UDESC
UNIVERSIDADE
DO ESTADO DE
SANTA CATARINA

Department of Computer Science
Graduate Program in Applied Computing

Proposition of Mobility Indicators Based on Traffic Information

Prof. Dr. Fabiano Baldo
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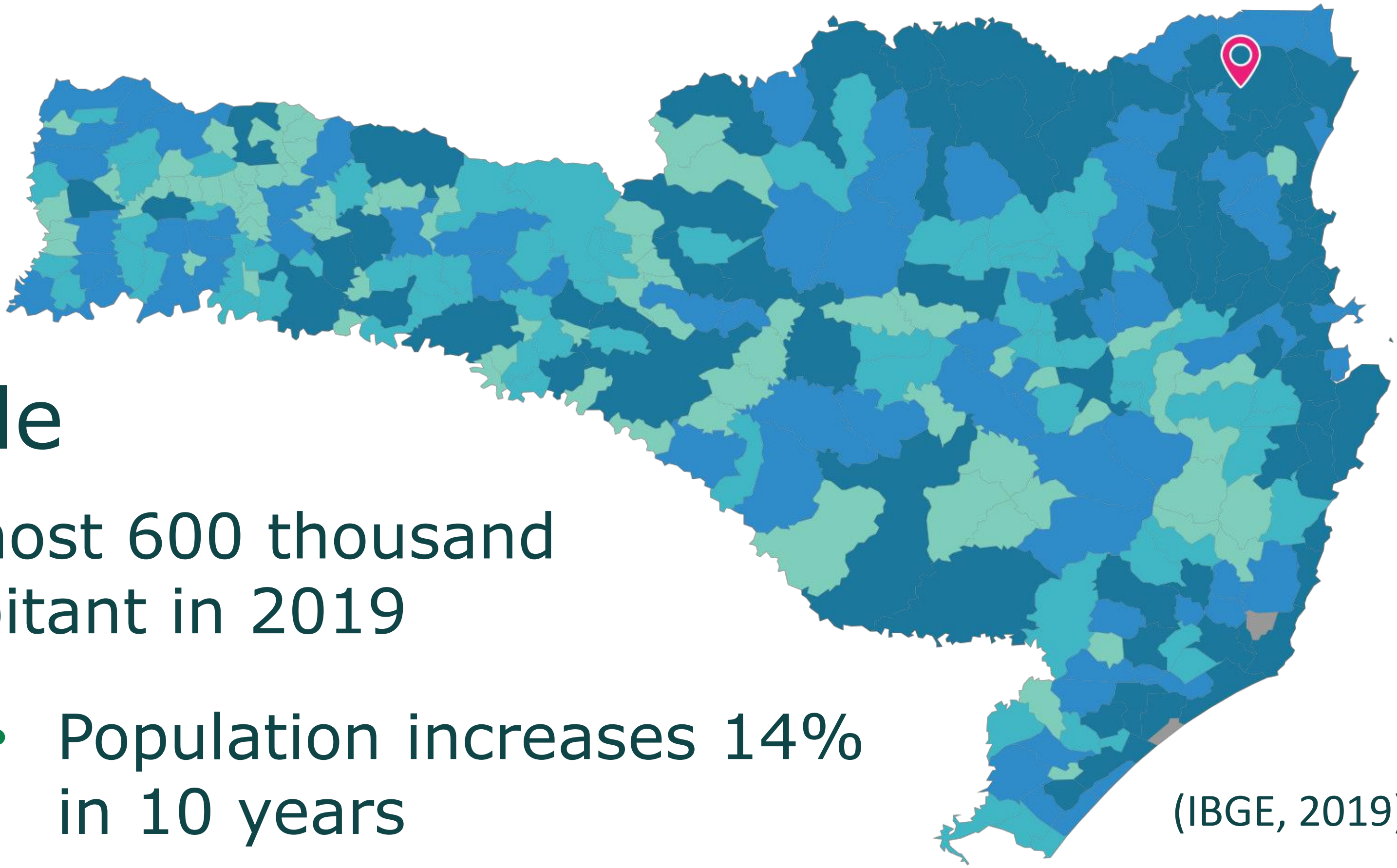
Short CV

- Associate professor of Santa Catarina State University;
- Department of Computer Science;
- Graduate program of Applied Computing
- Research Interest:
  - Trajectory data analysis;
  - Stream data mining;
  - Vehicle routing problem optimization.

Agenda

- Introduction;
- Problem;
- Objective;
- First Results;
- Next Steps;
- Team;
- Past Experiences.

Introduction



(IBGE, 2019)

- Joinville
  - Almost 600 thousand habitant in 2019
    - Population increases 14% in 10 years
      - Joinville had 1,827 km road network in 2017

Introduction

- Amount of vehicles in Joinville:

2009		2019
263,667 vehicles	X	414,837 vehicles
170,978 cars		266,958 cars

(DETRAN-SC, 2019)

- An increment of 56% of cars in 10 years;
- Rate of vehicle per habitant is 0.77;
  - Florianópolis has 0.72.

Introduction

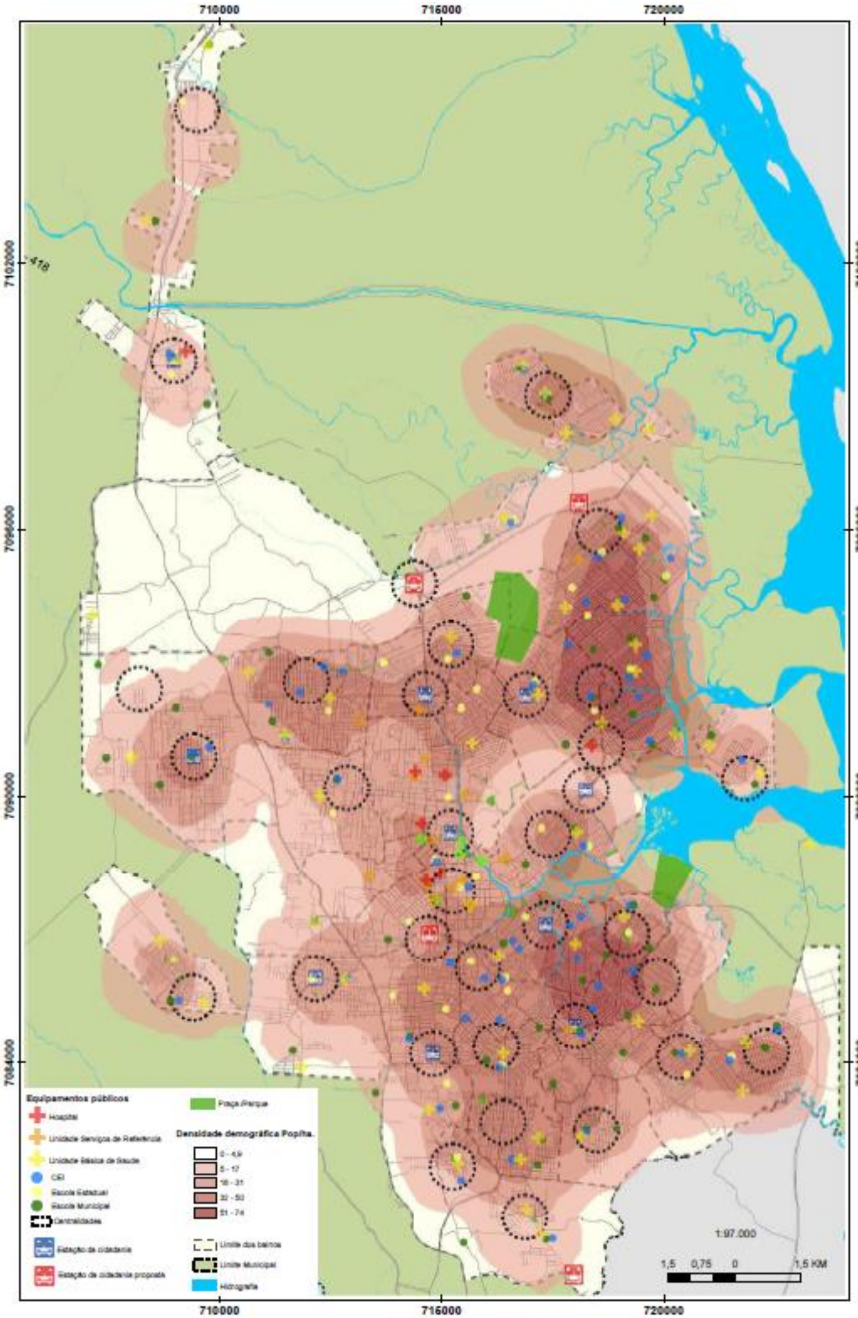
- Ways of transportation in Joinville

Way	%
Foot	23%
Car	35%
Public Transportation	24%
Motorcicle	6%
Bycicle	11%
Others	1%

(SEPUD-Joinville, 2016)

Introduction

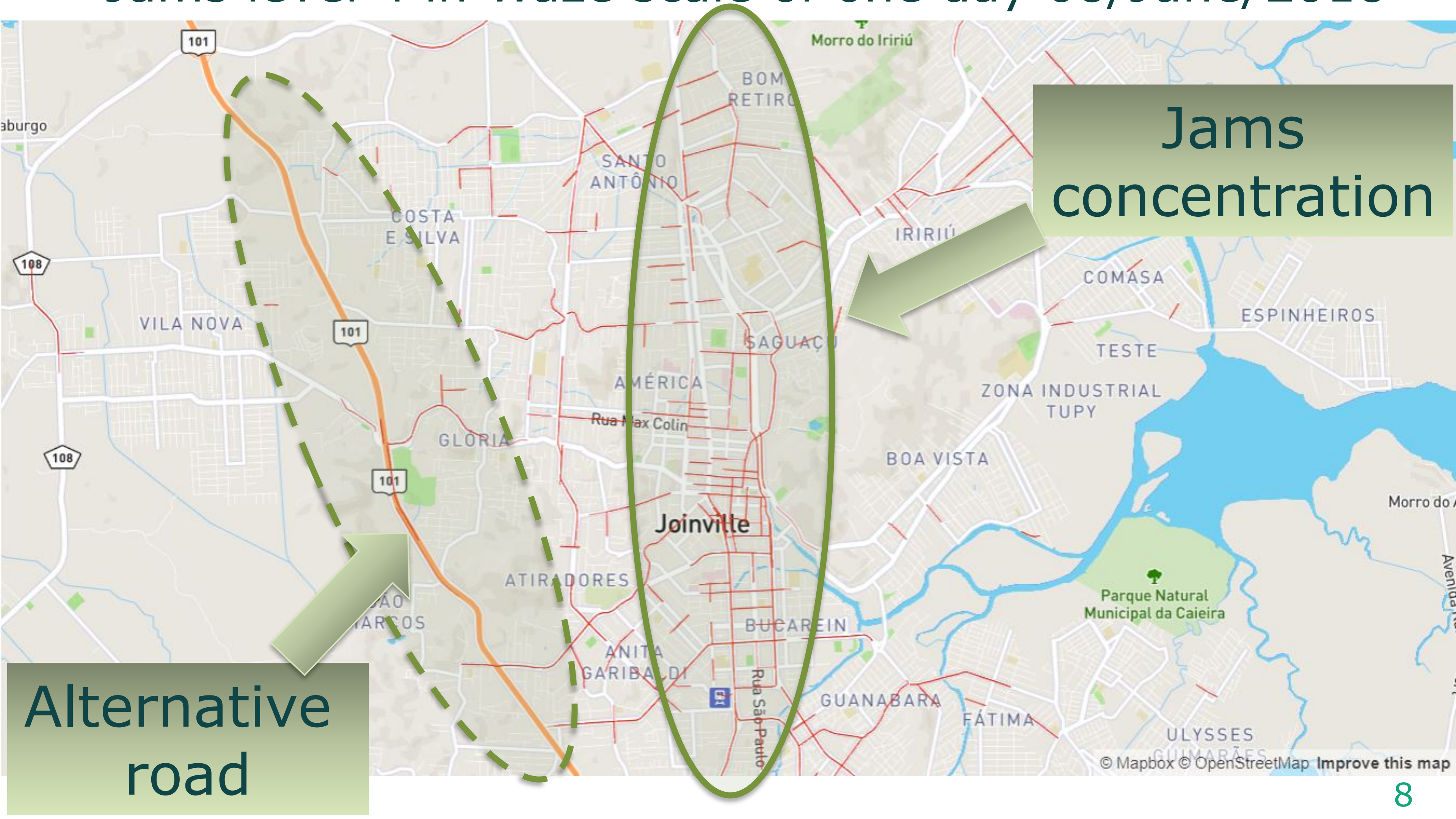
- Widespread territorial occupation;
- People live in the south and work in the north;
  - 30km from south to north;
- Scarce budget to invest the mobility.



(SEPUD-Joinville, 2016)

Introduction

- Jams level 4 in Waze scale of one day 08/June/2018



Problem

- Which are the regions or streets that should have the mobility investments prioritized?

Objective

- To build mobility indicators that allow the identification of the regions in the city with critical mobility problems based on the analysis of traffic information.

Smart Mobility Methodology

1. **Diagnostic** — Which streets should be intervened first?
2. **Demand modeling** — What is the traffic flow on those streets?
3. **Simulation** — How will traffic respond to different interventions?
4. **Intervention** — How can we accelerate the implementation?
5. **Follow-up** — How did traffic actually respond to the intervention?

(SEPUD-Joinville, 2018)

Data Sources

- Waze Connected Citizens Program
  - It provides **accidents** and **congestion** on reports within 2” of time interval.
- Speed limit radars
  - They **count** the number of **vehicles** within 15’’ of time interval.
- Accidents report
  - **More detailed** information about an **accident** in provide by Joinville firefighters.

- These data are collected since 2017.

Data Sources

Waze CCP	▪ Length(m) ▪ Speed (km/h) ▪ Delay (s)
Traffic Radars	▪ Traffic flow(veh/hour) ▪ Slots of 15 minutes ▪ 100 spots across the city
GIS	▪ +2000 streets ▪ +16000 sections
Accidents	▪ Location ▪ Entities involved (car, motorcycle, bike, etc)

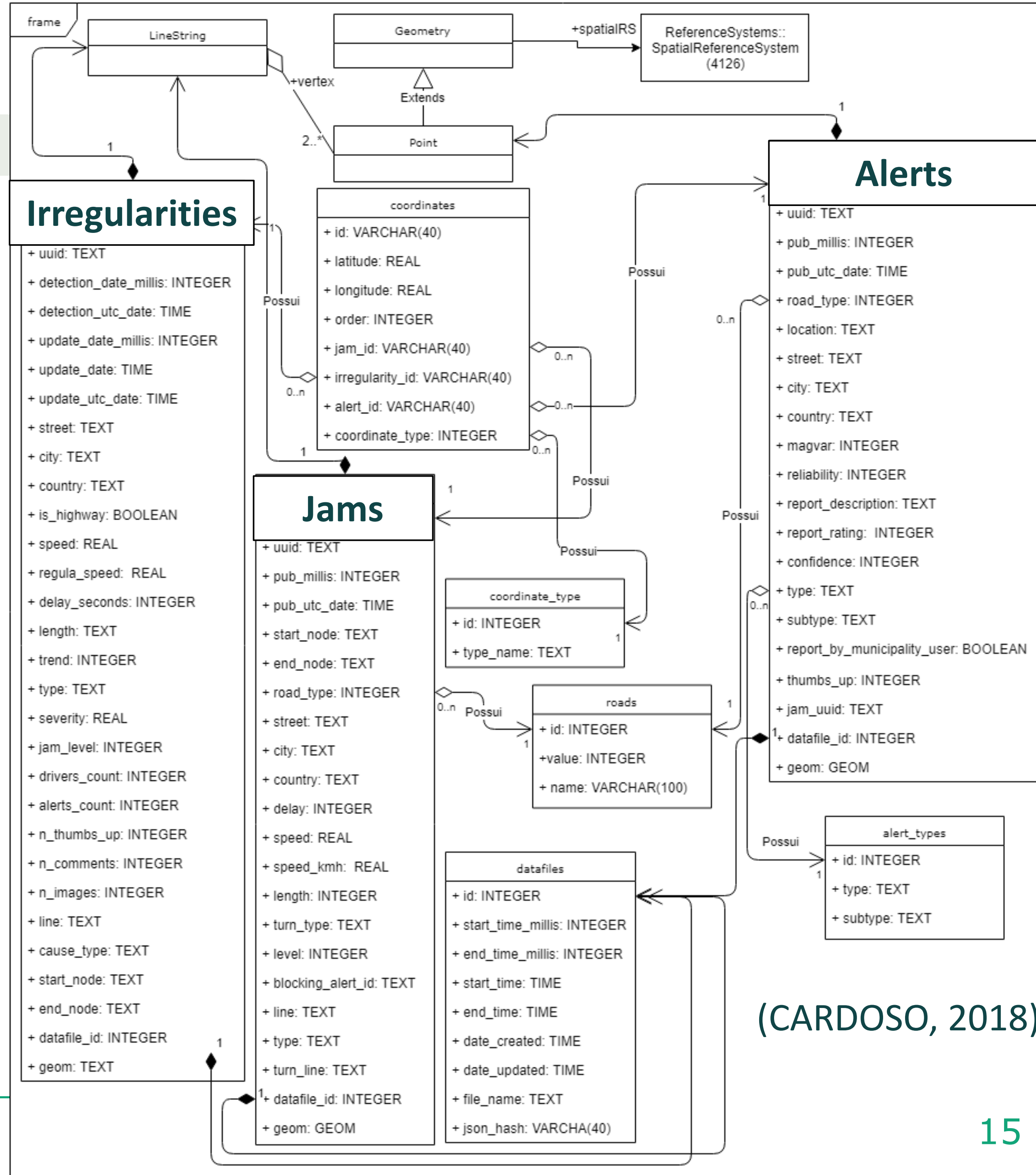
(SEPUD-Joinville, 2018)

Mobility Indicators

- Possible mobility indicators:
  - Geolocation of jams regarding:
    - Jams' average speed;
    - Jams' average frequency;
    - Jams' average duration;
    - Jams' average length.
  - Spatio-temporal correlation between jams;
  - Spatio-temporal correlation between jams and alerts;
  - Spatio-temporal jams and alerts patterns.

Data Sources

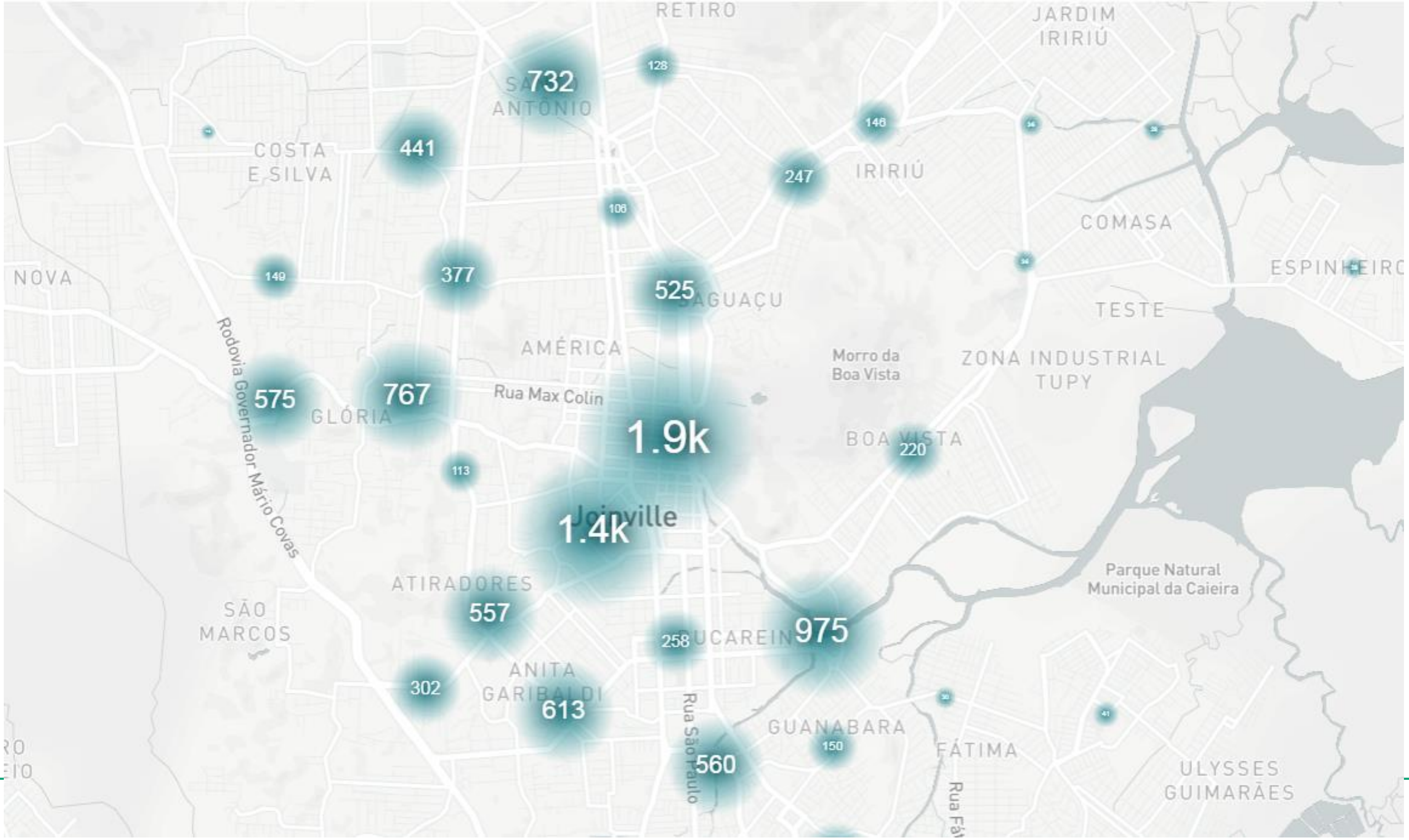
- Waze Database Schema



(CARDOSO, 2018)

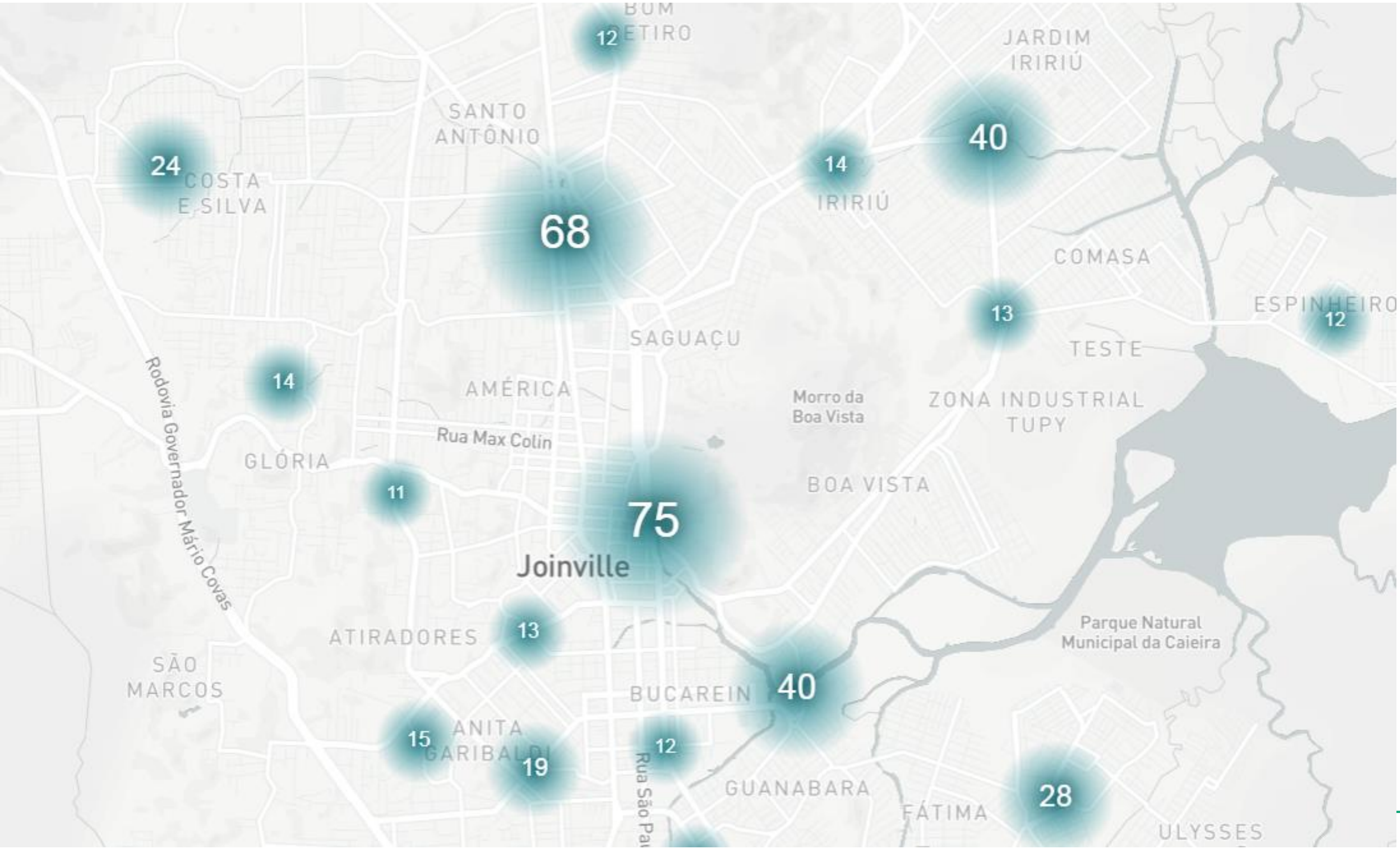
First Results

- Traffic jam alerts reported by users



First Results

- Accident alerts reported by users

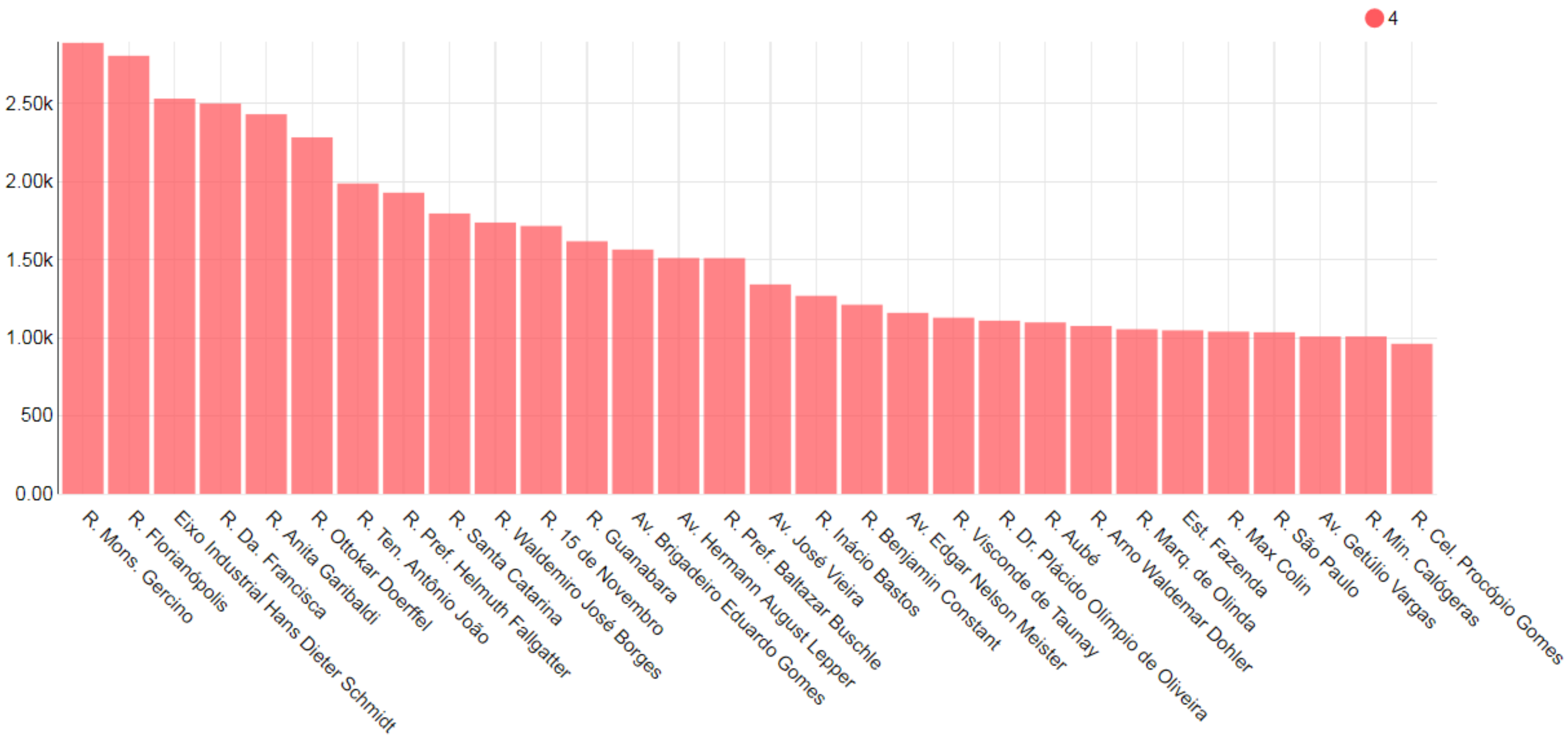


First Results

- Jams level 4 (highest level)

First Results

- Streets with highest jams' length



Next Steps

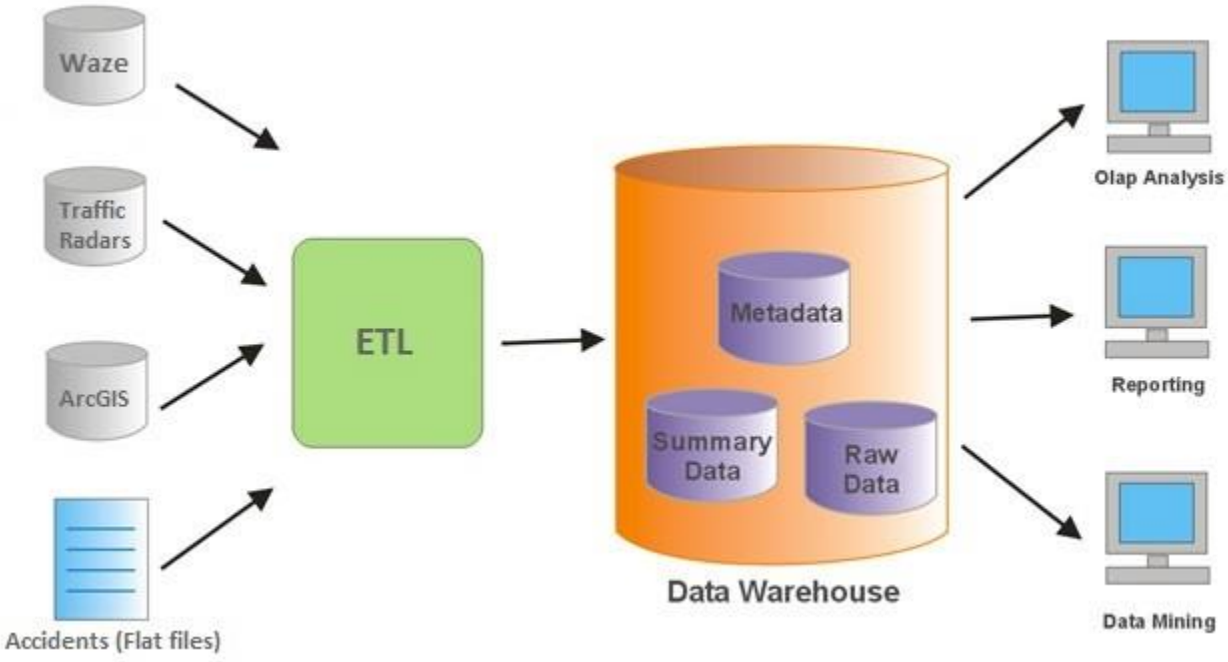
- Propose an appropriated data schema;
- Construct a suitable data index model;
- Apply data mining techniques;
- Propose mobilities indicators;
- Design intuitive dashboards.

Team

- Professors:
  - Prof. Dr. Elisa Henning
  - Prof. Msc. Éverlin Fighera Costa Marques
  - Prof. Dr. Fabiano Baldo
  - Prof. Dr. Omir Correia Alves Jr.
  - Prof. Dr. Rebeca Schroeder Freitas
  - Prof. Dr. Ana Mirthes Hackenberg
- Students:
  - Master graduate students
  - Undergraduate students

Work in progress

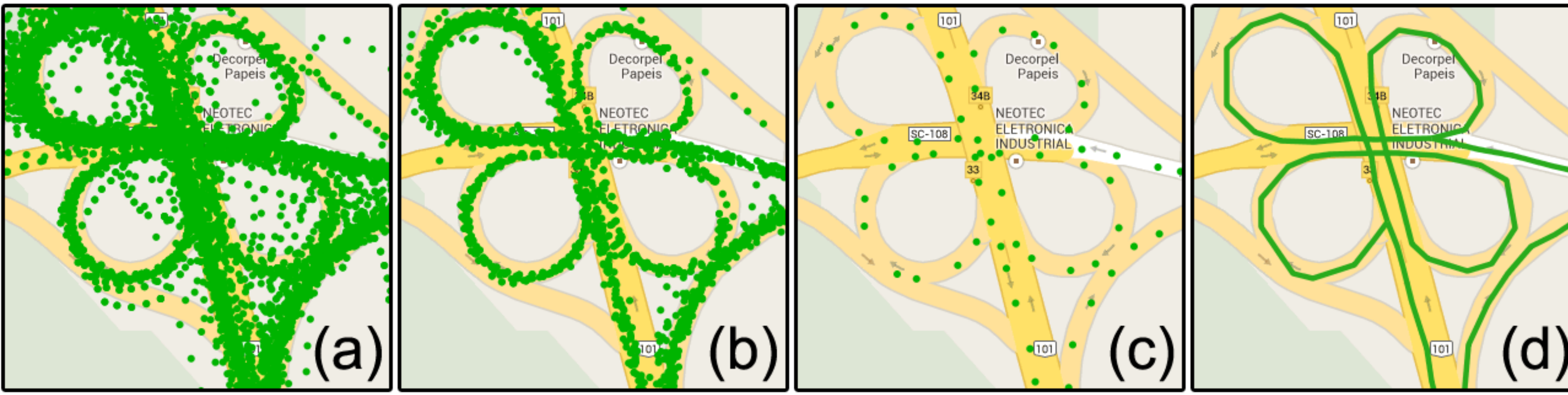
- Indexing Traffic Events



Duarte M. M. G., Schroeder R., Hara, C. S. (2019). An Indexing Framework for Traffic Events. In Workshop de Teses e Dissertações em Banco de Dados (WTDBD – SBBD).

Past Experiences

- Generation of road maps



Costa, G. H., & Baldo, F. (2015). Generation of road maps from trajectories collected with smartphone–a method based on genetic algorithm. *Applied Soft Computing*, *37*, 799-808.

Past Experiences

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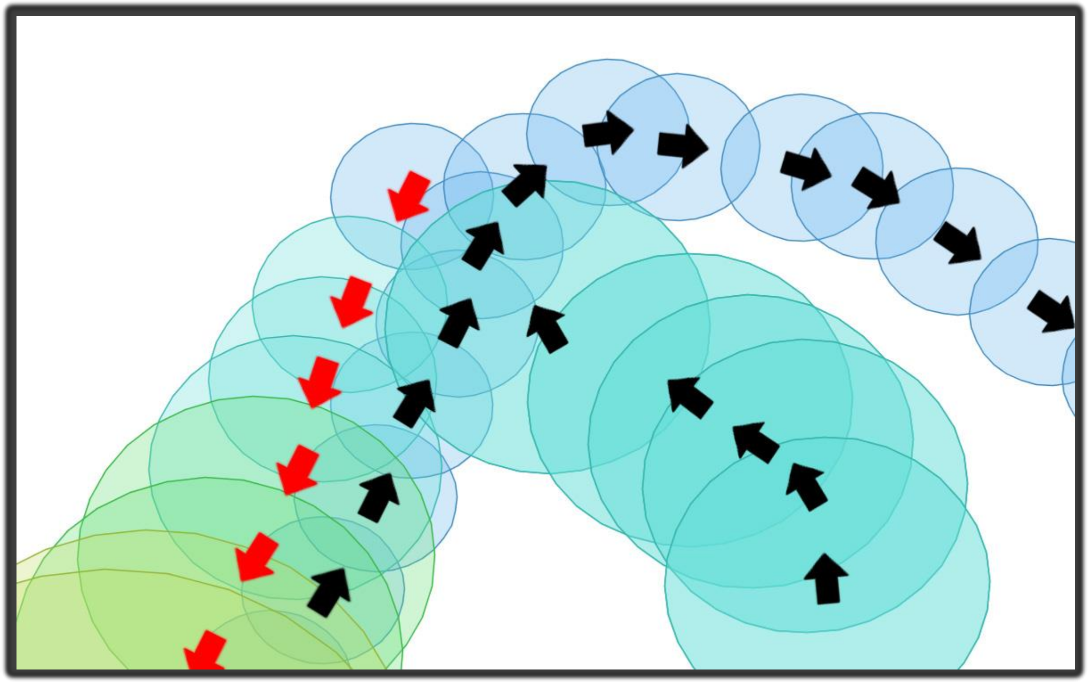

Past Experiences

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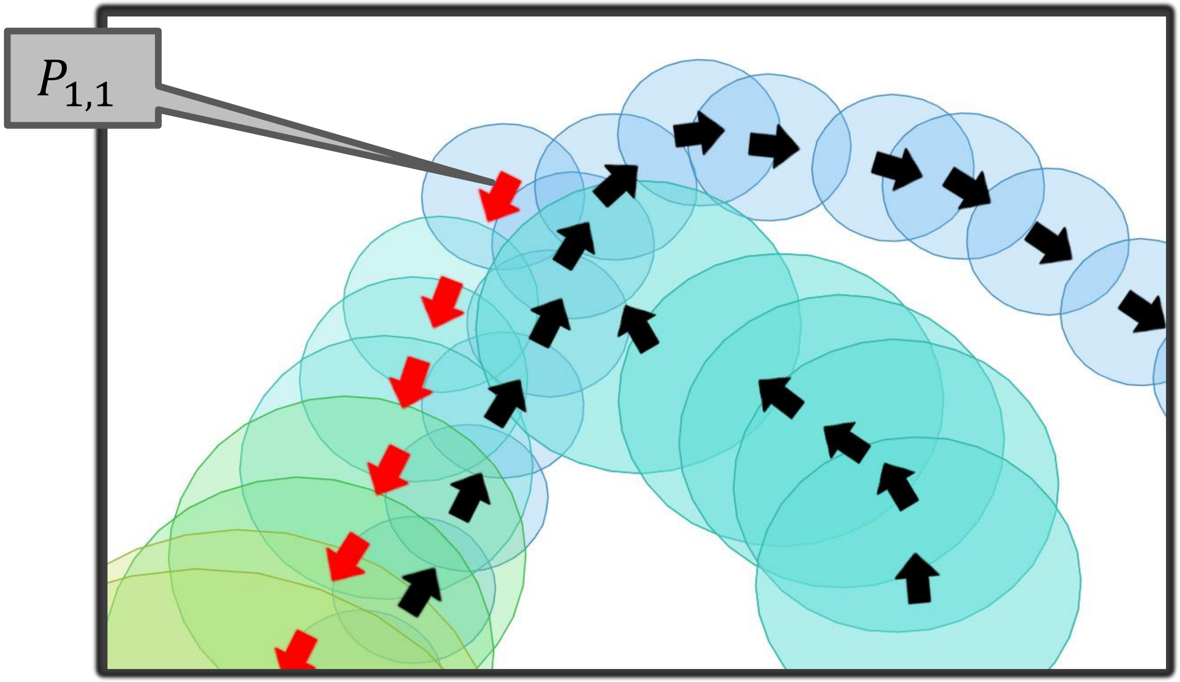

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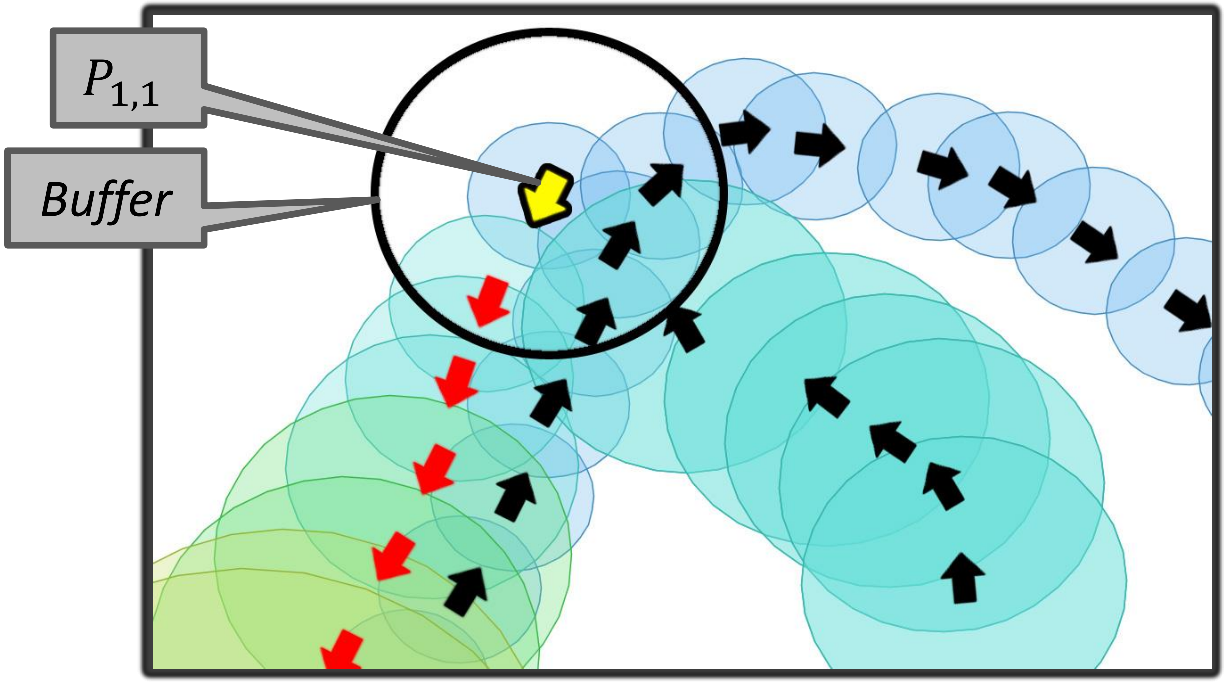

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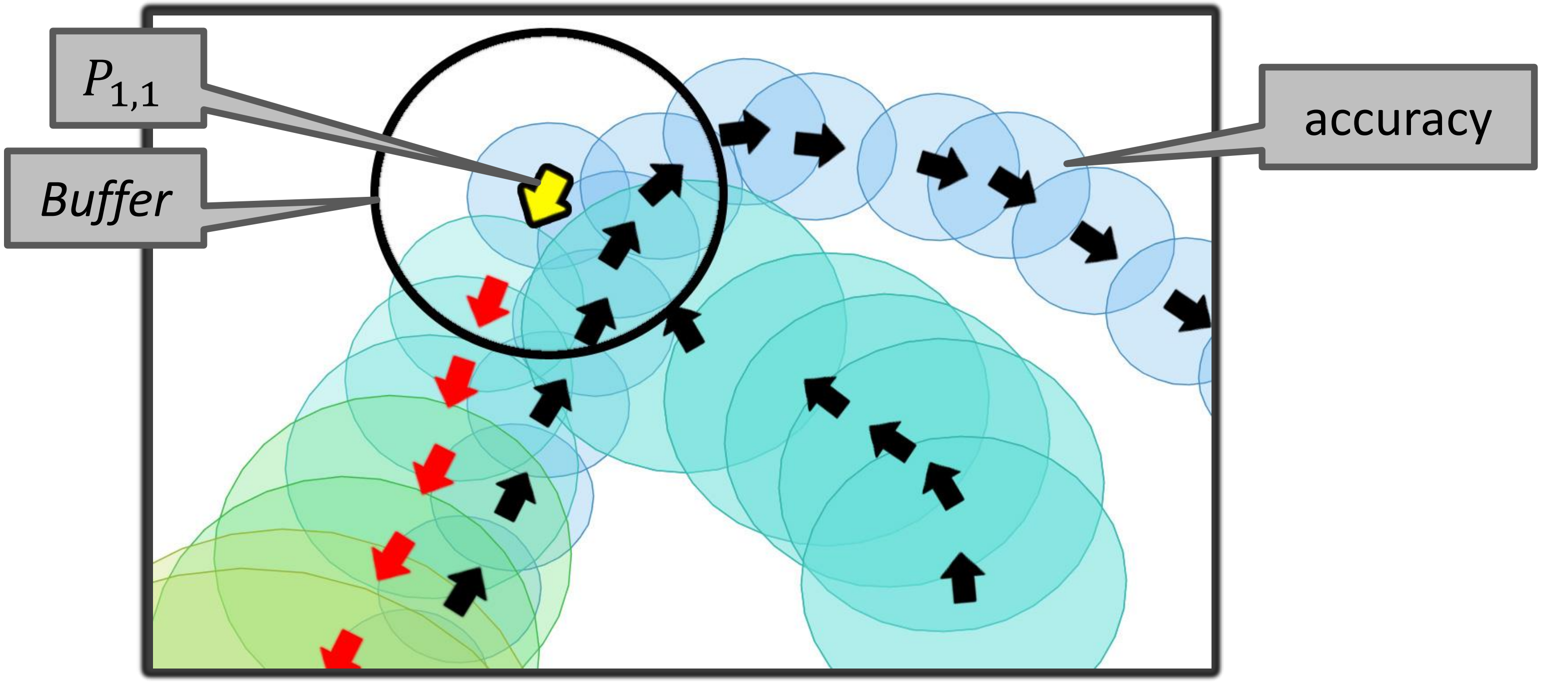

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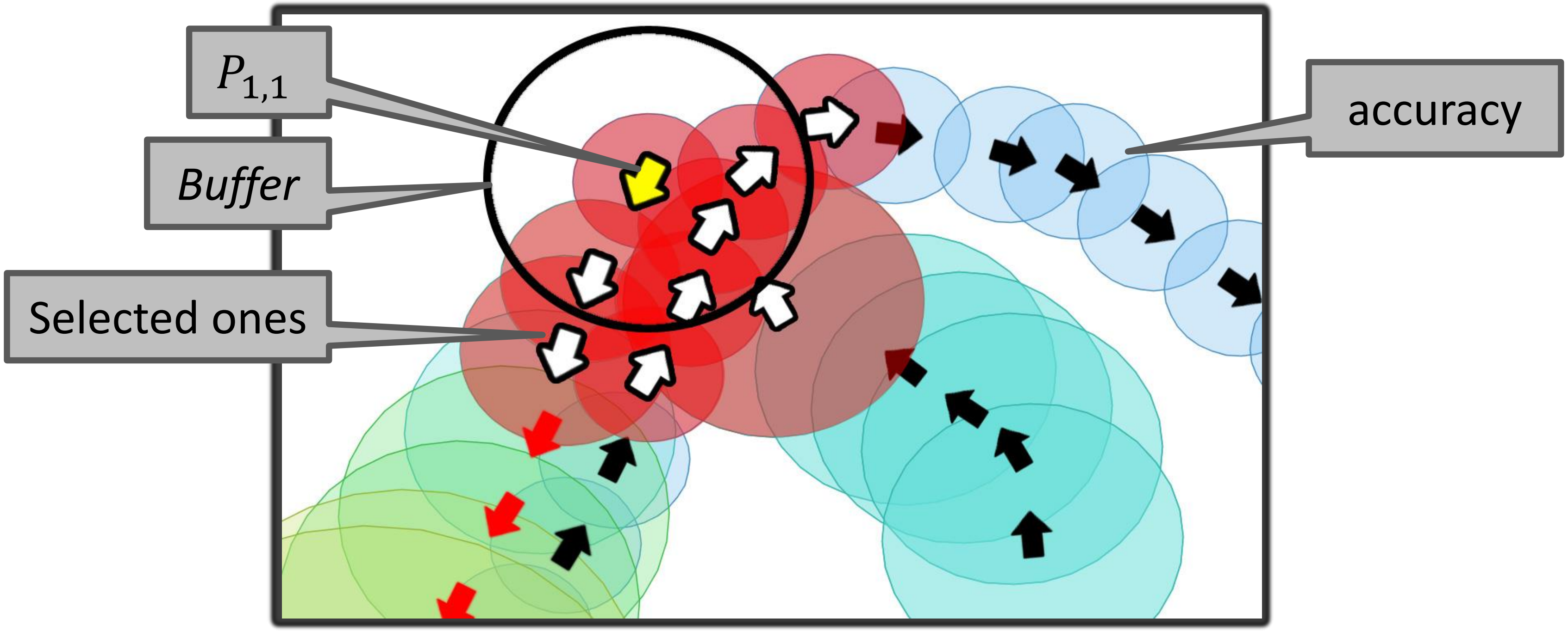
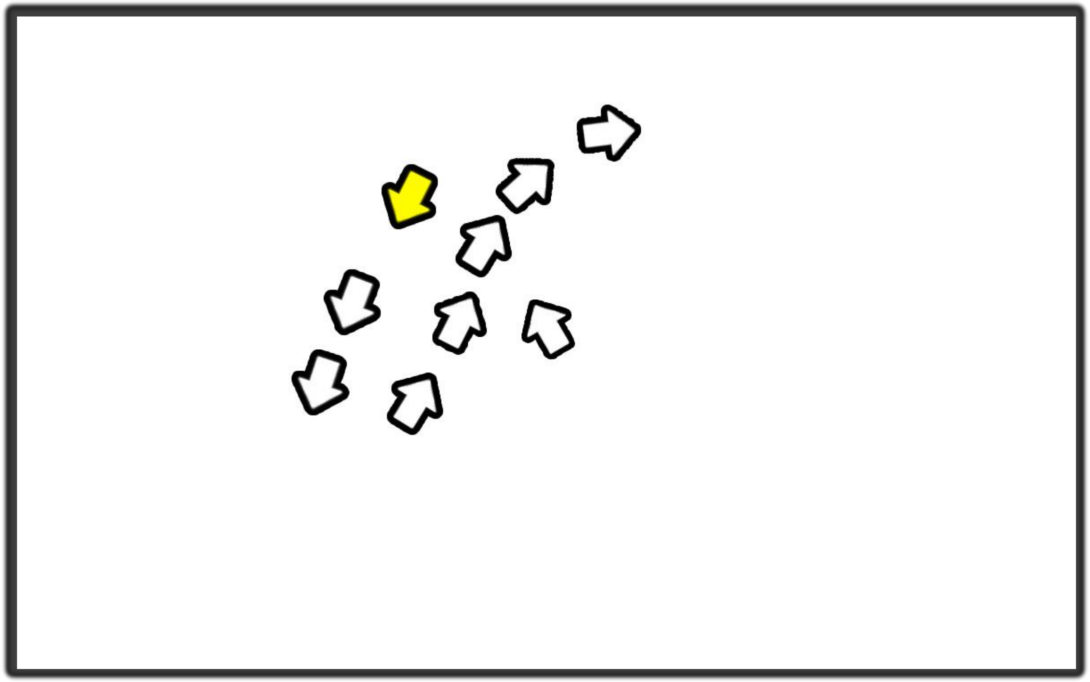


Past Experiences

- Generation of road maps



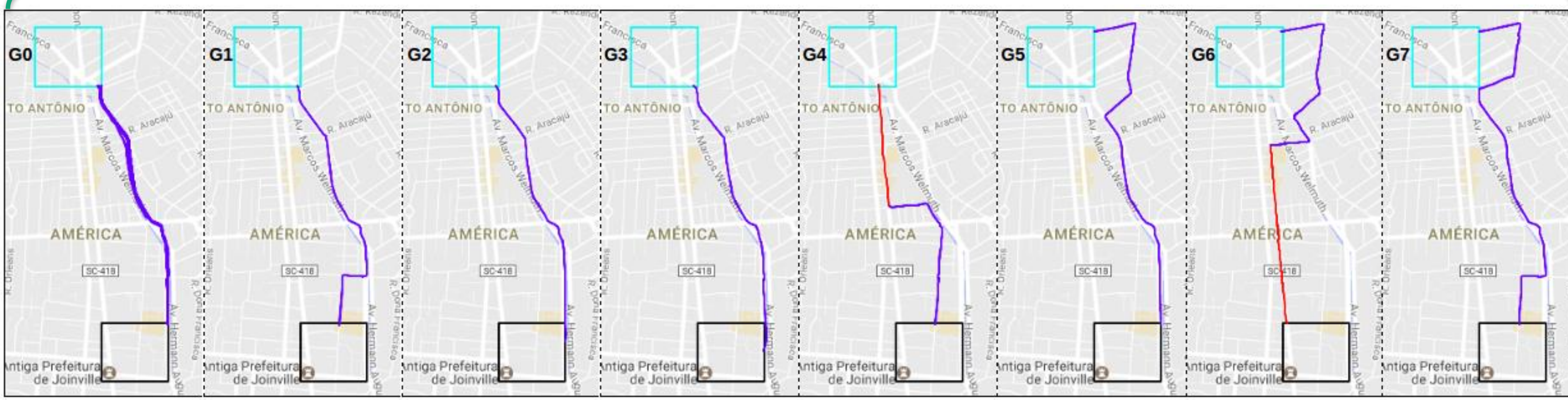
Past Experiences

$$FITNESS(C_x, S) = \frac{\sum_{i=1}^{n''} IT(S_i) \cdot MT + IA(S_i) \cdot MA + ID(C_x, S_i) \cdot MD}{n''}$$

- C_x: coordinate candidate
- S: set of near points
- n'': size of S set
- $IT(S_i)$: time influence
- $IA(S_i)$: accuracy influence
- $ID(C_x, S_i)$: distance influence

Past Experiences

- Suggest Alternative Routes



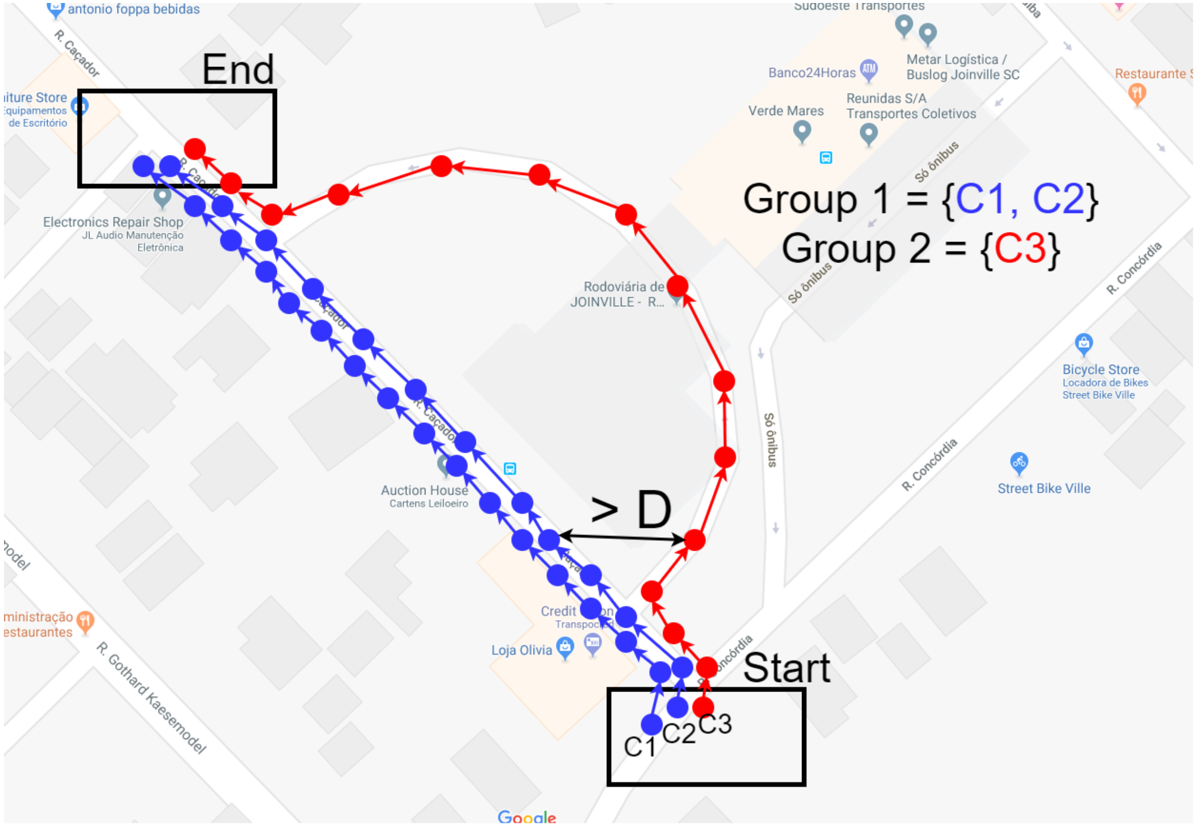
Schmitt, J. P., & Baldo, F. (2018). A Method to Suggest Alternative Routes Based on Analysis of Automobiles' Trajectories. In *2018 XLIV Latin American Computer Conference (CLEI)* (pp. 436-444). IEEE.

Past Experiences

- Suggest Alternative Routes

- **Group:**
  - Euclidean distance
  - D is a parameter
  - Groups are created dynamically to comport all candidates

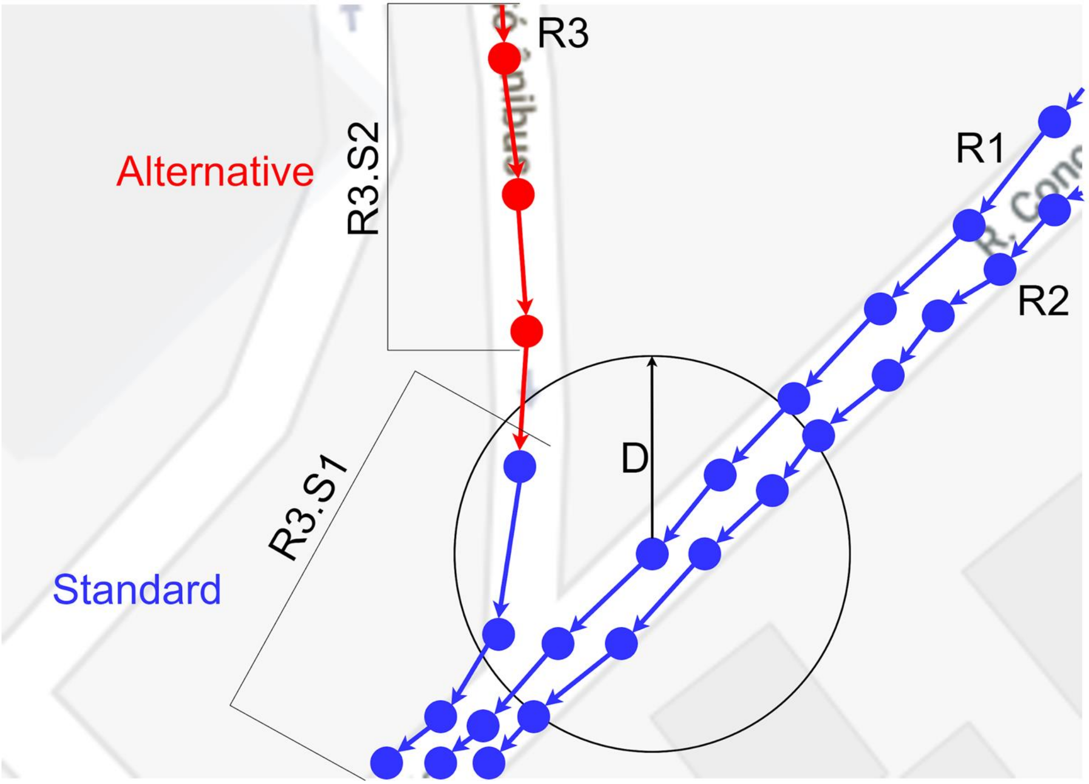
- **Standard and alternative groups**
  - Parameter K = number of standard groups



Past Experiences

- Suggest Alternative Routes

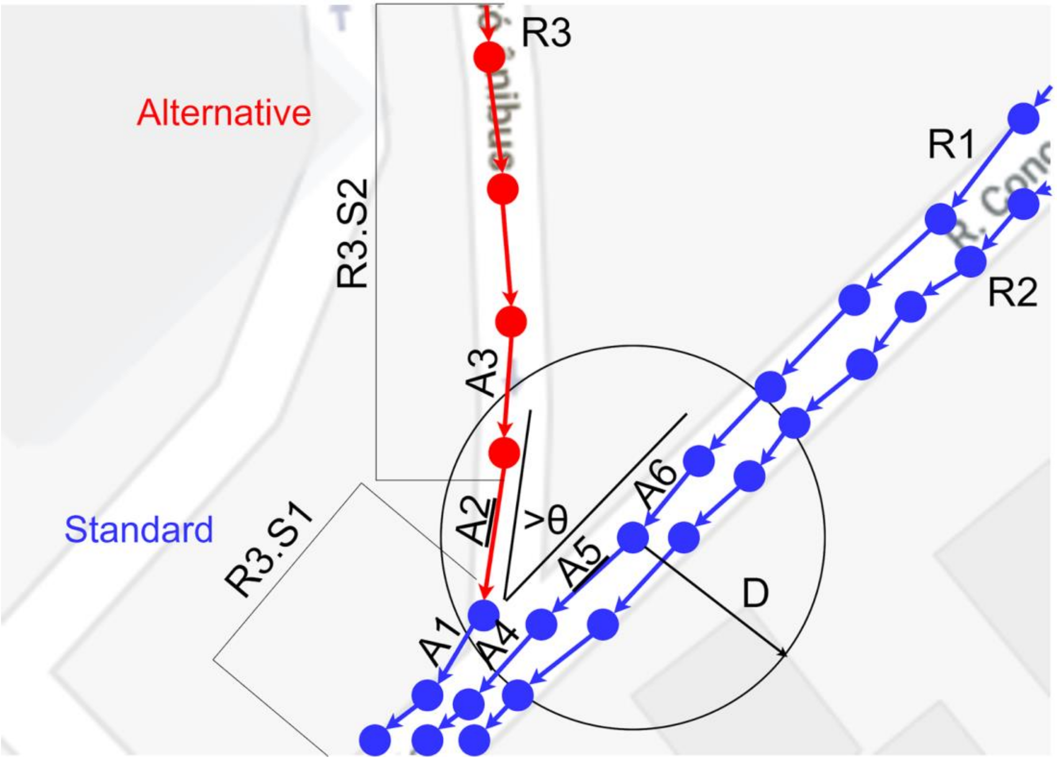
- **Route:**
  - Represents a path between start and end regions.
  - Used to suggest alternative directions.
  - First step:
    - Route segmentation by **distance**.



Past Experiences

- Suggest Alternative Routes

- **Route:**
  - Second step:
    - Route segmentation by **angle**.



Past Experiences

- Suggest Alternative Routes

Parameters:

- SH = Start Hour
- EH = End Hour
- SR = Start Region
- ER = End Region
- I = Interpolation
- SD = Std. Dev.
- σ = Sigma
- D = Distance
- θ = Angle
- KS = Standards groups

Algorithm 1 TODS - Algorithm

Require: $SH, EH, SR, ER, I, SD, \sigma, D, \theta, KS$

Recovering:

$t \leftarrow FindTrajectories(SR, ER)$

for $i \leftarrow 0$ **to** $Length(t)$ **do**

  $FilterNoisePoints(t[i], SD, \sigma)$

  $InterpolatePoints(t[i], I)$

end for

$C \leftarrow GetCandidates(t, SH, EH, SR, ER)$

$idx \leftarrow CreateClusteringGrid(C, D)$

Grouping:

$GT \leftarrow GetTrajectoriesGroups(C, idx)$

Separation:

$SGT \leftarrow GetStandardTrajectories(GT, KS)$

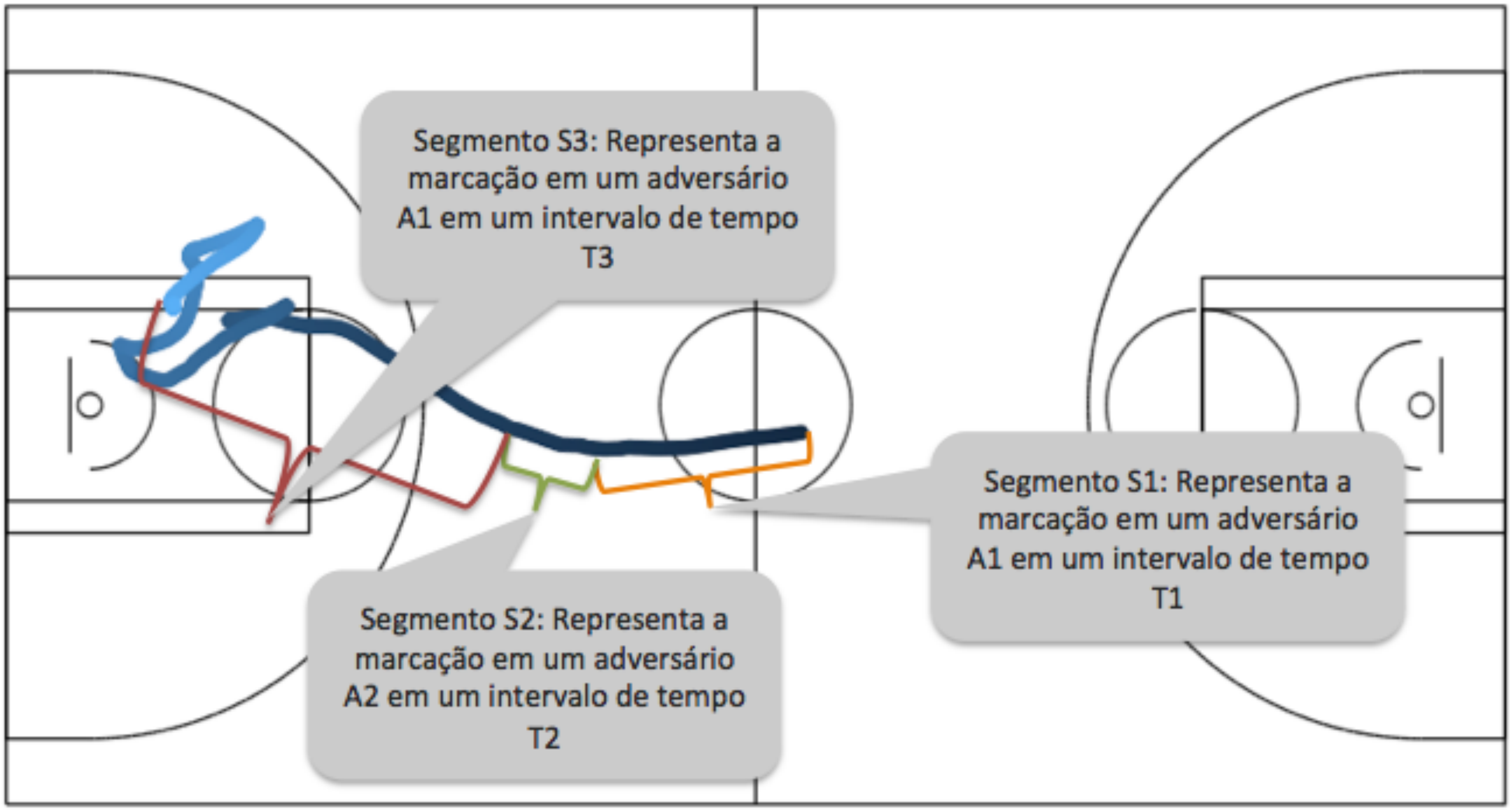
Segmentation:

$R \leftarrow GetTrajectoriesRoutes(GT, SGT, D, \theta)$

return SGT, R

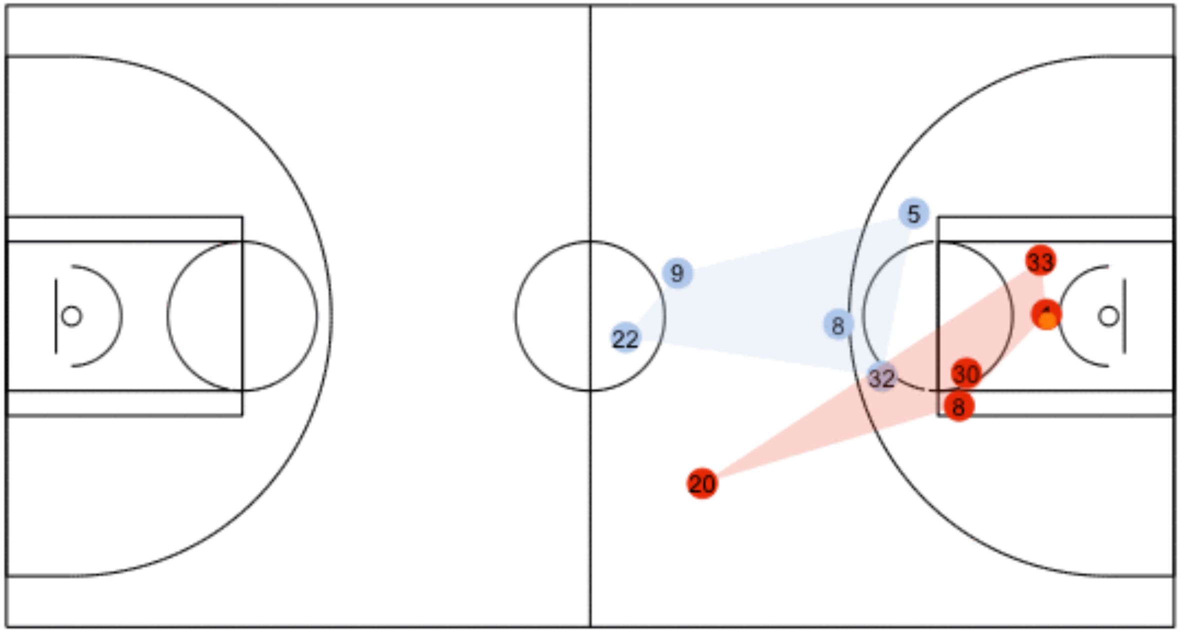
Past Experiences

- Guarding action recognition



Past Experiences

- Guarding action recognition



Past Experiences

- Guarding Coefficient

$$\varphi(P_d, P_o) = (w_\gamma * \gamma(P_d, P_o)$$
Spatial proximity

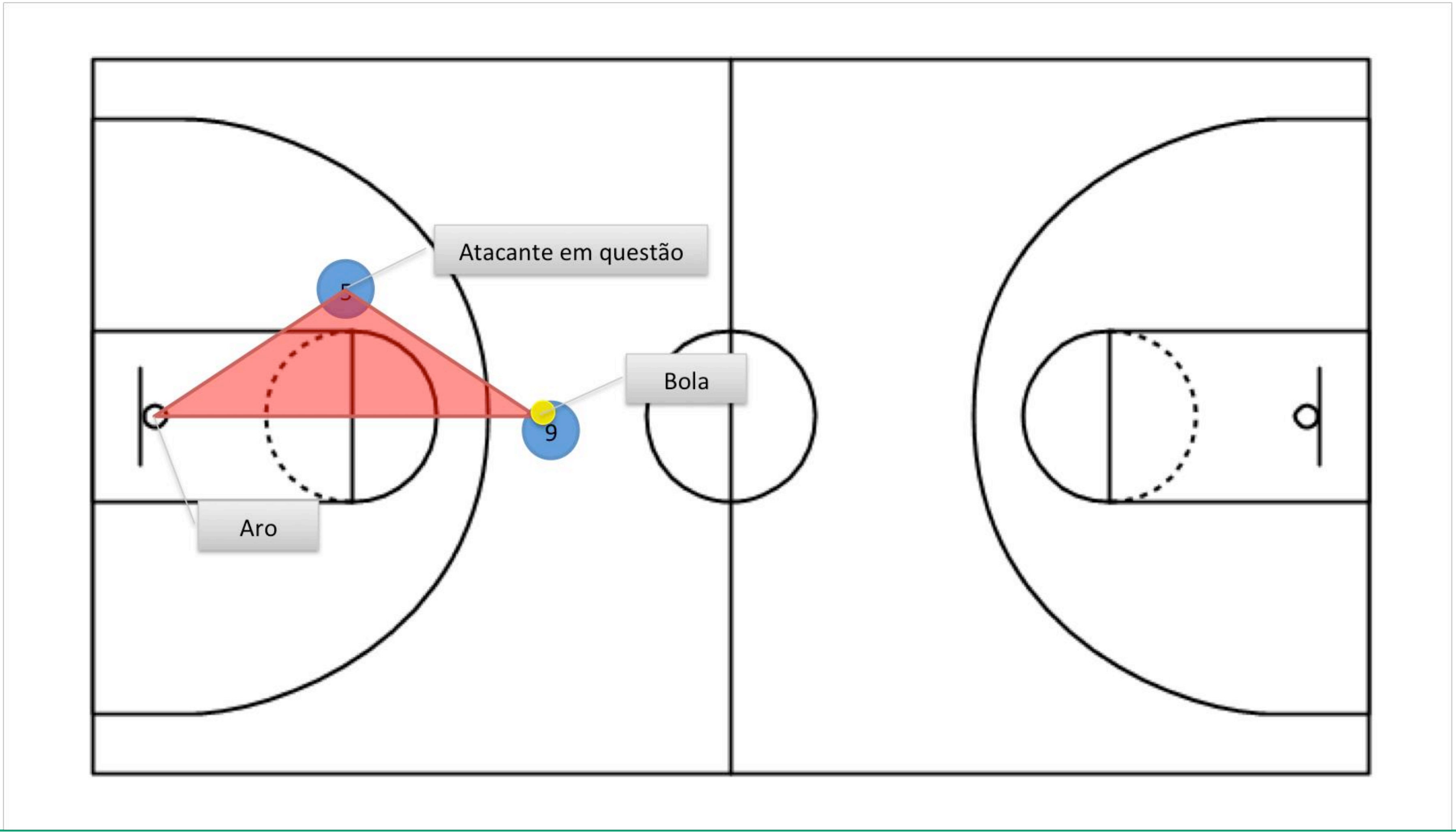
$$+w_\psi * \psi(P_d, P_o)$$
Position in the referential area

$$+w_\delta * \delta(P_d, P_o)$$
Direction similarity

$$+w_\sigma * \sigma(P_d, P_o)),$$
Velocity similarity

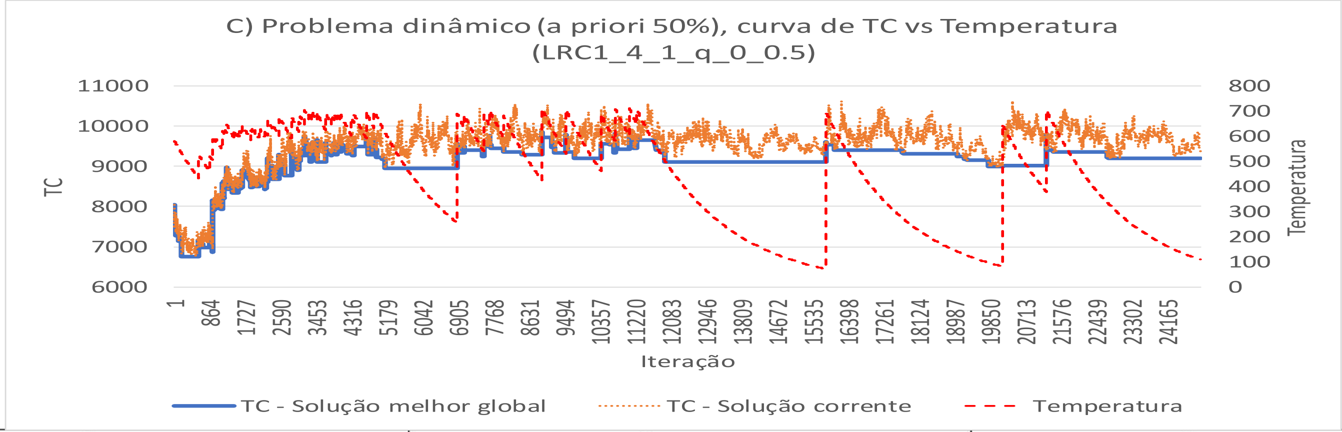
$$0 < \varphi \leq 1$$

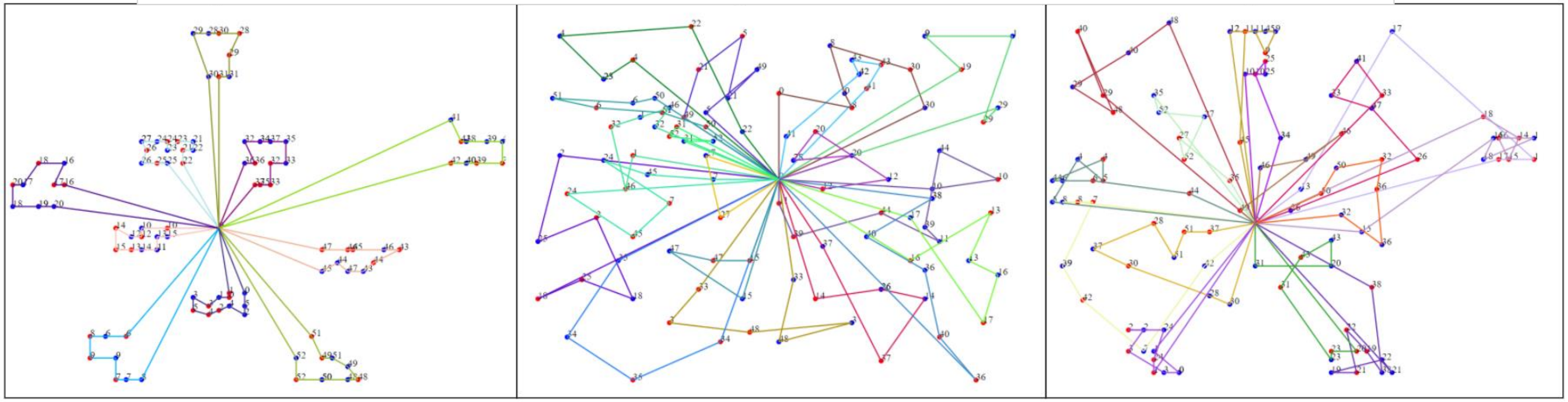
Past Experiences



Past Experiences

- Vehicle routing problem

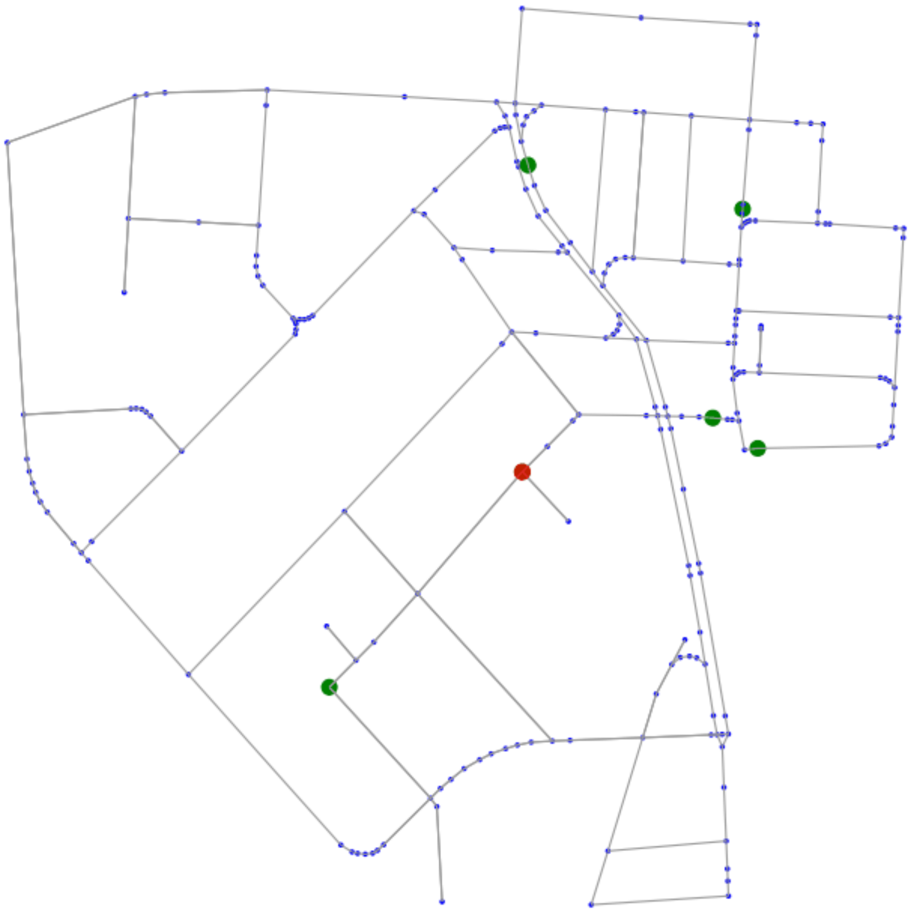




Schmitt, J. P., Baldo, F., & Parpinelli, R. S. (2018). A MAX-MIN Ant System with Short-Term Memory Applied to the Dynamic and Asymmetric Traveling Salesman Problem. In *2018 7th Brazilian Conference on Intelligent Systems (BRACIS)* (pp. 1-6). IEEE.

Past Experiences

- Vehicle Routing Problem



Past Experiences

- Vehicle routing problem
  - Green VRP (GVRP);
  - Dynamic VRP (DVRP);
  - Fractional or Split Delivery VRP (SDVRP);
  - Bi dimensional Vehicle Routing Problem with time windows constraints.

Gauer, V. P., Weiss, F., & Alves, O. C. (2019). Meta Heuristics Applied to VRP problem with Heterogeneity and Simultaneous Picking and Delivery. In *2019 LI Brazilian Symposium on Operational Research.*

Peripolli A., Alves, O.C. (2020). Bi dimensional VRP Problem with TW constraints. In Brazilian Symposium on Information Systems. (submitted in September 2019).

Past Experiences

- Data Management of large datastores:
  - Partitioning (RDF)
  - Query processing (RDF)
  - Data mining

Schroeder R., Hara C. S. (2015). Partitioning Templates for RDF. In Advances in Databases and Information Systems (ADBIS).

Penteado R. R. M., Schroeder R., Hara C. S. (2016). Exploring Controlled RDF Distribution. In IEEE International Conference on Cloud Computing Technology and Science (CloudCom).

Menezes S. L., Schroeder R., Parpinelli R. S. (2016). Mining of Massive Databases Using Hadoop MapReduce and Bio-inspired algorithms: A Systematic Review. RITA, v. 23(1).

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Thank you!

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