The Dynamic of Pricing in a TCP/AQM network

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Theme

Pricing in TCP/AQM networks

- affects the dynamic
- is a dynamic



3 Illustrations

- buffer vs. rate-based pricing
- RED pricing in hi-bandwidth links
- pricing with zero packet loss

Fluid Model



Closed-loop dynamic



1. Pricing Structures



buffer-based



high-frequency gain:
$$\frac{C^2}{2N}$$

rate-based



$$\frac{NK_p}{2R}W_0^3 - \frac{\dot{q}_{ref}K_p}{2}W_0^2 - 1 = 0$$

stability margin trends



2. RED and high-bandwidth links





K_{red} scales with N/C^2

TCP throughput formula



\mathbf{q}_0 scales with C

Suppose $N \propto C$





ns simulation (C = 15Mbps, N = 50flows, $T_p = 50ms$, $q_0 = 235pkts$)







fixed point: (W_i, p_i)

$$2/W_{1}^{2} = p_{1} + p_{2}$$

$$2/W_{2}^{2} = p_{1}$$

$$C_{1} = N_{1}W_{1}/R_{1} + N_{2}W_{2}/R_{2}$$

$$C_{2} = N_{1}W_{1}/R_{1}$$

$$R_{1} = T_{p1} + q_{1ref}/C_{1} + q_{2ref}/C_{2}$$

$$R_{2} = T_{p2} + q_{1ref}/C_{1}$$

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Example



$$C_{1} = R_{1}VV_{1}/R_{1} + R_{2}VV_{2}/R_{2}$$

$$C_{2} = N_{1}W_{1}/R_{1}$$

$$R_{1} = T_{p1} + q_{1ref}/C_{1} + q_{2ref}/C_{2}$$

$$R_{2} = T_{p2} + q_{1ref}/C_{1}$$
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$$P_{2} = 0$$



 $q_2 < q_{2ref} \implies p_2 = 0$

New fixed-point analysis

fixed point: (W_i, p₁, q₂)

$$2/W_{1}^{2} = p_{1} + p_{2}$$

$$2/W_{2}^{2} = p_{1}$$

$$C_{1} = N_{1}W_{1}/R_{1} + N_{2}W_{2}/R_{2}$$

$$C_{2} = N_{1}W_{1}/R_{1}$$

$$R_{1} = T_{p1} + q_{1ref}/C_{1} + q_{2}/C_{2}$$

$$R_{2} = T_{p2} + q_{1ref}/C_{1}$$



fixed-point analysis





To conclude

Pricing in TCP/AQM networks

- affects the dynamic
- is a dynamic
- 3 Illustrations
 - buffer vs. rate-based pricing
 - RED pricing in hi-bandwidth links
 - pricing via packet loss or delay