ends v middle

Q. what should a network owner do?
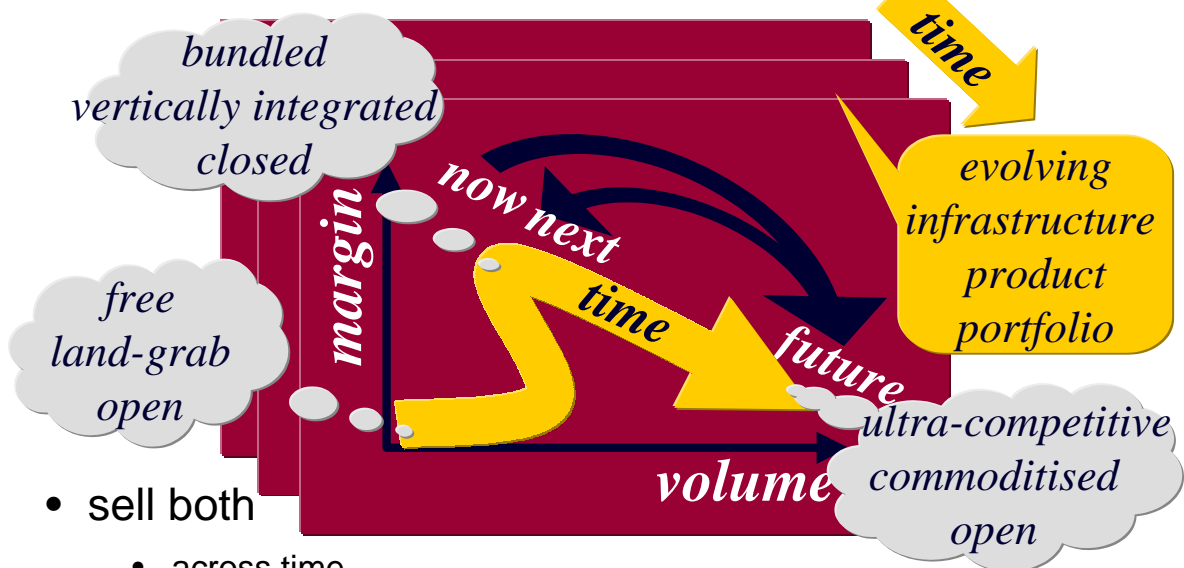
A. Design for Tussle

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a powerful compromise

- "ends is best", "middle is best", **"ends"**, **"middle"**, "ends", "middle"...

time

bundled vertically integrated closed

margin

now next

time

free land-grab open

future

volume

evolving infrastructure product portfolio

ultra-competitive commoditised open

- sell both
  - across time
  - across market

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evolution of evolvability research

❶ end to end arguments [SaltzerReedClark84]

- protect generic investment, surrender control to foster innovation

❷ end of e2e [ClarkBlumenthal00]

- ends not trusted to co-operate with whole
- middle needs investment incentive

❸ end of (end of e2e) [Shenker, Kelly, Varian, Crowcroft, Anderson etc]

- game theoretic mechanism design

❹ argument is the end [ClarkSollinsWroclawskiBraden02]

- design for tussle

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example: quality of service

materials & process equip	comp- onents	equip makers	network owners	service providers	content & applics	appli- ances	end users

❶ e2e: TCP/IP: ends: congestion control; middle: forwarding

- transmission control protocol (TCP) [VanJacobsen88]
  explicit congestion notification (ECN) [Floyd94]

❷ e2e problems

- ends not trusted: VoIP free-riding
- middle needs investment incentive
  Intserv [BradenClarkShenker94], Diffserv [ClarkWroclawski97]

❸ e2e fixed

- shadow pricing, proportional fairness [GibbensKelly99]
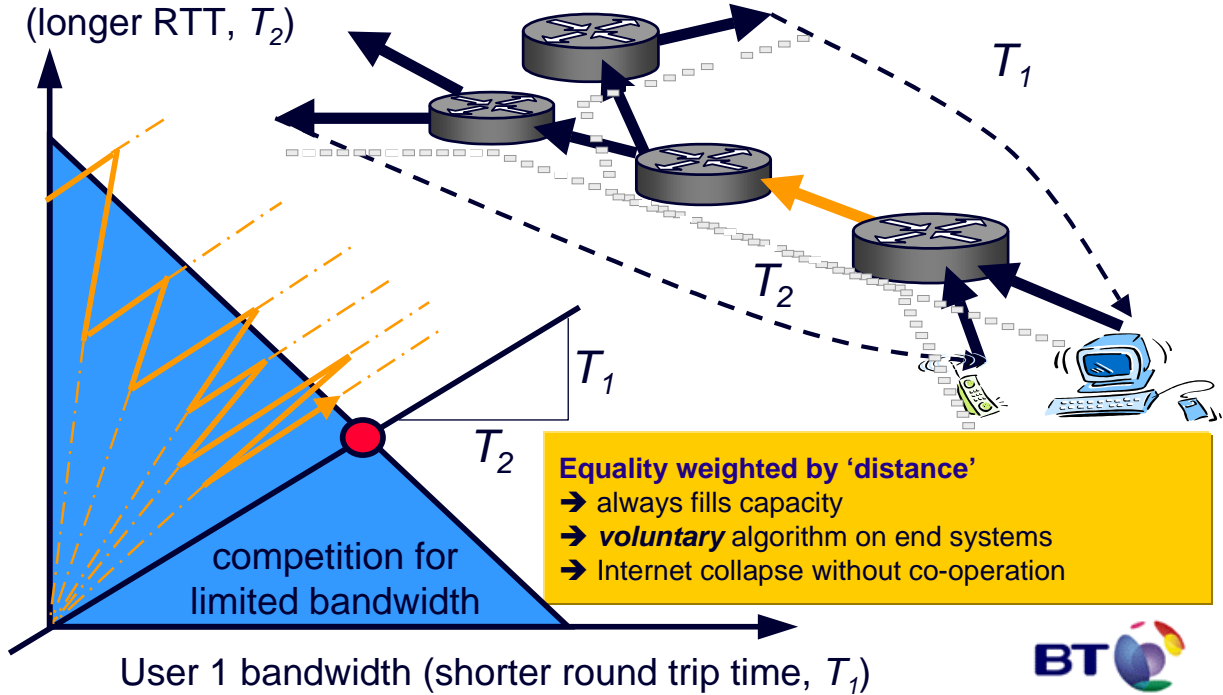
❹ design for tussle

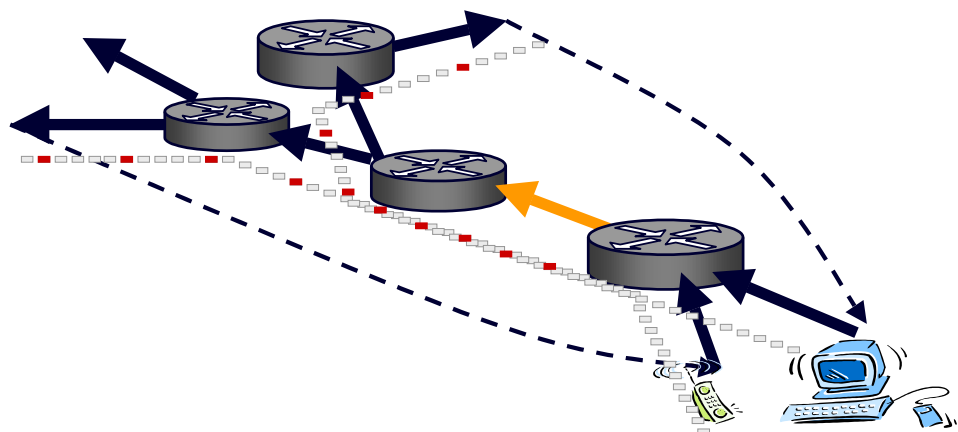- guaranteed QoS synthesis [Karsten02]
- control over control [Briscoe02]

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❶ e2e design

TCP: business model

User 2 b/w
(longer RTT, T_2)

T_1

T_1

T_2

T_2

T_1

T_2

competition for
limited bandwidth

Equality weighted by 'distance'
➔ always fills capacity
➔ *voluntary* algorithm on end systems
➔ Internet collapse without co-operation

User 1 bandwidth (shorter round trip time, T_1)

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❶ e2e design

explicit congestion notification (ECN)

• **without ECN: first sign of congestion is loss**
• **with ECN: mark packets randomly as congestion builds**

• **2001: ECN standardised into IP & TCP**
• extensible for marking *before* congestion onset (virtual queue)

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❷ e2e problems
greed breeds policing

- voice over IP
  - if experience congestion, send more

- integrated services
  - users reserve path resources (ReSerVation Protocol)
  - networks control admission then police traffic

- differentiated services
  - provision prioritised logical classes of service
  - traffic classified (Diffserv field in IP) and policed
  - congestion avoided for higher classes, usually

- middle takes control
 - can vertically integrate with media business

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❸ e2e gets fixed
DIY QoS

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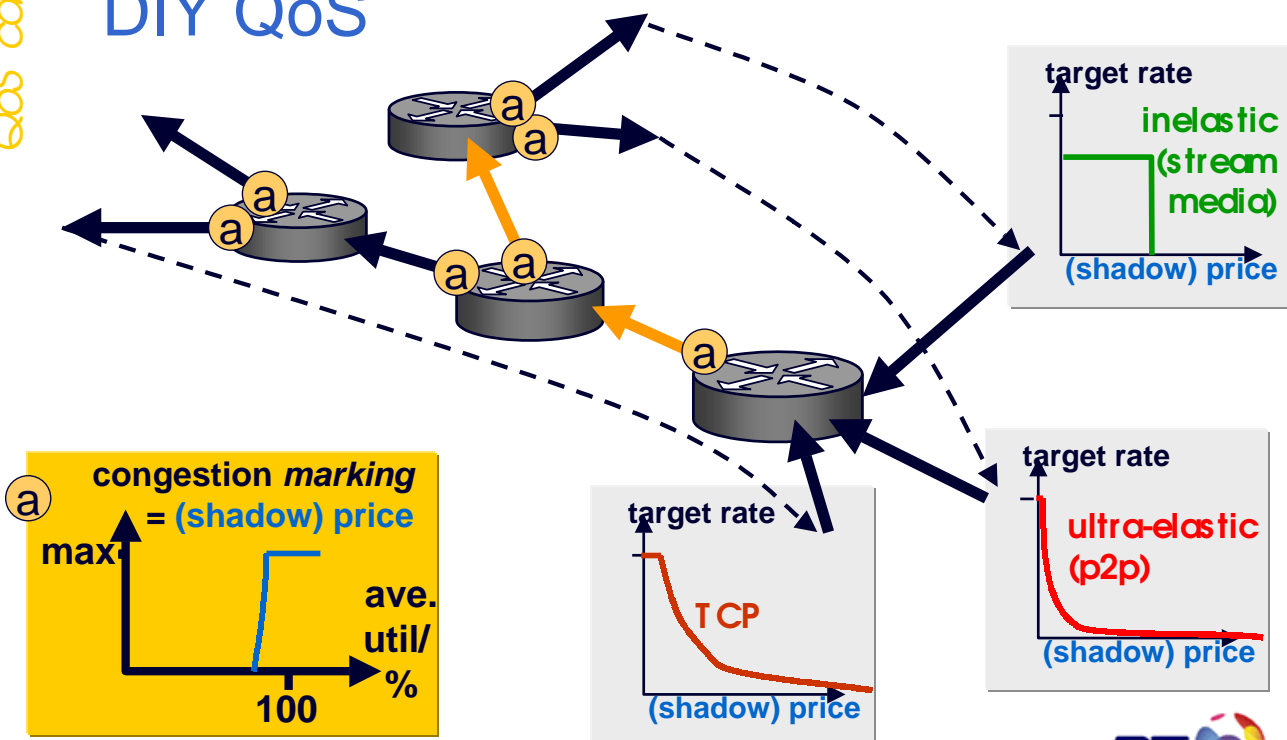
❹ design for tussle
guaranteed QoS synthesis

IP routers		Data path processing	
Reservation enabled		①	Reserved flow processing
RSVP/ECN gateway		②	Policing flow entry to CP
		④	Meter congestion per peer
ECN only		③	Bulk ECN marking CP prioritised over BE

- guarantees over simple middle
- allows vertically integrated media business at edge
- DIY QoS one notch in
- uses 3 QoS standards but not their architectures

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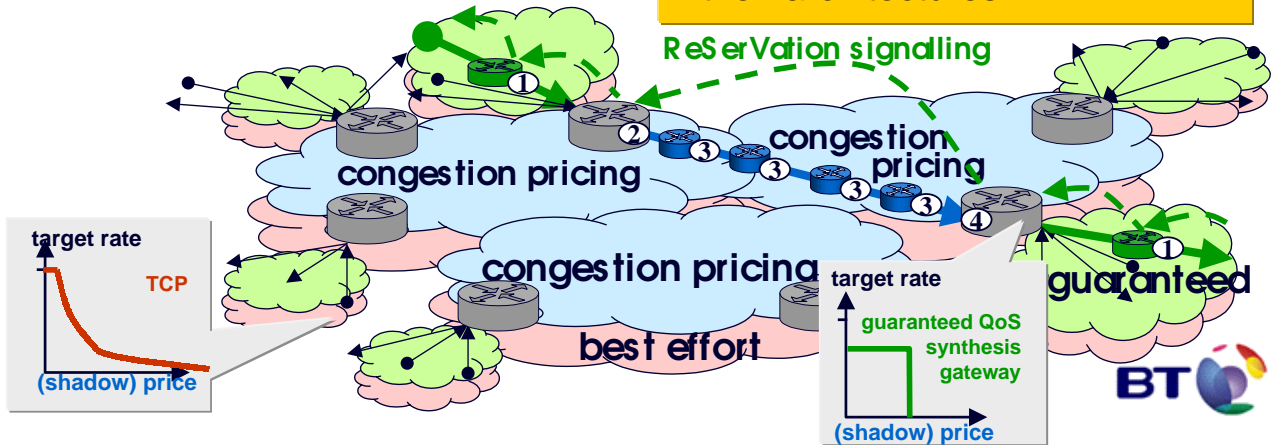
control over control

- control can migrate network owners · service providers · content & applics · appli-ances · end users
- sell different control models to different markets
  - DIY and "do it for you" customers
- equip makers ... can re-sell control package each time

- how to control where control is?
  - offering protocol response at a price 'switches on' its importance
- what controls where the control is?
  - market advantage, competition
 - regulation

other case studies

- QoS & admission control
- access routing (personal router, contractual mobility)
- session control
- context awareness
- location-based svcs
- presence
- messaging services

- file serving (p2p)
- service creation
- security services
- denial of svc mitigation
- deep packet inspection (applications do it too!)
- access network provisioning (collaborative / ad hoc wireless)

= we've designed/built for tussle

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summary of approach

- design *as if* e2e
  - include proofing against greed
  - based on underlying science
- design edge interception of e2e protocols
- let the tussle commence
  - capture market share with free, open product
  - pull in control from ends to edge
  - competition gradually commoditises
  - giving up control stimulates new innovation
- layer under next product
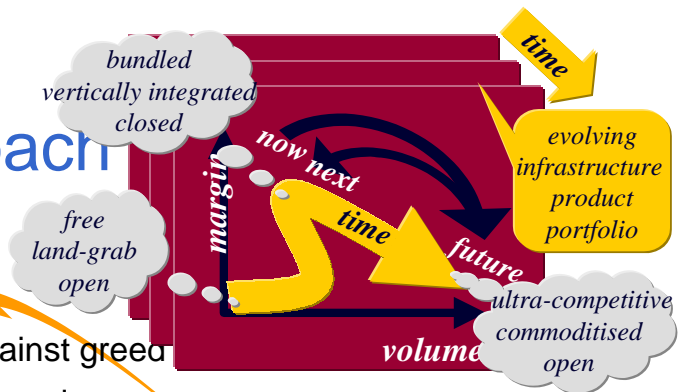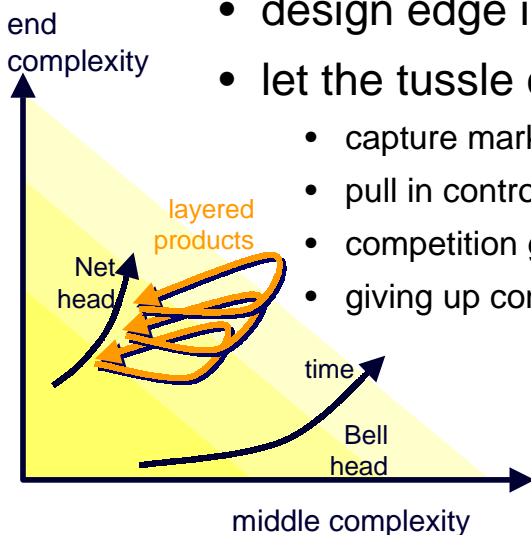
Net-head heart
Bell-head skins

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further info

- Bob.Briscoe@bt.com

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- [ClarkBlumenthal00] David Clark and Marjory Blumenthal, "Rethinking the design of the Internet: The end-to-end arguments vs. the brave new world," In Proc. Telecommunications Policy Research Conference (TPRC'00), URL: http://www.tprc.org/abstracts00/rethinking.pdf (Sep 2000)
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- [ClarkSollinsWroclawskiBraden02] David Clark, Karen Sollins, John Wroclawski and Robert Braden, "Tussle in Cyberspace: Defining Tomorrow' s Internet," InProc. ACM SIGCOMM' 02, Computer Communication Review 32 (4) URL: http://www.acm.org/sigcomm/sigcomm2002/papers/tussle.pdf (Aug 2002)

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issues for discussion

- design for tussle is subtle
  - takes years of hindsight to get right
  - too late for early market advantage?
  - open, free land grab gives some breathing space
  - can tendering process cope with subtlety?

- does designing for commoditisation bring it forward?
  - is having no plan B more risky?

- parallels in Microsoft product evolution?
  - BIOS, DOS, Win, COM, .NET, Office