Bayesian and Randomized Clock Auctions

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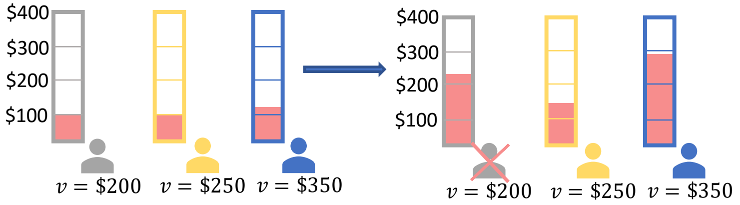
Setting

- Seller wants to distribute some service via an auction to a set of n bidders aiming to maximize social welfare
- Each bidder i has a **private value v_i** for being served
- There is a **feasibility constraint $\mathcal{F}$** comprising the k **maximal subsets** of bidders can be served simultaneously
- Examples include combinatorial auctions with single-minded bidders, knapsack auctions, etc.

Clock auctions

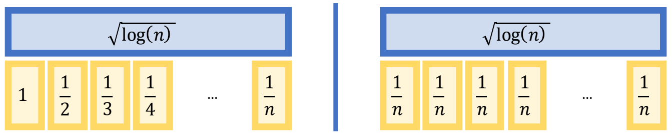
- **Clock auctions** provide a practical solution for this problem (e.g., used in the FCC Spectrum Auctions)
- This class of auctions generalizes the single-item Japanese auction to more complicated feasibility constraints



- Bidders face a series of non-decreasing personalized prices and can choose at any point to permanently exit the auction
- Clock auctions offer many appealing practical properties:
  1. **Obvious-strategyproofness** – bidders are far more likely to report their preferences accurately
  2. **Weak group-strategyproofness** – robust to coalitions
  3. **Unconditional winner privacy** – winners do not reveal true value
  4. **Transparency** – bidders can "trust" the auction pricing system without needing to verify computations
  5. **Simplicity and sophistication** – straightforward interface to bidders even with complex algorithmic "back-end"

Prior-independent clock auctions

- **Without any prior information**, clock auctions can perform quite poorly (even with unbounded computational power)
- We evaluate the performance of an auction by measuring the worst-case ratio of the optimal social welfare over the welfare of the auction across all instances
- Take instance where $\mathcal{F}$ admits two maximal solutions – one "large" blue bidder or many "small" yellow bidders



- Even for this simple structure, no prior-independent clock auction can achieve a $O(\log^{1-\epsilon} n)$-apx for any $\epsilon > 0$
- No bounded approximation in terms of k

Sequential posted price mechanisms

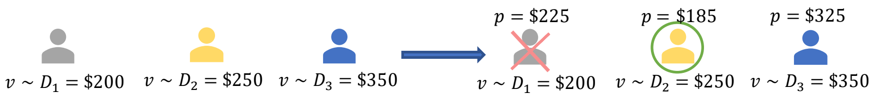
- **Sequential posted price mechanisms** (SPM) are simple clock auctions: offer a "take-it-or-leave-it" price to each bidder
- When bidder values are drawn from known distributions, SPMs can perform well for some basic feasibility constraints
- However, they perform poorly even on the following simple instance: bidders are divided into groups of different colors and an auction can serve bidders of at most one color

- Even when all bidders have values drawn from i.i.d. Bernoulli variables, no SPM can achieve better than a $O\left(\frac{\log k}{\log\log k}\right)$-apx

Results

Main Question: Can we design clock auctions which leverage randomization and/or prior distributional information to obtain better performance guarantees than any prior-independent clock auction or any SPM is able to achieve?

- We provide a series of gradually more complex clock auctions as the prior information becomes gradually more limited
- Full distributional priors: we design **single-query clock auctions** or posted-price mechanisms with "deferred acceptance". Make single offer to each bidder and select subset among accepting



- Access to only means and expected benchmark: we design **uniform ascending price auctions**
- No prior information: randomized non-uniform price auction

- In each case, our auction achieves a $O(\log\log k)$ approximation to the social welfare
- Exponential improvement over SPM and unbounded improvement over prior-free deterministic CA

Open Questions

- Can clock auctions using priors or randomization achieve a $O(1)$-apx for *any* downward closed $\mathcal{F}$?
- If so, are multiple rounds required? How does the performance improve with the number of rounds?

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