Recent Web Security Technology

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About myself: Lieven Desmet

- Research manager at KU Leuven
  - (Web) Application Security

- Active participation in OWASP
  - Board member of the OWASP Belgium Chapter
  - Co-organizer of the OWASP AppSec EU Conferences

- Program director at SecAppDev
iMinds-DistriNet, KU Leuven

- **Headcount:**
  - 10 professors
  - 65 researchers

- **Research Domains**
  - Secure Software
  - Distributed Software

- **Academic and industrial collaboration in 30+ national and European projects**

https://distrinet.cs.kuleuven.be
Covers the landscape of client-side Web security
- State-of-the-art in web security
- State-of-practice on the Web
- Recent research and standardization activities
- Security best practices per category
Recent Web Security Technology

Server-side security policies, enforced by the browser
Focus on vulnerabilities and logical flaws in the code, and server-side mitigations

This talk focuses on infrastructural support as a complementary line of defense
Recent security technology on the web

Web Browser → HTTP Request → HTTP Response → Web Server

Policy enforcement in the browser

Security Policy
Overview

- Introduction
- #1 Securing browser-server communication
- #2 Mitigating script injection attacks
- #3 Framing content securely
- Example security architecture: Combining CSP & Sandbox
- Wrap-up
Recap: Web’s Security Model

- Basic security policy for the web:
  - Same-Origin Policy

- What does it mean for scripts running on your page?

- What does it mean for frames included in your page?
Two basic composition techniques

Script inclusion

```html
<html><body>
 ...
 <script src="http://3rdparty.com/script.js"></script>
 ...
</body></html>
```

Iframe integration

```html
<html><body>
 ...
 <iframe src="http://3rdparty.com/frame.html"></iframe>
 ...
</body></html>
```
State of practice metrics

- Assessment of the most popular European Union websites
  - Top 1,000,000 websites from Alexa raking
  - Filter top 1,000 websites of 28 member states
  - Result: 23,050 European websites
Longitudinal study

- Crawl up to 200 pages per website
  - Use a headless browser (PhantomJS)
  - Capture all data and headers sent by server

- Compare two datasets:
  - September 2013
  - September 2015

<table>
<thead>
<tr>
<th>Time</th>
<th># of websites</th>
<th># of webpages</th>
<th>avg. # of pages/site</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 2013</td>
<td>20,147</td>
<td>3,499,080</td>
<td>174</td>
</tr>
<tr>
<td>September 2015</td>
<td>18,074</td>
<td>2,992,395</td>
<td>166</td>
</tr>
</tbody>
</table>

Notice: we removed the websites with less than 50 successfully crawled pages from our dataset.
#1 Securing browser-server communication
Overview

- **Attacks:**
  - Session hijacking
  - SSL Stripping

- **Countermeasures:**
  - Use of SSL/TLS
  - Secure flag for session cookies
  - HSTS header
  - Public Key Pinning
Network attacks: Session hijacking

Web Browser

Web Server

HTTP Request

HTTP Response

Cookie: PREF=ID=766awg-VZ

HTTP Request

HTTP Response

Cookie: PREF=ID=766awg-VZ
HTTPS to the rescue...

Web Browser

HTTP Request

HTTP Response

Web Server
HTTPS: State of practice

Usage in 2015

- 85% (Red)
- 15% (Green)
Availability of TLS (and SNI)

An extension to the TLS computer networking protocol by which a client indicates which hostname it is attempting to connect to at the start of the handshaking process.

<table>
<thead>
<tr>
<th>Server Name Indication</th>
<th>Other</th>
</tr>
</thead>
</table>

### Current View

<table>
<thead>
<tr>
<th>Browser</th>
<th>Aligned</th>
<th>Usage Issues</th>
<th>Show All</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firefox</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrome</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safari</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opera</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iOS Safari</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opera Mini</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Android Browser</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrome for Android</td>
<td>19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes

1. Only supported on Windows Vista or above (not Windows XP

Resources (2)

Feedback
Problem cured?

- **TLS usage statistics (for popular websites!):**
  - 67.5% of the websites don’t use TLS at all
  - Only 6.5% of the websites are using TLS for at least half of their pages

- **Remaining problems:**
  - Mixed use of HTTPS/HTTP and session cookies
  - Mixed content websites
  - SSL Stripping attacks
Mixed use of HTTPS/HTTP

- Cookies are bound to domains, not origins
- By default, cookies are sent both over HTTPS and HTTP
- Any request to your domain over HTTP leaks the (session) cookies...
Secure flag for cookies

- Issued at cookie creation (HTTP response)
  - Set-Cookie: PREF=766awg-VZ; Domain=yourdomain.com; Secure

- If set, the cookie is only sent over an encrypted channel

- Should be enabled by default for your session cookies!
Secure cookies: State of practice

Usage in 2015

- 85% usage in 2015
- 15% usage in 2013

Percentage of websites
Mixed content inclusions: TLS-enabled sites under attack

Source: Ping Chen et. al. A Dangerous Mix: Large-scale analysis of mixed-content websites. ISC 2013
Mixed content inclusions:
Large scale assessment of the state-of-practice

- Alexa Top 100,000 domains
- Crawled over 480,000 pages belonging to the Alexa top 100,000
- Discovered:
  - 18,526 TLS-protected sites
  - 7,980 sites have mixed content (43% of the sites)
  - 150,179 scripts are included over HTTP (26% of the sites)

Source: Ping Chen et. al. A Dangerous Mix: Large-scale analysis of mixed-content websites. ISC 2013
Distribution of mixed-JavaScript sites across the top Alexa Top 100,000

Source: Ping Chen et. al. A Dangerous Mix: Large-scale analysis of mixed-content websites. ISC 2013
Distribution of mixed-JavaScript sites across Top 10 site categories (McAfee’s web database)

Alexa Top 100,000 domains, grouped by McAfee’s site categories

Source: Ping Chen et. al. A Dangerous Mix: Large-scale analysis of mixed-content websites. ISC 2013
Browsers are more and more blocking mixed-content

- Mobile browsers were lagging behind

- Safari 9 and Android 5.x block mixed content

Source: Qualys, February 2014
HTTP to HTTPS bootstrapping

HTTP Request

Redirect to HTTPS

HTTP Response

HTTPS Request

HTTPS Response
HTTP to HTTPS bootstrapping

- HTTP 301/302 response
  - Location header redirects browser to the resource over HTTPS
  - Location: https://mysite.com/

- Meta refresh
  - Meta-tag in HEAD of HTML page
  - `<meta http-equiv="refresh" content="0;URL='https://mysite.com/'">`

- Via JavaScript
  - `document.location = "https://mysite.com"`
Network attacks: SSL Stripping

Web Browser

HTTP Request
HTTP Response

HTTP Request
HTTP Response

HTTP Request
HTTP Response

HTTP Request
Redirect to HTTPS

HTTPS Request
HTTPS Response

Web Server

Moxie Marlinspike, BlackHat DC 2009
Strict Transport Security (HSTS)

- Issued by the HTTP response header
  - Strict-Transport-Security: max-age=60000

- If set, the browser is instructed to visit this domain only via HTTPS
  - No HTTP traffic to this domain will leave the browser

- Optionally, also protect all subdomains
  - Strict-Transport-Security: max-age=60000; includeSubDomains

- HSTS Browser Preloading:
  - https://hstspreload.appspot.com/
HSTS: State of practice

Usage in 2015

Percentage of pages on a website having Strict-Transport-Security

- 2013: 15%
- 2015: 85%
HSTS: availability in browsers

<table>
<thead>
<tr>
<th>Browser</th>
<th>IE 8</th>
<th>IE 9</th>
<th>Edge</th>
<th>Firefox</th>
<th>Chrome</th>
<th>Safari</th>
<th>Opera</th>
<th>iOS Safari</th>
<th>Opera Mini</th>
<th>Android Browser</th>
<th>Chrome for Android</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>93.45%</td>
<td>93.45%</td>
<td>93.45%</td>
<td>93.45%</td>
<td>93.45%</td>
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</tr>
<tr>
<td>Global</td>
<td>79.14%</td>
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<td>79.14%</td>
<td>79.14%</td>
</tr>
</tbody>
</table>

Notes: Known issues (0) Resources (6) Feedback

The HTTP header is ‘Strict-Transport-Security’.
IE 11 added support in an update on June 9, 2015.
But can I trust the CAs?

- **Comodo (March 2011)**
  - 9 fraudulent SSL certificates

- **Diginotar (July 2011)**
  - Wildcard certificates for Google, Yahoo!, Mozilla, WordPress, …

- Breaches at **StartSSL (June 2011)** and **GlobalSign (Sept 2012)** reported unsuccessful

- …
Public Key Pinning (HPKP)

- Issued as HTTP response header
  
  ```
  Public-Key-Pins: max-age=2592000;
  pin-sha256="E9CZ9INDbd+2eRQozYqqbQ2yXLVKB9+xcprMF+44U1g=";
  pin-sha256="LPJNul+wow4m6DsqxbninhsWHlwfp0JecwQzYpOLmCQ=";
  report-uri="http://example.com/pkp-report"
  ```

- Freezes the certificate by pushing a fingerprint of (parts of) the certificate chain to the browser
- Options: max-age, includeSubdomains, report-uri
Public Key Pinning

Declare that a website's HTTPS certificate should only be treated as valid if the public key is contained in a specified list to prevent MITM attacks that use valid CA-issued certificates.

<table>
<thead>
<tr>
<th>Current Version</th>
<th>Usage relative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IE</strong></td>
<td></td>
</tr>
<tr>
<td>8</td>
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<td>10</td>
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<td>11</td>
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<tr>
<td><strong>Firefox</strong></td>
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<td>12</td>
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<tr>
<td>13</td>
<td></td>
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<tr>
<td><strong>Chrome</strong></td>
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<td>43</td>
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<td>44</td>
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<td>45</td>
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<tr>
<td><strong>Safari</strong></td>
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<td>47</td>
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<td>48</td>
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<tr>
<td>49</td>
<td></td>
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<tr>
<td><strong>Opera</strong></td>
<td></td>
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<td>8</td>
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<td>9</td>
<td></td>
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<tr>
<td>34</td>
<td></td>
</tr>
<tr>
<td><strong>iOS Safari</strong></td>
<td></td>
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<tr>
<td>7.1</td>
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<tr>
<td>8.4</td>
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<tr>
<td><strong>Opera Mini</strong></td>
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<tr>
<td>8</td>
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<tr>
<td>34</td>
<td></td>
</tr>
<tr>
<td><strong>Android Browser</strong></td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td><strong>Chrome for Android</strong></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Known issues (0), Resources (3), Feedback

The HTTP header syntax is 'Public-Key-Pins: pin-sha256="base64=="; max-age=expireTime [; includeSubdomains]; report-uri="reportURI"';

MS Edge status: Under Consideration
Recap: Securing browser-server communication

- **Use of TLS**
  - be aware of mixed-content inclusions!

- **Secure flag for cookies**
  - to protect cookies against leaking over HTTP

- **HSTS header**
  - to force TLS for all future connections

- **Public Key Pinning**
  - to protect against fraudulent certificates
Secure Communication Score (1)
Secure Communication Score (2)
#2 Mitigating script injection attacks
Overview

- Attack:
  - Cross-Site Scripting (XSS)

- Countermeasures:
  - HttpOnly flag for session cookies
  - X-Content-Type-Options header
  - Content Security Policy (CSP)
  - Subresource Integrity header
Example: Stored or persistent XSS

HTTP request injecting a script into the persistent storage of the vulnerable server

Regular http request

Http response containing script as part of executable content
HttpOnly flag for cookies

- Issued at cookie creation (HTTP response)
  - Set-Cookie: PREF=766awg-VZ; Domain=yourdomain.com; Secure; HttpOnly

- If set, the cookie is not accessible via DOM
  - JavaScript can not read or write this cookie

- Mitigates XSS impact on session cookies
  - Protects against hijacking and fixation

- Should be enabled by default for your session cookies!
HttpOnly: state-of-practice

Usage in 2015

- 85%
- 15%
Misinterpretation of content

- Browsers are very relax in how content get processed
- To detect how the content may be displayed/executed, browser try to detect the content type
- Attackers can confuse the browser (eg. by sending scripts as images)
  - For the server, the resources are harmless images
  - For the client, the resources are interpreted as scripts
X-Content-Type-Options

- To disable this ‘automatic sniffing’ behavior, browser can use:
  - X-Content-Type-Options: nosniff

- Best practice for all resources:
  - Explicit MIME content types on server
  - Use X-CTO to disable client-side sniffing
X-Content-Type-Options: State of practice

Usage in 2015

- 85%
- 15%
Content Security Policy (CSP)

- Issued as HTTP response header
  - `Content-Security-Policy: script-src 'self'; object-src 'none'`

- Specifies which resources are allowed to be loaded as part of your page

- Extremely promising as an additional layer of defense against script injection
CSP set of directives

- There are a whole set of directives
  - Here we discuss CSP v1.1 (February 11, 2014)

- default-src
  - Takes a sourcelist as value
  - Default for all resources, unless overridden by specific directives
  - Only allowed resources are loaded
CSP source lists

- Space delimited list of sources
  - ‘self’
  - ‘none’
  - origin(s)

- Examples
  - https://mydomain.com
  - https://mydomain.com:443
  - http://134.58.40.10
  - https://*.mydomain.com
  - https:
  - *://mydomain.com
CSP set of directives (2)

- **script-src**
  - From which sources, scripts are allowed to be included

- **object-src**
  - Flash and other plugins

- **style-src**
  - stylesheets

- **img-src**
  - images

- **media-src**
  - sources of video and audio
CSP set of directives (3)

- **child-src**
  - list of origins allowed to be embedded as frames
  - replaces the deprecated frame-src directive

- **font-src**
  - web fonts

- **connect-src**
  - To which origins can you connect (e.g. XHR, websockets)

- **frame-options**
  - Control framing of the page

- **sandbox**
  - Trigger sandboxing attribute of embedded iframes
CSP requires sites to “behave”

- Inline scripts and CSS is not allowed
  - All scripts need to be externalized in dedicated JS files
  - All style directives need to be externalized in dedicated style files
  - Clean code separation

- The use of `eval` is not allowed
  - To prevent unsafe string (e.g. user input) to be executed
Example: inline scripts

```html
<script>
function runMyScript() {
    alert('My alert');
}
</script>

<a href="#" onClick="runMyScript();">
This link shows an alert!</a>
```
Example: externalized scripts

External JS

<script src="myscript.js"></script>
<a href="#" id="myLink">This link shows an alert!</a>

JavaScript code

function runMyScript() {
  alert('My alert');
}

document.addEventListener('DOMContentLoaded',
  function () {
    document.getElementById('myLink').addEventListener('click', runMyScript);
  });
Insecure relaxations, but be careful!

- To temporary allow inline scripts
  - `Content-Security-Policy: script-src 'self' 'unsafe-inline'`

- To temporary allow eval
  - `Content-Security-Policy: script-src 'self' 'unsafe-inline' 'unsafe-eval'`

- To temporary allow inline style directives
  - `Content-Security-Policy: style-src 'self' 'unsafe-inline'`

Be careful!
Script/style nonces and hashes

To allow controlled inline-scripts:

- Mark your script with a nonce

```
Content-Security-Policy: default-src 'self'; script-src 'self'
https://example.com 'nonce-Nc3n83cnSAd3wc3Sasdfn939hc3'
```

```
<script nonce="Nc3n83cnSAd3wc3Sasdfn939hc3">alert("Allowed because nonce is valid.")
</script>
```

- Add a hash of your inline script to the policy

```
Content-Security-Policy: script-src 'sha256-YWIzOWNiNzJjNDRlYzc4MTgwMDhmZDIkOWI0NTAyMjgyY2MyMWUyNjc1ODJjYWJhNjU5MGU4NmZmNGU3OAo='
```

```
<script>alert('Hello, world.');</script>
```
CSP reporting feature

- CSP reports violations back to the server owner
  - server owner gets insides in actual attacks
    - i.e. violations against the supplied policy
  - allows to further fine-tune the CSP policy
    - e.g. if the policy is too restrictive

- report-uri directive
  - `report-uri /my-csp-reporting-handler`
  - URI to which the violation report will be posted
Example violation report


```json
{
  "csp-report": {
    "document-uri": "http://example.org/page.html",
    "referrer": "http://evil.example.com/",
    "blocked-uri": "http://evil.example.com/evil.js",
    "violated-directive": "script-src 'self' https://apis.google.com",
    "original-policy": "script-src 'self' https://apis.google.com; report-uri http://example.org/my_amazing_csp_report_parser"
  }
}
```

Based on “HTML5Rocks: An introduction to Content Security Policy” (Mike West)
CSP Reporting: one step further

- Apart from reporting violations via the report-uri directive
- CSP can also run in report only mode
  - Violation are reported
  - Policies are not enforced
Some CSP examples

- Examples:
  - Mybank.net lockdown
  - SSL only
  - Social media integration
  - Facebook snapshot
Example: mybank.net lockdown

- Scripts, images, stylesheets
  - from a CDN at https://cdn.mybank.net

- XHR requests
  - Interaction with the mybank APIs at https://api.mybank.com

- Iframes
  - From the website itself

- No flash, java, ....

Content-Security-Policy: default-src 'none';
script-src https://cdn.mybank.net;
style-src https://cdn.mybank.net;
img-src https://cdn.mybank.net;
connect-src https://api.mybank.com;
child-src 'self'

Based on “HTML5Rocks: An introduction to Content Security Policy” (Mike West)
Example: SSL only

Can we ensure to only include HTTPS content in our website?


Obviously, this should only be the first step, not the final one!

Based on “HTML5Rocks: An introduction to Content Security Policy” (Mike West)
Example: social media integration

- Google +1 button
  - Script from https://apis.google.com
  - Iframe from https://plusone.google.com

- Facebook
  - Iframe from https://facebook.com

- Twitter tweet button
  - Script from https://platform.twitter.com
  - Iframe from https://platform.twitter.com


Based on “HTML5Rocks: An introduction to Content Security Policy” (Mike West)
Example: Facebook snapshot

X-WebKit-CSP: default-src *;
  chrome-extension://lifbcibi1hkdhoafpjfnlhfpgnpldfi 'unsafe-inline'
  'unsafe-eval' https://*.akamaihd.net http://*.akamaihd.net;style-src * 'unsafe-inline';
http://*.akamaihd.net;
Third-party JavaScript is everywhere

- Advertisements
  - Adhese ad network

- Social web
  - Facebook Connect
  - Google+
  - Twitter
  - Feedsburner

- Tracking
  - Scorecardresearch

- Web Analytics
  - Yahoo! Web Analytics
  - Google Analytics

- ...
Number of remote script providers per site

- 88.45% includes at least 1 remote JavaScript library
- 2 out of 3 sites relies on 5 or more script providers
- 1 site includes up to 295 remote script providers

Source: Nick Nikiforakis et. al. You are what you include: Large-scale evaluation of remote JavaScript inclusions. CCS 2012
## Most popular JavaScript libraries and APIs

<table>
<thead>
<tr>
<th>Offered service</th>
<th>JavaScript file</th>
<th>% Alexa Top 10K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web analytics</td>
<td><a href="http://www.google-analytics.com/ga.js">www.google-analytics.com/ga.js</a></td>
<td>68,37%</td>
</tr>
<tr>
<td>Dynamic Ads</td>
<td>pagead2.googlesyndication.com/pagead/show_ads.js</td>
<td>23,87%</td>
</tr>
<tr>
<td>Web analytics</td>
<td><a href="http://www.google-analytics.com/urchin.js">www.google-analytics.com/urchin.js</a></td>
<td>17,32%</td>
</tr>
<tr>
<td>Social Networking</td>
<td>connect.facebook.net/en_us/all.js</td>
<td>16,82%</td>
</tr>
<tr>
<td>Social Networking</td>
<td>platform.twitter.com/widgets.js</td>
<td>13,87%</td>
</tr>
<tr>
<td>Social Networking &amp; Web analytics</td>
<td>s7.addthis.com/js/250/addthis_widget.js</td>
<td>12,68%</td>
</tr>
<tr>
<td>Web analytics &amp; Tracking</td>
<td>edge.quantserve.com/quant.js</td>
<td>11,98%</td>
</tr>
<tr>
<td>Market Research</td>
<td>b.scorecardresearch.com/beacon.js</td>
<td>10,45%</td>
</tr>
<tr>
<td>Google Helper Functions</td>
<td><a href="http://www.google.com/jsapi">www.google.com/jsapi</a></td>
<td>10,14%</td>
</tr>
<tr>
<td>Web analytics</td>
<td>ssl.google-analytics.com/ga.js</td>
<td>10,12%</td>
</tr>
</tbody>
</table>

*Source: Nick Nikiforakis et. al. You are what you include: Large-scale evaluation of remote JavaScript inclusions. CCS 2012*
CSP: State of practice

Usage in 2015

- 85% in 2013
- 15% in 2015
CSP 1.0: State of practice

Mitigate cross-site scripting attacks by whitelisting allowed sources of script, style, and other resources.

<table>
<thead>
<tr>
<th>Current aligned</th>
<th>Usage relative</th>
<th>Show all</th>
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<tr>
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http://caniuse.com/#search=csp
What’s next in CSP?

- CSP 2.0 introduces a set of new directives
- DOM events are now fired upon violations
  - Allows the application to be CSP-aware
- Extensions to CSP:
  - `upgrade-insecure-requests` instructs the browser to fetch resources over https
  - `block-all-mixed-content` achieves strict mixed content checking
CSP 2.0: State of practice

Content Security Policy Level 2

Mitigate cross-site scripting attacks by whitelisting allowed sources of script, style, and other resources. CSP 2 adds hash-source, nonce-source, and five new directives.

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<thead>
<tr>
<th>Current signed</th>
<th>Usage relative</th>
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</table>
Subresource Integrity (SRI)

- A lot of resources are served by third-party services (content delivery networks)
  - “Either you trust a CDN, or you host your scripts yourself”

- SRI guarantees the integrity of scripts loaded in the browser

```html
<script src="https://code.jquery.com/jquery-2.1.3.min.js"
  integrity="sha256-TXuiaAJuML3...uMLTXuiaAJ3"
  crossorigin="anonymous"></script>
```
Subresource Integrity

- Allows you to specify a hash of an external resource
  - Using the *integrity* attribute on *script* or *link* tags

- Browsers verify this hash before loading the file
  - Refuse to load the file if the hash does not match

- SRI supports the specification of multiple hashes
  - The strongest one available will be used by the browser

```html
<script src="myapplication.js" integrity="sha256-... sha512-...">
</script>

<link href="myapp.css" type="text/css" integrity="sha384-... sha512-...">
</link>
```
Recap: Mitigating script injection attacks

- **HttpOnly flag for session cookies**
  - To protect cookies against hijacking and fixation from JavaScript

- **X-Content-Type-Options header**
  - Disables client-side MIME sniffing

- **Content Security Policy (CSP)**
  - Domain-level control over resources to be included
  - Most promising infrastructural technique against XSS
  - Interesting reporting-only mode

- **SubResource Integrity (SRI)**
  - Protects the integrity of third-party served resources
Injection Mitigation Score (1)
Injection Mitigation Score (2)
#3 Framing content securely
Overview

- **Attacks:**
  - Click-jacking
  - Same domain XSS

- **Countermeasures:**
  - X-Frame-Options header / frame-ancestors
  - HTML5 sandbox attribute for iframes
Click-jacking

Source: “Busting Frame Busting: a Study of Clickjacking Vulnerabilities on Popular Sites” (W2SP 2010)
Unsafe countermeasures

A lot of unsafe ways exist to protect against clickjacking

- if (top.location != location)
  top.location = self.location;
- if (parent.location != self.location)
  parent.location = self.location;

Can easily be defeated by
- Script disabling/sandboxing techniques
- Frame navigation policies
- XSS filters in browsers

Source: “Busting Frame Busting: a Study of Clickjacking Vulnerabilities on Popular Sites” (W2SP 2010)
X-Frame-Options

- Issued by the HTTP response header
  - X-Frame-Options: SAMEORIGIN
  - Indicates if and by who the page might be framed

- 3 options:
  - DENY
  - SAMEORIGIN
  - ALLOW-FROM uri
XFO: State of practice (deprecated)

Usage in 2015

- 85%
- 15%
XFO has been integrated in CSP

- New CSP directive: frame-ancestors
  - Content-Security-Policy: frame-ancestors
    https://partnerA.com https://partnerB.com

- In contrast to X-Frame-Options, a sourcelist is allowed
  - Common advice is to tailor per partner
Limitations of framing content in same origin

- Iframe integration provides a good isolation mechanism
  - Each origin runs in its own security context, thanks to the Same-Origin Policy
  - Isolation only holds if outer and inner frame belong to a different origin

- Hard to isolate untrusted content within the same origin
HTML5 sandbox attribute

- **Expressed as attribute of the iframe tag**
  - `<iframe src="/untrusted-path/index.html" sandbox></iframe>`
  - `<iframe src="/untrusted-path/index.html" sandbox="allow-scripts"></iframe>`

- **Level of Protection**
  - Coarse-grained sandboxing
  - ‘SOP but within the same domain’
Default sandbox behavior

- Plugins are disabled
- Frame runs in a unique origin
- Scripts can not execute
- Form submission is not allowed
- Top-level context can not be navigated
- Popups are blocked
- No access to raw mouse movements data
Sandbox relaxation directives

- Relaxations:
  - allow-forms
  - allow-popups
  - allow-pointer-lock
  - allow-same-origin
  - allow-scripts
  - allow-top-navigation

- Careful!
  - Combining allow-scripts & allow-same-origin voids the sandbox isolation

- Plugins can not be re-enabled
HTML5 sandbox

sandbox attribute for iframes

Method of running external site pages with reduced privileges (e.g. no JavaScript) in iframes.

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<th>Usage-relaxed</th>
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Belgium: 96.74% + 0.11% = 96.85%
Global: 90.22% + 0.36% = 90.59%
Sandbox has been integrated in CSP

- New CSP directive: sandbox
  - `Content-Security-Policy: sandbox`
  - `Content-Security-Policy: sandbox allow-scripts`

- Similar options apply:
  - allow-forms
  - allow-pointer-lock
  - allow-popups
  - allow-same-origin
  - allow-scripts
  - allow-top-navigation
Recap: Framing content securely

- CSP: Frame ancestors
  - Robust defense against click-jacking
  - Any state-changing page should be protected

- CSP: Sandbox attribute
  - Coarse-grained sandboxing of resources and JavaScript
  - Interesting enabler for security architectures
Secure Framing Score (1)
Secure Framing Score (2)
Example security architecture: Combining CSP & Sandbox

“Securing the Client-Side: Building safe web applications with HTML5” (Mike West, Devoxx 2012)
CSP & HTML5 sandbox as security enabler

- Combination of CSP and HTML5 sandbox
  - Enabling technologies for drafting a web application security architecture
  - Allows to define whether or not certain functions/scripts are allowed to run in the origin of the site

- Presented by Mike West at Devoxx 2012
  - Used for document rendering in ChromeOS, …
Example of sandboxing unsafe javascript

**Main site**
- Secured with CSP
- Delegates insecure executions to the sandboxed iframe

**Sandboxed iframe**
- Runs in unique origin
- Allowed to run JS

Web Messaging

**Sandboxed JS execution environment**
Content-Security-Policy: script-src 'self'

```html
<html>
<head>
  <script src="main.js"></script>
</head>
<body>
  <a href="#" id="sandboxFrame"/>Click here</a>
  <iframe id="sandboxFrame" sandbox="allow-scripts"
          src="sandbox.html">
  </iframe>
  <div id="content"></div>
</body>
</html>
```
<html><head>
  <script>
    window.EventListener('message', function(event) {
      var command = event.data.command;
      var context = event.data.context;
      var result = callUnsafeFunction(command, context);
      event.source.postMessage({
        html: result
      }, event.origin);
    });
  </script>
</head></html>
document.querySelector('#click').addEventListener('click', function(){
    var iframe = document.querySelector('#sandboxFrame');
    var message = {
        command: 'render',
        context: {thing: 'world'}
    }
    iframe.contentWindow.postMessage(message, '*');
});

window.addEventListener('message', function(event){
    //Would be dangerous without the CSP policy!
    var content = document.querySelector('#content');
    content.innerHTML = event.data.html;
});
And what’s next?

- Seamless integrating unsafe input with the sandbox attribute
  - `<iframe sandbox seamless srcdoc="<p>Some paragraph</p>" />`<p>Some paragraph</p>" />

- Seamless attribute
  - Renders visually as part of your site
  - Only for same-origin content

- Srcdoc attribute
  - Content as a attribute value instead of a remote page
Conclusion

- Whole new range of security features
  - Browser-side enforcement, under control of the server

- NOT a replacement of secure coding guidelines, but an interesting additional line of defense for
  - Legacy applications
  - Newly deployed applications

- And most probably, there is many more to come in the next few years…
Is there a correlation between security features and website popularity?
State-of-practice?

- Secure Communication
  - HTTPS support
  - Secure Cookies
  - Strict-Transport-Security

- XSS Protection
  - HttpOnly cookies
  - X-Content-Type-Options
  - Content-Security-Policy

- Secure Framing
  - X-Frame-Options
Scores per country or vertical ...

Belgium (2015)

Finance (2015)
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