Speeding up Web Page Loads with **Shandian**

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10th USENIX Symposium on Networked Systems Design and Implementation

nsdi '13

APRIL 2–5, 2013
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Why is page load time (PLT) slow?


```
<html>
 <body onload="done();">
  <link src='1.css'>
  <script src='d3.js'></script>
  <script src='2.js'></script>
  <div id="content"></div>
 </body>
</html>
```


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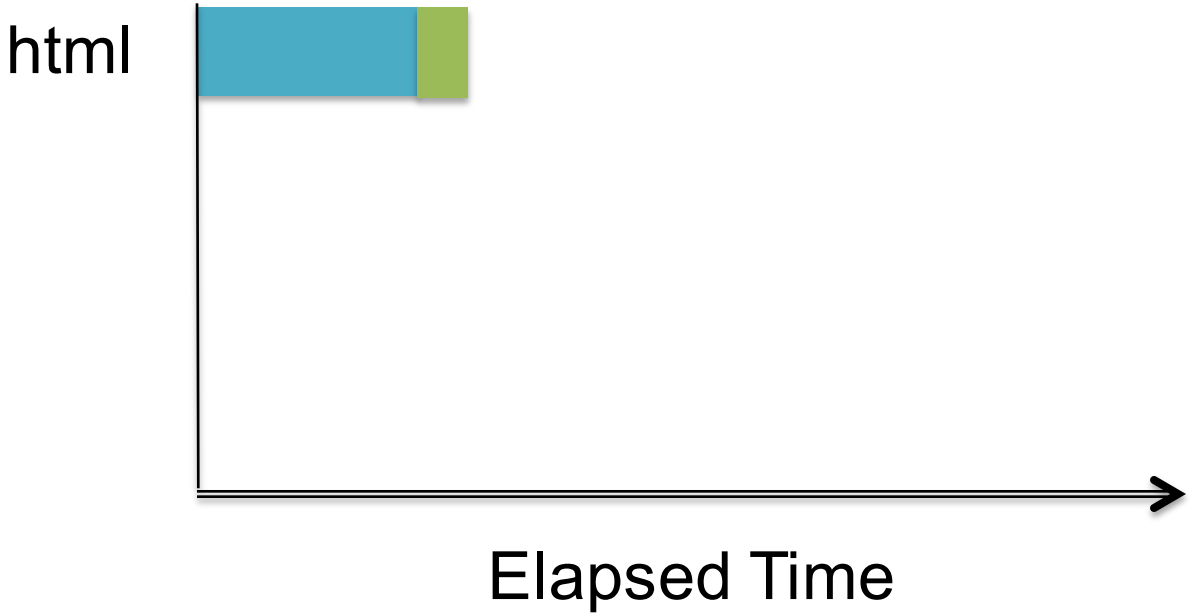

Network Computation

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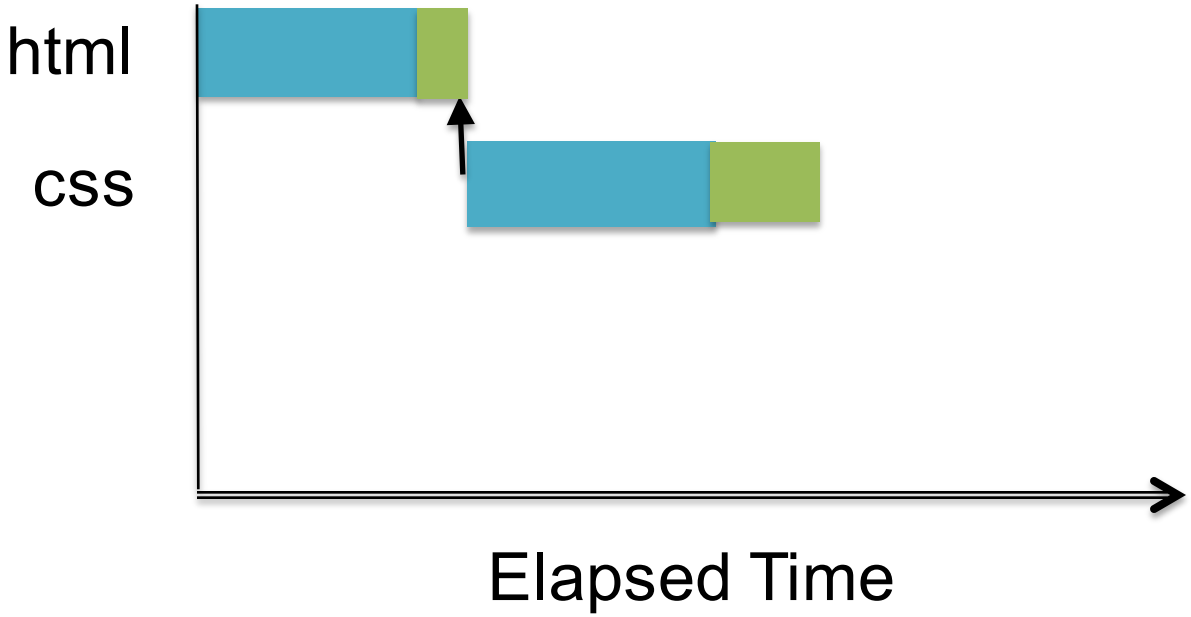

Network Computation → Dependency

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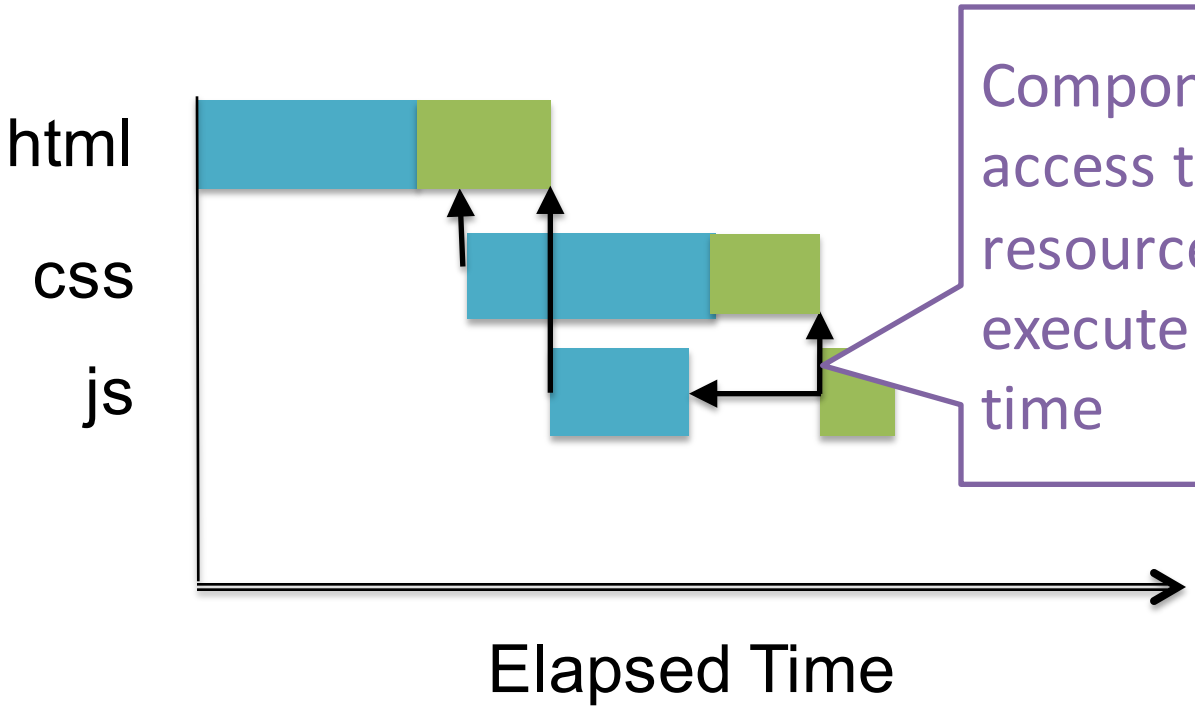
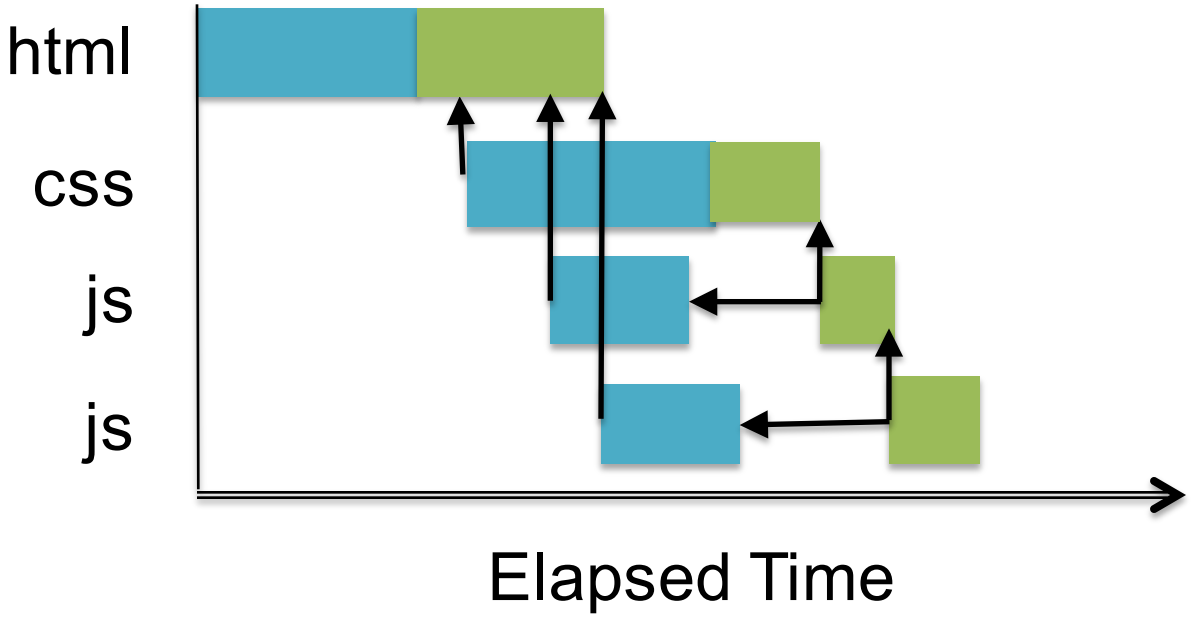


Network Computation → Dependency



Network Computation → Dependency

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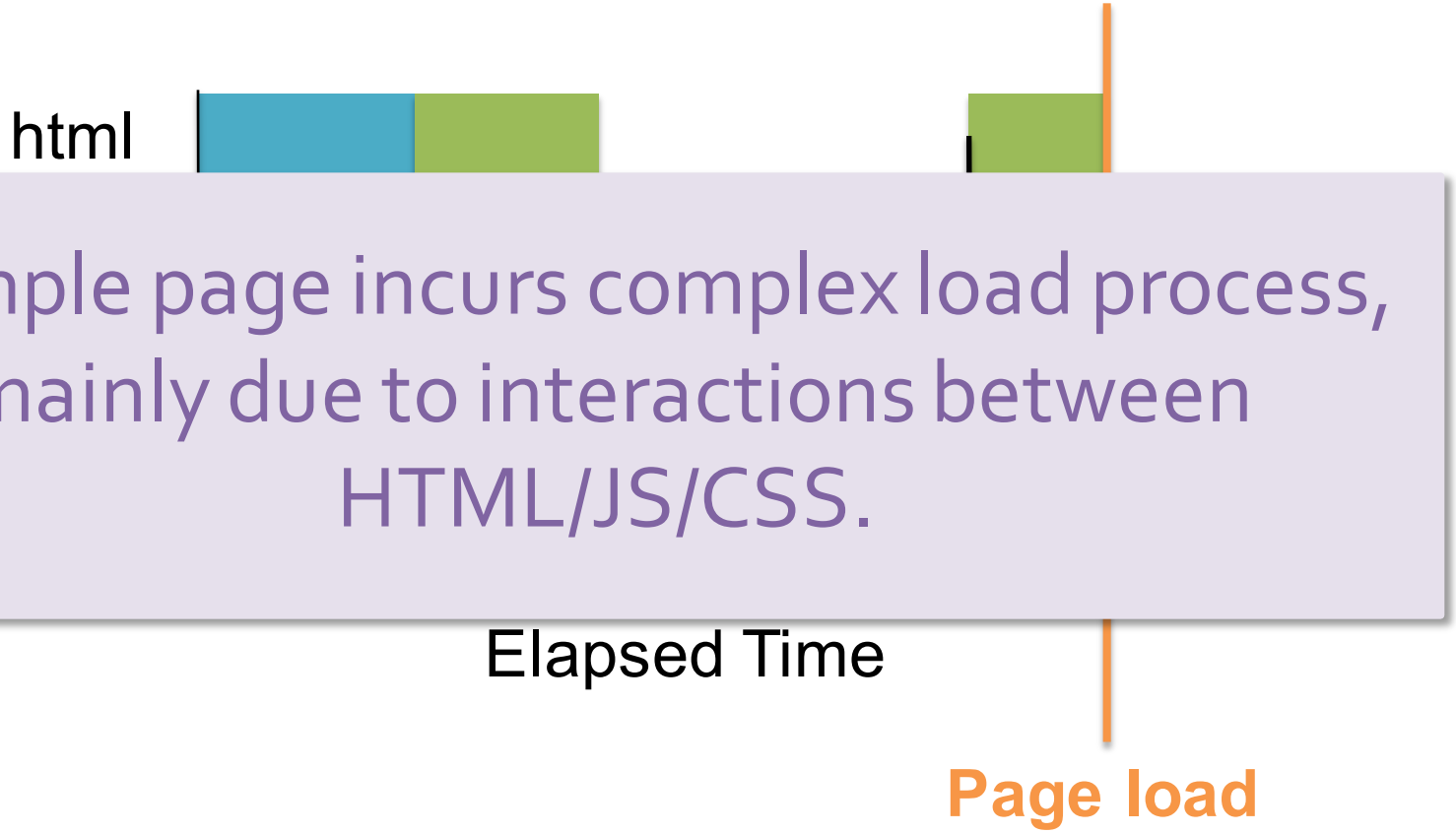

How much can SPDY help PLT?

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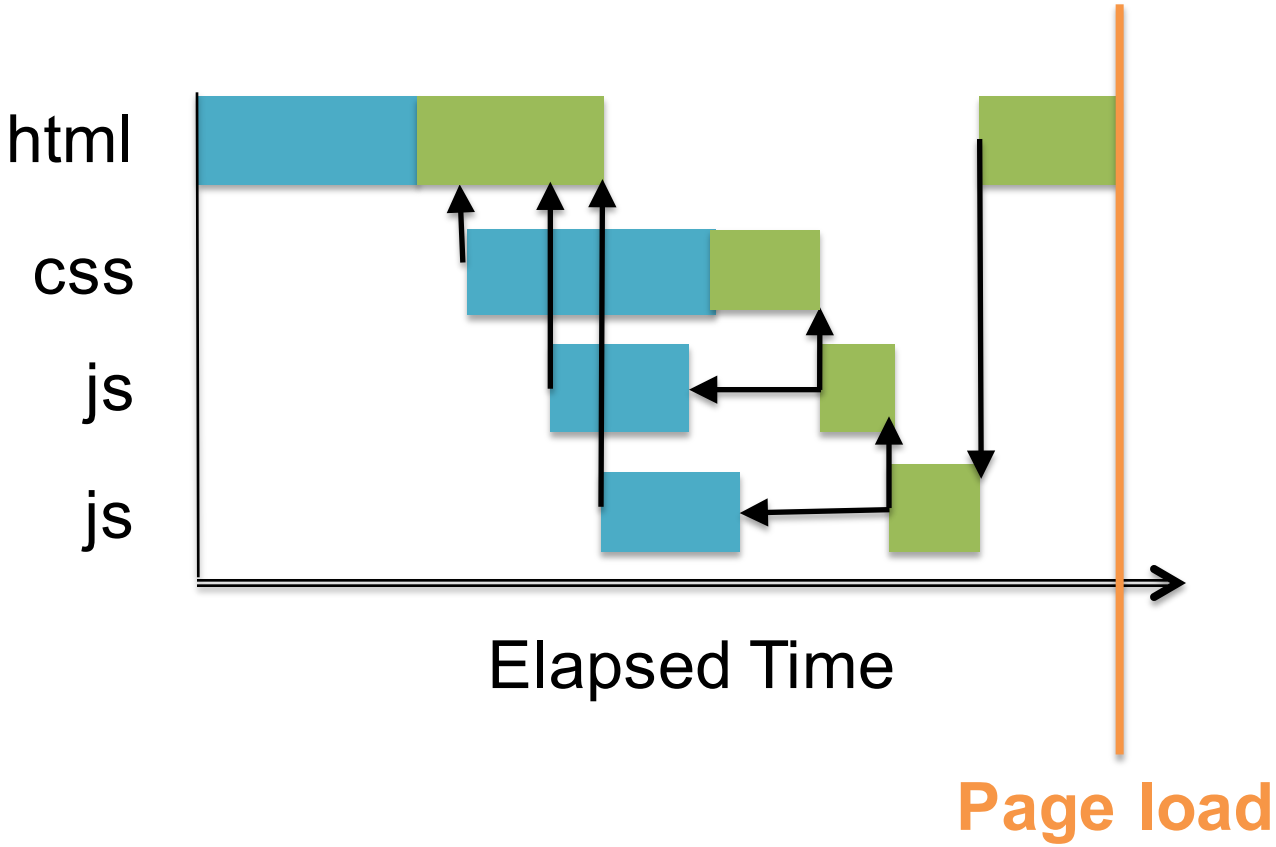

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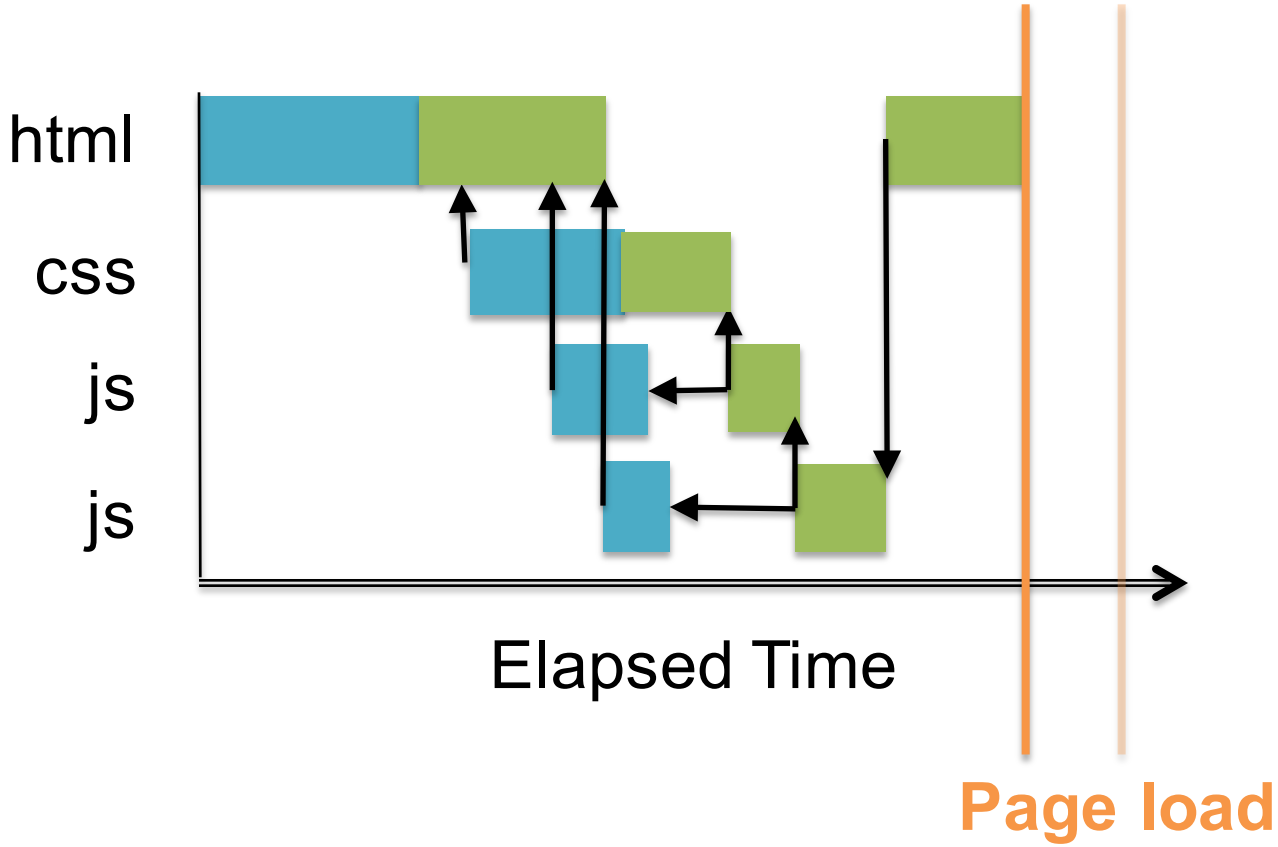
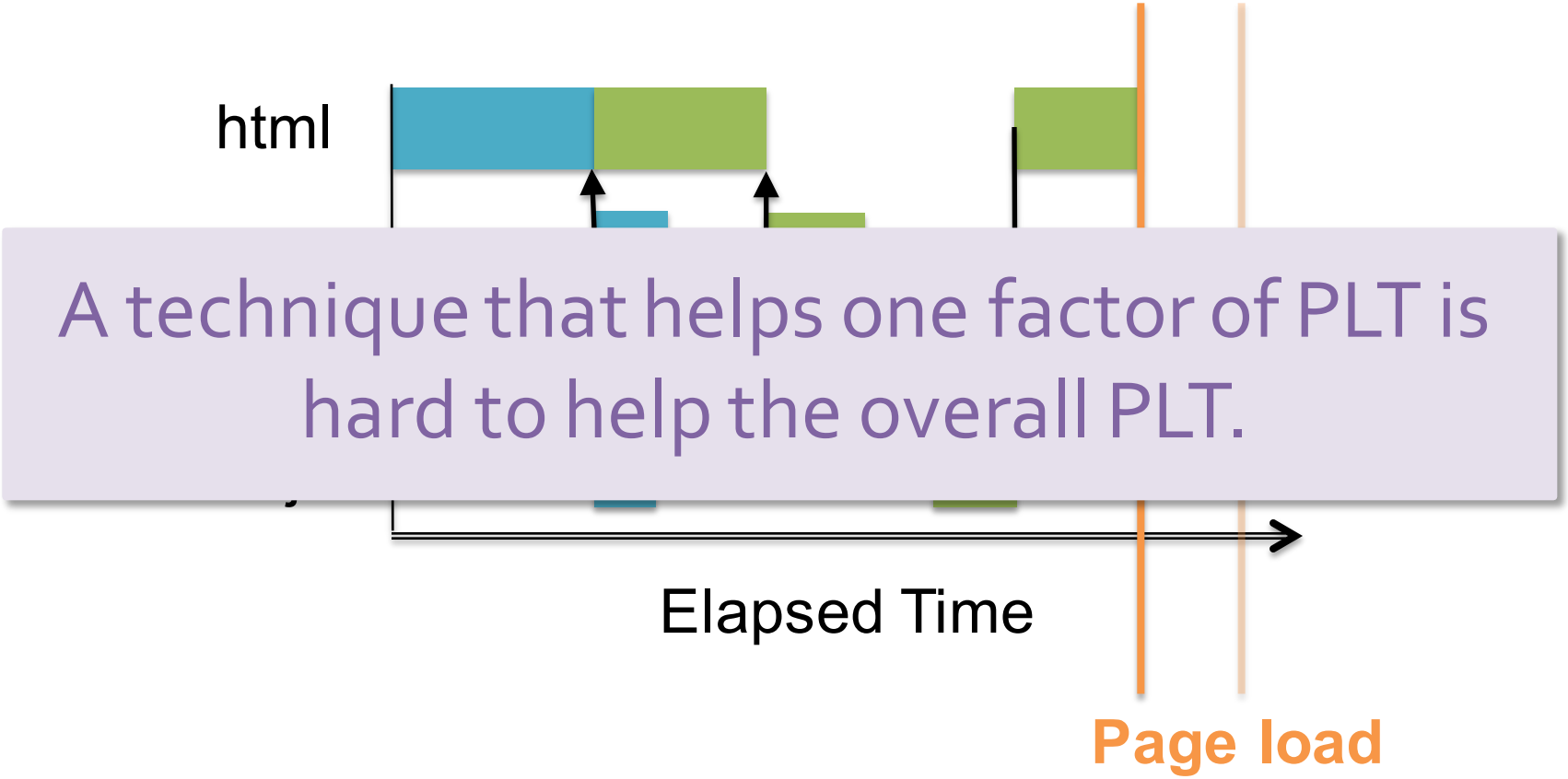
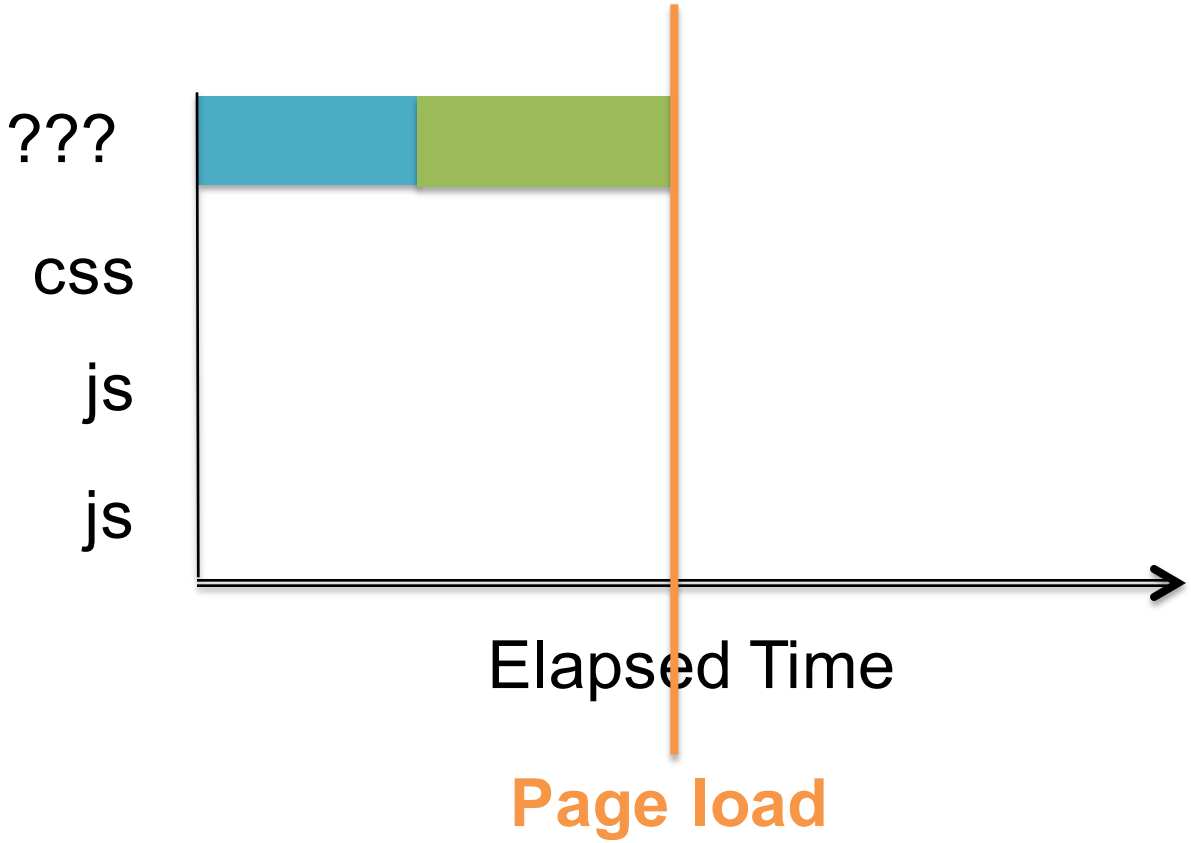


Network Computation → Dependency



Network Computation → Dependency

What does the simplest dependency graph look like?



Network Computation → Dependency

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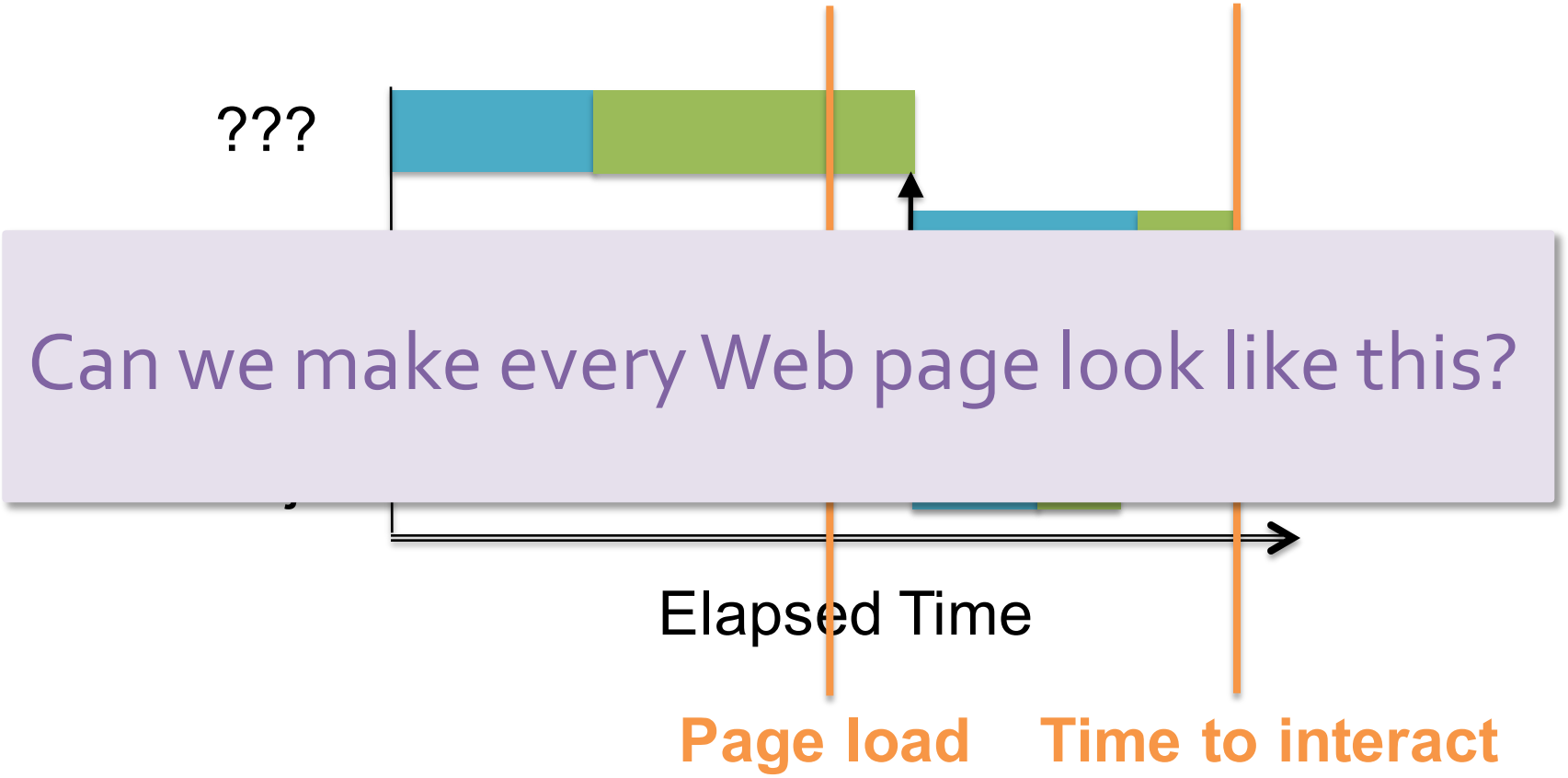


Can we make every Web page look like this?

Network Computation → Dependency

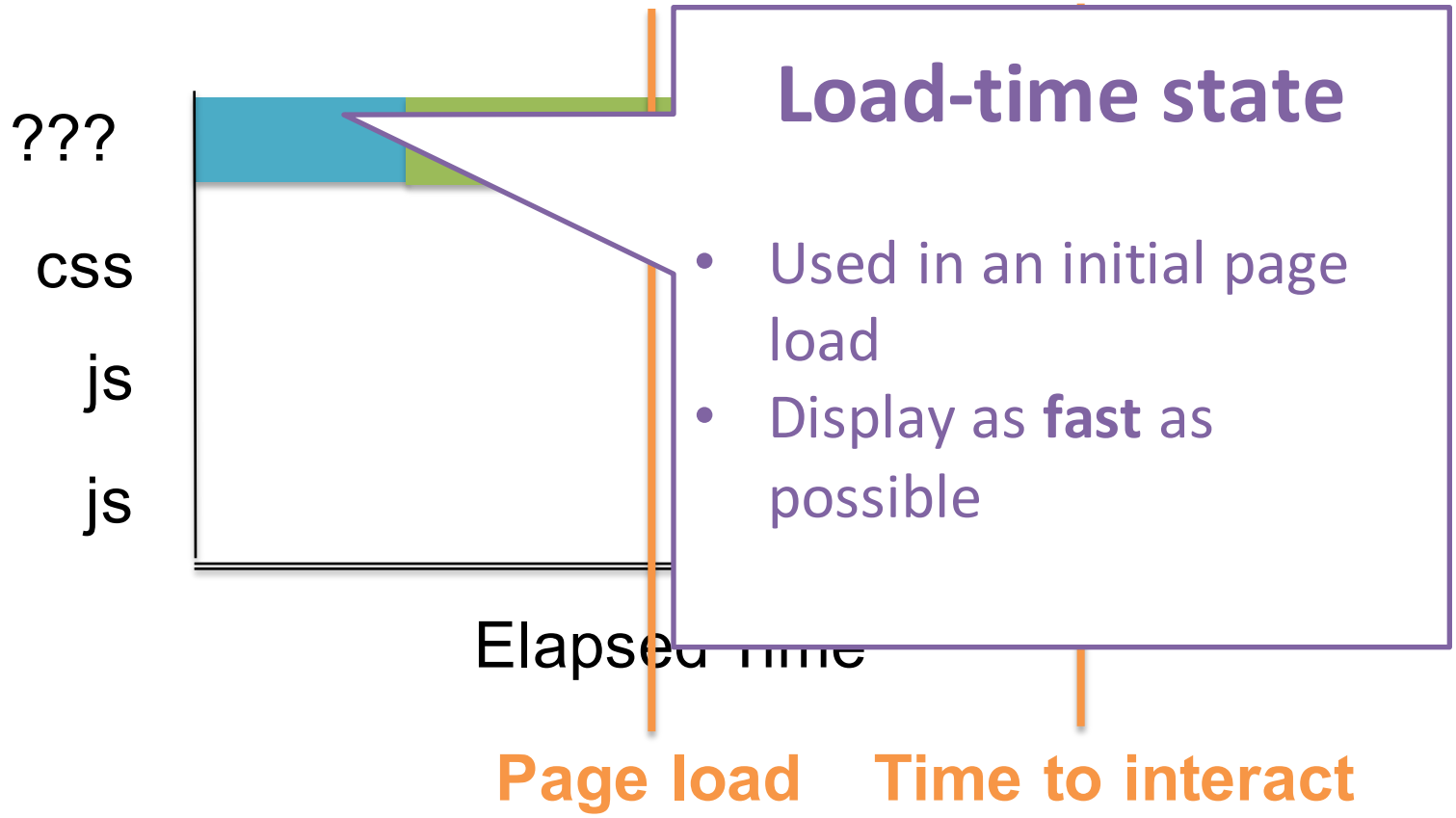
Yes, we want to make every page like this, automatically.

Approach: Split Browser

- Preprocess Web pages on a proxy server to simplify the client-side page load process

Approach: Split Browser

- Preprocess Web pages on a proxy server according to whether they are used initially

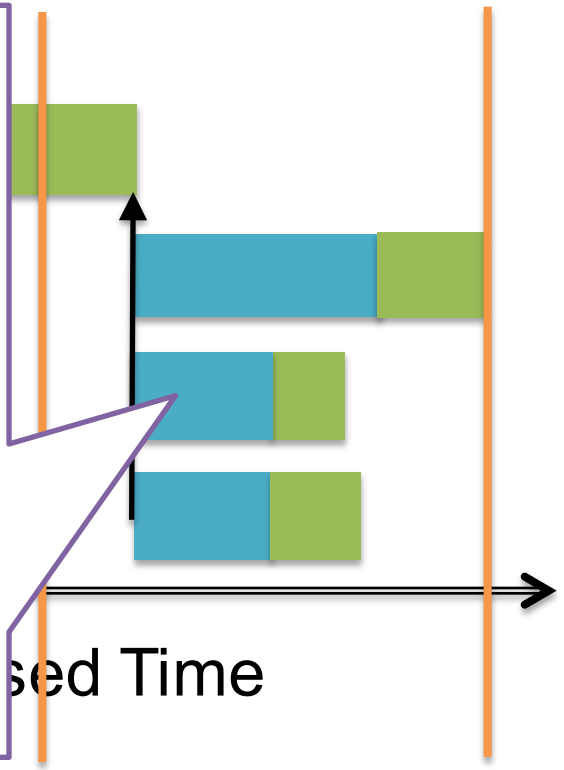


Approach: Split Browser

- Preprocess Web pages on a proxy server according to whether they are used initially

Post-load state

- Not used in an initial page load
- Ensure **correctness** of future interactions, and **compatibility** with existing technologies



Page load **Time to interact**

Outline

- Load-time state
- Post-load state
- Deployment and implementation
- Evaluation

Outline

- **Load-time state**
- Post-load state
- Deployment and implementation
- Evaluation

Load-time State

- Goal
  - Display as fast as possible
- Approach
  - Eliminate both contents and computation of JS and CSS on the client as many as possible

Loading load-time state

```
{“loadTimeState”:{
  “css”:[“#main{font-size:12px;}"],
  “html”:{“children”: [{
   “tagName”:”body”, ...
   “children”: [..., {
    “tagName”:”div”,“id”:”main”,
    “css”:[0]
 }]}]}}
```

Loading load-time state

```
{“loadTimeState”:{
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  “html”:{“children”: [{
   “tagNa
   “child
    “tagN
    “css”:[0]
 }]}]}}
```

A list of matched CSS rules

Loading load-time state

```
{“loadTimeState”:{
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   “children”: [..., {
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 }]}]}}
```

Visible HTML elements

Loading load-time state

```
{“loadTimeState”:{
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  “html”:{“children”: [{
   “tagName”:”body”, ...
   “children”: [..., {
    “tagName”:”div”,“id”:”main”,
    “css”:[0]
 }]}]}}
```
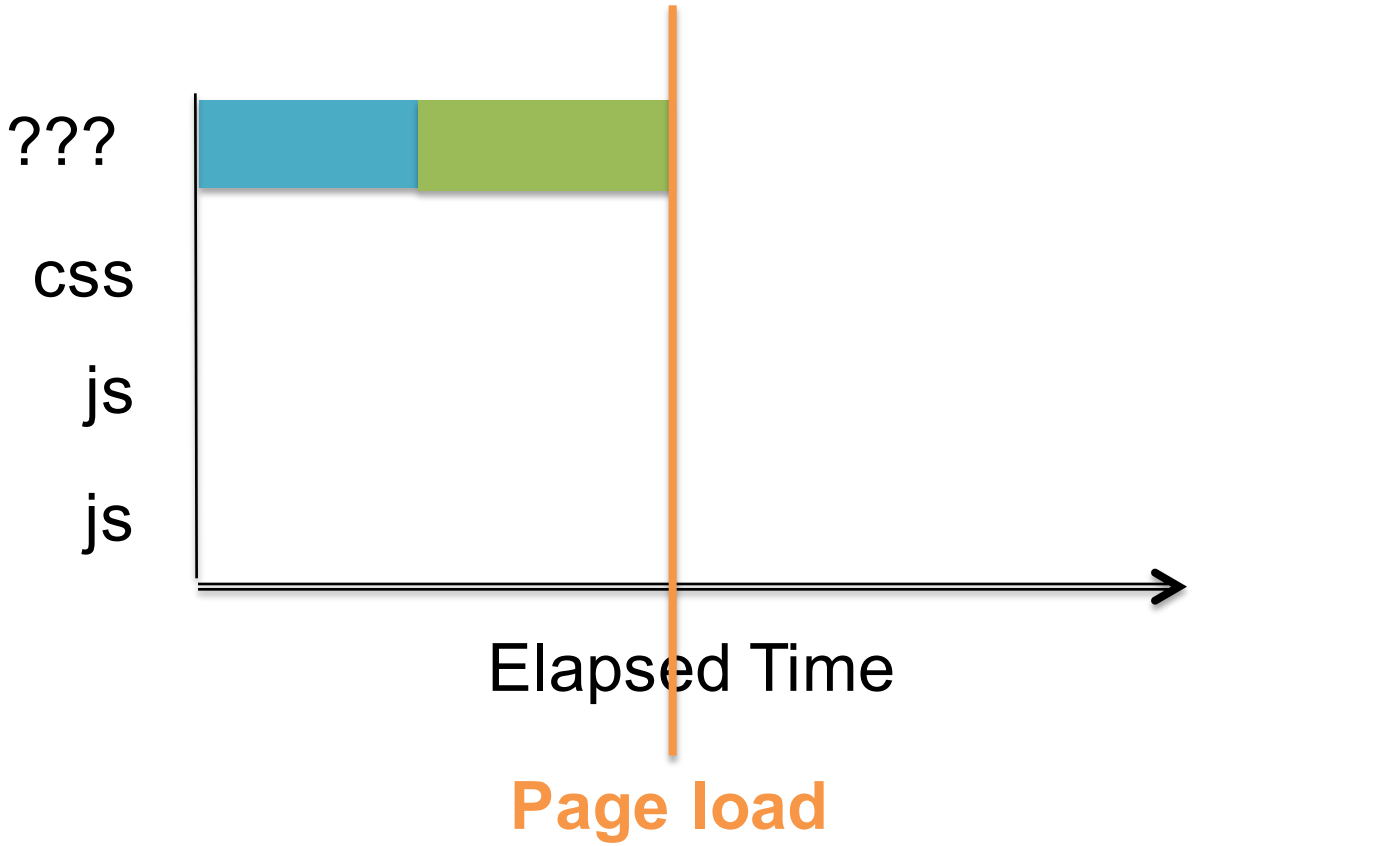

Which HTML element matches which CSS rules

Loading load-time state



Outline

- Load-time state
- Post-load state
- Deployment and implementation
- Evaluation

Post-load state

- Goals
  - **Correctness** of future interactions
    - Requirement: Post-load and load-time state contain full state of a Web page
  - **Compatibility**
    - Requirement: Post-load state contains unmodified JS/CSS snippets

Vanilla post-load state

- The entire Web page itself
- Pros
  - Easy to ensure correctness of interactions and compatibility with caching/CDN
- Cons
  - Redundant contents and computation from load-

From here, how much can we improve?

What's equivalent to eval'ing this CSS?

```
#main {
  font-size:12px;
}
#main {
  font-size:12px;
}
#main {
  font-size:12px;
}
```

What's equivalent to eval'ing this CSS?

```
#main {
  font-size:12px;
}
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  font-size:12px;
}
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  font-size:12px;
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```
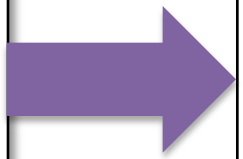



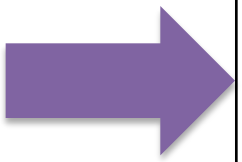
```
#main {
  font-size:12px;
}
```

What's equivalent to eval'ing this JS?

```
a += "hello world!\n"

a += "hello world!\n"

a += "hello world!\n"
```

What's equivalent to eval'ing this JS?

```
a += "hello world!\n"

a += "hello world!\n"

a += "hello world!\n"
```



```
a += "hello world!\n"
   + "hello world!\n"
   + "hello world!\n"
```

What's equivalent to eval'ing this JS?

```
function add(a, b) {
  return a + b;
}
function add(a, b) {
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}
function add(a, b) {
  return a + b;
}
```

What's equivalent to eval'ing this JS?

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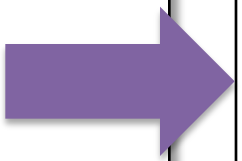


```
function add(a, b) {
  return a + b;
}
```

Post-load state

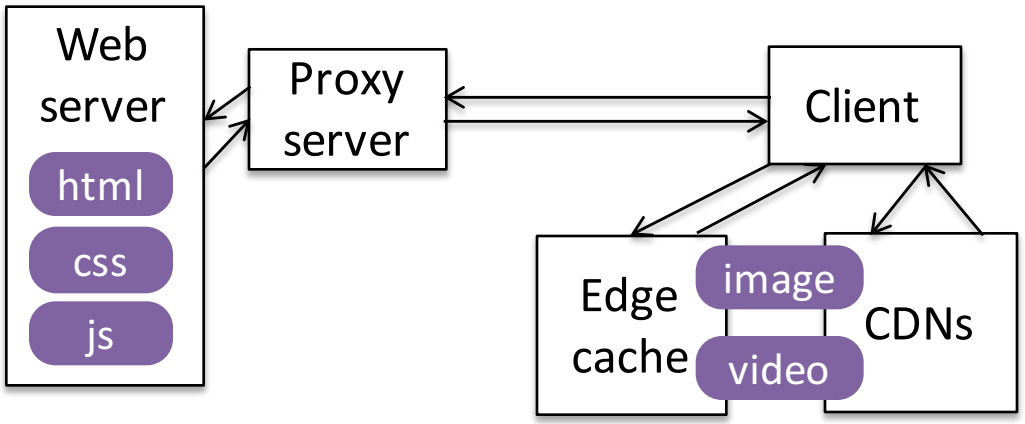
- Exploit the **idempotency** of evaluating CSS rules and JavaScript functions/statements
  - Eliminate redundant content that appeared in load-time state
  - Capture results of non-idempotent JS statements

Outline

- Load-time state
- Post-load state
- Deployment and implementation
- Evaluation

Deployment

- How to fast load on the proxy server?
  - Use a beefy server
  - Co-locate with Web front ends
    - As part of the website: reverse proxy
    - As a 3rd-party service: cloud servers



Implementation

- Server extension
  - Chrome's content_shell
  - Only handle HTML/JS/CSS
- Client browser
  - Chrome
  - JSON lexer, Blink, V8

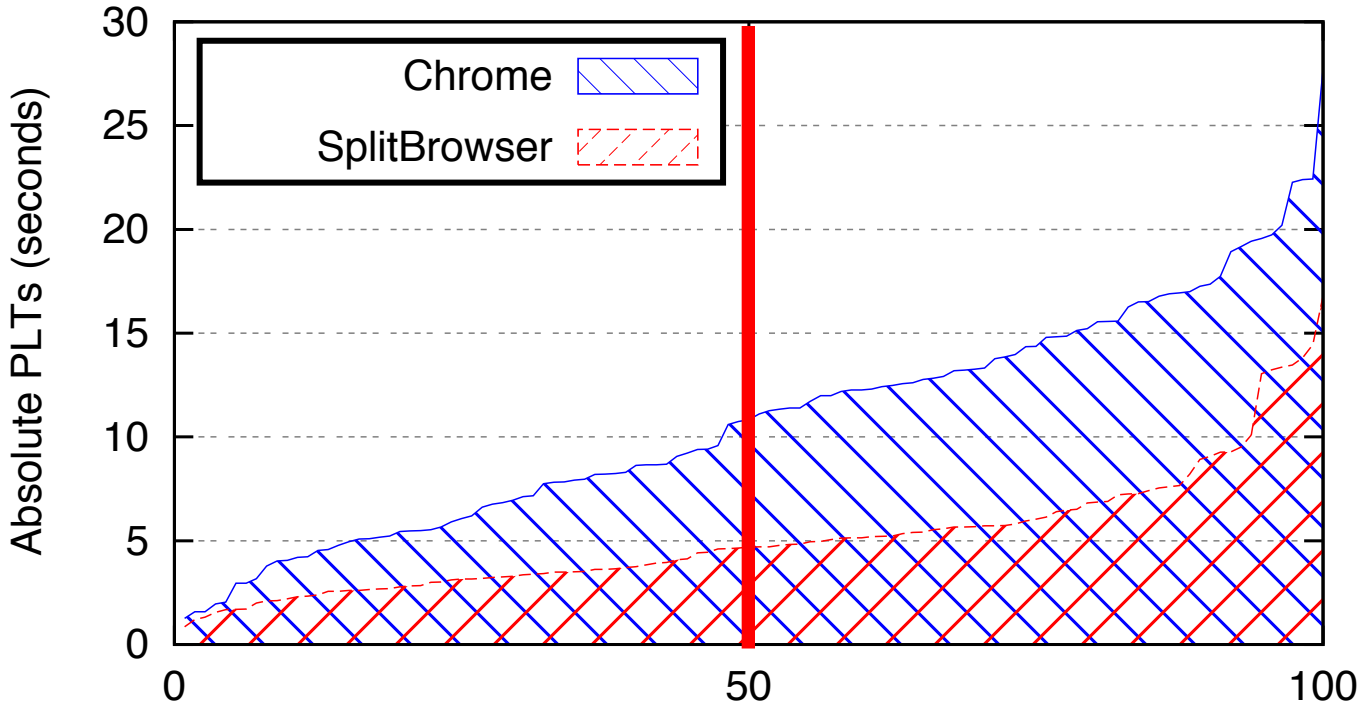
Outline

- Load-time state
- Post-load state
- Deployment and implementation
- Evaluation

Experimental setup

- Server: 2.4GHz 16 core CPU, 16GB memory
- Clients
  - Mobile: Nexus S, 1GHz Cortex-A8 CPU, 512MB RAM
  - Desktop: Linux VM, 2GHz CPU, 1GB memory
- Top 100 Web pages

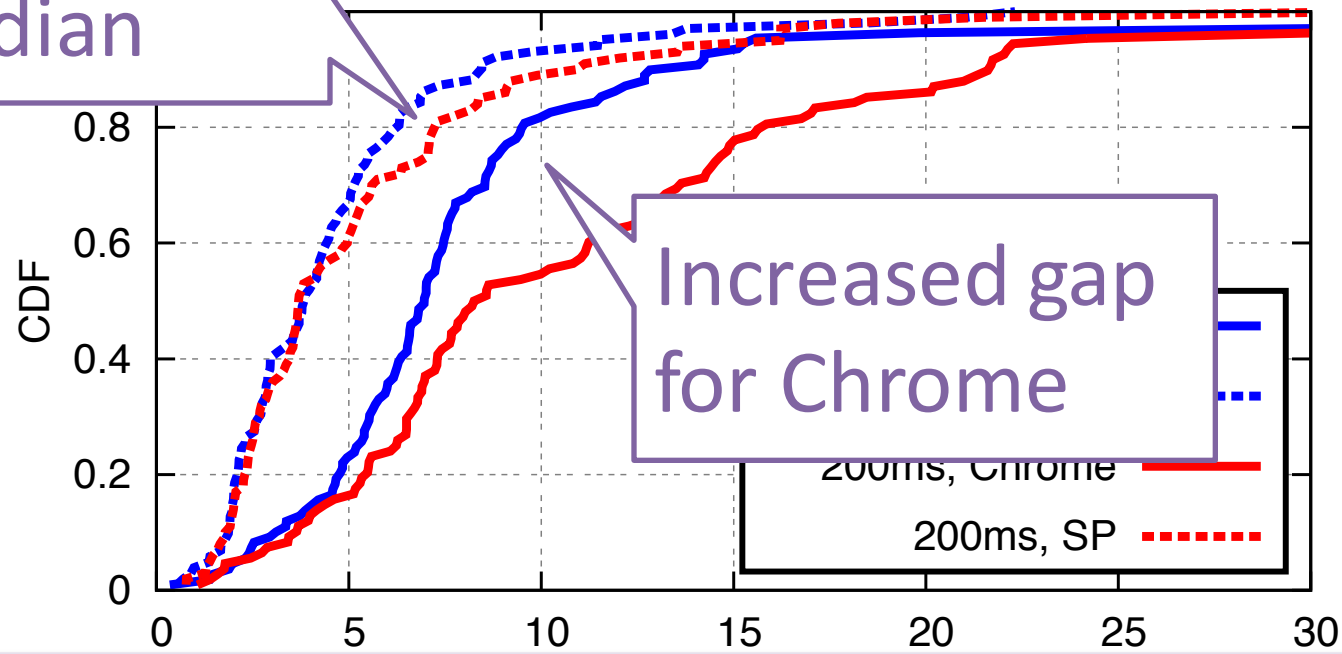
PLT on mobile



Shandian helps **60%** in the median case

PLT w/ varying RTT

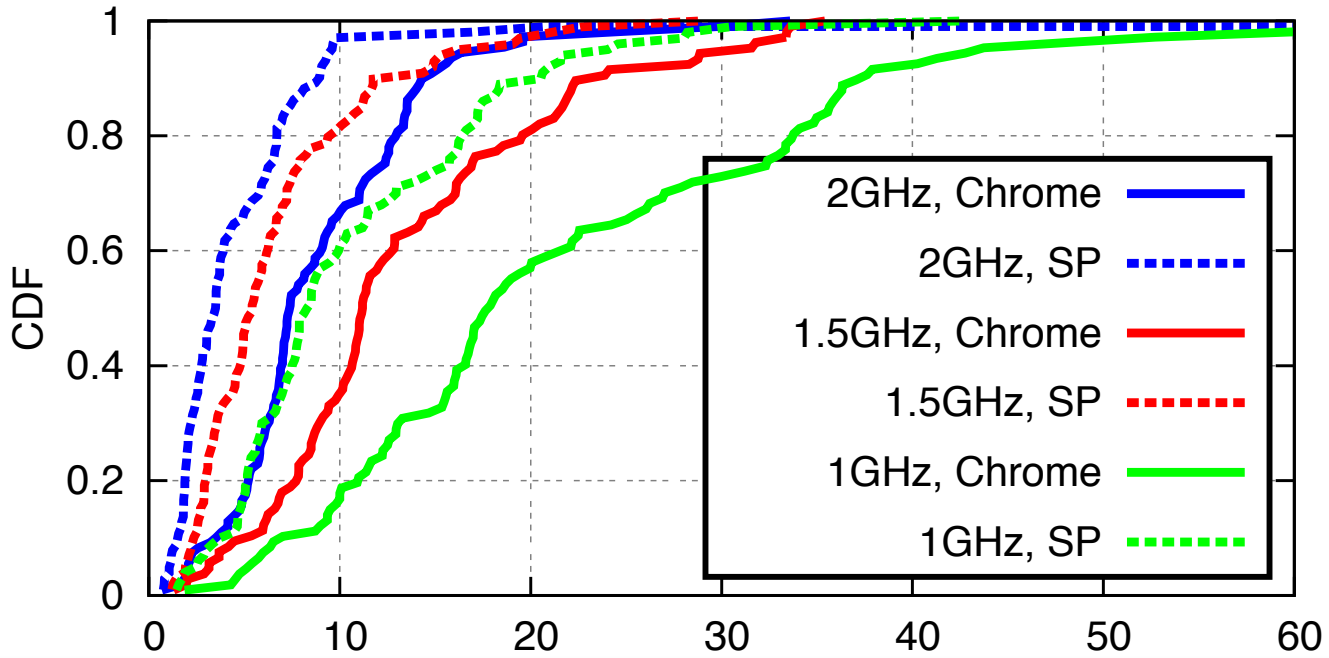
Small gap for Shandian



Increased gap for Chrome

Unlike Chrome, Shandian is not sensitive to RTT, due to simplified page load process

PLT w/ varying CPU



CPU has the same amount of impact for both Chrome and Shandian

More results

- PLT breakdowns
  - Time spent on proxy server is negligible
  - Most time is spent on client
- Page size
  - Shandian increases page size by 1% after applying gzip compression

Difference from related work

- Amazon Silk, Opera mini
  - Our client can run JavaScript
  - We place proxy servers near Web servers
- Prioritizing resources (server push, Klotski)
  - We remove page load dependencies on the client

Summary

- Split the page state according to whether they are used for an initial page load
- The dependency graph until the page is loaded is fairly simple
- Improve PLT by more than half consistently for various settings
- Is compatible with caching/CDNs