Metropolitan-Scale Taxicab Mobility Modeling

Lei Zhang, Maryam Ahmadi, Jianping Pan and Le Chang
University of Victoria, Victoria, British Columbia, Canada

University of Victoria

PANDA
Parallel, Networking and Distributed Applications

Introduction

In recent years, with the fast development of mobile devices, considerable research efforts have been made in mobile applications, systems and services. However, less attention has been paid to the modeling of realistic user mobility, which has a huge impact on the performance of mobile systems.

Purposes of Studying User Mobility:

- Reveal the regularity and characteristics of user mobility;
- Make the communication and networking schemes design more realistic and effective;
- Generate realistic synthetic traces to overcome the real-world trace shortage.

Contributions:

Proposed a trace-driven, realistic hierarchical taxicab mobility model:

- Macroscopically, taxicabs move among "hot" regions, which is modeled as a Continuous-time Markov process;
- Microscopically, taxicabs move within each region, following certain vehicle traffic distributions.

Related Work

Synthetic Models:

- Rely on stochastic assumptions of the user motion speed or direction;
- Simplification on temporal or spatial domains makes them too idealistic, without taking geographical information and time effect into account.

Existing Trace-driven Models:

- Proposed for modeling the human mobility in a small geographical area, e.g., campus or conference scenarios;
- Cannot be simply adopted in VANETs, due to the limited space and time span of the traces.

Region Division

Two criteria:

- **VKT**: Vehicular Kilometers Traveled over regions;
- **ART**: Accumulative Residence Time over regions.

Region Division

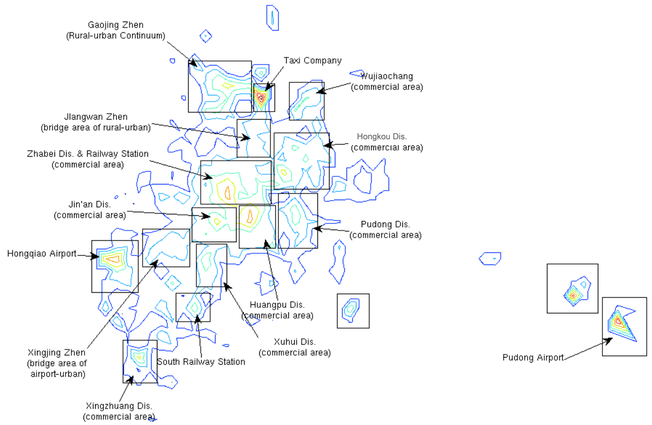

Figure 1. Identifying "Popular" Regions after Data Mining on Traces

Taxicab Mobility: Macroscopic View (1)

Transition Residence Time between Regions:

- Definition: the travel time within one region before the taxi leaves for the next one;
- We have discovered the distribution of transition residence time follows exponential distribution.

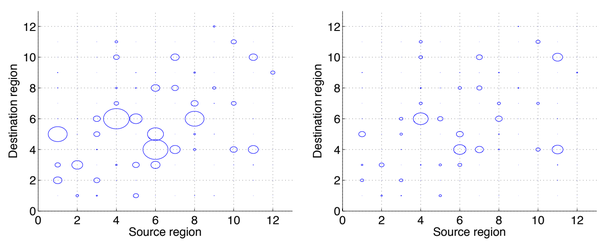

Figure 2. Average Transition Residence Time of Daytime and Nighttime

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Contact:

Lei Zhang: leiz@uvic.ca
Maryam Ahmadi: mahmadi@uvic.ca
Jianping Pan: pan@uvic.ca
Le Chang: lechang@uvic.ca

Taxicab Mobility: Macroscopic View (2)

Transition Probability between Regions:

- The transition probability between any two regions is calculated by normalizing the transition numbers between two regions;
- The transition probability of daytime and nighttime are similar to each other, although the transition number of nighttime is smaller.

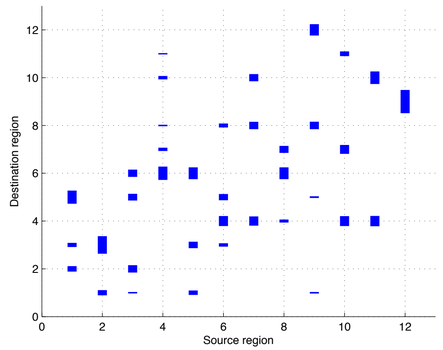

Figure 3. Transition Probability between Any Two Regions

Taxicab Mobility: Microscopic View

Movement within one region:

- The region a taxi enters is either the destination or transit region;
- The trajectory within a region should follow certain traffic distributions as observed from the trace.

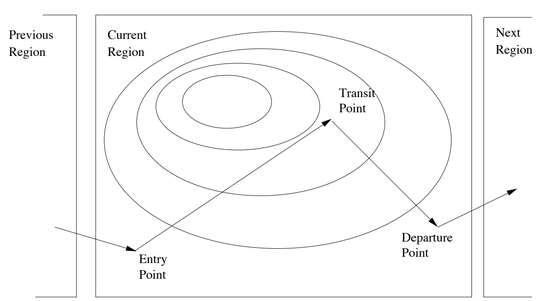

Figure 4. Movement within One Region

Model Verification

When applying the model from both macroscopic and microscopic views, we are able to generate synthetic traces. We compare the traffic load density distribution of the synthetic trace with the real one to evaluate how effective our model is.

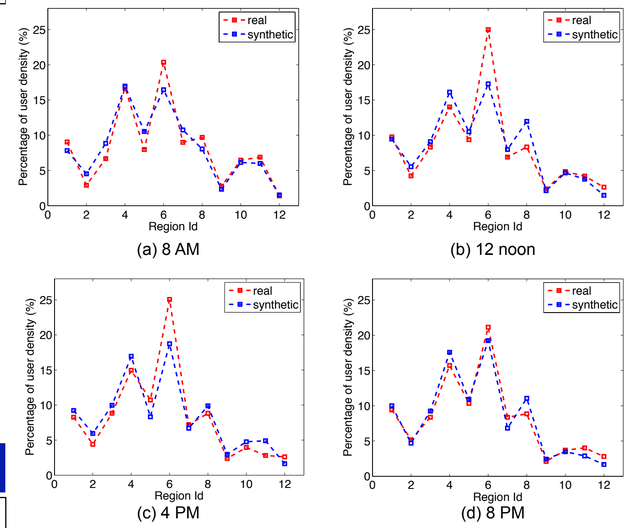

Figure 5. Taxicab Traffic Density Distribution

Conclusions

In this paper, we proposed a trace-driven hierarchical taxicab mobility model for large modern cities. Because the synthetic traces generated by the model match well with the real ones, we believe that the model can well capture the taxicab motion features on the social and geographical aspects at a city scale with both macroscopic and microscopic considerations. Our model keeps a balance between fidelity and tractability. It is not confined to the city where the taxicab traces are from, but can be easily extended to other city-like scenarios as well. We have already extended the model to a Continuous-time Markov process, and details are forthcoming after this paper.