Building Trustworthy Intrusion Detection Through Virtual Machine Introspection

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Outline

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Rootkits

Rootkits have become more sophisticated over the years.

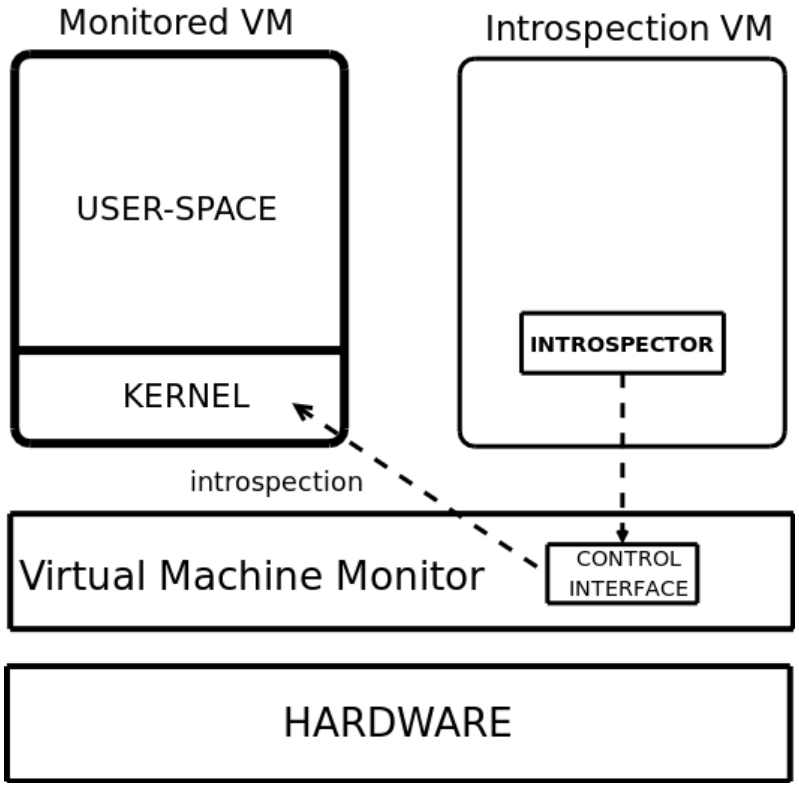
- User-level rootkits: usually, modify system binaries.
- Kernel-level rootkits: for example, a module inserted into the kernel.

Unfortunately, rootkits and IDSes work at the same level. A rootkit can attack or evade the IDS controls.

Proposed Approach

Virtual Machine Introspection: Standford University.

- Visibility: access VM's state from a lower level.
- Robustness: detect intrusions from another VM.

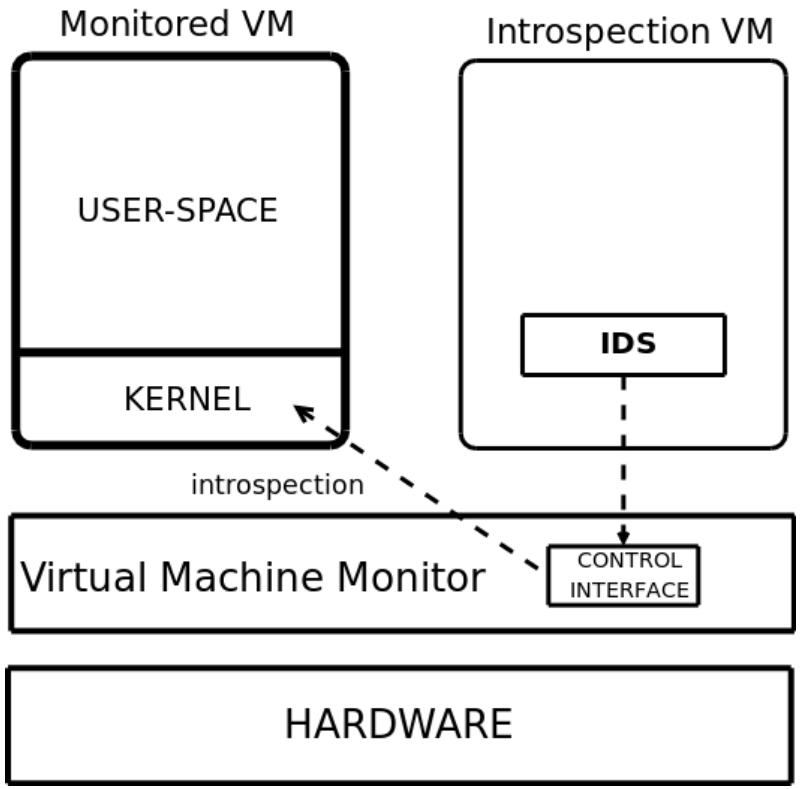


Semantic Problem

- How to detect intrusions/attacks inside the VM?
- Semantic problem: the data accessed through introspection are raw data.
- We also need to protect the IDS.

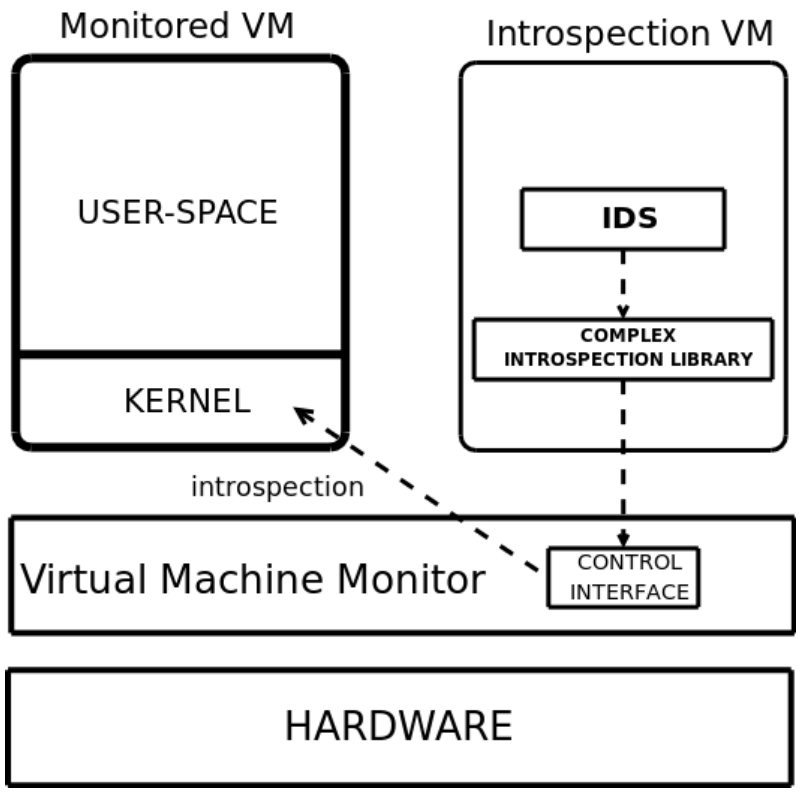
Solution #1

Modify an IDS to work at the hardware level.



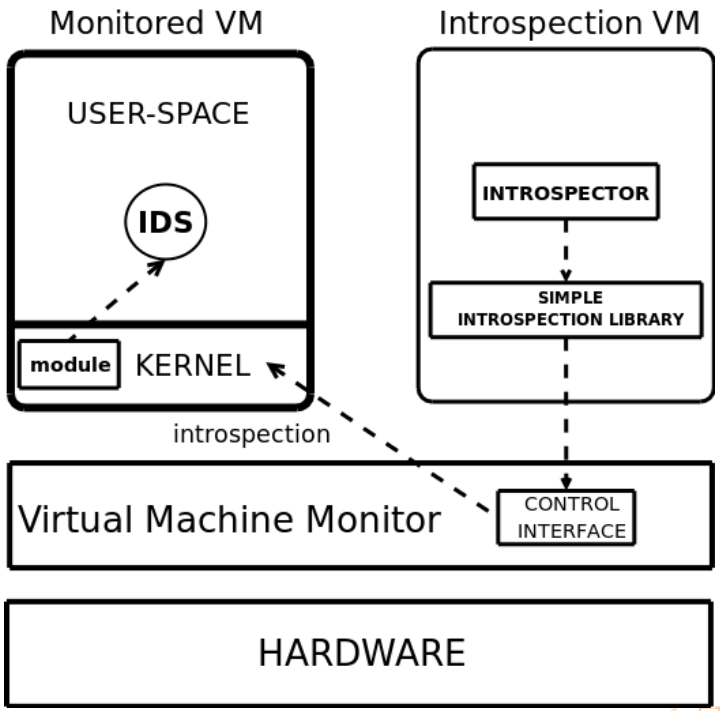
Solution #2

Build a complex introspection library to export an OS view of the VM's state.

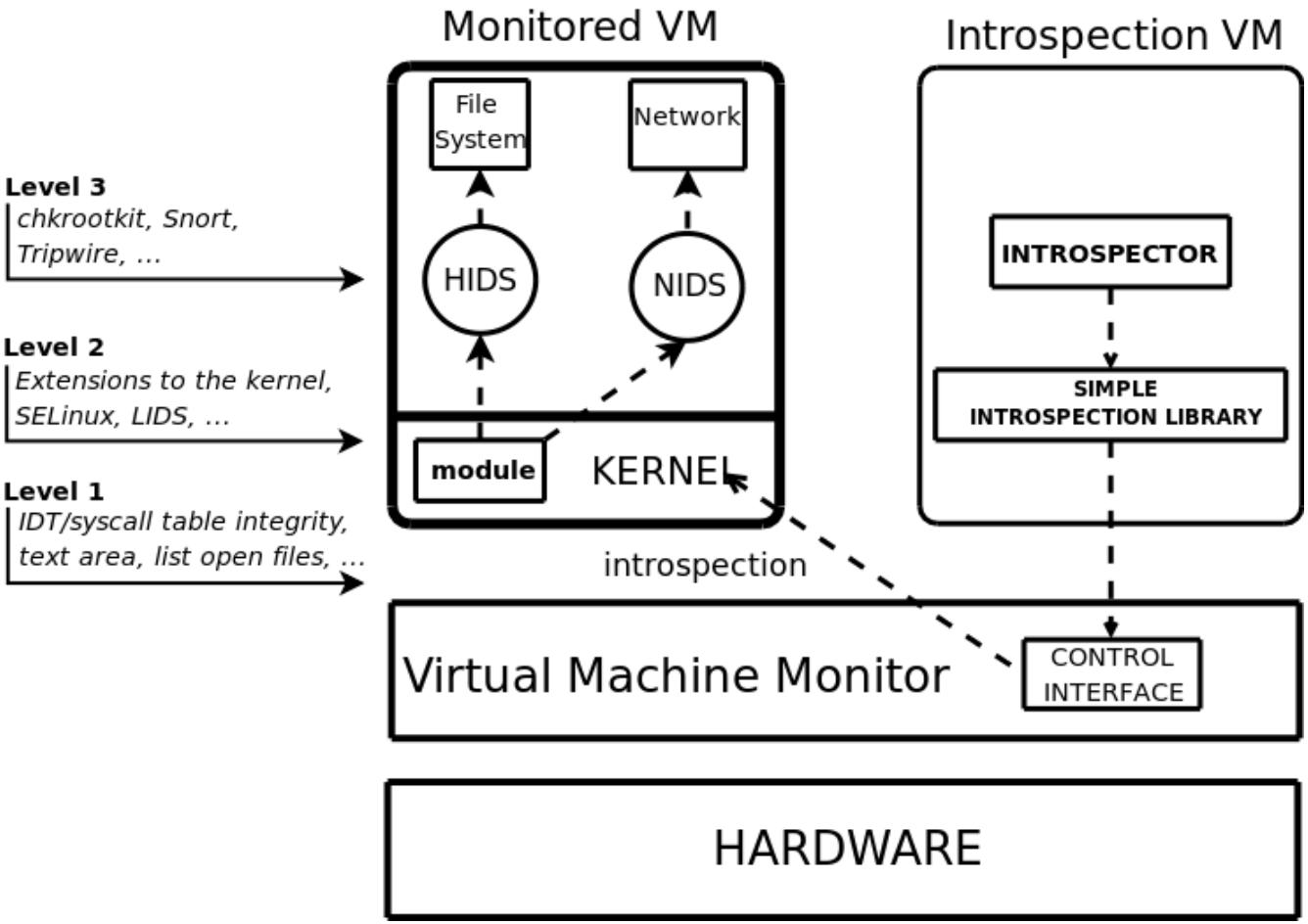


Our Solution: a Multi-Level Approach

1. Build a simple introspection library to check the kernel.
2. Extend the kernel to monitor the IDSes inside the monitored VM.
3. Use standard IDSes to detect attacks against the VM.



Chain of Trust



Psyco-Virt Architecture

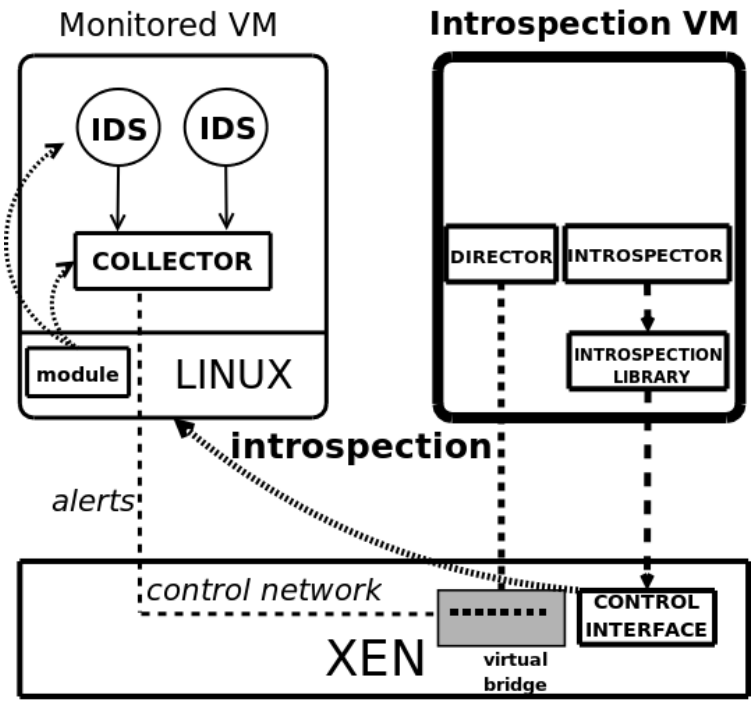
Psyco-Virt merges Host and Network IDSes with VMI.

- The first prototype is written in C, based on Xen.
- Introspection VM: monitors all the VMs.
- Monitored VM: executes the system to be monitored.
- Control Network: to exchange the alerts and commands among the VMs.

Introspection VM

Introspection VM: monitors all the VMs.

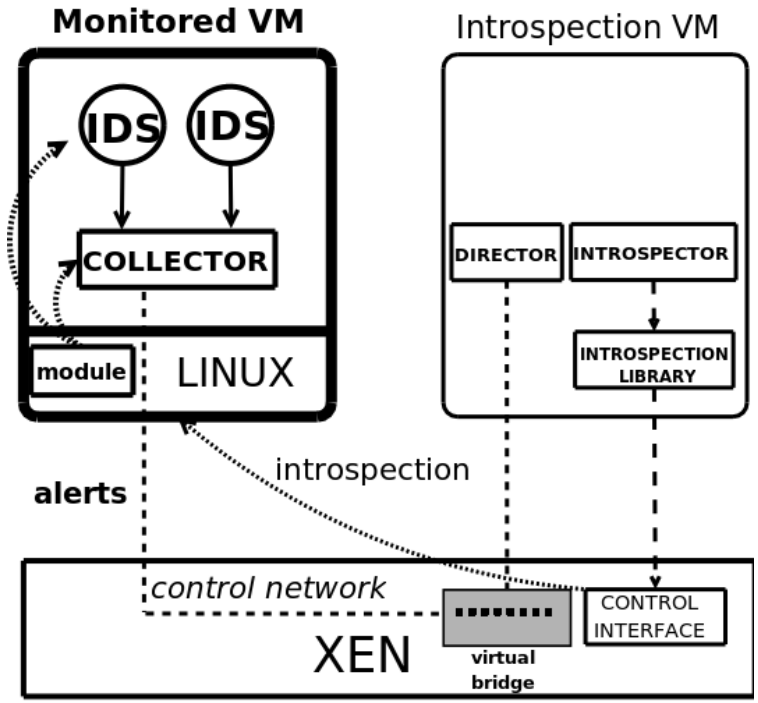
- The introspector protects kernel integrity.
- The director:
  1. collects the alerts;
  2. executes actions in response to an alert: stops a VM.



Monitored VM

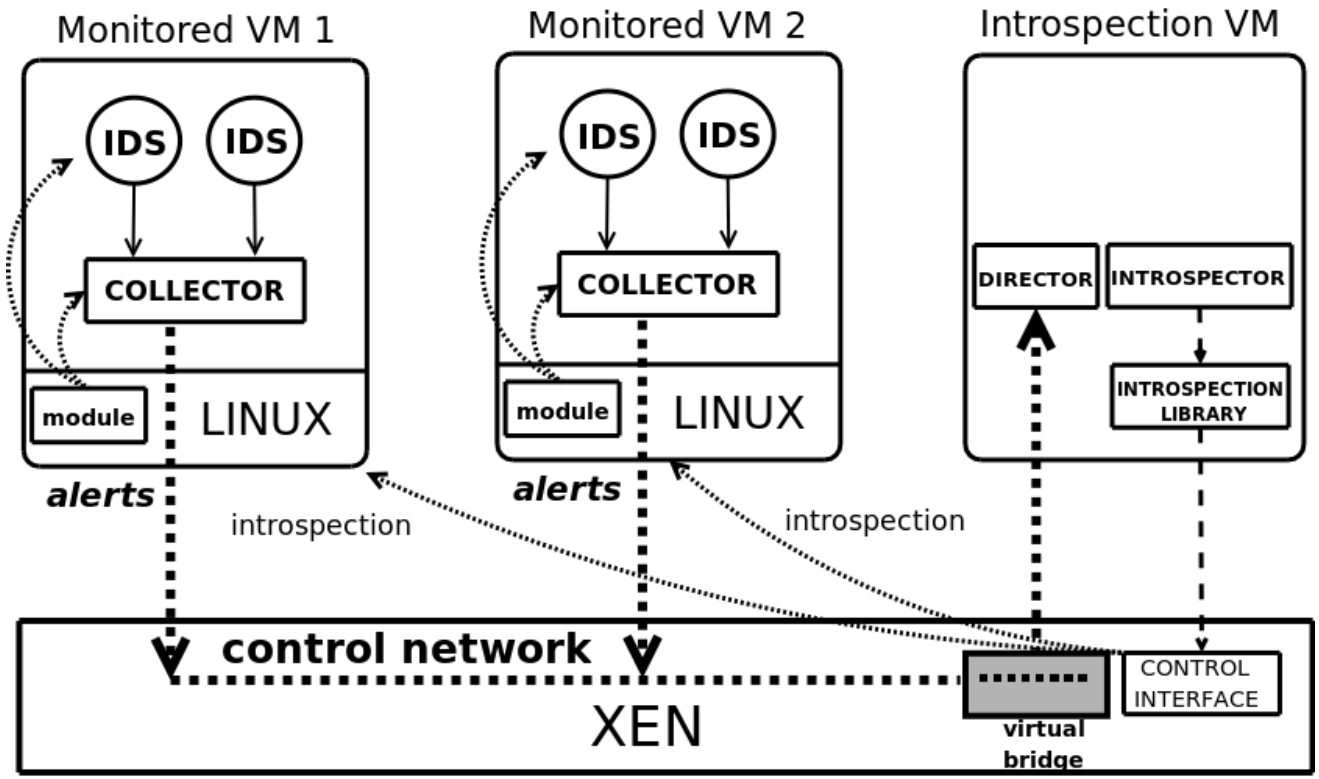
Monitored VM: executes the system to be monitored.

- Runs IDSes to detect attacks/intrusions.
- The collector receives all the alerts from the local IDSes.
- The kernel checks IDS integrity.



Control Network

Control Network: to exchange the alerts and commands among the VMs.



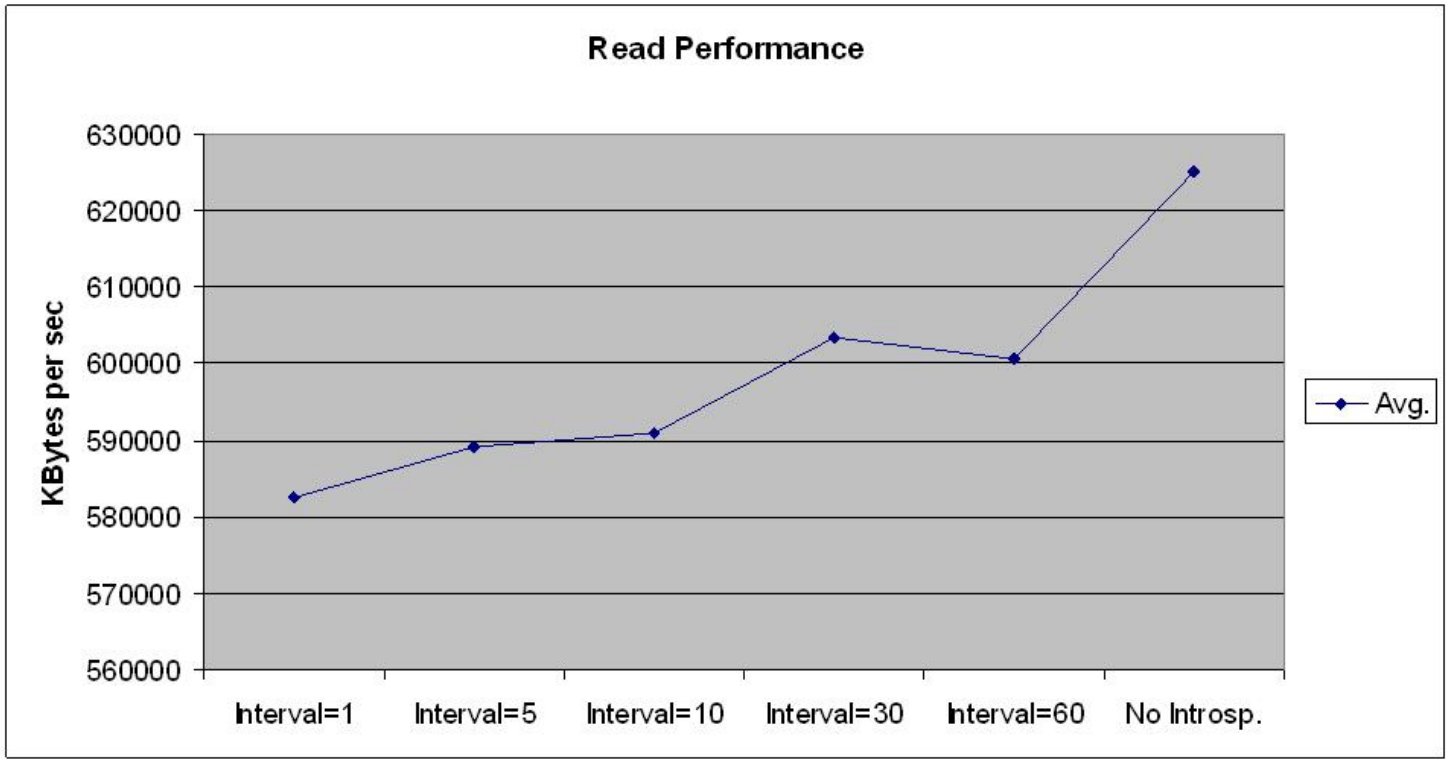
Attacks Detected

Currently, Psyco-Virt detects:

- Attacks to the kernel code also those inserting a malicious module.
- Udpates to the IDT and syscall table.
- Updates to the text area of a critical processes.
- Replacing ps and lsof.
- Interfaces set into promiscuous mode.

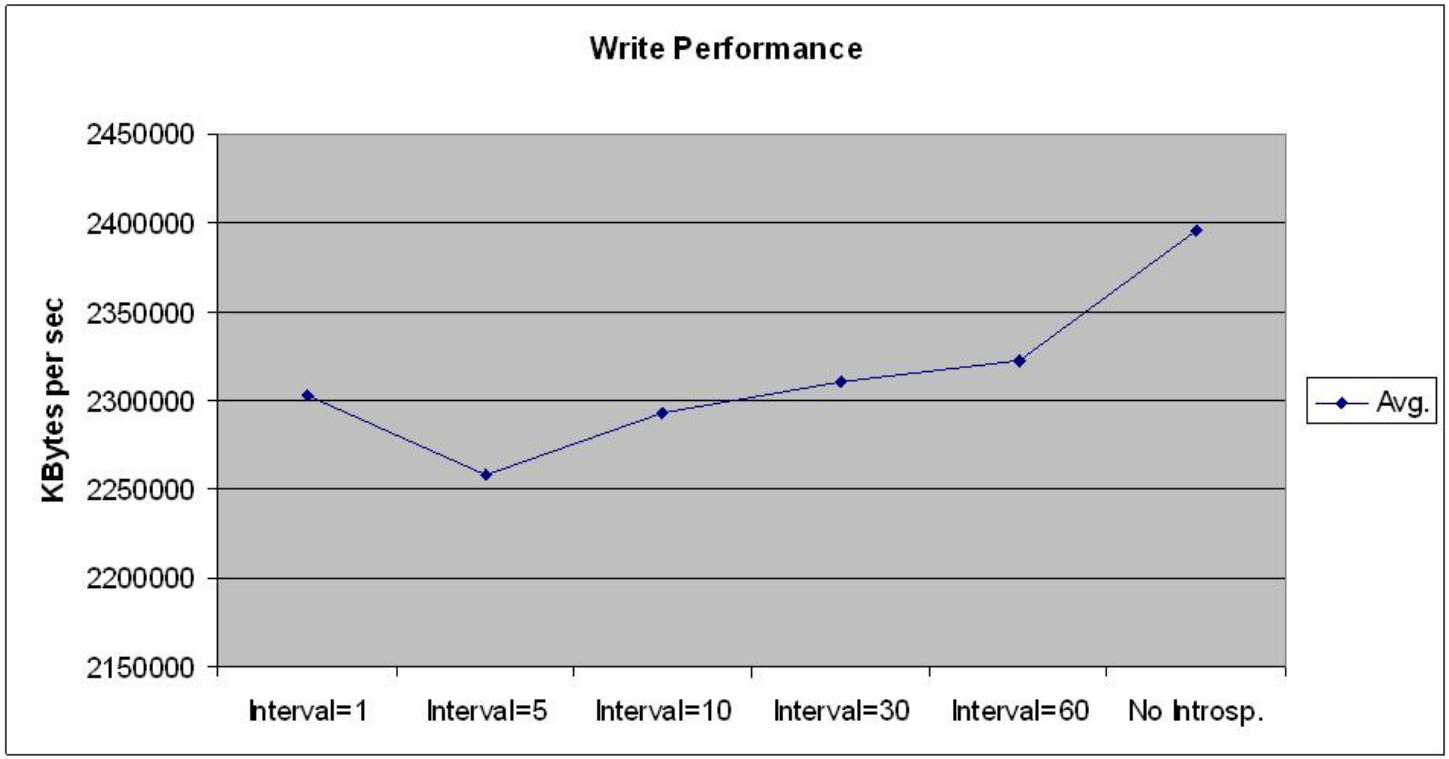
IOzone Read Performance

Overhead is less than 10%.



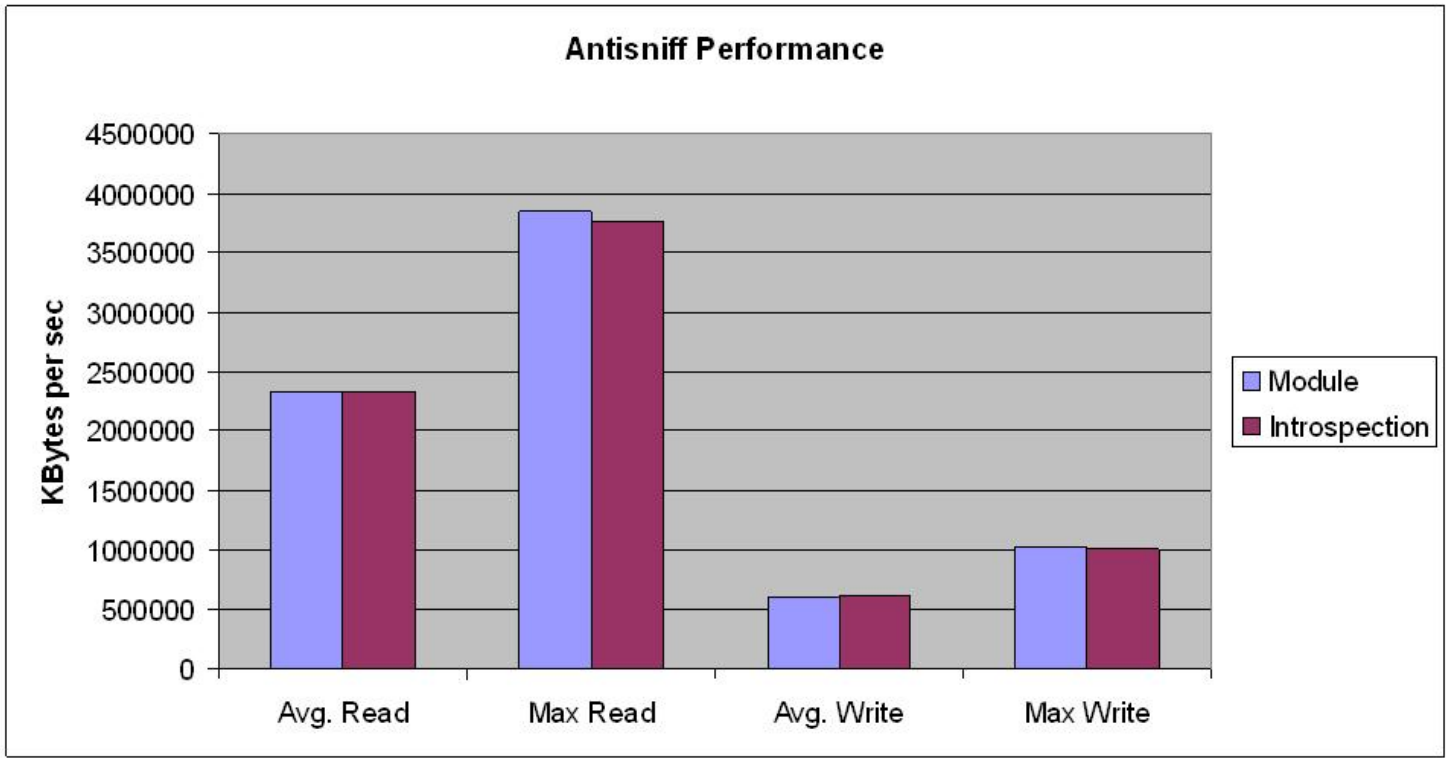
IOzone Write Performance

Overhead is less than 10%.



Antisniff

Antisniff implemented as a module or through introspection.



Limitations

Current limitations of the prototype:

- No checks on kernel dynamic data, such as stack.
- Other critical kernel data structures, besides IDT and syscall table, have to be protected.
- Attacks to the VMM.
- Attacking the kernel between each execution of the checks.

Results

- Using unmodified IDSes with virtual machine introspection.
- Preventing evasion of the controls and attacks to IDSes.
- Multi-Level approach to form a chain of trust:
  1. IDSes.
  2. Kernel.
  3. VMM.
- Acceptable overhead.

Future Works

- Checking at runtime memory invariants.
  - Using abstract interpretation of kernel code.
- Tracing a VM, such as using ptrace.
  - Verifying system call parameters.
- Using introspection as an attestation of the VM.
  - Attesting the software to a remote party.