HTTP priority design team

HTTP WG, IETF 106 Singapore

Design Team Goals

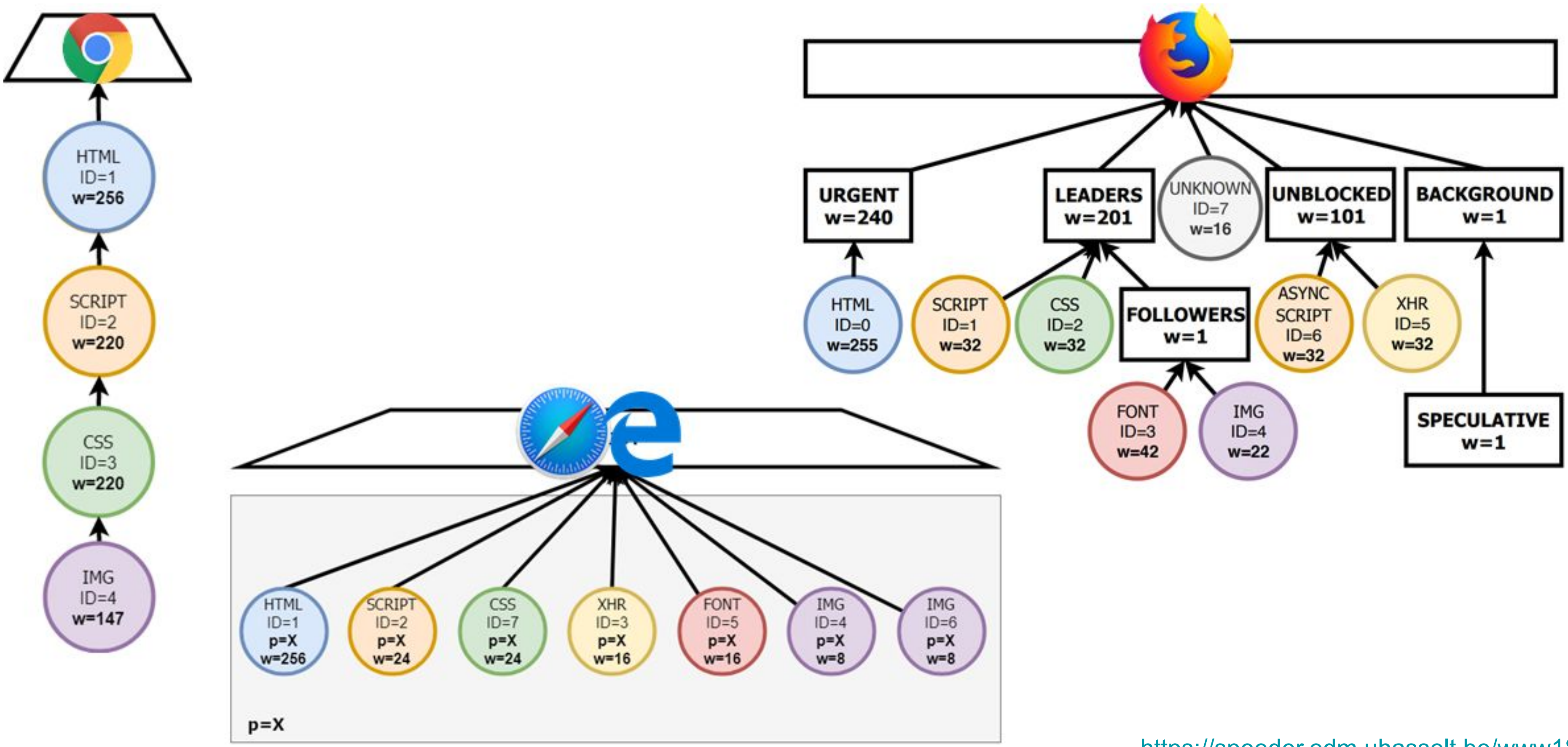
Requirement: Determine a solution for HTTP/3 to have some client-to-server priority hinting mechanism that it can ship with. This can be a minimal approach.

The following are potentially in scope (though not all are required):

- Mechanism to indicate that H2 priorities are not being used
- Mechanism to indicate what kind of priority hinting is being used
- Priority hinting mechanism that is non-minimal
- A plan to backport the new priority hinting to H2

Out of scope: Changes that would add complexity that we're not confident in that would risk shipping HTTP/3.

Motivation: HTTP/2, The Wild West

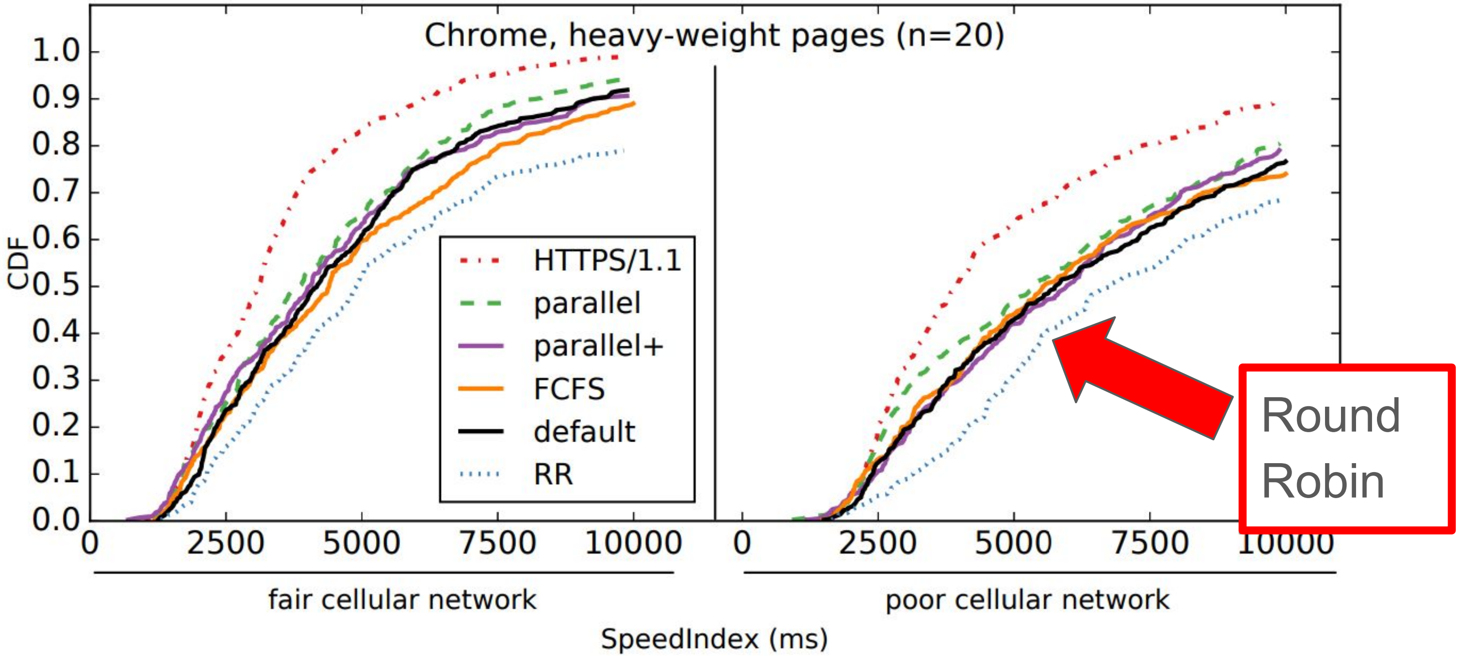


https://speeder.edm.uhasselt.be/www18/

Simulation Results

H2 on large pages (>1MB)

Higher line is faster

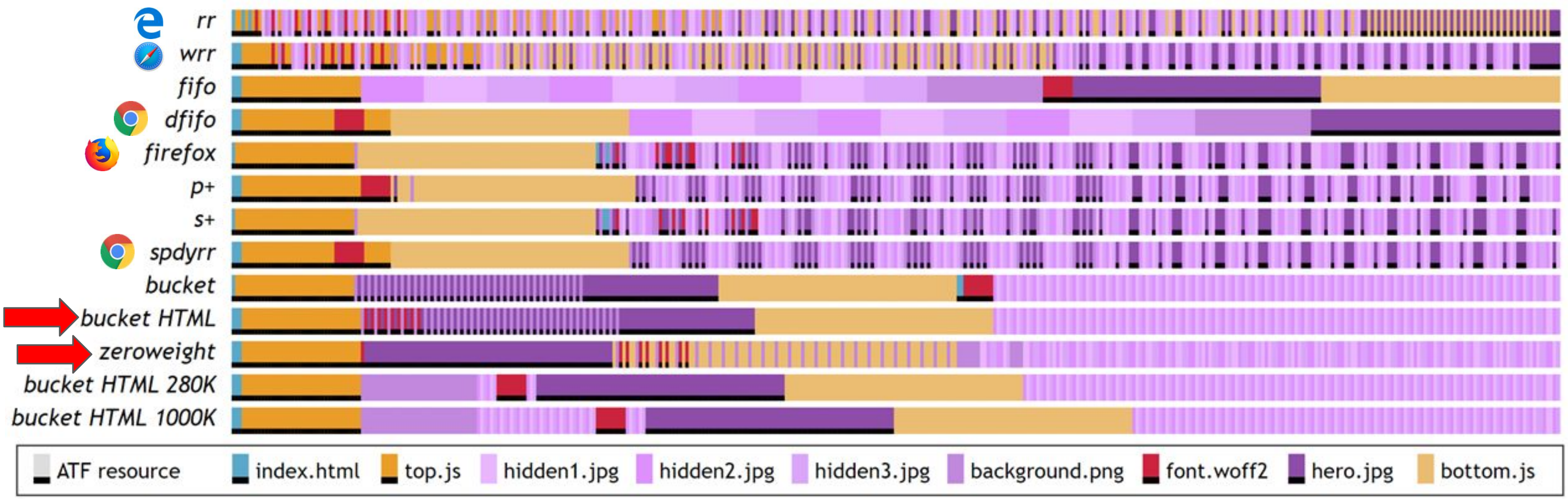


Chrome’s use of H2 is best of browsers, old Edge’s is worst (fair Round Robin)

(btw: fair RR is also H2’s default behaviour…)

https://speeder.edm.uhasselt.be/www18/

Can we do better?



https://h3.edm.uhasselt.be/

Can we do better?

Table 2: Mean speedup ratios compared to *rr* per other prioritization scheme from Figure 12. Higher mean values are better. #PH = number of placeholders used in this scheme.

Scheme	#PH	Mean All	Mean ATF	Mean 1000K
wrr	0	**1.05**	1.49	**1.28**
fifo	0	**1.27**	1.93	1.57
dfifo	5	**1.27**	2.30	1.72
firefox	6	1.07	**1.22**	1.25
p+	3	1.17	2.20	1.64
s+	8	1.14	1.45	1.56
spdyrr	5	1.14	1.96	1.57
bucket	0	1.20	2.13	**1.82**
bucket HTML	0	1.20	**2.49**	**1.83**
zeroweight	0	1.15	**2.8**	**1.9**

ATF = “above the fold”, critical resources

- Can do better than Chrome, with simpler schemes

- Server-side (re-)prioritization is **very** powerful, but difficult across browsers in H2

- Flexibility still needed
  (heterogeneous sites, HOL blocking)

https://h3.edm.uhasselt.be/
https://blog.cloudflare.com/better-http-2-prioritization-for-a-faster-web/

Experimental measurements

Background

All experiments done with gQUIC between Chrome and Google servers

Control group is SPDY priorities: 8 buckets, round robin within a bucket (spdyrr)
gQUIC default

<u>Experiment groups</u>

- Chrome H2 : Linked list (dfifo) - buckets, sequential within a bucket
- FIFO - lowest stream ID first
- LIFO - highest stream ID first
- Round Robin (rr)

YouTube QoE

LIFO

Android 3.34% higher rebuffer rate than SPDY, reduction in video resolution

Desktop 2.6% higher rebuffer rate than SPDY, reduction in video resolution

All other schemes were statistically insignificant

For reference, QUIC had 15.3% fewer rebuffers on Android, 18% on Desktop

Flywheel Data Compression Proxy

- All HTTP requests are proxied to Google servers over a QUIC connection
  - in a sense, the "best case" for prioritization
  - HTTP only; HTTPS requests are not proxied
  - Android Chrome users only

- Summary:
  - Chrome H2 > SPDY > {FIFO, LIFO, RoundRobin}
  - Improvements range from 0.4% faster to 1.7% faster

Flywheel Data Compression Proxy

FirstContentfulPaint relative to H2

(statistically-significant changes only, with 95% CIs, **green = H2 is faster**)

grp	25th percentile Percentage Difference	50th percentile Percentage Difference	75th percentile Percentage Difference	90th percentile Percentage Difference	95th percentile Percentage Difference
FIFO	- -0.40% [-1.77, 0.96] %	- 0.64% [0.15, 1.12] %	- 0.29% [-0.18, 0.76] %	- 0.75% [0.17, 1.34] %	- 1.77% [0.70, 2.85] %
LIFO	- -0.81% [-2.50, 0.88] %	- 0.64% [-0.12, 1.40] %	- 0.87% [0.43, 1.32] %	- 1.22% [0.47, 1.97] %	- 1.77% [0.44, 3.10] %
RoundRobin	- 0.61% [-1.03, 2.25] %	- 0.88% [0.22, 1.53] %	- 0.79% [0.17, 1.41] %	- 0.96% [0.19, 1.74] %	- 1.40% [0.10, 2.69] %
SPDY	- 0.40% [-0.70, 1.51] %	- 0.48% [-0.13, 1.08] %	- 0.62% [0.25, 1.00] %	- 0.64% [-0.14, 1.41] %	- 0.30% [-0.70, 1.29] %

Flywheel Data Compression Proxy

FirstContentfulPaint relative to SPDY

(statistically-significant changes only, with 95% CIs, **green = SDPY is faster**, **red = SPDY is slower**)

grp	25th percentile Percentage Difference	50th percentile Percentage Difference	75th percentile Percentage Difference	90th percentile Percentage Difference	95th percentile Percentage Difference
FIFO	- -0.81% [-2.14, 0.52] %	- 0.16% [-0.55, 0.87] %	- -0.33% [-0.81, 0.15] %	- 0.12% [-0.72, 0.96] %	- 1.47% [0.48, 2.47] %
H2	- -0.40% [-1.50, 0.70] %	- -0.48% [-1.07, 0.12] %	- -0.62% [-0.99, -0.25] %	- -0.63% [-1.40, 0.14] %	- -0.30% [-1.29, 0.69] %
LIFO	- -1.21% [-2.73, 0.31] %	- 0.16% [-0.56, 0.88] %	- 0.25% [-0.23, 0.72] %	- 0.58% [-0.01, 1.17] %	- 1.47% [0.59, 2.36] %
RoundRobin	- 0.20% [-1.39, 1.79] %	- 0.40% [-0.19, 0.98] %	- 0.17% [-0.30, 0.63] %	- 0.33% [-0.31, 0.96] %	- 1.10% [-0.01, 2.20] %

AMP

- AMP clicks from the Google Search results page
  - Android Chrome users only
  - Only AMP clicks that were *not* prerendered

- Summary:
  - SPDY > {Chrome H2, FIFO, LIFO, RoundRobin}
  - Improvements range from 0.5% faster to 1.4% faster

AMP

FirstContentfulPaint relative to SPDY
(statistically-significant changes only, with 95% CIs, **green = SPDY is faster**)

grp	25th percentile Percentage Difference	50th percentile Percentage Difference	75th percentile Percentage Difference	90th percentile Percentage Difference	95th percentile Percentage Difference
FIFO	- 0.35% [-0.29, 0.98] %	- 0.10% [-0.36, 0.57] %	- 0.32% [0.01, 0.64] %	- 0.32% [-0.35, 0.99] %	- 0.69% [-0.43, 1.82] %
H2	- 0.35% [-0.41, 1.10] %	- 0.41% [-0.40, 1.22] %	- 0.32% [-0.15, 0.80] %	- 1.08% [0.37, 1.78] %	- 1.20% [-0.19, 2.58] %
LIFO	- 0.35% [-0.44, 1.13] %	- 0.41% [-0.11, 0.93] %	- 0.51% [0.19, 0.83] %	- 0.88% [0.21, 1.54] %	- 1.45% [0.37, 2.52] %
RoundRobin	- 0.17% [-0.62, 0.96] %	- 0.00% [-0.69, 0.69] %	- 0.19% [-0.20, 0.58] %	- 0.76% [0.06, 1.46] %	- 0.94% [-0.32, 2.21] %

Summary

New design should therefore:

- Be simpler than HTTP/2 tree
- Work for both H2 and H3
- Allow for expressing both Chrome H2 and SPDY schemes
- Allow easy server-side (re-)prioritization
- Not use Round Robin as the default

The priority draft (draft-kazuho-httpbis-priority) includes all of these.

Proposed Design

an update to [draft-kazuho-httpbis-priority]

Extensible Priorities

Goal: Extensible without changing every client every time

=> Unique Key-value pairs, encoded using Structured Headers

Initially specifies 2 fields, **‘urgency’** and **‘progressive’**

‘urgency’ parameter is an integer between -1 and 6

‘progressive’ is 0 or 1

If 0, fifo within an urgency, 1 indicates round-robin

Urgency semantics

The draft details how these are intended to be used in Section 4.1

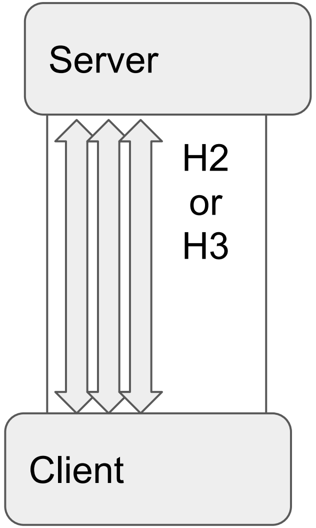
-1 prerequisite
0 default
1 to **5** supplementary
6 background

Semantics enable an origin server to effectively re-prioritize without knowing the priority of every other request.

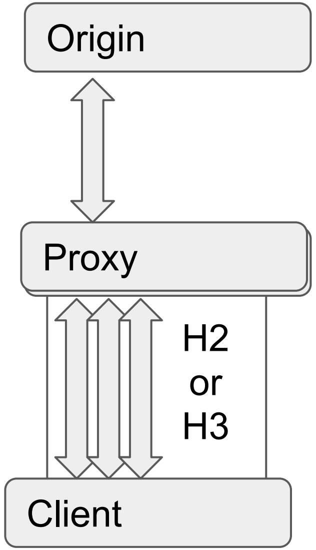
Semantics “hopefully” create more consistency across browsers

Two Key Use Cases

Client to Server over multiplexed HTTP



Within the 'server' - Override client priority



One Common Goal: Provide scheduling hints to the sender

Headers as an API

Headers are the standard API for an application using HTTP

Applications could *also* have a specific API, that's out of scope for the DT

However, Headers are End-To-End on the wire

Introduces complexities, still need a frame for re-prioritization

Solution: Senders locally consume application headers

Only frames are used to prioritize hop-by-hop

If a server receives this header from a client, it can ignore it

<u>Open Questions:</u> Could/should this be a pseudo-header?

Can/should this be exposed in the web API? (Whose decision?)

Wire Encoding Goals

The initial priority frame needs to be delivered prior to the HEADERS frame

Client should send first requests with initial priorities
even before it receives the server's SETTINGS

Allow Reprioritization even after a request has been sent

New Frame: HTTP/2

R: Reserved 1-bit field

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---------------------------------------------------------------+
|R|                        Stream ID (31)                       |
+---------------------------------------------------------------+
|                   Priority Field Value (*)                  ...
+---------------------------------------------------------------+
```

Only sent on the control stream, because of HTTP/2 extension constraints

MUST be sent immediately preceding corresponding headers

    A server only has to remember the most recent

Reprioritization also on the control stream

New Frame: H3

T: Bit to indicate request Stream ID or Push ID

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
[|T|    Empty    |   Prioritized Element ID (i)               ...]
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Priority Field Value (*)                  ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Initially sent on the request stream before headers

Reprioritization on the control stream

Proxy to Origin

‘priority’ header can be sent by proxy

- Indicates current priority on the *previous* hop

‘priority’ response header sent by origin

- Indicates to override the client’s priority
- Allows specifying a priority if the client specifies nothing

Example Deployment described in better-http-2-prioritization-for-a-faster-web

Issue #57

Negotiation with SETTINGS

Key use cases:

1) The client can indicate it does not use H2 priorities
2) The server expresses what information from the client it wants

Challenge: Either side may send first, neither can wait for the others

Ordered sequence of 8-bit identifiers, with the server's preference dominating

Up to 4 values in H2 (32 bits), 7 values in H3 (62 bits)

Draft defines:

H2-TREE

URGENCY - May be renamed EXTENSIBLE

Some smaller issues still TBD

Should ‘urgency’ start at -1? A higher value corresponds to higher priority?

current	-1 [0] 1 2 3 4 5 6
option a	0 [1] 2 3 4 5 6 7
option b	7 [6] 5 4 3 2 1 0

What is the best encoding of the key-value pairs?

All Issues: https://github.com/kazuho/draft-kazuho-httpbis-priority/issues

Design Team Goals: Review

Requirement: Determine a solution for HTTP/3 to have some client-to-server priority hinting mechanism that it can ship with. This can be a minimal approach.

The following are potentially in scope (though not all are required):

- Mechanism to indicate that H2 priorities are not being used ✓
- Mechanism to indicate what kind of priority hinting is being used ✓
- Priority hinting mechanism that is non-minimal ✓
- A plan to backport the new priority hinting to H2 ✓

Out of scope: Changes that would add complexity that we're not confident in that would risk shipping HTTP/3.

What’s next?

Update the draft to reflect this proposal
Determine if/how to break it up into multiple docs
Close smaller issues

Comments, Questions, Suggestions?
Add to H3, keep as extension?

Thanks to all design team members! [Group Notes]