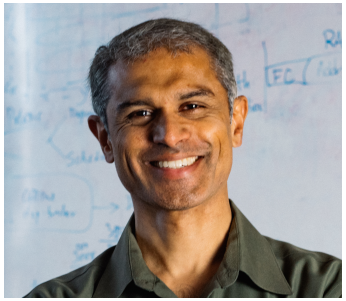
Polaris: Faster Page Loads Using Fine-grained Dependency Tracking









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Web Performance

- Users demand fast page loads
- Slow page loads lead to lost revenue and low search rank

Research: Site Speed Is Hurting ~~Your~~ Everyone's Revenue

IAN LURIE // MAY 9 2014

Site speed, site speed, site speed. Everyone around me is sick of hearing m

because I've pushed it on every client Portent's had since, oh, 2008.

Google Webmaster Central Blog

Official news on crawling and indexing sites for the Google index

Using site speed in web search ranking

Friday, April 09, 2010

Webmaster Level: All

You may have heard that here at Google we're obsessed with speed, in our products and on the web. As part of that effort, today we're including a new signal in our search ranking algorithms: site speed. Site speed reflects how quickly a website responds to web requests.

How One Second Could Cost Amazon $1.6 Billion In Sales

Research on U.S. Net habits suggests that if this sentence takes longer than a second to load, many citizens will have clicked elsewhere already. If you've got the patience (or are European) read on for more shocking data on not dawdling.

It's Official: Google Now Counts Site Speed As A Ranking Factor

Matt McGee on April 9, 2010 at 2:00 pm

Google has kept a promise it made last year: Site speed is now a ranking factor in Google's algorithm, and is already in place for U.S. searchers. But Google also cautions web site owners not to sacrifice relevance in the name of faster web pages, and even says this new ranking factor will impact very few queries. More on that below, but first the background on today's announcement from Google Fellow Amit Singhal and Matt Cutts, head of Google's web spam team.

Why Page Speed Matters

The first warning that site speed was on Google's radar came last November, when Cutts said there

Google Rank Website On Loading Time of the Page

By: Harsh Agrawal | In: SEO | Last Updated: 18/03/2015

ths back Google webmaster team indicated that they will start ranking websites their page loading time. Websites which take ages to load slows down the and they are considering this factor seriously. Apart from other parameters like e, meta descriptions, Google will also consider Page load time as one of the eason for your website search engine ranking.

How Website Speed Actually Impacts Search Ranking

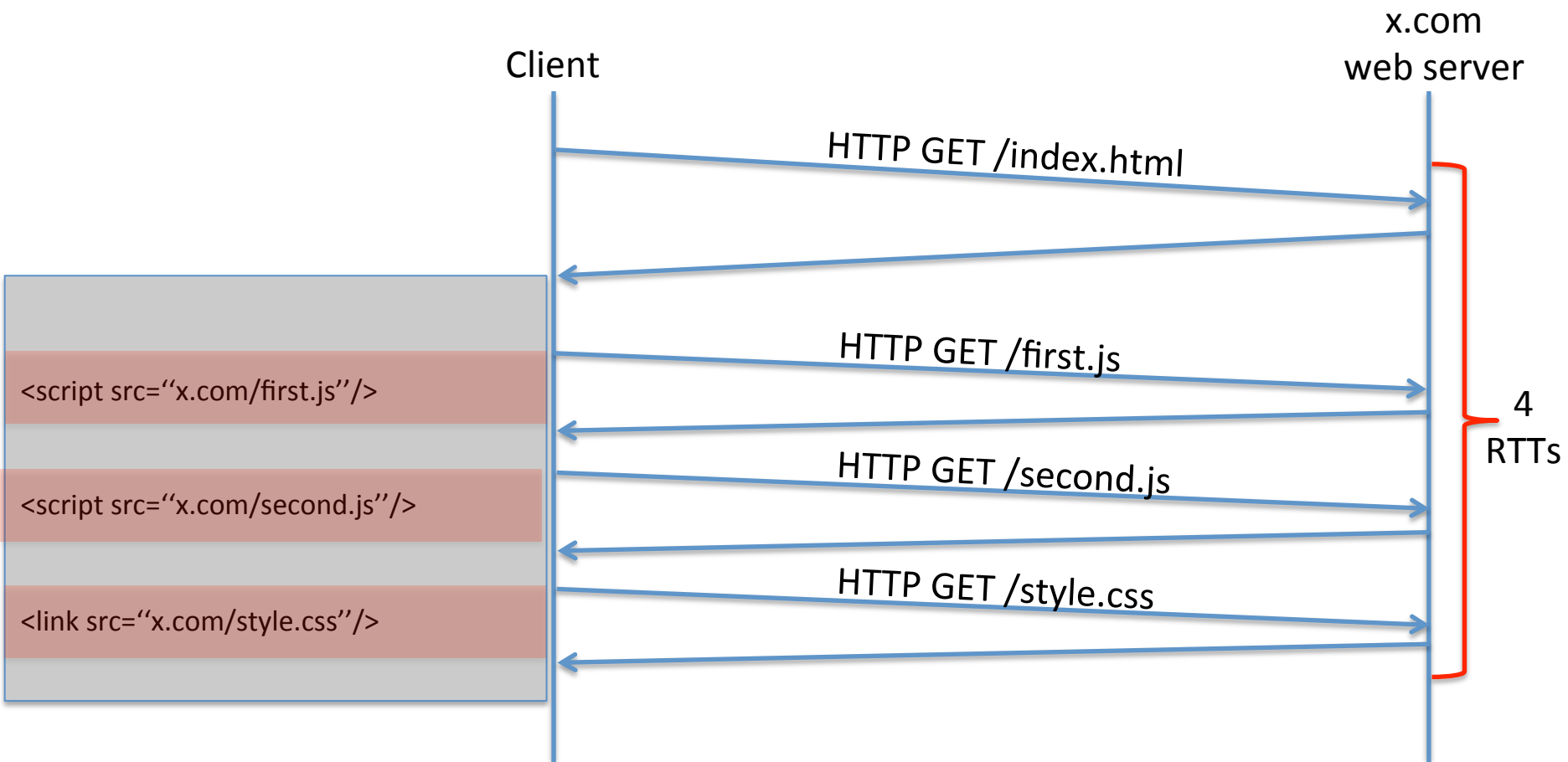
On-page SEO

The author's views are entirely his or her own (excluding the unlikely event of hypnosis) and may not always reflect the views of Moz.



Google uses a multitude of factors to determine how to rank search engine results. factors are either related to the content of a webpage itself (the text, its URL, the ti

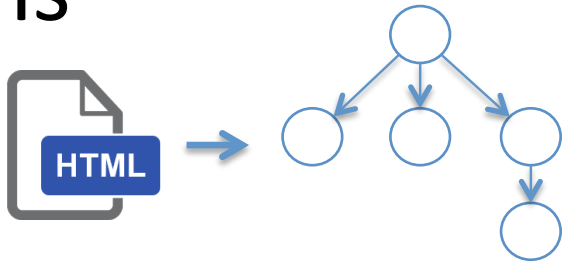
Page Load


Client
x.com
web server
HTTP GET /index.html
HTTP GET /first.js
HTTP GET /second.js
HTTP GET /style.css
4
RTTs
<script src=“x.com/first.js”/>
<script src=“x.com/second.js”/>
<link src=“x.com/style.css”/>

Dependency Graphs

Model page loads as directed acyclic graphs

- Page load time = time to completely resolve dependency graph



index.html

```
<script src=“x.com/first.js”’/>
<script src=“x.com/second.js”’/>
<link src=“x.com/style.css”’/>
```

first.js

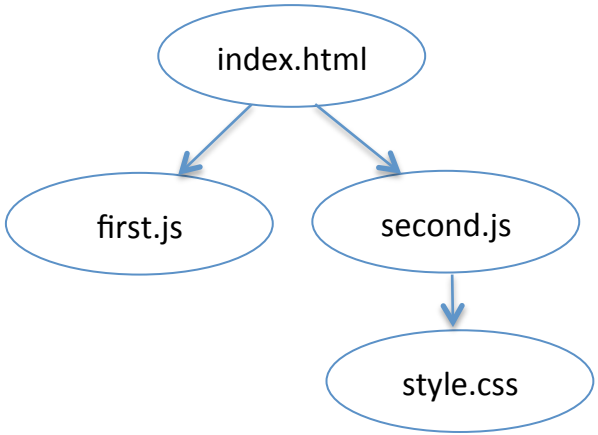
```
var x = 5;
```

second.js

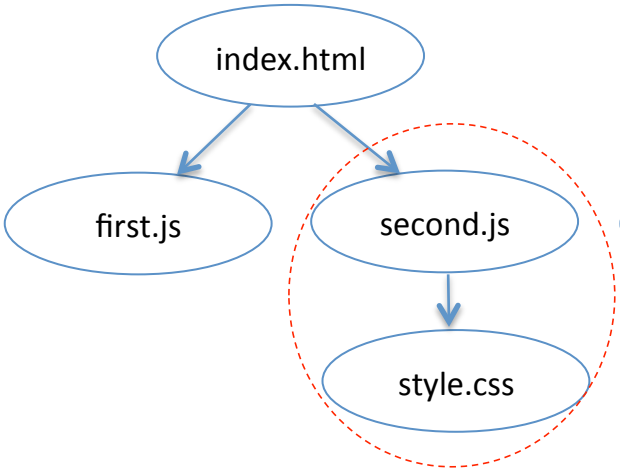
```
var n = document.getElementsByTagName(“link”);
if ( n == 0 ) {…}
```

style.css

```
p {
   color: red;
}
```



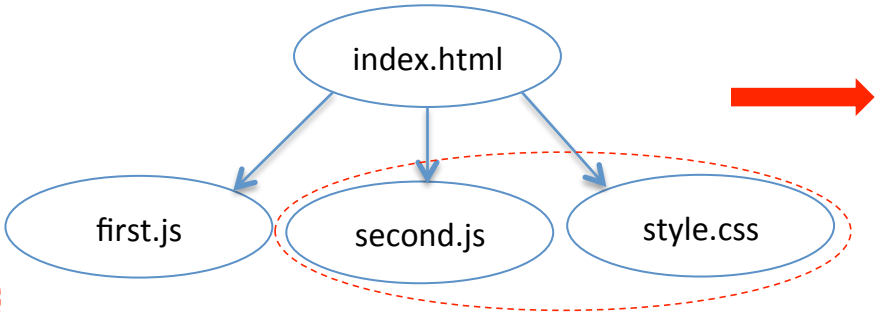
Dependency Graphs



True Dependency Graph

3 RTTs

Missing Dependencies



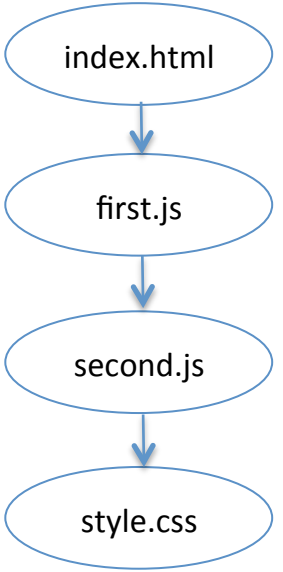
Lexical HTML Dependencies

```
<script src=‘‘x.com/first.js’’/>

<script src=‘‘x.com/second.js”/>

<link src=‘‘x.com/style.css’’/>
```

Conservative Assumptions

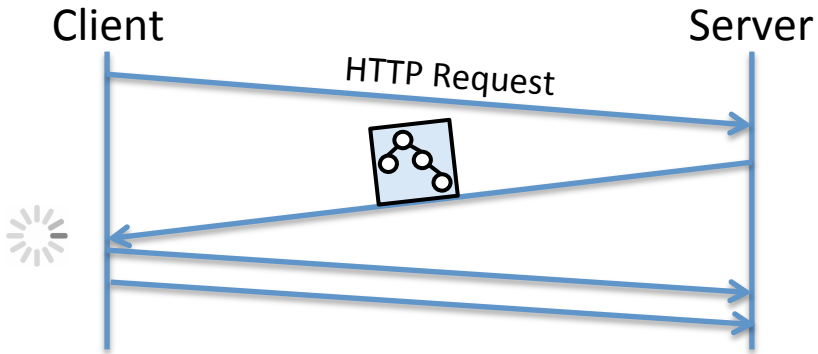


HTML Tag Order

4 RTTs

Outline

- Scout: tracks fine-grained dependencies between page's objects
  - Traditional dependency graphs miss 30% of edges
- Polaris: dynamic client-side scheduler written in JavaScript
  - Uses fine-grained dependencies to reduce page load times



  - 34% faster (1.3 seconds) on 12 Mbits/s link with 100 ms RTT

Scout

- Scout tracks many different dependencies across a page's state

3 Types of Dependencies

Write/Read

first.js

```
x = 6;
```

second.js

```
y = x + 5;
```

Read/Write

first.js

```
x = [1,3,5];
```

second.js

```
y = x.length;
```

third.js

```
x.push(7);
```

Write/Write

first.js

```
alert("first message");
```

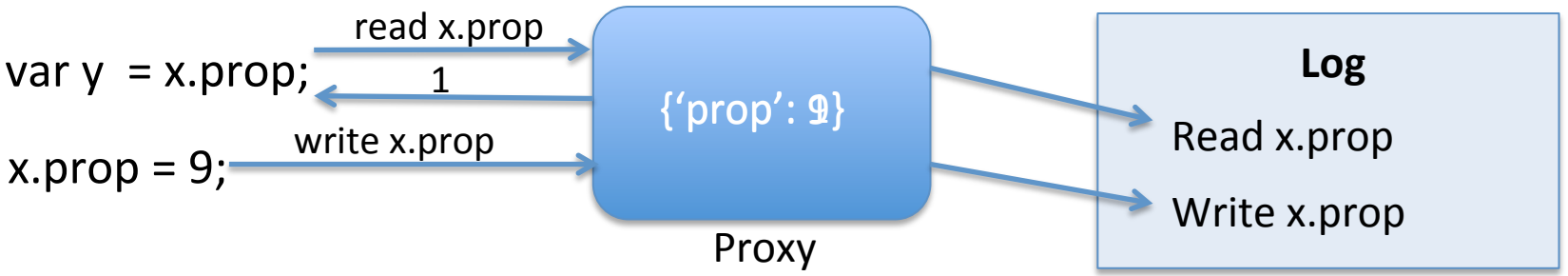
second.js

```
alert("second message");
```

Tracking Dependencies

- JS proxy objects

var x = ~~{'prop': 1};~~ new Proxy(**{'prop': 1}**, log_handlers);

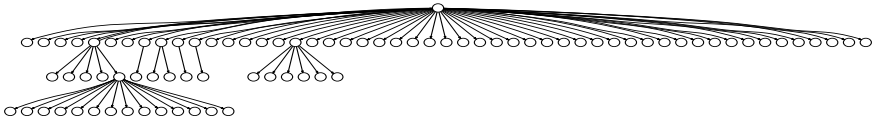


- Many others described in paper
  - Global variables
  - Recursive proxying (e.g., x.y.z)
  - DOM (e.g., document.getElementById("foo"))

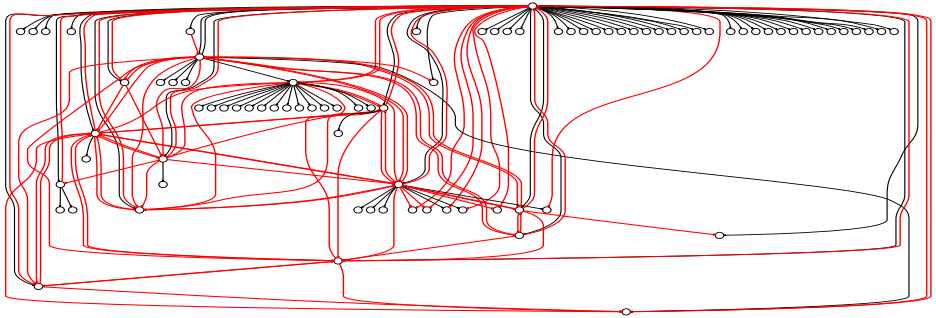
What we found

- Traditional graphs miss 30% of edges
- 80.8% of pages have altered critical paths

weather.com



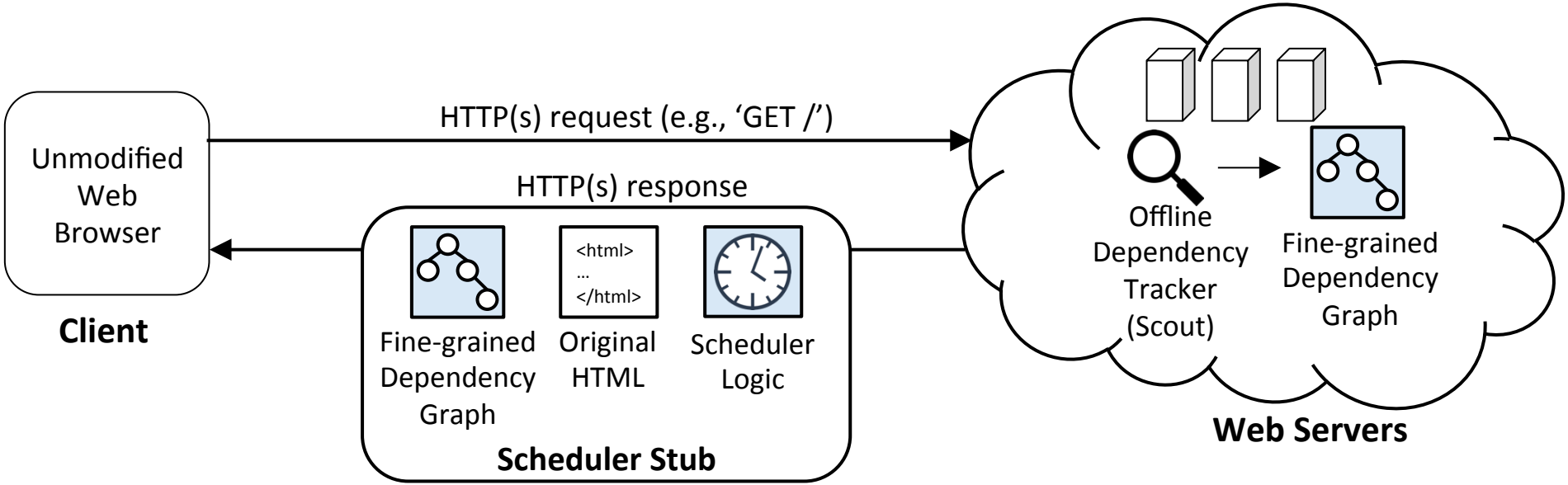
Traditional Dependency Graph



Complete Dependency Graph

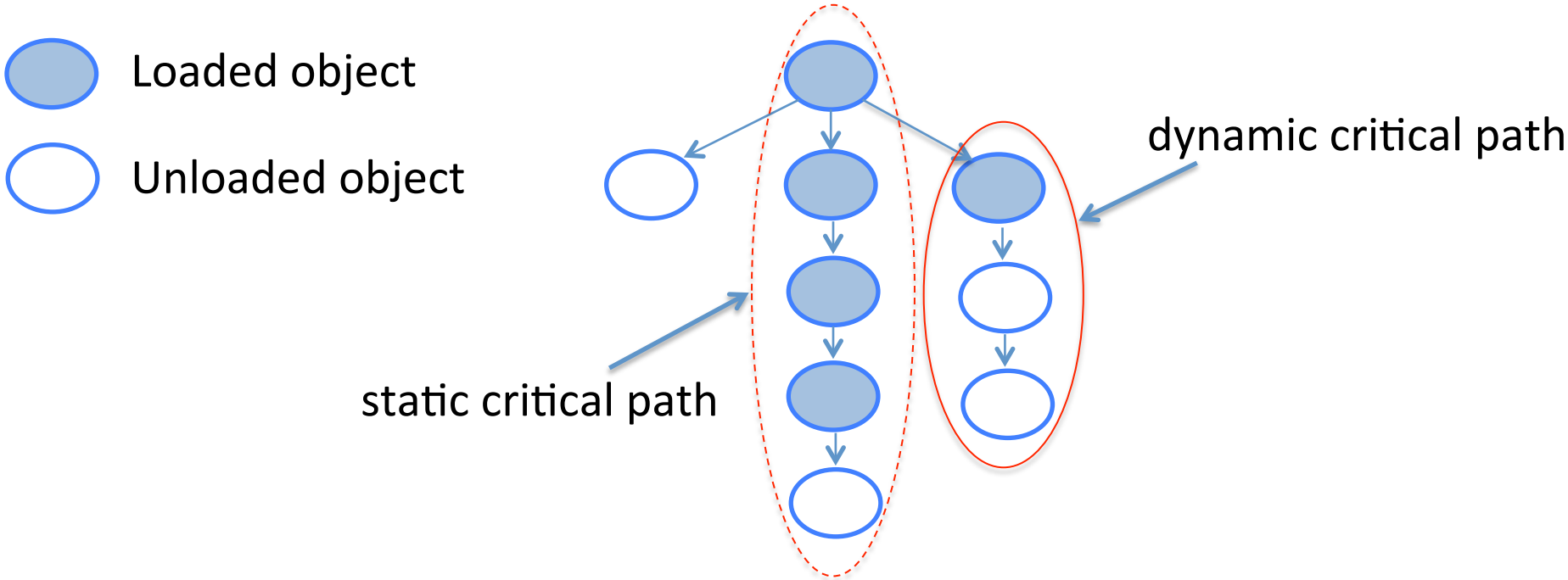
Adding all edges → removes conservative assumptions → faster page loads!

Polaris

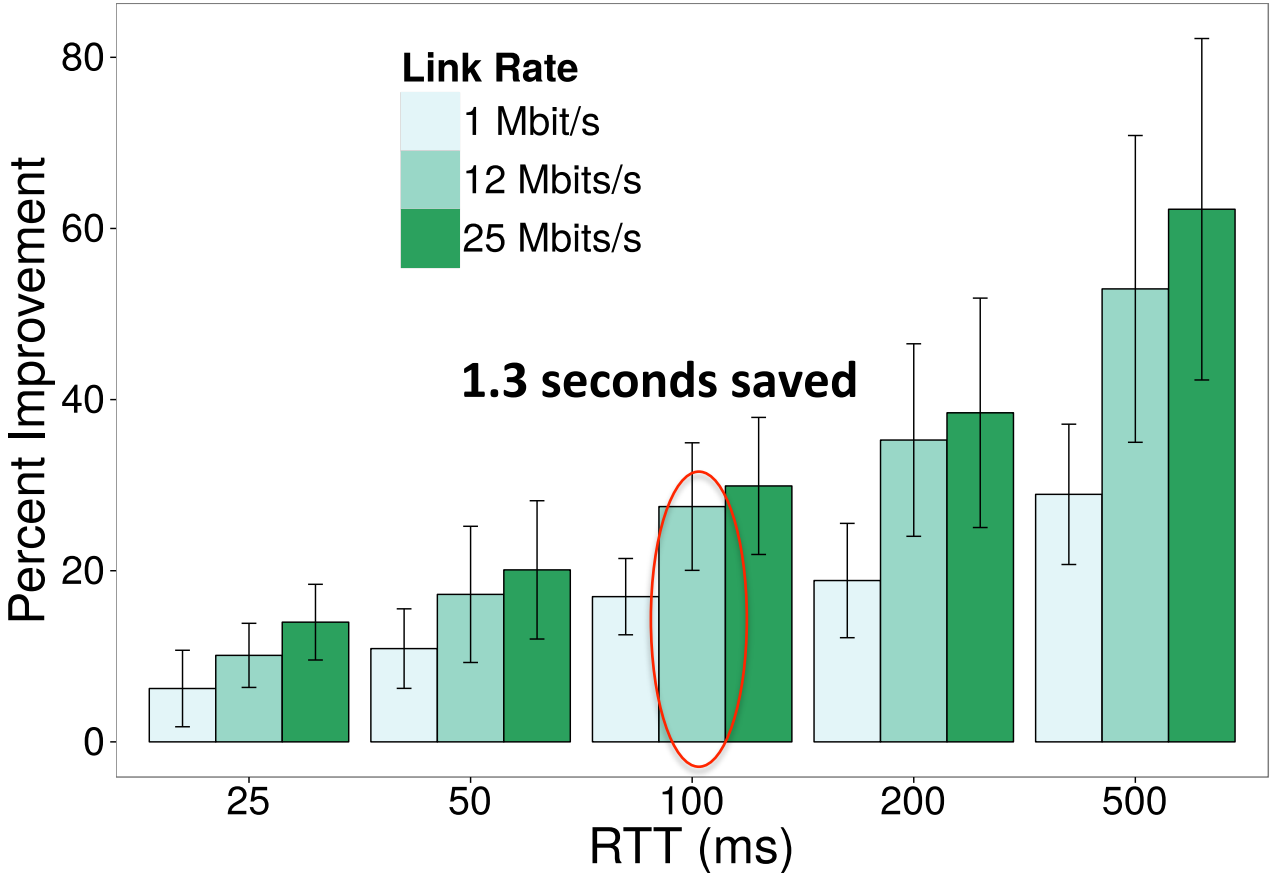

Unmodified Web Browser
Client
HTTP(s) request (e.g., 'GET /')
HTTP(s) response
<html>
...
</html>
Fine-grained Dependency Graph
Original HTML
Scheduler Logic
Scheduler Stub
Offline Dependency Tracker (Scout)
Fine-grained Dependency Graph
Web Servers

Request Scheduling with Polaris

Always fetch objects on the **dynamic critical path**

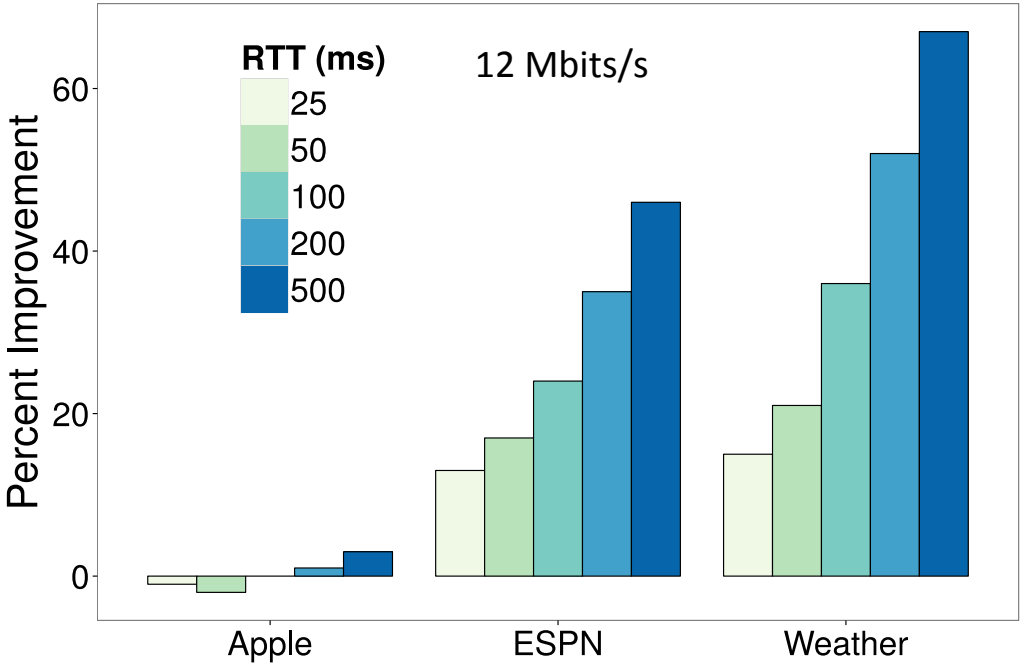


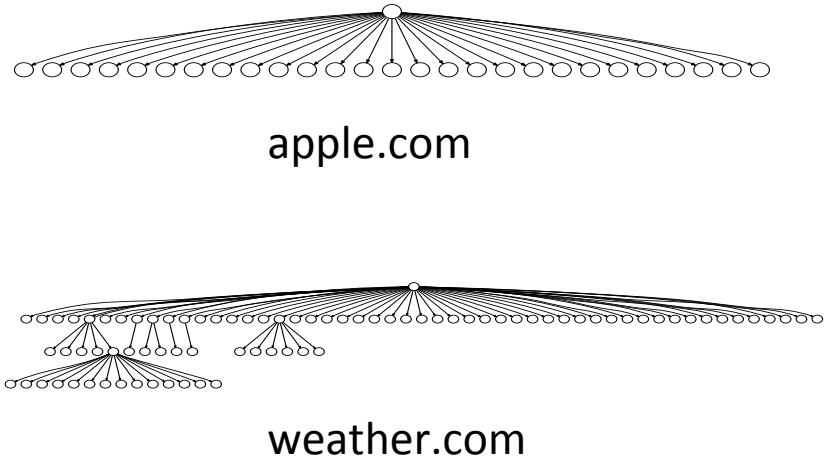
Evaluating Polaris



- Gains increase with increasing RTT
- Gains increase with increasing link rate
- Baseline is Firefox (which does speculative execution)
- Large error bars: page structure matters too!

Impact of Dependency Graph Structure





- Apple: scheduling doesn't matter (all requests have same priority)
- Weather: short and long chains so scheduling matters

Conclusion

- Browsers today are constrained by uncertainty!
  - Conservative assumptions lead to higher page load times
  - Klotski (NSDI '15), WProf (NSDI '13), Browser Developer Tools
- Scout: tracks fine-grained dependencies between page's objects
  - Prior dependency graphs miss 30% of edges
- Polaris: dynamic client-side scheduler written in JavaScript
  - Uses Scout's fine-grained dependencies to reduce page load times
  - 34% faster (1.3 seconds) on 12 Mbits/s link with 100 ms RTT

http://web.mit.edu/polaris **polarisweb@mit.edu**