An Online Mechanism for Ridesharing in Autonomous Mobility-on-Demand Systems

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Ridesharing in AMoD Systems

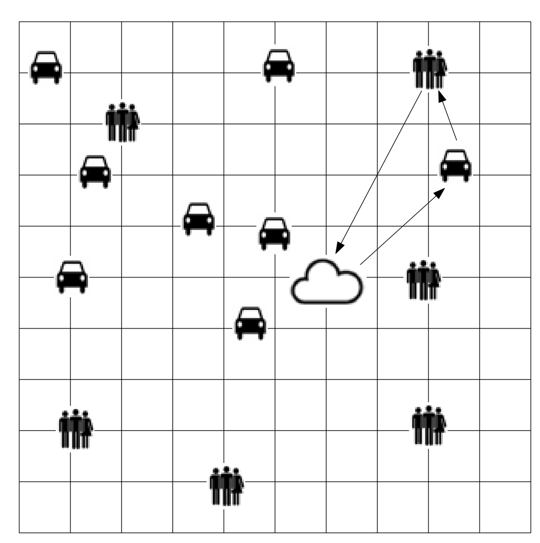
AMoD SYSTEMS:
- Fleets of driverless cars
- Information processing center
- Passengers
- Infrastructure (e.g., road networks)

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



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.

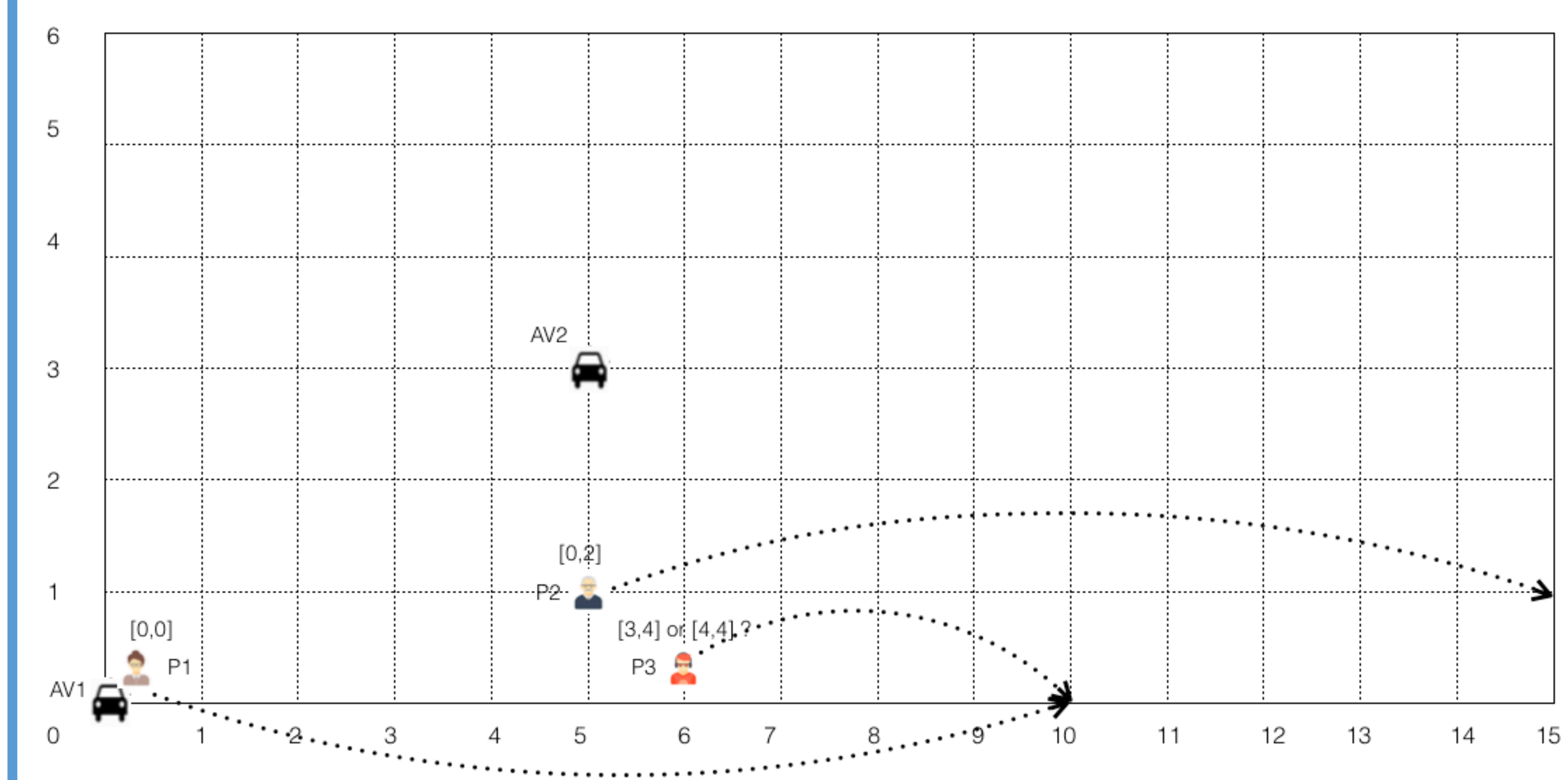
The IORS Mechanism

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.

An Example



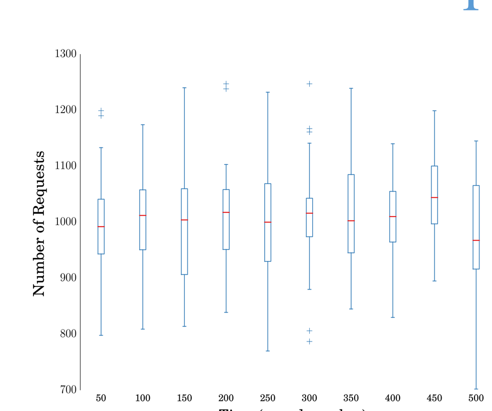
Problem:
At t=0, AV1 (0,0) AV2(5,3)
P1 request: (0,0) → (10,0), start time t=0, latest departure time t=0
P2 request: (5,1) → (15,1), start time t=0, latest departure time t=2
P3 request: (6,0) → (10,0), hesitates between:
-(a) start time t=3, latest departure time t=4
-(b) start time t=4, latest departure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

Resolution:
At t=0, AV1 picks up P1 and follows line y=0, estimated cost per unit demand10/10=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.

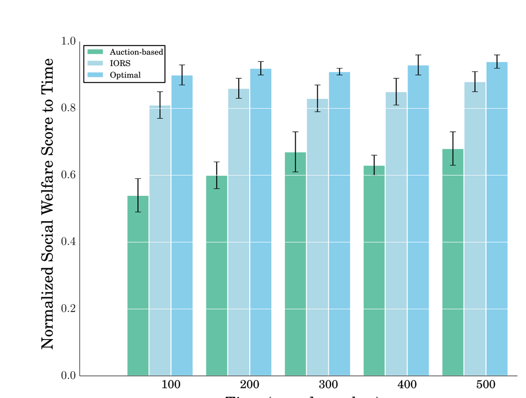
Results

PROPERTIES:
• Posted-Price
• Online
• Ex-post incentive compaible
• Others: individual rational, budget balance

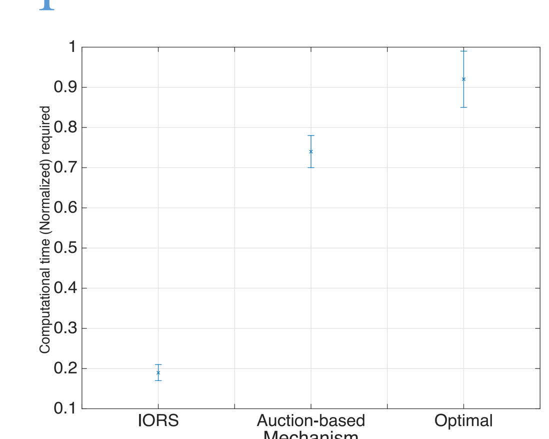
NUMERICAL RESULTS:
• Outperforms the bottom-up mechanism
• Close to the optimal solution with less computational time



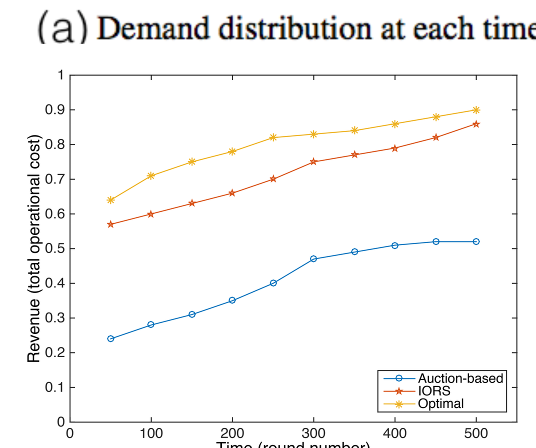
(a) Demand distribution at each time.



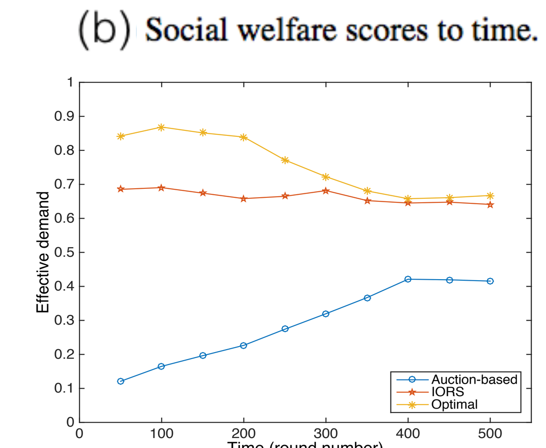
(b) Social welfare scores to time.



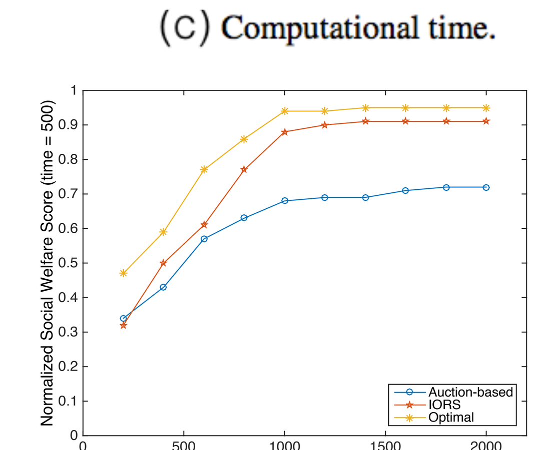
(c) Computational time.



(d) Revenue (total operational cost).



(e) Total effective unit demand.



(f) Varying the numbers of vehicles.

Key References

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