

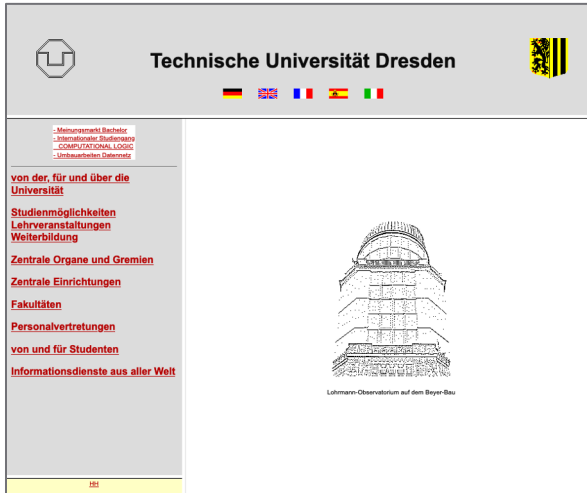
Lucas Vogel, Thomas Springer, Matthias Wählisch
Chair of Distributed and Networked Systems

From Files to Streams: A Critical Look at the Concept of the File-Based Web in the HTTP/3 Era

MIR³, 23.11.2023

Web content changed drastically

From mainly text



1997

2010

2023

Web content changed drastically

From mainly text to multimedia

Technische Universität Dresden

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Lehnmann-Observatorium auf dem Bayer-Gau

1997

TECHNISCHE UNIVERSITÄT DRESDEN

English | Suche

Startseite

[DIE TU DRESDEN](#) | [STUDIUM](#) | [FORSCHUNG](#) | [WEITERBILDUNG](#) | [INTERNATIONALES](#) | [SERVICE](#) | [AKTUELLES](#)

INFORMATIONEN FÜR

- Schüler
- Studieninteressierte
- Studierende
- Graduierte
- Absolventen
- Weiterbildungsinteressierte
- Mitarbeiter
- Webmaster
- Presse
- Unternehmen
- Gründer

Herzlich willkommen auf den Seiten der TU Dresden

Der designierte Rektor stellt sich am 22. Juli im Audimax vor

Professor Hans Müller-Steinhagen lädt zu einem Vortrag ein mehr...

Gutes Argument für ein Studium an der TU Dresden: die Stadt

Studierende entscheiden sich für eine lebenswerte und bezahlbare Stadt mehr...

Filmnächte am Elbufer: TU Dresden ist dabei

Vor jedem Kinofilm wird ein von der TU Dresden produzierter Spot gegen Fremdenfeindlichkeit zu sehen sein. mehr...

... mehr Aktuelles

... Archiv der Pressemitteilungen

Stand: 14.07.2010 13:24

Autor: Pressestelle (Zuständig für die Presseinformationen)

DRESDEN concept

ONLINE-BEWERBUNG

VERANSTALTUNGEN

... zum Veranstaltungskalender

- 09.07.2010, 06.08.2010, 10.09.2010, 14.10.2010 und 15.10.2010
Eltern-Campus-Tour
- 12.07.2010 - 13.08.2010
"Wir in Sachsen"
Wanderausstellung -
- 20.07.2010, 03.08.2010, 17.08.2010, 21.08.2010, 14.09.2010, 28.09.2010
Offene Sprechstunde zu Fragen rund um das Bewerbungsverfahren
- 23.07. - 08.08.2010
architekturpreis.sieben
- 08.08.2010
Museum-Sommernacht und Sommerfest im Botanischen Garten
- 29.08. - 10.09.2010
ICCL Summer School 2010

2010

2023

Web content changed drastically

From mainly text to multimedia to dynamic content and many content pieces

Technische Universität Dresden

von der, für und über die Universität

Studienmöglichkeiten
Lehrveranstaltungen
Weiterbildung

Zentrale Organe und Gremien

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Fakultäten

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... mehr Aktuelles

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2010

Technische Universität Dresden

STUDY AT TUD

MICROELECTRONICS

AREAS OF EXCELLENCE

WORKING AT TUD

GREEN CAMPUS

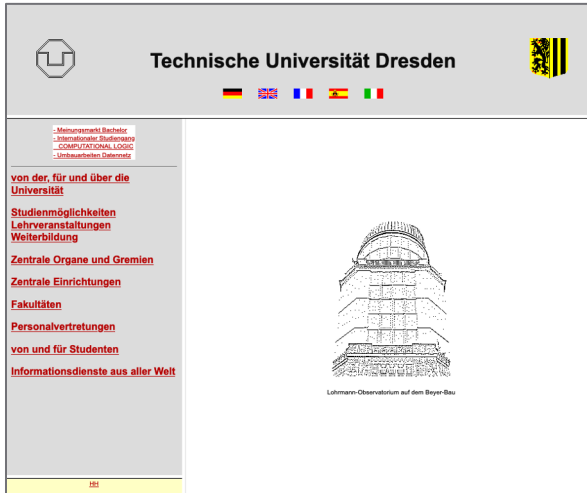
SHAPING STRUCTURAL CHANGE

NEWS

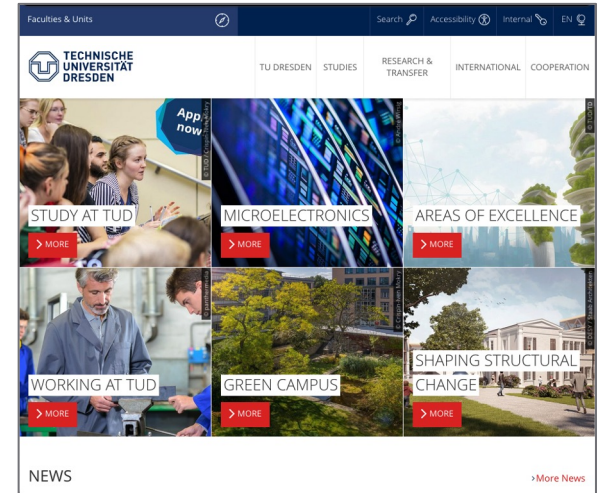
2023

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From mainly text to multimedia to dynamic content and many content pieces



16236%
more code



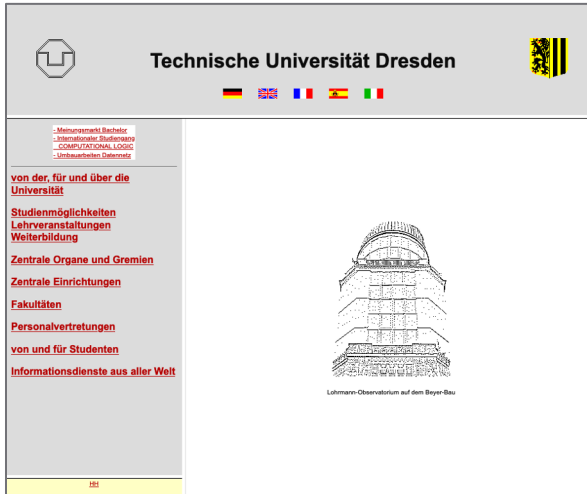
1997

2010

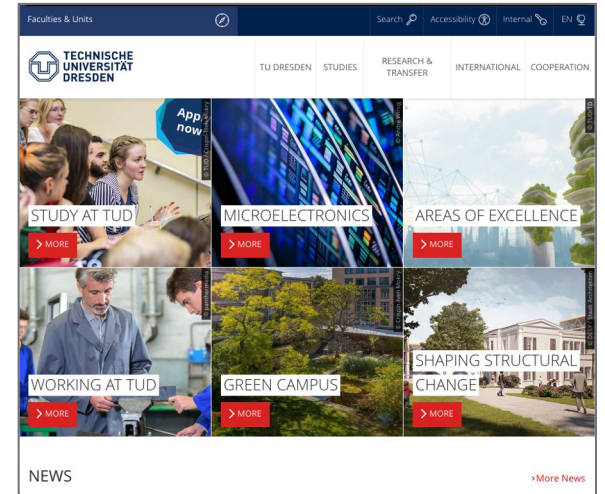
2023

Web content changed drastically

From mainly text to multimedia to dynamic content and many content pieces



16236%
more code



1997

2010

2023

Why does speed matter?

57%

Ratio of users that leave a web page if the loading time is >3 seconds.

-20%

Loss of Google's ad revenue if loading the result page needs +0.5 seconds.

Starting point of this talk

Reducing latency is crucial in the Web

During the last 20 years, a lot changed to **deliver** Web content **fast**.



Physical network
provides higher
data rates



Protocols improved
from HTTP/0.9 to
HTTP/3



CDNs + better
browser engines
improved delivery
and processing

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from HTTP/0.9 to
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browser engines
improved delivery
and processing

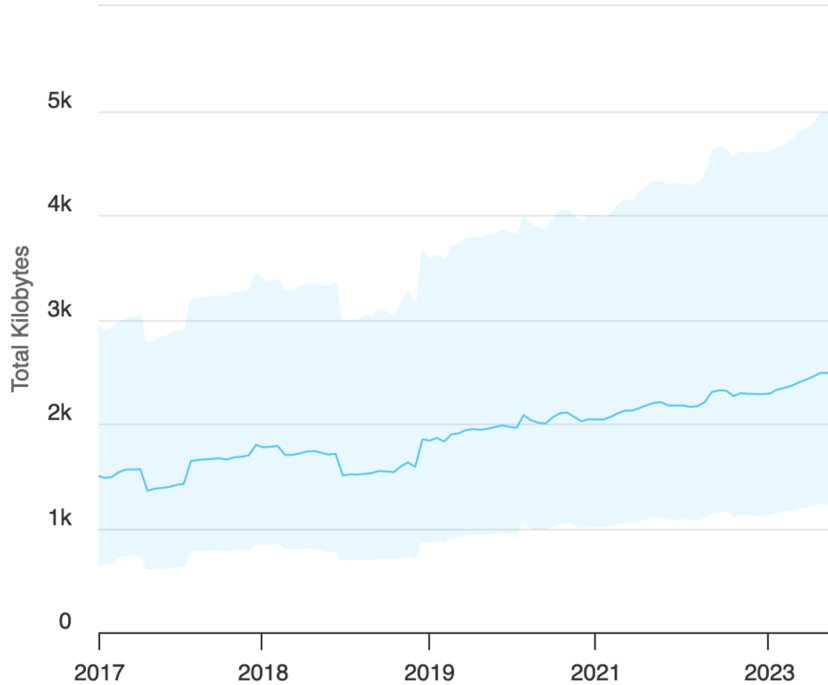
Unfortunately, we **didn't care** much about
presenting content **timely**.

Web page size vs. first contentful paint on a desktop

Timeseries of Total Kilobytes

Source: httparchive.org

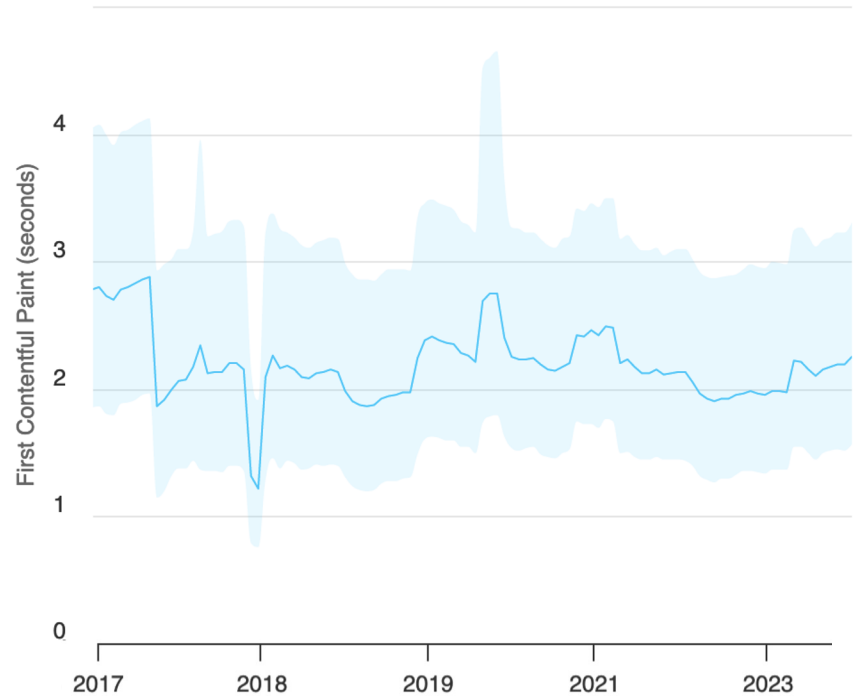
25 Dec 2016 → 1 Oct 2023



Timeseries of First Contentful Paint

Source: httparchive.org

18 Dec 2016 → 1 Oct 2023

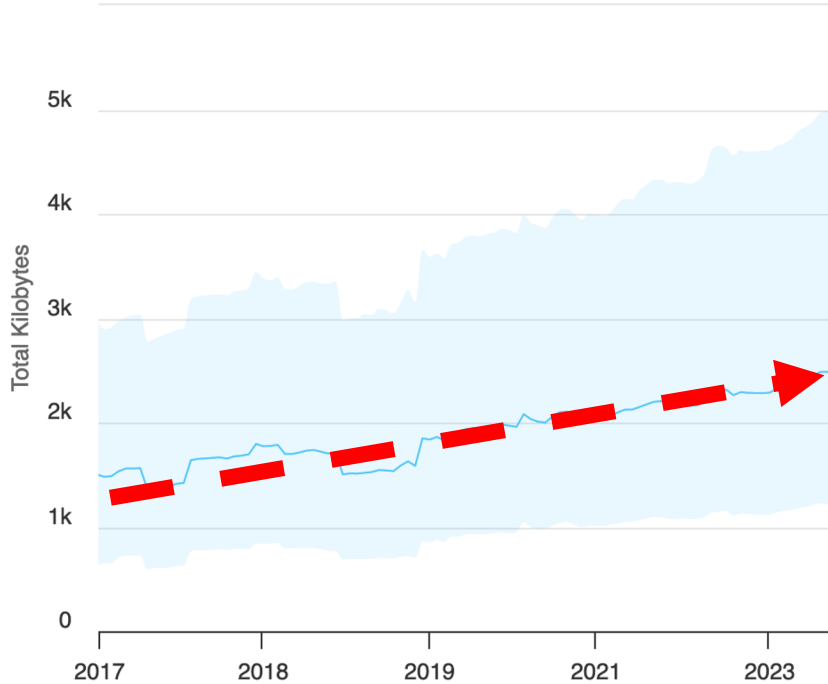


Web page size vs. first contentful paint on a desktop

Timeseries of Total Kilobytes

Source: httparchive.org

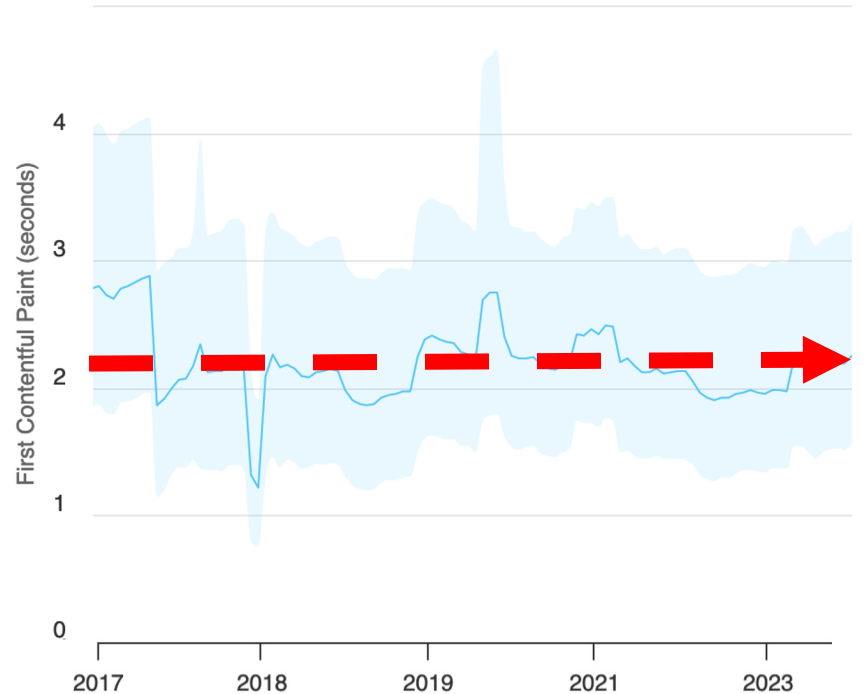
25 Dec 2016 → 1 Oct 2023



Timeseries of First Contentful Paint

Source: httparchive.org

18 Dec 2016 → 1 Oct 2023



What is this talk about?

What slows down content presentation?

Beyond transmission delay, the problem of render blocking.

Why are we faced with the situation?

A brief historic recap.

How can we improve the situation?

Split bundles and stream content pieces.

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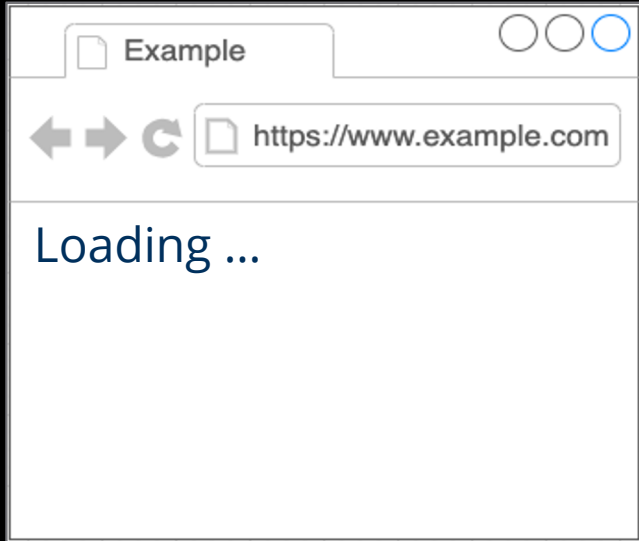
```
<head>
```

```
<script src="script.js"></script>
```

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

```
</head>
```

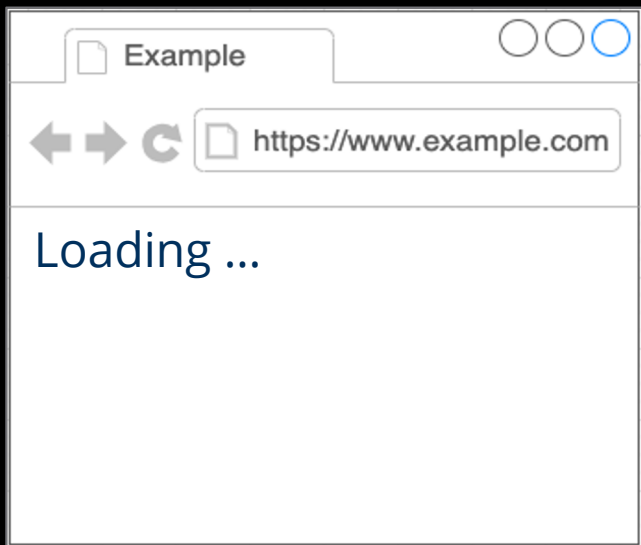
```
<body>Hello World!</body>
```



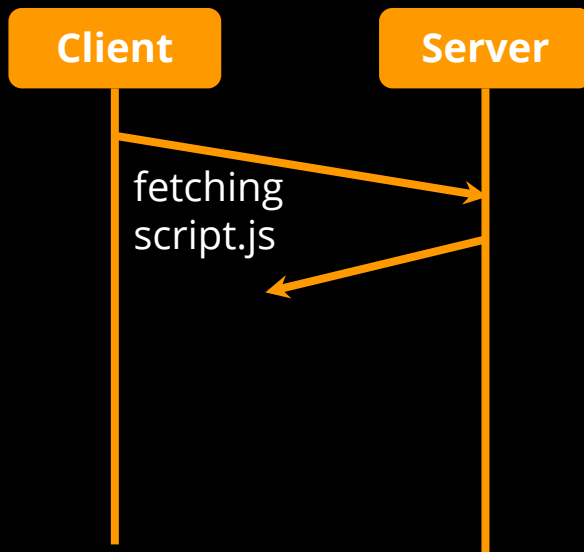
Client

Server

```
<head>
<script src="script.js"></script>
<link rel="stylesheet" type="text/css" href="style.css"/>
</head>
<body>Hello World!</body>
```

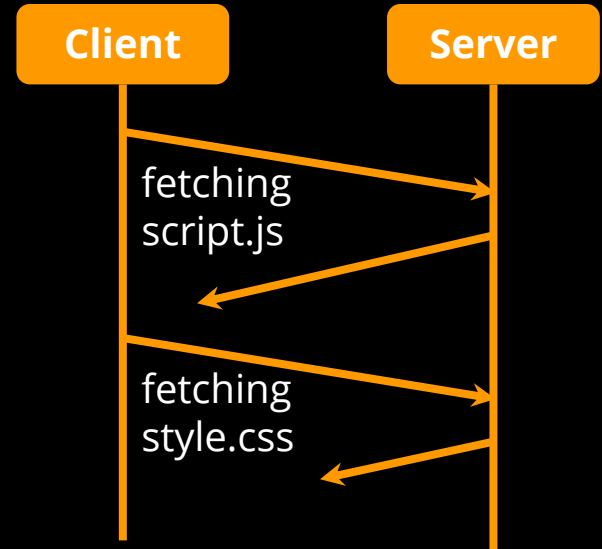


Rendering is blocked.

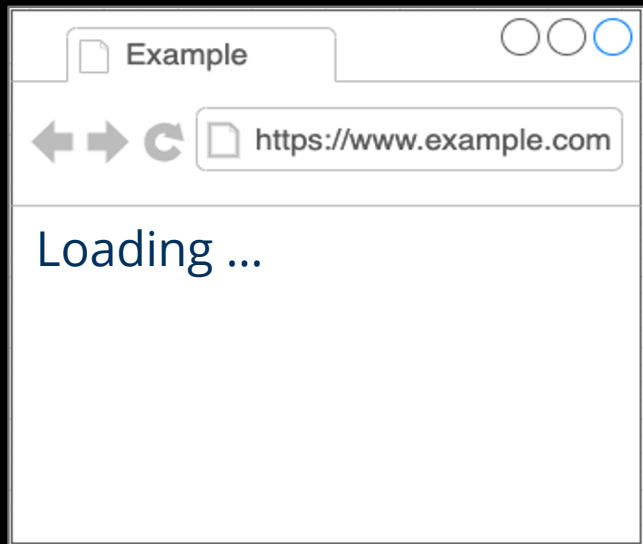


Rendering is blocked.

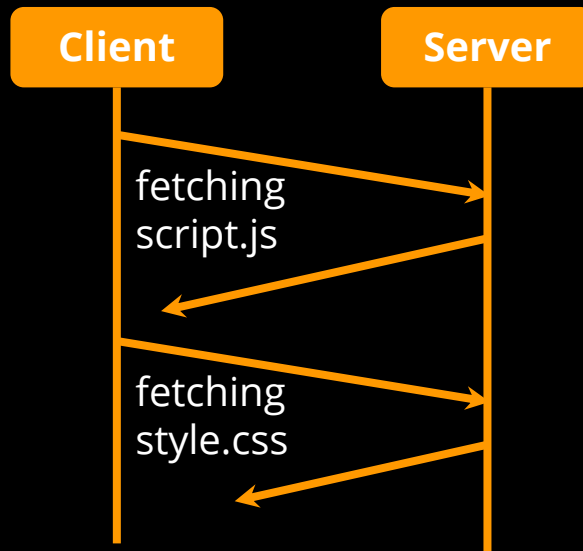
```
<head>  
<script src="script.js"></script>  
<link rel="stylesheet" type="text/css" href="style.css"/>  
</head>  
<body>Hello World!</body>
```



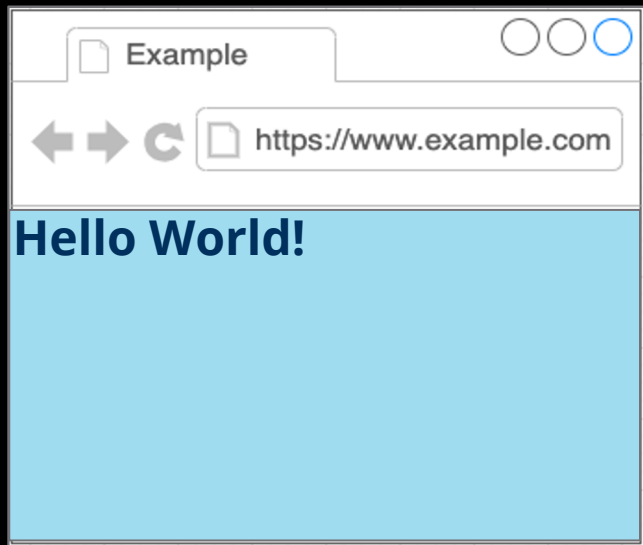

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```



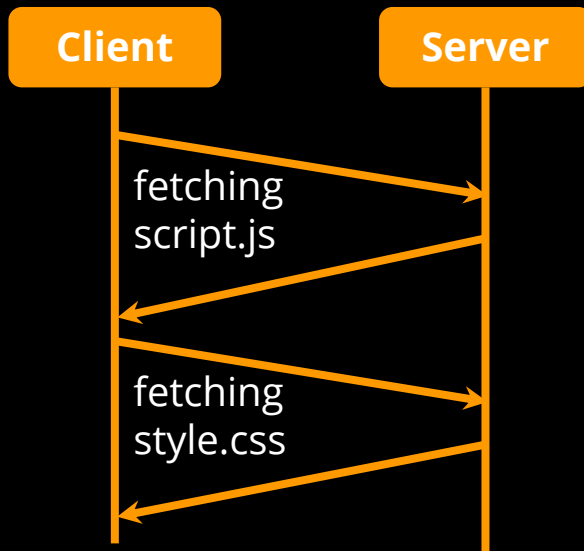
Rendering is blocked.



```
<head>
<script src="script.js"></script>
<link rel="stylesheet" type="text/css" href="style.css"/>
</head>
<body>Hello World!</body>
```

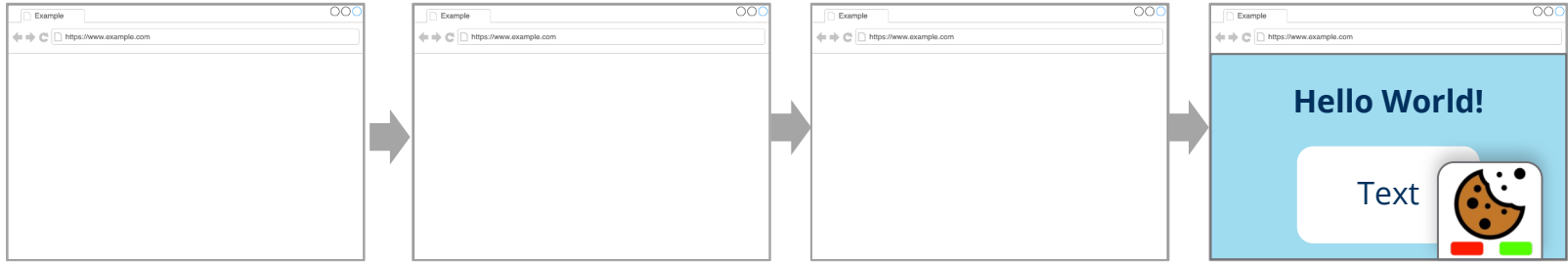


Rendering starts!



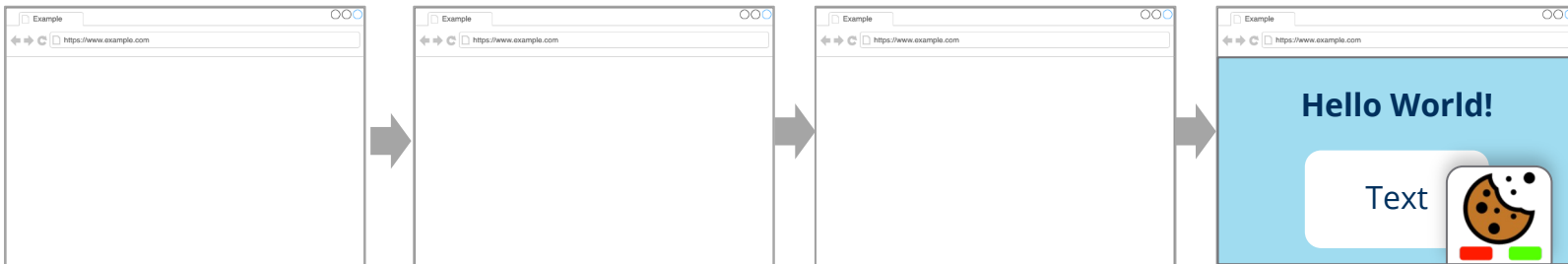
Render Blocking, a resource prevents a browser from rendering a Web page

Status quo
All or nothing



Render Blocking, a resource prevents a browser from rendering a Web page

Status quo
All or nothing

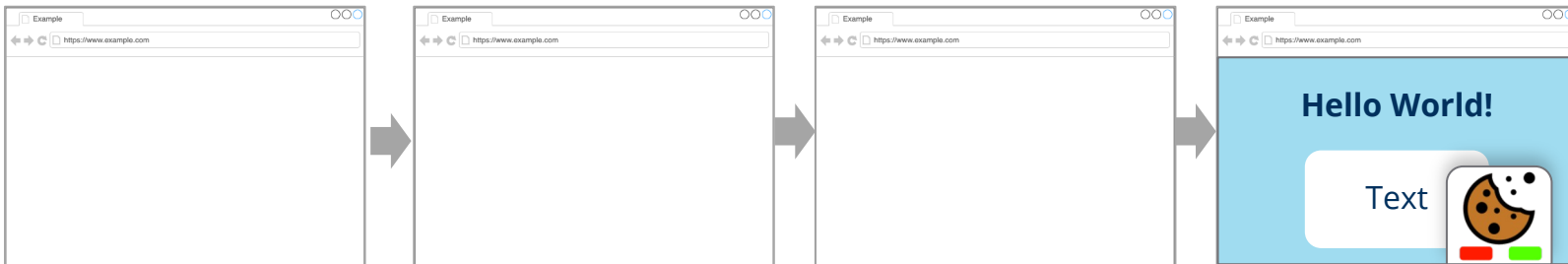


Naiv
Just don't block
the render?
(async/defer)



Render Blocking, a resource prevents a browser from rendering a Web page

Status quo
All or nothing



Naiv
Just don't block
the render?
(async/defer)



What we want
Progressive
content



Real-world example of Render Blocking



```
<body bgcolor="#e0e0e0" text="#0A0A0A" link="#bF0000" vlink="#ff0000" alink="#000000">  
<center> <table border="0" width="100%" height="100%">  
<frameset rows="23%,77%">
```

- No JavaScript
- CSS inline (**technically render blocking**)
- Fast due to focus on content

1997

2010

2023

Real-world example of Render Blocking



```
<link rel="stylesheet" type="text/css" href="http://tu-dresden.de/portal_css/Site%20Default/ploneStyles9374.css"/>
```

```
<script type="text/javascript" src="http://tu-dresden.de/portal_javascripts/Site%20Default/ploneScripts7921.js">
```

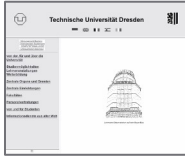
- No JavaScript
- CSS inline (**technically render blocking**)
- Fast due to focus on content
- JavaScript from CMS
- Minimal user control over included code
- both JS and CSS **fully render-blocking** (missing async/defer)

1997

2010

2023

Real-world example of Render Blocking



```
<link rel="stylesheet" type="text/css" href="https://tu-dresden.de/portal_css/tud.theme.webcms2/resourceplone.formwidget.contenttreecontenttree-cachekey-7a[...]df2e.css"/>  
<script type="text/javascript" src="https://tu-dresden.de/portal_javascripts/tud.theme.webcms2/popupforms-cachekey-1c4[...]112f.js"></script>
```

- No JavaScript
- CSS inline (**technically render blocking**)
- Fast due to focus on content

- JavaScript from CMS
- Minimal user control over included code
- both JS and CSS **fully render-blocking** (missing async/defer)

- JavaScript and CSS in **bundles** and collections
- Minimal user control over included code
- JS & CSS **fully render-blocking** (except tracking)

1997

2010

2023

Summary

Websites don't load significantly faster despite protocol improvements

Render blocking is the core problem

Solutions such as async/defer exist but aren't always easy to use

Code is combined into bundles

What is this talk about?

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A brief historic recap.

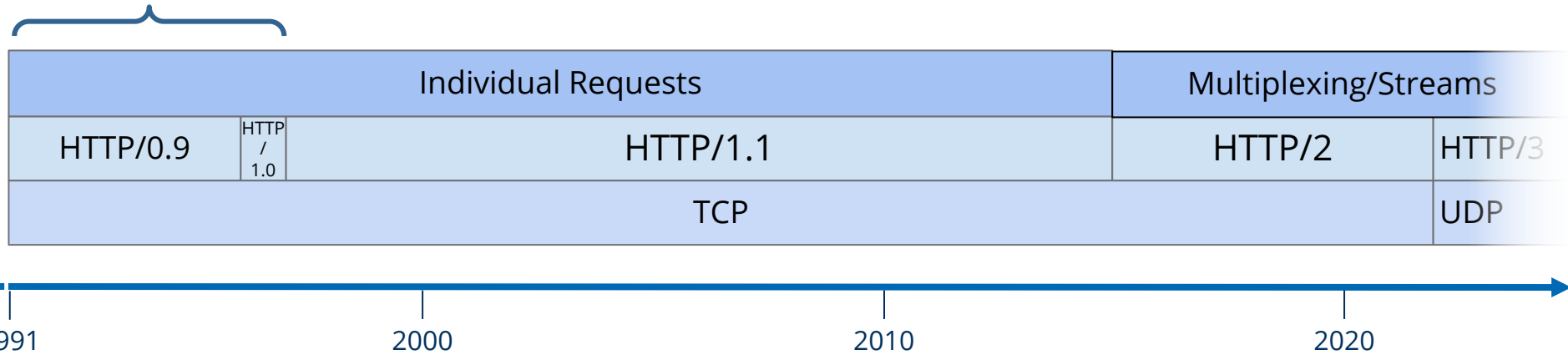
How can we improve the situation?

Split bundles and stream content pieces.

The problem: protocol vs. content

Solution: **bundling**

Penalty for every request: needed full TCP handshake



The problem: protocol vs. content

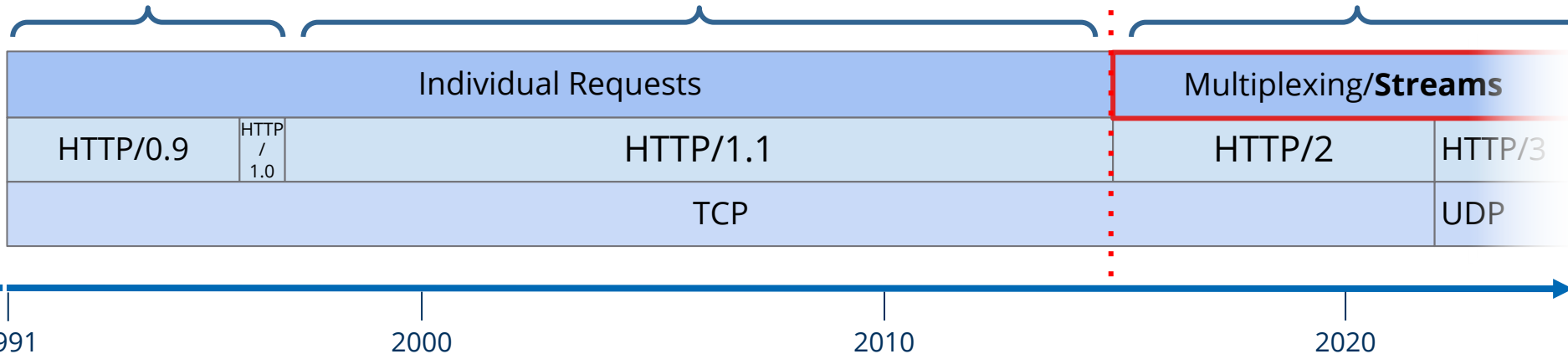
Solution: **bundling**

Penalty for every request: needed full TCP handshake

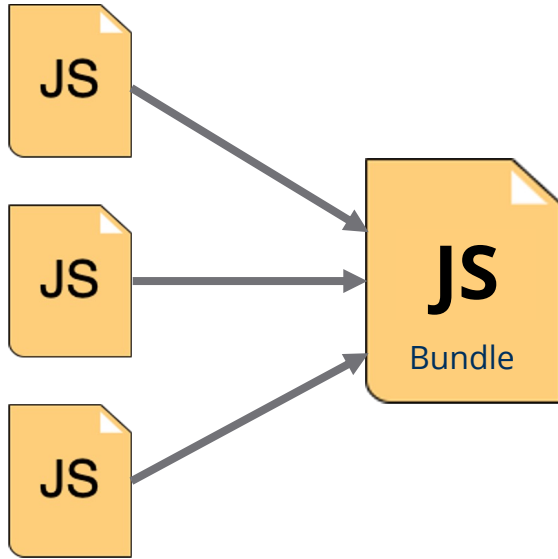
Less penalty for requests due to pipelining and keep-alive.
Still issues, due to buggy proxies and fixed request order

Solution: **splitting**

(almost) no penalty for requests due to 0-RTT, multiplexing and streams

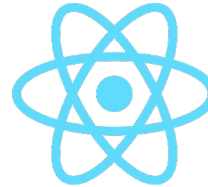


What are bundles?



- Started with **Browserify**, ca. 2013
- Today: most popular bundler: **Webpack**
- **By default: produces render-blocking bundles**

- **Webpack** is used by



React



Angular

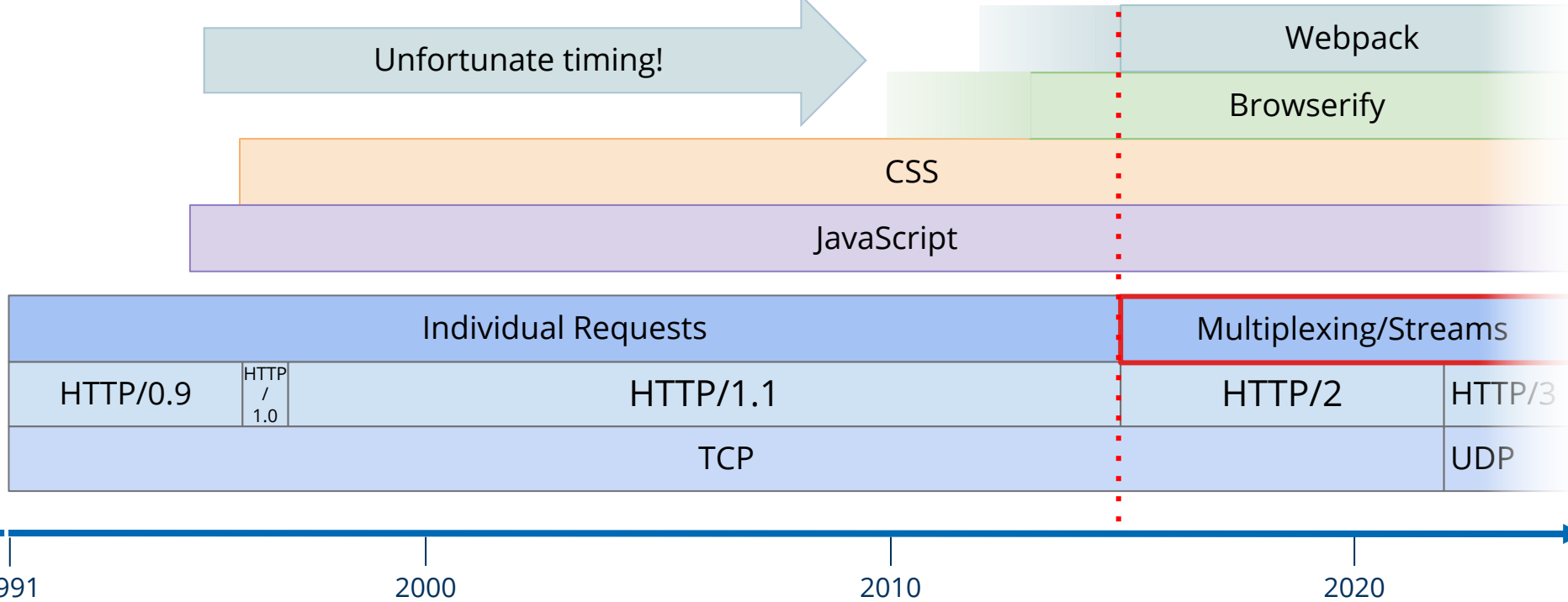


Vue.js

.. and many more

The problem: protocol vs. content

Unfortunate timing!



Bundling is an anti-pattern in HTTP/2

... but we still use bundling and render-blocking resources!

“ In HTTP/2, [bundling] will end up impacting the download-time of other resources as well, because of the way HTTP/2 works.”

—Erwin Hofman, 2022

[<https://www.erwinhofman.com/blog/two-main-performance-debts-of-http1/>]

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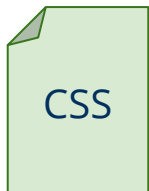
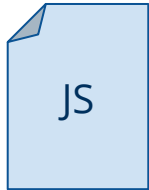
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What if ... we split as much as possible?

Initial files



What if ... we split as much as possible?

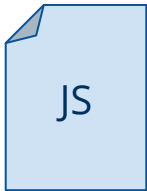
Initial files

Smallest possible chunks



```
<h1> Hello World </h1>
```

```
<p> Example Text </p>
```



```
function menu() {...}
```

```
function tracking() {...}
```



```
h1{ color: #18299d }
```

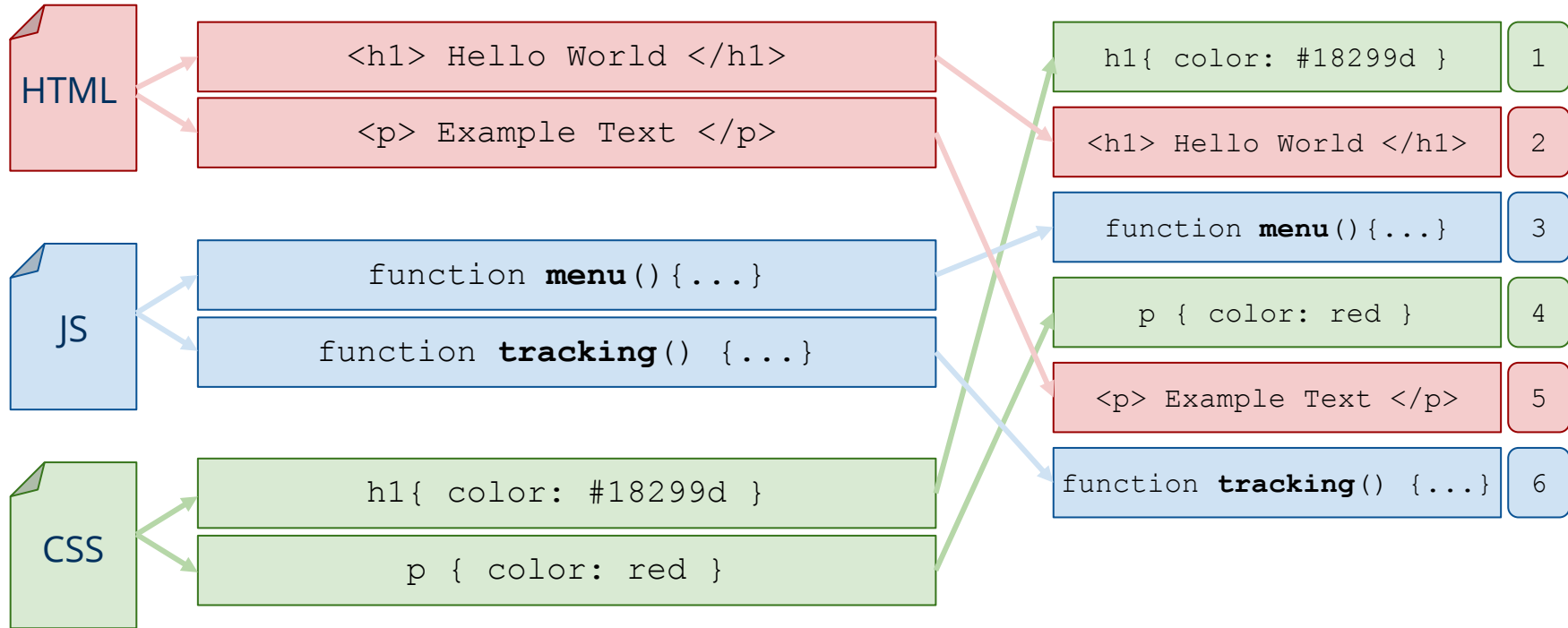
```
p { color: red }
```

What if ... we split as much as possible?

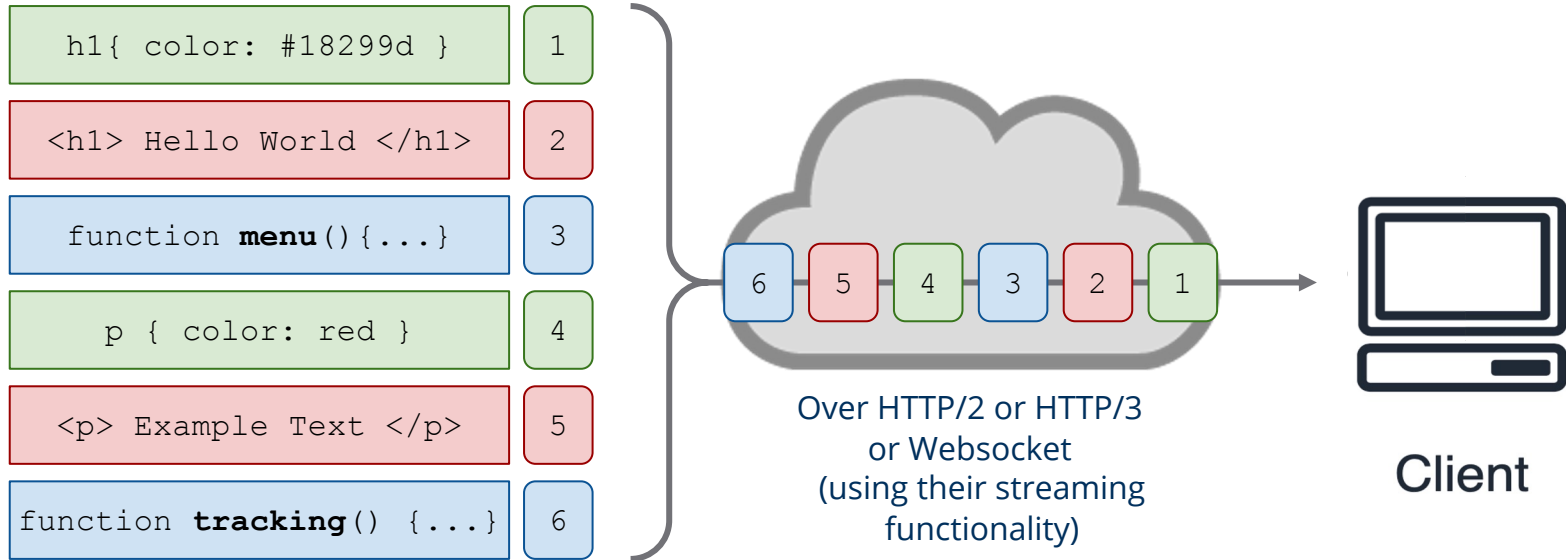
Initial files

Smallest possible chunks

Reorder for maximum (local) efficiency

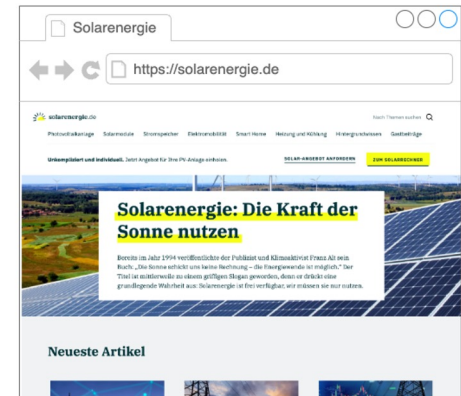
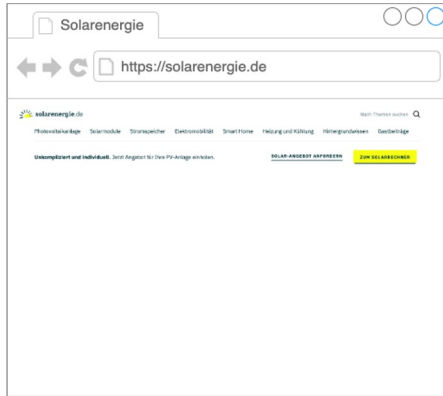


What if ... we stream splitted content?



Proposed streaming in practice

An example, www.solarenergie.de



Splitting, reordering, and streaming improve Web experience

Faster First Contentful Paint

Independent of actual length of web page
Improvements especially at slow network speeds

Faster total transfer

Content is ordered by priority leading to improved efficiency, as necessary code is transferred first
“Forces” efficiency

Improved UX

Better user experience due to reduced/removed layout shift
Faster interaction with web page

On-going research

Render & split **CSS**
into render critical &
uncritical parts

Vogel, Lucas, and Thomas
Springer. "Speed Up the Web
with Universal CSS Rendering."
*International Conference on
Web Engineering*. Cham:
Springer Nature Switzerland,
2023.

split **JS** into multiple
parts delay execution

Vogel, Lucas, and Thomas
Springer. "Waiter and
AUTRATAC: Don't Throw It
Away, Just Delay!."
*International Conference on
Web Engineering*. Cham:
Springer Nature Switzerland,
2023.

Render **HTML**
(with inline CSS and
JS)
**Reorder to be
streamable** and
render-able on the fly

Vogel, Lucas, and Thomas
Springer. "How Streaming Can
Improve the World (Wide
Web)." *Companion Proceedings
of the ACM Web Conference
2023*. 2023.

Conclusion

The Web is unnecessarily slow

Key takeaways

- Presenting web content fast is more than reducing transmission delays
- Bundles and render-blocking files slow down the Web

Proposed solution

- Consider loading behavior of web pages as a process over time and not file-based fetching
- Split content and stream pieces to send what is needed

Outlook

Next steps

- Fully automatic splitting of JavaScript
- Integration into current developer processes
- Streaming other media such as images

Open challenges

- How to leverage HTTP/3 features fully to support splitting and streaming best?
- Which websites would benefit from streaming most?
- What is the impact of current Web caches on streaming of content chunks?
- How to support multi-source, multi-path deployments?

Questions?

Sources

Slides: Web content changed drastically

- [left] <http://web.archive.org/web/19970716153203/http://www.tu-dresden.de/> [online, Nov. 19th, 2023]
- [middle] <http://web.archive.org/web/20100717183543/http://tu-dresden.de/> [online, Nov. 19th, 2023]
- [right] <http://web.archive.org/web/20230716104002/https://tu-dresden.de/> [online, Nov. 19th, 2023]

Slide: Why does speed matter?

- [1] afaco GmbH. Breitbandmessung Jahresbericht 2018/19. 2020. url: https://download.breitbandmessung.de/bbm/Breitbandmessung_Jahresbericht_2018_2019.pdf (besucht am 03. 04. 2020).
- [2] Fiona Fui-Hoon Nah. „A study on tolerable waiting time: how long are web users willing to wait?“ In: Behaviour & Information Technology 23.3 (2004), S. 153– 163.
- [3] Greg Linden. Marissa Mayer at Web 2.0. url: <http://glinden.blogspot.de/2006/11/marissa-mayer-at-web-20.html> (besucht am 12.01.2021).

Slide: What improved?

- [left] <https://blog.cloudflare.com/content/images/2018/07/QUIC-Badge-Dark-RGB-Horiz.png> [online, Nov. 19th, 2023]
- [top right] <https://www.akamai.com/content/dam/site/en/images/logo/akamai-logo-og-default.png> [online, Nov. 19th, 2023]
- [bottom right] Image by Ditaucis from Pixabay [online, Nov. 19th, 2023]

Slide: Web page size vs. loading time (Desktop)

- [left] <https://httparchive.org/reports/loading-speed> [online, Nov. 19th, 2023]
- [right] <https://httparchive.org/reports/state-of-the-web> [online, Nov. 19th, 2023]

Slide: What are bundles?

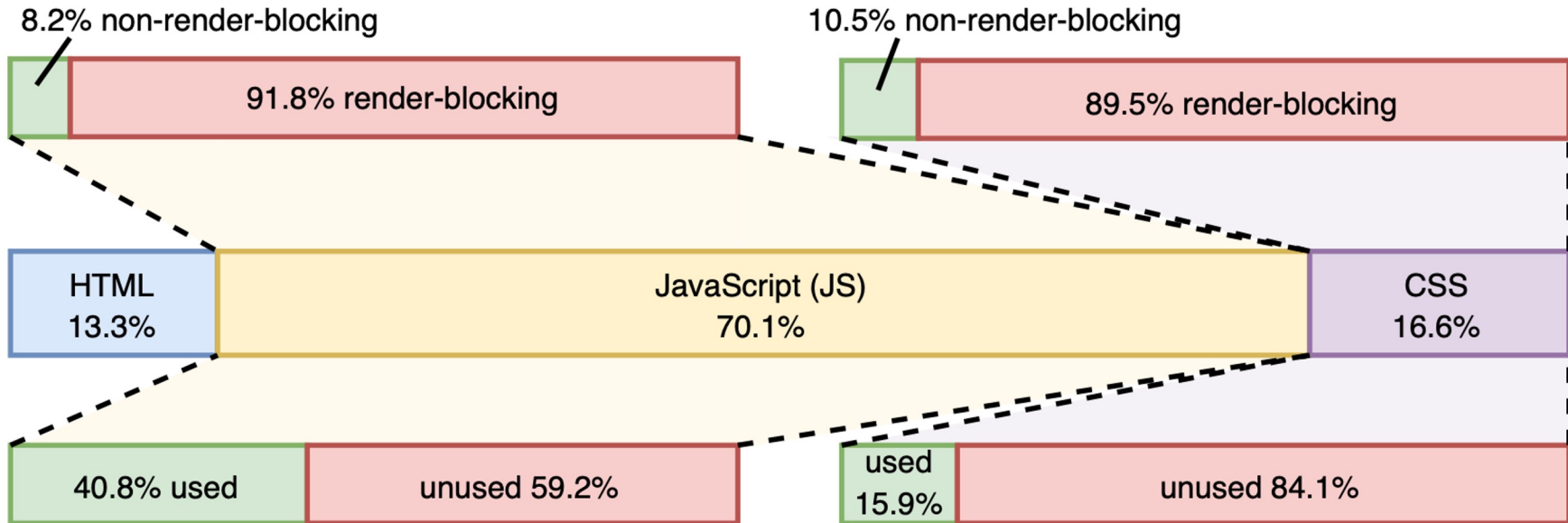
- [left, react logo] react.dev [online, Nov. 19th, 2023]
- [middle, angular logo] angular.io [online, Nov. 19th, 2023]
- [right, vue.js logo] vuejs.org [online, Nov. 19th, 2023]

Slide: How web pages can be streamed

- Vogel, Lucas, and Thomas Springer. "How Streaming Can Improve the World (Wide Web)." Companion Proceedings of the ACM Web Conference 2023.

Backup

Render blocking code. Average of top-10k Websites (Tranco).



Source:

Vogel, Lucas, and Thomas Springer. "User Acceptance of Modified Web Page Loading Based on Progressive Streaming." Web Engineering: 22nd International Conference, ICWE 2022, Bari, Italy, July 5–8, 2022, Proceedings. Cham: Springer International Publishing, 2022.