



Sponsored Search: Theory and Practice

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Outline

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



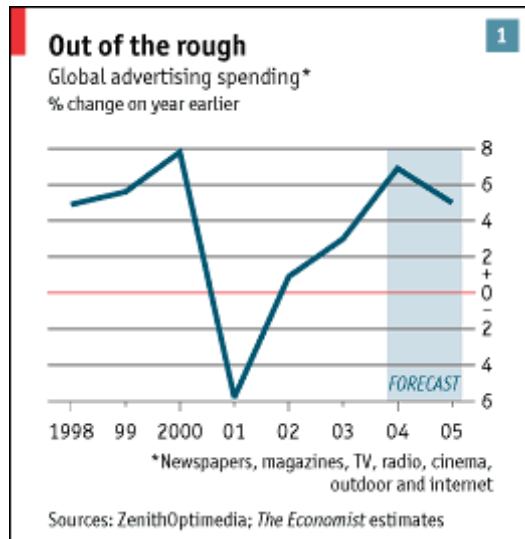
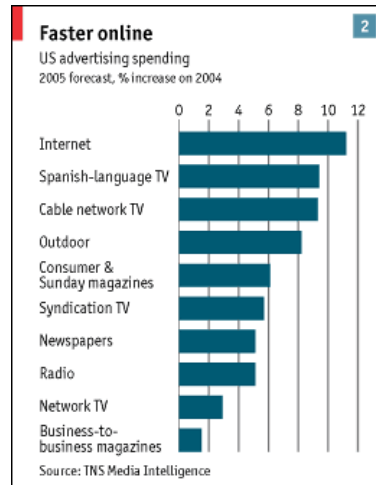
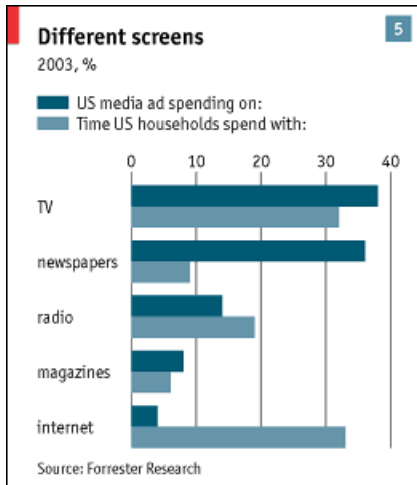
Why is Advertising Important?



- 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

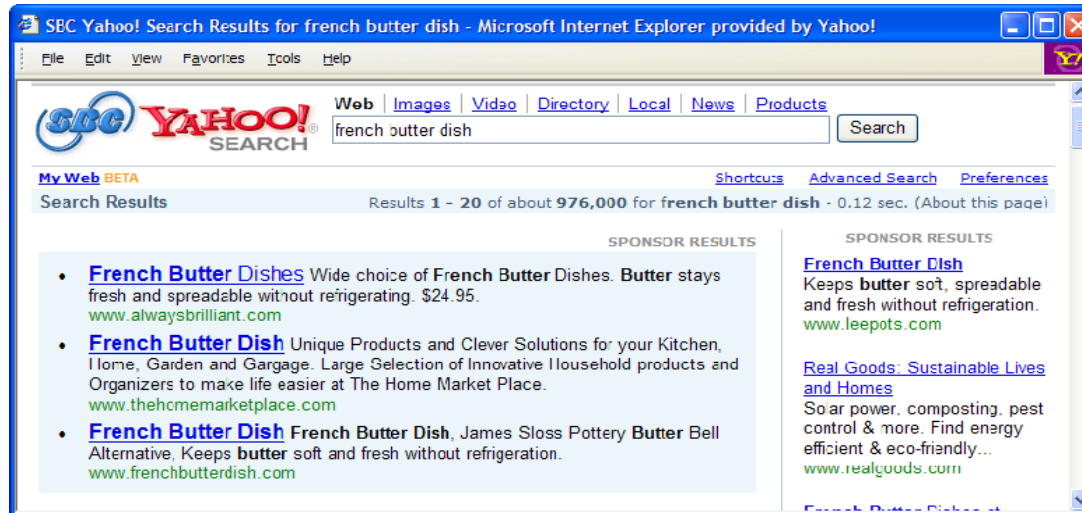


- Internet accounts for 30+% of viewing time
 - Yet only 4% of spend
 - \$370B overall
 - \$10B online
- Fastest growing advertising segment
- Steady shift toward Online advertising

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!

File Edit View Favorites Tools Help

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.

Sign up now »

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.your-company-site.com

Sign in to Google AdWords with your **Google Account**

Email:

Password:

Sign in

[Forgot your password?](#)

Learn about AdWords

How it works

[Why it works](#)

[Costs and payment](#)

[For local businesses](#)

[Assisted signup options](#)

[Success stories](#)

You create your ads
You create ads and choose keywords, which are words or phrases related to your business.
[Get keyword ideas](#)

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.

You attract customers
People can simply click your ad to make a purchase or learn more about you. It's that easy!

[Sign up now](#) | [Next topic »](#)

Keywords are what people search for on Google.

Create your ad
See your ad on Google and our partner sites.
www.yourbusiness.com



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 ?			
\$ <input type="text" value="0.77"/> <input type="button" value="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.			

Graph Display: Clicks to Bid Share of Potential



Default Bid Traffic Avg. PPC - \$1.84

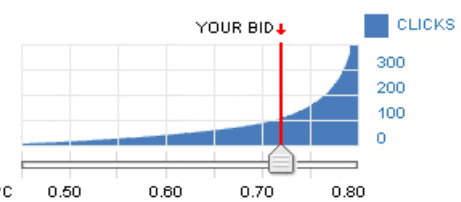
- Estimated Clicks 50
- Missed Clicks 1,254

Custom Bid Traffic Avg. PPC - \$0.78

- Estimated Clicks 250
- Missed Clicks 250

Content Match	
To get the most available traffic we estimate a PPC of \$0.80 ?	
\$ <input type="text" value="0.72"/> <input type="button" value="Estimate"/>	
Estimated Monthly Clicks	Share of Potential
263	90%

YOUR BID ↓



MAX CPC 0.50 0.60 0.70 0.80

Your Estimated Average CPC: **\$0.72**

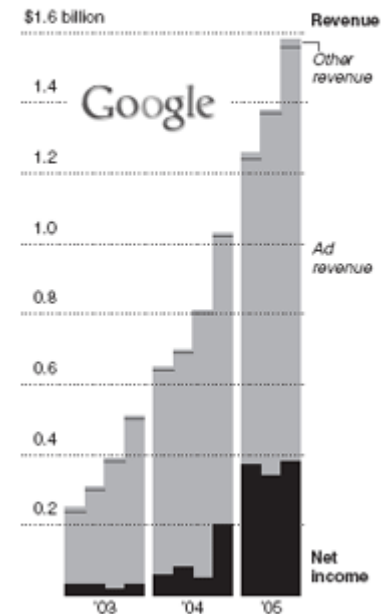


Why does it work?

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

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



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



The screenshot shows a search results page for "van morrison" on the GoTo search engine. The page has a yellow header with the search query and a "Search Tips" link. On the left, there are navigation links for various categories like Computing, Education & Career, Entertainment, Finance, Health, HomeLife, Reference, Shopping, and Travel. Below these are three promotional boxes: "List your site!" (listing various search engines), "Search over 250 auction sites" (including eBay), and "Compare 1000s of products at GoTo's shopping site". The main content area features a list of sponsored search results for "van morrison". Each result includes a link, a brief description, and the cost to the advertiser. The results are: 1. Van Morrison - eBay (cost: \$0.20), 2. Van Morrison For Less at Djangos.com! (cost: \$0.15), 3. Buy music by Van Morrison @ Amazon.com! (cost: \$0.15), and 4. Find and Bid on Van Morrison at eBay (cost: \$0.15).



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



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





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

The screenshot shows a Microsoft Internet Explorer browser window displaying search results for "french butter dish". The page layout includes a search bar, navigation links, and two columns of results. Annotations on the left and right sides identify specific advertising slots:

- Slot 1:** Points to the first sponsored result: "French Butter Dishes" from www.alwaysbrilliant.com.
- Slot 2:** Points to the second sponsored result: "French Butter Dish" from www.frenchbutterdish.com.
- Slot 3:** Points to the third sponsored result: "French Butter Dish" from www.leepots.com.
- Slot 4:** Points to the first sponsored result in the right column: "Real Goods: Sustainable Lives and Homes" from www.realgoods.com.
- Slot 5:** Points to the second sponsored result in the right column: "Butter Dish French Products at Nextag" from www.nextag.com.
- Slot 6:** Points to the third sponsored result in the right column: "French Butter Dishes at Shopping.com" from www.shopping.com.

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



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 : $P\{click \mid l_{(i)}, r = i\}B_{(i)}$
 - Total Value:
$$V = \sum_{i=1}^p P\{click \mid l_{(i)}, r = i\}B_{(i)}$$



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



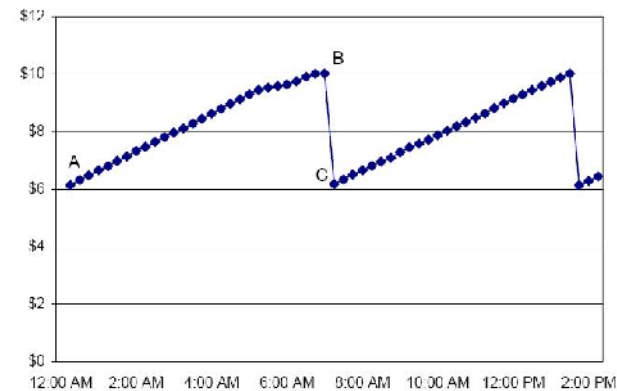
Vickrey-Clarke-Groves Mechanisms

- 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:

$$\begin{aligned} P\{click \mid l_{(i)}, r = i\} &= \alpha_i P\{click \mid l_{(i)}\} \\ &= \alpha_i Q(l_{(i)}) \end{aligned}$$

- 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 Edelman et al. and Varian
 - Increase bid (and payoff) until point of indifference.



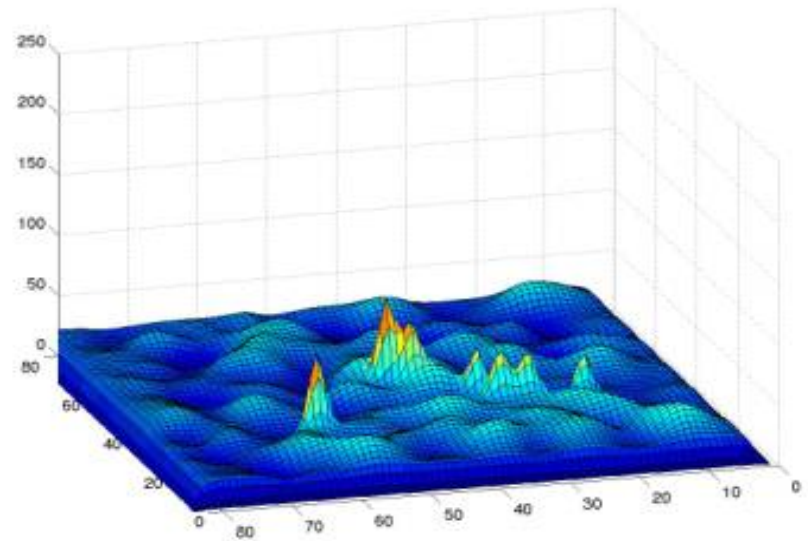
Making the Auction Work

- 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 $P\{click | l\}$
 - 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



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