E6998 - Virtual Machines
Review Session

Scott Devine

VMware, Inc.

Priniciples of Virtualization

- **Isolation**
- **Encapsulation**
- **Interposition**

System Virtualization Techniques

- **Architectures**
  - I/O Virtualization
- **CPU Virtualization**
  - Trap and Emulate
  - Binary Translation
  - x86 Hardware Assist
- **Memory Virtualization**
  - Software TLB
  - Page Table Shadowing
  - Nested Page Tables

Technique Evaluation

- **Performance**
  - CPU Overheads
  - Memory Footprint
- **Fidelity**
  - How faithful is the emulation
  - Under what conditions does the technique fail
- **Capabilities**
  - Isolation
  - Encapsulation
  - Interposition

Architectures

- **Examples**
  - Traditional
  - Hosted
  - ESX
  - Xen
  - KVM
- **Factors**
  - I/O Virtualization
  - Device Drivers
  - Installation
  - Application compatibility

CPU Virtualization

- **Techniques**
  - Trap and Emulate
  - Binary Translation
  - x86 Hardware Assist
- **Factors**
  - Capabilities of Hardware
  - Trap Cost / Avoidance
  - Hiding the Monitor

Memory Virtualization

- **Virtualization Techniques**
  - Emulated TLB
  - Shadow Page Tables
  - Nested Page Tables
- **Other factors**
  - Memory Tracing
  - Hiding the Monitor
- **Memory Interposition**
  - Copy-on-write
  - Page Sharing
  - Overshadow