Parallel & Distributed Computing
Virtualization
Lecture 12/2

Farhad M. Riaz

Farhad.Muhammad@numl.edu.pk

Department of Computer Science
NUML, Islamabad

Historical Background

- Early research has been done in the 50s
  - OS/360 for IBM System/360 (1964)
  - Multi-programming: OS/360 □ MVS □ OS/390 □ z/OS
- Java VM, VPNs, Storage
- Platform virtualization (server versus desktop)
  - VMware, Xen, KVM, …

- □ Virtualization already exists for quite a long time and for multiple applications
- □ Significant growth during the past 5 years

The Term Virtualization
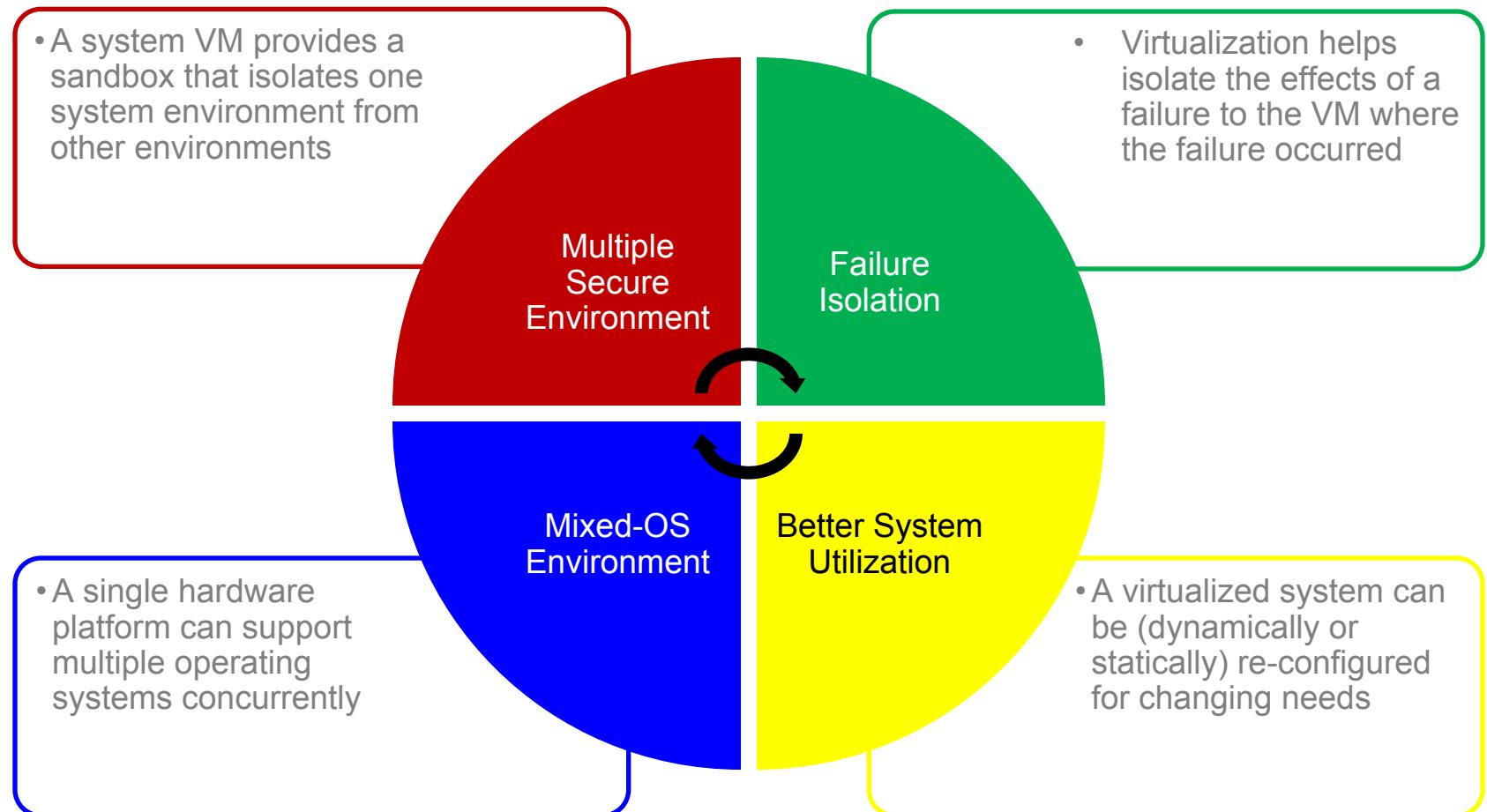
- … means abstraction of physical resources
- Virtual CPUs
- Virtual Memory: Uniform access/continuous addressing of physically separated storage
- Storage virtualization: Disks, tapes, …
- Network virtualization: VPNs, …
- Virtual Machine: Implementation of a computer through software
  - Platform virtualization (more later) & application virtualization

- Application virtualization: Databases as an example

Why Virtualization?

- Utilization: Server consolidation
- Isolation: Implication of errors is restricted to the virtual resource only
- Flexibility: Different applications/OSs share same physical hardware
  – Simultaneous usage
  – Configuration
- On-demand: virtual resource is created/destroyed on request
- Migration: Fault-tolerance; live updates; optimization of performance
- Research & Development: Research using new OS; test & debugging of new functionality

Benefits of Virtualization

- Here are *some* of the benefits that are typically provided by a virtualized system

- A system VM provides a sandbox that isolates one system environment from other environments

- Virtualization helps isolate the effects of a failure to the VM where the failure occurred

Multiple Secure Environment

Failure Isolation

Mixed-OS Environment

Better System Utilization

- A single hardware platform can support multiple operating systems concurrently

- A virtualized system can be (dynamically or statically) re-configured for changing needs

Virtualization Properties

- Fault Isolation

- Software Isolation

- Performance Isolation (accomplished through scheduling and resource allocation)

Isolation ①

- All VM state can be captured into a file (i.e., you can operate on VM by operating on file– cp, rm)

- Complexity is proportional to virtual HW model and independent of guest software configuration

Encapsulation ②

- All guest actions go through the virtualizing software which can inspect, modify, and deny operations
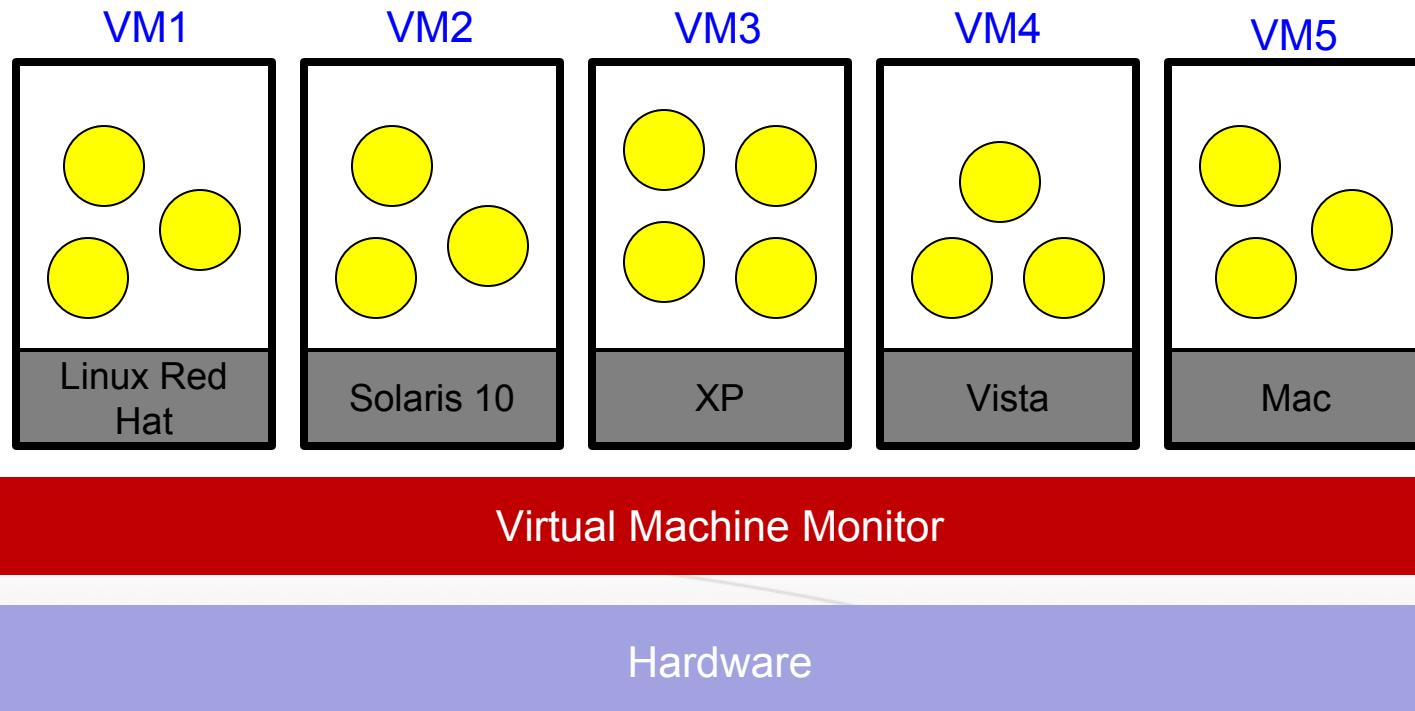
Interposition ③

Virtual Machines and Hypervisors

- 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

A Mixed OS Environment

- Multiple VMs can be implemented on a single hardware platform to provide individuals or user groups with their own OS environments

VM1 — Linux Red Hat
VM2 — Solaris 10
VM3 — XP
VM4 — Vista
VM5 — Mac

Virtual Machine Monitor

Hardware

Platform Virtualization

- Abstraction-layer "between" operating system and platform resources

- Different kinds
    - Full virtualization
    - Hardware-assisted virtualization
    - Partial virtualization
    - Para-virtualization
    - OS-level virtualization

Well-known Products

- Oracle VirtualBox
  - Runs on multiple host OSs
  - Open Source
- Parallels
  - Best known for Mac OS desktop virtualization and for Plesk
  - Commercial
- KVM (Kernel-based Virtual Machine) via RedHat
  - Widely used at GWDG (e.g. for Cloud test-bed)
  - Open Source
- VMware product family: vSphere, View, Workstation
  - Widely used at GWDG (e.g. for VM hosting)
  - Commercial

How does Platform Virtualisation works?
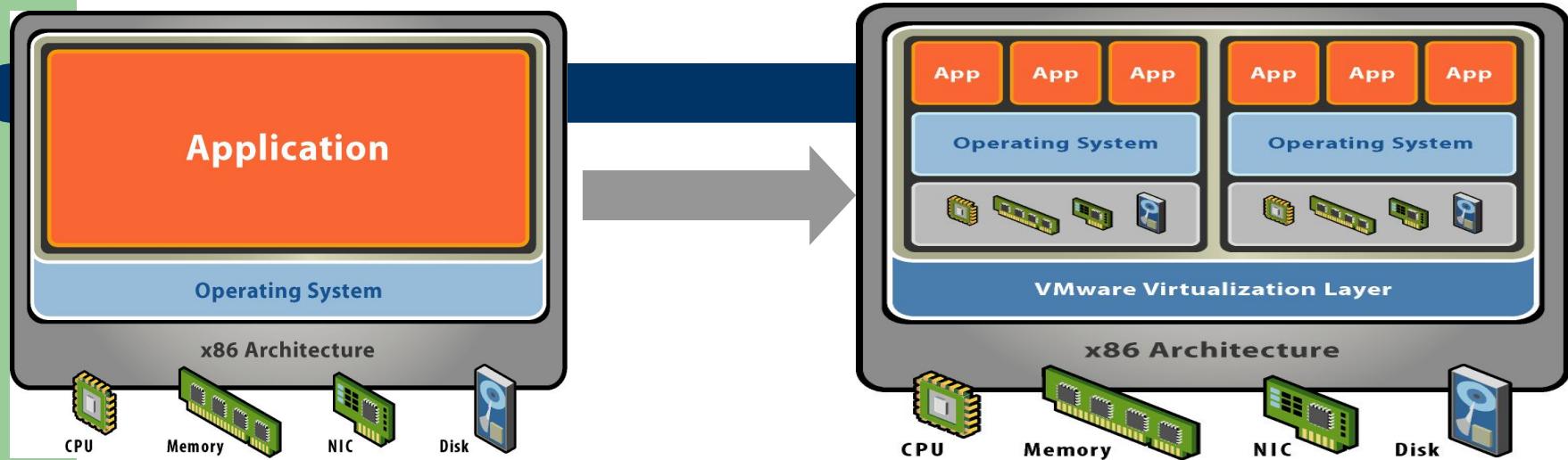
VMware

What is Virtualization?

Without Virtualizatio

With Virtualization
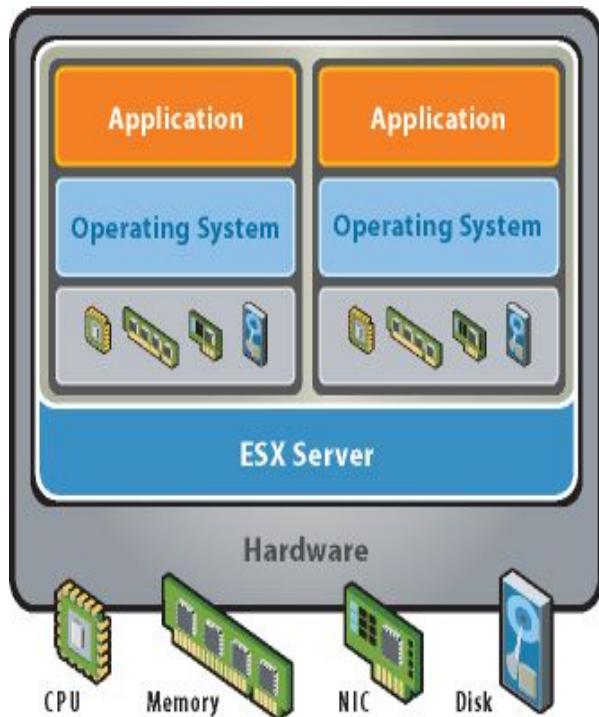
VMware provides hardware virtualization that presents a complete x86 platform to the virtual machine

Allows multiple applications to run in isolation within virtual machines
on the same physical machine

Virtualization provides direct access to the hardware resources to give you much greater performance than software emulation
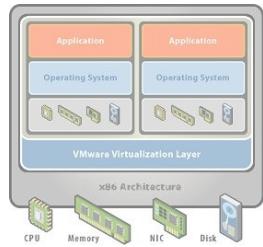
Key Properties of Virtual Machines

Partitioning

- Run multiple operating systems on one physical machine

- Divide system resources between virtual machines

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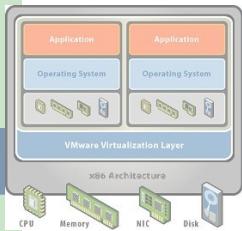
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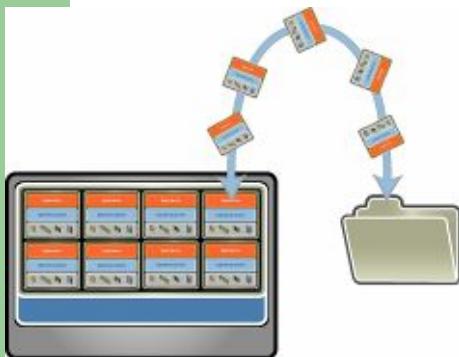
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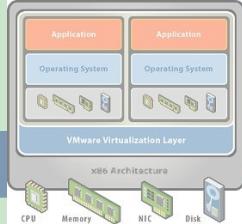
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  - Entire state of the virtual machine can be saved to files
  - Move and copy virtual machines as easily as moving and copying files

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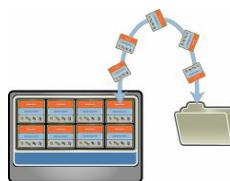
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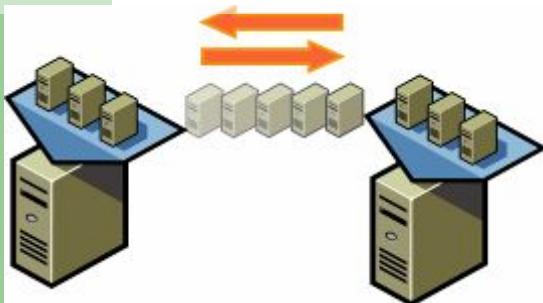
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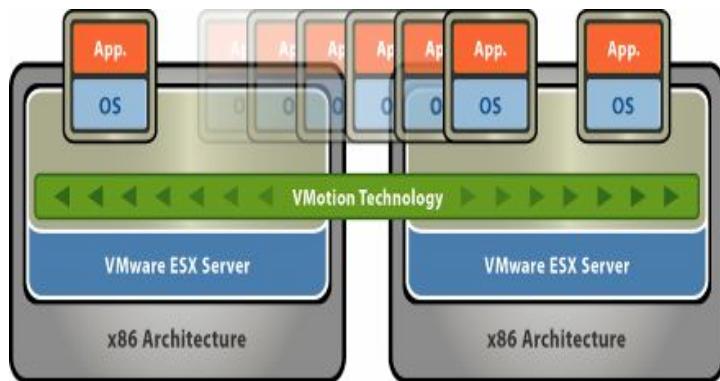
- **Hardware-Independence**
  - Provision or migrate any virtual machine to any similar or different physical server
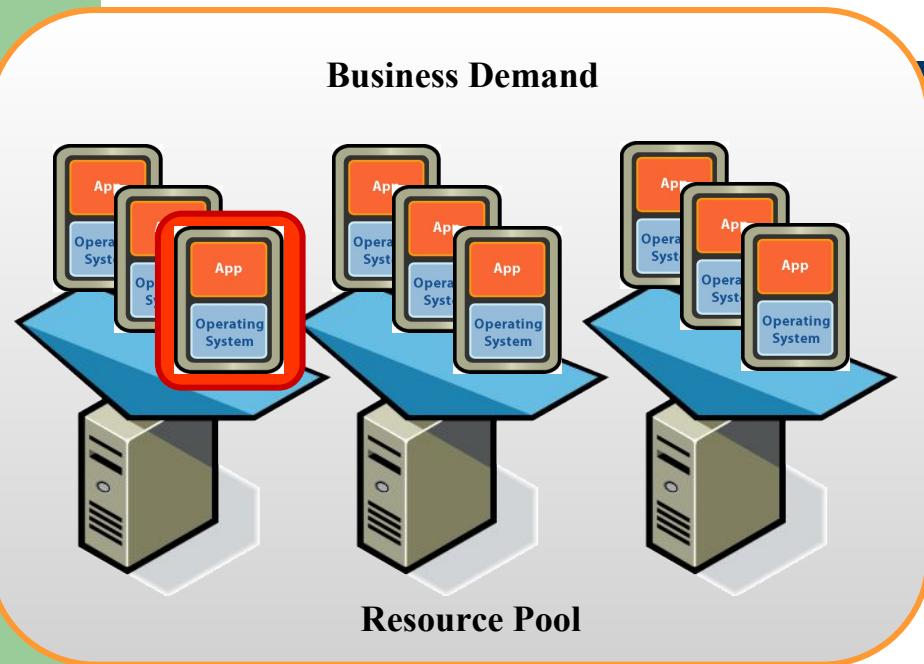
VMware VMotion

- Live migration of virtual machines
- Zero downtime

VMware DRS

Business Demand

Resource Pool
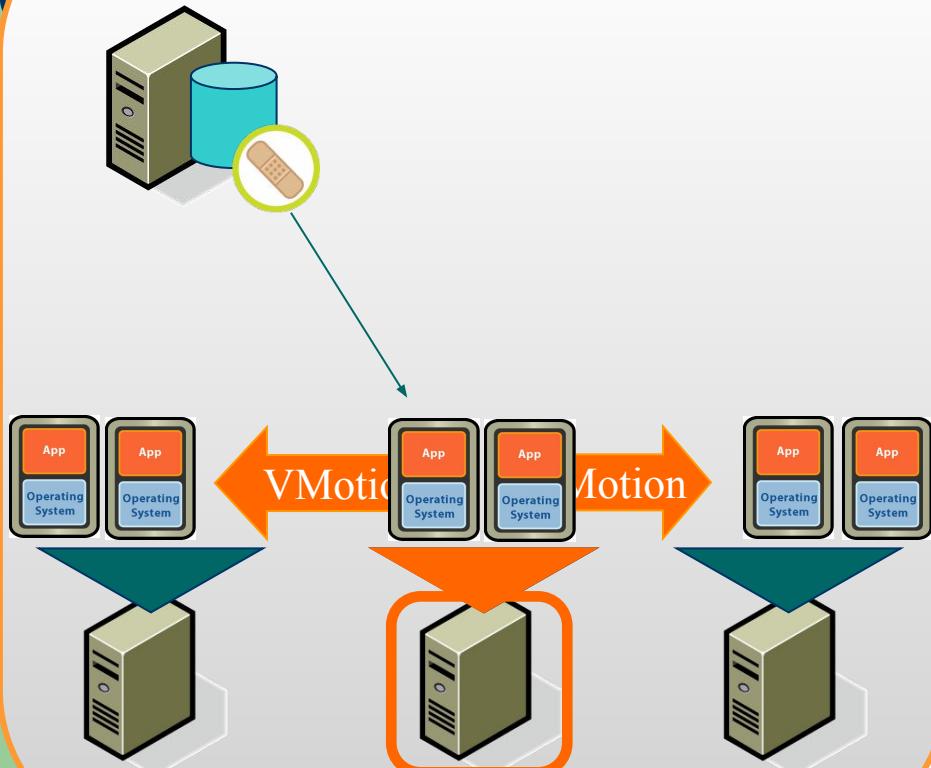
- Dynamic and intelligent allocation of hardware resources
- Ensure optimal alignment between business and IT

# Non-disruptive ESX Server Patching with Update Manager and DRS

Update Manager

App | App | App | App | App | App

Operating System (×6)

VMotion ◄►   VMotion ►
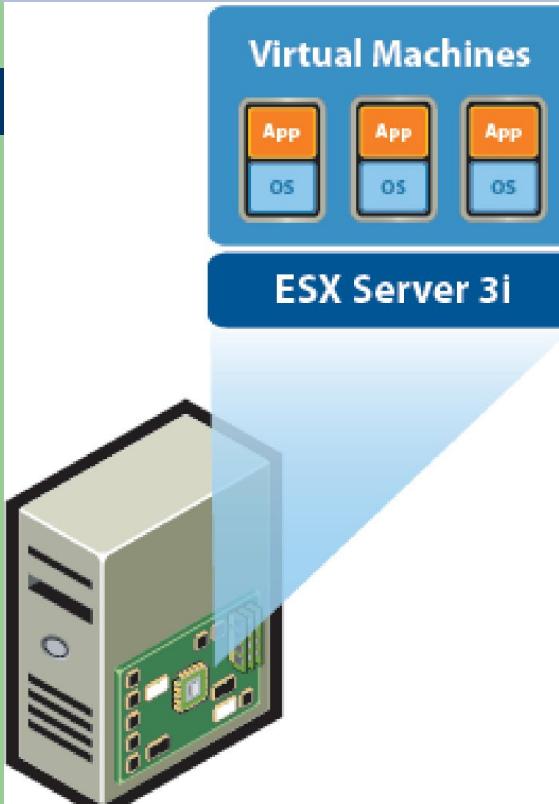
– Update Manager patches entire DRS clusters

- Each host in the cluster enters DRS maintenance mode, one at a time
- VMs are migrated off, host is patched & rebooted if required
- VMs are migrated back on
- Next host is selected

ESX Server 3i

Virtual Machines

App | App | App
OS | OS | OS

ESX Server 3i
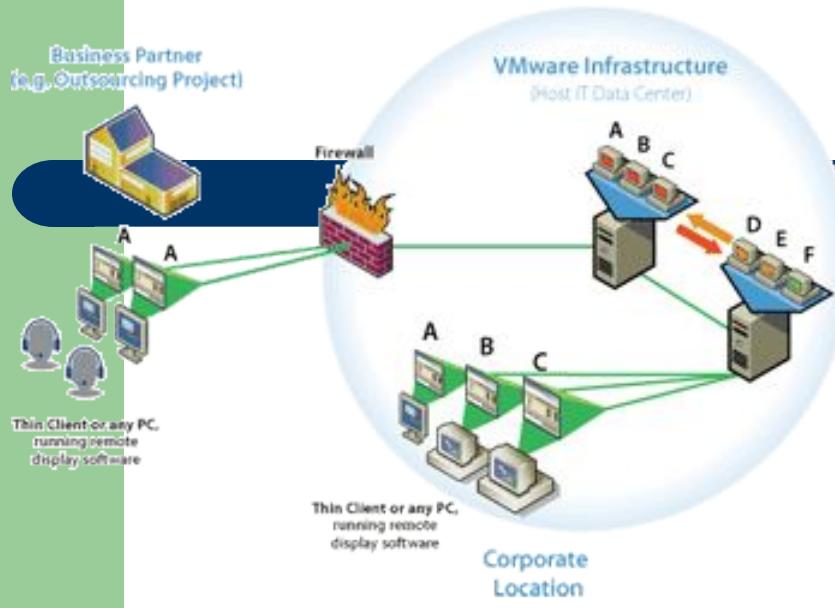
Physical Server

- Integrated in server systems
  - Easiest way to deploy and manage virtualization
    - Hardware is certified and ready-to-run
    - Intuitive start up experience that dramatically reduces deployment time
    - Optimized for remote management

- Thin architecture
  - Unparalleled security and reliability
    - Compact 32MB footprint
    - Only OS-independent design focused on virtualization

Virtual Desktops
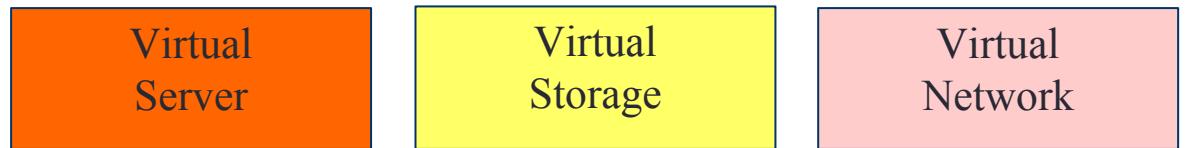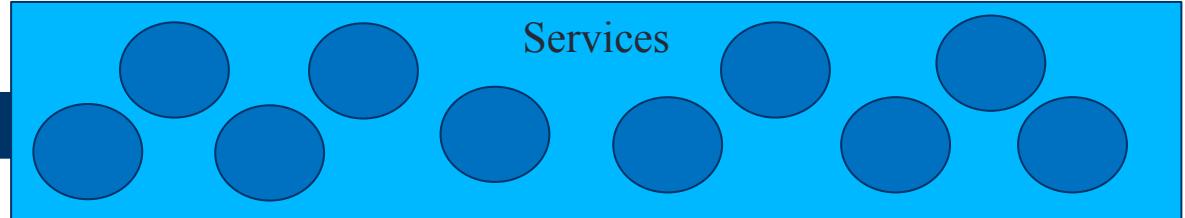
Benefits

- Central Management, Security, Compliance
- Business Continuity
- Standard PC management model and isolation

- Eliminated need to buy PCs
- Reduced time to add a new PC image to <10 min
- Administer all desktops worldwide centrally with VirtualCenter

Data Centers and Virtualization

- Separation of Resources und Applications
- Dynamic resource allocation
- "Resource as a Service"

GWDG:
- Server virtualization since 2007
- Storage virtualization in production

Services		
Virtualization-Management		
Virtual Server	Virtual Storage	Virtual Network
CPUs	Physical Storage	Physical Network