# Virtual Machine Based Intrusion Detection

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Based on Garfinkel et al. NDSS 2003 work

# Intrusion Detection Systems

- Two types
  - Network based Intrusion Detection Systems (NIDS)
    - Resistant against attacks
    - Do not know the individual host states
  - Host based Intrusion Detection System (HIDS)
    - High host visibility
    - Easier to attack.
    - Kernel level HIDS
      - User programs can modify kernel (e.g. sys_call_table) through loadable kernel modules
      - IDS crash could create system vulnerable

# Virtual Machine Introspection

- Idea: Use VMM level IDS. Do Virtual Machine introspection to detect attacks.
  - Advantage: Can observe machine states, harder to attack
  - Disadvantage: Potential costs

# VMM Capabilities

- VMM will be harder to attack
  - Simpler than traditional OS
    - Does not need to have networking
- Isolation due to VMM
  - IDS and Guest OS will be isolated.
- Inspection
  - VMI IDS can directly inspect the machine state
  - Harder to hide actions
- Interposition
  - VMI IDS can use VMM to be notified when certain events happen

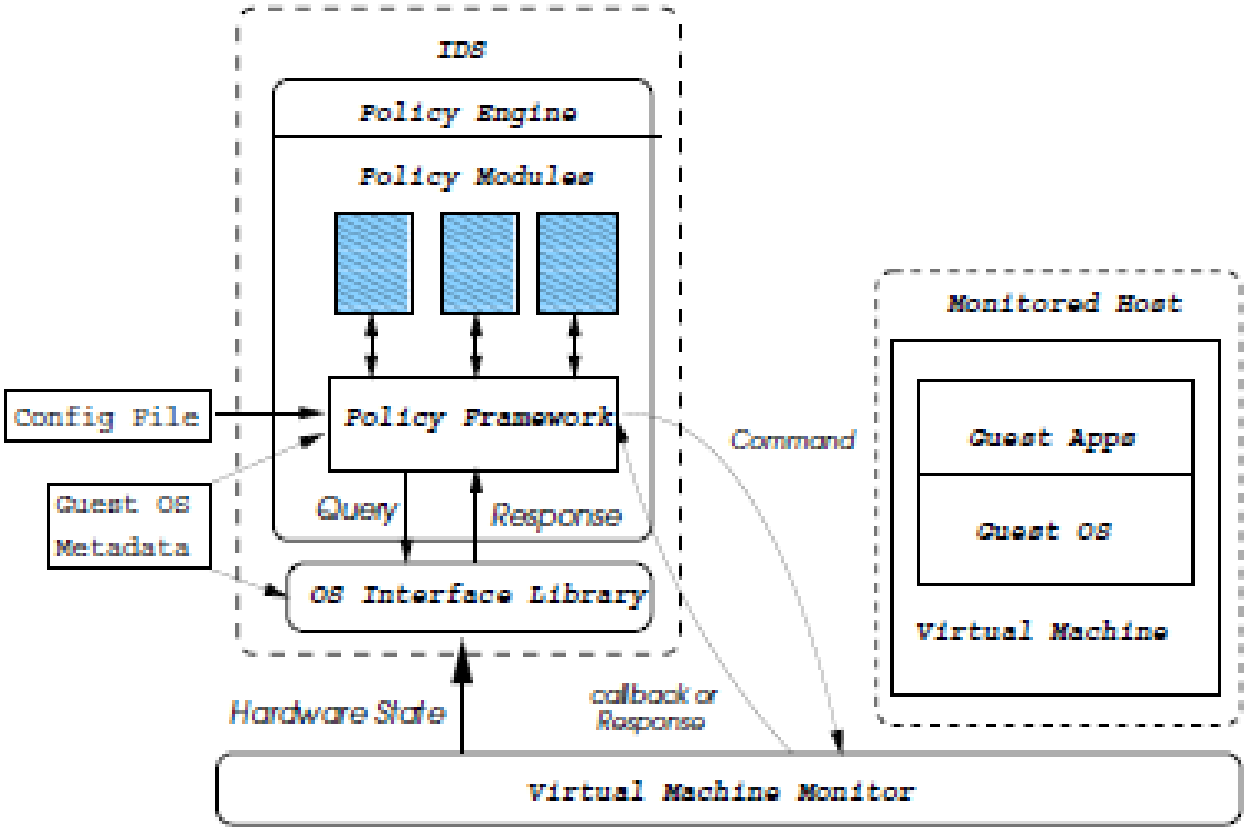
# Threat Model for VMI IDS

- Guest host is not trusted
  - All info. Gathered from guest host is assumed to be tainted and not to be trusted.
- VMM is trusted
- VMI IDS has some assumptions about the structure of the guest OS in order to implement some IDS policies.

# Design Goals

- Low overhead
  - Only monitor events that are closely related to intrusions (e.g., sensitive memory modifications etc.)
- Minimize change to VMM
  - VMM should be kept simple and bug free.
- Limit VMM exposure
  - IDS and VMM could be kept separate.
  - IDS compromise must not affect the VMM security

# VMI IDS Design



# VMM Interface

- Inspection Commands
  - Inspect state info such as memory, register, I/O devices
- Monitor Commands
  - Get notification for certain event occurrence.
- Administrative Commands
  - Allows the control of VM
    - Stop the VM if intrusion is detected.

# OS Interface Library

- Provides necessary functionality to translate VMM states to OS level semantics
  - E.g., display the content of the task structure for PID 231.

# Policy Engine

- Interprets the system state and event from VMM Interface and OS library interface
- Implements various policies such as burglar alarm, misuse detection, integrity checkers etc.
- Provides policy engine for more complex detection.

# Example Policies:

- Polling policy modules
  - Check for activities in a certain time intervals
- Lie detectors
  - See whether guest os lies about the OS parameters
  - E.g., check whether what ps returns is consistent with what VMM observes
- User program integrity detector
  - Make sure the images in memory not modified
- Signature detector
- Raw socket detector (burglar alarm)

# Event Driven Policy Modules

- Detecting tampering with OS code segment
  - Mark sensitive OS parts read only
  - Use copy-on-write mechanism to detect changes
- NIC access enforcer
  - Detect Ethernet device with promiscuous mode on.

# Sample Attacks

| Name | Description | nic | raw | sig | int | lie | mem |
|---|---|---|---|---|---|---|---|
| cdoor | Stealth user level remote backdoor | | D | | | | |
| t0rn | Precompiled user level rootkit | | | D | | D | |
| Ramen | Linux Worm | | | D | | | |
| lrk5 | Source based user level rootkit | P | | D | D | D | |
| knark-0.59 | LKM based kernel backdoor/rootkit | | | D | | D | P |
| adore-0.42 | LKM based kernel backdoor/rootkit | | | D | | D | P |
| dsniff 2.4 | All-purpose packet sniffer for switched networks | P | | | | | |
| SUCKIT | /dev/kmem patching based kernel backdoor | | | D | | D | P |

# Performance Overhead

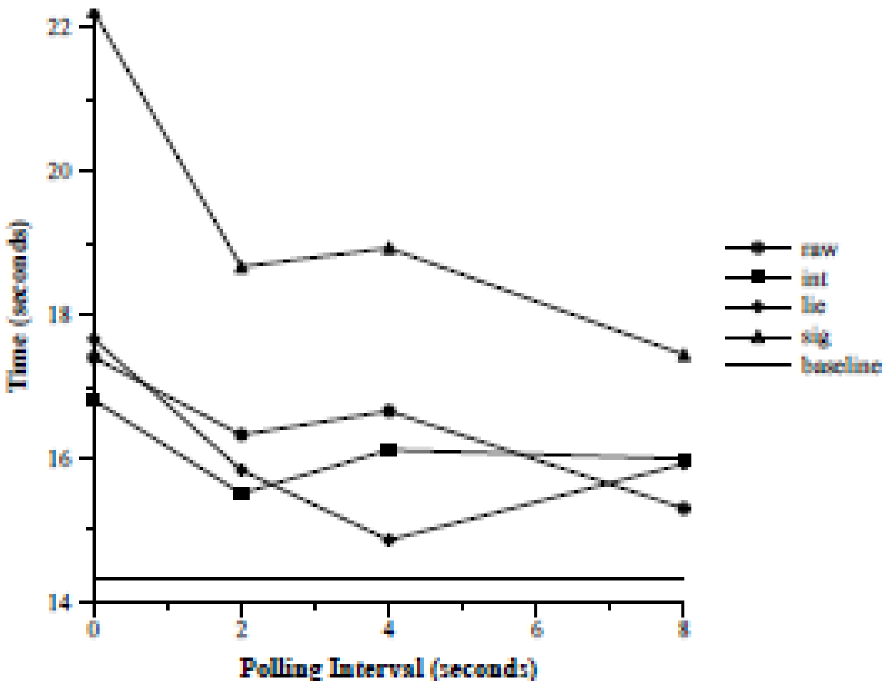



Figure 2. Performance of Polling Policy Modules

# Potential Issues

- OS library interface is complex and could be evaded.
  - In Limewire OS interface library is run as a separate OS.
- VMM existence could be detected
  - Check I/O performance time
- VMM could be subverted.
- Policy Engine could be attacked.
  - Sanitize inputs
  - Simpler High level policy language
  - Failing closed (suspend VMM if something goes wrong)
  - Potential bugs?

# Cloud auditing

- Such systems could be used for auditing purposes in cloud.
- Performance overhead is important.
- IDS typically have false positive issues
- Complex attacks may be harder to detect
  - (slowly stealing user private information)