ABR Rate Control for Multimedia Traffic Using Microeconomics

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ABR Traffic Management

• Management of ABR bandwidth to provide QoS in an efficient and fair manner

• Fairness
  – Max-min - Every user is entitled to a fair share
  – Equitable - Every user has the same level of utility (satisfaction)
  – The scalability of each application may be different, so max-min may not be equitable
Microeconomic Traffic Management

Microeconomics —

The study of the allocation of scarce resources among competing ends. *Nicholson*

- Advantages
  - Maximize utility
  - Efficient and equitable resource allocations
  - Strong theoretical foundation
Competitive Market Model

- Consumers and producers are price takers
- Price based on supply and demand
  - Each user pays \( \textit{tokens} \) for their consumption
  - Price influences user behavior
  - Market seeks equilibrium (supply = demand)
- Can yield efficient and equitable resource allocations
Price-Based ABR Traffic Management

- User (consumer) purchases bandwidth
- Switch (producer) sells bandwidth at market price

- Price is based on supply and demand, and is distributed using RM-cells
Switches

- ABR bandwidth priced (non-storable resource)
- Each output link is an independent dynamic competitive market
- Price for link $i$ is determined using a modified tâtonnement process
  - Allows demands to change dynamically
- Switch inserts the price in the RM-cell if, it is higher
Example Allocation and Prices

- Maximum link bandwidth
- 95% of link bandwidth
- Total allocated
- Price

\[ p_{n+1} = p_n \cdot \frac{d_n^i}{\alpha \cdot s^i} \]

new price \hspace{0.5cm} current price \hspace{0.5cm} aggregate demand

Aggregate demand \hspace{0.5cm} ABR capacity

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User

- Generates RM-cells to obtain route price
  - Received price corresponds to congested link
- Determines transmission rate based on
  - Price
  - Bandwidth desired
  - Budget
  - QoS profile, utility curve
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Optimality

Pareto optimal - *No user can increase their satisfaction without decreasing the satisfaction of another*

- Steady State
  - Reaches Pareto optimal distribution
  - Price equation always moves towards *equilibrium*

- Network Dynamics
  - Single equilibrium price does not exist
  - Can achieve optimal (Pareto) allocations over 92% of the time.

- Are *equitable* allocations achievable?
Experimental Results

• Determine
  – How equitable under dynamic conditions
  – Compare with perfect max-min and demand-based WMM

• Simulation
  – 152 users transmitting MPEG-compressed video traffic with random start times
  – Two types of users MoD and Teleconferencing
Average % GoB

Demand-WMM
Max-Min
Price Method

Average QoS Scores

Demand-WMM
Max-Min
Price Method

Average QoS Scores for MoD Users

Average QoS Scores for Teleconferencing Users

Price ABR
Demand-based WMM
Max-min
Conclusions

- ABR traffic management based on dynamic competitive markets
- Abilities
  - Allow users to maximize individual QoS
  - Adapt to changes in demand over time
  - Efficient and equitable allocations
  - Independent of traffic types
  - State-less implementation