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

BACKGROUND

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Motivation

- Google Ad Revenue 2014: $59 billion
- Yahoo Search Revenue 2014: $3.3 billion
- Predicted Global Digital Ad Spending 2015: $171 billion
- Market Cap Alphabet (GOOG): $513 billion
- Market Cap Yahoo: $32 billion
- COMPARISON American Airlines Market Cap: $29 billion
Adwords make it rain $$
How it works:

- You enter a search term

- Companies have already sent in bids for the term
  - More on this later

- The company who bid highest gets the highest ad position
How it works
Seriously tho

About 394,000 results (0.79 seconds)

Automated Retail Machines - AutoRetail.com
Ad  www.autoretail.com/
Customized Auto-Retail Machines. Sell Your Inventory 24/7. Start Now
Systems for Pricing

- Pay Per Impression: Pay for showing/viewing ad
  - 😊 for search engine, 😟 for advertiser

- Per Per Transaction: User has to act on it for the advertiser to pay
  - 😊 for advertiser, 😟 for search engine
  - Also known as Pay Per Conversion

- Per Per Click: The Compromise
GSP: Generalized Second Price

1. Submit your bid stating maximum willingness to pay for a click

2. User enters relevant keyword, user gets back sponsored ads on top of the results page.
   a. The ad with the highest bid is on top
   b. Second highest bid below it and so on…
   c. If the user clicks on ad at position k, advertiser pays the bid of the advertiser who is (or would be) at position k+1
How it works

About 512,000,000 results (0.59 seconds)

**Compare Car Rental Rates - KAYAK.com**
- [www.kayak.com/Compare-Car-Rentals](http://www.kayak.com/Compare-Car-Rentals)
- Compare 100s of Cars For No Fee. Save On Car Rentals In One Search.

**Compare Rental Car Prices - ORBITZ.com**
- [www.orbitz.com/CarRental](http://www.orbitz.com/CarRental)
  - 4.4 ★★★★★ rating for orbitz.com
  - Sort Rental Cars by Price, Type Company. Compare on ORBITZ!
  - Free Cancellation · Best Price Guarantee
  - Ratings: Selection 9.5/10 · Website 9/10 · Prices 9/10 · Service 8.5/10
  - Discount Car Rental Rates - Lowest Prices on Flights - Up to $675 Off Packages

**Car Rentals From $4.95 - hotwire.com**
- [www.hotwire.com/Car-Rentals](http://www.hotwire.com/Car-Rentals)
  - 4.2 ★★★★★ rating for hotwire.com
  - Find Rental Cars from $4.95/Day. Hotwire® Has All Big Car Brands!
  - Low Price Guarantee · Last Minute Savings · Great Car Rental Deals
  - Ratings: Selection 9.5/10 · Service 8.5/10 · Prices 8.5/10 · Fees 8.5/10
  - Rental Car Deals - Last Minute Car Rental - Flights Up To 40% Off

**Bargain Car Rental**
[www.bargaincarrentals.net/Pennsylvania](http://www.bargaincarrentals.net/Pennsylvania)
- Great Rates! Serving PA Residents
- Since 1973, 3 PA Locations-Call Us.
- 4400 Edgemont Ave, Brookhaven, PA

**Car Rental From $11/Day**
[www.rentalcars.com/](http://www.rentalcars.com/)
- 4.0 ★★★★★ rating for rentalcars.com
- Best Rates on All Cars Guaranteed.
- Search & Compare Prices Today!

**Car Rental**
[www.expedia.com/Car_Rentals](http://www.expedia.com/Car_Rentals)
- 4.2 ★★★★★ rating for expedia.com
- Cheap Rates from Top Brands.
- Book & Save Big on Car Rentals.
Example

Dorms fighting for ad space on the dash (3 slots):

Wharton: $12

AP/DK: $10

Danawell: $8

Worth: $2

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Slot 1: Wharton – pay: $10

Slot 2: AP/DK – pay: $8

Slot 3: Danawell – pay: $2
Example with reserve price

Dorms fighting for ad space on the dash (3 slots):

Wharton: $12
AP/DK: $10
Danawell: $8
Worth: $2

RESERVE PRICE: $5

Slot 1: Wharton – pay: $10
Slot 2: AP/DK – pay: $8
Slot 3: Danawell – pay: $5
Another Example with reserve price

Dorms fighting for ad space on the dash (3 slots):

Wharton: $12
AP/DK: $10
Danawell: $8
Worth: $2

RESERVE PRICE: $9

Slot 1: Wharton – pay: $10
Slot 2: AP/DK – pay: $9
Slot 3: <EMPTY>
Unique Features of GSP

- Bidding is continuous

- Bidders submit single bid even though multiple positions are being sold
Their Model

- Abstracted away: Click-through-rate
- For this paper: Click-through-rate of all bidders is identical
- CTR: it converts cost per click to cost per impression – GENIUS!

- Marginal utility for an additional click is considered constant
CTR – A simple example

Google says : CTR = clicks÷impressions

Dorms fighting for ad space on the dash (3 slots):

Wharton: $12 – CTR: 0.4 : 12*0.5 = 6
AP/DK: $10 – CTR: 0.7 : 10*0.7 = 7
Danawell: $8 – CTR: 0.5 : 8*0.5 = 4
Worth: $2 – CTR: 0.25 : 2*0.25 = 0.5

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Slot 1: AP/DK – pay: $6 per impression = $8.57 per click
Slot 2: Wharton – pay: $4 per impression = $8 per click
Slot 3: Danawell – pay: $0.5 per impression = $1 per click
Gaming the system

- Over time, bidders can react to competitors..

- Time for an example
GSP vs. VCG

- GSP does not have an equilibrium in dominant strategies.
- Truth-telling is also not usually an equilibrium in GSP.
- BUT in a single-slot case, GSP and VCG are the same.
- In multiple slots, they are different because:
  - VCG charges the bidder to account for the externality the bidder is causing to others.
  - GSP just charges next highest bid (plus perhaps an increment).
- Revenues are lower under VCG than under GSP.
WHY GSP?

- VCG is much harder to compute
- Testing and implementing would be costly
- VCG is difficult to explain to advertisers
- VCG revenues are lower than GSP revenues
Rules of GSP Model

- For a given keyword:
  - N positions on screen; K bidding advertisers
  - $\alpha_i$: Expected # clicks per period received by bidder at pos $i$
  - Value per click to bidder $k$ is $s_k$
  - $k$'s payoff at position $i$: $(\alpha_i * s_k) - ($ paid to search engine $)$

- For time $t$ when user enters keyword $a$, the last bid submitted by an advertiser $k$ is denoted $b_k$. If an advertiser has not submitted a bid, then $b_k = 0$

- $b^j = $ bid of $j$-th highest bidder; $g(j) = $ identity of $j$-th highest bidder.

- If multiple bidders bid the same amount, then they are ordered randomly

- SO $g(1)$: top position bidder, $g(2)$ second position, and so on....
Rules of GSP Model

- Bidder $g(i)$'s total payment $p^i = \alpha_i b^{i+1}$ for $i \in \{1, ..., min\{N, K\}\}$
- Bidder $g(i)$'s payoff $\alpha(s^i - b^{i+1})$
- If there are as many positions as bidders then the last bidder’s payment is $0$
- Of course in reality there will probably be a reserve requirement
So basically...

- Motivation to study: $$$ + perhaps make it more efficient?
- Important model to study since actual mechanisms are based on GSP
- Their model is based on the actual GSP + restrictions + simplifying assumptions
- Daniel will tell you more on Thursday