Wireless Network Pricing
Chapter 8: Outlook

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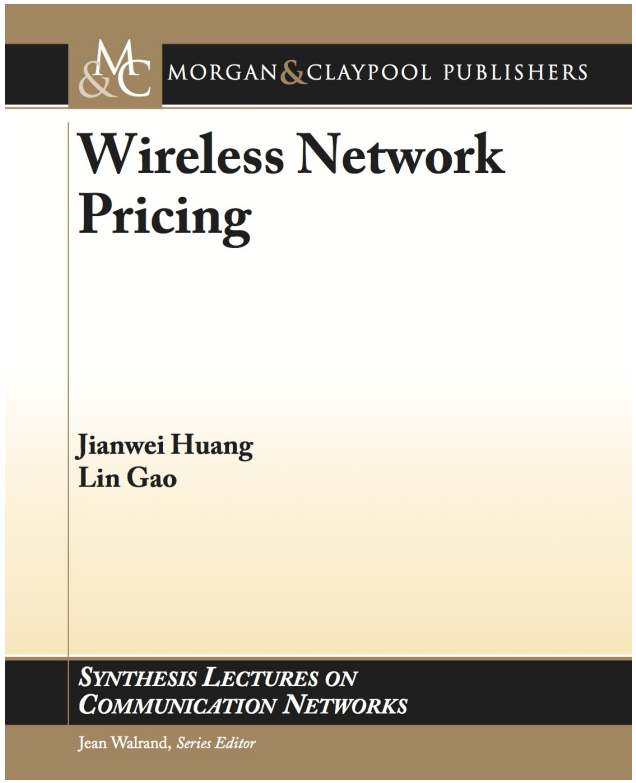
The Book



- E-Book freely downloadable from NCEL website: `http://ncel.ie.cuhk.edu.hk/content/wireless-network-pricing`
- Physical book available for purchase from Morgan & Claypool (`http://goo.gl/JFGlai`) and Amazon (`http://goo.gl/JQKaEq`)

Chapter 8: Outlook

Assumptions vs. Reality

- Two often used assumptions in this book:
  1. All market players have complete market information.
  2. One player (or one type of players) has the market power to determine the key market parameters (e.g., production quality or price), and other market players can only accept or reject the market parameters.
- In practice
  1. Market information is often incomplete to most market players.
  2. Market power is distributed among various market players.

Information Asymmetry

- Information Asymmetry: A situation in which one party in a transaction has more or superior information than the other.
- New Issue: Truthfulness (also called Incentive Compatibility)
  - How to design a truthful (incentive compatible) mechanism that credibly elicits the private information held by market players?
- Examples of Truthful Mechanism: Auction and Contract.

Information Asymmetry

- Significance of Truthful Mechanism Design – Revelation Principle
  - It allows a market designer to solve for an outcome or equilibrium by assuming all players truthfully report their private information.

Definition (Revelation Principle)

For any outcome resulting from any mechanism, there always exists a payoff-equivalent revelation mechanism where the players truthfully report their private information.

Distributed Market Power

- Distributed Market Power: The market power is distributed among various market players.
- New Issue: How to formulate the players' interactions?
  - Example: A firm sells a single product to a consumer. How to determine the price of the product if both the firm and the consumer have certain market power?
  - Non-cooperative game framework may no longer be suitable.
- A well studied approach: Bargaining.

Distributed Market Power

- Bargaining: A type of negotiation in which the buyer and seller of a good or service dispute the price which will be paid and the exact nature of the transaction that will take place, and eventually come to an agreement.
- Bargaining Solution
  - An outcome that both players feel acceptable, rather than strictly prefer in terms of certain criterion.

Section 8.1: Auction

Auction

Definition (Auction)

An auction is a process of buying and selling goods or services by offering them up for bid, taking bids, and then selling the item(s) to the highest bidder(s).

- Typical Issues in Auction Theory:
  - The truthful auction mechanism design.
  - The efficiency of a given auction design.
  - The optimal and equilibrium bidding strategies.
  - The revenue comparison.
- Auction Design
  - Allocation Rule Design: who is/are the winner(s) of an auction;
  - Payment Rule Design: what will be the payment(s) of the winner(s);

Auction vs. Pricing

- Information scenario:
  - Pricing is often used in under symmetric and complete information.
  - Auction is often used under asymmetric information.
- Price determination:
  - Under pricing: the sellers determine the market price based on their known information.
  - Under auction: the bidders collectively determine set the price, and the process accounts for market uncertainty.

Application of Auction in Wireless Networks

[1] L. Gao, J. Huang, Y.-J. Chen, and B. Shou, "An Integrated Contract and Auction Design for Secondary Spectrum Sharing," IEEE Journal on Selected Areas in Communications, vol. 31, no. 3, pp. 581-592, March 2013

[2] Y. Liu, M. Tao, and J. Huang, "An Auction Approach to Distributed Power Allocation for Multiuser Cooperative Networks," IEEE Transactions on Wireless Communications, vol. 12, no. 1, pp. 237-247, January 2013

[3] J. Huang, Z. Han, M. Chiang, and H.V. Poor, "Auction-Based Resource Allocation for Cooperative Communications," IEEE Journal on Selected Areas in Communications, vol. 26, no. 7, pp. 1226-1237, September 2008

[4] J. Huang, R. Berry, and M.L. Honig, "Auction-based Spectrum Sharing," Mobile Networks and Applications, vol. 11, no. 3, pp. 405-418, June 2006

Section 8.2: Contract

Contract

Definition (Contract)

A contract is an agreement entered into voluntarily by two or more parties with the intention of creating a legal obligation.

- Contract Theory studies how the economic agents construct contractual arrangements, generally in the presence of asymmetric information.
  - Closely related to the truthful (or incentive compatible) mechanism design.

Contract Models

- Moral Hazard: The information asymmetry is generated by the principal's inability to observe and/or verify the agent's action (termed as hidden action).
  - Example: insurance company's low willingness for insuring events that may be caused by clients' risky behaviors (such as fire or car accident)

Contract Models (Cont.)

- Adverse Selection: The information asymmetry is generated by the principal's inability to observe and/or verify the agent's type (termed as hidden information).
  - Signaling Game: The agent credibly conveys some information about itself to the principal
    - ⋆ Example: Job market signaling through education
  - Screening Game: The principle offers multiple contract options, which are incentive compatible such that every agent selects the option intended for his type.
    - ⋆ Example: Solomons wise judgment

Application of Contract in Wireless Networks

[1] L. Duan, T. Kubo, K. Sugiyama, J. Huang, T. Hasegawa, and J. Walrand, "Motivating Smartphone Collaboration in Data Acquisition and Distributed Computing," IEEE Transactions on Mobile Computing, October 2014

[2] L. Duan, L. Gao, and J. Huang, "Cooperative Spectrum Sharing: A Contract-based Approach," IEEE Transactions on Mobile Computing, vol. 13, no. 1, pp.174-187, January 2014

[3] L. Gao, X. Wang, Y. Xu, and Q. Zhang, "Spectrum Trading in Cognitive Radio Networks: A Contract-Theoretic Modeling Approach," IEEE Journal on Selected Areas in Communications, vol.29, no.4, pp.843-855, April 2011

Section 8.3: Bargaining

Bargaining

Definition (Bargaining)

Bargaining is a type of negotiation, in which the buyer and seller of a good or service discuss the price and the exact nature of the transaction that will take place, and eventually come to an agreement.

- Application Scenario: No participant has the total market power to determine the solution solely.
- Bargaining Solution: An outcome that both players feel acceptable.

Two Bargaining Approaches

- Axiomatic Approach for Bargaining Solution
  - Abstracting away the details of the bargaining process;
  - Considering only the set of outcomes that satisfy certain pre-defined properties (i.e., Axioms).
  - Typical Example: Nash Bargaining Model, 1950
- Strategic Approach for Bargaining Solution
  - Modeling the bargaining process as a game explicitly;
  - Considering the game outcome (i.e., Nash equilibrium) that results from the players' self-enforcing interactions.
  - Typical Example: Rubinstein Bargaining Model, 1982

Application of Bargaining in Wireless Networks

[1] L. Gao, G. Iosifidis, J. Huang, L. Tassiulas, and D. Li, "Bargaining-based Mobile Data Offloading," IEEE Journal on Selected Areas in Communications, June 2014

[2] A.H. Mohsenian-Rad, J. Huang, V.W.S. Wong, and R. Schober, "Repeated InterSession Network Coding Games: Efficiency and Min-Max Bargaining Solution," IEEE Transactions on Networking, August 2014

[3] Y. Yan, J. Huang, and J. Wang, "Dynamic Bargaining for Relay-Based Cooperative Spectrum Sharing," IEEE Journal on Selected Areas in Communications, vol. 1, no. 8, pp. 1480-1493, August 2013

Section 3.4: Chapter Summary

Key Concepts

- Incomplete information
- Distributed market power
- Auction, Contract, and Bargaining

Extended Reading

http://ncel.ie.cuhk.edu.hk/content/wireless-network-pricing