



LET'S MAKE THE WEB FASTER!

# HACKING PERFORMANCE WEB VITALS

MAXIMILIANO FIRTMAN



# MAXIMILIANO FIRTMAN

MOBILE+WEB DEVELOPER

HTML since 1996

JavaScript since 1998

AUTHOR

Authored 13 books and +70 courses

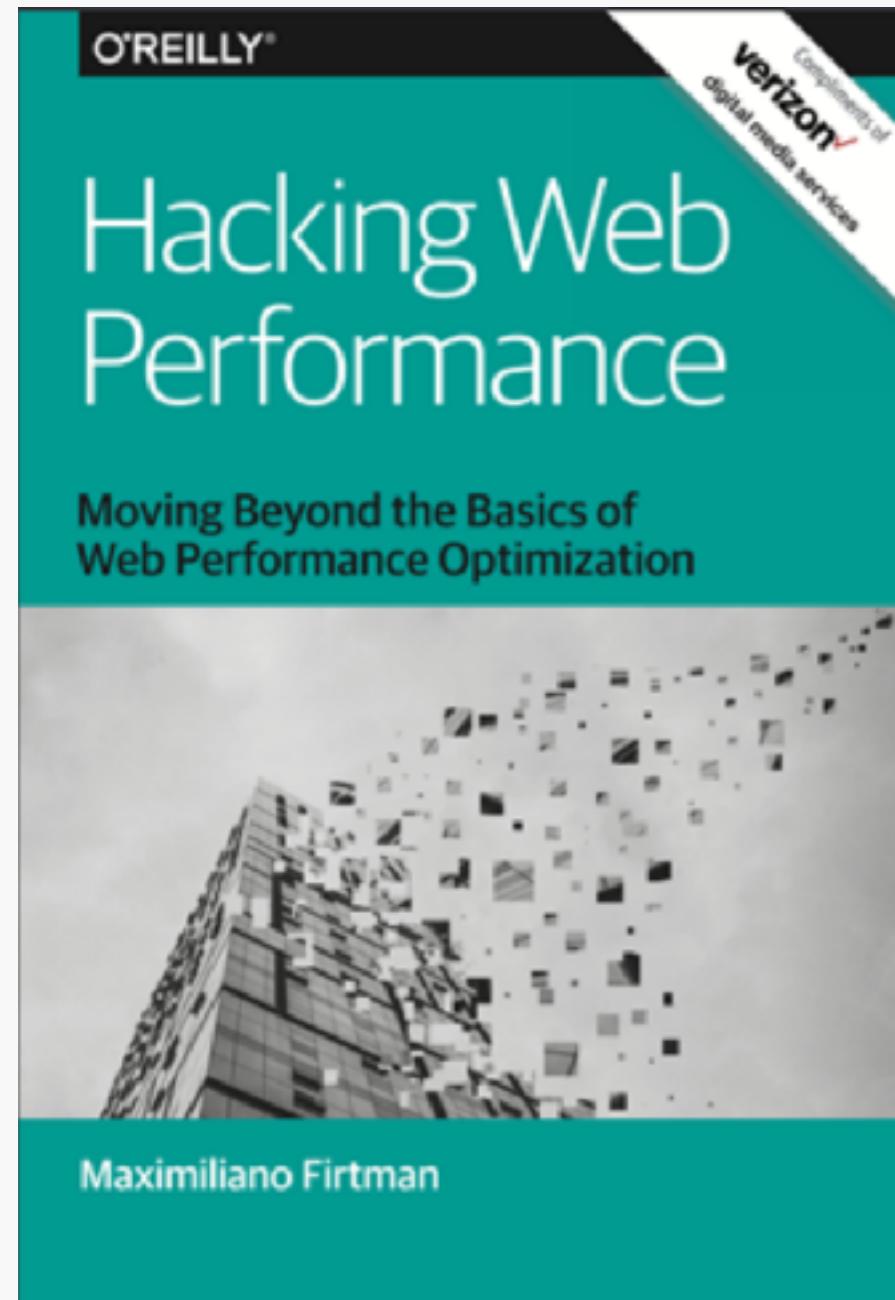
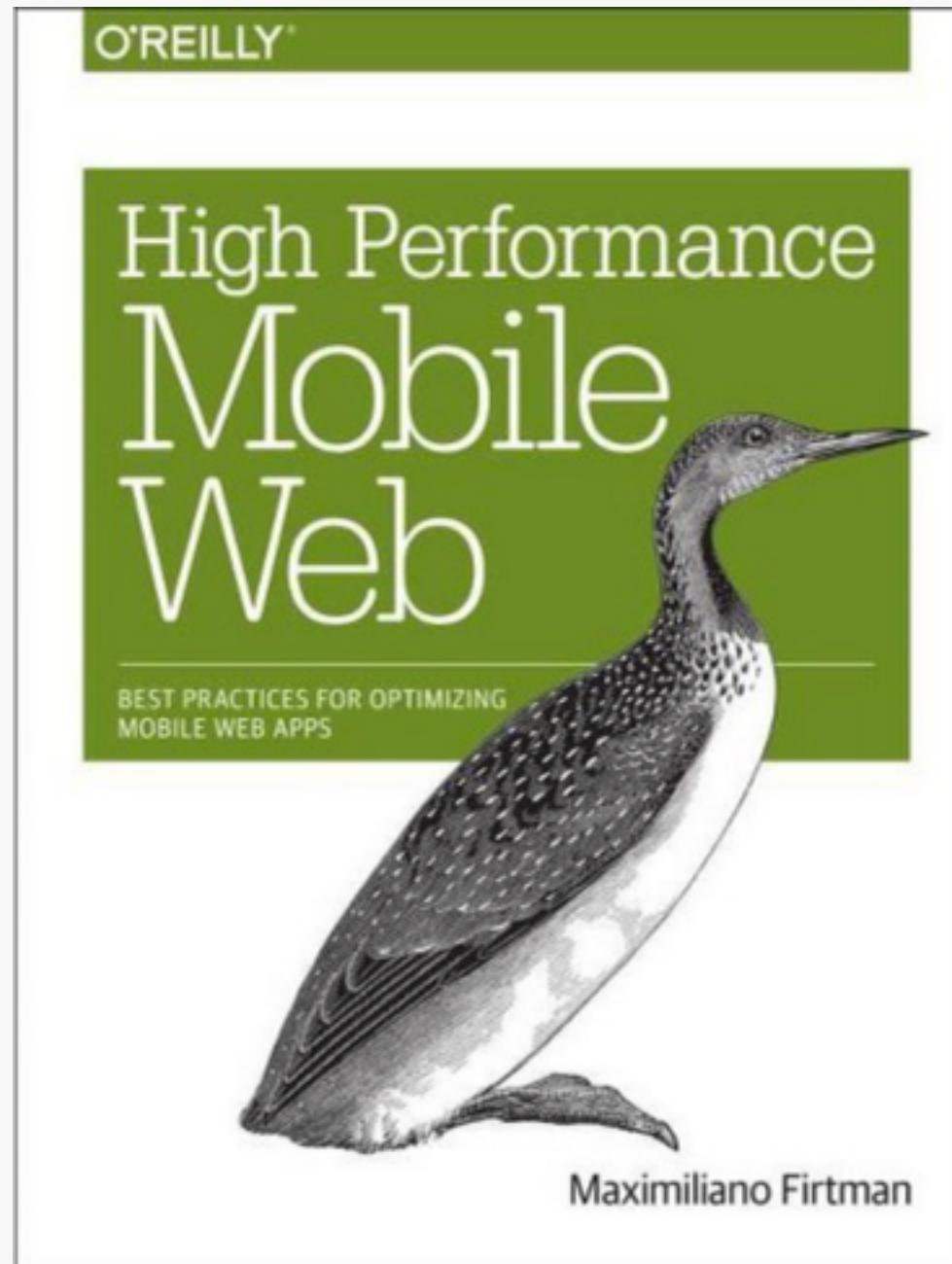
Published +150 webapps



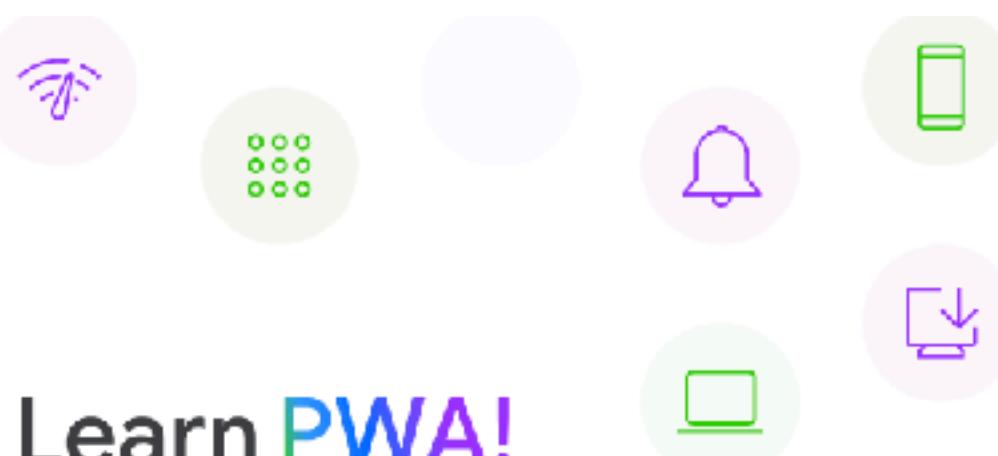
@FIRT · FIRT.DEV



# MAXIMILIANO FIRTMAN



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## Learn PWA!

Search

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001 Progressive Web Apps

002 Getting started

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006 Service workers

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# Learn PWA

A course that breaks down every aspect of modern progressive web app development.

## Welcome to Learn Progressive Web Apps!

Welcome to Learn Progressive Web Apps!

This course covers the fundamentals of Progressive Web App development in easy-to-understand pieces. Over the following modules, you'll learn what a Progressive Web App is, how to create one or upgrade your existing web content, and how to add all the pieces for an offline, installable app. Use the menu pane to navigate the modules. (The menu is at left on desktop or behind

Frontend **Masters**



**LinkedIn** Learning

**awwards.academy**

# Questions?

# Workshop site

`codeeurope.firt.dev`

I have 2 goals today...

Show you  
new tricks



Make you  
feel bad



# What we'll cover

The Problem

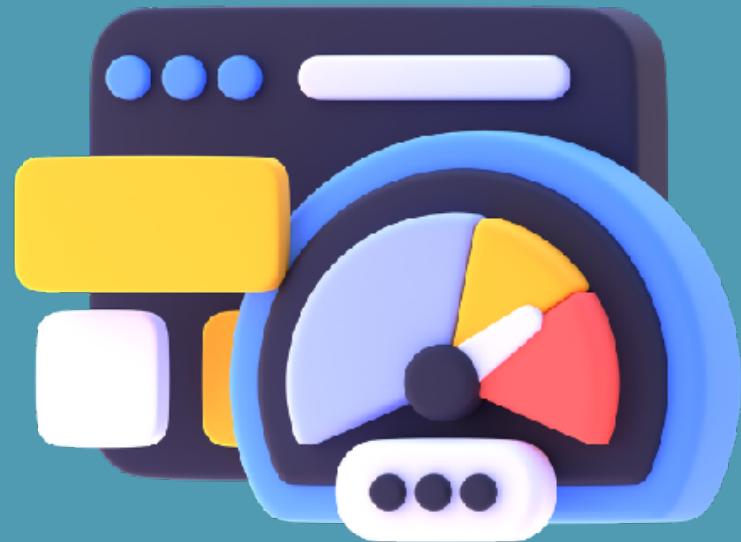
Web Vital Metrics

Tools for Vitals

Improvement Tips



# The Problem



You already know that...



<http://www.flickr.com/photos/steenslag/22689920/>  
borrowed from Steve Souders



Picture from Simon Howden [freedigitalphotos.net](http://freedigitalphotos.net)



Picture from Simon Howden freedigitalphotos.n

It's mostly frontend  
responsibility!

I know  
you are already...

You are already...

Optimizing the network  
transfer

You are already...

Working with TLS  
and HTTP/2

You are already...

**CSS as Appetizer**

You are already...

# JavaScript as Dessert

You are already...

# Optimizing Images

You are already...

# Defining a Policy for HTTP Cache

You are already...

# Using Service Workers

.. right?



I'm watching you

**What's the problem  
then?**

What's the problem then?

## Time to Interactive

MEDIAN MOBILE

12.1 seconds

▲20.7%

HTTP Archive with Lighthouse

What's the problem then?



1 2 3 4 5 6  
7 8 9 10 11  
12 12.1

You are already...

as page load time goes from 1s to  
10s, the probability of a mobile  
visitor to bounce

**Increases by 123%**



# Underestimating Mobile

iOS and Android

# Safari and Chrome?

# browsers with market share

Let's see in action





**ScientiaMobile\_CTO**  
@Scientia\_CTO

...

Replying to @firt @auchenberg and @scientiamobile

Hey Max, you are right. We have some of that data.  
According to our data, 7.6% of global smartphone traffic  
comes from the Facebook App. This and more in our  
MOVR report:



[Mobile Overview Report \(MOVR\) | ScientiaMobile](#)

ScientiaMobile's Overview Report (MOVR) provides timely device data on smartphones, tablets, and desktop devices ...

[scientiamobile.com](http://scientiamobile.com)

Using Cellular  
Networks!

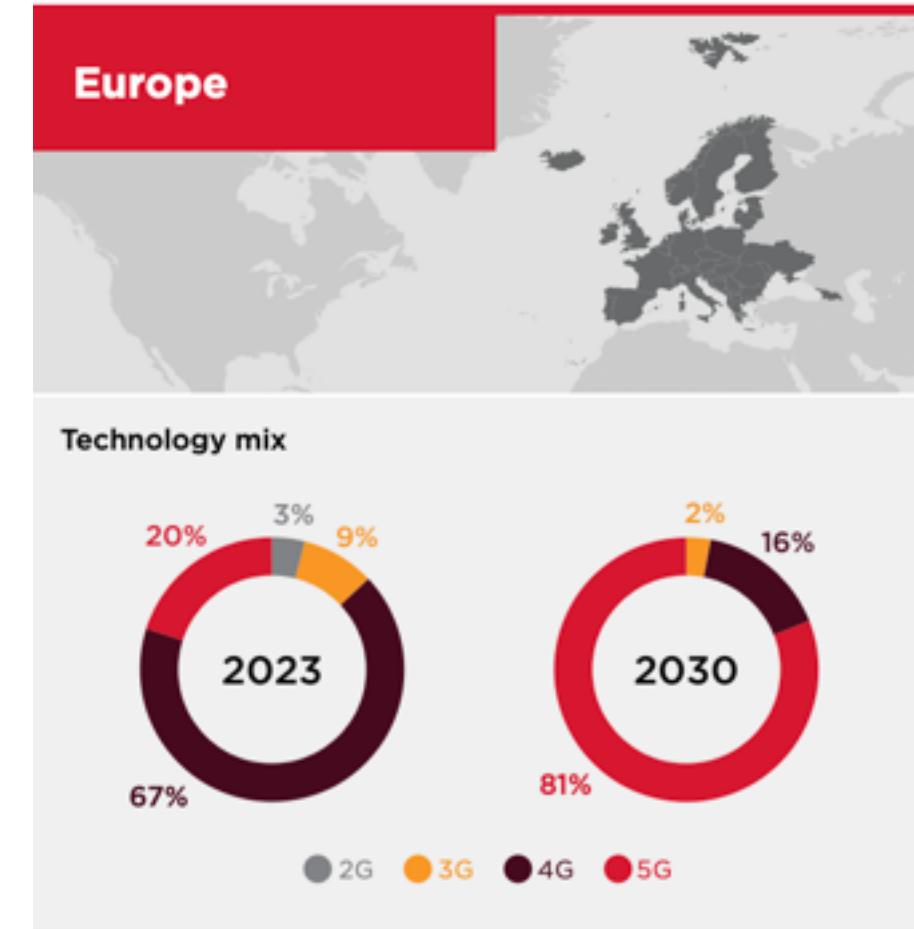
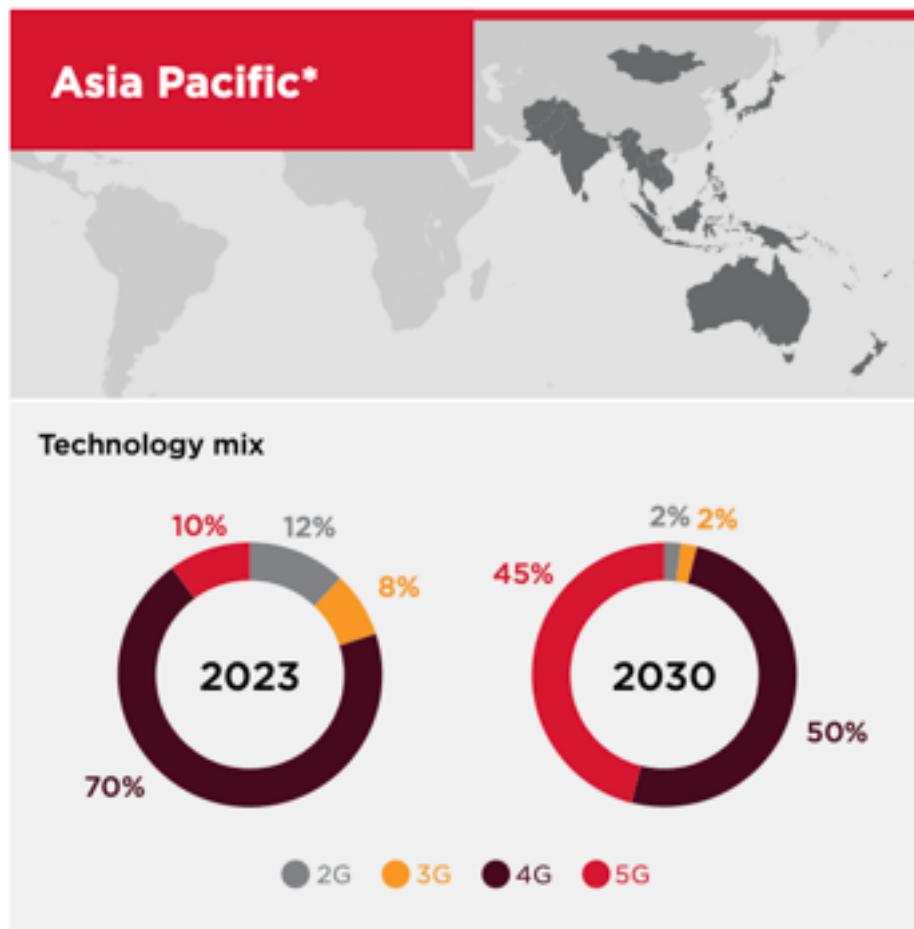
*We have 5G! We don't need to  
worry about performance...*

**4G** Percentage of connections  
(excluding licensed cellular IoT)

2023 **59%**  
2030 **35% ↓**

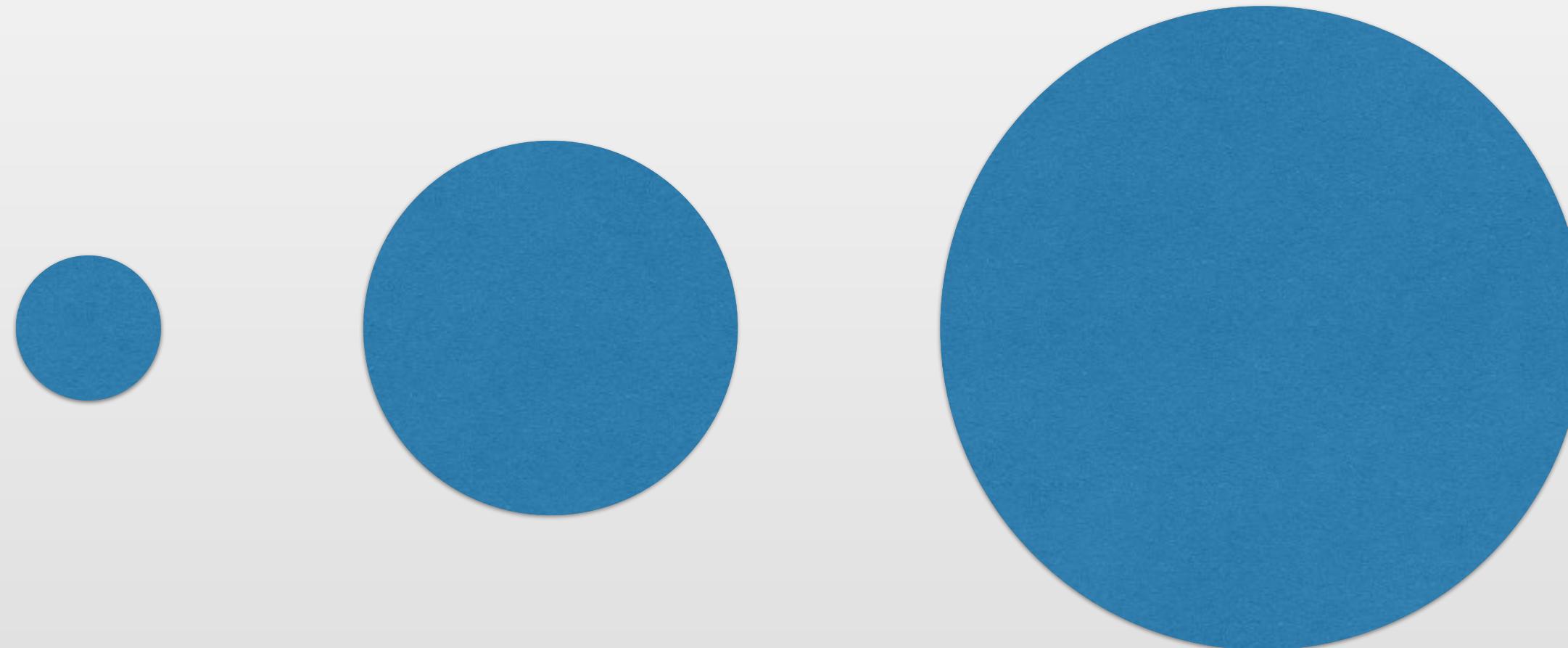
**5G** Percentage of connections  
(excluding licensed cellular IoT)

2023 **18%**  
2030 **56% ↑**



cellular networks

# Bandwidth





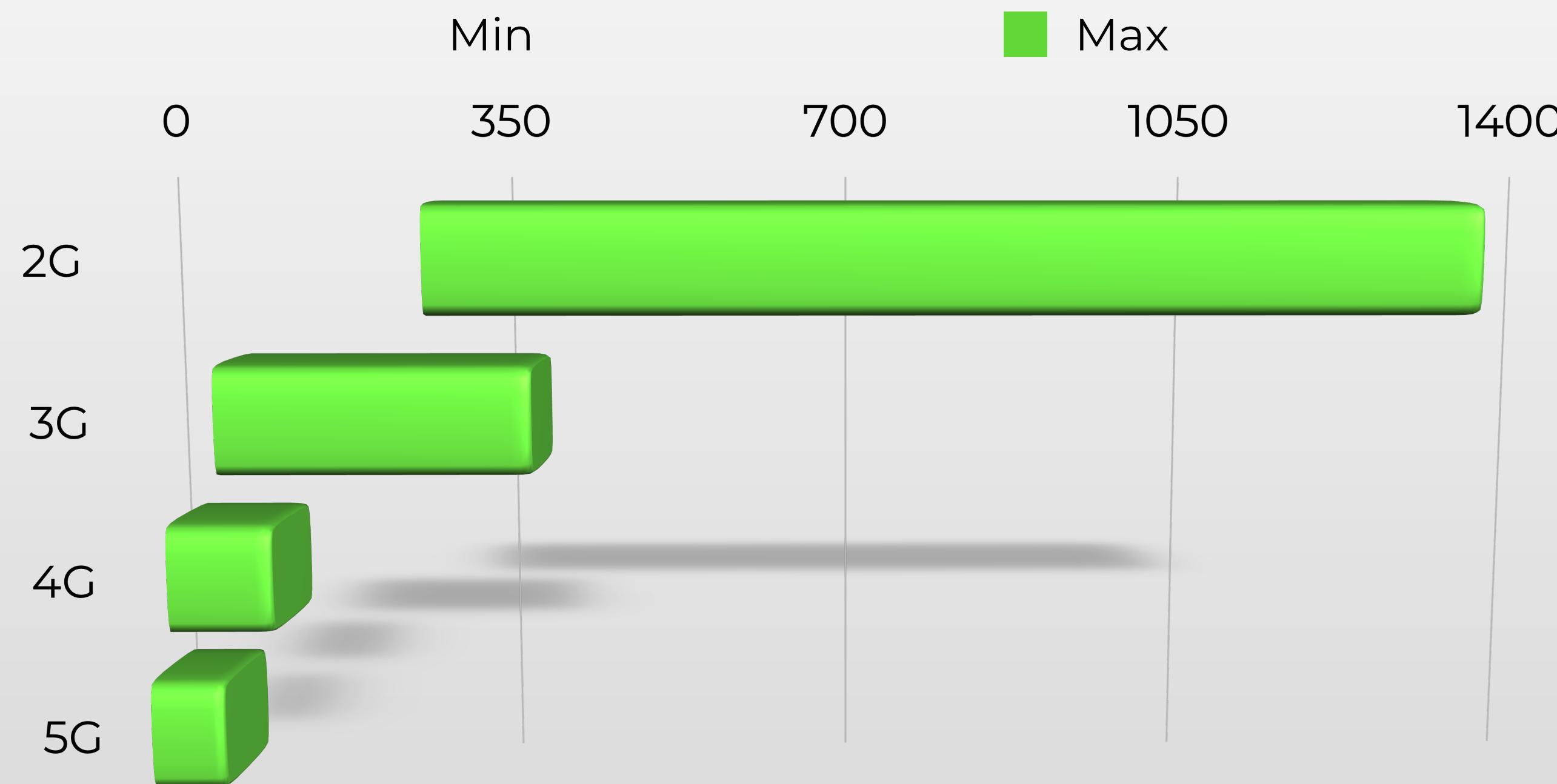
## DEFINITION

# Latency

Time delay between when a data packet is sent and when it is received, expressed in milliseconds.

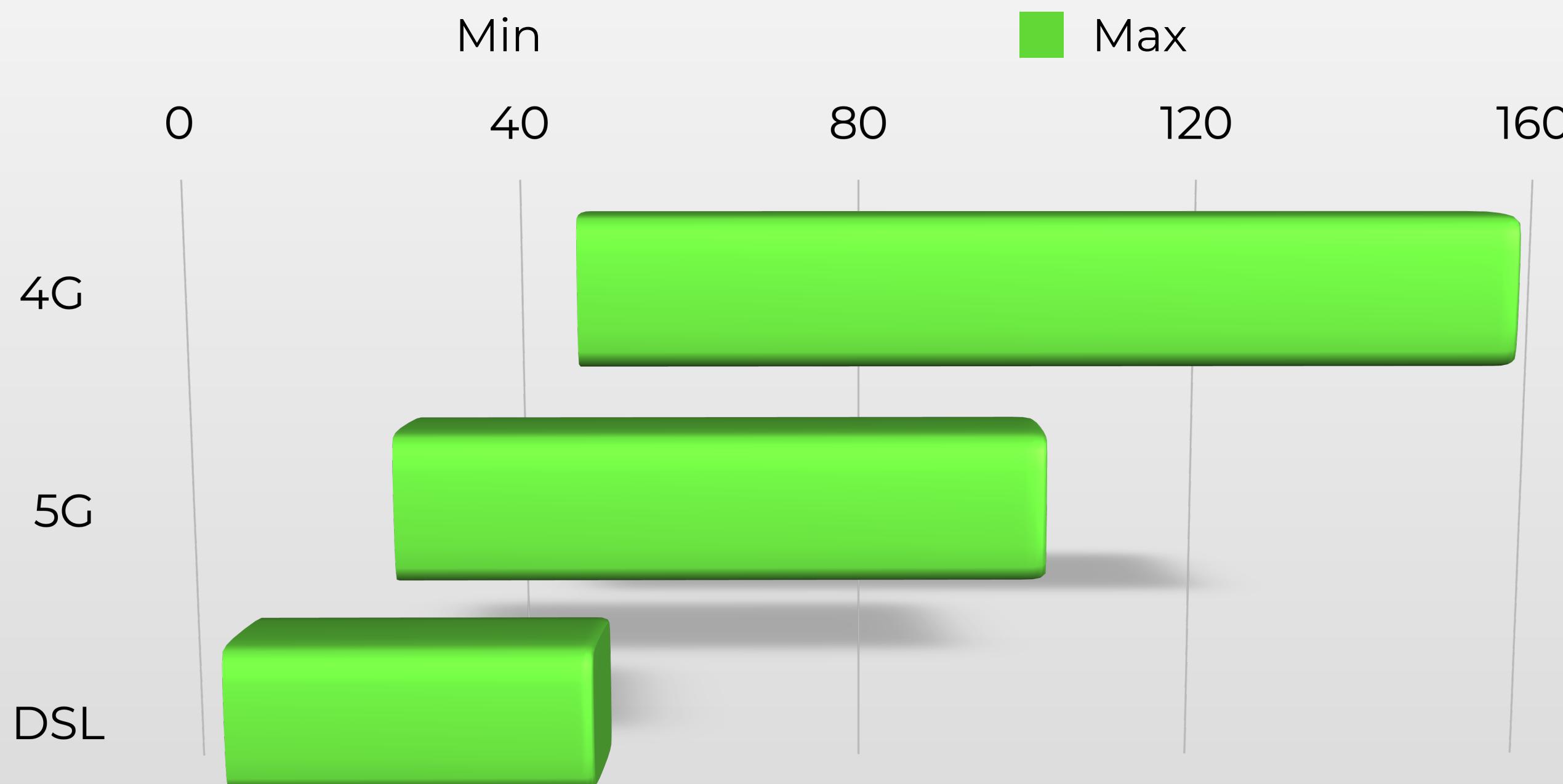
# Cellular Networks

## RTT - latency



# Cellular Networks

## RTT - latency



**IMPORTANT**



"Latency hardly impacts smartphone user experience in advanced 5G and 4G networks"

Verizon

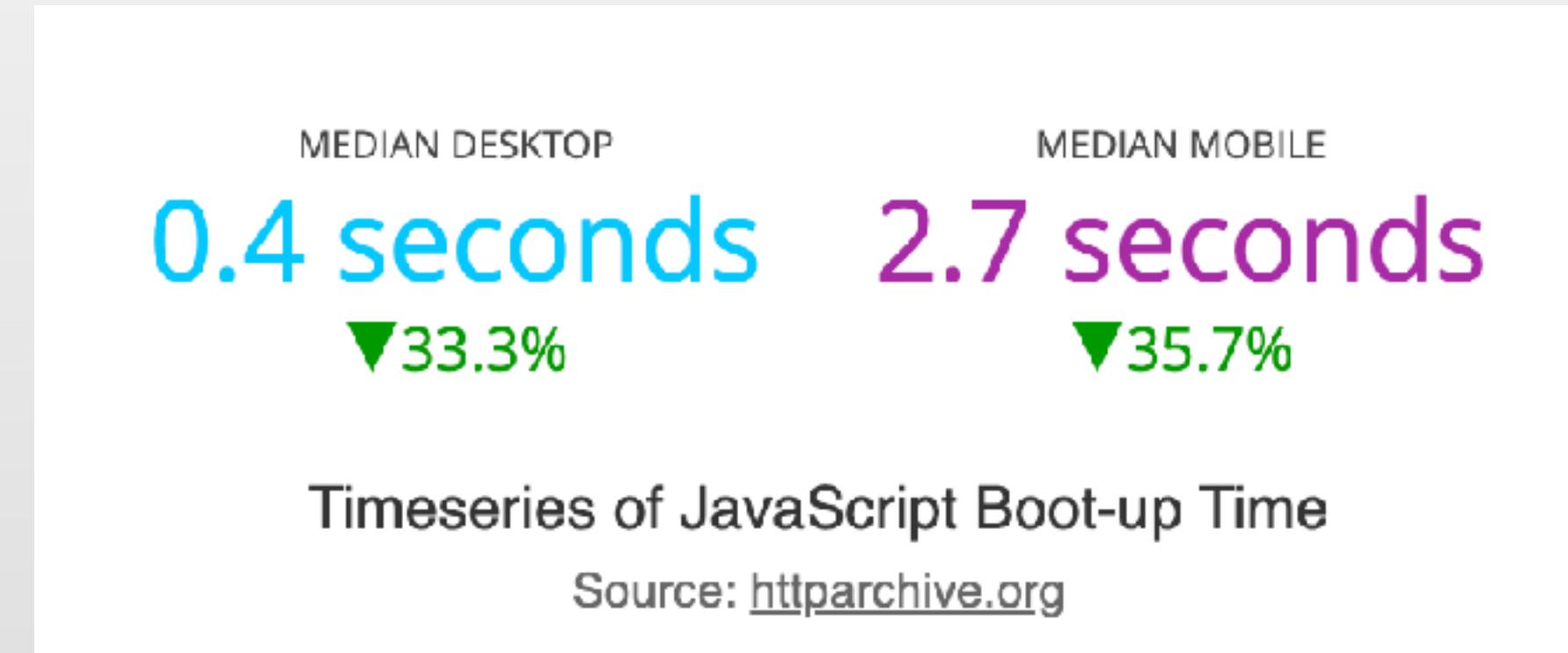


## WARNING

Not every country has  
"advanced" 4G/5G and 23%  
of users is still on 3G or  
worse

# Cellular Devices

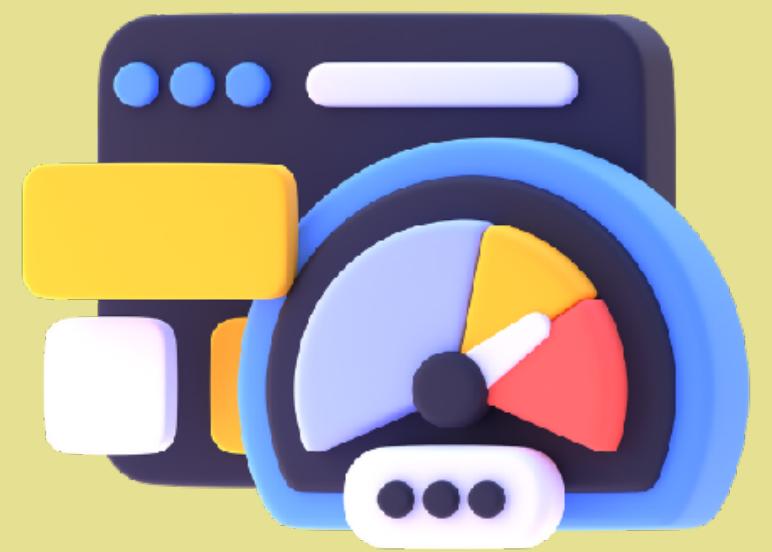
**CPU and GPU ~7x slower**





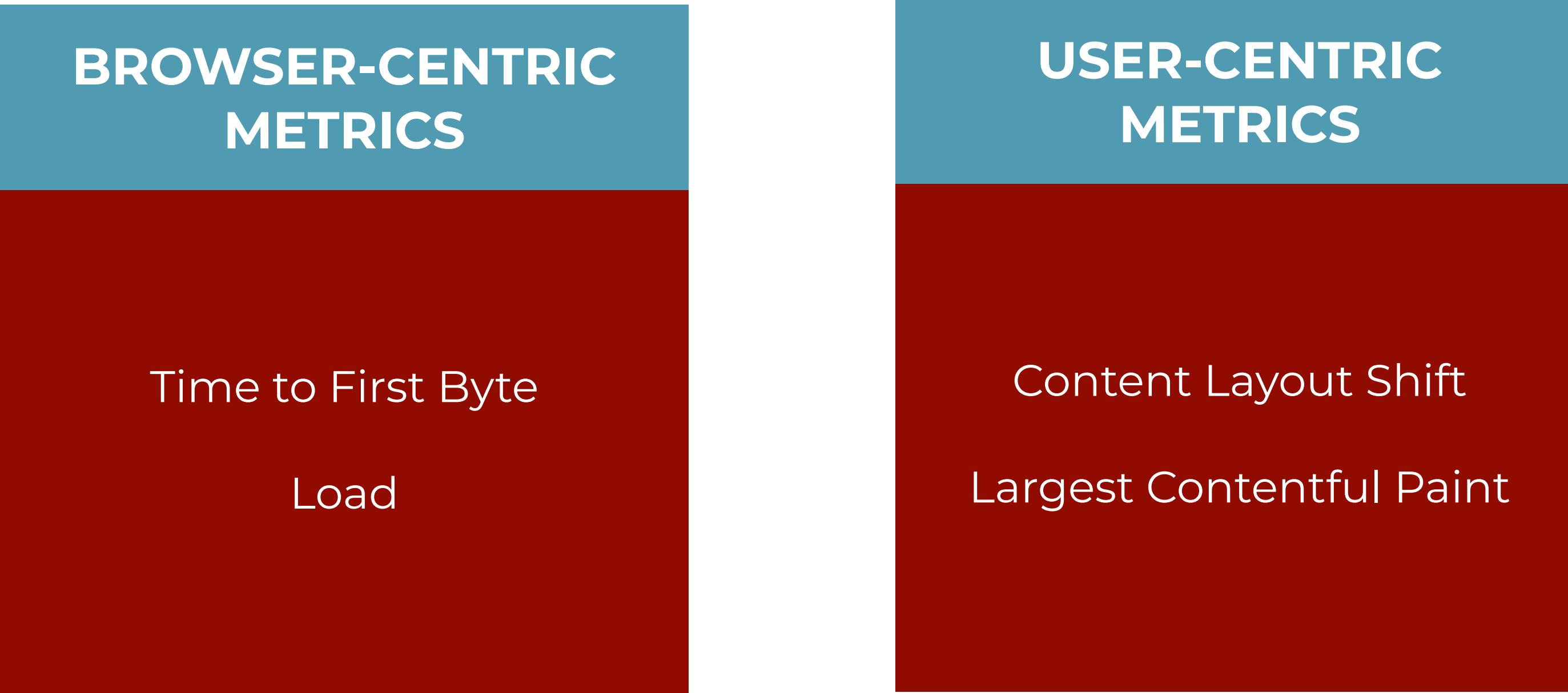
**WARNING**

We still have a  
performance issue on the  
Mobile Web



# Metrics and Tools

# We can't improve what we can't measure



# Browser-centric metrics

## Time to First Byte

(TTFB)

Browser-centric metrics

**First Paint**

Browser-centric metrics

# Page Load



**WARNING**

Browser-centric metrics  
are not so important for  
Web Performance  
Optimization

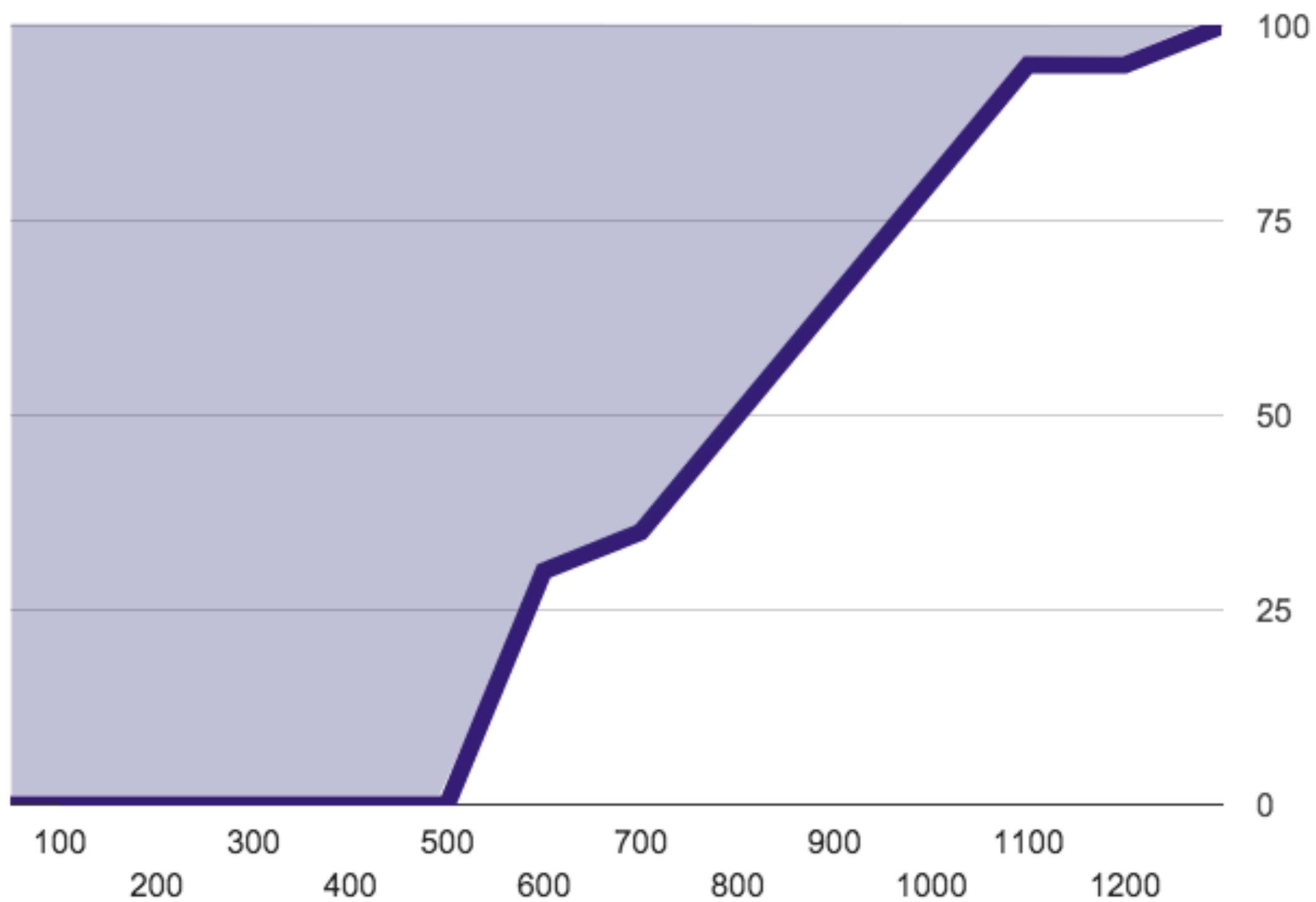
# User-centric metrics

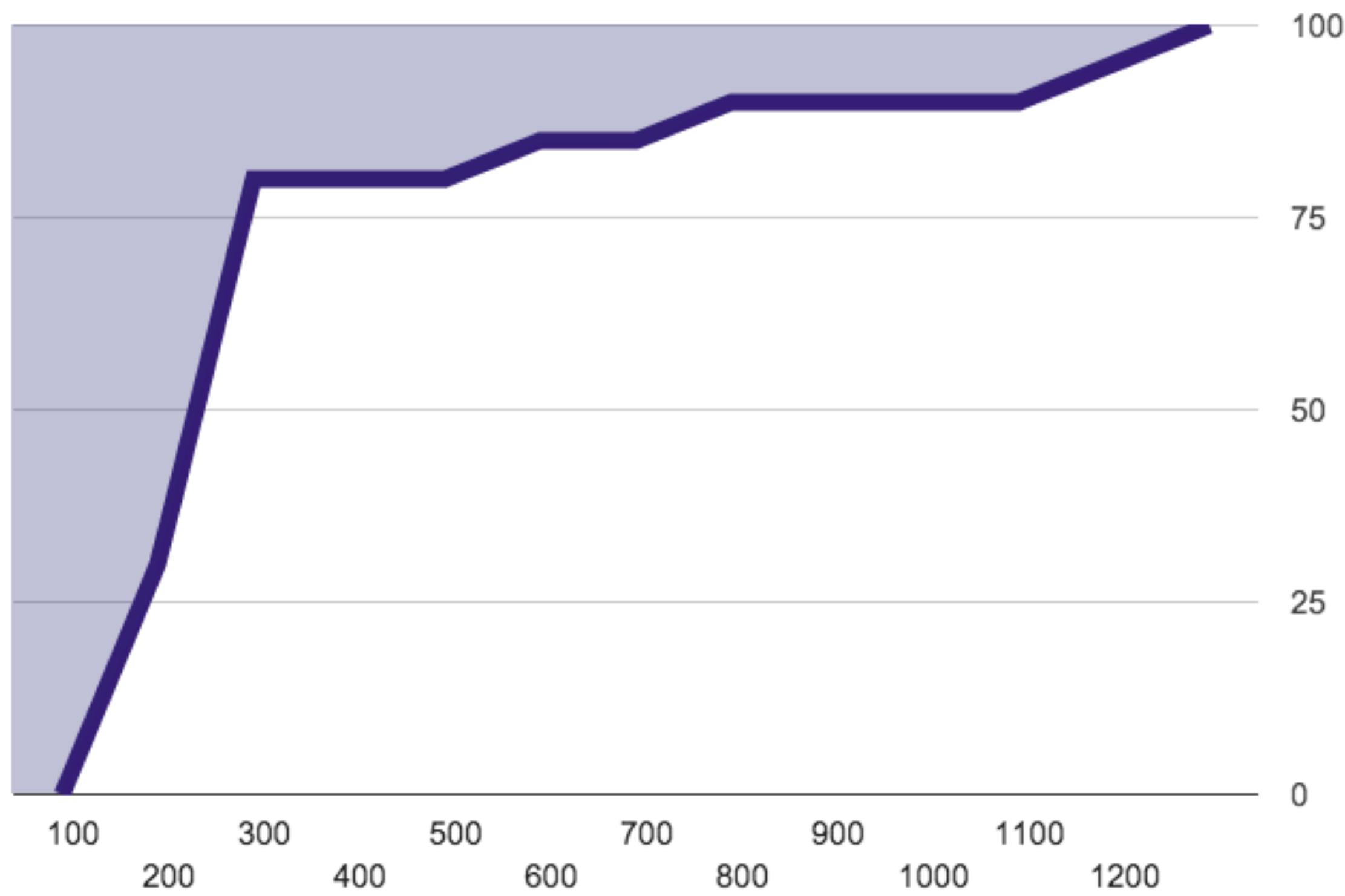
User-centric metrics

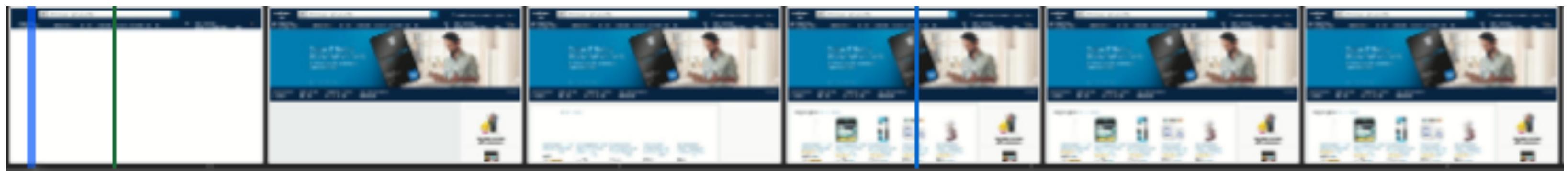
**First Interactive**

# User-centric metrics

## **Speed index**







User-centric metrics

**Time To Interactive**

User-centric metrics

**Largest Contentful**

**Paint (LCP)**

# Core Web Vitals

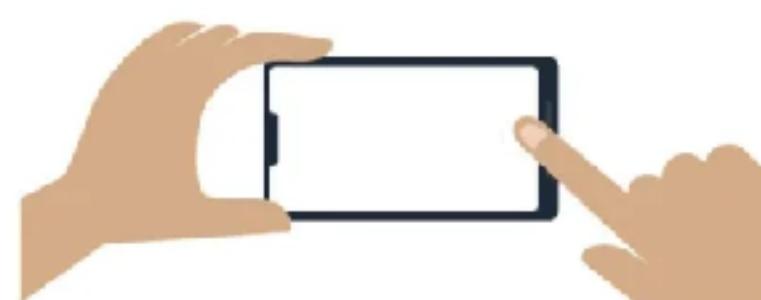


Calculated over the 75th percentile  
over mobile and web

# Core Web Vitals



(Loading)



(Interactivity)



(Visual Stability)

## LCP

Largest Contentful Paint



## FID

First Input Delay



## CLS

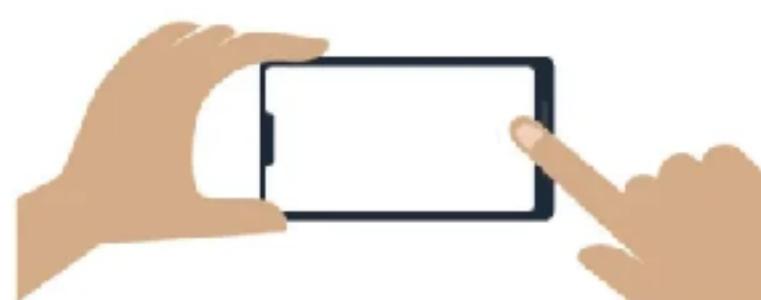
Cumulative Layout Shift



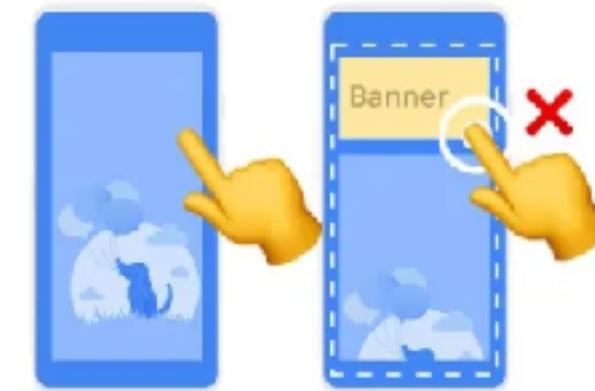
# Core Web Vitals



(Loading)



(Interactivity)



(Visual Stability)

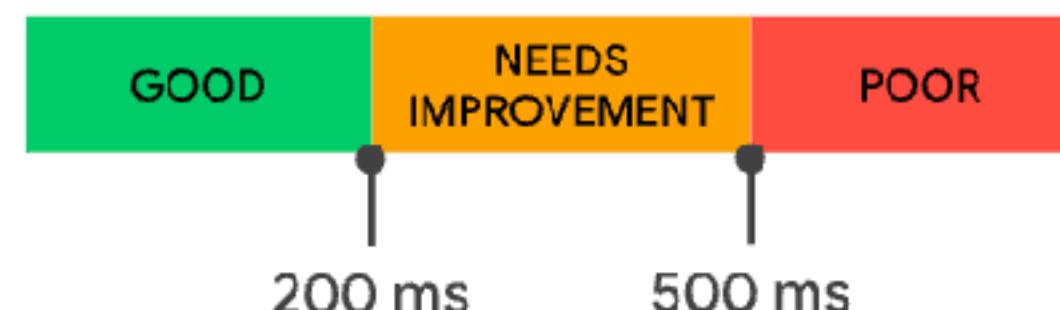
## LCP

**Largest Contentful Paint**



## INP

Interaction to Next Paint



## CLS

**Cumulative Layout Shift**



User-centric metric

**Largest Contentful Paint**

**LCP - initial load**

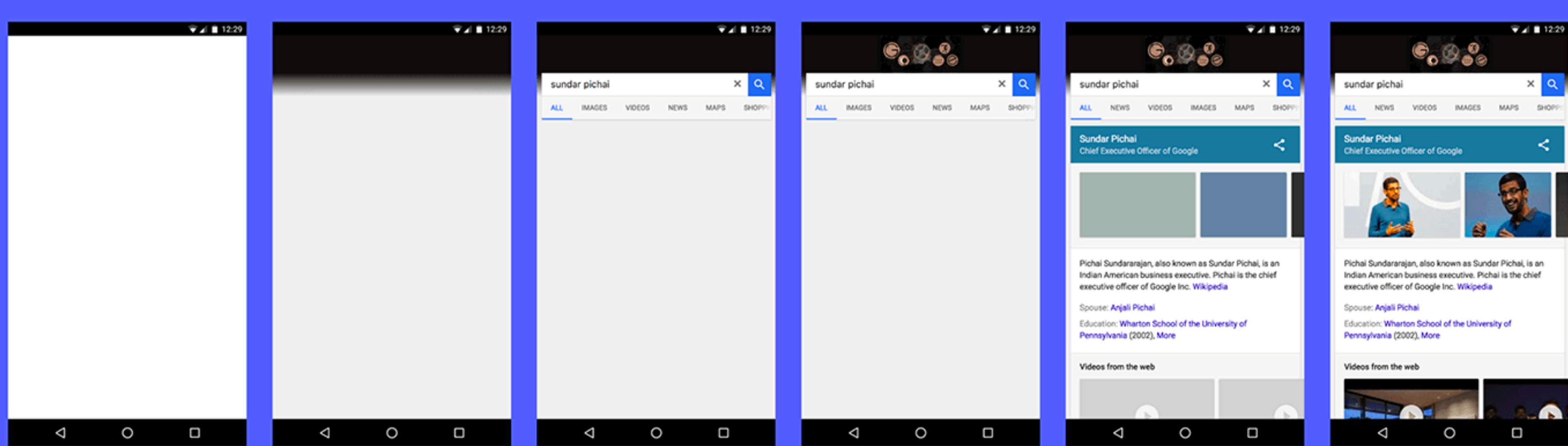


Image from [developers.google.com](https://developers.google.com)

ON

Visual stories >

US

...  
...  
...

Who has qualified for the September debates, so far

Only eight candidates have already qualified for the third Democratic debate hosted by ABC and Univision

How to make money with merch from a viral debate moment

Anderson Cooper: This is the question for 2020 Democrats ⓘ

Whether you trust scientists may depend on your political party, survey says

LIVE TV

ON

Who has qualified for the September debates, so far

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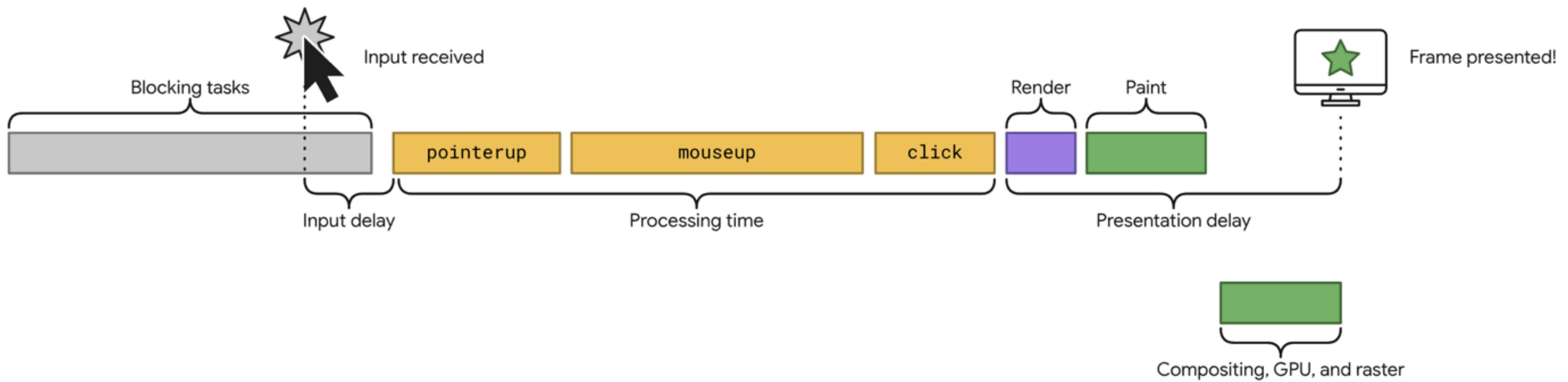
FCP

LCP

User-centric metric

**Interaction to Next Paint**

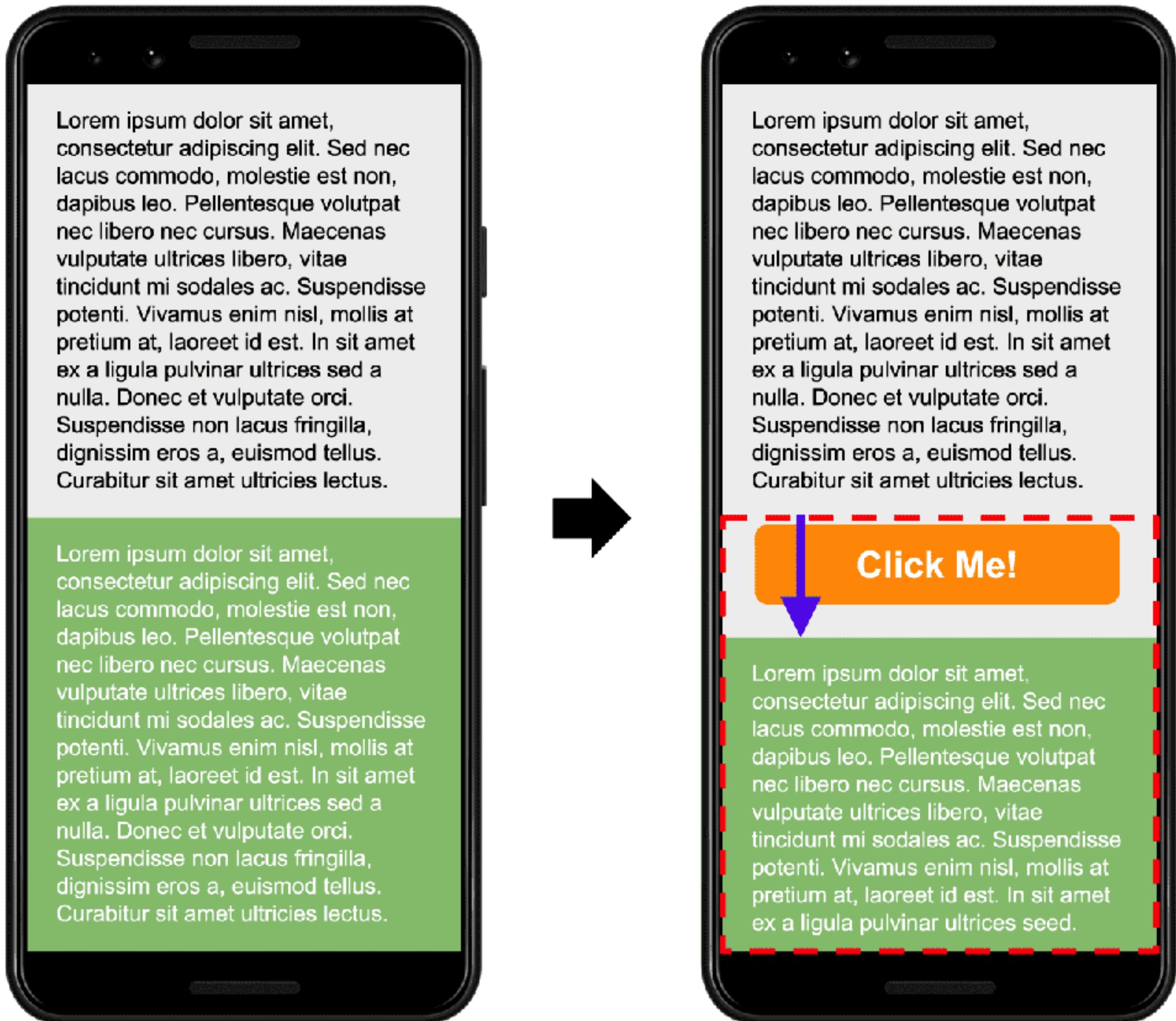
**INP - interactivity**



User-centric metric

**Cumulative Layout Shift**

**CLS - visual stability**





*But hey, my website is*

*fast*



**IMPORTANT**

How fast is fast?

We have to define our  
performance budgets

# Goals

LCP: 2.5s - 4.0s

INP: 200ms - 500ms

CLS: 0.1 - 0.25

# Did you checked Chrome UX?



**Origin Summary** — Over the previous 28-day collection period, the aggregate experience of all pages served from this origin **passes** the [Core Web Vitals](#) assessment. To view suggestions tailored to each page, analyze individual page URLs.

● First Contentful Paint (FCP) **1.7 s**



● First Input Delay (FID) [16 ms](#)



● Largest Contentful Paint (LCP) [2.1 s](#)



● Cumulative Layout Shift (CLS) [0.01](#)





## IMPORTANT

Optimizing the backend  
has less impact and it's not  
a simple or cheap task.



## IMPORTANT

Optimizing the frontend  
has high impact, it's  
relatively cheap to optimize  
and results are immediate.

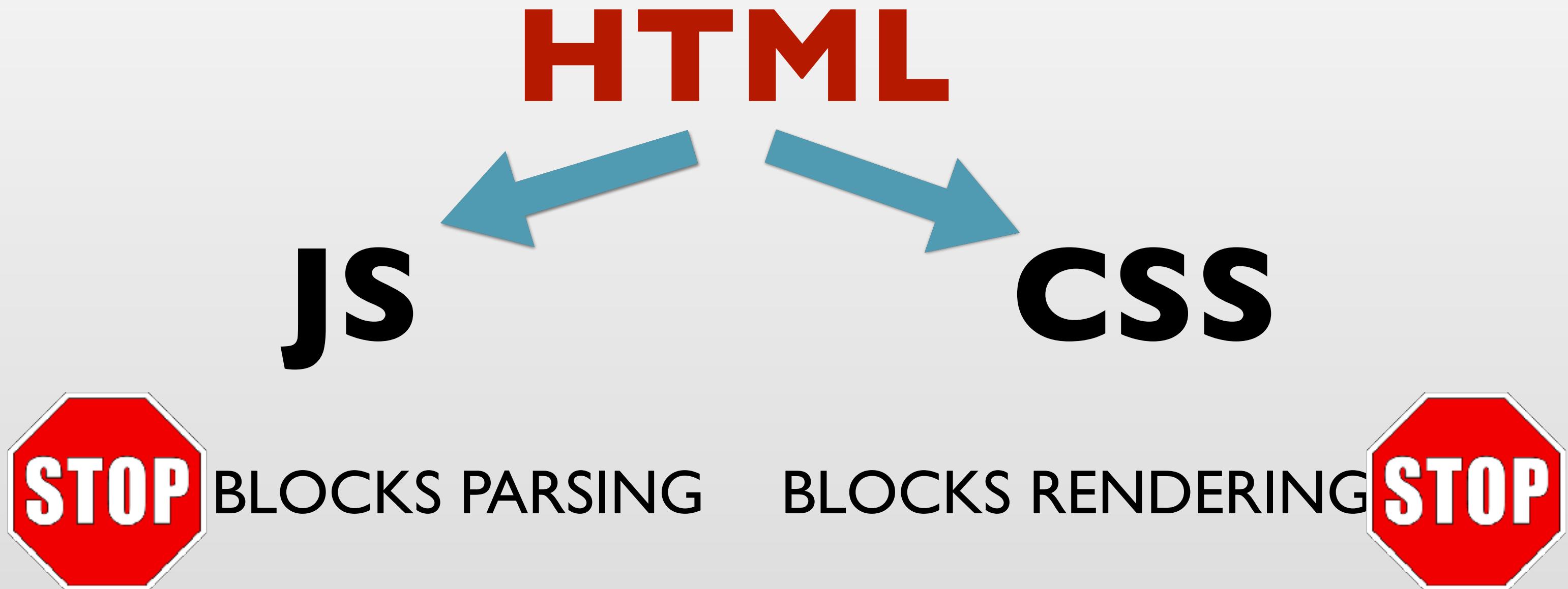


# How the browser works

# Browsing the Web

- Network layer
- Parsing
- Resource Discovery Phase
- Resource Prioritization
- Layout
- Paint

# Basic Performance



**Frame**

**Input Events**

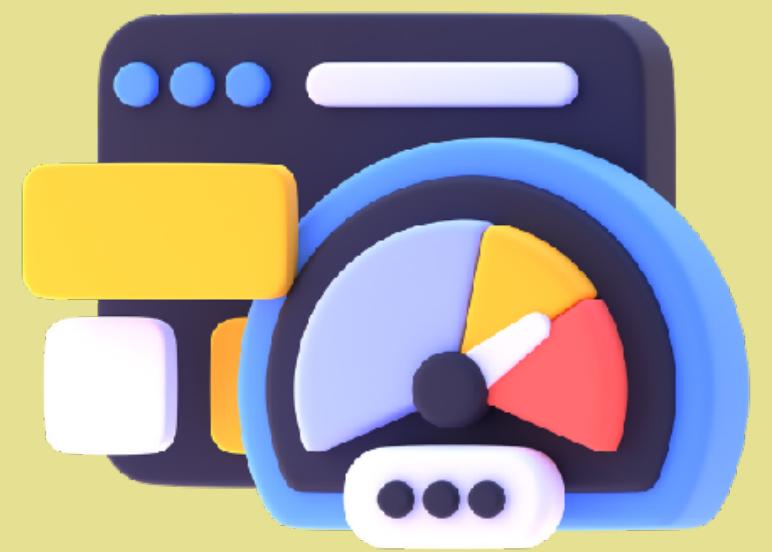
**Parse HTML,  
Styles, Layout**

**Paint and  
Composite**

**Idle**

**Timers**

**Frame**



# Hacking LCP

# Preloading

Help the browser discover resources  
that are obscure in the document

# Preloading

HTML

```
<link rel="preload" href="styles.css" as="style">
```

# Preloading

HTTP

```
Link: <https://otherhost.com/font.woff2>;  
rel=preload; as=font; crossorigin
```

# Speculation Rules API

HTML

```
<script type="speculationrules">
{
  "prerender": [
    {
      "urls": ["next.html", "next2.html"]
    }
  ]
}
</script>
```

# Fetch Priority

HTML

```
<link rel="preload" as="image"  
      href="hero.jpg" fetchpriority="high">  
  

```



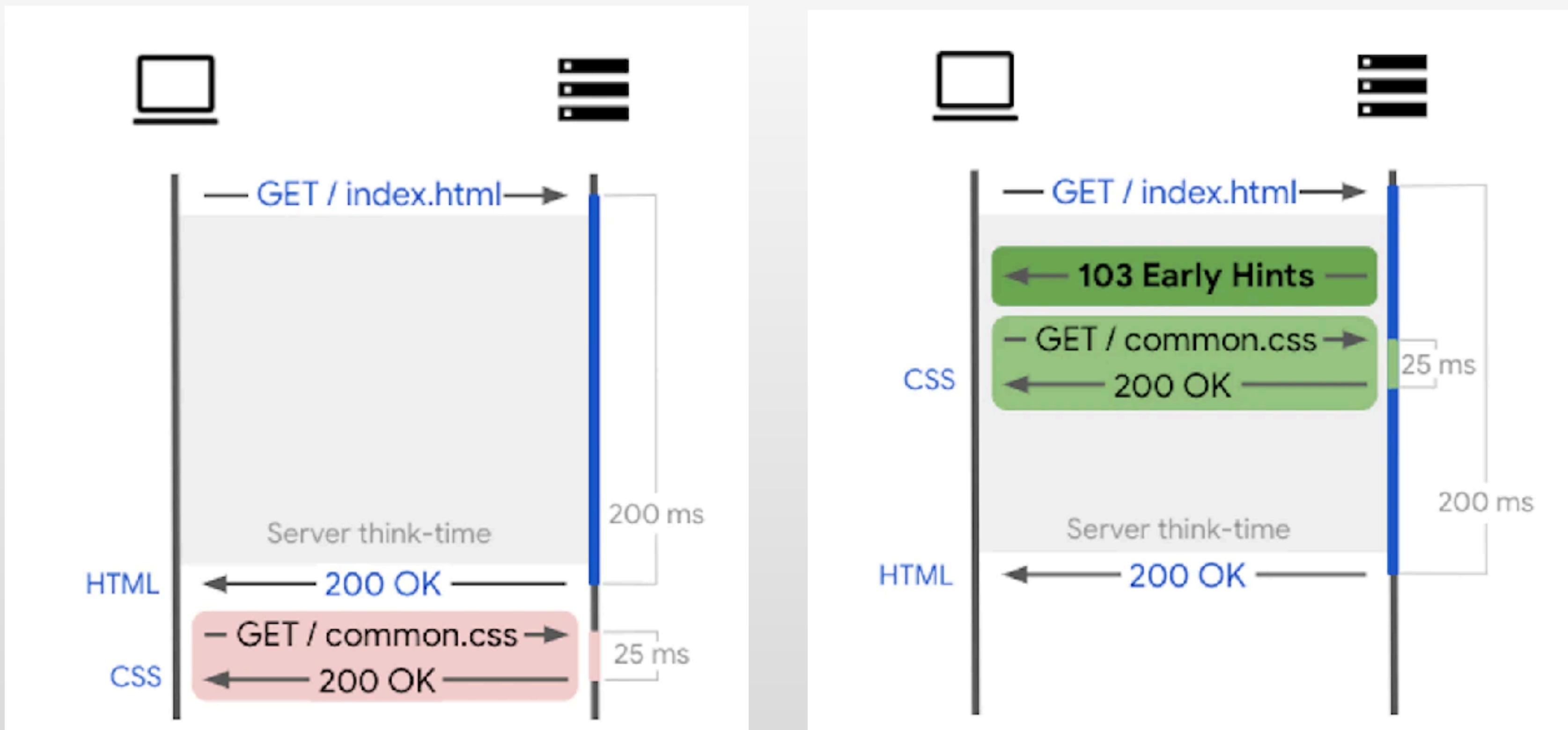
## WARNING

Fetch priority was called Priority hints before standardization, and the **fetchpriority** attribute was called **importance**.

# HTTP Early Hints

- HTTP Code 103
- We sent it before processing server-side
- Then we send HTTP Code 200

# LCP





## IMPORTANT

If a browser doesn't yet support Early Hints, nothing will happen; the browser will simply ignore it the 103 HTTP code and wait for 200

# Data Transfer

## HTTP/3

- Transport protocol over UDP
- Reduces latency and connection messages
- HTTP/2 Interface with TLS

## QUIC over HTTP (now HTTP/3)

- Google: +3%
- YouTube: -30% buffering
- Facebook similar protocol: +2%
- 75% of requests can be optimized

You are already...

# Use Zopfli

- Save 3-8% data transfer with GZIP
- It's ~80x slower

You are already...

# Use Brotli

- Save ~25% data transfer compared with GZIP
- Check Encoding Header

You are already...

# Use Brotli

- LinkedIn: 4% savings in load time
- Facebook: 17% savings on CSS, 20% on JavaScript

## Modern Image Formats

- SVG
- WebP, AVIF, Guetzli JPEG, Zopfli PNG
- Muted videos instead of GIFs

## Modern Cache Control

- Hash in filenames is common for versioning
- Browsers make conditional requests

Resource Loading

# Modern Cache Control

Cache-Control: immutable

## Modern Cache Control

It's a common new pattern to

- 1) serve from the cache
- 2) update it in the background for later

## Modern Cache Control

Cache-Control: stale-while-revalidate=99

## Warming up engines

- Help the browser to start ASAP
- DNS Queries: ~100ms
- TCP and TLS connection: ~100ms

## Announce DNS queries

HTML

```
<link rel="dns-prefetch" href="https://newdomain.com">
```

## Announce TLS connections

HTML

```
<link rel="preconnect" href="https://newdomain.com"  
crossorigin>
```

## Announce on HTTP Response

HTTP

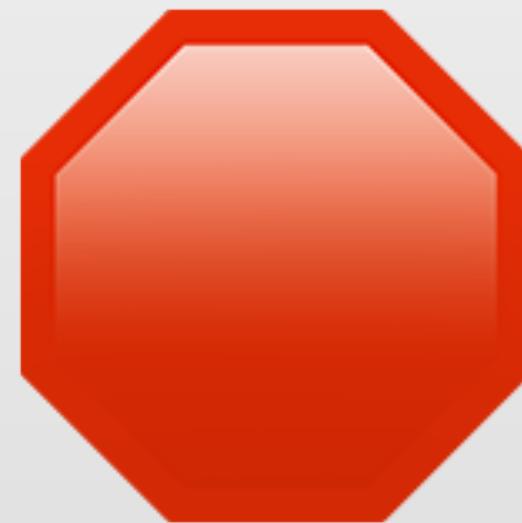
Link: <<https://my-analytics.com>>; **rel=preconnect**; crossorigin



# Hacking Content Layout Shift

Interaction Experience

# Client-side rendering



## Web Fonts

- Avoid FOUT (Flash of Unstyled Text)
- **font-display: optional or swap**

You are already...

# Lazy Load for Images

HTML

```

```

You are already...

# Async image decoding

HTML

```

```



# Hacking Next Iteration Paint

# Interaction Experience

# Move Heavy tasks to WebAssembly



**Stop serving legacy  
code**

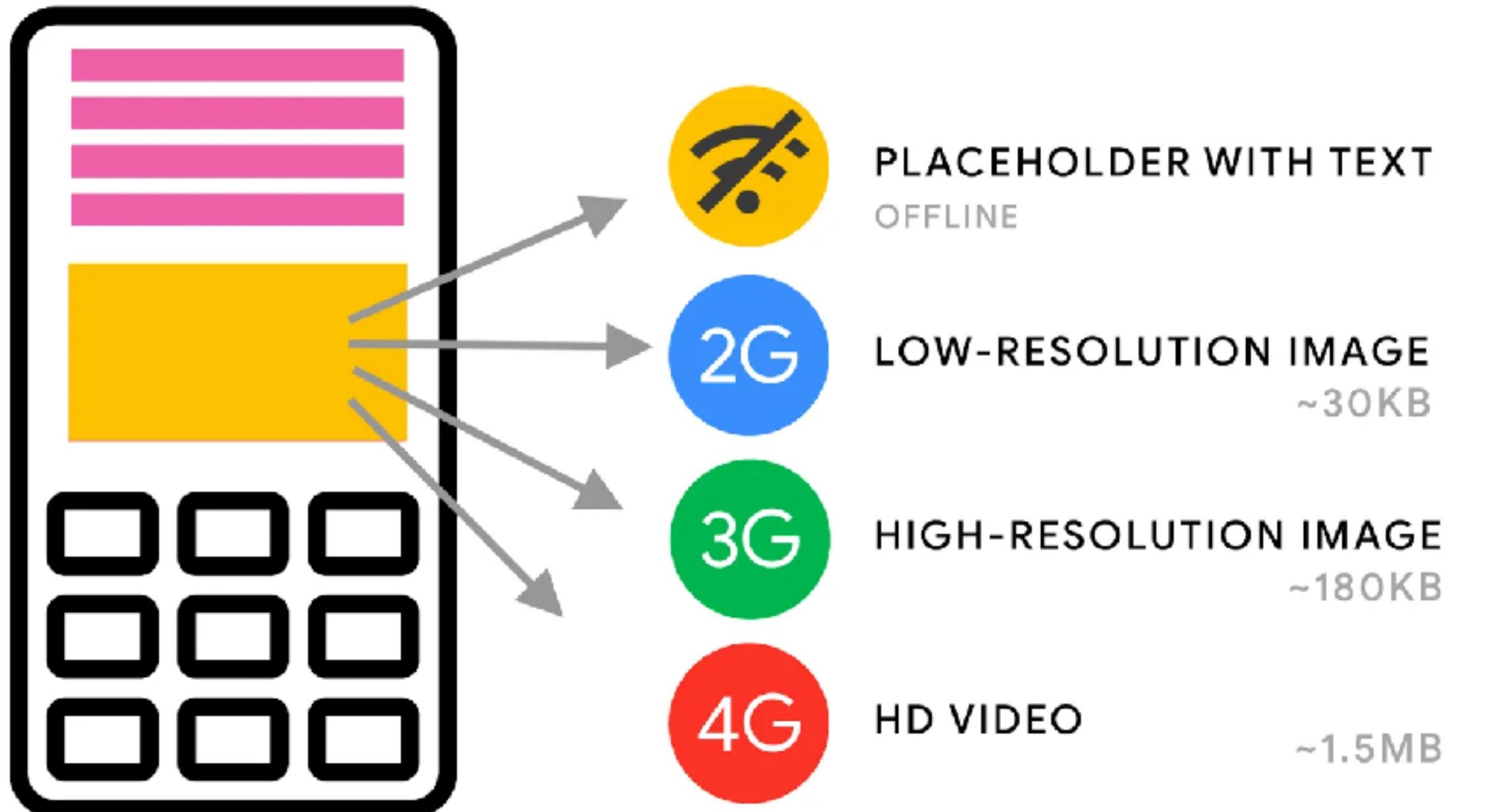
## Know about context with APIs

- Network Information
- Performance Observers
- Save-Data Client Hint
- Device Memory Client Hint

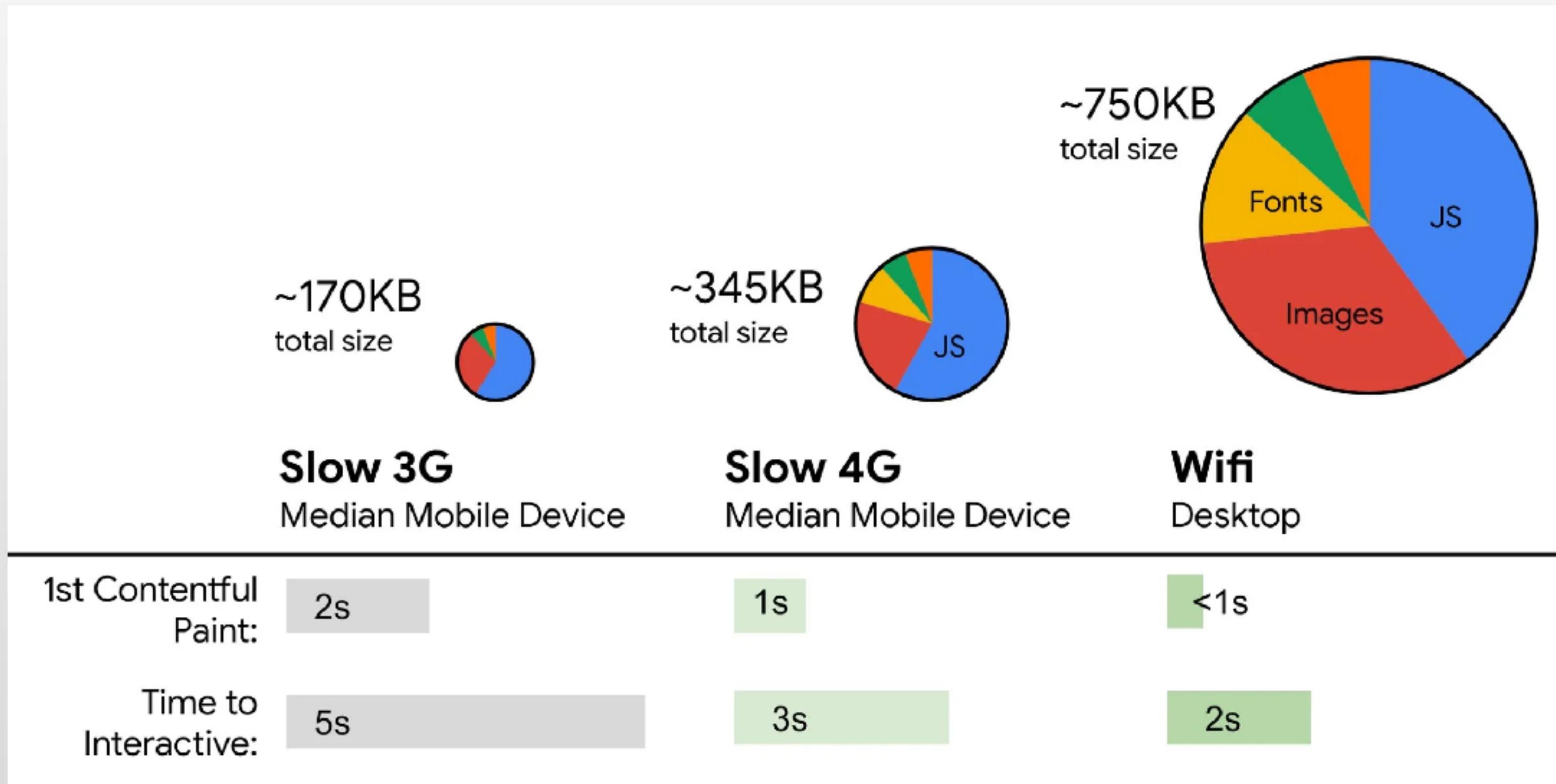
## Provide a Consistent Experience

- Web Fonts
- Change SW's cache policy
- SSR vs CSR
- Reduce amount of loaded data
- 1x image not matter DPR

# Interaction Experience



# Interaction Experience



## Get Reports from the Browser

- Reporting API
- Report-To header with a server endpoint
- Browser will send you reports about problems

**IMPORTANT**



Performance is TOP PRIORITY

There are more tricks

Push the limits

It's a worthwhile effort

Remember what's the GOAL

# What we've covered

The Problem

Web Vital Metrics

Tools for Vitals

Improvement Tips

Feeling bad?





THANKS! 🥰  
@firt firt.dev

MAXIMILIANO FIRTMAN