black hat
EUROPE 2019

Site Isolation

Confining Untrustworthy Code in the Web Browser

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about:us

Nasko Oskov

Charlie Reis

Defense

Browser evolution

Site Isolation architecture

Making it shippable

Offense

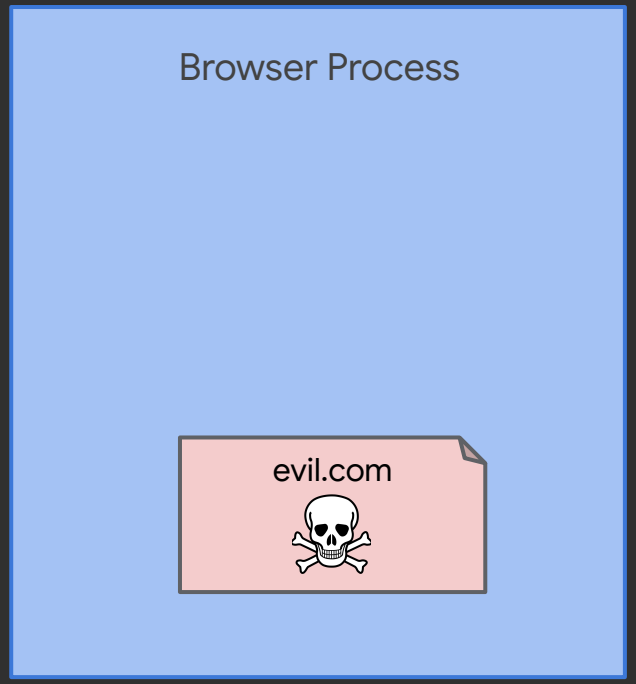
How to look for bypasses

Example vulnerabilities


about:history

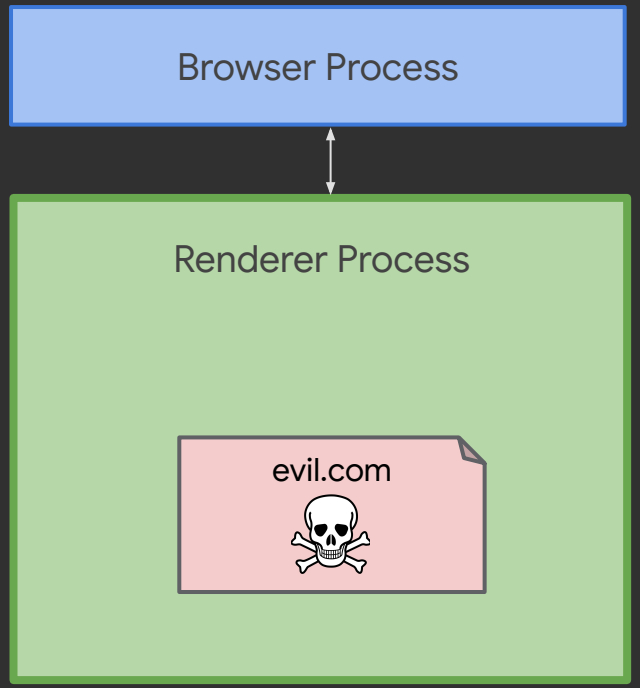
Late 1990s

Monolithic



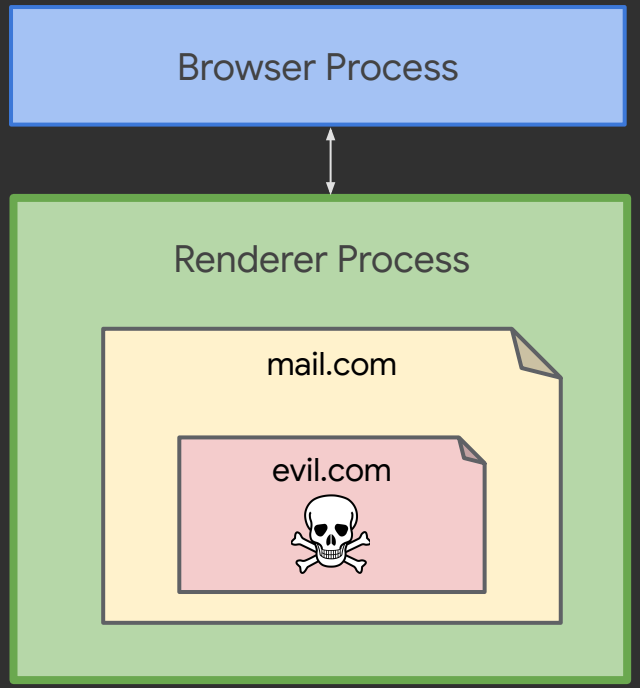
Late 2000s

Multi-process



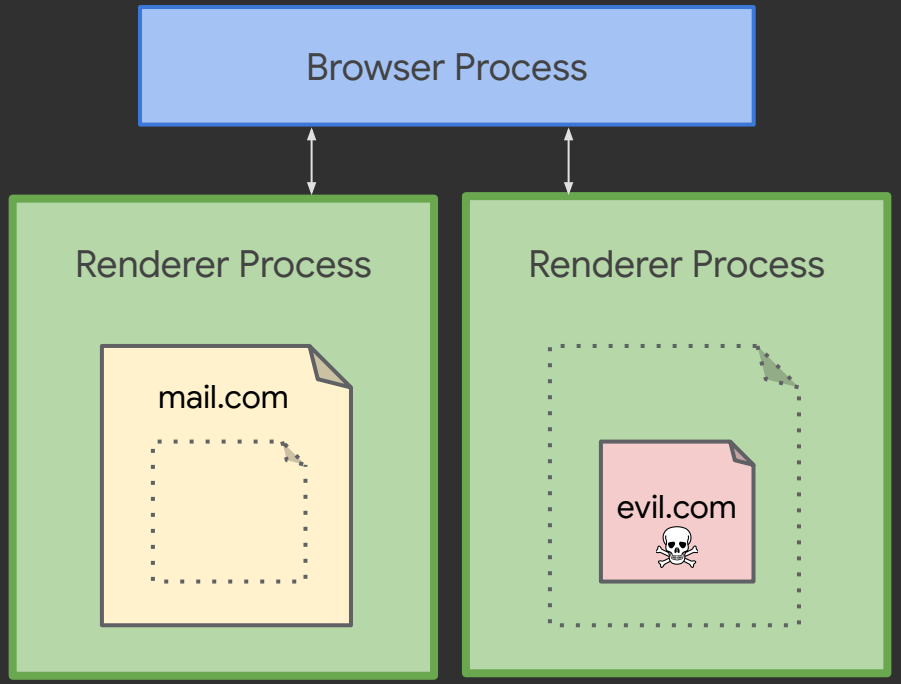
Late 2000s

Multi-process



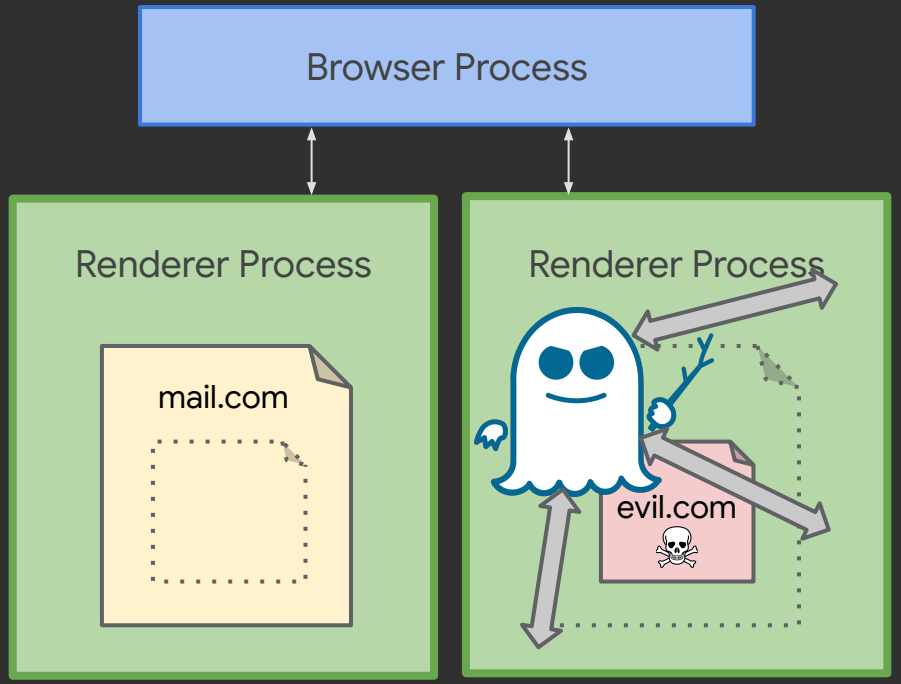
Late 2010s

Site Isolation



2018

Spectre




about:site-isolation

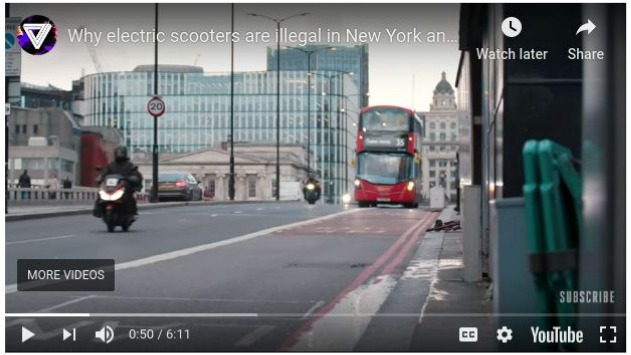
WATCH THIS | FEATURED VIDEOS | TRANSPORTATION

Why electric scooters are illegal in New York and London

The laws, regulations, and politics working against them

By Jon Porter | @JonPorty | Nov 25, 2019, 9:00am EST

SHARE

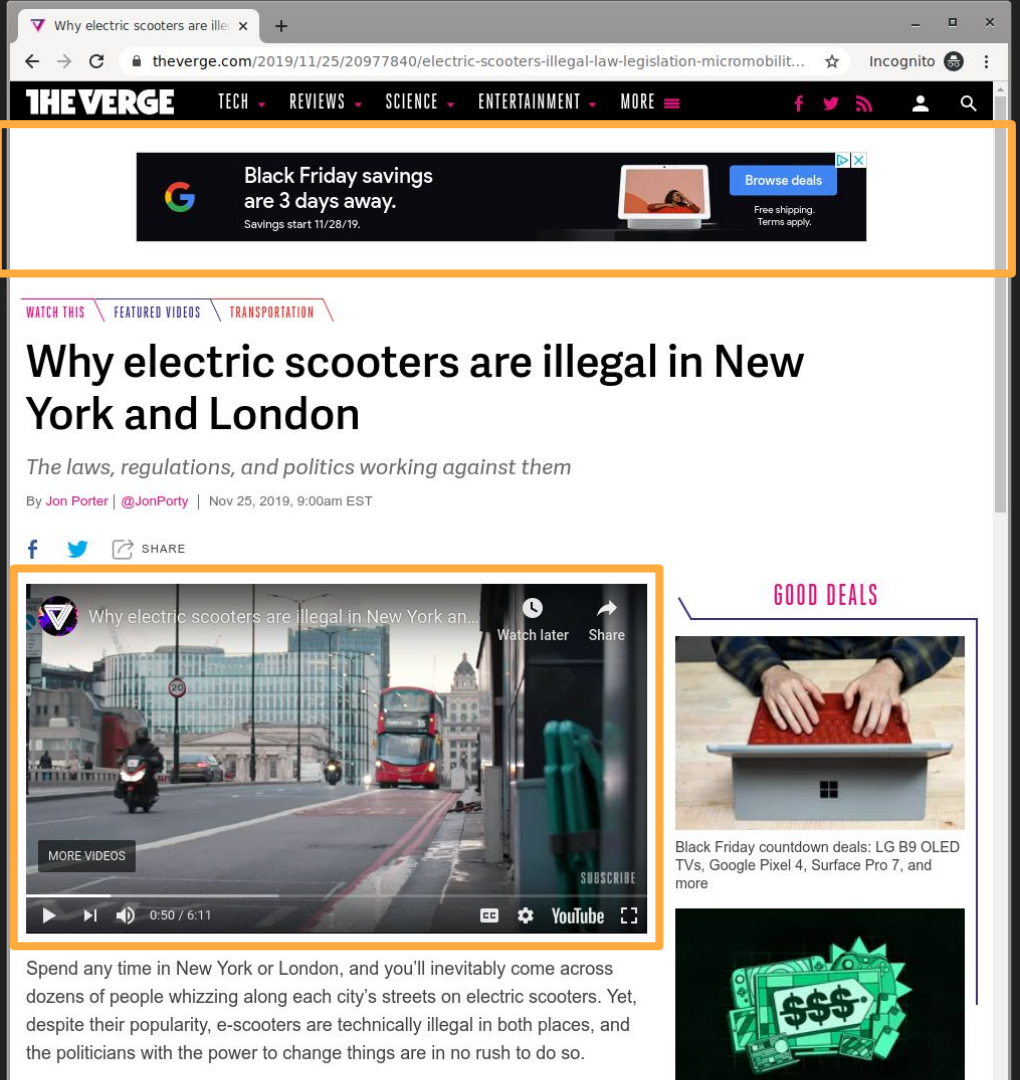


Spend any time in New York or London, and you'll inevitably come across dozens of people whizzing along each city's streets on electric scooters. Yet, despite their popularity, e-scooters are technically illegal in both places, and the politicians with the power to change things are in no rush to do so.

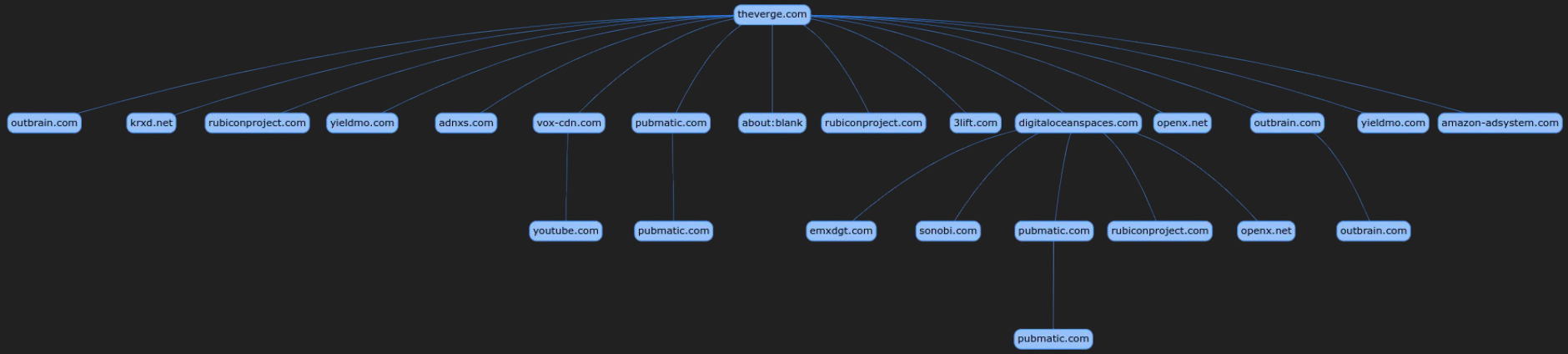
Ad

Video

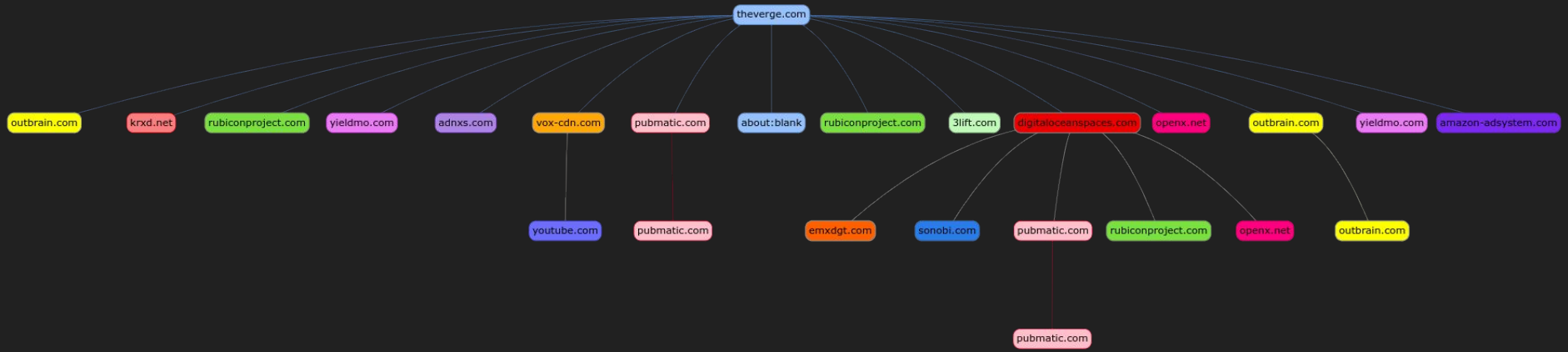
Article

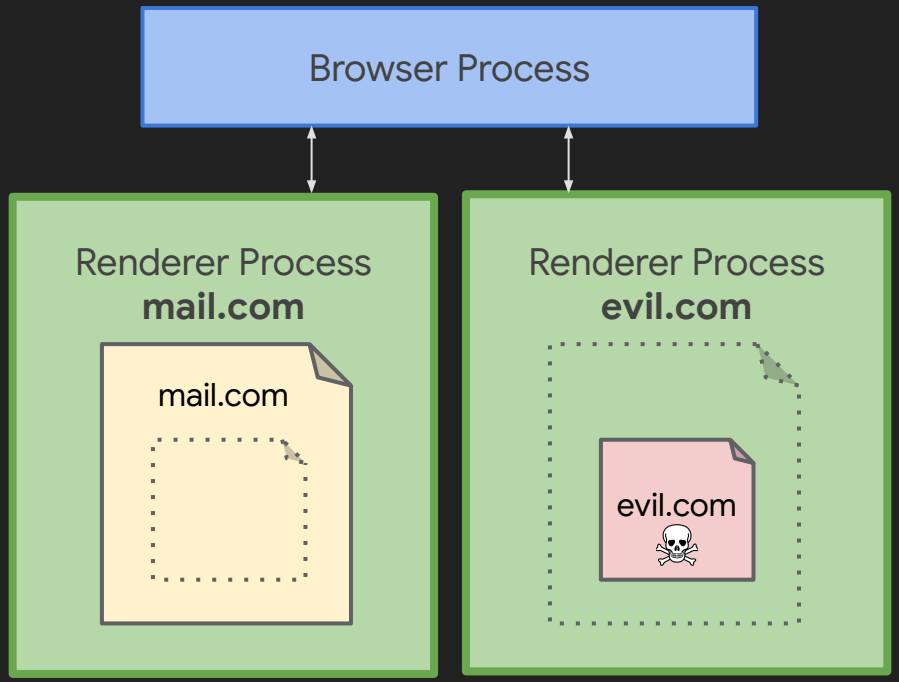


Without Site Isolation

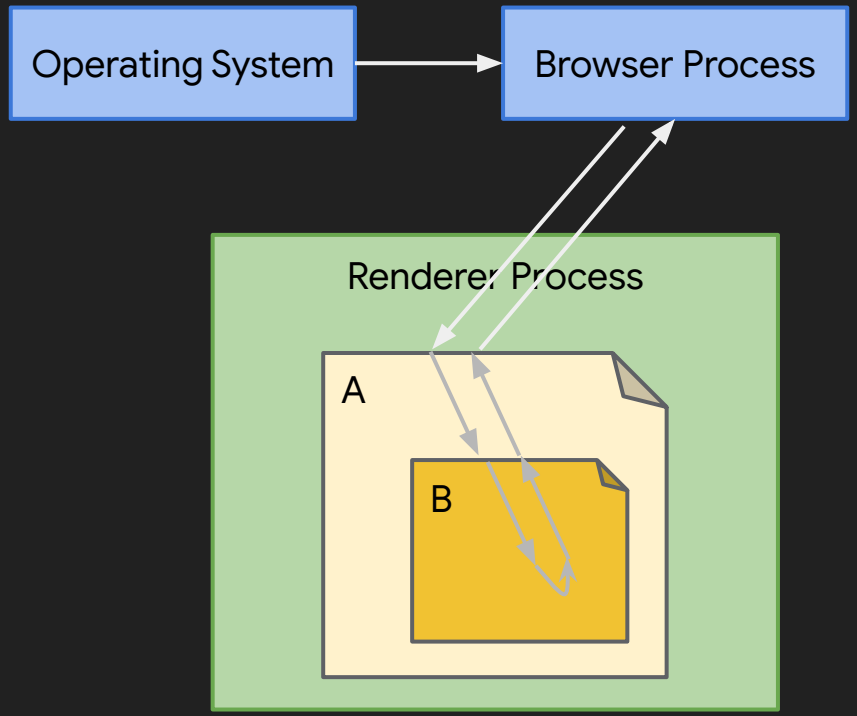


With Site Isolation

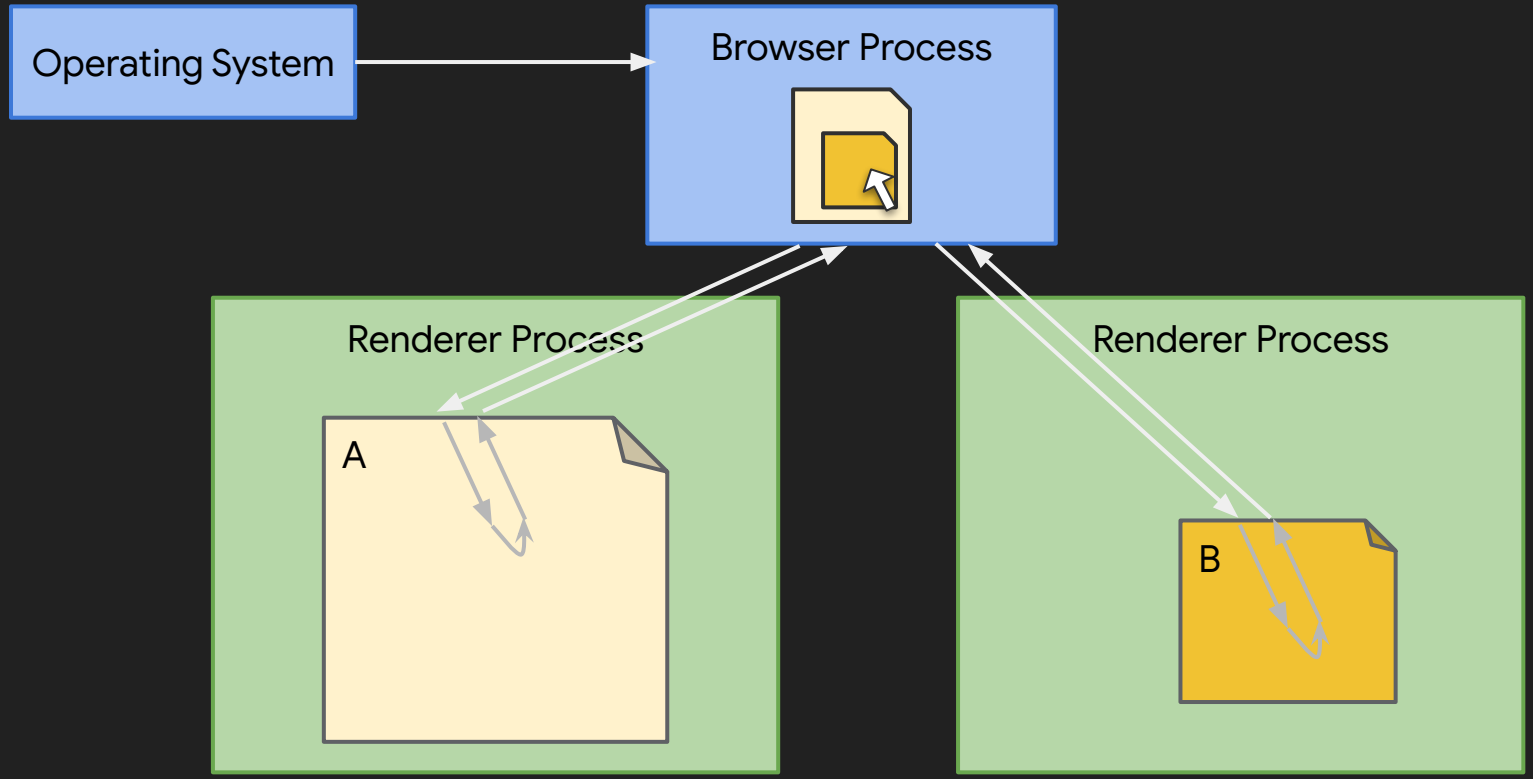



Browser Process
Renderer Process
mail.com
mail.com
Renderer Process
evil.com
evil.com

Example: Input events



Input events with out-of-process iframes

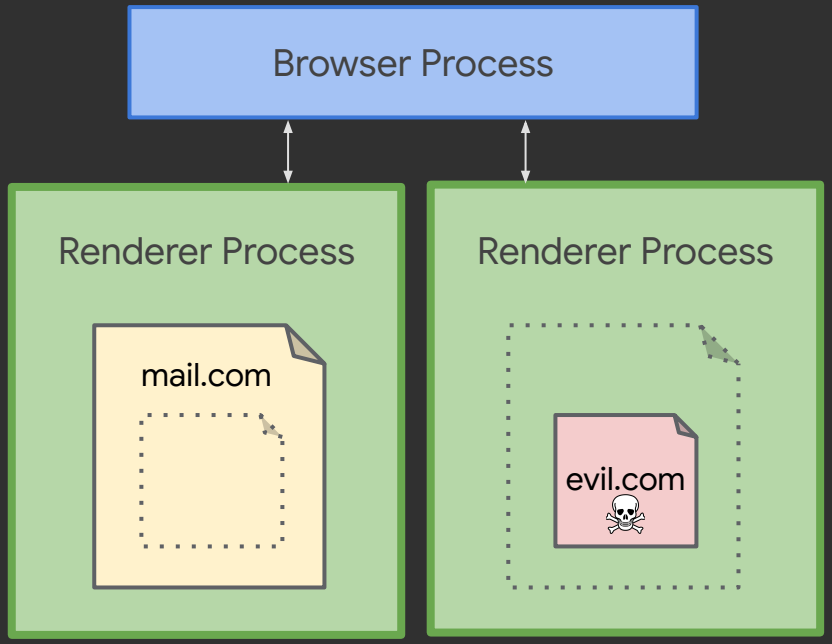


Updated browser features

- Accessibility
- Developer tools
- Drag and drop
- Extensions
- Find-in-page
- Focus
- Form autofill
- Fullscreen
- IME
- Input gestures
- JavaScript dialogs
- Mixed content handling
- Multiple monitor and device scale factor
- Password manager
- Pointer Lock API
- Printing
- Task manager
- Resource optimizations
- Malware and phishing detection
- Save page to disk
- Screen Orientation API
- Scroll bubbling
- Session restore
- Spellcheck
- Tooltips
- Unresponsive renderer detector and dialog
- User gesture tracking
- View source
- Visibility APIs
- Webdriver automation
- Zoom

Process Isolation FTW

Not yet...



Cross-Origin Read Blocking

Must allow images, scripts, stylesheets

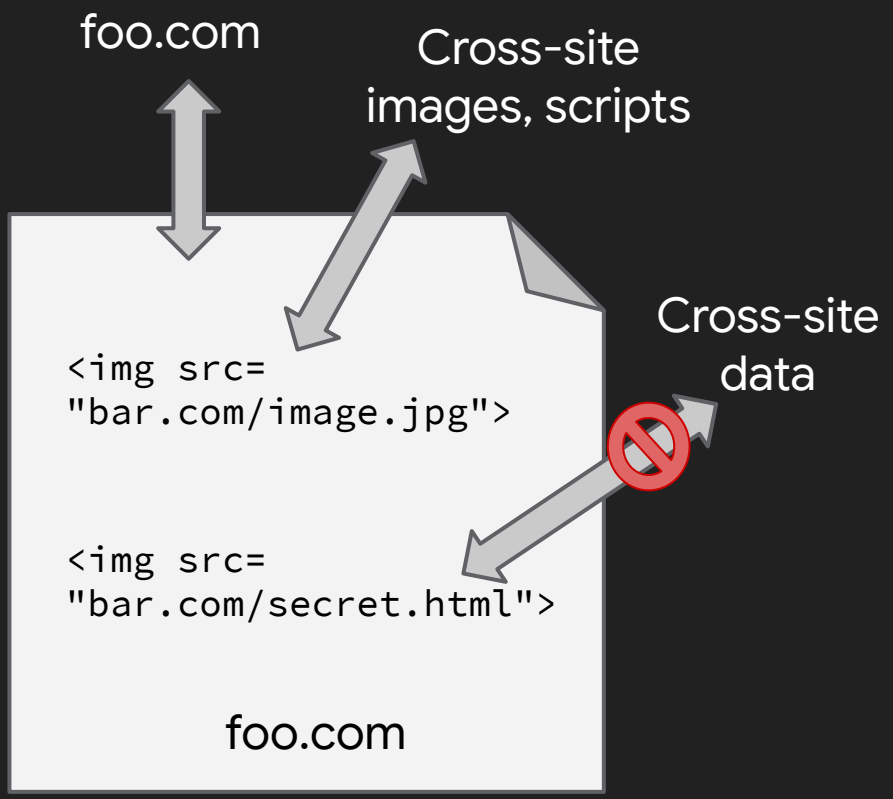
Want to protect sensitive data (HTML, XML, JSON)

Mislabeled Content-Types

- Custom sniffing
- Must allow responses like:

```
Content-Type: text/html
```

```
<!-- This is JS. -->
function a() {...}
```

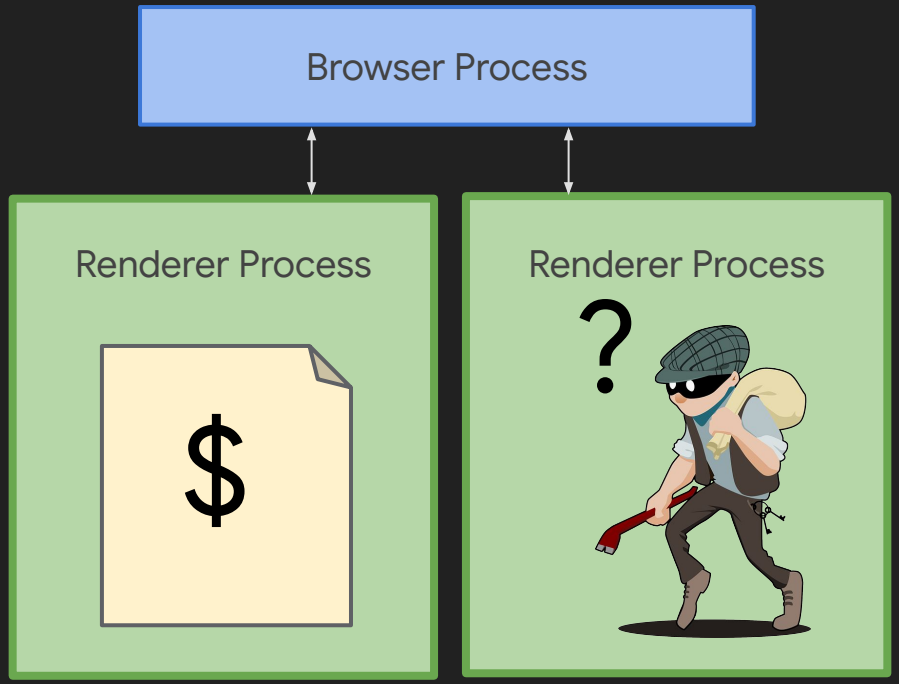


Security Benefits

Defending against Spectre

JavaScript can leak any memory within address space.
No bugs in browser required.

Must keep data worth stealing out of attacker's process.

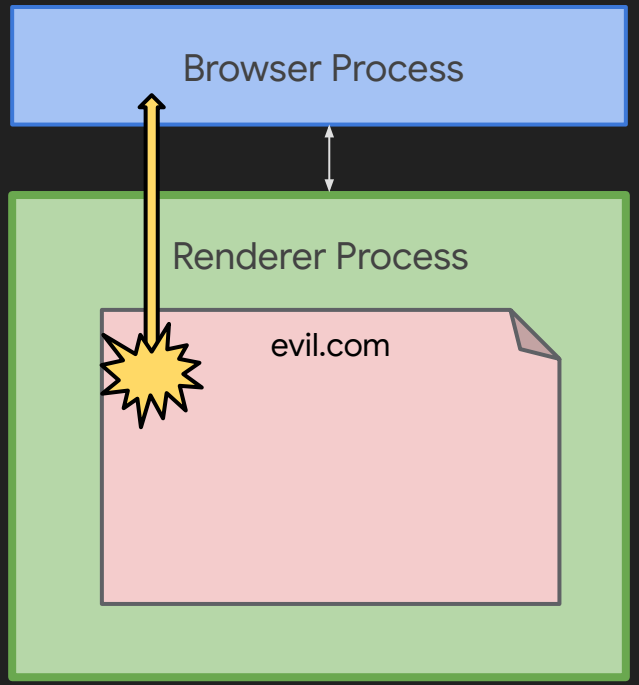


Compromised Renderer Processes

Harder than Spectre: Renderer process can lie to you!

UXSS, logic/memory bugs, RCE.

Must ensure browser process always checks for access to site data.



Addressing Limitations

- Sites vs Origins
  - **https://google.com** vs https://mail.google.com:443 (due to document.domain)
  - Opt-in origin isolation
- Many data types are not yet protected
  - Headers (CORP, Sec-Fetch-Site), more CORB-protected types, SameSite cookie defaults
- Cross-process transient execution attacks (e.g., Fallout, RIDL)
  - Combine with OS/HW mitigations


about:deployment

Compatibility & Performance

Don't break the web!

Performance implications?

- More processes. Memory overhead?
- Parallelism. Smaller processes.
- Latency: navigation, input events

Desktop: Isolate all sites

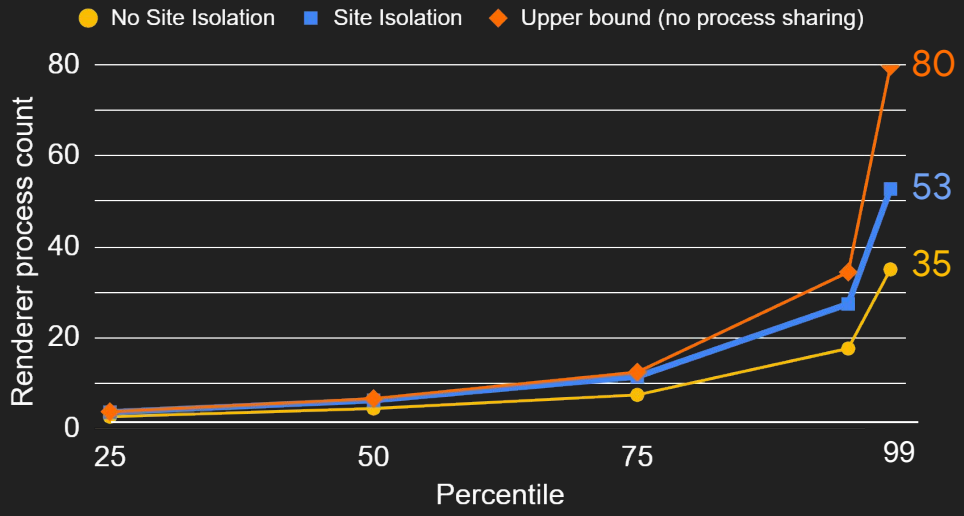
Shipped in May 2018 (Chrome 67): Windows, Mac, Linux, ChromeOS.

Many optimizations: spare process, same-site process sharing, etc

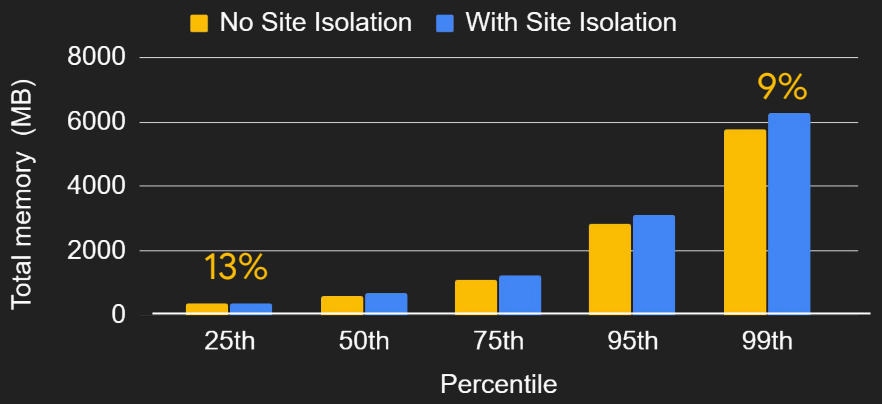
Workload helps: often many tabs open

Subframes can often share existing same-site process

Practical to Deploy



Renderer Process Count



Memory Overhead

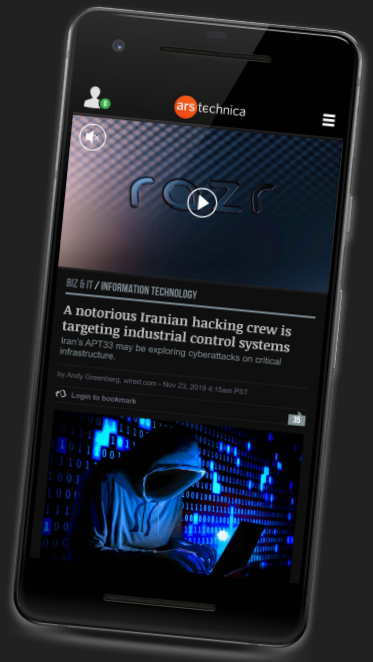
Android: Isolate subset of sites

Harder workload: single active tab

Isolate only high value sites: password-based

Shipped in September 2019 (Chrome 77)

(Still working on compromised renderer defenses here)



Fun stats for desktop launch

5 years of development

~450k lines of code, ~9k files touched

~4000 commits

Top 20 contributors landed 72% of the commits

Result

Practical to deploy

Chrome Desktop: All sites

Chrome Android: Password sites

Best path to protection against Spectre

Can limit damage from fully compromised renderers


about:offense

Chrome VRP covers Site Isolation bypasses

Breaking the Site Isolation process model:

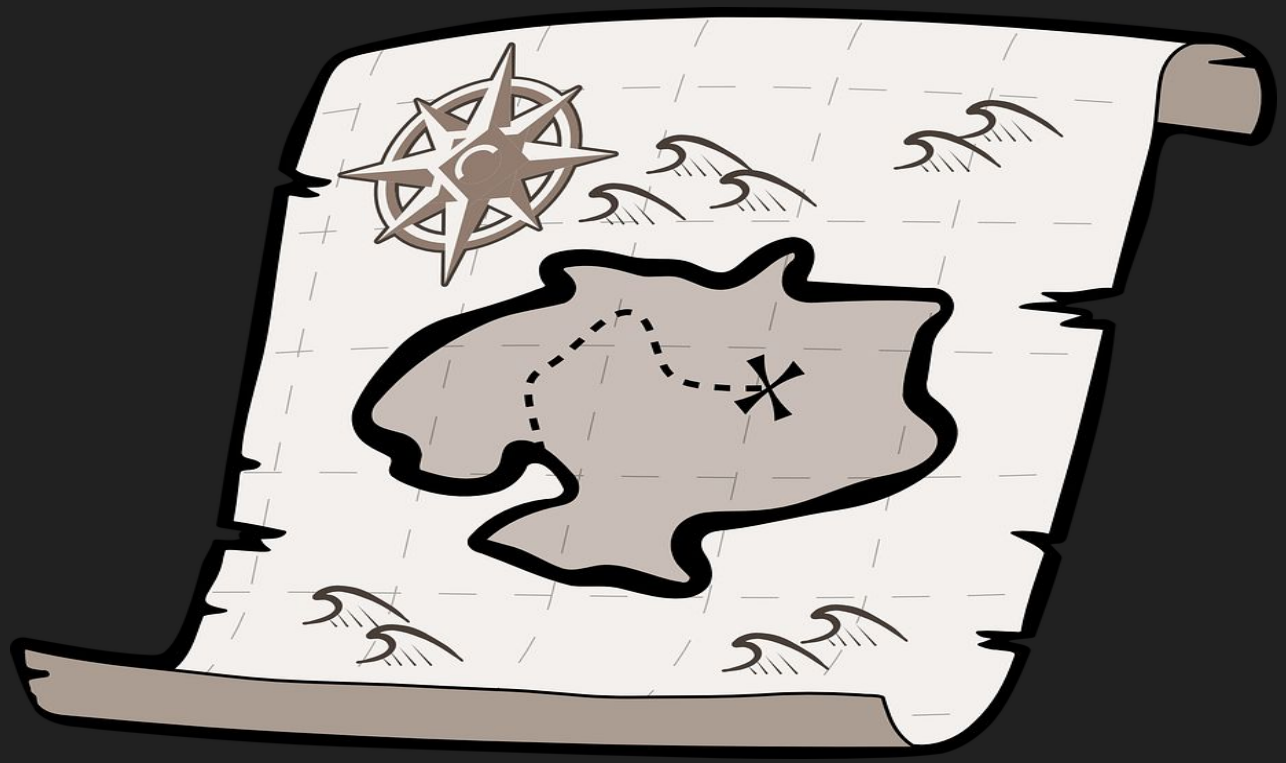
- Causing two sites to use the same process

Stealing cross-site data:

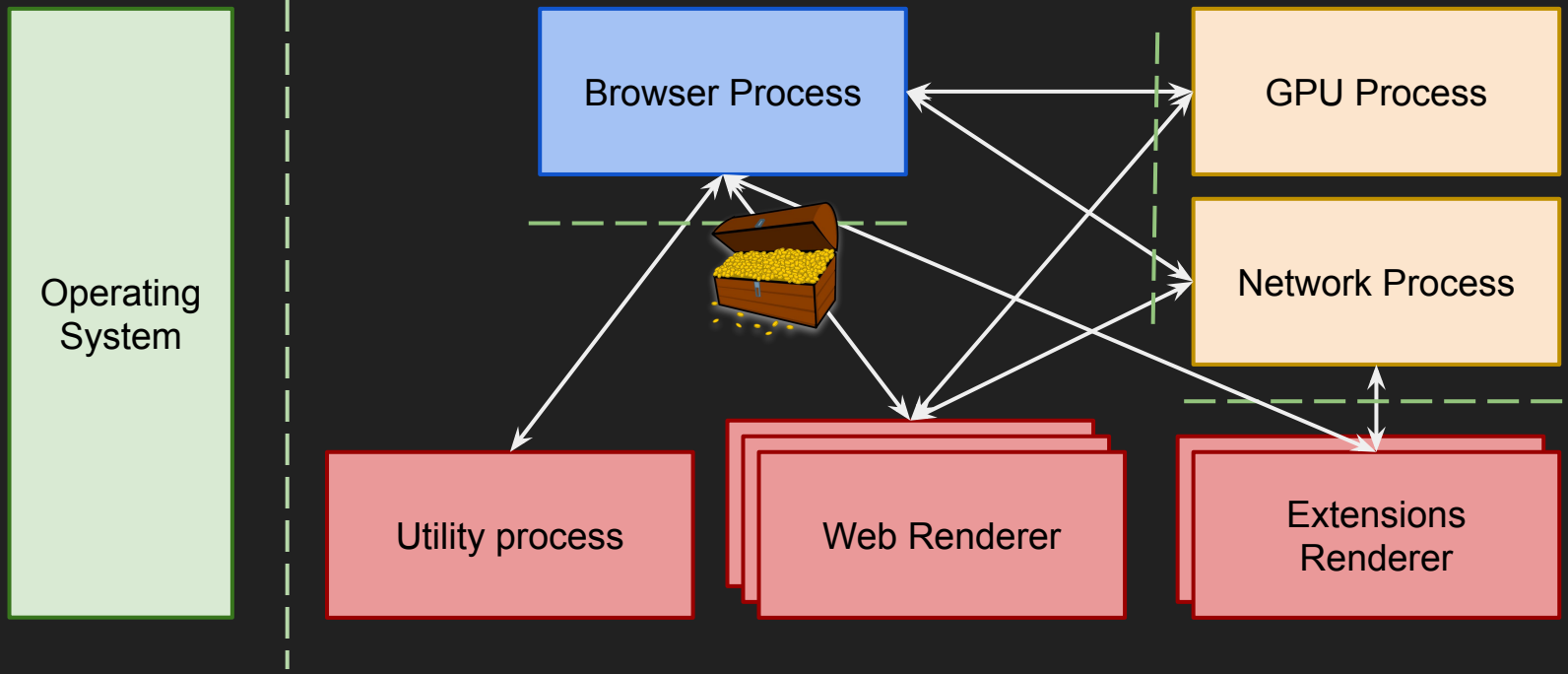
- Cookies
- HTML5 storage (localStorage, IndexedDB, etc)
- CORB bypass to fetch cross-site network data

Some areas are out of scope for now

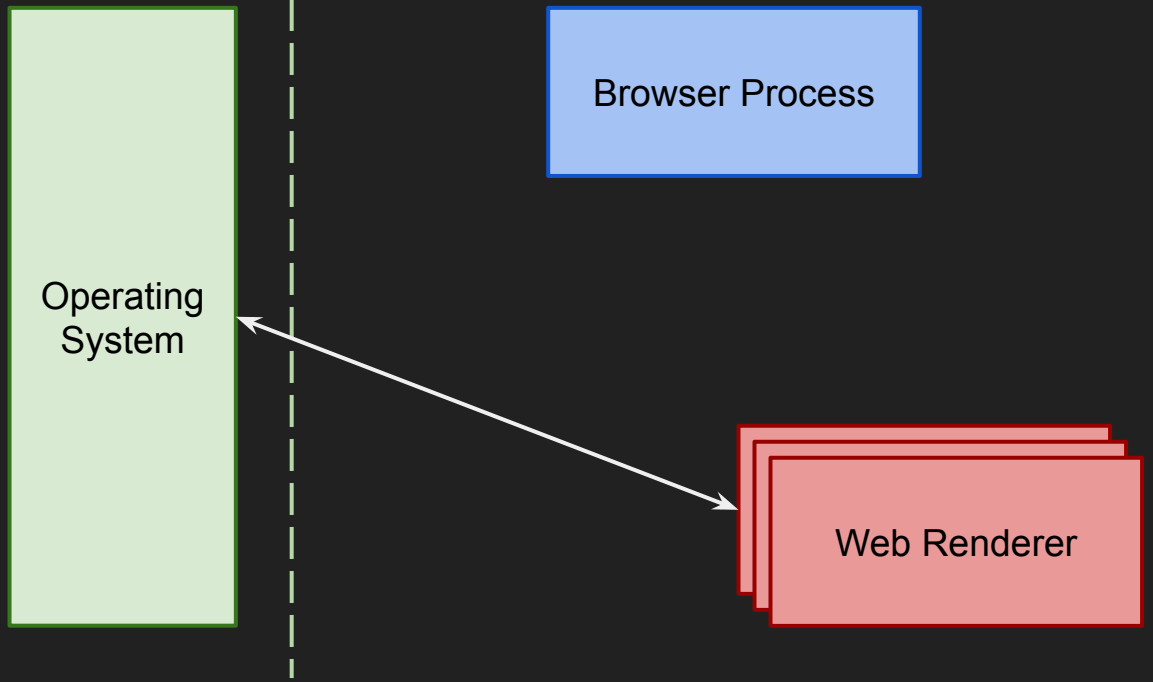
Bounty treasure map!



Chrome treasure map



Older Exploits: Attack OS kernel



UXSS
Logic Bugs
RCE

Web Renderer

How to look for bypasses?

No need for actual renderer exploit. Just use a debugger!

Explore the IPC surface

- `*_messages.h`
- `*.mojom`

Get creative and poke around different areas

- Escalate to higher privileged processes (e.g. Network, GPU)
- Look for corner cases - about:blank, session restore, blob:

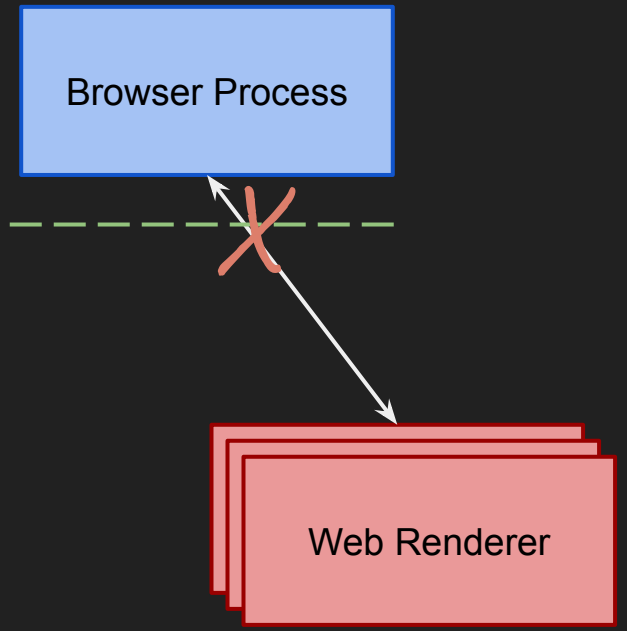

about:bugs

917668: Cross Domain Bug in IndexedDB

By lying about origin, any renderer can

- Enumerate
- Read
- Delete

IndexedDB for other origins.



IndexedDB Interface

[blink/public/mojom/indexeddb/indexeddb.mojom]

```
interface IDBFactory {
  GetDatabaseInfo(associated IDBCallbacks callbacks, url.mojom.Origin origin);
  Open(associated IDBCallbacks callbacks,
       associated IDBDatabaseCallbacks database_callbacks,
       url.mojom.Origin origin,
       mojo_base.mojom.String16 name,
       int64 version,
       int64 transaction_id);
  DeleteDatabase(associated IDBCallbacks callbacks,
                 url.mojom.Origin origin,
                 mojo_base.mojom.String16 name,
                 bool force_close);
  ...
}
```

IndexedDB Bug

blink/public/mojom/indexeddb/indexeddb.mojom

```
interface IDBFactory {
  GetDatabaseInfo(associated IDBCallbacks callbacks, url.mojom.Origin origin);
  Open(associated IDBCallbacks callbacks,
       associated IDBDatabaseCallbacks database_callbacks,
       url.mojom.Origin origin,
       mojo_base.mojom.String16 name,
       int64 version,
       int64 transaction_id);
  DeleteDatabase(associated IDBCallbacks callbacks,
                 url.mojom.Origin origin,
                 mojo_base.mojom.String16 name,
                 bool force_close);
  ...
}
```

The Fix

blink/public/mojom/indexeddb/indexeddb.mojom

```
interface IDBFactory {
  GetDatabaseInfo(associated IDBCallbacks callbacks, ~~url.mojom.Origin origin~~);
  Open(associated IDBCallbacks callbacks,
       associated IDBDatabaseCallbacks database_callbacks,
       ~~url.mojom.Origin origin,~~
       mojo_base.mojom.String16 name,
       int64 version,
       int64 transaction_id);
  DeleteDatabase(associated IDBCallbacks callbacks,
                 ~~url.mojom.Origin origin,~~
                 mojo_base.mojom.String16 name,
                 bool force_close);
  ...
}
```

886976: Site Isolation bypass using Blob URL

By lying about the origin of a `blob:` URL, attacker can:

- Cause the process model to put attacker blob: URL in victim process
- Use the blob: URL to execute arbitrary JavaScript in the victim origin

Awarded at $8000.

blob: URLs

example.html

```
var text = '<script>console.log(“attacker code”)</script>';

var blob = new Blob([text], {type : 'text/html'});
var url = URL.createObjectURL(blob);

// Lie to the browser about the origin url

frames[0].location.href = url;
```

blob: URLs Code

content/browser/blob_storage/blob_dispatcher_host.cc

```
void BlobDispatcherHost::OnRegisterPublicBlobURL(const GURL& public_url,
                                                 const std::string& uuid) {
  ...
  // Blob urls have embedded origins. A frame should only be creating blob URLs
  // in the origin of its current document. Make sure that the origin advertised
  // on the URL is allowed to be rendered in this process.
  if (!public_url.SchemeIsBlob() ||
      !security_policy->CanCommitURL(process_id_, public_url)) {
    ...
    bad_message::ReceivedBadMessage(this, bad_message::BDH_DISALLOWED_ORIGIN);
    return;
  }
  ...
```

blob: URLs Bug

content/browser/blob_storage/blob_dispatcher_host.cc

```
void BlobDispatcherHost::OnRegisterPublicBlobURL(const GURL& public_url,
                                                 const std::string& uuid) {
  ...
  // Blob urls have embedded origins. A frame should only be creating blob URLs
  // in the origin of its current document. Make sure that the origin advertised
  // on the URL is allowed to be rendered in this process.
  if (!public_url.SchemeIsBlob() ||
      !security_policy->CanCommitURL(process_id_, public_url)) {
    ...
    bad_message::ReceivedBadMessage(this, bad_message::BDH_DISALLOWED_ORIGIN);
    return;
  }
  ...
```

blob: URLs Fix

content/browser/child_process_security_policy_impl.cc

```
bool ChildProcessSecurityPolicyImpl::CanCommitURL(int child_id,
                                                  const GURL& url) {
  ...

  if (!CanAccessDataForOrigin(child_id, url))
    return false;

  ...

}
```

Finding bypasses is a thing now!

Conclusion

Site Isolation reduces value of many attacks:

Spectre, UXSS, even RCE

We are still addressing limitations: coverage, granularity.

Web also needs to evolve to better protect data.

Explore this new security frontier and find new attacks!