what are providers trying to achieve?

• selling QoS = managing risk of congestion
  1. ranking demand so insufficient willingness-to-pay self-rejects
  2. and/or exploiting a monopoly position (perhaps only over a route)

1. push-back from congestion only requires congestion charging
   – peak-demand and volume charging are imperfect but pragmatic proxies

2. exploiting monopoly could require any sort of charging model
   – but must still push-back from congestion at some timescale

• a game is playing out, converging on near-perfect competition
  – play the game conceptually and deploy the end-game (congestion pricing)?
  – or play the game out in full? deploying/withdrawing many models on the way

Q1. technical capabilities needed to support acceptable revenue models for providers?

Network cost economics (not market pricing) (perfect competition)

- infrastructure cost is sunk
- operational costs are usage independent
- usage and congestion cost **operator nothing**
- congestion damages service to **user**
- congestion income pays for infrastructure upgrade
- installation fee
- monthly fee
- 0
- congestion pricing
- installation fee \( \rightarrow 0 \)
sender or receiver pays? recap

- two part tariff
  - sending domain pays $C = \eta X + \lambda Q$ to receiving domain per accounting period
  - $X$ is capacity @ price $\eta$
  - $Q$ is QoS/usage-related (volume, peak demand, congestion) @ price $\lambda$
  - both prices relatively fixed

- usage related price $\lambda \geq 0$ (safe against ‘denial of funds’)
  - any receiver contribution to usage through end to end clearinghouse
  - or bias fixed charges against receiving domain to compensate

usage price, $\lambda \geq 0$

Capacity price, $\eta$
sign depends on relative connectivity

first step: allow evolution of model

Q1. technical capabilities needed to support acceptable revenue models for providers?

- decouple $Q_{ab}$ from $Q_{bd}$
  - e.g. $Q_{ab}$ is volume
  - $Q_{bd}$ is congestion
- common denominator is money
  - Profit attributable to flow, $\Pi_b = \lambda_{ab} Q_{ab} - \lambda_{bd} Q_{bd}$
- bulk pricing sufficient
  - each price for rest of path from boundary to destination
- price effects localised
- contracts localised
- self-regulating, avoiding inter-carrier compensat’n (ICC) regulation
- global standards unnecessary

strong form: route agnostic
- `price for overall profit, win some, lose some
- or don’t advertise loss-making routes

weak form: separate price for each subset of routes (e.g. all $N_d$)
Q2. Constraints on pairwise agreements to support concatenated service?

minimum interconnect requirements (a)

- **A2a)** confine retail complexity to a higher layer e2e market
  - sender/receiver re-apportionment
  - roaming

- otherwise locks-in to single model for all interconnect
  - sufficient condition: interconnect contracts strictly bilateral (pairwise)

minimum interconnect requirements (b)

- **A2b)** congestion pricing sufficient
  - can synthesise any QoS at edge, from congestion (ECN) pricing
  - simple, bulk, passive replacement for traffic policing
  - pushes back congestion upstream (cf. TCP)

- need longer slot to explain
  - simple, but unfamiliar territory for many
    - (cf 95th percentile peak demand or time of day volume pricing)
  - subject of IP QoS research since 1997
  - recently solved outstanding problems (to be proven)
    - direction of control (including routing/traffic engineering)
    - avoiding dynamic pricing in retail market
interconnect QoS settlements – summary

• single model for end-game: congestion pricing

• or extra cost & revenue of more complex interconnect
  • to exploit temporary monopoly positions?

interconnect QoS – settlements
agreeing an industry model

• scope: the usage/QoS part of tariffs
• if we don’t agree a layered industry model
  • it will cost us all hugely more to handle the mess
• alternatives within a single model:
  – only sender pays throughout network layer?
  – approx equal sender-receiver contribution throughout network layer?
• forum to agree this industry model?
end-game: inter-domain congestion pricing

- **passive & extremely simple**
- recall sending domain pays to receiving domain \( C = \eta X + \lambda Q \)
- congestion charge, \( Q \) over accounting period, \( T_a \) is \( Q = \Sigma T_a \rho_i^+ \)
- \( \rho_i \) metered by **single bulk counter** on each interface
- impairments trivial

\[
\rho_{AB} \\
\rho_{BD} \\
\pi_i \\
\pi_A = - (\lambda \rho)_{AB} \\
\pi_B = + (\lambda \rho)_{AB} - (\lambda \rho)_{BD} \\
\pi_D = + (\lambda \rho)_{BD} \\
\]