Simple Mechanisms for Welfare Maximization in Rich Ad Auctions

Divyarthi Mohan
Tel Aviv University/The Simons Institute

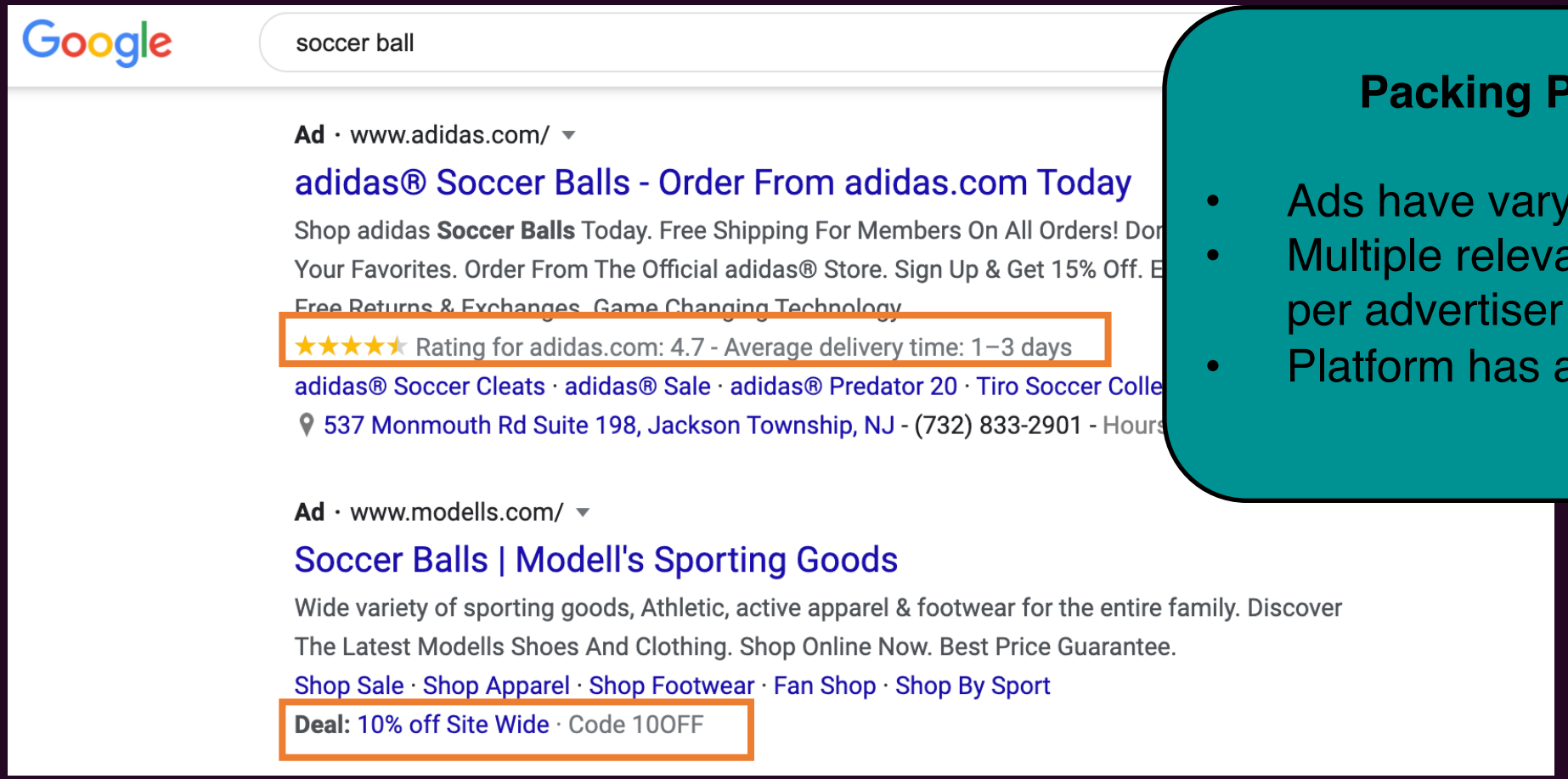
Gagan Aggarwal
Google Research

Kshipra Bhawalkar
Google Research

Aranyak Mehta
Google Research

Alex Psomas
Purdue University

Motivation – Rich Ad Auctions



Packing Problem:

- Ads have varying sizes
- Multiple relevant ad formats per advertiser
- Platform has a size constraint

Model – Rich Ads

Publicly known

Size w_j for all ads $j \in S$

Expected no. clicks α_j for all ads $j \in S$

Set of rich ads A_i

Value per click v_i

Unit-demand advertiser

Utility:

When $j \in A_i$ is allocated at price p the utility of i is $v_i \alpha_j - p$

Model – Rich Ads

Publicly known

Size w_j for all ads $j \in S$

Expected no. clicks α_j for all ads $j \in S$

Reported rich ads $S_i \subseteq A_i$

Bid per click b_i

Unit-demand advertiser

Utility:

When $j \in A_i$ is allocated at price p the utility of i is $v_i \alpha_j - p$

Model – Rich Ad Auction

Feasibility Constraints:

- [UNIT-DEMAND] Allocate (at most) one ad $j(i) \in S_i$ per advertiser i
- [KNAPSACK] Total space allocated is $\sum_i w_{j(i)} \leq W$

Objective:

- Choose a feasible allocation to maximize SOCIAL WELFARE $\sum_i v_i \alpha_{j(i)}$

Algorithm Design

Simpler Approximation Algorithm

Optimal is NP-Hard!

[Sinha-Zoltners'79]

Best of *Incremental-Bang-per-Buck* allocation and highest value ad gives a 2-approximation to the optimal social welfare.

[This Paper]

Lemma. Best of *Bang-per-Buck* allocation and highest value ad gives a 3-approximation to the optimal welfare.

--- *Bang-per-Buck* allocation: Allocate ads greedily in order of $\frac{b_i \alpha_j}{w_j}$ ---

Mechanism Design

Simple & Truthful Auction!

[This paper]

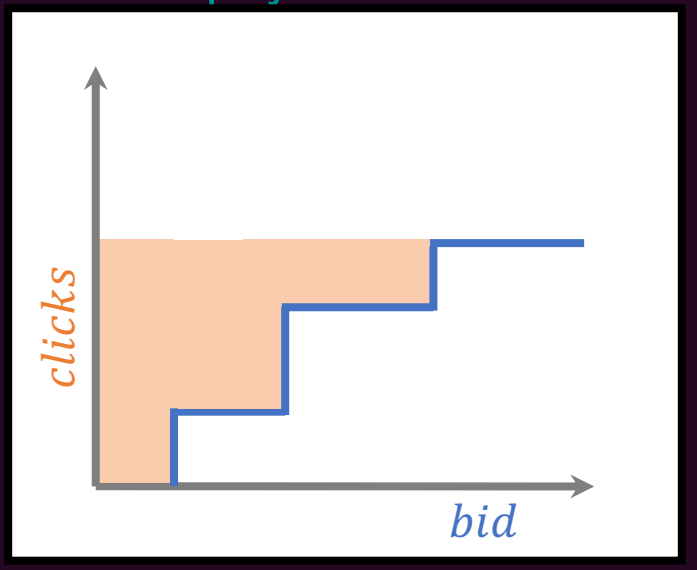
Main Theorem. There is a simple truthful mechanism which gets a 3-approximation to the optimal social welfare.

Monotone allocation rule

- *Bang-per-Buck* Allocation with prob. 2/3 and highest value ad with prob. 1/3
- Allocation (expected clicks) is monotone in both bid-per-click b_i and set of rich ads S_i

+

Myerson's lemma like payment rule



= Truthful Auction

Generalized Second Price Auction

- Our monotone allocation can be easily paired with GSP prices!
- GSP: The minimum bid b_i^* that won't change i's allocation
- Very simple payments
- GSP is very widely used in practice in ad auctions
- GSP is not truthful!

Q. Welfare guarantee at Equilibrium?

Price of Anarchy of GSP

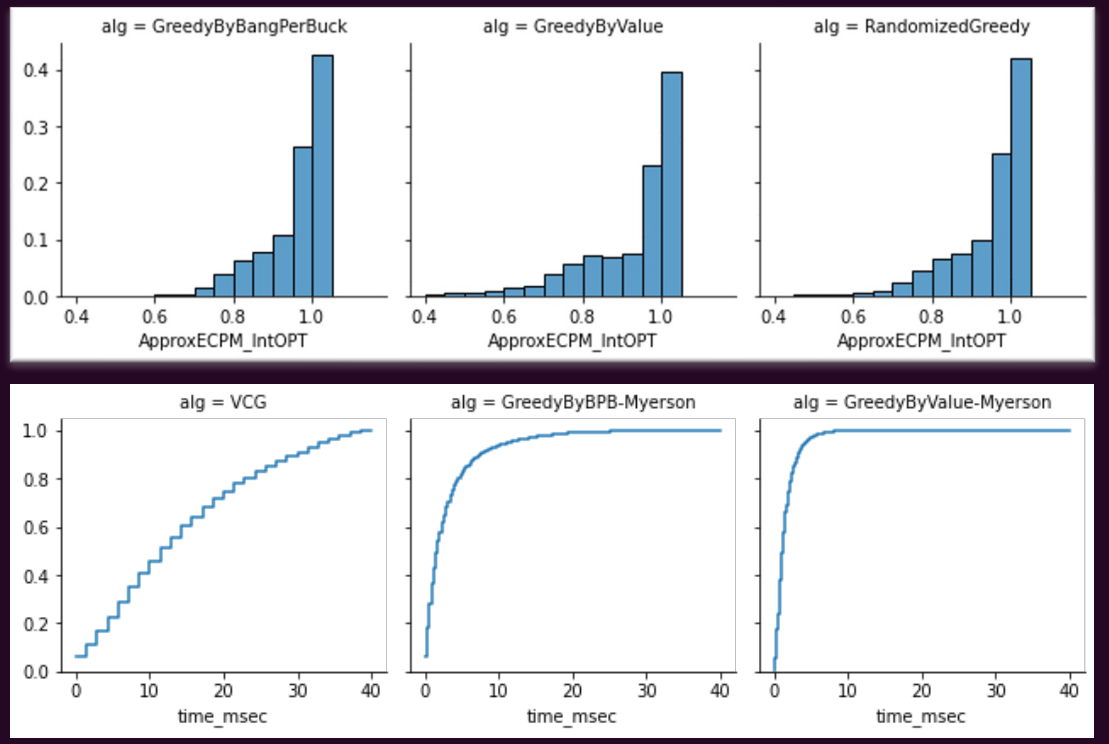
[This paper]

Theorem. Randomizing between the *Bang-per-Buck* allocation and highest value ad has a pure PoA of 6 and a Bayes-Nash PoA of $\frac{6}{\left(1-\frac{1}{e}\right)}$

Empirical Evaluation

Experimental Results

- On average our mechanism obtained 98% of the optimal welfare
- On average our mechanism was 10 times faster than VCG



Thank You!

divyarthim@tau.ac.il

@DivyarthiMohan

LINK TO PAPER