Virtual Machines & Security

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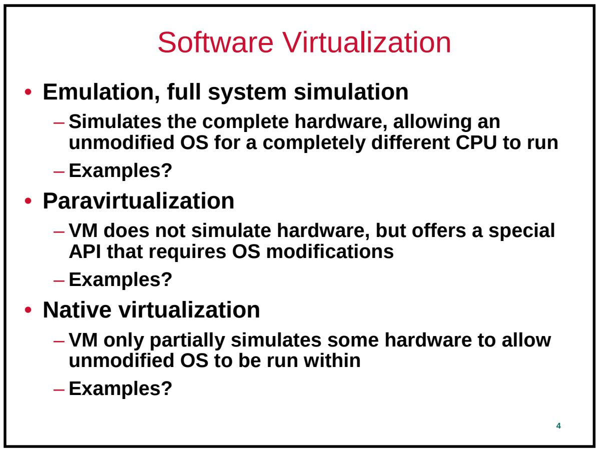
Virtual Machines

- **VM: Execution environment that gives the illusion of a real machine**
- **VMM/Hypervisor: host software which provides this capability**
- **Pioneered by IBM CP-40 (1967)**

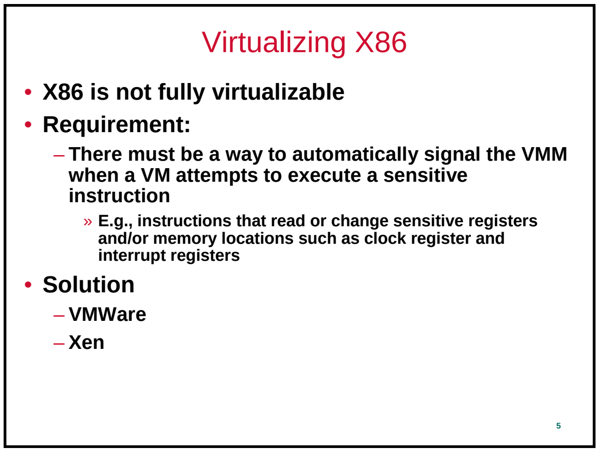
Why do People Build Virtual Machines?

- **Concurrent execution of different OS**
  - **Share machine**
- **Configure a different environment than the actual machine**
- **Run legacy OS/applications**
- **Isolation**
- **Easy migration**
- **Fast booting**
- **Facilitate debugging**



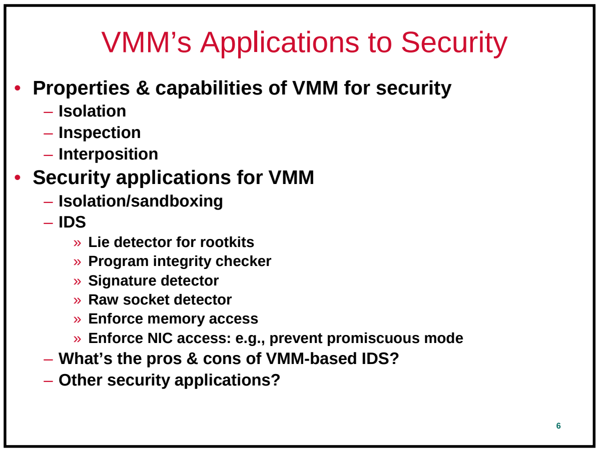
Software Virtualization

- Emulation, full system simulation
  - Simulates the complete hardware, allowing an unmodified OS for a completely different CPU to run
  - Examples?
- Paravirtualization
  - VM does not simulate hardware, but offers a special API that requires OS modifications
  - Examples?
- Native virtualization
  - VM only partially simulates some hardware to allow unmodified OS to be run within
  - Examples?



Virtualizing X86

- X86 is not fully virtualizable
- Requirement:
  - There must be a way to automatically signal the VMM when a VM attempts to execute a sensitive instruction
    - » E.g., instructions that read or change sensitive registers and/or memory locations such as clock register and interrupt registers
- Solution
  - VMWare
  - Xen



VMM’s Applications to Security

- Properties & capabilities of VMM for security
  - Isolation
  - Inspection
  - Interposition
- Security applications for VMM
  - Isolation/sandboxing
  - IDS
    - » Lie detector for rootkits
    - » Program integrity checker
    - » Signature detector
    - » Raw socket detector
    - » Enforce memory access
    - » Enforce NIC access: e.g., prevent promiscuous mode
  - What’s the pros & cons of VMM-based IDS?
  - Other security applications?

Terra: VMM on Tamper-Resistant Hardware

- **Trusted VMM**
  - **Combining security properties of VMM & tamper-resistant hardware**
- **Additional capabilities provided**
  - **Attestation**
  - **Root secure**
  - **Trusted path**

Attestation

- **Attestation**
  - **Attesting to a remote entity what software was loaded**
- **Why do we want attestation? What type of security problems does attestation address?**
- **Attestation chain**
  - **Firmware -> Bootloader -> VMM -> VM, application**
  - **Why is attestation chain necessary?**
- **Hardware assumptions & requirements**
  - **Secret public/private key in secure storage**
  - **Hash & sign what'll be loaded**
- **Properties achieved by attestation**
  - **What software was loaded (load-time attestation)**
  - **What software was run (run-time attestation)**
- **Challenges for attestation**
  - **Can only attest static part**
  - **No future gurantee (still need to solve the other problems)**

Root Secure

- **“Even the platform administrator cannot break the basic privacy & isolation”**
- **How to achieve it?**
- **Assumptions**
  - **Hardware assumptions?**
  - **Software assumptions?**

Trusted Path

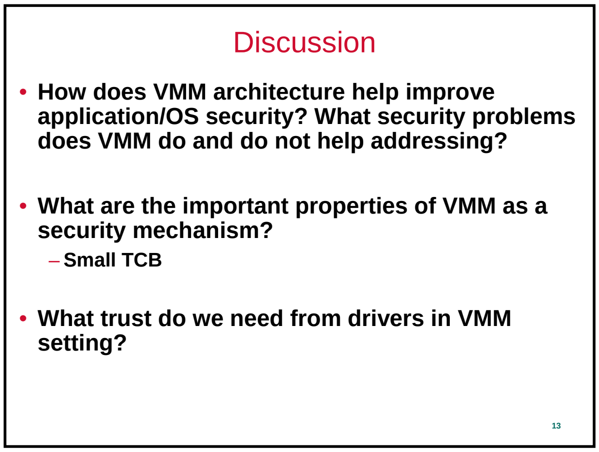
- A trusted path from the user to the application
  - Allows a user to establish which VM he’s interacting with
  - Allows a VM to ensure it is communicating with a human user
  - Ensures the privacy & integrity of communications btw users & VMs
- How to achieve it?
  - Virtual KVM in NetTop architecture
  - Compartmented mode workstation systems
- Hardware & software assumptions?
  - Device drivers?

Comparison with Secure Co-processor

- IBM 4758
  - Tamper-resistant PCMCIA card
  - CPU, memory, crypto accelerator
  - All sensitive computation happens in co-processor
  - Use host as sealed storage
  - Applications in privacy-preserving databases, etc.
- How do you compare the two different approaches?
  - Enabled applications?
  - Security guarantees?

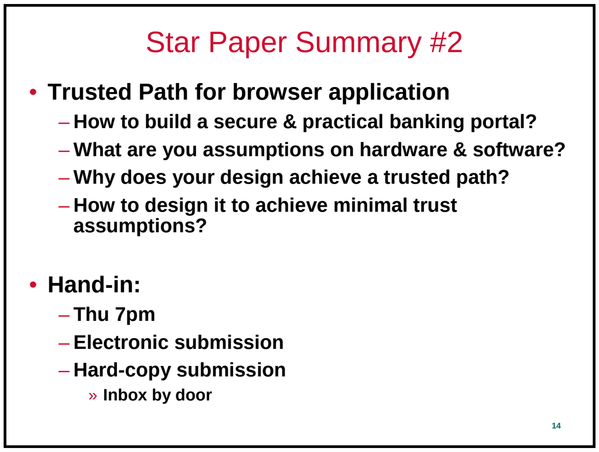
How do You Break a VMM?

- VMM has vulnerability too
  - Buffer overflows in VMWare & Xen
- From below
  - DMA, etc.



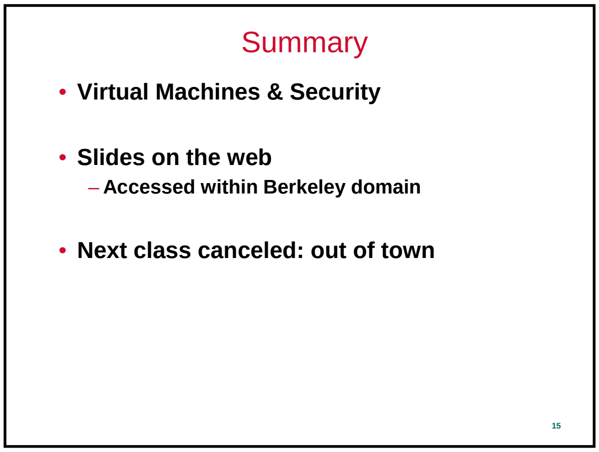
Discussion

- How does VMM architecture help improve application/OS security? What security problems does VMM do and do not help addressing?
- What are the important properties of VMM as a security mechanism?
  - Small TCB
- What trust do we need from drivers in VMM setting?



Star Paper Summary #2

- Trusted Path for browser application
  - How to build a secure & practical banking portal?
  - What are you assumptions on hardware & software?
  - Why does your design achieve a trusted path?
  - How to design it to achieve minimal trust assumptions?
- Hand-in:
  - Thu 7pm
  - Electronic submission
  - Hard-copy submission
    - » Inbox by door



Summary

- Virtual Machines & Security
- Slides on the web
  - Accessed within Berkeley domain
- Next class canceled: out of town