

Middleware Architectures 2

Lecture 5: Cloud Architectures

doc. Ing. Tomáš Vitvar, Ph.D.

tomas@vitvar.com • @TomasVitvar • https://vitvar.com



Czech Technical University in Prague

Faculty of Information Technologies • Software and Web Engineering • https://vitvar.com/lectures



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Overview

- Introduction
- Cloud Architecture
- Infrastructure as a Service

Terminology

- Cloud computing
- *aaS
- DevOps
- Cloud Native, Microservices
- Serverless

What is a Cloud?

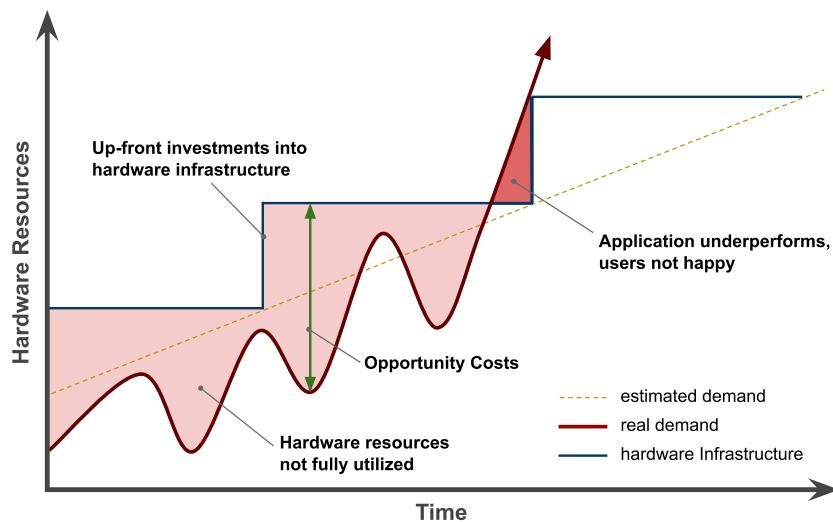
- A different way of thinking
 - *Got your grand mum's savings under your pillow?*
→ probably not, you better have them in your bank
 - *Data is your major asset*
 - *you better have them in a "bank" too*
 - *Someone can abuse your data?*
 - *banks bankrupt too, sometimes – it is a risk you take*
 - *there is a market and a competition*
- Outsourcing of application infrastructure
 - *Reliability and availability*
 - *Low costs – pay-per-use*
 - *Elasticity – can dynamically grow with your apps*
 - *CAPEX vs. OPEX*

What is a Cloud?

- Any app you access over the web?
- A datacenter?
 - Offers virtualization
 - Any company having a datacenter wants to move to
- Cloud provider should also offer services, such as:
 - scalability, storage
 - Possible to configure programmatically
 - integration to enterprise administration processes
 - usually REST interface

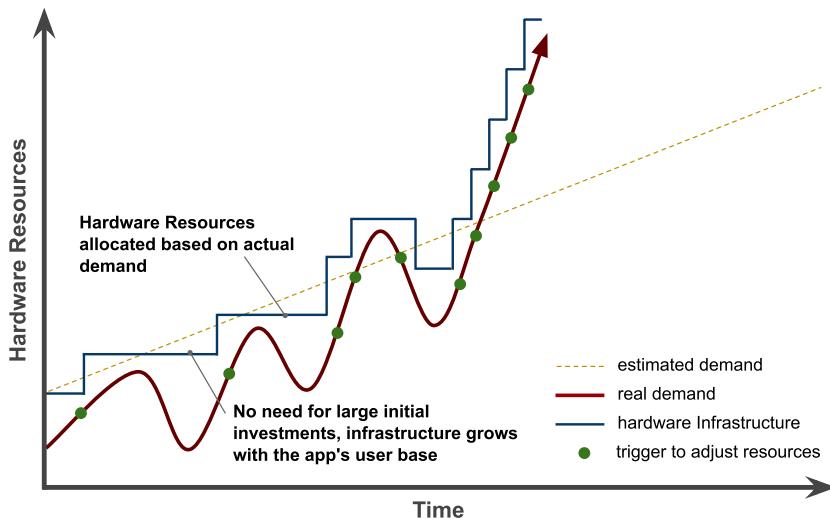
Traditional Solution to Infrastructure

- Traditional hardware model
 - Up-front hardware investments
 - Hardware not optimally utilized



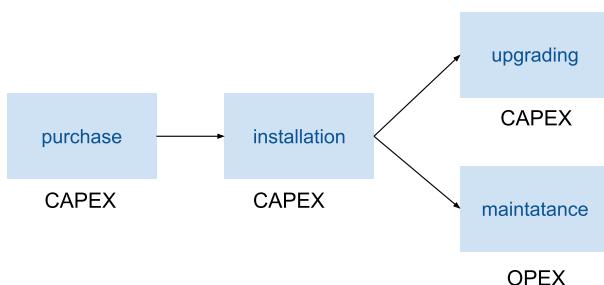
Good Performance – Cloud Solution

- Cloud Computing model
 - No up-front hardware investments
 - Hardware optimally utilized



CAPEX vs. OPEX

- Capital expenditure/capital expense (CAPEX)
 - money to spend to buy, maintain or improve fixed assets
→ buildings, vehicles, equipment or land
 - have impact on costs vs. profit and tax



- Operational expenditure (OPEX)
 - ongoing costs for running a product, business, or systems
 - OPEX are entirely tax-deductible
- Cloud lets you trade CAPEX for OPEX
 - No investments in data centers and infrastructures
 - You pay only when you consume resources

Cloud Computing Concepts

- **On-demand and self-service**
 - Resources are provisioned as they are requested and when they are required
 - No human interaction, automatic
- **Broad network access**
 - Capabilities are available over the network
- **Resource pooling**
 - Provider's computing resources reused by multiple tenants (multitenancy)
 - Resources are dynamically assigned/re-assigned according to demand
 - Computing resources: CPU, memory, storage, network
- **Scalability and elasticity**
 - Infrastructure may grow and shrink according to needs
 - Automatic or manual
- **Measured service**
 - Resource usage can be monitored, controlled and reported
- **Pay-per-use**
 - Consumers only pay for resources when they use them

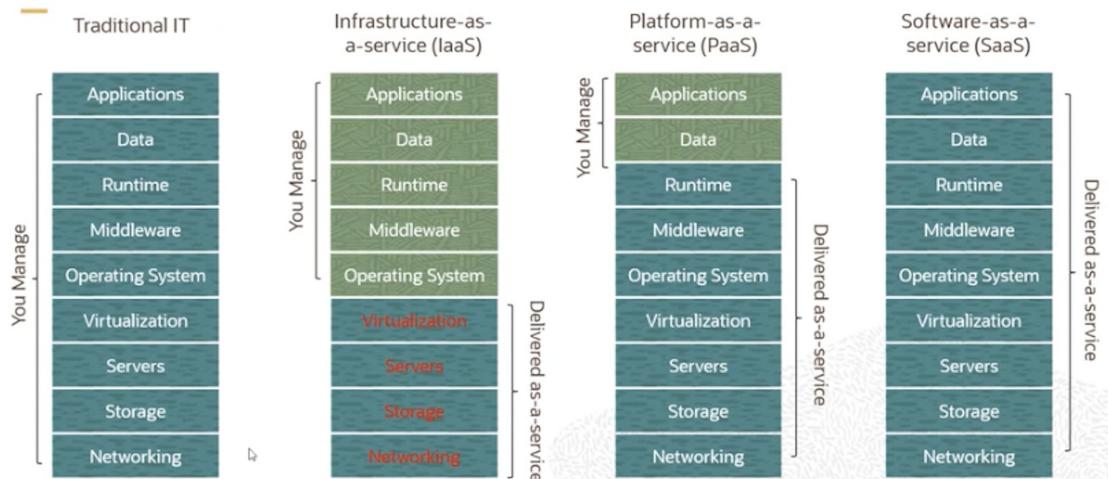
Cloud Computing Concepts (Cont.)

- Service Models (aka Cloud Layers)
 - IaaS – Infrastructure as a Service
 - PaaS – Platform as a Service, Serverless
 - MWaaS, DBaaS, ...
 - FaaS
 - SaaS – Software as a Service
- Deployment Models
 - Public Cloud
 - Private Cloud
 - Hybrid Cloud

Overview

- Introduction
- Cloud Architecture
 - *Service Models*
 - *Multitenancy*
- Infrastructure as a Service

Service Models



IaaS: Infrastructure as a Service

- Usage
 - Predefined shapes of compute instances (e.g. micro, small, large, extra-large)
→ for example: RedHat 7.8, 613 MB of memory, 1 TB block storage
 - Pay-per-use – pay for resources you use (time or amount)
→ no up-front costs
- IaaS Services Examples
 - Load balancer
 - Autoscaling
 - Connectivity with on-premise network
 - Resource monitoring
- IaaS providers
 - Amazon EC2, GoGrid, Rackspace, OpenNebula, Google Cloud, Oracle OCI, ...

PaaS: Platform as a Service

- Usage
 - Choose software platform, e.g., JEE, .NET, Python, etc.
 - Pay-per-use – pay for the resources you use; no up-front costs
 - Cloud native, microservices, containers
- PaaS features
 - Serverless
 - Auto Scaling and Load balancing
 - Local development environment
 - Administration API
- PaaS providers
 - Google App Engine – first PaaS service
 - Today, mostly Kubernetes, Google, Heroku, Azure, AWS, Oracle

SaaS: Software as a Service

- Software delivery model for applications hosted in the cloud
 - *typically software for end-users*
 - *services accessed using a web browser*
 - *provides API for programmatic access*
- SaaS characteristics
 - *Typically build on top of IaaS or PaaS*
 - *Configurable and customizable modern Web applications*
 - *Usually basic version for free, need to pay for "pro" version*
 - *Global availability - any computer, any device*
 - *Easy management - automatic and fast updates*
 - *Pay-per-use – pay for the time you use*
- SaaS providers
 - *Google Apps, Salesforce, ...*

Overview

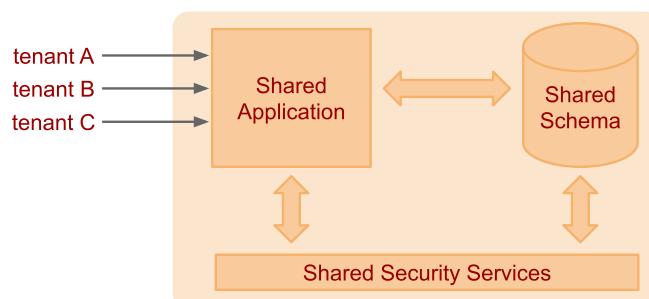
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- Infrastructure as a Service

Multitenancy

- Architectural approach where resources are shared between multiple tenants or consumers
- Implications
 - Centralization of infrastructure in locations with lower costs
 - Peak-load capacity increases
 - Utilisation and efficiency improvements for systems that are not well utilised
- Sharing options
 - Shared Everything
 - Shared Infrastructure
 - Virtual Machines
 - OS "virtualization"

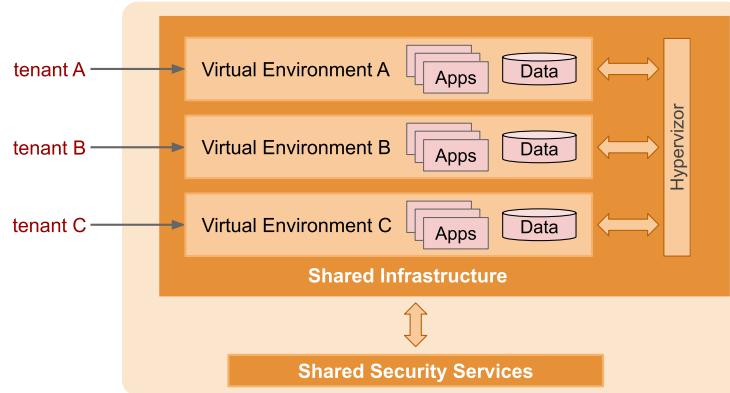
Shared Everything

- Resources are shared between all tenants or consumers
 - tenant: a service consumer
- Common for the SaaS model
- The application should provide tenant isolation
- Data for multiple tenants is stored in the same database tables



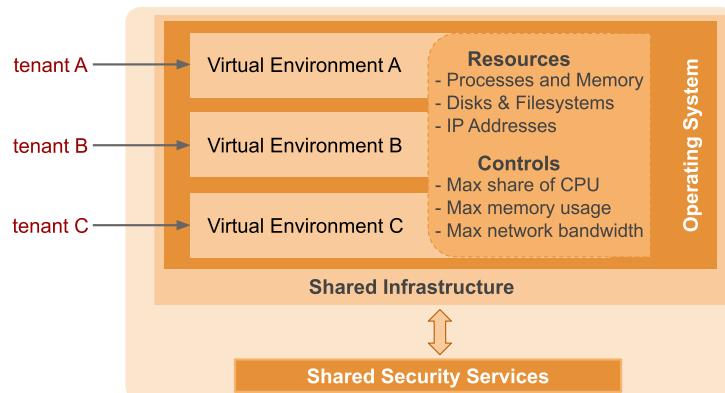
Shared Infrastructure: Virtual Machines

- Infrastructure shared via virtual machines
 - each tenant has its own virtual environment
 - Isolation provided by hypervisor
 - hypervisor: virtual machine manager; runs virtual machines
 - Resource contention depends on VM capability and configuration
 - Adds an additional layer and processes to run and manage



Shared Infrastructure: OS Virtualization

- Infrastructure shared via OS Virtualization
 - Each tenant has its own processing zone
 - Isolation provided by the operating system
 - Resource contention depends on zone configuration
 - No VMs to run and manage, no abstraction layer between app & OS



Overview

- Introduction
- Cloud Architecture
- Infrastructure as a Service
 - *Networking*
 - *Compute*
 - *Storage*
 - *Infrastructure as Code*

Overview

- Infrastructure = environment where your app is running
- Tenancy = your "space" in the cloud
- What you need
 - *Servers (compute instances) to run your app in a location (region)*
 - *Connectivity*
 - *Private network for intra-communication*
 - *Public network for internet communication*
 - *Firewall (security) rules*
 - *Route tables*
 - *Storage*
 - *Operating system*
 - *Your app data*
 - *Identity Management*
 - *Who and how can access and control your tenancy*
 - *Monitoring, Logging, Auditing*

Region

- Region = location on a planet where cloud data centers are located

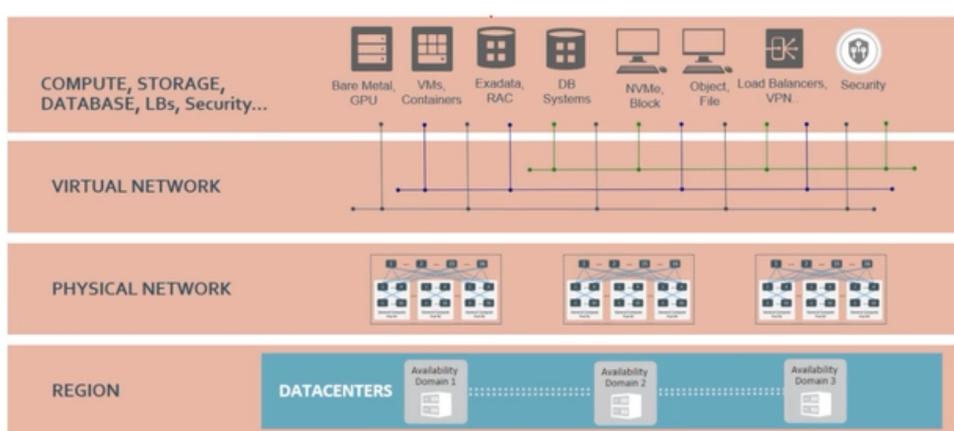


- Why location matters...

- Latency - your users should be close to your app
- Regulations - your data should be stored in EU
- Connectivity to external providers
 - Such as other cloud vendors

Datacenters

- Datacenter (aka Availability Domain – AD)
 - Computing resources in a location within a region
 - One or more datacenters exist in a region
 - They are completely de-correlated, independent
 - They have separated power supply, do not share underlying infrastructure
 - If one DC fails, the other one is up and running

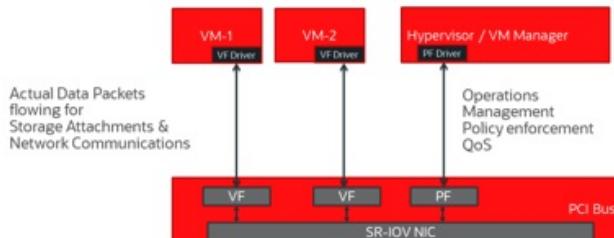


Off-box Network Virtualization

- Gen 1.0 Cloud, inefficient Resource Sharing
 - *On-Premise virtualization to share resources amongst multiple tenants in the cloud.*



- Gen 2.0 Cloud
 - *Smart-NIC accelerated SR-IOV (Single Root I/O Virtualization)*
 - Networking is a specialized function, needs hardware/sillicon to accelerate it

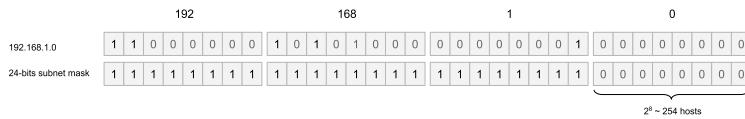


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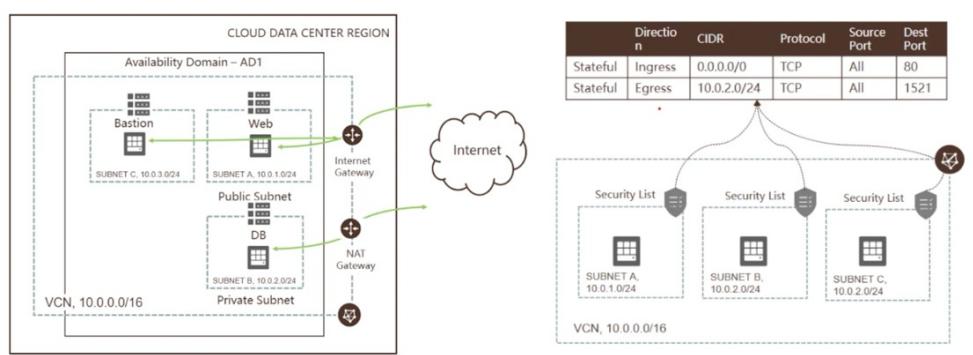
Virtual Cloud Network

- VCN = a private network in a **single region** in which your instances reside
- A single and contiguous IPV4 CIDR block of your choice
 - *CIDR (classless inter-domain routing) notation*
 - *IP address:*
 - *network prefix (the most significant bits) and*
 - *interfaces on the network (least significant bits) ~ network hosts*
 - *Example: 192.168.1.0/24*
 - *IP range: 192.168.1.0 - 192.168.1.255*
- You further create subnets on a VCN to organize your instances
 - *The subnets must be "within" the VCN, they can span across ADs*
 - *Example: using 27 bits for a subnet mask allow for 8 subnets*
 - **192.168.1.0/27, 192.168.1.32/27, 192.168.1.64/27, ...**
 - *Each subnet can have 32 hosts*



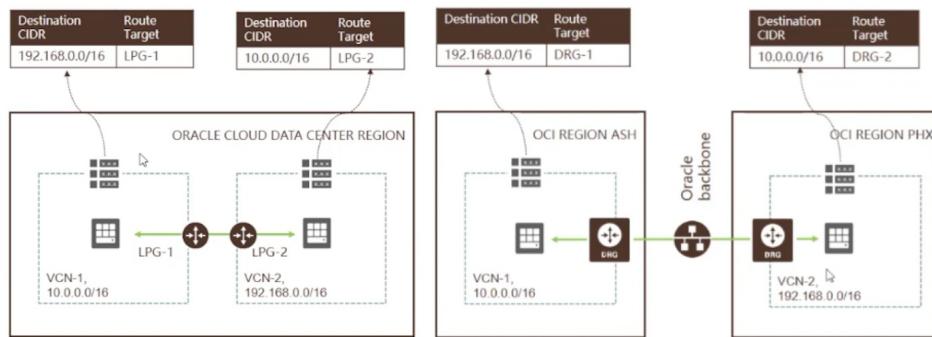
VCN Routing and Security

- Private and Public subnets
 - *Public can communicate in/out from/to Internet*
 - *Internet traffic routed to public subnet*
 - *Private can be completely isolated or communicate to Internet only*
- Route tables
 - *Required to route across subnets and in/out from the Internet*
- Security
 - *Control access to/from the subnet*



Peering

- Local Peering
 - Connecting two VCNs in a region
- Remote Peering
 - Connecting two VCNs across regions
- Connectivity with on-premise datacenter
 - Fast connection needs to be in place
 - Secure VPN needs to be established

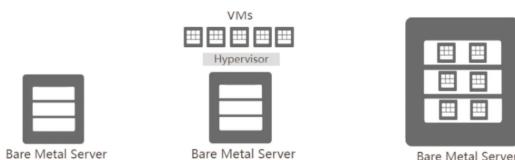


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Compute Instances

- Shape = amount of memory and CPU an instance is using
 - There are classes of shapes that you can choose from
 - Standard and HPC/GPU shapes
- Virtual Machine (VM) – multi-tenant model
 - A hypervisor to virtualize the underlying Bare Metal server into smaller VMs
- Bare Metal (BM) – single-tenant model
 - Direct hardware access, full bare metal server
 - Types of workloads: performance intensive, require a specific hypervisor
- Dedicated VM Hosts (DVM) – single-tenant model
 - VM instances running on dedicated single-tenant servers
 - Not shared with other customers



- States: start, stop, reboot, terminate
 - Billing pauses in STOP state but depends on shape

Image

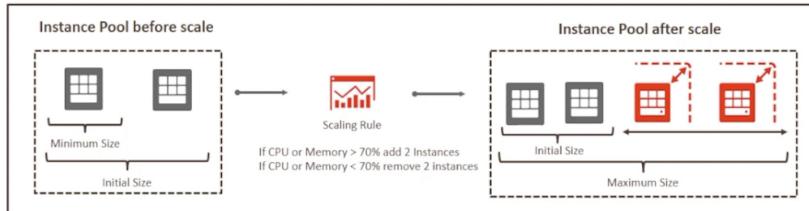
- Image
 - A template of a virtual hard drive with OS
 - Other software, libraries, configurations, etc.
- Stored on a boot volume
- Base images are provided
 - CentOS, Ubuntu, Windows Server, Oracle Linux, RedHat, etc.
 - Some may require licence costs
- Custom images
 - You can create a custom image from the base image
 - Specific packages, libraries or custom configuration
 - You store the image in the object storage

Autoscaling

- Instance configuration
 - OS image, metadata, shape, vNICs, storage, subnets
 - Apply configuration to multiple instances at the same time
 - You can manage them all together (start, stop, terminate)

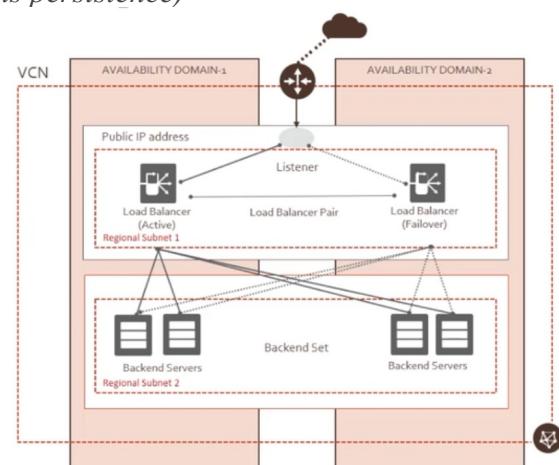


- Autoscaling
 - Automatically adjust a number of compute instances in an instance pool
 - Control using performance metrics such CPU or memory utilization
 - cooldown period – time between scale in and scale out (e.g. 300 seconds)



Load Balancer

- Managed service
 - Health check – checks health status of backends (TCP, HTTP)
 - Algorithm – round-robin, IP hash, least connections
- Supports protocols
 - TCP, HTTP 1.1, HTTP/2, WebSocket, SSL termination, end-to-end SSL
 - Supports sticky sessions (sessions persistence)
- High Availability
 - Primary and stand-by LB
 - Each LB is in different AD
 - Failover uses floating IP



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Object Storage

- Types of data to store
 - *Storage for unstructured data (images, media files, logs, backups)*
 - *Data managed as objects, provides API using HTTP verbs*
- Namespace
 - *Logical entity that serves as top-level container for all buckets and objects*
 - *Each tenancy is provided one unique namespace*
- Bucket
 - *A logical container for storing objects*
 - *Bucket names must be unique within tenancy*
 - *Hot bucket – standard, can be accessed immediately*
 - *Cold bucket – rarely accessed data, need to be restored*
 - *Minimum retention, such as 90 days*
 - *Time to First Byte (TTFB) is in hours, e.g. 4 hours*
- Object and metadata
 - *data managed as objects regardless data type*
- Example object URL path:
`/n/<namespace>/b/<bucket>/o/<object_name>`

Block Storage

- Local NVMe SSD device
 - *Locally attached device, provided by some shapes, 200K IOPS - 1M IOPS*
 - *Workloads that require high storage performance*
 - *usually no RAID, snapshots, backups*
- Block volumes
 - *Reside in storage servers*
 - *NVMe SSD based, up to 35K IOPS*
 - *Data stored on block volumes beyond the lifespan of compute instance*
 - *Multiple replicas across multiple storage servers*
- File Storage
 - *Network file server (NFS)*
 - *Client mounts a **mount target** (NFS endpoint) and an **export path***
 - *Example*
`sudo mount 10.0.0.6/example1/path /mnt/mountpointA`

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Overview

- Definition
 - Application envs (in a cloud) managed via definition files
 - Version control, team development, scripting, etc.
- Major Technologies
 - **Configuration Management Tools**
 - install and manage software on machines that already exist
 - Examples: Ansible, Chef, Puppet
 - **Abstraction of cloud infrastructure**
 - Terraform

Terraform

- Higher-level abstraction of the datacenter and associated services
- Supports many service providers
 - Google, Microsoft, Oracle, AWS
- Steps
 1. Description of resources in Hashicorp Configuration Language (HCL)
 - instances, networks, firewall rules, routing tables, etc.
 2. Terraform generates execution plan to reach the desired state
 3. Terraform executes the plan to reach the desired state; can generate incremental execution plan