

Week 9: Lecture A

Client-side Web Security and HTTPS

Tuesday, October 22, 2024

Announcements

- **Project 3: WebSec** released
 - **Deadline:** Thursday, November 7th by 11:59PM

Project 3: Web Security

Deadline: Thursday, November 7 by 11:59PM.

Before you start, review the [course syllabus](#) for the Lateness, Collaboration, and Ethical Use policies.

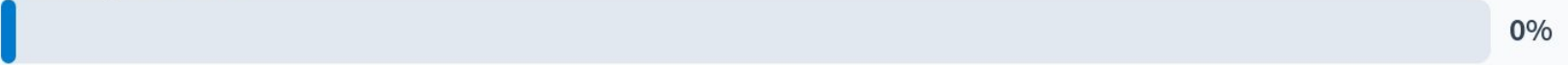
You may optionally work alone, or in teams of **at most two** and submit **one project per team**. If you have difficulties forming a team, post on **Piazza's Search for Teammates** forum. Note that the final exam will cover project material, so you and your partner should collaborate on each part.

The code and other answers your group submits must be entirely your own work, and you are bound by the University's Student Code. You may consult with other students about the conceptualization of the project and the meaning of the questions, but you may not look at any part of someone else's solution or collaborate with anyone outside your group. You may consult published references, provided that you appropriately cite them (e.g., in your code comments). **Don't risk your grade and degree by cheating!**

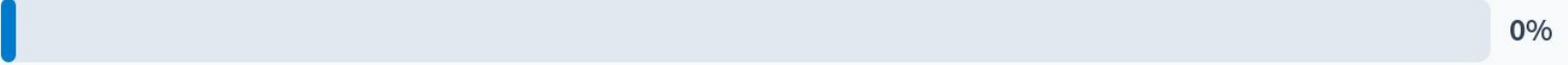
Complete your work in the **CS 4440 VM**—we will use this same environment for grading. You may not use any **external dependencies**. Use only default Python 3 libraries and/or modules we provide you.

Project 3 progress

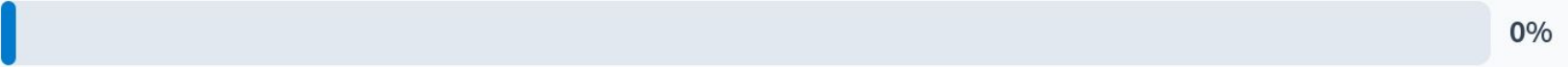
Working on Part 1



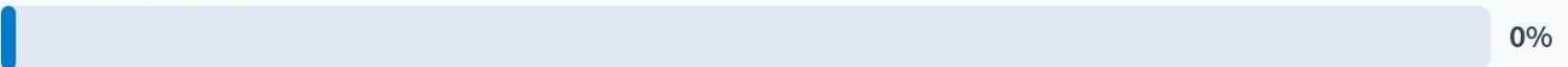
Working on Part 2



Working on Part 3



None of the above



Announcements

- **Project 2** grades are now available on **Canvas**
- **Statistics:**
 - Average score across all teams: **91.64%**
 - Three solved one of the extra credit targets
- **Fantastic job!**

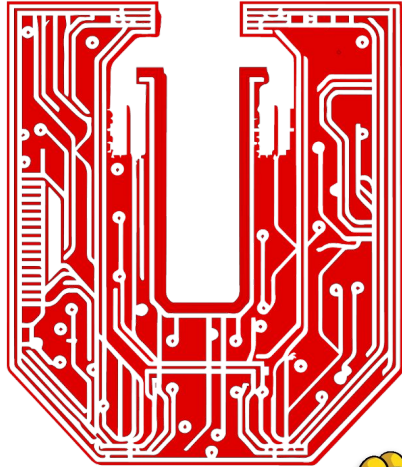


Announcements

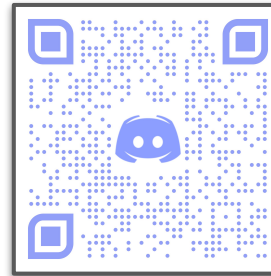
- **Project 2** grades are now available on **Canvas**
- Think we made an error? Request a regrade!
 - Valid regrade requests:
 - You have verified your solution is correct (i.e., we made an error in grading)

Project 2 Regrade Requests (see [Piazza](#) pinned link):
Submit by **11:59 PM** on **Monday 10/28** via [Google Form](#)

Announcements



utahsec



See Discord for
meeting info!

utahsec.cs.utah.edu

Questions?



Last time on CS 4440...

Web Attacks
SQL Injection
Cross-site Scripting
Cross-site Request Forgery

Code Injection in Web Apps

■ A common and dangerous class of attacks

- Shell Injection
- SQL Injection
- Cross-Site Scripting
- Control-flow Hijacking (buffer overflows)

```
GET /?path=$(rm -rf /) HTTP/1.1
```



Code Injection in Web Apps

■ A common and dangerous class of attacks

- Shell Injection
- SQL Injection
- Cross-Site Scripting
- Control-flow Injection

What is the universal flaw here?

```
GET /?path=$(rm -rf /) HTTP/1.1
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Code Injection in Web Apps

■ A common and dangerous class of attacks

- Shell Injection
- SQL Injection
- Cross-Site Scripting
- Control-flow Hijacking

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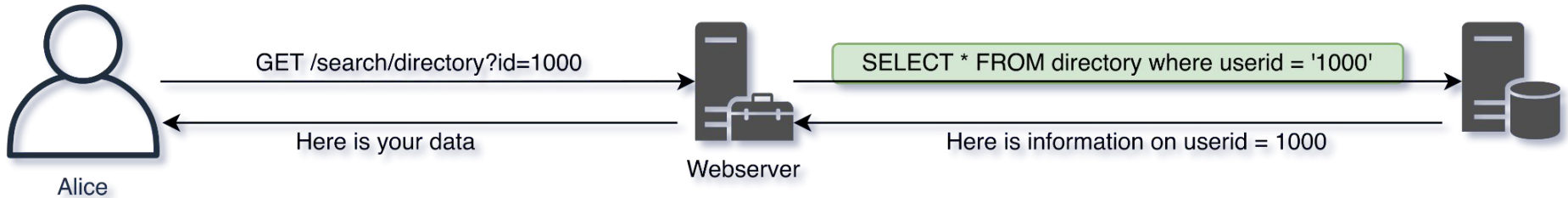
What is the universal flaw here?

Confusing input **data with **code**!**



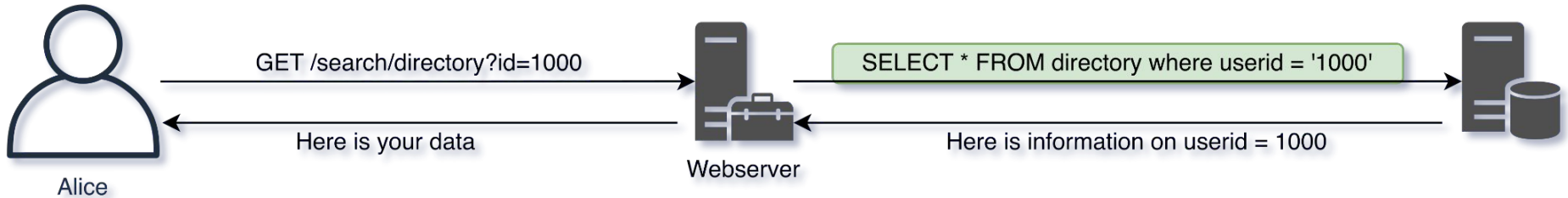
SQL Injection Attacks

- Attacker goal: ???



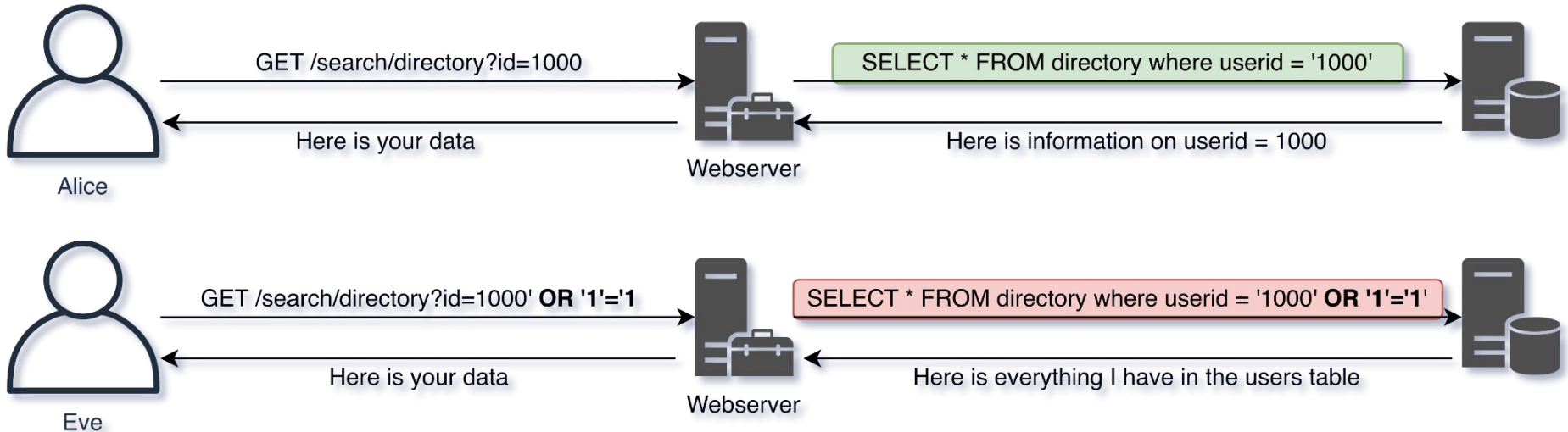
SQL Injection Attacks

- **Attacker goal:** inject or modify database **commands** to **read** or **alter** info



SQL Injection Attacks

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Project 3: SQL Injection Tips

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 - E.g., for **SQL Inject #0**:

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SELECT * FROM users WHERE username='$username' AND password='$password'
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Project 3: SQL Injection Tips

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2. What **input fields** are under our control?

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 - The **\$username** and **\$password** fields

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 - A SQL query that **logs us in as "victim"**

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 - A SQL query that **logs us in as "victim"**
4. What **steps** are needed for our attack to work?

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 - E.g., for **SQL Inject #0**:

```
SELECT * FROM users WHERE username='$username' AND password='$password'
```

2. What **input fields** are under our control?
 - The **\$username** and **\$password** fields
3. What is **the goal** of our SQL injection attack?
 - A SQL query that **logs us in as "victim"**
4. What **steps** are needed for our attack to work?
 1. Set **\$username** to **"victim"**
 2. Set **\$password** to their password

The correct **password** would log us in...

But **we do not know** the user's **password!**

Project 3: SQL Injection Tips

- **Solution:** craft a query that **closes-out unknowable fields**, resolves to **TRUE**

```
SELECT * FROM users WHERE username='$username' AND password='$password'
```

Example Attack:

```
... AND password='$password'
```

Project 3: SQL Injection Tips

- **Solution:** craft a query that **closes-out unknowable fields**, resolves to **TRUE**

```
SELECT * FROM users WHERE username='$username' AND password='$password'
```

Example Attack:

```
... AND password='$password'
```

```
... AND password='!'
```

- **Closes-out** unknowable password

Project 3: SQL Injection Tips

- **Solution:** craft a query that **closes-out unknowable fields**, resolves to **TRUE**

```
SELECT * FROM users WHERE username='$username' AND password='$password'
```

Example Attack:

```
... AND password='$password'
```

```
... AND password=' ' OR '1'='1'
```

- **Closes-out** unknowable password
- **'1'='1'** always resolves **TRUE**

Project 3: SQL Injection Tips

- **Solution:** craft a query that **closes-out unknowable fields**, resolves to **TRUE**

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Example Attack:

```
... AND password='$password'
```

```
... AND password='foo'
```

Project 3: SQL Injection Tips

- **Solution:** craft a query that **closes-out unknowable fields**, resolves to **TRUE**

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SELECT * FROM users WHERE username='$username' AND password='$password'
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Example Attack:

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Example Attack:

```
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- Creates a **FALSE** string comparison

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SELECT * FROM users WHERE username='$username' AND password='$password'
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Example Attack:

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- **Closes-out** unknowable password
- **'1'='1'** always resolves **TRUE**

Example Attack:

```
... AND password='$password'
```

```
... AND password='foo' = ''
```

- Creates a **FALSE** string comparison

Project 3: SQL Injection Tips

- **Solution:** craft a query that **closes-out unknowable fields**, resolves to **TRUE**

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SELECT * FROM users WHERE username='$username' AND password='$password'
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Example Attack:

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... AND password='' OR '1'='1'
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- **Closes-out** unknowable password
- **'1'='1'** always resolves **TRUE**

Example Attack:

```
... AND password='$password'
```

```
... AND password='foo' = ''
```

- Creates a **FALSE** string comparison
- But **FALSE == ''** ends up **TRUE**

Project 3: SQL Injection Tips

- **Solution:** craft a query that **closes-out unknowable fields**, resolves to **TRUE**

```
SELECT * FROM users WHERE username='$username' AND password='$password'
```

Example Attack:

```
... AND password='$password'
```

```
... AND password='' OR '1'='1'
```

- **Closes-out** unknowable password
- **'1'='1'** always resolves **TRUE**

Example Attack:

```
... AND password='$password'
```

```
... AND int(FALSE) == int('')
```

- Creates a **FALSE** string comparison
- But **FALSE == ''** ends up **TRUE**

Project 3: SQL Injection Tips

- **Solution:** craft a query that **closes-out unknowable fields**, resolves to **TRUE**

```
SELECT * FROM users WHERE password='$password'
```

Example Attack:

```
... AND password='$password'
```

```
... AND password='1' OR (FALSE) == int('')
```

- Closes-out unknowable fields
- '1'='1' always resolves to TRUE

Key idea: identify how you can exploit **SQL's command syntax** and **queries that resolve TRUE**

Result: Attacker does not need to know **the victim's password!**

FALSE string comparison
FALSE == '' ends up TRUE

Project 3: SQL Injection Tips

- **Write-out** your query and **how the server processes it**
 - Are you **closing-out** fields? **Commenting-out** the line?
- **Trial-and-error** with different **TRUE-resolving queries**
 - Pay attention to what server tells you!
 - E.g., “Incorrect username or password” versus “Error in MySQL query”

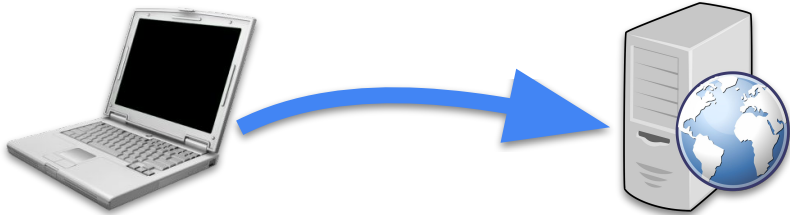
```
AND password=' ' OR '1'='1'
```

```
AND password=' ' OR '12345'
```

```
AND password=' '= ''
```


Interacting with Web Applications

- **GET request:** parameters in ???

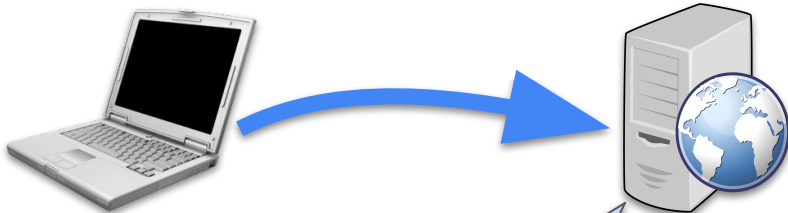


Interacting with Web Applications

- **GET request:** parameters in **URL**

1

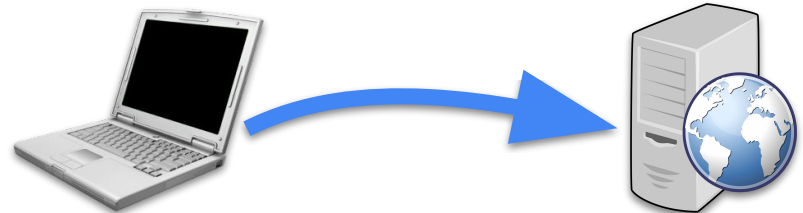
`www.bank.com/send.asp?to=snagy&amt=100`



2

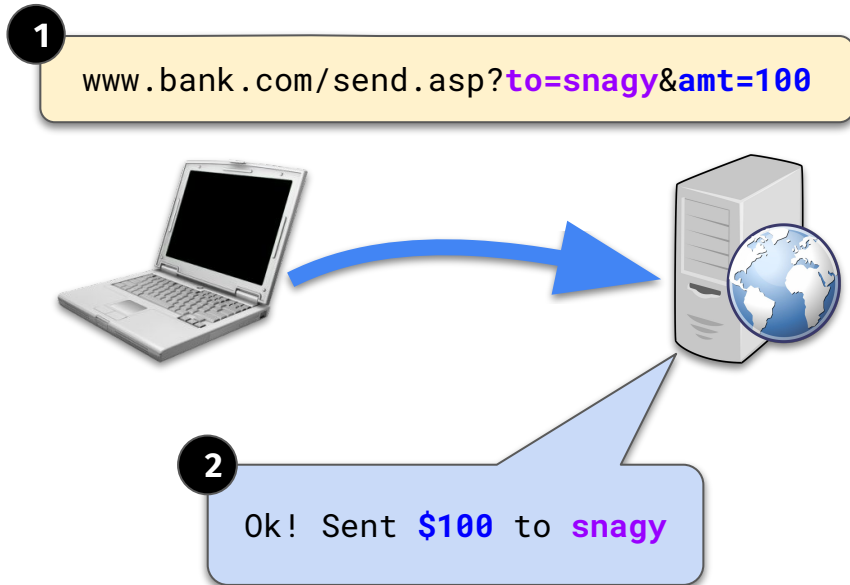
Ok! Sent **\$100** to **snagy**

- **POST request:** parameters in **???**

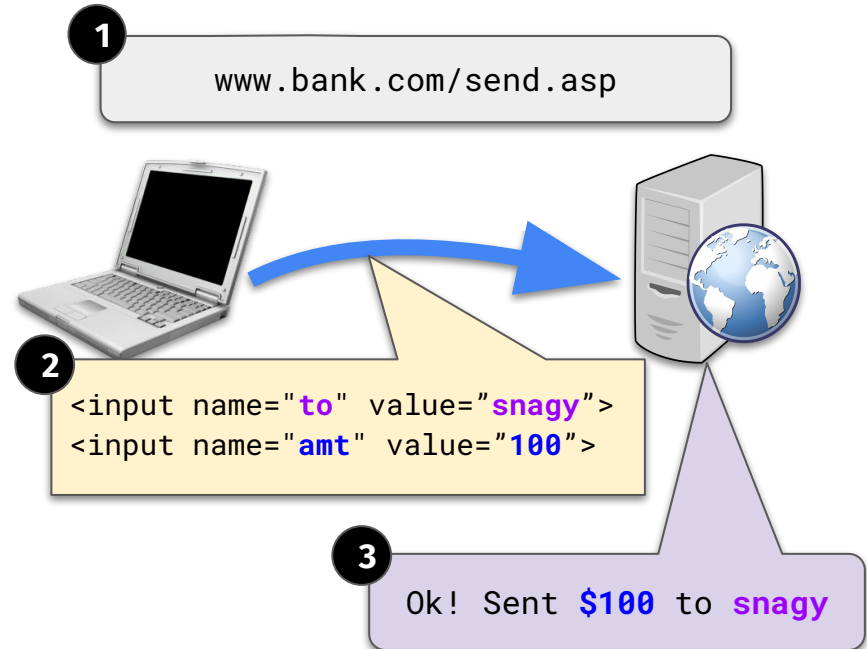


Interacting with Web Applications

■ GET request: parameters in URL



■ POST request: parameters in body



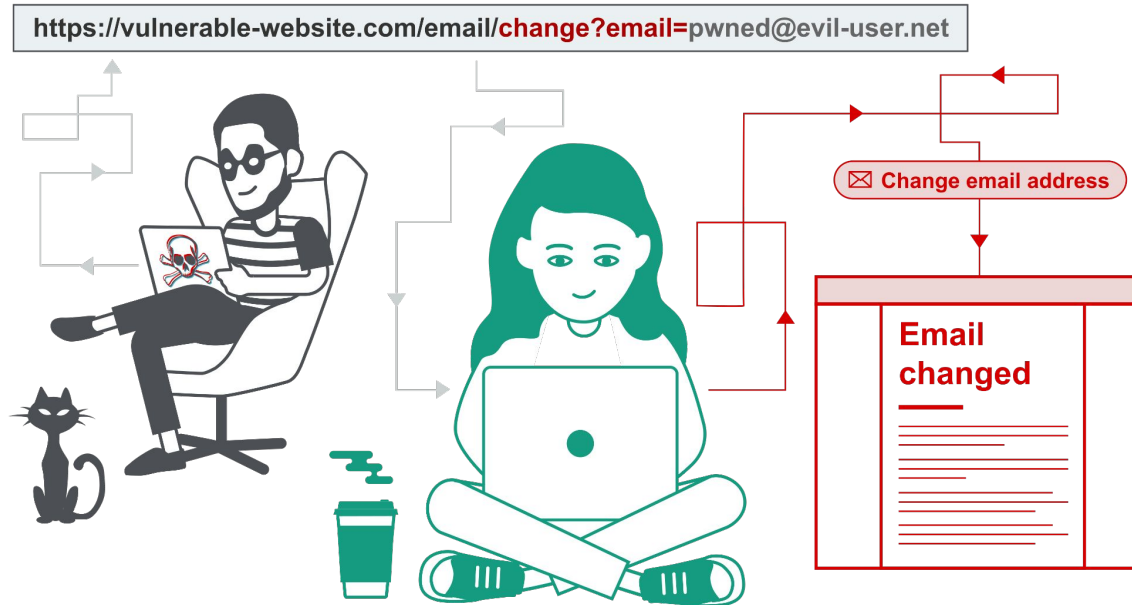
Cross-site Request Forgery (CSRF)

- **Attacker goal: ???**



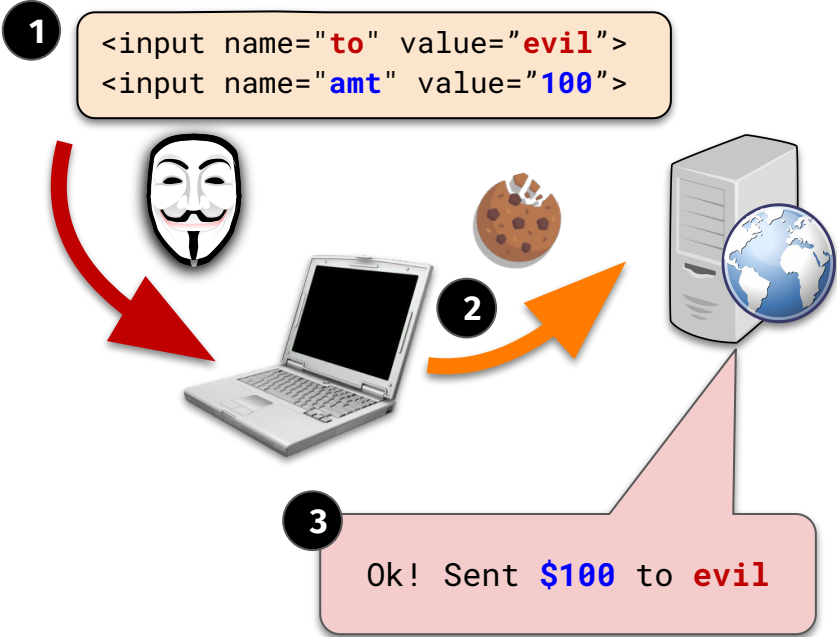
Cross-site Request Forgery (CSRF)

- **Attacker goal:** leverage **user's session** to execute **malicious commands**
 - Trick user into accessing **specially-crafted URLs (GET)** or **HTML pages (POST)**



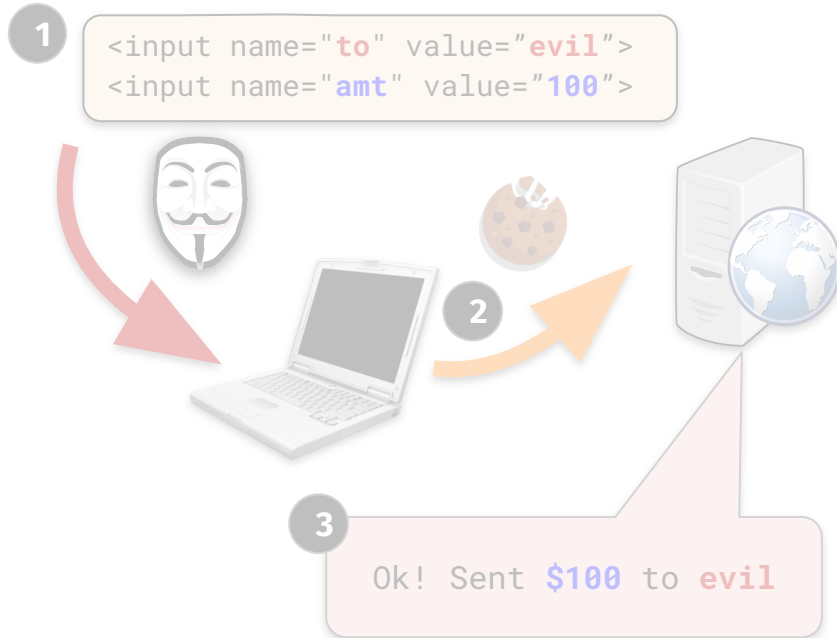
CSRF Attacks

- **POST-based CSRF (evil webpage)**

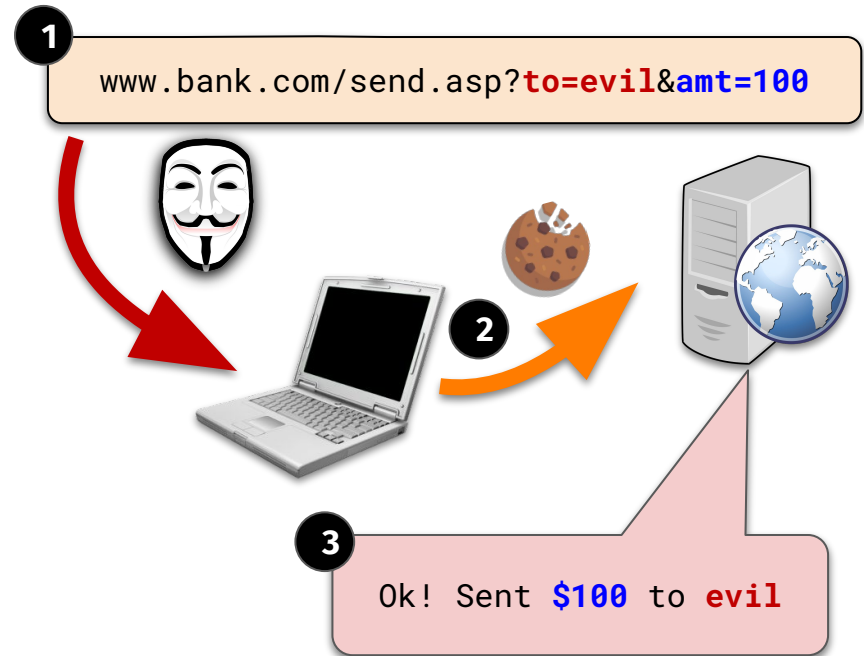


CSRF Attacks

POST-based CSRF (evil webpage)



GET-based CSRF (evil URL)



Interacting with Dynamic Web Applications

- **A powerful, popular web programming language**
 - Transmitted as **text**, rendered by **client's browser**
 - Can alter webpage contents, track events, read/set cookies, issue requests, read requests' replies, etc.

```
<script type="text/javascript">  
  function hello() { alert("Hello world!"); }  
</script>
```

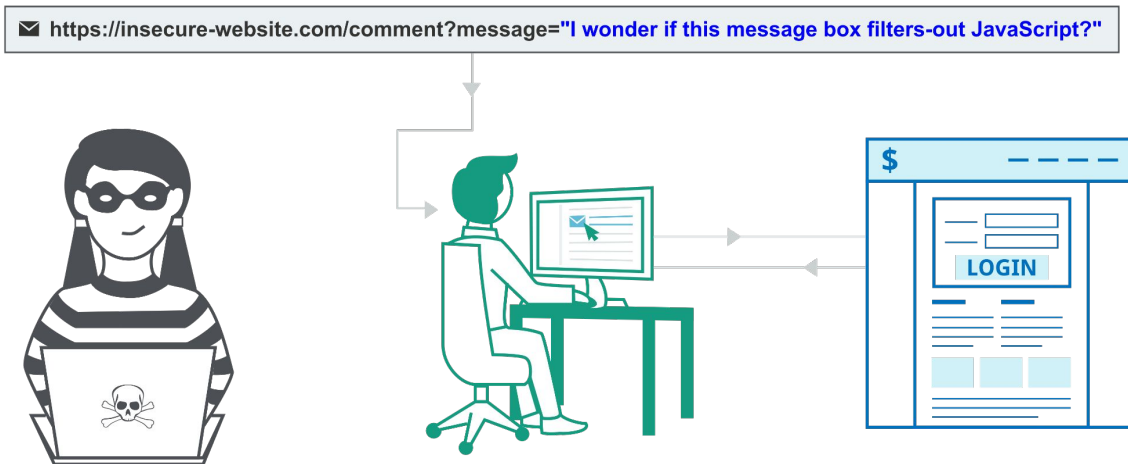
```

```



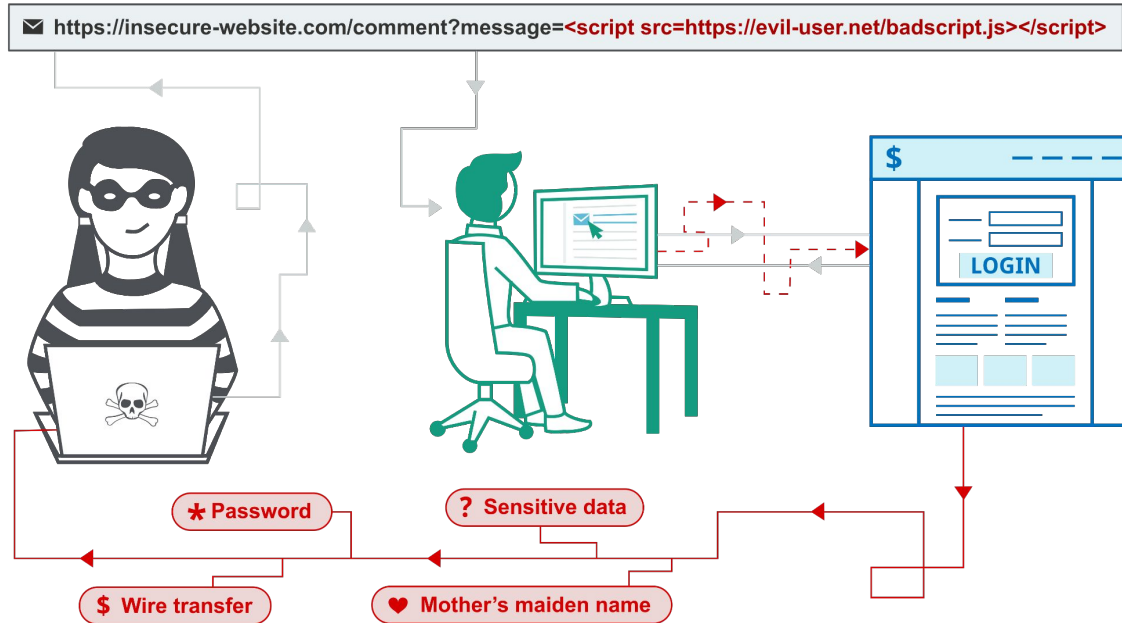
Cross-site Scripting (XSS)

- **Attacker goal: ???**



Cross-site Scripting (XSS)

- Attacker goal: submit **code as data** to website, get victim to **execute it**



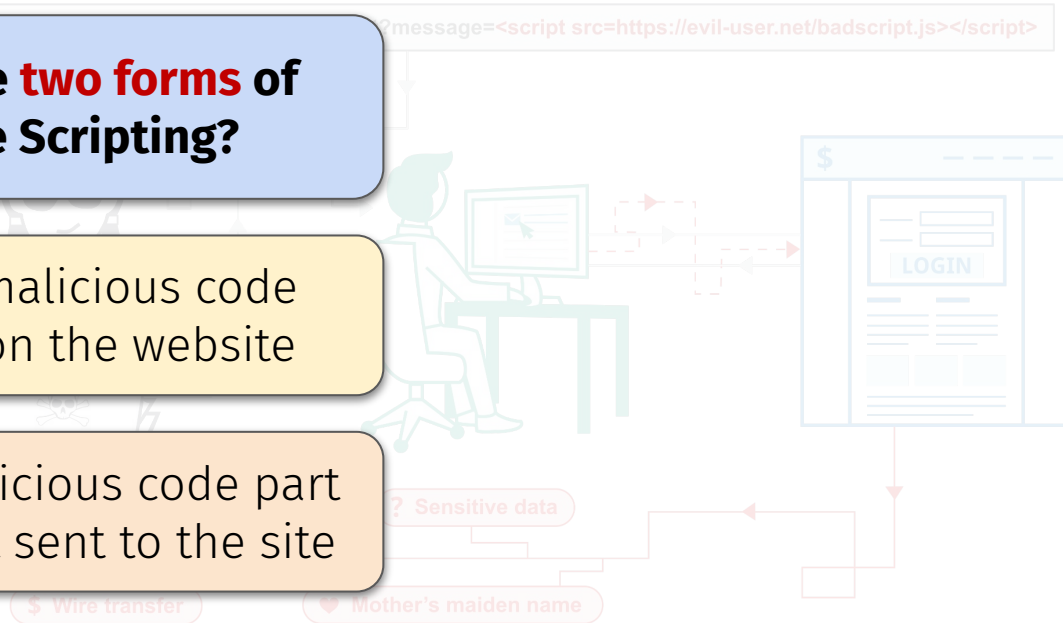
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- **Attacker goal:** submit **code as data** to website, get victim to **execute it**

What are the **two forms** of Cross-site Scripting?

Persistent: malicious code **embedded** on the website

Reflected: malicious code part of the **request** sent to the site



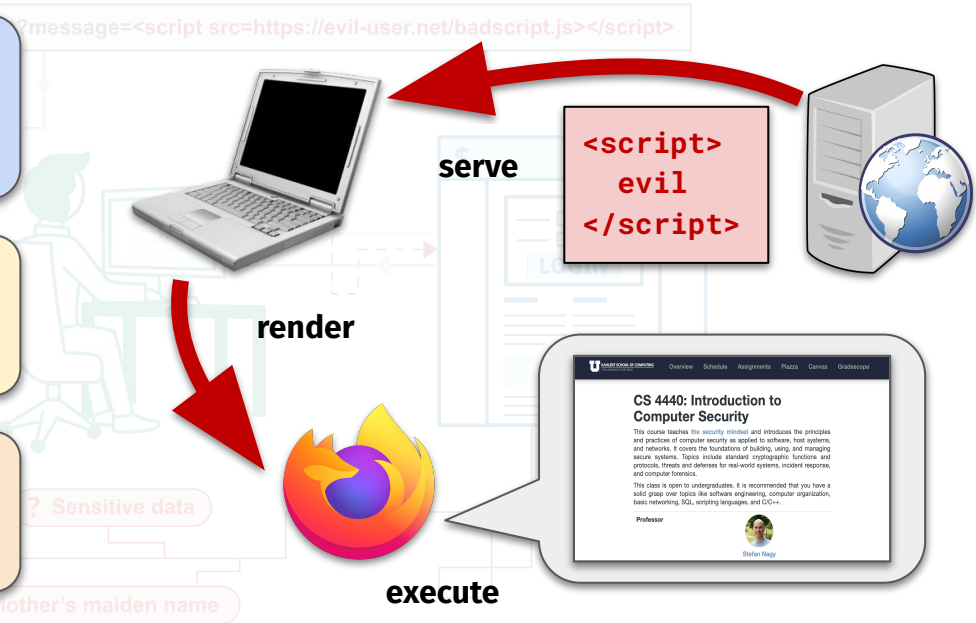
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Project 3: Beginner CSRF & XSS Tips

- Understand how your target **takes input**
 - **LOGIN** page: **POST** requests
 - **SEARCH** page: **GET** requests

Project 3: Beginner CSRF & XSS Tips

- Understand how your target **takes input**
 - **LOGIN** page: **POST** requests
 - **SEARCH** page: **GET** requests
- Set up your **attack parameters** accordingly
 - Desired username, password, method, etc.
 - Template makes this easy—use the **form!**

Project 3: Beginner CSRF & XSS Tips

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- **BSF 1–3**: exploiting the **SEARCH** page
 - **Weakness**: improperly filters search terms...
 - Can we leverage this to inject code?

Example SEARCH Input:

```
<input name="q" value="
    <script>
        alert(0);
    </script>
">
```

Project 3: Beginner CSRF & XSS Tips

- Understand how your target **takes input**
 - LOGIN page: **POST** requests
 - SEARCH page: **GET** requests
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 - Template makes this easy—use the **form!**
- **BSF 1–3**: exploiting the **SEARCH** page
 - **Weakness**: improperly filters search terms...
 - Can we leverage this to inject code?
- Test out **simple payloads first**, then move on to building your **full attacks!**

Example SEARCH Input:

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<input name="q" value="
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```


Project 3: Advanced XSS Tips

- **Builds off your skills** from **Part 2**
 - Master those first before attempting these!

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 - Attack embedded in a **static page**

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- **Builds off your skills** from **Part 2**
 - Master those first before attempting these!
- **Part 2: page-reflected** XSS
 - Attack embedded in a **static page**
- **Part 3: URL-reflected** XSS
 - Attack embedded in a **URL**

```
<input name="q" value="
  <script>alert(0);</script>
">
```

```
http://cs4440.eng.utah.edu/project3
/search?q=%3Cscript%3E...
```

Project 3: Advanced XSS Tips

- **Builds off your skills** from **Part 2**
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- **Part 2: page-reflected** XSS
 - Attack embedded in a **static page**

- **Part 3: URL-reflected** XSS
 - Attack embedded in a **URL**

- Test your attack by first embedding it in an **HTML page**, **then move to a URL!**

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 - Attack embedded in a **static page**

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<input name="q" value="
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- **Part 3: URL-reflected** XSS
 - Attack embedded in a **URL**

```
http://cs4440.eng.utah.edu/project3
/search?q=%3Cscript%3E...
```

- Test your attack by first embedding it in an **HTML page**, **then move to a URL!**
 - **Hint:** write a program to convert **JavaScript code characters** to a **URL-friendly encoding**
 - See https://www.w3schools.com/tags/ref_urlencode.ASP

Questions?



This time on CS 4440...

Browser-side Web Security
Isolation and Sandboxing
The Same-origin Policy
HTTPS, SSL, and TLS

Principles of Web Security

- **Privacy**
 - ???



Principles of Web Security

- **Privacy**
 - Malicious websites should not be able to **spy on me or my activities** online
- **Integrity**
 - ???



Principles of Web Security

- **Privacy**
 - Malicious websites should not be able to **spy on me or my activities** online
- **Integrity**
 - Malicious websites should not be able to violate the **integrity of my computer** or my **information on other websites**
- **Confidentiality**
 - ???



Principles of Web Security

■ Privacy

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■ Integrity

- Malicious websites should not be able to violate the **integrity of my computer** or my **information on other websites**

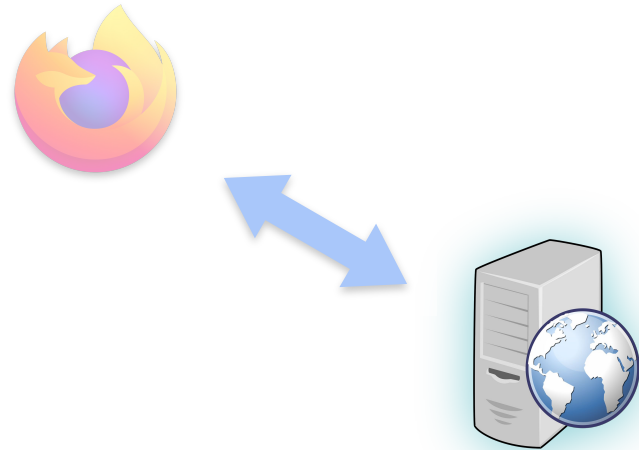
■ Confidentiality

- Malicious websites should not be able to **learn confidential information** from my computer or from other websites



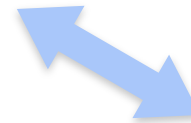
Web Security Risks

- **Risk #1:** [TotallySafeSite.com](#) should keep my **information secure**
 - E.g., database breaches, stolen login credentials, disgruntled employee, etc.
- **Defenses:** **server-side security**
 - ???



Web Security Risks

- **Risk #1:** [TotallySafeSite.com](#) should keep my **information secure**
 - E.g., database breaches, stolen login credentials, disgruntled employee, etc.
- **Defenses: server-side security**
 - Not storing info in plaintext
 - Principle of Least Privilege
 - Multi-factor authentication
 - Fix all server security bugs



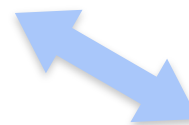
Web Security Risks

- **Risk #2** visiting [TotallySafeSite.com](https://www.totallysafesite.com) may access my **files and programs**
 - E.g., install malware, read sensitive information, alter local files, etc.
- **Defenses: browser-side security**
 - ???



Web Security Risks

- **Risk #2** visiting [TotallySafeSite.com](https://www.totallysafesite.com) may access my **files and programs**
 - E.g., install malware, read sensitive information, alter local files, etc.
- **Defenses: browser-side security**
 - Fix browser security bugs
 - Enable automatic updates
 - Privilege separation
 - **Sandbox all code** (e.g., JavaScript)



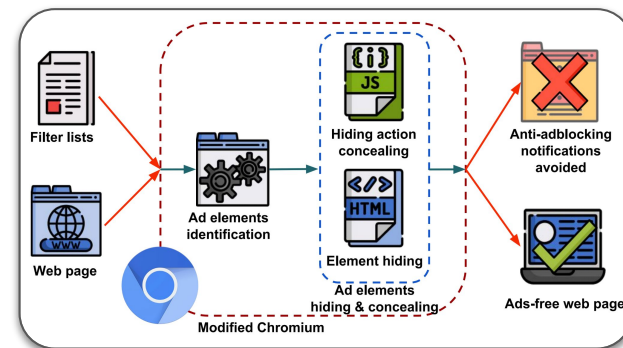
Client-side Web Defenses

Browser Sandboxing Techniques

- **General Process Sandboxing**
 - See Week 6B's lecture

Browser Sandboxing Techniques

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 - See Week 6B's lecture
- **DOM Mirroring**
 - Filter-out unsafe DOM elements
 - E.g., anti-adblocking functionality



Browser Sandboxing Techniques

■ General Process Sandboxing

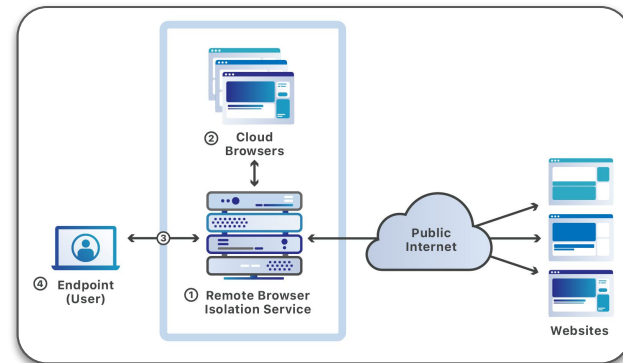
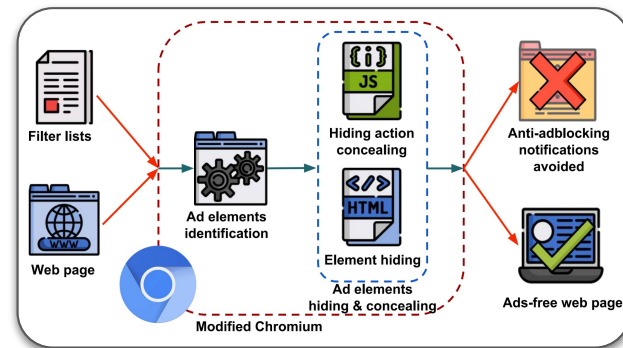
- See Week 6B's lecture

■ DOM Mirroring

- Filter-out unsafe DOM elements
- E.g., anti-adblocking functionality

■ Pixel Streaming / Remote Browser

- Render page remotely (e.g., container)
- **Pixel Reconstruction:** client only gets the final pixel array, not the application code
- **Remote Browser:** all interaction encrypted

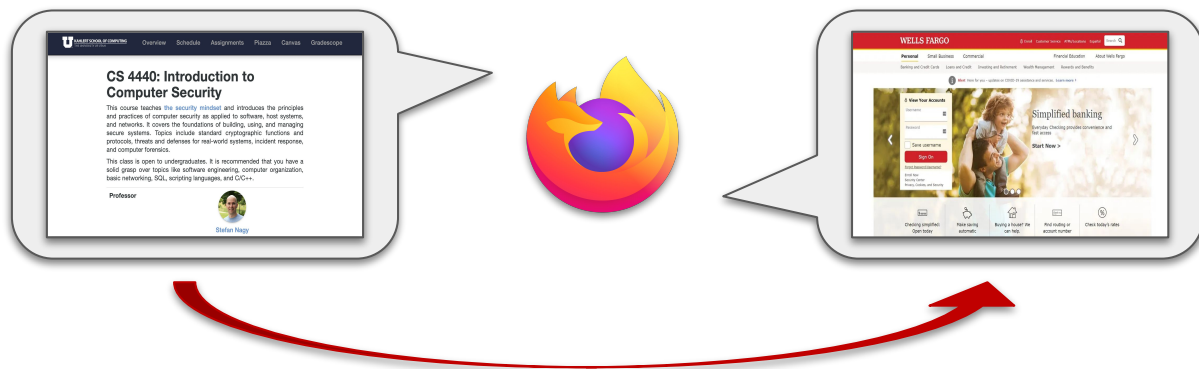


Web Security Risks

- **Risk #3:** `TotallySafeSite.com` tracks my info/interaction **with other sites**
 - E.g., spying on my GMail emails, purchasing things with my Amazon, etc.
- **Defenses: maintain site isolation**
 - Same-origin Policy
 - Multi-process browsing

Same-origin Policy

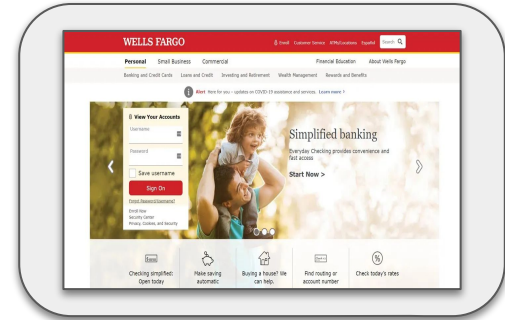
- **Goal:** make sure that scripts **don't abuse** the power of **JavaScript**



- Scripts from **CS 4440 website** shouldn't read **cookies** on **FellsWargo site**
 - ... or alter FellsWargo site's **layout**, or its read **keystrokes** typed by user to FellsWargo site

Same-origin Policy

- **Origin** = the **protocol** + the **hostname**
- **Example:** `http://www.cs.utah.edu/class...`
 - **Protocol:** HTTP
 - **Hostname:** `www.cs.utah.edu`



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Same-origin Policy

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 - **Protocol:** HTTP
 - **Hostname:** `www.cs.utah.edu`
- JavaScript from one page can **read, change, and interact freely** with **all pages from same origin**
 - Content cannot be accessed by **scripts of different origin**



Same-origin Policy

- Restricts access to content from the same **origin** (**protocol** + **host**)

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- Try the following, comparing to `http://example.com/home.html`

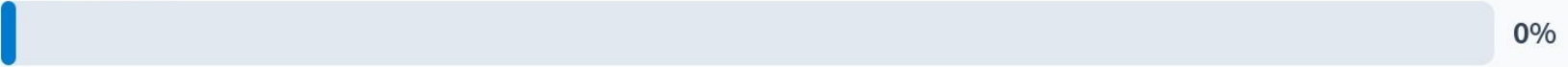
Candidate Request	SOP Result	Explanation
<code>https://example.com/index.html</code>		

For <http://example.com/home.html>, does <https://example.com/index.html> violate the SOP?

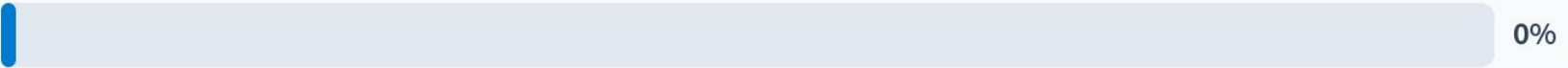
Passes SOP



Violates SOP



None of the above



Same-origin Policy

- Restricts access to content from the same **origin** (**protocol** + **host**)
- Try the following, comparing to `http://example.com/home.html`

Candidate Request	SOP Result	Explanation
<code>https://example.com/index.html</code>	FAIL	Different protocol (https)
<code>http://example.com/dir/other.html</code>		
<code>https://example.com/dir/inner/index.html</code>		
<code>http://example.com/dir/first/out/home.html</code>		
<code>http://en.example.com/dir/other.html</code>		

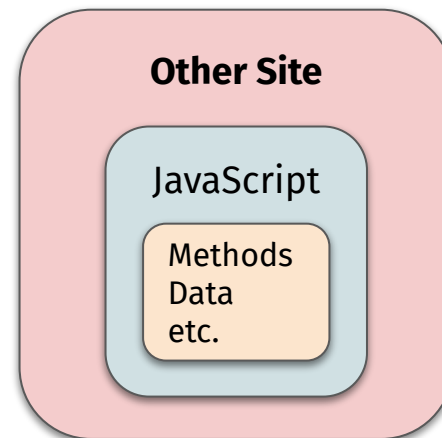
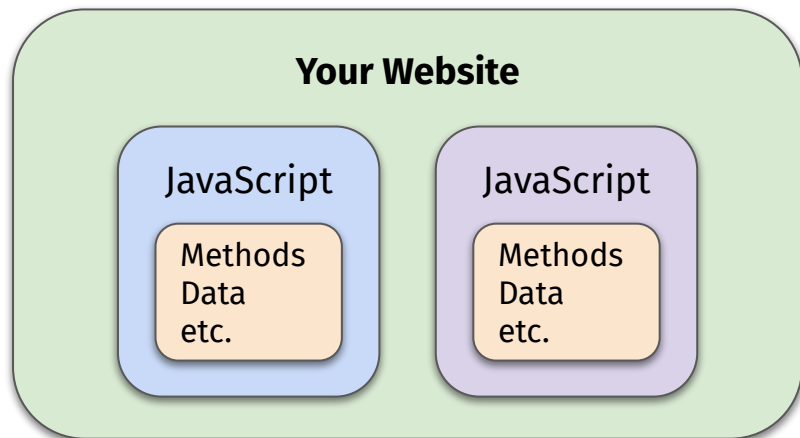
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<code>http://example.com/dir/other.html</code>	PASS	Same protocol, same host
<code>https://example.com/dir/inner/index.html</code>	FAIL	Different protocol (https)
<code>http://example.com/dir/first/out/home.html</code>	PASS	Same protocol, same host
<code>http://en.example.com/dir/other.html</code>	FAIL	Different host (en)

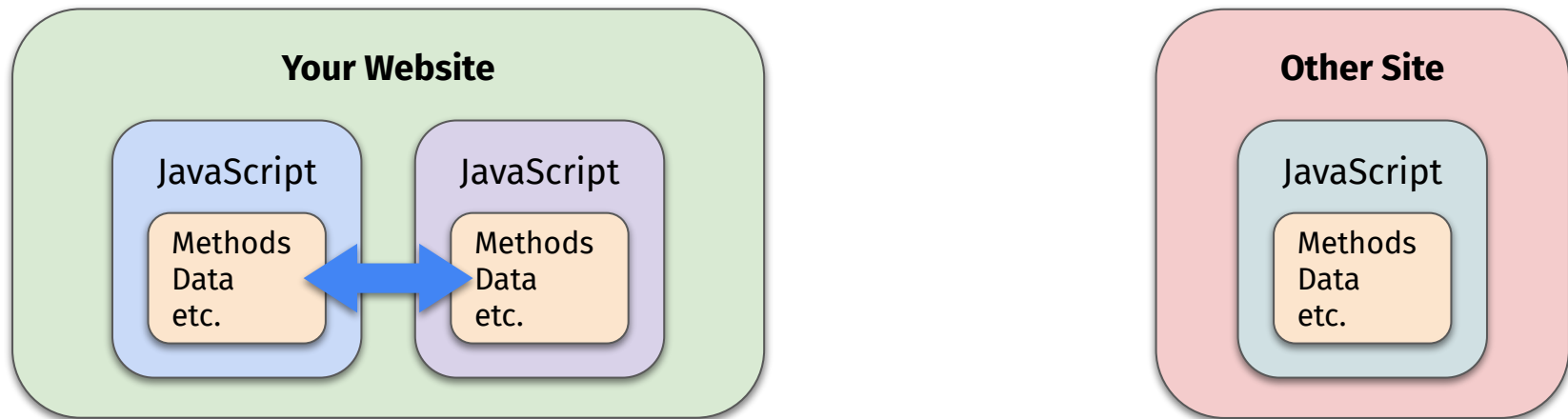
Same-origin Policy

- Implementation: **tagged sandboxing**



Same-origin Policy

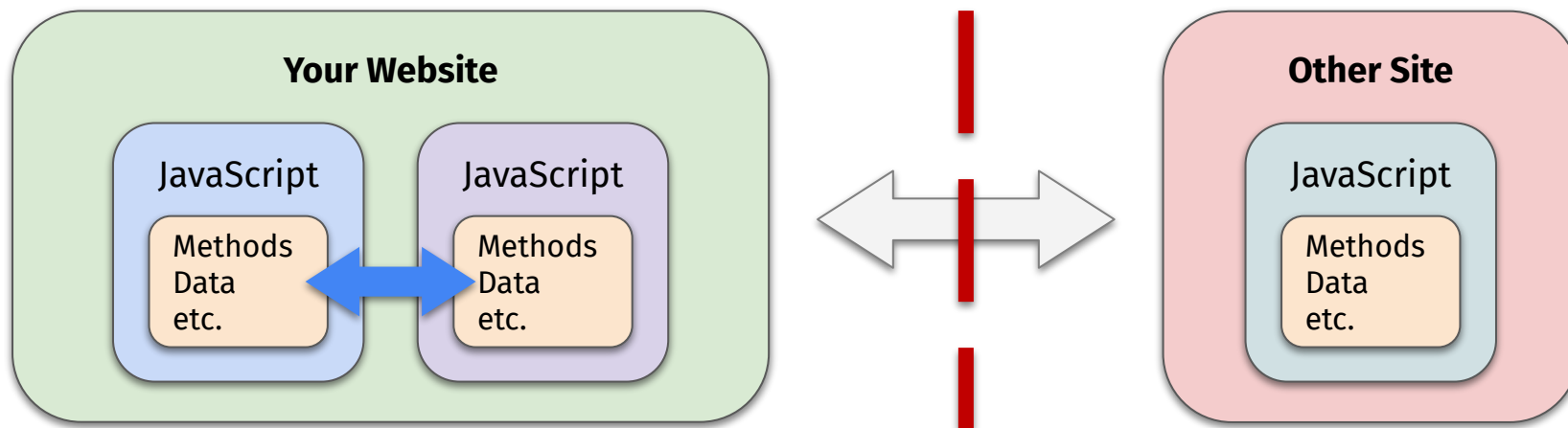
- Implementation: **tagged sandboxing**



- Scripts within **same origin** can interface with each other

Same-origin Policy

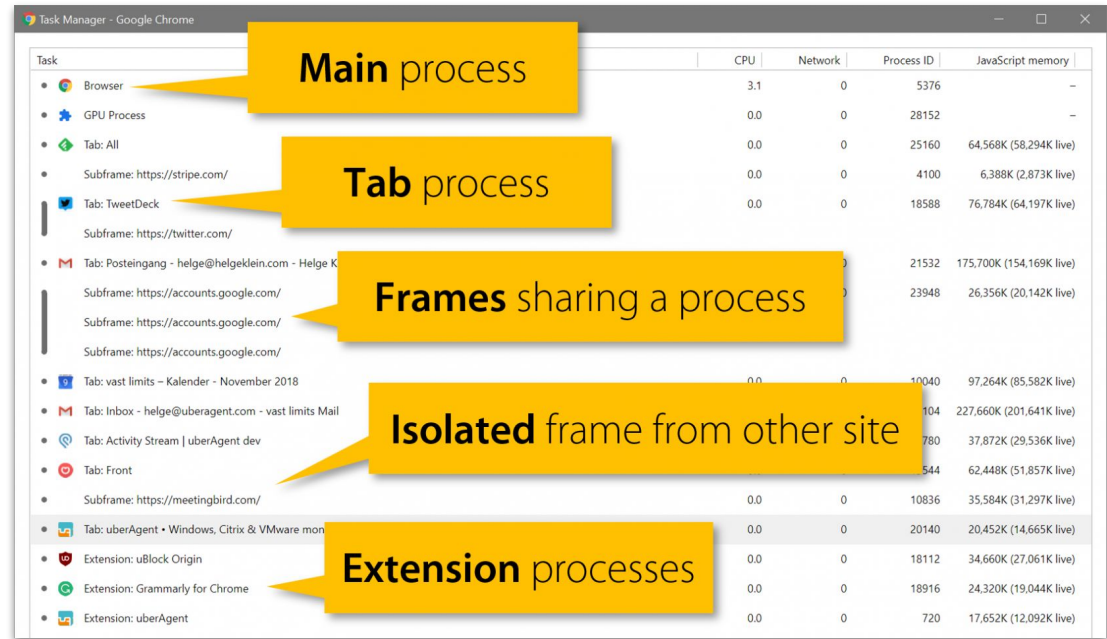
- Implementation: **tagged sandboxing**



- Scripts within **same origin** can interface with each other
- Scripts from **different origins** are completely blocked

Multi-process Browsing

- **Idea:** isolate “tabs” into **distinct processes**



Multi-process Browsing

- **Idea:** isolate “tabs” into **distinct processes**
 - **Site-level isolation!**
 - Piggyback off of MMU
- **Most browsers do this**
 - Chrome
 - Firefox
 - Etc.
- **Downside: ???**

The screenshot shows the Windows Task Manager window for Google Chrome. The 'Task' list on the left includes: Browser, GPU Process, Tab: All, Subframe: https://stripe.com/, Tab: TweetDeck, Subframe: https://twitter.com/, Tab: Posteingang - helge@helgeklein.com - Helge Klein, Subframe: https://accounts.google.com/, Subframe: https://accounts.google.com/, Subframe: https://accounts.google.com/, Tab: vast limits - Kalender - November 2018, Tab: Inbox - helge@uberagent.com - vast limits Mail, Tab: Activity Stream | uberAgent dev, Tab: Front, Subframe: https://meetingbird.com/, Tab: uberAgent - Windows, Citrix & VMware mon..., Extension: uBlock Origin, Extension: Grammarly for Chrome, and Extension: uberAgent. The table on the right has columns for CPU, Network, Process ID, and JavaScript memory. Yellow callout boxes point to specific rows: 'Main process' points to the 'Browser' row; 'Tab process' points to the 'Tab: TweetDeck' row; 'Frames sharing a process' points to the 'Subframe: https://accounts.google.com/' rows; 'Isolated frame from other site' points to the 'Tab: Front' row; and 'Extension processes' points to the 'Extension: uBlock Origin' row.

Task	CPU	Network	Process ID	JavaScript memory
Browser	3.1	0	5376	-
GPU Process	0.0	0	28152	-
Tab: All	0.0	0	25160	64,568K (58,294K live)
Subframe: https://stripe.com/	0.0	0	4100	6,388K (2,873K live)
Tab: TweetDeck	0.0	0	18588	76,784K (64,197K live)
Subframe: https://twitter.com/				
Tab: Posteingang - helge@helgeklein.com - Helge Klein			21532	175,700K (154,169K live)
Subframe: https://accounts.google.com/			23948	26,356K (20,142K live)
Subframe: https://accounts.google.com/				
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Tab: vast limits - Kalender - November 2018	0.0	0	10040	97,264K (85,582K live)
Tab: Inbox - helge@uberagent.com - vast limits Mail	0.0	0	104	227,660K (201,641K live)
Tab: Activity Stream uberAgent dev	0.0	0	780	37,872K (29,536K live)
Tab: Front	0.0	0	544	62,448K (51,857K live)
Subframe: https://meetingbird.com/	0.0	0	10836	35,584K (31,297K live)
Tab: uberAgent - Windows, Citrix & VMware mon...	0.0	0	20140	20,452K (14,665K live)
Extension: uBlock Origin	0.0	0	18112	34,660K (27,061K live)
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 - **Site-level isolation!**
 - Piggyback off of MMU
- **Most browsers do this**
 - Chrome
 - Firefox
 - Etc.
- **Downside: performance**
 - Lots of open tabs leads to lots of running processes!

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Questions?



Secure Web Communication

Principles of Secure Web Communication

- **Authentication**
 - ???

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- **Authentication**
 - The client must be able to verify that it is **talking to the desired server**
- **Integrity**
 - **???**

Principles of Secure Web Communication

■ Authentication

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■ Integrity

- Data transmitted between client and server **must not be attacker-modifiable**

■ Confidentiality

- ???

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Principles of Secure Web Communication

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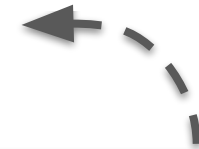
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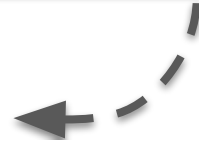
■ Confidentiality

- Data transmitted between the client and server must not be attacker visible

Assumptions:



Assume end-points (the **client** and **server**) **secure**



Principles of Secure Web Communication

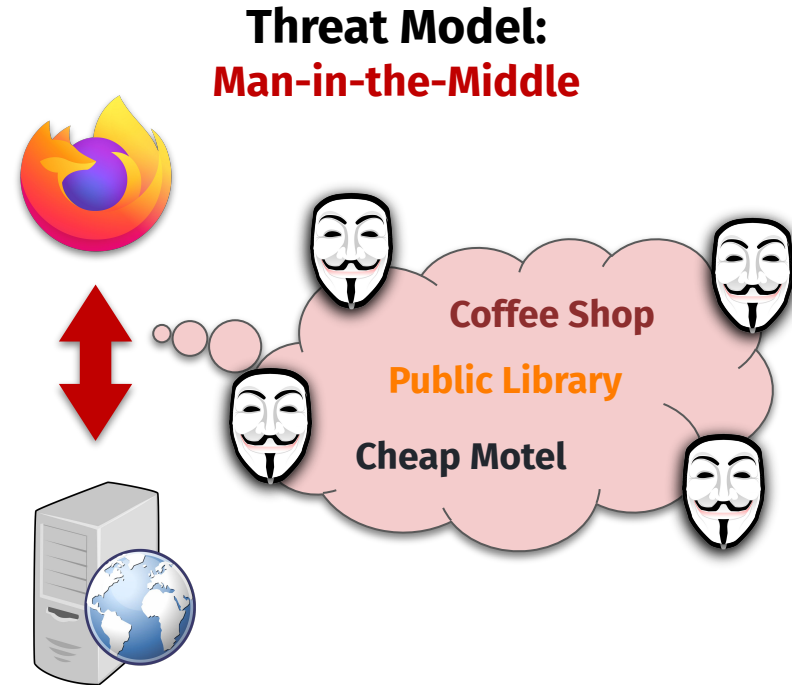
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Threat Model:



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Integrity

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Confidentiality

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Threat Model: Man-in-the-Middle

Parties that are trying to **spy on you:**
Hackers, your boss, the government

How can we make **web comm secure?**

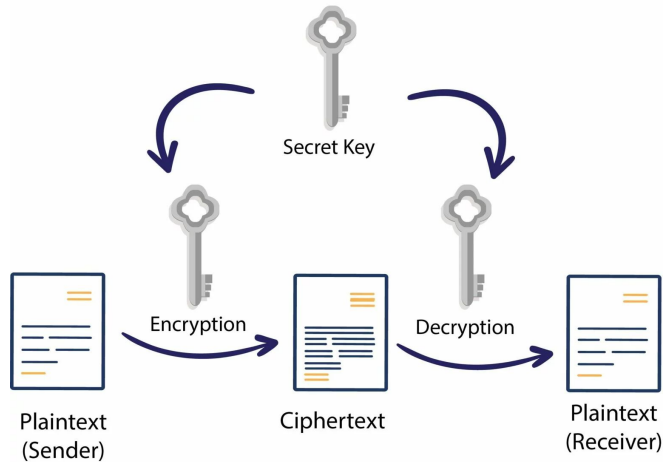


Crypto to the rescue!

- **Symmetric Crypto:**

Crypto to the rescue!

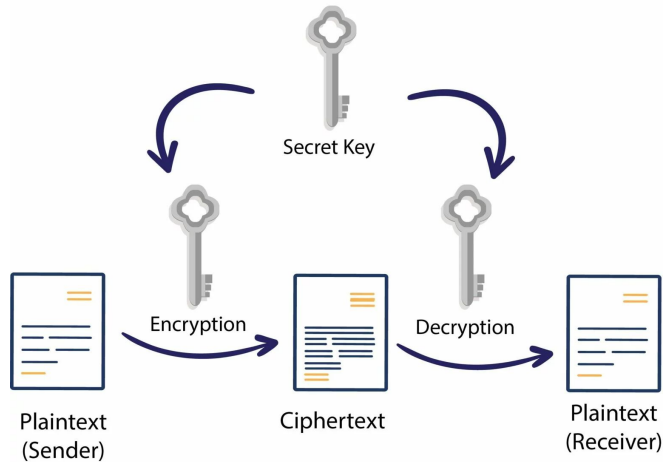
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- **Problem: ???**

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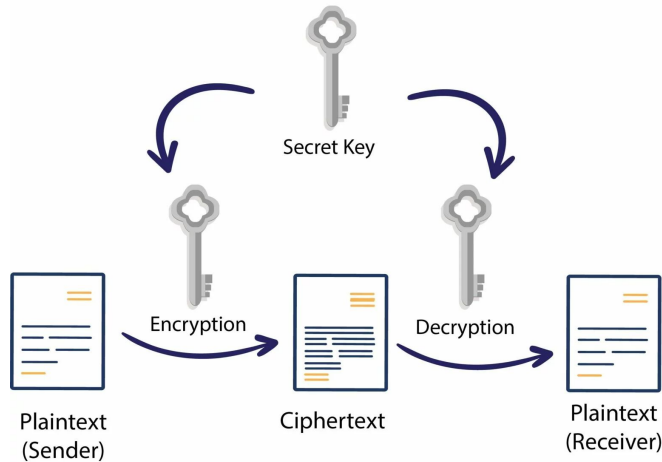
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- **Problem: pre-sharing entire key**
 - If intercepted, whole scheme ruined!

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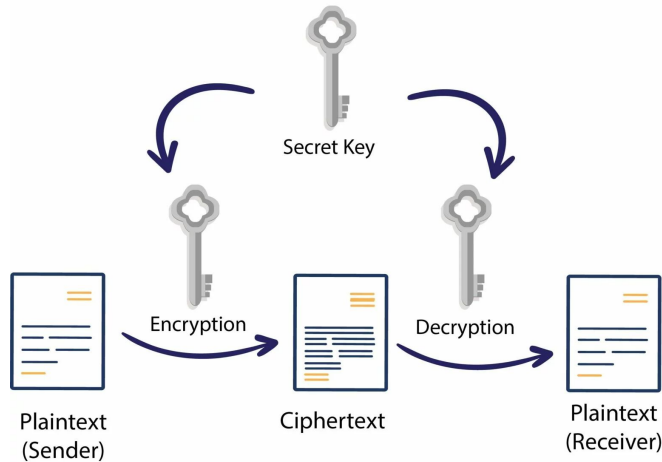


- **Problem: pre-sharing entire key**
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- **Public-key Crypto:**

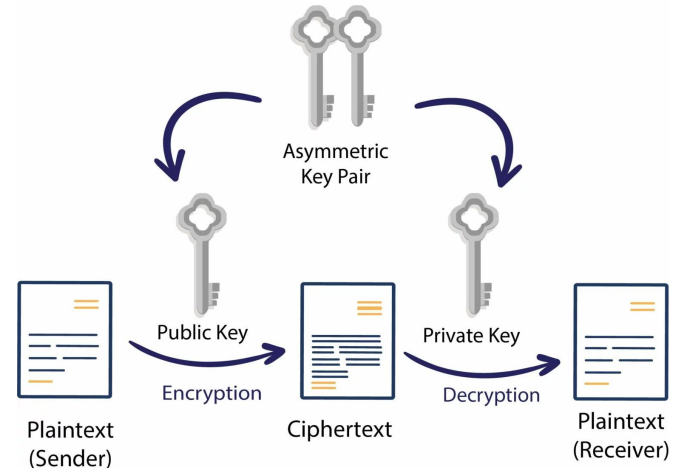
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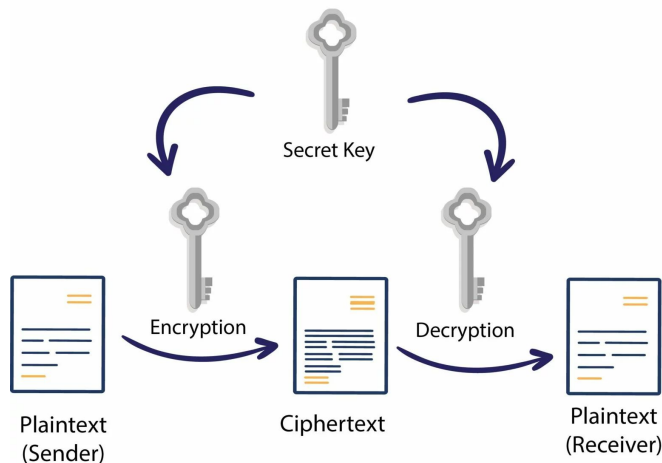
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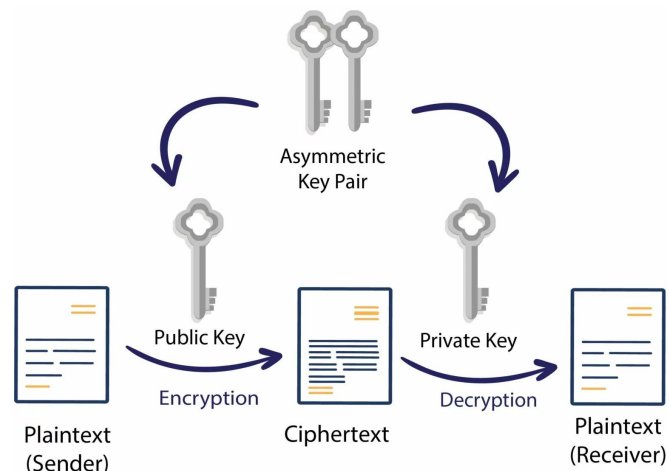
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■ Public-key Crypto:



- **Problem: lack of pre-authentication**
 - Is Bob's key really from the real Bob?

Crypto to the rescue!

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Parties that are trying to **spy on you:**
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How can we **overcome pre-auth?**

■ Public-key Crypto:



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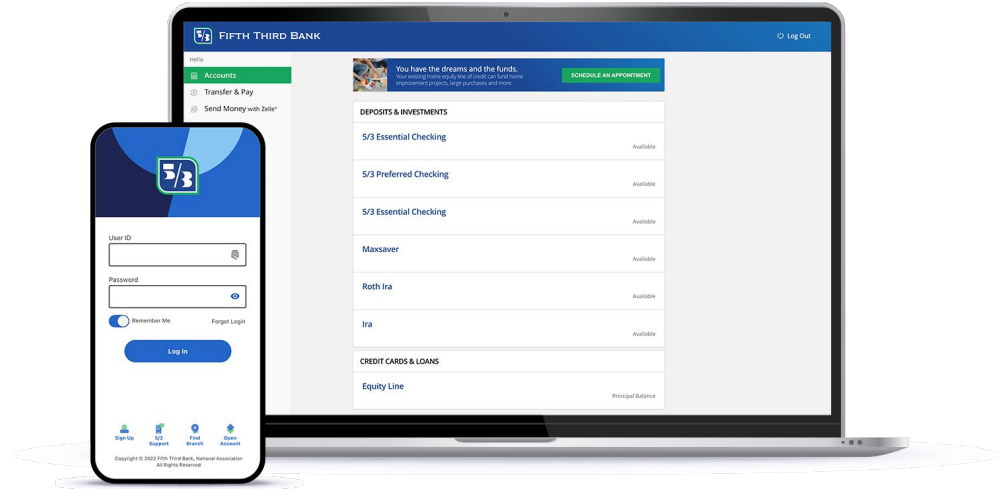
■ Problem: lack of pre-authentication

- Is Bob's key really from the real Bob?

HTTPS: HTTP over TLS

Recap: HyperText Transfer Protocol (HTTP)

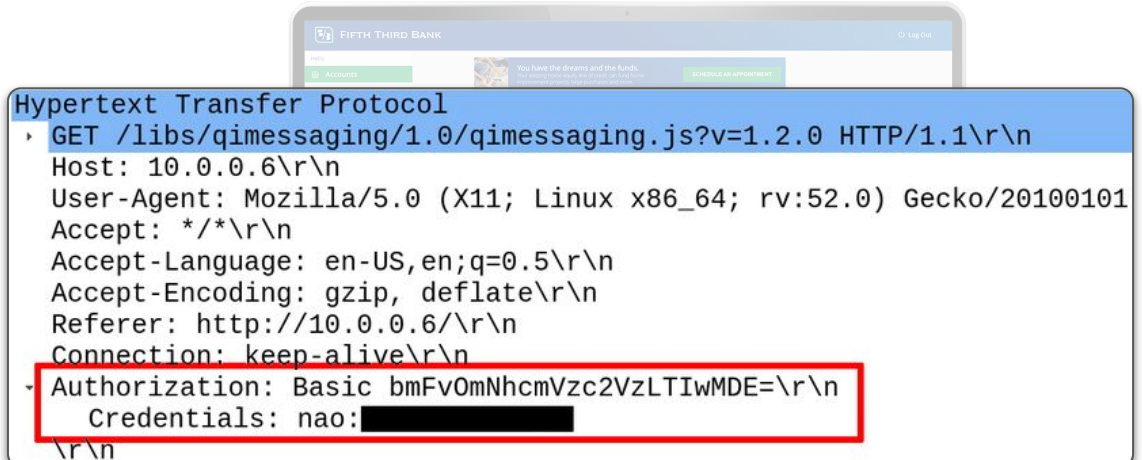
- **Protocol for transmitting hypermedia documents (e.g., web pages)**
 - Widely used
 - **Simple**
 - **Unencrypted**



Recap: HyperText Transfer Protocol (HTTP)

- **Protocol for transmitting hypermedia documents** (e.g., web pages)
 - Widely used
 - **Simple**
 - **Unencrypted**

Problem: no way of keeping data hidden from **prying eyes!**



```
Hypertext Transfer Protocol
  GET /libs/qimessaging/1.0/qimessaging.js?v=1.2.0 HTTP/1.1\r\n
Host: 10.0.0.6\r\n
User-Agent: Mozilla/5.0 (X11; Linux x86_64; rv:52.0) Gecko/20100101
Accept: */*\r\n
Accept-Language: en-US,en;q=0.5\r\n
Accept-Encoding: gzip, deflate\r\n
Referer: http://10.0.0.6/\r\n
Connection: keep-alive\r\n
Authorization: Basic bmFvOmNhcmVzc2VzLTIwMDE=\r\n
  Credentials: nao: [REDACTED]
\r\n
```

Recap: HyperText Transfer Protocol (HTTP)

- Protocol for transmitting hypermedia documents (e.g., web pages)
 - Widely used
 - Simple
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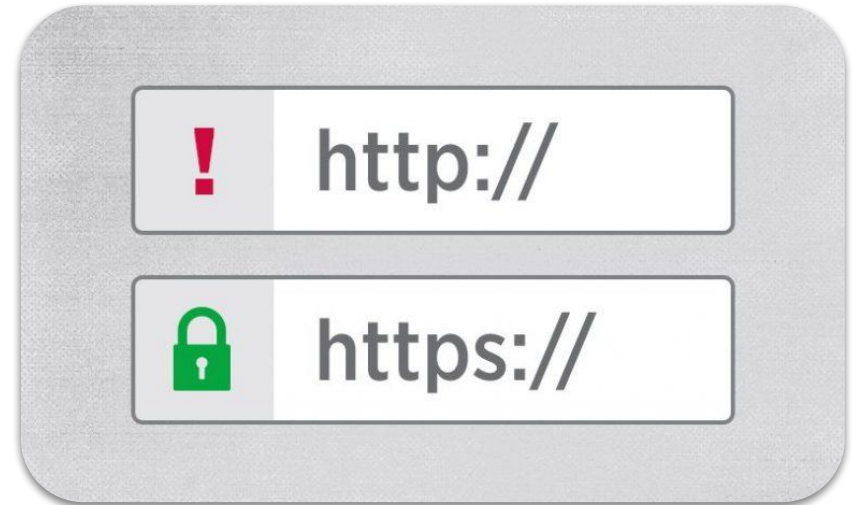
Problem: keeping data from prying eyes!

We need a **secure protocol** for comms: **HTTPS** (aka "HTTP over **SSL/TLS**")

```
Hypertext Transfer Protocol
GET /libs/gimessaging/1.0/gimessaging.js?v=1.2.0 HTTP/1.1\r\n
rv:52.0) Gecko/20100101.
Connection: keep-alive\r\n
Authorization: Basic bmFvOmNhcmVzc2VzLTIwMDE=\r\n
Credentials: nao: [REDACTED]\r\n
```

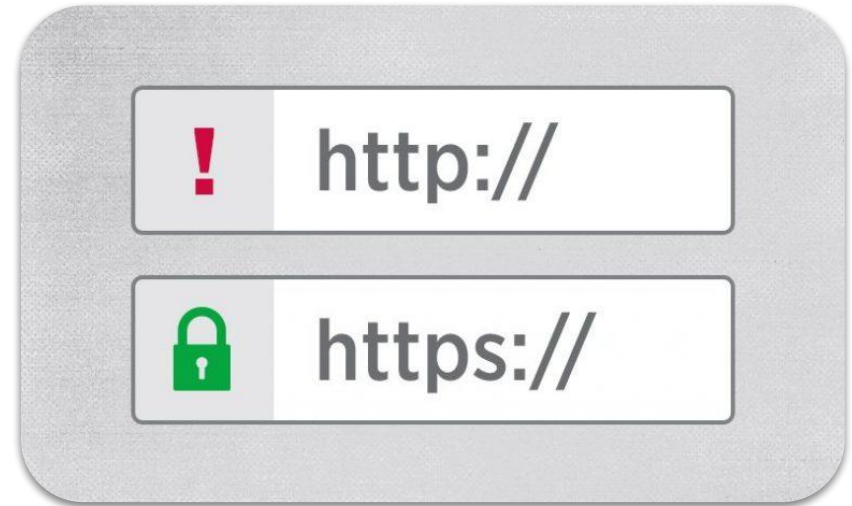

SSL and TLS

- The **physical protocols** by which **HTTPS public-key encryption** works



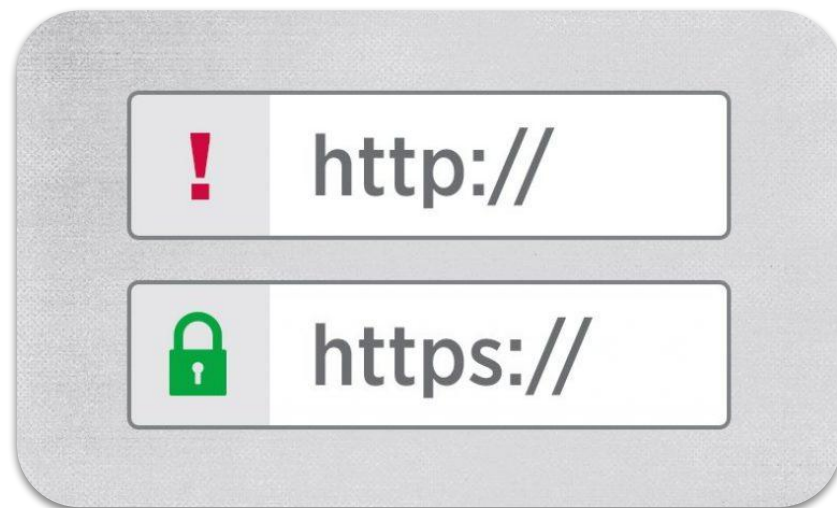
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SSL and TLS

- The **physical protocols** by which **HTTPS public-key encryption** works
- **SSL (Secure Socket Layer)**
 - Developed by Netscape
 - Obsolete—stop using it!
- **TLS (Transport Layer Security)**
 - Successor to SSL
 - Versions 1.0, 1.1, 1.2, 1.3
 - **Current IETF approved standard**



The TLS Handshake



Client Hello: Here's *Ciphers* I support, and a *random*



The TLS Handshake



Client Hello: Here's **Ciphers** I support, and a **random**



Server Hello: **Chosen Cipher**

Certificate: Here is my **Certificate** with my **PubKey**

Here's your **random** back encrypted with my **PrivKey**

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Switch to a **Symmetric Cipher**

Switch to a **Symmetric Cipher**

The TLS Handshake



Client Hello: Here's *Ciphers* I support, and a random

Server Hello: Chosen Cipher

We **do not** expect you to memorize the hairy details about **SSL/TLS!**

Key Exchange: Our *SynKey* encrypted with your PubKey

Switch to a *Symmetric Cipher*

Switch to a *Symmetric Cipher*

Higher-level TLS Handshake

Client says: “Howdy! Here is what cipher suites I support.”
“Here is a **random** number for you to encrypt.”

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Client says: “Great! You are who you say you are. Here’s our **symmetric key**.”

Handling Pre-authentication

- A **trusted authority vouches** that a certain public key belongs to a particular site
 - Format called x.509 (complicated)
- Browsers ship with public keys for large number of trusted **Certificate Authorities**
- **Important fields:**
 - Common Name (CN) (e.g., *.google.com)
 - Expiration Date (e.g., 2 years from now)
 - **Subject's Public Key**
 - Issuer (e.g., Verisign)
 - Issuer's signature
- **Common Name field**
 - Explicit name, e.g. cs.utah.edu
 - Or wildcard, e.g. *.utah.edu

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The **CA ecosystem** aims to address comm **pre-auth**

Example x509 Certificate

Subject: C=US/O=Google Inc/CN=www.google.com

Issuer: C=US/O=Google Inc/CN=Google Internet Authority

Serial Number: 01:b1:04:17:be:22:48:b4:8e:1e:8b:a0:73:c9:ac:83

Expiration Period: Jul 12 2010 - Jul 19 2012

Public Key Algorithm: rsaEncryption

Public Key: 43:1d:53:2e:09:ef:dc:50:54:0a:fb:9a:f0:fa:14:58:ad:a0:81:b0:3d
7c:be:b1:82:19:b9:7c3:8:04:e9:1e5d:b5:80:af:d4:a0:81:b0:b0:68:5b:a4:a4
:ff:b5:8a:3a:a2:29:e2:6c:7c3:8:04:e9:1e5d:b5:7c3:8:04:e9:39:23:46

Signature Algorithm: sha1WithRSAEncryption

Signature: 39:10:83:2e:09:ef:ac:50:04:0a:fb:9a:f0:fa:14:58:ad:a0:81:b0:3d
7c:be:b1:82:19:b9:7c3:8:04:e9:1e5d:b5:80:af:d4:a0:81:b0:b0:68:5b:a4:a4
:ff:b5:8a:3a:a2:29:e2:6c:7c3:8:04:e9:1e5d:b5:7c3:8:04:e9:1e:5d:b5

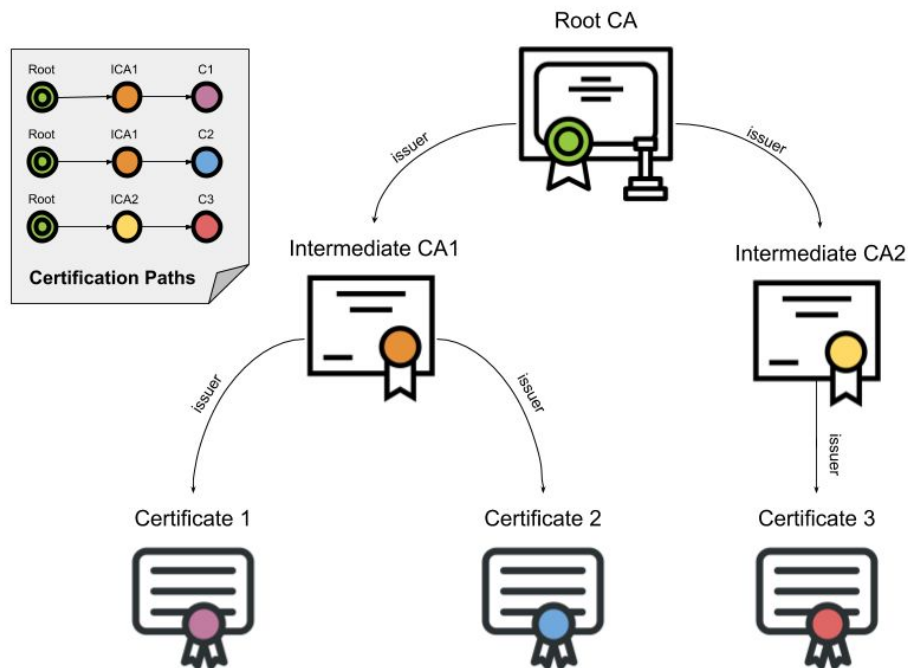
Certificate Chaining

- **Root CA** signs a **certificate-issuing certificate** for delegated authority

- Your browser “peels” this chain of certificates until finds one it trusts

- **Domain Validation:**

- Is the certificate expired?
- Does the registered email reply to me?
- Does DNS record match the cert owner?
- **More thorough, complicated certificate validation measures exist today**



Food for Thought

- Think of **CAs** like notaries or passport-issuing government entities

Is this ecosystem forever **trustable?**

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- Think of **CAs** like notaries or passport-issuing government entities

Is this ecosystem forever **trustable?**

What kinds of things could go **wrong?**

Next time on CS 4440...

Attacks on HTTPS, Networking 101