Hypervisor assisted malware detection (analysis)

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Outline

- Basics of hardware assisted virtualization
- Conventional malware detection
  - Signature based
  - Heuristics
- Malware analysis in ring -1
- Performance as a No.1 bottleneck
- Malware detection in ring -1
- Statistics as a prospering tool
Basics of hardware assisted virtualization

- Introduced in 2006 (Intel VT-x and AMD-V)
- Same theoretical basics, differences only in the implementation
- A new CPU privilege level (ring -1) for the hypervisor
- Hypervisor mediates between the hardware and (virtualized) operating systems.
  - Main tasks: management of resources, virtualizing processors and states
  - Examples: XenServer, Hyper-V Server, Blue Pill
- CPU can operate in root and non-root mode
  - Root mode - CPU executes the hypervisor
  - Non-root mode – CPU executes the guest operating systems
More details about hardware ass. virtualization

- Saving guest states
  - VMCB - Virtual Machine Control Block
  - VMCS – Virtual Machine Control Structure

- VM Exits: switching between root and non-root mode
  - Exceptions
  - Faults
  - Privileged instruction execution
  - Invalid opcode execution

- VM Exits can be intercepted and handled by the hypervisor
  - Basics of malware analysis and detection
Conventional malware detection

- Current AVs run at the same priv. level as malware do (ring 0, ring 3)
- Signature based - searching for static patterns
  - E.g., Byte sequences, header information
  - Difficult to handle new variants
  - Requires large databases
  - Low false positive rate
- Heuristics – searching for behaviour based patterns
  - E.g., Memory pages with specific information
  - New variants can be detected easily
  - Higher false positive rate
Malware analysis in ring -1

- Many research papers about hypervisor assisted malware analysis
  - Ether
  - Pyrenée
  - MAVMM
  - Patagonix, etc…

- Using a proprietary or existing virtualization software
  - Xen
  - KVM
  - TVMM
  - All of them requires a reboot – is it a problem?

- Performance problems…
Perfomance problems

- Guests being analysed are unusable

- Cause: No native support for decreasing the semantic gap between the hypervisor and the operating system
  - E.g., No CPU support for system call tracing $\rightarrow$ heavy use of syscalls by user-space malware

- Current solution for syscall tracing uses page faults
  - Problems: Excessive number of page faults by design
  - Filtering is not a efficient solution
Goals

- Detecting unknown parasitic malware in real time
- Transparency
- Low performance overhead
- Using heuristics (many advantages)
- False positives?

Solution: Stastics or Machine Learning

- Separating benign and malicious syscall sequences
- Creating stastics from benign and infected systems
- We can use hypothesis theory to differentiate them
Challenges

- Decreasing the semantic gap
  - Reconstructing operating system level structures in the hypervisor: process names, process features, memory protections, etc

- Solving performance issues (new syscall method)

- Automatically record benign and a lot of (>1000) malicious traces

- A system should be build to
  - Fetch malicious samples and execute them
  - Save and record syscall logs from the hypervisor (not trivial)
  - Revert the system
  - Start everything again
Performance issues

- Important to show that there is no significant performance degradation
- Create samples (performance counters) from native and monitored systems
- Sampling is relatively time consuming
- Questions:
  - What is the lowest number of sample elements required to draw conclusion?
  - Is there a significant difference between performances?
  - Compare 3 methods (unmonitored, old syscall methods, new approach)
Thank you