VShare: A Wireless Social Network Aided Vehicle Sharing System Using Hierarchical Cloud Architecture

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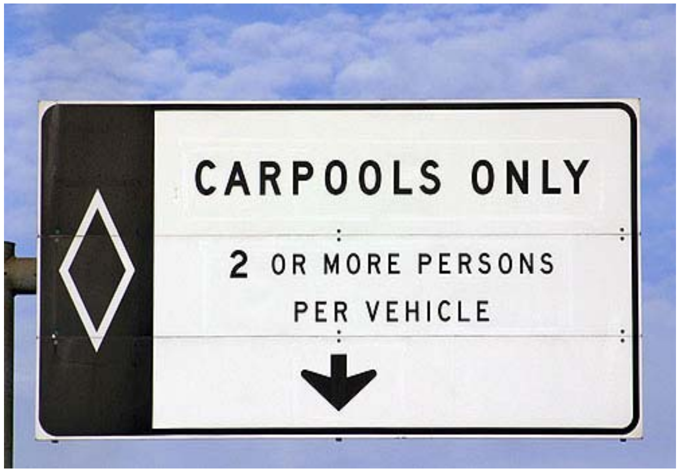
Outline

- Introduction
- System Design
  - Overview of Vshare
  - Design of VShare
- Performance Evaluation
- Conclusions

Introduction

Carpool commuting: multiple travelers with similar schedules and itineraries share one vehicle



[1] http://www.commuterconnections.org/commuters/ridesharing/what-it-is/

Introduction

Carpool commuting: benefits

- Alleviate traffic congestion, parking space tension
- Mitigate air pollution from vehicle emissions
- Privilege to use high occupancy vehicle (HOV) lanes

[2] https://thegreatermarin.wordpress.com/tag/commuting/

Introduction

How to match carpoolers?

Build carpool lanes in airports, bus stops:

wait in queues, make carpools spontaneously, first-come-first-service basis

- Cannot schedule carpooling in advance
- Small-scale user population in designated locations

Introduction

How to match carpoolers?

Utilize prior user mobility knowledge:

portable devices (e.g., smartphones) to collect individual trips, identify carpoolers based on travel routes and mobility models

- Cannot adapt to real time scenario

Introduction

How to match carpoolers?

Dynamic carpooling system

riders and drivers provide preferred travel information, calculate carpooling schedules based on objectives

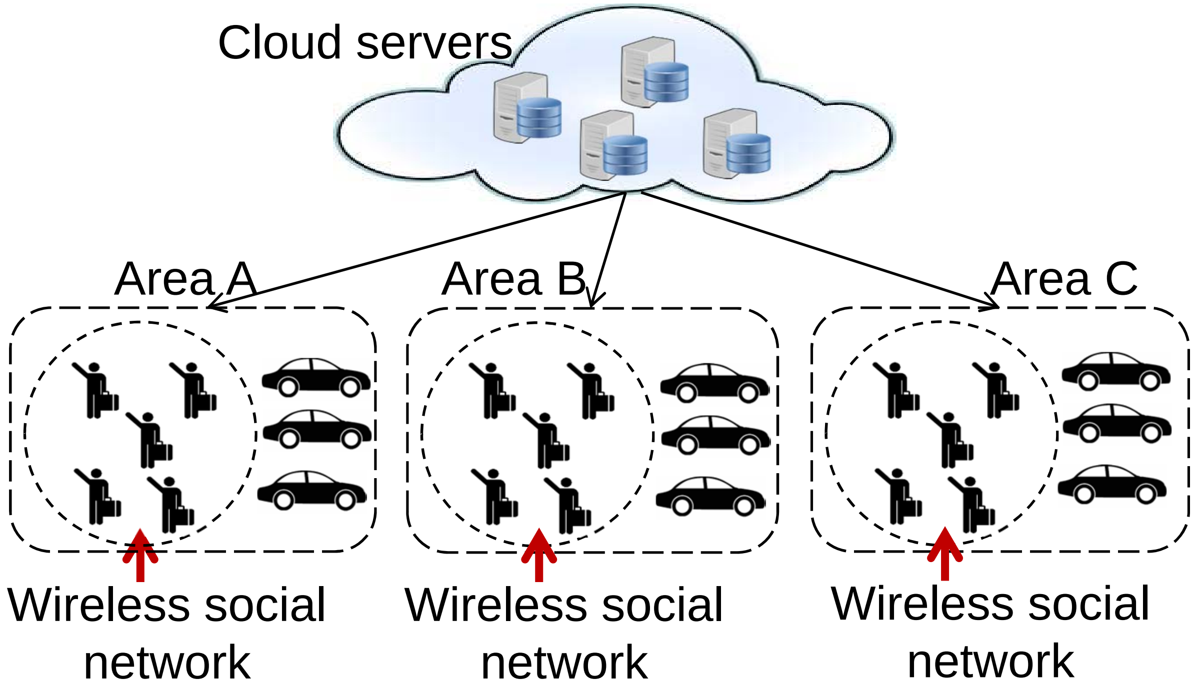
- Using a centralized server generates long computation latency

Introduction

Our proposed method: VShare

- Identifies carpoolers through the wireless social network
- Uses a hierarchical cloud server architecture to identify carpoolers

Advantage: matching latency is reduced



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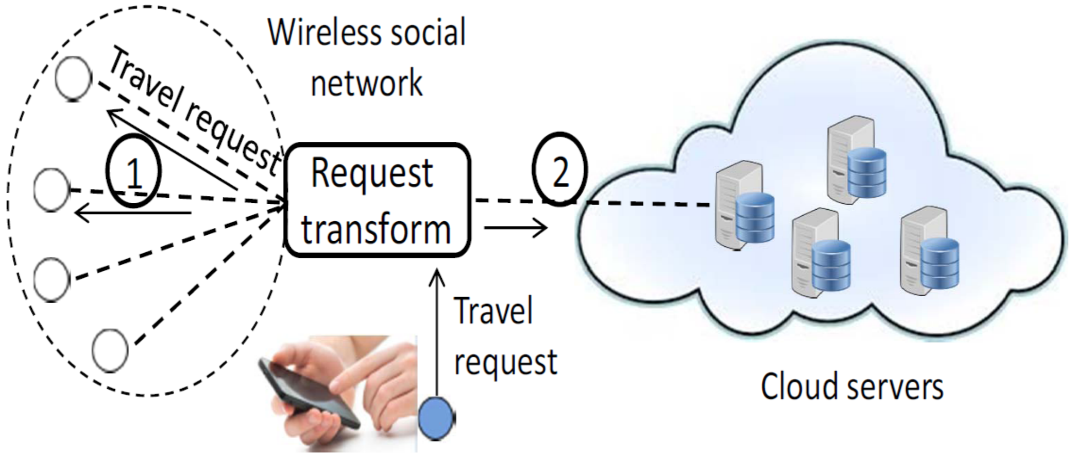
Overview of VShare



Step 1:

- request broadcasted to neighbors in nearby locations
- neighbors check travel schedule, respond to request

Step 2:

- cloud servers form a hierarchical architecture
- requests with the same departure location and destination location are stored in the same server

Goal: match carpoolers with short latency

Transformation of Travel Requests

Travel request

Departure	JFK airport
Destination	5th AVE
Travel time	9:30am
Max wait time	30min

Address code

000	Park Ave
001	5th Ave
002	JFK airport
003	1th Ave
⋮	⋮

Numerical string

Dep ID	Dest ID	Time	Max wait time
002	001	0930	30

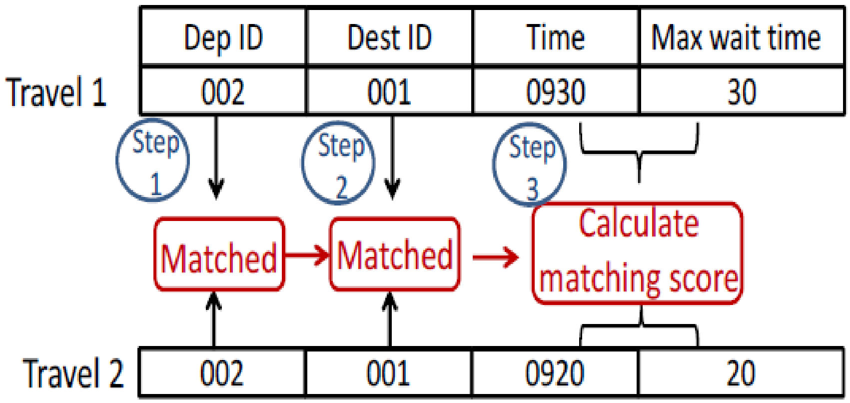
Dep ID: address code of departure location

Dest ID: address code of destination location

Time: departure time

Maximum wait time

Matching of Potential Carpoolers: Two carpoolers



1. Compare Dep ID and Dest ID sequentially, unmatched if different Dep ID or Dest ID
2. Calculate matching score

$$m_{ij} = 1 - (t_i - t_j)/w_j$$

t : departure time

w_j : maximum wait time

m_{ij}: degree of how long one needs to wait for another

Matching of Potential Carpoolers: Multiple Carpoolers

Input: a list of travel requests, $R = (r_1, r_2, ...r_u)$
Output: a carpool

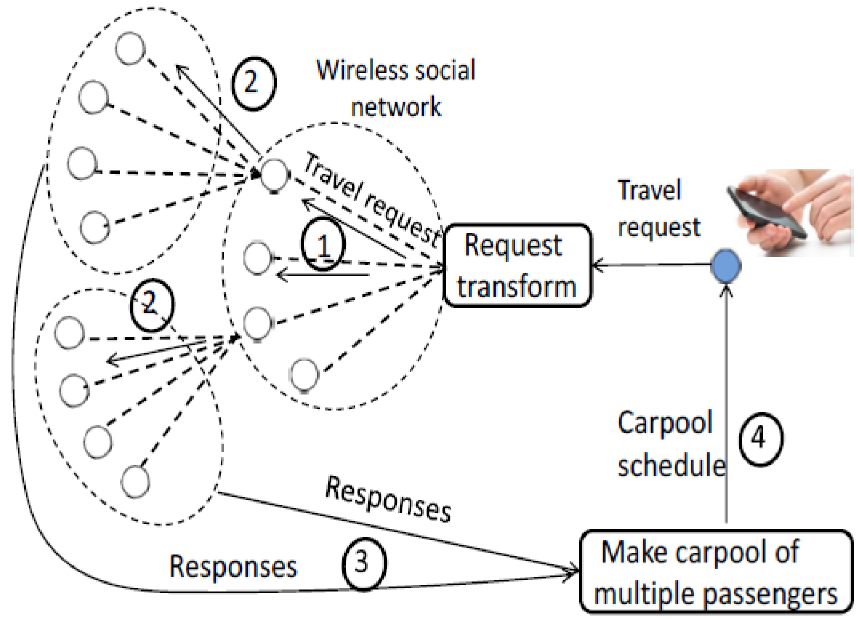
Algorithm 1

- Select one candidate from R at a time
- Calculate new carpool travel schedule
- Check if wait time of each passenger is within his/her maximum wait time
- Add candidate to the carpool if satisfied

Matching Via the Wireless Social Network

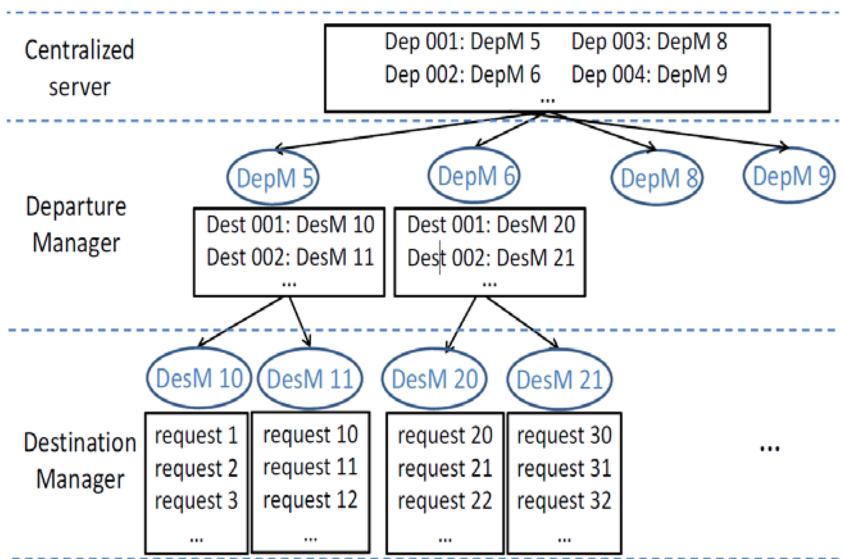
TTL: maximal hops a travel request is forwarded

- Sends a request to neighbors with TTL=2
- Receives multiple replies from its neighbors
- uses Algorithm 1 to make a carpool from multiple passengers
- Starts instant conversation with carpoolers



Matching Via Hierarchical Cloud Architecture

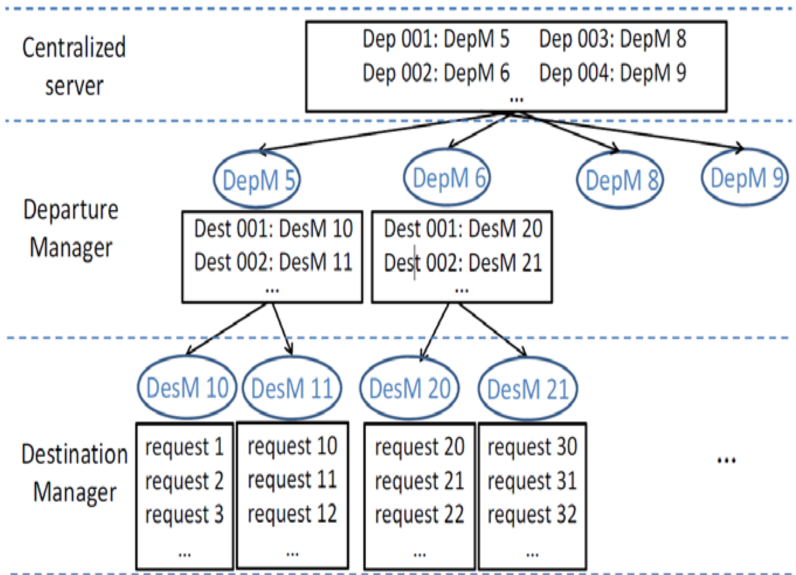
- Centralized server (CServer): distributes requests
- Departure managers (DepM): handles requests with the same departure ID
- Destination managers (DesM): handles and stores requests with the same departure ID and destination ID



Three-level hierarchy structure

Matching Via Hierarchical Cloud Architecture

- CServer passes a new request to DepM that is responsible for the request's departure ID
- DepM forwards the request to DesM that is responsible for the request's destination ID
- DesM only needs to match the travel time and maximum wait time using Algorithm 1



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Performance Evaluation: Settings

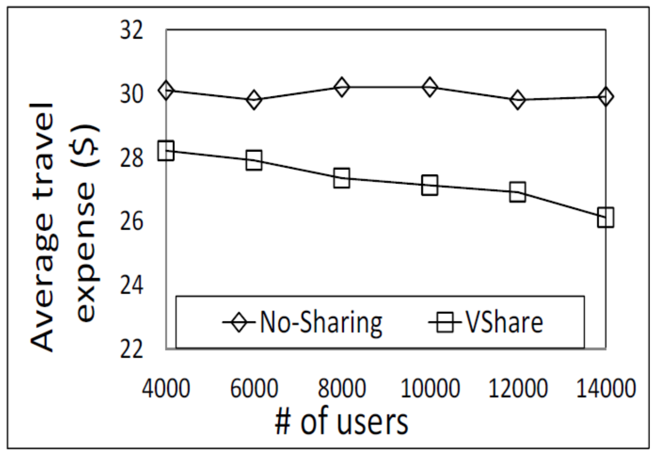
- Simulation using Cab mobility trace dataset [3]
  - GPS coordinates of 536 taxis over 30 days in San Francisco Bay Area
  - DBSCAN clustering algorithm [4] to identify 338 locations
  - Average # of travel requests/day: 14000
  - Each taxi's capacity is 4
- Comparison methods
  - Cloud: user travel requests are gathered and processed by a centralized cloud server
  - No-Sharing: each user occupies a single cab

[3] M. Piorkowski, N. Sarafijanovoc-Djukic, and M. Grossglauser, "A Parsimonious Model of Mobile Partitioned Networks with Clustering," in Proc. of COMSNETS, 2009.

Performance Evaluation: Results

- Average travel expense

Setting: single trip costs [20,40] dollars, evenly split among carpoolers



- Observation: VShare < No-Sharing, average travel expense drops as the numbers of users increases
- Reason: users are more likely to be potential carpoolers when user density is high

Performance Evaluation: Results

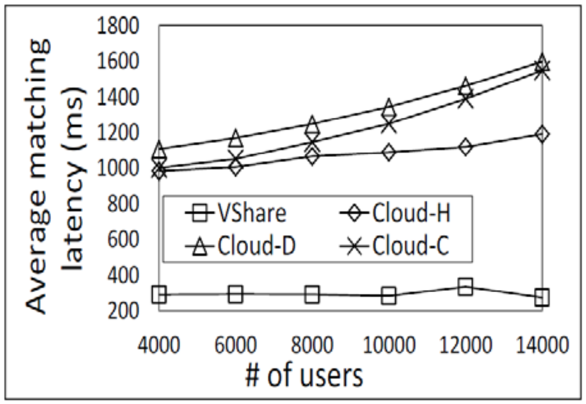
- Average matching latency

Variants of Cloud systems:

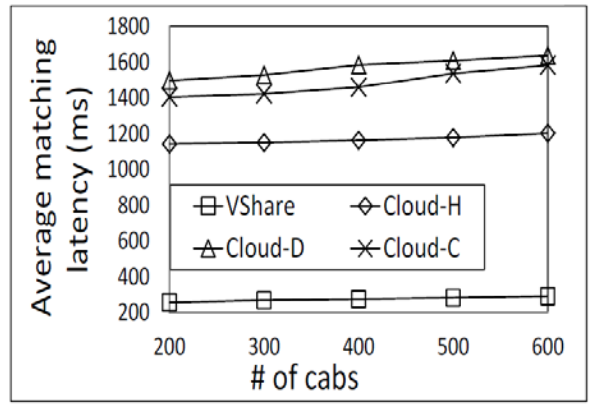
- **Cloud-D**: travel requests are stored in random cloud servers, matching carpoolers by a centralized server
- **Cloud-C**: a centralized server stores all travel requests, matching carpoolers
- **Cloud-H**: travel requests stored in hierarchical cloud architecture

Performance Evaluation: Results

- Average matching latency



(a) Performance with different number of users.

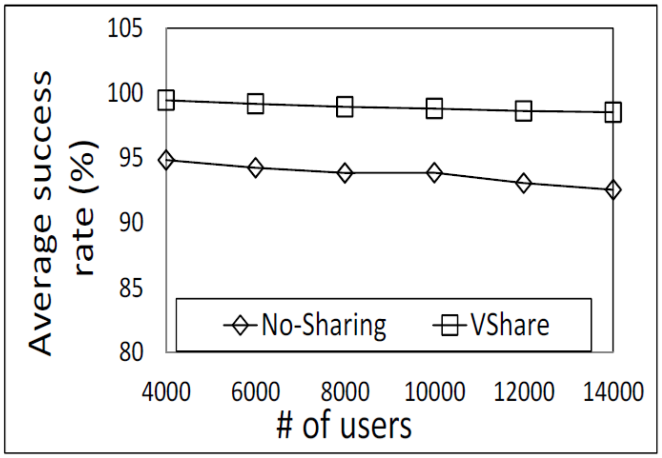


(b) Performance with different number of cabs.

- Observation: Cloud-D > Cloud-C > Cloud-H > VShare
- Reason: VShare first matches carpoolers among nearby users using the wireless social network within a short latency; hierarchical cloud architecture stores requests with the same departure and destination locations in the same server;

Performance Evaluation: Results

- Success rate of catching a taxi within maximum wait time



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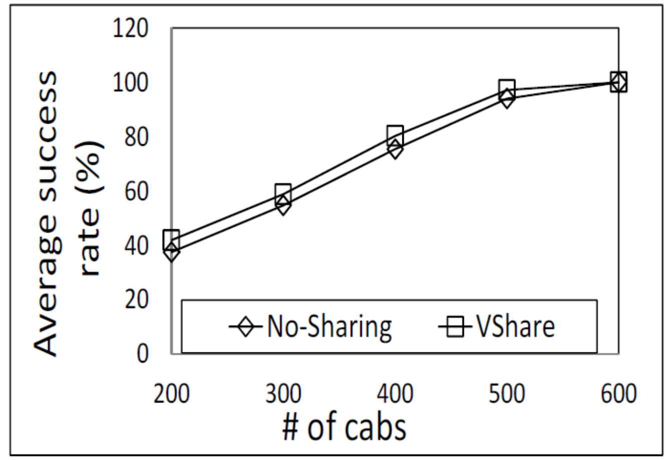
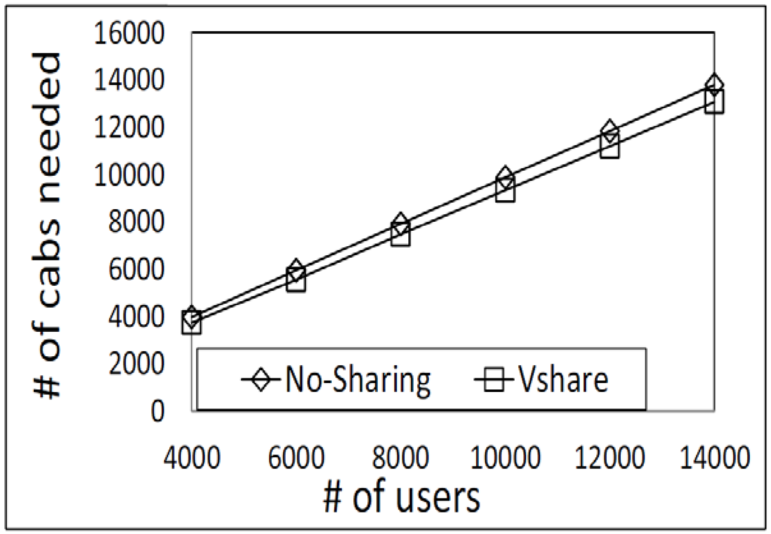


(b) Performance with different number of cabs.

- Observation: VShare > No-Sharing
- Reason: multiple users heading to the same destination can share one taxi. Given the same number of taxis, more passengers are transported.

Performance Evaluation: Results

- Number of taxis needed to transport all users within their maximum wait times



- Observation: VShare < No-Sharing
- Reason: each user in No-Sharing takes one cab; users in Vshare identify carpoolers nearby and share cabs with each other

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Conclusion

- VShare: dynamic vehicle sharing system
  - Leverages the wireless social network and hierarchical cloud server architecture
- Trace-driven simulations show:
  - Reduce user travel expense
  - Reduce carpool matching latency
  - Increase success rate of catching a taxi
  - Reduce # of taxis needed to transport a specific # of users
- Future work: identify carpoolers with different departure and destination locations

Thank you!

Questions & Comments?

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