Cloud Computing
CS 15-319

Virtualization- Part I

Lecture 17, March 19, 2012

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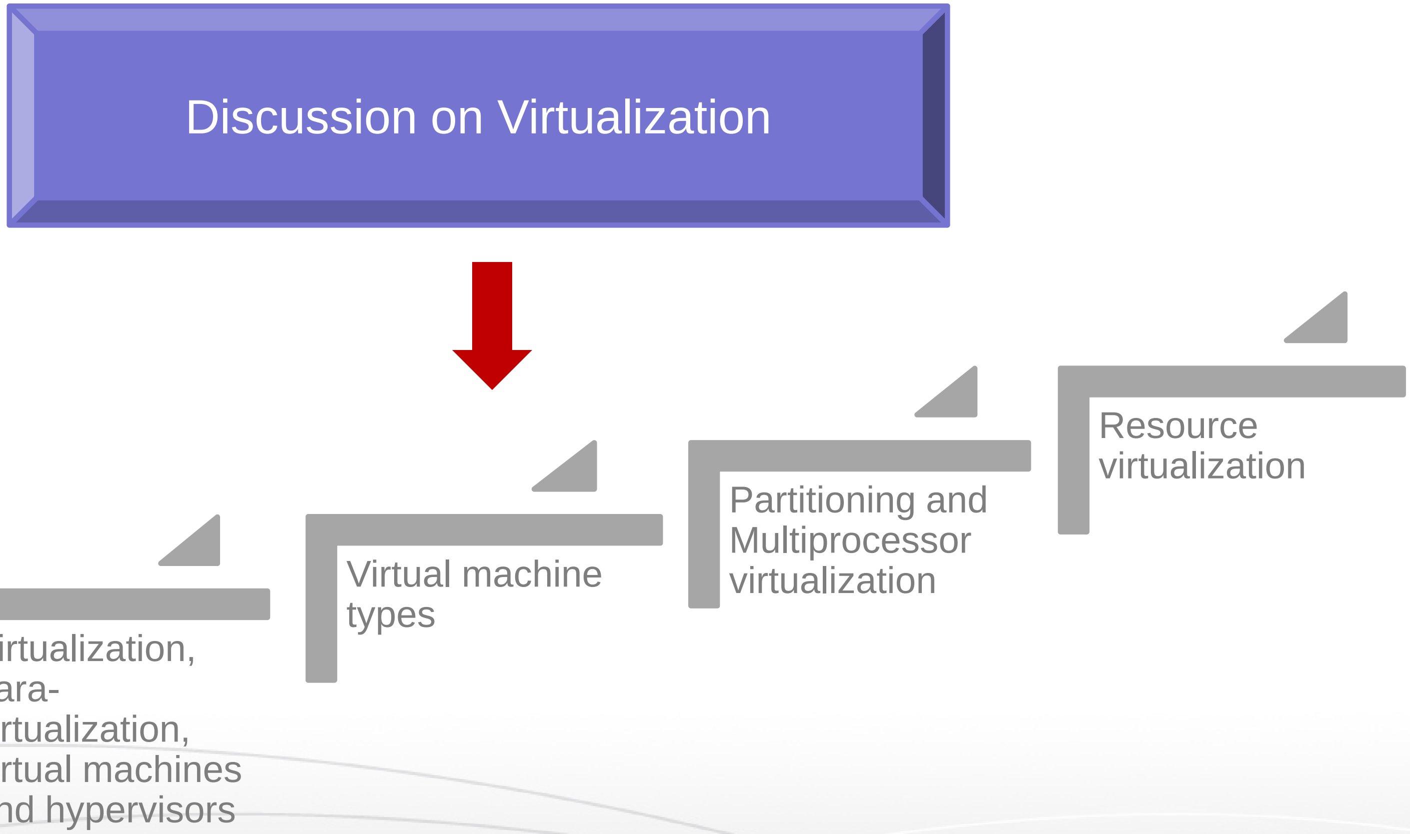
Today…

- Last session and part of this session
  - Apache Pig, Hive, Zookeeper
- The other part of today's session
  - Virtualization – *Part I*
- Announcement:
  - Project update is due on Wednesday March, 21

Objectives



Discussion on Virtualization

Why virtualization, and virtualization properties

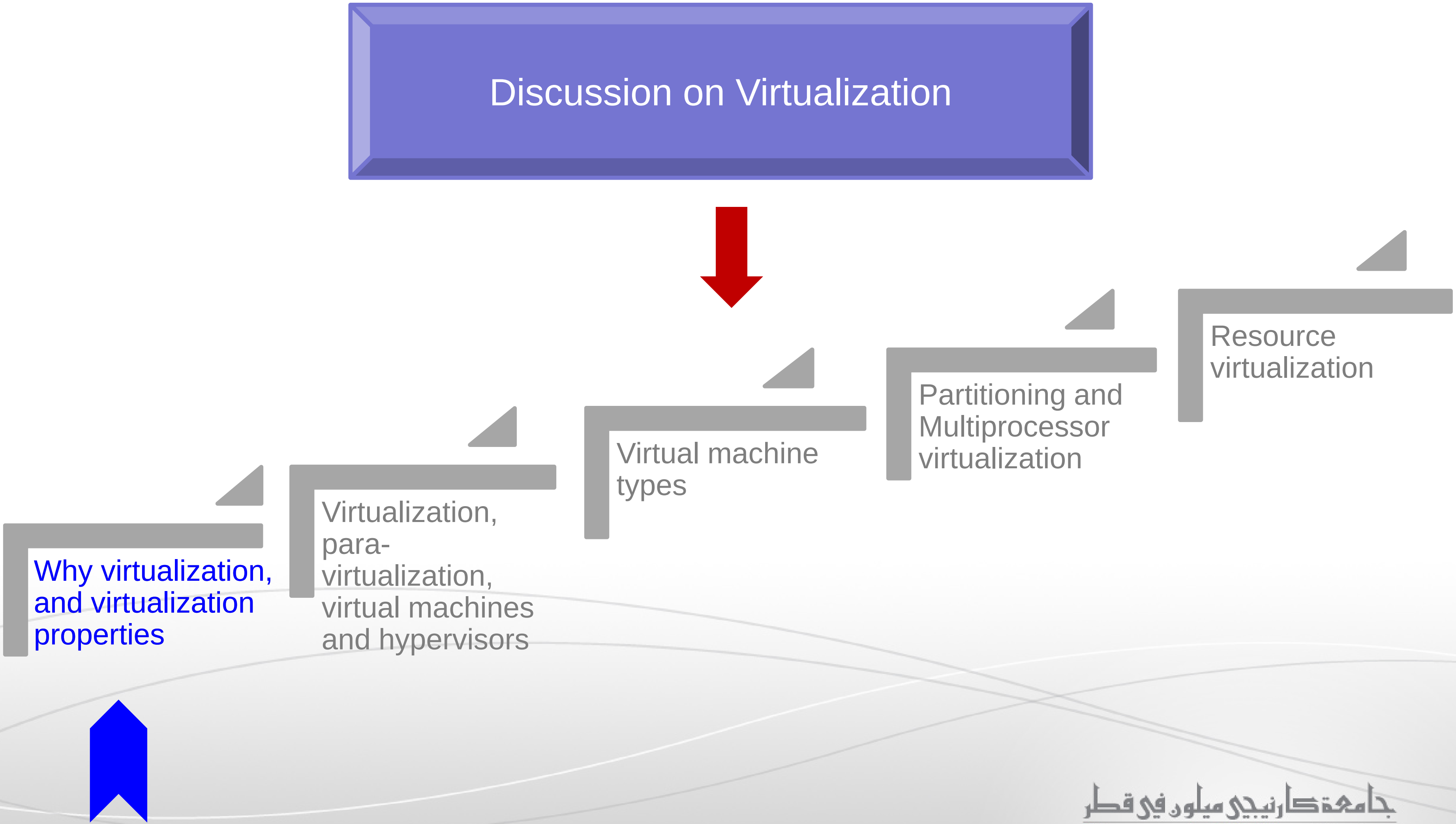
Virtualization, para-virtualization, virtual machines and hypervisors

Virtual machine types

Partitioning and Multiprocessor virtualization

Resource virtualization

Objectives



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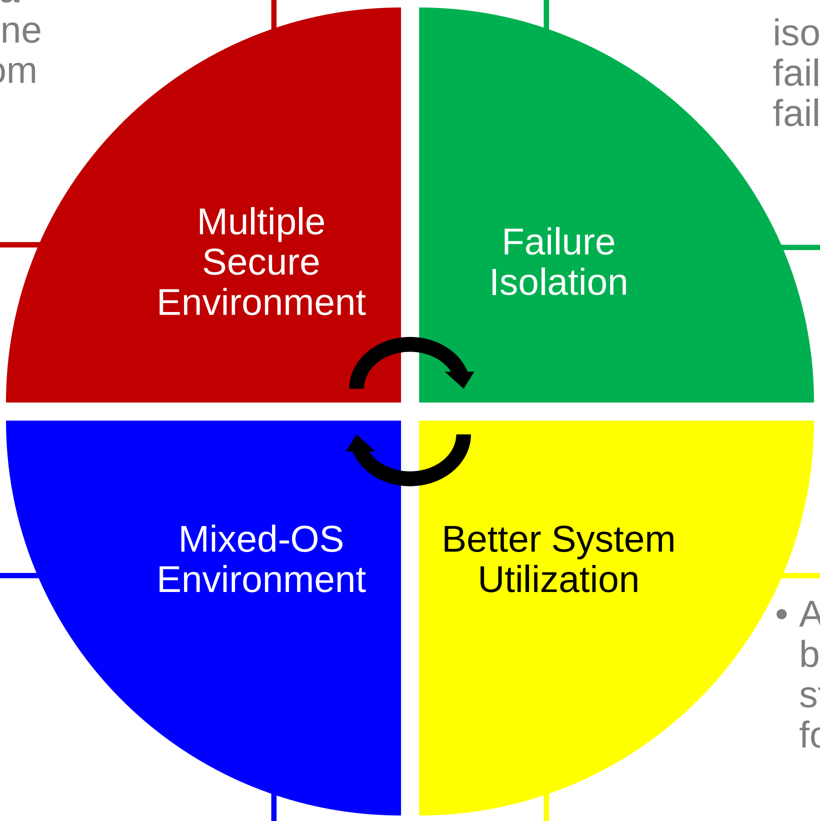
Benefits of Virtualization

- 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

Operating Systems Limtations

- OSs provide a way of virtualizing hardware resources among *processes*
- This may help isolate *processes* from one another
- However, this does not provide a *virtual machine* to a user who may wish to run a different OS
- Having hardware resources managed by a single OS limits the flexibility of the system in terms of available software, security, and failure isolation
- Virtualization typically provides a way of relaxing constraints and increasing flexibility

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

What is Virtualization?

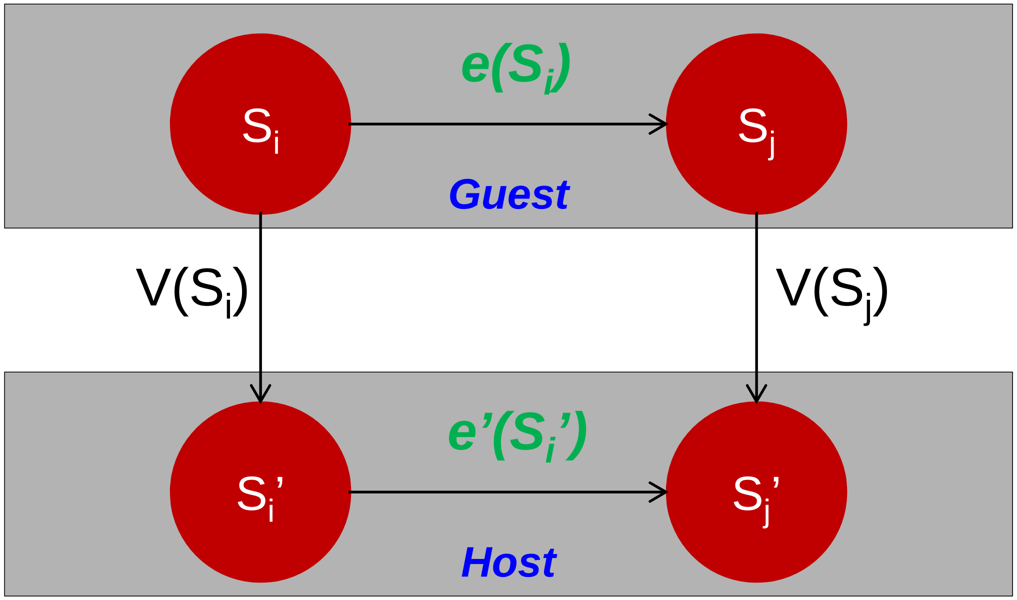
- Informally, a virtualized system (or subsystem) is a *mapping* of its interface, and all resources visible through that interface, to the interface and resources of a real system

- Formally, virtualization involves the construction of an isomorphism that *maps* a virtual *guest* system to a real *host* system (Popek and Goldberg 1974)

✓ Function V maps the guest state to the host state

✓ For a sequence of operations, ***e***, that modifies a guest state, there is a corresponding ***e'*** in the host that performs an equivalent modification

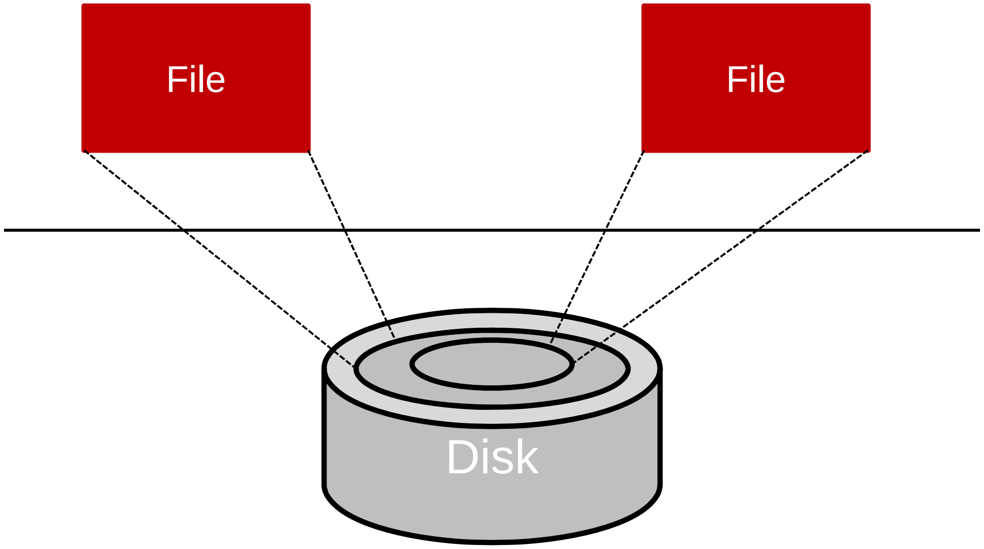
✓ How can this be managed?



Abstraction

- The key to managing complexity in computer systems is their division into *levels of abstraction* separated by *well-defined interfaces*

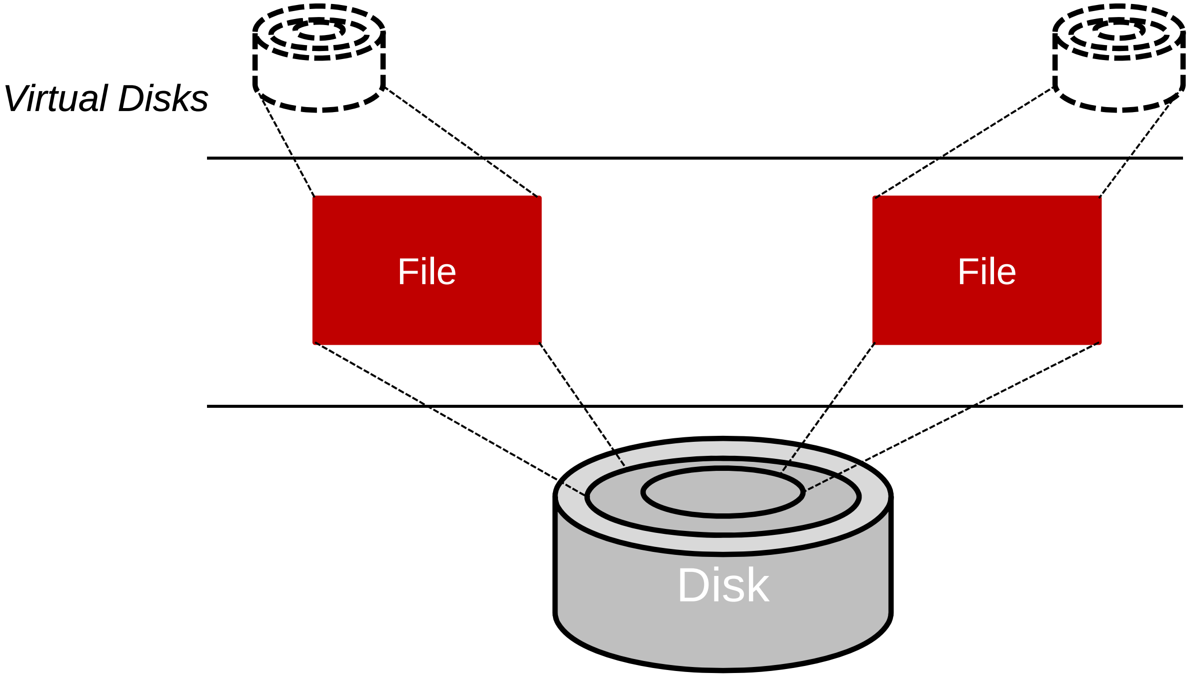
- Levels of abstraction allow implementation details at lower levels of a design to be ignored or simplified



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

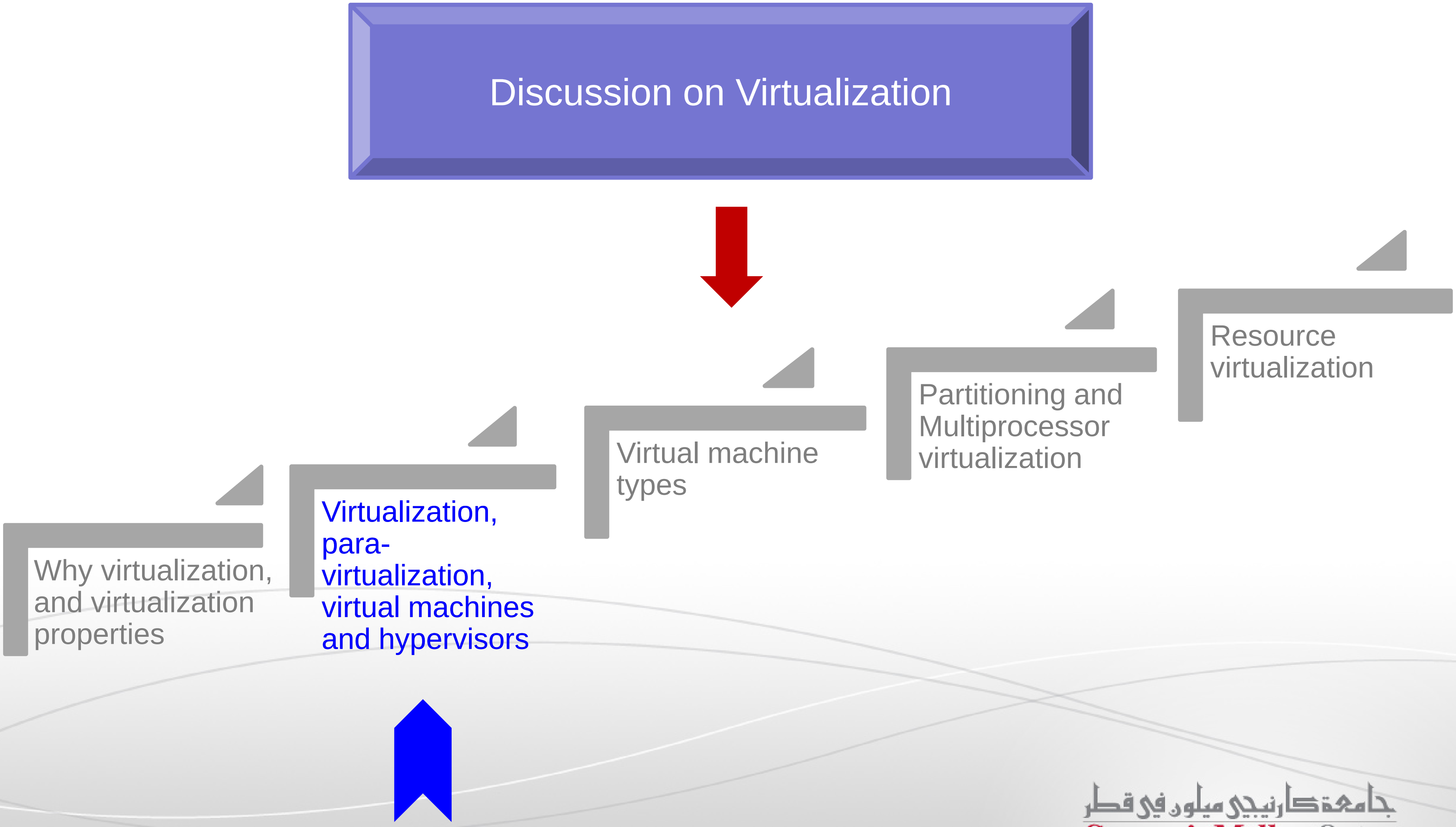
Virtualization and Abstraction

- 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



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

Objectives



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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

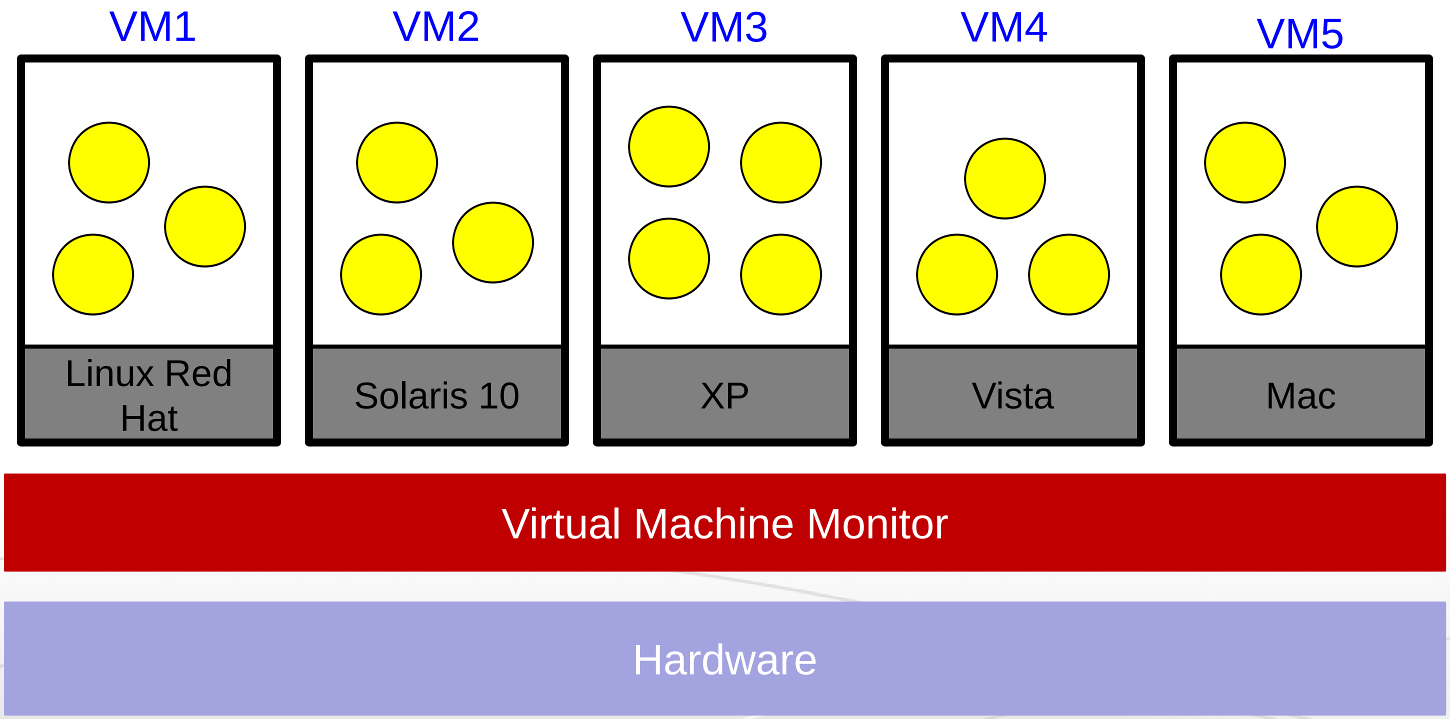
- This layer of software is often referred to as virtual machine monitor (VMM)

- 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



Full Virtualization

- Traditional VMMs provide full-virtualization:
  - The functionally provided is identical to the underlying physical hardware
  - The functionality is exposed to the VMs
  - They allow unmodified guest OSs to execute on the VMs
    - This might result in some performance degradation
  - E.g., *VMWare* provides full virtualization

Para-Virtualization

- Other types of VMMs provide para-virtualization:
  - They provide a virtual hardware abstraction that is *similar, but not identical* to the real hardware
  - They modify the guest OS to cooperate with the VMM
  - They result in lower overhead leading to better performance
  - E.g., *Xen* provides both para-virtualization as well as full-virtualization

Virtualization and Emulation

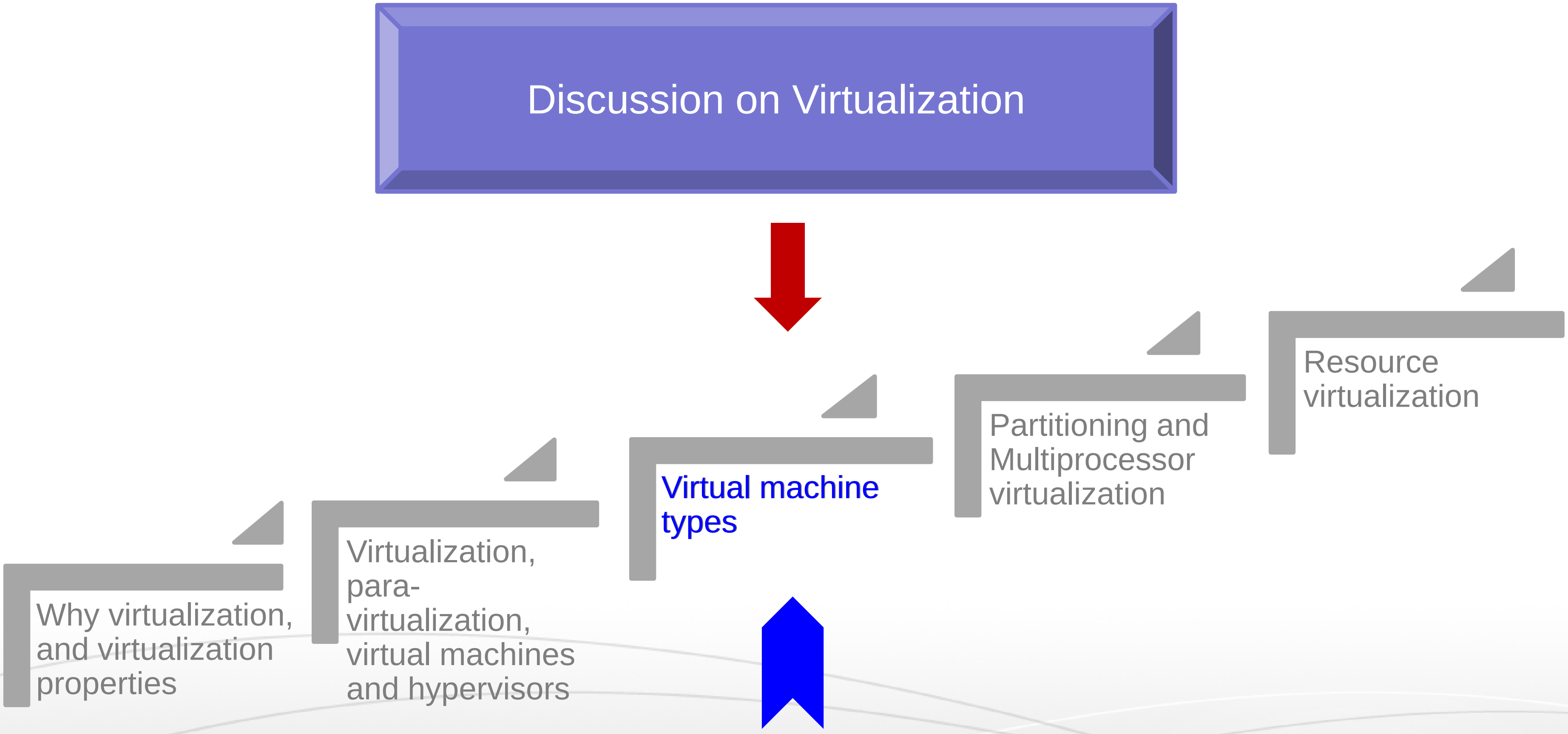
- VMs can employ *emulation techniques* to support cross-platform software compatibility

- Compatibility can be provided either at the system level (e.g., to run a Windows OS on Macintosh) or at the program or process level (e.g., to run Excel on a Sun Solaris/SPARC platform)

- Emulation is the process of implementing the interface and functionality of one system on a system having a different interface and functionality

- It can be argued that virtualization itself is simply a form of emulation

Next Class



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