COMP435: *SECURITY CONCEPTS!*

Lecture 21: Web Security Cont., Cross-Site Forgery Attacks

tinyurl.com/comp435-fa25

Quiz Topics!

- Network Security Topics! Especially…
  - *Firewalls &* packet filters – reading a packet filter table & interpreting the rules! Filling in the rules to meet a specification;
  - *Intrusion Detection & Intrusion Prevention Systems.* Given some initial params, should be able to calculate alarm precision, total no. of alarms, FPR, TPR, etc…
  - *The Network Stack!* The different levels of abstraction, what is the interface at each level, what does data look like & what does the payload look like at each
    - TCP 3-way handshake!
  - *Secure Tunnels*: How do they work conceptually. VPNs. How does the SSH protocol work.

HYPERTEXT TRANSFER PROTOCOL (HTTP)

HyperText Transfer Protocol (HTTP)

Def’n: Set of rules that dictate how browsers and servers exchange information

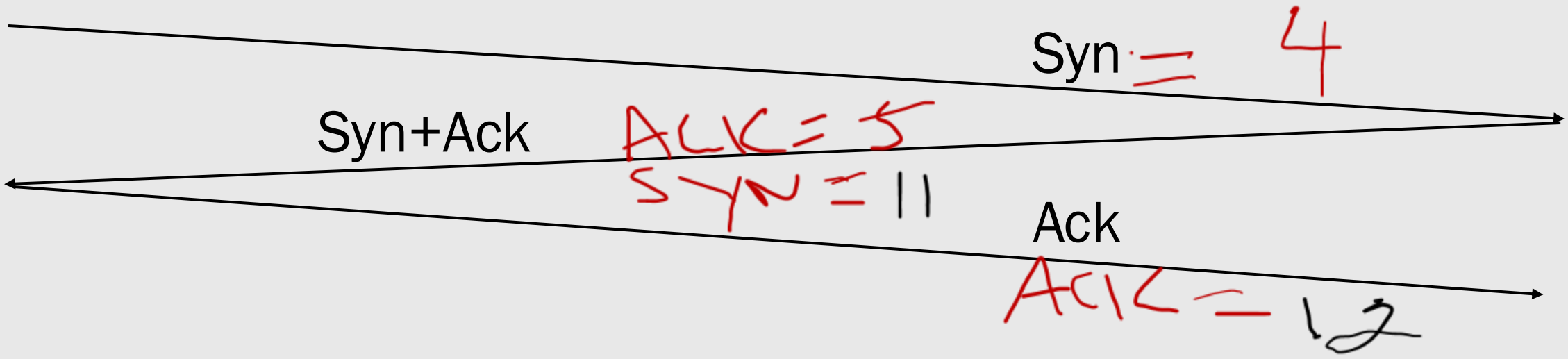
https://www.cs.unc.edu/~kakiryan/teaching.html

NSlookup www.cs.unc.edu

1. browser gets hostname from URL: www.cs.unc.edu
2. browser does DNS lookup to get IP address: 152.2.131.128
3. browser gets port number from URL: 80 default :)

https://www.cs.unc.edu/~kakiryan/teaching.html

4. browser establishes TCP connection to server



https://www.cs.unc.edu/~kakiryan/teaching.html

5. browser sends HTTP request to server

IP header (Dest addr: 152.19.160.128)
TCP header (Dest port: 80)
GET /~kakiryan/teaching/html HTTP/1.1 Referer: http://www.cs.unc.edu/~kakiryan/index.html User-Agent: Mozilla/5.0

https://www.cs.unc.edu/~kakiryan/teaching.html

5. browser sends HTTP request to server

IP header

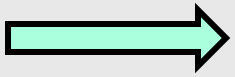
IP header (Dest addr: 152.19.160.128)
TCP header (Dest port: 80)
GET /~kakiryan/teaching/html HTTP/1.1 Referer: http://www.cs.unc.edu/~kakiryan/index.html User-Agent: Mozilla/5.0

IP packet

https://www.cs.unc.edu/~kakiryan/teaching.html

5. browser sends HTTP request to server

TCP header



IP header (Dest addr: 152.19.160.128)
TCP header (Dest port: 80)
GET /~kakiryan/teaching/html HTTP/1.1 Referer: http://www.cs.unc.edu/~kakiryan/index.html User-Agent: Mozilla/5.0

IP packet

https://www.cs.unc.edu/~kakiryan/teaching.html

5. browser sends HTTP request to server

application data

IP header (Dest addr: 152.19.160.128)
TCP header (Dest port: 80)
GET /~kakiryan/teaching/html HTTP/1.1 Referer: http://www.cs.unc.edu/~csturton/index.html User-Agent: Mozilla/5.0

IP packet

https://www.cs.unc.edu/~kakiryan/teaching.html

6. server responds

IP header (Src addr: 152.19.160.128, Dest addr...)

TCP header (Src port: 80, Dest port:...)

HTTP/1.1 200 OK

<html><body>....

https://www.cs.unc.edu/~kakiryan/teaching.html

7. browser renders HTML page:

Home Research Teaching Reading Group CV

Instructor of Record
- COMP 435: Computer Security Concepts (Fall 2025)
- COMP 311: Computer Organization (Fall 2025)
- COMP 520: Compilers (Summer Session II 2024)
- COMP 210: Data Structures and Analysis (Summer Session I 2024)
- COMP 210: Data Structures and Analysis (Summer 2022)
- COMP 110: Introduction to Programming and Data Science (Summer Session I 2021)

Graduate Teaching Assistant
- COMP 435: Computer Security Concepts (Fall 2023)
  - Guest Lecture on User Authentication
- COMP 435: Computer Security Concepts (Fall 2022)
  - Guest Lecture on Block Ciphers and Modes of Operation

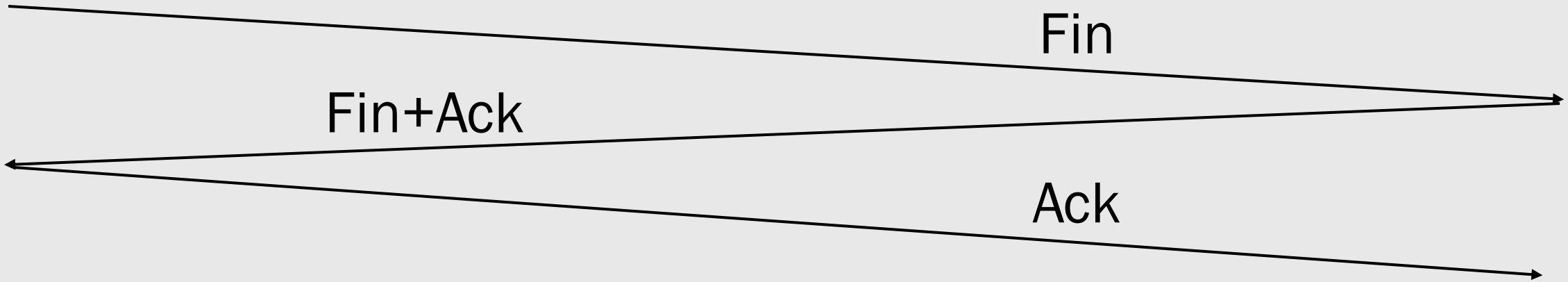
Head Teaching Assistant
- COMP 110: Introduction to Programming and Data Science (Fall 2021)
  - Guest Lecture on Recursion
- COMP 110: Introduction to Programming and Data Science (Spring 2021)
- COMP 110: Introduction to Programming and Data Science (Fall 2020)
- COMP 110: Introduction to Programming and Data Science (Summer Session II 2020)

Undergraduate Teaching Assistant
- COMP 211: Systems Fundamentals (Spring 2020)
- COMP 290: Tools for Computer Science (Spring 2020)
- COMP 110: Introduction to Programming and Data Science (Fall 2017-Fall 2019)
- COMP 101: Introduction to Computing (Spring 2018-Spring 2019)

Awards
- John M. Glotzer Graduate Teaching Assistant Award (2020-2021)

https://www.cs.unc.edu/~kakiryan/teaching.html

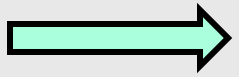
8. TCP connection is torn down



HTTP Request

```
GET /~kakiryan/teaching.html HTTP/1.1

Cookie: firstvisit=20210817
User-Agent: Mozilla/5.0

optional-body
```

HTTP Request

request line 

```
GET /~kakiryan/teaching.html HTTP/1.1

Cookie: firstvisit=20210817
User-Agent: Mozilla/5.0

optional-body
```

HTTP Request

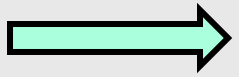
request line

other methods:
POST, CONNECT,
DELETE

```
GET /~kakiryan/teaching.html HTTP/1.1

Cookie: firstvisit=20210817
User-Agent: Mozilla/5.0


optional-body
```

HTTP Request

request line



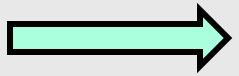
URL

- relative
- includes ?query

```
GET /~kakiryan/teaching.html HTTP/1.1

Cookie: firstvisit=20210817
User-Agent: Mozilla/5.0

optional-body
```

HTTP Request

request line



GET /~kakiryan/teaching.html HTTP/1.1

Cookie: firstvisit=20210817
User-Agent: Mozilla/5.0

optional-body

HTTP version

- 2.0 is newest
- 3.0 is in progress

HTTP Request

request headers ⟹

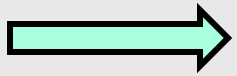
others:
Referer, Accept-Language, Expires

GET /~kakiryan/teaching.html HTTP/1.1

Cookie: firstvisit=20210817
User-Agent: Mozilla/5.0

optional-body

HTTP Request

request body 

Not used with GET

```
GET /~kakiryan/teaching.html HTTP/1.1

Cookie: firstvisit=20210817
User-Agent: Mozilla/5.0

optional-body
```

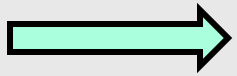
HTTP Response

```
HTTP/1.1 200 OK

Set-Cookie: lastvisit=20211001

<html><title>...
```

HTTP Response

status line

others:
404 Not Found



HTTP/1.1 200 OK

Set-Cookie: lastvisit=20211001

<html><title>...

HTTP Response

response header

others:
Location,
Allow

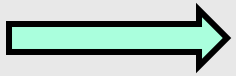
HTTP/1.1 200 OK

Set-Cookie: lastvisit=20211001

<html><title>...

HTTP Response

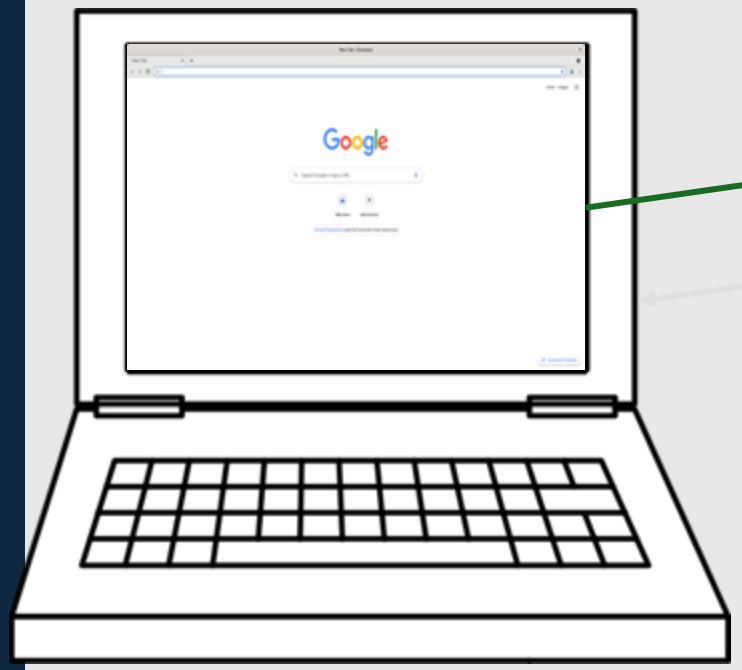
body
e.g., HTML page



HTTP/1.1 200 OK

Set-Cookie: lastvisit=20211001

<html><title>...



request

response

cs.unc.edu

mail.google.com

www.youtube.com

Ok, you've made a request, what gets returned in the response?!

HTML

Hypertext Markup Language (HTML)

```
<!DOCTYPE html PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN" "http://www.w3.org/TR/html4/loose.dtd">
<html> Scroll
  <head>…</head>
  <body>
    <div class="center">
      <div class="nav">…</div>
      <!--end nav-->
      <div class="top-c">…</div>
      <div class="content"> = $0
        <ul>
          <b> Instructor of Record </b>
          <li>
            <a href="435-fa25/435-fa25.html">COMP 435: Computer Security Concepts (Fall 2025)</a>
          </li>
          <li>
            <a href="311-fa25/311-fa25.html">COMP 311: Computer Organization (Fall 2025)</a>
          </li>
          <li>
            <a href="archive/summer-520.html">COMP 520: Compilers (Summer Session II 2024)</a>
          </li>
          <li>
            <a href="archive/summer-210.html">COMP 210: Data Structures and Analysis (Summer Session I 2024)</a>
          </li>
          <li>
            <a href="archive/summer-x-210.html">COMP 210: Data Structures and Analysis (Summer 2022)</a>
          </li>
          <li>
            <a href="https://21ss1.comp110.com">COMP 110: Introduction to Programming and Data Science (Summer Session I 2021)
            </a>
          </li>
        </ul>
        <ul>…</ul>
        <ul>…</ul>
        <ul>…</ul>
        <ul>…</ul>
      </div>
    </div>
  </body>
</html>
```

Hypertext Markup Language (HTML)

- Tags in the text provide annotation
- Browser renders the annotated text

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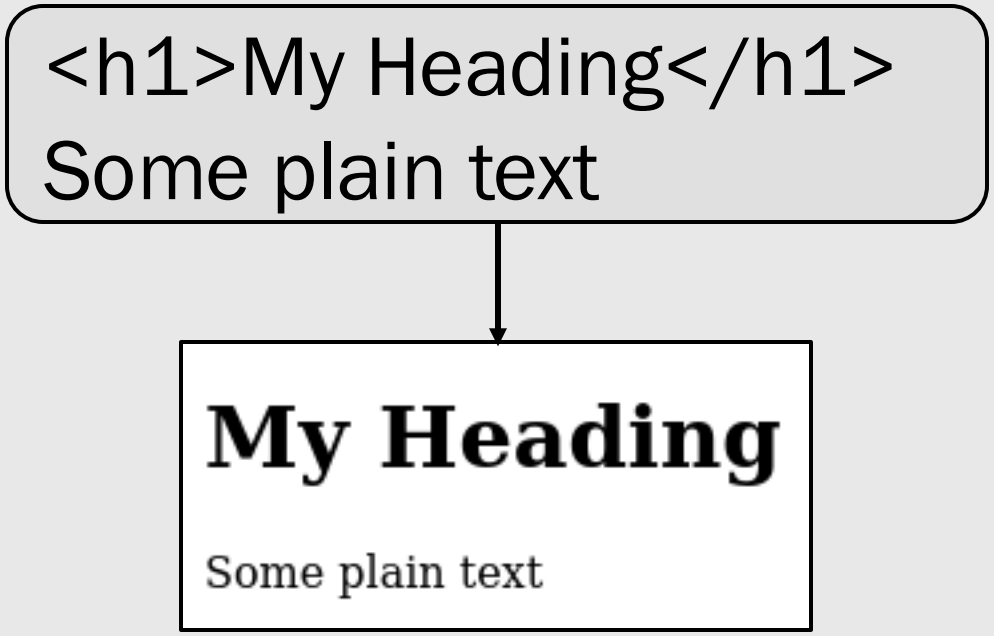
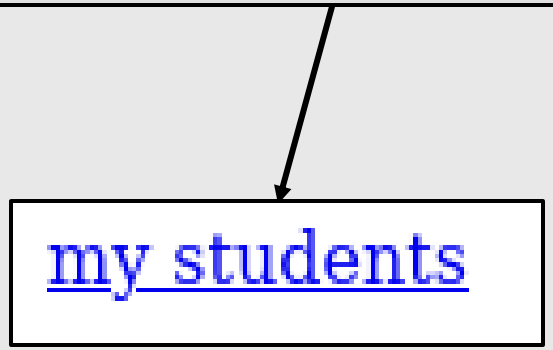


Hypertext Markup Language (HTML)

- Tags in the text provide annotation
- Browser renders the annotated text

My Students



Hypertext Markup Language (HTML)

- Tags in the text provide annotation
- Browser renders the annotated text
- Executable content is allowed

```
<script>
executable code fragment goes here
</script>
```

Javascript

<script> block

javascript: scheme

event handler

Javascript

<script> block

javascript: scheme

event handler

<script>document.write(Date())</script>

<script src="*url*"></script>

Javascript

<script> block

javascript: scheme

event handler

Click Here

Click Here

Javascript

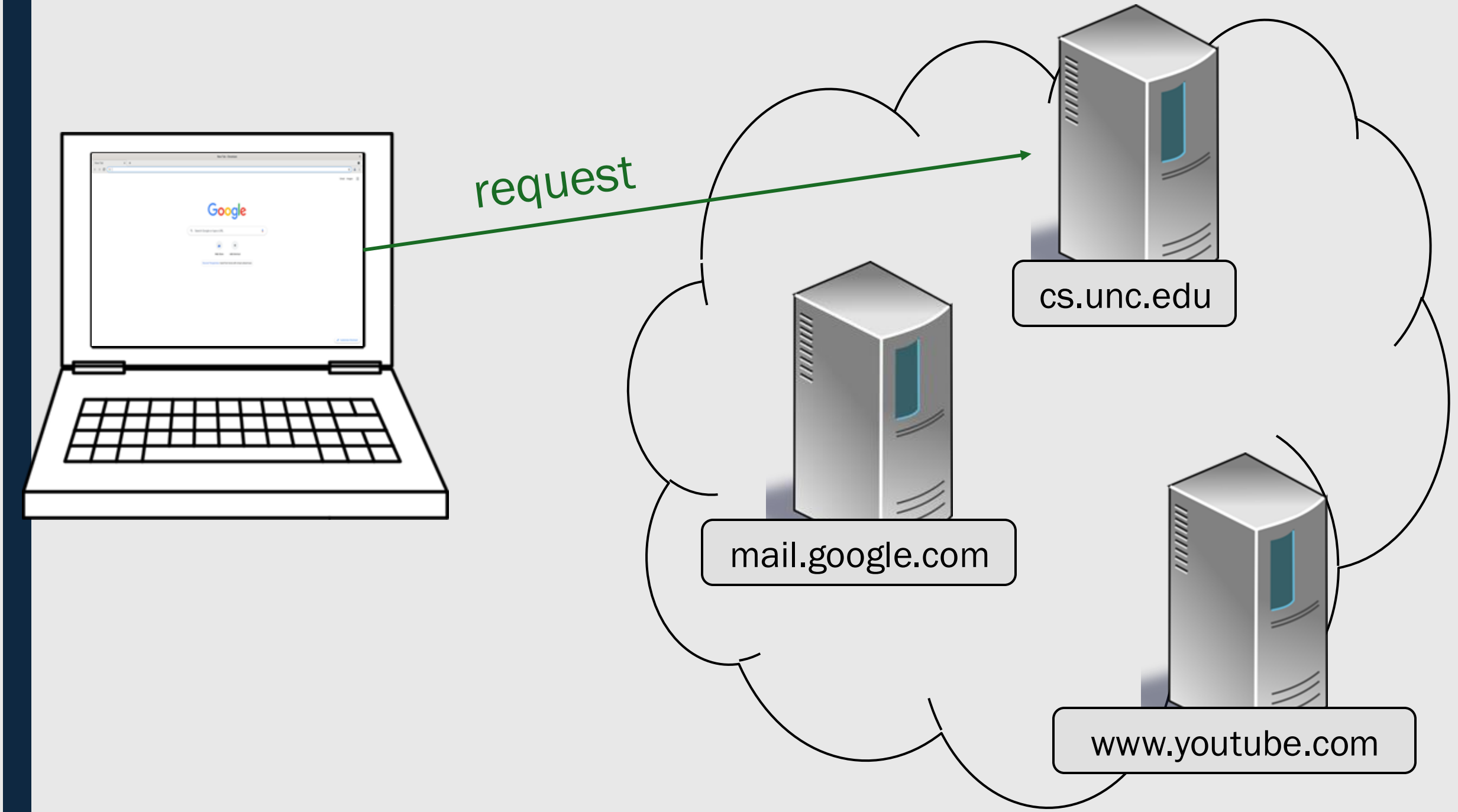
<script> block

javascript: scheme

event handler

```
<button type="button" onclick="executable javascript">
button text</button>

<div onmouseover="executable javascript">some text</div>
```


request
cs.unc.edu
mail.google.com
www.youtube.com

BROWSER REDIRECTION

Browser Redirection

Def’n: a browser is forwarded to a new site and loads a page other than the one originally requested

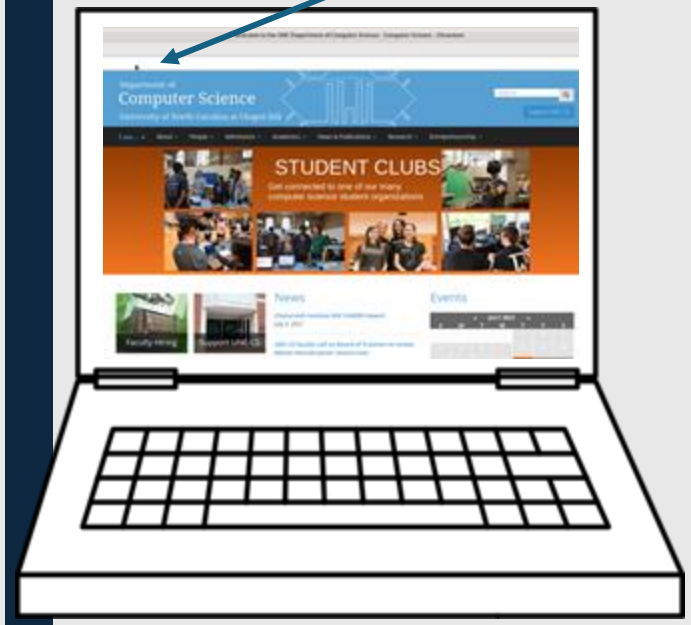
cs.unc.edu

request

response

cs.unc.edu

cs.unc.edu



cs.unc.edu

Browser Redirection

- JavaScript redirect
- Refresh meta tag
- Refresh header
- HTTP redirection

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- JavaScript redirect
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- Refresh header
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JavaScript Redirect in HTML

```
<script>window.location="url"</script>

<script>window.location.href="url"</script>
```

Refresh Meta Tag in HTML

```
<head>
<meta http-equiv="refresh" content="N; URL=new-url">
</head>
```

Browser Redirection

- JavaScript redirect
- Refresh meta tag
- Refresh header
- HTTP redirection

in HTTP response

Refresh Header in HTTP Response

HTTP/1.1 200 OK

Refresh: N; url=*new-url*

<html><title>...

HTTP Redirection in HTTP Response

HTTP/1.1 301 Moved Permanently

Location: *new-url*

CROSS SITE FORGERY REQUEST

Cross-Site Request Forgery (CSRF)

Def’n: An attacker injects a transaction request to a site from an authenticated user’s browser

a.k.a. XSRF, session riding, “C surf”

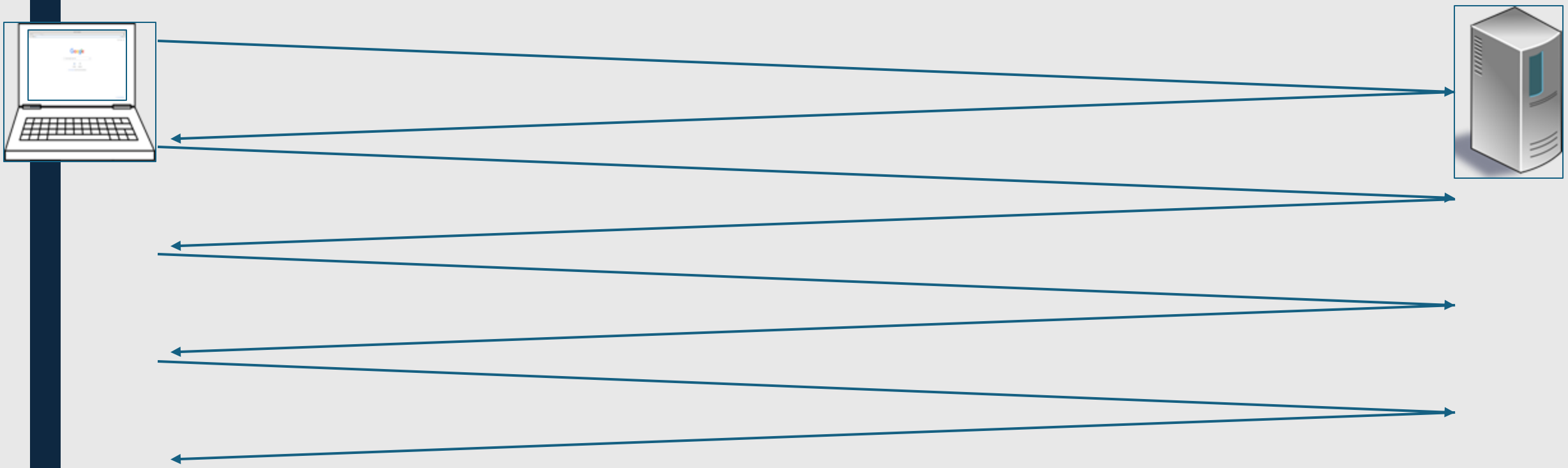
COOKIES

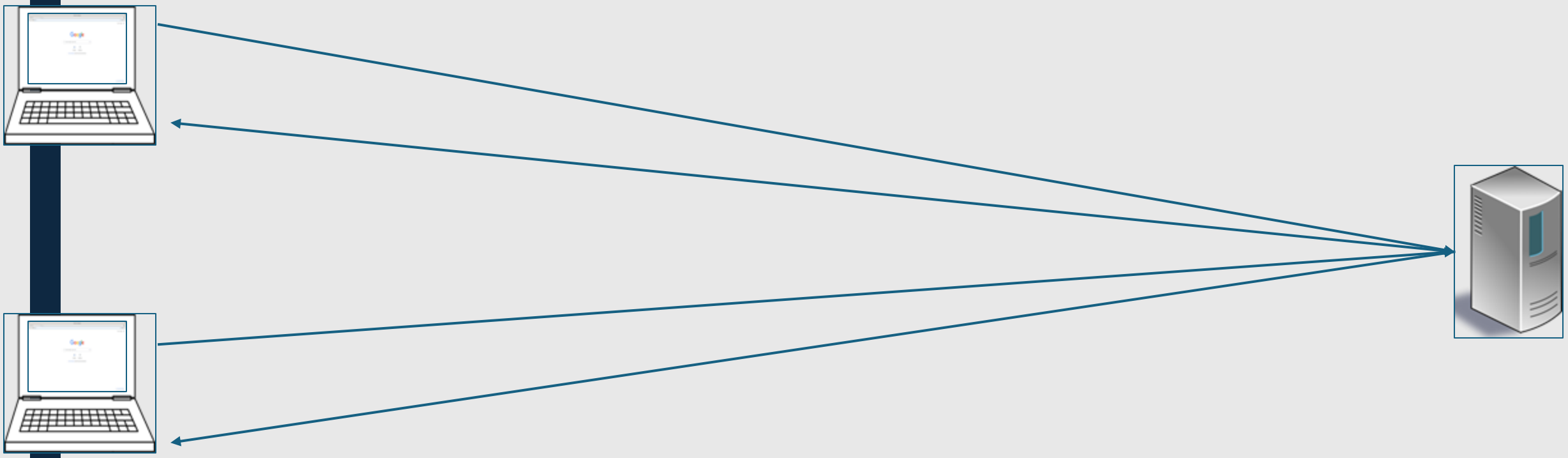
Browser Cookies

Def’n: data strings that enable a stateful browsing session between client and server

E.g., language=english; cartID=ba3fa9dea0;

HTTP is stateless!! So cookies help us keep track of some state ☺





GET www.target.com/s?searchTerm=masks

server sets a cookie to start linking future requests from this client together

HTTP response header contains Set-Cookie keyword followed by the cookie

A cookies just a key-value pair!

HTTP/1.1 200 OK

Set-Cookie: sessionID=9df3ecad22f7
Set-Cookie: userLocation=27599.NC

<html><title>...

GET www.target.com/s?searchTerm=kidsmasks

Cookie:
sessionID=9df3ecad22f7;userLocation=27599.NC

By default, cookies

- can be accessed by JavaScript
- are sent in the clear
- are returned to the requesting server directory

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- can be accessed by JavaScript
- are sent in the clear
- are returned to the requesting server directory

URI setting the cookie:	Cookie returned to:	Cookie not returned to:
sub.site.com/dir/file	sub.site.com/dir/fileA sub.site.com/dir/subdir/fileB	sub.site.com bub.site.com site.com

Cookie WS Problems

Threat Model

- Attacker is not “in the browser”
- Attacker is not eavesdropping on client--server communication
- Attacker can induce victim to click on a link

Alice

bank.com

1. Alice logs into bank.com
2. bank sends session ID to Alice's browser

Alice

bank.com

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2. bank sends session ID to Alice's browser

```
GET http://bank.com/fundxfer.php?to=csturton&value=2500 HTTP/1.1

Cookie: sessionID=2hdkg7s0zwlsl.-S_sfhl25JLLKx
User-Agent: Mozilla/5.0
```

Alice

bank.com

1. Alice logs into bank.com
2. bank sends session ID to Alice's browser

GET http://bank.com/fundxfer.php?to=kakiryan&value=2500 HTTP/1.1

Cookie: sessionID=2hdkg7s0zwlsl.-S_sfhl25JLLKx
User-Agent: Mozilla/5.0

Alice

bank.com

1. Alice logs into bank.com
2. bank sends session ID to Alice's browser

```
GET http://bank.com/fundxfer.php?to=kakiryan&value=2500 HTTP/1.1

Cookie: sessionID=2hdkg7s0zwlsl.-S_sfhl25JLLKx
User-Agent: Mozilla/5.0
```

Possible link locations: on a website Alice visits, embedded in an ad, in an image, in an email or text…

```
<a href="http://bank.com/fundxfer.php?to=kakiryan&value=2500">
Click here … Incredible News!!!
</a>
```

```
<img width="0" height="0" border="0"
src="http://bank.com/fundxfer.php?to=kakiryan&value=2500"/>
```

Notes on CSRF

- Requires that Alice is already logged in to bank.com
- Used for state-changing requests
- Request is indistinguishable from a legitimate request

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- Requires that Alice is already logged in to bank.com
- Used for state-changing requests
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This is an example of a confused deputy attack!

Not a Defense

- HTTPOnly cookie attribute
- HTTP over TLS (HTTPS)
- Checking the referer header

CSRF Defense: synchronizer tokens

Alice

HTTP/1.1 200 OK

Set-Cookie: sessionID=9df3ecad22f7

<html><body><input type="hidden"
name="csrftoken"
value="bda35f355ffca3fe"/>

bank.com

CSRF Defense: cookie to header

Alice

bank.com

HTTP/1.1 200 OK

Set-Cookie: sessionID=9df3ecad22f7;
csrftoken=bda35f355ffca3fe

<html><body>....

CSRF Defense: cookie to header

Alice

bank.com

POST http://bank.com/fundxferform HTTP/1.1

Cookie: sessionID=9df3ecad22f7; csrftoken=bda35f355ffca3fe
CSRFToken: bda35f355ffca3fe
User-Agent: Mozilla/5.0

....

CSRF Defense: double submitting cookies

Alice

bank.com

HTTP/1.1 200 OK

Set-Cookie: sessionID=9df3ecad22f7;
csrftoken=bda35f355ffca3fe

<html><body><input type="hidden"
name="csrftoken"
value="bda35f355ffca3fe"/>