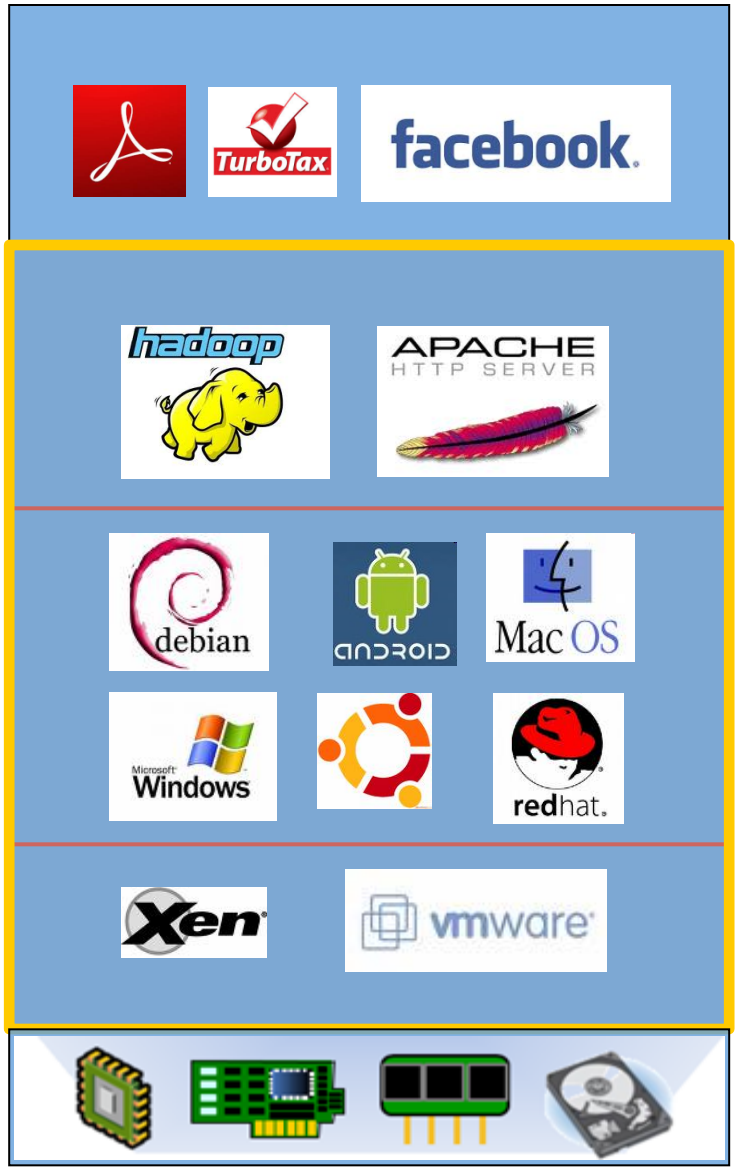
Cyber Experimentation of the Future (CEF)

Panel Discussion

Dr. Jinpeng Wei
Florida International University
Miami, FL, USA

The 31st Annual Computer Security Applications Conference (ACSAC), December 10th, 2015

Systems Software



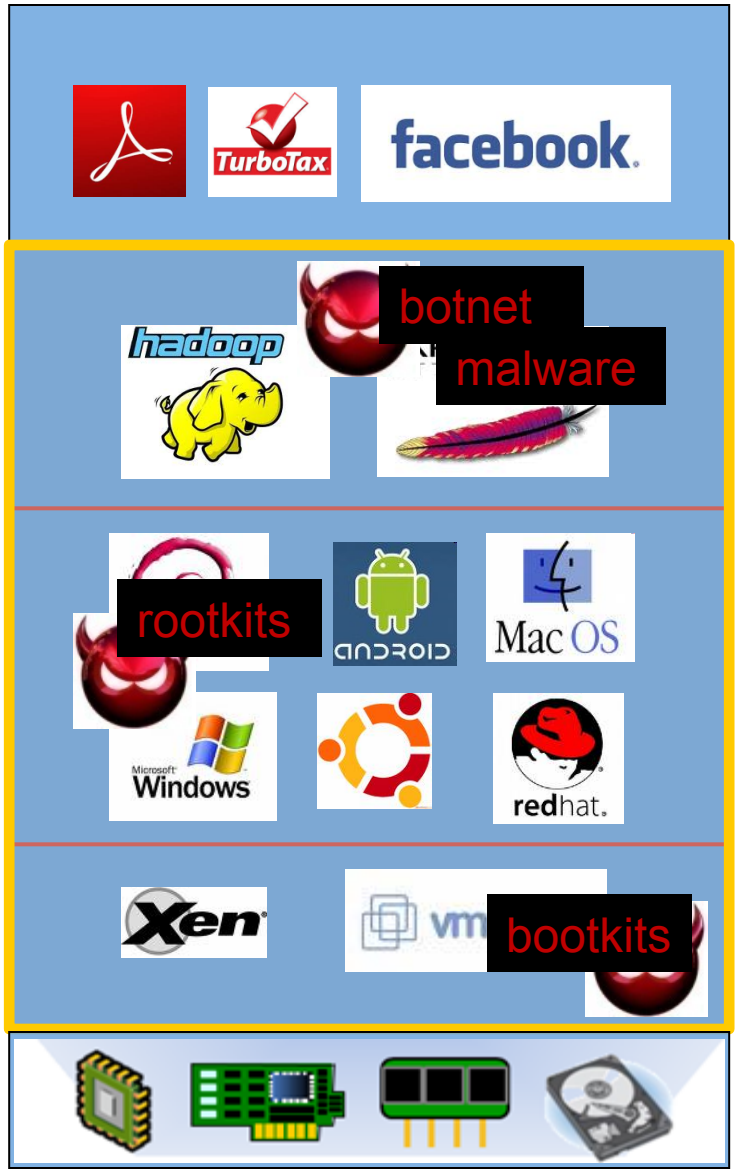
Applications

Middleware

Operating System

Virtual Machine Manager (VMM)

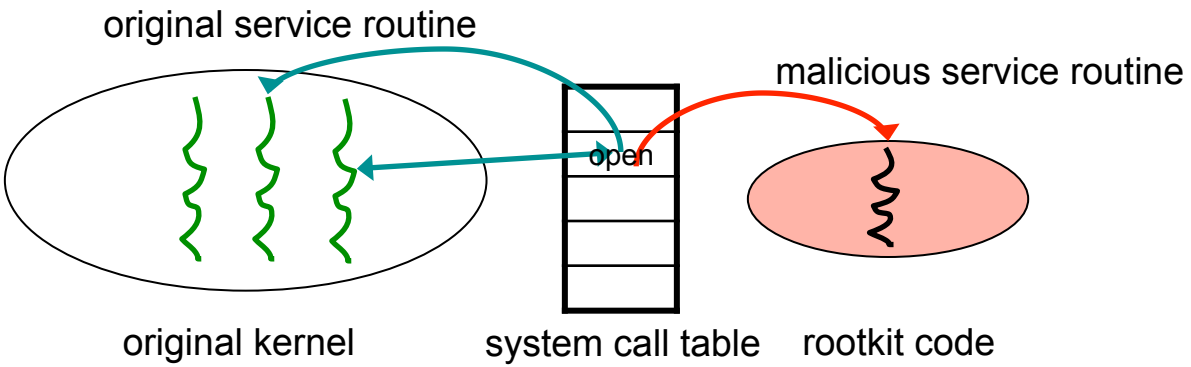
My Research on Systems Software Security



- ✓Runtime integrity of systems software
- ✓Malware analysis, detection, and defense
- ✓Secure software architecture
- ✓Software vulnerability modeling, detection, risk-assessment, and prevention
- ✓Security in cloud computing (e.g., MapReduce and Web Service Platforms)
- ✓More …

Integrity-Based Stealthy Rootkit Detection

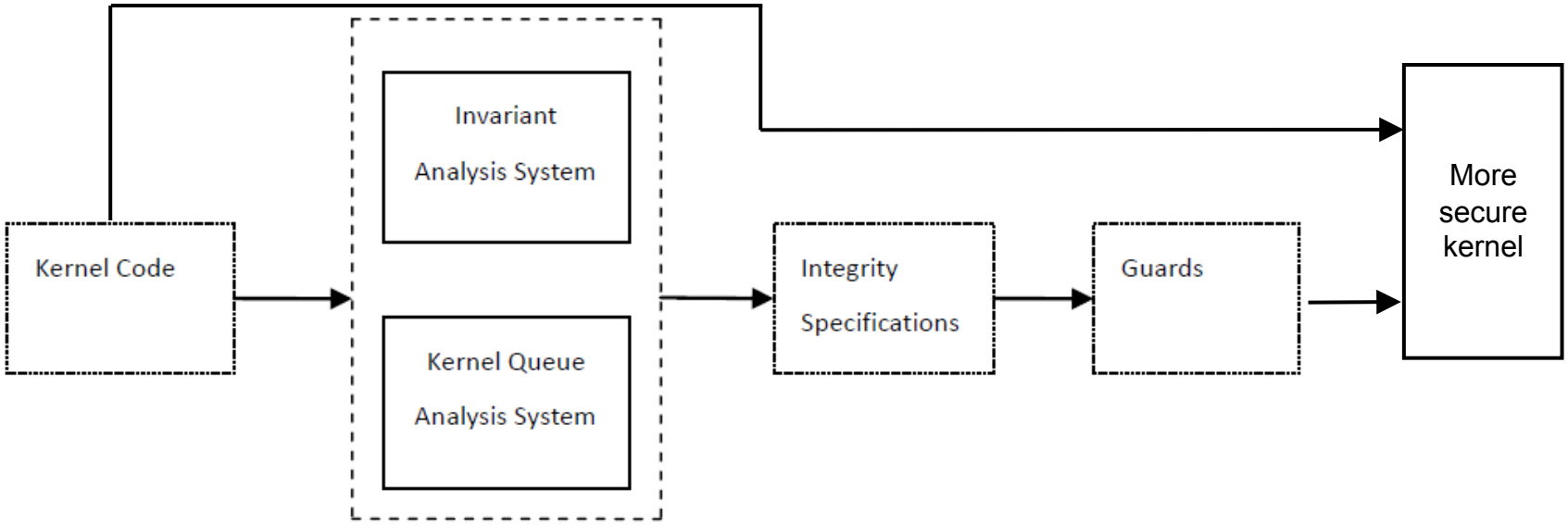
- Hypothesis: a rootkit has to violate the integrity of the victim OS to some extent
  - E.g., a rootkit tampers with the system call table to hide its files from user-space security tools



By knowing that the system call table loses integrity, we can infer that something is wrong!

Representative System Overview

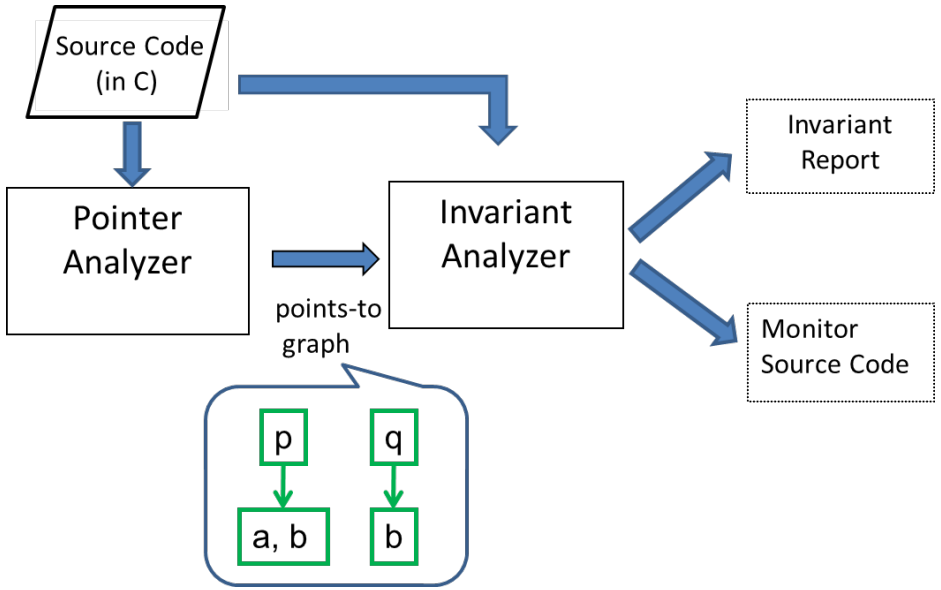
- Integrity-based defense system
  - Derive the specifications for certain integrity properties: e.g., data invariants
  - Retrofit monitors or guards to improve the runtime integrity



Data Invariant Based Detection

[Computers & Security, Vol. 43, June 2014]

- Data invariants
  - Constant invariant (e.g., b == 10)
  - Membership invariant (e.g., a ∈ {0, 2, 3})
  - Bound invariant, e.g., (a ≥ 0) & (a ≤ 3)
  - Non-zero invariant (e.g., b ≠ 0)



How to evaluate the effectiveness of the detection, given that points-to analysis is undecidable?

- False positives
- False negatives

Test Cases Used in Experimental Evaluation

- Benign test cases for Linux

Test program	*Description*
ltp	Linux Test Project: more than 700 test cases for the Linux kernel and more than 60 test cases for the network stack
Iperf	A network testing tool that measures the throughput of a network, thus exercising the network subsystem of the kernel
Andrew benchmark	A file system benchmark
Miscellaneous	Kernel compilation, ssh, scp, common commands

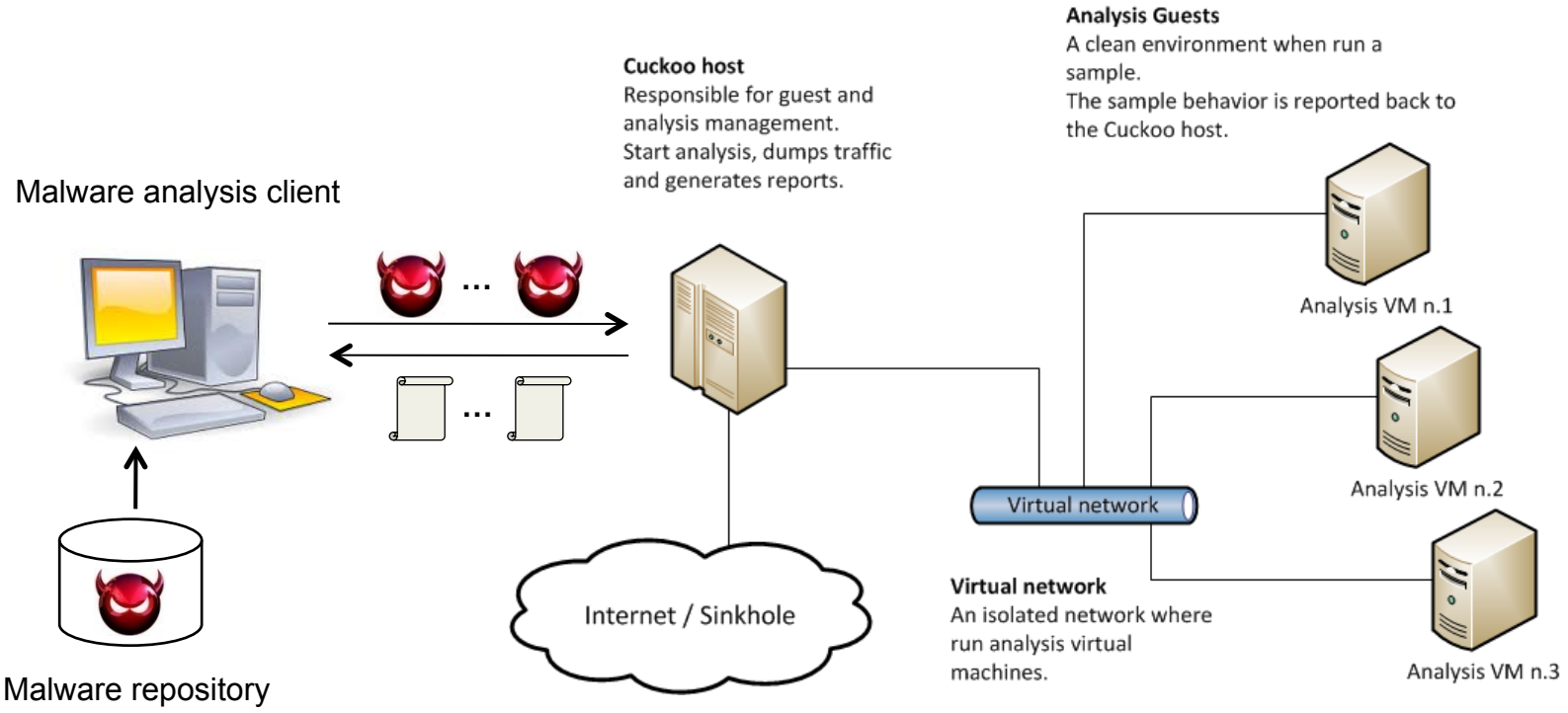
- Malicious test cases: real-world and synthetic rootkits

Experimental Evaluation of Accuracy

- False positive: one out of 141,280 (Linux), one out of 100,822 (WRK)
- False negative: successfully detect 10 real-world rootkit for Linux, 9 real-world and one synthetic kernel malware for WRK

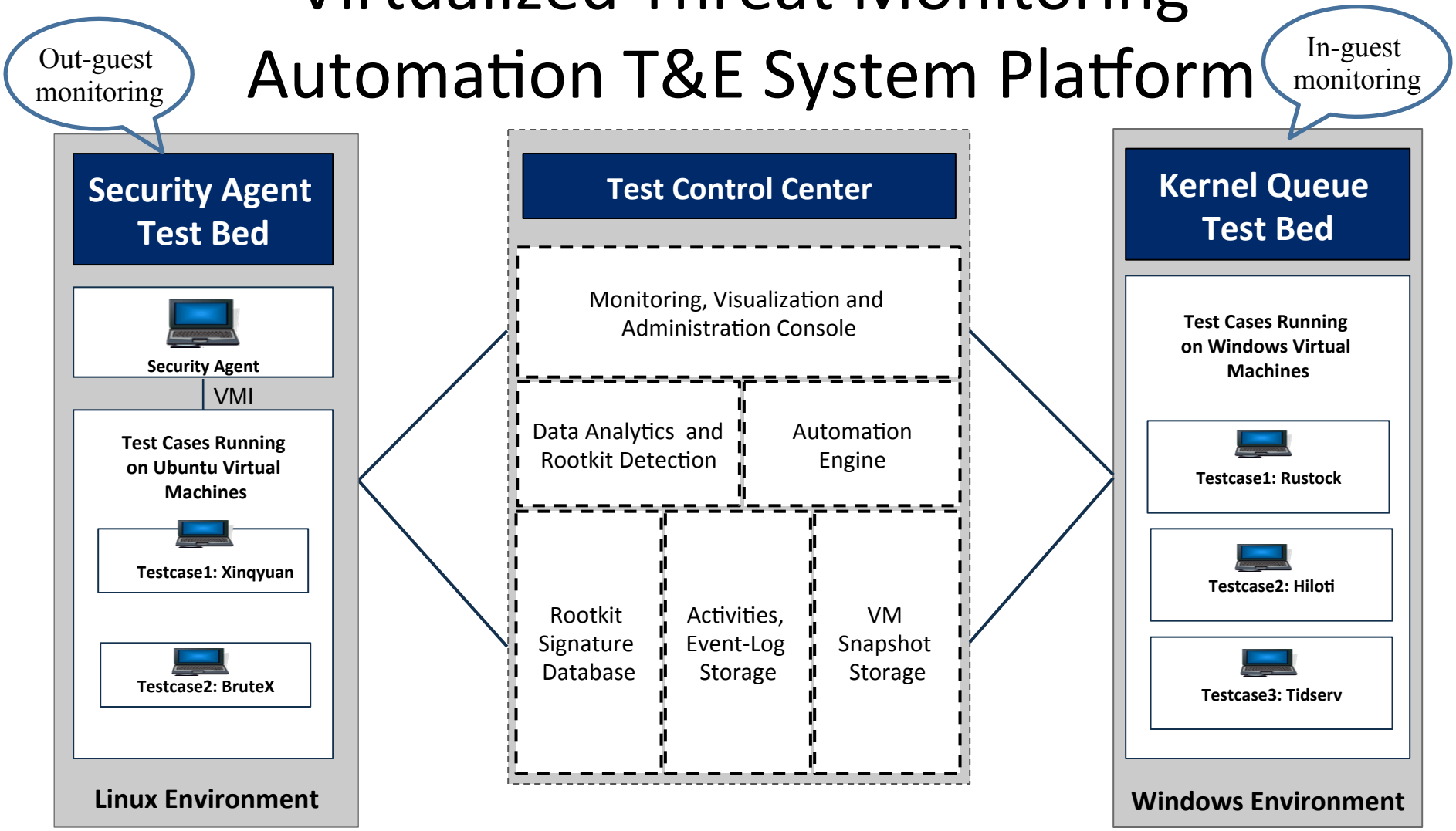
Kernel	Name	Violated Invariants
	Real-world Rootkits	
Linux kernel	Adore 0.42	sys_call_table[2,4,5,6,18,37,39,84,106, 107,120,141,195,196,220]
	Adore 0.53	sys_call_table[1,2,6,26,37,39,120,141,220]
	All-root	sys_call_table[24]
	Kbdv2	sys_call_table[24,106]
	Kbdv3	sys_call_table[30,199]
	Modhide	sys_call_table[5]
	Phide	sys_call_table[2,37,141]
	Rial	sys_call_table[3,5,6,141,167]
	Rkit 1.01	sys_call_table[23]
	Suckit 2	sys_call_table[59]
WRK	Real-world Malware Samples	
	Alureon	KiServiceTable[185]
	Bot Mailer 2	IDT[0] , IDT[1] ,..., IDT[255]
	Cutwail	KiServiceTable[x], where x=68,75,77,126,256
	Haxdoor	KiServiceTable[x], where x=49,50,128,134,151,181
	Rustock.A	IDT[0] , IDT[1] ,..., IDT[255]
	Rushtock.B	IDT[0] , IDT[1] ,..., IDT[255]
	Storm	KiServiceTable[77], KiServiceTable[151]
	TDL	KiServiceTable[185]
	Trojan.Mssync	KiServiceTable[x], where x=39,43,75,77,122,125,151,181
	Proof-of-Concept Malware Sample	
	Crash Kernel	$0 \leq$ ExpPoolScanCount ≤ 31

An Example Large-Scale Malware Behavior Analysis Experiment



- Utilize a virtualized environment (VMWare) to minimize the risk of malware propagation and ease the experimental environment setup (VM snapshots)
- Utilize the Cuckoo sandbox to capture malware's behavior (system calls, files, etc)
- Utilize a home-grown tool to monitor malware's kernel-level activities
- 63,200 malware samples automatically executed and analyzed
- Took weeks to finish

Virtualized Threat Monitoring Automation T&E System Platform



- Focus is on the test and evaluation (T&E) technology that is capable of planning, deploying, monitoring, execution, visualization & automation of threats in virtualized environment

My Perspective

- The role of experimental science and research infrastructure in the cybersecurity space
  - To evaluate a solution
    - Metrics hard to precisely quantify, e.g., this solution improves the security, by how much?
  - To verify a hypothesis
    - E.g., malware often uses mutex as infection markers
  - To understand a threat yet unknown

Future Infrastructure Needs

- Automated planning and deployment tools
- Workload generators (at given rate, pattern, etc)
- Monitoring (measurement) tools
  - Whole-system emulators
  - Instrumentation tools (custom features not provided by the original program)
  - Network monitoring tools (such as Wireshark)
- Experiment control tools
  - start/stop/abort/pause/resume/update
- Result analysis tools
  - Log parsing, data analysis, taint tracking, threat ontology

Thank You!

Jinpeng Wei

Email: weijp@cs.fiu.edu

http://www.cs.fiu.edu/~weijp

Research Topic: Result Integrity of MapReduce Computation on Public Cloud