CSci 5271
Introduction to Computer Security
Day 8: Defensive programming and design, part 2

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Outline

Bernstein's perspective

Announcements intermission

Techniques for privilege separation

Historical background

- Traditional Unix MTA: Sendmail (BSD)
  - Monolithic setuid root program
  - Designed for a more trusting era
  - In mid-90s, bugs seemed endless
- Spurred development of new, security-oriented replacements
  - Bernstein's qmail
  - Venema et al.'s Postfix

Distinctive qmail features

- Single, security-oriented developer
- Architecture with separate programs and UIDs
- Replacements for standard libraries
- Deliveries into directories rather than large files

Ineffective privilege separation

- Example: prevent Netscape DNS helper from accessing local file system
- Before: bug in DNS code
  - → read user's private files
- After: bug in DNS code
  - → inject bogus DNS results
  - → man-in-the-middle attack
  - → read user's private web data

Effective privilege separation

- Transformations with constrained I/O
- General argument: worst adversary can do is control output
  - Which is just the benign functionality
- MTA header parsing (Sendmail bug)
- `jpegtopnm` inside `xloadimage`

Eliminating bugs

- Enforce explicit data flow
- Simplify integer semantics
- Avoid parsing
- Generalize from errors to inputs

Eliminating code

- Identify common functions
- Automatically handle errors
- Reuse network tools
- Reuse access controls
- Reuse the filesystem

The “qmail security guarantee”

- $500, later $1000 offered for security bug
- Never paid out
- Issues proposed:
  - Memory exhaustion DoS
  - Overflow of signed integer indexes
- Defensiveness does not encourage more submissions

qmail today

- Originally had terms that prohibited modified redistribution
  - Now true public domain
- Latest release from Bernstein: 1998; netqmail: 2007
- Does not have large market share
- All MTAs, even Sendmail, are more secure now

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Note to early readers

- This is the section of the slides most likely to change in the final version
- If class has already happened, make sure you have the latest slides for announcements

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Techniques for privilege separation

Restricted languages

- Main application: code provided by untrusted parties
- Packet filters in the kernel
- JavaScript in web browsers
  - Also Java, Flash ActionScript, etc.

SFI

- Software-based Fault Isolation
- Instruction-level rewriting like (but predates) CFI
- Limit memory stores and sometimes loads
- Can’t jump out except to designated points
- E.g., Google Native Client

Separate processes

- OS (and hardware) isolate one process from another
- Pay overhead for creation and communication
- System call interface allows many possibilities for mischief

System-call interposition

- Trusted process examines syscalls made by untrusted
- Implement via `ptrace` (like strace, gdb) or via kernel change
- Easy policy: deny

Interposition challenges

- Argument values can change in memory (TOCTTOU)
- OS objects can change (TOCTTOU)
- How to get canonical object identifiers?
- Interposer must accurately model kernel behavior
- Details: Garfinkel (NDSS'03)

Separate users

- Reuse OS facilities for access control
- Unit of trust: program or application
- Older example: qmail
- Newer example: Android
- Limitation: lots of things available to any user

`chroot`

- Unix system call to change root directory
- Restrict/virtualize file system access
- Only available to root
- Does not isolate other namespaces

OS-enabled containers

- One kernel, but virtualizes all namespaces
- FreeBSD jails, Linux LXC, Solaris zones, etc.
- Quite robust, but the full, fixed, kernel is in the TCB

(System) virtual machines

- Presents hardware-like interface to an untrusted kernel
- Strong isolation, full administrative complexity
- I/O interface looks like a network, etc.

Virtual machine designs

- (Type 1) hypervisor: 'superkernel' underneath VMs
- Hosted: regular OS underneath VMs
- Paravirtualizaion: modify kernels in VMs for ease of virtualization

Virtual machine technologies

- Hardware based: fastest, now common
- Partial translation: e.g., original VMware
- Full emulation: e.g. QEMU proper
  - Slowest, but can be a different CPU architecture

Modern example: Chrom(ium)

- Separates “browser kernel” from less-trusted “rendering engine”
  - Pragmatic, keeps high-risk components together
- Experimented with various Windows and Linux sandboxing techniques
- Blocked 70% of historic vulnerabilities, not all new ones
- `http://seclab.stanford.edu/websec/chromium/`

Next time

- Protection and isolation
- Basic (e.g., classic Unix) access control