Internet Advertising and the Generalized Second Price Auction: Selling Billions of Dollars Worth of Keywords

Main Presentation
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Why not VCG?

- Generalized Second Price Auction
  - No equilibrium in dominant strategies
  - Typically equilibrium is not truthful
  - Easier to compute and explain to advertisers
  - Higher revenues than VCG

Static GSP Assumptions

- Bids change quickly and continuously
  - Could be complex equilibria, but assume there aren't
- Assume bids form equilibrium in static one-shot game with **complete information**
  - All values are common knowledge
  - Stable bids are static best response to other players'

Static GSP Equilibrium

- Player can force out player immediately above
  - Player in slot *i* below can increase the Player in slot *i*+1 payment enough so that Player in *i*+1 lowers his bid, and positions are swapped
- Eventually come to “locally envy-free” rest point

Locally Envy-Free Equilibrium

- Player will not want to swap with player immediately above or below
  - Paper proves it is a stable matching between advertisers and ad slots
- Lemma 5: Locally envy-free equilibrium of an auction is a stable assignment
- Lemma 6: If # bidders > # slots, any stable assignment is locally envy-free equilibrium of the auction

Locally Envy-Free Equilibrium (cont.)

- Equilibrium bidders' payments are the same as payments in dominant-strategy equilibrium of VCG
- Equilibrium is the worst locally envy-free equilibrium for the search engine and best locally envy-free equilibrium for the bidders

Theorem 7

- Shows that the payments locally envy-free is the same as VCG
- Shows that bidder cannot benefit by bidding less than equilibrium bid
  - Non-truthful bidding is not profitable in VCG, not profitable here
- Show that the equilibrium revenue is best possible locally envy-free outcome for bidders and worst possible outcome for the search engine

Significance of Theorem 7

- Locally envy-free obtains outcome similar to dominant-strategy equilibrium of the game induced by VCG
  - Advertisers select the position that makes them locally envy-free
  - Search engine gets $$$ >= VCG with an easy computation method
    - Not best locally envy-free equilibrium, but at least as good as VCG

Generalized English Auction

- Clock with a price increases over time
  - Player’s bid is price when they drop out
- Auction ends when next-to-last advertisers drops
- Very myopic procedure

Why analyze Generalized English Auction?

- Static GSP assumes long-run steady state
  - Can get there by starting bid at 0 and incrementally increasing it
    - Generalized English Auction
- Generalized English Auction has same equilibrium as VCG, which is worst-case for GSP
  - Equilibrium are roughly equivalent
- Bids get used to calculate prices using GSP
- Easier to analyze and prove things

Theorem 8 Notation

- α_k - click-rate at slot k
- s_i - value of click to bidder
- b_k - bid price per click
- p - drop out price

Theorem 8

- $\alpha_k (s_i - b_{k+1})$
  - profit for slot k
- $\alpha_{k-1} (s_i - p)$
  - profit for slot k - 1
- Prove that s_i is the optimal drop out point for agent i
  - If wait, could get slot k and gain nothing get slot k-1, at higher price and preferred k
  - If drop out before your value, miss opportunity to get k-1 at a cheaper price

Significance of Theorem 8

- Dominant strategies do not exist
- Generalized English auction payoffs coincide with VCG payments for all realizations of values
  - Bidders can be asymmetric
  - Distributions of values need not be known
- Unique and efficient equilibrium exist, but bidders do not have dominant strategies
  - Has ex post equilibrium

Conclusion

- Generalized Second Price auctions perform as well as VCG
- “Emerged in the wild,” but this paper proved its worth

Questions?


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