



Capacity Sharing

Bringing Together Cost, Value and Control

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a talk in two parts

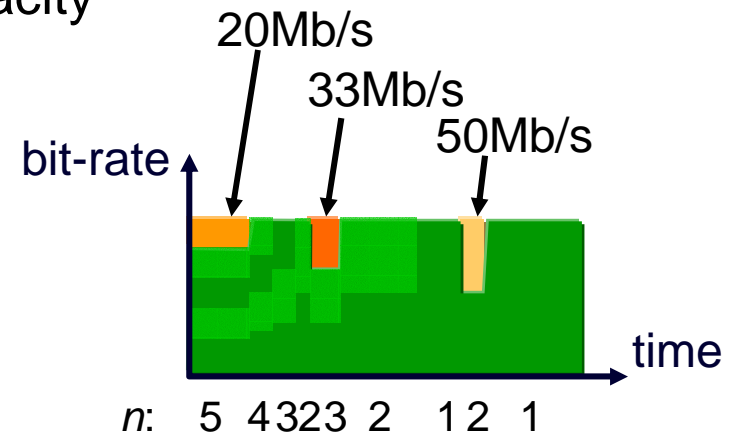
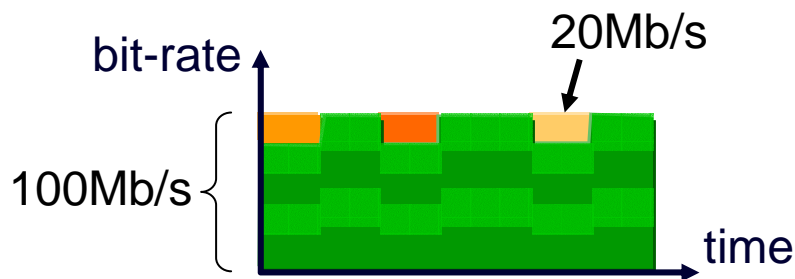
1. sharing capacity between commodity traffic
 - the network side (ensure end-to-end transports are nice)
 - net neutral for 'over-the-top' services
 - looks like engineering, but based on economics
 2. sharing capacity with added value services
 - change gear – commercial, but based on engineering
- mobile networks were designed for #2
 - treating #1 as an afterthought was a mistake

Capacity Sharing: Lest we Forget

- sharing is central to all developments in network access
 - and obviously core, campus & enterprise networks too
- for dedicated consumer access, utilisation \propto as speed \nearrow
 - ave. utilisation during peak 15min only 0.5% for 40M access
 - was 1.25% for 4M access; still higher in dial-up days
- cost efficiency will drive sharing closer to the end-user
 - that's why we see cellular, cable, passive optical networks, WiFi
 - that's why we see packet multiplexing & virtualisation
 - IP, Ethernet, MPLS
- central dilemma
 - performance isolation without losing efficiency of multiplexing

existing approaches are hopeless 'fair' bandwidth

- (weighted) equal bandwidth per-active-user
 - (weighted) round robin per-user
 - (weighted) fair queuing per-user
- each of n active users gets $1/n$ of capacity

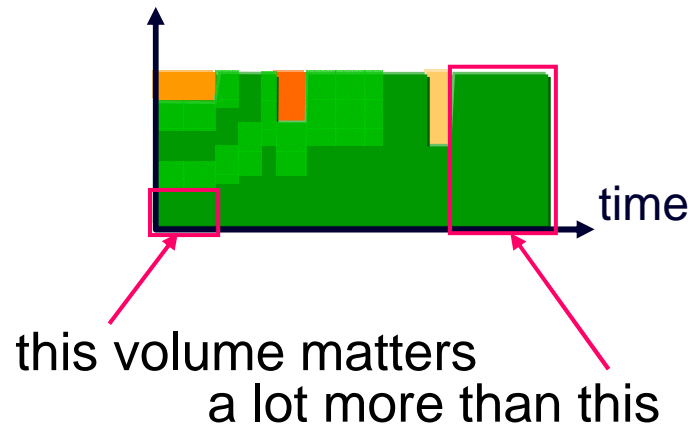


- how much I get
 - highly dependent on how often others are active
- no concept of time; no memory

existing approaches are hopeless

accounting by volume

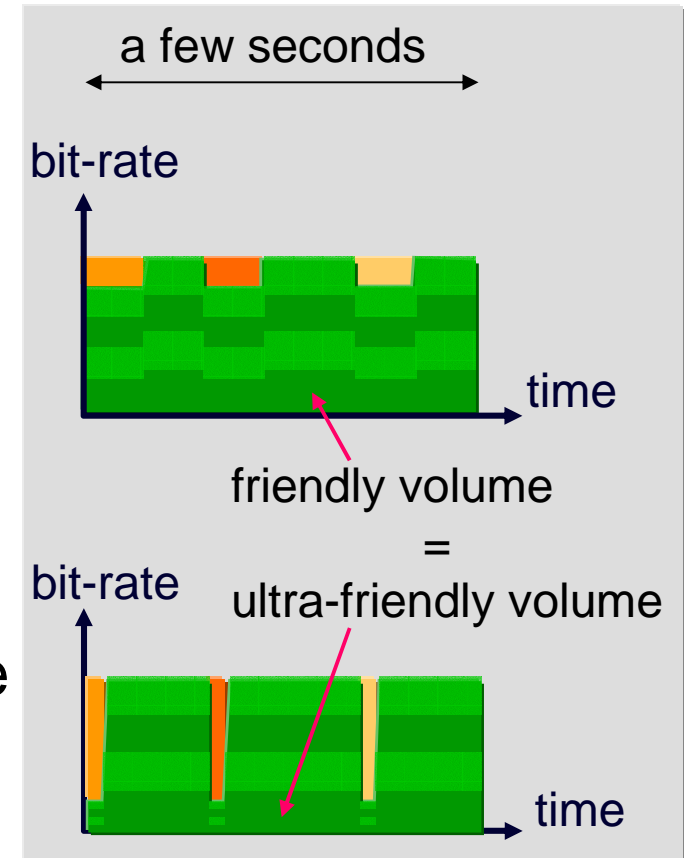
- introduce memory – a per-customer account
 - e.g. RADIUS or a traffic management node
 - measurable at one control point
 - not just per-link like WRR, WFQ
- but ...



- simple sum of volume loses information about
 - conditions at each link (space)
 - how conditions change (time)

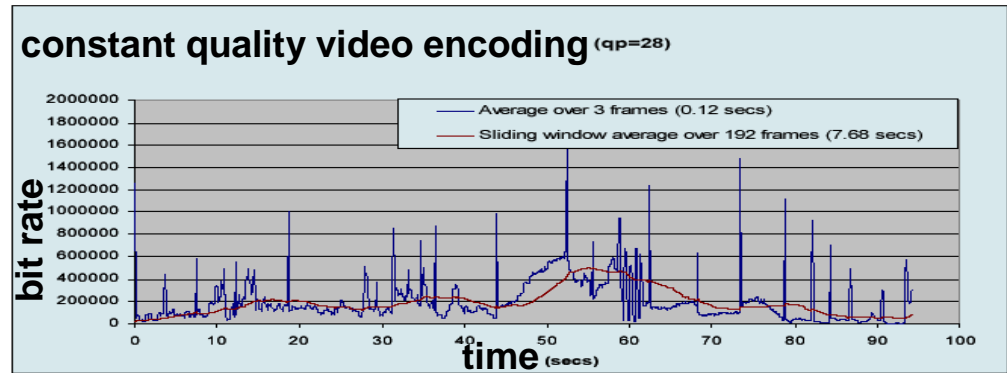
existing approaches are weak peak period volume

- state of the art in traffic management
 - count only peak-period volume
 - Comcast Fairshare [RFC6057]
 - some deep packet inspection (DPI)
- better, but...
- ...still penalises 'ultra-friendly' volume
 - BitTorrent [μ TP] & LEDBAT
 - equitable quality streaming (next slide)
- p2p & video
 - could potentially deliver a large proportion of traffic
 - while minimising impact on interactive apps



equitable quality streaming (EQS) video [Mulroy09]

- near-constant mean opinion score
>2x more videos in same capacity
- delivered over MuITCP
 - TCP with weight parameter, n
 - adjust n to ‘hardness’ of video
 - if peaks coincide
 - all MuITCPs back-off
 - whether in a peak or trough
 - equitable loss of quality
 - even if one taking more bit-rate than another
- in contrast ‘fair’ queuing forces all EQS streams to have equal bit-rate
>2x less videos in same capacity ☹️



summary so far

- multiple traffic management approaches deployed
 - fair queuing
 - volume limits
 - peak-volume-based traffic management
- often all three, and more... (QoS mechanisms)
- each patched a problem of its time
- a symptom of never really understanding the problem

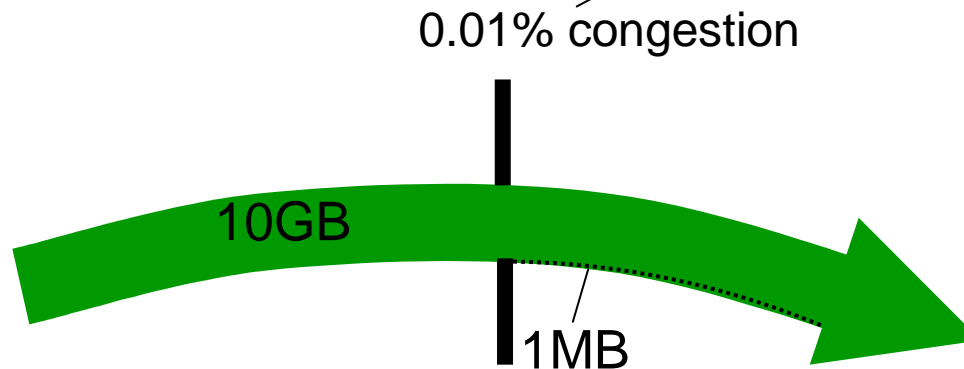
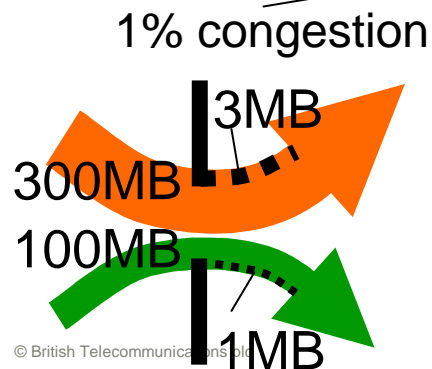
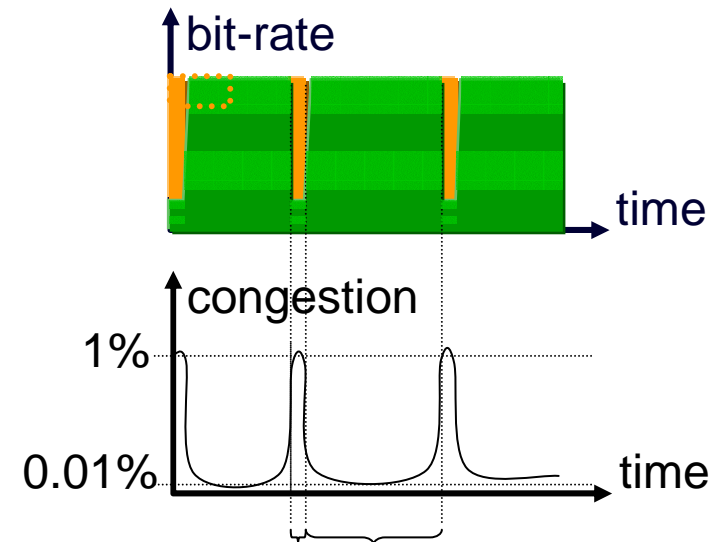
measuring contribution to congestion

- user's contribution to congestion = bytes weighted by congestion level = bytes dropped (or marked)* = 'congestion-volume'
- as simple to measure as volume

* congestion [Siris02] & Kutsher (next)

- radio uplink (interference)
- fixed links (queue lengths)
- radio downlink (power)

all signalled up and along the IP layer



if only... ingress net could see congestion...

flat fee congestion policing

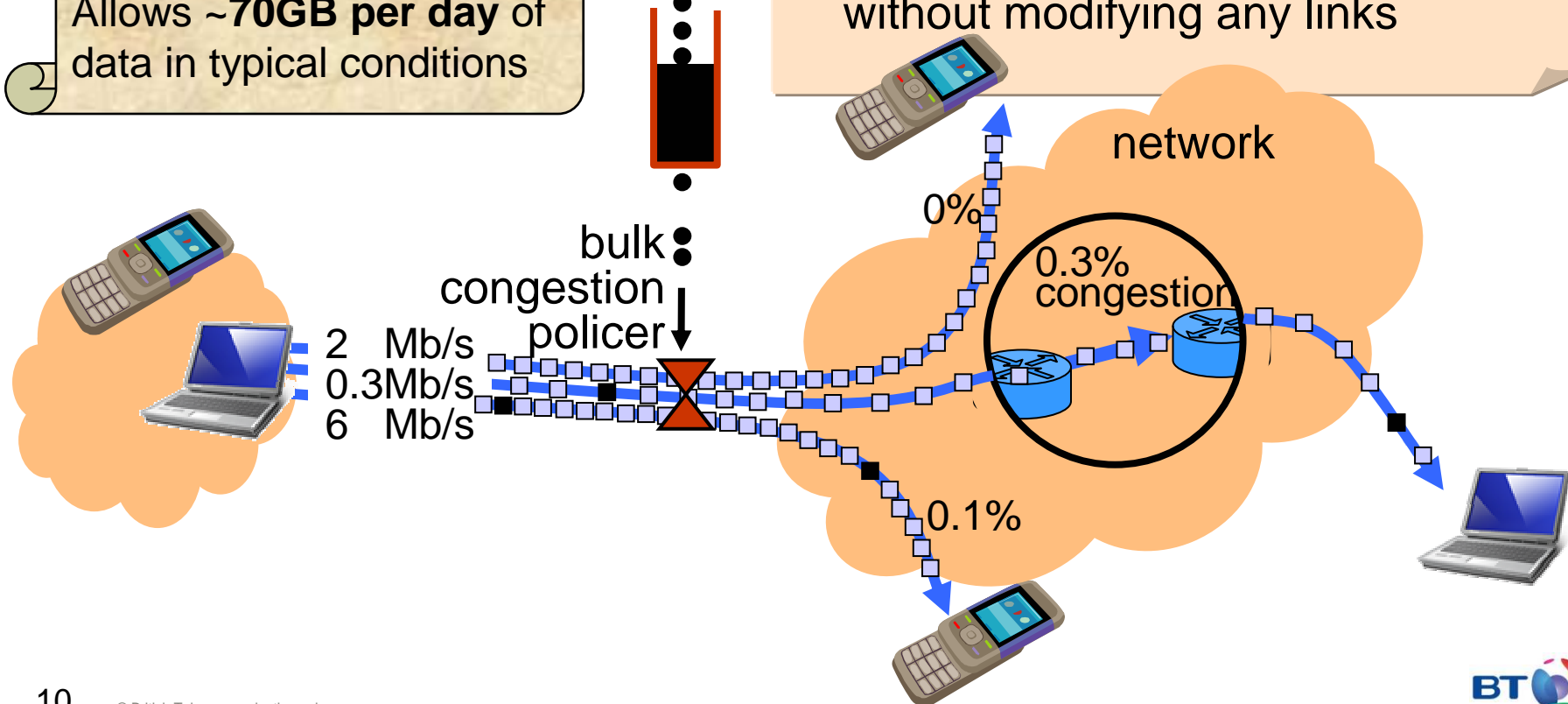
Acceptable Use Policy

'congestion-volume'
allowance: 1GB/month

@ €15/month

Allows ~70GB per day of
data in typical conditions

- performance isolation without losing efficiency of multiplexing
- edge control point
- controls capacity sharing of any link without modifying any links



“the capacity sharing I do isn’t about congestion”

- the focus on congestion can be misleading
 1. congestion signals to *avoid* quality impairment (spare slide)
 2. not ‘solving’ or minimising congestion *per se*,
using congestion signals to control capacity sharing
- for instance
 - if many users send continuously through one link
 - outcome of equal congestion policing would be equal bit-rates
- exploiting an inescapable fact
 - the greater the share of capacity you use
when others would like to use more,
the more congestion signals will be attributed to you

nonetheless, with ECN and well-sized thresholds in buffers and radio resources

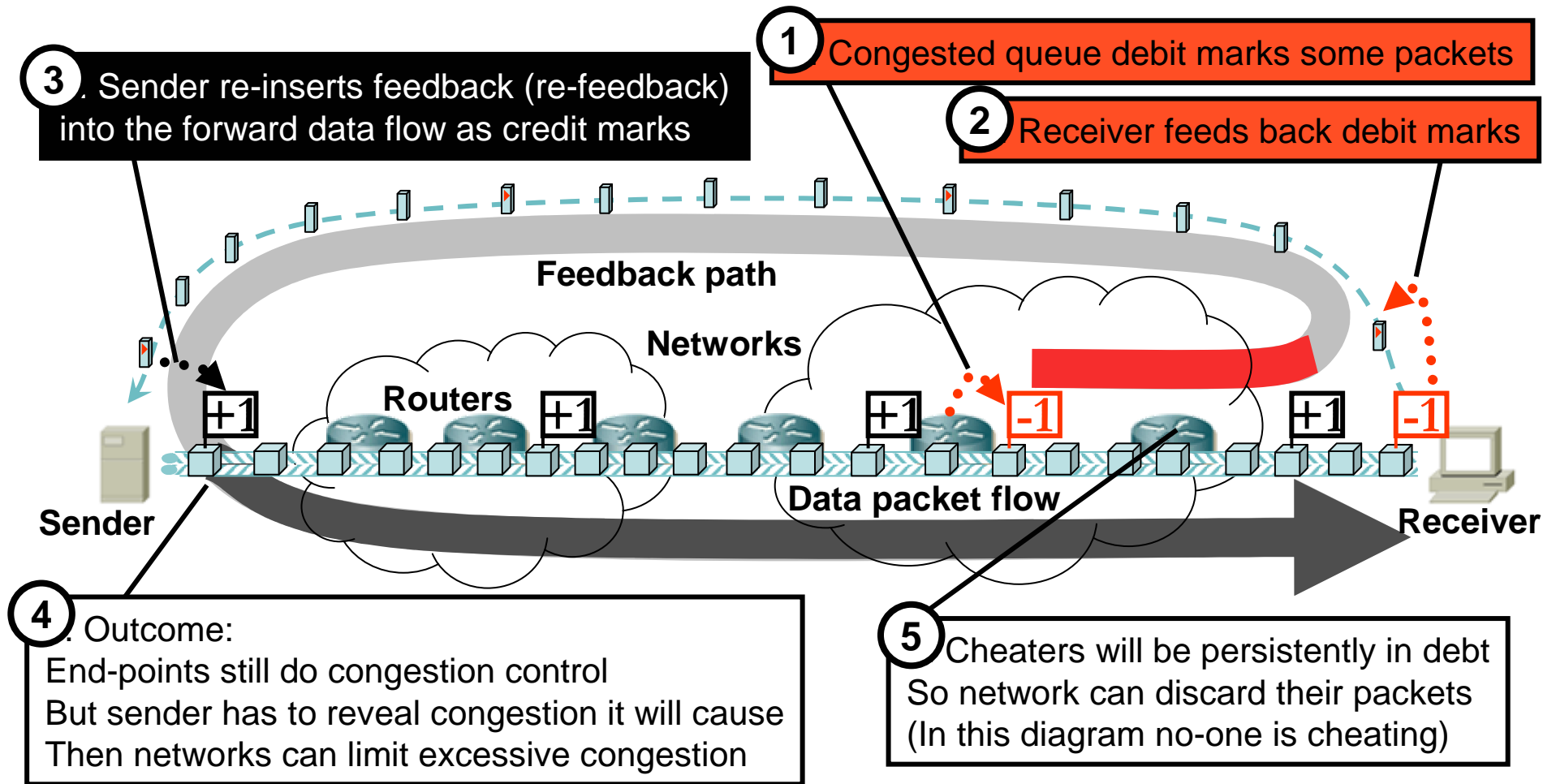
- congestion policing would maintain low latency and low loss for all too

“if only... ingress net could see congestion...”

Congestion Exposure [ConEx]

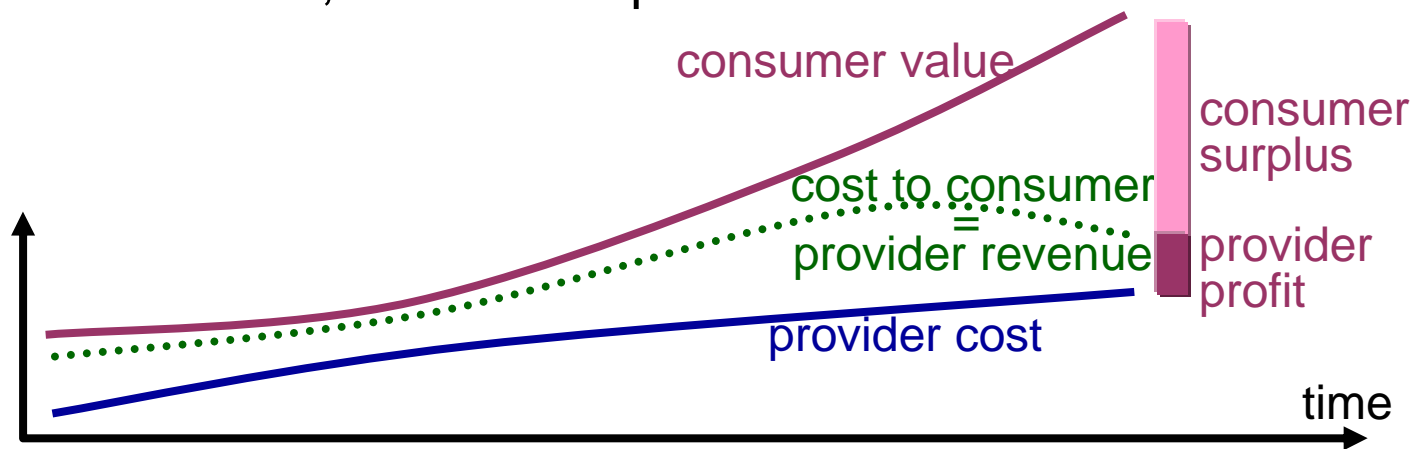
IETF activity to add new capability to IP

drop or standard ECN + re-inserted feedback (re-feedback)

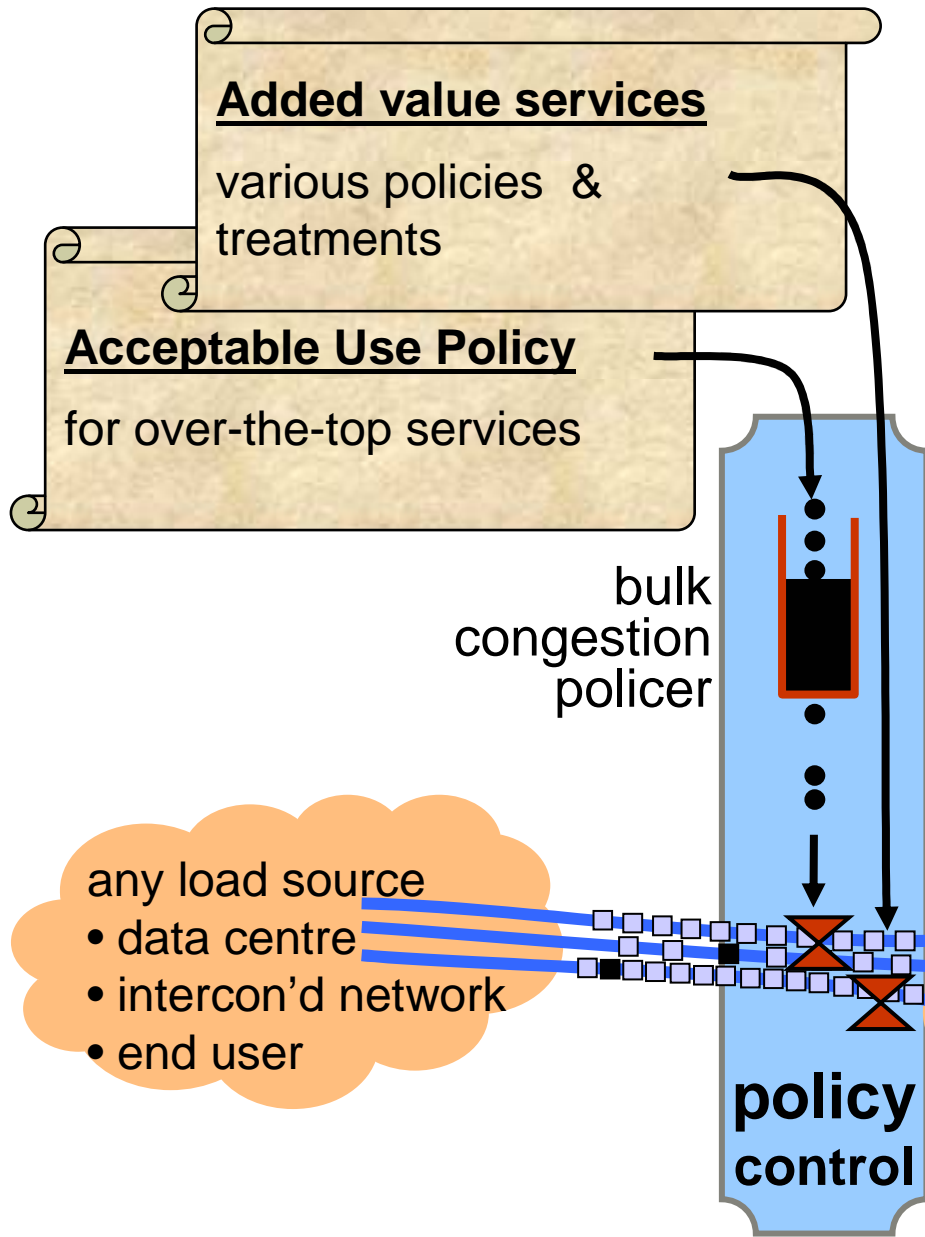


both value *and* cost

- even a CEO should understand both value *and* cost
- maximise profit = revenue – cost
 1. competitive market drives revenues down towards provider's marginal cost
 2. until then, revenue depends on consumer value



- in both cases
 - those who understand marginal costs will succeed
 - the marginal cost of traffic *is* its congestion-volume



added value and over-the-top services

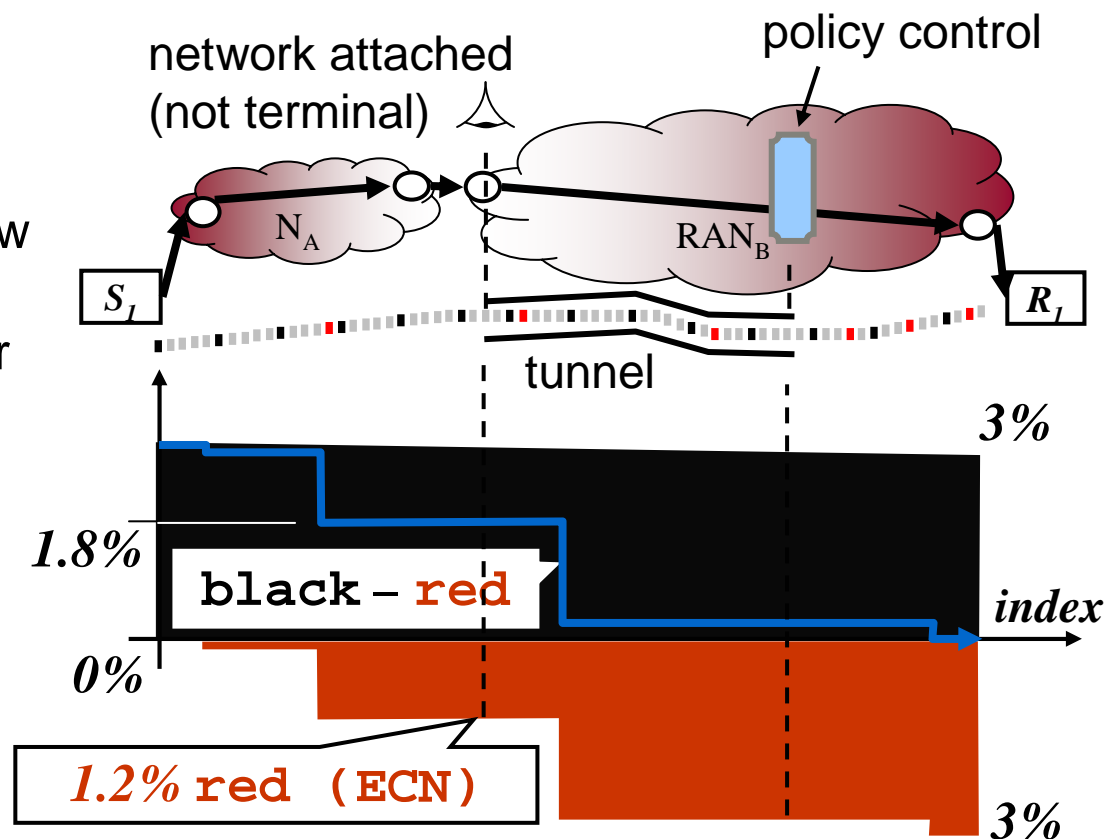
- today's policy control box (DPI)
- but with real-time cost info
 - brought to it in the packets
- cost info today is inaccessible
 - dynamic and
 - mainly in radio access network

remote viewing from the traffic mgmt box

- the volume of a flow is the same wherever metered
- but, whole path congestion-volume can be split
 - into congestion downstream and upstream of a point
 - can measure all three with ConEx
 - want to ignore congestion on the customer's side

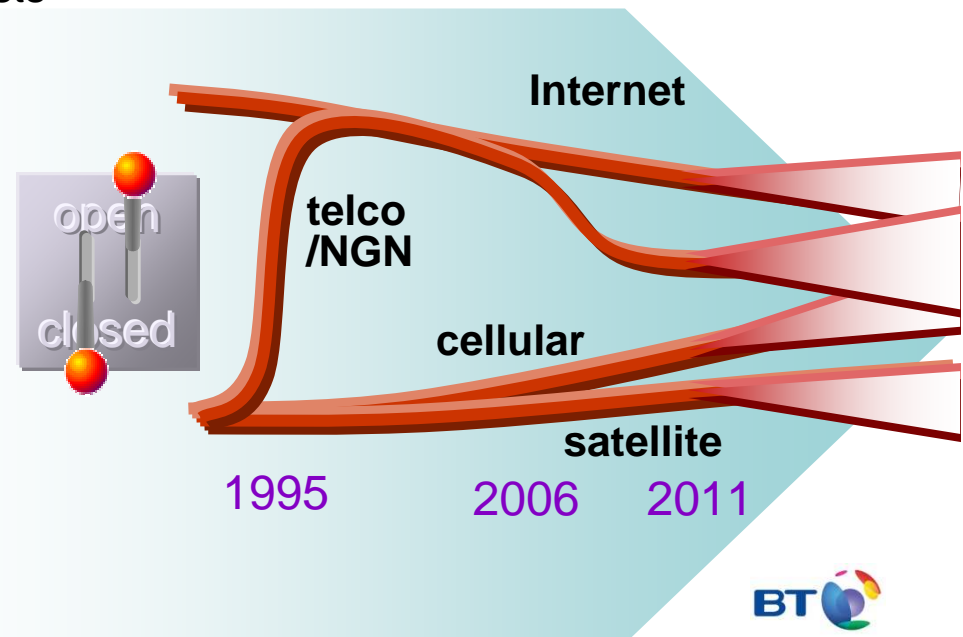
- at policy control box
 - can 'remote-view' split betw upstream & downstream
 - from point where customer attaches to your network

- solution: tunnel from the attachment point
 - inner headers 'freeze' congestion info from tunnel ingress



openness can be a tactic not a strategy

- edge policer is the focus all policy enforcement
 - **open:** per-user policing of bulk congestion volume
 - will allow much more freedom to innovate than current FQ constraint
 - new behaviours: e.g. very hi-speed, unresponsive, weighted, networked games
 - but all within overall responsibility envelope
 - **closed:** policing / enhancement of specific applications
 - optimising perceived value against marginal cost
 - using cost information carried in ConEx packets
- MVNOs / Retailers choose
 - how tightly to control true network costs
 - each product's market pos between open and closed
- Changing your mind
 - involves changing a policy
 - not new technology
- MNO / Wholesaler is agnosti
 - supports all positions
 - simultaneously



summary

- bringing together cost, value and control
 1. real-time marginal network cost info (ConEx-IP)
 2. market knowledge on customer value (DPI)
 3. 'edge' control point (on path, near edge)
- cost info is actually more important than value
 - to handle over-the-top traffic today
 - and as the market commoditises
- information on marginal cost is then all we need
 - but it's all we haven't got
 - we're working on this in ConEx at the IETF

references

- [Mulroy09] Mulroy, P., Appleby, S., Nilsson, M. & Crabtree, B., "[The Use of MuTCP for the Delivery of Equitable Quality Video](#)," In: *Proc. Int'l Packet Video Wkshp (PV'09)* IEEE (May 2009)
- [μ TP] Norberg, A., "uTorrent transport protocol," *BitTorrent.org* BitTorrent Enhancement Proposals (BEPs) 0029 (January 2010) (Draft)
- [Siris02] Siris, V.A., "Resource Control for Elastic Traffic in CDMA Networks," In: *Proc. ACM International Conference on Mobile Computing and Networks (MobiCom'02)* ACM (September 2002) <http://www.ics.forth.gr/netlab/future_wireless.html>

Congestion Exposure (ConEx) and re-feedback:
<<http://bobbriscoe.net/projects/refb/>>

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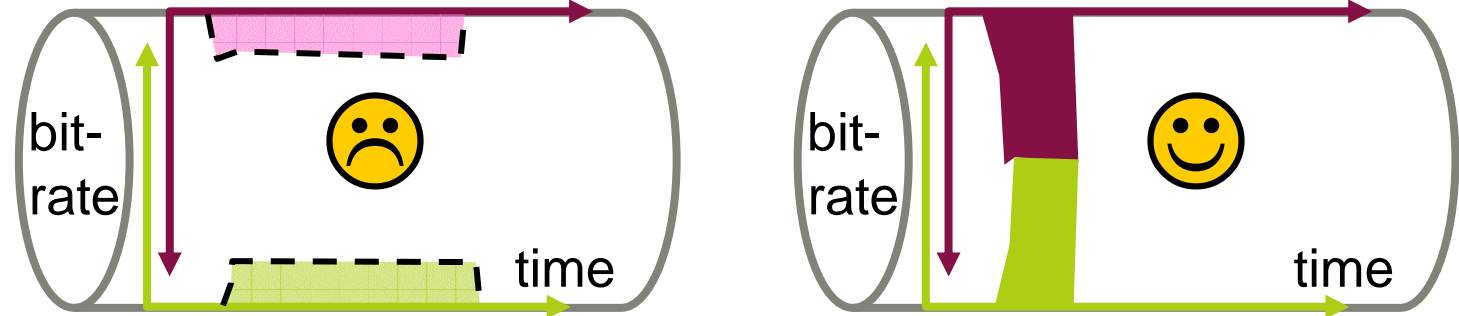
Q&A



congestion is not evil

congestion signals are healthy

- no congestion across whole path \Rightarrow feeble transport protocol
 - to complete ASAP, transfers should sense path bottleneck & fill it



the trick

congestion signal *without* impairment

- explicit congestion notification (ECN); update to IP (2001)
 - mark more packets as queue builds
 - then tiny queuing delay and tiny loss for all traffic
 - no need to avoid congestion signals to prevent impairment
- original ECN: gain too small to overcome deployment barriers