HTTP Cookie Hijacking in the Wild: Security and Privacy Implications

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Who we are

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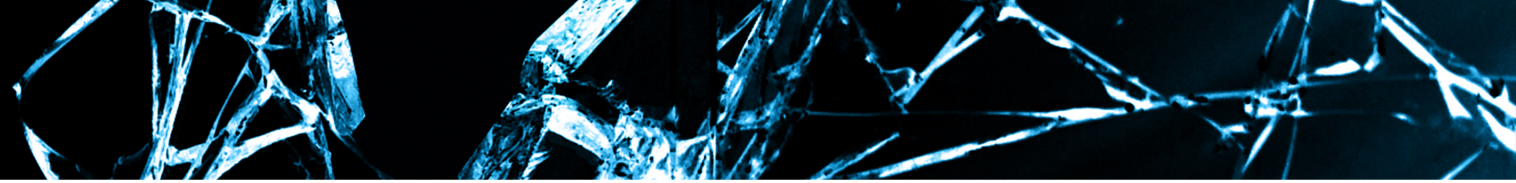
Current State of Affairs

- ☑ Public discussion about need for encryption
  - Crypto Wars, part 2
- ☑ Getting crypto right is difficult
  - DROWN, FREAK, POODLE, Logjam, …
- ☑ SSL/TLS is fundamental for securing our communications

- ☒ Talk about encryption?
  - More about lack of encryption
  - "*Web Services and our Quest for Finding Ubiquitous Encryption*"

    …sad tale without a happy ending … or partially happy?

Chapters

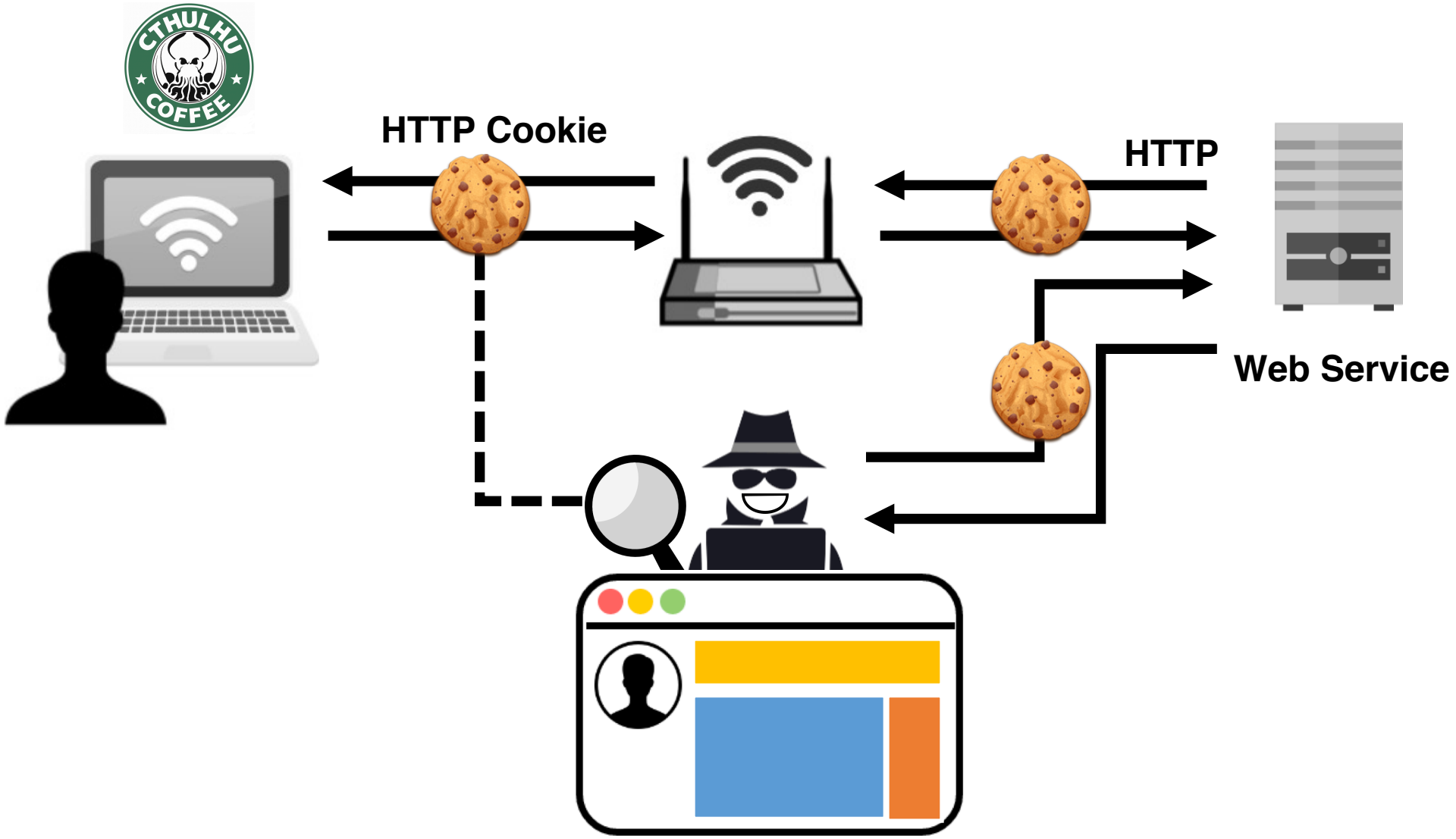


HTTP Threats Still Around

User tracking using third party cookies
(Englehardt et al., WWW 2015)

Cookie injection attacks via HTTP response
(Zheng et al., Usenix Security 2015)

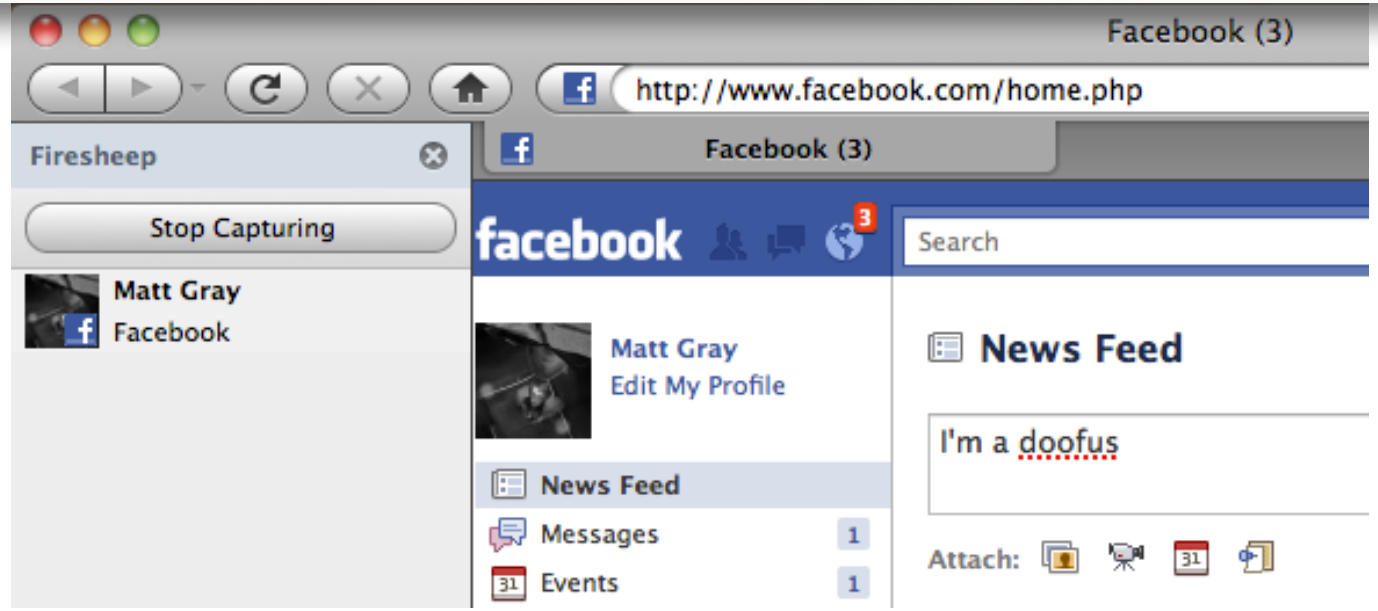
HTTP Cookie Hijacking



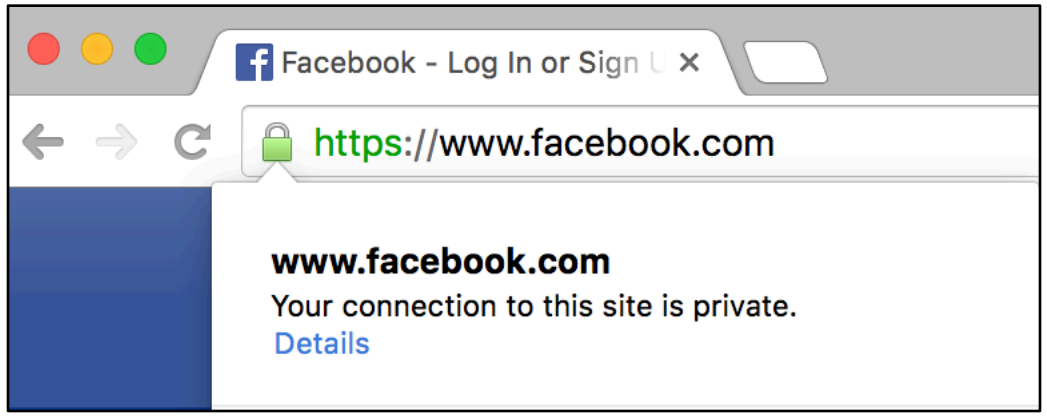
HTTP Cookie Hijacking – Known Threat

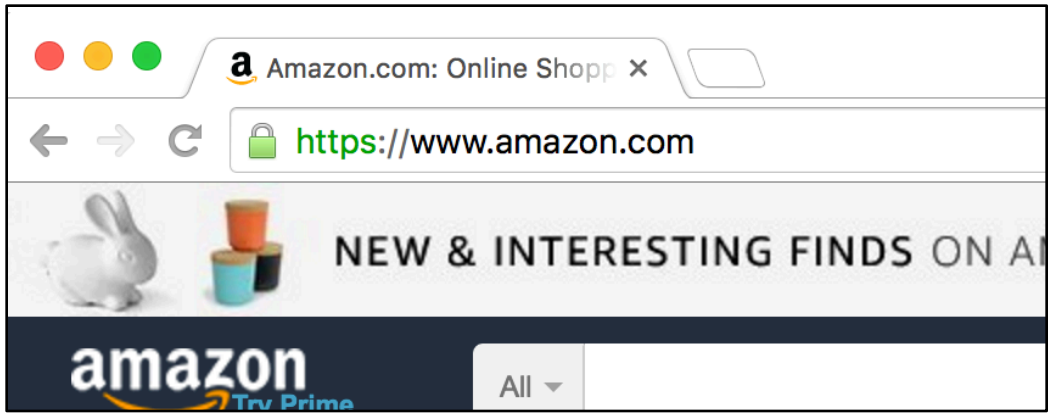
Firesheep In Wolves' Clothing: Extension Lets You Hack Into Twitter, Facebook Accounts Easily

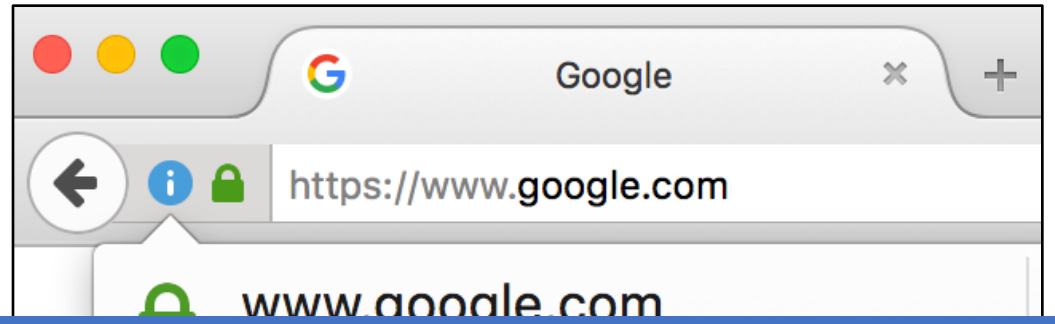
Posted Oct 24, 2010 by Evelyn Rusli

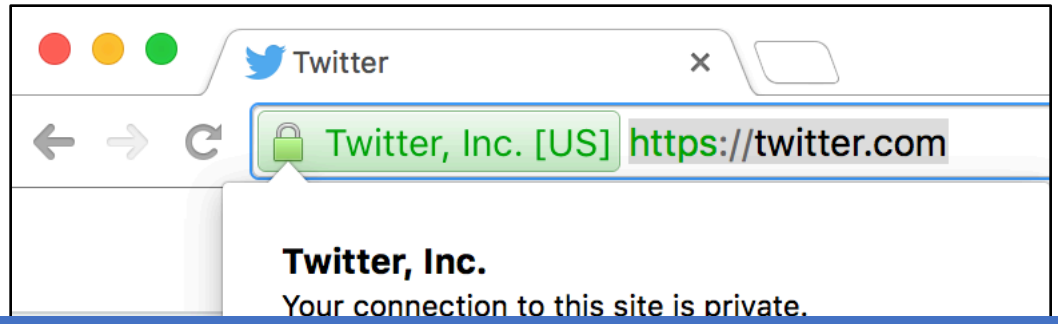


Migrating to HTTPS



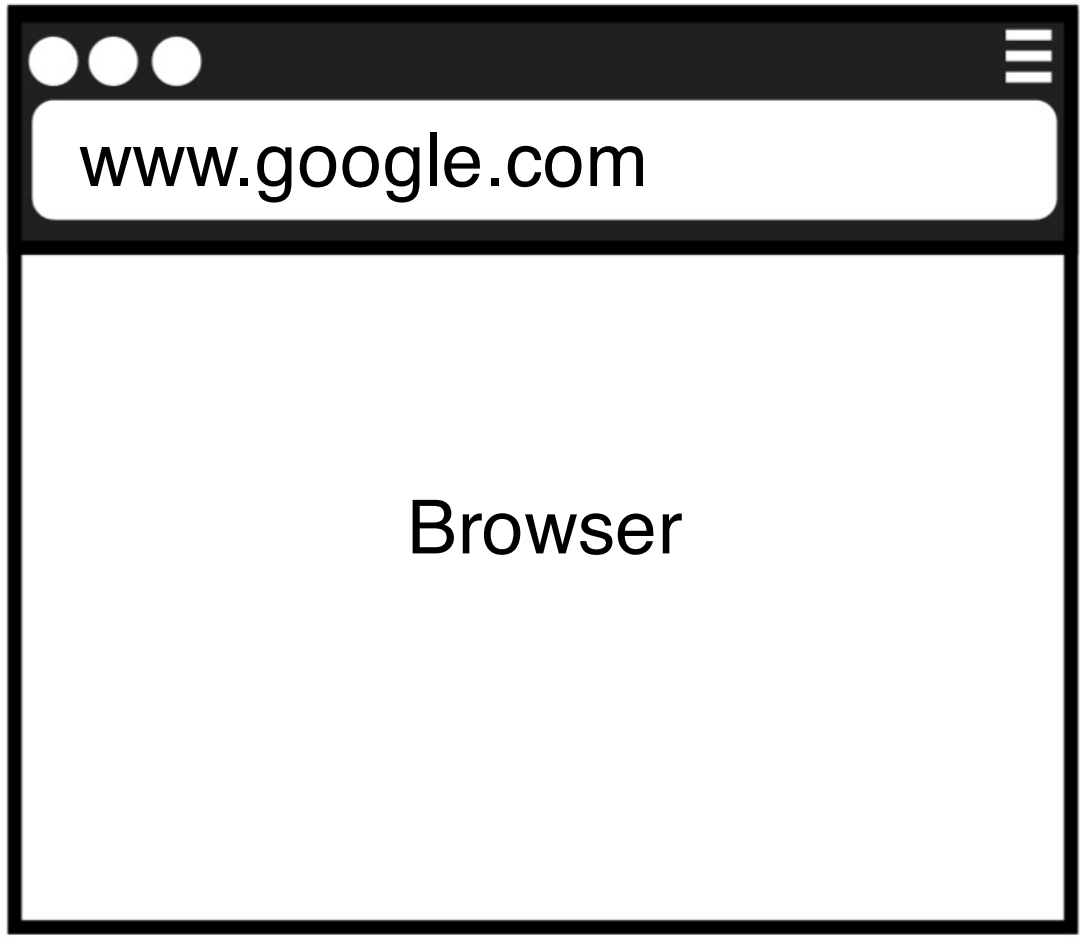


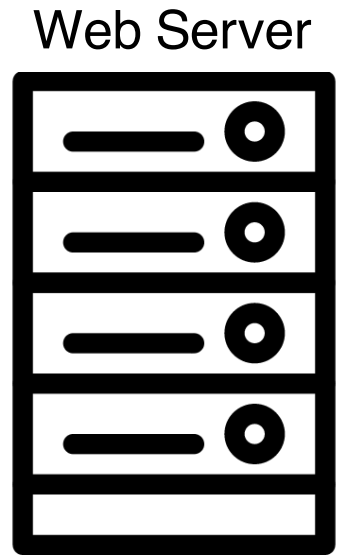




~40% of top sites(140k) on the internet support HTTPS
– SSL Pulse, 2016

Oh, you thought it was encrypted?





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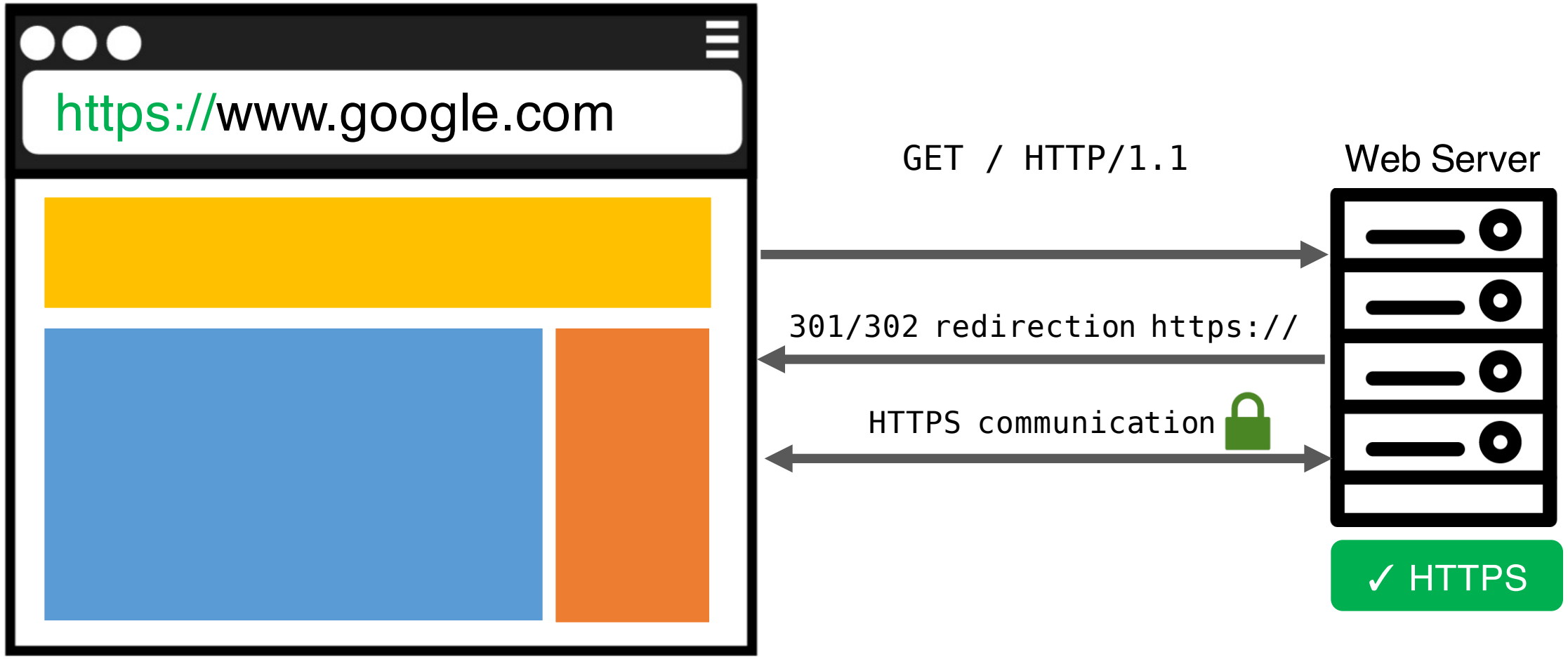

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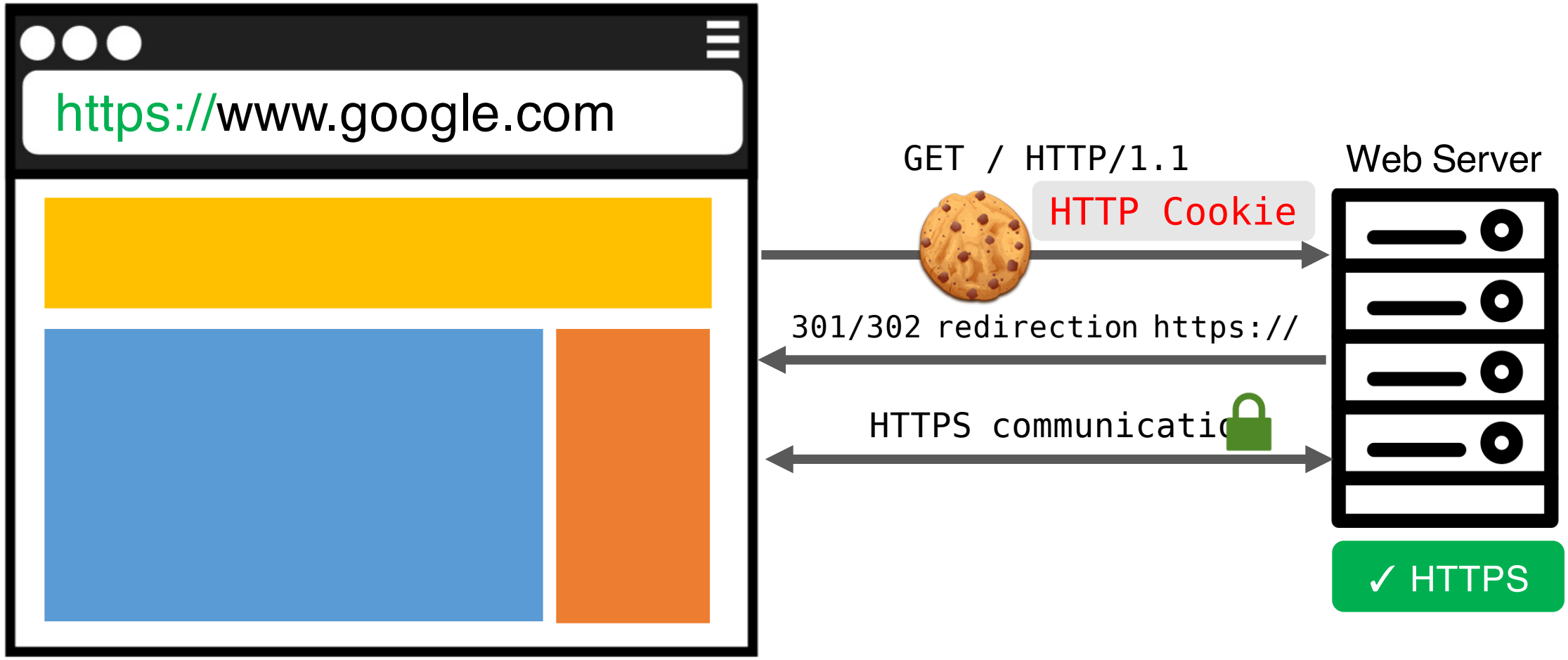


Cookie Hijacking in the Wild

- Sites support HTTPS, **but usually not ubiquitous**
  - Services offer personalization over HTTP
  - Complicated cookie inter-operability → Flawed access control

- Studied 25 major services from different categories
  - 15 have partial deployment of HTTPS
  - All 15 expose sensitive information and/or account functionality

Threat Model

What can we access using the stolen cookies?

Stealing Cookies

- Access to the targeted network
  - **Open Wi-Fi Network**, Wiretapping, Middle box, Proxy, **Tor exit node**
- Network traffic sniffing programs
  - e.g. TCPdump, Wireshark, TShark, Kismet, KisMac
- TCP Reassembly (if necessary)

Stealing Cookies

- Extracting Cookies
  - Cookies in HTTP headers:
    - HTTP Request: **Host, Cookie**

```
GET / HTTP/1.1
Host:                   www.google.com
Connection:             keep-alive
Cookie:                 SID=XXXXX; HSID=YYYYY; APISID=ZZZZZ
User-Agent:             Mozilla/5.0 (X11; Linux x86_64; rv:47.0)
Gecko/20100101 Firefox/47.0
Accept-Language:        en-US
Accept-Encoding:        gzip, deflate
```

    - HTTP Response: **Set-cookie**

```
Set-cookie:             SID=XXXXX; Expires=Mon, 01 Jan 1970 00:00:01 GMT;
Path=/; Domain=.google.com;
```

Accessing data using stolen cookies

- Send **HTTP** or **HTTPS** Requests with the stolen cookies
  - curl

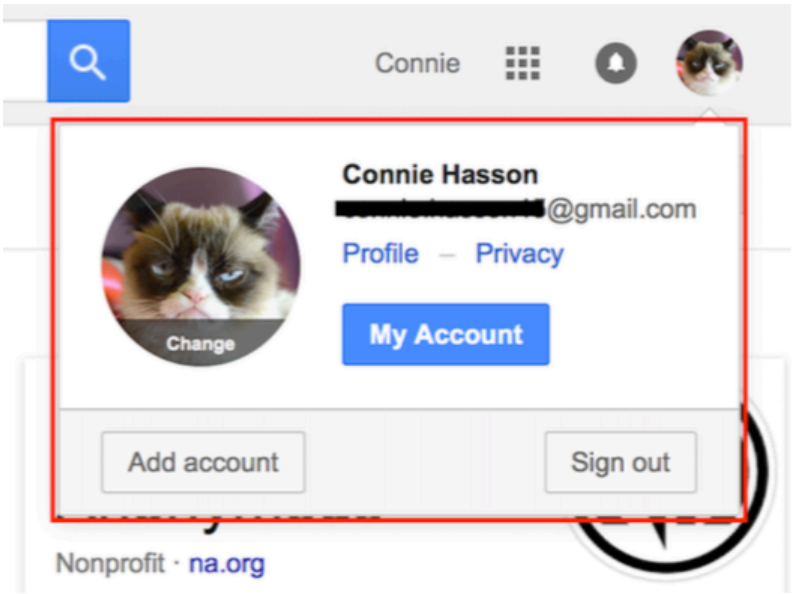
```
curl –H “User-Agent:”
     --cookie “name=value; name=value” http://example.com
```

  - Web Driver, PhantomJS (Render Javascript, Images)
  - Find XPaths of elements or texts contain user information
    - Differences size/elements/texts when loading page with cookie and without cookie

Search engines

Google | Baidu | Bing | Yahoo

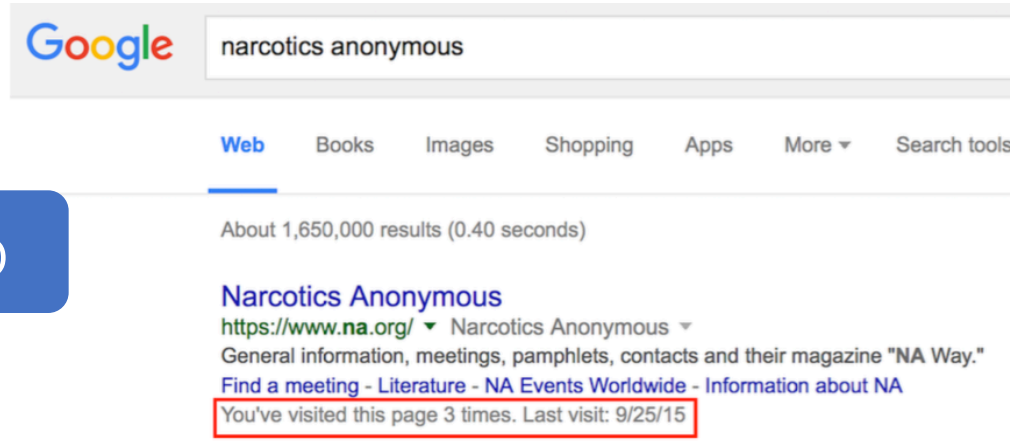
- User information
  email, profile picture, first/last name

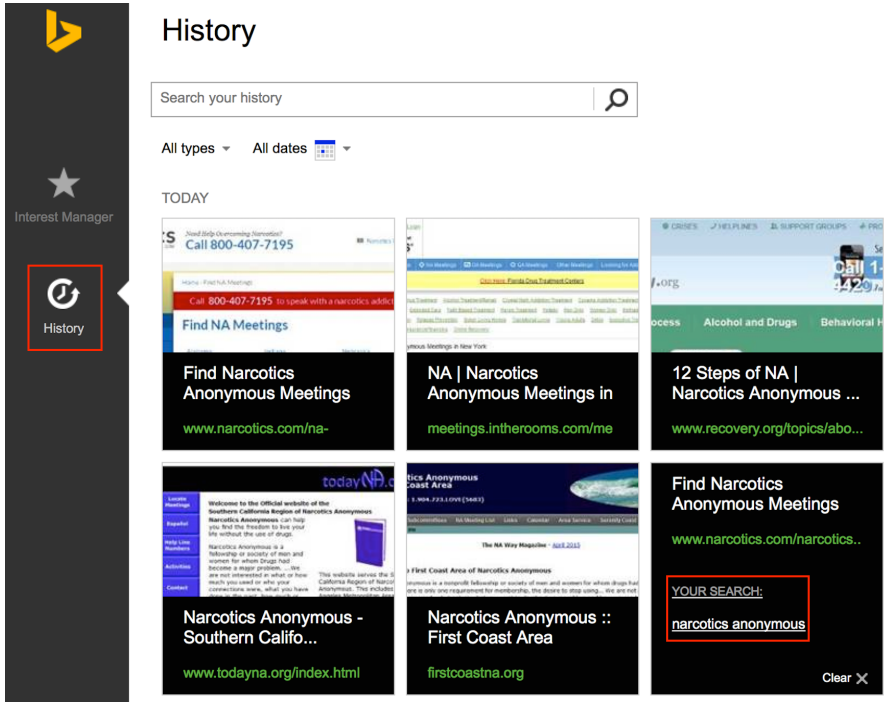


Search engines

Google | Baidu | Bing | Yahoo

- User information
  email, profile picture, first/lastname
- **Search/visited history**

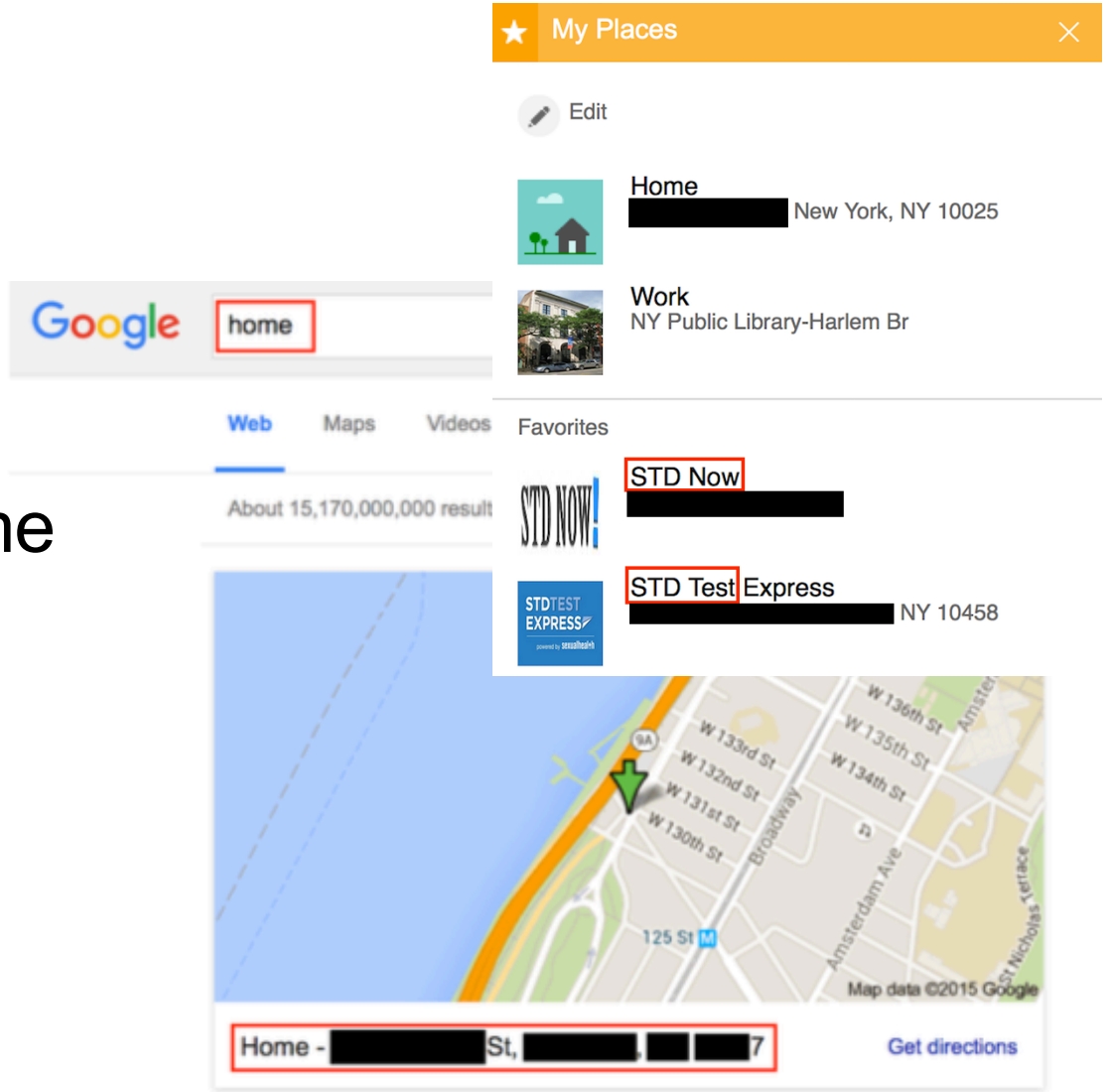




Search engines

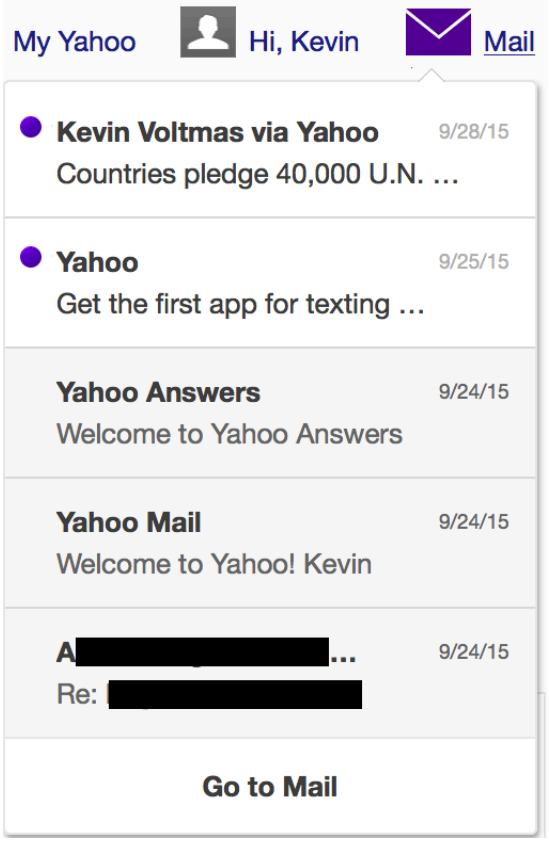
Google | Baidu | Bing

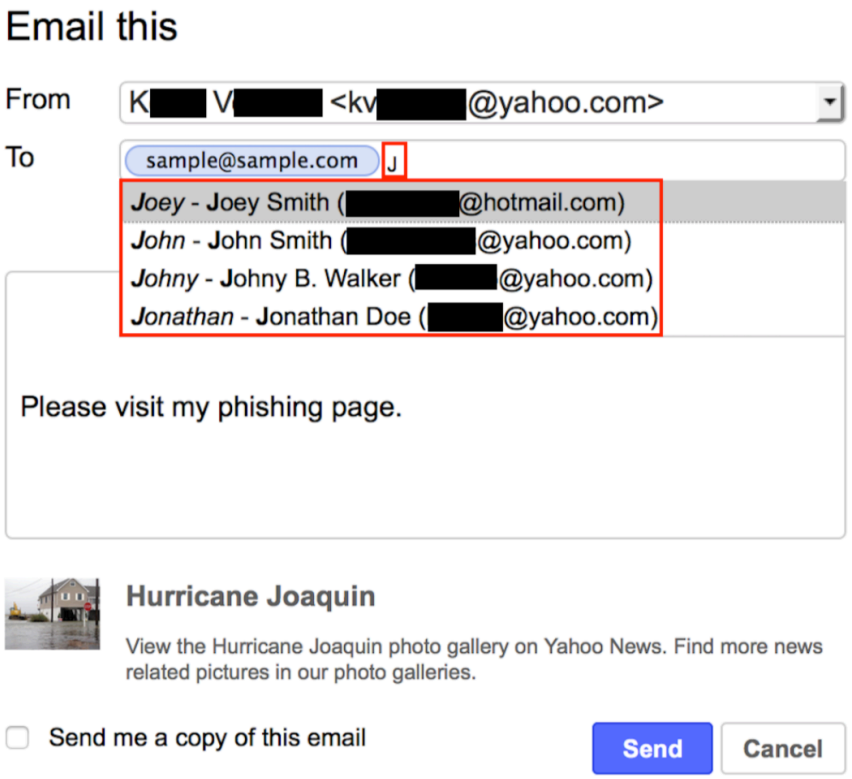
- User information
  email, profile picture, first/lastname
- Search/visited history
- **Saved locations**



Yahoo

- Many services
  - Yahoo answers
- Email notification title and snippet
- Extract contact list
- Send email as user





E-commerce

Amazon | Ebay | Walmart | Target

- All support HTTPS
- HTTPS pages only for login, account and checkout pages
- User information: username, email
- **Items in cart, wish list, recent view items, purchased items**

E-commerce

Amazon | Ebay | Walmart | Target

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- HTTPS pages only for login, account and checkout pages
- User information: username, email
- Items in cart, wish list, recent view items, purchased items
- **Ebay reveals shipping address**

E-commerce

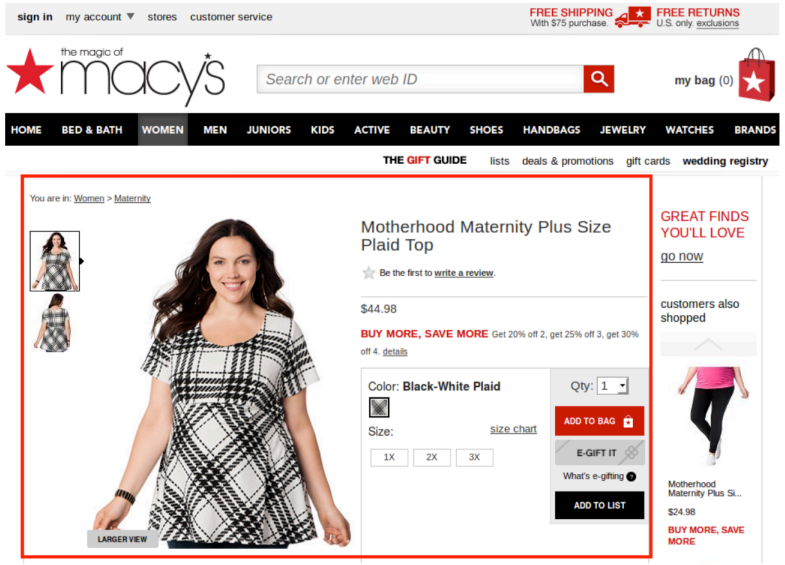
Amazon | Ebay | Walmart | Target

- All support HTTPS
- HTTPS pages only for login, account and checkout pages
- User information: username, email
- Items in cart, wish list, recent view items, purchased items
- Ebay reveals full shipping address
- **Facilitate spam and phishing**
  - Send recommendations to any email with custom message

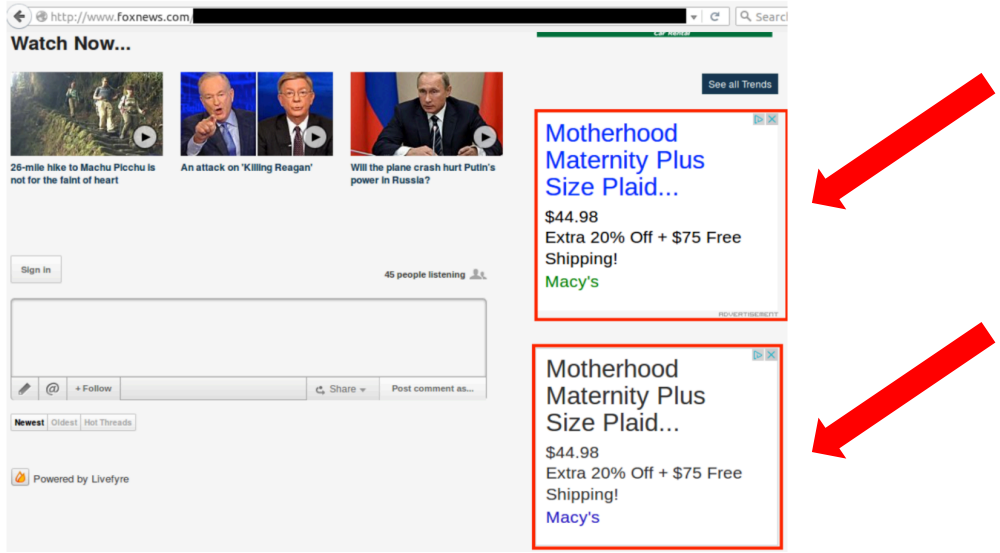
Ad Networks

- Ads presented to user based on user's profile
- Ads reveal browsing history and/or sensitive user data

visited by user



shown to attacker



Cookie Hijacking Cheat Sheet

Site	HttpOnly	non—HttpOnly
Amazon	—	x-main
Bing	—	_U, WLS
Baidu	—	BDUSS
CNN	—	CNNid, authid
Doubleclick	—	id
Ebay	—	cid, nonsession
Google	HSID	SID
Guardian	—	GU_U
HuffingtonPost	huffpost_s	huffpost_user huffpost_user_id last_login_username
MSN	MSNRPSAuth	—
New York Times	—	NYT-S
Target	—	WC_PERSISTENT guestDisplayName UserLocation
Walmart	—	customer, CID
Yahoo	F	T, Y
Youtube	VISITOR_INFO1_LIVE	—

Collateral Exposure – Extensions & Mobile Apps

Name	Type	Browser	#	Cookie leaked
Google Maps	app	Chrome	N/A	✓
Google Search	app	Chrome	N/A	✓
Google News	app	Chrome	1.0M	✓
Amazon Assistant	extension	Chrome	1.1M	✓
Bing Rewards	extension	Chrome	74K	✓
eBay for Chrome	extension	Chrome	325K	✓
Google Dictionary	extension	Chrome	2.7M	✓
Google Hangouts	extension	Chrome	6.4M	✗
Google Image Search	extension	Chrome	1.0M	✗
Google Mail Checker	extension	Chrome	4.2M	✗
Google Translate	extension	Chrome	5.5M	✗
Yahoo Mail Notification	extension	Chrome	1.2M	✗
Amazon	default search bar	Firefox	N/A	✓
Bing	default search bar	Firefox	N/A	✗
Ebay	default search bar	Firefox	N/A	✓
Google	default search bar	Firefox	N/A	✗
Yahoo	default search bar	Firefox	N/A	✗

Application	Platform	Version	#	Cookie leaked
Amazon	iOS	5.3.2	N/A	✗
Amazon	iOS	5.2.1	N/A	✓
Amazon	Android	28.10.15	10-50M	✗
Bing Search	iOS	5.7	N/A	✓
Bing Search	Android	5.5.25151078	1-5M	✓
Spotlight (Bing)	iOS	iOS9.1	N/A	conditionally
Siri (Bing)	iOS	iOS9.1	N/A	✗
Ebay	iOS	4.1.0	N/A	conditionally
Ebay	Android	4.1.0.22	100-500M	conditionally
Google	iOS	9.0	N/A	✗
Google	Android	5.4.28.19	1B+	✗
Gmail	iOS	4.1	N/A	✗
Gmail	Android	5.6.103338659	1-5B	✗
Google Search Bar	Android	5.4.28.19	N/A	✗
Yahoo Mail	iOS	4.0.0	N/A	conditionally
Yahoo Mail	Android	4.9.2	100-500M	✗

Collateral cookie exposure is common.
Android apps a little more secure.

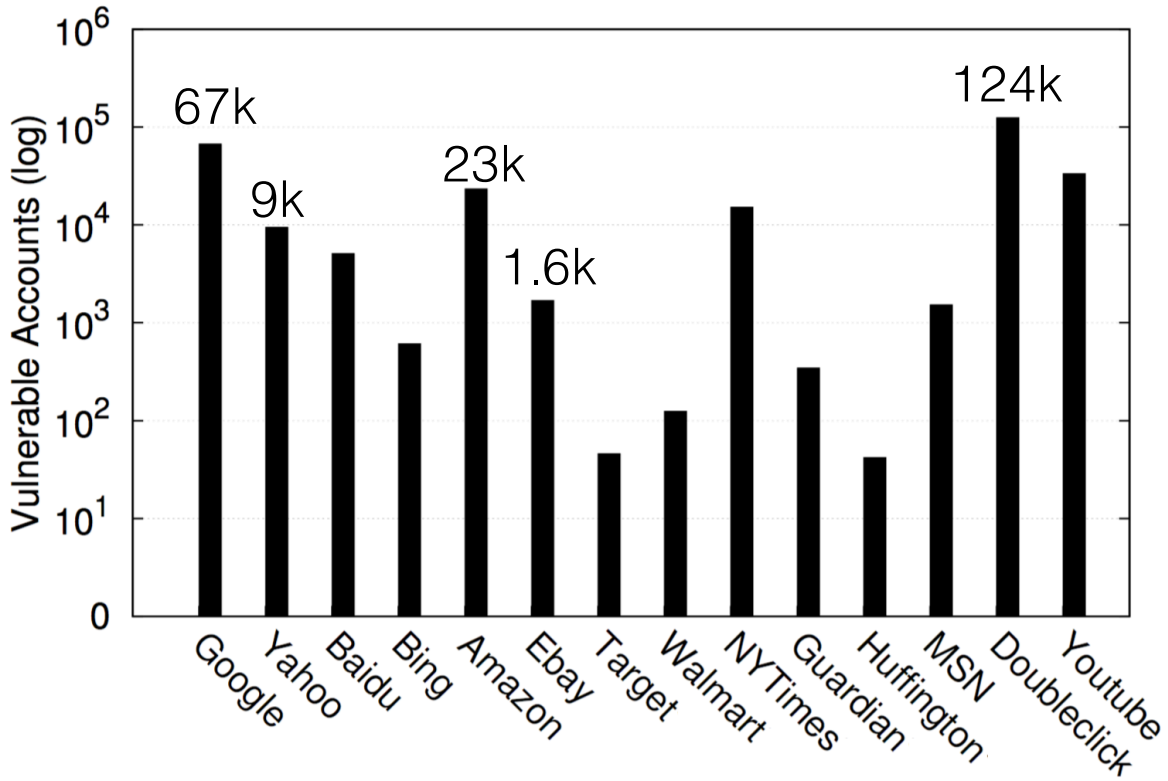
Attack Evaluation

- Do users behave differently when on public WiFi?
- Any mechanisms deployed that prevent hijacking?

- Monitored ~15% of Columbia's public WiFi for 30 days (IRB approval)

- Collected HTTP and HTTPS traffic
  - URL / SNI
  - Cookie name
  - Hash of cookie value (differentiate users per website)

Large-scale Cookie Exposure



In total, 282K vulnerable accounts

"Government agencies can collect HTTP traffic without notice to users or admins."

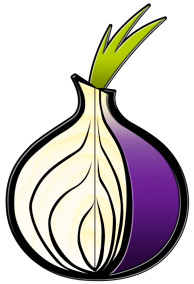
– Edward Snowden

The Washington Post

The Switch

NSA uses Google cookies to pinpoint targets for hacking

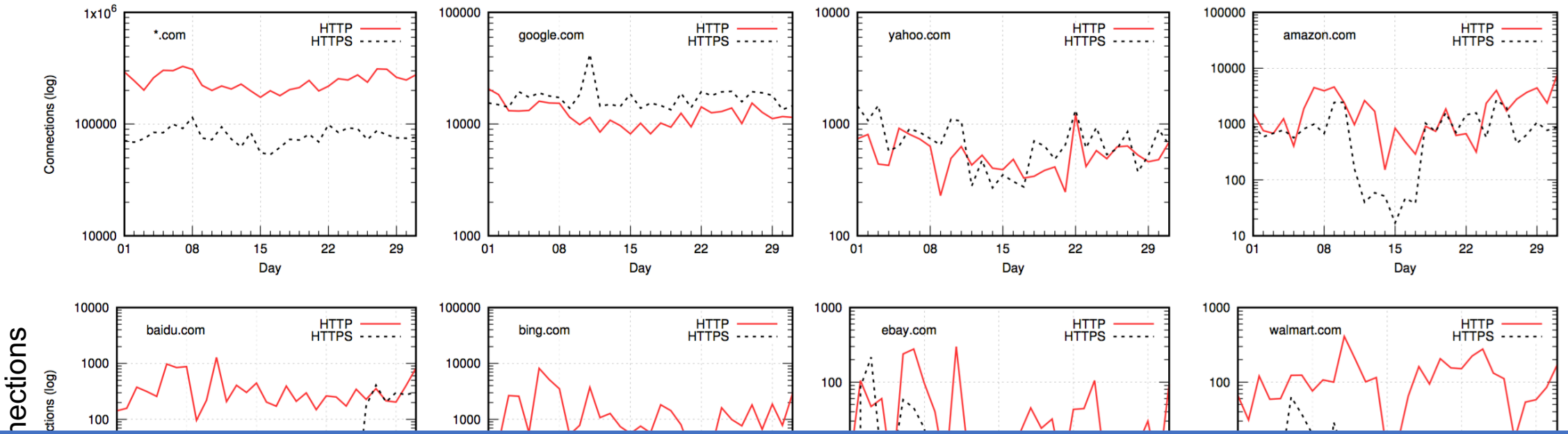
Attack Implications – Tor Network



- Used by privacy-conscious users, whistleblowers, activists
- Tor Bundle is *user-friendly*
  - HTTPS Everywhere pre-installed

- Monitored fresh Tor exit node for 30 days (IRB approval)
- **Did not** collect cookies, only aggregate statistics

Attack Implications – Tor Network



a practical deanonymization attack

Countermeasures

Server-controlled mechanisms

HTTPS Strict Transport Security (HSTS)

HSTS Preload

Client-controlled mechanisms

HTTPS Everywhere

HSTS

- Server instructs browser to only communicate over HTTPS
- HTTP response header sent over HTTPS

```
Strict-Transport-Security: max-age=10886400; includeSubdomains; preload
```

- HSTS Preload protects initial connection to server
  - Eliminates HTTP → HTTPS redirection

HSTS: Issues

- ✗ Preload requires HTTPS on all subdomains
  Legacy URL and functionality
- ✗ HSTS partial adoption
  Main google and regional pages (google.*) still not protected by HSTS

Protected	Not protected
account.google.com	google.com/account
mail.google.com	google.com/mail

- ✗ Early state of adoption and misconfigurations
  [Kranch and Bonneau, NDSS 2015]
- ✗ Attacks
  [J. Selvi, BlackHat EU ‘14], [Bhargavan et al., Security and Privacy ’14]

HTTPS Everywhere

- Browser extension from EFF and Tor
- Pre-installed in Tor browser
- Ruleset collections (community effort)

```
<ruleset name="Example">
<target host="example.com" />
<rule from="^http:" to "https:" />
</ruleset>
```

- Regular expressions rewrite "http://" to "https://"

```
http://example.com/foo → https://example.com/foo
```

HTTPS Everywhere: Issues

- ✘ Rulesets do not offer complete coverage (also contain human errors)
- ✘ Not functional in some HTTPS pages/requests (exclusion rule)
  Amazon: HTTPS breaks adding products to basket

```
<exclusion pattern="^http://(?:www\.)?amazon\.com/gp/twister/(?:ajaxv2|dynamic-update/)" />
```

- ✘ Complicated for large websites

```
http://rcm-images.amazon.com/images/foo.gif
```

```
https://images-na.ssl-images-amazon.com/images/foo.gif
```

- ✘ **Opt-in** option to reject all HTTP connections

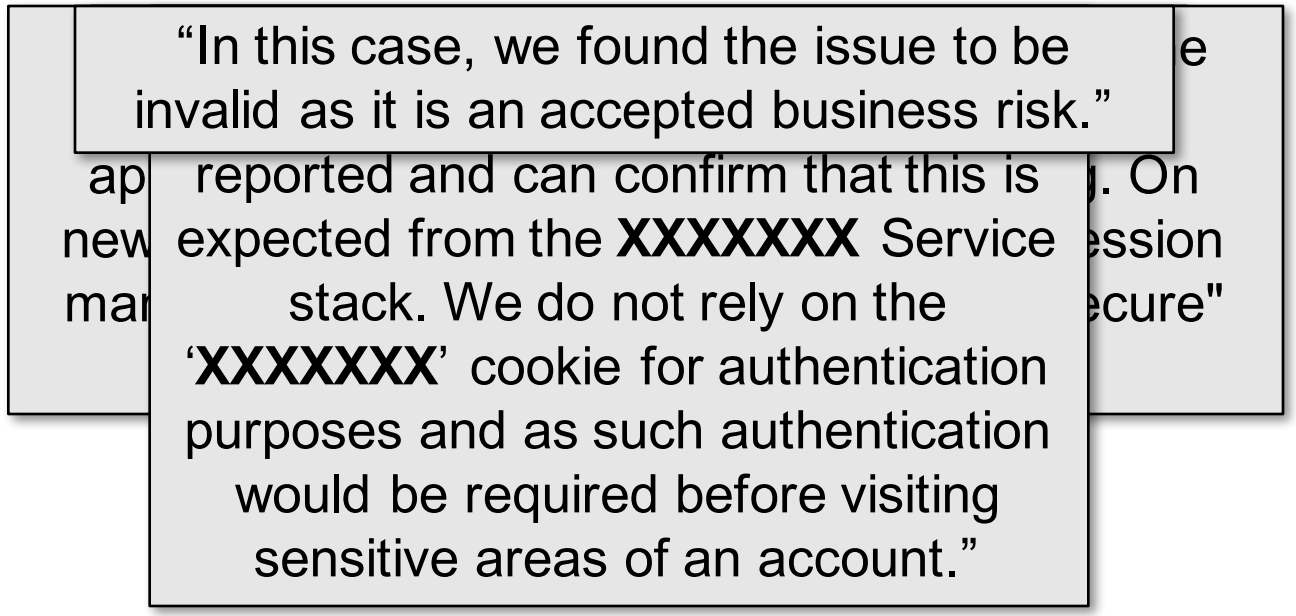
HTTPS Everywhere: Effectiveness

- Extract URLs of HTTP requests from WiFi dataset
- Test URLs against HTTPS Everywhere rulesets
  - Over 70% accounts remain exposed

Services	Exposed Accounts	Reduction
Google	31,729	53.12%
Yahoo	5,320	43.55%
Baidu	4,858	4.63%
Bing	378	38.03%
Amazon	22,040	5.68%
Ebay	1,685	0%
Target	46	0%
Walmart	97	23.62%
NYTimes	15,190	0%
Guardian	343	0.29%
Huffington	42	0%
MSN	927	39.25%
Doubleclick	124,352	0%
Youtube	264	99.21%
Total	207,271	26.62%

Disclosure

- Sent detailed reports to all audited web services



Sound Bytes

- Cookie hijacking remains a significant (yet overlooked?) threat.
- Services sacrifice security for usability and support of outdated clients or legacy codebase.
- Existing defenses are insufficient. They reduce the attack surface, but *a single HTTP request is all you need!*

Questions

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