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CO331 – Network and Web Security

19. Secure sessions

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HTTP Authentication

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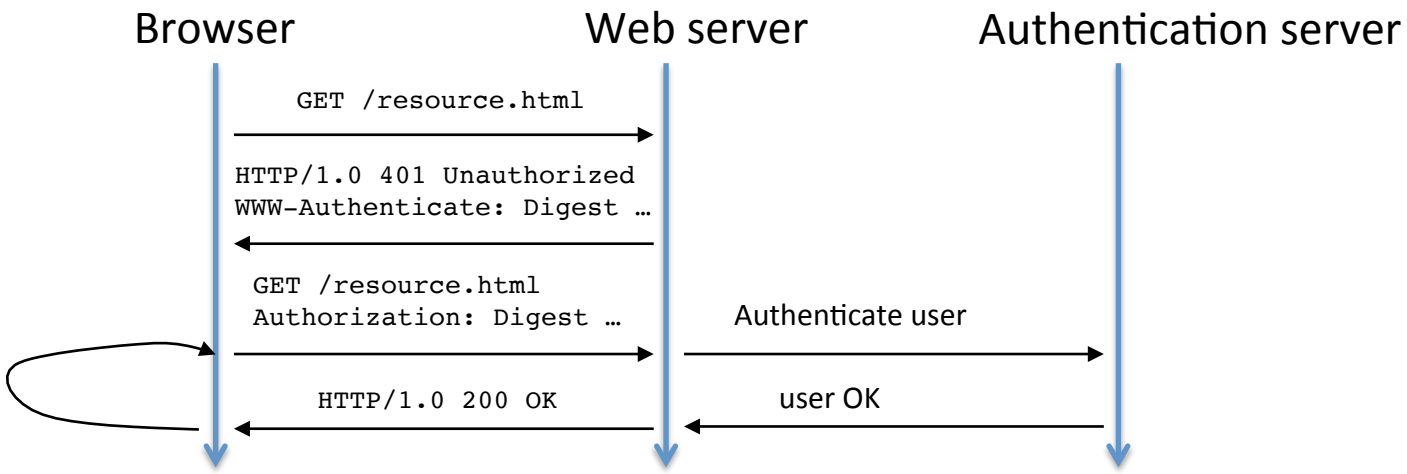
- In a stateless protocol, each time a user needs to do an action requiring authorization, its identity needs to be established anew
- HTTP Basic Authentication
  - Send username and password in clear text
  - Wise to use at least HTTPS
  - Essentially deprecated
- HTTP Digest Authentication
  - Send hash of password and server-generated nonce that may restrict validity
    - Time stamp, client IP, etc.
  - Does not protect other fields or headers
- Limitations
  - Inefficient: contact the authentication server at every request
  - Cumbersome: user needs to close browser to sign out
  - Annoying: user needs to re-authenticate for each different web asset
- Security issues
  - Credentials sent on the wire with every request
  - Password dialogue easy to spoof and confusing for user
  - MITM can tamper with Digest nonce and launch offline dictionary attack



Sessions

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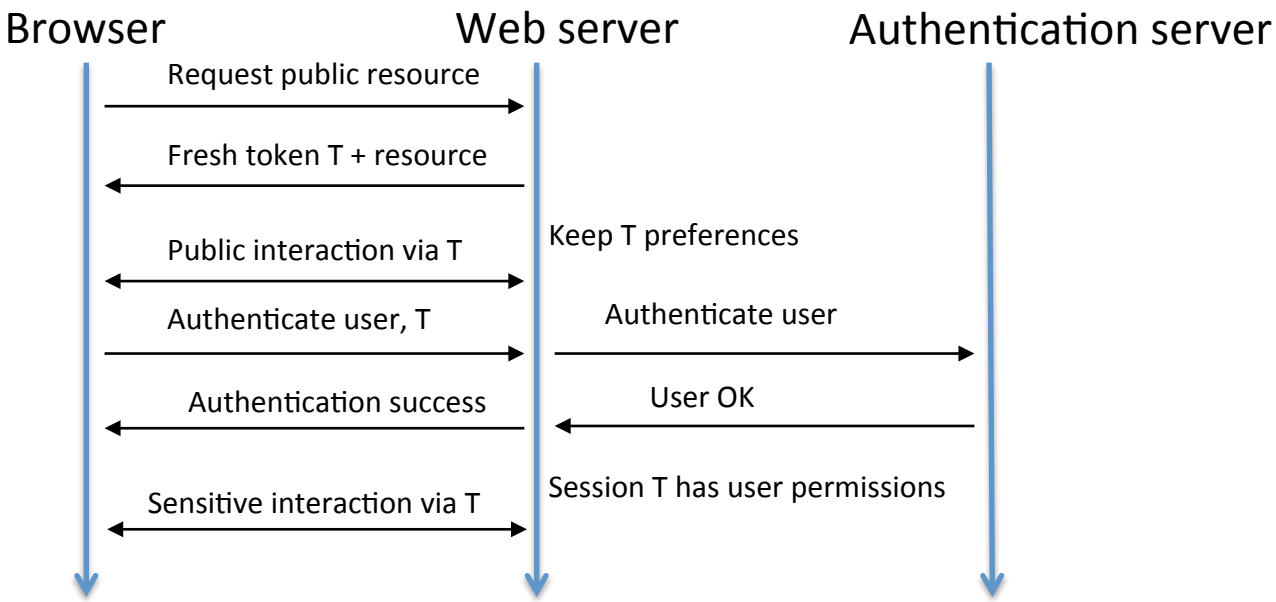

- Unauthenticated sessions
  - The server issues a short-lived token to the client
  - The client presents the token with request that affect client state on the server
  - Useful to keep track of web app state on behalf of anonymous user
- Authenticated sessions
  - The client authenticates once
  - The client presents the token when authorization is needed
  - More efficient, flexible, and complicated than HTTP Authentication
- Session token
  - Also know as session id, `SID`, `SSID`, `PHPSESSIONID`, …
  - Typically implemented as **cookies**
- Most servers provide modules to support sessions and handle session tokens

Attacks: session fixation

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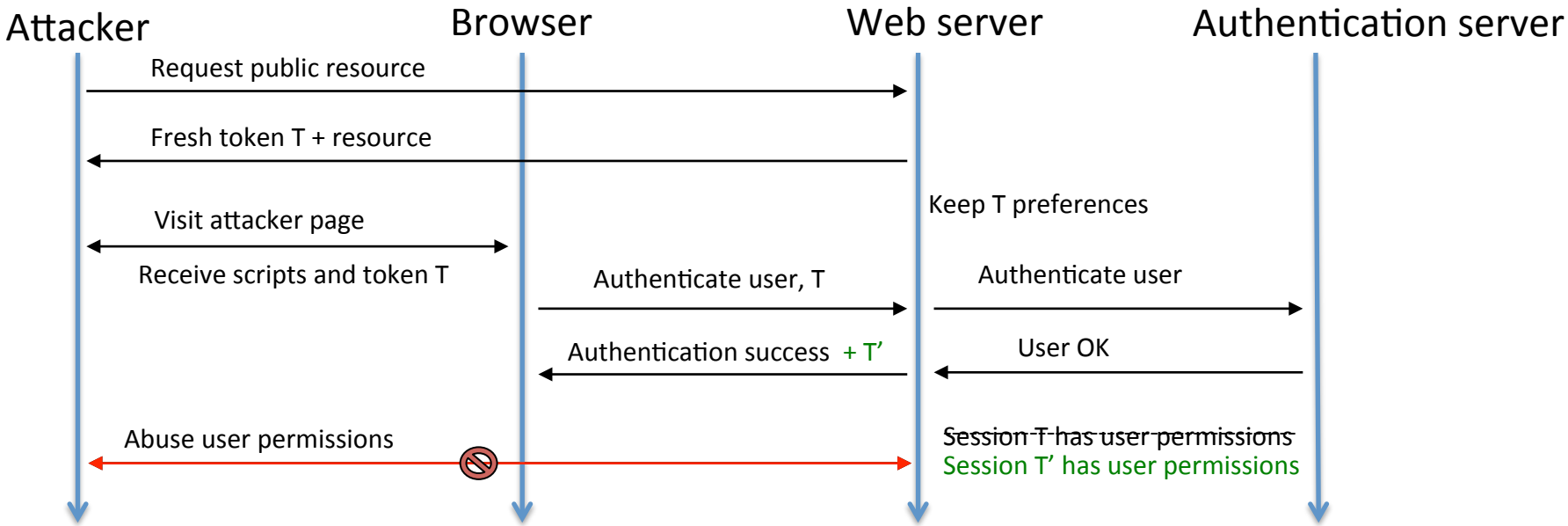
- Naïve session implementations may be open to session fixation attacks
- Attacker obtains unauthenticated session token by connecting to web server
- Tricks user to log in using attacker's token
  - For example using XSS or MITM
- After login, the token is associated to a valid session
  - Elevation of privilege: attacker can use token to perform authorized actions on behalf of the user
- Countermeasure: after login issue a new token



Attacks: session hijacking

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- Attacker obtains a valid token and performs sensitive actions on behalf of user
  - Guessing attack
  - MITM: steal over HTTP connection and WiFi
    - Possible also when HTTP is used only after logging in over HTTPS
  - XSS attack
- Mitigations
  - Send session tokens only over HTTPS
  - Invalidate session on server after logout
    - Restricts window-of-opportunity for attacker that has stolen a token
  - Use secure tokens
- Firesheep extension for Firefox: PoC session hijacking on Facebook, Twitter, etc.

Secure tokens

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- Tokens can be spoofed
  - Make tokens unpredictable using randomness
- Tokens can be stolen
  - Restrict where attacker can use them
    - Bind session to client-context such as IP address, SSL session Id, browser fingerprint
  - But…
    - User may get logged out unexpectedly
      - IP changes when switching from WiFi to Ethernet
      - SSL session Id changes when user re-open website with existing session
    - Website attacker can often use victim browser
- Secure token example
  - Session *data* = (timestamp, random value, user id, login status, client-context)
  - Option 1: server keeps data
    - Small token: MD5(*data*)
    - Overhead of database lookup for each request
  - Option 2: server sends data to client
    - Larger token: Encrypt-then-MAC(*data*)
    - Server must still keep track of login status

Attacks: CSRF

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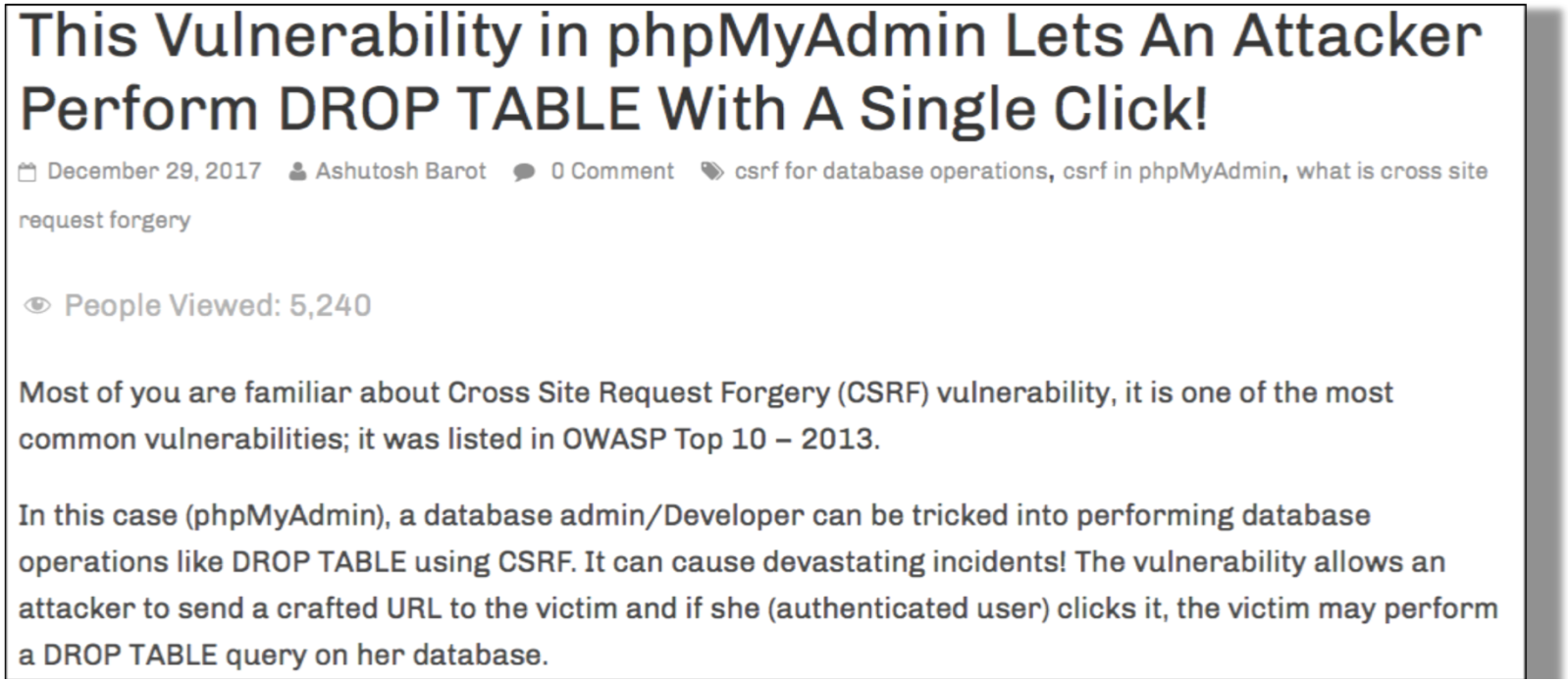
- Cross-Site Request Forgery (CSRF) exploits trust between browser and target
  - User is in position to issue requests that cause side-effects
    - User logged-in to a web application
    - IP-based access control in a LAN
- Easy to deploy
  - Attacker tricks user into issuing request that causes undesirable side-effects
  - Enough for user to visit malicious web page or click on link crafted by the attacker
- Widespread: last 3 months: 89 new CSRF-related CVEs



This Vulnerability in phpMyAdmin Lets An Attacker Perform DROP TABLE With A Single Click!

December 29, 2017 Ashutosh Barot 0 Comment csrf for database operations, csrf in phpMyAdmin, what is cross site request forgery

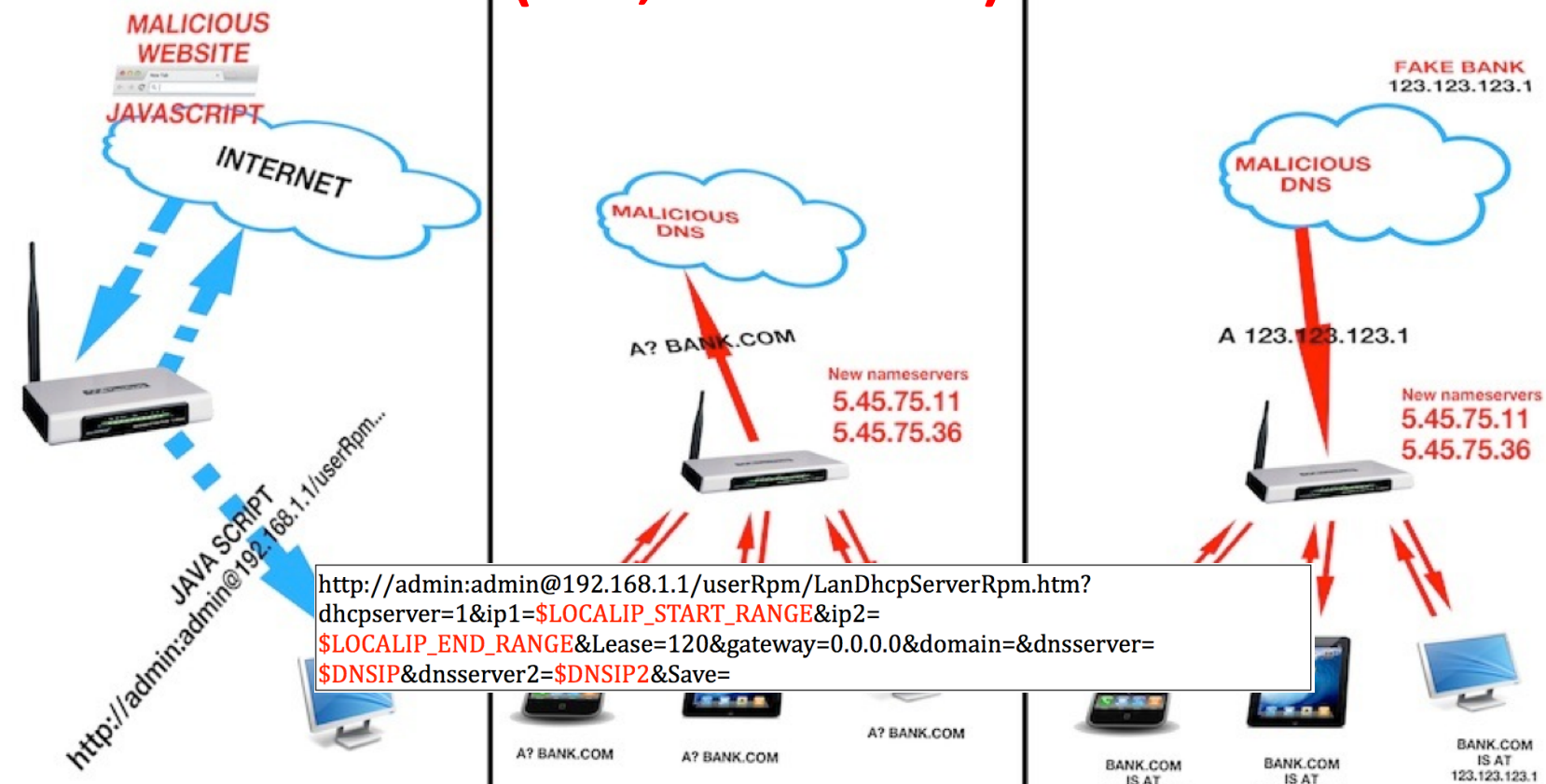
People Viewed: 5,240

Most of you are familiar about Cross Site Request Forgery (CSRF) vulnerability, it is one of the most common vulnerabilities; it was listed in OWASP Top 10 – 2013.

In this case (phpMyAdmin), a database admin/Developer can be tricked into performing database operations like DROP TABLE using CSRF. It can cause devastating incidents! The vulnerability allows an attacker to send a crafted URL to the victim and if she (authenticated user) clicks it, the victim may perform a DROP TABLE query on her database.

CSRF SOHO ROUTER ATTACK

(300,000 victims)



http://admin:admin@192.168.1.1/userRpm/LanDhcpServerRpm.htm?
dhcpserver=1&ip1=$LOCALIP_START_RANGE&ip2=
$LOCALIP_END_RANGE&Lease=120&gateway=0.0.0.0&domain=&dnsserver=
$DNSIP&dnsserver2=$DNSIP2&Save=

1

Malicious Javascript is loaded by a computer inside the local network and forces a local machine to automaticaly change the routers DNS settings.

2

The router is now set to use a malicous nameserver (DNS) for all devices in the network.

3

Devices that attempt to connect to financial (or other) sites can now be redirected to fake websites that can then capture login credentials.

(Team Cymru, 2014)

Attacks: session CSRF

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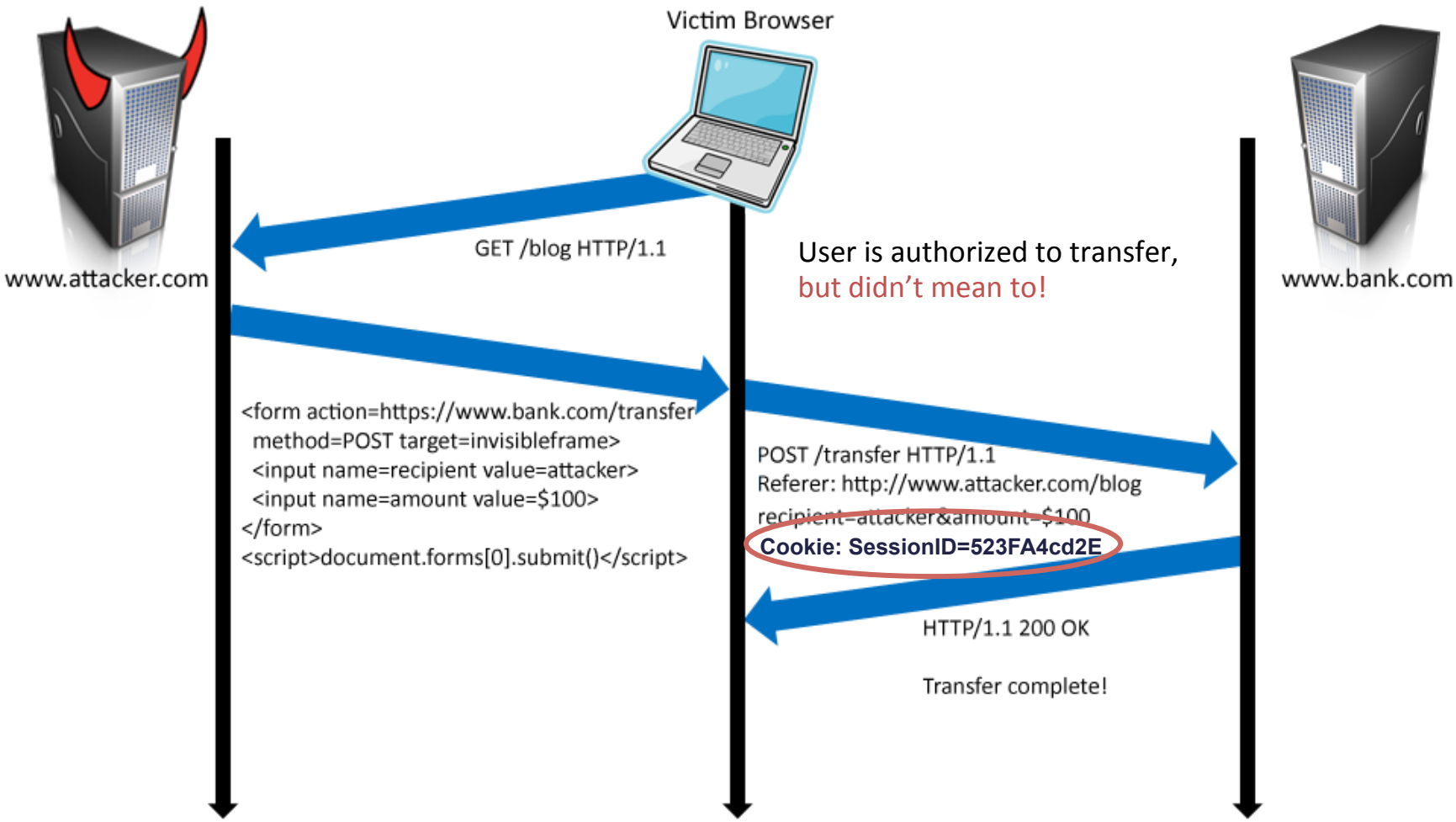

(Mitchell, 2008)

CSRF mitigations

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- Use POST and not GET for sensitive, state changing actions
  - POST body does not leak via `referer` header
  - POST body is not sent in redirections
- Embed a second token as a hidden field of each form presented on authenticated pages
  - The request from the attacker will have the cookie, but not this second token
- Option 1: double cookie
  - Use the same token in form and in cookie, server checks if they are the same
- Option 2: use different tokens in form and in cookie
  - Server knows which 2 should correspond
  - More secure and flexible: form token can be different for each form
  - Could be hash of session ID and intended action to save space on server
- Use SameSite attribute for session cookie
  - Restricts functionality: cannot access existing session via external link
    - Example: page from https://a.com with link to https://github.com/331/privateProject
  - Still not widely adopted, stress-tested
- Many frameworks offer built-in CSRF protections

```
<form action="/transfer.do" method="post">
<input type="hidden" name="CSRFToken"
value="OWY4NmQwODE4ODRjN2Q2NTlhMmZlYWE...
wYzU1YWQwMTVhM2JmNGYxYjJiMGI4MjJjZDE1ZDZ...
MGYwMGEwOA==">
…
</form>
```

Attacker does not know what value to use in the spoofed form!

CORS

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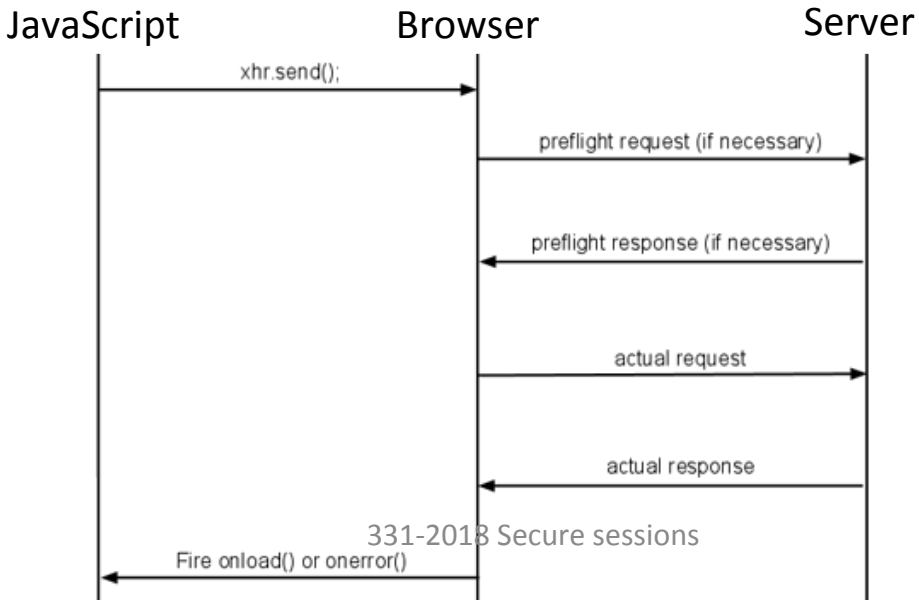
- SOP allows cross-origin communication *when both parties are willing to engage*
  - Script inclusion, postMessage, fragment identifier, etc
- SOP prevents cross-origin AJAX requests
  - Prevents attacker stealing anti-CSRF token by loading target page via AJAX
- Cross-Origin Resource Sharing (CORS) relaxes SOP for servers that opt in
  - Browser attaches `Origin=`*origin* header to cross-origin AJAX request
    - Upon redirection, `Origin` is set to null
  - If server accepts cross-domain requests from *origin*
    - It replies with header `Access-Control-Allow-Origin:` *origin* (or * for any origin)
    - Browser allows AJAX response to be received by script
  - If server does not care for CORS, response still reaches browser but is discarded



BrowserAudit

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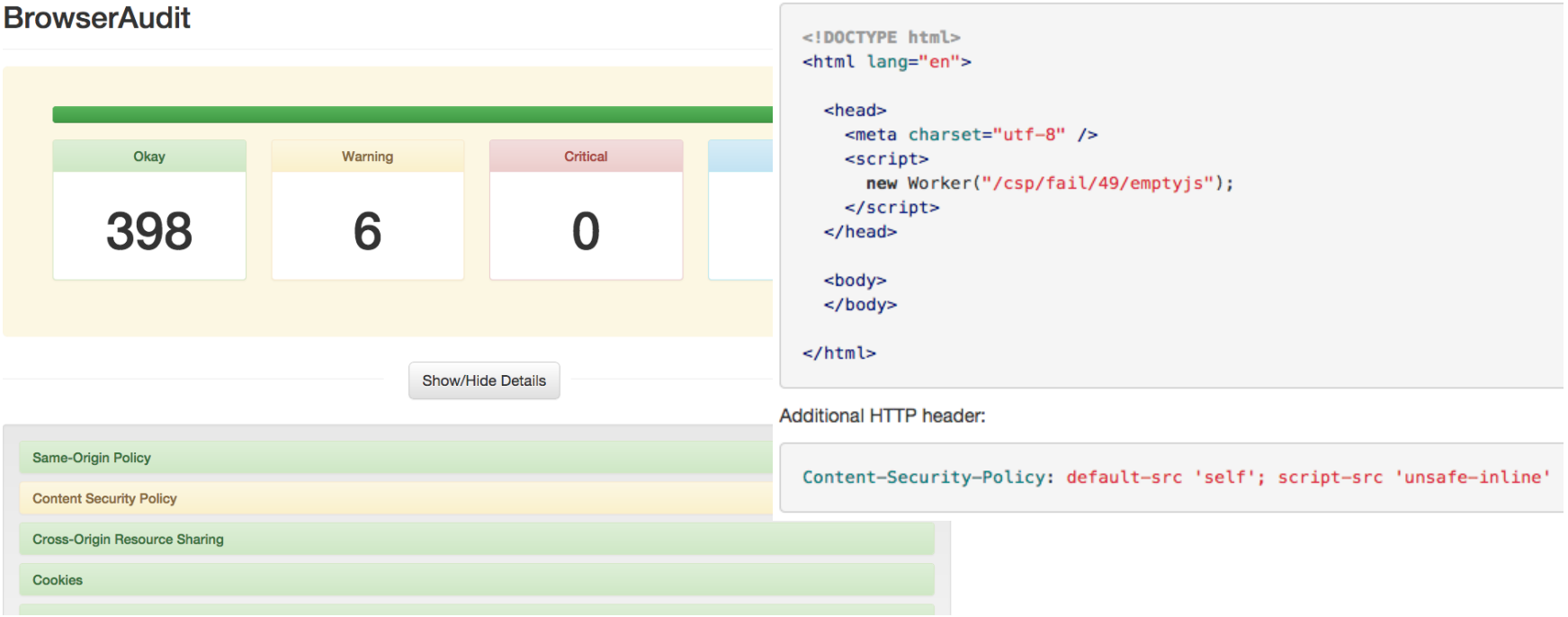
[*Hothersall-Thomas, Maffeis, Novakovic:* ISSTA'15]

- Automated testing framework for SOP, CSP, CORS, HSTS
- Started as award-winning BEng individual project at Imperial
  - Charlie Hothersall-Thomas (Netcraft), our 1st guest lecturer
- Test if a policy provides the expected security behaviour
- User can inspect test source code to understand policy intent
- Discovered security issues in Firefox, Chrome, Blackberry



Attacks: login CSRF

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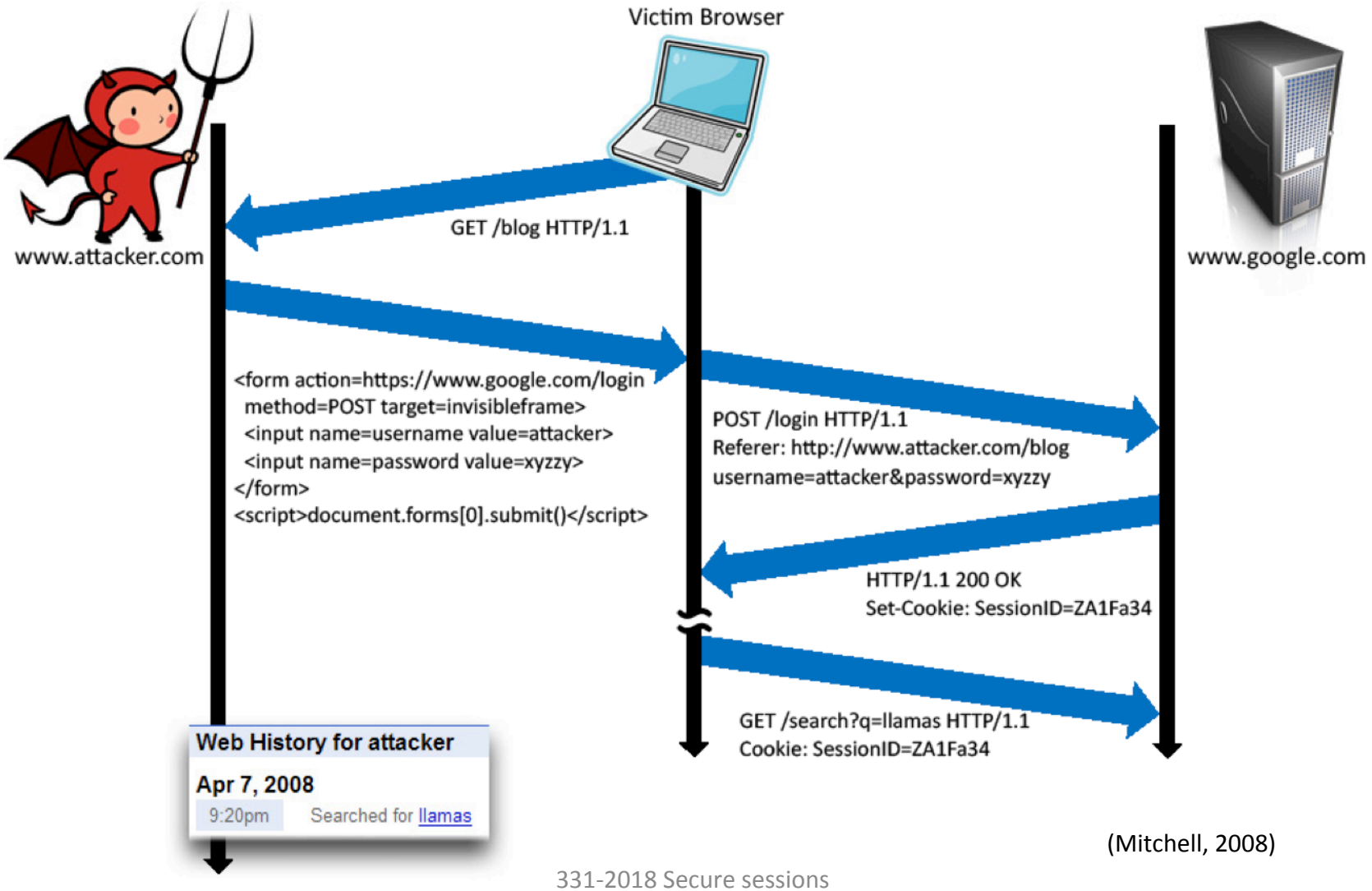

(Mitchell, 2008)

Login CSRF mitigations

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- Anti-CSRF token does not apply
  - Before login there is no session token to serve as 2nd-factor
- Validate `refer` or `origin` header of login request
  - Previous example:
    - POST request to `https://www.google.com/login`
    - With `referer` header `http://www.attacker.com/blog`
    - Very suspicious!
  - Only a partial mitigation
    - Sometimes `referer` and `origin` headers are stripped by network proxies, user preferences
    - See further reading
- Embed login form on a dedicated page
  - Served over HTTPS
  - From segregated domain that serves no other resources
  - Do not include 3-rd party scripts or iframes
  - This minimizes the risk of XSS, other mistakes

Secure sessions

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1. Use HTTPS wherever possible: also before/after login
2. Segregate login in a secure domain
3. Change session token after login
4. Protect sensitive actions with anti-CSRF token cryptographically related to session token
   - Possibly also related to action itself
   - Or use SameSite cookies if compatible with web application deployment constraints
5. Use specific and short-lived tokens
   - If same token used more than once, MITM can launch replay attacks
   - The more specific the token, the harder to generate and maintain, but the better the protection
6. Check `referer` header where available
7. Ask for re-authentication for special actions
   - Transfer money to a new bank account
   - Change email or password
   - Delete account
8. After predetermined idle time, session should expire, or at least degrade to lower security
   - For example, read only access