ENEE 457: Computer Systems Security

Web Security

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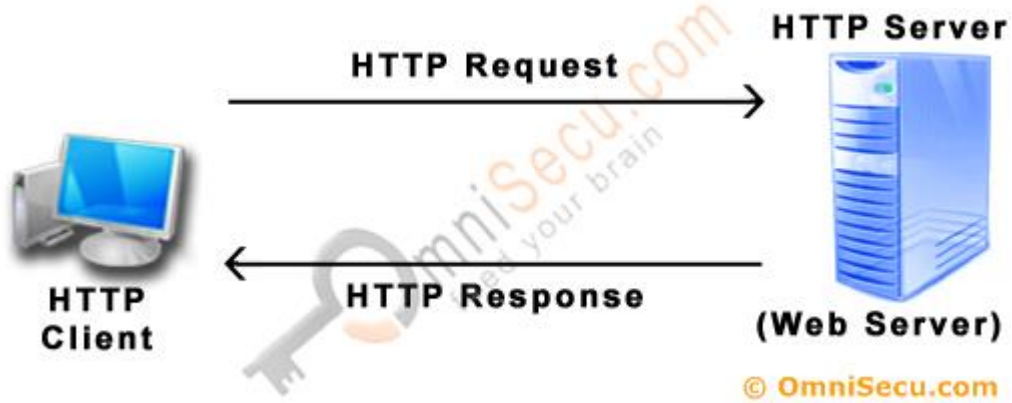
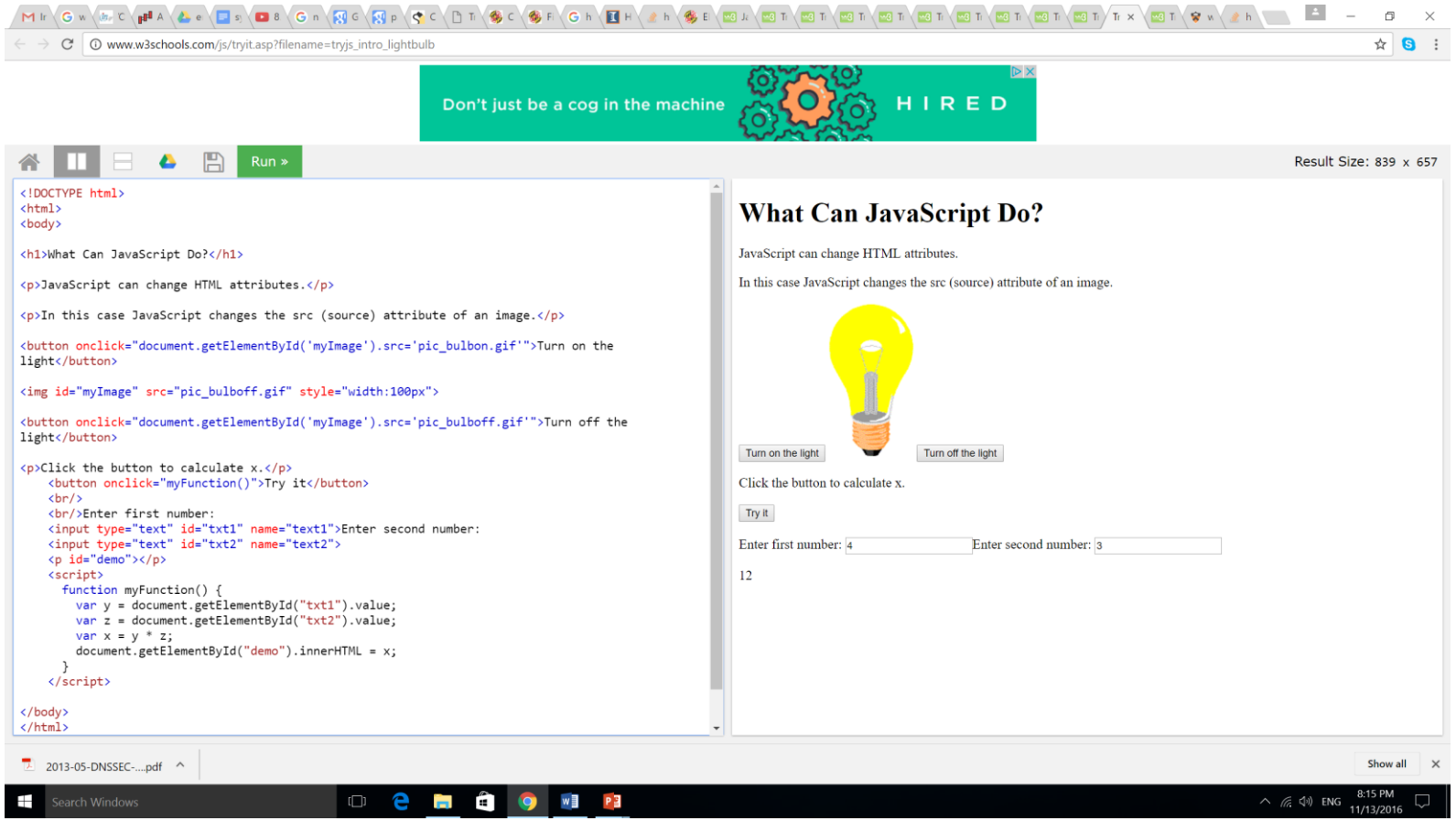
Back in the old days

- Clients will just send http requests
- Browser would just display information
- Servers will reply after talking to databases or other machines, sending mostly static content
- So the only attack vector was the server
  - We saw such attacks, e.g., buffer overflow



Now…

- Browser is super complicated
  - Java Script (you can execute Turing-Complete code at the client side)

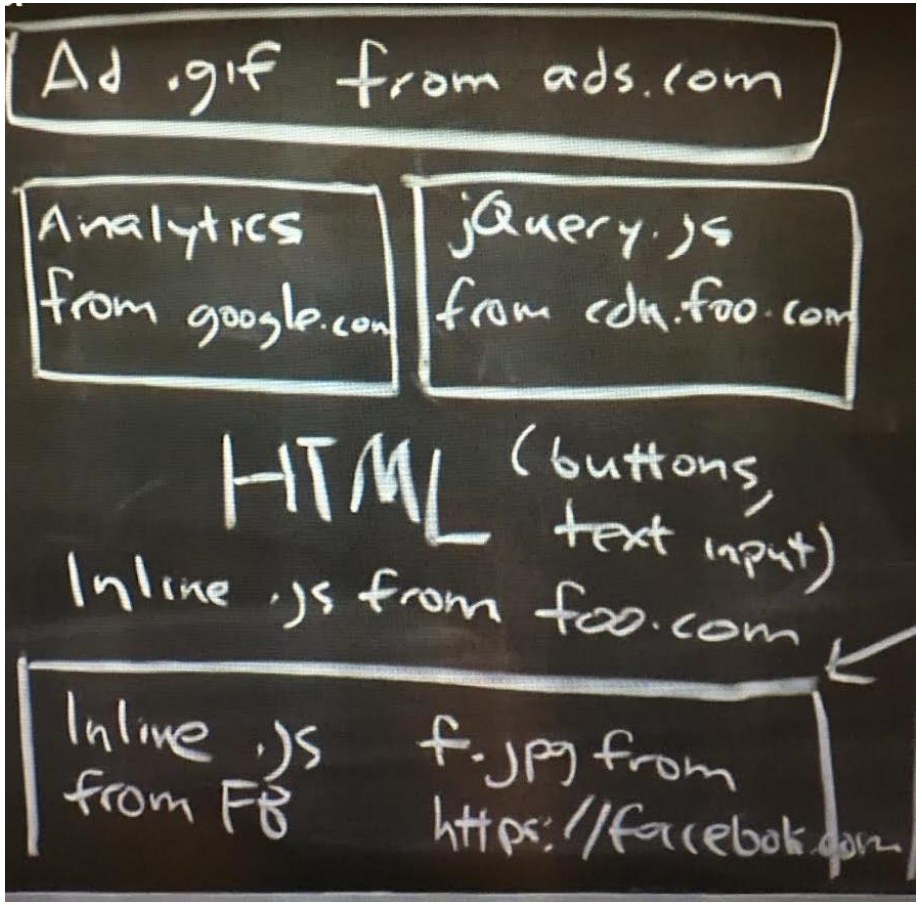


Desktop applications VS Web Application

- Word comes from Microsoft
- Turbotax comes from the company that created
- But web applications?
  - Many different parties provide content
  - Think about cnn.com
  - You look at one page, but there are a lot of parties contributing content

Various Issues Here

- A web page can
  - Call JS libraries from different websites
  - Have inline JS
  - Load other html frames that have different inline JS
  - (the loaded frame can be https! while the loader frame can be http)
- Main problem: Can JS from different origin mix state?



Solution to that: Same Origin Policy

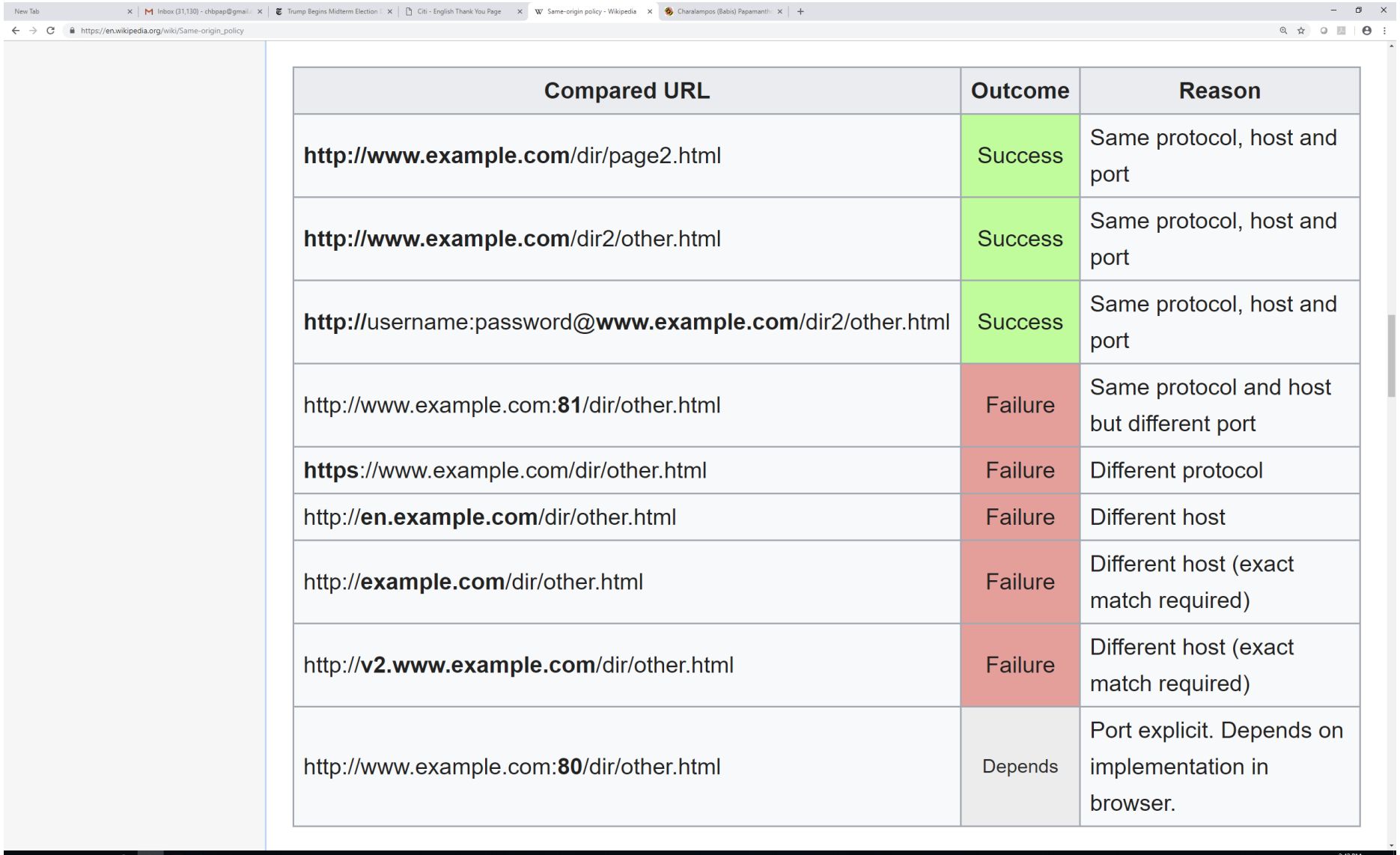
- **GOAL:** Two websites should not be able to tamper with each other
- But what does "non-tampering" mean? Hard.
  - One website should not be able to overwrite the display of another website without permission
  - But, two websites should be able to exchange data for collaboration
  - A website taking Google maps data and restaurant data
- **STRATEGY:** Each frame is assigned an origin and it can access resources only from its origin
- What is origin?
  - Protocol+hostname+port
  - http://foo.com/index.html (port 80)
  - https://foo.com/index.html (port 443)
  - http://bar.com: 8181/

Four ideas behind SOP policy

- Each origin has client side resources
  - e.g., cookies for password remembering
  - DOM storage (basically a key-value store)

- Each frame gets the origin of its URL
- Scripts execute with the authority of its frame
  - If foo.com imports some javascript, then this would only be able to access cookies from foo.com
- Passive content does not get any authority

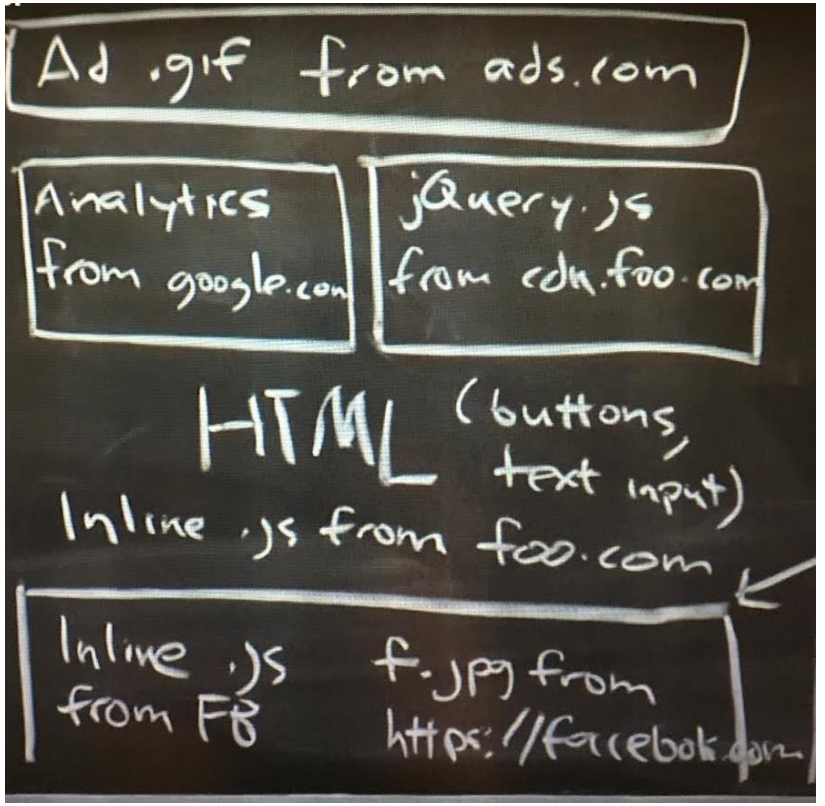
Example with http://www.example.com/dir/page.html



Compared URL	Outcome	Reason
http://www.example.com/dir/page2.html	Success	Same protocol, host and port
http://www.example.com/dir2/other.html	Success	Same protocol, host and port
http://username:password@**www.example.com**/dir2/other.html	Success	Same protocol, host and port
http://www.example.com:**81**/dir/other.html	Failure	Same protocol and host but different port
https://www.example.com/dir/other.html	Failure	Different protocol
http://**en.example.com**/dir/other.html	Failure	Different host
http://**example.com**/dir/other.html	Failure	Different host (exact match required)
http://**v2.www.example.com**/dir/other.html	Failure	Different host (exact match required)
http://www.example.com:**80**/dir/other.html	Depends	Port explicit. Depends on implementation in browser.

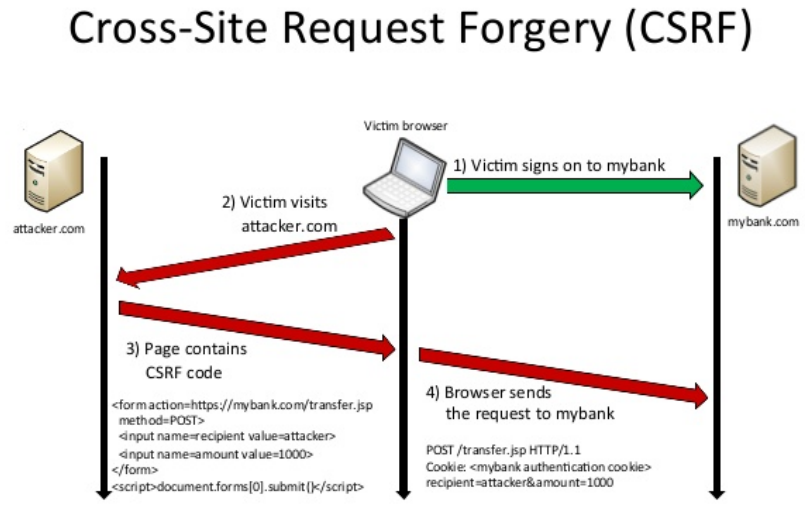
Let’s go back to our example

- Analytics and jQuery can access variables from foo.com
- But not from Facebook.com since they are in a different frame
- They can only communicate with a well-defined interface, POST-message (and foo.com can choose not to receive the message).



Cross-site request forgery

- Careful with cookies
  - I log into bank.com, and a cookie is planted in my machine with the password
  - Then the attacker makes me access a webpage, where he embeds
    - http://bank.com/xfer?amount=500 &to = attacker
  - Then my browser will read my cookies and it will do the transfer against my will…(CSRF)
  - How to prevent? Embed some randomness on form generation that the attacker cannot possibly know (apart from the cookie)
  - https://www.youtube.com/watch?v=6Cc43DEeazI



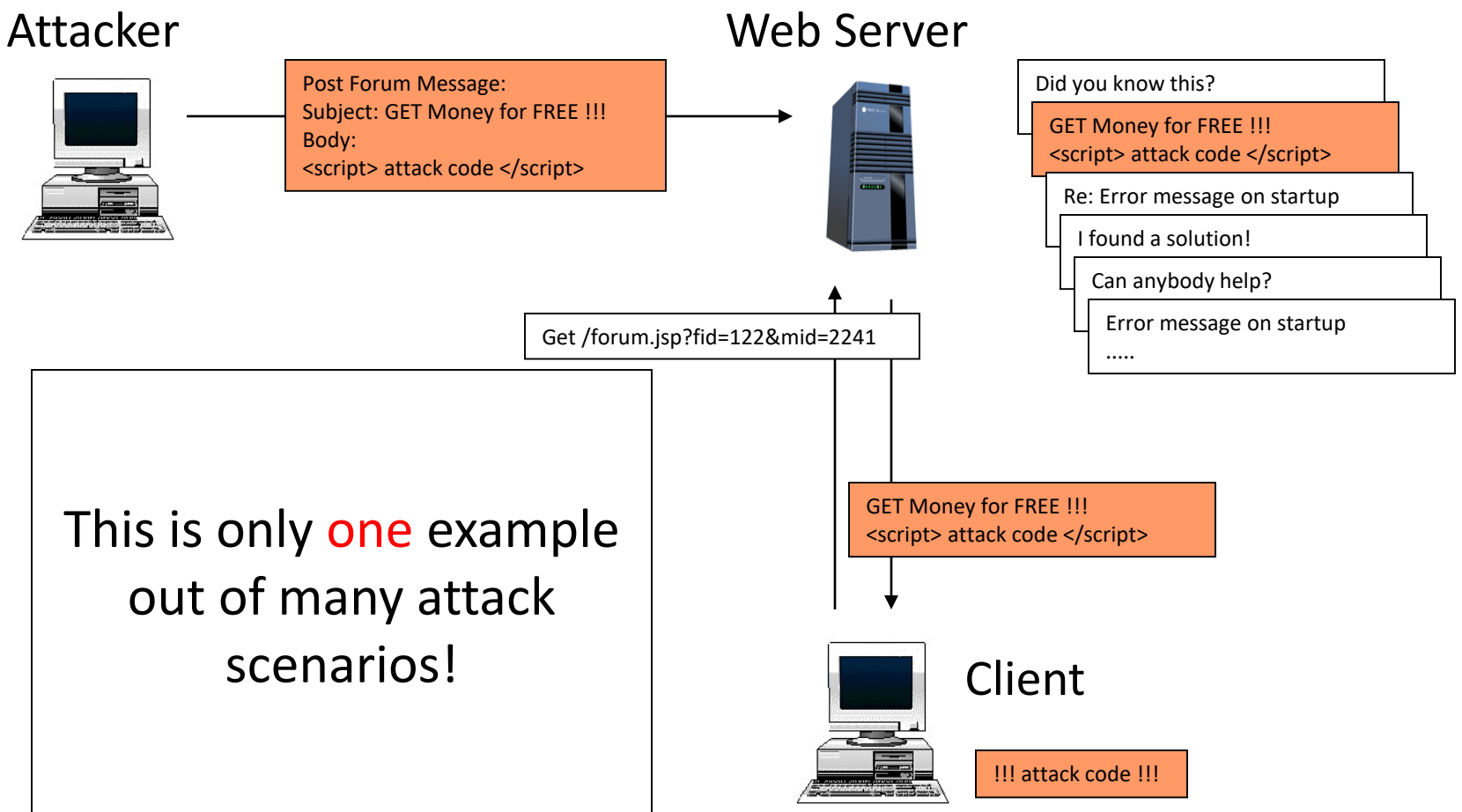
DNS rebinding attack

- Run attacker controlled JS with authority of victim
- That is possible only if victim call JS as a library, not easy for attacker
- So attacker gets the user to click on his webpage, and downloads its JS
- ATTACK:
  - Attacker registers attacker.com
  - User generates attacker.com DNS query
  - First it returns the correct IP, but with short TTL field (so it is not cached)
  - So at that point, attacker's code is at victim's machine, but with no right, due to SOP
  - The next DNS query attacker code does to attacker.com, the result is changed by the attacker, pointing to the victim address!
  - So SOP is broken, and now attacker's code can read cookies and access same domain!
  - TO solve: Ignore TTL and always cache the first request, this is called DNS pinning

Cross Site Scripting (XSS)

- Recall the basics
  - scripts embedded in web pages run in browsers
  - scripts can access cookies
    - get private information
  - scripts controlled by the same-origin policy
- Why would XSS occur
  - Web applications often take user inputs and use them as part of webpage (these inputs can have scripts)

XSS-Attack: General Overview



How XSS Works on Online Blog

- Everyone can post comments, which will be displayed to everyone who view the post
- Attacker posts a malicious comment that includes scripts (which reads local authentication credentials and sends to the attacker)
- Anyone who view the post can have local authentication cookies stolen
- Web apps will check that posts do not include scripts, but the check sometimes fail.
- Bug in the web application. Attack happens in browser.

XSS Example

- http://www.steve.org.uk/Security/XSS/Tutorial/simple.html

Protection against XSS attacks

- Sanitize the input
- Make sure it does not contain any scripts!

SQL Injection Attack

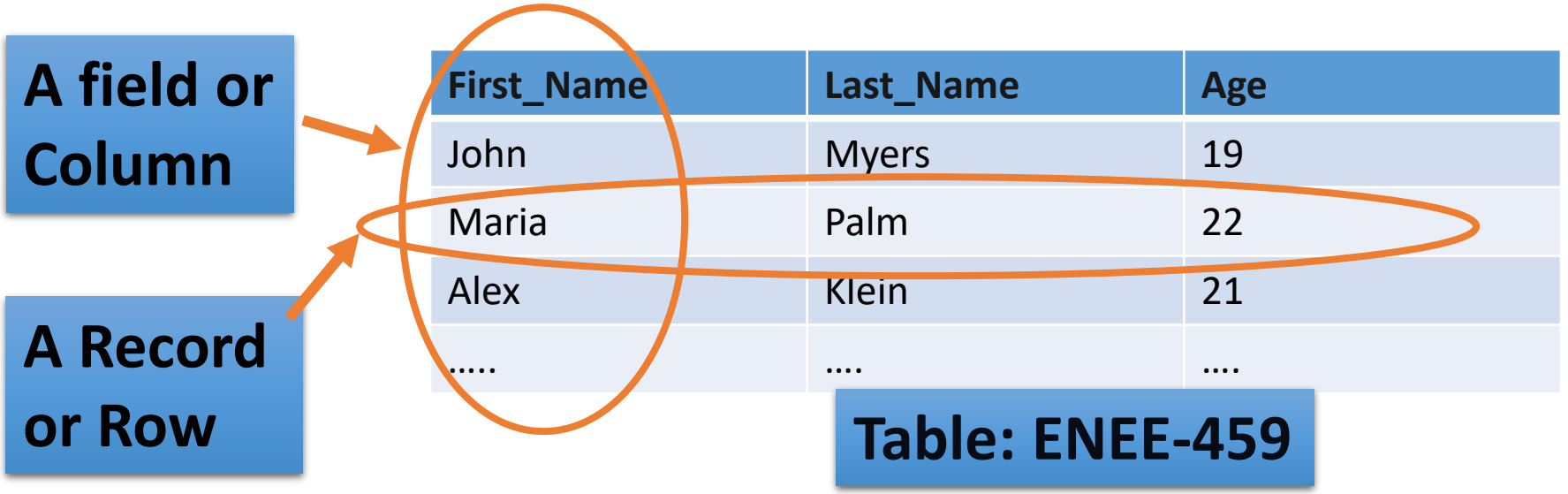
- Many web applications take user input from a form
- Often this user input is used literally in the construction of a SQL query submitted to a database. For example:

```
SELECT user FROM table
   WHERE name = 'user_input';
```

- An SQL injection attack involves placing SQL statements in the user input

SQL: Standard Query Language

- SQL lets you access and manage (Query) databases
- A database is a large collection of data organized in tables for rapid search and retrieval, with fields and columns



SQL Syntax

```
SELECT  First_Name
FROM ENEE-459
WHERE age=21
```

- SELECT statement is used to select data FROM one or more tables in a database
- Result-set is stored in a result table
- WHERE clause is used to filter records

SQL Syntax

```
SELECT  Last_Name
FROM ENEE-459
WHERE age=21
ORDER BY First_Name ASC
LIMIT 3
```

- ORDER BY is used to order data following one or more fields (columns)
- LIMIT allows to retrieve just a certain numbers of records (rows)

Login Authentication Query

- Standard query to authenticate users:

  select * from users where user='$usern' AND pwd='$password'

- Classic SQL injection attacks
  - Server side code sets variables $username and $passwd from user input to web form
  - Variables passed to SQL query

  select * from users where user='$username' AND pwd='$passwd'

- Special strings can be entered by attacker

  select * from users where user=M' OR '1=1 AND pwd=M' OR '1=1

- Result: access obtained without password
- Solution: Careful with single quote characters
- Filter them out!