Pricing Internet Access and Use

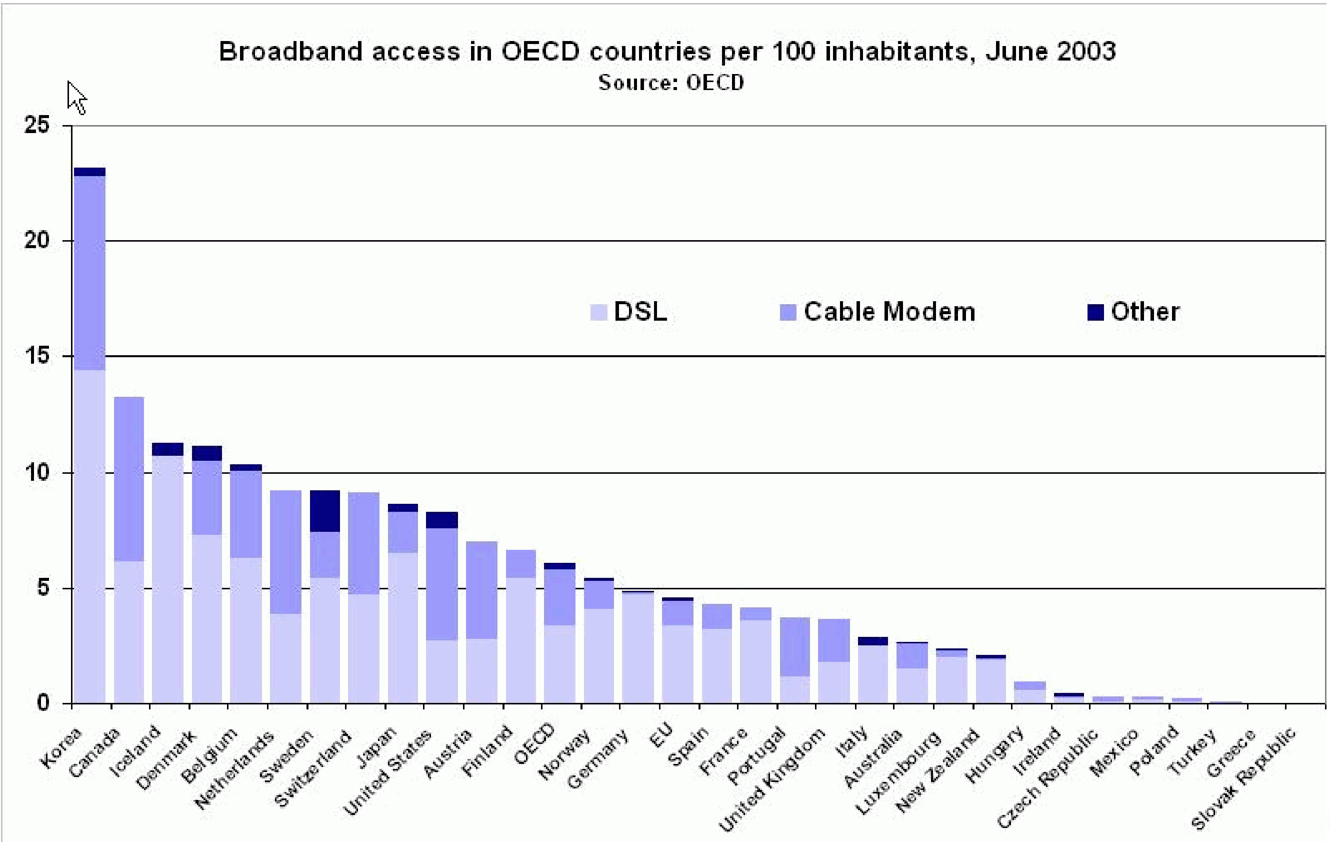
1. Introduction

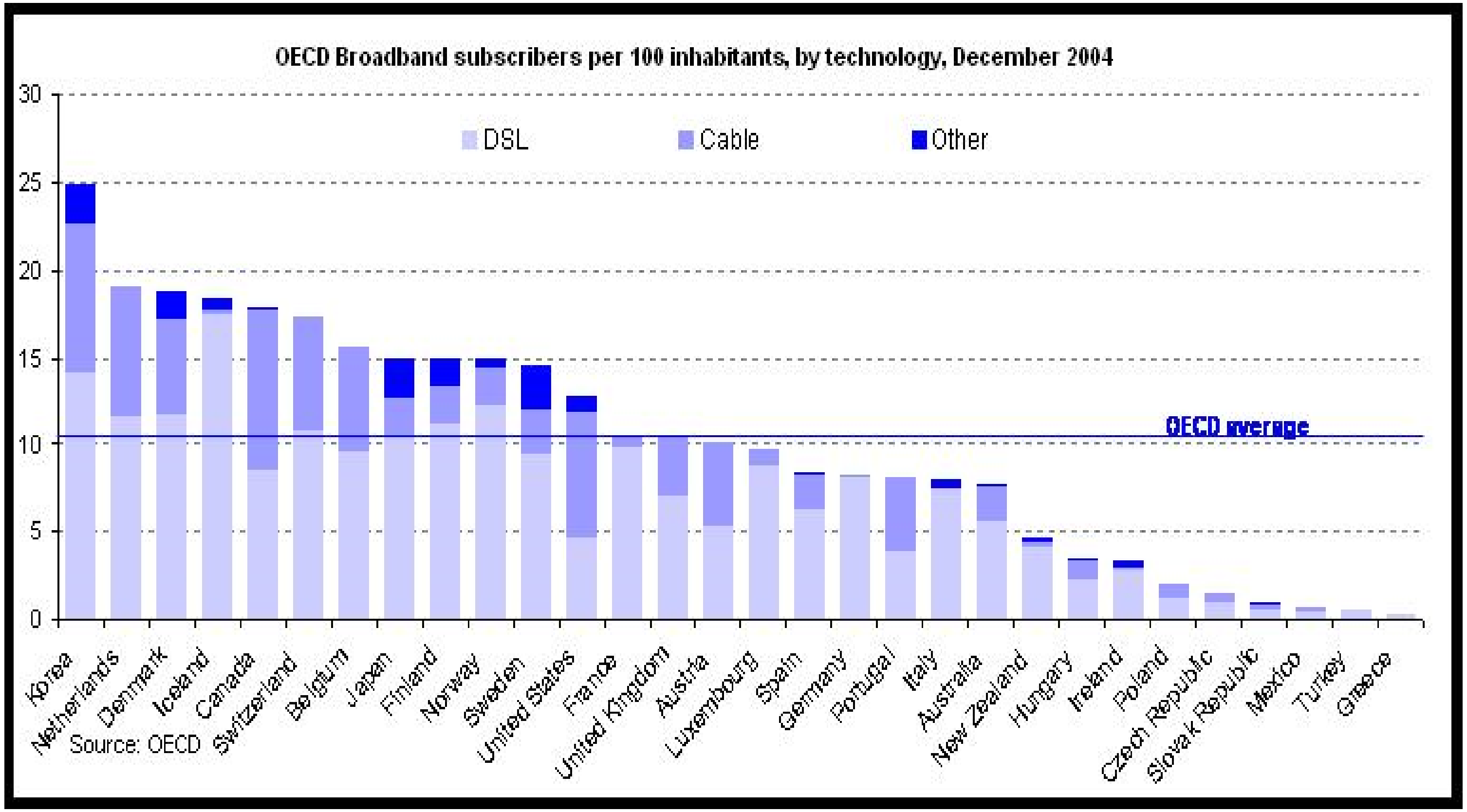
- Internet Commercialization
  - 9.5M (1996) to 110M (2001), 395M (2006)
  - 900M (2012) hosts
  - Audio, graphic, video activities
  - Demand for bandwidth
- Supply-side response
  - Engineering means to increase supply
  - Investment for infrastructure
  - Investment and over-provisioning of resources is inefficient

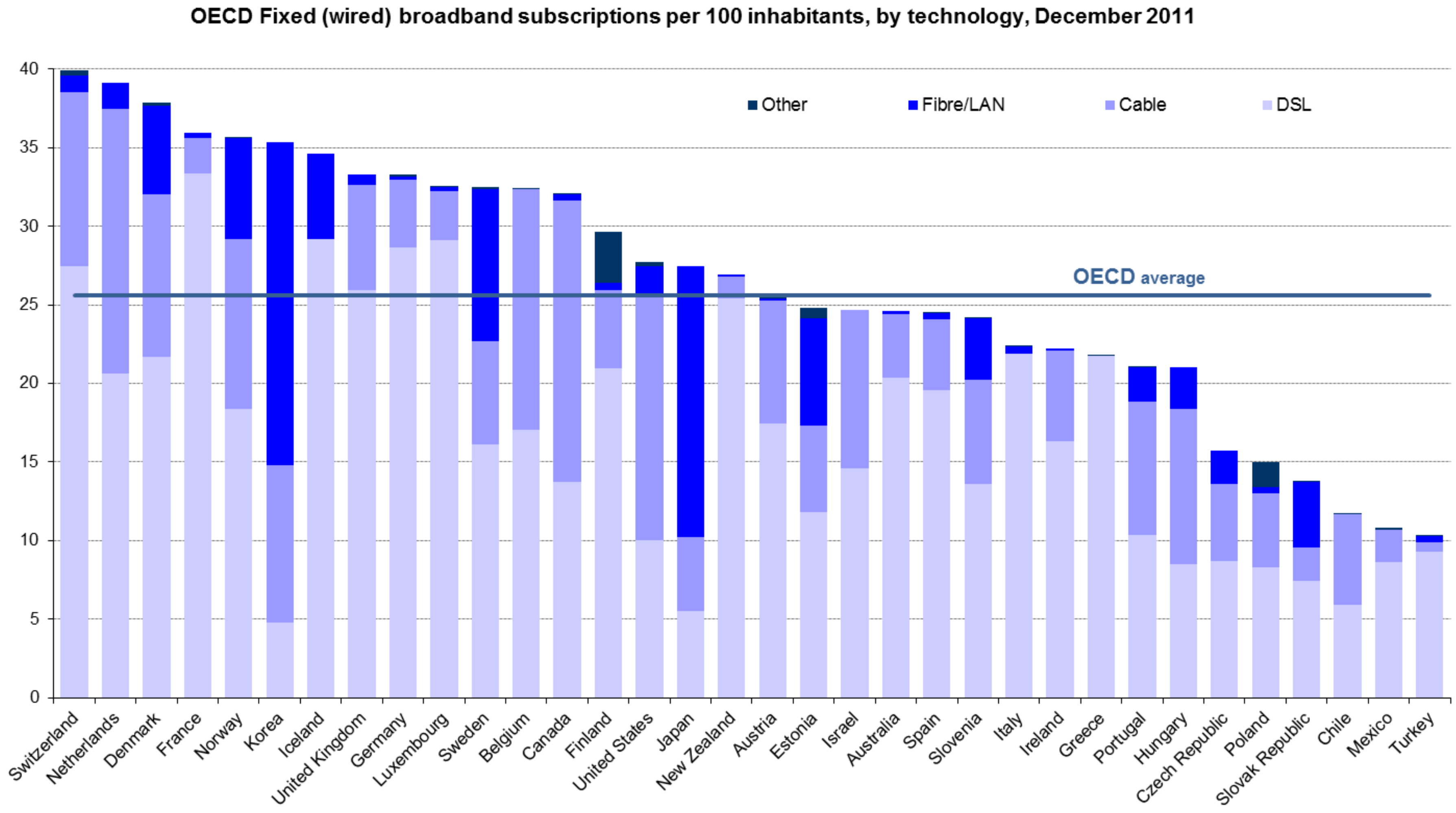
1. Introduction

- Internet congestion a problem?
  - ↑ users and intensity
  - Best-effort doesn't account for value (WTP)
  - Pricing ignores externalities (external cost of congestion)
- Demand-side approach
  - Economic pricing

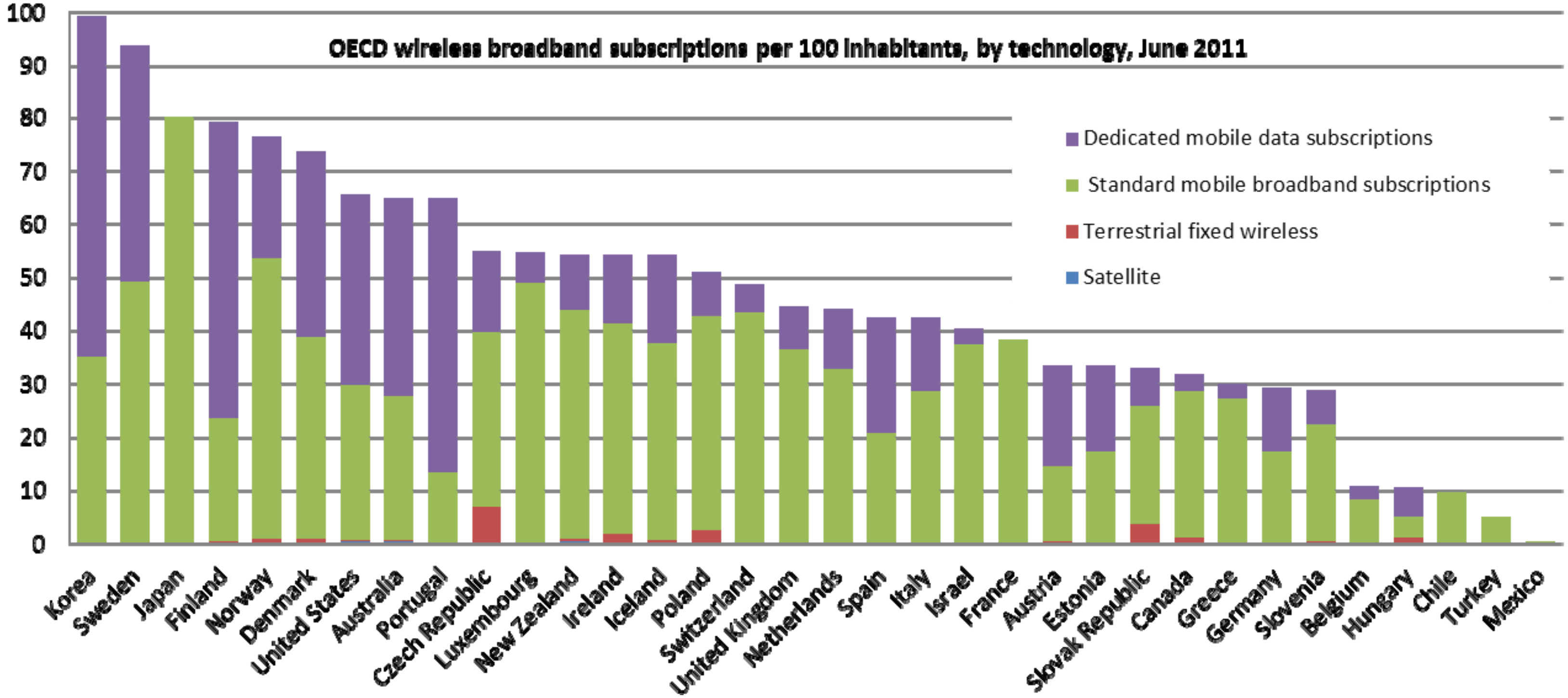
Broadband Access in OECD [www.oecd.org]




OECD Broadband subscribers per 100 inhabitants, by technology, December 2004
30
25
20
15
10
5
0
DSL
Cable
Other
OECD average
Korea
Netherlands
Denmark
Iceland
Canada
Switzerland
Belgium
Japan
Finland
Norway
Sweden
United States
France
United Kingdom
Austria
Luxembourg
Spain
Germany
Portugal
Italy
Australia
New Zealand
Hungary
Ireland
Poland
Czech Republic
Slovak Republic
Mexico
Turkey
Greece
Source: OECD


OECD Fixed (wired) broadband subscriptions per 100 inhabitants, by technology, December 2011
40
35
30
25
20
15
10
5
0
Other
Fibre/LAN
Cable
DSL
OECD average
Switzerland
Netherlands
Denmark
France
Norway
Korea
Iceland
United Kingdom
Germany
Luxembourg
Sweden
Belgium
Canada
Finland
United States
Japan
New Zealand
Austria
Estonia
Israel
Australia
Spain
Slovenia
Italy
Ireland
Greece
Portugal
Hungary
Czech Republic
Poland
Slovak Republic
Chile
Mexico
Turkey

Source: OECD



OECD wireless broadband subscriptions per 100 inhabitants, by technology, June 2011
Dedicated mobile data subscriptions
Standard mobile broadband subscriptions
Terrestrial fixed wireless
Satellite
100
90
80
70
60
50
40
30
20
10
0
Korea
Sweden
Japan
Finland
Norway
Denmark
United States
Australia
Portugal
Czech Republic
Luxembourg
New Zealand
Ireland
Iceland
Poland
Switzerland
United Kingdom
Netherlands
Spain
Italy
Israel
France
Austria
Estonia
Slovak Republic
Canada
Greece
Germany
Slovenia
Belgium
Hungary
Chile
Turkey
Mexico

1. Introduction

Road Map

Common property and congestion

Solutions to congestion

SOCP (Socially Optimal Congestion-based Price)

Internet pricing proposals

Interdisciplinary approach

2. Common Property, Congestion, and the Internet

Tragedy of commons (common property)

(i) Who owns the Internet?

(ii) Theoretical approach

(iii) Pricing with negative externality (Neg-X)

2. Common Property, Congestion, and the Internet

(i) Who

No individual agent

Information highway system

Must pay for access to the ISPs

Sending and receiving packets free

2. Common Property, Congestion, and the Internet

- Exchange information at zero cost
  - Many users don't pay for access
  - MC (adding a user with additional packet) $\rightarrow 0$
  - "Free content"
  - Flat-rate pricing (monthly pay) for home users

2. Common Property, Congestion, and the Internet

(ii) Theoretical approach

Private goods

- Excludable and rival

Common property

- Non-excludable, but rival

Internet is common property

- Neg-X
- External (congestion) cost

2. Common Property, Congestion, and the Internet

(iii) Pricing with Neg-X

MSC (marginal social cost)

Individual actions

Tragedy of the commons

Optimal Internet pricing

- P reflects MSC
- Consumers make socially optimal decision
  - more access → congestion → tx delay
- MSC = MPC + Neg-X

2. Common Property, Congestion, and the Internet

- User's point
  - MPB > P = MPC: continue to consume
  - P = MPC = 0 (once accessed)
  - 0 < MSC: price should reflect MSC
- Need to build Neg-X into pricing
  - MPB > MSC: continue to consume
  - MPB < MSC: usage declined during the congestion
  - P must reflect MSC to make consumers make proper decision

3. Solution to Internet Congestion

- Altruism
- Enhance capacity
- Government intervention: taxation
  - P = MSC
    - = MPC + Neg-X
    - = MPC + tax
  - Problems with tax
    - Congested/non-congested period
    - Which government get the tax revenue
    - How to measure the Neg-X for tax
- Economic pricing
  - Reflect consumers WTP

4. The Internet and SOCP

Highway analogy

- P = 0, MC = 0 when not congested
- P > 0
- Mackie-Manson and Varian (1995), Shy (2001)

4. The Internet and SOCP

(i) Model Assumption

$i = 1, 2, \ldots, n$ Internet users

Each transmits q_i packets

Total # of packets is Q tx in the network, $Q = \Sigma q_i$

Network capacity = κ

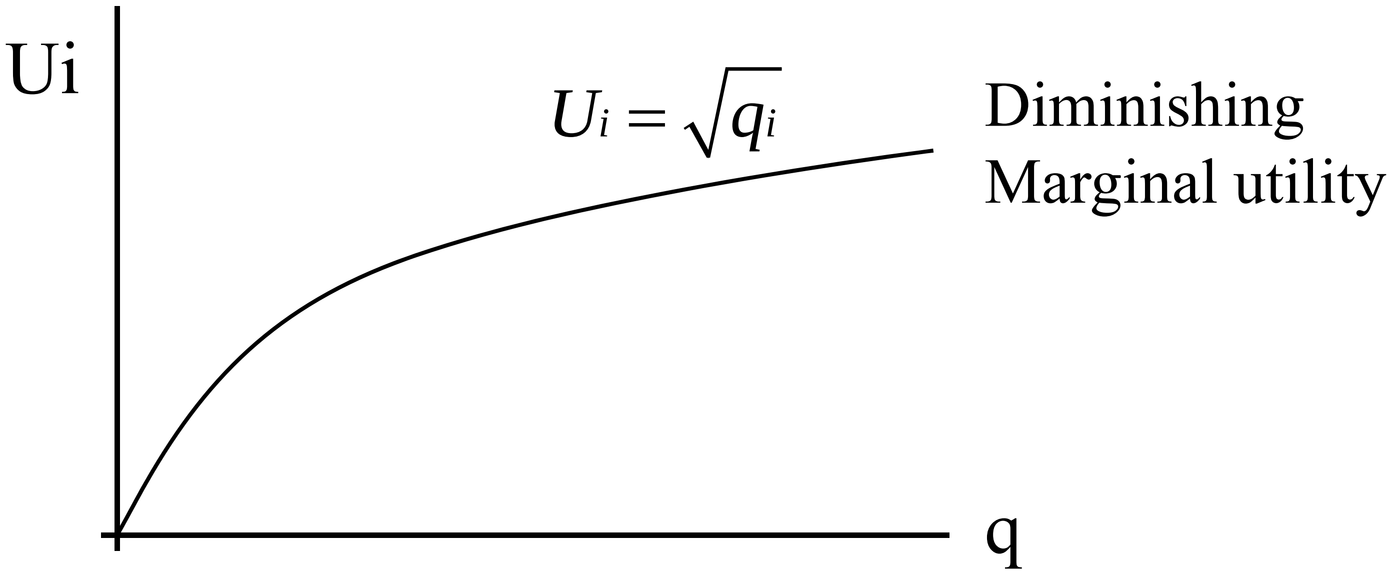
Utility (from usage) and disutility (from delays)

P = price/packet

U function

$$U_i = \sqrt{q_i} - \delta \frac{Q}{\kappa} - Pq_i$$

4. The Internet and SOCP



Q < κ : under-utilized

Q > κ : over-utilized

4. The Internet and SOCP

(ii) P = 0

$$q_i = \left(\frac{\kappa}{2\delta}\right)^2 \qquad Q = nq_i = n\left(\frac{\kappa}{2\delta}\right)^2$$

Proposition

Individual users usage of the Internet increases quadratically with the capacity of the network and decreases with the degree of disutility of delay

4. The Internet and SOCP

(iii) SOCP (P > 0)

SOCP

- Neg-X, and maximize W
- Welfare for the society
- Sum of individual consumer's utility

Two-step process

- (1) What is socially optimal tx level?
- (2) Prices that ensures (1)

4. The Internet and SOCP

(1) Socially optimal tx level (assume P = 0)

$$\operatorname*{Max}_{q} W = n\left(\sqrt{q} - \delta\frac{nq}{\kappa}\right)$$

$$q^* = \left(\frac{\kappa}{2\delta n}\right)^2 \qquad Q^* = nq^* = n\left(\frac{\kappa}{2\delta n}\right)^2$$

$$\frac{Q}{Q^*} = \frac{\left(\frac{\kappa}{2\delta}\right)^2}{\left(\frac{\kappa}{2\delta n}\right)^2} = n^2$$

: Internet is overused by the factor of n^2

4. The Internet and SOCP

(2) Socially optimal congestion-based price (assume P > 0)

$$\underset{q_i}{\text{Max}}\; U_i = \sqrt{q_i} - \delta \frac{Q}{\kappa} - Pq_i$$

$$P^* = \frac{\kappa - 2\delta\sqrt{q_i^*}}{2\kappa\sqrt{q_i^*}}$$

From $q^* = \left(\dfrac{\kappa}{2\delta n}\right)^2$ $\qquad P^* = \dfrac{\delta(n-1)}{\kappa}$

4. The Internet and SOCP

Socially optimal congestion-based price

$$P^* = \frac{\delta(n-1)}{\kappa}$$

Function of $\delta \uparrow$ $\quad P^* \uparrow$

$n \uparrow$ $\quad P^* \uparrow$

$\kappa \uparrow$ $\quad P^* \downarrow$

4. The Internet and SOCP - Summary

P = 0: W is not maximized
- Artificially high demand
- Bad investment decisions

P = MSC > 0
- Users recognize scarcity, adjust demands
- ↑W w/o need for investment
- Proper signals for investment

5. Internet Pricing Proposals

Flexible pricing arrangements
- Account for congestion
- Encourage (off-peak period) and discourage (peak period) usage
- Permit users to express WTP:
  - Best estimate of price comes from consumers

5. Internet Pricing Proposals

(i) Flat-rate pricing

Flat-rate for connection $20/month

Advantage

- Predictable, easy to administrate
- Encourage adoption

Disadvantage

- Encourage excessive use: not usage-based pricing
- No discrimination between customers

5. Internet Pricing Proposals

(ii) Usage-sensitive pricing: popular in long-distance phone service

Fee for usage (time, packet)

Advantage

- Recognizes scarcity

Disadvantage

- Metering
- Fees charged for off-peak period
- No discrimination between users with different priority, between users with different amount of traffic

5. Internet Pricing Proposals

(iii) Precedence model (altruism-based)

Priorities for different usage classes (contents of service)

Voluntarily choose class

Advantage

- Recognize priorities

Disadvantage

- Who decides priorities
- Not commercially palatable
- Tragedy of the commons - not practical

5. Internet Pricing Proposals

(iv) Static priority pricing

Priorities for different usage classes

Prices reflects priority

Advantages

- Recognizes quality and WTP

Disadvantage

- Not dynamic: dynamic network status of time
- High prices when no congestion

5. Internet Pricing Proposals

(v) Dynamic optimal pricing

Dynamic priority pricing to reflect

- Traffic flow
- Packet size
- Priority/QoS
- Social cost of time

5. Internet Pricing Proposals

(vi) Smart market mechanism

Dynamic Auction

'Bid field' in the header of packet

- Reflects value placed on the packet to tx
- Higher bid, higher priority
- Queue based on the bid

Advantage

- Economically efficient
- Accounts for quality and WTP

5. Internet Pricing Proposals

Disadvantage

- Information intensive, complex (technically feasible? cost effective?)
- Favors high WTP
- Open to some abuse

5. Internet Pricing Proposals

(vii) Paris metro pricing

Partition network with different prices

Advantage

- Users self-selected according to WTP

Disadvantage

- Overall traffic must be relatively low
- How to design efficient partitions?

5. Internet Pricing Proposals

(viii) Expected capacity pricing

Contract for excess capacity

Insurance against congestion

Advantage

- Recognize quality, WTP, social costs
- Kicks in when it has congestion

Disadvantage

- Complex for users?

5. Internet Pricing Proposals - Summary

Recognize social cost, WTP, QoS
More efficient use of Internet
Alleviate congestion
Devote resources to the WTP