Home > All articles

Content security policy

Content Security Policy can significantly reduce the risk and impact of cross-site scripting attacks in modern browsers.

Jun 15, 2012 – Updated Jun 19, 2020

Mike West
Twitter Mastodon

Lee Medley
Twitter GitHub

On this page

The web's security model is rooted in the same origin policy. Code from `https://bank.com` should only have access to `https://bank.com`'s data, and `https://evil.example.com` should certainly never be allowed access. Each origin is kept isolated from the rest of the web, giving developers a safe sandbox in which to build and play in theory, this is perfectly brilliant. In practice, attackers have found clever ways to subvert the system.

Cross-site scripting (XSS) attacks, for example, bypass the same origin policy by tricking a site into delivering malicious code along with the intended content. This is a huge problem, as browsers treat all of the code that shows up on a page as being legitimately part of that page's security origin. The XSS Cheat Sheet is an old but representative cross-section of the methods an attacker might use to violate this trust: by injecting malicious code if an attacker successfully injects any code at all, it's pretty much game over: user session data is compromised and information that should be kept secret is exfiltrated to The Bad Guys. We'd obviously like to prevent that if possible.

This overview highlights a defense that can significantly reduce the risk and impact of XSS attacks in modern browsers: Content Security Policy (CSP).

TL;DR

- Use allowlists to tell the client what's allowed and what isn't.
- Learn what directives are available.
- Learn the keywords they take.
- Inline code and `eval()` are considered harmful.
- Report policy violations to your server before enforcing them.

Source allowlists

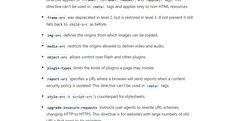
The issue exploited by XSS attacks is the browser's inability to distinguish between script that's part of your application and script that's been maliciously injected by a third party. For example, the Google +1 button at the bottom of this page loads and executes code from `https://apis.google.com/js/plusone.js`. In the context of this page's origin. We trust that code, but we can't expect the browser to figure out on its own that code from `apis.google.com` is awesome, while code from `apis.evil.example.com` (probably isn't). The browser happily downloads and executes any code a page requests, regardless of source.

Instead of blindly trusting everything that a server delivers, CSP defines the `Content-Security-Policy` HTTP header, which allows you to create an allowlist of sources of trusted content, and instructs the browser to only execute or render resources from those sources. Even if an attacker can find a hole through which to inject script, the script won't match the allowlist, and therefore won't be executed.

Since we trust `apis.google.com` to deliver valid code, and we trust ourselves to do the same, let's define a policy that only allows script to execute when it comes from one of those two sources:

```
Content-Security-Policy: script-src 'self' https://apis.google.com
```

Simple, right? As you probably guessed, `script-src` is a directive that controls a set of script-related privileges for a specific page. We've specified `'self'`, as one valid source of script, and `https://apis.google.com` as another. The browser dutifully downloads and executes JavaScript from `apis.google.com` over HTTPS, as well as from the current page's origin.



With this policy defined, the browser simply throws an error instead of loading script from any other source. When a clever attacker manages to inject code into your site, they'll run headlong into an error message rather than the success they were expecting.

Policy applies to a wide variety of resources

While script resources are the most obvious security risks, CSP provides a rich set of policy directives that enable fairly granular control over the resources that a page is allowed to load. You've already seen `script-src`, so the concept should be clear.

Let's quickly walk through the rest of the resource directives. The list below represents the state of the directives as of level 2. A level 3 exists has been published, but is largely unimplemented in the major browsers.

- `base-uri` restricts the URLs that can appear in a page's `<base>` element.
- `child-src` lists the URLs for workers and embedded frame contents. For example `child-src https://youtube.com` would enable embedding videos from YouTube but not from other origins.
- `connect-src` limits the origins that you can connect to (via XHR, WebSockets, and EventSource).
- `font-src` specifies the origins that can serve web fonts. Google's web fonts could be enabled via `font-src https://themes.googleusercontent.com`.
- `form-action` lists valid endpoints for submission from `<form>` tags.
- `frame-ancestors` specifies the sources that can embed the current page. This directive applies to `<frame>`, `<iframe>`, `<embed>`, and `<applet>` tags. This directive can't be used in `<meta>` tags and applies only to non-HTML resources.
- `frame-src` was deprecated in level 2, but is restored in level 3. If not present it still falls back to `child-src` as before.
- `img-src` defines the origins from which images can be loaded.
- `media-src` restricts the origins allowed to deliver video and audio.
- `object-src` allows control over Flash and other plugins.
- `plugin-types` limits the kinds of plugins a page may invoke.
- `report-uri` specifies a URL where a browser will send reports when a content security policy is violated. This directive can't be used in `<meta>` tags.
- `style-src` is `script-src`'s counterpart for stylesheets.
- `upgrade-insecure-requests` instructs user agents to rewrite URL schemes, changing HTTP to HTTPS. This directive is for websites with large numbers of old URLs that need to be rewritten.
- `worker-src` is a CSP Level 3 directive that restricts the URLs that may be loaded as a worker, shared worker, or service worker. As of July 2017, this directive has limited implementations.

By default, directives are wide open. If you don't set a specific policy for a directive, let's say, `frame-src`, then that directive behaves by default as though you'd specified `*` as the valid source (for example, you could load frames from anywhere, without restriction).

You can override this default behavior by specifying a `default-src` directive. This directive defines the defaults for most directives that you have unspecified. Generally, this applies to any directive that ends with `-src`. If `default-src` is set to `https://example.com`, and you fail to specify a `frame-src` directive, then you can load frames from `https://example.com`, and nowhere else. We specified only `script-src` in our earlier examples, which means that images, fonts, and so on can be loaded from any origin.

The following directives don't use `default-src` as a fallback. Remember that failing to set them is the same as allowing anything.

- `base-uri`
- `form-action`
- `frame-ancestors`
- `plugin-types`
- `report-uri`
- `sandbox`

You can use as many or as few of these directives as needed for your specific application, simply listing each in the HTTP header, separating directives with semicolons. Make sure that you list all required resources of a specific type in a single directive. If you write something like `script-src https://host1.com; script-src https://host2.com`, the second directive would simply be ignored. Something like the following would correctly specify both origins as valid:

```
script-src https://host1.com https://host2.com
```

If, for example, you have an application that loads all of its resources from a content delivery network (say, `https://cdn.example.net`), and know that you don't need any framed content or plugins, then your policy might look something like the following:

```
Content-Security-Policy: default-src https://cdn.example.net; child-src 'none';
```

Implementation details

You will see `X-Webkit-CSP` and `X-Content-Security-Policy` headers in various blogs on the web. Going forward, you should ignore these prefixed headers. Modern browsers (with the exception of IE) support the unprefixed `Content-Security-Policy` header. That's the header you should use.

Regardless of the header you use, policy is defined on a page-by-page basis: you'll need to send the HTTP header along with every response that you'd like to ensure is protected. This provides a lot of flexibility, as you can fine-tune the policy for specific pages based on their specific needs. Perhaps one set of pages in your site has a `<iframe>` on them, while others don't, you could allow the latter code to be loaded only when necessary.

The source list in each directive is flexible. You can specify sources by scheme (`data:`, `https:`), or ranging in specificity from hostname only (`example.com`, which matches any origin on that host: any scheme, any port), to a fully qualified URI (`https://example.com:443`, which matches only HTTPS, only `example.com`, and only port 443). Wildcards are accepted, but only as a scheme, a port, or in the leftmost position of the hostname: `*.i18n.example.com` would match all subdomains of `example.com` (but not `example.com` itself), using any scheme, on any port.

The source list also accepts four keywords:

- `'none'`, as you might expect, matches nothing.
- `'self'` matches the current origin, but not its subdomains.
- `'unsafe-inline'` allows inline JavaScript and CSS. (We'll touch on this in more detail in a bit.)
- `'unsafe-eval'` allows text-to-JavaScript mechanisms like `eval()`. (We'll get to this too.)

These keywords require single quotes. For example, `script-src 'self'` (with quotes) authorizes the execution of JavaScript from the current host. `script-src self` (no quotes) allows JavaScript from a server named `"self"` (and not from the current host), which probably isn't what you meant.

Sandboxing

There's one more directive worth talking about: `sandbox`. It's a bit different from the others we've looked at, as it places restrictions on actions that the page can take rather than on resources that the page can load. If the `sandbox` directive is present, the page is treated as though it was loaded inside of an `<iframe>` with a `sandbox` attribute. This can have a wide range of effects on the page forcing the page into a unique origin, and preventing form submission, among others. It's a bit beyond the scope of this article, but you can find details on valid sandboxing attributes in the "Sandboxing" section of the HTML5 spec.

The meta tag

CSP's preferred delivery mechanism is an HTTP header. It can be useful, however, to set a policy on a page directly in the markup. Do that using a `<meta>` tag with an `http-equiv` attribute:

```
<meta http-equiv="Content-Security-Policy" content="default-src https://cdn.examp
```

This can't be used for `frame-ancestors`, `report-uri`, or `sandbox`.

Inline code is considered harmful

It should be clear that CSP is based on allowlist origins, as that's an unambiguous way of instructing the browser to treat specific sets of resources as acceptable and to reject the rest. Origin-based allowlists don't, however, solve the biggest threat posed by XSS attacks: inline script injection. If an attacker can inject a script tag that directly contains some malicious payload (`<script>sendMyCookiesToEvilSite()</script>`), the browser has no mechanism by which to distinguish it from a legitimate inline script tag. CSP solves this problem by banning inline script entirely. It's the only way to be sure.

This ban includes not only scripts embedded directly in `script` tags, but also inline event handlers and `javascript:` URLs. You'll need to move the content of `script` tags into an external file, and replace `javascript:` URLs and `<a ... onclick="...">` (`javascript:` with appropriate `addEventListener()`s. For example, you might rewrite the following from:

```
<script>
    function doMessageThings() {
        alert('Yes an ANCZ0R!');
    }
</script>
<button onclick='doMessageThings()'>Ook I be awesing?</button>
```

to something more like:

```
<!-- awesing.html -->
<script src='awesing.js'></script>
<button id='awesing'>Ook I be awesing?</button>

// awesing.js
function doMessageThings() {
    alert('Yes an ANCZ0R!');
}
document.addEventListener('DOMContentLoaded', function () {
    document.getElementById('awesing').
        addEventListener('click', doMessageThings);
});
```

The rewritten code has a number of advantages above and beyond working well with CSP: it's already best practice, regardless of your use of CSP. Inline JavaScript moves structure and behavior in exactly the way you shouldn't. External resources are easier for browsers to cache, more understandable for developers, and conducive to compilation and minification. You'll write better code if you do the work to move code into external resources.

Inline style is treated in the same way: both the `style` attribute and `style` tags should be consolidated into external stylesheets to protect against a variety of surprisingly clever data exfiltration methods that CSS enables.

If you must have inline script and style, you can enable it by adding `'unsafe-inline'` or an allowed source to a `script-src` or `style-src` directive. You can also use a nonce or a hash (see below), but you really shouldn't. Banning inline script is the biggest security win CSP provides, and banning inline style likewise hardens your application. It's a little bit of effort up front to ensure that things work correctly after moving all the code out of line, but that's a tradeoff that's well worth making.

If you absolutely must use it

CSP Level 2 offers backward-compatibility for inline scripts by allowing you to add specific inline scripts to the allowlist using either a cryptographic nonce (number used once) or a hash. Although this may be cumbersome, it is useful in a pinch.

To use a nonce, give your script tag a nonce attribute. Its value must match one in the list of trusted sources. For example:

```
<script nonce="EDNnf03nceIOfn39fn3+Aw==">
    // Some inline code I can't remove yet, but need to wrap.
</script>
```

Now, add the nonce to your `script-src` directive appended to the `nonce-` keyword:

```
Content-Security-Policy: script-src 'nonce-EDNnf03nceIOfn39fn3+Aw==';
```

Remember that nonces must be regenerated for every page request and they must be unguessable.

Hashes work in much the same way. Instead of adding code to the script tag, create a SHA hash of the script itself and add it to the `script-src` directive. For example, let's say your page contained this:

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

Your policy would contain this:

```
Content-Security-Policy: script-src 'sha256-qznLcsROx4GACP2dm0UCKCzCG-HiZgpwhgQ3Z
```

There are a few things to note here. The `sha256-` prefix specifies the algorithm that generates the hash. In the example above, `sha256` is used. CSP also supports `sha384-` and `sha512-`. When generating the hash, do not include the `<script>` tags. Also capitalization and whitespace matter, including leading or trailing whitespace.

A Google search on generating SHA hashes will lead you to solutions in any number of languages. Using Chrome 40 or later, you can open DevTools and then reload your page. The Console tab will contain error messages with the correct sha256 hash for each of your inline scripts.

Eval too

Even when an attacker can't inject script directly, they might be able to trick your application into converting otherwise-inert text into executable JavaScript and executing it on their behalf. `eval()`, `new Function()`, `setTimeout([string], ...)`, and `setInterval([string], ...)` are all vectors through which injected text might end up executing something unexpectedly malicious. CSP's default response to this risk is to completely block all of these vectors.

This has more than a few impacts on the web platform:

- You must parse JSON via the built-in `JSON.parse`, rather than relying on `eval`. Fortunately JSON operations are available in every browser since IE8 and Firefox

completely sure.

- Rewrite any `setTimeout` or `setInterval` calls you're currently making with inline functions rather than strings. For example:

```
setTimeout("document.querySelector('a').style.display = 'none';", 10);
```

would be better written as:

```
setTimeout(function () {
    document.querySelector('a').style.display = 'none';
}, 10);
```

- Avoid inline templating at runtime: Many templating libraries use `new Function()` liberally to speed up template generation at runtime. It's a nifty application of dynamic programming, but comes at the risk of evaluating malicious text. Some frameworks support CSP out of the box, falling back to a robust parser in the absence of `eval`. AngularJS's ng-csp directive is a good example of this.

However, a better choice would be a templating language that offers precompilation (Handlebars does, for instance). Precompiling your templates can make the user experience even faster than the fastest runtime implementation, and it's safer too. If eval and its text-to-JavaScript brethren are essential to your application, you can enable them by adding `'unsafe-eval'` as an allowed source in a `script-src` directive, but we strongly discourage this. Banning the ability to execute strings makes it much more difficult for an attacker to execute unauthorized code on your site.

Reporting

CSP's ability to block untrusted resources client-side is a huge win for your users, but it would be quite helpful to have some sort of notification sent back to the server so that you can identify and squash any bugs that allow malicious injection in the first place. To this end, you can instruct the browser to `POST` JSON-formatted violation reports to a location specified in a `report-uri` directive.

```
Content-Security-Policy: default-src 'self'; ...; report-uri /my_amazing_csp_repo
```

Those reports will look something like the following:

```
{
    "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 htt
    }
}
```

This contains a good chunk of information that will help you track down the specific cause of the violation, including the page on which the violation occurred (`document-uri`), that page's referrer (note that unlike the HTTP header field, the key is *not* misspelled), the resource that violated the page's policy (`blocked-uri`), the specific directive it violated (`violated-directive`), and the page's complete policy (`original-policy`).

Report-Only

If you're just starting out with CSP, it makes sense to evaluate the current state of your application before rolling out a draconian policy to your users. As a stepping stone to a complete deployment, you can ask the browser to monitor a policy, reporting violations but not enforcing the restrictions. Instead of sending a `Content-Security-Policy` header, send a `Content-Security-Policy-Report-Only` header.

```
Content-Security-Policy-Report-Only: default-src 'self'; ...; report-uri /my_amaz
```

The policy specified in report-only mode won't block restricted resources, but it will send violation reports to the location you specify. You can even send *both* headers, enforcing one policy while monitoring another. This is a great way to evaluate the effect of changes to your application's CSP: turn on reporting for a new policy, monitor the violation reports and fix any bugs that turn up; when you're satisfied with its effect, start enforcing the new policy.

Real World Usage

CSP 1 is quite usable in Chrome, Safari, and Firefox, but has very limited support in IE 10. You can view specifics at caniuse.com. CSP Level 2 has been available in Chrome since version 40. Massive sites like Twitter and Facebook have deployed the header (Twitter's case study is worth a read), and the standard is very much ready for you to start deploying on your own sites.

The first step towards crafting a policy for your application is to evaluate the resources you're actually loading. Once you think you have a handle on how things are put together in your app, set up a policy based on those requirements. Let's walk through a few common use cases and determine how we'd best be able to support them within the protective confines of CSP.

Use case #1: social media widgets

- Facebook's Like button has a number of implementation options. We recommend sticking with the `<iframe>` version as it's safely sandboxed from the rest of your site. It requires a `child-src https://facebook.com` directive to function properly. Note that, by default, the `<iframe>` code that Facebook provides loads a relative URL, `//facebook.com`. Change that to explicitly specify HTTPS: `https://facebook.com`. There's no reason to use HTTP if you don't have to.
- Twitter's Tweet button relies on access to a script and a frame, both hosted at `https://platform.twitter.com`. (Twitter likewise provides a relative URL by default; edit the code to specify HTTPS when copy/pasting it locally.) You'll be all set with `script-src https://platform.twitter.com; child-src https://platform.twitter.com`, as long as you move the JavaScript snippet that Twitter provides out into an external JavaScript file.
- Other platforms have similar requirements, and can be addressed similarly. We suggest just setting a `default-src` of `'none'`, and watching your console to determine which resources you'll need to enable to make the widgets work.

Including multiple widgets is straightforward: simply combine the policy directives, remembering to merge all resources of a single type into a single directive. If you wanted all three social media widgets, the policy would look like this:

```
script-src https://apis.google.com https://platform.twitter.com; child-src https
```

Use case #2: lockdown

Assume for a moment that you run a banking site and want to make sure that only those resources you've written yourself can be loaded. In this scenario, start with a default policy that blocks absolutely everything (`default-src 'none'`), and build up from there.

Let's say the bank loads all images, style, and script from a CDN at `https://cdn.mybank.net`, and connects via XHR to `https://api.mybank.com/` to pull various bits of data down. Frames are used, but only for pages local to the site (no third-party origins). There's no Flash on the site, no fonts, no extras. The most restrictive CSP header that we could send is this:

```
Content-Security-Policy: default-src 'none'; script-src https://cdn.mybank.net;
```

Use case #3: SSL only

A wedding-ring discussion forum admin wants to ensure that all resources are only loaded via secure channels, but doesn't really write much code; rewriting large chunks of the third-party forum software that's filled to the brim with inline script and style is beyond his abilities. The following policy would be effective:

```
Content-Security-Policy: default-src https:; script-src https: 'unsafe-inline';
```

Even though `https:` is specified in `default-src`, the script and style directives don't automatically inherit that source. Each directive completely overwrites the default for that specific type of resource.

The future

Content Security Policy Level 2 is a Candidate Recommendation. The W3C's Web Application Security Working Group has already begun work on the specification's next iteration, Content Security Policy Level 3.

If you're interested in the discussion around these upcoming features, skim the public-webappsec@ mailing list archives, or join in yourself.

Last updated: Jun 19, 2020 — Improve article

← RETURN TO ALL ARTICLES

Except as otherwise noted, the content of this page is licensed under the Creative Commons Attribution 4.0 License, and code samples are licensed under the Apache 2.0 License. For details, see the Google Developers Site Policies.

SHARE

SUBSCRIBE