Never Drive Alone
Boosting Carpooling with Network Analysis
Contents

• Introduction to Carpooling
• Complex Network Oriented Study Methodology
• Carpooling Scenario Analysis
• Carpooling Assignment Suggestion
• Conclusions
Contents

• Introduction to Carpooling
• Complex Network Oriented Study Methodology
• Carpooling Scenario Analysis
• Carpooling Assignment Suggestion
• Conclusions
Carpooling

• Is the sharing of a car between a number of people from a certain origin to a certain destination.

• A Single-Occupant-Vehicle is someone driving alone even though she can potentially travel with someone else.
Why Carpooling?
Why Carpooling?

- Eco-Friendly Transportation System
- Save Time
- Save Money
- Reduce Traffic Congestion
- Reduce CO2 Emission
Carpooling Related Work

- High Occupancy Vehicle lanes
- Agent Based Model
- Study Based on Data
- Negotiation and Feedback
- Energy Consumption
- Economical
- Psychological
Carpooling on Web
Contents

• Introduction to Carpooling
• Complex Network Oriented Study Methodology
• Carpooling Scenario Analysis
• Carpooling Assignment Suggestion
• Conclusions
Our idea comes from Mobility Data
Mobility Profiles

• Describes an abstraction in space and time of the systematic movements of a user.
• The exceptional movements are completely ignored.

Individual History  Trajectory Clusters  Routines

C_1  C_2  C_3

r_1  r_2
Carpooling Interaction

- Carpooling Interaction: a user can offer a ride to another user or a user can get a lift from another user.

- Routines containment: a routine $r_1$ is contained in another routine $r_2$ if the starting point and the ending point of $r_1$ are spatio-temporally close enough to some points of $r_2$. 
Carpooling Network

• Carpooling Network

• Carpooling User Network

• Carpooling Temporal Network
Objective

- Given a Carpooling User/Temporal Network $N$, select a subset of edges that minimizes $|S|$
  - $S =$ set of single occupant vehicles $=$ set of isolated nodes
  provided that the edges are coherent, i.e.:
    - indegree$(n) = 0$ OR outdegree$(n) = 0$ (a driver cannot be a passenger)
    - indegree$(n) \leq$ capacity$(n)$
- Similar definitions possible for other objective functions, e.g. $\#$ vehicles $\left( = \#$resulting components of the graph $\right)$
Greedy Assignment

- Input Carpooling User Network
- Output D, P, S

1. Possible passengers are sorted and considered according to some criteria c'
2. For each possible passengers u her possible drivers are sorted and considered according to some criteria c''
3. Then, u is assigned to the first driver v that still has free places

\[
\begin{align*}
\text{D} &= \{z\{x,w\}\} \\
\text{P} &= \{x\{z\}, w\{z\}, v\{y\}\} \\
\text{S} &= \{u\}
\end{align*}
\]
Carpooling Ranking Scores

• A user is a *good passenger* if she can take a lift form many *good drivers*; measured by her *passengerness*.

• A user is a *good driver* if she can take a lift form many *good passengers*; measured by her *driverness*.

• Kleinberg's HITS Algorithm

\[
p_i^{(k)} = \sum_{j=1}^{n} A_{ij} d_j^{(k-1)} \quad \forall i \in N
\]

\[
d_j^{(k)} = \sum_{i=1}^{n} A_{ij} p_i^{(k-1)} \quad \forall j \in N
\]
Carpooling Community

- It is a set of users who share more routines with the user inside the community rather than the users outside the community.
Carpooling Community

- It is a set of users who share more routines with the user inside the community rather than the users outside the community.

- **Idea:** perform carpooling assignment separately for each community
Never Drive Alone Method

1. Given a set of mobility profiles $M$, empty $D^*$, $P^*$, $S^*$ and a slot duration $dur$
2. Build carpooling network $G$ using $M$
3. Extract carpooling user network $G'$ from $G$
4. Calculate on $G'$ driverness $d$ and passengerness $p$
5. Extract from $G'$ carpooling communities $C$
6. For each time stamp $ts$
7. Consider a certain carpooling temporal network $G_{ts,ts+dur}$
8. For each community in $G_{ts,ts+dur}$ perform a greedy assignment using $c' = (k_{out}, p)$ and $c'' = (k{in}, d)$
9. Return $D^*$, $P^*$, $S^*$
Contents

• Introduction to Carpooling
• Complex Network Oriented Study Methodology
• Carpooling Scenario Analysis
• Carpooling Assignment Suggestion
• Conclusions
Mobility Dataset

• 9.8 million car travel
• 160,000 vehicles
• 1\textsuperscript{st} May to 31\textsuperscript{st} May 2011
• Tuscany, Italy

• We considered separately weekday trajectories traveled in Pisa and Florence province
Mobility Profiles Analysis
Mobility Profiles Analysis
Carpooling User Network Analysis
Carpooling Community Analysis
Contents

• Introduction to Carpooling
• Complex Network Oriented Study Methodology
• Carpooling Scenario Analysis
• Carpooling Assignment Suggestion
• Conclusions

FIND YOUR CARPOOL MATCH AND START SAVING
Carpooling Assignment Suggestion Evaluation

- We evaluate the Never Drive Alone method measuring the number of SOV and the number of systematic car traveling after suggesting assignments.
- We evaluate the method using random criteria, using only degree criteria and using also ranking information.
- We evaluate the method using or not the information given by the communities.
- We evaluate the method using fixed time slot and time slot starting dynamically after every interesting carpooling interaction.
Random Suggestion Criteria
Carpooling Assignment
Suggestion Evaluation

methods and criteria

Pisa

drivers
passengers
sov
systematic cars
drivers
passengers
sov
Carpooling Assignment Suggestion Evaluation

Florence

methods and criteria

class assignment percentage
Carpooling Assignment Suggestion Evaluation

Pisa

\[ r = \text{random} \quad g_1 = \text{in/out-degree} \quad g_2 = \text{driver/passenger-ness} \]
\[ w = \text{all network} \quad c = \text{split to communities} \]
Contents

• Introduction to Carpooling
• Complex Network Oriented Study Methodology
• Carpooling Scenario Analysis
• Carpooling Assignment Suggestion
• Conclusions
Conclusions

• Characterize and describe potential carpooling network interactions

• Different type of carpooling communities

• Smart carpooling assignment suggestion
Questions ?