The Hacking Protocols
and
The Hackers Sword

HTTP / HTTPS / URL'S

"The light-saber is a Jedi's weapon – not as clumsy or random as a blaster."

Obi-Wan Kenobi, "Star Wars: Episode IV"

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Introduction

- Why are firewalls basically meaningless for Web security?
  - People might not realize: if you have a Web site on the www, you have 1 (or 2) hole(s) in your firewall – ports 80 (and 443)!
  - Why? HTTP communicates over TCP port 80 and HTTPS communicates over TCP port 443
  - A firewall must let traffic through ports 80 and 443!

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Protocols of the Web

- HTTP = Hypertext Transfer Protocol
  - "Language" spoken over the Web
  - Textural based
  - Request/Response mechanism
  - How can we make it secure?!?
  - HTTP over TCP Port 80
- HTTPS = HTTP over SSL
  - Same as HTTP but text is encrypted
  - HTTPS over TCP Port 443

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Protocols of the Web

- No matter what, all Web browsers/servers must use HTTP
- Request/Response stateless protocol
  - Client sends an HTTP request to communicate to the server its intentions
  - Server returns an HTTP response to communicate its desires

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HTTP/0.9 & 1.0

- HTTP/0.9
  - First official version of HTTP
  - Somewhat limited
- HTTP/1.0
  - Even though 1.0 is "old" (released in 1996), it is still used
  - Most are using to 1.1…
  - Again, request made by client, response made by server

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HTTP/1.0

- The URL (Universal Resource Locator) initiates the request from the client
- The request contains (among other things) a *Request method*
- The method is like a command to the server..
  - GET
  - HEAD
  - POST

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The HTTP/1.0 Request

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HTTP/1.0 Response

- To respond, the server sends back a response message
- The message contains:
  - Response code: a numeric code that has some meaning
  - Header fields: additional info about the response
  - Data: the content or body of the response. If requesting HTML docs, this is the actual HTML page

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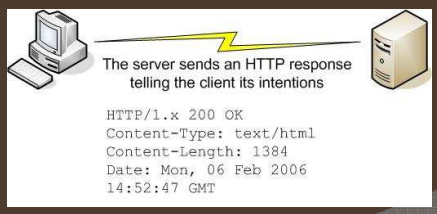
The HTTP/1.0 Response



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HTTP/1.1

- Official spec as of 2001
- Widely used by popular browsers
- HTTP/1.1
  - Extends HTTP/1.0 by adding some interesting new features
  - Examples:
    - New methods
    - New response codes
    - New header fields

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Query String Support

- The HTTP/1.1 URL supports a query string & script parameter passing
  - The query string is at the heart of any Web application
  - The query string is the primary way attackers get access to a Web server
  - Anything after the "?" can be processed by a server script (PHP, ASP, etc…)
  - Ex: …`/myscript.php?id=112233&name=myname`

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An HTTP Req/Resp Example…

- The message that the browser sends to the server might be:

```
GET / HTTP/1.1
Accept: image/gif, image/x-xbitmap,
   image/ jpeg, image/pjpeg, */*
Accept-Language: en-us
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0
   (compatible; MSIE 5.01; Windows NT)
Host: hypothetical.ora.com
Connection: Keep-Alive
```

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```
HTTP/1.1 200 OK
Date: Mon, 06 Dec 1999 20:54:26 GMT
Server: Apache/1.3.6 (Unix)
Last-Modified: Fri, 04 Oct 1996 14:06:11 GMT
Content-length: 327
Connection: close
Content-type: text/html

<title>Sample Homepage</title>
<img src="/images/oreilly_mast.gif">
<h1>Welcome</h2>
Hi there, this is a simple web page.  Granted, it may not
be as elegant as some other web pages you've seen on the
net, but there are
some common qualities:

<ul>
  <li> An image,
  <li> Text,
  <li> and a <a href="/example2.html"> hyperlink. </a>
</ul>
```

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HTTPS – Secure HTTP

- HTTPS is a protocol used to encrypt an HTTP stream
- In essence, it is HTTP over SSL (Secure Socket Layer)
- HTTPS is used when sensitive info is being sent via HTTP (typically through an HTML form)
  - Credit card transactions
  - Transactions involving your SSN
- **This is not foolproof!!!**

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The Universal Resource Locator

- Most Web attacks today are quite elegant
- The attack usually starts with small steps and each proceeding step takes them deeper
- The elegance is in the fact that only a browser is used or needed
- The carrier of the attack payload?
- **The URL!**

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URL Structure

- A URL (Universal Resource Locator) is a mechanism for uniquely identifying a Web resource.
- Generic form:
  `protocol://server/path/resource?parameters`
- Protocol: `http`, `https`, `ftp`, etc.
- Server: `www.uwp.edu`
- Path: `/staff/knautz`
- Resource: `res.php?id=12345&name=tim`

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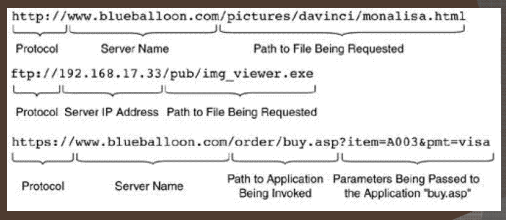
URL Structure

- Some URL Examples:



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URL's & Parameter Passing

- The last example in the previous slide shows parameters being passed to a server-side resource
- The *query string* is used to pass info from the browser to a Web server
- When a form is submitted, the form elements are gathered up and sent to the server as a query string
- Example
  `http://www.uwp.edu/query.php?id=123&name=tim`
  - `id=123&name=tim` is the query string

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URL Encoding

- URL's are made up of letters, numbers and symbols
- Some symbols have a special meaning within the confines of a URL and some do not
- However, some symbols have a meaning for the Web server receiving the URL…

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URL Encoding

- ? = Query string separator
- & = parameter delimiter. Separates name=value pairs
- = = Name/value separator
- + = Translates into a space
- : = protocol separator
- % = escape character for specifying hex, i.e. %20 is a space

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URL Special Characters

- What if you really need to put a "&" in the URL?
- I.e., `book=pride&prejudice&payment=visa`
- Most Web servers will break the QS into 3 parameters: `book=pride`, `prejudice=`, `payment=visa`
- The URL spec allows us to pass special chars by using two-digit hex encoded ASCII prefixed with a % symbol:
  …`?book=pride%26prejudice&pmt=visa`

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Meta-Characters

- Some characters do not have a special meaning in a URL
- But, if these characters make it into an application, they may have meaning there
- For example:
  - * is a "wildcard" character in shell scripts
  - | (pipe) is the pipe character in shell scripts.
    - This is especially lethal in Perl scripts: can cause commands to be executed on the server

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Meta-Characters

- For example (cont):
  - ` (back-tick) means "execute" in shell scripts or command output substitution. The output of the command inside the ` is executed and the output is placed in a variable

    ```
    files=`ls -al`
    ```

  - `files` contains the output of the `ls` command

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Unicode Encoding

- ASCII works pretty well…
  - English needs only a single byte to store characters
  - Not robust enough for other languages like Chinese
- Most OS's support multi-byte character sets: Unicode
  - 2 byte character set
  - Encoded %u*XXYY* where *XX* is the high-order byte & *YY* is the low-order byte
  - ASCII `%00` - `%FF` = Unicode `%0000` - `%00FF`

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Abusing URL Encoding

- When Unicode is used incorrectly, certain Web servers can be fooled exposing vulnerabilities
- Unicode Vulnerabilities
  - In 2000, Microsoft IIS vulnerable to the "Unicode Bug":
    - Illegal Unicode encoding of "/"
    - Allowed users to make URLs that could navigate outside of the document root
    - Allowed users to call the command shell (cmd.exe)

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Abusing URL Encoding

- Unicode Vulnerabilities (cont)
  - "Unicode Bug" (cont)
    - Example:

```
http://192.168.7.21/scripts/..%c0%af..
  /winnt/system32/cmd.exe?/c+dir+d:\
```

    - How does it work?
      - Hacker knows the system is IIS and that the scripts are in a `scripts` directory at `c:\inetpub`
      - `%c0%af` translates into "/" making the directory equivalent to ../..
      - The whole thing now executes cmd.exe

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Abusing URL Encoding

- Unicode Vulnerabilities (cont)
  - "Unicode Bug" (cont)
    - How does `%c0%af` translate into "/"?
    - Unicode (specifically UTF-8) encoding allows for multi-byte character encoding up to 3 bytes

Bytes	Bin	Dec	Hex
1	00101111	47	2F
2	11000000 10101111	49327	C0 AF
3	11100000 10000000 10101111	14713007	E0 80 AF

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Abusing URL Encoding

- Unicode Vulnerabilities (cont)
  - "Unicode Bug" (cont)
    - But, according to the spec., a UTF-8 decoder is not supposed to accept encoding of a character longer than necessary
    - The "/" is encodable in 1 byte so the 2 or 3 byte encoding should have been rejected by IIS!!!

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Abusing URL Encoding

- Unicode Vulnerabilities (cont)
  - "Double Decode" or "Superfluous Decode"
    - May of 2001 another bug was discovered in IIS
    - Very similar to the "Unicode bug"; same result

```
http://192.168.7.21/scripts/..%25%32%66..
  /winnt/system32/cmd.exe?/c+dir+d:\
```

    - `%25` = "%", `%32` = "2", `%66` = "f"
    - But we still have to decode again as `%2f` is not encoded
    - The result: ../..
- Summary: URL encoding can be a huge security risk!

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HTML Forms

- We've all seen forms before…
- There are 2 aspects to handling forms:
  - Client-side processing
  - Server-side processing
- Browsers tasks:
  - Display the form
  - Allow input to the fields
  - Build a properly encoded URL
  - Send the URL to the server

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HTML Forms

- Servers tasks:
  - Separate the query string
  - Process the input elements
- How do we know that the input elements are "proper"?
- What is secure form handling?

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HTML Forms

- Anatomy of an HTML Form:
  - *Method*: The HTTP method used in the form submission. Usually GET or POST
  - *Action*: The server-side application that is run to process the forms input elements
  - *Input elements*: The form data. Every element must have a name
  - *Submit button*: Special button used to send the data
- Let's look at an example…

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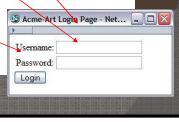
HTML Forms

```
<?xml version = "1.0"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
  "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns = "http://www.w3.org/1999/xhtml">
  <head><title>Acme-Art Login Page</title></head>
  <body>
    <form method="POST" action="/cgi-bin/login.cgi">
      <table>
        <tr>
          <td>Username: </td>
          <td><input name="user" type="text" width="20" /></td>
        </tr>
        <tr>
          <td>Password: </td>
          <td><input name="pass" type="password" width="20" /></td>
        </tr>
      </table>
      <input type="submit" value="Login" />
    </form>
  </body>
</html>
```



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Parameter Passing Via GET & POST

- See `http://www.cs.uwp.edu/staff/knautz/form_elements.html`
  - 2 forms, each with the same controls
  - Method is different for each
  - Notes:
    - The URL is different for each
      - POST → no form data passed in the URL
      - GET → form data passed in the URL including the password in plain text!
    - The HTTP request is different
      - POST → parameters passed as the content of the HTTP request
      - GET → parameters passed in the URL

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Summary

- Web traffic is primarily HTTP or HTTPS
- HTTP and HTTPS are subjected to nearly 100% of all Web attacks
- Firewalls cannot stop these attacks!
- The URL is a tiny portal into your Web servers inner workings
- Firewalls, intrusion detection systems and proxy security technologies are useless
- Your ports 80 and 443 are open
- The URL is the sword of a Web attacker
- Understand the URL!

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