Incentive Management in E-Commerce: Specific Internet Issues

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The online medium brings new incentive challenges

- Problems specific to online auctions:
  - Proxy bidding
  - Closing rule, Amazon vs. eBay
  - False-name bidding
- Controlling network traffic:
  - At the TCP level
  - At the JWT level
- Others we won’t speak about:
  - P2P networks
  - two-producer systems

Online Auctions I: Proxy bidding

- Both a convenience measure, and a solution to “sniping”
- Pushes auction towards a 2nd-price auction
- Concrete manifestation of the revelation principle

Online Auctions II: Closing rules

- eBay: hard deadline
  - “We know that some bidders will act on auctions and will show interest before placing a bid; their goal is to dip in and out of the auction before completing the bid in order to cause confusion by bidding.
  - Amazon: we make sure competing bidders have a chance—often a minor—of seeing the bidders who were actually in the auction.
  - Closing rule: whenever a bidder sees the last 3 minutes of an auction, the auction is automatically extended for an additional 10 minutes from the time of the last bid. If no additional bid is placed within 10 minutes, the auction will end with the “bidder” who bid last.
  - Why not at all? Interesting analysis by Rush & Ockenfeld.
    - Numerical: No extension, market equilibrium is reached.
    - Strategic: Avoid bidding war, “it leaves everything the same”

Online Auctions III: False identities

- Imagine a combinatorial auction with goods and the following two bids, each for (A), (B), and (LAB):
  - Agent 1: (A,B,AB)
  - Agent 2: (A,B,AB)
- Hence, in GVA, Agent 1 will get the two goods, pay 8, and hence 12-8=4
- But in the Internet, Agent 1 could create a misrepresentation, Agent 3, and split his bid as follows:
  - Agent 1: (A,B)
  - Agent 3: (B,AB)
  - Agent 2: (A,B,AB)
- Hence, in GVA, Agent 1 and “3" will each win and pay $8-2=6, and thus in reality, Agent 1 will be paying $4, with an overall utility of 112-4=8
- What to do?
  - There are 10 examples of combinatorial auctions that are not composable, non-monotonic settings have individually rational:
  - Some proposals for action that balance economy efficiency

Beyond Auctions

Incentives at the infrastructure
Reminder: The infrastructure

TCP/IP at the end nodes

- A flow is broken into packets
- Each packet is marked with the flow ID, numbered sequentially, and associated with the destination IP (perhaps with the help of a DNS).
- The first packet is sent to the gateway (initial router as the first leg of the journey; additional packets follow it, first leisurely and then with increasing frequency.
- If a flow is detected, the receiving endcouponiously sends back acks with the last transmitted packet. If it received three acks in a row that the last is Ws, or if the "time out" (no ack within a specific period), TCP concludes that the flow was dropped, and starts resending the flow from the.
- Automatic flow balancing: For every notice of a dropped packet TCP drops the sending rate by M2; for every notice an ack’d packet TCP increases the sending rate by D2, where w is the current rate.

TCP/IP in the middle:
a day in the life of a router

- Accepts packets, each with a destination IP address
- Routing: Using a (constantly updated) routing table, sends the packet along the link, until there’s congestion
- Buffering: If there’s congestion, the message is maintained in a FIFO queue, unless the queue is full
- Best effort: If it’s full the packet is unceremoniously dropped

TCP/IP and the tragedy of the commons

- Each user decides how many packets to send and how frequently
- These individual decisions jointly determine the congestion of the network
- The locally optimal action of increasing one’s sending rate leads to global overuse of the network and thus a poor service to everyone

A game theoretic model:
Prisoners’ Dilemma

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Key game theoretic concepts

- Games in matrix (aka normal) form
- Nash equilibrium
- Dominant strategy
- (Social) efficiency
Some evidence that this is not idle speculation

- Close encounters in 1987, 1992
- The rise of UDP-based traffic
- Advent of "efficient" TCP implementations
- The multiple-connection trick

The jury's still out on whether bandwidth is inherently scarce [plentiful] [fer vs. hungry apps and bottlenecks at regional and local levels]. But enough have worried about it to make some proposals...

RFC2309 of the IETF in 1998: Two recommendations for improving congestion management

- **Technological** From FIFO to other queuing schemes
  - E.g.: Fair queuing, RED (Random Early Detection), CIOKe *
  - Not our focus
- **Economic**: Charging usage fees, cleverly
  - Our focus

* Not all listed in the RFC

Changing FIFO alone is not enough

- Can't achieve maximal efficiency without instituting some form of payments
- Replacing FIFO by a version of Fair Queuing does at least achieve fairness and is also "learnable" quickly by a simple protocol

Other arguments for usage fees, beside efficient use of network resources

- Quality of Service (QoS) guarantees (delay, throughput)
- People can discover their own utility function
- Not held hostage to obsolete technologies

Two pricing proposals

- Vicious strikes again: Economic optimization
- Paris Metro Pricing: Psychological simplification
Vickrey strikes again  
(Mackie-Mason & Varian, 1993)

- A fairly academic proposal, dubbed “smart market”
- Each packet has a “bid” field
- When network is not congested, no usage charge
- When it is congested, the highest bids are accepted up to the link’s capacity
- Prices change on a minute-by-minute basis
- The price is the “clearing price”, or the price just above the rejected bid
- This is exactly Vickrey pricing, generalizing 2nd-price auction to the M+1-th price auction, for M units of good.

A simple alternative: Paris Metro Pricing (PMP)  
Odlyzko, 1998

- Divide the bandwidth into a few (e.g., 4) virtual channels
- Each channel will be identical but charged differently
- Expensive channels will naturally attract fewer, more urgent flows
- Advantages:
  - Simple, predictable expense to end users
  - Relative ease to implement (no metering)
- Disadvantage:
  - Inefficient use of the network
  - Indeed, not clear what precise quantity is being optimized

Beyond TCP: Smoothing out Focused Loading

- Many users demand network resources at some (locally), predictable in advance
- Canonical example: long distance phone
  - people want to talk as early as possible, minimize cost
  - utility maxis when rates drop at 5 PM
  - network de-mands spikes
- Computer networks: load can be even more focused
  - sudden onset: TicketMaster server as tickets go on sale
  - deadline: IRS server just before taxes are due

Various criticisms

- Congestion information not available to end users
  - But see our most proposal by Gibbons and Kelly
- The willingness of users to pay is not enough to recover costs of network, and so is not that material
- Social optimality an overly simplistic criterion
- It’s unrealistic to assume that pricing schemes can be enforced universally
- The scheme requires a fairly radical change to the routing software, and in particular details accounting
- Doesn’t handle multicast
- ...

Where do we stand on TCP

- Outstanding question: Is bandwidth an issue? Jury’s out
- Internet bodies urged to consider changing TCP for congestion management, changing FHTO more imminent than usage charging
- A fairly active area of research

Proposed Mechanisms

- We’ll discuss two explicitly, two more in the paper
- Why more than one mechanism? Many variables:
  - Types of equilibrium
  - Performance under overload
  - Cost of coordination
  - Time needed to coordinate
  - Communication cost
  - Agents may have different preferences
- To begin with, we’ll make two assumptions:
  1. all agents have the same preferences
  2. mechanism designer knows these preferences
**Mechanism 1 (a straw-man): Preselection**

1. Decide if each slot will be free according to $p$
2. Each agent chooses a slot

Select $p$ so that agents are indifferent between all time slots:
- $E[p]$ constant for all slots
- $p$: call this probability distribution $p^*$

**Mechanism 2: Collective Reward**

1. The mechanism assigns agents “names” corresponding to slot numbers
2. Each agent chooses a slot
3. The mechanism computes $p^*$, and determines which slots will actually be free as follows:
   - $\text{count}(x)$: the number of agents given name $x$
   - $d^*(x) = \text{count}(x) \cdot d(x)$
   - $S$: the set of slots which minimize $d^*$

$$ p(x) = \begin{cases} p^*(s) & s \in S \\ 0 & s \notin S \end{cases} $$

**Preselection: Equilibria**

- Any set of strategies is a weak equilibrium, e.g.:
  - agents randomize (load balancing)
  - agents pick the “best” slots deterministically: minimize $d$
- it is a weak optimal equilibrium
- agents pick some slot deterministically: for needed loading!
- Theorem: if
  - agents have identical utility functions
  - payoffs are independent of agents’ moves
  then a strict, optimal equilibrium does exist.

**Collective Reward: Equilibrium**

- A strict equilibrium: $a_i$ chooses slot name($i$)
- All other agents play this strategy—$a_i$ could:
  1. play the strategy too
     - $a_i$ gets the same utility regardless of what the others do
     - $a_i$ gets the best utility regardless of what the others do
  2. select a different slot
     - $a_i$’s slot will then be free
     - $a_i$ has unique optimal, and for area exist, equilibrium

**Two More Mechanisms**

- **Bulldozing**
  - agents coordinate with each other by broadcasting their intended slot choice
  - agents get free slots according to $p^*$ iff their distribution is optimal
  - strict, optimal equilibrium
- **Discriminatory**
  - agents are assigned slots by the system
  - each agent gets the slot free according to $p^*$ iff the slot is the assigned slot, otherwise he pays in
  - dominant strategy unique, optimal equilibrium

**What else you should read**

- [Loridan & Tuzato, 2004]
- [Recommendation on Queue Management and Congestion Avoidance in the Internet, RFC 2309, Boren et al., pp. 1-10 (only non-technical reading)]
- [Making Greed Work in Networks, Shook et al., 12.3 (feel free to skim overview for an introduction on the topic)]
- [Pricing for the Network, Markandu & Varian, all essays appendix]
- [Partitions Pricing for the Network, Olshansky, all essays appendix (which you should refer back to for a general overview of the topic)]
- [Pricing Computer Networks: Reducing the Revenue Gap, Stigler et al., subsequently it is called “the ‘share the benefits’ approach”)]
- [Extraneous and some Evaluation of Congestion Control, Gibbons and Kelly (differential taxation taxes proposal based on RED, that is shown to implement in-market like what is otherwise)]
- [Greedy Combinatorial Auctions, Lipton et al., RFC 2309, pp. 1-10 (only non-technical reading)]