Greedy User Tuning for Rate Control

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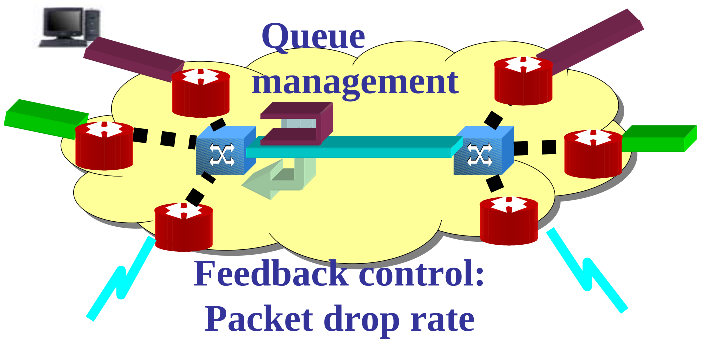
Problem: How to automatically control greedy users in a scalable manner?

Approach: Tune their utility function automatically using washout filter-based feedback .



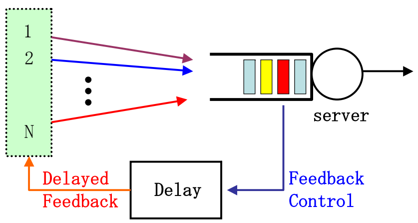
Mathematical Modeling (Kelly's Framework):

- **Rate control problem formulated as a constrained optimization problem:**

$$\text{maximize} \quad \sum_i U_i(x_i)$$
$$\text{subject to} \quad Ax \le C$$

- **Proposed end-user algorithm:**

$$\dot{x}_i(t) = \kappa\left(w_i(t) - x_i(t)\,p_i(t)\right)$$
$$\text{where} \quad w_i(t) = x_i(t)\,U_i'(t)$$



End-User Utility & Resource Price Function Design

- **User utility functions** $U^a(x) = \frac{-1}{a\,x^a}, \quad a > 0$
  - **-Price elasticity of demand decreases with** a
- **Resource price function**

$$p(y) = y^b, \quad b > 0$$

- **Responsiveness increases with** b

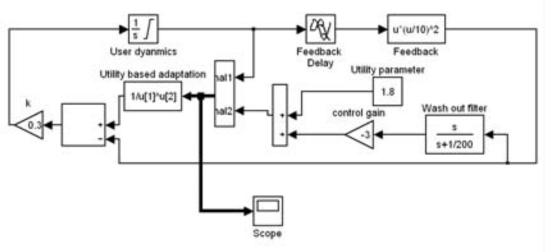
- **Network rate control system is stable regardless of communication delay if**

$$\frac{b+1}{a} < 1$$

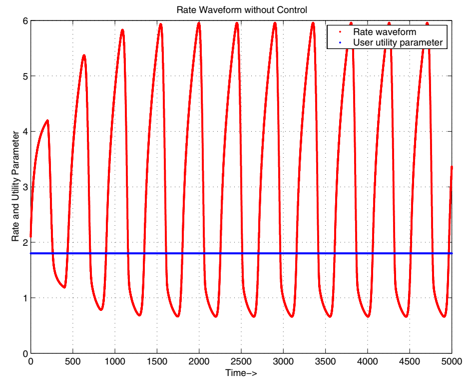
- **Clearly, more elasticity in demand will destabilize the system**
- **Periodic orbit is generated via period doubling bifurcation of the underlying map**
- **A washout filter is a stable high-pass filter with transfer function**

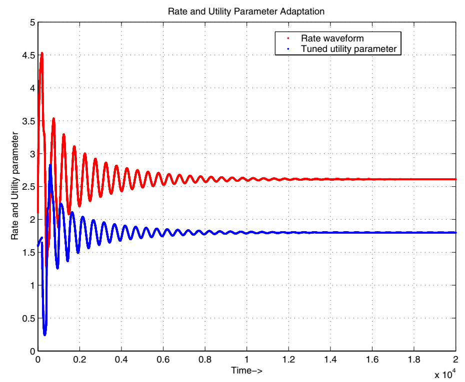
$$G(s) = \frac{s}{s+a}, \ a>0$$

- **We can tune the utility parameter automatically using washout filter-based feedback**



Washout filter-based control schematics





Rate waveform and user utility parameter in the presence of controller

Conclusions:

1. **Greedy users can be controlled in a scalable manner by adaptively changing the shape of their utility functions**
2. **Better performance in the presence of aggressive users**
3. **Shielding of less aggressive users**
4. **Control does NOT modify the original operating point**