Flow Rate Fairness: Dismantling a Religion

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presented by Brighten Godfrey

Fairness in networks

- Flow rate equality!
- Easily circumvented
- Doesn’t even optimize for any metric of interest

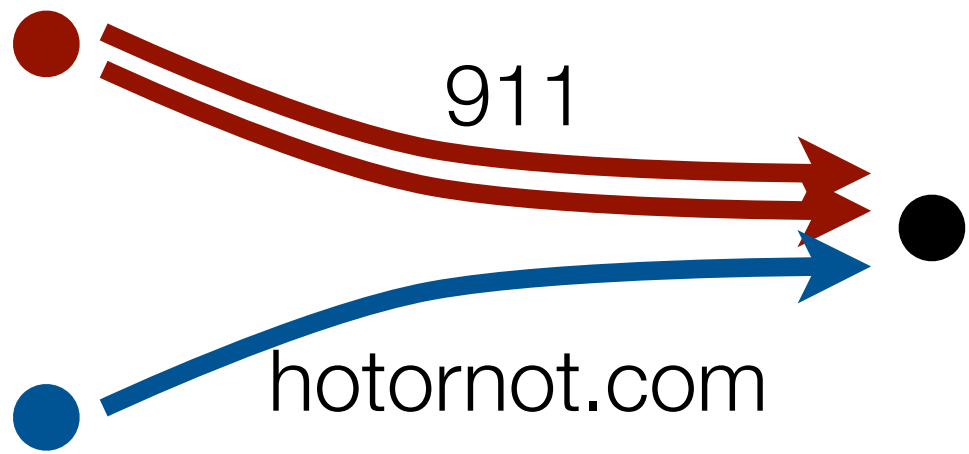


Fig. 1: Poppycock.

Fairness in real life

- **Plentiful resources:** use as much as you want
    - e.g. air, advisor's grant money
- **Scarce resources:** pay for what you want
    - price set by market
    - result (under assumptions): socially optimal allocation

Fig. 2. Invisible hand of the market.

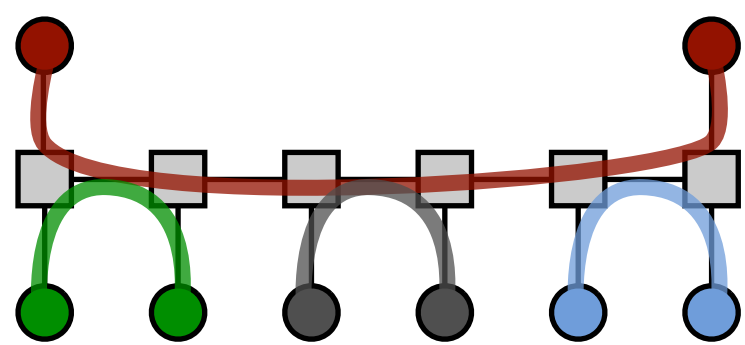
Four main points

- Flow rate fairness is not useful
- Cost fairness is useful

- Flow rate fairness is hard to enforce
- Cost fairness is feasible to enforce

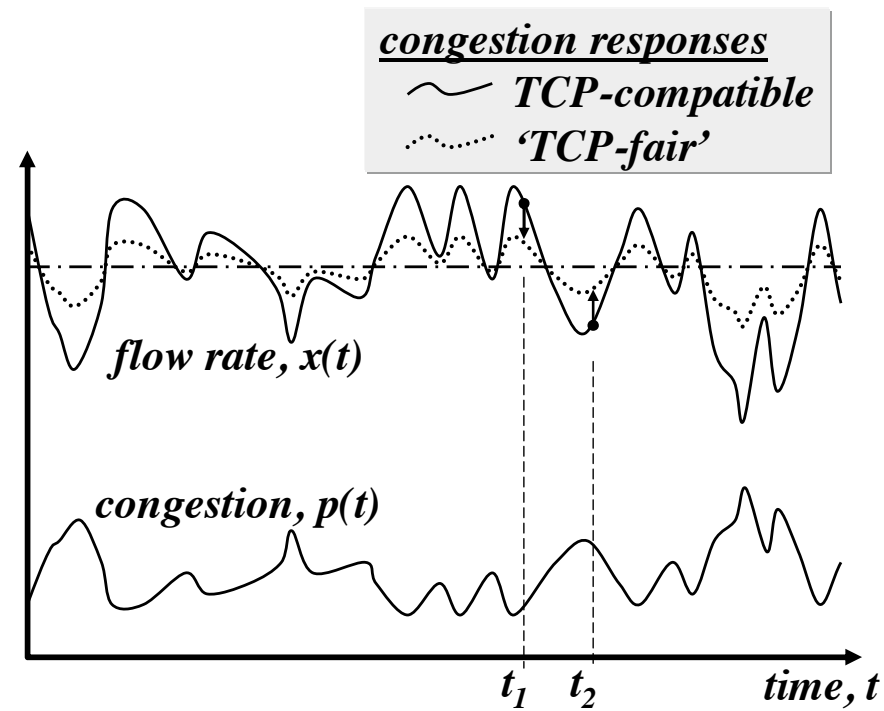
FRF is not meaningful or useful

- It doesn't measure benefits
  - e.g., SMS message vs. a packet of a video stream
- It doesn't measure costs
  - e.g., "parking lot" network: long flow causes significant congestion but is given equal rate by fair queueing
- Therefore, doesn't equalize cost or benefit



FRF is not meaningful or useful

- Myopic: no notion of fairness across time
- Example: “TCP-fair” flows
  - Defined to get same aggregate rate as TCP across time
  - But can be smoother
  - So they use less bandwidth when resources are plentiful (t_1) and more when resources are scarce (t_2) — hardly “fair”!



FRF is not meaningful or useful

- In summary, FRF does not optimize utility (except for strange definitions of utility)

- So, even cooperating entities should not want to use it!

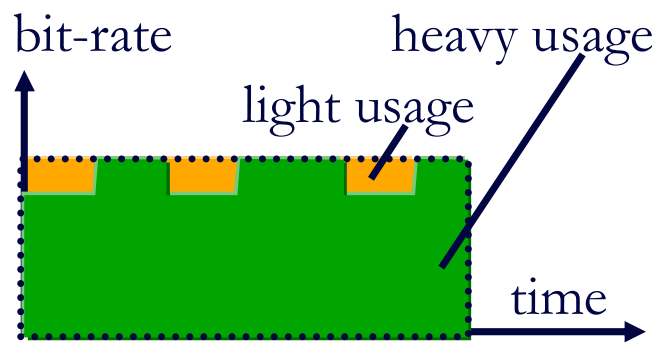
Cost fairness is useful

- Economic entities pay for the costs they incur
  - Note this is “fair” (in a real-world sense), not “equal”—and that’s fine
- In other words, networks charge packets for the congestion they cause
  - Networks can easily lie about congestion!
  - So it’s really a market price, not exactly congestion
- Result: senders want to maximize utility; since they are charged, they will seek to balance benefit with cost (utility = benefit - cost)

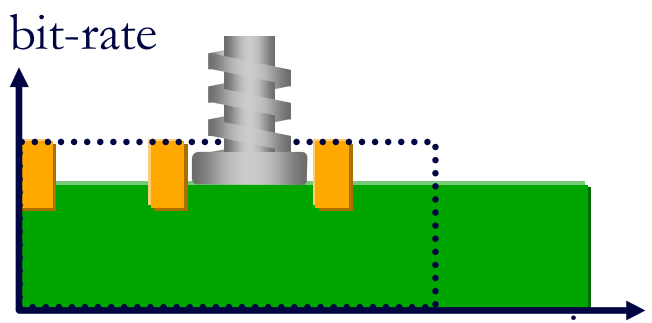
Cost fairness is provably useful

- [Frank Kelly 1997]: Cost fairness maximizes aggregate utility
- i.e.: any different outcome results in suboptimal utility
- Why won’t anyone listen to Kelly? Hello??! ... where did everybody go?

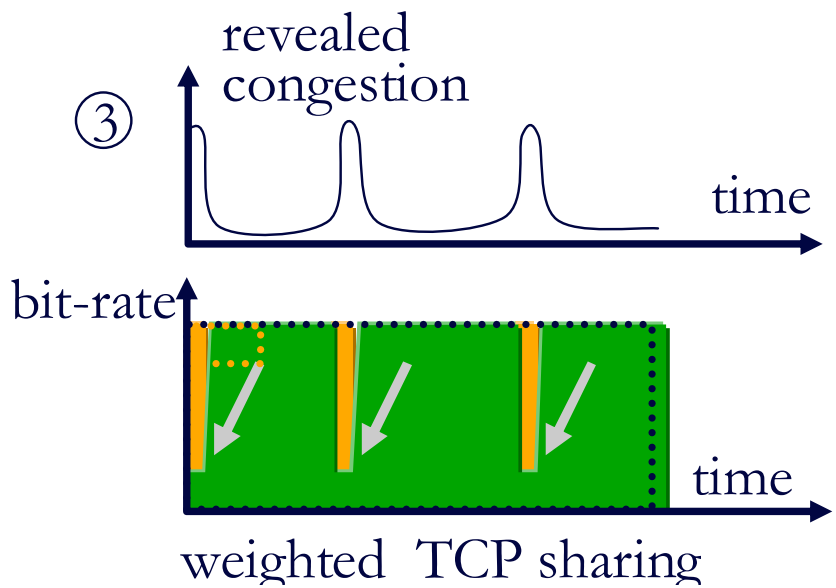
Cost fairness is useful: example [Briscoe '09]



'unfair' TCP sharing



throttling heavy usage



weighted TCP sharing

Key point: Benefit per bit his high for light flow and low for heavy flow.

Four main points

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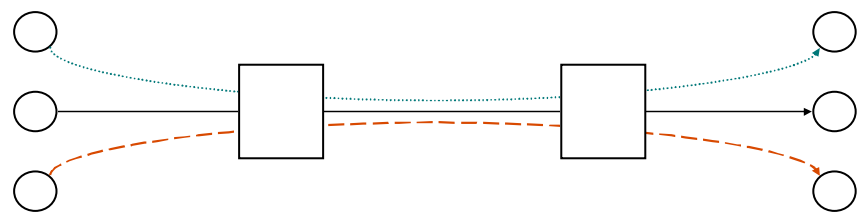
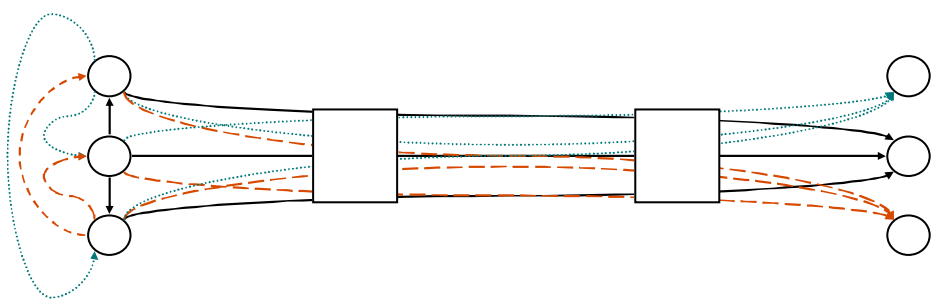
- Cost fairness is useful

- Flow rate fairness is hard to enforce
- Cost fairness is feasible to enforce

FRF is hard to enforce

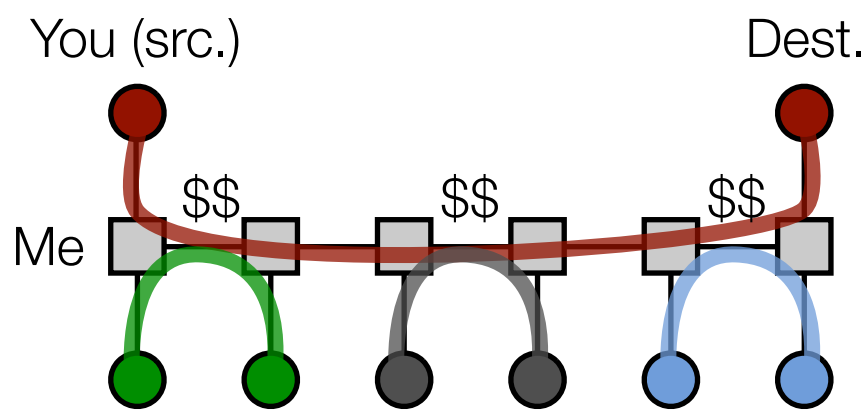
- Just run your flow longer
- Create more flows (sybil attack)
  - More TCP flows between same source/destination (web browsers)
  - Spoof source IP / MAC address
  - Multiple flows to other destinations (BitTorrent)





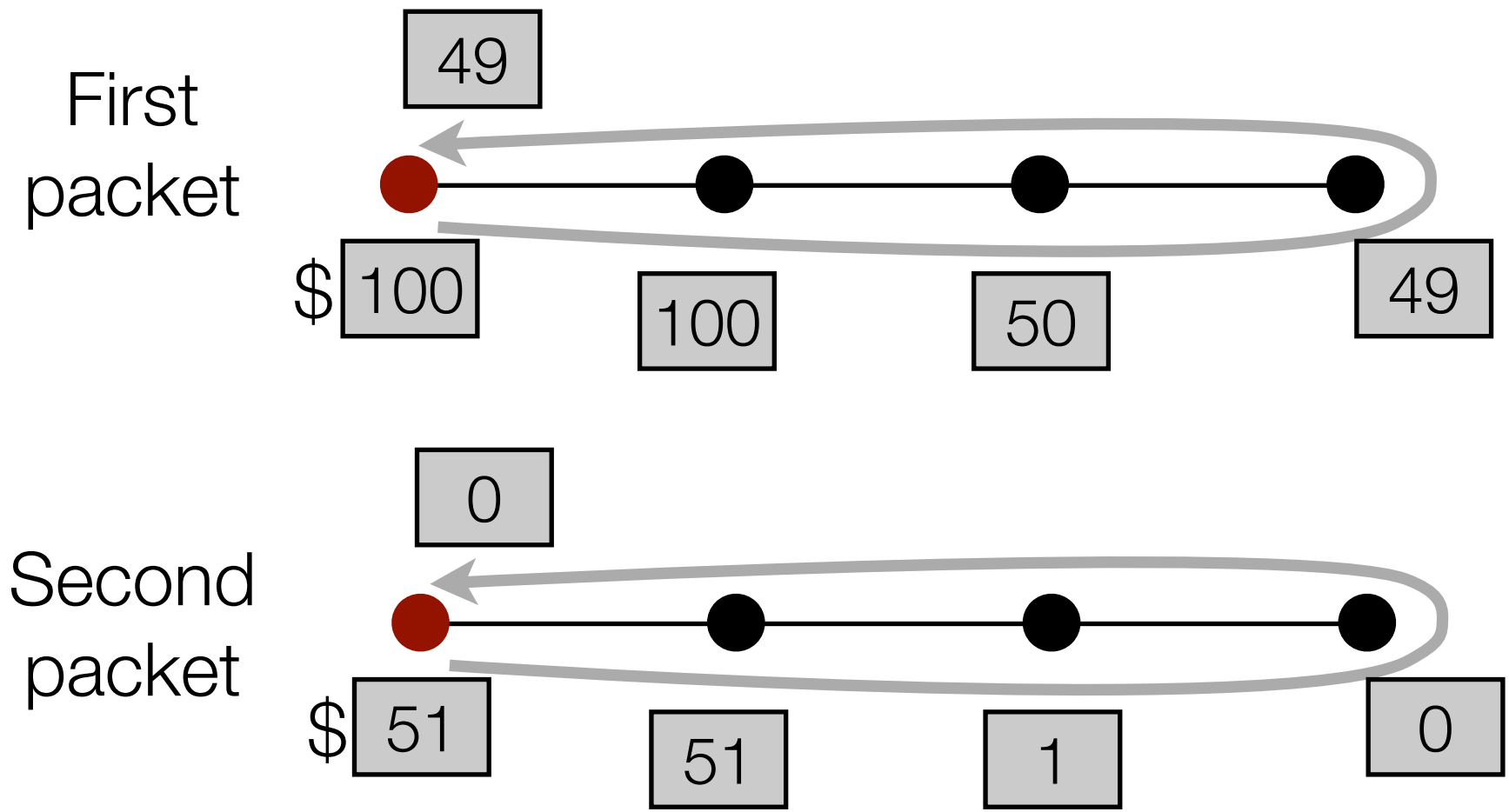
Cost fairness is feasible to enforce

- You send me a packet; I handle delivery and charge you for it
- How much do I charge? Depends on cost on entire remainder of path!
- The next hop I send it to is going to charge me, so I need to know how much, so I can cover my cost with your payment
- Not the only way of arranging payments, but it is convenient (payments between neighbors that already have an economic relationship



Implementation: Re-Feedback [SIGCOMM'05]

- **Key property:** every hop knows total congestion along downstream path



Other issues

- What about other notions of fairness used simultaneously?
  - That’s fine, but in the end someone pays
- User interface
  - Price may be changing quickly
  - Can be fixed by paying for a block of “congestion credits for a month (say)

Conclusion

- “It just isn’t realistic to create a system the size of the Internet and define fairness within the system without reference to fairness outside the system.”
- Cost fairness optimizes aggregate utility and is feasible to enforce
- Flow rate fairness does not optimize utility and is not feasible to enforce
    - Cease publication on the topic and stop teaching it in undergraduate courses

Discussion

- In light of this paper, what use is (weighted) fair queueing?
- If you were redesigning the Internet, would you use this general approach?
- Security implications?
    - Bots may now effectively have access to micropayments