CSE 127: Computer Security

Web Intro

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UCSD

Winter 2022

Some slides from Nadia Heninger, Deian Stefan, Zakir Durumeric, Dan Boneh, and Kirill Levchenko

Brief: Mitigating side channels

Next: Web Intro

https://www.microsoft.com/en-us/research/video/verifying-constant-time-implementations/

Mitigating Cache-based Side Channels

- There's never a completion solution to avoiding side-channel attacks. A few mitigations are:

- **Application-specific:** Disable resource sharing, or isolate applications. One example is page coloring.

- **Compiler-based:** One example is Biscuit, developed at Georgia Tech. Able to guess misses and alerts the CPU scheduler about abnormal behaviour.

- **Redesigning Hardware**: Hard due to large overheads involved.

- Other solutions are ASLR (although, easy to defeat by Spectre and Meltdown)

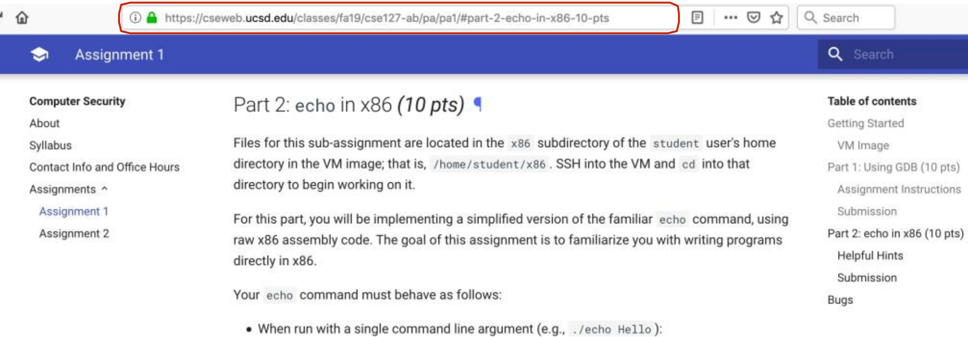
Overall, secure algorithms still need secure implementation.

Lecture objectives

- Basic understanding of how the web works
- Understand relevant attacker models
- Understand browser same-origin policy

HTTP protocol

- Protocol from 1989 that allows fetching of resources (e.g., HTML documents)
- Resources have a uniform resource location (URL):



https://cseweb.ucsd.edu/classes/fa19/cse127-ab/pa/pa1/#part-2-echo-in-x86-10-pts

Part 2: echo in x86 *(10 pts)*

Files for this sub-assignment are located in the `x86` subdirectory of the `student` user's home directory in the VM image; that is, `/home/student/x86`. SSH into the VM and `cd` into that directory to begin working on it.

For this part, you will be implementing a simplified version of the familiar `echo` command, using raw x86 assembly code. The goal of this assignment is to familiarize you with writing programs directly in x86.

Your `echo` command must behave as follows:

- When run with a single command line argument (e.g., `./echo Hello`):

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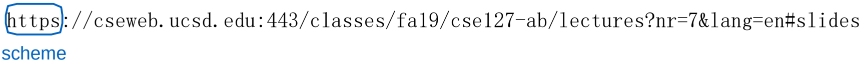

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scheme

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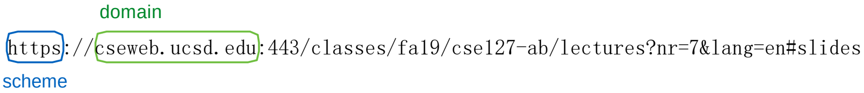

domain

`https://cseweb.ucsd.edu:443/classes/fa19/cse127-ab/lectures?nr=7&lang=en#slides`

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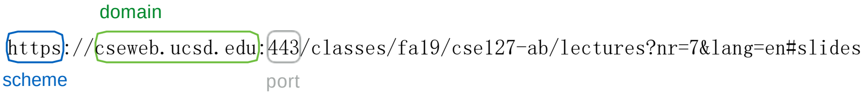

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scheme

port

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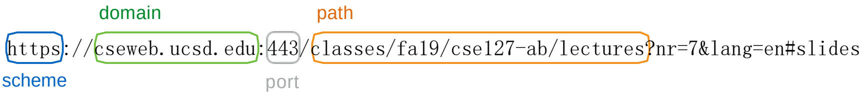

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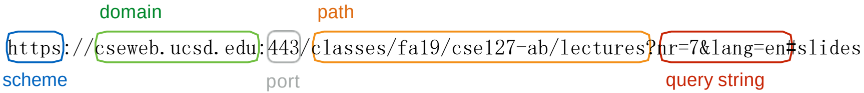

domain path

https://cseweb.ucsd.edu:443/classes/fa19/cse127-ab/lectures?nr=7&lang=en#slides

scheme port query string

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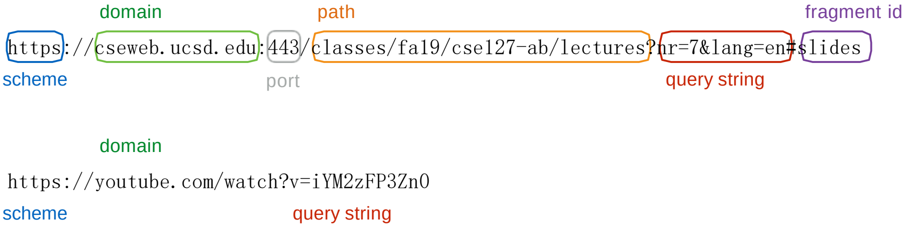

domain

path

fragment id

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scheme

port

query string

domain

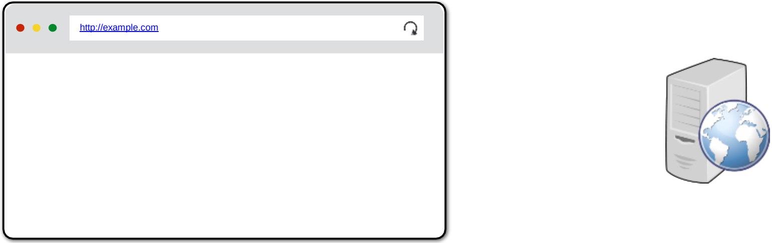
https://youtube.com/watch?v=iYM2zFP3Zn0

scheme

query string

HTTP protocol

- Clients and servers communicate by exchanging individual messages (as opposed to a stream of data).



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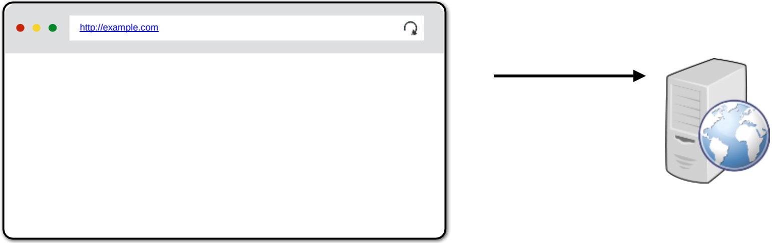

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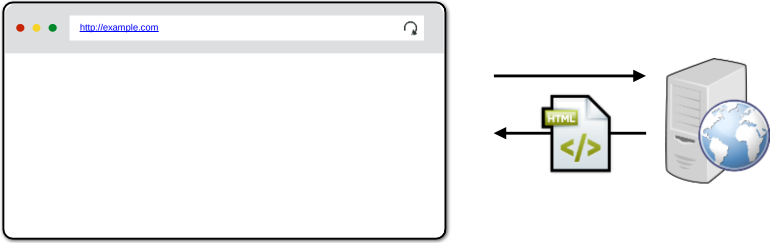

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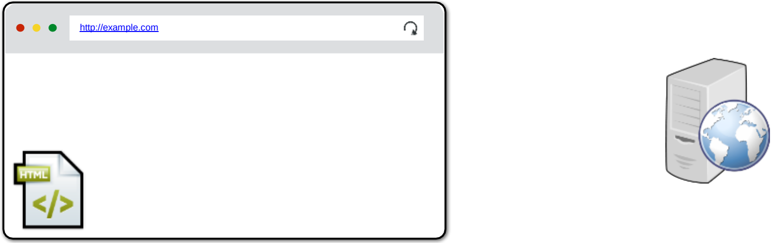

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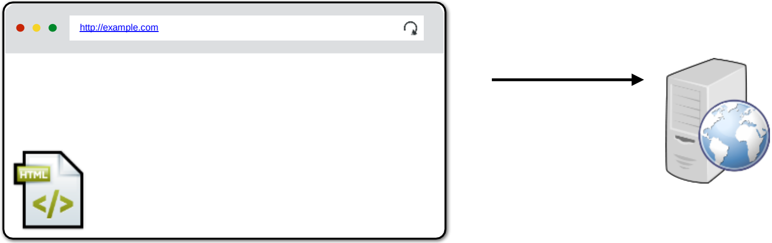

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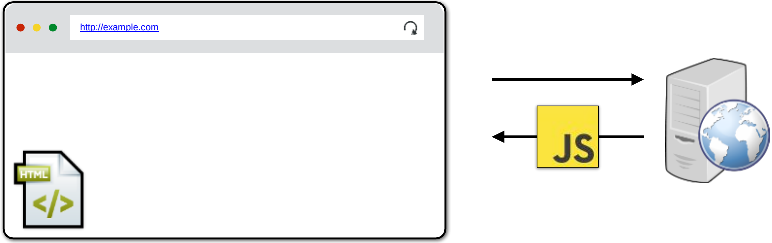

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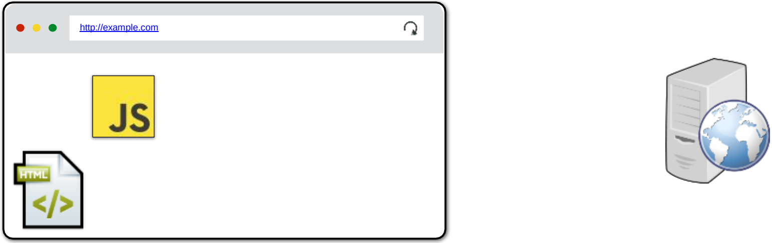

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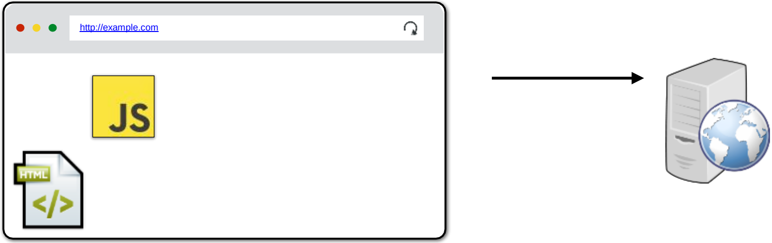

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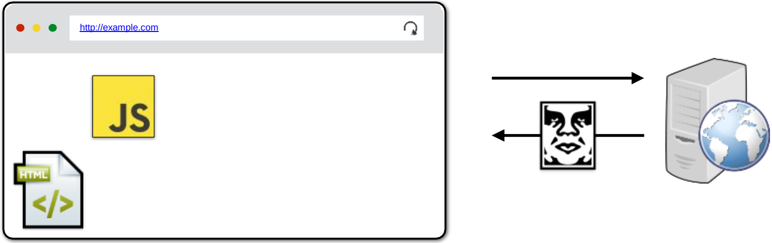

HTTP protocol

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http://example.com
JS
HTML
</>

Anatomy of a request

```
GET /index.html HTTP/1.1

Accept: image/gif, image/x-bitmap, image/jpeg, */*
Accept-Language: en
Connection: Keep-Alive
User-Agent: Mozilla/1.22 (compatible; MSIE 2.0; Windows 95)
Host: www.example.com
Referer: http://www.google.com?q=dingbats
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Anatomy of a request

method

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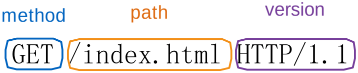

method

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version

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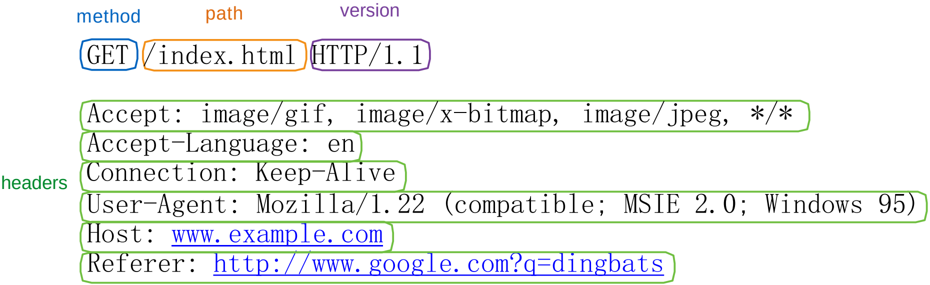

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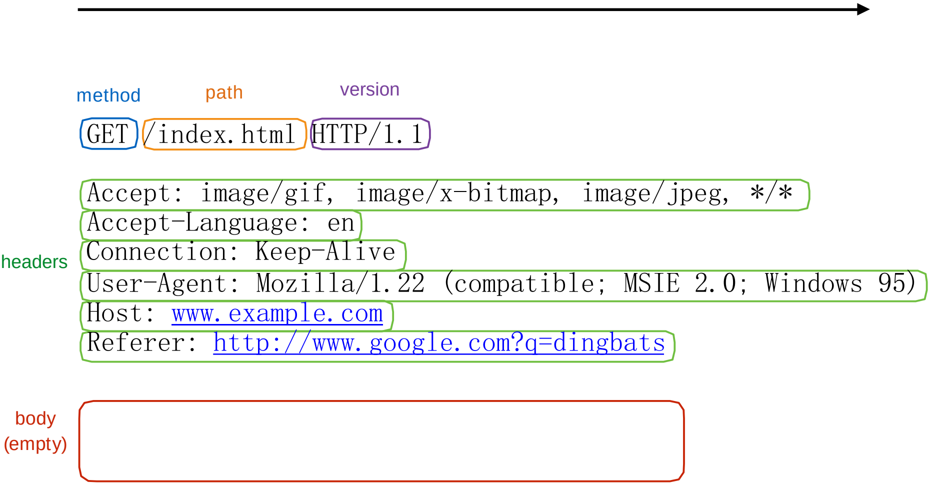

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Anatomy of a response

```
HTTP/1.0 200 OK
Date: Sun, 21 Apr 1996 02:20:42 GMT
Server: Microsoft-Internet-Information-Server/5.0
Connection: keep-alive
Content-Type: text/html
Last-Modified: Thu, 18 Apr 1996 17:39:05 GMT
Set-Cookie: ...
Content-Length: 2543

<html>Some data... whatever ... </html>
```

Anatomy of a response

status code

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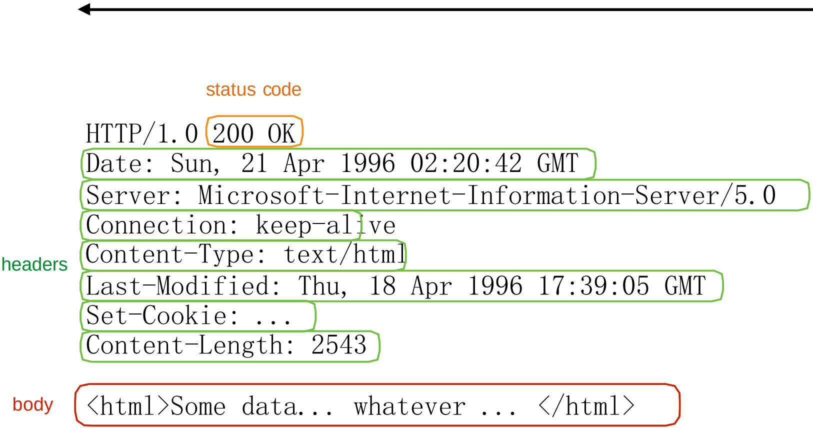

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Many HTTP methods

- GET: Get the resource at the specified URL.
- POST: Create new resource at URL with payload.
- PUT: Replace current representation of the target resource with request payload.
- PATCH: Update part of the resource.
- DELETE: Delete the specified URL.

In practice: it’s a mess

- GETs should NOT change server state; in practice, they sometimes do
- Old browsers don’t send PUT, PATCH, and DELETE
  - So, almost all side-effecting requests are POSTs; real method hidden in a header or request body

In practice: we need state

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- What is this useful for?

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- HTTP cookie: small piece of data that a server sends to the browser, who stores it and sends it back with subsequent requests
- What is this useful for?
  - Session management: logins, shopping carts, etc.
  - Personalization: user preferences, themes, etc.
  - Tracking: recording and analyzing user behavior

Setting cookies in response

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Connection: keep-alive
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Set-Cookie: userID=F3D947C2
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Sending cookie with each request

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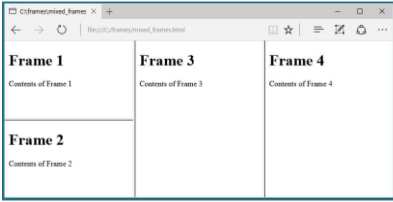
Going from HTTP response to code execution…

Basic browser execution model

- Each browser window….
  - Loads content
  - Parses HTML and runs Javascript
  - Fetches sub resources (e.g., images, CSS, JavaScript)
  - Respond to events like onClick, onMouseover, onLoad, setTimeout

Nested execution model

- Windows may contain frames from different sources
  - ➢ Frame: rigid visible division
  - ➢ iFrame: floating inline frame
- Why use frames?



Frame 1

Contents of Frame 1

Frame 2

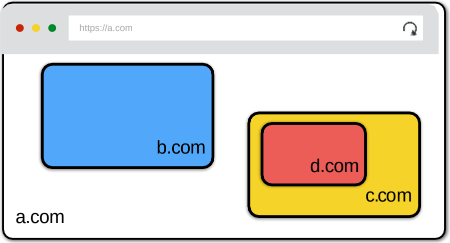
Contents of Frame 2

Frame 3

Contents of Frame 3

Frame 4

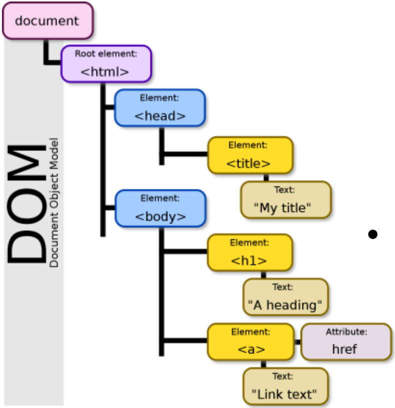
Contents of Frame 4



Nested execution model

- Windows may contain frames from diff sources
  - Frame: rigid visible division
  - iFrame: floating inline frame
- Why use frames?
  - Delegate screen area to content from another source
  - Browser provides isolation based on frames
  - Parent may work even if frame is broken

Document object model (DOM)

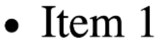


- Javascript can read and modify page by interacting with DOM
  - ➢ OO interface for reading and writing website content
- Includes browser object model
  - ➢ Access window, document, and other state like history, browser navigation, and cookies

https://en.wikipedia.org/wiki/Document_Object_Model

Modifying the DOM using JS

```
<html>
  <body>
    <ul id=“t1”>
      <li>Item 1</li>
    </ul>
...
  </body>
</html>
```



- Item 1

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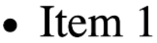

- Item 1

```
        <script>
          const list    = document.getElementById( ‘t1’);
          const newItem = document.createElement( ‘li’ );
          const newText = document.createTextNode( ‘Item 2’ );
          list.appendChild(newItem);
          newItem.appendChild(newText)
        </script>
```

Modifying the DOM using JS

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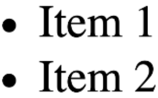

- Item 1
- Item 2

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Modern websites are complicated

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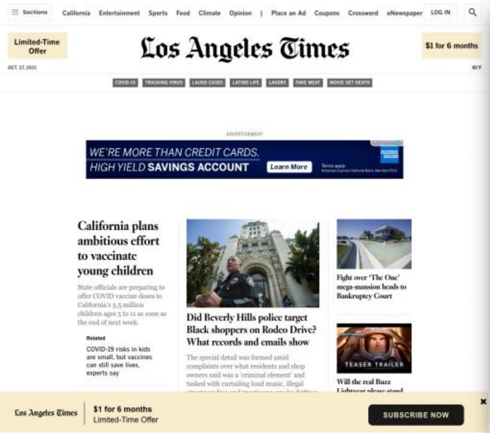

Los Angeles Times

OCT. 27, 2021

81°F

California plans ambitious effort to vaccinate young children

State officials are preparing to offer COVID vaccine doses to California's 3.5 million children ages 5 to 11 as soon as the end of next week.

Related

COVID-19 risks in kids are small, but vaccines can still save lives, experts say

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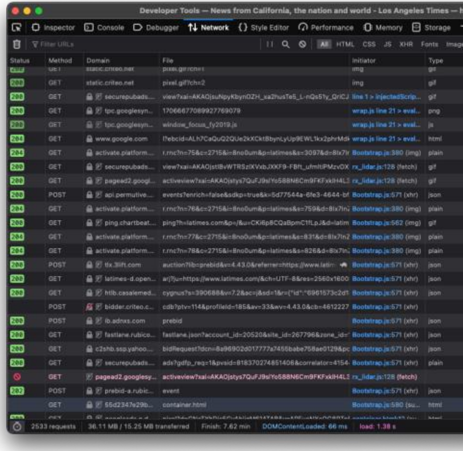

Developer Tools — News from California, the nation and world - Los Angeles Times

Status	Method	Domain	File	Initiator	Type
200	GET	static.criteo.net	pixel.gif?ch=1	img	gif
200	GET	static.criteo.net	pixel.gif?ch=2	img	gif
200	GET	securepubads...	view?xai=AKAOjsuNpyKbynOZH_xa2husTe5_L-nQs51y_QrICJ	line 1 > injectedScrip...	gif
200	GET	tpc.googlesyn...	17066677089927769079	wrap.js line 21 > eval...	png
200	GET	tpc.googlesyn...	window_focus_fy2019.js	wrap.js line 21 > eval...	js
204	GET	www.google.com	l?ebcid=ALh7CaQuQ2QUe2kXCktBbynLyUp9EWL1kx2phrMdk	wrap.js line 21 > eval...	html
204	GET	activate.platform...	r.rnc?n=75&c=2715&i=8no0um&p=latimes&s=3097&d=8lx7lr	Bootstrap.js:380 (img)	plain
200	GET	securepubads...	view?xai=AKAOjstIBvWTRSzlXVxbJXKF9-FBft_ufmltPMzvOX	rx_lidar.js:128 (fetch)	gif
200	GET	pagead2.googl...	activeview?xai=AKAOjstys7QuFJ9slYo588N6Cm9FKFxklH4L:	rx_lidar.js:128 (fetch)	gif
200	POST	api.permutive...	events?enrich=false&sdkp=true&k=5d77544a-6fe3-4644-bf	Bootstrap.js:571 (xhr)	json
204	GET	activate.platform...	r.rnc?n=76&c=2715&i=8no0um&p=latimes&s=759&d=8lx7ln:	Bootstrap.js:380 (img)	plain
200	GET	ping.chartbeat....	ping?h=latimes.com&p=/&u=CKi6p8CQaBpmC1fLpJ&d=latim	Bootstrap.js:562 (img)	gif
204	GET	activate.platform...	r.rnc?n=77&c=2715&i=8no0um&p=latimes&s=831&d=8lx7ln2	Bootstrap.js:380 (img)	plain
204	GET	activate.platform...	r.rnc?n=78&c=2715&i=8no0um&p=latimes&s=826&d=8lx7ln:	Bootstrap.js:380 (img)	plain
200	POST	tlx.3lift.com	auction?lib=prebid&v=4.43.0&referrer=https://www.latim	Bootstrap.js:571 (xhr)	json
200	GET	latimes-d.open...	arj?ju=https://www.latimes.com/&ch=UTF-8&res=2560x1600	Bootstrap.js:571 (xhr)	json
200	GET	htlb.casalemed...	cygnus?s=390688&v=7.2&ac=j&sd=1&r={"id":"6961573c2d1	Bootstrap.js:571 (xhr)	json
	POST	bidder.criteo.c...	cdb?ptv=114&profileId=185&av=33&wv=4.43.0&cb=4612227	Bootstrap.js:571 (xhr)	
200	POST	ib.adnxs.com	prebid	Bootstrap.js:571 (xhr)	json
200	GET	fastlane.rubico...	fastlane.json?account_id=20520&site_id=267796&zone_id='	Bootstrap.js:571 (xhr)	json
200	GET	c2shb.ssp.yahoo...	bidRequest?dcn=8a96902d017777a7455babe758ae0129&pc	Bootstrap.js:571 (xhr)	json
200	GET	securepubads...	ads?gdfp_req=1&pvsid=818370274851408&correlator=4154	Bootstrap.js:571 (xhr)	plain
🚫	GET	pagead2.googlesy...	activeview?xai=AKAOjstys7QuFJ9slYo588N6Cm9FKFxklH4L:	rx_lidar.js:128 (fetch)	
202	POST	prebid-a.rubic...	event	Bootstrap.js:571 (xhr)	json
	GET	55d2347e29b...	container.html	Bootstrap.js:580 (su...	html

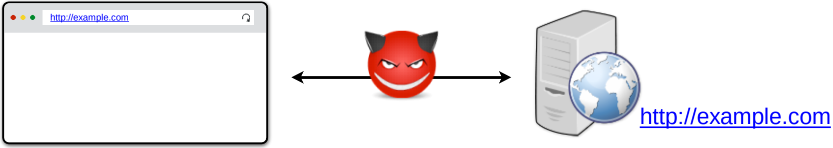
2533 requests | 36.11 MB / 15.25 MB transferred | Finish: 7.62 min | DOMContentLoaded: 66 ms | load: 1.38 s

Lecture objectives

- Basic understanding of how the web works
- Understand relevant attacker models
- Understand browser same-origin policy

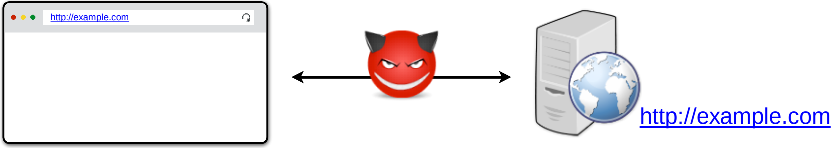
Relevant attacker models

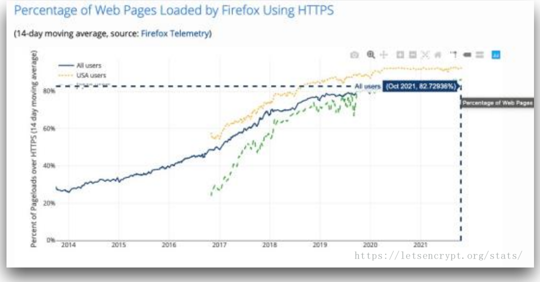
Network attacker



Relevant attacker models

Network attacker



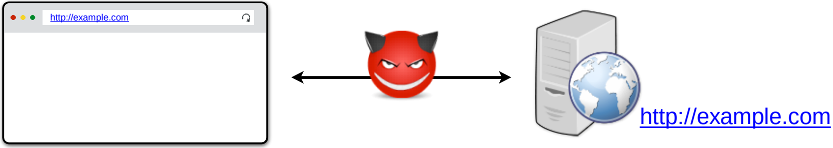

Percentage of Web Pages Loaded by Firefox Using HTTPS

(14-day moving average, source: Firefox Telemetry)

https://letsencrypt.org/stats/

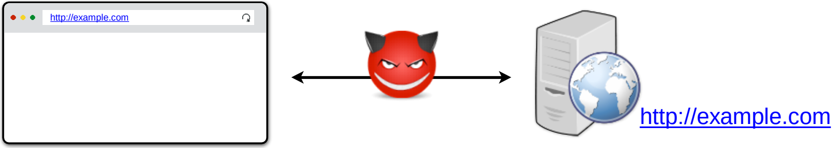
Relevant attacker models

Network attacker



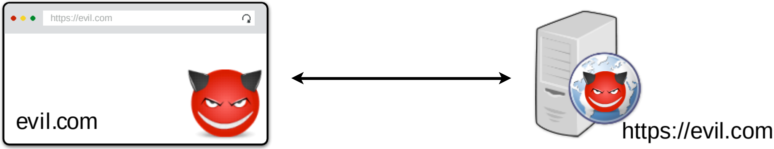
Relevant attacker models

Network attacker



http://example.com

Web attacker



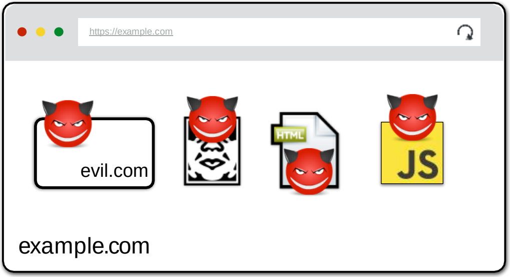
evil.com

https://evil.com

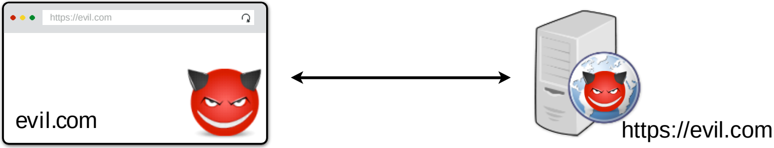
Relevant attacker models

Gadget attacker

Web attacker with capabilities to inject limited content into honest page



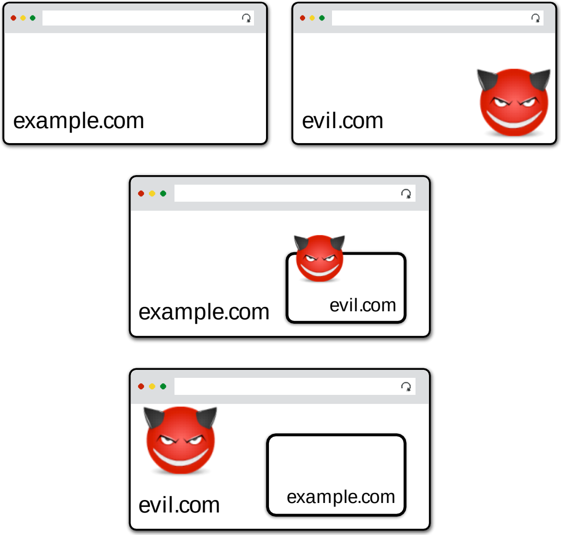
Most of our focus: web attacker



evil.com

https://evil.com

And variants of it



Lecture objectives

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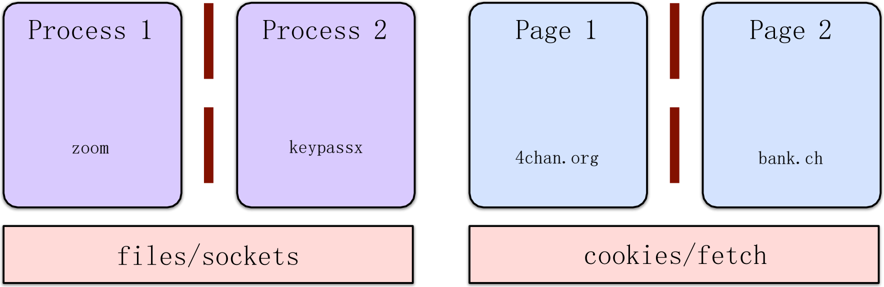
Web security model

Safely browse the web in the presence of attackers

- The browser is the new OS analogy



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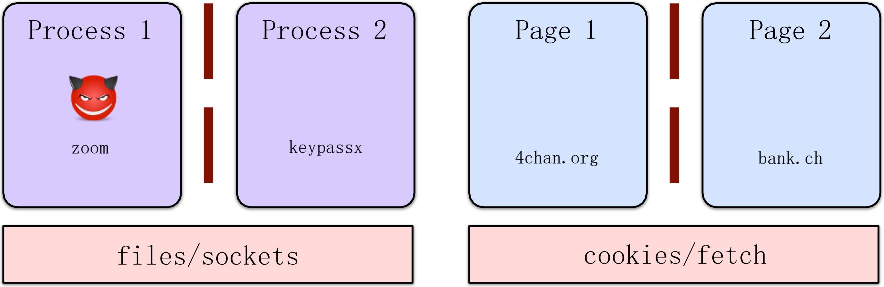

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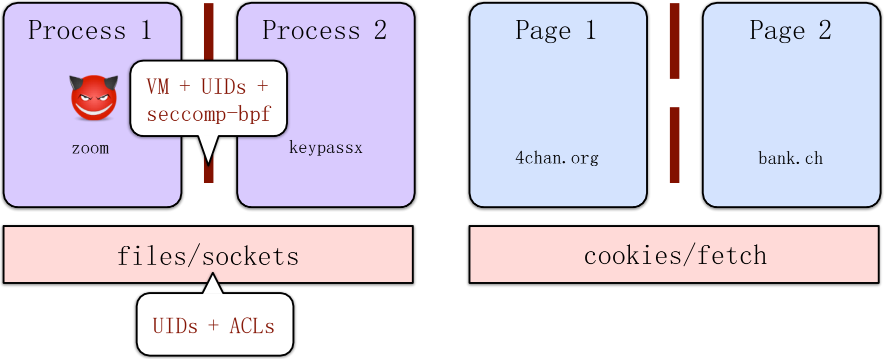

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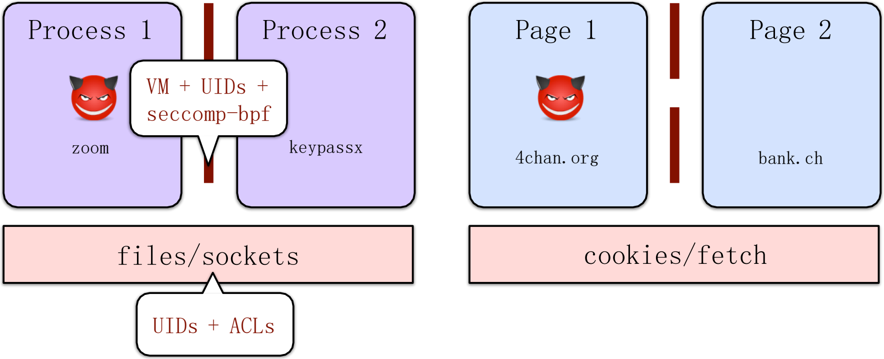

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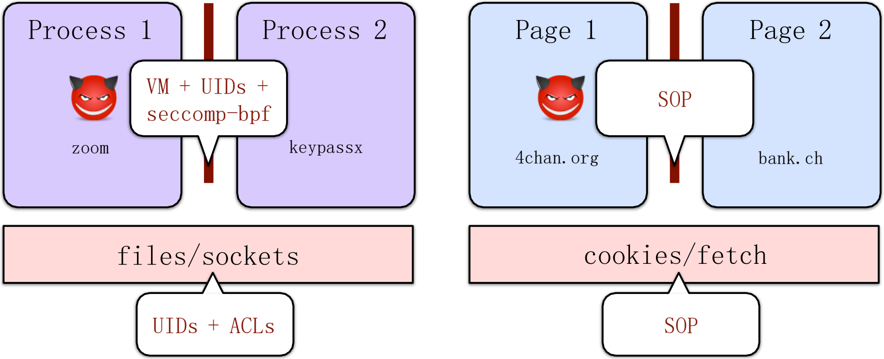

Same origin policy (SOP)

- Origin: isolation unit/trust boundary on the web
  - (scheme, domain, port) triple derived from URL
- SOP goal: isolate content of different origins
  - **Confidentiality**: script contained in evil.com should not be able to read data in bank.ch page
  - **Integrity**: script from evil.com should not be able to modify the content of bank.ch page

There is no one SOP

- There is a same-origin policy for…
  - the DOM
  - message passing (via postMessage)
  - network access
  - CSS and fonts
  - cookies