DCS/CSCI 2350: Social & Economic Networks

Sponsored Search Market
Reading: Chapter 15 [EK]

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Questions

- How does Google make money from web search?
  - Connection with auctions and matching markets
“The best minds of my generation are thinking about how to make people click on ads. I think that sucks.”

Jeff Hammerbacher, early Facebook employee

From CHI-2018 Conference
Photo: Ishtiaque Ahmed

Agenda

- Brief history
- Conventions
- Matching markets
- Vickrey-Clarke-Groves (VCG) auction
- Generalized second-price (GSP) auction
Search market

- Early days
  - Yahoo! negotiates deal with advertisers
  - Shows the ad a certain number of times
  - Effective?
- Since year ~2000
  - Keyword based advertising by Overture (bought out by Yahoo! in 2003 for $1.63B)
  - New market

Conventions

1. Pay per click
   - Advertisers pay Google on per click basis
   - How much?
2. Price setting by auction
   - Fixed price for keywords doesn't work. Why?
   - Main challenge in auction: multiple ad spots
Preliminaries 1

- Search keyword (e.g., pizza)
- Multiple ad slots

<table>
<thead>
<tr>
<th>Slot</th>
<th>Ad</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>?</td>
</tr>
<tr>
<td>3</td>
<td>?</td>
</tr>
</tbody>
</table>

Preliminaries 2

- Click-through-rate (CTR) of a slot
  - # of clicks/hr for that slot
  - Assumptions
    - Advertisers know CTR
    - CTR solely depends on the slot, not on the ad

<table>
<thead>
<tr>
<th>CTR</th>
<th>Slot</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 clicks/hr</td>
<td>1</td>
</tr>
<tr>
<td>5 clicks/hr</td>
<td>2</td>
</tr>
<tr>
<td>2 clicks/hr</td>
<td>3</td>
</tr>
</tbody>
</table>
Preliminaries 3

- Revenue/click
  - Advertisers get some revenue/click
  - Assumption
    - Solely depends on the advertiser, not on the slot
    - Private information

<table>
<thead>
<tr>
<th>Advertiser</th>
<th>Revenue/Click</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>$3/click</td>
</tr>
<tr>
<td>y</td>
<td>$2/click</td>
</tr>
<tr>
<td>z</td>
<td>$1/click</td>
</tr>
</tbody>
</table>

Matching market?

- Will MCP work?
  - What will be the valuations of the advertisers?
  - CTR (clicks/hr) × revenue($/click) (Unit: $/hr)
- Doesn’t work because Google doesn’t know the advertisers’ valuations
First-price auction?

- Did not work
  - Underbidding
  - Turbulent market

- Second-price auction for multiple items?

Vickrey-Clarke-Groves (VCG) mechanism
VCG mechanism

- Alternative view of second-price auction
  - Outcome maximizes the social welfare
  - Winner is charged the “harm” he/she causes to the other bidders
- How to calculate the harm caused by a bidder?
  - Calculate the increase in others’ valuations in an alternative universe where that bidder is not there

VCG price

VCG price: Each bidder pays the harm he/she causes to the other bidders

(harm = total amount everyone would’ve been better off if that bidder were not there)
Steps of VCG mechanism

1. Ask bidders to submit valuations (CTR × revenue/click)
   [valuations are independent and private, but truth-telling is dominant strategy]
2. Choose a socially optimal assignment (e.g., by MCP algorithm, but ignoring MCP prices)
3. Charge bidders their respective VCG price

Example

<table>
<thead>
<tr>
<th>CTR #clicks/hr</th>
<th>Slot</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
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<td>2</td>
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<td>2</td>
</tr>
<tr>
<td>z</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Slot</th>
<th>Advertiser</th>
<th>Valuation $/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>30, 15, 6</td>
</tr>
<tr>
<td>2</td>
<td>y</td>
<td>20, 10, 4</td>
</tr>
<tr>
<td>3</td>
<td>z</td>
<td>10, 5, 2</td>
</tr>
</tbody>
</table>

How much should x, y, and z pay?
VCG pros and cons

- **Pros**
  - Unique outcome
  - Maximizes social welfare
  - Bidders will submit their true valuations

- **Cons**
  - Complex for bidders
  - Difficult to explain an outcome to bidders

(Superficially) Generalized Second-Price (GSP) Auction
GSP auction

1. Each advertiser bids a single number: how much they’ll pay per click
2. Google gives the i-th slot to the i-th highest bidder, who pays the bid of (i+1)-st highest bidder

Analysis

- Game
  - Players: bidders or advertisers
  - Strategy: bid amount
  - Payoff: revenue – price paid
- Nash equilibrium
  - Nobody has any incentive to change the bid unilaterally
GSP pros and cons

- **Single item:** GSP = VCG = 2\textsuperscript{nd} price auction
- **Pros**
  - Nash equilibrium always exists
  - One Nash eq. maximizes social welfare
- **Cons (for multiple items or slots)**
  - Bidders may not be truthful (contrast w/ VCG)
  - May not optimize social welfare (contrast VCG)
  - Multiple Nash equilibrium possible (contrast VCG)
  - Maximizes Google’s revenue? Maybe!

Examples

- Bidders gain more by lying
- Multiple Nash equilibria
- Compare with VCG