Understanding the Usage of New Internet Protocols in the Wild

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The Internet as we know it?

- Well known properties of the Internet

8000+ RFCs

Protocol Performance

Actors

Technologies

HOW ARE PROTOCOLS USED IN THE WILD?

It depends / we don’t know
Net-Ray Protocol Observatory

Goal: measure protocol adoption & usage regularly at large

Entire Internet

TCP IW

1 2 4 10 ?

IFIP Networking’17
SIGCOMM Internet-QoE’17

push.comsys.rwth-aachen.de

ACM IMC’17

iw.comsys.rwth-aachen.de
Current Internet Change: HTTP1 → HTTP2 (Talk Focus: Push)

- HTTP is driving the Web
- HTTP2 standardized in 2015
- "Can change Internet traffic!"

Is it used? [IFIP Networking'17]

- Adoption study: Internet-wide probing: entire IPv4 space + 50% DNS

HTTP2: 5.3M / 151M domains (increasing)
HTTP2 Push: 7K / 151M domains

HTTP/1.1
GET
index.html
GET
style.css
GET
query.js

HTTP/2 (no Push)
GET
index.html
GET
style.css
GET
query.js

HTTP/2 (with Push)
GET
index.html
GET
style.css
GET
query.js

Alexa: 20% HTTP2
Alexa: 0.6% HTTP2 Push

Internet Measurement
How much faster is H2/H2-Push over H1?

- **PLT measurements in Chrome**
- **H1 vs H2-push**
  - Most sites benefit from just switching on H2
  - A few sites are slowed down by H2
    - This is also supported by related works

- **H2-no-push vs H2-push**
  - Most sites: push makes no difference
  - Some websites are accelerated up to 63%
  - Others are slowed down by up to 67%

**Takeaway:** H2 (Push) can **speed-up** but also **slow-down** the Web!
Why can’t push keep its promise?

- We tried to correlate PLT improvements to how push is being used
  - The amount of objects does not seem to make a difference
  - Nor does the amount of bytes pushed
  - Or if it is a certain fraction of resource on the page
  - Only high RTTs show a trend in PLT reduction
    - Push saves round trips
    - Yet, for CDN-typical RTTs below 50ms there is no trend

Takeaway: Optimizing push is site-dependent
No Guidelines on *What to Push* *How*

- **Number of objects that are pushed**
  - 50% of all pages push no more than 6 objects
  - 20% push at least 17 objects
  - One site even pushed 72 objects

- **Ratio of pushes to available resources**
  - Some sites push all their resources
  - Other only parts
  - There is no pattern visible

- **Still push on 2\(^\text{nd}\) visit? Not standardized!**
  - IP based: Servers identify clients by IP and don’t push again (NATs?)
  - Cookie-based, Client-side JS Code, …

*Takeaway: No optimal strategy exists – site dependent optimization!*
HTTP2 Push: End-User Perception

- Push can speed-up or slow-down the Web
  - Is the protocol engineered correctly? → Do users perceive it?

- User Study [ACM SIGCOMM Internet-QoE’17]
  - Lab Study
  - Crowdsourcing
    - 28 subjects
    - 323 subjects
Study Design

- Pair-wise comparison study
  - Side-by-side loading process
  - Show video (reproducible)
    - Which version loaded faster?
      - Left, No Difference, Right
  - Allow users to replay video
  - Monitor time and activity on website

<table>
<thead>
<tr>
<th>Condition</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_0$</td>
<td>Control (same video, e.g., H1 vs. H1)</td>
</tr>
<tr>
<td>$C_1$</td>
<td>H1 vs. H2 without push (or vice versa)</td>
</tr>
<tr>
<td>$C_2$</td>
<td>H1 vs. H2 with push (or vice versa)</td>
</tr>
<tr>
<td>$C_3$</td>
<td>H2 w/o push vs. H1 (or vice versa)</td>
</tr>
</tbody>
</table>

Try yourself: [https://userstudy.comsys.rwth-aachen.de](https://userstudy.comsys.rwth-aachen.de)
Example Video

Try yourself: https://userstudy.comsys.rwth-aachen.de
Participants Overview and Comparison

<table>
<thead>
<tr>
<th>Study</th>
<th>Users</th>
<th>Gender</th>
<th>Age</th>
<th>Expertise</th>
<th>Online [h]</th>
<th>Duration [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab</td>
<td>28</td>
<td>6, 21, 1</td>
<td>6, 20, 2</td>
<td>0, 9, 19</td>
<td>7, 11, 10</td>
<td>273.72</td>
</tr>
<tr>
<td>Crowd</td>
<td>323*</td>
<td>72, 246, 5</td>
<td>143, 119, 61</td>
<td>7, 95, 221</td>
<td>86, 130, 107</td>
<td>114.37</td>
</tr>
</tbody>
</table>

*after filtering 82 out of 405

- **Compare votes contained in both groups**
  - Verdict: Average over votes, encoding -1, 0, +1

- Takeaway: Lab (controlled) & Crowd (uncontrolled) yield similar ratings
HTTP2 Push QoE: Some Pages Benefit Some Don’t

- Lab + crowd votes combined:
  - avg. 34.83 votes, min. 17 votes

- Is Push the decisive factor?
  - H2 w/o push slower than H1
    - Resource order impacts time
  - H2 push is perceived fastest
    - Pushes render critical CSS
  - H2 push is perceived slowest
    - Delay of index HTML
    - Delay discovery 3rd party content
  - H1 rendering starts earlier

Takeaway: H2 Push is no silver bullet
- Some pages perceived faster, some slower

Takeaway 2: H2 Push user perception cannot be predicted from technical metrics (not shown)!
Summary: HTTP2

- **H2 adoption is increasing but still low**
  - CDNs have a huge potential to increase the adoption
  - Data available at: [https://push.comsys.rwth-aachen.de](https://push.comsys.rwth-aachen.de)

- **Almost no deployment for Server Push**
  - No out of the box support
  - We find questionable use of server push

- **Server Push not production ready**
  - Requires complex, site-dependent optimization
  - Easy to make it wrong and slow down sites!
  - Only high RTTs makes it likely that push helps