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Software-Defined Networking

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Network Virtualization Part 1

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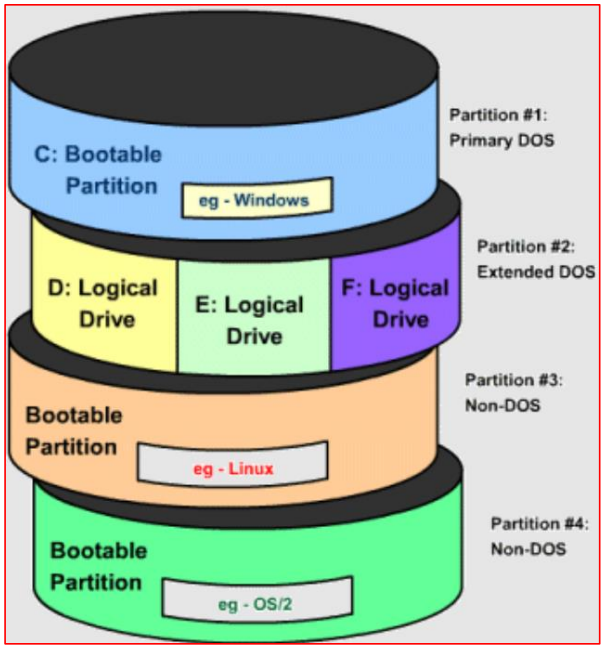
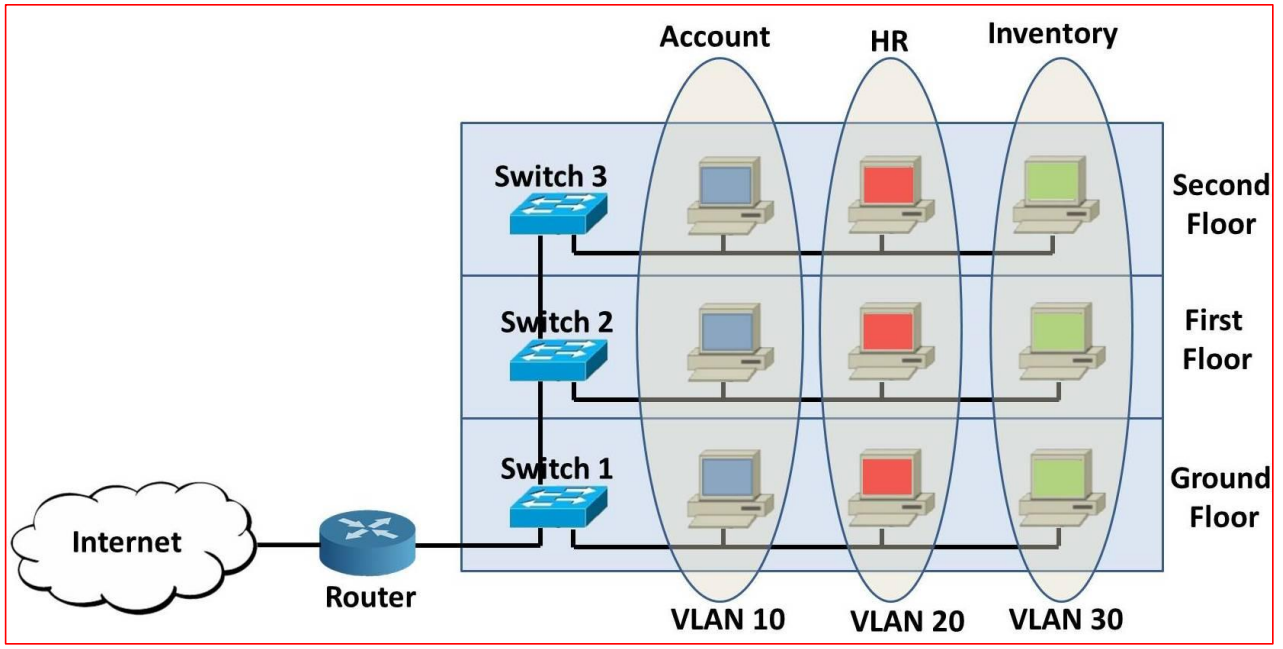
Primer on Virtualization

Virtualization

- The act of creating a virtual (rather than actual) version of something
  - Typically used to share resources
  - such as memory, storage, network resources, and etc.





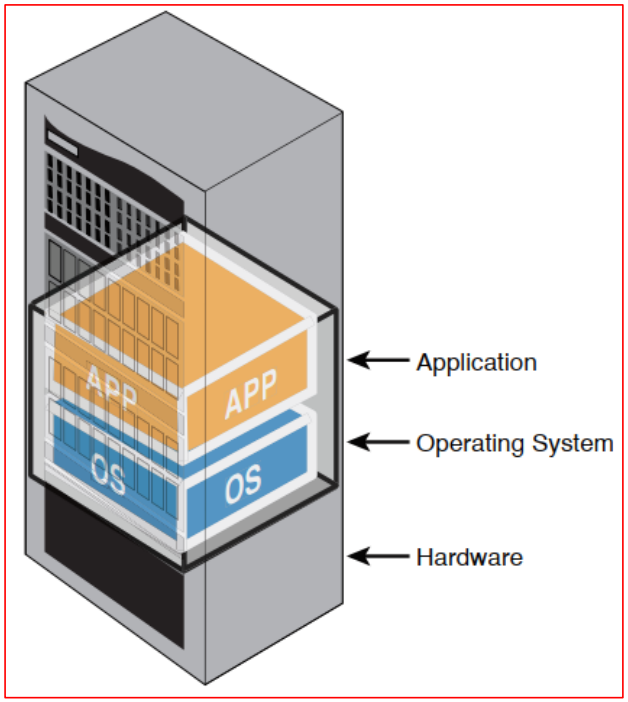
What has made virtualization in the past decade different

Virtual Machine (VM)

- A VM is a tightly isolated software container that runs its own operating system and applications as if it were a physical computer
- A virtual machine is an emulation of a physical computer.

The big problem that VMs fix

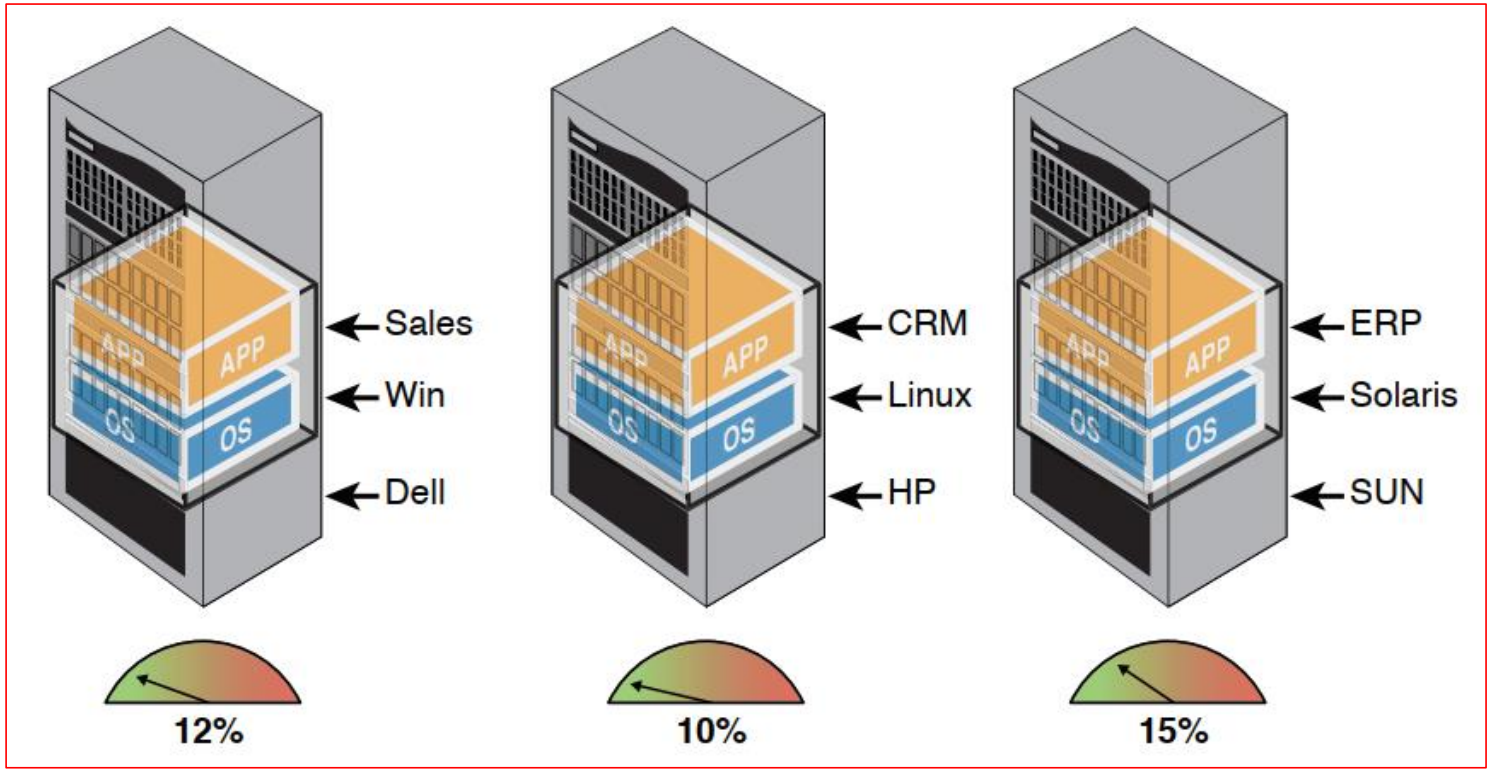
- Think about a big company and its applications
  - CRM, ERP, Sales, Web, Email, Git, Chat, etc.



Each application requires its own server to run on

Server proliferation

What's so bad about server proliferation?

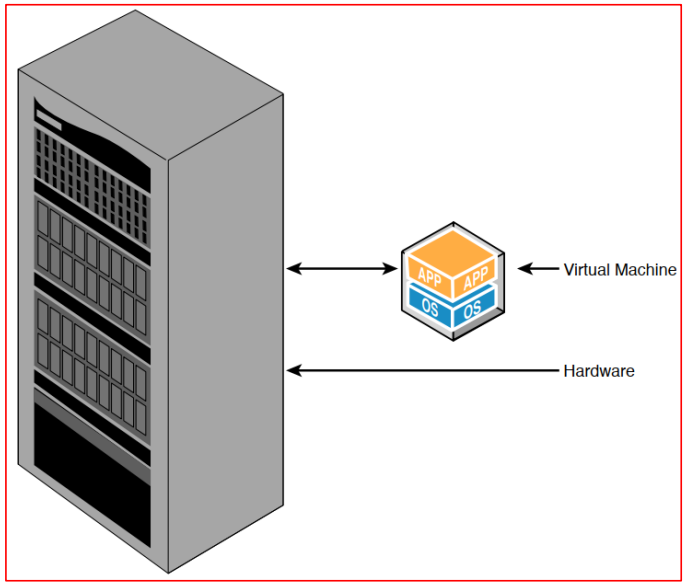


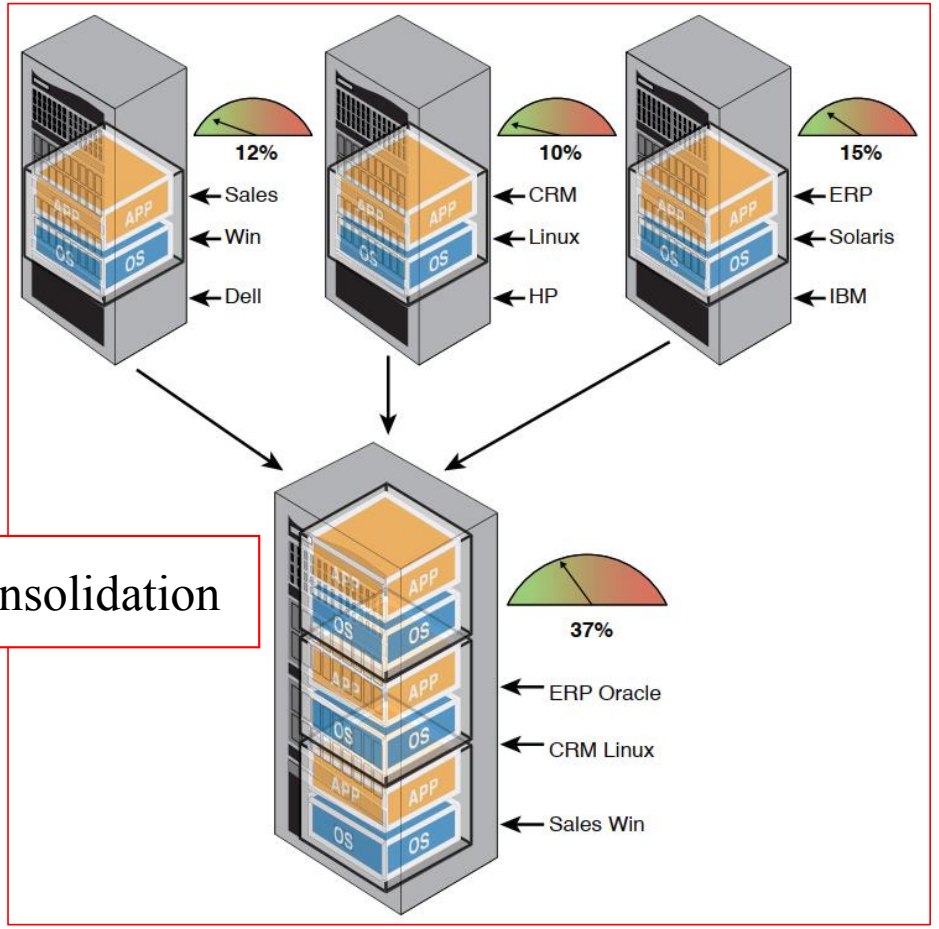
- On average nonvirtualized enterprise servers are only running at about 5% to 10% utilization.
  - Inefficient spending on servers, power, cooling, personnel to manage, …

Server proliferation is bad unless …

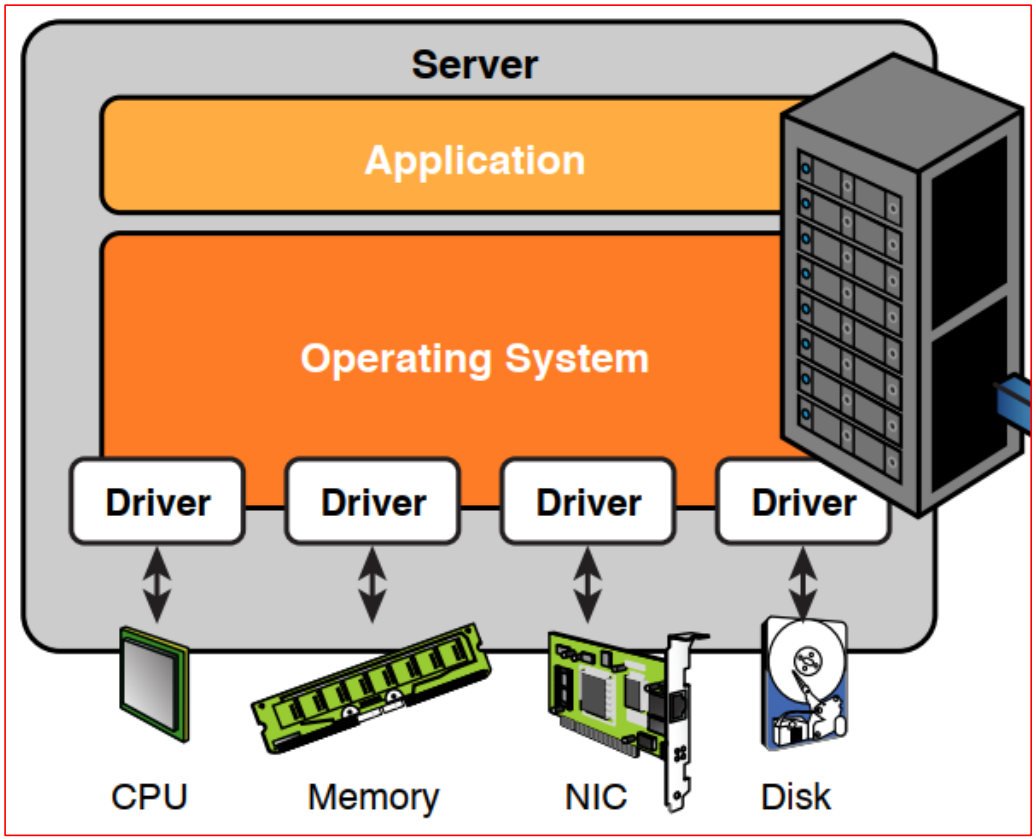
How VMs Fix the Underutilized Server Problem

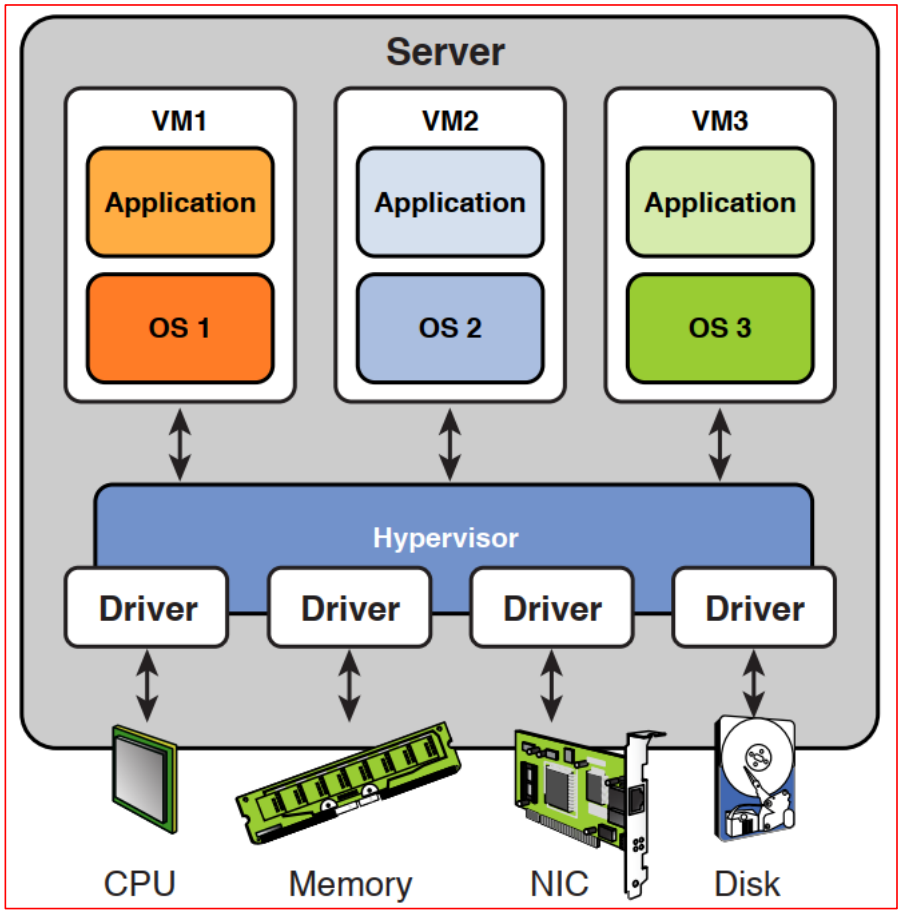
- VM creates a software version of a server that runs within a hardware server.
- Each VM can be customized to the application needs.
- Many VMs can run on the same physical server.



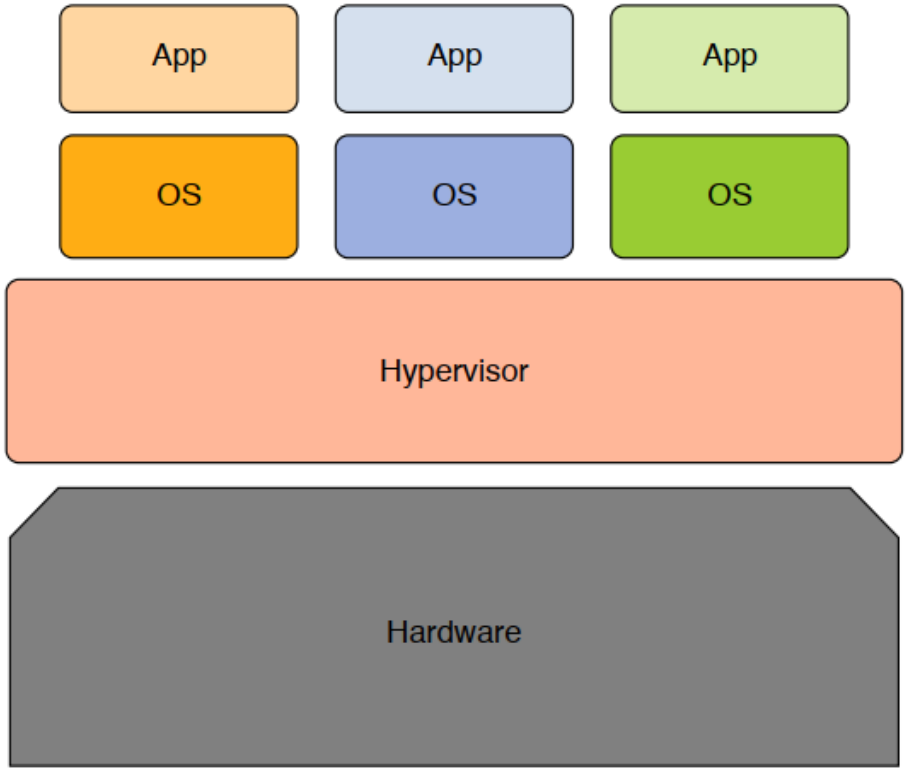


Hypervisor

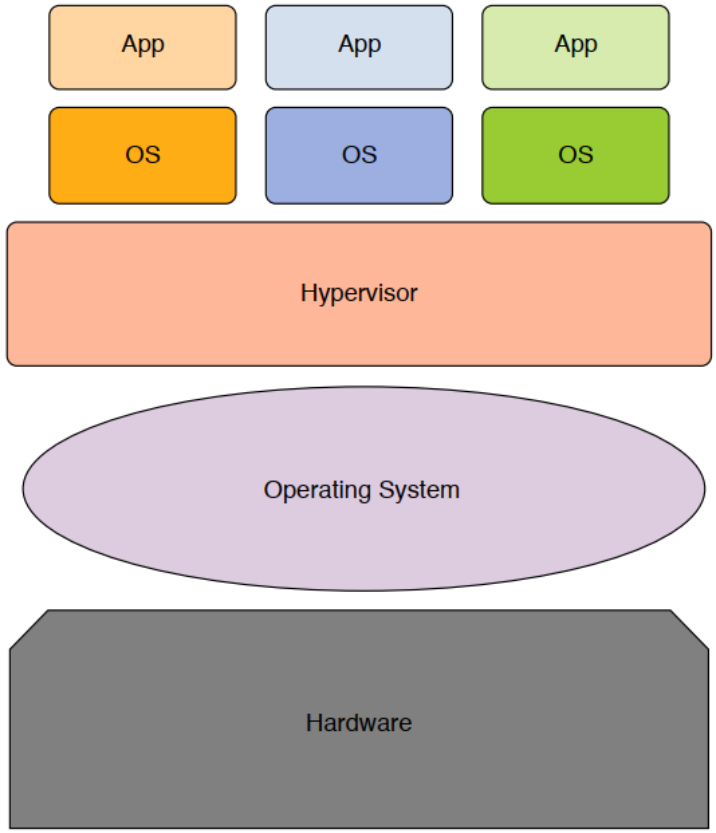

Server
Application
Operating System
Driver
Driver
Driver
Driver
CPU
Memory
NIC
Disk


Server
VM1
VM2
VM3
Application
Application
Application
OS 1
OS 2
OS 3
Hypervisor
Driver
Driver
Driver
Driver
CPU
Memory
NIC
Disk

Types of Hypervisors



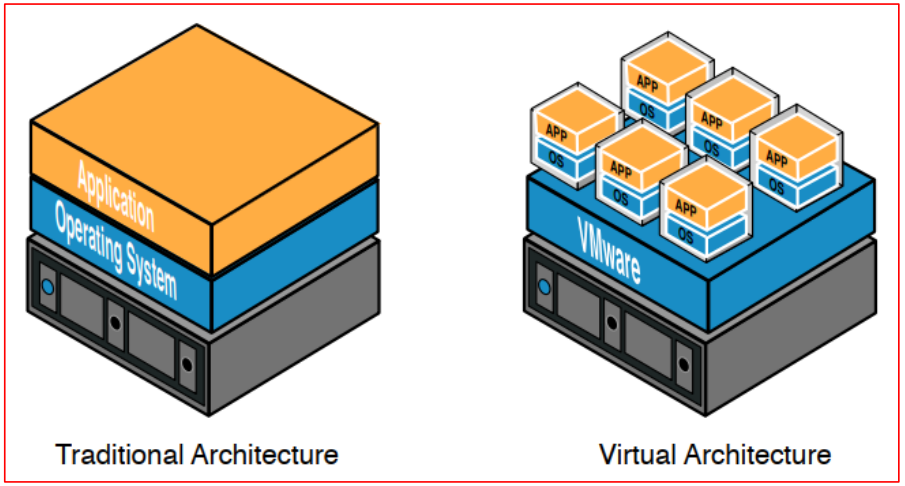
❖ **Type 1 hypervisors** (bare metal hypervisors)
- ➢ Interface directly with the hardware resources
- ➢ VMware ESXi (as part of vSphere package)
- ➢ Microsoft Hyper-V

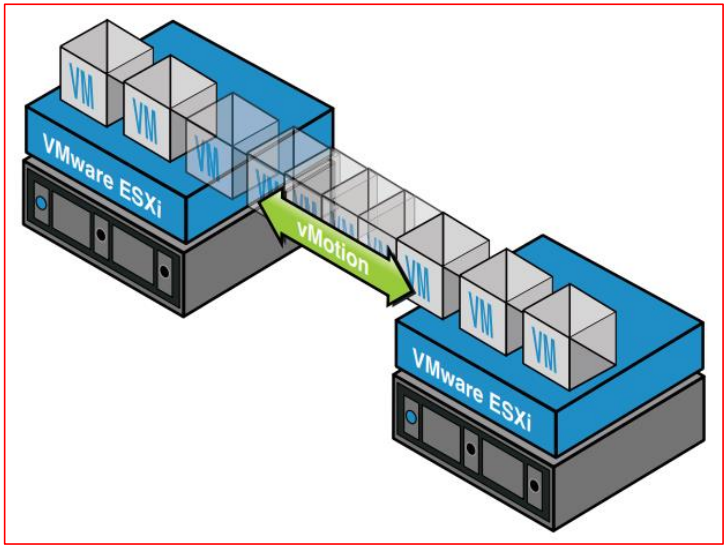


❖ **Type 2 hypervisors** (hosted hypervisors)
- ➢ Interface with the native OS running on the server
- ➢ VMware Workstation
- ➢ Oracle VirtualBox

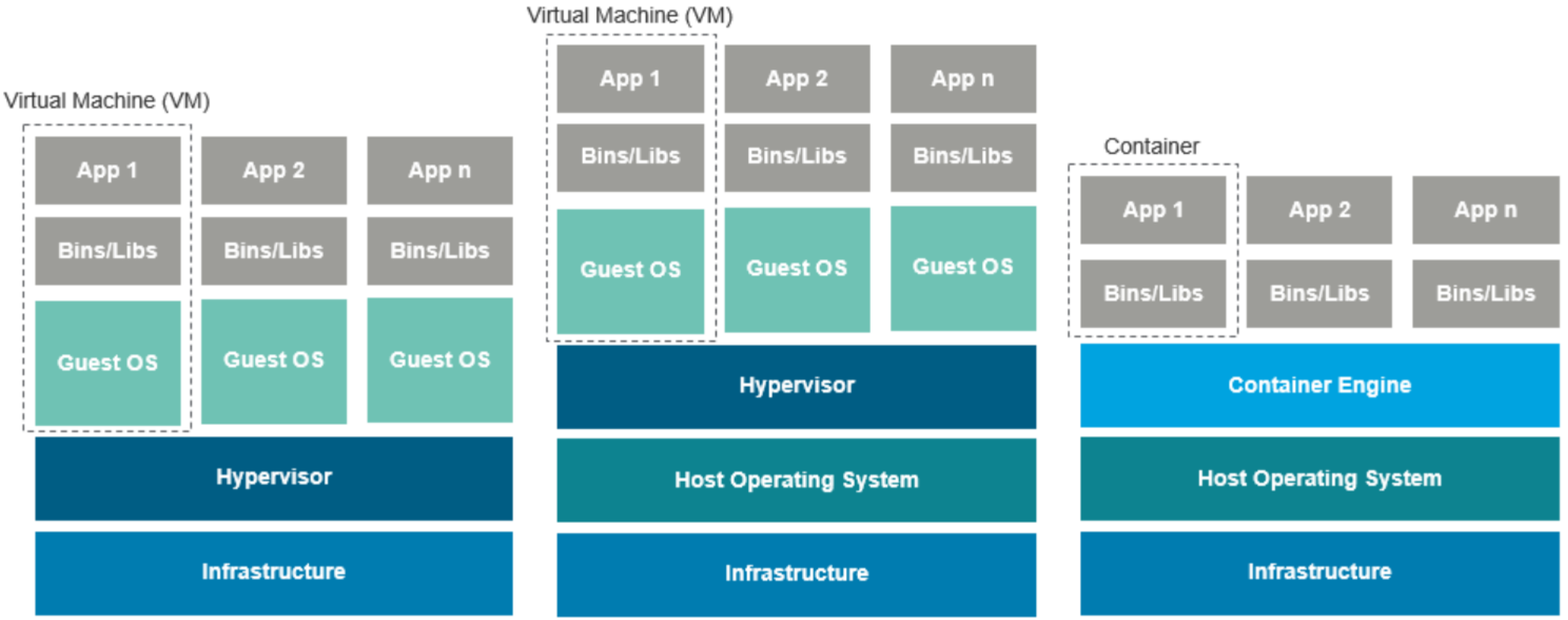
Benefits of Virtual Machines

- Reduces the expenses from server proliferation.
  - (Servers, Energy, Cooling, Space, Cabling, etc.)
- Solves the problem of one application per server.
  - Minimizes resource competition.
  - Isolates application failures
- Application availability and fault tolerance
- Flexibility
- Faster Application Spin-Up and Provisioning
- Development Operations (DevOps)





Containers (OS-Level Virtualization)



- Containers are a lighter-weight, more agile way of handling virtualization.
- A hypervisor virtualizes underlying physical hardware.
- Containers virtualize the operating system. They share a common operating system.

Data Center

Large facilities with 10s of thousands of networked servers

Types of Data Centers

- Specialized data centers built for one big app
  - Social networking: Facebook
  - Web Search: Google, Bing

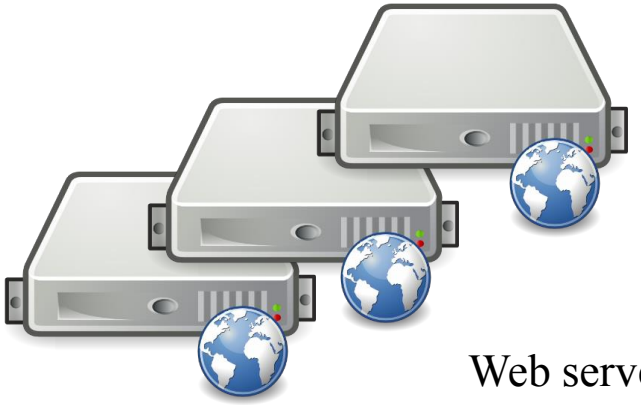
- "Cloud" data centers
  - Amazon EC2
  - Microsoft Azure
  - Google App Engine

Cloud Computing

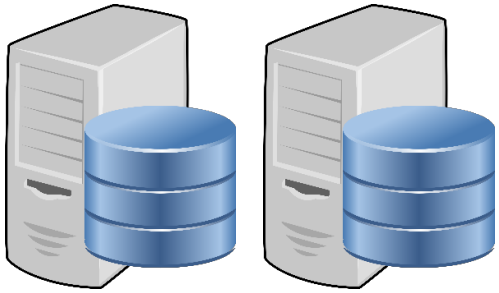
Cloud computing is the on-demand delivery of IT resources over the Internet with pay-as-you-go pricing. Instead of buying, owning, and maintaining physical data centers and servers, you can access technology services, such as computing power, storage, and databases, on an as-needed basis from a cloud provider like Amazon AWS.

- On-demand
  - Use resources when you need it; pay per use (metered usage)
- Elastic
  - Scale up & down based on demand
- Multi-tenancy
  - Multiple independent users share infrastructure (private and public clouds)
  - Security and resource isolation
  - SLAs on performance & reliability
- Dynamic Management
  - Workload movement: move work to other locations
  - Resiliency: isolate failure of servers and storage

Cloud Example



Web servers



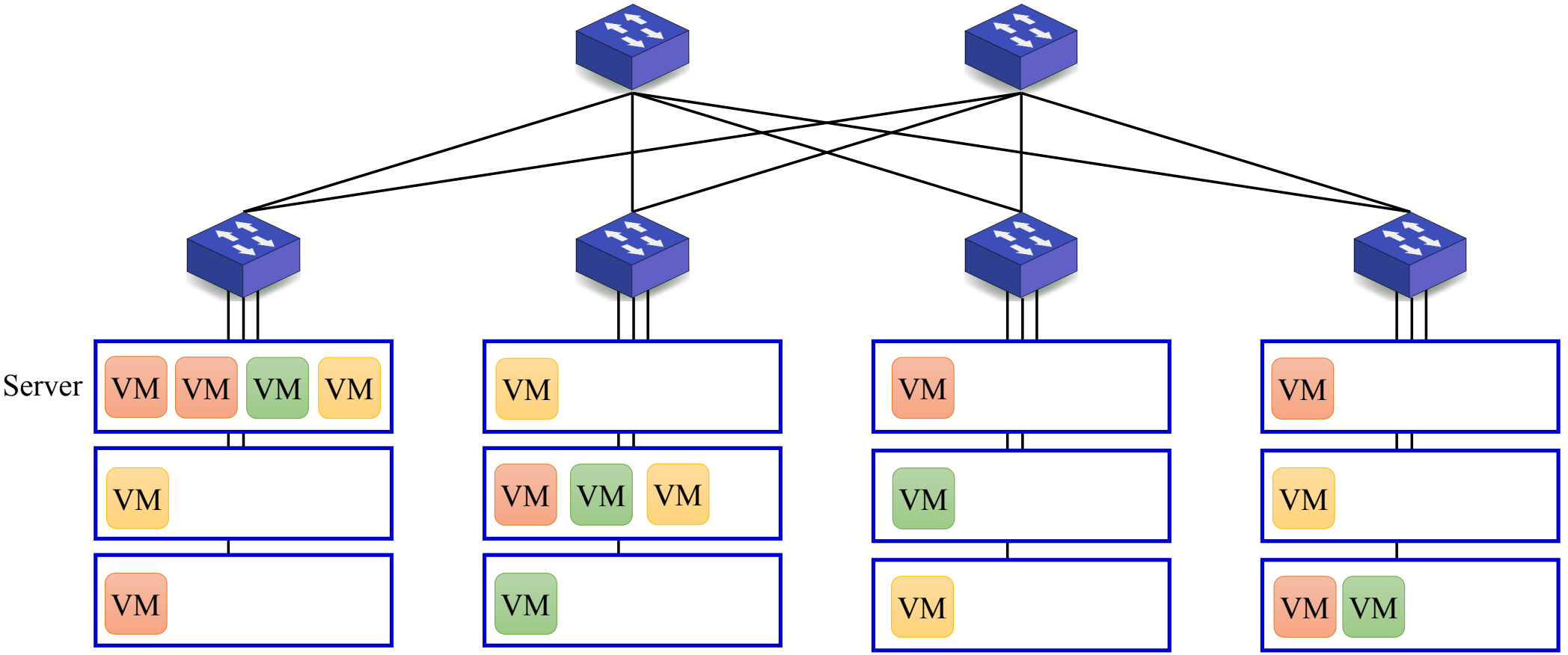
Storage servers

Load balancer

Computation servers

Cloud Data Center

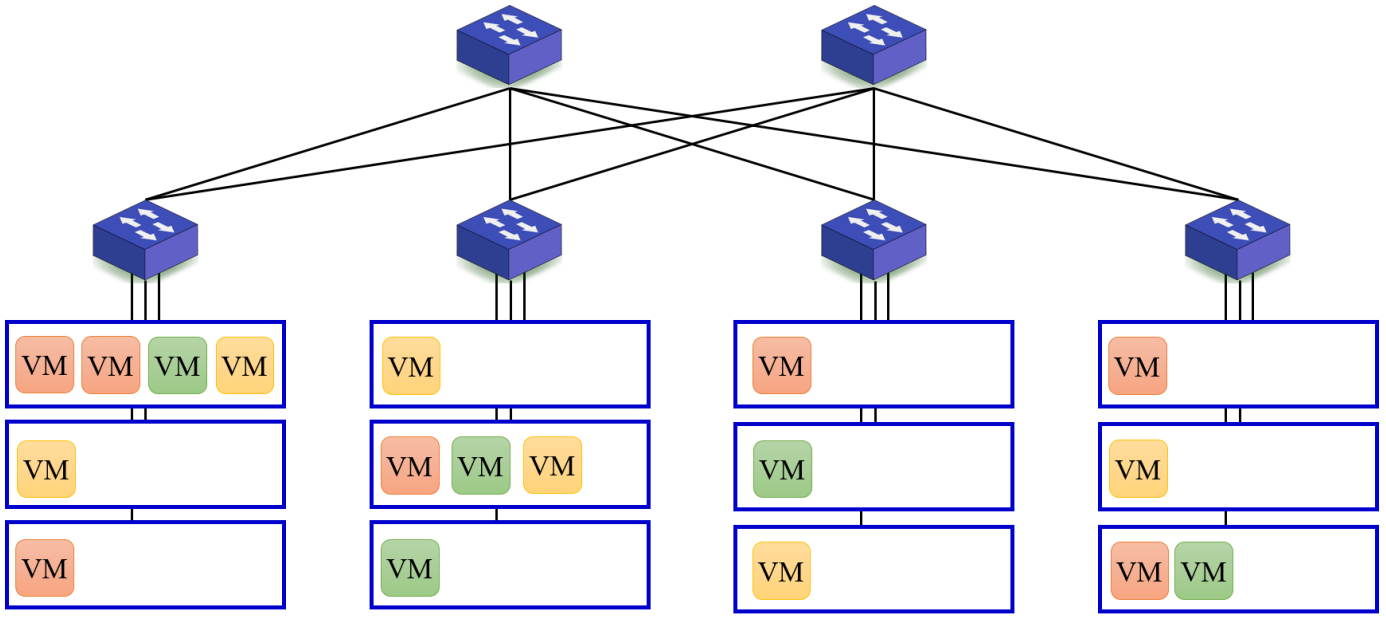
The main enabling technology for cloud computing is **virtualization**



What about networking?

Networking Challenges in a Cloud Data Center

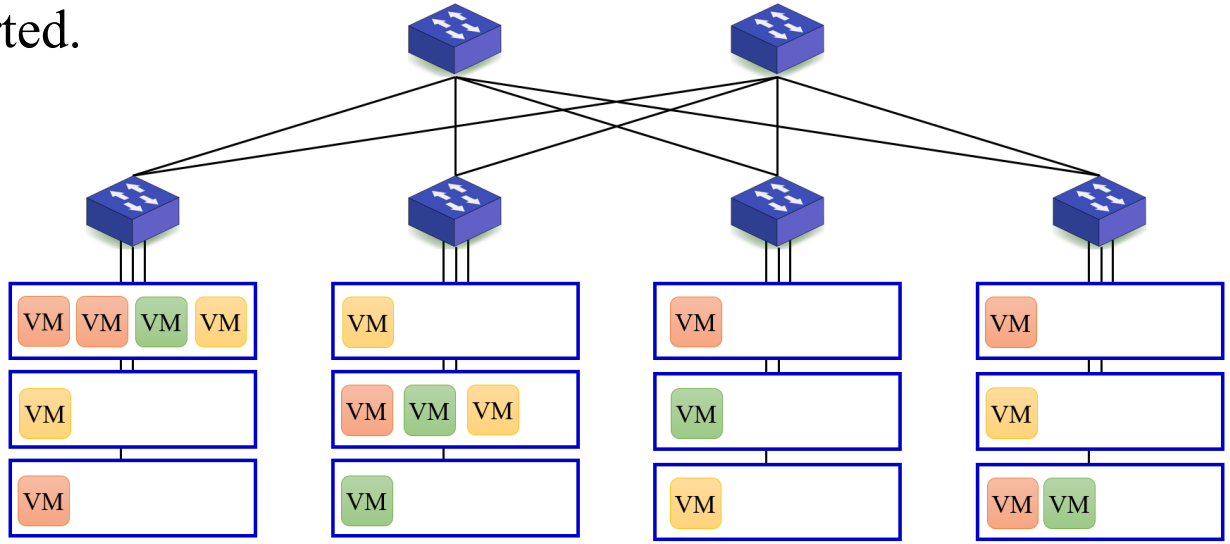
- Isolating tenants in the data center's network
  - VLAN ?



Networking Challenges in a Cloud Data Center

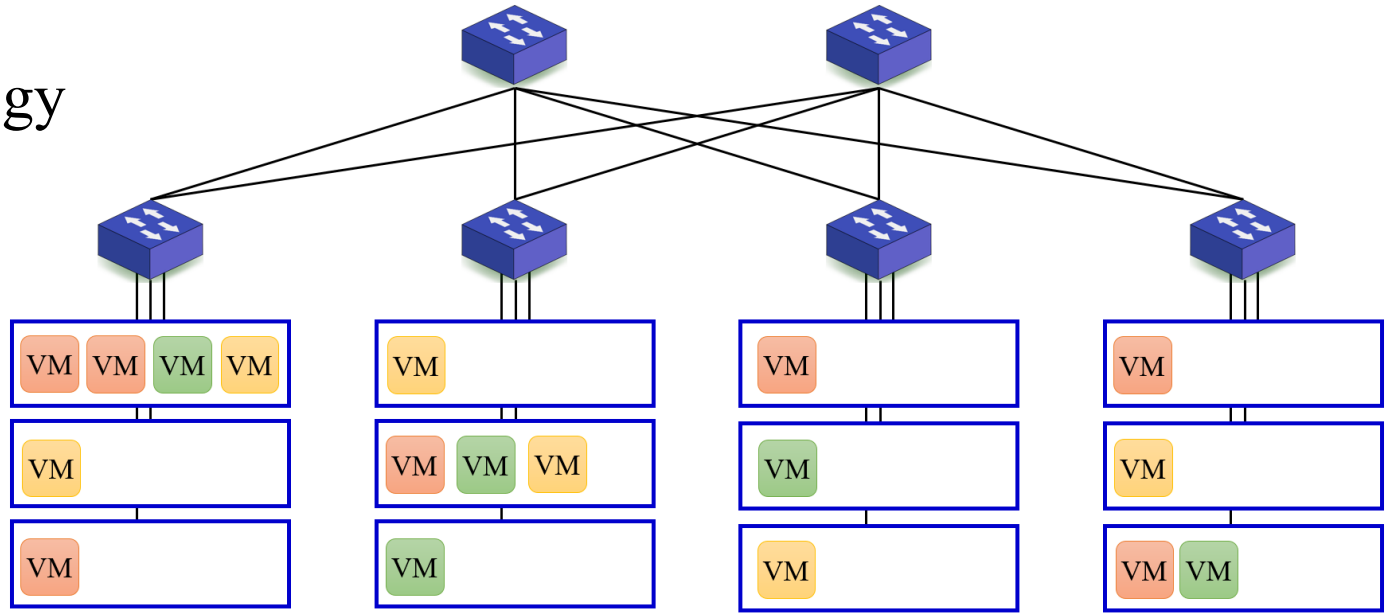
- Challenge of virtual machine mobility for data center networking
  - The IP address of a VM is drawn from the subnet of physical network on which it resides.
  - If a VM is to migrate to another server, either it needs to move to a server where that subnet is also present, or it needs a new IP address.
  - The first choice limits where it can move within the datacenter, which affects the efficiency of resource usage.
  - The second option is quite a disruptive thing: TCP connections are dropped, and applications may need to be restarted.

- Furthermore, some applications depend on layer-2 adjacency between communicating peers, and thus depend on some set of VMs staying in a given subnet even as they move around within the datacenter



Networking Challenges in a Cloud Data Center

- IP assignment
- Custom protocols
- Custom network policy
- Custom network topology

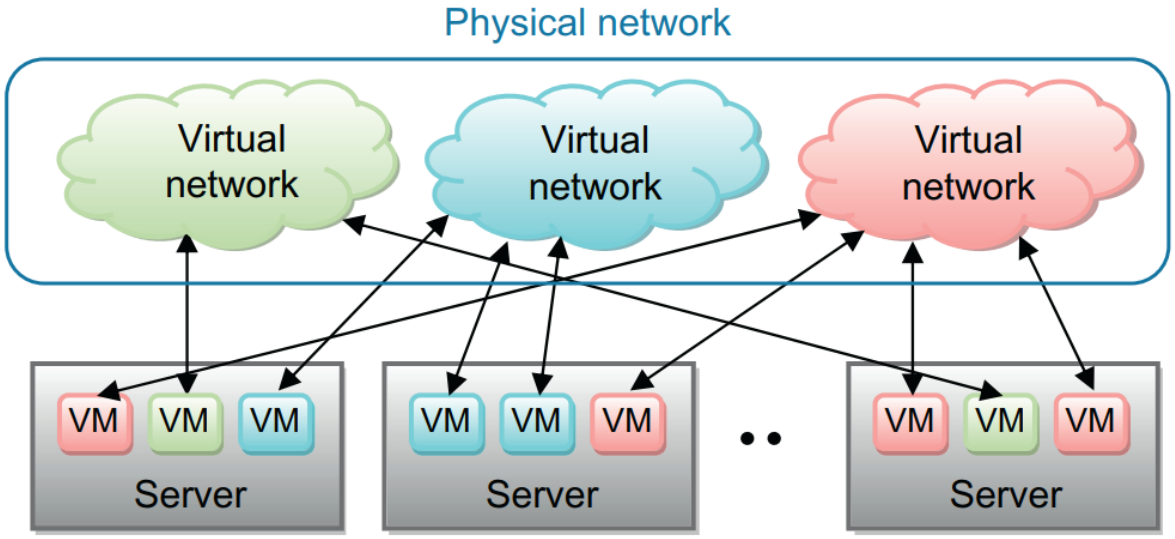


Network Virtualization in Cloud

- The goal of a multi-tenant cloud data center is to make the customer experience much the same as if they were using their own private data center.

- In this example, the physical resources are divided up among three different tenant.

- The server administrator allocates virtual machine resources to each tenant that may reside on different servers across the network.



- The network administrator also allocates **virtual network resources** to each tenant that interconnects the given tenant's virtual machines.

- The virtual machine network connections and virtual networks are isolated from each other

Network Virtualization

- Network Virtualization refers to abstracting network resources that were traditionally delivered in hardware to software.
  - Network virtualization can combine multiple physical networks to one virtual, software-based network,
  - or it can divide one physical network into separate, independent virtual networks.