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Confucius Queue Management

Adapting Home Routers to Congestion Control's Reactions for Consistent Low Latency

draft-zhang-iccrg-confucius

Bochun Zhang and Zili Meng

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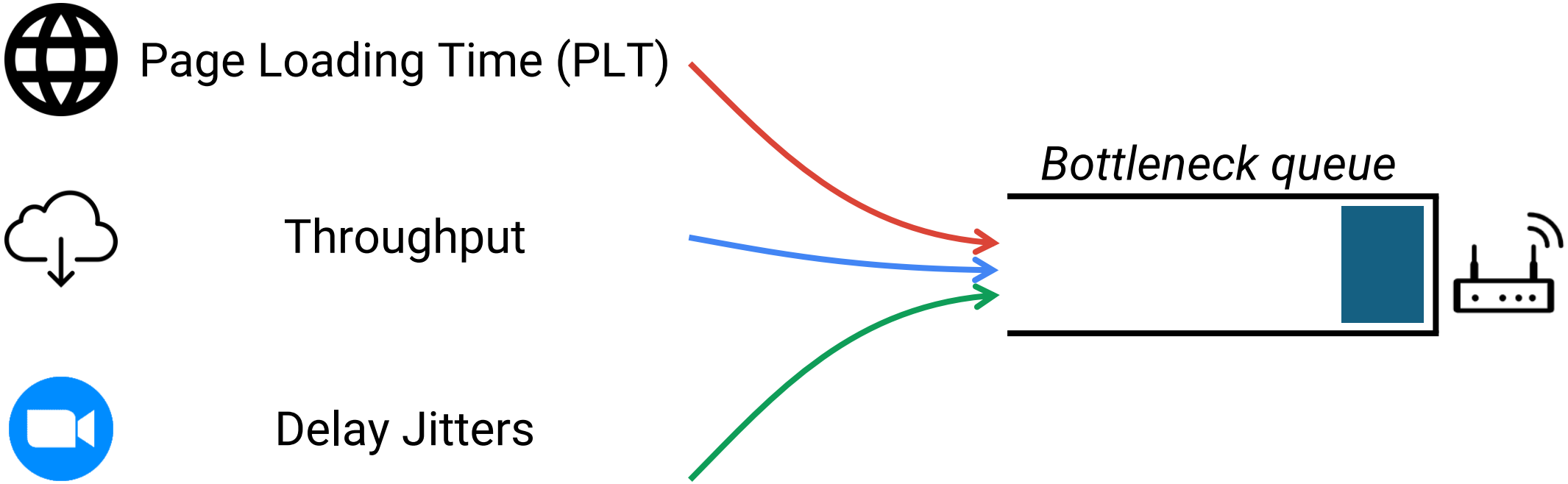
Background

- Flows have different objectives and behaviors.



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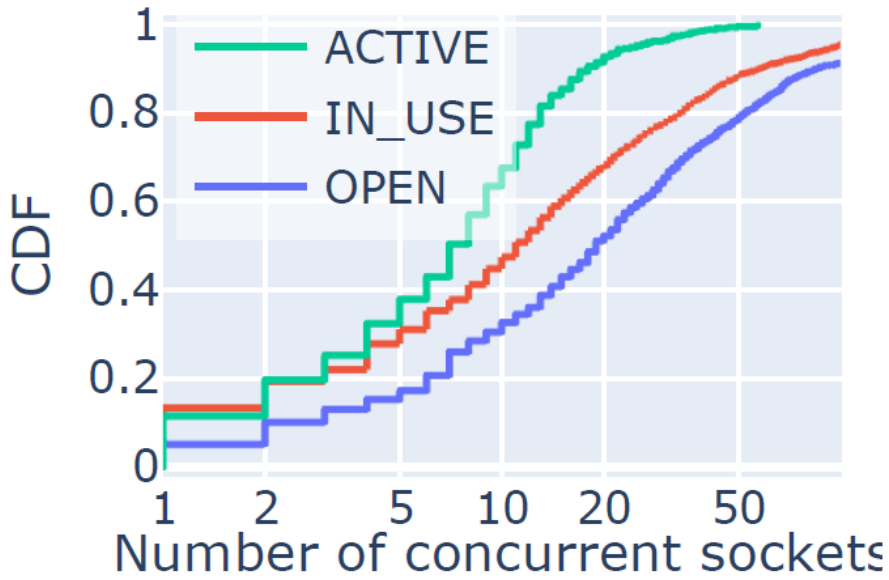
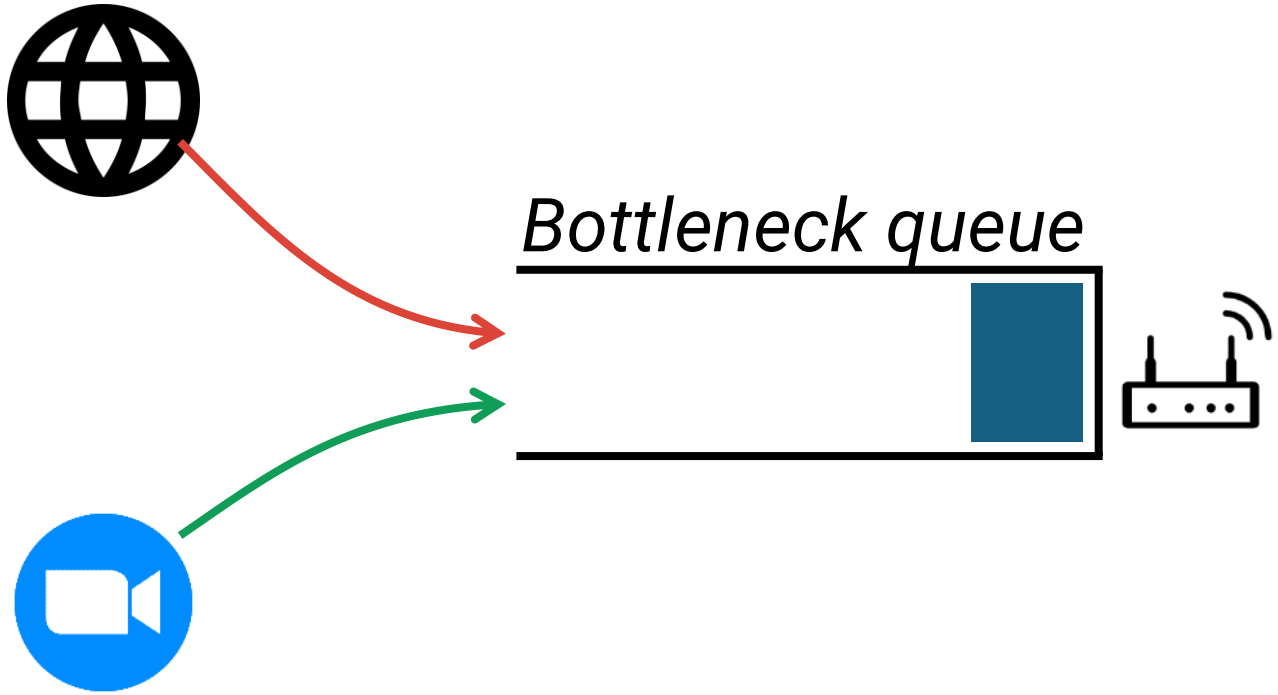
Competing with Bursty Traffic

- Some flows (e.g., Web flows) can be extremely bursty.
- 8 active flows in the median in the Alexa Top 1000 websites.



Script (>100 KB):
edge.permutive.app, imasdk.googleapis.com, z.moatads.com, securepubads.g.doubleclick.net, assets.bounceexchange.com, cdn.doubleverify.com, www.googletagmanager.com

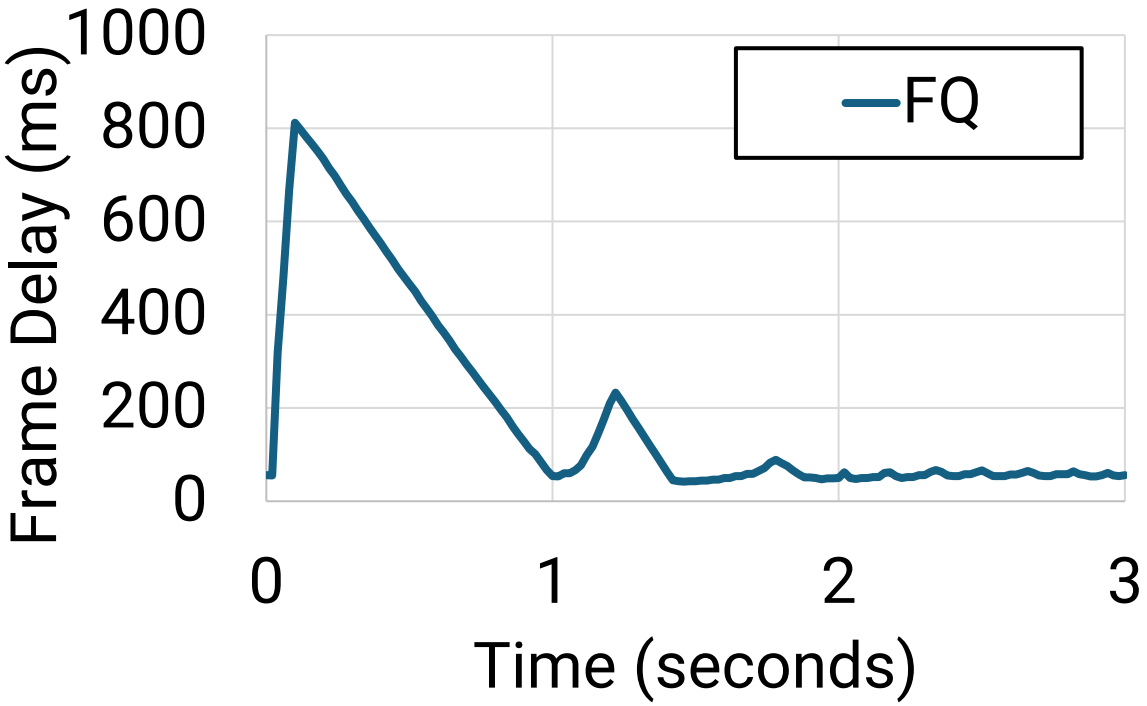
Motivating Example

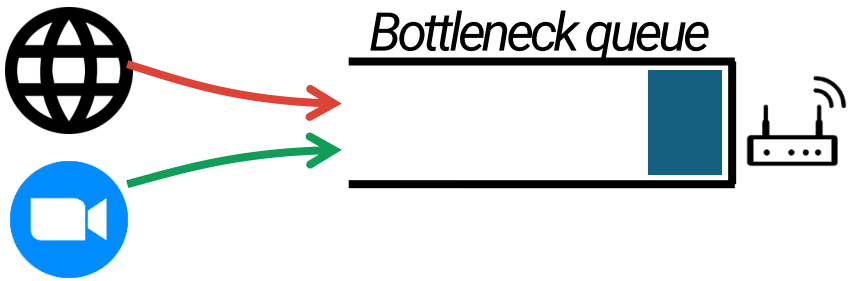


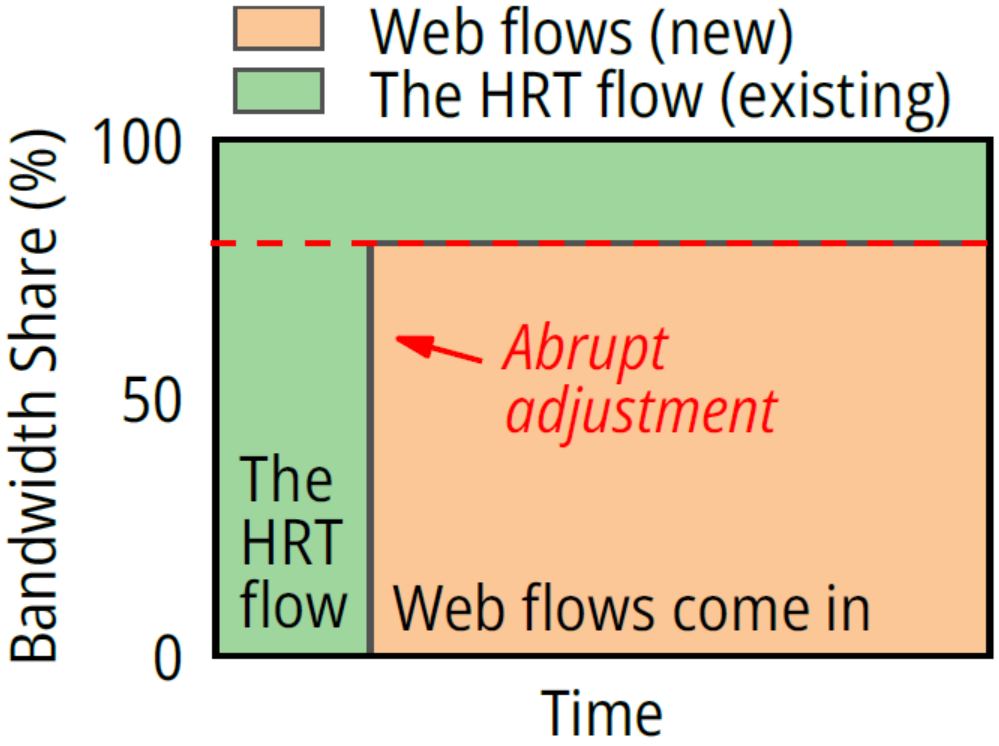
Interactive streaming flows, such as videoconferencing, are both heavy and real-time (HRT).

Motivating Example

Volatile: Web flows will degrade video flows.



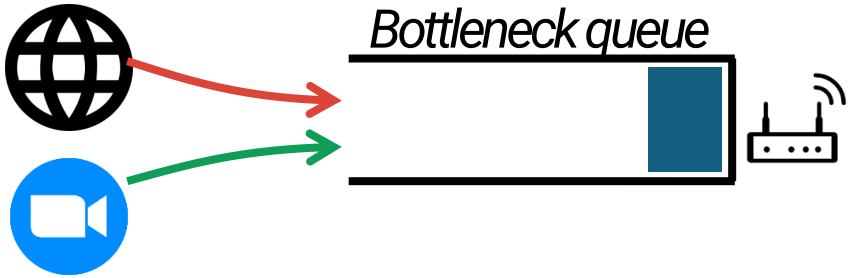


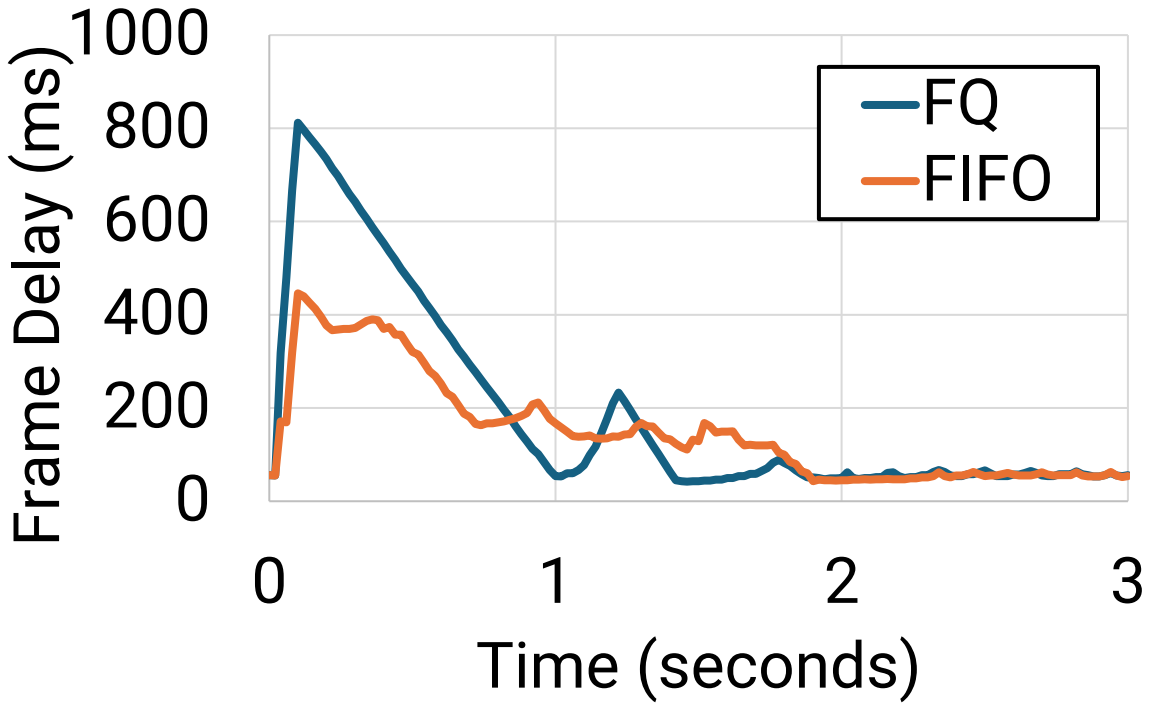


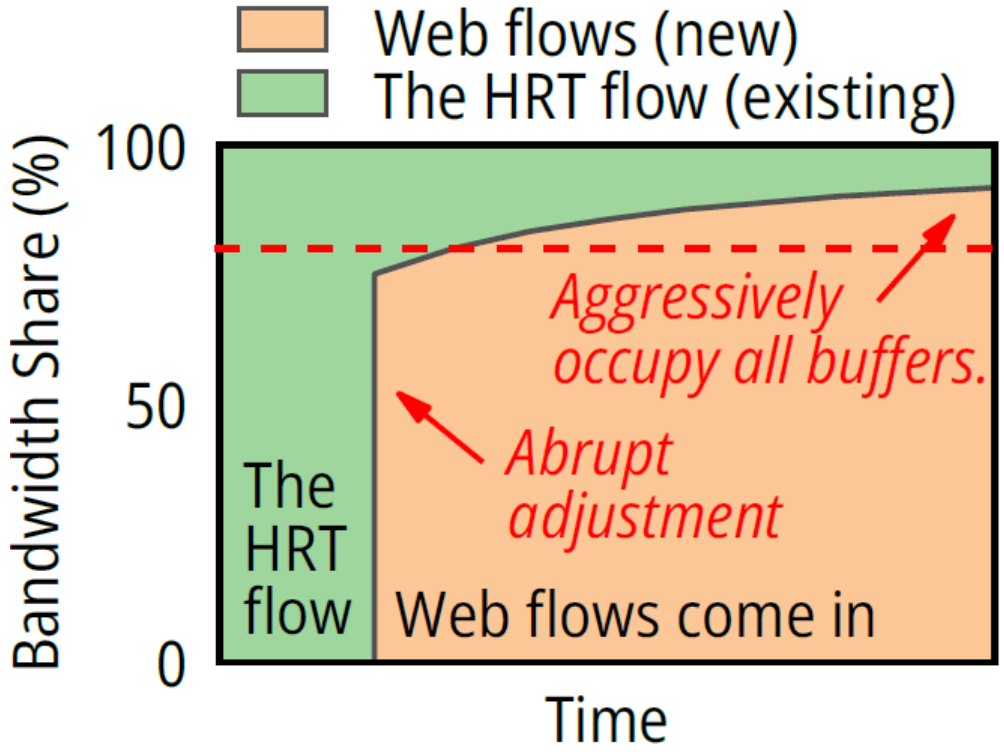
Motivating Example

Volatile: Web flows will degrade video flows.

Unfair: Web or HRT flows far from fair share.







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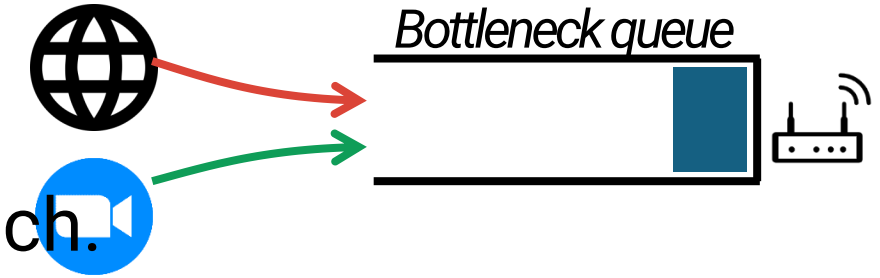
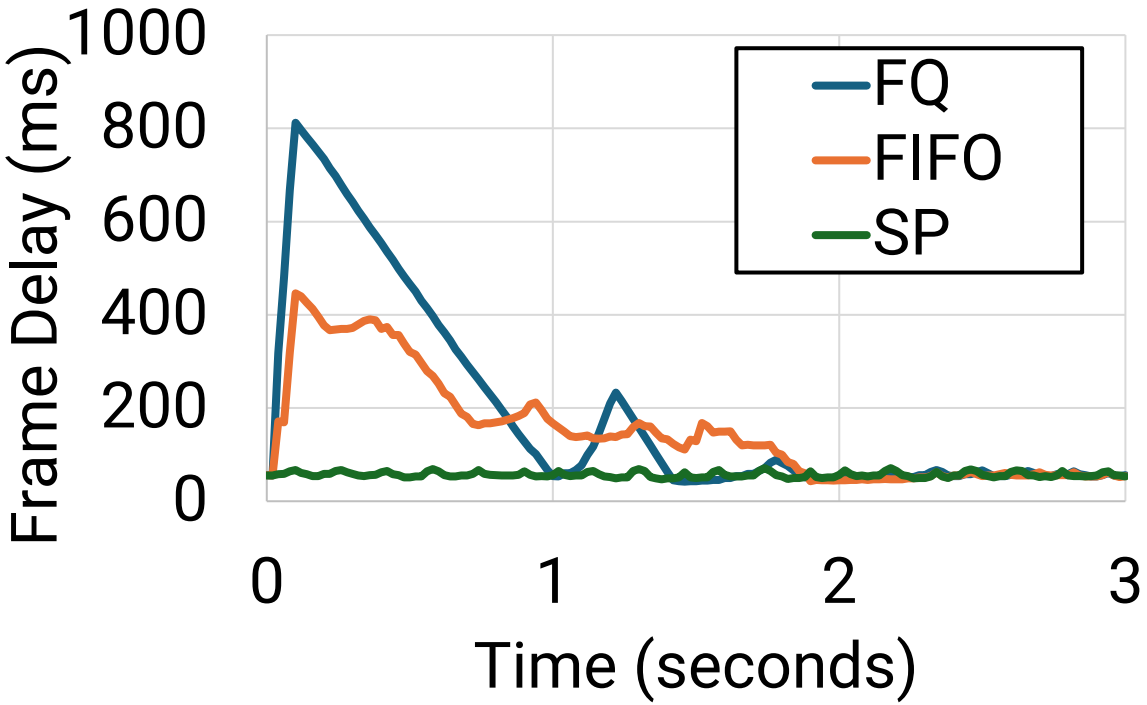
Motivating Example

Volatile: Web flows will degrade video flows.

Unfair: Web or HRT flows far from fair share.

Impractical: Routers cannot know which is which.



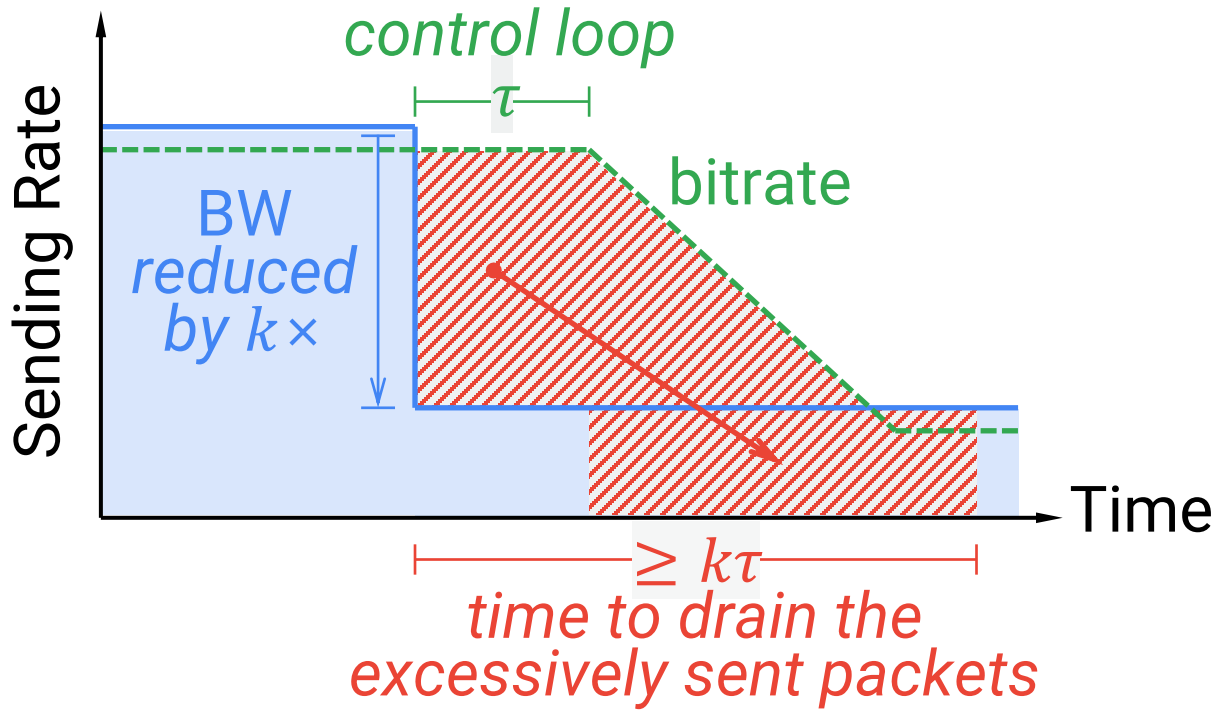


But the page loading time is 113% more than FQ!

Tame Volatility & Achieve Fairness

- Two root causes of delay degradation:

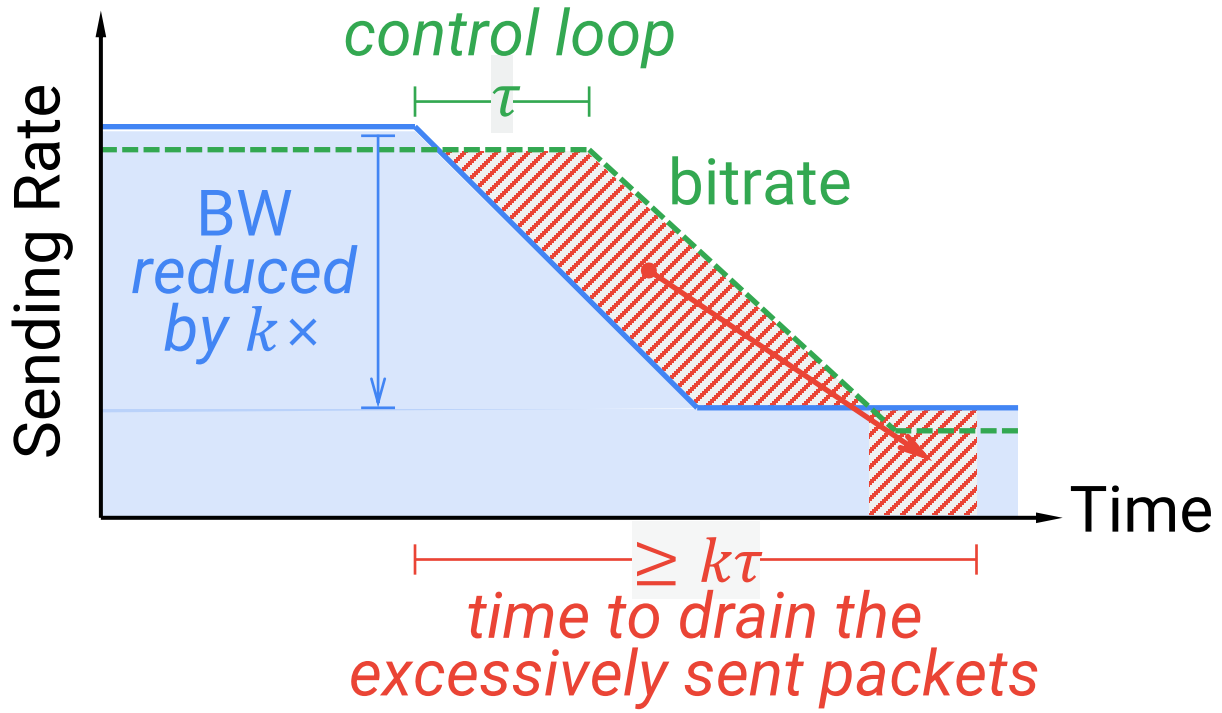
1. The sender needs some time to react.
   - Feedback loop (RTT)
   - **Responsiveness (CCA)**
2. The excessively sent packets need to be drained.
   - Scheduling policy



Tame Volatility & Achieve Fairness

- Reducing the available bandwidth gently will help.

Intuitively, drain more packets at the beginning and give CCAs some time to react!



Confucius Algorithm

- Deficit Weighted Round Robin (DWRR)

- When the new flows join the competition, instead of directly setting its weight to 1, we gradually increase its weight from $\frac{1}{\mathcal{F}_{new}}$ to 1

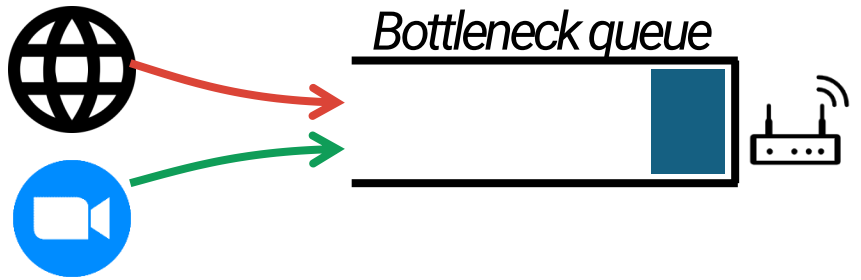
Algorithm 1: Reweight: run every $1/\lambda$ ms.

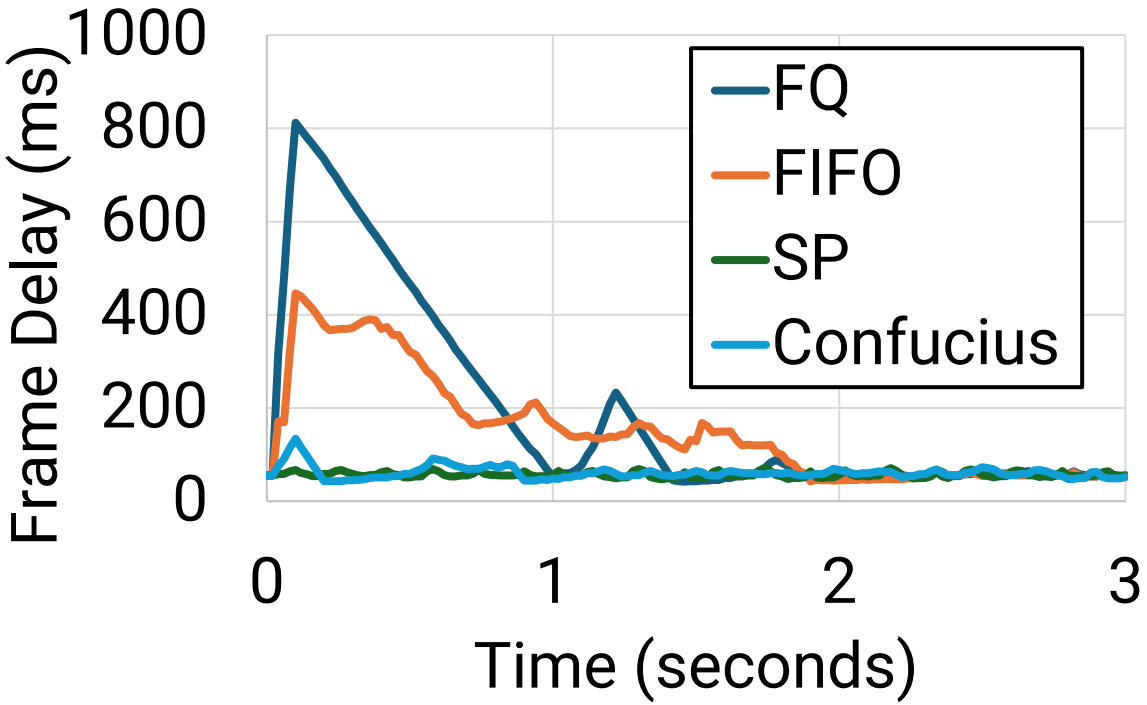
```
1  Reweight ()
2      foreach f ∈ F_new do
3          w_f ← 2w_f // The weight doubles every 1/λ ms
4      ratio = (Σ_{i∈F_new} w_i) / (Σ_{i∈(F_all − F_new)} w_i)
5      if ratio < 1 then // New flows are the minority
6          foreach f ∈ F_new do
7              w_f ← w_f/ratio
8      foreach f ∈ F_new do
9          if w_f ≥ 1 then // The new flow is old enough
10             F_new ← F_new − {f}
11             w_f ← 1
```

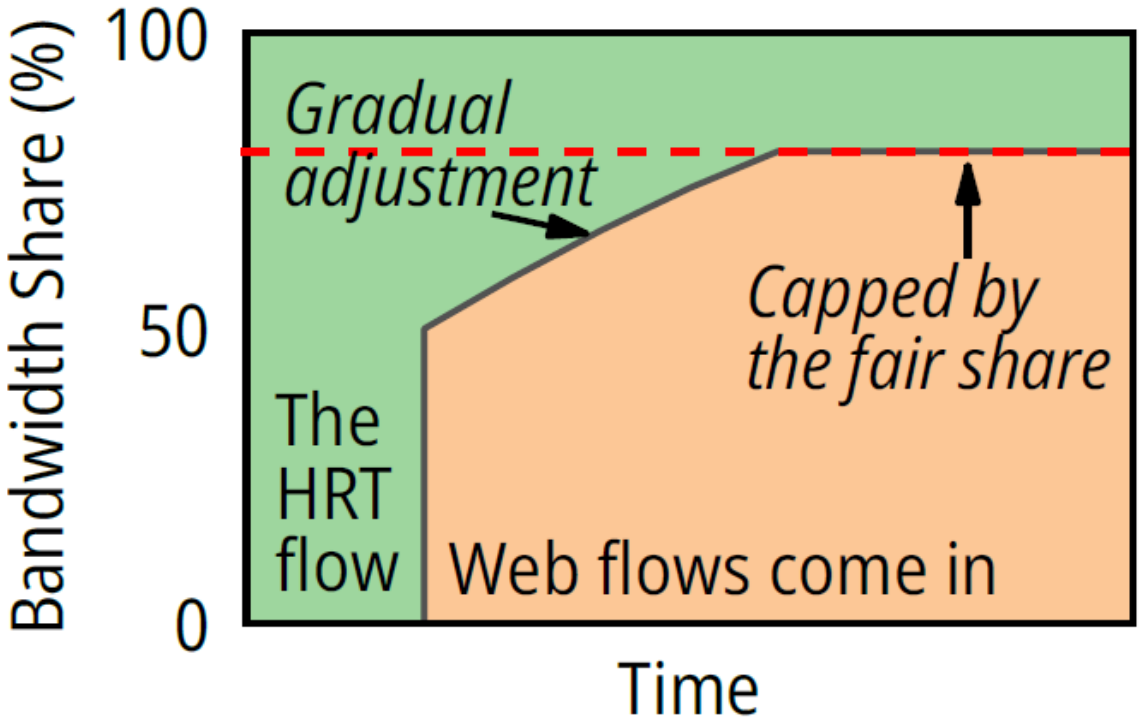
Smooth Queue Management

Reducing the bandwidth *gently* will help.

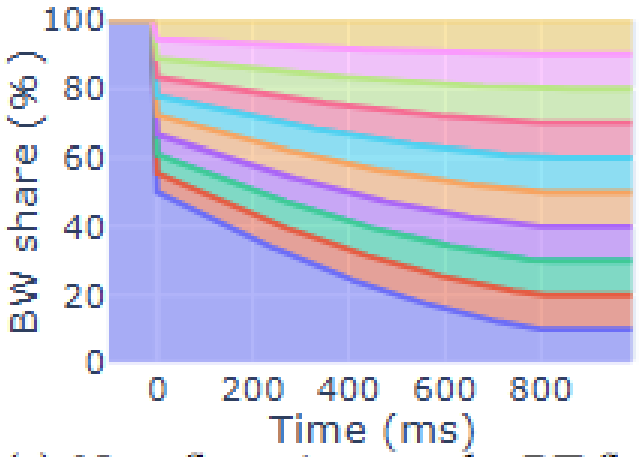
Intuitively, drain more packets at the beginning and give CCAs some time to react!



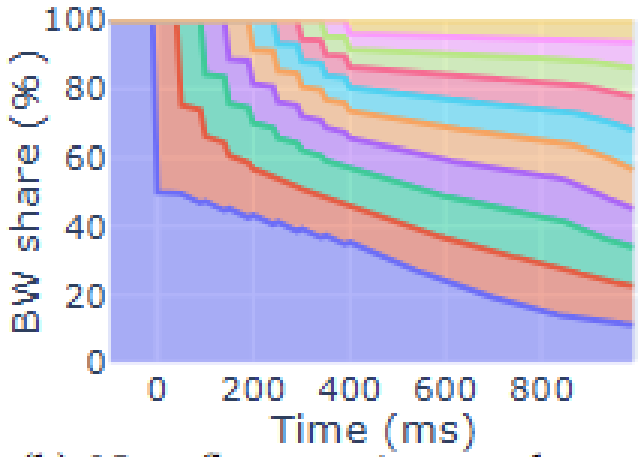




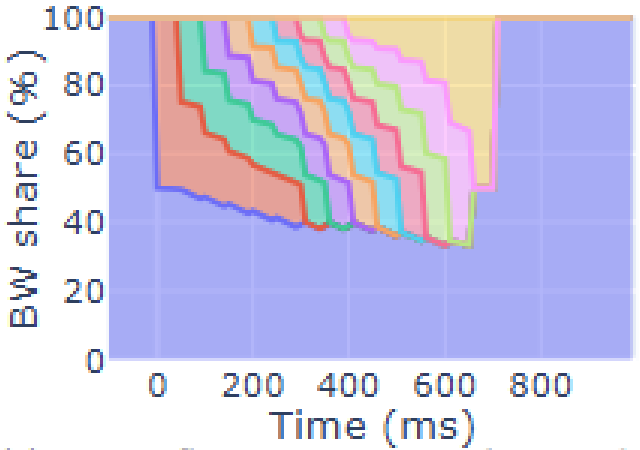
Examples of Confucius



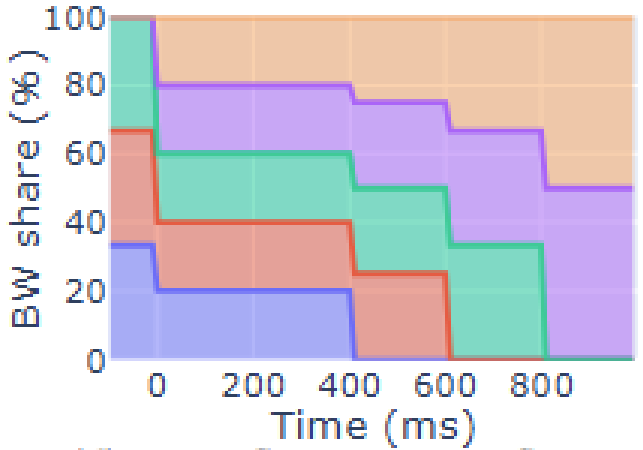
(a) New flows impact the RT flow.



(b) New flows arrive one by one.



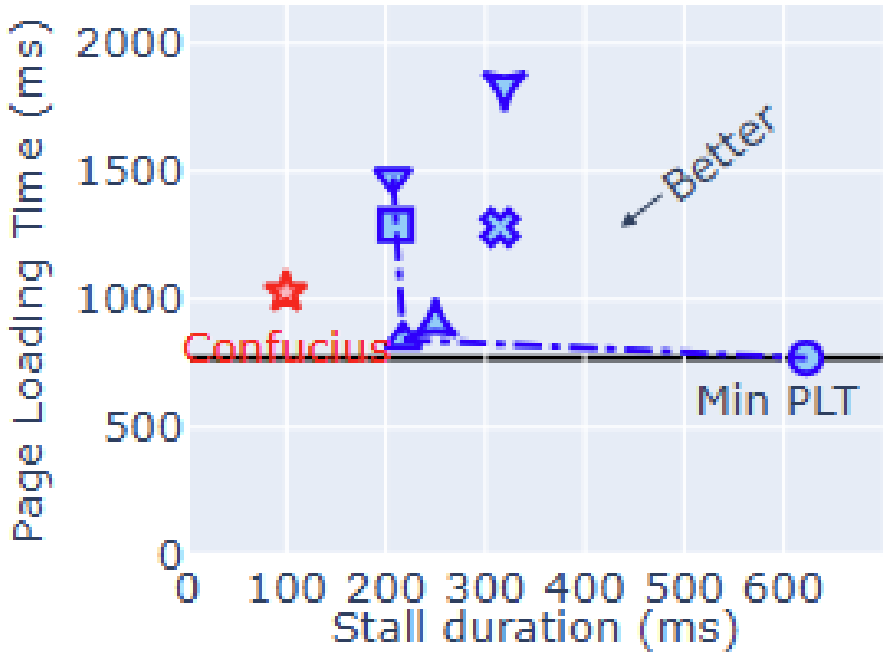
(c) New flows arrive and complete.



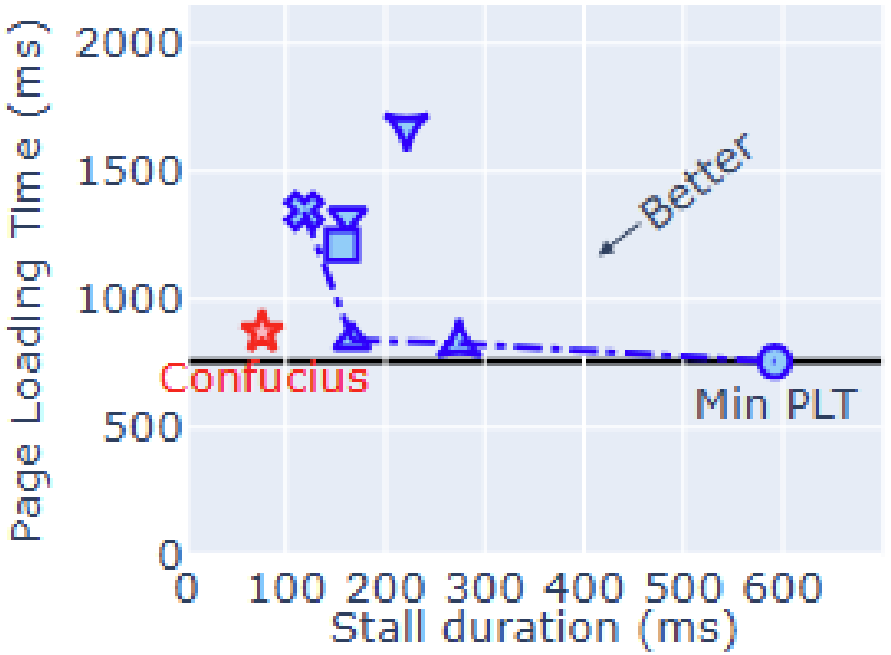
(d) New flows are RT flows.

Evaluation

- ns-3 simulation (over 2000 websites and 5 bandwidth datasets)



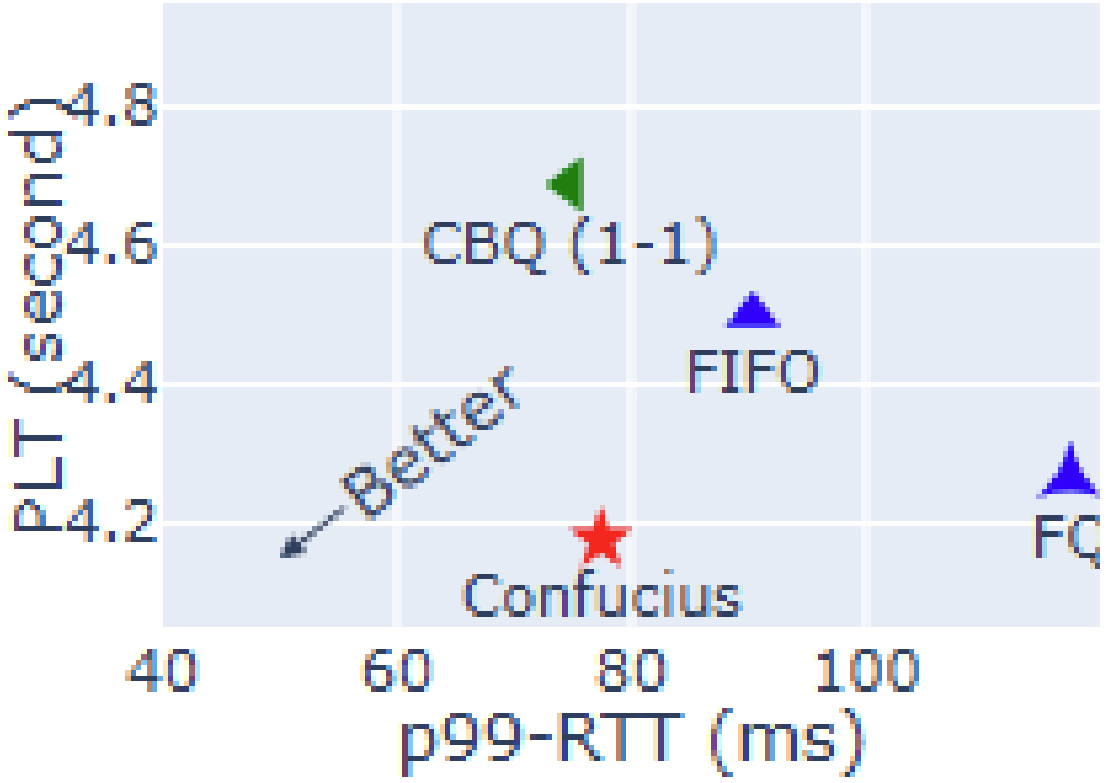
(a) When the RT flow uses Copa.



(b) When the RT flow uses GCC.

Evaluation

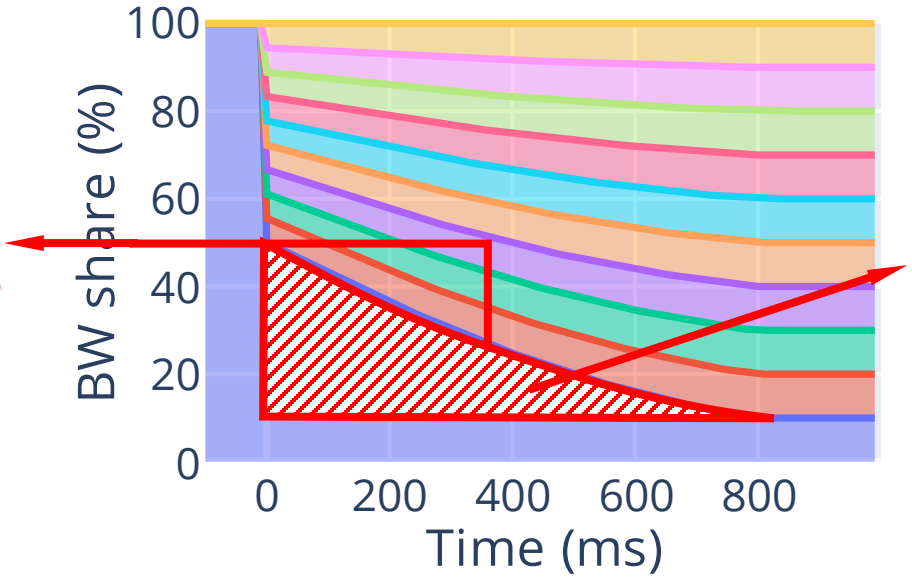
- Linux kernel implementation over OpenWrt



Theoretical features

- The amount of jammed traffic is theoretically bounded.
  - No matter how many and how long the competing flows are.

The exponential decrease follows how CCAs reduce their rates. This bounds the delay degradation.



The area (integral) under an exponential curve is bounded for any time. This bounds the FCT degradation.

Thank you!

Questions? Comments?

More information at: draft-zhang-iccrg-confucius