Are your Sites Truly Isolated?

Automatically Detecting Logic Bugs in Site Isolation Implementations

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February 25, 2026

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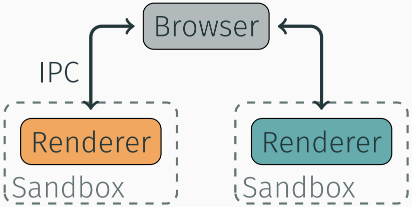
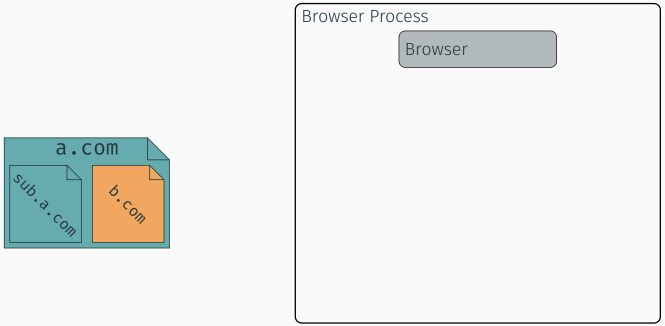
Site Isolation

- 1 renderer process per site[1]
- site = scheme + eTLD+1
- inter-process communication (IPC)



[1] Reis, Moshchuk, and Oskov, “Site Isolation: Process Separation for Web Sites within the Browser.”

Site Isolation Architecture



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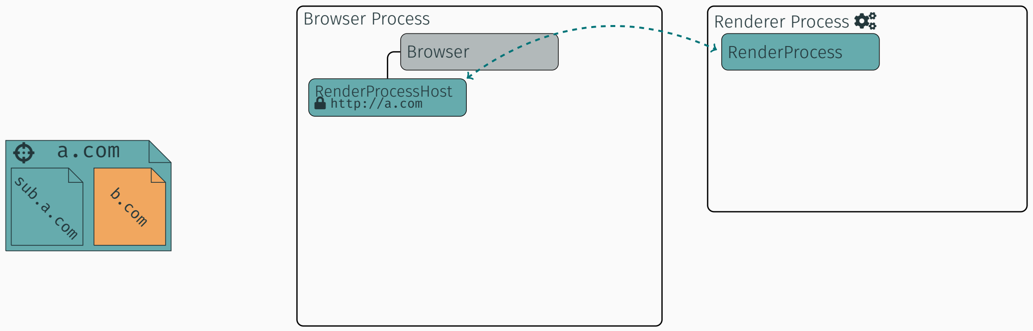

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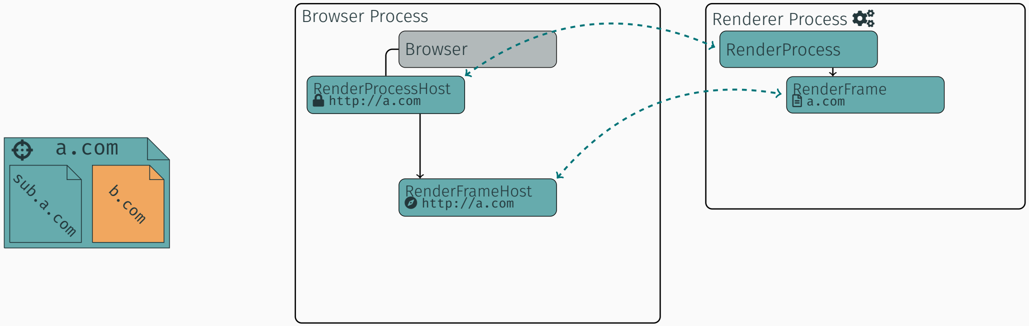

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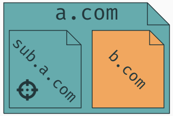

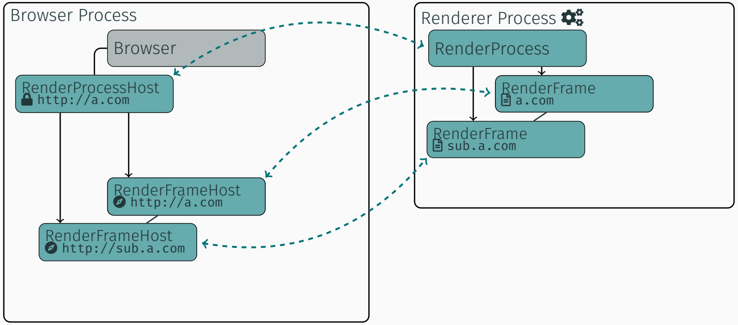

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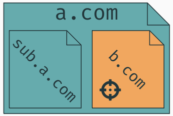

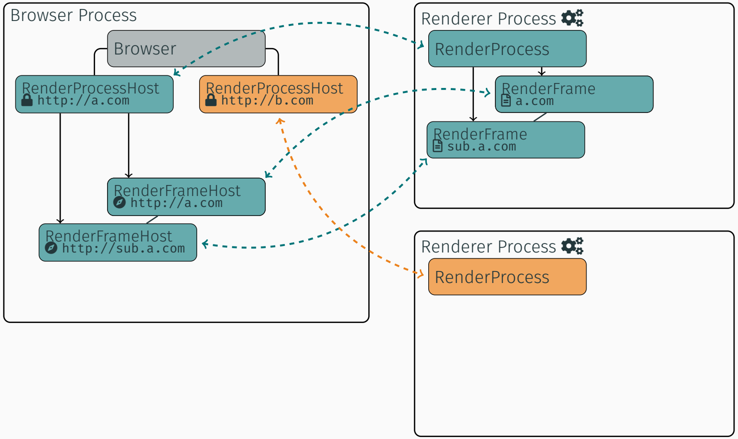
Browser Process
Browser
RenderProcessHost http://a.com
RenderProcessHost http://b.com
RenderFrameHost http://a.com
RenderFrameHost http://sub.a.com
Renderer Process
RenderProcess
RenderFrame a.com
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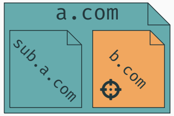

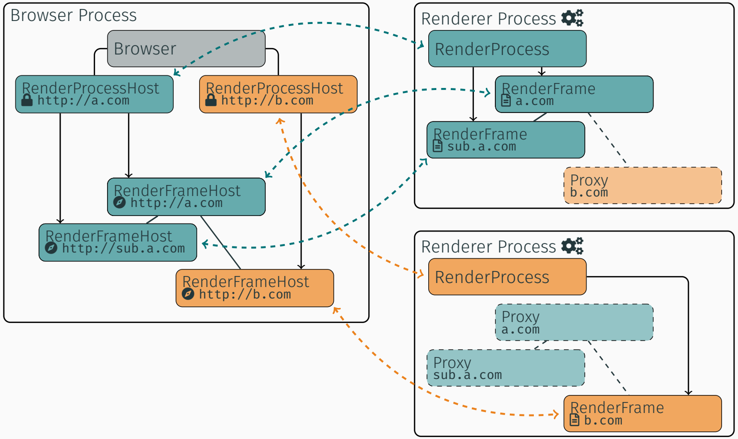

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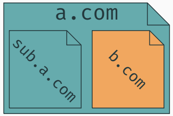
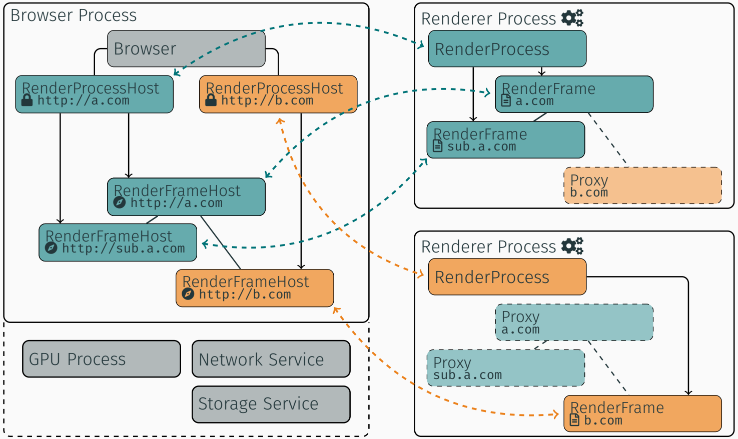


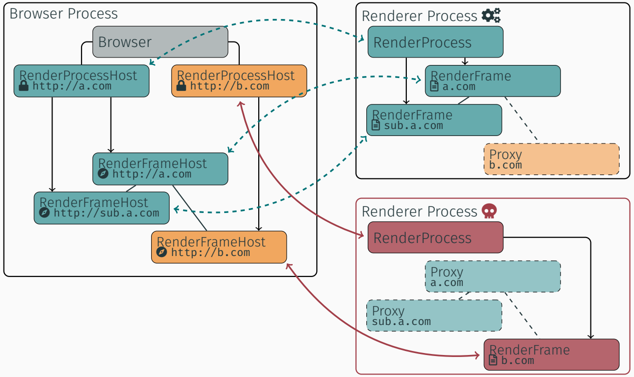


Site Isolation Bypass

Causes:

1. Missing Security Checks
2. Bypassed Security Checks
3. Origin Confusion

→ Semantic bug



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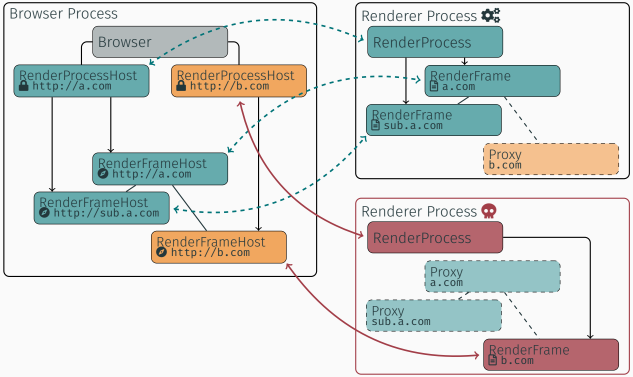

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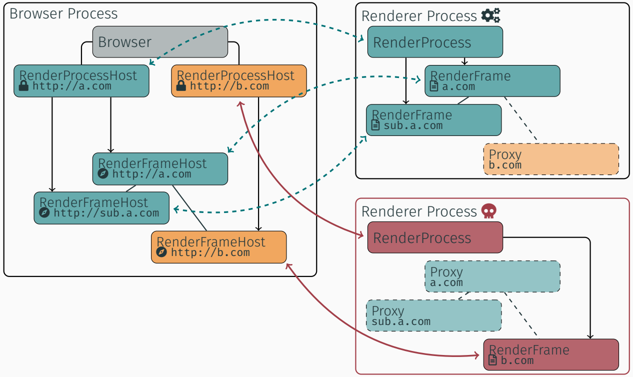

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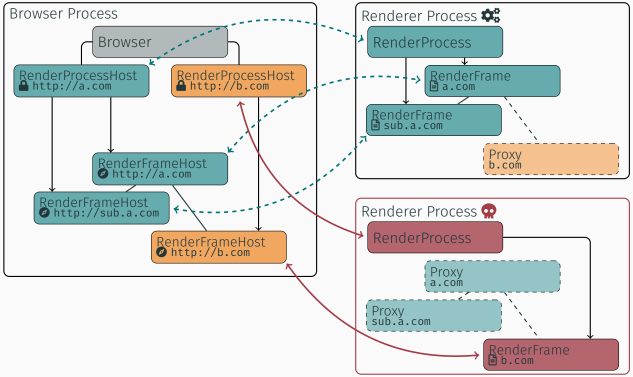

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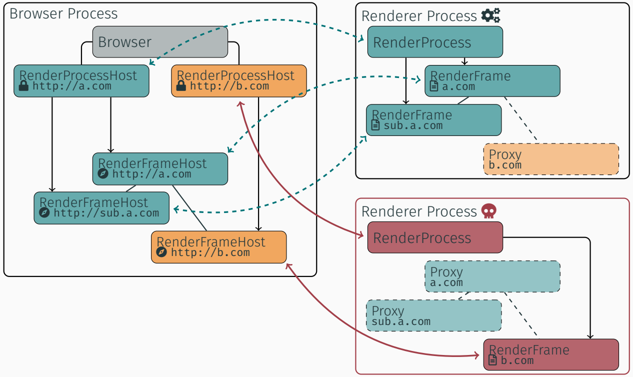
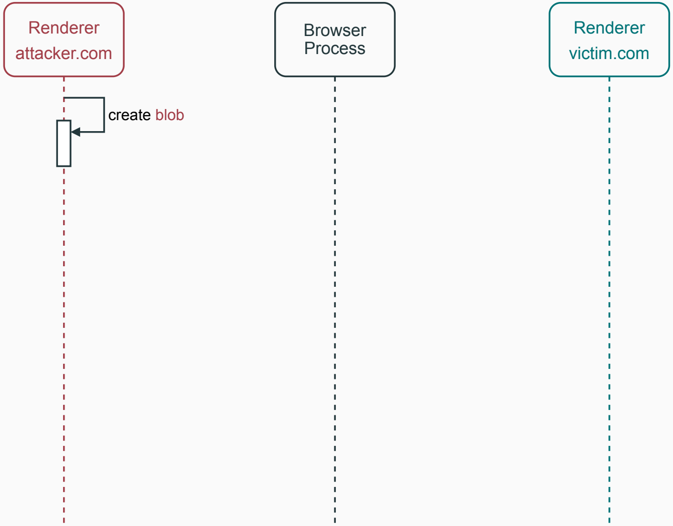


SI Bypass Example: CVE-2018-18345



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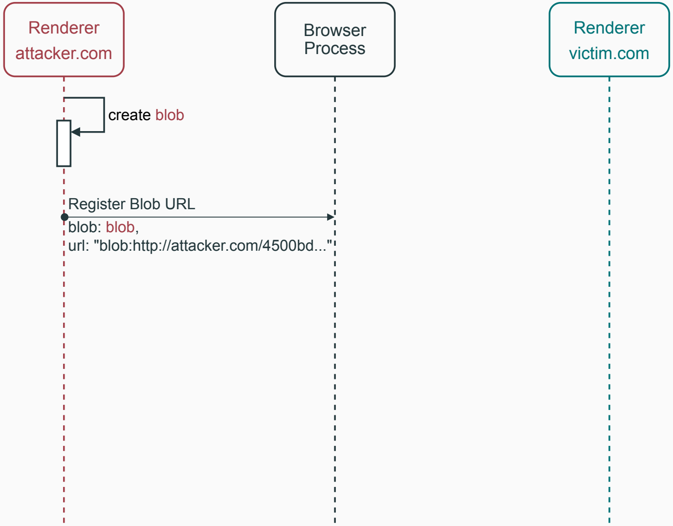

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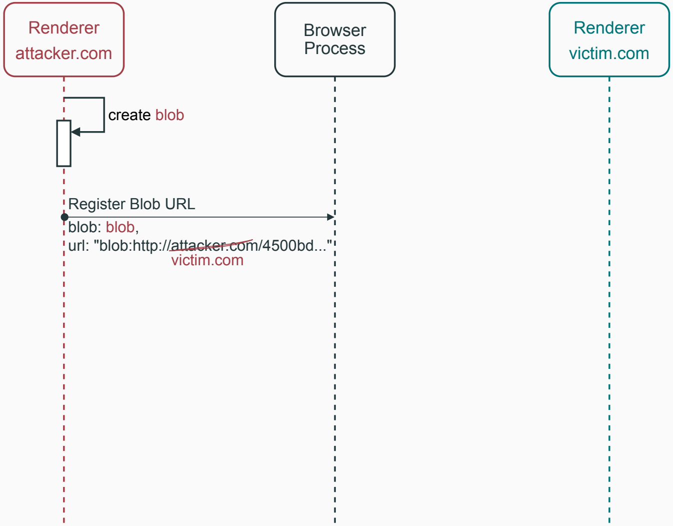

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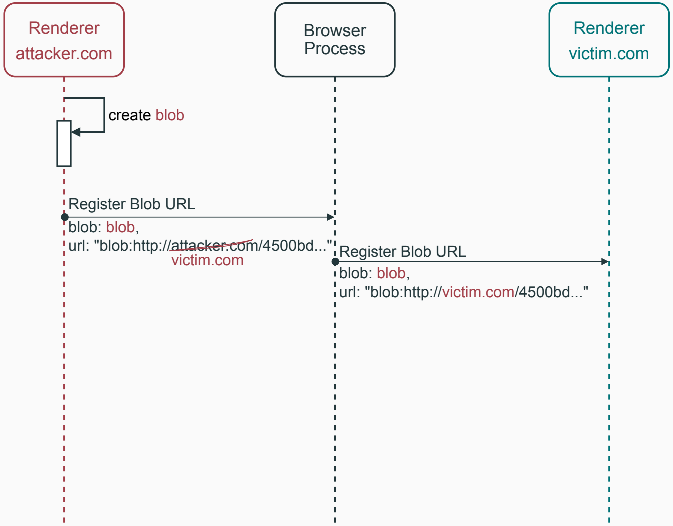

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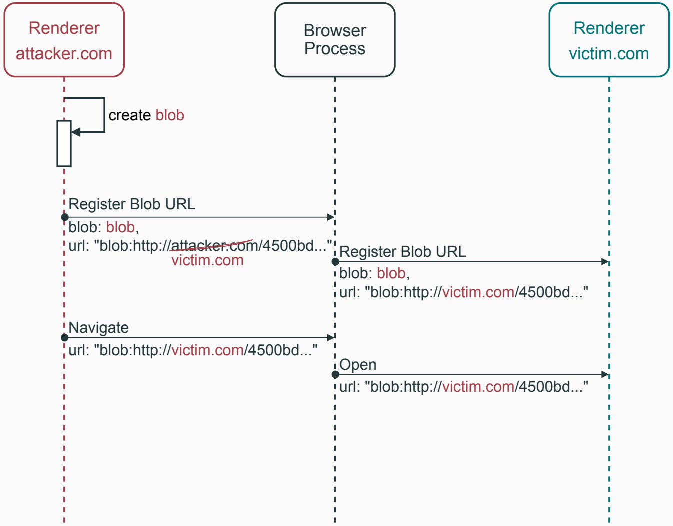
Renderer
attacker.com
Browser Process
Renderer
victim.com
create blob
Register Blob URL
blob: blob,
url: "blob:http://~~attacker.com~~/4500bd..."
victim.com
Register Blob URL
blob: blob,
url: "blob:http://victim.com/4500bd..."
Navigate
url: "blob:http://victim.com/4500bd..."
Open
url: "blob:http://victim.com/4500bd..."

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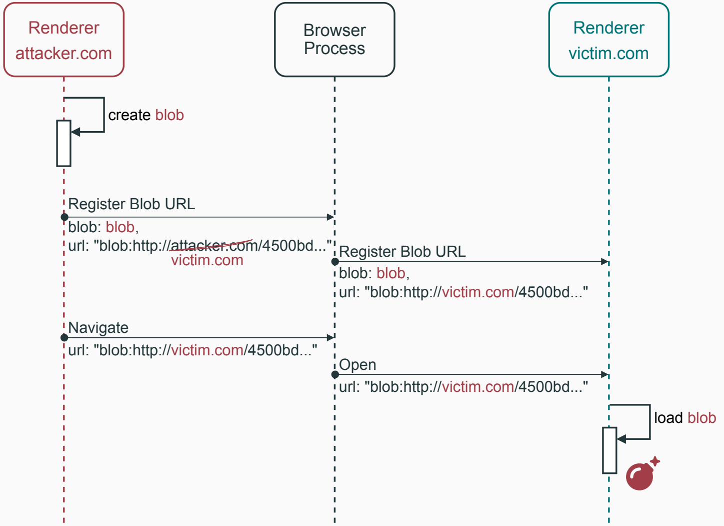
Renderer
attacker.com
Browser Process
Renderer
victim.com
create blob
Register Blob URL
blob: blob,
url: "blob:http://~~attacker.com~~/4500bd..."
victim.com
Register Blob URL
blob: blob,
url: "blob:http://victim.com/4500bd..."
Navigate
url: "blob:http://victim.com/4500bd..."
Open
url: "blob:http://victim.com/4500bd..."
load blob

Design

1. Detection of SI bypass bugs
   ➞ detection at runtime
   ➞ Process Sanitizer & Leak Sanitizer
2. Cover all APIs / IPC interactions
   ➞ WebIDL-based Grammar
3. Complex navigations to trigger Origin Confusion
   ➞ favor navigation API
4. Simulate compromised renderer process
   ➞ mutate IPC messages

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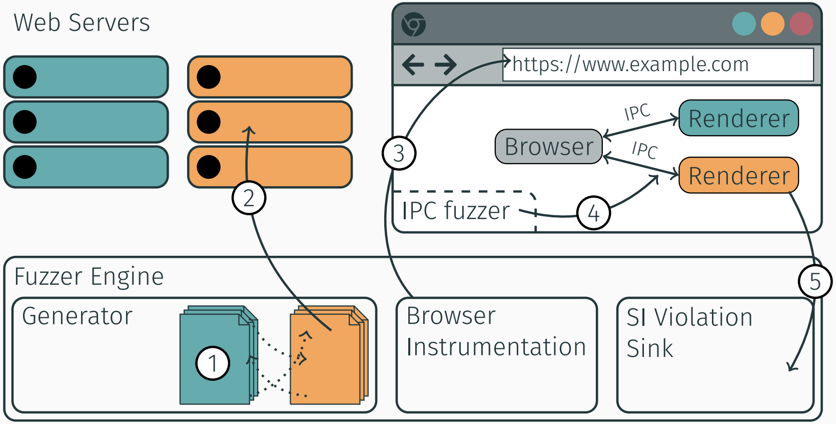
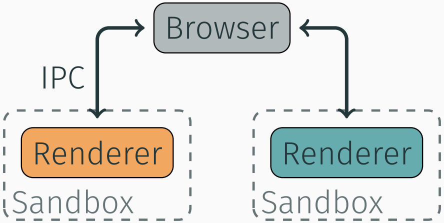
Site Isolation Bypass Fuzzing



Process Sanitizer

→ detect cross-site reuse of renderers

1. input documents contain correct site
2. tag renderer process with site
3. compare document and tag



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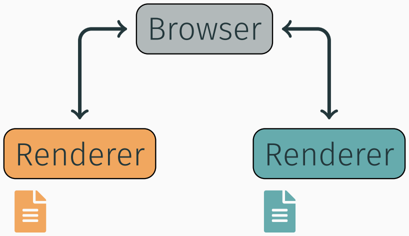

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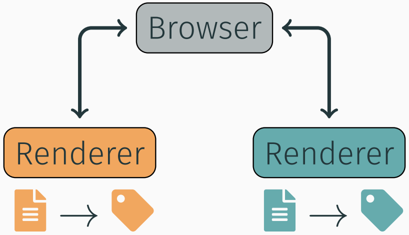

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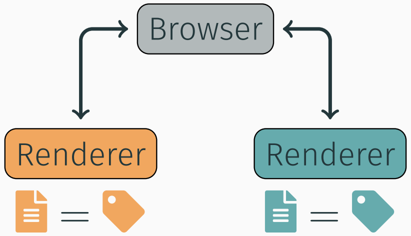

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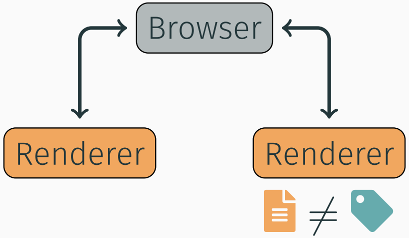

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→ detect data leaks across renderers

1. inject secret string in victim context
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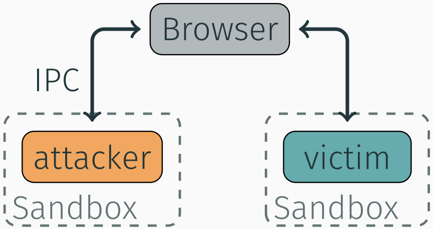

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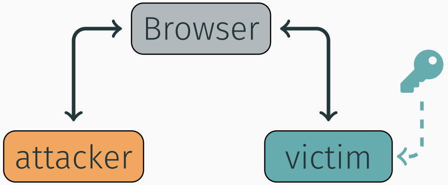

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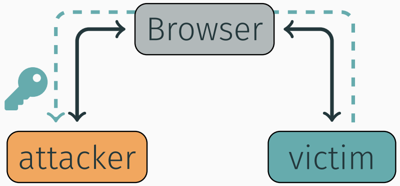

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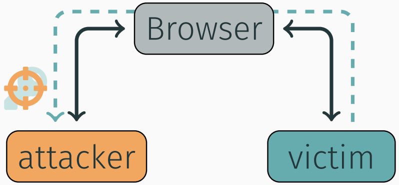
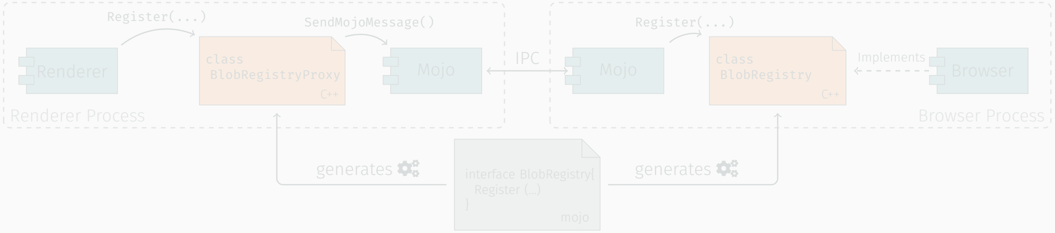


IPC Hooks

- We want...
  - to mutate all IPC messages
  - little changes to the browser code

→ Patch the IPC interface generation



C++ IPC bindings generation in Chrome

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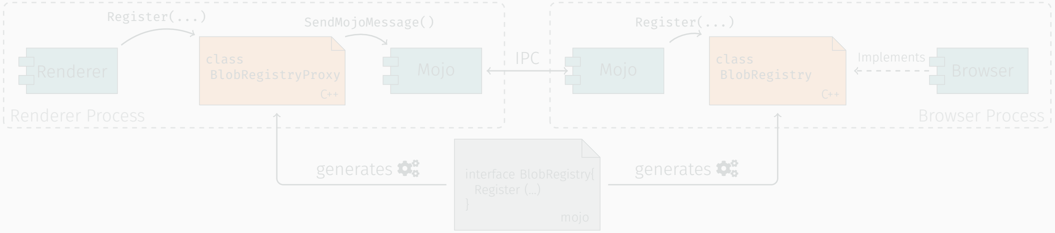

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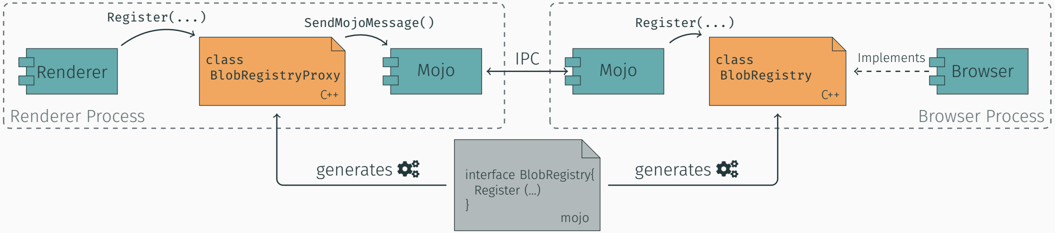

C++ IPC bindings generation in Chrome

IPC Fuzzer JavaScript API

- How to sync JS generation and IPC mutations?

→ JavaScript API to enqueue mutations

→ Reproducible crashes

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let text = `<html><body><script>
            var src = "http://attacker.com";
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IPC Fuzzer JavaScript API

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var blob = new Blob([text], { type: "text/html" });

IPCFuzzer.mutate_url_replace_host("http://victim.com");
var url = URL.createObjectURL(blob);
```

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var blob = new Blob([text], { type: "text/html" });

IPCFuzzer.mutate_url_replace_host("http://victim.com");
var url = URL.createObjectURL(blob);

url = url.replace("attacker.com", "victim.com");
location.href = url;
```
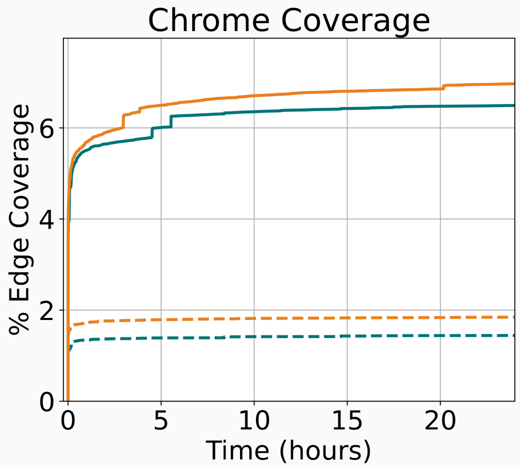
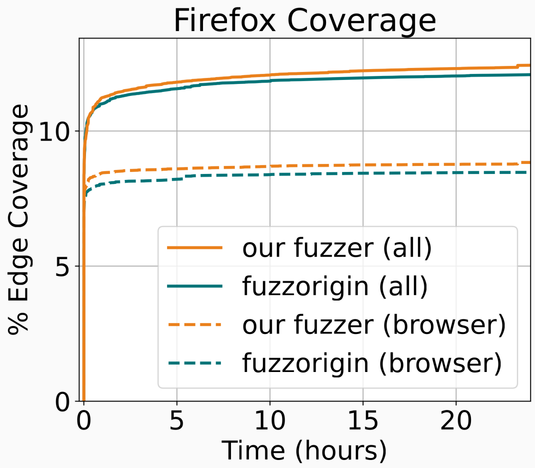

Findings

Browser	Description	Tracker
●	renderer can spoof URL in `history.replaceState`	CVE-2024-9392
◎	`Window.name` leaks on navigation	#384781865†
●	visited URLs are leaked for link colouring	#1938107
●	Cross-Origin-Read-Blocking (CORB) missing	#1532642‡

† Marked Duplicate
‡ Known issue

Coverage Evaluation



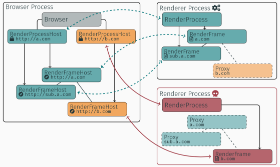


Site Isolation Bypass

Causes:

1. Missing Security Checks
2. Bypassed Security Checks
3. Origin Confusion

→ Semantic bug



Site Isolation Bypass Fuzzing

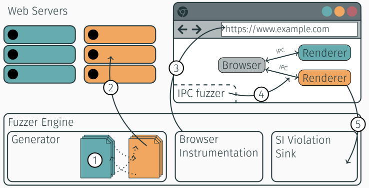


Figure 2: SI Bypass Fuzzer Architecture

Leak Sanitizer

→ detect data leaks across renderers

1. inject secret string in victim context
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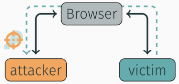
3. detect secret string in ipc messages



Findings

Table 1: SI Bypass Fuzzer Findings

Browser	Description	Tracker
●	renderer can spoof URL in `history.replaceState`	CVE-2024-9392
●	`Window.name` leaks on navigation	#384781865†
●	visited URLs are leaked for link colouring	#1938107
●	Cross-Origin-Read-Blocking (CORB) missing	#1532642‡

† Marked Duplicate
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Questions?

Full Paper:

jan.drescher@tu-braunschweig.de

jan-niklas-drescher-5968081

@jndre@infosec.exchange

References

Reis, Charles, Alexander Moshchuk, and Nasko Oskov. “Site Isolation: Process Separation for Web Sites within the Browser.”. In: 2019, pp. 1661–1678.

Findings: CVE-2024-9392

```
IPCFuzzer.activate_leak_sanitizer();
IPCFuzzer.mutate_url("http://127.0.0.2:8080/victim.html");
window.history.replaceState("foo","", null);
window.location.reload();
```

Proof-of-Concept for Firefox History Confusion

Fuzzer Evaluation

Reproduction on known vulnerabilities

Vulnerability	Chrome Version		Class	Reproduction Time
	Vulnerable	Evaluated		
CVE-2022-1637	< 101.0.4951.64	99.0.4844.84	3	14 minutes
CVE-2019-5856	< 76.0.3809.87	67.0.3396.99	1	1 minute
CVE-2018-18345	< 71.0.3578.80	67.0.3396.99	1	11.4 hours

Oracle Evaluation

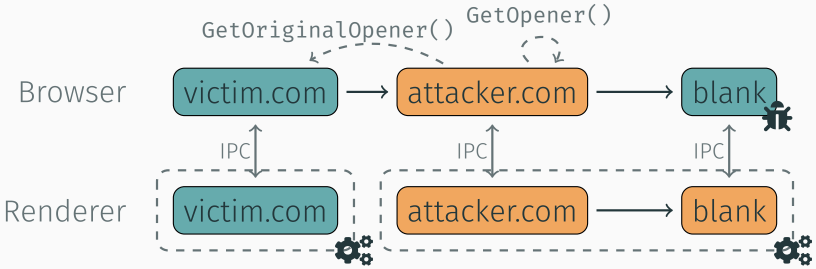
- Add sanitizer to vulnerable browser
- Test if sanitizer detects the PoC exploit

Oracle Evaluation on known PoC's

ID	Class	LeakSan	ProcessSan
CVE-2018-16074	3	○	●
CVE-2019-5773	1	●	○
#40093844	2	●	○
CVE-2024-1671	3	●	○
CVE-2022-3044	1	○	○

SI Bypass Example: CVE-2022-1637

```
let win = window.open('data:,hello', '_blank');
// manipulate IPC message
console.log('Exfiltrated cookies: ' + win.document.cookie);
```



Chrome SI bypass caused by Origin Confusion

Known SI Bypass Vulnerabilities

ID	Description	Class	In Scope
CVE-2024-1671	Origin confusion in session history leaks URL of srcdoc iframe	3	●
CVE-2022-4913	Compromised renderer can access extension storage	1	◑
CVE-2022-3661	Compromised renderer can message any extension content script	1	◑
CVE-2022-3044	No access checks for clipboard interface	1	●
CVE-2022-1637	Cross-origin iframe can spoof the hostname of top-frame by opening new window with `javascript:` URI and target `_blank`	3	●
CVE-2022-0305	Hidden bug report for Service Worker	?	?
CVE-2022-0294	No checks in PushMessaging interface that verify if the referenced ServiceWorker belongs to the same origin as the renderer	1	●
CVE-2022-0292	Fenced frame can open textttfile: URLs	1	●
CVE-2022-0291	Hidden bug report for storage	?	?
#40060671	Compromised renderer can spoof PortContext and claim to be WorkerContext of arbitrary extension	1	◑
CVE-2021-38010	`URLLoader` leaked to ServiceWorker, compromised renderer can read the response of redirected cross-origin requests	1	○
CVE-2021-30507	Compromised renderer can spoof texttX-Chrome-offline header to read arbitrary file	1	○
CVE-2021-21222	TOCTOU bug in `GeneratedCodeCache`: compromised renderer can change value after the hash computation	2	○
CVE-2021-21175	`X-Frame-Options` error of cross-origin iframe is leaked to parent	1	●
#40054801	Compromised renderer that outlives state in the browser process can bypass security checks to spoof origin	2	●
CVE-2020-6435	Compromised renderer can spoof sender id to extension	1	◑
CVE-2020-6385	Origin checks in `BlobURLStoreImpl::Register` skipped if renderer process simulates detachment	2	●
CVE-2020-6380	Compromised renderer can spoof origin, message any extension	1	◑
CVE-2019-13763	Compromised renderer can spoof origin and leak data from textttPaymentManager	1	●
CVE-2019-13738	Sandboxed iframe shares execution context with initial non-sandboxed `about:blank` frame	3	●
CVE-2019-13727	Compromised renderer can create WebSocket to arbitrary URL and leak the response headers	1	●
CVE-2019-13682	Spoofing origin in protocol handler registration leads to SI bypass	1	●
CVE-2019-5865	CORS bypass: compromised renderer can set `Host` header during redirect	1	○
CVE-2019-5862	Compromised renderer can spoof `document_url_` and register arbitrary files from victims site in AppChache	1	○
CVE-2019-5856	Missing browser-side checks, compromised renderer can access filesystem of other origins	1	●
CVE-2019-5773	Compromised renderer can spoof origin when accessing IndexedDB	1	●
#40093845	Compromised renderer can spoof origin and access code cache of other site	1	●
#40093844	Invalid checks on texttttws: URLs, compromised renderer can leak cookies	2	●
CVE-2018-18345	`BlobURLRegistry::RegisterURL` access check based on renderer provided `host` and `public_url`	1	●
CVE-2018-16074	BlobURLs created from different opaque origins have opaque origin but are all handled in the same process	3	●
CVE-2018-16073	Data URL in iframe is loaded in same process if embedding page is loaded from cache	3	●
CVE-2018-6165	Refresh during navigation triggers origin confusion	3	●
CVE-2018-6121	Compromised renderer can commit url of extension	1	●
#40092826	Cookies leaked to cross-site renderer in presence of DevTools	1	●
#40092525	Compromised renderer can spoof origin during filesystem url creation	1	●

Mojo IDL Example

```
module blink.mojom;

import "mojo/public/mojom/base/unguessable_token.mojom";
import "services/network/public/mojom/url_loader_factory.mojom";
import "third_party/blink/public/mojom/blob/blob.mojom";
import "url/mojom/url.mojom";

interface BlobURLStore {
  // TODO(https://crbug.com/1376126): This should probably create and return a
  // new blob: URL rather than letting the caller in the renderer provide one.
  [Sync] Register(
      pending_remote<blink.mojom.Blob> blob,
      url.mojom.Url url) => ();

  Revoke(url.mojom.Url url);

  ResolveAsURLLoaderFactory(
    url.mojom.Url url,
    pending_receiver<network.mojom.URLLoaderFactory> factory);

  ResolveAsBlobURLToken(url.mojom.Url url,
                        pending_receiver<BlobURLToken> token,
                        bool is_top_level_navigation);
};
```

Firefox IPDL Example

```
struct BlobURLRegistrationData
{
  nsCString url;
  IPCBlob blob;
  nsIPrincipal principal;
  nsCString partitionKey;
  bool revoked;
};

sync protocol PContent
{
parent:
     async StoreAndBroadcastBlobURLRegistration(nsCString url, IPCBlob blob,
                                               nullable nsIPrincipal principal, nsCString aPartitionKey);
child:
    async BlobURLRegistration(nsCString aURI, IPCBlob aBlob,
                              nullable nsIPrincipal aPrincipal, nsCString aPartitionKey);

}
```

Excerpt of PContent.ipdl