Learning Objectives

What can we do to a VM?

- To understand the VM-handling mechanisms of a hypervisor
- To understand how many different value-added services are constructed on top of VM-handling mechanisms
Starting a VM

Hypervisor:
- gains control (e.g. clock tick)
- saves previous VM’s CPU registers
- loads next VM’s CPU registers
- jumps to next VM’s next-PC (in correct privilege state)

Stopping a VM

- Save CPU registers into Hypervisor data area
- Hypervisor stops and starts VM all the time:
  - to share CPUs
  - to serialize access to resources
**VM State While Stopped**

VM State:
- Memory (all guest physical memory)
  - Includes: Application state, OS state
- CPU state (registers)
- Small amount of I/O state
  - Let’s stop VM when I/O is quiescent!

“Freeze” a VM

- Once suspended, the VM image is self-contained
  - VM can be (e.g.) copied to a file
  - (LARGE file!)

What else can we do with this?
Move a VM

- Freeze
- Copy
- Restart

Virtualized

Virtualized

Snapshot and Rollback a VM

Virtualized

Why?
Can this process be optimized?
Archive a VM

Rapid Provisioning
Virtual Appliances

- http://www.vmware.com/appliances/directory/
- 1000+ downloadable appliances
- e.g., mail server, web server, hotel system, firewall, virus scanner, etc...

Deploying Secure Desktops

- Increased security and flexibility
  - Better isolation between users
  - Users can have “admin” privileges within their Guest OS

Is this common? Where?
**Live Migration**

Optimizing live migration from source to destination VMM:

- Copy every page from source to destination machine
  - reset dirty bit in VMM's page table for every page copied
- Repeat:
  - Find next non-dirty page in source machine
  - Copy to destination machine and reset dirty bit
- Until only minimal subset of pages left
- Suspend VM on source
- Copy remaining pages to destination
- Resume VM on destination

**Load Balancing**

- Management software monitors load on all physical machines
- If loads are mismatched, migrate a VM from a loaded to a less-loaded machine
- Independent of Application!
- Independent of Operating System!
High Availability

- For critical applications, keep a standby VM available on a different hardware system
- Regularly copy active VM image to standby VM (but don’t activate it)
- Activate standby VM if active VM stops responding (VM crashes? VMM crashes? Hardware system fails?)

- Independent of Application!
- Independent of Operating System!

Goals of System Virtualization

- Multiple OS running on the same hardware
- Pre-configured virtual machines
- Load balancing
- High availability