EECS228a – Lecture 2
Research Topics

Pravin Varaiya
Shyam Parekh
www.eecs.berkeley.edu/~varaiya

Outline

- Economics of Networks
- 802.11 WLANs
- Sensor Networks
- Congestion Control
- Traffic Models

Economics of Networks

Outline

- Hangover
- Pricing of Services
- Competition of Users
- Competition of Providers
- Suggested Readings:
  - http://www-inst.eecs.berkeley.edu/~228a/papers/telecomRevolution.htm
  - http://info.isoc.org/internet-history/
  - http://www.sims.berkeley.edu/resources/infoecon/Networks.html

Hangover

Bubble: Wired

- Over-Investment
  - Based on unrealistic growth forecast
  - Overcapacity: Fiber $\rightarrow 5\times100$ in three years
  - Too many companies competing for same market
- Debt
  - Wireless: Expensive spectrum licenses
  - Fibers
  - IT in companies: PCs, Servers, Networks
- Fraudulent Claims
  - WorldCom, Global Crossing, Enron

Bubble: Wireless

- Over-Investment
  - Based on unrealistic growth forecast
  - Overcapacity: Fiber $\rightarrow 5\times100$ in three years
  - Too many companies competing for same market
- Debt
  - Wireless: Expensive spectrum licenses
  - Fibers
  - IT in companies: PCs, Servers, Networks
- Fraudulent Claims
  - WorldCom, Global Crossing, Enron
Economics

Key Ideas

- Value of services to users: externality, QoS, CoS
- Market segmentation
- Flat rate pricing; congestion pricing; Paris metro pricing; time-of-day pricing
- Incentive compatibility
- Inter-ISP settlements; Peering agreements
- Internet as a public good

Value of Services

- Externality: Kazaa
- Value per bit: email vs. fax vs. picture
- Value of bit rate: video stream vs. radio
- Value of low latency: video stream vs. video conference
- Value of low response time: browsing with DSL vs. browsing with 56k
- QoS affects value and usage
- Value of QoS depends on application, user
- Question: How do you define/measure value?

Market Segmentation

- Businesses vs. Residential Customers
- Network Application Providers vs. public Web Sites
- Principle: Charge more users with higher utility
- Question: What makes segmentation possible? What limits it?

Differentiated Pricing

- Examples:
  - First Class & Economy in plane: More space but much more expensive
  - Paris Metro: More expensive → Fewer Users → Better Service (e.g., Stanford vs. Berkeley?)
  - Suggests Class of Service:
    - Better service by mechanism: e.g., priority
    - Better service by fewer users: e.g., expensive network; congestion pricing (e.g., packet marking); time-of-day
  - Alternative: QoS: You know what you pay for
    - Service Level Agreement (implementation?)
    - QoS of accepted calls: end-to-end test
  - Question: How would you price a product whose quality varies statistically?

Incentive Compatibility

- How to discover the user's willingness to pay?
- Examples:
  - California Electricity: Providers offer bids and CA buys cheaper first → prices escalate
  - Highest bidder auction: Spectrum auctions
  - Highest gets but two highest pay
  - Second highest price: Incentive compatible
- Question: Is TCP incentive-compatible?

Competition

- Basic supply and demand:
  - More capacity than traffic → prices drop and providers go bankrupt; recovering fixed costs
  - Internet traffic doubles every year instead of every 100 days ...
- Quality service is still rare and valuable:
  - Businesses use video conference over ISDN
  - Users pay a lot for CATV and pay-per-view
  - T1 service expensive: demand exists
- Question: What is the role of state regulation?
Economics
Game Theory
- Framework to analyze result of interaction of self-interested agents
- Suggests strategies for
  - Pricing services
  - Peering agreements
  - Routing
  - QoS definitions
  - Evolution of industry (e.g., consolidation vs. specialization)
- Two parts: Games & Mechanism Design

802.11 Wireless LANs
- We will explore
  - Physical Layer
  - Medium Access Control
  - Security Issues
  - Quality of Service Issues

802.11 Wireless LANs
Overview
- Sometimes referred to as Wireless Ethernet or Wi-Fi networks

<table>
<thead>
<tr>
<th>Key Standards</th>
<th>Max Rate</th>
<th>Spectrum</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11</td>
<td>2 Mbps</td>
<td>2.4 GHz</td>
<td>1997</td>
</tr>
<tr>
<td>802.11a</td>
<td>54 Mbps</td>
<td>5 GHz</td>
<td>1999</td>
</tr>
<tr>
<td>802.11b</td>
<td>11 Mbps</td>
<td>2.4 GHz</td>
<td>1999</td>
</tr>
<tr>
<td>802.11g</td>
<td>54 Mbps</td>
<td>2.4 GHz</td>
<td>2003</td>
</tr>
</tbody>
</table>
- Factors such as cost of deployment/maintenance and end-user flexibility are fueling phenomenal growth

802.11 Wireless LANs
Security Issues
- Basic security using the Wired Equivalent Privacy (WEP) standard based on Symmetric Key cryptology
- 802.1x attempted to rectify the serious flaws of WEP using stronger authentication

802.11 Wireless LANs
Quality of Service
- How to introduce QoS notions in an inherently non-guaranteed service?
- Basic idea: Service prioritization using different length of medium access deferral for different classes

802.11 Wireless LANs
Research issues of interest in this course
- Analytic and simulation based modeling for
  - Parameter tuning
  - Performance prediction
  - Impact of specific protocol features
  - Performance offered to upper layer protocols (e.g., TCP)
  - QoS differentiation and impact on various data, voice, and video applications
  - Investigate 802.11e (standardization in progress)
- Evaluation of various fairness criteria
Sensor Networks

- Ad hoc multihop networks
- Sensor nodes perform
  - Sense local environment
  - Communicate own observations
  - Relay messages from others

Sensor Networks

Research issues of interest in this course

- Evaluation of various routing schemes
  - Scalability with number of nodes
  - Convergence time
  - Robustness to topology changes including failures
  - Energy efficiency
  - Application level performance
- Localization, failure detection
- Application-specific Sensor Network strategies (e.g., PEDAMACS)

Congestion Control

Outline

- Motivation
- Examples
- Issues

Motivation

- At user level: Issues with QoS
- At network level: Losses, inefficiency, unfairness
- At switch level: Scalability problems

Examples

- TCP
- Congestion in routers
- Call Admission Control

Issues

- Fairness vs. Optimality
- Simplicity
- Robustness
Traffic Models

Outline

- Why bother?
- Transactions
- Packet flows

Why Bother?

- Network should be robust; not based on detailed traffic assumptions
- Traffic characteristics impact
  - Effectiveness of multiplexing
  - Buffer sizes required
  - Time scale of bandwidth allocations

Transactions

- File transfers:
  - File sizes: Heavy tailed
  - Timing of requests: Poisson
  - Geography:
    - Kazaa - poor locality
    - Akamai - improved locality
- Other applications:
  - Video conferences
  - VoIP

Packet Flows

- Self-Similarity:
  - Heavy Tail + TCP → Self Similar Flows
  - Heavy Tail Files + Structure of Web Sites → Self Similarity
- Relevance:
  - Not obvious - a matter of time scale