
CSS
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中国互联网安全领袖峰会
Cyber Security Summit
智慧安全 连接赋能

Graffiti: the spraying attacks slayer

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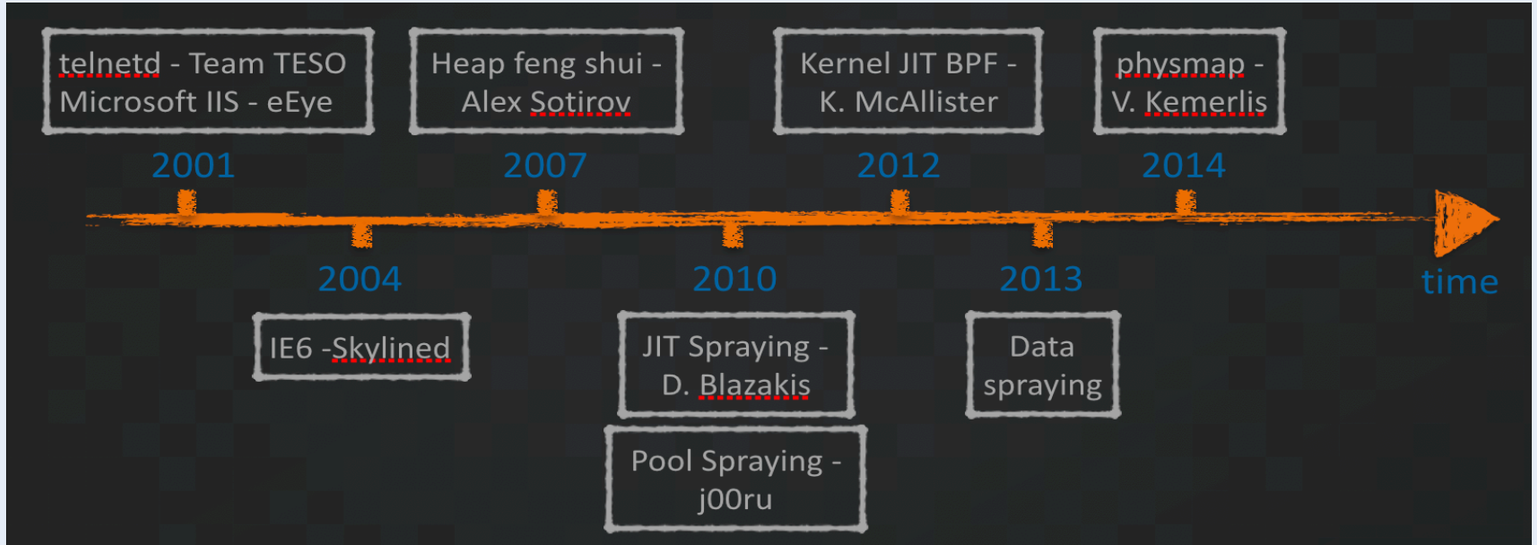
whoami

- Security researcher at Cisco Talos
- Ph.D. from Telecom ParisTech/Eurecom
- Hackademic
- Malware analysis / Memory forensics / Mitigations

SPRAYING

- Traditional code based spraying
- JIT spraying
- Data spraying and stack pivoting

SPRAYING - TIMELINE



SPRAYING – 64 bit

- Spraying still a valuable technique
  - UAF vulnerabilities
  - Flaws in ASLR implementation
  - Particular types of vulnerabilities[1]
  - 32bit processes in 64bit OS[2]

[1] https://ifsec.blogspot.it/2013/11/exploiting-internet-explorer-11-64-bit.htm
[2] http://blog.skylined.nl/20160622001.html

RELATED WORK

HEAP SPRAYING

- Egele et al. – DIMVA 09
- Nozzle – USENIX Security 09
- Bubble – ESSoS 10

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- Bania – Whitepaper 10
- JITDefender – IFIP 10
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DATA SPRAYING

- EMET – Microsoft 09
- Browser solutions

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DATA SPRAYING

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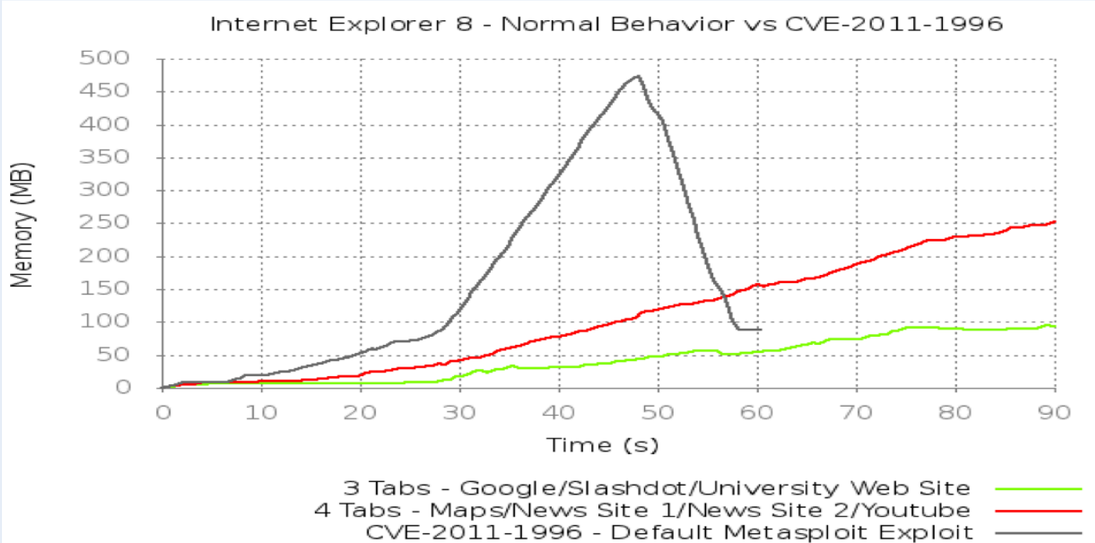
No comprehensive and scalable solutions vs spraying

No OS agnostic solutions

MEMORY FOOTPRINT



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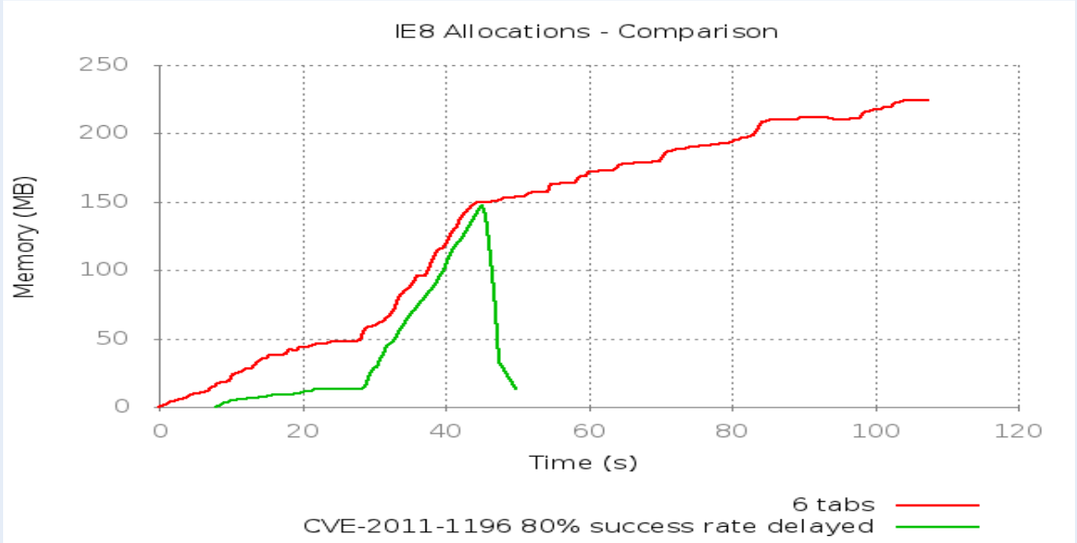


RELIABILITY – HEAP SPRAYING

- 80%: 131 MB – CVE-2011-1996
- 0%: < 131 MB - CVE-2011-1996
- Possible Watering hole scenarios

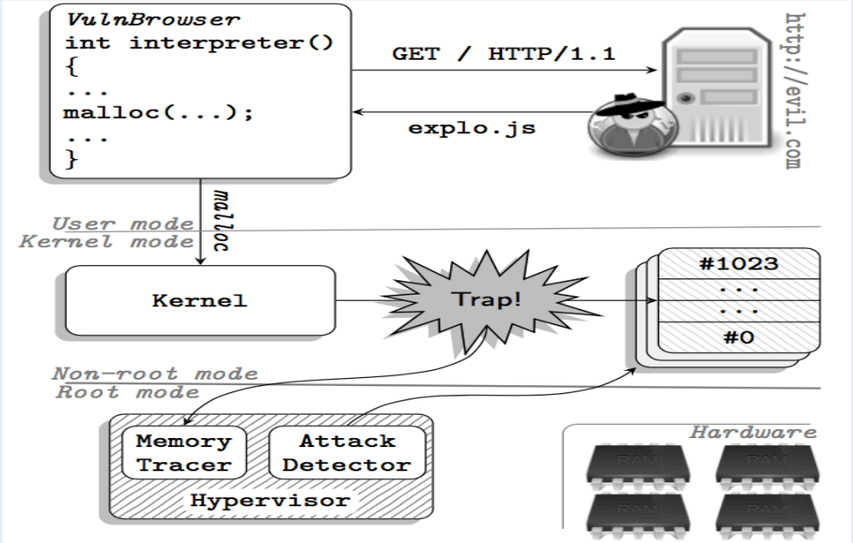
GOALS

- The system should be completely independent from the memory allocator used by the protected application
- The system should not require any OS dependent information
- The overhead introduced by the system should be “reasonable”
- Modular framework based on plugins

VIRTUALIZATION – VT-x

- `vmexit/vmentry` transitions
- `vmcall` instruction
- Virtual Machine Control Structure (`VMCS`)
- Extended Page Tables (`EPT`):
  - EPT misconfigurations
  - EPT violations

ARCHITECTURE OVERVIEW



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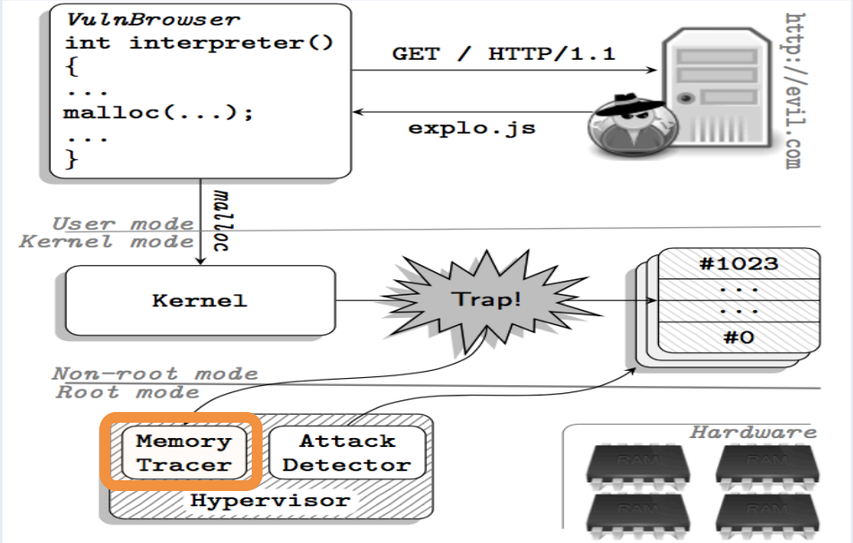
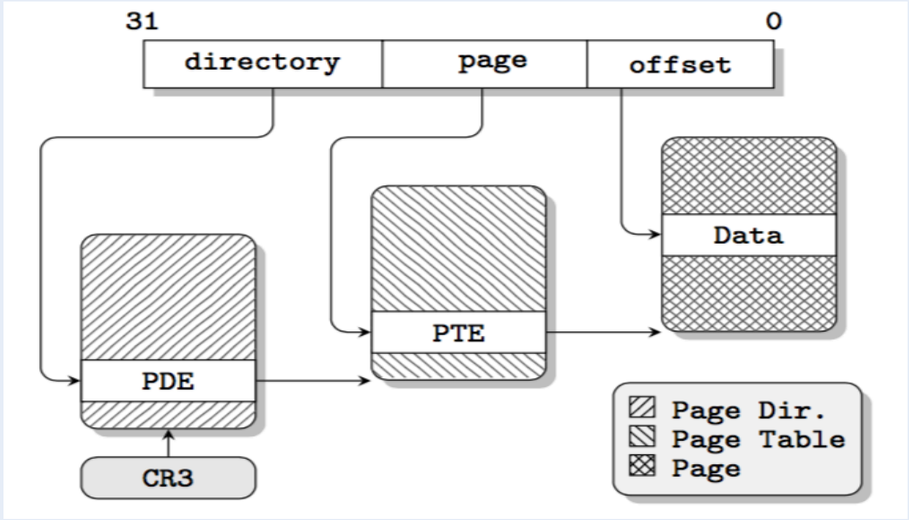


MEMORY TRACER



MEMORY TRACER

- Detection by looking at the PTEs:
  - page creation/modification/removal
- Detection by looking at the PDEs:
  - page table creation/modification/removal

INTERFERENCE PROBLEM

- Overhead issues:
  - A modification of the memory page of the running process creates a side effect modification of a memory page in another process
  - Due to kernel memory optimizations

INTERFERENCE PROBLEM

- Overhead for Internet Explorer 10 (IE): 22%
- Overhead for Acrobat Reader and Firefox on top of IE10: 63%
- IE's overhead increased from 22% to 63%

MICRO-VIRTUALIZATION

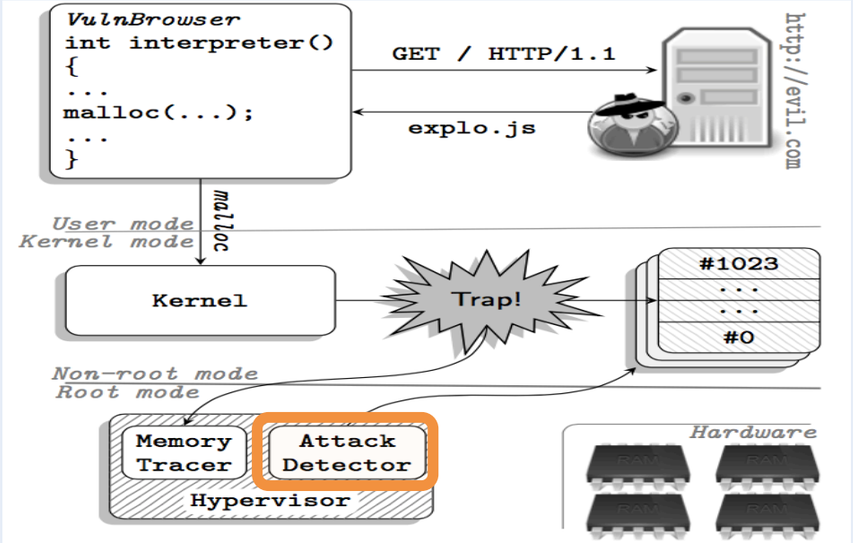
- Each monitored process runs inside its own virtual memory sandbox
- Graffiti enables the memory protection only for actual running and monitored process

MICRO-VIRTUALIZATION - DETAILS

- Micro-virtualization is based on EPT:
  - Select a set of physical pages to monitor the target process
  - One EPT Pointer (EPTP) per process

DEMO 0x00

ARCHITECTURE OVERVIEW



STATIC ANALYZER

- Set of heuristics to detect the different spraying techniques:
  - Malicious code detector [ACSAC10, SEC11]

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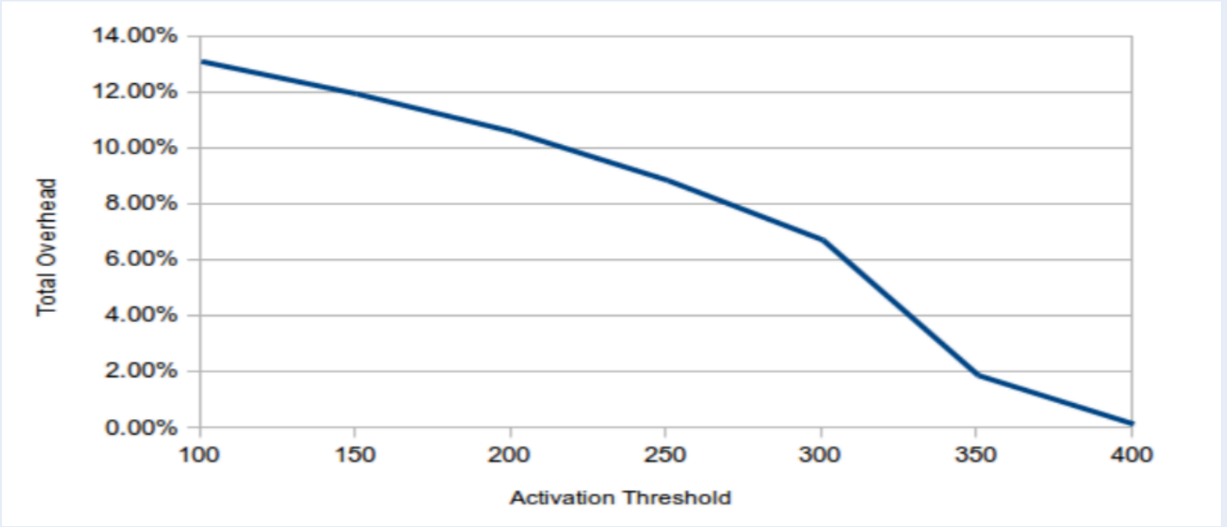
- Set of heuristics to detect the different spraying techniques:
  - Malicious code detector [ACSAC10, SEC11]
  - Self-unpacking shellcode detector [ACSAC07]
  - Data spraying detector [RAID13, RAID15]

EXPERIMENTS: OVERHEAD

- The memory tracer is always active:
- Stress suite results (8MB every 2s):
  - Windows 7: 24%
  - Linux 3.2: 25%

EXPERIMENTS: OVERHEAD



DETECTION ACCURACY

CVE	Application	Exploit Technique	Detected
2010-0248	Adobe Flash player	ROP + packed sc	Yes
2011-0609	Adobe Reader	JIT + packed sc	Yes
2011-2462	Adobe Reader	ROP + packed sc	Yes
2010-2883	Adobe Reader	Ret2Lib + packed sc	Yes
2011-1996	IExplorer	ROP	Yes
2009-2477	Firefox	Plain Shellcode	Yes

DETECTION ACCURACY

- System tested with 1000 malicious PDF, 1000 benign PDF documents and top 1000 Alexa websites.
- Conservative threshold (150MB)
- Graffiti detected all the attacks with zero false alarms

GLOBAL EXPERIMENTS

- Final global test in which real users use Graffiti during their everyday activities for a total of 8-10 hours per day in a period of 7 days.
- Conservative threshold of 150MB on IE8 for Windows 7 machines

GLOBAL EXPERIMENTS

- 492 distinct web pages visited
- Detector activated 55 times (~8 times per day)
- 12 alerts on pages that seemed to be benign. A closer inspection of the false positive shows the data spraying to be the only responsible

GRAFFITI - CONFIGURATION

- godfather/hyperdbg/hyperdbg_host.c:
  - #define TARGET1 “iexplorer.exe”
- godfather/hyperdbg/godfather.c:
  - #define EXPLOIT_THRESHOLD THRESHOLD_150MB
- Compilation:
  - make -f Makefile.windows

DEMO

DEMO 0x01

LIMITATIONS

- Possible evasion of the three heuristics described:
  - Code pointer frequency
  - Shellcode frequency analysis
- Big chunks and then ad-hoc allocation functions
- Current supported OS: Windows and Linux
- Architecture dependent (Intel)

FUTURE

- Propose stronger heuristics
- More comprehensive testing:
  - New browser versions
  - Kernel Heap spraying

CONCLUSIONS

- First efficient and comprehensive solution to defeat spraying
- Micro-virtualization
- Open source

SOURCE CODE & PAPER

- https://github.com/graffiti-hypervisor/graffiti-hypervisor

- “Micro-Virtualization Memory Tracing to Detect and Prevent Spraying Attacks”

Stefano Cristalli, Mattia Pagnozzi, Mariano Graziano, Andrea Lanzi, Davide Balzarotti

25th USENIX Security Symposium

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THANK YOU

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