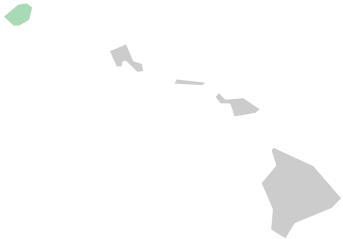
#LocoMocoSec

Kauai, Hawaii

2019



Content Security Policy

A successful mess between hardening and mitigation

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We work in a focus area of the **Google** security team (ISE) aimed at improving product security by targeted proactive projects to mitigate whole classes of bugs.

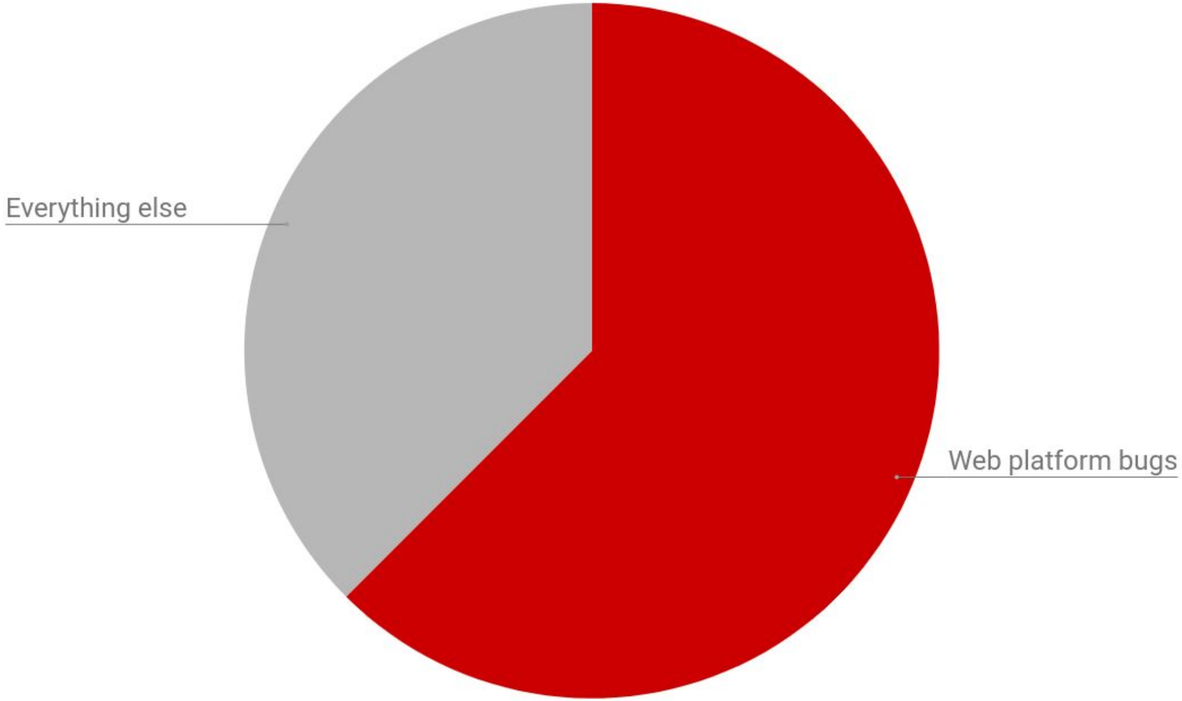
Agenda

- Why CSP - aka XSS is still an issue
- Google CSP stats - how many XSS got mitigated in 2018
- CSP building blocks - mapping XSS sinks to CSP properties
- Rolling out a nonce-based CSP
- Advanced CSP Kung Fu
- Productionizing CSP

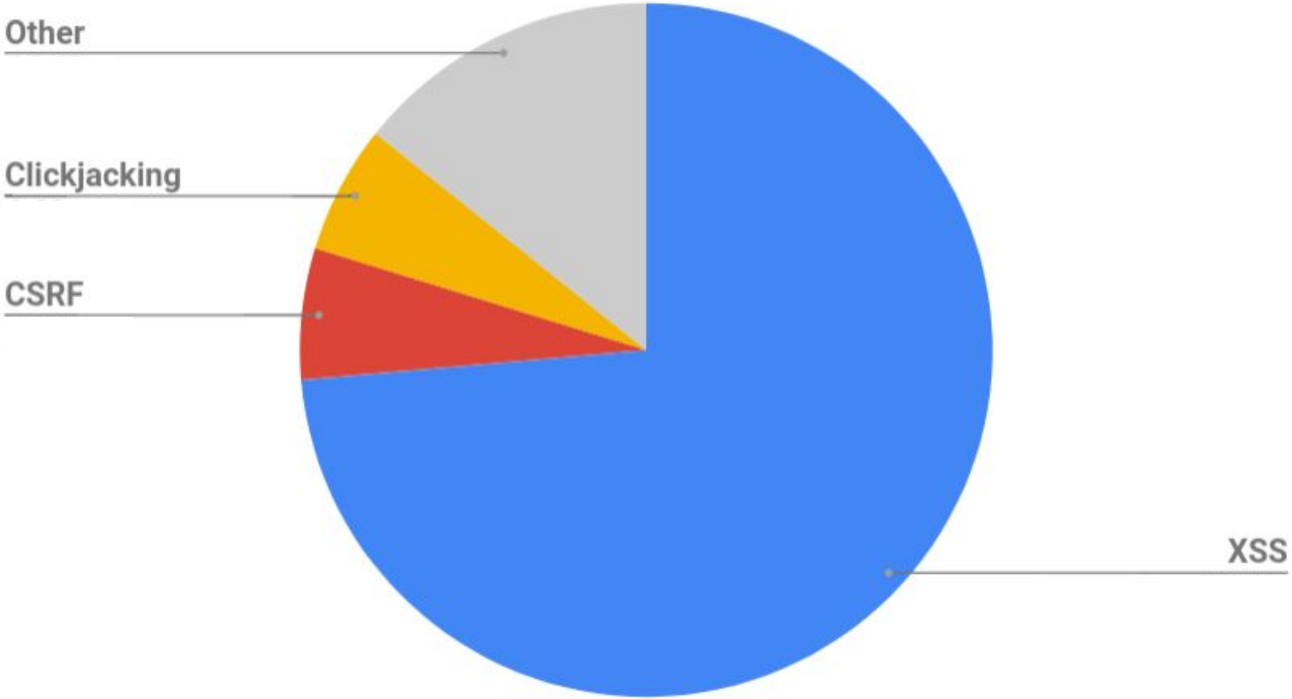
Vulnerability Trends

Why you should care about XSS

Total Google VRP Rewards (since 2014)



Google VRP Rewards for Web Platform Bugs

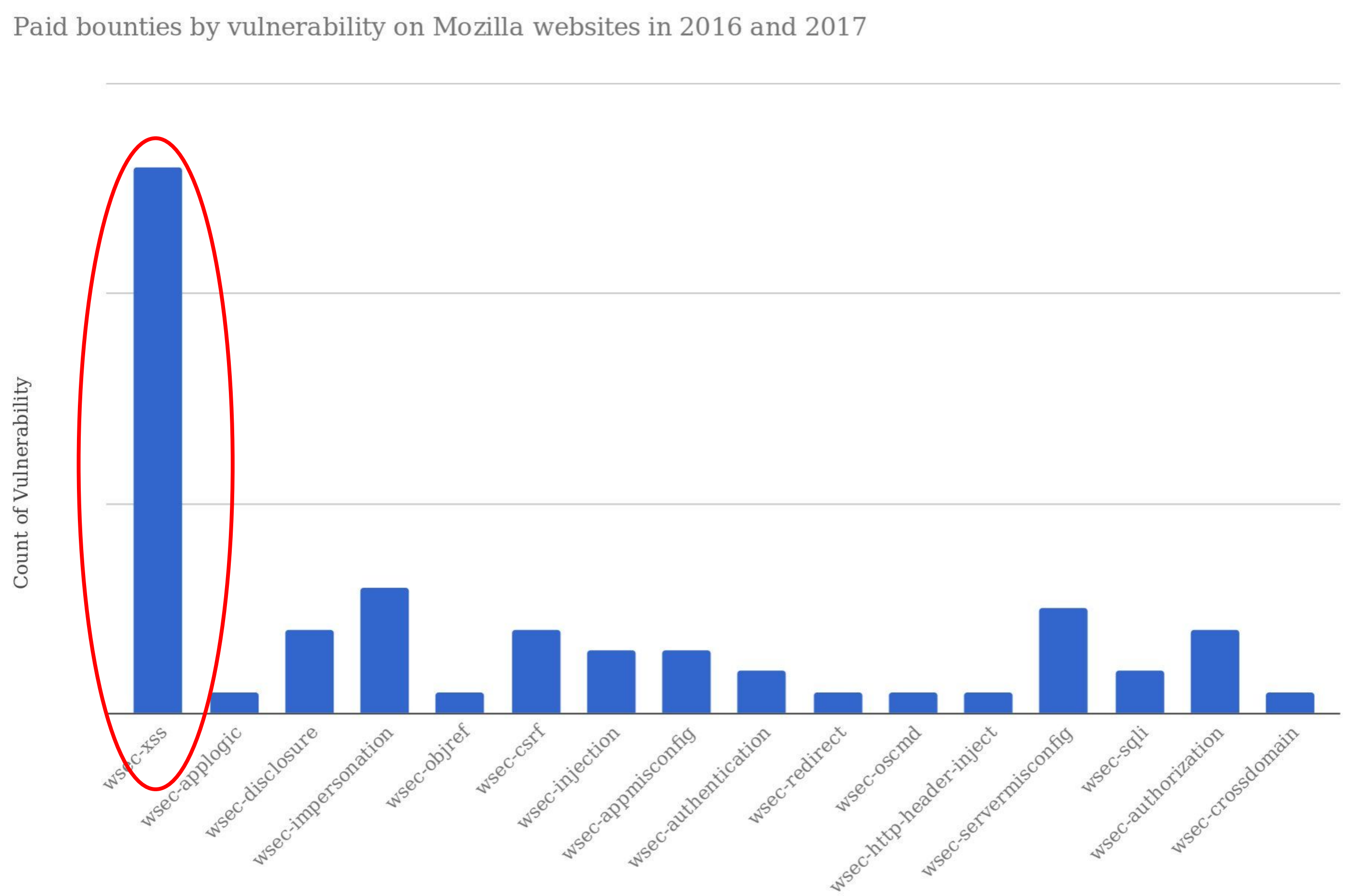


VULNERABILITIES BY INDUSTRY

	MEDIA & ENTERTAINMENT	FINANCIAL &BANKING	GAMING	HEALTHCARE	ECOMMERCE & RETAIL	TECHNOLOGY	TRANSPORTATION	TRAVEL & HOSPITALITY	HACKERONE PLATFORM
CROSS-SITE SCRIPTING (XSS)	35%	19%	28%	31%	26%	34%	32%	47%	26%
IMPROPER AUTHENTICATION	16%	22%	23%	18%	15%	14%	20%	12%	12%
CROSS-SITE REQUEST FORGERY (CSRF)	8%	10%	5%	12%	11%	9%	3%	11%	8%
VIOLATION OF SECURE DESIGN PRINCIPLES	12%	17%	12%	8%	11%	11%	11%	10%	10%
INFORMATION DISCLOSURE	12%	14%	23%	8.5%	10%	14%	19%	7%	12%
DENIAL OF SERVICE	0%	2%	2%	0%	7%	0%	1%	2%	2%
OPEN REDIRECT	4%	5%	5%	3%	5%	5%	3%	4%	4%
PRIVILEGE ESCALATION	3%	3%	5%	7%	5%	6%	4%	4%	4%
MEMORY CORRUPTION	0%	0%	1%	0%	4%	0%	0%	0%	1%
CRYPTOGRAPHIC ISSUES	1%	3%	3%	1%	3%	3%	2%	0%	2%
UI REDRESSING (CLICKJACKING	2%	2%	0%	1%	2%	2%	1%	0%	1%
COMMAND INJECTION	2%	2%	0%	3%	1%	2%	0%	2%	1%
SQL INJECTION	2%	2%	3%	6%	0%	0%	3%	2%	2%
CODE INJECTION	2%	0%	1%	3%	0%	2%	2%	0%	1%

Figure 2: *Percentage of vulnerability type by industry from 2013 to May 2017.*

Source: HackerOne report, 2017



Source: @jvehent, Mozilla (legend)

The Need for Defense-in-Depth

- The majority of application vulnerabilities are web platform issues
- **XSS** in its various forms is still a big issue
- The web platform is not secure by default
- Especially for sensitive applications, defense-in-depth mechanisms such as CSP are very important in case primary security mechanisms fail

Mitigation ≠ Mitigation

Reducing the attack surface

- Measurable security improvement
- Disable unsafe APIs
- Remove attack vectors
- Target classes of bugs
- Defense-in-depth (Don't forget to fix bugs!)

Example:

- block eval() or javascript: URI
  ⟶ all XSS vulnerabilities using that sink will stop working
- nonce-based CSP

vs

"raising the bar"

- Increase the "cost" of an attack
- Slow down the attacker

Example:

- whitelist-based CSP
  ⟶ sink isn't closed, attacker needs more time to find a whitelist bypass
  ⟶ often there is no control over content hosted on whitelisted domains (e.g. CDNs)

Hardening Steps induced by CSP

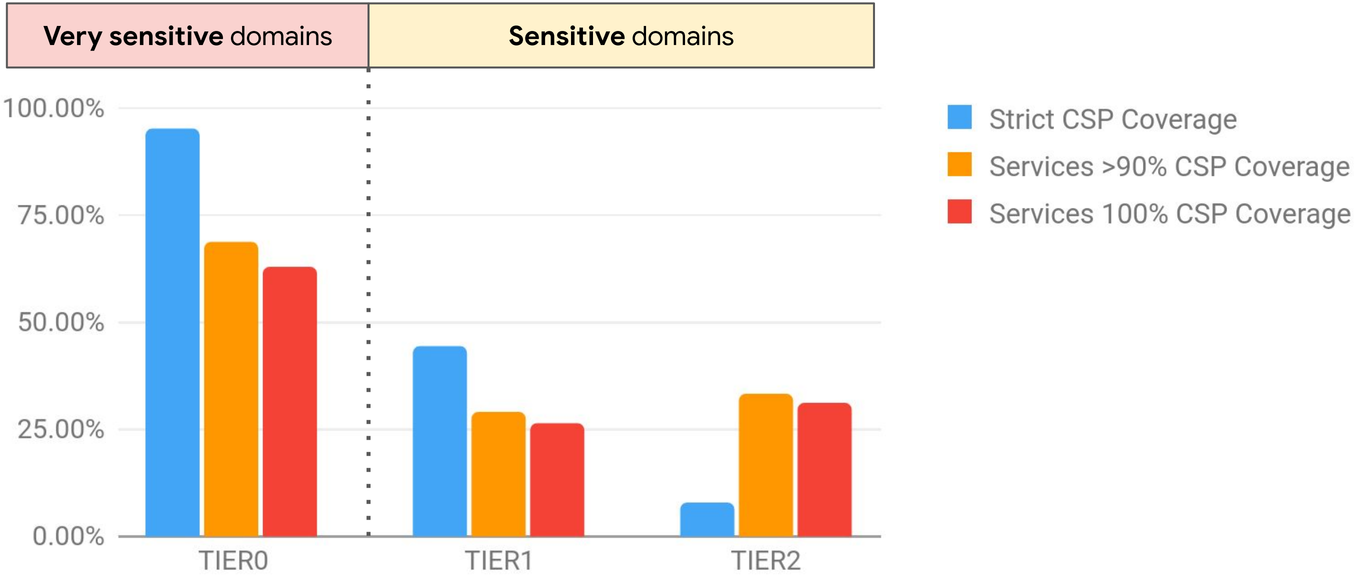
- Refactor inline event handlers
- Refactor uses of eval()
- Incentive to use contextual templating system for auto-noncing

XSS blocked by CSP @Google

An analysis of externally reported XSS in 2018

CSP Coverage at Google

Currently a nonce-based CSP is <u>enforced</u> on: **62%** of all outgoing Google traffic
80+ Google domains (e.g. accounts.google.com)
160+ services

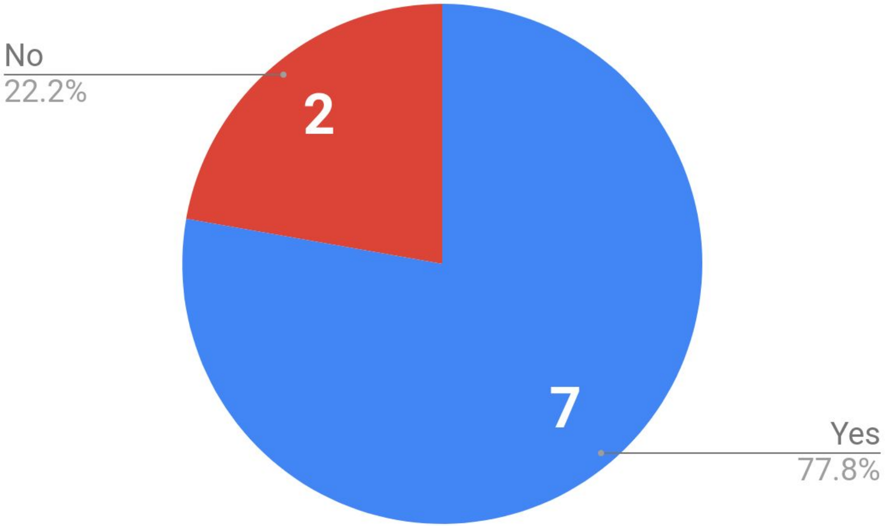


Google Case Study: >60% of XSS Blocked by CSP

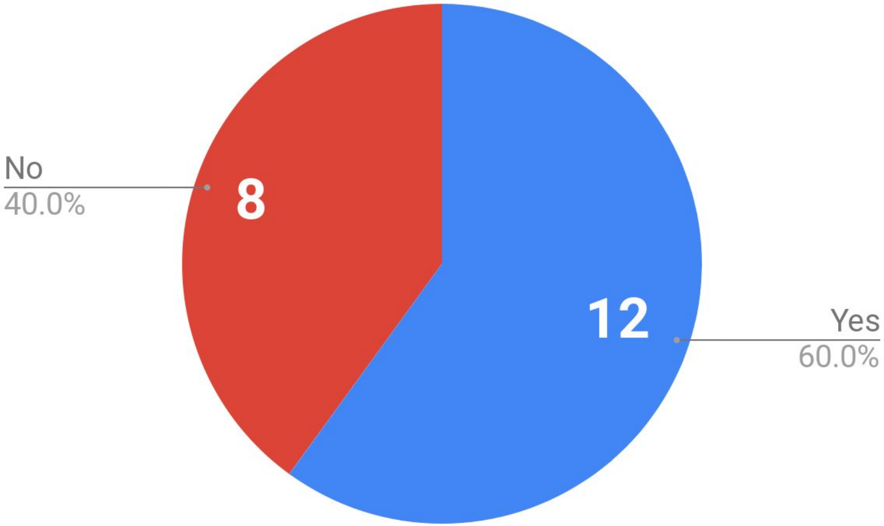
- Externally reported XSS in 2018
- Among 11 XSS vulnerabilities on very sensitive domains
  - 9 were on endpoints with strict CSP deployed, in 7 of which (**78%**) CSP successfully prevented exploitation
- Among all valid 69 XSS vulnerabilities on sensitive domains
  - 20 were on endpoints with strict CSP deployed
  - in 12 of which (**60%**) CSP successfully prevented exploitation

Google Case Study: >60% of XSS Blocked by CSP

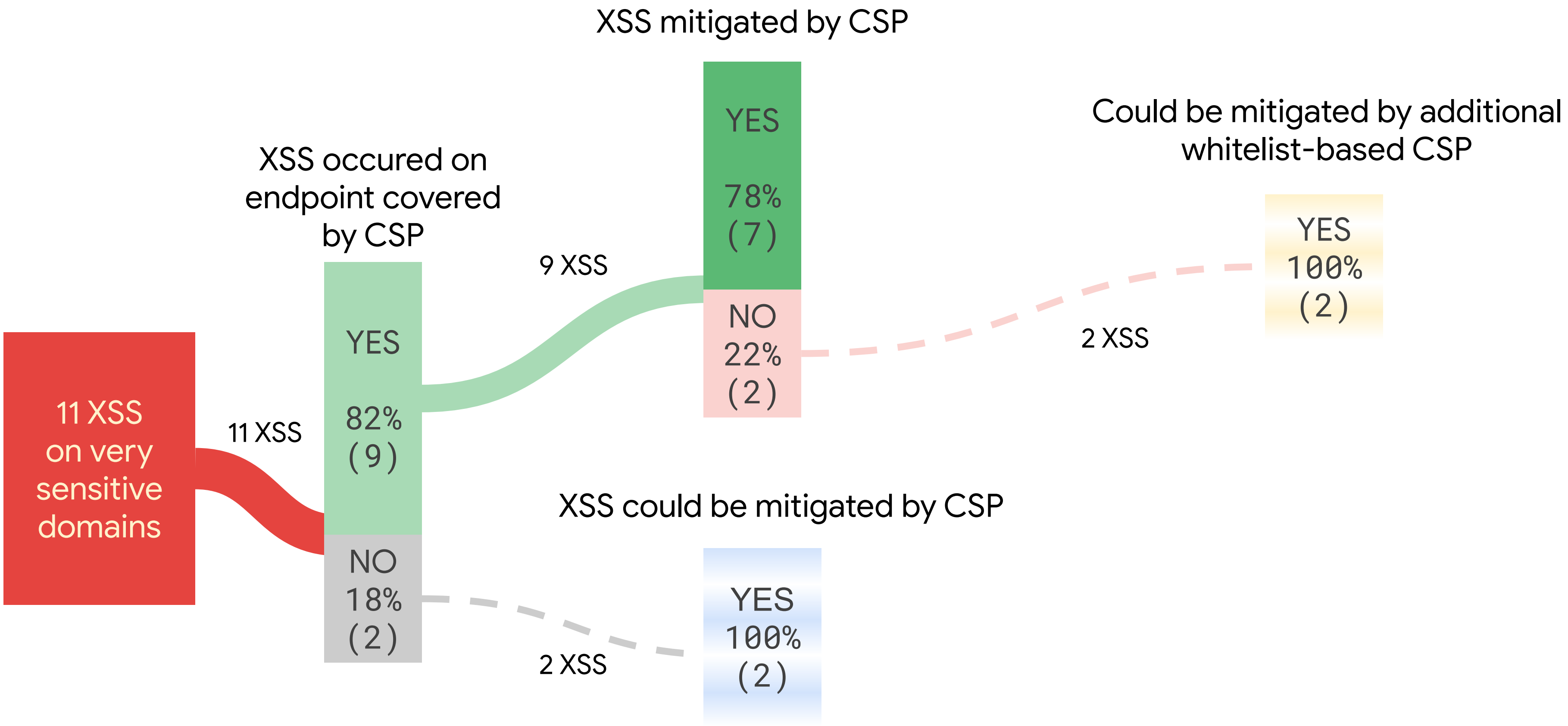
Very sensitive domains **with CSP**



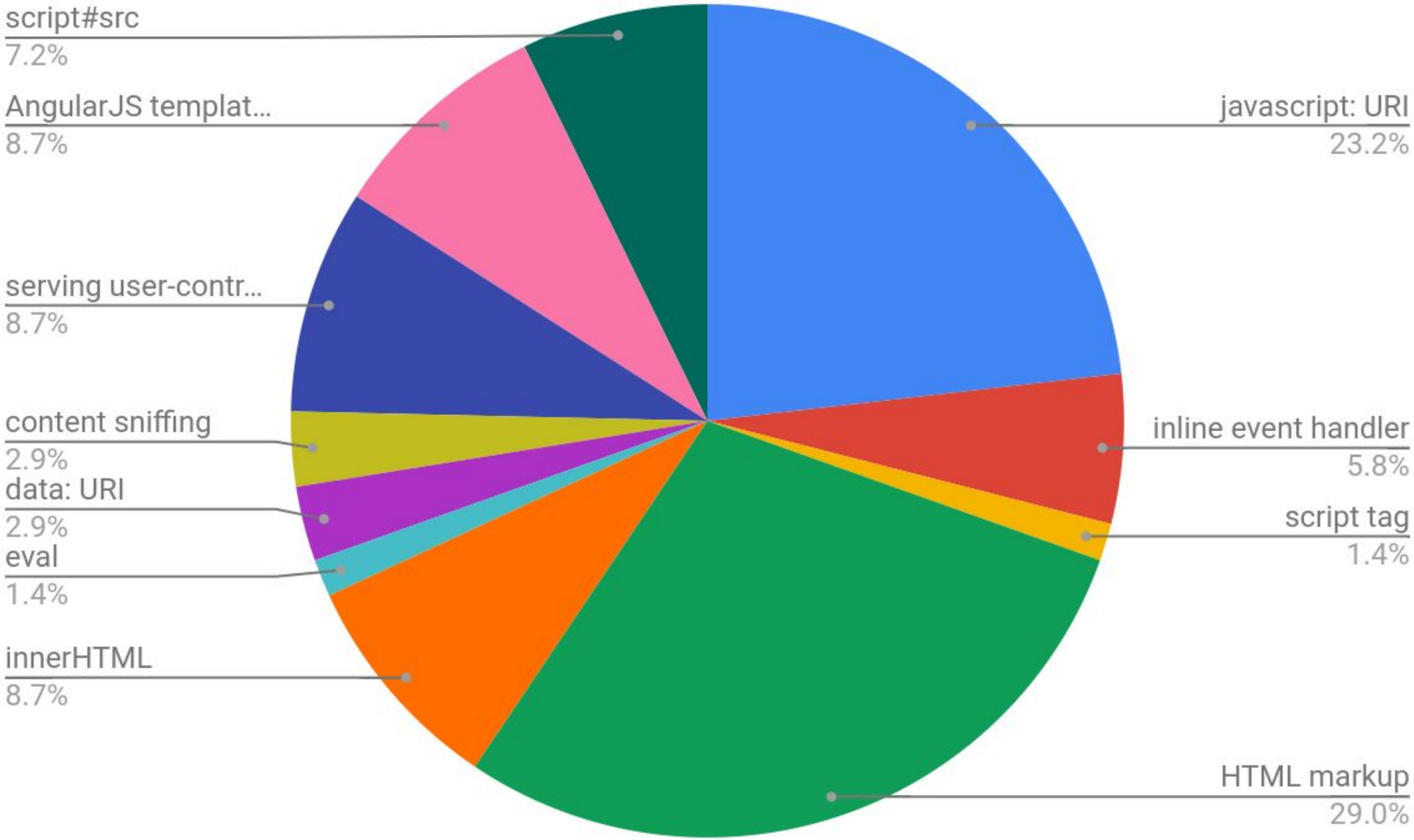
All sensitive domains **with CSP**



On Very Sensitive Domains: ~80% of XSS Blocked by CSP



Externally Reported XSS Exploited via



Mapping Common XSS Sinks to CSP Features

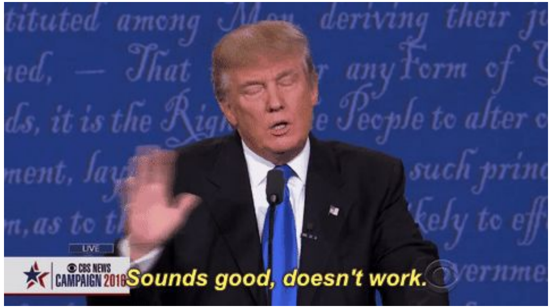
XSS sink (*injection into...*)	CSP blocks if...
javascript: URI (i.e., javascript:**alert(1)**)	~~'unsafe-inline'~~
data: URI (i.e., **data:text/html,<script>alert(1)</script>**)	~~'unsafe-inline'~~
(inner)HTML context (i.e., **<script>alert(1)</script>**)	~~'unsafe-inline'~~
inline event handler (i.e., onerror=**alert(1)**)	~~'unsafe-inline'~~
eval() (i.e., eval('**alert(1)**')	~~'unsafe-eval'~~
script#text (i.e., var s = createElement('script'); s.innerText = '**alert(1)**';)	'sha256-...' 'nonce-...' '~~strict-dynamic~~' (if scripts are not blindly nonced)
script#src (i.e., var s = createElement('script'); s.src = '**attacker.js**';)	'nonce-...' '~~strict-dynamic~~' (if scripts are not blindly nonced)
AngularJS-like template injection (i.e., **{{constructor.constructor('alert(1)')()}}**)	Must be addressed in the framework. e.g. upgrade AngularJS to Angular 2+

Step-by-Step Towards a Stronger CSP

Incremental rollout of a nonce-based CSP

Why NOT a whitelist-based CSP?

```
script-src 'self' https://www.google.com;
```



TL;DR Don't use them! They're almost always trivially bypassable.

- >95% of the Web's whitelist-based CSP are bypassable automatically
  - Research Paper: https://ai.google/research/pubs/pub45542
  - Check yourself: http://csp-evaluator.withgoogle.com
  - The remaining 5% might be bypassable after manual review
- Example: JSONP, AngularJS, ... hosted on whitelisted domain (esp. CDNs)
- Whitelists are hard to create and maintain ⟶ breakages

More about CSP whitelists:
ACM CCS '16, IEEE SecDev '16, AppSec EU '17, Hack in the Box '18,

Recap: What is a nonce-based CSP

Content-Security-Policy:

```
script-src 'nonce-r4nd0m' 'strict-dynamic';
object-src 'none'; base-uri 'none';
```

Execute only scripts with the correct *nonce* attribute

```
✔ <script nonce="r4nd0m">kittens()</script>
✘ <script nonce="other-value">evil()</script>
```

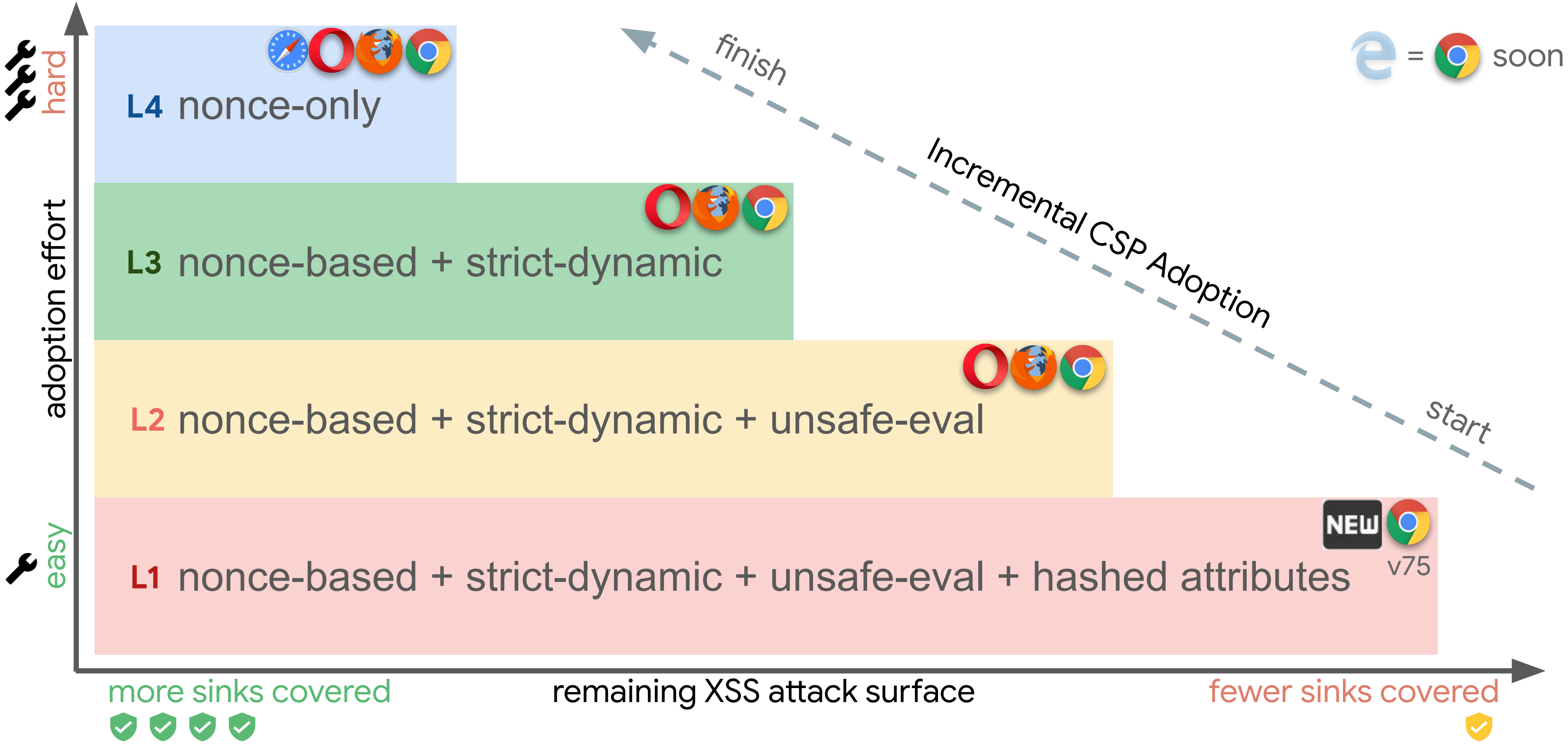
Trust scripts added by already trusted code

```
✔<script nonce="r4nd0m">
   var s = document.createElement('script')
   s.src = "/path/to/script.js";
✔  document.head.appendChild(s);
 </script>
```

Incremental Rollout of a nonce-based CSP

- Trade-off between **covered XSS sinks** vs. **ease of deployment**
- CSP security guarantees are not binary
    - Aim for actual reduction of attack surface instead of "raising the bar"
    - Trivial example: CSP w/o 'unsafe-eval' will block **all** eval-based XSS
- Refactoring work mostly varies based on
    - Type of CSP
    - Application (e.g. how many inline event handlers, use of eval(), size, etc.)

Towards a Stronger nonce-based CSP (Level 1-4)



soon

L2: nonce-based + strict-dynamic + unsafe-eval

```
script-src 'nonce-r4nd0m' 'strict-dynamic' 'unsafe-eval';
object-src 'none'; base-uri 'none';
```

TL;DR Sweet spot! Good trade off between refactoring and covered sinks.

PROs:

+ Reflected/stored XSS mitigated
+ Little refactoring required
  - <script> tags in initial response must have a valid nonce attribute
  - inline event-handlers and javascript: URIs must be refactored
+ Works if you don't control all JS
+ Good browser support

CONs:

- eval() sink not covered
- DOM XSS partially covered
  - e.g. injection in dynamic script creation possible

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L2: nonce-based + strict-dynamic + unsafe-eval

```
script-src 'nonce-r4nd0m' 'strict-dynamic' 'unsafe-eval';
object-src 'none'; base-uri 'none';
```

XSS Sinks Covered:

javascript: URI	✓
data: URI	✓
(inner)HTML context	✓
inline event handler	✓
eval	✘
script#text	✘ ✓ if script is hashed
script#src	✘
AngularJS-like template injection	✘ (✓ if upgraded to Angular 2+ or similar)

L2: nonce-based + strict-dynamic + unsafe-eval

soon

```
script-src 'nonce-r4nd0m' 'strict-dynamic' 'unsafe-eval';
object-src 'none'; base-uri 'none';
```

Common Refactoring Steps:

```
<html>
 <a href="javascript:void(0)">a</a>
 <a onclick="alert('clicked')">b</a>
 <script src="stuff.js"/>
 <script>
  var s =
    document.createElement('script');
  s.src = 'dynamicallyLoadedStuff.js';
  document.body.appendChild(s);
 </script>
</html>
```

```
<html>
 <a href="#">a</a>
 <a id="link">b</a>
 <script nonce="r4nd0m" src="stuff.js"/>
 <script nonce="r4nd0m">
  var s = document.createElement('script');
  s.src = 'dynamicallyLoadedStuff.js'
  document.body.appendChild(s);
  document.getElementById('link')
    .addEventListener('click', alert('clicked'));
 </script>
</html>
```

L3: nonce-based + strict-dynamic

soon

```
script-src 'nonce-r4nd0m' 'strict-dynamic';
object-src 'none'; base-uri 'none';
```

TL;DR Sweet spot! Good trade off between refactoring and covered sinks.

PROs:

+ Reflected/stored XSS mitigated
+ Little refactoring required
  - `<script>` tags in initial response must have a valid nonce attribute
  - inline event handlers and javascript: URIs must be refactored
+ Works if you don't control all JS
+ Good browser support

CONs:

- DOM XSS partially covered
  - e.g. injection in dynamic script creation possible

L3: nonce-based + strict-dynamic

soon

```
script-src 'nonce-r4nd0m' 'strict-dynamic';
object-src 'none'; base-uri 'none';
```

XSS Sinks Covered:

javascript: URI	✓
data: URI	✓
(inner)HTML context	✓
inline event handler	✓
eval	✓
script#text	✘
	✓ if script is hashed
script#src	✘
AngularJS-like template injection	✘ (✓ if upgraded to Angular 2+ or similar)

soon

L3: nonce-based + strict-dynamic

```
script-src 'nonce-r4nd0m' 'strict-dynamic';
object-src 'none'; base-uri 'none';
```

Common Refactoring Steps:

```
<html>
 <a href="javascript:void(0)">a</a>
 <a onclick="alert('clicked')">b</a>
 <script src="stuff.js"/>
 <script>
  var s =
    document.createElement('script');
  s.src = 'dynamicallyLoadedStuff.js';
  document.body.appendChild(s);
  var j = eval('(' + json + ')');
 </script>
</html>
```

```
<html>
 <a href="#">a</a>
 <a id="link">b</a>
 <script nonce="r4nd0m" src="stuff.js"/>
 <script nonce="r4nd0m">
  var s = document.createElement('script');
  s.src = 'dynamicallyLoadedStuff.js'
  document.body.appendChild(s);
  document.getElementById('link')
    .addEventListener('click', alert('clicked'));
 var j = JSON.parse(json);
 </script>
</html>
```

L3.5: **hash**-based + strict-dynamic

soon

```
script-src 'sha256-avWk...' 'strict-dynamic';
object-src 'none'; base-uri 'none';
```

Refactoring steps for **static/single-page apps**:

```
<html>
 <a href="javascript:void(0)">a</a>
 <a onclick="alert('clicked')">b</a>
 <script src="stuff.js"/>
 <script>
  var s =
    document.createElement('script');
  s.src = 'dynLoadedStuff.js';
  document.body.appendChild(s);
 </script>
</html>
```

```
<html>
 <a href="#">a</a>
 <a id="link">b</a>
 <script> // sha256-avWk...
  var urls = ['stuff.js',''dynLoadedStuff.js'];
  urls.map(url => {
    var s = document.createElement('script');
    s.src = url;
    document.body.appendChild(s); });
  document.getElementById('link')
    .addEventListener('click', alert('clicked'));
 </script>
</html>
```

soon

L4: nonce-only

```
script-src 'nonce-r4nd0m';
object-src 'none'; base-uri 'none';
```

TL;DR Holy grail! All traditional XSS sinks covered, but hard to deploy.

PROs:

+ Best coverage of XSS sinks possible in the web platform
+ Supported by all major browsers
+ Every running script was explicitly marked as trusted

CONs:

- Large refactoring required
  - **ALL** `<script>` tags must have a valid `nonce` attribute
  - inline event-handlers and javascript: URIs must be refactored
- You need be in control of all JS
  - all JS libs/widgets must pass nonces to child scripts

soon

L4: nonce-only

```
script-src 'nonce-r4nd0m';
object-src 'none'; base-uri 'none';
```

XSS Sinks Covered:

javascript: URI	✓
data: URI	✓
(inner)HTML context	✓
inline event handler	✓
eval	✓
script#text	✓ (✘ iff untrusted script explicitly marked as trusted)
	✓ if script is hashed
script#src	✓ (✘ iff untrusted URL explicitly marked as trusted)
AngularJS-like template injection	✘ (✓ if upgraded to Angular 2+ or similar)

L4: nonce-only

soon

```
script-src 'nonce-r4nd0m';
object-src 'none'; base-uri 'none';
```

Refactoring Steps:

```html
<html>
 <a href="javascript:void(0)">a</a>
 <a onclick="alert('clicked')">b</a>
 <script src="stuff.js"/>
 <script>
  var s =
    document.createElement('script');
  s.src = 'dynamicallyLoadedStuff.js';
  document.body.appendChild(s);
 </script>
</html>
```

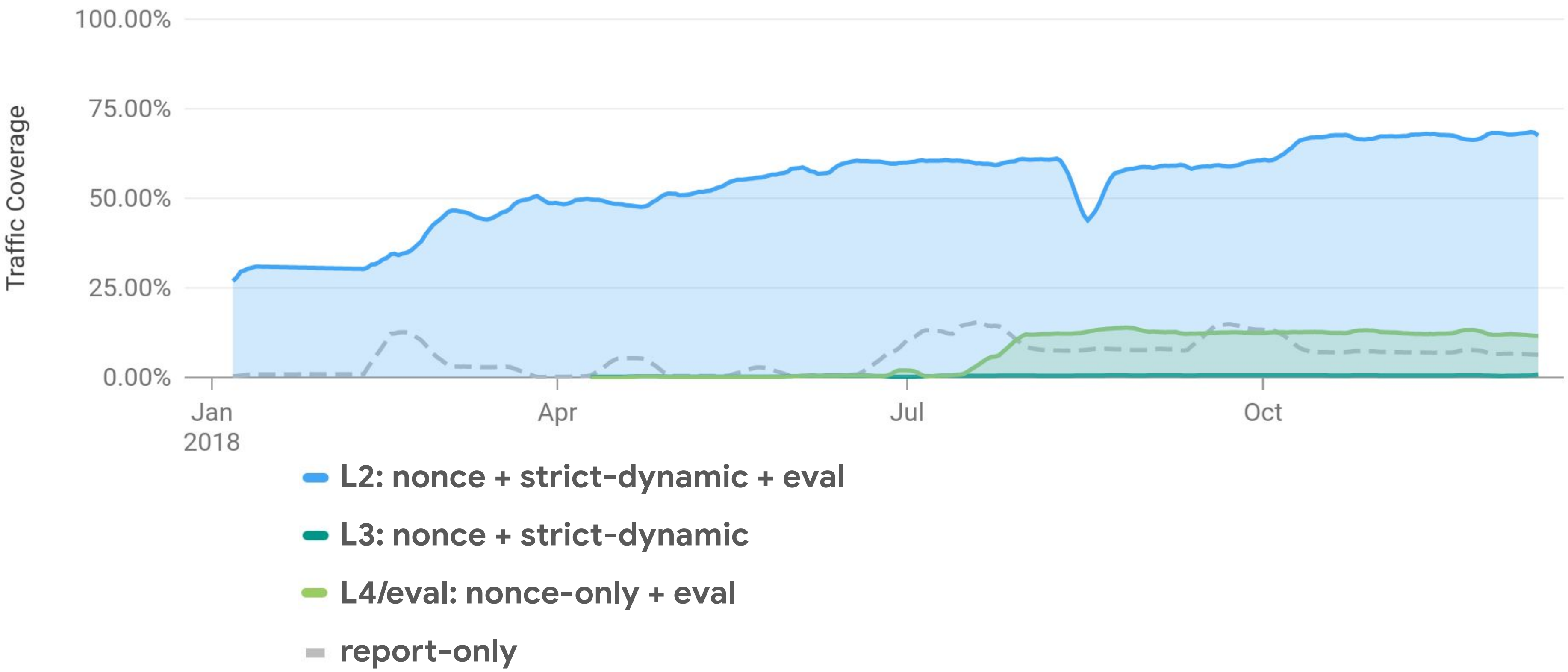
```html
<html>
 <a href="#">a</a>
 <a id="link">b</a>
 <script nonce="r4nd0m" src="stuff.js"/>
 <script nonce="r4nd0m">
  var s = document.createElement('script');
  s.src = 'dynamicallyLoadedStuff.js'
  s.setAttribute('nonce', 'r4nd0m');
  document.body.appendChild(s);
  document.getElementById('link')
    .addEventListener('click', alert('clicked'));
 </script>
</html>
```

XSS Attack Surface by CSP Type

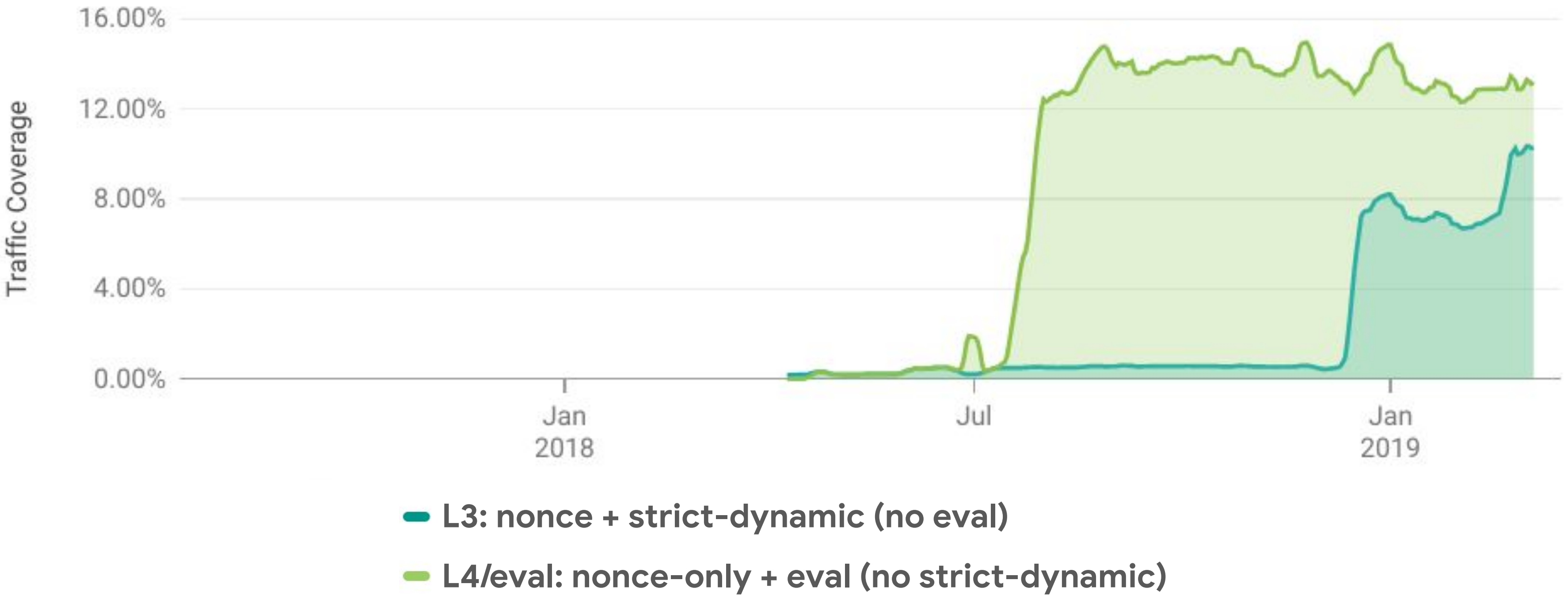
	L1 nonce-based, strict-dynamic, eval, hashed attributes	L2 nonce-based, strict-dynamic, eval	L3 nonce-based, strict-dynamic	L4 nonce only	L5 nonce only, whitelist	Trusted Types
javascript: URI	✓	✓	✓	✓	✓	~(1)
data: URI	✓	✓	✓	✓	✓	~(1)
(inner)HTML context	✓	✓	✓	✓	✓	~(1)
inline event handler	~	✓	✓	✓	✓	~(1)
eval	✗	✗	✓	✓	✓	✓
script#text	✗	✗	✗	~	~	✓
script#src	✗	✗	✗	~	✓	✓
AngularJS-like template injection	✗	✗	✗	✗	✗	~

1) limited to DOM XSS

CSP Coverage at Google by Type (2018)



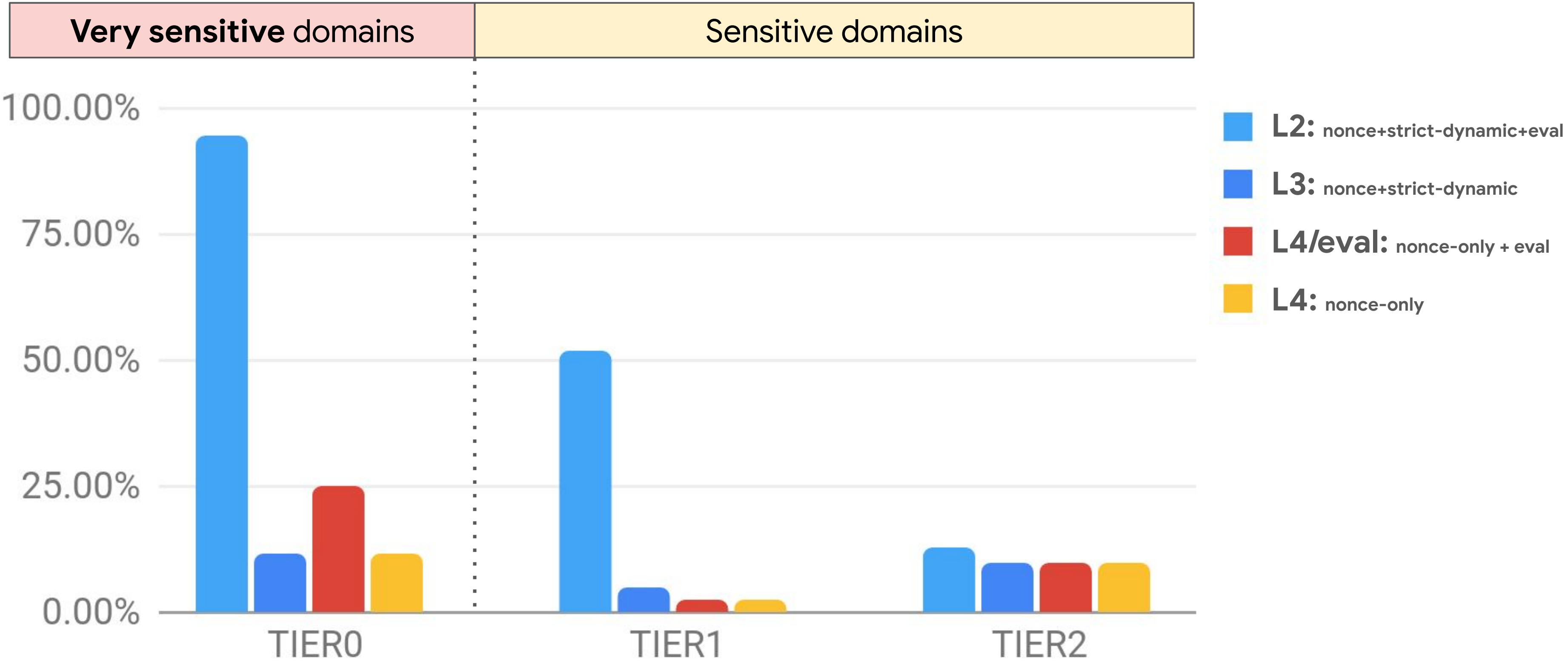
CSP Coverage at Google by Type (excl. L2, 2019)



CSP Types @Google (examples)

		L2: nonce+strict-dynamic+eval	L4/eval: nonce-only + eval	L3: nonce+strict-dynamic
	Domain Tier	Strict CSP ▼	Nonce-only	No Eval
+ accounts.google.com	TIER0	100.00%	47.62%	8.74%
+ chrome.google.com	TIER0	100.00%	99.97%	0.45%
+ myactivity.google.com	TIER1	100.00%	13.90%	13.90%
+ meet.google.com	TIER1	100.00%	21.10%	0.03%
+ passwords.google.com	TIER0	100.00%	100.00%	0.00%
+ notifications.google.com	TIER1	100.00%	100.00%	100.00%
+ takeout.google.com	TIER0	100.00%	100.00%	0.00%
+ remotedesktop.google.com	TIER0	100.00%	100.00%	100.00%
+ cloudsearch.google.com	TIER0	100.00%	100.00%	100.00%
+ issuetracker.google.com	TIER0	100.00%	100.00%	0.00%
+ script.google.com	TIER0	100.00%	0.02%	0.60%
+ *.meet.google.com	TIER1	100.00%	7.69%	7.69%
+ source.cloud.google.com	TIER1	100.00%	0.00%	100.00%
+ dev.cloud.google.com	TIER1	100.00%	0.00%	100.00%
+ lers.google.com	TIER1	100.00%	0.00%	100.00%
+ console.actions.google.com	TIER0	100.00%	0.00%	0.00%
+ console.cloud.google.com	TIER0	100.00%	0.00%	0.00%

CSP Types @Google by Domain Sensitivity (2019)



Advanced CSP Techniques

Guru section ahead!

New in CSP3 - script-src-elem and script-src-attr

script-src-elem

- applies to all script requests and inline script blocks.
- unlike script-src, this directive doesn't control attributes that execute scripts (inline event handlers)

script-src-attr

- controls attributes e.g. inline event handlers
- **'unsafe-hashes'** keyword allows the use of hashes for inline event handlers
- overrides the **script-src** directive for relevant checks.

(**style-src-elem** and **style-src-attr** are similar)

NEW v75

L1: nonce-based + strict-dynamic + unsafe-eval + hashed attributes

```
script-src-attr 'unsafe-hashes' 'sha256-....';
script-src-elem 'nonce-r4nd0m' 'strict-dynamic' 'unsafe-eval';
object-src 'none'; base-uri 'none';
```

TL;DR Only use if you can't refactor inline event handlers / javascript: URIs

PROs:

+ Almost no refactoring required
    - `<script>` tags in initial response must have a valid nonce attribute
+ Strictly better than no CSP
  → Good starting point

CONs:

- Many sinks not covered (see next slide)
- Currently only supported in Chrome v75+
- In case of HTML injection
  → hashed event-handlers can be chained (ROP-like)

PoC: https://poc.webappsec.dev/csp/hashed_attr_csp.html

NEW v75

L1: nonce-based + strict-dynamic + unsafe-eval + hashed attributes

```
script-src-attr 'unsafe-hashes' 'sha256-....';
script-src-elem 'nonce-r4nd0m' 'strict-dynamic' 'unsafe-eval';
object-src 'none'; base-uri 'none';
```

XSS Sinks Covered:

javascript: URI	✓
data: URI	✓
(inner)HTML context	✓
inline event handler	~ (all hashed event handlers can be reused)
eval	✘ (✓ if 'unsafe-eval' removed from CSP)
script#text	✘
	✓ if script is hashed instead of nonced
script#src	✘
AngularJS-like template injection	✘ (✓ if upgraded to Angular 2+ or similar)

NEW v75

L1: nonce-based + strict-dynamic + unsafe-eval + hashed attributes

```
script-src-attr 'unsafe-hashes' 'sha256-jE1Jw...' 'sha256-rRMdk...';
script-src-elem 'nonce-r4nd0m' 'strict-dynamic' 'unsafe-eval';
object-src 'none'; base-uri 'none';
```

Required Refactoring:

```
<html>
 <a href="javascript:void(0)">
 <a onclick="alert('clicked')">
 <script>alert('hi')</script>
 <script src="stuff.js"/>
</html>
```

```
<html>
 <a href="javascript:void(0)">  // sha256-rRMdk...
 <a onclick="alert('clicked')">// sha256-jE1Jw...
 <script nonce="r4nd0m">alert('hi')</script>
 <script nonce="r4nd0m" src="stuff.js"/>
</html>
```

NEW v75

L1.5: hash-based + strict-dynamic + hashed attributes

```
script-src-attr 'unsafe-hashes' 'sha256-jE1Jw...' 'sha256-rRMdk...';
script-src-elem 'sha256-CXAtY...' 'strict-dynamic';
object-src 'none'; base-uri 'none';
```

Refactoring steps for static/single-page apps:

```html
<html>
 <a href="javascript:void(0)">
 <a onclick="alert('clicked')">
 <script src="stuff.js"/>
</html>
```

```html
<html>
 <a href="javascript:void(0)">  // sha256-rRMdk...
 <a onclick="alert('clicked')"> // sha256-jE1Jw...
 <script>  // sha256-CXAtY...
  var s = document.createElement('script');
  s.src = 'stuff.js'
  document.body.appendChild(s); // allowed by strict-dynamic
 </script>
</html>
```

Double Policies - The Best of Both Worlds

```
script-src 'nonce-r4nd0m'; object-src 'none'; base-uri 'none';
```

```
script-src 'self';
```

- More than one CSP header per response!
- Every CSP is enforced independently of each other by the browser
  - Adding additional CSPs can only add constraints
  - e.g. in order to run a script has to pass **every** CSP on the response!
- This allows very advanced setups
  - e.g. instead of allowing a script to load if it's whitelisted **OR** has a nonce (single CSP), it is possible to enforce that the script is from a trusted origin **AND** has a nonce
- Multiple CSPs can either be set via
  - multiple response headers
  - or in a single response header split via **,** (comma) - RFC 2616

Double Policies - Example

CSP#1 CSP#2

```
script-src 'self', script-src 'nonce-r4nd0m'; object-src 'none'; base-uri 'none';
```

Allowed - ✓ CSP#1, ✓ CSP#2 - script has nonce and is hosted on same domain

```
<html>
 ✓ <script nonce="r4nd0m" src="foo.js"></script>
</html>
```

Blocked - ✓ CSP#1, ✘ CSP#2 - missing nonce attribute

```
<html>
 ✘ <script src="foo.js"></script>
</html>
```

Blocked - ✘ CSP#1, ✓ CSP#2 - domain not whitelisted

```
<html>
   ✘ <script nonce="r4nd0m" src="example.org/foo.js"></script>
</html>
```

L5: Double Policy: separate whitelist + nonce-only

```
script-src 'self', script-src 'nonce-r4nd0m'; object-src 'none'; base-uri 'none';
```

TL;DR Very hard to deploy (approach also makes sense for 'strict-dynamic' CSPs)

PROs:

+ Can block XSS where
  - nonced/trusted scripts get redirected
  - injection into script#src

CONs:

- Large refactoring required
- Additional burden of creating/maintaining whitelist
- Complex approach

L5: Double Policy: separate whitelist + nonce-only

```
script-src 'self', script-src 'nonce-r4nd0m'; object-src 'none'; base-uri 'none';
```

XSS Sinks Covered:

javascript: URI	✓
data: URI	✓
(inner)HTML context	✓
inline event handler	✓
eval	✓
script#text	✓ (✘ iff untrusted script explicitly marked as trusted)
	✓ if script is hashed
script#src	✓ (only scripts from whitelisted domains, due to double policy usual whitelist bypasses don't apply!)
AngularJS-like template injection	✘ (✓ if upgraded to Angular 2+ or similar)

CSP Beyond XSS - What About <style> Injections?

```
style-src-elem 'nonce-r4nd0m';
style-src-attr 'unsafe-inline';
```

- Aims to block CSS attacks by requiring CSP nonces for <style> tags:
  - CSS Keylogger - https://github.com/maxchehab/CSS-Keylogging
  - @import-based - https://medium.com/@d0nut/better-exfiltration-via-html-injection-31c72a2dae8b
- <style> tags are more powerful (CSS selectors!) than inline style attributes
- Reduces refactoring effort to noncing of <style> blocks
- `style-src 'nonce-r4nd0m'` would be better (stricter)
  - but much harder to deploy, because **all** inline styles would need to get refactored
- Can be combined with `script-src` CSP directives

Productionizing CSP

Better reporting and browser fallbacks

Meaningful CSP Reports

```
script-src 'nonce-r4nd0m' 'strict-dynamic' 'report-sample'; report-uri /csp;
object-src 'none'; base-uri 'none';
```

- Add the **'report-sample'** keyword to the script-src directive
  → inline violations will contain a sample of the blocked expression
- Allows to differentiate between blocked inline scripts and inline event handlers
- Allows to identify which script was blocked
  → Possible to identify false positives (e.g. noise due to browser extensions)
- Example report:

```
csp-report:
  blocked-uri:"inline"
  document-uri:"https://f.bar/foo"
  effective-directive:"script-src"
  script-sample:"hello(1)"
```

Overview of CSP Fallbacks

ignored	in presence of	since version
`'unsafe-inline'`	`'nonce-...'`	CSP v2
	`'sha256-...'`	CSP v2
https:, http:, any.whitelist.com	`'strict-dynamic'`	CSP v3
`script-src` (for elements)	`script-src-elem`	CSP v3
`script-src` (for attributes)	`script-src-attr`	CSP v3
`style-src` (for elements)	`style-src-elem`	CSP v3
`style-src` (for attributes)	`style-src-attr`	CSP v3

Fallbacks for Old Browsers

```
script-src 'nonce-r4nd0m' 'strict-dynamic' https: 'unsafe-inline';
object-src 'none'; base-uri 'none';
```

ignored

not supported

CSP as seen by CSP3 Browser

```
script-src 'nonce-r4nd0m' 'strict-dynamic' https: 'unsafe-inline';
object-src 'none'; base-uri 'none';
```

CSP as seen by CSP2 Browser

```
script-src 'nonce-r4nd0m' 'strict-dynamic' https: 'unsafe-inline';
object-src 'none'; base-uri 'none';
```

CSP as seen by CSP1 Browser

```
script-src 'nonce-r4nd0m' 'strict-dynamic' https: 'unsafe-inline';
object-src 'none'; base-uri 'none';
```

Conclusions

Enough! What should I remember of this talk?

Wrapping up

- Nonce-based CSPs cover the classical reflected/stored XSS very well
- A nonce-based CSP with 'strict-dynamic'
  - is a good trade-off between security and adoption effort
  - covers classical reflected/stored XSS very well
  - has limitations when it comes to DOM XSS
  - was able to block 60%-80% of externally reported XSS at Google
- If possible upgrade to nonce-only
- CSP is a defense-in-depth mechanism
  - it's meant to protect the user when primary security mechanisms (e.g. escaping) fail
  - it's not an excuse to not fix underlying bugs
- Always double check your CSP with the CSP Evaluator: csp-evaluator.withgoogle.com

In Brief

Use a **nonce-based CSP with strict-dynamic:**

```
script-src 'nonce-r4nd0m' 'strict-dynamic';
object-src 'none'; base-uri 'none';
```

L3

If possible, upgrade to a **nonce-only CSP**:

```
script-src 'nonce-r4nd0m';
object-src 'none'; base-uri 'none';
```

L4

Recommended reading: csp.withgoogle.com

#LocoMocoSec

Kauai, Hawaii

2019

Mahalo! 🤙

Questions?

Slides:

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