Threat Modeling for Mobile Health Systems

04/30/2020
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Slides Key:

- Non-Technical: managerial, strategic and high-level (general audience)
- Technical: Tactical / IOCs; requiring in-depth knowledge (sysadmins, IRT)
Introduction

• Advances in mobile health (mHealth), respectively IoTHealth, are likely to reduce costs and improve the quality of healthcare.

• Although telehealth systems may improve the quality of healthcare, the digitalization of health records, the collection, evaluation and provisioning of patient data, and the transmission of patient data over public networks pose new privacy and security threats to patients and healthcare providers.

• Threat modeling serves as a foundation for the analysis and specification of security requirements. It involves understanding of system complexity and identification of all possible threats to the system.
Threat Modeling Overview

- Threat modeling is an important aspect of the security development lifecycle, which is a process aiming to build better and more secure systems or software.
- It is a technique, which aims to find assets, analyze potential threats and mitigate them. This provides defenders with important insights:
  - The most likely attack vectors
  - Assets an attacker is attracted to
  - Attack vectors that otherwise would have gone unnoticed
• STRIDE is an acronym that stands for 6 categories of security risks:
  • Spoofing
  • Tampering
  • Repudiation
  • Information Disclosure
  • Denial of Service
  • Elevation of Privileges

• Each category of risk aims to address one aspect of security.

• To follow STRIDE, you decompose your system into relevant components, analyze each component for susceptibility to the threats, and mitigate the threats.

Checkmarx
Spoofing

- Spoofing refers to the act of posing as someone else (i.e. spoofing a user) or claiming a false identity (i.e. spoofing a process).
  - This category is concerned with **authenticity**.

**mHealth Security Perspective:** Attacker using user authentication information to access sensitive medical data

- Use of Email spoofing to lure patients into disclosing personal information or harvesting user credentials.
  - Commonly, the spoofed emails are sent modifying the sender name or email address. Also, sometimes the body of the message is formatted in such a way that it appears to be legitimate to the recipient.
Mitigations/Countermeasures

- **Strong authentication**: User must be authenticated to the system using a strong password policy, biometrics or multi-factor authentication mechanisms.

- **Encryption**: All credentials must be encrypted, and it has to be ensured that credentials do not traverse the wire in clear text form. (S/MIME)

- **Cryptographic protocols**: Cryptographic protocols such as TLS/SSL must be used to ensure a secure (encrypted) communication between system components.

- **Email Spoofing**
  - **Validation tools**: Sender Policy Framework (SPF), Domain-based Message Authentication, Reporting & Conformance (DMARC) used to create policies to detect spoofed addresses.
Tampering

- Tampering refers to malicious modification of data or processes. Tampering may occur on data in transit, on data at rest, or on processes.
  - This category is concerned with integrity.
- mHealth Security Perspective: Attacker modifying data in transit (e.g. from Body Area Networks (BAN) to Local Area Networks (LAN)) or at rest

Mitigations/Countermeasures

- Strong authorization: Appropriate access control mechanisms such as role-based access control (RBAC) must be deployed with least privileges and separation of duties principles. Users must be assigned to access with minimum privileges.
- Data hashing and signing: All confidential data must be hashed and signed to ensure that the data is valid (untampered and came from the correct/expected source).
- Secure communication links: The communication links between system components must be ensured by using protocols that provide message integrity and confidentiality.
Repudiation

- Repudiation refers to the ability of denying that an action or an event has occurred.
  - This category is concerned with **non-repudiation**.

**mHealth Security Perspective:** Authorized user performs illegal operations and system cannot trace it, other parties cannot prove this.

**Mitigation/Countermeasures**

- Secure audit trails: All activities (such as successful and unsuccessful authentication) and sensitive data (e.g. cookies and authentication credentials) must be logged and recorded.
Information Disclosure

• Information Disclosure refers to data leaks or data breaches. This could occur on data in transit, data at rest, or even to a process.
  • This category is concerned with confidentiality.

• mHealth Security Perspective: Leaking raw data or medical records

Mitigation/Countermeasures

• Strong authorization: Ensure that an appropriate access control mechanisms is deployed and only authorized users can access to data.

• Encryption: Ensure that all sensitive data is encrypted (in storage or during transit) and only authorized users can read this data.

• Secure communication links: Ensure that all communication links are secured with protocols that provide message confidentiality.
Denial of Service

- Denial of Service refers to causing a service or a network resource to be unavailable to its intended users.
  - This category is concerned with availability.
- mHealth Security Perspective: Attacker jamming BAN or DoS’ing hospital environment
  - Mitigating this class of security risks is tricky because solutions are highly dependent on a lot of factors.
Elevation of Privileges

• Elevation of Privileges refers to gaining access that one should not have.
  • This category is concerned with **authorization**.

• **mHealth Security Perspective**: Attacker gains access to security systems as a trusted entity

**Mitigation/Countermeasures:**

• Proper authorization mechanism (e.g. role-based access control).

• Principle of least privilege: All authorized user must have a least privilege and minimum required access.
## Threat Class 1: Authentication Threats

<table>
<thead>
<tr>
<th>Description</th>
<th>STRIDE</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient identity loss or identity sharing: the patients leave their login credentials on a public place (e.g. write them down on a piece of paper) or share them with family, friends or relatives.</td>
<td>Spoofing</td>
<td>Low</td>
</tr>
<tr>
<td>Personnel identity loss or identity sharing: healthcare providers, and/or system admins leave their login credentials in public places or share them with others.</td>
<td>Spoofing</td>
<td>High</td>
</tr>
<tr>
<td>Identity spoofing: patients reveal login credentials to someone (e.g. social engineering attack).</td>
<td>Spoofing</td>
<td>Low</td>
</tr>
<tr>
<td>Identity theft and misuse: informal healthcare assistant (e.g. friends or family members) misuse patient identity to obtain medical services.</td>
<td>Elevation of Privileges</td>
<td>Medium</td>
</tr>
<tr>
<td>Identity theft and misuse: system admins misuse patient identity for malicious acts (e.g. curiosity, disclosure, fraud and/or sabotage).</td>
<td>Spoofing</td>
<td>High</td>
</tr>
<tr>
<td>Spoofing of source: patient medical devices may be spoofed by attackers, which may lead to incorrect data being delivered to patient communication devices.</td>
<td>Spoofing</td>
<td>High</td>
</tr>
<tr>
<td>Spoofing of source: patient communication devices may be spoofed by attackers, which may lead to data being written to the attacker's target instead of the patients communication device.</td>
<td>Spoofing</td>
<td>Medium</td>
</tr>
<tr>
<td>Spoofing of source: Personal/Electronic Health Record (PHR/EHR) servers or telehealth service servers may be spoofed by attackers, which may lead to incorrect data being delivered to PHR/EHR servers or telehealth service servers.</td>
<td>Spoofing</td>
<td>High</td>
</tr>
</tbody>
</table>
### Threat Class 2: Authorization and Access Threats

<table>
<thead>
<tr>
<th>Description</th>
<th>STRIDE</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unauthorized access: unauthorized access to system data using shared (or stolen) passwords.</td>
<td>Elevation of Privileges</td>
<td>High</td>
</tr>
<tr>
<td>Unauthorized access: patient intentional or accidental access beyond authorized privileges.</td>
<td>Elevation of Privileges</td>
<td>Low</td>
</tr>
<tr>
<td>Unauthorized access: system admins and informal healthcare professionals gain intentional unauthorized access to patient data for malicious acts (e.g. curiosity, disclosure).</td>
<td>Elevation of Privileges</td>
<td>High</td>
</tr>
<tr>
<td>Data tampering: patients intentionally or accidentally modify, add and/or delete data because of over-privileges or inapplicable access control of a resource.</td>
<td>Tampering</td>
<td>Medium</td>
</tr>
<tr>
<td>Data tampering: formal healthcare professionals and system admins intentionally or accidentally modify, add and/or delete data because of over-privileges or inapplicable access control of a resource.</td>
<td>Tampering</td>
<td>High</td>
</tr>
<tr>
<td>Elevation using impersonation: informal healthcare professionals (e.g. friends or family members) may impersonate the patients context in order to gain additional privileges.</td>
<td>Elevation of Privileges</td>
<td>Medium</td>
</tr>
<tr>
<td>Elevation using impersonation: formal healthcare professionals or system admins may impersonate the context of other healthcare professionals or system admins in order to gain additional privileges.</td>
<td>Elevation of Privileges</td>
<td>High</td>
</tr>
<tr>
<td>Unauthorized access to administration interfaces: malicious users may be able to gain access to configuration management through administration interfaces.</td>
<td>Elevation of Privileges</td>
<td>High</td>
</tr>
</tbody>
</table>
## Threat Class 3: Privacy Threats

<table>
<thead>
<tr>
<th>Description</th>
<th>STRIDE</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unauthorized disclosure: patients accidentally access some confidential data via malware or file-sharing tools installed on their communication devices.</td>
<td>Information Disclosure</td>
<td>Low</td>
</tr>
<tr>
<td>Unauthorized disclosure: formal healthcare professionals and system admins intentionally or accidentally access some confidential data via malware or file-sharing tools installed on their communication devices.</td>
<td>Information Disclosure</td>
<td>High</td>
</tr>
<tr>
<td>Lost device: patients losing their communication devices would cause exposure of sensitive data such as login credentials and PHR.</td>
<td>Information Disclosure</td>
<td>Medium</td>
</tr>
<tr>
<td>Stolen device: theft of patient communication devices that would cause exposure of sensitive data such as login credentials and PHRs.</td>
<td>Information Disclosure</td>
<td>Medium</td>
</tr>
<tr>
<td>Weak access control: improperly protected data stored in patients' communication devices could allow attackers to read information not intended for disclosure.</td>
<td>Information Disclosure</td>
<td>Medium</td>
</tr>
</tbody>
</table>
### Threat Class 4: Auditing and Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>STRIDE</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential data repudiation: patient denies or claims not receiving, writing or editing data.</td>
<td>Repudiation</td>
<td>Medium</td>
</tr>
<tr>
<td>Potential data repudiation: formal healthcare professionals or admins deny or claim not receiving, writing or editing data.</td>
<td>Repudiation</td>
<td>High</td>
</tr>
<tr>
<td>Log files tampering: patients, system admins or formal or informal healthcare providers delete or update log files in any way.</td>
<td>Repudiation</td>
<td>High</td>
</tr>
<tr>
<td>Insufficient auditing: logging sufficient and appropriate data to handle repudiation claims.</td>
<td>Repudiation</td>
<td>High</td>
</tr>
</tbody>
</table>
Reference Materials
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• MS ISAC Guide to DDoS Attacks

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• Threat Modeling of Internet of Things Health Devices
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• Privilege Escalation Attacks: Types, Examples, And Prevention
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Questions

Upcoming Briefs

• Quantitative Risk Management
• Russian Government’s Targeting of America’s Health Care Sector

Product Evaluations

Recipients of this and other Healthcare Sector Cybersecurity Coordination Center (HC3) Threat Intelligence products are highly encouraged to provide feedback to HC3@HHS.GOV.

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