Virtual Machines

What is a Virtual Machine?

- Java Virtual Machine (Application Virtualization)
- Software to simulate hardware
- Independent
- ‘Separate’
- Use one piece of hardware to simulate many computers

Topics

- What are Virtual Machines?
- Why are they related to security?
- Getting past Virtual Machines

Flavors of Virtualization

- Hardware Virtual Machine
  - Emulation (full system virtualization)
    - Complete hardware virtualization. Unmodified Guest OS for a different CPU can run
  - Native Virtualization (full virtualization)
    - Simulates hardware to run to run an unmodified OS, but OS has to be for the same type of CPU

- Application Virtual Machine (Paravirtualization)
  - Does not simulate hardware, but offers API that requires OS modifications like JIT compilers or interpreters
- Virtual Environment (Virtual Private Server)
  - Used to run applications, doesn’t simulate a kernel
  - Operating System-Level Virtualization

- Machine Aggregation (clustering)
  - Use number of different computers to simulate a more powerful single machine
  - Parallell Virtual Machine (PVM)
  - Message Parsing Interface (MPI)

Why use it?

- Running multiple operating systems
- Physical space
- Mobility (USB Drives)
- Sandboxing
- Honeypots

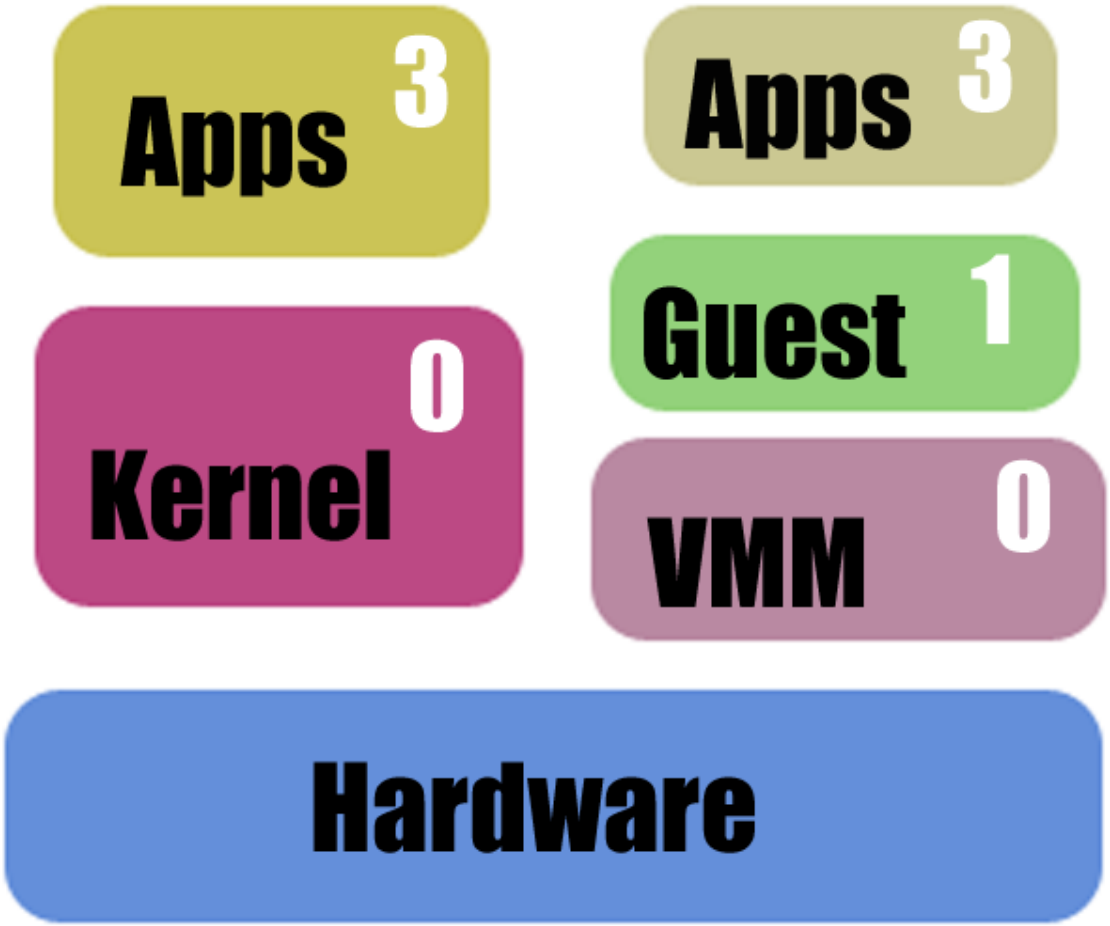
Hypervisor / VMM

- Platform allowing multiple operating systems to run
- Abstraction layer for a virtual machine
  - Equivalence
  - Resource Control
  - Efficiency

Virtualization Requirements

- Popek and Goldberg Virtualization Requirements
- Instruction Set Architecture must possess:
  - Operate in user mode or system mode
  - Uniformly addressable memory (relative to a register)
- All instructions affecting the functioning of the VMM are controlled by the VMM

- A computer is virtualizable if it is virtualizable or a VMM without timing dependencies can be constructed for it. (Recursive)
- x86 processors compliant:
  - Intel Virtulization Technology (IVT)
    - Most P4, Pentium D, Xeon, Core Duo, Core 2 Duo
  - AMD Virtualiation (AMD-V, Pacifica)
    - K8, all F's and onwards


Apps 3
Apps 3
Guest 1
Kernel 0
VMM 0
Hardware

Explanation of the Diagram

- Kernels manage CPU, Memory and devices and interfaces them with applications
- VMM splits the left and right side to keep them isolated
- Ring level determines the amount of ‘power that layer has

Sandboxing

- Installing new infrastructure software
- Installing downloaded software on the net
- Browsing Security – Undo Disk in VPC

Honeypots

- Used to detect malicious users
- Set up a VM network
- Let someone attack your system, then watch them, since no useful information is being stolen
- Only software layer being attacked

Misconceptions

- Virtual Machines aren’t an end-all security guarantee
- Software still using CPU and memory of host machine
- Equivalence, Resource Control and Efficiency aren’t always completely achieved

Detecting a VM

- Run loops on remote machine suspected to be a VM
- Loops contain commands a certain VM (Xen, VMWare) don’t do particularly well
- Run Loop they do well
- Detect differences of speed opposed to non-VM’s

Java Virtual Machine Attack

- Attacking a JVM that permits untrusted code to execute after it's verified to be type-safe
- Sending JVM a program and waiting for a memory error
- Once it type-checks, it rearranges the memory so the type system is defeated

The program

```
Class A {
   A a1;
   A a2;
   B b;
   A a4;
   A a5;
   int i;
   A a7;
}
```

```
Class B {
   A a1;
   A a2;
   A a3;
   A a4;
   A a5;
   A a6;
   A a7;
}
```

Memory Error

- The i^{th} bit of a word is flipped for some reason
- If 2^i is larger than the object size, x xor 2^i is likely to point to the base of a B object.
- Then, there is an object with type A that actually points to a B object

Exploiting the Memory Error

```
A p;
B q;
int offst = 6*4
void write(int addr,
  int value) {
  p.i = addr - offst;
  q.a6.i = value;
}
```

- offst is the offset of the field i from the object A
- i and a6 of object B are equal offsets from their bases
- If p and q are at the same address, the second statement writes at the offset of an offset
- value is written at offst + (addr – offst) = addr

Results

- This lets anyone calling write() to write value v into address a
- Fill an array with machine code
- Overwrite a virtual method table with the address of the array
- Remote code execution

VMware Attack

- NAT in VMware was not validating PORT and EPRT commands from FTP
- Specially formatted commands allowed heap-based buffer overflow
- Vulnerability allowed attacker to execute code on host machine