Internet Economics

IS231 Guest Lecture
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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

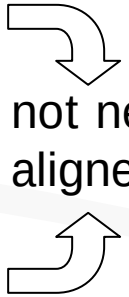
Network Services

- 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.

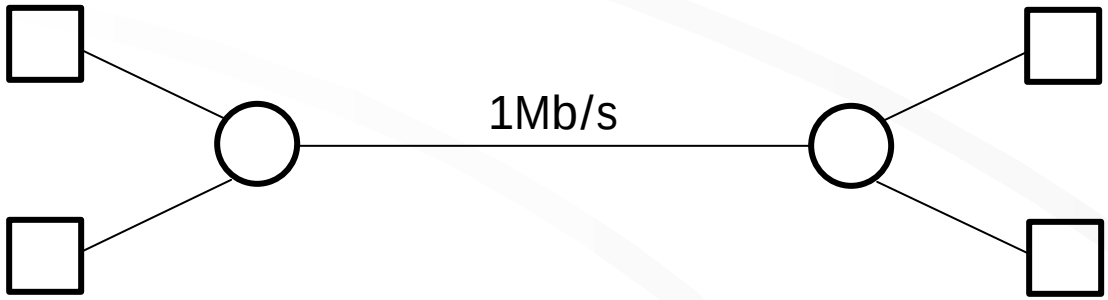
Resource Allocation Goals (Objective Functions)

- 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.

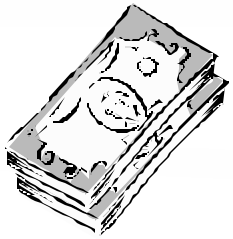


Technical Approach to Resource Allocation

- 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

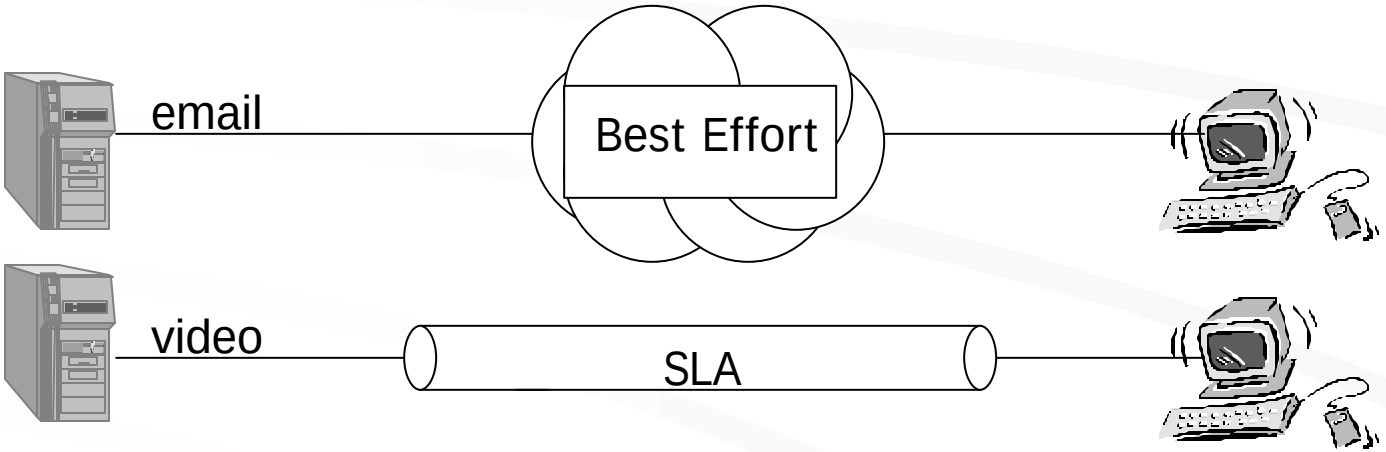
- Supply: cost of providing network service
  - fixed cost (FC)
  - marginal cost (MC)
  - average cost (AC)
- Demand: how much users value (and are willing to pay for) the service
  - more difficult to quantify
  - need empirical measurement

What Makes Network Economics Interesting?

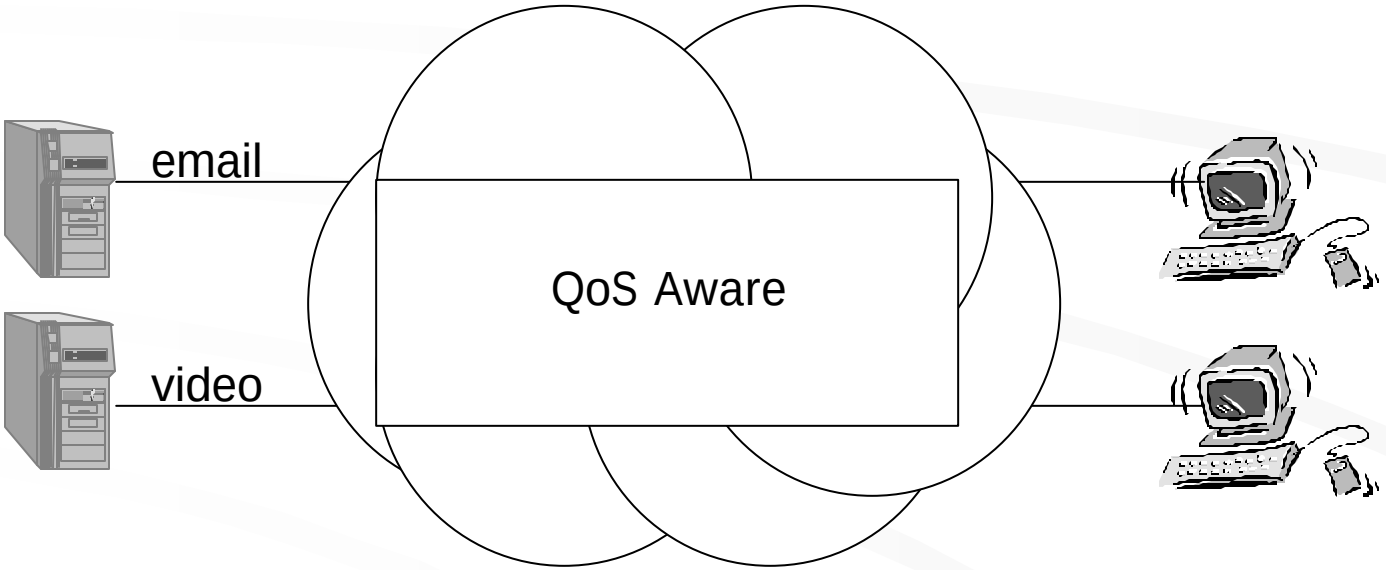
- Network services exhibit
  - High fixed cost, low marginal cost (strong economies of scale)
    - e.g., trenching cost most significant; deploy dark fiber (excess capacity); install switches when needed
  - Significant joint costs (strong economies of scope)
  - Positive/negative network externalities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

- Traditional economics not applicable

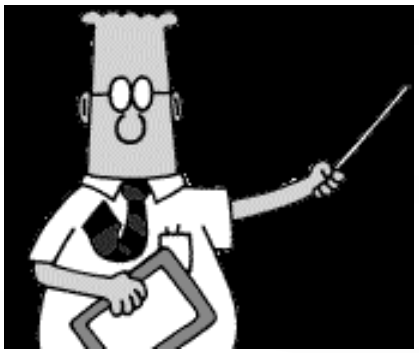
Example: Service Differentiation



Example: Service Differentiation



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 → negative network externality
2. Differing willingness-to-pay (WTP) → 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

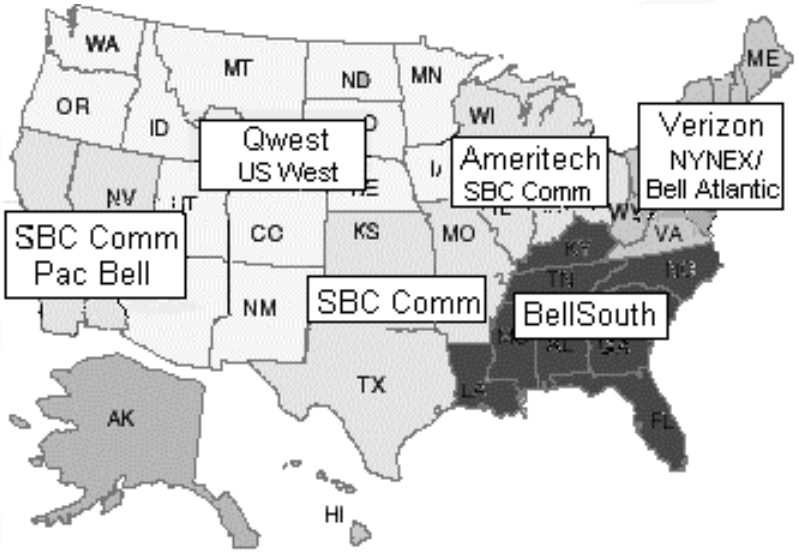
Desirable Properties of Pricing Schemes

- 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

Beyond Pricing

- Some strategies for improving efficiency (and/or profits):
  - Service differentiation → 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
  - ...