SecureApplication Development

secappdev.org

Advanced XSS Defense

Eoin Keary & Jim Manico

Part 1: Basic XSS Defense

Jim Manico
OWASP Board Member
Independent Security Instructor

Eoin Keary
OWASP Board Member
CTO BCC Risk Advisory
www.bccriskadvisory.com

Where are we going?

Stop XSS!

- What is Cross Site Scripting (XSS)
- Reflective XSS
- Stored XSS
- Contextual Output Encoding
- HTML Sanitization
- Testing for XSS

What is XSS?

- Cross-site Scripting (XSS)
- Attacker driven JavaScript
  - Most common web vulnerability
  - Easy vulnerability to find via auditing
  - Easy vulnerability to exploit
  - Certain types of XSS are very complex to fix
  - Difficult to fix all XSS for a large app
  - Easy to re-introduce XSS in development
  - Significant business and technical impact potential

XSS Attack Payload Types

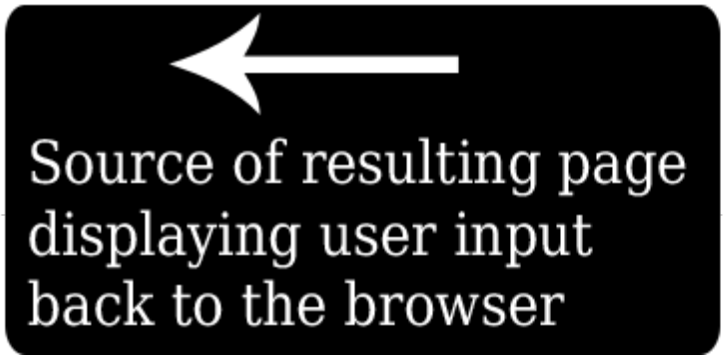
- Session hijacking
- Site defacement potential
- Network scanning
- Undermining CSRF defenses
- Site redirection/phishing
- Data theft
- Keystroke logging
- Loading of remotely hosted scripts

Input Example

Consider the following URL :

www.example.com/saveComment?comment=Great+Site!

```
6  <h3> Thank you for your comments! </h3>
7  You wrote:
8  <p/>
9  Great Site!
10 <p/>
```

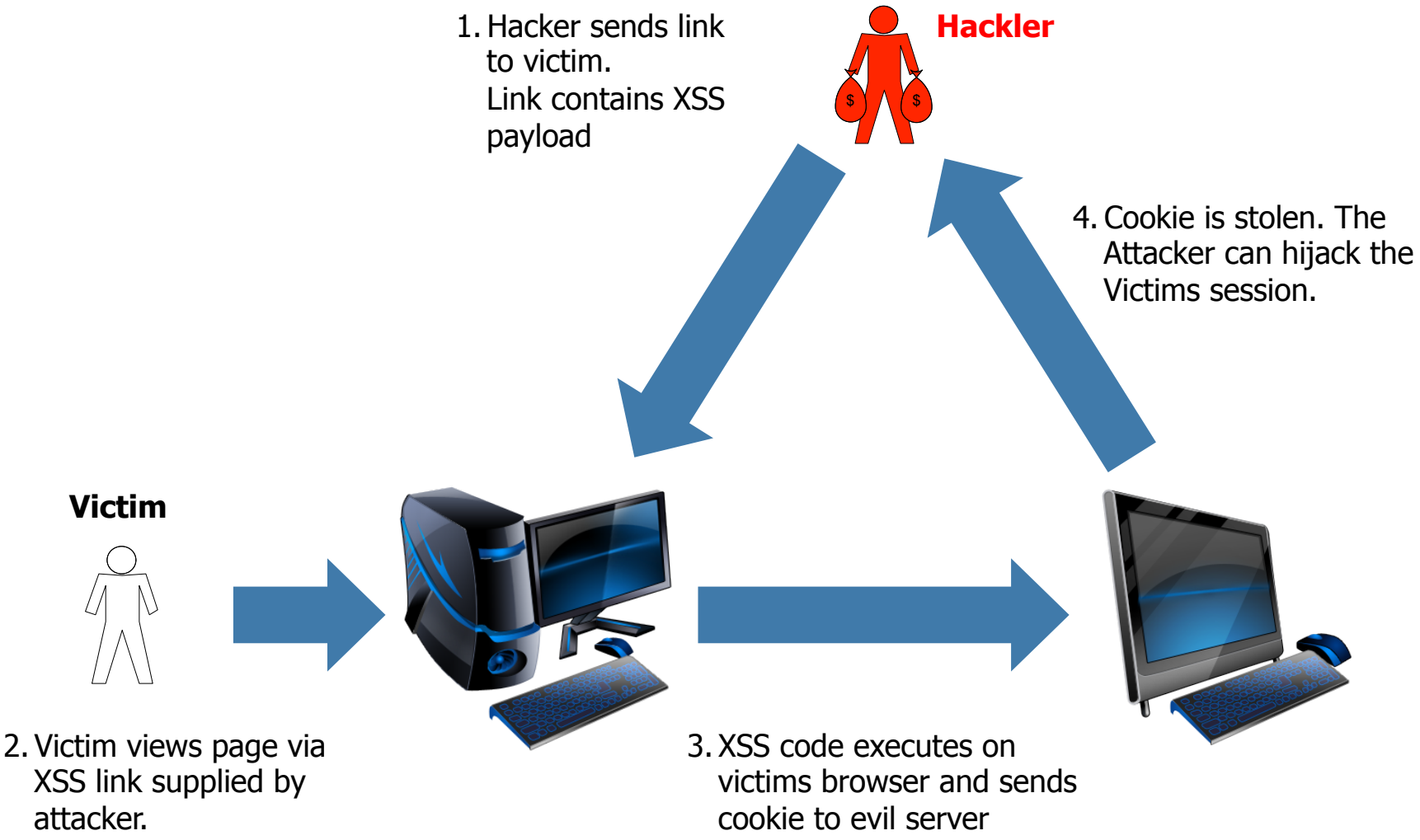


How can an attacker misuse this?

XSS Variants

Reflected/ Transient	■ Data provided by a client is immediately used by server-side scripts to generate a page of results for that user. ■ Search engines
Stored/ Persistent	■ Data provided by a client is first stored persistently on the server (e.g., in a database, filesystem), and later displayed to users ■ Bulletin Boards, Forums, Blog Comments
DOM based XSS	■ A page's client-side script itself accesses a URL request parameter and uses this information to dynamically write some HTML to its own page ■ DOM XSS is triggered when a victim interacts with a web page directly without causing the page to reload. ■ Difficult to test with scanners and proxy tools – why?

Reflected XSS



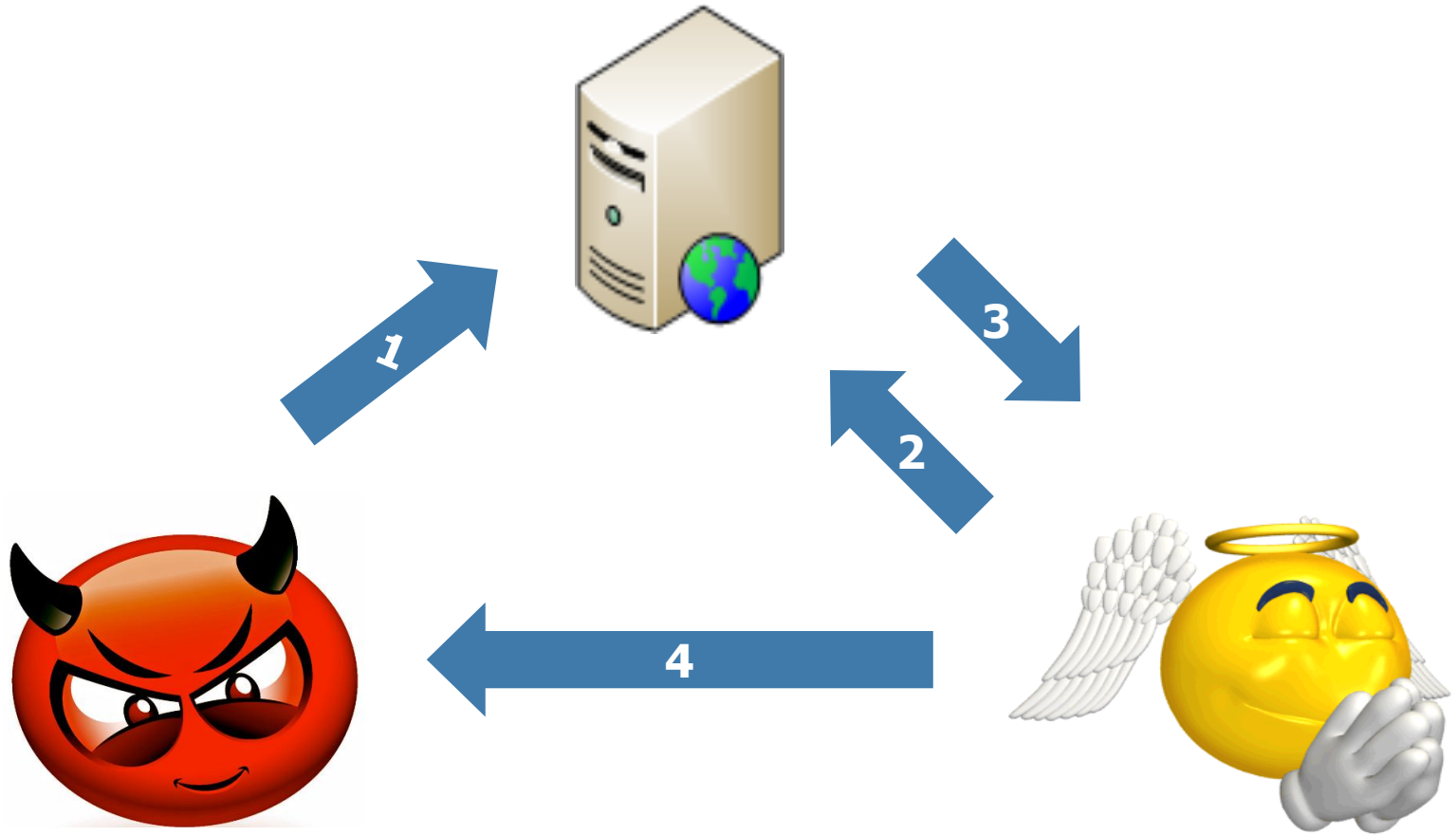
Reflected XSS Code Sample

```
//Search.aspx.cs
public partial class _Default : System.Web.UI.Page
{
    Label lblResults;
    protected void Page_Load(object sender, EventArgs e)
    {
            //... doSearch();
            this.lblResults.Text = "You Searched For " +
                    Request.QueryString["query"];
    }
```

OK: http://app.com/Search.aspx?query=soccer

NOT OK: http://app.com/Search.aspx?query=<script>...</script>

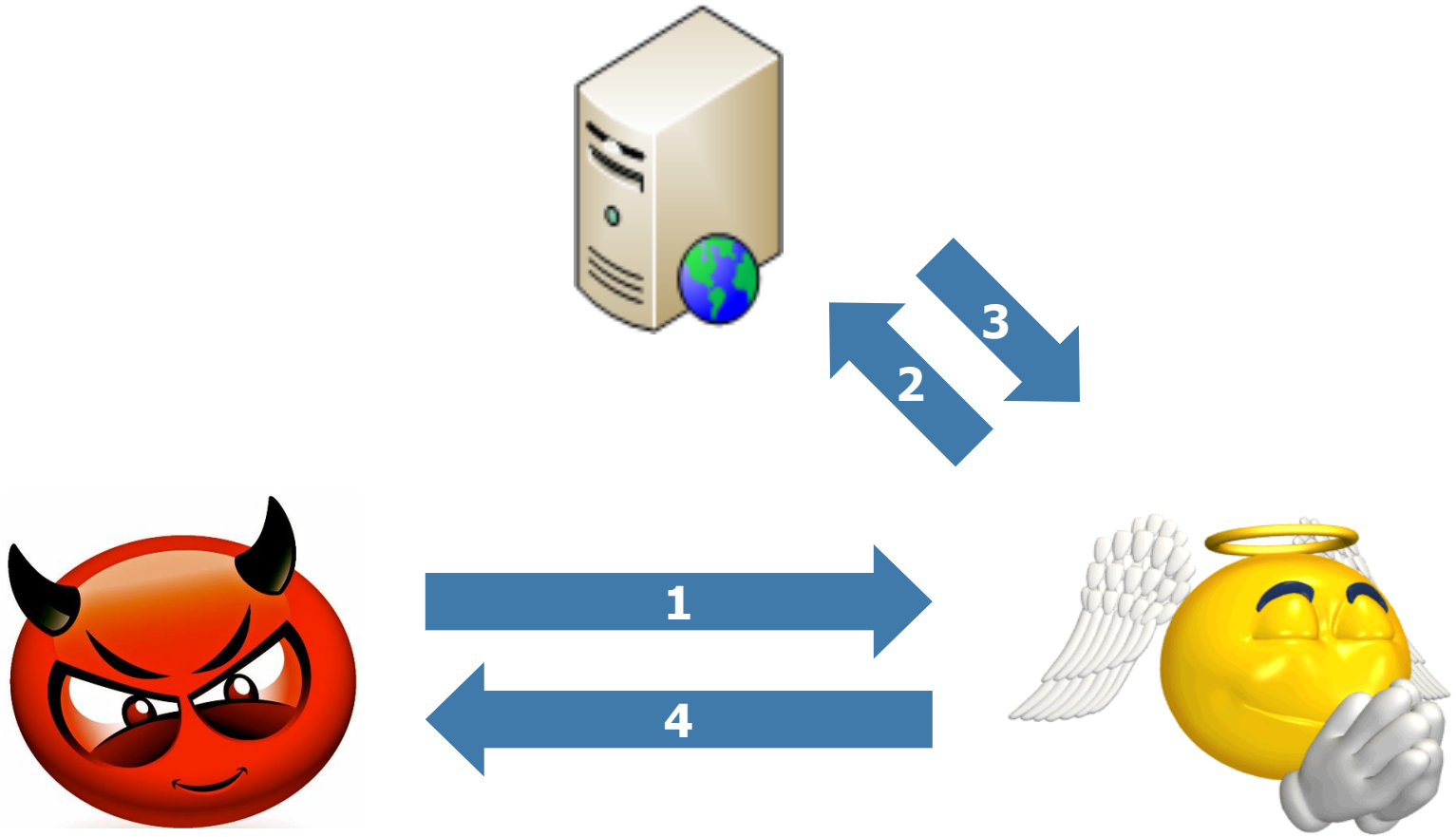
Persistent/Stored XSS



Persistent/Stored XSS Code Sample

```
<%
int id = Integer.parseInt(request.getParameter("id"));
String query = "select * from forum where id=" + id;
Statement stmt = conn.createStatement();
ResultSet rs = stmt.executeQuery(query);
if (rs != null) {
        rs.next ();
        String comment = rs.getString ("comment");
%>
User Comment : <%= comment %>
<%
}
%>
```

DOM-Based XSS



DOM-Based XSS

http://www.com/index.jsp#name=<script>alert(document.cookie)<script>

```
<HTML>
   <TITLE>Welcome!</TITLE>
   Hi
   <SCRIPT>
   var pos=document.URL.indexOf("name=")+5;

         document.write(document.URL.substring(pos,document.URL.length));
   </SCRIPT>
   <BR>
   Welcome to our system
</HTML>
```

OK : http://a.com/page.htm?name=Joe

NOT OK: http://a.com/page.htm?name=<script>...</script>

In DOM XSS the attack is NOT embedded in the HTML

Test for Cross-Site Scripting

- Make note of all pages that display input originating from current or other users
- Test by inserting malicious script or characters to see if they are ultimately displayed back to the user
- Examine code to ensure that application data is HTML encoded before being rendered to users
- Very easy to discover XSS via dynamic testing
- More difficult to discover via code review

Test for Cross-Site Scripting

- Remember the three common types of attacks:
  - Input parameters that are rendered directly back to the user
  - Server-Side
  - Client-Side
- Input that is rendered within other pages
- Hidden fields are commonly vulnerable to this exploit as there is a perception that hidden fields are read-only
- Error messages that redisplay user input

Test for Cross-Site Scripting

- Each input should be tested to see if data gets rendered back to the user.
  - Break out of another tag by inserting "> before the malicious script
  - Bypass **<script>** "tag-hunting" filters

```
<IMG SRC="javascript:alert(document.cookie)">
<p style="left:expression(eval('alert(document.cookie)'))">
\u003Cscript\u003E
```

- May not require tags if the input is inserted into an existing JavaScript routine **<- DOM XSS**

```
<SCRIPT> <% = userdata %> </SCRIPT>
```

Danger: XSS Weak Defense Used

- Getting rid of XSS is a difficult task
- How can we prevent XSS in our web application
  - Eliminate <, >, &, ", ' characters?
  - Eliminate all special characters?
  - Disallow user input? (not possible)
  - Global filter?
- Why won't these strategies work?

XSS Defense: The Solution?

Depends on the type of user input

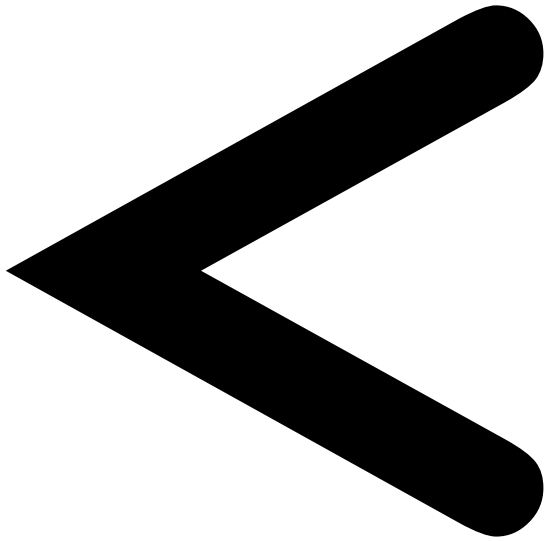
- HTML, Strings, Uploaded Files

Depends on **where** user input is displayed in an HTML document

- HTML Body
- HTML Attribute
- JavaScript Variable Assignment

Several defensive techniques needed depending on context

- Input Validation
- Output Encoding
- Sandboxing



<

HTML Entity Encoding: The Big 6

1.	&	&amp;
2.	<	<
3.	>	>
4.	"	"
5.	`	'
6.	/	/

Output Encoding Code Sample

```
StringBuffer buff = new StringBuffer();
if ( value == null ) {
      return null;
}
for(int i=0; i<value.length(); i++) {
                char ch = value.charAt(i);
                if ( ch == '&' ) {
                        buff.append("&amp;");
                } else if ( ch == '<') {
                        buff.append("&lt;");
                } else if ( ch == '>') {
                        buff.append("&gt;");
                } else if ( Character.isWhitespace(ch ) ) {
                        buff.append(ch);
                } else if ( Character.isLetterOrDigit(ch) ) {
                        buff.append(ch);
                } else if ( Integer.valueOf(ch).intValue() >= 20 &&
                                Integer.valueOf(ch).intValue() <= 126 ) {
                        buff.append( "&#" + (int)ch + ";" );
                }
}
return buff.toString();
```

Simple HTML encoding method for HTML context

Best Practice: Validate and Encode

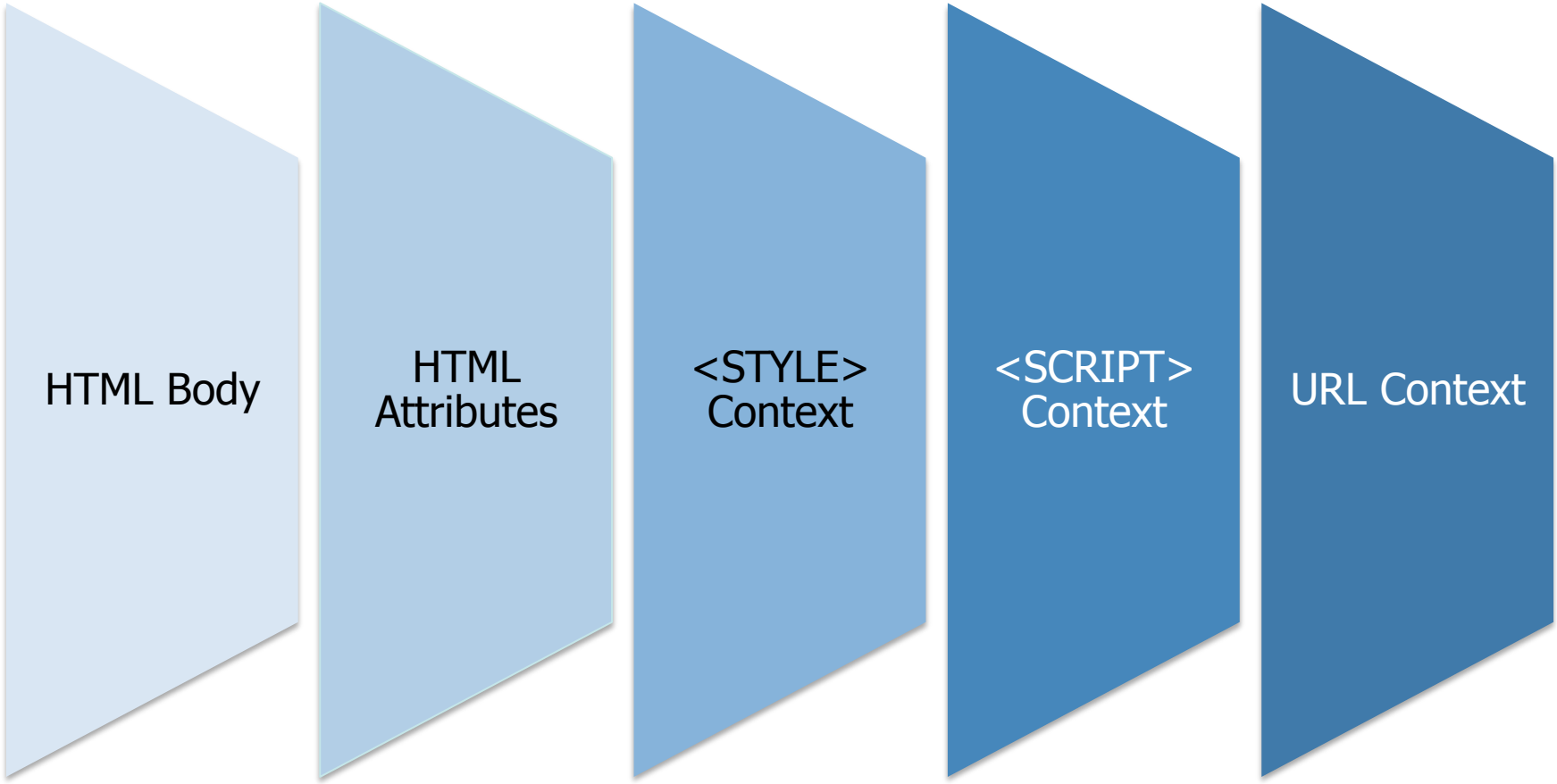
```
String email = request.getParameter("email");
out.println("Your email address is: " + email);
```

```
String email = request.getParameter("email");
String  expression =
"^\w+((-\w+)|(\.\w+))*\@[A-Za-z0-9]+((\.|-)[A-Za-z0-9]+)*\.[A-Za-z0-9]+$";

Pattern pattern = Pattern.compile(expression,Pattern.CASE_INSENSITIVE);
Matcher matcher = pattern.matcher(email);
if (macher.maches())
{
        out.println("Your email address is: " +  Encode.forHTML(email));
}
else
{
        //log & throw a specific validation exception and fail safely
}
```

Danger: Multiple Contexts

Different encoding and validation techniques needed for different contexts!



XSS Defense by Data Type and Context

Data Type	Context	Defense
String	HTML Body/Attribute	HTML Entity Encode/HTML Attribute Encoder
String	Java String	Java String Encoding
String	JavaScript Variable	JavaScript Hex Encoding
String	GET Parameter	URL Encoding
String	Untrusted URL	URL Validation, avoid javascript: URL's, Attribute encoding, safe URL verification
String	CSS Value	Strict structural validation, CSS Hex encoding, good design
HTML	HTML Body	HTML Validation (JSoup, AntiSamy, HTML Sanitizer)
Any	DOM	DOM XSS Cheat sheet
Untrusted JavaScript	Any	Sandboxing
JSON	Client parse time	JSON.parse() or json2.js

Safe HTML Attributes include: align, alink, alt, bgcolor, border, cellpadding, cellspacing, class, color, cols, colspan, coords, dir, face, height, hspace, ismap, lang, marginheight, marginwidth, multiple, nohref, noresize, noshade, nowrap, ref, rel, rev, rows, rowspan, scrolling, shape, span, summary, tabindex, title, usemap, valign, value, vlink, vspace, width

XSS Defense by Data Type and Context

Context	Encoding	Freemarker	OWASP Java Encoder
HTML Body	HTML Entity Encode	?html	Encoder.forHtmlContent
HTML Attribute	HTML Entity Encode		Encoder.forHtmlAttribute
Java String	Java String Encoding	?j_string	Encoder.forJava
JavaScript Variable	JavaScript Hex Encoding	?js_string	Encoder.forJavaScript Encoder.forJavaScriptBlock Encoder.forJavaScriptAttribute
GET Parameter	URL Encoding	?url	Encoder.forUriComponent
Untrusted URL	URL Validation, avoid javascript: URL's, attribute encoding, safe URL verification	?html	Encoder.forUri
CSS Value	Strict structural validation, CSS Hex encoding, good design	???	Encoder.forCssString Encoder.forCssUrl
HTML Body	HTML Validation (JSoup, AntiSamy, HTML Sanitizer)	???	OWASP HTML Sanitizer

OWASP Java Encoder Project

https://www.owasp.org/index.php/OWASP_Java_Encoder_Project

- No third party libraries or configuration necessary.
- This code was designed for high-availability/high-performance encoding functionality. Redesigned for performance.
- Simple drop-in encoding functionality
- More complete API (uri and uri component encoding, etc) in some regards.
- This is a Java 1.5 project.
- Last updated February 14, 2013 (version 1.1)

OWASP Java Encoder Project

https://www.owasp.org/index.php/OWASP_Java_Encoder_Project

The Problem

Web Page built in Java JSP is vulnerable to XSS

The Solution

```
<%-- Basic HTML Context --%>
<body><b><%= Encode.forHtml(UNTRUSTED) %>" /></b></body>

<%-- HTML Attribute Context --%>
<input type="text" name="data" value="<%= Encode.forHtmlAttribute(UNTRUSTED) %>" />

<%-- Javascript Block context --%>
<script type="text/javascript">
var msg = "<%= Encode.forJavaScriptBlock(UNTRUSTED) %>"; alert(msg);
</script>

<%-- Javascript Variable context --%>
<button onclick="alert('<%= Encode.forJavaScriptAttribute(UNTRUSTED) %>');">click me</
button>
```

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OWASP Java Encoder Project

https://www.owasp.org/index.php/OWASP_Java_Encoder_Project

HTML Contexts

Encode#forHtmlContent(String)
Encode#forHtmlAttribute(String)
Encode#forHtmlUnquotedAttribute(String)

XML Contexts

Encode#forXml(String)
Encode#forXmlContent(String)
Encode#forXmlAttribute(String)
Encode#forXmlComment(String)
Encode#forCDATA(String)

CSS Contexts

Encode#forCssString(String)
Encode#forCssUrl(String)

JavaScript Contexts

Encode#forJavaScript(String)
Encode#forJavaScriptAttribute(String)
Encode#forJavaScriptBlock(String)
Encode#forJavaScriptSource(String)

URI/URL contexts

Encode#forUri(String)
Encode#forUriComponent(String)

XSS in HTML Body

Reflective XSS attack example:

example.com/error?error_msg=You cannot access that file.

Untrusted data may land in a UI snippet like the following:

```
<div><%= request.getParameter("error_msg") %></div>
```

Sample test attack payload:

```
example.com/error?
error_msg=<script>alert(document.cookie)</script>
```

HTML Encoding stops XSS in this context!

HTML Body Escaping Examples

OWASP Java Encoder

```
<body><b><%= Encode.forHtml(UNTRUSTED) %>" /></b></body>

<p>Title: <%= Encode.forHtml(UNTRUSTED) %></p>

<textarea name="text">
<%= Encode.forHtmlContent(UNTRUSTED) %>
</textarea>
```

Freemarker

```
<textarea name="text">
${textValue?html}
</textarea>

<p>Title: ${book.title?html}</p>
```

XSS in HTML Attributes

- Where else can XSS go?
  - <input type="text" name="comments" value="">
- What could an attacker put in here?
  - <input type="text" name="comments"
    - value="hello" onmouseover="/*fire attack*/">
- Attackers can add event handlers:
  - onMouseOver
  - onLoad
  - onUnLoad
  - etc…

HTML Attribute Context

- Aggressive escaping is needed when placing untrusted data into typical attribute values like width, name, value, etc.
- This rule is NOT ok for complex attributes likes href, src, style, or any event handlers like onblur or onclick.
- Escape all non alpha-num characters with the &#xHH; format
- This rule is so aggressive because developers frequently leave attributes unquoted
-

HTML Attribute Escaping Examples

OWASP Java Encoder

```
<input type="text" name="data"
value="<%= Encode.forHtmlAttribute(UNTRUSTED) %>" />

<input type="text" name="data"
value=<%= Encode.forHtmlUnquotedAttribute(UNTRUSTED) %> />
```

Freemarker

```
<input type=text name="data" value="${user?xhtml}">
```

Freemarker requires that your attributes are double-quoted in order to be safe

URL Parameter Escaping

Escape **all** non alpha-num characters with the %HH format

<a href="/search?data=<%=DATA %>">

Be careful not to allow untrusted data to drive entire URL's or URL fragments

This encoding only protects you from XSS at the time of rendering the link

Treat DATA as untrusted after submitted

URL Parameter Escaping Examples

OWASP Java Encoder

```
<%-- Encode URL parameter values --%>
<a href="/search?value=<
%=Encode.forUriComponent(parameterValue)%>&order=1#top">

<%-- Encode REST URL parameters --%>
<a href="http://www.codemagi.com/page/<
%=Encode.forUriComponent(restUrlParameter)%>">
```

Freemarker

```
<a id="activate" href="action?token=${token?url}">Click
Here</a>
```

Handling Untrusted URL's

1) First validate to ensure the string is a valid URL
2) Avoid Javascript: URL's
3) Only allow HTTP or HTTPS only
4) Check the URL for malware inbound and outbound
5) Encode URL in the right context of display

```
<a href="UNTRUSTED URL">UNTRUSTED URL</a>
```

Escaping when managing complete URL's

Assuming the untrusted URL has been properly validated....

OWASP Java Encoder

```
<a href="<%= Encode.forHTMLAttribute(untrustedURL) %>">
Encode.forHtmlContext(untrustedURL)
</a>
```

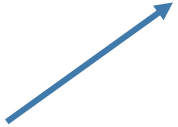
Freemarker

```
<a href="${untrustedURL?xhtml}">${untrustedURL?xhtml}</a>
```

XSS in JavaScript Context

http://example.com/viewPage?name=Jerry

```
627 <script>
628     //create variable for Jerry
629     var name = “Jerry”;
630 </script>
```



- What attacks would be possible?
- What would a %0d%0a in the name parameter do in the output?

JavaScript Escaping Examples

OWASP Java Encoder

```
<button
onclick="alert('<%= Encode.forJavaScript(alertMsg) %>');">click
me</button>

<button
onclick="alert('<%= Encode.forJavaScriptAttribute(alertMsg) %>');
">click me</button>

<script type="text/javascript”>
var msg = "<%= Encode.forJavaScriptBlock(alertMsg) %>";
alert(msg);
</script>
```

Freemarker

```
<button
onclick="alert('${message?js_string?xhtml}');">click me</button>
```

XSS in the Style Tag

Applications sometimes take user data and use it to generate presentation style

```
169 body {
170     font-size: 0.8em;
171     color: black;
172     font-family: Geneva, Verdana Arial, Helvetica, sans-serif;
173     background-color: white;
174     margin: 0;
175     padding: 0;
176 }
177
```

URL parameter written within style tag

Consider this example:

http://example.com/viewDocument?background=white

CSS Pwnage Test Case

<div style="width: <%=temp3%>;"> Mouse over

temp3 =
ESAPI.encoder().encodeForCSS("expression(alert(String.fromChar
Code (88,88,88)))");

<div style="width: expression\28 alert\28 String\2e
fromCharCode\20 \28 88\2c 88\2c 88\29 \29 \29 ;"> Mouse over

- Pops in at least **IE6** and **IE7**.

lists.owasp.org/pipermail/owasp-esapi/2009-February/000405.html

CSS Context: XSS Defense

Escape **all** non alpha-num characters with the \HH format

text</style>

Do not use any escaping shortcuts like \"

Strong positive structural validation is also required

If possible, design around this "feature"

- Use trusted CSS files that users can choose from
- Use client-side only CSS modification (font size)

XSS in CSS String Context Examples

OWASP Java Encoder

```
<div
style="background: url('<%=Encode.forCssUrl(value)%>');">

<style type="text/css">
background-color:'<%=Encode.forCssString(value)%>';
</style>
```

Freemarker

???

Other Encoding Libraries

- Ruby on Rails
  - http://api.rubyonrails.org/classes/ERB/Util.html
- Reform Project
  - Java, .NET v1/v2, PHP, Python, Perl, JavaScript, Classic ASP
  - https://www.owasp.org/index.php/Category:OWASP_Encoding_Project
- ESAPI
  - PHP.NET, Python, Classic ASP, Cold Fusion
  - https://www.owasp.org/index.php/Category:OWASP_Enterprise_Security_API
- .NET AntiXSS Library
  - http://wpl.codeplex.com/releases/view/80289

Dangerous Contexts

There are just certain places in HTML documents where you cannot place untrusted data

- Danger: <a $DATA>

There are just certain JavaScript functions that cannot safely handle untrusted data for input

- Danger: <script>eval($DATA);</script>

HTML Sanitization and XSS

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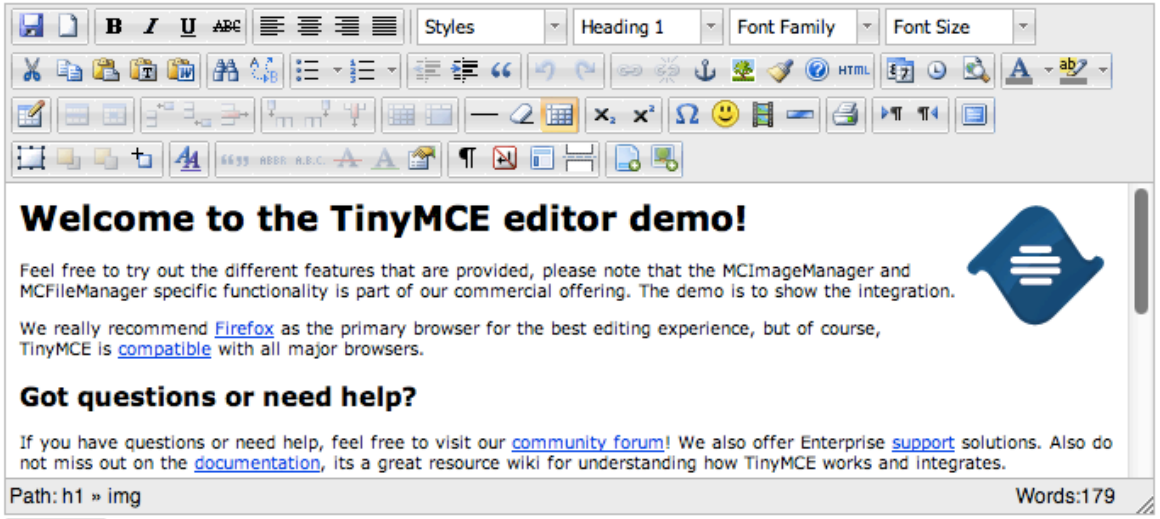
What is HTML Sanitization

- HTML sanitization takes markup as input, outputs "safe" markup
  - Different from *encoding*
  - URLEncoding, HTMLEncoding, will not help you here!
- HTML sanitization is everywhere
  - TinyMCE/CKEditor Widgets
  - Web forum posts w/markup
  - Javascript-based Windows 8 Store apps
  - Outlook.com
  - Advertisements

This example displays all plugins and buttons that comes with the TinyMCE package.



SUBMIT

Source output from post

Element	HTML
content	Welcome to the TinyMCE editor demo! Feel free to try out the different features that are provided, please note that the MCImageManager and MCFileManager specific functionality is part of our commercial offering. The demo is to show the integration. We really recommend Firefox as the primary browser for the best editing experience, but of course, TinyMCE is compatible with all major browsers. Got questions or need help? If you have questions or need help, feel free to visit our community forum! We also offer Enterprise support solutions. Also do not miss out on the documentation, its a great resource wiki for understanding how TinyMCE works and integrates. Found a bug? If you think you have found a bug, you can use the Tracker to report bugs to the developers. And here is a simple table for you to play with.

Why are HTML sanitization bugs important?

- Worst case scenario
  - Script running from a mail message executes within the security context of the mail application
  - …from the preview pane that appears automatically
  - Attacker could set up auto-forwarding, impersonate you, steal all your mail, etc.
- Yet, HTML sanitization bugs are pervasive
  - Fuzzing? Can be helpful, but difficult
  - Threat modeling? Not so relevant…
  - Smart hackers with some free time – very relevant

And the underlying platforms continue to change. All of them.

This is a hard problem.

The Many Bugs – Example #1

- Sanitizer Bypass in validator Node.js Module by @NealPoole (https://t.co/5omk5ec2UD)
  - Nesting

```
Input: <scrRedirecRedirect 302t 302ipt type="text/
javascript">prompt(1);</scrRedirecRedirect 302t 302ipt>

Output: <script type="text/javascript">prompt(1);</script>
```

Observation: Removing data from markup can create XSS where it didn't previously exist

The Many Bugs – Example #2

- CVE-2011-1252 / MS11-074
  - SharePoint / SafeHTML

```
Input:
<style>div{color:rgb(0,0,0)&a=expression(alert(1))}</style>

& → &amp;

Output:
<style>div{color:rgb(0,0,0)&amp;a=expression(alert(1))}</
style>
```

Observations:

- Sanitizer created a delimiter (the semi-colon)
- Legacy IE CSS expression syntax required to execute script
- Context mismatch
  - Sanitizer: "expression" is considered to be in a benign location
  - Browser: "expression" is considered to be the RHS of a CSS property set operation

The Many Bugs – Example #3

- CodeIgniter <= 2.1.1 xss_clean() sanitizer bug
  - (CVE-2012-1915)
  - Credit: Krzysztof Kotowicz (@kkotowicz)
    - Thx @NealPoole and @adam_baldwin!
  - Fake tag closure

```
Input and Output:

<img/src=">" onerror=alert(1)>

<button/a=">" autofocus onfocus=alert&#40;1&#40;></button>
```

Observations:

- No content modification required to trigger the vulnerability
- Sanitizer: “>” recognized as closing the IMG or BUTTON element
  - Allows script through, believing it to be in the raw HTML context
- Browser: “>” recognized as an attribute value
  - Browser executes onerror / onfocus event handlers

The Many Bugs – Example #4

- Wordpress 3.0.3 (kses.php)
  - Credit: Mauro Gentile (@sneak_)
    - Thx @superevr!
  - Lower case attribute name check

```
Input and Output:

<a HREF="javascript:alert(0)">click me</a>
```

Observations:

- No content modification required to trigger the vulnerability
- Sanitizer: Only lower case "href" recognized as an attribute name
- Browser: HREF attribute recognized, javascript: URL executes on click
- Sanitizer and browser don't agree on what constitutes an attribute name

HTML Santization Bugs: What's the lesson?

1. High level: Parsing / "context management" is hard

   Sanitizers must *exactly* emulate client-side parsing

   - An opportunity for a vulnerability any time the sanitizer and browser get out of sync
   - Sanitizer output must be safe for *all* useragents
     - If this is even possible!

What's the lesson? (cont.)

2. Parsing is the difficult part of sanitization

- The "business logic" is easy
  - Eg: What tags, attributes, CSS, etc. are considered acceptable
- Logically, the sanitizer was built to define this business logic
  - The sanitizer's value is not derived from being yet another HTML parser!
- All the bugs identified previously are parsing / "context management" related
- Thank you to to @randomdross for this info!

OWASP HTML Sanitizer Project

https://www.owasp.org/index.php/OWASP_Java_HTML_Sanitizer_Project

- HTML Sanitizer written in Java which lets you include HTML authored by third-parties in your web application while protecting against XSS.
- This code was written with security best practices in mind, has an extensive test suite, and has undergone adversarial security review https://code.google.com/p/owasp-java-html-sanitizer/wiki/AttackReviewGroundRules.
- Very easy to use.
- It allows for simple programmatic POSITIVE policy configuration. No XML config.
- Actively maintained by Mike Samuel from Google's AppSec team!
- This is code from the Caja project that was donated by Google. It is rather high performance and low memory utilization.

Solving Real World Problems with the OWASP HTML Sanitizer Project

The Problem

Web Page is vulnerable to XSS because of untrusted HTML

The Solution

```
PolicyFactory policy = new HtmlPolicyBuilder()
   .allowElements("p")
   .allowElements(
       new ElementPolicy() {
         public String apply(String elementName, List<String> attrs) {
           attrs.add("class");
           attrs.add("header-" + elementName);
           return "div";
         }
       }, "h1", "h2", "h3", "h4", "h5", "h6"))
   .build();
String safeHTML = policy.sanitize(untrustedHTML);
```

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Other HTML Sanitizers

- Pure JavaScript, client side HTML Sanitization with CAJA!
  - http://code.google.com/p/google-caja/wiki/JsHtmlSanitizer
  - https://code.google.com/p/google-caja/source/browse/trunk/src/com/google/caja/plugin/html-sanitizer.js
- Python
  - https://pypi.python.org/pypi/bleach
- PHP
  - ~~http://htmlpurifier.org/~~
  - http://www.bioinformatics.org/phplabware/internal_utilities/htmLawed/
- .NET
  - ~~AntiXSS.getSafeHTML/getSafeHTMLFragment~~
  - http://htmlagilitypack.codeplex.com/
- Ruby on Rails
  - https://rubygems.org/gems/loofah
  - http://api.rubyonrails.org/classes/HTML.html
- Java
  - https://www.owasp.org/index.php/OWASP_Java_HTML_Sanitizer_Project

Summary

Stop XSS!

- What is Cross Site Scripting (XSS)
- Reflective XSS
- Stored XSS
- Contextual Output Encoding
- HTML Sanitization
- Testing for XSS

Part 2 : Advanced XSS Defense

Advanced XSS	JavaScript and iFrame sandboxing
	Content Security Policy
	Avoid dangerous JavaScript API's
	Object sealing
	Handle JSON safely
	HTTP Only Cookies

XSS Defense by Data Type and Context

Data Type	Context	Defense
String	HTML Body/ Attribute	HTML Entity Encode
String	JavaScript Variable	JavaScript Hex encoding
String	GET Parameter	URL Encoding
String	Untrusted URL	URL Validation, avoid javascript: URL's, Attribute encoding, safe URL verification
String	CSS	Strict structural validation, CSS Hex encoding, good design
HTML	HTML Body	HTML Validation (JSoup, AntiSamy, HTML Sanitizer)
Any	DOM	DOM XSS Cheat sheet
Untrusted JavaScript	Any	Sandboxing
JSON	Client parse time	JSON.parse() or json2.js

Safe HTML Attributes include: align, alink, alt, bgcolor, border, cellpadding, cellspacing, class, color, cols, colspan, coords, dir, face, height, hspace, ismap, lang, marginheight, marginwidth, multiple, nohref, noresize, noshade, nowrap, ref, rel, rev, rows, rowspan, scrolling, shape, span, summary, tabindex, title, usemap, valign, value, vlink, vspace, width

DOM Based XSS Defense

DOM Based XSS is a complex risk

Suppose that x landed in …
<script>setInterval(x, 2000);</script>

For some Javascript functions, even JavaScript that is properly encoded will still execute!

Dangerous JavaScript Sinks

Direct execution	■ eval() ■ window.execScript()/function()/setInterval()/setTimeout(), requestAnimationFrame() ■ script.src(), iframe.src()
Build HTML/ JavaScript	■ document.write(), document.writeln() ■ elem.innerHTML = danger, elem.outerHTML = danger ■ elem.setAttribute("dangerous attribute", danger) – attributes like: href, src, onclick, onload, onblur, etc.
Within execution context	■ onclick() ■ onload() ■ onblur(), etc

Source: https://www.owasp.org/index.php/DOM_based_XSS_Prevention_Cheat_Sheet

Some Safe JavaScript Sinks

Setting a value	■ elem.innerText(danger) ■ formfield.val(danger)
Safe JSON parsing	■ JSON.parse() (rather than eval())

Dangerous jQuery!

- jQuery will evaluate <script> tags and execute script in a variety of API's

```
$('#myDiv').html('<script>alert("Hi!");</script>');
$('#myDiv').before('<script>alert("Hi!");</script>');
$('#myDiv').after('<script>alert("Hi!");</script>');
$('#myDiv').append('<script>alert("Hi!");</script>');
$('#myDiv').prepend('<script>alert("Hi!");</script>');
$('<script>alert("Hi!");</script>').appendTo('#myDiv');
$('<script>alert("Hi!");</script>').prependTo('#myDiv');
```

http://tech.blog.box.com/2013/08/securing-jquery-against-unintended-xss/

jQuery API's and XSS

Dangerous jQuery 1.7.2 Data Types	
CSS	Some Attribute Settings
HTML	URL (Potential Redirect)

jQuery methods that directly update DOM or can execute JavaScript	
$() or jQuery()	.attr()
.add()	.css()
.after()	.html()
.animate()	.insertAfter()
.append()	.insertBefore()
.appendTo()	Note: .text() updates DOM, but is safe.

jQuery methods that accept URLs to potentially unsafe content	
jQuery.ajax()	jQuery.post()
jQuery.get()	load()
jQuery.getScript()	

Don't send untrusted data to these methods, or properly escape the data before doing so

jQuery – But there's more…

More danger

- jQuery(danger) or $(danger)
  - This immediately evaluates the input!!
  - E.g., $("<img src=x onerror=alert(1)>")
- jQuery.globalEval()
- All event handlers: .bind(events), .bind(type, [,data], handler()), .on(), .add(html)

Same safe examples

- .text(danger), .val(danger)

Some serious research needs to be done to identify all the safe vs. unsafe methods

- There are about 300 methods in jQuery

Source: http://code.google.com/p/domxsswiki/wiki/jQuery

Client Side Context Sensitive Output Escaping

Context	Escaping Scheme	Example
HTML Element	(&, <, >, ") → &entity; (', /) → &#xHH;	$ESAPI.encoder(). encodeForHTML()
HTML Attribute	All non-alphanumeric < 256 → &#xHH	$ESAPI.encoder(). encodeForHTMLAttribute()
JavaScript	All non-alphanumeric < 256 → \xHH	$ESAPI.encoder(). encodeForJavaScript()
HTML Style	All non-alphanumeric < 256 → \HH	$ESAPI.encoder(). encodeForCSS()
URI Attribute	All non-alphanumeric < 256 → %HH	$ESAPI.encoder(). encodeForURL()

Encoding methods built into a jquery-encoder:
https://github.com/chrisisbeef/jquery-encoder

JQuery Encoding with JQencoder

Contextual encoding is a crucial technique needed to stop all types of XSS

jqencoder is a jQuery plugin that allows developers to do contextual encoding in JavaScript to stop DOM-based XSS

- http://plugins.jquery.com/plugin-tags/security
- $('#element').encode('html', UNTRUSTED-DATA);

"Secure" DOM XSS/AJAX Workflow

Initial loaded page should only be static content

Load JSON data via AJAX or via embedded JSON safely per

https://www.owasp.org/index.php/XSS_(Cross_Site_Scripting)_Prevention_Cheat_Sheet#JSON_entity_encoding

Only use the following methods to populate the DOM

- Node.textContent
- document.createTextNode
- Element.setAttribute

Caution: Element.setAttribute is one of the most dangerous JS methods

Caution: If the first element to setAttribute is any of the JavaScript event handlers or a URL context based attribute ("src", "href", "backgroundImage", "background", etc.) then XSS will pop

Best Practice: DOM Based XSS Defense I

- Untrusted data should only be treated as displayable text
- JavaScript encode and delimit untrusted data as quoted strings
- Use document.createElement("…"), element.setAttribute("…","value"), element.appendChild(…), etc. to build dynamic interfaces
- Avoid use of HTML rendering methods
- Make sure that any untrusted data passed to eval() methods is delimited with string delimiters and enclosed within a closure or JavaScript encoded to N-levels based on usage and wrapped in a custom function

Best Practice: DOM Based XSS Defense II

Limit the usage of dynamic untrusted data to right side operations. And be aware of data which may be passed to the application which look like code (eg. location, eval()).

Limit access to properties objects when using object[x] access functions

Sanitize JSON Server-side on input and output. Use JSON.toJSON() and JSON.parse() to parse JSON in the browser safely.

Run untrusted script in a sandbox (ECMAScript object sealing, HTML 5 frame sandbox, etc)

Should you trust all JSON?

```
"user":
   {
      "name": "Jameson",
      "occupation": "Distiller",
      "location": (function() { alert("XSS 1!"); return "somewhere"})(),
      "_location_comment": "Once parsed unsafely, the location XSS will run automatically, as a self-executing function. JSON.parse can help with this, and jQuery's $.parseJSON uses it by default (as do $.ajax, etc)",
      "bio": "<script type='text/javascript'>alert('XSS!');</script>",
      "_bio_comment": "This XSS will execute once it is added to the DOM, if not properly escaped  before adding it. This is more of a persistent kind of XSS attack."
   }
```

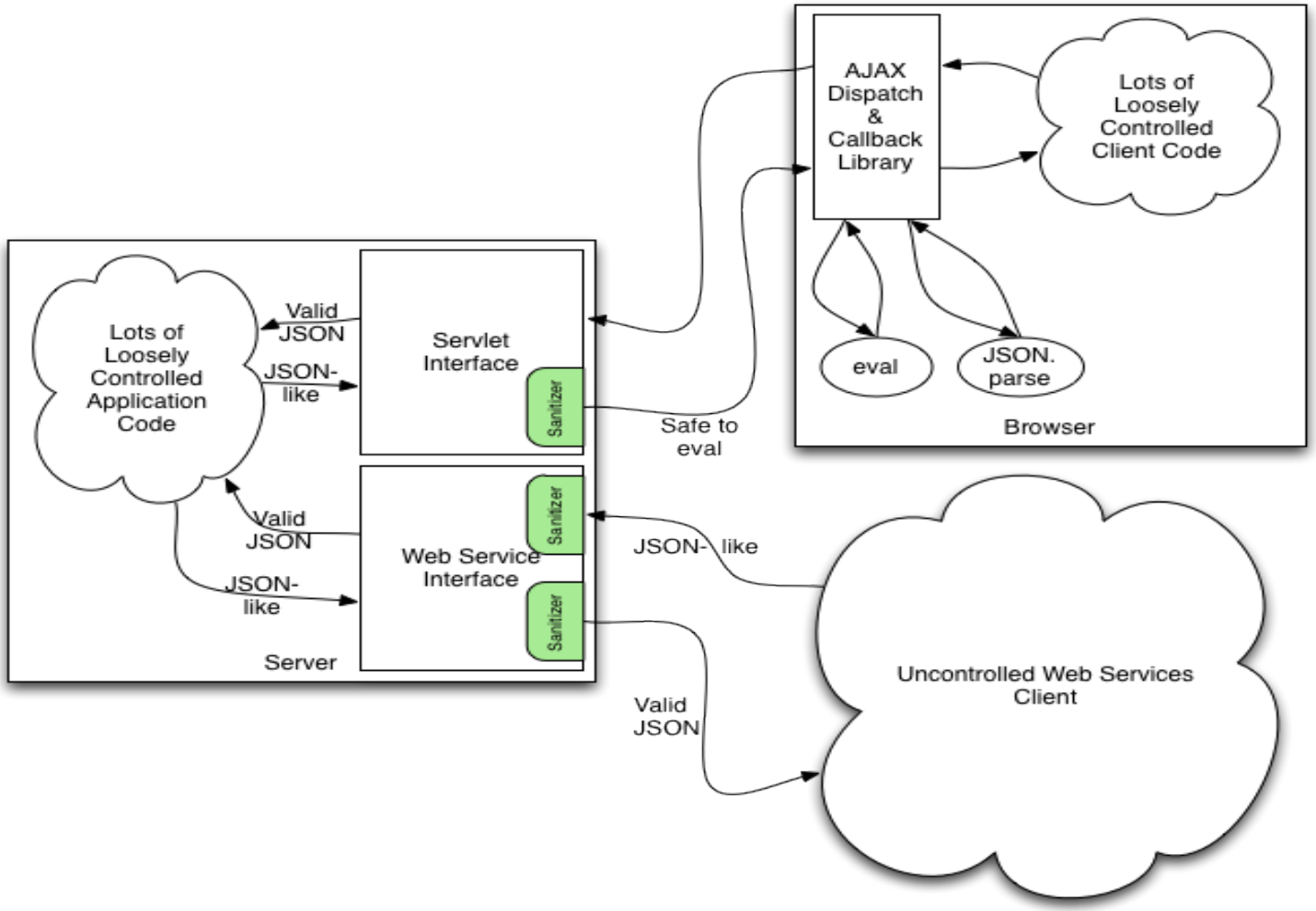
OWASP JSON Sanitizer Project

https://www.owasp.org/index.php/OWASP_JSON_Sanitizer

- Given JSON-like content, converts it to valid JSON.
- This can be attached at either end of a data-pipeline to help satisfy Postel's principle: *Be conservative in what you do, be liberal in what you accept from others.*
- Applied to JSON-like content from others, it will produce well-formed JSON that should satisfy any parser you use.
- Applied to your output before you send, it will coerce minor mistakes in encoding and make it easier to embed your JSON in HTML and XML.

OWASP JSON Sanitizer Project

https://www.owasp.org/index.php/OWASP_JSON_Sanitizer



Eoin Keary & Jim Manico

Server Side JSON Sanitization

The Problem

Web Page is vulnerable to XSS because of parsing of untrusted JSON incorrectly

The Solution

JSON Sanitizer can help with two use cases.

1) **Sanitizing untrusted JSON on the server that is submitted from the browser** in standard AJAX communication

2) Sanitizing potentially untrusted JSON server-side before sending it to the browser. The output is a valid Javascript expression, so can be parsed by Javascript's eval or by JSON.parse.

Best Practice: Sandboxing

JavaScript Sandboxing (ECMAScript 5)

- Object.seal(obj)
- Object.isSealed(obj)
- Sealing an object prevents other code from deleting, or changing the descriptors of, any of the object's properties

iFrame Sandboxing (HTML5)

- <iframe src="demo_iframe_sandbox.jsp" sandbox=""></iframe>
- Allow-same-origin, allow-top-navigation, allow-forms, allow-scripts

Best Practice: Content Security Policy

Anti-XSS W3C standard

CSP 1.1 Draft 19 published August 2012

- https://dvcs.w3.org/hg/content-security-policy/raw-file/tip/csp-specification.dev.html

Must move all inline script and style into external scripts

Add the X-Content-Security-Policy response header to instruct the browser that CSP is in use

- Firefox/IE10PR: X-Content-Security-Policy
- Chrome Experimental: X-WebKit-CSP
- Content-Security-Policy-Report-Only

Define a policy for the site regarding loading of content

Best Practice: Content Security Policy

Externalize all Java-Script within web pages	■ No inline script tag ■ No inline JavaScript for onclick or other handling events ■ Push all JavaScript to formal .js files using event binding
Define Content Security Policy	■ Developers define which scripts are valid ■ Browser will only execute supported scripts ■ Inline JavaScript code is ignored

Best Practice: Content Security Policy

X-Content-Security-Policy

Application uses	■ Content-Security-Policy header
Externalize all Java-Script within web pages	■ No inline script tag ■ No inline JavaScript for onclick or other handling events ■ Push all JavaScript to formal .js files using event binding
Define Content Security Policy	■ Developers define which scripts are valid ■ Browser will only execute supported scripts ■ Inline JavaScript code is ignored

Content Security Policy Directives

- Script-src: allowed script sources
- Object-src: allowed object sources
- Img-src: allowed image sources (html, css)
- Media-src: allowed media sources
- Style-src: allowed CSS sources
- Frame-src: allowed sources for child frames
- Font-src: allowed font sources (CSS)
- Connect-src: allowed remote destinations
- Default-src: allowed sources for any

Content Security Policy by Example 1

Source:
http://people.mozilla.com/~bsterne/content-security-policy/details.html

Site allows images from anywhere, plugin content from a list of trusted media providers, and scripts only from its server:

X-Content-Security-Policy: allow 'self'; img-src *; object-src media1.com media2.com; script-src scripts.example.com

Content Security Policy by Example 2

Source: http://www.html5rocks.com/en/tutorials/security/content-security-policy/

Site that loads resources from a content delivery network and does not need framed content or any plugins

X-Content-Security-Policy: default-src https://cdn.example.net; frame-src 'none'; object-src 'none'

Best Practice: X-Xss-Protection

- Use the browser's built in XSS Auditor

- X-Xss-Protection:
  - [0-1] (mode=block)
- X-Xss-Protection:
  - 1; mode=block

XSS Defense with no Encoding!

- Advanced XSS-resistant JavaScript-centric web architecture

1) Deliver main HTML document with static data only in the HTML and embedded JSON
2) Parse JSON and populate the static HTML with safe JavaScript API's
3) Safe JavaScript API's include:
    1) Node.textContent
    2) document.createTextNode
    3) Element.setAttribute (second parameter only)

4) This is not failsafe, you can still do stupid things like:
    1) // The textContent of a <script> element is active content.
    2) var scriptElement = document.createElement('script');
    3) scriptElement.textContent = userData.firstName; // XSS!
    4) document.body.appendChild(scriptElement);

5) Adam Barth was right!
    1) http://www.educatedguesswork.org/2011/08/guest_post_adam_barth_on_three.html

Summary

Advanced XSS	JavaScript and iFrame sandboxing
	Content Security Policy
	Avoid dangerous JavaScript API's
	Object sealing
	Handle JSON safely
	HTTPOnly Cookies

<script>alert('THANK YOU!');</script>

@manicode
jim@owasp.org
jim@manico.net

http://slideshare.net/jimmanico