UPDATE

SEARCH – a New Slow Start Algorithm for TCP and QUIC

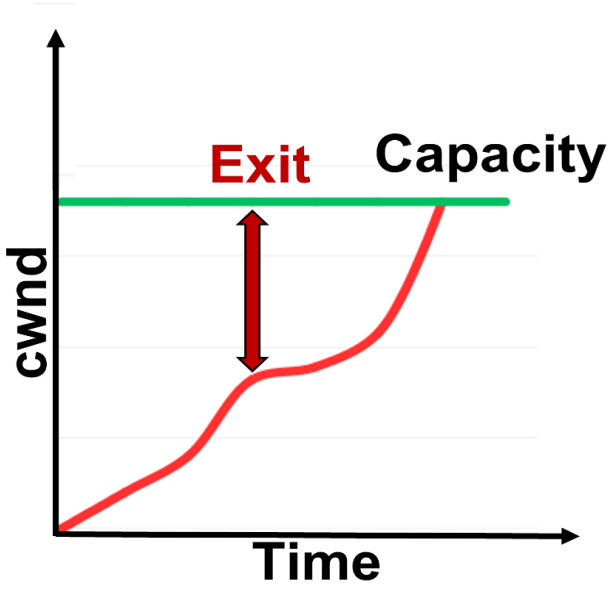
Jae Chung
Feng Li
Maryam Ataei Kachooei
Mark Claypool

IETF CCWG
Dublin, Ireland
November 2024

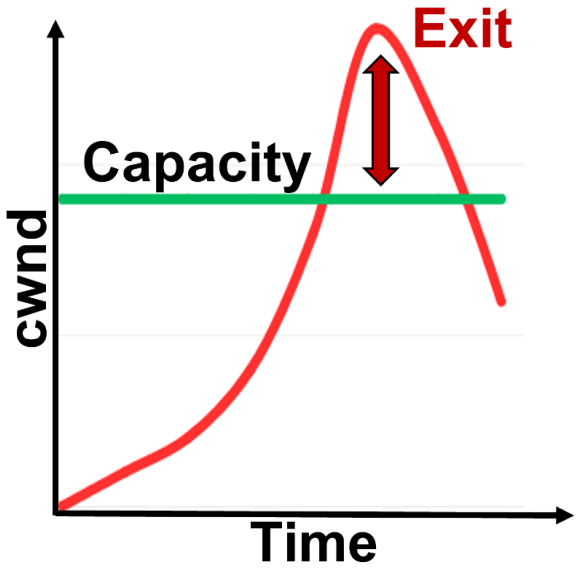
Viasat

WPI

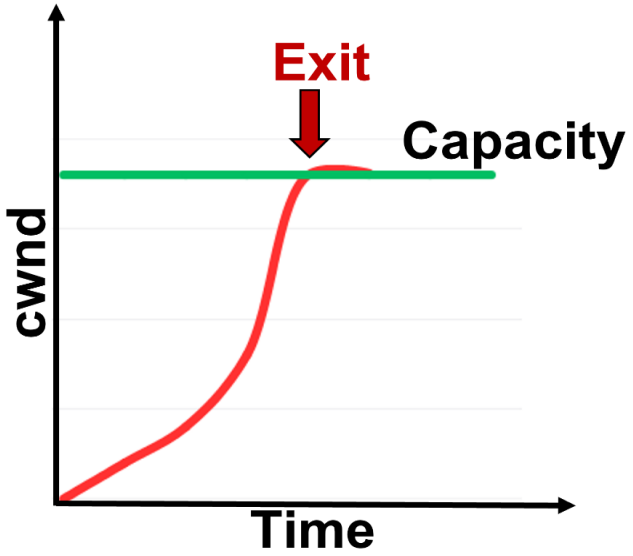
Motivation



Exit Too Early



Exit Too Late

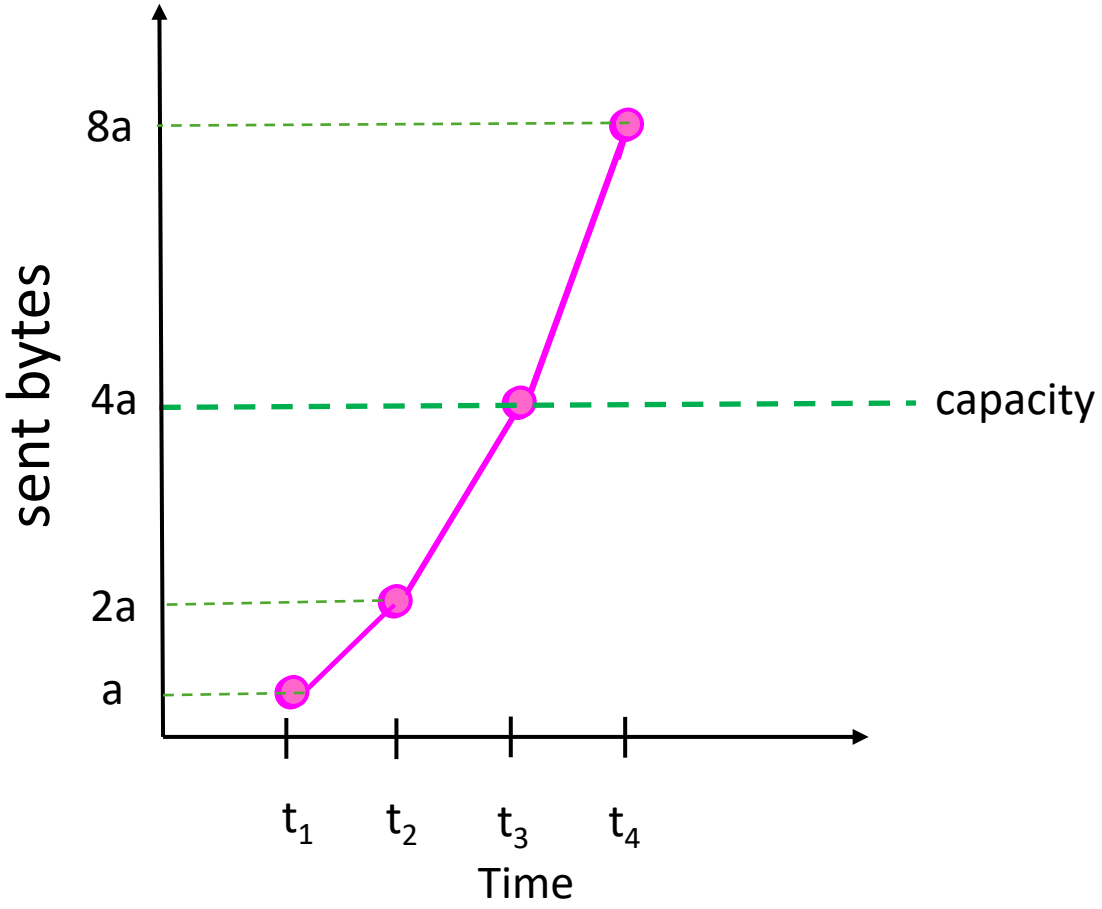


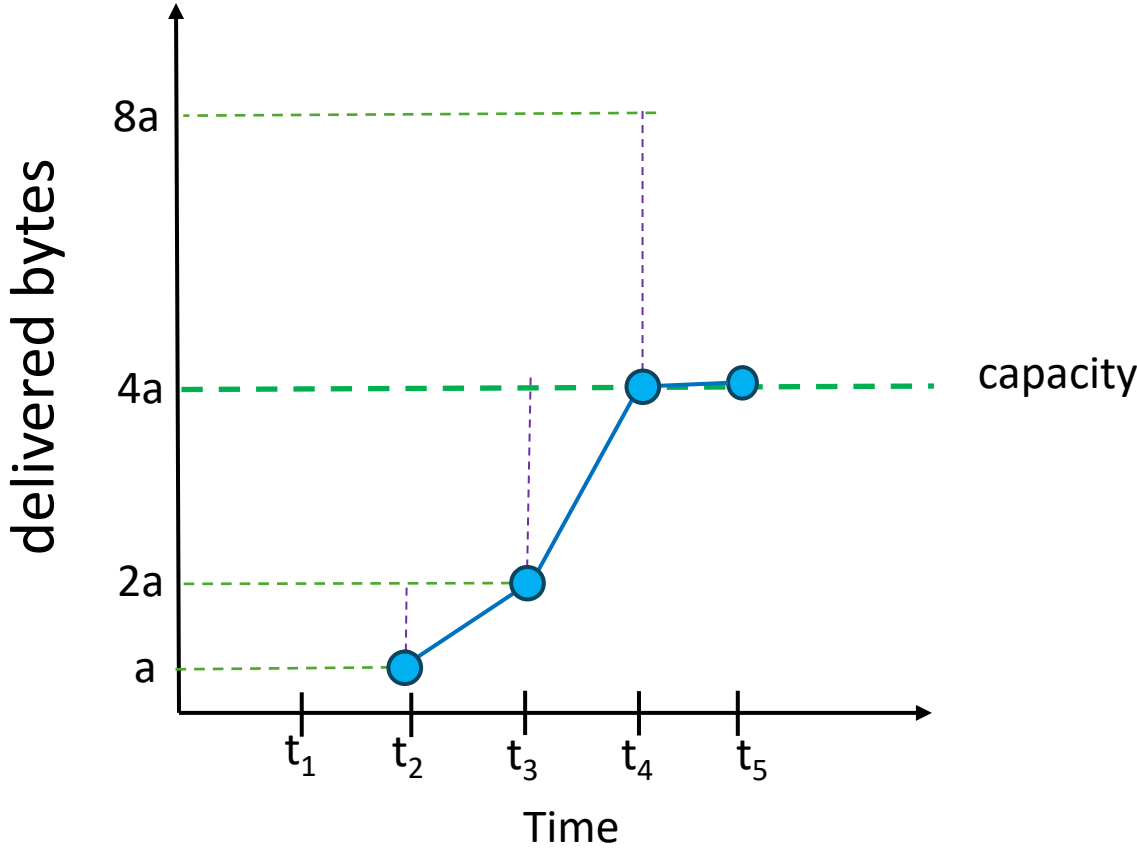
Exit at Choke Point

HyStart over wireless

SEARCH

SEARCH – Slow start Exit at Right CHokepoint





SEARCH – **S**low start **E**xit at **R**ight **CH**okepoint

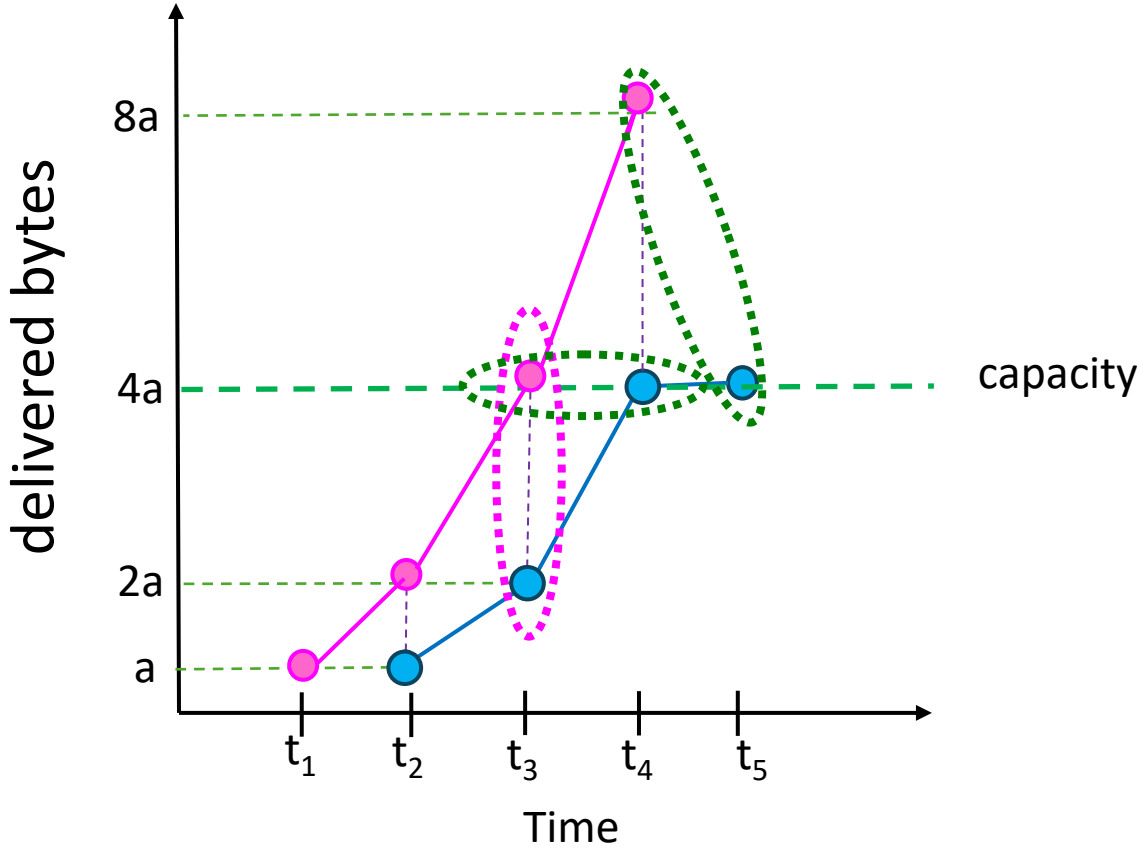
sent’ = 2 · delv $_{previous}$

diff = sent’ – delv $_{now}$

normalized_diff = diff / sent’

normalized_diff ≥ threshold?

→ exit slow start



Outline

- SEARCH Review (done)
- Updates (next)
  - Algorithm
  - Reduce Bytes per Flow
  - Test Rate Limited Flows
- Next Steps

Algorithm Update

0	1	2	3	4	5
10	20	10	20	30	20

bins are **bytes received** during that interval

0	1	2	3	4	5
10	30	40	60	90	110

bins are **cumulative bytes received** up to that interval

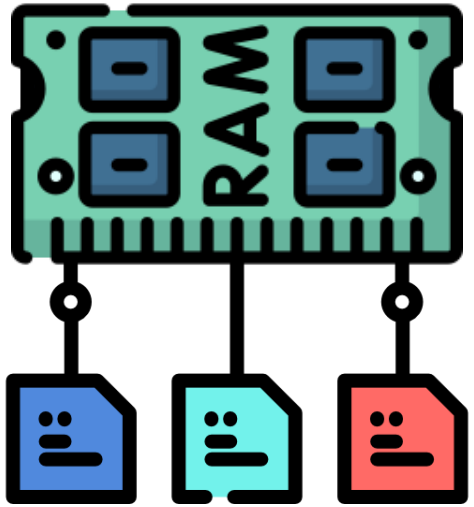
Bytes delivered from **bin 1** to **bin 4**?

$$\sum_{1}^{4} \text{bin}[i] = \text{bin}[1] + \text{bin}[2] + \text{bin}[3] + \text{bin}[4]$$

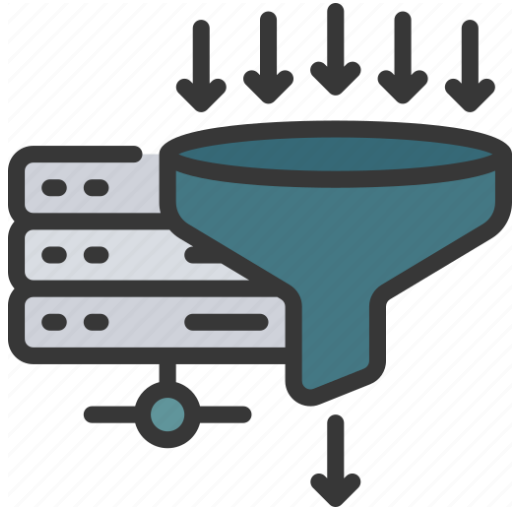
bin[4] - bin[0]

Suggested Updates from Last IETF Meeting

Per-flow memory use



Rate-limited flows



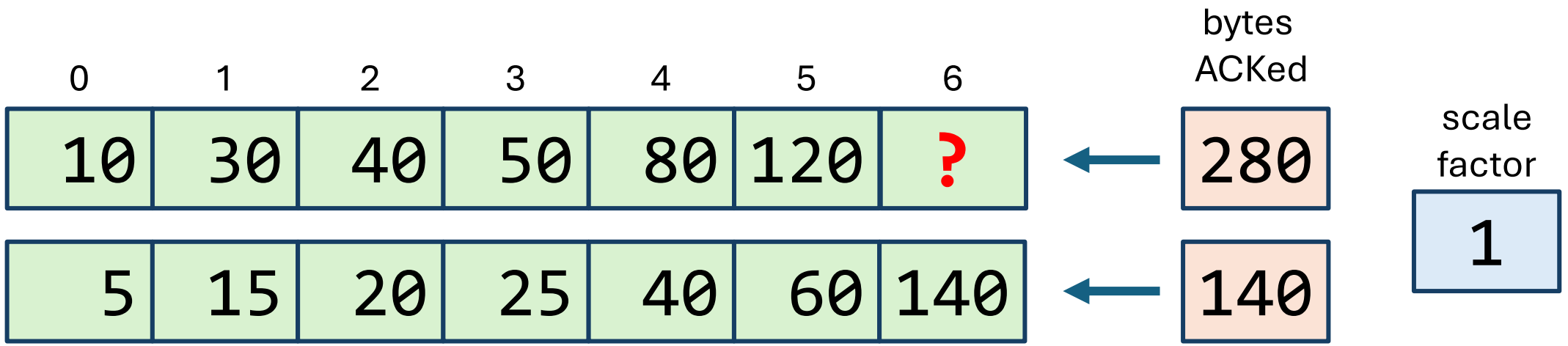
Reduce Bytes Per Flow

SEARCH-specific per-flow data

```
u32   bin[TOTAL_BINS];     // array of bins
u32   bin_duration_us;     // duration of each bin
u32   bin_end_us;          // end time of latest bin
s32   curr_idx;            // total number of bins
u8    scale_factor;        // divisions by 2 (shifts)
```

- Reduce number of bits for each bin

u32 → u8



Error with Reduced Bits Per Bin

sent’ = 2 · delv $_{previous}$

diff = sent’ – delv $_{now}$

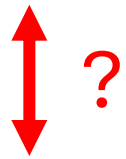
normalized_diff = diff / sent’

normalized_diff ≥ threshold?

→ exit slow start

```
u32 bin[TOTAL_BINS];
```

normalized_diff



?

```
u8 bin[TOTAL_BINS];
```

normalized_diff

Error with Reduced Bits Per Bin

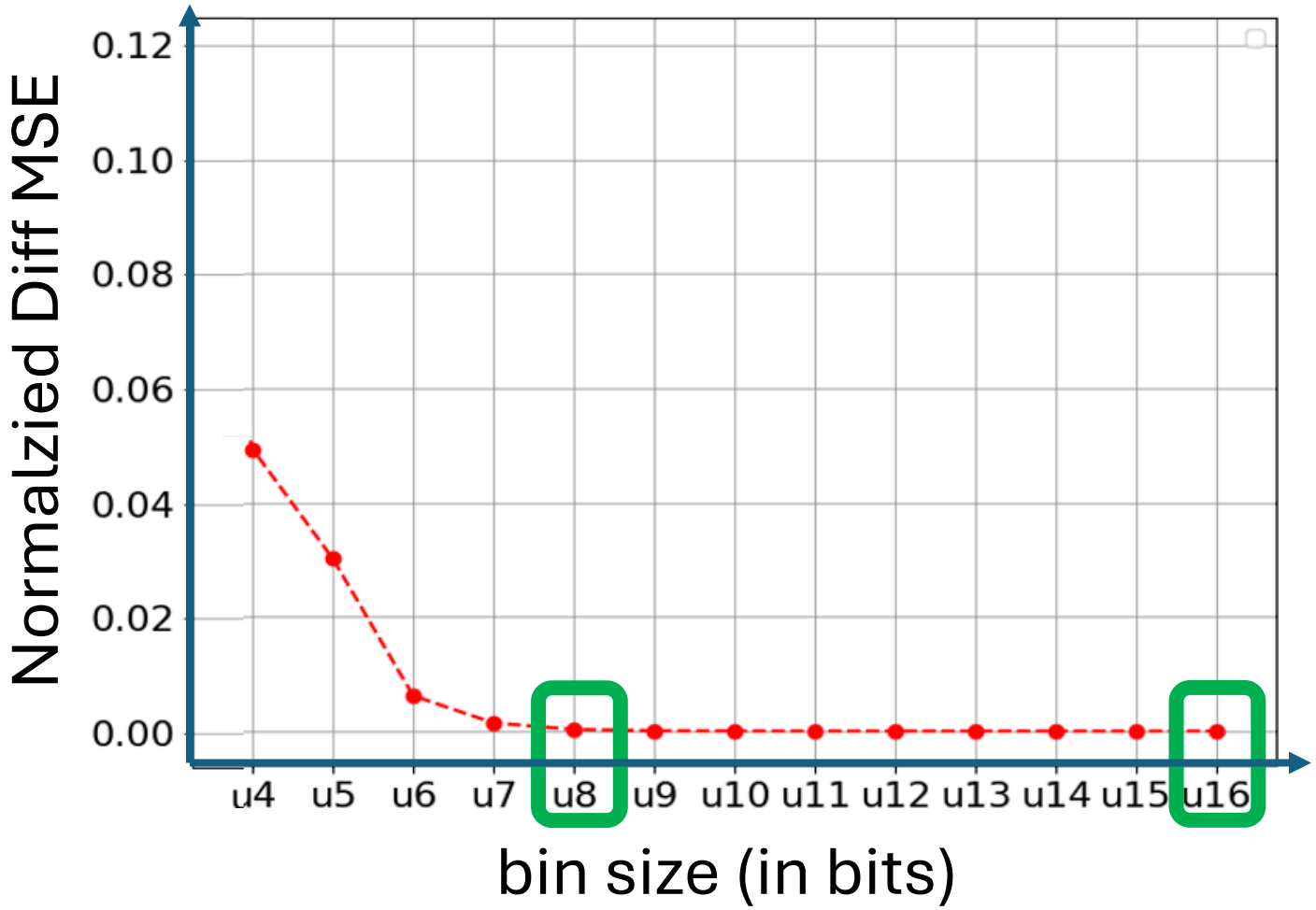
```
u32 bin[TOTAL_BINS];
```

normalized_diff

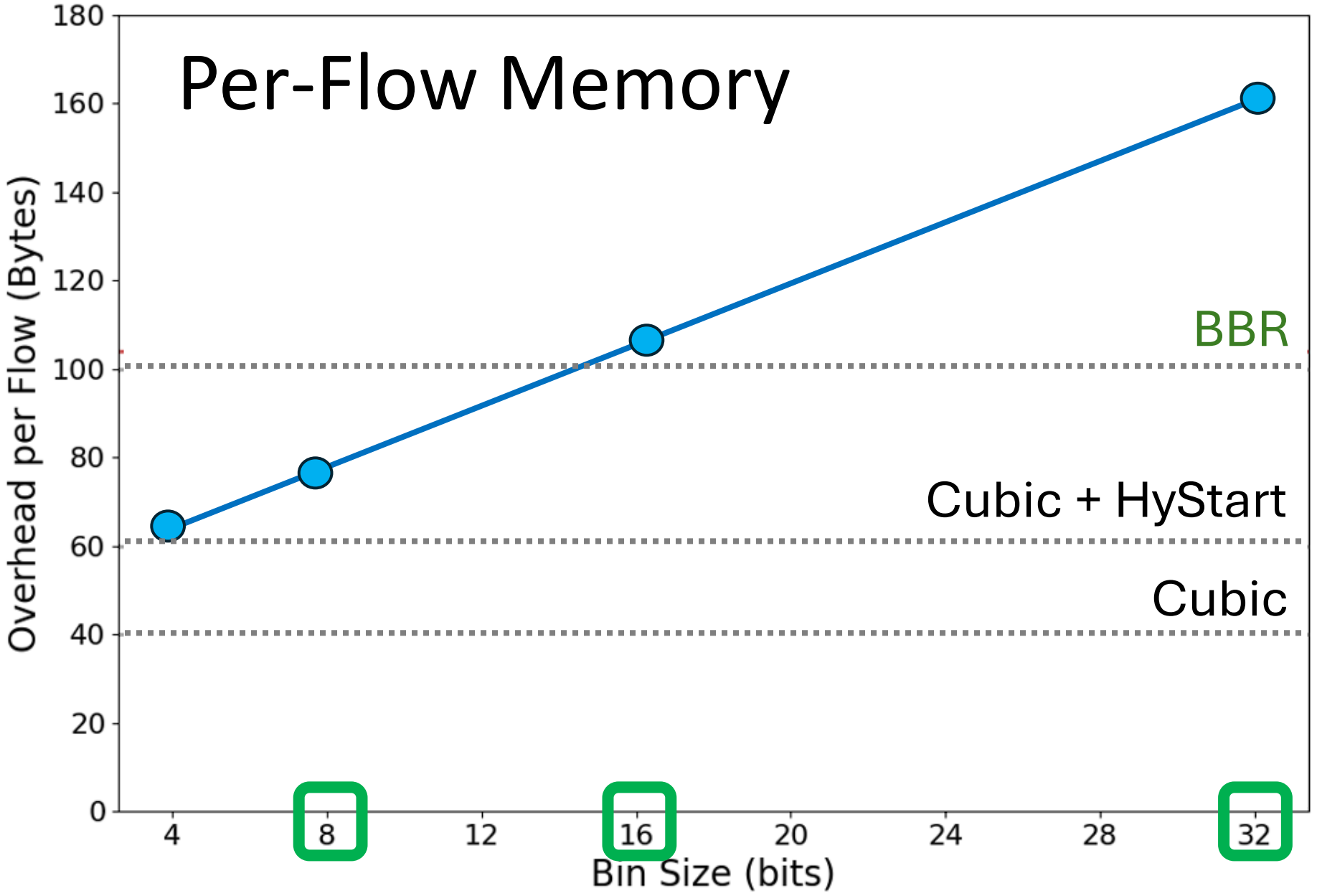
↕ ?

normalized_diff

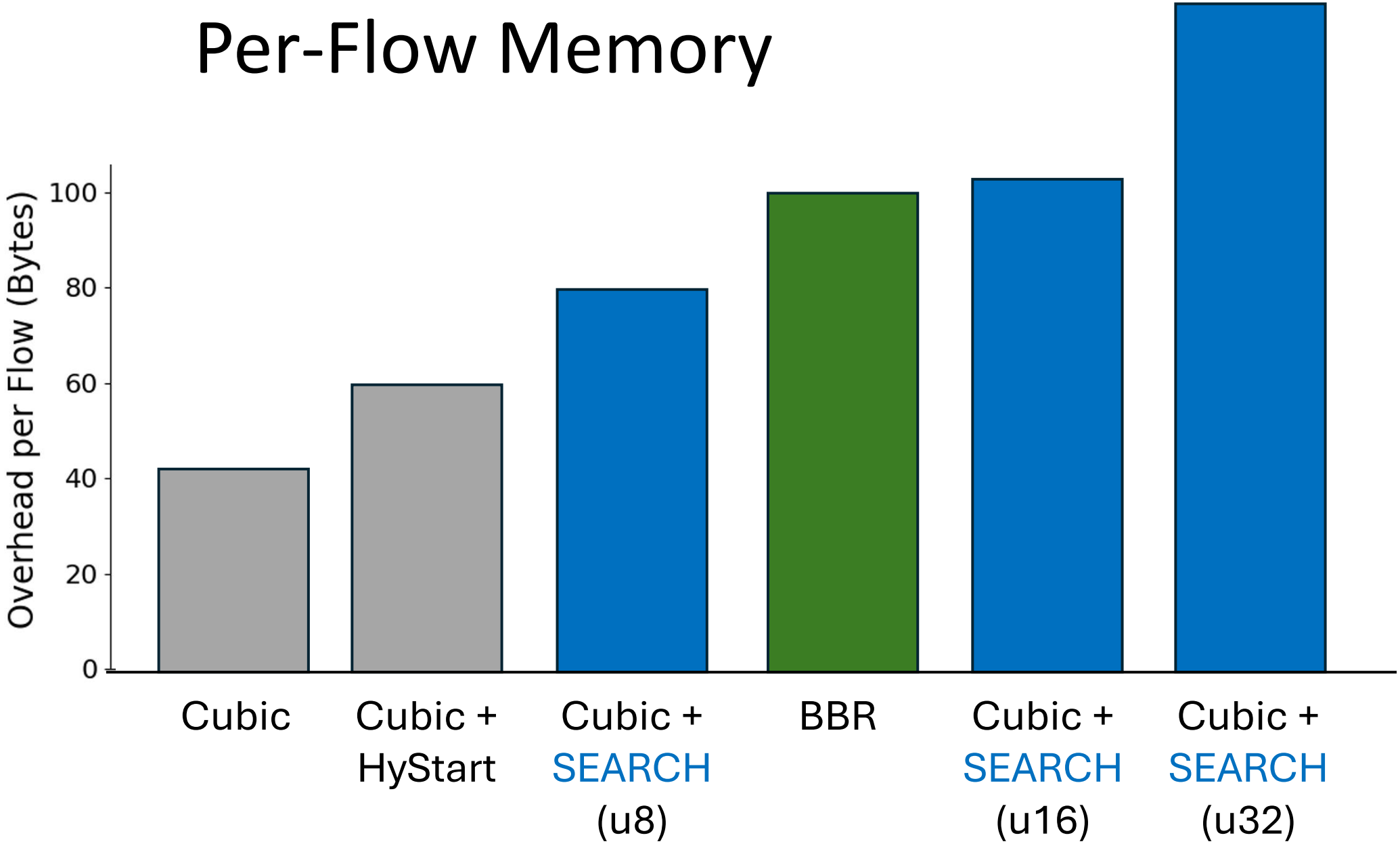
```
u8 bin[TOTAL_BINS];
```



Linux
Private
ICSK_CA_PRIV
104 bytes

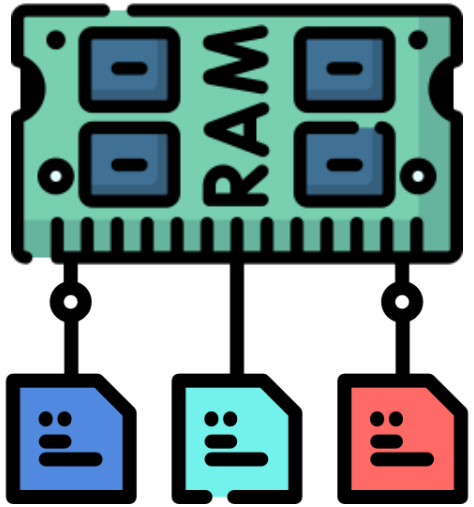


Per-Flow Memory

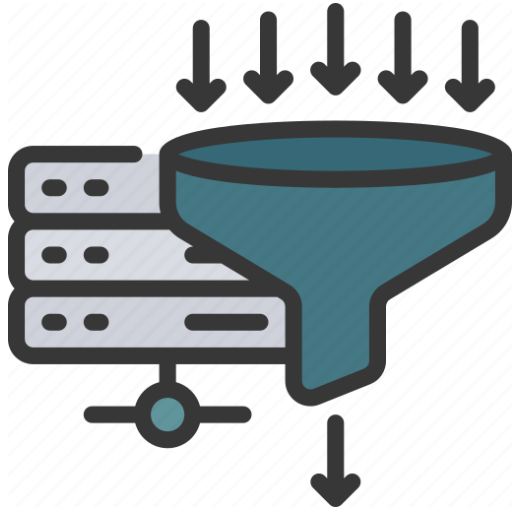


Suggested Updates from Last IETF Meeting

Per-flow memory use



Rate-limited flows



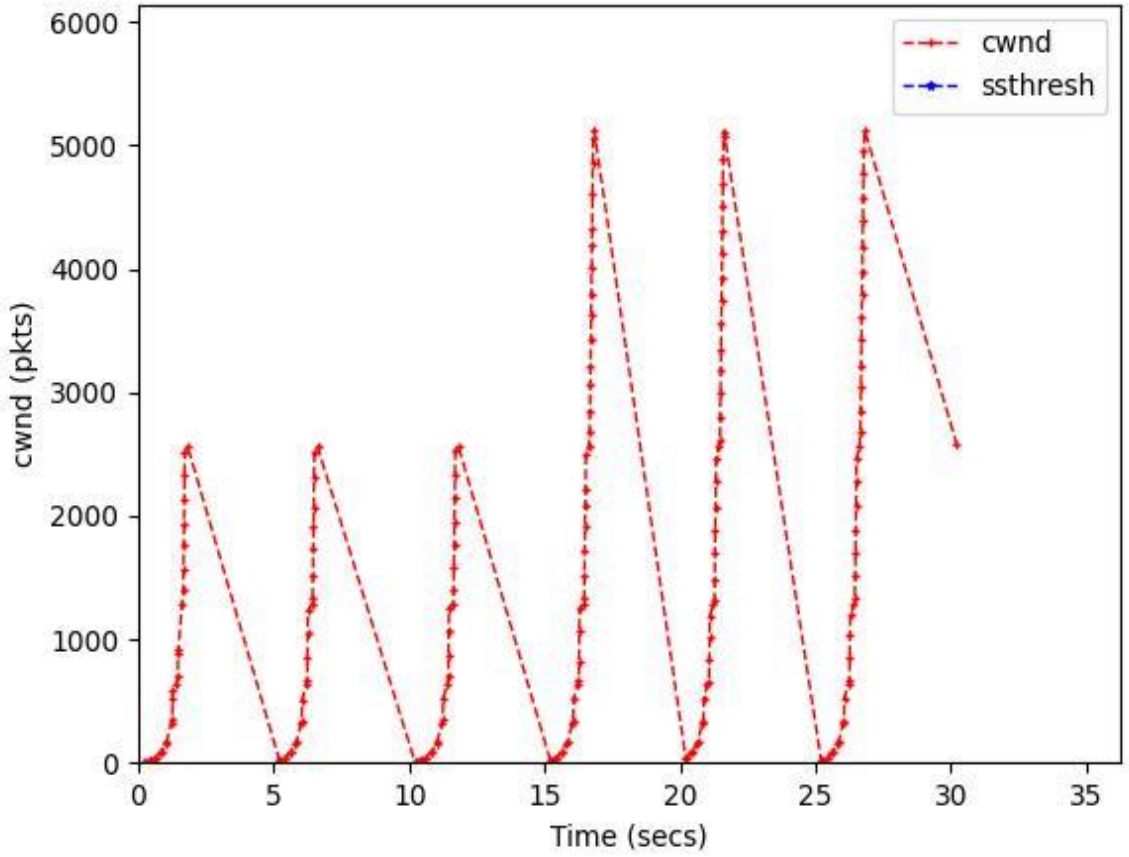
Test Rate Limited Flows

- Application limited TCP flow
  - Periodic – e.g., HTTP streaming
  - Intermittent – e.g., Web browsing
  - Application rate limited – e.g., CBR traffic

- Receiver / Sender limited TCP flow
  - e.g., buffer size limits

Test Rate Limited Flow – Application

- AWS EC2 Linux
- netem to add 200 ms latency
- Application limited flow (e.g., HTTP server)
  - 3x 32 MB chunks at 5 s intervals
  - 3x 64 MB chunks at 5 s interval



Outline

- SEARCH Review (done)
- Updates (done)
  - Algorithm (done)
  - Bytes per Flow (done)
  - Rate Limited Flows (done)
- Next Steps (next)

Next Steps

- CCWG seeks empirical evidence of safety
- Most impactful → data from deployments in the field
- Looking for volunteers!
- We will help with SEARCH deployment
  - Provide implementation (currently, Linux and Quicly, working on FreeBSD version)
  - Help with installation and trouble shooting
  - Give assistance with data collection and analysis

Summary

SEARCH

https://search-ss.wpi.edu/

- SEARCH
  - Determines “choke point” from expected delivered bytes
  - Exits slow start after congestion point, before loss
- Updates (now version 3.0)
  - Algorithm tweak (cumulative bytes)
  - Reduced bytes per flow
  - App-limited flows
- Looking for volunteers to try it out!

Thank-you for your attention!

SEARCH – a New Slow Start Algorithm for TCP and QUIC

Jae Chung
Feng Li
Maryam Ataei Kachooei
Mark Claypool

IETF CCWG
Dublin, Ireland
November 2024

Viasat

WPI

References

- Improving TCP Slow Start Performance in Wireless Networks with SEARCH
  - *IEEE World of Wireless, Mobile and Multimedia Networks (WoWMoM)*
  - Perth, Australia, June 2024
- Improving QUIC Slow Start Behavior in Wireless Networks with SEARCH
  - *IEEE Local and Metropolitan Area Networks (LANMAN)*
  - Boston, Massachusetts, USA, July 2024
- Implementation of the SEARCH Slow Start Algorithm in the Linux Kernel
  - *0x18 NetDev Conference*
  - Santa Clara, California, USA, July 2024