INFRASTRUCTURE AS A SERVICE:

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CHAPTER- 3

INFRASTRUCTURE AS A SERVICE:

Topics to be Covered

- **INFRASTRUCTURE AS A SERVICE:**

- **Introduction**

- **Hypervisors**

- **Resource virtualization**

- **Examples**

- **How to implement IAAS .**

POPULAR CLOUD PROVIDERS

Cloud vs. On-premise Comparison Chart

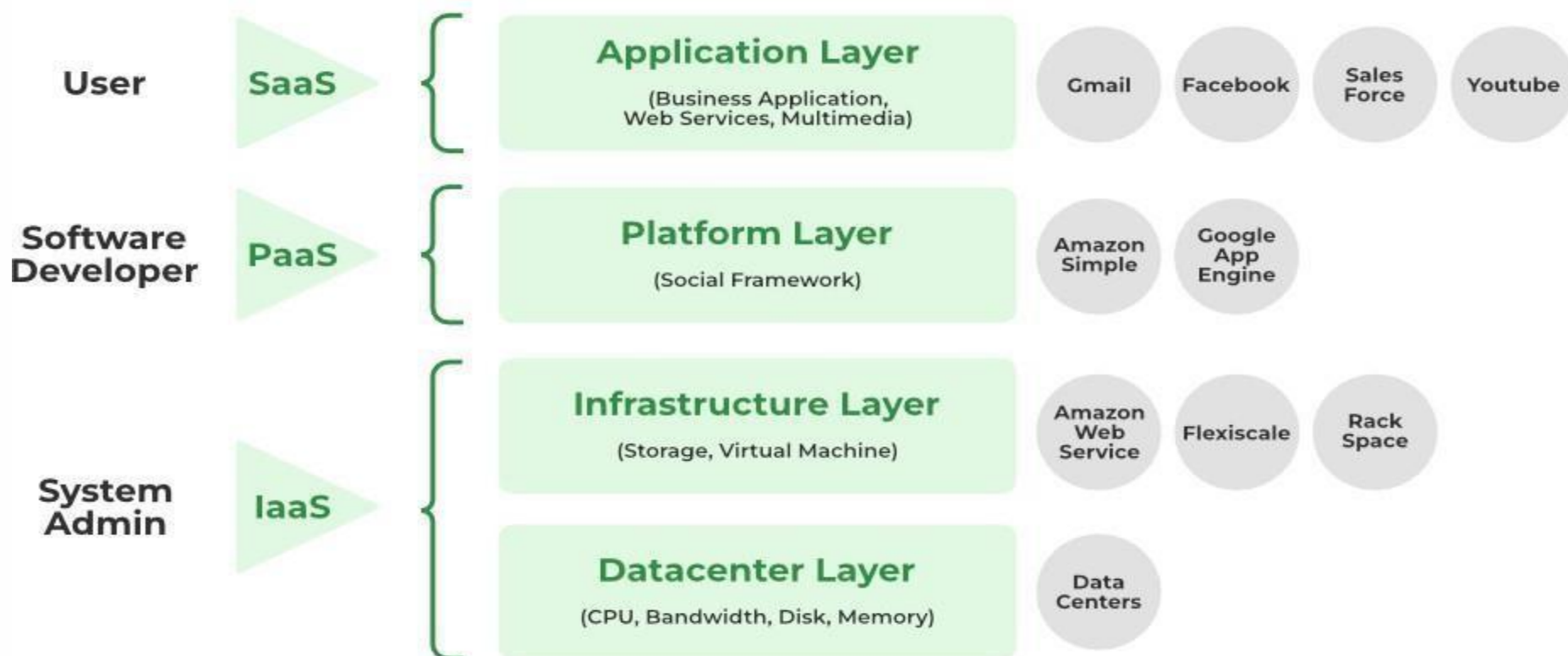| Aspect	Cloud solutions	On-premise solutions
Upfront costs	Lower upfront costs	Higher upfront costs
Maintenance	Managed by cloud provider	Self-managed by organization
Scalability	Easily scalable based on demand	Limited scalability, may require hardware upgrades
Flexibility	Offers flexibility to adjust resources as needed	Requires additional investments for flexibility
Total cost of ownership	Predictable subscription fees, potential cost savings	Higher total cost of ownership due to maintenance costs
Security	Data security managed by cloud provider	Organization has control over data security measures
Accessibility	Remote access from anywhere with internet connectivity	Access limited to on-premise network
Customization	Limited customization options	Full control for customization and tailored solutions

CLOUD COMPUTING

Provides mobile access to files from everywhere

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Layers of Clouds

Cloud Computing Layers

User — **SaaS**

Application Layer
(Business Application, Web Services, Multimedia)

Gmail · Facebook · Sales Force · Youtube

Software Developer — **PaaS**

Platform Layer
(Social Framework)

Amazon Simple · Google App Engine

System Admin — **IaaS**

Infrastructure Layer
(Storage, Virtual Machine)

Amazon Web Service · Flexiscale · Rack Space

Datacenter Layer
(CPU, Bandwidth, Disk, Memory)

Data Centers

Service Class	Main Access & Management Tool	Service content
SaaS	Web Browser	**Cloud Applications** Social networks, Office suites, CRM, Video processing
PaaS	Cloud Development Environment	**Cloud Platform** Programming languages, Frameworks, Mashups editors, Structured data
IaaS	Virtual Infrastructure Manager	**Cloud Infrastructure** Compute Servers, Data Storage, Firewall, Load Balancer

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IAAS

Infrastructure as a Service (IaaS)

Definition:

IaaS provides virtualized computing resources like servers, storage, and networks over the internet.

It acts as the foundational layer where users control and manage the infrastructure themselves.

Scalability: Resources can be scaled up or down based on demand.

Cost Efficiency: Pay-as-you-go model eliminates upfront hardware costs.

Flexibility: Complete control over the operating system, applications, and middleware.

Where It Is Used:

Disaster Recovery: Storing and retrieving critical data during emergencies.

Big Data Analysis: Companies like Netflix use IaaS to process and analyze massive datasets.

Web Hosting: Hosting applications and websites with high traffic demands.

Examples:

Amazon EC2, Microsoft Azure Virtual Machines, Google Compute Engine.

MANAGES

YOU MANAGE	IAAS	PAAS
• APPLICATION	• **APPLICATION**	• **APPLICATION**
• DATA	• **DATA**	• **DATA**
• RUNTIME	• **RUNTIME**	• **RUNTIME**
• MIDDLEWARE	• **MIDDLEWARE**	• **MIDDLEWARE**
• OS	• **OS**	• **OS**
• VIRTUALIZATION	• **VIRTUALIZATION**	• **VIRTUALIZATION**
• SERVERS	• **SERVERS**	• **SERVERS**
• STORAGE	• **STORAGE**	• **STORAGE**

IaaS: Think of renting an empty plot of land (virtual servers). You build everything—foundation, structure, and interiors—according to your needs.

PaaS: Rent a pre-built mall structure (platform) where you can add your shop's interiors and designs, focusing only on what you want to sell.

SaaS: Lease a fully operational shop in the mall (application) that's ready to use, where you just display your products and serve customers.
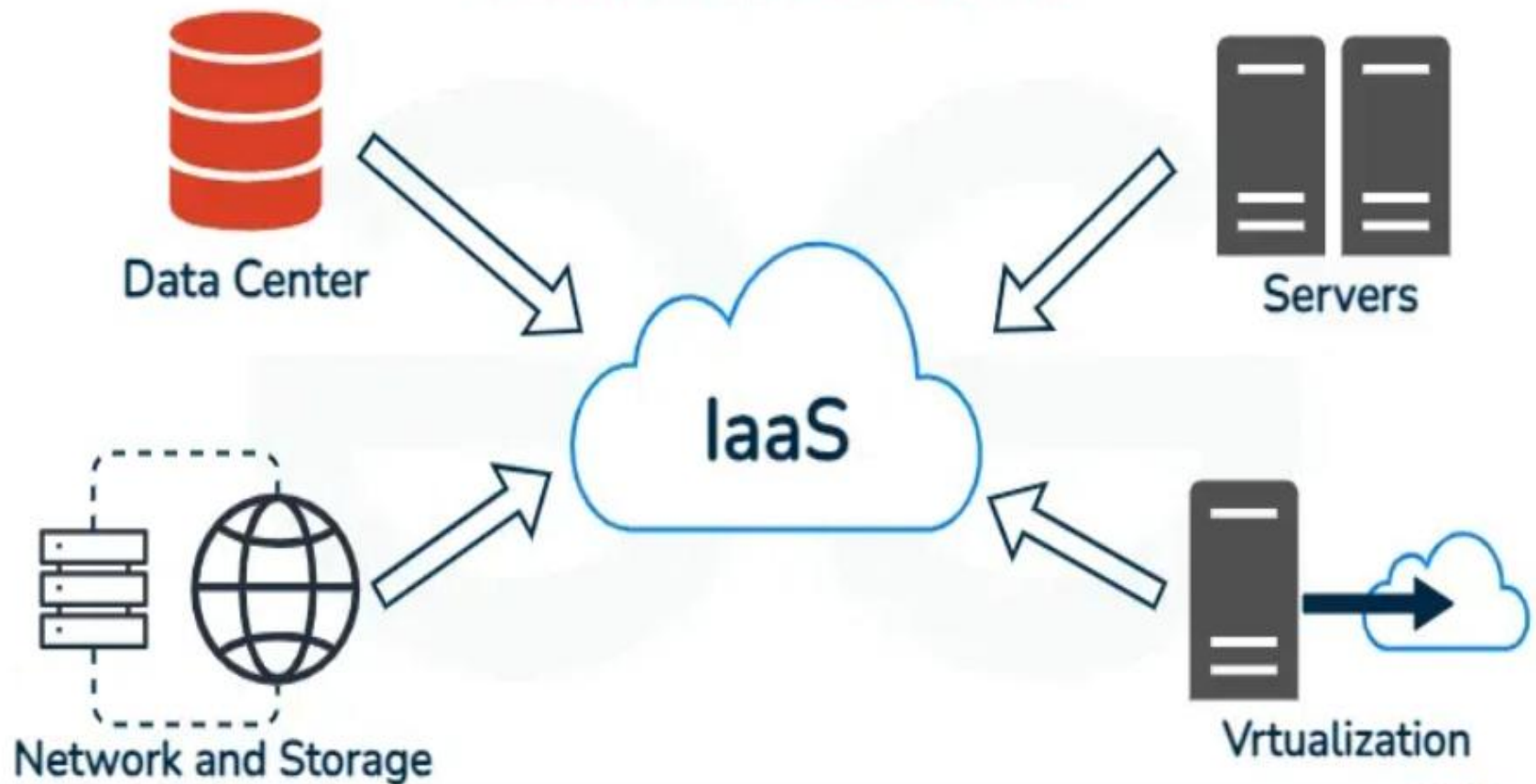
Infrastructure as a Service (IaaS)

Infrastructure as a Service (IaaS) delivers virtualized compute, storage and networking over the internet. Instead of buying physical servers, customers rent virtual machines, storage, and networking on-demand from a provider and manage the OS, middleware and applications themselves. IaaS sits at the bottom of the cloud stack (IaaS → PaaS → SaaS).

Infrastructure As A Service

Data Center

Servers

IaaS

Network and Storage

Vrtualization

What is IaaS?

Hypervisors (the core of IaaS)

What a hypervisor does: it abstracts the physical hardware and presents virtual machines (VMs) to tenants.

•**Type-1 (bare-metal)** — runs directly on physical hardware. Lower overhead and used in production IaaS. Examples: VMware ESXi, KVM, Xen, Microsoft Hyper-V (when run in a datacenter mode).

•**Type-2 (hosted)** — runs on top of a host OS (less efficient, used for dev/test). Examples: VirtualBox, VMware Workstation.

Key hypervisor features used by IaaS

•CPU scheduling & vCPU allocation (overcommit, pinning)

•Memory management (ballooning, swapping)

•Device passthrough (PCI/PCIe SR-IOV, GPU virtualization)

•Snapshotting and live migration (vMotion, live migration)

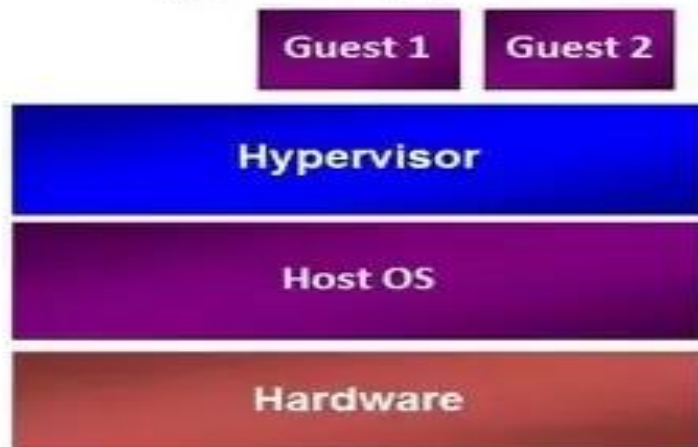•Storage and network integration (connect VMs to SAN/NAS and virtual switches)

Hypervisor Design:
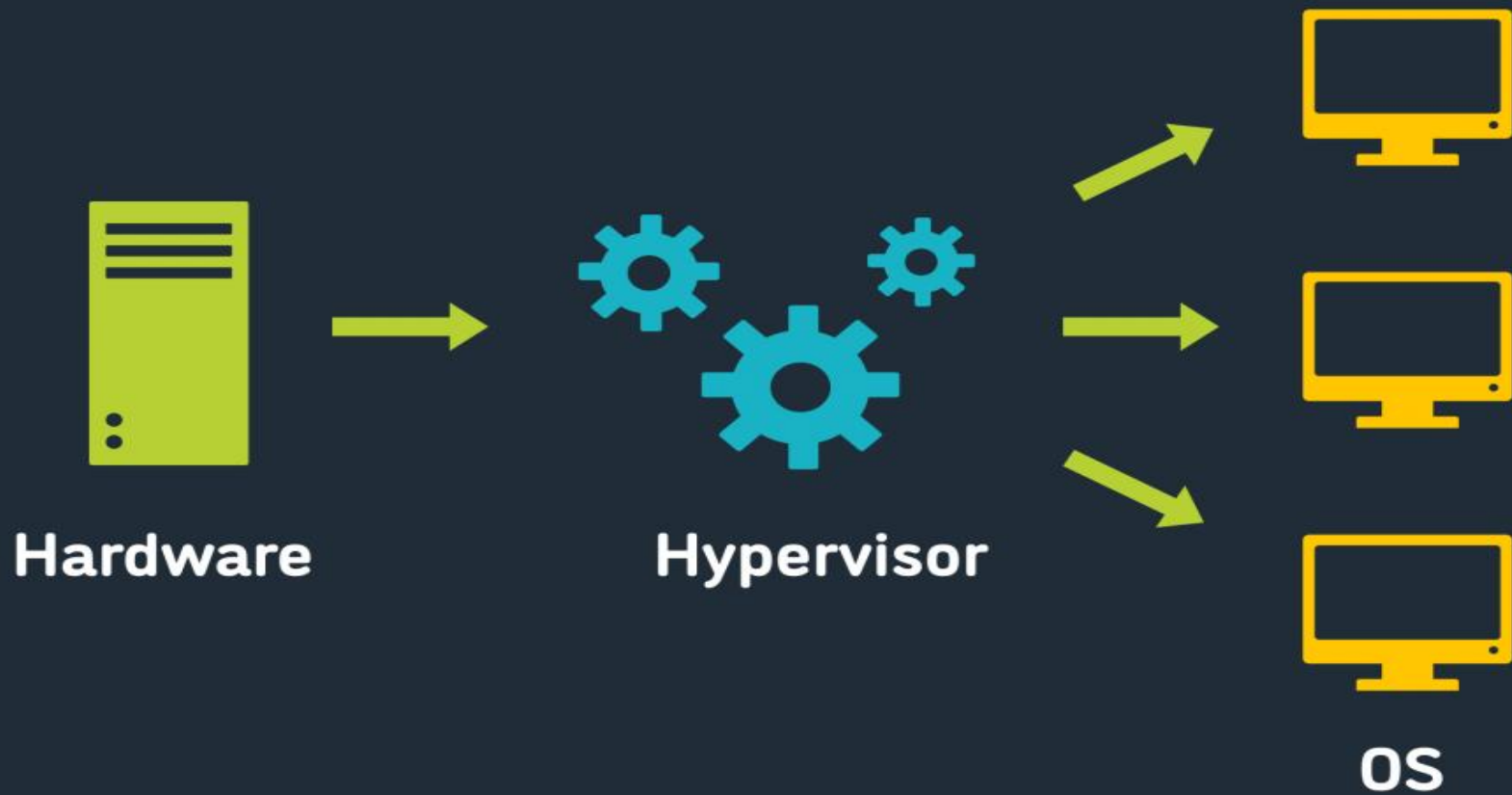## Two approaches

Type 2 Hypervisor

| Guest 1 | Guest 2 |

Hypervisor

Host OS

Hardware

Examples:
Virtual PC & Virtual Server
VMware Workstation
KVM

Type 1 Hypervisor

| Guest 1 | Guest 2 |

Hypervisor

Hardware

Examples:
Hyper-V
Xen
VMware ESX

Hardware → **Hypervisor** → **OS**

Diagram by virtasant

Resource virtualization — what gets virtualized and how

Compute

•vCPUs and vRAM assigned to VMs.

•Techniques: CPU overcommit, affinity/pinning, dynamic memory.

Storage

•Abstract physical disks into *storage pools* or LUNs.

•Mechanisms: SAN (block), NAS (file), local SSD pools, thin provisioning, deduplication, snapshots, replication.

Networking

•Virtual switches, bridges and logical routers.

•VLANs, VXLAN/GENEVE overlays, security groups, virtual load balancers.

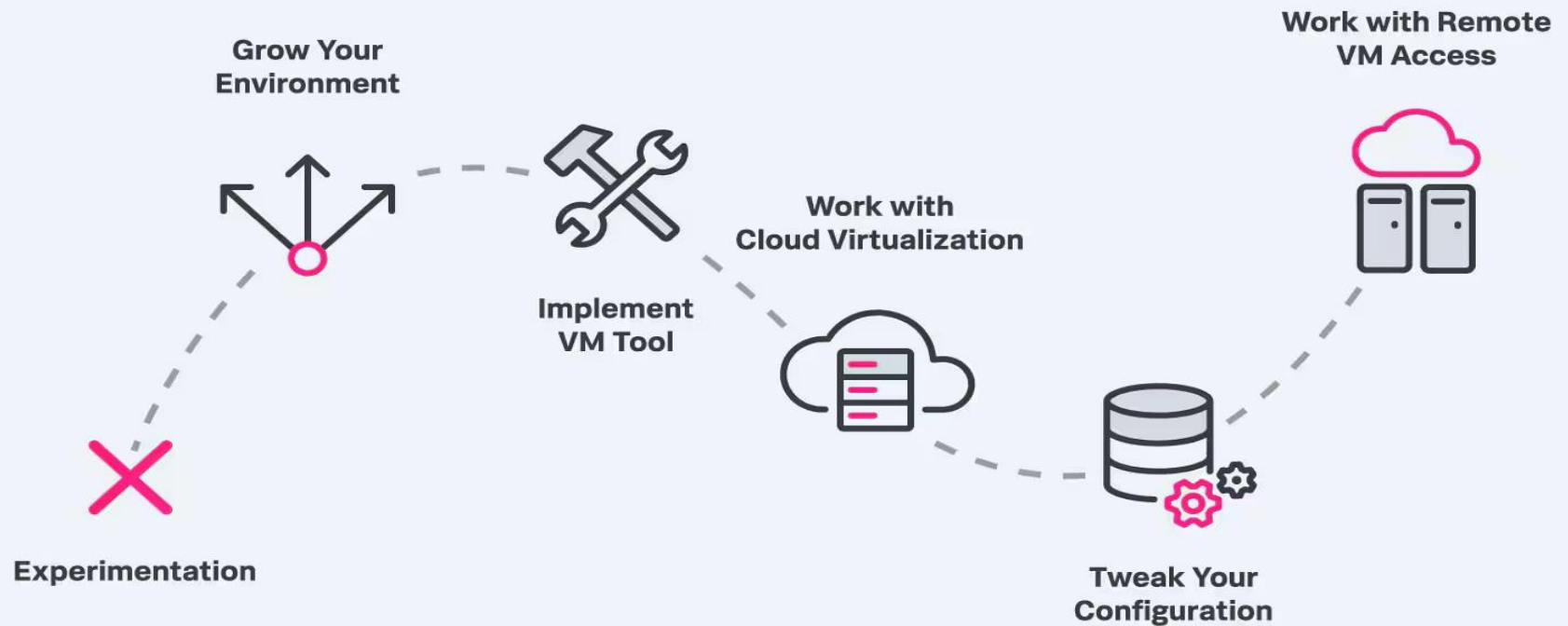•SDN controllers (Neutron in OpenStack, NSX in VMware) provide programmability.

Other resources

•GPUs (vGPU), specialized NICs via SR-IOV, and virtual TPMs for security.

Steps to a Virtual Environment

-

Grow Your Environment

Work with Remote VM Access

Implement VM Tool

Work with Cloud Virtualization

Experimentation

Tweak Your Configuration

Examples of IaaS platforms / providers

- **Public clouds**: AWS EC2, Google Compute Engine, Microsoft Azure Virtual Machines.
- **Private / on-premises stacks**: OpenStack, VMware vSphere/vCenter + vSAN, Nutanix, Proxmox.
- **Hybrid solutions**: VMware Cloud on AWS, Azure Stack.

How to implement IaaS — step-by-step

1.Plan & design
1. Define workload requirements (CPU, RAM, storage IOPS, latency, network).
2. Decide public vs private vs hybrid and tenancy/isolation model.
3. Choose availability zones, rack and network topology.

2.Choose your stack
1. Hypervisor: KVM, VMware ESXi, Xen, Hyper-V.
2. Management/orchestration: OpenStack, VMware vCenter + vCloud, or cloud provider APIs.
3. Storage backend: SAN (FC/iSCSI), NVMe over Fabrics, or vSAN.

3.Procure & prepare hardware
1. Servers with enough CPU cores and memory, RAID controllers, NVMe/SSD for caching.
2. Redundant network switches, BGP/ECMP design for top-of-rack networking.
3. Power, HVAC and physical security.

4. Install hypervisors on hosts

1. Deploy bare-metal hypervisors (Type-1) to each compute node.
2. Configure management network (separate VLAN for hypervisor mgmt).

5. Configure storage

1. Create storage pools/LUNs; connect via FC or iSCSI.
2. Configure thin provisioning, snapshot policies and replication.

6. Configure virtual networking

1. Setup virtual switches, VLANs, overlay networks (VXLAN/GENEVE).
2. Define tenant networks, security groups, and firewall rules.

7. Deploy management & orchestration layer

1. Example: Install OpenStack (Nova, Neutron, Cinder, Glance, Keystone) or vCenter.
2. Configure image catalog, flavors (VM sizes), quotas, and multi-tenant projects.

8. Integrate automation & IaC

1. Provide APIs, CLI and web console. Integrate Terraform, Ansible, or CloudFormation (public clouds).
2. Store golden VM images and CI/CD integration.

9. Security & identity

1. Configure IAM, RBAC, VPN/DirectConnect for private connectivity, network ACLs.
2. Harden hypervisors, encrypt storage, use secure boot or TPM if required.

10. Monitoring & logging

1. Implement monitoring (Prometheus, Nagios, Zabbix), centralized logging (ELK/EFK).
2. Set alerts/SLAs, capacity planning dashboards.

11. Backup & disaster recovery

1. VM snapshots, offsite replication, regular backups, recovery drills.

12. Testing & cutover

1. Run performance testing, failover scenarios, and tenant onboarding before production.

Steps to Implement Infrastructure as a Service (IaaS)

1

Evaluate Your Business Needs And Goals

2

Explore Your IaaS Provider Options

3

Plan and Design Your Architecture

4

Deploy Your Resources

5

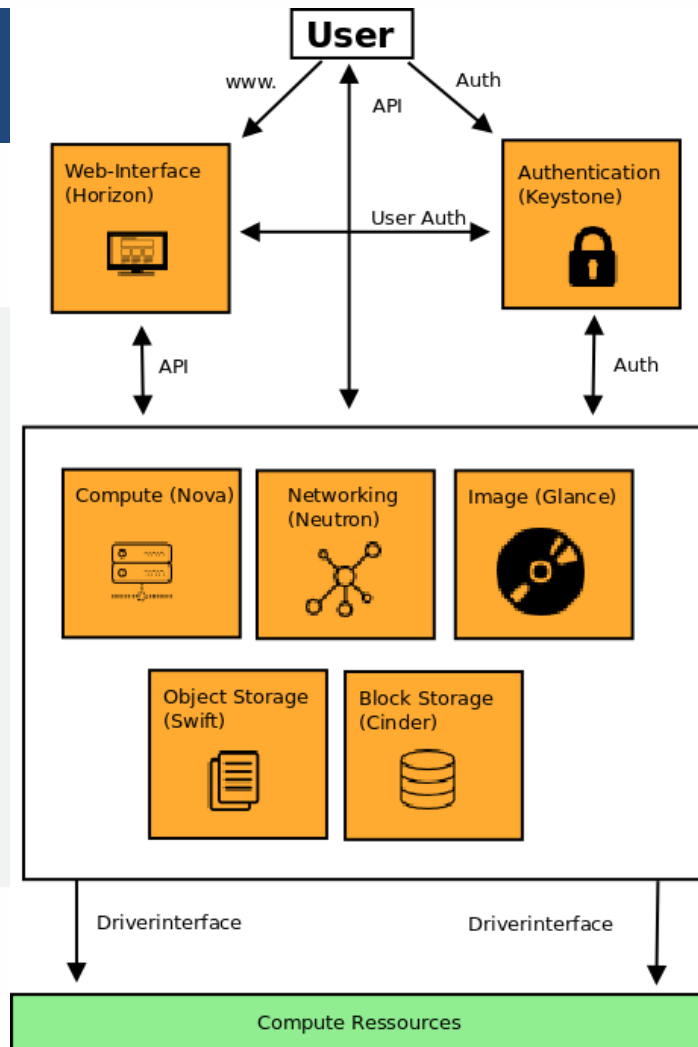### Perform Routine Maintenance

Cloudwards

Implementation example: Minimal private IaaS with OpenStack + KVM

- Compute: KVM on each host (libvirt)
- Networking: Open vSwitch + Neutron (VXLAN)
- Storage: Ceph as backend for Cinder (block) and Glance (images)
- Identity: Keystone
- Orchestration: Heat (optional)
- Automation: Terraform/Ansible to provision VMs and networks

This stack gives APIs compatible with many tools and a mature ecosystem for IaaS.
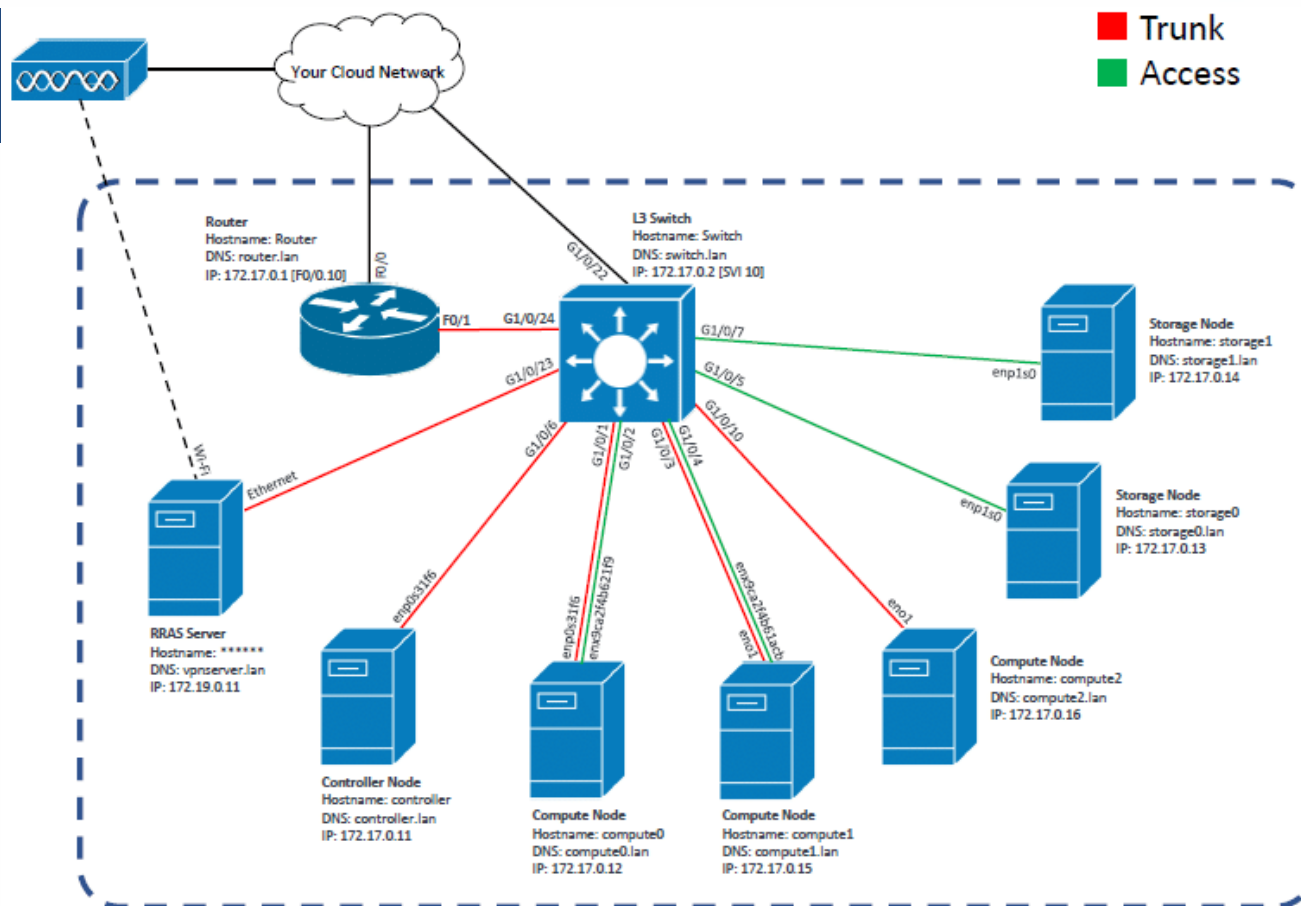
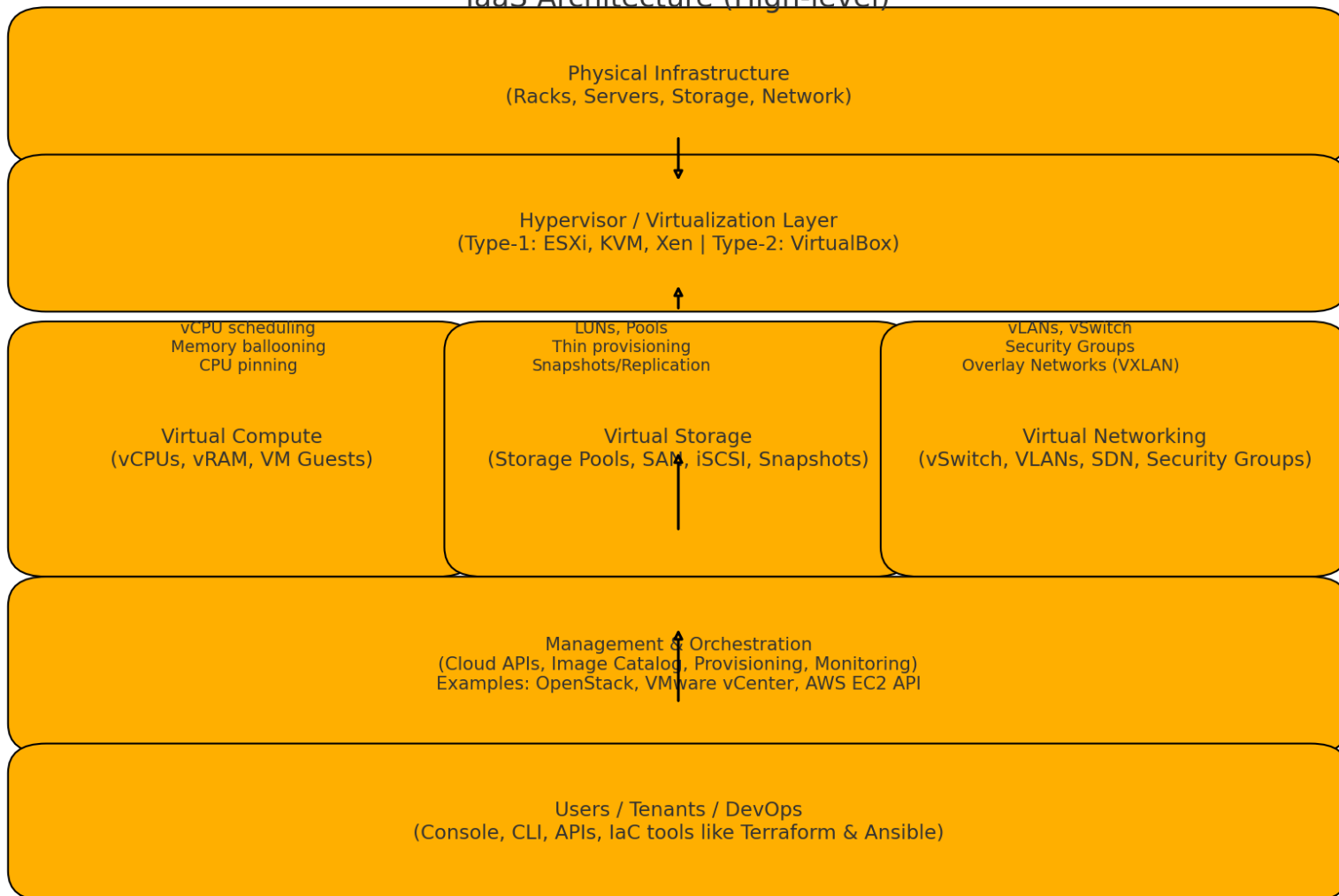Fig: Configuration of our deployed OpenStack architecture

Typical IaaS API & user workflow

1. User authenticates to cloud console or via API (keystone / IAM).

2. User selects an image + flavor (VM size) and network.

3. Management orchestrator schedules a host, attaches storage and network.

4. Hypervisor creates the VM from the image and boots it.

5. User accesses the VM (SSH/RDP) and manages the OS/apps.

IaaS Architecture (High-level)

Physical Infrastructure
(Racks, Servers, Storage, Network)

Hypervisor / Virtualization Layer
(Type-1: ESXi, KVM, Xen | Type-2: VirtualBox)

vCPU scheduling
Memory ballooning
CPU pinning

Virtual Compute
(vCPUs, vRAM, VM Guests)

LUNs, Pools
Thin provisioning
Snapshots/Replication

Virtual Storage
(Storage Pools, SAN, iSCSI, Snapshots)

VLANs, vSwitch
Security Groups
Overlay Networks (VXLAN)

Virtual Networking
(vSwitch, VLANs, SDN, Security Groups)

Management & Orchestration
(Cloud APIs, Image Catalog, Provisioning, Monitoring)
Examples: OpenStack, VMware vCenter, AWS EC2 API

Users / Tenants / DevOps
(Console, CLI, APIs, IaC tools like Terraform & Ansible)

DIGITAL LEARNING CONTENT

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