An opportunistic client user interface to support centralized ride share planning

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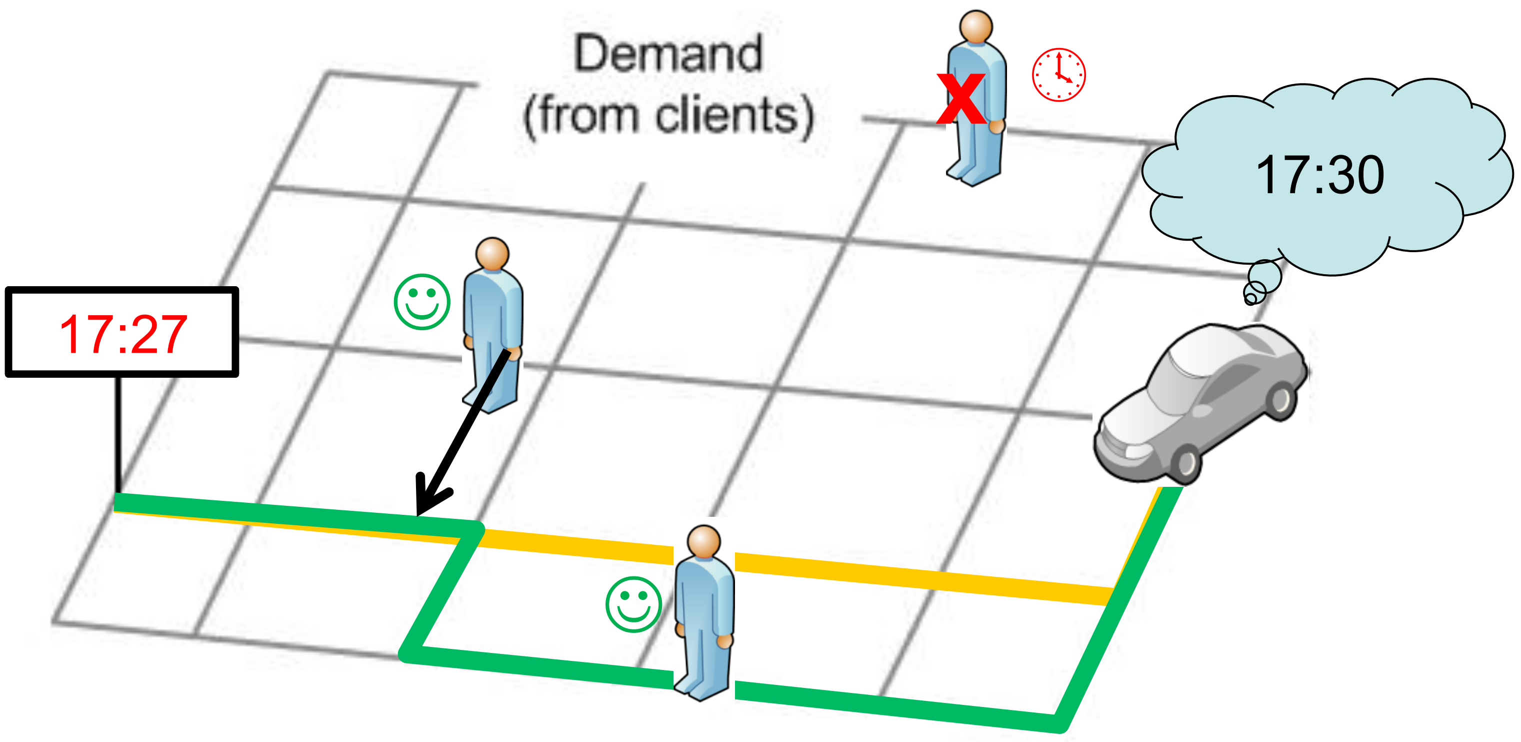
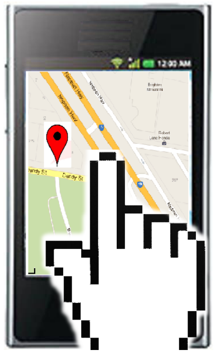
Example





Opportunistic ride sharing example

State of the Art

-Various commercial and personal centralized ride-share applications: CoWaG (GER), flinc (GER), Avego (USA), Zimride (USA), Coseats (AUS)

-Require precise spatio-temporal information about the client's origin and destination

-Apply heuristics for ride-matching

-Scale and granularity issues, e.g., rural vs. urban environments, exact pick-up or drop-off locations, or just the closest available.

State of the Art

-These require:

Additional private information, e.g., age, telephone numbers, first and last names, social media accounts (Facebook, Google+, etc.).

Additional communication channels for subsequent negotiations, e.g., to confirm pick-up and drop-off locations or visual identification, via e.g., voice or text.

Problem Statement

Existing ride-sharing systems are rigid. They rely on the communication of discrete spatio-temporal constraints and additional private information from both vehicle and client to perform ride-matching.

Problematic for two reasons:

1. Privacy issues, e.g. location, other meta data,
2. Ad-hoc communications cannot be immediately quantified.

Hypothesis

The proposed architecture provides an effective client user interface for use in ride-sharing applications.

Effective:

-The communication of all available rides satisfying a client's spatio-temporal constraints.

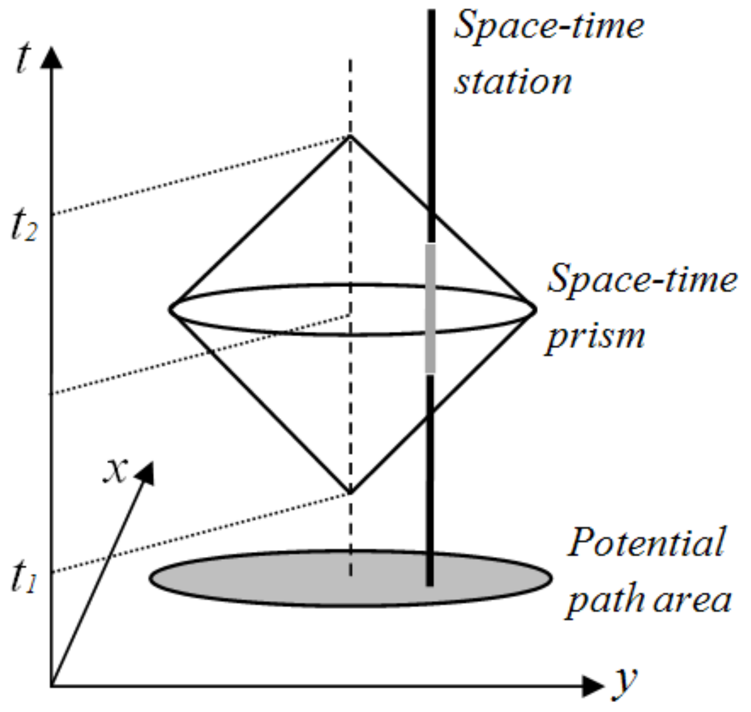
-The protection of the vehicle's current location and destination, and the client's current location.

Timegeography

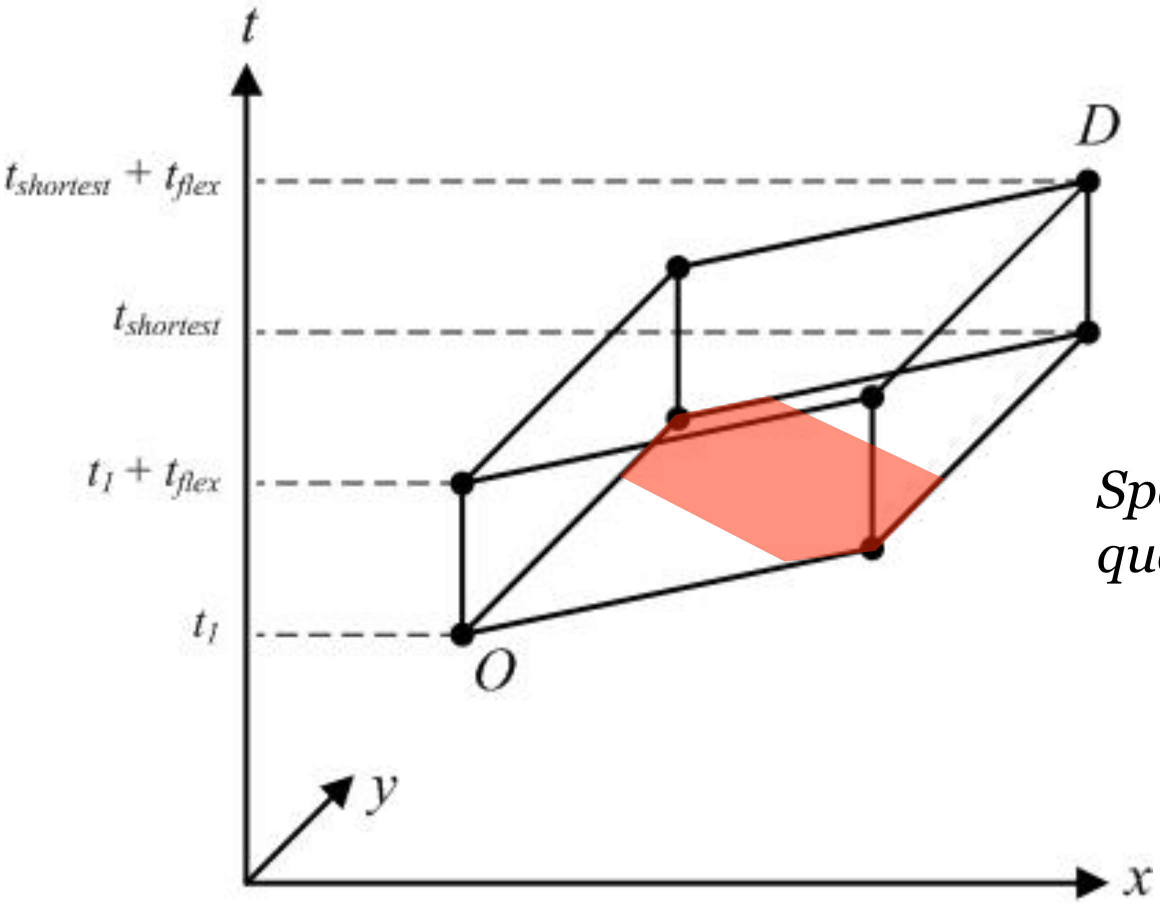
Vehicle movement can be represented using timegeography concepts

1. **Classical**
   Free space, Hägerstrand (1970)

2. **Modern extensions**
   Network space, Miller (1999)
   Probabilistic, Winter (2009)



Vehicle accessibility

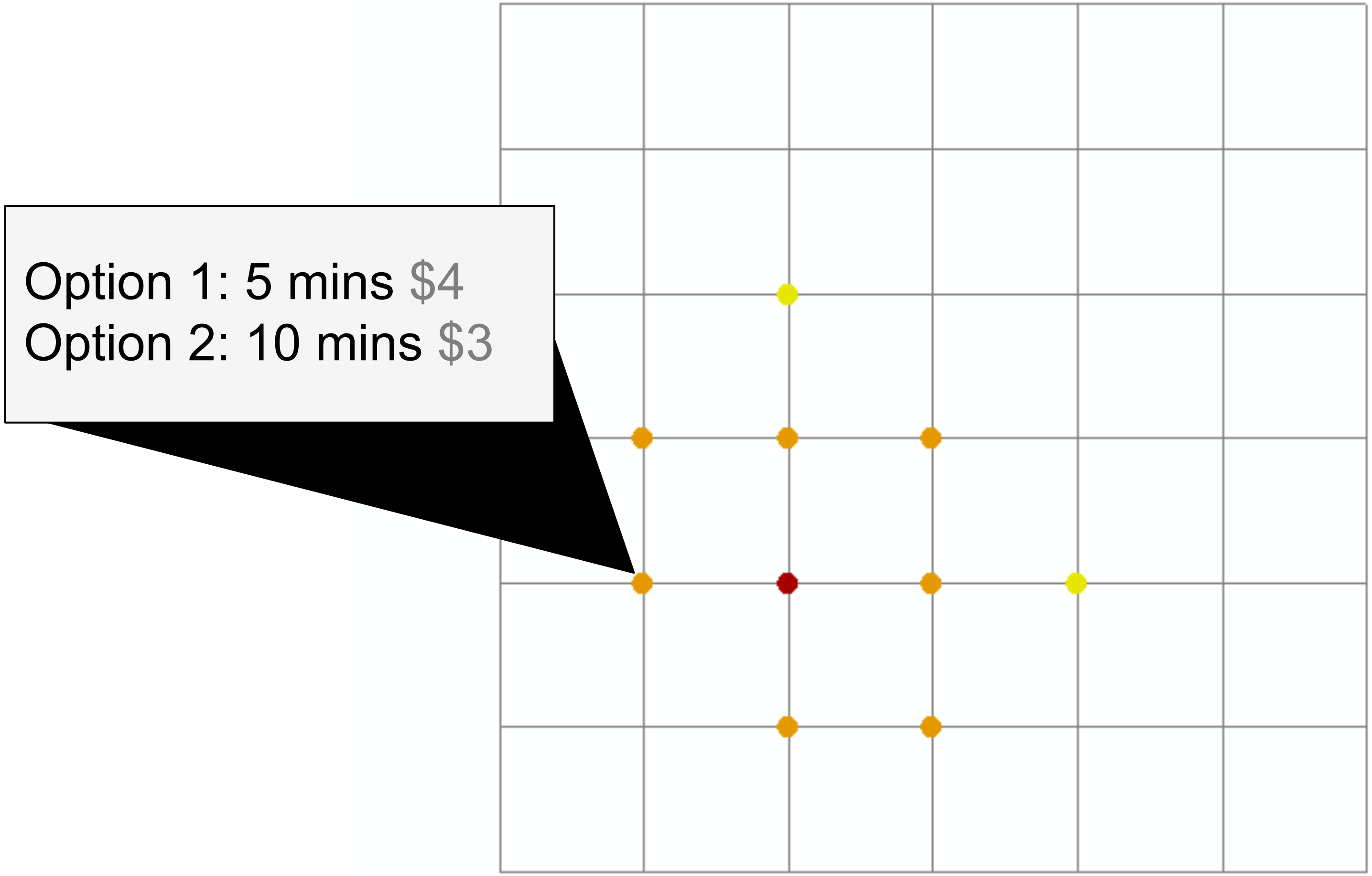


Vehicle's 'flexibility bank'

Spatio-temporal query

Edge cost according to some metric, e.g., Euclidean distance

Launch pads



$[t_n , t_{n+2}]$

Launch pads

Visualized according to service ***stability***

Launch Pads

-Communicate the vehicle's *local accessibility*, within the spatio-temporal limits of its OD constraints

-Discrete points in space-time — ideal for describing pick-up and drop-off options

-Visualised according to the service stability of the location

-Removes visual clutter in 2D

Proposed Strategy

Allow the client to explore mobility options in a mobile context, without (1) knowing the individual destinations of vehicles and (2) without revealing their own location.

OppRide strategy:

1. Intuitive visualisation of vehicle accessibility
2. Architecture protecting privacy client ↔ vehicle
3. Either human or autonomic driver vehicles

OppRide Architecture

-Centralized authority (a trusted entity) performs ride-matching

-Client creates a *mobility request*, selecting their destination first

-Vehicle launch pads are only revealed to the client if all of their OD constraints in their request can be satisfied:

-Origin point *-Departure time*
-Destination point *-Arrival time*

-Individual vehicle IDs hidden – only their potential is shown

-Upon selecting a pad, the client can make a *mobility contract* with the corresponding vehicle. After which the positions of both parties are shared.

Experiment Design

-To test the effectiveness of our approach we develop a MAS
- -Repast, JAVA
- -Micro level

-Abstracted (grid) transportation network

-Client and vehicle agent types

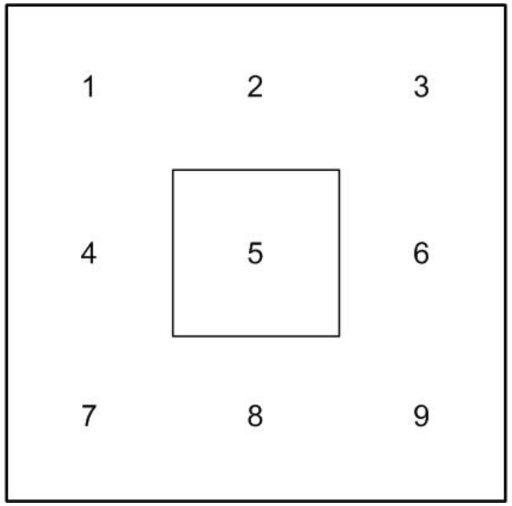
-Shortest path calculation: Dijkstra's algorithm

Service Coverage

-Observing vehicle accessibility only (we do not consider client constraints)

-Vehicle agents move between random O and D in zones 1-4, 6-9, around a centralized *service area* in zone 5.

-Observe the *service coverage* of vehicles with a flexibility of ⅓ their shortest path length:



➔**Vehicle diversity**
The mean number of different vehicle agents observed per vertex, per time step

➔**Vehicle counts**
The mean number of discrete vehicle agent visits per vertex, per time step

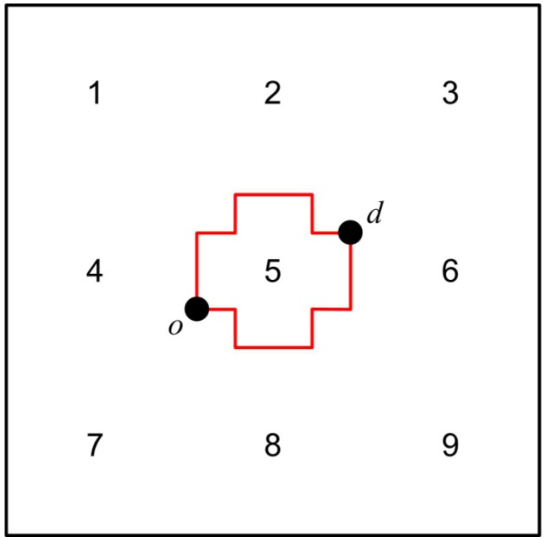
Probability of pick-up

-Introduce a client's OD constraints and observe their success of getting a ride within zone 5.

-Vehicle agents again move between random O and D in zones 1-4, 6-9.

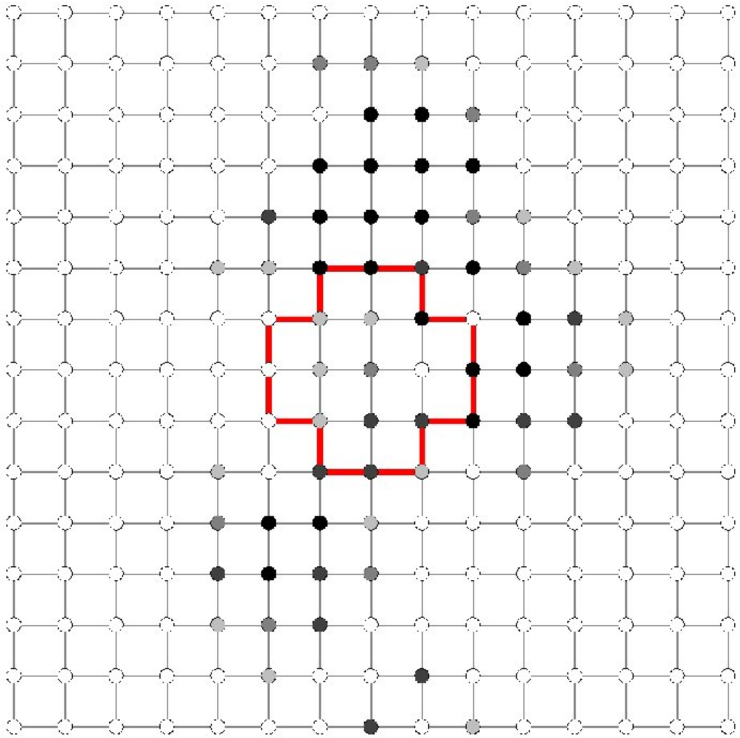
-Observe a client's probability of pick-up whilst varying:

➔**Vehicle Agent Population size**
➔**Vehicle Agent Flexibility**

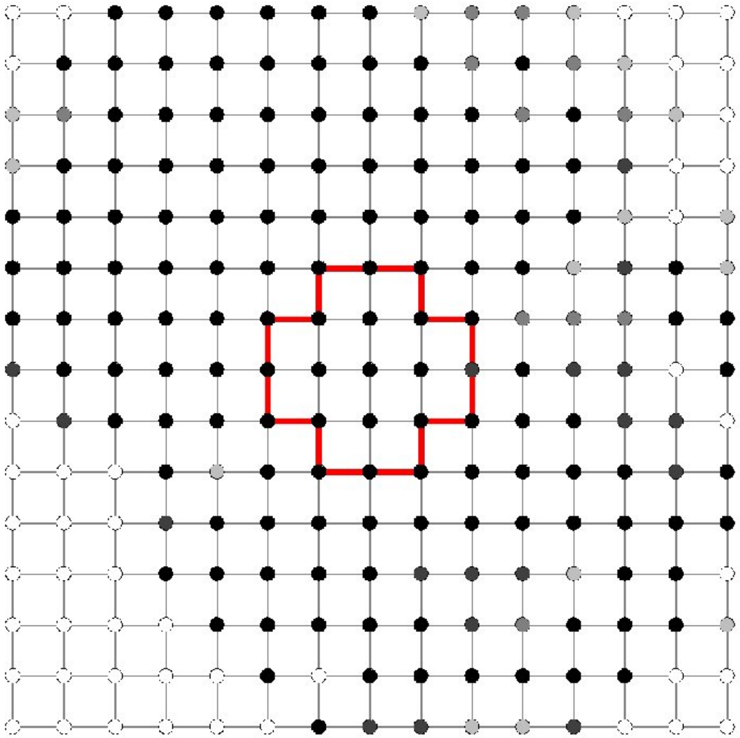


Results – Service Coverage

(P) 5 vehicles



(Q) 20 vehicles



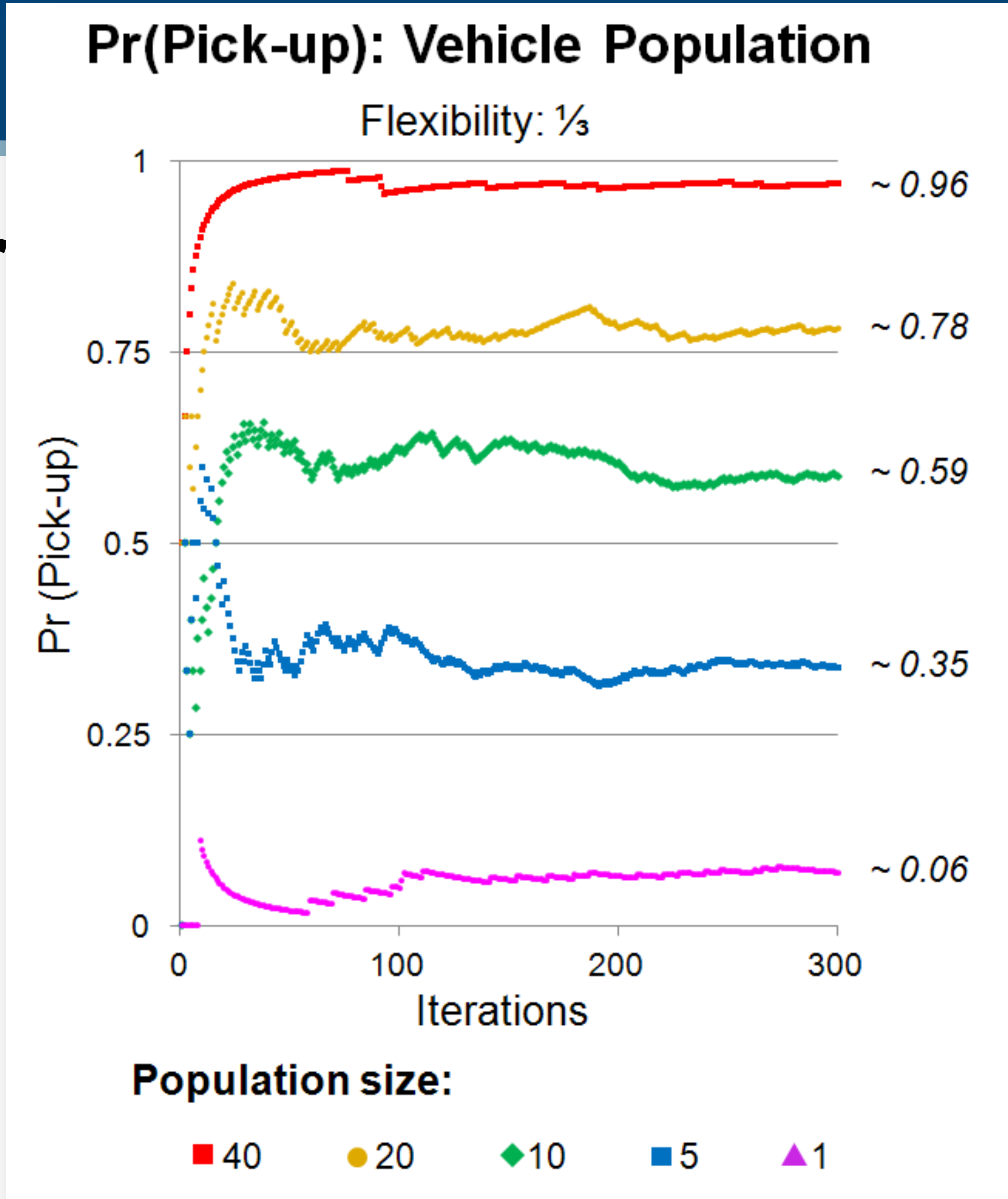
Results – Service Coverage

Vehicle flexibility: ⅓

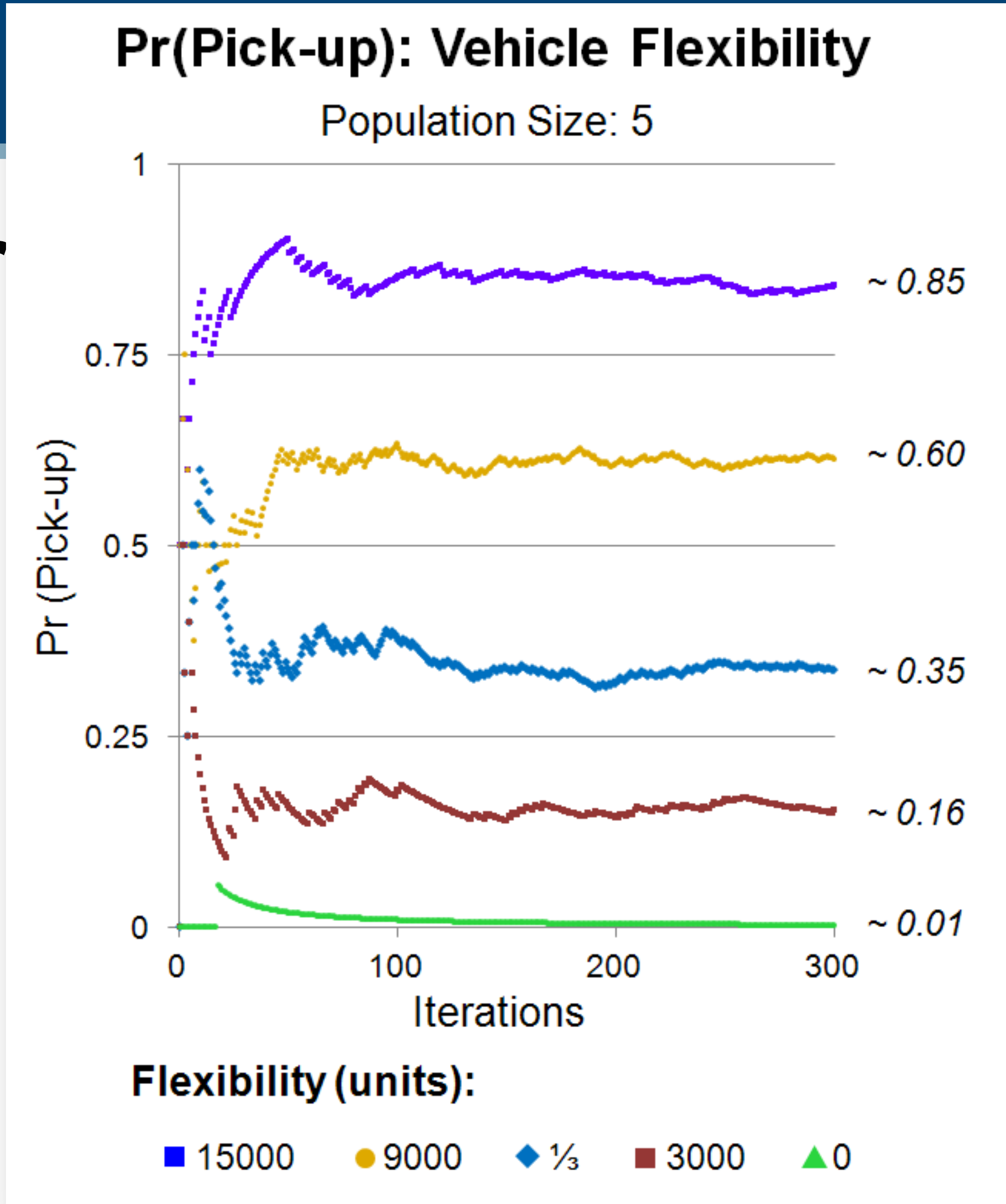
Population Size	Diversity	Counts
1	0.11	0.25
5	0.55	1.22
10	1.11	2.52
20	2.21	4.96
40	4.47	10.07

- Significant service coverage exists with a sufficient population size

Results – Pr ... ults



Results – Pr



ults

- Greater flexibility
- Larger launch pads
- Greater probability of pick-up

Discussion

-Ride matching is a complex task.

-The observed results reflect the behaviour of transportation in reality

Private taxi	**Public bus**
-Unlimited flexibility -Can satisfying a client's OD constraints with very high probability	-Fixed route, no flexibility -Perchance intersection of client OD constraints with the bus' accessibility

-It is a system designer's responsibility to search for a balance between vehicle population size and flexibility

Proof of concept

-By quantifying flexibility and including this in a representation of a vehicle's accessibility we can see that latent potential exists for exploitation by clients.

-Effective in regards to communicating potential using launch pads concept
-Effective in regards to protecting privacy using our OppRide architecture

-When used in a mobile context, OppRide can facilitate opportunistic ride-sharing behaviour.

Conclusion

-Key Contributions:

- Formal incorporation of flexibility into a representation of vehicle accessibility
- Communication of vehicle accessibility using launch pads
- Architecture which protects privacy client ↔ vehicle

-Balance is required between flexibility and vehicle population size

Further Work

-Continuous representation using OSM data (in progress)

-Negotiation of discretised pick-up and drop-off locations client ↔ vehicle

-Alternative ride-sharing architectures, e.g., landing pads, re-negotiation process, and multiple clients

-Effects of heterogeneous vehicle flexibilities and client preferences

-Applications of utility measures, .e.g., dynamic fare schemes, carbon emissions, etc.

Questions

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Example. Continuous WIP

Single client UI

Repast Simphony 2.0
Postgis 2.1