

P. PORTO

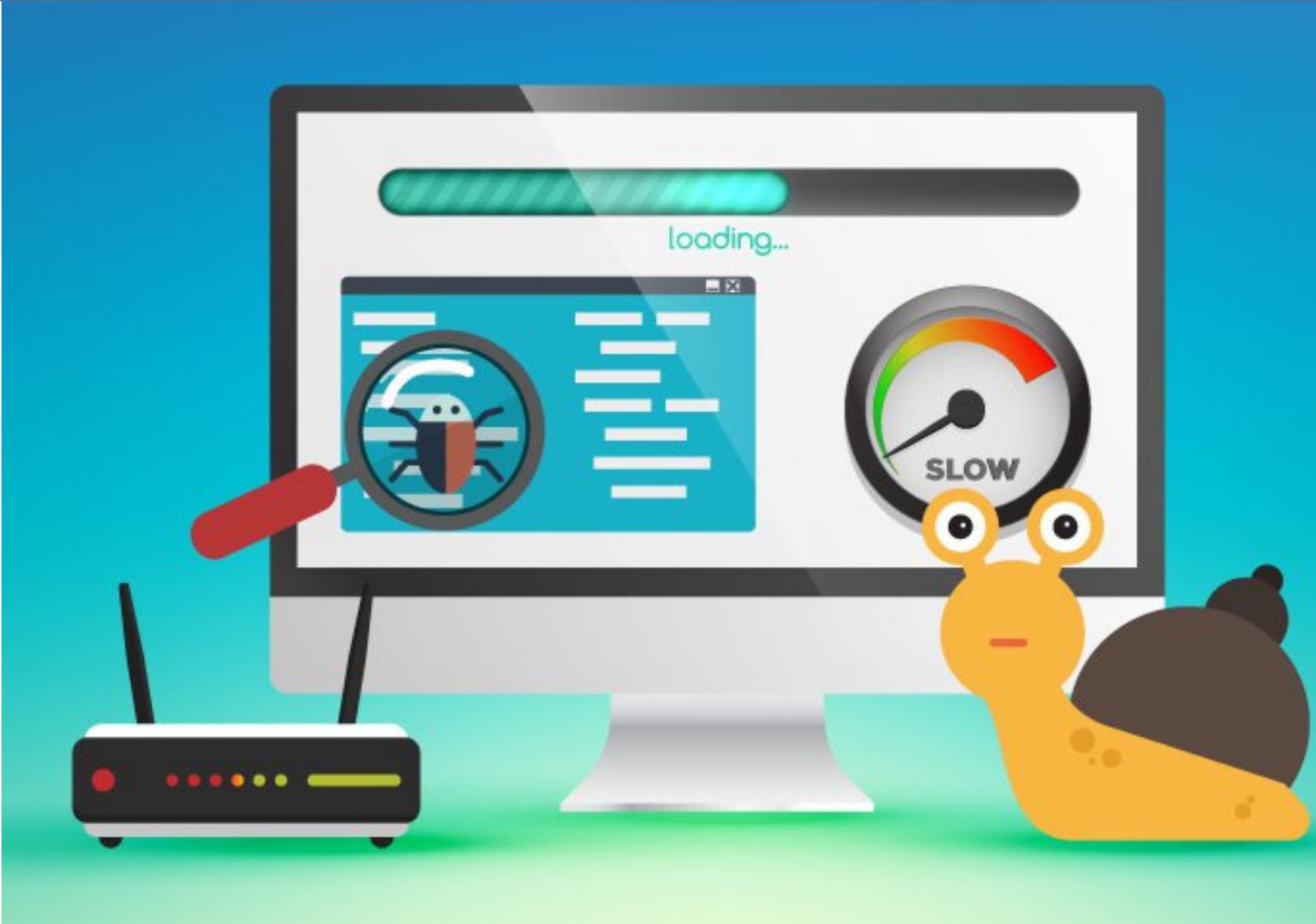
TESTES E PERFORMANCE WEB

TECNOLOGIAS E SISTEMAS DE INFORMAÇÃO PARA A WEB

**POLITÉCNICO
DO PORTO
ESCOLA
SUPERIOR
DE MEDIA ARTES E
DESIGN**

M02 – PERFORMANCE METRICS

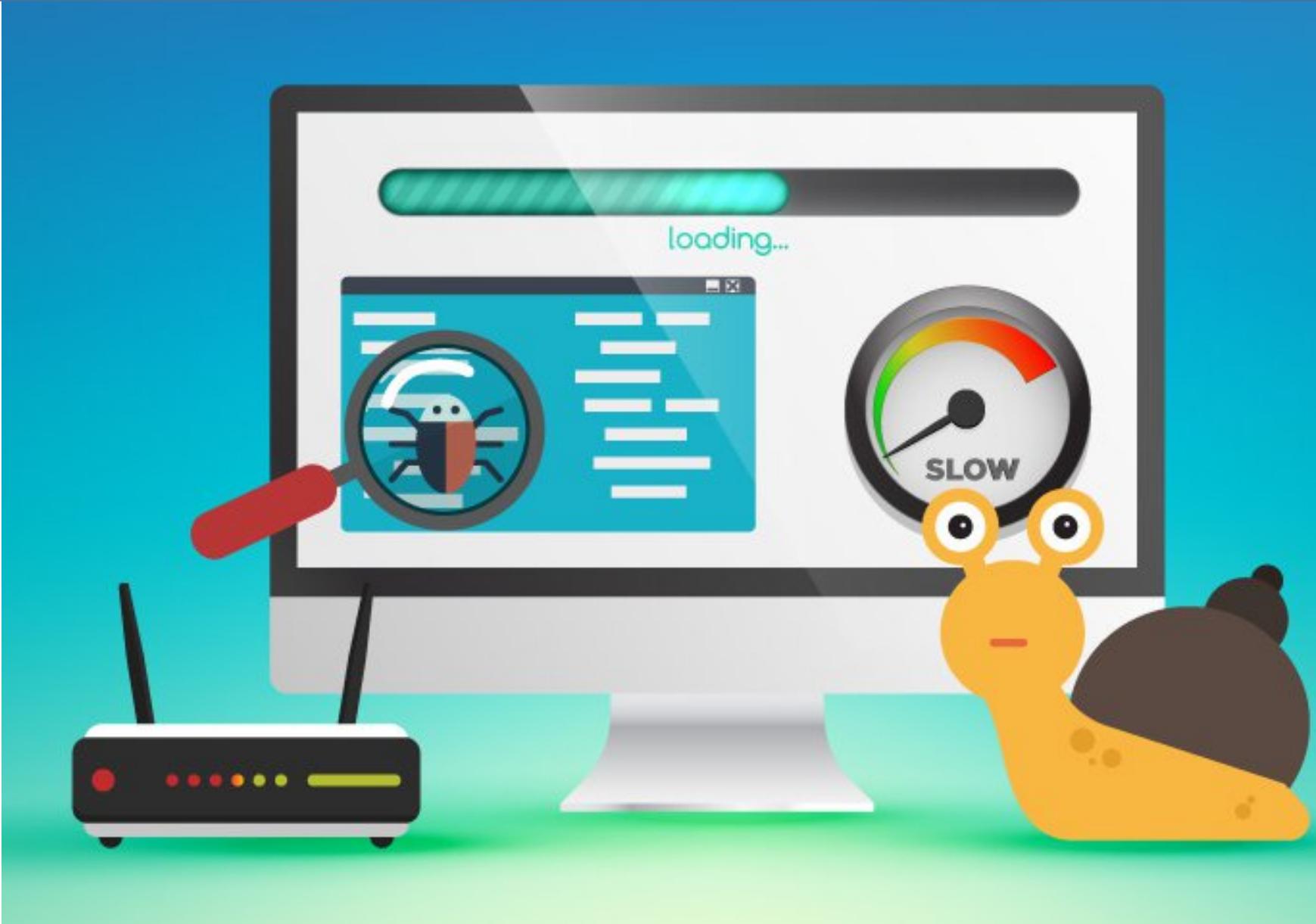
TSIW 2023/2024



AGENDA

1. Introduction;
2. Metrics:
 - 2.1. First Contentful Paint (FCP);
 - 2.2. Largest Contentful Paint (LCP);
 - 2.3. Time to Interactive (TTI);
 - 2.4. First Input Delay (FID);
 - 2.5. Total Blocking Time (TBT);
 - 2.6. Cumulative Layout Shift (CLS).
3. Core Web Vitals;
4. Final remarks.

INTRODUCTION



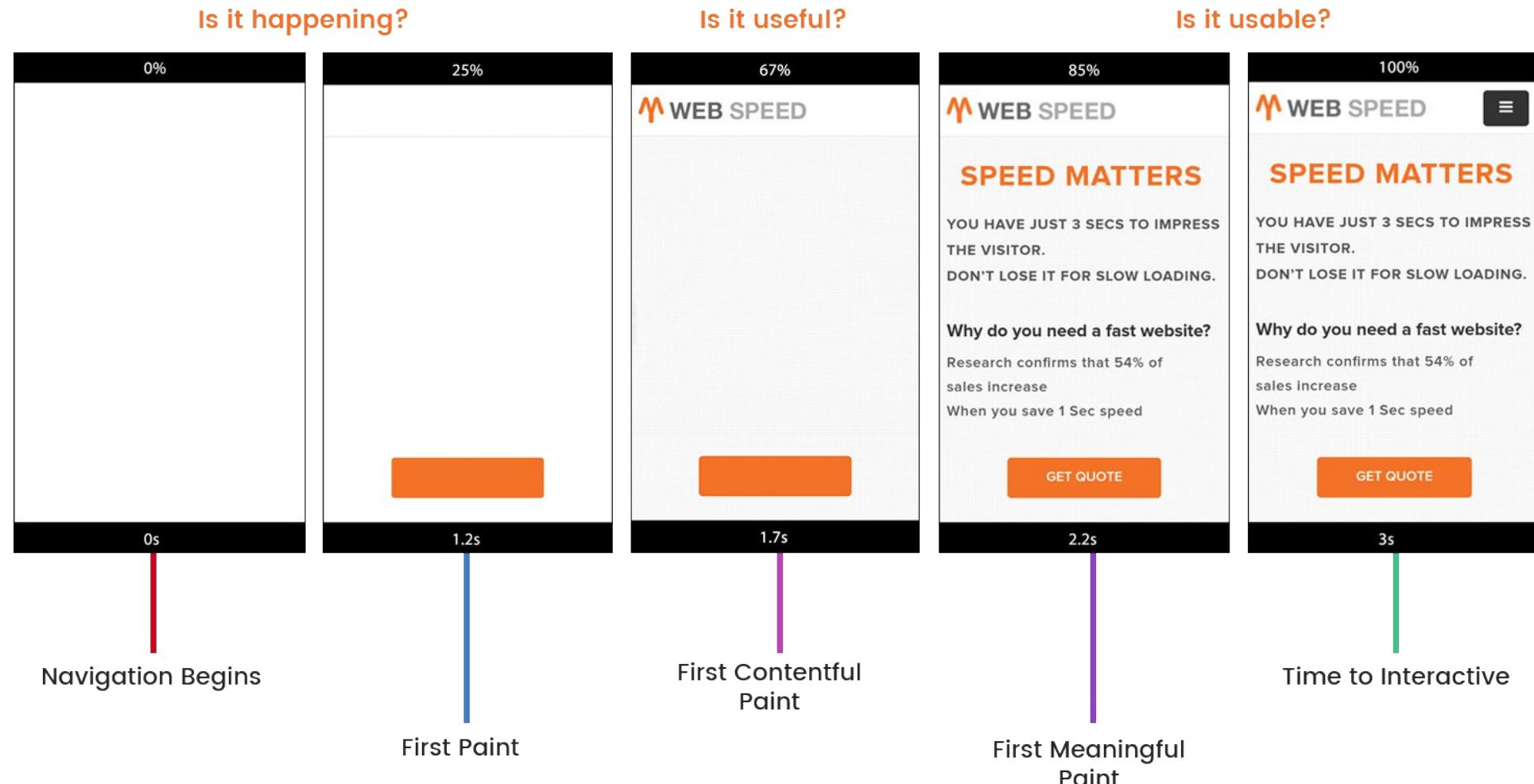
1. INTRODUCTION

- We talk about performance but what specifically do we mean?
- The truth is performance is relative:
 - A website might be fast for one user (on a fast network with a powerful device) but slow to another (on a slow network with a low-end device);
 - Two websites may finish loading in the exact same amount of time, yet one may seem to load faster if it loads content progressively rather than waiting until the end to display anything;
 - A website may appear to load quickly but respond slowly to user interaction.

1. INTRODUCTION

- So when talking about performance it's important to be precise and to refer to performance in terms of objective criteria that can be quantitatively measured;
- These criteria are known as metrics.
- To help ensure the metrics that are relevant to users, we frame them in key questions:
 - **Is it happening?** Did the navigation start well? Has the server responded?
 - **Is it useful?** Has enough content rendered that users can engage with it?
 - **Is it usable?** Can users interact with the website, or is it busy?
 - **Is it delightful?** Are the interactions smooth and natural, free of lag?

1. INTRODUCTION



1. INTRODUCTION

- **How metrics are measured?**
- Performance metrics are generally measured in one of two ways:
 - In the lab: using tools to simulate a page load in a controlled environment;
 - In the field: how real users actually loading and interacting with the page.
- **Types of metrics:**
 - **Perceived load speed:** how quickly a page can load and render all of its visual elements to the screen;
 - **Load responsiveness:** how quickly a page can load and execute any required JavaScript code in order for components to respond quickly to user interaction.

1. INTRODUCTION

- **Types of metrics (cont):**
 - **Runtime responsiveness:** after a page load, how quickly it respond to user interaction?
 - **Visual stability:** do elements on the page shift in ways that users don't expect and potentially interfere with their interactions?
 - **Smoothness:** do transitions and animations render at a consistent frame rate and flow fluidly from one state to the next?

1. INTRODUCTION

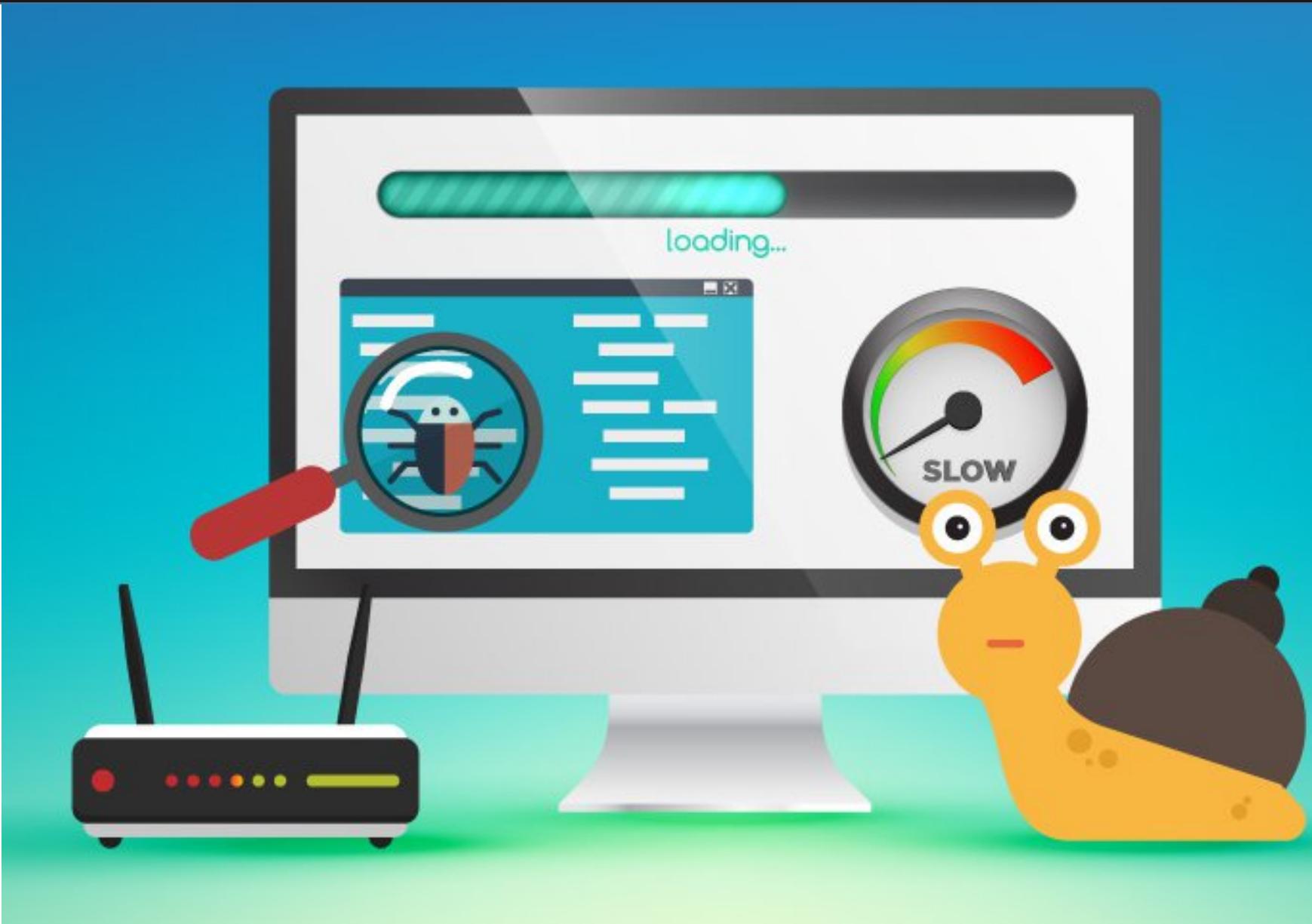
- **Important metrics to measure:**
 - **First Contentful Paint (FCP):** measure the time from when the page starts loading to when some page's content is rendered on the screen (**lab and field**);
 - **Largest Contentful Paint (LCP):** measure the time from when the page starts loading to when the largest element is rendered on the screen (**lab and field**);
 - **First Input Delay:** measure the time from when a user first interacts with the website (i.e. when user click a link or tap a button) to the time when the browser is actually able to respond to that interaction (**only in field**).

1. INTRODUCTION

- **Important metrics to measure (cont):**

- **Time to Interactive (TTI):** measures the time from when the page starts loading to when it's visually rendered, its initial scripts (if any) have loaded, and it's capable of reliably responding to user input quickly (**only in lab**);
- **Total Blocking Time (TBT):** is the amount of time which long tasks blocks the main thread and affects the usability of the web page (**only in lab**);
- **Cumulative Layout Shifts:** measure the cumulative score of all unexpected layout shifts that occur between when the page starts loading and when its lifecycle state changes to hidden (**lab and field**).

METRICS



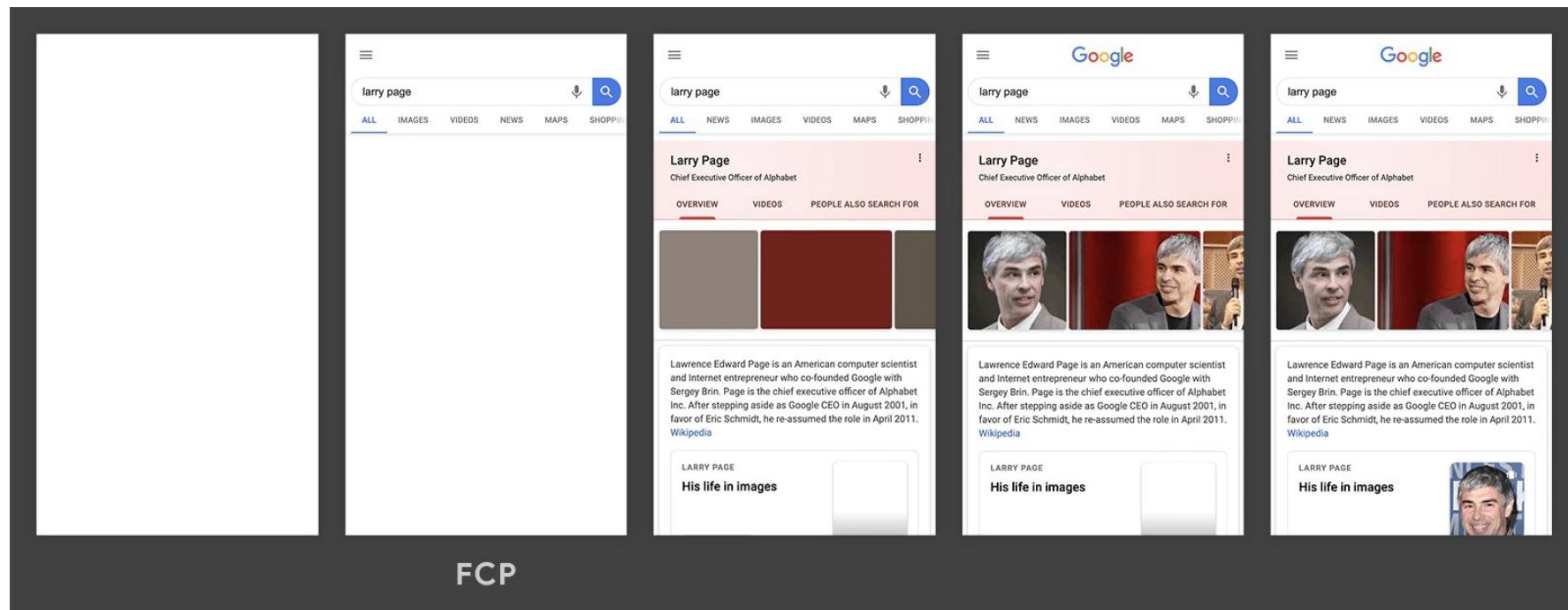
2. METRICS

- There are dozens of web performance metrics that you need to track and monitor to make sure you are giving your users the best digital experience;
- However, there are 6 metrics that stand out due to their connection to user experience:
 - First Contentful Paint (FCP);
 - Largest Contentful Paint (LCP);
 - Time to Interactive (TTI);
 - First Input Delay (FID);
 - Total Blocking Time (TBT);
 - Cumulative Layout Shifts (CLS).
- After understanding these metrics it is important to explore the right tools to track them.

2. METRICS

First Contentful Paint (FCP)

- Measures the time from when the page starts loading to the time which the first visual element (text or image) is painted.



2. METRICS

First Contentful Paint (FCP)

- **Important user-centric metric for:**
 - Measuring perceived load speed;
 - Providing the first feedback to the user that the page is actually loading.
- It marks the first point in the timeline where we can see something on the screen;
- A fast FCP helps reassure the user that something is happening.

2. METRICS

First Contentful Paint (FCP)

- **What FPC measures?**
 - How long it takes the browser to render the first piece of DOM content after a user navigates to the page;
 - DOM content:
 - Text;
 - Image (including background images);
 - Non-white <canvas> element;
 - SVGs.
 - Anything inside an iframe is not included.

2. METRICS

First Contentful Paint (FCP)

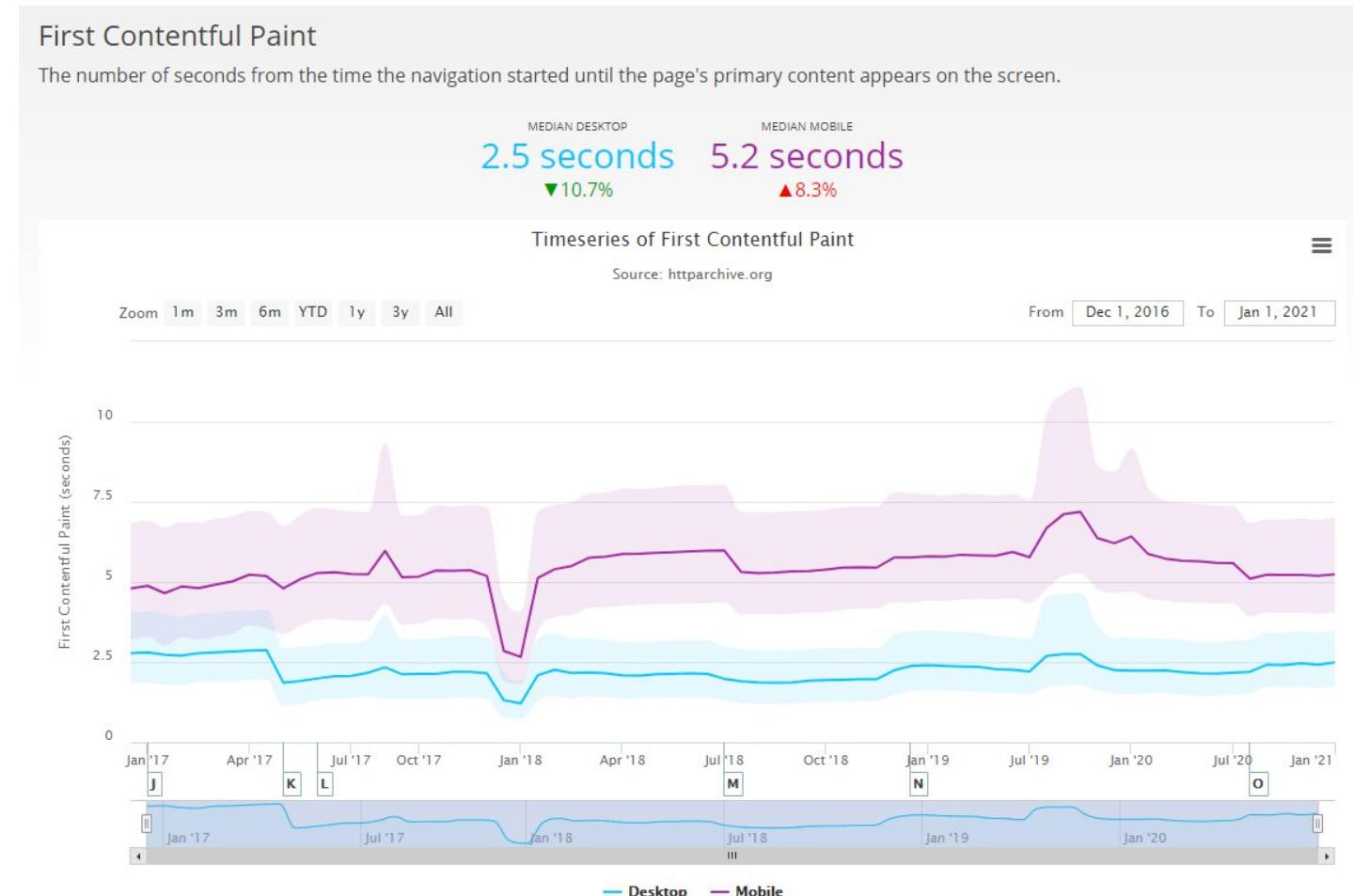
- **FCP Score:**

- Comparison of tested page's FCP time and FCP times for real websites, based on HTTP archive data;
- For example, websites in the 99 percentile render FCP in about 1.5 seconds. If the tested website loads in 1.5 second, the FCO score is 99.

FCP time (in seconds)	Color-coding	FCP score (HTTP Archive percentile)
0–2	Green (fast)	75–100
2–4	Orange (moderate)	50–74
Over 4	Red (slow)	0–49

2. METRICS

First Contentful Paint (FCP)



2. METRICS

Largest Contentful Paint (LCP)

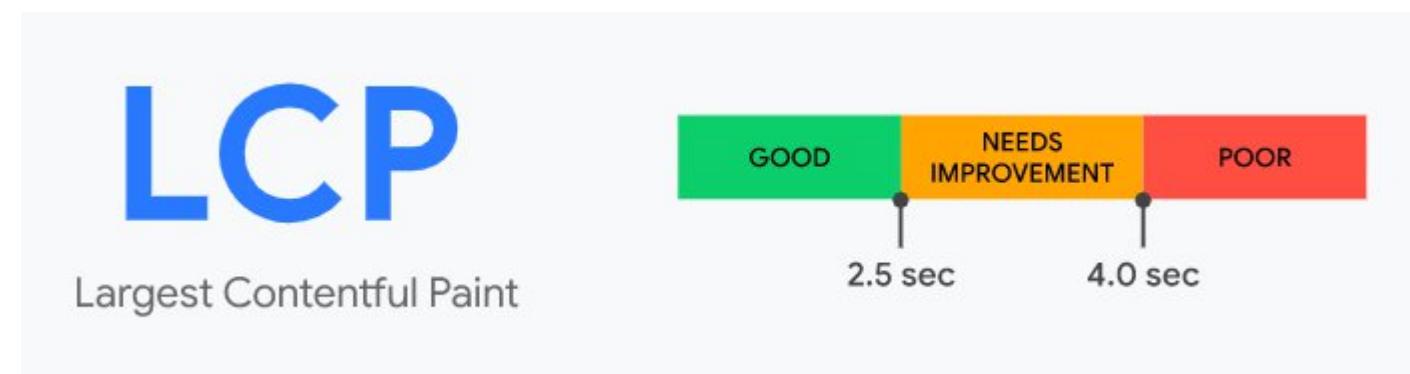
- Reports the render time of the largest text or image visible within the viewport;
- Important user-centric metric for measuring perceived load speed;
- It marks the page load timeline point when the page's main content has loaded;
- A fast LCP helps reassure the user that the page is useful;
- What elements are considered:
 - elements;
 - <image> elements inside an <svg> element;
 - <video> elements (the poster image is used);
 - An element with a background image loaded via the url() function;
 - Block-level elements containing text nodes or other inline-level text elements children.

2. METRICS

Largest Contentful Paint (FCP)

- **LCP Score:**

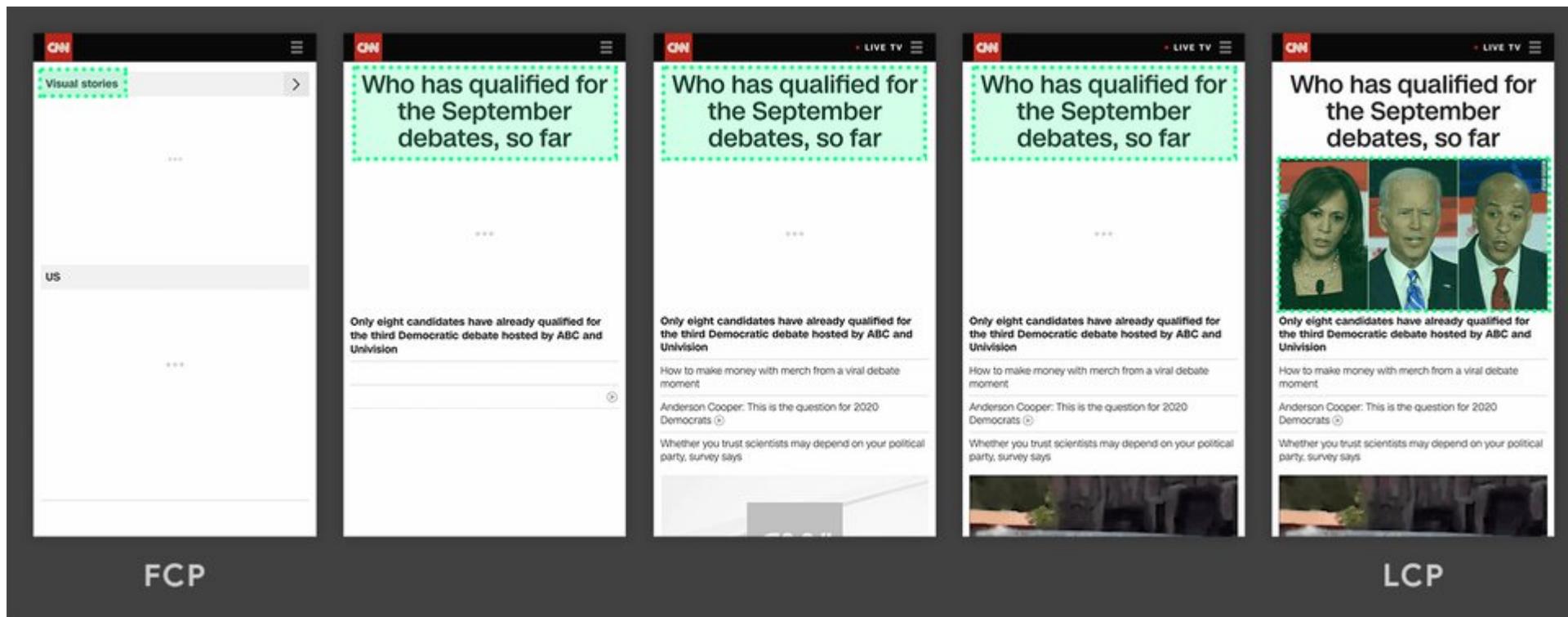
- To provide a good user experience, websites should strive to have LCP occurring within the first 2.5 seconds of the page starting to load;
- To ensure you're hitting this target for most of your users, a good threshold to measure is the 75 percentile of page loads, segmented across mobile and desktop devices.



2. METRICS

Largest Contentful Paint (LCP)

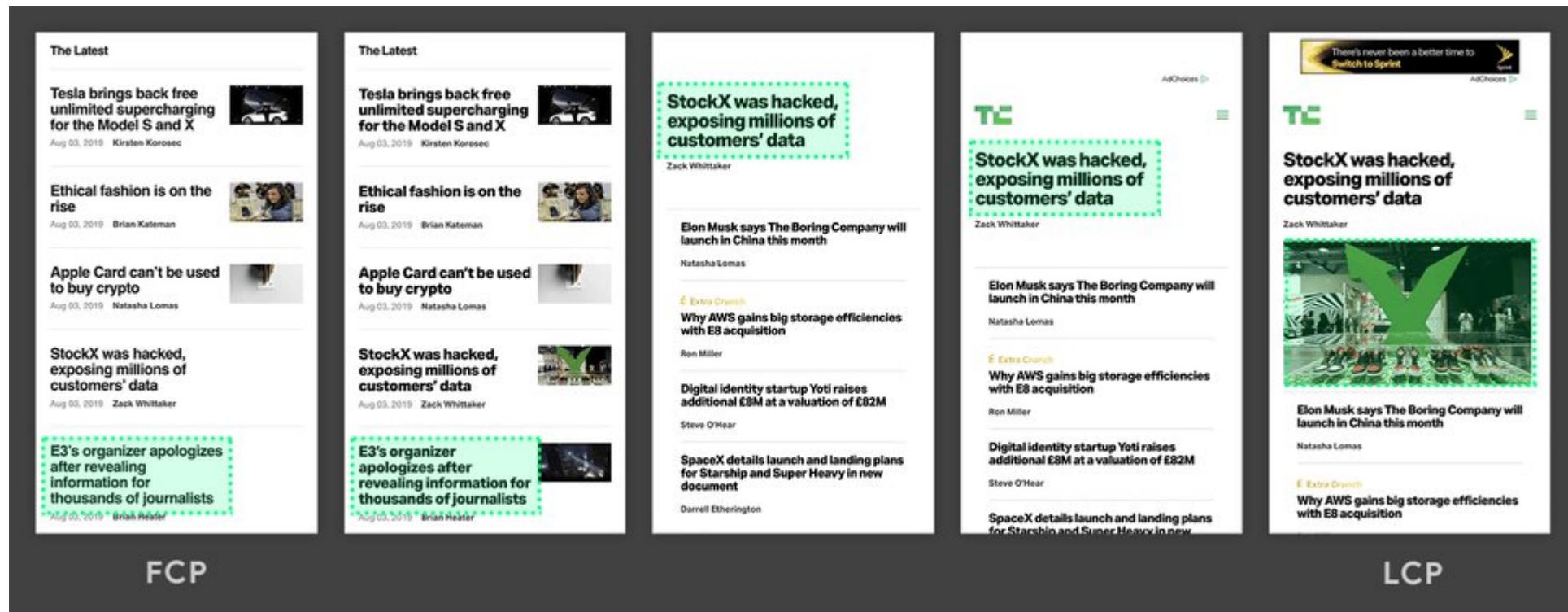
- Usually the largest element changes as content loads;
- Here, new content is added to DOM and changes what element is the largest:



2. METRICS

Largest Contentful Paint (LCP)

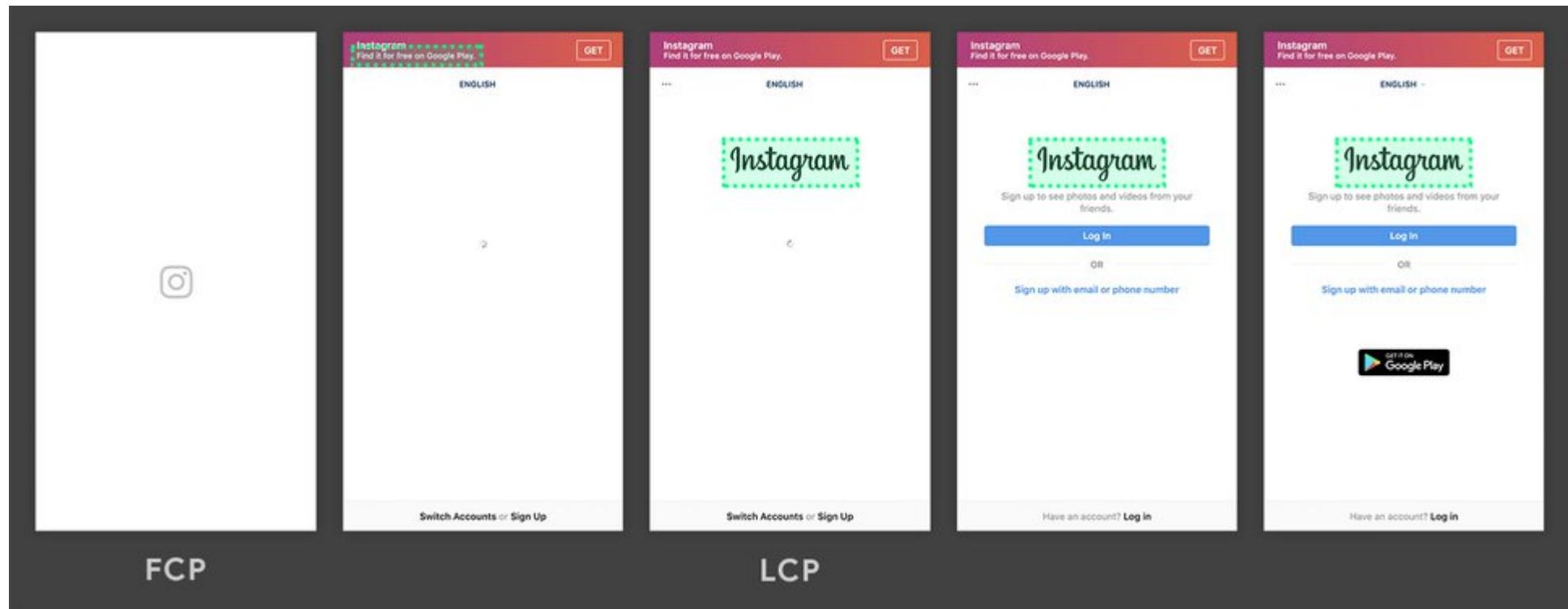
- Here, layout changes and content (previously the largest) is removed from the viewport:



2. METRICS

Largest Contentful Paint (LCP)

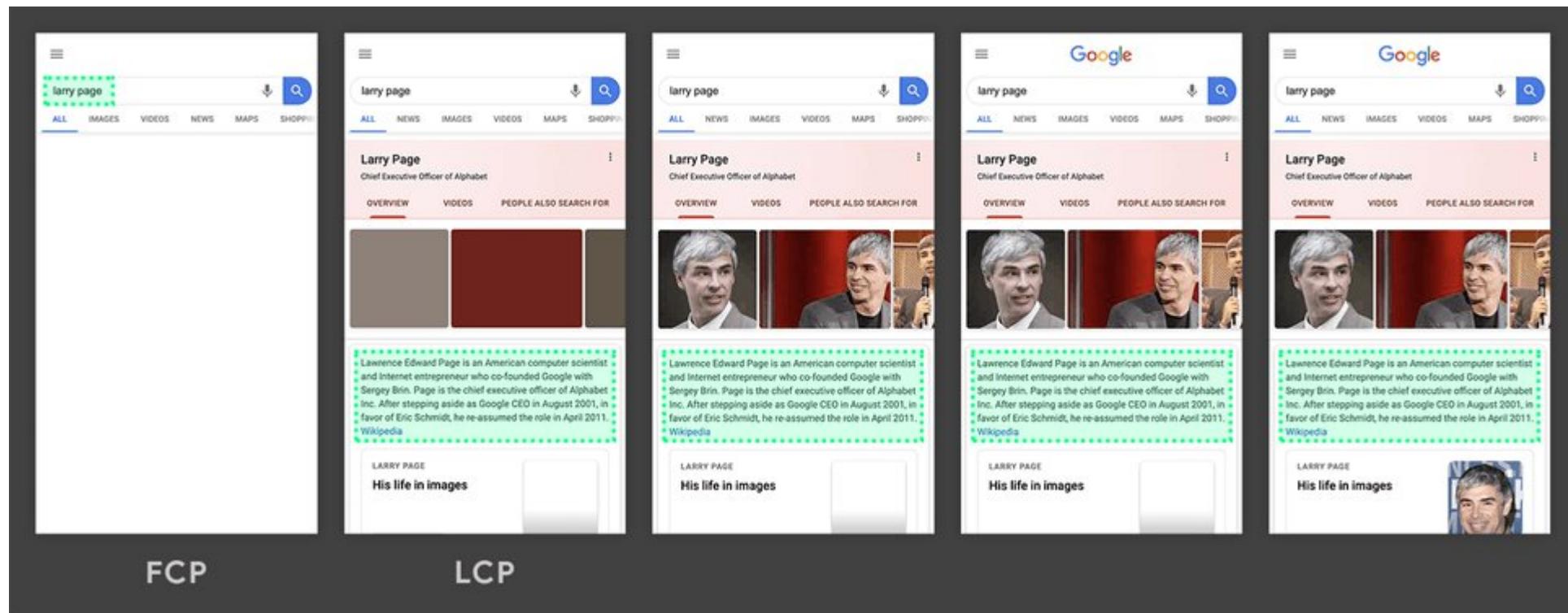
- In this example, the LCP occurs before the page fully loads:



2. METRICS

Largest Contentful Paint (LCP)

- Also, In this example, the LCP occurs before the page fully loads:



2. METRICS

Time To Interactive (TTI)

- Measures how long it takes a page to become fully interactive;
- A page is considered fully interactive when:
 - The page displays useful content, which is measured by the FCP;
 - Event handlers are registered for most visible page elements;
 - The page responds to user interactions within 50 milliseconds.
- Measuring TTI is important since sites optimize content visibility at the expense of interactivity. This can create a frustrating user experience. The website appears to be ready but the user cannot interact with it.

2. METRICS

Time To Interactive (TTI)

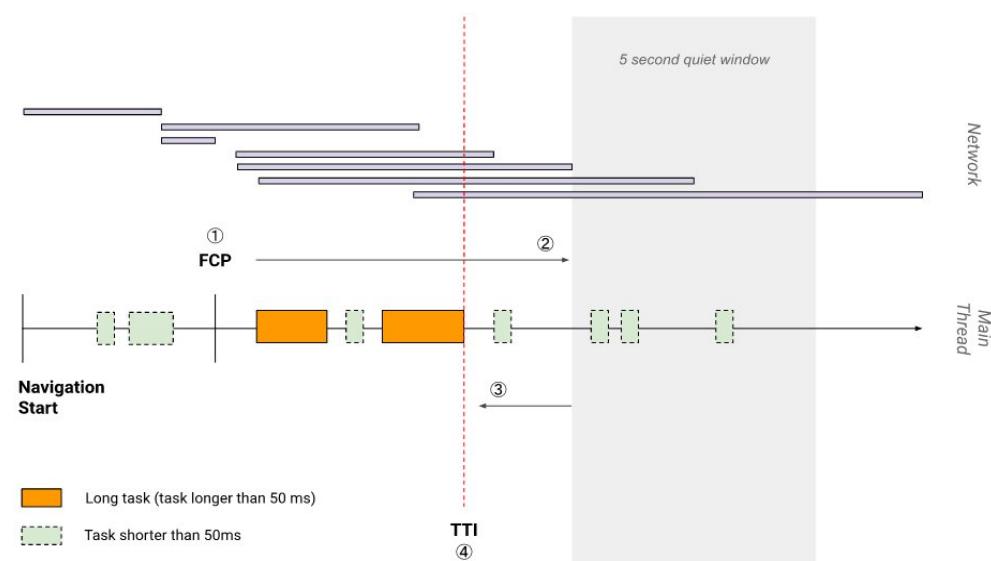
- **TTI Score:**
 - To provide a good user experience, websites should strive to have a TTI in less than 5 seconds when tested on average mobile hardware;
 - The TTI score is a comparison of your page's TTI and the TTI of real websites, based on data from the HTTP archive;
 - For example, if a website TTI is 2.2 seconds, the website TTI score is 99.

TTI metric (in seconds)	Color-coding
0–3.8	Green (fast)
3.9–7.3	Orange (moderate)
Over 7.3	Red (slow)

2. METRICS

Time To Interactive (TTI)

- Starts at FCP;
- Search forward in time for a Quiet Window (QW) for at least 5 seconds, where QW is defined as: no long tasks and no more than two in-flight network GET requests;
- Search backwards for the last long task before the QW, stopping at FCP if no long tasks are found;
- TTI is the end time of the last long task before the QW (or same value as FCP if no long tasks are found).

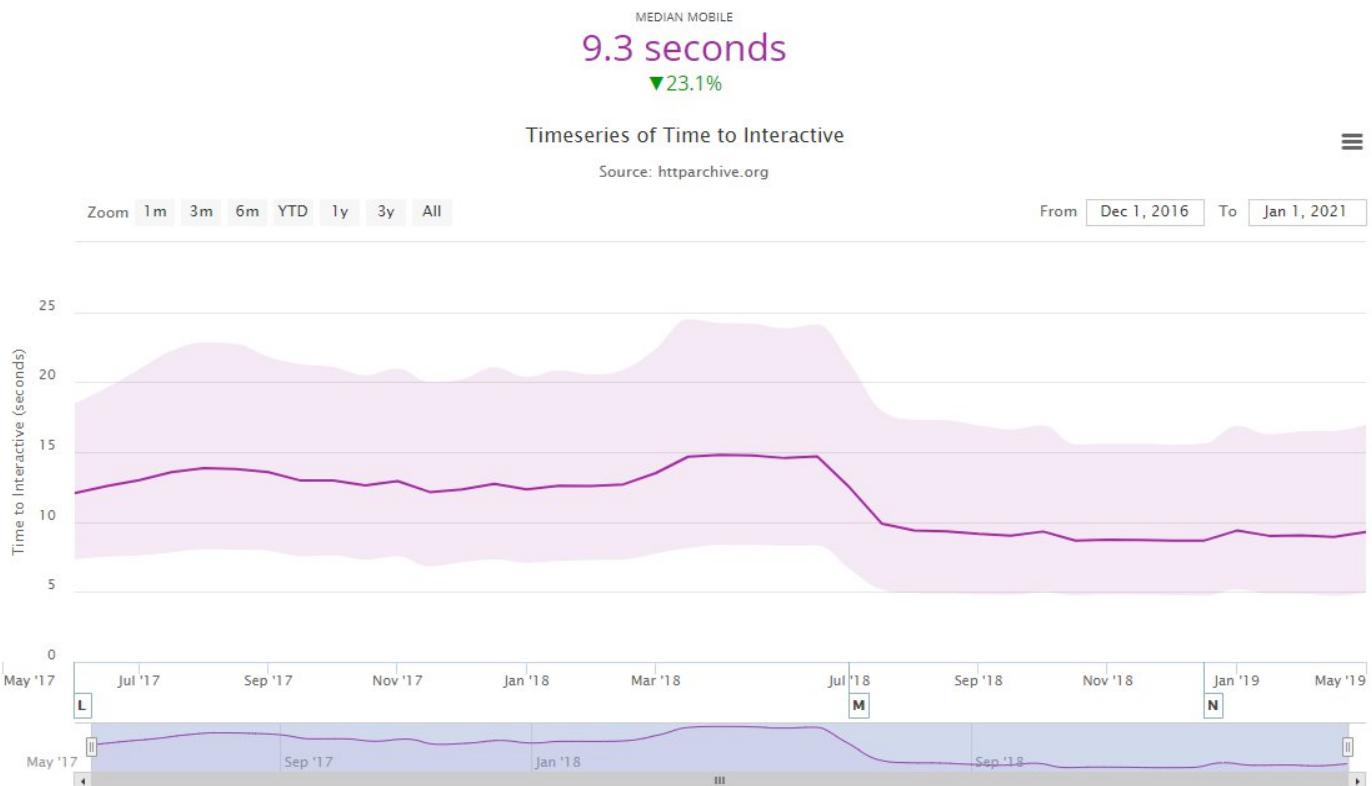


2. METRICS

Time To Interactive (TTI)

Time to Interactive

The number of seconds from the time the navigation started until the CPU had at least 5 seconds of quiescence. This metric comes from Lighthouse as it is only available in mobile tests. [Read more](#).



2. METRICS

First Input Delay (FID)

- Measures the time from when a user first interacts with a page (i.e. when they click a link, tap on a button, or use a custom JavaScript-powered control) to the time when the browser is actually able to begin processing event handlers in response to that interaction;
- Important, user-centric for measuring load responsiveness since it quantifies the experience users feel when trying to interact with unresponsive pages;
- A low FID helps ensure that the page is usable.

2. METRICS

First Input Delay (FID)

- **FID Score:**
 - To provide a good experience, websites should strive to have a FID in less than 100 milliseconds;
 - To ensure hitting target for most users, a good threshold to measure is the 75th percentile of page loads, segmented across mobile and desktop devices.



2. METRICS

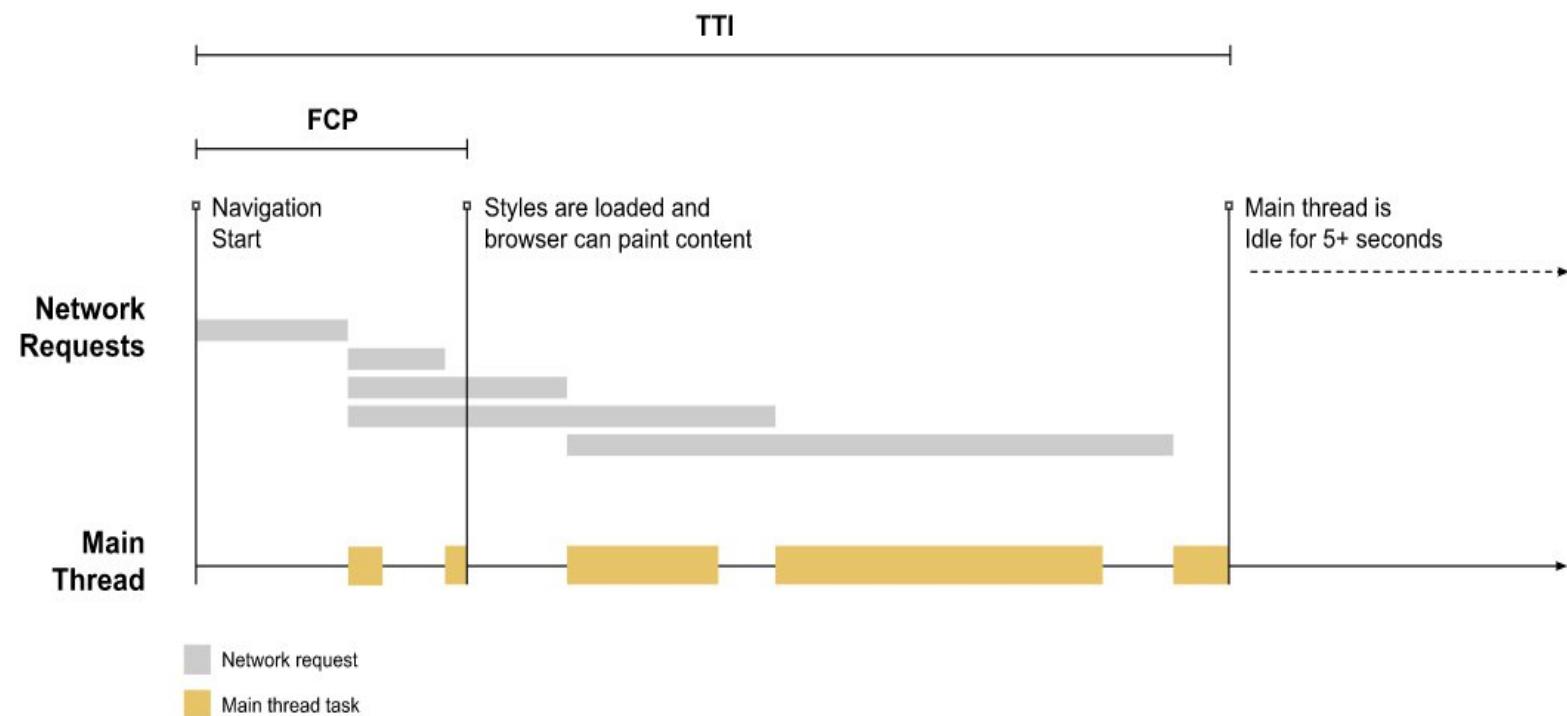
First Input Delay (FID)

- **Be aware:**
 - As developers who write code that respond to events, we often assume our code is going to be run immediately (as soon as the event happens);
 - But as users, we all experienced the opposite (we load a page on our mobile phone, try to interact with it, and then get frustrated when nothing happens);
 - In general, input delay, happens because the browser's main thread is busy doing something else, so it can't respond to the user;
 - Common reason: browser is busy parsing and executing large JS files loaded by the app. While it is doing that, it cannot run any event listeners because the JavaScript is loading.

2. METRICS

First Input Delay (FID)

- Long First Input Delays typically occur between FCP and TTI because the page has rendered some of its content but is not yet reliable to interact.



2. METRICS

First Input Delay (FID)

- If a user tries to interact with the page during a long task of the main thread (e.g. click on link), there will be a delay between when the click is received and when the main thread is able to respond;
- It has to wait until the task completes before it can respond to the input;
- The time it must wait is the FID value for this user on this page.

2. METRICS

Total Blocking Time (TBT)

- Measures the total amount of time between First Contentful Paint (FCP) and Time To Interactive (TTI) where the main thread was blocked for long enough to prevent input responsiveness;
- It helps quantify the severity of how non-interactive a page is prior to it becoming reliable;
- A low TBT helps ensure that the page is usable.

2. METRICS

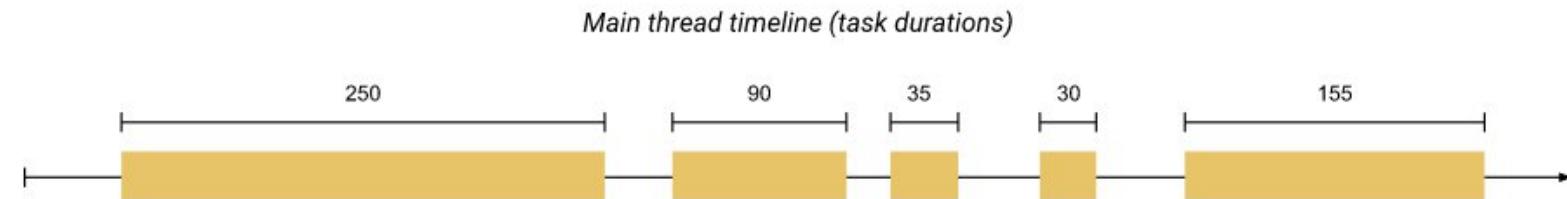
Total Blocking Time (TBT)

- The main thread is considered “blocked” any time there’s a long task (task that runs on the main thread for more than 50 milliseconds);
- When say the main thread is “blocked” because the browser cannot interrupt a task that’s in progress. So in the event that a user does interact with the page in the middle of a long task, the browser must wait for the task to finish before it can respond;
- If the task is long enough (e.g. anything above 50 milliseconds), it is likely that the user will notice the delay and perceive the page is sluggish or janky.

2. METRICS

Total Blocking Time (TBT)

- **TBT Score:**
 - To provide a good user experience, websites should strive to have a TBT of less than 300 milliseconds when tested on average mobile hardware;
 - Consider the following diagram of the browser's main thread during page load:

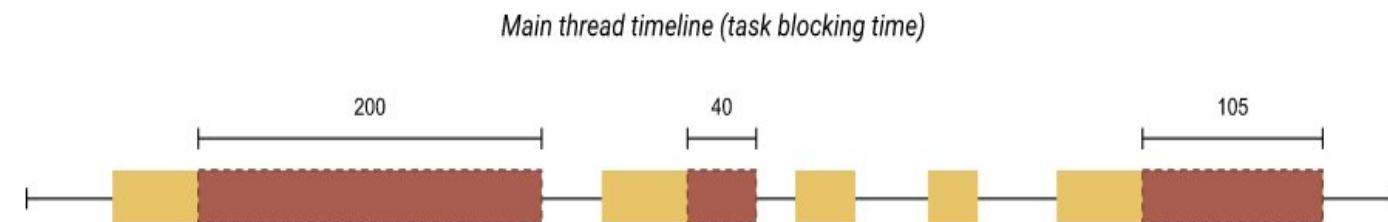


- The above timeline has five tasks, three of which are long tasks because their duration exceeds 50 milliseconds.

2. METRICS

Total Blocking Time (TBT)

- **TBT Score:**
 - The next diagram shows the blocking time for each of the long tasks:



- So while the total time spent running tasks on the main thread is 560 milliseconds, only 345 milliseconds of that time is considered blocking time;
 - Blocking time of a long task is its duration in excess of 50 milliseconds. And the total blocking time for a page is the sum of the blocking time for each long task that occurs between FCP and TTI.

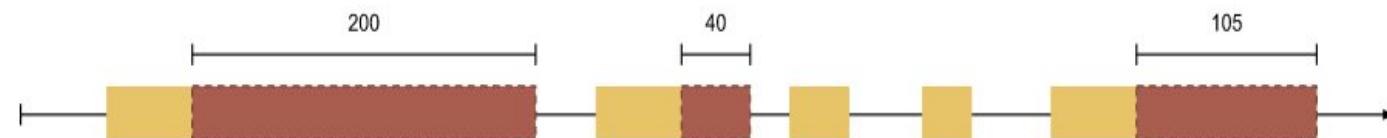
2. METRICS

Total Blocking Time (TBT)

- **TBT Score:**

	Task duration	Task blocking time
Task one	250 ms	200 ms
Task two	90 ms	40 ms
Task three	35 ms	0 ms
Task four	30 ms	0 ms
Task five	155 ms	105 ms
Total Blocking Time		345 ms

Main thread timeline (task blocking time)



2. METRICS

Cumulative Layout Shifts (CLS)

- Measure the sum total of all individual layout shifts scores for every unexpected layout shift that occurs during the entire lifespan of the page;
- A layout shift occurs any time a visible element changes its position from one rendered frame to the next;
- Important, user-centric metric for measuring visual stability because it helps quantify how often users experience unexpected layout shifts;
- A low CLS helps ensure that the page is delightful.

2. METRICS

Cumulative Layout Shifts (CLS)

- **CLS Score:**

- To provide a good user experience, websites should strive for a CLS score < 0.1 ;
- To ensure hitting this target for most users, a good threshold to measure is the 75th percentile of page loads, segmented in mobile and desktop devices.



2. METRICS

Cumulative Layout Shifts (CLS)

- **CLS Score:**
 - To calculate Layout Shift Score (LSS), the browser looks at the viewport size and the movement of the unstable elements in the viewport between two frames;
 - **Unstable element** – any time an element that is visible within the viewport changes its start position between two frames;
 - The LSS is a product of two measures of that movement:
 - *impact fraction * distance fraction*

2. METRICS

Cumulative Layout Shifts (CLS)

- **CLS Score:**
 - **Impact Fraction (IF):**
 - Measures how unstable elements impact the viewport area of 2 frames;
 - The union of the visible areas of all unstable elements for both frames as a fraction of the viewport total area is the IF for current frame.
 - **Distance Fraction (DF):**
 - Measures the distance that unstable elements have moved, relative to the viewport;
 - The distance fraction is the greatest distance any unstable element has moved in the frame (horizontally or vertically) divided by the viewport's largest dimension (width or height, whichever it greater).

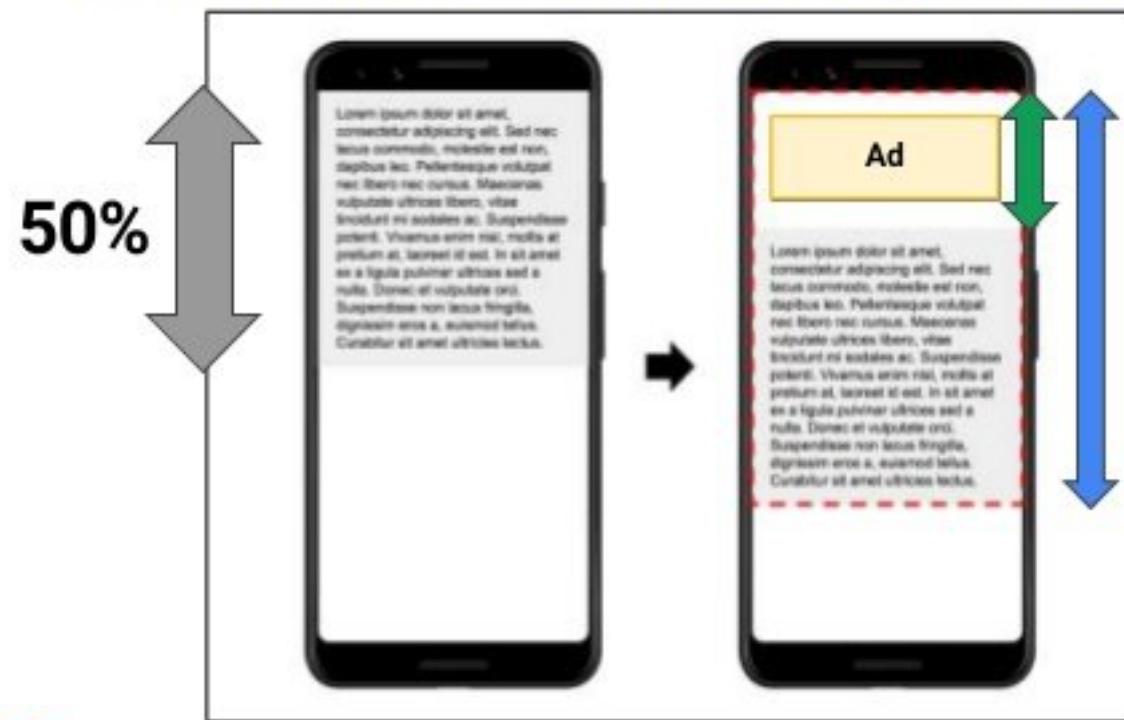
2. METRICS

Cumulative Layout Shift (CLS)

- **CLS Score:**

$$LS = 0.25 * 0.75 = 0.1875$$

Calculating Cumulative Layout Shift (CLS)



Distance Fraction

25%

Impact Fraction

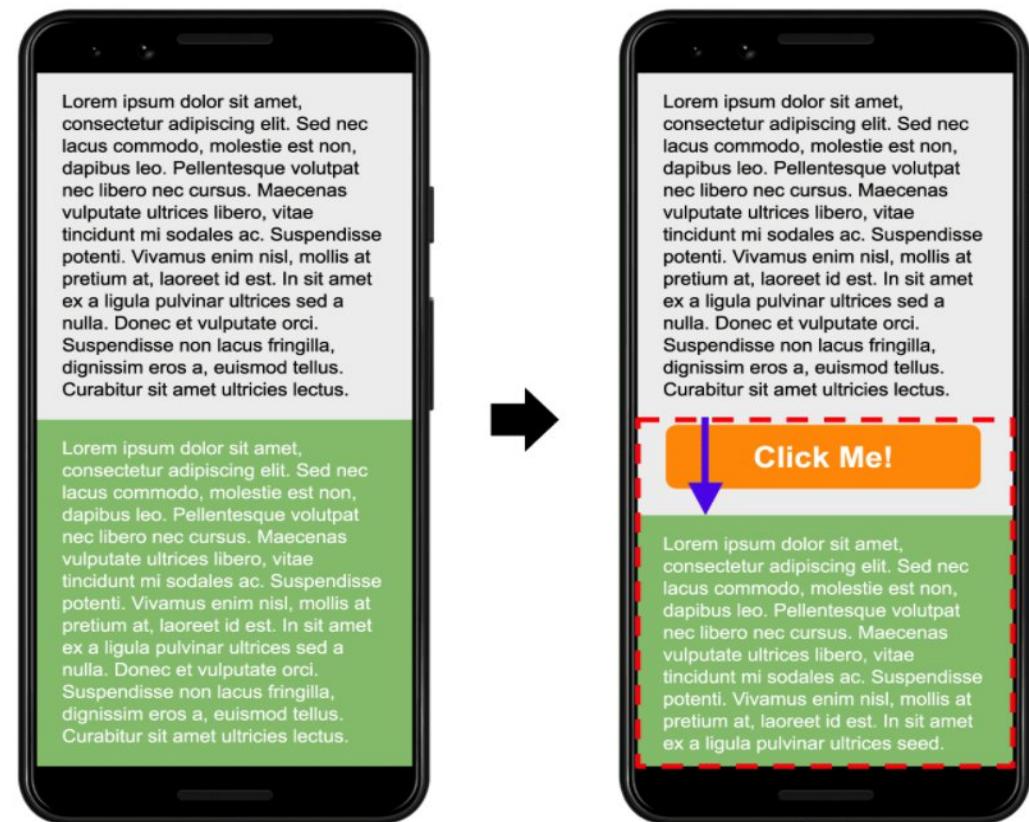
75%

2. METRICS

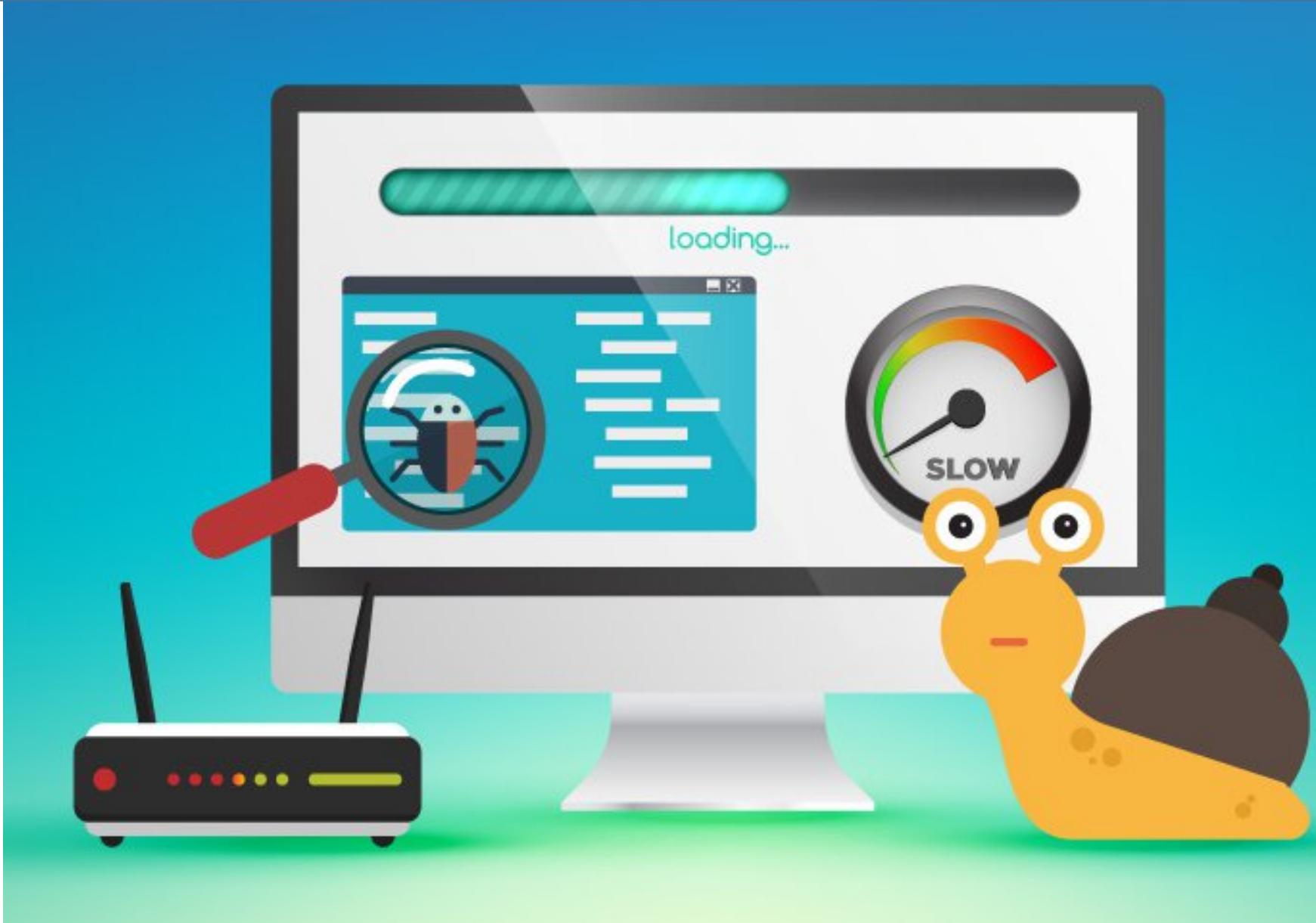
Cumulative Layout Shifts (CLS)

- **CLS Score:**

$$LS = 0.50 * 0.14 = 0.07$$



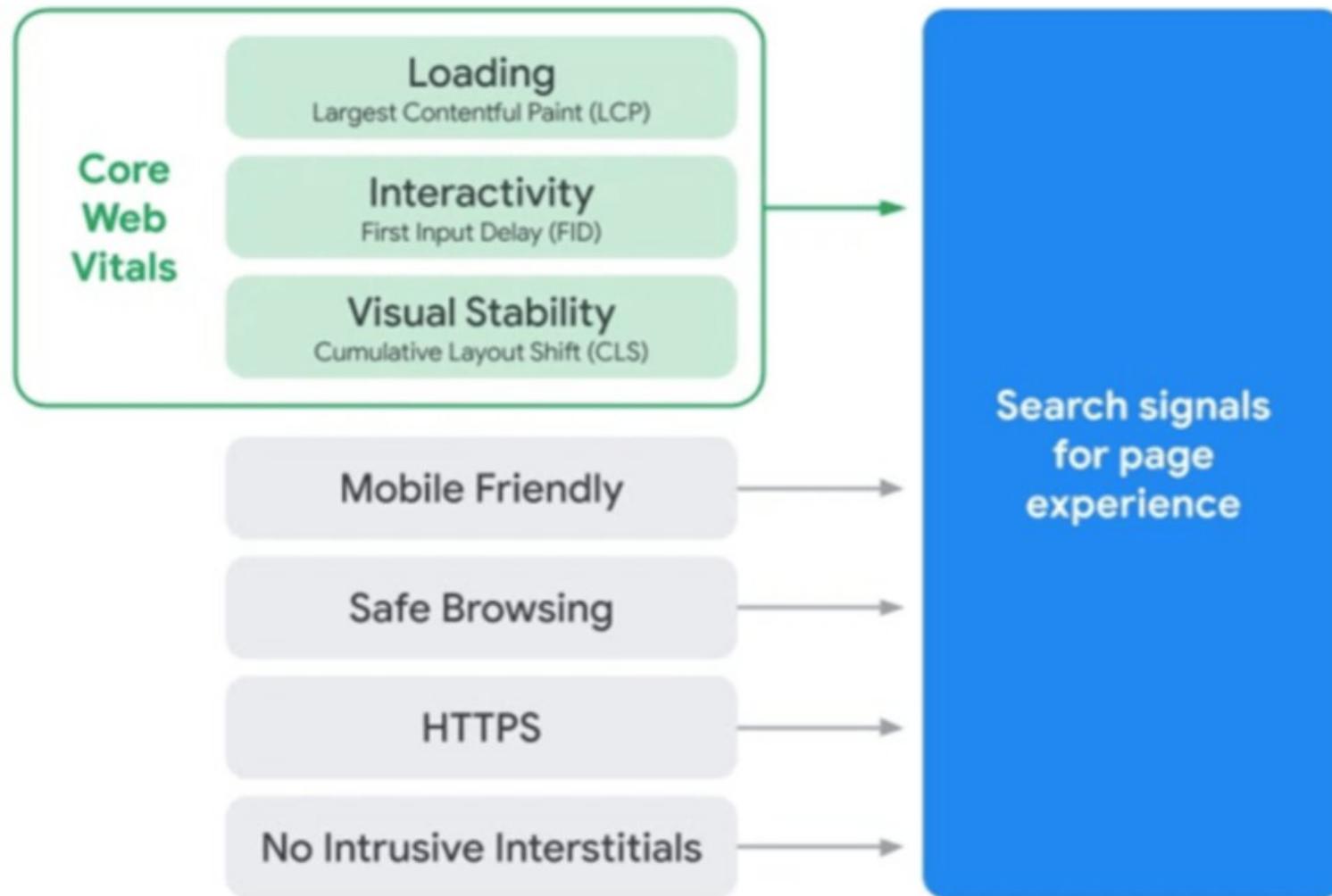
CORE WEB VITALS



3. CORE WEB VITALS

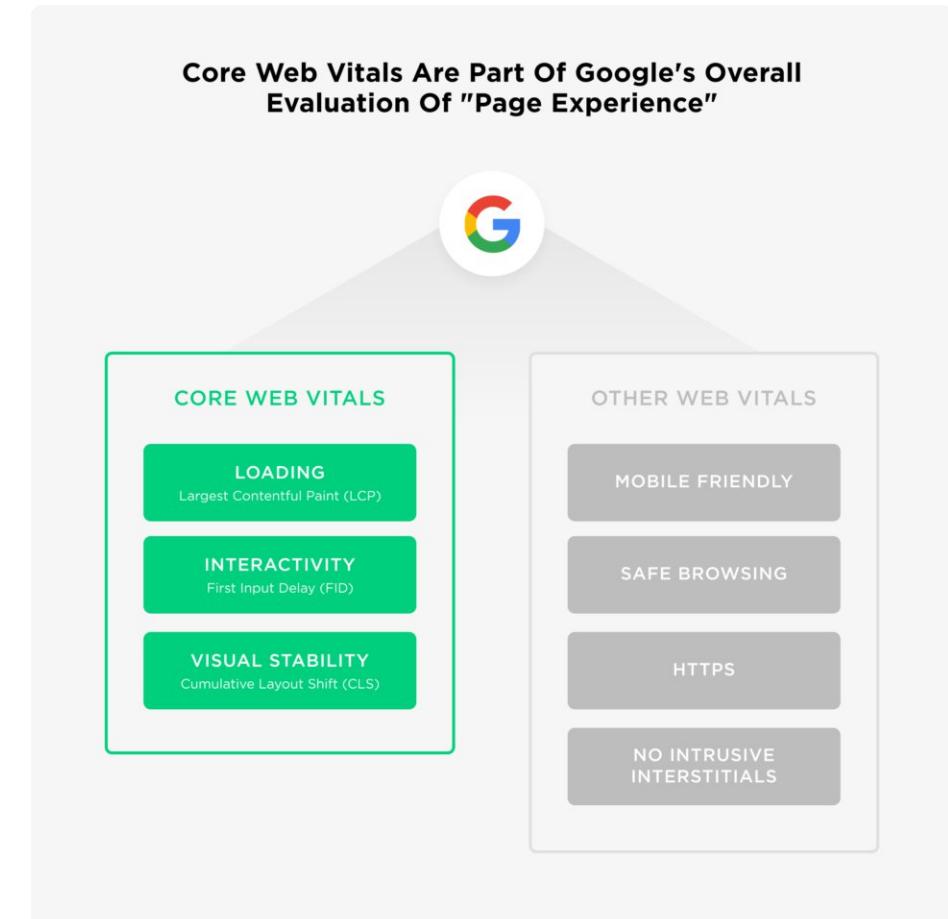
- Web vitals is an initiative by Google to provide unified guidance for quality signal that are essential to delivering a great user experience on the web;
- Google has provided a number of tools over the years to measure and report on performance. This abundance of both tools and metrics are confusing;
- Website owners should not have to be performance gurus;
- The web vitals initiative aims to simplify the landscape, and help websites focus on the metrics that matter most, the Core Web Vitals;
- Core web vitals are a set of indicators linked to the speed, response time and visual stability of a page;
- According to Google, these KPI's will help website owners to better assess the user experience.

3. CORE WEB VITALS



3. CORE WEB VITALS

- **Mobile friendliness:** your page is responsible and mobile friendly;
- **Safe browsing:** there are no security issues for a user to be concerned with and no malware present;
- **HTTPS:** you have a security license on your website, making it secure;
- **Intrusive Interstitial:** mobile content is easily found and readable (pop-ups, text size and other features are accounted for accessibility).



3. CORE WEB VITALS

- Represent a UX distinct facet measurable in the field, and reflects the real-world experience of a critical user-centric outcome;
- Focuses on 3 UX: loading, interactivity, and visual stability;
- Includes the following metrics:

Core Web Vitals



(Loading)



(Interactivity)



(Visual Stability)

LCP

Largest Contentful Paint

FID

First Input Delay

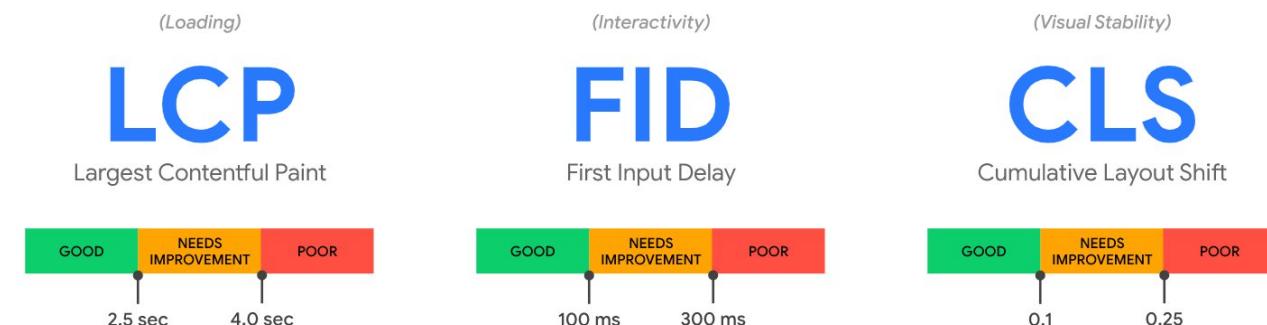
CLS

Cumulative Layout Shift

3. CORE WEB VITALS

Metrics

- Largest Contentful Paint (LCP): measures loading performance. To provide a good user experience, LCP should occur within 2.5 seconds of when the page first starts loading;
- First Input Delay (FID): measures interactivity. To provide a good user experience, pages should have a FID of less than 100ms;
- Cumulative Layout Shifts (CLS): measures visual stability. To provide a good user experience, pages should maintain a CLS of less than 0.1.



3. CORE WEB VITALS

Core Web Vitals

Now in your favorite developer tools

	LCP	FID	CLS
 PageSpeed Insights	✓	✓	✓
 Chrome UX Report <small>Brand new API, BigQuery and Dashboard</small>	✓	✓	✓
 Search Console	✓	✓	✓
 Chrome DevTools	✓	TBT	✓
 Lighthouse	✓	TBT	✓
 Web Vitals Extension	✓	✓	✓

LCP = Largest Contentful Paint, FID = First Input Delay, CLS = Cumulative Layout Shift, TBT = Total Blocking Time

3. CORE WEB VITALS

Field Tools

	LCP	FID	CLS
Chrome User Experience Report	✓	✓	✓
PageSpeed Insights	✓	✓	✓
Search Console (Core Web Vitals report)	✓	✓	✓

Lab Tools

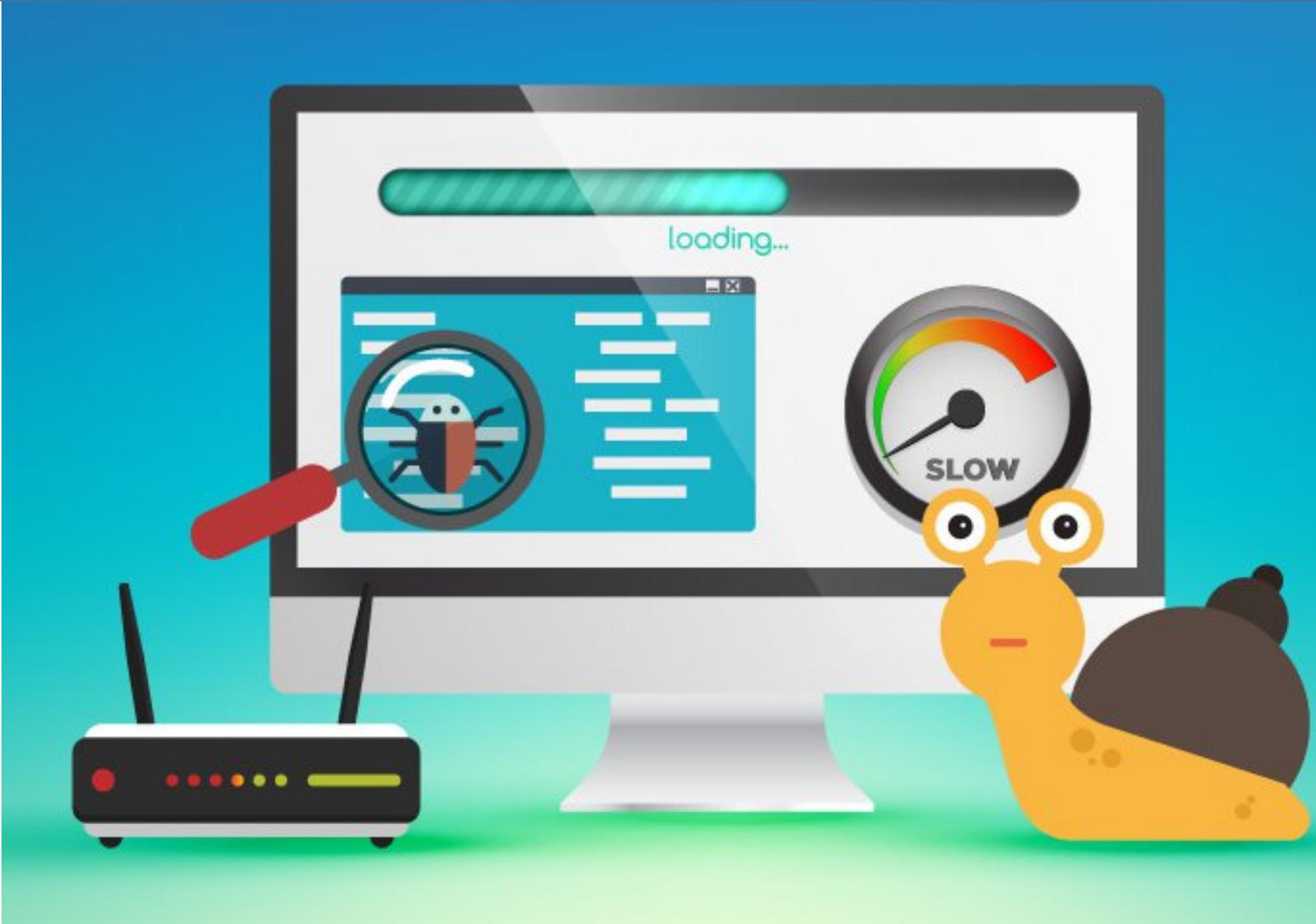
	LCP	FID	CLS
Chrome DevTools	✓	X (use TBT instead)	✓
Lighthouse	✓	X (use TBT instead)	✓

3. CORE WEB VITALS

Other Web Vitals

- For example, the metrics Time to First Byte (TTFB) and First Contentful Paint (FCP) are both vital aspects of the loading experience, and are both useful in diagnosing issues with LCP (slow server response times or render-blocking resources respectively);
- Similarly, metrics like Total Blocking Time (TBT) and Time to Interactive (TTI) are lab metrics that are vital in catching and diagnosing potential interactivity issues that will impact FID. However, they are not part of the Core Web Vitals set because they are not field-measurable, nor do they reflect a user-centric outcome.

FINAL REMARKS



4. FINAL REMARKS

- In short, each metric captures some aspect of page load speed;
- Web vitals appeared to unify metrics and tools;
- To make sure you are giving your users the best digital experience you need to track and monitor performance metrics;
- For that you need to chose the right tools.

