COMS E6998-9:

Software Security and Exploitation

Lecture 8: Fail Secure; DoS Prevention; Evaluating Components for Security

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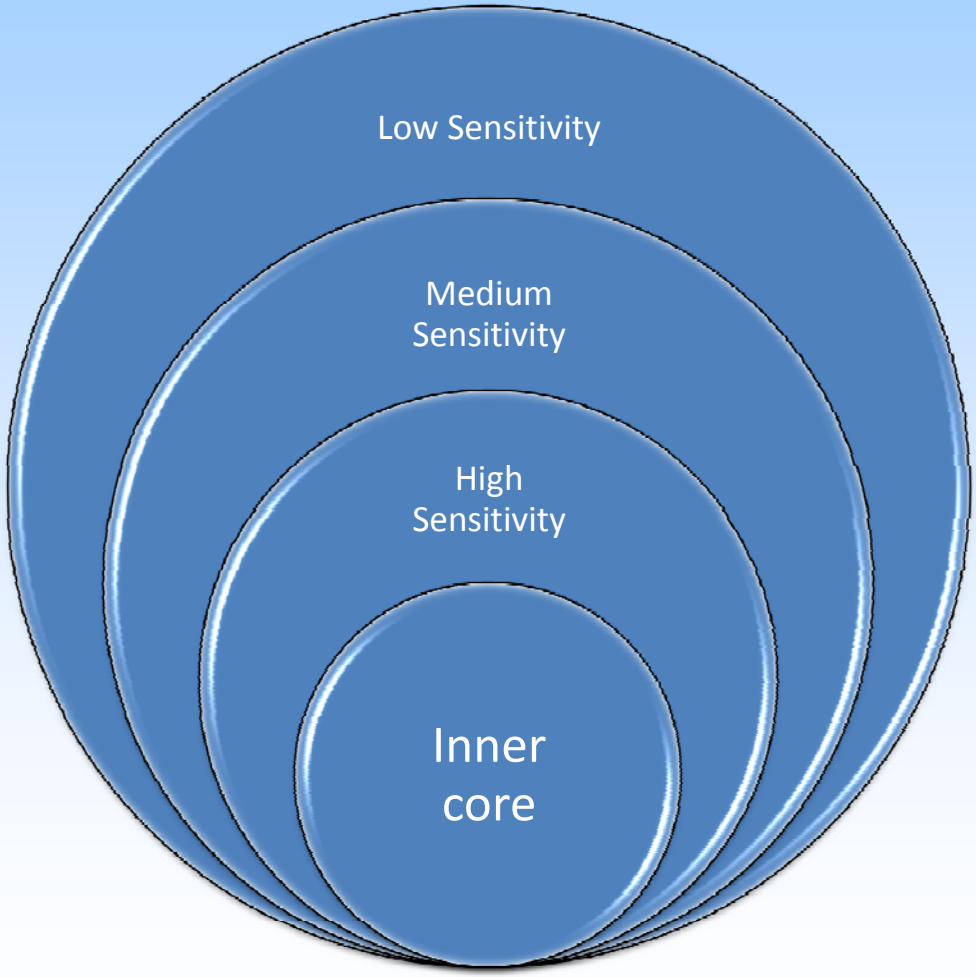
Failing Securely and Denial of Service Prevention

Overview

- We'll begin this section by looking at three of the most important concepts in computer security:
  - Defense in depth
  - Compartmentalization
  - Principle of least privilege
- Applying these three principles can greatly reduce (and sometimes eliminate) the impact of a vulnerability

Defense in depth - intro



Compartmentalization

- Closely related to defense in depth is compartmentalization
- The idea is to separate processes, applications and functionality so that a compromise of one system doesn't mean a compromise of them all
- Partitioning can happen at the
  - Network level: Firewalls, routers, etc.
  - Operating system level: ACLs, containers, VMs, etc.
  - Application level: forked processes, exception handling, etc.

Least Privilege

- An application or process should only be given the permissions it needs to complete a task; no more and no less
- Some immediate consequences:
  - Big applications that have to do certain tasks with elevated privileges (root, administrator) should be broken up into components
  - Many of the applications that run as administrator have a very small amount of code that needs that permission
  - You shouldn't just assign a high permission level to make something work; understand what permissions are needed and why

Security and Exception Handling

- One of the biggest software security sins is not planning for failure
- Environmental failures, bugs and exceptions will occur: it's how they're handled that makes the difference
- When writing exception handlers consider:
  - What data needs to be saved (what was the application doing)
  - What data needs to be purged
  - Degrade functionality and security commensurately (eg. Don't just stop logging if you get a disk full message)
  - Calls to APIs can fail so check return values

Error Handling Tips

- Have a clear understanding of the API you are calling
  - Does it set the error code variable to give more information? (*errno*, SetLastError())
  - Does it return an error value?
- Carefully write error handlers
  - Use try/catch to handle exceptions
  - Return values can be handled with if statements
  - Where relevant use information like GetLastError() inside your error handling code to better understand the error**

  WARNING: Make sure your API actually sets an error code before making decisions based on it
- Test your error handler
  - Most error handlers are woefully under-tested
  - Use fault injection techniques to execute them

Beware of disclosing too much information

- The natural developer tendency is to be as detailed as possible in an error message for debugging
- Detail can give attackers a HUGE advantage
- Common offenses:
  - ODBC Errors – Disclose SQL query strings, settings, implementation details, etc.
  - Login failure – Disclose whether the Username or Password was wrong
- Remember, generic error messages to a user is good
  - Can also include an incident number where details are stored in a secure log

Patchability

- Vulnerabilities are inevitable so the system must be designed so that it is patchable with minimal user impact
- Consider how patches:
  - Will be delivered to users
  - Can be applied to systems
  - Will impact the system (reboot, re-image, downtime, etc.)
  - Can be distributed simply (consider patch size)
  - Can be distributed if the system is being actively attacked
  - Can be authenticated as from the vendor

Race Conditions

- Also called Time Of Check To Time Of Use (TOCTTOU) vulnerabilities
- Happens because we assume that a sequence of actions are continuous and that no resources are modified in the middle

Understanding DoS weaknesses

- Motivations of attackers may be simply to interrupt service
- Security is also about ensuring that a user cannot deny other users legitimate access to functionality and data
- Some of the most difficult attacks to prevent against
- May include starving: memory, disk space, bandwidth, CPU
- Consider carefully:
  - How the application receives data
  - If safeguards (such as login attempt lockout) can be leveraged by an attacker
  - That point loads can and will occur
  - How the system should respond under heavy load

Throttling for DoS prevention

- The reason that many actual outages occur is poor failure planning
- One technique to deal with DoS attacks is throttling
- The idea is to degrade service selectively under attack as opposed to cutting it off
- Remember: Attackers may use a reactive defense against you

Authentication and Authorization

To begin, a few definitions

- *Identification* is the act of professing that you are something or someone
- *Authentication* is the act of proving authenticity (or proving identity)
- *Authorization* is associating privileges with that one entity has on another entity (such as privileges a user has over a file)

Authentication

- There are several ways to authenticate:
  - Something you are
  - Something you have
  - Something you know
  - *Something you do (often considered to be a subset of *something you are*)
- Using any *n* of the above is described as *n*-factor authentication
  - E.g. Using an ATM card with a PIN

Authorization - Types of Access Control

- Mandatory Access Control – Access control based on the sensitivity of the object
- Discretionary Access Control – Access control based on the discretion of the object owner
- Role-Based Access Control – Access control based on an entities role

Authentication Technologies

- Basic authentication
- Digest authentication
- X.509 certificates
- Kerberos
- SSL/TLS
- *LDAP and Active Directory

OS Security Models - Windows

- Uses Access Control Lists (ACLs) to protect resources by restricting what can be done with them
- Discretionary ACLs (DACLs) define what can be done to objects
- System ACLs (SACLs) determine what to log when a resource is accessed
- DACLs and SACLs are composed of a list of zero or more Access Control Entries (ACE)

Windows Warnings

- Analyze business logic to set ACLs appropriately
  - Formalize access control requirements in a specification
  - Ensure the resources are deployed, implemented, and tested to meet specifications
- Never use a NULL DACL
  - This defaults to everyone, full control
- Be careful with ACE order – it matters
  - Specify deny permissions before allow
- Be careful with ACL inheritance

OS Security Models – Linux/Unix

- Permissions are defined for:
  USER (u), GROUP (g) and OTHERS (o)
- Permissions can be set for:
  READ (r), WRITE (w) or EXECUTE (x)
- Some flavors of Linux/Unix support more granular ACLs
- Setuid allows users to run executables with temporarily elevated privileges in order to perform specific tasks (e.g. passwd)

Unix/Linux tips and warnings

- Chroot() system call enables you to “change the filesystem root” to a specific directory and confine an application
- Beware the symbolic link – many UNIX exploits take advantage of insecure temporay file creation
  - Result: Bait and Switch

3rd Party and OS Component Security

Understanding the "Weakest Link" Principle

- Software is only as secure as its weakest component
- Whenever something is added to a system we inherit both its utility and its vulnerabilities
- A heroic security effort on one component can be negated by adding a weaker component
- Need to focus on addressing risk broadly

Inherited risks from 3rd party components

- Several risk come from external components:
  - Coding flaws
  - Mismatch in handling data (not sanitizing memory, etc.)
  - Updates and patches that could become a product liability
  - A broader audience of folks looking for vulnerabilities
  - Licensing issues
  - Maintenance issues

Evaluation: Security Quality versus Quality of Security Service

- When we evaluate a component for security we must also look carefully at its supplier
- Need to ensure that the software is at a comparable level in terms of security quality
- Need to ensure that lifecycle practices include security too because you are essentially signing up for a “service”

Questions to start asking vendors or component providers about security

- Do you have a dedicated team to assess and respond to security vulnerability reports in your products?
- What is your vulnerability response process?
- What process improvements have you made as a result of vulnerabilities reported in your software?
- What is your patch release strategy?
- What training does your development and testing organizations receive on security?
- What level is this product certified to: EAL, CC, ...?

Some Questions about Security Showing to consider in RFPs

- How is security involved in your SDLC?
- What percentage of your dev and test team is focused on security?
- Does your company monitor the latest attack trends in the underground community and consider how those trends may affect your software?
- Do you offer organizations secure implementation guidance?
- Do you patch all currently supported and vulnerable versions of your applications / platforms at the same time?
- What are the terms and period of your security support agreement?
- Does your development team perform regular audits

Creating a safety net around other people's code

- Be suspicious of data received
- Remember that an external component may not handle data the same way you do
- Updates may change the way the component works or the bounds of data that is returned
  - Particularly a concern for web services
- Enforce assumptions about data in your own code – especially the 3rd party code is beyond your control
- Remember that external API calls can fail and create error handlers accordingly