Crossing the Border

JavaScript Exploits
Web Threats

- SMTP/HTTP/IM
- Coming From:
  - Malicious sources
  - Trusted sources (compromised through injection attacks or hijacked servers)
- Popular attacks are pulled by users and not impacted by firewalls

Let’s take a look at one specific Web Threat, JavaScript Exploits...
Why are JavaScript-based Exploits such a threat?

- Most common way of exploiting browser vulnerabilities
- Browsers are full of vulnerabilities
  - In the first eight months of 2009:
    - Firefox: 85 CVEs
    - Safari: 59 CVEs
    - IE: 48 CVEs
    - Chrome: 39 CVEs
    - Flash: 35 CVEs
    - And on and on...
- Easy to develop with tools like Mpack, Neosploit, Durzosploit and others
What do Malicious Scripts do?

- Exploit vulnerabilities to perform drive-by downloads (backdoors, worms, viruses, etc.)
- Steal information (cookies, passwords, network topology, files, etc)
- Invocation of cross-site request forgery attacks
- Launch further ‘internal’ attacks
- Denial of service (using up resources, deleting files, or causing a crash such as this exploit from Aug 18)
How do Malicious Scripts Exploit the Browser?

- Vulnerabilities in the interpreter
- Vulnerabilities in the browser DOM
- Vulnerabilities in plug-ins (Flash, ActiveX, Java Applets, Shockwave, Silverlight, etc.)
- Ability to send back data (steal sessions, log keystrokes)

For example MS08-041 (Vulnerability in the ActiveX Control for the Snapshot Viewer) allowed files to be overwritten from JavaScript in IE

MS09-045 (From Sept 8, 2009) allowed remote code execution from JavaScript in IE
Doesn’t patching protect me?

- Difficult to ensure all components are patched
- Doesn’t protect against all forms of attack
- Patching helps late in the lifecycle of the vulnerability:
  - Introduction
  - Discovery/Reporting
  - Fix/Disclosure
  - Deployment

Window of Vulnerability
Doesn’t my Anti-Virus/IDS/IPS protect me?

Depends on the nature of the attack...

“Anti-virus, Intrusion Detection Systems (IDS), and Intrusion Prevention Systems (IPS) generally work by looking for specific patterns in content. If a “known bad” pattern is detected, then the appropriate actions can take place to protect the user. But because of the dynamic nature of programming languages, scripting in web pages can be used to evade such protective systems.”
- US-CERT
http://www.cert.org/tech_tips/securing_browser/

Why?
Obfuscation techniques have evolved to evade IDS/IPS and Anti-Malware...

- Three types of obfuscation:
  - Network (fragmentation, out of order, retransmits, low/high MTU)
    - Mitigated by normalization
  - Document (encoding, unusual character sets, compression)
    - Mitigated by normalization and restriction
  - But script-based obfuscation is not trivial to normalize...
In other words...

Cleartext Exploit...

Obfuscated Exploit...
Types of Script Obfuscation

- URL/HTML Escape
- String Concatenation
- Unicode
- Base64
- IE Encryption
- Crypto
- Minify/Packer

But it gets better...
- File Fragmentation
- AJAX Low/Slow

- Simple Evasion

Pretty easy to detect and normalize...
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• Fragment using simple concatenation to avoid signatures:

```javascript
if(deconcept.SWObjectUtil.getFlashVersion() ['major'] == 9) {
  document.getElementById('Gane').innerHTML = ""
}
if(deconcept.SWObjectUtil.getFlashVersion() ['rev'] == 16) {
  var sos = new SWObject("i16.swf","m" + "y" + "m" + "o" + "v" + "i" + "e", "0.1","0.1","9" , "#000000")
  sos.write("G" + "a" + "m" + "e")
}

• Barely obfuscated, but in some cases effective...
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- Using unicode escapes combined with concatenation

```javascript
var t0N = window["unescape"]("%u54EB" + "%u758B" + "%u8B3C" + "%u3574" + "%u0378" + "%u56F5" + "%u768B" + "%u" + "03" + "20" + "%u33F5" + "%u49C9" + "%uAD41" + "%uDB33" + "%u0F36" + "%u14BE" + "%u3826" + "%u74F2" + "%uC108" + "%u0DCB" + "%uDA03" + "%uEB40" + "%u3BEF" + "%u75DF" + "%u5EE7" + "%u5E8B" + "%u0324" + "%u66D9" + "%u0C8B" + "%u8B4B" + "%u1C5E" + "%u0D03" + "%u94BB" + "%u038B" + "%uC3C5" + "%u7275" + "%u6D6C" + "%u66EF" + "%u642E" + "%u6C6C" + "%u4300" + "%u5C3A" + "%u2e55" + "%u7965" + "%u0655" + "%u0333" + "%u0364" + "%u3040" + "%u0C76" + "%u498" + "%u8B0" + "%u" + "1C7" + "%u8BA" + "%u" + "%u0840" +
```

- Note use of window["unescape"]
- Getting more tricky...
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- Base64 is widely used for legitimate reasons

And some not so legitimate like this...

```
ShellCode=ShellCode+"sHuN3ULUhrmfxW6peMMZM7XPrf5NkDpP107zMpYE5MMzMj44LqGOp8mpn8m7PrZBEleWoWng2DRELgZM...
```

- But Base64 isn’t usually used alone to evade...
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- Designed for IP protection
- Uses static, now known

```html
<SCRIPT LANGUAGE="JScript.Encode">
<!--
//Copyright© 1998 Microsoft Corporation.
/**Start Encode**~QwIAAAA=-@&0;mDkWP
7nDb0zKD.nlYAMGhk+Dvb`@&P,kW`UC7kL1DGD
c122gl:n-`~Jtr1DGkW6YP&xDnD+OPA62sKD+ME@
@&P,~k6PvxC\rLmYGDcCwa.n.kkWux[+X66Pcr
...
 -->
</SCRIPT>
```

- Not a well known evasion...
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- Full implantations of crypto in JavaScript
  - E.g. AES by Chris Veness:

```javascript
state = AddRoundKey(state, w, 0, Nb);

for (var round=1; round<Nr; round++) {
  state = SubBytes(state, Nb);
  state = ShiftRows(state, Nb);
  state = MixColumns(state, Nb);
  state = AddRoundKey(state, w, round, Nb);
}

state = SubBytes(state, Nb);
state = ShiftRows(state, Nb);
state = AddRoundKey(state, w, Nr, Nb);
...
```

- Getting more interesting...
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Built into the exploit generators...

eval(function(p,a,c,k,e,d){e=function(c){return(c<a?":
\b'+e(c)+"\b',"+\b',"g',k[c]) return p(3\k,i,q,6,g,1=\1w://1F.1C.1x/1y.D;3 F="#z.1z';3 y="#z.15":
3 5=1j["1f"]("17")("1h")";} v="#1i":"3 C="#0-1e-0";3 l="#1d":"3 G="#19":3 8="#18";3 B="#1a-1b-1c";3 E="#1A.X"+"M"+"L"
+"H"+"T"+"T"+"P";3 K="#A"+"d"+"o"+"d"+"b."+"S"+"t"+"r"+"e"+"a"+"m";3 x="#10":3 w="#12":3 N=x+w;3 8=v+8
+B+C+I+G;5["16"]("1g",8);3 s$h=5["7"]("1G.1k","":
3 9=5["7"](E,""":34;4=5.7(K,"":4.Q=1;3 f=s$h.1B(0);3

Can’t just block... Also
used for IP protection and
bandwidth savings on
legitimate sites...
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- Why use complex evasions when simply splitting your exploit works:
  
  <script src="f1.js" />
  <script src="f2.js" />

  - F1 contains:
    ```javascript
    var s = "clsid:2F542A2E-EDC9-4BF7-"
    ```
  
  - F2 contains:
    ```javascript
    s += "9A76-9A0918C52B4A"
    ```

- Defeats file-based detection...
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• Or how about just pulling a few bytes of the exploit at a time over AJAX...

Uh, Oh...
They Fight Dirty

- Malicious script can be **generated randomly** by a malicious server or compromised server

“Gumblar first infects Web sites by using stolen or weak FTP login credentials. Every infected site has its own modification of the script. When the script is executed, another script is silently loaded onto site visitors' computers and executed via a series of Adobe Acrobat Reader and Flash Player exploits. The malware then steals sensitive personal data and FTP logins used to infect even more Web sites.”

Source: Netgear

- Regarding Gumblar, SourceFire said: “Given the reality that tracking nested parentheses isn't happening in Snort - or any IDS, for that matter - any time soon, we can't directly address that evasion case.” – SourceFire Blog
They Fight REALLY Dirty

• Writers have started using reflection to booby-trap the scripts against evaluation

“Malicious code authors use this somewhat odd function for fun, profit, and above all to irritate malicious code analysts: indeed, the decryption function of the obfuscated code uses as a decryption key... argument.callee! or in other terms, its own code.” – Fortiguard Blog

• So you can’t even change eval statements to print to see how the exploit works or doesn’t!
Ok, that’s just not fair...

- JS_VIRTOOL uses the source URL as a decryption key
- Calculates a CRC of its own decryption function as the rest of the key material
- Can’t be analyzed offline/out of context
- The obfuscated exploit is different depending on the source
Like Border Security, there are a lot of different approaches to the problem of keeping bad stuff out.
The Great Wall
The Great Wall of China
万里长城

The Great Wall of China is the longest building on earth with a length of 6,380 kilometers (3,965 miles), of which the main wall spans 2,100 km (1,300 mi). It consists of a system of several sections, sometimes not connected, that differ in age and construction method.

Construction of the Great Wall during Chinese history

The Great Wall – No Script

• Plug-in for Firefox allows white-listing by origin

• Benefits
  • Very effective when well used

• Drawbacks
  • Trusted sites can be compromised (go around the wall!)
  • Desensitizes after a while (like SSL popups)
  • Not suitable for an enterprise environment
  • Usability issues galore...
NoScript - NoThanks

- What do I allow? – Usually “All On Page”... A LOT
- My Whitelist is over 1300
- From v1.0 to the current (v1.9.8.8) 483 updates!!!
- How do we know what we are allowing???
Countermeasures should be transparent to the user...
Shamian Island

In 2005 a team from Microsoft developed a technique where script was wrapped in safety before entering the browser (e.g. eval() becomes \_\_safeEval())

**Benefits**
- Deployable as a Network or Host-based countermeasure
- Potential to disrupt malware within its execution environment (via segregation like the Island)

**Drawbacks**
- Broken pages, especially where reflection was involved
- Introduces latency
- Evade-able, and didn’t catch heap overflows
- Content-Length?

Shamian Island – BrowserShield
Customs

People's Republic of China
PASSPORT

中华人民共和国护照

Crossing the Border - JavaScript Exploits

OWASP
When dealing with obfuscated content, an IDS/IPS is much like a customs agent.

**Benefits**
- Deployable in existing Network/Host IDS/IPS
- Decent potential for true positives

**Drawbacks**
- Misses Ajax Low/Slow
- Potential for False Positives when script is obfuscated for Intellectual Property Protection or Compression
What can an IDS/IPS look for:

- Cleartext or mildly obfuscated malicious code
- Suspicious patterns of usage for functions like eval, unescape, document.write, and others...
  - for instance eval(unescape(...))
- Multiple occurrences of potentially evasive functions like String.fromCharCode()
- Potential escaped shellcode (presence of multiple escaped NOP sled)
- Density characteristics of the script code (lack of operators, spacing)
- Suspicious use of string concatenation
An automated browser (in a protected environment) patrolling for malicious sites that perform drive-by downloads

In 2007 Google did this and found that 10% of the Web is malicious

Capture-HPC automates browsers and multi-media applications looking for system impact

Benefits
- Identifies outwardly malicious sites

Drawbacks
- Identifies only drive-by
- Always behind
- Does not cover legitimate sites that have been compromised
- Does not cover authenticated or intranet content
Terrorist Watch List - Reputation Service

- Provides central reputation service for URLs
- Includes internet scans, adds additional knowledge like domain’s age, accessibility, location and recent activity

**Benefits**
- URL filtration can be deployed at the perimeter or host-based
- Up to the minute protection
- Global benefits (through outbreak correlation)
- Efficient

**Drawbacks**
- May not cover legitimate sites that have been compromised
- Does not cover authenticated or intranet content
Today’s Options

- NoScript
- BrowserShield
- IDS/IPS
- Internet Scanning
- Reputation Service

All have benefits, none sufficiently protect alone...
What's important is the INTENT...

For Border Security, that would mean seeing your thoughts...

For Inspecting Script that means pealing back the layers of obfuscation...

Through Interpretation
In the following example the attack is obfuscated in two ways. The escape function is used to encode special characters and the entire pattern is shifted by three character codes:

```javascript
var s =
"ydu%23v@qhz%23Dfwlyh%5BRemhfw+%25ZVfulsw1Vkh00%25%2C%3Eydu%
23i@qhz%23Dfwlyh%5BRemhfw+%25Vfulswlqj1IlohV%7CvwhpRemhfw%25
%2C%3Eydu%23z@v1H%7BsdqgHqylurqphqwVwulqjv+%25%28WHPS%28%2
5%2C%3Eydu%23r@iiRshqWh%7BwIlloh+111..."

var e = "";for (var i = 0; i < unescape(s).length; i++) {e += String.fromCharCode((unescape(s).charCodeAt(i)) - 3);}
eval(e);
```

In the resultant code the exploit is easy to detect:

```javascript
var s=new ActiveXObject("WScript.Shell");
var f=new ActiveXObject("Scripting.FileSystemObject");
var w=s.ExpandEnvironmentStrings("%TEMP%");
var o=f.OpenTextFile(...
```
We need to see that...
But How?

- Add JavaScript interpreter to the IDS/IPS or Network AV
  - Challenges:
    - Performance - Running at wire-speed
    - Simulating aspects of the DOM and Plug-ins
    - Not introducing vulnerabilities
- Hook the real JavaScript interpreter
  - Challenges:
    - Vulnerabilities in layers above us
    - Again... Not introducing NEW vulnerabilities!
- Interpret in a sandbox and make signatures out of the original obfuscated patterns
  - Challenges:
    - Requires a lot of processing
    - Either delays users or doesn’t protect the first user
    - Doesn’t protect against randomly generated exploits
Obfuscation techniques keep evolving...

As does the protection...

Best bet at staying safe?

- Always patch (Browser, OS, Plug-ins)
- Use a mixture of protection
- For risky surfing use a disposable VM!
Thanks

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References

- AES In JavaScript: http://www.movable-type.co.uk/scripts/aes.html
- Packer: http://dean.edwards.name/packer/
- JSMIn: http://www.crockford.com/javascript/jsmin.html
- Fortinet on arguments.callee: http://blog.fortinet.com/malicious-javascript-obfuscation-to-be-called-or-not-to-be
- Capture HPC: https://projects.honeynet.org/capture-hpc/wiki