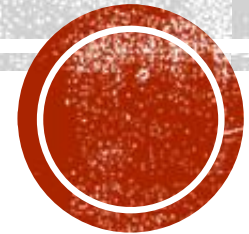


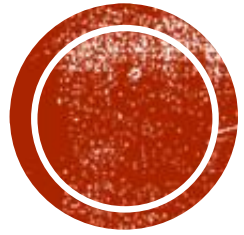
VIRTUALIZATION



ROOTS OF VIRTUALIZATION

- Technology evolution both drives and is driven, by ever increasing levels of abstraction in hardware and software
- High-level programming language allow software development, while shielding programmers away from the complexity of OS
- OS provides a lower level of abstraction that frees software developers from the complex and varied details to interact with and manage physical resources such as memory and I/O devices
 - OS must be fully cognizant of the hardware on which it resides





VIRTUALIZATION

Why Virtualization is Important?

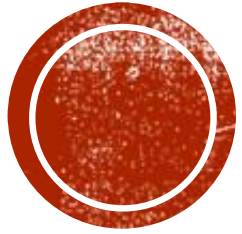
https://www.youtube.com/watch?v=vUUC_eDb2z0

EXAMPLE — VIRTUAL MEMORY

- **Memory virtualization** enables software programs to gain access to more memory than is physically installed, by background swapping of data to disk storage.
 - Virtualization techniques can be applied to other IT infrastructure layers –
 - Networks, storage, server hardware, operating systems and applications.



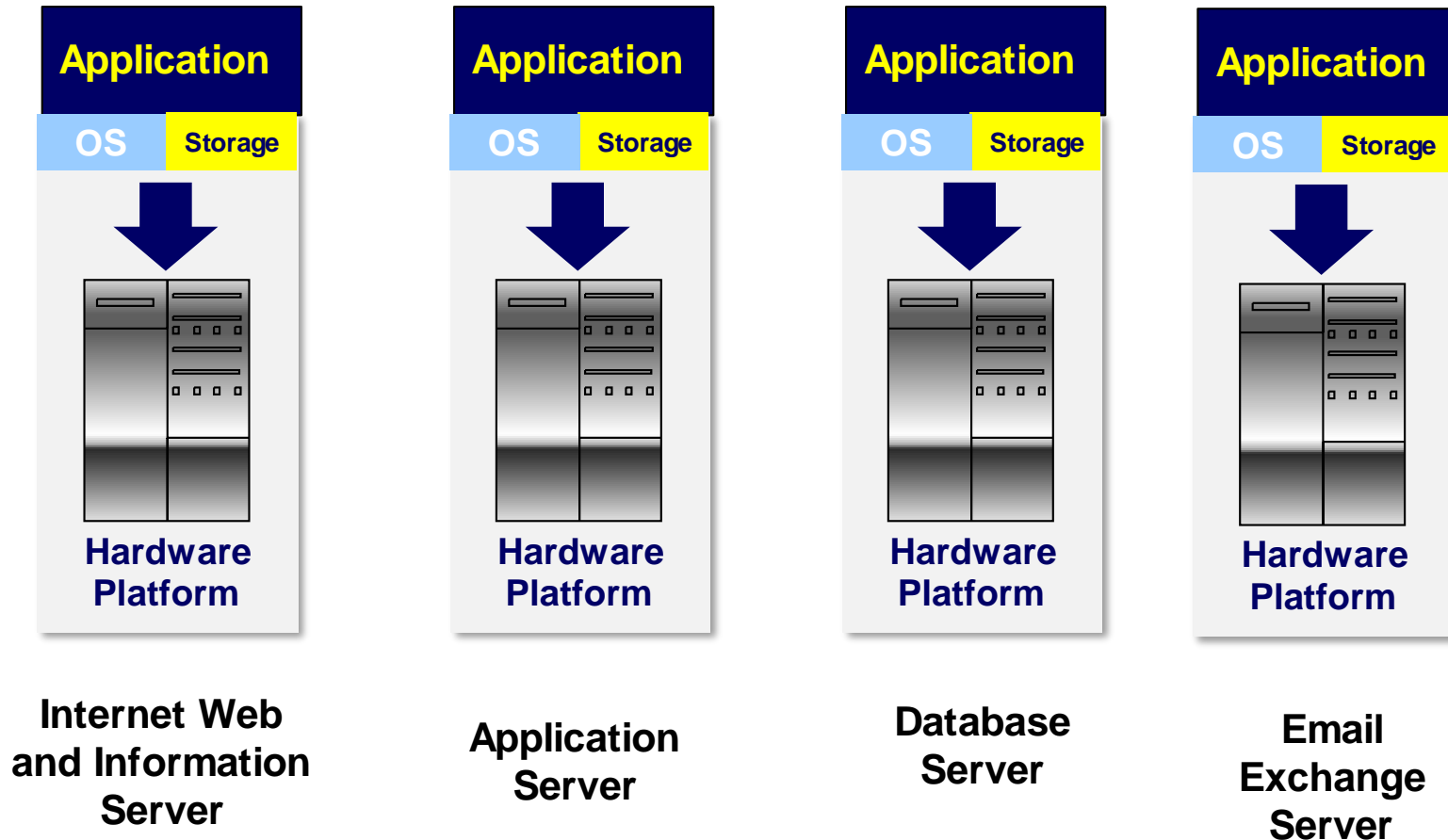
Virtualization in Practice



SERVER CONSOLIDATION



TRADITIONAL SERVER INFRASTRUCTURE

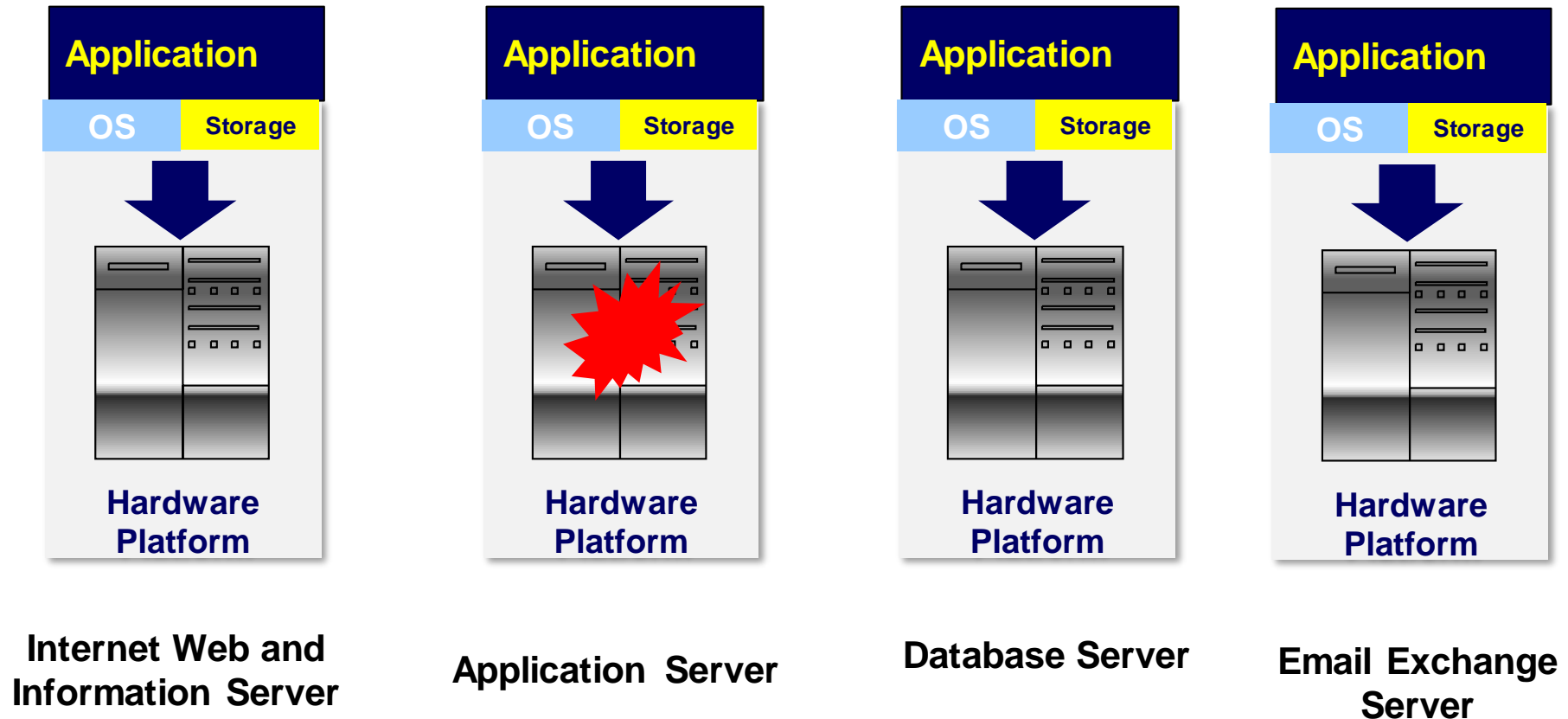


THE TRADITIONAL SERVER CONCEPT

- Servers are viewed as an **integral** computing unit
 - The unit includes the hardware, the OS, the storage, and the applications.
- Servers are often identified and referred to by their function
 - File server, Database server, SQL server, Web server Exchange server, ...
- When current server capacity reaches its limit, a NEW server must be added



SERVER FAILURE



A hardware failure causes service interruption



THE TRADITIONAL SERVER CONCEPT

Advantages

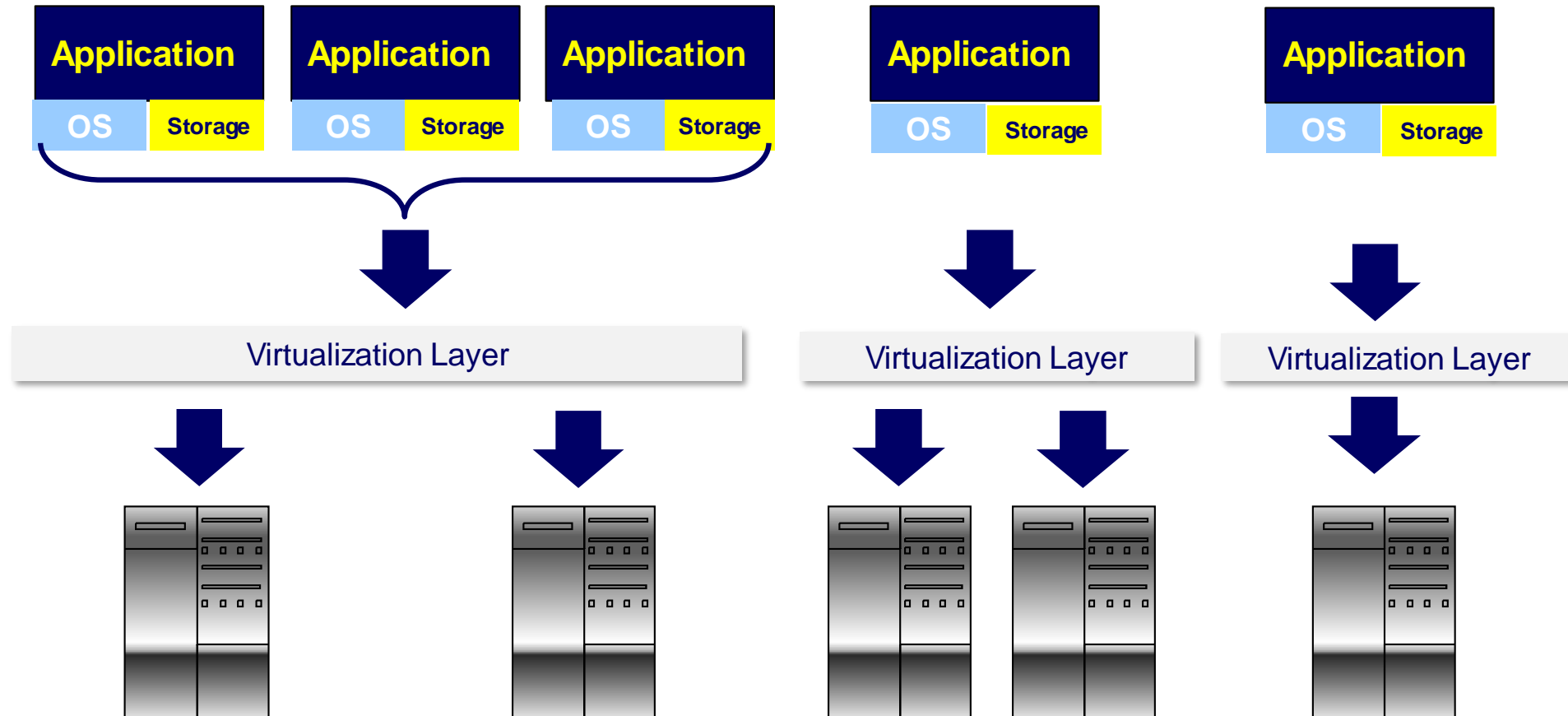
- Ease of configuration and conceptualization
- Ease of deployment
- Backup is manageable
- The client-server paradigm is well-suited for a variety of applications and services
 - Virtually, any application or service can be deployed on such a computing infrastructure

Disadvantages

- Maintenance cost is high
 - Acquisition and hardware repair cost
- Replication is challenging
 - Redundancy is costly and difficult to implement
- Scalability may be a limiting factor
- Highly vulnerable to hardware failures
- Often, utilization is low



VIRTUALIZED SERVER INFRASTRUCTURE



Hardware Infrastructure



SERVER VIRTUALIZATION

- Server virtualization enable server Consolidation and Containment
 - Eliminating “server sprawl” via deployment of systems as “virtual machines” that can run safely and move transparently across shared hardware
- A virtual server can be serviced by one or more hosts, and one host may house more than one virtual server.
 - This is results in increased server utilization rates
 - From 5-15%, traditional servers, to 60-80%



THE VIRTUAL SERVER CONCEPT

- Virtual servers can still be referred to by their function i.e. email server, database server, etc.
- If the environment is built correctly, virtual servers will not be affected by the loss of a host.
- Hosts may be removed and introduced almost at will to accommodate maintenance.



THE VIRTUAL SERVER CONCEPT

- Virtual servers can be scaled out easily.
 - Amount of resources allocated to a virtual server can be adjusted dynamically to meet the computation requirements of the virtual server
- Server “cloning” can be easily achieved
 - Multiple, identical virtual servers can be easily created based on server templates
- Virtual servers can be migrated from host to host dynamically, as needed.



VIRTUALIZATION ADVANTAGES

- Workload consolidation to reduce hardware, power and space requirement
- Ability to run multiple OSs, and leverage their advantages based on the application
 - Run legacy software on more efficient, modern architecture
 - Dynamically migrate workloads to provide fault tolerance
- Provide redundancy to mitigate of disaster
- Greater automation

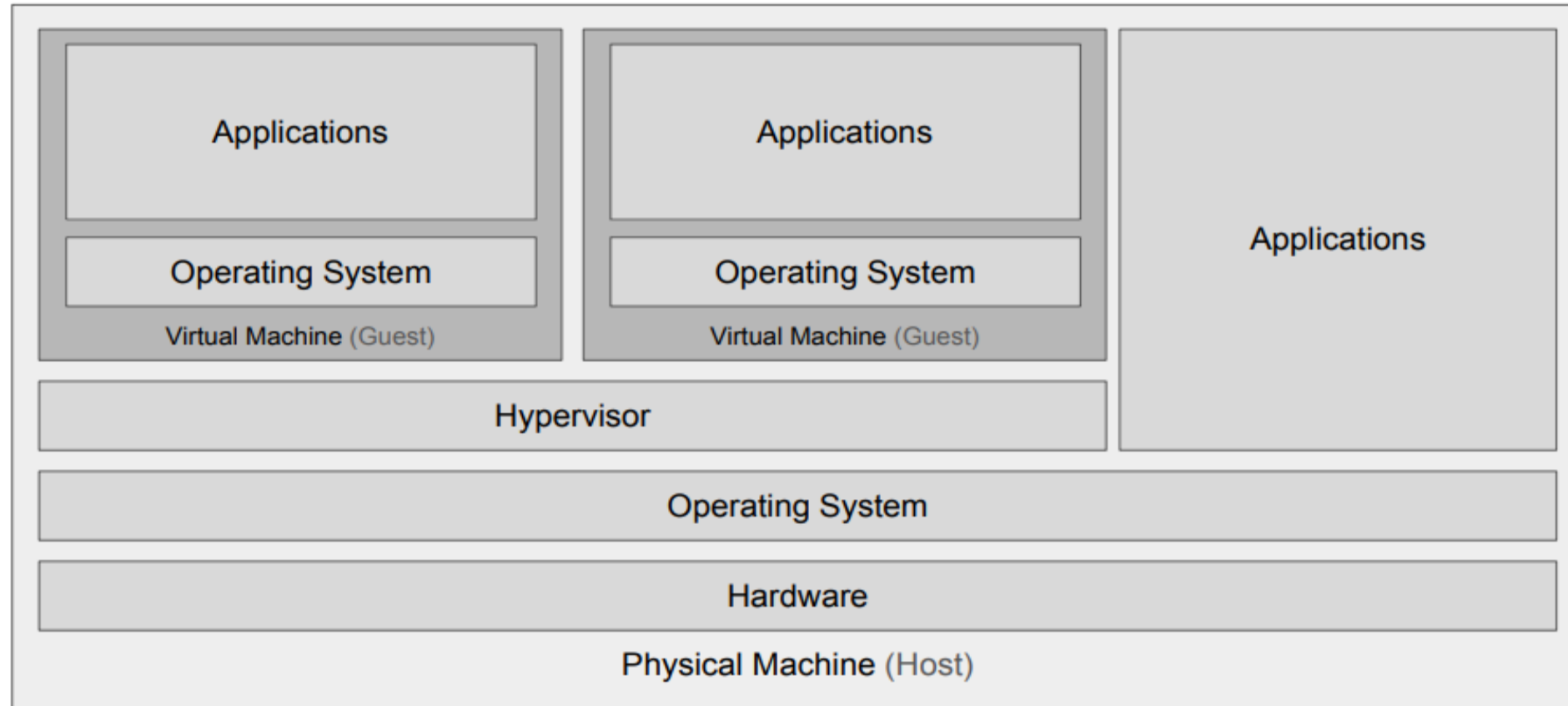


VIRTUALIZATION - DEFINITIONS

- Virtualization
 - The process of creating a virtual version of a physical object.
- Virtual Machine
 - Visual representation of a physical machine (Not JVM).
- Virtual Machine Monitor (VMM) or Hypervisor
 - A process that separates a computer's operating system and applications from the underlying physical hardware.
 - Hypervisor monitors and manages running virtual machines.
- Host Machine
 - The physical machine that a virtual machine is running on.
- Guest Machine
 - The virtual machine, running on the host machine.



VIRTUALIZATION



VIRTUALIZATION

- Virtualization abstracts the hardware of computing infrastructure into several different execution environments,
 - Creates the illusion that each separate environment is running on its own private computing infrastructure
 - Makes servers, workstations, storage, network and other systems independent of the physical hardware layer
- The fundamental technology that powers *Cloud Computing*!
 - Virtual resources can be started and stopped easily and quickly

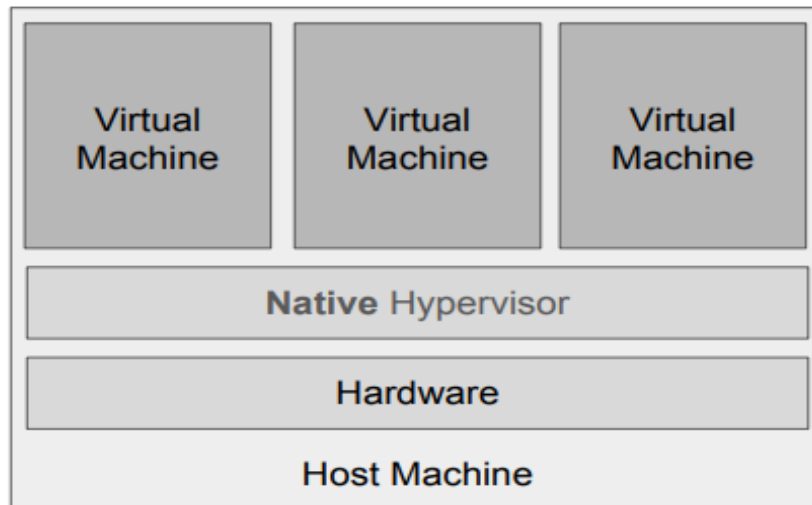


HYPERVERSORS

- Type 1: Native Hypervisors

- Run directly on the host machine and share resources (such as memory and devices) between guest machines
- Examples: VMware ESX and XEN.

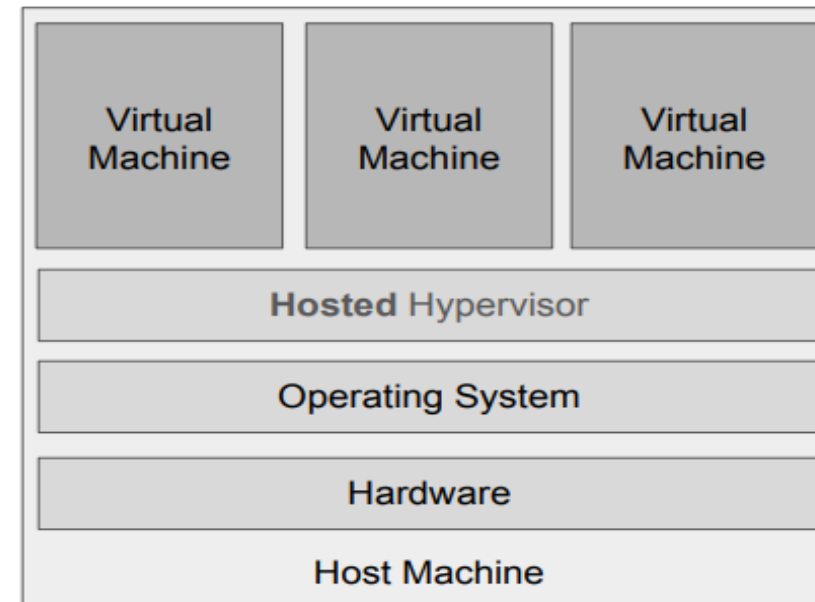
Type 1 - Native



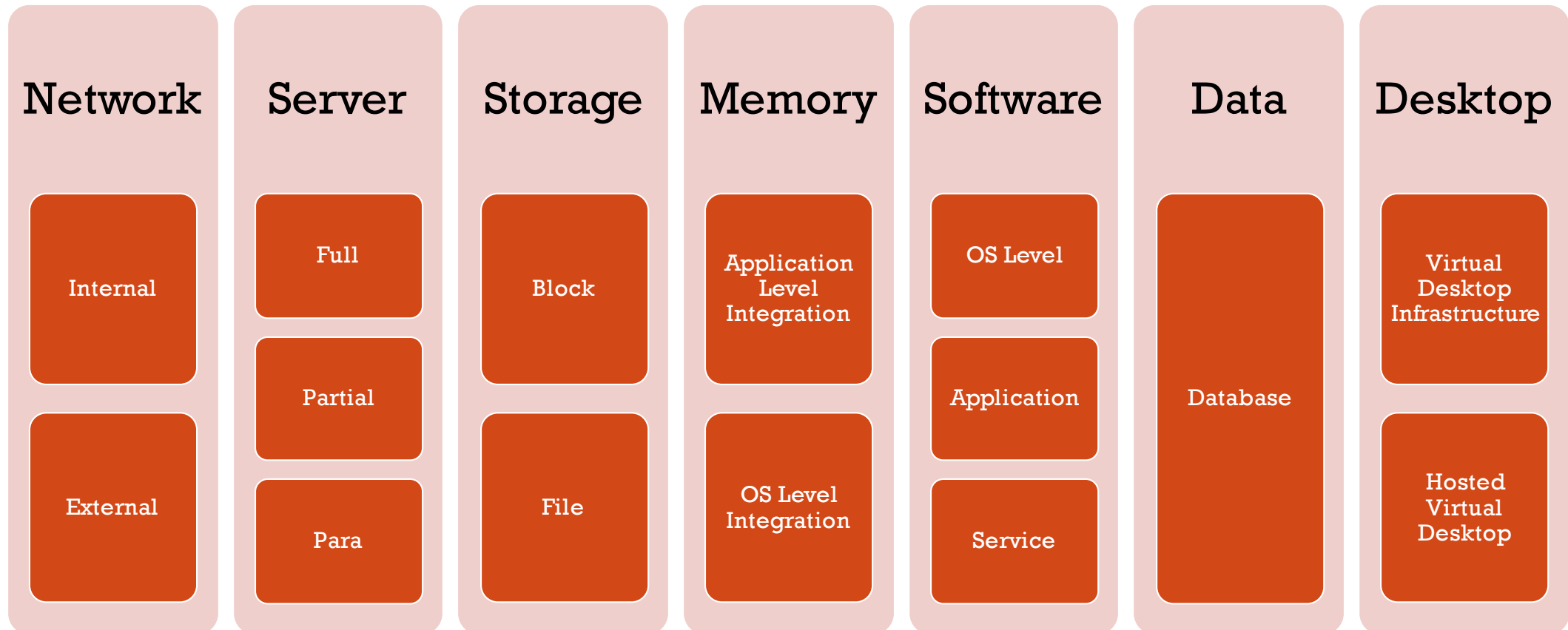
- Type 2: Hosted Hypervisors

- Run as an application inside an operating system, and support virtual machines running as individual processes.
- Examples: VirtualBox, QEMU, and JVM.

Type 2 - Hosted



VIRTUALIZATION



VIRTUAL RESOURCES IN THE CLOUD

- **Network virtualization** the process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a **virtual network**
 - External Network Virtualization - VLAN
 - Internal Network Virtualization – Software defined network
- **Server virtualization** is the process of using software on a physical server to create multiple partitions or "virtual instances" each capable of running independently.
- **Storage virtualization** pools physical storage from multiple network storage to enable a single storage device that is managed from a central console



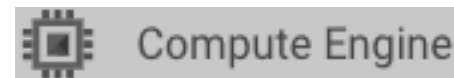
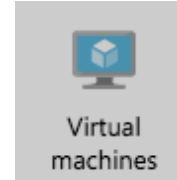
VMS IN THE CLOUD

- Getting VMs from

- AWS EC2

- Azure

- Google Cloud

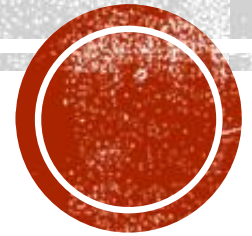


TODO ITEMS:

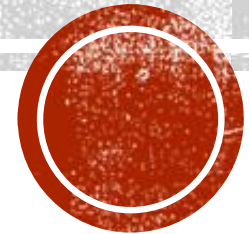
- First homework deadline is next week. Check Canvas for details.
- [Optional]: Reading on Canvas for physical servers vs. virtual servers.
- Before next lecture, install Docker on your machine.
 - <https://www.docker.com/products/docker-desktop>
 - Some students may experience issues downloading and installing docker on their machines due to older Windows versions.
 - For those students facing issues, please try Docker toolbox installation.



OPTIONAL MATERIALS



VIRTUALIZATION COMMON INTERVIEW QUESTIONS



QUESTIONS

- Mention the types of virtualization.
- What are the main benefits of virtualization?
- Explain memory and storage virtualization.
- What is hypervisor?

