Cloud Computing

Introduction #1

key concepts

service models

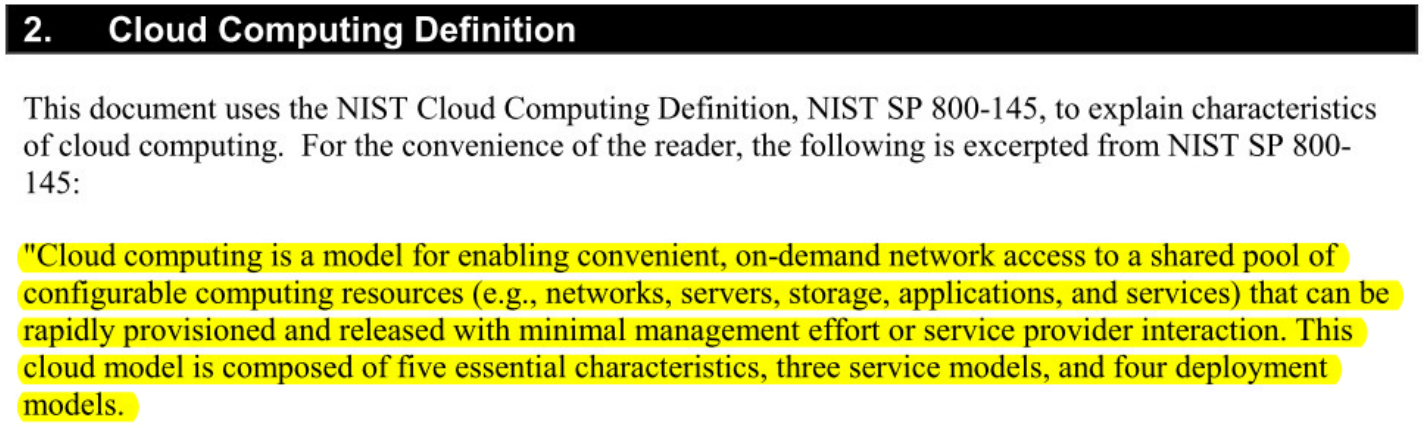
deployment models

Objectives

- Define Cloud Computing
  - 5 characteristics
  - 3 deployment models
  - 3 service models
- Basic understanding of the evolution of cloud computing
- Explain how some emerging technologies are being supported by the cloud
- Explain concepts and components of cloud infrastructure
- First contact with different types of cloud storage
- Understand the 3 service models
  - IaaS
  - PaaS
  - SaaS

Cloud Computing - definition

- "A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction"
  - https://csrc.nist.gov/publications/detail/sp/800-146/final
  - "Um modelo para a disponibilização, a pedido, via redes de computadores, de recursos computacionais configuráveis, partilhados, rapidamente provisionáveis e libertáveis, com esforço e interação mínimos, do utilizador perante o fornecedor."



2. Cloud Computing Definition

This document uses the NIST Cloud Computing Definition, NIST SP 800-145, to explain characteristics of cloud computing. For the convenience of the reader, the following is excerpted from NIST SP 800-145:

"Cloud computing is a model for enabling 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.

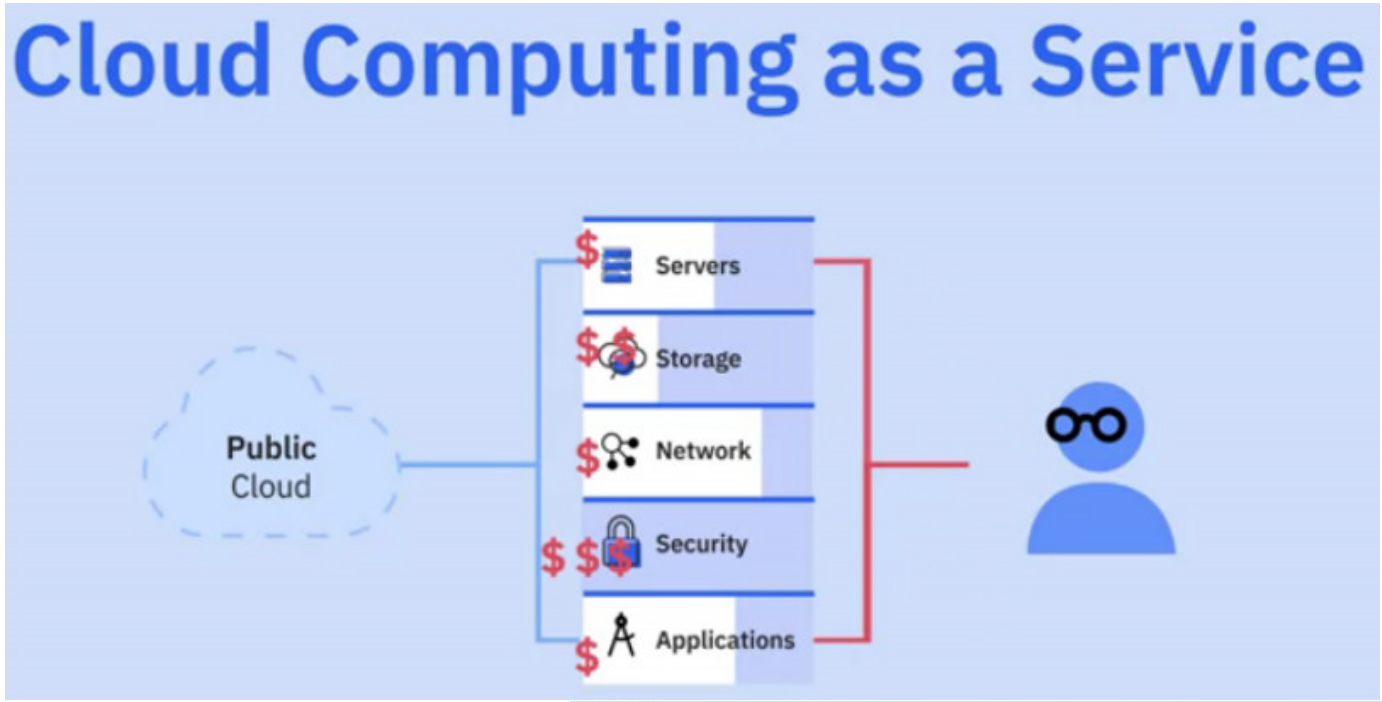
Cloud Computing - definition

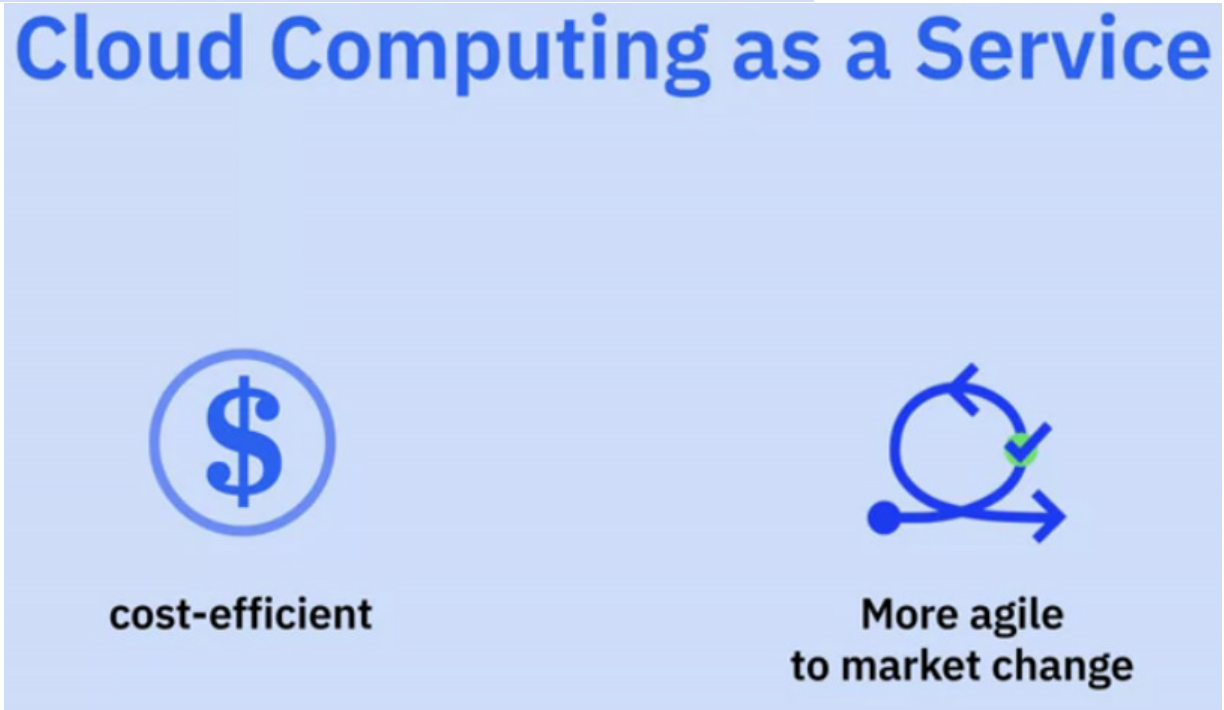
- 5 essential characteristics
- 3 deployment models
- 3 service models

Cloud Computing - definition

- 5 essential characteristics
  - On-demand self-service
    - Access not requiring human interaction
  - Broad network access
    - Access through standard mechanisms and platforms
  - Resource pooling
    - Resources dynamically assigned in function of demand ; economies of scale for the provider ; cost-efficiency for the customer
  - Rapid elasticity
    - Access more when needed; access less when not needed
  - Measured service
    - Resource usage is measured and reported. "Pay as you go", for what you use or reserve

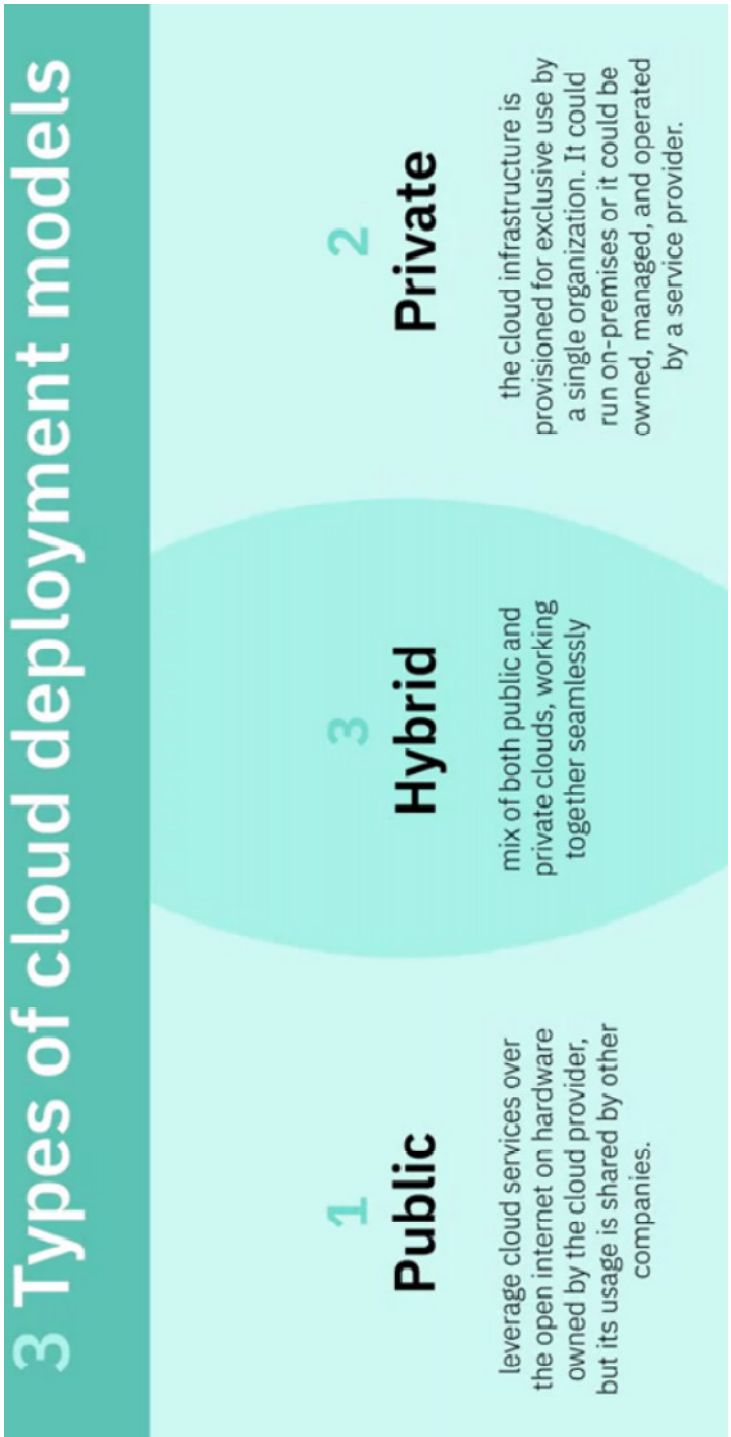
Cloud Computing - definition





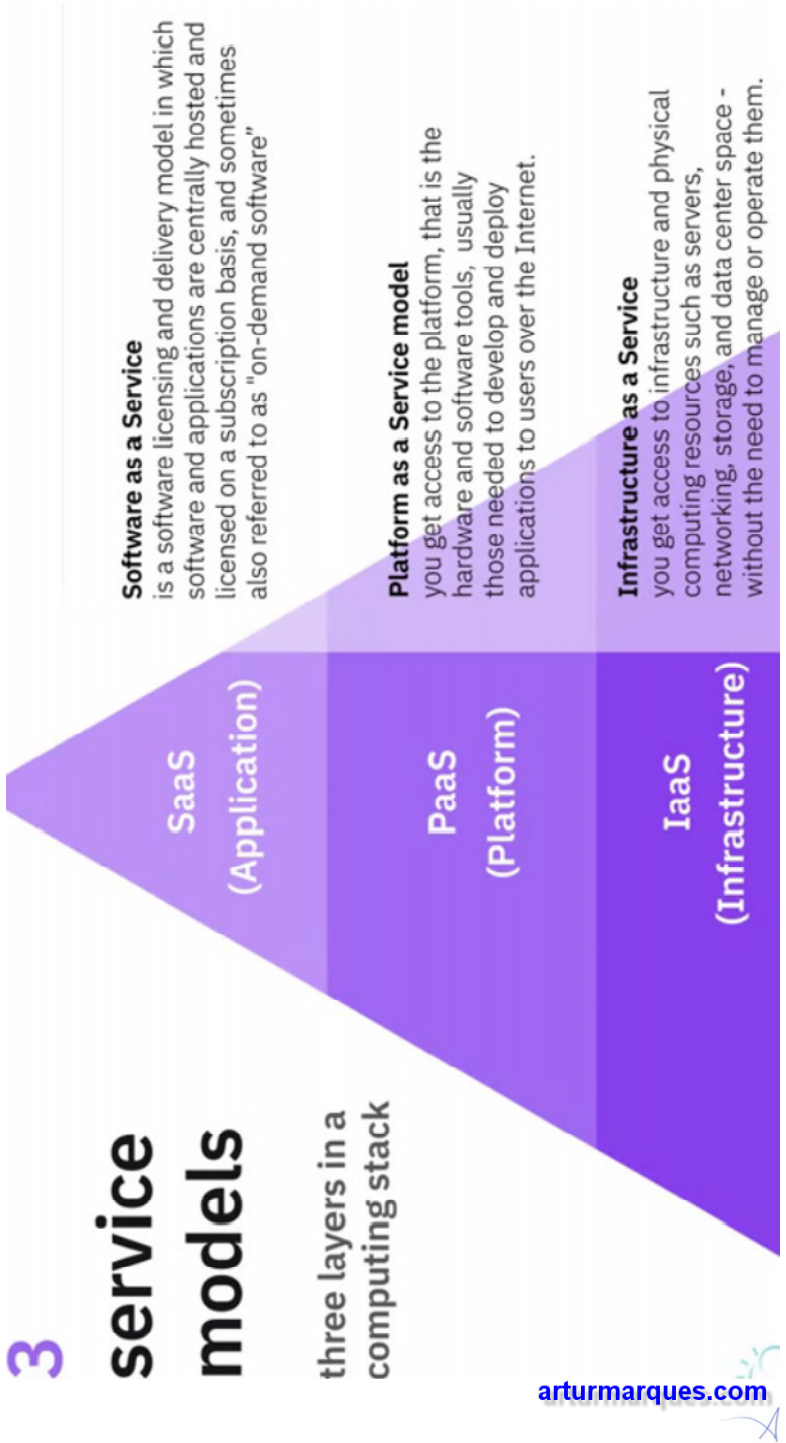
Cloud Computing - definition

- 3 deployment models
  - Public
    - Services on the open internet, on hw owned by the cloud provider, shared by *
  - Private
    - Exclusive use by a single entity. Can be run on-premises or owned, managed and operated by a service provider.
  - Hybrid
    - Mix of {public, private} working together



Cloud Computing - definition

- 3 service models / 3 layers in a computing stack
  - IaaS = Infrastructure as a Service
    - Customer gets access to the infrastructure, abstracting its management
    - Infrastructure?
    - Abstracting?
  - PaaS = Platform as a Service
    - {hw , sw tools} both abstracted
    - Hw?
    - Sw tools?
  - SaaS = Software a Service
    - "on-demand" software
    - Sw delivery and licensing both abstracted



Cloud Computing - evolution

- 1950s
  - "mainframes" with high-volume processing power
  - Time-sharing / resource-pooling
    - Via "dumb" terminals
    - It was very clear that the storage layer and the CPU were the same for all
- 1970s
  - The "Virtual Machine" (VM) Operating System
  - "mainframes" with multiple virtual systems, on a single physical node
  - VM feels like having its "own resources", but they are shared resources
- The maturation of Hypervisors and virtualization
  - SW layer that enables multiple operating systems to run alongside each other, sharing the same physical computing resources
  - Increasingly reliable logical separation of VMs
  - Servers already online => new need? => provision new VM
  - Pay-as-you-go => "utility computing model" => key driver of Cloud Computing
  - CapEx => OpEx

Cloud Computing Evolution

1950s

Large-scale mainframes with high-volume processing power.

The practice of time sharing, or resource pooling, evolved.

Multiple users were able to access the same data storage layer and CPU power.

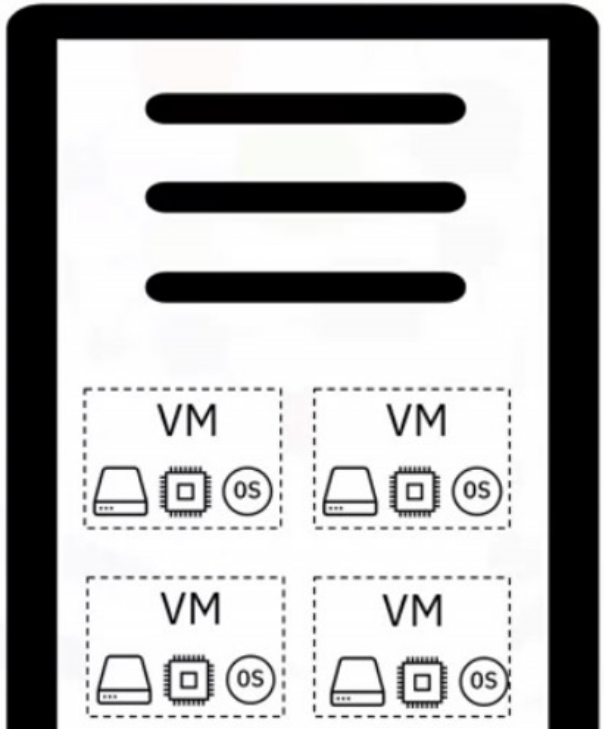
1970s

Virtual Machine (VM),

Mainframes to have multiple virtual systems, or virtual machines, on a single physical node.

Virtual Machines

VMs – multiple distinct compute environments on the same physical hardware



Each virtual machine hosted guest operating systems that behaved as though they had their own memory, CPU, and hard drives, even though these were shared resources.

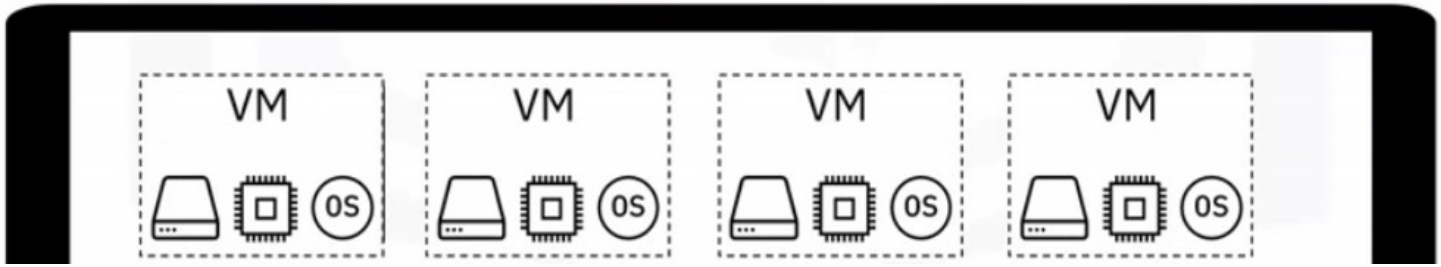
Virtualization

A huge catalyst for evolutions in computing.

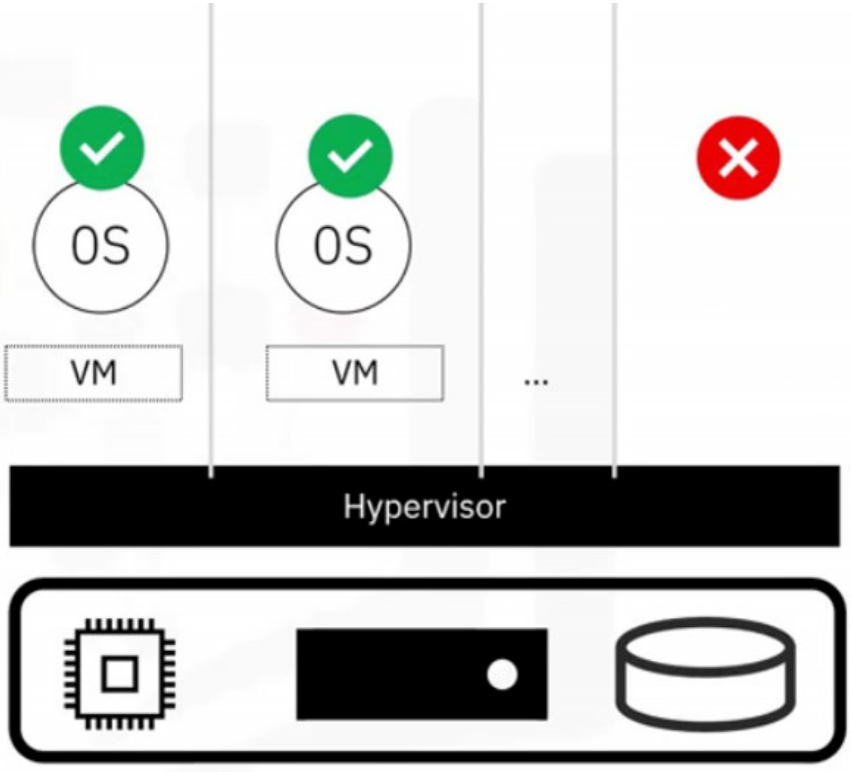
Shared hosting environments

Virtual private servers

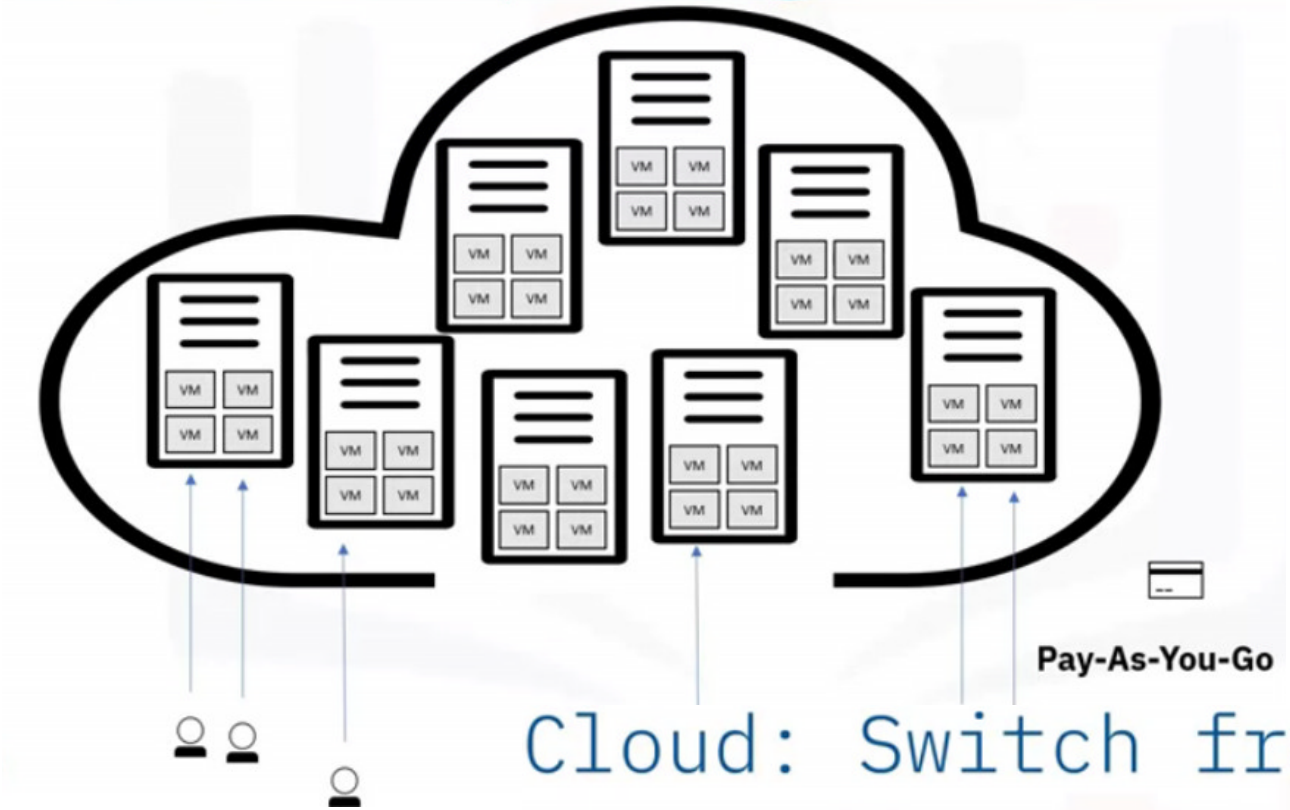
Virtual dedicated servers



Hypervisor



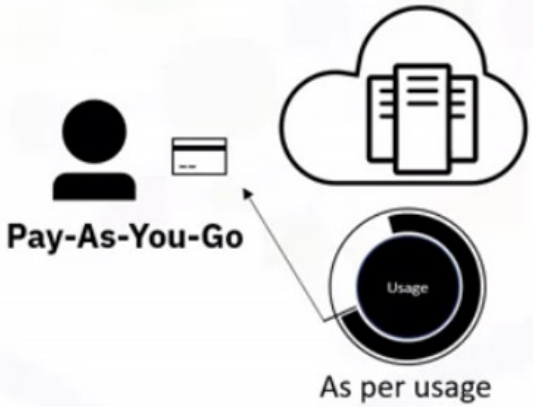
Cloud computing is born

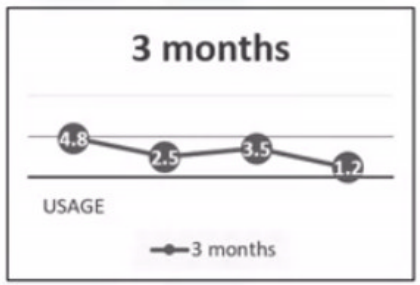


Cloud: Switch from CapEx to OpEx

Capital **Ex**pense
(High up-front costs)

Operating **Ex**pense
(No or low up-front costs)





Scale their workloads during usage peaks, and scale down when usage subsided

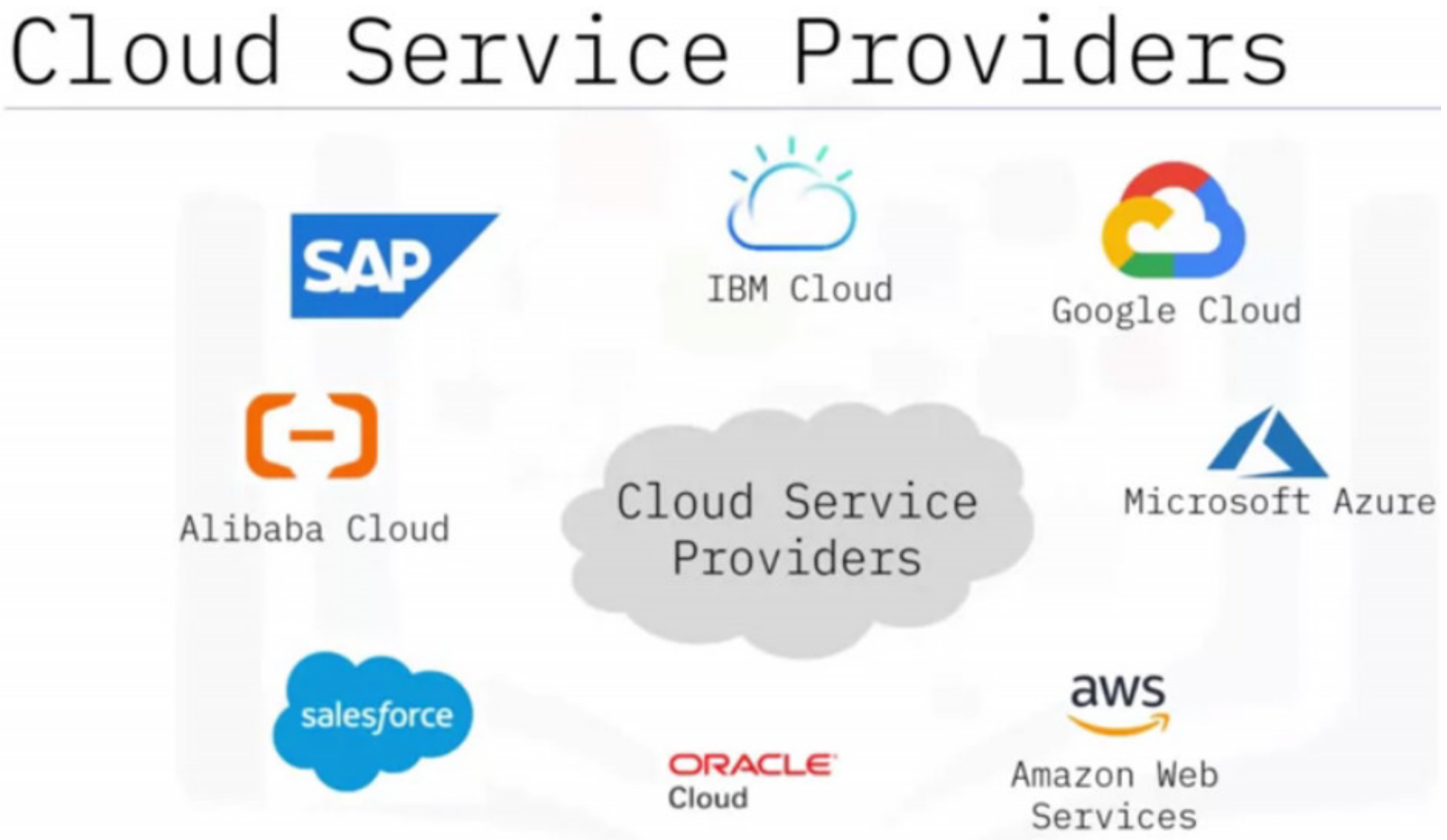
Cloud Computing - considerations

- Infrastructure and workloads
  - Upfront costs vs. diluted, across time, costs
  - Not all computational needs are cloud ready, as-is
- SaaS and development platforms
  - Paying for access to SW vs. off-the-shelf software
  - Impact of bad decisions?
- Benefits of cloud adoption
  - Flexibility
    - Abstraction (of what?)
    - Scalability
    - Access from "anywhere"
  - Efficiency
    - Maintenance externalization
    - More adequate to a global workforce
  - Strategic Value
    - Focus
    - Agility

Cloud Computing - considerations

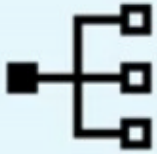
- Challenges of cloud adoption
  - Data security (loss, unavailability, ...)
  - Governance and sovereignty issues
  - Legal, regulatory, and compliance issues
  - Lack of standardization (impact on integration, interoperability)
  - Hard to choose (deployment model, service model, provider, ...)
    - Business continuity
    - Disaster recovery

Cloud Computing - major players



Cloud Computing - supporting emerging tech

Cloud = enabler for ...



AI

Automation

IoT

Blockchain

Cloud Computing - IoT

- IoT
  - (giant) network of connected things and people, continuously running sensors, collecting data
    - Unprecedented amount of data!
- Cloud for IoT
  - Storage / storing the collected data
    - From Points of Presence (POPs) that can minimize latency, depending on device location
  - Backend analytics / computation
  - Serving user interfaces
- Example(s)
  - https://www.welgevonden.org/uncategorized/a-new-approach-to-anti-rhino-poaching-all-you-need-to-know-about-welgevondens-wildlife-protection-project/

Cloud Computing - AI

- AI
  - the ability of a digital entity to perform tasks commonly associated with intelligent beings ...
- Cloud for AI
  - Computing power to make sense of (immense volumes of) data
- Example(s)
  - Number crunching
  - Software agents = agency property
  - Recommender systems, digital assistants w/NLP (Natural Language Processing)
  - Autonomous vehicles

Cloud Computing - Blockchain

- Blockchain
  - A secure, immutable Network allowing members to view only those transactions that are relevant to them ... often serving as a decentralized source of trustable information / "truth" ...
- Cloud for blockchain
  - Provides the globally distributed, scalable, computing resources
- Example(s)
  - The storage of entries requiring decentralized "trust and transparency"
    - food production
    - money transactions

Cloud Computing - the trio

A 3-Way Relationship

cloud
provides globally distributed, scalable, and cost-efficient computing resources

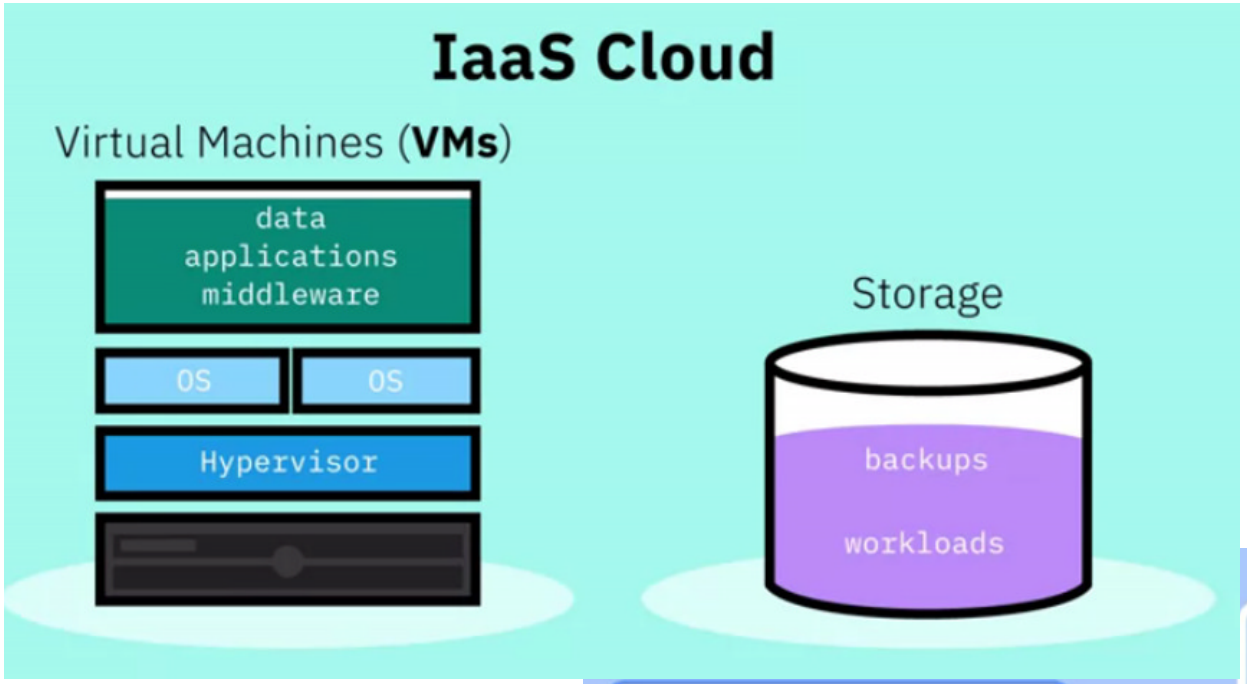
blockchain
provides the trusted, decentralized source of truth

Artificial Intelligence
powers the analytics and decision-making from the data collected

IaaS

- A form of cloud computing that delivers
  - Compute
  - Network
  - Storage
  - To consumers, on-demand, over the internet, on a pay-as-you-go model
- The cloud provider manages
  - Physical data centers, cooling, power, networking and security, servers, storage, etc. = "the infrastructure", including the virtualization or hypervisor layer
- Usually, the provider enables solutions for
  - Reading the performance and usage of the delivered resources
  - Auto-scaling
  - Load-balancing
- The Customers create/"provision"
  - VMs
    - In a region and zone, made available by the provider
  - Storage (DAS / Direct Attached Storage, File (NAS), Block (fiber optic), Object (demands API for access)
  - Track and monitor the performance and usage of their cloud services and manage disaster recovery

IaaS



(A) Physical data centers

(B) Compute

(C) Network

(D) Storage

Object storage is the most common mode of storage in the cloud, given that it is highly distributed and resilient.

IaaS - use cases + concerns

- Use cases
  - Test and development
  - Business continuity and disaster recovery
  - Faster deployment and scaling
  - High performance computing
  - Big data analysis / Number crunching
- Concerns
  - Dependency of a third party
  - Depending on the tools made available, lack of transparency

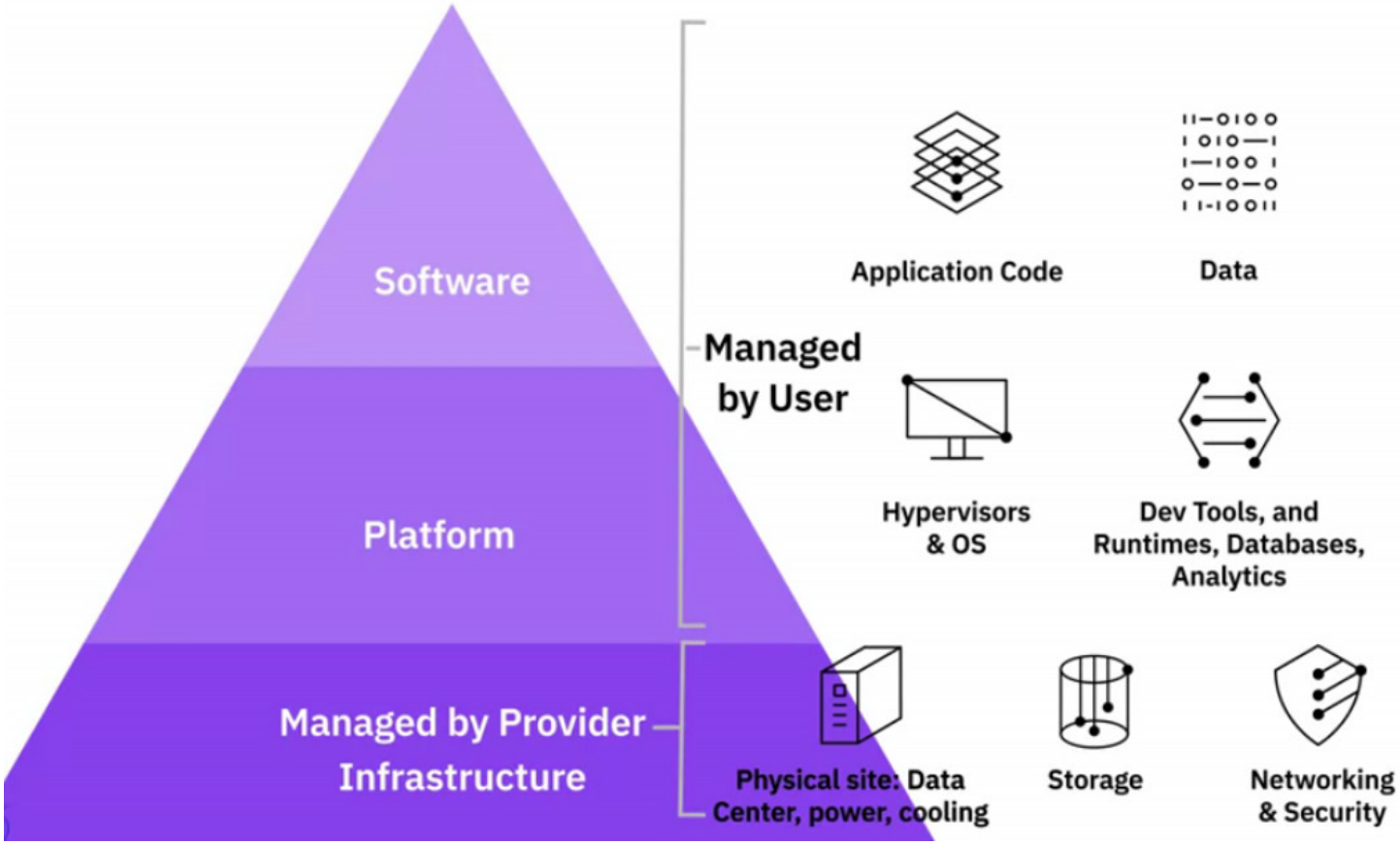
PaaS

- A cloud computing model that provides customers a complete platform to develop, deploy, run, and manage applications created by them or acquired from a third-party
- The PaaS provider
  - Hosts the infrastructure
  - The operating system
  - The application runtimes
  - APIs
  - Databases
  - Middleware, other tools
  - Is responsible for the installation, configuration, operating of the application infrastructure
  - Sets policies, to which customers must agree

PaaS

- Customers
  - Pay per usage
  - Purchase resources on-demand
  - Abstract distributed caching, queuing, messaging, file and data storage, workload management, user identity, analytics
  - Usually work with application servers, DBMSs (Database Management Systems), mobile back-end services, integration services, BPMSs (Business Process Management Systems), event processing systems, that are "simply available", abstracting all types of maintenance
  - "just code" and manage their application code
- Strategic value
  - Build, test, deploy, enhance, scale apps, rapidly and cost-effectively

PaaS



PaaS Providers Host & Manage:

Installation, Configuration, Operation of Application Infrastructure:

Servers	Networks	Storage	Operating system
Application runtimes	APIs	Middleware	Databases

PaaS

Essential Characteristics of PaaS

High level of Abstraction
- ✓Eliminate complexity of deploying applications

- **Support Services and APIs**
  - ✓Simplify the job of developers

- **Run-time environments**
  - ✓Executes code according to application owner and cloud provider policies

- **Rapid deployment mechanisms**
  - ✓Deploy, run, and scale applications efficiently

- **Middleware capabilities**
  - ✓Support a range of application infrastructure capabilities

Use Cases

- API development and management
- Internet of Things (IoT)
- Business analytics/intelligence
- Business Process Management (BPM)
- Master data management (MDM)

PaaS - Pros and Risks/Cons

- Pros
  - Scalability
  - Faster time to market
  - Agility and (freedom to focus on) innovation
- Risks
  - Information security threats
  - Dependency on the provider's infrastructure
  - Customer lacks control over the service offering, namely tools

SaaS

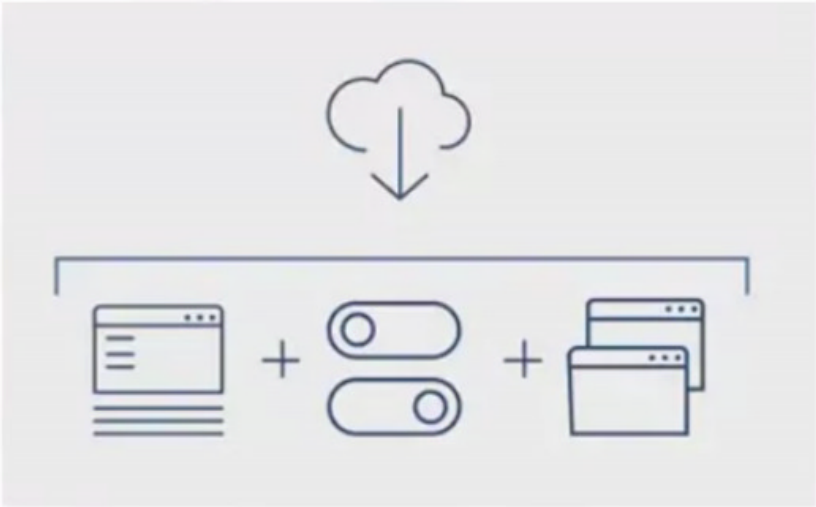
- A cloud offering that provides users with access to a service provider’s cloud-based software
- The provider
  - Maintains the servers, databases, everything that "is" the application
  - Manages access to the application, including security, compliance, availability, and performance
- Consumers
  - Use the software
  - Subscription model
  - Customize it with "point and click" ease
    - Customizations are preserved in upgrades
- Examples
  - Office365, Google Gmail, many CRMs, etc.

SaaS

What is SaaS?

Software-as-a-service:

a cloud offering that provides access to a service provider's cloud-based software.



Providers maintains:

- Servers
- Databases
- Application Code
- Security

Providers manages Application

- Security
- Availability
- Performance

SaaS Supports

Email and Collaboration

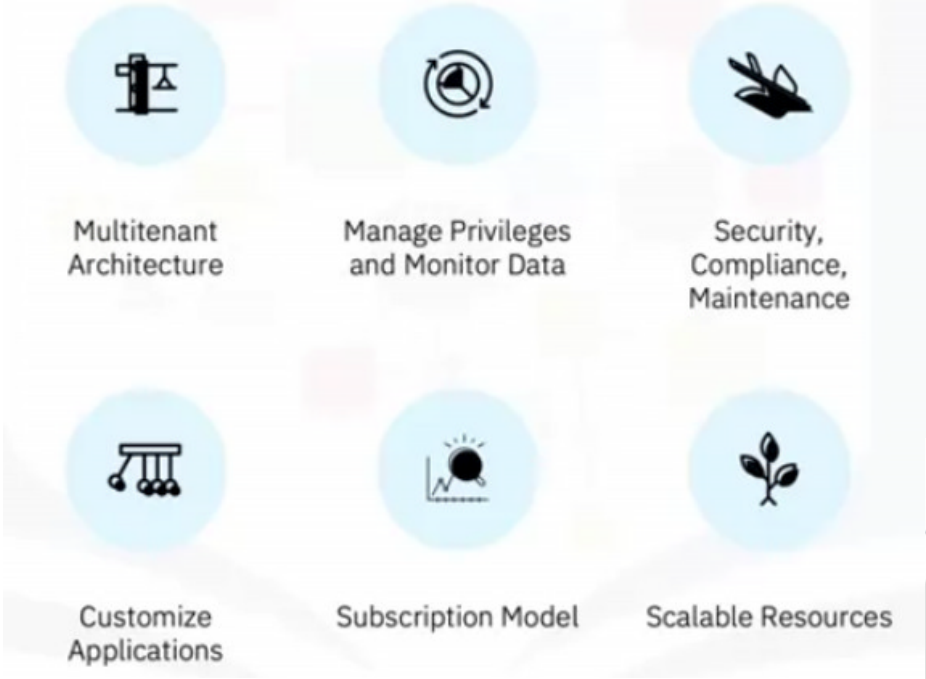
Customer Relationship Management

Human Resource Management

Financial Management

SaaS

Key Characteristics



Key Benefits

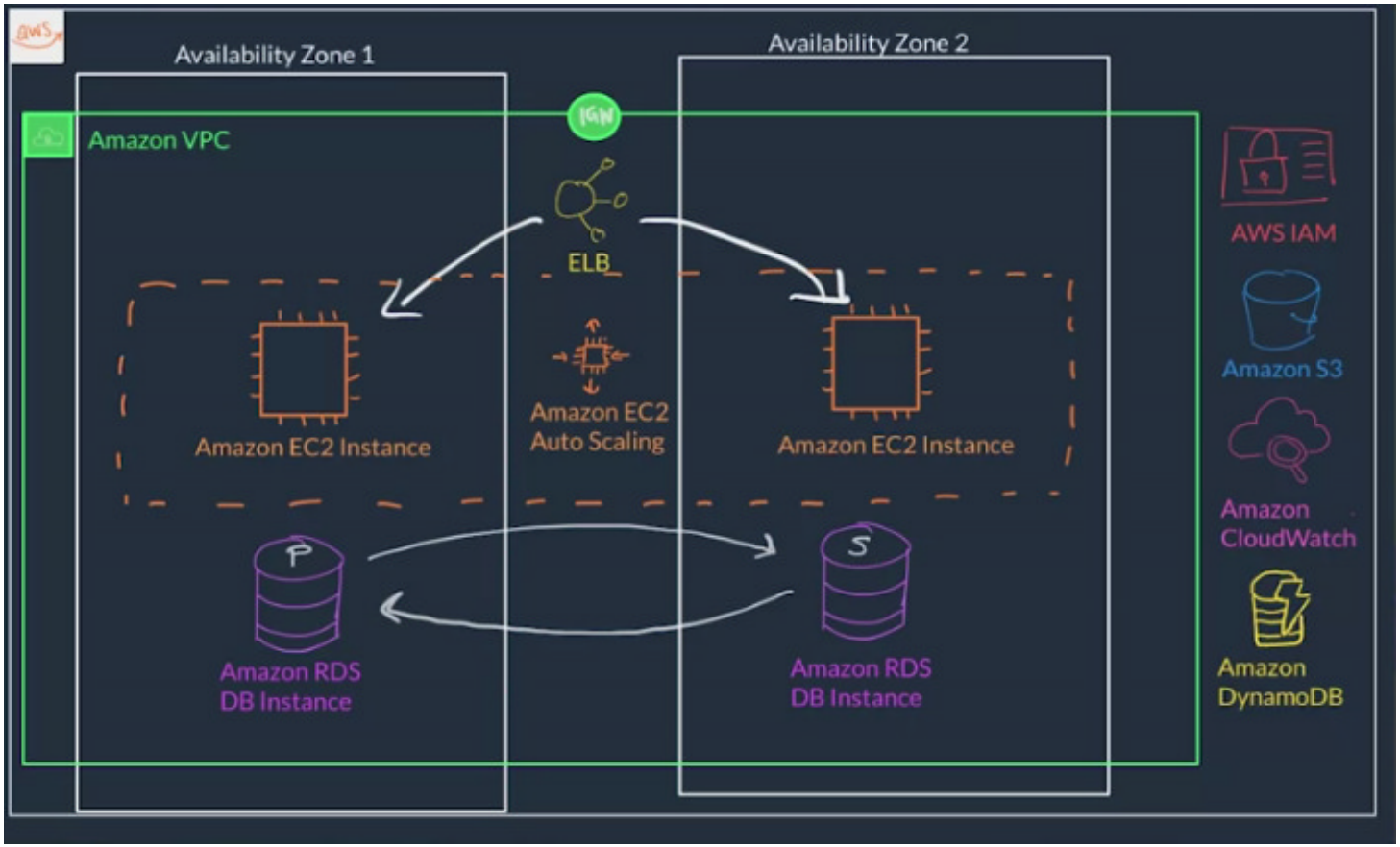
- Greatly reduce the time from decision to value
- Increase workforce productivity and efficiency
- Users can access core business apps from anywhere
- Buy and deploy apps in minutes
- Spread out software costs over time

SaaS - Pros and Risks/Cons

- Pros
  - Reduce on-premises IT infrastructure and CapEx
  - Abstract software installation and maintenance
- Risks
  - Data ownership and data safety
  - Business-critical data maintained by a third-party
  - Requires constantly good Internet connection

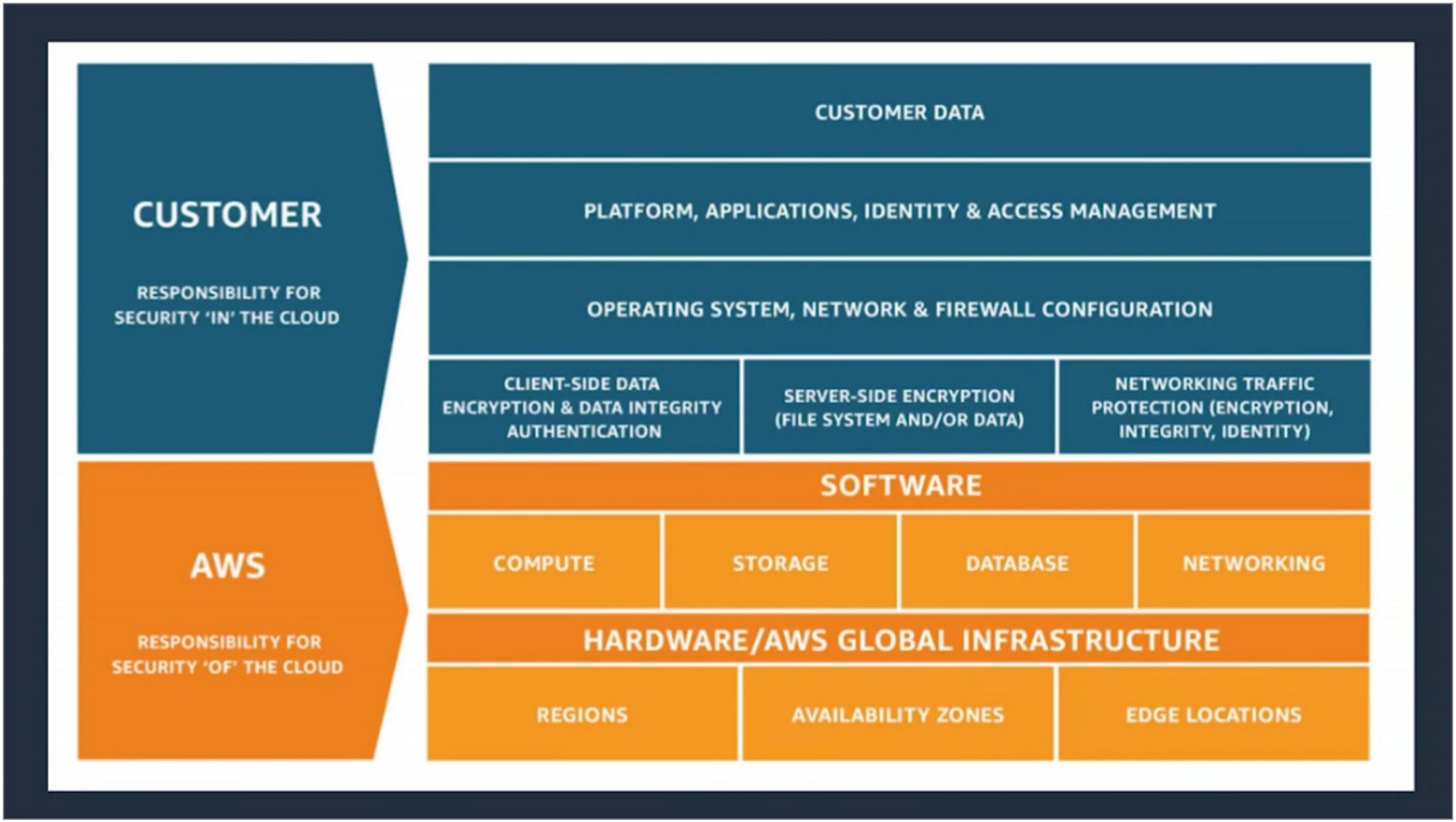
Cloud Computing – AWS perspective

- https://aws.amazon.com/what-is-cloud-computing/
- http://docs.aws.amazon.com/whitepapers/latest/aws-overview/types-of-cloud-computing.html
- https://aws.amazon.com/what-is-aws/



Cloud Computing – AWS perspective

- Shared responsibility?



Cloud Computing – AWS perspective

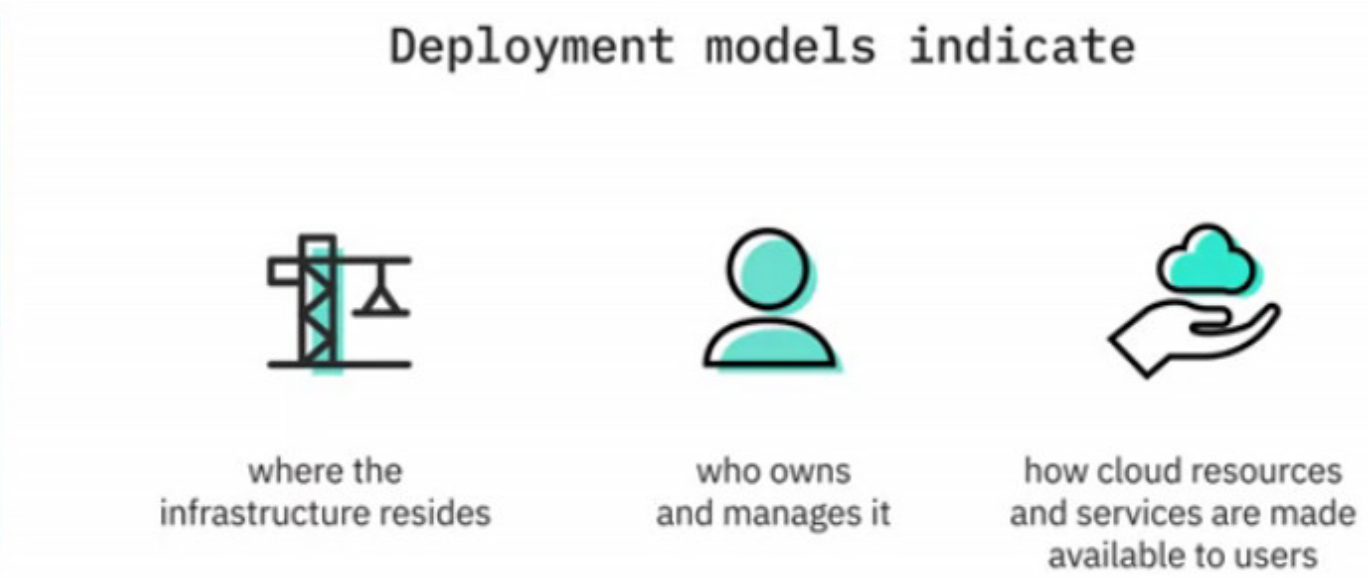
- Shared responsibility varies, service to service
- https://aws.amazon.com/compliance/shared-responsibility-model/

Category	Examples of AWS Services in the Category	AWS Responsibility
Infrastructure services	Compute services, such as Amazon Elastic Compute Cloud (Amazon EC2)	AWS manages the underlying infrastructure and foundation services.
Container services	Services that require less management from the customer, such as Amazon Relational Database Service (Amazon RDS)	AWS manages the underlying infrastructure and foundation services, operating system, and application platform.
Abstracted services	Services that require very little management from the customer, such as Amazon Simple Storage Service (Amazon S3)	AWS operates the infrastructure layer, operating system, and platforms, as well as server-side encryption and data protection.

Category	AWS Responsibility	Customer Responsibility
Infrastructure services	AWS manages the infrastructure and foundation services.	You control the operating system and application platform, as well as encrypting, protecting, and managing customer data.
Container services	AWS manages the infrastructure and foundation services, operating system, and application platform.	You are responsible for customer data, encrypting that data, and protecting it through network firewalls and backups.
Abstracted services	AWS operates the infrastructure layer, operating system, and platforms, as well as server-side encryption and data protection.	You are responsible for managing customer data and protecting it through client-side encryption.

Deployment Models

- Meaning?
  - Where the infrastructure is
  - Who owns and manages the infrastructure
  - How cloud resources and services are made available to users



Deployment Models : Public

- Public Cloud
  - "a virtualized multi-tenant architecture enabling tenants or users to share computing resources, residing outside their firewalls"
  - NOT dedicated to a single user
  - Users get access to {servers, storage, network, security, apps as services} over the internet
  - Provisioning interfaces = {web consoles, APIs, CLIs, SDKs}
  - Provider owns, manages, provisions, maintains
  - $ = {subscription over time, per-usage}
- The good?
  - Most significant economies of scale
  - Theoretical reliability
- The bad
  - Security issues (e.g. data loss, data spread globally, compliance with different regulations)

Deployment Models : Public

Public cloud use cases

1.

Building and testing applications, and reducing time-to-market for their products and services.

2.

Businesses with fluctuating capacity and resourcing needs

3.

build secondary infrastructures for disaster recovery, data protection, and business continuity.

4.

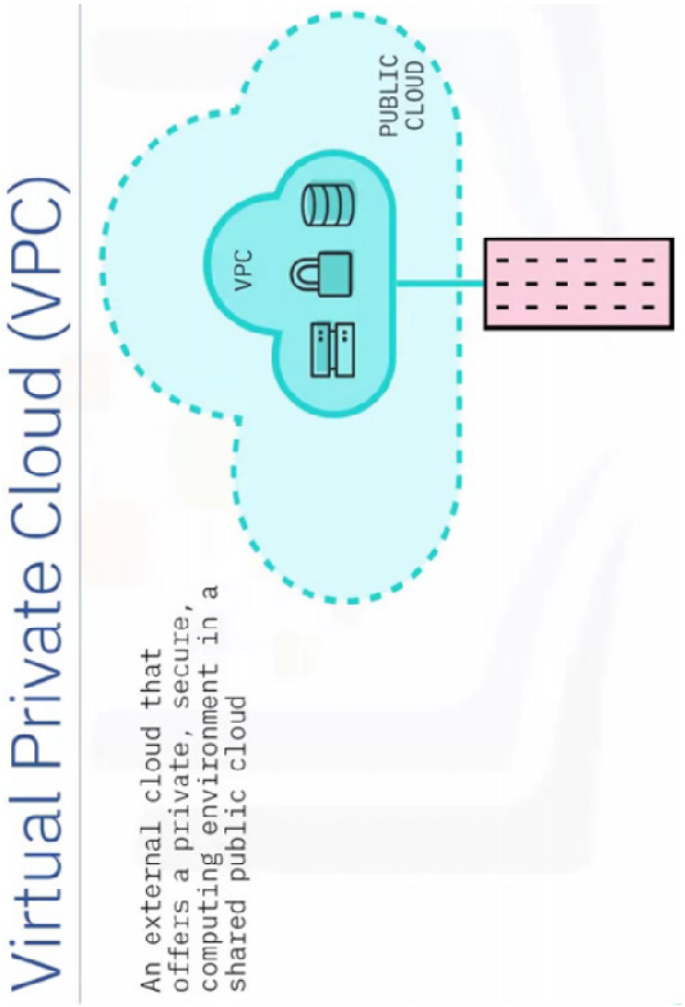
cloud storage and data management services for greater accessibility, easy distribution, and backing up their data.

5.

IT departments are outsourcing the management of less critical and standardized business platforms and applications to public cloud providers.

Deployment Models : Private

- Private Cloud
  - "cloud infrastructure provisioned for exclusive use by a single organization comprising multiple consumers, such as the business units within the organization"
  - "a private cloud is a virtualized environment modeled to bring in the benefits of a public cloud platform without the perceived disadvantages of an open and shared public platform"
    - Full control over access, security, compliance
  - Owned, managed, operated by the organization OR by a third-party, OR by a combination of them
    - If provisioned over a provider's infrastructure, is owned, managed, operated by the provider
      - External private cloud == Virtual Private Cloud == VPC
  - On-premises OR off-premises



Deployment Models : Private

Common Use Cases

Modernize and unify in-house & legacy applications

Integrate data & application services from existing applications

Build applications anywhere & move them without compromising security or compliance

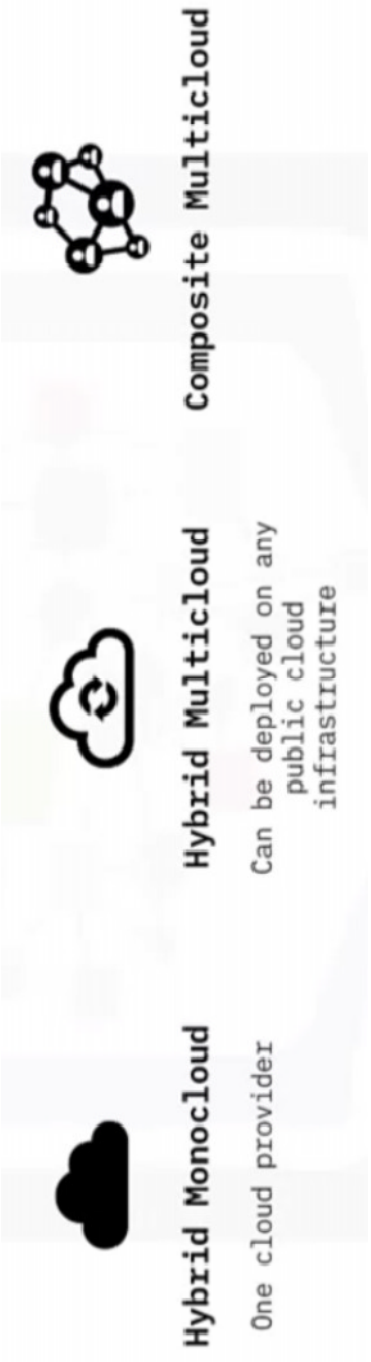
Full control over critical security & compliance issues within dedicated cloud

Deployment Models : Hybrid

- Hybrid Cloud
  - "a computing environment that connects an organization's on-premise private cloud and third-party public cloud into a single flexible infrastructure for running the organization's applications and workloads."
    - @private = for sensitive highly regulated and mission-critical applications or workloads with reasonably constant performance and capacity reqs. @public = for less sensitive and more dynamic workloads
  - the flexibility to choose the optimal cloud for each application or workload, workloads move freely between the two clouds as needs change.
  - Interoperability = the public and private cloud services can understand each other's APIs, configuration, data formats, and forms of authentication and authorization
  - Scalability
  - Portability

Deployment Models : Hybrid

- Hybrid Cloud
  - Hybrid Monocloud
    - 1 cloud provider
  - Hybrid Multicloud
    - an open standards-based stack that can be deployed on any public cloud infrastructure
  - Composite Multicloud
    - distributes single applications across multiple providers, allowing to move application components across different cloud services and vendors as needed



Deployment Models : Hybrid

Hybrid Cloud Use Cases

Software-as-a-Service integration

Data & AI integration

Enhancing legacy apps

VMware migration

Referências

- https://csrc.nist.gov/publications/detail/sp/800-146/final
- https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-146.pdf
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