Scalable Cloud Security via Asynchronous Virtual Machine Introspection

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Introduction

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• Existing techniques for prevention are slow to detect attacks.

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How can the cloud detect attacks inside a VM? How to provide strong security guarantees at low cost?
ScaasS

• **Scanning as a Service** framework for security in cloud data centers.
  
  • Scans for a wide range of attacks within both application and the operating system.

• Uses an **asynchronous checkpointing** mechanism to replicate a VM’s memory onto a Scanner host for analysis.

• Uses **VM introspection** techniques to study the memory of the virtual machine.
Where do we stand?

Overhead

window for vulnerability
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Memory
Safety tools
eg: valgrind

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Virus Scanners.
eg: McAfee

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Scaas Architecture

- VMs periodically send checkpoints to the Scanners for analysis.

- A Scanner host uses VM introspection techniques to search for evidence of vulnerabilities.
  - Ensures integrity of Key Kernel data structures.
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VM Checkpointing

VM execution timeline

interval
10 - 100 ms

Checkpoints

VM’s Memory is clean

VM
VM Checkpointing

interval 10 - 100 ms

Checkpoints

VM execution timeline

VM’s Memory is dirtied
VM Checkpointing

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Checkpoints

VM execution timeline

Send dirty pages

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Replica RAM

VMI Scanner
VM Checkpointing

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 Replica RAM

 Apache

 sshd

 Kernel

 VMI Scanner

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Apache

sshd

Kernel

VMI Scanner
Network buffering using Remus in Xen

- All network packets are buffered for each interval.
- The buffer content is released only at the end of the interval.
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ScaaS Execution

- Pause briefly at each checkpoint to be scanned for security vulnerabilities.
- ScaaS says if it is safe to release the buffer.
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Attack Detection and Response

• **Forensic analysis:** Do analysis that cannot be done on runtime.

• **Rollback and Replay:** Useful when using breakpoints that trigger errors such as buffer overflow.

• **Honeypot mode:** Resume and run in a sandbox.
Prototype Evaluation

• Prototype of ScaaS using Xen 4.5.2
• 1Gbps link between Primary and Scanner host.
• Checkpointing using Remus.
• VM introspection using libVMI.
Types of Scans

• **Process Black/White List Enforcer:**
  
  • Determines current running processes in a VM. Triggers errors depending on whether a target process is running or not.

• **Memory Fingerprinter:**
  
  • Hashes the memory pages to compare against known good states. eg: sys call table, that doesn’t change that often.
• Benchmarks vs. different checkpoint intervals
• CPU intensive benchmarks perform well with longer intervals
• httpperf is a latency sensitive benchmark
  • Longer the interval worse the performance.
Emulated Scan cost

- Performance change of application w.r.t. emulated scan costs.
- Normalized wrt to zero-cost scan
- httpperf costs worsens with scan cost
  - as it has to hold buffer data for longer periods
Fingerprinter causes high overhead initially but becomes negligible as checkpointing interval increase.

CPU usage at scanner host

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Conclusion

• ScaaS: Framework for security Scanning as a Service.

• Tool for attack detection and forensic analysis on memory.
  • examining memory checkpoints for an attack.
  • highly scalable and fast.
Discussion

• What types of attacks can we detect?

• Do we need to keep a history of checkpoints? Why? How?

• What is a reasonable cost for ScaaaS?