Trusted Types - W3C TPAC

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https://github.com/WICG/trusted-types
Slides: https://tinyurl.com/tttpac

DOM XSS

DOM XSS is a growing, prevalent problem

source ⇒ sink

`location.hash ⇒ bar.innerHTML`

- At Google, DOM XSS is already **the most common XSS variant**

Reasons:

- Growing complexity of client-side code
- Easy to introduce, hard to prevent & detect

DOM XSS is **easy to introduce**

- DOM API has ~70 sinks that can result in JavaScript execution

```
innerHTML, HTMLScriptElement.src, eval()
```

- These sinks are extremely common in applications
- DOM API “insecure by default”

```
(input) => document.querySelector('log').innerHTML = input
```

DOM XSS is **hard to detect**

- Sources far away from sinks, complex data flows (e.g. server roundtrip)
- **Static** checks don’t work reliably:

```
foo.innerHTML = bar // what is bar?
foo[(_ => "innerHTML")()] = bar
foo[k] = v
```

- **Manual review** is infeasible
- **Dynamic** (taint-tracking, fuzzing) has a small code coverage

DOM XSS is **hard to mitigate**

- **HTML Sanitization, CSP -** bypasses via [script gadgets]

```
<div data-role=popup id='--><script>"use strict"
alert(1)</script>'></div>

<template is=dom-bind><div
c={{alert('1',ownerDocument.defaultView)}}
b={{set('_rootDataHost',ownerDocument.defaultView)}}>
</div></template>
```

- **In-browser XSS filters** - DOM XSS [out of scope]

Addressing DOM XSS @ Google

Safe HTML Types

- Stop tracking a **string**, leverage the **type system**
- https://github.com/google/safe-html-types/blob/master/doc/safehtml-types.md
- Wrappers for strings, representing values known to be safe to use in various HTML contexts and with various DOM APIs:
  - `SafeHTML (<b>I'm safe</b>)`
  - `SafeURL (https://click.me)`
  - `TrustedResourceURL (https://i.am.a/script.js)`
  - `...`

Producing Safe HTML types

- **Producing** the typed value is safe by construction

```
goog.html.SafeHtml.create("DIV", {"benign": "attributes"}, "text");
```

- ... or sanitization (integrate with your sanitizers, templating systems, ...)

```
goog.html.SafeUrl.sanitize(untrustedUrl);
```

- or gets reviewed manually

```
goog.html.uncheckedconversions.safeUrlFromStringKnownToSatisfyTypeContract(
"url comes from the server response", url);
```

Consuming Safe HTML types

- A typed object is propagated throughout the application code
- Taint tracking not necessary
- Wrappers over DOM XSS sinks that **accept only** typed values

```
goog.dom.safe.setLocationHref(locationObj, safeURL)
```

- Compiler prohibits the use of native sinks

```
let foo = “bar”; location.href = foo
```

Compile error!

Safe HTML Types advantages

- DOM is **secure by default**
- Only the code **producing a safe type** can introduce XSS
- Reduce the security-relevant code by **orders of magnitude**
  - Stable components (sanitizers, templating libs)
  - Custom application code producing the types
  - Scales extremely well (<1 headcount for all of Google)
- Very successful at preventing XSS
- … as understood by the compiler

Safe HTML Types limitations

- Reliance on compilation
  - Not all code is compiled
  - Different compilation units
  - Cross-language boundaries
- Compiler limitations
  - JS type system is unsound
  - Reflection, dynamic code
  - Missing type information
  - False positive/false negative tradeoff
- No protection at runtime

Trusted Types

Safe HTML types built into the platform

Trusted Types

1. API to create string-wrapping objects of a few types:
    a. **TrustedHTML** (.innerHTML)
    b. **TrustedURL** (a.href)
    c. **TrustedScriptURL** (script.src)
    d. **TrustedScript** (el.onclick)

    TrustedURL<"//foo">.toString() == "//foo"

2. Opt-in enforcement:
    Make DOM XSS sinks accept only the typed objects

Trusted Types

Without enforcement:

- Use types in place of strings with no breakage
- Backwards compatible (use the light polyfill defining the types)

With enforcement:

- DOM XSS attack surface reduction - **minimizing the trusted codebase**
- Only the code producing the types can introduce DOM XSS
- Design facilitates limiting the “DOM XSS capability” via policies

Trusted Types - policies

Policy

```
const myPolicy = TrustedTypes.createPolicy('my-policy', {
  createHTML(html) {
    return mySanitizer(html)
  },
  createScriptURL(url) {
    const u = new URL(url, document.baseURI)
    if (u.origin === window.origin)
      return u.href;
    throw new TypeError('Invalid URL!')
  }
})
```

Sanitize HTML

Name

Only same origin scripts

Rules

Trusted Types - creating & using types

```
> document.body.innerHTML = myPolicy.createHTML(location.hash);
Running mySanitizer…

> document.body.innerHTML = location.hash
TypeError: HTMLBodyElement.innerHTML requires TrustedHTML assignment
(dispatch a securitypolicyviolation event?)
```

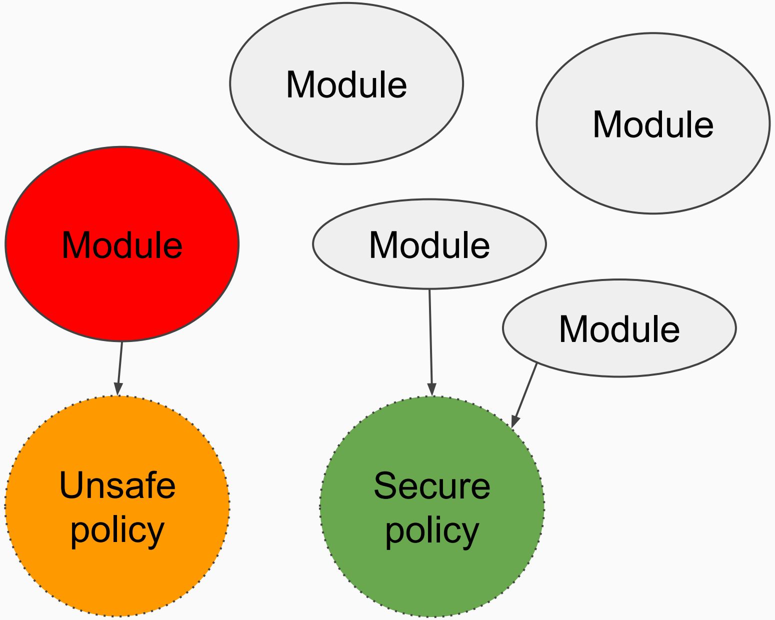
Trusted Types - guarding policy usage

```
(function() {
  // Seemingly unsafe policy
  const unsafePolicy = TrustedTypes.createPolicy('unsafefoo', {
    createHTML: (s) => s,
  });

  // No XSS because of the usage limitation
  return fetch('/get-html')....then(
    (response) => unsafePolicy.createHTML(response)
  );
})();
```

Trusted Types - guarding policy usage

- Only the code **calling an insecure policy** can cause DOM XSS
- Policy reference similar to a CSP script nonce
- Rest of codebase is “DOM XSS neutral”
- Enables gradual adoption with **immediate security benefits**
- Example blogging application - DOM XSS can only be caused by a Markdown renderer.



Enforcement & guarding policy creation

An X-Bikeshed-Later[*] response header with a list of allowed policy names:

Content-Security-Policy: trusted-types foo bar

```
TrustedTypes.createPolicy('foo', ...) // OK
TrustedTypes.createPolicy('bar', ...) // OK
TrustedTypes.createPolicy('baz', ...) // Policy disallowed
```

Content-Security-Policy: trusted-types *

[*] For now, Content-Security-Policy

Policies

- Trusted objects can be created via **policies**
- A policy defines application-specific rules to create types
- Multiple policies can coexist
  - A strict HTML sanitizer for the comment editing section
  - A custom one for application templating system
- Limit policy creation
  - Response header value
- Limit policy usage
  - Guard the reference
  - Example: HTML sanitizers need a no-op policy to use internally only

Trusted Types status

Implementations:

- Chrome - http://crbug/739170, http://w3c-test.org/trusted-types/

  ```
  google-chrome-unstable --enable-blink-features=TrustedDOMTypes
  --enable-experimental-web-platform-features
  ```

- Polyfill - https://github.com/WICG/trusted-types
  - https://wicg.github.io/trusted-types/demo/
- Tinyfill - `TrustedTypes={createPolicy:(n, rules) => rules}`

Trusted Types status

Integration trials

- JS libraries and frameworks: DOM interpolation, templating
  - Angular, Polymer + https://github.com/Polymer/polymer-resin
  - Pug - https://github.com/mikesamuel/pug-plugin-trusted-types
- External examples:
  - Sanitizers: http://koto.github.io/DOMPurify/demos/trusted-types-demo.html
  - Angular app: gothinkster/angular-realworld-example-app - 44 lines ugly patch
  - React app gothinkster/react-redux-realworld-example-app - trivial patch
- Internally - adopting Trusted Types at Google applications

Summary

- Makes DOM XSS **easy to detect** & **difficult to introduce**
    - Based on a solution with proven track record
      (most core Google applications use it)
    - Promotes containing security-relevant code
    - Power to the authors (custom rules, multiple policies)
    - Control to the security teams (policy review, header control)

- Backwards-compatible, polyfillable
- **Easy to implement** in UAs (1Q 2*intern project at Google)
- **Extensible**: more types, browser-provided policies, userland libraries