DEBUGGING FRONT-END PERFORMANCE

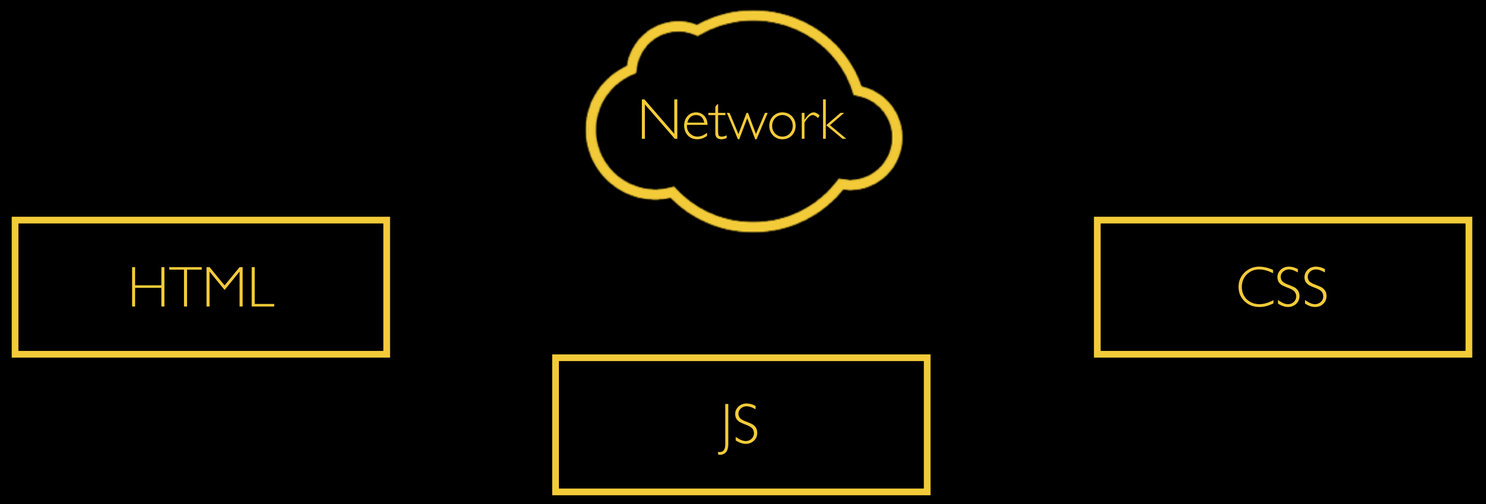
Tim Kadlec (@tkadlec) & Pat Meenan (@patmeenan)

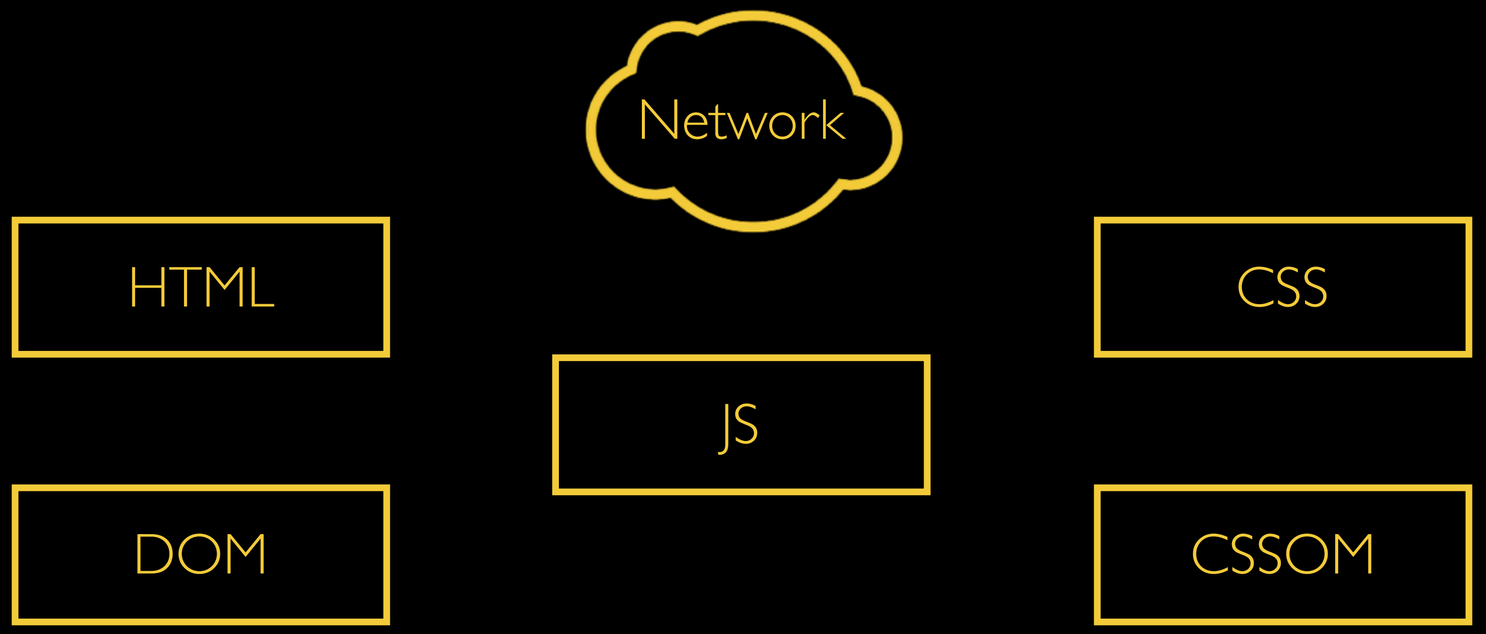
September 19-20, 2016 at Velocity Conference NY (#velocityconf)

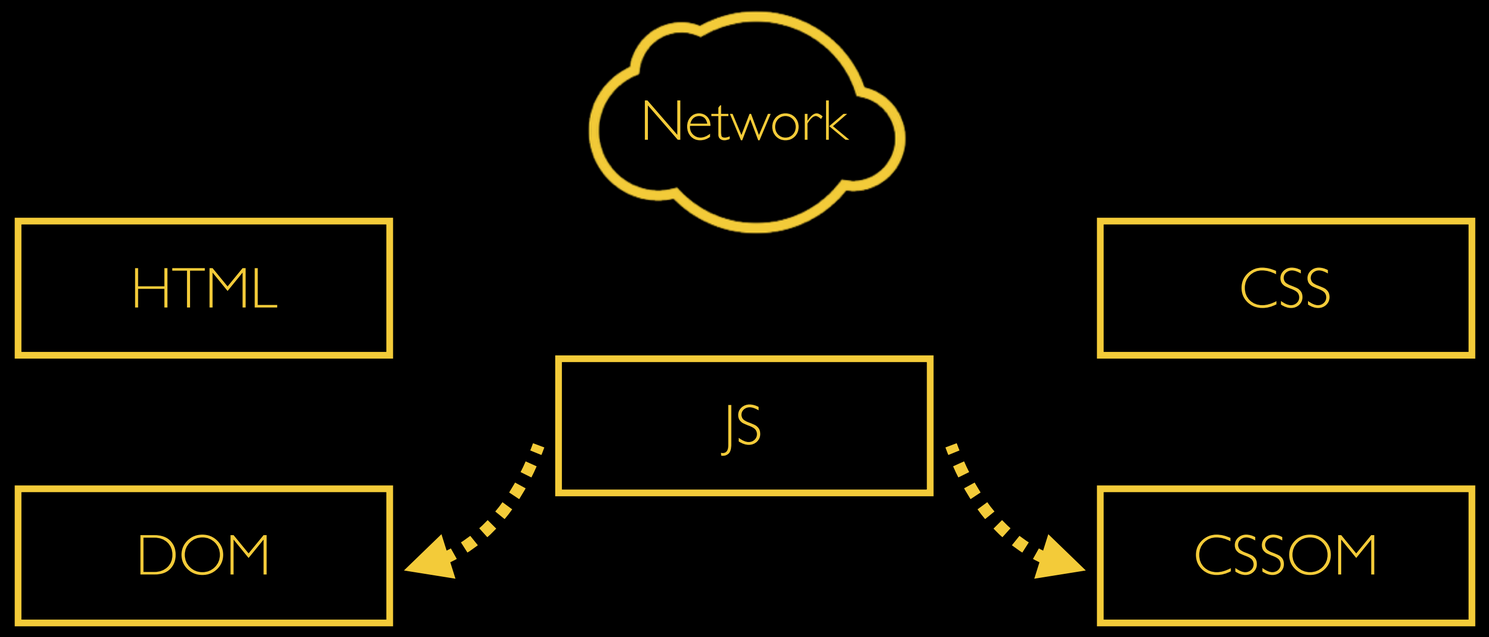
LET’S DO ALL THE THINGS YOU WANNA DO

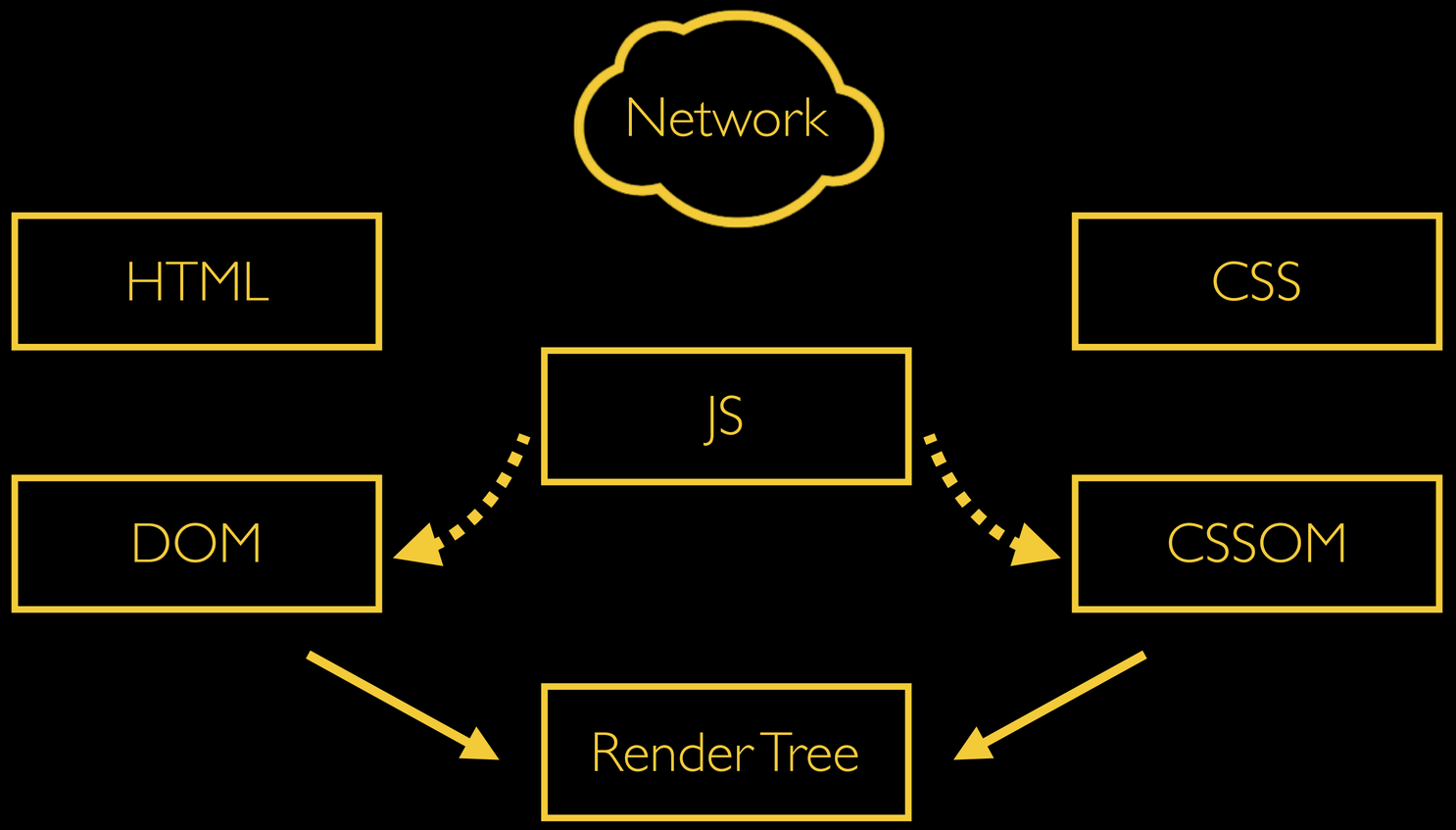
WHERE DO WEBSITES COME FROM?

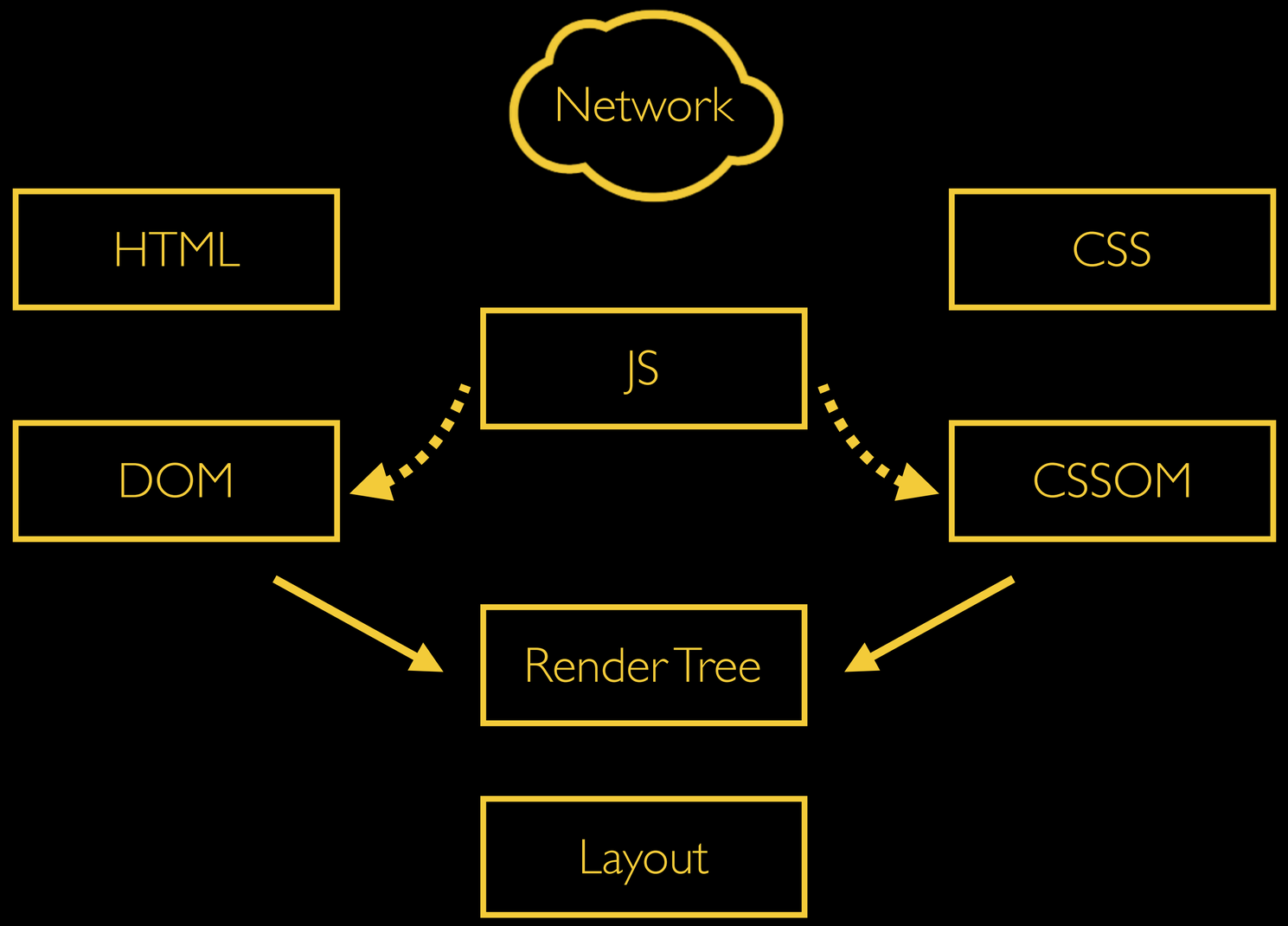
Network

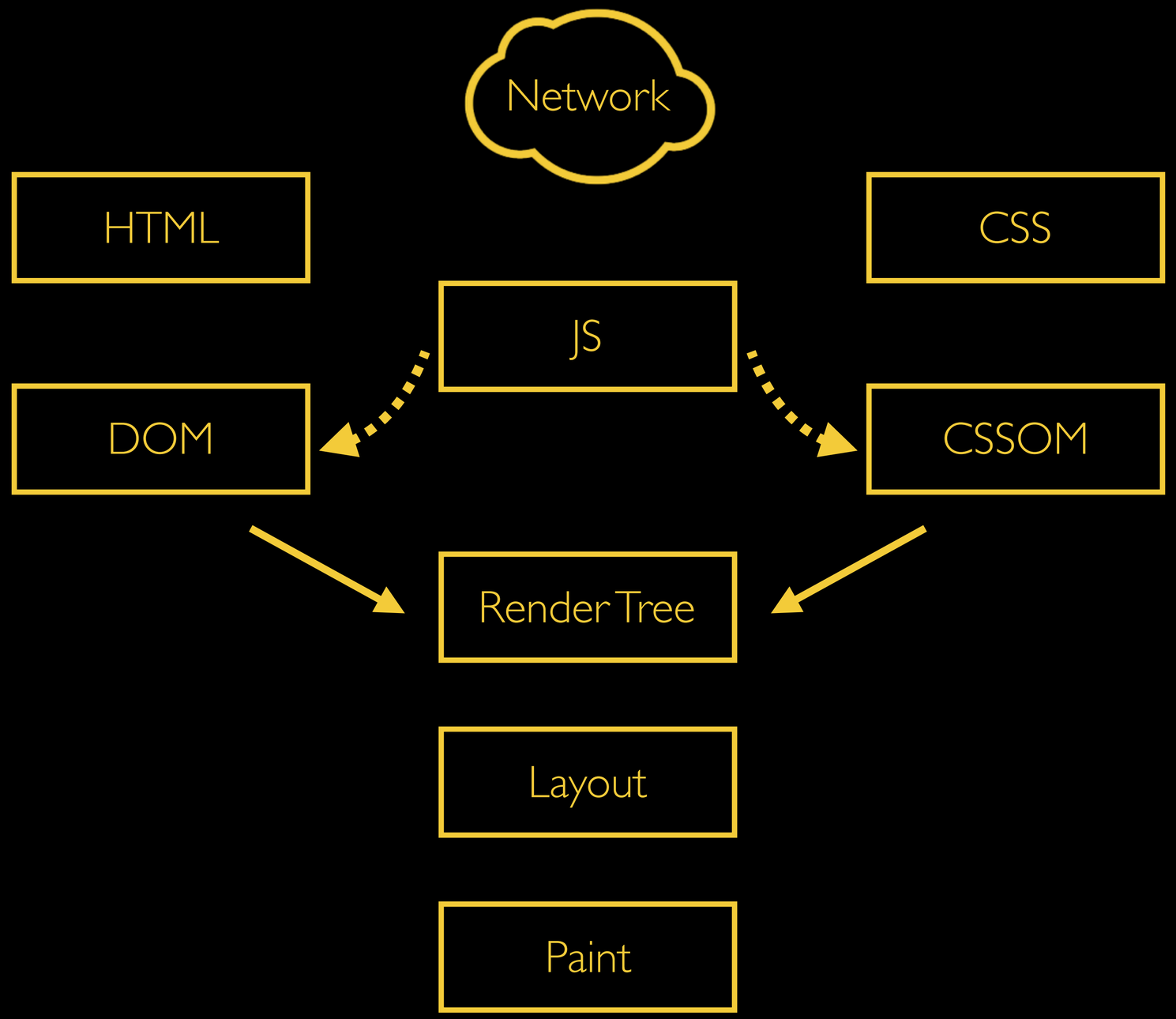

Network
HTML
CSS
JS

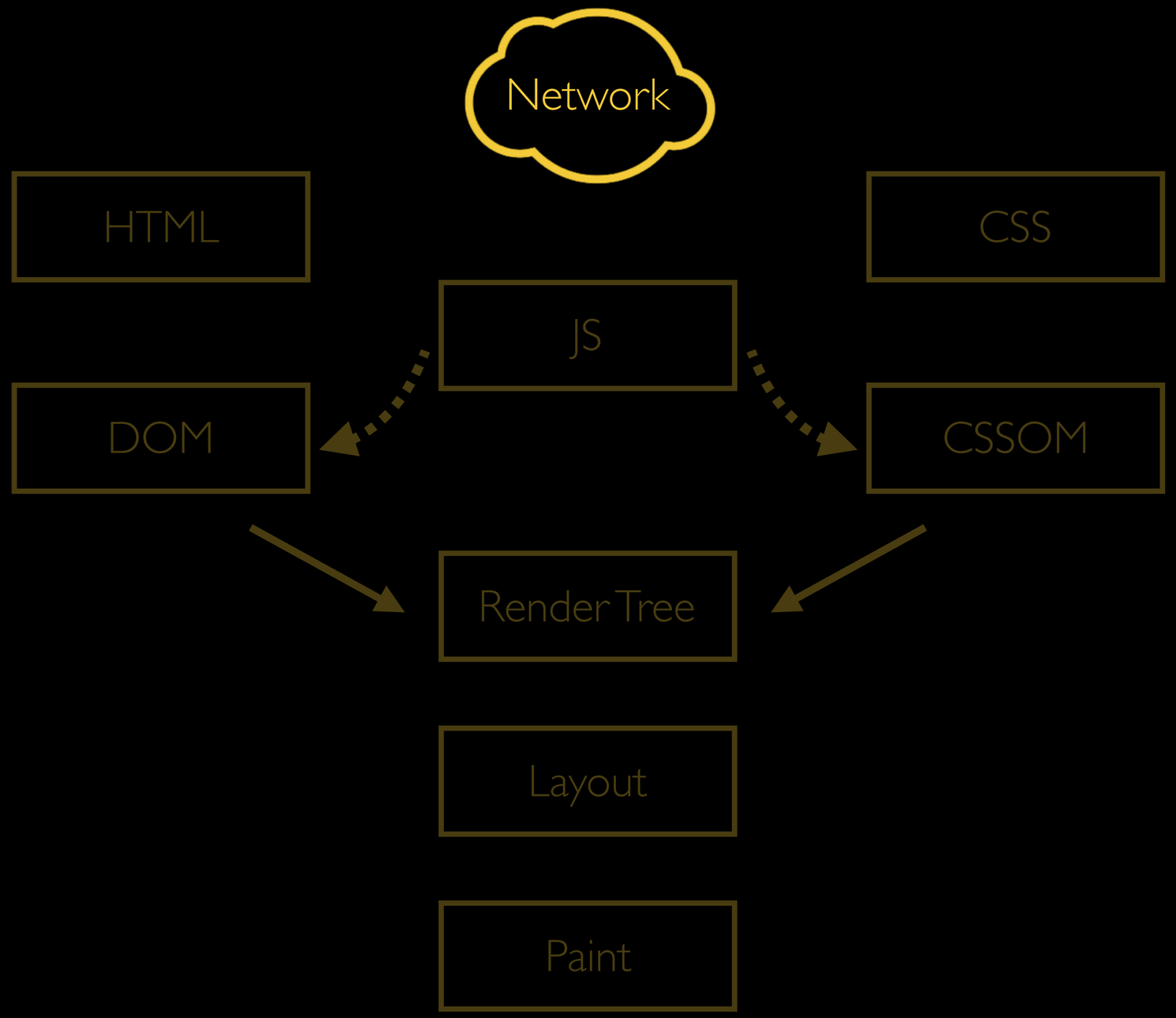

Network
HTML
CSS
JS
DOM
CSSOM


Network
HTML
CSS
JS
DOM
CSSOM


Network
HTML
CSS
JS
DOM
CSSOM
Render Tree

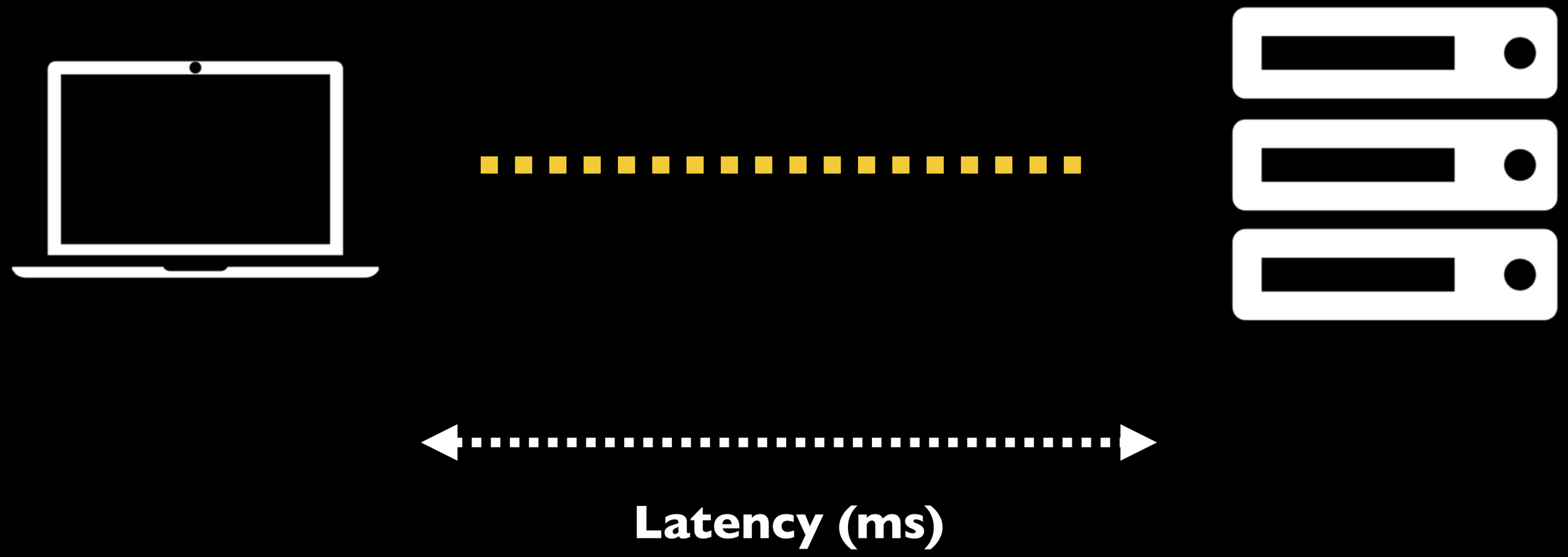

Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout

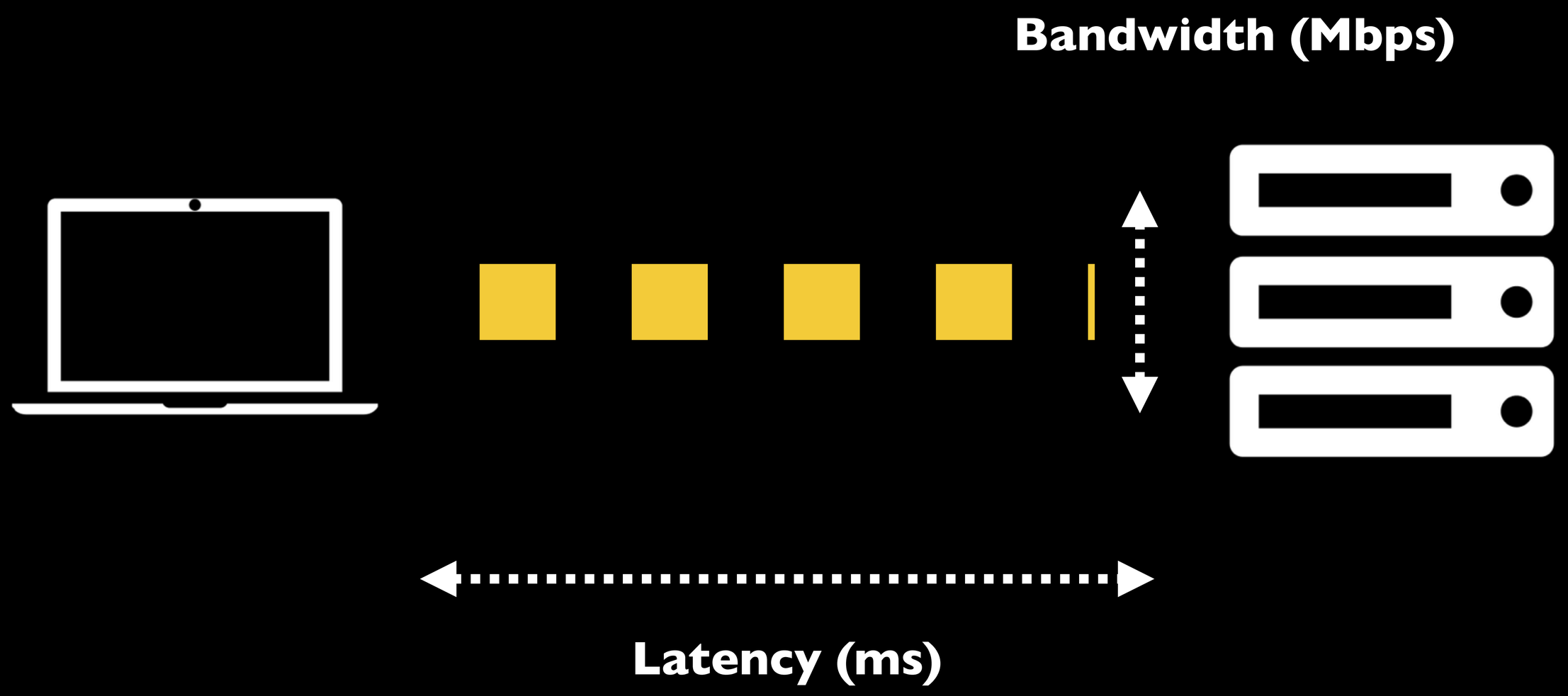

Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint


Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

1 BANDWIDTH

2 LATENCY


Latency (ms)


Bandwidth (Mbps)
Latency (ms)

It's the Latency, Stupid

rescomp.stanford.edu/~cheshire/rants/Latency.html

It's the Latency, Stupid

Stuart Cheshire, May 1996.

(Revised periodically)

Years ago David Cheriton at Stanford taught me something that seemed very obvious at the time -- that if you have a network link with low bandwidth then it's an easy matter of putting several in parallel to make a combined link with higher bandwidth, but if you have a network link with bad latency then no amount of money can turn any number of them into a link with good latency.

It's now many years later, and this obvious fact seems lost on the most companies making networking hardware and software for the home. I think it's time it was explained again in writing.

Fact One: Making more bandwidth is easy.

Imagine you live in a world where the only network connection you can get to your house is a 33kbit/sec modem running over a telephone line. Imagine that this is not enough for your needs. You have a problem.

The solution is easy. You can get two telephone lines, and use them together in parallel, giving you a total of 66kbit/sec. If you need even more you can get ten telephone lines, giving you 330kbit/sec. Sure, it's expensive, and having ten modems in a pile is inconvenient, and you may have to write your own networking software to share the data evenly between the ten lines, but if it was important enough to you, you could get it done.

It may not be cheap, but at least it's possible.

People with ISDN lines can already do this. It's called "bonding" and it uses two 56 (or 64) kbit/sec ISDN channels in parallel to give you a combined throughput of 112 (or 128) kbit/sec.

Fact Two: Once you have bad latency you're stuck with it.

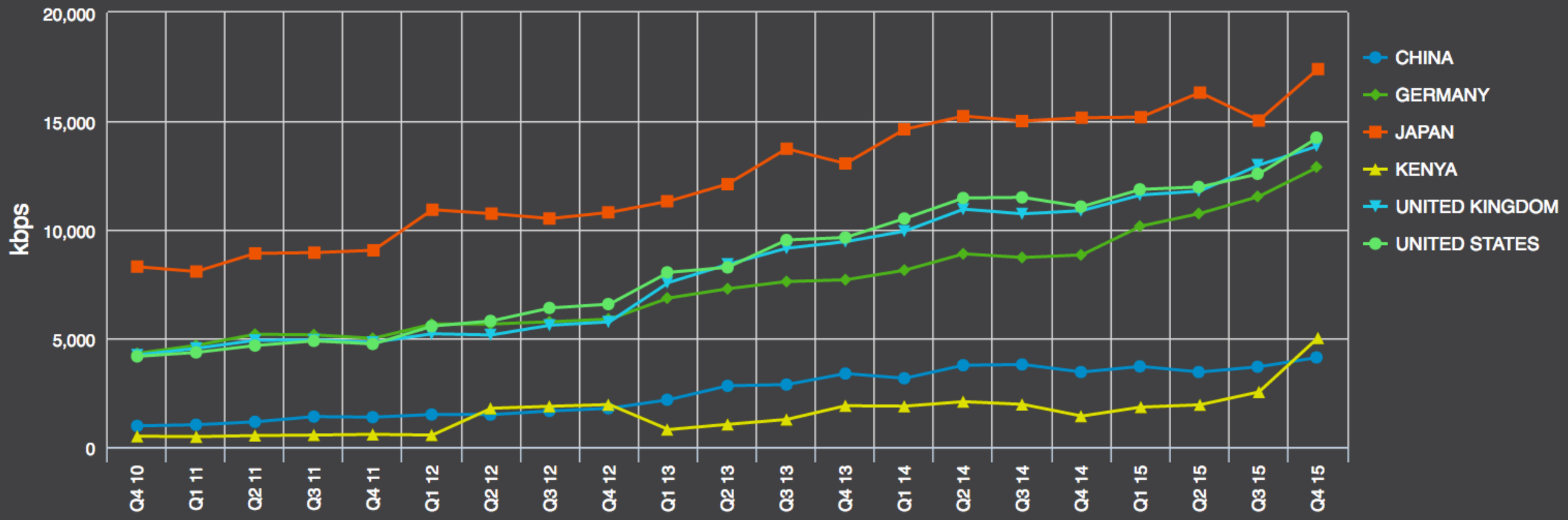
If you want to transfer a large file over your modem it might take several seconds, or even minutes. The less data you send, the less time it takes, but there's a limit. No matter how small the amount of data, for any particular network device there's always a minimum time that you can never beat. That's called the latency of the device. For a typical Ethernet connection the latency is usually about 0.3ms (milliseconds -- thousandths of a second). For a typical modem link the latency is usually about 100ms, about 300 times worse than Ethernet.

If you wanted to send ten characters over your 33kbit/sec modem link you might think the total transmission time would be:

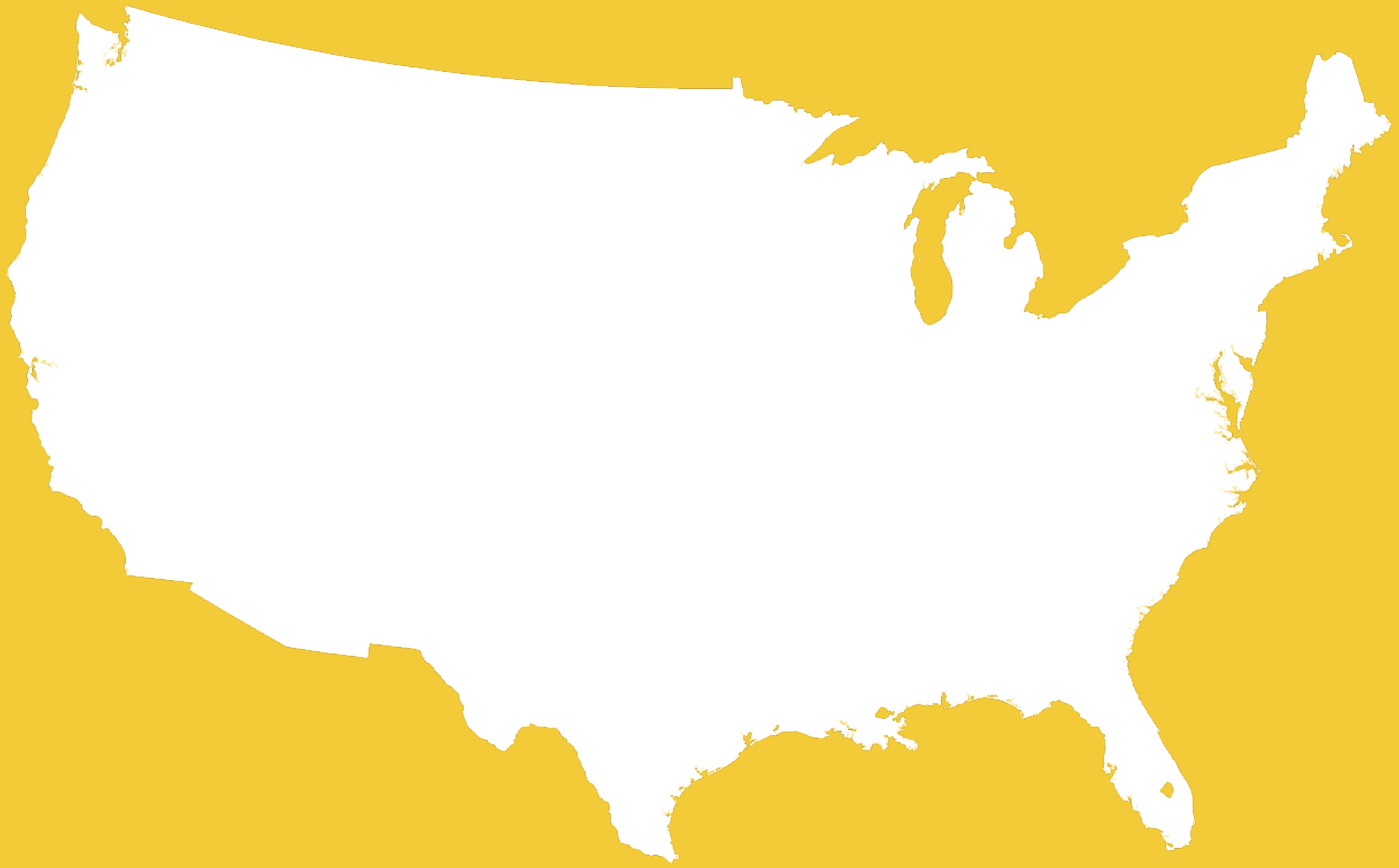
80 bits / 33000 bits per second = 2.4ms.

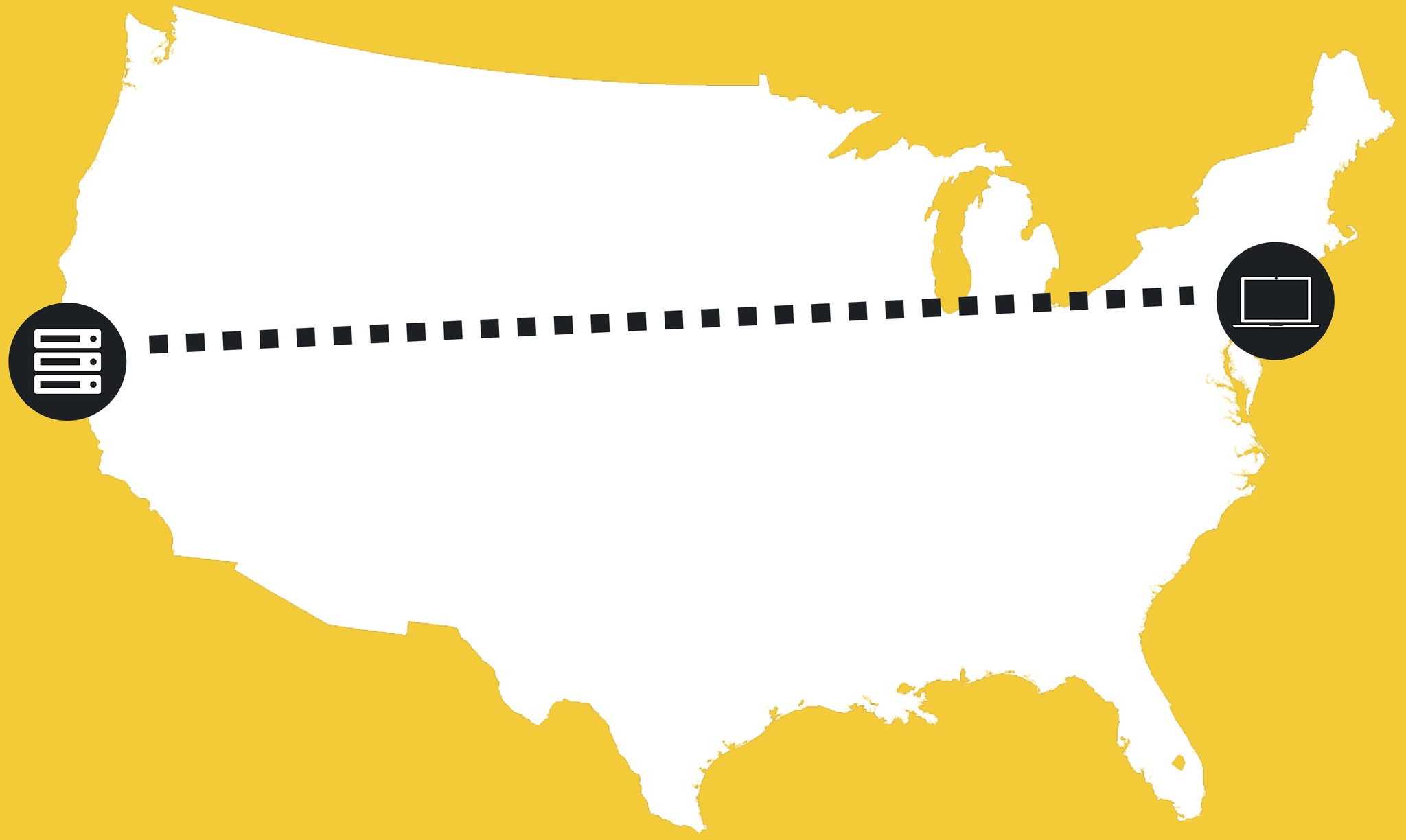
HTTP://STANFORD.IO/22WYP7M

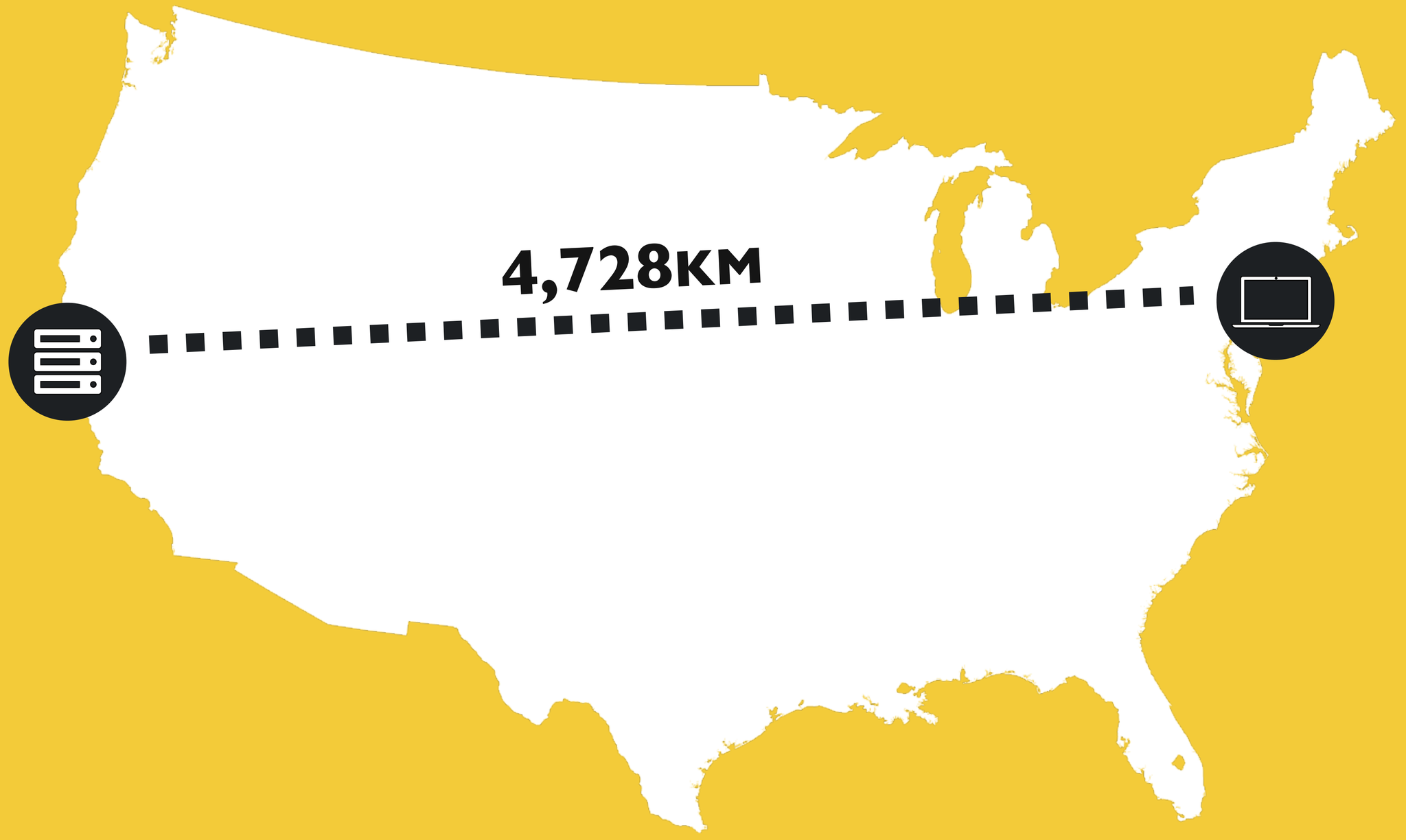
AVERAGE CONNECTION SPEED

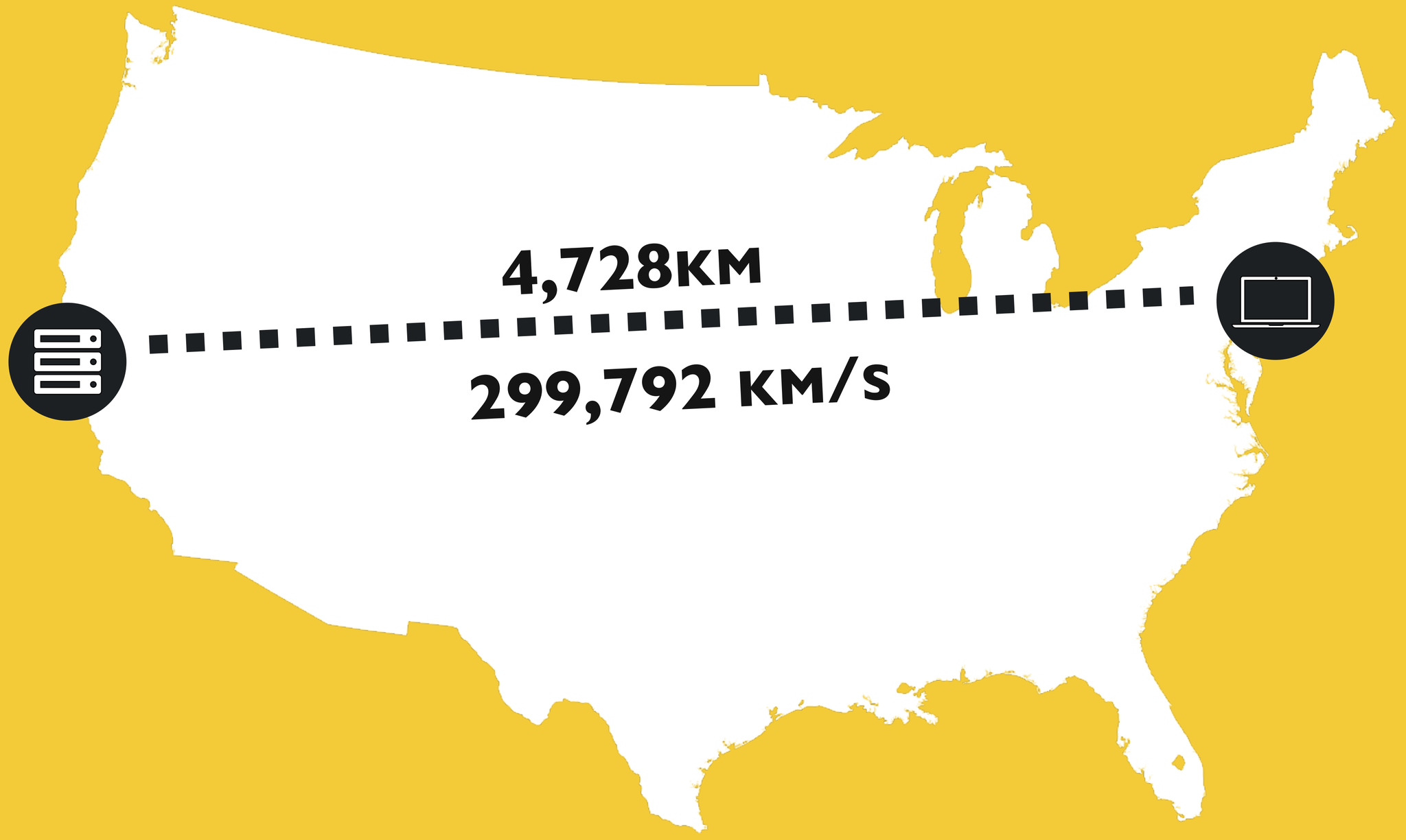


Source: http://bit.ly/1WRjumM



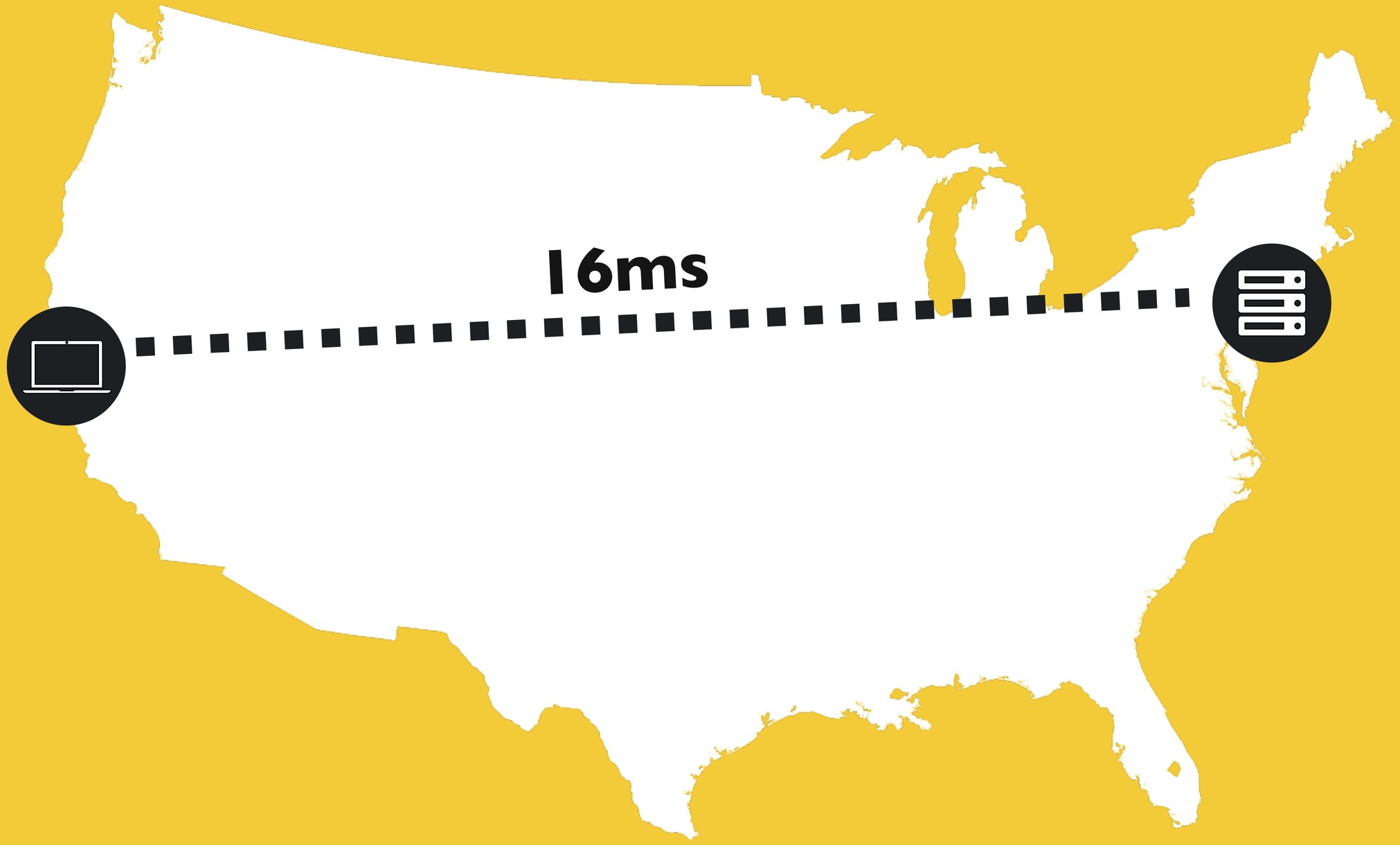


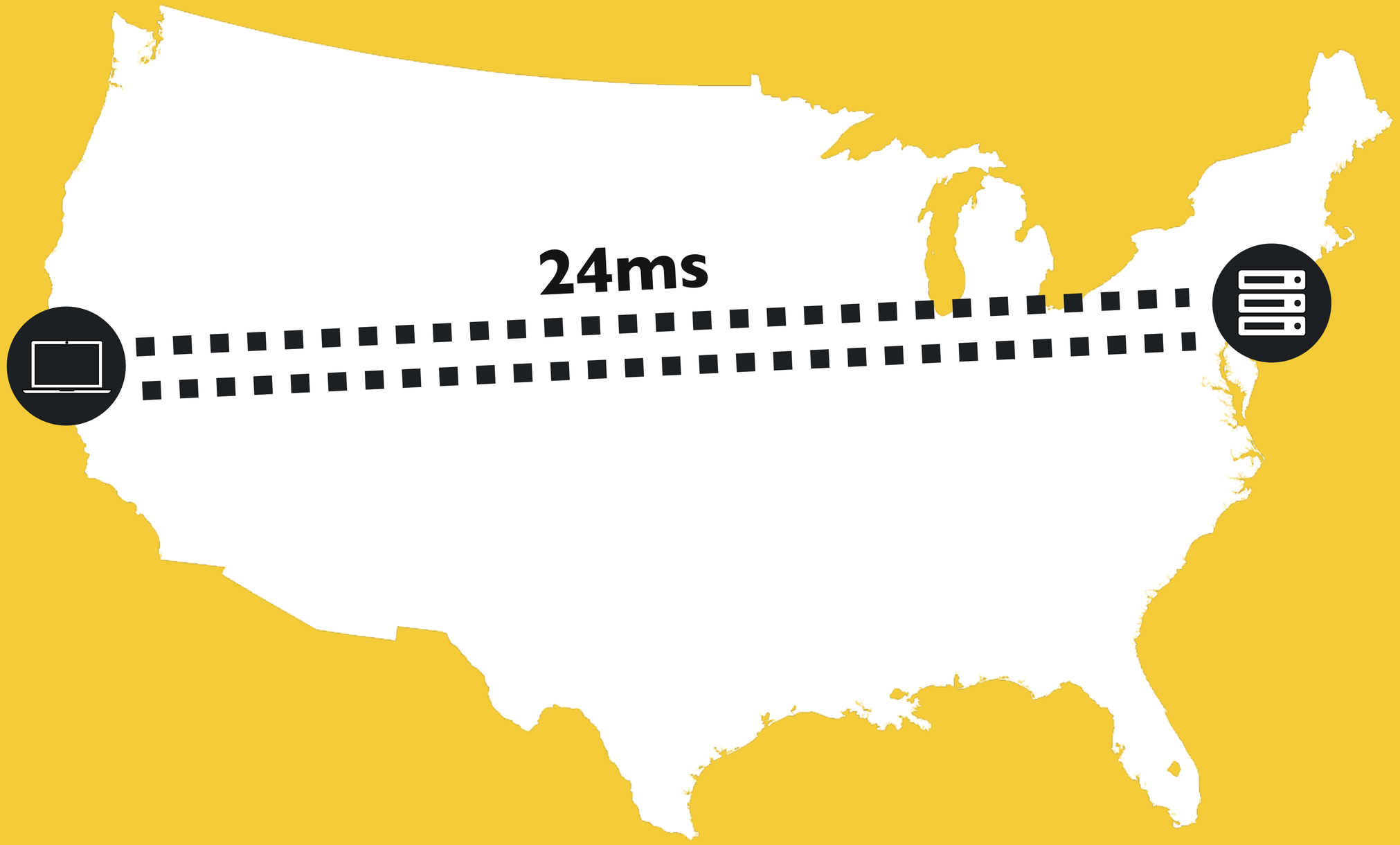

4,728KM

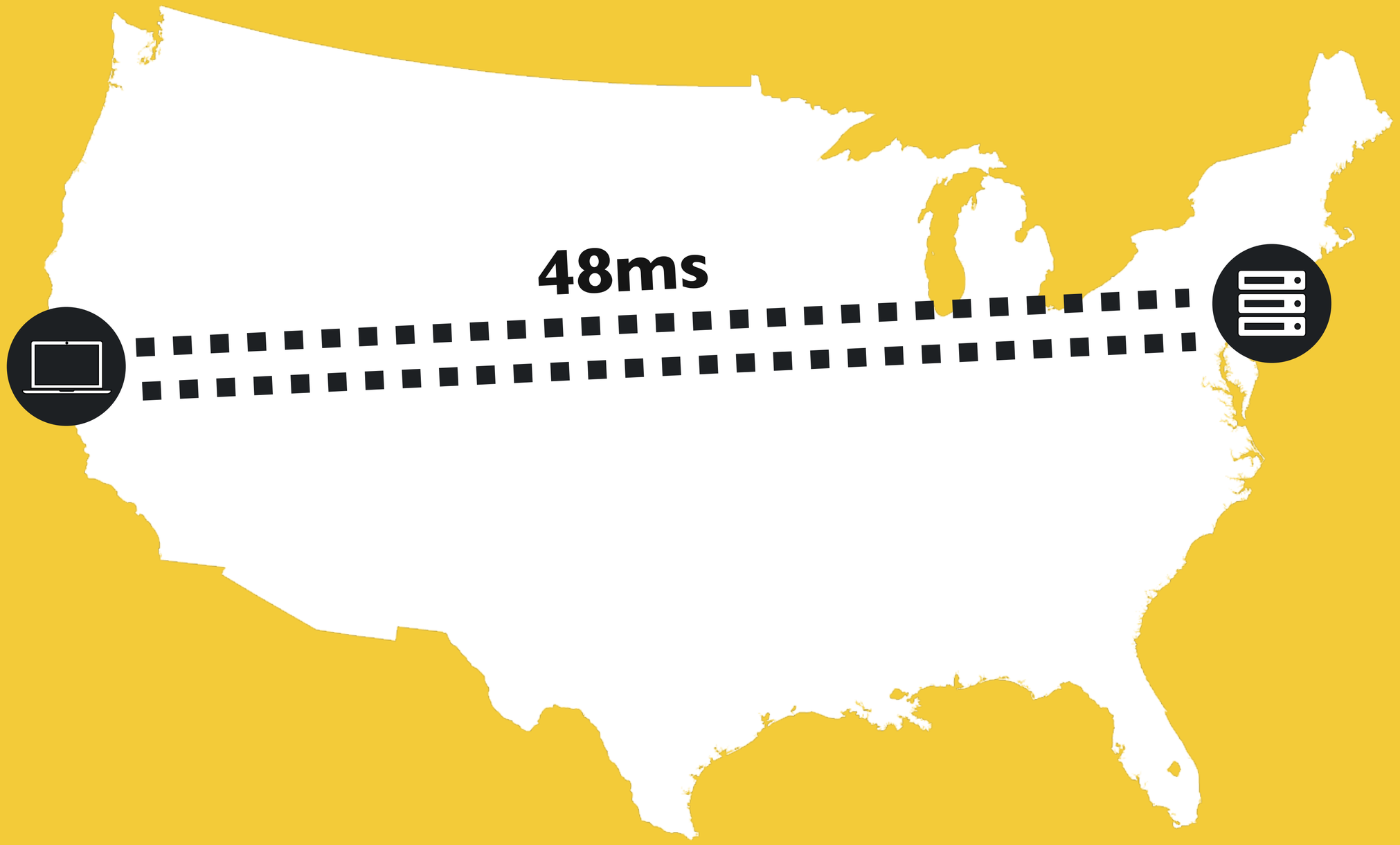

4,728KM
299,792 KM/S

4,728km / 299,792 km/s

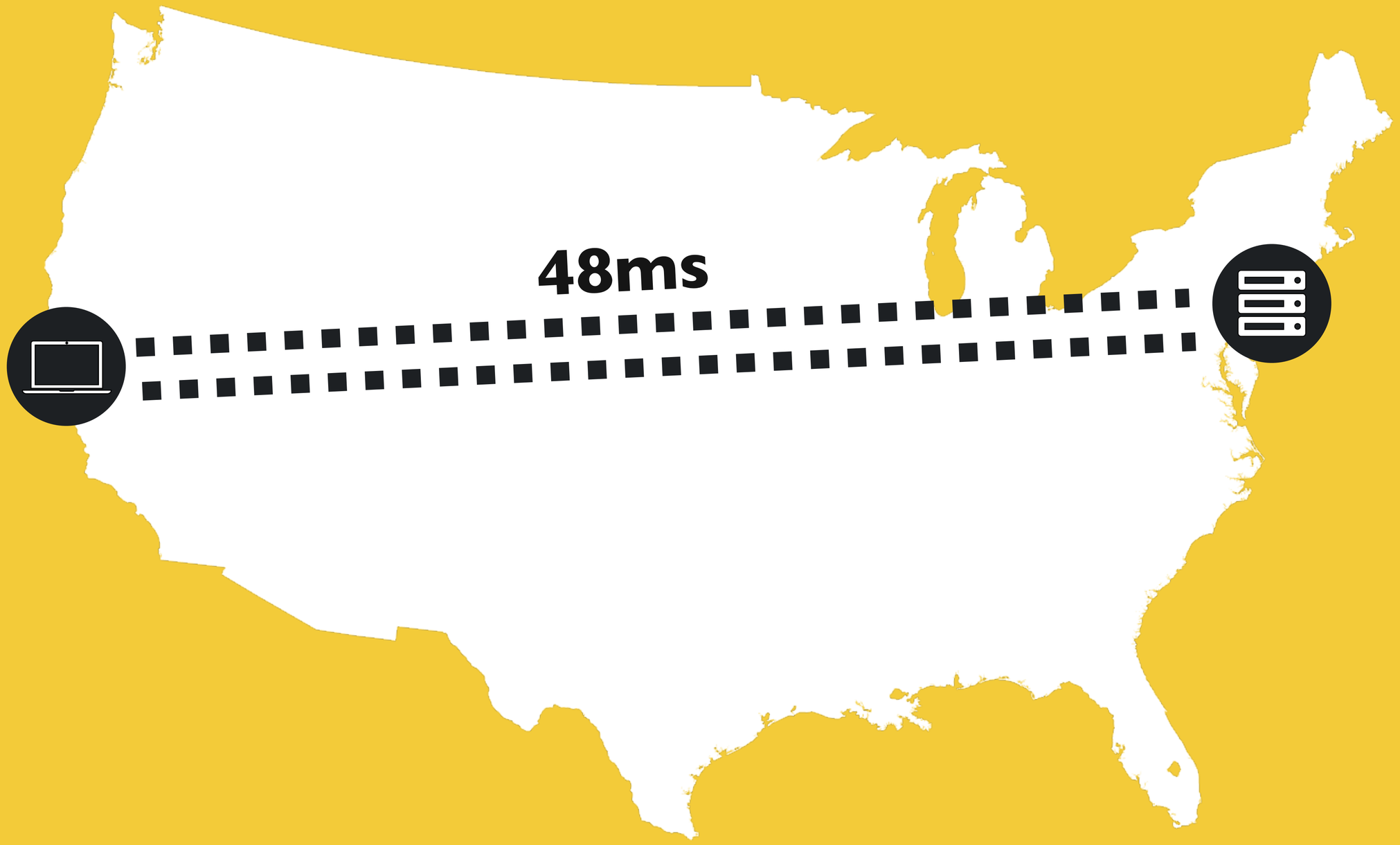
16ms

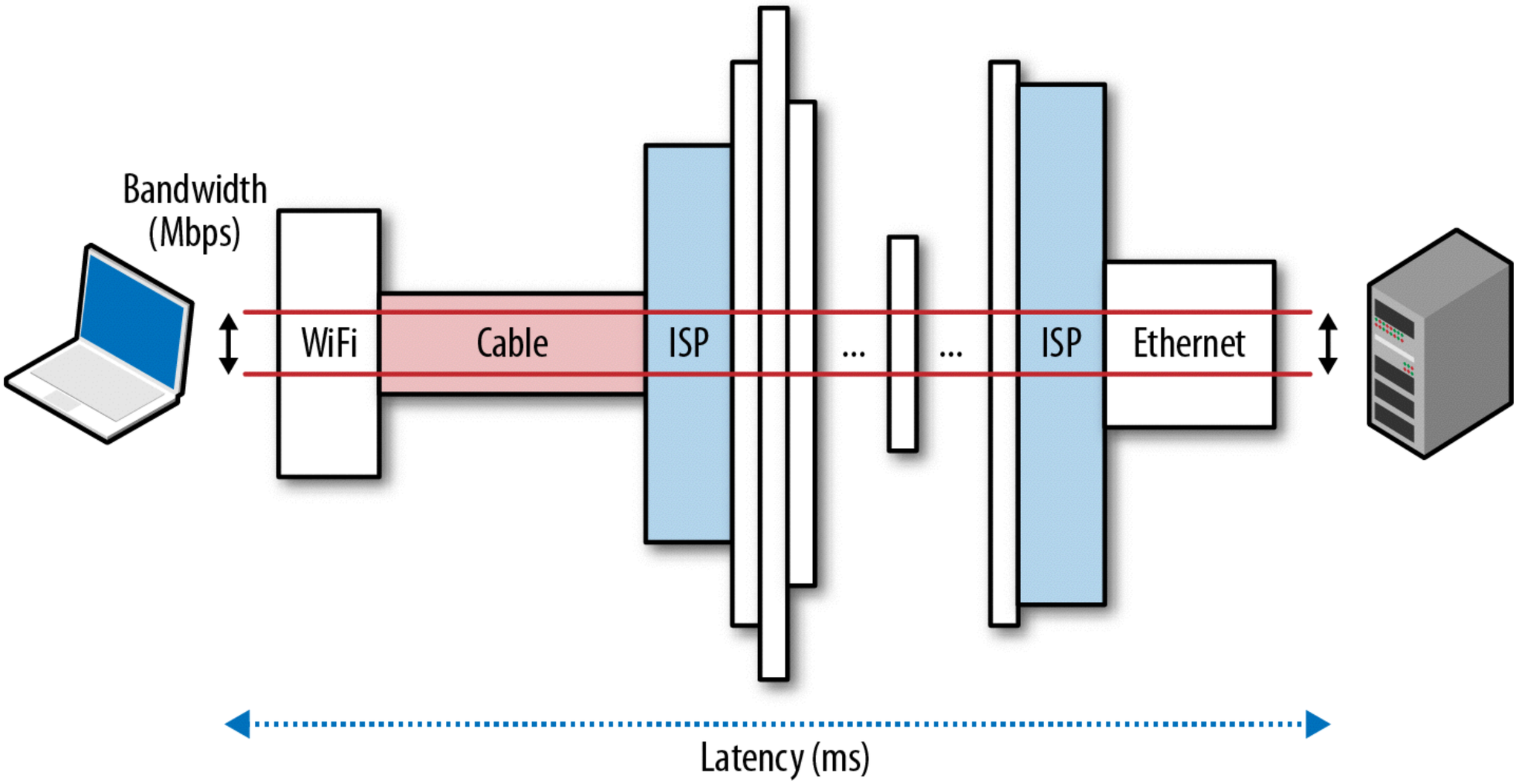

16ms


24ms


48ms

```
ping 54.193.201.148
```

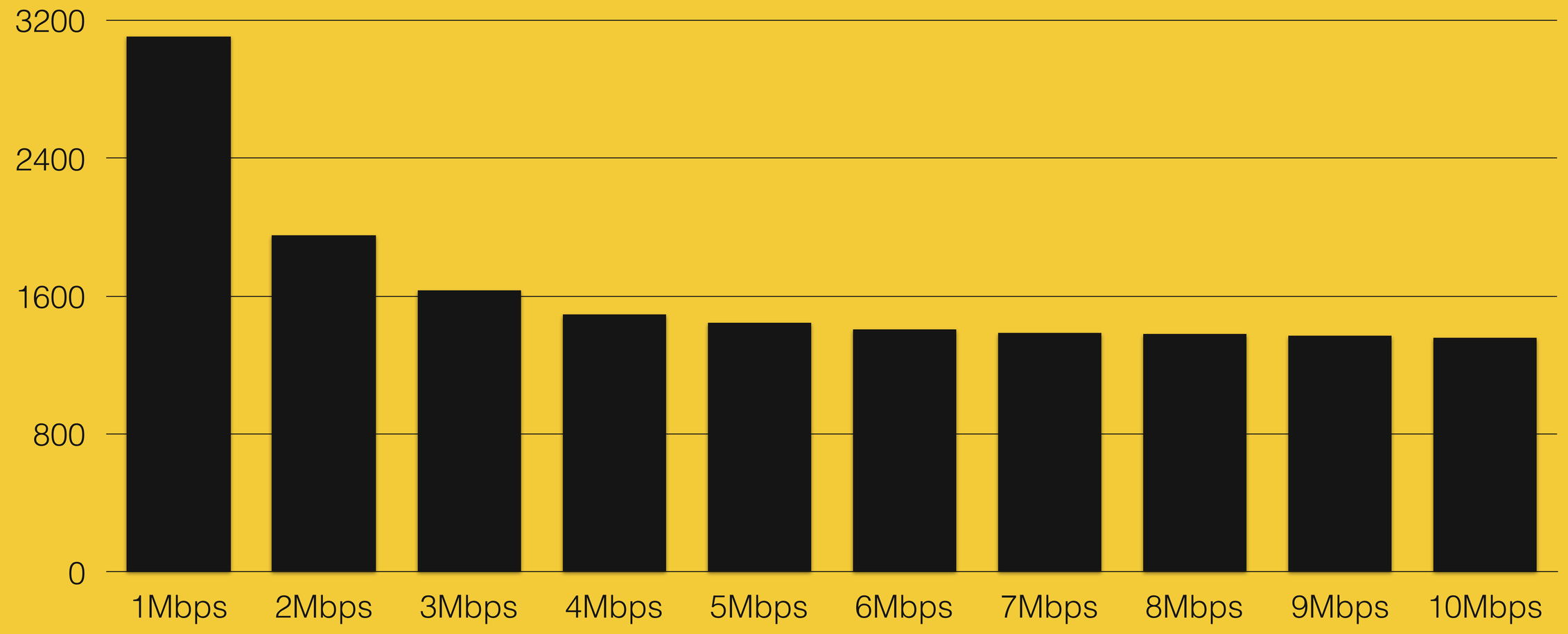

48ms



Source: http://chimera.labs.oreilly.com/books/1230000000545/

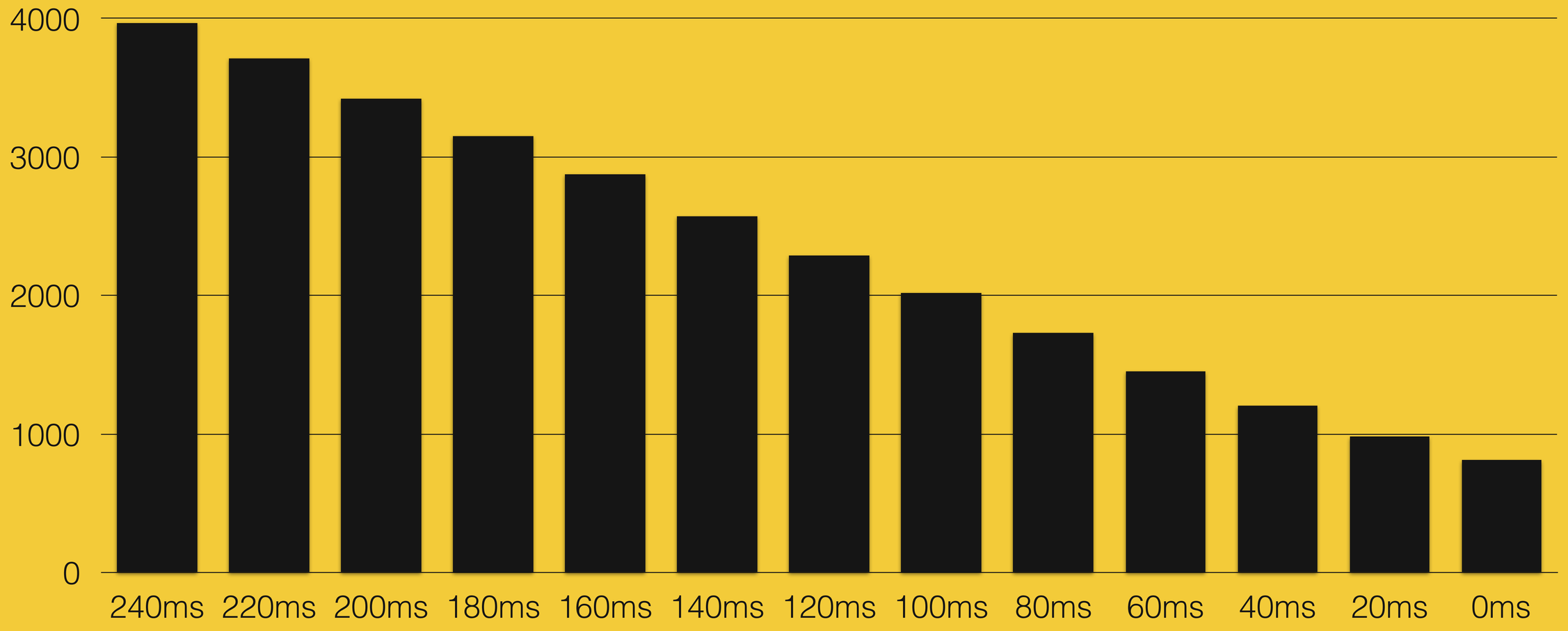
```
traceroute 54.239.108.215
tracert 54.239.108.215
```

BANDWIDTH IMPACT

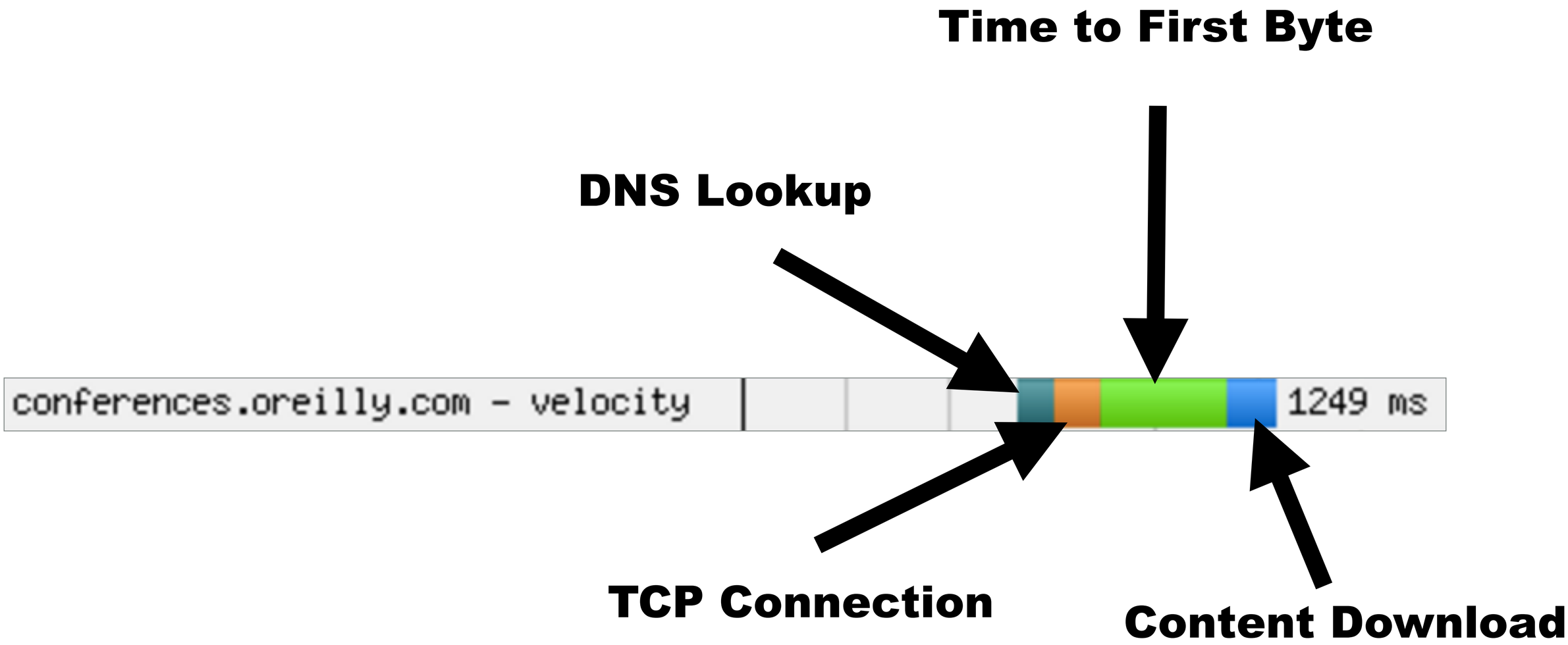


Source: http://bit.ly/1rNCOIC

LATENCY IMPACT

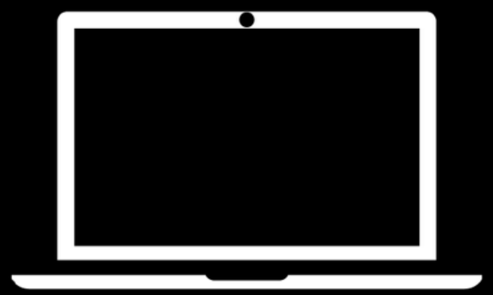


Source: http://bit.ly/1rNCOIC

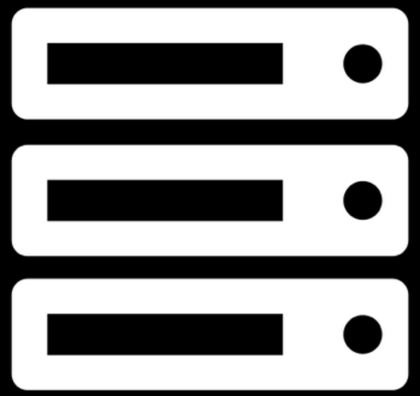

Time to First Byte
DNS Lookup
conferences.oreilly.com - velocity
1249 ms
TCP Connection
Content Download

DNS Lookup

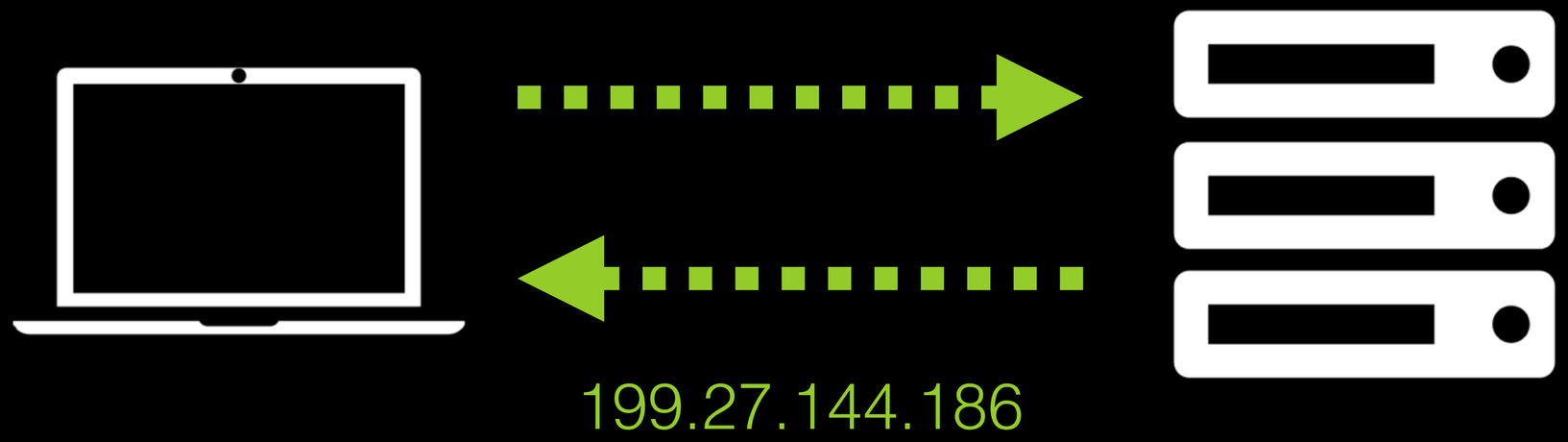
DNS
Lookup



www.velocityconf.com



DNS
Lookup



DNS
Lookup

Browser Cache

OS Cache

Router Cache

ISP DNS Cache

Recursive search

About Histograms - DNS

chrome://histograms/DNS

```
Histogram: AsyncDNS.ResolveSuccess recorded 9358 samples, average = 94.7 (flags = 0x1)
0       ...
2       -O                                                                  (3 = 0.0%) {0.0%}
3       O                                                                   (2 = 0.0%) {0.0%}
4       ...
8       O                                                                   (1 = 0.0%) {0.1%}
9       ...
24      -----O                                                              (116 = 1.2%) {0.1%}
28      -----------------O                                                  (383 = 4.1%) {1.3%}
32      --------------O                                                     (389 = 4.2%) {5.4%}
37      ------O                                                             (178 = 1.9%) {9.6%}
43      -----O                                                              (157 = 1.7%) {11.5%}
50      ----------------------------------------------O                     (1358 = 14.5%) {13.1%}
58      ------------------------------------------------------------------------O (2060 = 22.0%) {27.6%}
67      -------------------------------------O                              (1065 = 11.4%) {49.7%}
77      ----------------------------------O                                 (978 = 10.5%) {61.0%}
89      ------------------------------O                                     (873 = 9.3%) {71.5%}
103     -------------------O                                                (541 = 5.8%) {80.8%}
119     -----------O                                                        (312 = 3.3%) {86.6%}
137     ----------O                                                         (291 = 3.1%) {89.9%}
158     --------O                                                           (232 = 2.5%) {93.0%}
182     ----O                                                               (127 = 1.4%) {95.5%}
210     --O                                                                 (59 = 0.6%) {96.9%}
242     --O                                                                 (54 = 0.6%) {97.5%}
279     -O                                                                  (35 = 0.4%) {98.1%}
322     -O                                                                  (28 = 0.3%) {98.5%}
372     -O                                                                  (28 = 0.3%) {98.8%}
429     -O                                                                  (19 = 0.2%) {99.1%}
```

CHROME://HISTOGRAMS/DNS

About Histograms - DNS

chrome://histograms/DNS

```
Histogram: AsyncDNS.ResolveSuccess recorded 9358 samples, average = 94.7 (flags = 0x1)
0       ...
2       -O                                                                  (3 = 0.0%) {0.0%}
3       O                                                                   (2 = 0.0%) {0.0%}
4       ...
8       O                                                                   (1 = 0.0%) {0.1%}
9       ...
24      -----O                                                              (116 = 1.2%) {0.1%}
28      -----------------O                                                  (383 = 4.1%) {1.3%}
32      --------------O                                                     (389 = 4.2%) {5.4%}
37      ------O                                                             (178 = 1.9%) {9.6%}
43      -----O                                                              (157 = 1.7%) {11.5%}
50      ----------------------------------------------O                     (1358 = 14.5%) {13.1%}
58      ------------------------------------------------------------------------O (2060 = 22.0%) {27.6%}
67      -------------------------------------O                              (1065 = 11.4%) {49.7%}
77      ----------------------------------O                                 (978 = 10.5%) {61.0%}
89      ------------------------------O                                     (873 = 9.3%) {71.5%}
103     -------------------O                                                (541 = 5.8%) {80.8%}
119     -----------O                                                        (312 = 3.3%) {86.6%}
137     ----------O                                                         (291 = 3.1%) {89.9%}
158     --------O                                                           (232 = 2.5%) {93.0%}
182     ----O                                                               (127 = 1.4%) {95.5%}
210     --O                                                                 (59 = 0.6%) {96.9%}
242     --O                                                                 (54 = 0.6%) {97.5%}
279     -O                                                                  (35 = 0.4%) {98.1%}
322     -O                                                                  (28 = 0.3%) {98.5%}
372     -O                                                                  (28 = 0.3%) {98.8%}
429     -O                                                                  (19 = 0.2%) {99.1%}
495     O                                                                   (6 = 0.1%) {99.3%}
571     O                                                                   (14 = 0.1%) {99.3%}
659     O                                                                   (11 = 0.1%) {99.5%}
761     O                                                                   (5 = 0.1%) {99.6%}
878     O                                                                   (5 = 0.1%) {99.6%}
```

About Histograms - DNS

chrome://histograms/DNS

```
Histogram: AsyncDNS.ResolveSuccess recorded 9358 samples, average = 94.7 (flags = 0x1)
0       ...
2       -O                                                          (3 = 0.0%) {0.0%}
3       O                                                           (2 = 0.0%) {0.0%}
4       ...
8       O                                                           (1 = 0.0%) {0.1%}
9       ...
24      -----O                                                      (116 = 1.2%) {0.1%}
28      ----------------O                                           (383 = 4.1%) {1.3%}
32      -------------O                                              (389 = 4.2%) {5.4%}
37      ------O                                                     (178 = 1.9%) {9.6%}
43      -----O                                                      (157 = 1.7%) {11.5%}
50      ----------------------------------------------O             (1358 = 14.5%) {13.1%}
58      ------------------------------------------------------------------------O (2060 = 22.0%) {27.6%}
67      -------------------------------------O                      (1065 = 11.4%) {49.7%}
77      ----------------------------------O                         (978 = 10.5%) {61.0%}
89      -------------------------------                             (873 = 9.3%) {7[illegible]}
103     -----------[illegible]                                      (41 = [illegible]%) {[illegible]}
119     -----------O                                               (2 = [illegible]) {[illegible]}
137     ----------O                                                 (1 [illegible]
158     --------O                                                   (2 [illegible]3
182     ----O                                                       (7 [illegible]5
210     --O                                                         (9 [illegible].6% [illegible]6.9
242     --O                                                         (54 [illegible].6%) {97.5[illegible]
279     -O                                                          (35 = 0.4%) {98.1%}
322     -O                                                          (28 = 0.3%) {98.5%}
372     -O                                                          (28 = 0.3%) {98.8%}
429     -O                                                          (19 = 0.2%) {99.1%}
495     O                                                           (6 = 0.1%) {99.3%}
571     O                                                           (14 = 0.1%) {99.3%}
659     O                                                           (11 = 0.1%) {99.5%}
761     O                                                           (5 = 0.1%) {99.6%}
878     O                                                           (5 = 0.1%) {99.6%}
```

80%+

20-100MS

About DNS

chrome://dns

Future startups will prefetch DNS records for 10 hostnames

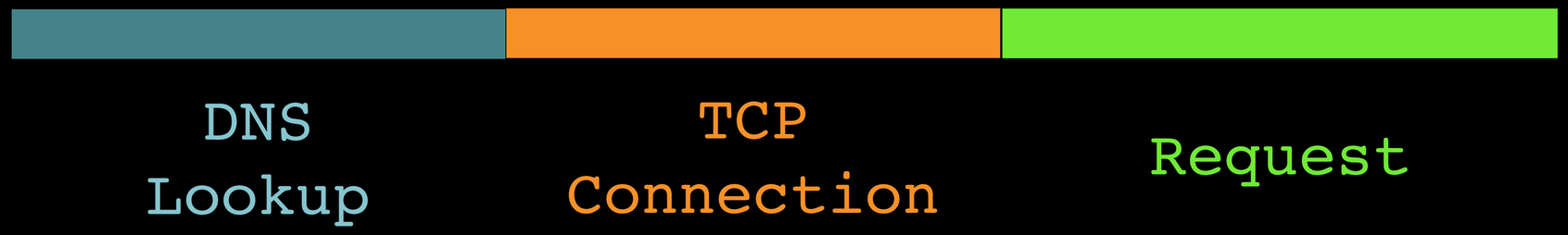
Host name	How long ago (HH:MM:SS)	Motivation
http://c.go-mpulse.net/	21:22	n/a
http://smashingconf.com/	23:02	n/a
http://static.getclicky.com/	23:01	n/a
https://apis.google.com/	23:34	n/a
https://csi.gstatic.com/	02:32	n/a
https://lh5.googleusercontent.com/	23:34	n/a
https://plus.google.com/	23:34	n/a
https://ssl.gstatic.com/	23:35	n/a
https://www.google.com/	23:35	n/a
https://www.gstatic.com/	23:34	n/a

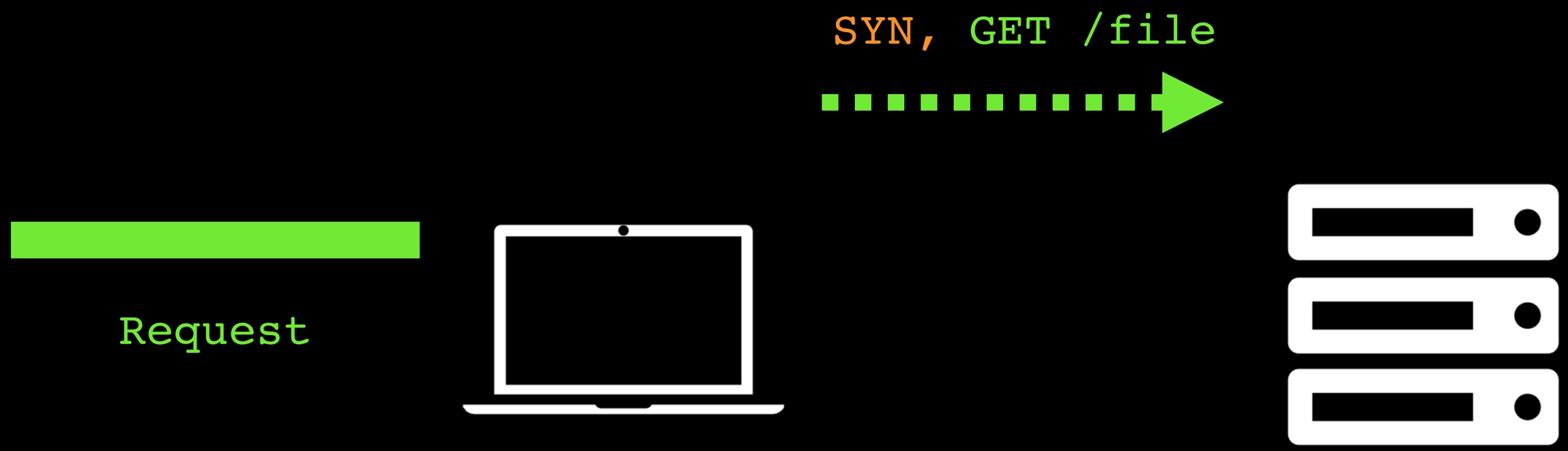
Host for Page	Page Load Count	Subresource Navigations	Subresource PreConnects	Subresource PreResolves	Expected Connects	Subresource Spec
http://smashingconf.com/	3	165	2	0	40.059	http://smashingconf.com/
		3	2	0	1.584	http://static.getclicky.com/
https://plus.google.com/	3	3	2	0	1.584	https://apis.google.com/
		3	2	0	1.584	https://plus.google.com/
		3	2	0	1.584	https://ssl.gstatic.com/
[illegible]	[illegible]	6	5	0	1.168	https://apis.google.com/
		5	5	0	0.943	https://lh5.googleusercontent.com/
		11	5	0	1.531	https://plus.google.com/

CHROME://DNS

DNS
Lookup
TCP
Connection

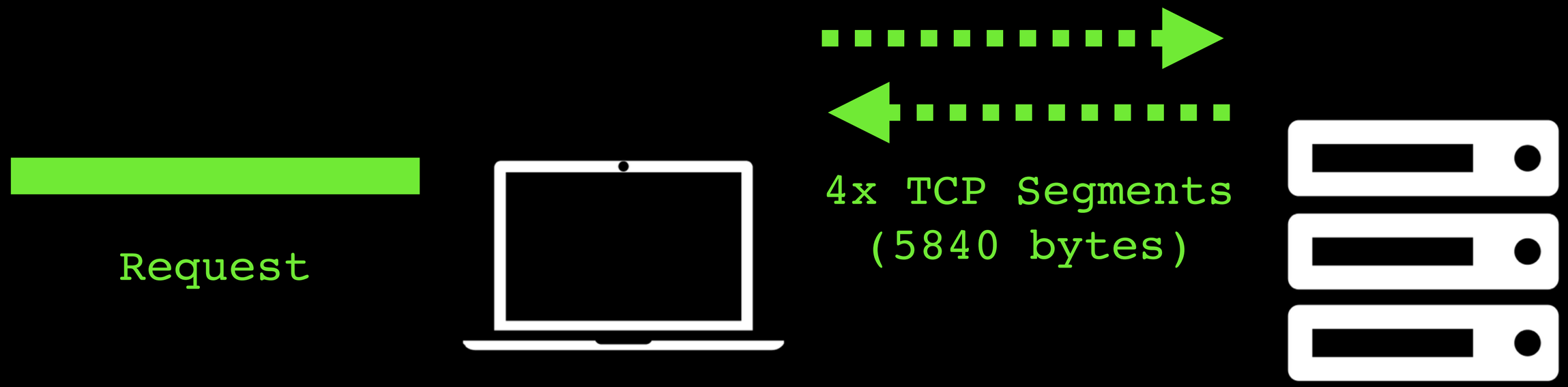
TCP
Connection
SYN
SYN ACK
ACK

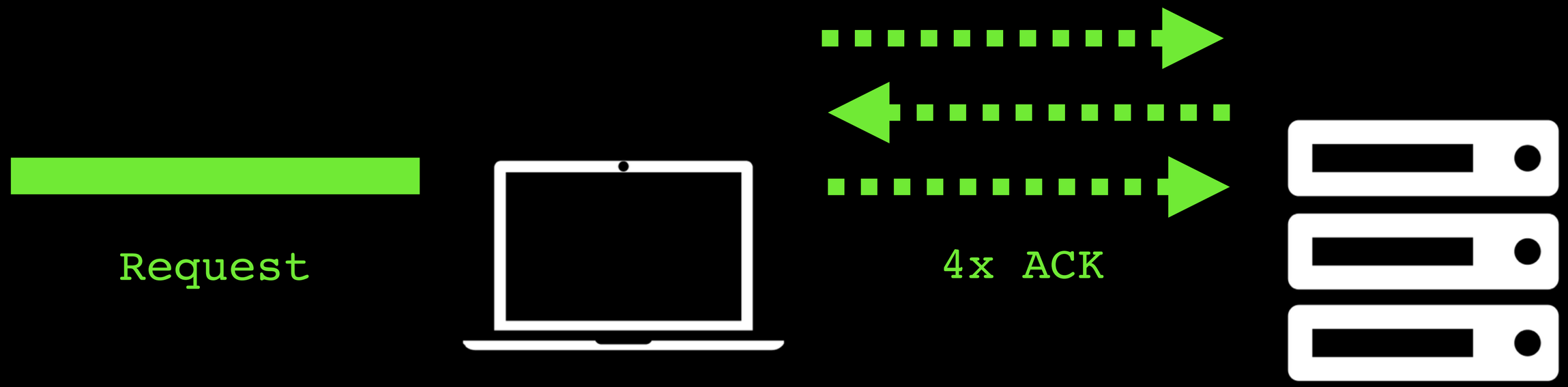

DNS
Lookup
TCP
Connection
Request

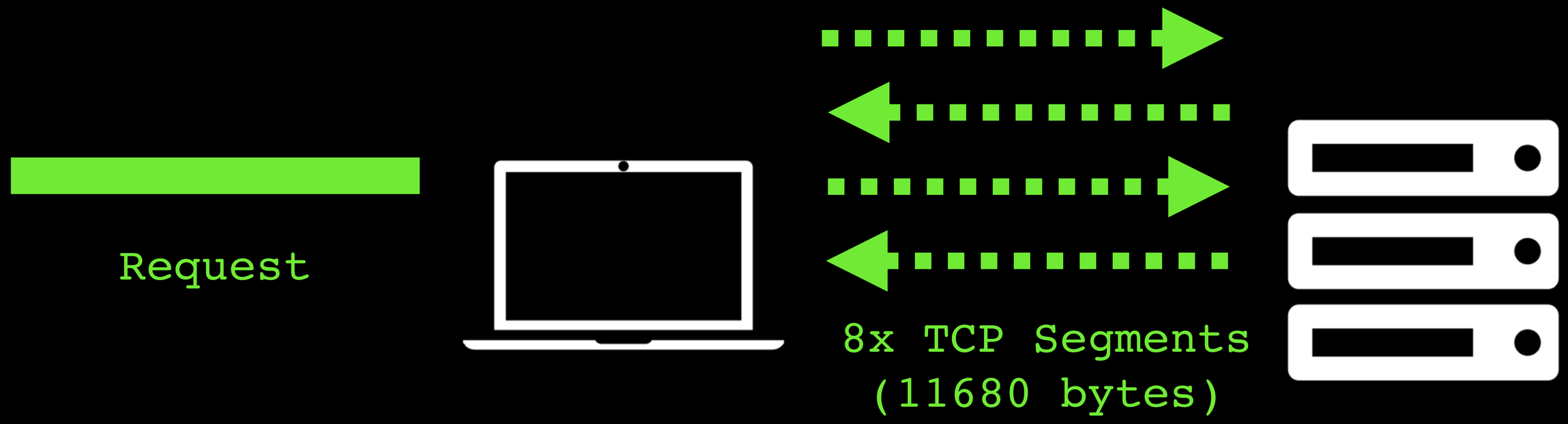

SYN, GET /file
Request

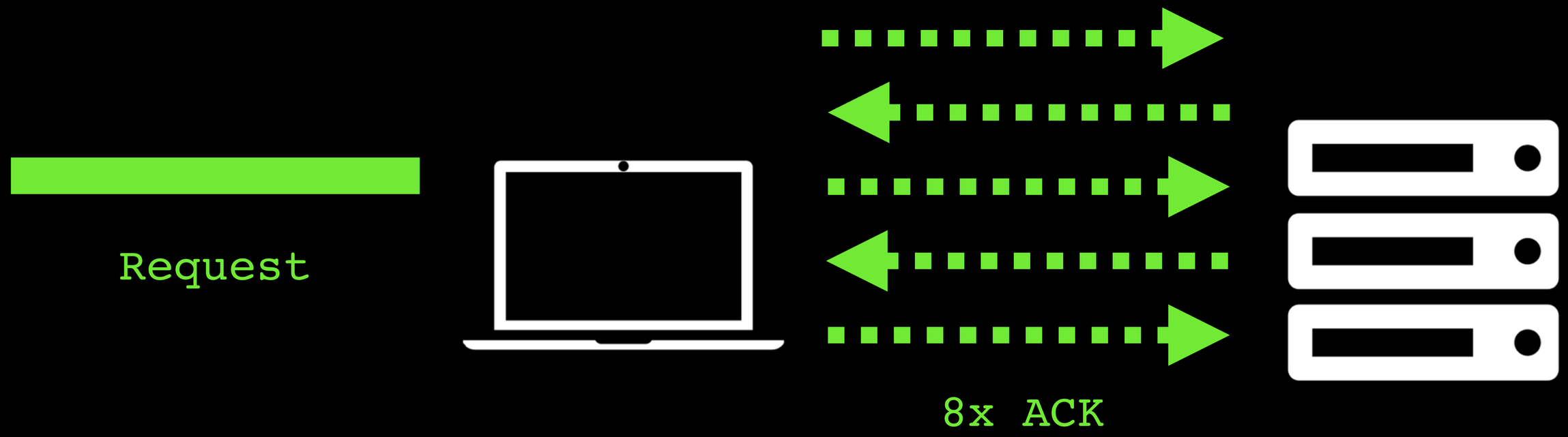
TCP SLOW-START

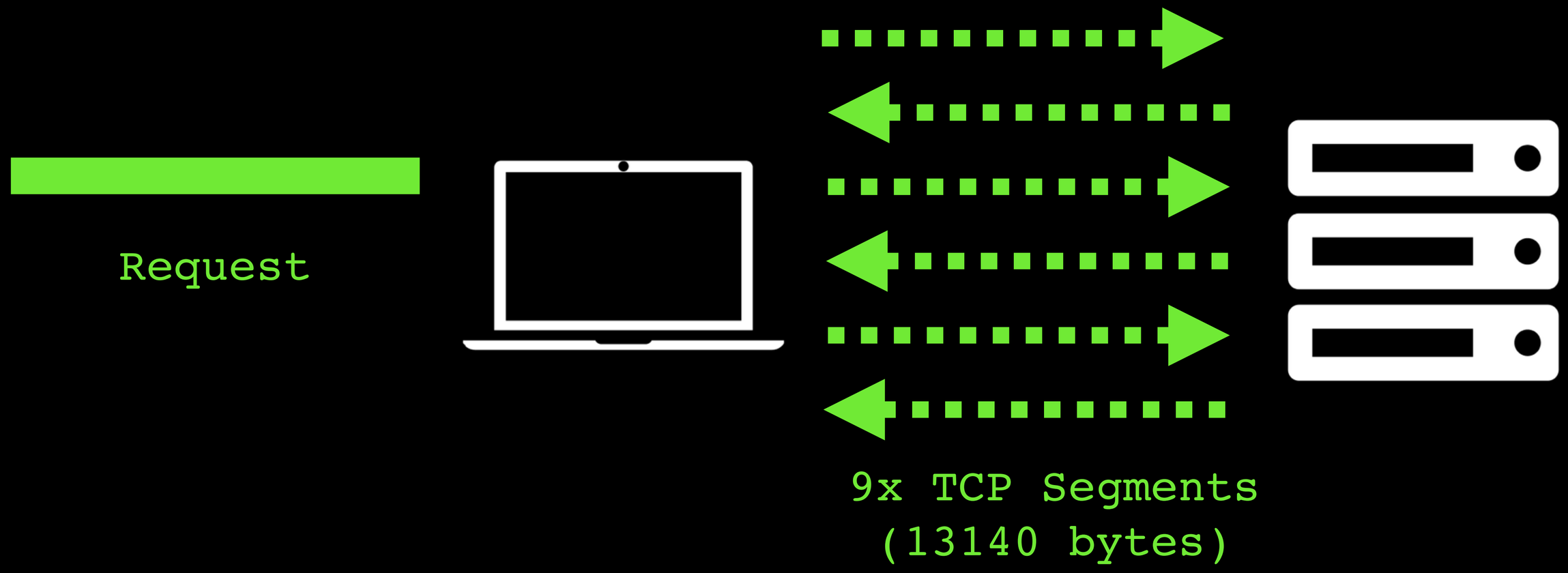
Make sure we’ve got the bandwidth before trying to use it


Request
4x TCP Segments
(5840 bytes)


Request
4x ACK

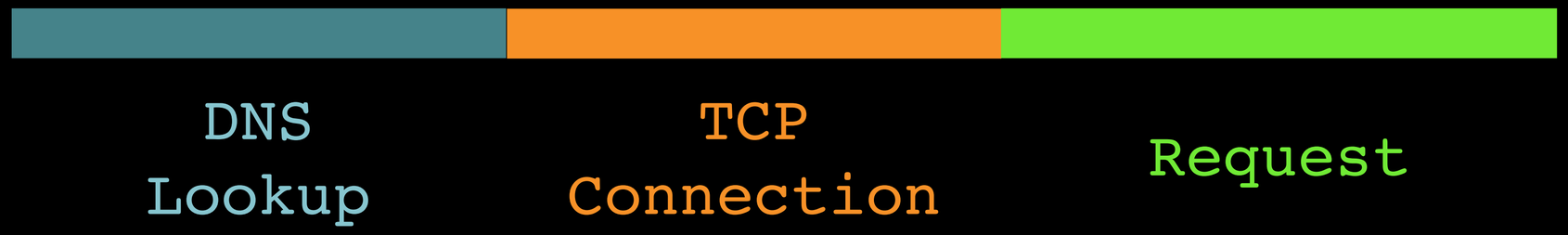

Request
8x TCP Segments
(11680 bytes)


Request
8x ACK


Request
9x TCP Segments
(13140 bytes)

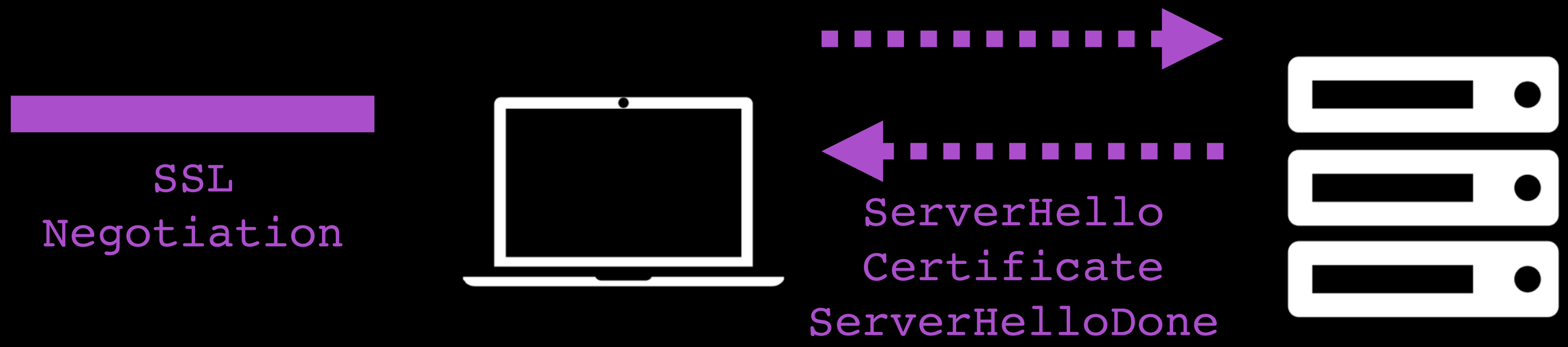
Request
GET /file-2

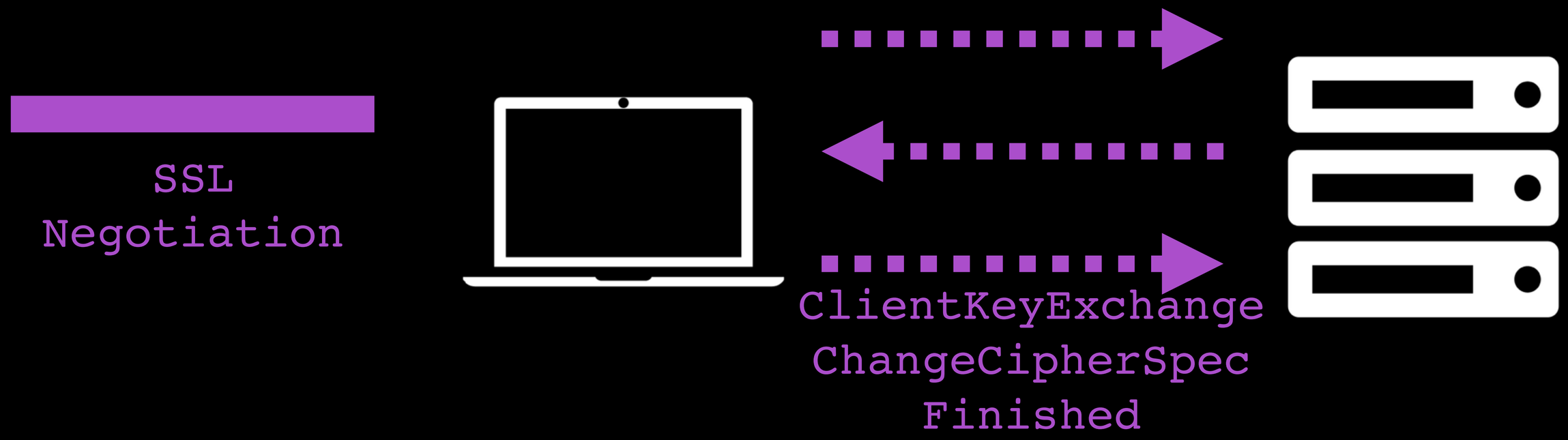
Request
16x TCP Segments
(23360 bytes)

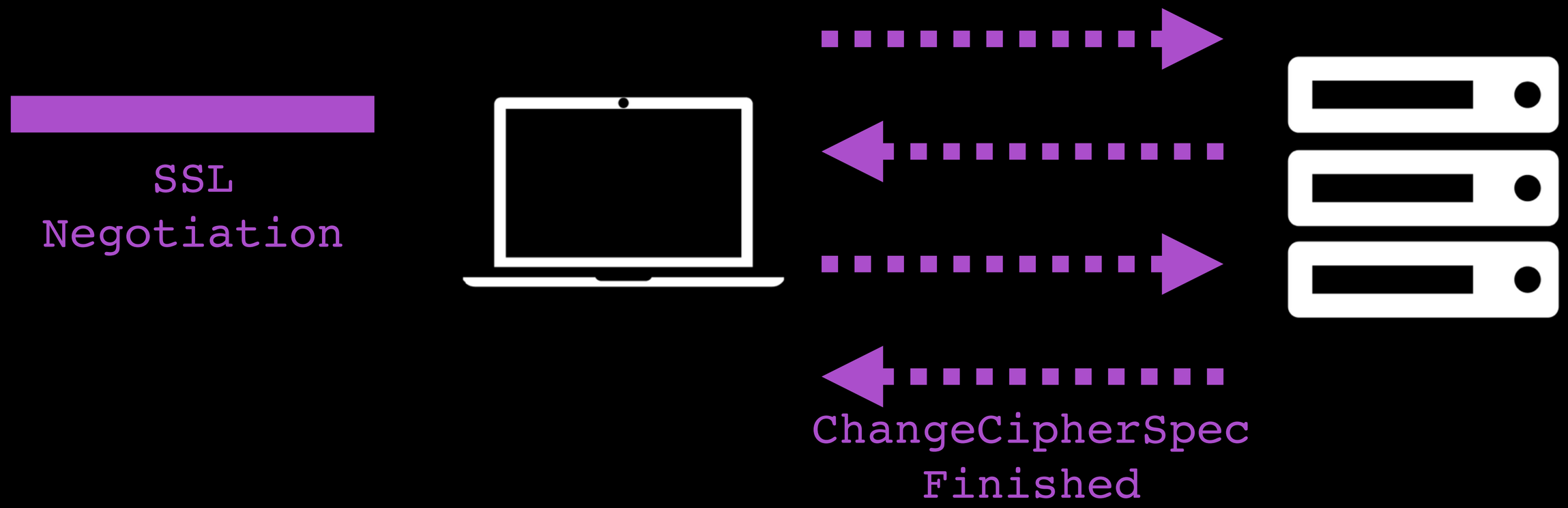

DNS
Lookup
TCP
Connection
Request

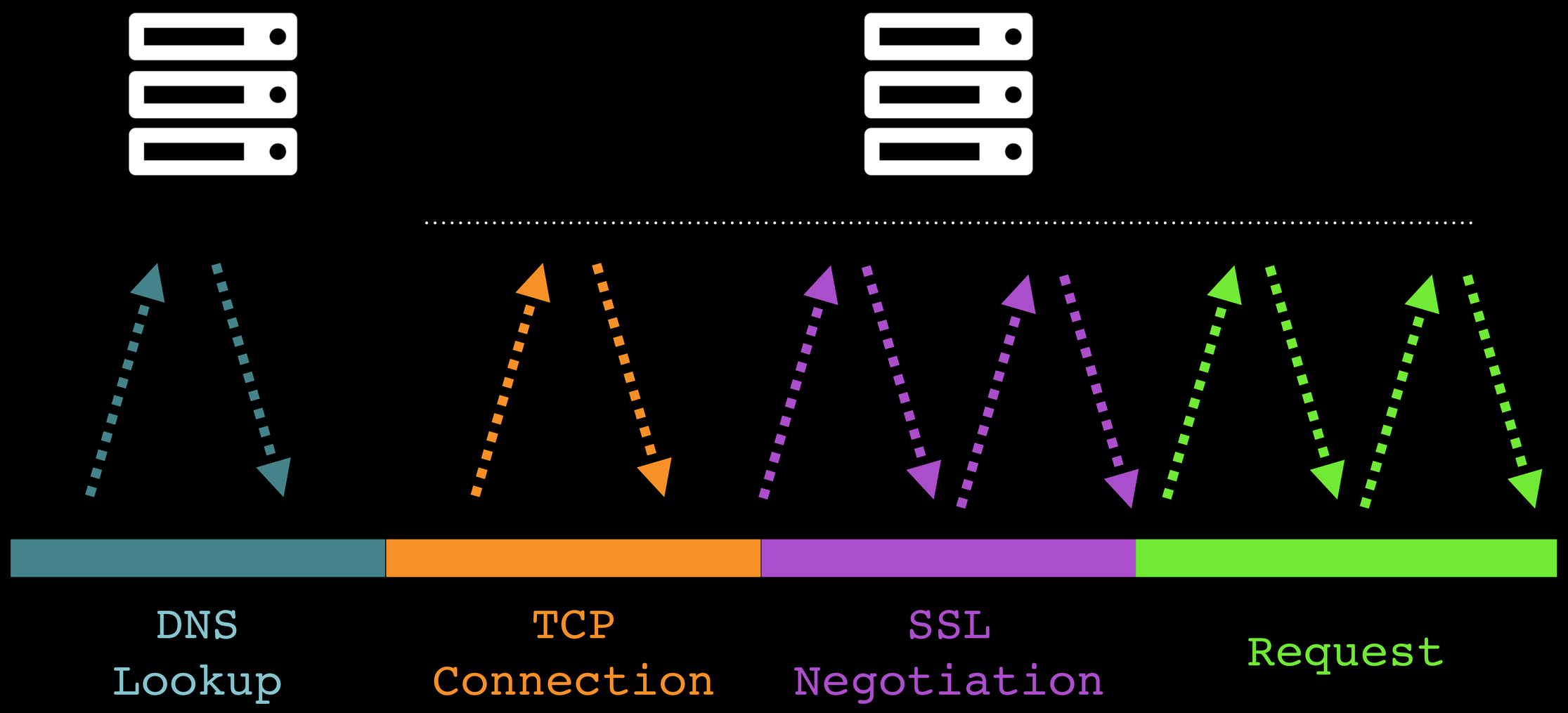
DNS
Lookup
TCP
Connection
SSL
Negotiation
Request

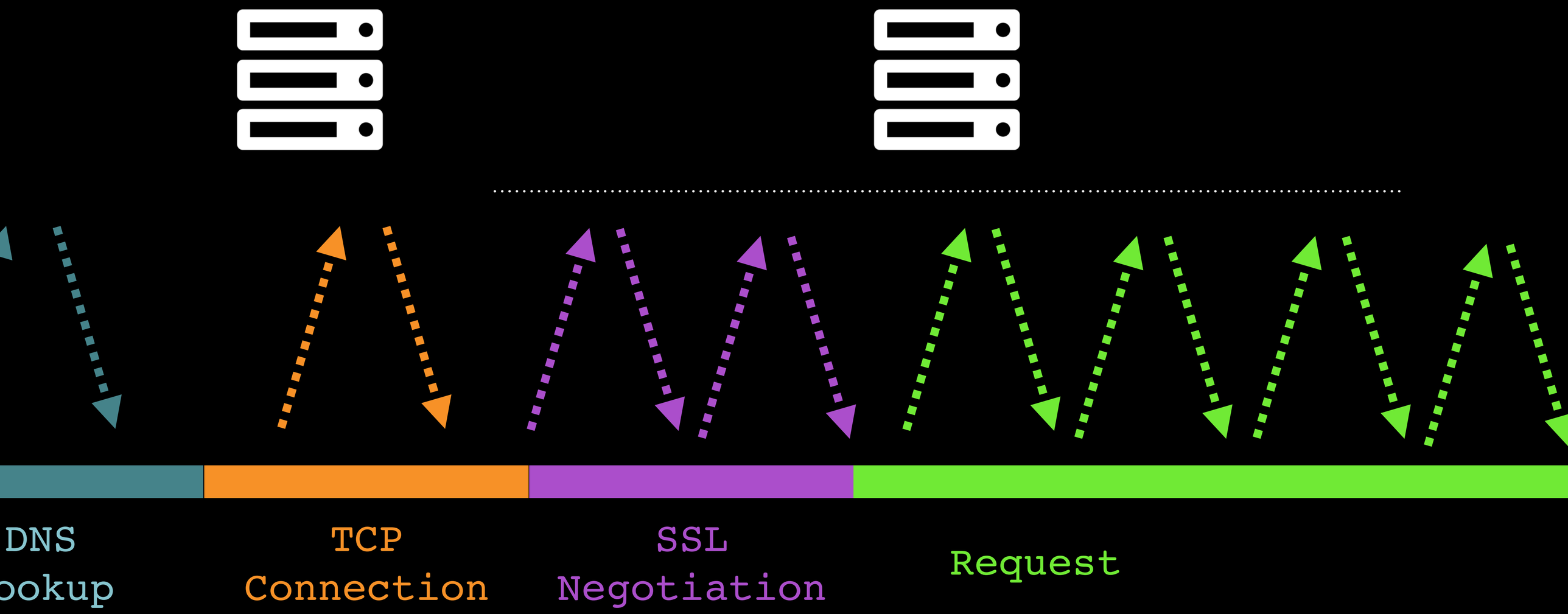
ClientHello
SSL
Negotiation


SSL
Negotiation
ServerHello
Certificate
ServerHelloDone

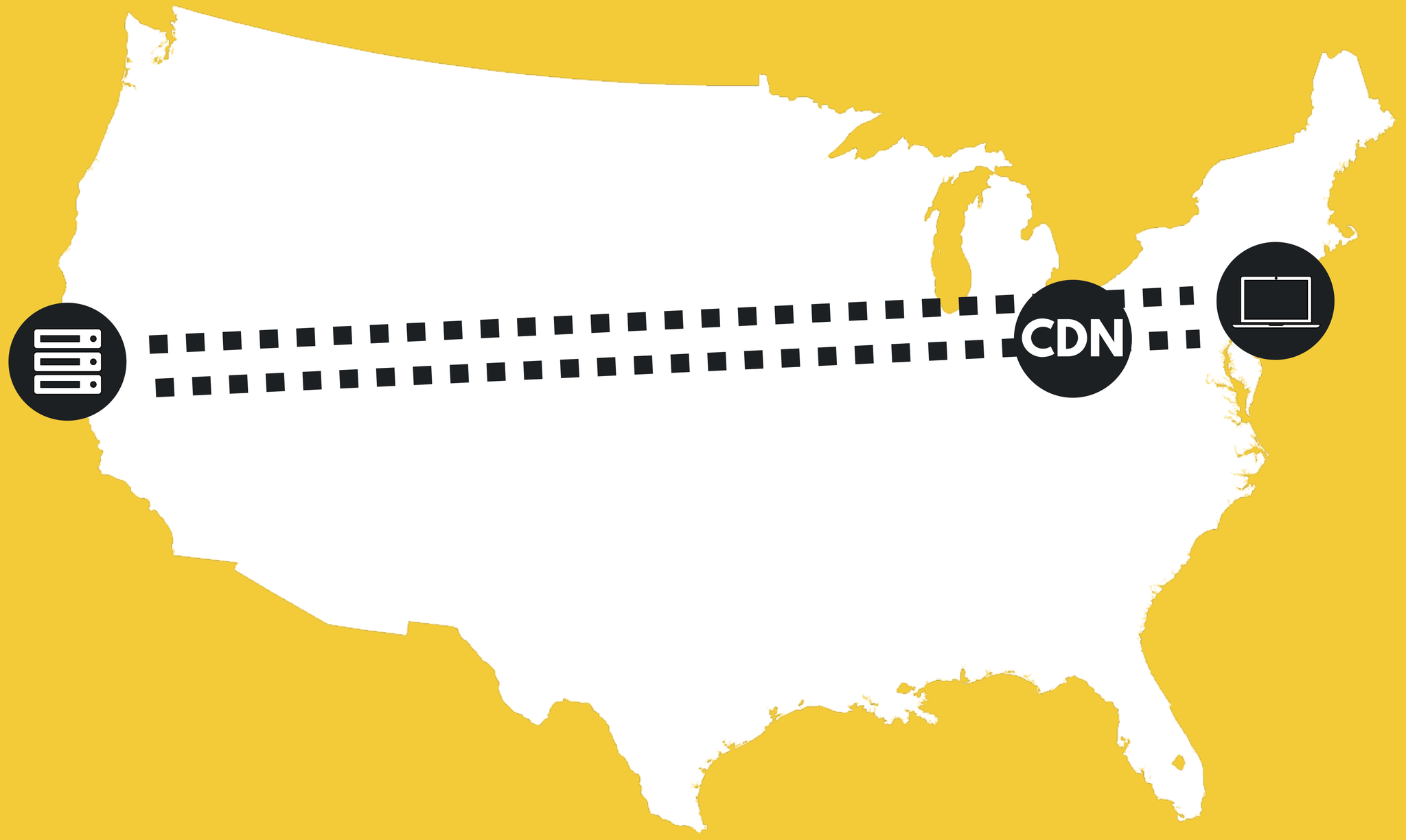

SSL
Negotiation
ClientKeyExchange
ChangeCipherSpec
Finished

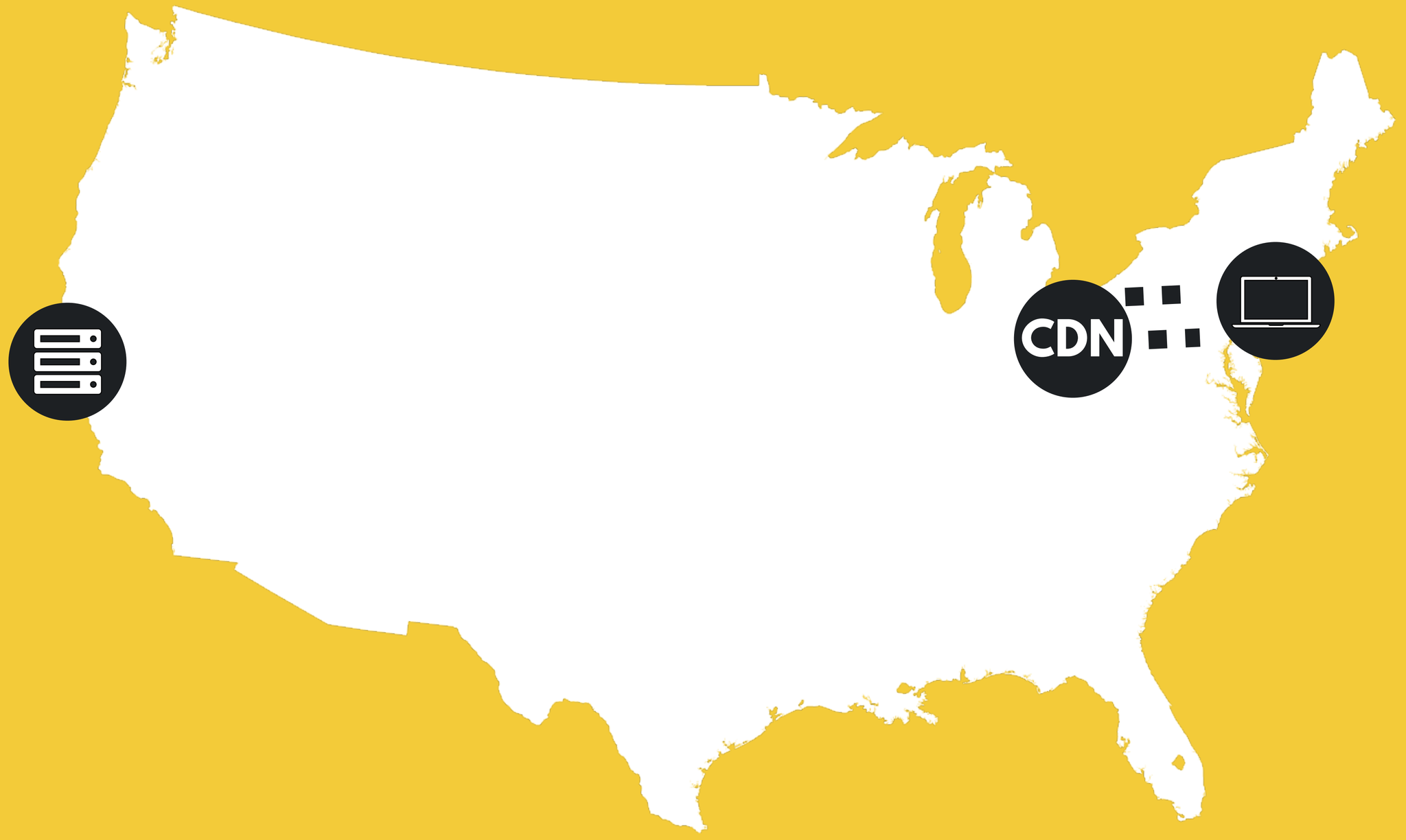

SSL
Negotiation
ChangeCipherSpec
Finished


DNS
Lookup
TCP
Connection
SSL
Negotiation
Request


DNS
ookup
TCP
Connection
SSL
Negotiation
Request

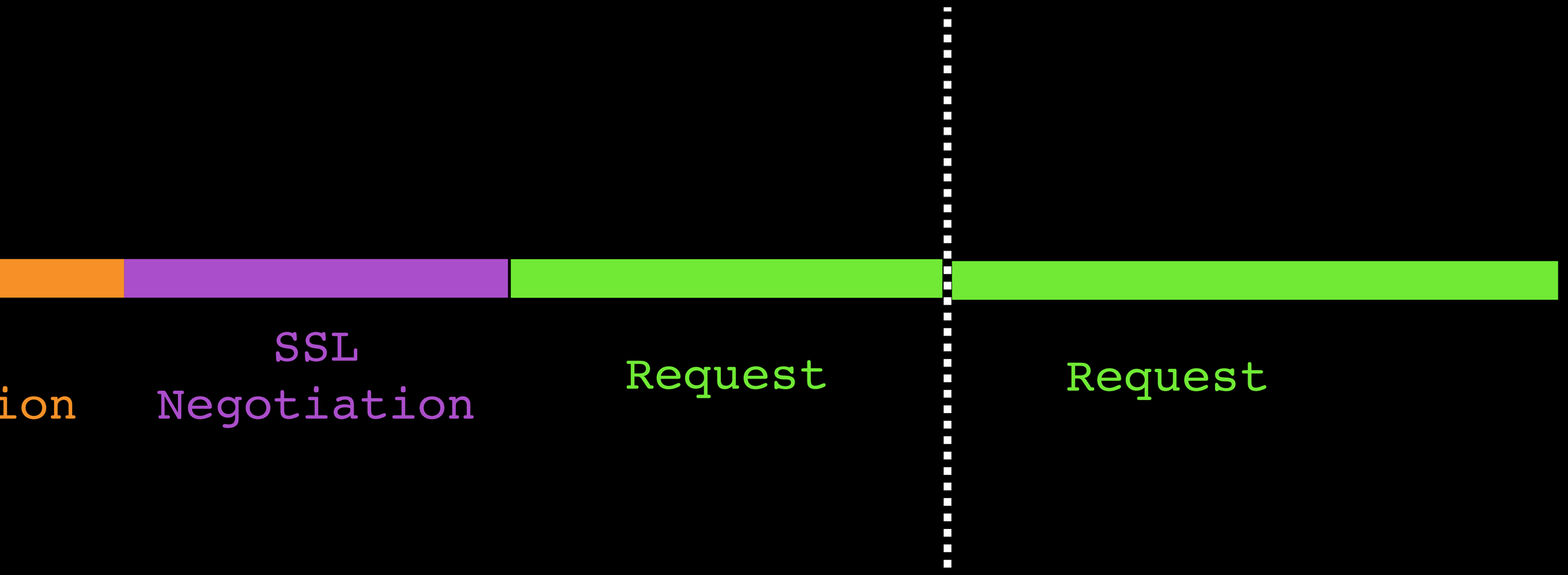
1 USE A CDN

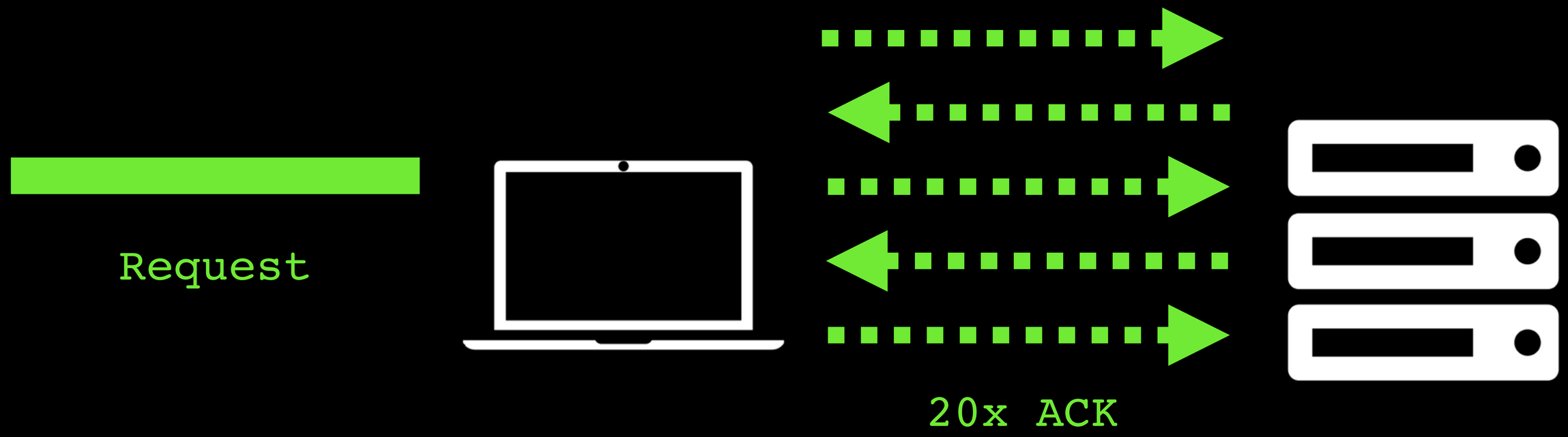

CDN


CDN

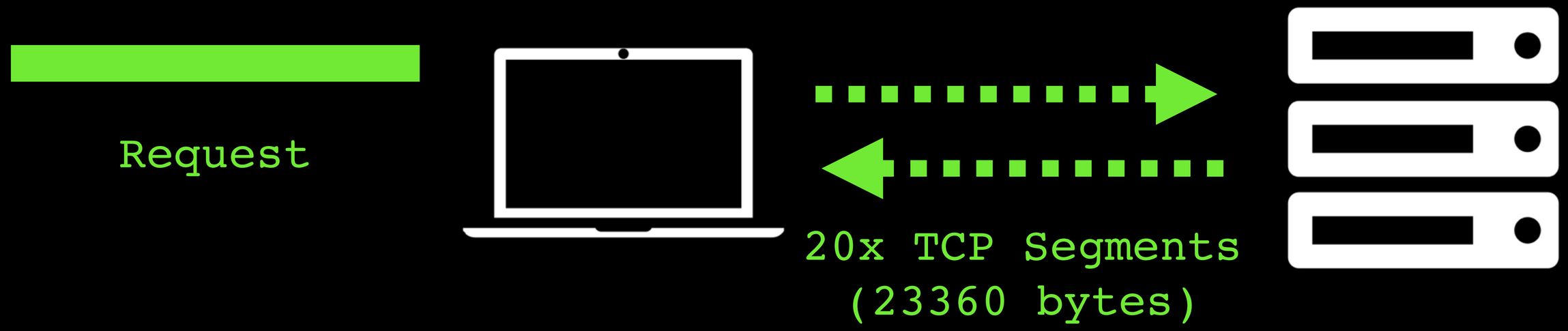
2 USE KEEP ALIVE

DNS
Lookup
TCP
Connection
SSL
Negotiation
Request


ion
SSL
Negotiation
Request
Request


Request
20x ACK

Request
GET /file-2


Request
20x TCP Segments
(23360 bytes)

```
KeepAlive On



<ifModule mod_headers.c>
Header set Connection keep-alive
</ifModule>
```

3 RESOURCE HINTS

Resource Hints

w3c.github.io/resource-hints/

W3C Editor's Draft

ReSpec

Resource Hints

W3C Editor's Draft 07 October 2015

This version:
https://w3c.github.io/resource-hints/
Latest published version:
http://www.w3.org/TR/resource-hints/
Latest editor's draft:
https://w3c.github.io/resource-hints/
Editor:
Ilya Grigorik, Google, igrigorik@gmail.com
Repository:
We are on Github.
File a bug.
Commit history.

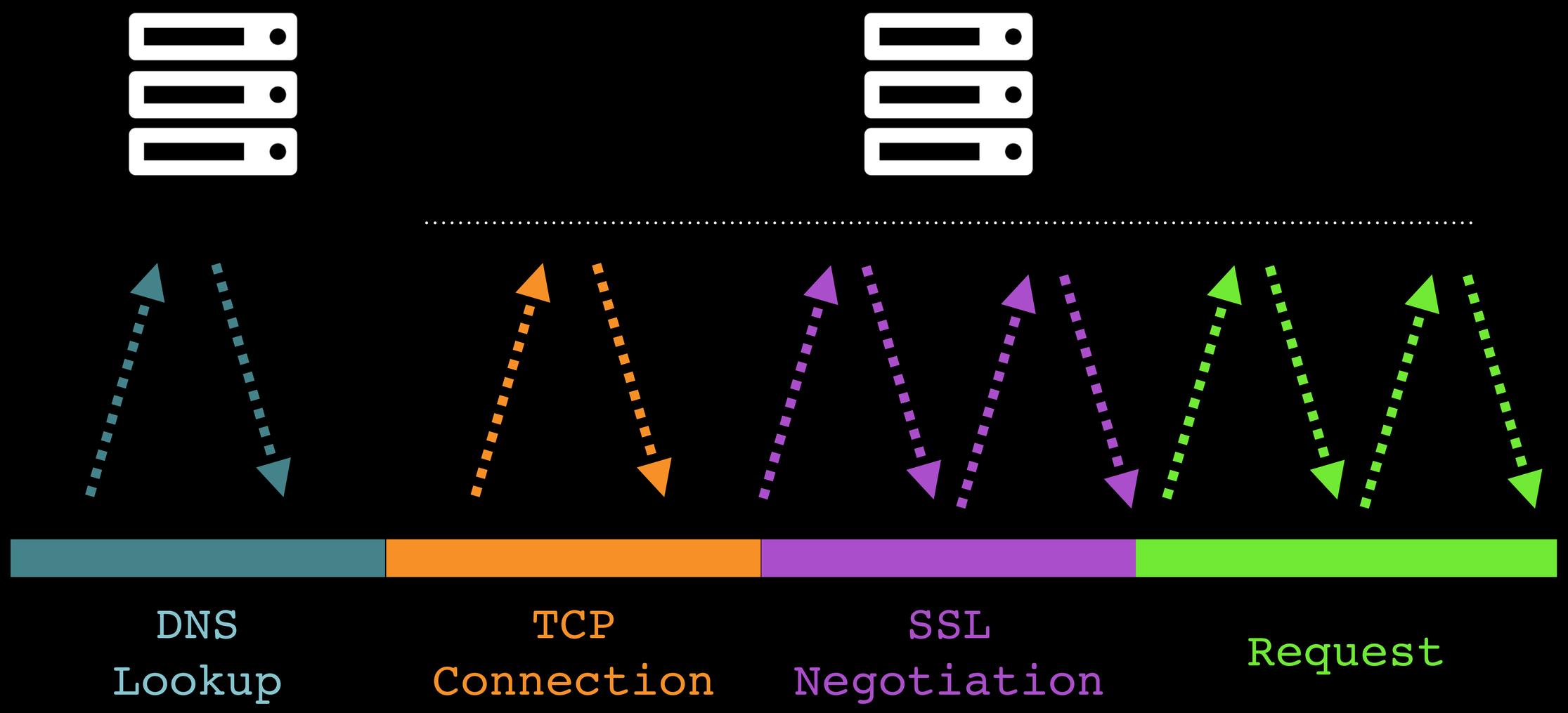
Copyright © 2015 W3C® (MIT, ERCIM, Keio, Beihang). W3C liability, trademark and document use rules apply.

Abstract

This specification defines the `dns-prefetch`, `preconnect`, `prefetch`, and `prerender` relationships of the HTML Link Element (`<link>`). These primitives enable the developer, and the server generating or delivering the resources, to assist the user agent in the decision process of which origins it should connect to, and which resources it should fetch and preprocess to improve page performance.

Status of This Document

This section describes the status of this document at the time of its publication. Other documents may supersede this document. A list of current W3C publications and the latest revision of


DNS
Lookup
TCP
Connection
SSL
Negotiation
Request

```
header('Link: <path/to/critical.css>;
rel=preload; as=stylesheet');
```

```
<link rel="preload" href="/path/to/styles.css">
```

```
function preload(url) {
    var hint = document.createElement("link");
    hint.rel = "preload";
    hint.href = url;
    document.head.appendChild(hint);
}
```

Can I use... Support tables for

caniuse.com/#search=dns-prefetch

Resource Hints: dns-prefetch - WD

Global 66.35% + 0.45% = 66.8%

Gives a hint to the browser to perform a DNS lookup in the background to improve performance. This is indicated using `<link rel="dns-prefetch" href="http://example-domain.com/">`

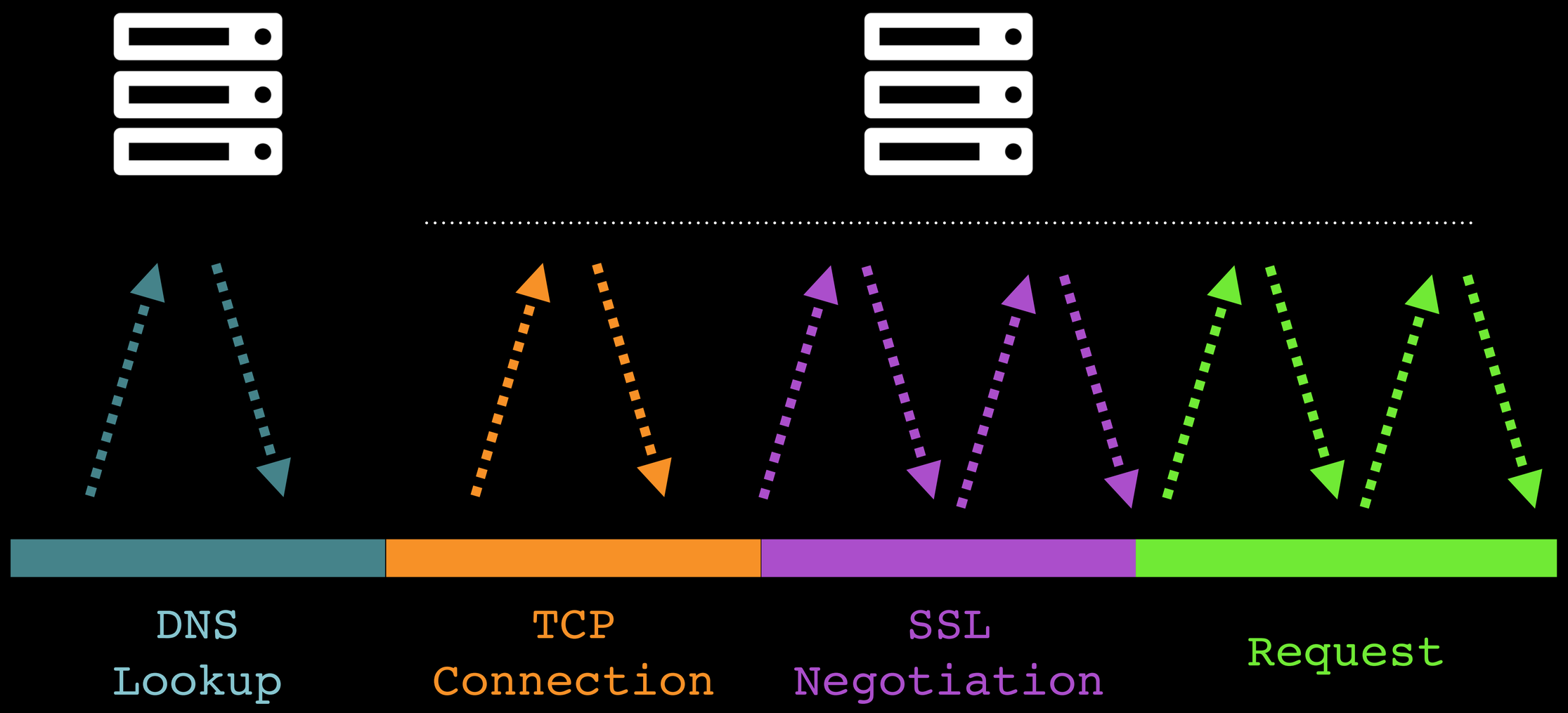
Current aligned | Usage relative | Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			29						
			45						
			48					4.3	
		45	49			8.4		4.4	
8		46	50			9.2		4.4.4	
11	13	47	51	9.1	38	9.3	8	50	50
	14	48	52	10	39				
		49	53	TP	40				
		50	54						

Notes | Known issues (0) | Resources (3) | Feedback

[1] IE9 supported `dns-prefetch` as `prefetch` as the former wasn't defined yet.

```
<link rel="dns-prefetch" href="//
host_name_to_prefetch.com">
```


DNS
Lookup
TCP
Connection
SSL
Negotiation
Request

Can I use... Support tables for

caniuse.com/#search=preconnect

Resource Hints: preconnect - WD

Global 52.52%

Gives a hint to the browser to begin the connection handshake (DNS, TCP, TLS) in the background to improve performance. This is indicated using `<link rel="preconnect" href="https://example-domain.com/">`

Current aligned | Usage relative | Show all

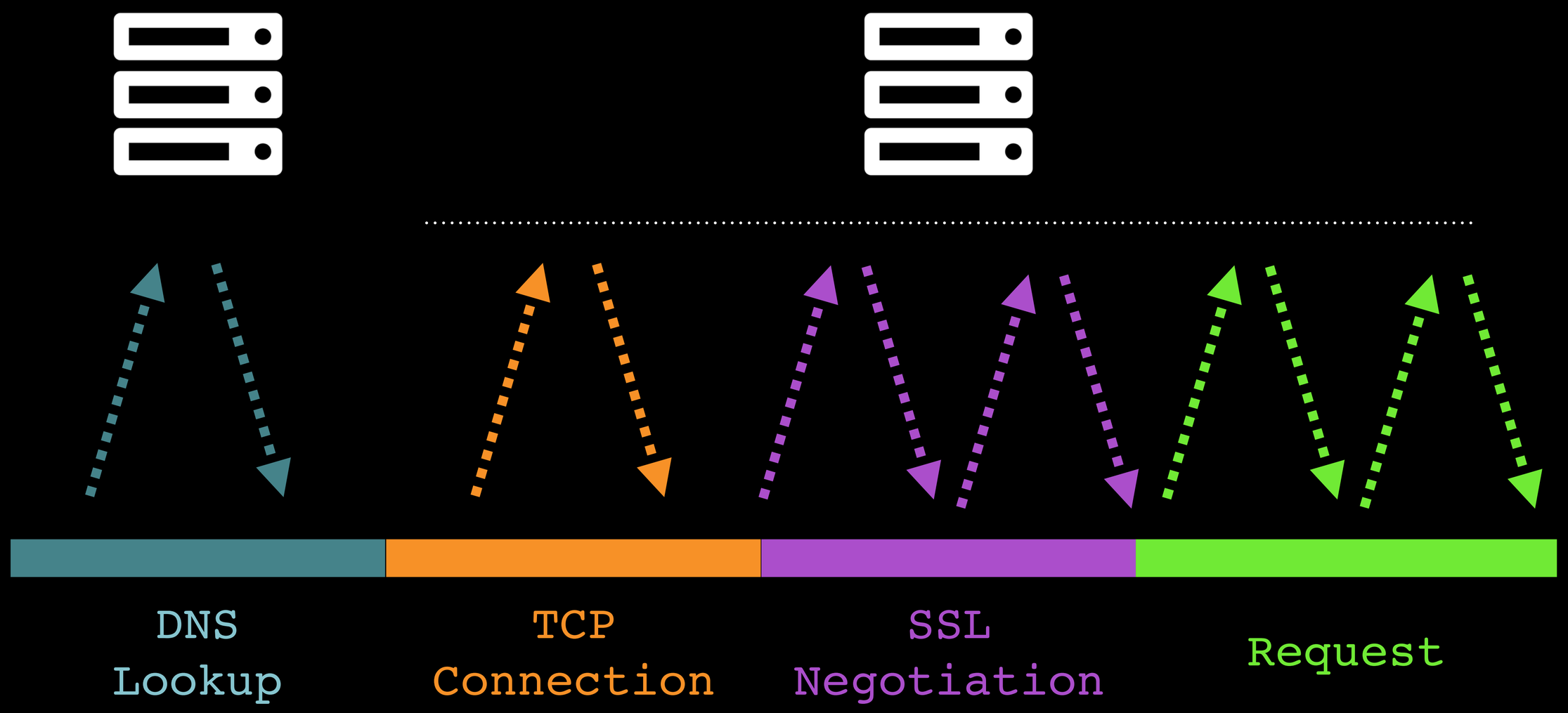
IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			29						
			45						
			48					4.3	
		45	49			8.4		4.4	
8		46	50			9.2		4.4.4	
11	13	47	51	9.1	38	9.3	8	50	50
	14	48	52	10	39				
		49	53	TP	40				
		50	54						

Notes | Known issues (0) | Resources (4) | Feedback

MS Edge status: Under Consideration

[1] Firefox 39 did not support 'crossorigin' attribute and preconnects were not processed by the preload parser. Both of these features were enabled in Firefox 41.

```
<link rel="preconnect" href="//
host_name_to_prefetch.com">
```


DNS
Lookup
TCP
Connection
SSL
Negotiation
Request

```
<link rel="dns-prefetch" href="//
host_name_to_prefetch.com">

<link rel="preconnect" href="//
host_name_to_prefetch.com">
```

Can I use... Support tables for

caniuse.com/#search=preload

Resource Hints: preload - WD

Global 39.75%

Using `<link rel="preload">`, browsers can be informed to prefetch resources without having to execute them, allowing fine-grained control over when and how resources are loaded.

Current aligned | Usage relative | Show all

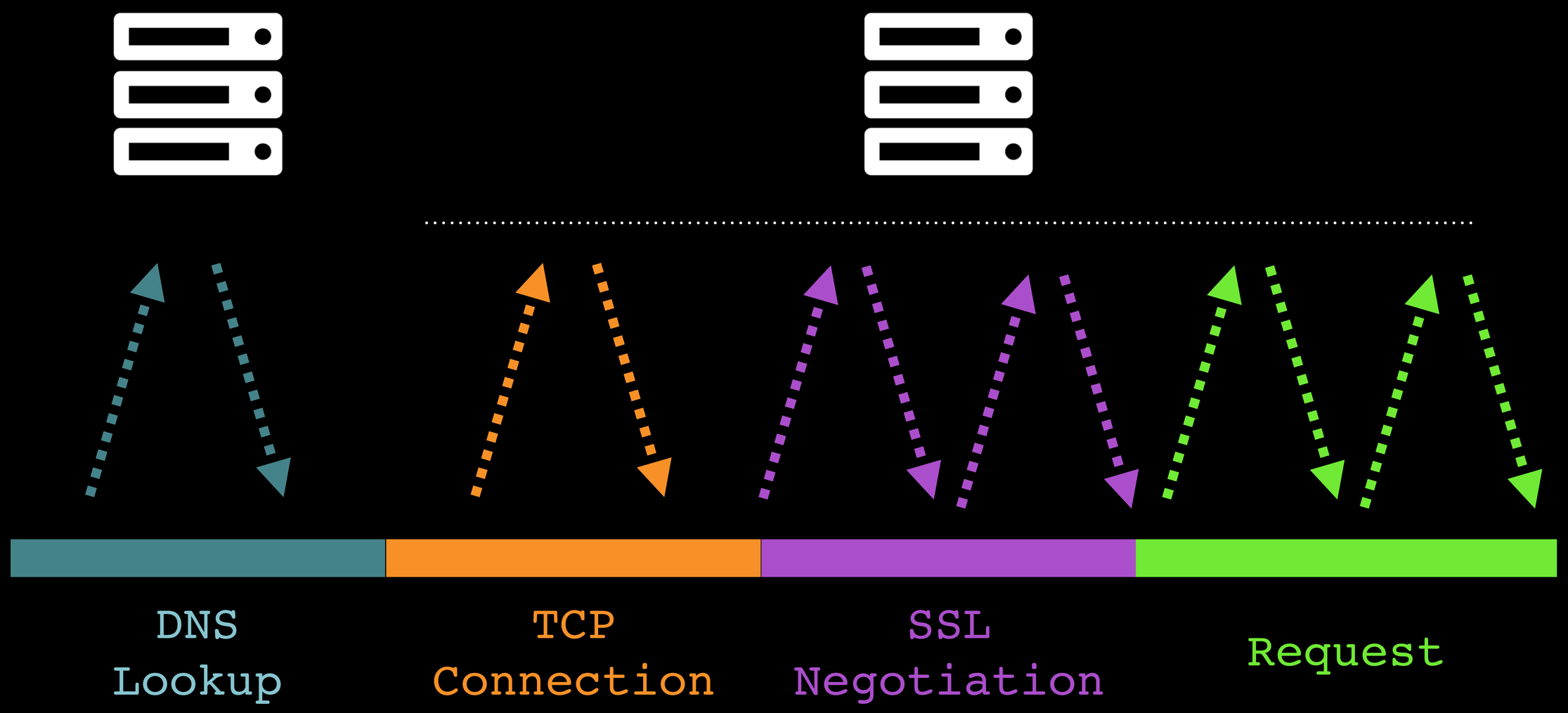
IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			29						
			45						
			48					4.3	
		45	49			8.4		4.4	
8		46	50			9.2		4.4.4	
11	13	47	51	9.1	38	9.3	8	50	50
	14	48	52	10	39				
		49	53	TP	40				
		50	54						

Notes | Known issues (0) | Resources (4) | Feedback

MS Edge status: Under Consideration

= Supported = Not supported = Partial support = Support unknown

```html
<link rel="preload" href="/style/other.css"
as="style">
```


DNS
Lookup
TCP
Connection
SSL
Negotiation
Request

Can I use... Support tables for

caniuse.com/#search=prefetch

Resource Hints: prefetch - WD

Global 66.28%

Informs the browsers that a given resource should be prefetched so it can be loaded more quickly. This is indicated using `<link rel="prefetch" href="(url)">`

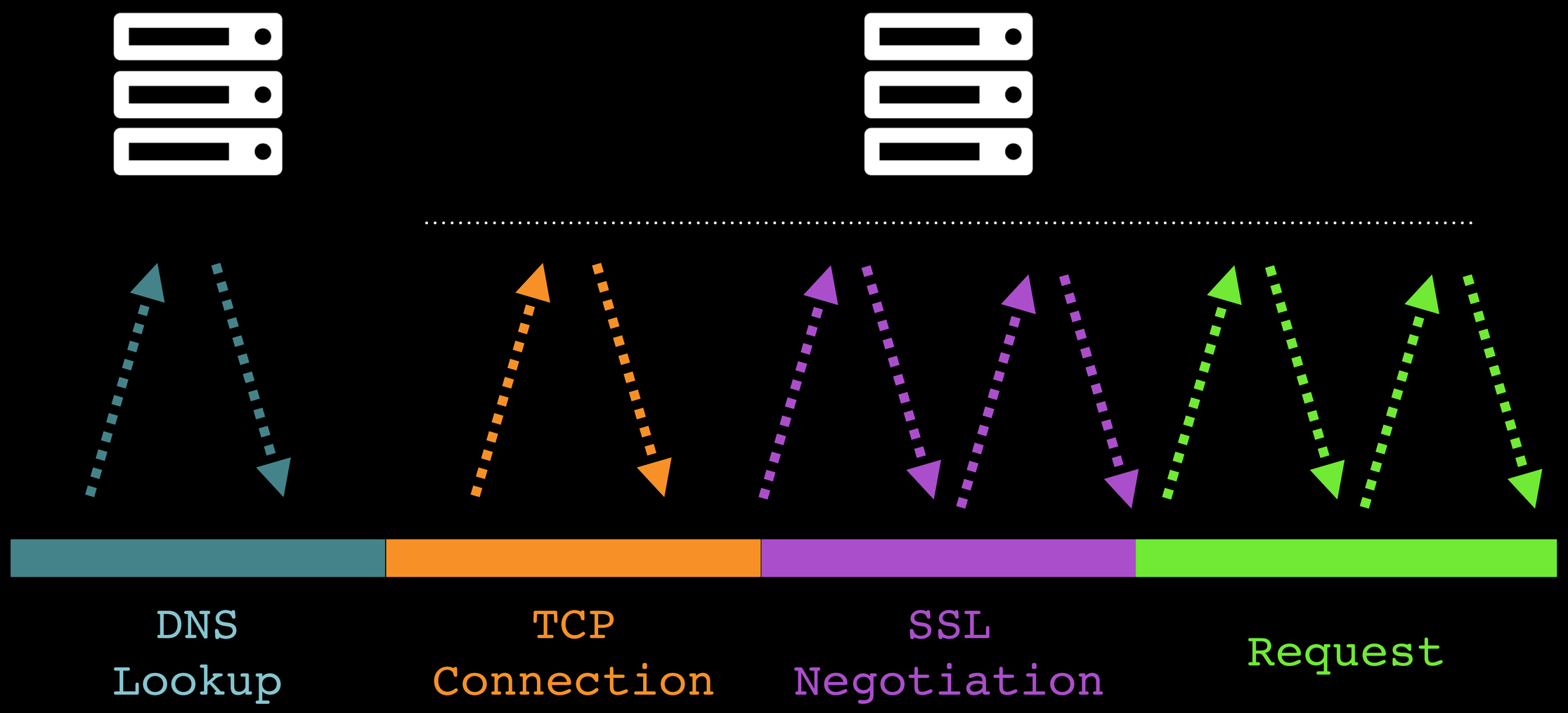
Current aligned | Usage relative | Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			29						
			45						
			48					4.3	
		45	49			8.4		4.4	
8		46	50			9.2		4.4.4	
11	13	47	51	9.1	38	9.3	8	50	50
	14	48	52	10	39				
		49	53	TP	40				
		50	54						

Notes | Known issues (0) | Resources (3) | Feedback

No notes

```
<link rel="prefetch" href="/style/other.css"
as="style">
```


DNS
Lookup
TCP
Connection
SSL
Negotiation
Request

Can I use... Support tables for

caniuse.com/#search=prerender

Resource Hints: prerender - WD

Global 55.31%

Gives a hint to the browser to render the specified page in the background, speeding up page load if the user navigates to it. This is indicated using `<link rel="prerender" href="(url)">`

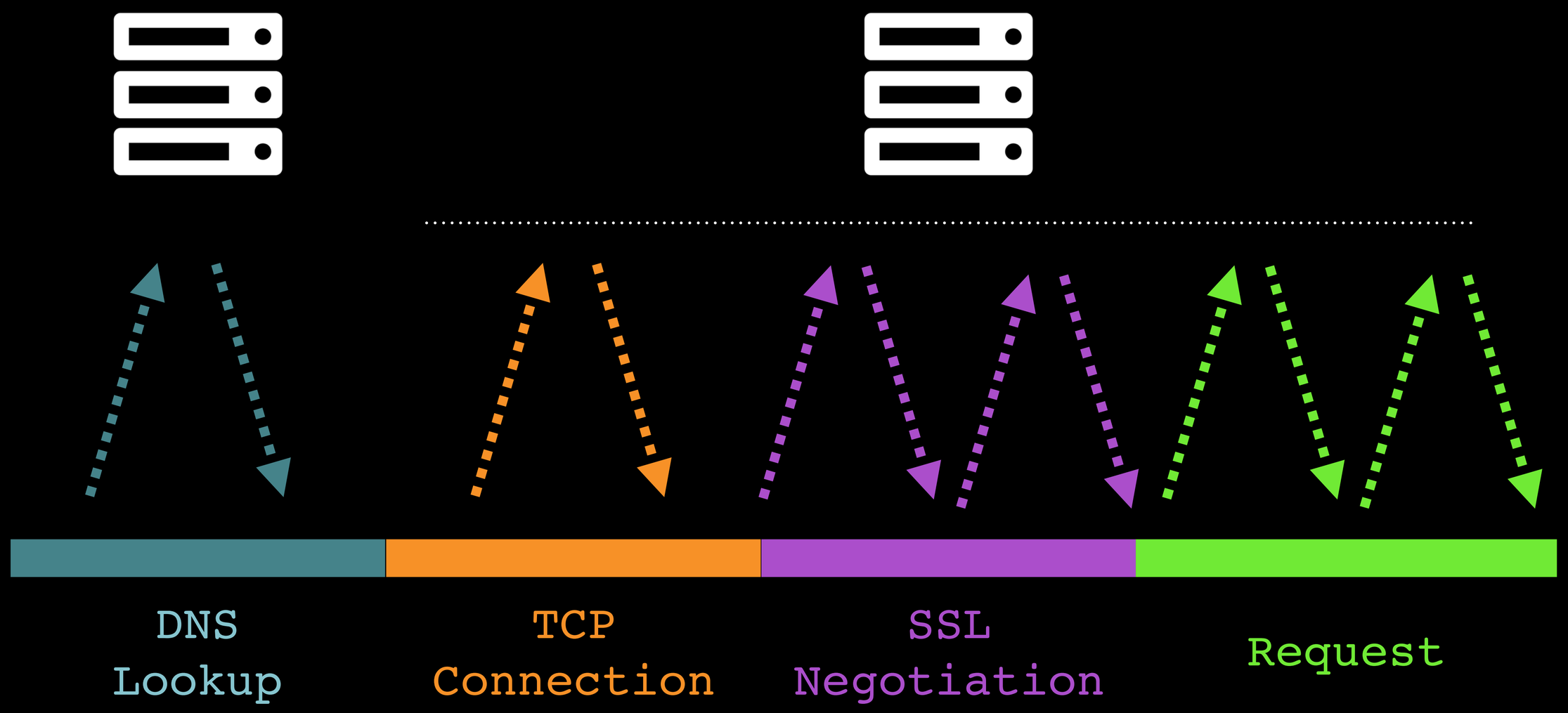
Current aligned | Usage relative | Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			29						
			45						
			48					4.3	
		45	49			8.4		4.4	
8		46	50			9.2		4.4.4	
11	13	47	51	9.1	38	9.3	8	50	50
	14	48	52	10	39				
		49	53	TP	40				
		50	54						

Notes | Known issues (1) | Resources (2) | Feedback

No notes

```
<link rel="prerender" href="//example.com/next-page.html">
```


DNS
Lookup
TCP
Connection
SSL
Negotiation
Request

`dns-prefetch`

Resolve DNS ahead of time

Ex: Third party content where you know the domain, but not the full URL

`dns-prefetch`

`preconnect`

TCP Handshake/SSL negotiation ahead of time

Ex:Third party content where you know the domain, but not the full URL

`dns-prefetch`

`preconnect`

`preload`

Fetch a resource ahead of time

Ex: Image or script you know you will need for current page

`dns-prefetch`
`preconnect`
`preload`

`prefetch`

Fetch a resource that will be needed for next navigation

Ex: Image or script that will likely be needed on the next page

`dns-prefetch`
`preconnect`
`preload`

`prefetch`
`prerender`

Prerender a page in the background for future navigation

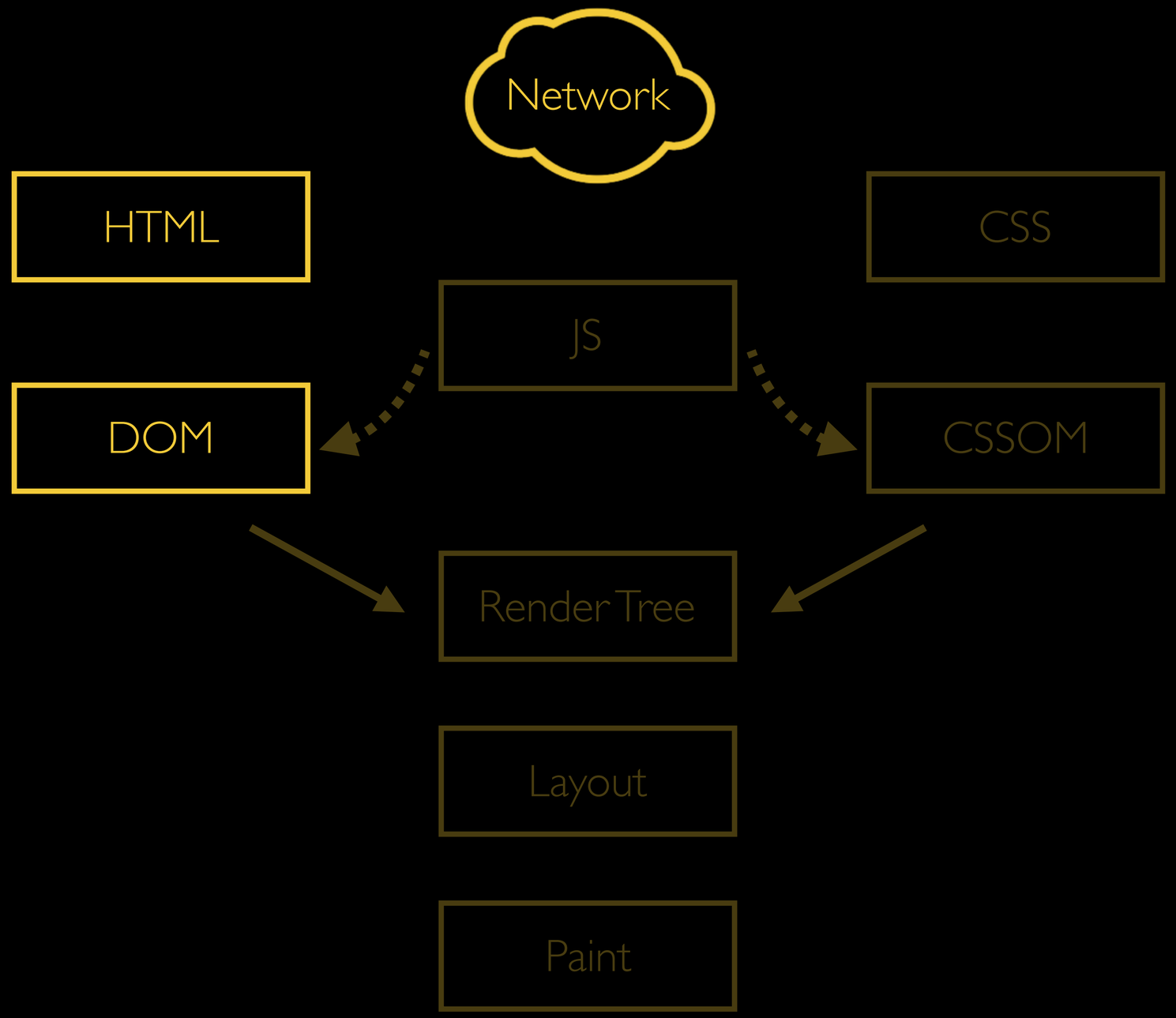
Ex: Marketing funnel where next navigation is predictable

dns-prefetch
preconnect
preload

Current Page

prefetch
prerender

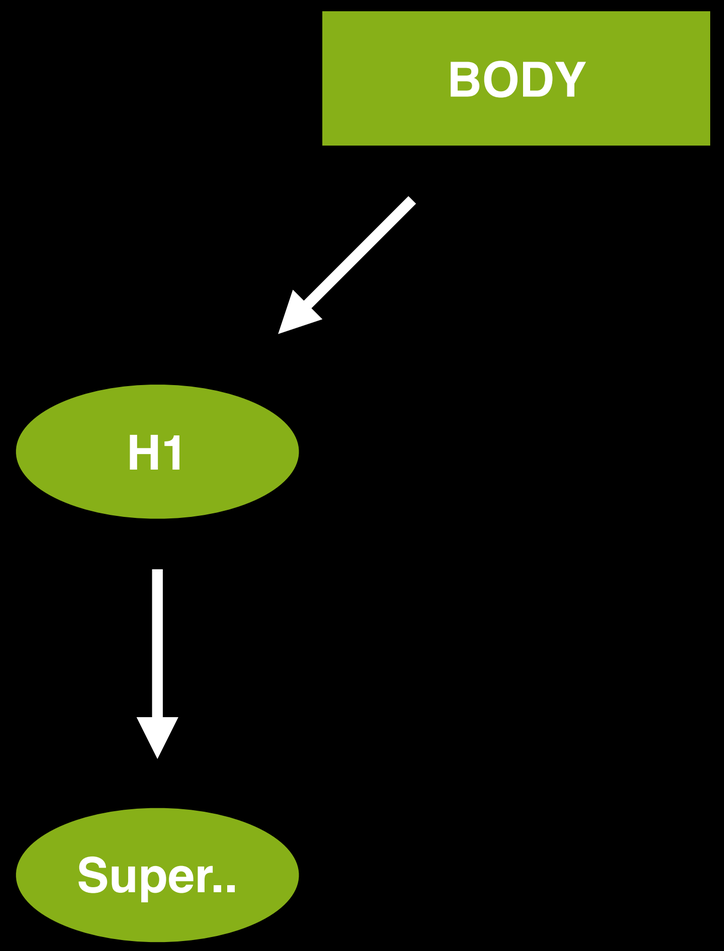
Next Navigation


Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

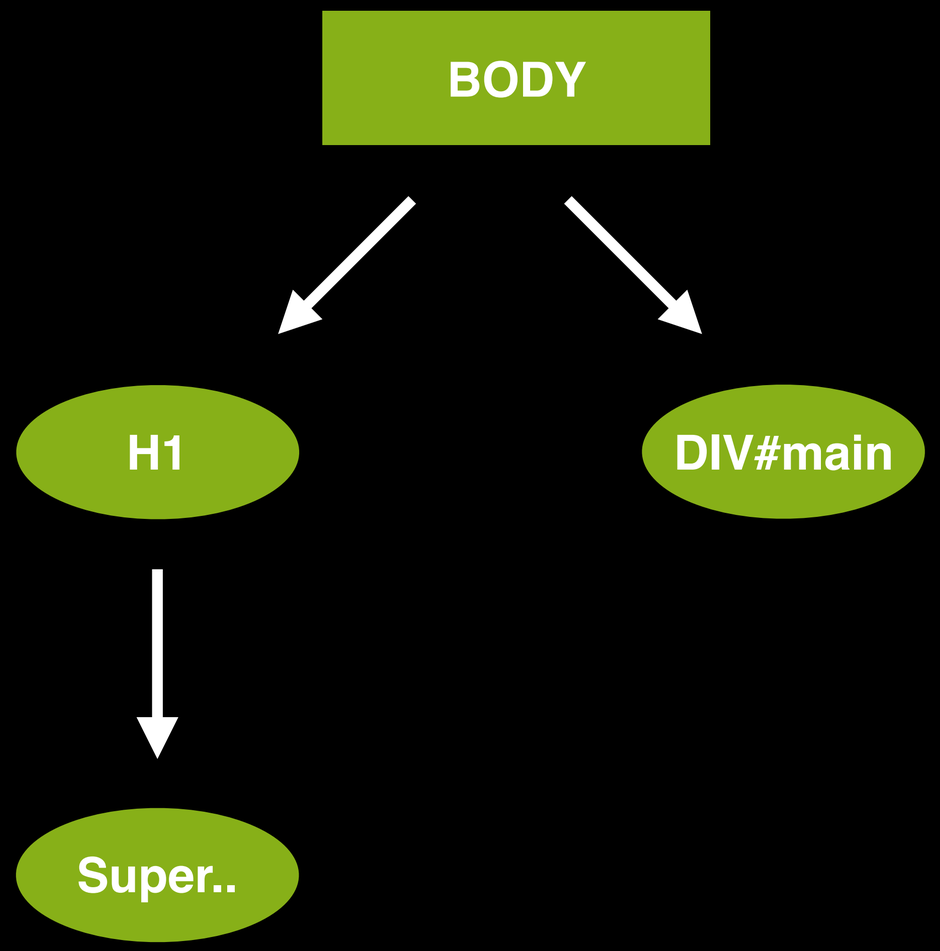
```html
<html>
<head>
  <meta charset="UTF-8">
  <title>Hey there</title>
</head>
<body>
```

BODY

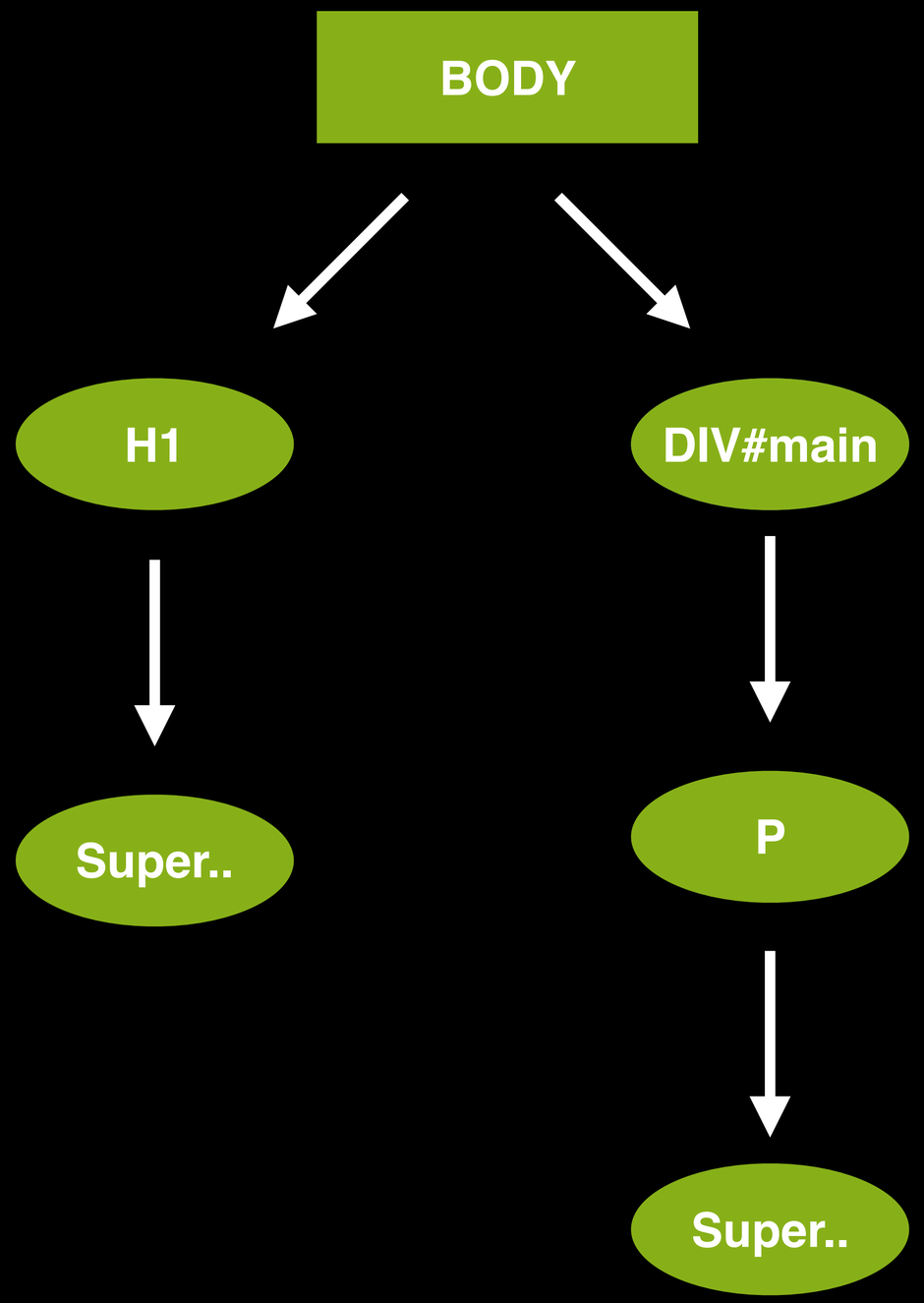
```html
<html>
<head>
  <meta charset="UTF-8">
  <title>Hey there</title>
</head>
<body>
  <h1>Super awesome site</h1>
```

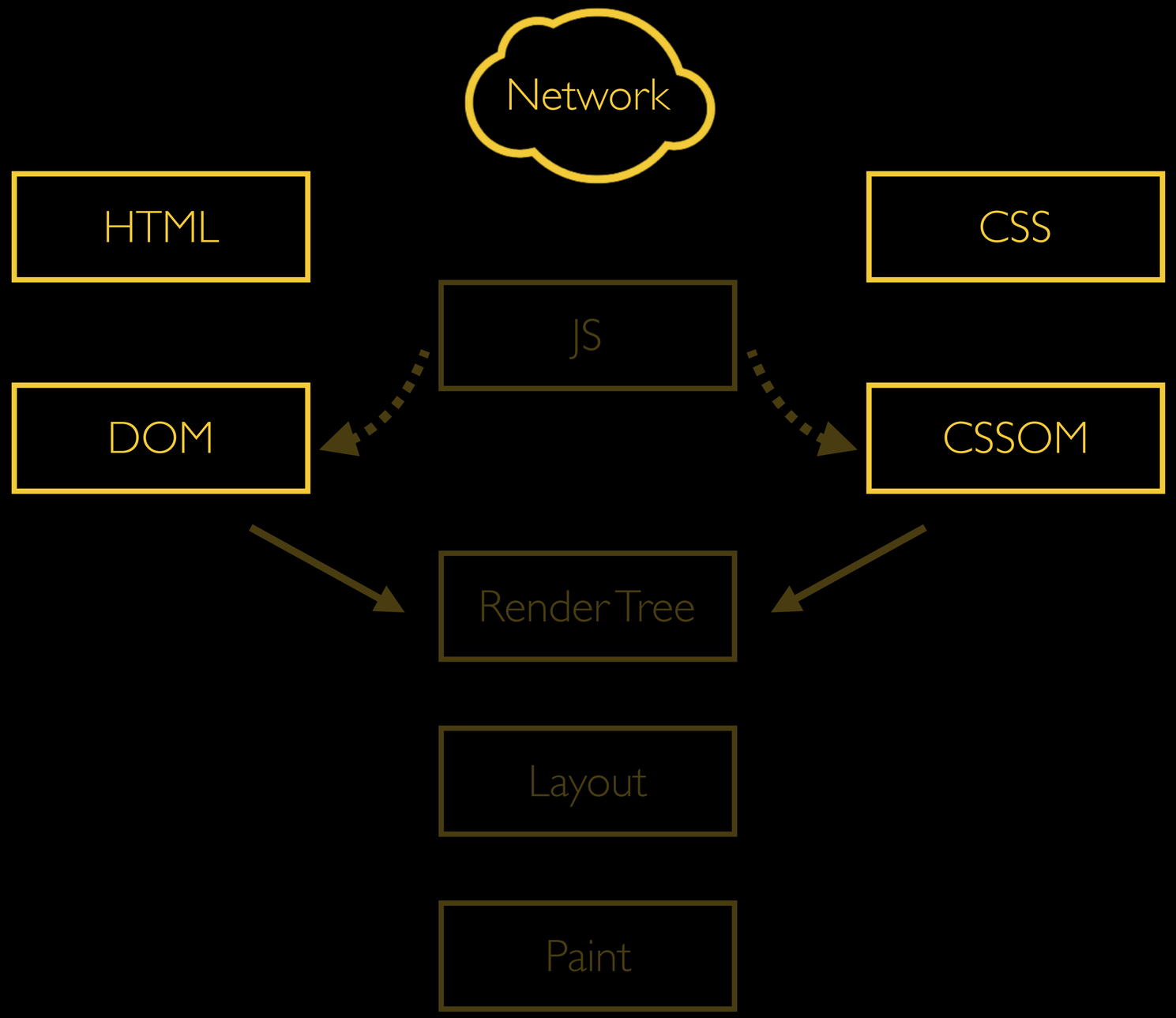


```html
<html>
<head>
  <meta charset="UTF-8">
  <title>Hey there</title>
</head>
<body>
  <h1>Super awesome site</h1>
  <div id="main">
```



```html
<html>
<head>
 <meta charset="UTF-8">
 <title>Hey there</title>
</head>
<body>
 <h1>Super awesome site</h1>
 <div id="main">
  <p>Super interesting stuff, I'm
sure.</p>
 </div>
</body>
</html>
```

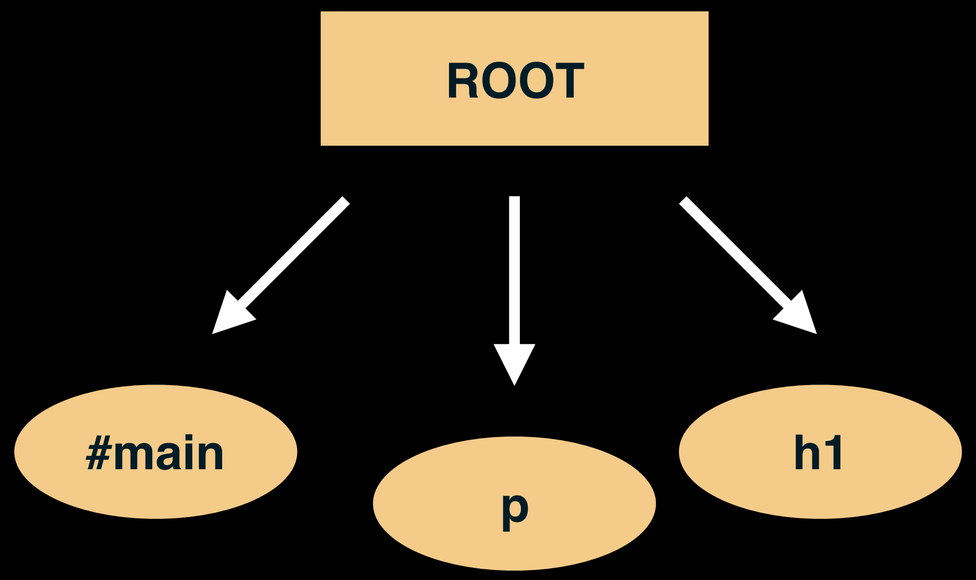


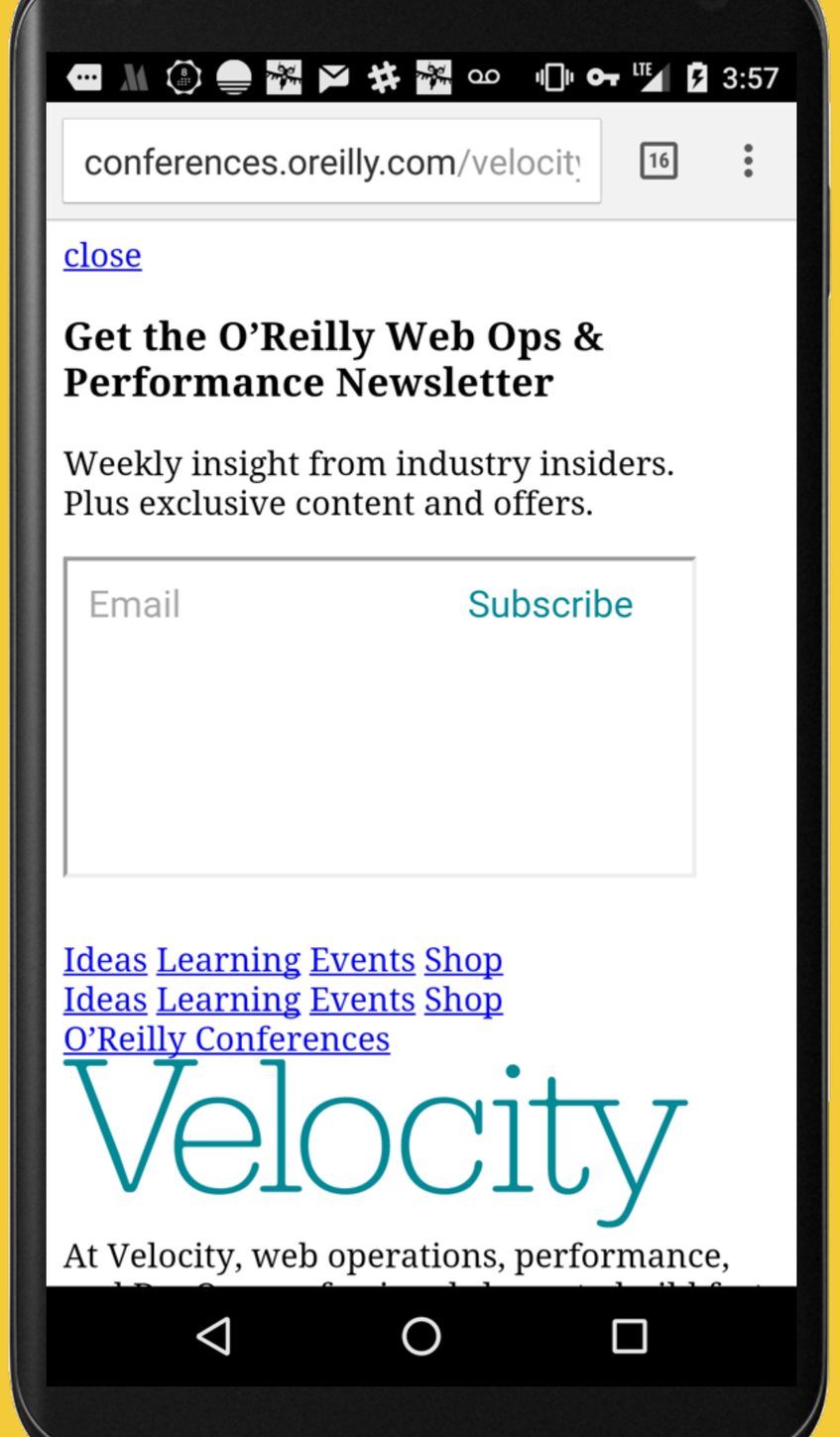

Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

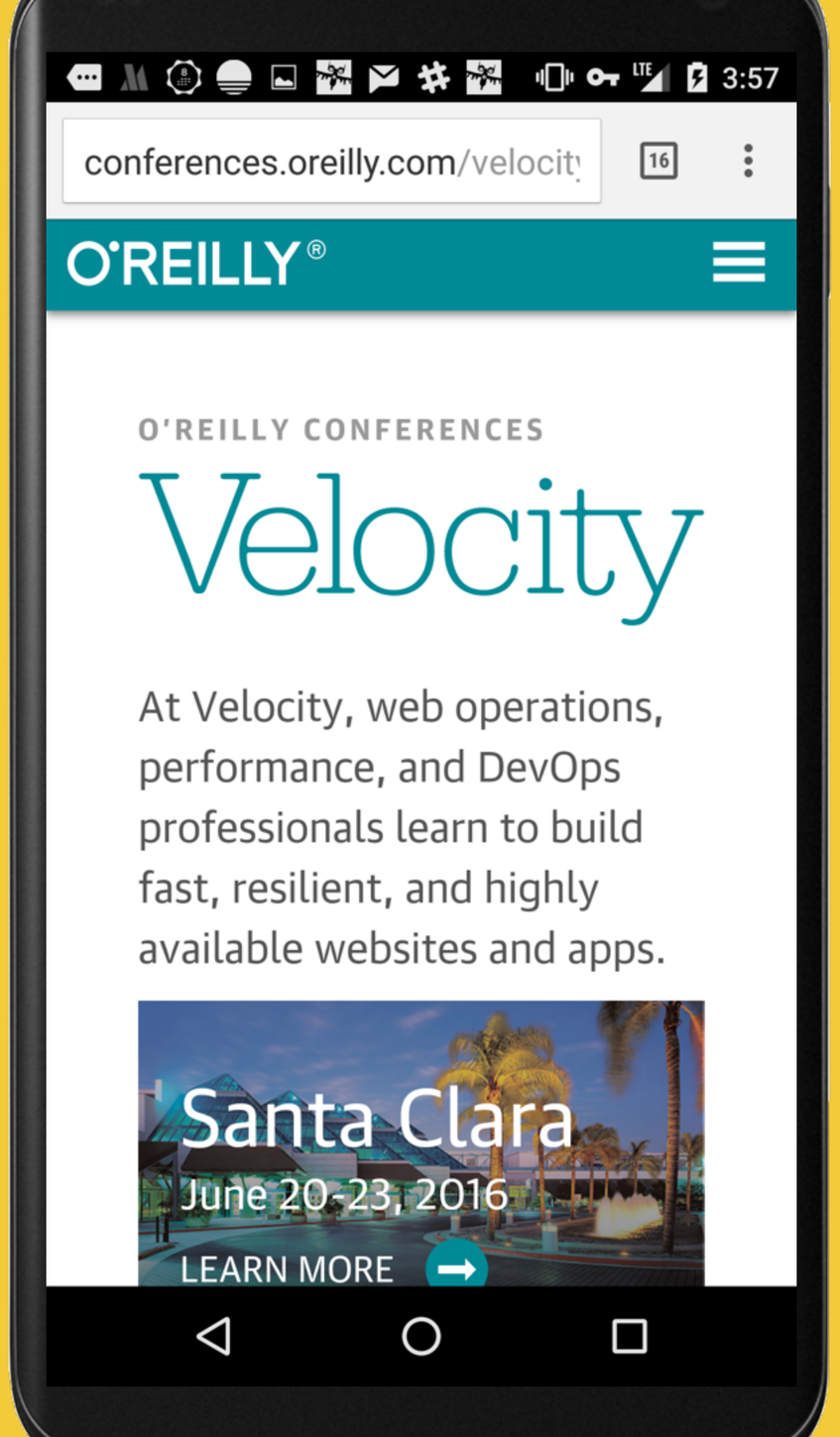
```html
<html>
<head>
 <meta charset="UTF-8">
 <title>Hey there</title>
 <link rel="stylesheet" href="style.css" />
</head>
<body>
 <h1>Super awesome site</h1>
 <div id=“main">
  <p>Super interesting stuff, I'm sure.</p>
 </div>
</body>
</html>
```

```
#main{
 color: green;
}
h1 {
 font-size: 2em;
}
p{
 color: orange;
}
```

```
#main{
 color: green;
}
h1 {
 font-size: 2em;
}
p{
 color: orange;
}
```




3:57
conferences.oreilly.com/velocity
16
close
Get the O'Reilly Web Ops & Performance Newsletter
Weekly insight from industry insiders.
Plus exclusive content and offers.
Email
Subscribe
Ideas Learning Events Shop
Ideas Learning Events Shop
O'Reilly Conferences
Velocity
At Velocity, web operations, performance,

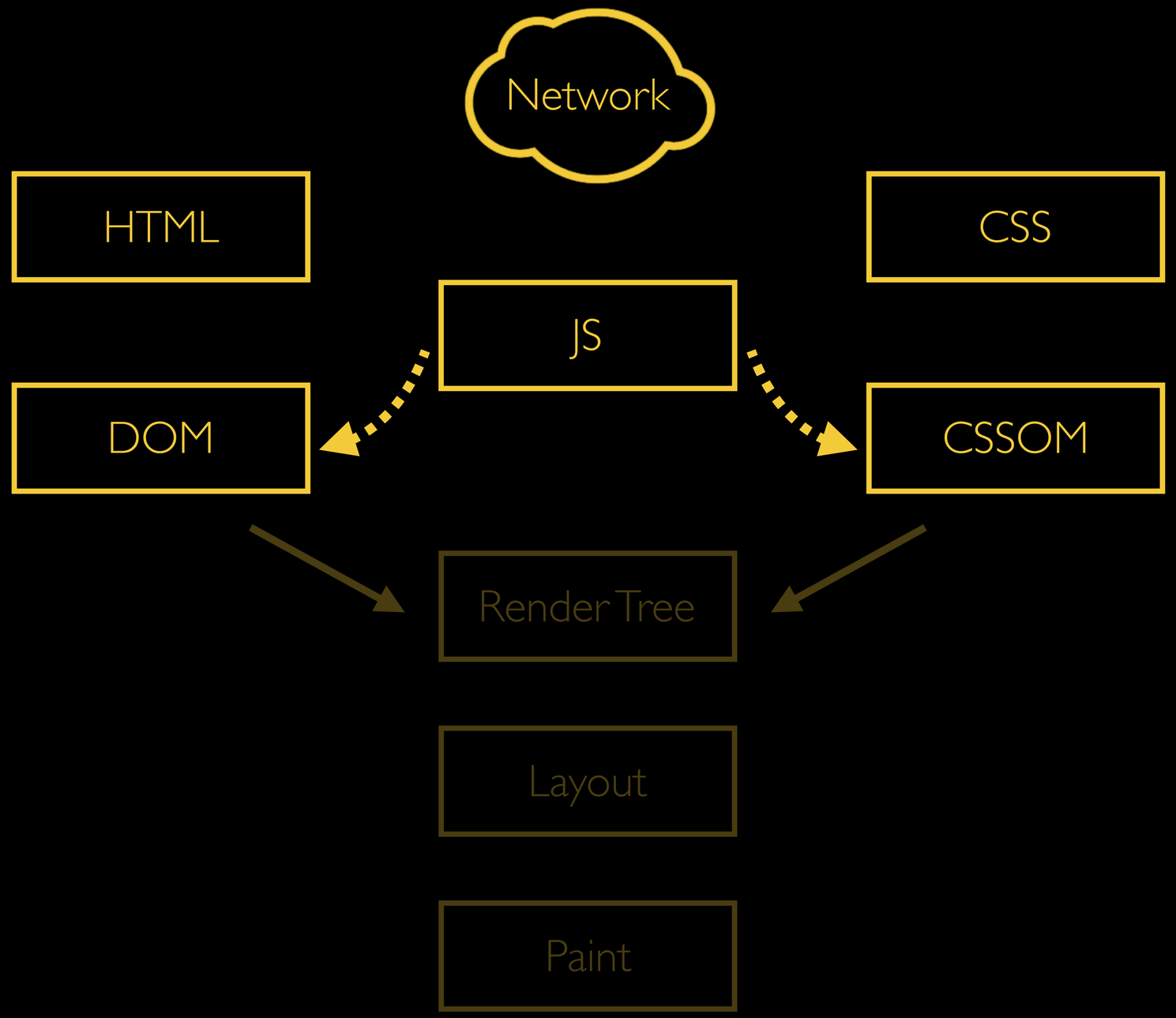

3:57
conferences.oreilly.com/velocity
16
O'REILLY®
O'REILLY CONFERENCES
Velocity
At Velocity, web operations, performance, and DevOps professionals learn to build fast, resilient, and highly available websites and apps.
Santa Clara
June 20-23, 2016
LEARN MORE

CSS IS RENDER BLOCKING

```
<link rel="stylesheet" href="style.css" />

<link rel="stylesheet" href="print.css" media="print" />

<link rel="stylesheet" href="large.css" media="(min-width:
30em)" />
```


Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

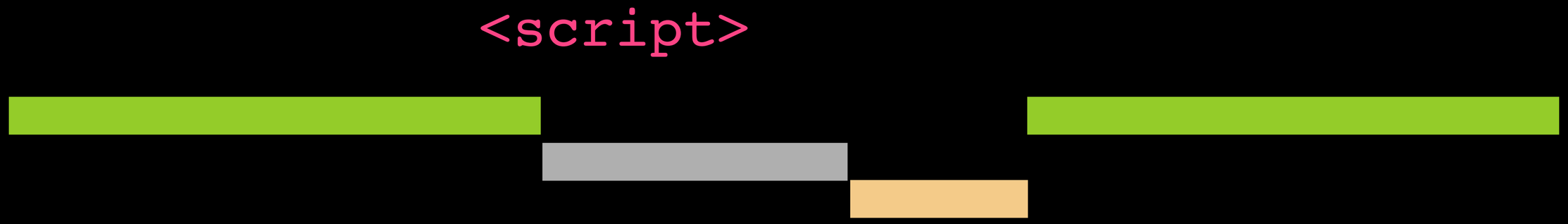
```
document.write(“We got a safe in the trunk with money in a stack, with dice in the front and Brooklyn’s in the back.”);
```

```
document.getElementById(‘#main').style.height = "100px";
```

```
<script type="text/javascript"
src="jquereactgular.js"></script>
```

<script>

<script>

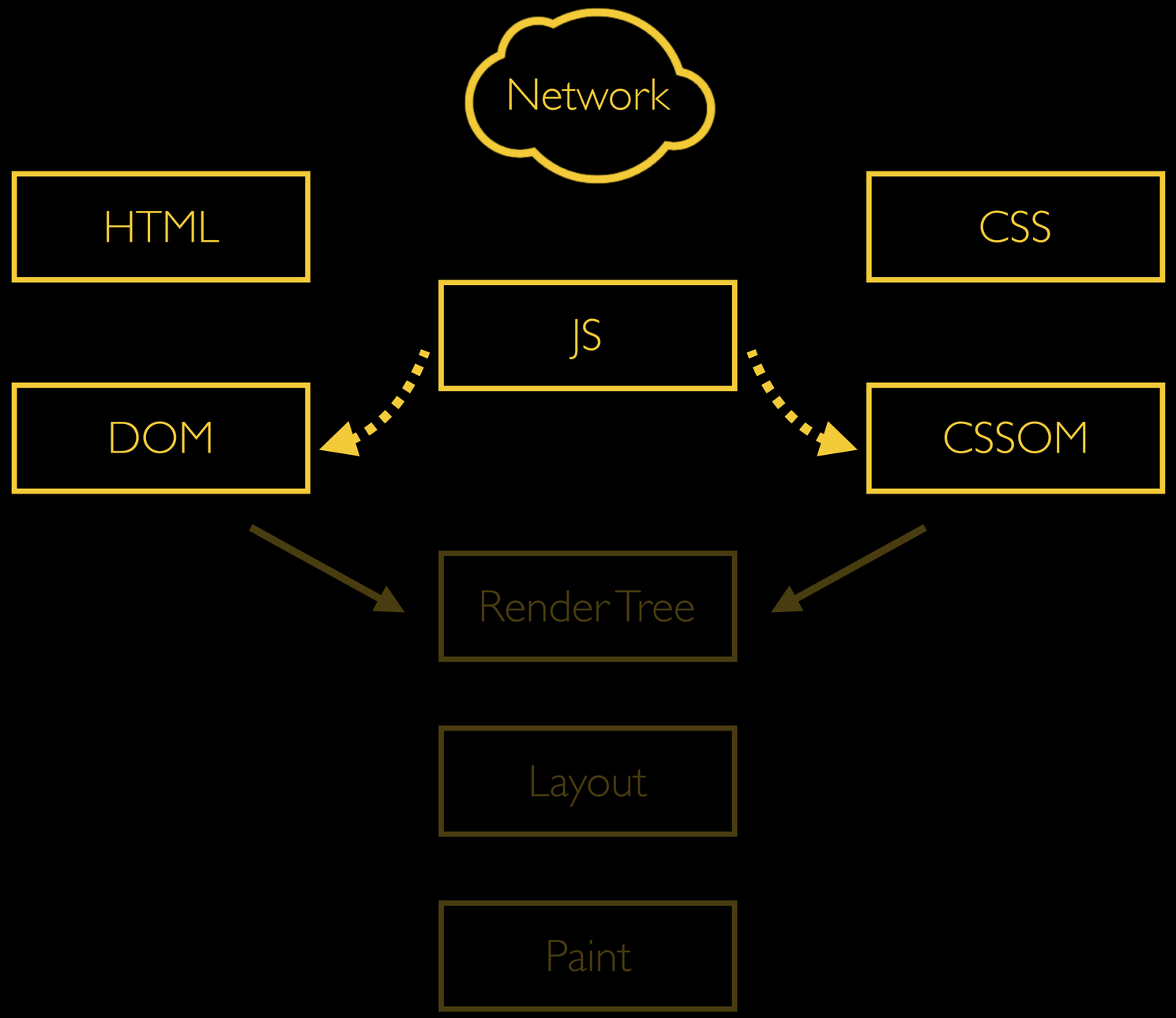

<script>

JS IS PARSER BLOCKING

```
<script type="text/javascript"
src="jquereactgular.js"></script>
```

```
<link rel="stylesheet" href="/styles.css" />

<script type="text/javascript"
src="jquereactgular.js"></script>
```


Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

CSS BLOCKS JS EXECUTION

JS EXECUTION BLOCKS DOM

Can I use... Support tables for

caniuse.com/#search=Async

async attribute for external scripts - LS

Global 88.63% + 0.06% = 88.69%

The boolean async attribute on script elements allows the external JavaScript file to run when it's available, without delaying page load first.

Current aligned | Usage relative | Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			29						
			45						
			48					4.3	
		45	49			8.4		4.4	
8		46	50			9.2		4.4.4	
11	13	47	51	9.1	38	9.3	8	50	50
	14	48	52	10	39				
		49	53	TP	40				
		50	54						

Notes | Known issues (0) | Resources (4) | Feedback

[1] Using script.async = false; to maintain execution order for dynamically-added scripts isn't supported in Safari 5.0

```
<script type="text/javascript" async
src="blah.js.php"></script>
```

```
<script async>
```

<script async>

<script async>

Can I use... Support tables for

caniuse.com/#search=defer

defer attribute for external scripts - LS

Global 88.69% + 1.13% = 89.83%

The boolean defer attribute on script elements allows the external JavaScript file to run when the DOM is loaded, without delaying page load first.

Current aligned | Usage relative | Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			29						
			45						
			48					4.3	
		45	49			8.4		4.4	
[1] 8		46	50			9.2		4.4.4	
11	13	47	51	9.1	38	9.3	8	50	50
	14	48	52	10	39				
		49	53	TP	40				
		50	54						

Notes | Known issues (1) | Resources (4) | Feedback

[1] Partial support in older IE refers to a buggy implementation (see issue).

```
<script type="text/javascript" defer
src="blah.js.php"></script>
```

```
<script defer>
```

<script defer>

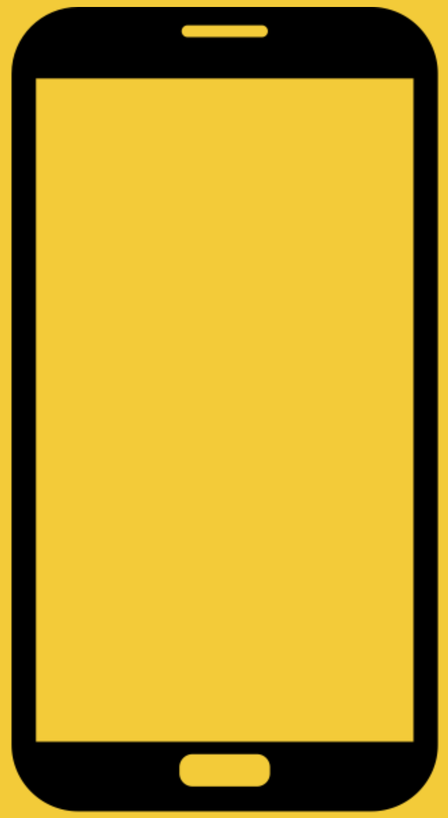
<script defer>

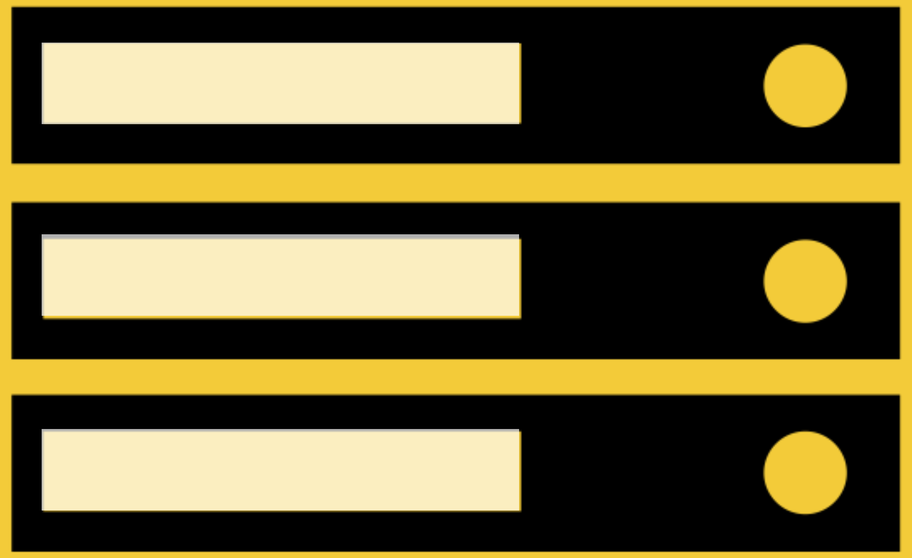
LET’S HAVE A CHAT ABOUT SPA’S

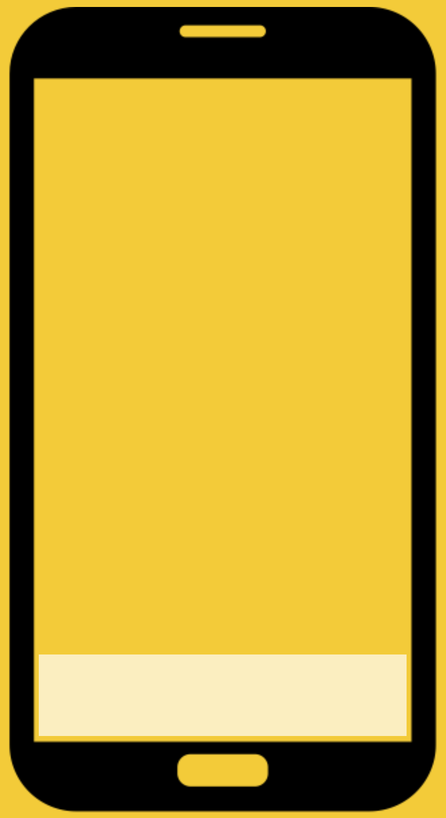
ANDY & BILL'S LAW

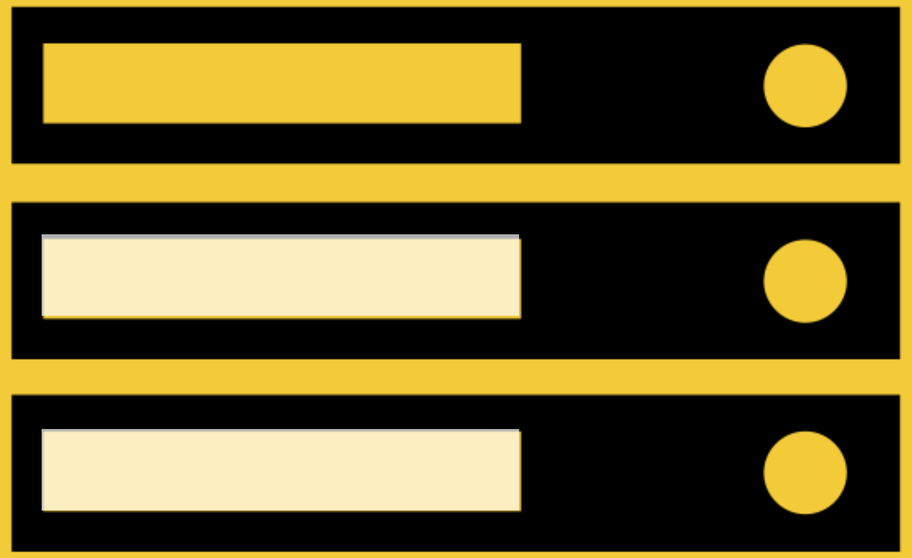
"…as bandwidth grows, and as processing power grows, and as browsers get better we just keep filling everything up."

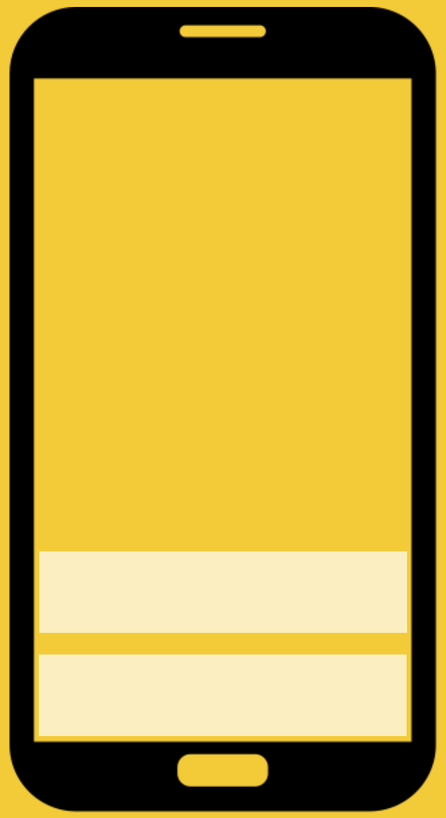
– Jeff Veen

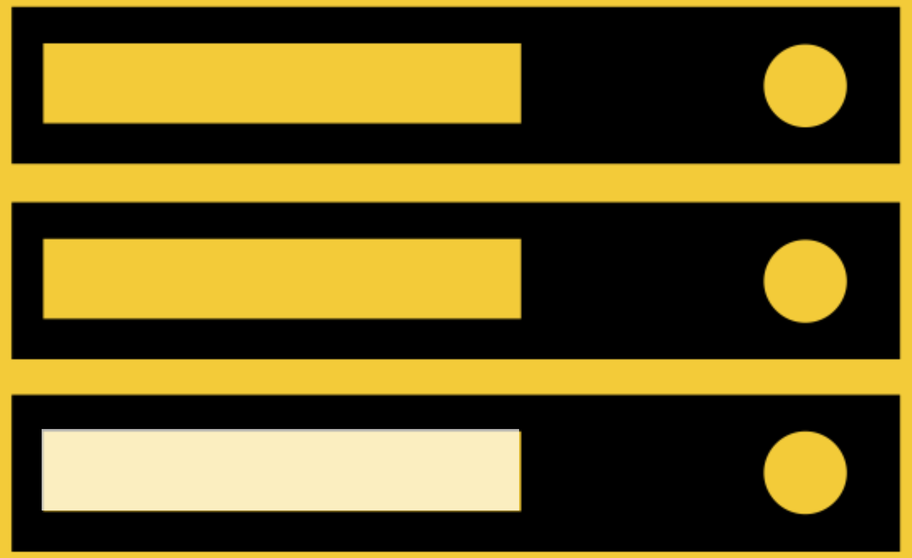


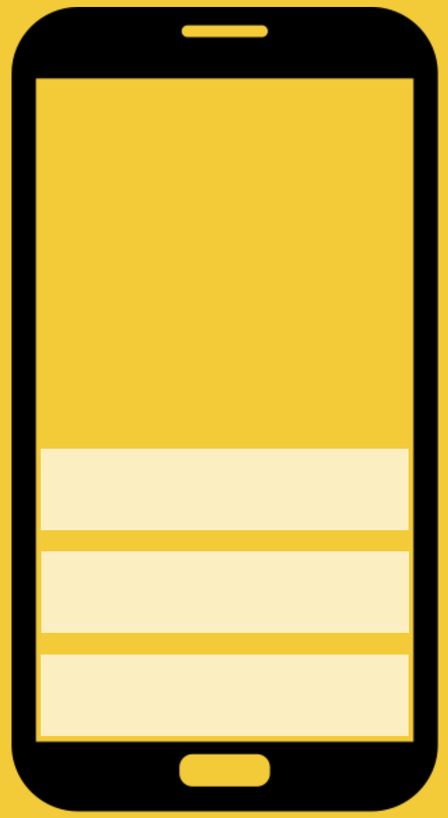


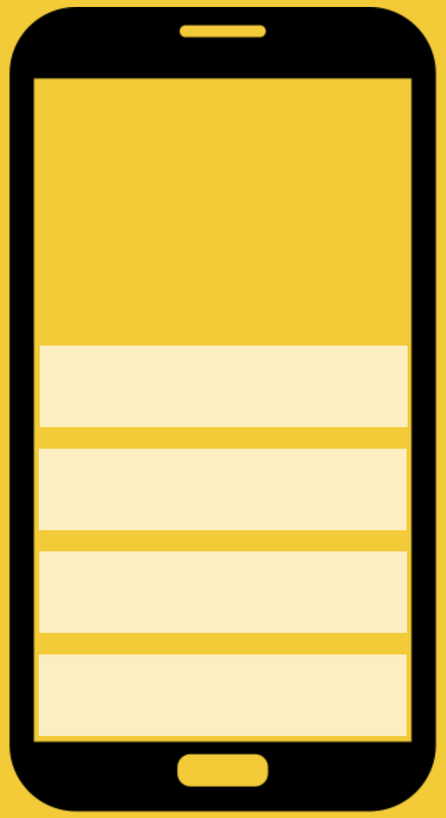


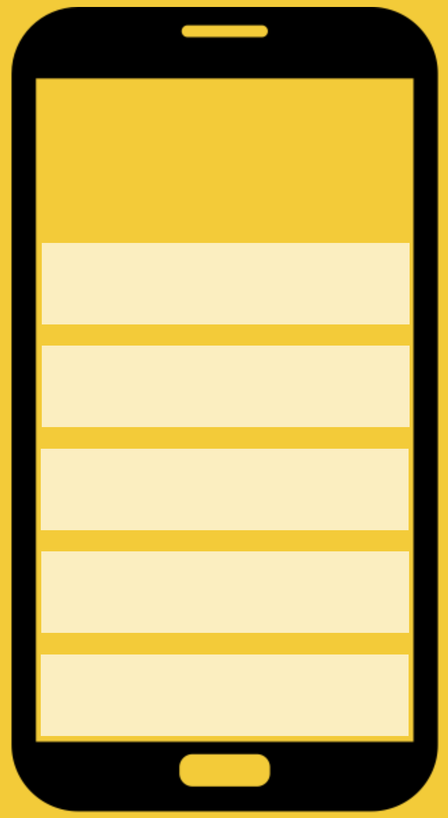


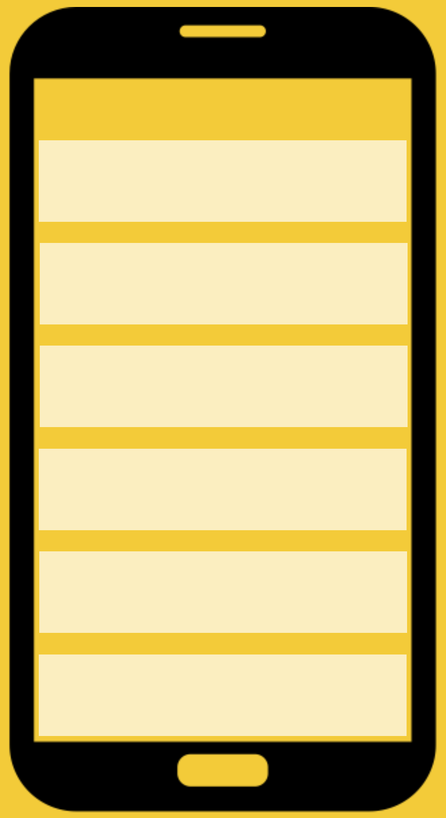












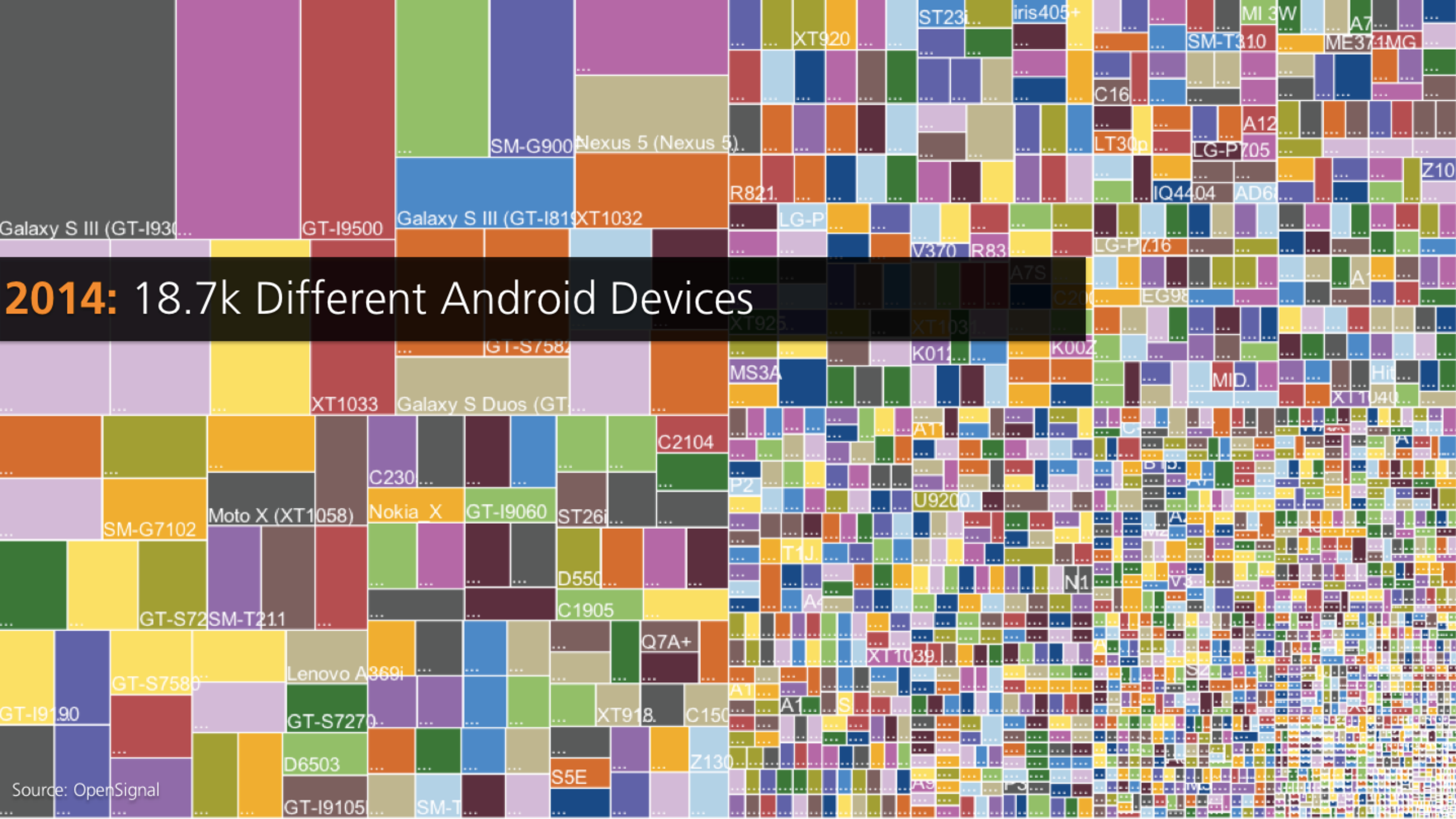
"…25% of new Android phones have only 512MB of RAM."

– Jen Fitzpatrick

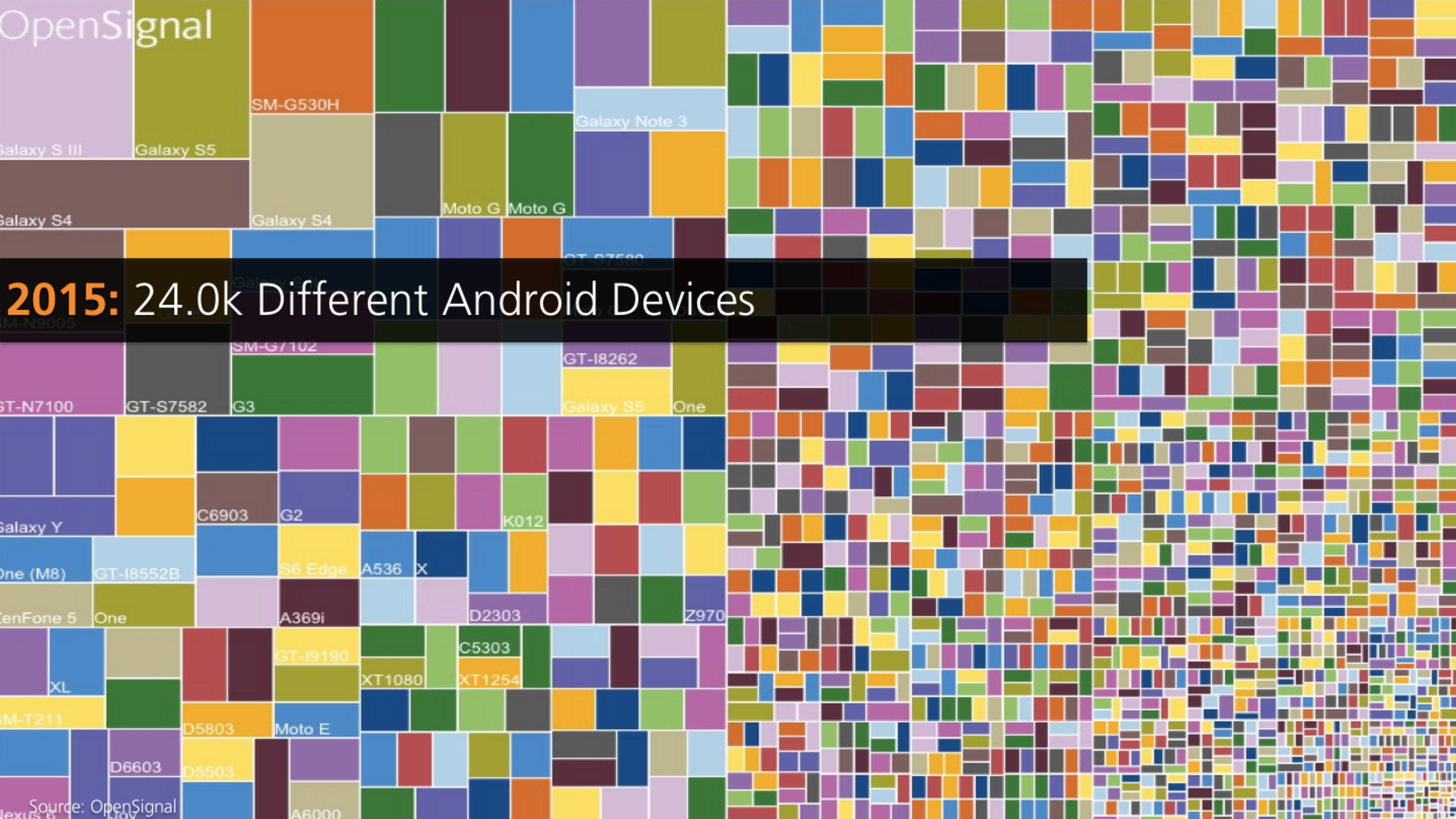
VP of product management for Google Maps

Device	Browser	Median Parse	Median Execution	Median Total
Blackberry 9650	Default, BB6	171ms	554ms	725ms
UMX U670C	Android 2.3.6 Browser	168ms	484ms	652ms
Galaxy S3	Chrome 32	39ms	297ms	336ms
Galaxy S3	UC 8.6	45ms	215ms	260ms
Galaxy S3	Dolphin 10	2ms	222ms	224ms
Kindle Touch	Kindle 3.0+	63ms	132ms	195ms
Geeksphone Peak	Firefox 25	51ms	109ms	160ms
Kindle Fire	Silk 3.17	16ms	139ms	155ms
Lumia 520	IE10	97ms	56ms	153ms

2014: 18.7k Different Android Devices



2015: 24.0k Different Android Devices

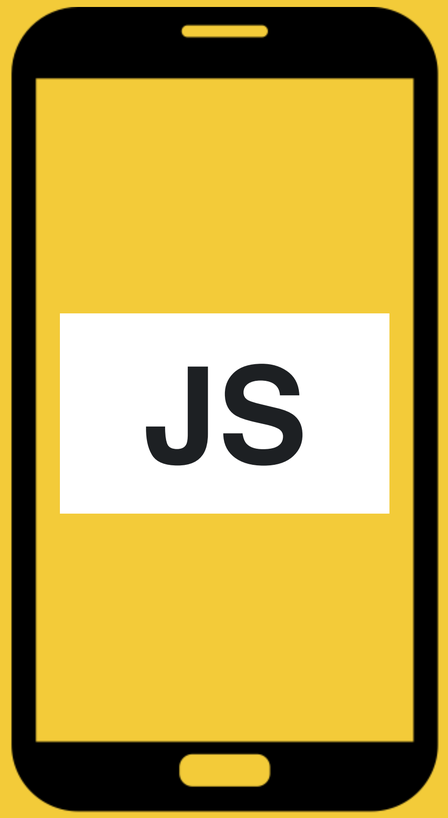


"…allowed us to drop our initial page load times to 1/5th of what they were previously…."

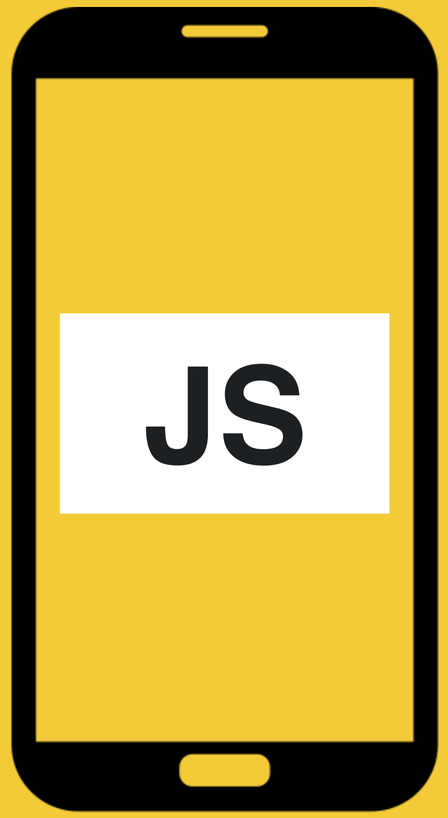
https://blog.twitter.com/2012/improving-performance-on-twittercom

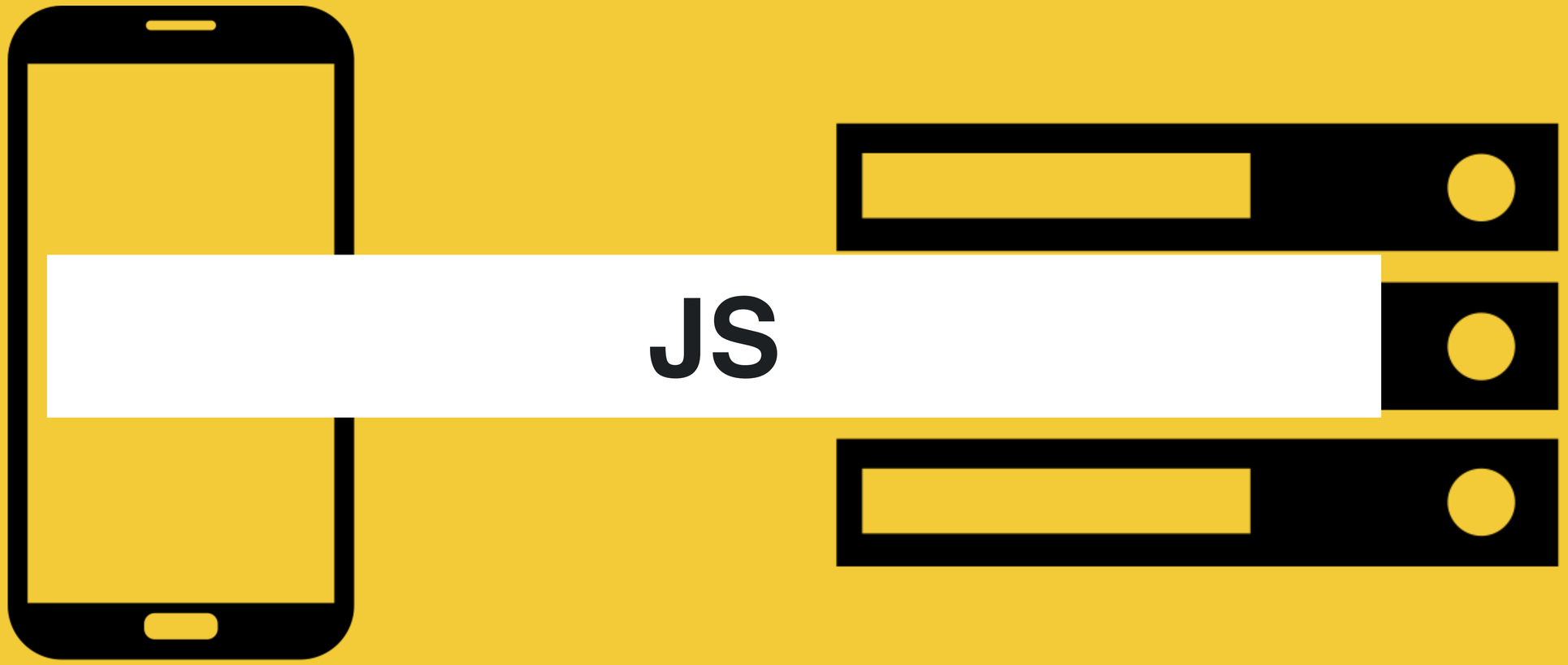
“…and reduce differences in performance across browsers.”

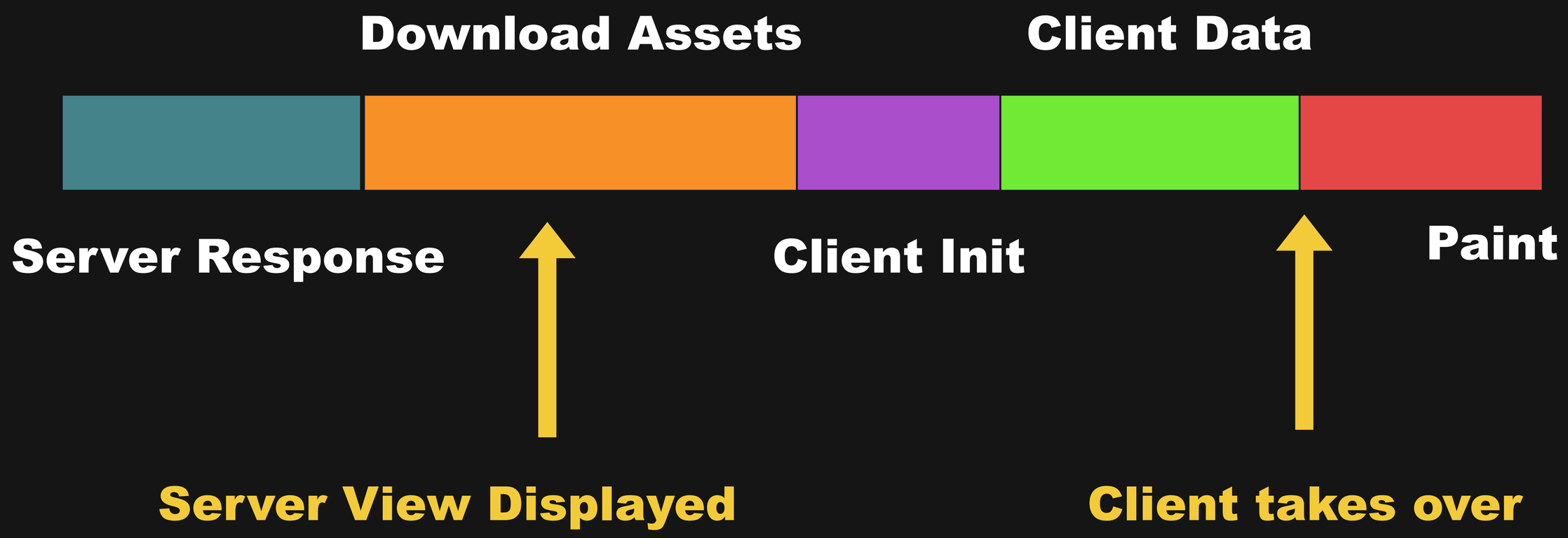
https://blog.twitter.com/2012/improving-performance-on-twittercom


JS

Download Assets
Client Data
Server Response
Client Init
Paint


JS

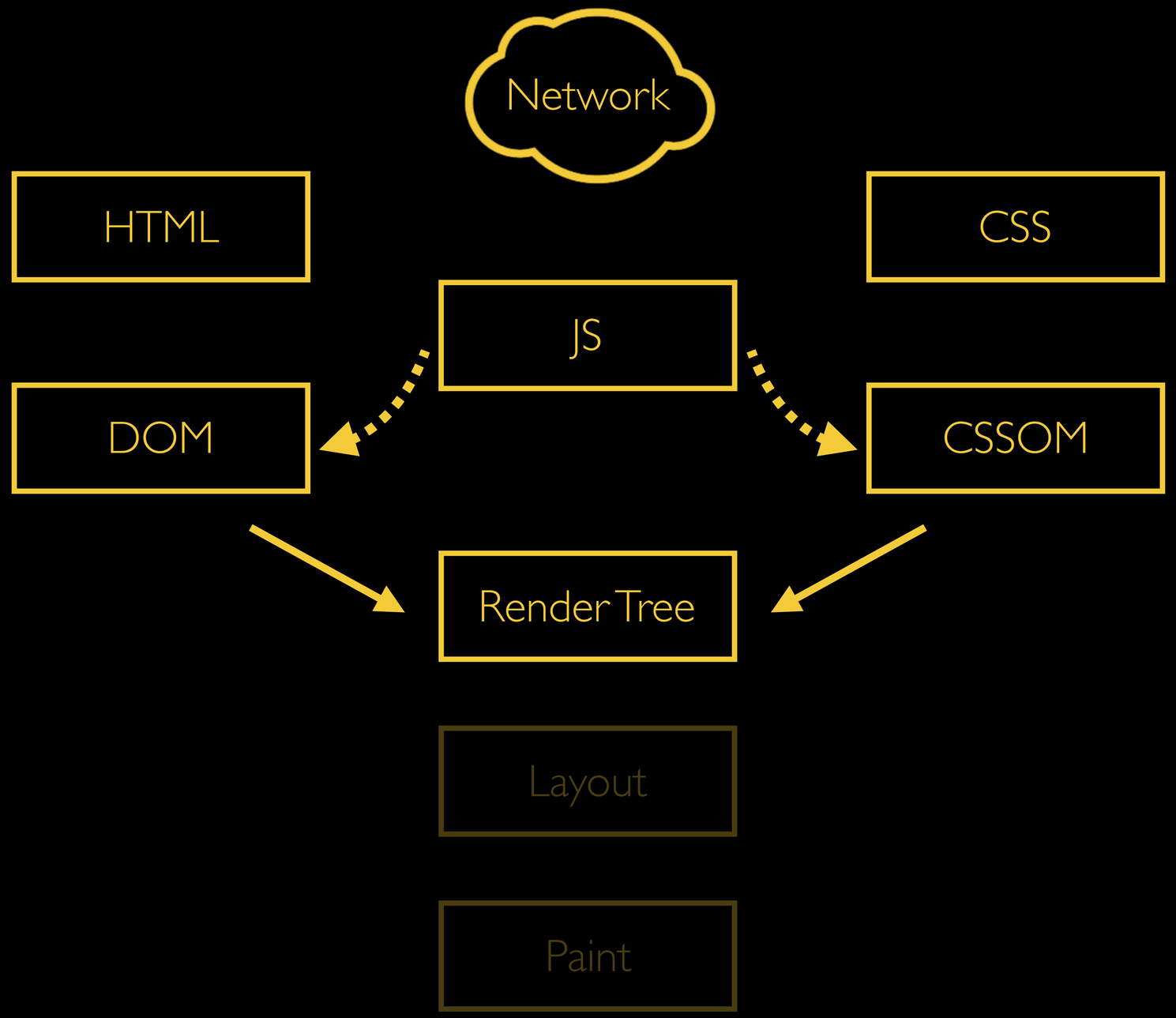

JS

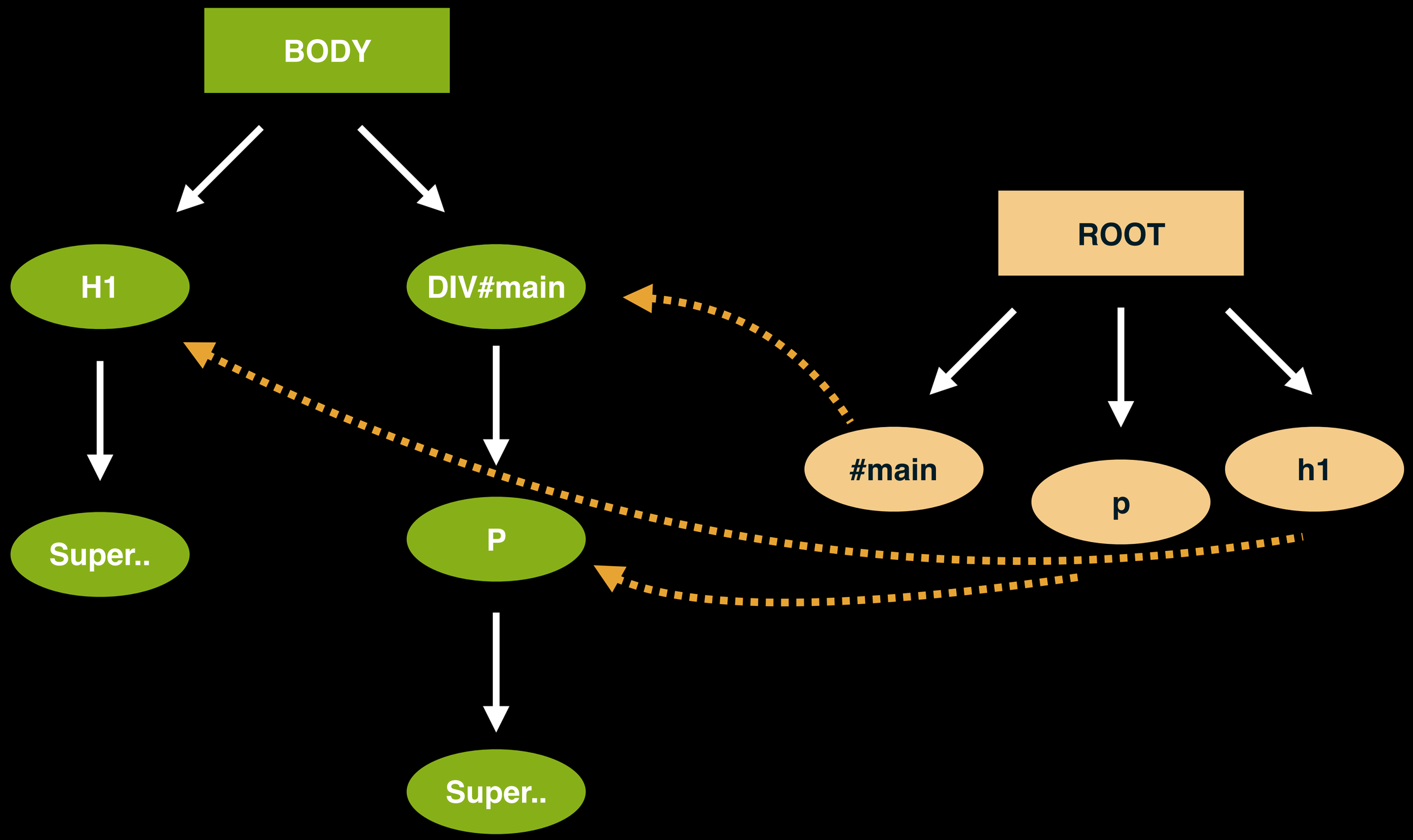

Download Assets
Client Data
Server Response
Client Init
Paint
Server View Displayed
Client takes over

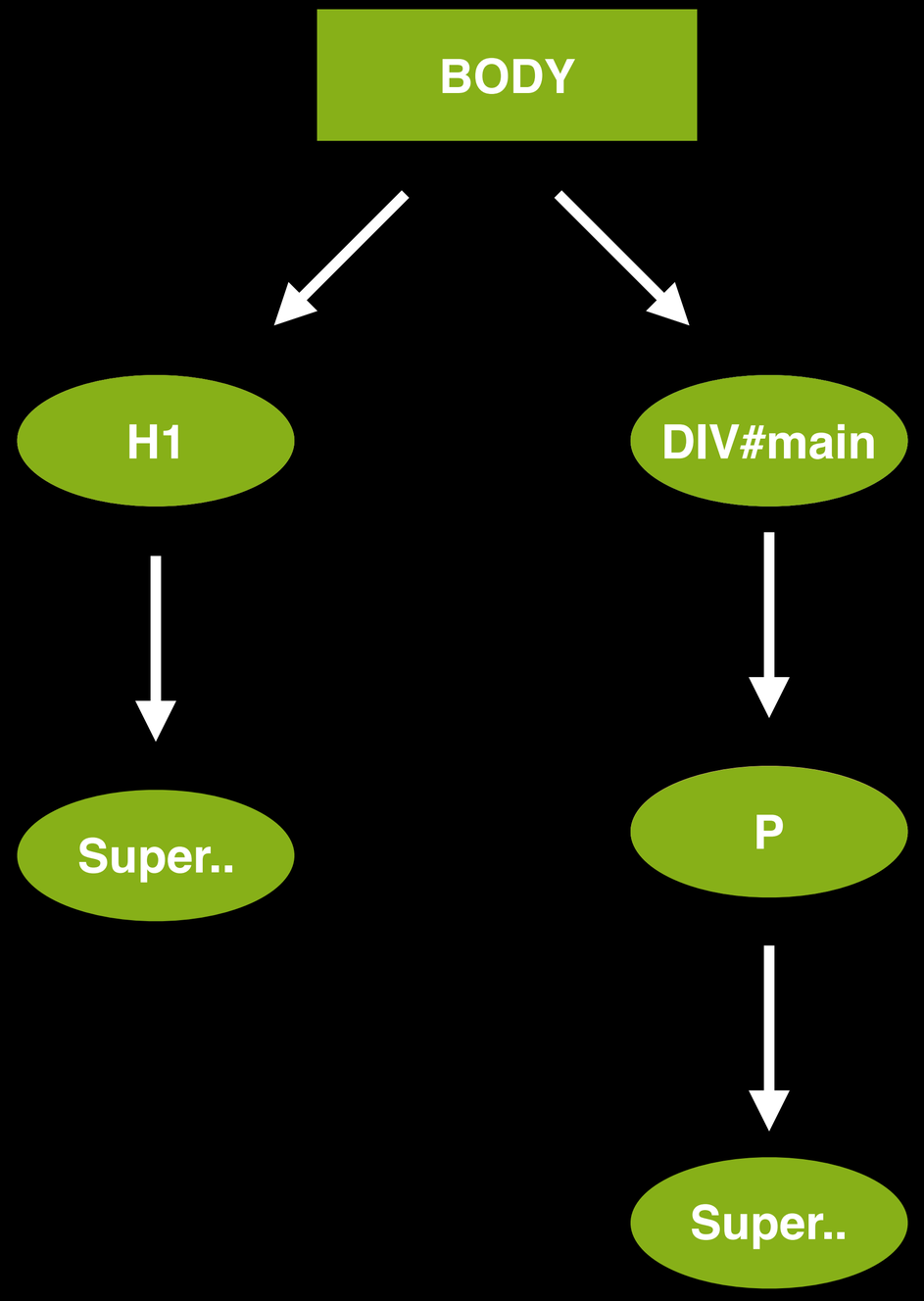
NETFLIX

70% FASTER STARTUP TIMES

http://techblog.netflix.com/2015/08/making-netflixcom-faster.html

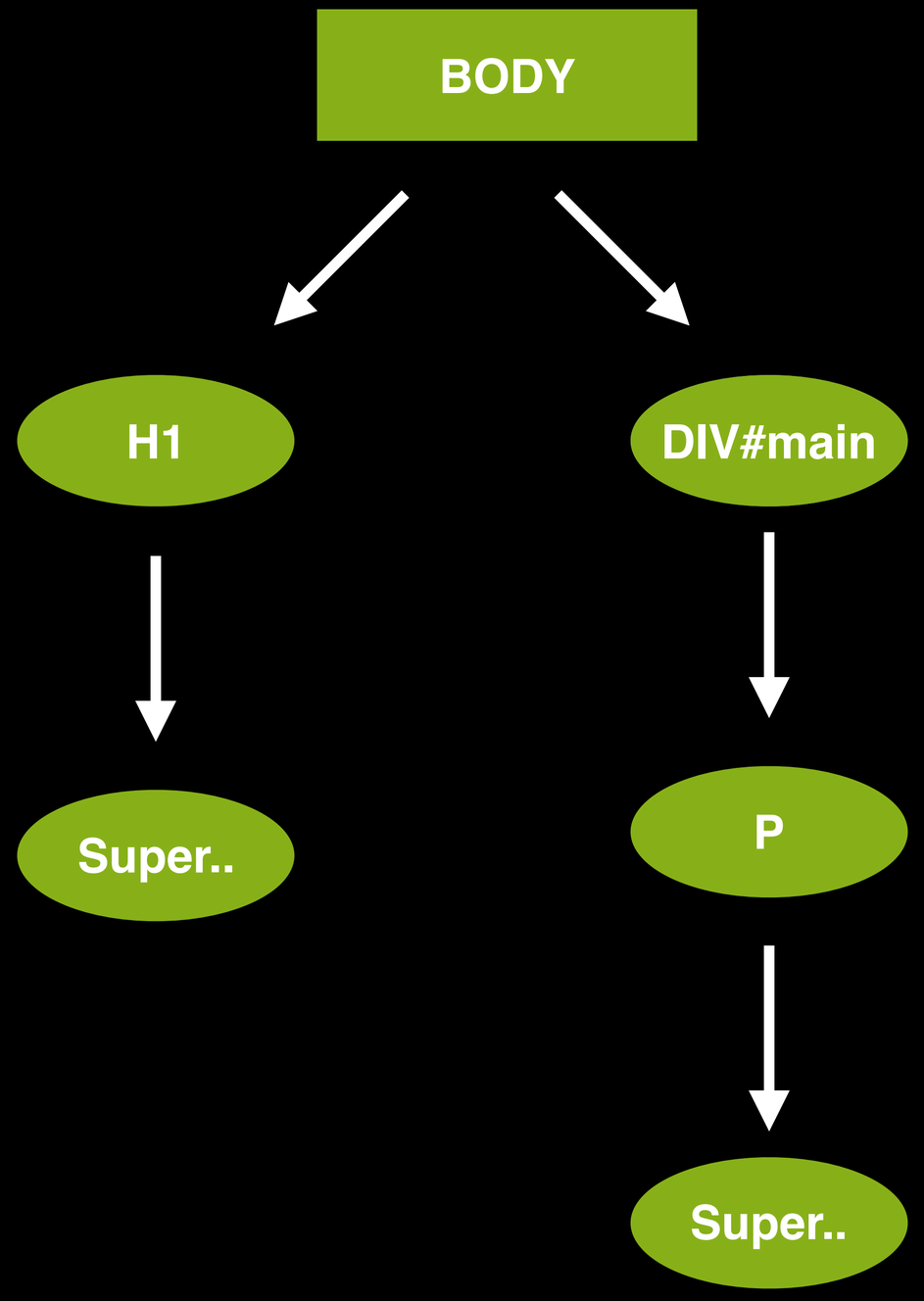

Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

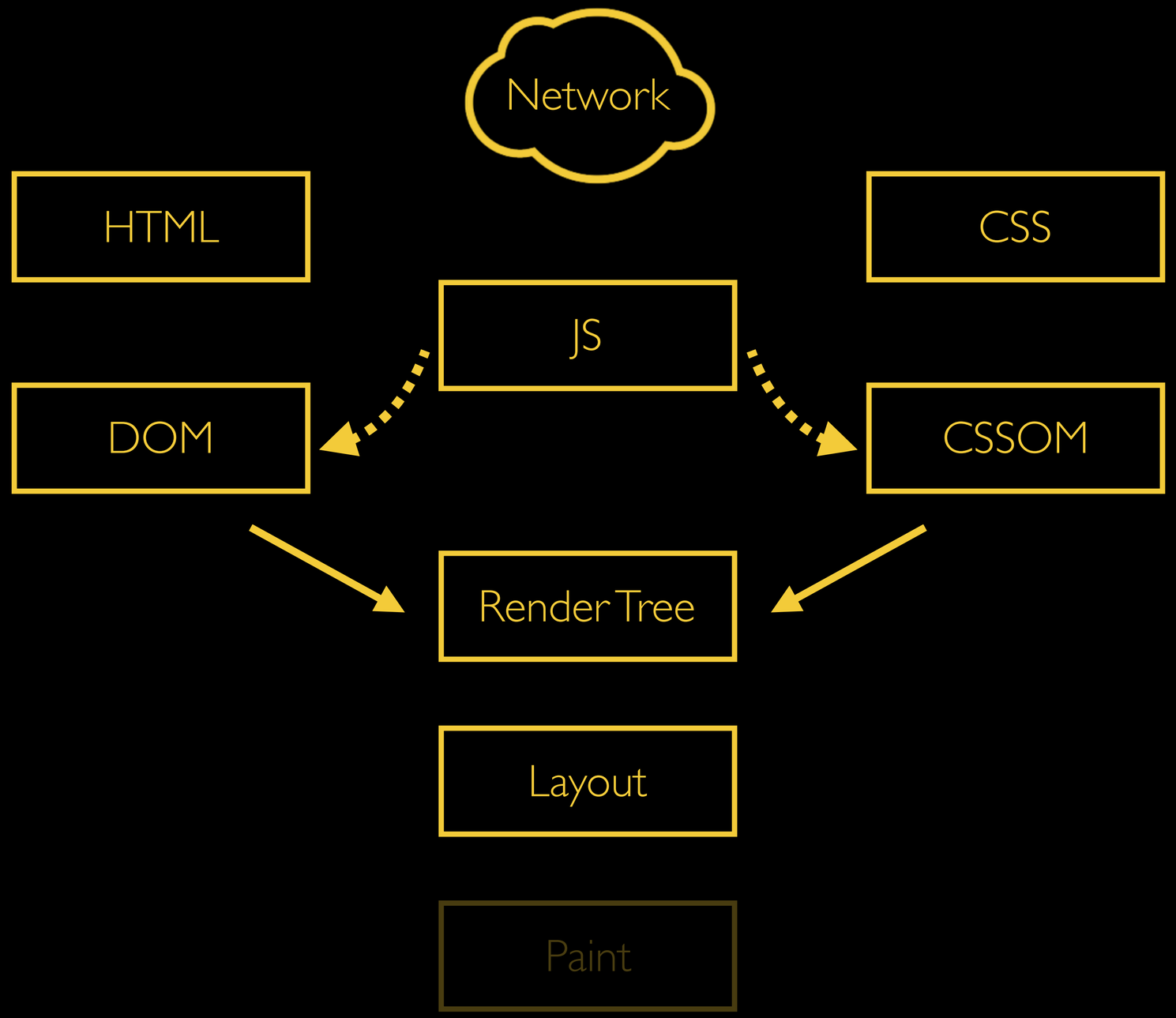

BODY
H1
DIV#main
Super..
P
Super..
ROOT
#main
p
h1

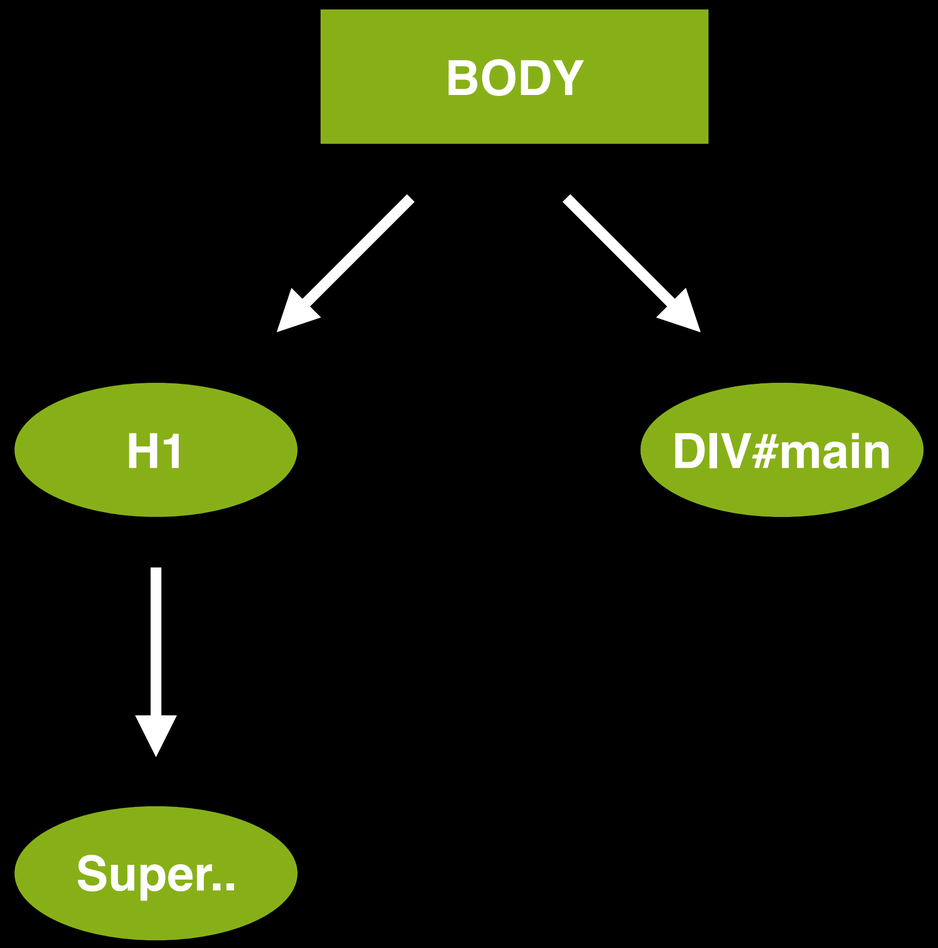

BODY
H1
DIV#main
Super..
P
Super..

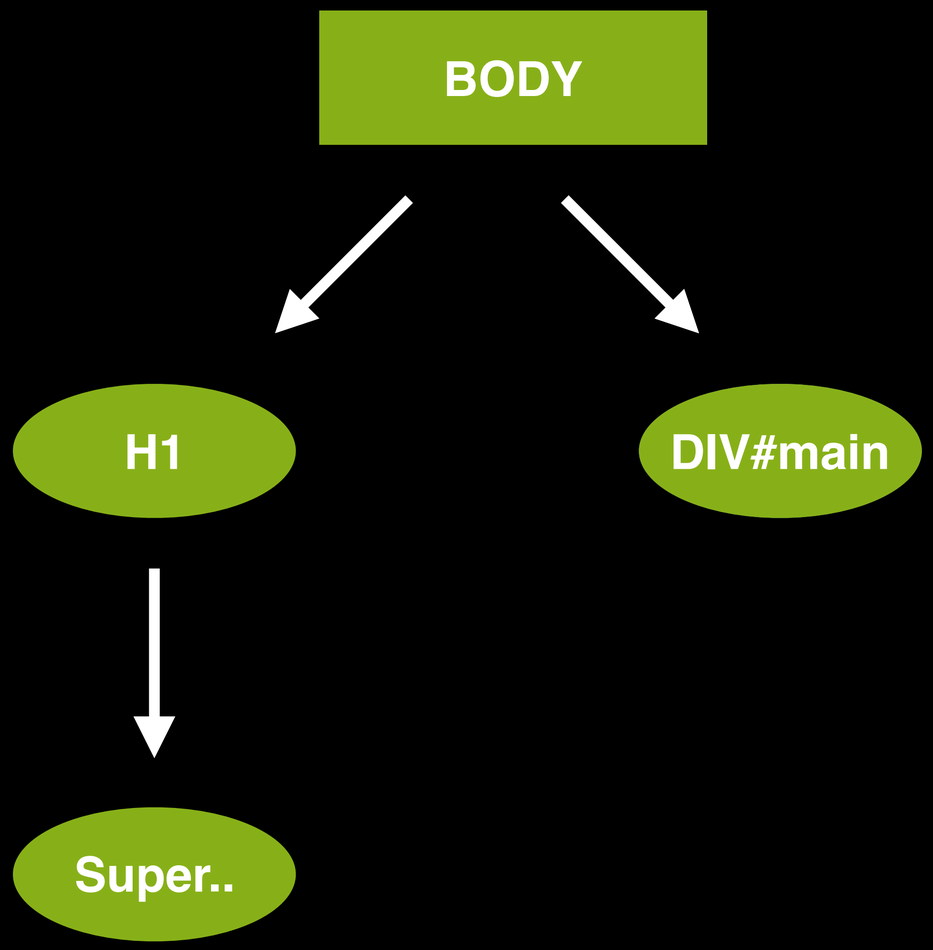
```
#main{
 color: green;
}
h1 {
 font-size: 2em;
}
p{
 color: orange;
}
```

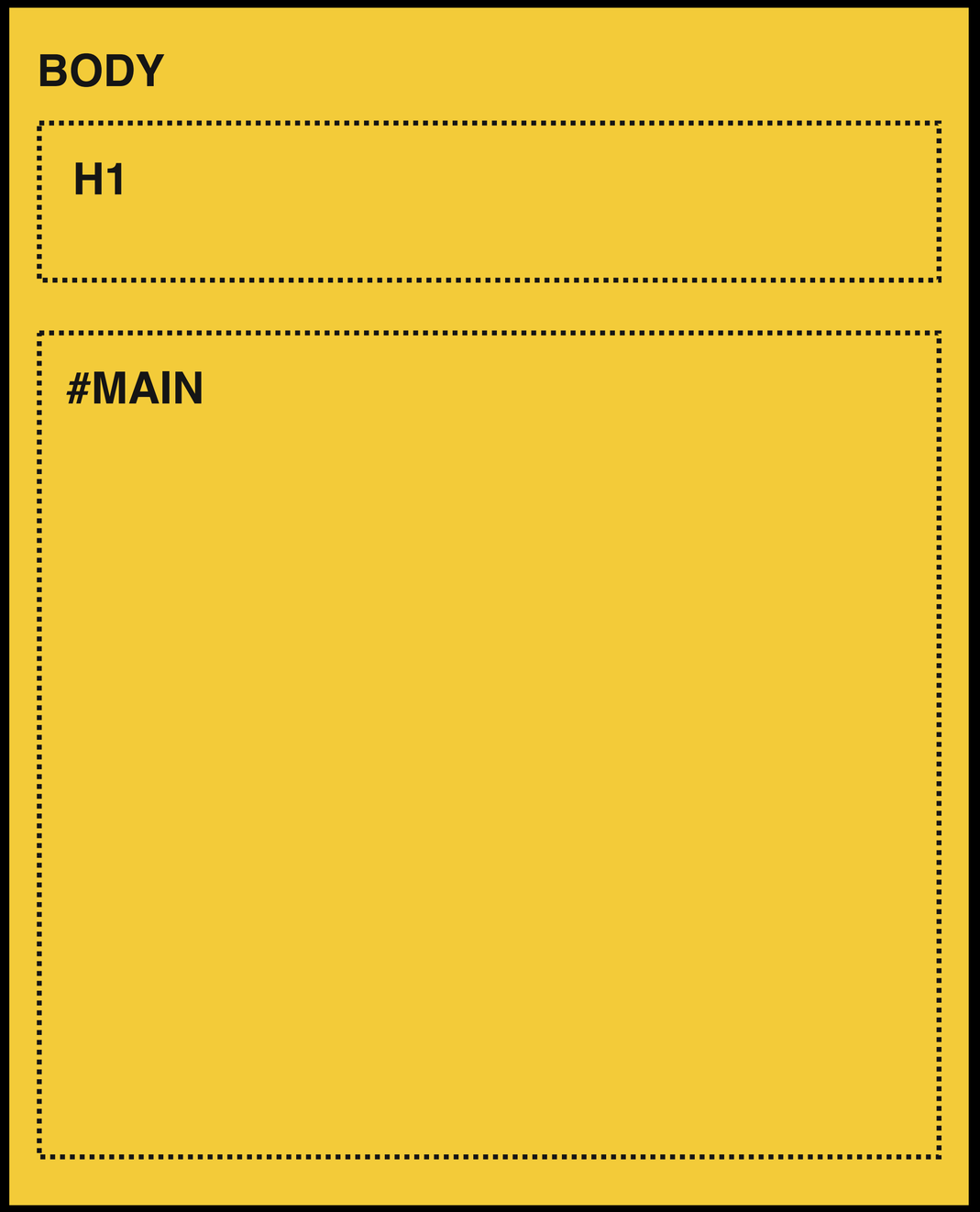
```
#main{
 color: green;
}
h1 {
 font-size: 2em;
}
p{
 display: none;
}
```

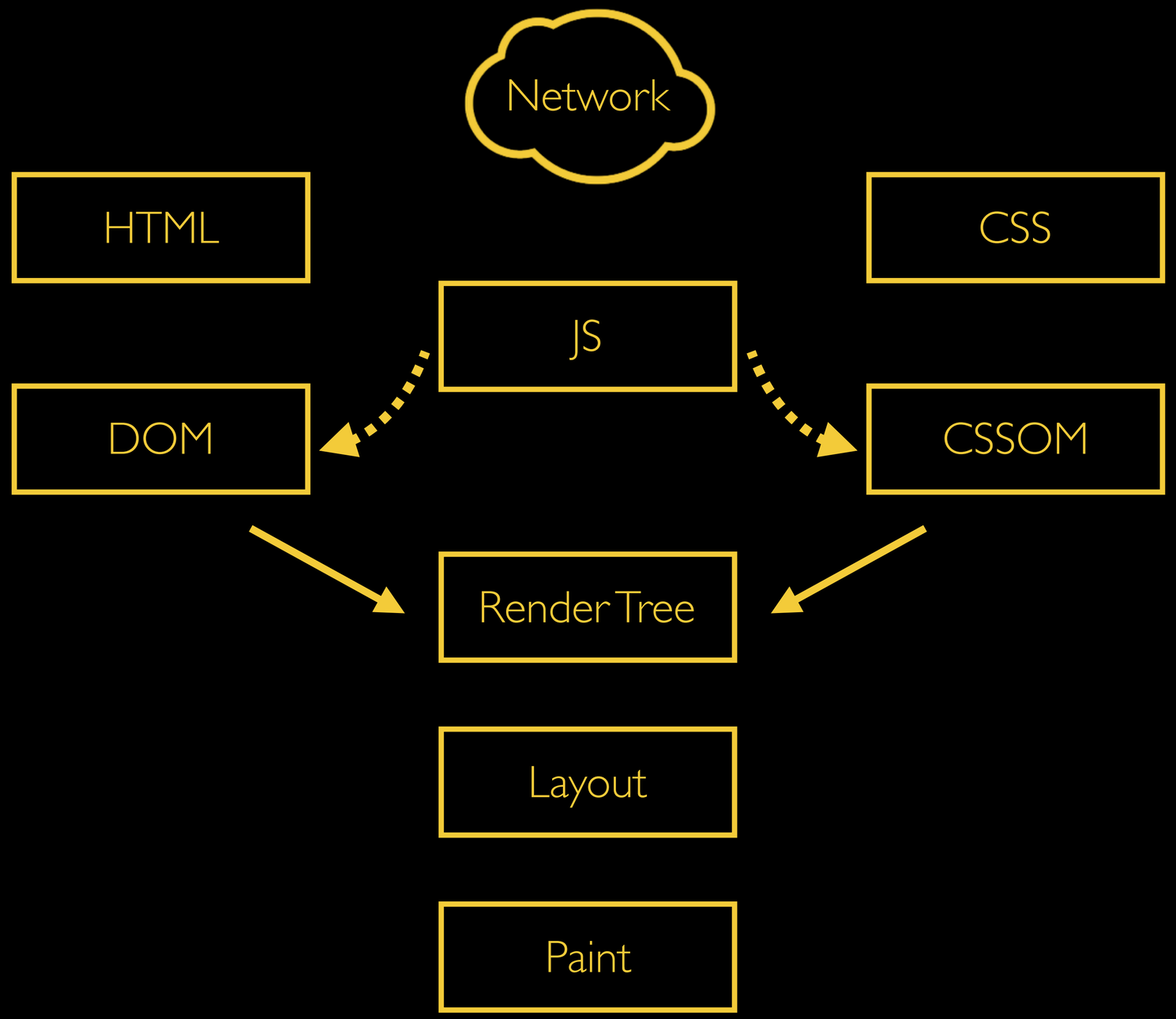

BODY
H1
DIV#main
Super..
P
Super..


Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint


BODY
H1
DIV#main
Super..


BODY
H1
DIV#main
Super..


BODY
H1
#MAIN


Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

THE CRITICAL PATH

1

```
<html>
<head>
 <meta charset="UTF-8">
 <title>Hey there</title>
 <link rel="stylesheet" href="style.css" />
 <script type=“text/javascript” src=“jquereactugular.js“>
 </script>
</head>
<body>
 <h1>Super awesome site</h1>
 <div id=“main">
  <p>Super interesting stuff, I'm sure.</p>
 </div>
</body>
</html>
```

```
<html>
<head>
 <meta charset="UTF-8">
 <title>Hey there</title>
 <link rel="stylesheet" href="style.css" />
 <script type="text/javascript" src="jquereactuguular.js">
 </script>
</head>
<body>
 <h1>Super awesome site</h1>
 <div id="main">
  <p>Super interesting stuff, I'm sure.</p>
 </div>
</body>
</html>
```

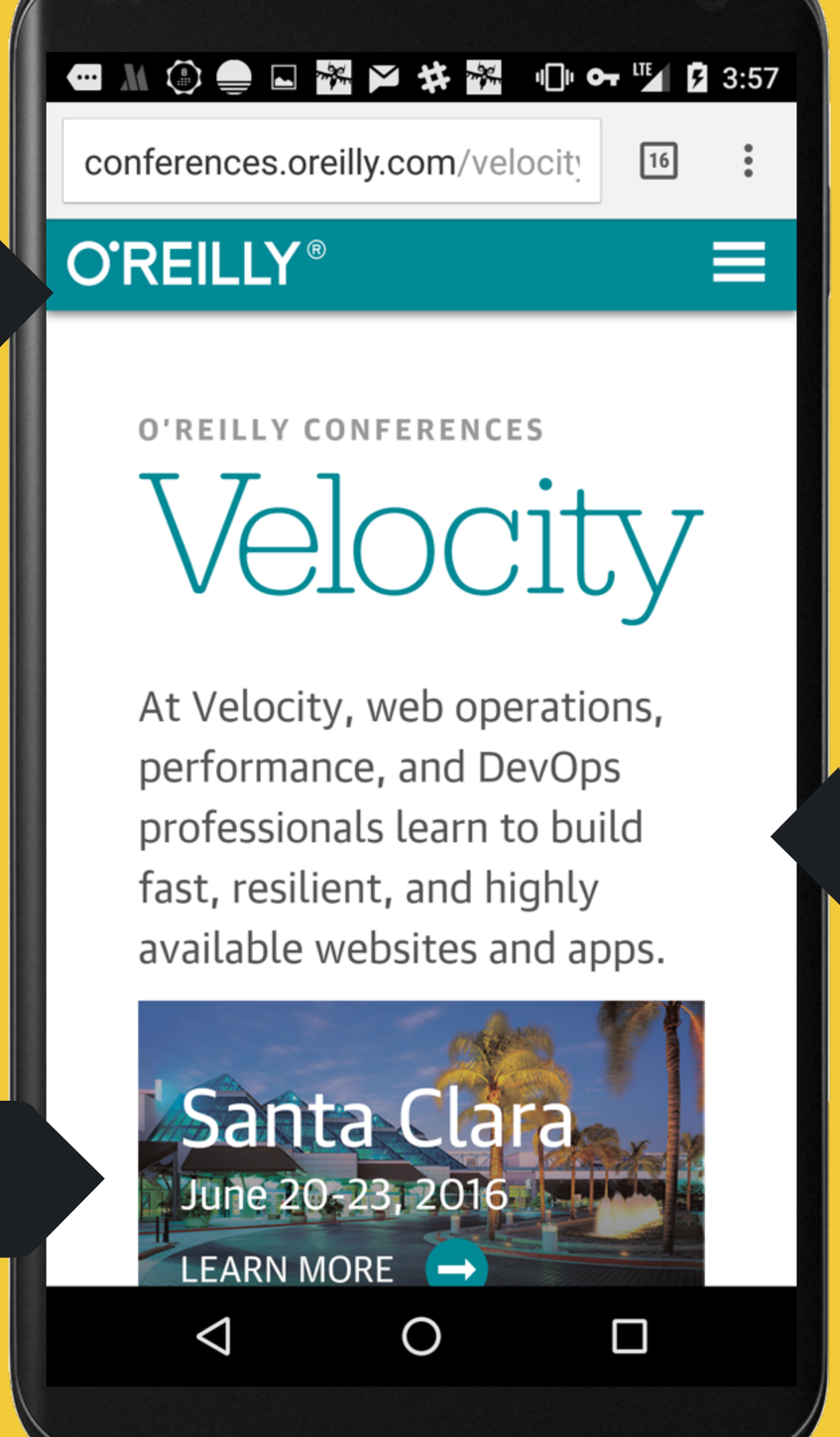
2

```html
<html>
<head>
 <meta charset="UTF-8">
 <title>Hey there</title>
 <link rel="stylesheet" href="style.css" />
 <script type="text/javascript" src="jquereactugular.js">
 </script>
</head>
<body>
 <h1>Super awesome site</h1>
 <div id="main">
  <p>Super interesting stuff, I'm sure.</p>
 </div>
</body>
</html>
```

3

```html
<html>
<head>
 <meta charset="UTF-8">
 <title>Hey there</title>
 <link rel="stylesheet" href="style.css" />
 <script type=“text/javascript” async
src=“jquereactugular.js“ ></script>
</head>
<body>
 <h1>Super awesome site</h1>
 <div id=“main">
  <p>Super interesting stuff, I'm sure.</p>
 </div>
</body>
</html>
```

```html
<html>
<head>
 <meta charset="UTF-8">
 <title>Hey there</title>
 <link rel="stylesheet" href="style.css" />
 <script type=“text/javascript” async
src=“jquereactugular.js“ ></script>
</head>
<body>
 <h1>Super awesome site</h1>
 <div id=“main">
  <p>Super interesting stuff, I'm sure.</p>
 </div>
</body>
</html>
```



.branding-bar

#event-description

a.block-link

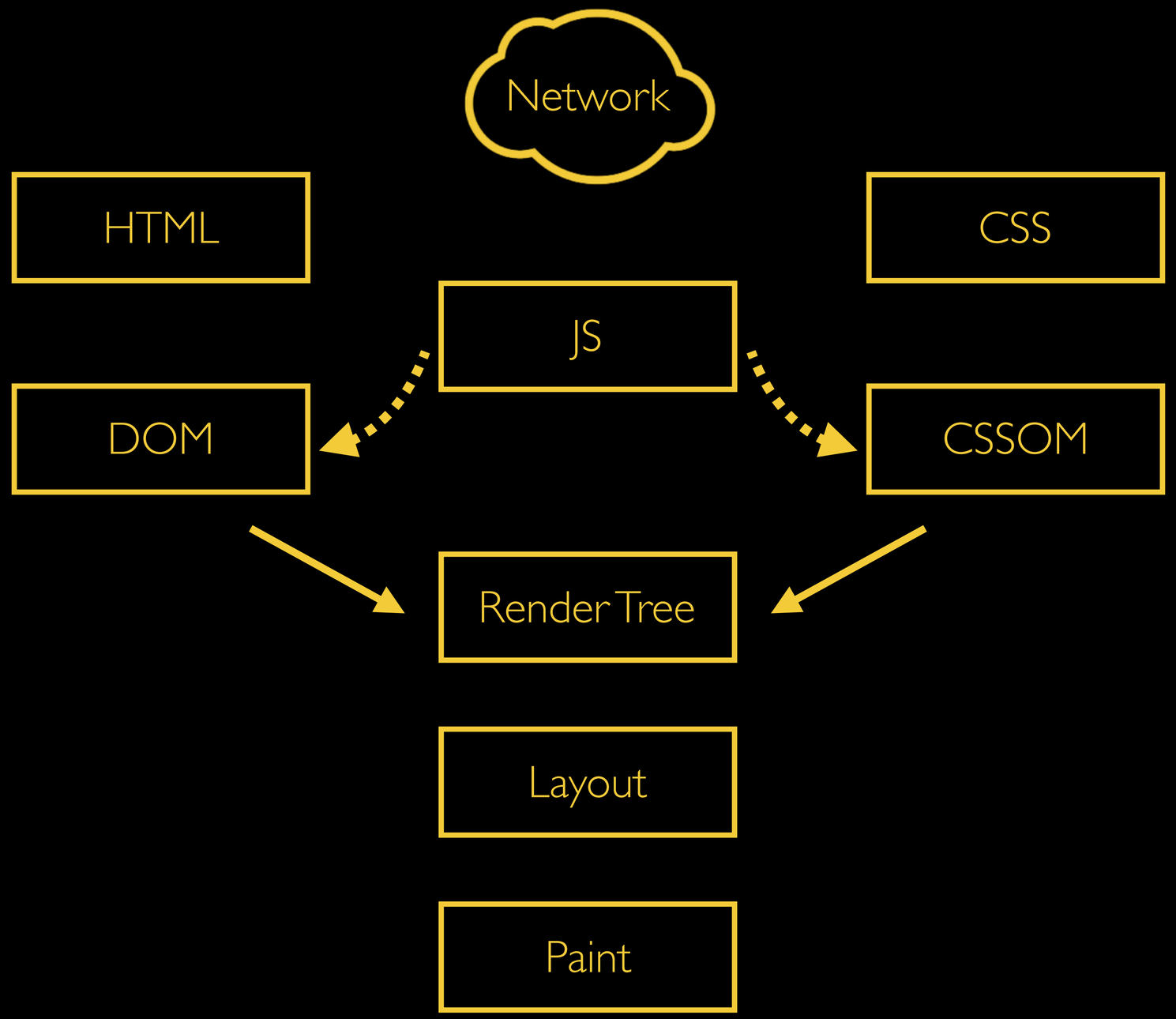
```html
<link rel="stylesheet" href="style.css" />
```

```
<style type="text/css">
  //critical css inlined and minimized
</style>

<script type="text/javascript" >
  loadCSS('/path/to/full/css');
  //set a cookie
</script>
```

```html
<html>
<head>
 <meta charset="UTF-8">
 <title>Hey there</title>
 <style type=“text/css”>
  //critical css inlined and minimized
 </style>
 <script type=“text/javascript” async
src=“jquereactugular.js“ ></script>
</head>
<body>
 <h1>Super awesome site</h1>
 <div id=“main">
  <p>Super interesting stuff, I'm sure.</p>
 </div>
</body>
</html>
```

http://bit.ly/1Jw2jj7


Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

DO YOU WANNA BUILD A DOM TREE?

FONTS?

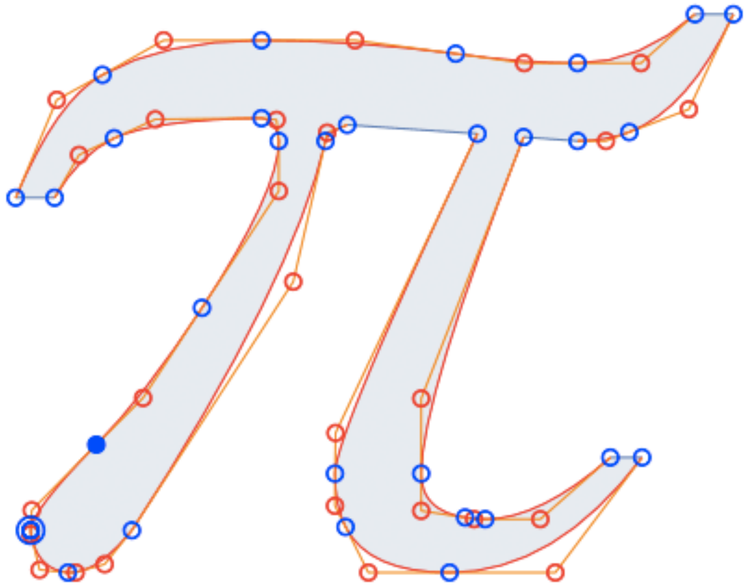
Paul Bakaus
@pbakaus

Follow

Two weeks on a slow 2G connection have been eye-opening. Worst offender so far: Web fonts.

RETWEETS **106** LIKES **181**

7:20 PM - 17 Sep 2016



π	ρ	ς	σ	τ	υ	φ
π	ρ	ς	σ	τ	υ	φ
ό	ύ	ώ	β	ϑ	ϒ	΄ϒ
ό	ύ	ώ	X	ϑ	ϒ	X
ϱ	ϛ	ϛ	ϝ	ϝ	ϟ	ϟ
X	X	X	X	X	X	X

Can I use... Support tables for

caniuse.com/#feat=woff2

Detected your country as "U.S.A.". Would you like to import usage data for that country?

Import No thanks

x Feature: WOFF 2.0 - Web Open Font Format

WOFF 2.0 - Web Open Font Format - CR

Global 61.3%

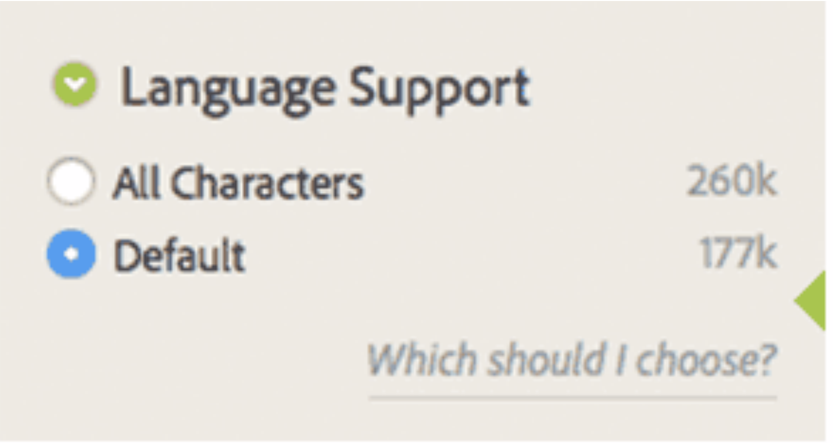
TrueType/OpenType font that provides better compression than WOFF 1.0.

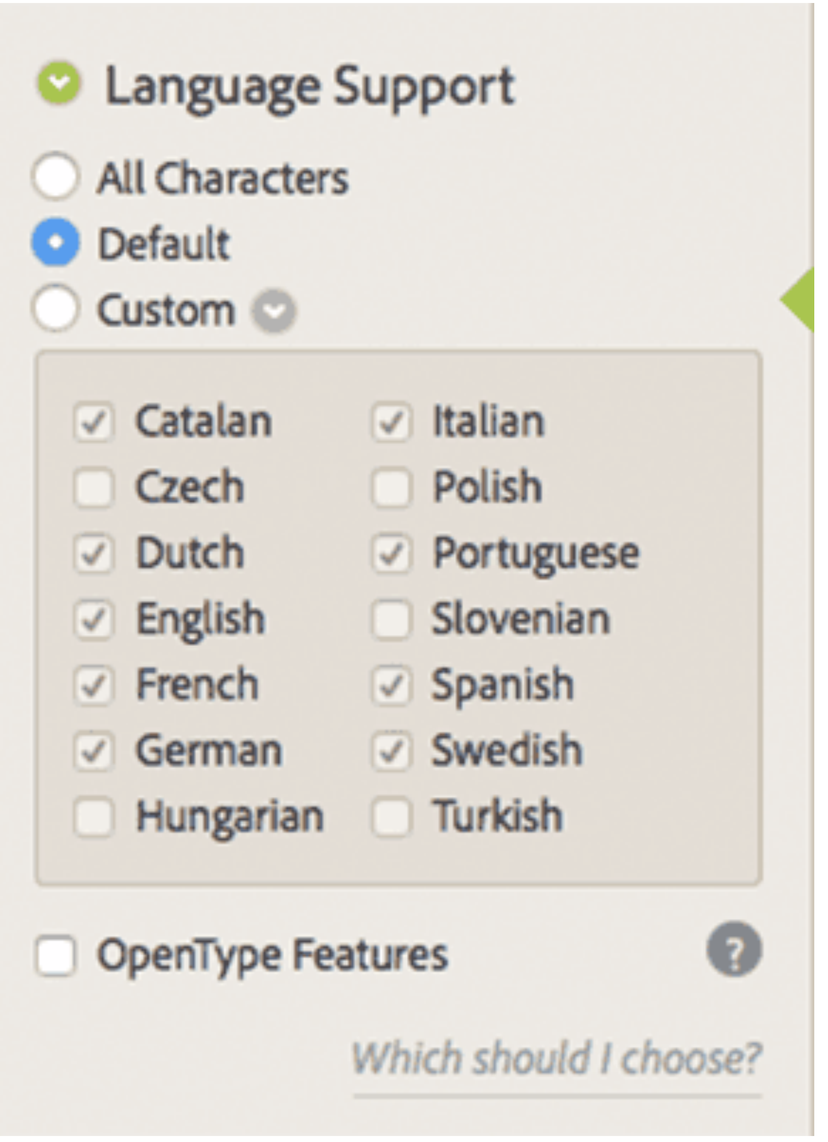
Current aligned Usage relative Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			49						
			51			9.2		4.4	
8	13	47	52			9.3		4.4.4	
11	14	48	53	9.1	39	10	all	52	51
		49	54	10	40				
		50	55	TP	41				
		51	56						

Notes Known issues (0) Resources (6) Feedback

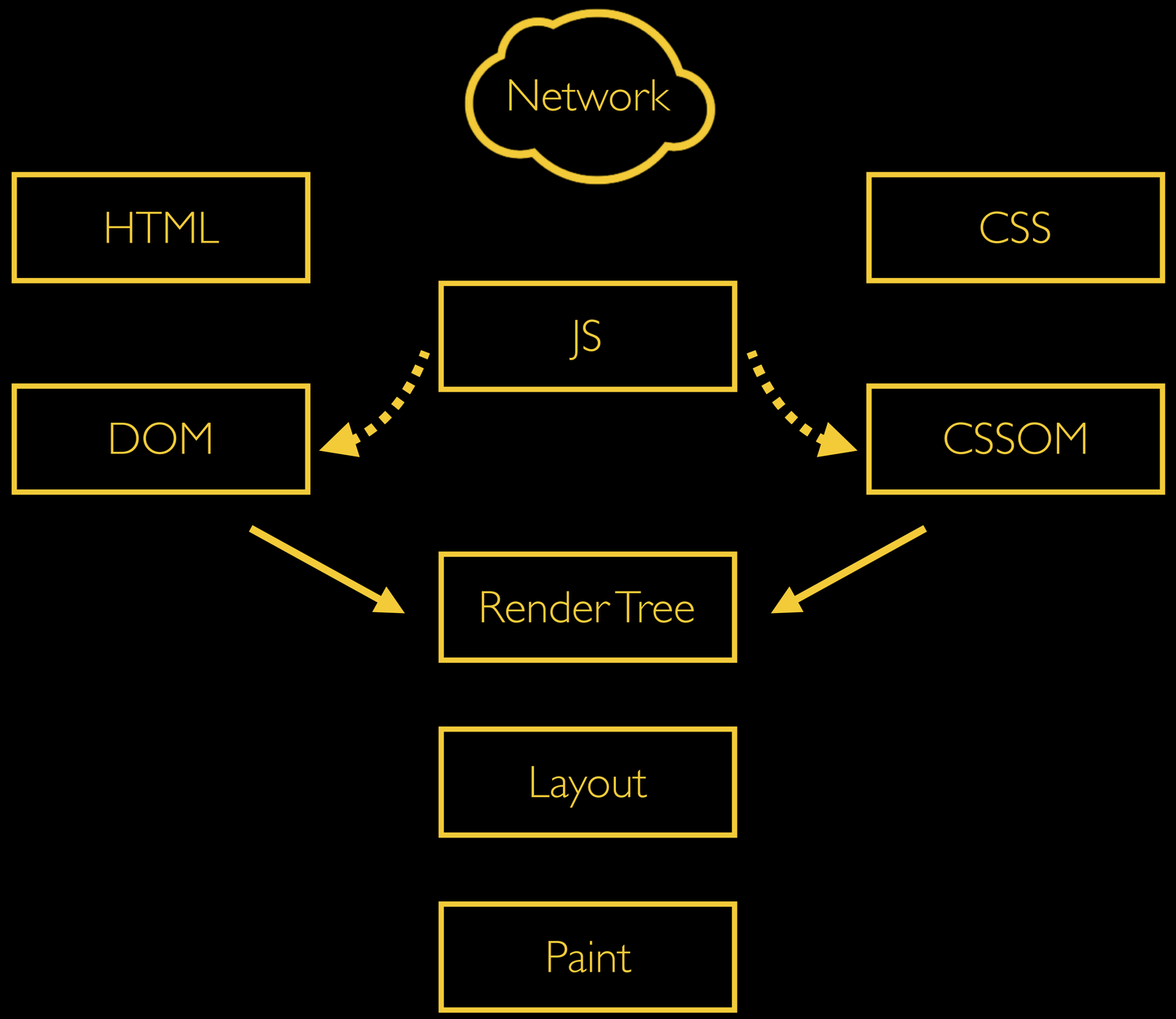
SUBSETTING

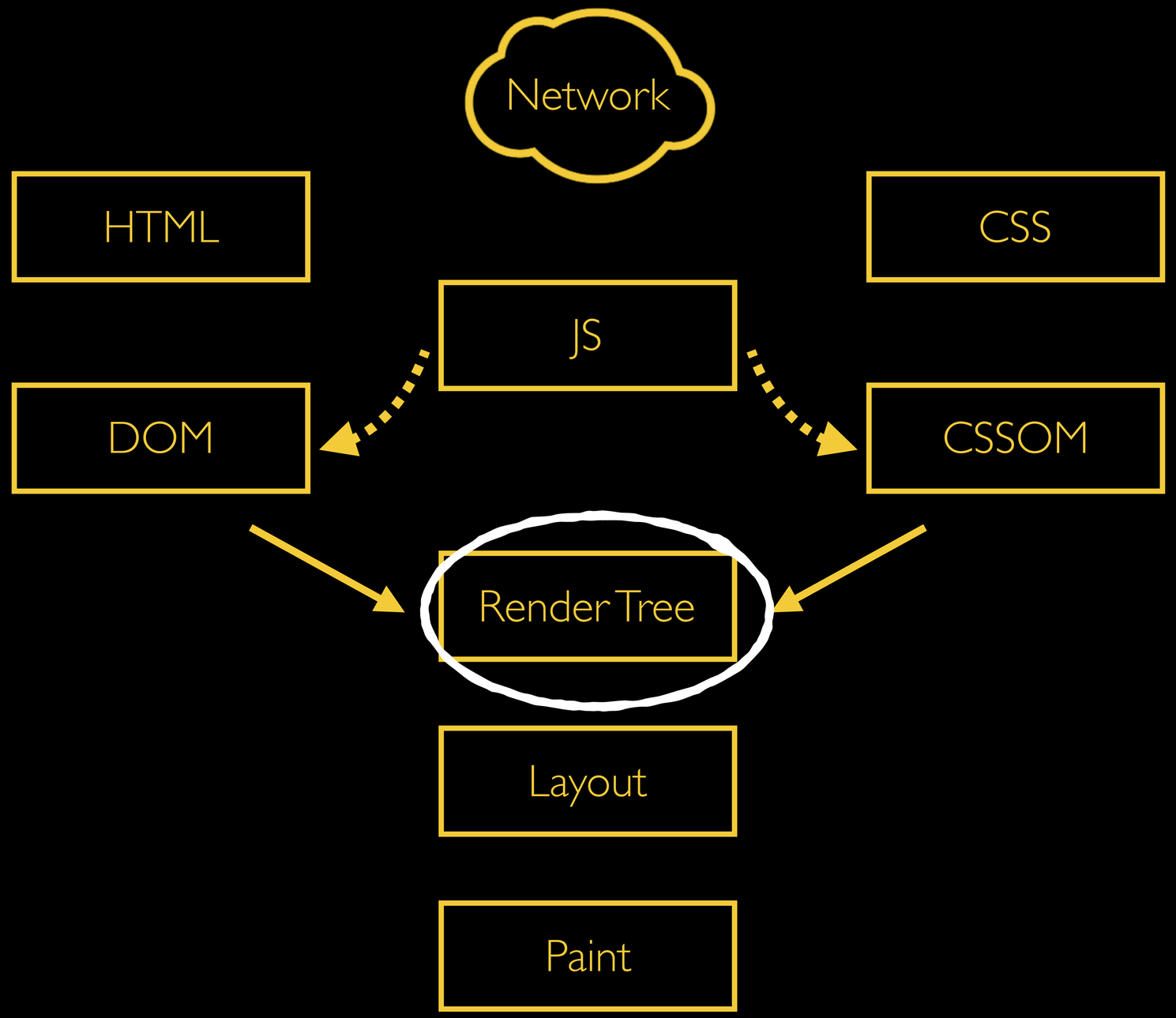

Language Support
All Characters 260k
Default 177k
Which should I choose?


Language Support
All Characters
Default
Custom
Catalan
Italian
Czech
Polish
Dutch
Portuguese
English
Slovenian
French
Spanish
German
Swedish
Hungarian
Turkish
OpenType Features
Which should I choose?

```
<link href="http://
fonts.googleapis.com/css?
family=Open+Sans&text=Hello"
rel="stylesheet">
```

```
<link href="http://
fonts.googleapis.com/css?
family=Open+Sans&text=Hello"
rel="stylesheet">
```

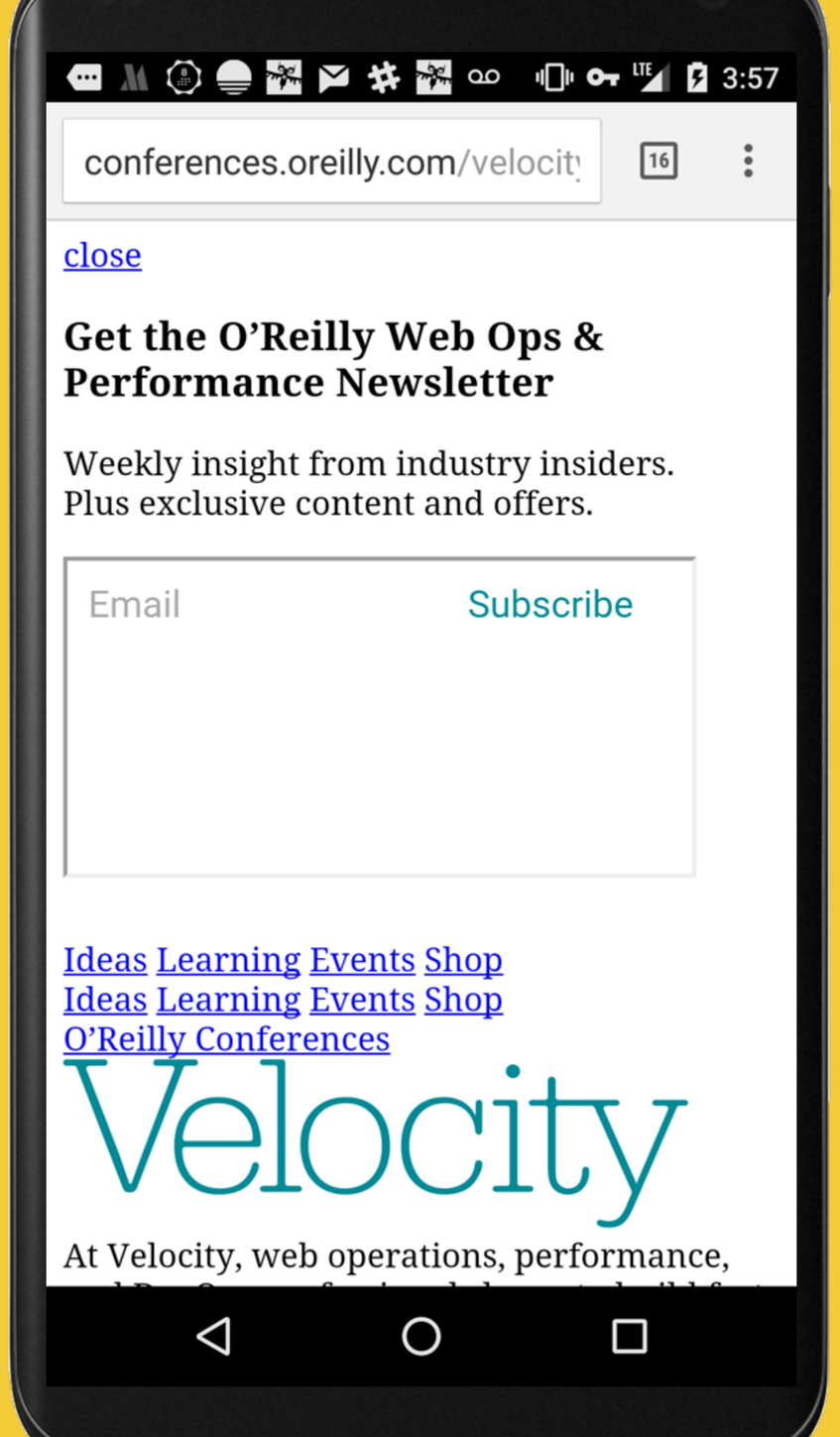

Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

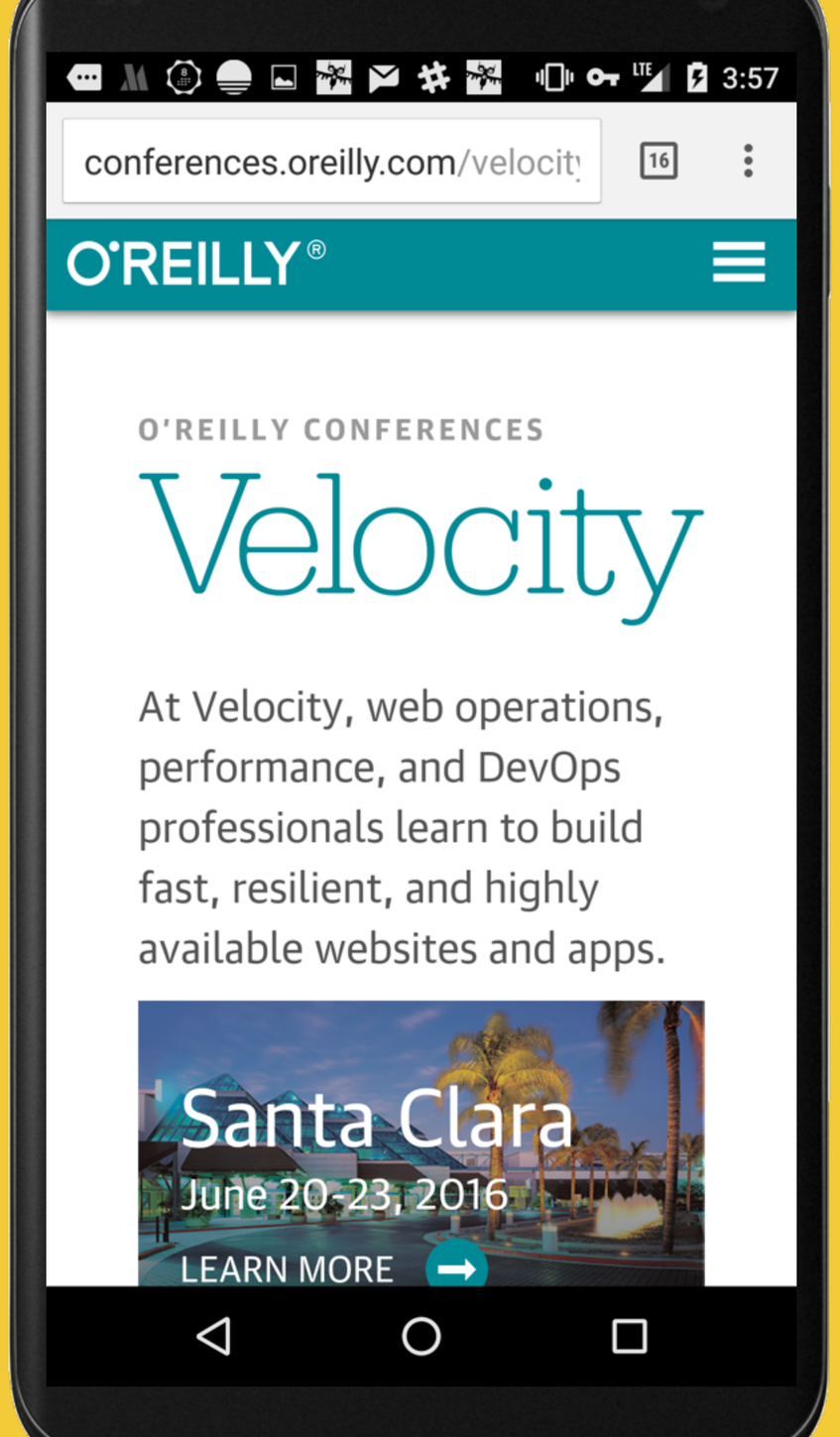

Network
HTML
CSS
JS
DOM
CSSOM
Render Tree
Layout
Paint

USE NOT, WASTE NOT

```
@font-face {
  font-family: "some-font";
}

@media (min-width: 400px) {
  body {
    font-family: "some-font", Georgia,
serif
  }
}
```


3:57
conferences.oreilly.com/velocity
16
close
Get the O'Reilly Web Ops & Performance Newsletter
Weekly insight from industry insiders.
Plus exclusive content and offers.
Email
Subscribe
Ideas Learning Events Shop
Ideas Learning Events Shop
O'Reilly Conferences
Velocity
At Velocity, web operations, performance,


3:57
conferences.oreilly.com/velocity
16
O'REILLY®
O'REILLY CONFERENCES
Velocity
At Velocity, web operations, performance, and DevOps professionals learn to build fast, resilient, and highly available websites and apps.
Santa Clara
June 20-23, 2016
LEARN MORE

FOUT

Flash of Unstyled Text

●○○○○ 3 19:25

http://gizmo.do/6LWnVGb

●●●●● Verizon 3G 5:15 PM

http://www.slate.com/arti...

[redacted]

FOIT

Flash of Invisible Text

Browser	Timeout	Fallback	Swap
Chrome 35+	3 seconds	Yes	Yes
Opera	3 seconds	Yes	Yes
Firefox	3 seconds	Yes	Yes
Internet Explorer	0 seconds	Yes	Yes
Safari	No timeout	N/A	N/A

Browser	Timeout	Fallback	Swap
Chrome 35+	3 seconds	Yes	Yes
Opera	3 seconds	Yes	Yes
Firefox	3 seconds	Yes	Yes
Internet Explorer	0 seconds	Yes	Yes
Safari	~~No timeout~~ 3s	N/A	N/A

```
@font-face {
  font-family: 'League Gothic';
  font-display: auto;
  src: …
  …
}
```

1. FONT BLOCK
2. FONT SWAP
3. FONT FAILURE

```
font-display: auto|fallback|block|swap|optional;
```

```
var font = new FontFace("Awesome Font", "url(/fonts/awesome.woff2)", {
  style: 'normal', unicodeRange: 'U+000-5FF', weight: '400'
});

font.load(); // don't wait for render tree, initiate immediate fetch!

font.ready().then(function() {
  // apply the font (which may rerender text and cause a page reflow)
  // once the font has finished downloading
  document.fonts.add(font);
  document.body.style.fontFamily = "Awesome Font, serif";

  // OR... by default content is hidden, and rendered once font is
available
  var content = document.getElementById("content");
  content.style.visibility = "visible";

  // OR... apply own render strategy here...
});
```

```
var font = new FontFace("Awesome Font", "url(/fonts/awesome.woff2)", {
  style: 'normal', unicodeRange: 'U+000-5FF', weight: '400'
});

font.load(); // don't wait for render tree, initiate immediate fetch!

font.ready().then(function() {
  // apply the font (which may rerender text and cause a page reflow)
  // once the font has finished downloading
  document.fonts.add(font);
  document.body.style.fontFamily = "Awesome Font, serif";

  // OR... by default content is hidden, and rendered once font is
available
  var content = document.getElementById("content");
  content.style.visibility = "visible";

  // OR... apply own render strategy here...
});
```

```
var font = new FontFace("Awesome Font", "url(/fonts/awesome.woff2)", {
  style: 'normal', unicodeRange: 'U+000-5FF', weight: '400'
});

font.load(); // don't wait for render tree, initiate immediate fetch!

font.ready().then(function() {
  // apply the font (which may rerender text and cause a page reflow)
  // once the font has finished downloading
  document.fonts.add(font);
  document.body.style.fontFamily = "Awesome Font, serif";

  // OR... by default content is hidden, and rendered once font is
available
  var content = document.getElementById("content");
  content.style.visibility = "visible";

  // OR... apply own render strategy here...
});
```

```
var font = new FontFace("Awesome Font", "url(/fonts/awesome.woff2)", {
  style: 'normal', unicodeRange: 'U+000-5FF', weight: '400'
});

font.load(); // don't wait for render tree, initiate immediate fetch!
```

```
font.ready().then(function() {
  // apply the font (which may rerender text and cause a page reflow)
  // once the font has finished downloading
  document.fonts.add(font);
  document.body.style.fontFamily = "Awesome Font, serif";

  // OR... by default content is hidden, and rendered once font is
available
  var content = document.getElementById("content");
  content.style.visibility = "visible";

  // OR... apply own render strategy here...
});
```

Can I use... Support tables for

caniuse.com/#feat=font-loading

x Feature: CSS Font Loading

CSS Font Loading - CR

Global 54.17%

This CSS module defines a scripting interface to font faces in CSS, allowing font faces to be easily created and loaded from script. It also provides methods to track the loading status of an individual font, or of all the fonts on an entire page.

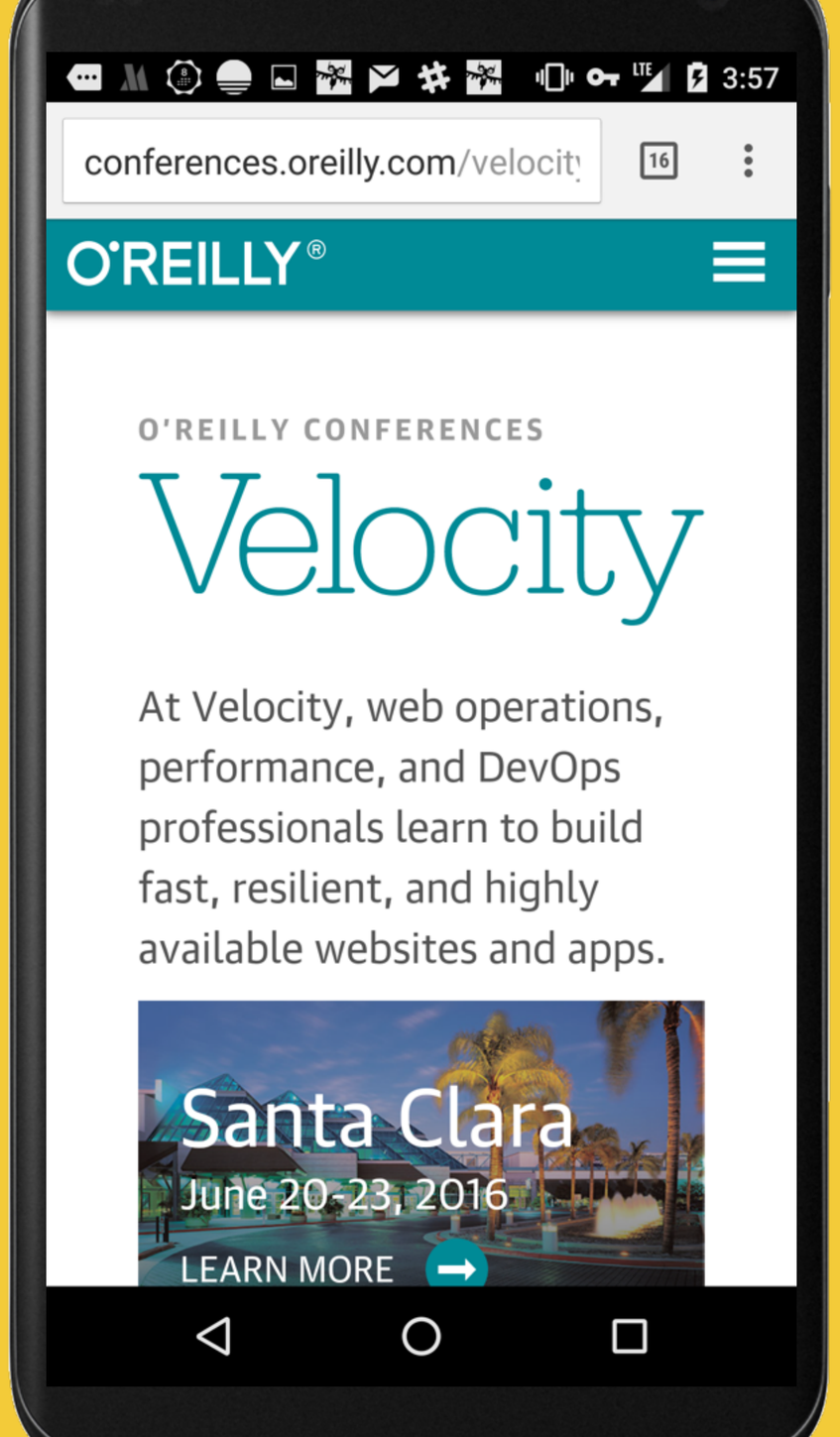
Current aligned | Usage relative | Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			29						
			45						
			48					4.3	
		45	49			8.4		4.4	
8		46	50			9.2		4.4.4	
11	13	47	51	9.1	38	9.3	8	50	50
	14	48	52	10	39				
		49	53	TP	40				
		50	54						

Notes | Known issues (1) | Resources (4) | Feedback

[1] Can be enabled in Firefox using the `layout.css.font-loading-api.enabled` flag. Enabled by default in Firefox 41. See this bug

THE CRITICAL PATH + PRELOAD


3:57
conferences.oreilly.com/velocity
16
O'REILLY®
O'REILLY CONFERENCES
Velocity
At Velocity, web operations, performance, and DevOps professionals learn to build fast, resilient, and highly available websites and apps.
Santa Clara
June 20-23, 2016
LEARN MORE

```
<style>
 @font-face {
  font-family: LatoSubset;
  src: url(“data:application/x-font-
woff;charset=utf-8; base64,d09GRgABAA…
</style>
```

```
<link rel="preload" href="lato.woff2" as="font"
type="font/woff2" crossorigin>
```

```
var font = new FontFace("Awesome Font", "url(/fonts/awesome.woff2)", {
  style: 'normal', unicodeRange: 'U+000-5FF', weight: '400'
});

font.load(); // don't wait for render tree, initiate immediate fetch!

font.ready().then(function() {
  // apply the font (which may rerender text and cause a page reflow)
  // once the font has finished downloading
  document.fonts.add(font);
  document.body.style.fontFamily = "Awesome Font, serif";

  // OR... by default content is hidden, and rendered once font is
available
  var content = document.getElementById("content");
  content.style.visibility = "visible";

  // OR... apply own render strategy here...
});
```

Before

591 ms

802 ms

1.01 s

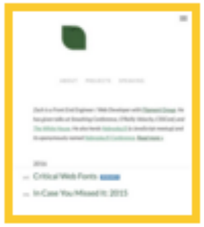
1.30 s

1.80 s

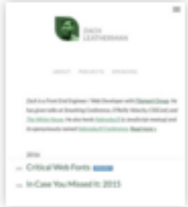
1.87 s

2.01 s

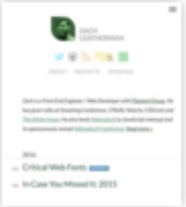
2.10 s



2.17 s



2.39 s

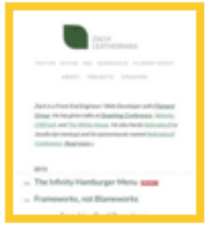


After

551 ms

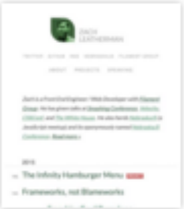
726 ms

970 ms

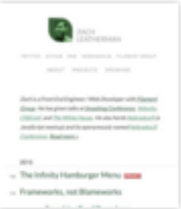


1.06 s

1.56 s

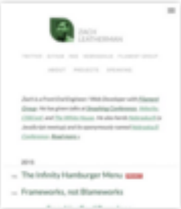


2.44 s

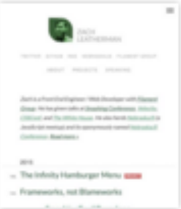


2.46 s

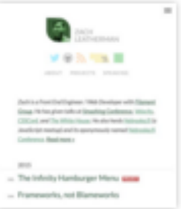
2.56 s



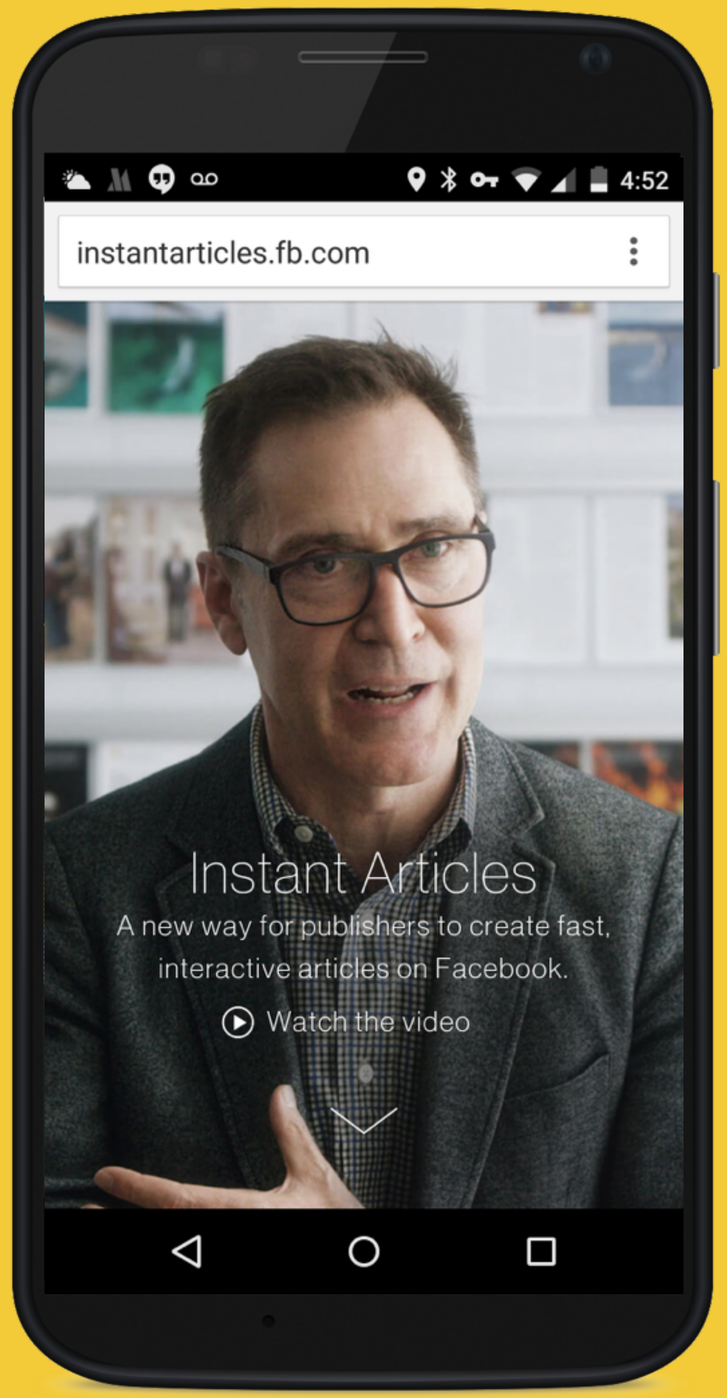
2.64 s

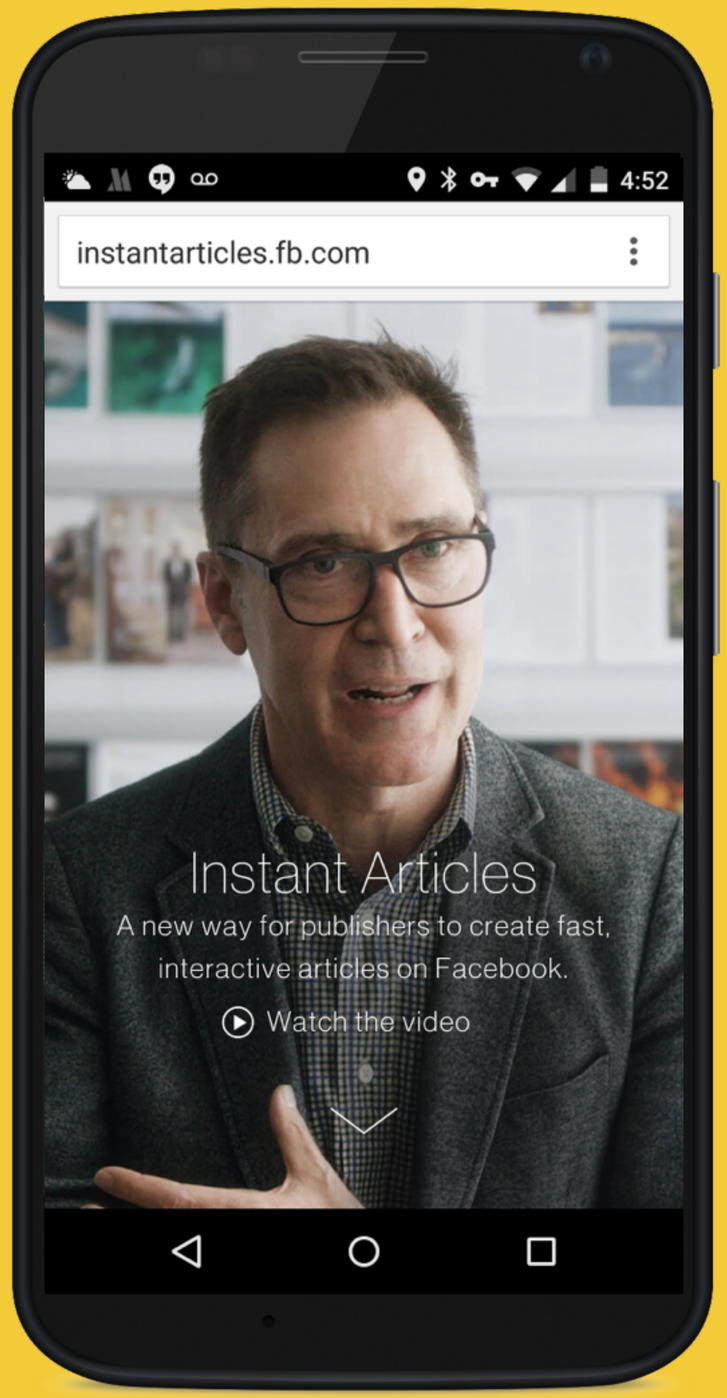


2.80 s



IMAGES?


4:52
instantarticles.fb.com
Instant Articles
A new way for publishers to create fast, interactive articles on Facebook.
Watch the video


4:52
instantarticles.fb.com
Instant Articles
A new way for publishers to create fast, interactive articles on Facebook.
Watch the video

360px x 510px

1300px x 1024px

Request
Decode
Copy to GPU
Display

Request
Decode
Copy to GPU
Display

RGB to YUV

RGB to YUV → Chroma Subsampling

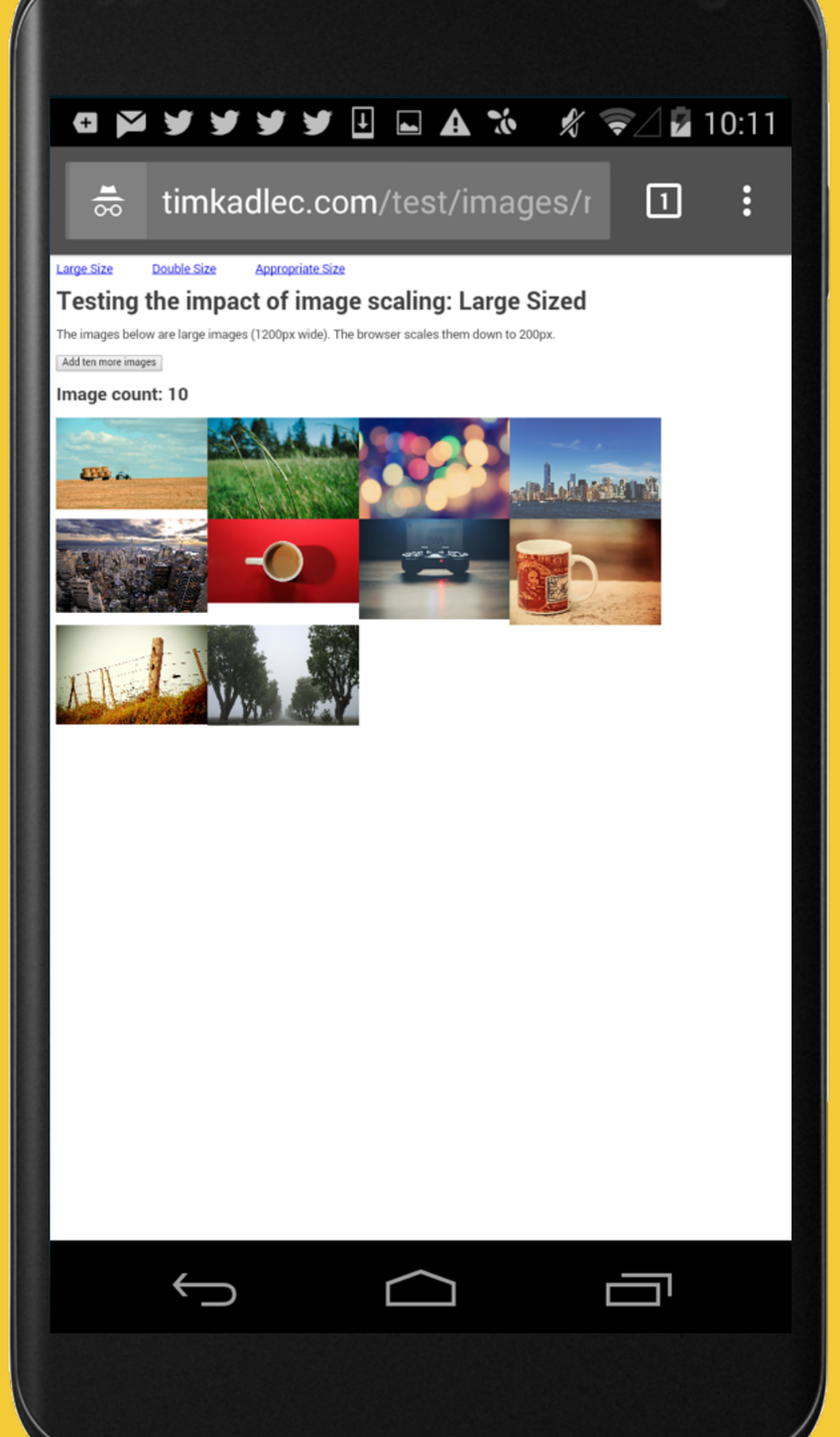
RGB to YUV → Chroma Subsampling → DCT / Quantization

RGB to YUV → Chroma Subsampling → DCT / Quantization → Huffman Encoding

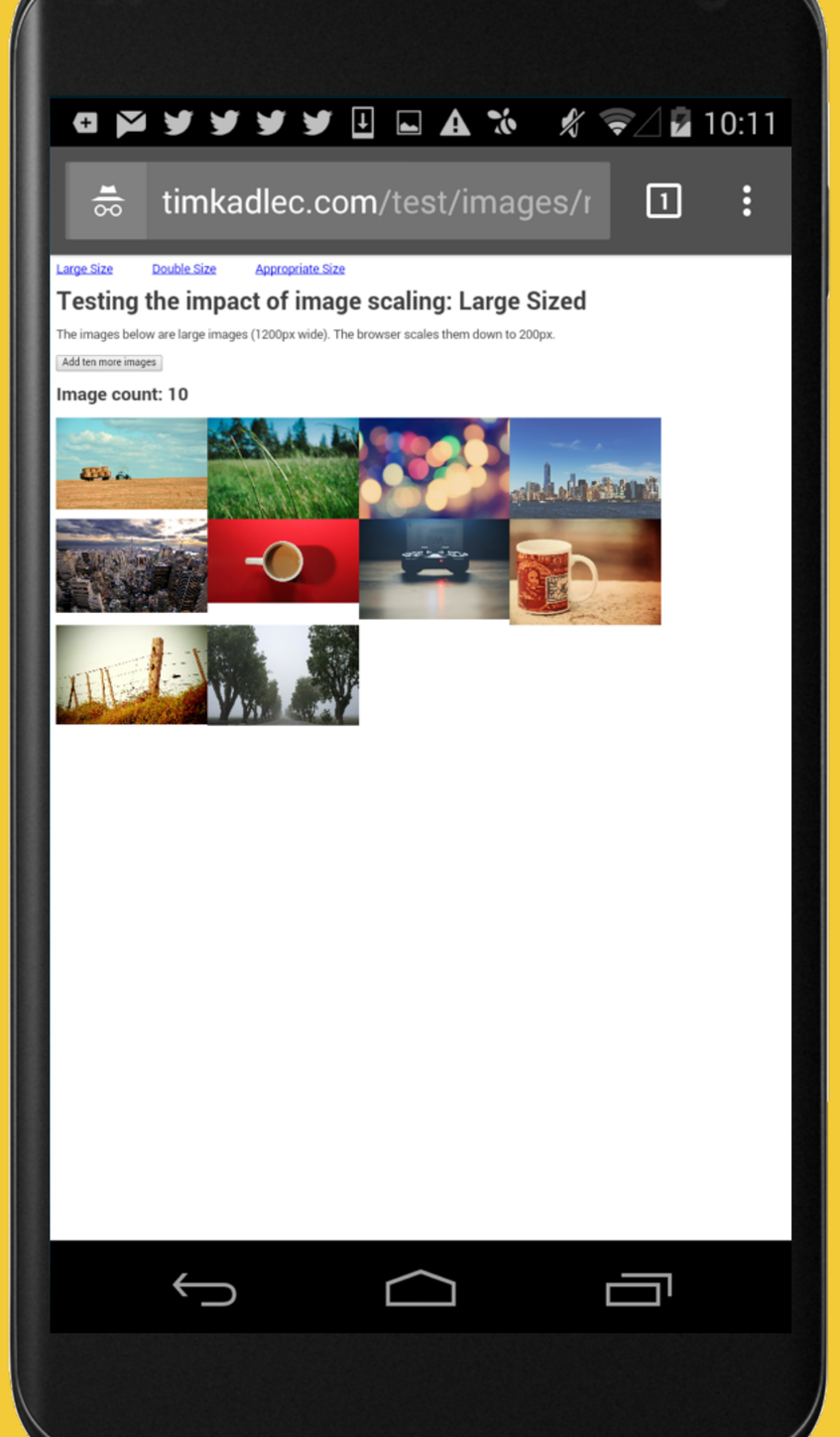
RGB to YUV → Chroma Subsampling → DCT / Quantization → Huffman Encoding

YUV to RGB ← Chroma Upsampling ← iDCT / Dequantization ← Huffman Decoding

2GB RAM
Quad-core 1.5 GHz Krait CPU
Adreno 320 GPU

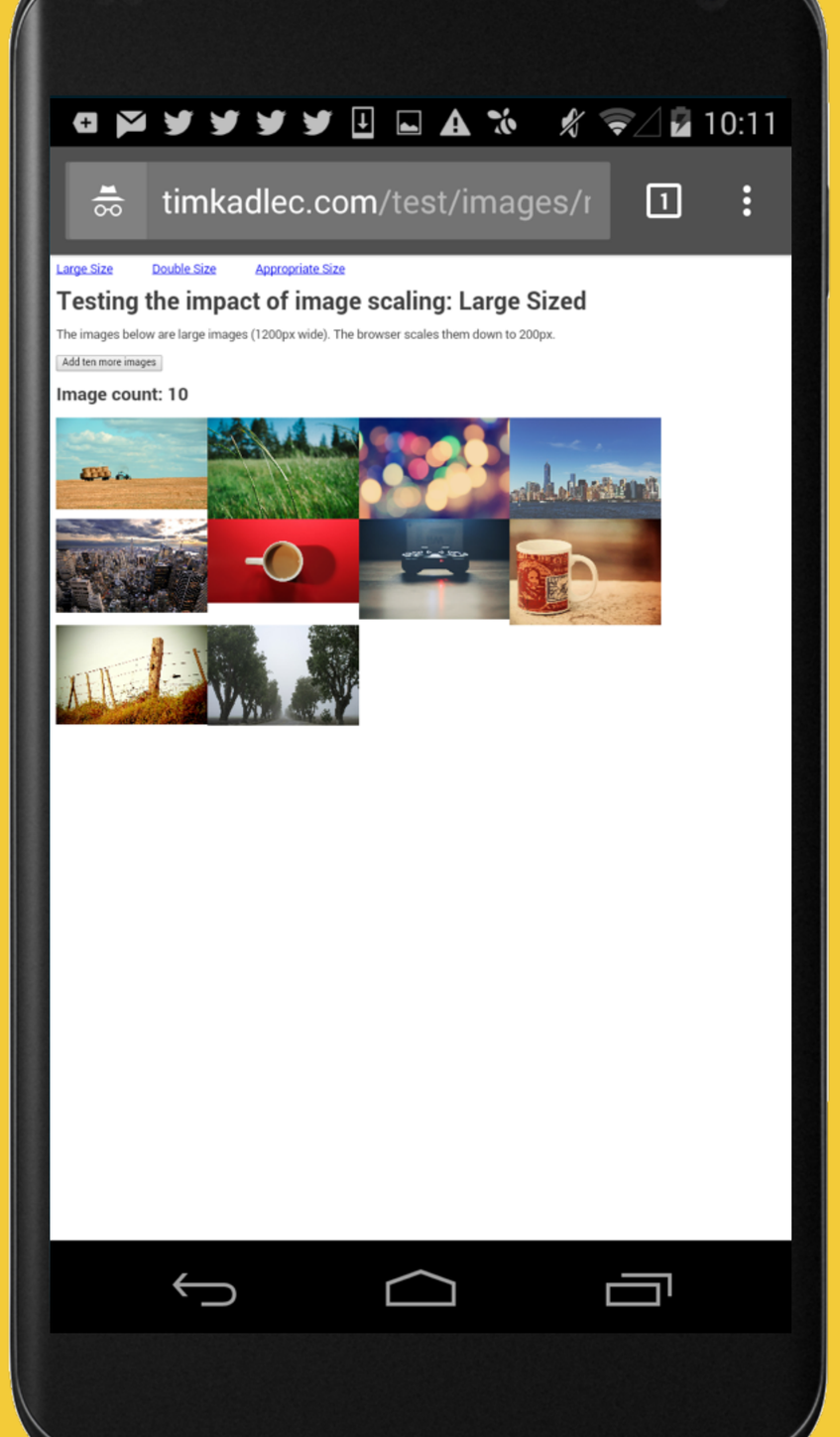


Resized: 30.38ms



Resized: 30.38ms

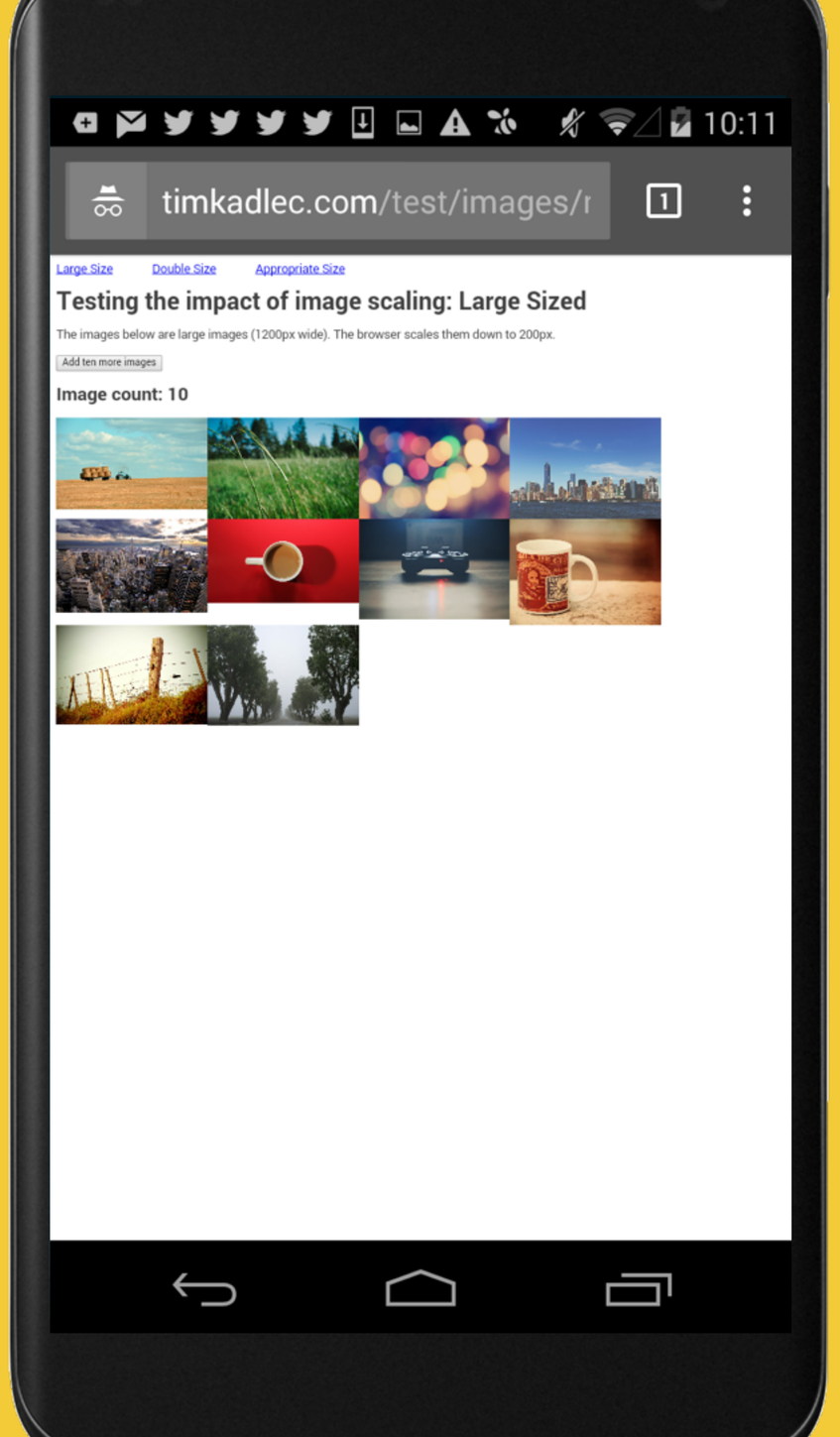
Double: 102.77ms



Resized: 30.38ms

Double: 102.77ms

Large (6x): 1,534.99ms



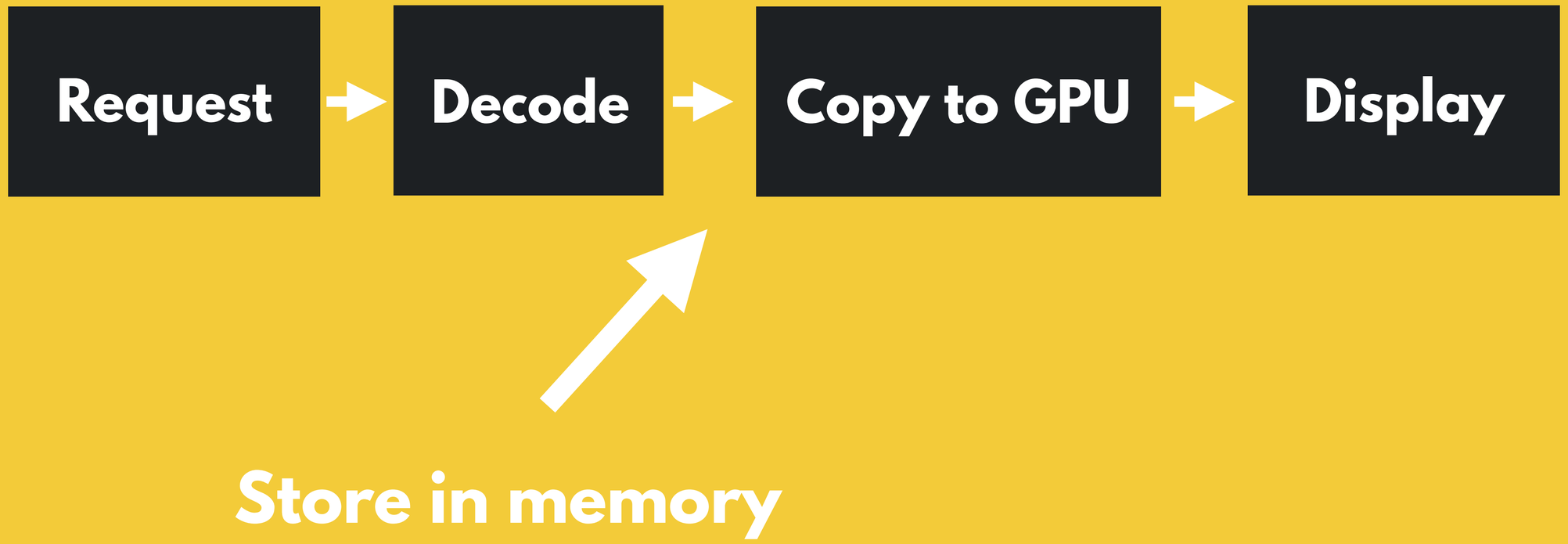
Resized: 30.38ms

Double: +238.3%

Large (6x): +4952.6%

RESIZE IMAGES

Request
Decode
Copy to GPU
Display


Request
Decode
Copy to GPU
Display
Store in memory

R: 190
G: 187
B: 181
A: 1
R: 177
G: 167
B: 157
A: 1
R: 45
G: 48
B: 46
A: 1

W x H x 4

1300px x 1024px

1300 x 1024 x 4

5,324,800

1300 x 1024 x 4

1300 x 1024 x 4

600px x 600px

200px x 200px

550px x 550px

150px x 150px

(600 x 600 - 550 x 550) x 4 =

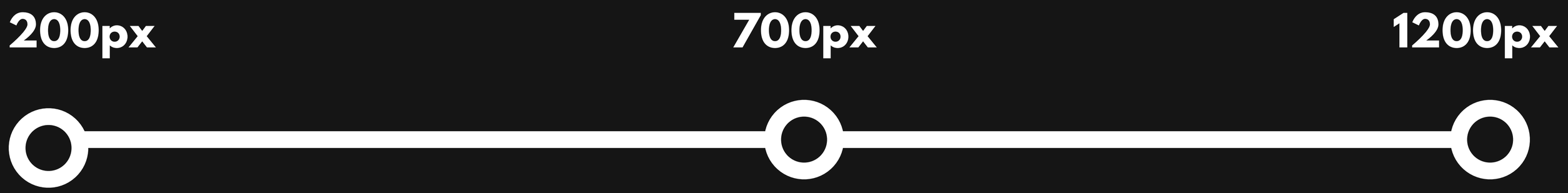
230,000 wasted bytes

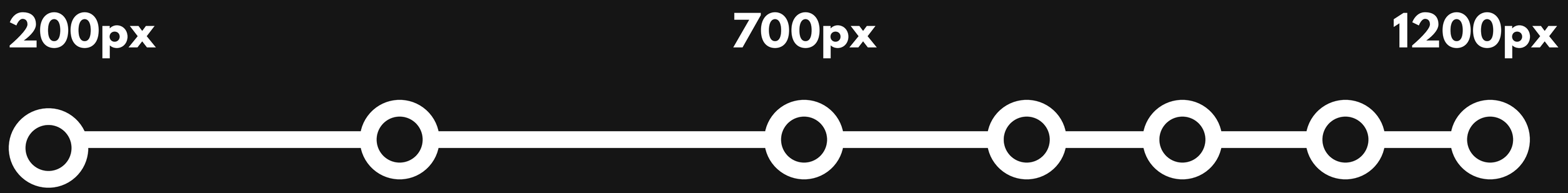
230,000 wasted bytes

(200 x 200 - 150 x 150) x 4 =
70,000 wasted bytes

230,000 wasted bytes

70,000 wasted bytes


200px
700px
1200px


200px
700px
1200px

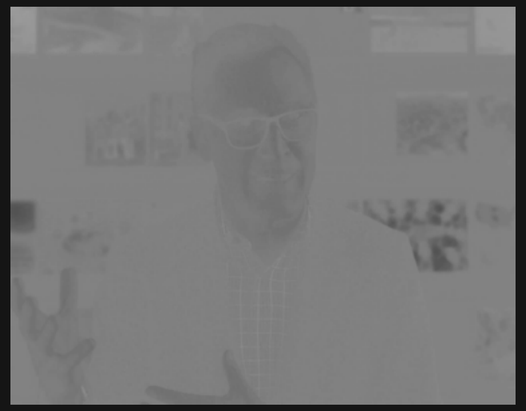
YUV to RGB ← Chroma Upsampling ← iDCT / Dequantization ← Huffman Decoding

Luma

(light)

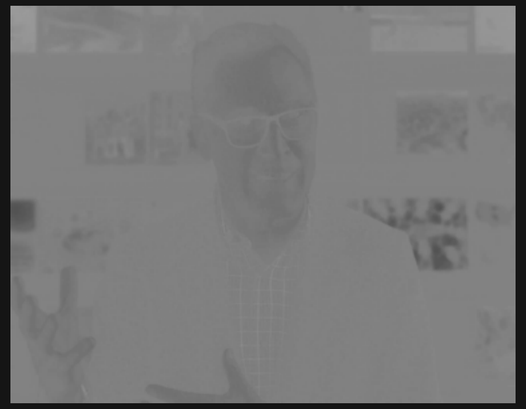
Chroma

(color)



Y

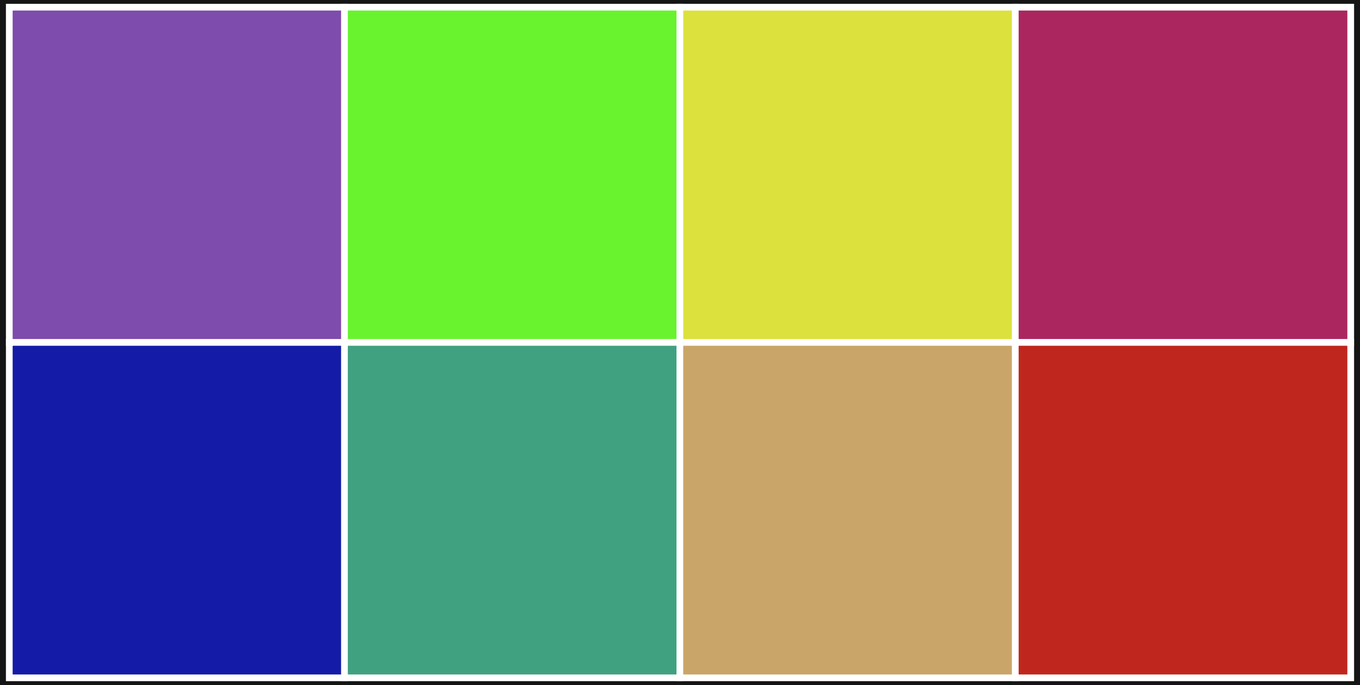
C_B



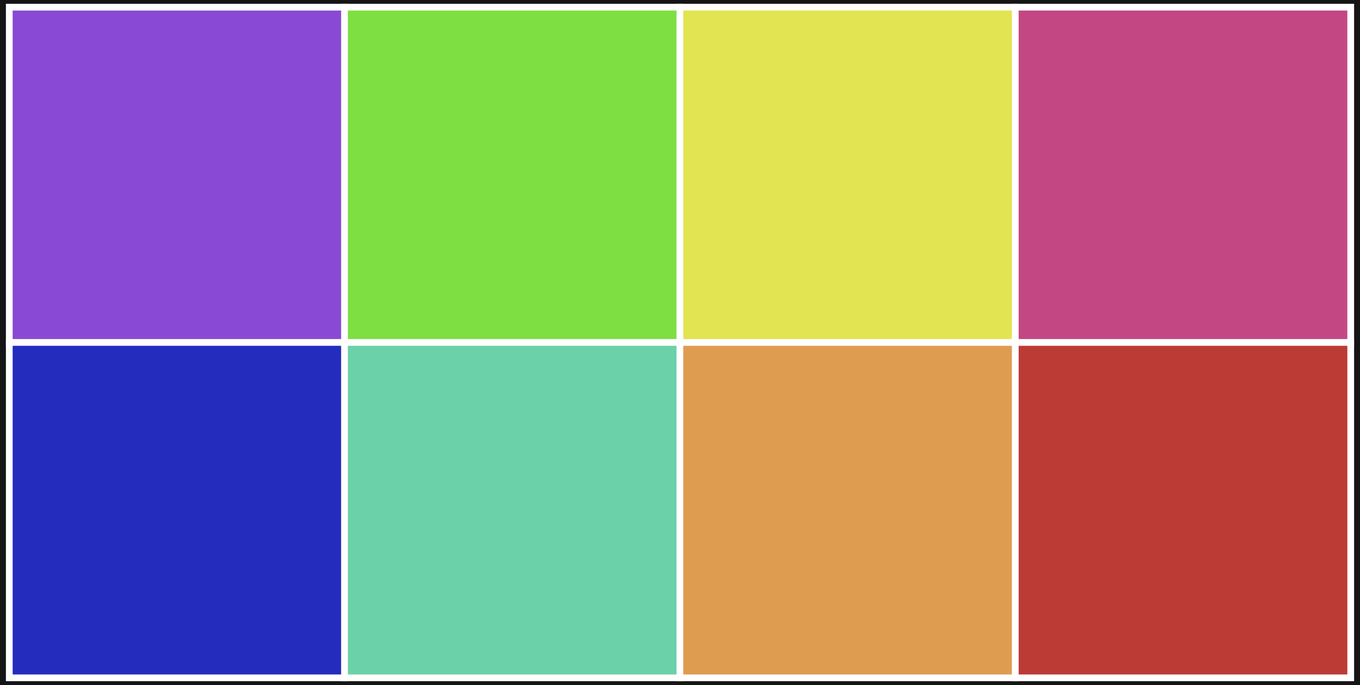
C_R

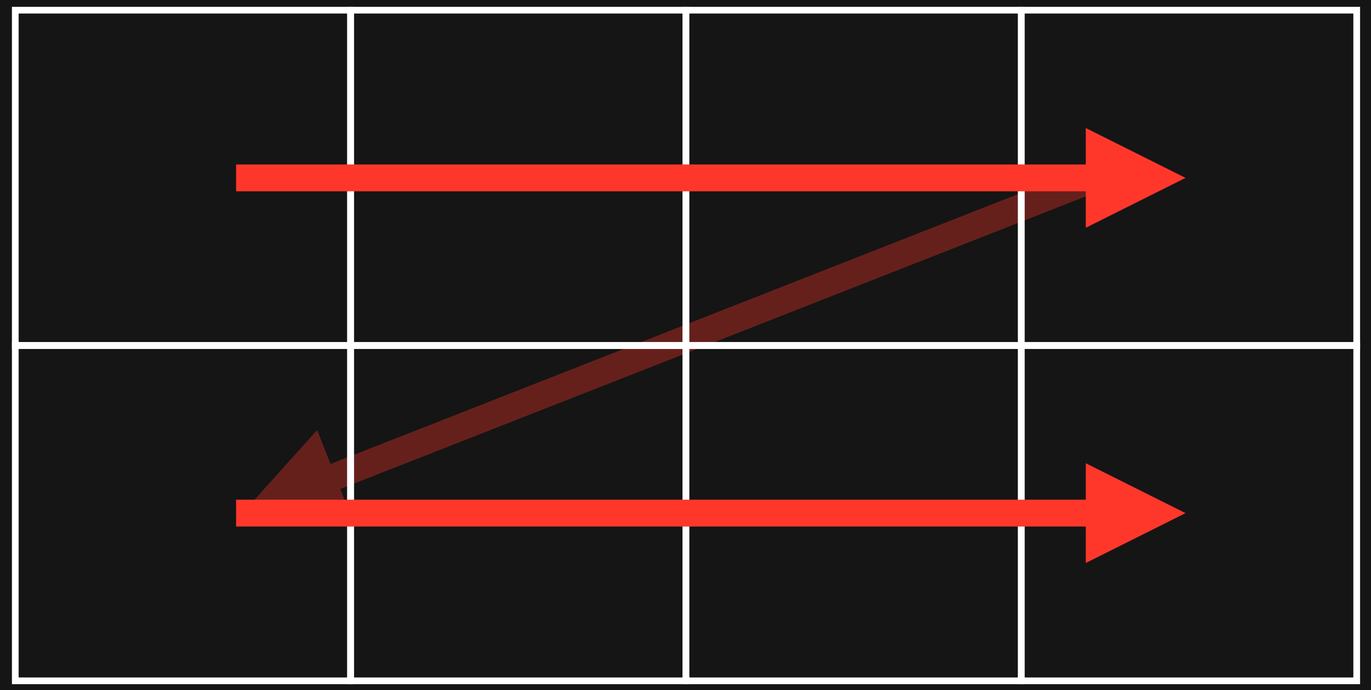
Chroma Subsampling

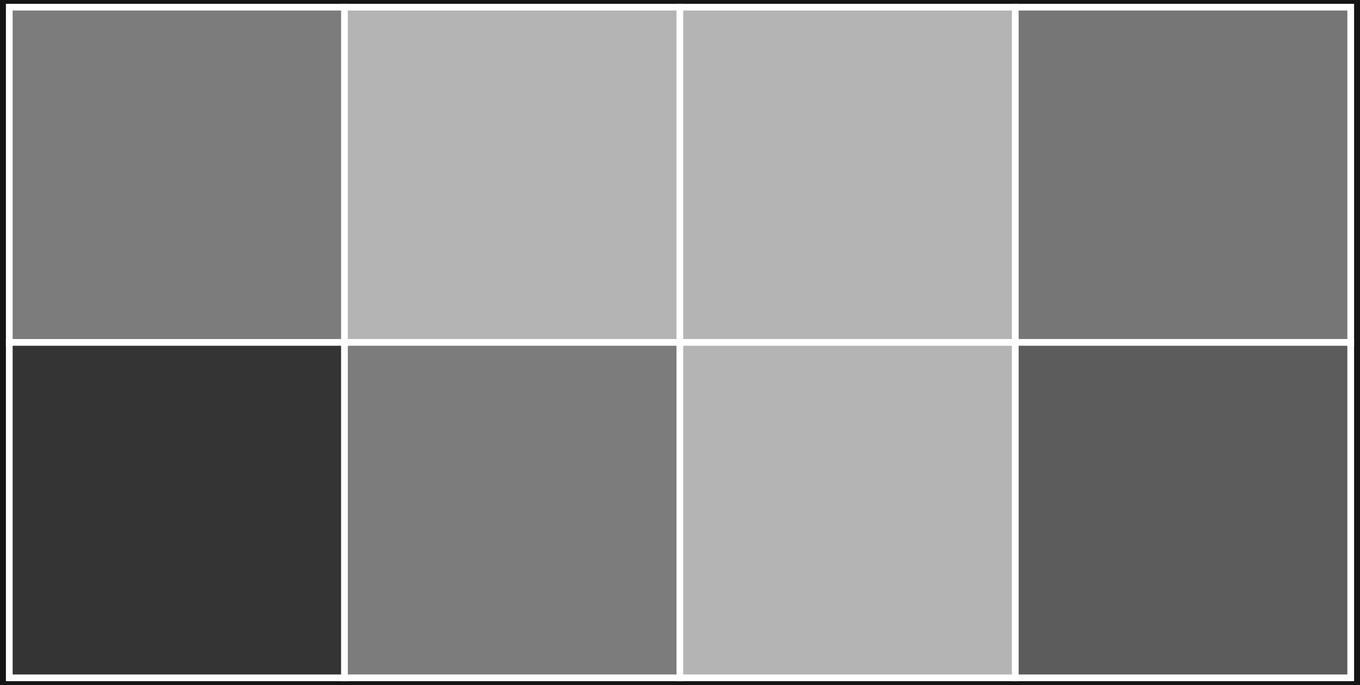
J:a:b



4 : a : b

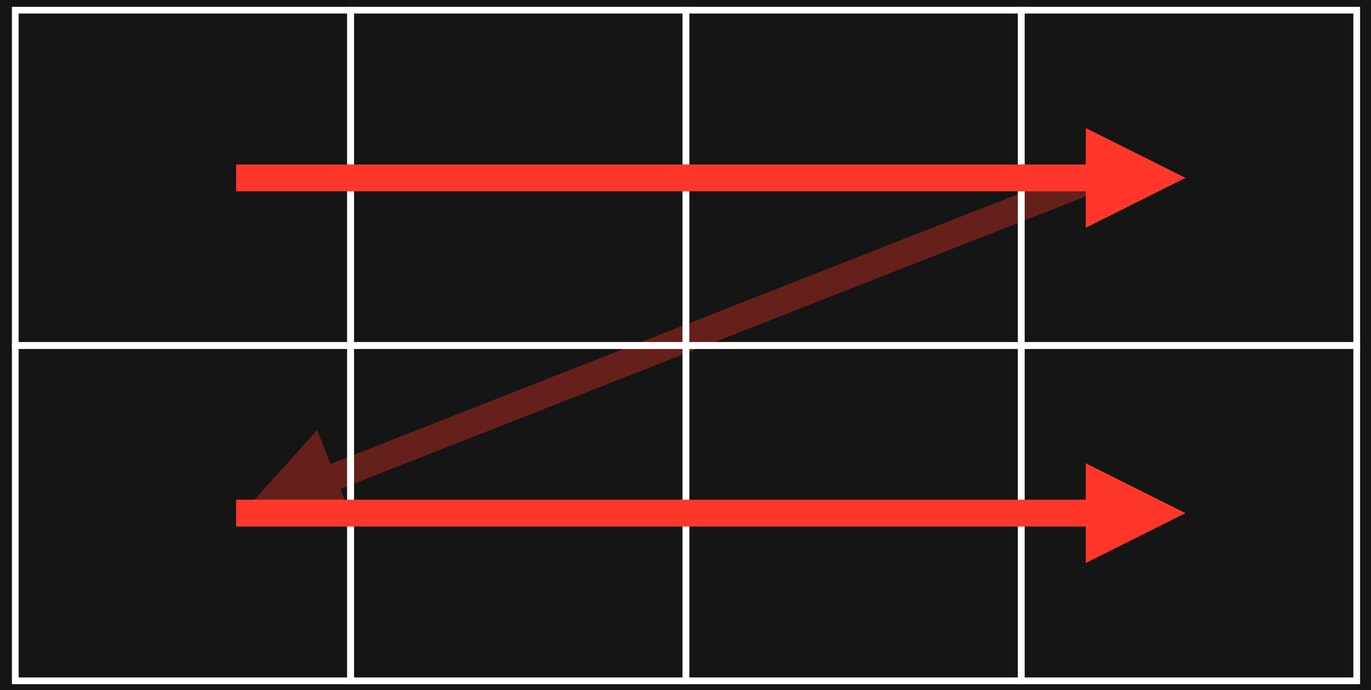


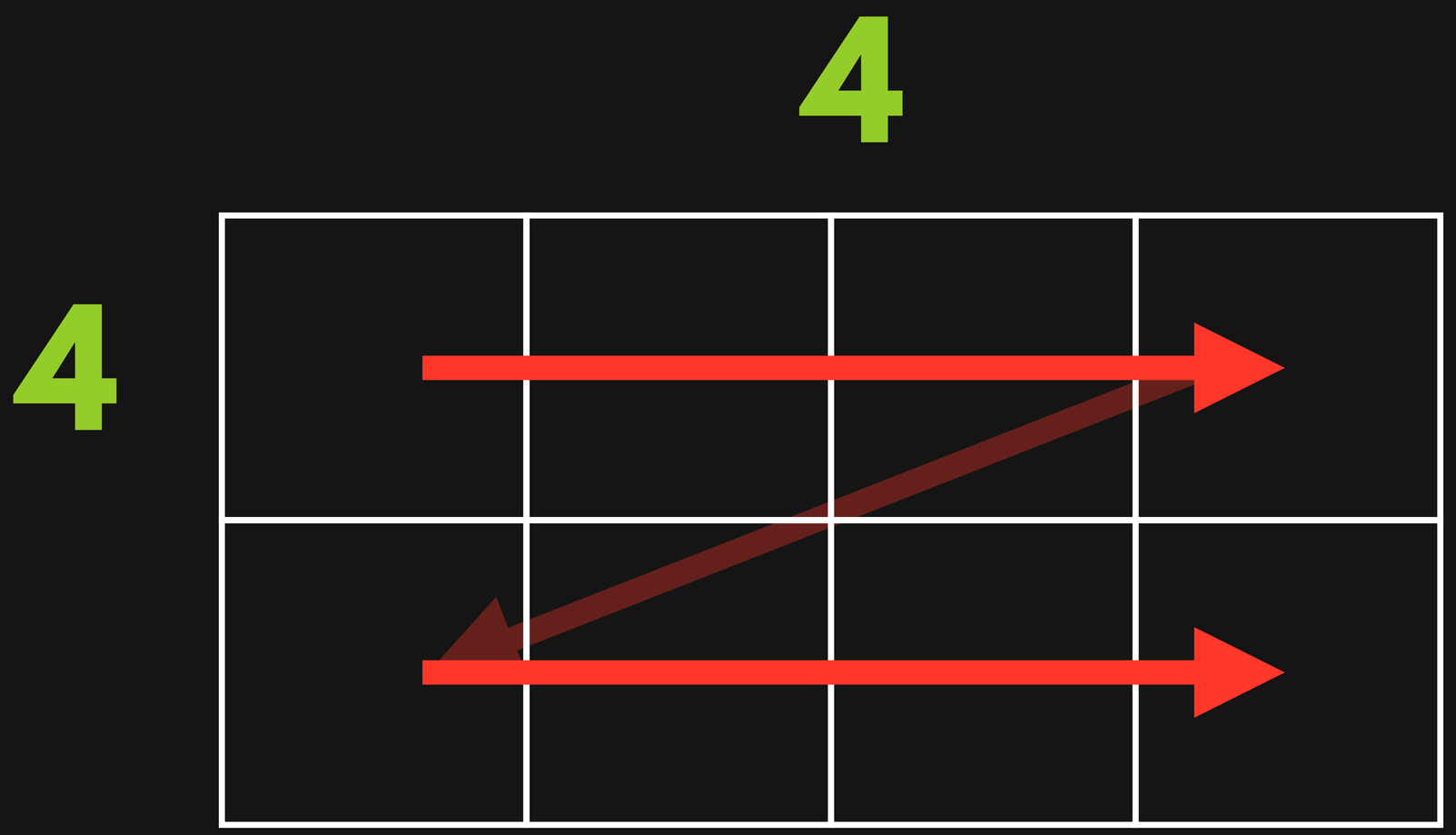


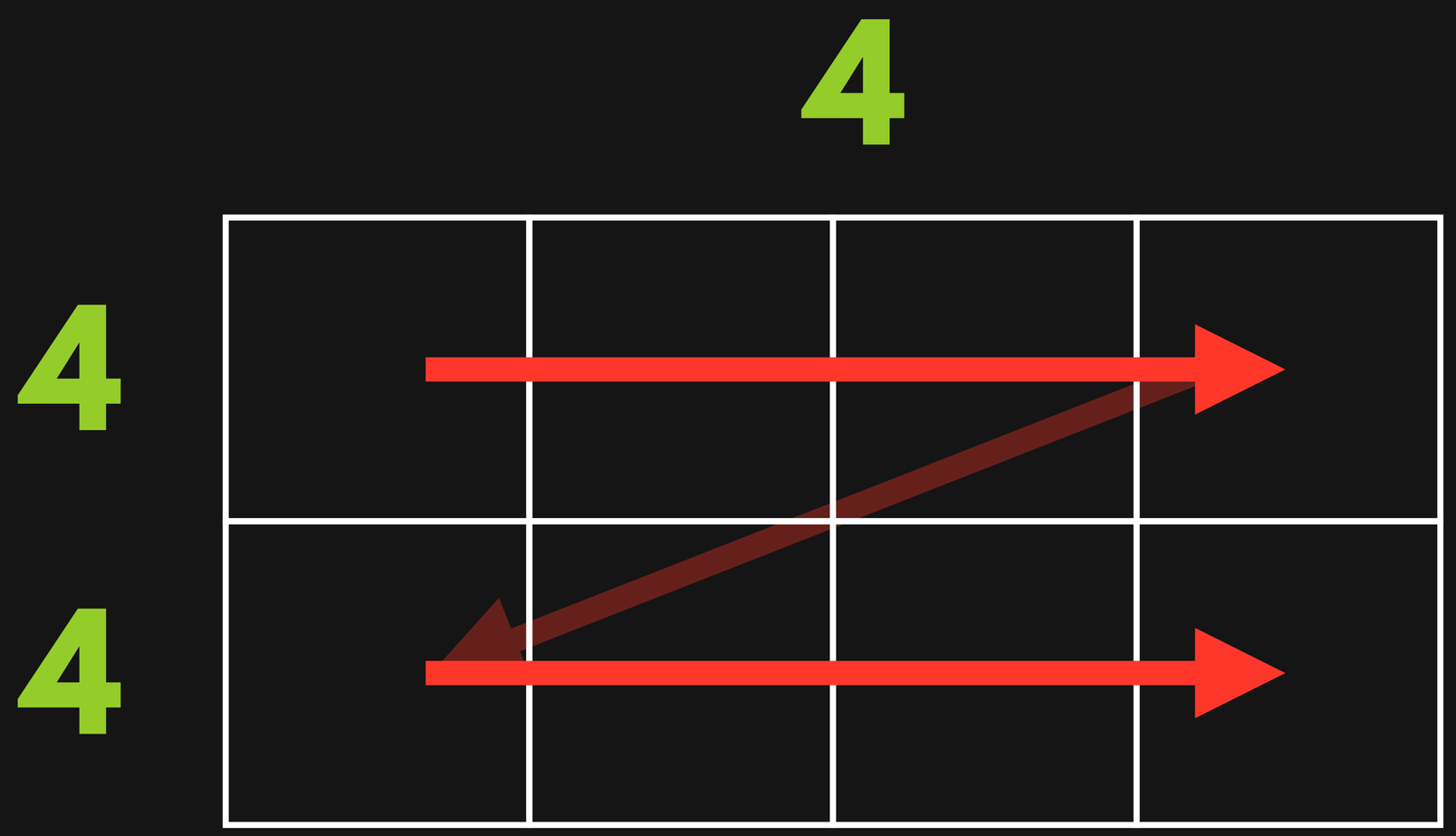


4:4:4

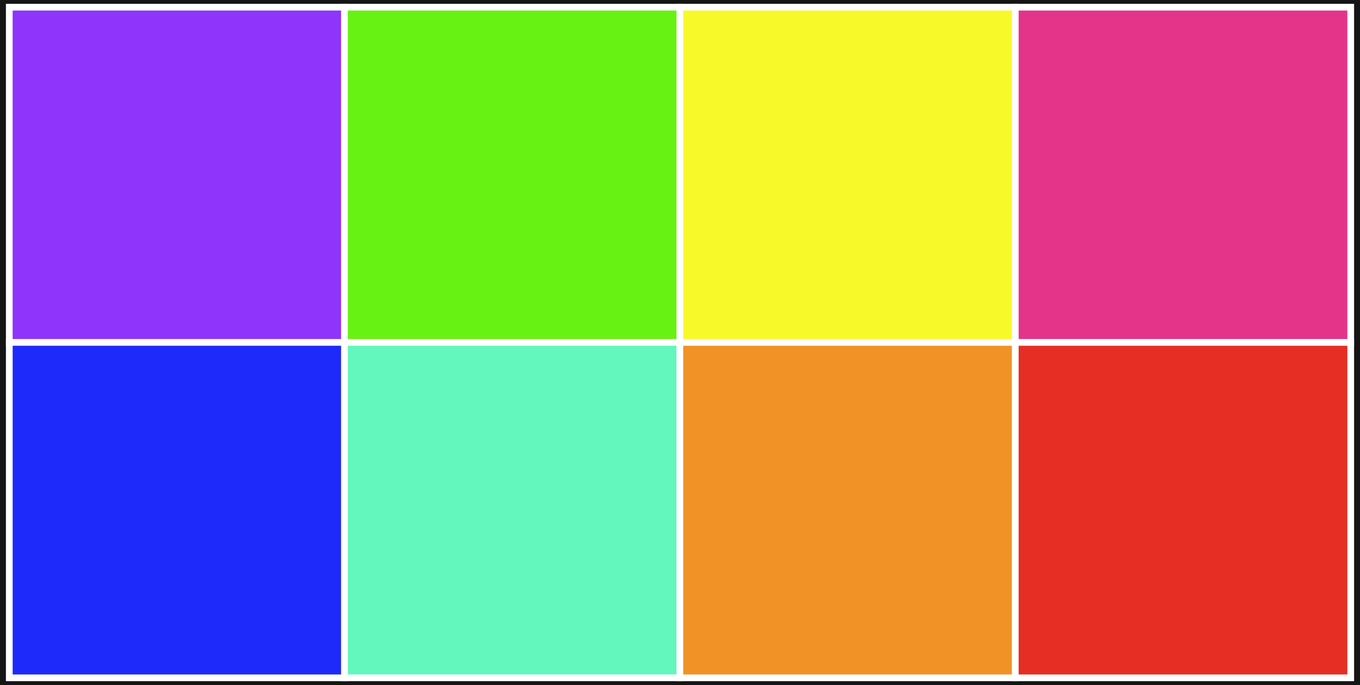
4

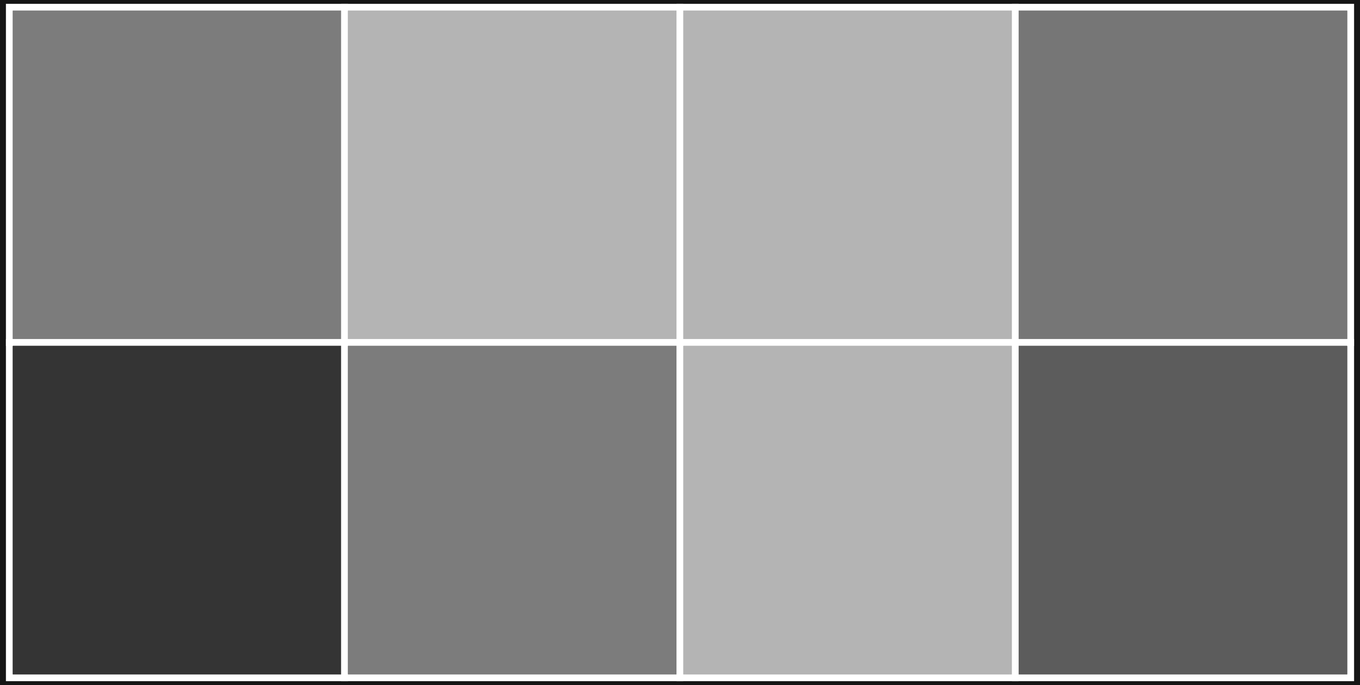


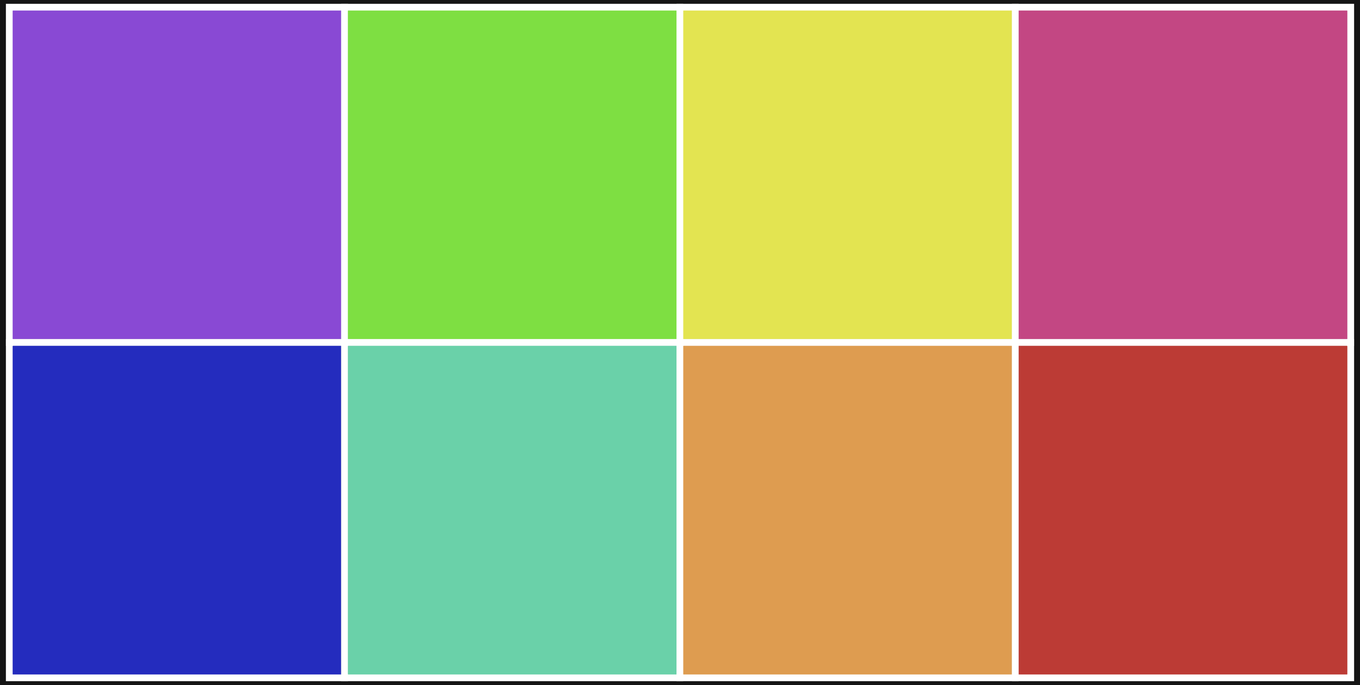

4
4



8 total

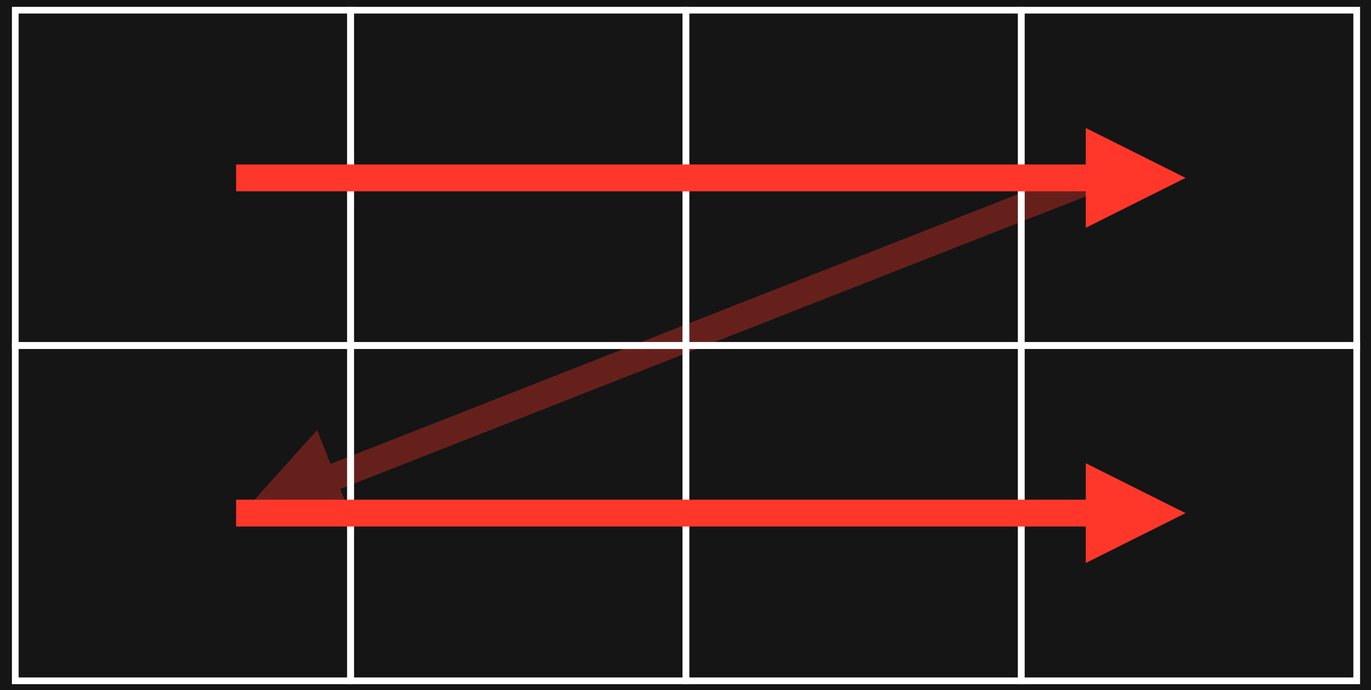


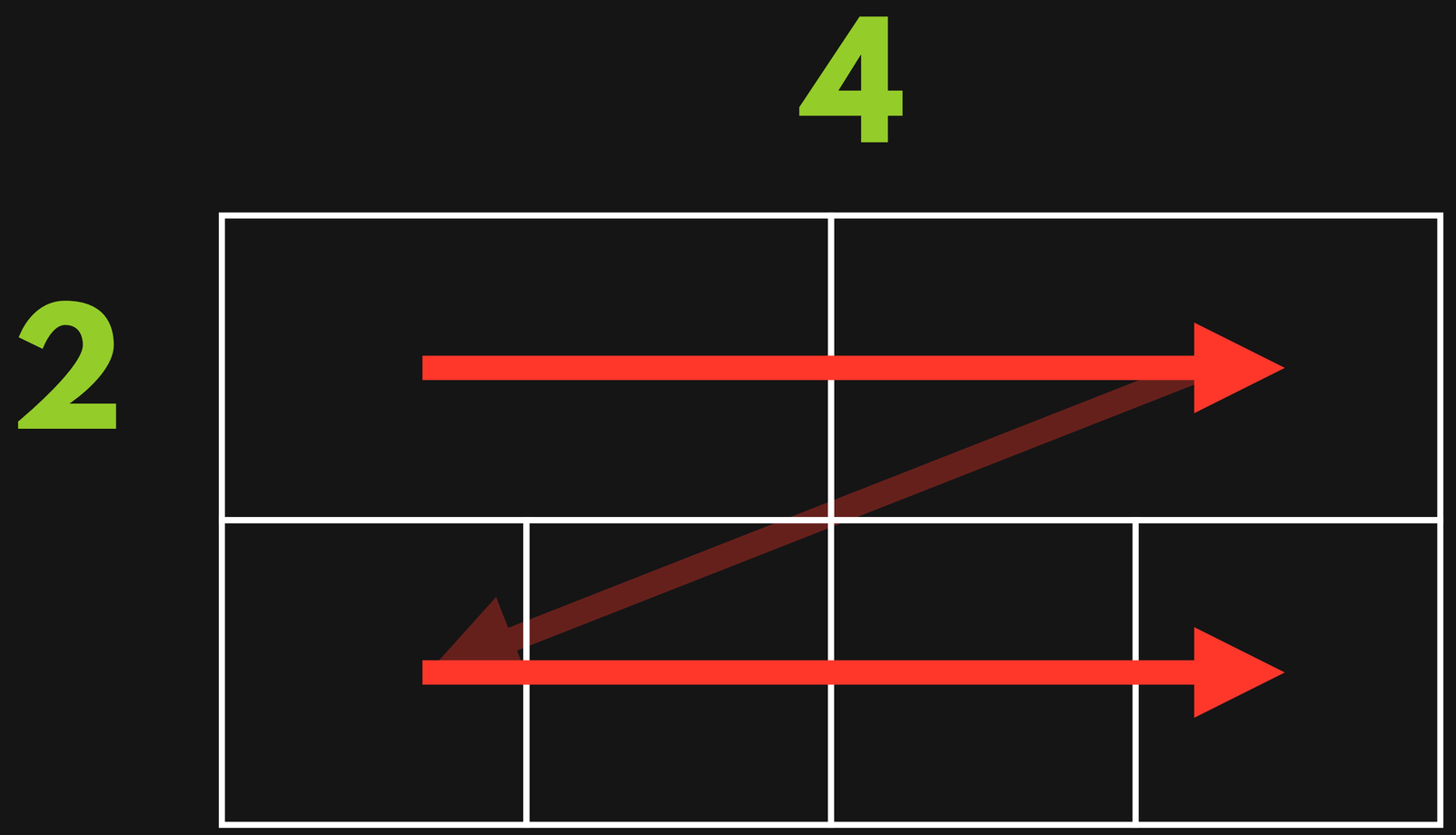


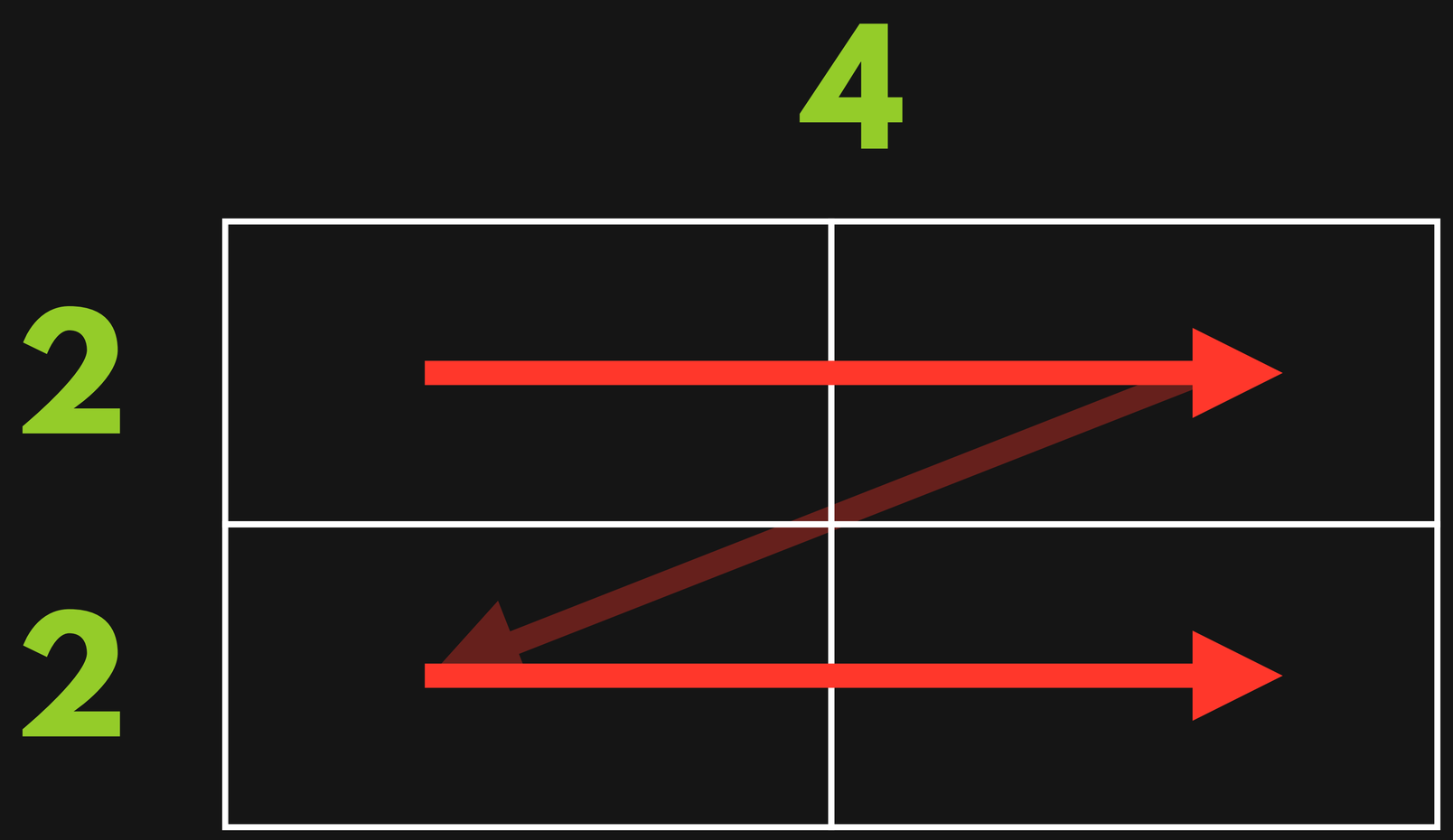


4 : 2 : 2

4

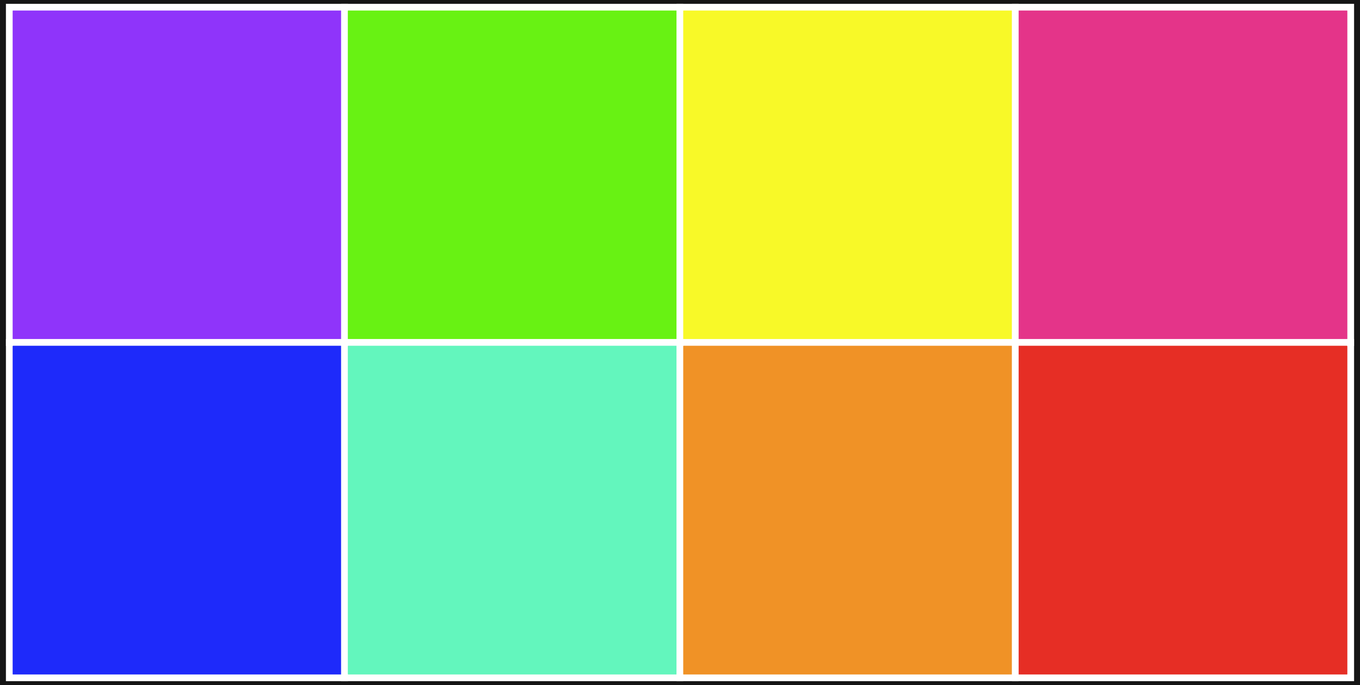


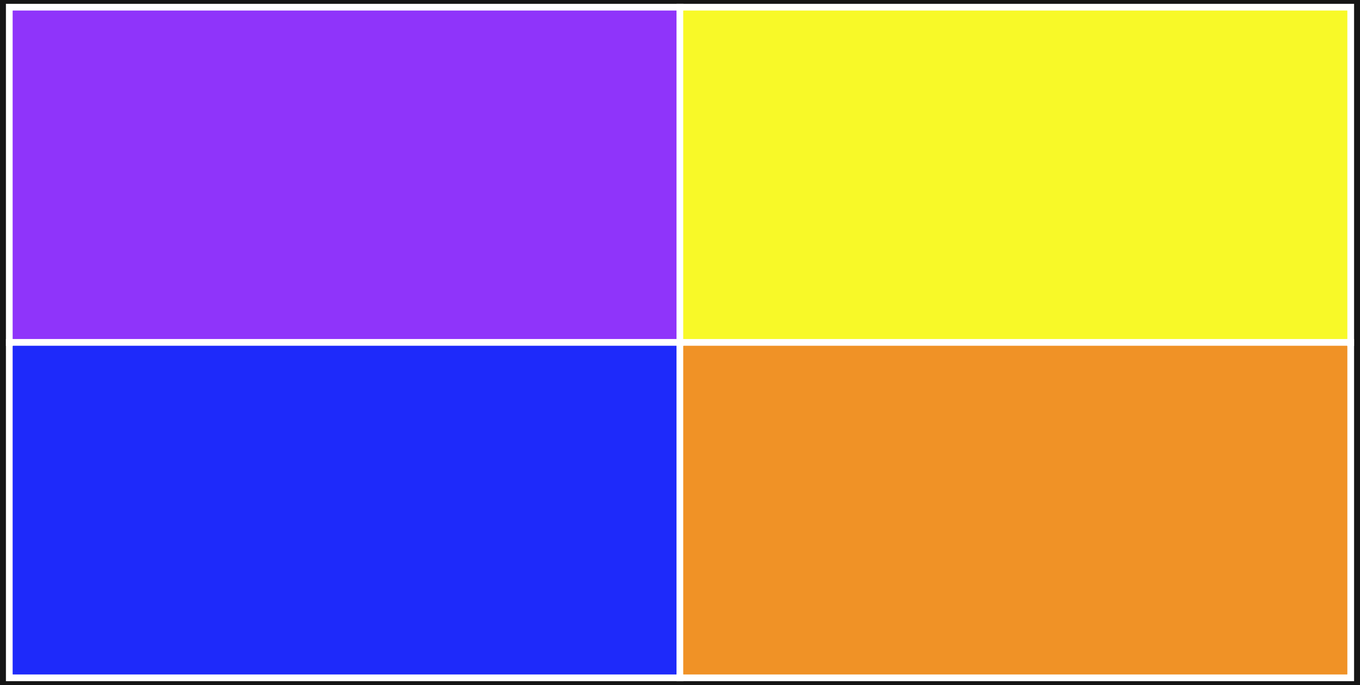

4
2

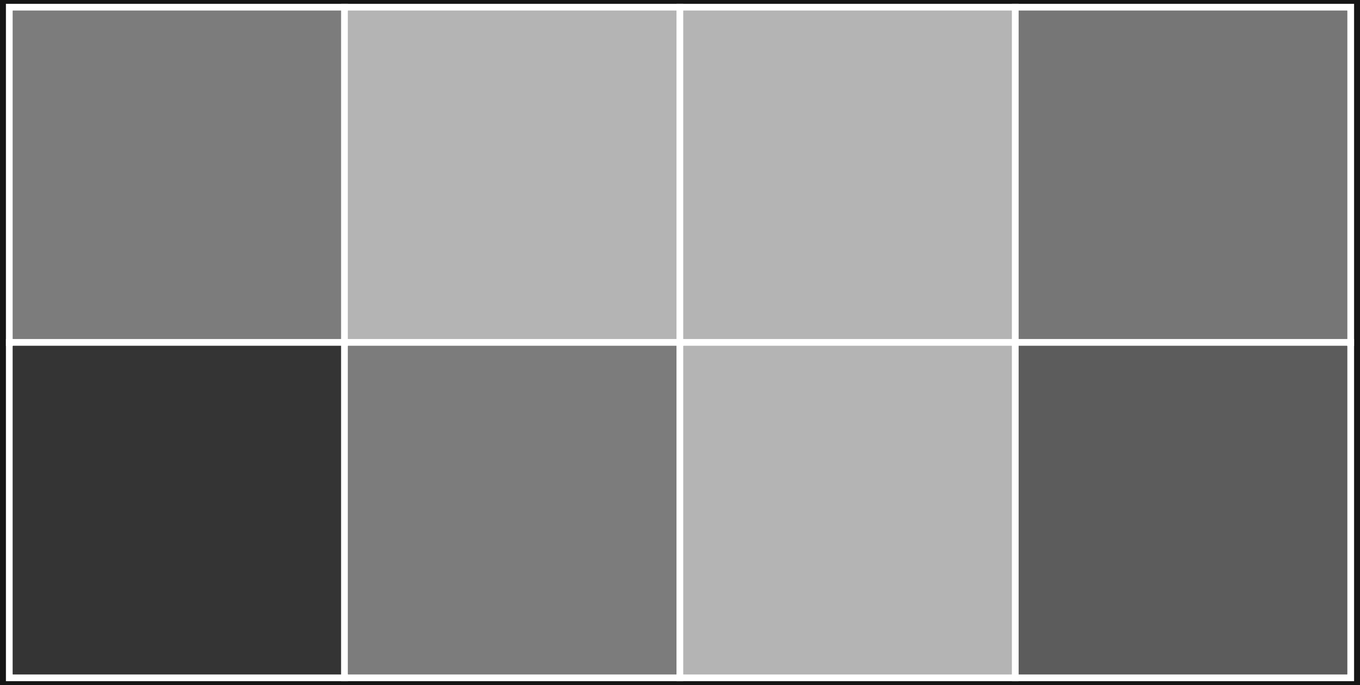


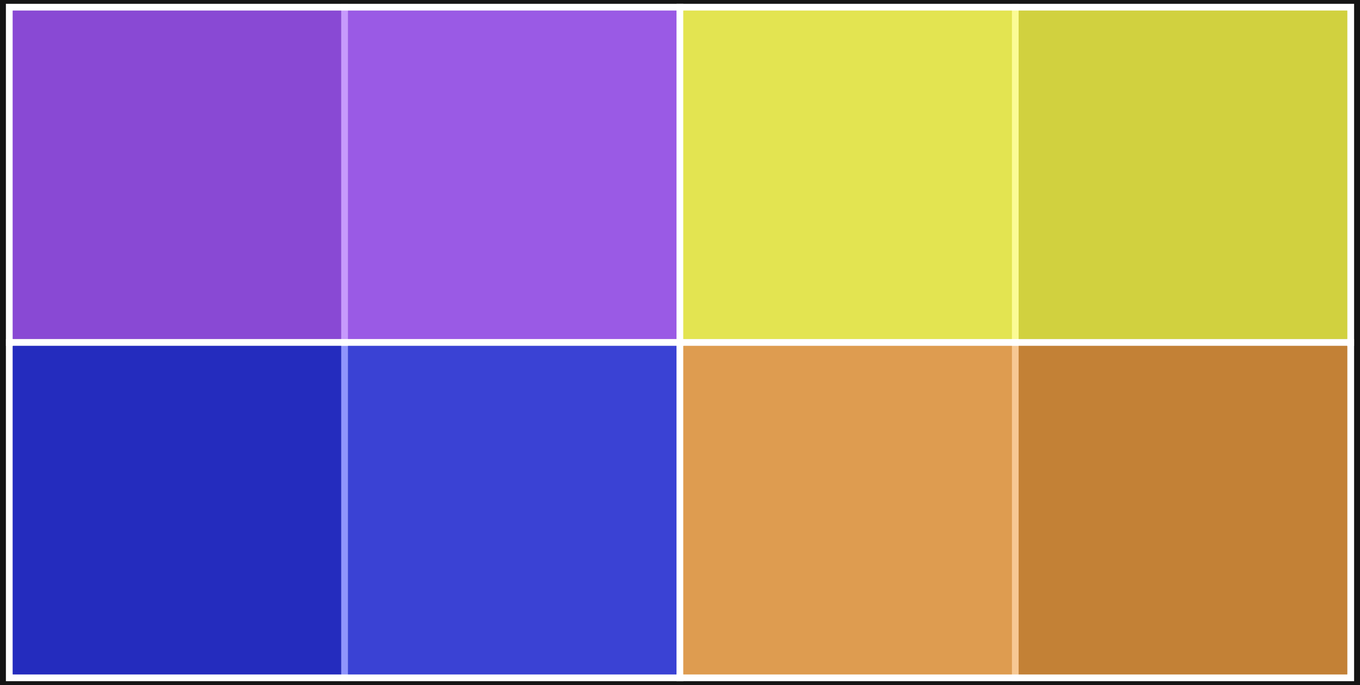
4 total

(50% savings)



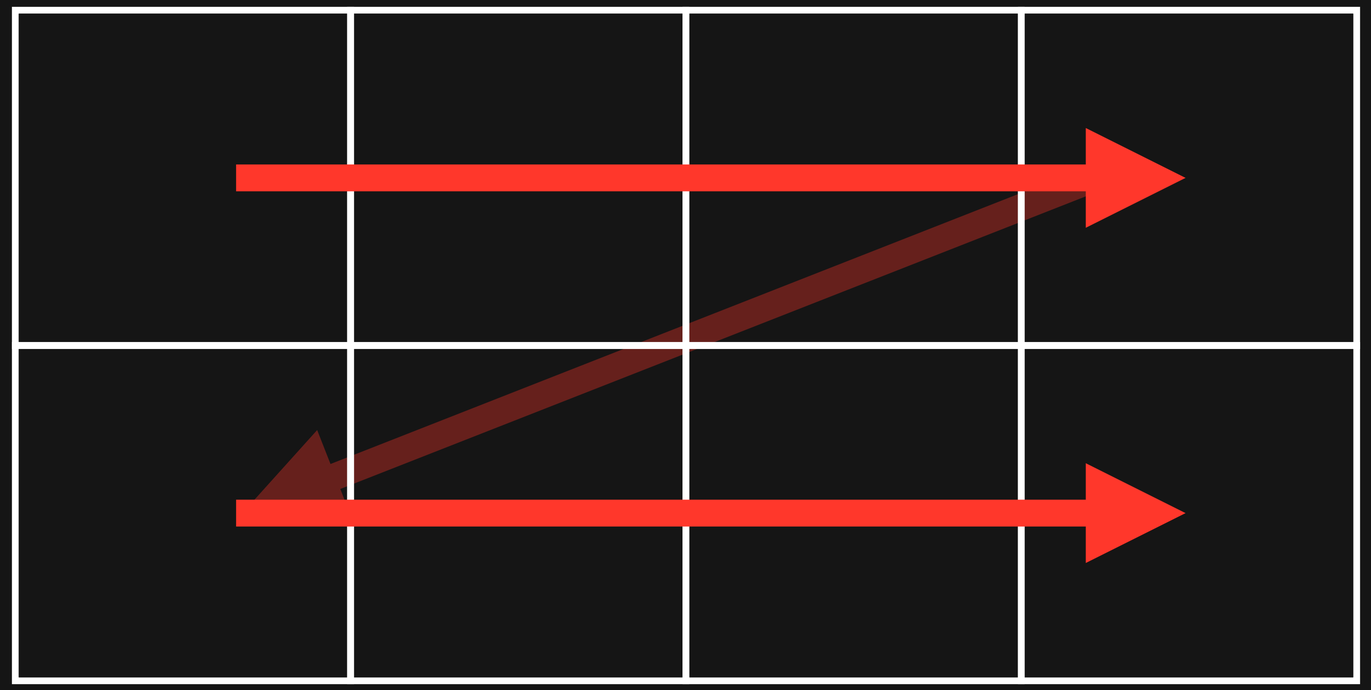


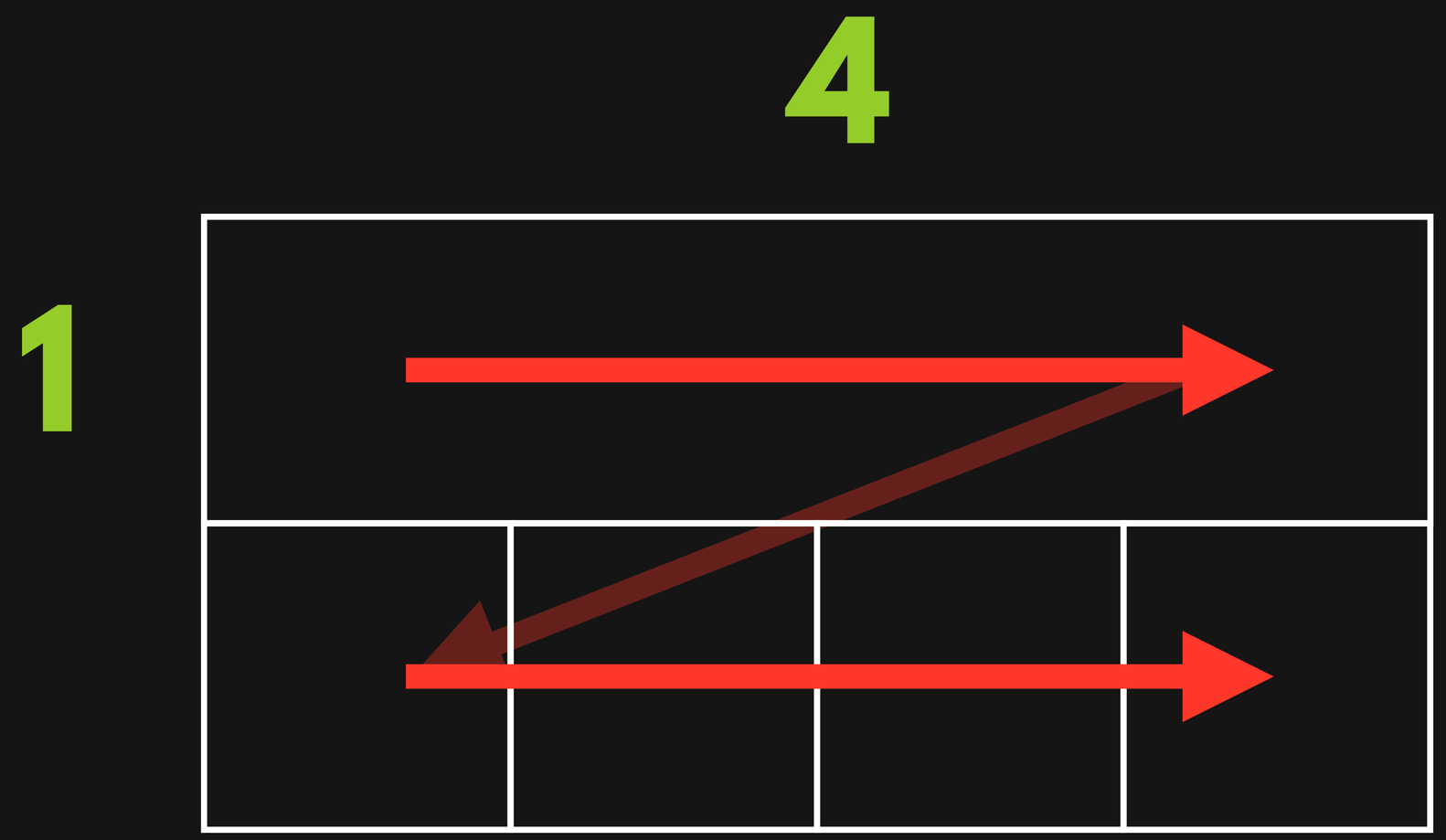


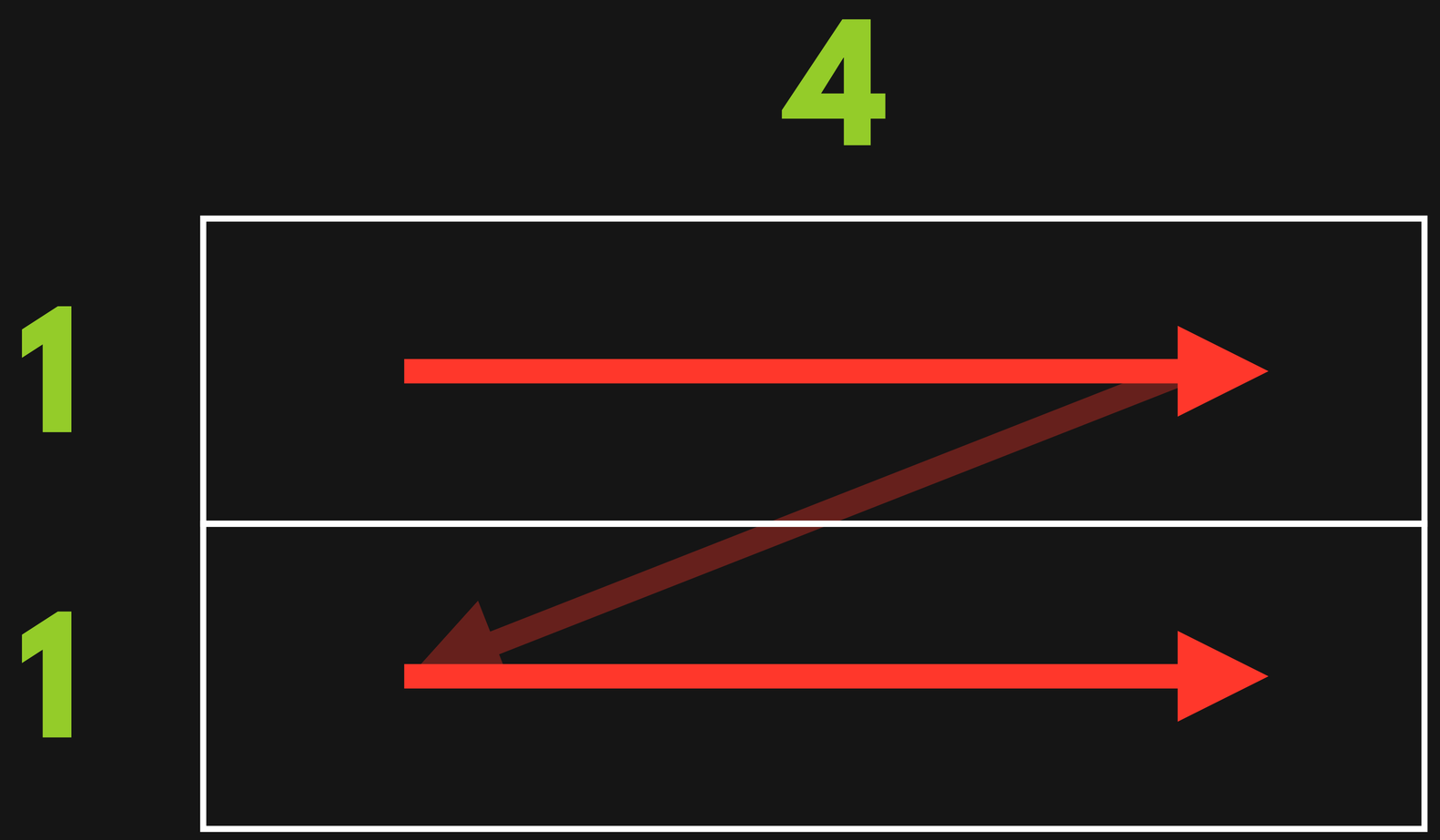


4 : 1 : 1

4

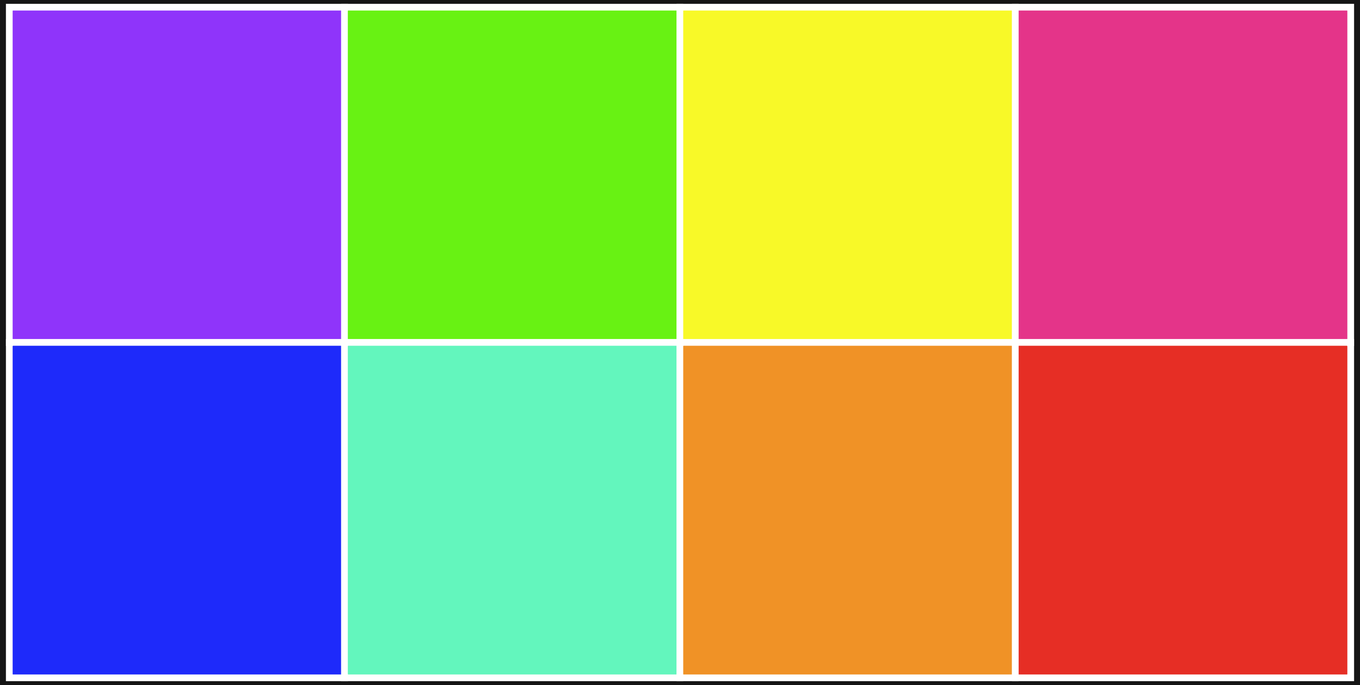


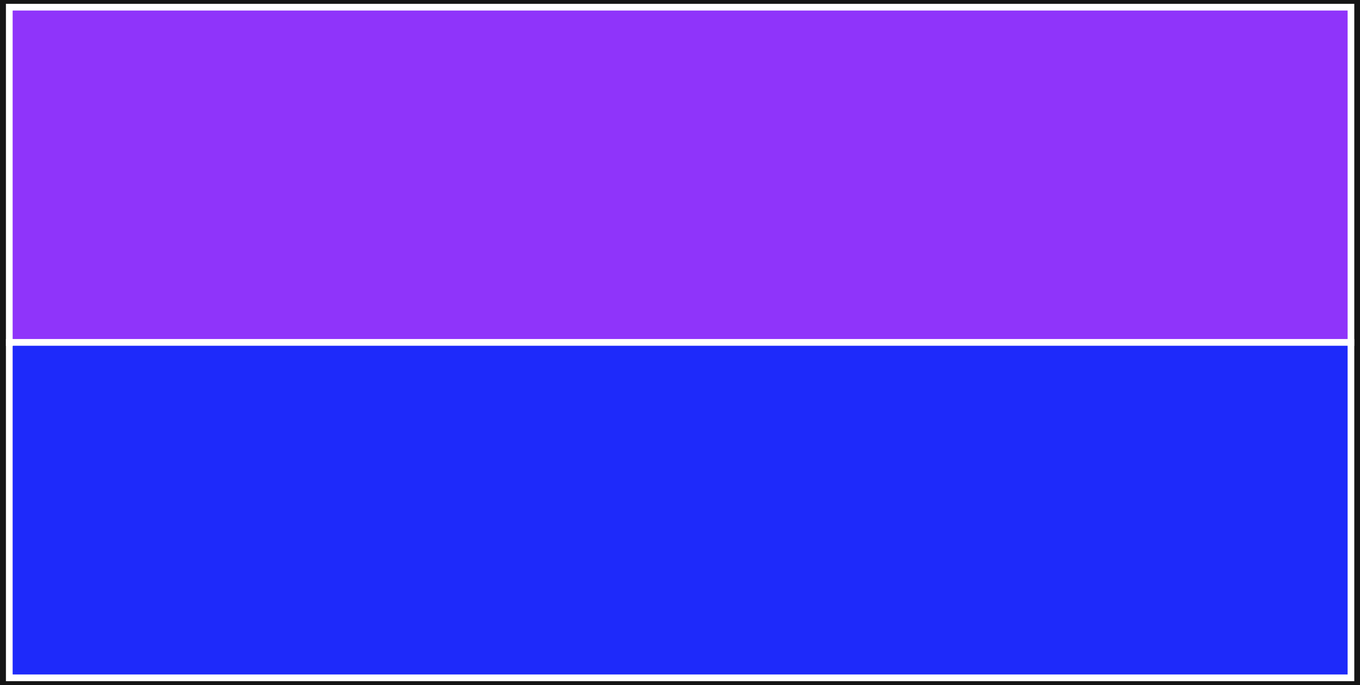

4
1

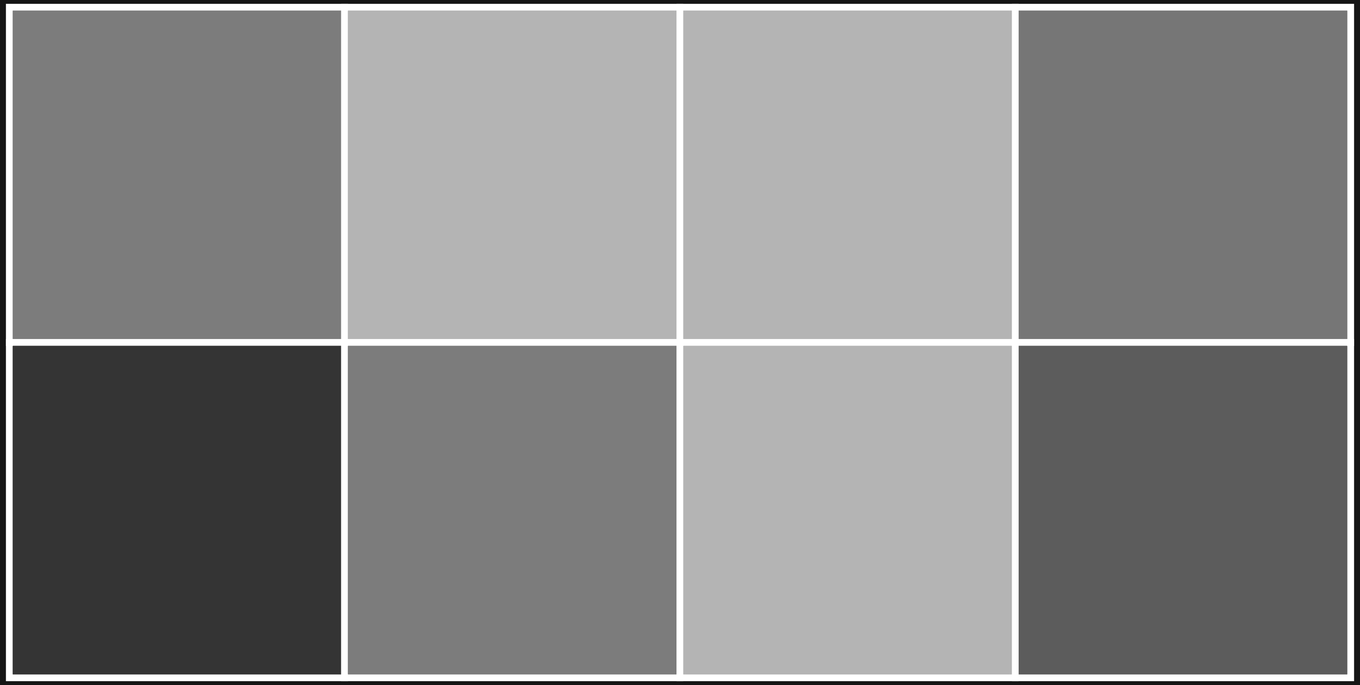


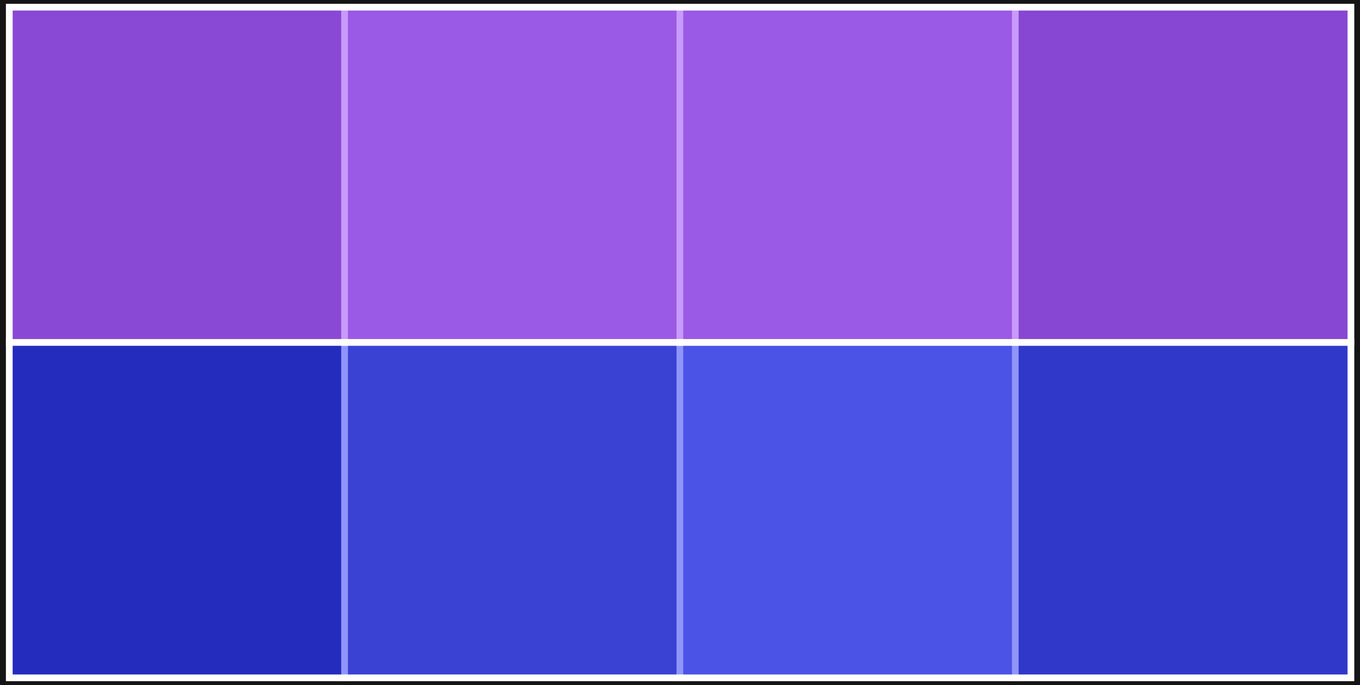
2 total

(75% savings)



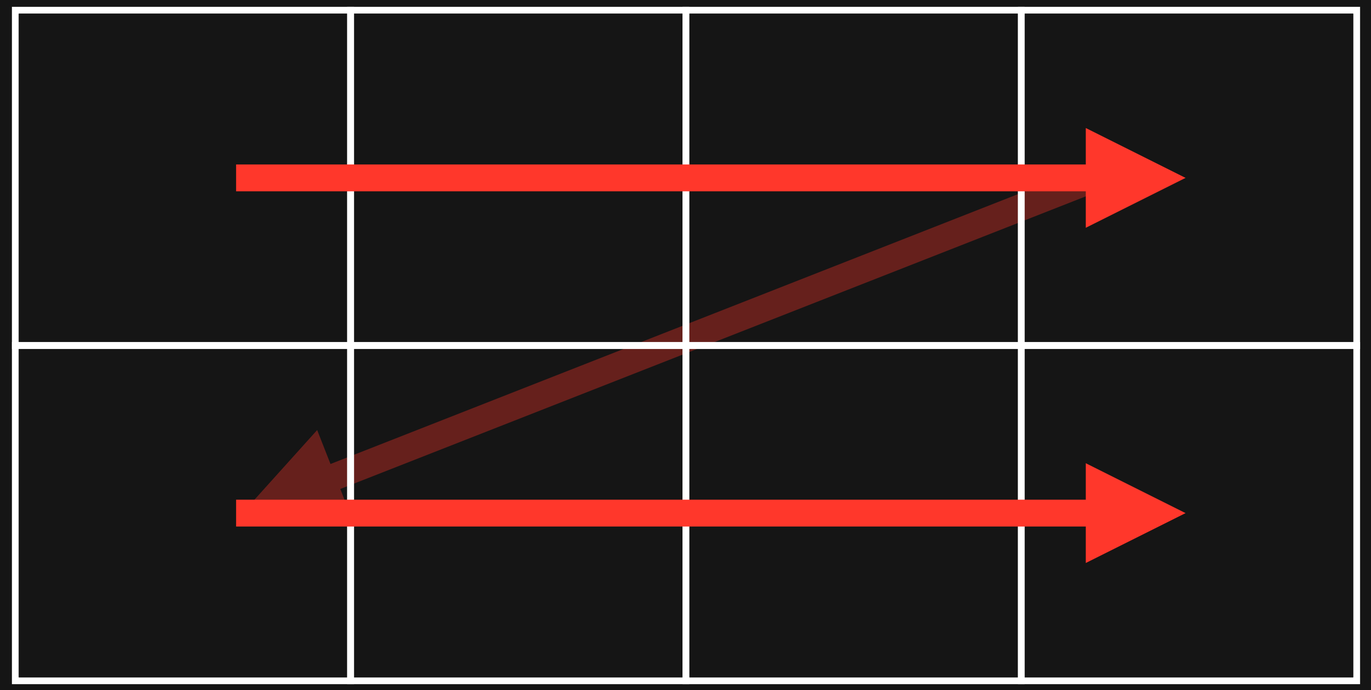


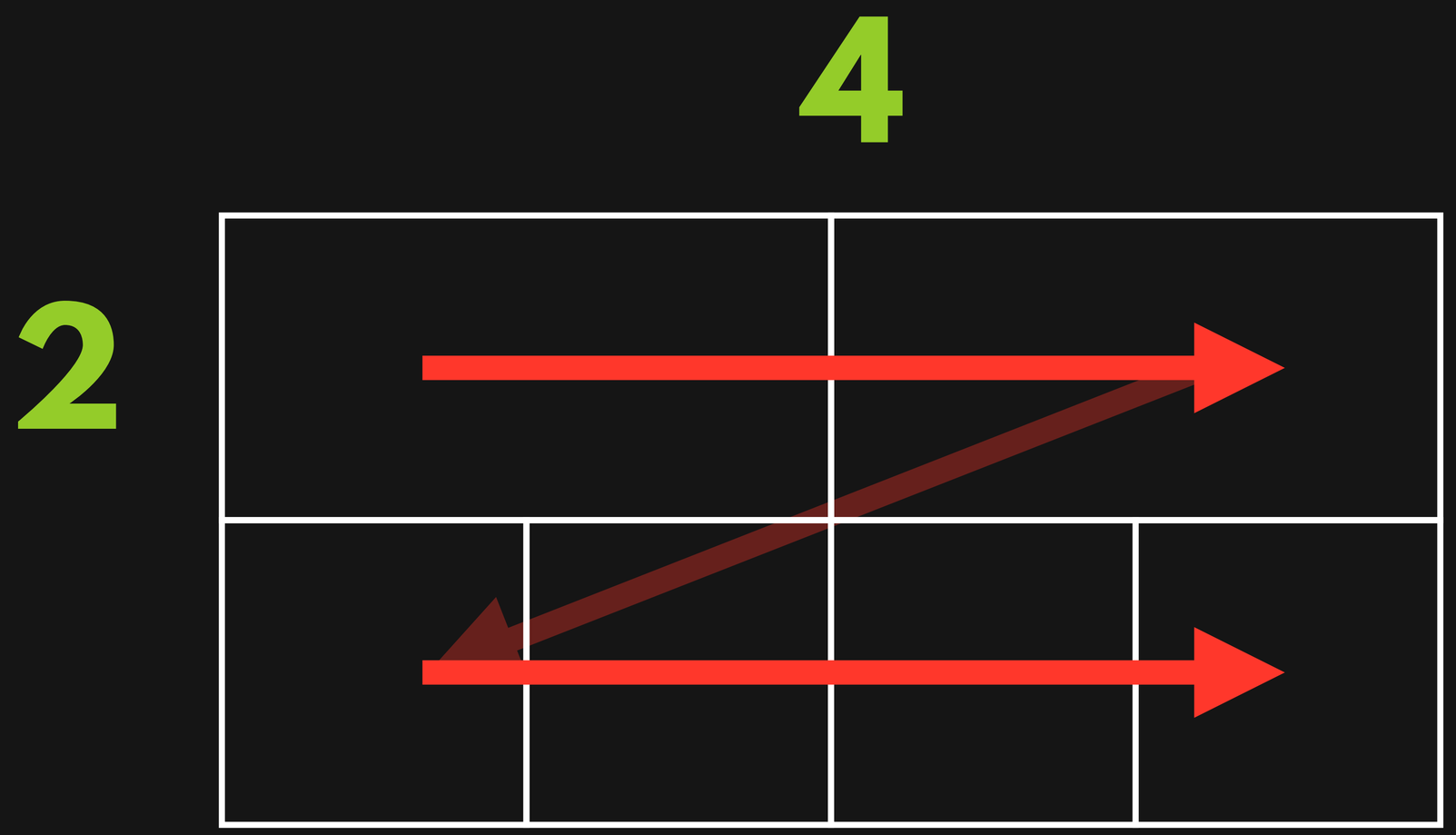


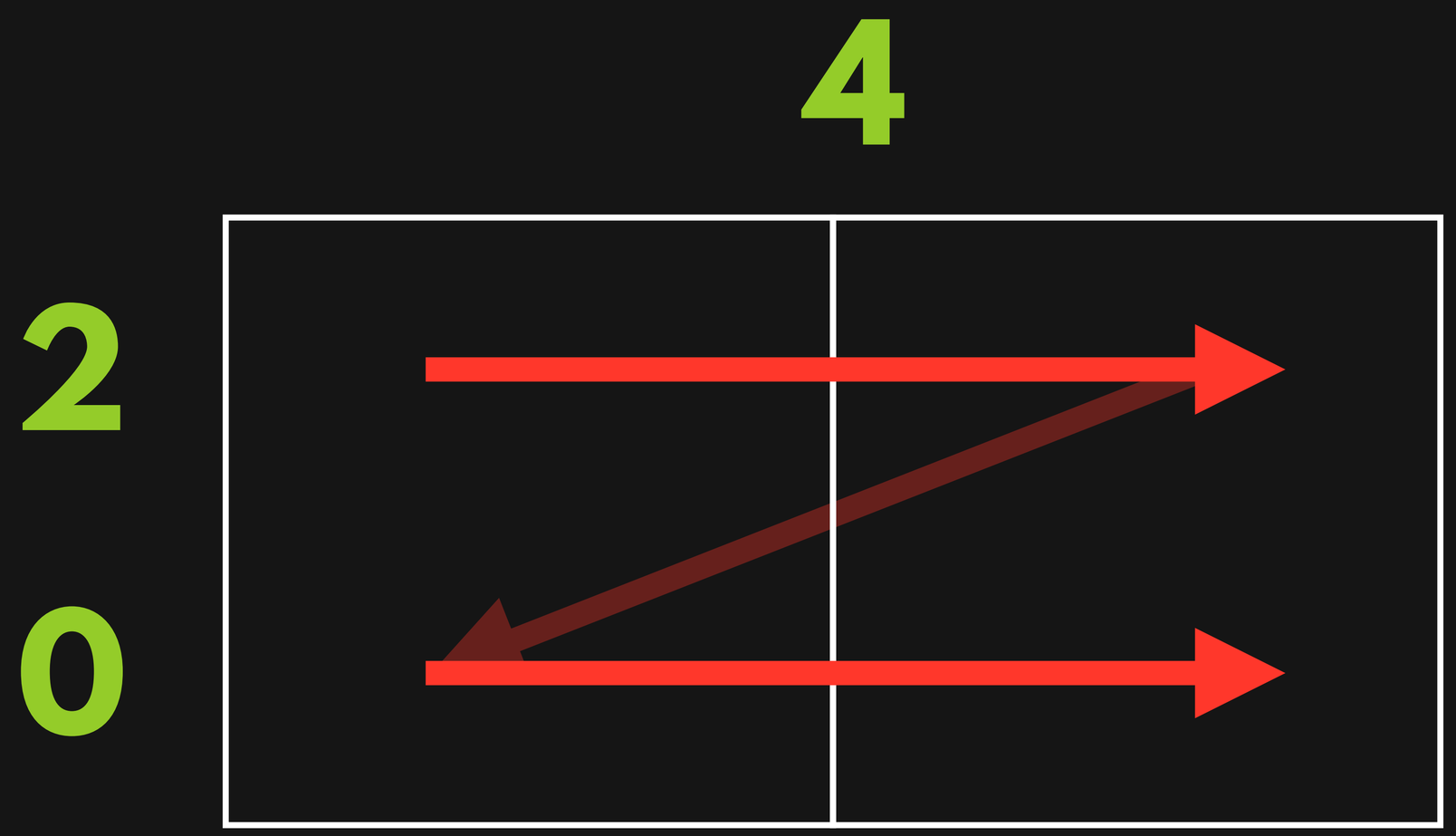


4 : 2 : 0

4

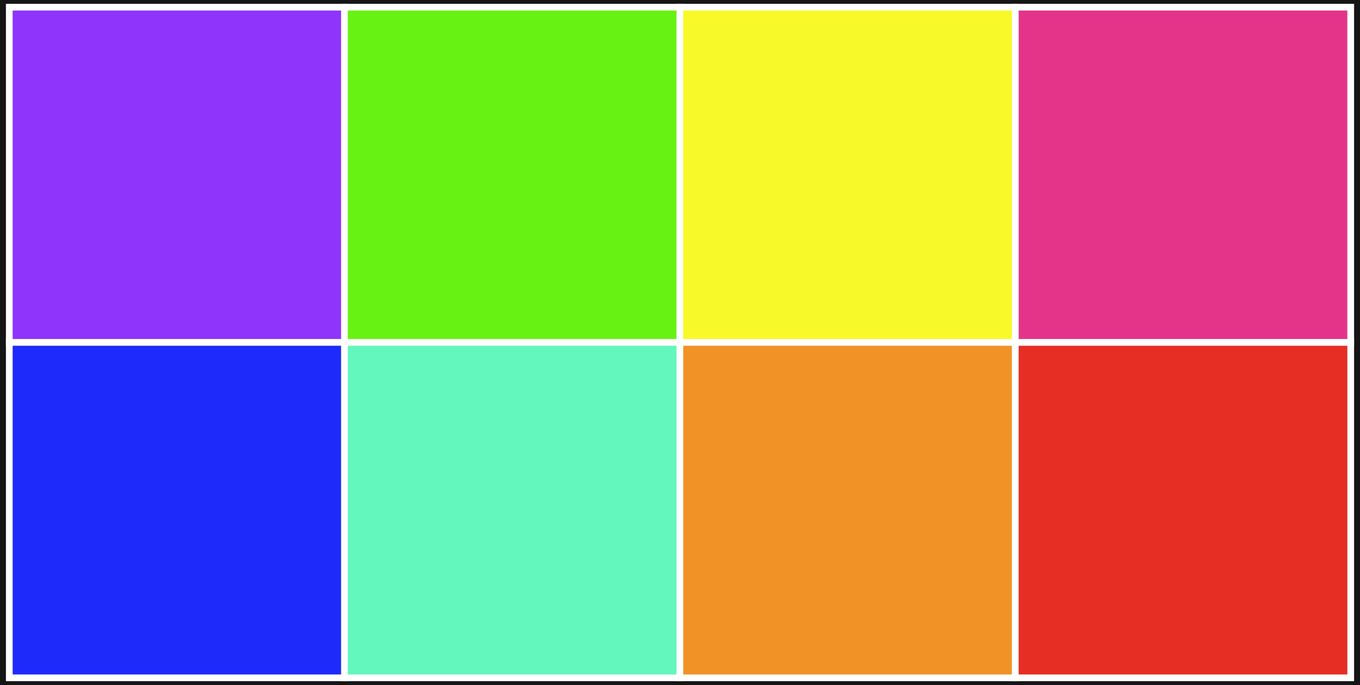


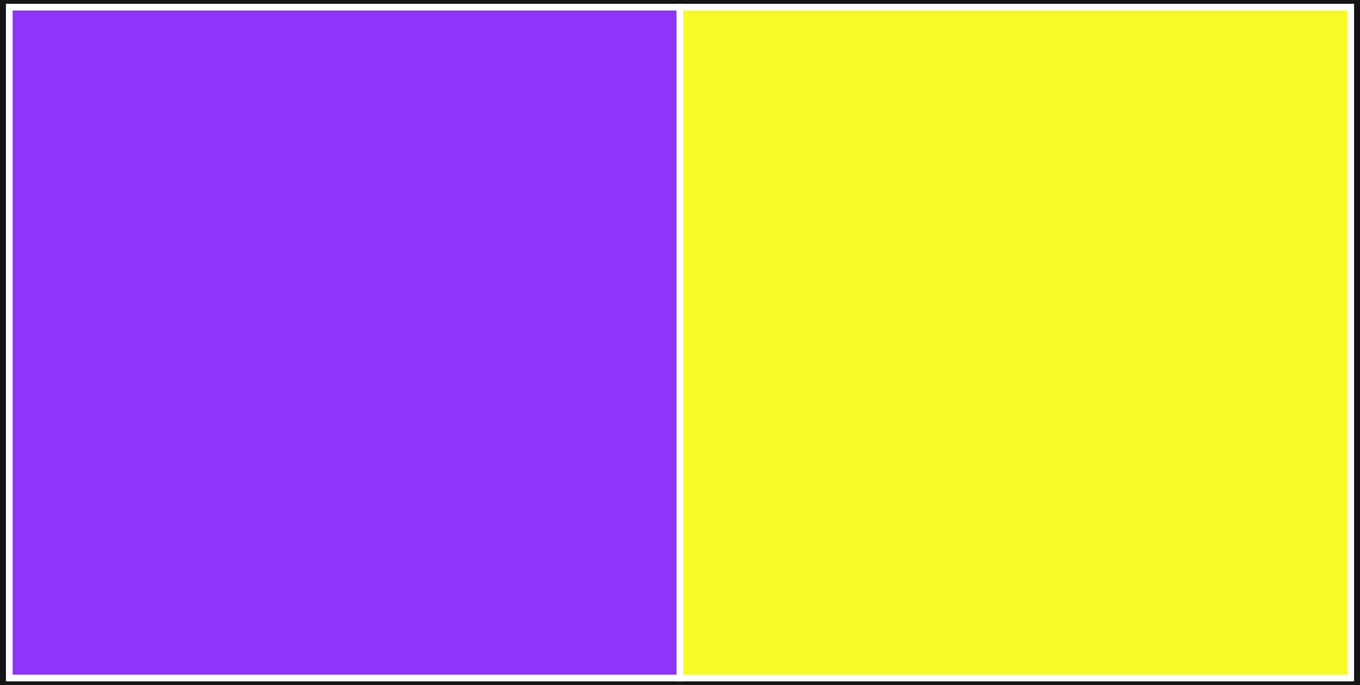

4
2

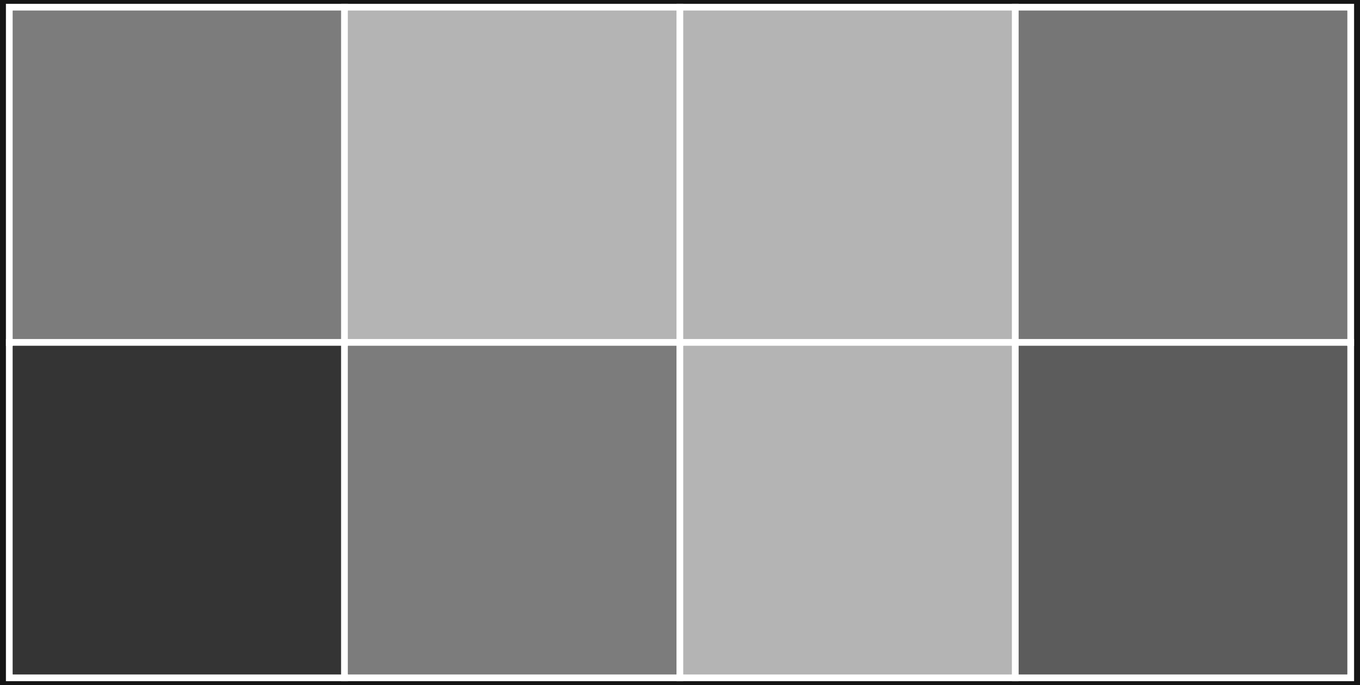


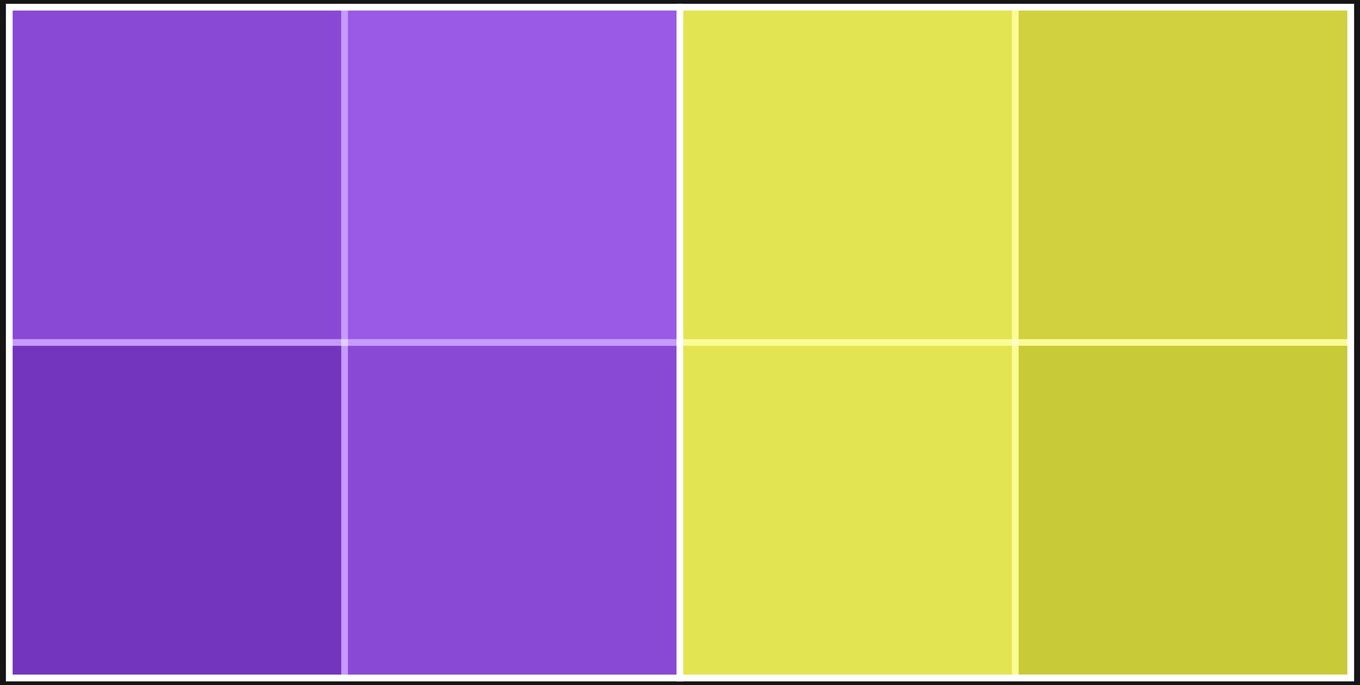
2 total

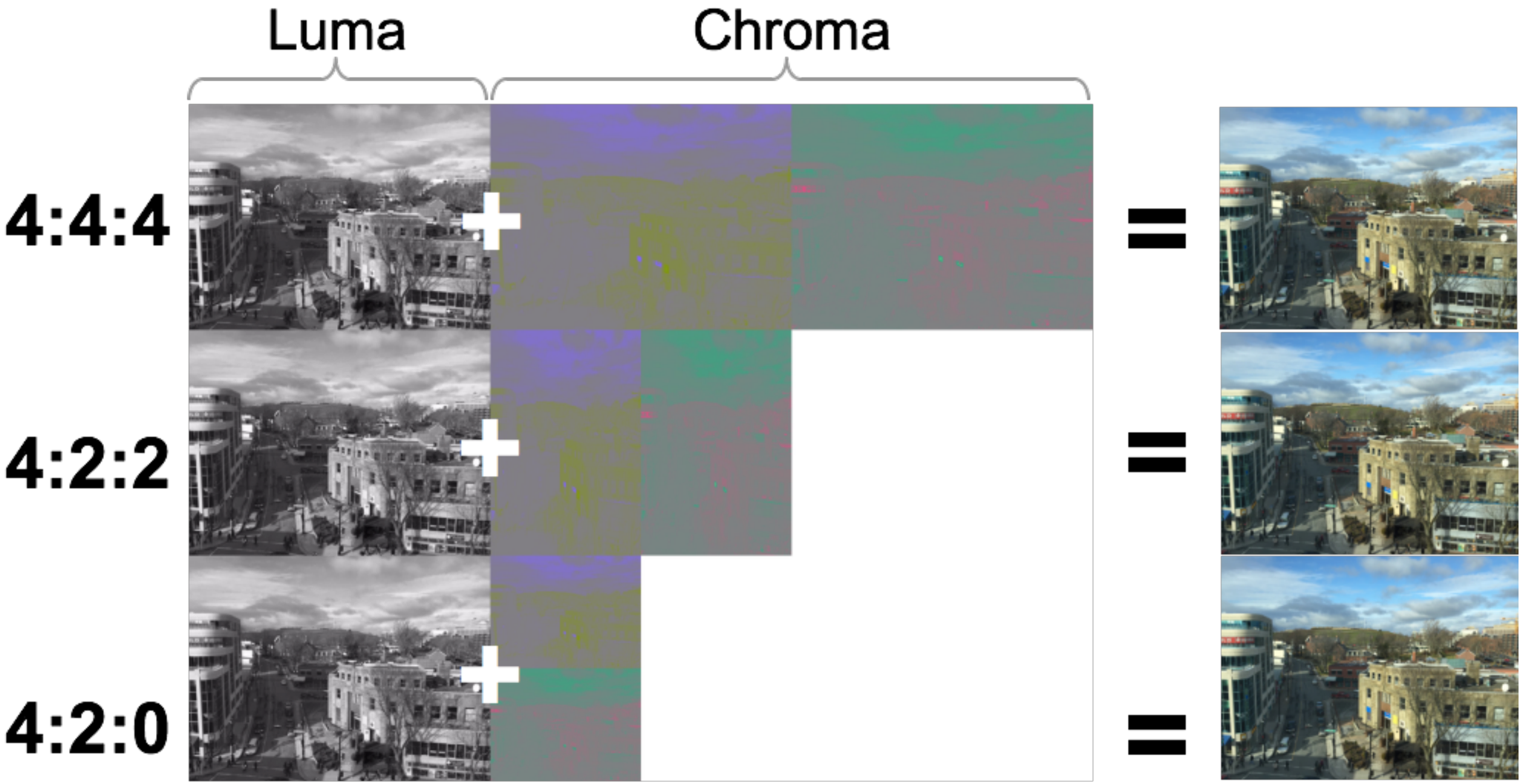
(75% savings)










Luma
Chroma
4:4:4
4:2:2
4:2:0

Request
Decode
Copy to GPU
Display

Request
Decode
Copy to GPU
Decode
Display

(W x H x 3)

-

(W x H x SUBSAMPLE_LEVEL x 2)

1300px x 1024px

RGBA	5,324,800
4:4:4	3,993,600
4:2:2	2,662,400
4:2:0	1,996,800

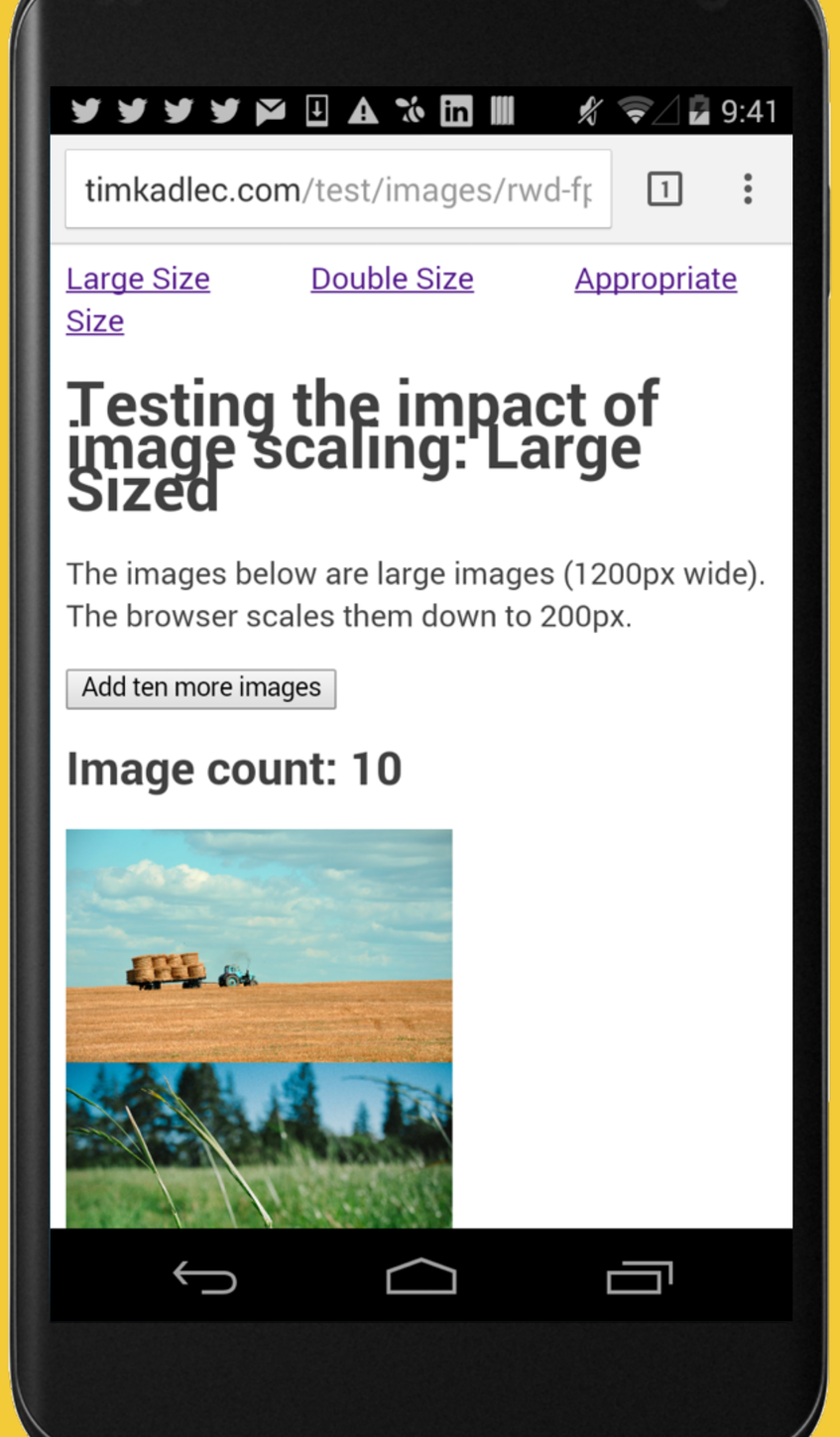
4:2:0

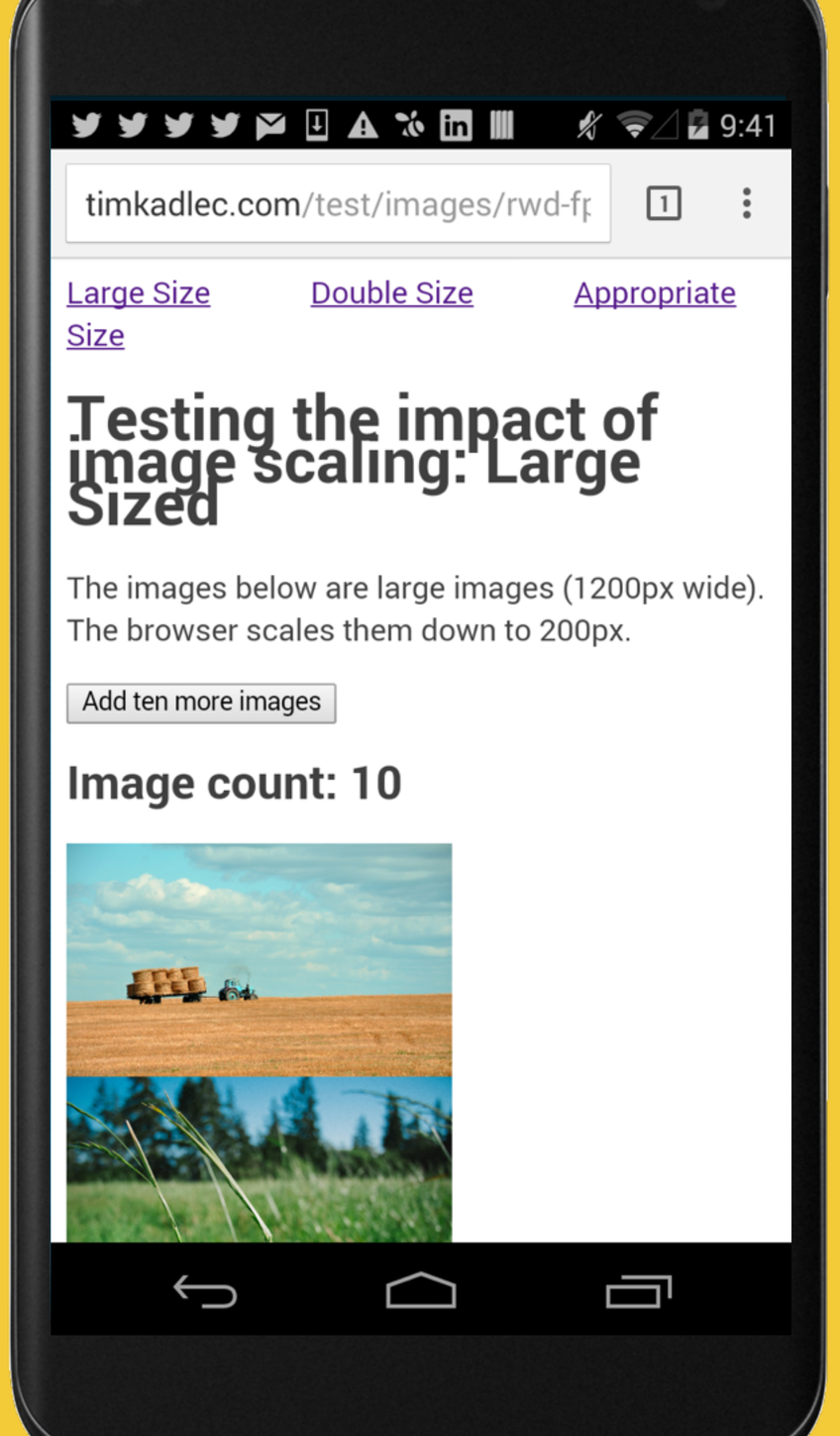
62.5%

memory savings

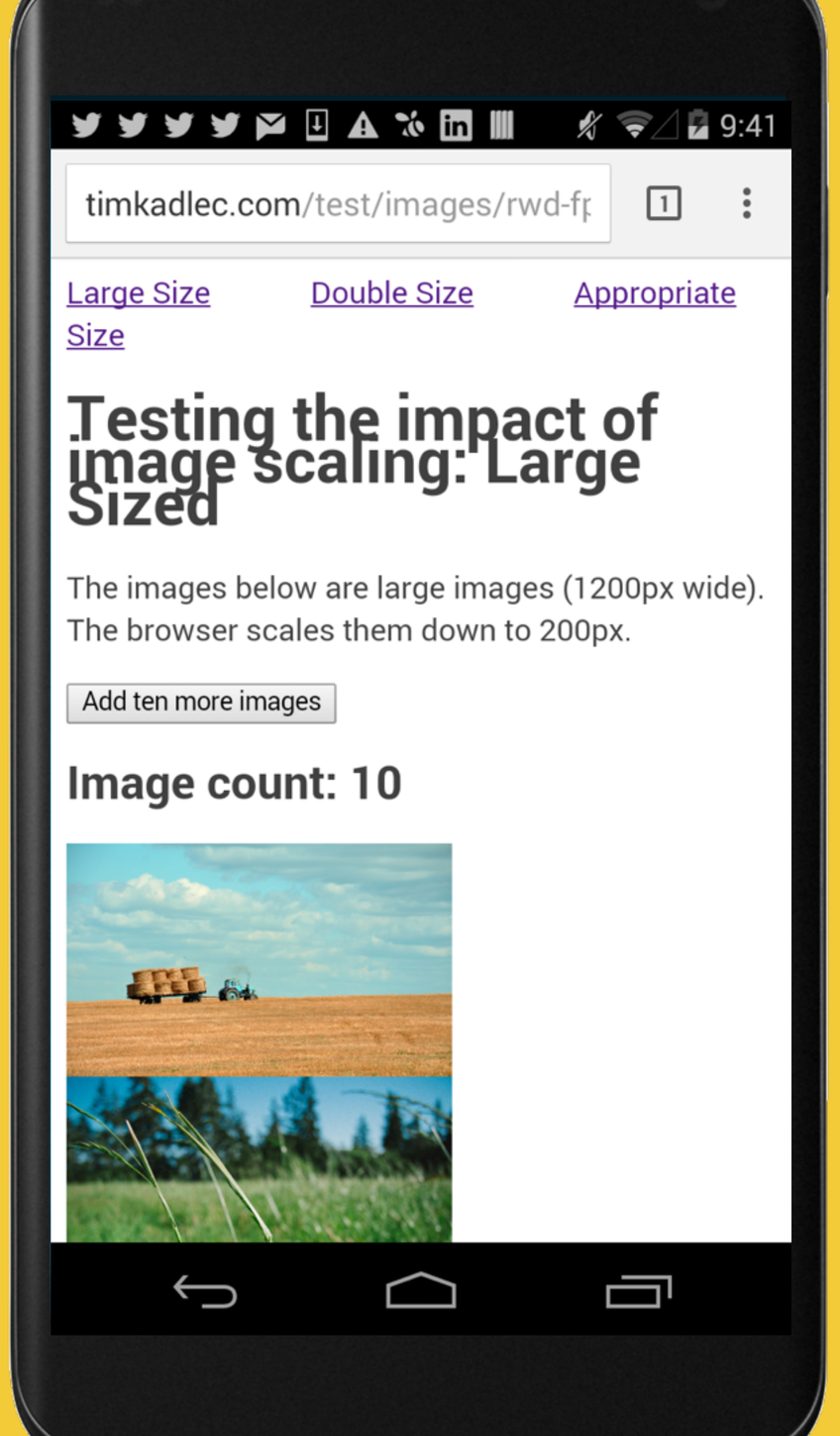
Source: http://time.com/3445111/#1

```html
<meta name="viewport"
      content="width=device-width,
               minimum-scale=1.0"
/>
```

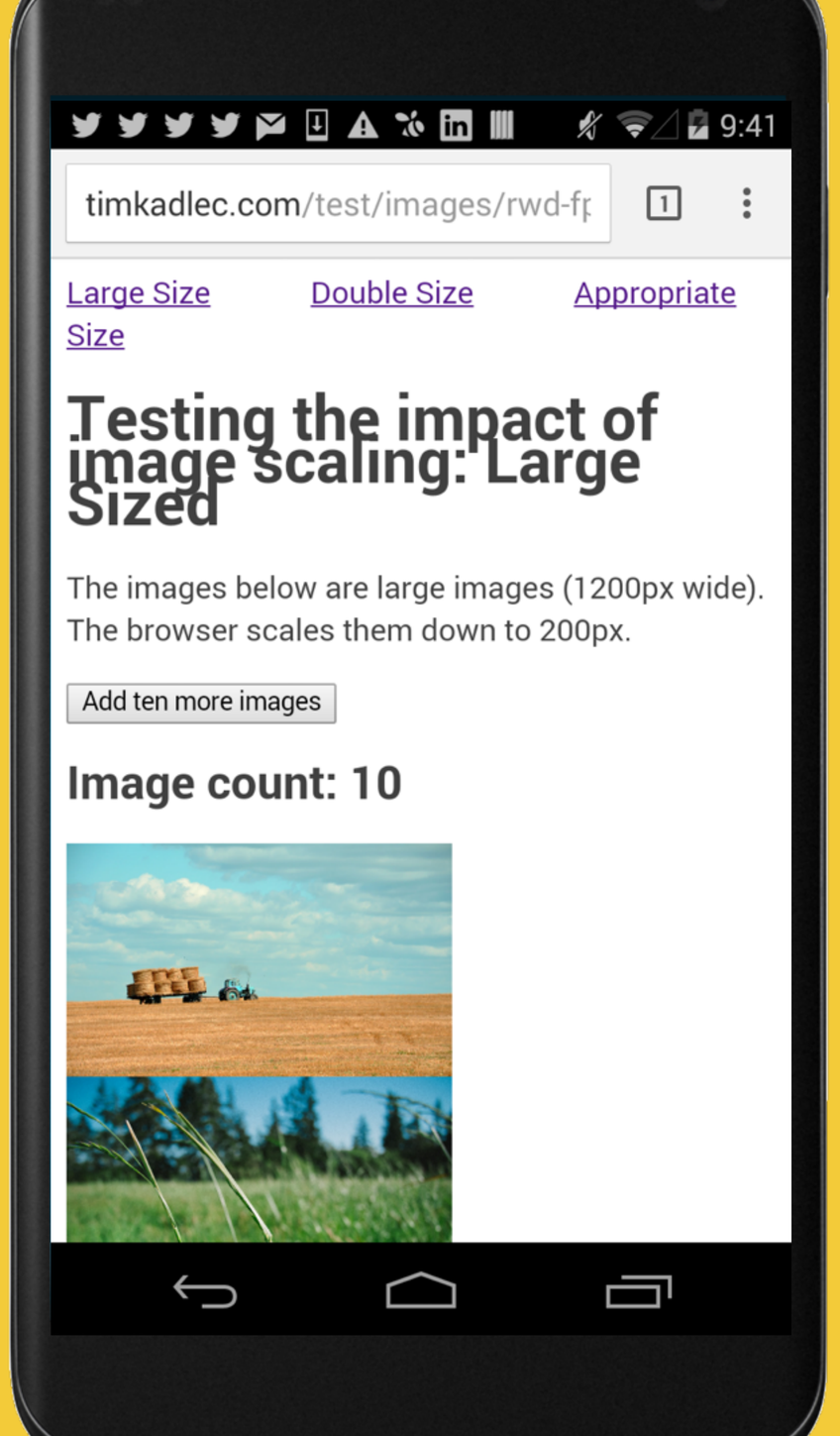

9:41
timkadlec.com/test/images/rwd-fr
Large Size
Double Size
Appropriate Size
Testing the impact of image scaling: Large Sized
The images below are large images (1200px wide). The browser scales them down to 200px.
Add ten more images
Image count: 10



Resized: 30.38ms

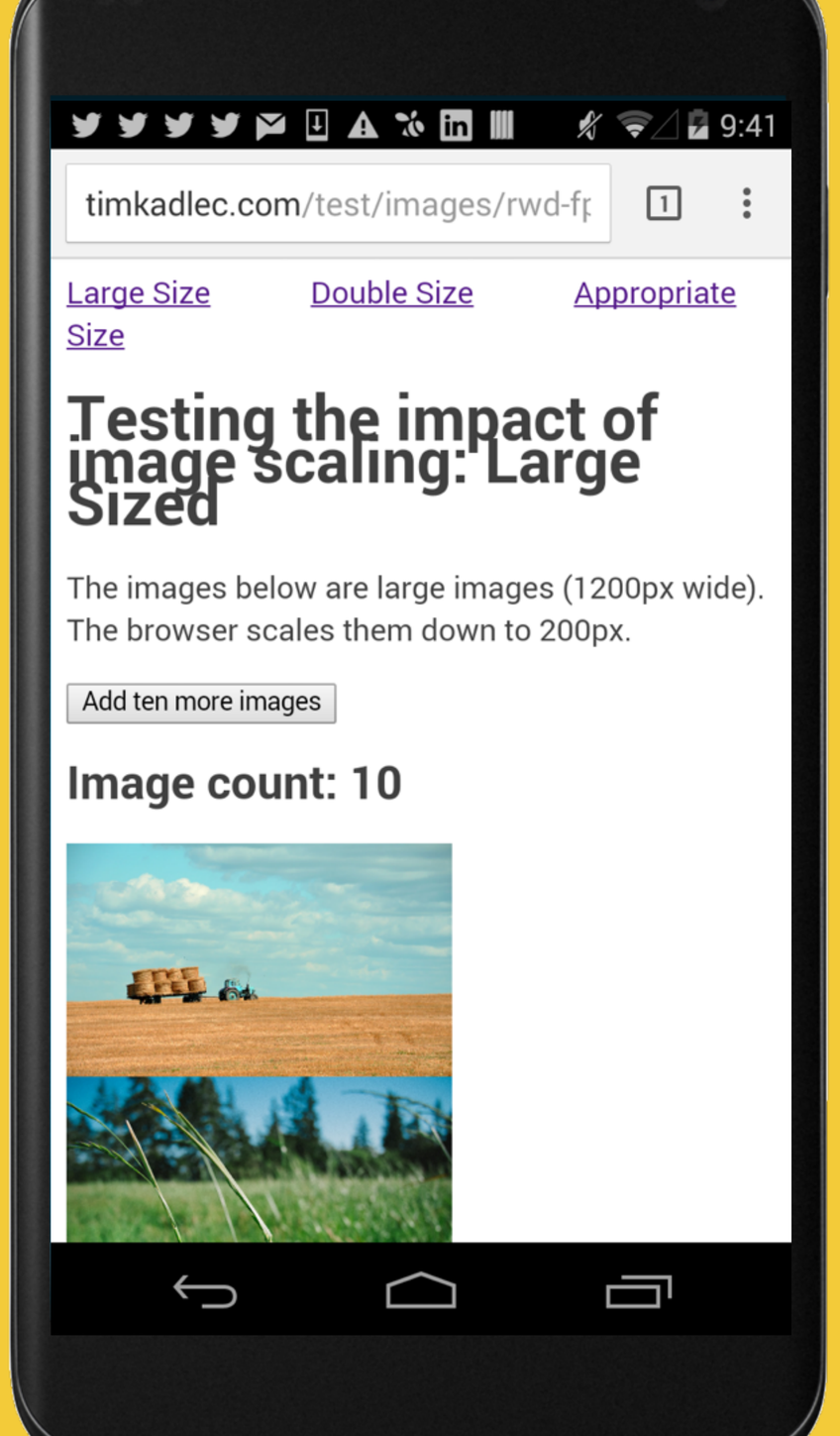


Resized: 5.62ms



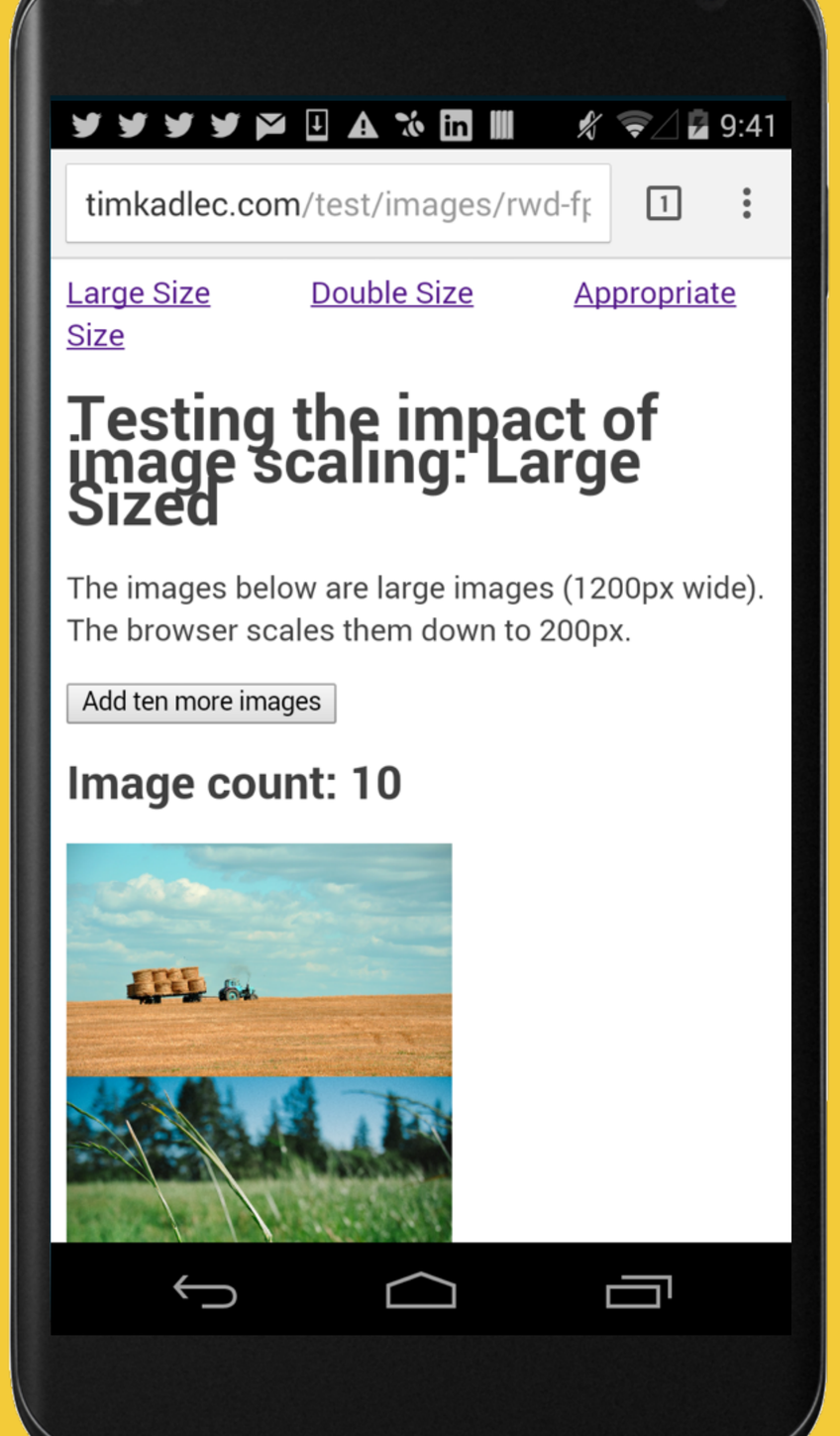
Resized: 5.62ms

Double: 102.77ms



Resized: 5.62ms

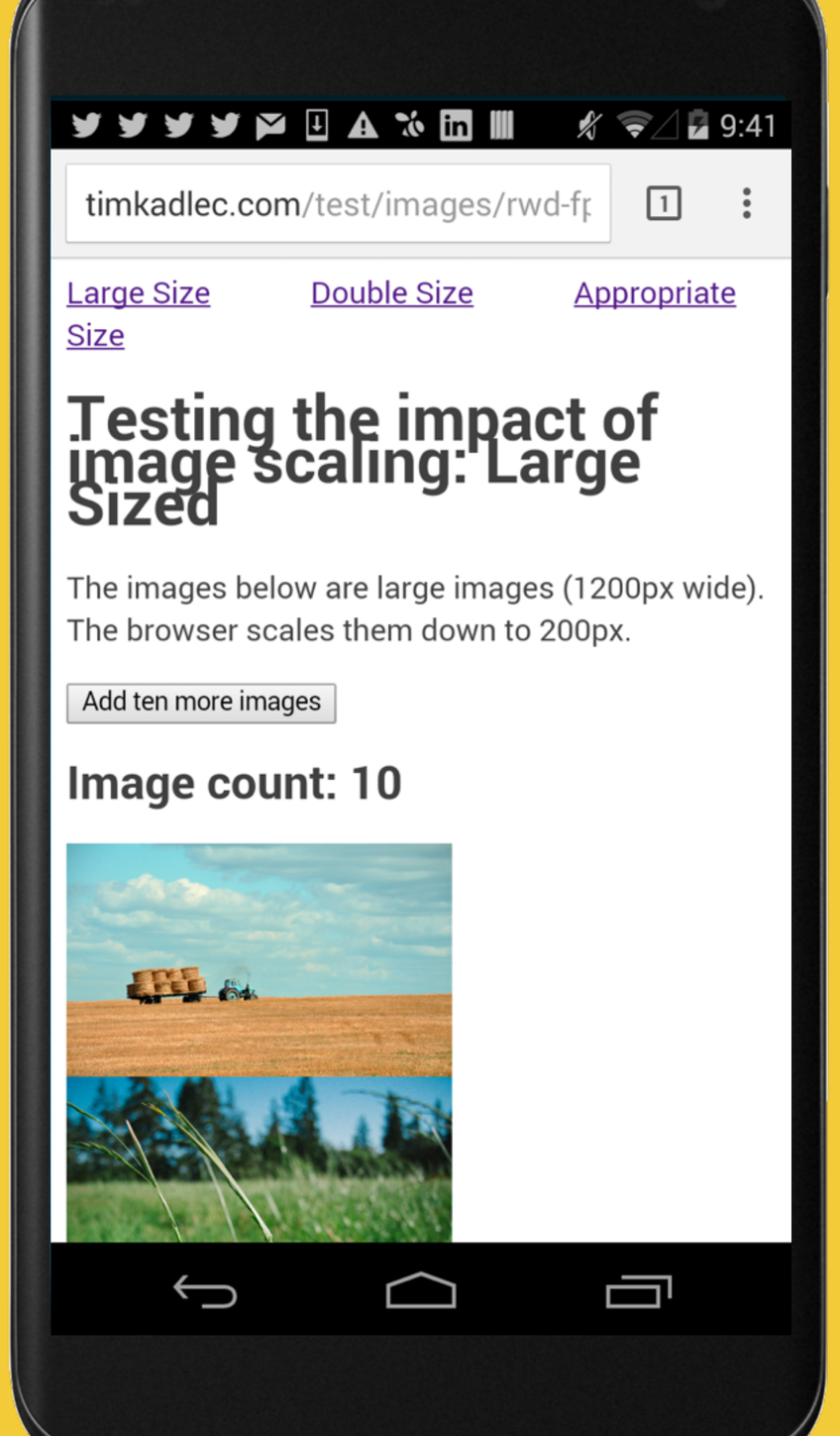
Double: 27.74ms



Resized: 5.62ms

Double: 27.74ms

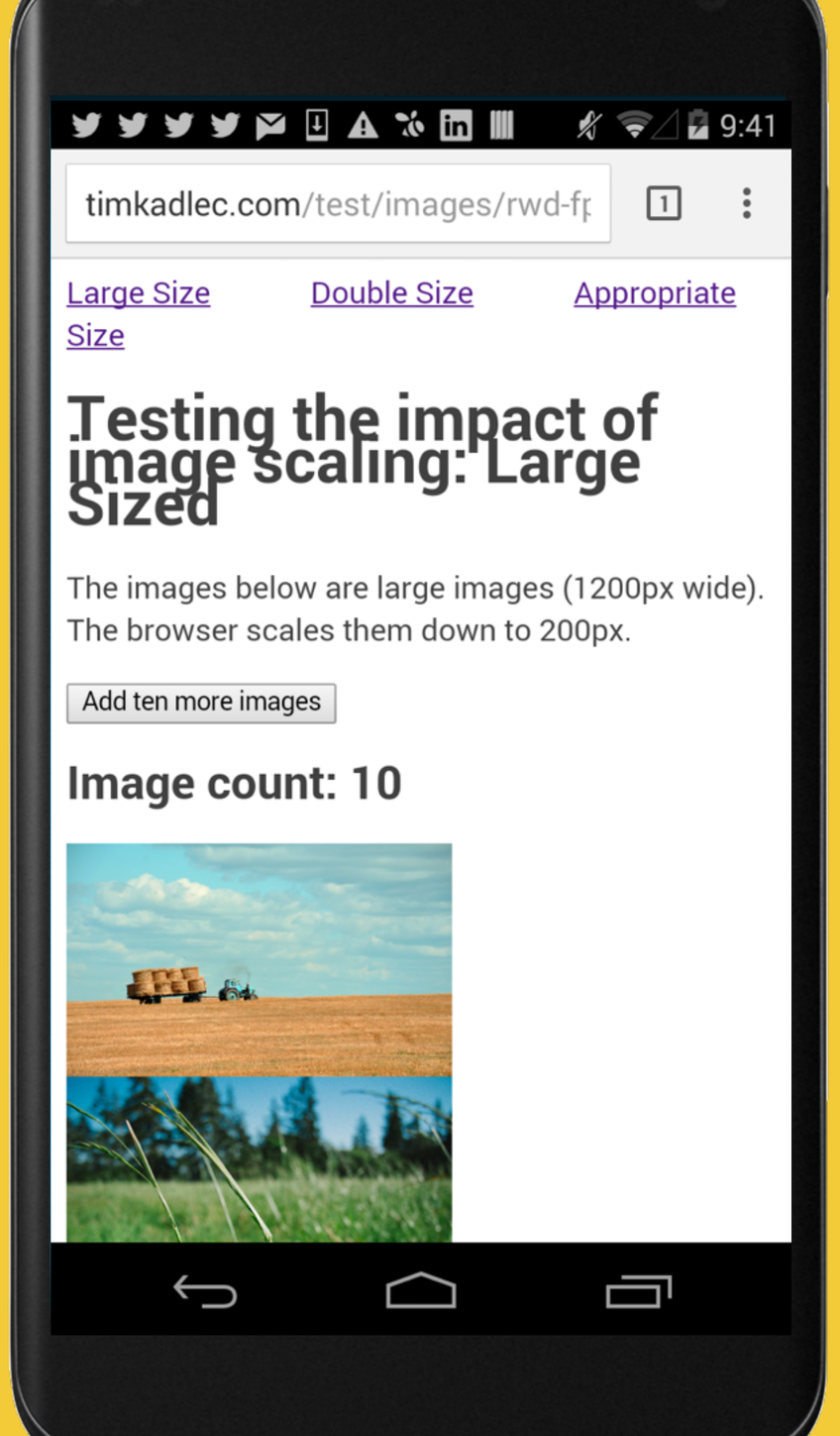
Large (6x): 1534.99ms



Resized: 5.62ms

Double: 27.74ms

Large (6x): 462.11ms



Resized: 5.62ms

Double: +393.6%

Large (6x): +8122.6%

THANK YOU!

Tim Kadlec (@tkadlec) & Pat Meenan (@patmeenan)

September 19-20, 2016 at Velocity Conference NY (#velocityconf)