flow rate fairness dismantling a religion

<draft-briscoe-tsvarea-fair-00.pdf>

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why the destructive approach?

destruction will breed creation

- Internet resource allocation/accountability
  - 'needs fixing' status since the Internet's early days
- will never come off 'needs fixing' status
  - unless we discard an idea that predated the Internet
- fairness between flow rates (used in TCP fairness, WFQ)
  - proven bogus 9yrs ago, but (I think) widely misunderstood / ignored
  - fairness between flow rates still the overwhelmingly dominant ideology
  - obscured by this idea, we wouldn't know a bad fix from a good one
- resource allocation/accountability now 'being fixed'
  - e.g. Re-ECN: Adding Accountability for Causing Congestion to TCP/IP <draft-briscoe-tsvwg-re-ecn-tcp-03.txt>
  - this talk is not about the re-ECN protocol, but about why we need something like it
- can't build consensus unless people accept Internet has no fairness ctrl

You got to be careful if you don't know where you're going,
because you might not get there [Yogi Berra]

exec summary

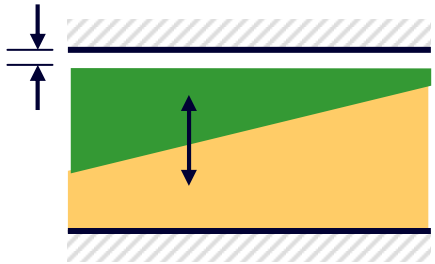
- fair allocation...

of what?		among what?
×	rate	× flows
✓	congestion	✓ bits, sent by users

- don't have to throw away everything we've engineered
  - only the ideology that created it
  - new mechanisms overarch existing TCP, WFQ etc
- don't have to throw away traditional flat pricing etc
  - new mechanisms use congestion pricing concepts internally
  - but as signals to hard engineered mechanisms
- can do fairness between fairnesses within sub-groups
  - NATO, commercial ISPs, universities, countries with social objectives
  - including what we have today as a sub-group

fairness and congestion control

- congestion control dimensions
  - utilisation — how close to full
  - fairness — what share for each user
  - stability — dynamics



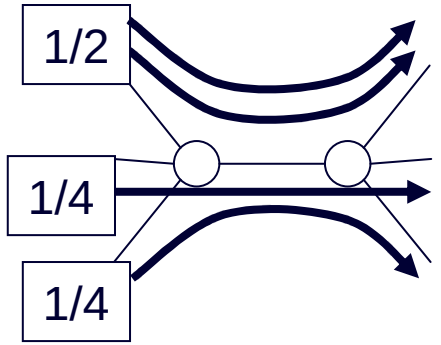
- can alter fairness independently of utilisation
  - e.g. XCP, opening multiple TCPs
- fairness nothing to do with functioning of network
  - there will always be *an* allocation
  - any allocation ‘works’
- a social requirement on engineering

who should decide what fairness to have?

- certainly not the IETF
- candidates
  - governments
  - network owner (e.g. military, university, private, commercial)
  - market
- should be able to do all the above
  - IETF skill should be to ‘design for tussle’ [Clark, 2002]
  - basis of the design of re-ECN <draft-briscoe-tsvwg-re-ecn-tcp-03>
- currently the IETF does decide
  - based on an unsubstantiated notion of fairness between flow rates
    - which has no basis in real life, social science, philosophy or anything
  - this view isn’t even complete enough to be a form of fairness

today's shares are just the result of a brawl

- flow rate fairness is not even wrong
  - it doesn't even answer the right questions
  - it doesn't allocate the right thing
  - it doesn't allocate between the right entities
- how do you answer these questions?
  1) how many flows is it fair for an app to create?
  2) how fast should a brief flow go compared to a longer lasting one?

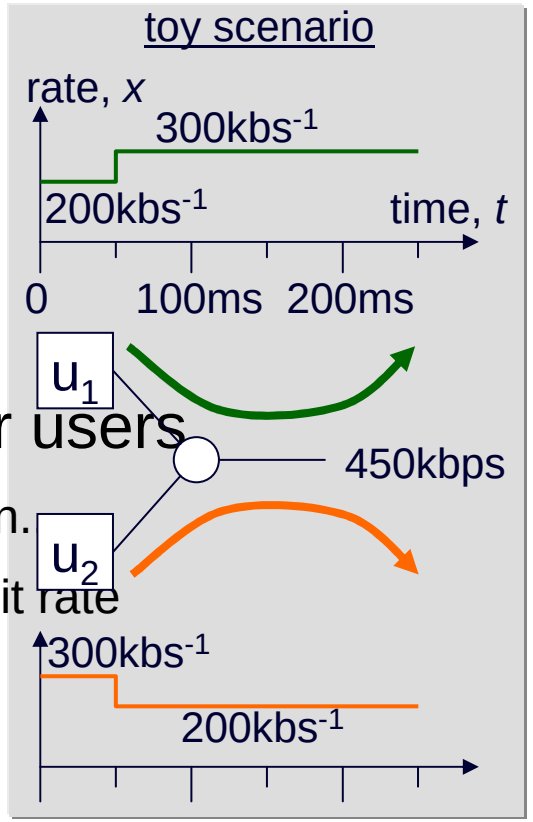


is this important?

- working with packets depersonalises it
  - it's about conflicts between real people
  - it's about conflicts between real businesses
- 1st order fairness – average over time
  - 24x7 file-sharing vs interactive usage
- 2nd order fairness – instantaneous shares
  - unresponsive video streaming vs TCP
  - fair burden of preventing congestion collapse
- not some theoretical debate about tiny differences
  - huge differences in congestion caused by users on same contract
  - hugely different from the shares government or market would allocate
  - yes, there's a lot of slack capacity, but not that much and not for ever
- allocations badly off what a market would allocate
  - eventually lead to serious underinvestment in capacity
- 'do nothing' will not keep the Internet pure
  - without an architectural solution, we get more and more middlebox kludges

fair allocation... of what? among what?

of ‘cost’ among bits



- cost of one user’s behaviour on other users
  - congestion volume = instantaneous congestion...
    - ...shared proportionately over each user’s bit rate
    - ...over time
- instantaneous congestion

  p = 10%
- congestion volume, $v = x(t).\Delta t.p(t)$

  v_1 = 200kbs^{-1} x 50ms x 10% + 300kbs^{-1} x 200ms x 10%

  = 1kb + 6kb = 7kb

  v_2 = 300kbs^{-1} x 50ms x 10% + 200kbs^{-1} x 200ms x 10%

  1.5kb + 4kb = 5.5kb

toy scenario for illustration only; strictly...
- a super-linear marking algorithms to determine p is preferable for control stability
- the scenario assumes we’re starting with full buffers

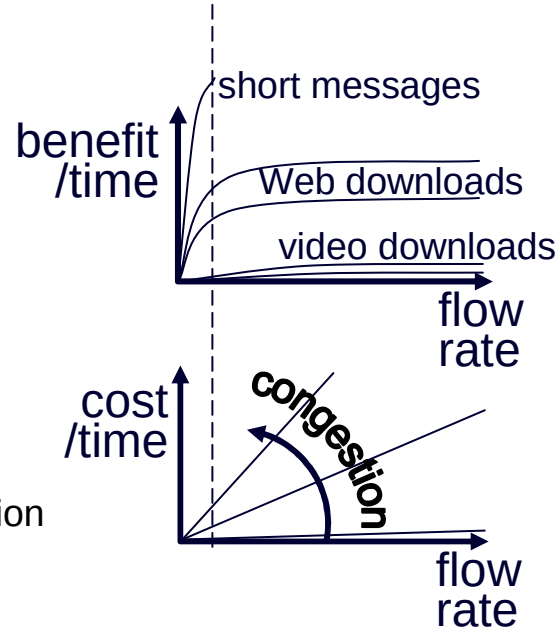
- as $\Delta t \rightarrow \delta t$. integrates easily & correctly over time and

fair allocation... of what?

not rate

- what discipline deals with fairness?
  - political economy (supported by philosophy)
- fairness concerns shares of
  - benefits (utility), costs or both
- benefit ≠ flow rate
  - users derive v different benefit per bit from each app
- cost ≠ flow rate
  - cost of building network covered by subscriptions
  - cost to other users depends on congestion
  - no cost to other users (or network) if no congestion
  - very different costs for same flow rate with diff congestion
- "equal flow rates are fair"?
  - no intellectual basis: random dogma
- even if aim were equal benefits / costs
  - equal flow rates would come nowhere near achieving it

- actually cost is a sufficient measure
  - for a free market to maximise benefits
  - or to bring about other forms of fairness



fair allocation... among what?

not flows

- we expect to be fair to people, institutions, companies
  - 'principals' in security terms
- why should we be fair to transfers between apps?
  - where did this weird argument come from?
  - like claiming food rations are fair if the boxes are all the same size
    - irrespective of how many boxes each person gets
    - or how often they get them
- max-min-, proportional-, TCP- fairness of flow rates
  - not even in same set as *weighted* proportional fairness*
  - flow A can go *w* times as fast as B
    - hardly a useful definition of fairness if A can freely choose *w*
  - interesting part is what regulates A's choice of *w*
- flow rates & their weights are an outcome of a deeper level of fairness
  - congestion cost fairly allocated among *bits* (RED algorithm)

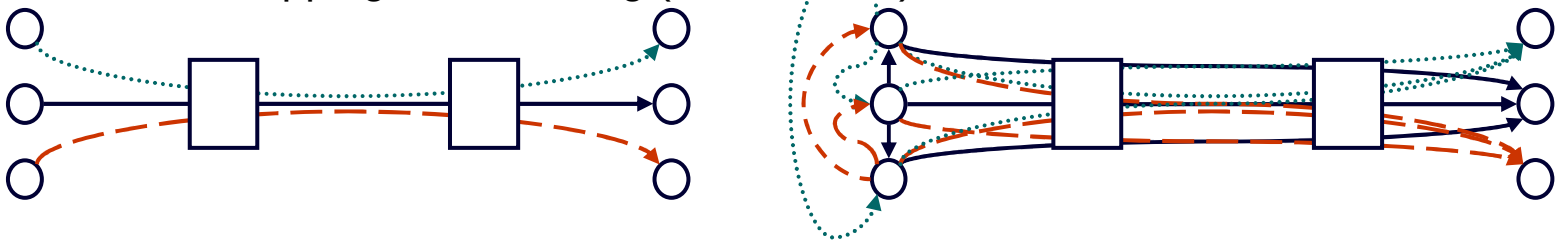
* XCP, for example, makes this common mistake

fair allocation...
over time

- users A & B congest each other
  - then A & C cause similar congestion, then A & D...
  - is it fair for A to get equal shares to each of B, C & D each time?
- in life fairness is not just instantaneous
  - even if Internet doesn't always work this way, it must *be able* to
  - efficiency and stability might be instantaneous problems, but not fairness
- need somewhere to integrate cost over time (and over flows)
  - the sender's transport is the natural place
- places big question mark over router-based fairness (e.g. XCP)
  - at most routers data from any user might appear
    - each router would need per-user state
    - and co-ordination with every other router

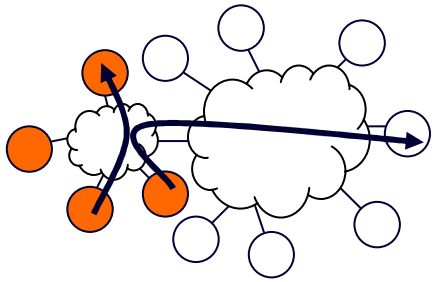
enforcement of fairness

- if it's easy to 'cheat', it's hardly a useful fairness mechanism
  - whether intentionally or by innocent experimentation
- if every flow gets equal rate
  - the more flows you split your flow into, the more capacity you get
  - fairness per source-destination pair is no better
    - Web/e-mail hosting under one IP addr
    - stepping stone routing (cf bitTorrent)

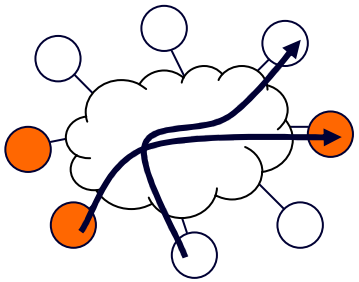


- by design cost allocation among *bits* is immune to such cheating

fairness between fairnesses



- to isolate a subgroup who want their own fairness regime between them
  - must accept that network between them also carries flows to & from other users
- in life, local fairnesses interact through global trade
  - e.g. University assigns equal shares to each student
    - but whole Universities buy network capacity from the market
  - further examples: governments with social objectives, NATO etc



- cost fairness sufficient to support allocation on global market
  - then subgroups can reallocate the right to cause costs within their subgroup
    - around the edges (higher layer)
  - naturally supports current regime as one (big) subgroup
    - incremental deployment
- different fairness regimes will grow, shrink or die
  - determined by market, governments, regulators, society – around the edges
  - all just congestion marking at the IP layer – neck of the hourglass

religion
politics
legal
commercial
app
transport
network
link
physical

simple, practical & realistic

steps towards architectural change

- need MulTCP or equiv on sender
  - & (rough) policy control of flow weights
- could have deployed MulTCP in the trust climate of the ‘80s
  - today, too dangerous to offer an API controlling an app’s own flow weight
  - tho apps already open multiple flows
- re-ECN: a change to IP
  - evolutionary pressure on transports
  - **IP sender** has to mark at least as much congestion as emerges at the receiver
  - **networks** use these markings to gradually tighten fairness controls
  - weighted **sender transports** evolve
  - **receiver transports** evolve that can negotiate weighting with sender
- propose to use last reserved bit in IPv4 header
- in return re-ECN enables
  - fairness
  - choice of fairness regimes
  - robustness against cheating
  - incremental deployment with strong deployment incentives
  - a natural mitigation of DDoS flooding
  - differentiated QoS
  - safe / fair evolution of new cc algs
    - DCCP, hi-speed cc etc.
  - policing TCP’s congestion response for those hooked on per flow fairness

conclusions

- we have nothing to lose but an outdated dogma
  - we can keep everything we've engineered, and traditional pricing
  - but no-one should ever again claim fairness based on flow rates
  - unless someone can give a rebuttal
    using a respected notion of fairness from social science

- this is important – conflicts between real people / businesses
- TCP, WFQ etc are insufficient to control fairness
  - we have freedom *without any form of fairness at all*
  - × rate is absolutely nothing like a measure of fairness
  - × being fair to flows is as weird as talking to vegetables
  - × not considering fairness over time is a huge oversight
- Kelly's weighted proportional fairness explained this in 1997
- re-ECN makes this underlying 'cost fairness' practical
  - networks can regulate congestion with engineering, rather than pricing
- sub-groups can assert different fairness regimes at higher layers
  - 'freedom without fairness' can then prove itself by natural selection

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- spare slides:
  - illustrations of problems with rate fairness:
    - TFRC
    - max-min
  - why cost fairness, not benefit fairness
  - calibrating ‘cost to other users’

Q&A

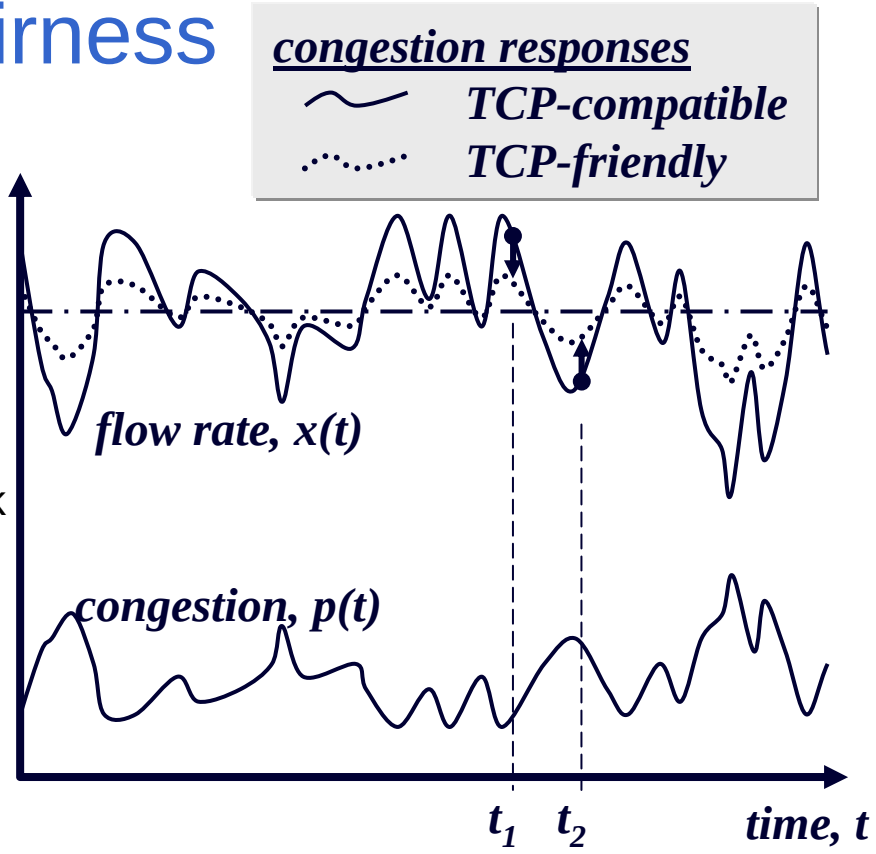
UCL

BT

illustration: TCP-friendly rate control (TFRC)

problems with rate fairness

- TCP-friendly
  - same ave rate as TCP
  - congestion response can be more sluggish
- compared to TCP-compatible
  - higher b/w during high congestion
  - lower b/w during low congestion
- giving more during times of plenty doesn't compensate for taking it back during times of scarcity



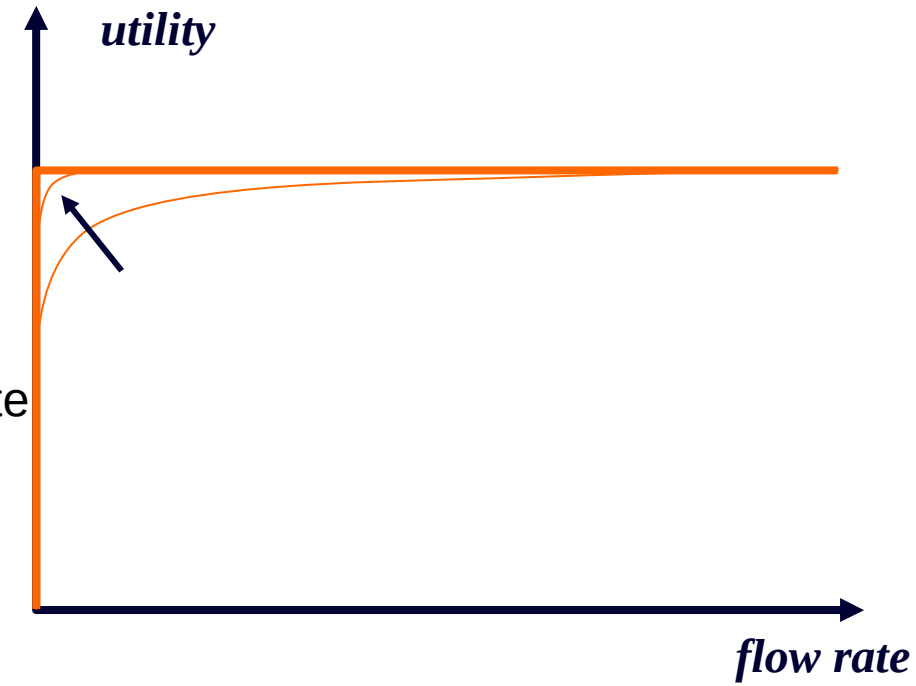
- TCP-friendly flow causes more congestion volume than TCP
- need lower rate if trying to cause same congestion cost

- TFRC vs TCP is a minor unfairness
  - compared to the broken per flow notion common to both

illustration: max-min rate fairness

problems with rate fairness

- max-min rate fairness
  - maximise the minimum share
  - then the next minimum & so on
- if users take account of the congestion they cause to others
- max-min rate fairness would result if all users' valuation of rate were like the sharpest of the set of utility curves shown [Kelly97]
  - they all value high rate exactly the same as each other
  - they all value very low rate just a smidgen less
  - ie, they are virtually indifferent to rate



- users aren't that weird

∴ max-min is seriously unrealistic

fair allocation... of what?

why cost fairness, not benefit fairness?

- two electricity users
  - one uses a unit of electricity for a hot shower
  - next door the other uses a unit for her toast
- the one who showered enjoyed it more than the toast
  - should she pay more?
- in life, we expect to pay only the cost of commodities
  - a competitive market drives the price to cost (plus 'reasonable' profit)
  - if one provider tries to charge above cost, another will undercut
- cost metric is all that is needed technically anyway
  - if operator does charge by value (benefit), they're selling snake-oil anyway
  - don't need a snake-oil header field

calibrating ‘cost to other users’

- congestion volume
  - both a measure of ‘cost to other users’
  - and a measure of traffic not served
- a monetary value can be put on ‘cost to other users’
  - the cost of upgrading the network equipment
  - so that it wouldn’t have dropped (or marked) the volume it did
- only applies in a competitive market
  - or some other welfare maximising ‘invisible hand’