



## Sponsored Search: Theory and Practice

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10 August 2006

### Outline

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- Why online advertising is important
- A brief history of sponsored search
- An auction theory view
- The prediction problem



# Why is Advertising Important?

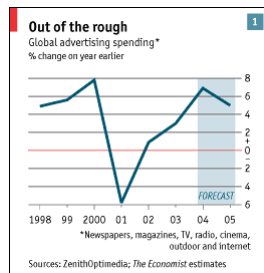
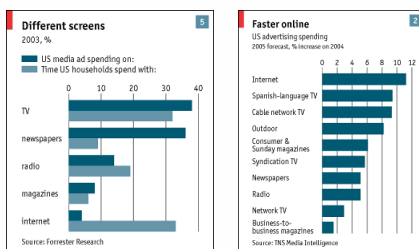


- Push communication
- Connects merchants with prospective customers
  - Valued based on effectiveness
  - The right information, at the right time to the right person
- Monetizes consumer services
  - Consumer pays by attention
  - Basis for many large-scale consumer services

3



# 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

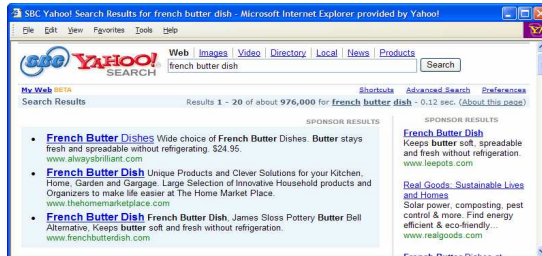
Source: The Economist

4





## The Keyword Marketplace



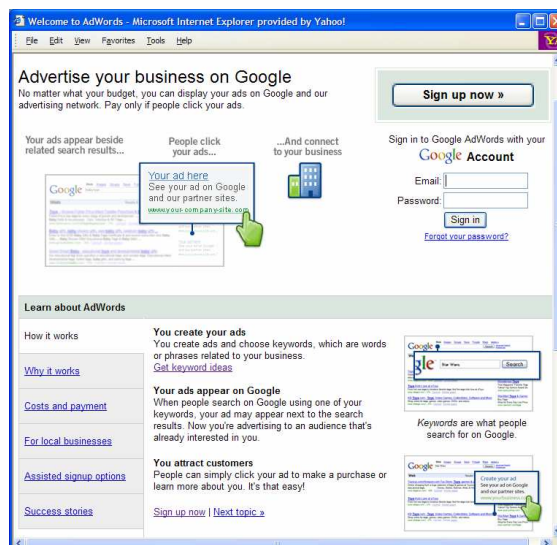
- Advertisers specify keywords targets and bids for traffic
  - Advertiser prices clicks not impression (CPC)
- Search engine ranks based on match and bid
- Search engine provide performance feedback
  - CTR, impressions, available clicks

5

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## Advertiser Experience



6

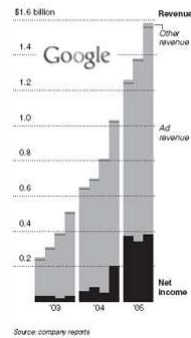
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# Y! Why does it work?

- Fine-grained targeting
  - Explicit statement of interest
  - Information seeking mode
- Meterable user behavior
  - Clicks
- Performance Data
  - Valuation and optimization

### Staggering Growth

Google's revenue, which is almost entirely from ads, has grown significantly every quarter since 1993. And the company has become increasingly profitable.



Source: company reports

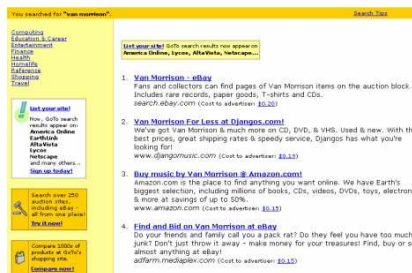
Source: The New York Times



7

# Y! Originated by GoTo.com 1998

- 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



8





## 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

9

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## Improved by Google: 2002

- CTR feedback
  - Addresses need for editorial review
- Default broad match
  - Address over-specificity of Exact Match
- Second-bid pricing
  - To reduce transaction costs



10

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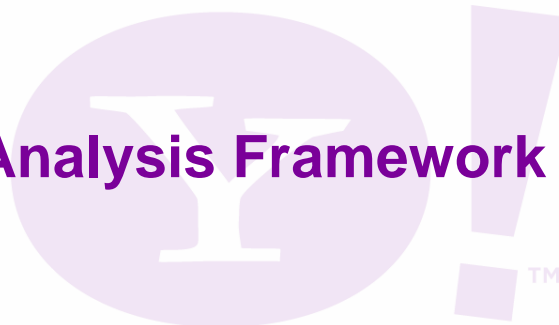
## How Did it Work?

- 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

11

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## Analysis Framework



12

# Y! 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

13

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# Y! The "Position" Auction

The screenshot shows a Microsoft Internet Explorer browser window displaying Yahoo! search results for 'french butter dish'. The page layout includes a search bar at the top, navigation links, and search results. Annotations with arrows point to specific areas:

- Slot 1:** Points to the first sponsored result: "French Butter Dishes Wide choice of French Butter Dishes. Butter stays fresh and spreadable without refrigerating. \$24.95. www.alwaysbrilliant.com"
- Slot 2:** Points to the second sponsored result: "French Butter Dish French Butter Dish, James Sloss Pottery Butter Bell Alternative. Keeps butter soft and fresh without refrigeration. www.frenchbutterdish.com"
- Slot 3:** Points to the third sponsored result: "French Butter Dish Keeps butter soft, spreadable and fresh without refrigeration. www.leepots.com"
- Slot 4:** Points to the first organic search result: "1. French Butter Dish handmade Butter Bell Alternative by James Sloss"
- Slot 5:** Points to the second organic search result: "2. French Butter Dish on eBay"
- Slot 6:** Points to a sponsored result on the right side of the page: "Butter Dish French Products at Nextag"

A text box on the right side of the page states: "Publisher allocates presentation slots for listings that match a query".

14

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## The Position Auction

- Matching determines candidate set
  - Relevance to query
- Presentation influences click likelihood
  - Likelihood falls off with rank
- Notation:
  - Listings:  $\{l_1, l_2, \dots, l_n\}$
  - Value at rank  $i$ :  $P\{click | l_{(i)}, r = i\}B_{(i)}$
  - Total Value:  $V = \sum_{i=1}^p P\{click | l_{(i)}, r = i\}B_{(i)}$

15

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## Efficient Allocation

- Allocation Rule
  - Maximize total value:  $V^* = \max \sum_{i=1}^p P\{click | l_{(i)}, r = i\}B_{(i)}$
- 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

16

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## 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

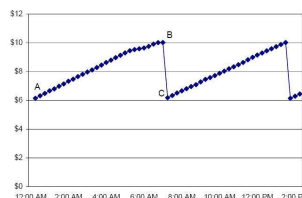
17

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## 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



18

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## The Adwords Auction

- Quality score ranking
  - A simplification: 
$$P\{click | l_{(i)}, r = i\} = \alpha_i P\{click | l_{(i)}\} = \alpha_i Q(l_{(i)})$$
  - 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

19

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## 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.

20

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## 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

21

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## Estimating Click Rates

- Problem: estimate  $P\{click | l\}$ 
  - 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  $P\{click | l, r\} = \alpha_r P\{click | l\}$   
to available data

22

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## 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

23

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## 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

24

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# Backup Slides

25



## 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

26

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## Setting Bids

Account Summary Campaigns Reports Account Administration

Geography Distribution Keywords Pricing Create Ad Review Budget & Schedule Activate

### Set Pricing

Enter a **maximum cost per click (CPC)**. Experiment with different amounts until you are satisfied with your estimated results. [Tips: Pricing Strategies](#)

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

\$ 0.77 [Estimate](#)

	Estimated Monthly Clicks	Estimated Average Position	Share of Potential
Default Bidded Keywords (5)	443	3.0	96%
Ad Group Total (6)	493	2.1	77%

16.6% 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](#)

Estimated Monthly Clicks	Share of Potential
263	90%

Graph Display:  Clicks to Bid  Share of Potential

**Default Bid Traffic Avg. PPC - \$1.84**

- Estimated Clicks 50
- Missed Clicks 1,254

**Custom Bid Traffic Avg. PPC - \$0.78**

- Estimated Clicks 250
- Missed Clicks 250

**YOUR BID**

MAX CPC 0.50 0.60 0.70 0.80  
Your Estimated Average CPC: **\$0.72**

< Previous Skip Write Ad Next: Write Ad >

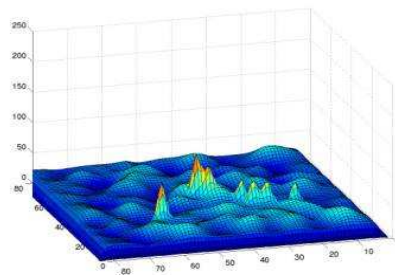
27

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## 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



28

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