Dealing with Unreliable Software: Exile, Jail, and other Sentences

Bernd Grobauer, Siemens CERT
Heiko Patzlaff, Siemens CERT
Martin Wimmer, Siemens CERT
Trust is the basis of good working relationships – or is it?

Stuff I work with:

- Mozilla Firefox
- Acrobat Reader
- Microsoft Office
- Calculator

Stuff I trust:

- Mozilla Firefox
- Acrobat Reader
- Microsoft Office
- Calculator

- Complex and extensible through plugins
- Vulnerability-ridden
- Very much in focus of attacker
- Frequently process content downloaded from Internet
Complexity: Fuzzing Input/Protocol Complexity

# of Vulns found during MoBB:

- MSIE: 25
- Apple Safari: 2
- Mozilla: 1
- Opera: 1
- Konqueror: 1
Extensibility: The next big headache ...
### Vulnerabilities over Vulnerabilities

#### Zero-day exploits of MS products 06/07

(excerpt, source [eEye07])

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<td>Microsoft HTML Help Workshop Multiple File Handling Buffer Overflow Vulnerabilities</td>
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### Critical vulnerability unpatched for 300 days

- 33 unpatched IE and Microsoft Office vulnerabilities

Date: 05/10/2007

Source: [FrSIRT07]
Attacker-Focus

Then: the good old times of scanning worms

Now: Drive-by infections via browsers & tampered documents
What to do

- Traditional security mechanisms
  - Patch systems
  - Virus scanners
  - Firewalls
  - Host intrusion prevention systems

- Separation / Isolation of critical systems
  - Do not hinder vulnerabilities to be exploited
  ... but: *restrict their impact!*
Poor man’s separation

- Start browser as different user with limited rights

- What other methods of separation are there?
- How do they affect integration/usability?
Degrees of Separation

Ease of Integration

Increasing Separation

- Physical Separation
- OS-Virtualization
- Application-Virtualization
- Strict Access Controls
Physical Separation

- Basic Idea: Run untrusted client software on dedicated system, enable remote access for users

- Enabling Technologies:
  - Terminal-Server Solutions (RDP, Citrix, ...)
  - Windows-Forwarding (X11)

- Integration/Usability Issues:
  - works only with network access to server
  - how to download/upload data
  - how to view data (where are the viewer applications located?)
  - may be cumbersome to use (cut & paste, ...) (depending on used technology)

- Use Case:
  - Providing tightly controlled Internet-WWW-connectivity in high-security environment
OS Virtualization

- Allows running more than one operating system on the same hardware simultaneously

![Diagram showing OS Virtualization]

- Host OS
- Virtual Machine Monitor (VMM)
- Hardware Layer
- Alternative: Hypervisor
- VM0
- VMn
The NSA NetTop Project (1999-2000)

- Project envisioned use of virtualization technology to
  - provide additional layer of security to COTs components
  - "unclutter" desktop by putting several devices (filter component, encryption component, different clients for different security levels) on one box
- Commercialized as HP "NetTop"

(Source: Meushaw, R. & Simard D., "NetTop", Tech Trend Notes, Volume 9, Edition 4)
Our Experiment: Secure yet User-Friendly Browsing (I)

- Open trustworthy webpages in „real“ user environment
- Open downloaded trustworthy document types with applications on „real“ user environment
- Open untrustworthy webpages in browser running on virtual machine
- Open downloaded untrustworthy document types with applications on virtual machine
- Give user as much support as possible:
  - automatically open webpages/documents in trusted/untrusted environment based on configurable policy
  - provide user-guidance
Our Experiment: Secure yet User-Friendly Browsing (II)

Implementation using browser helper object and controlled communication between trusted environment and OS in VMWare
Our Experiment: Secure yet User-Friendly Browsing (III)

- Technical Experiences:
  - URL-based dispatch works rather nicely:
    - BHO examines URL
    - If URL is to be displayed in other browser,
      - request is stopped
      - user is informed via information window
      - request is forwarded to other browser
  - Filetype-based dispatch harder: reliable determination of filetype requires download
- Points to ponder:
  - user experience still clumsy
  - OS in virtual machine requires
    - license
    - maintenance (patching!)
  - also virtual machines may be vulnerable (cf. Ormandy, „An Empirical Study into the Security Exposure to Hosts of Hostile Virtualized Environments“)
Application Virtualization

- Layer between the operating system and applications
- Virtualizing the system environment of programs, providing components such as registry entries, files, environment variables, and global objects
- First steps towards application virtualization: Unix chroot and BSD jail

BSD jail = \text{chroot} + \text{restricting activities such as module loading, mounting files systems, etc.}

- hiding processes not within jail
- restricting access to network ports

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Application Virtualization (II)

Several products offering „application virtualization“ available for Windows:

- **Application centric**
  - Central administration of applications in client-server-environments
  - Support for different program versions
    - altiris
    - MS Softgrid
    - CITRIX

- **Security driven**
  - Security sandboxes
  - Isolating malware infections
    - Sandbox
    - GreenBorder

OS Virtualization vs. Application Virtualization

- Application Virtualization draws separating border tighter around application; less overhead, easier integration, better usability
- But: what does the exact border look like? Does it keep everything inside that it should?
Test-Cases for Application Virtualization Solutions

- Does the sandbox provide total isolation from infection by hostile web sites, 0-day threats, spyware, trojans, keyloggers, blended malware attacks and other contemporary malware threats?
- Is personal data on the "real PC" inaccessible to sandboxed programs?
- Does the product prevent sandboxed programs from reading and writing to raw memory?
- Does the product prevent sandboxed programs from accessing key system data such as system configuration and network information?
- Does the product prevent sandboxed programs from deliberately crashing the system?
- Can a hostile program escape the sandbox by terminating the application virtualization solution?

[Source: http://www.techsupportalert.com/security_virtualization.htm]
Strict Access Controls: SELinux, for example (I)

- Concept of subjects/objects and associated access vectors

- Rules that allow/deny access based on some system. SELinux associates each subject/object with a security context:
  
  \[
  \text{identity} : \text{role} : \text{domain/type} : \text{sensitivity-level} : \text{compartment}
  \]

- The security context
  - is used to control whether a subject is allowed to access an object with a certain access vector
  - is not static but goes through transitions – and getting the transitions right is actually at least as tricky as defining access restrictions for each context
Strict Access Controls: SELinux, for example (II)

SELinux offers several access control systems:

**identity : role : domain/type : sensitivity-level : compartment**

### Role-based AC

- Put additional constraints on type enforcement:
  - only allow transitions if role is in both start and end domain/type
  - replace UNIX user with identity and grant rights for different contexts by giving several roles to user

### Type Enforcement

- Lock down access based on a system of subject domains and object types:
  - allow certain access vectors to objects of a certain type only for subjects in a given domain
  - describe transitions between domains and types for newly created subjects/objects

### MLC/MLS

- MCS = Multi-category security
- MLS = Multi-level security

- Put additional constraints on type enforcement based on ordering of sensitivity levels and sets of compartments
  - MCS is subset of MLS, as it uses only one sensitivity level. Access is granted only to subjects that possess all compartments/categories that are demanded for the object in question
  - MLS has its theoretical foundation in Bell-La Padua
Strict Access Controls: SELinux, for example (III)
Type Enforcement applied to Postfix

Source: Hinrichs, Naldurg: „Attack-based Domain Transition Analysis“
Strict Access Controls: SELinux, for example (IV)

Type Enforcement offers best possibility for application separation:

- With an appropriate set of rules, the type enforcement mechanism can separate subjects from one another on the same system
- In the default case,
  - a process is given a particular domain
  - all new processes created from that process are labeled with one of a set of domains created specifically for that application
- Thus, if a subject is compromised, the type enforcement rules constrain the actions an attacker can take with help of the compromised subject.

So far, mostly used for server rather than client applications, e.g., hardening IBM Websphere with SELinux (pilot project for British government)
Windows Vista: Improved Separation Mechanisms built in?

- **Windows Resource Protection (WRP)**
  - Prevent system registry keys and system files from being replaced
- **User Account Control (UAC)**
  - **Basic idea:**
    - Use administrator account only if absolutely necessary
    - In all other cases use standard user profiles
      - Avoid silent installations of malware
  - **How realized:**
    - Administrative user tokens are split into
      - a full administrator access token and
      - a standard user access token
    - Desktop and explorer are launched with standard user access token
    - Applications inherit their access control data
      - hence, they all run as a standard user as well
    - Users are prompted if administrative rights are required
- **Mandatory Integrity Control (MIC)**
- **File System and Registry Virtualization**
Mandatory Integrity Control

- Based on Biba model
- Four integrity levels
  - low (e.g., MS Internet Explorer)
  - medium (default)
  - high (elevated, administrative privileges)
  - system (only for system objects/processes)
- Securable objects:
  - files, folders, pipes, processes, threads, registry keys, services, ...
- Hinders low integrity code from modifying processes of higher integrity levels

![Diagram showing services.exe classified as system and malware attacks failing due to low classification.]
Conclusion

- Risk of compromise of untrusted/highly vulnerable applications can be mitigated by separating applications from productive environment
- Several possibilities exist:
  - Physical Separation
  - OS-Virtualization
  - App.-Virtualization
  - Strict Access Controls

- For client applications, user usability not sufficient for most use cases
- Possible solution for high-security environment
- Allow better integration
- Will increasingly become a part of modern operating systems as standard features