Lecture 5: Virtualization Basics

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Reading Materials

- VMWare virtualization concepts: https://www.youtube.com/watch?v=EvXn2QiL3gs
- Xen: Art of Virtualization: https://www.cl.cam.ac.uk/research/srg/netos/papers/2003-xensosp.pdf
- RedHat Virtualization: https://www.redhat.com/en/topics/virtualization
- https://kubernetes.io/docs/tutorials/kubernetes-basics/

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Physical Machines/ Virtual Machines/ Containers

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Types of Virtualization

- Hardware emulation
  - Most complex: a hardware VM is created for each instance
- Full Virtualization
  - Uses hypervisor to share underlying hardware across guest VMs
  - Mediates between guest OS and underlying H/W
- Paravirtualization
  - Differs from full virtualization in that integrate ndling code into OS – thus the guest OS code is modified
- Operating system level virtualization
  - Virtualizes server on top of operating systems
  - Single OS that isolates the servers

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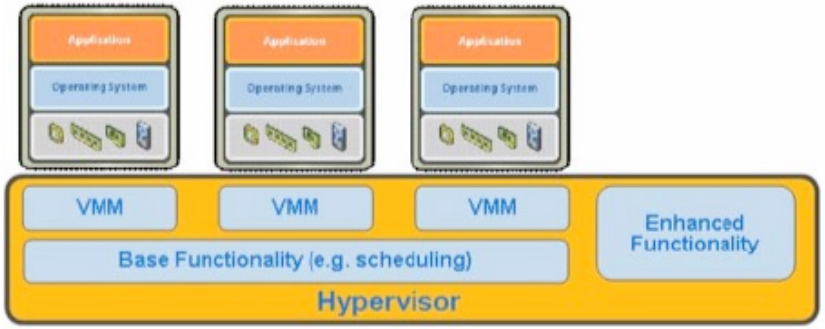
Hypervisor and VMM

- Hypervisor runs on bare metal machine
- Functionality/role of hypervisor is dependent o type of virtualization



Hypervisor manages virtual machine monitors

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- So what is required in supporting virtualization, i.e., running multiple OS inst machine?
  - OS typically has all the
  - Need to somehow not allow all the OS instanc run at ring 0, but still be able to function as OS
- Solution
  - Hypervisor runs at ring 0
  - OS runs at higher layer than ring 0, but lower than user applications
  - OS level instructions that required ring 0 privilege → need to be now run by hypervisor instead!

Three types of virtualization (for CPU)

- Depending on how hypervisor handles the critical instructions from OS (ring 0), there are different virtualization methods
  - Full virtualization using binary translation
  - OS assisted virtualization or Paravirtualization
  - Hardware assisted virtualization

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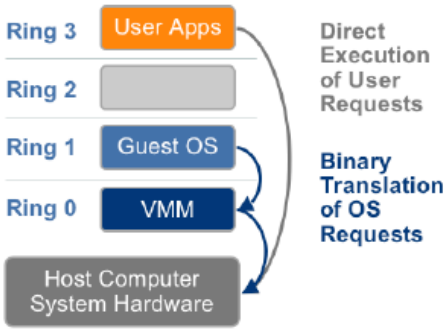

Figure 5 – The binary translation approach to x86 virtualization

Full Virtualization Para Virtualization H/W Assisted Virtualization

Memory Virtualization

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- Memory virtualization requires further vir OS level virtual memory
  - Another level of MMU virtualization that maps multiple MMU into physical memory

Device and I/O Virtualization

- Requires managing the routing of I/O requests between virtual devices and shared physical hardware
- Example: Virtual Network Interface and switches
- Virtual devices emulate the physical devices

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Comparison of Three Virtualization Methods

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Iterative Memory Copy for Live Migration

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Deconstructing Amazon EC2 request machine API

- User goes to Amazon EC2 portal and specifies desired parameters for a machine
  - Resource: CPU, mem, disk
  - Stack: OS and possibly with additional software
- Amazon AWS Cloud manager (resource pool manager) provisions the user request
  - Finds appropriate physical resource
  - Dispatches the request to virtualization manager on the identified resource
  - Cloud Manager invokes EC2 API to provisions the request
- Virtualization manager on physical server
  - Copies the pre-built software stack (virtual appliance)
  - Provisions a guest VM and configures parameters (IP address, access rules,…) at run/boot time
- Cloud manager returns login credentials to user

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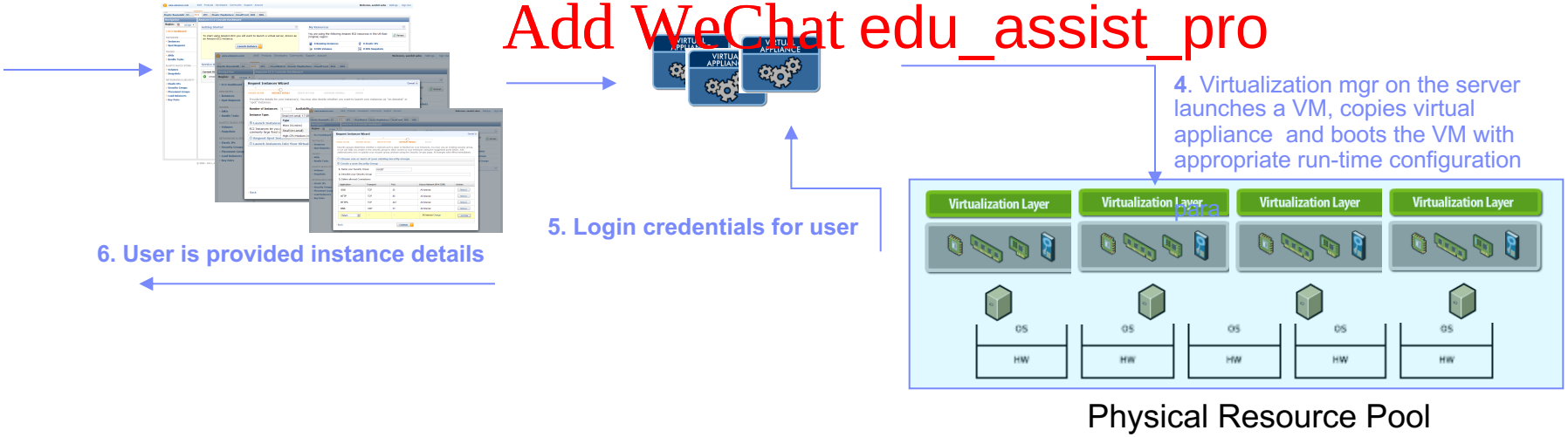

Key building blocks

- Cloud manager
- Virtual machine
- Virtual appliance
- Configuring virtual appliance at run to meet the configuration parameters

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Another important application of Virtualization

- Note that virtual machines are created on demand by issuing requests to hypervisor
- Virtual machines can be moved from one physical server to another in real time!
- VMWare vMotion management software lets one move running virtual machines in real time from one server to
  - Opens up lot of interesting
  - Zero down-time maintenan upgrades
  - Dynamic workload balancing

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Moving all VMs from server A to server B

Deconstructing Amazon EC2 request machine API

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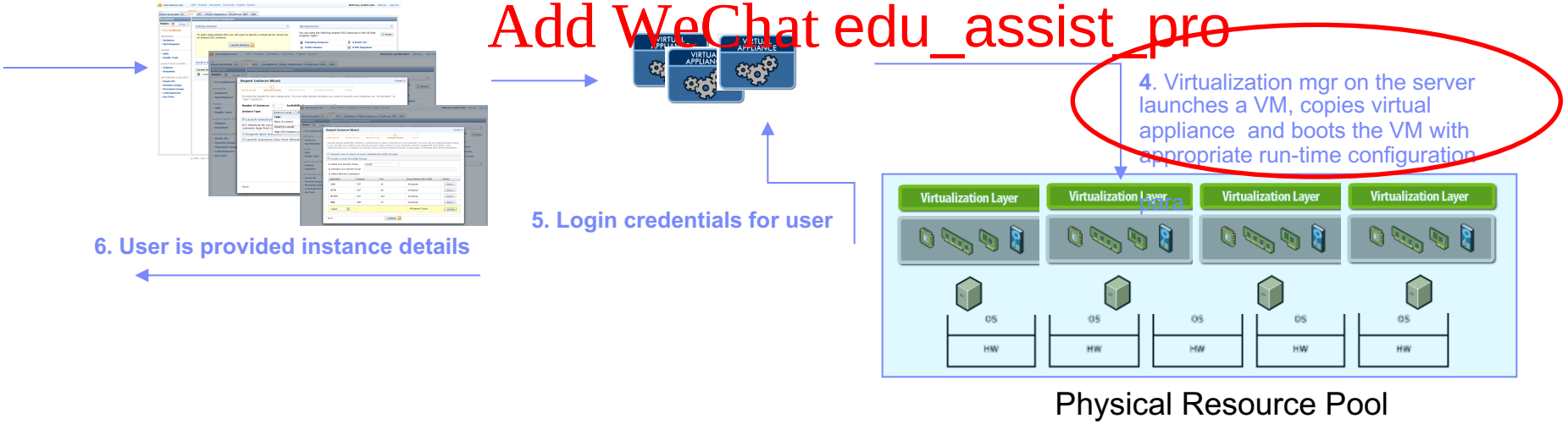
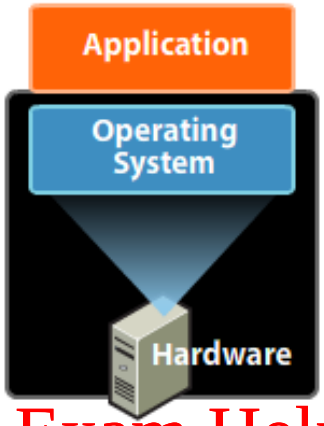
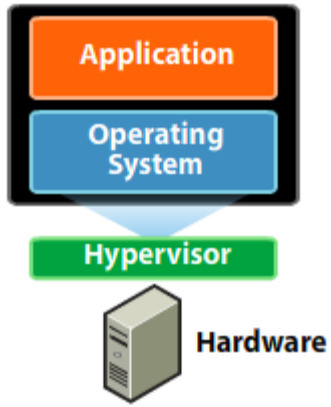


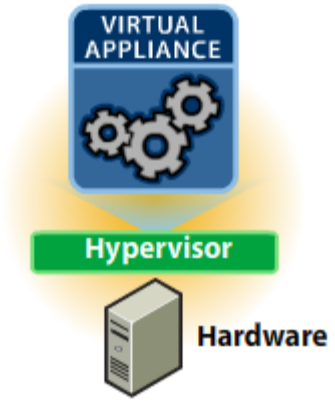
Virtual Appliance

- How was Amazon EC2 able to start a (virtual) server with a software stack such as Operating System (win203, SUSE linux 32-bit, LAMP stack etc.) almost instantly?
  - User is able to choose from a list of available pre-built stack
- Virtual Appliance
  - A virtual machine image file consisting of pre-built/installed software bundled with operating system
  - Built in a such a manne machine boots from thi stack
  - Install once and replicate many times
- Benefit
  - No need to install the software as long as same virtual machine technology used
  - Removes the need for time consuming installation and configuration of software





allows the application and the operating system



to be packaged as a self contained, ready to run virtual appliance

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VMWare Virtual Appliance Demo

- http://download3.vmware.com/media/vam/vam_demo.html

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VMWare Virtual Appliance Marketplace

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Reference Materials

- ESXi: http://www.vmware.com/products/vsphere-hypervisor/
- vSphere: Mastering VMWare vSphere 5.5 – Scott Lowe
- vCloud: http://www.vmware.com/products/vcloud-suite

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Monolith vs Micro-Services

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Dockers and Containers

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- More light weight and runs as user space processes
- Containers provide the separation