CSCI 1800 Cybersecurity and International Relations

Security Through Software Engineering

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Outline

• Security modeling including access control
• Federal security regulations and standards
• Software vulnerability assessments
• Microsoft’s Security Development Lifecycle
• Introduction to Threat Analysis
Policy, Models and Trust

• To have secure systems, engineers need clear
  – Security goals
  – Effective implementation strategy

• A security policy puts constraints on actions that subjects can take with respect to objects in the system in order to achieve security goals.
Security Policy Components

- **Subjects**
  - Individual or group agents interacting with a system.

- **Objects**
  - Informational/computational resources affected by policy.

- **Actions**
  - Actions that may be done to objects, e.g. read, edit, copy, remove

- **Permissions**
  - Rules for actions that subjects may take on objects.

- **Protections**
  - Features of policy, e.g. confidentiality, availability, anonymity.
Security Model

• An abstraction providing conceptual language to specify security policies.
  – E.g. Unclassified (U), Confidential (C), Secret (S), Top Secret (TS)
  – **Special compartments** for special information (SCI) such as human intelligence (HUMINT), satellite observations (GEOINT)
Two Models of Access Control

• **Discretionary access control**
  – Owner may specify permissions on files
  – More relaxed

• **Mandatory access control**
  – Administrator fixes permissions in advance.
  – More strict

• **Rules have subjects** (parties requesting access) and **objects** (those things being accessed).
Bell-LaPadula (BLP) Access Control Model

• Applies to confidentiality – dates from the 1970s
• Objects x and users u have security levels L(x) & L(u)
  – Examples of security levels: U, C, S, TS
• For users u and v, v has higher clearance than u if L(u) ≤ L(v). u can pass info to v but not vice versa.
• No “read up” (user can’t see more secure data)
  – User u can read x only if L(x) ≤ L(u)
• No “write down” (user can’t use more secure data)
  – User u can write to object x only if L(u) ≤ L(x).
Ken Biba (‘77) Access Control Model

- BLP model weakness: handles only confidentiality
- Biba’s model deals with **data integrity**: the accuracy and consistency of data over its life-cycle.
- Let $I(x)$ and $I(u)$ be the integrity of user $u$ & object $x$
  - The higher $I(u)$ or $I(x)$, the more trustworthy or accurate the user $u$ or object $x$ is.
- **Don’t corrupt data** by reading from lower integrity level, don’t write to higher integrity level.
  - User $u$ can read object $x$ only if $I(u) \leq I(x)$.
  - User $u$ can write to object $x$ only if $I(x) \leq I(u)$. 
Role-Based Access Control

• Components: users, roles, permissions, sessions
  – A role is a collection of users.
  – A session is an interaction for a period of time.

• Role hierarchy is defined, as in a corporation.
  – President IsA manager IsA employee
  – Higher role user inherits permissions of lower one
  – When is this not a good idea?

• Role constraints may be imposed
  – Example: avoid conflicts of interest.
USG Security Standards

  – Division D: minimal protection criteria
  – Division C: discretionary access control
  – Division B: mandatory access control
  – Division A: system has a formal process for verification of security

  – Defines key concepts related to security evaluations
  – Framework for documenting security goals
  – Not a certification vouching for product security.
Government Regulations & Standards

• Federal Information Processing Standards (FIPS 140-2)
  – Standards for designing/handling of cryptographic modules used by US government organizations
  – Last updated in 2002

• Security levels:
  1. **No physical security**, can run modules on open machine
  2. **Some physical security**, e.g. tamper-evident coatings, some role-based authentication, trusted OS
  3. **Prevent physical tampering**, identity-based authentication instead of role-based authentication
  4. **Tighter physical security**, all keys and messages destroyed when unauthorized attempts made.
Government Regulations & Standards

• **HIPAA (1996)**
  – Sets privacy standards on patient records for healthcare providers and employers.

• **Family Educational Rights and Privacy Act (FERPA) (‘74)**
  – Requires protection of privacy of educational records in US

• **Federal Information Security Management Act (FISMA)**
  – Revised in 2014 – provides government information security.
  – It requires federal agencies to implement processes and controls designed to ensure the confidentiality, integrity, and availability of system-related information. Must follow FISMA and NIST standards, and legislative requirements, such as the Privacy Act of 1974.
Software Vulnerability Assessment

• The problem: software can be enormous
  – Mac OS X 10.4 has > 86 million lines of code!
  – Code can have both performance & security bugs

• “A vulnerability is a security exposure that results from a product weakness ... the product developer did not intend to introduce and should fix once it is discovered.”*

• How many errors per 1000 lines of code (LOC)?
  – Estimates vary from 5-50 defects per KLOC
  – Some open-source have bug density of .4 bugs/KLOC!†

* Microsoft definition
Lect 12 3/14/16 © JE Savage
Software Vulnerability Assessment

• Approaches to vulnerability assessment:
  – **Black-box analysis**
    • Penetration testing without knowledge of innards.
    • Pentest – look for security vulnerabilities
  – **White-box analysis**
    • Same but with full knowledge of hardware/software, network environment, etc.
Code Analysis for Privacy/Security

• Problem: Cybercrime is here to stay.
• Goal: Find and remove privacy/security hazards.
  – Static code analysis studies non-running programs.
  – Dynamic analysis examines running programs.
• Good analysis requires training and investment
  – Software engineers generally not educated on this.
  – Microsoft’s Security Development Lifecycle (SDL) represents a big step forward.
• Benefits: Improved security, privacy and reliability.
Incident Classifications in 2015*

Classification in order of frequency:
1. Point-of-sale (POS) intrusions
2. Web attacks – stolen credentials, vulnerability exploits.
4. Crimeware
5. Insider and privilege misuse
6. Payment card skimmers
7. Miscellaneous errors that compromises security.
8. Physical theft and loss data/IT related assets.
9. Denial of service (DoS) attacks – no breach

Microsoft’s Security Development Lifecycle (SDL)

• Bill Gates inaugurated Microsoft’s Trustworthy Computing Initiative in 2002.
  – Success with major new corporate initiatives often requires support from top management.
• Every product that impacts privacy or may be used by children needs security analysis.
  – This means almost all hardware/software products
• Average cost of fixing a security bug was $300K!
• Microsoft code is now among the most secure!
Microsoft’s SDL

- Personnel must be trained.
- Security requirements, risk assessment needed
- Must do threat modeling (STRIDE) and reduce attack surface.
  - Spoofing, Tampering, Repudiation, Information Disclosure, Denial of service, Elevation of privilege.
- Implementation requires good tools to protect against attacks
- Must plan for post-release handling of errors
- Verification needed via dynamic analysis including fuzzing.
Modeling System Threats

- *Data flow analysis* preferable to exploring assets or motivations of attackers.
- Group components by *trust boundaries*
Information Security Attributes
The CIA Triad

• **Confidentiality**: Access to information is limited to those with proper authorization.

• **Integrity**: Maintaining the consistency, accuracy and trustworthiness of data during its life cycle.

• **Availability**: Reliable access is maintained to resources by authorized parties.
STRIDE Threats*

- S – Spoofing
- T – Tampering
- R – Repudiation
- I – Information Disclosure
- D – Denial of Access or Service
- E – Elevation of Privilege

* Microsoft’s mnemonic for types of software threats
STRIDE Explained

- S – pretending to be another person or thing
- T – modifying something one should not
- R – falsely claiming not to have taken an action
- I – exposing information to those unauthorized
- D – denying users access to a service
- E – acquiring access at an elevated level
## STRIDE Elaborated

<table>
<thead>
<tr>
<th>Threats</th>
<th>Objectives</th>
</tr>
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<tbody>
<tr>
<td>Spoofing</td>
<td>Authenticity</td>
</tr>
<tr>
<td>Tampering</td>
<td>Integrity</td>
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<tr>
<td>Repudiation</td>
<td>Non-Repudiation</td>
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<td>Information Disclosure</td>
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<tr>
<td>Denial of Service</td>
<td>Availability</td>
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<tr>
<td>Elevation of Privilege</td>
<td>Proper Authorization</td>
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</tbody>
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Options to Address Threats

• Mitigate a threat
  – Increase the work to exploit it

• Eliminate a threat
  – Usually requires elimination of features

• Transfer of a threat
  – Let some other system element cope with it

• Accept a threat
  – Risk acceptance may be less costly than other steps
Source Material

Is Open Source Software a Panacea?

• Software is available for modification under liberal copyright policy.

• Do many eyeballs on the code make it secure?
  – “… in reality that doesn’t happen” Cowan 2002.

• Russia believes it – avoids US software.
  – Putin orders Russian government to move to Open Source Software by 2015. (12/28/2010)

• Problems: No incentive to find bugs. Coders not trained to find them. It is hard!

Review

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- Software vulnerability assessments
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- Introduction to Threat Analysis