BUS5001 – Cloud Platforms and Analytics

Week 02 – Cloud Architectures

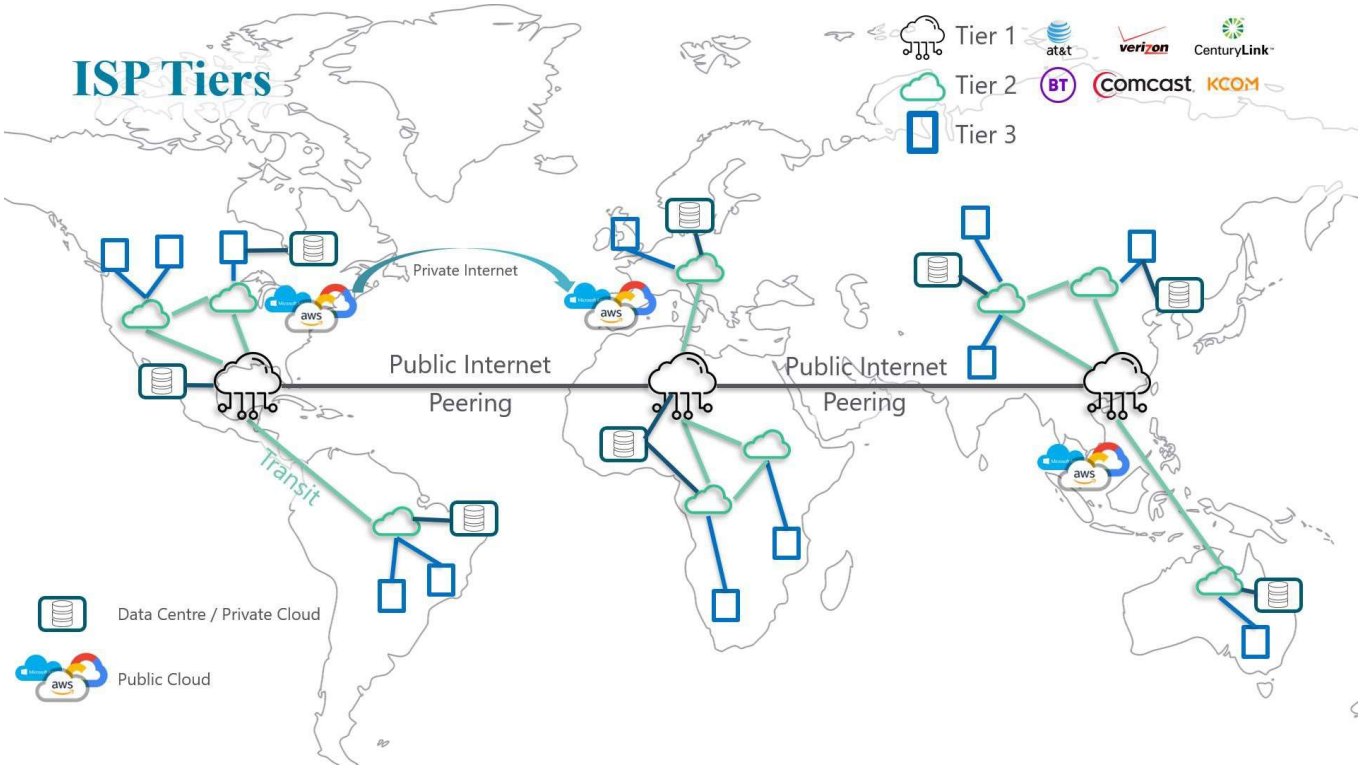
Centre for Data Analytics and Cognition
La Trobe University, Australia

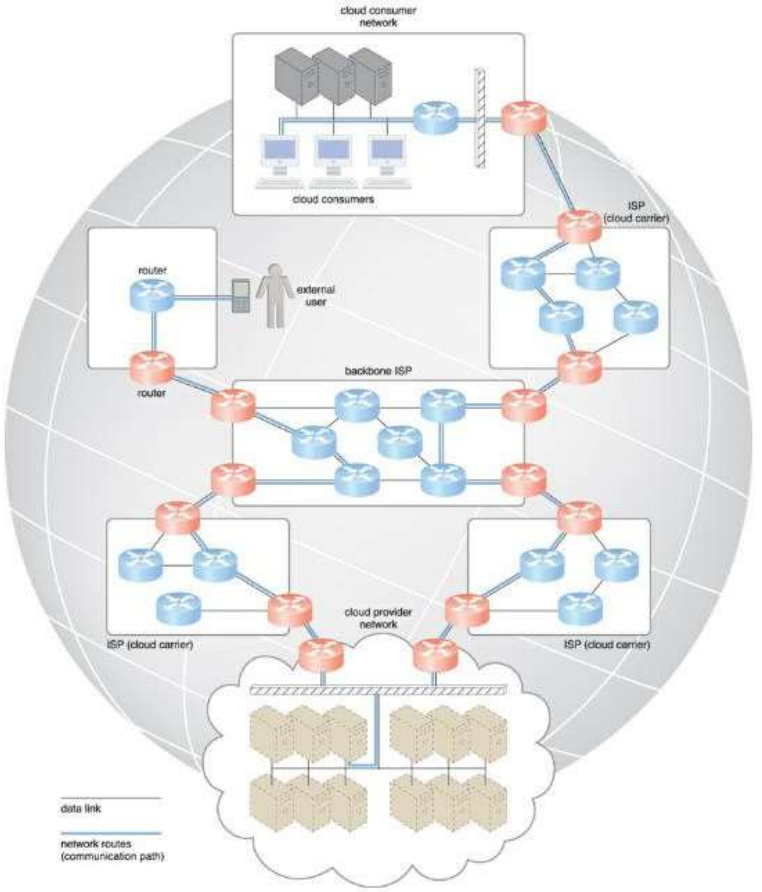
Recap of Week 01

- What is the Cloud?
- What are the Roles involved?
- Boundaries
- Essential Characteristics of the Cloud / Benefits
- Service Models
- Deployment Models
- Cloud Components / Services

The Technologies that Enable the Cloud

- Broadband Networks and Internet Architecture





Internet Architecture – Tiers / Internetworking

Tier 1

- Internet providers are the networks that are the backbone of the Internet. They are sometimes referred to as backbone Internet providers.

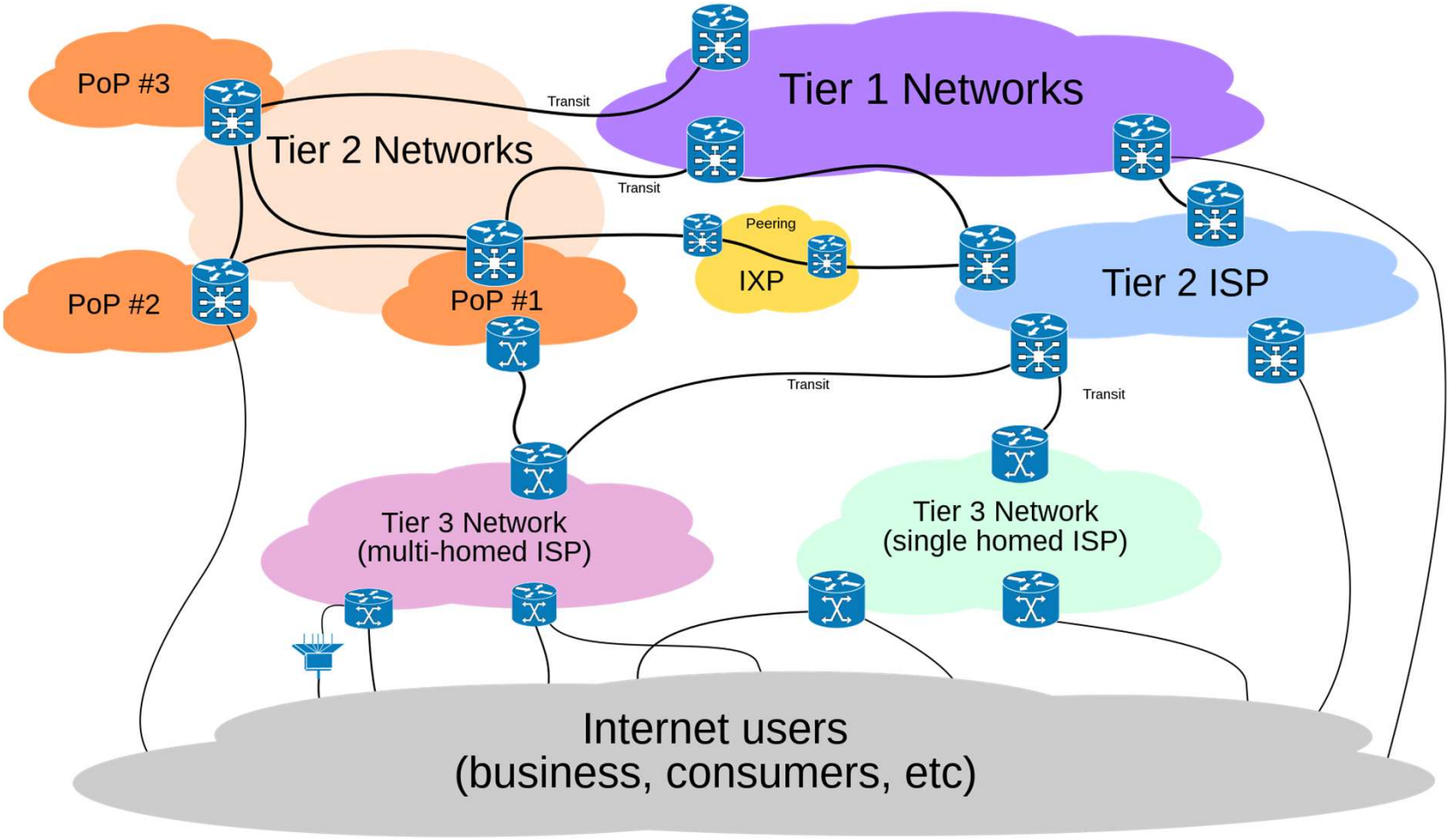
Tier 2

- Large regional / national providers. The interconnected ISPs of Tier 2 connect with Tier 1 providers, as well as the local ISPs of Tier 3.

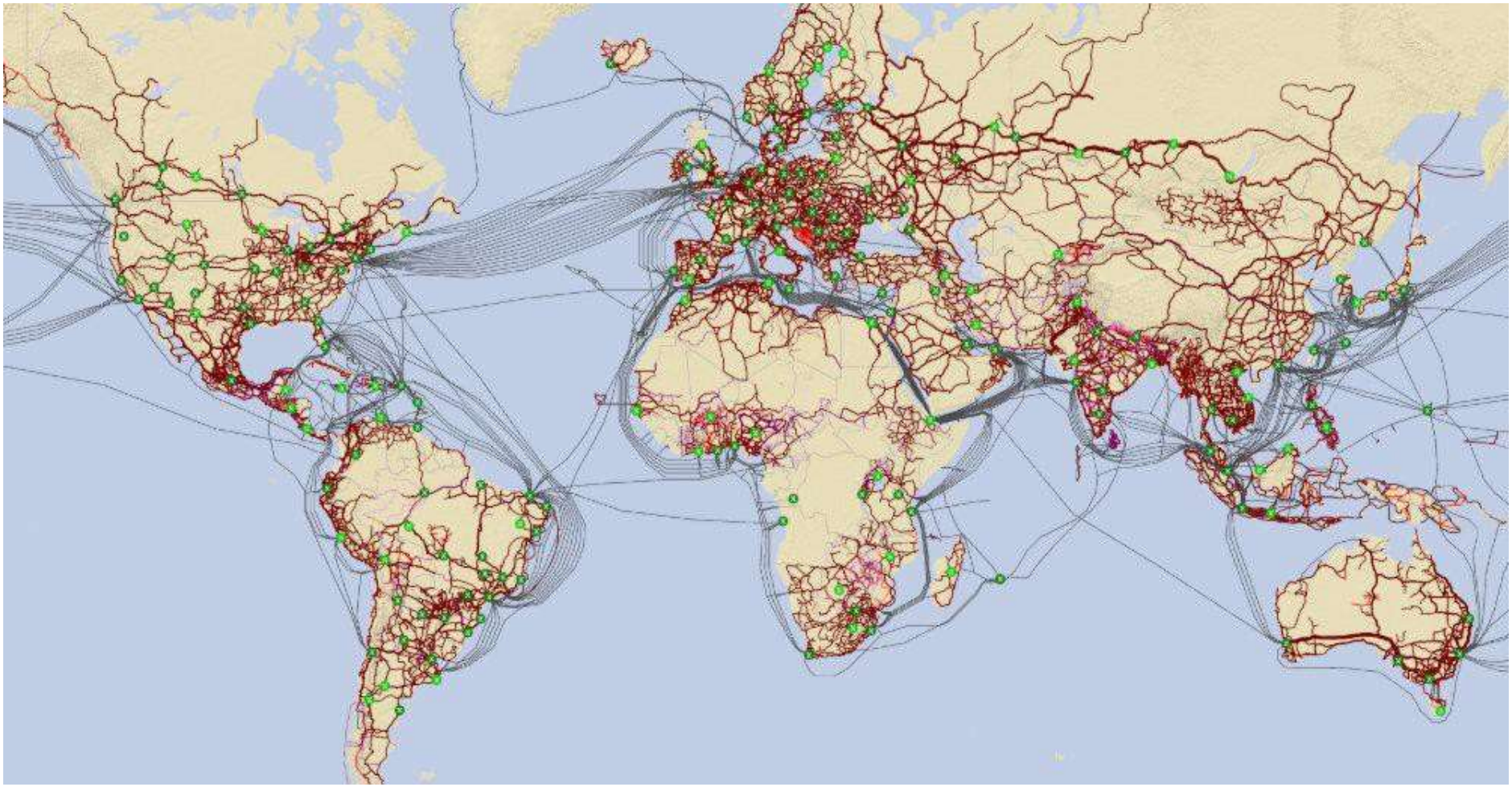
Tier 3

- A provider that strictly purchases Internet transit.

Internet Architecture



A Map of all Internet Cables on Earth



Interactive map here - https://www.itu.int/itu-d/tnd-map-public/

Tier 1 ISPs

- Centre for Applied Internet Data Analysis (CAIDA) Autonomous System (AS) Ranking
  - https://asrank.caida.org/
- Wikipedia (Ranked by Fiber route)

Name	Headquarters	AS number	CAIDA AS rank[10]	Fiber route (km)
AT&T[11]	United States	7018	20	660,000[12]
Deutsche Telekom Global Carrier[13]	Germany	3320	24	250,000[14]
GTT Communications	United States	3257	6	232,934[15][16]
Liberty Global[17][18]	United Kingdom[19]	6830	27	800,000[20]
Lumen Technologies (formerly CenturyLink, formerly Level 3)[21][22][23]	United States	3356	1	885,139[24][25]
NTT Communications (formerly Verio)[26]	Japan	2914	4	?
Orange[27]	France	5511	11	495,000 [28]
PCCW Global	Hong Kong	3491	10	?
T-Mobile US (formerly Sprint)[29]	United States	1239	26	30,000[30]
Tata Communications (formerly Teleglobe)[31]	India	6453	7	700,000[32]
Telecom Italia Sparkle (Seabone)[33]	Italy	6762	8	560,000
Arelion (formerly Telia Carrier)[34]	Sweden	1299	2	65,000[35]

Between Tier 1 and Tier 2

- They have a significant global presence and can reach over 50% of the Internet through settlement-free peering.

- However, they may still need to purchase transit from Tier 1 networks or other providers to reach certain parts of the Internet.

- These networks are typically classified as Tier 2 networks because they lack routes to one or more Tier 1 networks.

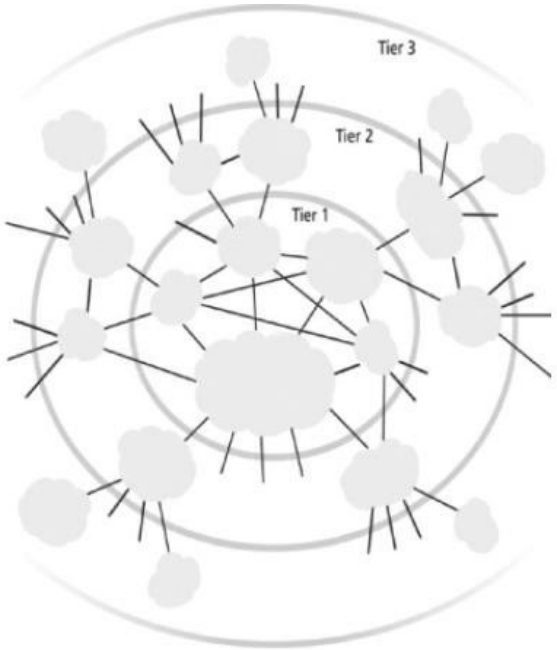
Name	Headquarters	AS Number	CAIDA AS Rank[10]	Reason
RETN[56]	United Kingdom	9002	12	Purchases transit from Level 3/AS3356
Comcast[52]	United States	7922	19	Network limited to the US; Purchases transit from Tata/AS6453, otherwise full reach via peering
Singtel[48]	Singapore	7473	15	Purchases transit from Arelion/AS1299, Zayo/AS6461, Tata Communications/AS6453.
Hurricane Electric[53]	United States	6939	6	IPv4: Purchases transit from Arelion/AS1299 to reach NTT/AS2914, Cogent/AS174, and Tata/AS6453 IPv6: Lack of peering with Cogent/AS174.[54][55]
Telstra[61]	Australia	4637	14	Purchases transit from Level 3/AS3356, Arelion/AS1299, Zayo/AS6461.
China Telecom	China	4134 4809	52	Purchases transit from Level 3/AS3356, Cogent/AS174.
Verizon Enterprise Solutions (formerly XO Communications)[59][60]	United States	2828	83	IPv6: Purchases transit from T-Mobile US/AS1239 to reach Vodafone (CW)/AS1273 and Telecom Italia Sparkle (Seabone)/AS6763.
Vodafone Carrier Services (formerly Cable & Wireless)[57]	United Kingdom	1273	11	Purchases transit from Arelion/AS1299 to reach AT&T/AS7018.[58]
Cogent Communications (formerly PSINet)[49]	United States	174	3	No IPv6 routes to Hurricane Electric/AS6939.[50][51]

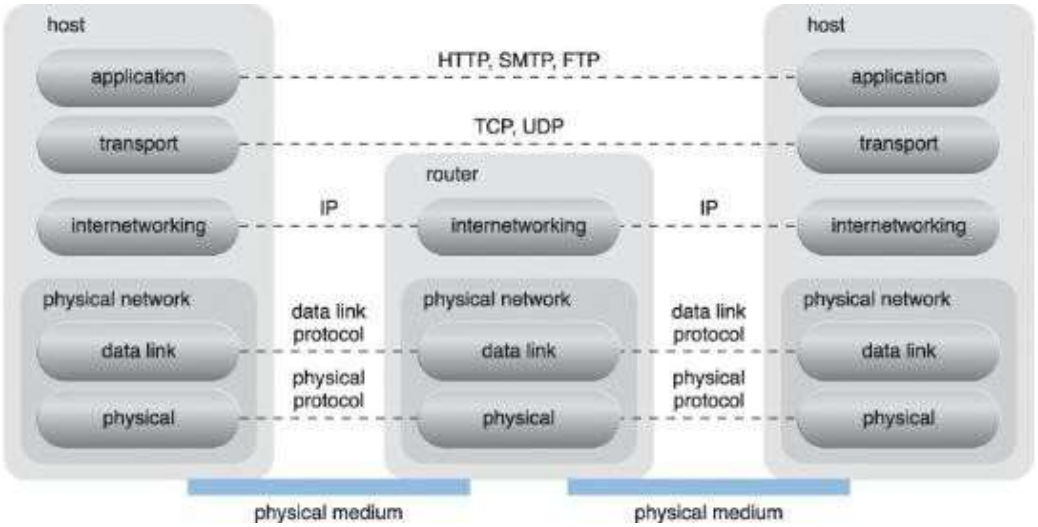
Tier 2 ISPs

Name	AS Number	August 2021 degree[1][2]	Reason
Fiber Telecom	41327	2145	Purchases transit from Level3/AS3356, GTT/AS3257, Telecom Italia Sparkle/AS6762, Telia Carrier/AS1299.
FiberRing	38930	35	Purchases transit from NTT America/AS2914, Telia Carrier/AS1299, Tata Communications/AS6453, Cogent/AS174.
Core-Backbone GmbH	33891	1311	Purchases transit from Level3/AS3356, Telia Carrier/AS1299.
SG.GS	24482	417	Purchases IP transit from NTT America/AS2914, Cogent/AS174 and Tata Communications/AS6453.
PT Mora Telematika Indonesia	23947	243	Purchases transit from Cogent/AS174, Global Telecom & Technology (GTT)/AS3257, Hurricane Electric/AS6939.
Fibrenoire	22652	127	Purchases transit from Telia Carrier/AS1299, Cogent/AS174, Tata Communications/AS6453, GTT/AS3257.
Internap	14744	33	Purchases transit from Cogent/AS174, NTT America/AS2914, Verizon/AS701.
KCOM Group	12390	69	Purchases transit from KPN/AS286, Level 3/AS3356, Cogent/AS174, NTT America/AS2914.
SK broadband	9318	537	Purchases transit from Telia Carrier/AS1299, Cogent/AS174, NTT America/AS2914, Tata Communications/AS6453, PCCW Global/AS3491, Verizon/AS701.
HGC Global	9304	637	Purchases transit from Cogent/AS174, NTT America/AS2914, Telecom Italia Sparkle/AS6762, Tata Communications/AS6453.
Turk Telekom International (d/b/a Euroweb.ro)	9121	250	Purchases IP transit from Level3/AS3356, Telia Carrier/AS1299, NTT America/AS2914, Deutsche Telekom Global Carrier/AS3320, China Telecom/AS4134&AS4809.
Stealth Communications	8002	47	Purchases transit from Cogent/AS174, NTT America/AS2914.
Comcast	7922	192	Purchases transit from Tata Communications/AS6453, NTT America/AS2914.
Telkom Indonesia International	7713	551	Purchases transit from Level3/AS3356, Cogent/AS174, Telia Carrier/AS1299, NTT America/AS2914, Telecom Italia Sparkle/AS6762, Tata Communications/AS6453, Singtel/AS7473.
Singtel	7473	359	Purchases transit from Telia Carrier/AS1299, Zayo/AS6461, Tata Communications/AS6453 and PCCW Global/AS3491.
Hurricane Electric	6939	9243	IPv4: Purchases transit from Telia Carrier/AS1299.[3] IPv6: Does not provide IPv6 routing/connectivity to Cogent/AS174.[4]
British Telecom	5400	151	Purchases transit from Level3/AS3356, Telia Carrier/AS1299, NTT America/AS2914.

Travel through the Internet

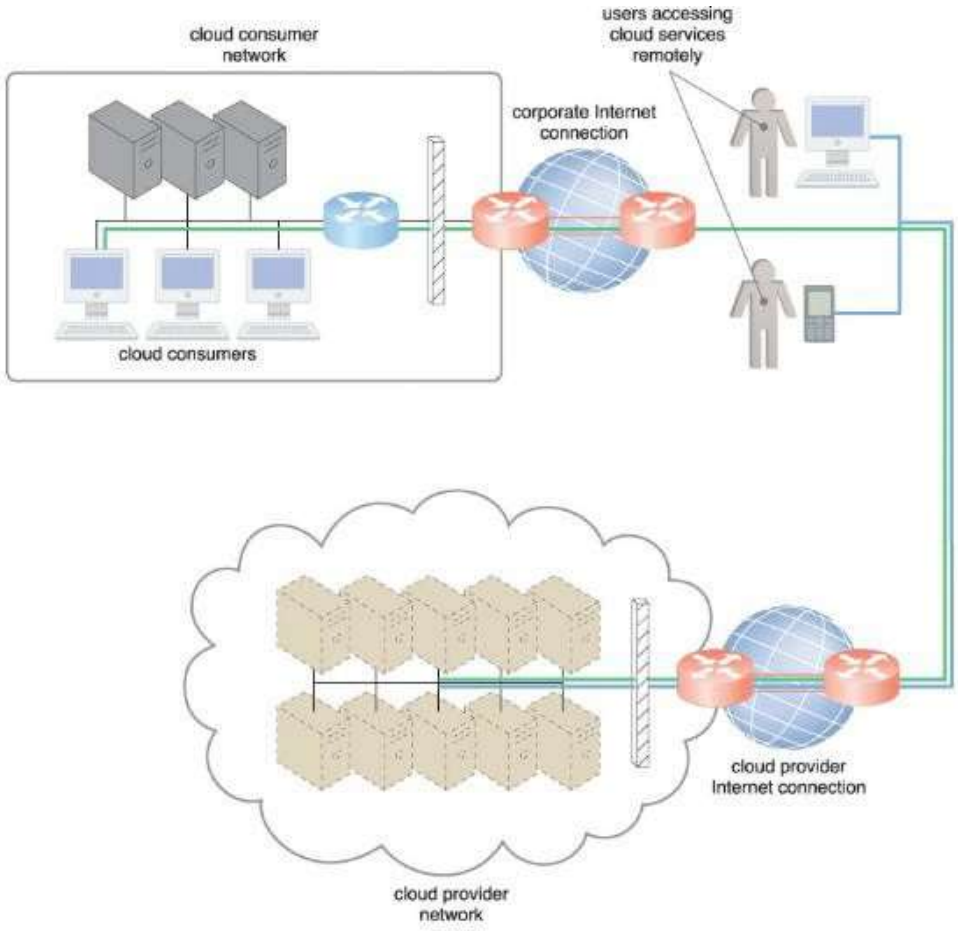
- Decentralised provisioning and management not controlled by a central entity
- Connected through common protocols / standards





Internetworking Architecture in Cloud Deployment

- On premise deployment models
- Centralised servers / storage on organisations own data centre
- Connectivity through dedicated Local Area Network (LAN)
- When spreading the trust boundary the internet becomes a connecting medium
  - Cloud service user
  - End users not on the internal network
  - Cloud provider



Network Bandwidth and Latency Issues

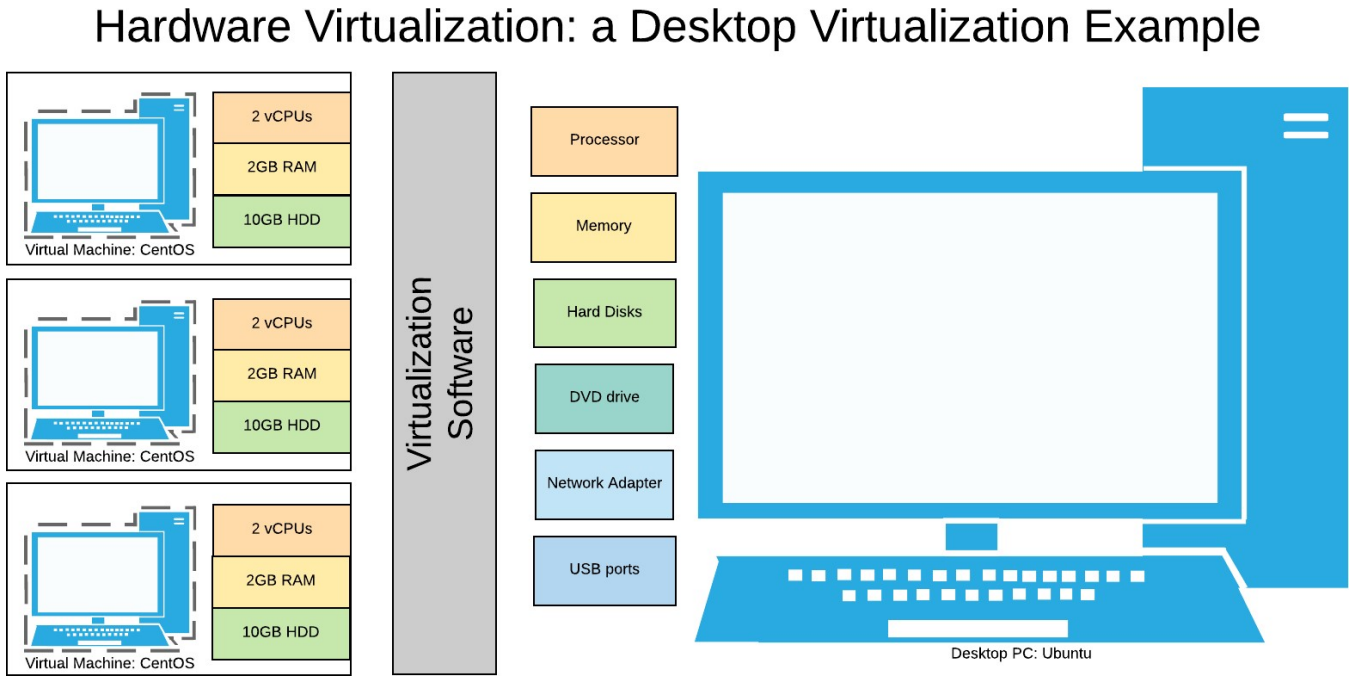
- Quality of Service (QoS)
  - Bandwidth: The speed of a link. QoS can tell a router how to use bandwidth. For example, assigning a certain amount of bandwidth to different queues for different traffic types.
  - Delay (Latency): The time it takes for a packet to go from its source to its end destination. This can often be affected by queuing delay, which occurs during times of congestion and a packet waits in a queue before being transmitted. QoS enables organizations to avoid this by creating a priority queue for certain types of traffic. More nodes (hops) more latency (degradation of service)
  - Loss: The amount of data lost as a result of packet loss, which typically occurs due to network congestion. QoS enables organizations to decide which packets to drop in this event.
  - Jitter: The irregular speed of packets on a network as a result of congestion, which can result in packets arriving late and out of sequence. This can cause distortion or gaps in audio and video being delivered.
- Service levels across Cloud Providers and Cloud Carriers
  - QoS across multiple IPs

Data Centres

- A **data centre** is a centralized physical facility where corporate computers, network, storage, and other IT equipment that support business operations live.
  - Enterprise data centres are typically constructed and used by a single organization for their own internal purposes. These are common among tech giants.
  - Colocation data centres function as a kind of rental property where the space and resources of a data centre are made available to the people willing to rent it.
  - Managed service data centres offer aspects such as data storage, computing, and other services as a third party, serving customers directly.
  - Cloud data centres are distributed and are sometimes offered to customers with the help of a third-party managed service provider.
- Data Centre's reside in data centre facilities
  - Components require significant infrastructure to support the center's hardware and software. These include power subsystems, uninterruptible power supplies (UPS), ventilation, cooling systems, fire suppression, backup generators, and connections to external networks.

Virtualisation

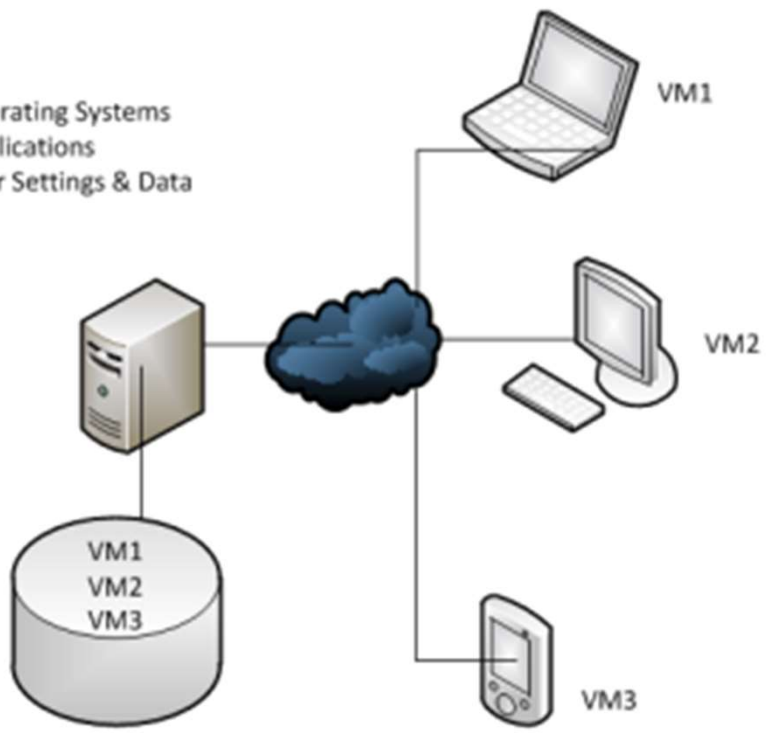
- Virtualisation converts a physical resource in to one or more virtual resources
  - Desktop
  - Servers
  - Storage
  - Network



Desktop Virtualisation

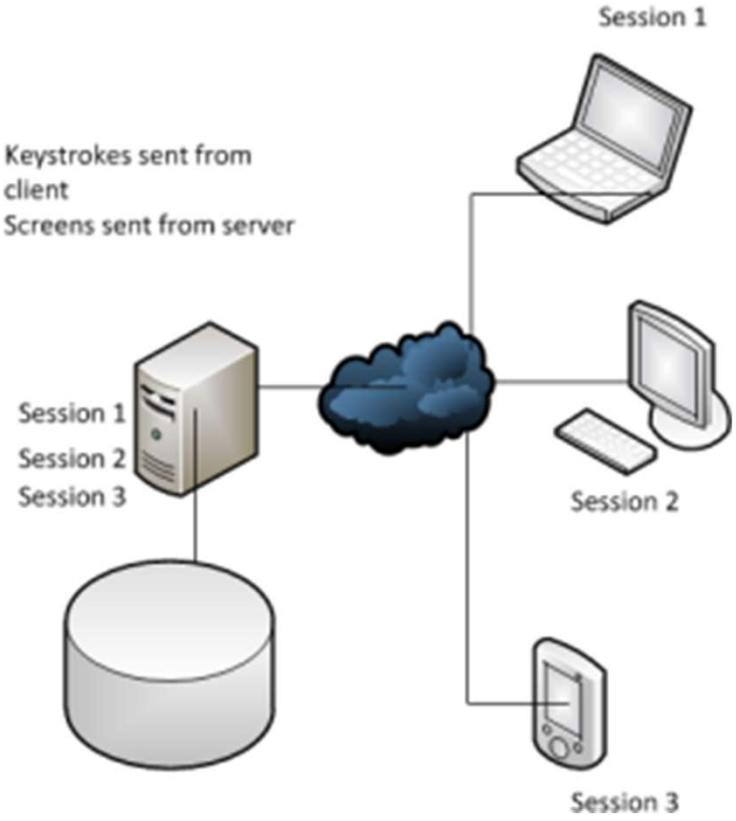
Virtual Desktop Infrastructure

- Operating Systems
- Applications
- User Settings & Data



Session Virtualization

- Keystrokes sent from client
- Screens sent from server



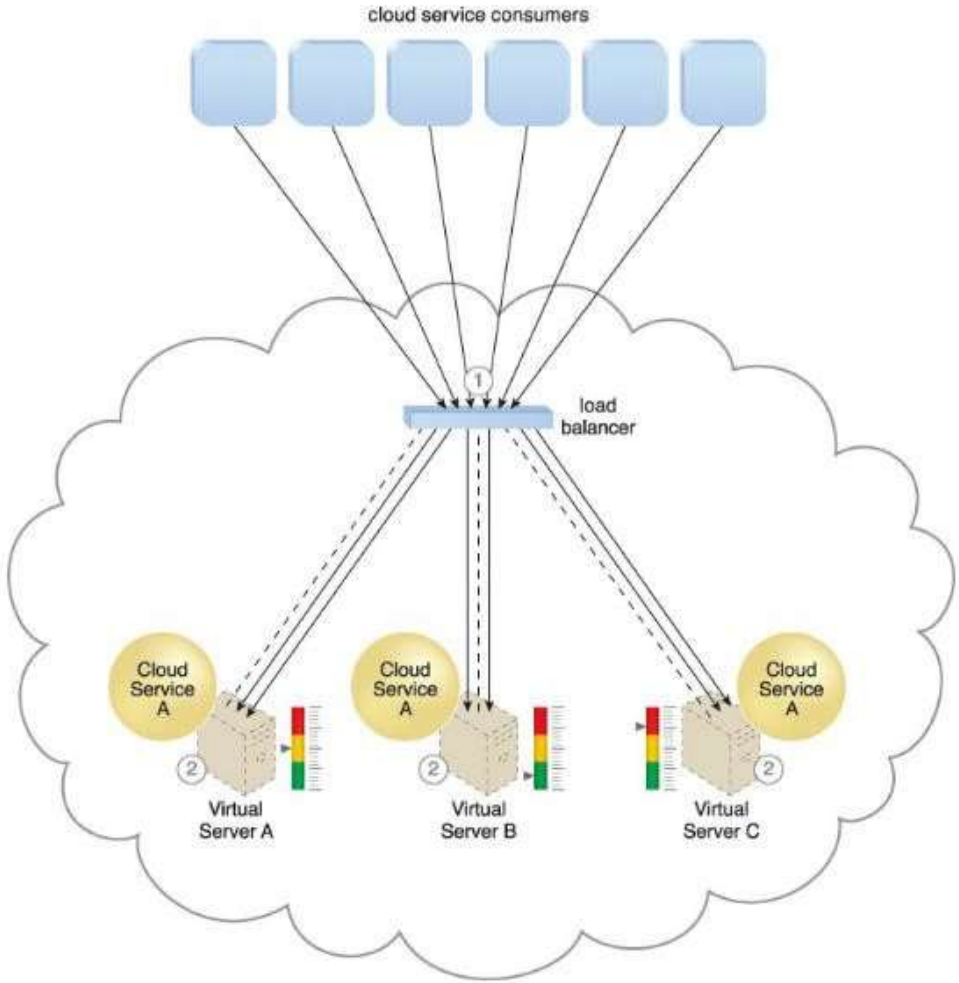
Hypervisors

- Type 1 Hypervisor (Bare-Metal Hypervisor): Type 1 hypervisor, also known as a bare-metal hypervisor, runs directly on the host machine's hardware without the need for an underlying operating system. E.g.VMware ESXi, Microsoft Hyper-V, Citrix XenServer, and KVM.

- Type 2 Hypervisor (Hosted Hypervisor): Type 2 hypervisor, also known as a hosted hypervisor, runs on top of an existing operating system e.g. Oracle VirtualBox, VMware Workstation, Parallels Desktop

Load Balancing

- Load balancing is specialised variation of Workload Distribution which allow you to Scale services
- Redundant deployments of services are created and front ended by the Load Balancing system which would manage the allocation requests that are received
- Load balancers can either be external or built in
- Intercept messages sent by Cloud Service Consumers and forward them to the servers

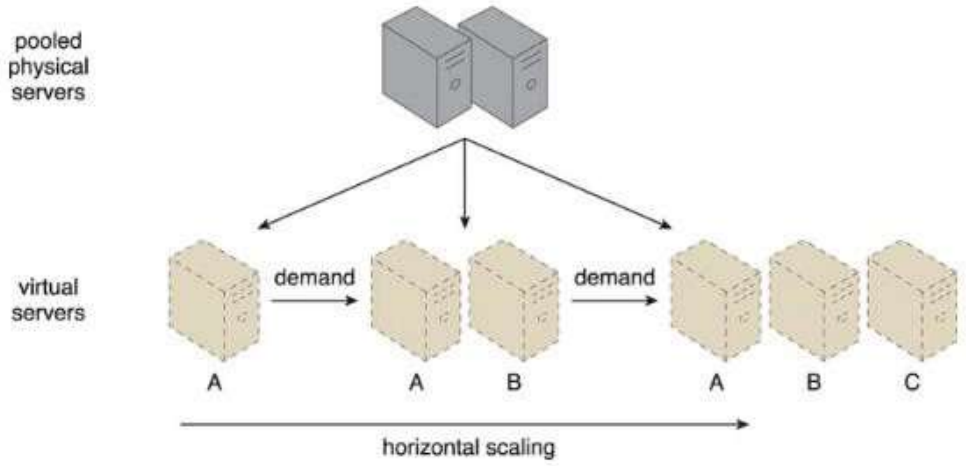


Scaling

- Scaling refers to the ability of a service provider to be able to handle increasing or decreasing load
- Two types of Scaling
  - Horizontal
  - Vertical

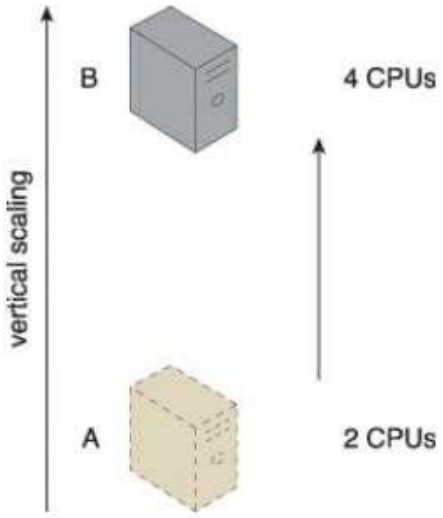
Horizontal Scaling

- Horizontal scaling or scaling out and in refers to adding or removing nodes to your pool of resources



Vertical Scaling

- Vertical scaling or scaling up or down refers to increasing the power of your existing resource pool; i.e. increase CPU / RAM / Storage



Scaling Pros & Cons

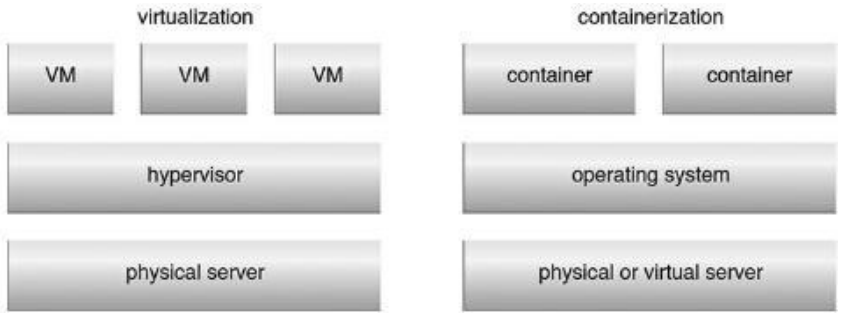
- Horizontal scaling is generally less expensive with Vertical scaling requiring more specialised hardware and it can be restricted by maximum capacity of your hardware resource
- Vertical scaling generally has higher possibilities for downtime, while horizontal scaling can be automated
- Horizontal scaling generally requires more complex maintenance due to the number of nodes

Containerisation

- Containerization is an operating system-level virtualization technology used to deploy and run applications and cloud services without the need to deploy a virtual server for each solution.
- Portability between different platforms and clouds.
- Better hardware resource utilisation is achieved by reducing CPU, memory and storage usage footprint in comparison to virtual servers.
- Agility that allows developers to integrate with their existing DevOps environment. Furthermore, containers allow versions of an software code and its dependencies to be tracked. Including inspect differences between different the versions, and roll back to previous versions, when required.
- Higher speed in the delivery of enhancements. Containerizing monolithic applications using microservices helps development teams create functionality with its own life cycle and scaling policies.
- Flexibility to work on virtualized infrastructures or on bare metal servers

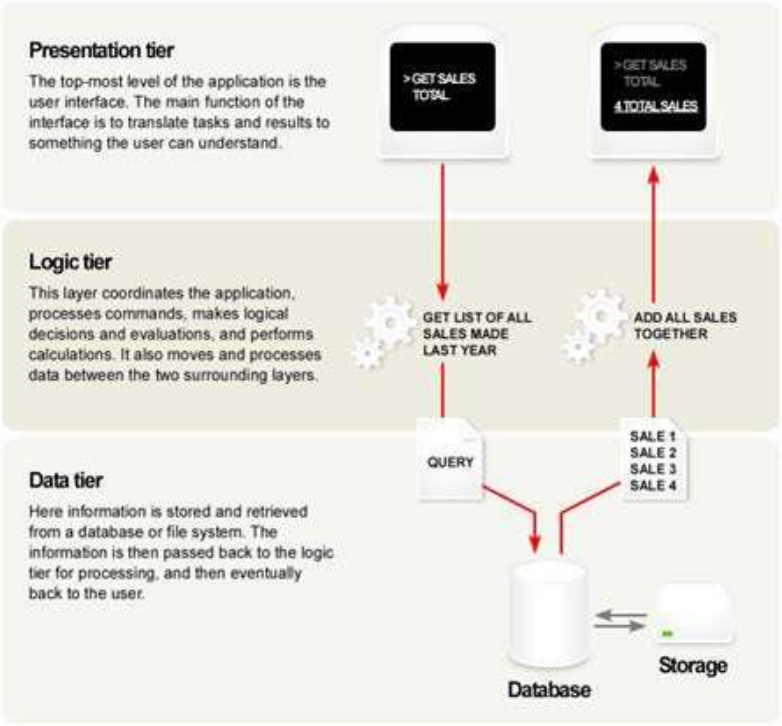
Key Components of a Container

- Container Engine
  - The container engine is specialized software that is deployed in an operating system to abstract the required resources and enable the definition and deployment of containers.
- Container Build File
  - Descriptor that represents the requirements of the application and services that run inside the container, as well as the configuration parameters required by the container engine in order to create and deploy the container.
- Container Image
  - Allows the engine to deploy an image based on pre-defined requirements, normally read-only.
- Container
  - An executable instance of a pre-defined or customized container image that contains the application or service.
- Networking Address
- Storage



Web

- Web technology is very commonly used for cloud service implementations and for front-ends used to remotely manage cloud-based IT resources.
- Fundamental technologies of Web architecture include the URL, HTTP, HTML, REST, JSON and XML.

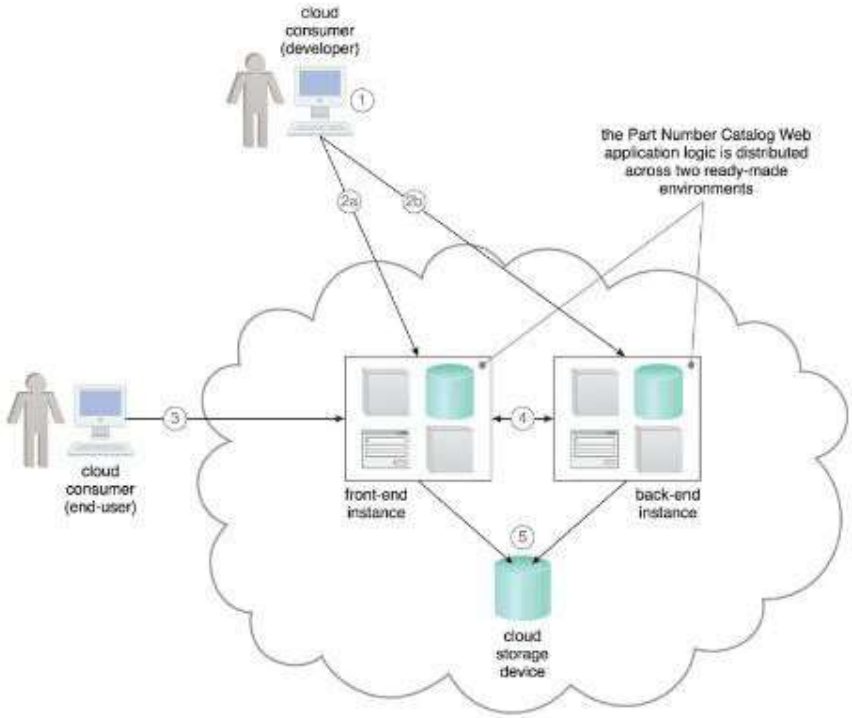


Benefits – Reduced Cost

- Reduced Investments and Proportional Costs
  - Reduction / elimination of up front IT costs (Capital Expenditure)
  - Measured usage allows expenditure directly related to operations rather than anticipated expenditure
  - Pooled resources at a Data Centre made available to multiple consumers
  - Best practices and patterns, optimised cloud architectures, governance adopted reduce operational costs and inefficiencies

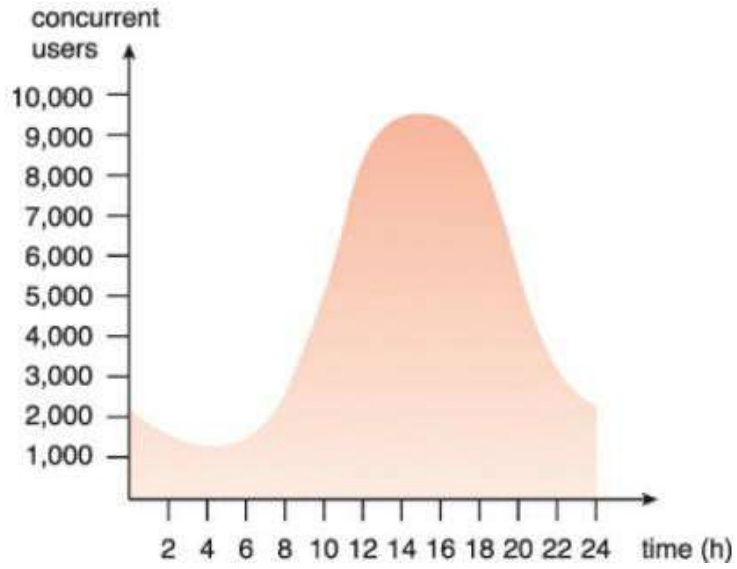
Benefits – Ready Made Services

- Availability of ready made services that can be utilised within an organisation



Benefits – Increased Scale

- Ability to align infrastructure to the usage demand fluctuations
  - Resources can be increased or released with demand
  - Ability to fulfill unpredictable demand

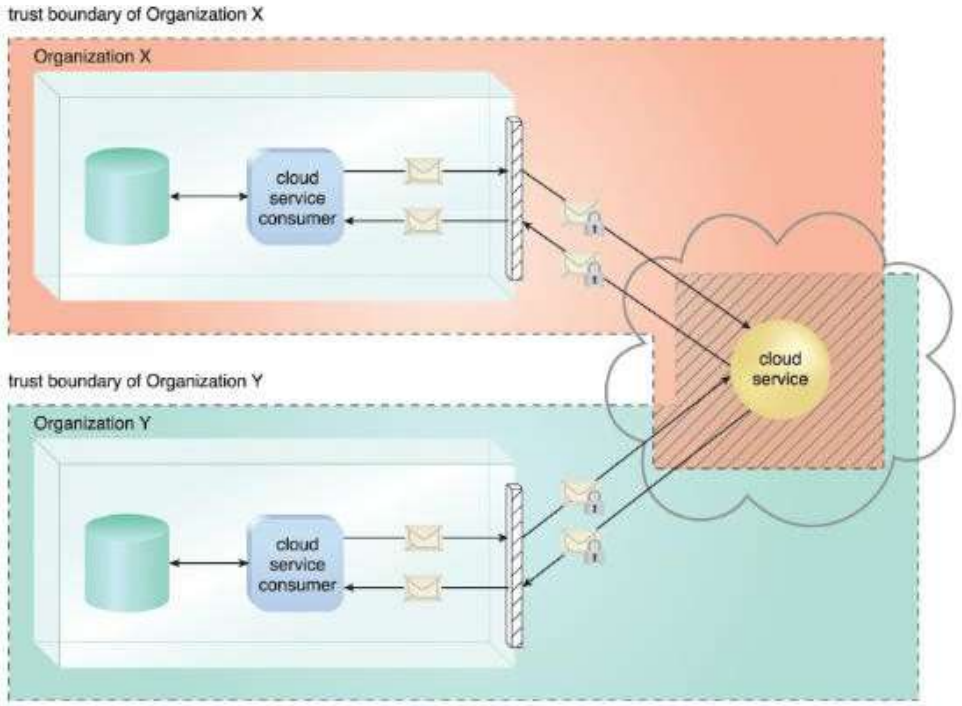


Benefits – Increased Availability / Reliability

- Ability to provide guaranteed SLAs for availability
- Avoid and recover from exceptional conditions
- Failover support should it be required
- High Availability Disaster Recovery (HADR)

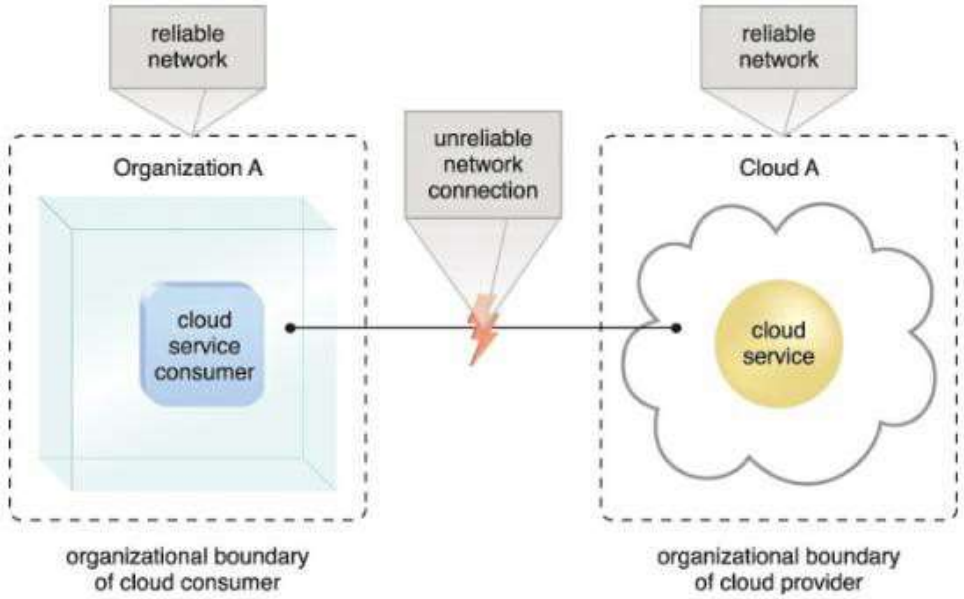
Challenges – Security Vulnerabilities

- Increased risk of security vulnerabilities
  - Negotiating overlapping trust boundaries
    - Meltdown / Spectre vulnerabilities in Intel chips
    - Overlapping security architectures, standards and policies



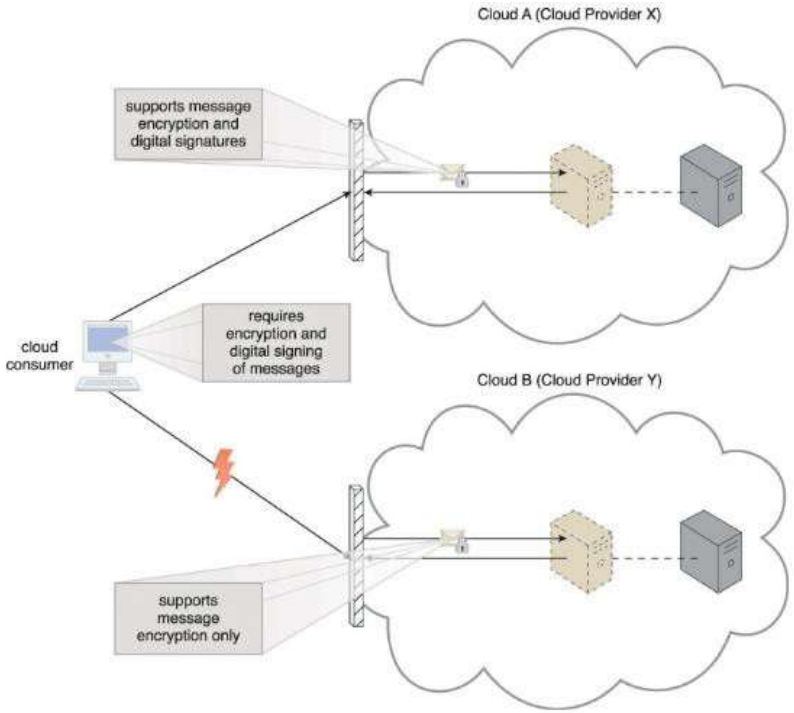
Challenges – Operational Governance Control

- Reliability is solely dependant on the SLAs in place with the cloud service provider
- Distances between consumer and provider introduce QoS issues
- Needs a framework to measure SLA's at the consumer service level rather the cloud service level, have legal contracts in place with penalties for breach



Challenges – Limited Portability between Cloud

- There are no established standards with regards to Cloud service development
- Solutions built with these services would require development effort to port between clouds



Challenges – Multi Region

- Can cause legal and compliance issues especially with respect to the movement and processing of data
  - GDPR – General Data Protection Regulation
  - A regulation that requires businesses to protect the personal data and privacy of EU citizens for transactions that occur within EU member states

The Cloud and DevOps

Operations Teams	Monitor	Dev Teams	Design
	Detect / Predict Failure		Develop
	Manage Environment		Deliver
	Fix Bugs		Run

DevOps

- DevOps brings both of these together
- A DevOps approach applies agile and lean principles to all stakeholders in an organization
  - The Business
  - Customer
  - Suppliers
  - Partners
- When developing, operating and using Software
- DevOps approach to producing software
  - Short iterations on a continuous delivery schedule
  - New features and bug fixes in rapid cycles
  - This means that
    - Businesses can seize market opportunities (Agility)
    - And reduce time to addressing customer feedback in products.

Discussion

- Divide into groups
- Pick a service in a cloud provider of your choice, discuss and come up with the following
  - What is the service used for?
  - What are its special features?
  - Any limitations or caveats to be considered?
  - What are the costs?
  - What is one competing service in another cloud provider?
  - Give us an example of how you would use it.
- Pick a leader who will present to the class

Microsoft Azure

What is Microsoft Azure?

- Microsoft Azure is a cloud computing platform and an online portal that allows you to access and manage cloud services and resources provided by Microsoft.
- Azure has more than 200 products and services that cater to different needs and scenarios4.
- Some of the popular Azure services and products are:
  - Azure Virtual Machines: A dedicated physical server to host your Azure VMs for Windows and Linux.
  - Azure Web Apps: A service that lets you build and host web applications without managing the underlying infrastructure.
  - Azure Storage: A scalable and durable cloud storage service that supports blobs, files, queues, and tables.
  - Azure SQL Database: A fully managed relational database service that supports SQL Server and Azure SQL features.
  - Azure Cognitive Services: A collection of AI services that enable you to add vision, speech, language, and decision capabilities to your applications.

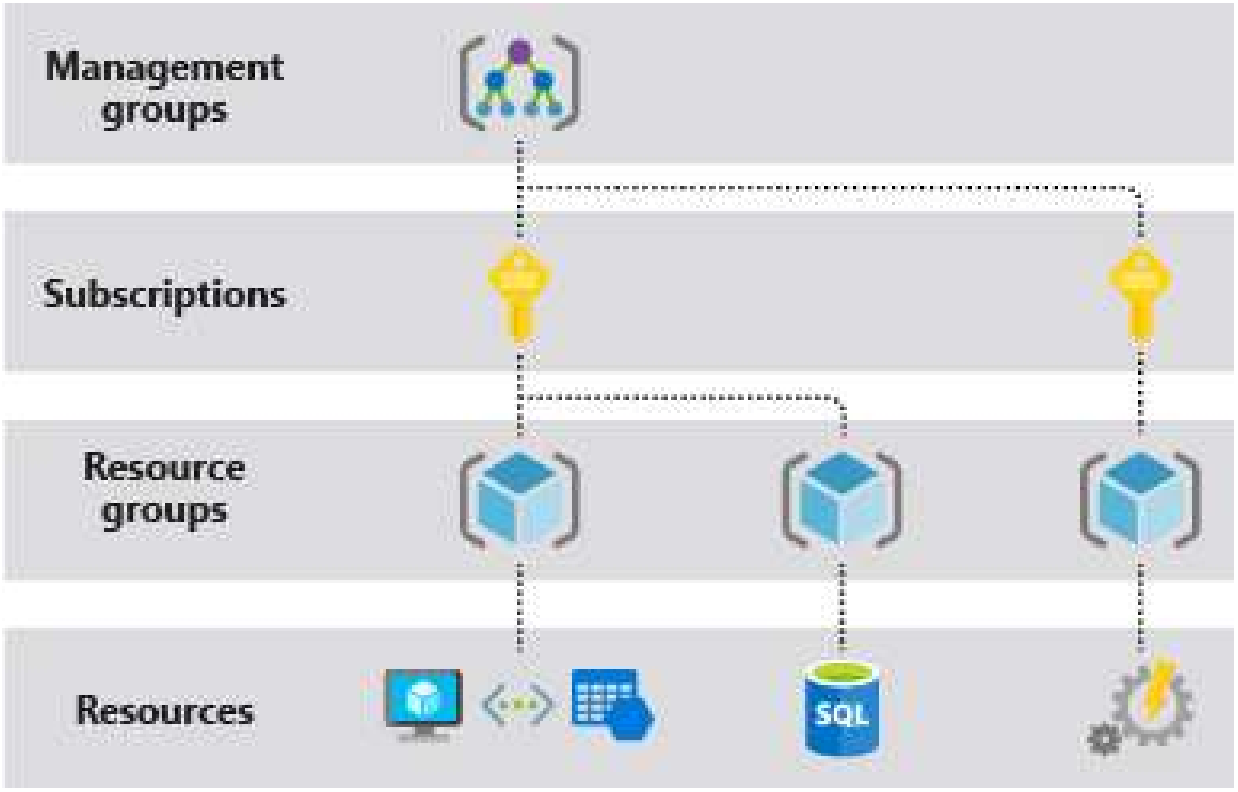
Azure History

- Microsoft Azure was first announced on October 28, 2008, as a cloud computing operating system that was targeted at businesses and developers without additional coding.
- The original name Windows Azure was a deliberate response in competition to the Amazon EC2 and Google App Engine, which were already offering cloud computing services at that time.
- Windows Azure was built as an extension of the Windows NT, which was the beginning of Microsoft's cloud platform as a service (PaaS).
- Windows Azure was an internal project that went by the code name "Project Red Dog" in the mid-2000s, when it began.

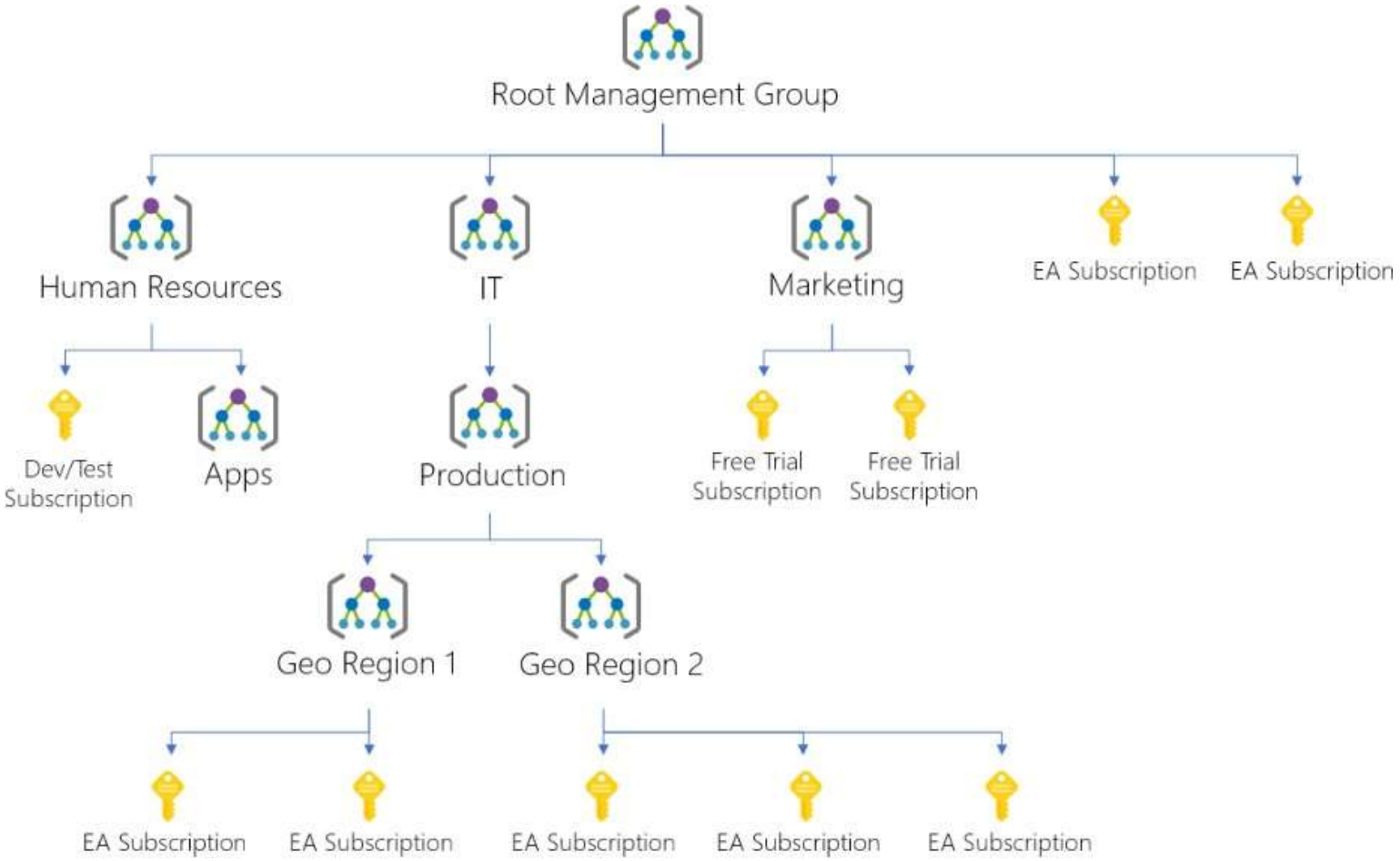
Azure History

- In 2008, Microsoft announced Azure as a cloud computing operating system that was code-named “Red Dog” and was an extension of Windows NT.
- In 2010, Microsoft launched Azure as a commercial service that offered compute, storage, and networking capabilities in the cloud.
- In 2012, Microsoft introduced Azure Virtual Machines, which enabled customers to run Windows and Linux workloads on the cloud.
- In 2014, Microsoft rebranded Azure as Microsoft Azure and added various features and services, such as Azure Machine Learning, Azure IoT Hub, and Azure Functions.
- In 2016, Microsoft acquired LinkedIn, which became one of the largest customers of Azure.
- In 2018, Microsoft announced Azure Sphere, which is a solution for securing IoT devices and microcontrollers.
- In 2019, Microsoft won the JEDI contract from the US Department of Defense, which is worth $10 billion over 10 years and involves migrating the Pentagon’s data to Azure.
- In 2020, Microsoft launched Azure Synapse Analytics, which is a unified data platform that combines data warehousing, big data analytics, and data integration.
- In 2021, Microsoft announced Azure AI milestone, which is a new generation of Neural Text-to-Speech models that can produce natural speech with no significant difference from human recordings
- . Microsoft Azure has more than 1.3 million active customers, and hosts more than 2 trillion messages per week.

General Structure of Resources

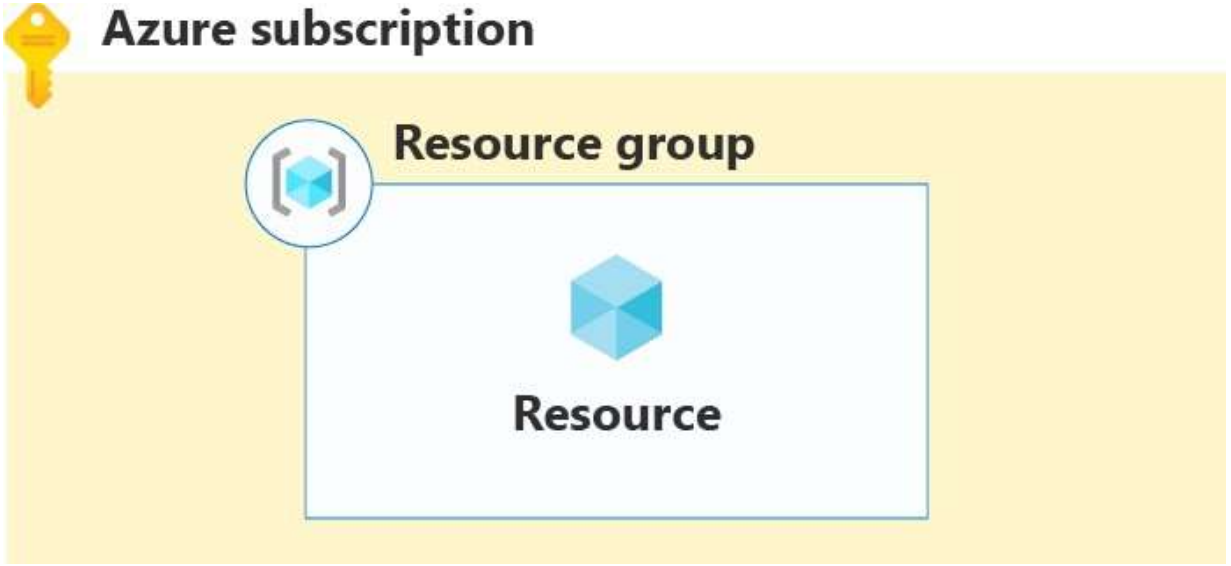


Enterprise Scale



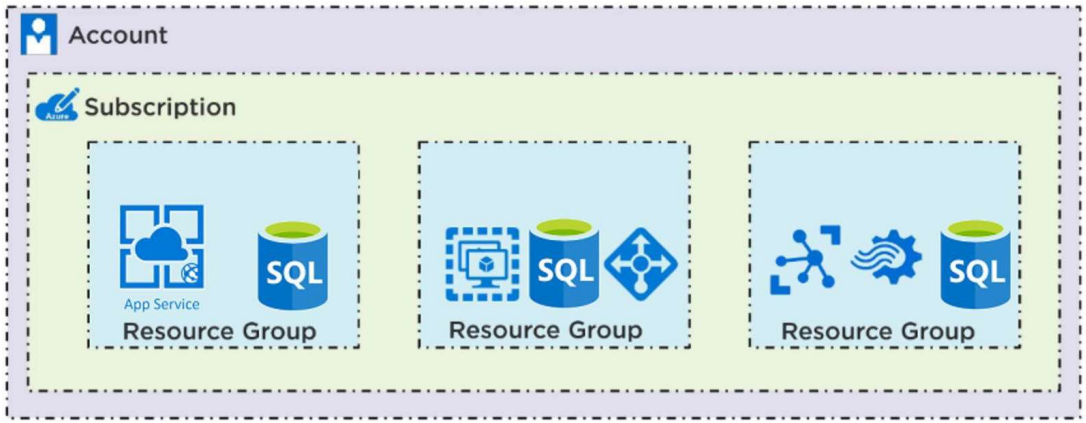
Subscriptions

- A subscription is a logical container for your resources. Each Azure resource is associated with only one subscription. Creating a subscription is the first step in adopting Azure.



Resource Groups

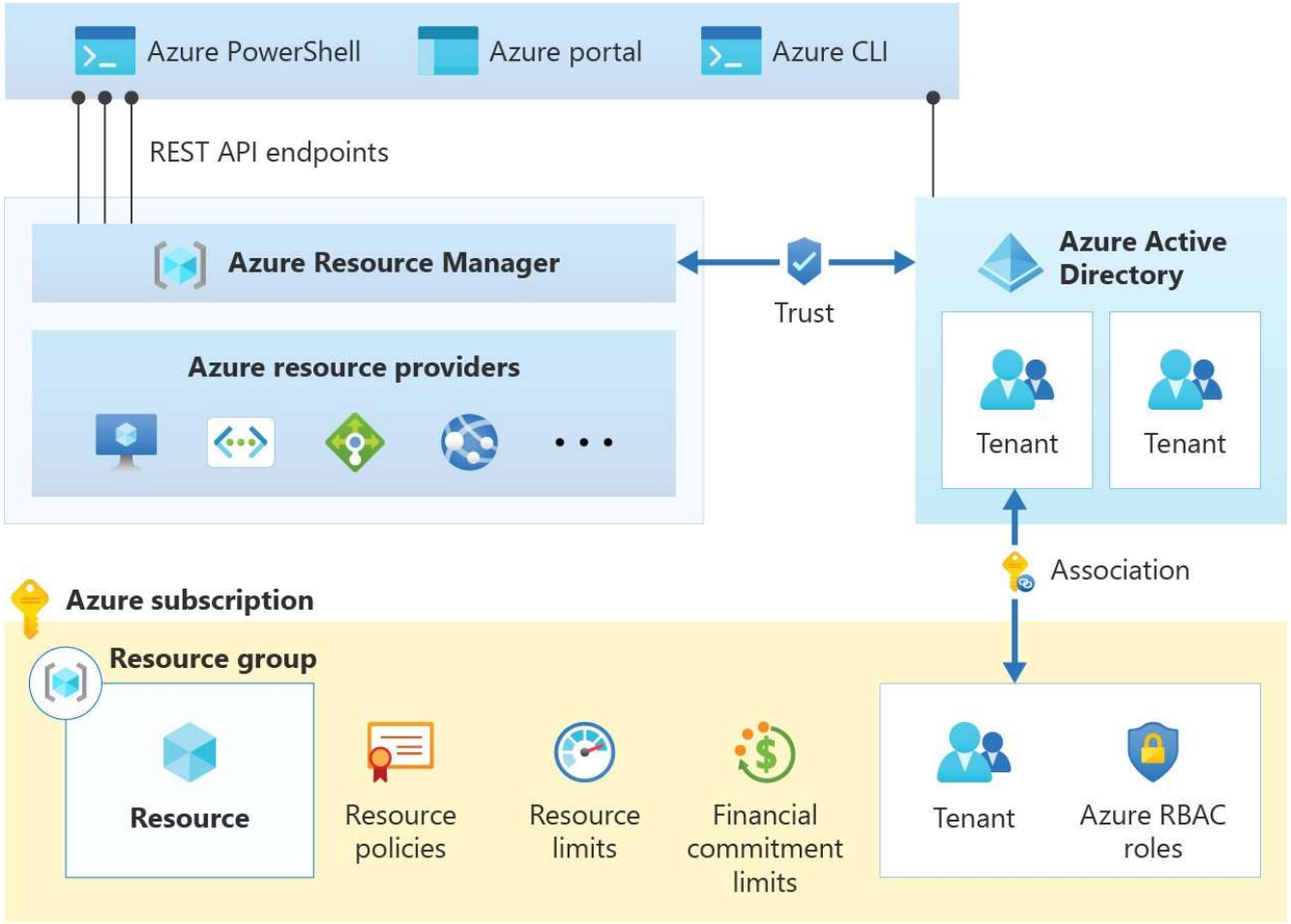
- A resource group is a logical container that holds related resources for an application or solution. It is used to organize resources in a way that makes it easier to manage and track them.
- A resource group is a logical container that associates multiple resources so you can manage them as a single entity—based on lifecycle and security. For example, you can create or delete resources as a group if the resources share a similar lifecycle—such as the resources for an N-tier application. In other words, everything that you create, manage, and deprecate together is associated within a resource group.



Azure Resource

- In Azure, a resource is an entity managed by Azure. Virtual machines, virtual networks, and storage accounts are all examples of Azure resources.

Azure Resource Management



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