Generalized Fairness

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Generalized Fairness

- Real-time applications need non-zero Minimum Cell Rate (MCR)
- In TM4, Distribution of excess bandwidth (fairness) is implementation specific.
- TM4.0 has five examples of fair distribution
- We have shown that two of the examples are not meaningful and have proposed a sixth example that is a superset of the remaining three definitions
- We developed a switch algorithm that implements the proposed definition

Pricing Function

- T = Small time interval, W = Number of bits
  R = Average rate W/T
- Cost C = f (W,R). If C is restricted to continuous differentiable functions of type: $C = \Sigma_{ij}\ a_{ij}\ W^i R^j$
- For <u>all</u> values of W and R:
  - $C \geq 0 \quad \partial C/\partial W \geq 0 \quad \partial C/\partial R \geq 0$
  - $\partial(C/W)/\partial W \leq 0$ [Economy of Scale]
  - $\partial(C/R)/\partial R \leq 0$ [Economy of Scale]
- The <u>only</u> function that satisfies all 5 conditions is:

$$C = a_{00} + a_{10}W + a_{01}R + a_{11}\ WR$$

A Simple Pricing Fn

- f() is non-decreasing w.r.t to W
  f() is non-increasing w.r.t to T $\Rightarrow$ non-decreasing w R
- A simple function satisfying these requirements is:
  $C = c + w W + r R$
  Here, c = Fixed cost per connection
  w = Cost per bit (How much)
  r = Cost per Mbps (How fast)
- This cost function implies that the excess bandwidth should be allocated using the proposed generalized fairness function

TM4.0 Definitions

1. B(i) = B/n
2. B(i) = MCR(i) + (B-M)/n
3. B(i) = Max{MCR(i), Max-Min Share}
4. B(i) = B*(MCR(i)/M)
5. B(i) = w(i)*B/Sum(w(j))

- Definition 5 does not always guarantee MCR
- Definition 3 may result in total of fair share being more than the capacity
- Notation: n = # of active VCs bottlenecked here
  B = Bandwidth available for the bottlenecked VCs
  $M = \Sigma MCR(I)$

General Definition

- Fair Share

$$B(i) = MCR(i) + \frac{w(i)\,(B - M)}{\Sigma_{j=1,n}\, w(j)}$$

- This definition is a superset of 1, 2, 4 in TM4.0
- Always ensures MCR
- If all vendors implement the generalized fairness, the network manager can select network-wide their desired fairness criteria by appropriately setting weights.

Mapping to TM 4.0

- w(i) = w, MCR(i)=0: B(i) = B/n
  This is Definition 1 (Max-min Fair).
- w(i) = w: B(i) = MCR(i) + (B - M)/n
  This is Definition 2 (MCR plus equal share)
- w(i) = MCR(i):
  B(i) = MCR(i) + (B-M) MCR(i) / M
  = B* (MCR(i)/M)
  This is Definition 4 (Proportional to MCR)