Increasing ridership and user permanence in ridesharing systems using a novel peer-to-peer exchange mechanism

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Peer-to-Peer Ridesharing

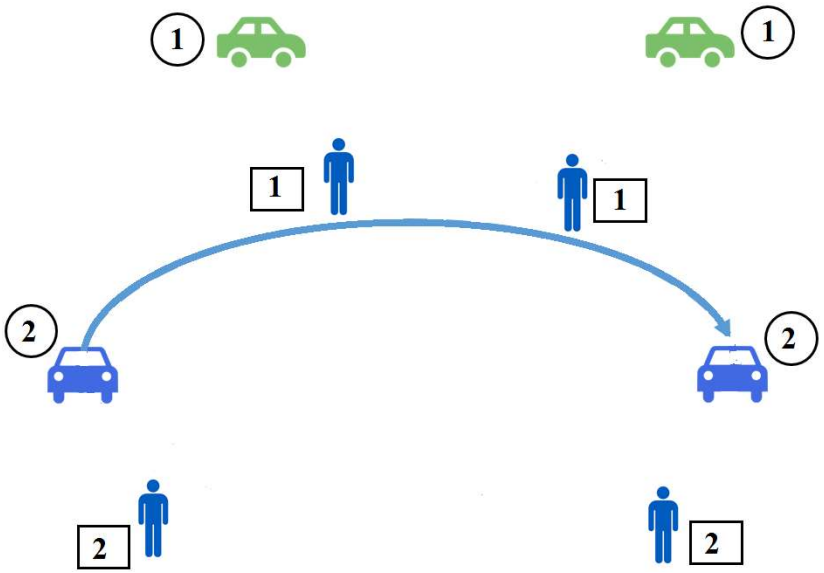
- Ride-sharing system
  - One-time ride-matches
  - Close to departure time (or by a certain deadline)
  - Convenience and flexibility to be used on a daily basis
- Peer-to-Peer (P2P) ride-sharing
  - Drivers are traveling to perform activities, and not for the sole purpose of transporting riders
- Dynamic system
  - Request for rides can be incorporated at any time

Peer-to-Peer Ridesharing

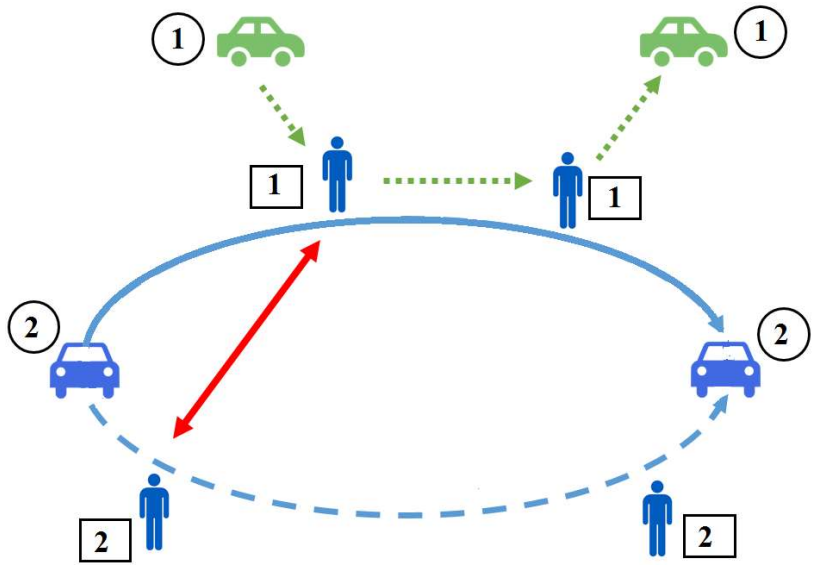
- Upon registering in the system, participants provide:
  - Origin and destination locations
  - Travel time windows
  - Travel time budgets

- Ridesharing system:
  - Matches riders and drivers
  - Matches riders on a FIFS basis: sub-optimal

Ride-Matching on a FIFS basis

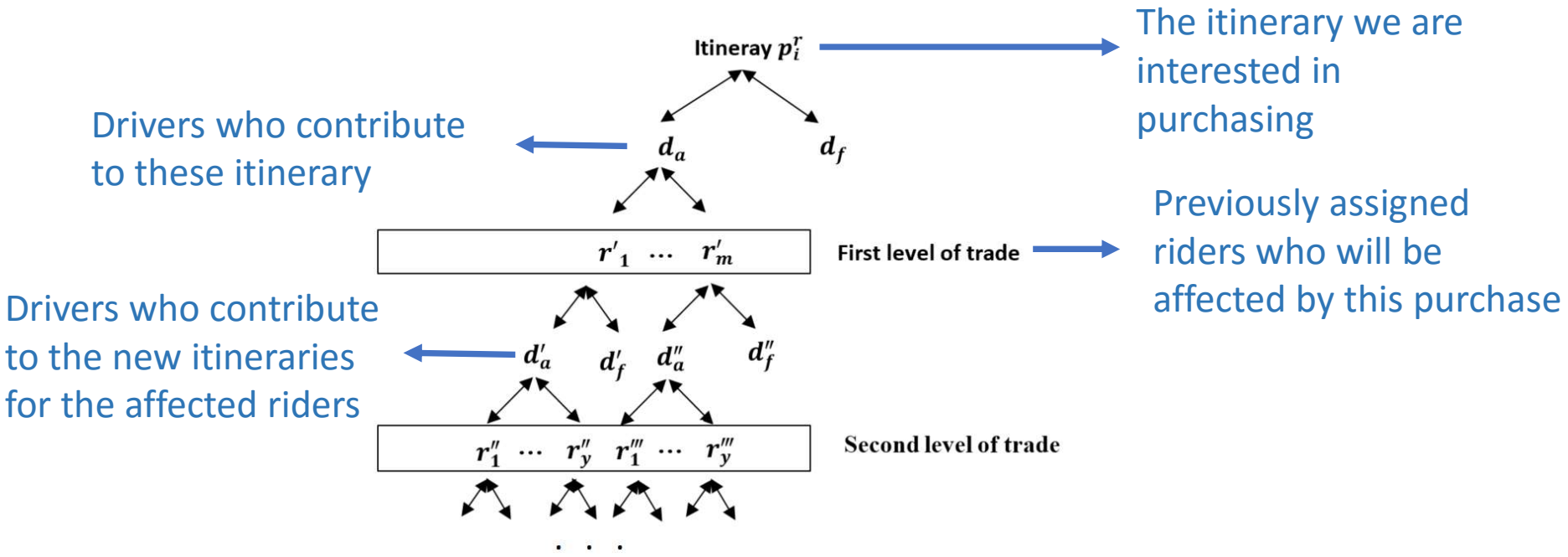


P2P Ride Exchange

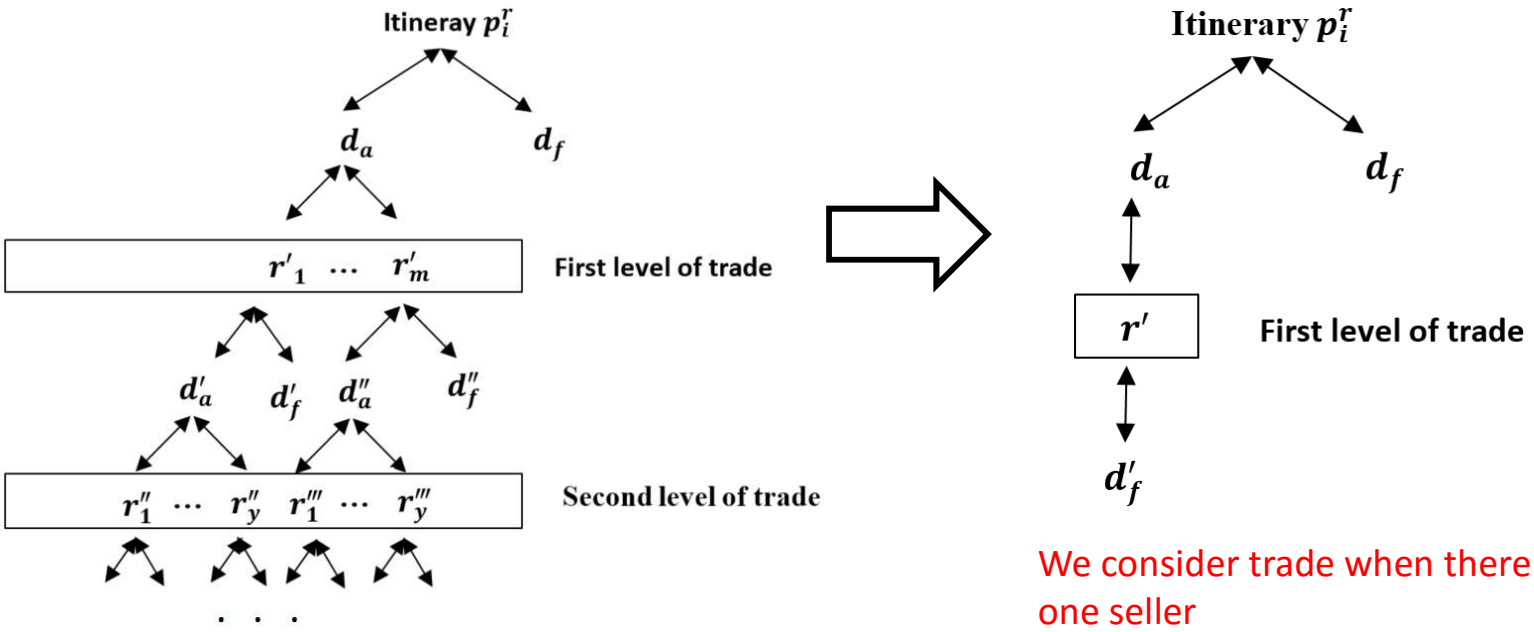


Note:
Since the objective of the trade is to increase the performance of the system, the trade takes place only if the system can find an alternative itinerary for the seller

Complexity of the exchange



Limiting the level of trade



We consider trade when there is only one seller

Bilateral trade

Properties:

1. Truthfulness, or incentive compatibility: any participating agent is always better off by truthfully eliciting its type rather than lying.

2. Individual rationality: the agent is better off participating in the system than staying out.

3. Budget balance: the mechanism is financially self-sufficient (no external subsidies are needed)

Operators' posted price

Optimal price is calculated to maximize the expected surplus:

$$p^* = \underset{p}{\operatorname{argmax}} \left(\iint_{(c_1,v_2)=(c_1(0),p)}^{(c_1,v_2)=(p,v_2(0))} (v_2 - c_1)\phi(c_1, v_2) \;\; dv_2 dc_1 \right)$$

- τ: price (to be optimized)
- c_1: = $\theta_1(t'_{r1} - t_{r1}) + c'_{r1}t'_{r1} - c_{r1}t_{r1}$
- $v_2 = \theta_2(t_{out} - t_{r2}) + c_{out}t_{out} - c_{r2}t_{r2}$
- θ_1: seller's value of time
- θ_2: buyer's value of time
- t_{r1}: travel time of the seller's current itinerary
- t'_{r1}: travel time of the seller's new itinerary
- t_{r2}: travel time of the buyer's itinerary
- t_{out}: travel time of the buyer's outside alternative
- c_{out}: the cost of the outside option to the buyer

Satisfies the requirements on the previous slide

Numerical Experiments

No. of participants	No. of Riders	No. of Drivers	Release period (min)	No. of satisfied riders (including exchange)	No. of exchanges	No. of involved drivers	No. of additional drivers	No. of retained riders due to exchange	Potential number of additional first level exchanges
Low spatiotemporal proximity									
500	100	400	15	79	1	93	3	3	7
500	250	250	15	126	5	129	3	15	13
500	400	100	15	92	1	65	1	3	12
Moderate spatiotemporal proximity									
1000	200	800	30	158	5	179	5	11	12
1000	500	500	30	265	10	262	6	28	22
1000	800	200	30	182	7	141	3	20	15
High spatiotemporal proximity									
1000	200	800	15	183	6	195	5	14	18
1000	500	500	15	349	12	283	9	30	26
1000	800	200	15	254	5	160	1	15	20

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