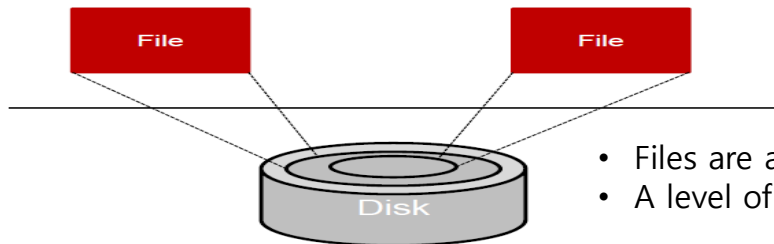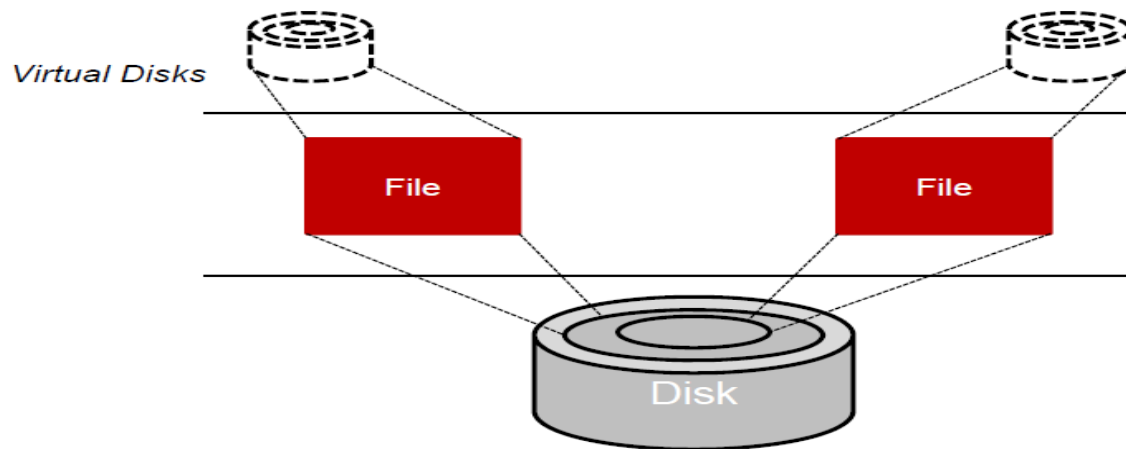# 1. Virtualization Overview

What is virtualization?

- Informally, a virtualized system (or subsystem) is a *mapping* of its interface, and all resources visible through that interface, to the interface and resources of a real system
- Formally, virtualization involves the construction of an isomorphism that *maps* a virtual *guest* system to a real *host* system (Popek and Goldberg 1974)
- The key to managing complexity in computer systems is their division into *levels of abstraction* separated by *well-defined interfaces*
  - Levels of abstraction allow implementation details at lower levels of a design to be ignored or simplified

- Files are an abstraction of a Disk
- A level of abstraction provides a simplified interface to underlying resources

Virtualization and Abstraction

■ Virtualization uses abstraction but is different in that it doesn't necessarily hide details;

- The level of detail in a virtual system is often the same as that in the underlying real system

Virtual Disks

File

File

Disk

• Virtualization provides a different interface and/or resources at the same level of abstraction

What is server virtualization?

- **Creating multiple logical server OS instances on one physical piece of hardware**

- **All HW drivers are virtualized – same virtual HW regardless of physical HW**

- **Each virtual machine is completely independent of the others and doesn't 'realize' it's virtualized**

Why virtualize?

- More efficient HW utilization

- More efficient staff

- Long-term matching resources & needs

- Quick and nimble server provisioning

- Testing & Troubleshooting

- More effective redundancy

- HW maintenance w/o app downtime

- Simplify system imaging

- Disaster Recovery

HW Utilization Facts

- **Individual ebb and flow of resources**

- **Cumulative usage of 28 servers in the MAIS data center evaluated for virtualization:**

- **44GB RAM, 138.15Ghz CPU, and 1323GB HD**

  - ✓ **45% of RAM not used 99.9% of time.**

  - ✓ **25% of RAM never used concurrently.**

  - ✓ **85% of CPU not used 99.9% of time.**

  - ✓ **81% of CPU never used concurrently.**

  - ✓ **68% of hard disk space unused**

Hard Disk Utilization

Server Local Disk	Total (GB)	Used (GB)	Free (GB)
SAN Manager	48	8	40
IIS app test	68	9	59
TNG Scheduling	68	13	55
PeopleSoft 8 HE	34	7	27
PeopleSoft 8 FIN	34	24	10
IIS / SQL:Research app	68	31	37
File Servers	136	56	80
Stat Version Control	34	6	28
Stat Version Control	17	6	11
SQL: eLearning dev	68	16	52

Hard Disk Utilization

Server Local Disk	Total (GB)	Used (GB)	Free (GB)
IIS: eLearning dev	68	11	57
SQL: eLearning Prod	68	10	58
IIS: eLearning Prod	34	13	21
Machine Room environ	68	6	62
IIS document server	170	88	82
Domain Controller	34	7	27

■ **More Efficient Hard Disk Utilization**

✓ **Total: 1323 GB**

✓ **Used: 418 GB**

✓ **Free: 905 GB(68% unused)**

■ **SAN in 30GB chunks**

1 fiber channel >1 server

Virtual HDs more granular

Share free space – allocate as needed

Virtualization vs. Consolidation

- Virtualized servers = separate OSes

- Consolidation = same OS

- Virtualized servers must each be administered, patched, etc

- Consolidated applications can introduce conflicts and support issues

Strategy for web hosting

■ **Reduce costs by consolidating services onto the fewest number of physical machines**

http://www.vmware.com/img/serverconsolidation.jpg

Tactics
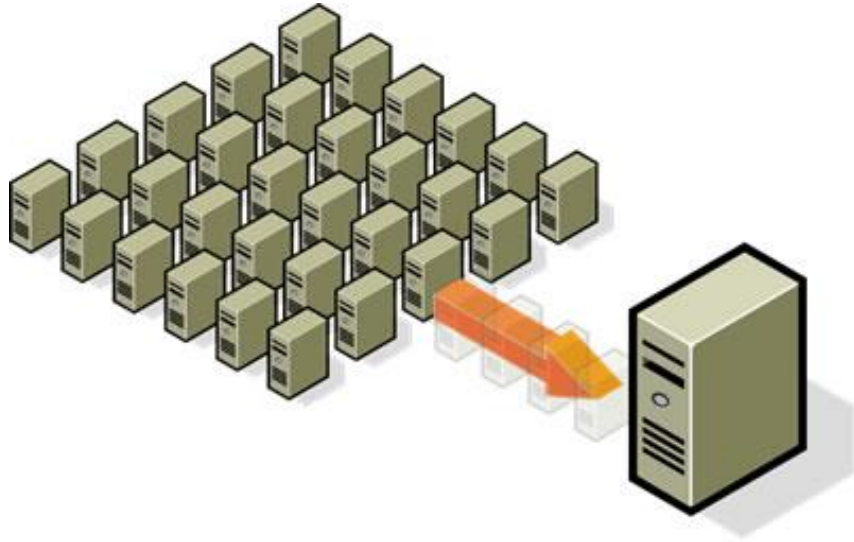
- **Consolidate shared environments (WebSphere, PHP, HTML, ASP) onto fewer boxes configured with one OS each**
  - ✓ **Still a large number of physical servers to support**
- **Investigate options for virtualization to consolidate Windows and Linux hosting offerings onto one or two machines**
- **Investigate options for virtualization to lower costs for "co-location" services for customers**

Virtualization Defined

- **Virtualization is a broad term that refers to the abstraction of resources across many aspects of computing**

- **For our purposes - One physical machine to support multiple virtual machines that run in parallel**
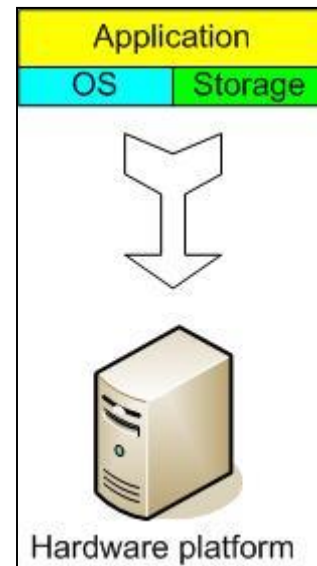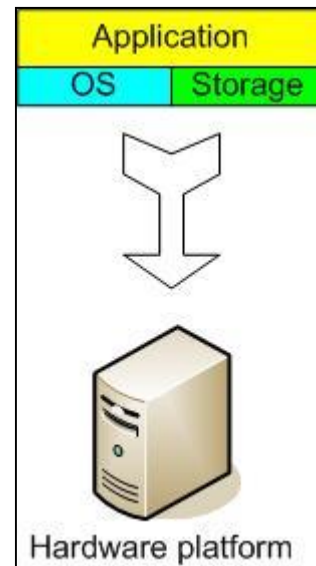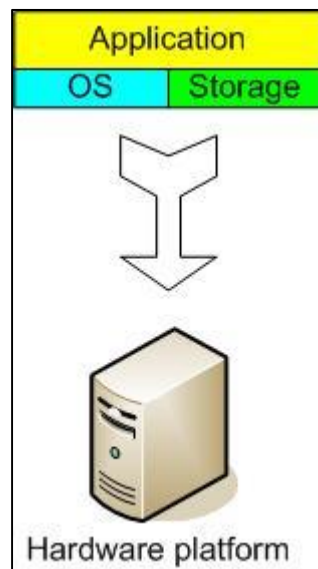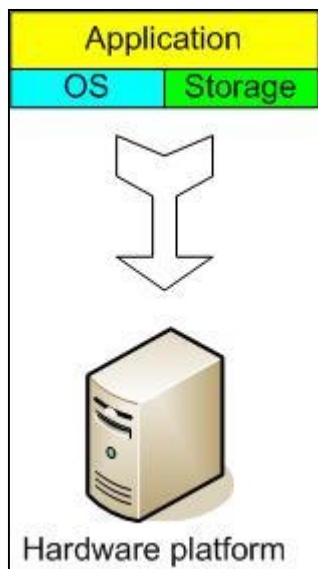
Problem Assessment – Why Virtualization?

- Too many servers for too little work

- Aging hardware reaching end of usable life

- High infrastructure requirements

- Limited flexibility in shared environments

2. Traditional server

The Traditional Server Concept

Web Server	App Server	DB Server	EMail
Windows	Linux	Linux	Windows
IIS	Glassfish	MySQL	Exchange

And if something goes wrong …
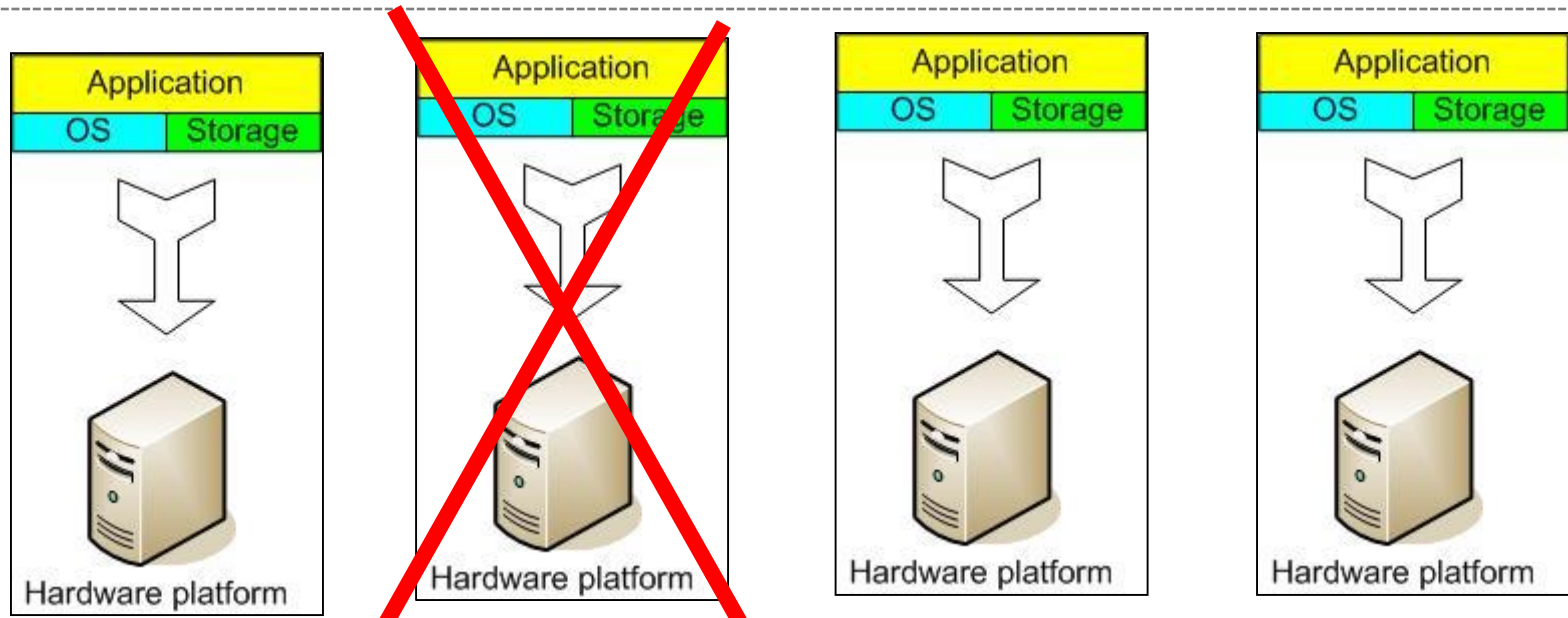
Web Server	App Server	DB Server	EMail
Windows	DOWN!	Linux	Windows
IIS		MySQL	Exchange

The Traditional Server Concept

- **System Administrators often talk about servers as a whole unit that includes the hardware, the OS, the storage, and the applications**

- **Servers are often referred to by their function i.e. the Exchange server, the SQL server, the File server, etc**

- **If the File server fills up, or the Exchange server becomes overtaxed, then the System Administrators must add in a new server**

The Traditional Server Concept

- **Unless there are multiple servers, if a service experiences a hardware failure, then the service is down**

- **System Admins can implement clusters of servers to make them more fault tolerant. However, even clusters have limits on their scalability, and not all applications work in a clustered environment**

The Traditional Server Concept

- **Pros**
  - ✓ **Easy to conceptualize**
  - ✓ **Fairly easy to deploy**
  - ✓ **Easy to backup**
  - ✓ **Virtually any application/service can be run from this type of setup**
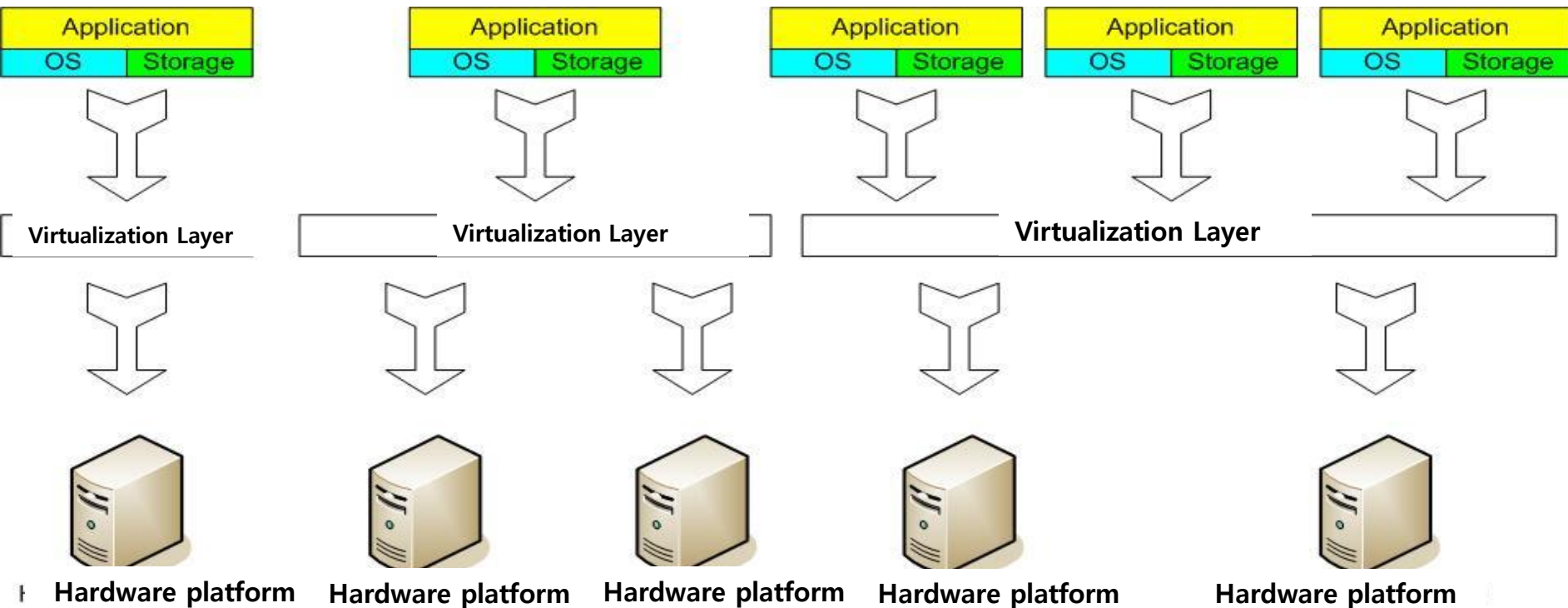- **Cons**
  - ✓ **Expensive to acquire and maintain hardware**
  - ✓ **Not very scalable**
  - ✓ **Difficult to replicate**
  - ✓ **Redundancy is difficult to implement**
  - ✓ **Vulnerable to hardware outages**
  - ✓ **In many cases, processor is under-utilized**

3. Virtual server

The Virtual Server Concept

Application	Application	Application	Application	Application
OS — Storage	OS — Storage	OS — Storage	OS — Storage	OS — Storage

Virtualization Layer   **Virtualization Layer**   **Virtualization Layer**

Hardware platform   **Hardware platform**   **Hardware platform**   **Hardware platform**   **Hardware platform**

Virtual Machine Monitor (VMM) layer between *Guest OS* and hardware

Virtual Machine and Hypervisor

■ The concept of virtualization can be applied not only to subsystems such as disks, but to an entire machine denoted as a virtual machine (VM)

■ A VM is implemented by adding a *layer of software* to a real machine so as to support the desired VM's architecture

■ This layer of software is often referred to as **virtual machine monitor** (VMM)

· - Early VMMs are implemented in firmware

· - Today, VMMs are often implemented as a co-designed firmware-software layer, referred to as the **hypervisor**

Research into Virtualization

- Reduce the number of physical machines
- Isolate environments but share hardware
- Make better use of existing capacity
- Virtualize Network and SAN interfaces to reduce infrastructure needs
- Ultimately save on maintenance and leases

More options available today than ever before...

Virtualization Software

- **MS Virtual PC 2004 – workstation only**
- **VMWare Workstation 5 – workstation only**
- **MS Virtual Server 2005, Standard (4p)**
- **MS Virtual Server 2005, Enterprise (32p)**
- **VMWare GSX Server 3.1**
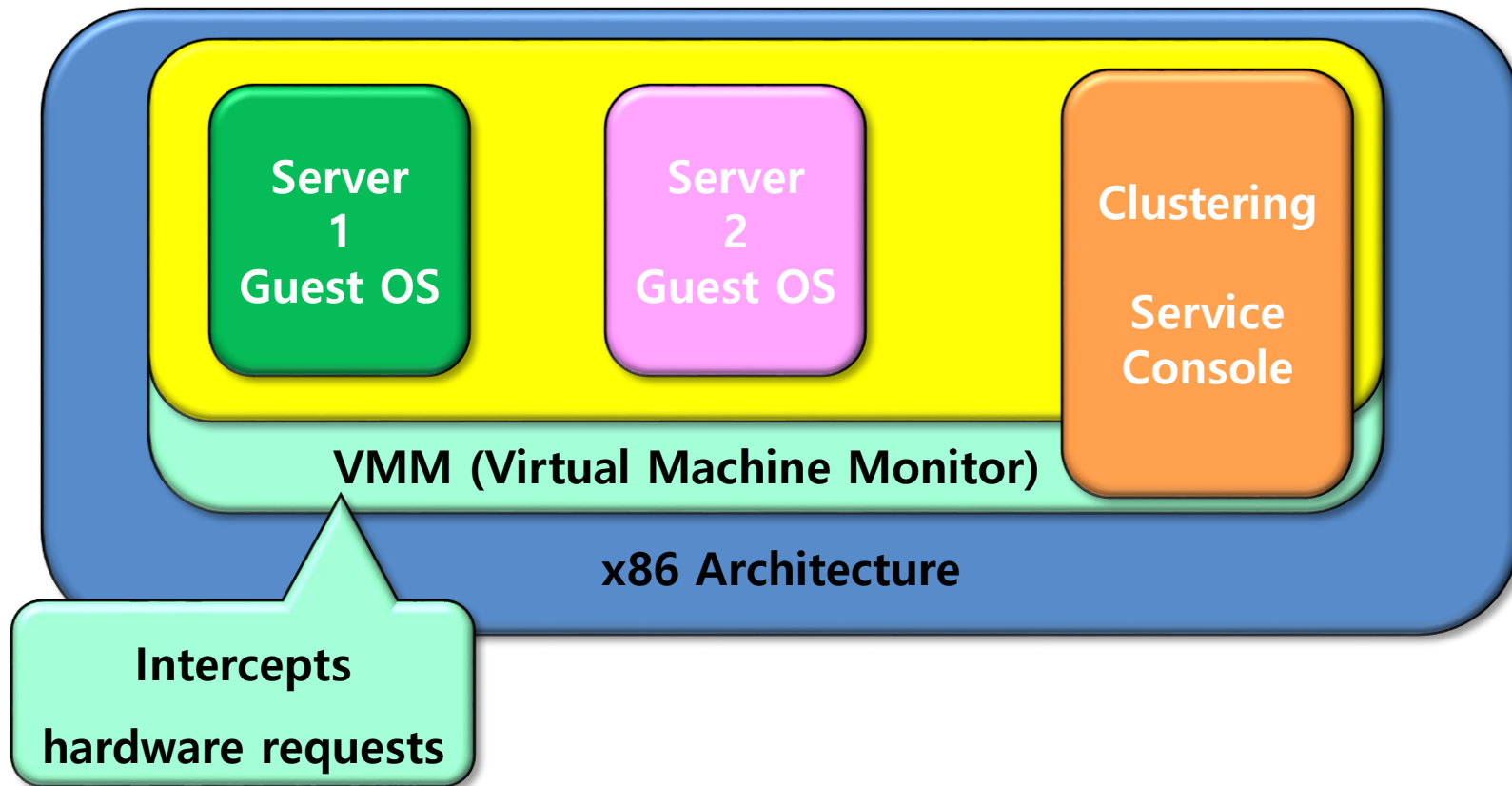- **VMWare ESX Server 2.5**
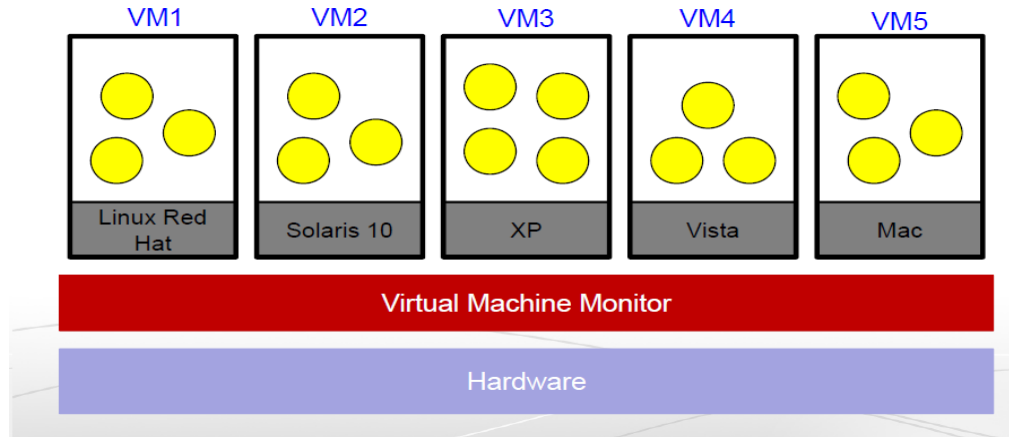
More Software Options

- **Wide array of virtualization products now available in the marketplace**

- **Partnerships with Operating System vendors (i.e. SuSE, RedHat, Sun) yield tighter integration and better performance**

Close-up*

| Server 1 Guest OS | Server 2 Guest OS | Clustering Service Console |

VMM (Virtual Machine Monitor)

x86 Architecture

Intercepts hardware requests

The Virtual Server Concept

- **Virtual servers seek to encapsulate the server software away from the hardware**

  - ✓ **This includes the OS, the applications, and the storage for that server**

- **Servers end up as mere files stored on a physical box, or in enterprise storage**

- **A virtual server can be serviced by one or more hosts, and one host may house more than one virtual server**

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**
  - ✓ **If the administrators find that the resources supporting a virtual server are being taxed too much, they can adjust the amount of resources allocated to that virtual server**
- **Server templates can be created in a virtual environment to be used to create multiple, identical virtual servers**
- **Virtual servers themselves can be migrated from host to host almost at will**

The Virtual Server Concept

Pros

- ✓ **Resource pooling**
- ✓ **Highly redundant**
- ✓ **Highly available**
- ✓ **Rapidly deploy new servers**
- ✓ **Easy to deploy**
- ✓ **Reconfigurable while services are running**
- ✓ **Optimizes physical resources by doing more with less**

Cons

- ✓ **Slightly harder to conceptualize**
- ✓ **Slightly more costly (must buy hardware, OS, Apps, and now the abstraction layer)**