Tussle for Control of Quality of Service: Operator or Consumer?

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What use is a pricing scheme for quality of service (QoS) in data communications that has all the right economic and engineering properties, but is completely unsaleable to consumers? Congestion pricing combined with a flat subscription fee is just such a scheme. But we demonstrate that it is the *only* scheme that a *wholesale* communications operator will need at the heart of its operations.

The incentive compatibility of congestion avoidance pricing has been proven in the seminal work of Kelly [8], building on [9]. Briefly, congestion avoidance charges shadow the externality between users. And operators can recover their sunk costs by topping up fixed fees with congestion charges. Incentives are correct both for rate control and routing. Congestion pricing is also practical to engineer — a fixed price is applied to packet markings already standardised into the Internet protocol, called explicit congestion notification (ECN[11]). Metering costs are low, whether at an access or interconnect interface. But despite near-perfection in both economic and engineering terms, numerous user studies [10, 2, 1] show that no ordinary consumer wants the unpredictability of congestion pricing.

Previously, researchers have been preoccupied with schemes for QoS that were both technically feasible and acceptable to consumers. However, in 2000 the Market Managed Multi-service Internet (M3I) project set out to enable a "Tussle in Cyberspace" [4] — to define a space in which pricing models could evolve — to build for unpredictable outcomes. This space had to embody the underlying economics of networking: fixed fee plus congestion pricing. Its non-marketability didn't matter; from this rudimentary scheme, we showed how a variety of other schemes more acceptable to the market could be synthesised:

- An Internet-wide reserved capacity scheme. To participate, operators need only deploy a gateway (based on [5]) between their access network and the wider Internet. Strong per-flow guarantees are possible across the connectionless, congestion-priced Internet within the ring of gateways, with no need for over-provisioning.[7]
- A differentiated service scheme weighted by a constant willingness to pay. Again gateways are used to isolate consumers from dynamic pricing. We also demonstrated convergence across fixed and wireless congestion.[12]
- A base case, with raw retail congestion pricing, handled by an agent on the end-system able to synthesise any conceivable response to pricing under policy control, whether for a constant rate stream or a networked game.

As unattended processes (eg. peer-to-peer) grow as a proportion of demand, we predict that this last case will become prevalent — unlike humans, software can react to avoid unpredictable pricing. However, for us mere mortals, the familiar retail services above will still be synthesised by the operator from congestion pricing.

Rather than re-thinking the end to end principle [3], we have restored trust in the end system using pricing [6]. But further still, we have designed for QoS control to be movable between the network and the end-system, depending on the outcome of tussles in the marketplace.

So fixed fee plus congestion pricing is near-perfect in economic, engineering *and* market terms.

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Authors' biographies

Bob Briscoe joined BT in 1980 and now leads the Edge Lab, one of the Research Labs of BTexact Technologies. In the late-1980s he managed the transition to IP of many of BT's R&D networks and systems. In the mid-1990s he represented BT on the HTTP working group of the IETF and in the ANSA distributed systems research consortium, which led to the creation of the OMG and CORBA. In 2000 he initiated and was technical director of the Market Managed Multi-service Internet (M3I) consortium, a successful European collaborative project investigating the feasibility and user acceptability of controlling Internet quality on fast time-scales through pricing. His published research, standards contributions and patent filings are in the fields of loosely coupled distributed systems, scalable network charging and security solutions (esp. multicast), managing fixed and wireless network loading using pricing and on the structure of communications markets. He is also studying part-time for a PhD at University College London.

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David Songhurst is a research consultant at BTexact. Until 1995 he led the Performance Engineering Section at BT Laboratories, working on traffic studies and network modelling and performance. In 1995 he left BT and worked for three years with Lyndewode Research, Cambridge, on the CA$hMAN project - a collaborative project in the European ACTS programme dealing with multi-service network charging schemes. He then joined BTexact to work on the Fifth Framework Project M3I (Market Managed Multi-Service Internet) where he led the Economic Modelling Workpackage, and is now working on applications of M3I principles to quality of service in fixed and wireless networks. He is the editor of the book "Charging Communication Networks: from Theory to Practice".

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