Selling Multiple Items via Social Networks [AAMAS'18]

[1]Dengji Zhao, [2]Bin Li, [1]Junping Xu, [2]Dong Hao, and [3]Nicholas R. Jennings

[1]ShanghaiTech University, China

[2]University of Electronic Science and Technology of China, China

[3]Imperial College London, UK

Auction Items via Social Networks without Advertising

- SETTING: Consider a seller sells multiple units of a commodity in a social network. Each node/buyer in the social network can only directly communicate with her neighbours. Initially, the seller is not ware of the whole network.
- QUESTION: Without advertising via third party platforms such as newspapers or search engines, **how could the seller sell the items to EVERYONE in the social network?**
- ASSUMPTIONS:
  - Every agent in the social network demands at most one item.
  - Every agent has a private valuation on the items.
  - Every agent owns a private neighbour set to whom she can share information.
- CHALLENGE: Design auctions that not only incentivize all agents in the social network to share the sale information to all their neighbours, but also improve both the allocation efficiency and the seller's revenue compared with holding an auction among the seller's neighbours only.

Selling one item in the social network [Li et al. AAAI'17]

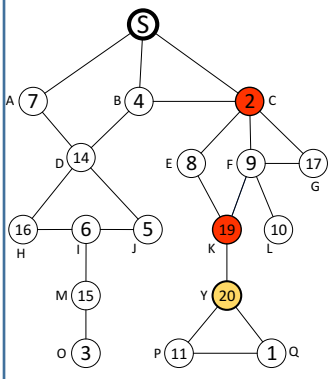

Fig. 1: An instance of social network

Information Diffusion Mechanism

- Identify the buyer with the highest valuation, denoted by m.
- Find m's critical diffusion sequence $C_m=\{C,K,Y\}$.
- Allocate the item to the first buyer i in C_m whose bid is the highest bid when diffusion critical node i+1 does not participate in the auction.
- The winner w pays the highest bid without her participation.
- Each buyer in $C_w \setminus w$ is rewarded the payment increase (not social welfare increase) due to her diffusion action.

Theorem [Li et al.]: IDM is incentive compatible (i.e. reporting valuations truthfully and sharing sale information to all neighbours is a dominant strategy) and individually rational. The revenue of the seller given by IDM is at least the revenue given by VCG among the seller's neighbours only.

Our Contribution: Generalize IDM for K items

Generalized Information Diffusion Mechanism

- Identify the optimal allocation tree based on the reported data.
- **Allocation Policy**: The allocation is done with a DFS-like procedure in the optimal allocation tree. Initially the seller gives w_i *(no of winners in the efficient allocation under i's subgraph)* items to each i in Children(s). Repeat the allocation process defined in the following until all items are allocated.
  1. Let Q be a (LIFO) stack, initially Q =Children(s). Remove a node i from Q, add i to winner set W if i receives an item when *some* of her children don't participate.
  2. Update every w_i according to allocated items.
  3. For each child j of i, if $w_j > 0$, give w_j items to j and add j into Q.
- **Payment Policy**: For all $i \in N$, her payment is:

$$\begin{cases} SW_{-D_i} - (SW_{-C_i^K} - v_i') & if\ i \in W, \\ SW_{-D_i} - SW_{-C_i^K} & if\ i \in \bigcup_{i \in W} P_j \setminus W, \\ 0 & otherwise. \end{cases}$$

where SW-x denotes the feasible maximum social welfare when allocating K items among agents of –x. The set $-D_i$ and $-C_i$ are carefully designed for achieving desirable properties.

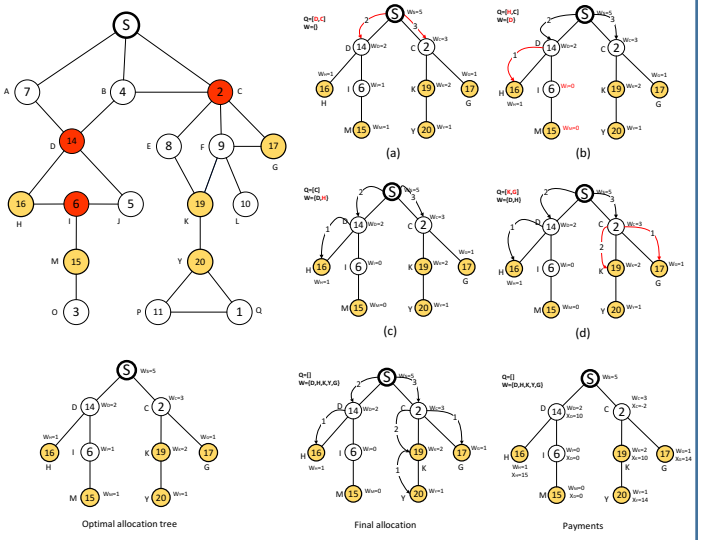

Fig. 2: A running example for selling 5 items.

Theorem: The generalized information diffusion mechanism is individually rational and incentive compatible. The revenue of the generalized information diffusion mechanism is greater than or equal to $K \times v_{K+1}$, where v_{K+1} is the (K + 1)-th largest valuation report among seller's neighbours.

The Key Literature

[1] Dengji Zhao, Bin Li, Junping Xu, Dong Hao, Nick Jennings. **Selling Multiple Items via Social Networks**. AAMAS 2018.
[2] Bin Li, Dong Hao, Dengji Zhao, and Tao Zhou. **Mechanism design in social networks**. AAAI2017.
[3] Bin Li, Dong Hao, Dengji Zhao, Tao Zhou. **Customer Sharing in Economic Networks with Costs**. IJCAI-ECAI 2018.
[4] Galen Pickard, Wei Pan, Iyad Rahwan, Manuel Cebrian, Riley Crane, Anmol Madan, and Alex Pentland. Time-critical social mobilization. Science, 334(6055):509-512, 2011.
[5] Roger B Myerson. 1981. Optimal auction design. Mathematics of Operations Research 6, 1 (1981), 58–73