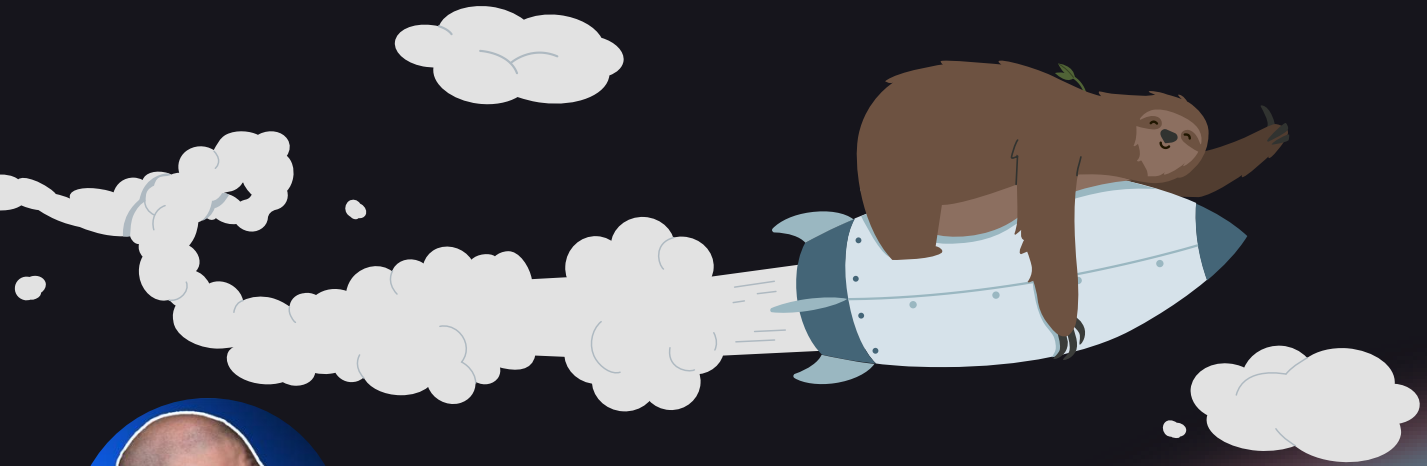
FUNDAMENTALS of Web Performance



Todd H. Gardner
Request Metrics

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Workshop Outline

~~1. Importance~~

~~2. Measuring~~

~~3. Tests and Tools~~

~~4. Setting Goals~~

5. Improving

~~Waterfall Charts~~

~~Flame Charts~~

~~Statistics~~

FUNDAMENTALS of
Web Performance

Improving Web Performance

FUNDAMENTALS of Web Performance

Todd H. Gardner

Improving Web Performance

First Things First

Focus on the easiest fixes for your worst metric from real user data.

Todd H. Gardner

Improving Web Performance

Last Things Never

You shouldn’t try to do everything.

Sometimes it’s fast enough.

Todd H. Gardner

Improving Web Performance

The Secret of Performance

Do. Fewer. Things.

Todd H. Gardner

Workshop Outline

Improving

- **Improving TTFB**
- Improving FCP
- Improving LCP
- Improving Returning Experience
- Improving CLS
- Improving INP

Improving Time to First Byte TTFB

Todd H. Gardner

Improving Web Performance

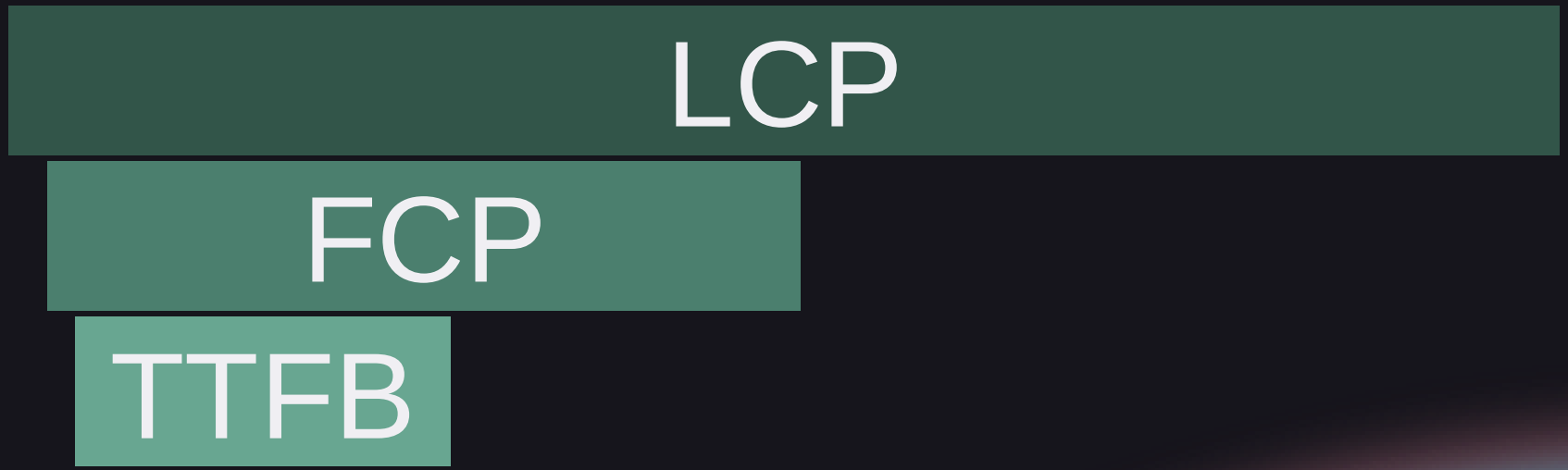
Time to First Byte

How quickly your host **responds**.

Todd H. Gardner

Improving Web Performance

Time to First Byte



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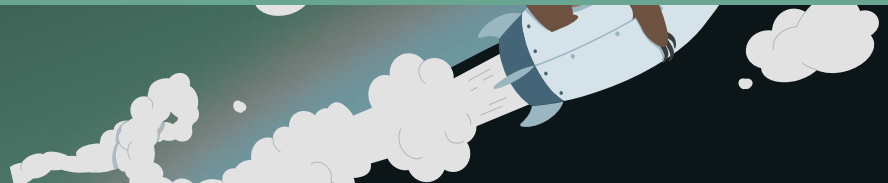
Baseline TTFB

Hosted DevStickers

http://eu.devstickers.shop:3000/

- Chrome Throttling
- Chrome Performance Profile



Do you need to worry about this?

TTFB

Time To First Byte

Check your RUM or CrUX p75 Data

Source: [web.dev](web.dev)

Tactics

1. Compress HTTP Responses
2. Efficient Protocols
3. Host Capacity
4. Host Proximity

1. Compress HTTP Responses

Reduce the size of plain text

HTML, CSS, JavaScript

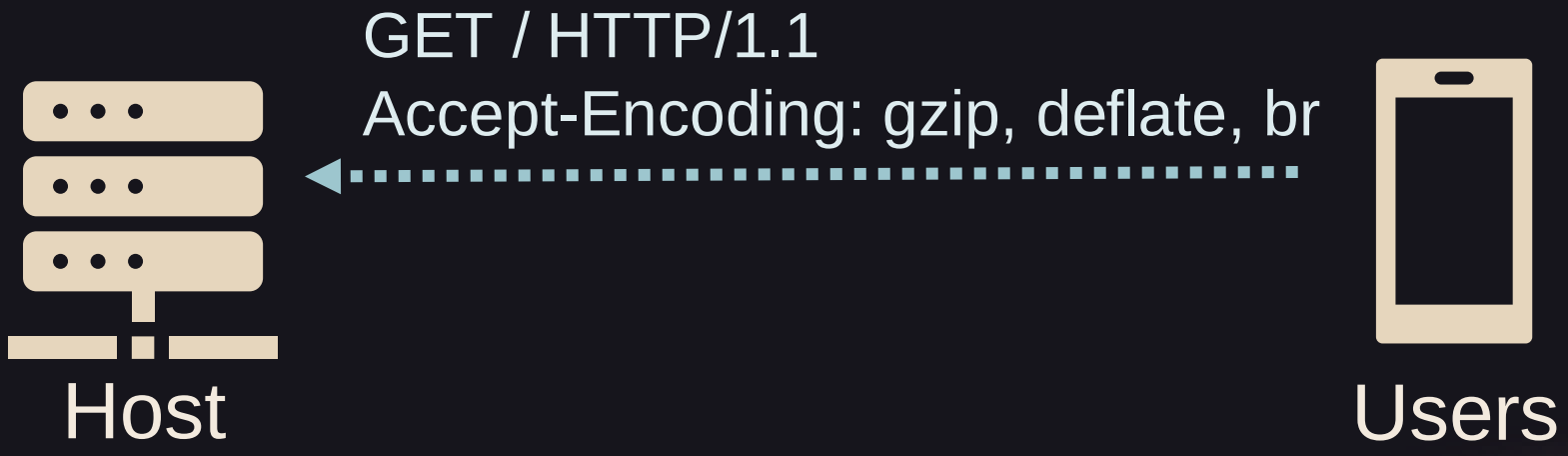
Todd H. Gardner

GZip and Brotli

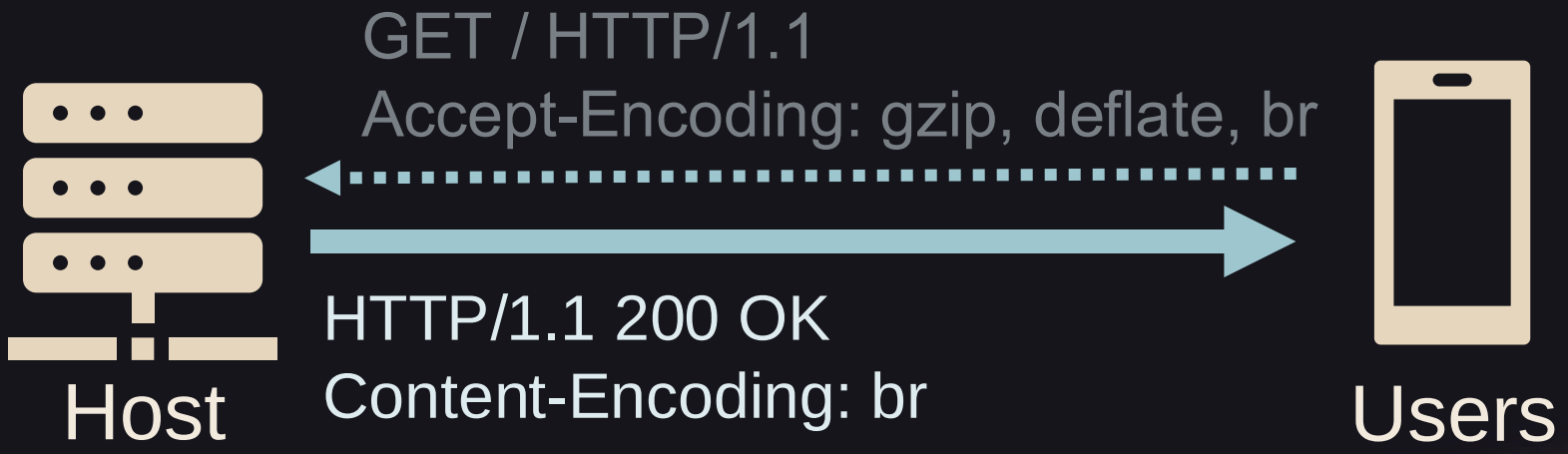
	Uncompressed	Gzip (6)	Brotli (6)
HTML Document	1112 KB	282.9 KB 25%	20.6 KB **1.7%**
CSS File	197.5 KB	31.1 KB 16%	28.4 KB **14%**
JavaScript File	89.5 KB	30.8 KB 34%	30.1 KB **34%**

Source: CoralNodes

Content Encoding



Content Encoding

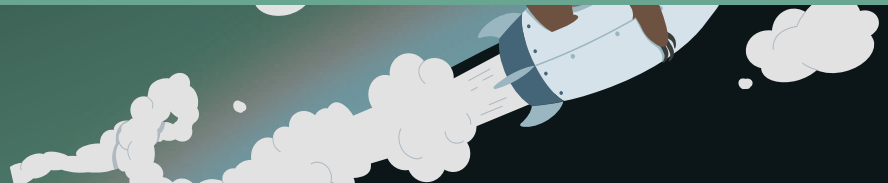


Enable Compression

Local DevStickers

http://localhost:3000/

- server/performance-config.js



2. Efficient Protocols

HTTP/1.1

HTTP/2

HTTP/3

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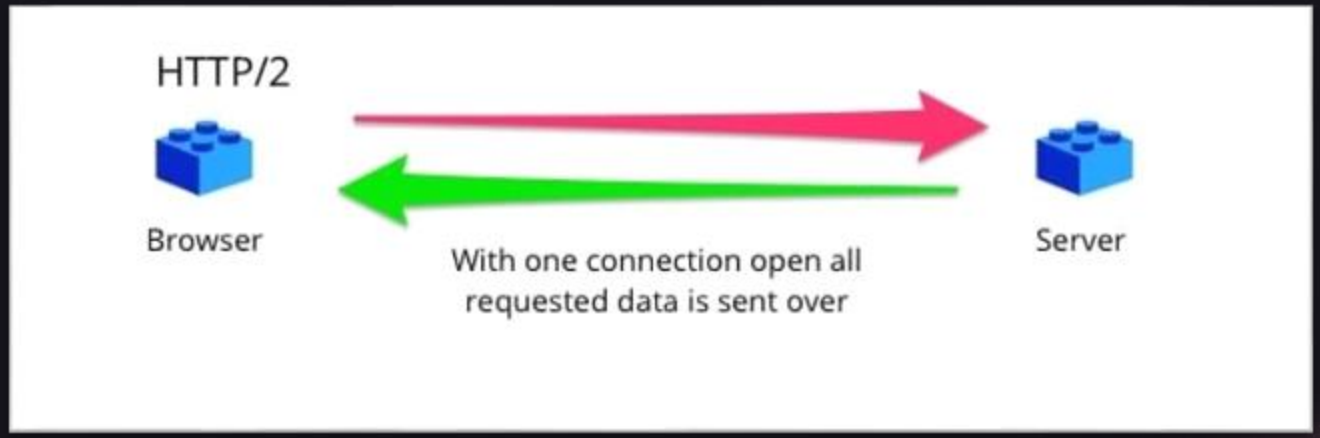
HTTP/1.1

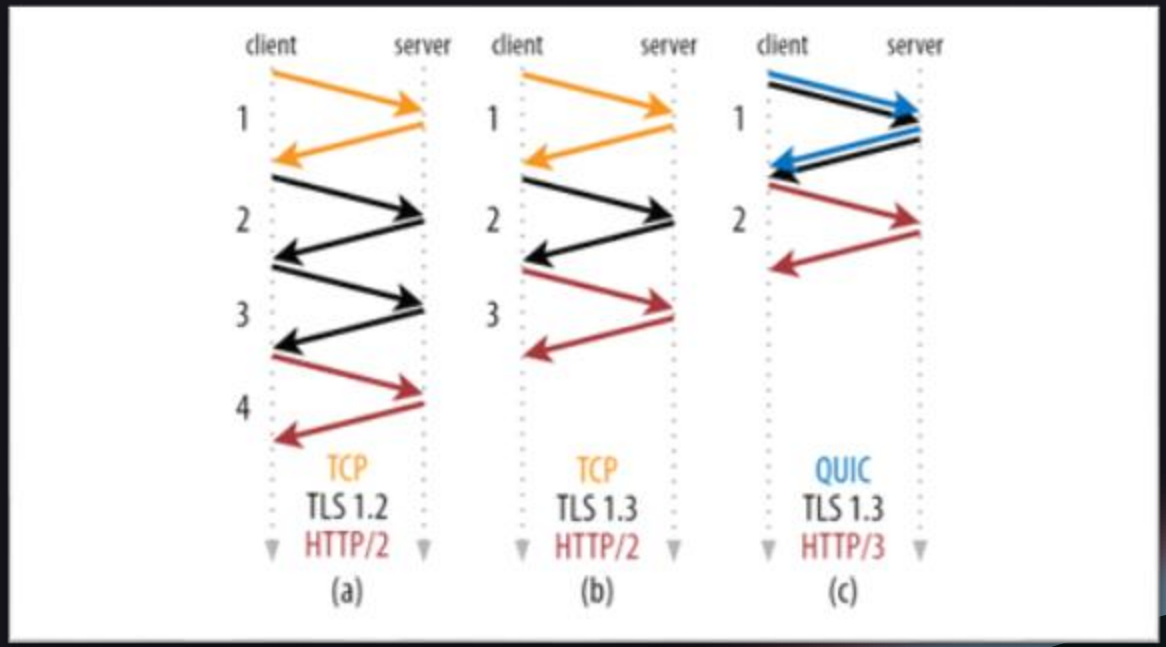
Source: Yoast

HTTP/2



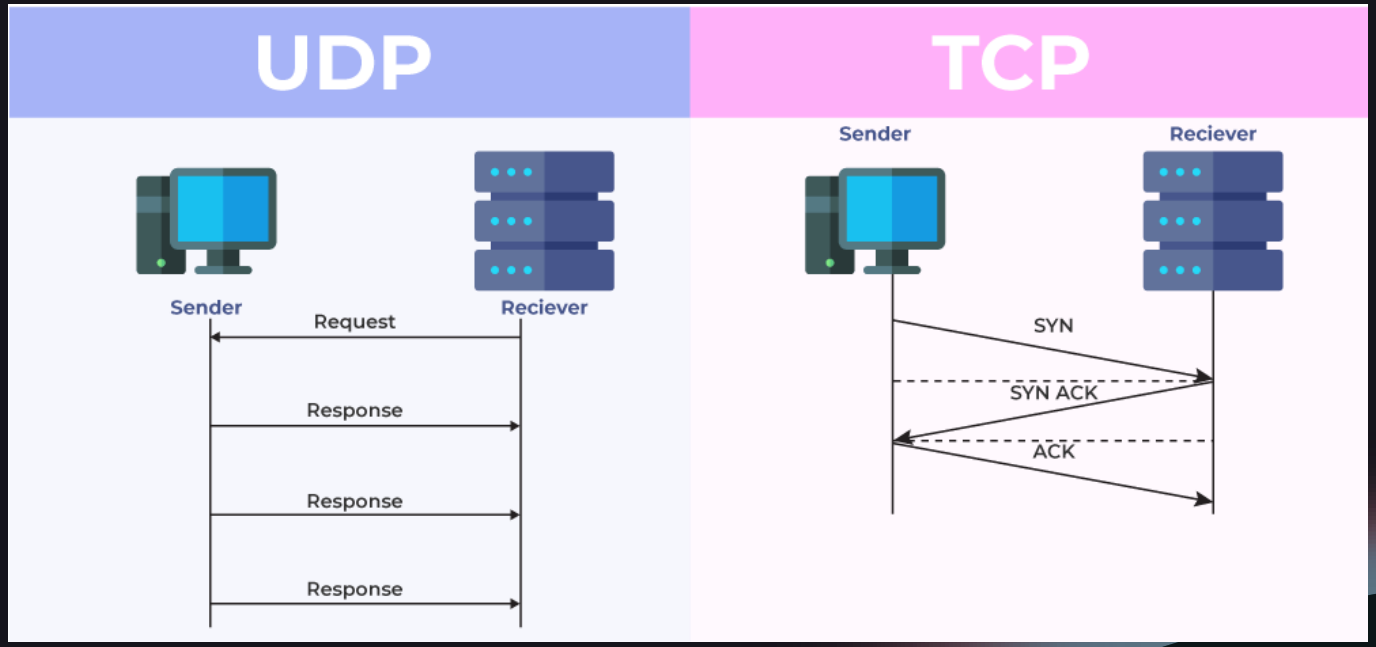
Source: Yoast

HTTP/3



Source: Smashing

TCP vs UDP

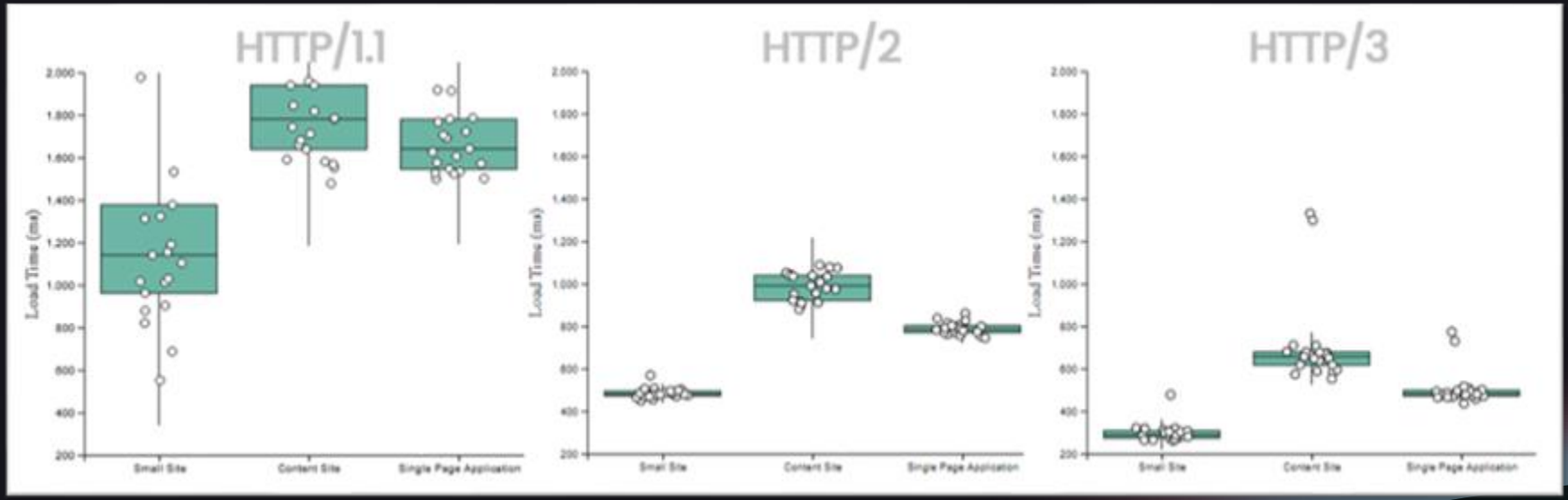


Source: GeeksForGeeks

I have a UDP joke…

… but you might not get it.

Comparing Protocols



Source: Request Metrics

HTTP/3 Drawbacks

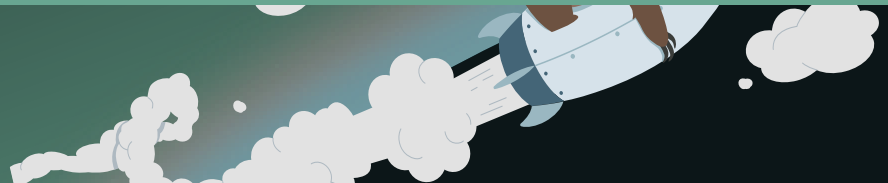
- Require HTTPS (so does HTTP/2)
- UDP Networking
- Difficult to Debug (curl)

Try HTTP/3

Proxied DevStickers

https://eu.devstickers.shop/

- H3 Protocol
- H2 via chrome://flags/
- Caddy



3. Host Capacity

Right-size your host for your workload

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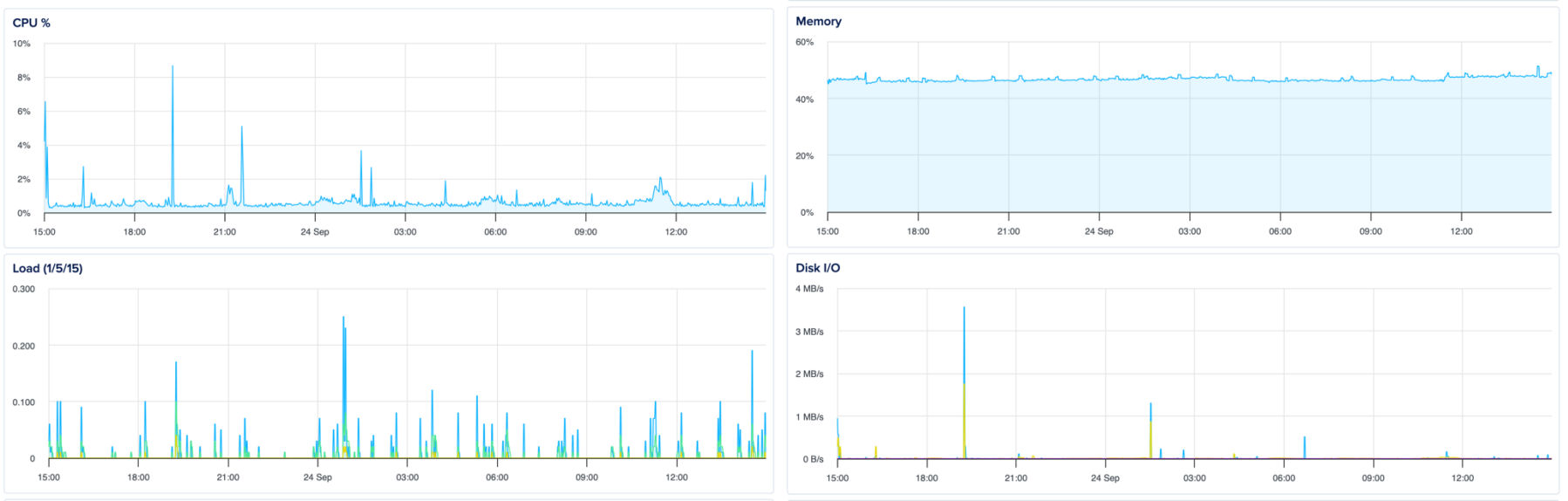
3. DigitalOcean Metrics

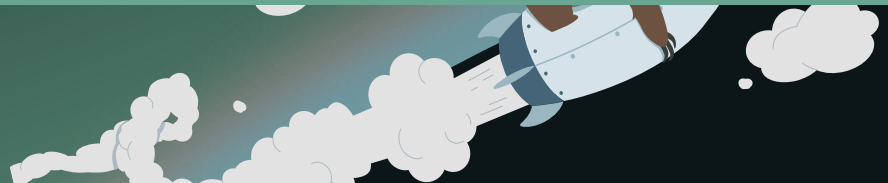


Remove Artificial Delay

Local DevStickers

http://localhost:3000/

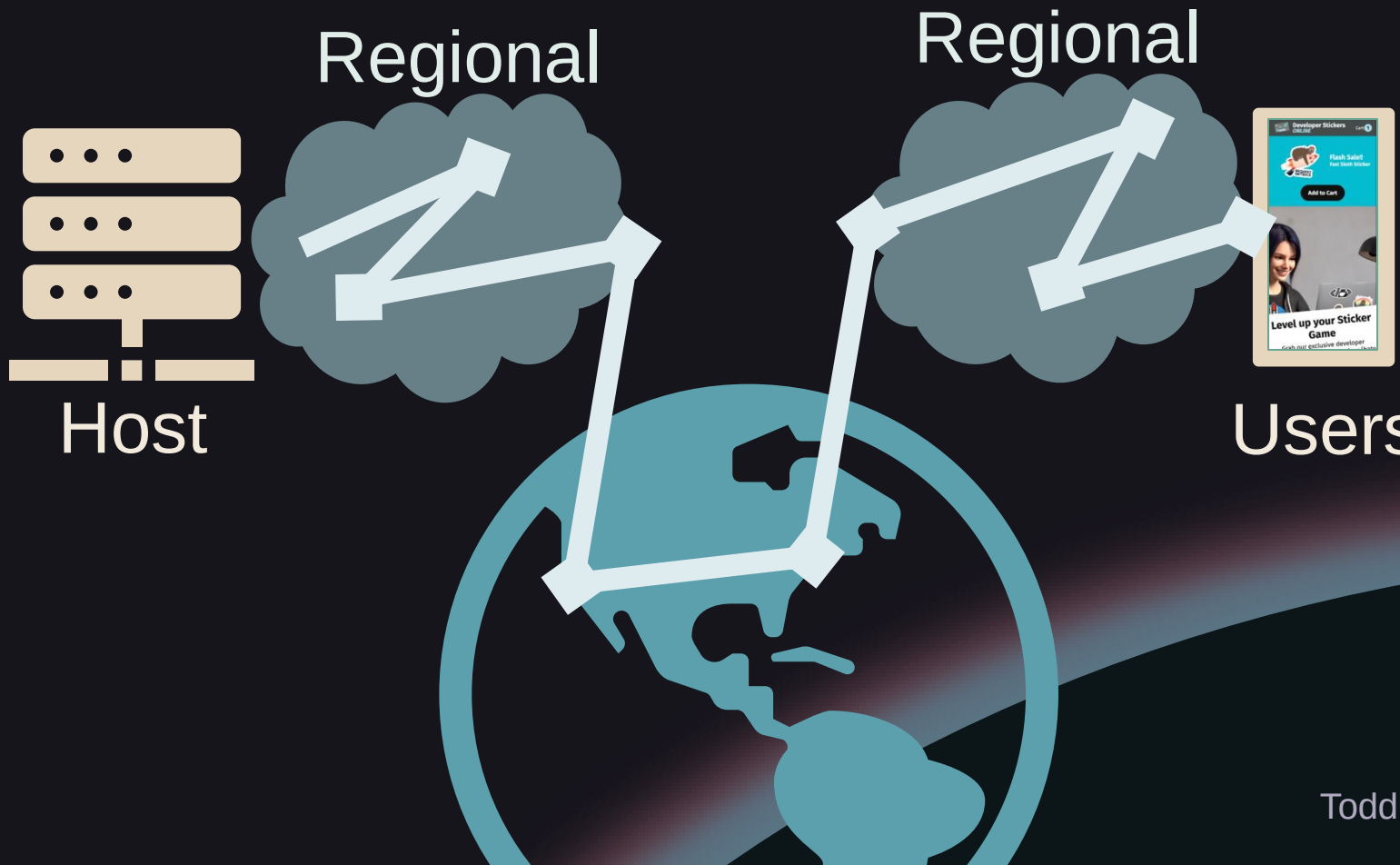
- server/performance-config.js



4. Host Proximity

Put your hosts close to your users

Network Hops



Todd H. Gardner

Network Hops

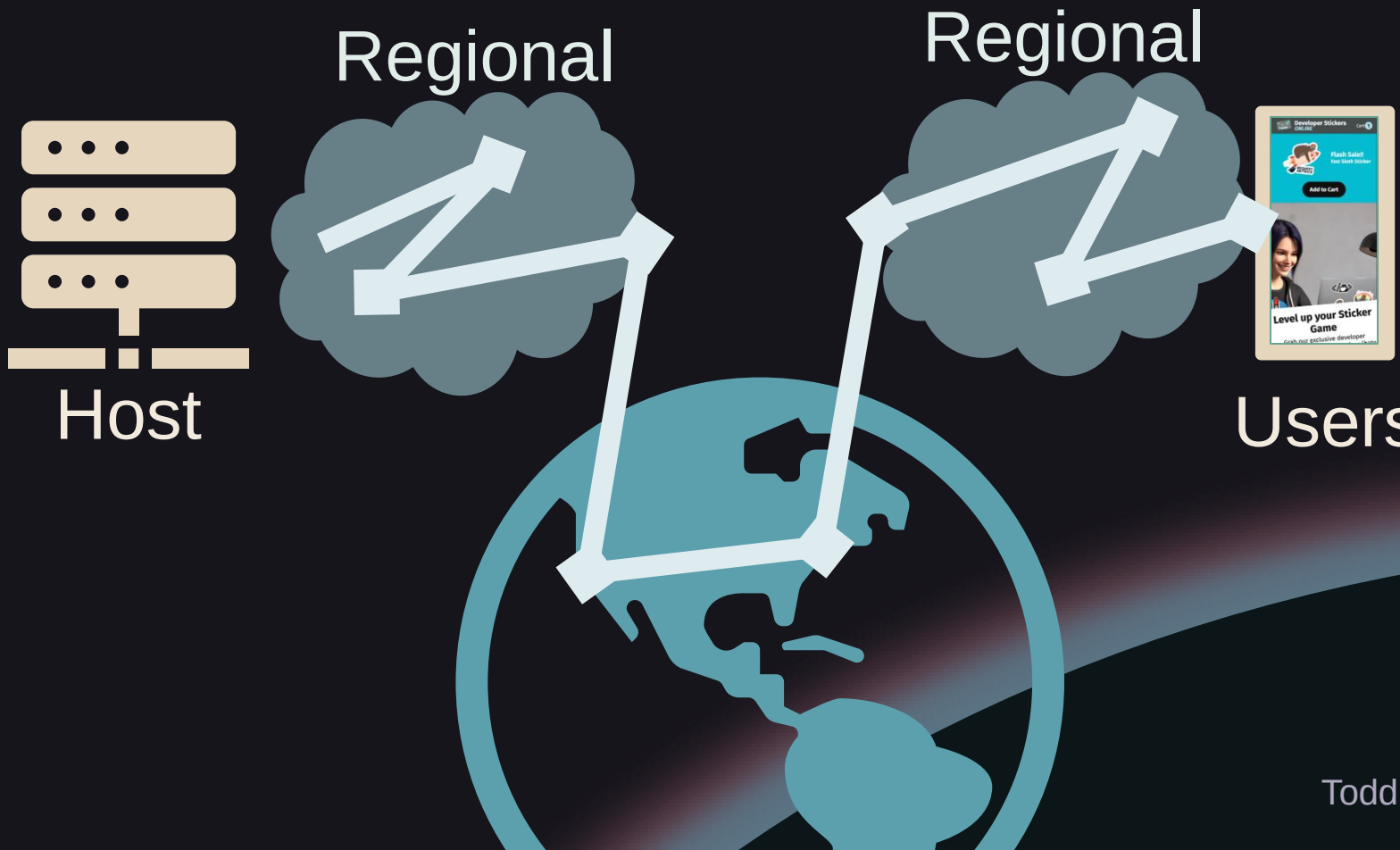
Minneapolis **Amsterdam**

117 ms

Source: WonderNetwork

Todd H. Gardner

Network Hops



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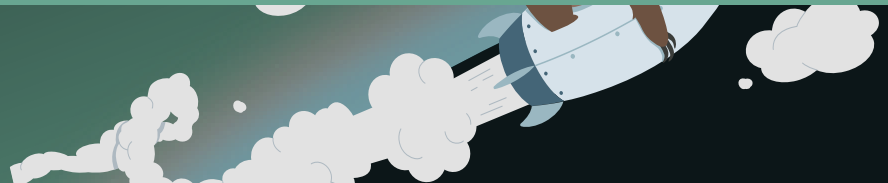
Network Hops

Try CDN

CDN DevStickers

https://www.devstickers.shop/

- BunnyCDN
- Compare with Baseline TTFB



Tactics

1. Compress HTTP Responses
2. Efficient Protocols
3. Host Capacity
4. Host Proximity

100% Operations Work

- We didn’t change any code or content

Workshop Outline

Improving

- ~~Improving TTFB~~
- **Improving FCP**
- Improving LCP
- Improving Returning Experience
- Improving CLS
- Improving INP

Improving First Contentful Paint FCP

Todd H. Gardner

Improving Web Performance

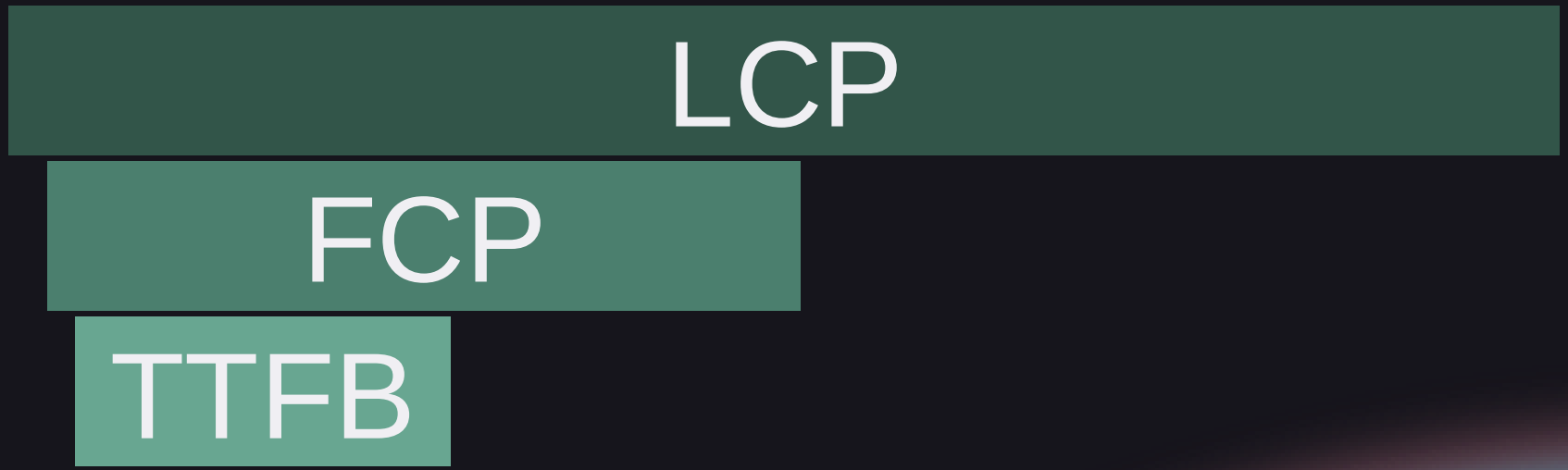
First Contentful Paint

How fast your site visibly loads the **something.**

Source: Request Metrics

Improving Web Performance

First Contentful Paint



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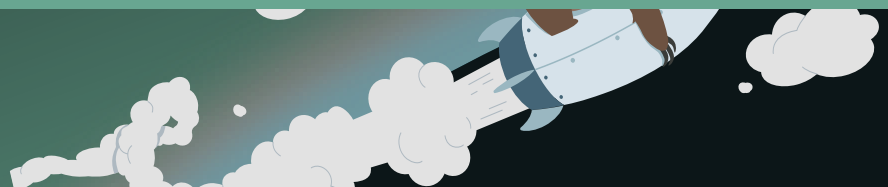
Baseline FCP

CDN DevStickers

https://www.devstickers.shop/

- Chrome Throttling
- Chrome Performance Profile



Do you need to worry about this?

FCP

First Contentful Paint

Check your RUM or CrUX p75 Data

Source: [web.dev](web.dev)

Tactics

1. Remove Sequence Chains
2. Preloading Resources
3. Lazy load Resources

1. Remove Sequence Chains

Collapse your dependencies

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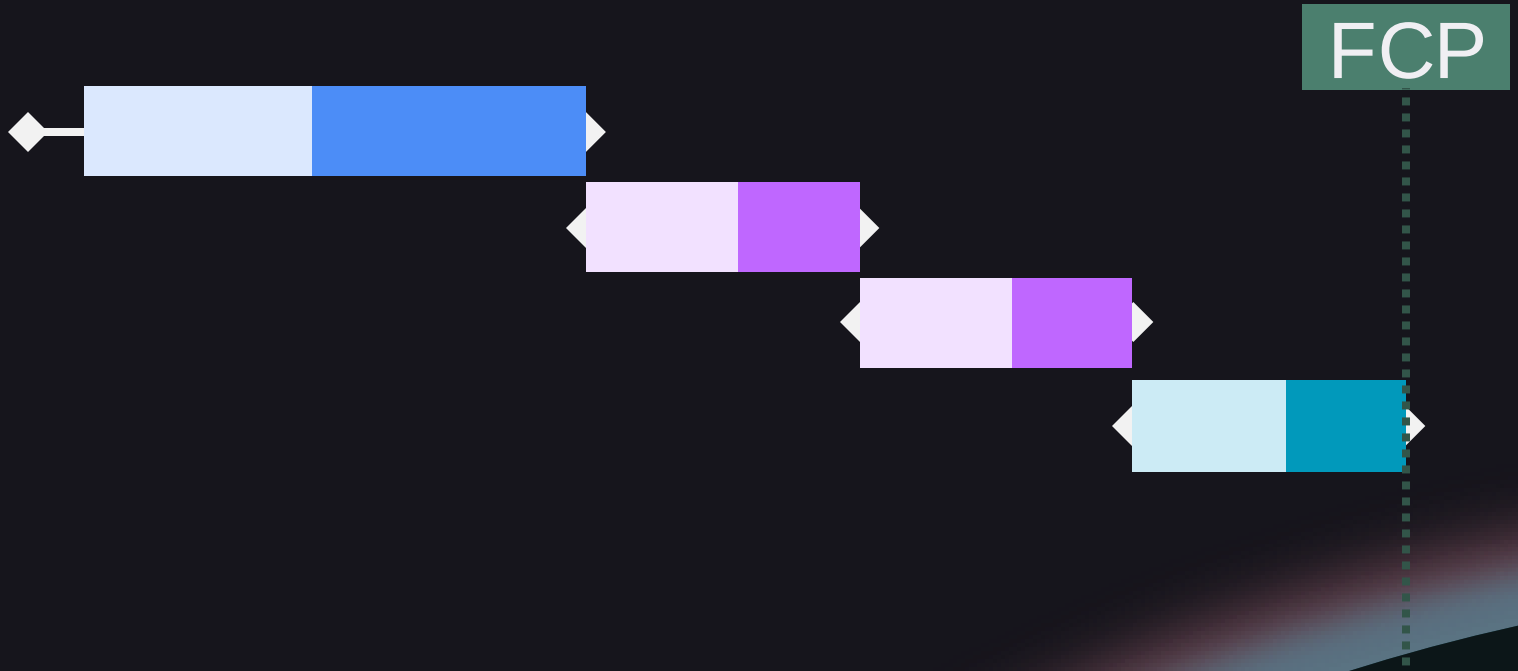
Waterfall



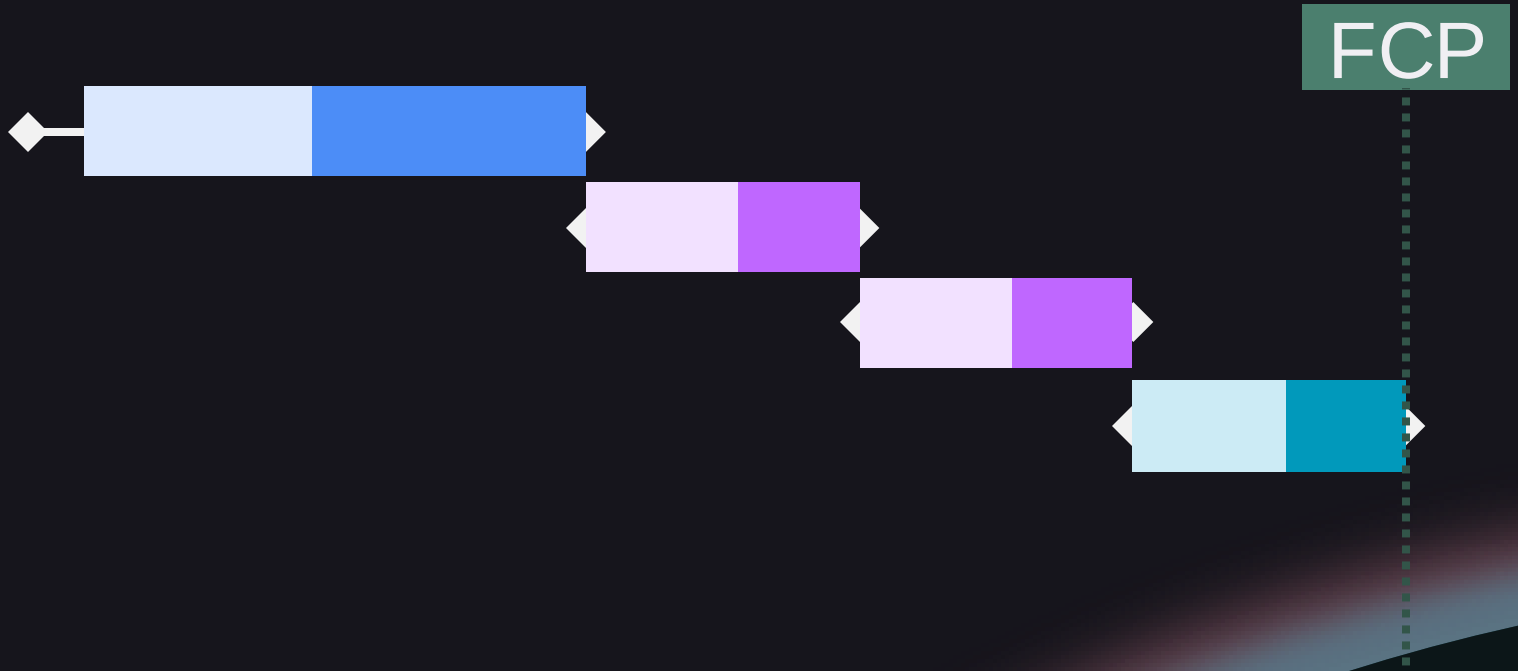
Render Blocking

CSS and **Fonts** are **Render Blocking**.

They prevent the page from rendering until complete

Source web.dev

Render Blocking



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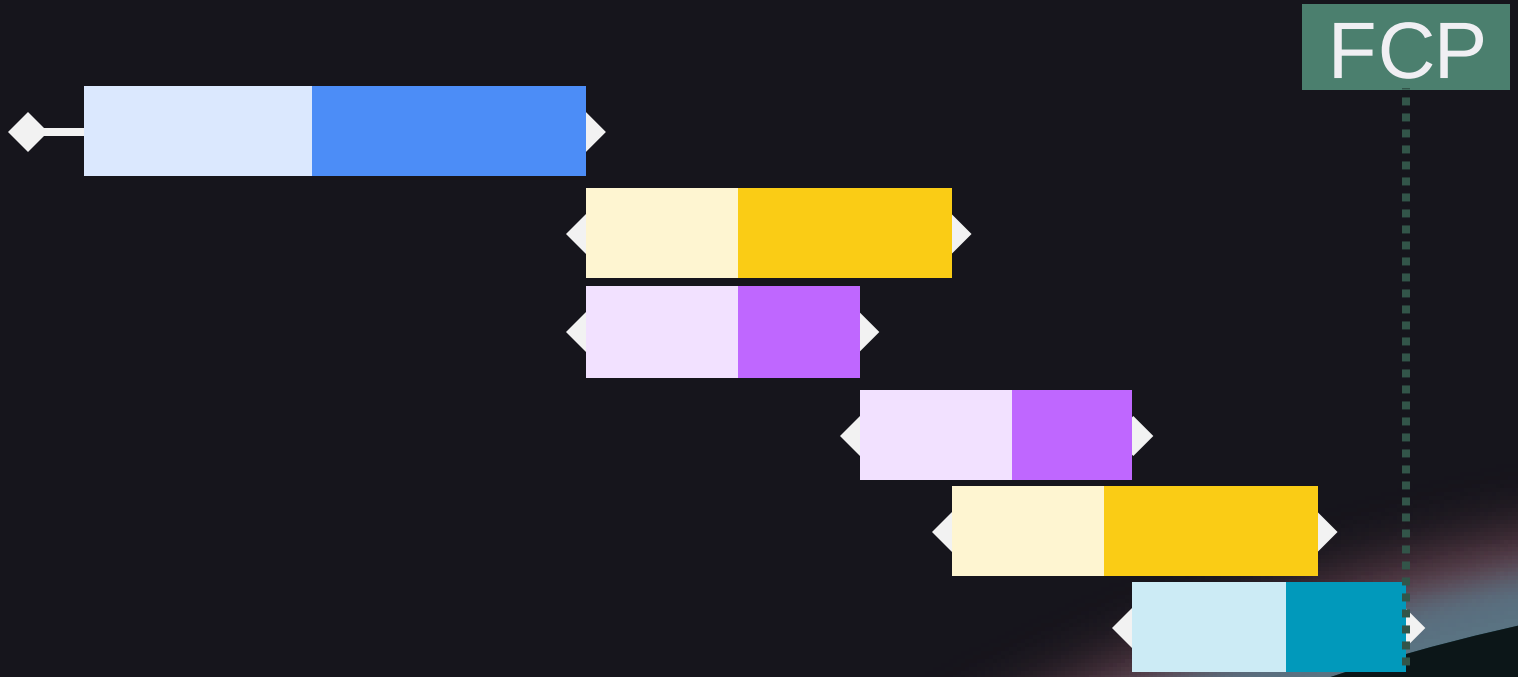
CSS @import

```
2
3   @import "./colors.css";
4   @import "./normalize.css";
5   @import "./typography.css";
6
```

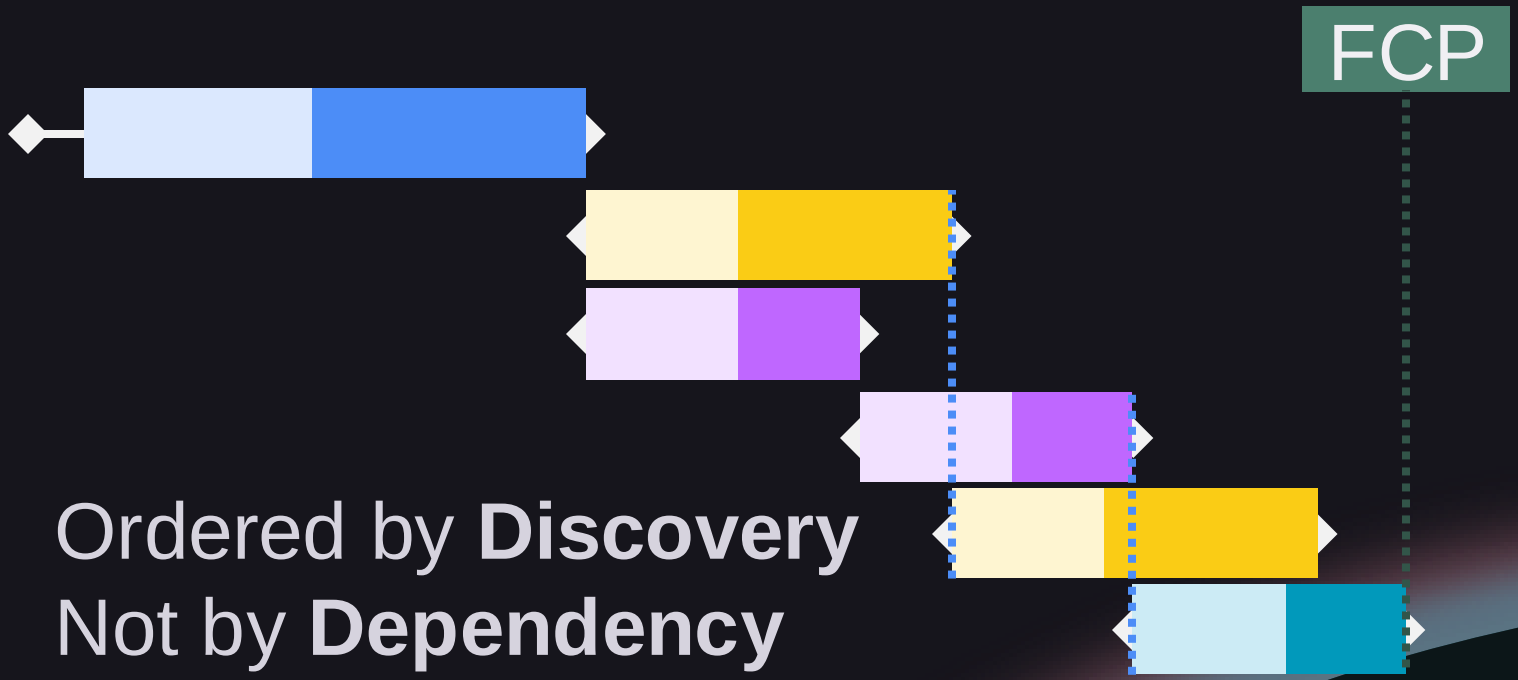
CSS @font-face

```
4
5   @font-face {
6     font-family: 'Fira Sans';
7     font-style: italic;
8     font-weight: 100;
9     font-display: swap;
10    src: url(https://fonts.gstatic.com/s/firasans/v17/va9A4kDNxMZdWfMOD5VvkrCqUT3f
11    unicode-range: U+0460-052F, U+1C80-1C88, U+20B4, U+2DE0-2DFF, U+A640-A69F, U+F
12  }
13
```

Multiple Chains



Multiple Chains



Ordered by **Discovery**
Not by **Dependency**

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JavaScript Module Import

```
88
89  import { onLCP, onCLS, onINP } from "./web-vitals.mjs";
90
91  onLCP(console.log);
92  onCLS(console.log);
93  onINP(console.log);
94
```

JavaScript Script Injection

```
102
103  const el = document.createElement("script")
104  el.setAttribute("src", "/otherScript.js");
105  document.body.appendChild(el);
106
```

Todd H. Gardner

Module Bundlers

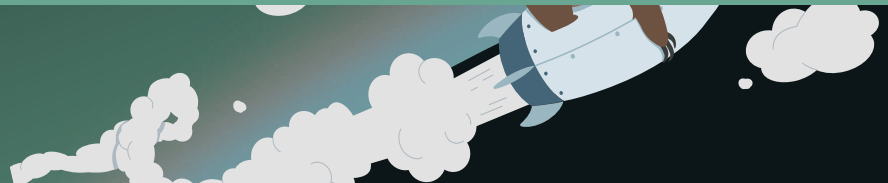
- Webpack
- Rollup
- Vite

Module Bundler

CDN DevStickers

https://www.devstickers.shop/

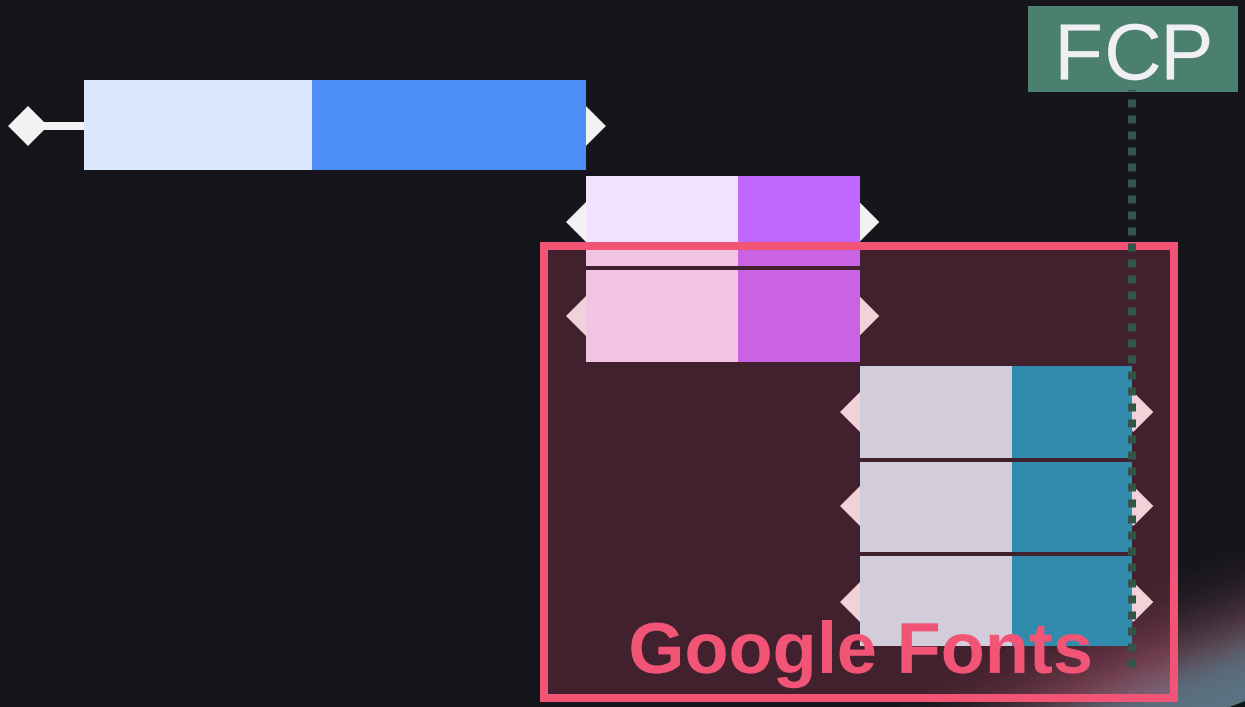
- npm run bundle



2. Preload Resources

Start critical path resources as soon as possible.

Waterfall



Link Preconnect

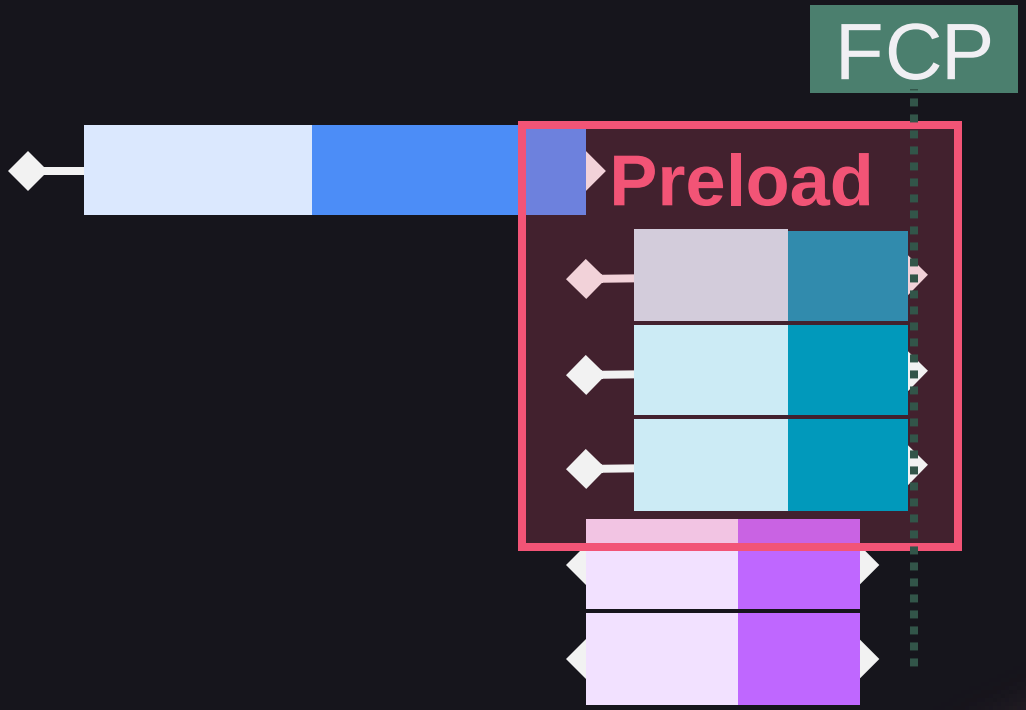
```
8
9   <!-- Google Fonts -->
10  <!-- Default embed code for "Fira Sans" with default options in the UI -->
11  <link rel="preconnect" href="https://fonts.googleapis.com">
12  <link rel="preconnect" href="https://fonts.gstatic.com" crossorigin>
13  <link
14    href="https://fonts.googleapis.com/css2?family=Fira+Sans:ital,wght@0,100;0,2
15    rel="stylesheet">
16
```

Link Preload

```
12
13    <link rel="preload" as="font" crossorigin
14      href="https://fonts.gstatic.com/s/firasans/v17/va9B4kDNxMZdWfMOD5VnLK3eRhf6X
15    <link rel="preload" as="font" crossorigin
16      href="https://fonts.gstatic.com/s/firasans/v17/va9f4kDNxMZdWfMOD5VvkrByRCf4V
17    <link rel="preload" as="font" crossorigin
18      href="https://fonts.gstatic.com/s/firasans/v17/va9E4kDNxMZdWfMOD5Vvl4jLazX3d
19    <link
20      href="https://fonts.googleapis.com/css2?family=Fira+Sans:ital,wght@0,100;0,2
21      rel="stylesheet">
22
```

Source: MDN

Waterfall



Link Preload

- style
- script
- image
- font
- fetch

crossorigin (CORS)

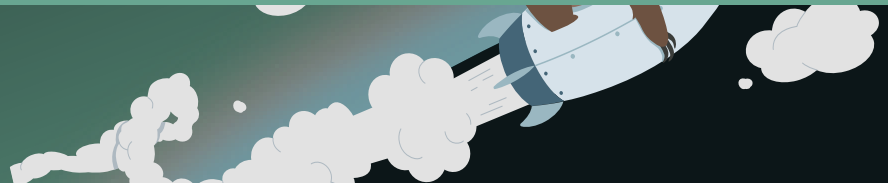
Source: MDN

Preload Fonts and CSS

CDN DevStickers

https://www.devstickers.shop/

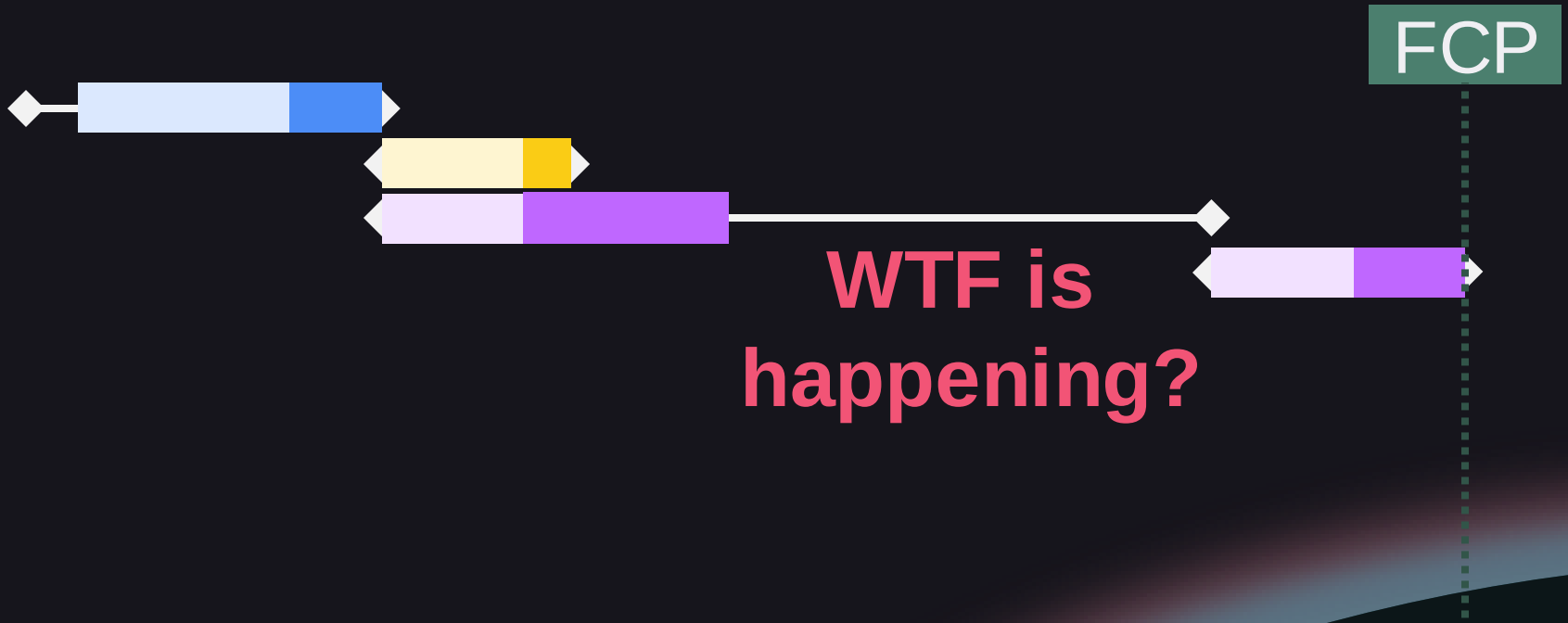
- Add preload for fonts from the network panel
- Caution: This is not guaranteed by Google to remain working. For best results, host the font files locally.



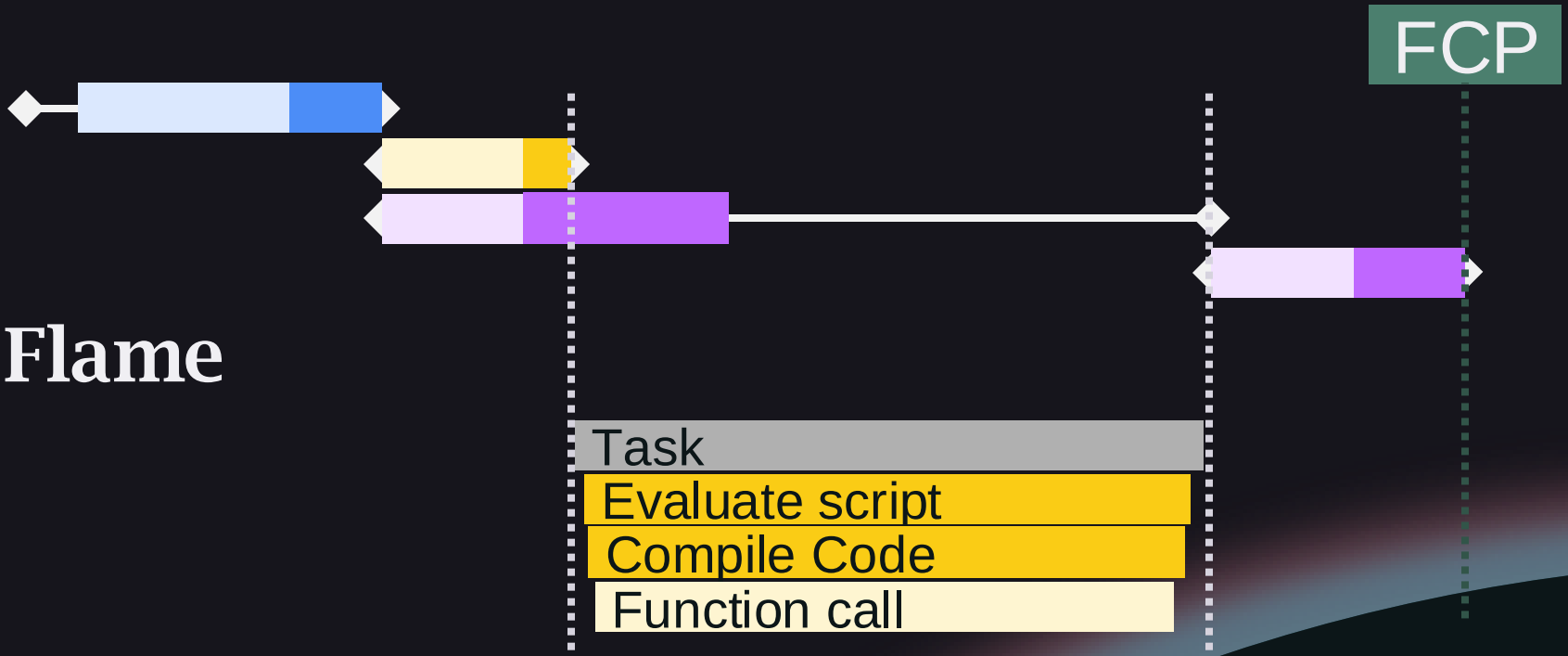
3. Lazy Loading

Remove resources that aren’t critical path.

Waterfall



Waterfall



Flame

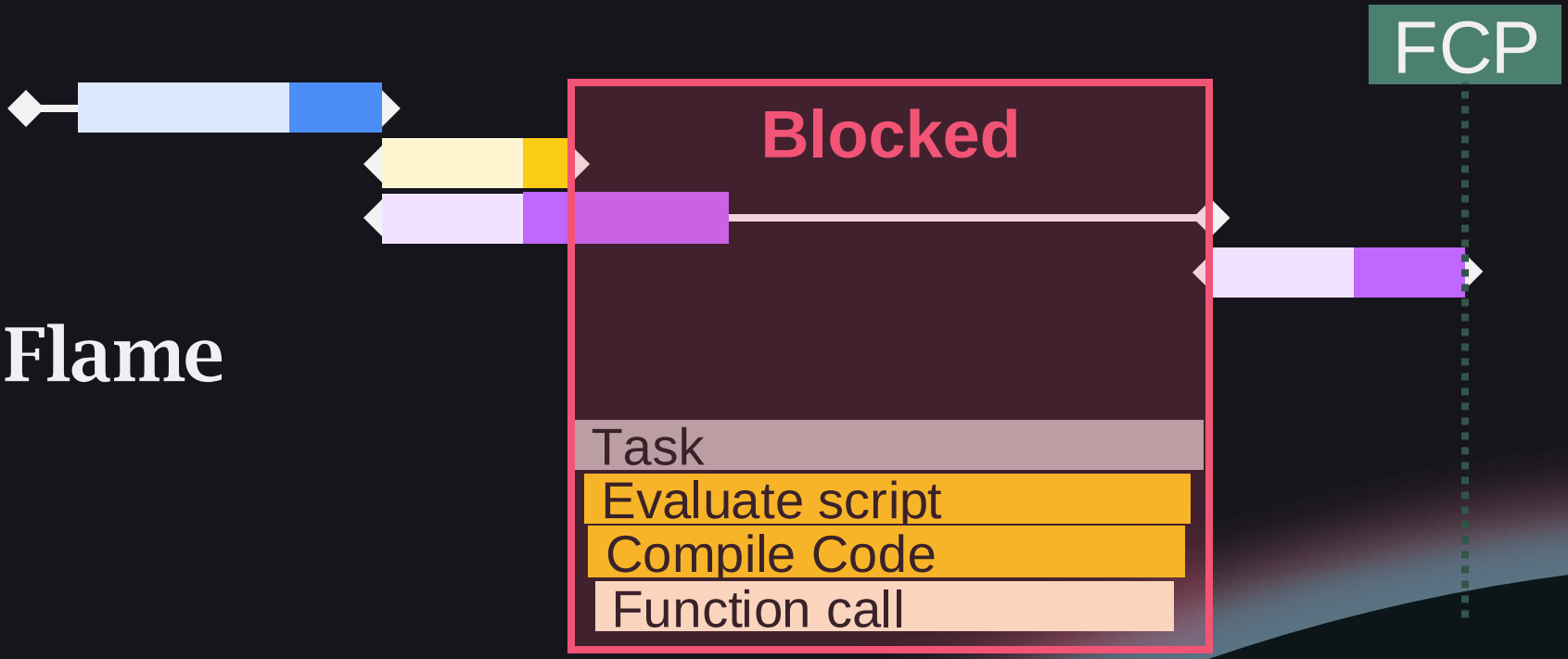
Parser Blocking

JavaScript is **Parser Blocking**.

It prevents parsing content, rendering, and main execution.

Source web.dev

Waterfall



Flame

Script defer

```
30
31    <script defer src="/assets/js/scripts.js"></script>
32
```

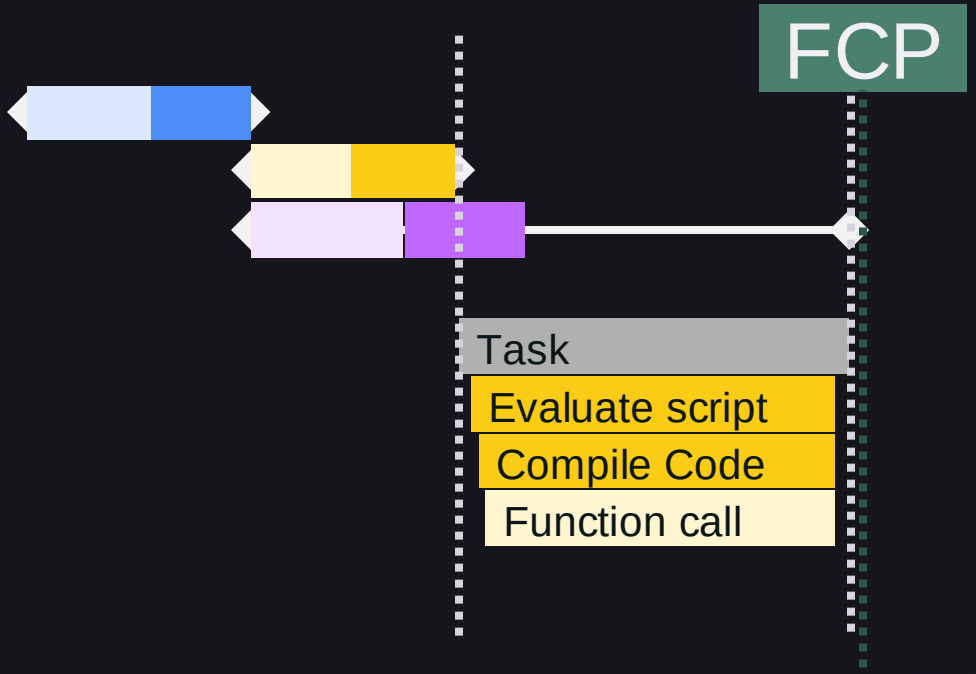
Script async

```
30
31    <script async src="/assets/js/scripts.js"></script>
32
```

Defer vs Async

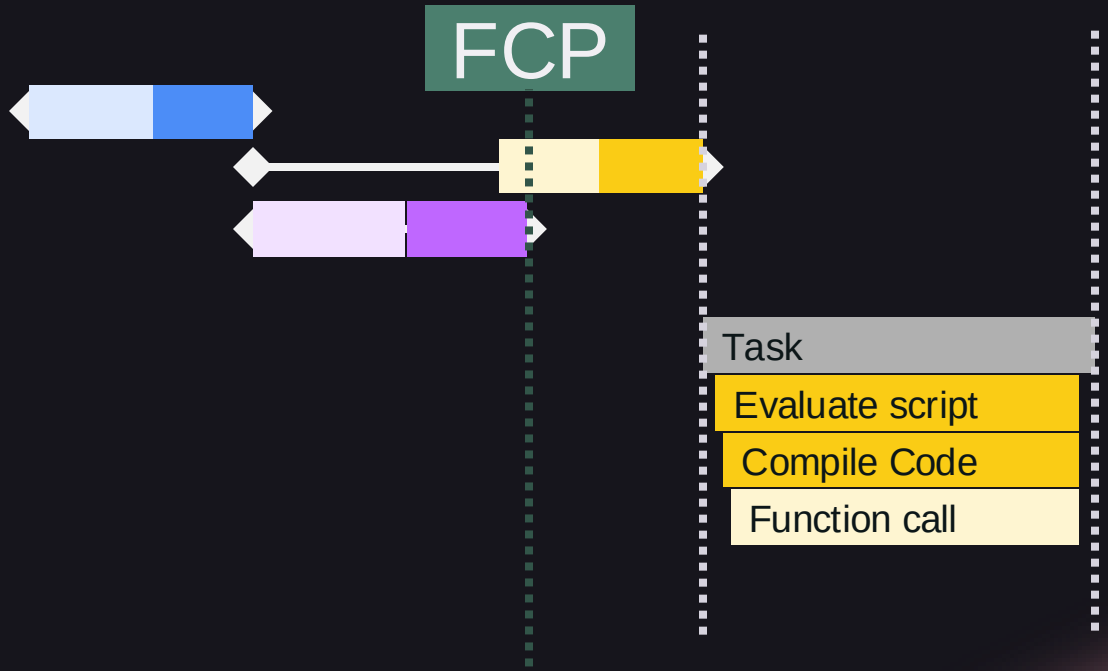
WTF is the difference?

<script>



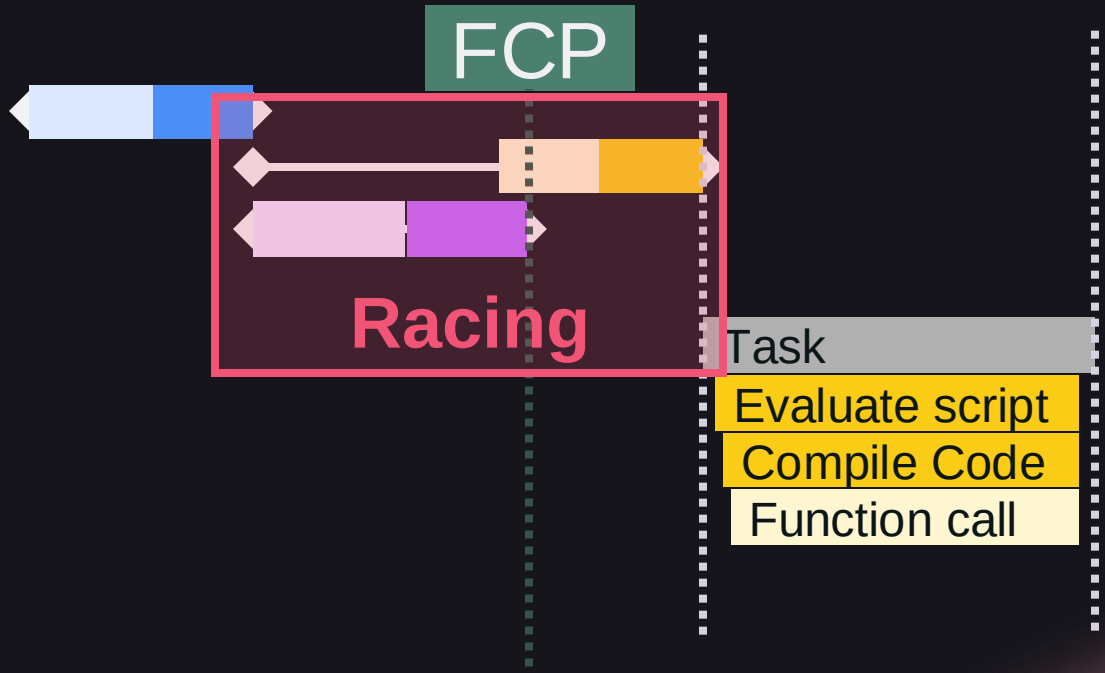
Downloads and executes blocking

<script async>



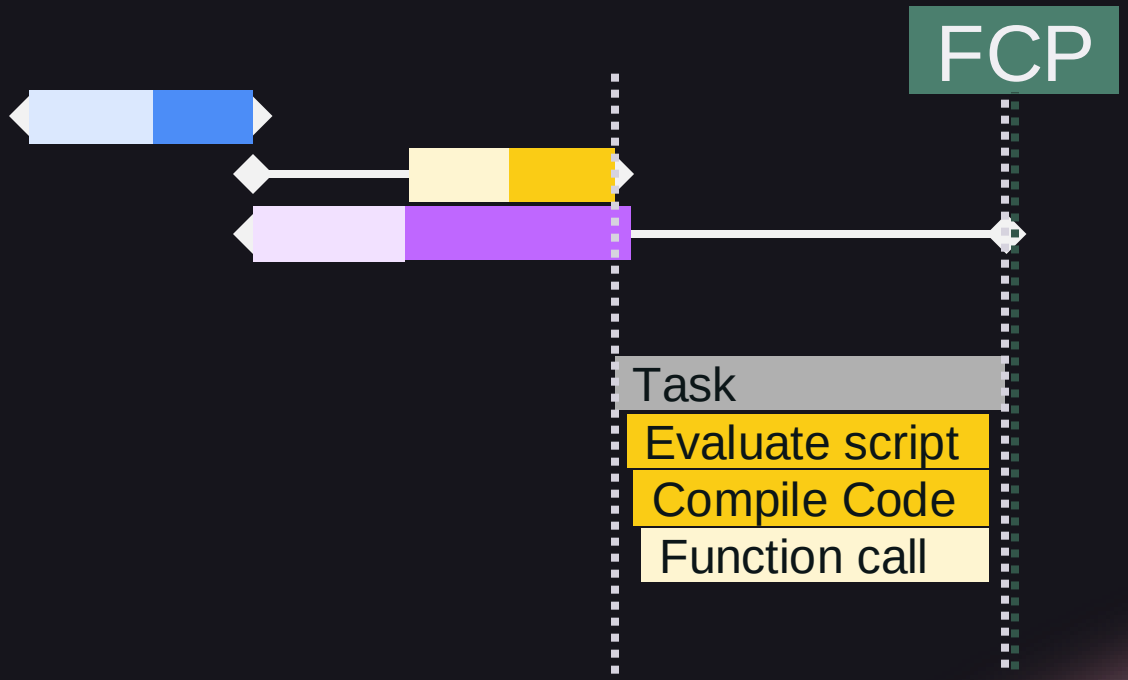
Downloads lazy,
but **executes**
blocking

<script async>



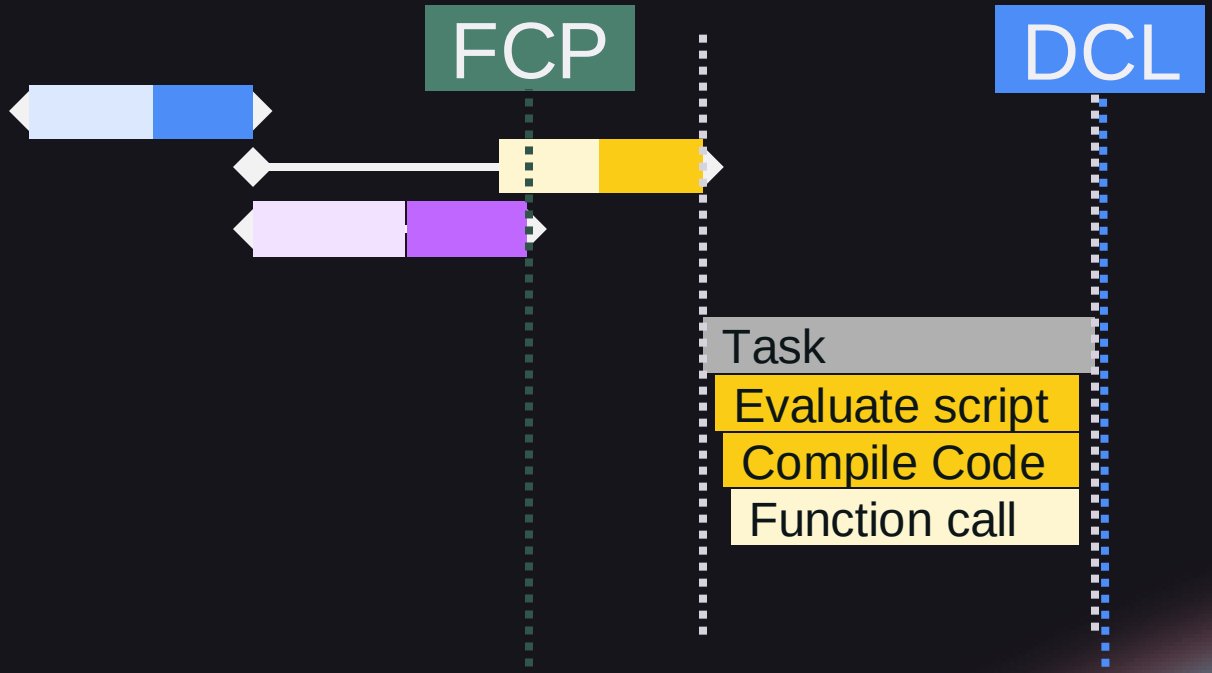
Downloads lazy, but **executes** as soon as its ready

<script async>



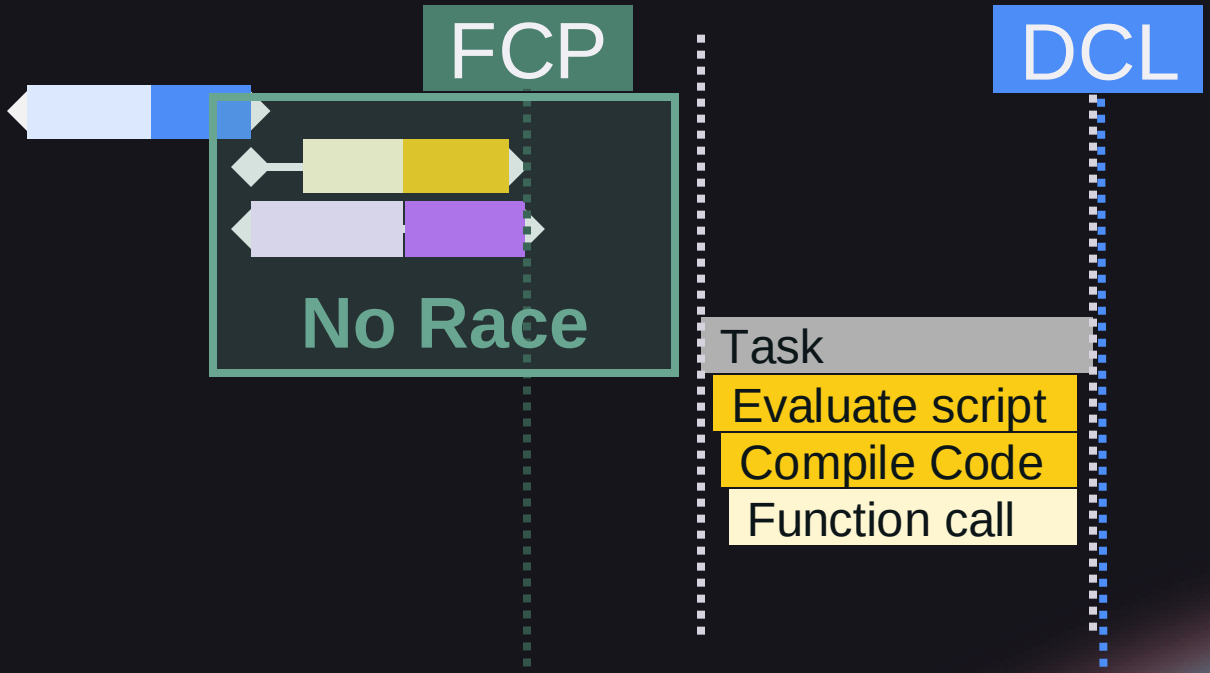
Downloads lazy, but **executes** as soon as its ready

<script defer>



Downloads lazy,
but **executes**
before
DOMContentLoaded

<script defer>



Downloads lazy,
but **executes**
before
DOMContentLoaded

Defer vs ASync

- You almost never want **async**
- Multiple Deferred scripts will execute in order they appear

script modules

```
6
7   <script src="/assets/js/scripts.mjs" type="module"></script>
8
```

- Always Deferred

Source: web.dev

<script> Placement

<head>

</body>

<script> Placement

<head> </body>

It *probably* doesn't matter anymore

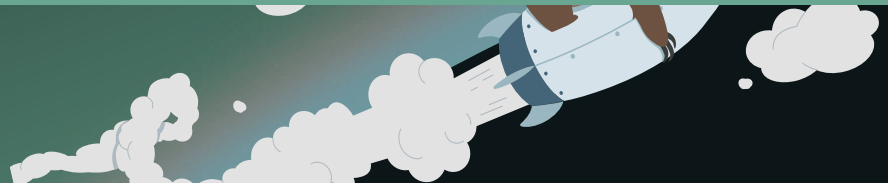
**forces the order you start fetching scripts instead of letting the browser do it

Defer Scripts

CDN DevStickers

https://www.devstickers.shop/

- Add defer to all scripts



Tactics

1. Remove Sequence Chains
2. Preloading Resources
3. Lazy load Resources

Workshop Outline

Improving

- ~~Improving TTFB~~
- ~~Improving FCP~~
- **Improving LCP**
- Improving Returning Experience
- Improving CLS
- Improving INP

Improving Largest Contentful Paint LCP

Todd H. Gardner

Improving Web Performance

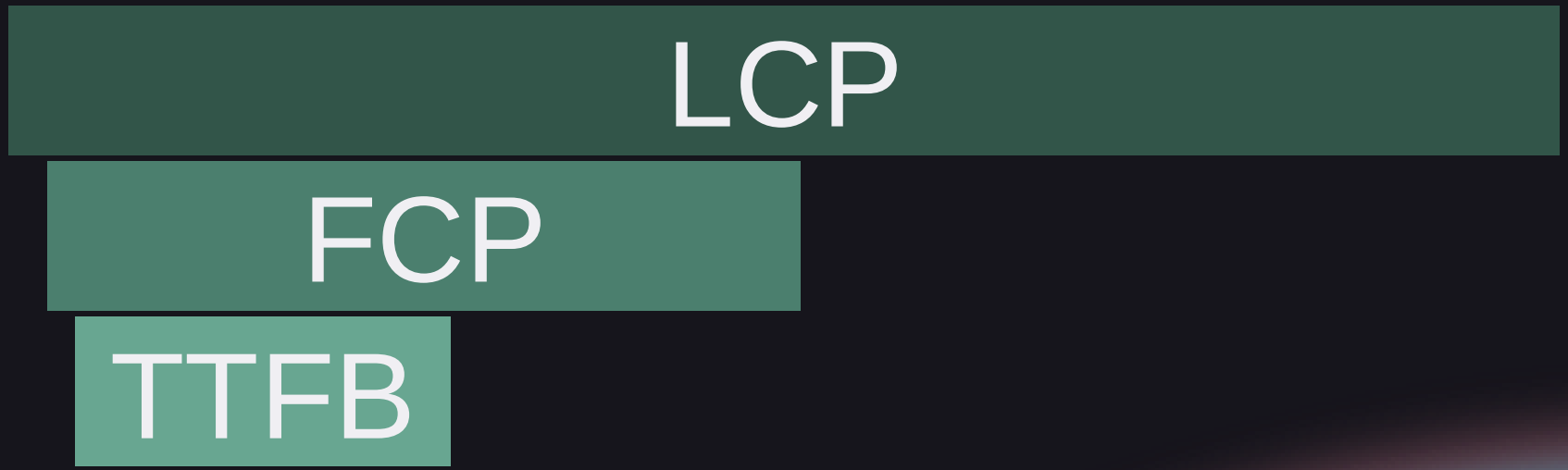
Largest Contentful Paint

How fast your site visibly loads the **most important** element

Source: Request Metrics

Improving Web Performance

Largest Contentful Paint



Todd H. Gardner

Improving Web Performance

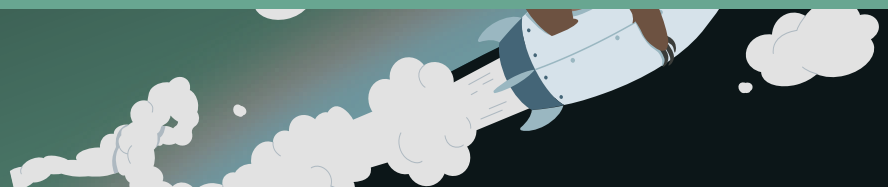
Largest Contentful Paint

Baseline LCP

CDN DevStickers

https://www.devstickers.shop/

- Chrome Throttling
- Chrome Performance Profile



Do you need to worry about this?

Check your RUM or CrUX p75 Data

Source: [web.dev]

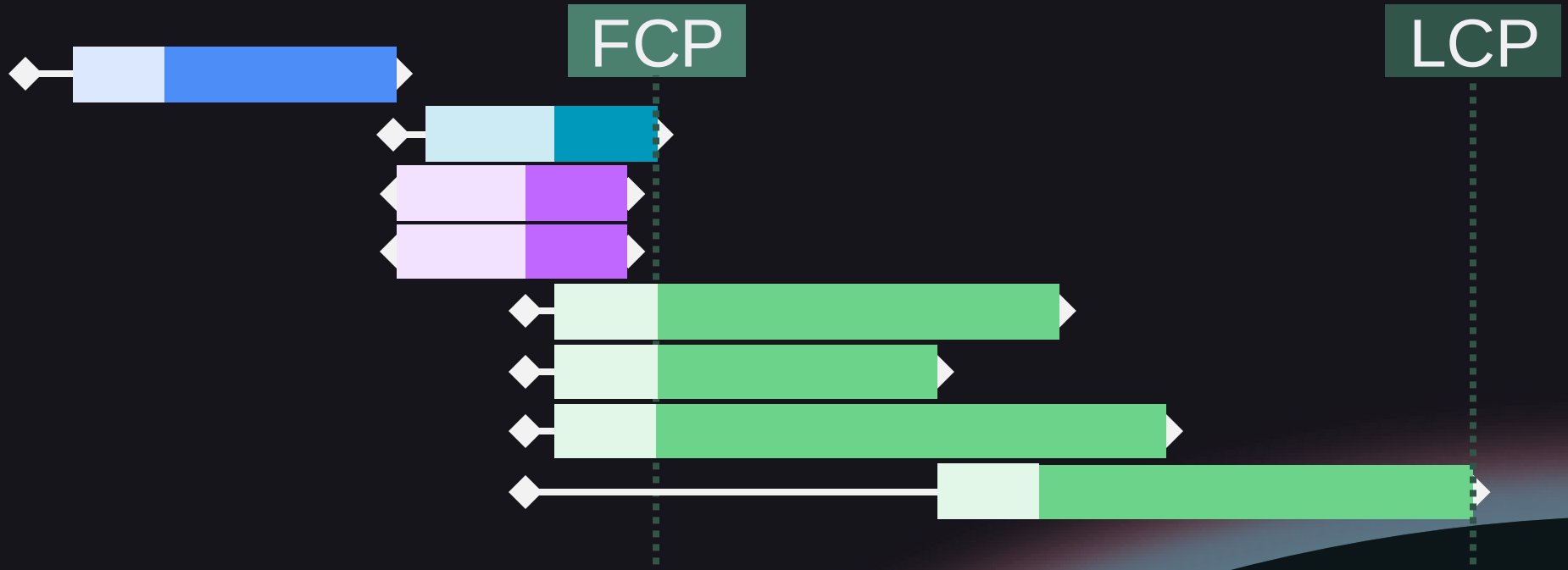
Tactics

1. (More) Lazy Loading
2. Eager Loading
3. Optimizing Images

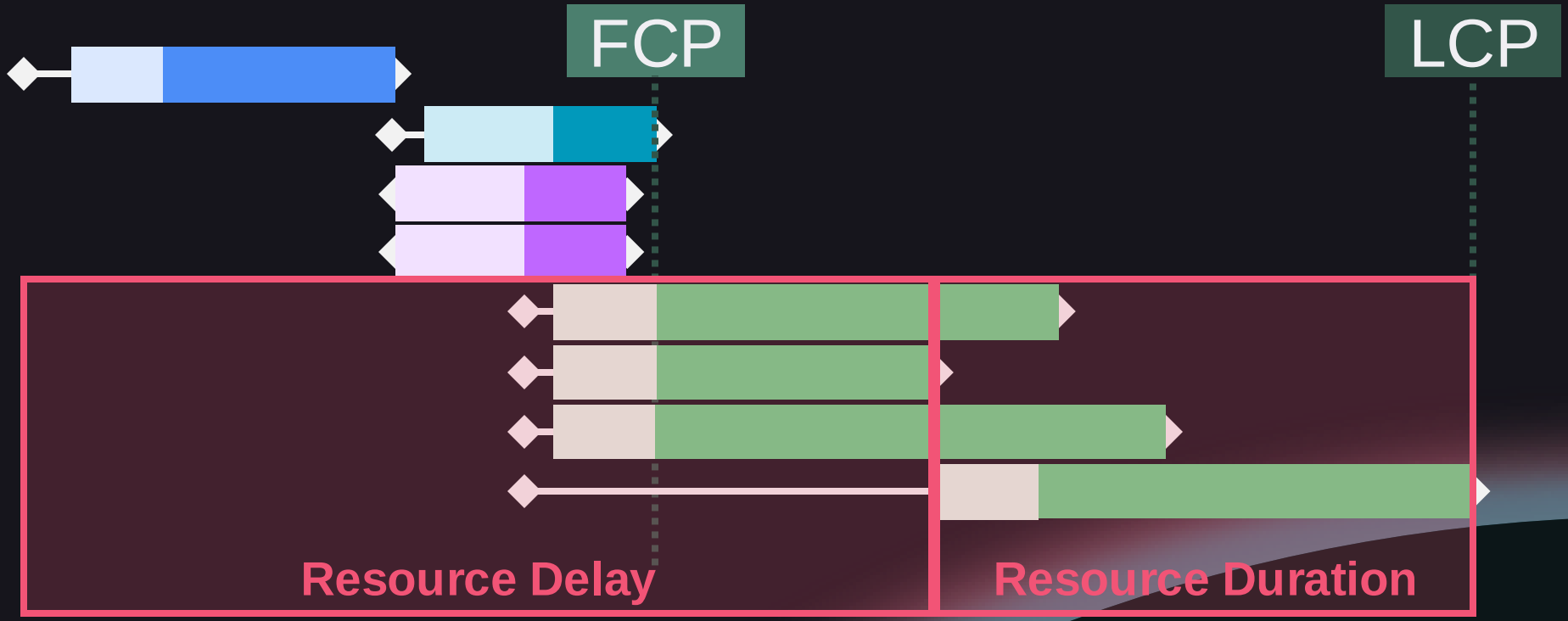
1. (More) Lazy Loading

Remove resources that aren’t critical path.

Waterfall



Waterfall



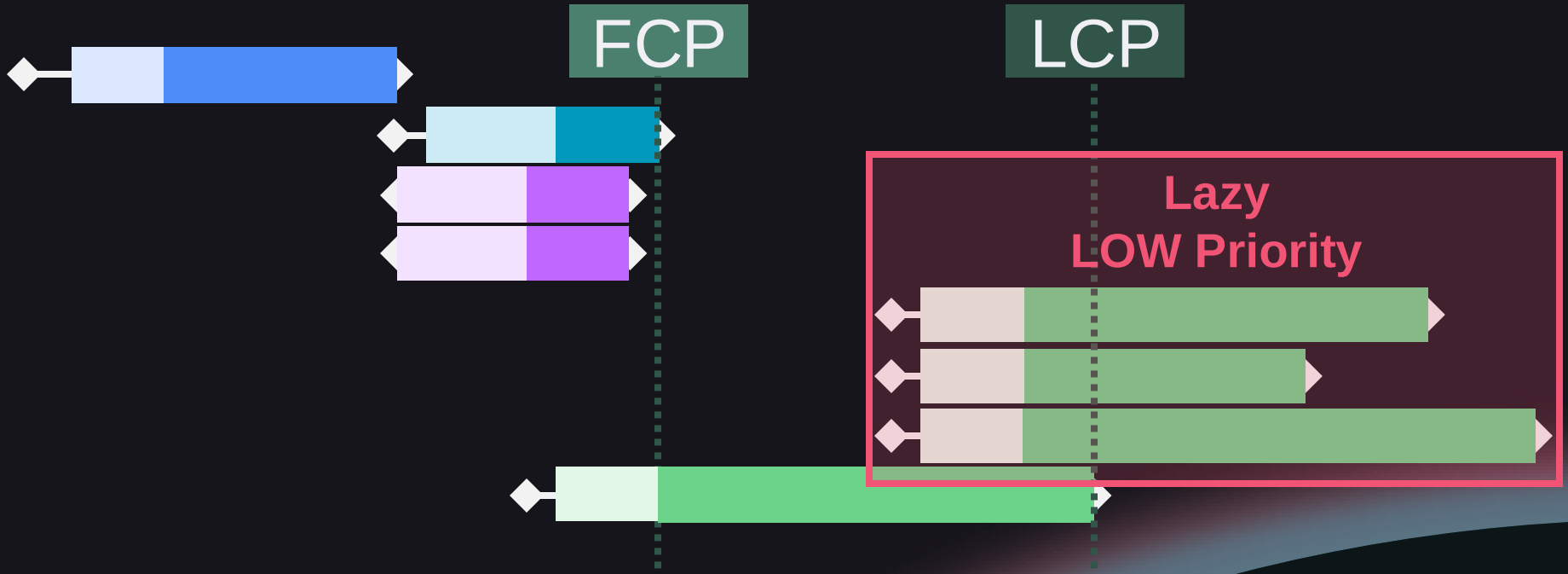
Lazy Loading

```
95
96  <img src="/assets/img/fast-sloth-sticker.png"
97    alt="Fast Sloth Sticker"
98    loading="lazy" />
99
```

```
95
96  <iframe src="https://example.com/frame" loading="lazy"></iframe>
97
```

Source: MDN

Waterfall

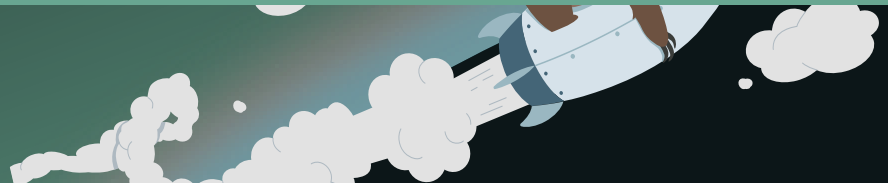


LazyLoad Images

Local DevStickers

http://localhost:3000/

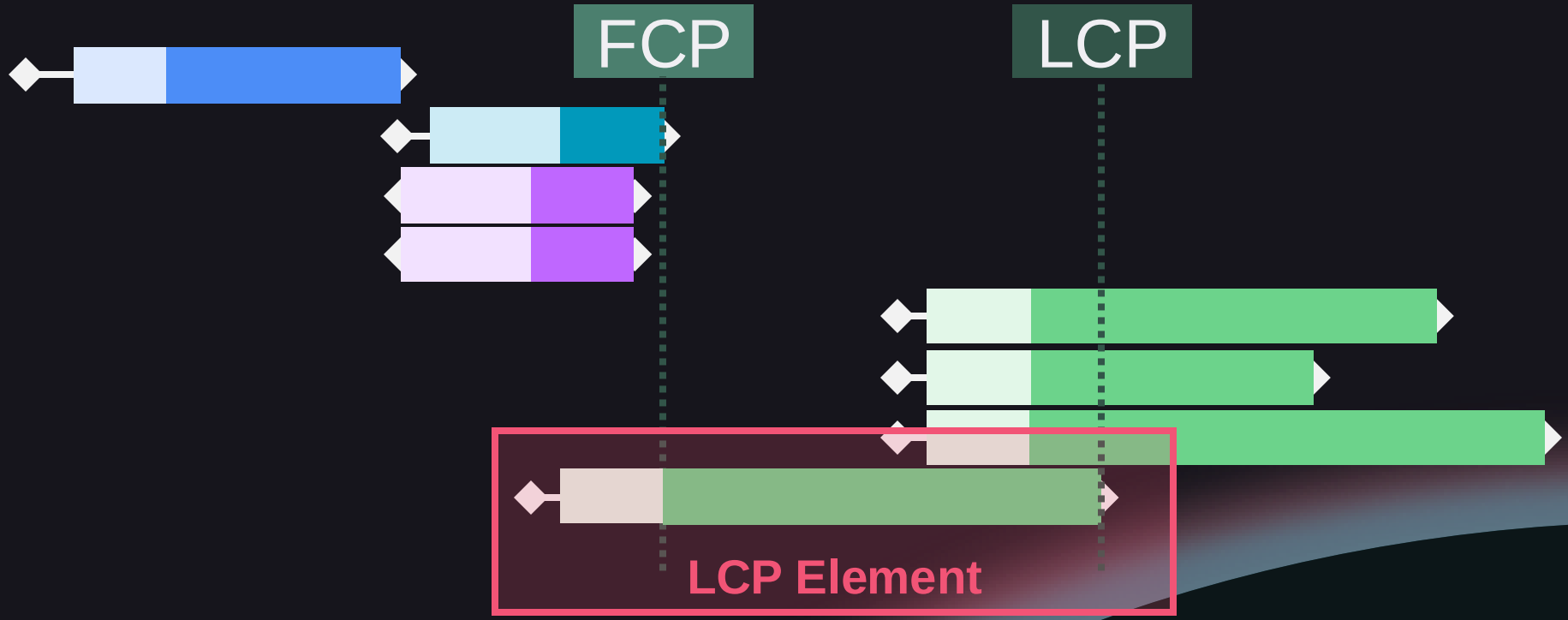
- Add loading=”lazy” to non-LCP images



2. Eager Loading

Start critical path resources as soon as possible.

Waterfall



Link Preload

```
3
4   <head>
5     <link rel="preload" as="image" href="/assets/img/hero-desktop.png">
6
```

Source: MDN

FetchPriority

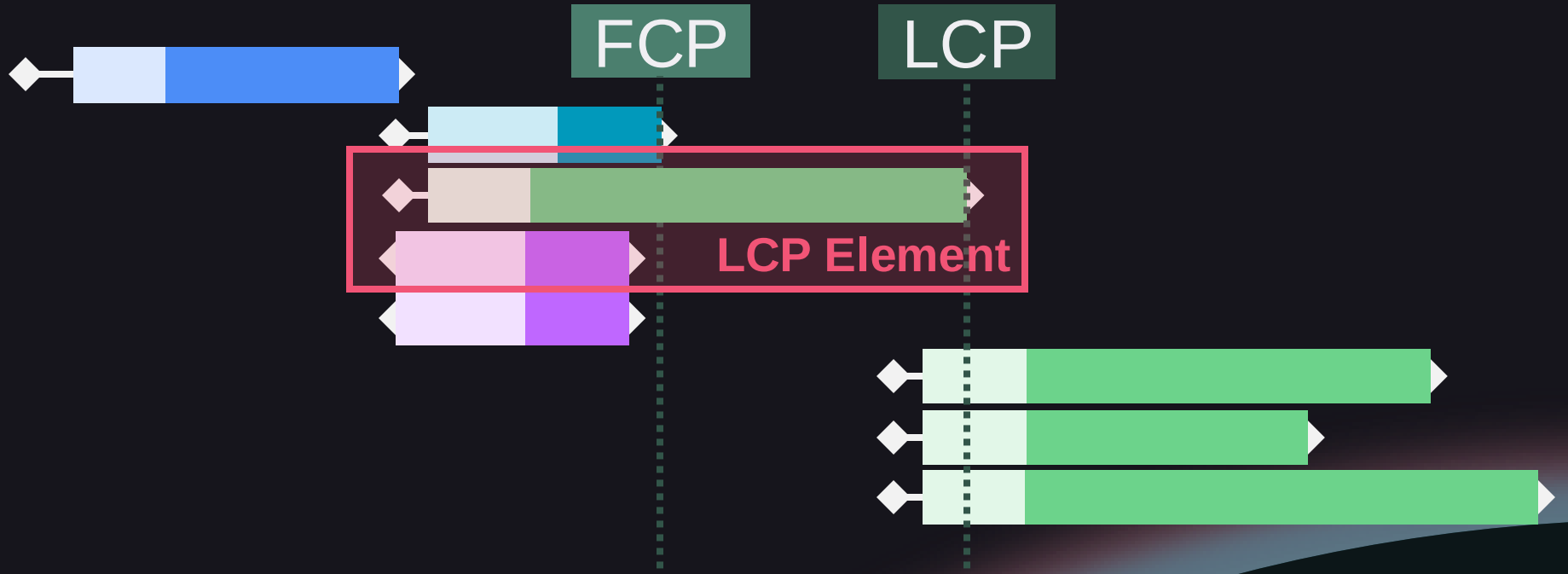
```
70
71    <img class="desktop" src="/assets/img/hero-desktop.png"
72      alt="Developer Stickers" fetchpriorty="high" />
73
```

<img>, <script>, <link>

**No Gecko Support

Source: Web.dev

Waterfall

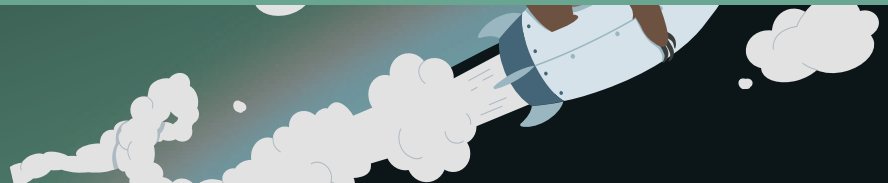


Eager Load LCP Image

Local DevStickers

http://localhost:3000/

- preload and fetchpriority to LCP image



3. Optimizing Images

Send as few bytes as possible

Todd H. Gardner

3. Optimizing Images

Didn’t we already add HTTP Compression?

3. Optimizing Images

A. Image Format
B. Responsive Images

Todd H. Gardner

A. Image Format

JPG
13 KB
Lossy

PNG
5.5 KB
Lossless

WebP
2.7 KB
Lossy

AVIF
2.6 KB
Lossy

Source: Request Metrics

A. Image Format

JPG
13 KB
Lossy

PNG
5.5 KB
Lossless

Preferred

WebP
2.7 KB
Lossy

AVIF
2.6 KB
Lossy

Source: Request Metrics

A. Image Format

JPG
32.7 KB
Lossy

PNG
90.6 KB
Lossless

WebP
12.1 KB
Lossy

AVIF
11.8 KB
Lossy

Source: Request Metrics

A. Image Format

JPG
32.7 KB
Lossy

PNG
90.6 KB
Lossless

Preferred

WebP
12.1 KB
Lossy

AVIF
11.8 KB
Lossy

Source: Request Metrics

A. Image Format

Source: TinyPNG

B. Responsive Images

hero-desktop.png

2800px +

720px

hero-mobile.png

600px

B. Responsive Images

```
70
71      <picture class="illustration">
72        <source media="(max-width: 720px)"
73            srcset="/hero-mobile.png?width=360 360w,
74                    /hero-mobile.png?width=720 720w,
75                    /hero-mobile.png?width=1440 1440w" />
76        <source media="(min-width: 721px)"
77            srcset="/hero-desktop.png?width=720 720w,
78                    /hero-desktop.png?width=1440 1440w,
79                    /hero-desktop.png?width=2800 2800w">
80        <img src="/hero-desktop.png?width=2800"
81          alt="Developer Stickers Online"
82          fetchpriorty="high"
83          height="1200" width="2800" />
84      </picture>
85
86
```

B. Responsive Images

```
70
71      <picture class="illustration">
72        <source media="(max-width: 720px)"
73            srcset="/hero-mobile.png?width=360 360w,
74                    /hero-mobile.png?width=720 720w,
75                    /hero-mobile.png?width=1440 1440w" />
76        <source media="(min-width: 721px)"
77            srcset="/hero-desktop.png?width=720 720w,
78                    /hero-desktop.png?width=1440 1440w,
79                    /hero-desktop.png?width=2800 2800w">
80        <img src="/hero-desktop.png?width=2800"
81          alt="Developer Stickers Online"
82          fetchpriorty="high"
83          height="1200" width="2800" />
84      </picture>
85
86
```

Mobile

Desktop

Default

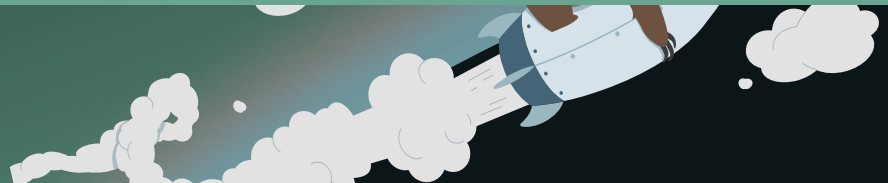
B. Responsive Images

Local DevStickers

http://localhost:3000/

- imagePngResizer
- imagePngOptimizer
- imagePngToWebP

- Replace
  - /assets/img/(.*).png
  - /assets/img/webp/$1.webp
- Responsive Hero

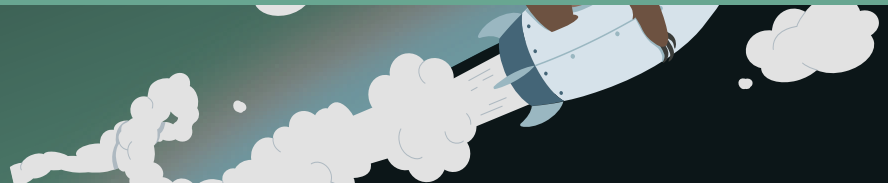


Results

CDN DevStickers

https://www.devstickers.shop/

- Deploy



Tactics

1. (More) Lazy Loading
2. Eager Loading
3. Optimizing Images

Workshop Outline

Improving

- ~~Improving TTFB~~
- ~~Improving FCP~~
- ~~Improving LCP~~
- **Improving Returning Experience**
- Improving CLS
- Improving INP

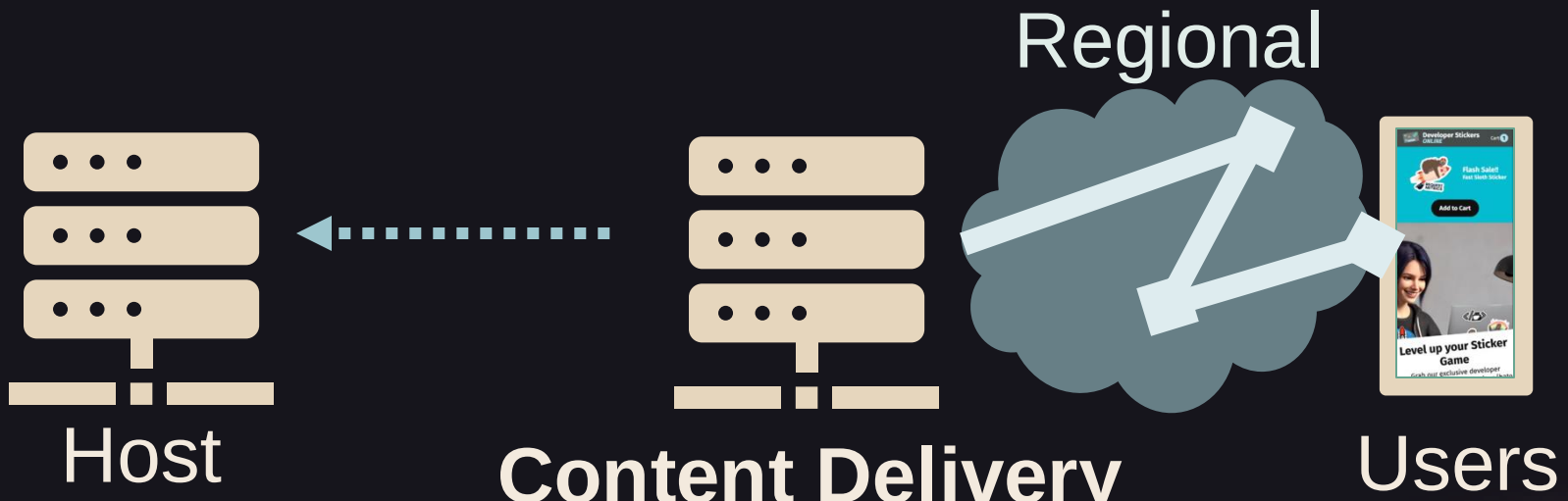
Improving Return User Experience

Todd H. Gardner

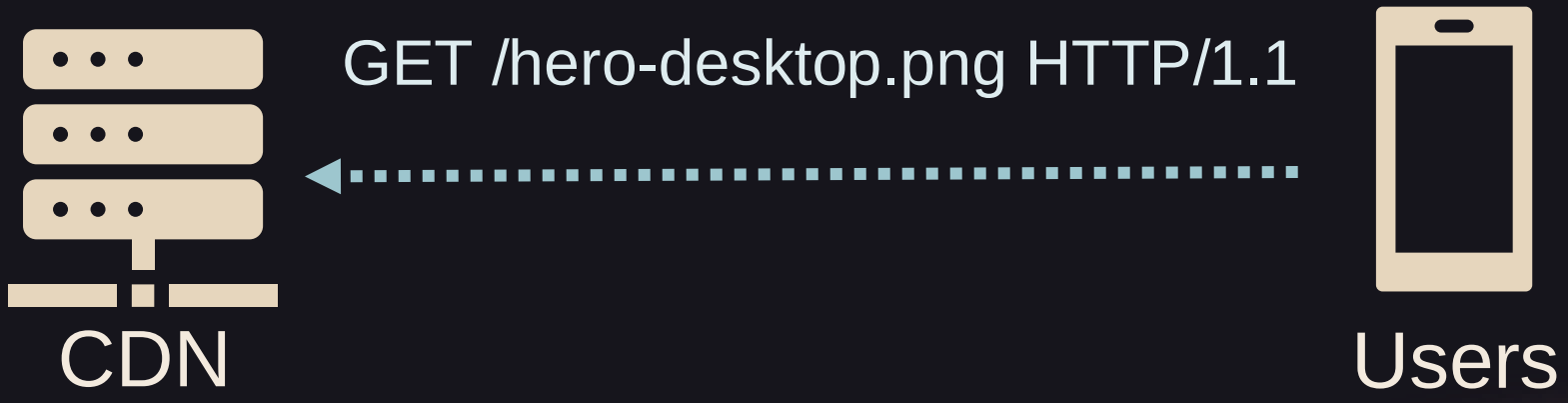
The 2 Hardest Problems in Software

1. Naming Things
2. Caching
3. Off-by-one errors

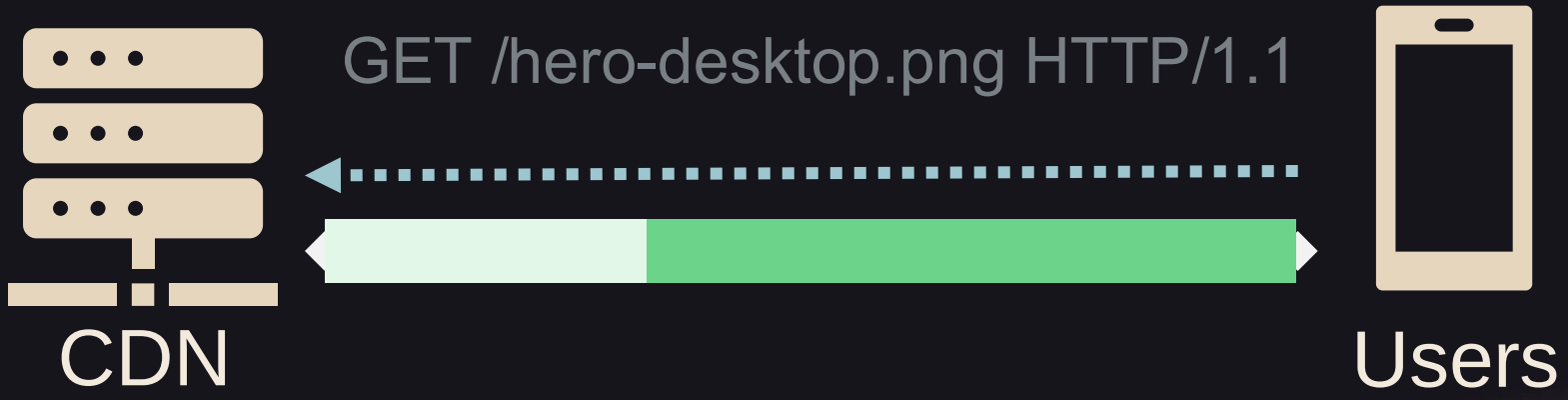
Server Caching



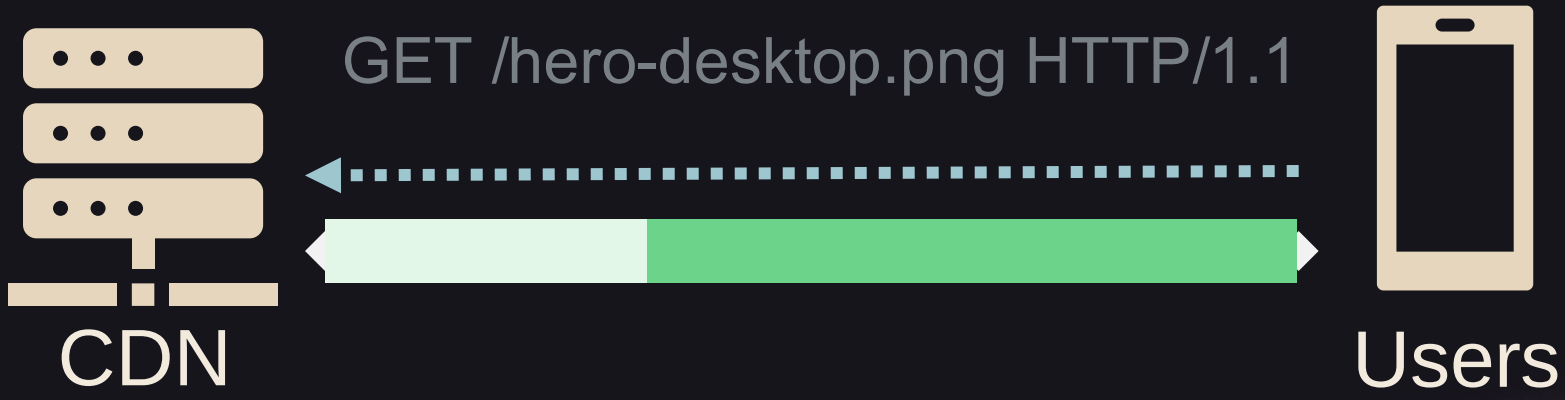
Browser Caching



Browser Caching

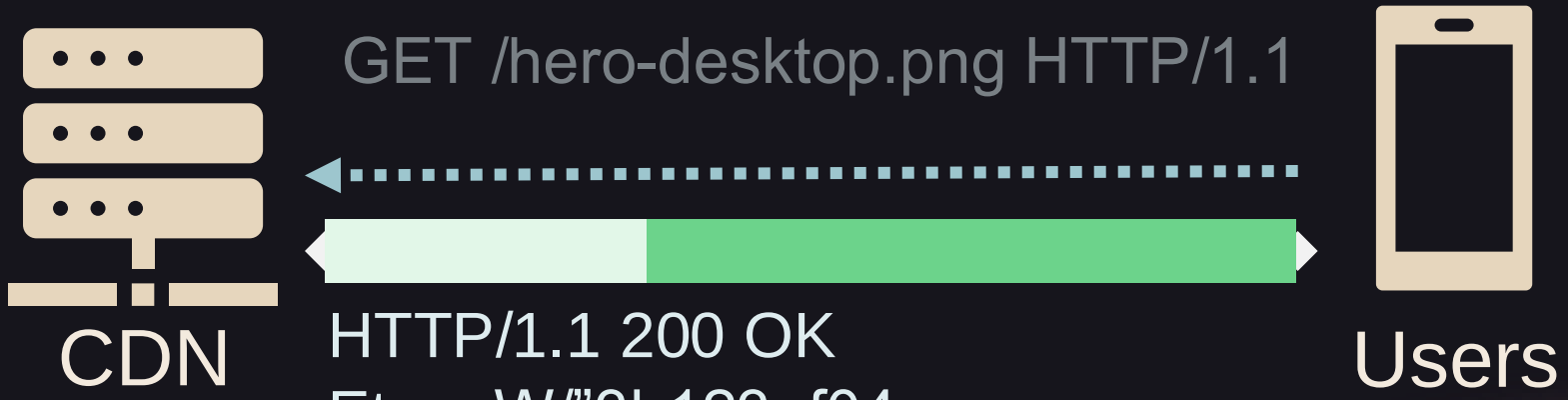


Browser Caching

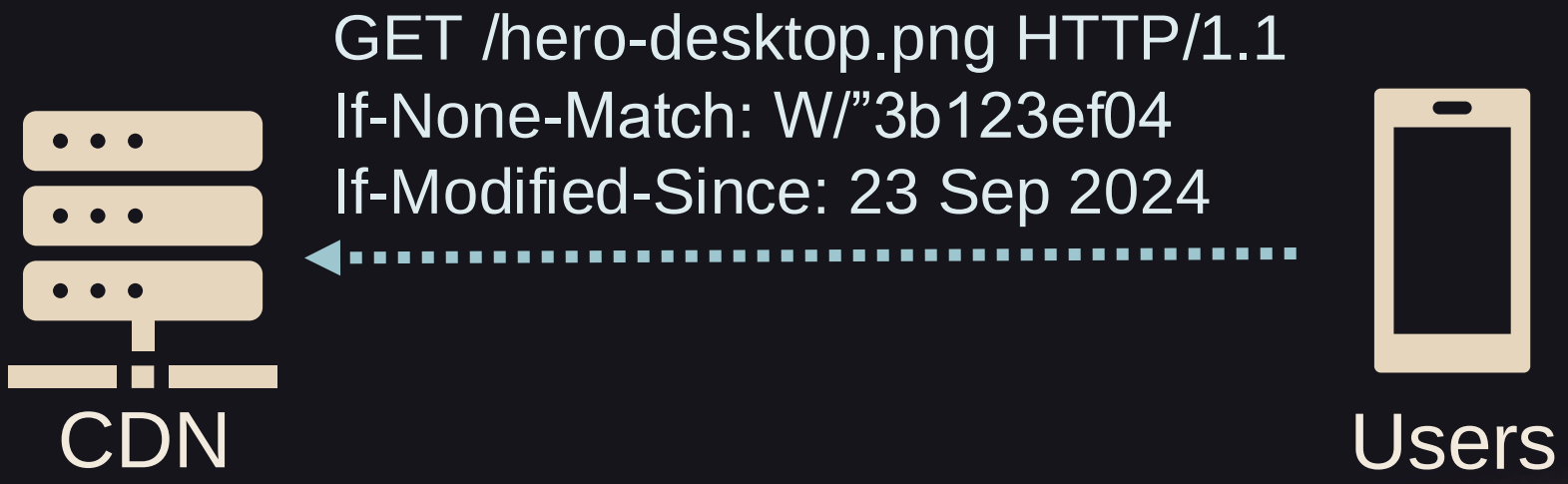


DNS	TCP	SSL	Request	Response	Processing

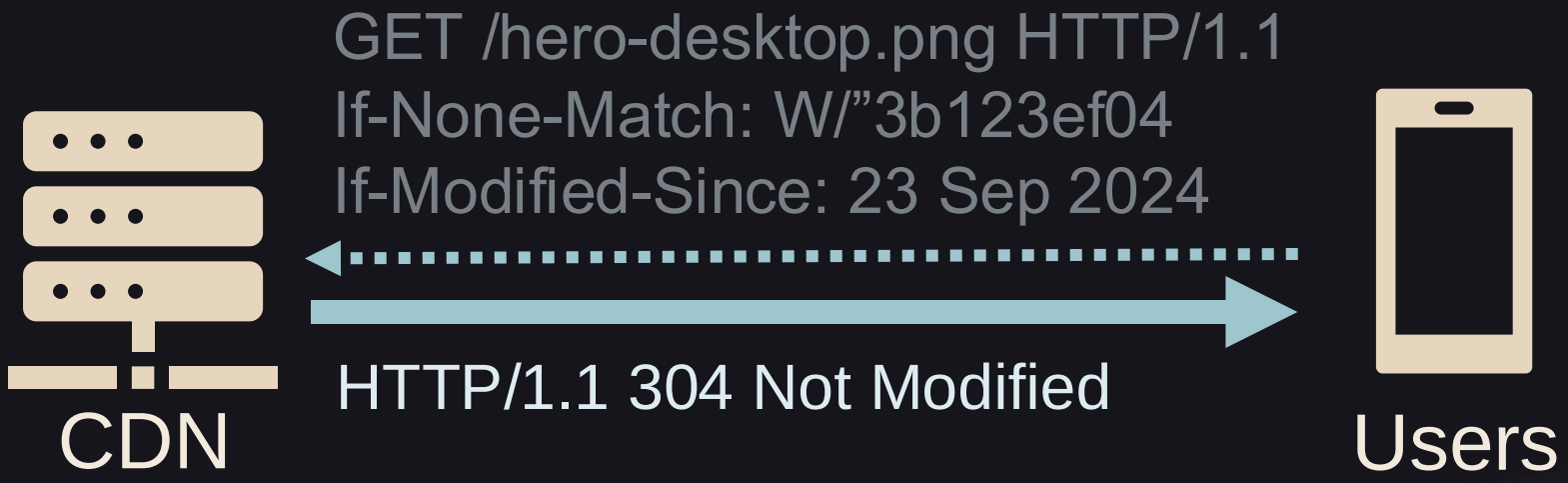
Browser Caching



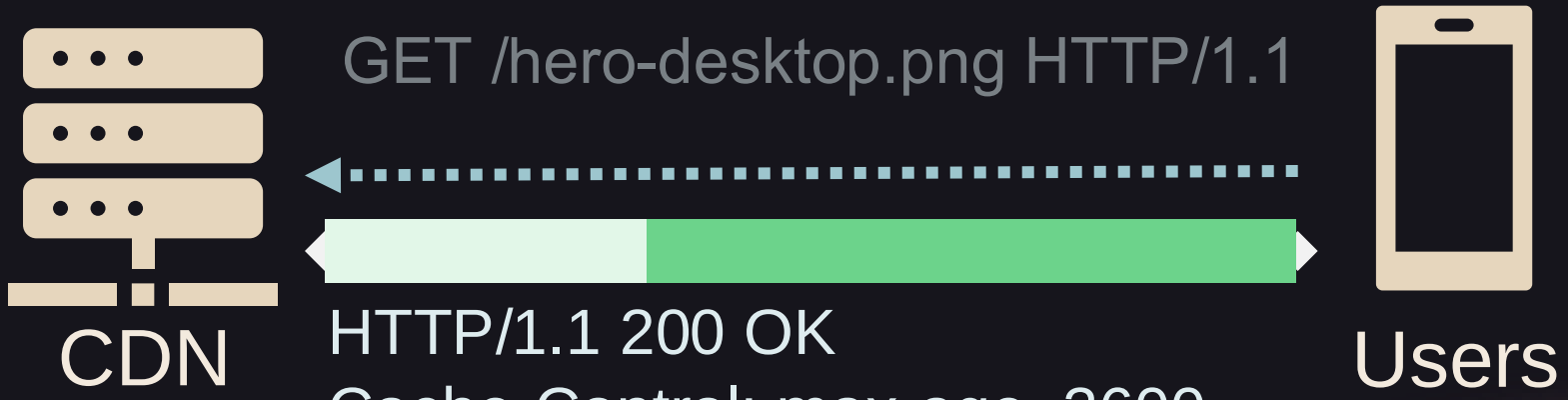
Browser Caching



Browser Caching

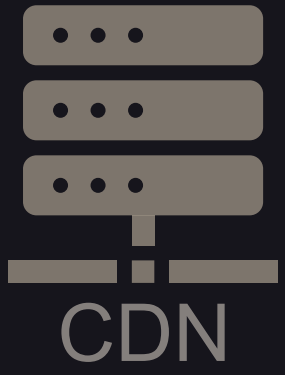


Browser Caching



Improving Web Performance / Return UX

Browser Caching



GET /hero-desktop.png HTTP/1.1

Free Request!

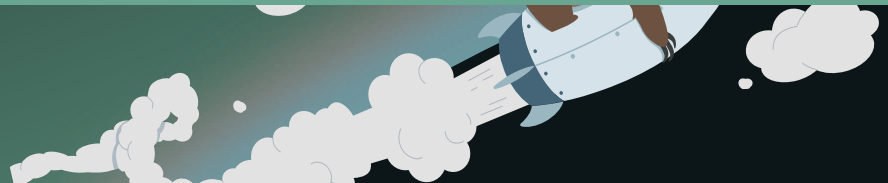
Todd H. Gardner

Enable Caching Headers

Local DevStickers

http://localhost:3000/

- Enable Caching Headers
- ./server/performance-config.js



Workshop Outline

Improving

- ~~Improving TTFB~~
- ~~Improving FCP~~
- ~~Improving LCP~~
- ~~Improving Returning Experience~~
- **Improving CLS**
- Improving INP

Improving Cumulative Layout Shift CLS

FUNDAMENTALS of Web Performance

Todd H. Gardner

Improving Web Performance

Cumulative Layout Shift

How smooth and predictably elements load into the page

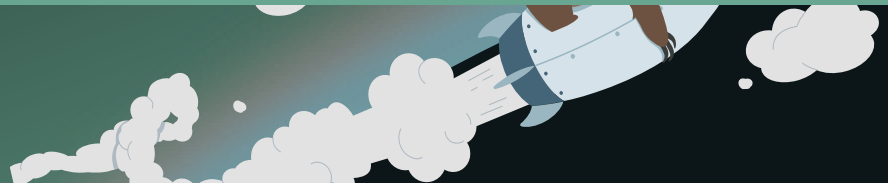
Source: Request Metrics

Baseline CLS

CDN DevStickers

https://www.devstickers.shop/

- Chrome Throttling
- Chrome Performance Profile



Do you need to worry about this?

CLS

Cumulative Layout Shift

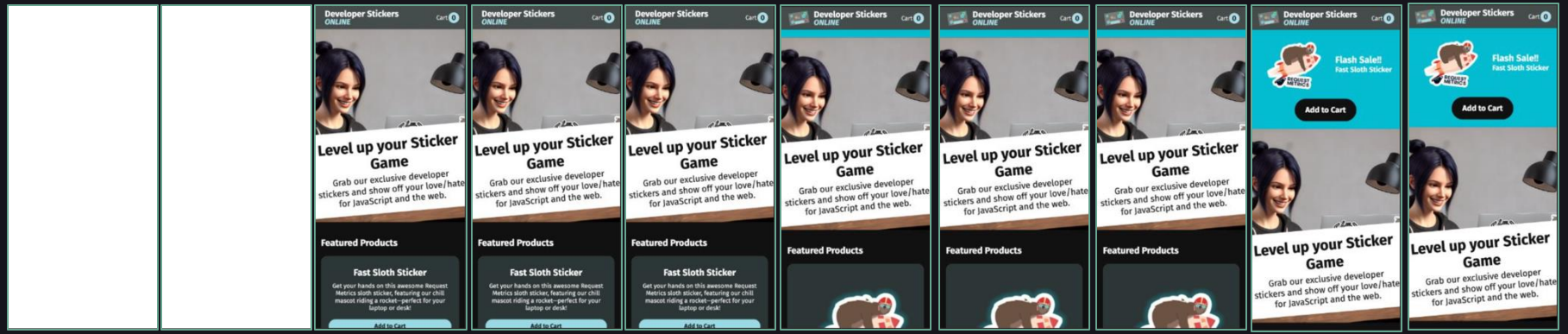
Check your RUM or CrUX p75 Data

Source: [web.dev](web.dev)

Tactics

1. Layout Size Hints

Lazy Image Dimensions



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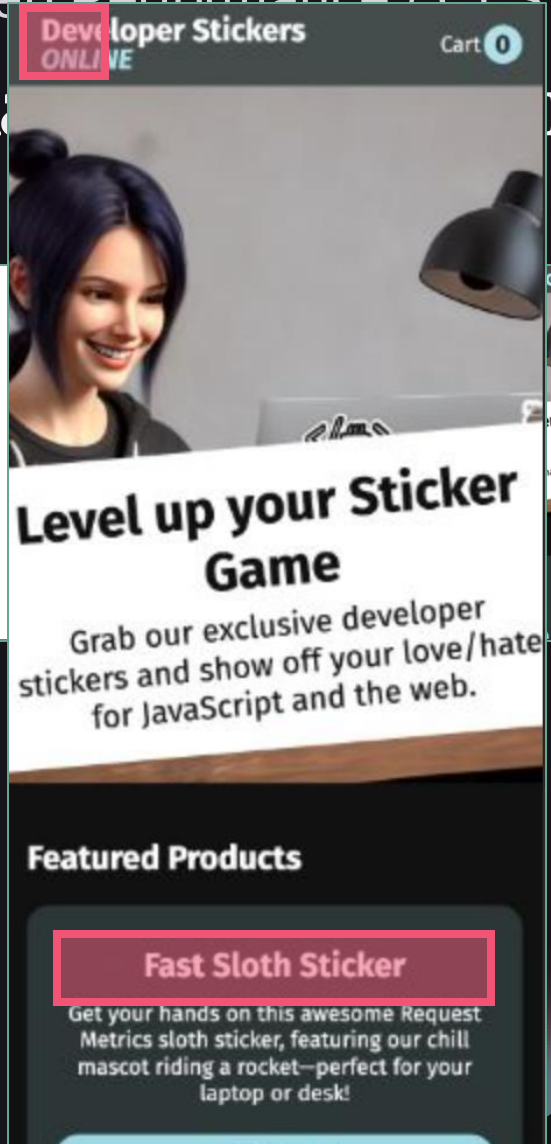
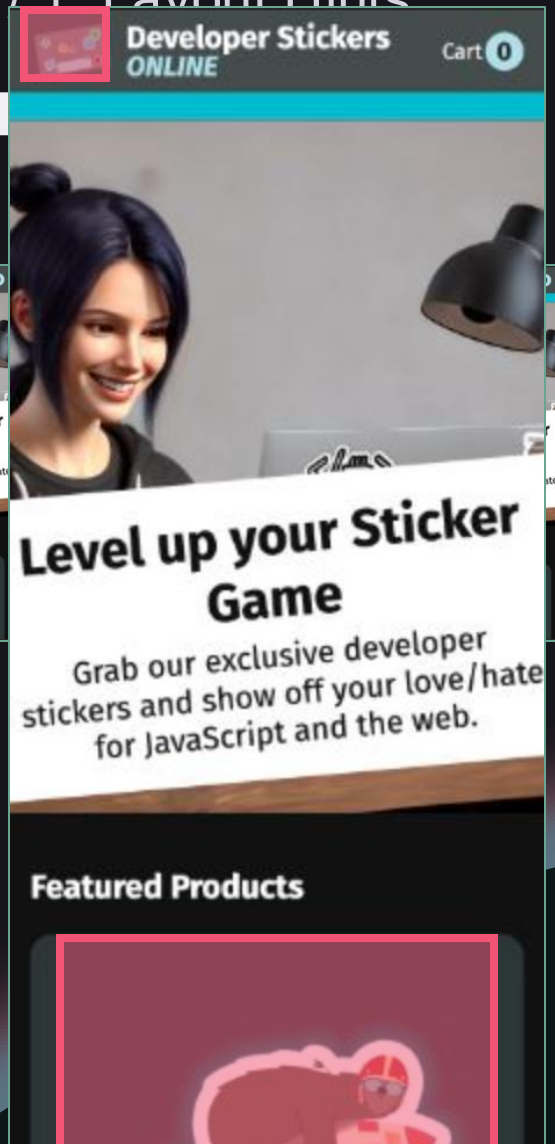
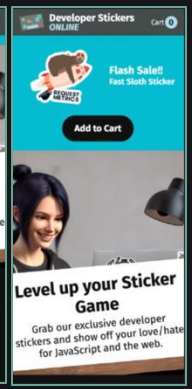
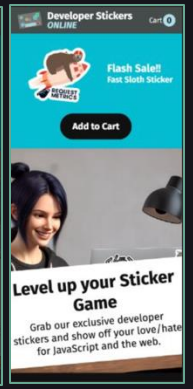
Improving Web Performance / CLS / 1. Layout Hints

Lazy Ima









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Lazy Images

```
34
35          <img src="/assets/img/devstickers-logo.png"
36            alt="Developer Stickers Online" loading="lazy"
37            width="500" height="500" />
38
```

Lazy Images

```
34
35          <img src="/assets/img/devstickers-logo.png"
36            alt="Developer Stickers Online" loading="lazy"
37            width="500" height="500" />
38
```

500px?!?!

Lazy Images

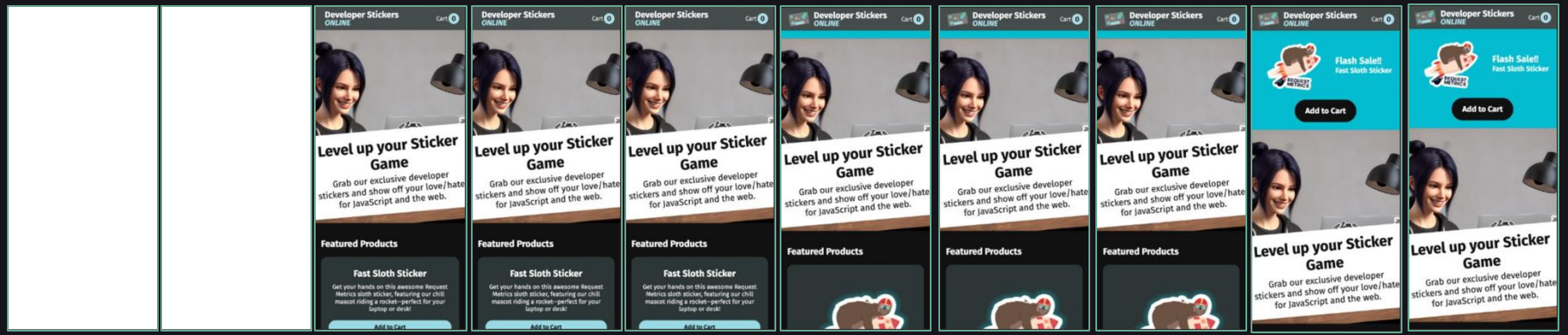
```
34
35          <img src="/assets/img/devstickers-logo.png"
36            alt="Developer Stickers Online" loading="lazy"
37            width="500" height="500" />
38
```

Calculated for aspect-ratio

aspect-ratio: 1 / 1

Source: MDN

Late Content Size



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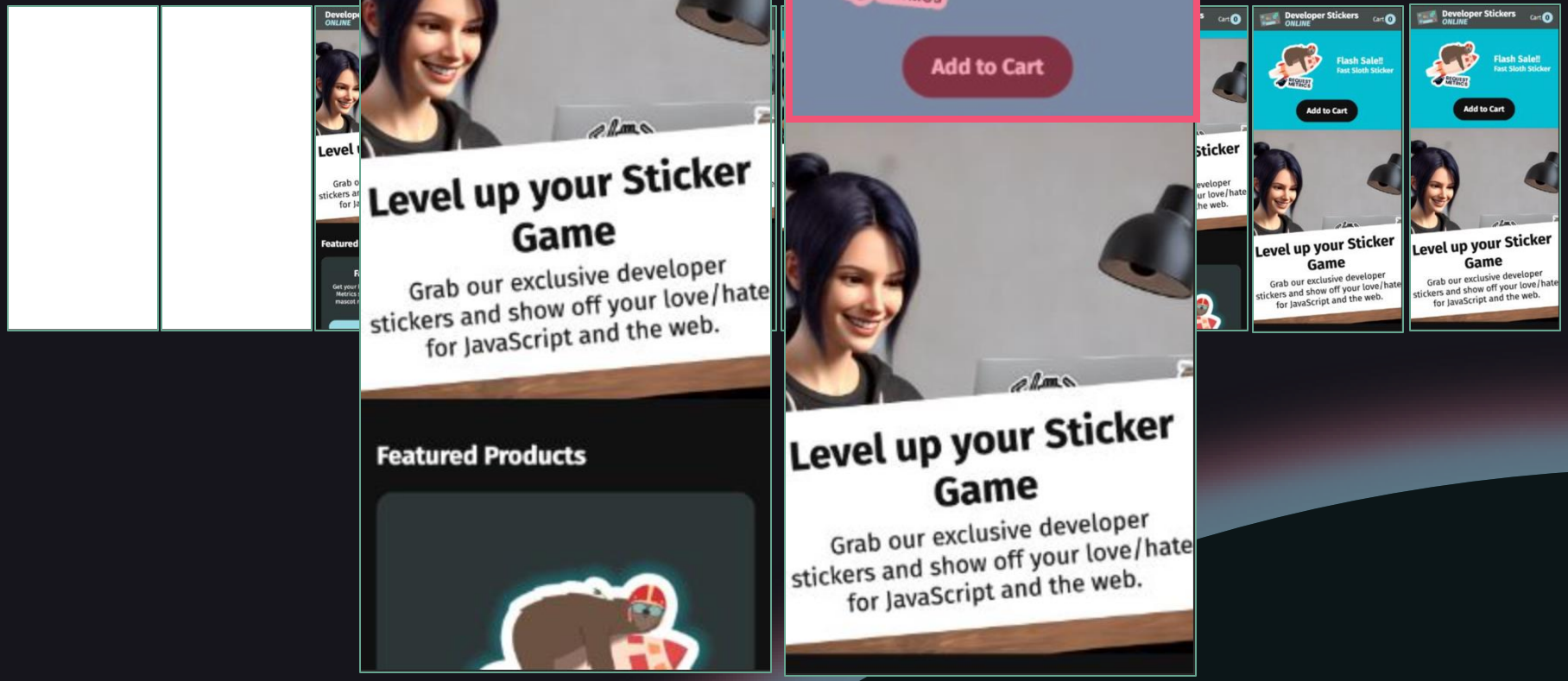
Improving Web Performance / CLS / 1. Layout Hints

Late Conte



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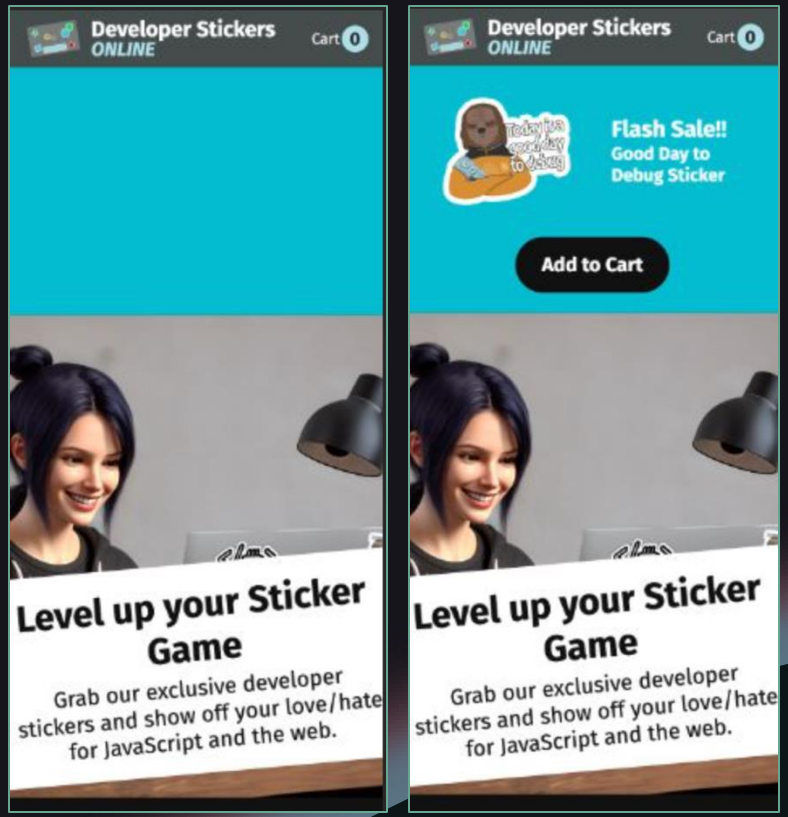
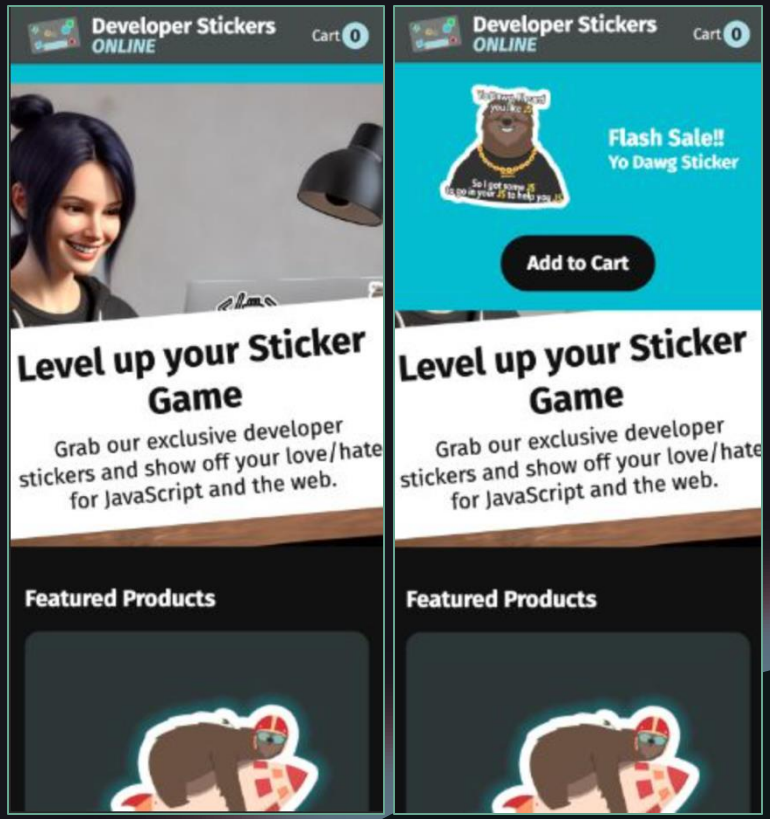
Late Content Size

```
363
364  #promo-banner {
365    height: 260px;
366  }
367
```



Late Content Size

```
367
368  #promo-banner {
369    position: absolute;
370    top: 60px;
371    left: 0;
372    right: 0;
373    z-index: 1;
374  }
375
```

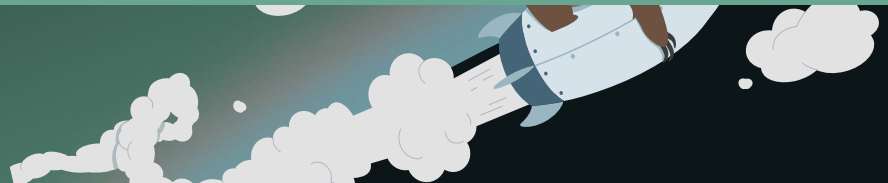


Add Layout Hints

Local DevStickers

http://localhost:3000/

- img height and width
- #promo-bar

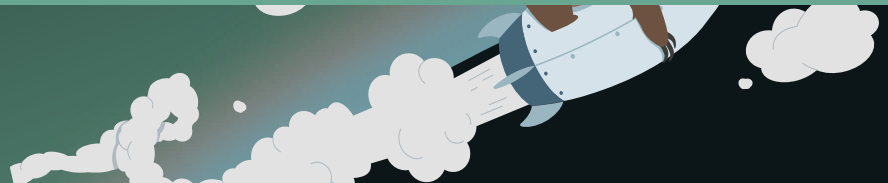


Results

CDN DevStickers

https://www.devstickers.shop/

- Deploy



Workshop Outline

Improving

- ~~Improving TTFB~~
- ~~Improving FCP~~
- ~~Improving LCP~~
- ~~Improving Returning Experience~~
- ~~Improving CLS~~
- **Improving INP**

Improving Interaction to Next Paint INP

Todd H. Gardner

Improving Web Performance

Interaction to Next Paint

How quickly users can interact

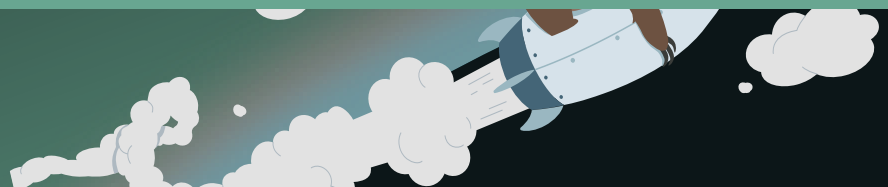
Source: Request Metrics

Baseline INP

CDN DevStickers

https://www.devstickers.shop/

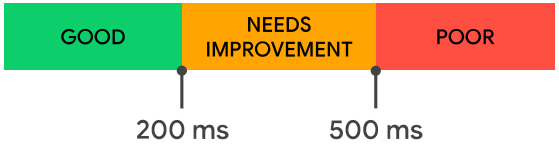
- Chrome Throttling
- Chrome Performance Profile
- Click Add to Cart



Do you need to worry about this?

INP

Interaction to Next Paint



Check your RUM or CrUX p75 Data

Source: [web.dev](web.dev)

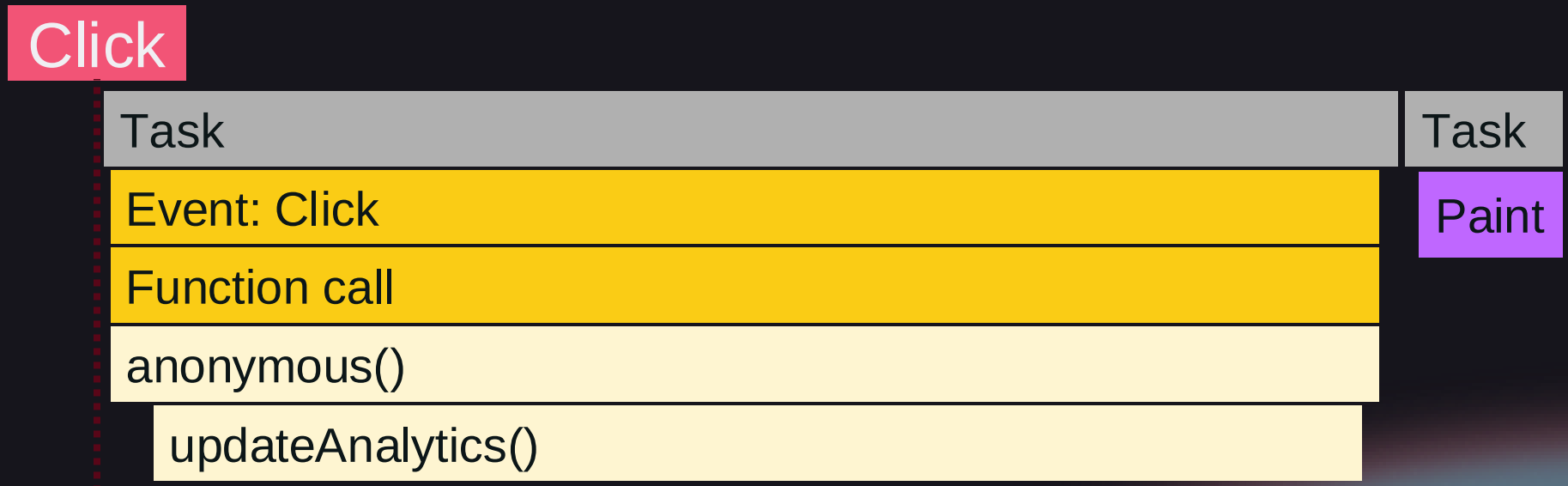
Tactics

1. Yield the main thread

1. Yield the main thread

```
26
27  document.body.addEventListener("click", async (evt) ⇒ {
28    const el = evt.target;
29    if (el.matches("button.add-to-cart")) {
30      const productId = parseInt(el.getAttribute("data-product-id"), 10);
31      updateAnalytics();
32      await addToCart(user, productId);
33    }
34  });
35
```

Flame

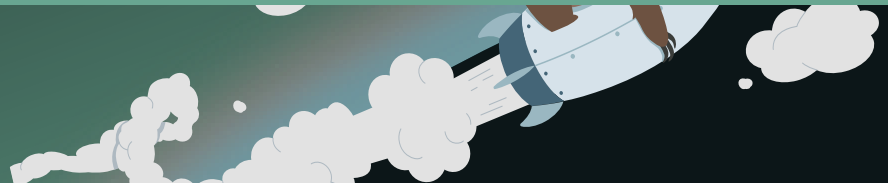

Click
Task
Task
Event: Click
Paint
Function call
anonymous()
updateAnalytics()

Debug Long Task

Local DevStickers

http://localhost:3000/

- Run Performance Profiler
- Click Button



Todd H. Gardner

setTimeout

- Schedules code to run in the future
- Allows other work to run.

Source: web.dev

requestAnimationFrame

- Schedules code to run just before the next paint.
- Useful for animations

Source: web.dev

1. Yield the main thread

```
27  document.body.addEventListener("click", async (evt) => {
28    const el = evt.target;
29    if (el.matches("button.add-to-cart")) {
30      const productId = parseInt(el.getAttribute("data-product-id"), 10);
31      requestAnimationFrame(async () => {
32        el.textContent = "Added!";
33        el.setAttribute("disabled", "disabled");
34        setTimeout(() => {
35          updateAnalytics();
36        },);
37        await addToCart(user, productId);
38        setTimeout(() => {
39          el.textContent = "Add to Cart";
40          el.removeAttribute("disabled");
41        }, 1500);
42      });
43    }
44  });
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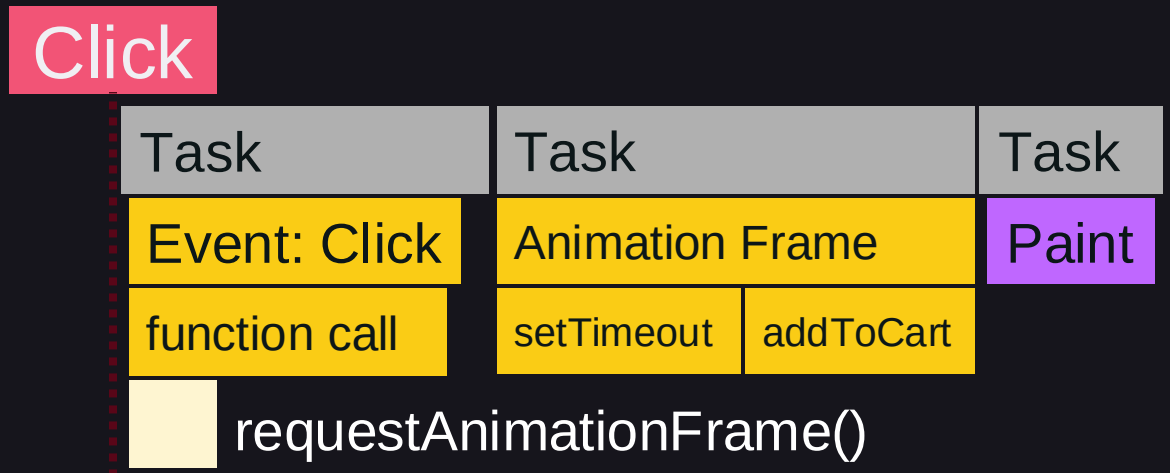
Flame

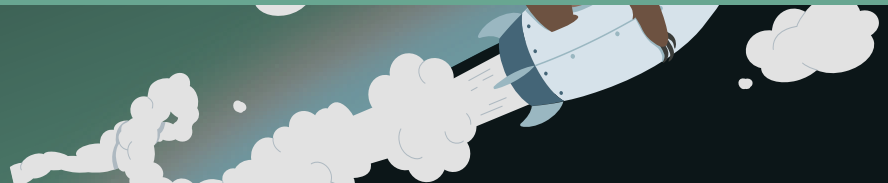

Click
Task
Task
Task
Task
Event: Click
Animation Frame
Paint
Timer Fired
function call
setTimeout
addToCart
updateAnalytics()
requestAnimationFrame()

Add Yielding

Local DevStickers

http://localhost:3000/

- Confirm in Profiler



Workshop Outline

~~1. Importance~~

~~2. Measuring~~

~~3. Tests and Tools~~

~~4. Setting Goals~~

~~5. Improving~~

~~Waterfall Charts~~

~~Flame Charts~~

~~Statistics~~

FUNDAMENTALS of
Web Performance

Performance Review

FUNDAMENTALS of
Web Performance

Performance Review

Why is Web Performance Important

- User Experience
- SEO
- Online Advertising

User Expectations

- **40% of users abandon** a site at 3 seconds

- **75% of users** that experience a “slow” site **will not return**

Source: Time is Money, Everts

Performance Review / Important

SEO and Performance

“Search ranking change that incorporates **page experience metrics**. We will introduce a new signal that combines **Core Web Vitals** with our existing signals”

Source: Google Search Central Blog

Performance Review

Core Web Vitals

1. Largest Contentful Paint (LCP)
2. Cumulative Layout Shift (CLS)
3. Interaction to Next Paint (INP)

Todd H. Gardner

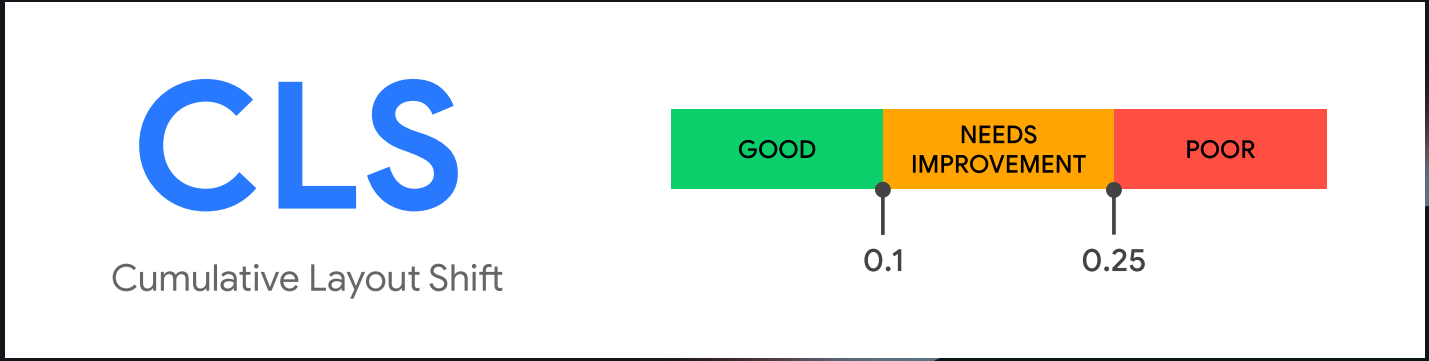
Largest Contentful Paint

How fast your site visibly loads the **most important** element

Source: Request Metrics

Cumulative Layout Shift

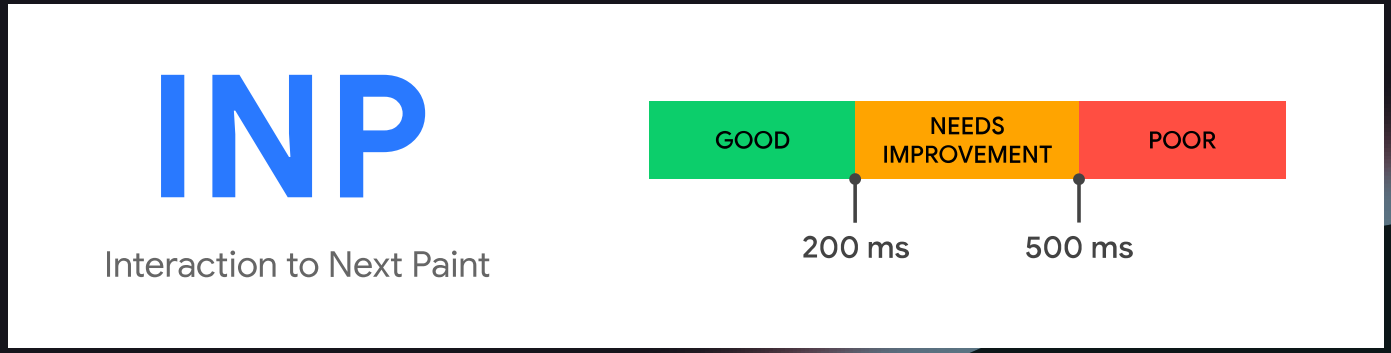
How smooth and predictably elements load into the page



Source: Request Metrics

Interaction to Next Paint

How quickly users can interact



Source: Request Metrics

How Fast is **Fast Enough?**

Todd H. Gardner

Lab Data vs Field Data

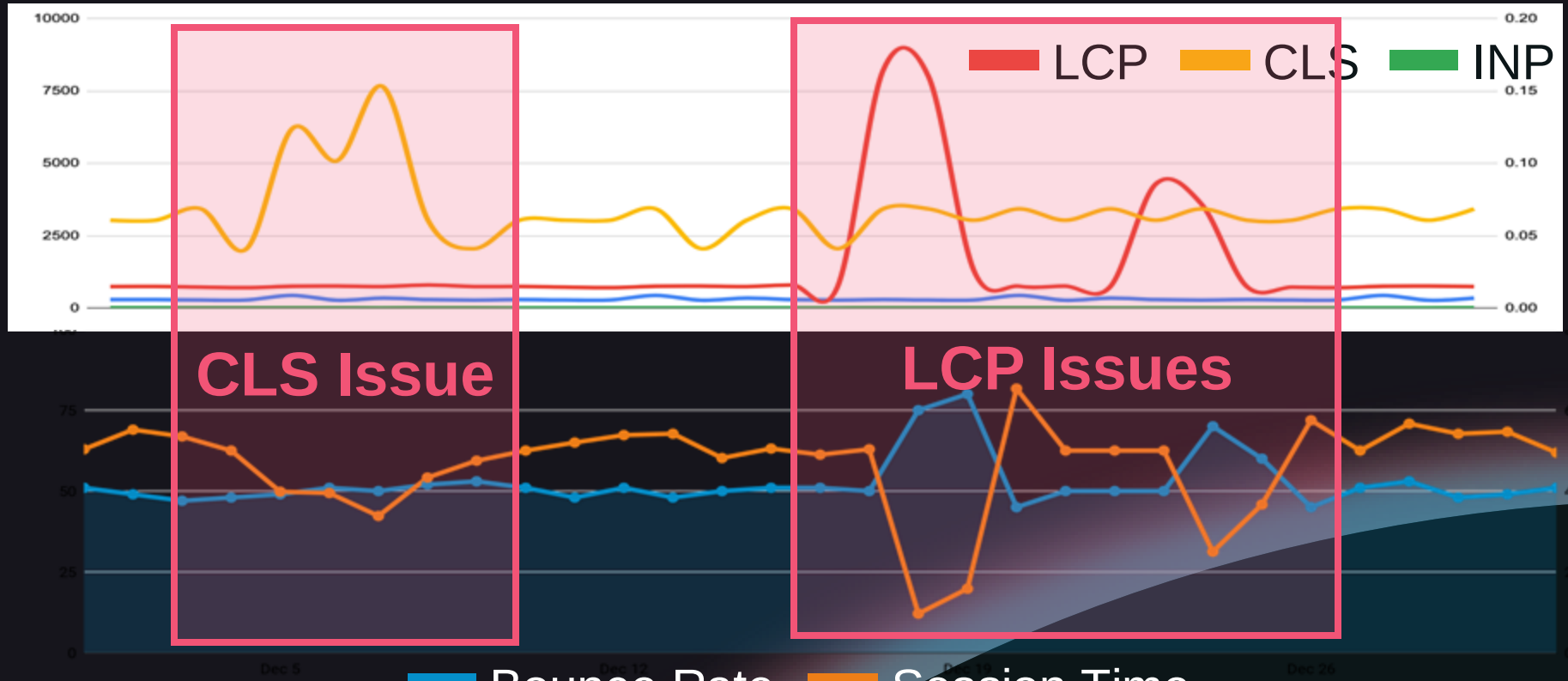
Lab Data is ***diagnostic***

Field Data is ***experience***

Todd H. Gardner

Performance Review / Fast

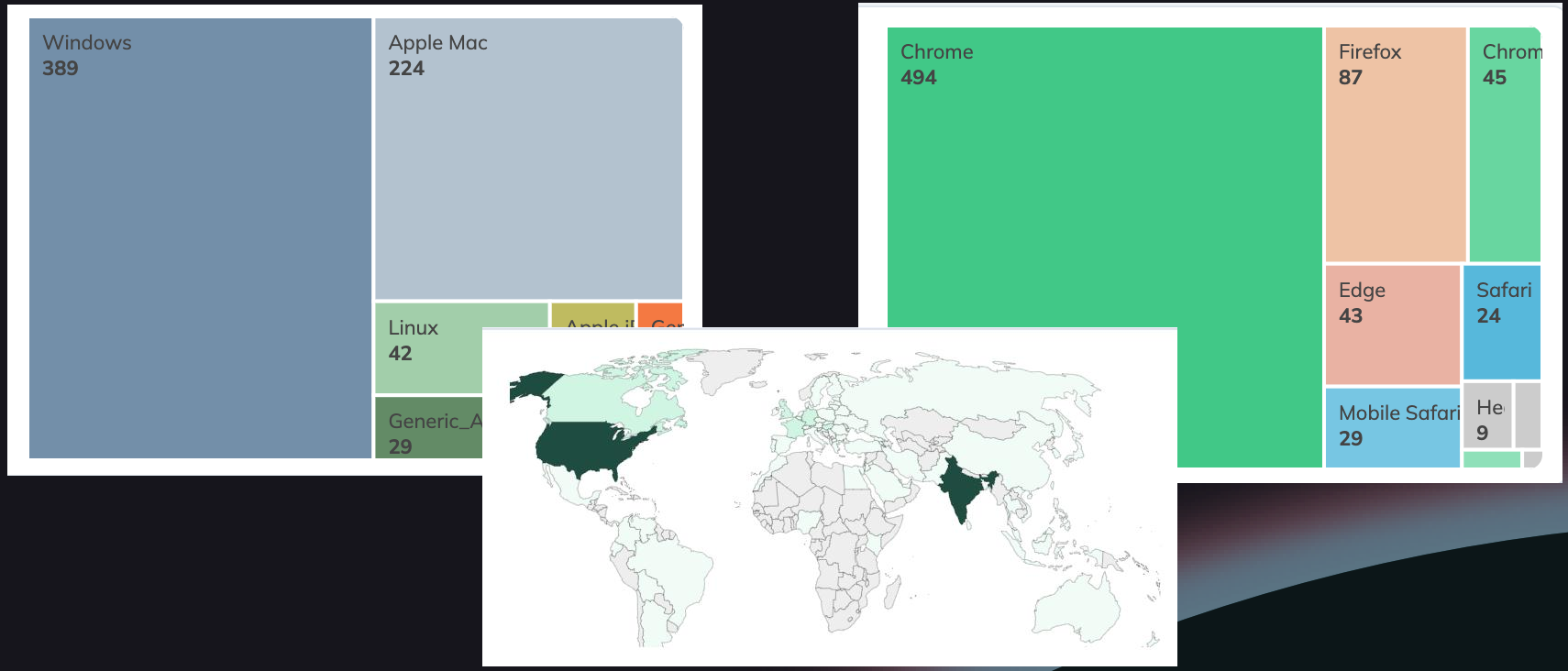
Follow Your Business Metrics



Todd H. Gardner

Performance Review / Fast

Understand Your Users



Source: Request Metrics

Todd H. Gardner

First Things First

Focus on the easiest fixes for your worst metric from real user data.

What do I do now?

Performance Review / Next Steps

Test Your Project

bit.ly/speed-chex

Todd H. Gardner

Performance Review / Next Steps

Install RUM Tools

REQUEST METRICS

Web Performance Monitoring

RequestMetrics.com

Todd H. Gardner

Join the Next Workshop

INTERMEDIATE
Web Performance

Coming Spring 2025

Performance Review / Next Steps

Tag Me

bit.ly/sup-todd

Todd H. Gardner

FUNDAMENTALS of Web Performance

End of Part 2

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