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Ridesharing in AMoD Systems

AMoD SYSTEMS:

- Fleets of driverless cars
- Information processing center
- Passengers
- Infrastructure (e.g., road networks)

OBJECTIVE:

- To promote ridesharing

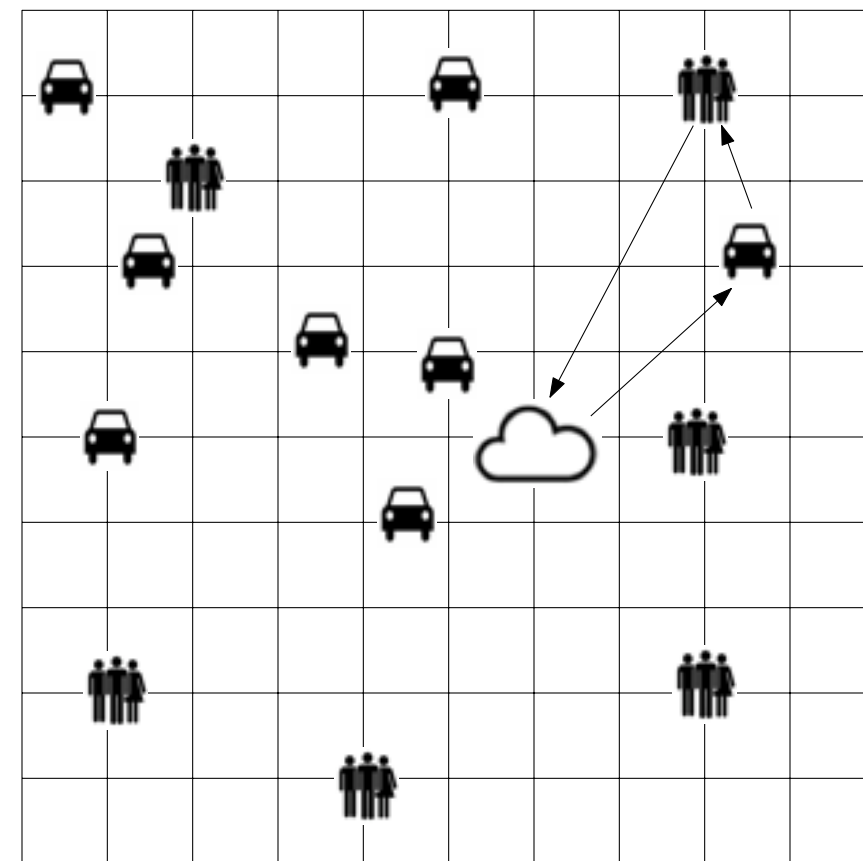
CHALLENGES:

- Truthful demand needed
- Passengers may not cooperate (due to self-interestedness, privacy)

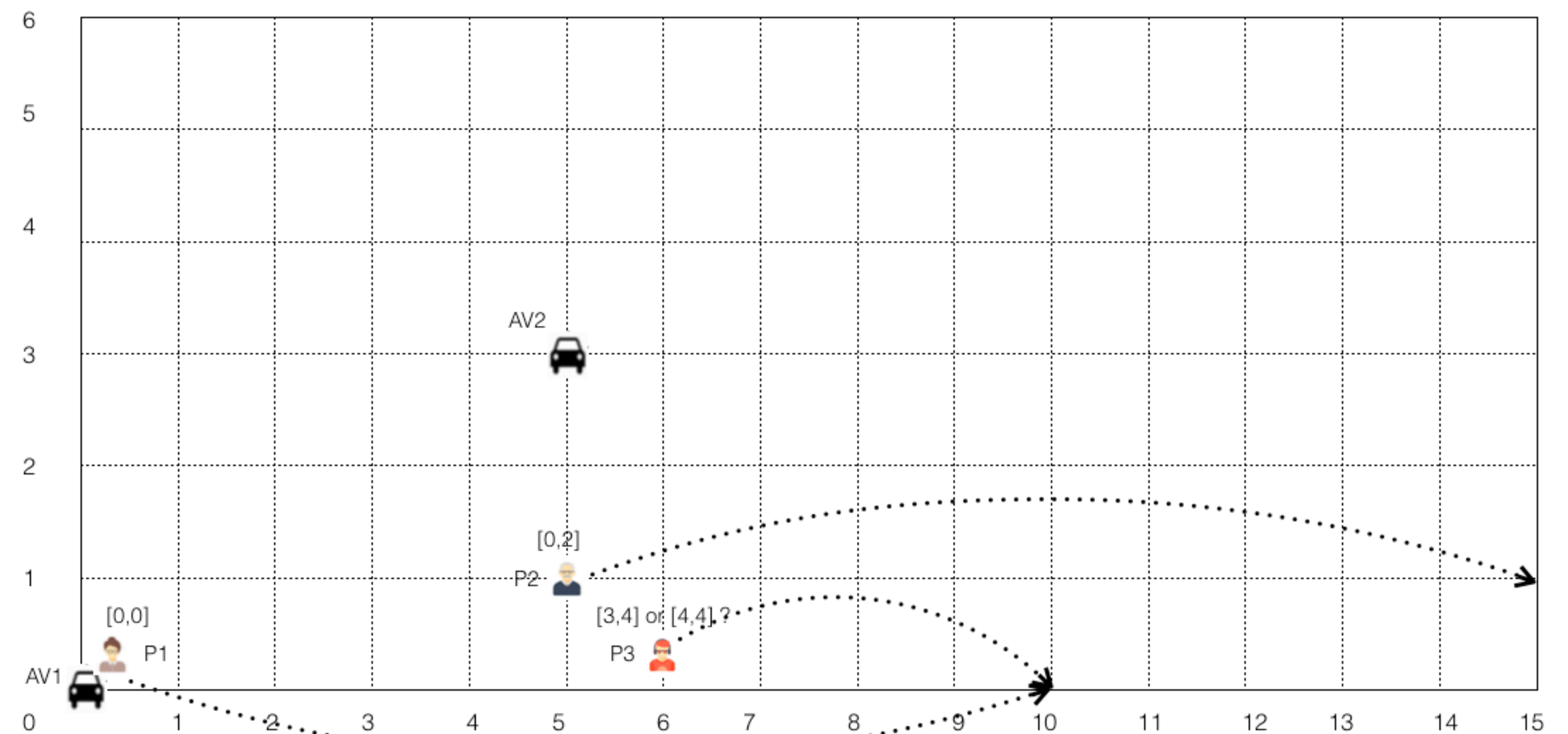
SOLUTION:

- Mechanism design

Ridesharing in an AMoD System



An Example



Problem:

At $t=0$, AV1 (0,0) AV2(5,3)
P1 request: (0,0) \rightarrow (10,0), start time $t=0$, latest departure time $t=0$
P2 request: (5,1) \rightarrow (15,1), start time $t=0$, latest departure time $t=2$
P3 request: (6,0) \rightarrow (10,0), hesitates between:
- (a) start time $t=3$, latest departure time $t=4$
- (b) start time $t=4$, latest departure time $t=4$

Resolution:

At $t=0$, AV1 picks up P1 and follows line $y=0$, estimated cost per unit demand $10/10=1$
AV2 picks up P2 and goes down along $x=5$, cost $=12/10=1.2$
At $t=2$, AV2 (5,1), AV1(2,0), AV2 picks up P2, then turns left and follows line $y=1$.
If (a): At $t=3$, AV1(3,0), AV2(5,0), AV2 picks up P3, cost $=(12+2)/(10+4)=1$
If (b): At $t=4$, AV1(4,0), AV2(7,1), P3 is not possible to be serviced.

Problems of Existing Mechanisms for Ridesharing

- Direct valuation revelation
- Additional constraints to satisfy desirable properties (e.g., strategyproofness, budget balance)
- Neglecting non-monetary factors (e.g., waiting time)
- Do not work in online settings

Our Contributions

We introduced the **first posted-price, online** mechanism, called the Integrated Online Ridesharing (IORS) mechanism to promote ridesharing in AMoD systems.

We showed that IORS mechanism is **ex-post incentive compatible**, and demonstrated the **competitiveness of IORS** compared with two benchmarks via simulation.

The IORS Mechanism

FARE ESTIMATION:

- for each request r_i^t from passenger i at time t , the mechanism first checks if a vehicle is available.
- if so, the mechanism compares the cost per unit demand before and after adding the request into the coalitions, then selects the maximum fare as the quote.
- if not, the mechanism rejects the request.

PICKUP ASSIGNMENT:

- the mechanism selects the n_t requests that produces the lowest cost per unit demand for pickup.

PAYMENT CALCULATION:

- the mechanism calculates the final payment immediately after the fulfillment of each trip.

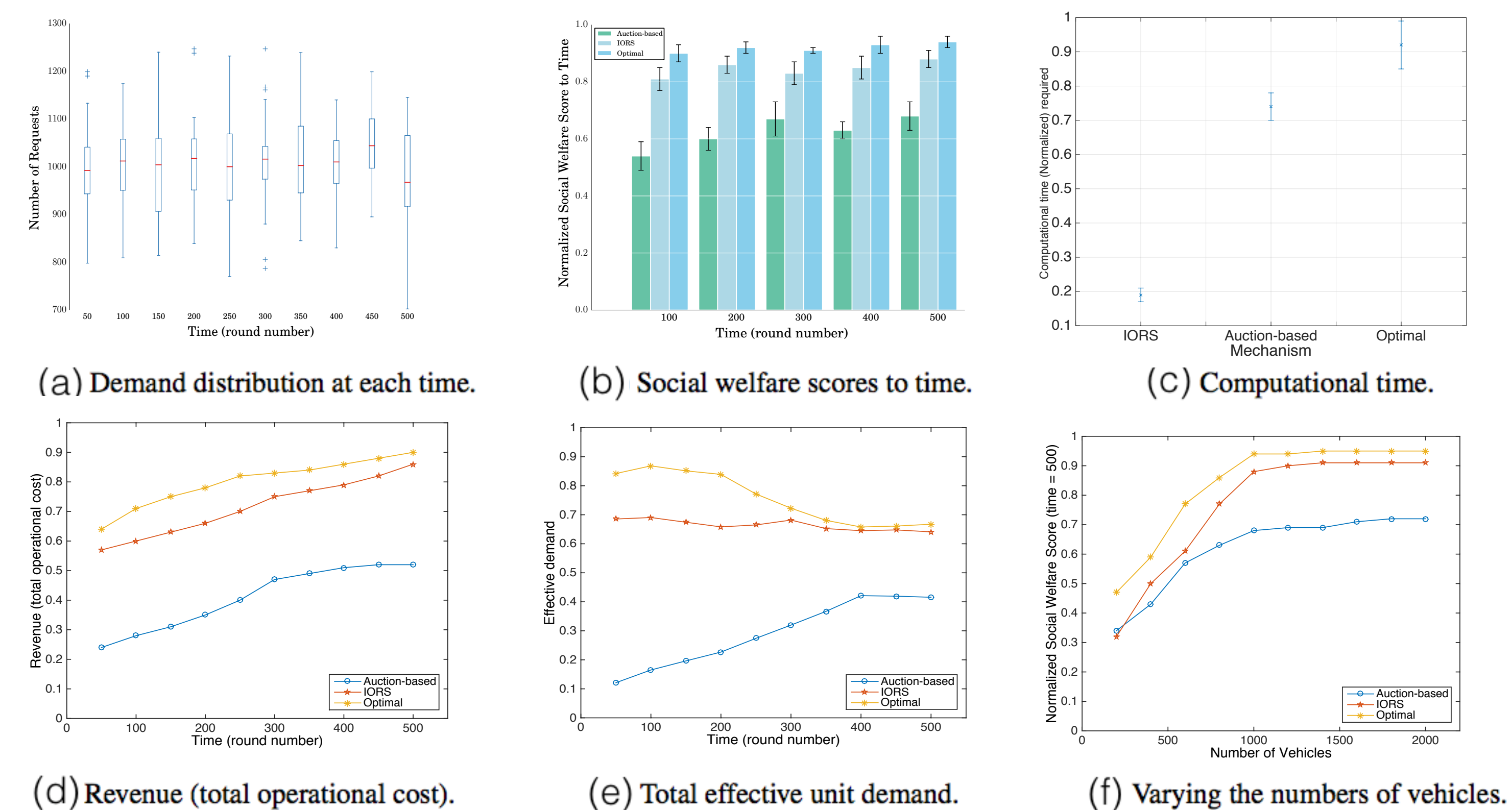
Results

PROPERTIES:

- **Posted-Price**
- **Online**
- **Ex-post incentive compatible**
- Others: individual rational, budget balance

NUMERICAL RESULTS:

- **Outperforms the bottom-up mechanism**
- **Close to the optimal solution with less computational time**



Key References

- [Parkes and Singh, 2004] David C Parkes and Satinder P Singh. An mdp-based approach to online mechanism design. In Advances in Neural Information Processing Systems, pages 791–798, 2004.
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- [Zhao et al., 2015] Dengji Zhao, Sarvapali D Ramchurn, and Nicholas R Jennings. Incentive design for ridesharing with uncertainty. arXiv preprint arXiv:1505.01617, 2015.