Internet Economics

IS231 Guest Lecture
September 27 2002

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Outline

• Introduction
• Resource Sharing, Resource Allocation
  - Efficiency, Equity
  - Technical and economic mechanisms
  - Example: Service Differentiation
• Pricing
• Industrial Organization
Why Internet Economics?

• The Internet is a shared communication infrastructure
• When demand exceeds supply → network congestion
• We want to promote efficient and equitable use of network resources
• Technical mechanisms for resource allocation (e.g., TCP) can be augmented with economic-based mechanisms
• New network services for new network applications
Network Services

• Data transport
  - packets and flows, multicast, QoS, etc.

• Storage
  - caching, replication, hosting, backup, etc.

• Processing
  - computation, query, transaction, encryption, adaptation, presentation, etc.

• Value-added services
  - Firewalls, Spam filtering
  - Content delivery, Resource/service discovery
  - Data collection (sensing, metering, aggregating, reporting)
  - Billing and payment
  - Etc.
Resource Allocation Goals (Objective Functions)

• Technical efficiency
  - Performance (latency, throughput) vs. cost
  - Survivability (availability, redundancy) vs. cost

• Economic efficiency
  - Social surplus
  - Pareto efficiency

• Other objectives
  - Profit
  - Penetration/usage s.t. cost recovery (e.g., universal service)
  - Equity, stability, predictability, etc.
Technical Approach to Resource Allocation

• Example: TCP Congestion Control
  - All hosts reduce transmission rate when there is congestion
  - Some TCP-unfriendly implementations ignore congestion signal
Economic Approach to Resource Allocation

- makes the go round

- Network as an economic system
  - Heterogeneous ownership of resources/services
  - Distributed consumers of resources/services
  - Money is exchanged!

- Economics-based allocation model explicitly incorporates
  - Demand-side conditions: consumer behavior (important when humans are part of system)
  - Supply-side conditions: cost structures (e.g., economies, market failures)
Supply & Demand in the Network Context

• **Supply:** cost of providing network service
  - fixed cost (FC)
  - marginal cost (MC)
  - average cost (AC)

• **Demand:** how much users value (and are willing to pay for) the service
  - more difficult to quantify
  - need empirical measurement
What Makes Network Economics Interesting?

• Network services exhibit
  - High fixed cost, low marginal cost (strong economies of scale)
    • e.g., trenching cost most significant; deploy dark fiber (excess capacity); install switches when needed
  - Significant joint costs (strong economies of scope)
  - Positive/negative network externalities (demand-side economies/diseconomies of scale)

• Traditional economics not applicable
Example: Service Differentiation

- Email: Best Effort
- Video: SLA
Example: Service Differentiation

QoS Aware

email

video
Why QoS?

Different applications have different needs – let’s build a smart network that supports them all!
Why QoS? Economist’s View

1. Network congestion $\rightarrow$ negative network externality
2. Differing willingness-to-pay (WTP) $\rightarrow$ quality differentiation allows price discrimination
3. Economies of scope cost savings (e.g., statistical multiplexing)
Question

• How to allocate network resources to different applications and service classes?
• How to price?
Pricing: Another Religious War

• Usage-based vs. Flat-rate pricing
• Marginal cost pricing (supply-side)
  - Problem: efficient, but cannot recover fixed cost
  - Solutions: Ramsey pricing, non-linear pricing
• Marginal WTP pricing (demand-side)
  - Price discrimination or differential pricing
  - Strong motivation for service differentiation, e.g., QoS
  - e.g., Time-of-day pricing
• Market-based pricing
  - e.g., Congestion pricing
  - Auctions: when demand-curve cannot be readily determined
  - Mechanisms difficult to design; high transaction costs
The Role of Prices

• Allocate resources to maximize economic efficiency
• Serve as feedback signals
  - Help users make efficient consumption choices
  - Help provider make optimal capacity expansions
Desirable Properties of Pricing Schemes

• Delgrossi and Ferrari 1999
• Service provider’s perspective
  - Encourage efficient resource usage (incentive compatibility)
  - Low cost (implementation, metering, accounting and billing)
  - Competitive prices
  - Cost recovery
• User’s perspective
  - Fairness
  - Predictability (reproducibility)
  - Stability
  - Transparency (comprehensibility)
  - Controllability

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Beyond Pricing

• Some strategies for improving efficiency (and/or profits):
  - Service differentiation $\rightarrow$ price discrimination
  - Service bundling
  - Horizontal mergers and vertical integration of service providers
Horizontal Mergers

• Examples:
  - Four baby bells left:
    SBC (Southwestern Bell, Pacific Bell, Ameritech), Verizon (Bell Atlantic, Nynex), BellSouth, Qwest (US West)
  - Worldcom bought MCI (UUNET), tried to buy Sprint

• Reasons for horizontal mergers:
  - Economies of scale

• Reasons against horizontal mergers:
  - no network externality benefits (all networks are interconnected anyway)
  - Industry concentration reduces competition
Vertically Related Markets

- Upstream/downstream relationship
- Examples:
  - Detroit: steel v. automobile
  - Voice: local v. long distance
  - Data: fiber v. connectivity v. data center v. content
  - Software: OS v. applications
Vertical Integration

• Good:
  - economies of scope savings (opposite of outsourcing)
  - internalize transaction costs
  - reduce prices & increase total welfare

• Bad:
  - if one component is monopolistic
  - foreclose competition in other component
Closing Remarks

• Technical and economic efficiency should be the goal of network resource allocation
• Well designed pricing schemes should align them
• Pricing is not everything
  - Service bundling and unbundling
  - Peering and interconnection architectures
  - Vertical integration and horizontal mergers
  - …