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*

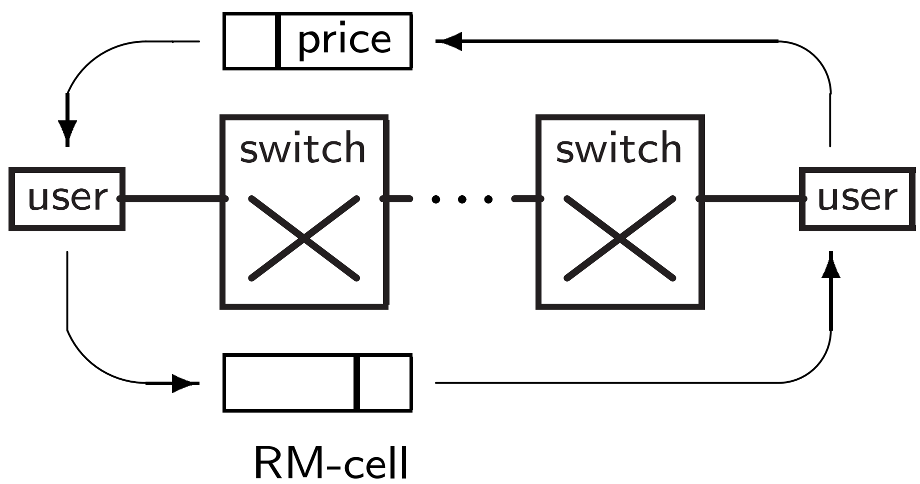
- Advantages
  - Maximize utility
  - Efficient and equitable resource allocations
  - Strong theoretical foundation

Competitive Market Model

- Consumers and producers are price takers
- Price based on supply and demand
  - Each user pays (*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

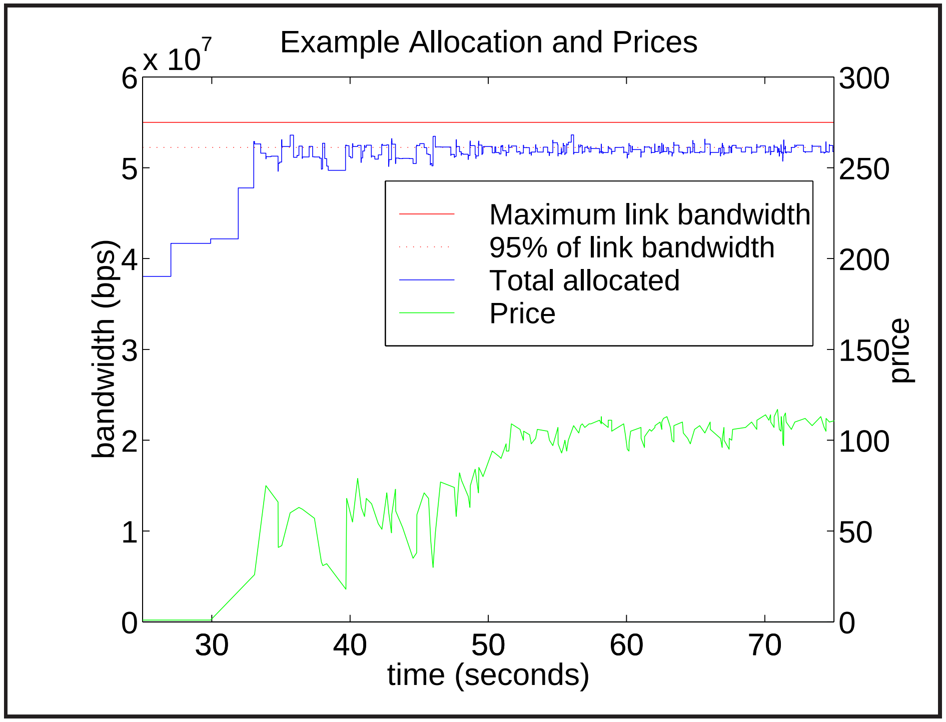
- User (consumer) purchases bandwidth
- Switch (producer) sells bandwidth at market price



- 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**

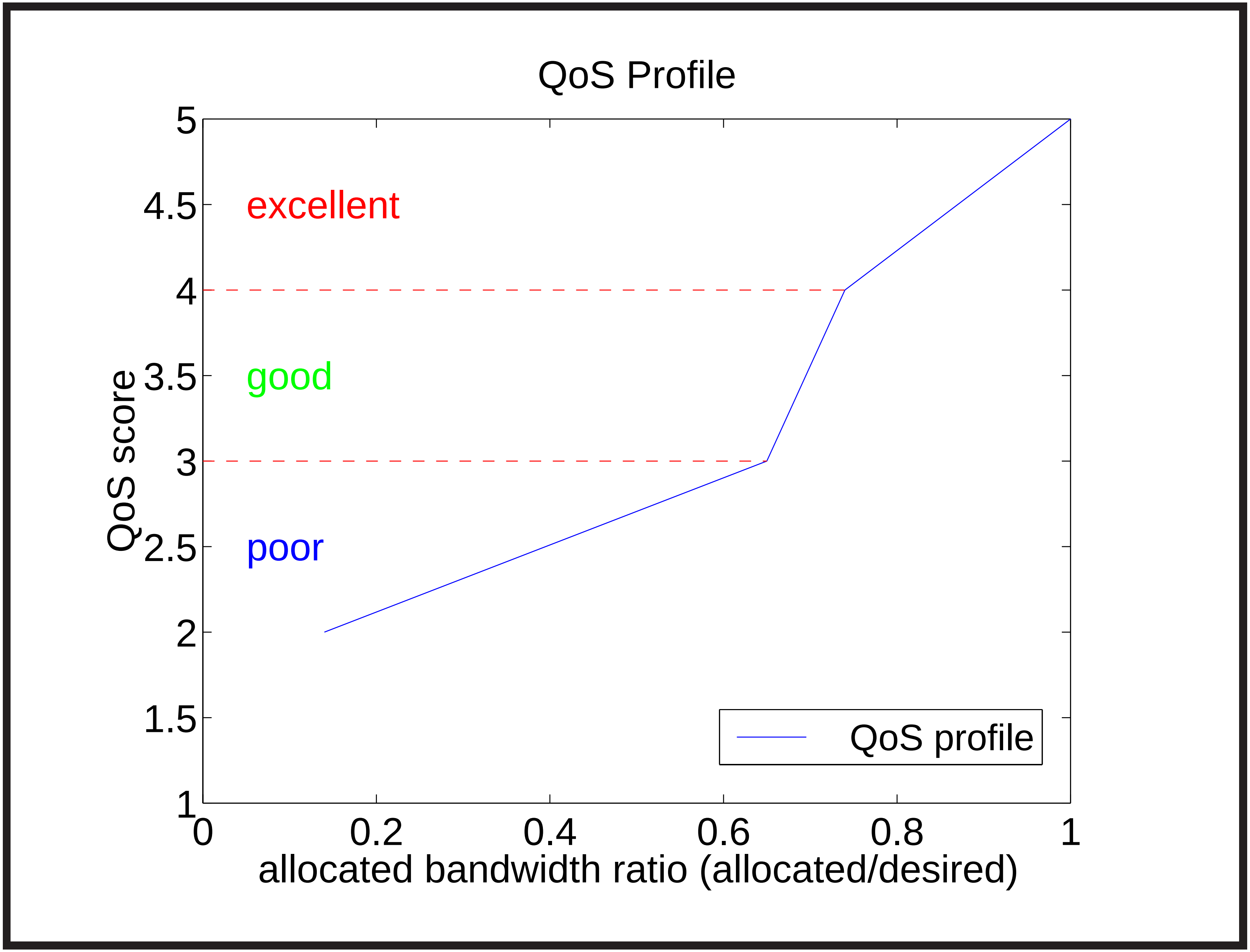


new price → current price → aggregate demand → ABR capacity

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

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


QoS Profile
QoS score
5
4.5
4
3.5
3
2.5
2
1.5
1
0
0.2
0.4
0.6
0.8
1
allocated bandwidth ratio (allocated/desired)
excellent
good
poor
QoS profile

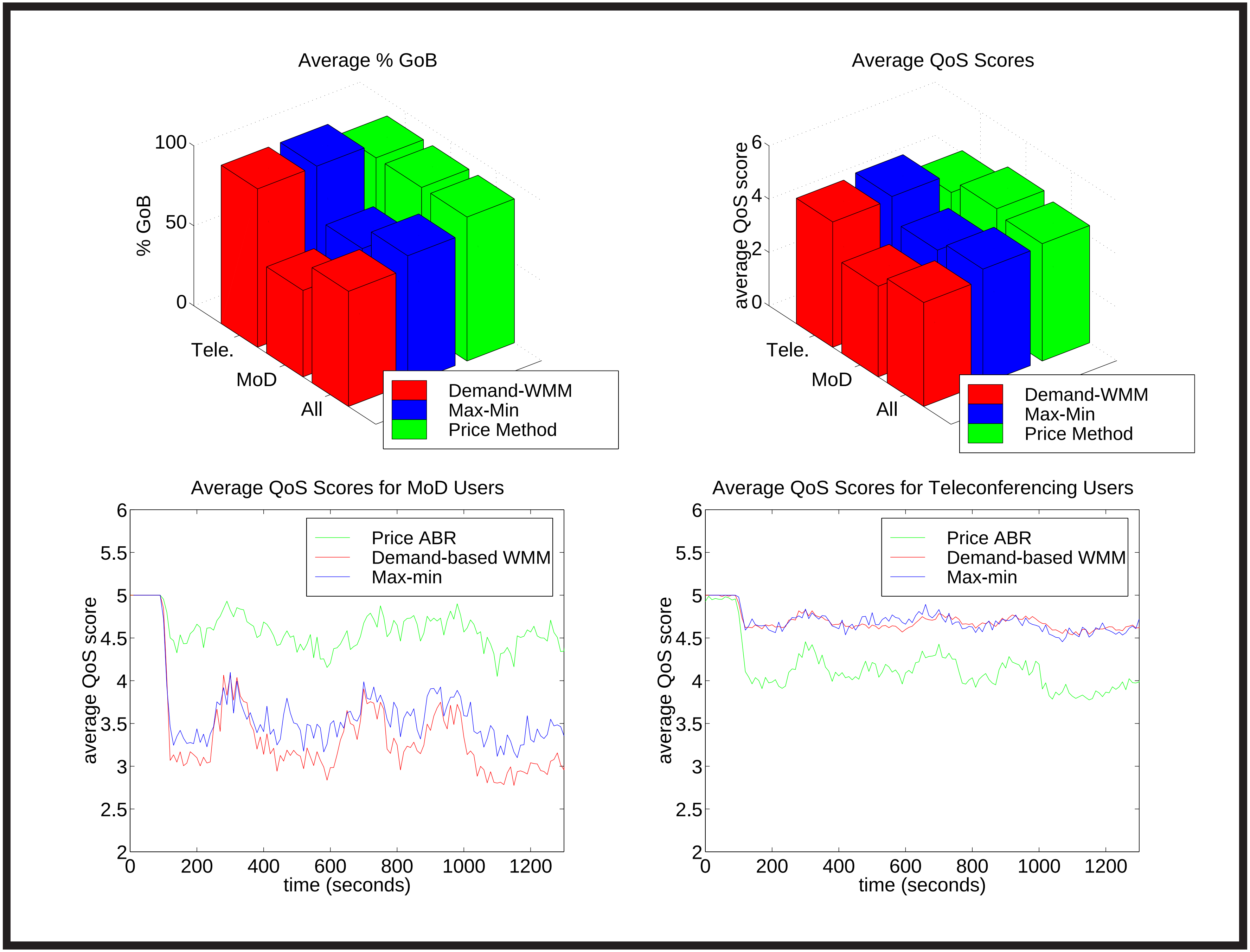
Optimality

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
% GoB
100
50
0
Tele.
MoD
All
Demand-WMM
Max-Min
Price Method
Average QoS Scores
average QoS score
6
4
2
0
Tele.
MoD
All
Demand-WMM
Max-Min
Price Method
Average QoS Scores for MoD Users
average QoS score
Price ABR
Demand-based WMM
Max-min
time (seconds)
Average QoS Scores for Teleconferencing Users
average QoS score
Price ABR
Demand-based WMM
Max-min
time (seconds)

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