Sandboxing and Isolation

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Review

- **Preventing privilege escalation**
  - **Drop privileges asap**
  - **Privilege separation**

Sandboxing

- **Building a controled environment for untrusted third-party applications**
  - **Can only access the given resources**
  - **Ensure application does not deviate from pre-approved behavior**
- **Examples**
  - **Filesystem isolation**
  - **Disk quotas**
  - **I/O rate limiting**
  - **Memory limits**
  - **CPU quotas**
  - **Network control and rate limiting**

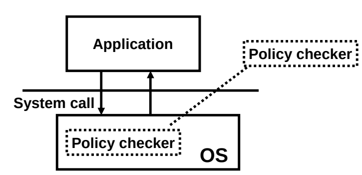
Different Examples

- **chroot, BSD jail commands**
  - **Only for file permissions**
  - **Coarse grained**
  - **http://en.wikipedia.org/wiki/Jail_(computer_security)**
- **System call interposition**
  - **More general**
- **Java virtual machine**
  - **More fine grained**
- **Virtual machine**
  - **Whole system**

System Call Interposition

- **Malicious programs usually need to make system calls to do harm to the system**
- **System call interface is a natual place to place security checks & enforce security policies**
- **What kind of policies do we want to enforce?**
  - **A process cannot open certain files**
  - **A process may have restricted network access**
  - **A process may not send network packets after reading certain files**
- **Policy can be written as**
  - **Whethre a single action is allowed**
  - **Whether a sequence of action is allowed**
  - **An automata**

How to Enforce a Policy?



- **Intercept system calls**
- **Information passed on to policy checker before system call is processed**
- **Policy checker**
  - **In kernel**
  - **User space**
    - **Be careful with race conditions**

Sandboxing Case Study: iPhone & Android

- **Miller attacks on iPhone & Android**
- **Security architecture & consequences**

iPhone design weakness & consequences

- **Security design weakness:**
  All processes of interest run with administrative privileges
- **Consequences: iPhone attack (Miller Jul 2007)**

iPhone Safari downloads malicious web page

- **Arbitrary code is run with administrative privileges**
- **Can read SMS log, address book, call history, other data**
- **Can perform physical actions on the phone.**
  - **system sound and vibrate the phone for a second**
  - **could dial phone numbers, send text messages, or record audio (as a bugging device)**
- **Can transmit any collected data over network to attacker**

See http://www.securityevaluators.com/iphone/

Android

- **Operating system for T-Mobile Google phone**
  - **Open Handset Alliance**
- **Miller's attack: Oct 24, 2008**
  - **Exploit an unpatched vulnerability**
  - **Surfing malicious website can exploit browser**
- **Consequences**
  - **Get full privilege of the browser**
    - **E.g., access to cookies, keystrokes entered in browser**
  - **However, can't do other things such as dial the phone directly**
  - **Contrast to iPhone**

Android Security Architecture

- **Each application runs in its own process**
  - **Its own Java Virtual Machine**
- **Application signing**
  - **Each application (.apk files) is signed**
- **Sandboxing**
  - **Each application package (.apk file) installed is given unique userID**
  - **Can only access to its own data**
  - **Default setting: no other permission**
  - **Explicitly declare permission needed at install time and get approval from user**
  - **Grant data access permission to other processes**
  - **http://code.google.com/android/devel/security.html**

Challenges for Sandboxing

- **Complete mediation**
- **Tradeoff between usability/convenience and security**

Administravia

- **Midterm Statistics:**
  Mean: 34.29
  Standard deviation: 7.77
  1st quartile: 28.38
  2nd quartile (median): 34.25
  3rd quartile: 39.75

  Extra Credit:
  Mean: 1.48
  Standard deviation: 1.76
  1st quartile: 0
  2nd quartile (median): 1
  3rd quartile: 2

Administravia

- Slides format?
  - 3 or 6 slides a page
- Project 2

Fault Isolation

- Fault Isolation
  - The fault in one program or one part of the code cannot harm other programs or other parts of the code
  - Very important for security in running untrusted or untrustworthy code
  - "Harmness"
    - » E.g., read/write memory it's not supposed to
- Hardware fault isolation
  - Processes
  - What properties/protection does process provide?
    - » Memory protection
    - » Other resources such as file handles are separated as well
  - Works well for some applications

Disadvantage of Hardware Fault Isolation

- Process inter communication is expensive
  - Add significant performance overhead if often
- Why is process inter communication expensive?
  - Trap from user to kernel back to user
  - Context switch is expensive
    - » Flush TLB, cache miss, etc.
  - Often 2-3 orders of magnitude more expensive than normal procedure call

How to Address This?

- Software Fault Isolation (SFI)
- Question:
  how to protect a piece of code from harming other parts of the program even though they run in the same address space?

Motivation

- Today's systems are designed to be extensible
  - OS kernel module/drivers
- Extension accounts for over x% of Linux kernel code
  - x=70 [Chou et. al.]
- Windows XP desktops
  - Over 35,000 drivers with over 120,000 versions [Swift et. al.]
- Drivers cause 85% of reported failures in Windows XP [Swift et. al.]

Desired Properties of Extensible Architecture

- Efficiency
- Security model: extension code may be
  - Malicious
  - Buggy
- Protection
  - Extension should not read and/or write to certain regions in host ← Isolation, sandbox
    - » Do no harm to others
    - » Why do we care about Read?
  - Other more sophisticated security policies
  - Need more efficient mechanisms than hardware fault isolation

Software Fault Isolation

- Idea: insert code in extension code to ensure certain security properties
- SFI [Wahbe et. al. 93]
  - Software fault isolation
  - Security property to guarantee:
    Extension code only writes and jumps to dedicated data and code region
  - How to ensure this?