Sponsored Search: Theory and Practice

Jan Pedersen
Chief Scientist
Yahoo! Search and Marketplace Group
10 August 2006
Outline

• Why online advertising is important
• A brief history of sponsored search
• An auction theory view
• The prediction problem
Why is Advertising Important?

• Push communication
• Connects merchants with prospective customers
  – Valued based on effectiveness
  – The right information, at the right time to the right person
• Monetizes consumer services
  – Consumer pays by attention
  – Basis for many large-scale consumer services
Online Advertising

- Internet accounts for 30+% of viewing time
  - Yet only 4% of spend
  - $370B overall
    - $10B online
- Fastest growing advertising segment
- Steady shift toward Online advertising

Source: The Economist
The Keyword Marketplace

- Advertisers specify keywords targets and bids for traffic
  - Advertiser prices clicks not impression (CPC)
- Search engine ranks based on match and bid
- Search engine provide performance feedback
  - CTR, impressions, available clicks
Advertiser Experience

Welcome to AdWords - Microsoft Internet Explorer provided by Yahoo!

Advertise your business on Google
No matter what your budget, you can display your ads on Google and our advertising network. Pay only if people click your ads.

Your ads appear beside related search results...
People click your ads...
...And connect to your business

Your ad here
See your ad on Google and our partner sites.
www.yourcompany website.com

Learn about AdWords

How it works
You create your ads
You create ads and choose keywords, which are words or phrases related to your business.
Get keyword ideas

Why it works
Your ads appear on Google
When people search on Google using one of your keywords, your ad may appear next to the search results. Now you're advertising to an audience that's already interested in you.

Costs and payment
For local businesses
Assisted signup options
Success stories

Sign up now | Next topic »
Setting Bids

Set Pricing

Enter a maximum cost per click (CPC). Experiment with different amounts until you are satisfied with your estimated results.

**Sponsored Search**

To get the most available traffic we estimate a PPC of **$0.80**

$0.77 Estimate

<table>
<thead>
<tr>
<th>Default Bidded Keywords (5)</th>
<th>Estimated Monthly Clicks</th>
<th>Estimated Average Position</th>
<th>Share of Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>443</td>
<td>3.0</td>
<td>96%</td>
</tr>
</tbody>
</table>

Ad Group Total (5)

<table>
<thead>
<tr>
<th>Estimated Monthly Clicks</th>
<th>Estimated Average Position</th>
<th>Share of Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>493</td>
<td>2.1</td>
<td>77%</td>
</tr>
</tbody>
</table>

14.6% of your traffic is from overridden bids on Sponsored Search keywords.

**Content Match**

To get the most available traffic we estimate a PPC of **$0.80**

$0.72 Estimate

<table>
<thead>
<tr>
<th>Estimated Monthly Clicks</th>
<th>Share of Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>263</td>
<td>90%</td>
</tr>
</tbody>
</table>

Graph Display:

- Clicks to Bid
- Share of Potential

Default Bid Traffic Avg. PPC - $1.84

- Estimated Clicks: 30
- Missed Clicks: 1,254

Custom Bid Traffic Avg. PPC - $0.78

- Estimated Clicks: 250
- Missed Clicks: 250

Your Estimated Average CPC: **$0.72**
Why does it work?

• Fine-grained targeting
  – Explicit statement of interest
  – Information seeking mode

• Meterable user behavior
  – Clicks

• Performance Data
  – Valuation and optimization

Source: The New York Times
• Response to Search Engine optimization
  – Manipulation of search results
• Conceptualized as sponsored search
  – Transparent ranking criteria
• Minimal technology
  – Advertisers bid on exact phrases
  – Editors checked for relevance
How Did it Work?

• Advertiser provides keyword
  – Exact match to query

• Advertiser bids for position
  – Given full information about other bids
  – In realtime

• Advertiser is charged per click
  – Charged the full bid price
• CTR feedback
  - Addresses need for editorial review
• Default broad match
  - Address overspecificity of Exact Match
• Second-bid pricing
  - To reduce transaction costs
How Did it Work?

• Advertiser provides keyword
  – Broad matched to query

• Advertiser bids for clicks
  – No direct feedback on competing bids
  – Retrospective performance reports

• Advertiser pays per click
  – Pricing discounts from max bid
  – Second bid pricing
Analysis Framework
Auction Design

• Given Objective
  – Efficiency or Revenue optimization
  – Choose allocation and pricing rule
    • The rules of the game
  – Study equilibrium behavior
    • Is objective obtained?
    • Are there simple strategies?

• Distributed Optimization
  – With independent self-interested agents
    • With private data
The “Position” Auction

Publisher allocates presentation slots for listings that match a query.

- **Slot 1**: French Butter Dishes
- **Slot 2**: French Butter Dish, James Sloss Pottery Butter Bell Alternative. Keeps butter soft and fresh without refrigeration. www.frenchbutterdish.com
- **Slot 3**: French Butter Dish Keeps butter soft, spreadable and fresh without refrigeration. www.leepots.com
- **Slot 4**: Real Goods: Sustainable Lives and Homes
- **Slot 5**: Butter Dish French Products at Nextag
- **Slot 6**: French Butter Dishes at Shopping.com
The Position Auction

• Matching determines candidate set
  – Relevance to query

• Presentation influences click likelihood
  – Likelihood falls off with rank

• Notation:
  – Listings: \( \{l_1, l_2, \ldots, l_n\} \)
  – Value at rank i: \( P\{\text{click} \mid l_{(i)}, r = i\}B_{(i)} \)
  – Total Value:
    \[
    V = \sum_{i=1}^{p} P\{\text{click} \mid l_{(i)}, r = i\}B_{(i)}
    \]
Efficient Allocation

• Allocation Rule
  – Maximize total value:
    \[ V^* = \max \sum_{i=1}^{p} P\{click \mid l(i), r = i\} B(i) \]

• But bids might not be truthful
  – Advertiser is maximizing payoff
    Payoff = Value – Price
  – What should the advertiser bid?
    • Certainly less than value
  – Direct maximization may not be efficient

• Efficient auctions often also maximize revenues
  – If there is plenty of competition
  – Reserve prices important for illiquid markets
Vickrey-Clarke-Groves Mechanisms

- Set pricing so that
  - Price is externality imposed on other bidders
    \[ p(j) = V_{-j}^* - V_{[j]}^* \]
  - Optimal strategy is to bid true value
    - Without concern for other’s bids
- More complex mechanisms are revenue equivalent
  - Strategic behavior of bidders drive prices to VCG
    - Assuming allocation remains the same
- Often referred to as second-bid pricing
  - Not often used in batch auctions
The GoTo Auction

• Rank by Bid
  – Not efficient
  – Therefore not revenue maximizing

• Original GoTo auction was first price
  – No equilibrium
  – Price laddering

• Later Modified to second bid pricing
The Adwords Auction

• Quality score ranking
  – A simplification: 
    \[ P\{\text{click} \mid l_{(i)}, r = i\} = \alpha_i P\{\text{click} \mid l_{(i)}\} = \alpha_i Q(l_{(i)}) \]
  – Rank by: 
    \[ Q(l_i) B_i \]
  – Price clicks: 
    \[ \frac{Q(l_{(i+1)})}{Q(l_{(i)})} B^{(i+1)} \]

• Not VCG pricing
  – Doesn’t consider full externality
The GSP Auction

• Current pricing is Generalized Second Price
  – Pay minimum to preserve rank
    • For Bid ranking: $B_{(i+1)}$
    • For Quality score ranking: $\frac{Q_{(i+1)}}{Q_{(i)}} B_{(i+1)}$
• Not VCG pricing
  – Does not consider the full externality
  – But does offer a pure strategy equilibrium
    • Recent results due to Edleman et al. and Varian
    • Increase bid (and payoff) until point of indifference.
Making the Auction Work

• Defining the matching algorithm
  – The meaning of a keyword target
• Estimating quality score
  – Priors
  – Fraud
• Maximizing revenues
  – Page layout
  – Reserve prices
Keyword Targeting

- Keywords are concepts not queries
  - How to match appropriately?
  - How to discover associated concepts?
- Precision vs Recall
  - Classical IR problem
- Advertisers can opt out of broad match
Estimating Click Rates

• Problem: estimate \( P\{\text{click} \mid l\} \)
  – Need to average over all positions
    • Yet we observe only a few positions
  – Need an estimate for new listings
    • And for listings with few observations

• Bayesian estimation framework
  – Fit \( P\{\text{click} \mid l, r\} = \alpha_r P\{\text{click} \mid l\} \)
    to available data
Fraud and Traffic Quality

• Not all Clicks are equal
  – Priced in aggregate as a bundle
  – Discounting to fairly value partner contribution

• Fraud techniques
  – Bid slamming
  – Robotic clicks --- budget exhaustion
  – Impression SPAM
Revenue Maximization

- Efficient auctions also revenue maximize
  - Given sufficient competition
- Reserve pricing for thin markets
  - Min bid
  - Critical in the tail
- eCPM reserve pricing
  - To eliminate low quality listings
  - Recent Google initiative
- Placement Algorithm
  - North vs East listings
Summary

• Sponsored Search is an incredibly efficient marketing tool
  – Highly targeted
  – Highly metered
  – Optimized for effectiveness

• What are its limits?
  – Inventory
  – Direct response campaigns only