Vigilante and Potemkin

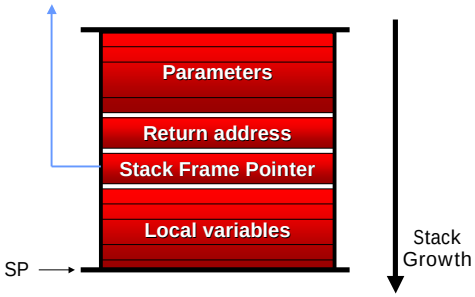
Presenter: *Ýmir Vigfússon*

Based in part on slide sets from *Mahesh Balakrishnan* and *Raghavan Srinivasan*.

Security vulnerabilities

- Lazy programmers
- Bad programmers
  - BIND, Sendmail, WU-FTP
- ✘ Buffer overflows
- ✘ Format string attacks
- ✘ Integer overflows
- ✘ Race conditions
- ✘ Command injection
- ✘ …

Simple buffer overflow

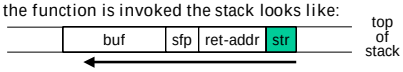


Simple buffer overflow

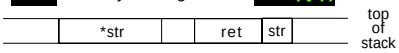
- Code on a server (written by a lazy programmer):

```
void func(char *str) {
  char buf[128];
  strcpy(buf, str);
  do-something(buf);
}
```

- When the function is invoked the stack looks like:



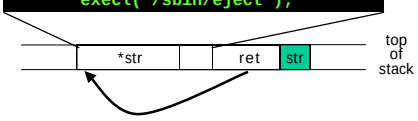
- What if `*str` is 136 bytes long? After `strcpy()`:



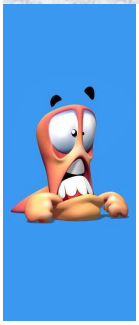
Simple buffer overflow

```
31 c0 b0 3f cd 80 31 db 89 d9
b1 02 31 c0 b0 3f cd 80 eb 1f
5e 89 76 08 31 c0 88 46 07 89
46 0c b0 0b 89 f3 8d 4e 08 8d
56 0c cd 80 31 db 89 d8 40 cd
80 e8 dc ff ff ff /sbin/eject

execl("/sbin/eject");
```



Worms



11/1988 — Cornell grad student Robert Morris writes the *Internet Worm*

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Worms

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07/2001 – CodeRed – MS IIS

09/2001 – Nimda – MS IIS+email

01/2003 – Slammer – MS SQL

08/2003 – Blaster – MS Win RPC

05/2004 – Sasser – MS Win LSASS

08/2005 – Zotob – MS Win Plug-n-Play

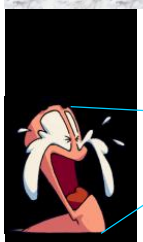
(more to come)

Worms

		Infected	2x
07/2001	CodeRed – MS IIS	360,000	37m
01/2003	Slammer – MS SQL	75,000	8.5s
08/2003	Blaster – MS Win RPC	500,000	37m

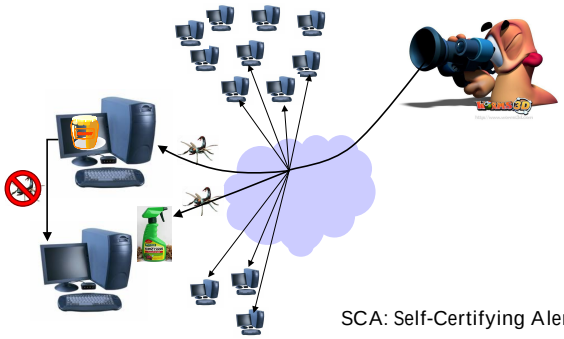
Vigilante

Manuel Costa, Jon Crowcroft, Miguel Castro, Antony Rowstron, Lidong Zhou, Lintao Zhang, Paul Barham



- Automates worm defense
  - Run heavily instrumented versions of software on detector machines
- Uses collaborative infrastructure to detect worms

Overview



SCA: Self-Certifying Alert

Dynamic dataflow analysis

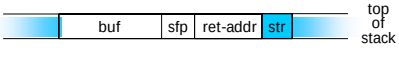
Dirty data loaded into PC → Execution control vuln.

Dirty data to be executed → Code execution vuln.

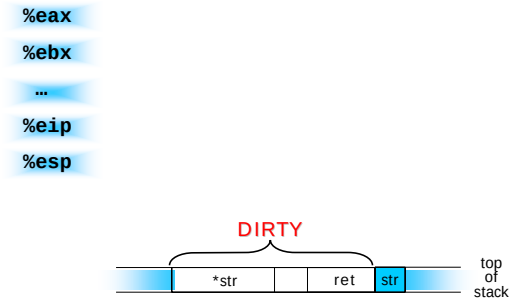
Critical fn. argument dirty → Function argument vuln.

- Specific to C/C++ vulnerabilities
- E-mail? Format string attacks?

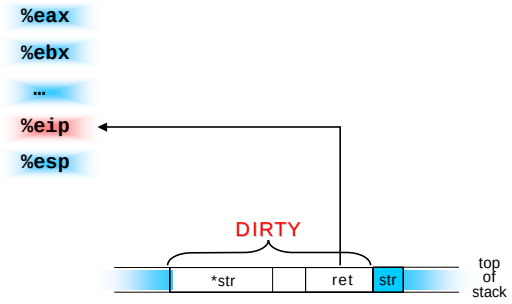
SCA generation



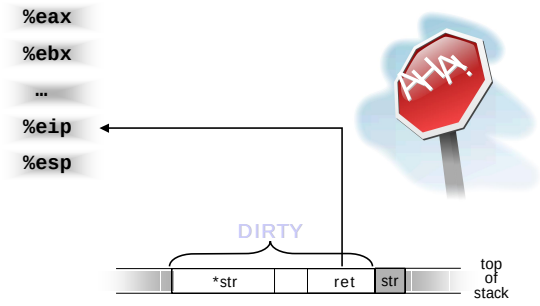
SCA generation



SCA generation

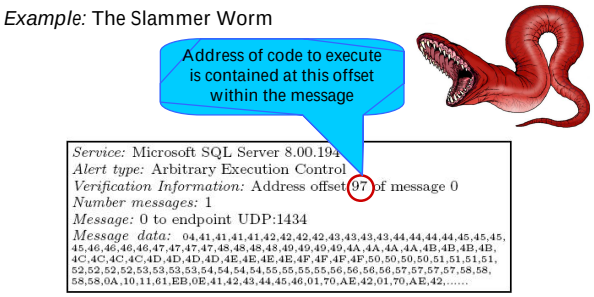


SCA generation



SCA generation

Example: The Slammer Worm



Execution control SCA

SCA verification

- Hosts run same software with identical configuration within sandbox
- Replace code / address in SCA with a call to *verified()*

No trust required

Fast, simple and generic verification

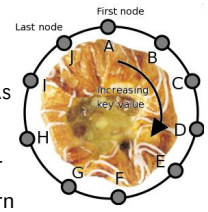
No false positives

Assumes address / code / argument is supplied verbatim in messages

Assumes message replay suffices for exploit reproduction

SCA distribution

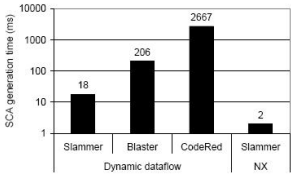
- Flooding over secure Pastry overlay
- Denial-of-Service attacks? (DoS)
  - Don't forward already blocked SCAs
  - Forward only after verification
  - Rate-limit SCAs from each neighbor
  - Use super-peers so worms can't learn the topology



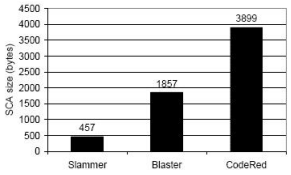
Local response

- Verify SCA
- Data and Control Flow Analysis
- Generate *filters* – conjunctions of conditions on single messages
- Two levels:
  - General filter with false positives
  - Specific filter with no false positives

Evaluation: SCA generation



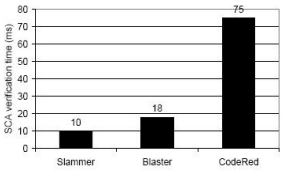
SCA Generation Time



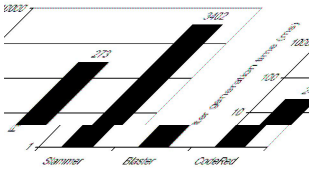
SCA Sizes

Evaluation: SCA verification

- Verification is fast. The sandbox VM is always running.



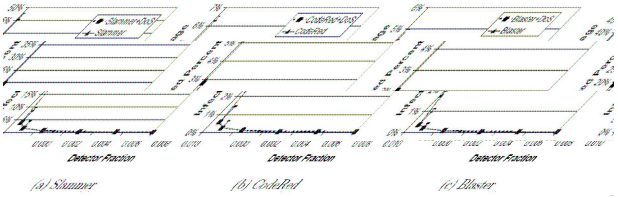
SCA Verification Time



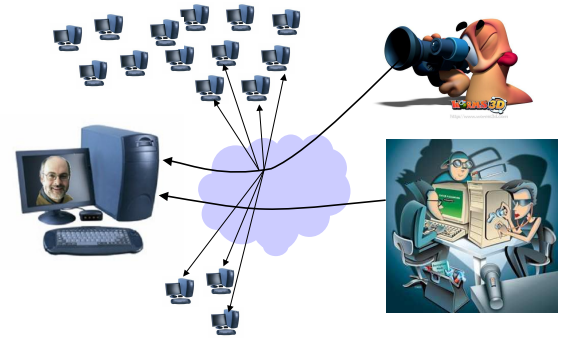
Filter generation

Simulation on real worms

- Simulate worm epidemic on 500,000 nodes, 1000 super-peers
- Includes worm-induced congestion
- DoS: Each host sends fake SCAs to all neighbors



Internet Dangers



Honeypots

"A *honeypot* is a network-connected system that is carefully monitored so that intrusions can be easily detected and precisely analyzed."

- Scalability
- Fidelity
- Containment

Honeypots

Low interaction
- High scaling
- Low fidelity

High interaction
- Low scaling
- High fidelity

Containment means that compromised honeypots should not be able to attack third-party systems.

A honeyfarm is a set of honeypots.

Potemkin Honeyfarm

Michael Vrable, Justin Ma, Jay Chen, David Moore, Erik Vandekieft, Alex C. Snoeren, Geoffrey M. Voelker and Stefan Savage

"Dynamically bind physical resources to external requests only for the *short* periods of time necessary to emulate the execution behavior of dedicated hosts."

Potemkin: a honeyfarm system that exploits:

- Virtual machines
- Aggressive memory sharing
- Late binding of resources

Potemkin Honeyfarm

Potemkin

Catherine II

Kijong Dong, N-Korea

Potemkin Honeyfarm

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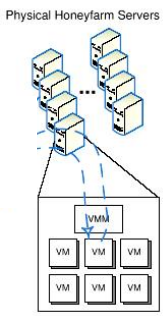
Potemkin: a honeyfarm system that exploits:

- Virtual machines
- Aggressive memory sharing
- Late binding of resources

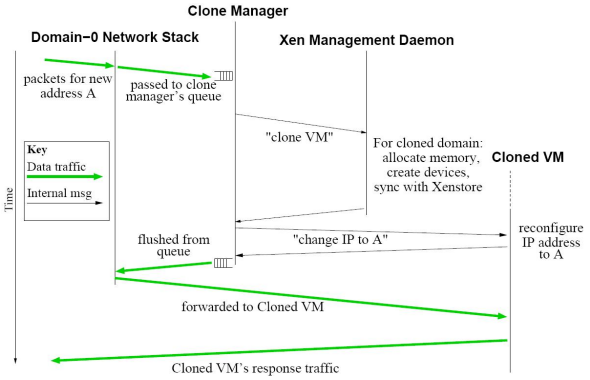
Potemkin Architecture

Virtual Machine Monitors (VMMs)

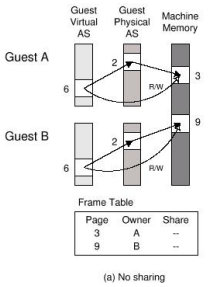
- Easy to manage. Physical resources not a major restriction.
- Each IP address spawns a new VM.
  - *Problem:* Expensive
  - *Observation*: Targets are homogenous
  - *Solution:* clone a VM from a reference image, change IP (etc.), accept packets.



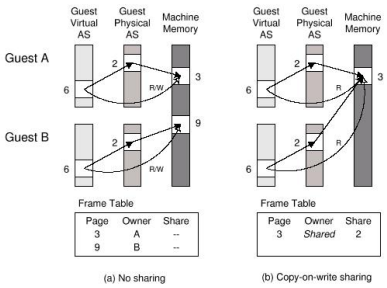
Flash Cloning



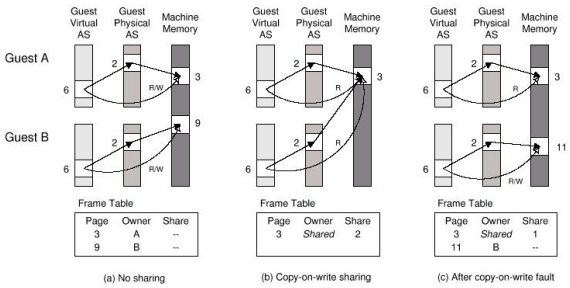
Delta Virtualization



Delta Virtualization



Delta Virtualization



Potemkin Architecture

- What if VMs are compromised?
- Gateway router policy:
  - Isolate the HoneyFarm, only send outgoing packets in response to incoming ones.
  - Other packets are internally *reflected*. Infections spread within HoneyFarm.
  - Universal identifier captures causal relationship of communication.
- Directs incoming traffic, contains outgoing traffic, resource management, user interface

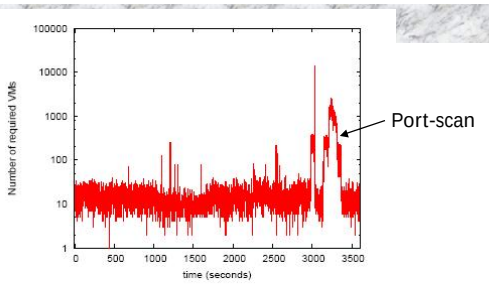
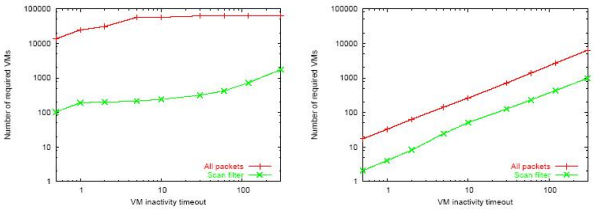


Figure 4: Required number of VMs active in response to all measured traffic from a /16 network when VMs are aggressively recycled after 500 milliseconds of inactivity. Traffic is from the one hour period starting Monday, March 21, 2005 04:05 GMT.

Evaluation: Scan filter



(a) Maximum number of simultaneous VMs

(b) Average number of simultaneous VMs

Food for thought

- How can HoneyFarms attract traffic?
- HoneyPot detection
- DoS attacks