Incentive Problems in Peer-to-Peer Systems

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Sept. 24, 2010

Outline

- Why are Incentive mechanism in need? Why is design of incentive mechanisms difficult?
- Classification of incentive mechanisms and examples
- Analytical tools
- Future research directions

Why incentive?

- Features of peer-to-peer:
  - Decentralization(no single administrative entity -- different from distributed system)
    - Selfish
    - Collusion attack (users forming groups to maximize benefit)
  - High churn rate
  - Availability of cheap identities -- whitewashing attack and sybil attack
  - Hidden actions
  - Care for performance (completely tit-for-tat is impossible)

Various incentive mechanisms

- Exchange-based:
  - BitTorrent
- Currency
  - Mojonation, Karma
- Reputation
- Others
  - SRE(Sharing ratio enforcement)
  - Domain-specific (binding with QoS)
  - Relating to Social Network (use the trust between friends)
- Another method of classification:
  - Direct reciprocity and indirect reciprocity

BitTorrent

- Symmetric interest
  - Can not be used in streaming
- Attacks towards BitTorrent
  - Many free-riding software developed:
    - BitTyrant (link to more neighbors and adjust the upload bandwidth according to the marginal gain)
    - "Large View Exploit" (link to more neighbors to get more chance to be optimistically unchocked without upload anything)
- Exclusively relying on one's own direct observations do not make use of all the information available.

Reputation System

- More scalable than direct reciprocity systems, but rely on third party observations and must handle trust issues which are absent in the direct reciprocity systems.
- Extremely vulnerable to whitewash attacks and sybil attacks -- easy to clean bad reputation
- To deal with the trust issues:
  - "A Robust Reputation System for P2P and Mobile Ad-hoc Networks" proposes to track the *reputation ratings* and *trust ratings* of the neighbors.
  - But only limit the attacks rather than eliminate them.

Currency

- Real money?
  - Not system compatible
  - Online clearing need extensive infrastructure support
  - Require money exchange at the protocol's time intervals.
  - Legal issues
- Virtual money?
  - Virtual: have no value outside of the system
  - How to avoid double-spending? (a thrid party mediator)
  - How to decide price? how to elicit true valuation?
  - Example: Karma (DHT neighbors as "bank-set" and use auctions to decide price)
- Some one prove that optimal mechanisms typically involve money transfer

Sharing Ratio Enforcement

- Idea:
  - Enforce each peer must maintain its sharing-ratio (uploaded bytes over downloaded bytes) above a threshold level
  - invitation to join in the system
- Solution to collusion attack:
  - Entropy

SRE (cont.)

- "SRE" may be viewed as a variated reputation system.
  - Similarity: indirect reciprocity, making use of indirect observation
  - Variation:
    - The reputation is not based on the couting of "response" or "refusal" to a request, but the amount of contribution and consumption
    - Whether peer *i* cooperates with peer *j* depends on sharing-ratio -- when it drops below the threshold level, all the peers don't cooperate with it anymore because it is evicted from the system.
- Some thoughts:
  - Can SRE be used in a decentralized way in the live streaming? Sharing the share-ratio information about a stranger among friends?

Domain specific solutions

- Binding the contribution with the QoS:
  - Peers bid for the level of service, such as the distance to the root in a broadcast tree
  - At the cost of decreased social good.

Relating to social network

- Traditionally we assume peers are unrelated identities. Social network provides some help, such as trust relationship.
- Example: NABT (networked asynchronous bilateral trading)
  - Idea:
    - Peers set credit limits for its friends
    - Upload data when the credit balance is within the limits
    - Exchange credit when trade between friends of friends.

Analytical tools

Mainly borrowed from micro-economics:

- Game theory
  - IPD(also known as Tit-for-tat) (iterated prisoner's dilemma) Game -- BitTorrent
- Mechanism design
  - Inverse game theory
  - Algorithmic mechanism design : a rigorous methodology to create games with a particular set of desired outcomes in mind.

Future research directions

- Satisfy:
  - Trade off between distributed (not totally distributed) and central support (simple)
- Associate social networks
  - more trust
    - the reported information is more reliable: record sharing ratio in a distributed way and share sharing ratio about strangers among friends
    - credit
- Cross overlay
  - Encourage peers that are not interested in downloading file A to help distribute file A

End

Thank you