Secure Programming Lecture 12: Web Application Security III

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OWASP Top 10 list 2013

- A1 Injection ✓
- A2 Broken Authentication & Session Management ✓
- A3 Cross-Site Scripting (XSS) ✓
- A4 Insecure Direct Object References ✓
- A5 **Security Misconfiguration**
- A6 **Sensitive Data Exposure**
- A7 **Missing Function Level Access Control**
- A8 **Cross-Site Request Forgery (CSRF)**
- A9 **Using Components with Known Vulnerabilities**
- A10 **Unvalidated Redirects and Forwards**

Missing function-level access control (A7)

This is OWASP's term for not authorizing properly the *operations*, i.e., functions, that the web app implements.

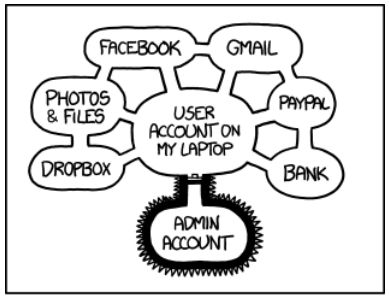
This is separate from handling authorization of

- pages (apps might have several functions per page)
- external objects, e.g., files on filesystem

Common mistake:

- Hiding navigation links to "unauthorized" sections
- . . . assuming (wrongly) this prevents non-authorized users visiting them
- e.g., no AdminPage link if not logged in as an admin

XKCD #1200



IF SOMEONE STEALS MY LAPTOP WHILE I'M LOGGED IN, THEY CAN READ MY EMAIL, TAKE MY MONEY, AND IMPERSONATE ME TO MY FRIENDS, BUT AT LEAST THEY CAN'T INSTALL DRIVERS WITHOUT MY PERMISSION.

OWASP authorization advice

- Have well-specified policy
  - if non-trivial, separate it from code
- Manage authorization in a separate module
  - have a single route through code
  - can trace to make sure authorization happens
- Make authorization checks for each *function*
- Use deny-by-default policy

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Unvalidated redirects and forwards (A10)

Web apps often allow *redirections* which

- send users off-site with a polite message
- reroute them immediately

http://www.example.com/redirect.jsp?url=www.disney.com

or *forwards* which

- redirect internally to different parts of the same site

http://www.example.com/login.jsp?fwd=admin.jsp

Question. What's the security risk here?

Giving attackers legitimacy

- Attackers can craft URLs that fool users:

www.example.com/redirect.jsp?url=www.evilhacker.com

These kind of **open redirect** links are favourites for phishing attacks, especially as ultimate destinations can be concealed in URL encodings.

However, this may not directly harm `www.example.com`.

So, preventing open reirects is a typical example of a *community wide* desirable security measure (like older cases in network security: open mail relays, ICMP broadcast, etc.): good practice of all provides security for others.

Avoiding redirects and forwards

1. Don't use them
2. Use them but not with user-supplied parameters.
3. If user-supplied parameters must be used, use an indirection (index value)

Another solution is to do the generation (& validation) of external links statically.

Question. Why is static generation of external links still not bullet-proof?

Information leakage

Reminder from your first security course:

Confidentiality is defined as the

unauthorised learning of information

Presumes notions of

- **authorisation** likely based on an . . .
- **access control policy** likely based on . . .
- **authentication**.

Information leakage

Information can be learned in a variety of ways:

- direct exposure
  - display on a public web page
  - may be *inadvertent* on part of user
- indirect/inferred exposure
  - programming mistakes showing wrong info
  - display of consequences of info
- leakage through *side-channel* attacks
  - e.g., timing attacks
- (via) offline mechanisms
  - social engineering to get passwords, etc

The Privacy Crisis

Some security researchers and commentators have said:

"Privacy is dead, get over it!"

We can't stop people intentionally sharing personal information, but it is our job to ensure:

- good policy: advise users about it and its impacts
- good programming: don't leak data accidentally
- good design: don't force users to leak data
- good UX/UI: so users understand what they're doing

Of course there may be *competing incentives* to expose personal data (**Q.** for example?).

But it is better that data handling practices are defined and explained clearly in **privacy policies** for end users.

Example: search data

Google

- may save your web search history forever
- gives users the option to turn this off; then searches are partially "anonymized" after 18 months.

If you haven't looked at this before, visit:

- `https://history.google.com/history/`

Anonymization of data is **very difficult or impossible** in general: many examples of *linkage attacks* have recovered identities.

Example: voice control

Apple's **Siri** keeps voice data for up to two years:

> *Here's what happens. Whenever you speak into Apple's voice activated personal digital assistant, it ships it off to Apple's data farm for analysis.*
>
> *Apple generates a random number to represent the user and it associates the voice files with that number. This number — not your Apple user ID or email address — represents you as far as Siri's back-end voice analysis system is concerned.*
>
> *Once the voice recording is six months old, Apple "disassociates" your user number from the clip, deleting the number from the voice file. But it keeps these disassociated files for up to 18 more months for testing and product improvement purposes.*

Wired's article from 2013, attempting to clarify Apple's behaviour.

Example: an amazing mind reader

See the video campaign by Safe Internet Banking in Belgium.

Exercise. What has this got to do with banking? And why should it have anything to do with it?

Privacy by Design

Privacy by design (PbD) is a methodology introduced by the Information and Privacy Commissioner of Ontario in the 1990s. It has 7 foundational principles:

1. Be **proactive and preventative**, not remedial
2. Make **privacy the default setting**
3. Put **privacy into the design**
4. Encourage **win-win** (not privacy-security trade-off)
5. Provide **full lifecycle protection** (end-to-end)
6. Be **transparent and opten** about practices
7. Be **respectful and user-centric**

This process is encouraged in the new EU GDPR General Data Protection Regulation, coming into law from 2016.

Basic strategy for sensitive data handling

0. **Define your policy**, devise requirements
1. **Label the data parts** at least informally
2. **Sanitize** to remove sensitive parts/meta-data
3. **Follow the data** through the app and check

Check questions for data flow:

- is the data *stored* as plain text long term (e.g. backups)?
- is the data *transmitted* as plain text?
- are encryption algorithms strong enough?
- are browser security directives/headers set appropriately?

OWASP advice for sensitive data:

1. Don't store unnecessarily
2. Encrypt appropriately (e.g., large keys if long term)
3. Use known strong encryption algorithms
4. Manage passwords properly
5. Disable auto-completion on forms, disable caching

Regulation

If you manipulate or store user data you have (legal) responsibilities for managing it properly. For example:

- **DPA** UK Data Protection Act
  - organisations must register and data must be kept "safe and secure". The ICO prosecutes and fines.
- **GDPR** set to come into EU state laws 2016-.
  - breaches notified, rights of erasure, data portability
- **Finance**: Payment Card Industry Data Security Standard
  - requirements for anyone who processes card data
  - larger merchants are audited
- **Health**: HIPPA (in the US)

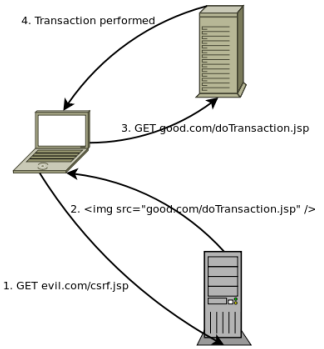
Given the scale and frequency of data lossage, regulation/enforcement increasing. (Expect security companies to push for and profit from this.)

Cross Site Request Forgery (CSRF) (A8)

- Exploit *browser's* trust relationship with a web site
  - local intranet web site (home router admin, . . .)
  - banking or email site user is logged into
  - browser is authorized to connect here
- Attacker triggers malicious action
  - get user to open malicious link
  - browser undertakes action on target site

Question. How does CSRF differ from XSS?

CSRF in pictures



CSRF in code

Alice **is logged in** to the (hypothetical) GeeMail web mail system.

She sends an email with this form:

```
<form
  action="http://geemail.com/send_email.htm"
  method="GET">
  Recipient's Email address:  <input
    type="text" name="to">
  Subject:  <input type="text" name="subject">
  Message:  <textarea name="msg"></textarea>
  <input type="submit" value="Send Email">
</form>
```

Example GET request

Which sends a request like this:

```
http://geemail.com/send_email.htm?to=bob%40example.com
 &subject=hello&msg=What%27s+the+status+of+that+proposal%3F
```

Attacker's cross-site request

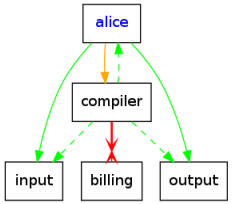
Now Mallory just needs Alice to visit a site which loads an image link, e.g., by putting a fake image on his own blog:

```
<img src="http://geemail.com/send_email.htm?
     to=charlie@geemail.com&subject=Hi&msg=My+
     email+address+has+been+stolen">
```

and Alice's browser will send an Email!

Confused Deputy problem

CSRF is a case of the Confused deputy problem.



The issue motivates the use of *capabilities*.

See *The Confused Deputy* by Norm Hardy, ACM SIGOPS Operating Systems Review, 1988. Picture credit: FP7 project Serscis

Avoiding CSRF problems

In general: tricky. Need some way to assure the server code that the request has come from intended place.

- `Referer` header not tamper proof, may be absent
- Session ID cookie sent based on *destination*
- The *Same Origin Policy* restricts client-side code

Best strategy: use a good framework that provides built-in protection.

But how do they work?

- Don't use GET for any (sensitive) state change
  - basic starting point
- Use a "double cookie" trick, repeated in POST
  - set a secure secret session ID in a cookie
  - submit it in cookie *and* hidden field on form
  - server-side, check fields identical
- this works but has drawback (**Q.** what?)
- Use a special CSRF token in POST
  - secure random number (challenge) for each login
  - send this with POST and check server-side
  - save state: generate using hmac from session ID

Future: idea for an `Origin` header in POST.

See *Robust defenses for cross-site request forgery*, Barth et al, ACM CCS 2008.

Same-Origin Policy (browser-side isolation)

The **same origin policy** is a standard browser-side mechanism to protect simultaneously running web applications from one another.

It restricts access to:

- DOM (i.e., representation of the document)
- APIs for web access (XMLHttpRequest)
- Cookies, HTML5 local storage APIs

to pages from the *same domain*, i.e., protocol-host-port.

Have been vulnerabilities in implementation. JavaScript code can override the defaults.

Browser **sandboxing** enhances this (e.g., in Chrome, separate tabs/frames run in separate processes).

Misconfiguration (A5)

The *whole* web app stack must be secured (**Q.** Why?)

- Make sure **up to date** wrt security patches
  - OS, Web/App Server, DBMS, app framework, libs. . .
- Disable **unnecessary features**
  - Default accounts, demo pages, debug interfaces
- Use **minimum privilege** settings
  - Security settings for frameworks and libraries
- Ensure **error handling doesn't expose info**
- Have a **repeatable security config process**
  - An app-specific checklist to work through
  - Proactive deployment of updates
  - Uniform configuration for devel, QA, deployment

Inherited vulnerabilities (A9)

Big cause of real-life vulnerabilities:

patch was available but not installed

- Need to stay up-to-date
- Can be harder than might be hoped
  - no unique clearing house (but CVE, NVD v.~good)
  - unsatisfiable compatibility dependencies
- Future: expect to see more **automated tools**

Review questions

Authorization

- How might you design a web based admin front-end to a database server, supposing that the server provides a collection of databases and its own notion of user and authorization?

Redirection

- What is an open redirect in a web application and why is it undesirable?

Handling sensitive data

- Describe three ways that a web application programming flaw might result in stored private user data being leaked.

CSRF

- Draw a picture showing how a CSRF attack might work against an online banking user. What might an attacker be able to do?
- What does a defence mechanism against CSRF need to be able to do?

Deployment

- Give three recommendations for securing the deployment environment (server, database, application framework) for a web app.

References

This lecture contained material from:

- the OWASP Top 10
- *The Tangled Web: a Guide to Securing Modern Web Applications* by Michal Zalewski, No Starch Press, 2012.

as well as papers and other sources cited.