Cloud Computing : Introduction

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Learning Objective

After completing this talk, you should be familiar with:

- Cloud computing definition
- Describing cloud computing in one sentence
- Factors that lead to the adoption of cloud computing
- Explaining cloud concepts such as, infrastructure as a service, platform as a service, and software as a service
- Business benefits of cloud computing for IT, application development, and testing
- Describing cloud computing deployment models
- Identifying cloud computing adoption risks
- Differentiating between traditional IT and cloud computing services.

Cloud computing

- Cloud computing is the on-demand delivery of IT resources over the Internet with **pay-as-you-go** pricing. Instead of buying, owning, and maintaining physical data centers and servers, you can access technology services, such as computing power, storage, and databases, on an as-needed basis from a **cloud service provider**(CSP).
- Cloud computing is the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet ("the cloud") to offer faster innovation, flexible resources, and economies of scale.
- User typically pay only for cloud services as per their use, helping lower your operating costs, run your infrastructure more efficiently and scale as your business needs change.

Evolution of Cloud Computing

Grid Computing

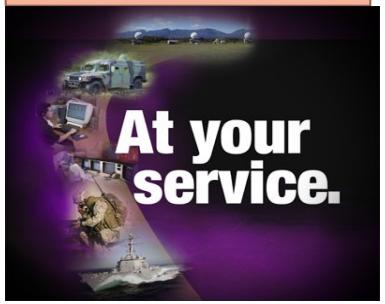
- Solving large problems with Parallel computing
- Made mainstream By Global Alliance

Utility Computing

- Offering computing resources as a metered service
- Introduced in late 1990s

SaaS Computing

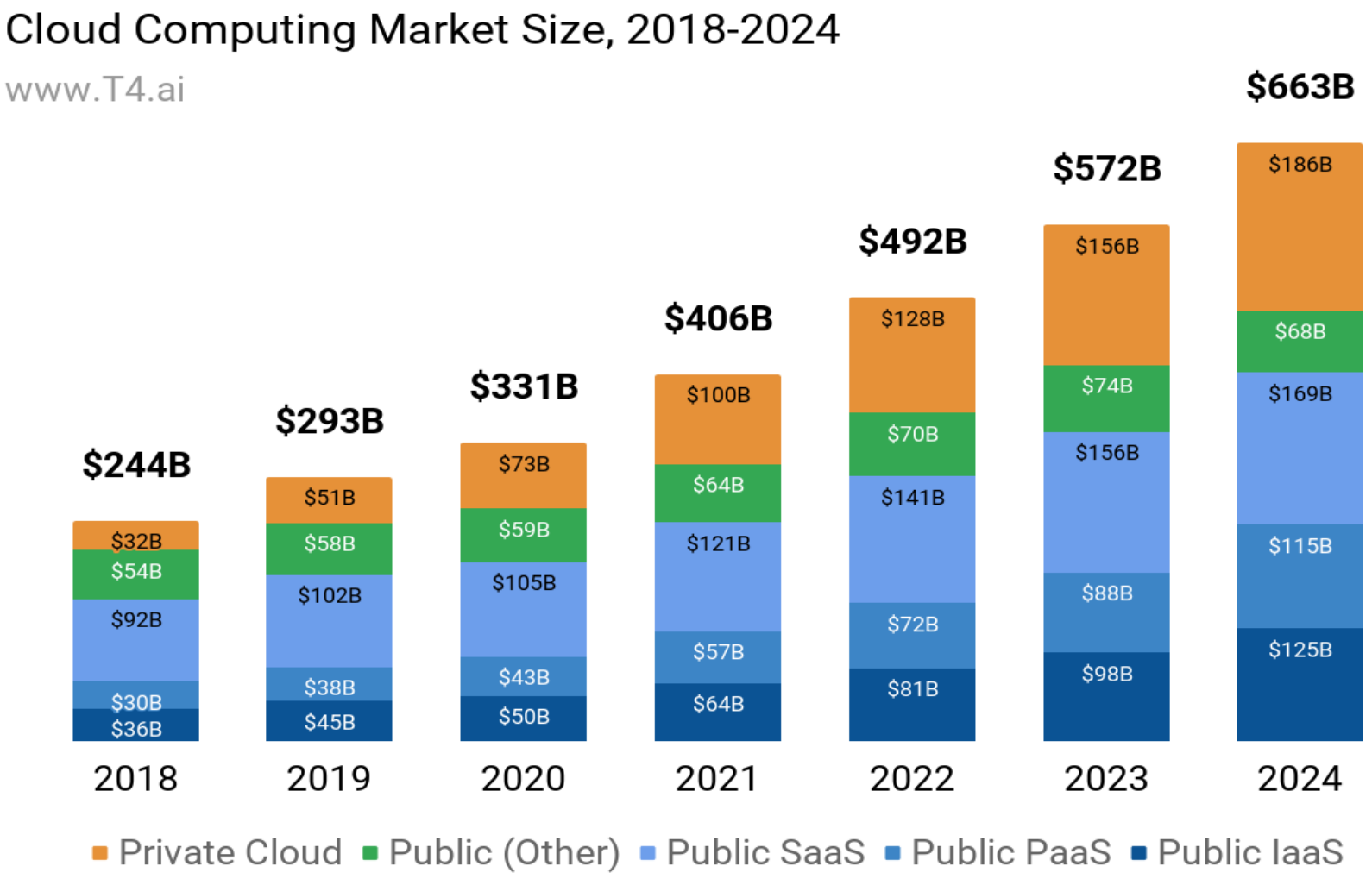
- Network-based subscriptions to applications
- Gained momentum in 2001



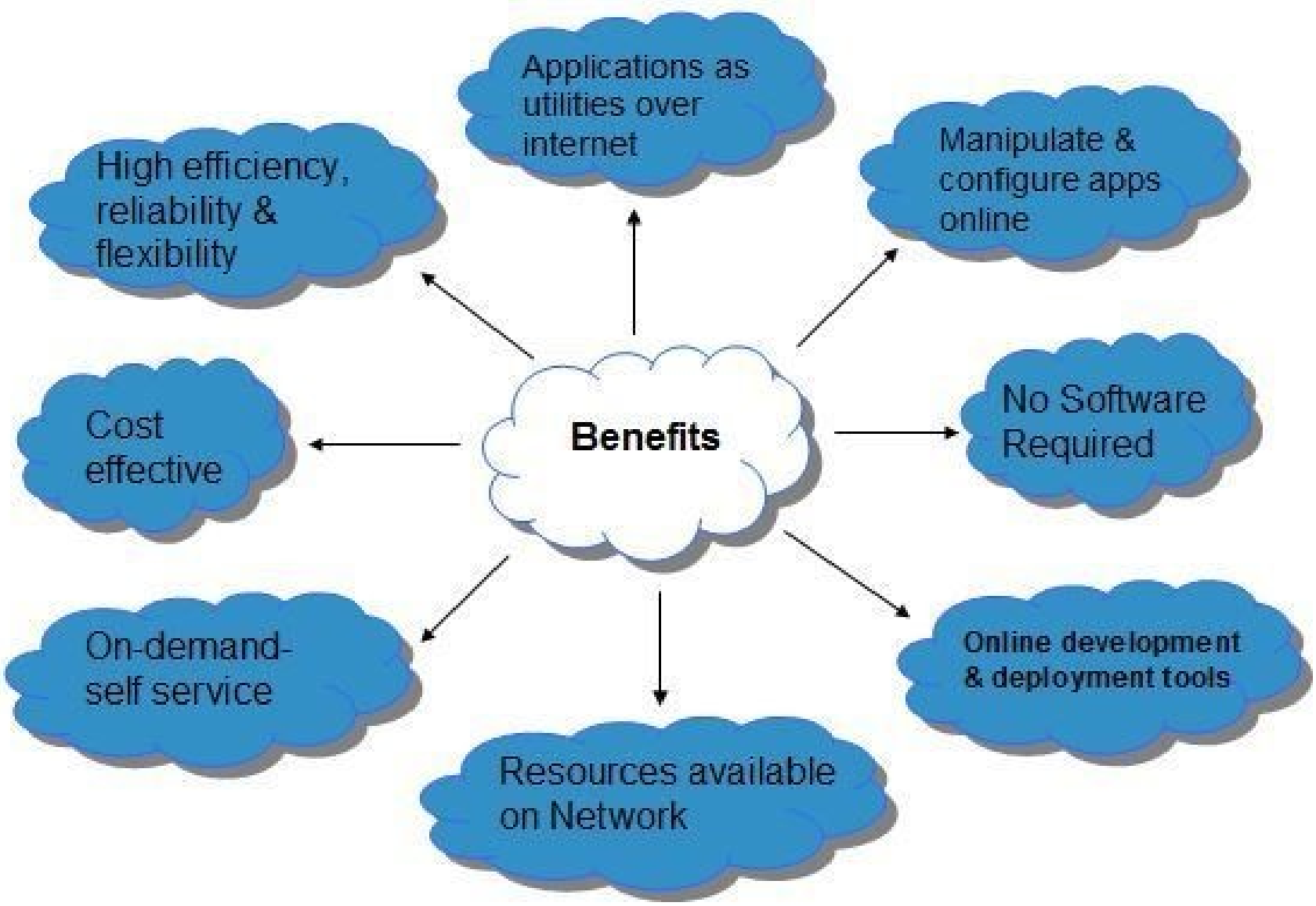
Cloud Computing

- Next-Generation Internet computing
- Next-Generation Data Centers

Growth of Cloud Computing Market



Top benefits of cloud computing



Top benefits of cloud computing

Cost

- Cloud computing eliminates the capital expense of buying hardware and software and setting up and running on-site datacenters—the racks of servers, the round-the-clock electricity for power and cooling, the IT experts for managing the infrastructure. It adds up fast.

Speed

- Most cloud computing services are provided self service and on demand, so even vast amounts of computing resources can be provisioned in minutes, typically with just a few mouse clicks, giving businesses a lot of flexibility and taking the pressure off capacity planning.

Top benefits of cloud computing

Global scale

- The benefits of cloud computing services include the ability to scale elastically. In cloud speak, that means delivering the right amount of IT resources—for example, more or less computing power, storage, bandwidth—right when it is needed and from the right geographic location.

Productivity

- On-site datacenters typically require a lot of "racking and stacking"—hardware setup, software patching, and other time-consuming IT management chores. Cloud computing removes the need for many of these tasks, so IT teams can spend time on achieving more important business goals.

Top benefits of cloud computing

Performance

- The biggest cloud computing services run on a worldwide network of secure datacenters, which are regularly upgraded to the latest generation of fast and efficient computing hardware. This offers several benefits over a single corporate datacenter, including reduced network latency for applications and greater economies of scale.

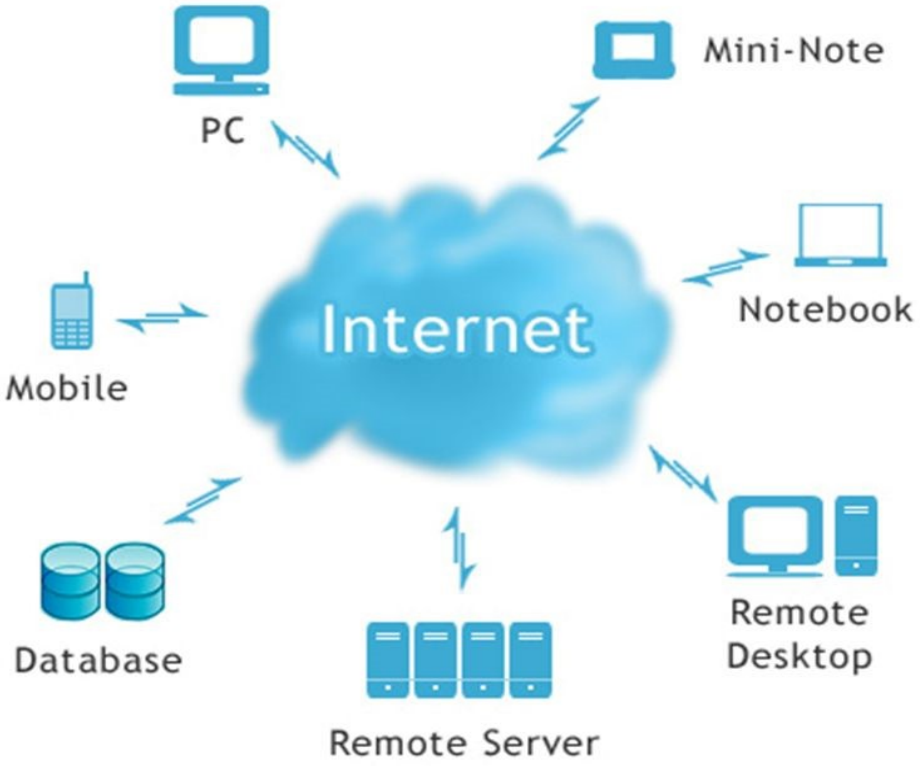
Reliability

- Cloud computing makes data backup, disaster recovery and business continuity easier and less expensive because data can be mirrored at multiple redundant sites on the cloud provider's network.

Security

- Many cloud providers offer a broad set of policies, technologies and controls that strengthen your security posture overall, helping protect your data, apps and infrastructure from potential threats.

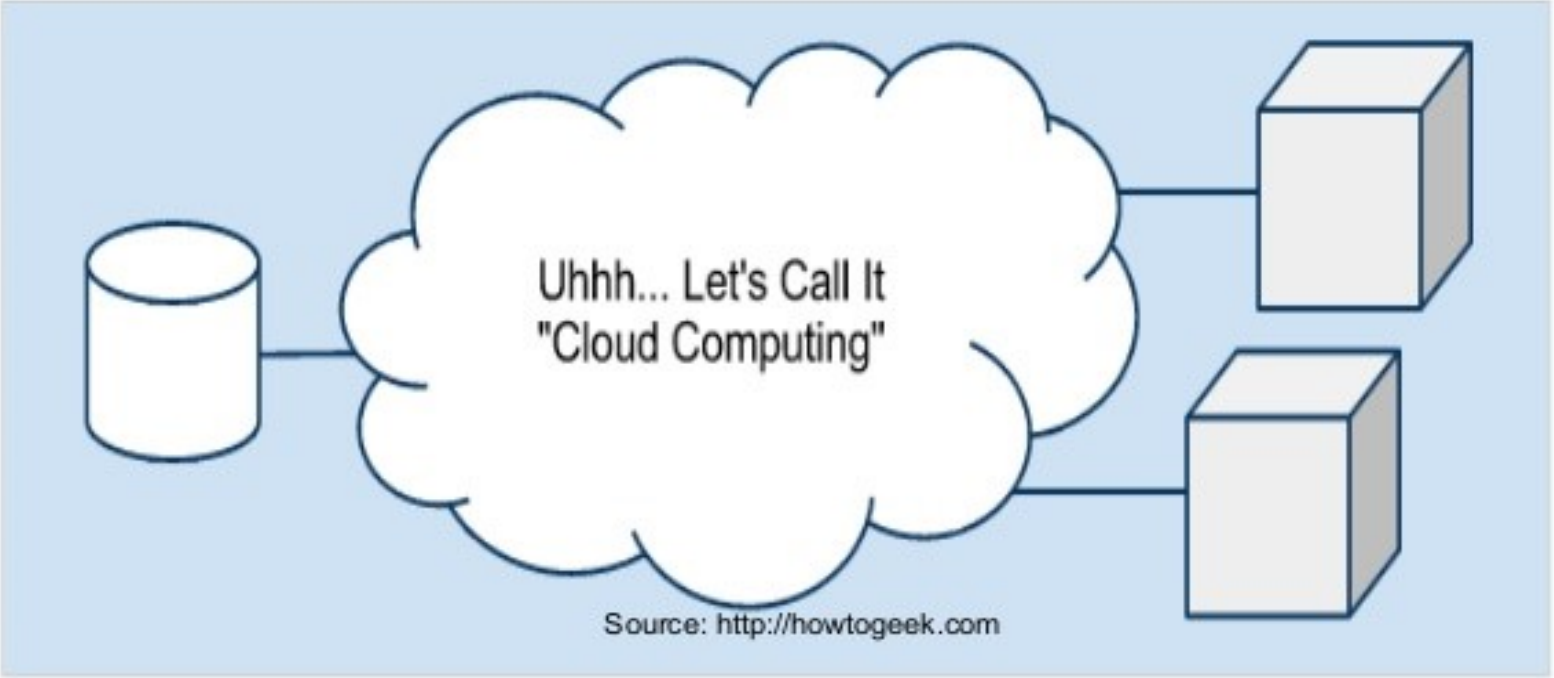
Cloud Computing



Why is it called the cloud?

Why is it called Cloud Computing ?

Because in network diagrams, the Internet is depicted as a cloud



Why is it called cloud computing?

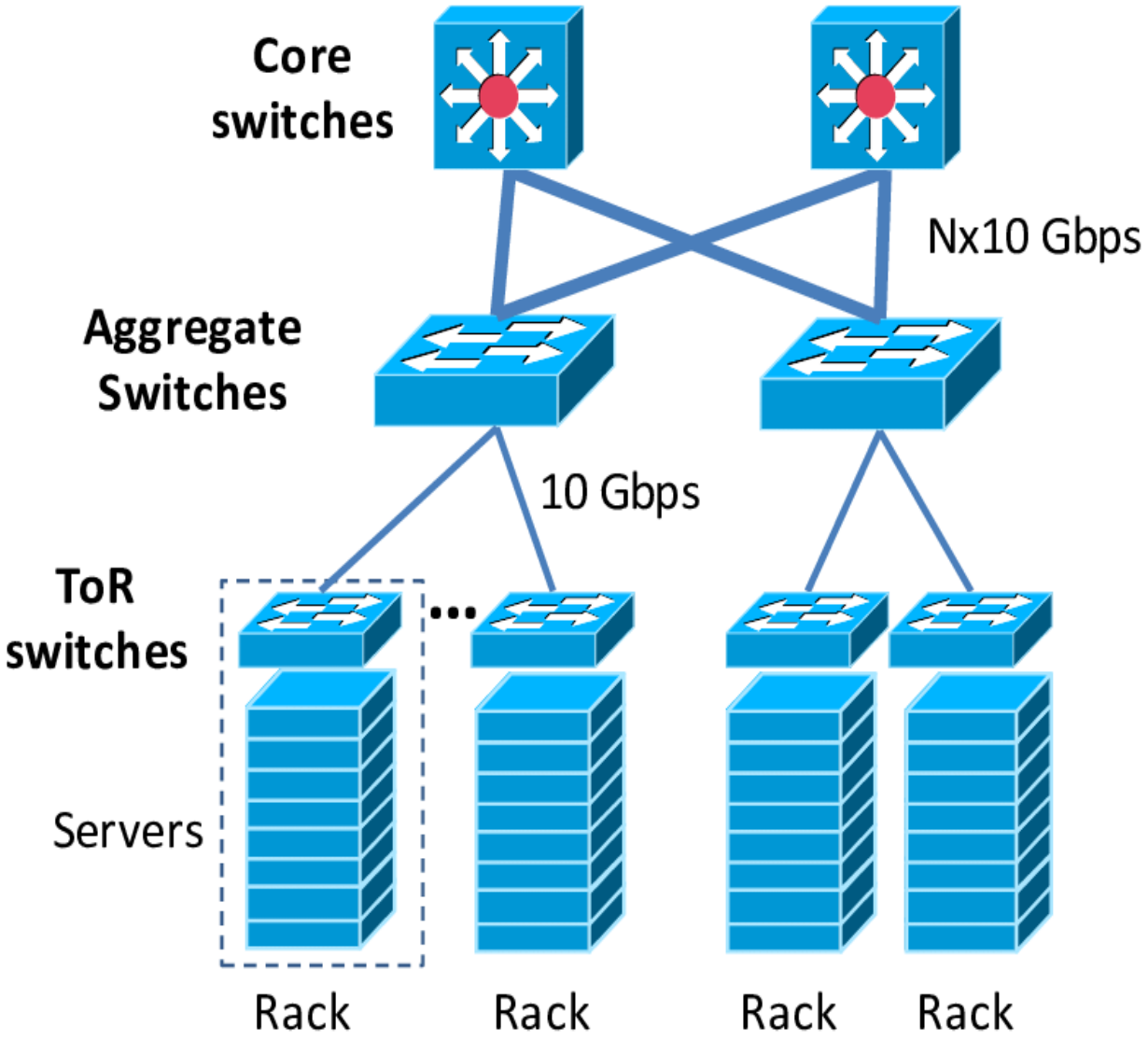
- A fundamental concept behind cloud computing is that the **location of the service**, and many of the details such as the hardware or operating system on which it is running, are largely irrelevant to the user.
- It's with this in mind that the metaphor of the cloud was borrowed from old telecoms network schematics, in which the public telephone network (and later the internet) was often represented as a cloud to denote that the just didn't matter -- it was just a cloud of stuff.

Cloud Computing

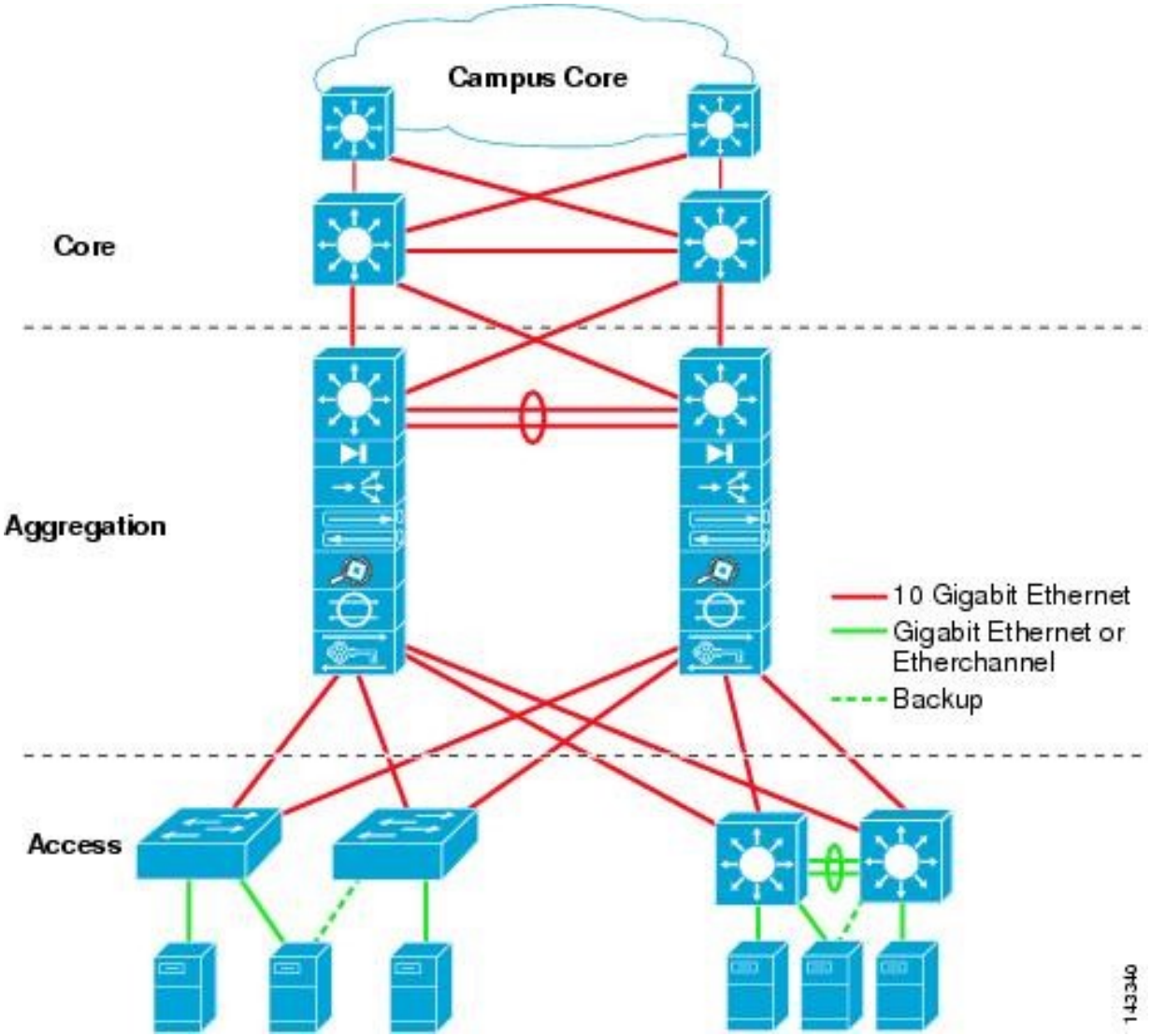
Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., **networks**, **servers**, **storage**, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of **five essential characteristics**, **three service models**, and **four deployment models**.

- Source: **NIST, US Department of Commerce**
- http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

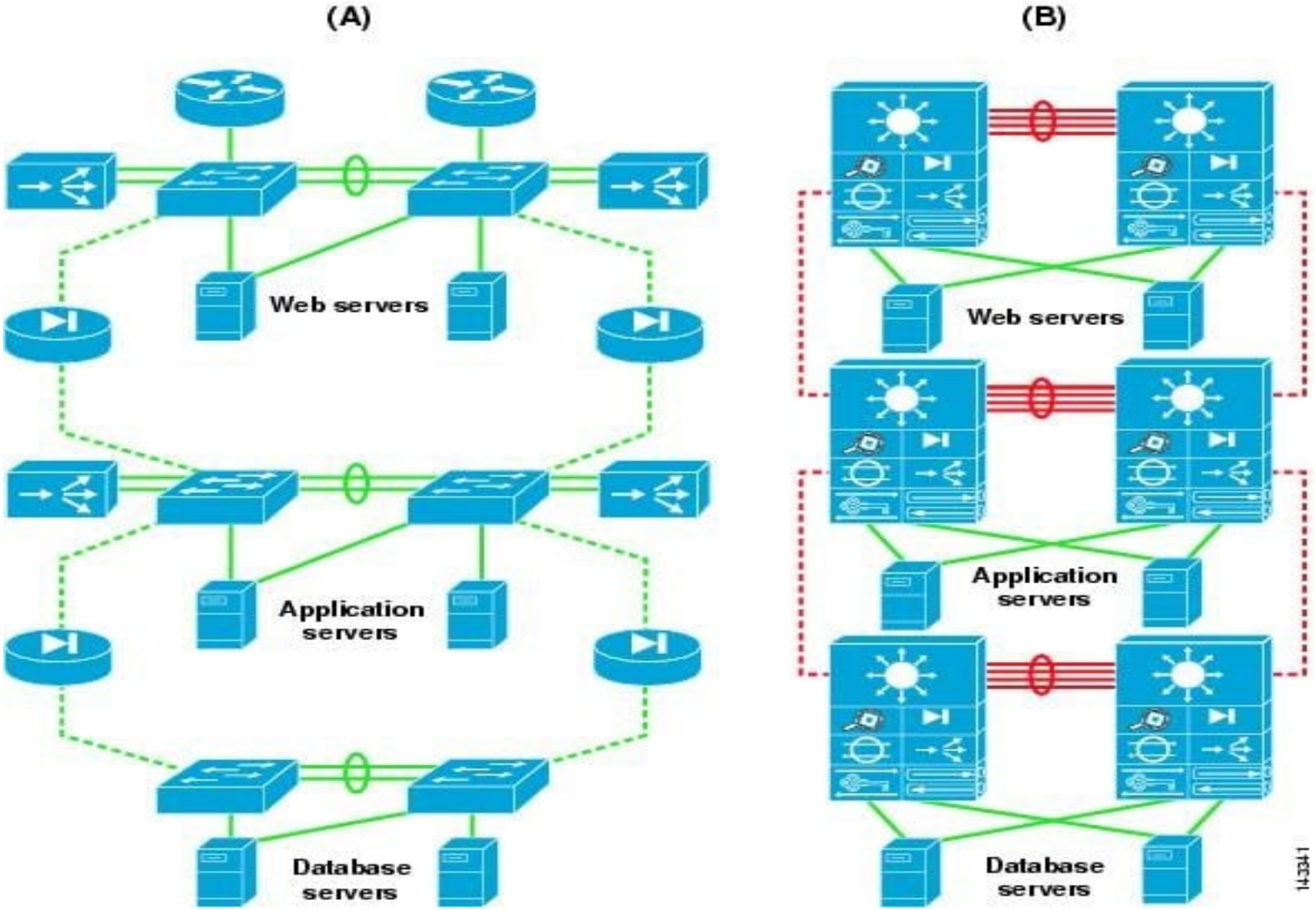
Basic layer design of Datacenter's Networks



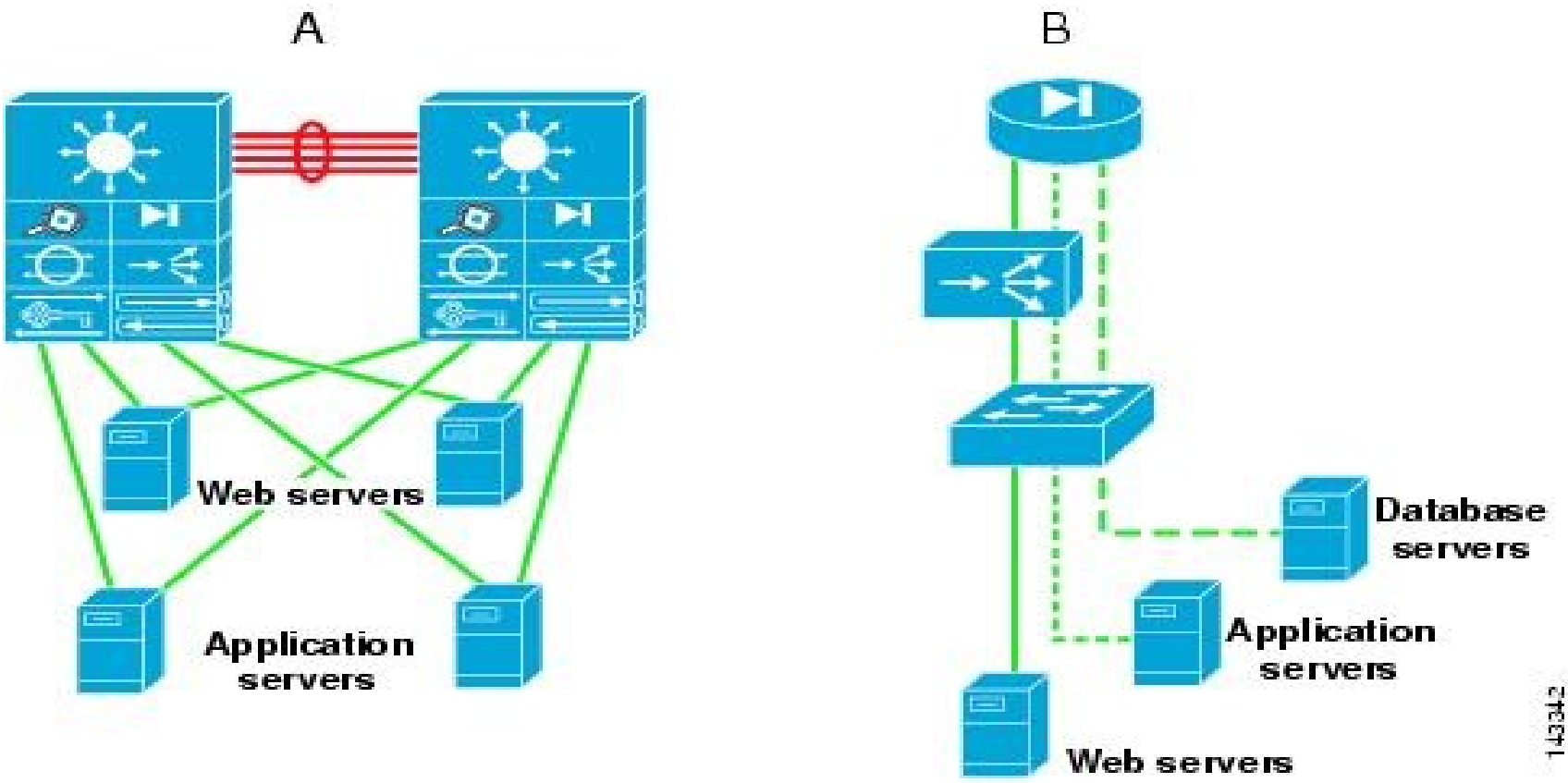
The data center network design: basic layered design.



Physical Segregation in a Server Farm with Appliances (A) and Service Modules (B)



Logical Segregation in a Server Farm with VLANs



(A) shows the physical topology, and the right side

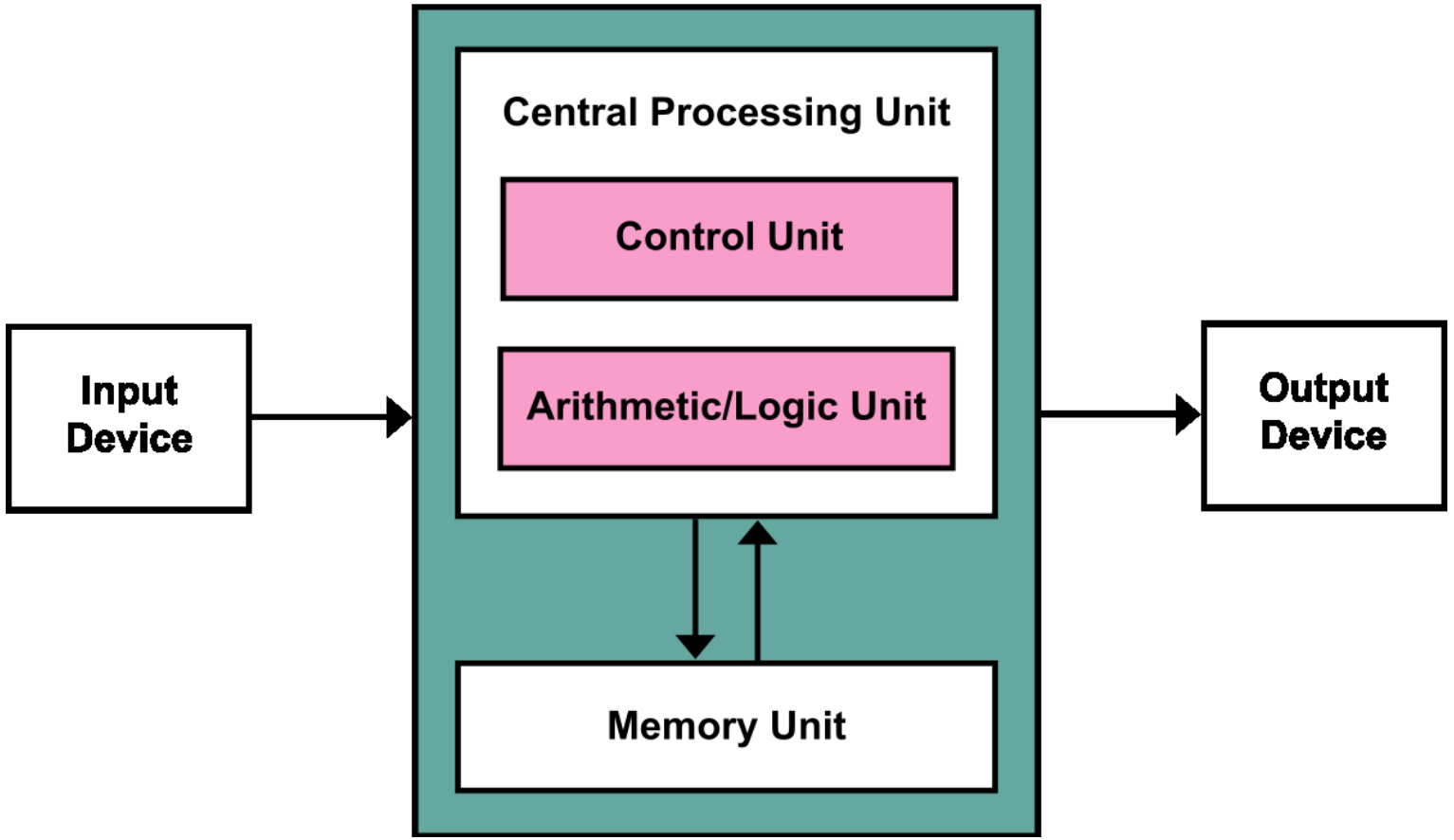
(B) shows the VLAN allocation across the service modules, firewall, load balancer, and switch.

https://www.dell.com/en-in/work/shop/povw/poweredge-mx7000

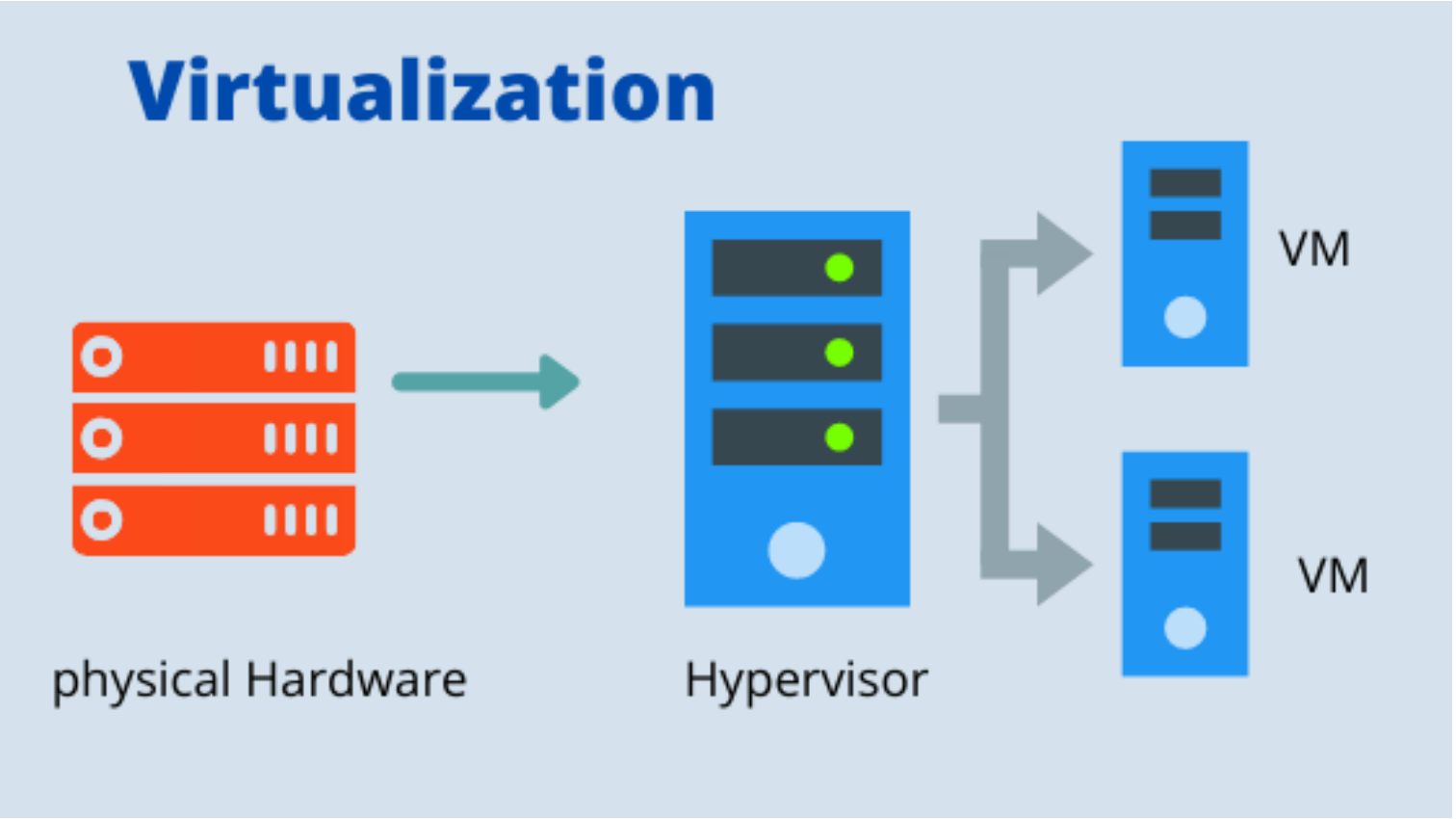
PowerEdge MX7000 Modular Chassis

Von Neumann Architecture [1945]

Von Neumann architecture is based on the stored-program computer concept, where instruction data and program data are stored in the same memory.



Virtualization



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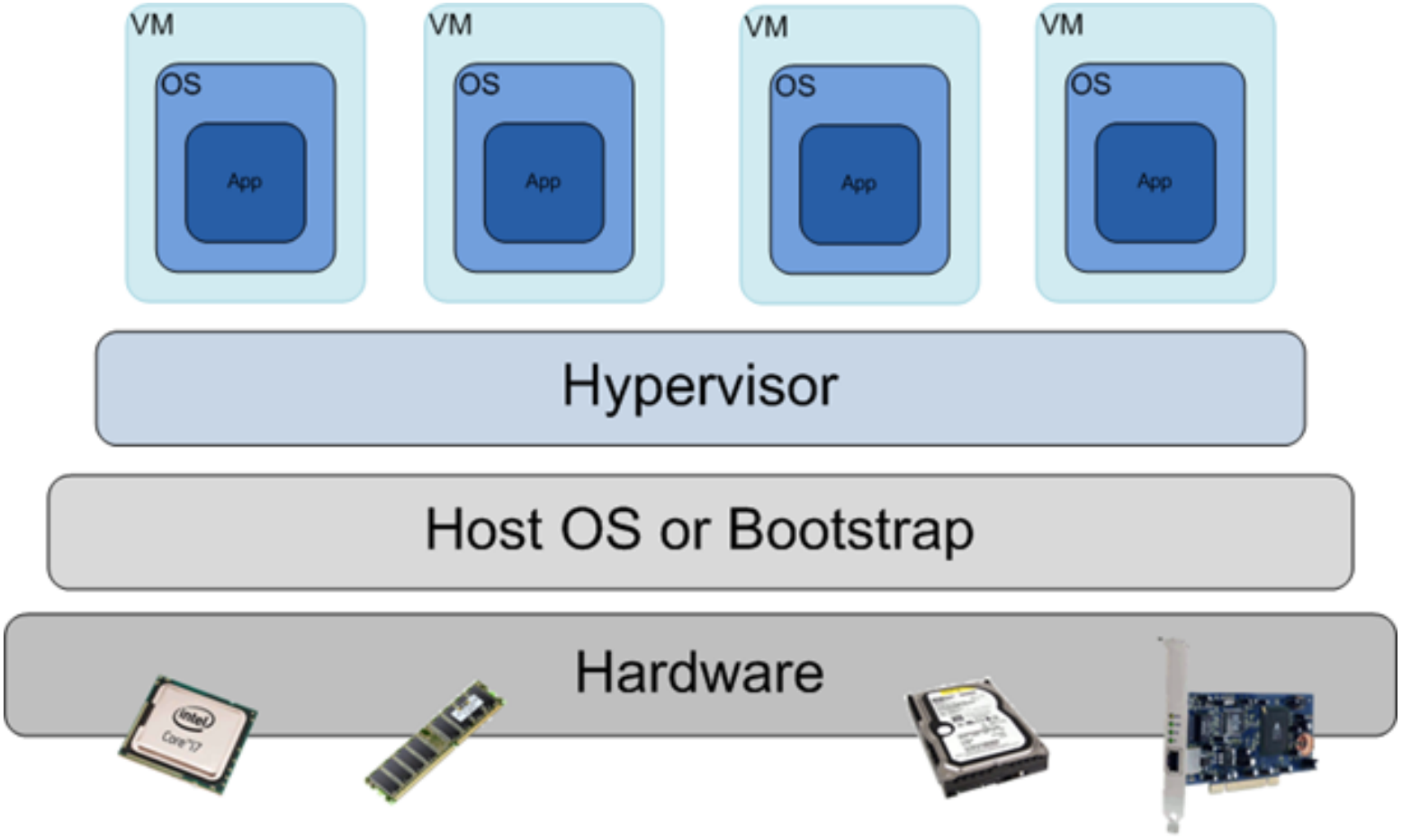
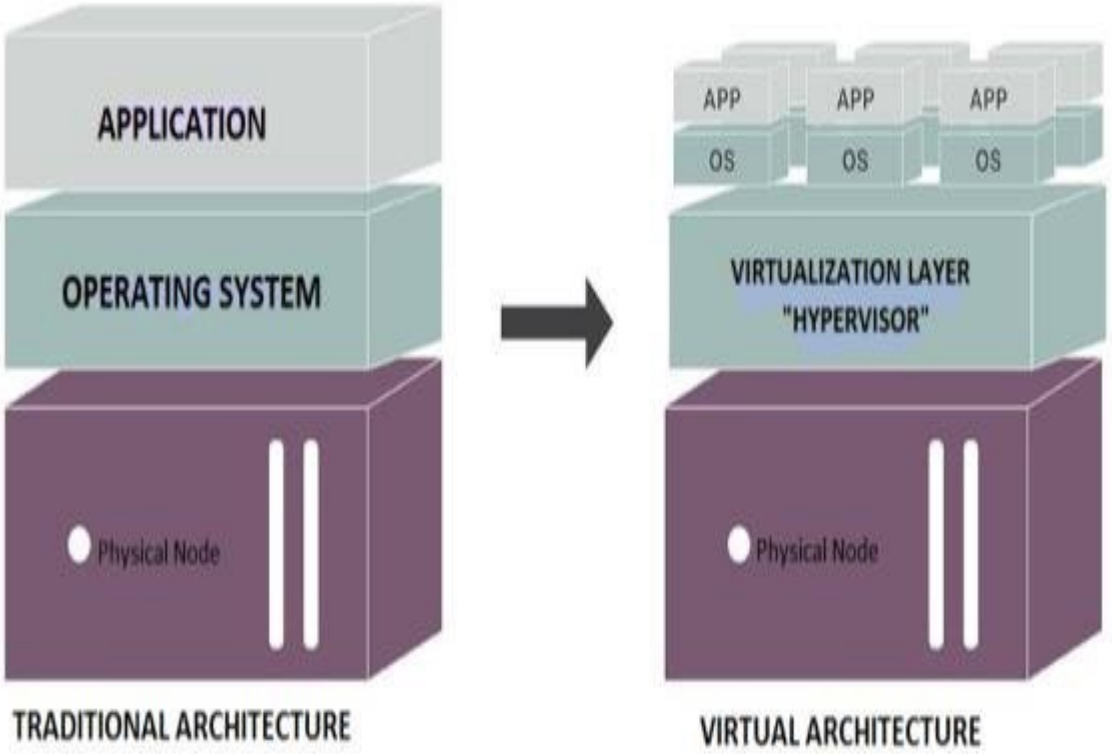
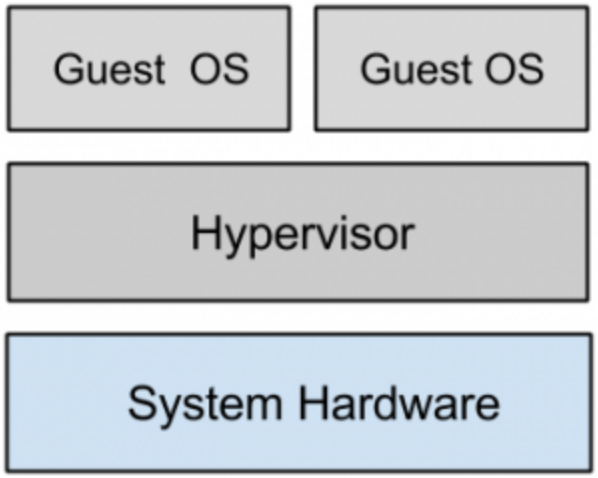


Traditional Architecture vs. Virtual Architecture

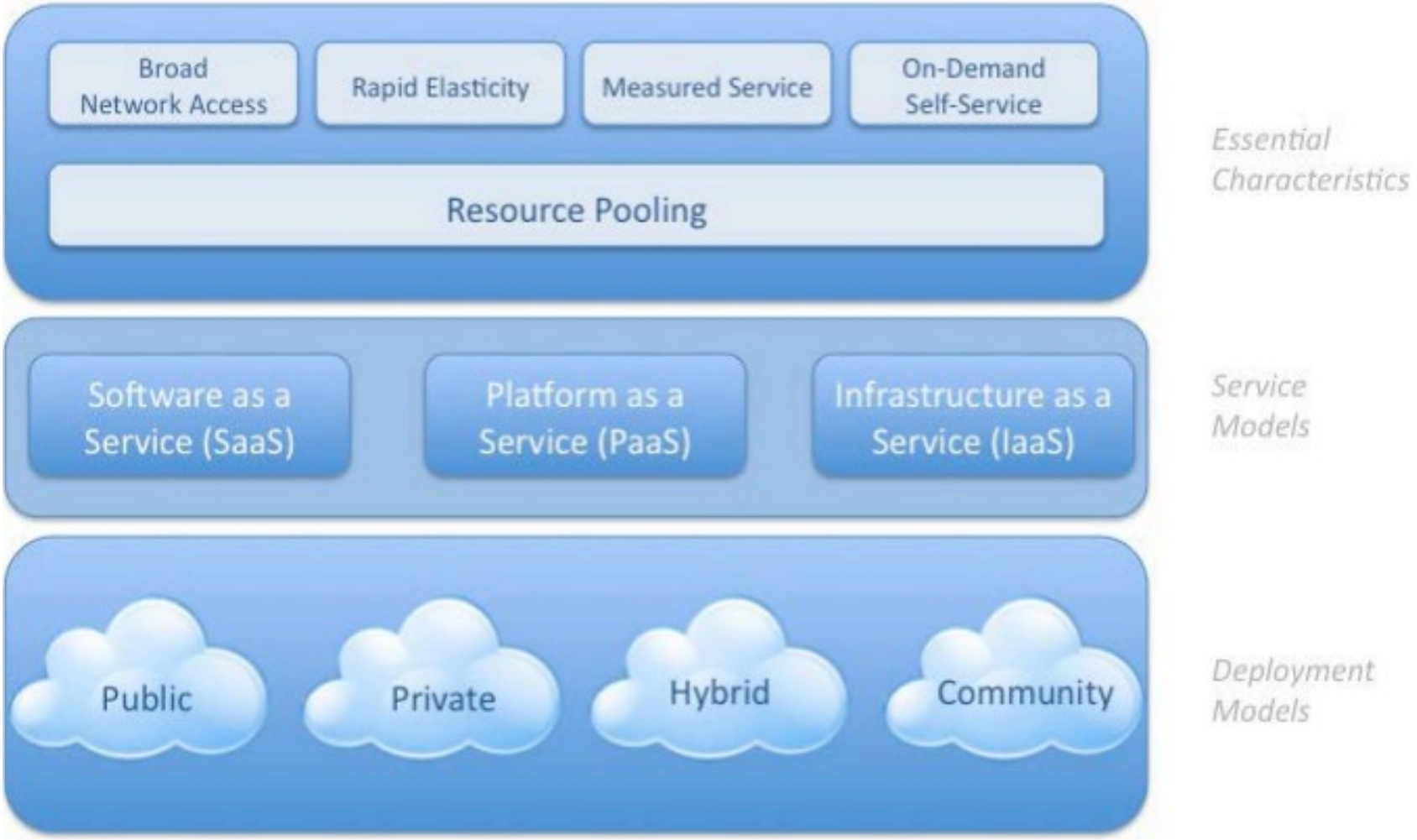




5 essential features of Cloud according to NIST

- **On-demand self-service** — Services can be provided on demand to consumers with no humans in the loop
- **Broad network access** — Services are available over the network in real-time through standard mechanisms
- **Resource pooling** — Resources are pooled to enable concurrent service provision to multiple users (multi-tenant model), while being adjusted to the actual demand of each user
- **(Rapid) elasticity** — Requests for extra resource are self-managed and automatic in relation to demand; from the consumer's perspective, the supply of resources has no limit
- **Measured (quality of) service** — Services leverage a quantitative and qualitative metering capability making usage-based billing and validation of the service quality available

Visual Model of Cloud Computing Definition



Cloud Computing: Essential Characteristics (NIST)

On-demand self service

- Users automatically access computing resources (e.g. servers, storage etc.) as needed.

Broad network access

- Services available over the network can be accessed using mobile/smart phones, tablets, laptops and desktops.

Resource pooling

- Computing resources (including memory and bandwidth) can be pooled to serve multiple customers at the same time.
- Location independence

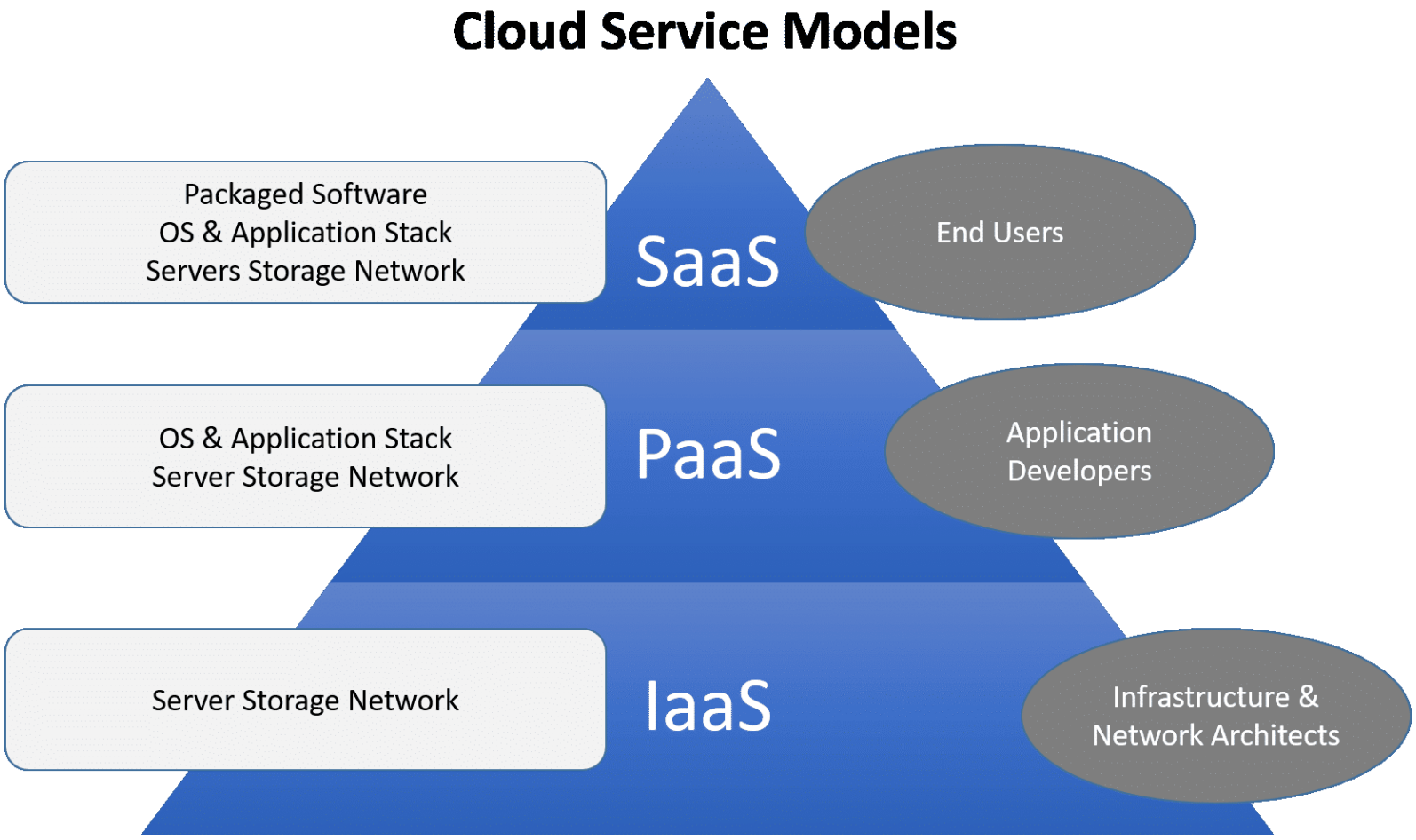
Rapid elasticity

- Ability to quickly scale in/out service with demand, at any time.

Measured service

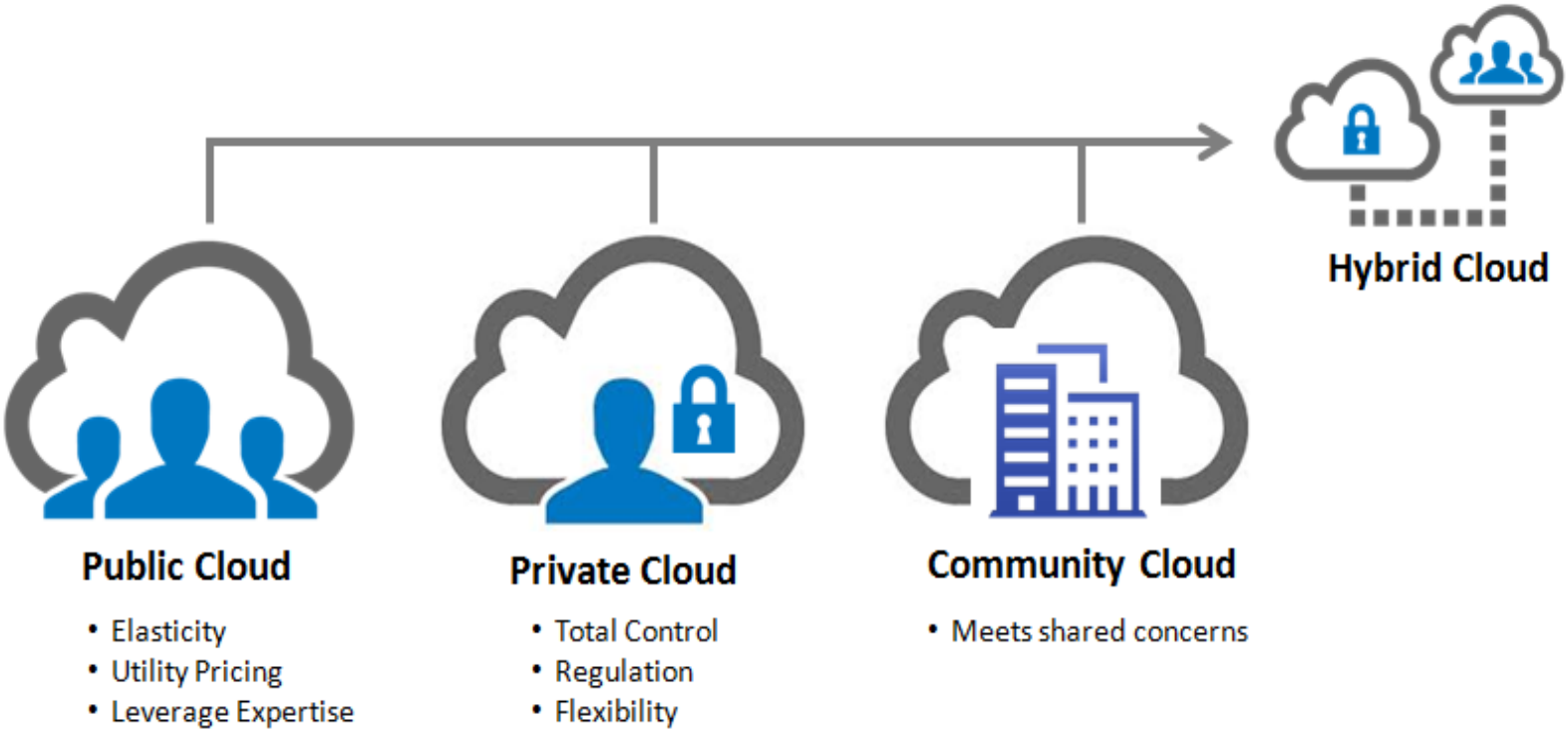
- Control, optimise services based on metering (i.e. pay-per-use pricing model)
- Type of service include storage, processing, bandwidth etc.

3 type of service models



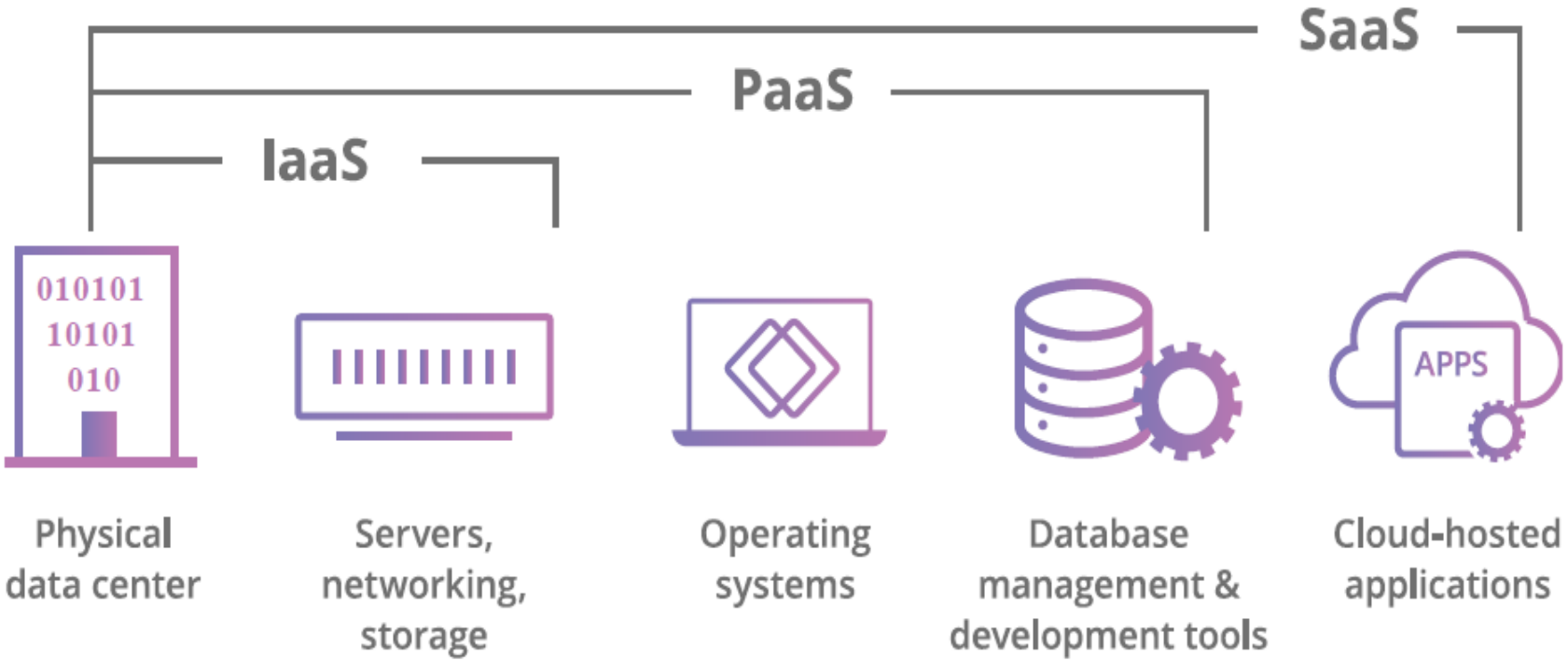
4 deployment models of Cloud

- There are four cloud deployment models: **public, private, community, and hybrid**.
- Each deployment model is defined according to where the infrastructure for the environment is located.

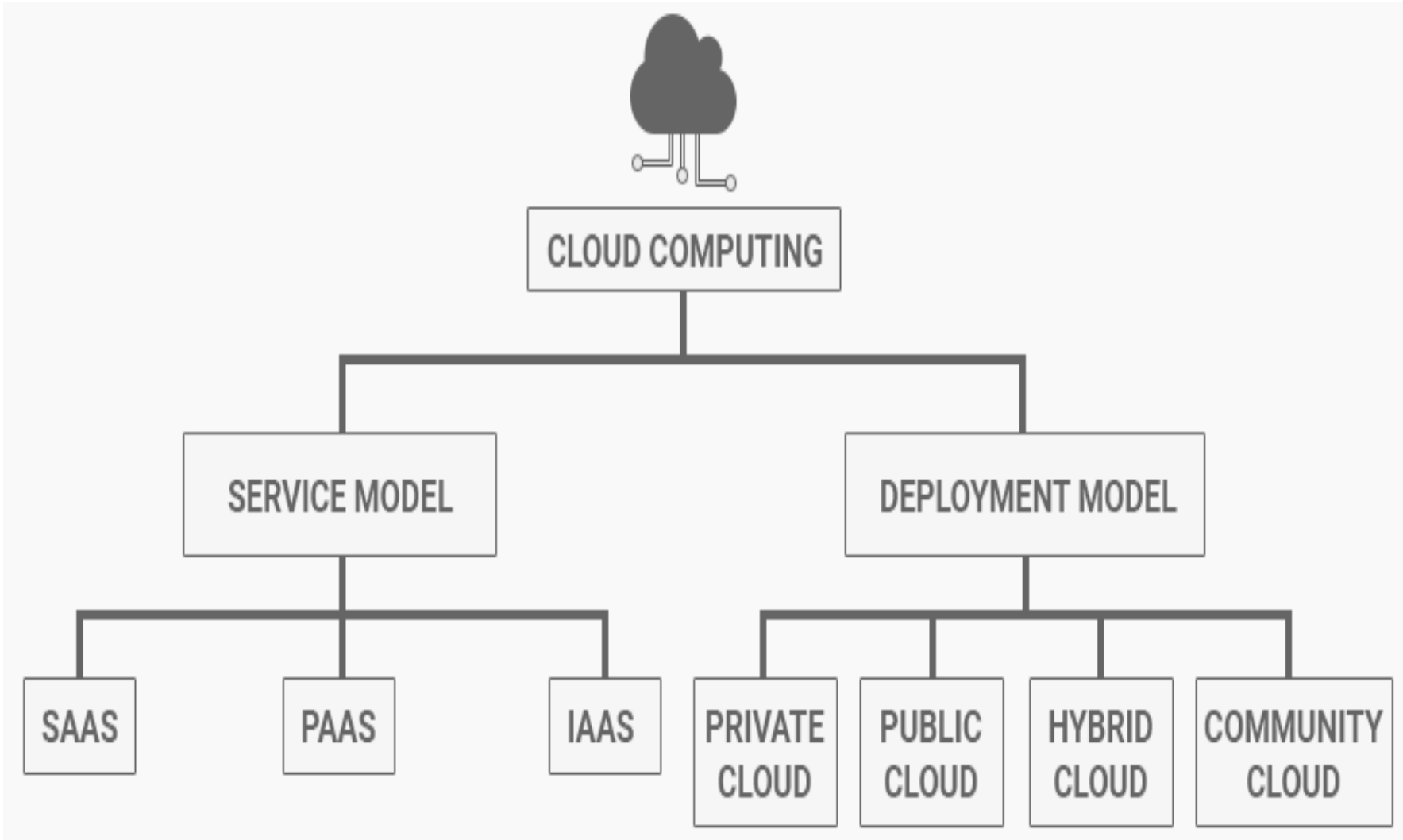


NIST Service model of Cloud: IaaS, PaaS, and SaaS

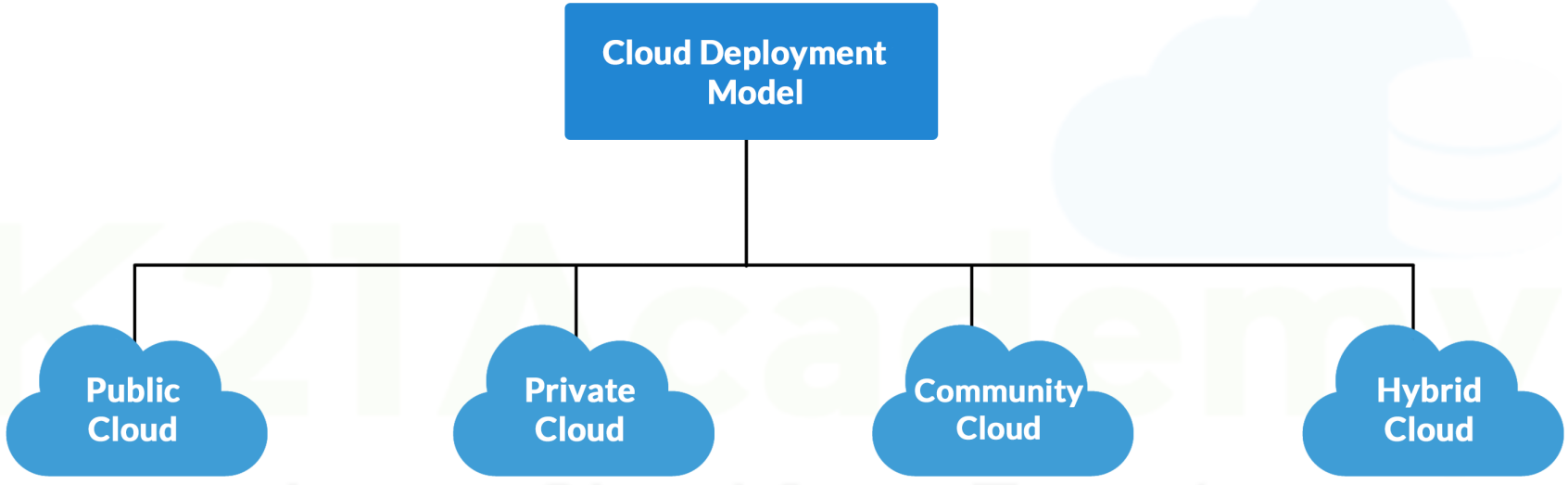
NIST cloud computing services fall into three broad categories: infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS).



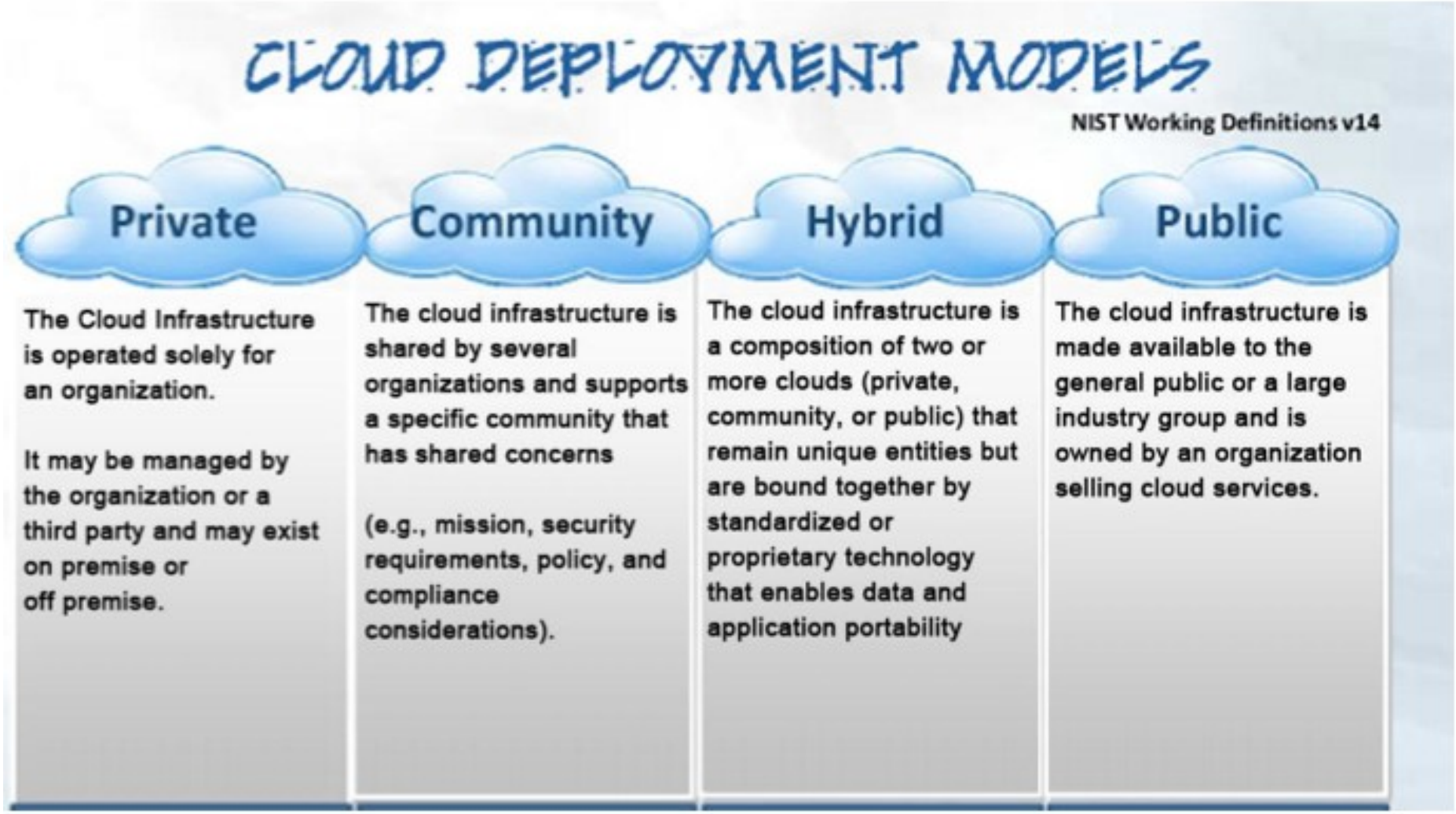
Cloud Computing



Deployment models of cloud computing

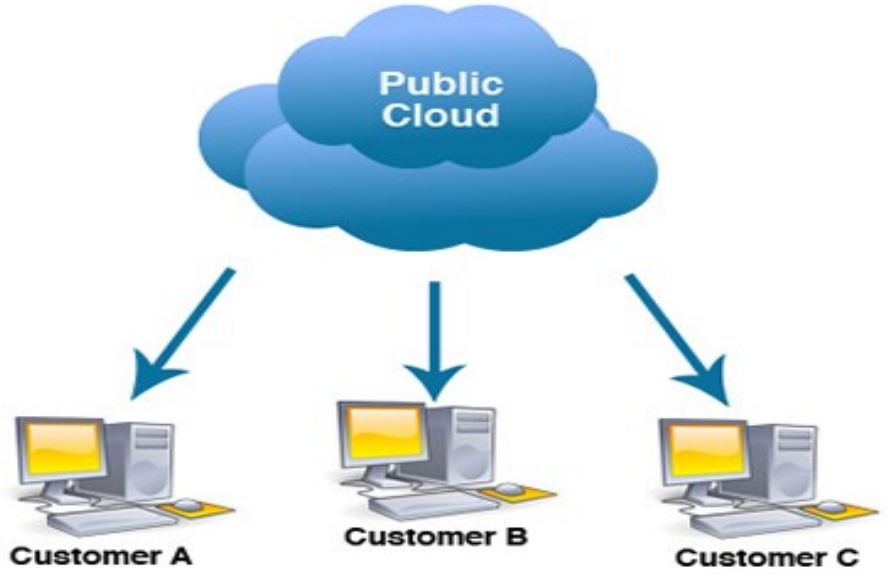


Deployment models of cloud computing

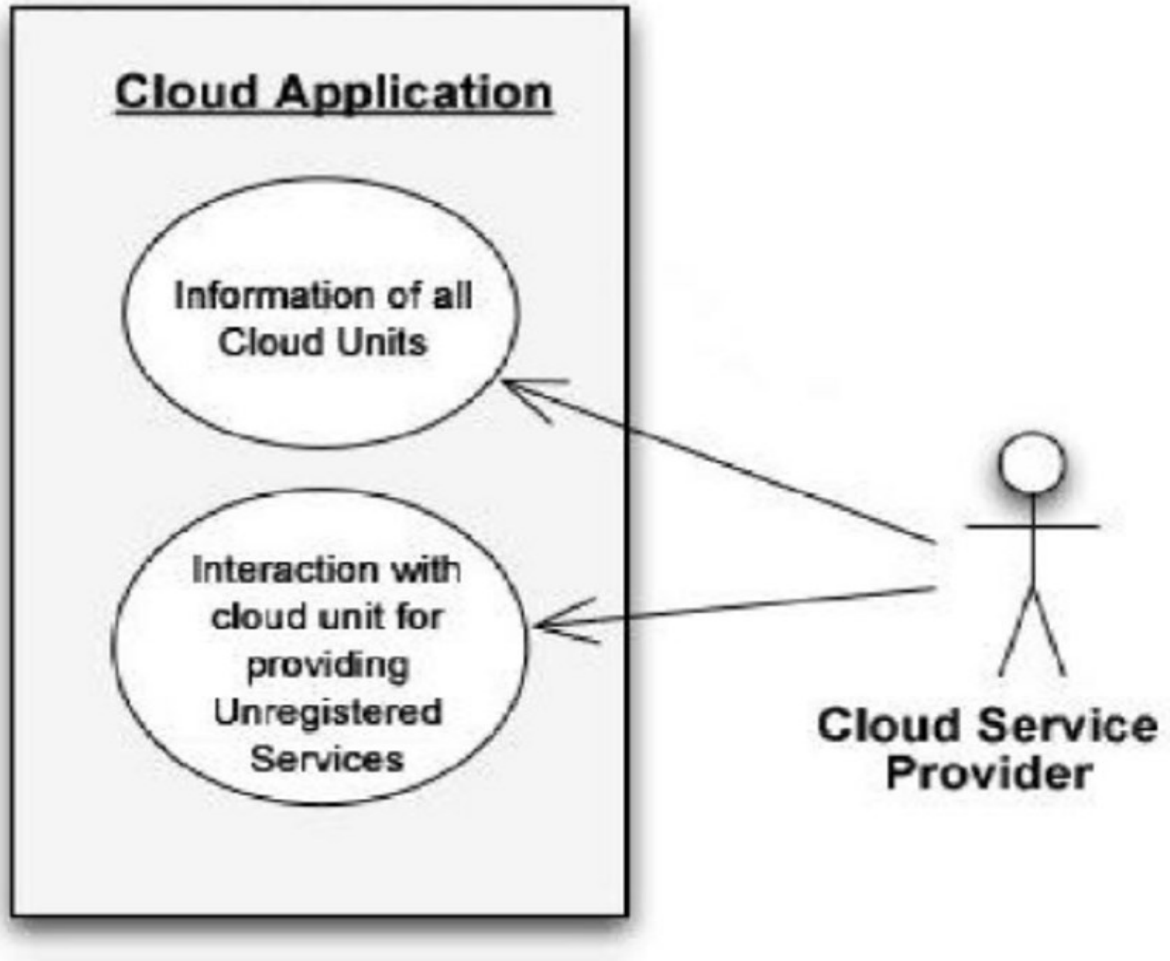


Deployment models of cloud computing : Public cloud

- Public clouds are owned and operated by a third-party cloud service providers(CSP), which deliver their computing resources like servers and storage over the Internet.
- Microsoft Azure is an example of a public cloud. With a public cloud, all hardware, software and other supporting infrastructure is owned and managed by the cloud provider. You access these services and manage your account using a web browser.



Use case diagram of Cloud Service Provider

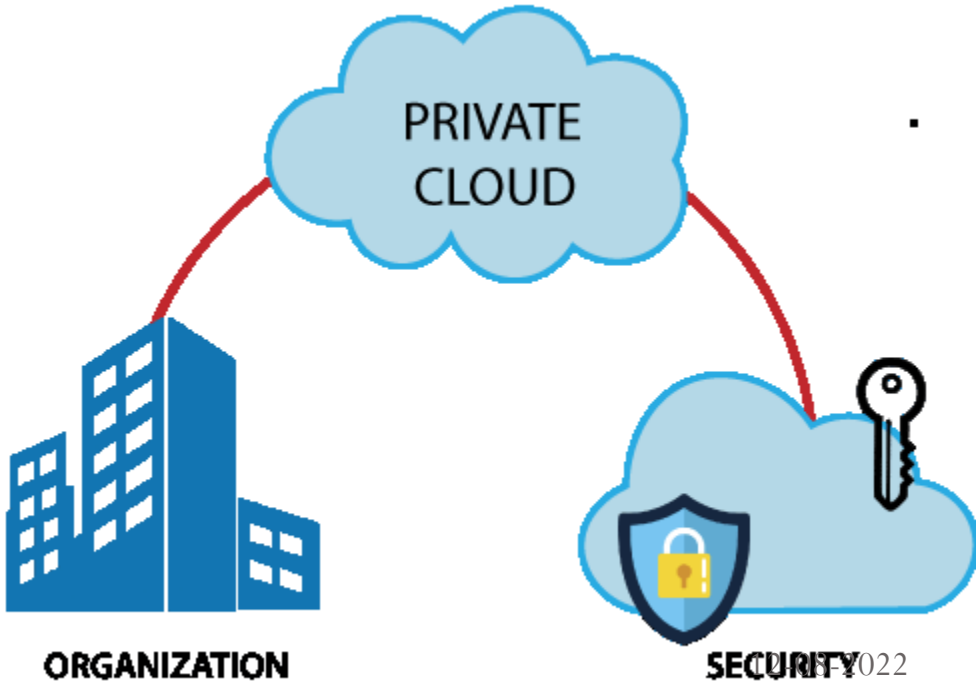


Deployment models of cloud computing : Public cloud

- A cloud is called a 'Public cloud' when the services are left over a network that aims for public use.
- Technically there may be little or no distinction between public and exclusive cloud architecture, nonetheless, safety consideration may be significantly different for services (applications, storage, and most resources) that are provided by a service provider for a public network and when communication is effected over a non-trusted network.
- Normally, public cloud company like Amazon AWS, Microsoft and Google own and operate the facilities and offer access just through the Web (direct connection is not offered).

Deployment models of cloud computing : Private cloud

- A private cloud refers to cloud computing resources used exclusively by a single business or organization.
- A private cloud can be physically located on the company's on-site datacenter. Some companies also pay third-party service providers to host their private cloud. A private cloud is one in which the services and infrastructure are maintained on a private network.



Deployment models of cloud computing : Private cloud

- Private cloud is a cloud facility run only for a single company, whether taken care of internally or by a third-party and held inside or externally.
- Undertaking a private cloud job calls for a significant degree and diploma of involvement to virtualize business environment, and calls for the organization to re-evaluate decisions regarding already existing sources. When done right, it can boost business, yet every action in the task raises security issues that should be addressed to stop serious susceptibilities.

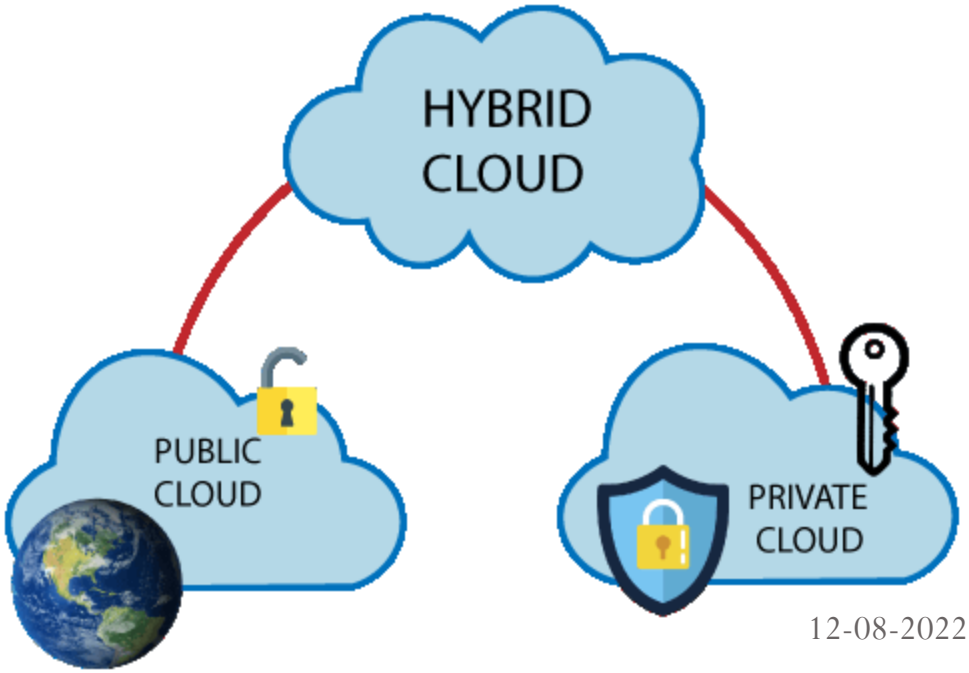
Public vs Private Cloud

VS

Publicly Shared Virtualized Resources		Privately Shared Virtualized Resources
Supports Multiple Customers		Cluster of Dedicated Customers
Supports Internet Connectivity		Connectivity Over Internet, Fiber, and Private Network
Suited for Less Confidential Information		Suited for Secured Confidential Information and Core Systems

Deployment models of cloud computing : Hybrid cloud

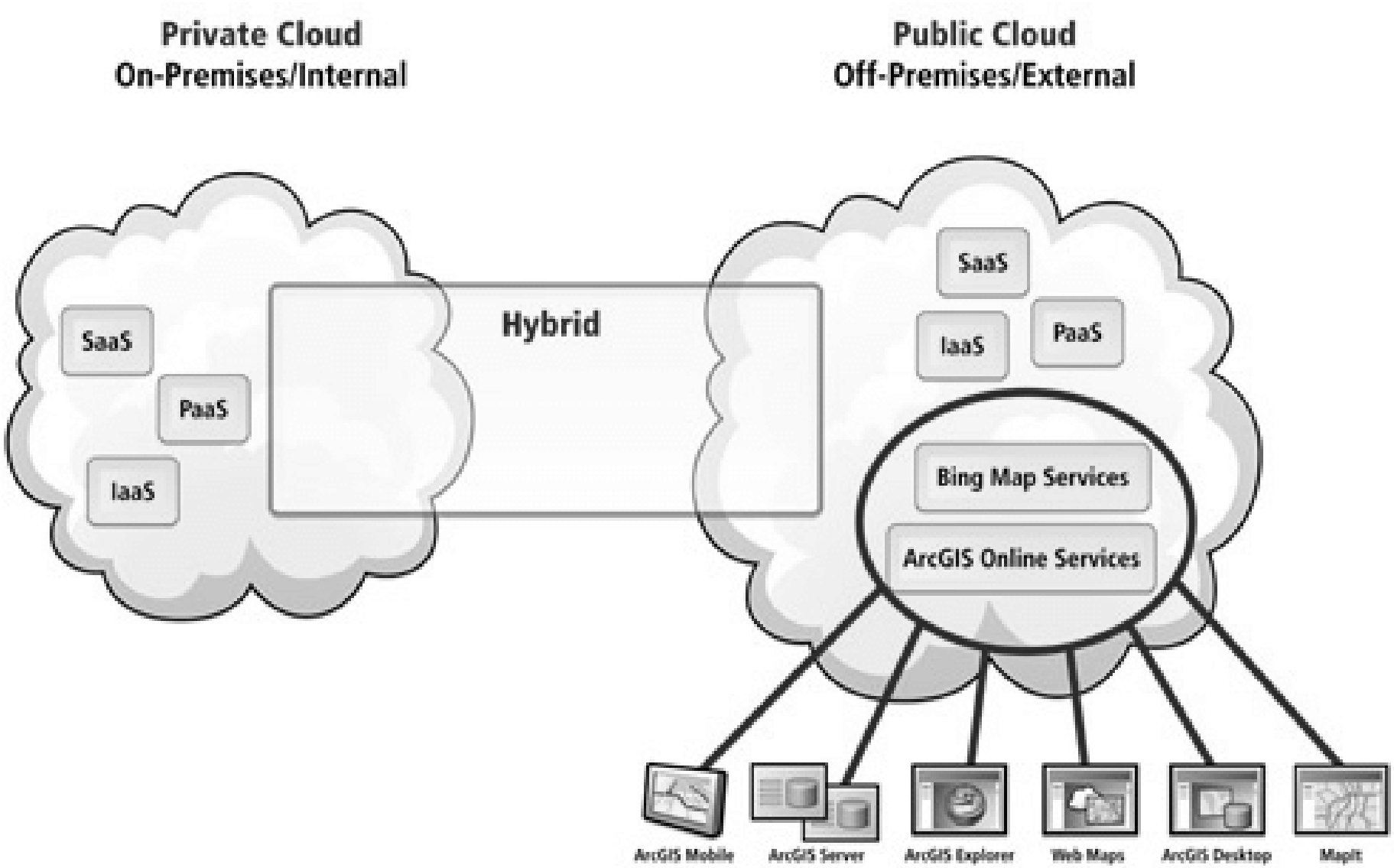
- Hybrid clouds combine public and private clouds, bound together by technology that allows data and applications to be shared between them.
- By allowing data and applications to move between private and public clouds, a hybrid cloud gives your business greater flexibility, more deployment options and helps optimise your existing infrastructure, security and compliance.



Deployment models of cloud computing : Hybrid cloud

- Hybrid cloud is a composition of two or even more clouds (private, neighborhood or people) that stay distinct bodies however, are bound together, supplying the benefits of several implementation models. Such make-up increases deployment choices for cloud services, permitting IT organizations to utilize public cloud computing resources to fulfill temporary needs. This capability enables hybrid clouds to utilize cloud breaking for scaling throughout clouds.
- Cloud bursting is an application implementation design in which an application runs in an exclusive cloud or information facility and "bursts" to a public cloud when the demand for computing ability boosts. A key benefit of cloud bursting and a hybrid cloud model is that an organization just pays for added compute resources when they are required.
- Cloud bursting allows information centers to develop an in-house IT facilities that assists average works, and use cloud sources from public or private clouds, during spikes in processing demands. By utilizing "hybrid cloud" architecture, firms and individuals have the ability to acquire diplomas of mistake tolerance combined with locally prompt functionality without dependence on internet connectivity.
- Hybrid cloud architecture needs both on-premises resources and off-site (distant) server-based cloud facilities.
- Hybrid clouds lack the versatility, protection and certainty of in-house applications. Hybrid cloud gives the adaptability of in home applications with the fault tolerance and scalability of cloud based services.

Hybrid Cloud



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.

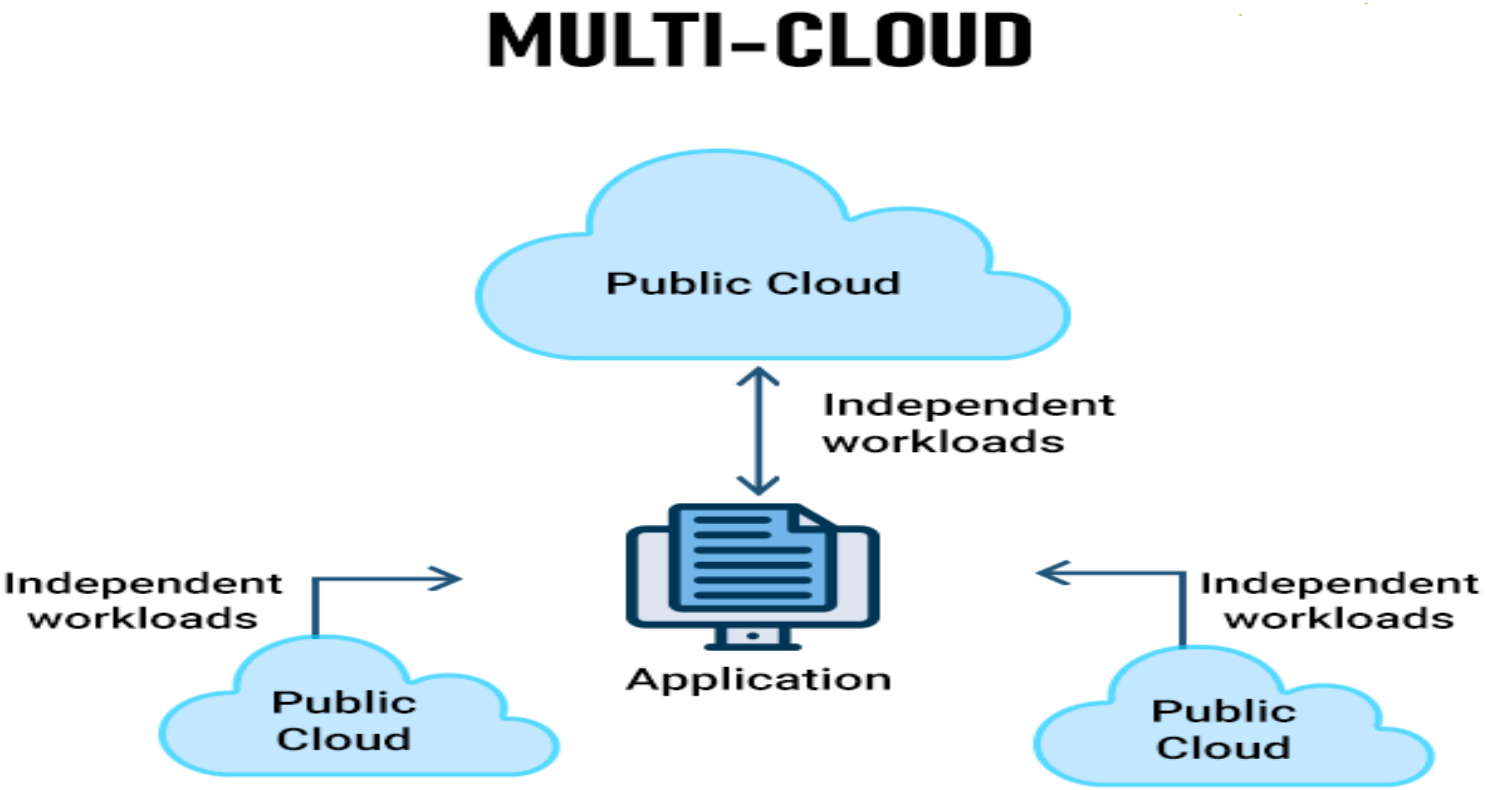
Public, Private or Hybrid Cloud: Which One is Right for You?

Community Cloud

- Community cloud shares facilities in between many companies from a particular neighborhood with usual concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third-party and hosted internally or on the surface.
- The prices are dispersed over fewer individuals than a public cloud (yet even more than a personal cloud), so just some of the expense savings potential of cloud computer are understood.
- Community cloud is a cloud infrastructure that allows systems and services to be accessible by a group of several organizations to share the information. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them.
- **Example:** Our government organization within India may share computing infrastructure in the cloud to manage data. **https://cloud.gov.in/**

Multi-Cloud

Multicloud is a cloud approach made up of more than 1 cloud service, from more than one cloud vendor(public or private). In general "Multi-cloud" means **multiple public clouds**.



Defining MultiCloud

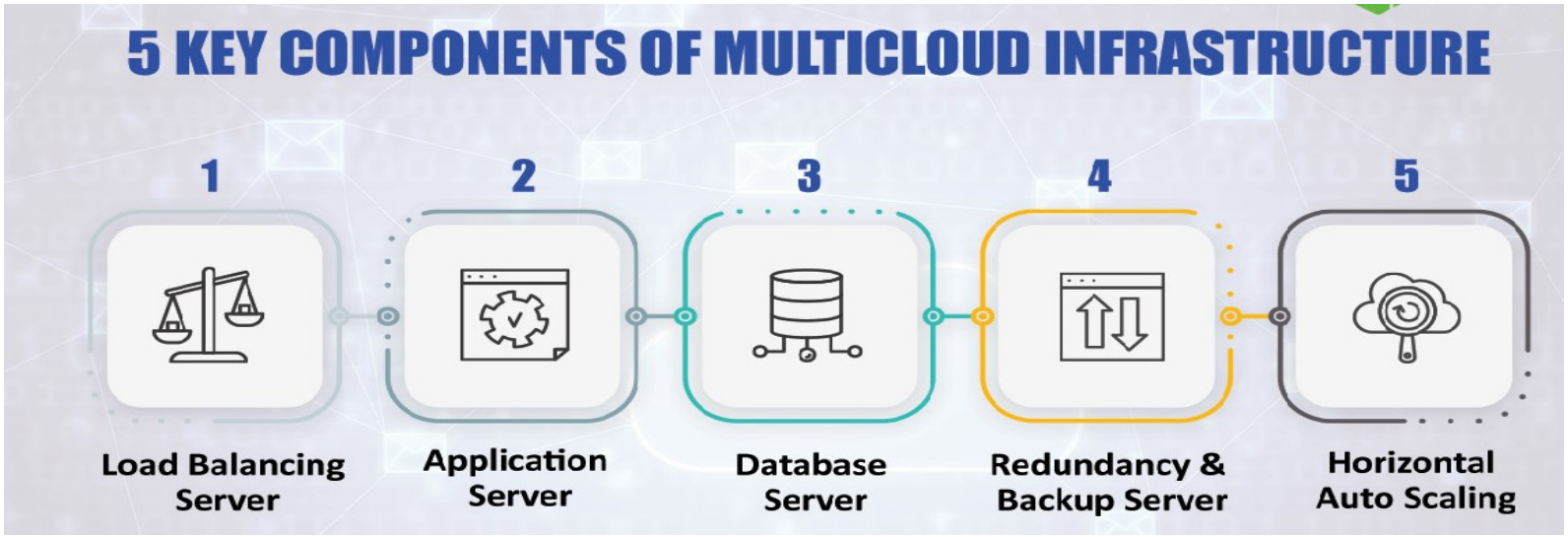
- Multicloud is a cloud approach made up of more than 1 cloud service, from more than 1 cloud vendor(public or private). In general "Multi-cloud" means multiple public clouds.
- A company that uses a multi-cloud deployment incorporates multiple public clouds from more than one cloud provider.
- Instead of a business using one vendor for cloud hosting, storage, and the full application stack, in a multi-cloud configuration they use several.

Defining MultiCloud

- Multicloud infrastructure is defined as a cloud environment that allows enterprises to use two or more cloud platforms.
- Multicloud infrastructure often relies on public cloud. A company's cloud environment generally needs to leverage at least two public cloud services for a 'multicloud' tag.
- Multicloud infrastructure combines on-premise activities with applications and services operating on multiple public cloud platforms, allowing companies to leverage the upsides of each vendor while mitigating the disadvantages.
- Multi-cloud deployments have a number of uses. A multi-cloud deployment can leverage multiple IaaS (Infrastructure-as-a-Service) vendors, or it could use a different vendor for IaaS, PaaS (Platform-as-a-Service), and SaaS (Software-as-a-Service) services.
- Multi-cloud can be purely for the purpose of redundancy and system backup, or it can incorporate different cloud vendors for different services.

5 Key Components of Multicloud Infrastructure

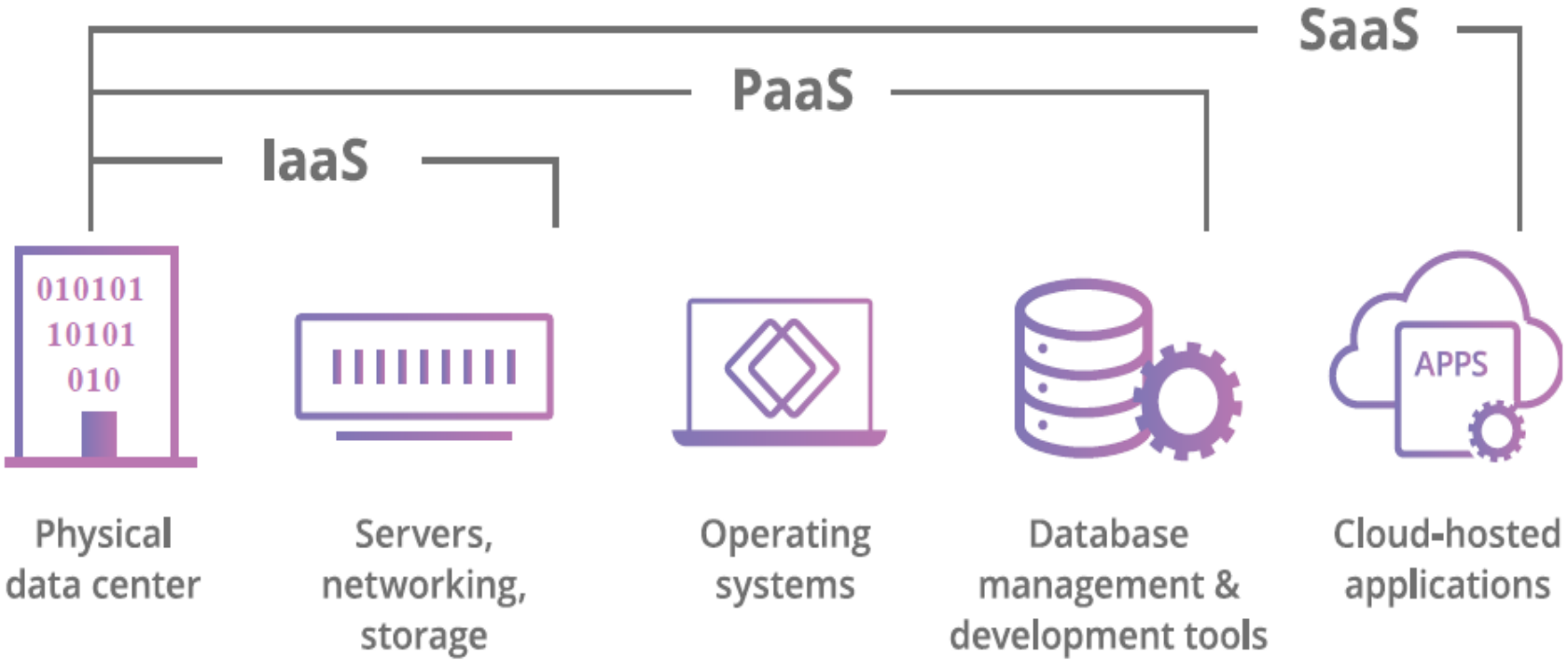
1. Load balancing server
2. Application server
3. Database server
4. Redundancy and backup server
5. Horizontal auto scaling



Types of cloud services
IaaS, PaaS, serverless and SaaS

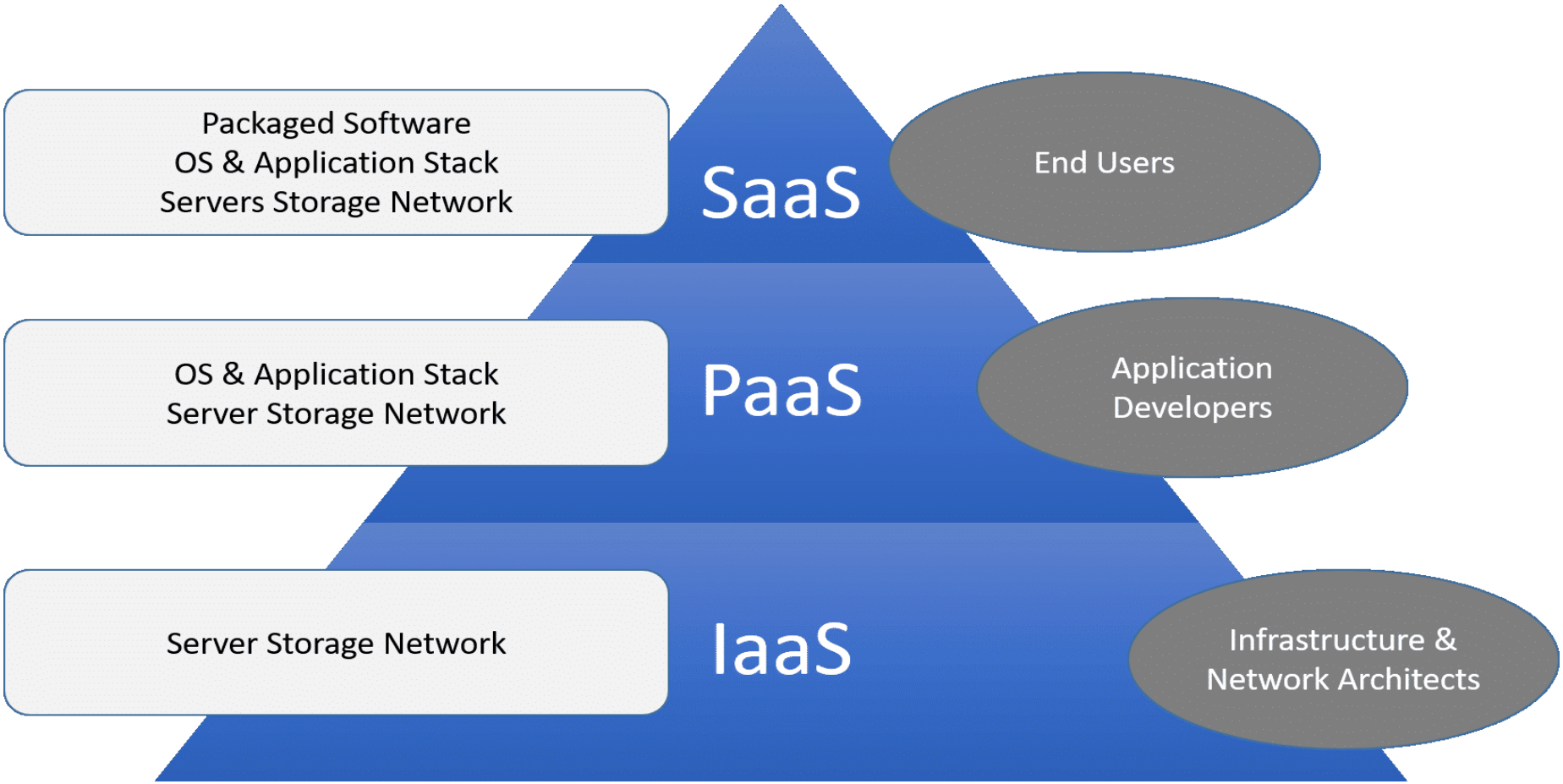
Types of cloud services: IaaS, PaaS, serverless and SaaS

Most cloud computing services fall into four broad categories: infrastructure as a service (IaaS), platform as a service (PaaS), serverless and software as a service (SaaS).

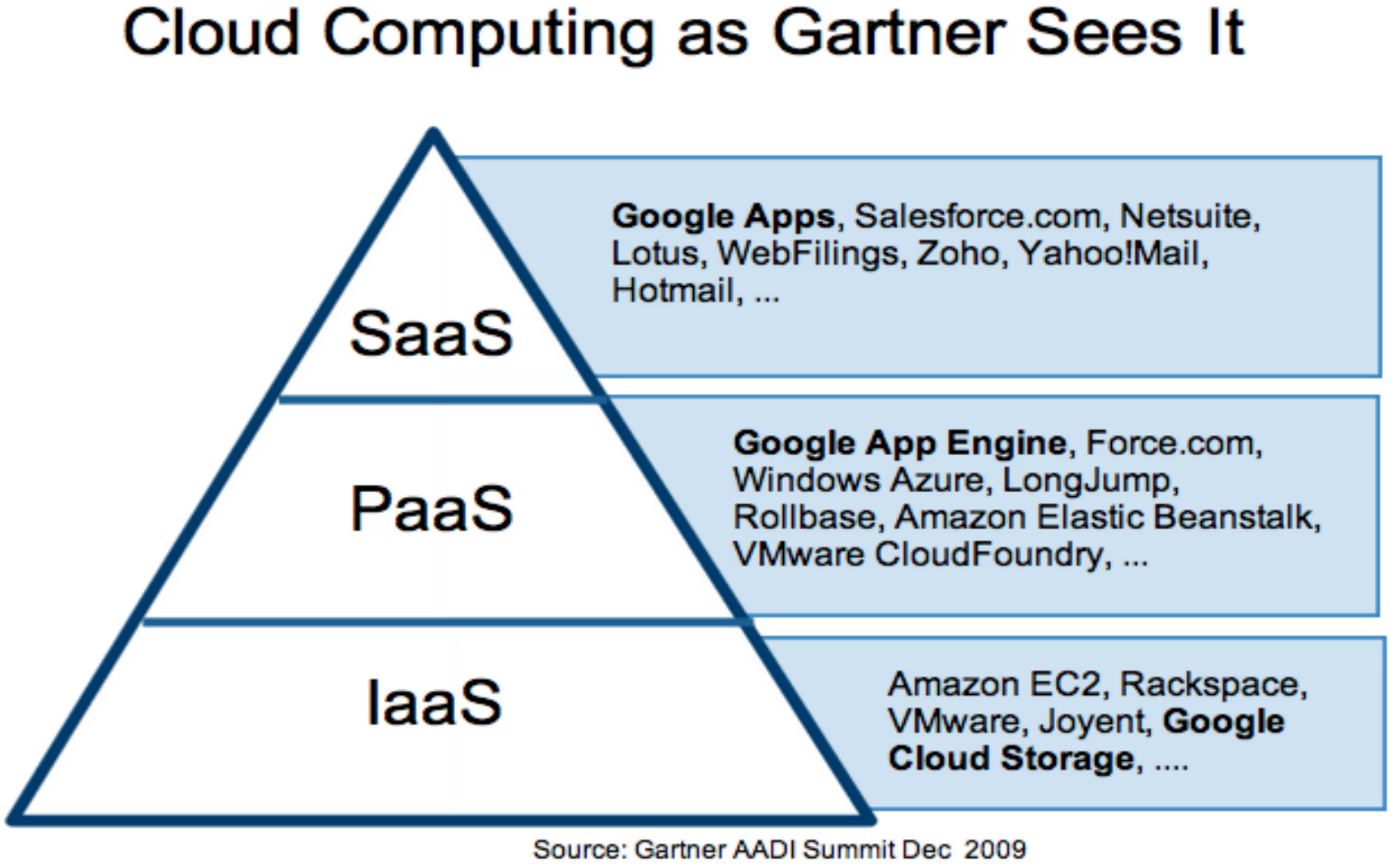


Types of cloud services: IaaS, PaaS, serverless and SaaS

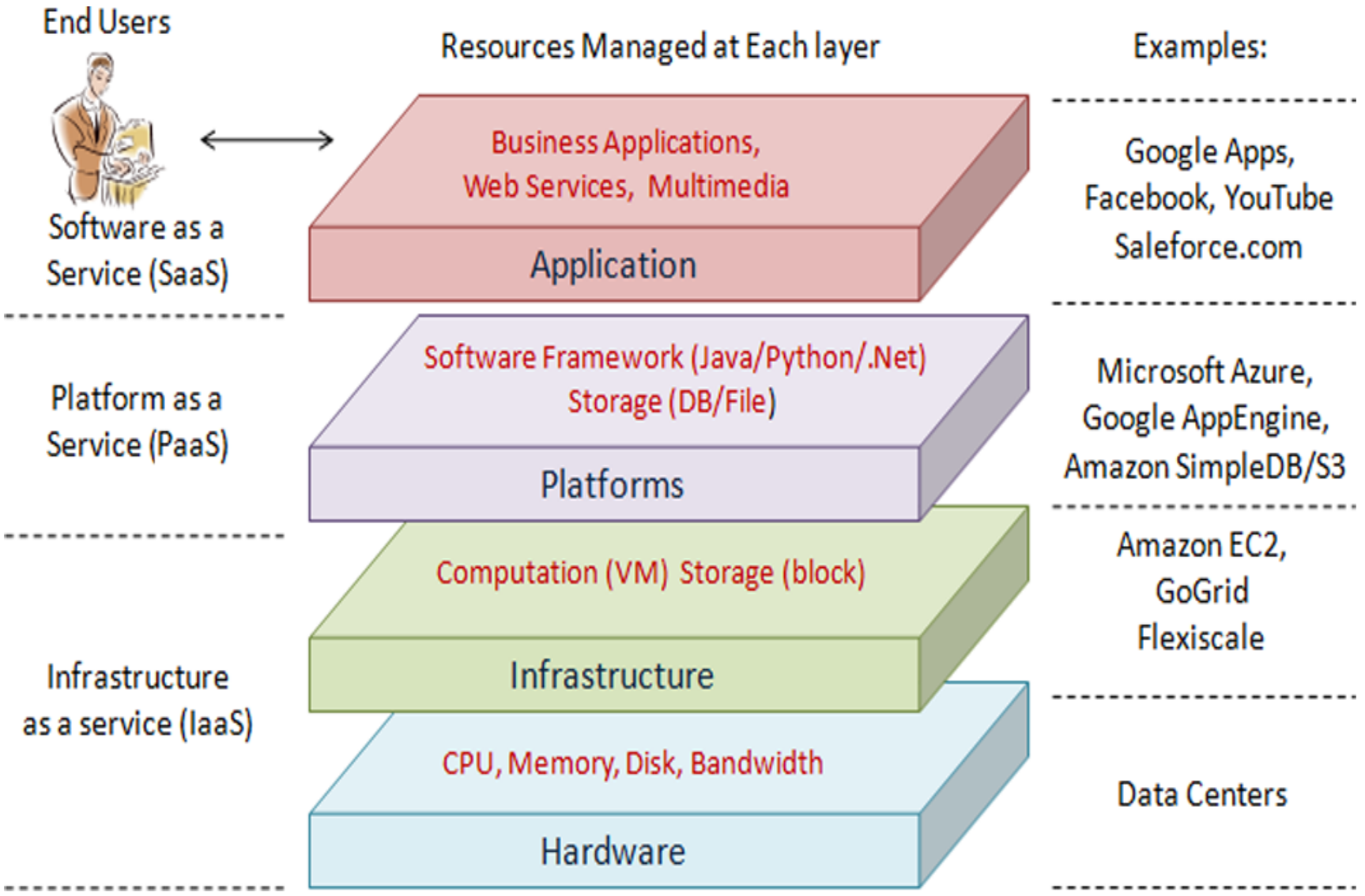
[Cloud Computing Stack]



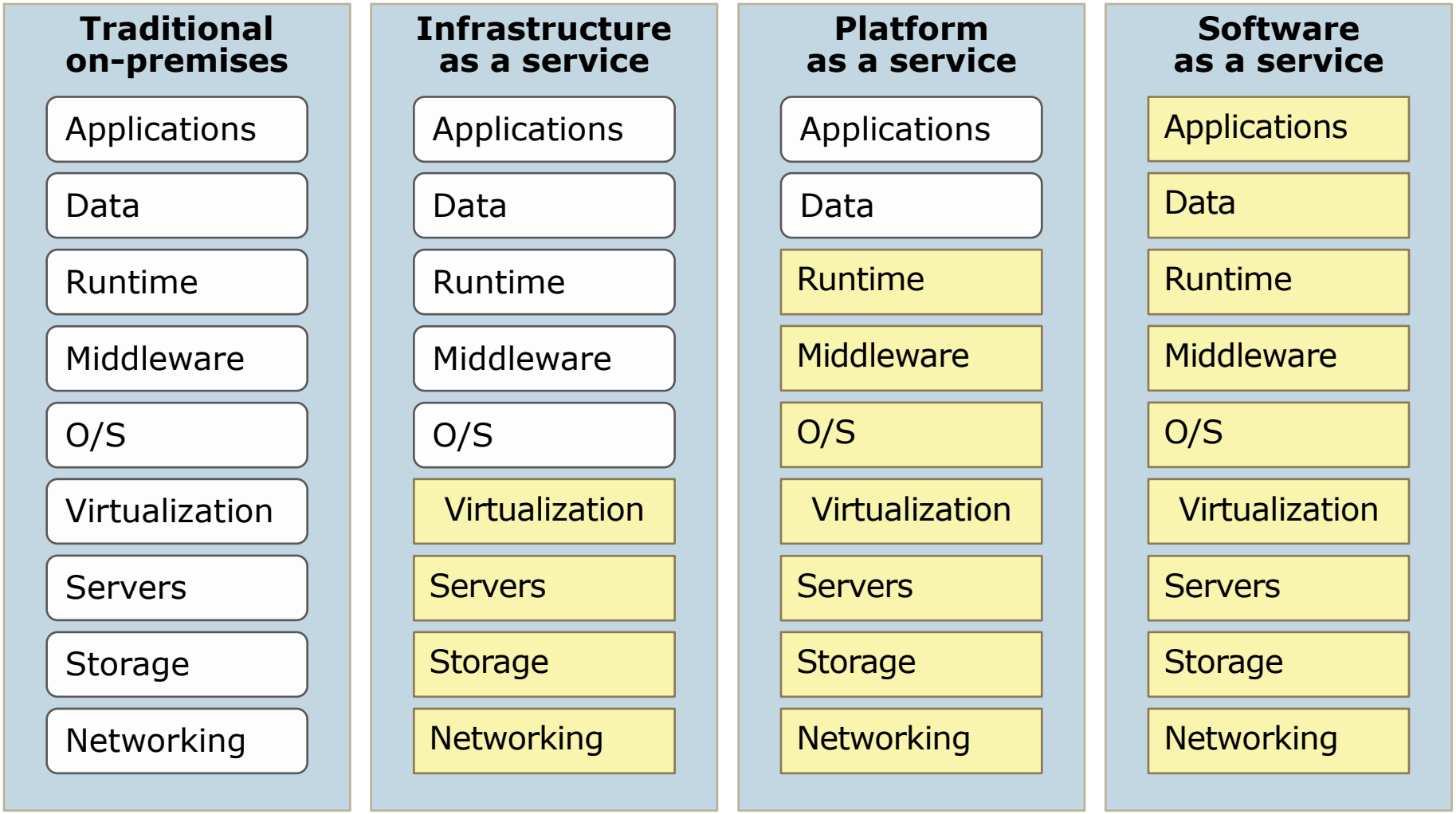
Types of cloud services: IaaS, PaaS, serverless and SaaS



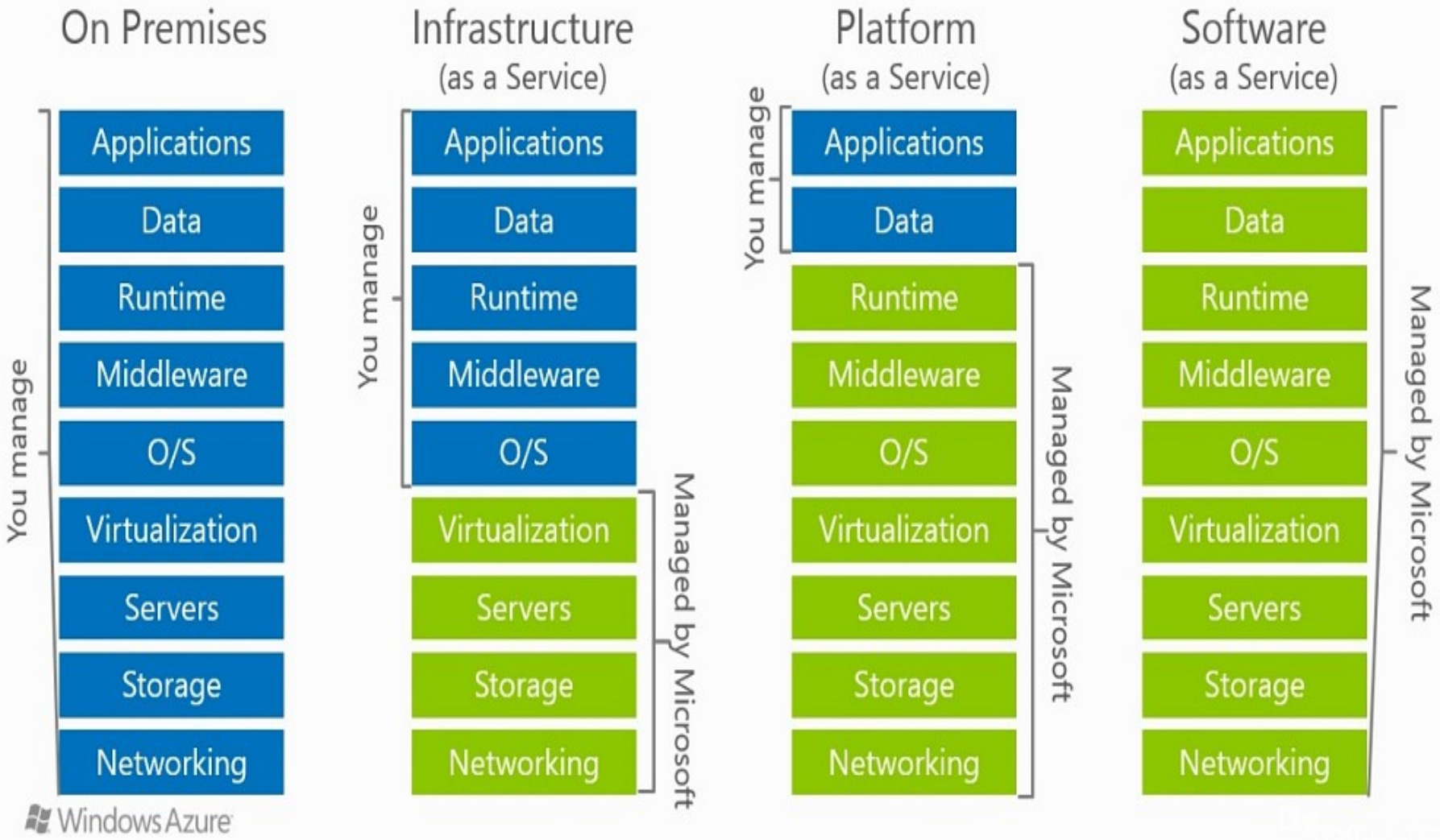
Cloud Layer Architecture



Split of Responsibilities: provider-side and consumer-side

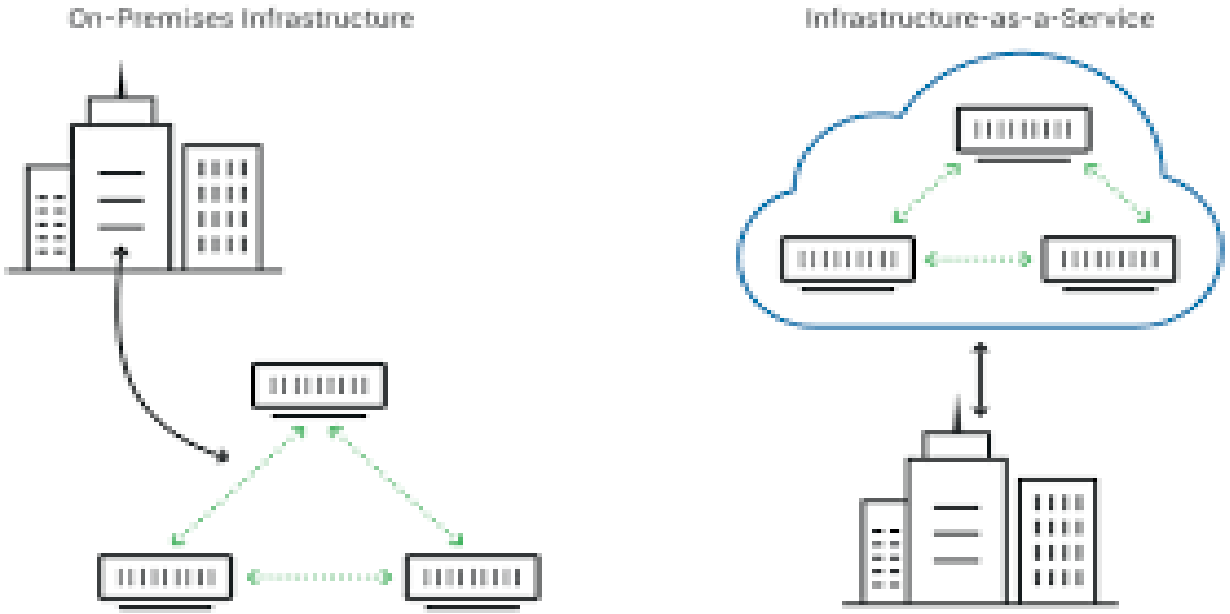


Cloud Models



[1] IaaS (Infrastructure as a Service)

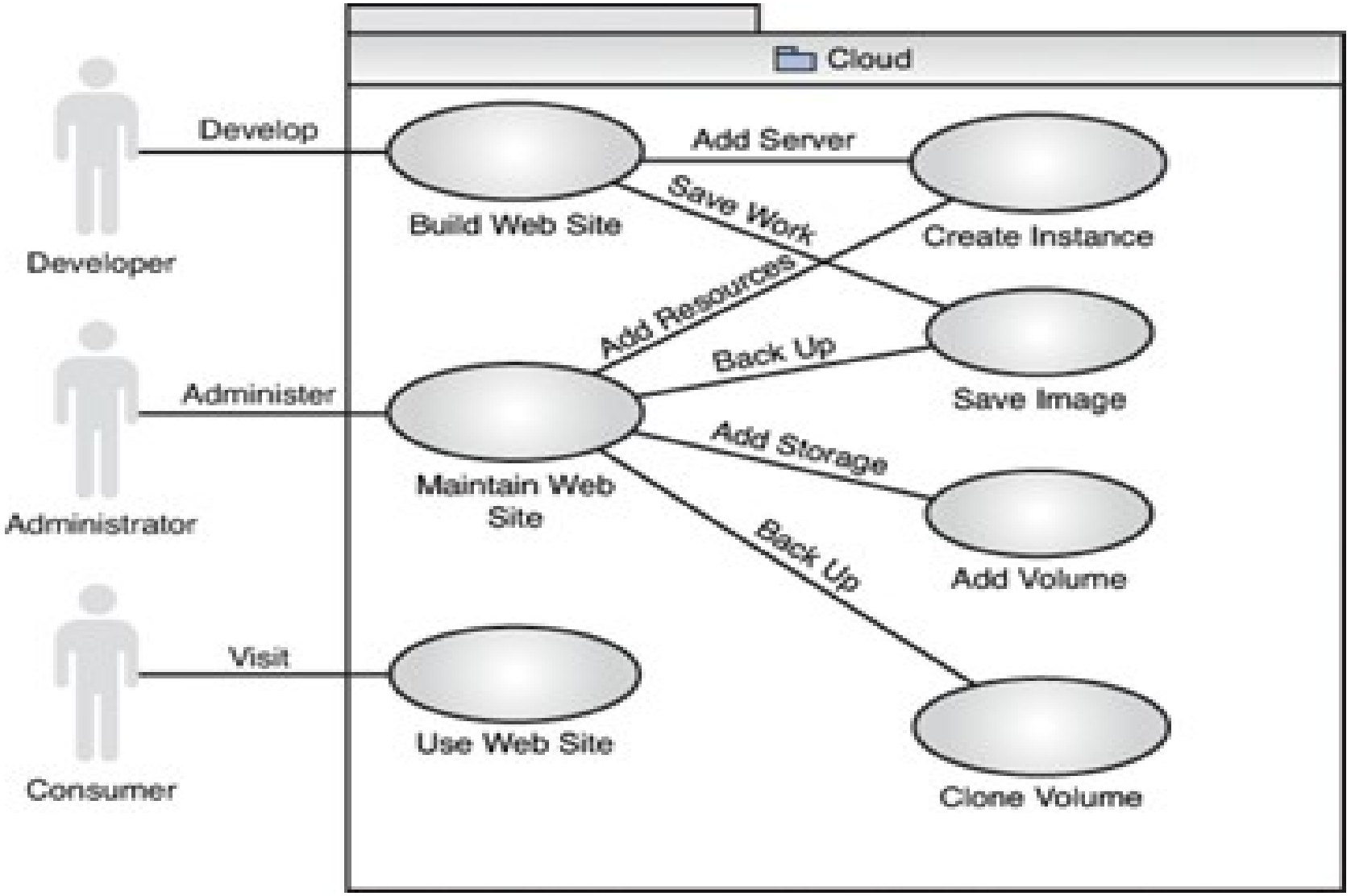
- In computing, infrastructure refers to the computers and servers that run code and store data, and the wires and appliances that make connections between those machines. Example: servers, hard drives, and routers are all part of infrastructure.
- The top 5 vendors of IaaS till this day: Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform (GCP), Alibaba Cloud, IBM Cloud



Infrastructure as a Service (IaaS)

- Infrastructure as a Service, sometimes abbreviated as IaaS, contains the basic building blocks for cloud IT and typically provide access to networking features, computers (virtual or on dedicated hardware), and data storage space.
- Infrastructure as a Service provides you with the highest level of flexibility and management control over your IT resources and is most similar to existing IT resources that many IT departments and developers are familiar with today.
- IaaS is used for Internet-based access to storage and computing power.
- IaaS lets you rent IT infrastructure - servers and virtual machines, storage, networks, and operating systems - from a cloud provider on a pay-as-you-go basis.

Use Cases | Infrastructure as a Service Cloud Concepts



Common IaaS business scenarios

- **Test and development:** Teams can quickly set up and dismantle test and development environments, bringing new applications to market faster. IaaS makes it quick and economical to scale up dev-test environments up and down.

- **Website hosting:** Running websites using IaaS can be less expensive than traditional web hosting.

- **Storage, backup and recovery:** Organisations avoid the capital outlay for storage and complexity of storage management, which typically requires a skilled staff to manage data and meet legal and compliance requirements. IaaS is useful for handling unpredictable demand and steadily growing storage needs. It can also simplify planning and management of backup and recovery systems.

Common IaaS business scenarios

- **Web apps:** IaaS provides all the infrastructure to support web apps, including storage, web and application servers and networking resources. Organisations can quickly deploy web apps on IaaS and easily scale infrastructure up and down when demand for the apps is unpredictable.

- **High-performance computing:** High-performance computing (HPC) on supercomputers, computer grids or computer clusters helps solve complex problems involving millions of variables or calculations. Examples include earthquake and protein folding simulations, climate and weather predictions, financial modeling and evaluating product designs.

- **Big data analysis.** Big data is a popular term for massive data sets that contain potentially valuable patterns, trends and associations. Mining data sets to locate or tease out these hidden patterns requires a huge amount of processing power, which IaaS economically provides.

Advantages of IaaS

- **Eliminates capital expense and reduces ongoing cost.** IaaS sidesteps the upfront expense of setting up and managing an onsite datacentre, making it an economical option for start-ups and businesses testing new ideas.
- **Improves business continuity and disaster recovery.** Achieving high availability, business continuity and disaster recovery is expensive, since it requires a significant amount of technology and staff. But with the right service level agreement (SLA) in place, IaaS can reduce this cost and access applications and data as usual during a disaster or outage.
- **Innovate rapidly.** As soon as you have decided to launch a new product or initiative, the necessary computing infrastructure can be ready in minutes or hours, rather than the days or weeks—and sometimes months—it could take to set up internally.
- **Respond quicker to shifting business conditions.** IaaS enables you to quickly scale up resources to accommodate spikes in demand for your application— during the holidays, for example—then scale resources back down again when activity decreases to save money.

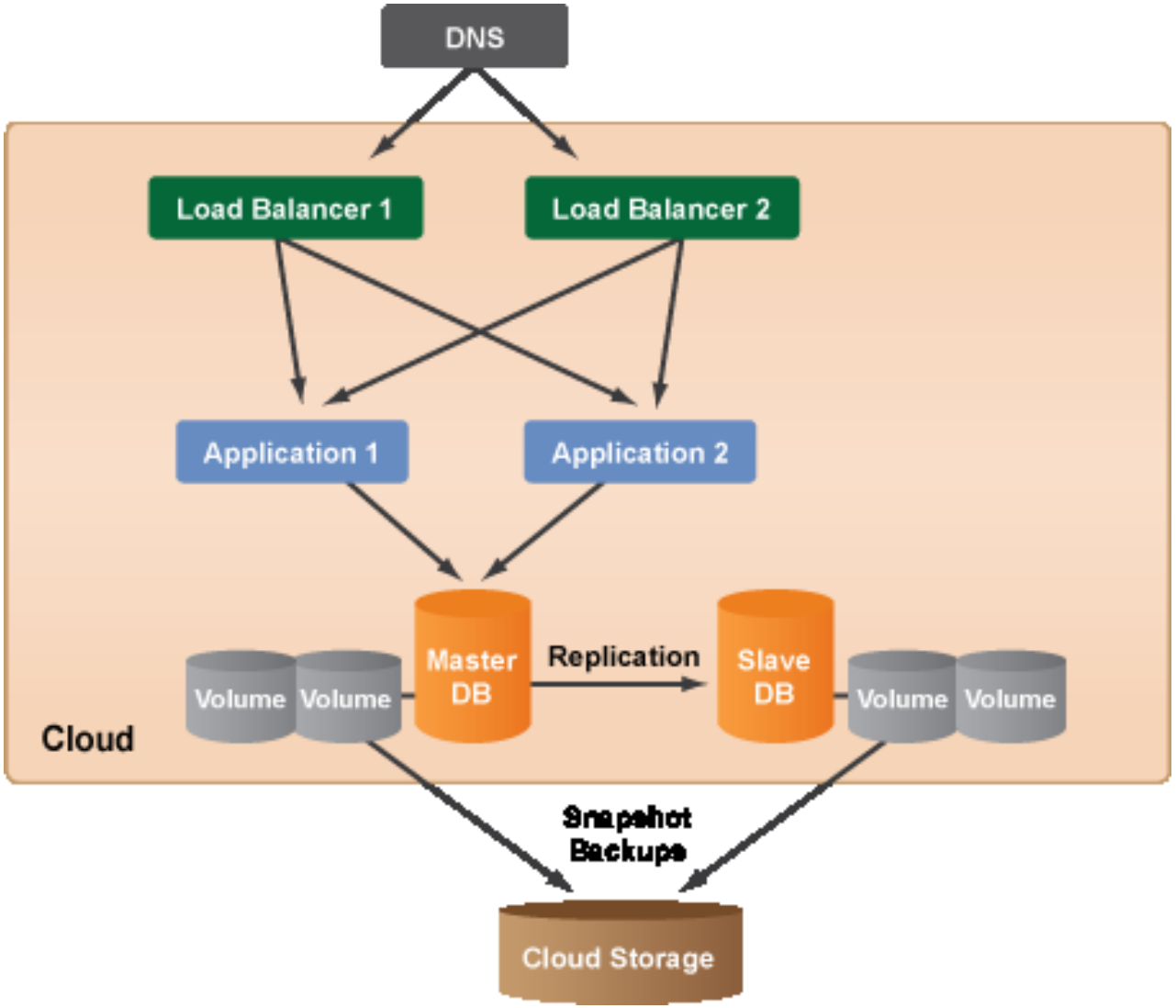
Advantages of IaaS

- **Focus on your core business**. IaaS frees up your team to focus on your organisation's core business rather than on IT infrastructure.
- **Increase stability, reliability and supportability**. With IaaS there is no need to maintain and upgrade software and hardware or troubleshoot equipment problems. With the appropriate agreement in place, the service provider assures that your infrastructure is reliable and meets SLAs.
- **Better security.** With the appropriate service agreement, a cloud service provider can provide security for your applications and data that may be better than what you can attain in-house.
- **Gets new apps to users faster.** Because you don't need to first set up the infrastructure before you can develop and deliver apps, you can get them to users faster with IaaS.

[2] Platform-as-a-service (PaaS)

- Platforms as a service remove the need for organizations to manage the underlying infrastructure (usually hardware and operating systems) and allow you to focus on the deployment and management of your applications.
- PaaS helps you be more efficient as you don't need to worry about resource procurement, capacity planning, software maintenance, patching, or any of the other undifferentiated heavy lifting involved in running your application.
- PaaS gives developers the tools to build and host web applications.
- PaaS is designed to give users access to the components they require to quickly develop and operate web or mobile applications over the Internet, without worrying about setting up or managing the underlying infrastructure of servers, storage, networks, and databases.

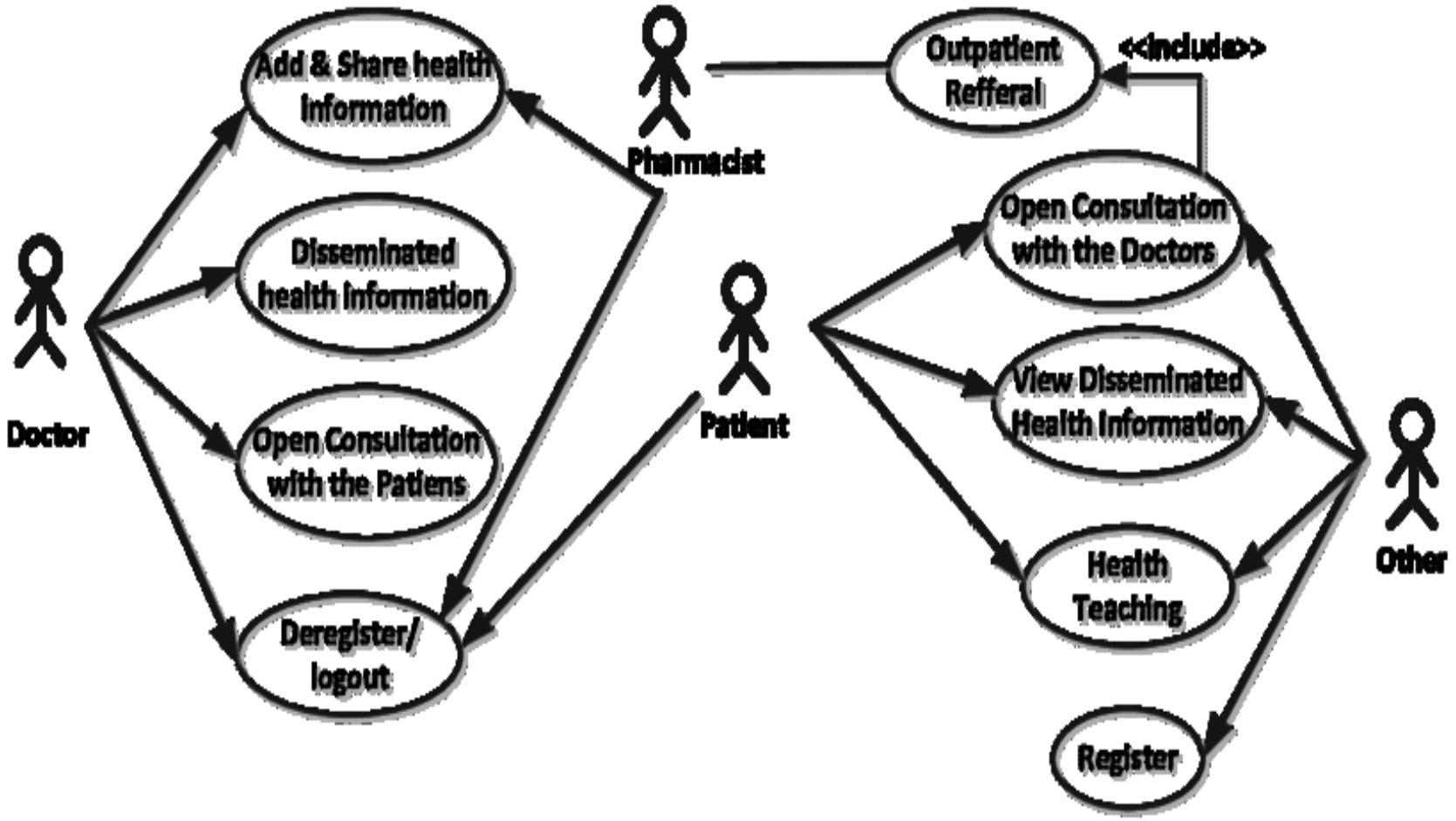
Redundant 3-Tier Architecture



[3] Software-as-a-service (SaaS)

- Software as a Service provides you with a completed product that is run and managed by the service provider. In most cases, people referring to Software as a Service are referring to end-user applications.
- SaaS is used for web-based applications. SaaS is a method for delivering software applications over the Internet where cloud providers host and manage the software applications making it easier to have the same application on all of your devices at once by accessing it in the cloud.
- SaaS offering you do not have to think about how the service is maintained or how the underlying infrastructure is managed; you only need to think about how you will use that particular piece of software.
- A common example of a SaaS application is web-based email where you can send and receive email without having to manage feature additions to the email product or maintaining the servers and operating systems that the email program is running on.

Use Case Diagram SaaS e-health Education

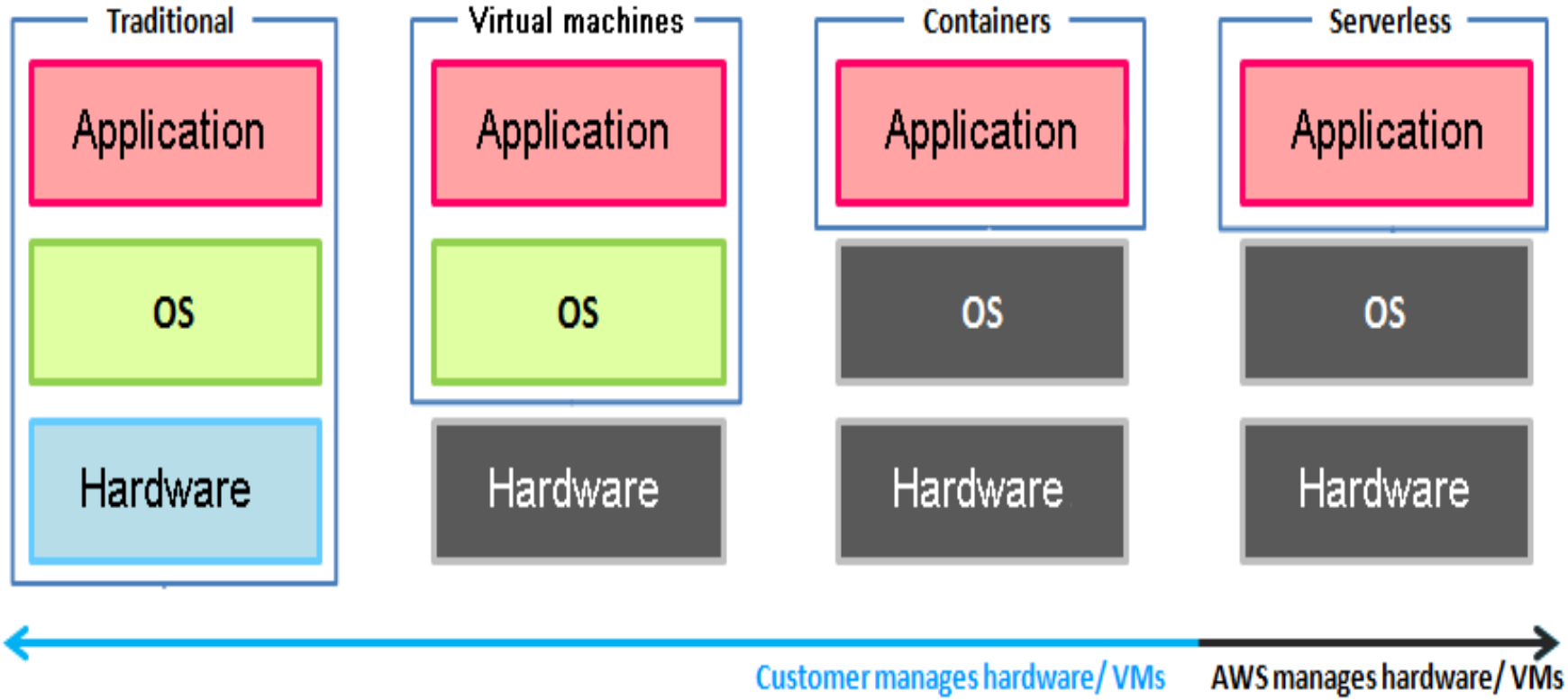


Difference between virtualization & Cloud Computing

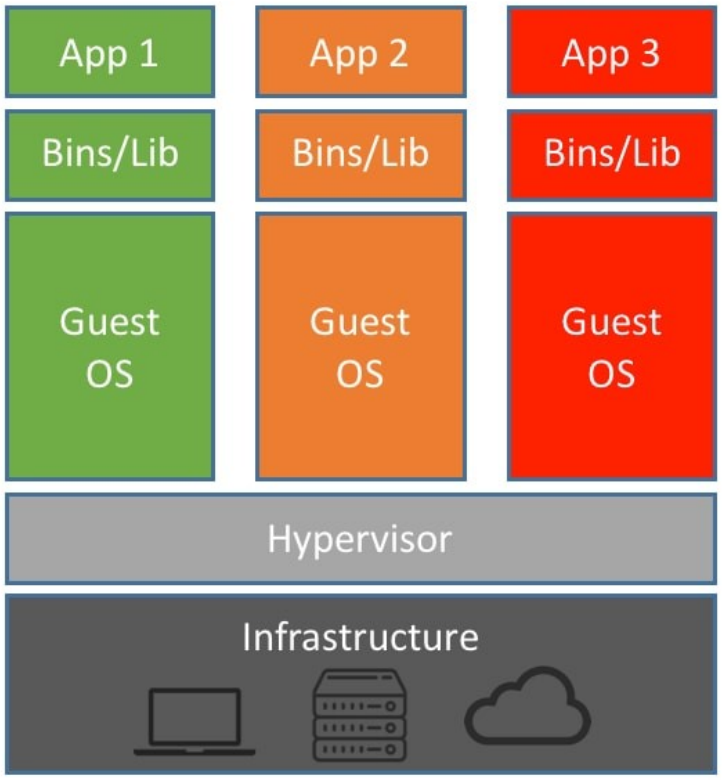
	Virtualization	Cloud
Definition	Technology	Methodology
Purpose	Create multiple simulated environments from 1 physical hardware system	Pool and automate virtual resources for on-demand use
Use	Deliver packaged resources to specific users for a specific purpose	Deliver variable resources to groups of users for a variety of purposes
Configuration	Image-based	Template-based
Lifespan	Years (long-term)	Hours to months (short-term)
Cost	High capital expenditures (CAPEX), low operating expenses (OPEX)	Private cloud: High CAPEX, low OPEX Public cloud: Low CAPEX, high OPEX
Scalability	Scale up	Scale out
Workload	Stateful	Stateless
Tenancy	Single tenant	Multiple tenants

Serverless computing

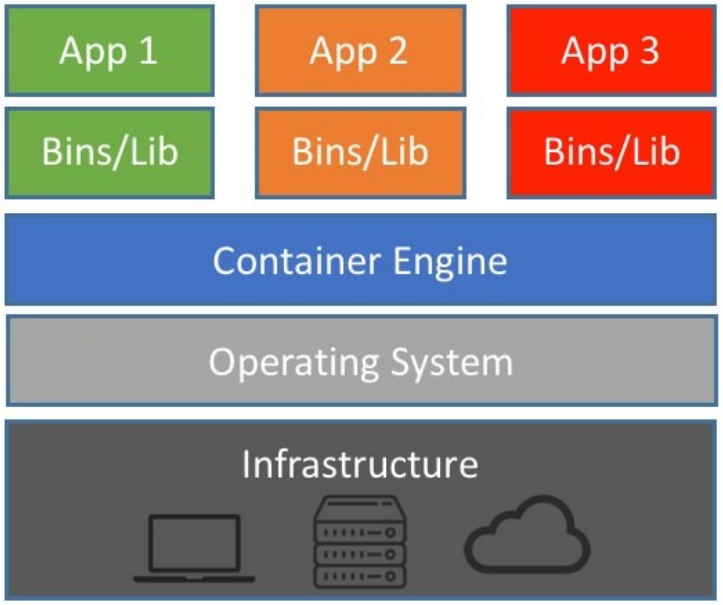
- **Serverless computing** is a cloud **computing** execution model in which the cloud provider runs the **server**, and dynamically manages the allocation of machine resources.



Machine virtualization vs Containers



Machine Virtualization



Containers

Container

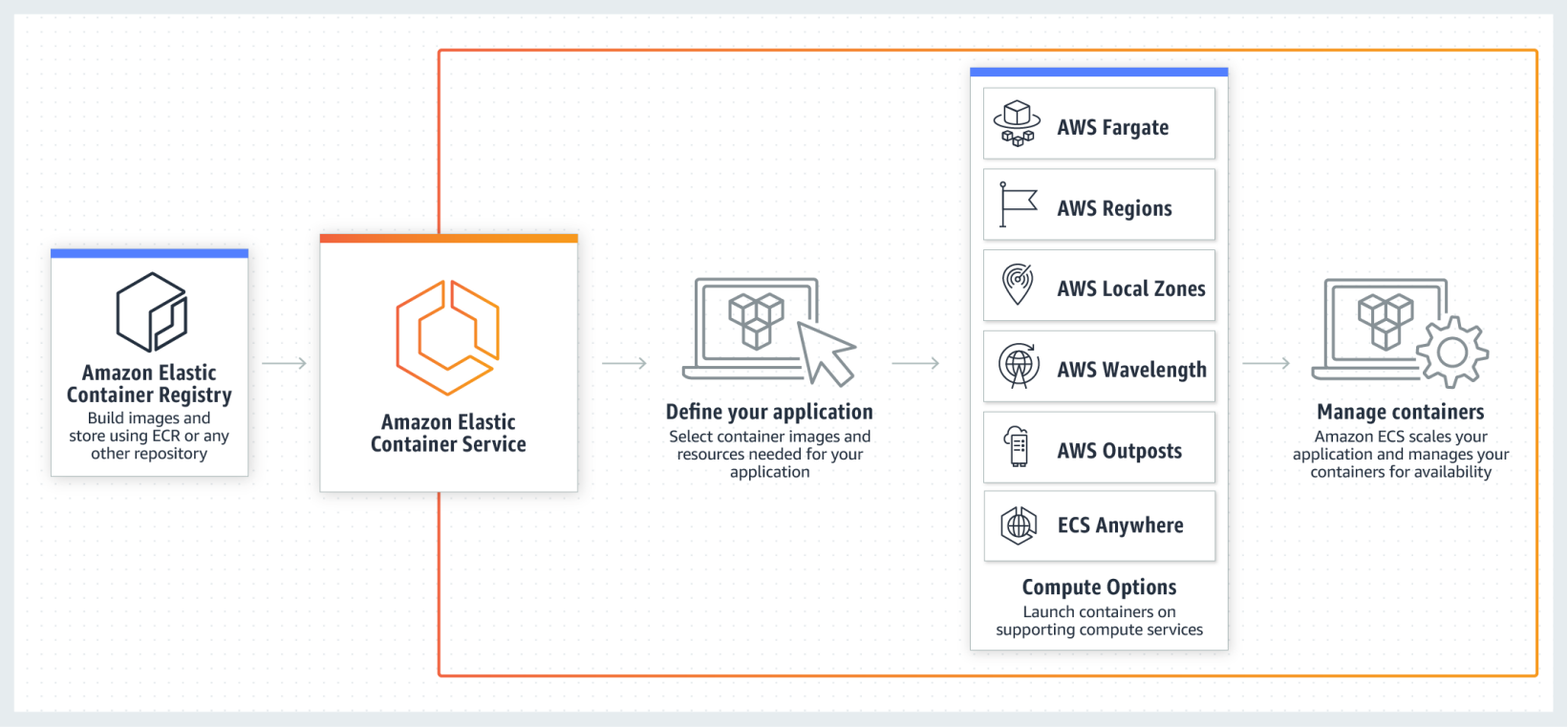
- Containers provide a standard way to package your application's code, configurations, and dependencies into a single object.
- Containers share an operating system installed on the server and run as resource-isolated processes, ensuring quick, reliable, and consistent deployments, regardless of environment.
- Containers are a powerful way for developers to package and deploy their applications. They are lightweight and provide a consistent, portable software environment for applications to easily run and scale anywhere.
- Building and deploying microservices, running batch jobs, for machine learning applications, and moving existing applications into the cloud are just some of the popular use cases for containers.

AWS containers

- Secure: AWS offers 210 security, compliance, and governance services and key features which is about 40 more than the next largest cloud provider. AWS provides strong security isolation between your containers, ensures you are running the latest security updates, and gives you the ability to set granular access permissions for every container.
- Reliable: AWS container services run on the best global infrastructure with 69 Availability Zones (AZ) across 22 Regions. AWS provides >2x more regions with multiple availability zones than the next largest cloud provider (22 vs. 8). There are SLAs for all our container services (ECS, EKS, and Fargate) giving you ease of mind.
- Choice: AWS container services offer the broadest choice of services to run your containers. You can choose AWS Fargate if you want serverless compute for containers and Amazon EC2 if you need control over the installation, configuration, and management of your compute environment. You can also choose which container orchestrator to use: Amazon Elastic Container Service (ECS) or Amazon Elastic Kubernetes Service (EKS).
- AWS Integrations: AWS container services are deeply integrated with AWS by design. This allows your container applications to leverage the breadth and depth of the AWS cloud from networking, security, to monitoring. AWS combines the agility of containers with the elasticity and security of the cloud.

Amazon Elastic Container Service (Amazon ECS)

Amazon ECS leverages serverless technology from AWS Fargate to deliver autonomous container operations, which reduces the time spent on configuration, patching, and security.



Serverless computing

- **Serverless computing** is a method of providing backend services on an as-used basis.
- **Servers** are still used, but a company that gets backend services from a **serverless** vendor is charged based on usage, not a fixed amount of bandwidth or number of **servers**.
- Serverless allows you to build and run applications and services without thinking about servers. It eliminates infrastructure management tasks such as server or cluster provisioning, patching, operating system maintenance, and capacity provisioning.
- You can build them for nearly any type of application or backend service, and everything required to run and scale your application with high availability is handled for you.

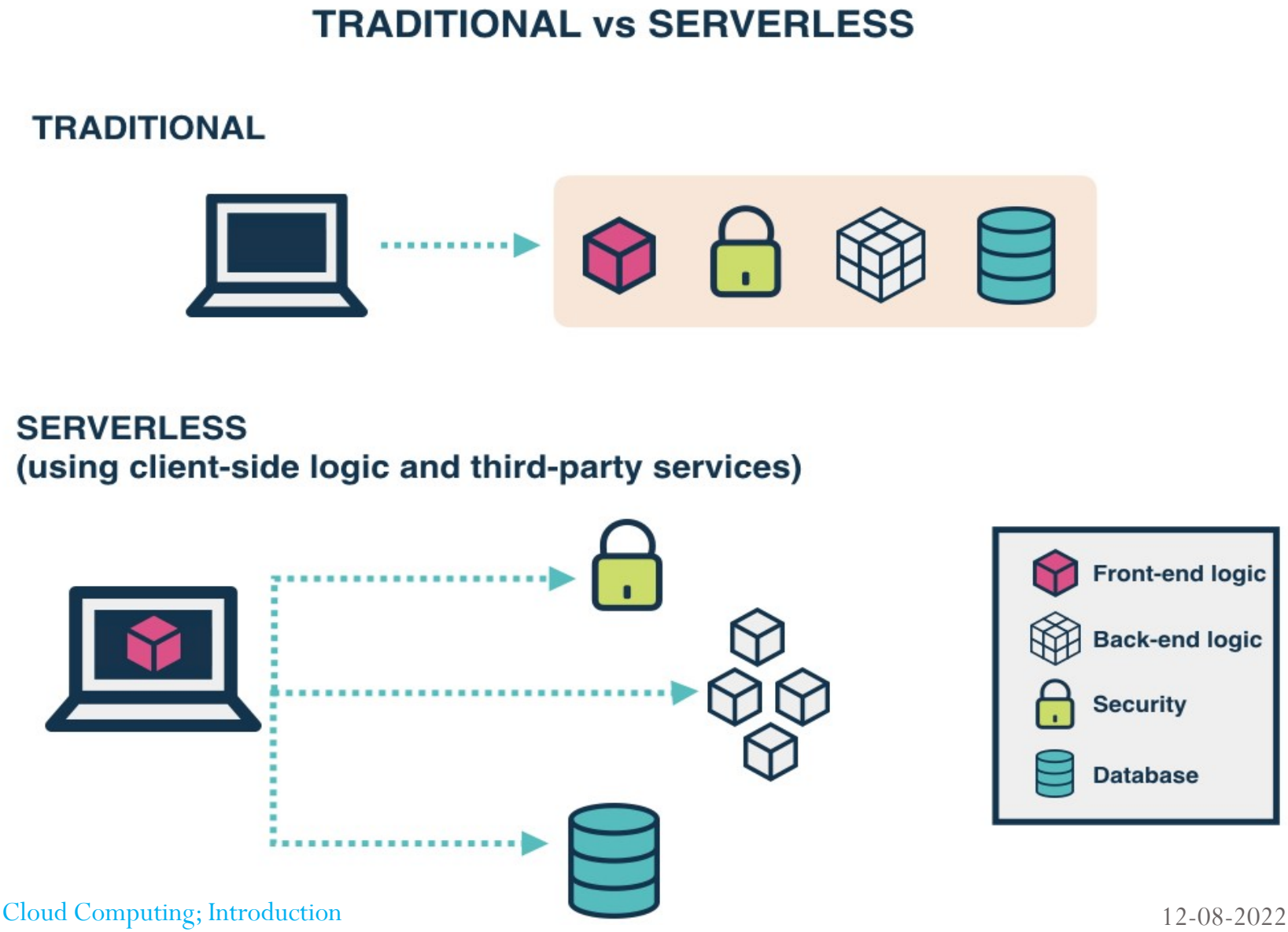
Common containers use cases

- **Microservices:** Containers provide process isolation that makes it easy to break apart and run applications as independent components called microservices.
- **Batch processing:** Package batch processing and ETL jobs into containers to start jobs quickly and scale them dynamically in response to demand.
- **Machine learning:** Use containers to quickly scale machine learning models for training and inference and run them close to your data sources on any platform.
- **Hybrid applications:** Containers let you standardize how code is deployed, making it easy to build workflows for applications that run between on-premises and cloud environments.
- **Application migration to the cloud**: Containers make it easy to package entire applications and move them to the cloud without needing to make any code changes.
- **Platform as a service:** Use containers to build platforms that remove the need for developers to manage infrastructure and standardize how your applications are deployed and managed.

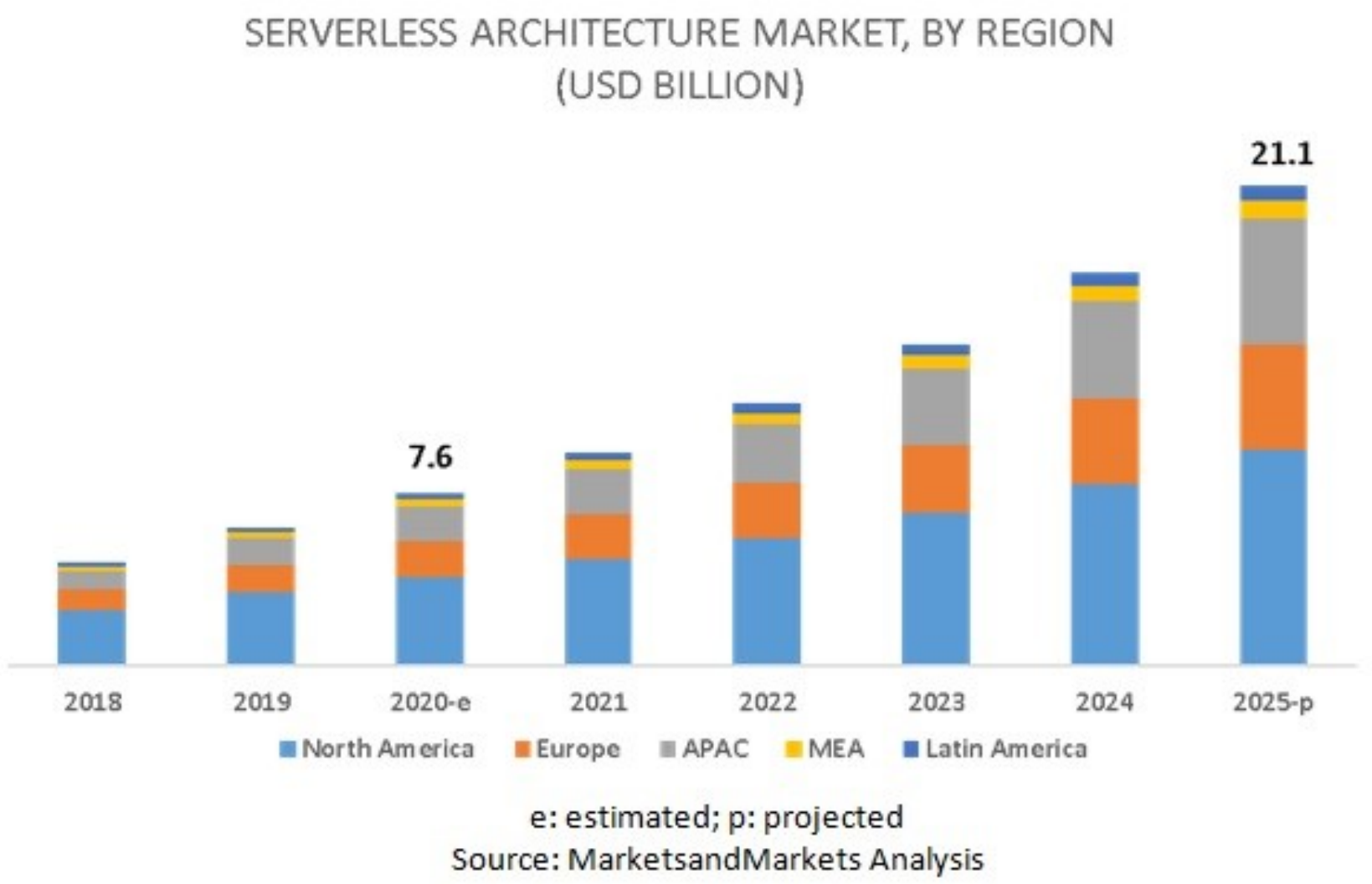
Serverless computing

- Serverless is the native architecture of the cloud that enables you to shift more of your operational responsibilities to AWS, increasing your agility and innovation.
- Serverless enables you to build **modern applications** with **increased agility** and lower total cost of ownership.
- Building serverless applications means that your developers can focus on their core product instead of worrying about managing and operating servers or runtimes, either in the cloud or on-premises.
- Serverless technology reduced overhead lets developers reclaim time and energy that can be spent on developing great products which scale and that are reliable.
- A computing model in which the cloud provider provisions and manages servers. It enables developers to spend more time building apps and less time managing infrastructure.

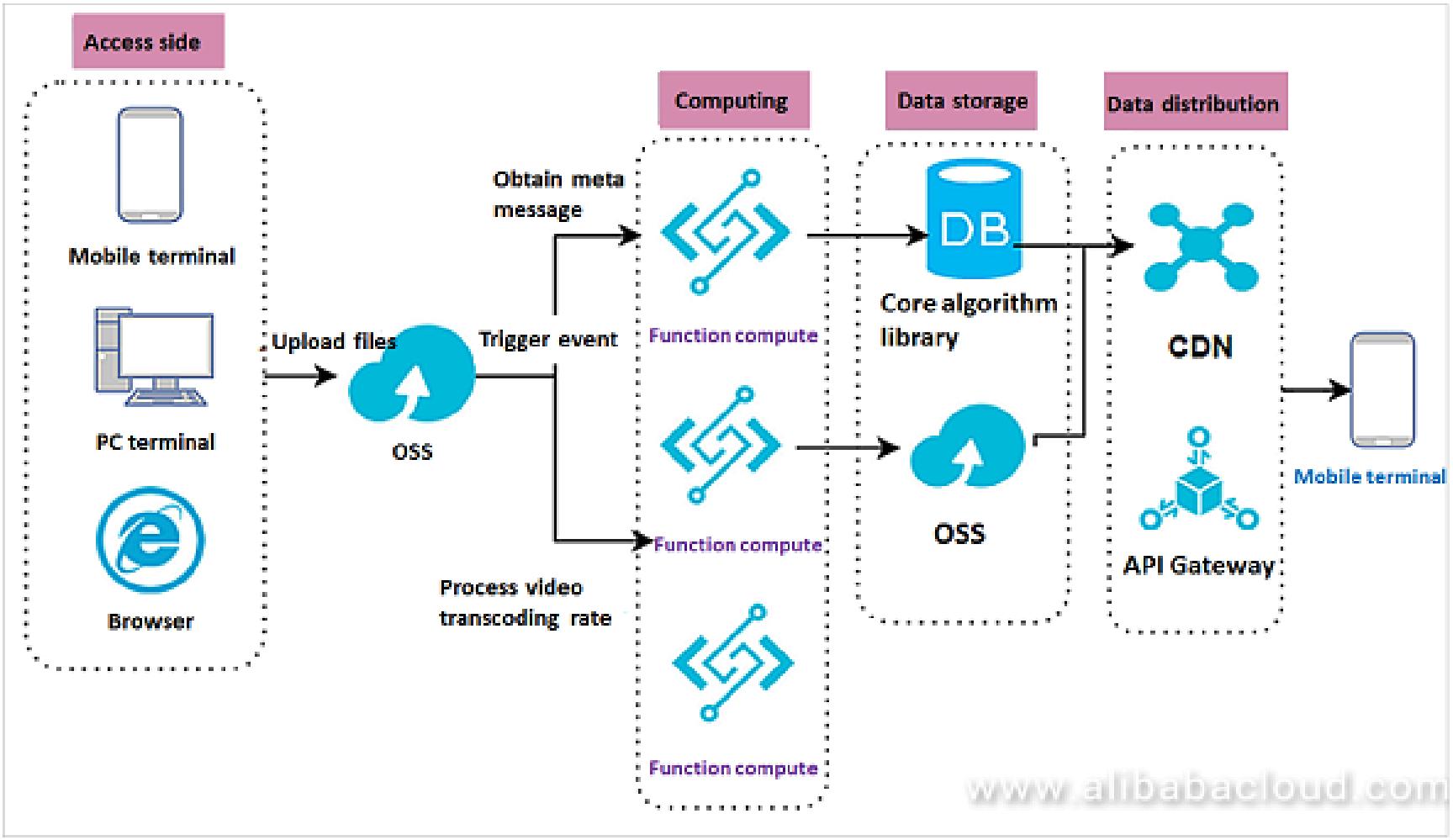
Serverless computing



Serverless market prediction



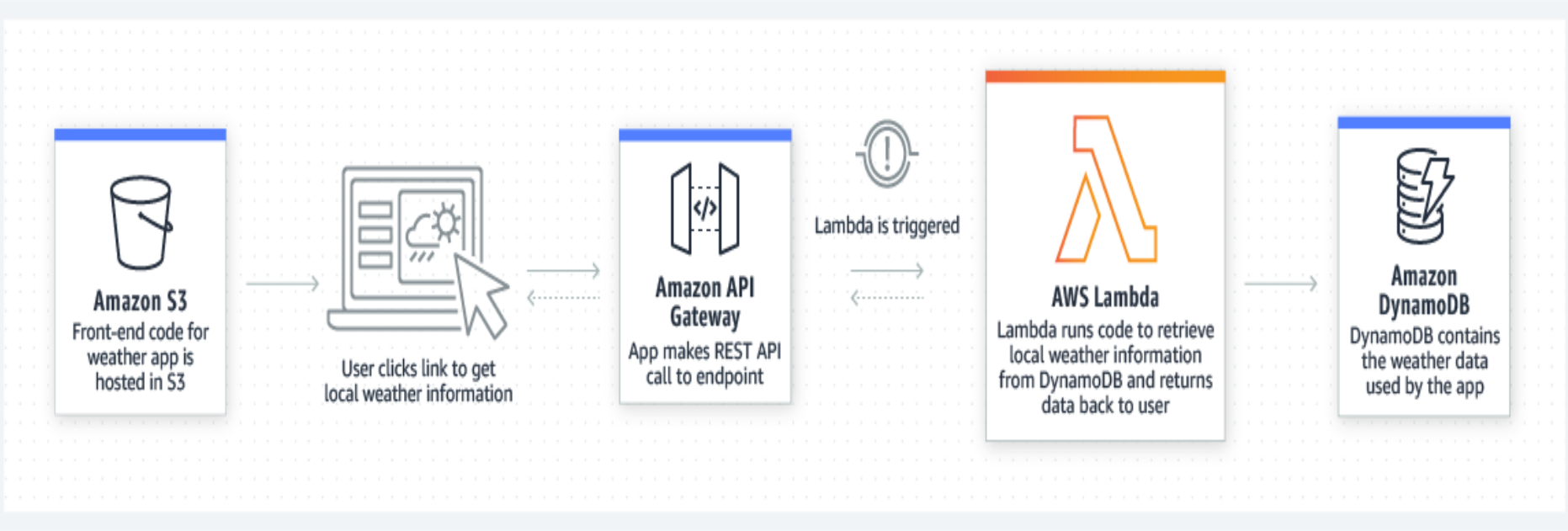
4 Use Cases of Serverless Architecture



Web applications and backends

- A serverless web applications and backends can be build using AWS Lambda, Amazon API Gateway, Amazon S3, and Amazon DynamoDB to handle web, mobile, Internet of Things (IoT), and chatbot requests.

Example: Weather application



Cloud Computing Deployment Models: On-premises

- Deploying resources on-premises, using virtualization and resource management tools, is sometimes called "private cloud".
- On-premises deployment does not provide many of the benefits of cloud computing but is sometimes sought for its ability to provide **dedicated resources**.
- In most cases this deployment model is the same as legacy IT infrastructure while using application management and virtualization technologies to try and increase resource utilization.

Cloud Computing Deployment Models: Cloud

- A cloud-based application is fully deployed in the cloud and all parts of the application run in the cloud.
- Applications in the cloud have either been created in the cloud or have been migrated from an existing infrastructure to take advantage of the benefits of cloud computing.
- Cloud-based applications can be built on low-level infrastructure pieces or can use higher level services that provide abstraction from the management, architecting, and scaling requirements of core infrastructure.

Cloud Computing Deployment Models: Hybrid

- A hybrid deployment is a way to connect infrastructure and applications between cloud-based resources and existing resources that are not located in the cloud.
- The most common method of hybrid deployment is between the cloud and existing on-premises infrastructure to extend, and grow, an organization's infrastructure into the cloud while connecting cloud resources to internal system.

Categories of Cloud Computing Risks

Less Control

Many companies and governments are uncomfortable with the idea of their information located on systems they do not control. Providers must offer a high degree of security transparency to help put customers at ease.

Technology Immaturity

Lack of world-wide adopted Standards. Use of closed proprietary technologies. Lack of knowledge and trust.
API Jungle.
Legal uncertainties

Data Security

Migrating workloads to a shared network and compute infrastructure increases the potential for unauthorized exposure. Authentication and access technologies become increasingly important.

Vendor Lock-in

Interoperability constraints.
Low level of portability of application and services based on cloud.
Contract and exit strategies
Limitations on sharing or transferring data

Compliance

Complying with SOX, HIPAA
and other regulations may prohibit the use of clouds for some applications.
Comprehensive auditing capabilities are essential.

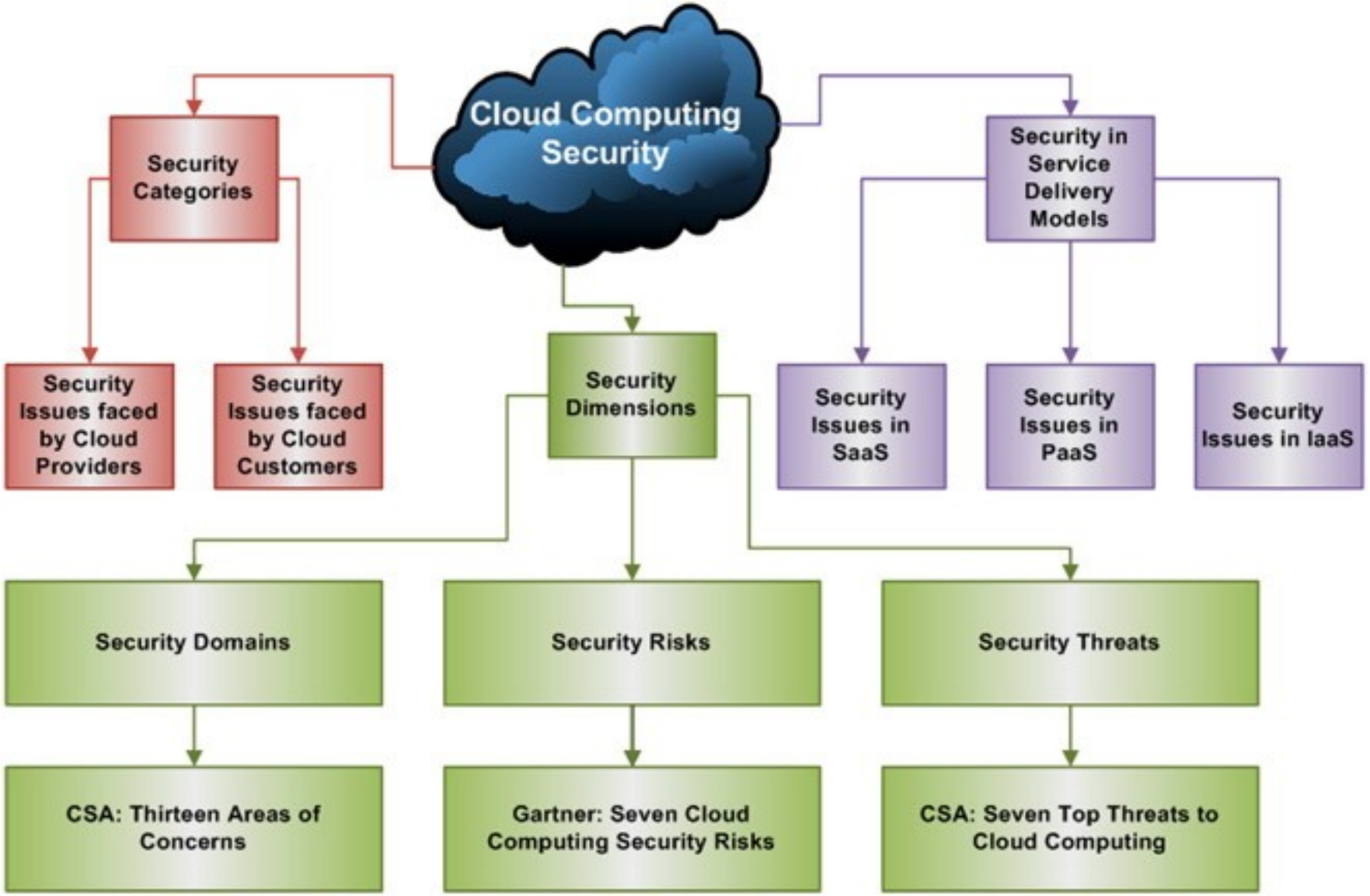
Reliability

High availability will be a key concern. IT departments will worry about a loss of service should outages occur. Mission critical applications may not run in the cloud without strong availability guarantees.

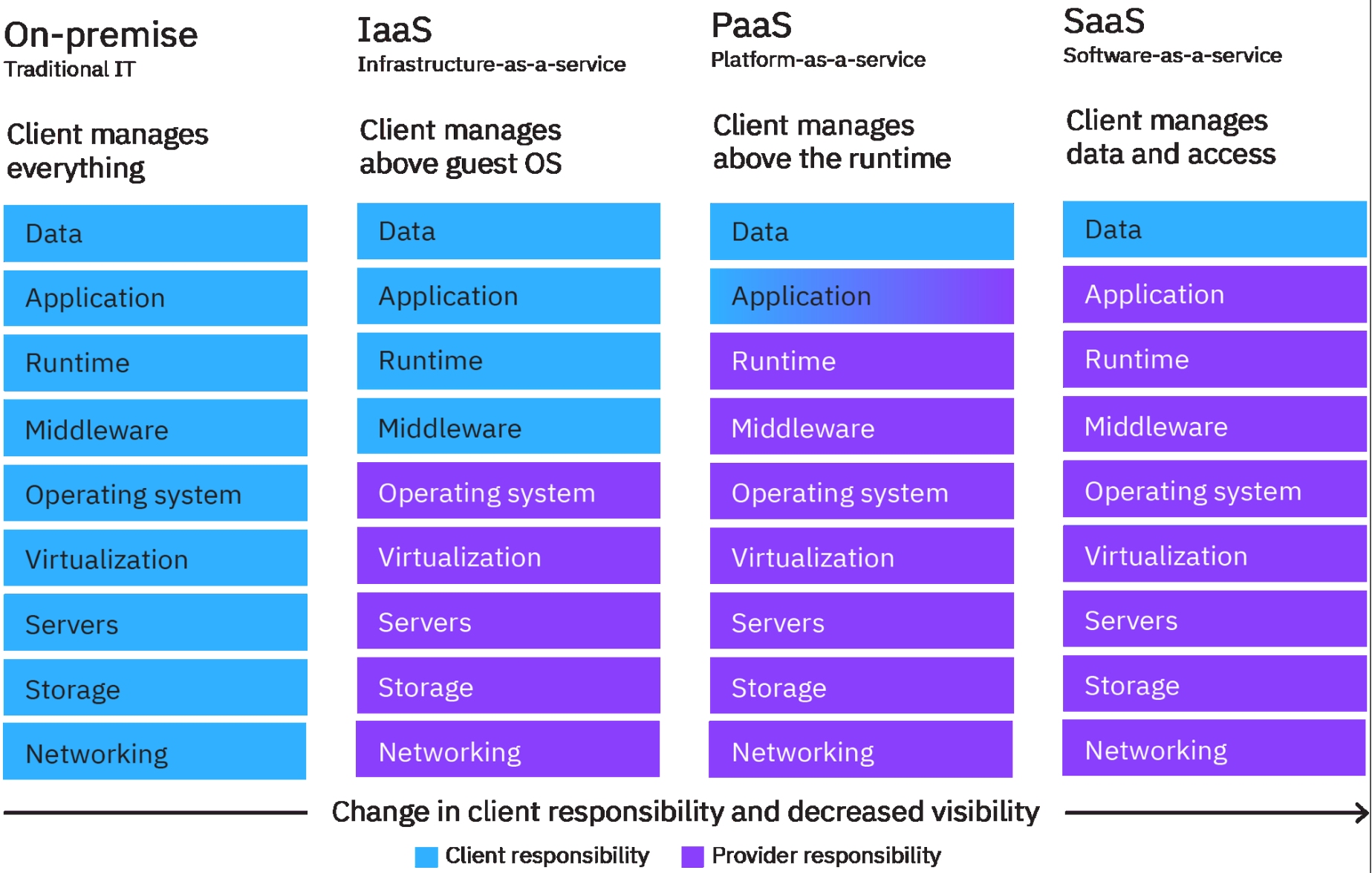
Security Management

Providers must supply easy controls to manage firewall and security settings for applications and runtime environments in the cloud.

Cloud Computing Security, gaps, threat , risks

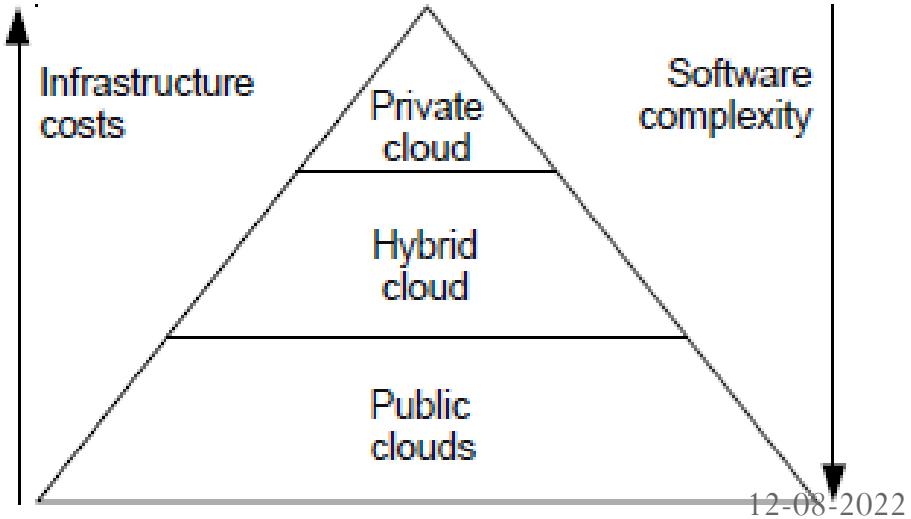


Shared and changing security responsibilities



Cloud Software Engineering

- In general cloud computing refers to both software and hardware **resources** that are delivered over the internet.
- These resources, more commonly known as **services**, are scalable, configurable, measurable, and easily accessible on-demand self-service resources.
- Using these services software development in the cloud can be cheaper, more efficient and more flexible way of producing new software than traditional on-premises software development.



What is a cloud-based application?

- A cloud-based app is an internet run program with components that store and drive online with some or all processes executed on the cloud.
- In cloud-based applications, a user interacts through a web or mobile browser.
- The data processing in cloud-based application takes place on the remote server bae and is managed with the help of an API.
- A user's device serves only as an input device in the cloud app and does not interfere with the major process.
- A cloud-based app is different from a web-based application.

Characteristics of a cloud-based application

- In cloud application development, the app's data is stored in the cloud infrastructure and could be partly cached on a user's device. This means there are minimum requirements for devices to run the application.
- The cloud infrastructure can temporarily store information on a user's device to allow the user to access it while offline. Once the user is online again, the cloud app is updated and uploads the generated data from offline to the cloud storage location.
- One can set up backup schedules as well data optimization, compression and encryption as a user in any way you want.
- A cloud application can be accessed with the help of any internet-connected device, including desktop, tablet, and mobile. This helps the user to get independent of browser capacities.
- Cloud-based applications also offer access to third-party cloud computing services with API integration and are more easily customized than a web app.

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Thanks for Your Attention!

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Exercises

Cloud Computing: Introduction

Q.1 Differentiate between Grid computing. Distributed computing and cloud computing. Also draw the relationship between them.

Q.2 Describe the characteristics of cloud computing environments.

Q.3 Discuss the different barriers of cloud computing.

Q.4 What do you understand by service oriented architecture (SOA). How it support cloud computing? Explain.

Q.5 What are the essential characteristics of cloud computing?

Q.6 Explain the keys steps in implementing Cloud computing based applications.

Q.7 Differentiate between Distributed Computing and Cloud Computing.

Q.8 How Cloud Computing can help in solving Gene Expression Data Analysis? Explain in details

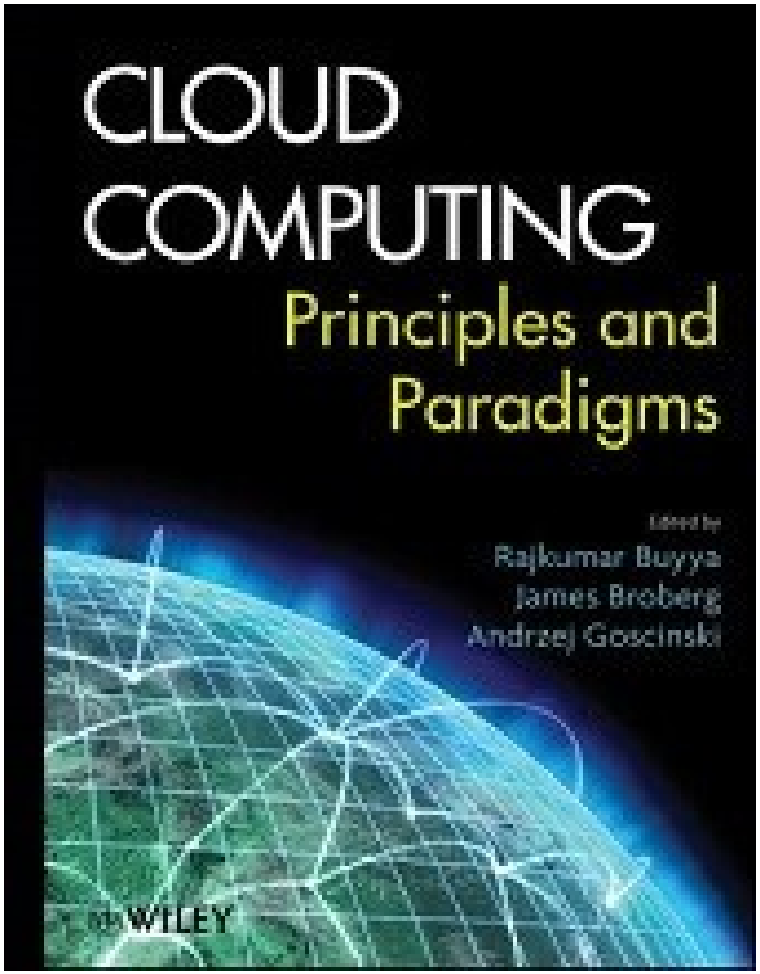
Q.9 What do you mean by Social Network Analysis? How Cloud Computing can help in this problem.

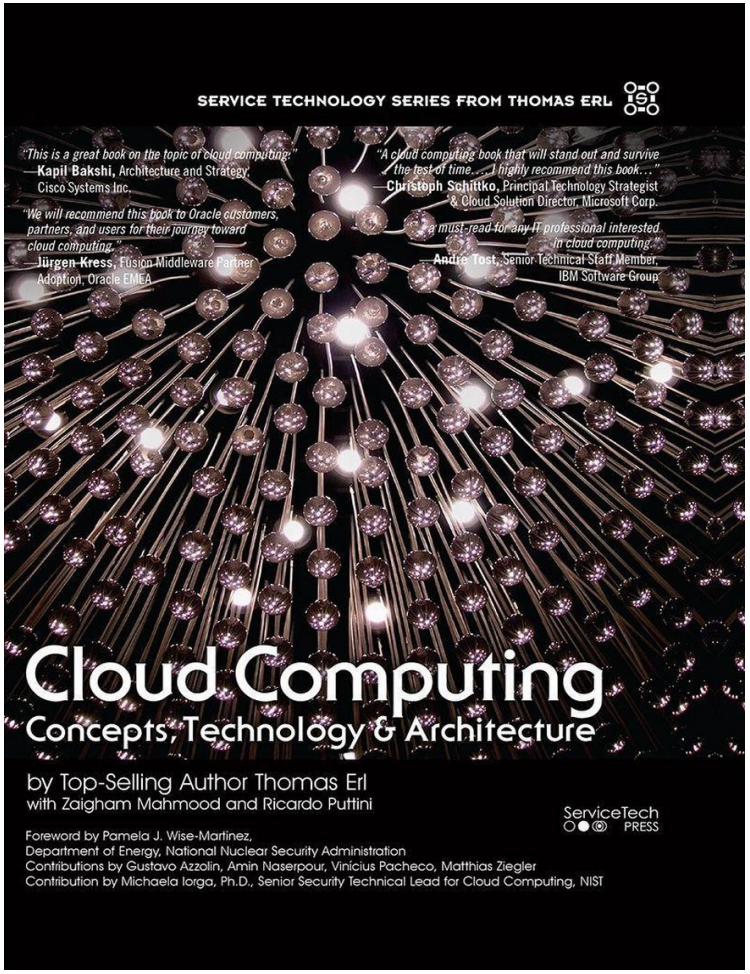
Q.10 Explain a brief noted on cloud adoption and cloud rudiments?

Q.11 List the different cloud application available in market? Briefly explain the scenarios/situation of" when to not use clouds"?

Q.12

Suggested Reading





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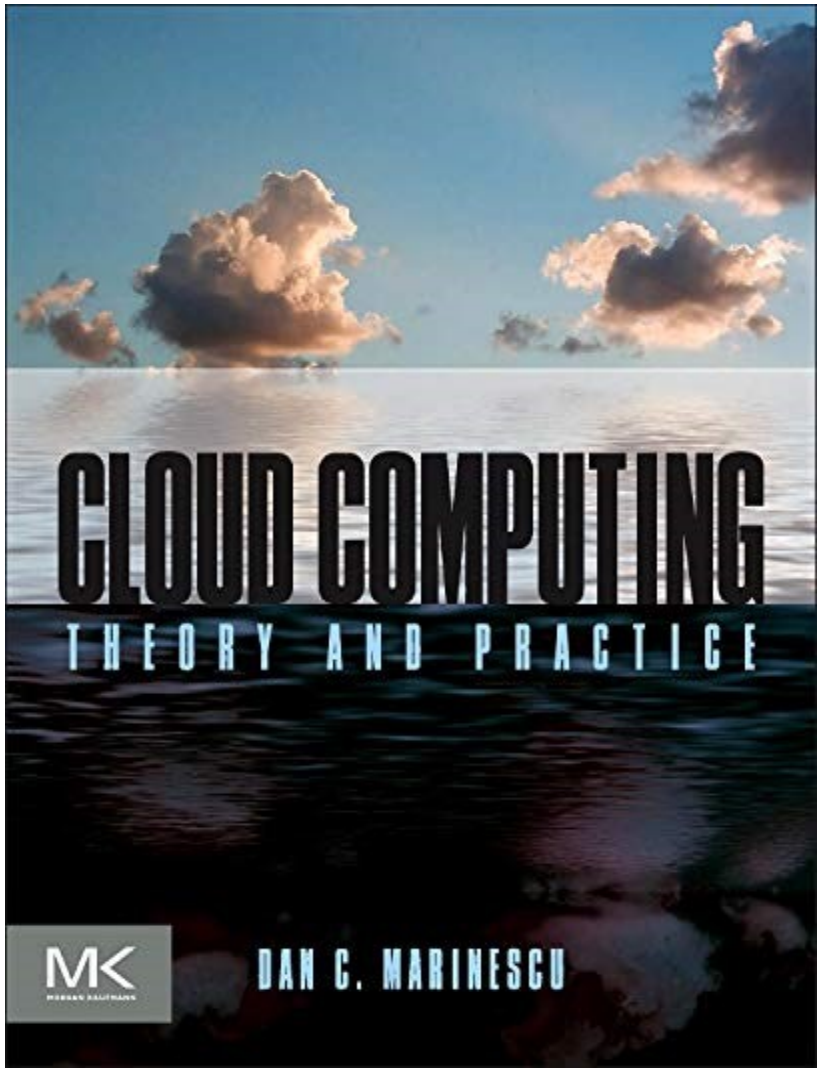

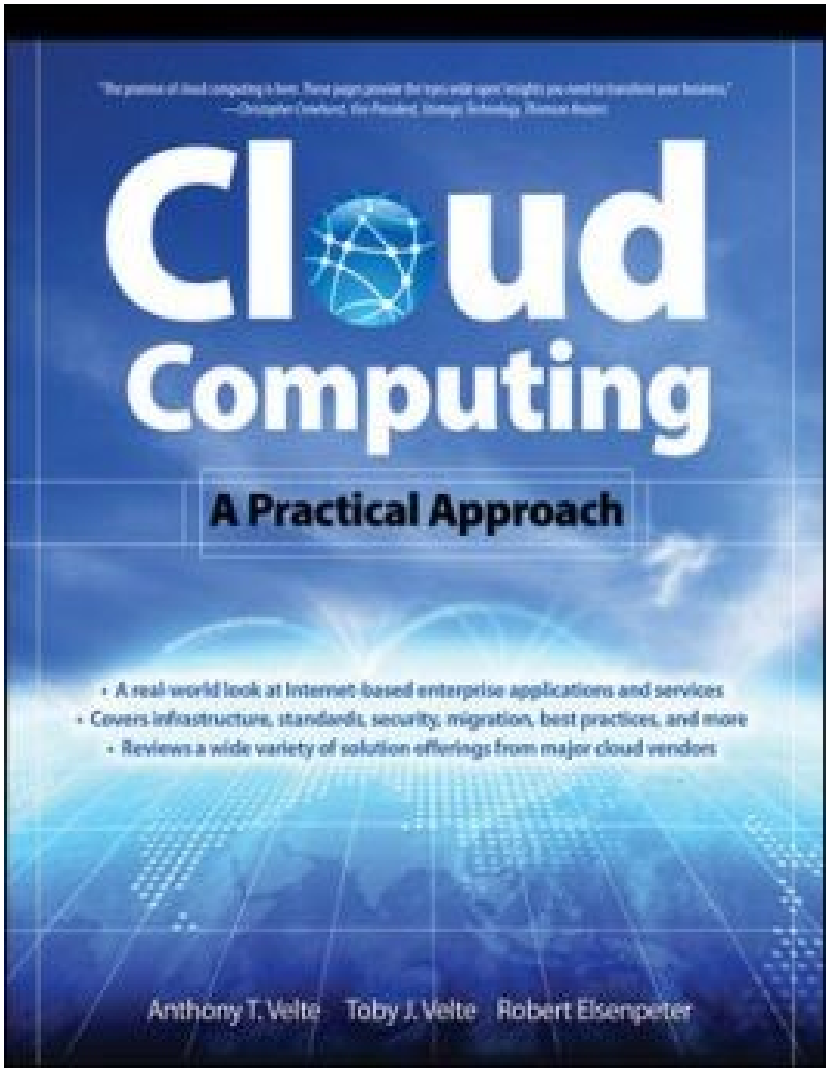

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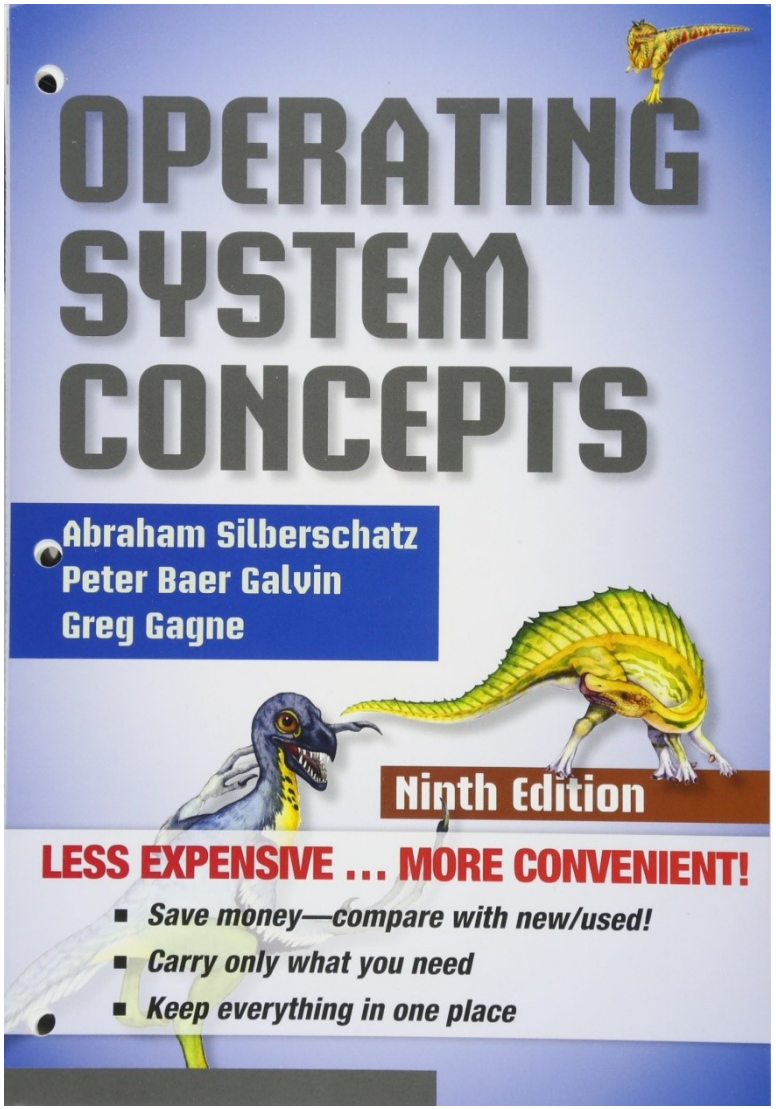

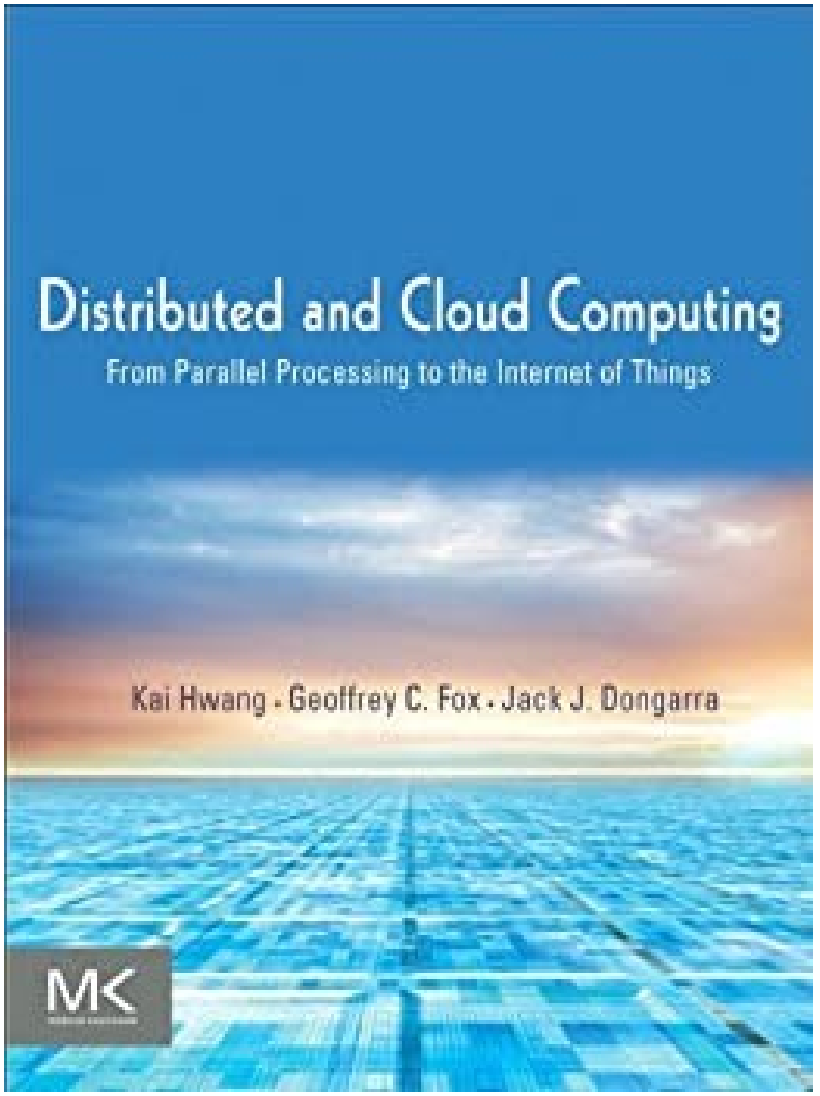

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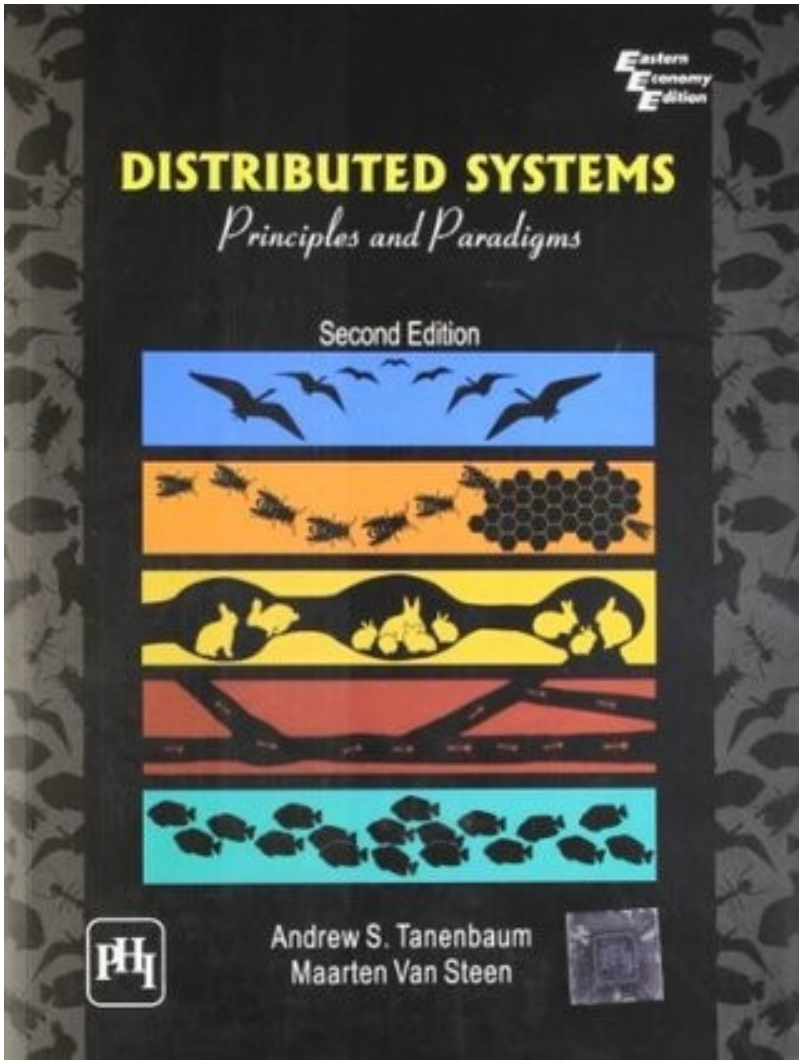

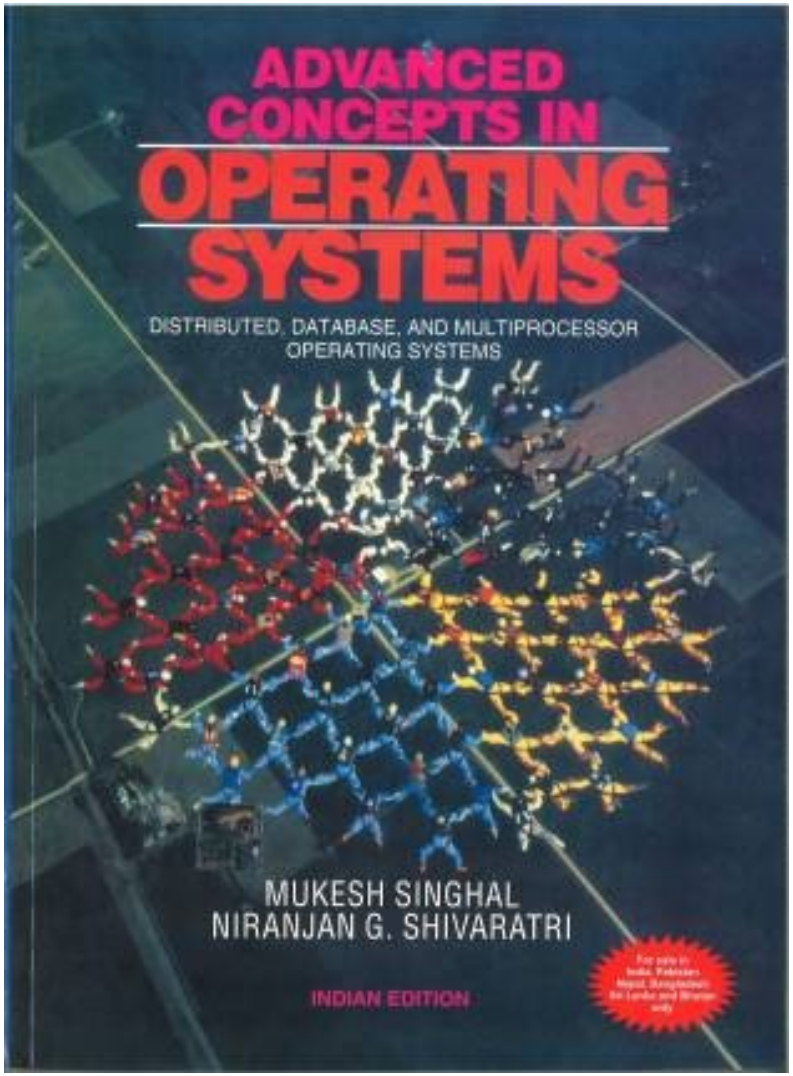

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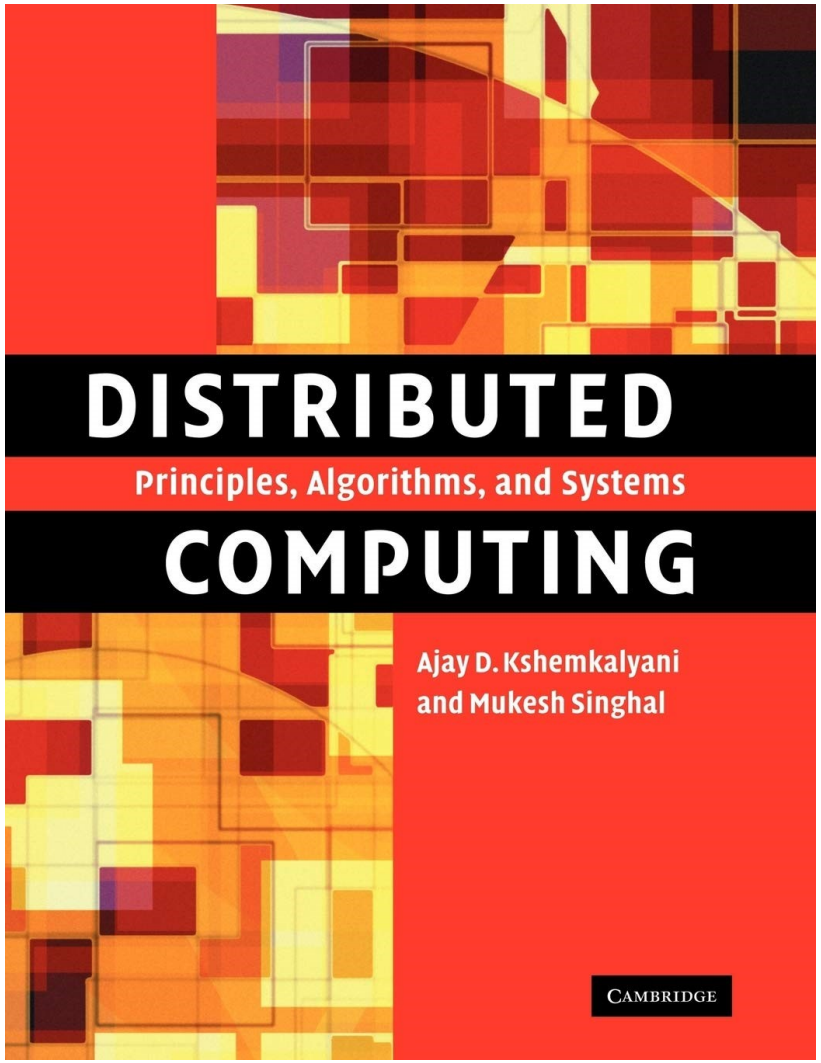

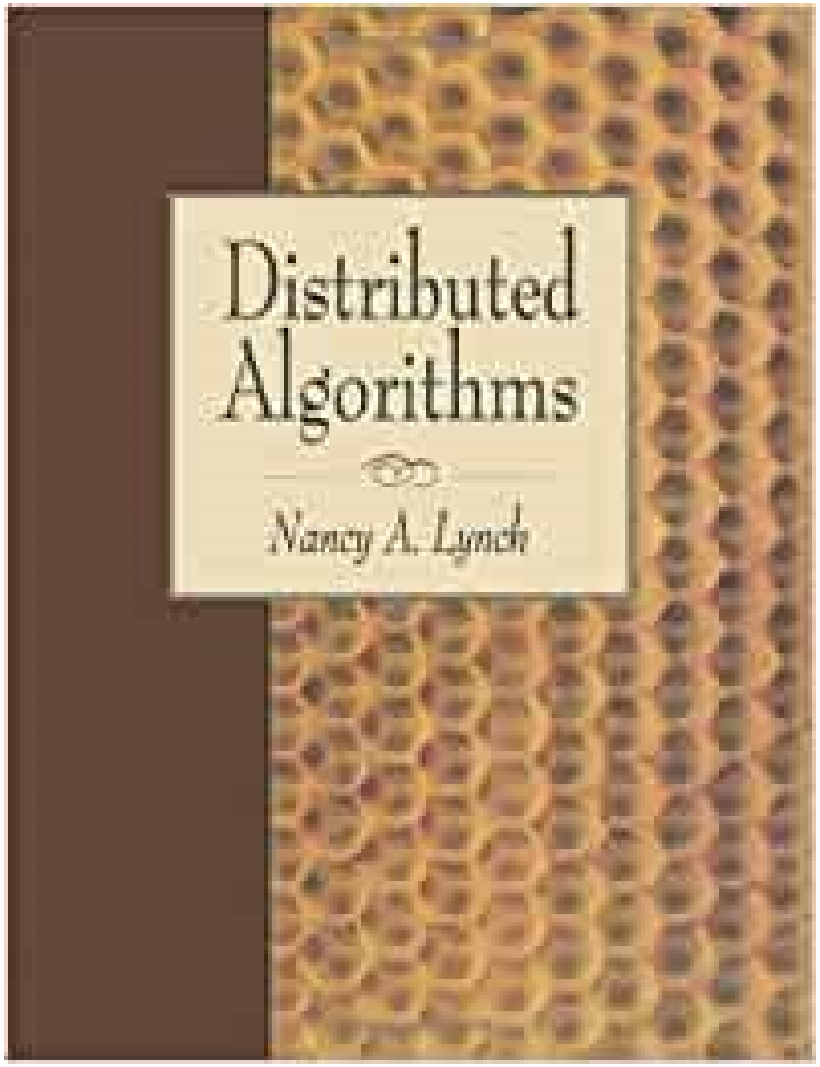

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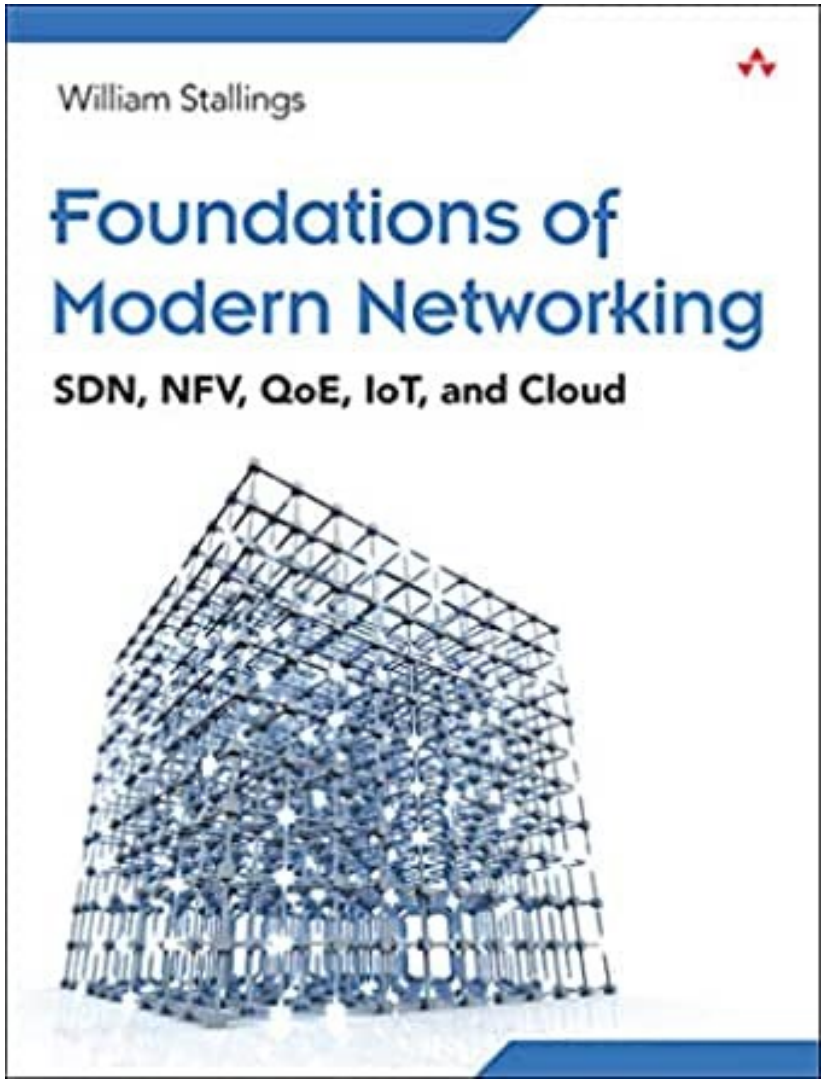


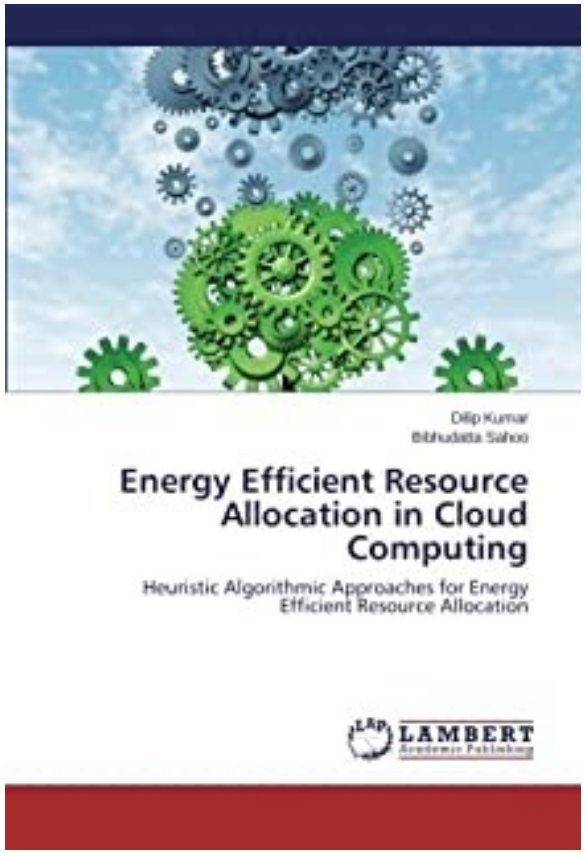
Motivation:

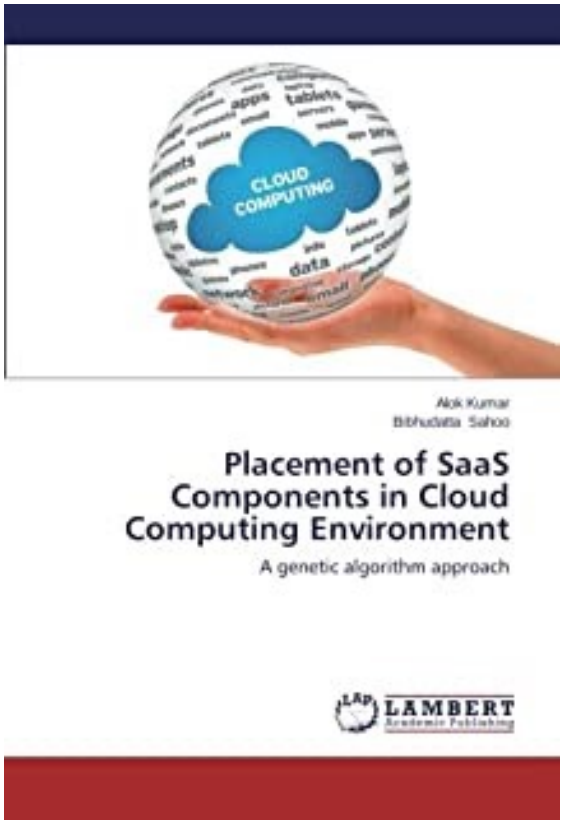
Table 1. Worldwide Public Cloud Services Forecast (Millions of Dollars)

	2016	2017	2018	2019	2020
Cloud Business Process Services (BPaaS)	40,812	43,772	47,556	51,652	56,176
Cloud Application Infrastructure Services (PaaS)	7,169	8,851	10,616	12,580	14,798
Cloud Application Services (SaaS)	38,567	46,331	55,143	64,870	75,734
Cloud Management and Security Services	7,150	8,768	10,427	12,159	14,004
Cloud System Infrastructure Services (IaaS)	25,290	34,603	45,559	57,897	71,552
Cloud Advertising	90,257	104,516	118,520	133,566	151,091
Total Market	**209,244**	**246,841**	**287,820**	**332,723**	**383,355**

Source: Gartner (February 2017)

Publications from Cloud Computing Research Lab





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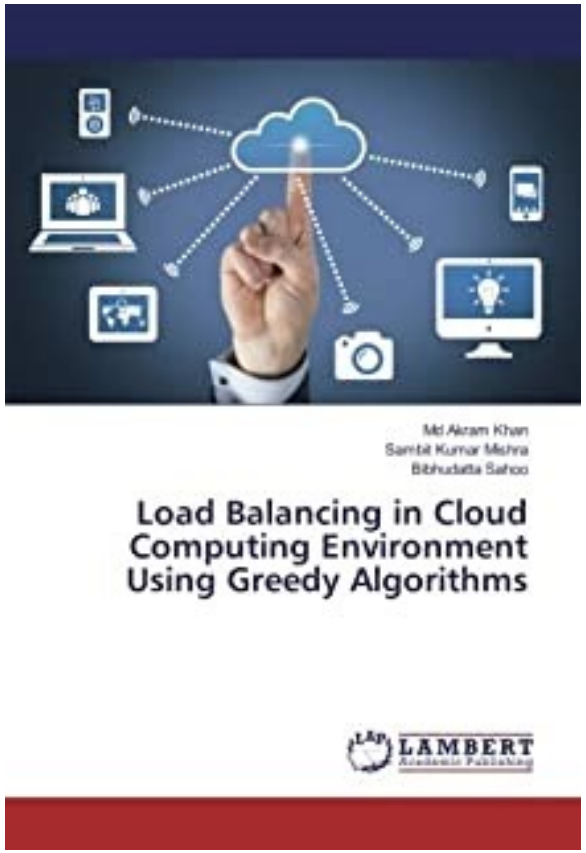

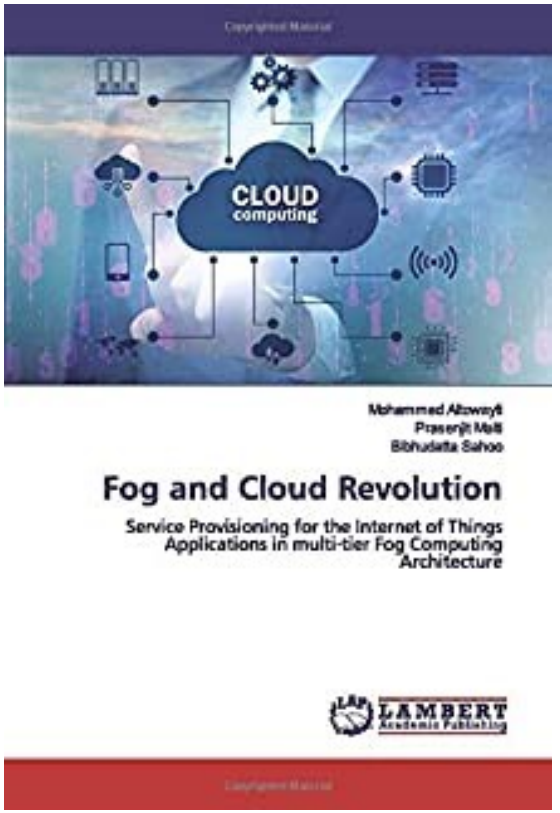

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