The Economics of Web Search

CS315 – Web Search and Data Mining

Slides adopted from a talk by:
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Search engine Advertisement

- Search engines are highly profitable
  - Revenue comes from selling ads related to queries
  - 99% of Google’s revenue from ads
  - Yahoo, Bing also use similar models

- Banner ads (Doubleclick)
  - Standardized ad shapes with images
  - Loosely related to content

- Context linked ads (Google AdSense)
  - Related to content on page

- Search linked ads (Google Adwords)
  - Related to search terms

Search engine ads

- Ads are highly effective due to high relevance
  - But even so, advertising still requires scale
    - 2% of ads ("impressions") might get clicks
    - 2% of clicks might convert into sales
    - So only 4 / 10,000 who see an ad actually buy
    - Cost Per Million impressions (CPM) will not be large
    - But this performance is good compared to conventional advertising!

- Search technology exhibits increasing returns to scale
  - High fixed costs for infrastructure, low marginal costs for serving

What services do S.E.’s provide?

- Search engines are matchmakers
  - Match up those seeking info to those having info
  - Match up buyers with sellers

- The assignment problem:
  Match efficiently providers to consumers

- Computer Science meets Economics
The advent of the web

- By mid-1990s IR algorithms were very mature
  - Very little difference in IR TREC competitions
  - Mostly DARPA-sponsored
  - Exclusively based on classic IR content matching

- The Web comes along
  - CS researchers were quick to react
  - Crucial NSF grants:
    - 1993 to UIC - NCSA (Mosaic);
    - 1994 to Stanford (Digital Libraries Initiative)

- Link structure improves relevance of search results dramatically

Google was not born to be an ad co.

- Brin and Page tried (and “failed”) to sell algorithm to Yahoo for just $1 million
  - Yahoo believed that search was in a commodity business, nothing new to find
  - Yahoo was in the Directory business, adding “value” to information
  - Most people thought this way, banner ads were the only (boring) game

- Google is created in late 1998 with no real idea of how they would make money
  - Put a lot of effort into improving algorithms
  - Started selling intranet search devices
  - Then tried selling keywords (like everyone else) via negotiation

Online vs Brick & Mortar business

- **Kaizen (Jap.):** continuous improvement
  - You need to experiment continually in order to improve

- Hard to continually experiment for offline companies (they sell a product)
  - Manufacturing

- Very easy to experiment continually for online companies (they sell online service)
  - Amazon, eBay, Google...
  - Leads to very rapid (and subtle) improvement
  - Yellow or blue ad background? What size font?
  - Learning-by-doing leads to significant competitive advantage

Business model (aka: how to make money out of it?)

- **Initially:** sell keywords
  - “college fellowship” priced at $5/million impressions. Why $5?
  - All SE’s and Dir’s did it; it does not scale; it does not feel fair

- Then: Sell search ranking
  - They split the results: some organic, some ad-driven (2000)
  - But people did not like their ranks be ad-driven

- **GoTo Ad Auction**
  - GoTo’s model was to auction search results – did not work
  - Changed name to Overture, auctioned ads – looked promising
  - Google liked ad auction, tried to improve on Overture’s model (2001)
  - Lawsuit by Overture (2002) settled in 2003
  - Google licenses technology from Yahoo (bought Overture for $1.63B)
Original Overture/Yahoo Model

- Rank ads depending on bids
  - Higher bidder gets higher up slot
- High bidders pay what they bid
  (1st price auction) (about $0.50)
- How-to bid example:
  - Conversion Rate = 1% sales per click
  - Net profit per sale = $20
  - If you bid PPC=$0.20/click, you are expected to break even

Google Ads Model

- Ads are selected based on query+keywords
- Ranking of ads is based on expected revenue
- Now also used by Yahoo/Overture, bing...

Google's Auction Version

- S.E. really auctions impressions, so it can set
  price /impression = Price /click * clicks /impression
- Rank ads by expected revenue
  - expected revenue = bid * expected clicks
  - This makes economic sense: revenue = price * quantity
- Next-bidder-price:
  Each bidder pays price determined by bidder below
  - Price = minimum bid necessary to retain position
  - Motivated by engineering, not economics:
    People would do it by trial & error anyway, continuously manipulating prices, overloading your servers,…

Auctioning in Game Theory

- When everyone bids optimally, we have Nash equilibrium
- Basic principle of equilibrium:
  each bidder prefers the position she is in to any other position
  - You are in position 3;
    If you bid a little more, you end up in position 2, where you get more clicks and gain some more money.
  - Is the bid increase worth the extra gain?
  - Similarly if you bid a little less – is bid decrease worth the savings?
- It gives set of inequalities that can be analyzed to describe equilibrium
  - Inequalities can also be inverted to give values as a function of bids
  - The highest value people end up in higher positions
Implications of analysis

- Basic theoretical result: *incremental cost per click has to be increasing in the click through rate.*
- Why? If incremental cost per click ever decreased, then someone bought expensive clicks and passed up cheap ones.

Simple example

- Suppose all advertisers have same value $v$ for click

Two cases:
- **Undersold** auctions:
  - There are more slots on page than bidders.
  - $r$ = The minimum price per click (the “reserved price”) (say, 5 cents).
- **Oversold** auctions:
  - There are more bidders than slots on page.
  - Last bidder pays price determined by $1^{st}$ excluded bidder.

Undersold Auctions

- Equilibrium means:
  - Bidder in each slot must be ***indifferent to being in last slot***
  - $(v - p_s)x_s = (v - r)x_m$

Example of Undersold case

- Two bidders
  - $x_1 = 100$ clicks
  - $x_2 = 80$ clicks
  - $v = 0.50$
  - $r = 0.05$

- Solve equation
  - $p_s x_s = r x_m + v(x_s - x_m)$

- $P_s * 100 = 0.05 * 80 + 0.50 * (100-80)$
- $p_s = 14$ cents, $p_s = 5$ cents
- Google’s Revenue = $0.14 * 100 + 0.05 * 80 = $18
Oversold Auctions

- Each bidder has to be indifferent between having his slot and not being shown:

  \[(v - p_s)x_i = 0 \implies p_s = v\]

- Example: 2-slots, 3 bidders:
  \[p_s = \text{50 cents for each slot, and Google's revenue = } 0.50 \times 100 + 80 = \$90\]

- Revenue takes big jump when advertisers have to compete for slots!
- The vast majority of Google’s revenue comes from oversold auctions.

How to determine how many ads to show

- Showing more ads:
  - Pushes revenue up, particularly moving from undersold to oversold
  - But relevancy goes down (irrelevant ads will sneak in)
  \[\implies \text{Users click less in future (“ad blindness”)}\]

- Google emphasizes “Ad Quality”
- What does this mean, really?
- An ad that looks as “good” as the organic results?!

Other forms of online ads

- Top-of-organic vs RHS ads
  - Initially top ads sold negotiated, but RHS revenue much higher
  - Now all are auctioned, but for top ads are only selected if they are very relevant
  - If you only see RHS ads:
    good enough to be shown, but not relevant enough for top of organic
- Contextual ads
  - AdSense puts relevant text ads next to content
  - Treats the content of the page as a query!
  - Publisher (content owner) puts some Javascript on page and shares in revenue from ad clicks

- Ad effectiveness
  - Increase reach
  - Target frequency
  - Privacy issues

Analytics: Monitoring & fine-tuning

- Increase reach
- Target frequency
- Privacy issues
Google Analytics Tag

Google Web Site Optimizer

Testing enables marketers to improve site performance by making incremental changes. Identify variables of the page (homepage, landing page) and test combinations to determine what works best together.

Example Variables: Headline, Button, Offer, Button Text, Color, Text, Picture

What happened to Spammers?

Google Reaches $500 Million Settlement With Government

Google will pay $500 million to settle federal government charges that it knowingly showed illegal ads for Canadian pharmacies in the United States, the Justice Department announced on Wednesday.

The federal investigation, which was first disclosed in May, found that Google was aware that some Canadian pharmacies that advertised on its site failed to require a prescription for substances like the painkiller Oxycodone and the stimulant Ritalin. Google continued to accept their money and assisted the pharmacies in placing ads and improving their Web sites, according to the Justice Department.

Since Google has taken significant steps to close these pharmacies. Web sites are liable for advertising that breaks federal criminal law.

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