Section 5: Secure Systems Design and Development

Having learned basics of computer security and data security, in this section, you will learn how to develop secure systems.

In particular, we will learn threat modeling process during secure system design.
Objectives

- To introduce application types
- Understand secure software development process
- Learn threat modeling
- Case Study – Example threat modeling
Software applications can be categorized into the above types. Application type generally influences the type of architecture and threat models to be used.
Agents run unassisted and carry out a specific function. An agent can communicate with other agents and users. A software agent can perceive the changes in the environment and react to them. Agents are useful in distributed applications and there is need for communication, especially over the Internet. Agents have ability to reason and can work based on messages received and changes to environment.
Applets may be put inside a web page to make it dynamic. In that case, applets are downloaded from the web server just like any other resource (e.g., audio or image). Applets are usually written in JAVA. Applet has a very specific and narrow function and does not run independently. Applets are usually run in a “sandbox”, thus putting security restrictions on their access to resources such as hard drive.
Client - Server computing is distributed computing in which tasks are divided into server side tasks and client side tasks. Clients and Server often run on different hardware and interact over the network. Server usually listens to connection and client initiates the connection.
Client Application

- Contains User Interface Logic
- Accepts inputs from users
- Runs on PCs, Work Stations etc.
Server Applications

• Server accepts client requests and processes them
• Connects to database and other components
General distributed applications. Programs running on, often, different hardware interact with each other by sending and receiving messages.
Most web applications are client-server applications. Web client (such as browser) initiates a connection to the web server and requests a resource. The resource may be a static HTML file, which may be found on a local file system at the server. If the requested page has dynamic information, such as customer information, it needs to contact an application server, which in turn contacts a database server. Usually database server stores and protects information.

In this section, we focus on web applications due to their relevancy and interest from (usable) security view point.
Secure Software Development

- Computer security (and usable security) should be incorporated into all phases of software development lifecycle
  - Requirement Analysis
  - Design
  - Implementation
  - Testing

Security must be incorporated to all phases of software development lifecycle.

During the requirement phase, the project team can explore how security could be integrated into the development process, identify important security objectives, and list all security feature requirements. Security requirements may be requested by the client or may be required by regulation.

During the design phase security is achieved by threat modeling as explained later.

During the implementation phase secure coding guidelines must be followed.

During testing, testing tools such as fuzzer may be used to test the software. A fuzzer supplies invalid input to the program to determine vulnerabilities. Static code analysis tools may be used to detect programming flaws. Finally code reviews, where experts go through the code and identify potential problems.
Threat Modeling

Threat modeling is a systematic process to ensure application security.
Threat Modeling consists of identifying major threats to information assets in the system, exploring vulnerabilities and suggesting safeguards to prevent attacks.

Reference:
1. http://www.sans.org/reading_room/whitepapers/securecode/threat_modeling_a_process_to.ensure.application_security_1646
2. Threat Modeling (Microsoft Professional Books Series) by Frank Swiderski, Window Snyder, Window Snyder, Microsoft Press, June 2004
Data Flow Approach

- Follow the flow of data through the system
- Identify the key processes
- Identify threats to those processes considering both technical and human factors

Data flow approach is one of the approaches for visualizing system design. However, other methods may be used as well.
Threat Modeling Process

1. Analyze from Three Perspectives
2. Characterize the System
3. Identify and Document Threats
4. Rate Threats
5. Identify High Risk Threats

Develop Countermeasures
Identify Entry & Exit Points

- Identify the points where data enters and exits the application

1. Analyze from Attackers’ Perspective

How can I get into the system?
Identify Assets

- Identify all information assets and list them
- Example: customer credit card information database

What do I have to protect?

1. Analyze from Administrator’s Perspective
Identify the trust levels

- Define privileges of an External Entity to access system through entry/exit points

What ports should I assign to which services?

1. Analyze from Administrator’s Perspective
Identify User’s Security Needs

- Find out and list user’s security needs.
- What security functions are to be performed by the user?

I want to add this to the shopping cart.

1. Analyze from User’s Perspective
Use Scenarios

- How the system should be used or should not be used

Can I update my mailing address using the system?

2. Characterize the System
User Model

• Identify Usage Scenarios
• For each usage scenario:
  – Identify security changes intended by user in each usage scenario.
  – Identify the necessary feedback mechanism to inform users about the security state of the system.
• List users expectations about security and explain how those expectations are met
User Interface Design

- Design multiple design of each security related user Interface
- Perform usable security analysis and improve the interface as necessary
External Dependencies

- Define systems dependence on outside resources and security policies

System will be secure assuming users will select strong passwords.

2. Characterize the System
External Security Notes

- Provides security and integration information
- For example, a note may require end users to change their password once in three months. A note may require the programmer to pre-filter the input for SQL injection attacks before submitting to the system.

Who cares about the notes?

2. Characterize the System
Internal Security Notes

- Any notes that would make the threat model easier to understand
- Notes specify what is included and any concessions made in the design
Implementation Assumptions

• Details of features that would be developed later
System Modeling

- Visual representation of how subsystems work together within the system.
- Data Flow Diagrams (DFD) may be used for visualizing the system.

A picture is worth a million words!

2. Characterize the System

We use DFD for simplicity. UML can be a good choice as well.
For performing STRIDE+H threat analysis, in DFDs, the external entities may be identified with (H) to clearly distinguish them from other (non-human) external systems or entities. This will help us focus on identifying human factor threats.
2. Characterize the System
Threat Profile

- Identify the goals of adversary
- Identify the vulnerabilities in the system because of these goals

I am just curious, what's in that email?

3. Identify and Document Threats
Identify the threats

• Analyze each entry/exit point and determine how these may be attacked
Questions to be asked

• How can the adversary
  – Modify or control the system?
  – Retrieve information within the system?
  – Manipulate information within the system?
  – Cause the system to fail or become unusable?
  – Gain additional rights? [SANS05]
    (Exploiting both human and technical factors)

3. Identify and Document Threats
Questions to be asked

• Can the adversary access the asset
  – Without being audited?
  – And skip any access control checks?
  – And appear to be another user?
  [SANS05]

3. Identify and Document Threats
STRIDE+H model

- Use security model (e.g. STRIDE+H) to classify and document threats
  - Spoofing (gaining access with false identity)
  - Tampering (integrity violation)
  - Repudiation (users may deny their actions)
  - Information Disclosure (confidentiality violation)
  - Denial of Service
  - Elevation of Privilege
  - Human Factors

3. Identify and Document Threats
Rate Threats w/ DREAD model

• DREAD model - threats may be rated on a 1-10 scale in terms of:
  – Damage Potential
  – Reproducibility
  – Exploitability
  – Affected Users
  – Discoverability
Identify High Risk Threats

- Rate all threats using DREAD model
- Pick the most important threats to be addressed
Counter Measures

• Counter Measures could be a mechanism or policy to prevent or mitigate the threats
• Go back to Step 3 (Identify and Document Threats), if needed.
Example: Add two numbers
It would be tempting to go ahead and start implementing. Often, client gives you sketchy requirements, at best. So it is important that we find out more.

Requirement Analysis

Original Requirement Statement by the client:
“Add two numbers”
Ask additional questions to find out more information. The more information you can find, the better it is.

Analysis

• What are the other requirements?
  – Are these real numbers or integers?
  – What kind of interface must be provided?

• What are the security requirements?
  – Are these numbers confidential? (like salary)
  – What are the usable security requirements? (can users make typos?)
  – What are the integrity requirements (like overflow errors?)
Revised Requirement Statement

• Users may enter two integers using a web form and the program should display the sum. Program should display errors when the input numbers are not in the right format or there are overflow errors.
Draw DFDs to visualize the system (you may also use UML). Entities are represented by rectangles. The processes are represented by circles.
Level 1 DFD is expanded. The filter process obtain two integers from the user. These are passed to add. Add adds these integers and displays the result for the user.
Modules

- Filter: prompt user for numbers, read numbers, make sure that the numbers are in the right format. Calls add method with two integers.
- Add: adds two integers and displays the result. If there is an overflow displays error.
User Interface Design

First Number: 0
Second Number: 0
Add
Sum

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Write psuedo code for the method

```java
int a, b;
boolean done=false;
while(!done)
{
    Read two numbers
    If (Numbers in the correct format)
    {
        add(number1, number2);
        done = true;
    }
}
```
Add Method

Add(int a, int b)
{
    int sum = a + b;
    if (sum < a || sum < b)
        Out("Overflow error");
    else
        Out(sum);
}

Trust boundaries are identified as above. Entry/Exit point to the system would be the web input form. Anyone can read the web page and submit information. Users are not allowed to modify web pages. The second trust boundary is between Filter and add. Users don’t have direct access to add method. Add assumes that the inputs are integers – no error checking is done inside. Only applications can cross through this boundary.
Analyze system from three perspectives: Use, Defense and Offense to list potential threats.

Threats may be rated using a model (such as DREAD) to spot the important threats.

<table>
<thead>
<tr>
<th>Threat Label</th>
<th>Threat</th>
<th>Description</th>
<th>STRIDE +H Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Overloading</td>
<td>An attacker may load the page several times</td>
<td>Denial of Service</td>
</tr>
<tr>
<td>T2</td>
<td>Bad data entry</td>
<td>Users may make typos</td>
<td>Human factors</td>
</tr>
</tbody>
</table>
The system may crash due to over load if:

- An attacker user uses bot to submit several automated requests
  
  OR

- If an attacker overload the system by reloading several pages (that is possible if the available memory is below 10 MB and the number of users are more than 20)

The threat T1 is mitigated as follows: Provide Captcha, provide more memory.
User Interface Redesigned

First Number 0  Second Number 0

Type the word:

Add

Sum

Threat Analysis
Filter Method Redesigned

```java
int a, b;
boolean done=false;
while(!done)
{
    if (captcha is correctly verified){
        Read two numbers
        If (Numbers in the correct format)
        {
            add(number1, number 2);
            done = true;
        }
    }
}
```

Make necessary changes to mitigate the threat.
Add Method Redesigned

private Add(int a, int b)
{
    int sum = a + b;
    if (sum < a || sum < b)
        Out("Overflow error");
    else
        Out(sum);
}
Test Plan

• Develop a test plan for each module.

Example, for filter module: if the following inputs are specified, the expected output would be:

<table>
<thead>
<tr>
<th>First Number</th>
<th>Second Number</th>
<th>Expected Output/Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>Call add</td>
</tr>
<tr>
<td>23.3</td>
<td>14.6</td>
<td>Round numbers and call add</td>
</tr>
<tr>
<td>xslkl</td>
<td>2</td>
<td>Display error</td>
</tr>
<tr>
<td>30</td>
<td>21</td>
<td>Display Error</td>
</tr>
</tbody>
</table>
Perform additional threat modeling based on selected implementation platform, operating system, etc.
Implementation and Testing

• Follow secure coding practices (see the next slide)
• Test each module; Integrate and test
• Use automatic web input generators for testing
For developing secure software, a number of design principles should be followed. First, secure the weakest link. For example, the weakest link may be an end-user thus GUI design must follow the usable security requirements. Write simple code or may be misunderstood or may be difficult to debug and can result in programmer (human) errors. Practice defense in depth – i.e., add multiple layers of security. Fail Security means – the program should not fall apart because of an error – it should be handled. Assign least possible privilege to do the task. Compartmentalizing system would help prevent problem in one compartment from affecting other areas of the system. System design should be simple and easy to follow. Assume that information by de-facto is private unless stated otherwise. Don’t assume that security problems or vulnerabilities can be hidden from a possible attacker. Do not trust. Use community resources for security.

Secure Coding Guidelines for Java are available at:
http://www.oracle.com/technetwork/java/seccodeguide-139067.html
Case Study: E-Tailing Application

E-Tailing application (Developing an online store such as amazon.com)
Case Study: Application Name and Description

- Web E-Tail application using a database server as backend and a web browser as the front end.
Case Study: Security Objectives

• Protect the confidentiality of customer data
• Ensure availability of application
• Ensure the integrity of the data
• Ensure non-repudiation of customer /employee actions
• Ensure usability of security functions
Case Study: Application Overview

- Uses web-browser as the front end; customers can browse product catalog
- Uses database server as the backend
- Business Logic resides on the web server
# Identify Entry & Exit Points

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Trust Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>HTTP Port</td>
<td>Non-secure web pages accessed through this port</td>
<td>Anonymous user</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Authenticated Users</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-Authenticated Users</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Administrators</td>
</tr>
<tr>
<td>E2</td>
<td>Login Page</td>
<td>Users enter their credential to enter</td>
<td>Authenticated Users</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-Authenticated Users</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Administrators</td>
</tr>
<tr>
<td>E3</td>
<td>Customer Profile Page</td>
<td>Display customer contact information</td>
<td>Authenticated Users</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Administrators</td>
</tr>
</tbody>
</table>

1. Analyze from Attackers’ Viewpoint
# Identify Assets

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Trust Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>User Login Data</td>
<td>Login password, Last login, etc.</td>
<td>Authenticated Users</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Administrators</td>
</tr>
<tr>
<td>A2</td>
<td>Administrator Data Information</td>
<td>Login password, Last login, etc.</td>
<td>Administrators</td>
</tr>
<tr>
<td>A3</td>
<td>Customer Profile Page</td>
<td>Customer address, phone number, email</td>
<td>Authenticated Users</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Administrators</td>
</tr>
</tbody>
</table>

(Assets an attacker would be interested in)

1. Analyze from Attackers’ Viewpoint
## Identify the trust levels

<table>
<thead>
<tr>
<th>ID</th>
<th>Trust Levels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Anonymous User</td>
<td>Any user who accesses the website, but not logged in</td>
</tr>
<tr>
<td>T2</td>
<td>Authenticated Users</td>
<td>Internet Users submitted valid credentials</td>
</tr>
<tr>
<td>T3</td>
<td>Administrator Read Only</td>
<td>Administrator Access; but read only. Cannot update or change information.</td>
</tr>
</tbody>
</table>

1. Analyze from Attackers’ Viewpoint
## Use Case Scenarios

<table>
<thead>
<tr>
<th>ID</th>
<th>Use Case Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>An anonymous user accesses the system for browsing products</td>
</tr>
<tr>
<td>U2</td>
<td>An anonymous user adds product into the shopping cart</td>
</tr>
<tr>
<td>U3</td>
<td>User logs into save the shopping cart</td>
</tr>
<tr>
<td>U4</td>
<td>User tags the computer so he/she does not have to enter password to login next time</td>
</tr>
</tbody>
</table>

2. Characterize the System
User Model

- **U4**: User tags the computer so that he/she does not have to enter password to login next time
  - The user identifying information should be stored into the Session – Automatic login should be enabled
  - Users should be advised against using this feature in public computers; should be told whether the feature is currently enabled and should be informed how this feature may be disabled, if users wish so.
- User expects that his/her order history would be private. This expectation is met by requiring user authentication before access to history.
Conduct Usability Studies to improve the interface
Inquiry: survey

- What features would you like on the login page?
Inspection: Cognitive Walkthrough

- Talk about different functionalities of login page
- What must be included – how would the users use them?
Testing

- Low-fidelity prototyping (see next slide) and test using “Think Aloud Protocol”
A personal picture selected during the signup process can act as the login button. This is to reassure users that they are at the right site. The username may be either entered in the previous screen or obtained from session. In this step, security related interfaces should be designed and usability analysis should be performed. (See Usable Security Section)
## External Dependencies

<table>
<thead>
<tr>
<th>ID</th>
<th>External Dependencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED1</td>
<td>E-Tailing Application would execute on Linux System</td>
</tr>
<tr>
<td>ED2</td>
<td>Apache web server will be used</td>
</tr>
<tr>
<td>ED3</td>
<td>MySQL will be the database</td>
</tr>
</tbody>
</table>

2. Characterize the System
## External Security Notes

<table>
<thead>
<tr>
<th>ID</th>
<th>External Security Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES1</td>
<td>Website administrator should upgrade apache and enable SSL</td>
</tr>
<tr>
<td>ES2</td>
<td>Database administrator should disable windows login</td>
</tr>
</tbody>
</table>

### 2. Characterize the System
## Internal Security Notes

<table>
<thead>
<tr>
<th>ID</th>
<th>Internal Security Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS1</td>
<td>Database Server trusts the connections from the server side application.</td>
</tr>
<tr>
<td>IS2</td>
<td>Web Application authenticates Internet Users</td>
</tr>
</tbody>
</table>
# Implementation Assumptions

<table>
<thead>
<tr>
<th>ID</th>
<th>Implementation Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA1</td>
<td>Current Implementation does not support paypal payment system</td>
</tr>
<tr>
<td>IA2</td>
<td>No webservices are provided at this point</td>
</tr>
</tbody>
</table>

2. Characterize the System
Dataflow Diagram

Customers → Web Server → Database Server

E1 Request → Response

E2 Query → Results

Customers/Web Server Boundary

Web Server/Database System

Web Page Files

2. Characterize the System
# Threat T1

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ID</strong></td>
<td>T1</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Disclosure of private information; if an attacker uses stolen user credentials, will be able to access the user's account</td>
</tr>
<tr>
<td><strong>STRIDE+H classification</strong></td>
<td>Spoofing; Information Disclosure</td>
</tr>
<tr>
<td><strong>Mitigated</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Entry Points</strong></td>
<td>E1, E2</td>
</tr>
<tr>
<td><strong>Assets Involved</strong></td>
<td>A1, A3</td>
</tr>
</tbody>
</table>

---

3. **Identify and Document Threats**
Threat T1

1.1 Using HTTP

1.2 Attacker Snoops

1.3 Phishing

AND

1.2.1 Attacker identifies password from the data

3. Identify and Document Threats
Disclosure of personal picture may make it easy for someone to obtain the password by conducting a phishing attack.
Guessing the username by knowing the first name and last name of the user may be mitigated by encouraging users to select unpredictable user names. To reduce a site obtaining the user name by phishing and then performing a man-in-the-middle attack to display the personal picture on phisher’s website, users may be asked randomly selected additional security questions if the request is coming from an untagged computer.
DREAD Rating

• Rate each threat using DREAD:
  – Damage Potential
  – Reproducibility
  – Exploitability
  – Affected Users
  – Discoverability
DREAD Ratings for Threat T1

<table>
<thead>
<tr>
<th>Category</th>
<th>Rating (Out of 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage Potential</td>
<td>8</td>
</tr>
<tr>
<td>Reproducibility</td>
<td>9</td>
</tr>
<tr>
<td>Exploitability</td>
<td>2</td>
</tr>
<tr>
<td>Affected Users</td>
<td>2</td>
</tr>
<tr>
<td>Discoverability</td>
<td>9</td>
</tr>
<tr>
<td>Average</td>
<td>6</td>
</tr>
</tbody>
</table>

4. Rate Threats
Active Learning Task

- Find and document other threats (draw attack trees) and calculate DREAD ratings
- Identify the most important threats

5. Identify High Risk Threats
Review: Identify Vulnerabilities

- Identify vulnerabilities for the most important threats
- Find solutions; i.e., by designing safeguards

Develop Countermeasures
# Vulnerability Analysis

<table>
<thead>
<tr>
<th>ID</th>
<th>V1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Web Server accepts HTTP connections</td>
</tr>
<tr>
<td>STRIDE+H classification</td>
<td>Spoofing; Information Disclosure</td>
</tr>
<tr>
<td>Threat ID</td>
<td>T1</td>
</tr>
<tr>
<td>Mitigated?</td>
<td>Yes</td>
</tr>
<tr>
<td>Mitigation</td>
<td>Place Login forms in the HTTPS area; Disable Administrator login from Web.</td>
</tr>
<tr>
<td>Entry Points</td>
<td>E1, E2</td>
</tr>
<tr>
<td>Assets Involved</td>
<td>A1, A2, A3</td>
</tr>
</tbody>
</table>

**Develop Countermeasures**
## Vulnerability Analysis

<table>
<thead>
<tr>
<th>ID</th>
<th>V2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Users may be subject to phishing attacks</td>
</tr>
<tr>
<td>STRIDE+H classification</td>
<td>Spoofing; Information Disclosure</td>
</tr>
<tr>
<td>Threat ID</td>
<td>T1</td>
</tr>
<tr>
<td>Mitigated?</td>
<td>Yes</td>
</tr>
<tr>
<td>Mitigation</td>
<td>Employ Phishing filters; Educate users about the phishing attacks</td>
</tr>
<tr>
<td>Entry Points</td>
<td>E1, E2</td>
</tr>
<tr>
<td>Assets Involved</td>
<td>A1, A3</td>
</tr>
</tbody>
</table>
Active Learning Task

• Complete the threat analysis, identify potential vulnerabilities, suggest safeguards, and draw the mitigated attack trees.

• Reminder: Build Defense in depth!!!
Assignment

- Perform threat analysis on an application you like (such as facebook, webCT, or Zimbra). Identify potential vulnerabilities from both technical and human perspectives and suggest safeguards; draw attack trees and mitigated attack trees.
In this section we take a closer look at Software Security. Major problems with software security are, buffer overflow, race conditions and incomplete mediation.
Buffer overflow is shown in the slide, where there is a space of 30 bytes are reserved for data. Exceeding the allocated space by storing 1 in the location data[30], creates a buffer overflow causing the program to circumvent and important security check. (Programmer needs some usable security as well – just remember that C starts counting from 0)

A great link for OS related vulnerabilities:
Incomplete Mediation

• If data exchanged between components of the system (such as client and server) is compromised or altered system may fail.

• Example: Form data

http://www.wiu.edu/users/mfbg/submit?user='binto'&operation='viewaccount'

submitted from a web browser may be altered before reaching the server

The data is exchanged between a web client and server as part of URL (in GET mode). This URL may be intercepted by an adversary and be changed, thus server receiving unexpected input.

http://www.wiu.edu/users/mfbg/submit?user='binto'&operation='viewaccount'

An adversary can intercept this and change the operation into, say, “changepassword”, or much worse, something invalid. This confuses the server and the server may shutdown.
Race Conditions

- Security processes may have multiple steps, but they are supposed to be atomic, i.e., execute all or nothing.
- An attacker may be able to make some changes between steps thereby compromising security.

For example an attacker can try to stop a program after the verification phase and before the execution phase. For example, a system program may need to create a temporary file. After the program creates a temporary file, an attacker can replace the temporary file with a link to the system password file. Once this is done, when the former program writes to the temporary file, the linked password file would be overwritten.
A virus may be a file virus, macro virus, boot sector virus or partition virus. An example for trapdoor would be a bank consultant leaving a secret entry point into the system, which may be used later to access customer information. An easy to use firewall software and antivirus scanners can detect and remove most malware or protect systems from attacks.

Malware

- Virus – relies on an external entity to propagate from one system to another
- Worm – worm propagates itself without help on an external entity
- Trojan horse – appear to be a useful program doing something bad behind
- Trapdoor – with a trapdoor added to a system someone can access it
- Rabbit – A program designed to exhaust all system resources.
Human Factor Threats

- Can the page may be spoofed?
- Does it have a recognizable URL? (or could be easily confused with a fake URL)
- Are the passwords guessable?
- Can users forget their password?
- Will users set one of the most common passwords?
- Will users set the same password on multiple websites?
More Human Factor Threats

• Is the secondary authentication as strong as primary authentication?
• Can the password lock out mechanism be used for Denial of Service?
• Could the password be captured during login?
Denial of Service (DoS) Attacks

Threats
DoS attacks work by making the system to do more than it can handle thus slowing it down or crashing it.

DoS Attacks

- DoS attacks don’t often include intrusion to the system
- Prevents legitimate users from accessing the system
- Works by overloading the system by exceeding the limits of the system such as memory, disk space or network bandwidth
DoS Attack Examples

- TCP SYN Flood Attack
- Smurf IP Attack
- UDP Flood Attack
- ICMP Flood Attack
- Ping of Death
- Teardrop Attack
- Land Attack
- Echo/Chargen Attack
TCP SYN Flood Attack

- Memory space is allocated on initiation of every TCP/IP connection
- Requesting several connections and leaving them half open server can run out of buffer space
- Legitimate connections are delayed or timed out because of this
Prevention techniques

• SYN Cookies: instead of allocating memory, it sends a SYNACK with an indentifying “cookie” which the client needs to send back to initiate the connection

• RST Cookies: server sends wrong SYNACK; in normal case client should then generate RST to indicate that something is wrong
Prevention Techniques

• Stack Tweaking: reduce the timeout in the TCP stack thus removing the half open connection from the queue faster

Bottom line: don’t allocate resources until verifying that the connection is legitimate.
Land Attack

- Attacker sends a forged packet with same source address and destination IP address (of the victim)
- Host sends messages back and forth to itself
- This causes the system to shutdown
Echo/Chargen Attack

- Character Generator (chargen) service generates a random stream of characters
- Echo service just bounces the packet back to the source
- An attacker can simply connect a chargen service to echo service thus generating large amount of data in the network
An employee leaving an organization could plant a “time bomb”, which may be activated at a pre-programmed time. A terrorist may setup time bombs on many system, triggering at particular time.
Setting break points will let an attacker to stop at different points, examine memory locations, and processor registers to find out what a program does.

Software Reverse Engineering

• Someone can analyze a software and find out how it works and reverse engineer it
• This can be accomplished by using a debugger and setting break points
Although code may be encrypted for protection, before executing it, it has to be decrypted thereby subjecting the code to attack. To confuse an attacker, some invalid instructions may be added to the code, but this doesn’t completely prevent attacks although this can considerably increase the time for an attacker to understand the code.
The technique involves, deliberately keeping some instructions incorrect. These incorrect instructions can be dynamically corrected at the time of execution. Modern processors pre-fetch instructions for efficiency. Thus, many instructions are brought into the processor instruction cache. In debug mode, however, pre-fetch is disabled. If there is no pre-fetch the instruction never gets corrected, thus executing incorrect code.
Metamorphism prevents an attacker from designing code which will affect all copies of an executable program. By making the executable codes different, it would be hard for an attacker to design code that would affect all computers the same.
Digital rights management is an attempt to manage control over digital products. For example, a music file may be sold for playing 10 times, but not more.
DRM Example

- Adobe PDF can have passwords to open or other constraints enforced by acrobat reader.
Active Learning Task

- Research on DRM has shown that removal of the restrictive DRM policies can in fact reduce piracy! Discuss this counter-intuitive result.
Reference

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