the cost of freedom

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degrading specific Internet applications

- a trend with two possible causes
  - technical deficiency   : Internet market   : global   :
  - regulatory deficiency   : access market   : mostly US-specific
- outline of talk
  1. technical deficiency with current Internet
     - resource allocation architecture allows those who bully most to get most (p2p, video)
       – network cannot arbitrate, because key usage information inaccessible to it
     - lacking a proper solution, operators kludge it by degrading likely culprit apps
       – intentions can be honourable, but confusable with degrading their competition
       – confusion can be conveniently exploited by either side
  2. proposed solution to both these problems (and more)
     - loose global grouping of researchers re-architecting Internet since 2000
     - 1-bit app-neutral fix to the Internet Protocol, in early standards process
- purpose of talk
  - does the proposed solution create a playing field you would be happy with?
  - if so, it needs support - cannot sustain through standards without a lot more help

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"freedom to use my line how I want"
limits freedom of others

- no. of access lines that can congest any other Internet link
  - staying around 1,000 – 100,000
  - cf. ~10M lines ringed in red

- congestion on shared links
  - not just a technical issue
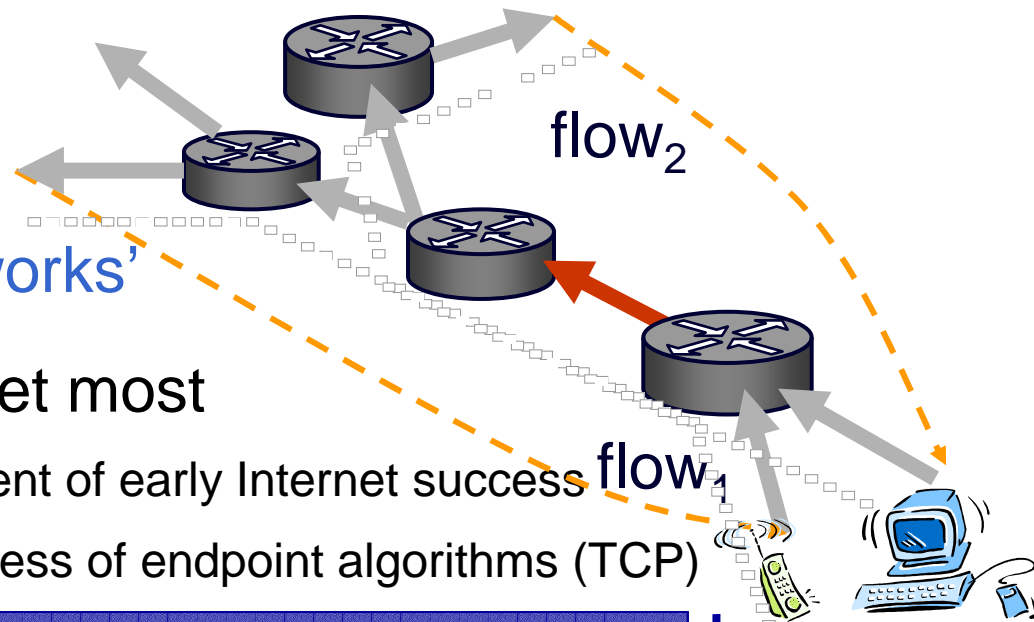 - continual conflict betw. real people & between real businesses
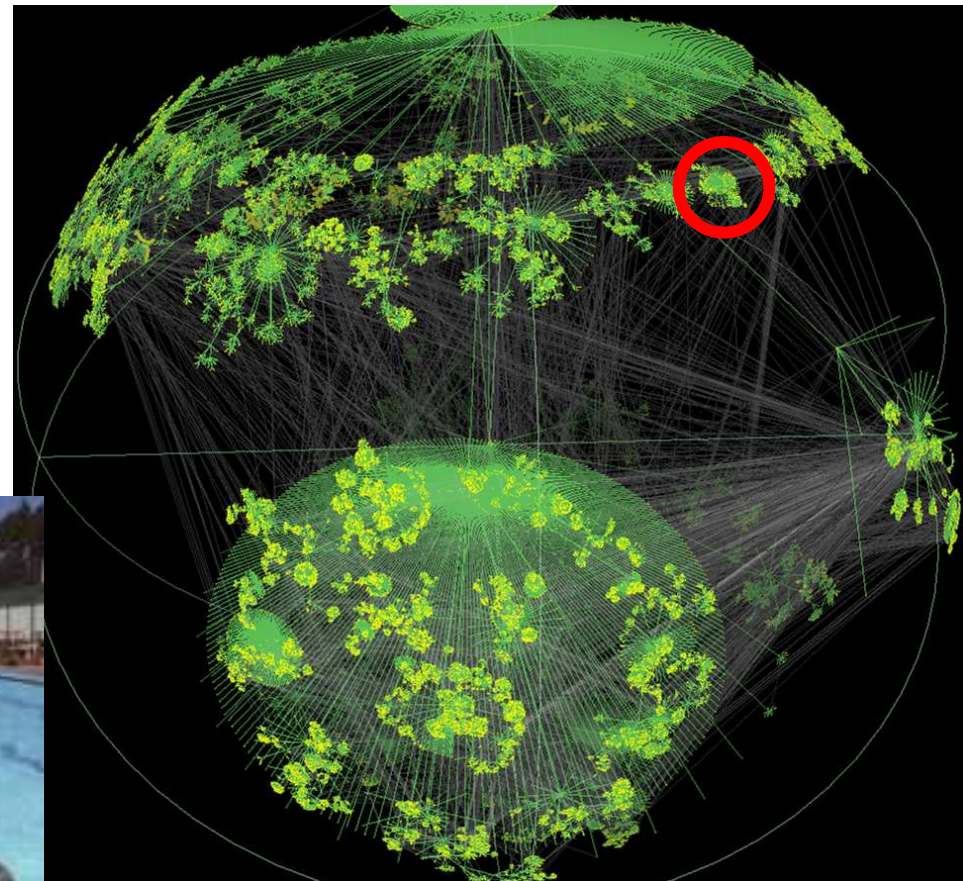
Internet topology visualization produced by Walrus (Courtesy of Young Hyun, CAIDA)
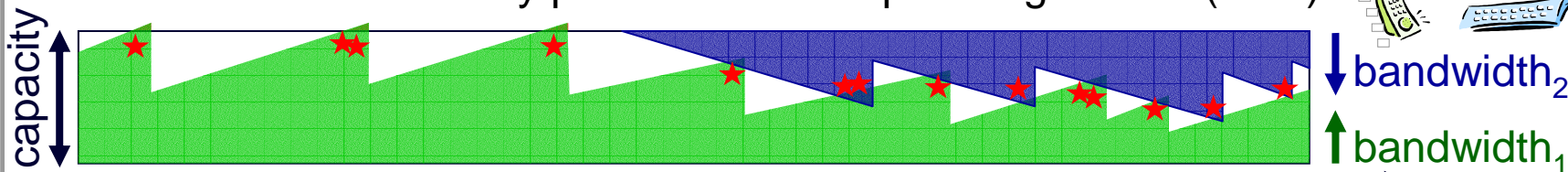

- need better usage control not just access link capacity
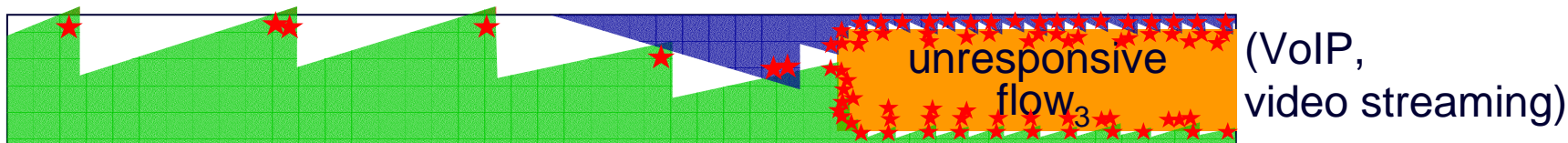 - but volume is an inadequate metric
  - so ISPs resort to targeting apps

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freedom

how Internet sharing 'works'

- those who push most, get most
  - restraint: the other ingredient of early Internet success
  - reliant on voluntary politeness of endpoint algorithms (TCP)

$flow_2$

$flow_1$

capacity

$\downarrow bandwidth_2$

$\uparrow bandwidth_1$

  - a game of chicken – taking all and holding your ground pays

time

unresponsive $flow_3$

(VoIP, video streaming)

  - or starting more 'TCP-fair' flows than anyone else

(browsers x4, bitTorrent x50)
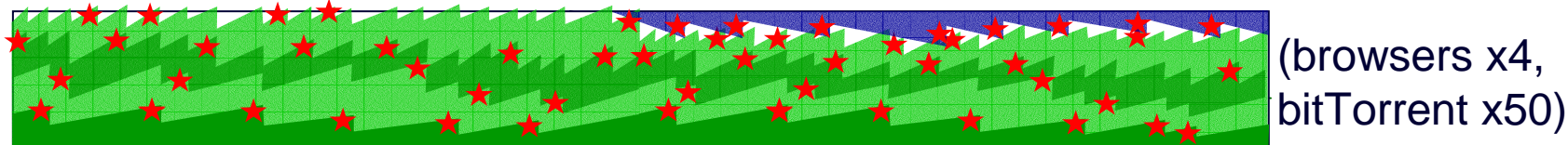
  - or for much longer than anyone else (p2p file-sharing)

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ineffective kludges are making matters worse
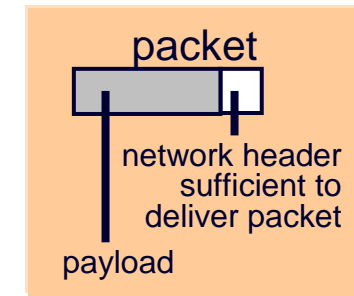## fuelling adversarial climate

- deep packet inspection (DPI) cannot win arms race against obfuscation
  - 80% of payloads now carry randomised app identifier
  - latest p2p apps use payload encryption & imitate other apps
  - more & more false positives, more customer support calls

packet

network header
sufficient to
deliver packet

payload

download
bit rate

← 200kbps
(2M contended)

← 30kbps

customer of an ISP using DPI to throttle p2p turns *off* encryption in BitTorrent client

- intentions might be honourable
  - protecting the many from the few
- but counter-productive
  - if easily bypassed and easily turned against itself
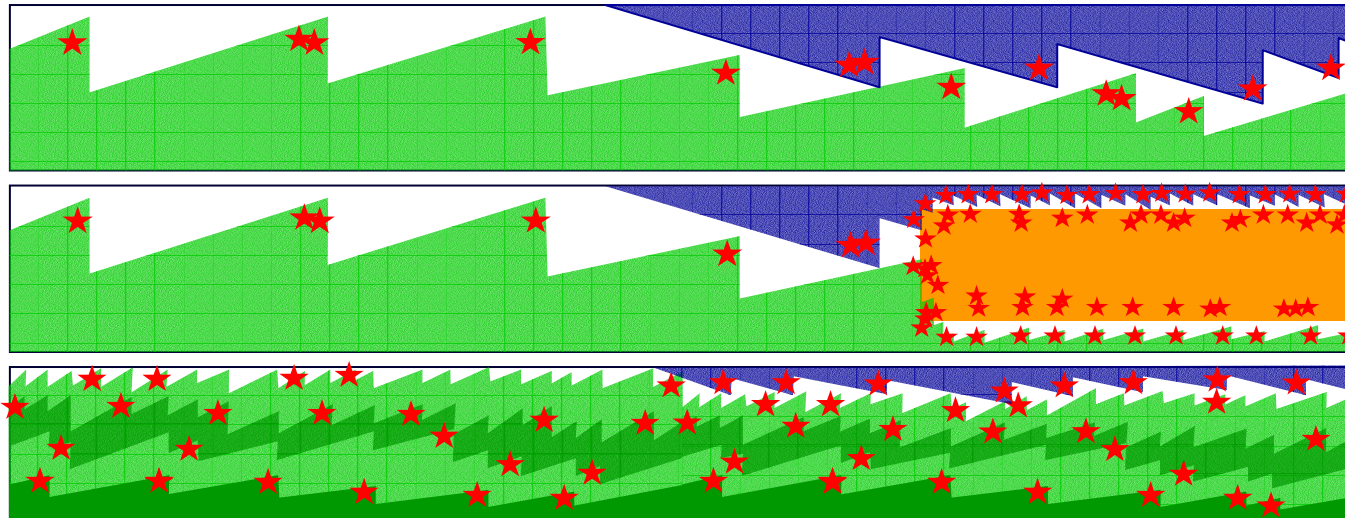 - if (mis)interpretable as discriminating against competition
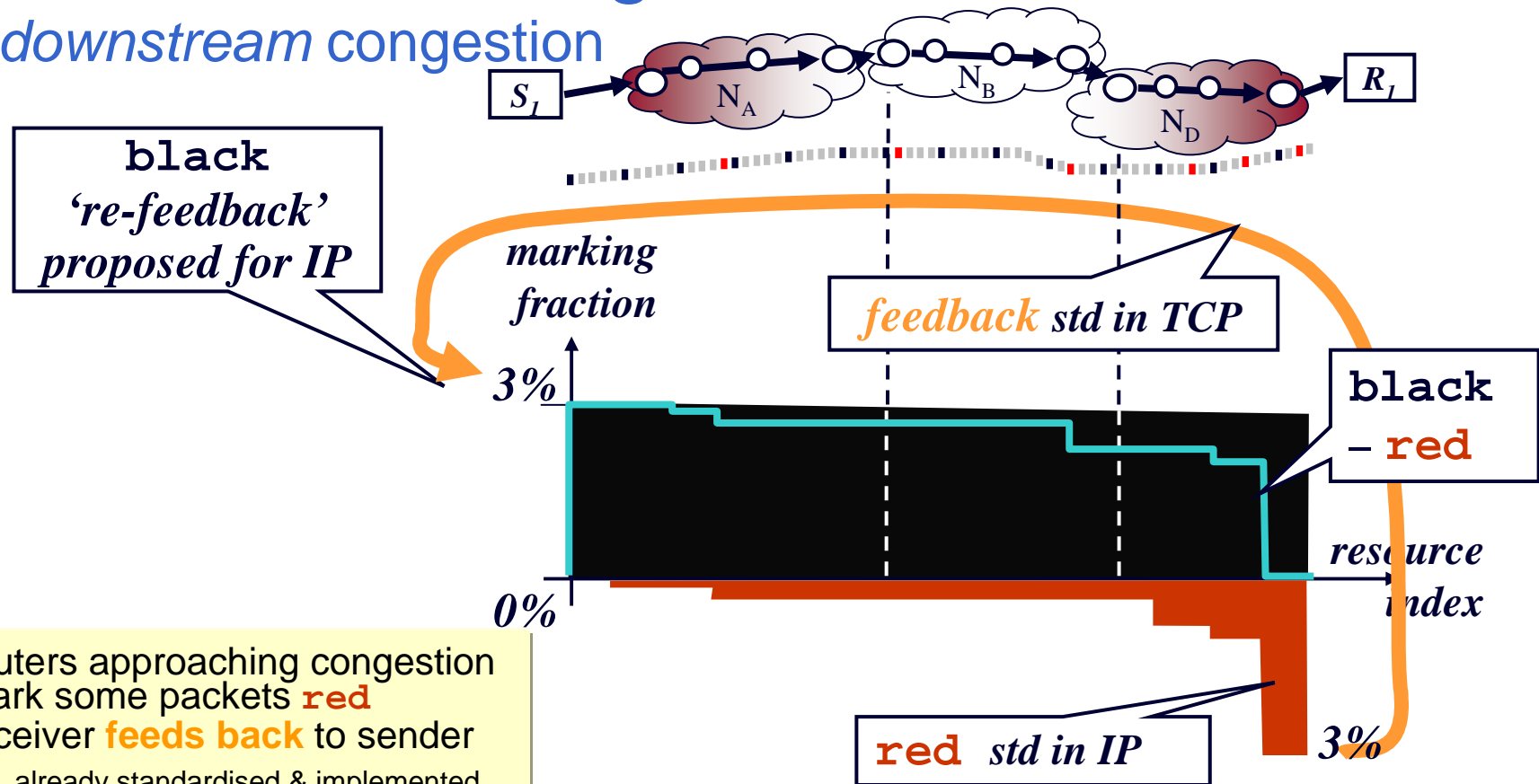
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the missing metric
congestion volume (not volume)

- a competitive market tends towards cost

  - cost of each customer's usage is "stuff sent that can't get through"

  - but impractical to measure absence of stuff

  - explicit congestion notification (ECN): standardised into IP in 2001

  - mark "stuff that wouldn't get through" if congestion got worse
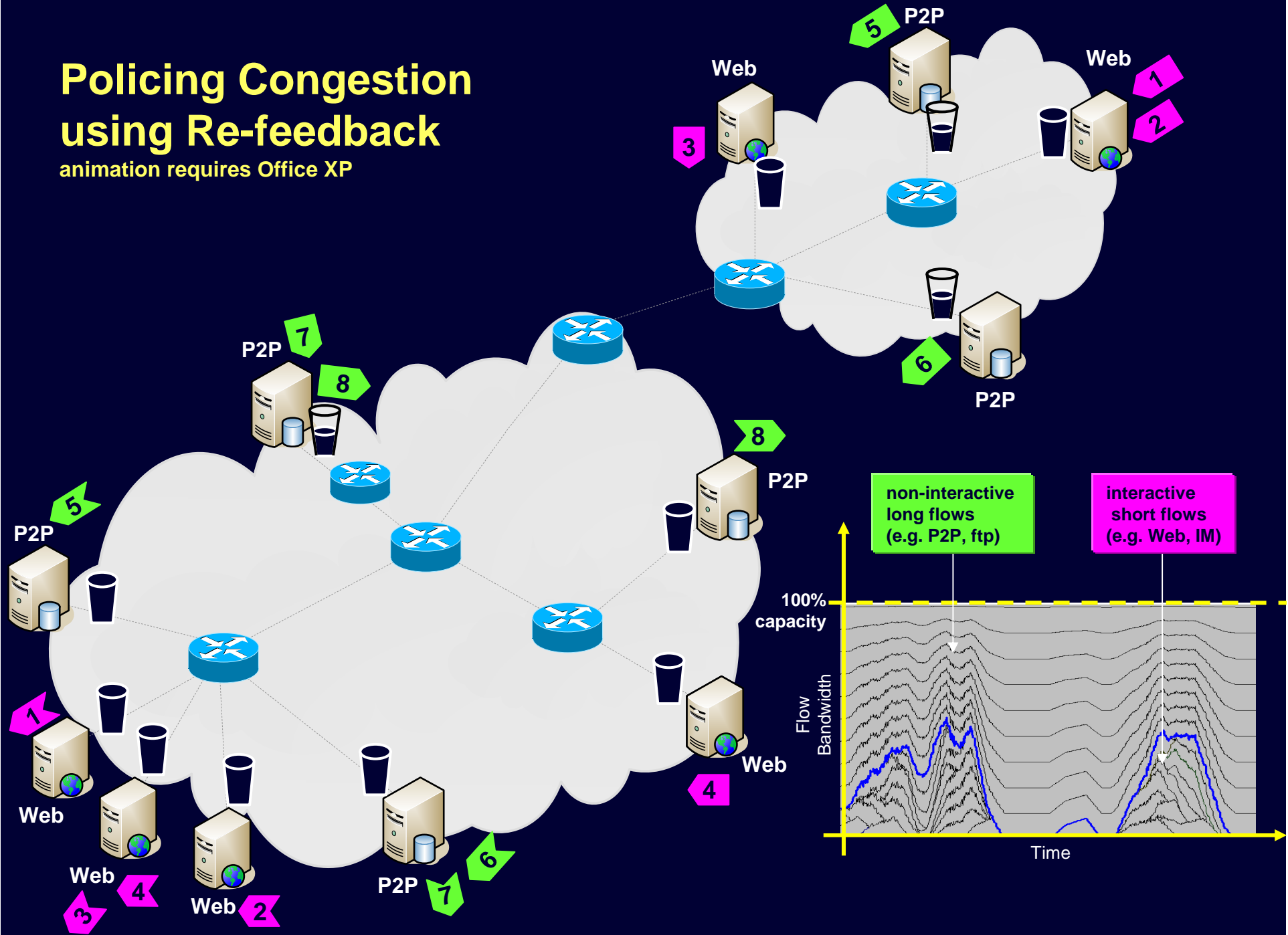
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the other missing metric

downstream congestion

S_1 N_A N_B N_D R_1

black *'re-feedback' proposed for IP*

marking fraction

feedback std in TCP

black − red

3%

0%

resource index

red std in IP

3%

- routers approaching congestion mark some packets **red** receiver **feeds back** to sender
  - already standardised & implemented
  - not generally turned on by operators

- sender re-inserts **feedback** by marking packets **black**
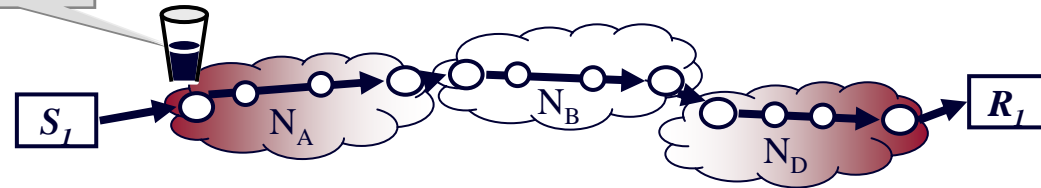 - **re-feedback** requires standardisation

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Policing Congestion using Re-feedback

animation requires Office XP

non-interactive long flows (e.g. P2P, ftp)

interactive short flows (e.g. Web, IM)

100% capacity

Flow Bandwidth

Time

using the downstream congestion metric

one example: per-user policer

congestion
volume
allowance

overdraft

**non-interactive long flows
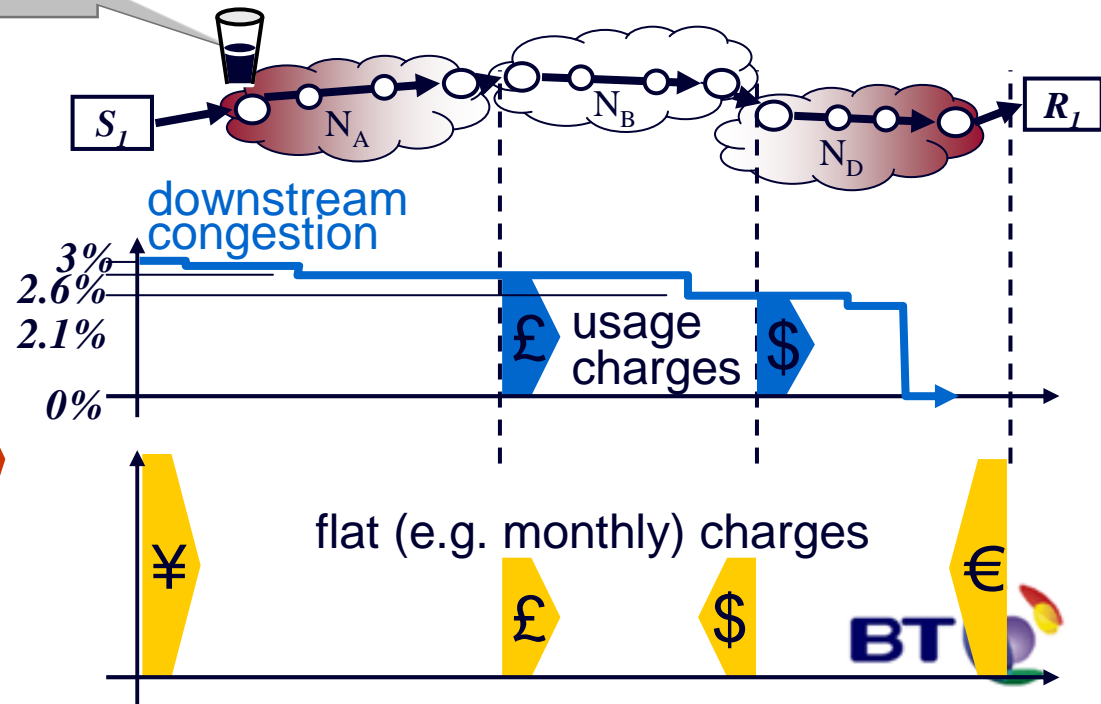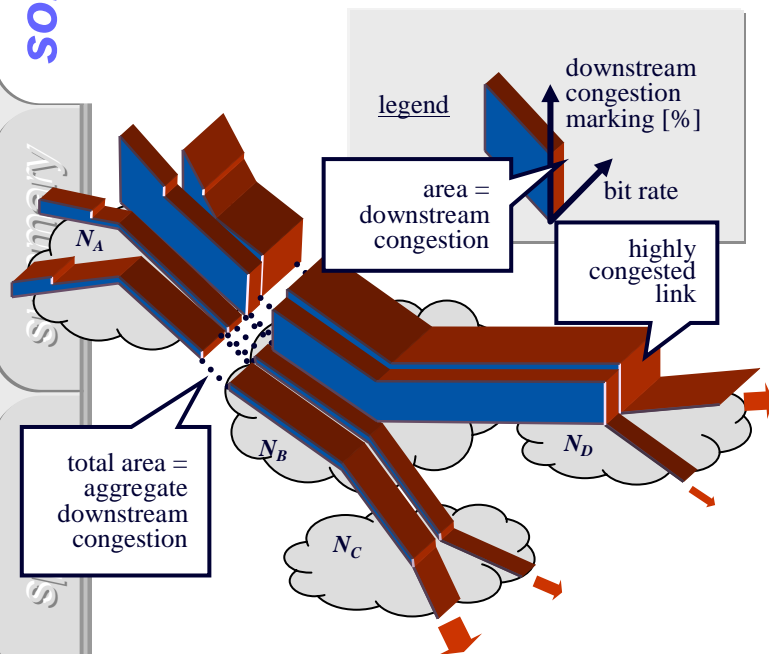(e.g. P2P, ftp, DDoS)**

two different customers, same deal

**interactive short flows
(e.g. Web, IM)**

other examples

- make flows respond to congestion (VoIP, video, DDoS)
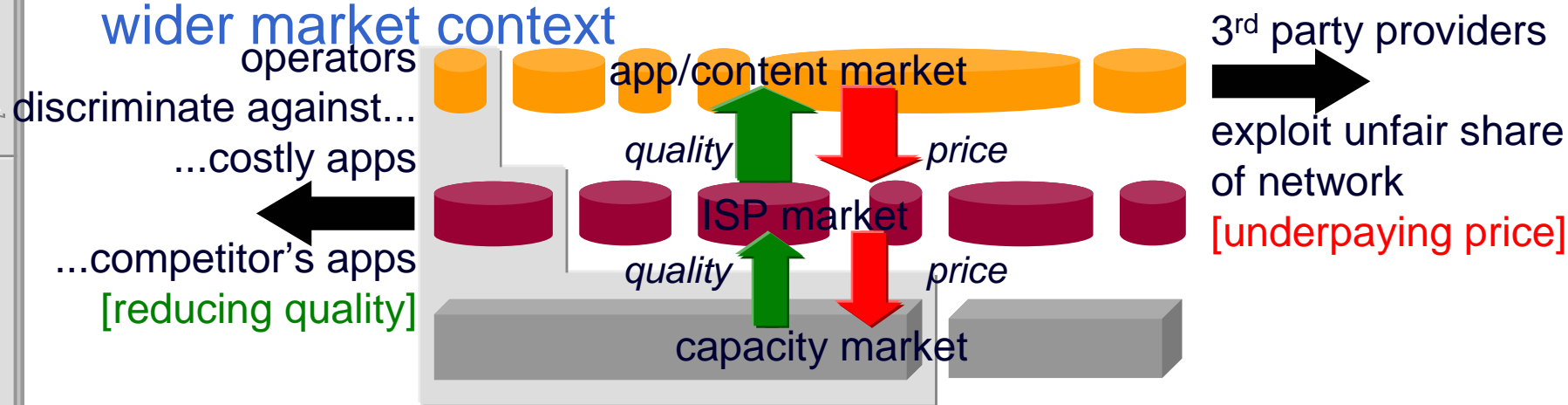- no policing at all

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inter-domain accountability for congestion

- metric for inter-domain SLAs or usage charges

  - N_B applies penalty to N_A in proportion to bulk volume of **black** less bulk volume of **red** over, say, a month

  - could be tiered penalties, directly proportionate usage charge, etc.

  - flows de-aggregate precisely to responsible networks

  - N_A can deploy policer to prevent S_1 costing more than revenue

legend

downstream congestion marking [%]

area = downstream congestion

bit rate

highly congested link

total area = aggregate downstream congestion

N_A

N_B

N_C

N_D

S_1

N_A

N_B

N_D

R_1

downstream congestion

3%
2.6%
2.1%

0%

£ usage charges $

flat (e.g. monthly) charges

¥

£

$

€

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degrading specific Internet applications

wider market context

operators discriminate against...

...costly apps

...competitor's apps
[reducing quality]

3rd party providers

exploit unfair share of network
[underpaying price]

app/content market

quality   *price*

ISP market

quality   *price*

capacity market

- solution: identify costly *bits*

  - then quality can rise to match willingness to pay

market	problem	appropriate remedy	inappropriate remedy
Internet	architecture	fix architecture	US net neutrality regulation
access	weak competition (US)	fix US access regulation	US net neutrality regulation
	going well (e.g. UK)	no change	

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designed for tussle

Internet needs all these answers – market selection finds balance

demand side – freedom to degrade others

- the Internet is all about the freedom to get what I want (within my line rate)

limited by how much I impinge on the freedom of others

- enforceable congestion control

freedom within fairness

- differentiated quality of service

you'll get what you contract to have

- you'll get what *we* infer you want given what you're doing

supply side – freedom to degrade competitors

architecture allows extremes but doesn't help them and provides handles for the market to make it very hard for them

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summary

- Internet needs to be able to discriminate
    - against bits limiting the freedom of others – *bits* causing congestion
    - then wouldn't need to discriminate against *apps* causing congestion
- operators can choose not to limit their users' freedoms
    - but they take responsibility for congestion their users cause in other nets
- if operators do discriminate against apps
    - customers need enough choices to be able to switch operators
    - or apps can often obfuscate themselves anyway
- these economic effects require change to the Internet Protocol
    - making IP more suitable as the basis of a converged architecture
    - early in standards process – link on next slide
    - please assess it – urgently needs support through standards

open

closed

**public
Internet**

**telco
/NGN**

cellular

satellite

1995   2006

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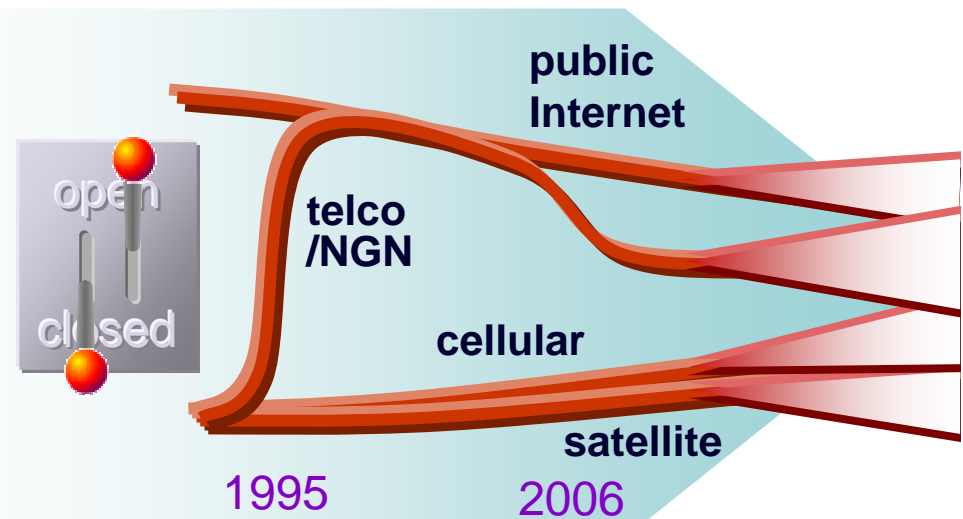
the cost of freedom
<www.cs.ucl.ac.uk/staff/B.Briscoe/present.html#0612crn>
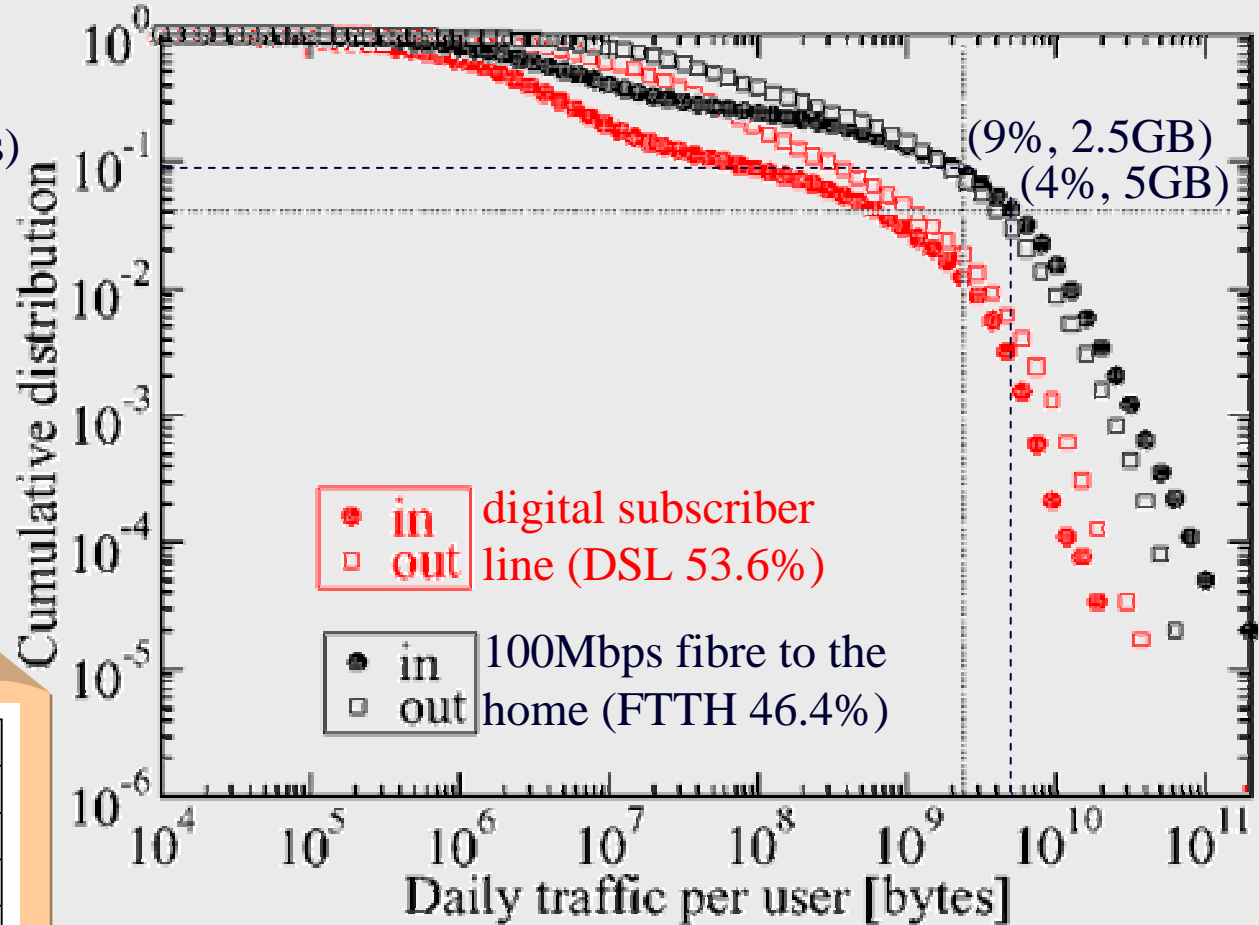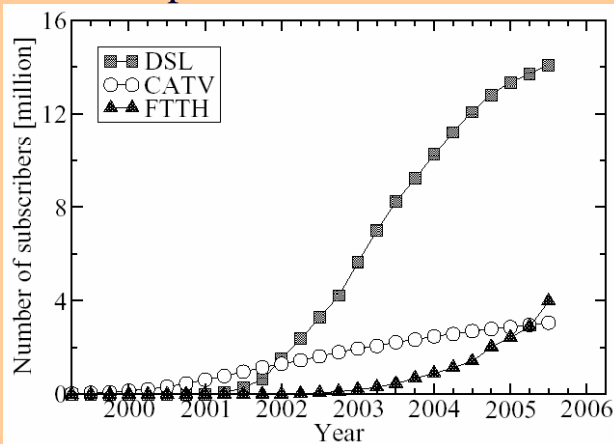
Q&A
& spare slides

capacity growth will prevent congestion?

Distribution of customers' daily traffic into & out of a Japanese ISP (Feb 2005)

(5GB/day equivalent to
0.46Mbps if continuous)

(9%, 2.5GB)
(4%, 5GB)

in digital subscriber
out line (DSL 53.6%)

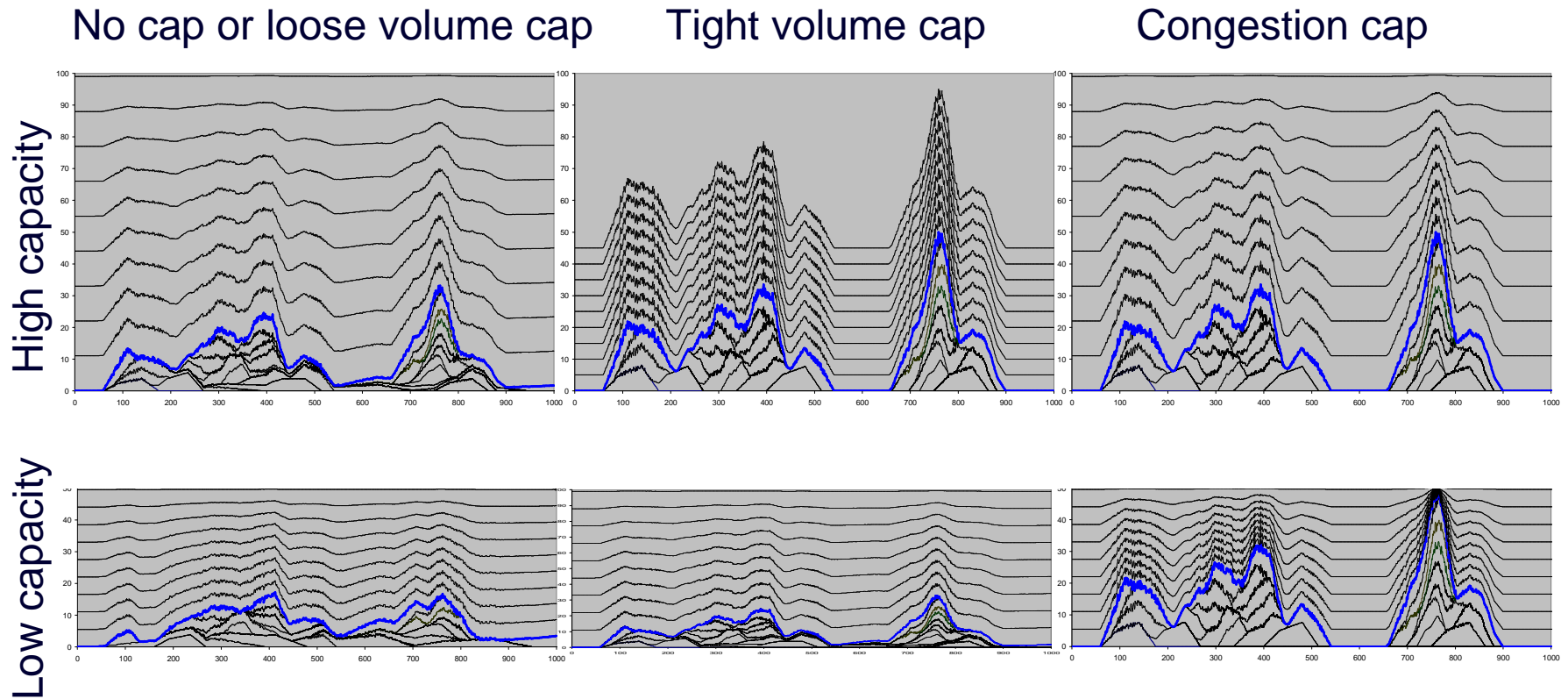**in** 100Mbps fibre to the
out home (FTTH 46.4%)

Changing technology shares
of Japanese access market

Courtesy of Kenjiro Cho et al
The Impact and Implications of the Growth
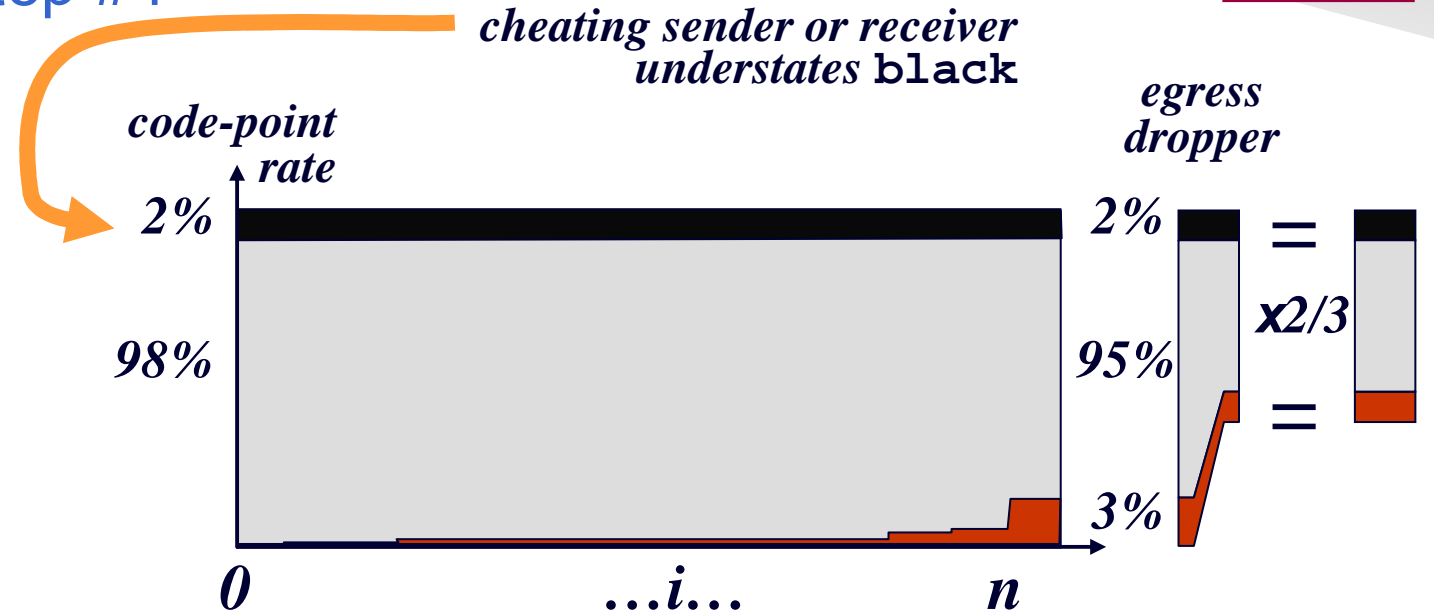in Residential User-to-User Traffic, SIGCOMM'06

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congestion cap auto-adjusts
## volume cap always a hard compromise

No cap or loose volume cap   Tight volume cap   Congestion cap

High capacity

Low capacity

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incentives
solution step #4

cheating sender or receiver
understates `black`

egress
dropper

code-point
rate

2%

98%

0　　　**…i…**　　　**n**

2%

95%

3%

x2/3

=

=

- won't sender or receiver simply understate congestion?
- no – drop enough traffic to make fraction of `red` = `black`
- goodput best if rcvr & sender honest about feedback & re-feedback

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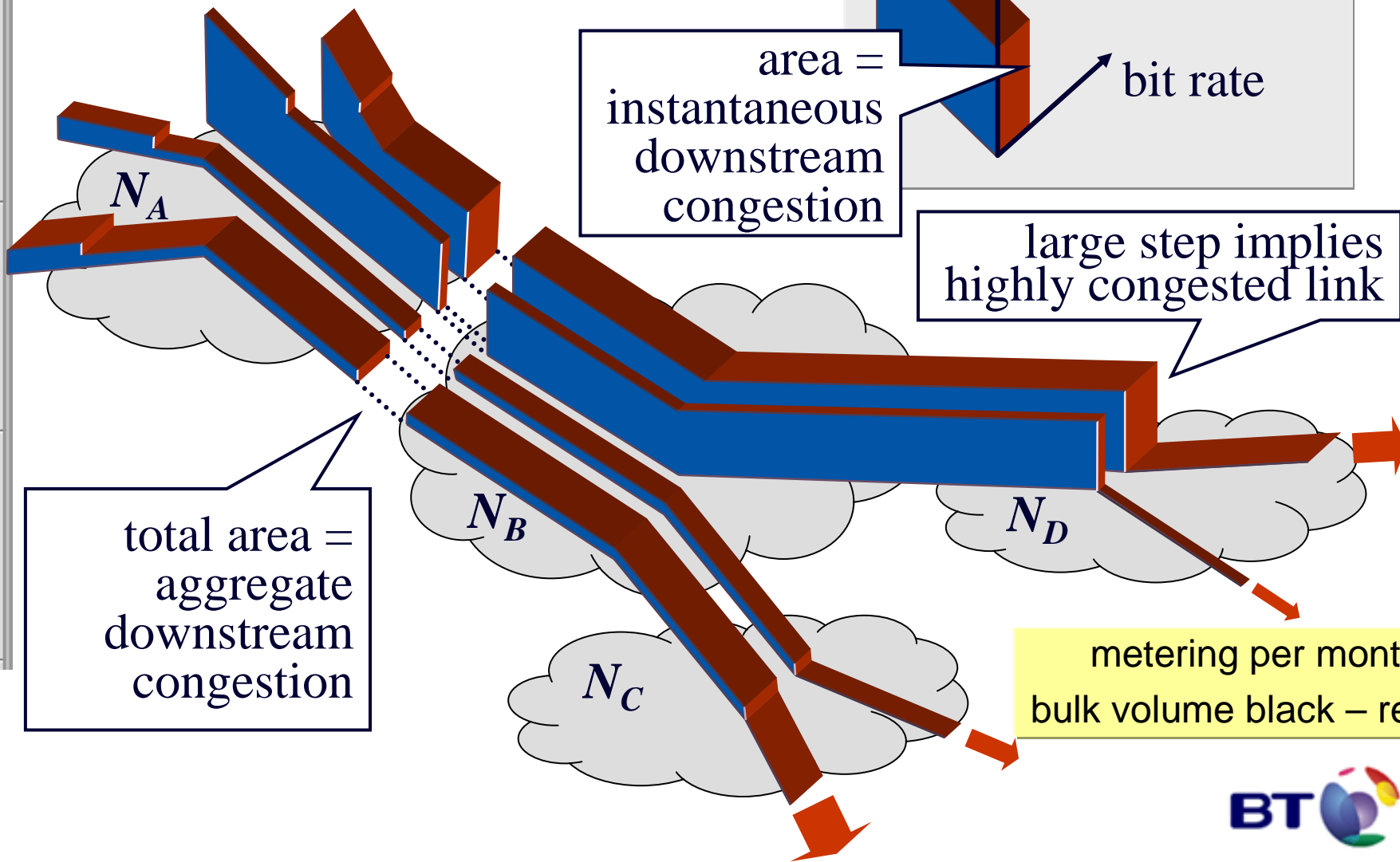
prime directive
for re-architecting the Internet

- 'design for tussle'
  - design so major social & economic struggles can be resolved at 'run-time'
    - by market or social regulation
  - if instead you try to embed political outcomes into the architecture at 'design-time'
    - powerful economic forces will ignore/violate the architecture to achieve their ends

- Internet > public Internet
  - eg. in BT's 21C network, public Internet & PSTN replacement are just IP virtual private networks

- resource allocation architecture
  - but current Internet inherently open (to abuse)
  - re-feedback allows more control
  - making IP more generic as the basis of a converged architecture
  - then each operator's choice between open & closed can be determined by market forces
  - but the whole spectrum of choices can be neutral to specific apps

open

closed

public Internet

telco /NGN

cellular

satellite

1995   2006

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