ECML PKDD 2017
SKOPJE, Macedonia 18-22 SEPTEMBER
The European Conference on Machine Learning & Principles and Practice of Knowledge Discovery
TDLSG : Advances in Mining Large-Scale Time-Dependent Graphs

# Finding the Nearest Service Provider on Time-Dependent Road Networks

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# AGENDA

1. Introduction
2. Problem Statement
3. Competition Network Expansion
4. Experimental Evaluation
5. Conclusion and Future Work

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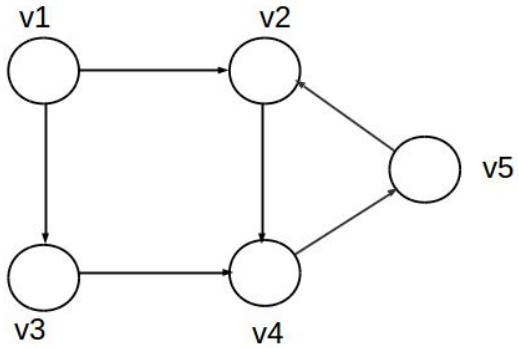
# Urban mobility and traffic issues

# TIME-DEPENDENT NETWORK

## Travel time according to a function of time




# PROBLEM STATEMENT

## Time-dependent Nearest Server

Given a **time-dependent road network**, a set of **service providers (POIs)** and a **query** point, find the provider that reaches the query point in the short amount of time.

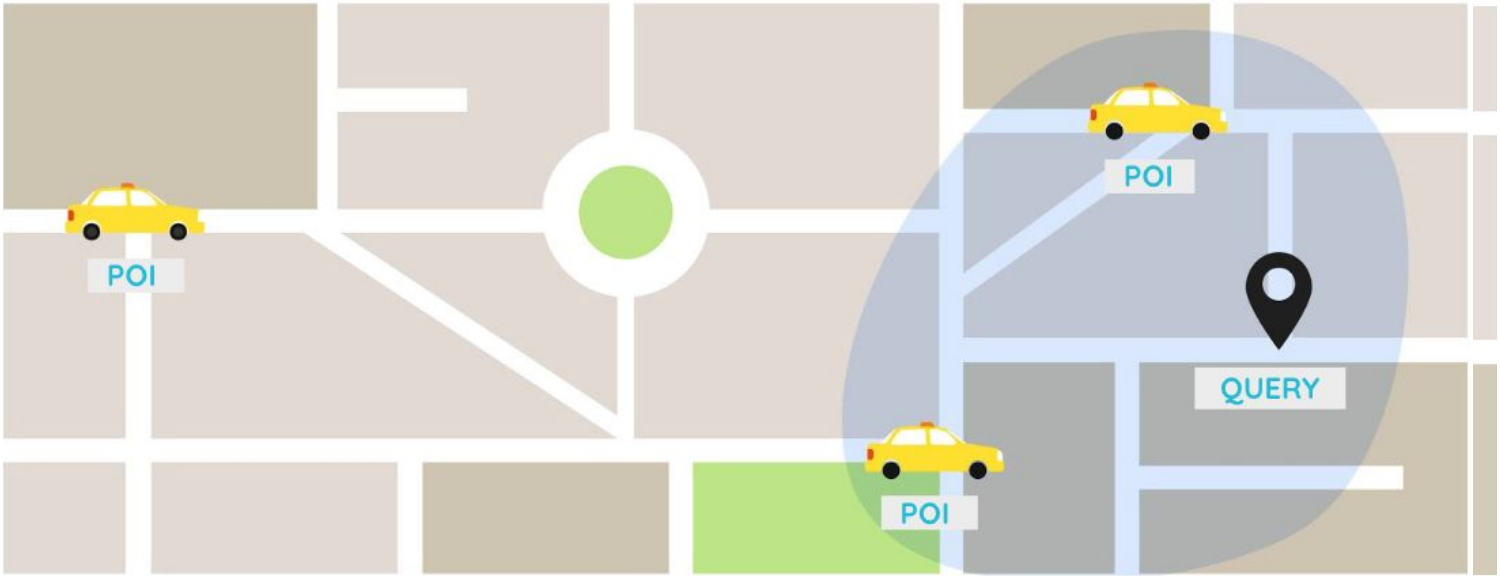
# CONTRIBUTIONS

- Propose the **Competitive Network Expansion (CNE)**, a new method to solve Time Dependent Nearest Server (**TDNS**) problem that calculates exact travel time;
- Propose a reduction of TDNS problem to time-dependent fastest path problem.

# COMPETITIVE NETWORK EXPANSION: Candidate Selection

**Goal:** reduce the number of evaluated POIs

- Produce a set of candidate POIs according to a time function based on the (Euclidean) distance;
- We apply k-NN queries between the query point and the POIs using a R-Tree index.

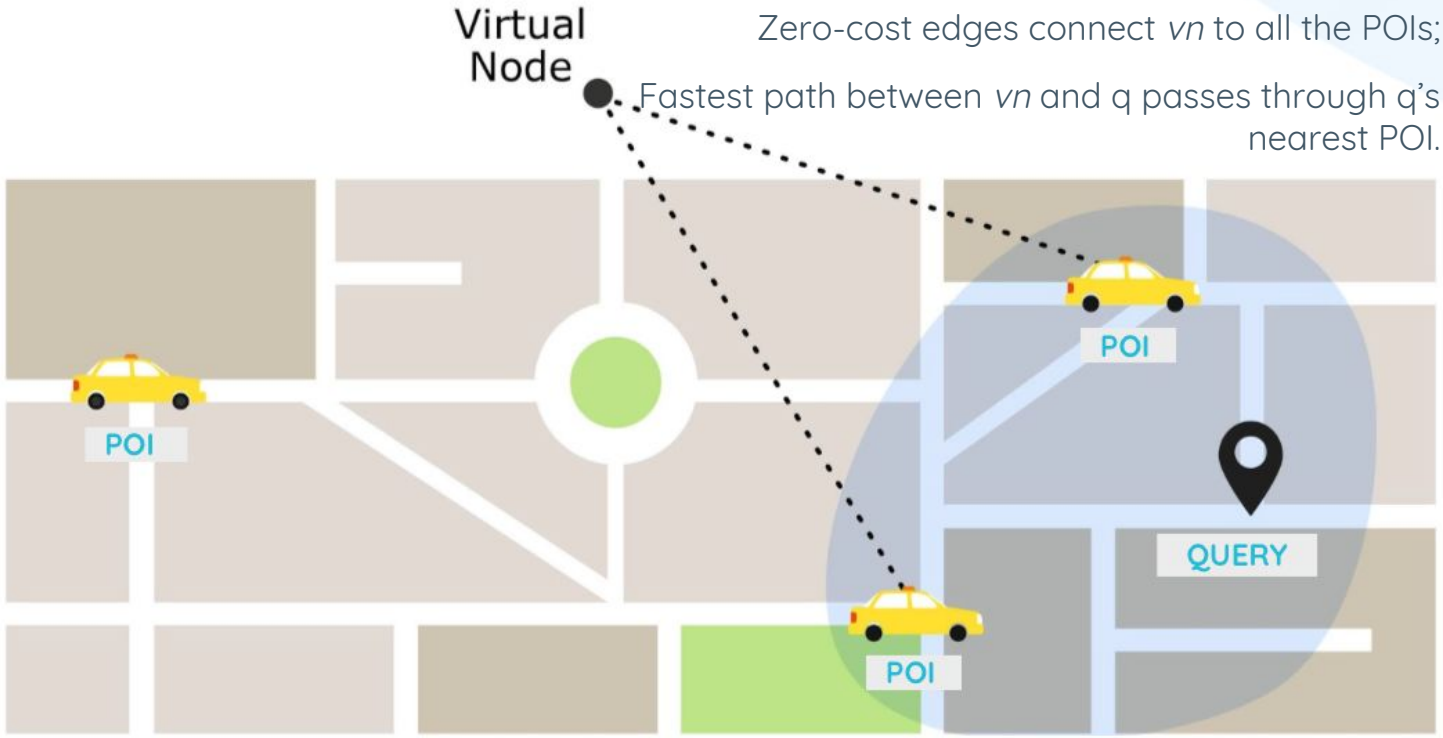


# COMPETITIVE NETWORK EXPANSION: Reduction to the Fastest Path

A virtual node is connected to all the selected POIs;

Zero-cost edges connect *vn* to all the POIs;

Fastest path between *vn* and q passes through q's nearest POI.



# COMPETITIVE NETWORK EXPANSION: Search Step

Uses a variant of **A*** [Goldberg and Harrelson, 2005] algorithm to find out the fastest path from the virtual node to the query point.

# EXPERIMENTAL EVALUATION

## SETUP

- Graphast framework [Magalhães et al., 2015];
- Virtual machine on AWS with 2 intel XEON CPUs clocked at 2.4 GHz, 8 GB of RAM and Ubuntu OS.

## DATASET

- Fortaleza road network;
- Travel time functions synthetically generated;
- Real and synthetic POIs.

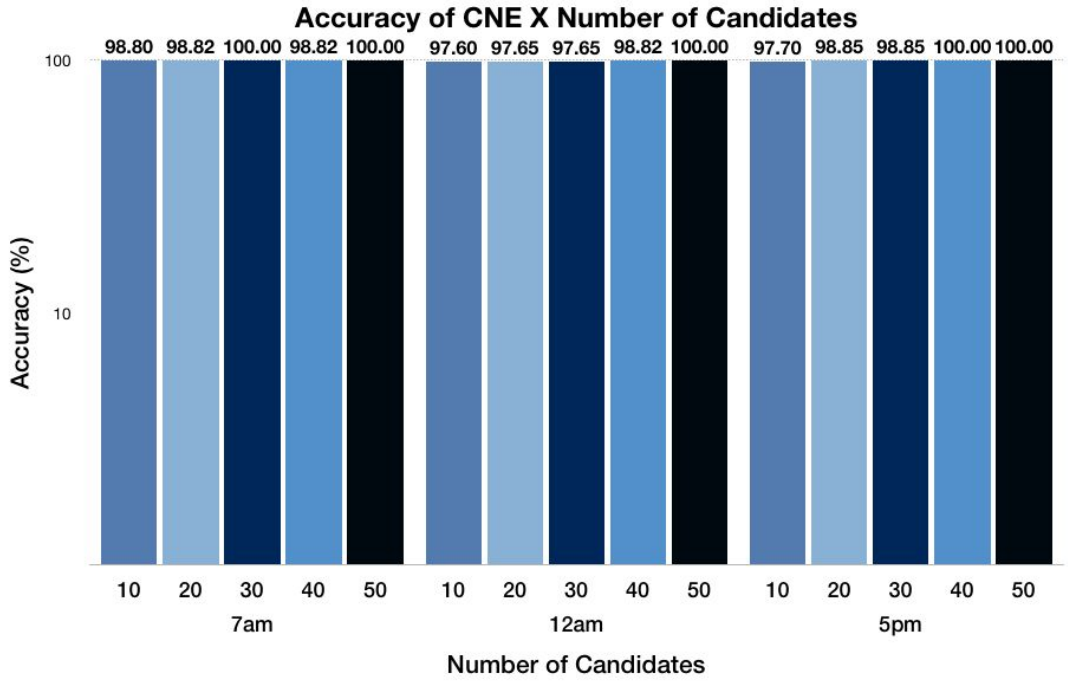
## ALGORITHMS

- Our solution: CNE
- Naive
- BFS on reverse graph [Chucre et al., 2016]

# EXPERIMENTAL EVALUATION
## Accuracy of candidate selection

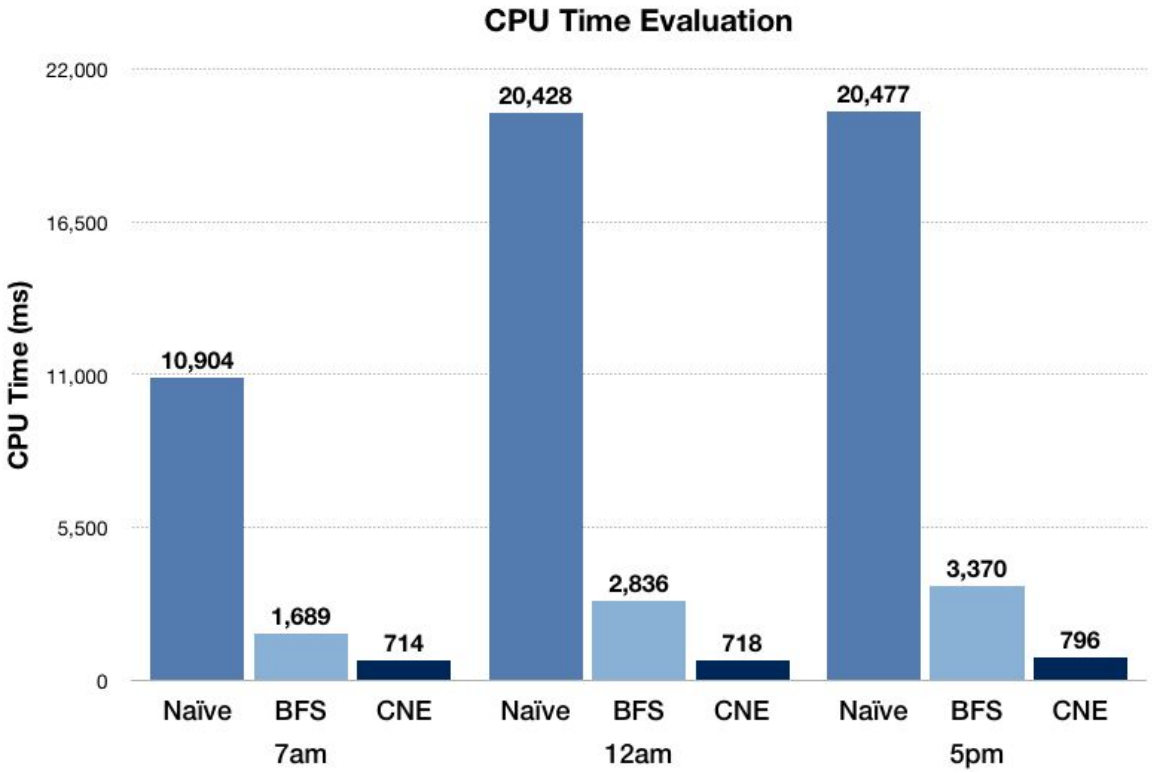
Taxi positions from July 23th, 2016

- 7am: 360 POIs
- 12am: 216 POIs
- 5pm: 398 POIs



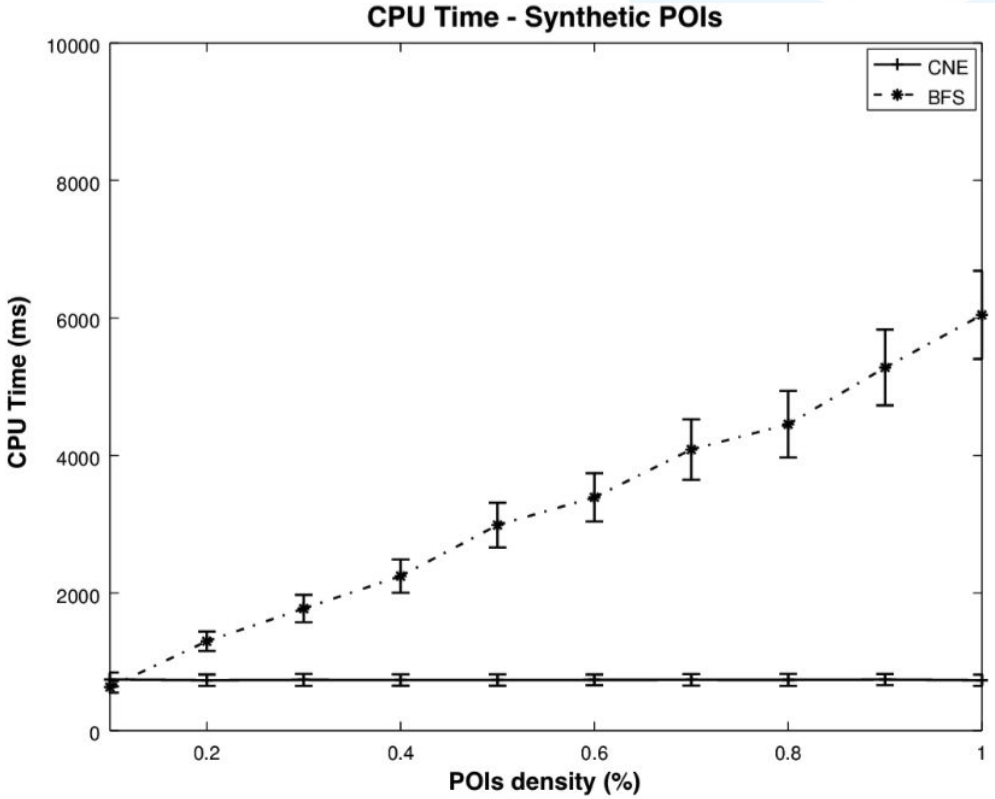
# EXPERIMENTAL EVALUATION
## CPU Time - Real POIs

Execution time
(50 candidates)



# EXPERIMENTAL EVALUATION
## CPU Time - Synthetic POIs

Execution time
(50 candidates)



# CONCLUSIONS AND FUTURE WORK

- **Contributions**
  - Reduction of the TDNS problem to the fastest path problem.
  - Application of candidate generation phase to quickly update POIs locations with negligible effects on the correctness.
- **Future Directions**
  - Improve the way candidate POIs are chosen.
  - Solve the problem of computing a continuous version of the TDNS query.
  - Investigate how we can compute TDNS queries over dynamic networks, where travel-time functions can be updated over time.

# Thank you!

## Any questions?

You can find me at

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# REFERENCES


- Goldberg, A.V., Harrelson, C.. “Computing the shortest path: A* search meets graph theory”. In: Proceedings of the Sixteenth Annual ACM-SIAM Symposium on Discrete algorithms, Philadelphia, PA, USA (2005) 156–165
- Magalhães, R.P., Coutinho, G., Macedo, J., Ferreira, C., Cruz, L., Nascimento, M.: “Graphast: an extensible framework for building applications on time-dependent networks”. In: Proceedings of the 23rd SIGSPATIAL International Conference on Advances in Geographic Information Systems, ACM (2015) 93
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