Virtual Machine Security

CSE497b - Spring 2007

Introduction Computer and Network Security

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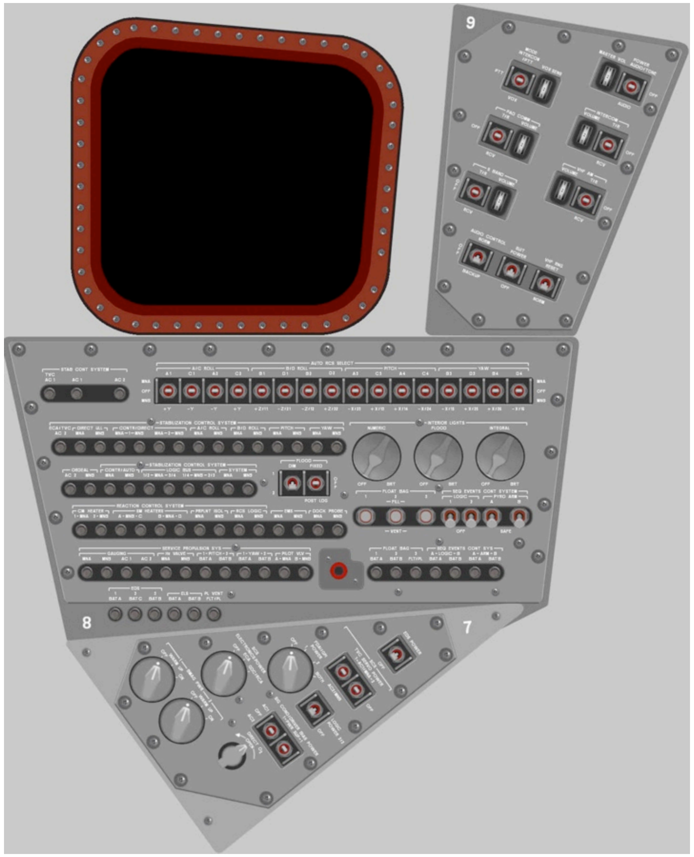
Operating System Quandary

- Q: What is the primary goal of system security?
  - OS enables multiple users/programs to share resources on a physical device
- Q: What happens when we try to enforce Mandatory Access Control policies on UNIX systems
  - Think SELinux policies
- What can we to do to simplify?

Virtual Machines

- Instead of using system software to enable sharing, use system software to enable ***isolation***
- Virtualization
  - “a technique for hiding the physical characteristics of computing resources from the way in which others systems, applications, and end users interact with those resources”
- Virtual Machines
  - Single physical resource can appear as multiple logical resources



Virtual Machine Architectures

- ***Full system simulation***
  - CPU can be simulated
- ***Paravirtualization (Xen)***
  - VM has a special API
  - Requires OS changes
- ***Native virtualization (VMWare)***
  - Simulate enough HW to run OS
  - OS is for same CPU
- ***Application virtualization (JVM)***
  - Application API

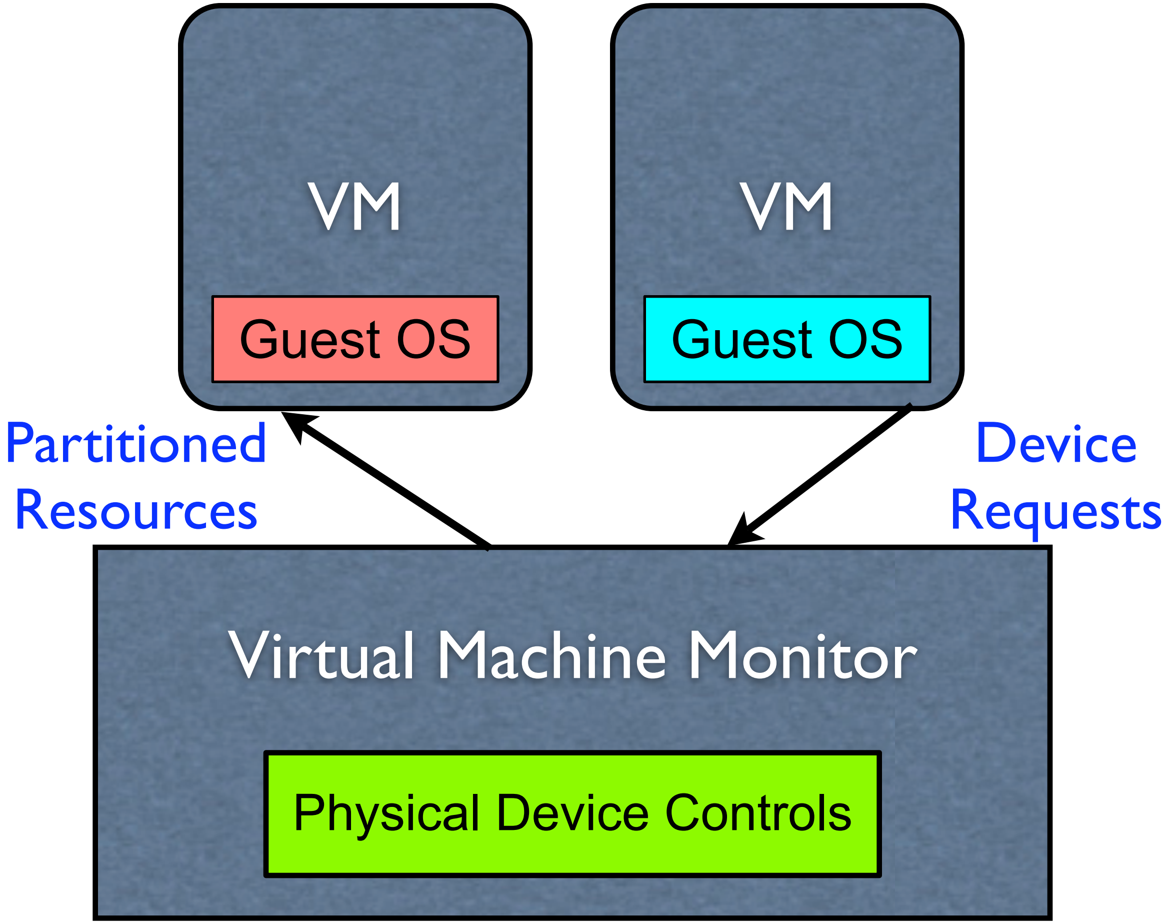
Virtual Machine Types

- ***Type I***
  - Lowest layer of software is VMM
  - E.g., Xen, VAX VMM, etc.
- ***Type II***
  - Runs on a host operating system
  - E.g., VMWare, JVM, etc.

- Q: What are the trust model issues with Type II compared to Type I?

VM Security

- Isolation of VM computing
- Like a separate machine



Ensure Protection of VMM

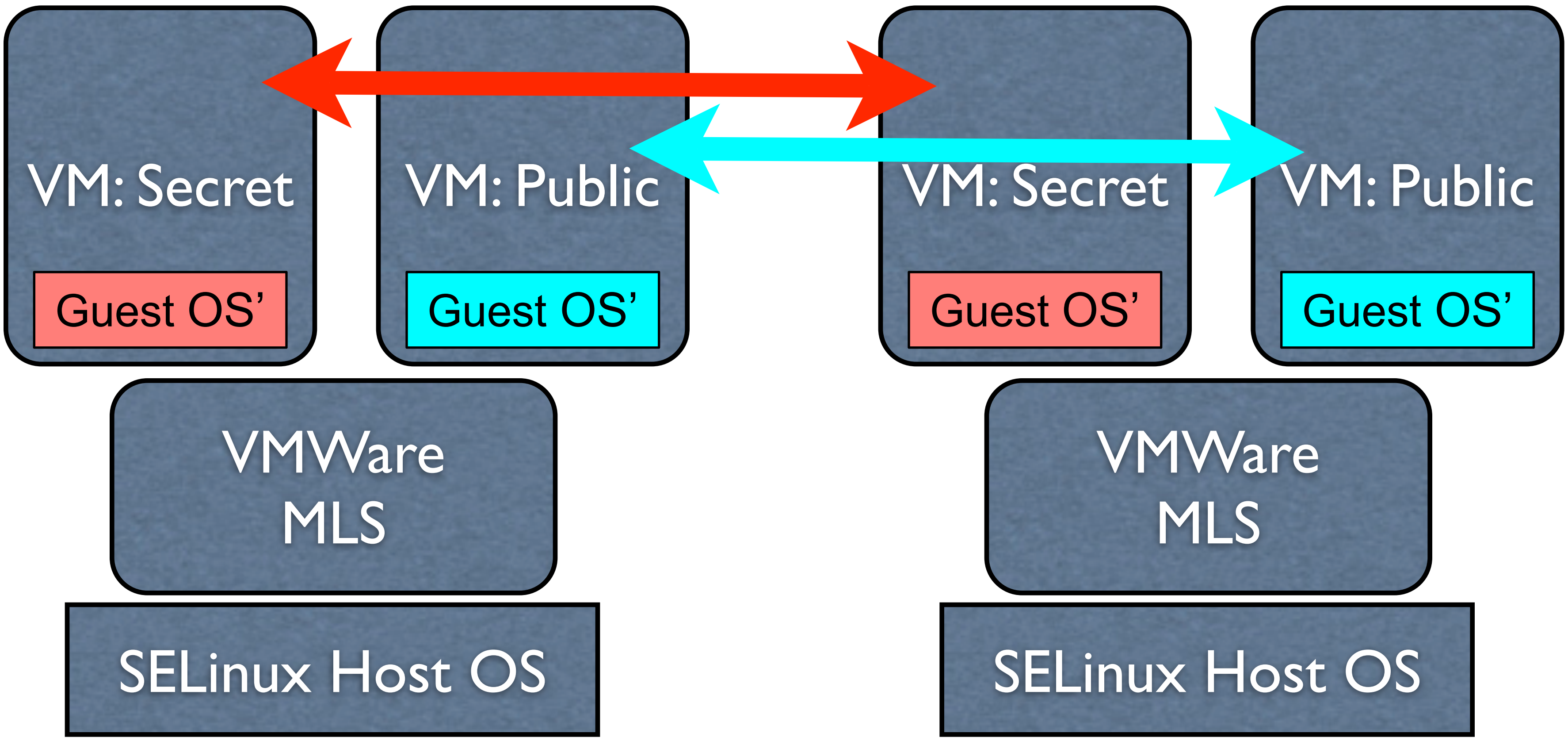
- Processor Instructions
  - Each processor supports an instruction set
  - Some can only be run privileged mode
    - i.e., a more privileged ring (ring 0)
- *Privileged versus Sensitive* Instructions
  - Privileged: only run in ring 0
  - Sensitive: read or write privileged state
  - All *sensitive* instructions must be *privileged*
- Examples
  - Page Table Entries: memory accesses
  - Code Segment Selector read: this register indicates level

A Proper VMM

- Virtualization Requirements
  - Protect sensitive state
    - Sensitive instructions must be virtualized (i.e., require privilege)
    - Access to sensitive data must be virtualized (ditto)
  - Need to hide virtualization
    - Systems cannot see that they are being virtualized
  - I/O Processing
    - Need to share access to devices correctly
    - Special driver interface
  - Self-virtualization: Run VMM as VM
    - Can’t do this on traditional x86, but now we have VT architecture

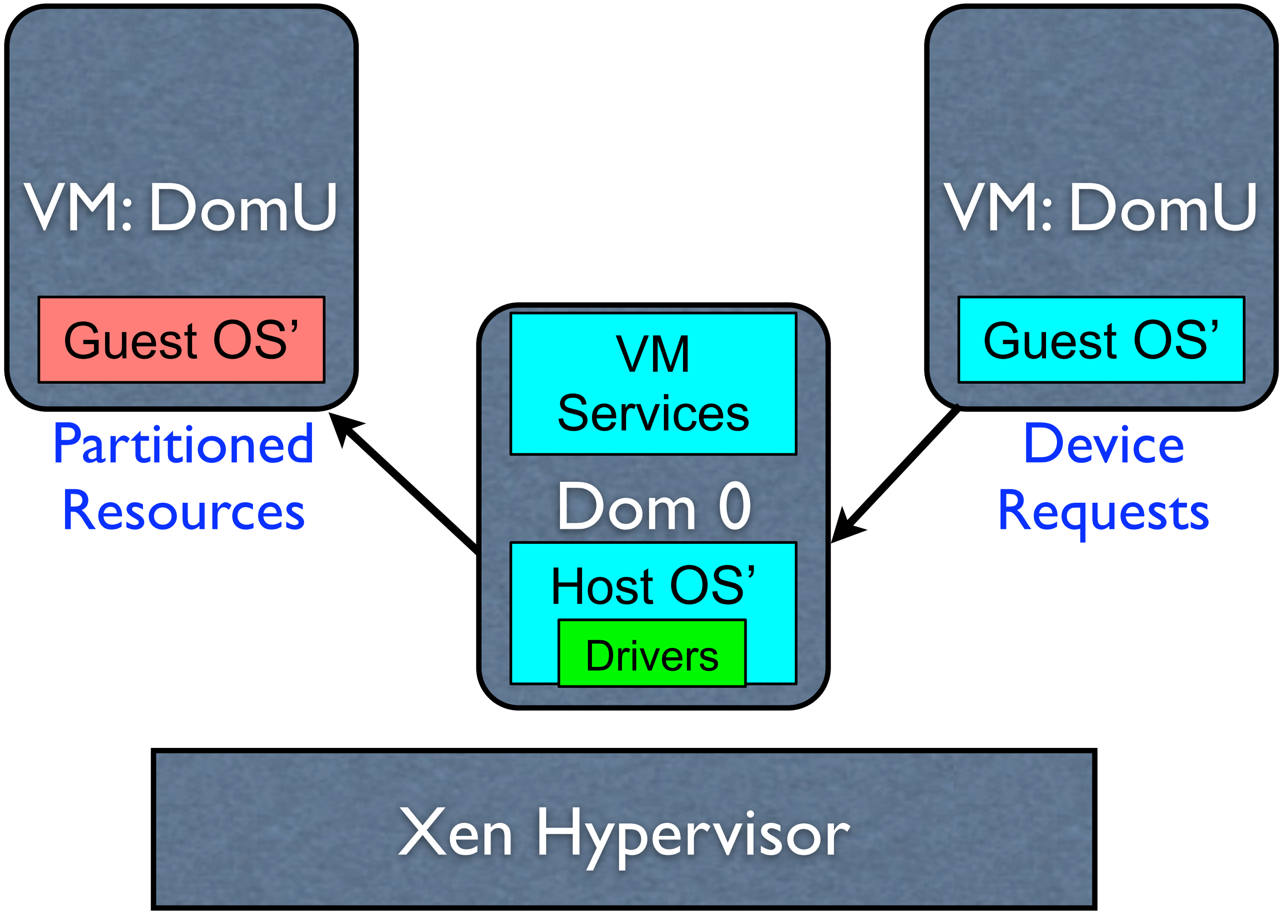
NetTop

- Isolated networks of VMs
- Alternative to “air gap” security



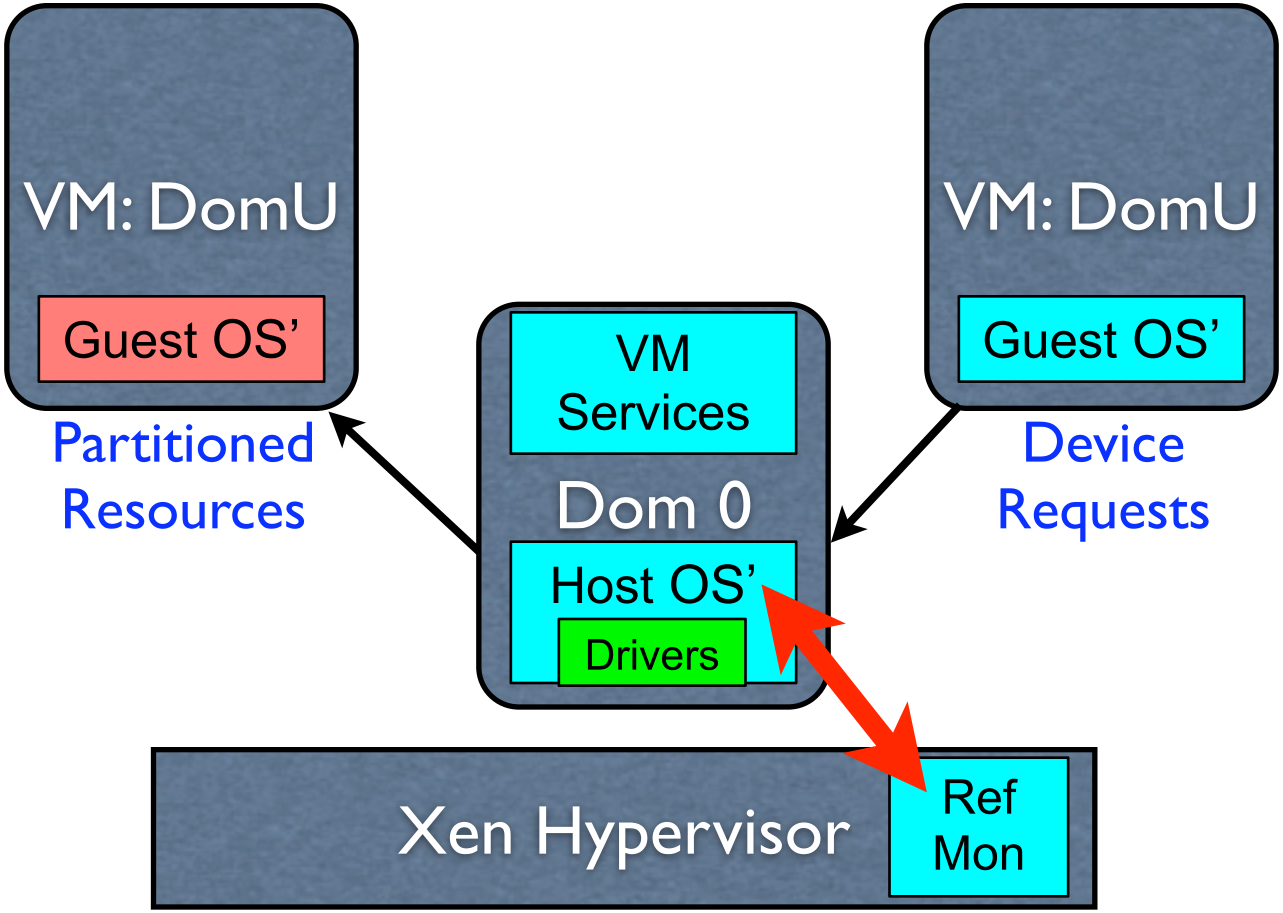
Xen

- Paravirtualized Hypervisor
- Privileged VM



Xen sHype

- Controlled information flows among VMs



Xen sHype Policies

- Type Enforcement over VM communications
  - VM labels are subjects
  - VM labels are objects
- How do VMs communicate in Xen?
  - Grant tables: pass pages between VMs
  - Event channels: notifications (e.g., when to pass pages)
- sHype controls these
- Q: What about VM communication across systems?

Xen Security Modules

- Comprehensive Reference Monitor interface for Xen
  - Based on LSM ideas
- Includes about 57 “hooks” (more expected)
  - Supports sHype hooks
  - Plus, hooks for VM management, resource partitioning
- Another aim: Decompose domain 0
  - Specialize kernel for privileged operations
  - E.g., Remove drivers

VM Security Status

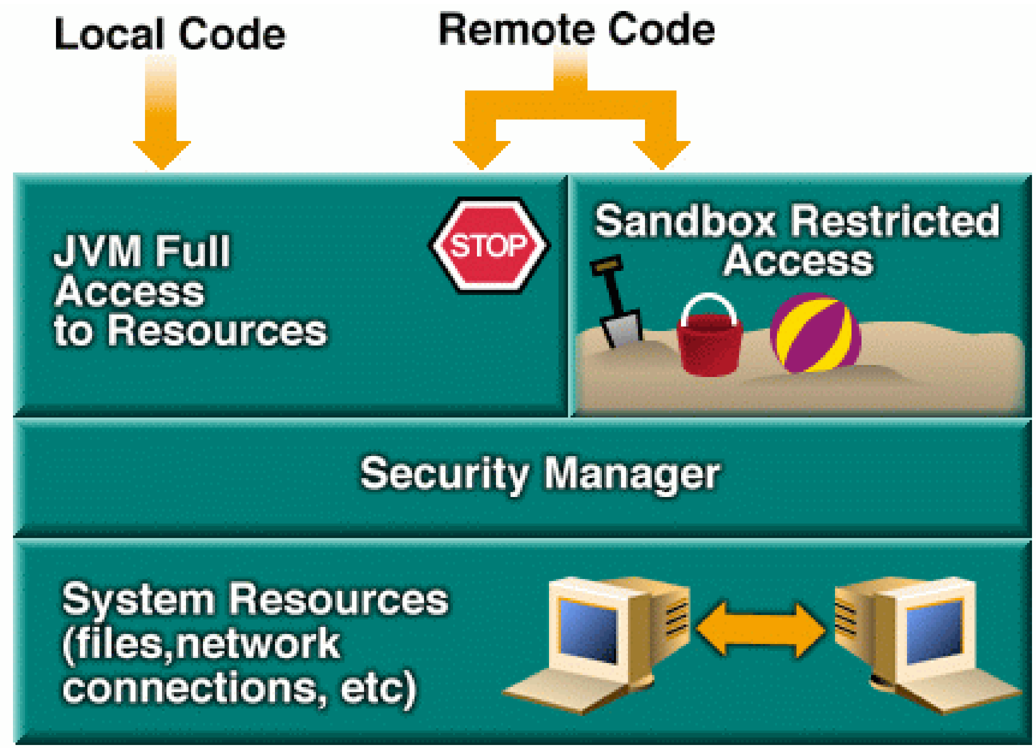
- Aim is simplicity
  - Are we achieving this?
- Do we care what happens in the VMs?
  - When might we care?
- Trusted computing base
  - How does this compare to traditional OS?

Java Virtual Machine

- Interpret Java bytecodes
  - Machine specification defined by bytecode
  - On all architectures, run same bytecodes
    - Write once, run anywhere
- Can run multiple programs w/i JVM simultaneously
  - Different ‘classloaders’ can result in different protection domains
- How do we enforce access control?

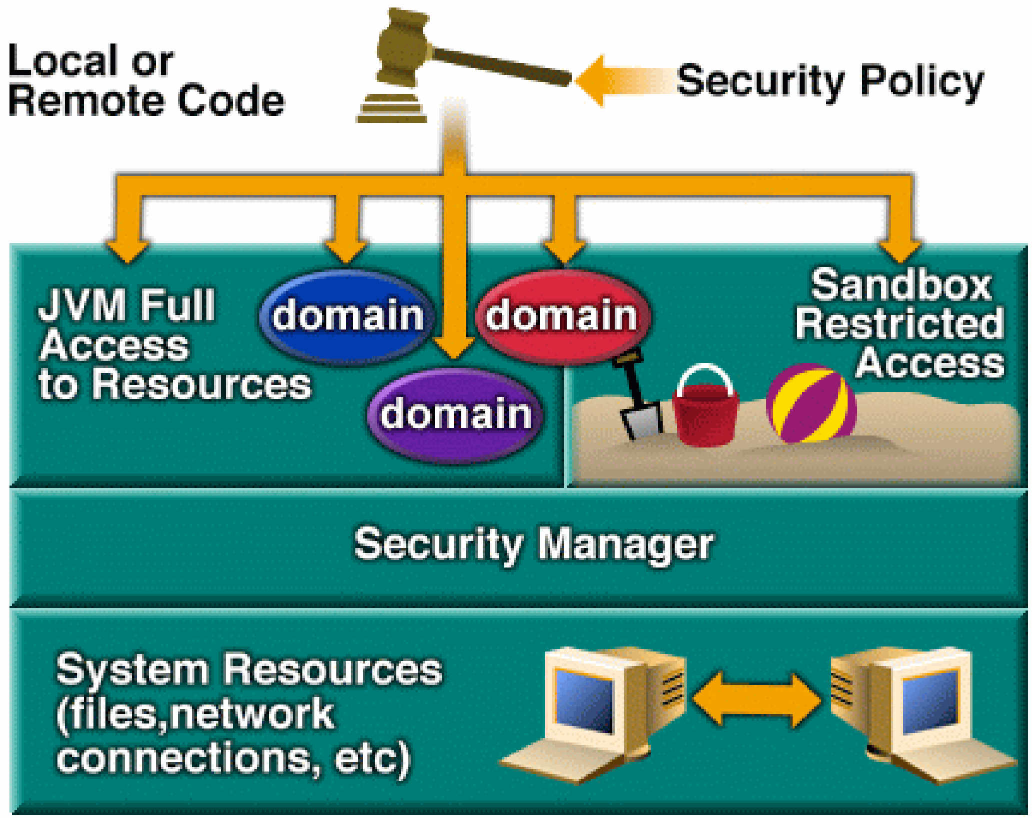
Java Security Architecture

- Java 1.0: Applets and Applications



Java Security Architecture

- Java 1.1: Signed code (trusted remote -- think Authenticode)
- Java 1.2: Flexible access control, included in Java 2



Stack Inspection

- Authorize based on protection domains on the stack
  - Union of all sources
    - All must have permission

class	method	protection domain	
Example2b	main()	CDROM	1
com.artima.security.stranger.Stranger	doYourThing()	**STRANGER**	2
com.artima.security.friend.Friend	doYourThing()	FRIEND	3
java.security.AccessController	dPrivileged()	BOOTSTRAP	4
com.artima.security.friend.Friend$1	run()	FRIEND	5
TextFileDisplayer	doYourThing()	CDROM	6
java.io.FileReader	<init>()	BOOTSTRAP	7
java.io.FileInputStream	<init>()	BOOTSTRAP	8
java.lang.SecurityManager	checkRead()	BOOTSTRAP	9
java.lang.SecurityManager	checkPermission()	BOOTSTRAP	10
java.security.AccessController	checkPermission()	BOOTSTRAP	11
java.security.AccessControlContext	checkPermission()	BOOTSTRAP	12

Do Privileged

- doPrivileged terminates backtrace
- Like setuid, with similar risks

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com.artima.security.friend.Friend$1	run()	FRIEND	5
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Virtual Machine Threats

- How does the insertion of a virtual machine layer change the threats against the system?

Virtual Machine Rootkit

- Rootkit
  - Malicious software installed by an attacker on a system
  - Enable it to run on each boot
- OS Rootkits
  - Kernel module, signal handler, ...
  - When the kernel is booted, the module is installed and intercepts user process requests, interrupts, etc.
  - E.g., keylogger
- VM Rootkit
  - Research project from Michigan and Microsoft
  - If security service runs in VM, then a rootkit in VMM can evade security
  - E.g., Can continue to run even if the system appears to be off

Take Away

- VM systems focus on isolation
  - Enable reuse, but limited by security requirements
- Enable limited communication
  - The policies are not trivial, but refer to coarser-grained objects