

# images, performance and cognitive load

TOBIAS BALDAUF

TOBIAS.BALDAUF@TRIVAGO.COM

@TBALDAUF

SLIDO.COM #DEVDAYS2019





## Gym

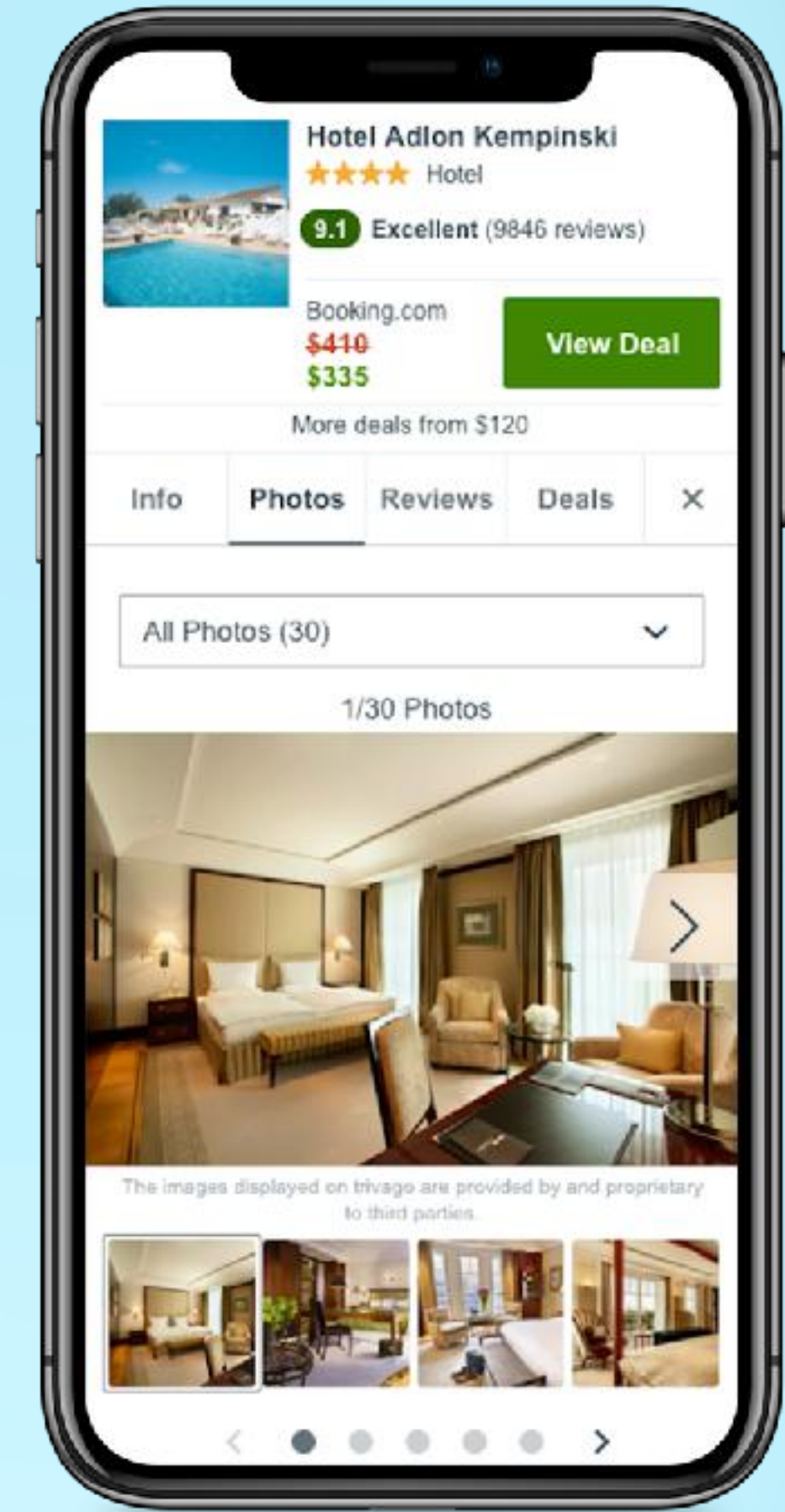
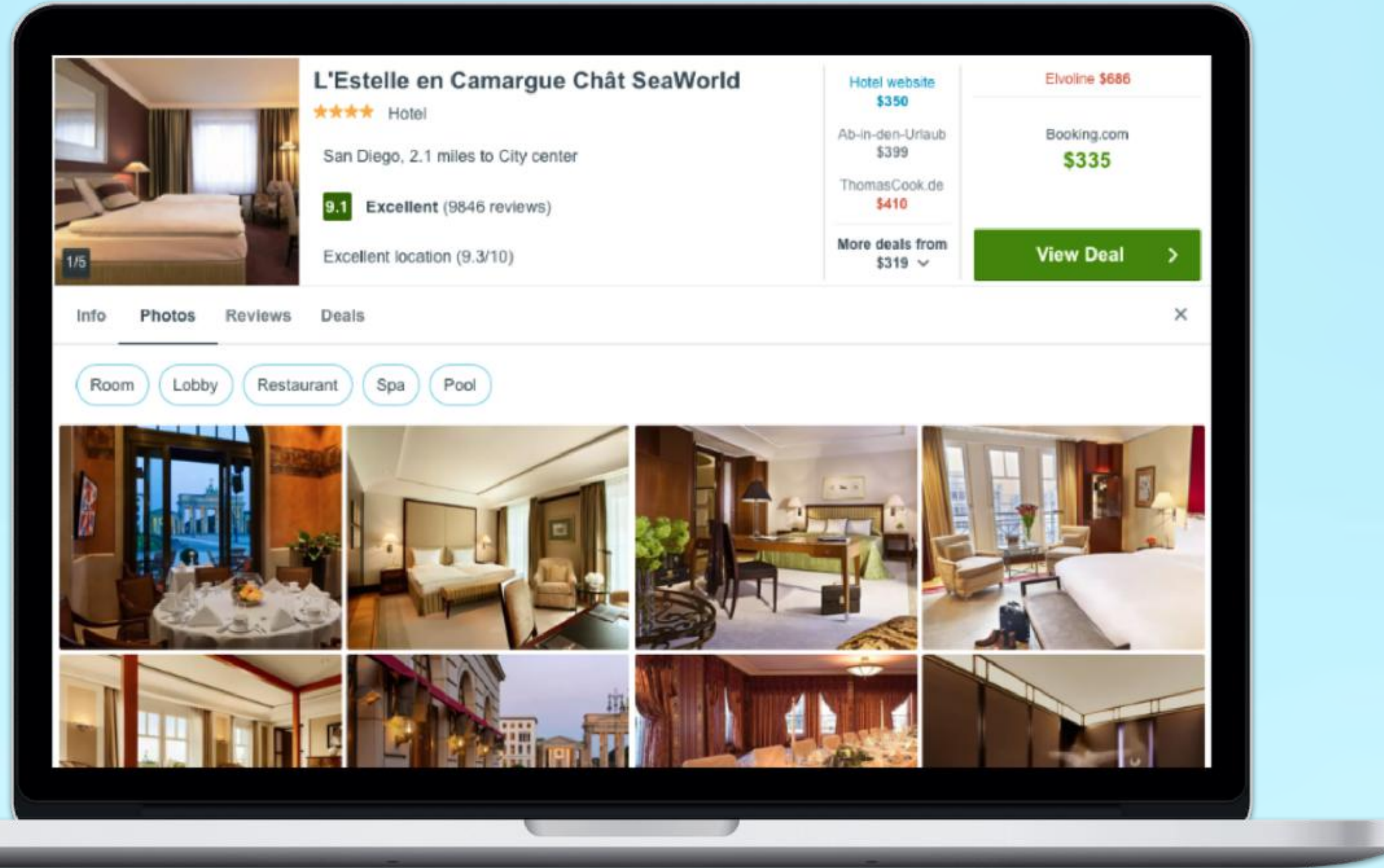
The gym at Comfort Hotel LT is equipped for both cardio and weights workouts.

Open 24 hours, every day of the year, so you can exercise whenever you want.

Gym is FREE for our accommodation clients.









Vilnius

Check-in Tue, 05/14/19 | Check-out Fri, 05/17/19 | Room One-person room


Price / night \$600+

Accommodation All types | Guest rating All | Hotel location City center | More filters Select

View Map

Sort by Our recommendations

How payments to us affect ranking



### Hotel Kempinski Cathedral Square

★★★★★ Hotel

Vilnius, 0.4 miles to City center

**9.5** Excellent (1158 reviews)  
Extremely clean · Excellent location

More details

Expedia \$255

Cancelon.com \$275

otel.com \$245

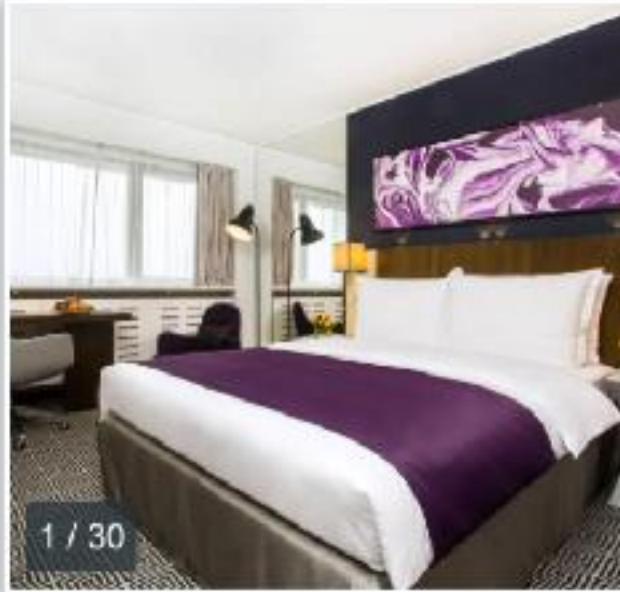
More deals from \$235

Booking.com \$639

Hotels.com \$255  
3 nights for \$766

Free breakfast

View Deal



### Radisson Blu Hotel Lietuva Vilnius

★★★★★ Hotel

Vilnius, 0.4 miles to City center

**8.6** Excellent (1426 reviews)  
Extremely clean · Excellent service

More details

RadissonBlu \$130

Hotels.com \$119


Cancelon.com \$112

More deals from \$106

Trip.com \$343

Booking.com \$119  
3 nights for \$358

View Deal



### Artagonist

Hotel

Vilnius, 0.6 miles to City center

Hotels.com \$111

priceline.com \$121

Expedia \$111

Booking.com \$121


trivago.com


Hotel Adlon Kempinski

★★★★★ Hotel

Expedia \$80 View Deal

Info Photos Reviews Deals







# Image CDNs

"We realized that maintaining an inhouse image optimization solution would be enough work for a dedicated team. By using an Image CDN, **our engineers can focus on our core business** while our users benefit from fast, good-looking images across all devices & networks."

*Tobias Baldauf, Trivago*



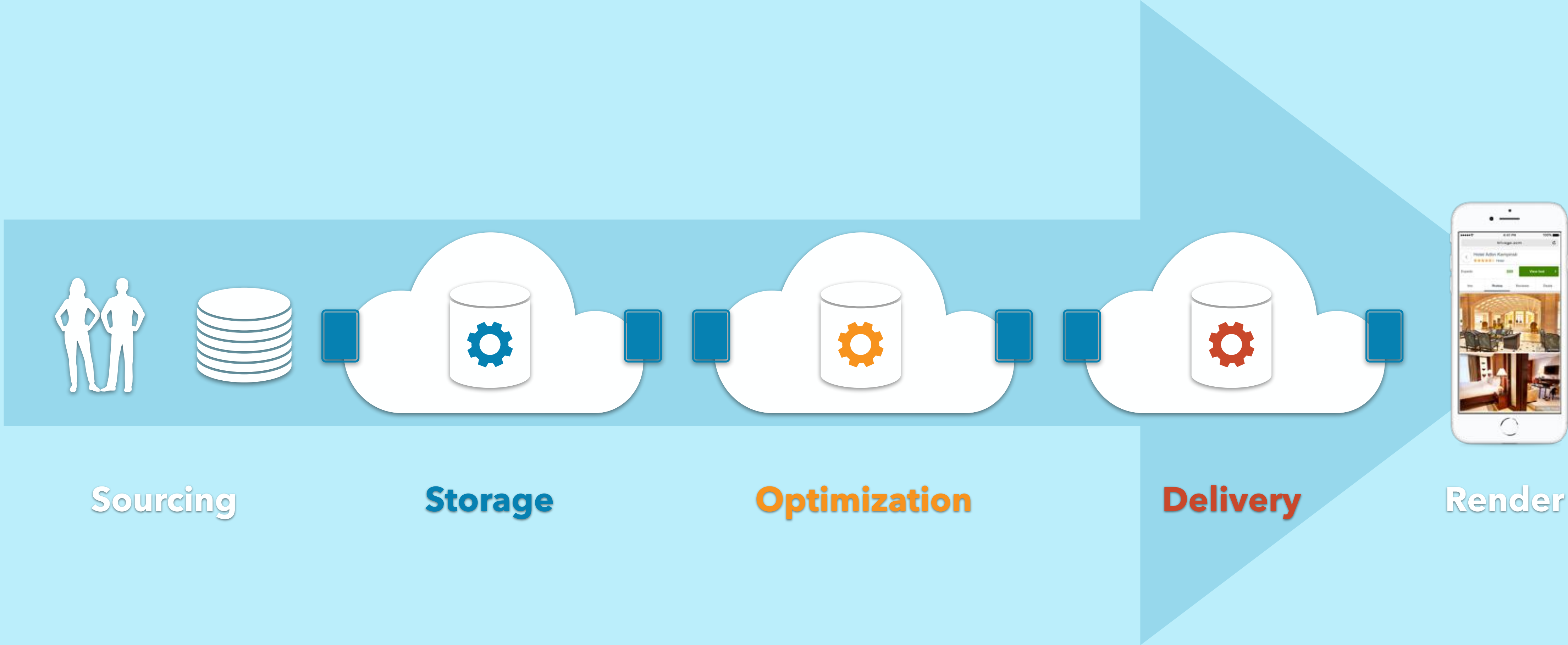
# Image CDNs



**80%**  
Decrease in  
image size (KB)

- Auto quality
- Auto cropping
- WebP

**getting us here**



Sourcing

Storage

Optimization

Delivery

Render

MEDIAN DESKTOP  
**899.6 KB**  
▲21.8%

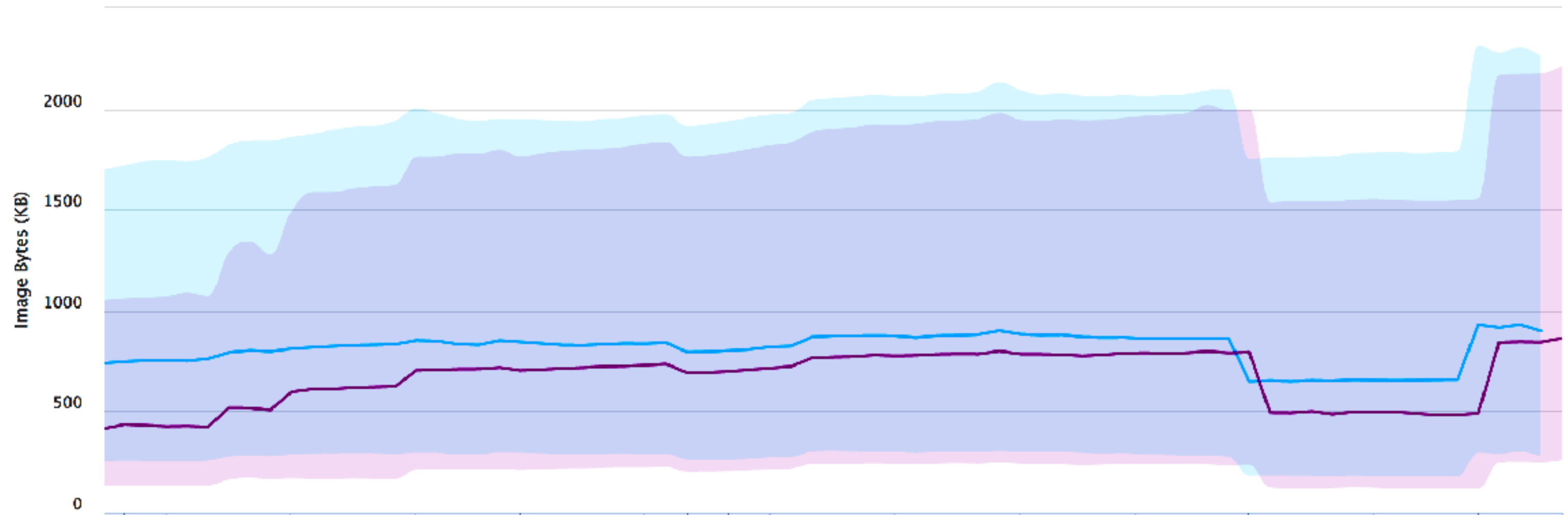
MEDIAN MOBILE  
**862.9 KB**  
▲108.0%

### Timeseries of Image Bytes

Source: httparchive.org

Zoom 1m 3m 6m YTD 1y 3y All

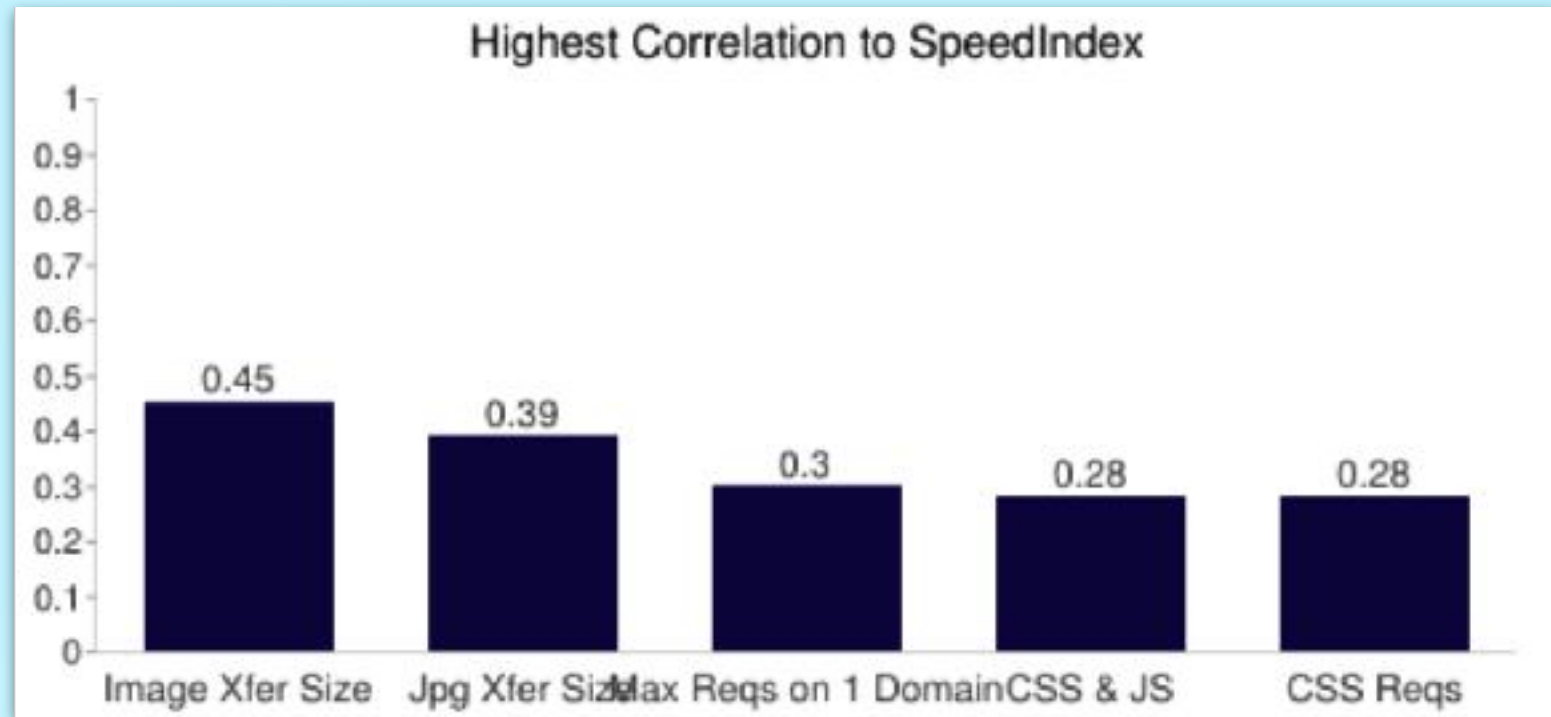
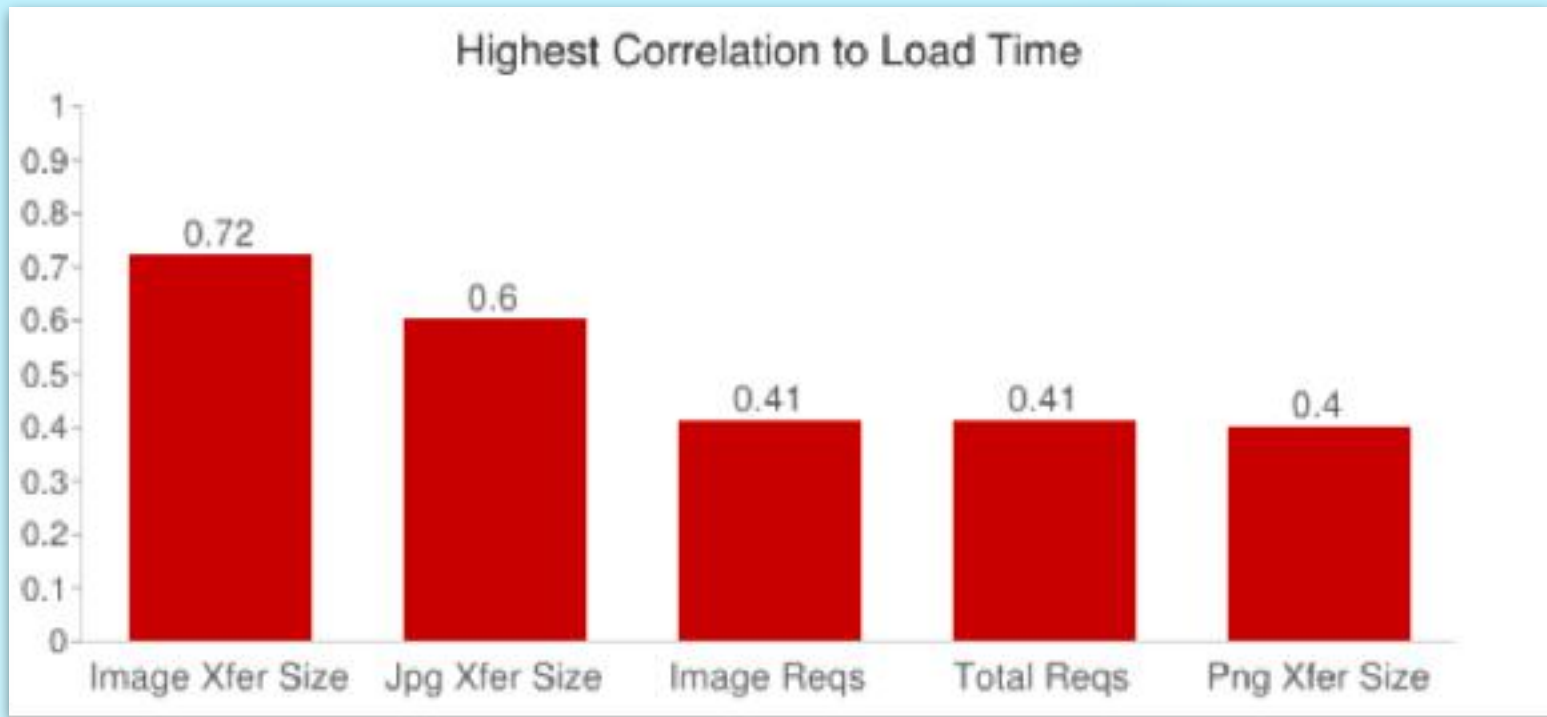
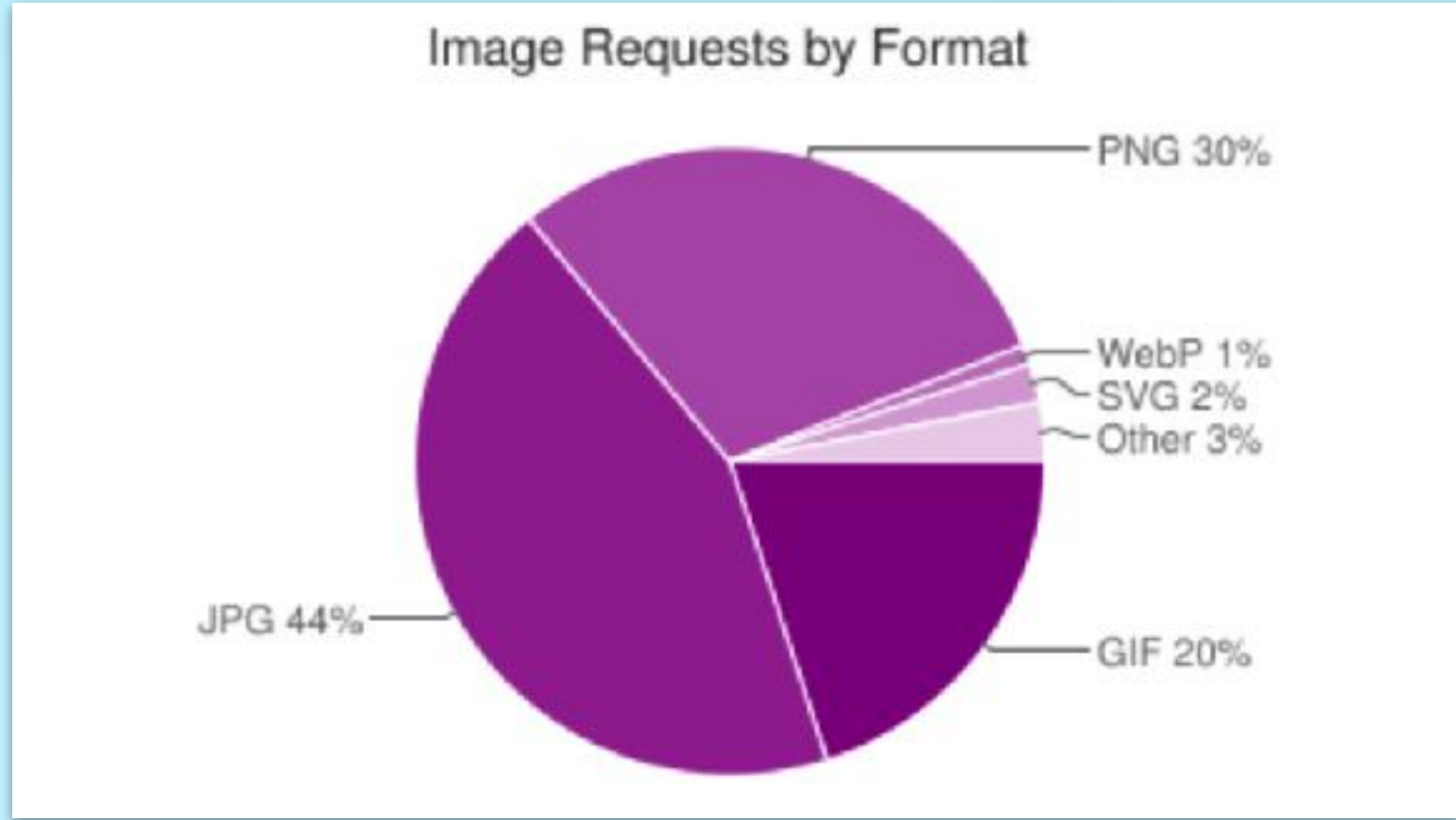
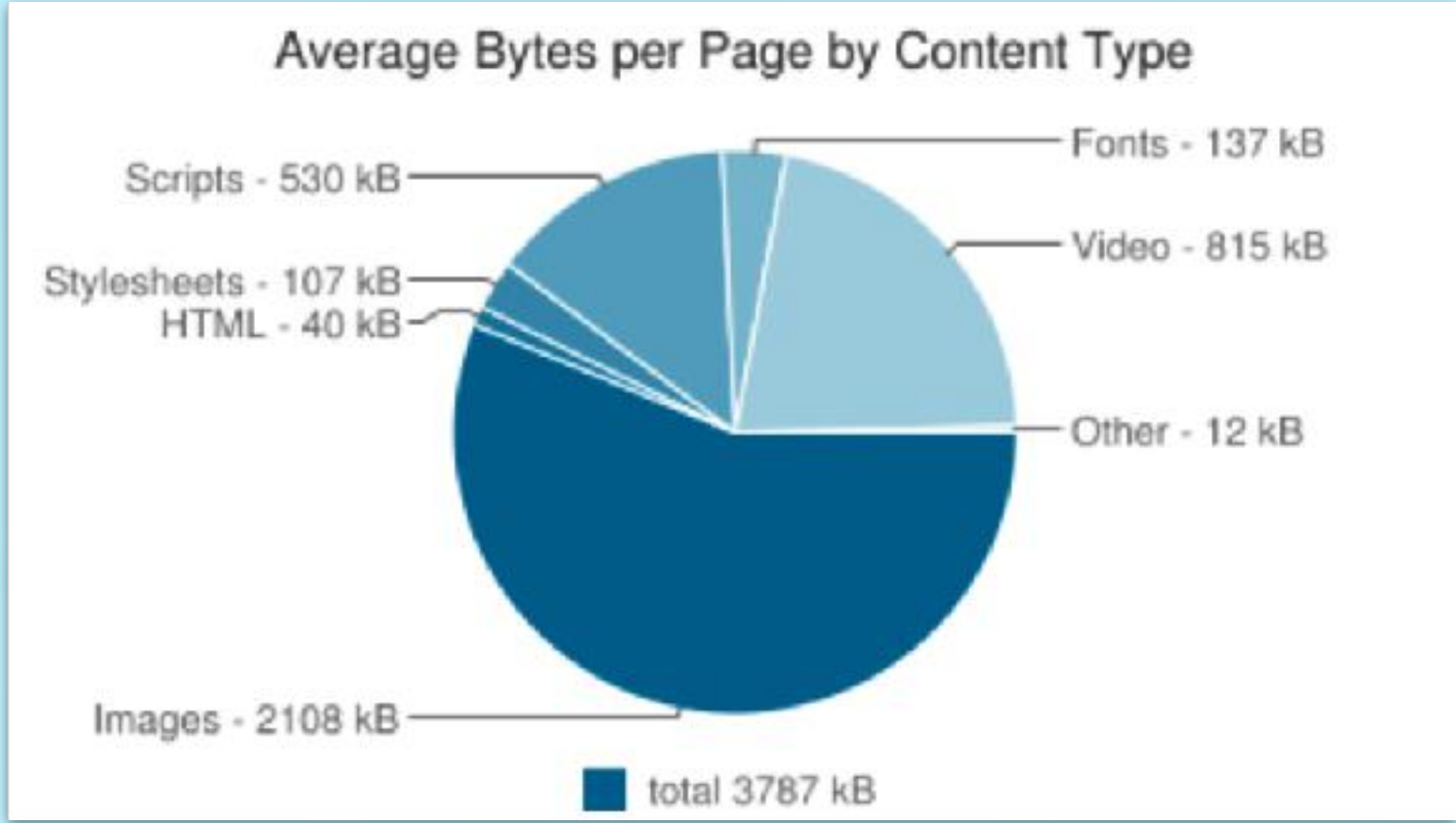
From Feb 15, 2016 To Apr 1, 2019



Apr '16 Jul '16 Oct '16 Jan '17 Apr '17 Jul '17 Oct '17 Jan '18 Apr '18 Jul '18 Oct '18 Apr '19

2011 2012 2013 2014 2015 2016 2017 2018 2019





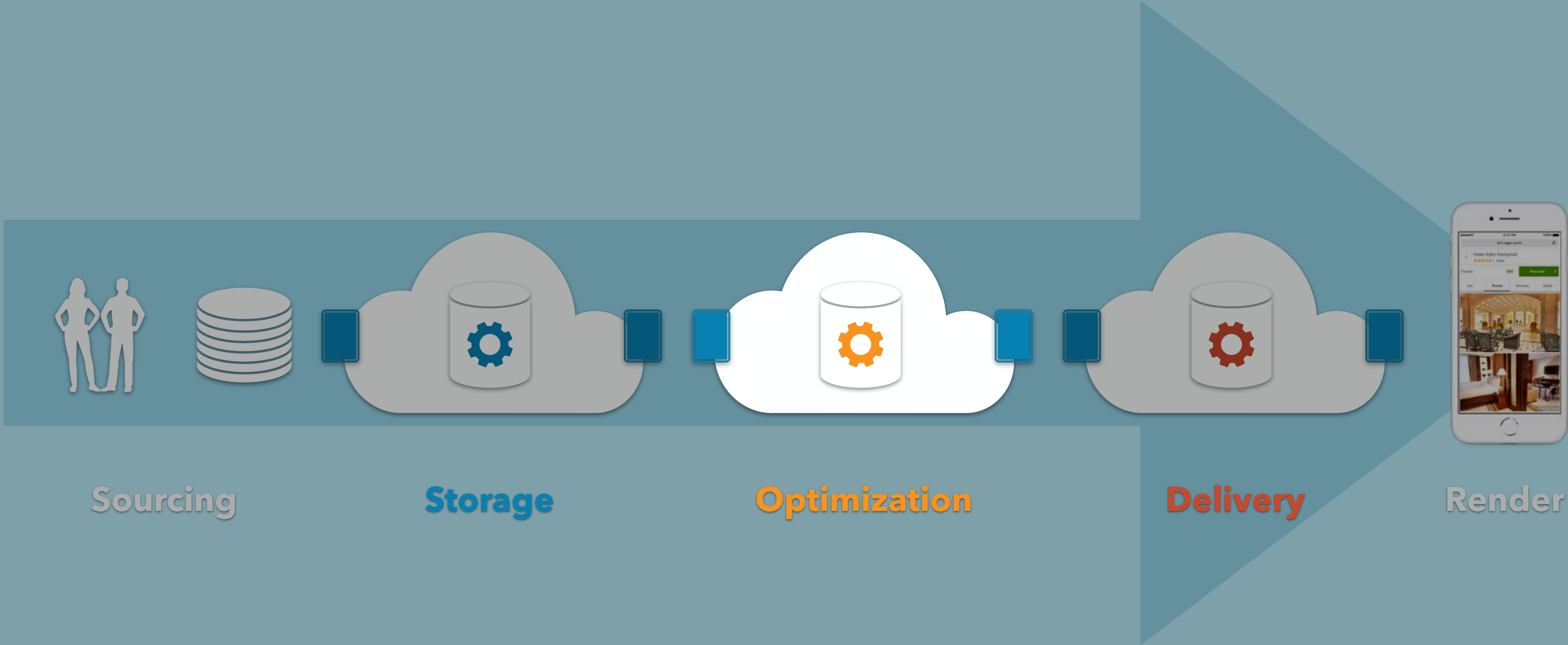


**optimize**

**deliver**

**render**





Sourcing

Storage

Optimization

Delivery

Render





9142kb



```
1 function optimize_quality_level () {
2     local -i __current_jpeg_quality=$1
3     local -i __current_jpeg_quality_summand_subtrahend=$2
4     local -i __iteration_counter="0"
5     local __current_dssim_score="0"
6     while ( (( $(echo "${__current_dssim_score} ≥ ${DSSIM_UPPER_BOUND}" | bc -l) )) || (( $(echo
    "${__current_dssim_score} < ${DSSIM_LOWER_BOUND}" | bc -l) )) ) && (( ${__iteration_counter}<7 ));
7     do
8         __current_dssim_score=$(calculate_dissimilarity "${__current_jpeg_quality}")
9         if (( $(echo "${__current_dssim_score} < ${DSSIM_LOWER_BOUND}" | bc -l) )); then
10            local __arithmetic_operator="-"
11        elif (( $(echo "${__current_dssim_score} ≥ ${DSSIM_UPPER_BOUND}" | bc -l) )); then
12            local __arithmetic_operator="+"
13        fi
14        __current_jpeg_quality_summand_subtrahend=$(echo "scale=0;
    ${__current_jpeg_quality_summand_subtrahend}/2" | bc -l)
15        if (( ${__current_jpeg_quality_summand_subtrahend}=0 )); then
16            __current_jpeg_quality_summand_subtrahend="1"
17        fi
18        __current_jpeg_quality=$(echo "scale=0;
    ${__current_jpeg_quality}${__arithmetic_operator}${__current_jpeg_quality_summand_subtrahend}" | bc
    -l)
19        (( __iteration_counter++ ))
20    done
21    echo ${__current_jpeg_quality}
22 }
```



**dssim**

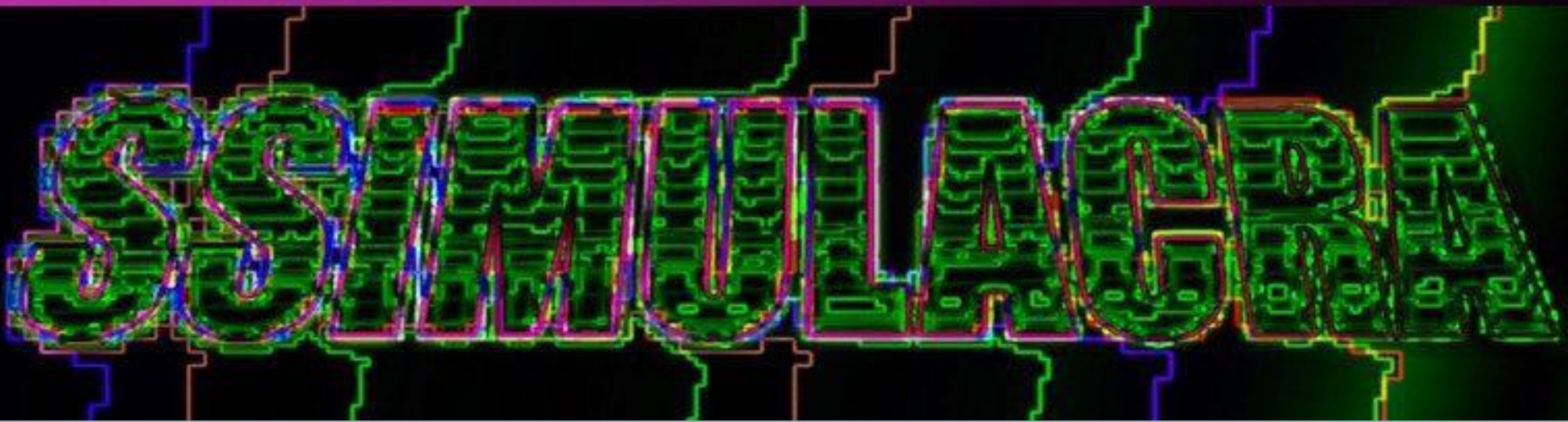
q85







**SSIMULACRA**







lesson #1.







# lesson #2.





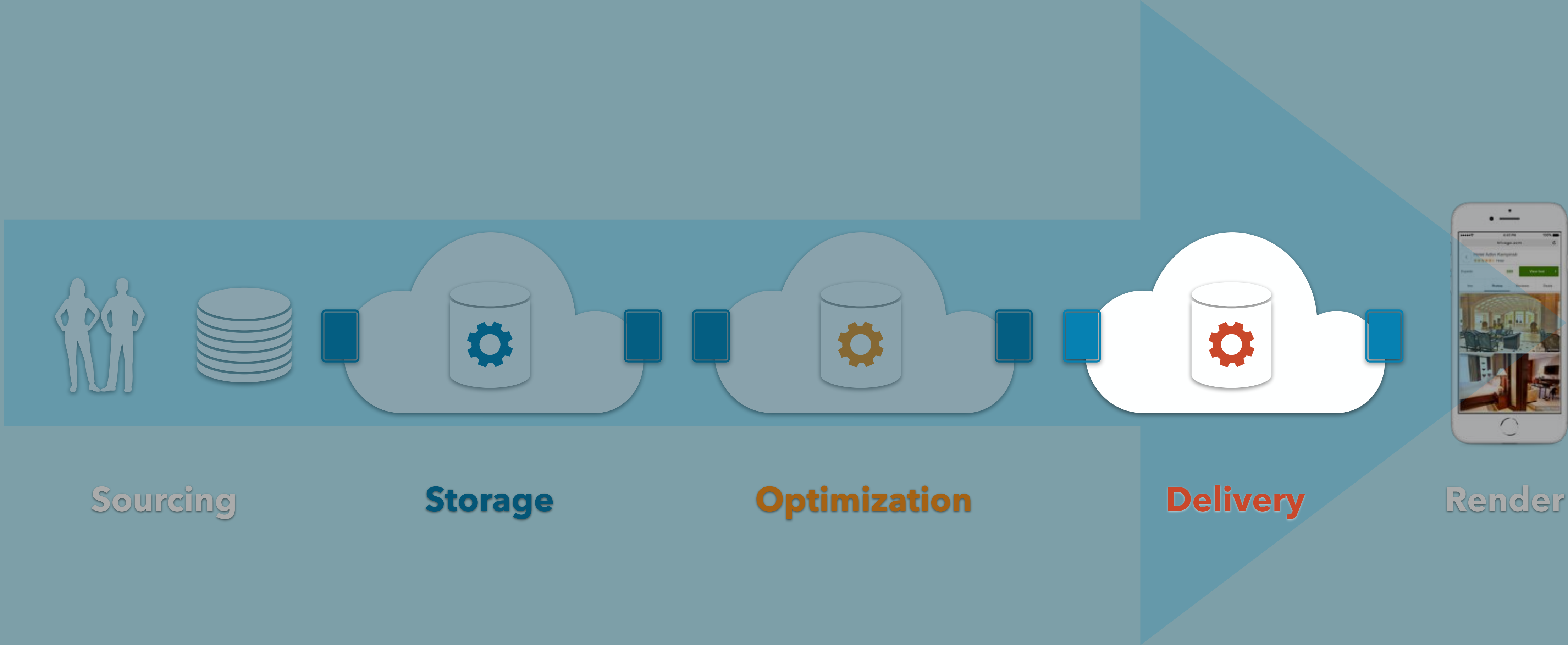


# lesson #3.











trivago.com.br Homepage (Baseline)

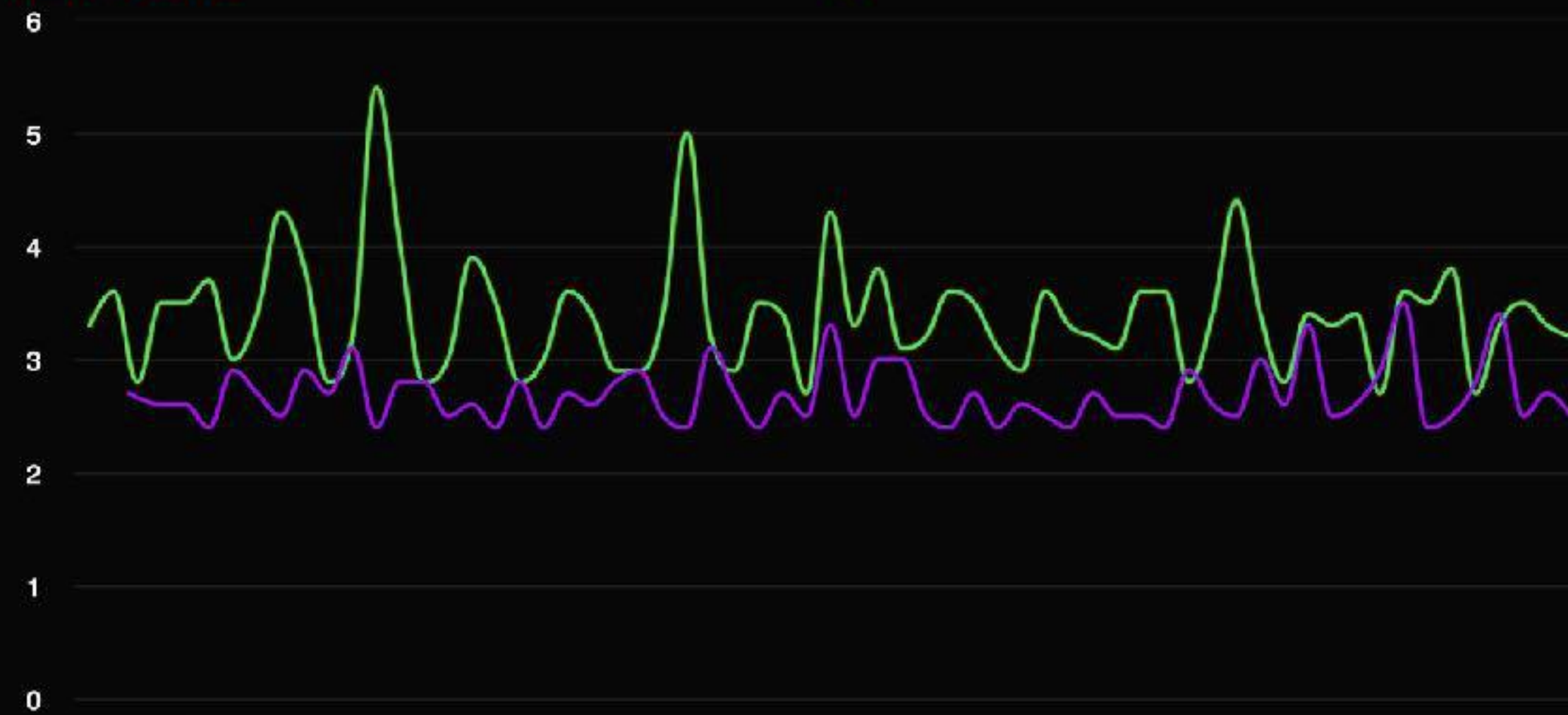
**3.4s**

#2 31% slower

trivago.com.br Homepage (Akamai)

**2.6s**

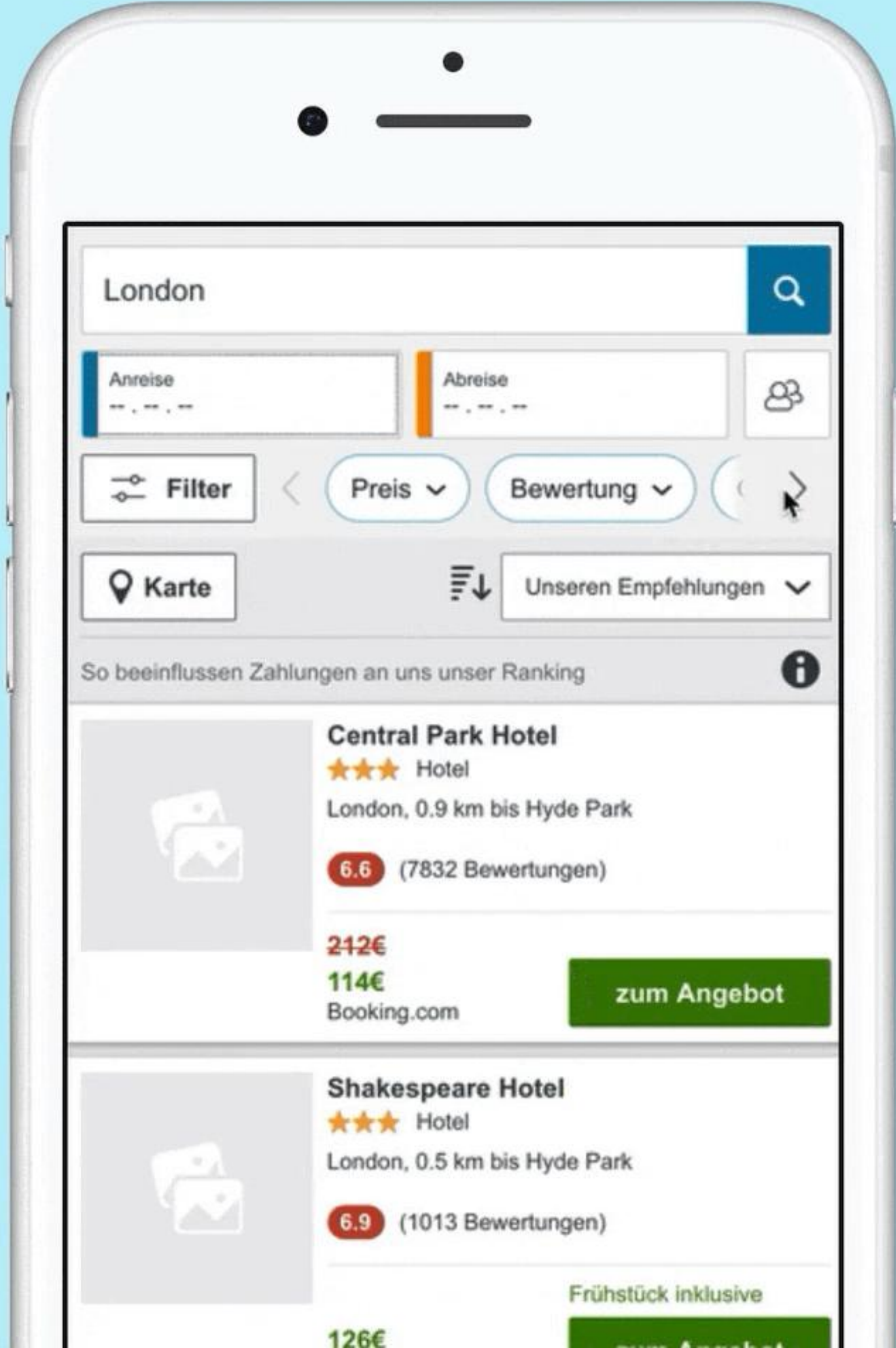
#1





lesson #4.





London



Anreise

--. --. --

Abreise

--. --. --



Filter

Preis

Bewertung

Karte

Unseren Empfehlungen

So beeinflussen Zahlungen an uns unser Ranking



### Central Park Hotel

★★★ Hotel

London, 0.9 km bis Hyde Park

6.6 (7832 Bewertungen)

212€

114€

Booking.com

zum Angebot

### Shakespeare Hotel

★★★ Hotel

London, 0.5 km bis Hyde Park

6.9 (1013 Bewertungen)

126€

Frühstück inklusive

zum Angebot



# lesson #5.



Vilnius

Anreise Do, 23.05.19 Abreise Fr, 24.05.19 Zimmer Doppelzimmer Suchen

Preis / Nacht 500€+ Unterkunft Alle Typen Gästebewertung Beliebiger Hotelstandort Zentrum Mehr Filter Wählen

Karte ansehen

Sortiert nach Unseren Empfehlungen

So beeinflussen Zahlungen an uns unser Ranking

**Stikliai Hotel**  
 4.5 Hotel  
 Vilnius, 1.0 km bis Zentrum  
 9.0 Hervorragend (488 Bewertungen)  
 Hervorragende Lage · Hervorragende Sauberkeit

Amoma.com 256€  
 Hotels.com 167€  
 Booking.com 252€

Roomdi ~~372€~~  
 Expedia 167€

Mehr Angebote ab 165€  
 zum Angebot

**Radisson Blu Hotel Lietuva Vilnius**  
 4.5 Hotel  
 Vilnius, 0.7 km bis Zentrum  
 8.6 Hervorragend (1426 Bewertungen)  
 Hervorragende Sauberkeit · Hervorragender Service

RadissonBlu 92€  
 Expedia 92€  
 Booking.com 92€

Roomdi ~~178€~~  
 Hotels.com 92€

Mehr Angebote ab 90€  
 zum Angebot

**City Gate**  
 3.5 Hotel  
 Vilnius, 1.9 km bis Zentrum  
 8.3 Sehr gut (1840 Bewertungen)  
 Hervorragende Lage · Hervorragender Service

Booking.com 50€  
 1-2-FLY.com 332€  
 Roomdi 407€

Expedia 50€

Mehr Angebote ab 48€  
 zum Angebot

**Hotel Ecoltel Vilnius**  
 3.5 Hotel  
 Vilnius, 0.8 km bis Zentrum  
 7.6 Gut (611 Bewertungen)  
 Sehr gute Preis-Leistung · Sehr gute Sauberkeit

Hotelwebseite 42€  
 Expedia 40€  
 Hotelreservierung 38€

Roomdi ~~119€~~  
 Booking.com 44€

Mehr Angebote ab 36€  
 zum Angebot

**Hotel Novotel Vilnius Centre**  
 4.5 Hotel  
 4-Sterne-Hotel mit der dritthöchsten Bewertung in Vilnius  
 Vilnius, 0.3 km bis Zentrum

Novotel 105€  
 Amoma.com 107€  
 Booking.com 105€

Roomdi ~~161€~~  
 Expedia 105€

Mehr Angebote ab 105€  
 zum Angebot

Elements Console Network

imgcy

View: Group by frame Preserve log

Hide data URLs

All XHR JS CSS Img Media Font Doc WS Manifest Other

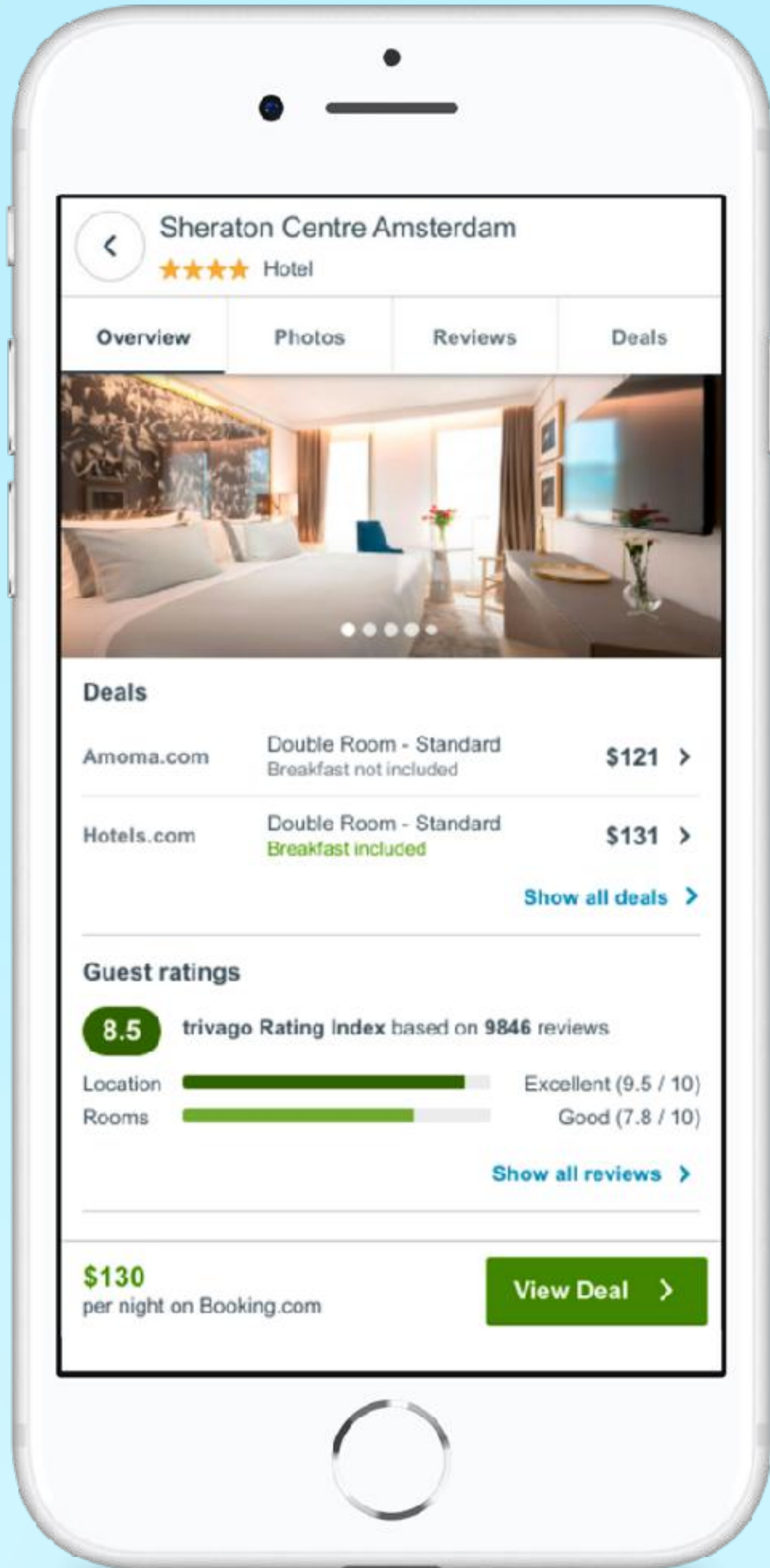
Name	Sta...	Type	Initiator	Size	Time	Waterfall
140931_v3.jpeg	200	we...	pricese...	35...	12...	
321301_v1.jpeg	200	we...	pricese...	29...	12...	
98515_v3.jpeg	200	we...	pricese...	45...	13...	
102815_v6.jpeg	200	we...	pricese...	47...	14...	
111419_v8.jpeg	200	we...	pricese...	19...	14...	
154074_v3.jpeg	200	we...	pricese...	20...	14...	
140887_v6.jpeg	200	we...	pricese...	29...	14...	
140928_v4.jpeg	200	we...	pricese...	31...	14...	
178052_v2.jpeg	200	we...	pricese...	26...	23...	

9 / 32 requests | 285 KB / 414 KB transferred | 268 KB / 684 KB resources



# lesson #6.

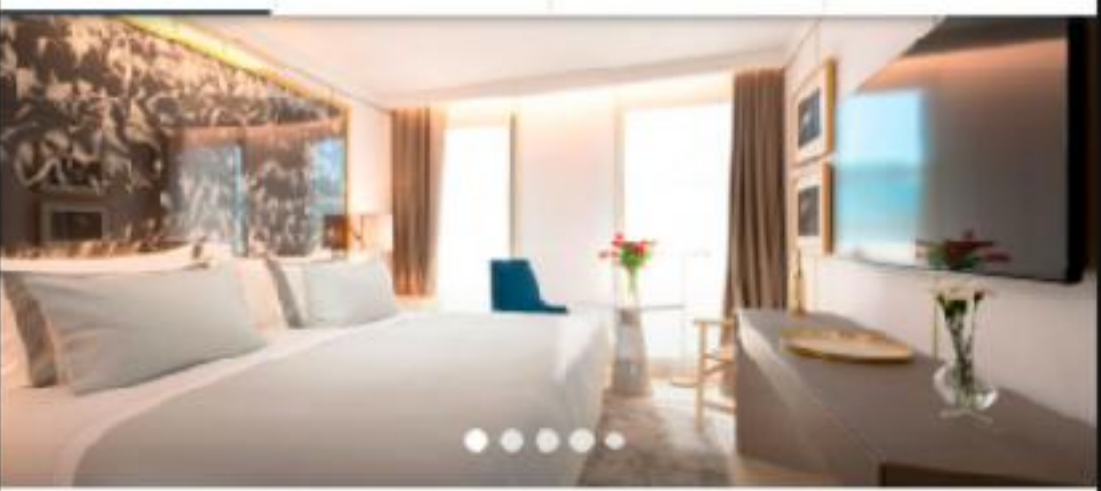




< Sheraton Centre Amsterdam

★★★★★ Hotel

- Overview
- Photos
- Reviews
- Deals



Deals

- Amoma.com Double Room - Standard \$121 >  
Breakfast not included
- Hotels.com Double Room - Standard \$131 >  
Breakfast included

Show all deals >

Guest ratings

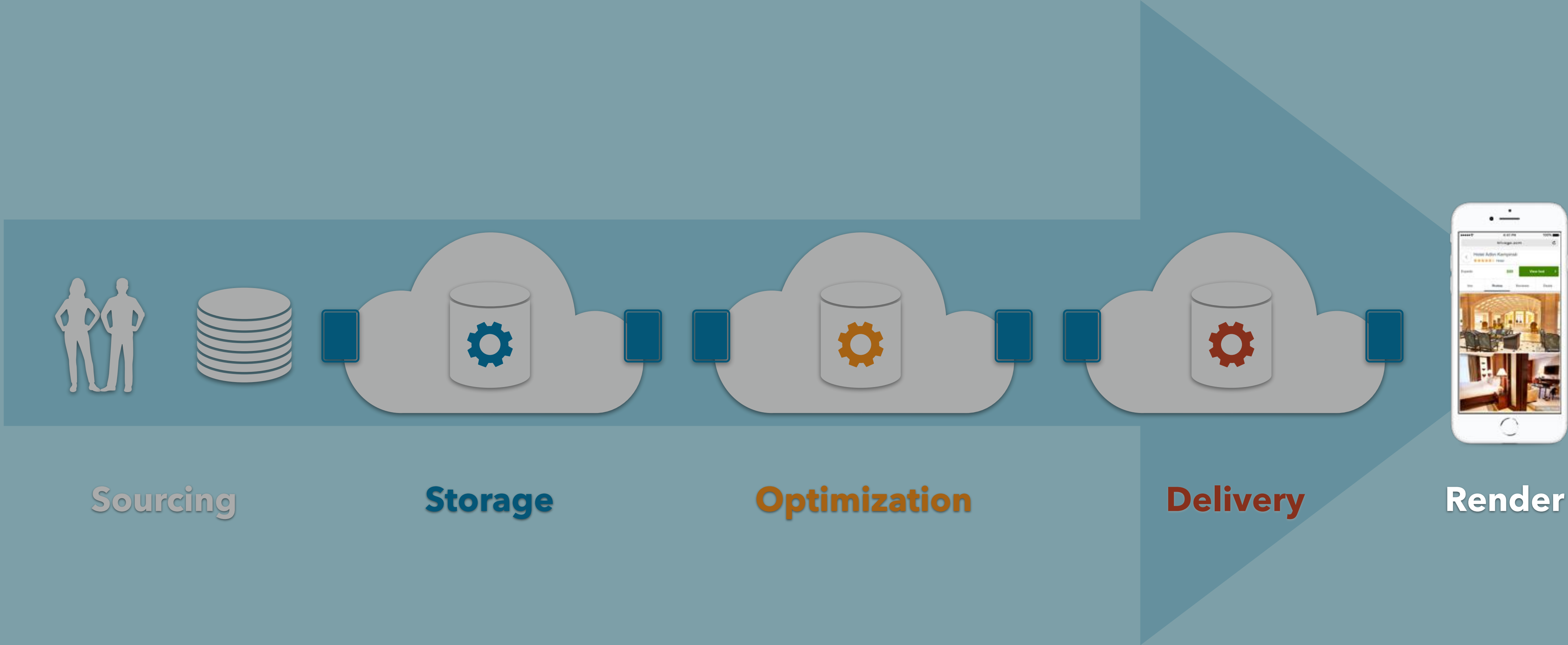


Show all reviews >

\$130 per night on Booking.com

View Deal >















# lesson #7.





```
1 https://imgcy.trivago.com/if_ar_gte_1.2/c_lfill,e_improve,g_auto,h_450,q_auto,w_980/if_else,c_limit,  
e_improve,h_450,q_auto,w_980/if_end/f_auto/image.jpeg|
```







lesson #8.





```
1 https://imgcy.trivago.com/c_lfill,e_improve:indoor,g_auto,h_420,q_auto,w_960/image.jpeg
```



# lesson #9.

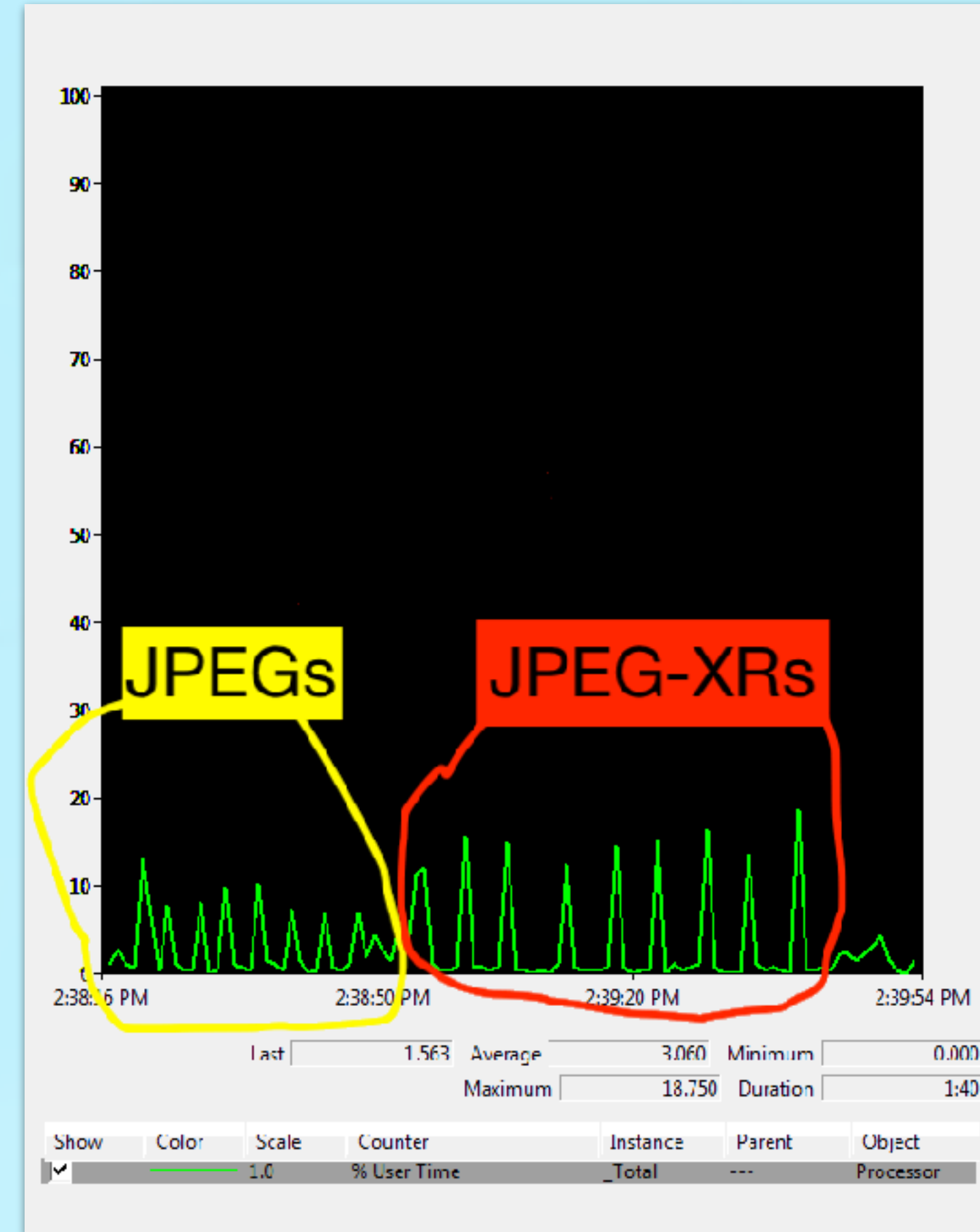






lesson #10.





<https://calendar.perfplanet.com/2018/dont-use-jpeg-xr-on-the-web/>



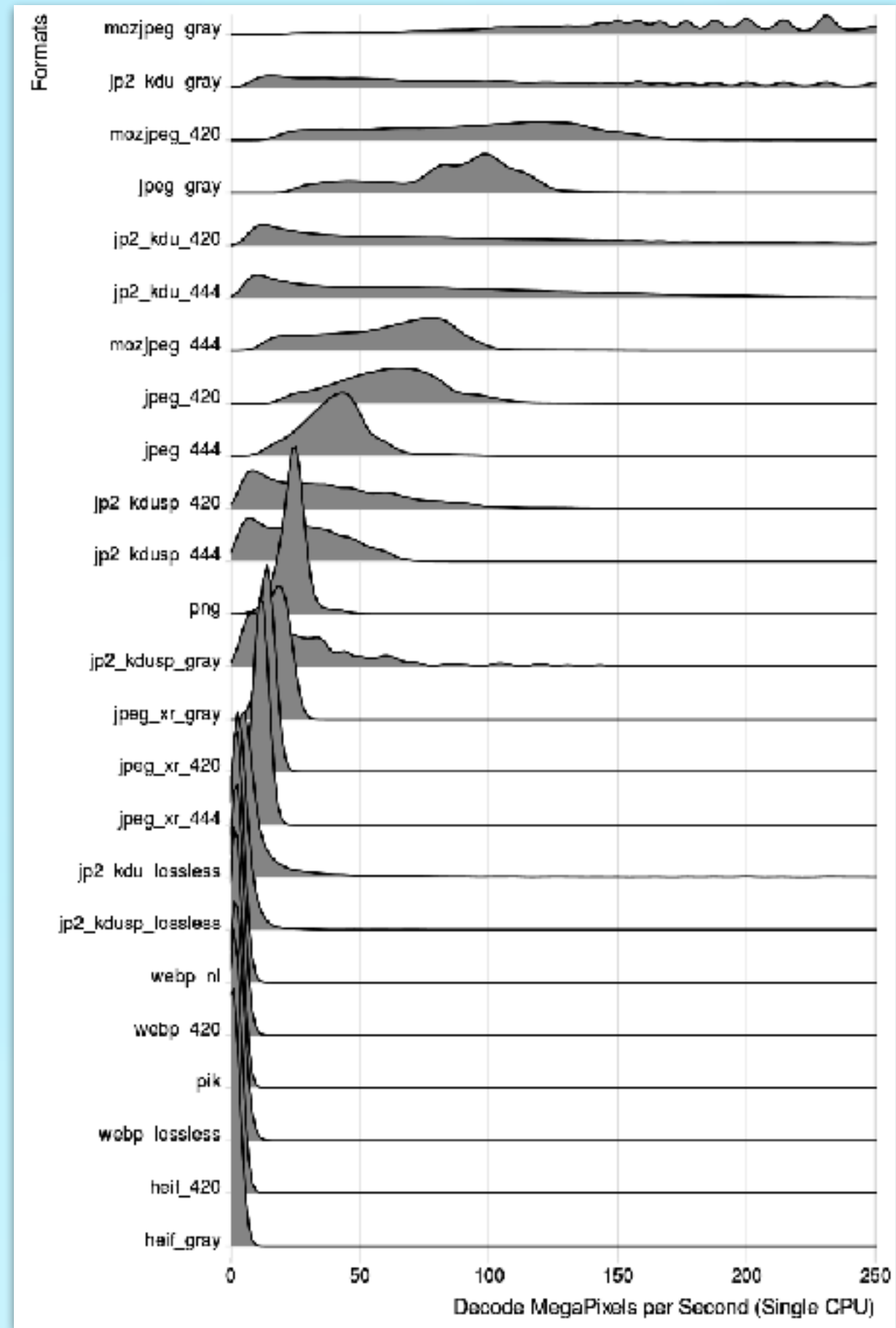


JPEG



lesson #11.





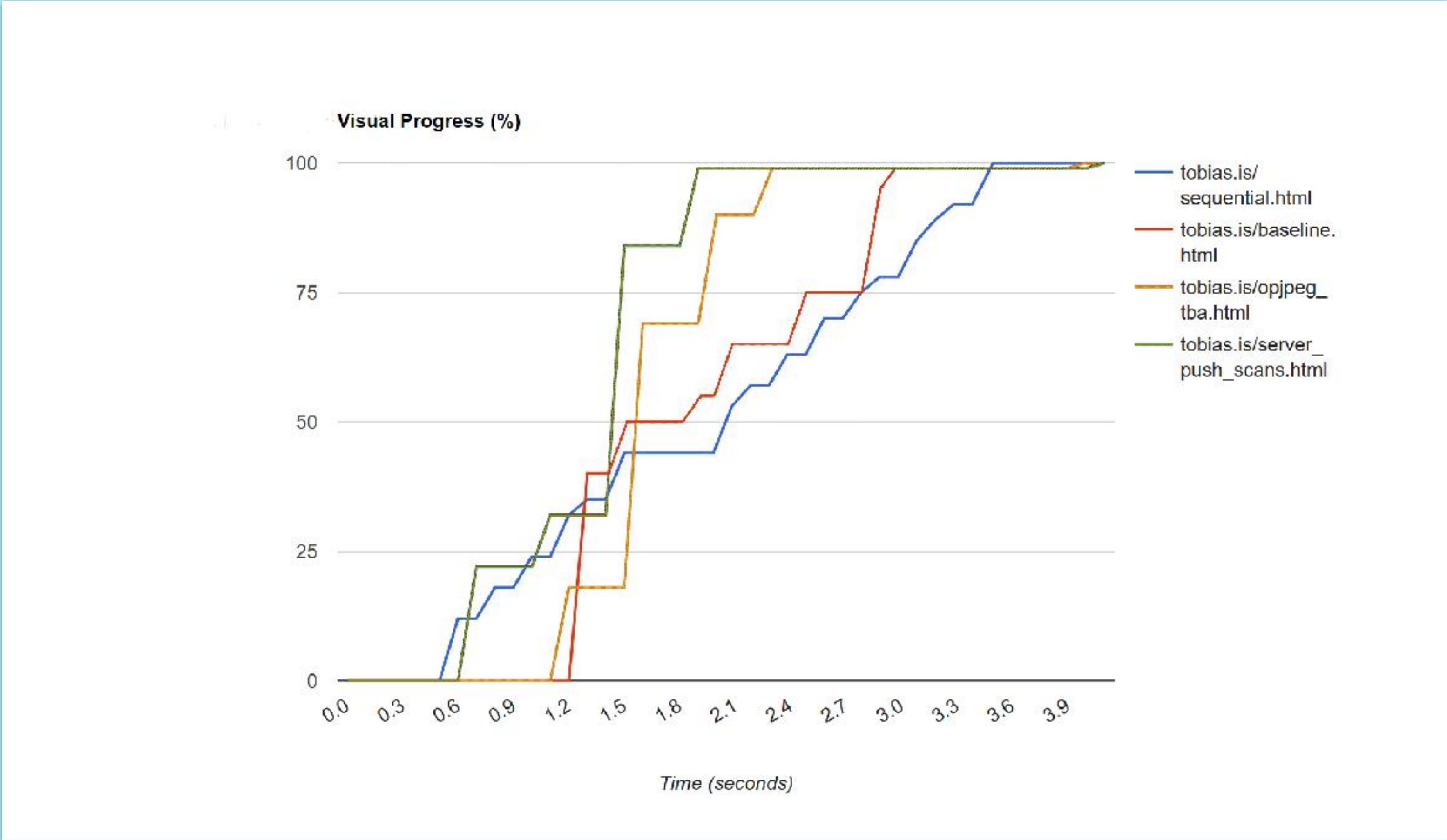
Courtesy of Colin Bendell, Cloudfinary





[https://cloudinary.com/blog/progressive\\_jpegs\\_and\\_green\\_martians](https://cloudinary.com/blog/progressive_jpegs_and_green_martians)





<https://blog.cloudflare.com/parallel-streaming-of-progressive-images/>



lesson #12.



London



Anreise

-- . -- . --

Abreise

-- . -- . --

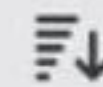


Filter

Preis

Bewertung

Karte



Unseren Empfehlungen

So beeinflussen Zahlungen an uns unser Ranking



### Hotel Grange City

★★★★★ Hotel

London, 0.8 km bis Tower Bridge

8.3 Sehr gut (3073 Bewertungen)

330€

313€

lastminute

zum Angebot

Mehr Angebote ab 296€



### Apex Temple Court




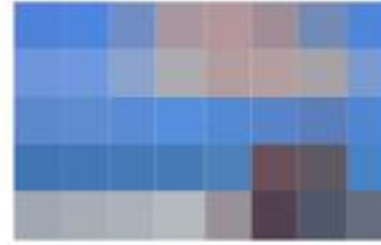







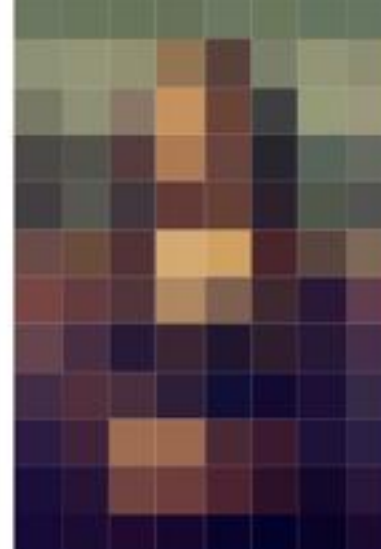
★★★★★ Hotel

London, 1.5 km bis Trafalgar Square

9.1 Hervorragend (6183 Bewertungen)







419€



Original	LQIP	SQIP default	SQIP pixels plugin 8px width
			
Size:	354B (gz: 282 B)	896B (gz: 479B)	1.9K (gz: 470 B)
			
Size:	435B (gz: 369 B)	980B (gz: 513B)	4.1K (gz: 845 B)
			
Size:	442B (gz: 372 B)	937B (gz: 487B)	4.5K (gz: 915 B)

<https://github.com/axe312ger/sqip>



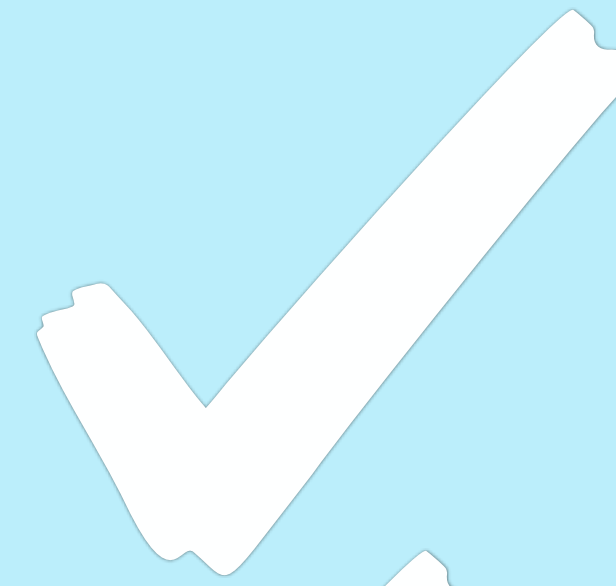
	<p><b>7.6 Good</b> (69 reviews)</p> <p>Very good service · Very clean</p>	<p>More deals from <b>£31</b></p>	<p><b>View Deal</b></p>
	<p><b>Urban Serviced Apartments</b></p> <p>Serviced apartment</p> <p>Skopje, 5.3 miles to Kondovo</p> <p><b>8.8 Excellent</b> (301 reviews)</p> <p>Excellent service · Excellent location</p>	<p>Expedia <b>£25</b></p> <p>ebookers.com <b>£25</b></p> <p>priceline <b>£29</b></p> <p>More deals from <b>£19</b></p>	<p><b>Booking.com</b> <b>-34%</b></p> <p><del>£29</del></p> <p>Hotels.com</p> <p><b>£19</b></p> <p><b>View Deal</b></p>
	<p><b>Evroset</b></p> <p>★★ Hotel</p> <p>Skopje, 4.4 miles to Kondovo</p> <p><b>8.1 Very good</b> (27 reviews)</p> <p>Excellent service · Extremely clean</p>	<p>priceline <b>£34</b></p> <p>More deals from <b>£34</b></p>	<p><b>Booking.com</b></p> <p><b>£34</b></p> <p>Free breakfast</p> <p><b>View Deal</b></p>
	<p><b>Hotel Vlaho</b></p> <p>★★★★ Hotel</p> <p>1st Highest Rated 4-Star Hotel in Skopje</p> <p>Skopje, 5.4 miles to Kondovo</p> <p><b>8.8 Excellent</b> (470 reviews)</p> <p>Extremely clean · Excellent service</p>	<p>Hotels.com <b>£41</b></p> <p>HomeAway <b>£98</b></p> <p>ebookers.com <b>£41</b></p> <p>More deals from <b>£41</b></p>	<p><b>Roomdi</b> <b>-54%</b></p> <p><del>£99</del></p> <p>Booking.com</p> <p><b>£45</b></p> <p>Free breakfast</p> <p><b>View Deal</b></p>
	<p><b>Dolce International</b></p> <p>★★★★ Hotel</p> <p>Skopje, 5.3 miles to Kondovo</p> <p><b>8.3 Very good</b> (155 reviews)</p> <p>Excellent service · Excellent value for money</p>	<p>Expedia <b>£44</b></p> <p>Hotels.com <b>£44</b></p> <p>ebookers.com <b>£44</b></p> <p>More deals from <b>£39</b></p>	<p><b>Roomdi</b> <b>-61%</b></p> <p><del>£101</del></p> <p>Booking.com</p> <p><b>£39</b></p> <p><b>View Deal</b></p>
	<p><b>Hotel Aristocrat Palace</b></p> <p>★★★ Hotel</p> <p>Skopje, 5.4 miles to Kondovo</p> <p><b>8.4 Very good</b> (214 reviews)</p> <p>Excellent service · Excellent value for money</p>	<p>Hotels.com <b>£41</b></p> <p>ebookers.com <b>£40</b></p> <p>priceline <b>£39</b></p> <p>More deals from <b>£37</b></p>	<p><b>Roomdi</b> <b>-60%</b></p> <p><del>£99</del></p> <p>Booking.com</p> <p><b>£39</b></p> <p>Free breakfast</p> <p><b>View Deal</b></p>



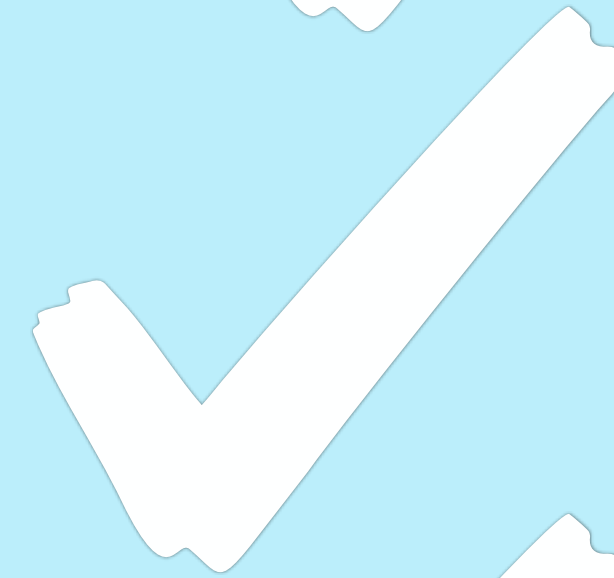
**takeaways**



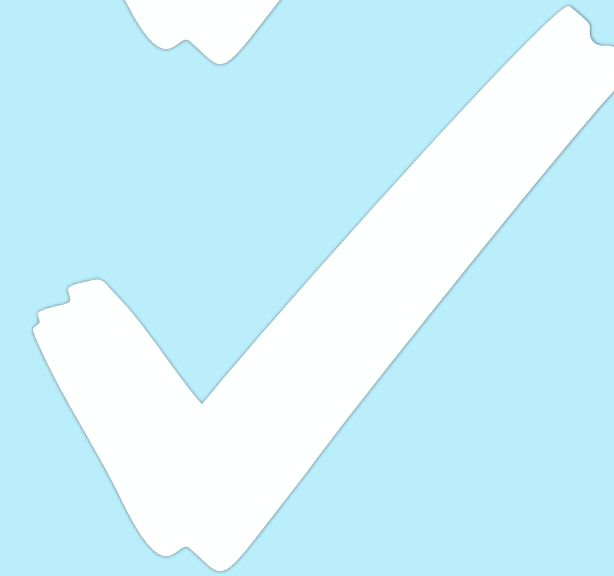
**optimize**



**deliver**



**render**



show the  
right stuff  
fast & beautifully



The image shows a browser window displaying a blog post on the Trivago website. The browser's address bar is empty. The website's header includes the Trivago logo, a 'Topics' dropdown menu, and links for 'About' and 'Open Source'. A 'Follow us on' link is located in the top right corner. The 'Topics' dropdown menu is open, listing various categories: Accessibility, Backend, Cloud, Data Science, Engineering Culture, Front-End (highlighted), Mobile, Monitoring, Open Source, and User Experience. Below the menu is a blue graphic with a circuit breaker diagram. The main heading of the article is 'Circuit Breaker with AWS Step Functions', with a 'Backend' tag below it. The post is dated 'Posted on 09 April 2019'. The introductory text reads: 'Many of our data pipelines interact with external services. The availability of an external service can adversely affect the health our pipelines. This is how we handle it using AWS Step Functions'. A 'Read the post >' link is at the bottom of the visible content.

trivago Topics About Open Source Follow us on

- Accessibility
- Backend
- Cloud
- Data Science
- Engineering Culture
- Front-End
- Mobile
- Monitoring
- Open Source
- User Experience

Backend

## Circuit Breaker with AWS Step Functions

Posted on 09 April 2019

Many of our data pipelines interact with external services. The availability of an external service can adversely affect the health our pipelines. This is how we handle it using AWS Step Functions

[Read the post >](#)

<https://tech.trivago.com/>







The screenshot shows the Trivago website's 'Open Positions' page. The header includes the Trivago logo and navigation links: Home, About, Careers (highlighted), Press, Get listed, Support, and Investor Relations. The main content area features a decorative background of blue triangles and lines. Below the header, there is a section titled 'Open Positions' with a sub-header 'Ready to check into trivago? Below you'll find a detailed overview of all our open positions. Have a look around, and if you're motivated to go the distance, hit apply and show us what you're made of!'.

On the left side, there is a 'Filter Roles' sidebar with the following filters:

- Job Family: Software Engineering
- Experience Level: Professional (3-5 Years)
- Language: English
- Location: Düsseldorf

The main content area displays a table of open positions:

Role	Job Family	Language	Location
<b>UX Engineer</b>	Software Engineering	English	Düsseldorf
<b>Software Engineer - FinTech</b>	Software Engineering	English	Düsseldorf
<b>Cloud Platform Engineer</b>	Software Engineering	English	Düsseldorf
<b>Senior Java Engineer - Accommodation Matching</b>	Software Engineering	English	Düsseldorf
<b>Quality Assurance Engineer</b>	Software Engineering	English	Düsseldorf
<b>Cloud Engineer - Hotel Search</b>	Software Engineering	English	Düsseldorf
<b>Software Engineer, Data Platform Cloud - Hotel Search</b>	Software Engineering	English	Düsseldorf

<https://jobs.trivago.com/>



**thank you!**

**TOBIAS BALDAUF**

**TOBIAS.BALDAUF@TRIVAGO.COM**

**@TBALDAUF**

**SLIDO.COM #DEVDAYS2019**

**[HTTPS://SPEAKERDECK.COM/TBALDAUF/IMAGE-FORMATS-PERFORMANCE-AND-COGNITIVE-LOAD](https://speakerdeck.com/tbaldauf/image-formats-performance-and-cognitive-load)**



# links

DSSIM: <https://github.com/kornelski/dssim>

mozjpeg: <https://github.com/mozilla/mozjpeg>

SSIMULACRA: <https://github.com/cloudinary/ssimulacra>

cjpeg-dssim: <https://github.com/technopagan/cjpeg-dssim/>

H2 opJPEGs: <https://calendar.perfplanet.com/2016/even-faster-images-using-http2-and-progressive-jpegs/>

pJPEG Streaming: <https://blog.cloudflare.com/parallel-streaming-of-progressive-images/>

Bad JPEG-XR: <https://calendar.perfplanet.com/2018/dont-use-jpeg-xr-on-the-web/>

Saliency Mapper: <https://github.com/technopagan/mss-saliency>

Cloudinary: <https://cloudinary.com/documentation>

SQIP: <https://github.com/axe312ger/sqip>