

Lecture 15

Markets, Mechanisms and Machines

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Online advertising

- Many online platforms use economic mechanisms to determine market outcomes
 - Online advertising
 - Online search "verticals" (travel, jobs, real estate)
 - Online retail



Features of online marketplaces

- Dynamic environments
 - Composition of the marketplace, demand and supply change
- Limited information available to market designers
 - Have to rely on inference to make allocations and predict behavior of players
- Difficult for bidders to properly form expectations about the future
 - Need to rely on adaptive learning
 - May have much more information relative to static environments

Selling advertising slots

- Traditional model: direct negotiation with advertisers
 - **Pro's** : Predictable outcomes and allocations; direct relationship between platform and advertisers
 - **Con's** : Advertiser behavior cannot respond to changing demand; hard to change prices and allocations if tastes or volumes change
- Market-based model: auction or other similar market mechanism that “automates” pricing and allocations
 - **Pro's** : Responds to changing demand through competition of advertisers; more inclusive for new or smaller advertisers
 - **Con's** : Market participants need to know how to play; harder to predict the market

Prediction of online advertising marketplaces in equilibrium

- **Assumption:** bidders know their objective functions and can optimize them.
- **Equilibrium:** bidder's bid must be best response to competing bid distribution.
- **Observation:** competing bids distribution is observed in data.
- Approach to recover primitives:
 1. given bid distribution, solve for bid strategy
 2. invert bid strategy to get bidder's value for item from bid.
- **Solution:** using values predict outcome of new mechanism

Prediction of online advertising marketplaces in equilibrium

The image shows a screenshot of a Bing search results page for the query "insurance". The page layout includes a top navigation bar with links for Web, Images, Videos, Shopping, News, Maps, More, MON, and Hotmail. The search bar contains the word "insurance" and a magnifying glass icon. On the left side, there is a vertical navigation menu with categories like "INSURANCE", "Local listings for insurance", "Insurance Types", "Insurance Companies", "Insurance Agents", "Insurance Quotes", "Advice for insurance", and "Reference Articles on insurance". Below this menu are sections for "RELATED SEARCHES" (Health Insurance, Auto insurance, Home Insurance, Car Insurance, Life Insurance, Term Life Insurance, Medical Insurance, Cheap Car Insurance) and "SEARCH HISTORY" (insurance, lake ski resorts, w2, hweb, See all, Clear all | Turn off).

The main content area displays search results for "insurance". At the top, it says "ALL RESULTS" and "1-20 of 259,600,060 results". There are several sponsored sites listed, including:

- Car Insurance** - www.pemco.com: Saving Pacific NorthWest Since 1945. Great Service, Flex Coverage.
- GEICO Car Insurance** - www.GEICO.com/insurance: GEICO could save you over \$500 on Car Insurance. Get a free quote.
- Nationwide® Official Site** - www.Nationwide.com: Shop For Car Insurance and Save with Nationwide. Get a Quote Today.
- Progressive® Auto Ins.** - www.Progressive.com: Get auto insurance rates fast! Quote and Compare. Buy and Print.

Below the sponsored sites, there are organic search results:

- Car Insurance Comparison | Auto Insurance Quotes | insurance.com**: For affordable rates on auto, home, life, health and other insurance coverage, turn to insurance.com. Easily compare rates from top companies with a single application to find a ... www.insurance.com - Cached page - Mark as spam
- Insurance - Wikipedia, the free encyclopedia**: Insurance, in law and economics, is a form of risk management primarily used to hedge against the risk of a contingent loss. Insurance is defined as the equitable transfer of the risk ... Principles of Insurance - Indemnification - Insurers' business model en.wikipedia.org/wiki/Insurance - Wikipedia on Bing - Mark as spam
- Allstate Car Insurance Quotes, Home Insurance, Financial Products and ...**: Allstate auto insurance quotes and anonymous ballpark estimates to help protect you, your family and your automobile. Insurance and financial products include car insurance, home ... www.allstate.com - Cached page - Mark as spam
- Listings for insurance near Redmond, Washington** (change location):
 1. Allstate Insurance Co - (425) 885-2929
14650 Redmond Way - Redmond - Directions
 2. Allstate Insurance Co - (425) 883-4529
16907 Redmond Way - Redmond - Directions
 3. Alyzad, Ali - State Farm Insurance Age... - (425) 885-9230
16610 Cleveland St Ste P - Redmond - Directions

At the bottom of the page, there are more search results and a footer with "Internal preview" and "Help improve Bing".

Auction for keywords

- The ads are allocated and priced for each user query
- Pricing and allocation decisions are combined and fully automated by an “auction”:
 - Real-time
 - Pay per click
 - Score-weighted
 - Generalized second price (GSP)
 - With possible reserve prices and thresholds

Allocating and pricing multiple heterogeneous objects



Need to allocate and price multiple heterogeneous objects (slots) at the same time with little computation

N-pirate problem

- Need to allocate and price multiple heterogeneous objects (slots) at the same time with little computation
- Imagine N pirates that need to split a heterogeneous treasure
- If one pirate is accused of claiming an unfair share of the treasure, he gets thrown overboard
- Easiest to imagine solution for 2 pirates and generalize
- Leads to the envy free refinement of Nash equilibrium in multi-unit auction: no bidder benefits from switching bid with any other bidder

GSP auction

- Components of the auction
 - Bids of bidders
 - Payment per click
 - Model for user clicks (multiplicative)
 - Position effect
 - Advertiser effect (score)
 - GSP payment and allocation rule:
 - bidders ranked by score-weighted bids
 - expected payment of each bidder proportional to score-weighted bid of the bidder ranked below

GSP auction

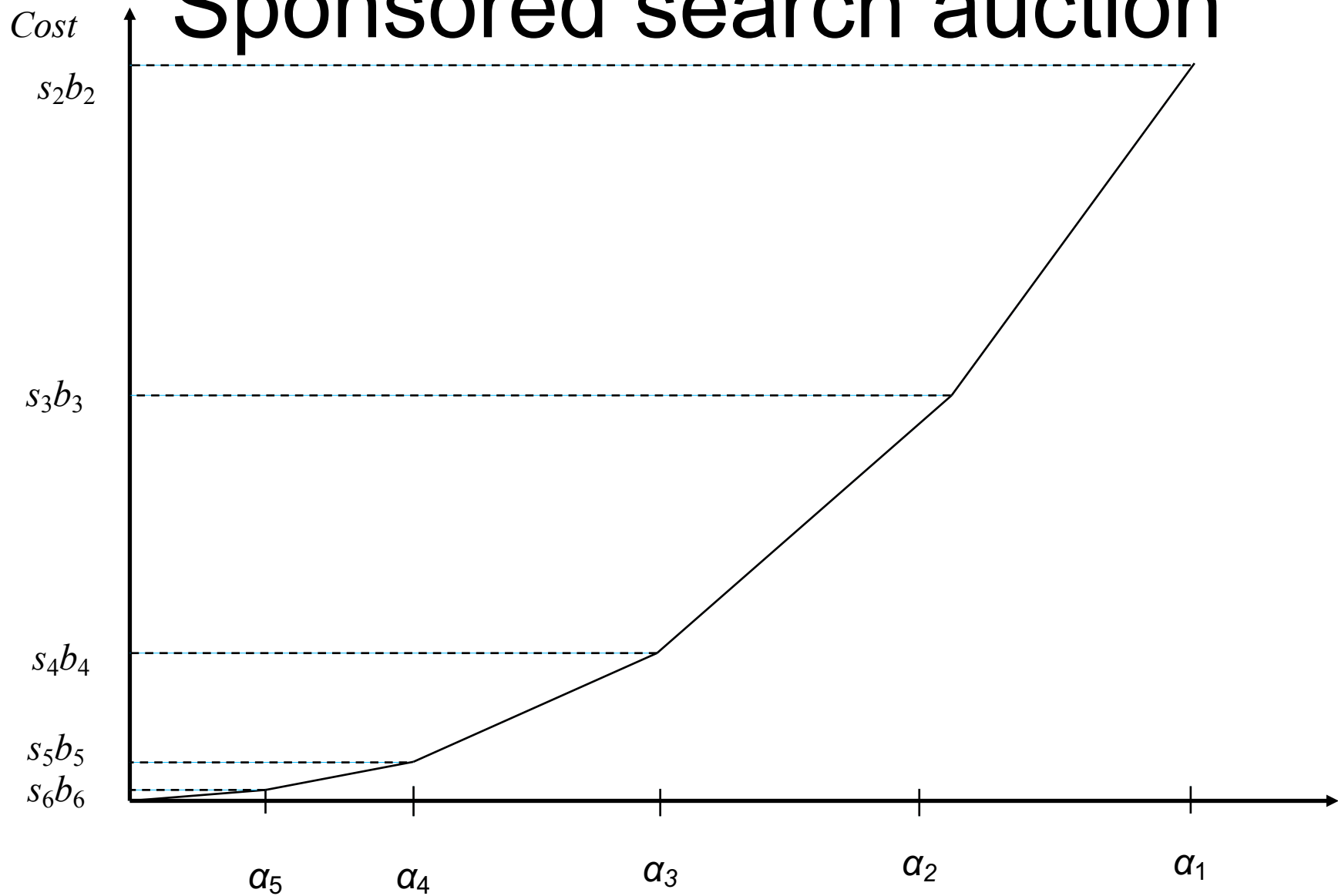
- Example: 4 bidders, 3 slots, reserve price R

<i>Bid</i>	<i>Score</i>	<i>Slot clickthrough rate</i>	<i>Score- weighted bid</i>	<i>Price</i>	<i>Expected payment per search</i>
b_1	s_1	α_1	$s_1 b_1$	$s_2 b_2 / s_1$	$\alpha_1 s_2 b_2$
b_2	s_2	α_2	$s_2 b_2$	$s_3 b_3 / s_3$	$\alpha_2 s_3 b_3$
b_3	s_3	α_3	$s_3 b_3$	\min $\{s_4 b_4 / s_3, R\}$	$\alpha_3 \min$ $\{s_4 b_4, s_3 R\}$
b_4	s_4	0	$s_4 b_4$	0	0

Sponsored search auction

- Assume that bidders can interact with high frequency: by changing bids sufficiently can learn own and opponent scores as well as bids
- This game has complete information
- Moreover, with high frequency assumption can focus on the *ex-post refinement*: bidders are happy with how they bid after they learned what their opponents bids
- Best response constructed by considering incremental cost per click: how much more bidder i needs to pay to get an extra click?

Sponsored search auction



- Cost of bidder i as a function of her score-weighted bid
- It is a convex function: look at the marginal cost

Sponsored search auction

- In a Nash equilibrium with ex-post refinement

$$\alpha_i \left(v_i - \frac{s_k b_k}{s_i} \right) \geq \alpha_l \left(v_i - \frac{s_m b_m}{s_i} \right), \quad l = m - 1 \geq i = k - 1$$

$$\alpha_i \left(v_i - \frac{s_k b_k}{s_i} \right) \geq \alpha_l \left(v_i - \frac{s_m b_m}{s_i} \right), \quad i + 1 = k \geq m = l + 1.$$

or

$$\min_{l < i} \frac{s_l b_l \alpha_i - s_{i+1} b_{i+1} \alpha_l}{\alpha_l - \alpha_i} \geq s_i v_i \geq \max_{l > j} \frac{s_{i+1} b_{i+1} \alpha_j - s_{l+1} b_{l+1} \alpha_l}{\alpha_i - \alpha_l}.$$

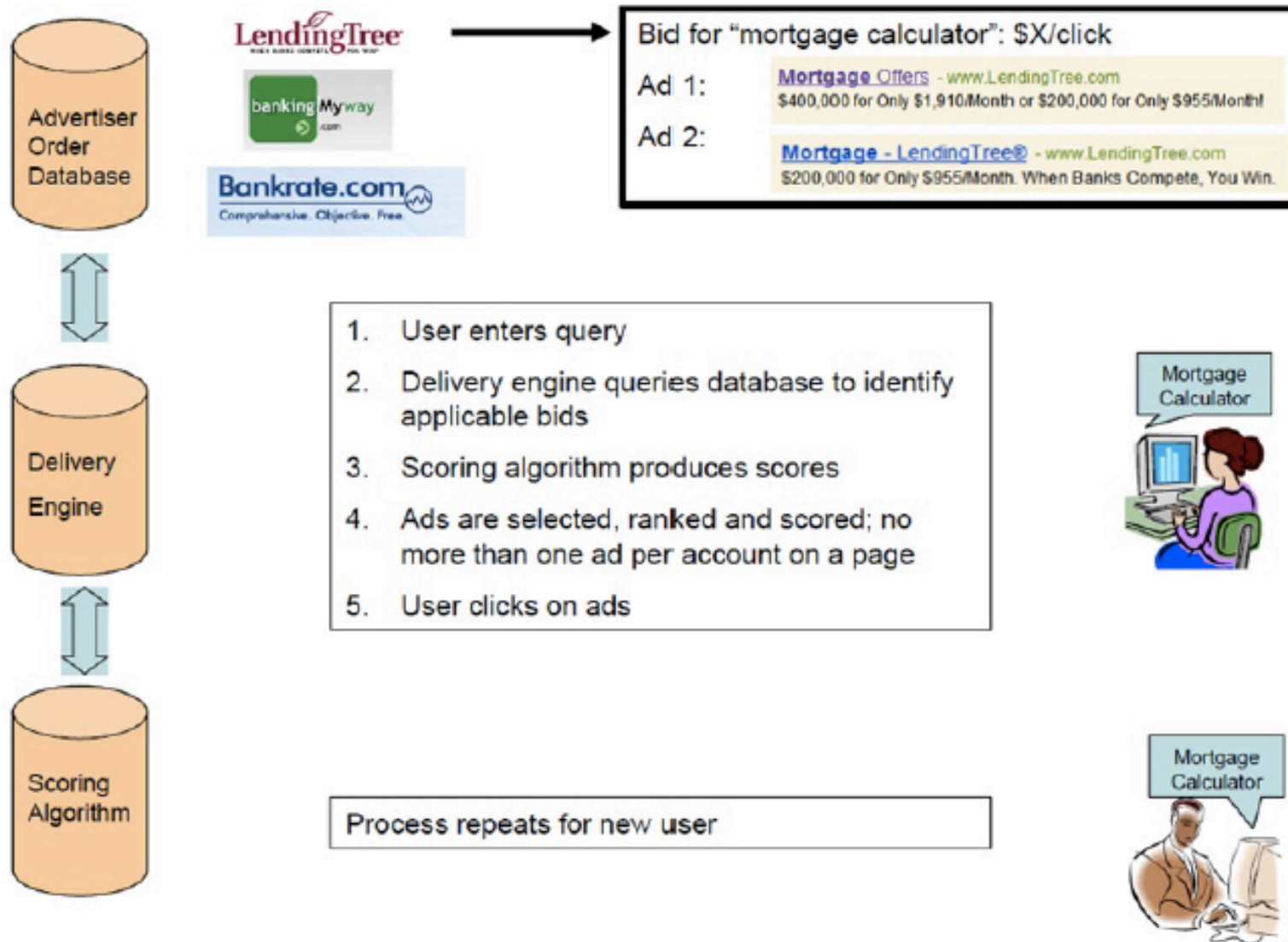
- Each bidder sets her bid to have score weighted value between marginal cost needed to decrease and increase clicks at the margin
- There are multiple Nash equilibria

Sponsored search auction

- Edelman, Ostrovsky, Schwartz (2007) show that equilibrium always exists
- There is an equilibrium where bidders pay Vickrey payoffs
- This equilibrium generates the lowest revenue to the auctioneer
- However, this auction is not truthful: bidders have incentive to shade their bids

Sponsored search auction

- In reality users arrive at high rate with little feedback to bidders



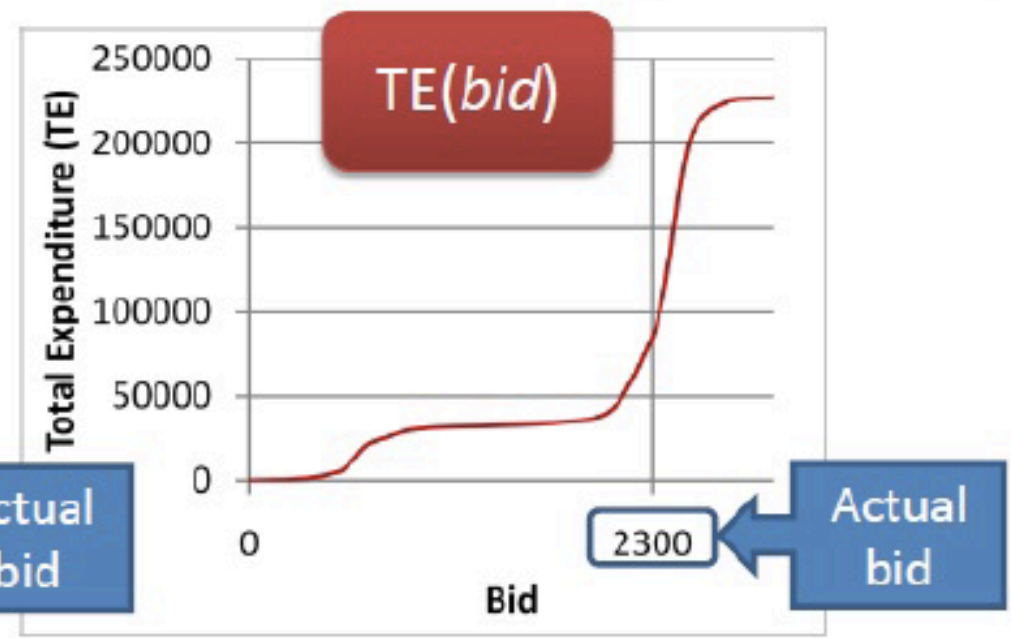
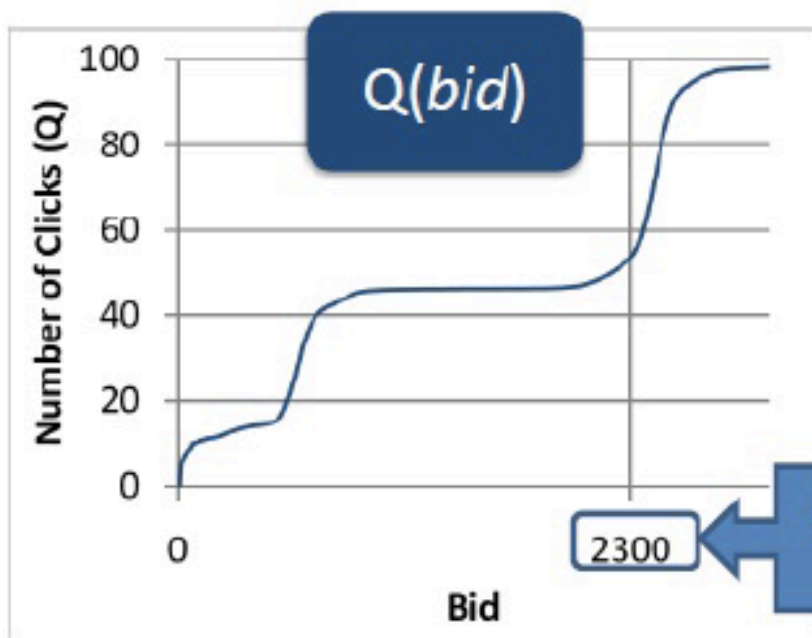
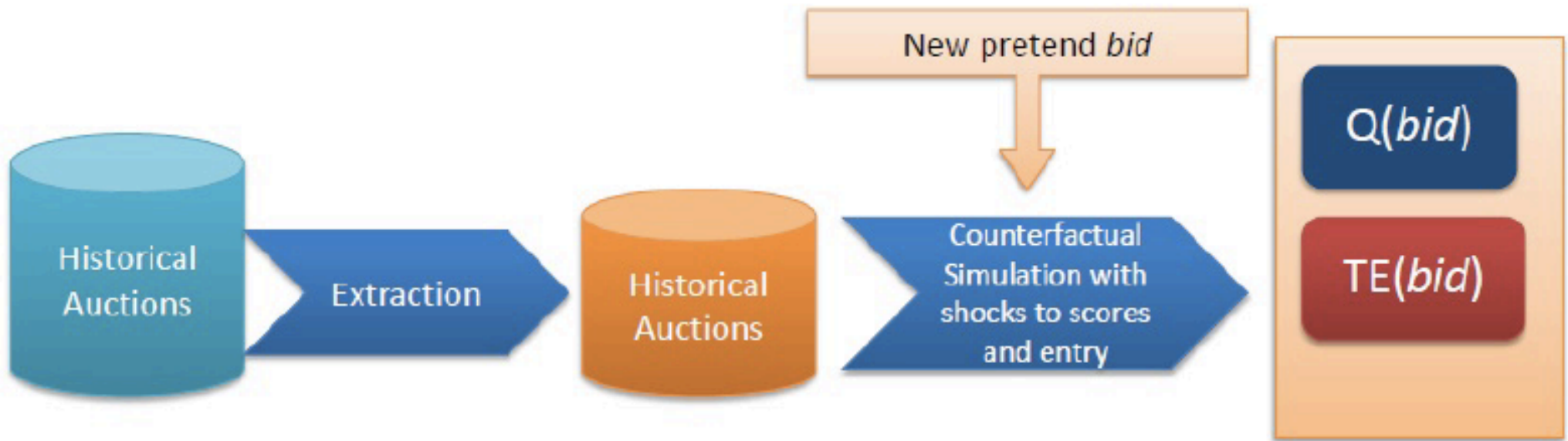
Sponsored search auction

- Bidders do not observe realization of scores
 - In fact, scores are generated by proprietary production algorithm
- Can model bidders responding to expected outcome over many user queries
- Bidders characterized by values per click (VPC)
- Expected utility of bidder i is

$$\text{Utility}(\text{bid}_i; \text{VPC}_i) = \text{VPC}_i \text{Clicks}_i(\text{bid}_i) - \text{Payment}_i(\text{bid}_i)$$

- $\text{Clicks}_i(\text{bid}_i)$ and $\text{Payment}_i(\text{bid}_i)$ are expected allocation and payment rule (with score uncertainty)

Modeling the bidders



Bid optimization

- Keep increasing the bid until marginal cost exceeds value

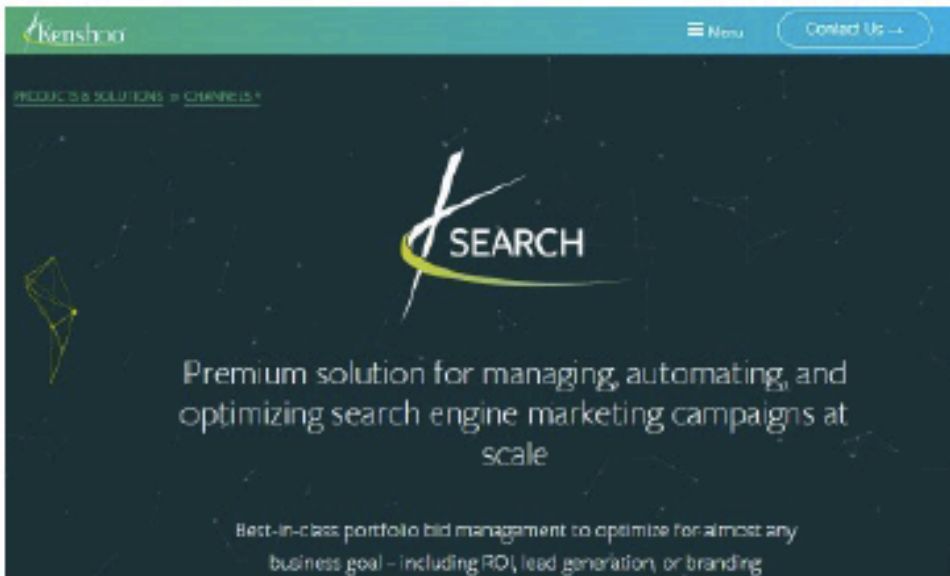
$$\text{Utility}(\text{bid}_i; \text{VPC}_i) = \text{VPC}_i \text{Clicks}_i(\text{bid}_i) - \text{Payment}_i(\text{bid}_i)$$



$$\text{VPC}_i = (\partial \text{Payment}_i(\text{bid}_i) / \partial \text{bid}_i) / (\partial \text{Click}_i(\text{bid}_i) / \partial \text{bid}_i)$$

- Note: can use similar approach if there are other objectives or there are budget constraints

Bid optimization



Kenshoo

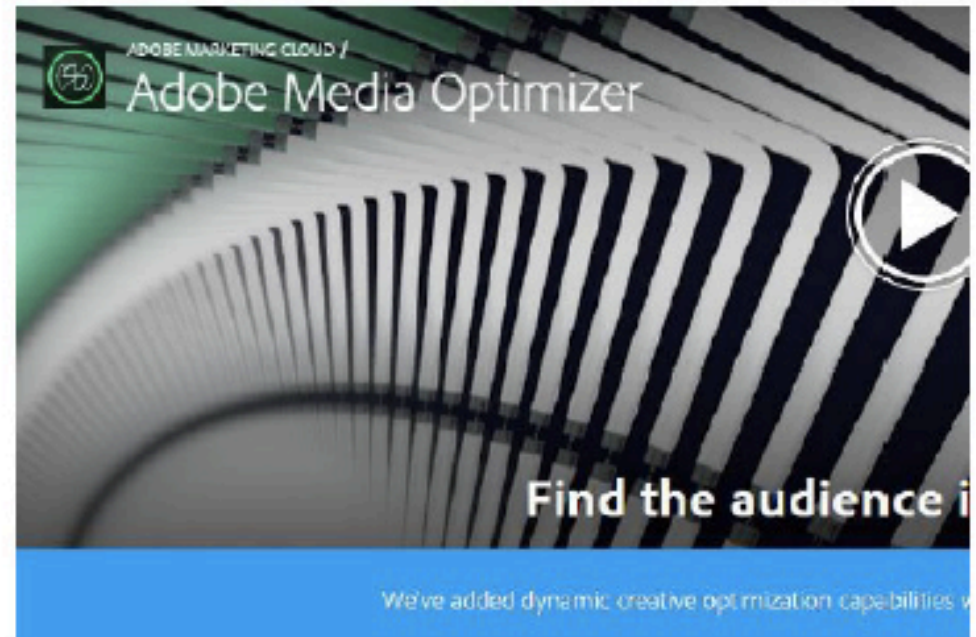
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