ATM Efficiency With User Feedback

Jeffrey K. MacKie-Mason
Dept. of Economics
Univ. of Michigan

Liam Murphy
Dept. of Computer Science & Engineering
Auburn University

John Murphy
School of Electronic Engineering
Dublin City University

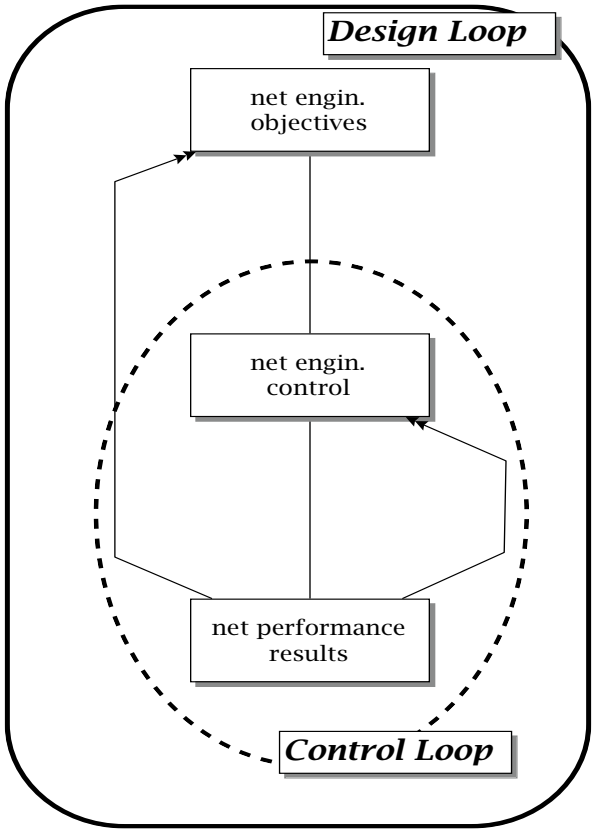
 © 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

User-Centric Network Performance

- **Network only as good as users perceive it to be**
  - or owners, managers
  - ultimate objective: *maximize value to appropriate people*
- Engineering problem is subset of the economic problem

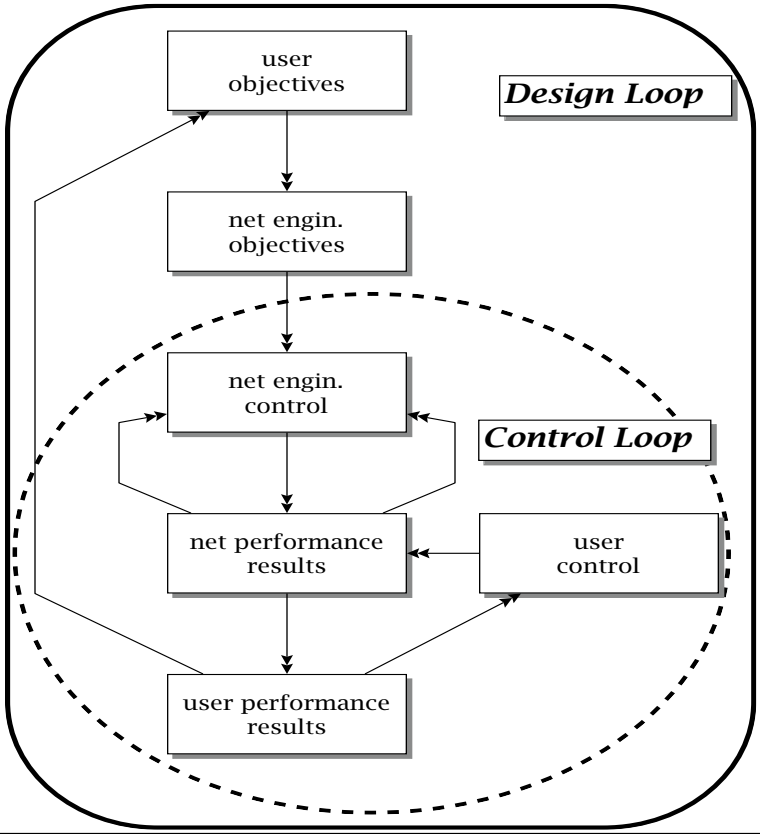
 © 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Engineering Problem



 © 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Economic Problem



 © 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Performance Concepts

- **Network performance**: e.g, min delay s.t. cost bound
  - E.g., min $\Sigma_t \Sigma_i d_{it}$
- **Economic performance**: aggregation of user valuations (functions of delay, cost, etc.)
  - E.g., max $\Sigma_t \Sigma_i u_{it}(d_{it})$

  u_{it} = concave benefit function, $u' < 0$
  - *Ex*: min $\Sigma_t \Sigma_i \alpha_{it} d_{it}$, $\alpha > 0$
  - So, user objective could be min wtd avg of delays

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Performance Concepts

- **Sometimes in conflict**. Consider:
  - 10 Mbps line
    - 1 video source at 5 Mbps
    - 1 ABR source with 10Mbps peak, 5Mbps mean
  - **standard allocation**: 5 Mbps to video, residual to ABR
    - video gets zero delay
    - ABR gets some delay
  - **But, if delay more costly to ABR** , then better allocation might be
    - 10 Mbps committed to ABR (zero delay)
    - unused bandwidth available to video (some delay)

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

User Valuations are Heterogeneous

- ***between users***: delay costs A more than B
- ***within users***:
  - delay costs A more in the morning than in the afternoon
  - email delay to B costs A more than email delay to C
- ***between applications***: video delay costs A more than email delay
- **Implication**: need add'l tools for congestion control

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

User Feedback for Congestion Control

- one view: ***users are dumb terminals***
- alternative: ***users are smart devices***
  - network intelligence moving outward to increase network efficiency
  - users can manage load within connections (control variables)
- **feedback**
  - network provides signal about state to users
  - users can (sometimes) adapt sending rate
- **Implication**: user feedback is a tool -- use when appropriate

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Feedback is a Flexible Concept

- User feedback **already present** over various time horizons
  - subscribe to network?
  - initiate a connection (session)?
  - flat usage fee: long-run averaged cost feedback
- Feedback within connection is **just matter of degree**
  - when to implement feedback depends on benefit-cost tradeoff
    - transaction cost
    - user response time

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Feedback is a Flexible Concept Cont d

- **"Tight loop" possible**:
  - users can send willingness-to-pay with cells
  - network prioritizes on the fly
  - loop tightened because users send "reaction function"

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Modeling Overview

- Network model: 2 nodes, ATM
- Usage types
- User benefits from types
- Feedback mechanisms

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

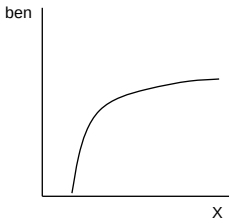
Usage Types

- **Adaptive vs. non-adaptive**
  - Can application respond to feedback?
  - Tolerates some input rate variation or loss
  - Artifact of time horizon
    - CBR can't respond within connection, but may not request connection
- **Of adaptive**:
  - ***inelastic***: requires delay guarantee
    - e.g., video codec level 2
  - ***best efforts***: no delay guarantee required
    - e.g., e-mail

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Modelling User Benefits

- **inelastic**
  - only cells delivered within delay bound have value
  - benefit concave in delivered cells

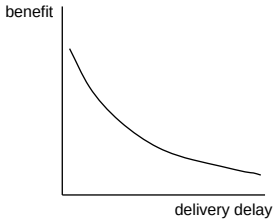


  - send rate solves $\partial ben(x) / \partial x = p$

 © 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Modelling User Benefits

- **best efforts**
  - "message" = (x,v,h(d))
  - benefit = max[v - h(d(x)), 0]



  - sending rate depends on cells remaining, expected future prices, expected delivery delay

ATM Efficiency With Pricing © 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Feedback mechanisms

- **Closed-loop**
  - congestion measured by buffer occupancy
  - price = f(occupancy) is transmitted to users
  - users choose sending rate

ATM Efficiency With Pricing © 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Feedback mechanisms Cont d

- **preliminary results** (not tuned for optimal pricing):
  - 20 video sources with random frame sizes
  - 1 - 39 elastic data sources with random frame sizes
  - 85% average utilization

		% cell loss	user value	% value increase
unpriced	inelastic	0%	240	
	best efforts	19%	146	
	combined	12%	386	
	.			
priced	inelastic	2%	239	
	best efforts	0%	204	
	combined		443	14.8%

ATM Efficiency With Pricing © 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Feedback mechanisms Cont d

- **Tight-loop**
  - users stamp cells with willingness-to-pay
  - price = hurdle set to control delay
  - cells admitted if WTP > hurdle
  - users pay hurdle price < WTP by design

© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy

Summary

- **User-centric performance**

  ==> heterogeneity is key

- Can **design to heterogeneity by involving users**

  ==> feedback

- **Variety of feedback mechanisms** to explore
  - can do feedback on shorter time horizons
  - closed-loop vs. tight-loop

- ***Users are smart devices!***

ATM Efficiency With Pricing
© 1995 Jeff MacKie-Mason, John Murphy, Liam Murphy