Autogenerating Content Security Policies to Prevent Code Injection in Mobile Web Applications

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- Disadvantage: Susceptibility to code injection attacks

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4. Unsafe data is rendered, causing all present Javascript code to be executed

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- <script>alert('EVIL')</script>

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  - WiFi SSIDs
  - File metadata
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- Unconventional injection channels
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  - WiFi SSIDs
  - File metadata
  - ...
- More severe impacts
  - More sensitive access via HTML5 (GPS, high-res cameras, always with its user)
  - More extensive access via JS-interfaces (accelerometer, contacts, SMS, spreading of infection)

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- Origins/Keywords:https://example.ch, data:, 'self', 'unsafe-inline', 'unsafe-eval', 'sha-[hash]', 'strict-dynamic', ...

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  - Disallowed: <img src="http://disallowed.ch/image.png">
- CSP definition: <meta http-equiv="Content-Security-Policy" content="default-src 'self'; img-src http://allowed.ch;">

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  - <img src="https://example.ch">
  - <embed src="https://example.ch">
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- URLs to connect to
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  - new WebSocket('https://example.ch');
  - <form action="https://example.ch">
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  - <script>alert('XSS')</script>
  -
  - <style>.content { width: 30px; } </style>
  - document.querySelector('div').setAttribute('style', 'width: 30px;');
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  - <style>.content { width: 30px; } </style>
  - document.querySelector('div').setAttribute('style', 'width: 30px;');
  - ...
- Evaluation of strings in scripts and styles
  - eval("alert('XSS')")
  - window.setTimeout("alert('XSS')", 1000);
  - CSSStyleSheet.insertRule(".content { width: 30px; }")
  - ...

What can be restricted?

- Some other things
  - plugin-types
  - frame-ancestors
  - upgrade-insecure-requests
  - navigate-to
  - ...

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  - One reason for this is that frameworks like jQuery heavily rely on string evaluation

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  - Many applications make use of APIs that are incompatible with strict CSP rules
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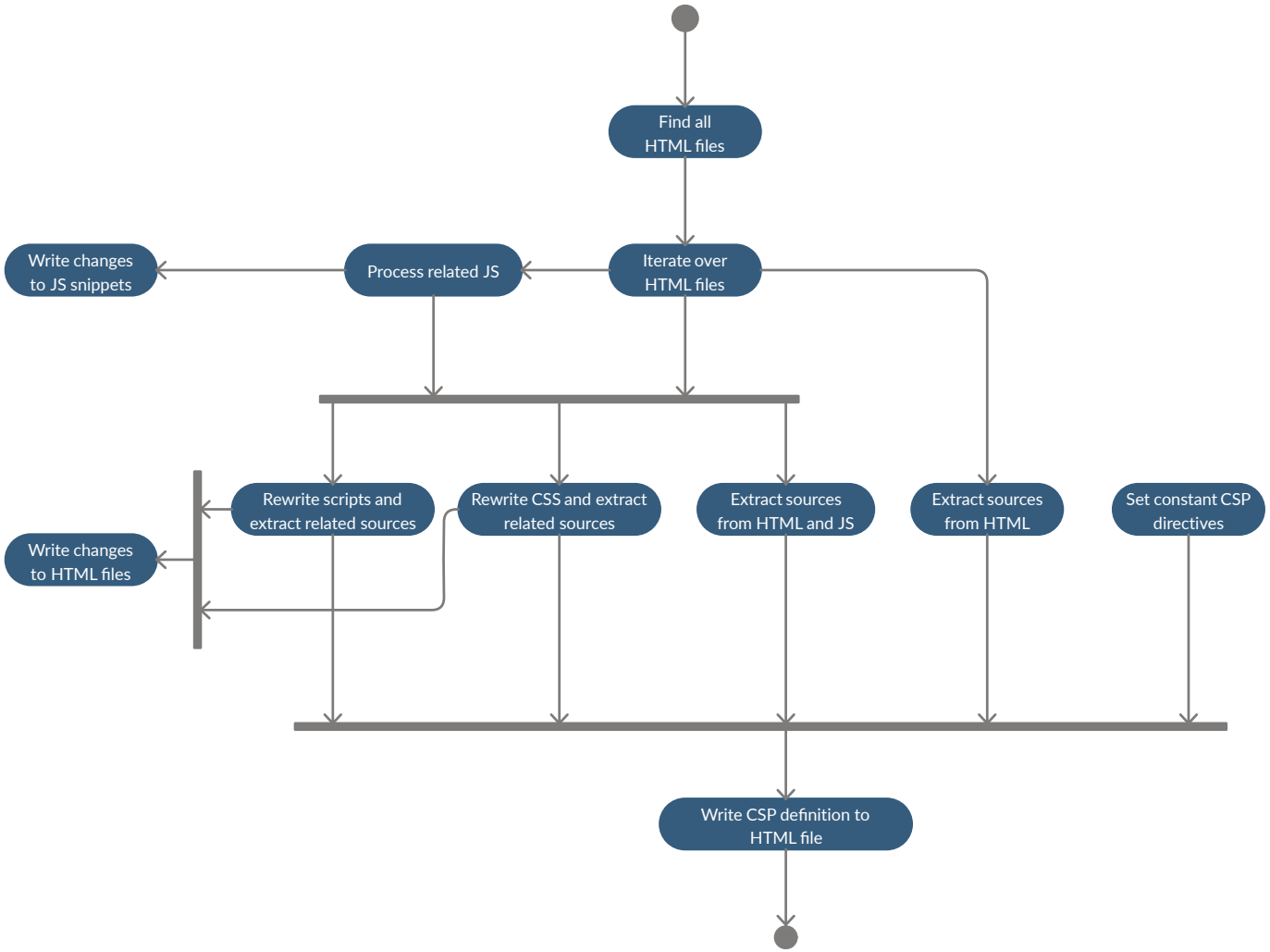
  - Automatic generation of CSP rules would make it easy to deploy CSP for existing apps
  - Incompatible APIs should be rewritten in order to avoid losing strictness
  - Care must be taken to avoid breaking app functionalities

The pipeline



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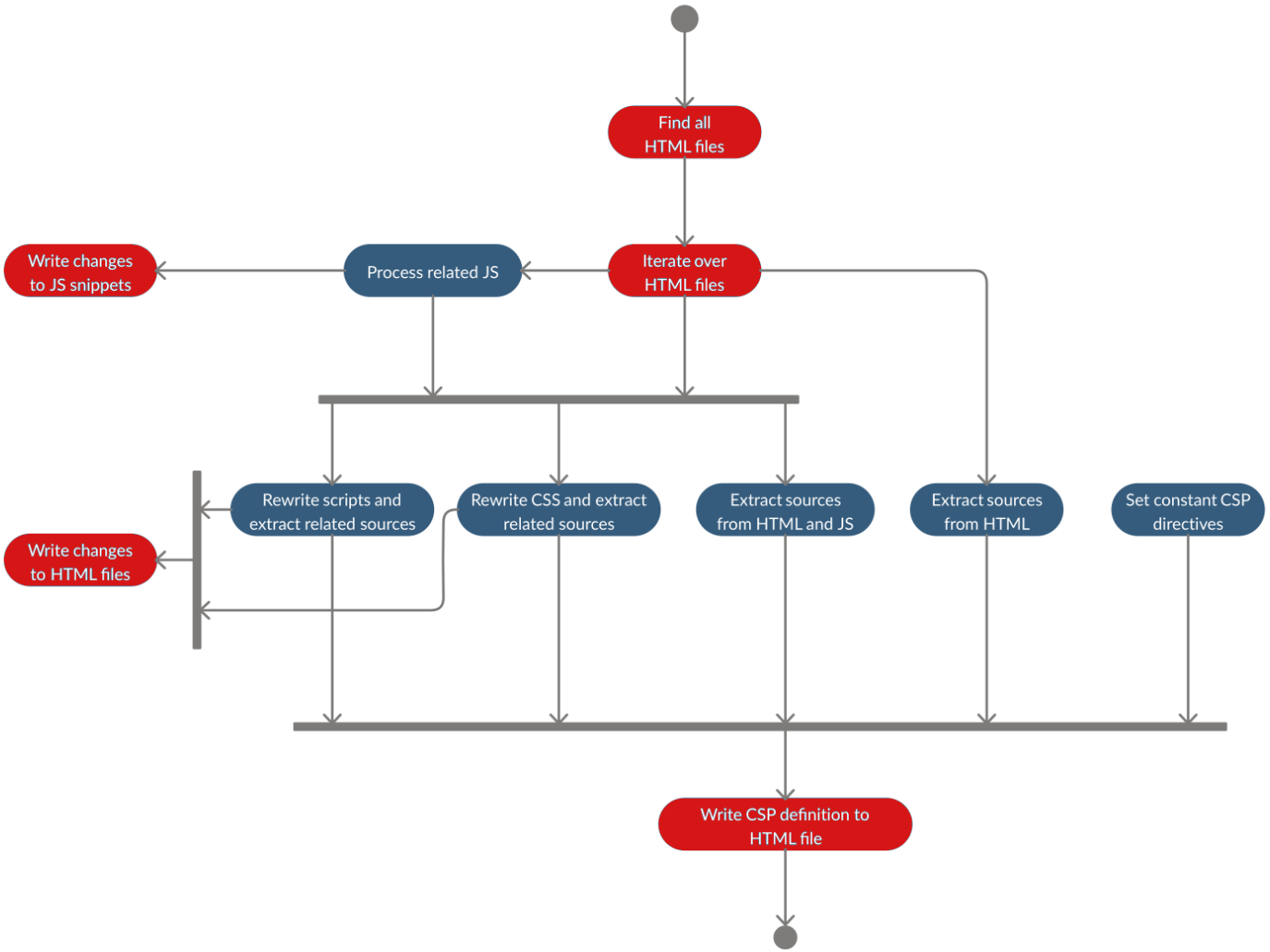

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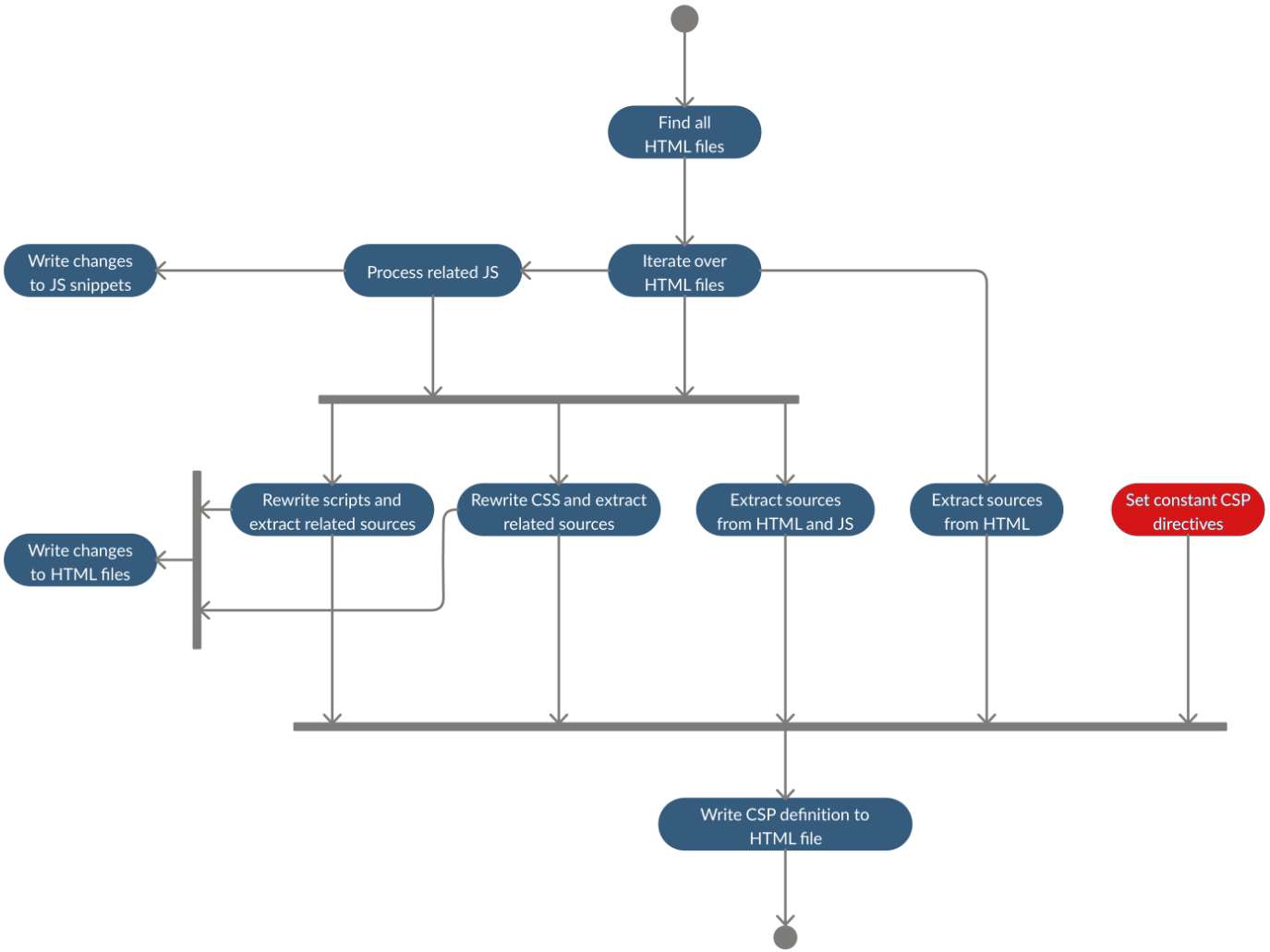

Setting constant CSP directives

- "default-src 'self'; upgrade-insecure-requests;"

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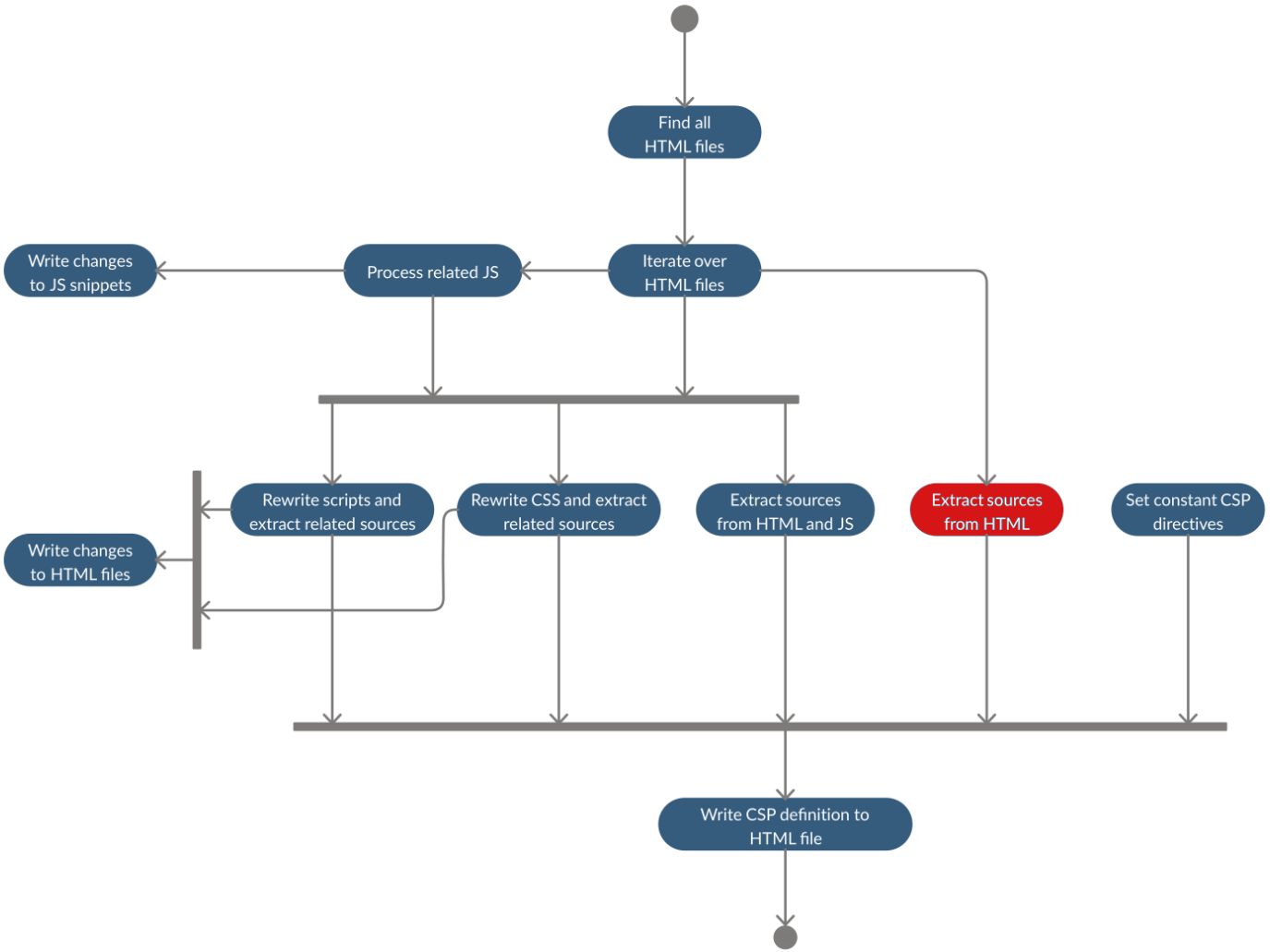
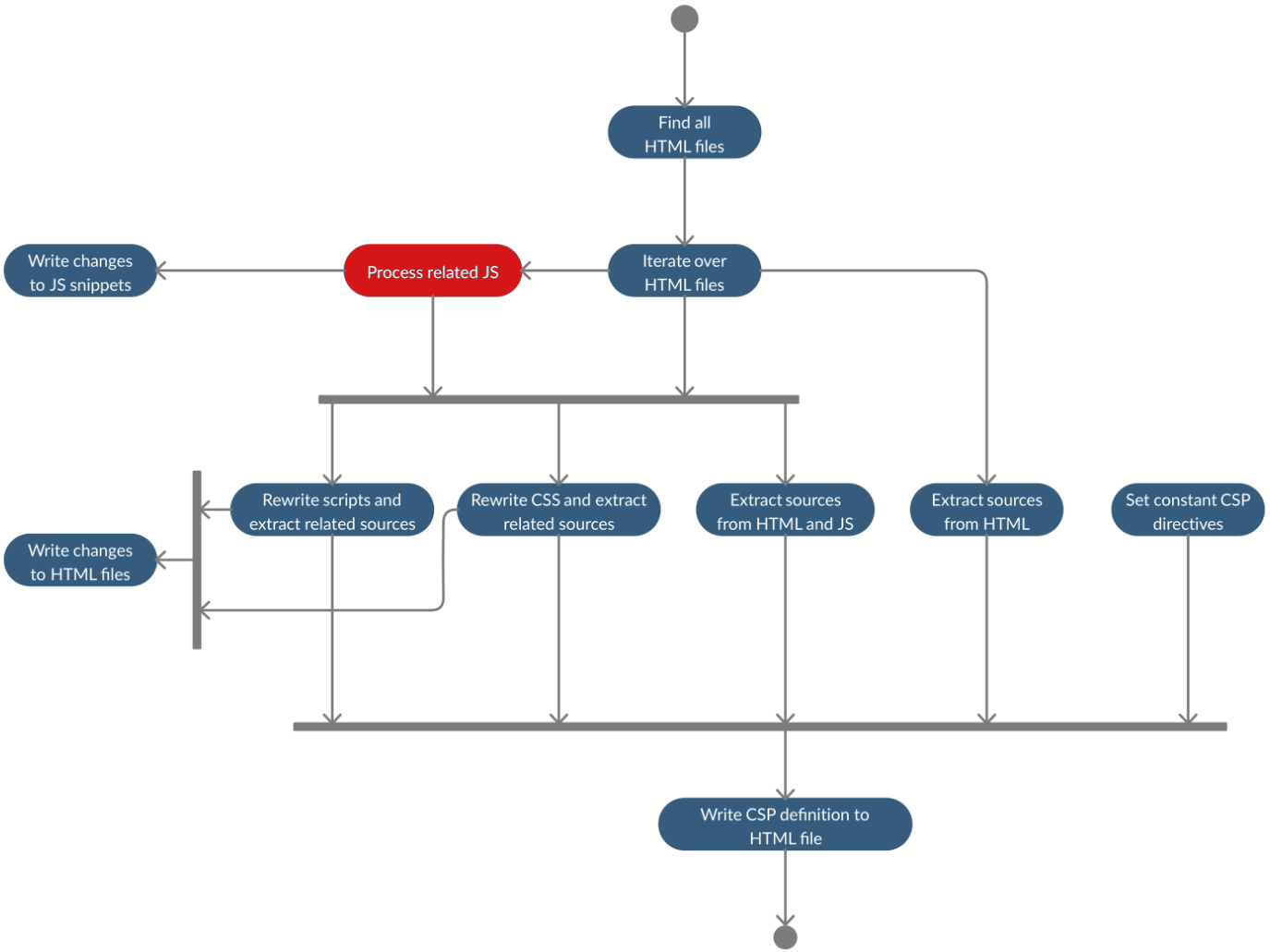


Extracting sources from HTML

- manifest-src:
  <link rel="manifest" href="https://example.ch">
- base-uri:
  <base href="https://example.ch/">
- plugin-types:
  <object data="https://example.ch/flash"
  type="application/x-shockwave-flash">
- form-action:
  <form action="javascript:alert('FORM')" method="post">

The pipeline



Processing related Javascript

- Gather all related Javascript

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  - Extract code from inline Javascript tags
    <script>alert('INLINE')</script>
  - Load code from external Javascript tags
    <script src="app.js"></script>
  - Extract code from inline event handlers

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- Extract sources for connect-src
  - XMLHttpRequest.open("GET", "https://example.ch");
  - new WebSocket("https://example.ch");
  - ...
- Extract sources for worker-src
  - new Worker("https://example.ch/w.js");
  - navigator.serviceWorker.register("https://example.ch/w.js");
  - ...

Processing related Javascript

Rewriting APIs impacted by style-src

setAttribute

```
// Original
a.setAttribute("style", "display:none");

// Rewritten
a.style.display = "none";
```

Processing related Javascript

Rewriting APIs impacted by style-src

cssText

```
// Original
a.style.cssText = "background-color:none";

// Rewritten
a.style.backgroundColor = "none";
```

Processing related Javascript

Rewriting APIs impacted by style-src

insertRule

```
// Original
stylesheet.insertRule("#someId { color: white }", 0);

// Rewritten
var newStyleTag = document.createElement("style");
newStyleTag.innerText = "#someId { color: white }";
document.head.appendChild(newStyleTag);
```

Processing related Javascript

Rewriting APIs impacted by script-src

eval

```
// Original
eval('alert("Example")');
eval('{"key1": "value1", "key2": "value2"}');

// Rewritten
alert("Example");
JSON.parse('{"key1": "value1", "key2": "value2"}');
```

Processing related Javascript

Rewriting APIs impacted by script-src

setTimeout/setInterval

```
// Original
setTimeout('alert("Example")', 1000);
setInterval('alert("Example")', 1000);

// Rewritten
setTimeout(function() {alert("Example")}, 1000);
setInterval(function() {alert("Example")}, 1000);
```

Processing related Javascript

Rewriting APIs impacted by script-src

Function

```
// Original
new Function("a", "b", "return a*b");

// Rewritten
function(a, b) {return a*b};
```

Processing related Javascript

Rewriting APIs impacted by script-src

setAttribute for event handlers

```
// Original
a.setAttribute("onclick", 'alert("XSS")');

// Rewritten
a.onclick = function() {alert("XSS")};
```

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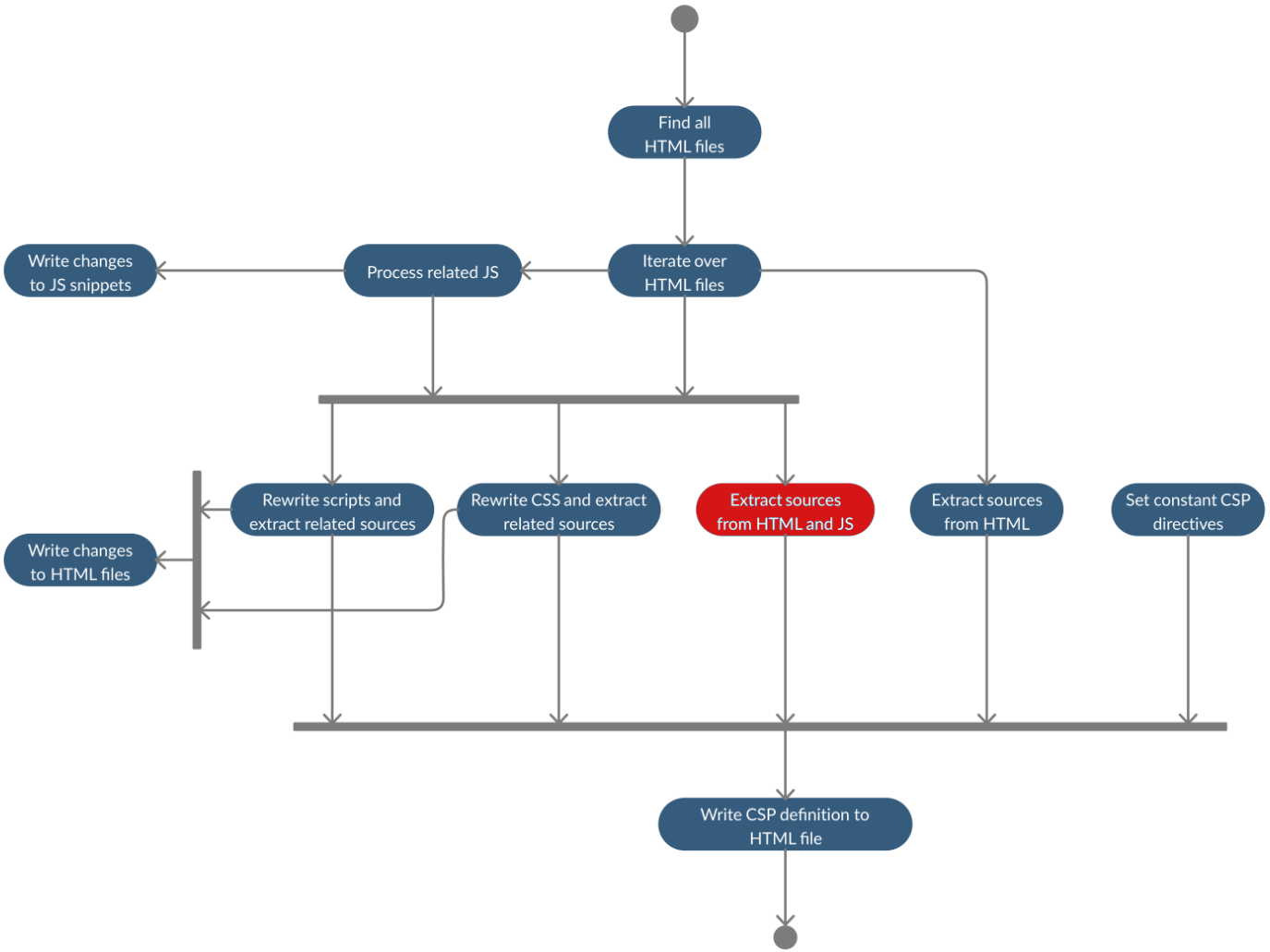

Extracting sources from HTML and Javascript

- connect-src:
  <a ping="https://example.ch">
- frame-src:
  <iframe src="https://example.ch">
- img-src:
  <img src="https://example.ch/image.jpg">
- media-src:
  <audio src="https://example.ch">
- object-src:
  <object data="https://example.ch">

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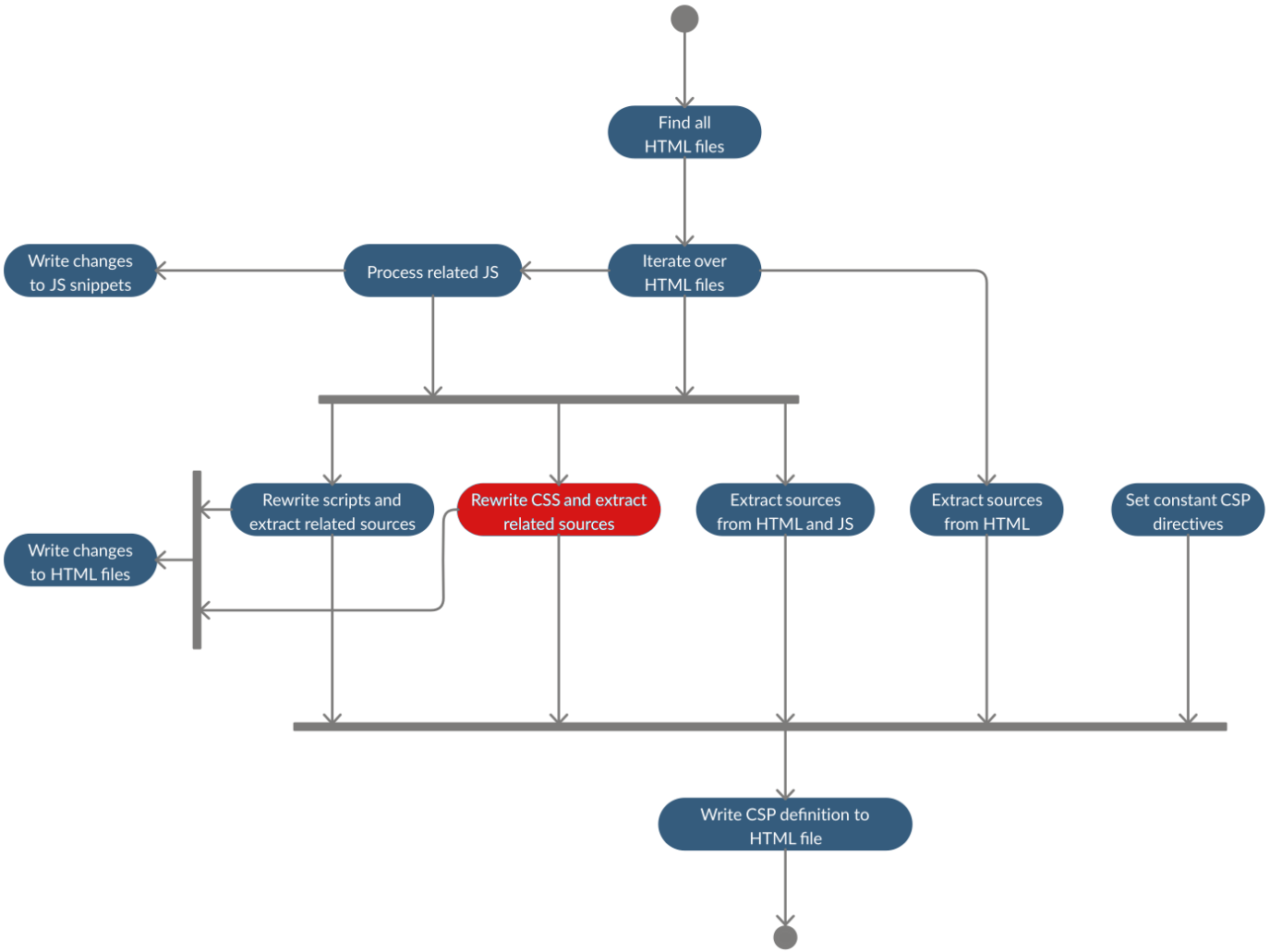
- Combine with data from JS

The pipeline



Rewriting styles and extracting related sources

Rewriting inline style attributes

```
// Original
<div style="height: 100px;">

// Rewritten
<div id="tmYuSGfL">
<style>#tmYuSGfL { height: 100px; }</style>
```

Rewriting styles and extracting related sources

- Iterate over all CSS rules

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  - style-src:
    @import url("https://example.ch/styles.css")
  - font-src:
    @font-face { src: url("https://not-example.com/font"); }
  - img-src:
    background-image: url("image.gif");

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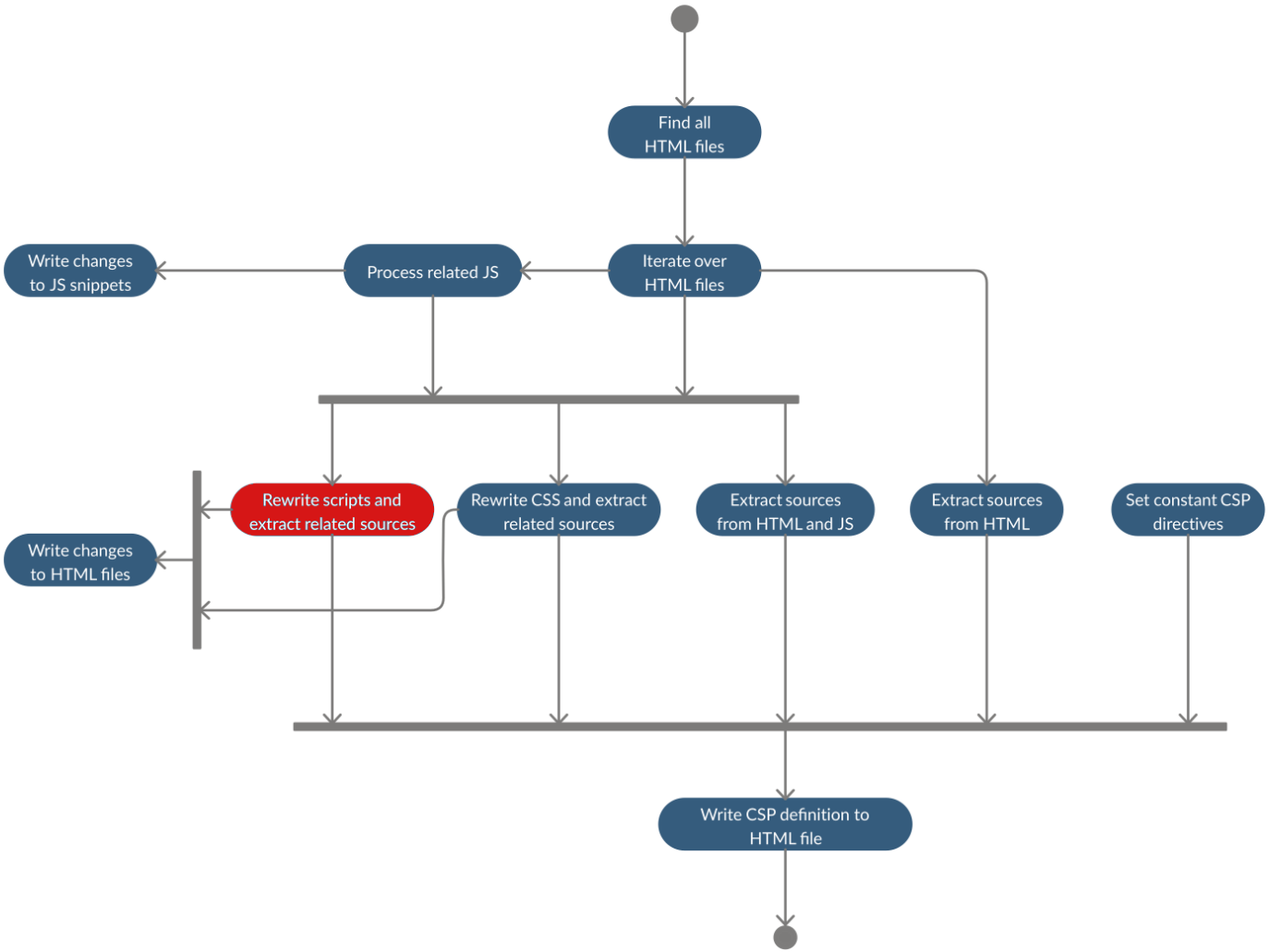

Rewriting scripts and extracting related sources

Rewriting inline event handlers

```
// Original
<div onclick='alert("Example")'>

// Rewritten
<div id="tmYuSGfL">
<script>
  document.getElementById("tmYuSGfL")
    .addEventListener(
      "onclick",
      function() { alert("Example") }
    )
</script>
```

Rewriting scripts and extracting related sources

- Generate all hashes

Rewriting scripts and extracting related sources

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Rewriting scripts and extracting related sources

- Generate all hashes
- Combine with data from JS
- Add 'strict-dynamic'

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Limiting patterns

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  - HTML templating engines
  - Inability to rewrite remote resources

Empirical results

API	% Apps	% Apps (w/o library files)
setTimeout / setInterval	98.30	73.65
eval	89.45	36.89
cssText	83.27	28.68
Function	61.21	29.41
setAttribute (style)	30.91	21.45
insertRule	4	4
setAttribute (event handler)	3.88	3.31

Table 1: Apps containing CSP-relevant APIs

Empirical results

Keyword	% Rewritten	% Not rewritten
script-src: unsafe-inline	3.27	0.61
script-src: unsafe-eval	0	98.55
style-src: unsafe-inline	8	22.91
style-src: unsafe-eval	2.42	81.33

Table 2: Apps we could/couldn't rewrite in relation to total number of apps

Empirical results

Keyword	% Rewritten	% Not rewritten
script-src: unsafe-inline	84.28	15.72
script-src: unsafe-eval	0	100
style-src: unsafe-inline	25.88	74.12
style-src: unsafe-eval	2.89	97.11

Table 3: Apps we could/couldn't rewrite in relation to number of apps that needed rewriting

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Thank You for Your Attention.

Questions?