eXogenous-Loss aware Queue Management (XQM)

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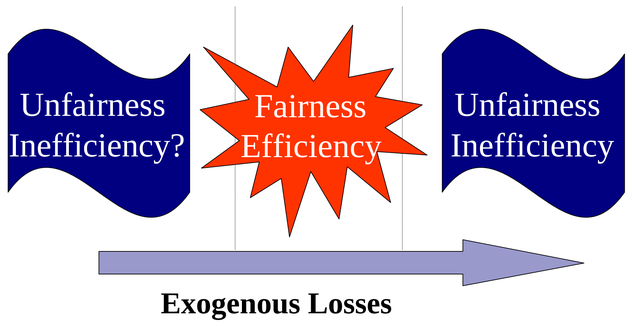
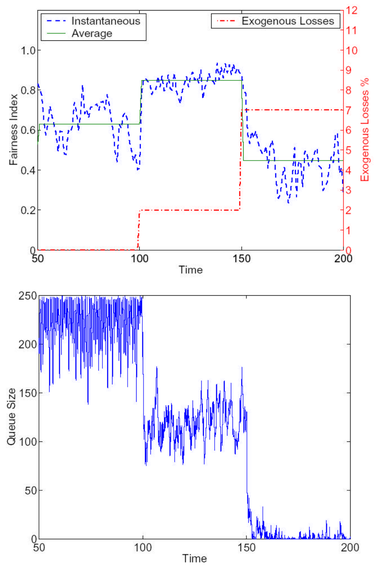
A Case for Exogenous Losses

Exogenous Losses
- Produced outside of the transmission control system
- Independent from the source behavior
- Independent from its long-term fair share
- Unavoidable Problematic "Noise"
- Wireless and cross-traffic losses

Level of Impact





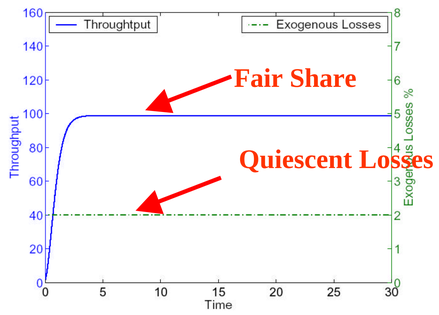
Why low levels of exogenous losses help?
- Impose an upper limit on TCP throughput
- Randomness in losses prevent monopoly

Model
- Extend a fluid Model
- Quiescent loss rate

Efficiency & Fairness

$$\sum_{i=1}^{m} \hat{x}_i = C \qquad \hat{x}_i = \frac{1}{\hat{r}_i}\sqrt{2(\frac{1}{\hat{q}_i} - 1)}$$

$$\hat{q}_i = \frac{2}{(\hat{x}_i \times \hat{r}_i)^2 + 2}$$



Model Derivations

$$r_i(t) = D_i + \frac{b(t)}{C}$$

$$\dot{b}(t) = \sum_{i=1}^{m} x_i(t - D_{s_i b}) - C$$

$$q(t) = 1 - (1 - p_c(t))(1 - p_e(t))$$

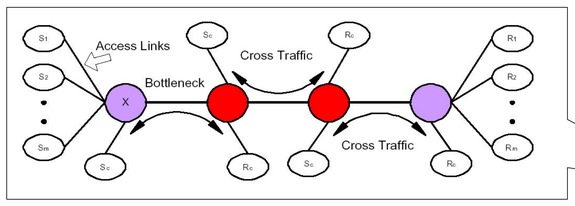
$$p_c(t) = \begin{cases} 0 & v(t) \le B_{min} \\ \sigma(v(t) - \varsigma) & B_{min} < v(t) < B_{max} \\ 1 & v(t) \ge B_{max} \end{cases}$$

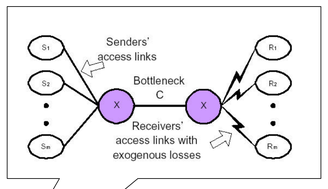
$$\dot{v}(t) = -\beta C(v(t) - b(t))$$

$$x_i(t) = \frac{w_i(t)}{r_i(t)}$$

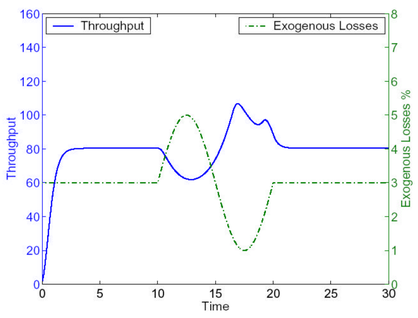
$$\dot{x}_i(t) = \frac{x_i(t - r_i(t))}{r_i^2(t)x_i(t)}(1 - q(t - D_{bs_i}(t))) - \frac{x_i(t)x_i(t - r_i(t))}{2}(q(t - D_{bs_i}(t)))$$

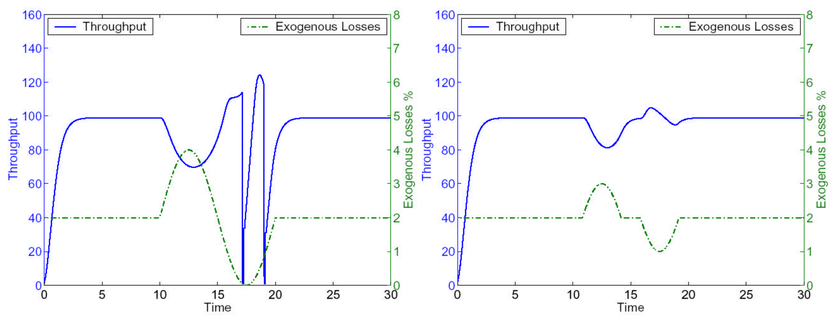
$$i = 1, 2, .., m$$





Active Tuning of Exogenous Losses
- Exogenous Losses are changing with time
- Ex: Sinusoidal (long and short term behavior)
- **Long-Term Adjustments**
  Inefficiency to efficiency
- **Short-Term Compensation**
  Smoothness

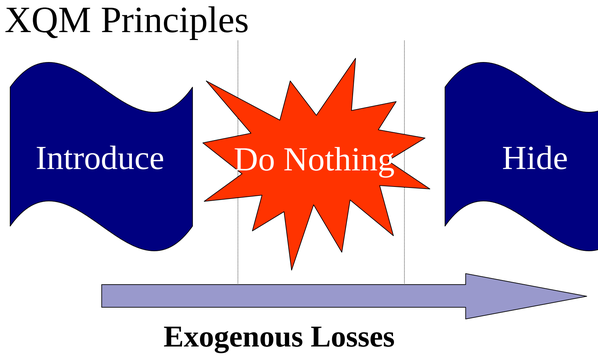




Leveraging Exogenous Losses

XQM (eXogenous aware Queue Management)
- To be placed at the edges of the Network
- Will maintain state for flows passing through
- Estimated RTTs are measured from the middle
- Estimated throughput is measured every Measurement Period MP
- Control is applied every control period CP
- MP and CP are decoupled

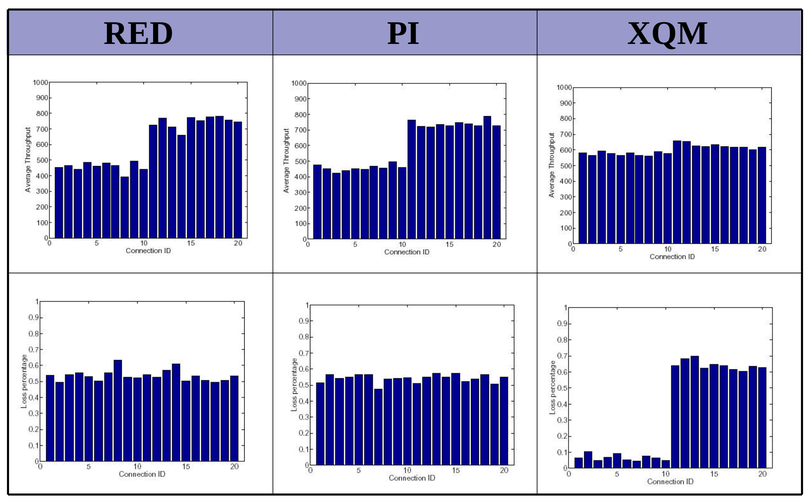
XQM Principles



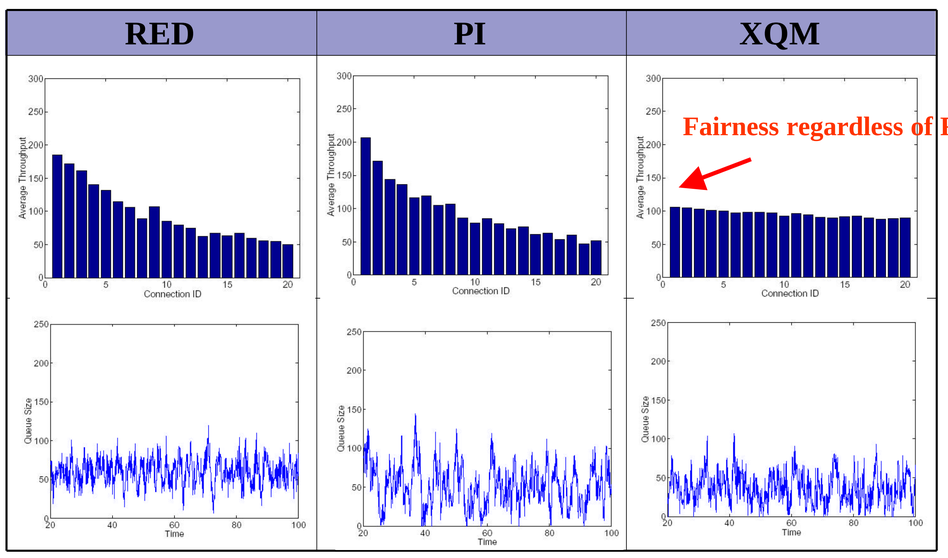
XQM can provide better Fairness for connections with different Round-Trip Times and different number of congested links

$$q_i(t + CP) = q_i(t) + \delta \times (x_i(t, MP) - \hat{x}_i) + \alpha(b(t) - \hat{b})$$

Simulations with different number of congested links



Simulations with different RTT



Conclusions
- Small level of exogenous losses improve fairness while remain efficient
- Noise should not be filtered out blindly (SNOOP and ITCP)
- XQM can achieve fairness and efficiency through tuning exogenous losses

On Going Work
- Issue of time scale on the measurements and control periods.
- Stability analysis for XQM
- Implementation

Reference : Guirguis, Mina; Bestavros, Azer; Matta, Ibrahim. *On the Efficiency and Fairness of Transmission Control Loops: A Case for Exogenous Losses*, May 16, 2003. BUCS Technical Report

This work was supported in part by NSF grants ANI-0095988, ANI-9986397, EIA-0202067 and ITR ANI-0205294, and by grants from Sprint Labs and Motorola Labs.

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