Principles for Internet Congestion Management

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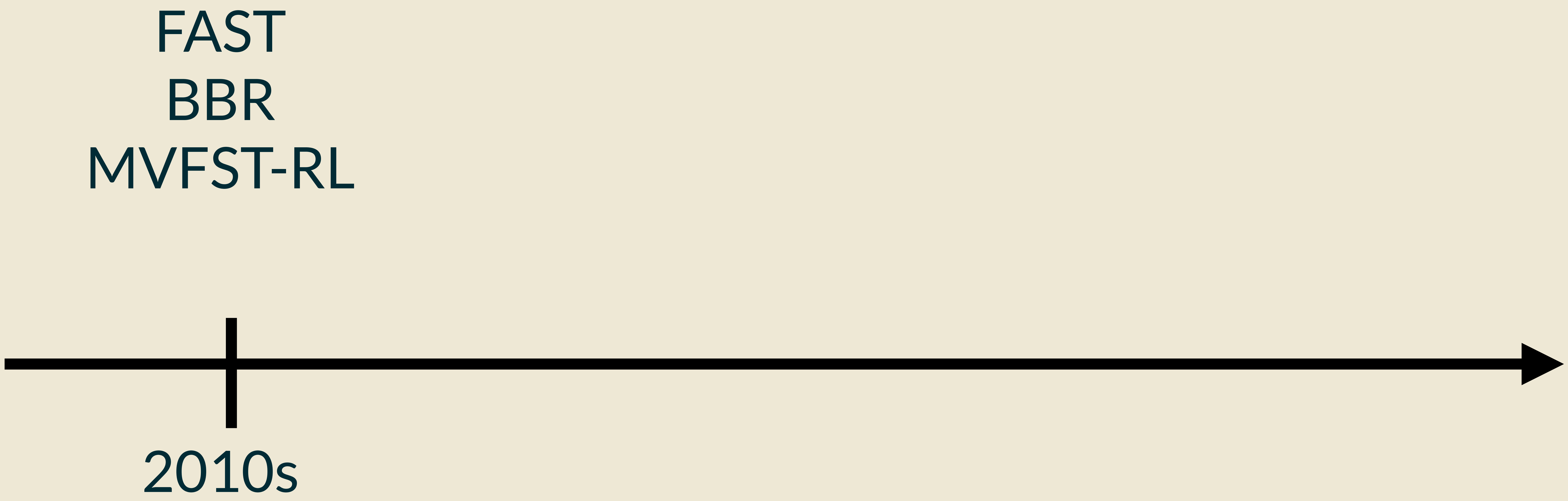
Congestion Control Today: A Wild West



Congestion Control Today: A Wild West

FAST
BBR
MVFST-RL

Researchers raise
fairness concerns

2010s

2018-

TCP Friendliness (TCPF)
concerns clearly did not prevent
new algorithms' deployment

Goal: Congestion Control Algorithm Independence (CCAI)

A stream's throughput should not depend on its choice of congestion control algorithm (CCA), relative to others' choices.

CCAI impact on congestion control design

Congestion control design concerns:

- Discovering available bandwidth
- Minimizing delay
- Ensuring fairness

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- Discovering available bandwidth
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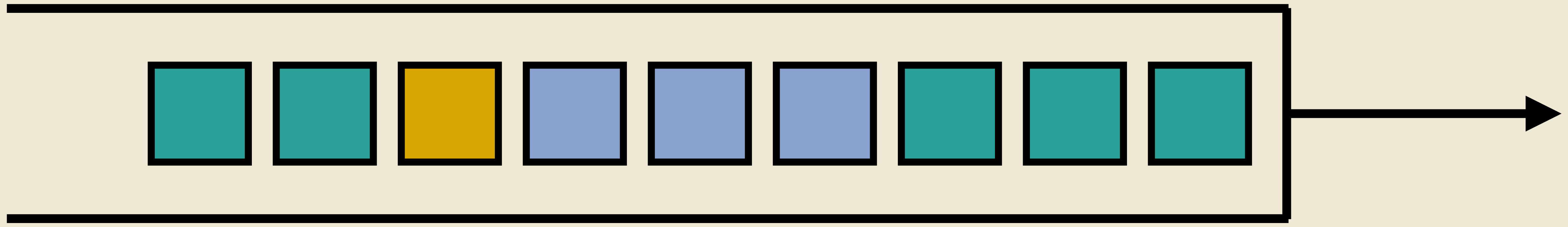
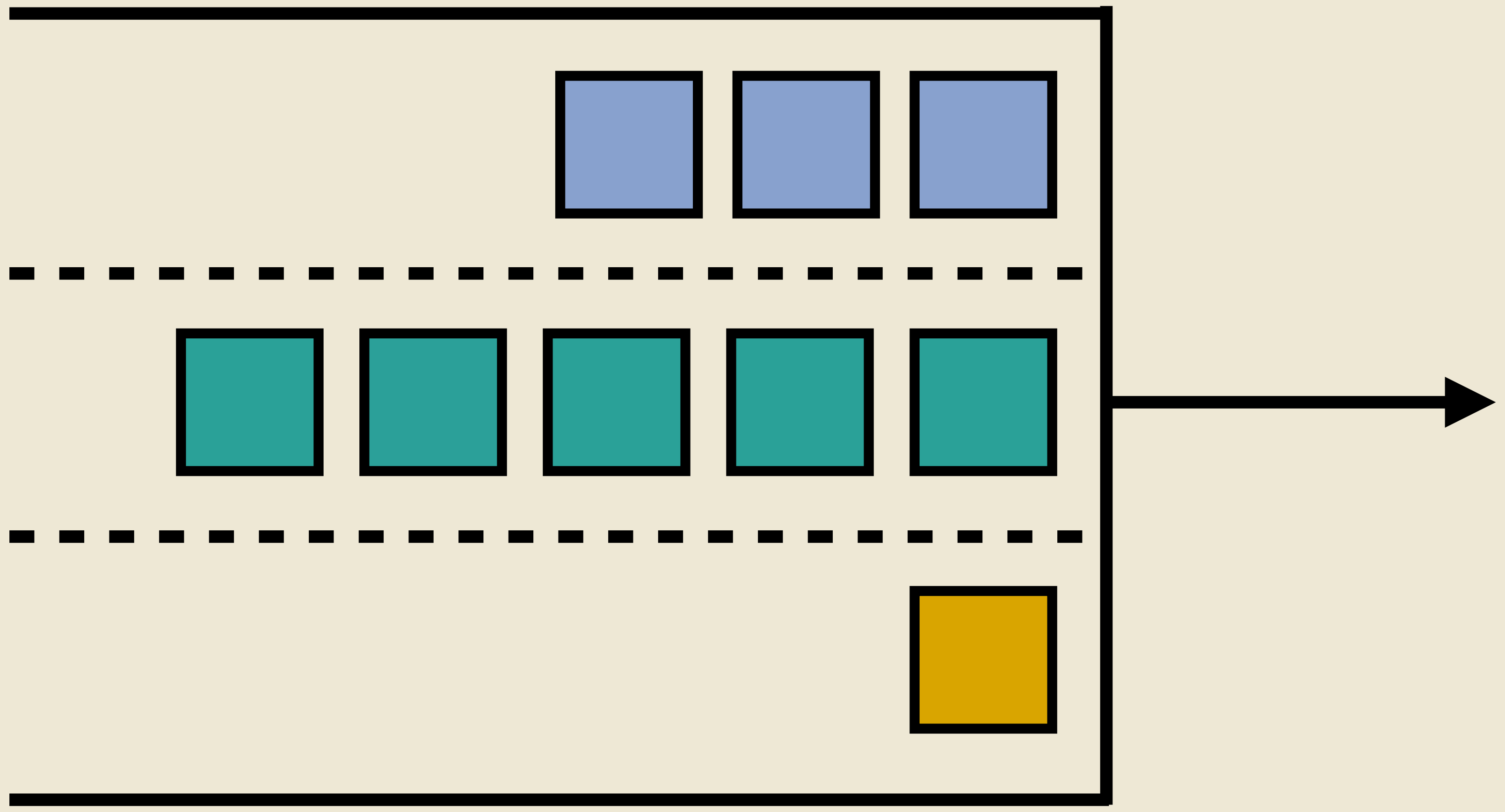
- ~~Ensuring fairness~~

CCAI allows CCA designs to focus on bandwidth-latency tradeoff

Simplest path to CCAI: isolation

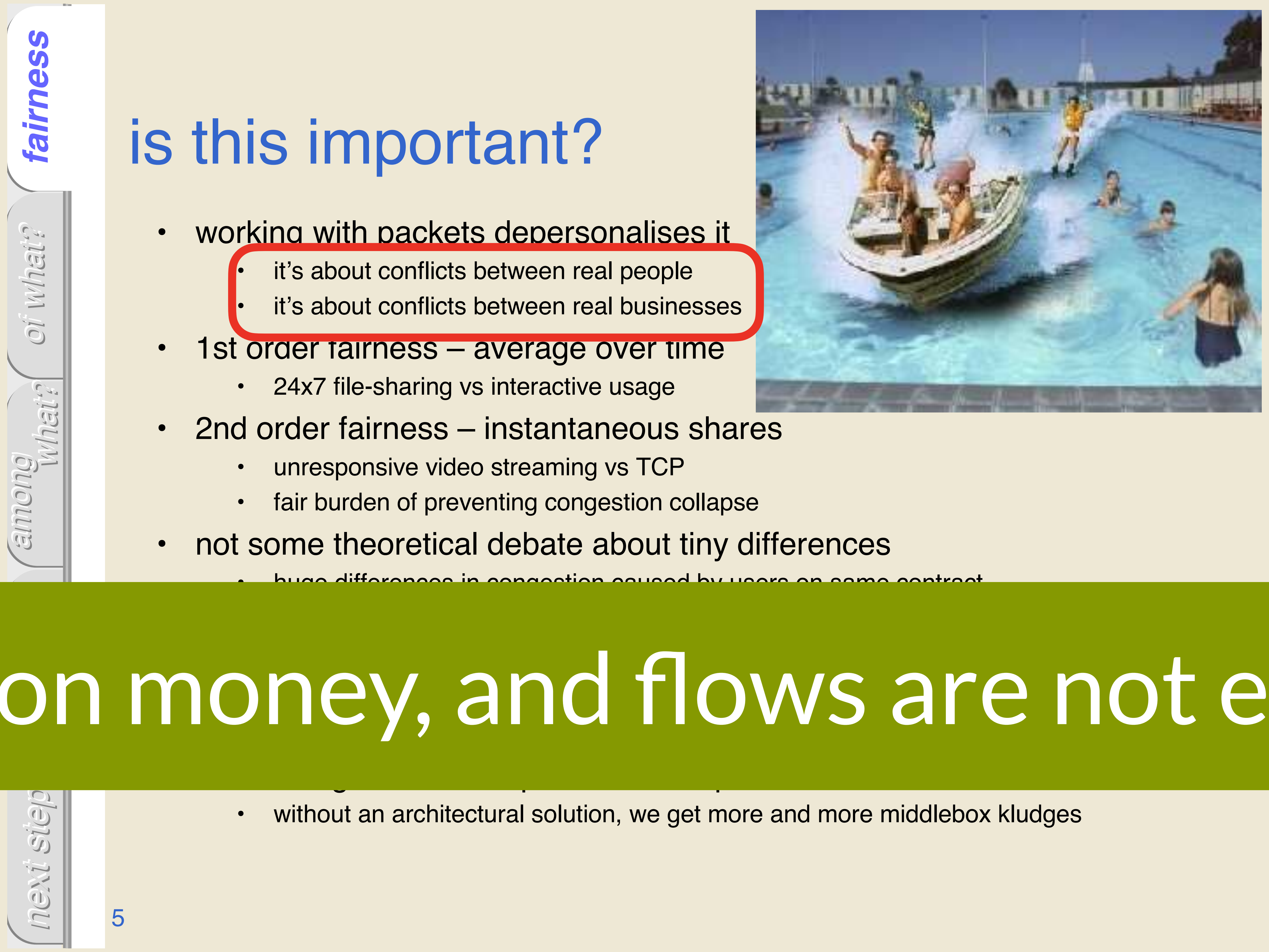


Traditional FIFO queues:
No isolation, no CCAI



Fair queueing:
Flow isolation, CCAI

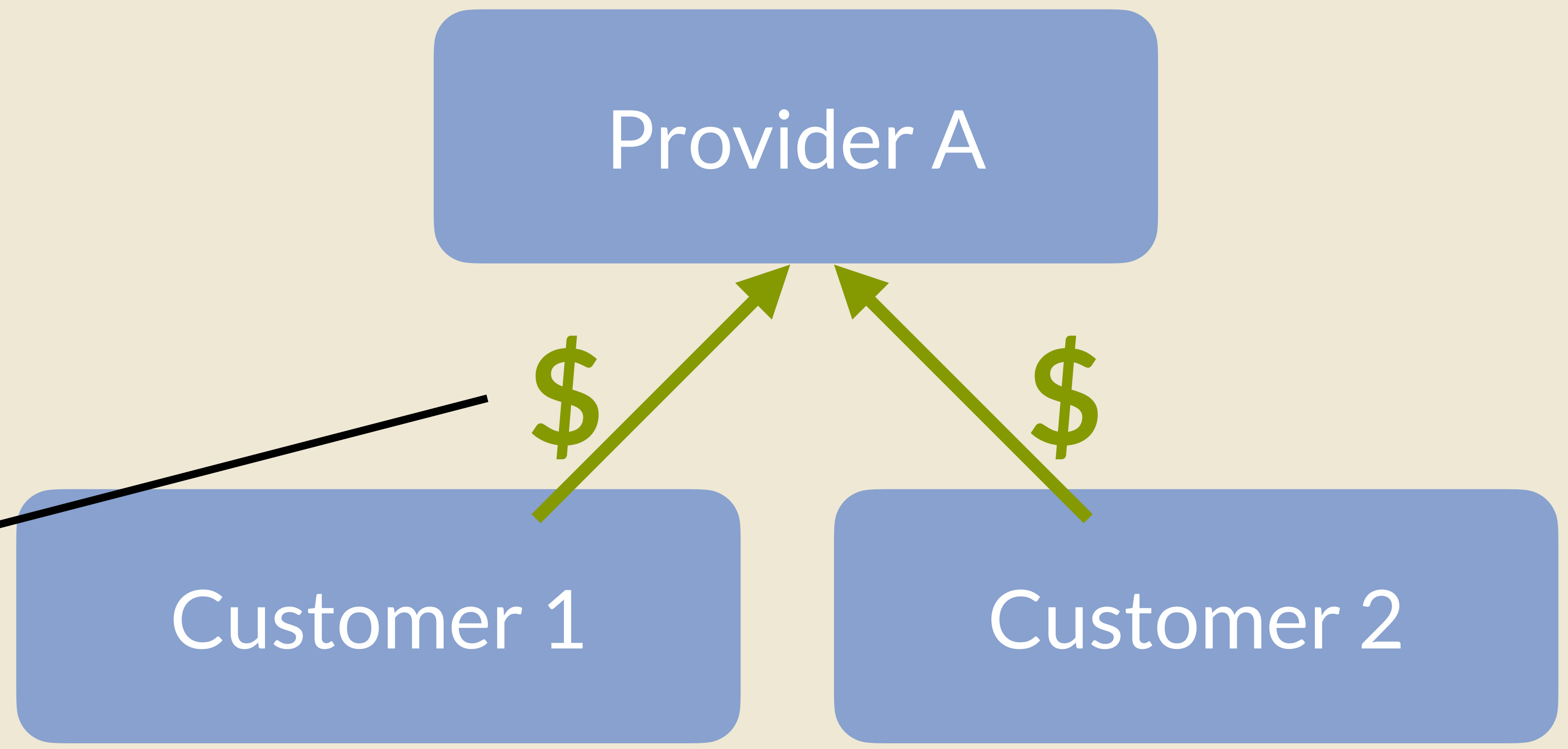
Fair queueing: not consistent with Internet economics



Internet runs on money, and flows are not economic units

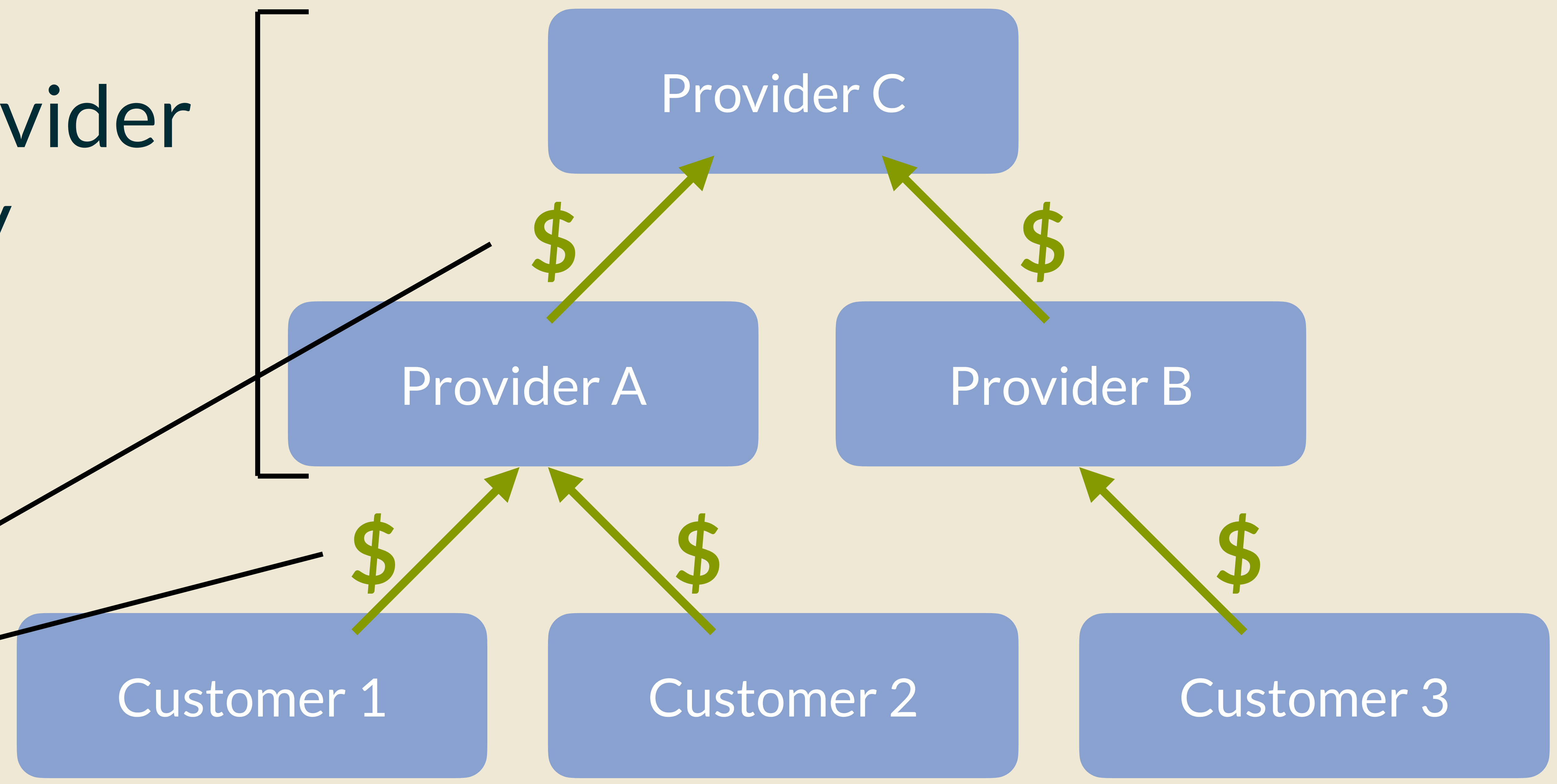
"Flow Rate Fairness: Dismantling a Religion" -Bob Briscoe, IETF 2007

Internet economics: based on recursive access



Pay for **access**

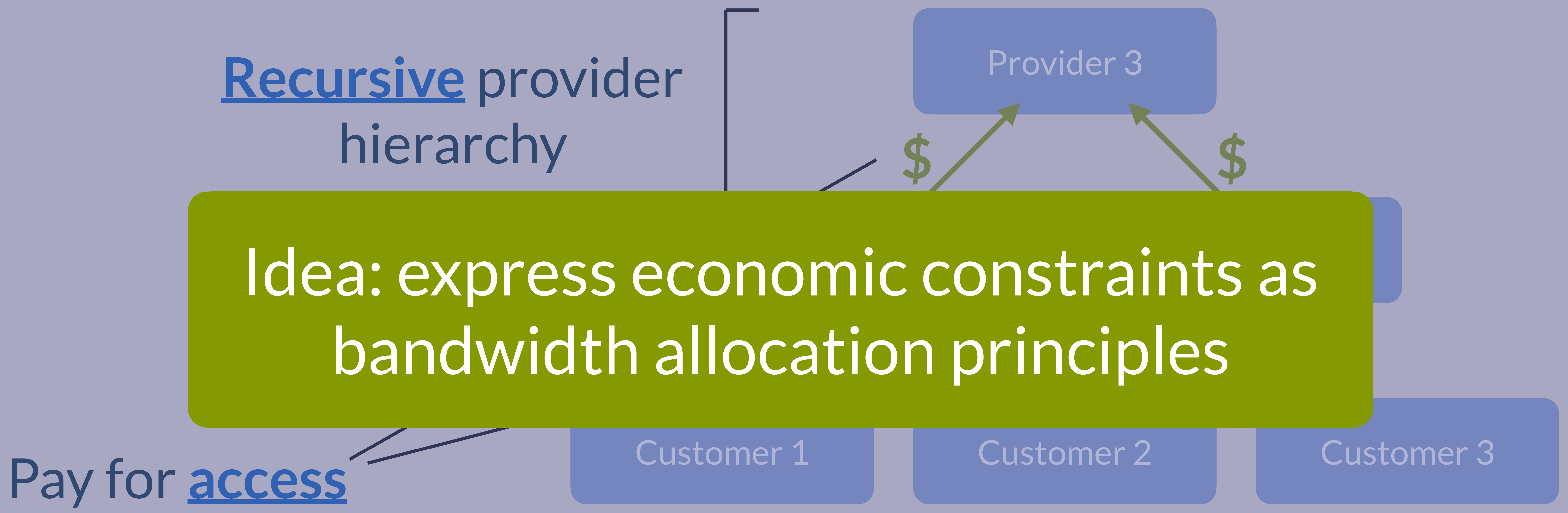
Internet economics: based on recursive access



Recursive provider hierarchy

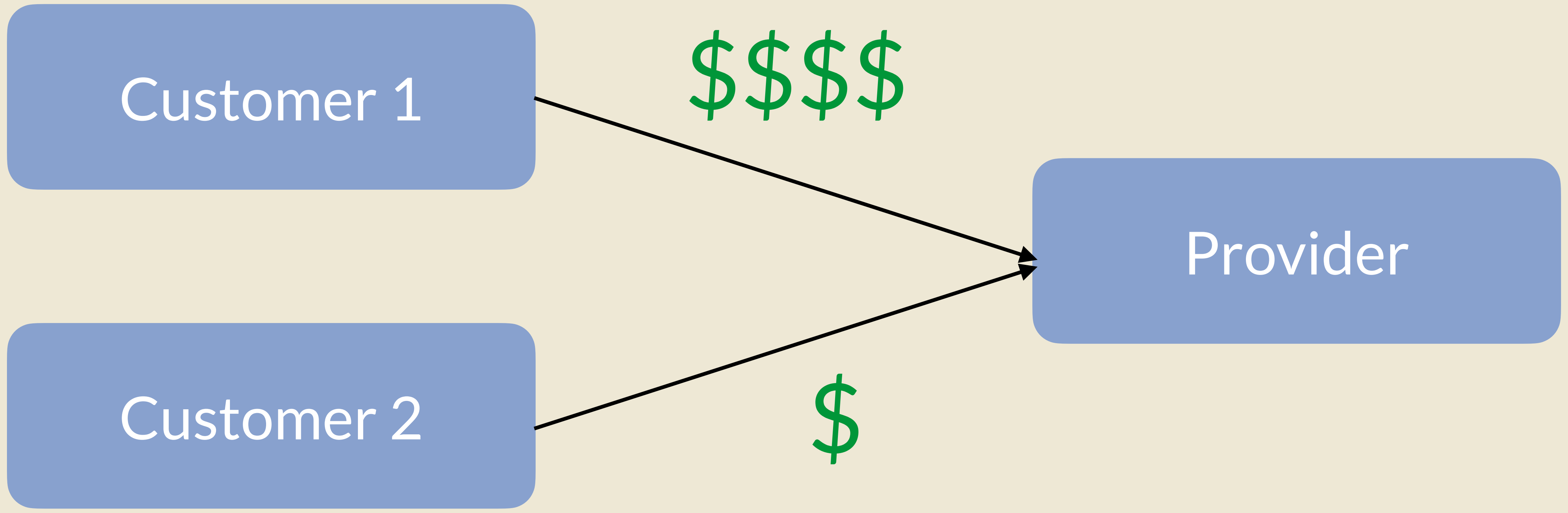
Pay for access

Principles for a bandwidth allocation framework



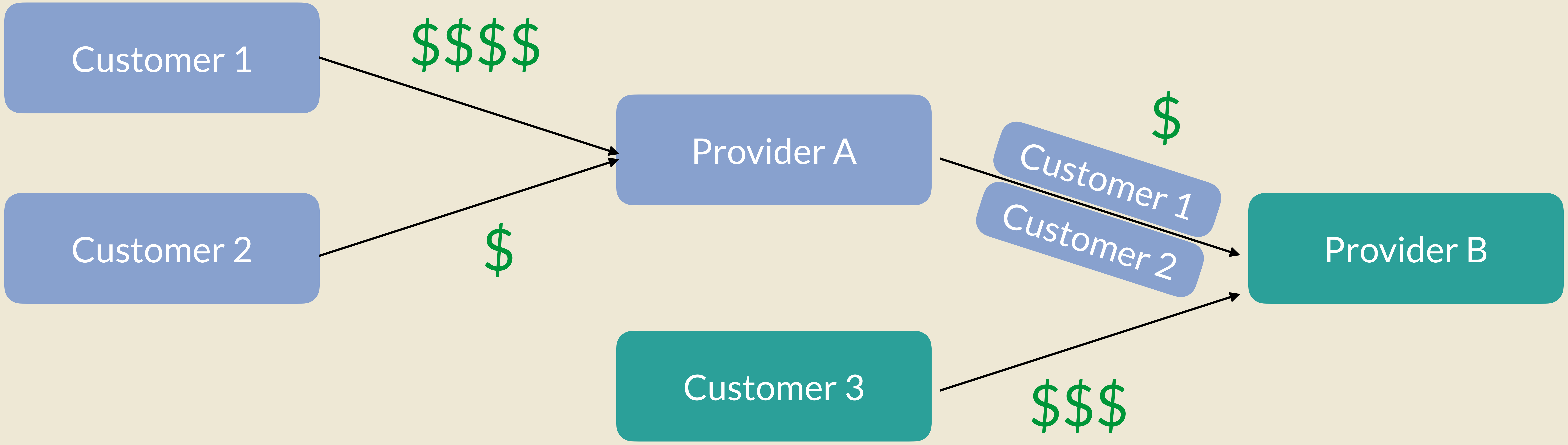
Idea: express economic constraints as bandwidth allocation principles

1: Relative rights



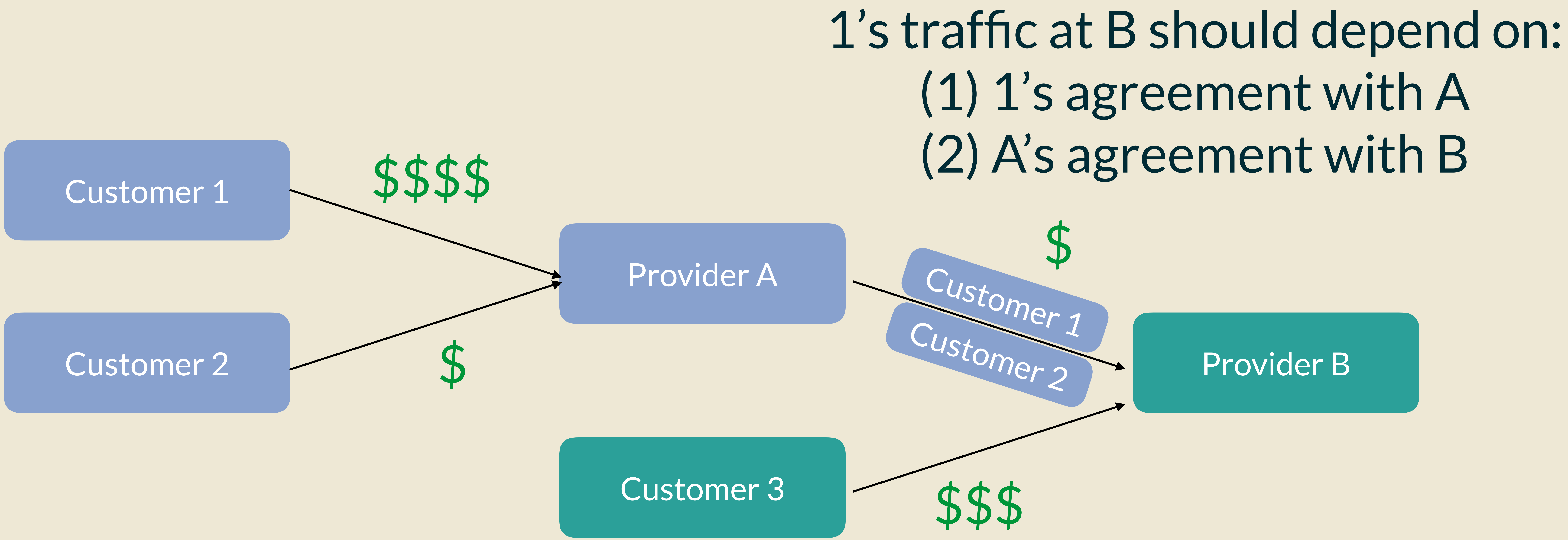
When there is congestion, allocate more bandwidth to higher-paying customers

2: Follow the money



Relative rights should follow traffic through the network

2: Follow the money



Relative rights should follow traffic
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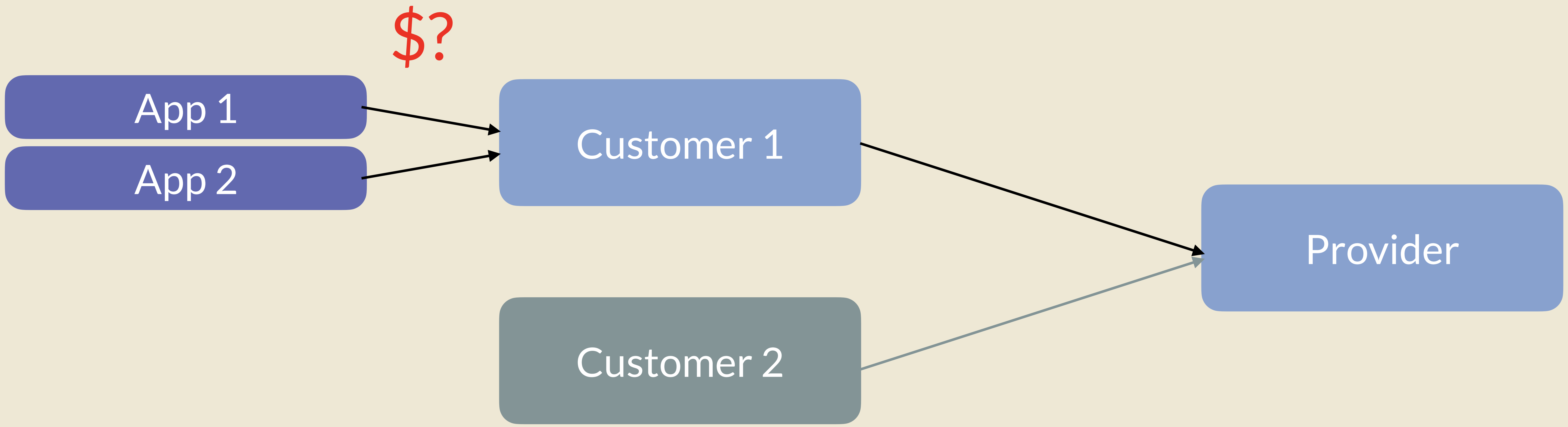
3: Endpoint control



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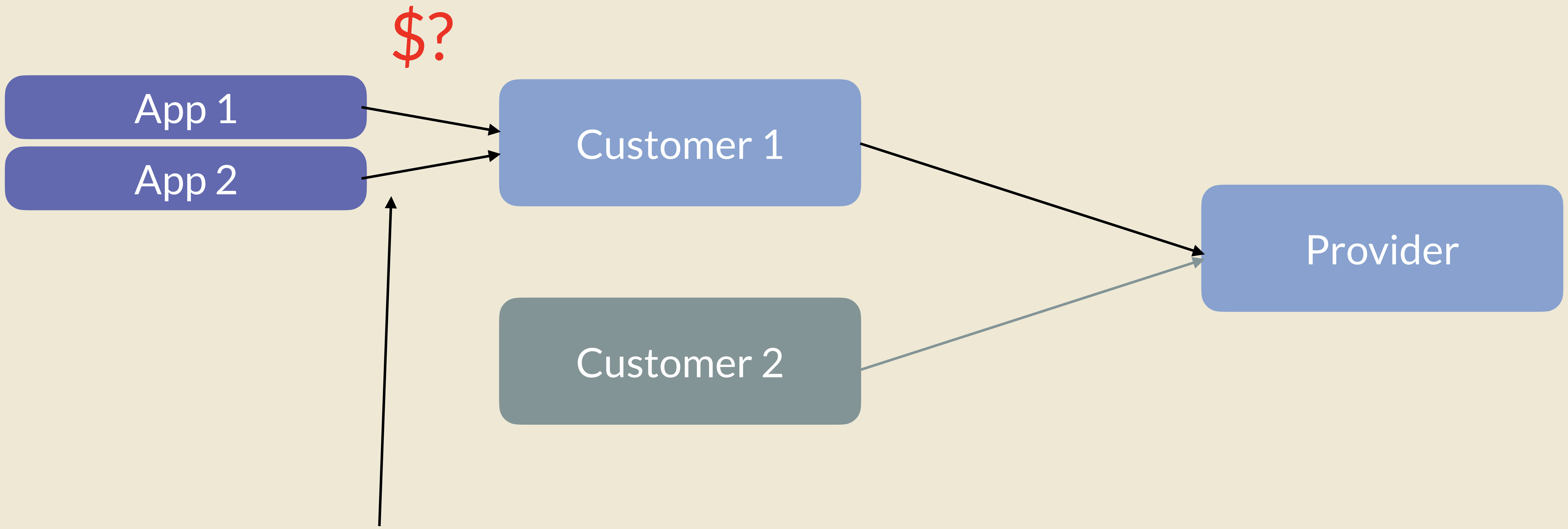
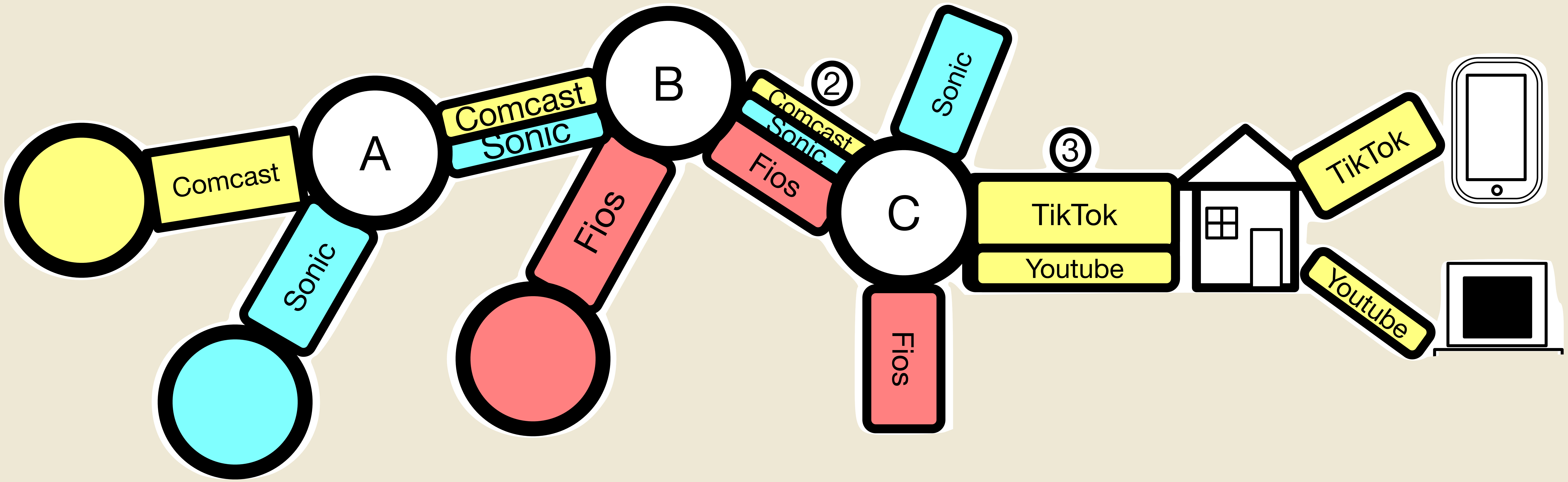


App 1 vs App 2:
Customer 1 decides at endpoints

See paper for discussion of how to achieve this

Our answer: RCS (Recursive Congestion Shares)



Mechanism: similar to HWFQ, but we set the weights carefully!

Evaluation: Does RCS achieve CCAI?

- Q1: Does RCS guarantee CCAI **in all cases**?
  - No, in adversarial cyclical-interaction cases (see paper for example)

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  - Model using game-theory framework

RCS achieves CCAI in most random + realistic topologies

Topology Type	CCAI	No CCAI (possible for CCAs to manipulate allocation)
Random	17,787 (95%)	936 (5%)
CAIDA-Sampled	2,897 (100%)	0 (0%)

Average BW Gain: 0.011%

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- Q3: Do these results apply in practice with real CCAs? Yes
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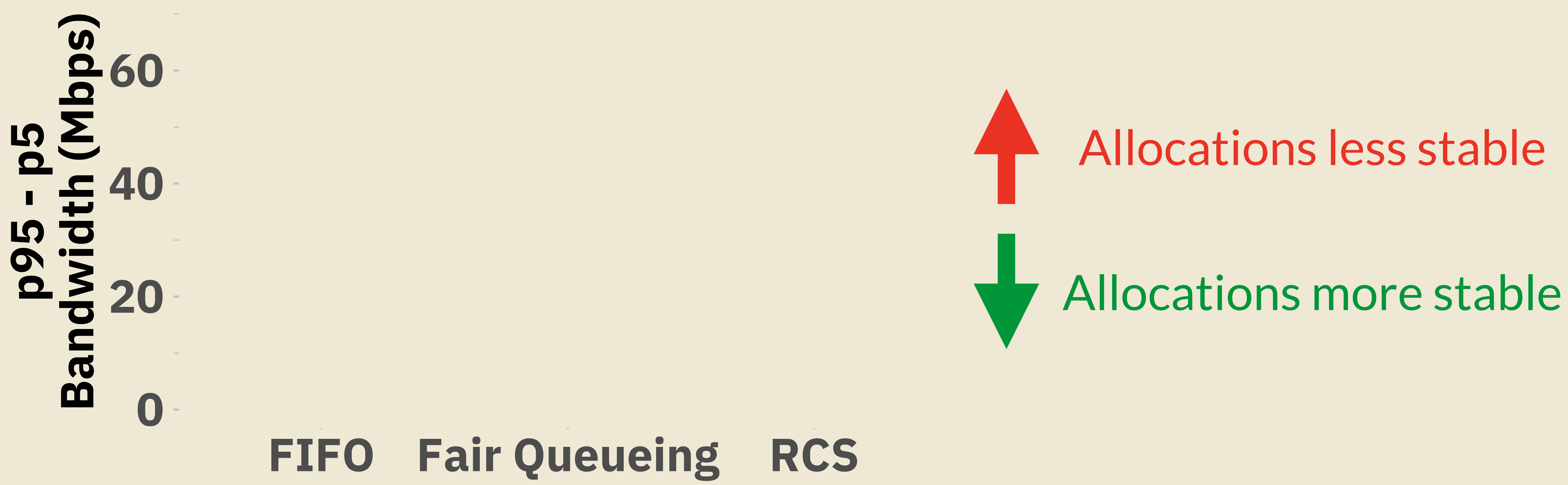
RCS achieves CCAI with today's real CCAs

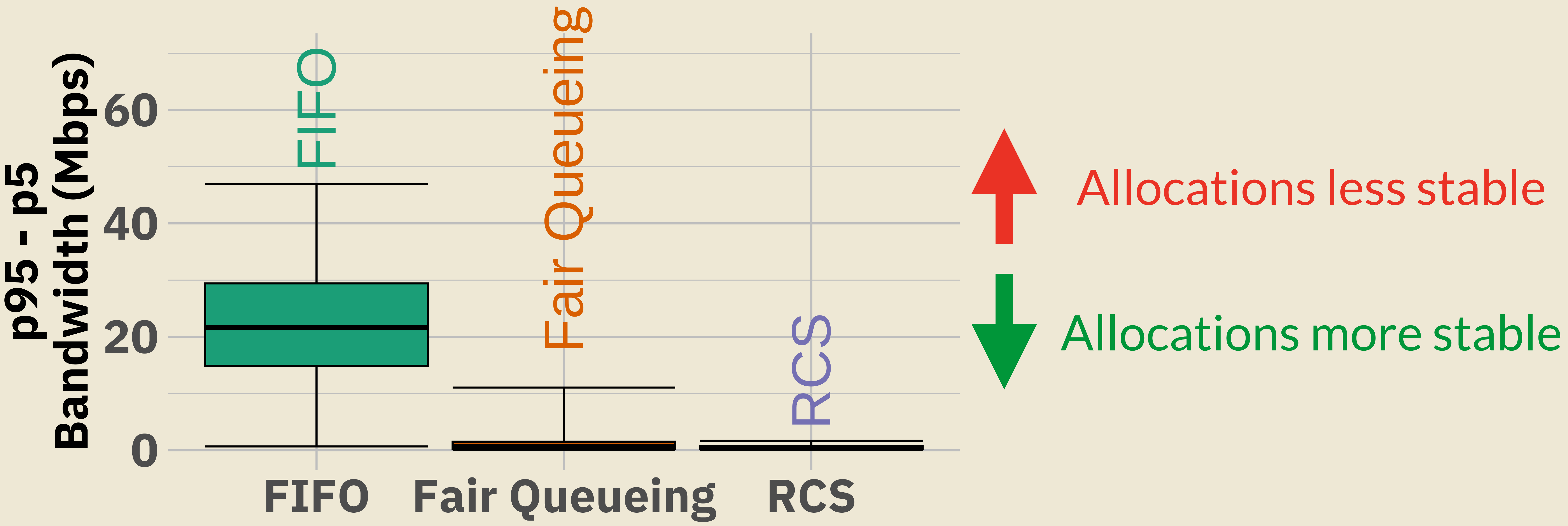
Do allocations remain stable across topologies?



Setup: 10 CAIDA-sampled topologies,
10 random CCA assignments (Reno, Cubic, BBR) to each flow per topology

RCS achieves CCAI with today's real CCAs

Allocations do remain stable across topologies



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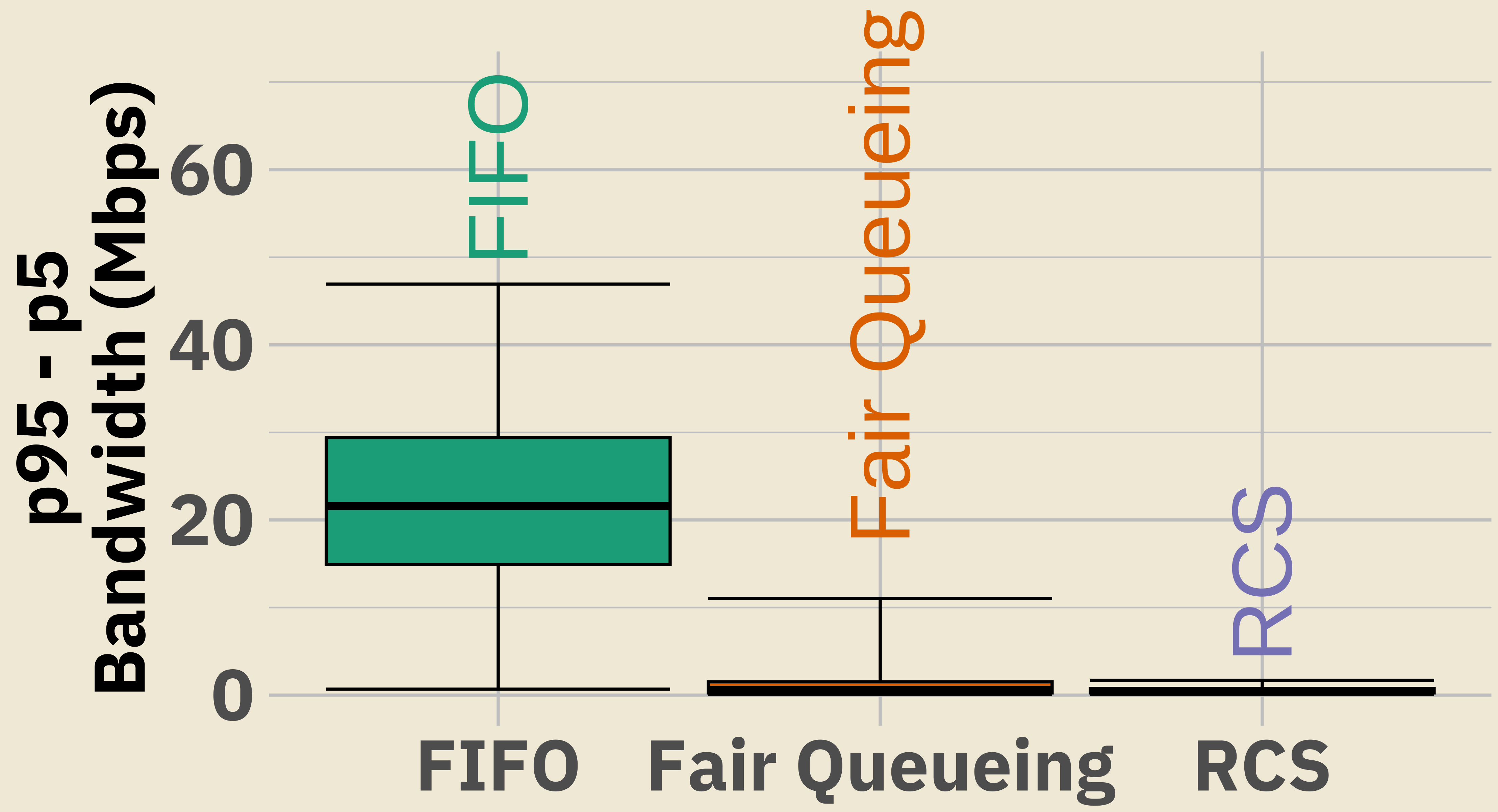
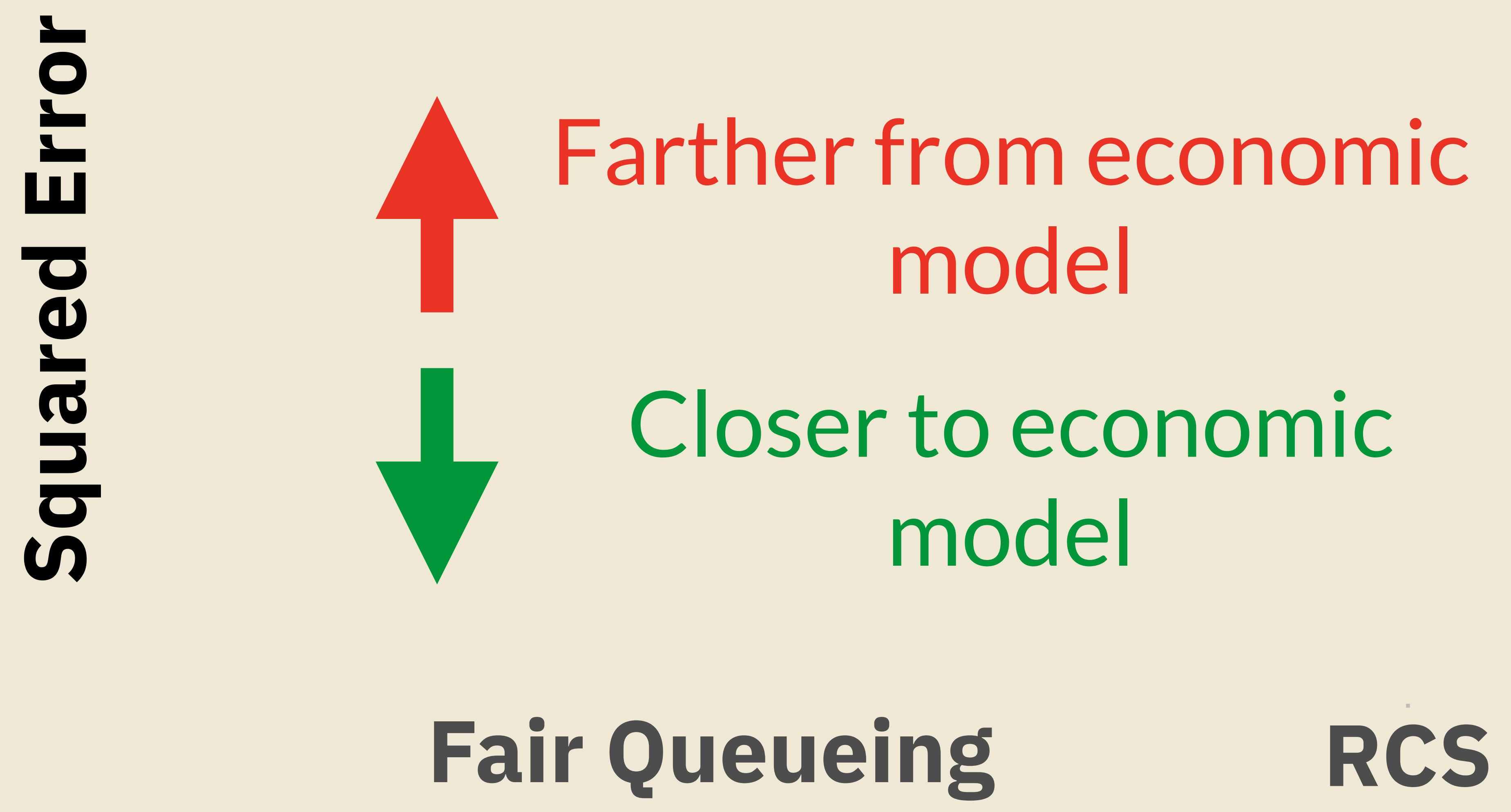


Are allocations close to what game-theoretic analysis predicted?



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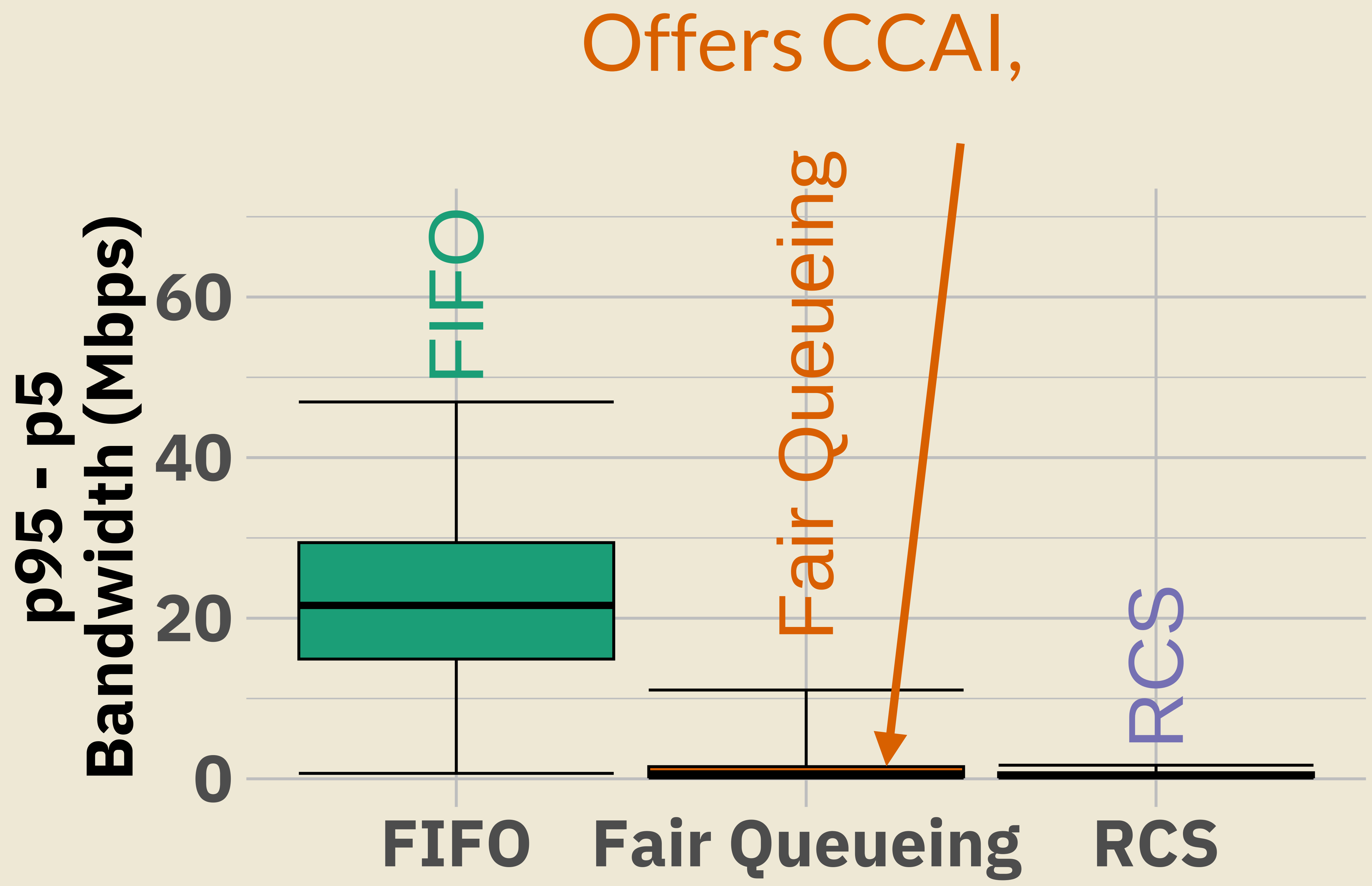
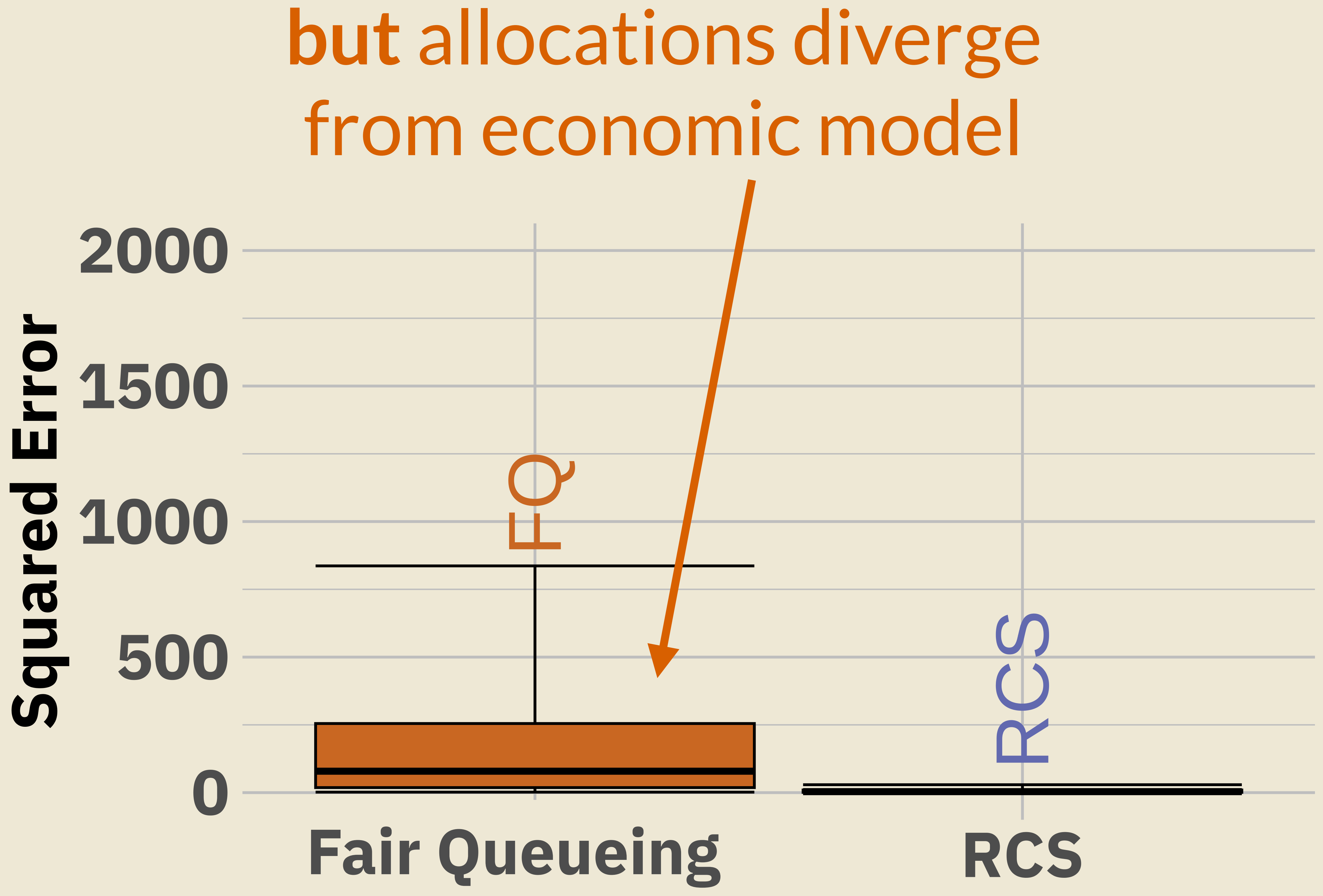
Fair Queueing:





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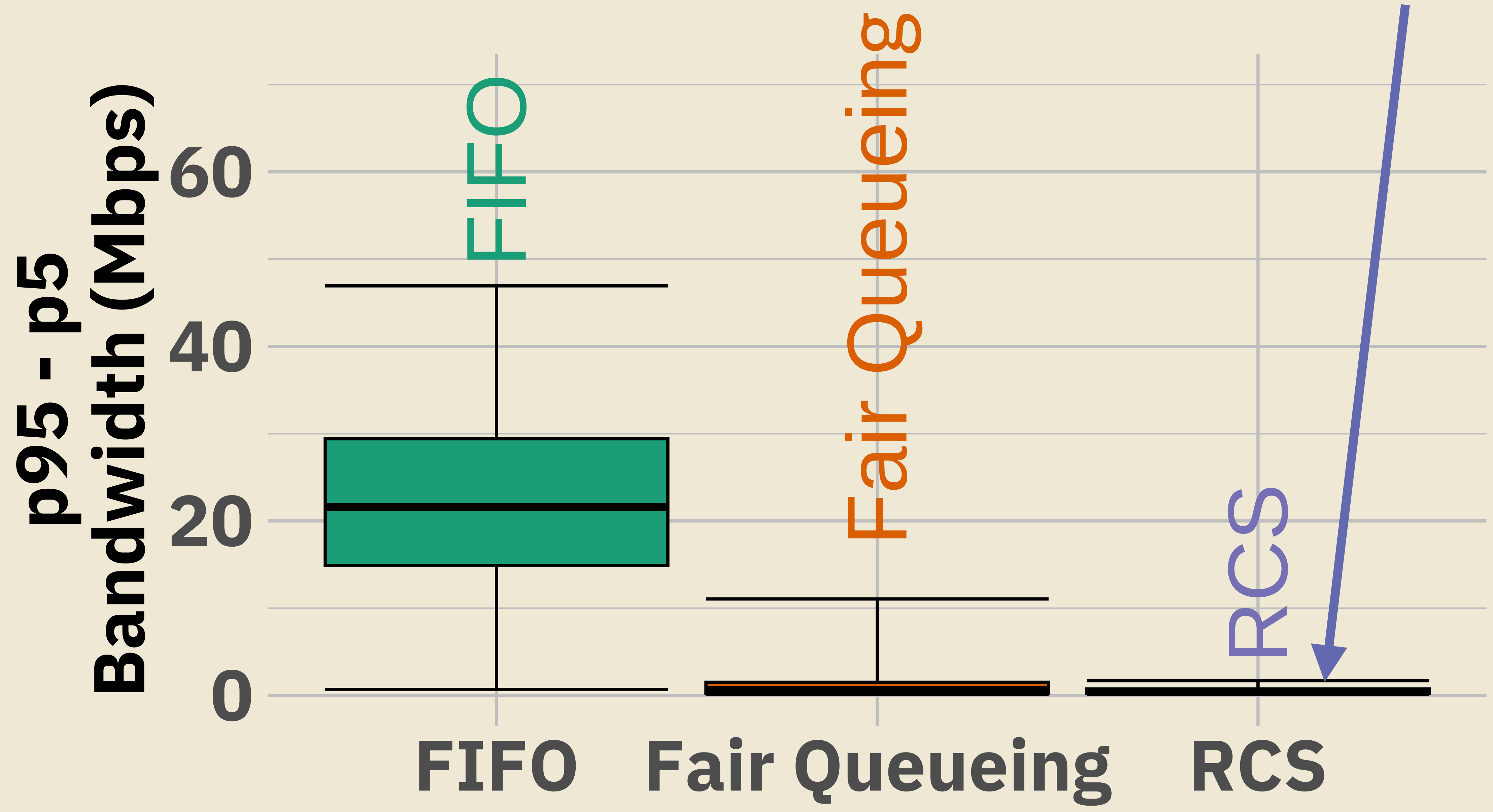
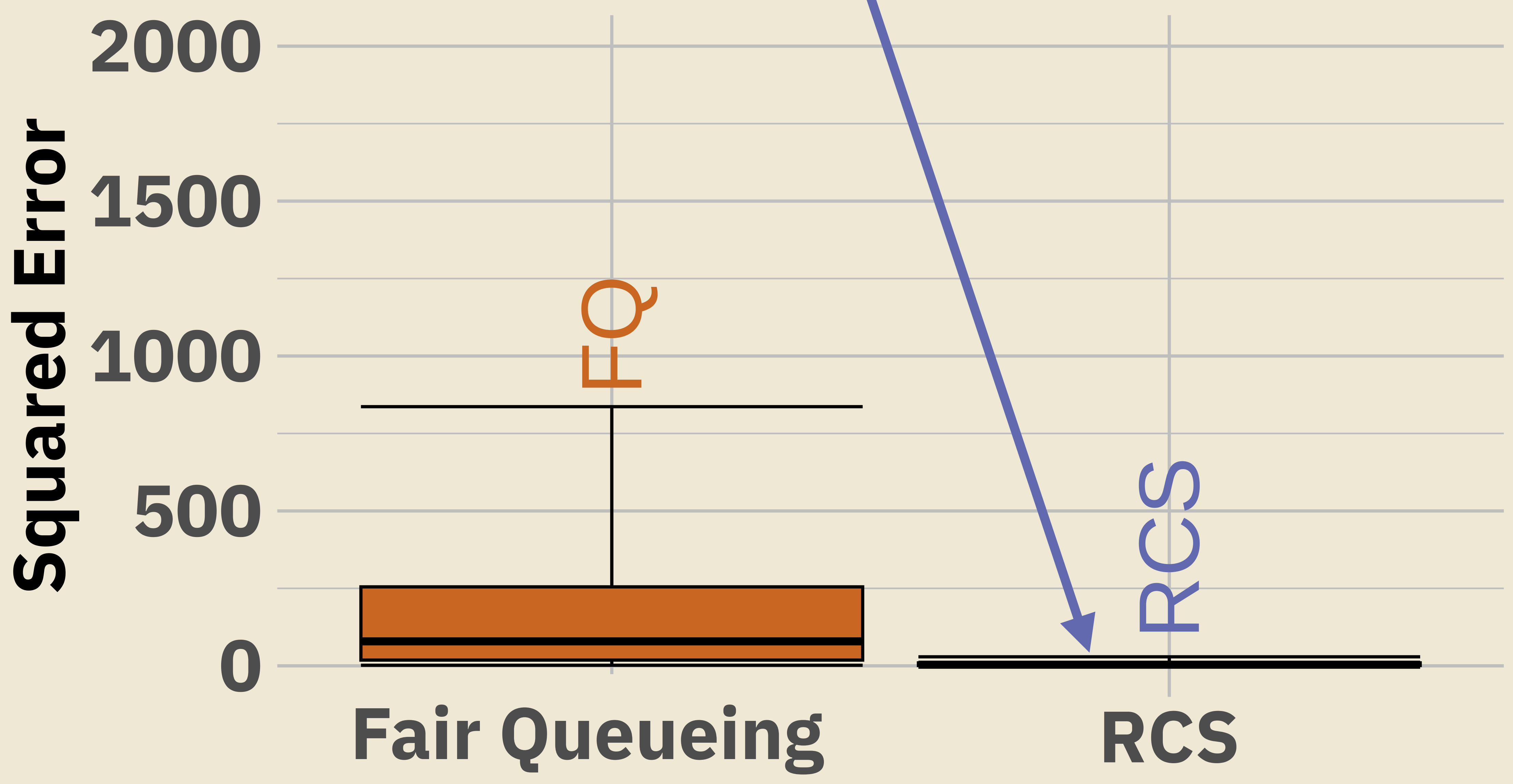
RCS achieves CCAI with today's real CCAs

RCS:

Offers CCAI,

and allocations consistent with economic model





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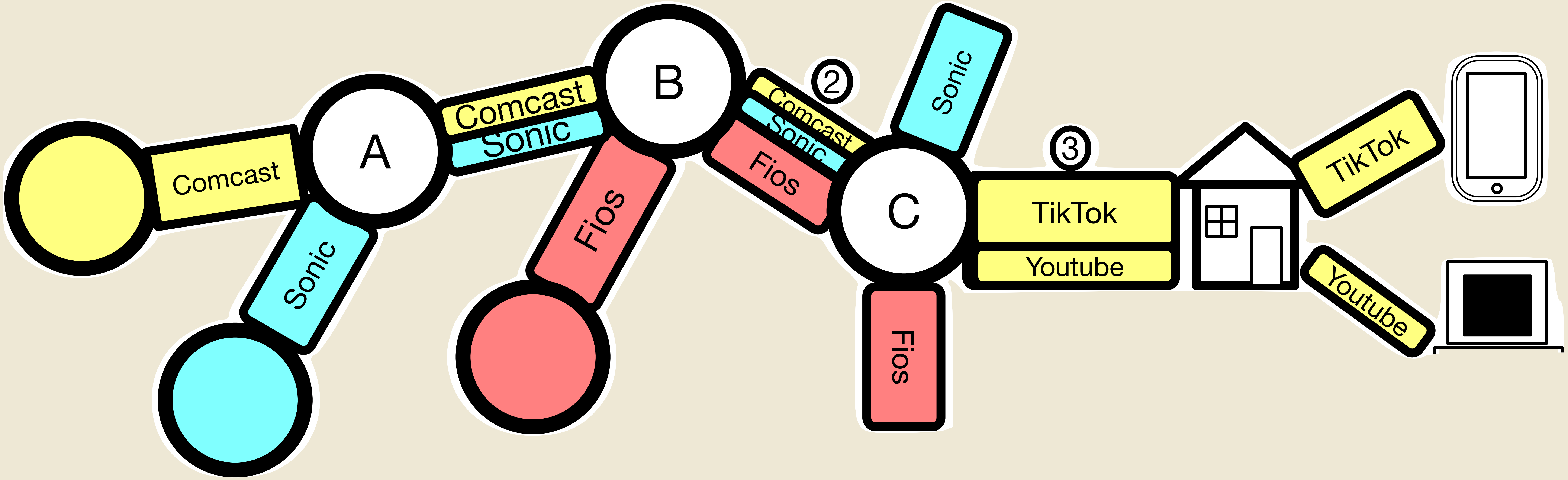
Discussion

- Implementation concerns
  - See paper: Implementing RCS is possible on modern switch hardware
- Net neutrality concerns
  - See paper: RCS conforms to widely accepted net neutrality definitions
- Adoption incentives
  - RCS offers incremental benefits scaling with deployment

RCS: Bandwidth Allocation Framework for Congestion Control Algorithm Independence



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