

Online Algorithms

Performance-based Advertising The AdWords Problem

Mining of Massive Datasets
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History of Web Advertising

■ Banner ads (1995-2001)

- Initial form of web advertising
- Popular websites charged X\$ for every 1,000 “impressions” of the ad
 - Called “CPM” rate
(Cost per thousand impressions)
 - Modeled similar to TV, magazine ads
- From **untargeted** to **demographically targeted**
- **Low click-through rates**
 - Low ROI for advertisers



Performance-based Advertising

- Introduced by Overture around 2000
 - Advertisers **bid** on **search keywords**
 - When someone searches for that keyword, the **highest bidder's ad is shown**
 - Advertiser is charged only if the ad is clicked on
- Similar model adopted by Google with some changes around 2002
 - Called **Adwords**

Algorithmic Challenges

- **Performance-based advertising works!**
 - Multi-billion-dollar industry
- **What ads to show for a given query?**
 - (Today's lecture)
- **If I am an advertiser, which search terms should I bid on and how much should I bid?**
 - (Not focus of today's lecture)

AdWords Problem

- A stream of queries arrives at the search engine: q_1, q_2, \dots
- Several advertisers bid on each query
- When query q_i arrives, search engine must pick a subset of advertisers whose ads are shown
- **Goal:** Maximize search engine's revenues
- **Clearly we need an online algorithm!**

Expected Revenue

Advertiser	Bid	CTR	Bid * CTR
A	\$1.00	1%	1 cent
B	\$0.75	2%	1.5 cents
C	\$0.50	2.5%	1.125 cents

Click through
rate

Expected
revenue

The Adwords Innovation

Instead of sorting advertisers by bid, sort by expected revenue!

Advertiser	Bid	CTR	Bid * CTR
B	\$0.75	2%	1.5 cents
C	\$0.50	2.5%	1.125 cents
A	\$1.00	1%	1 cent

Adwords Problem

■ Given:

- A set of bids by advertisers for search queries
- A click-through rate for each advertiser-query pair
- A budget for each advertiser (say for 1 day, month...)
- A limit on the number of ads to be displayed with each search query

■ Respond to each search query with a set of advertisers such that:

- The size of the set is no larger than the limit on the number of ads per query
- Each advertiser has bid on the search query
- Each advertiser has enough budget left to pay for the ad if it is clicked upon

Limitations of Simple Algorithm

Instead of sorting advertisers by bid, sort by expected revenue!

Advertiser	Bid	CTR	Bid * CTR
B	\$0.75	2%	1.5 cents
C	\$0.50	2.5%	1.125 cents
A	\$1.00	1%	1 cent

- CTR of an ad is unknown
- Advertisers have limited budgets and bid on multiple ads (BALANCE algorithm)

Estimating CTR

- Clickthrough rate (CTR) for a query-ad pair is measured historically
 - Averaged over a time period
- Some complications we won't cover in this lecture
 - CTR is position dependent
 - Ad #1 is clicked more than Ad #2
 - Explore v Exploit: Keep showing ads we already know the CTR of, or show new ads to estimate their CTR?