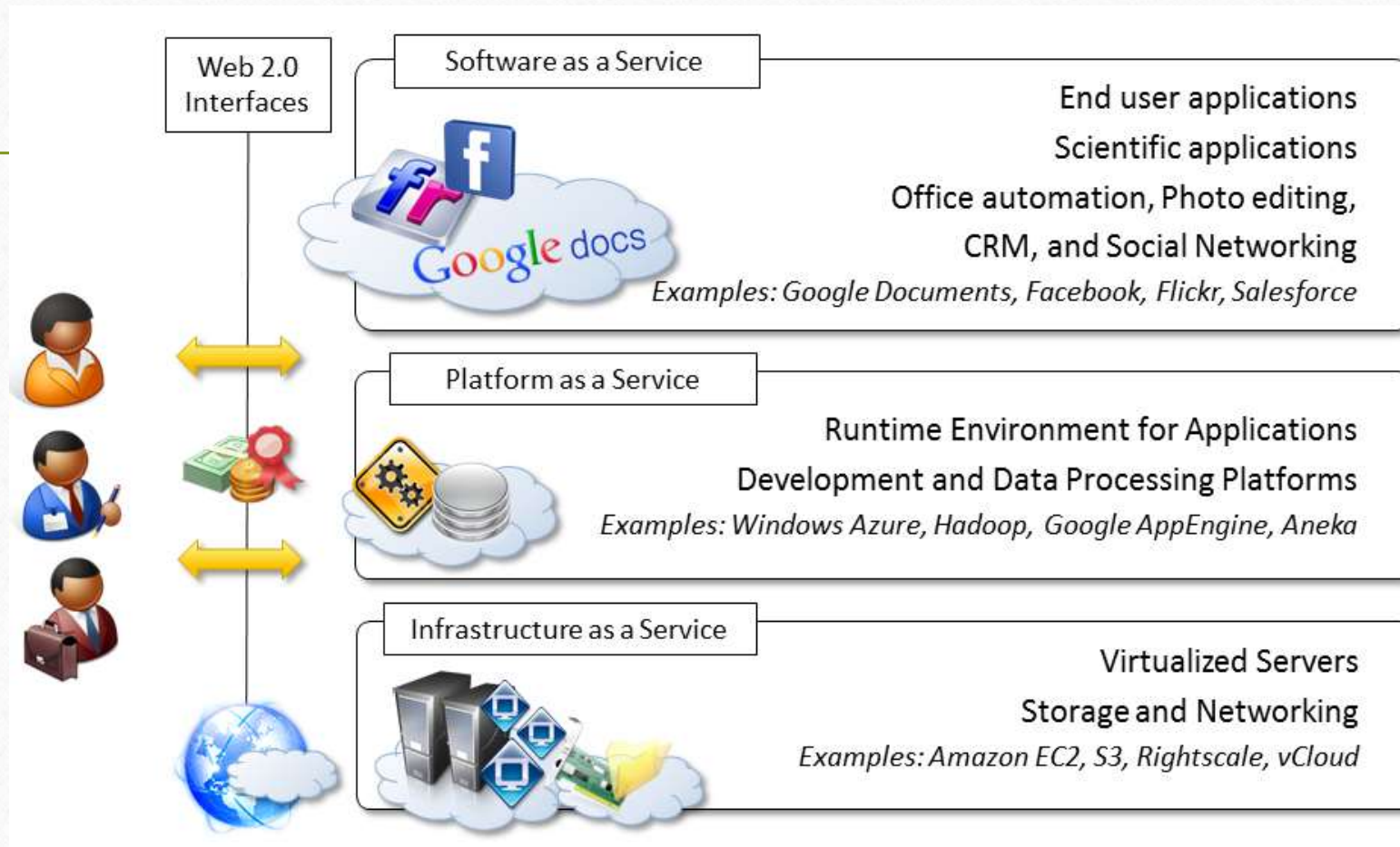


Available to the  
general public  
and owned by a  
single  
organization  
selling cloud  
services.



Any combination  
of two or more  
private /  
community or  
public clouds.

# Cloud Computing Reference Models



# Cloud Computing Reference Models

- Cloud computing has the capability to deliver a variety of diverse IT services.
  - The diverse set of cloud computing services offerings can be categorized as
- 

- Software-as-a-Service (SaaS)
- Platform-as-a-Service (PaaS)
- Infrastructure-as-a-Service (IaaS)



- The cloud computing reference model is an abstract model that characterizes and standardizes the functions of a cloud computing environment by partitioning it into abstraction layers and cross-layer functions.

# Cloud Computing Reference Models

## Infrastructure-as-a-Service (IaaS)

- IaaS is an instant computing infrastructure (**virtual hardware, storage, and networking**), provisioned and managed over the internet.
- Virtual hardware is utilized to provide **compute on demand** in the form of virtual machines instances.
- Instances are created on users request on the cloud provider's infrastructure, and users are given tools and interfaces to configure the software stack installed in the virtual machine.

# Cloud Computing Reference Models

## Infrastructure-as-a-Service (IaaS)

- Virtual storage is delivered in the form of raw disk space or object store.
- 
- Virtual networking identifies the collection of services that manage the networking among virtual instances and their connectivity towards the Internet or private networks.



# Cloud Computing Reference Models

## Platform-as-a-Service (PaaS)

- PaaS is a complete **development and deployment** environment in the cloud, with resources that enable you to deliver everything from simple cloud-based apps to sophisticated, cloud-enabled enterprise applications.
- PaaS includes infrastructure (servers, storage, and networking) and platform (middleware, development tools, database management systems, business intelligence, and more) to support the web application life cycle.

# Cloud Computing Reference Models

## Software-as-a-Service (SaaS)

- SaaS is a software distribution model in which a third-party provider hosts applications and makes them available to customers over the internet.
- It is closely related to the application service provider (ASP) and on demand computing software delivery models.



# Cloud Computing Reference Models

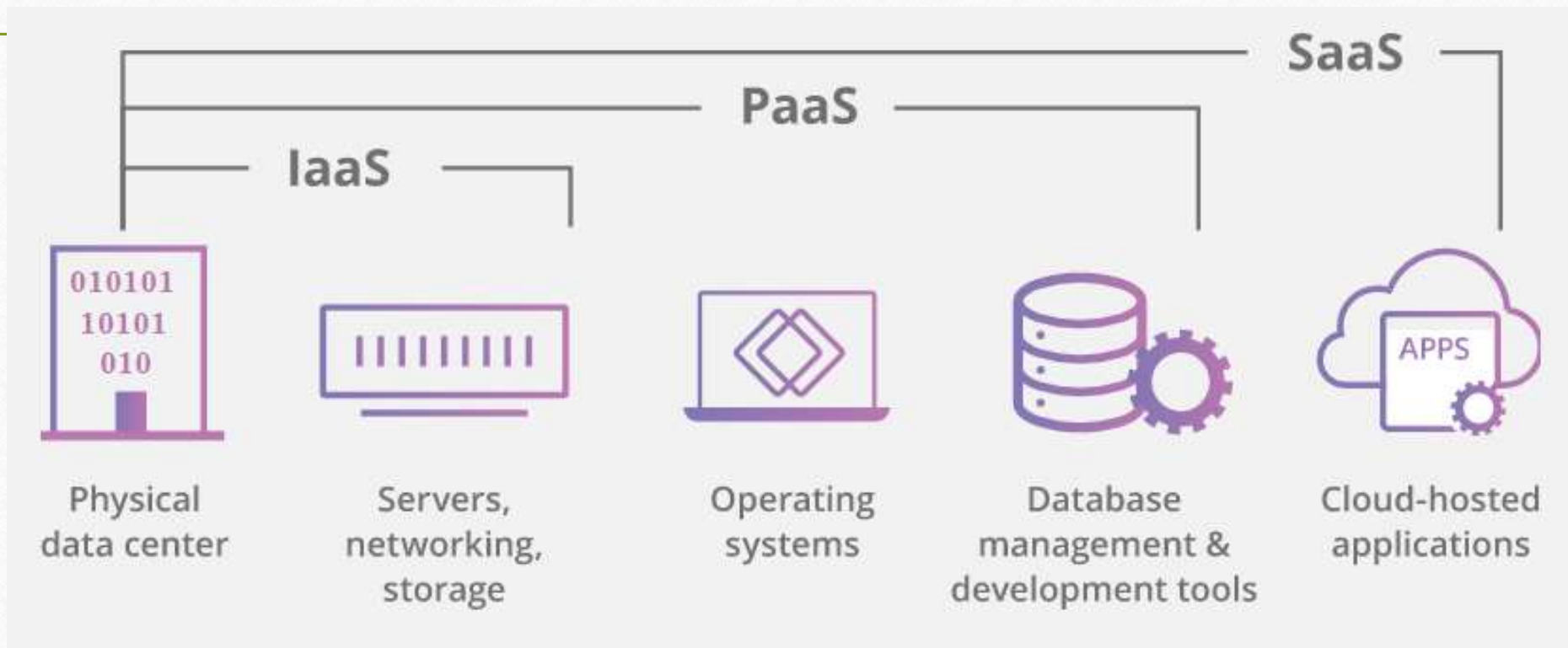
## Platform-as-a-Service (PaaS)

- PaaS providers provide the Programming languages, Application frameworks, Databases, and Other tools as services.
- **Example:** Google App Engine, Force.com, Joyent, Azure.



# Cloud Computing Reference Models

## Difference between IaaS, PaaS, and SaaS



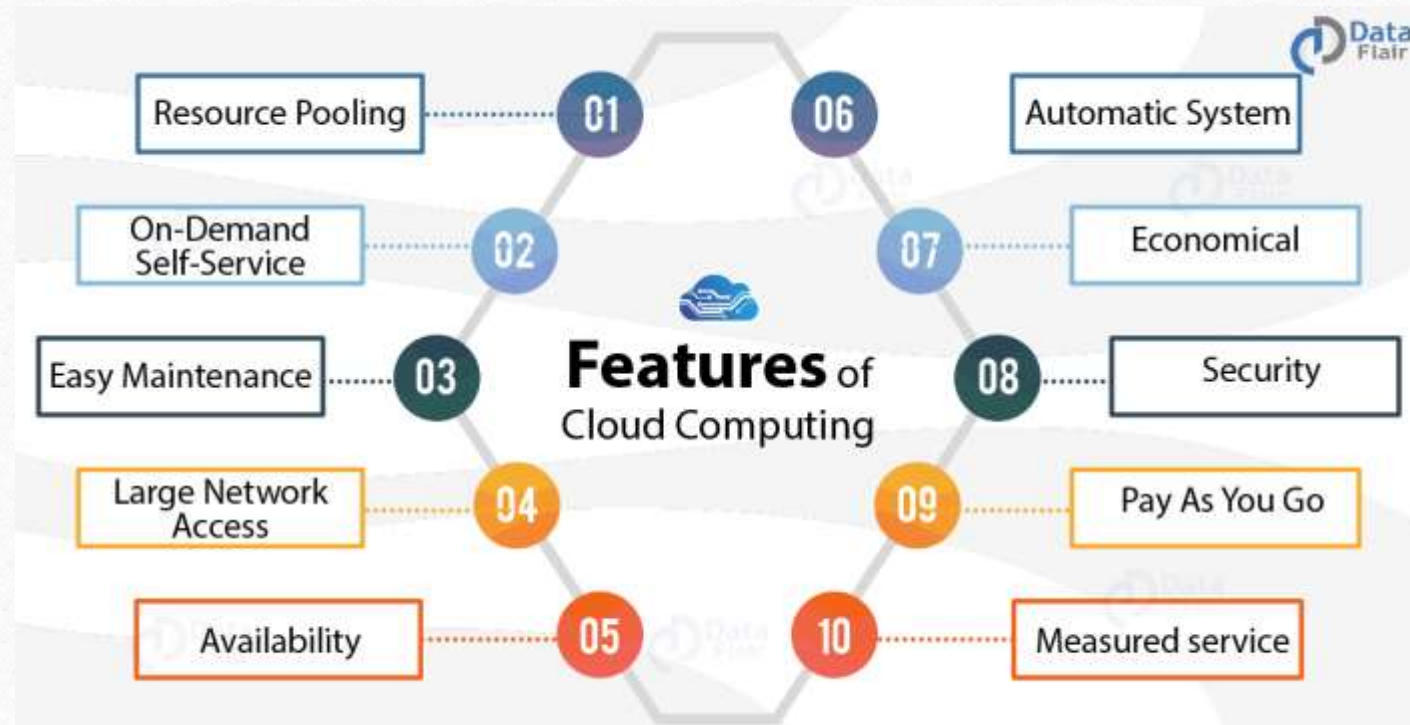
# Cloud Computing Reference Models

## Difference between IaaS, PaaS, and SaaS

IaaS	Paas	SaaS
It provides a virtual data center to store information and create platforms for app development, testing, and deployment.	It provides virtual platforms and tools to create, test, and deploy apps.	It provides web software and apps to complete business tasks.
It provides access to resources such as virtual machines, virtual storage, etc.	It provides runtime environments and deployment tools for applications.	It provides software as a service to the end-users.
It is used by network architects.	It is used by developers.	It is used by end users.
IaaS provides only Infrastructure.	PaaS provides Infrastructure+Platform.	SaaS provides Infrastructure+Platform+Software.

# Cloud Computing : Characteristics & Benefits

- Cloud computing has some interesting characteristics that bring benefits to both Cloud Service Consumers (CSCs) and Cloud service providers (CSPs).



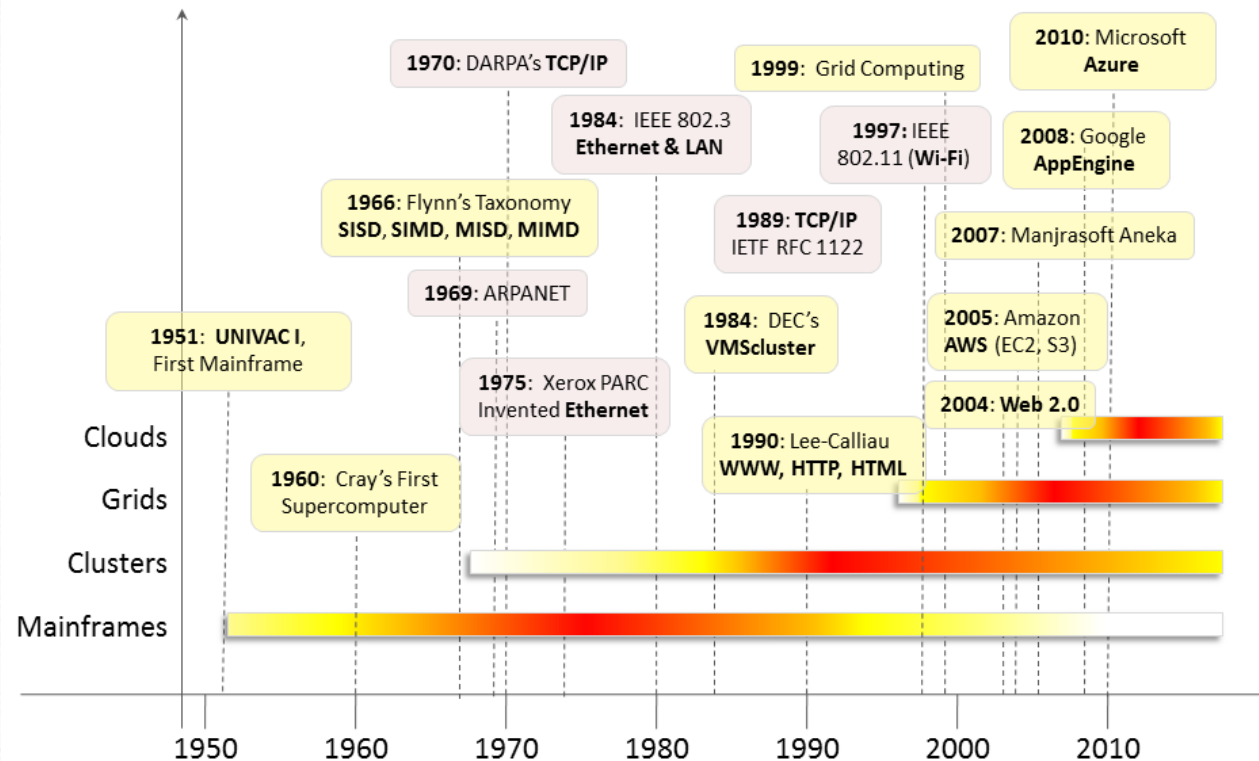
# Cloud Computing : Challenges Ahead

- Major cloud computing challenges businesses are facing today

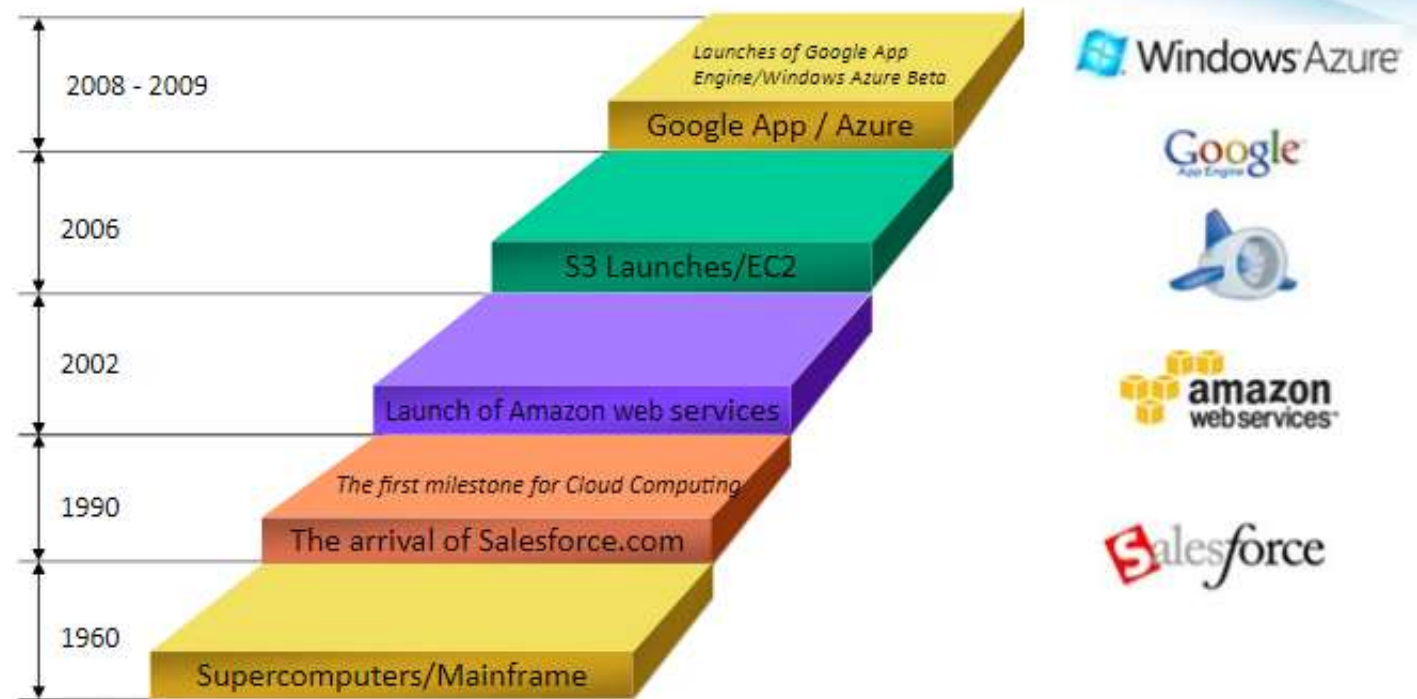


# Cloud Computing : Historical Developments

- The idea of renting computing services by leveraging large distributed computing facilities has been around for a long time.

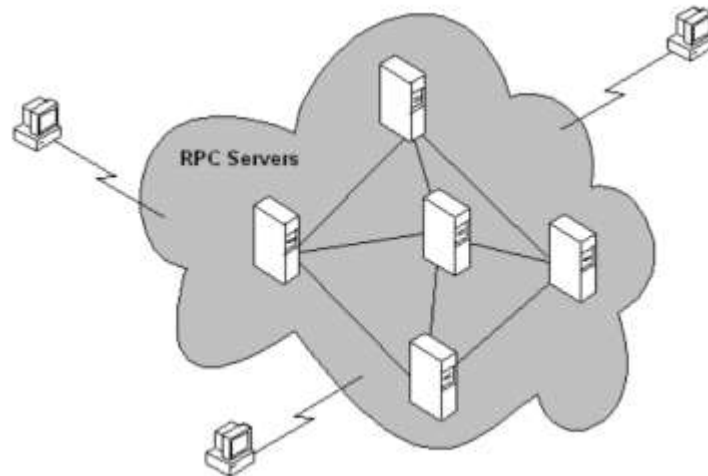


# Cloud Computing : Historical Developments



# Distributed Systems

- Clouds are essentially **large distributed computing facilities** that make available their services to third parties on demand.
- A distributed system is a collection of independent computers that appears to its users as a single coherent system.
- Distributed system hide the complex architecture they rely on and provide a **single interface** to the users.



# Distributed Systems

- The primary purpose of distributed systems is to share resources and to utilize them better.
- 
- Distributed system exhibit properties similar to cloud computing i.e.
    - Heterogeneity
    - Openness,
    - Scalability
    - Transparency
    - Concurrency
    - Continuous availability
    - Independent failures

# Why Distributed Systems?

- The primary purpose of distributed systems is
    - Computational resource sharing
    - Faster computation
    - Fault tolerance (Reliability)
    - Communication (Information sharing)
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# Milestones of Cloud Computing

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- Three major milestones have led to cloud computing
  - Mainframes:
  - Cluster Computing
  - Grid Computing

# Milestones of Cloud Computing

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## **Mainframes :**

- Mainframes cannot be considered as perfect example of distributed systems.
- First examples of large computational facilities leveraging multiple processing units.
- They offer large computational power by using multiple processors, which were presented as a single entity to users.
- Mainframes were powerful, highly reliable computers specialized for large data movement and massive IO operations.
- Used by large organizations for bulk data processing such as online transactions, enterprise resource planning, and other operations involving the processing of significant amount of data.

# Milestones of Cloud Computing

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## **Mainframes :**

- The most attractive features of mainframes is the ability to be highly reliable computers that are “always on” and capable of tolerating failures transparently.
- System shut down is not required to replace failed components, and the system could work without interruptions.
- Batch processing is the main application of mainframes.
- Popularity and deployments of mainframes have reduced, but evolved versions of such systems are still in use for transaction processing (i.e., online banking, airline ticket booking, supermarket and telcos, and government services).

# Milestones of Cloud Computing

## Cluster Computing :

- Started as a low-cost alternative to the use of mainframes and supercomputers.
- Computational power of commodity machines could be leveraged to solve problems previously manageable only on expensive supercomputers.
- Cheaper computing machines could be connected by a high-bandwidth network and controlled by specific software tools that manage them as a single system.
- Started in 1980s, clusters became the standard technology for parallel and high-performance computing.
- Cluster technology considerably contributed to the evolution of tools and framework for distributed computing i.e. *Parallel **Virtual Machine (PVM)**, and **Message Passing Interface (MPI)***.

# Milestones of Cloud Computing

## Grid Computing :

- Appeared in the early 90s as an evolution of cluster computing.
- Grid computing proposed a new approach to access large computational power, huge storage facilities, and a variety of services (analogous with power grid).
- Users can “consume” resources as utilities i.e. power, gas, and water.
- Grids were developed as aggregation of geographically dispersed clusters by means of Internet connection.
- Clusters belonged to different organizations and arrangements were made among them to share the computational power.

# Milestones of Cloud Computing

## **Grid Computing :**

- Grids were developed as aggregation of geographically dispersed clusters by means of Internet connection.
- Clusters belonged to different organizations and arrangements were made among them to share the computational power.
- Different from a “large cluster”, a computing grid was a dynamic aggregation of heterogeneous computing nodes, and its scale was nationwide or even worldwide.

# Milestones of Cloud Computing

## Summary

- Cloud computing is considered as the successor of Grid computing.
- It embodies aspects of all the three major technologies i.e. mainframes, cluster and grid.
- Clouds have virtually infinite capacity, are tolerant to failures, and always on as in the case of mainframes.
- The infrastructure of computing clouds are commodity machines as in the case of clusters.
- The services are consumed on pay-per-use basis.

# Virtualization

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- Is a collection of solutions allowing the **abstraction** of some of the fundamental elements for computing such as: hardware, runtime environments, storage, and networking.
- Provides multiple machines (computing environments) at the same time virtually.
- Host system can simulate interfaces that is expected by a guest system (hence virtual).
- Allows sharing a single physical instance of resource or an application to multiple users.



# Virtualization

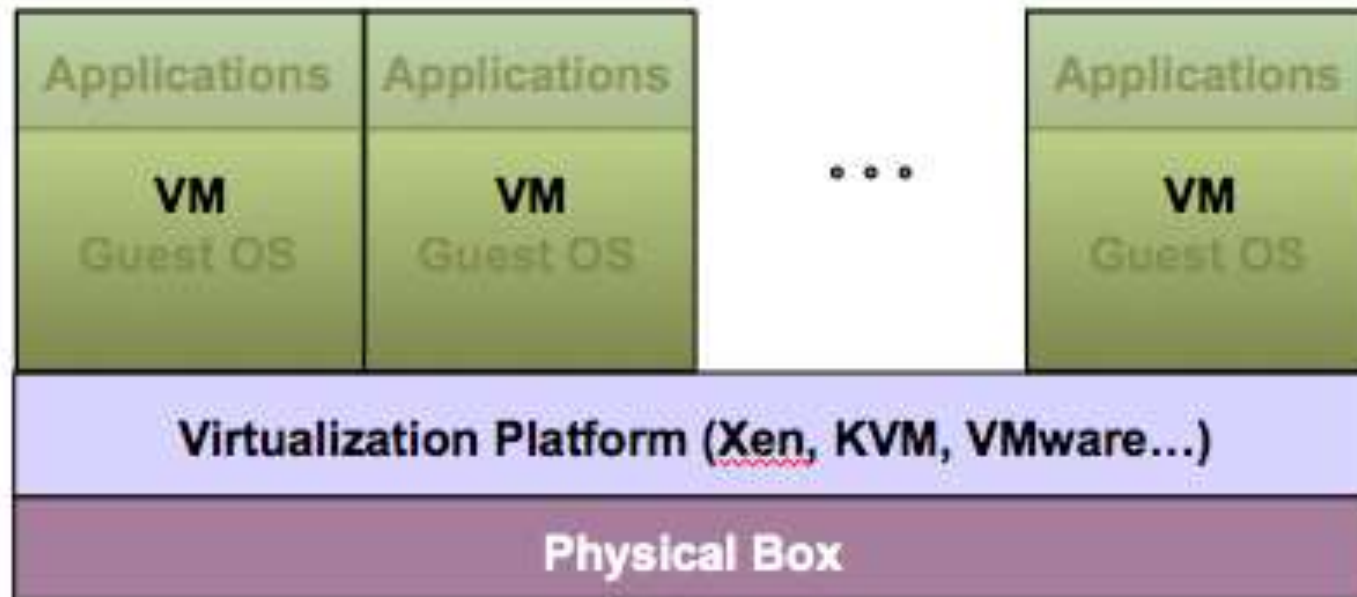
## Types of virtualization



Virtualization						
Hardware	Network	Storage	Memory	Software	Data	Desktop
<ul style="list-style-type: none"><li>• Full<ul style="list-style-type: none"><li>• Bare-Metal</li><li>• Hosted</li></ul></li><li>• Partial</li><li>• Para</li></ul>	<ul style="list-style-type: none"><li>• Internal Network Virtualization</li><li>• External Network Virtualization</li></ul>	<ul style="list-style-type: none"><li>• Block Virtualization</li><li>• File Virtualization</li></ul>	<ul style="list-style-type: none"><li>• Application Level Integration</li><li>• OS Level Integration</li></ul>	<ul style="list-style-type: none"><li>• OS Level</li><li>• Application</li><li>• Service</li></ul>	<ul style="list-style-type: none"><li>• Database</li></ul>	<ul style="list-style-type: none"><li>• Virtual desktop infrastructure</li><li>• Hosted Virtual Desktop</li></ul>

# Virtualization Architecture

- A Virtual machine (VM) is an isolated runtime environment (guest OS and applications)
- Multiple virtual systems (VMs) can run on a single physical system



# Web 2.0

- The Web is the primary interface through which Cloud computing deliver its services.
- 
- Encompasses a set of technologies and services that facilitate interactive information sharing, collaboration, user-centered design, and application composition.
  - Such evolved features has transformed the Web into a rich platform for application development and is known as **“Web 2.0”**.
  - Web 2.0 brings *interactivity* and *flexibility* into Web pages, which provide enhanced user experience that are normally found in desktop applications.
  - These capabilities are obtained by integrating a collection of standards and technologies such as *XML*, *Asynchronous Javascript and XML (AJAX)*, *Web Services*, and others.

# Service-Oriented Computing (SOC)

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- Service orientation is the core reference model for Cloud computing systems. The concept of services is considered as main building blocks of application and system development.
- *Service-Oriented Computing (SOC)* supports the development of rapid, low-cost, flexible, interoperable, and evolvable applications and systems.
- A **service** is an abstraction representing a self-describing and platform independent component that can perform any function.

# Service-Oriented Computing (SOC)

- Service can be anything from a simple function to a complex business process.
- Virtually any piece of code that performs a task can be turned into a service and expose its functionalities through a network accessible protocol.
- A service is supposed to be loosely coupled, reusable, programming language independent, and location transparent.

# Service-Oriented Computing (SOC)

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- Loose coupling allows services to serve different scenarios more easily and makes them reusable.
- Independence from a specific platform increases services accessibility.
- Thus, a wider range of clients, which can look up services in global registries and consume them in location transparent manner, can be served.

# Utility-Oriented Computing

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- Utility computing is a vision of computing, defining a service provisioning model for compute services in which resources such as storage, compute power, applications, and infrastructure are packaged and offered on a pay-per-use basis.
- The first traces of this service provisioning model can be found in the mainframes era.
- IBM and other mainframe providers offered mainframe power to organizations such as banks and government agencies throughout their datacenters.

# Building Cloud Computing Environment

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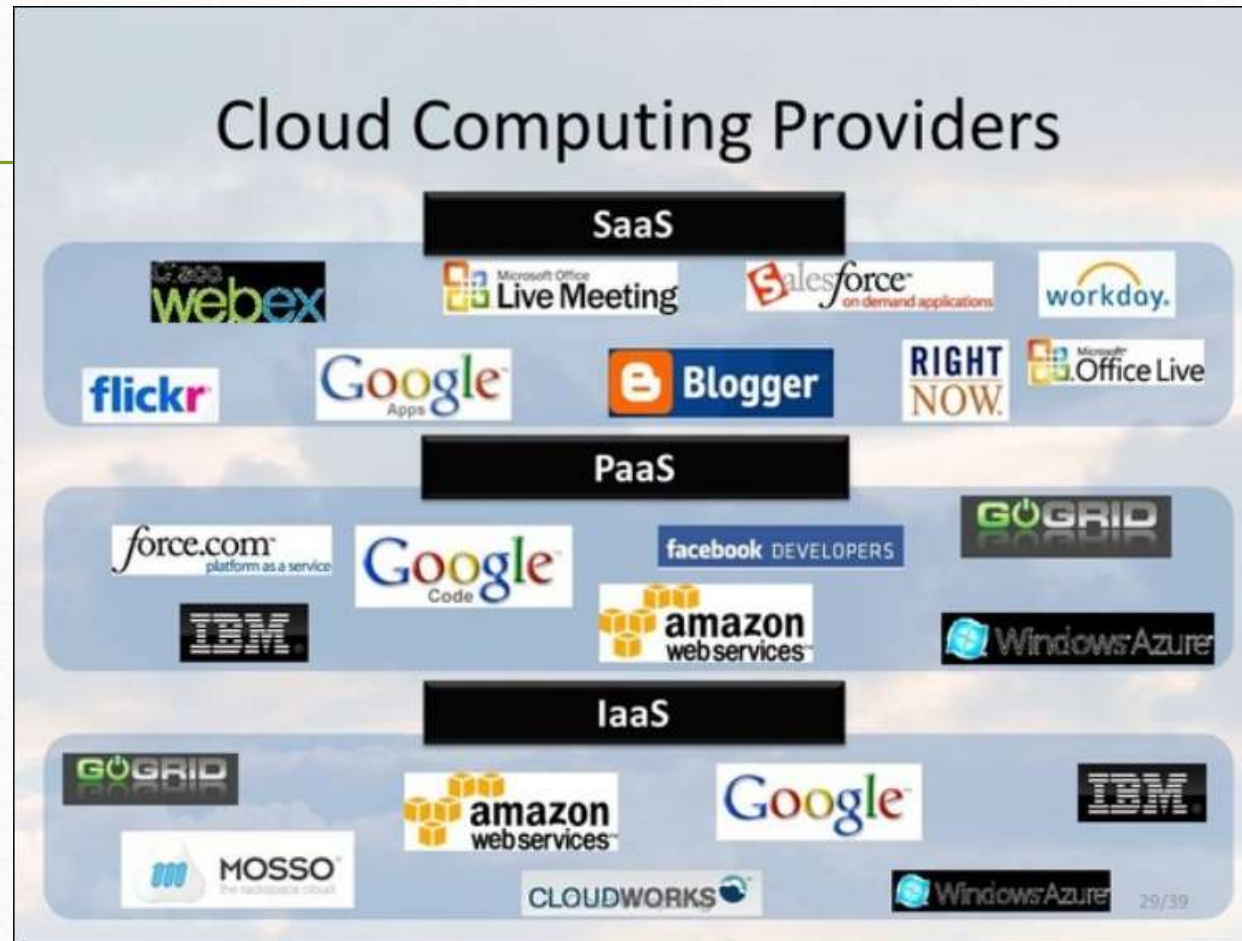
- Building cloud environment involves of applications and system development, creation of frameworks, platforms, and infrastructures delivering Cloud-computing services.
- **Five Steps to Building a Cloud-Ready Application Architecture**
  - Design the application as a collection of services or API's.
  - Decouple the data
  - Consider communications between application components
  - Model and design for performance and scaling
  - Make security systemic within the application

# Cloud Computing Platforms in Industry

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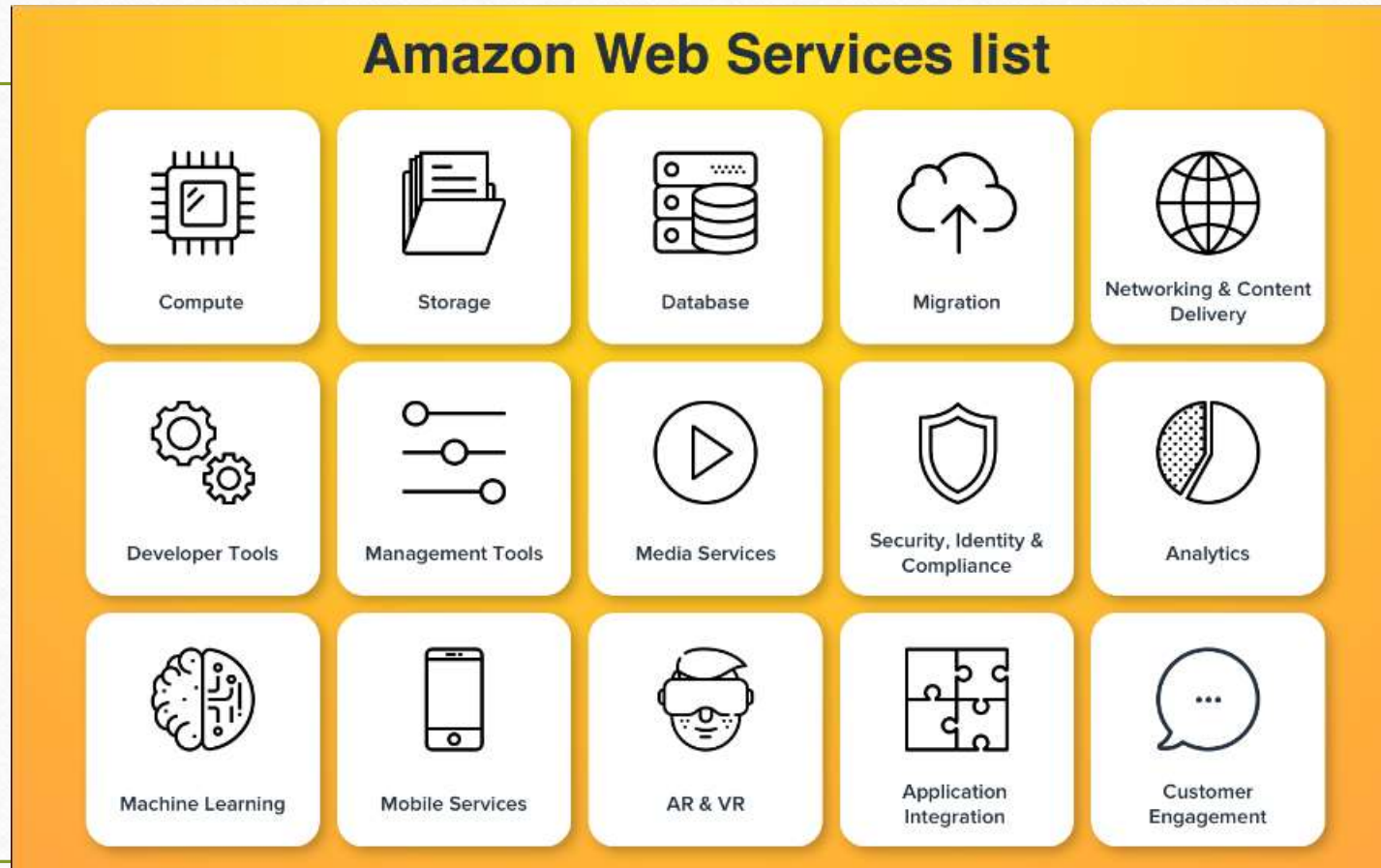
- Cloud computing applications are developed by leveraging platforms and frameworks.
- Cloud vendors provides a collection of services that includes bare metal infrastructure to customizable applications serving specific purposes.

# Cloud Computing Service Provider



# Cloud Computing Platforms in Industry

- Amazon Web Services (AWS)



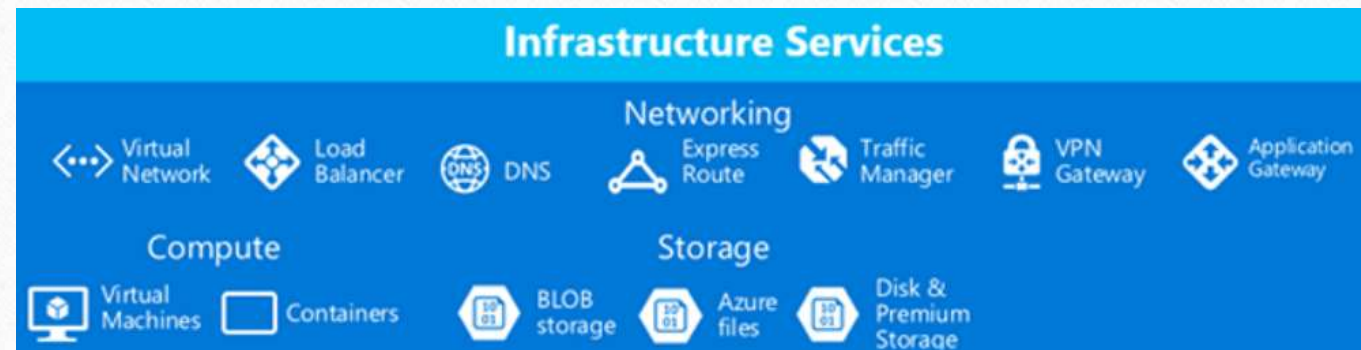
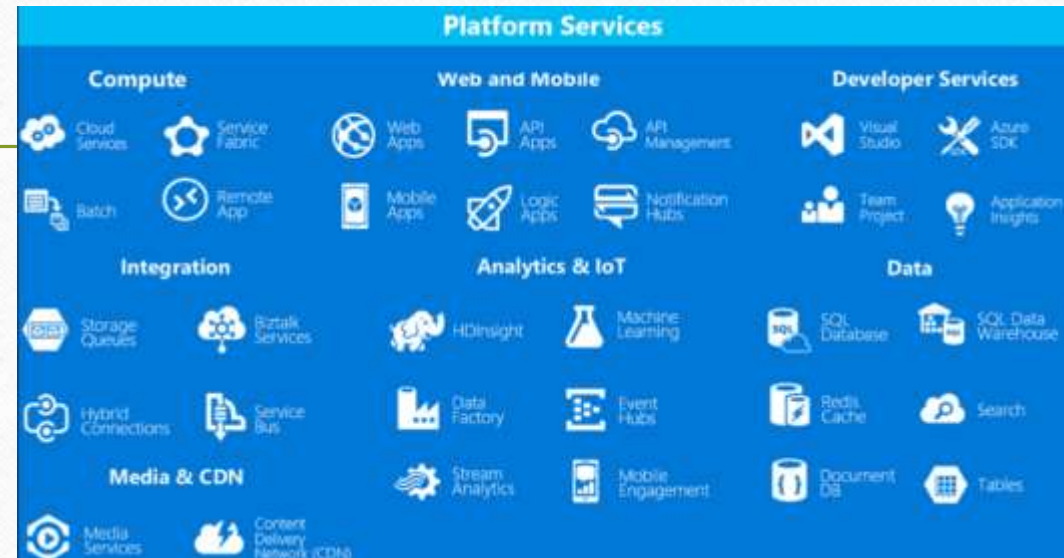
# Cloud Computing Platforms in Industry

- Google AppEngine



# Cloud Computing Platforms in Industry

- Microsoft Azure



# Cloud Computing Platforms in Industry

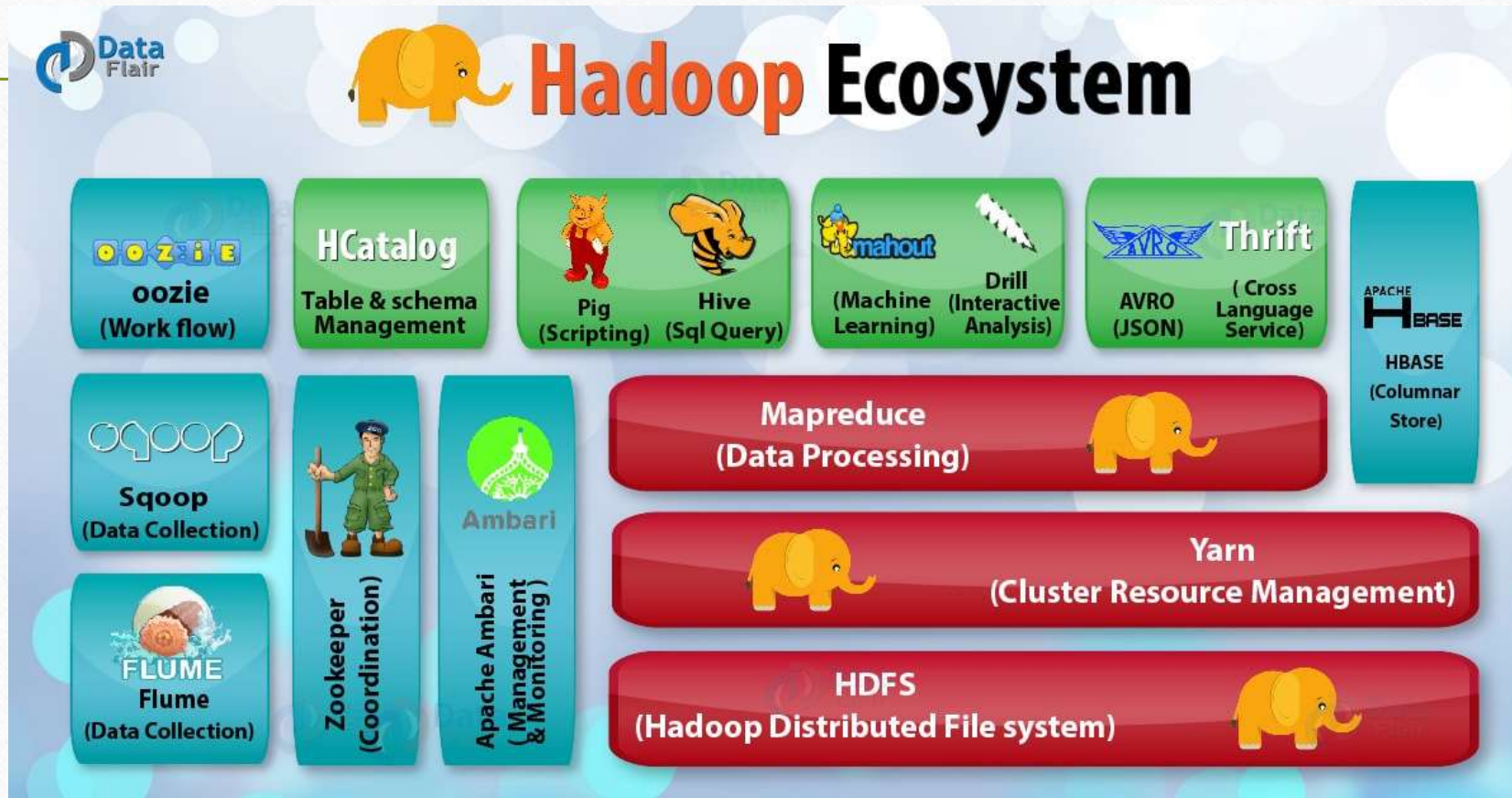
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## **Hadoop**

- The Apache Hadoop project develops open-source software for reliable, scalable, distributed computing.
- The Apache Hadoop software library is a framework that allows for the distributed processing of large data sets across clusters of computers using simple programming models.
- It is designed to scale up from single servers to thousands of machines, each offering local computation and storage.

# Cloud Computing Platforms in Industry

- Hadoop Ecosystem and their components



# Cloud Computing Platforms in Industry

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## **SalesForce**

- **Salesforce** is a cloud computing service as a software (SaaS) company that specializes in customer relationship management (CRM).
- **Salesforce's** services allow businesses to use cloud technology to better connect with customers, partners and potential customers.

# Cloud Computing Platforms in Industry

## SalesForce Products

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# Cloud Computing Platforms in Industry

## SalesForce Products



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*Thank You*