北京
2019

遨游“视”界 做你所想
Explore World, Do What You Want

Congestion Control Fairness and Active Queue Management

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Akamai
Experience the Edge

出品: LiveVideoStack 音视频技术社区 CSDN

深圳 2019

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LiveVideoStackCon 2019 深圳

2019.12.13-14

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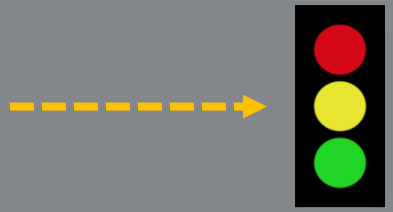
出品：LiveVideoStack 音视频技术社区

Our Adventure Awaits

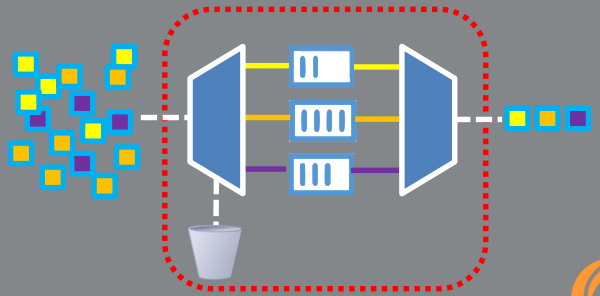
Internet



Congestion Control

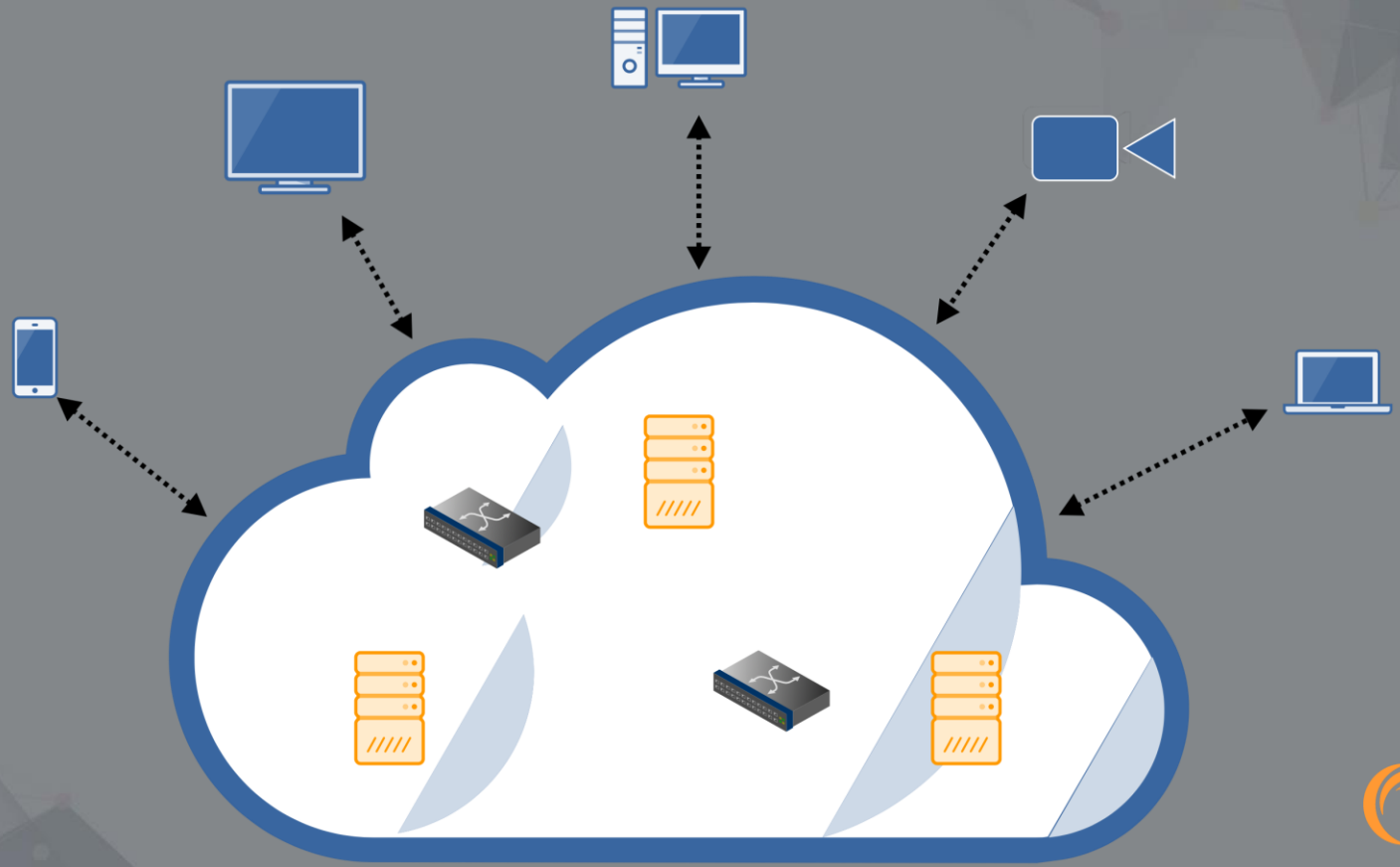
Fairness

Competition



AQMs

The Internet

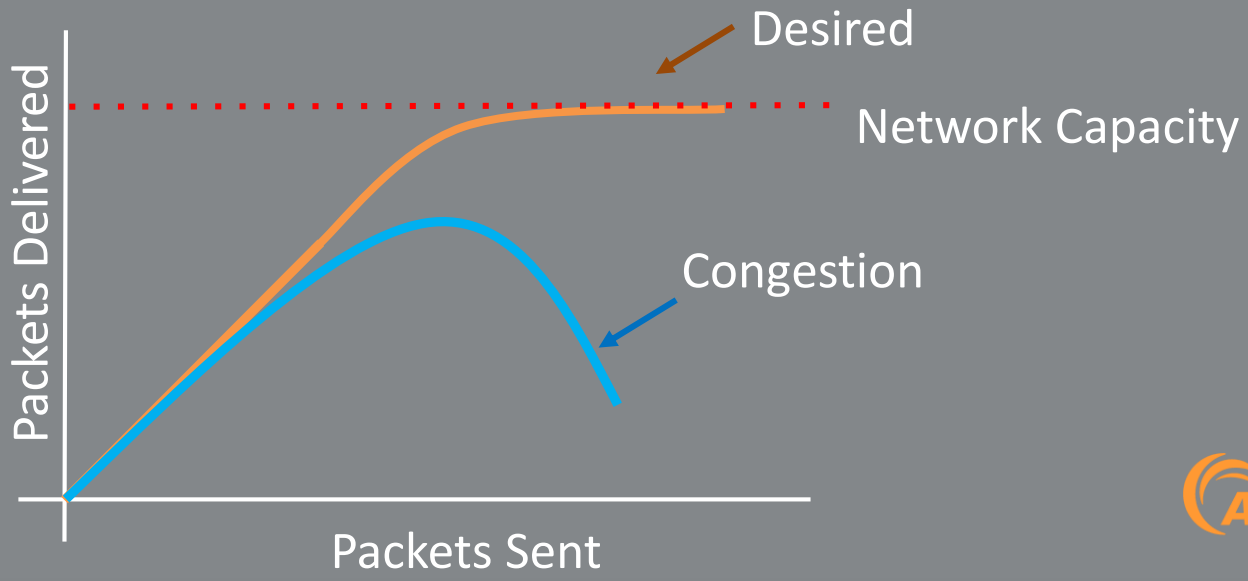


Congestion Collapse

- Network congestion and retransmission is preventing the network from delivering data.

- 1986: Lasted over a year. Decrease in throughput by a factor of 1000.

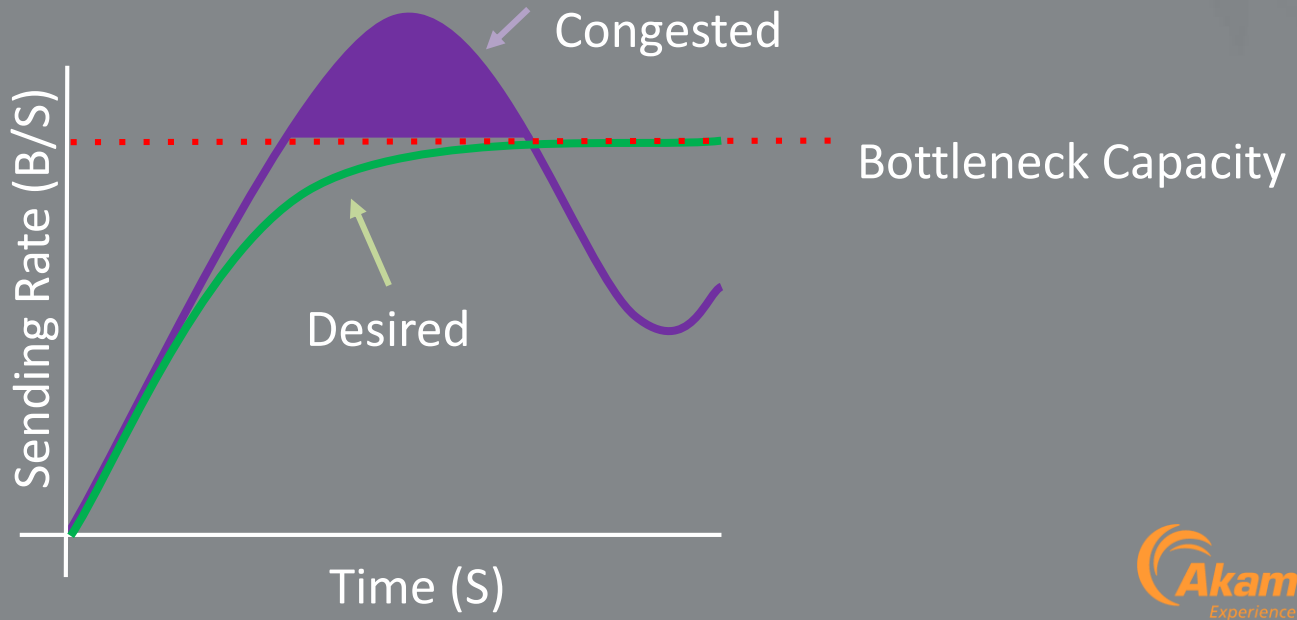
Network View



TCP Congestion Control

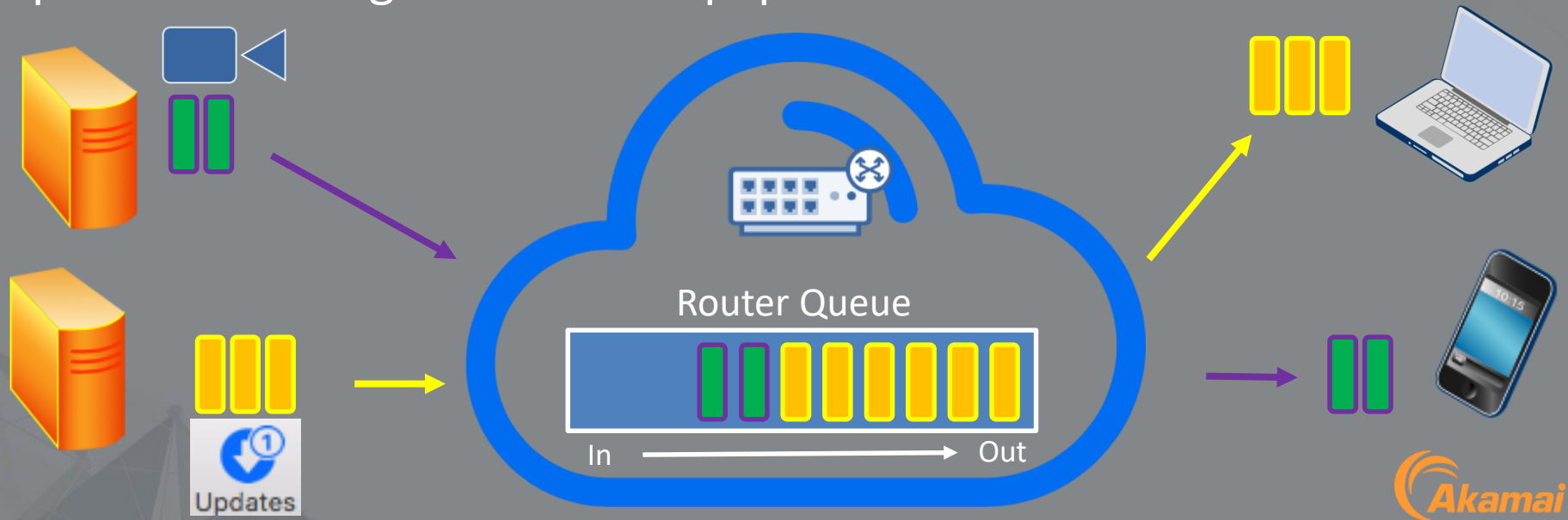
- Congestion Control is TCP/IP’s attempt to match performance with available network bandwidth.

Single Flow View

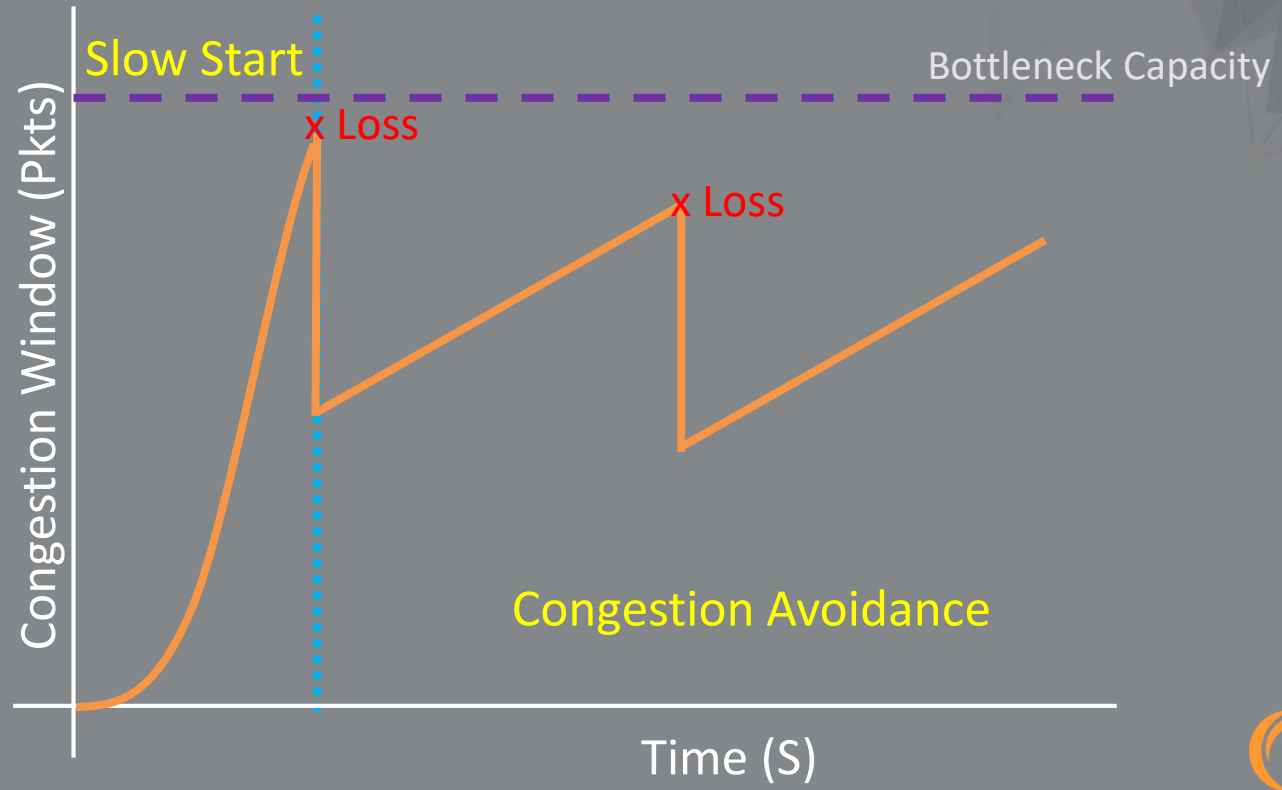


Bufferbloat

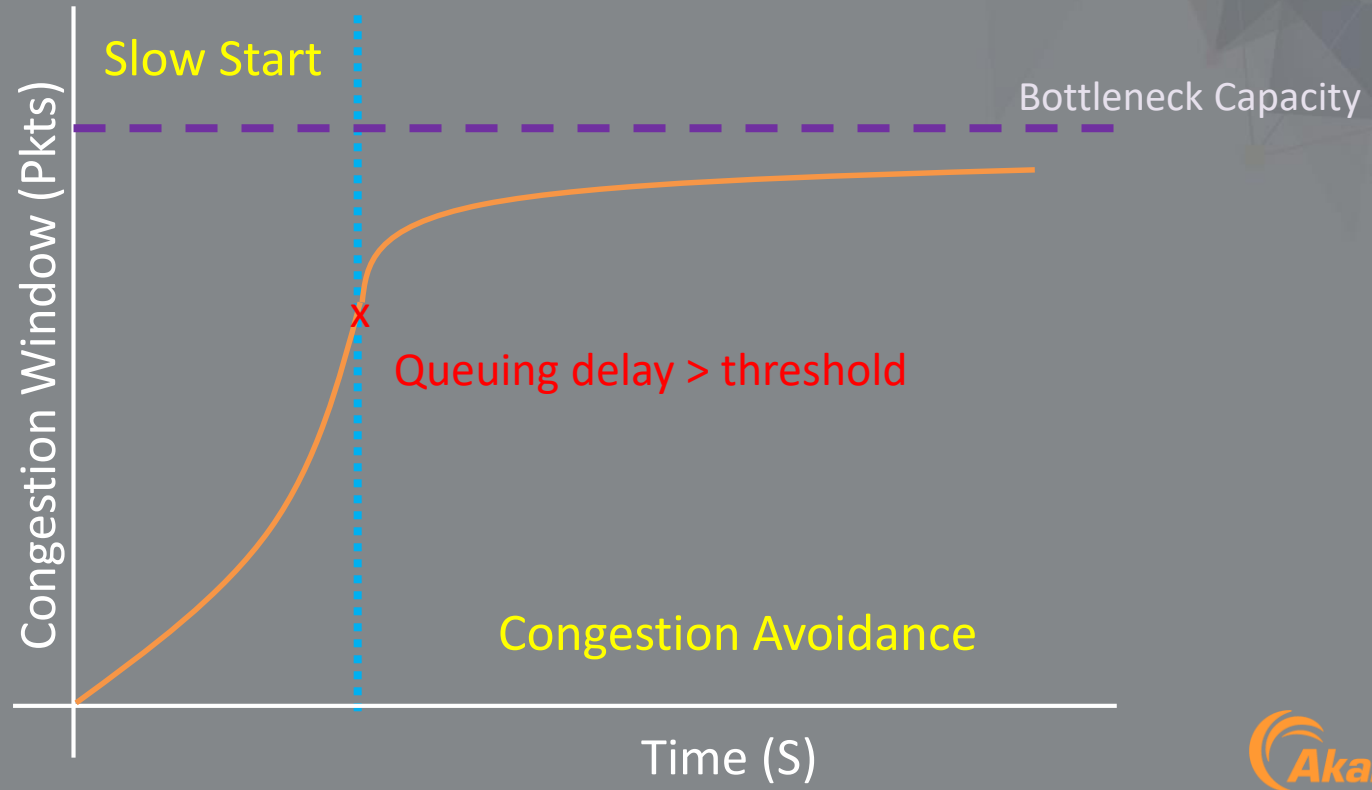
A Definition: High latency or latency variation caused by excess packet buffering in network equipment.



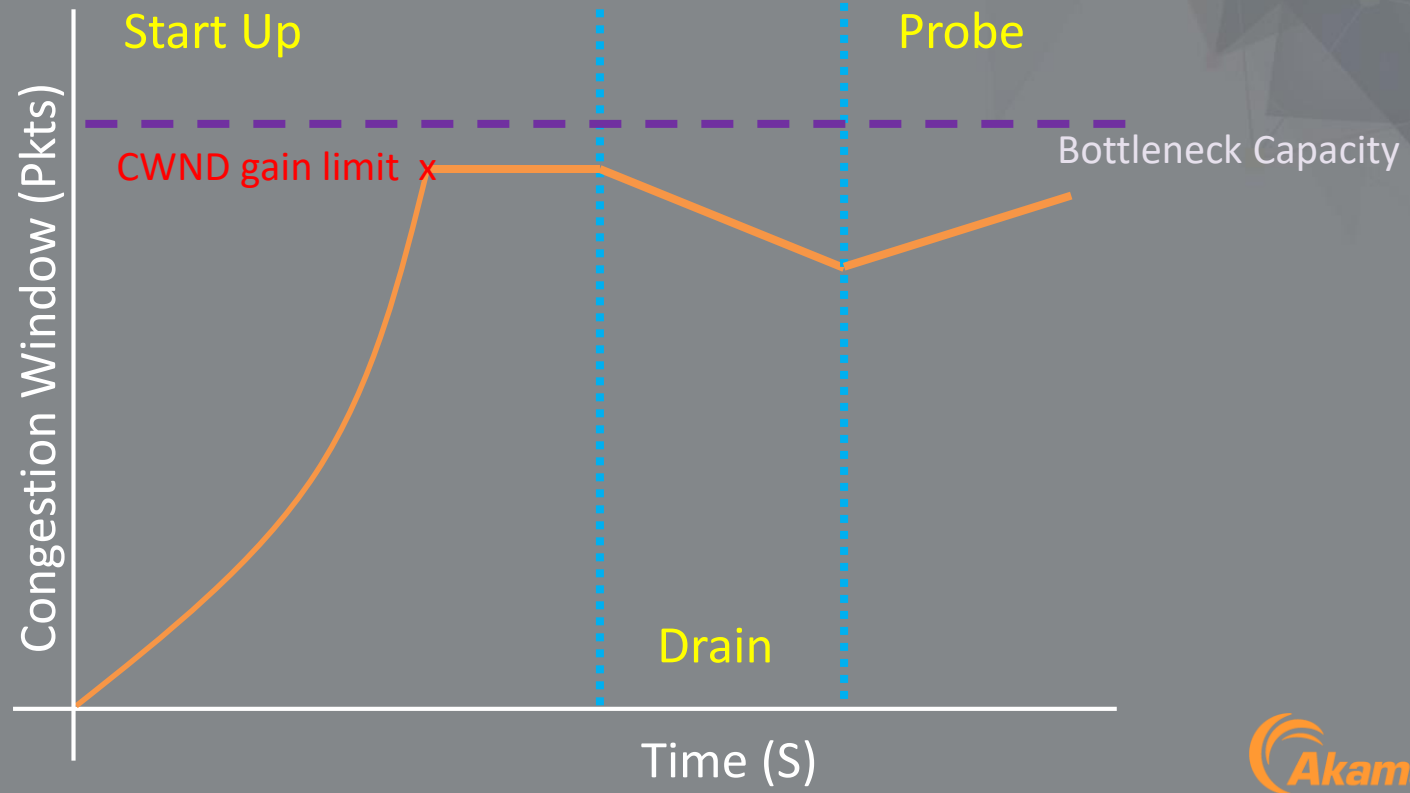
TCP Congestion Control - Reno



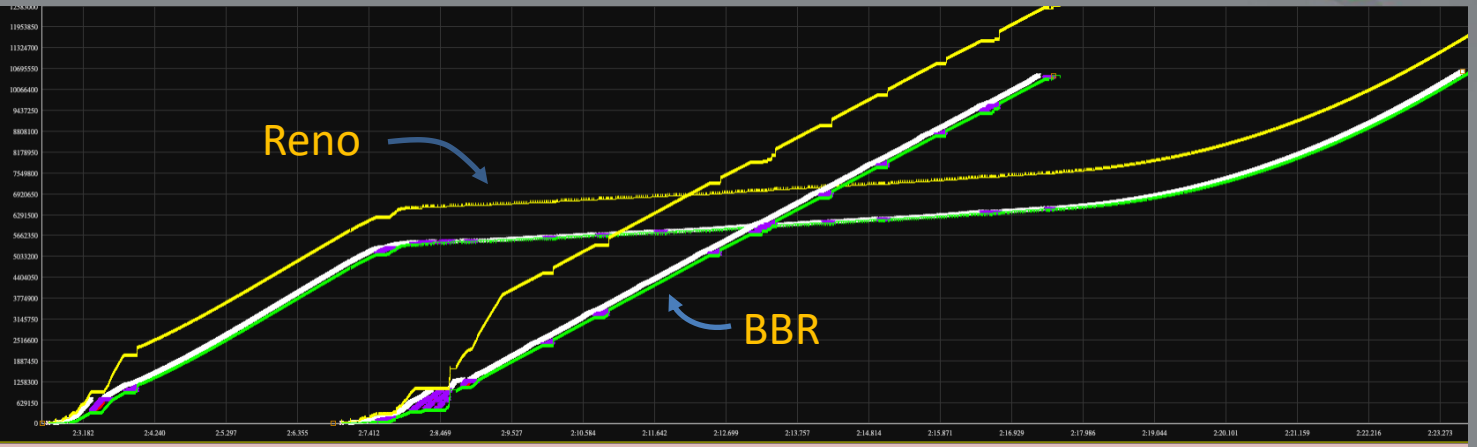
TCP Congestion Control - FastTCP



TCP Congestion Control - BBR

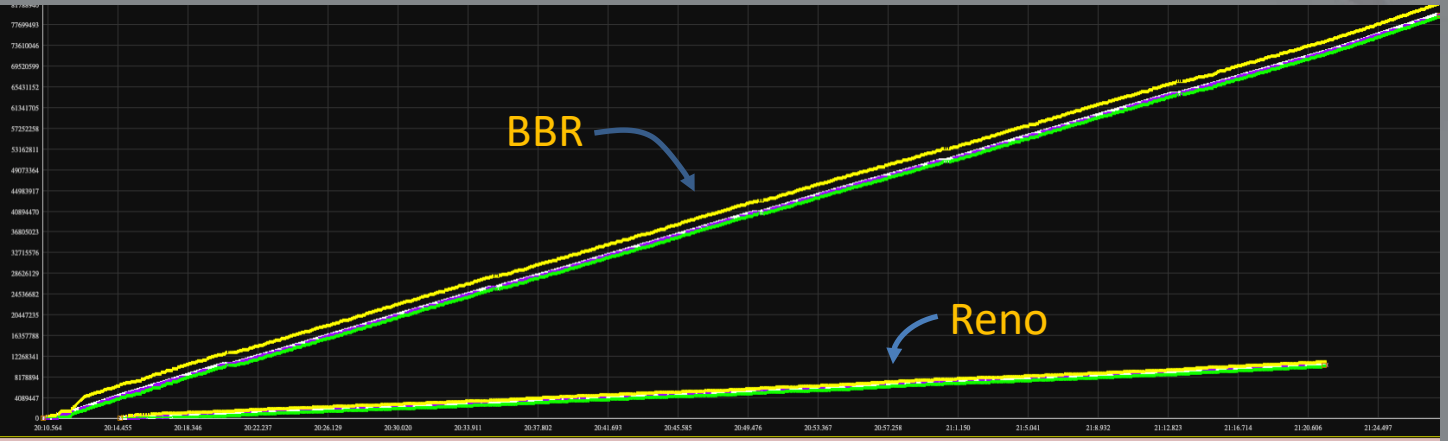


Congestion Control Fairness



Reno vs BBR
50ms latency
1% loss
10 Mbit Bandwidth
50 packet buffer

Congestion Control Fairness



BBR vs Reno
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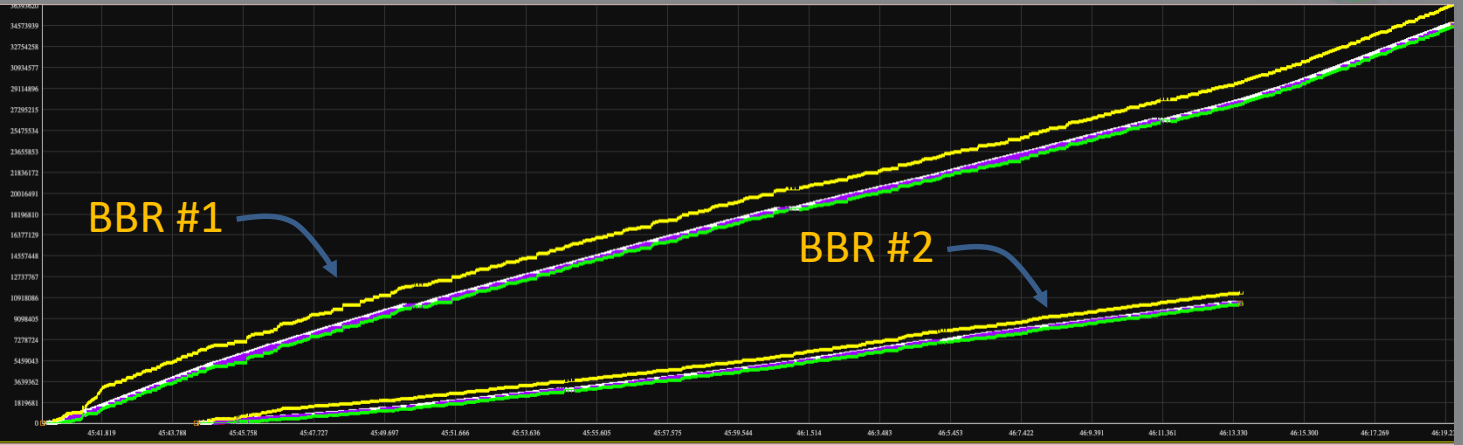
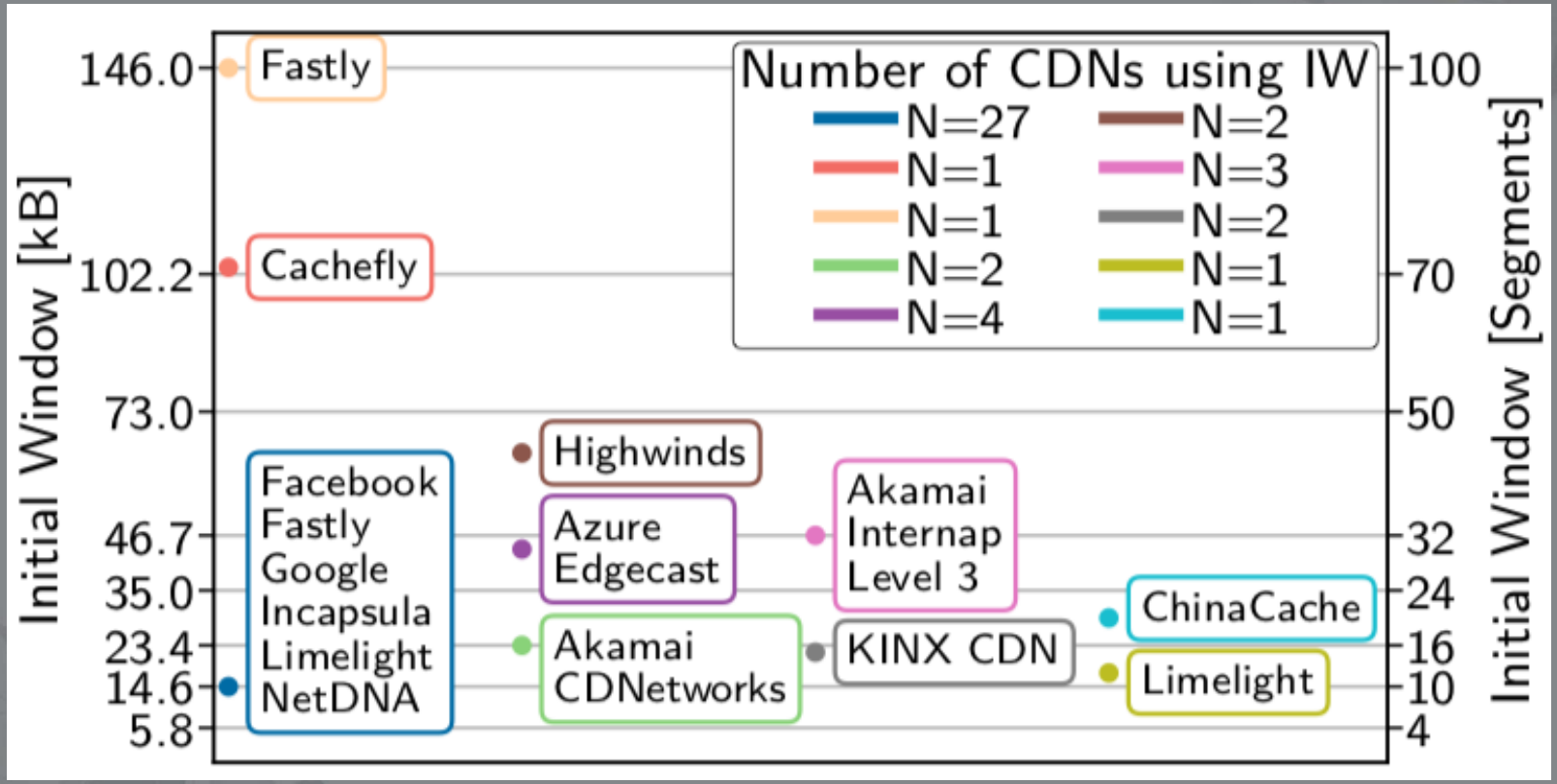
Congestion Control Fairness



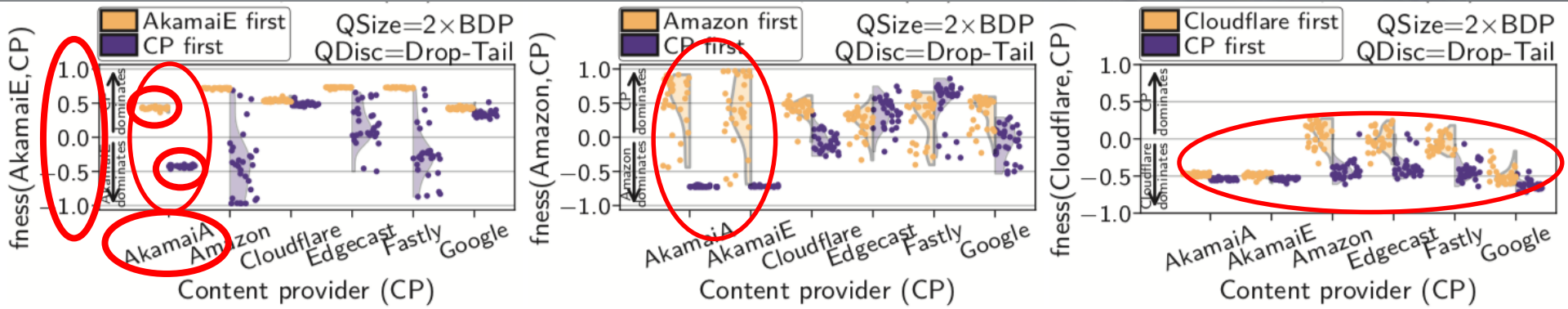
BBR vs BBR
50ms latency
1% Loss
10 Mbit B/W Limit
50 packet buffer

TCP Initial CWND



From: Demystifying TCP Initial Window Configurations of Content Distribution Networks - Jan Rüth and Oliver Hohlfeld

Content Provider Fairness



30x download for 45 seconds with Host CP. Target CP joins after 5 seconds.

Key takeaways:

1) Who starts first matters
2) Cloudflare is very aggressive

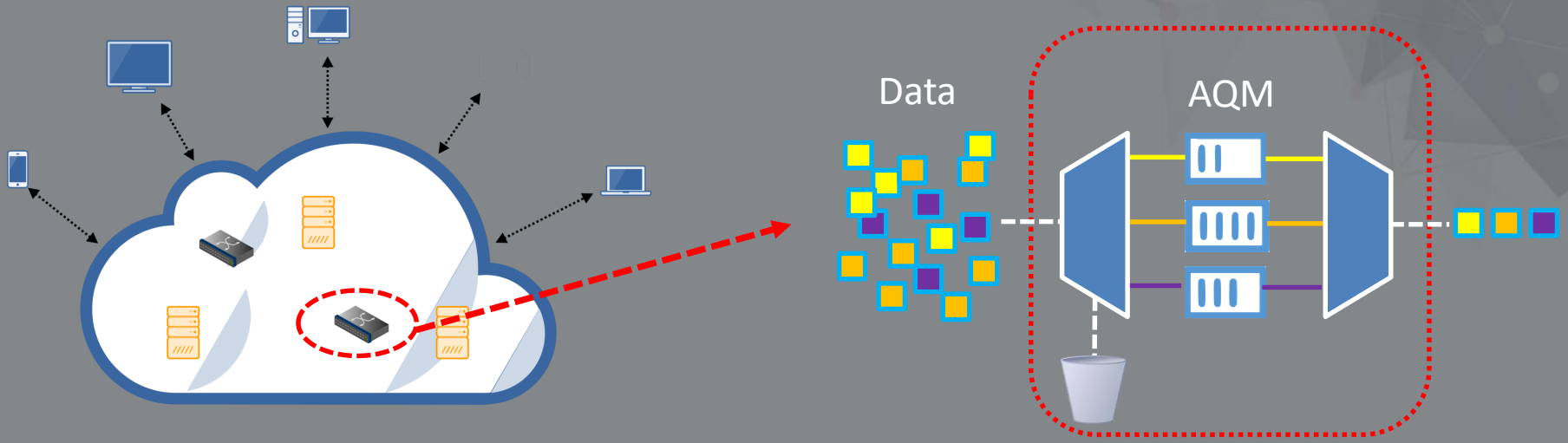
$$fness(a,b) = \begin{cases} 1 - \frac{bytes(a)}{bytes(b)} & \text{if bytes(b)} \geq \text{bytes(a)} \\ -1 + \frac{bytes(b)}{bytes(a)} & \text{if bytes(a)} > \text{bytes(b)} \end{cases}$$

From: An Empirical View on Content Provider Fairness - Jan Rüth, Ike Kunze, and Oliver Hohlfeld

Question

How Can Network Traffic Be More Fair?

Active Queue Management (AQM)



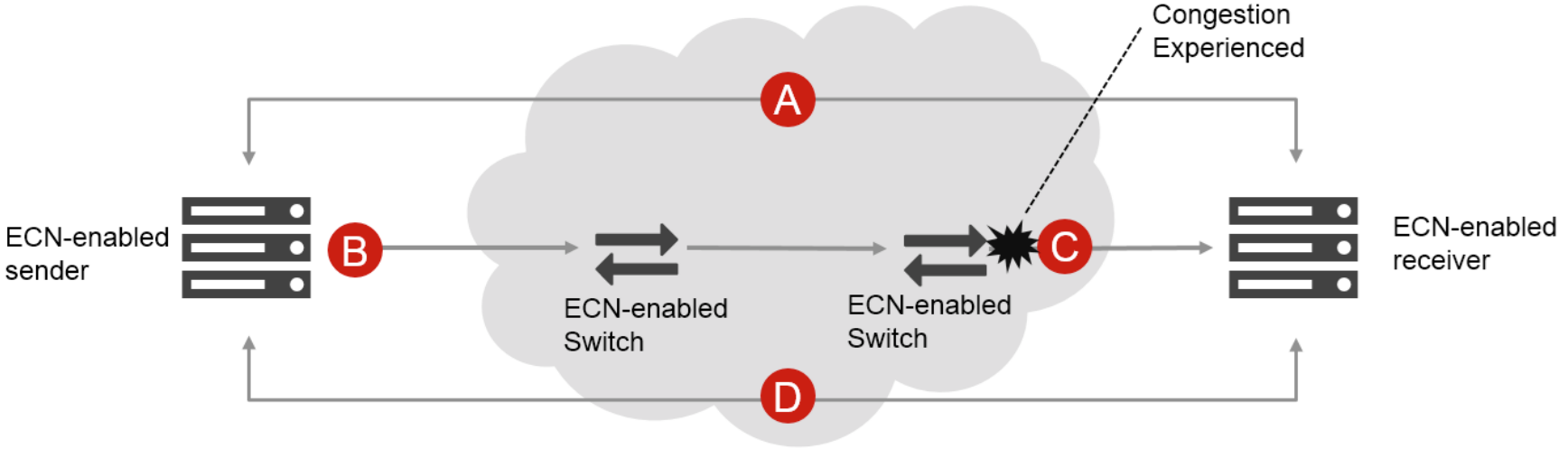
Routers and Switches employ AQM to drop packets from flows:

1) To minimize long standing buffers (bufferbloat)
2) To improve latency
3) To minimize congestion from aggressive and misbehaving flows

Common AQM Policies

1) Random Early Drop / Detection / Discard (RED)
   - Drop packets based on a statistical probability tied to average queue length.
2) Proportional Integrated Controller Enhanced (PIE)
   - Drop packets based on a statistical probability affected by queue latency.
3) Controlled Delay (CoDEL)
   - If the lowest queuing delay experienced from all packets in a sliding time interval is greater than a set value (5ms), drop the last packet in the interval.
4) Fair Queue Control Delay (FQ-CoDel)
   - Uses fair queuing with CoDel to more evenly distribute bandwidth amongst flows.
5) Common Applications Kept Enhanced (CAKE)
   - Enhanced AQM that builds on FQ_CoDel.

Explicit Congestion Notification



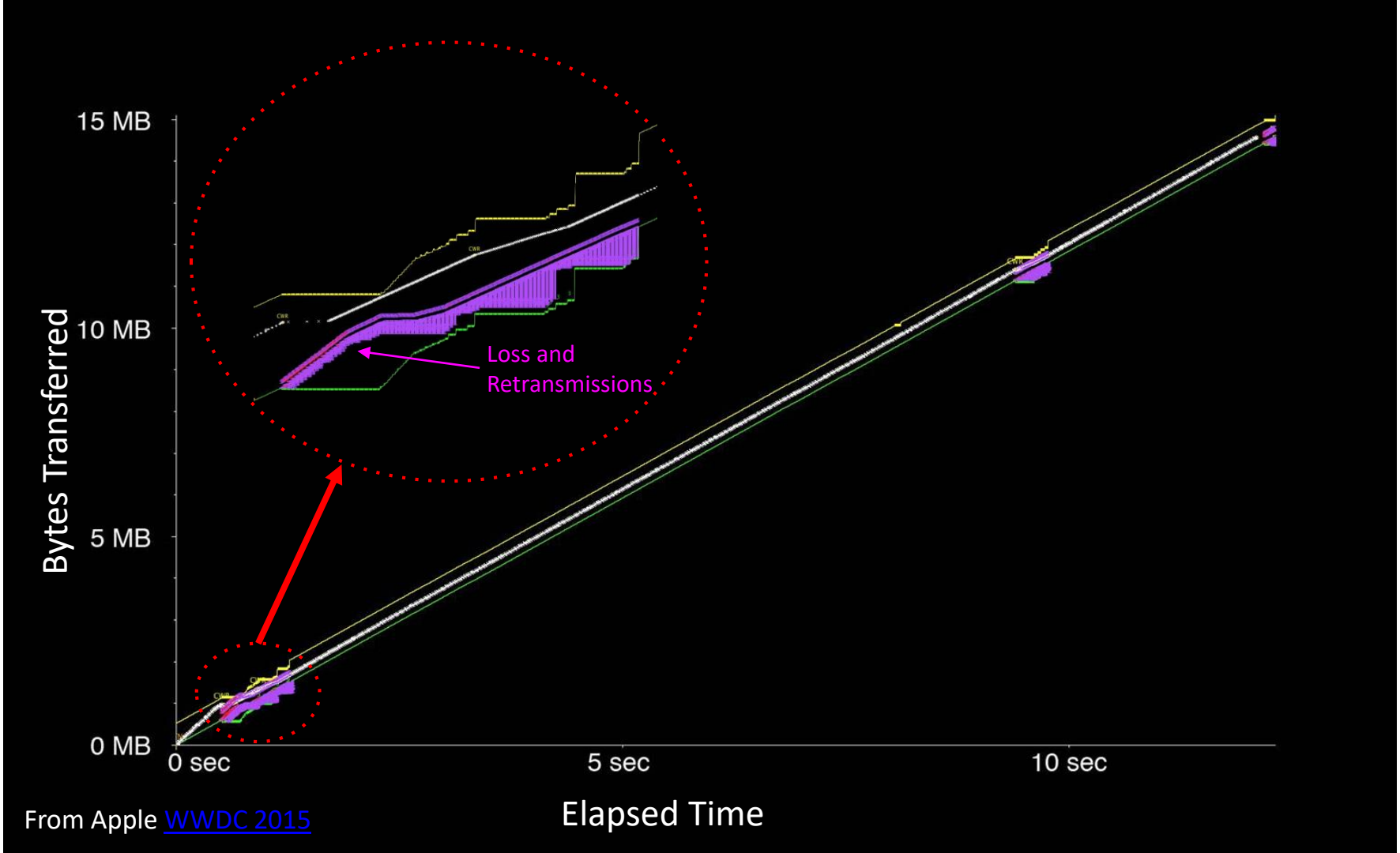
A ECN (Explicit Congestion Notification) negotiated during connection establishment

B ECT set (ECN Capable Transport)

C CE set (Congestion Experienced)

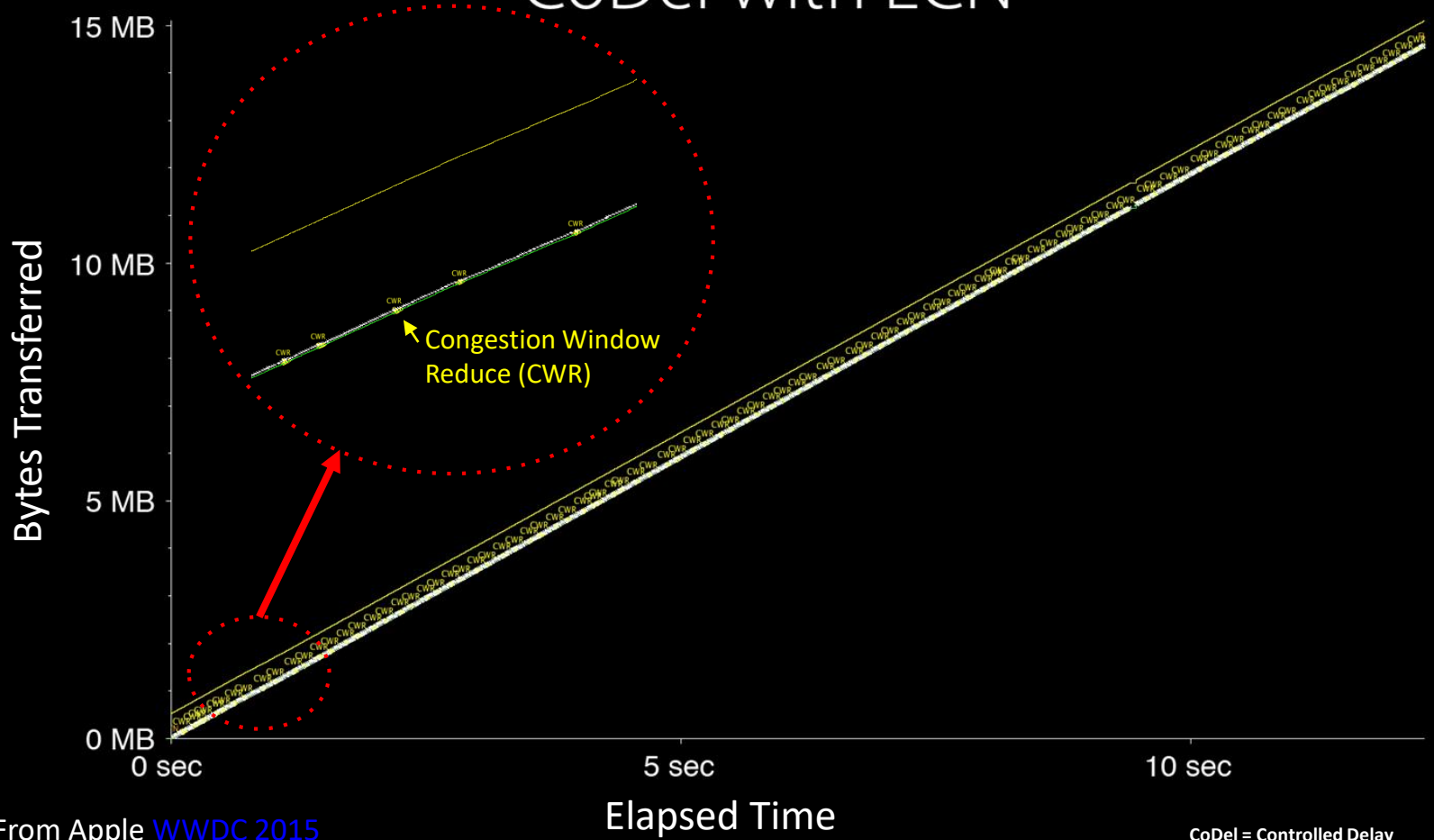
D Receiver echoes congestion experienced CE to sender

From: NetEye (https://www.neteye-blog.com/2016/01/explicit-congestion-notification-3/)



From Apple WWDC 2015

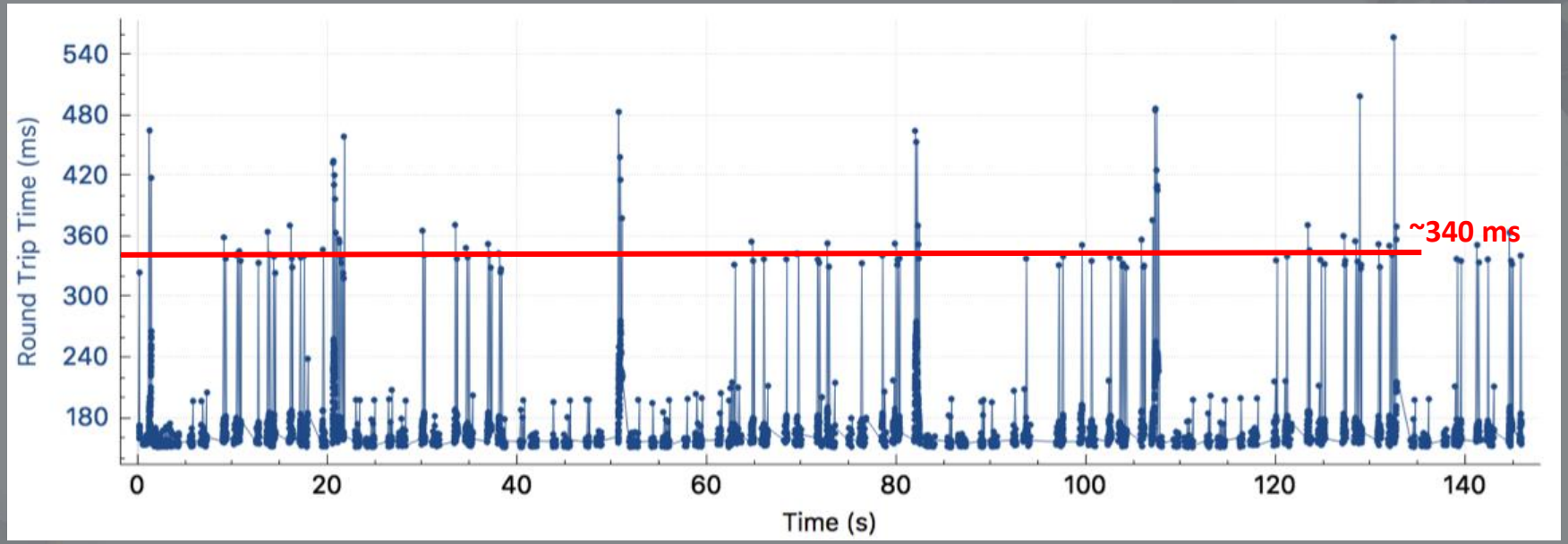
CoDel with ECN



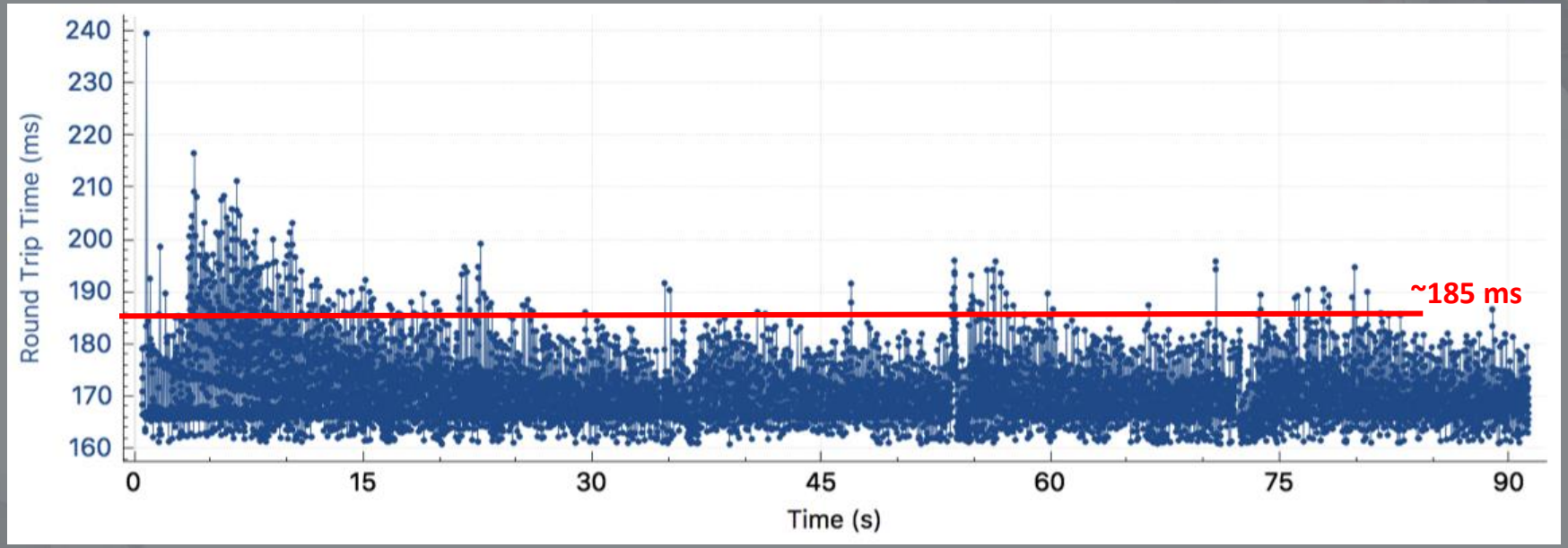
From Apple WWDC 2015

CoDel = Controlled Delay

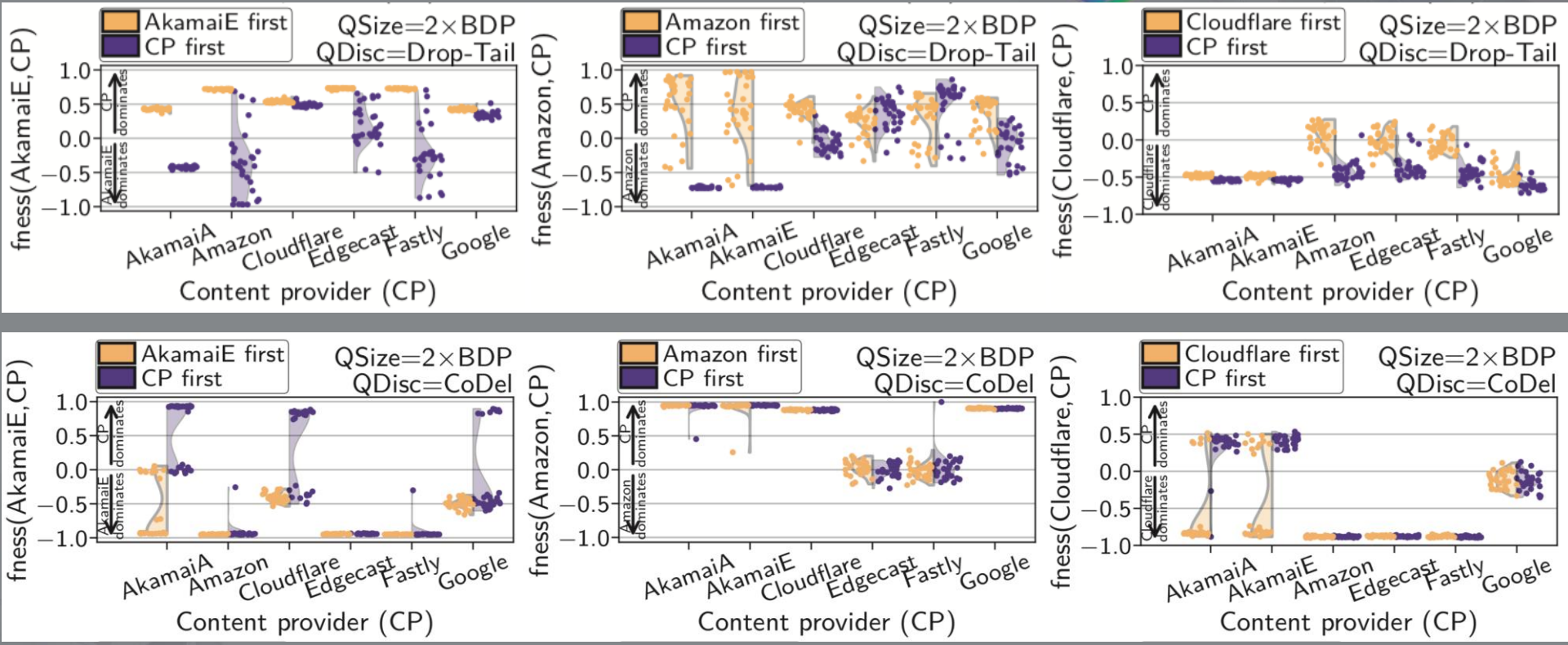
Latency Without ECN



Latency With ECN



AQM with CoDel



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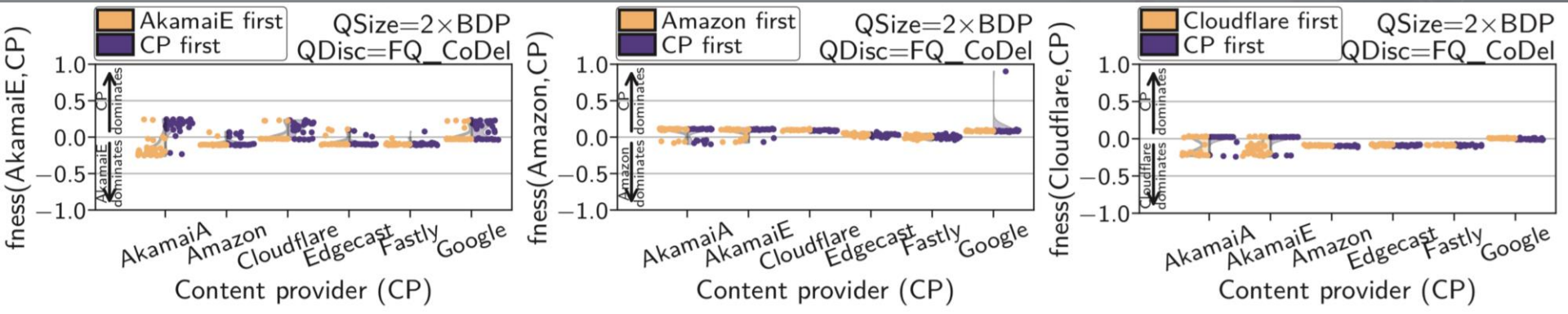
AQM With FQ_CoDel



Fair queuing ensures that TCP flows are serviced equally.

Key takeaways:

1) Bandwidth fairness is close
2) Aggressive congestion control algorithms are reigned in.

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Conclusion

Adaptive Queue Management (AQM) is important for:

1. Bandwidth equality
2. Low latency via reduction in bufferbloat
3. A better Internet experience overall

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Thank you

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