

# MobVis: A Framework for Analysis and Visualization of Mobility Traces

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Federal University of Ouro Preto



# Introduction

## • Mobility •

Growth of mobile devices and mobility data.

## IoT

Increase on the amount of shared data.



[Vehicle Tracking - by storyset](#)

# Introduction

## Mobility

Growth of mobile devices and mobility data.

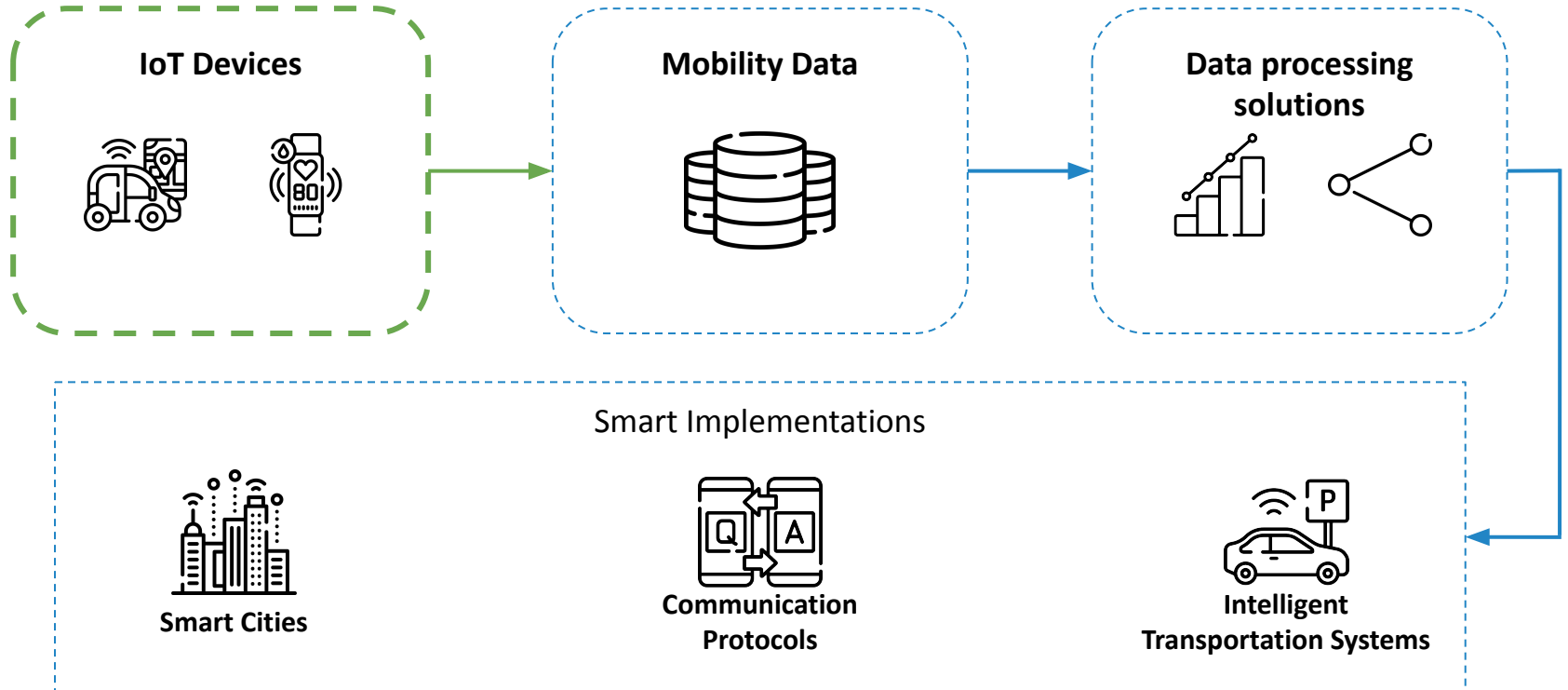
• IoT •

Increase on the amount of shared data.

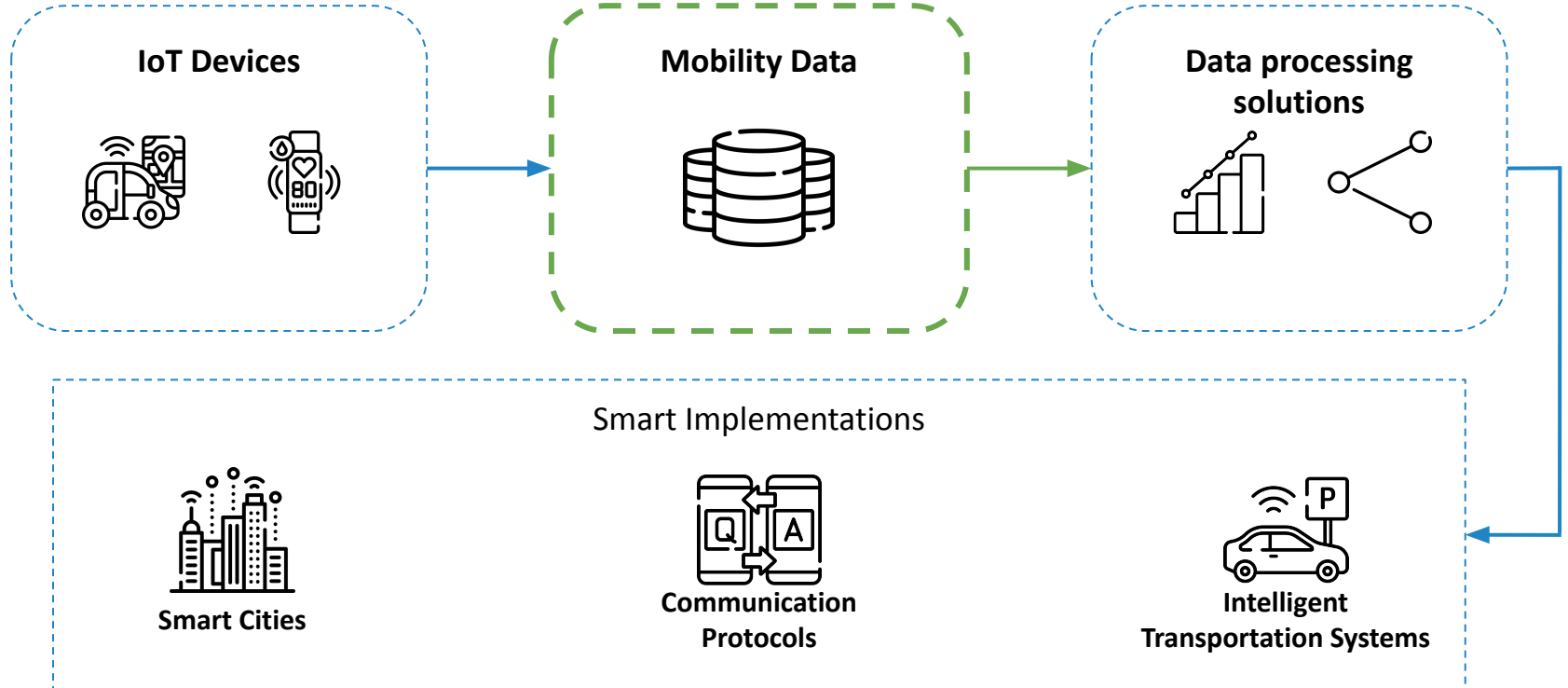


[Smart devices - by Freepik](#)

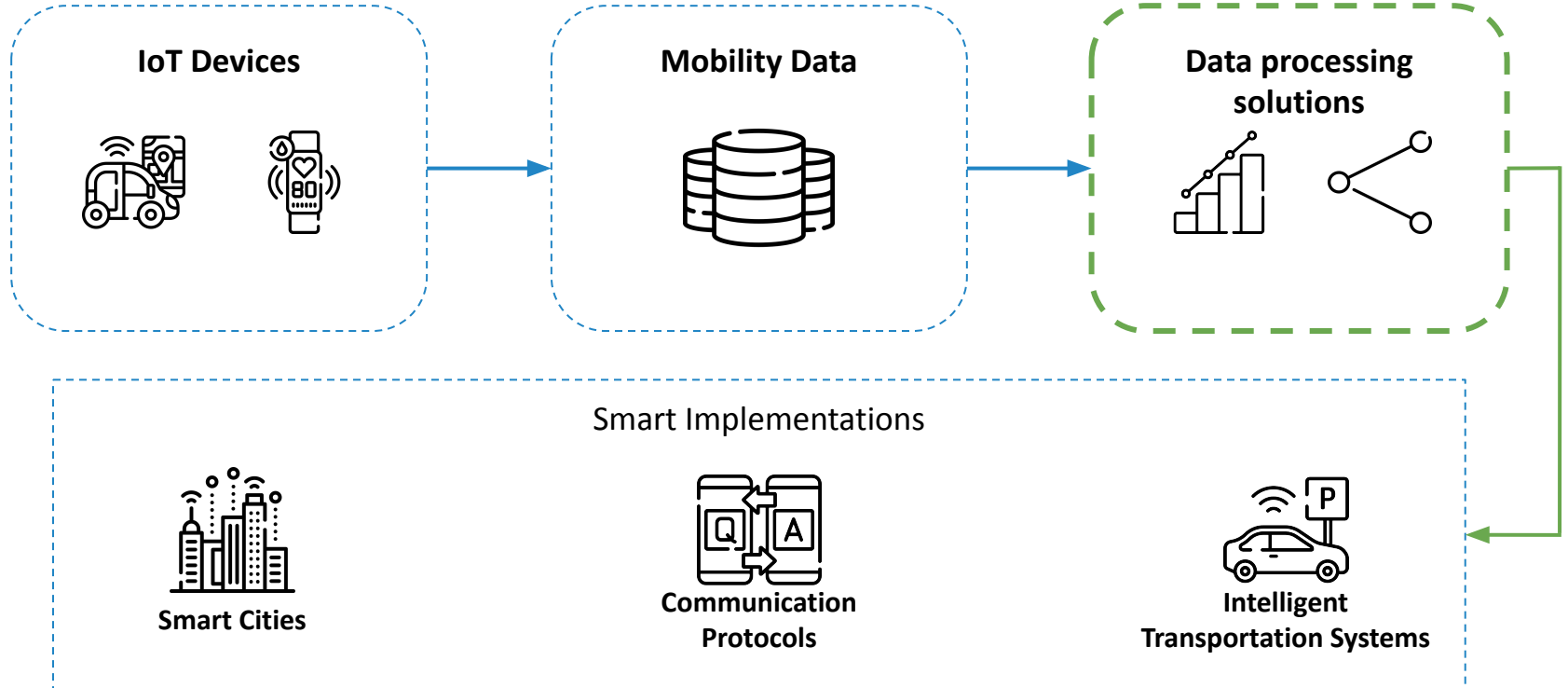
# Motivation



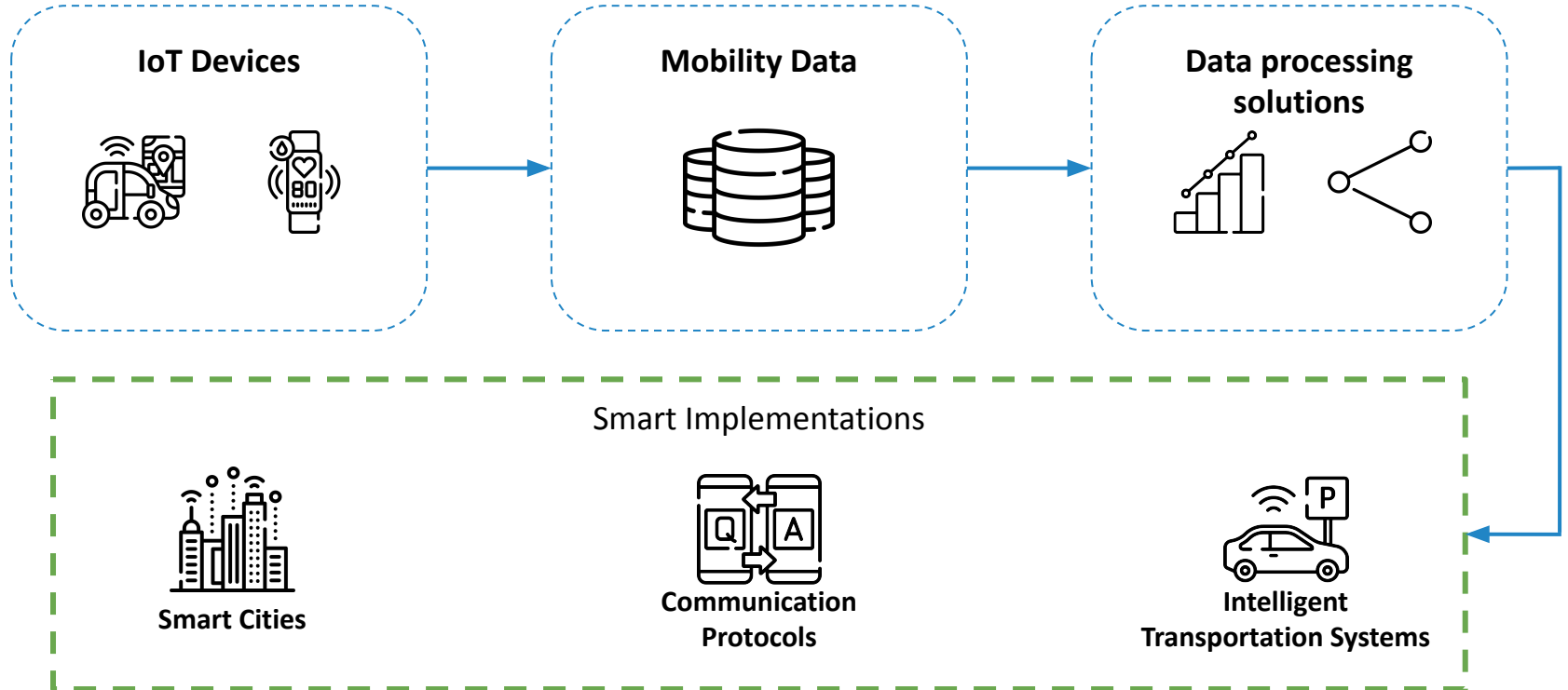
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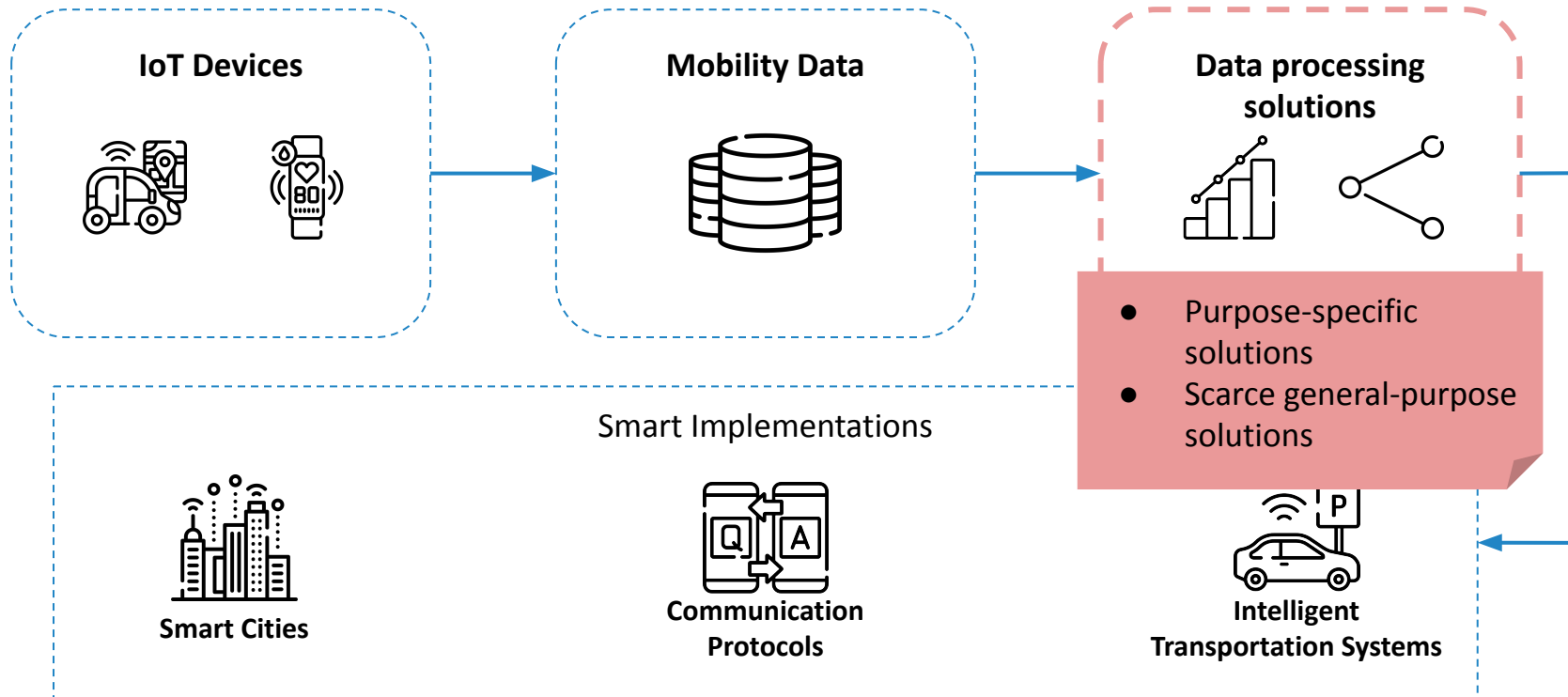
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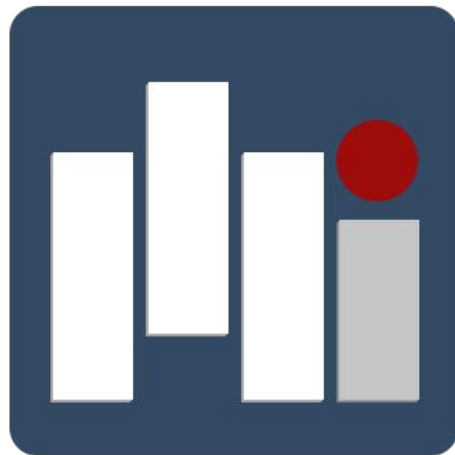
# Motivation





# Contributions

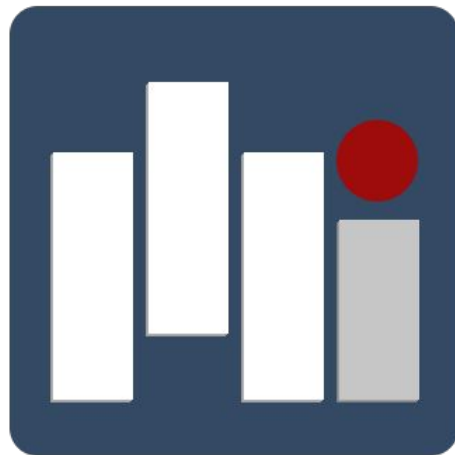
- **Mobility Visualization Framework (MobVis):**
  - Simple open-source environment made with Python:
    - Compute and visualize many metrics on the same place;
    - Make comparisons between traces from different sources.



<https://github.com/lucNovais/MobVis>

# Contributions

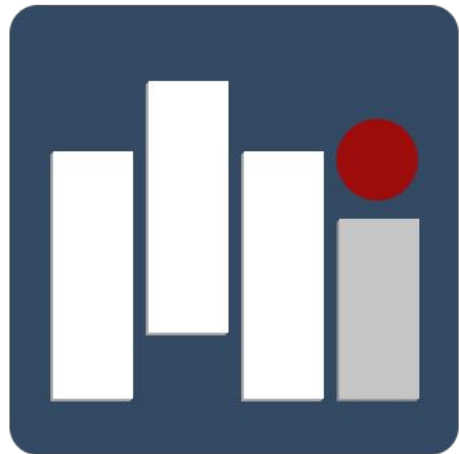
- **A web service (MobVis-Web):**
  - Eases the use of the framework features;
  - Allows hosting MobVis on a powerful computer.



<https://github.com/lucNovais/MobVis>


# Contributions

- **Use case evaluation:**
  - Real taxi data (SFCab);
  - Synthetic IoT-Objects trace generated from SWIM model.



<https://github.com/lucNovais/MobVis>



# Related Work

	 Metrics	 Visualization	 Input Formats	 Web Service	 Synthetic Models
					
					
<b>MOCHA</b>					
					
					








# Related Work

	 Metrics	 Visualization	 Input Formats	 Web Service	 Synthetic Models
	✓	✗	✗	✗	✓
bandicoot					
MOCHA					
					
					










# Related Work

	 Metrics	 Visualization	 Input Formats	 Web Service	 Synthetic Models
	✓	✗	✗	✗	✓
	🔒	🔒	✗	✓	✗
<b>MOCHA</b>					
					
					

# Related Work










	 Metrics	 Visualization	 Input Formats	 Web Service	 Synthetic Models
	✓	✗	✗	✗	✓
	🔒	🔒	✗	✓	✗
MOCHA	✓	✗	✗	✗	✗
					
					

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MOCHA	✓	✗	✗	✗	✗
	✂	✂	✗	✗	✓
					



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	🔒	🔒	✗	✓	✗
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	✂	✂	✗	✗	✓
	✓	✓	✓	✓	✗

# Related Work



Metrics



Visualization



Input Formats



Web Service



Synthetic Models

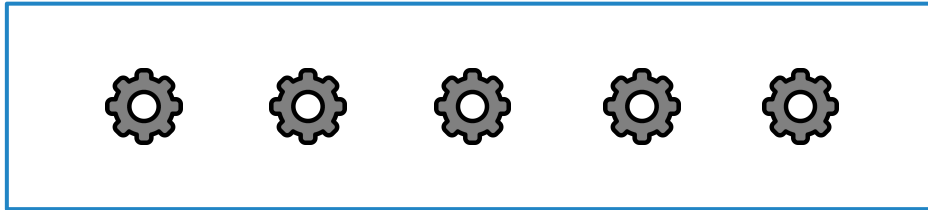
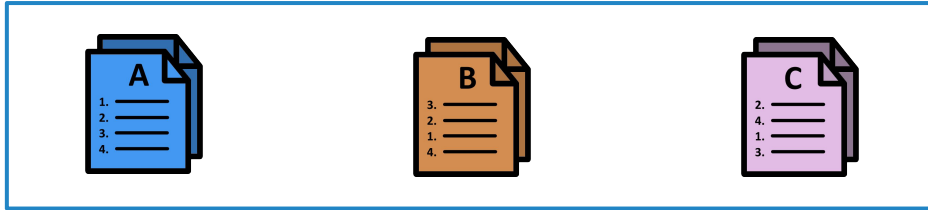
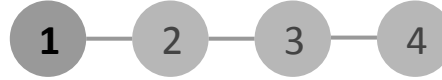
 **MobVis**



- Our main contribution is to provide many useful features on the same place!
- Several projects can benefit from MobVis.

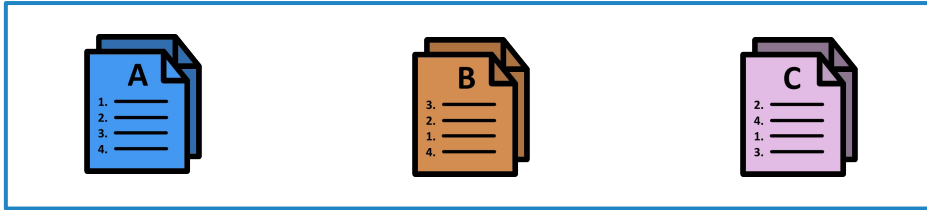
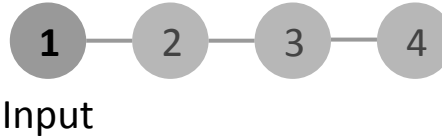
# MobVis Design

- Execution Pipeline:



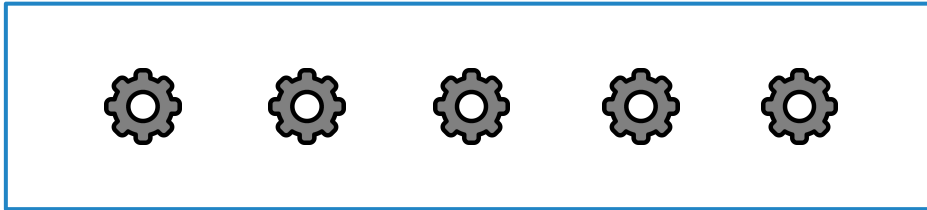
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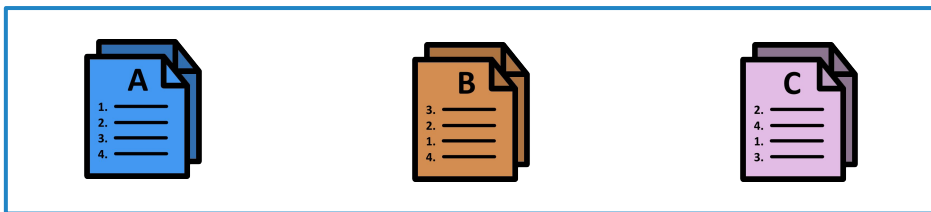
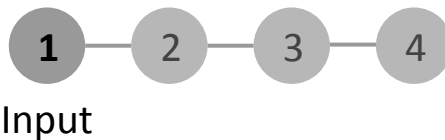
**Input data:**

- Different formats
- Different orders



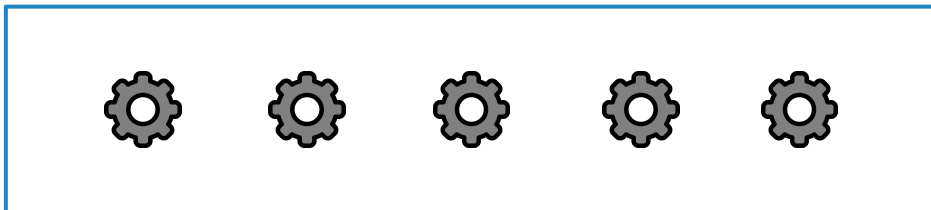
# MobVis Design

- Execution Pipeline:



**Input data:**

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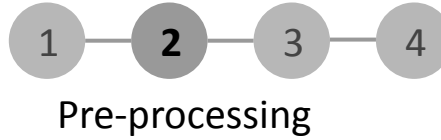


**Configuration parameters:**

- Pre-processing tasks to perform
- Characteristics to extract

# MobVis Design

- Execution Pipeline:

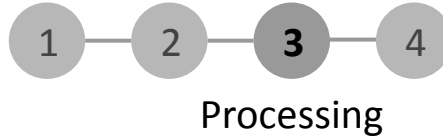


**Standardized data:**

- {id, t, x, y}
- Ordered by: id and t

# MobVis Design

- Execution Pipeline:

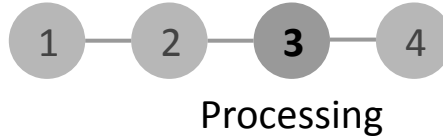


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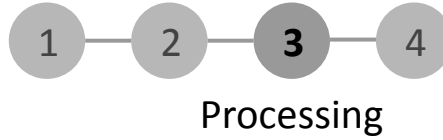
**Main characteristics:**

- Geo-locations
- Home-locations
- Contacts



# MobVis Design

- **Execution Pipeline:**

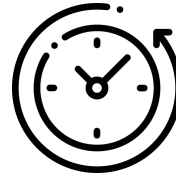
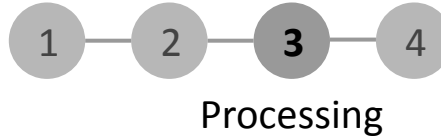


**Trace metrics:**

- Spatial
- Temporal
- Social

# MobVis Design

- Execution Pipeline:

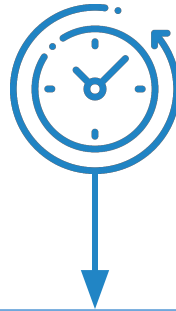
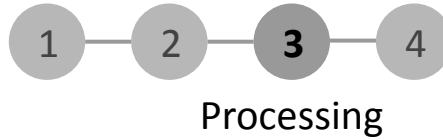


**Spatial metrics:**

- Travel Distance
- Radius of Gyration
- Visit Order

# MobVis Design

- Execution Pipeline:

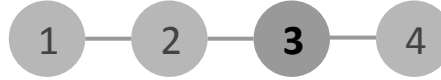


## Temporal metrics:

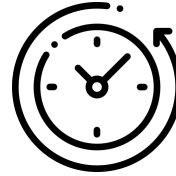
- Travel Time
- Visit Time

# MobVis Design

- Execution Pipeline:



Processing

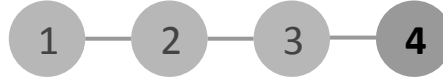


**Social metrics:**

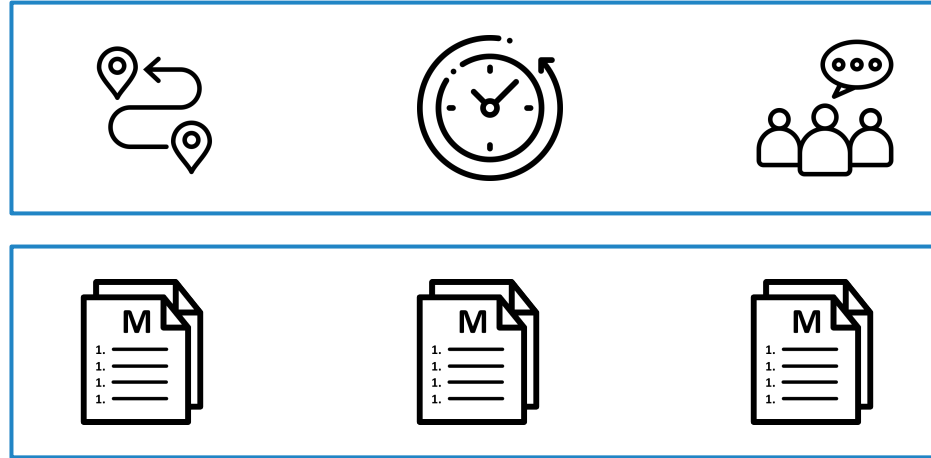
- Intercontact Time
- Contact Duration

# MobVis Design

- Execution Pipeline:

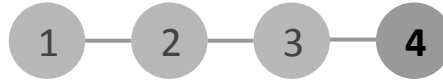


Visualization and  
Data Export



# MobVis Design

- Execution Pipeline:



Visualization and  
Data Export



**Output:**

- Interactive plots
- Tabular data

# Use Case

- **Two distinct mobility traces:**
  - **IoT-Obj:** synthetic trace generated by SWIM model
  - **SFCab:** real trace from taxis in San Francisco city

## Use Case

- **Two distinct mobility traces:**

- **IoT-Obj:** synthetic trace generated by SWIM model

- **SFCab:** real trace from taxis in San Francisco city

- **Num. of nodes:** 100
- **Max dist.:** 0.014
- **Pause threshold:** 10 min
- **Contact radius:** 0.130
- **Dist. formula:** Euclidean



## Use Case

- **Two distinct mobility traces:**

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- **SFCab:** real trace from taxis in San Francisco city

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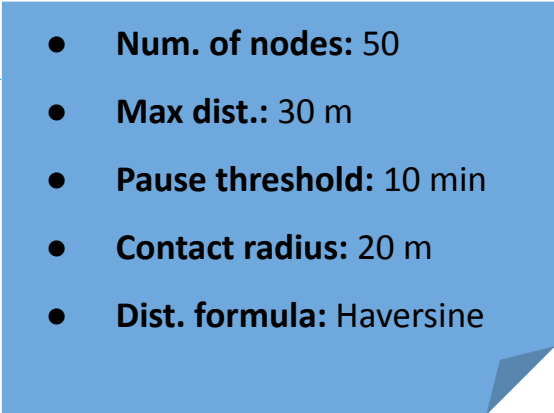
\* the nodes coordinates were normalized by the trace author

## Use Case

- **Two distinct mobility traces:**

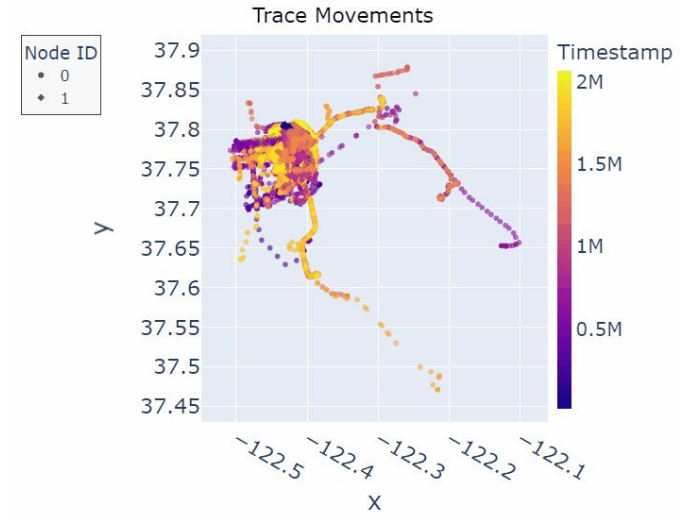
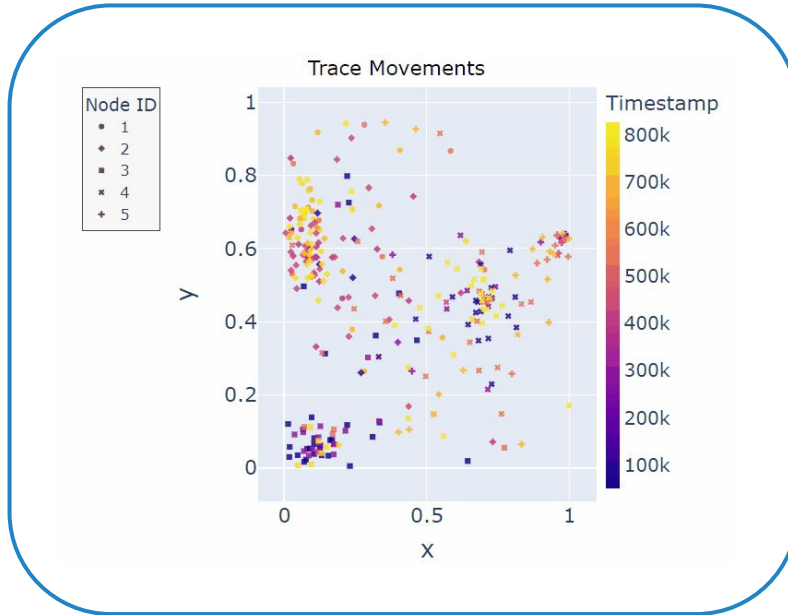
- **IoT-Obj:** synthetic trace generated by SWIM model

- **SFCab:** real trace from taxis in San Francisco city

- 
- **Num. of nodes:** 50
  - **Max dist.:** 30 m
  - **Pause threshold:** 10 min
  - **Contact radius:** 20 m
  - **Dist. formula:** Haversine

# Use Case - Spatiotemporal plots

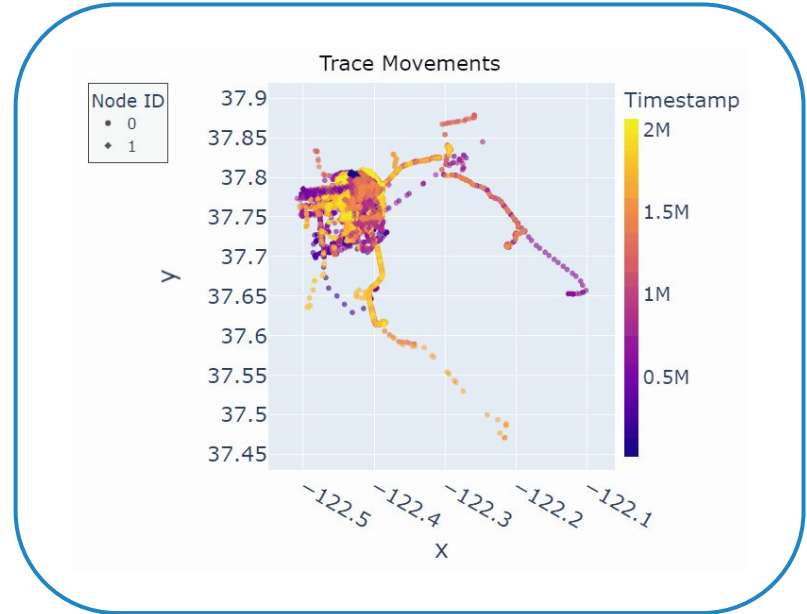
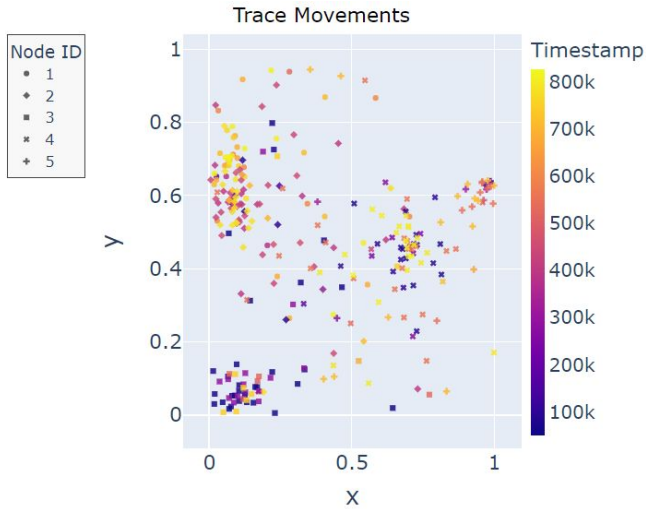
- **IoT-Obj:** Trace Movements



Shows the positions of the trace nodes in time

# Use Case - Spatiotemporal plots

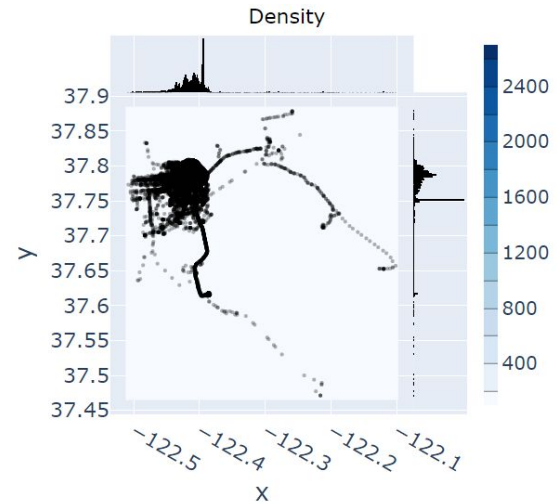
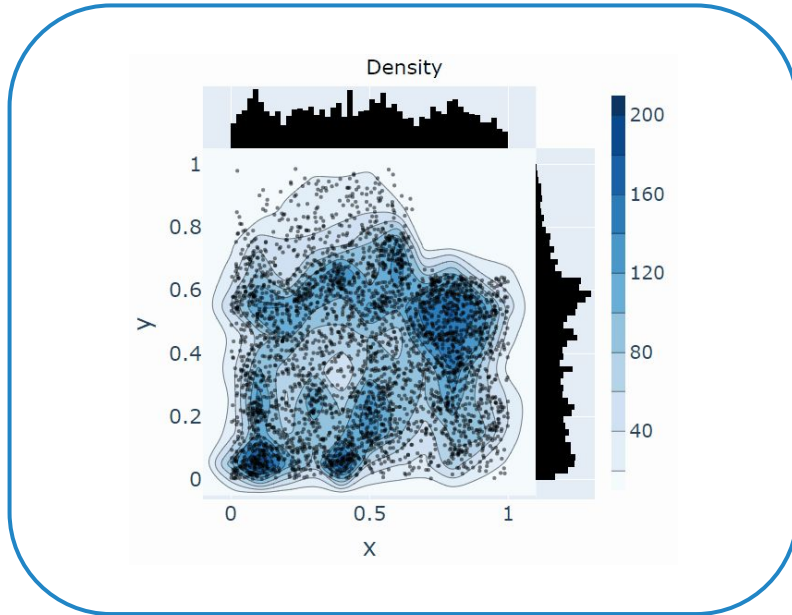
- **SFCab: Trace Movements**



Shows the positions of the trace nodes in time

# Use Case - Spatiotemporal plots

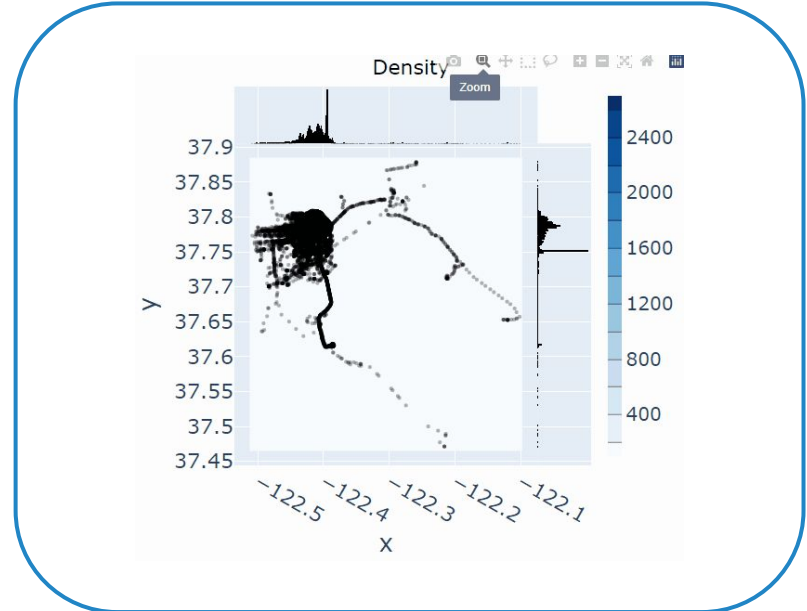
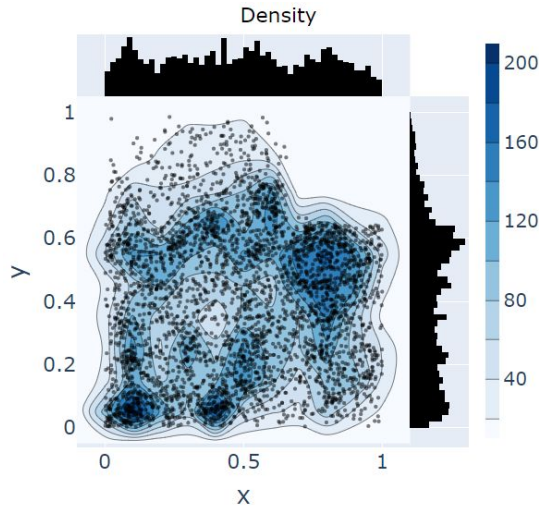
- **IoT-Obj:** Density of the Area



Shows the density levels of the trace area

# Use Case - Spatiotemporal plots

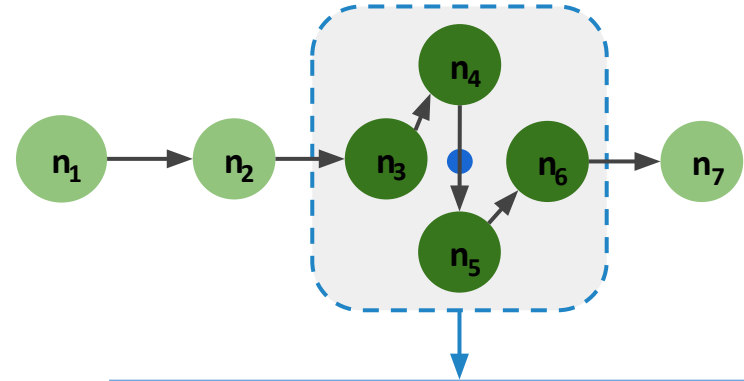
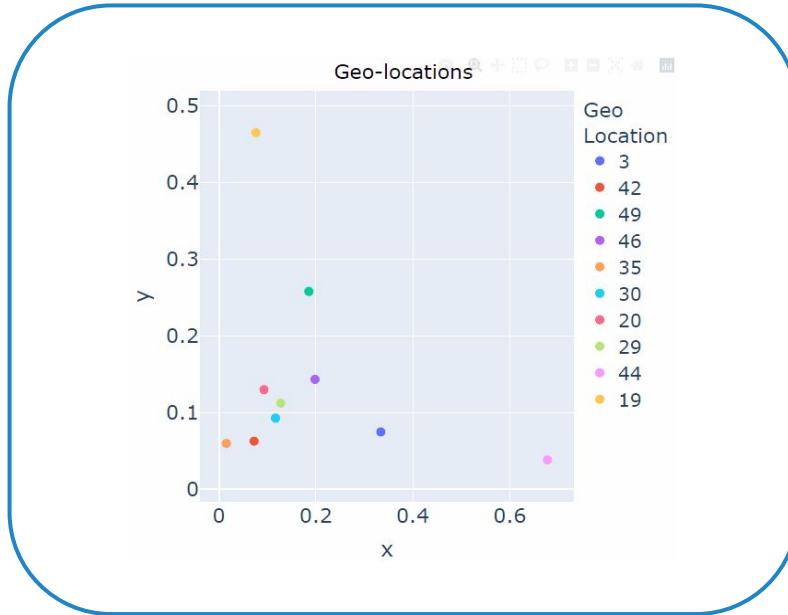
- **SFCab**: Density of the Area



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# Use Case - Spatiotemporal plots

## ● IoT-Obj: Geo-locations



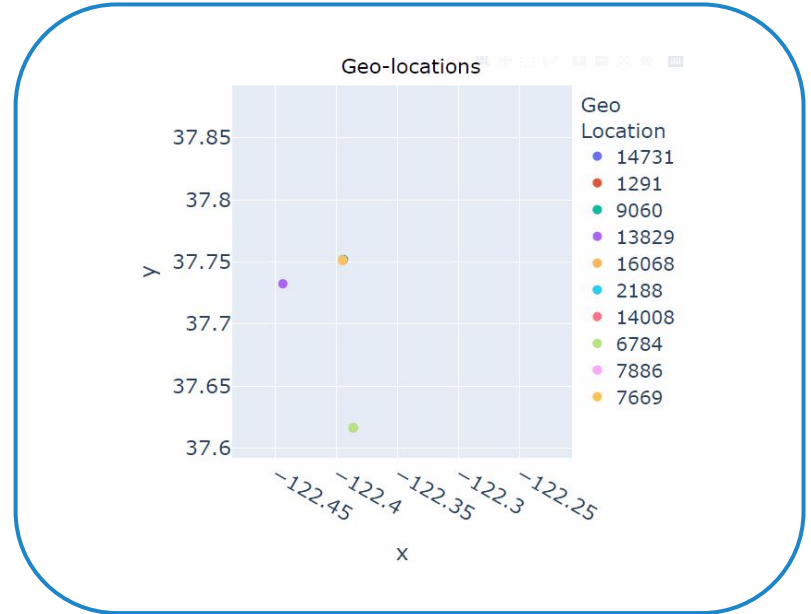
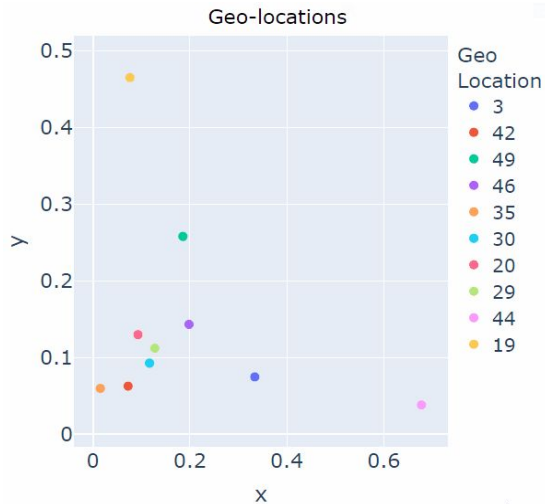
### Geo-location:

- $\text{Dist}(n_i, n_{i+1}) \leq \text{max\_dist}$
- $n_i.\text{time} - n_{i+1}.\text{time} \geq \text{time\_thold}$

Shows the Geo-locations on the trace area

# Use Case - Spatiotemporal plots

- **SFCab: Geo-locations**

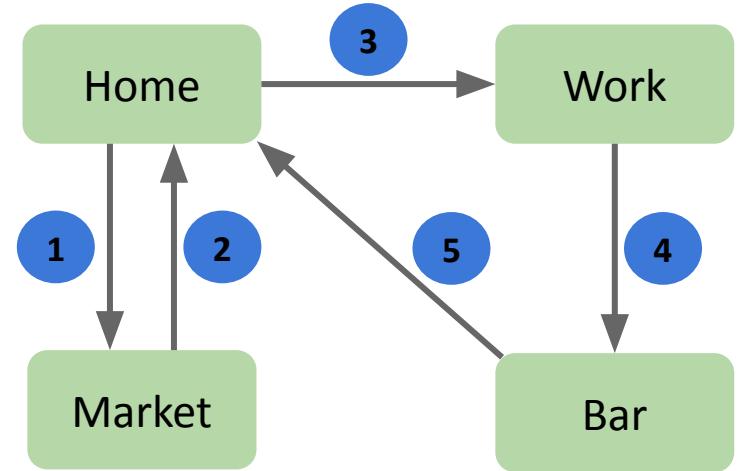
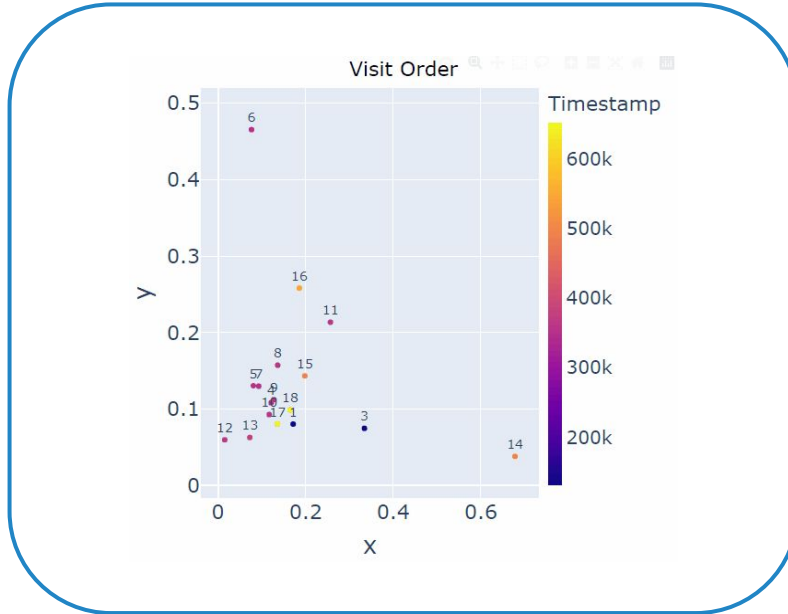


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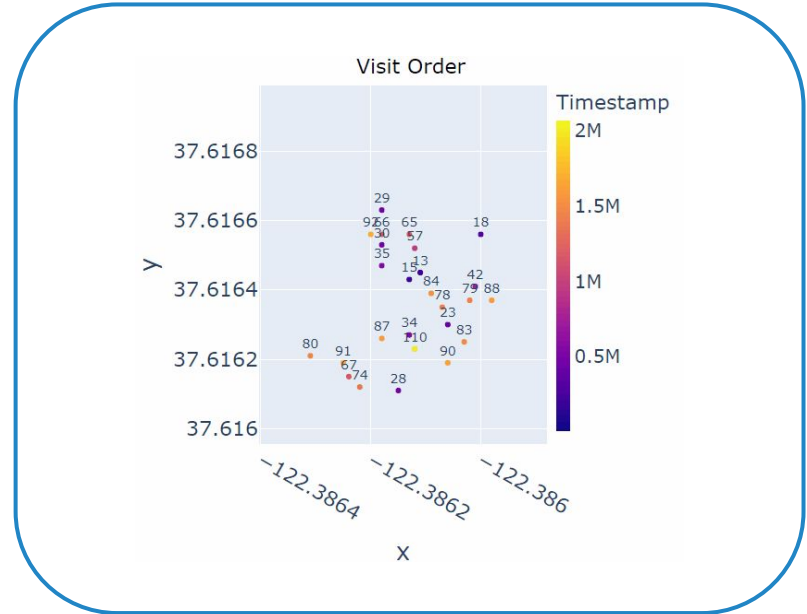
- **IoT-Obj:** Visit Order



Shows the Geo-locations visited in order by a specified node

# Use Case - Spatiotemporal plots

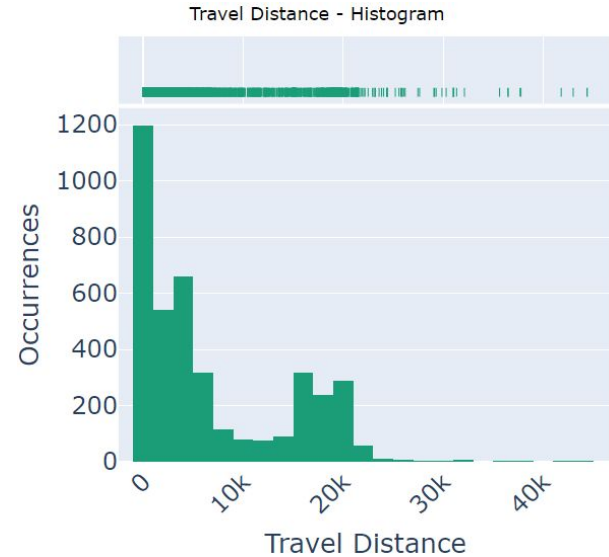
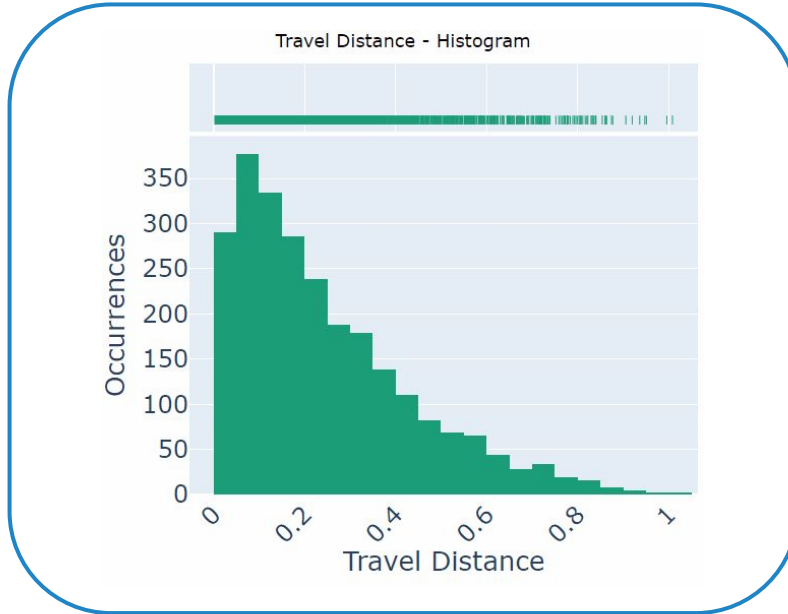
- **SFCab: Visit Order**



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# Use Case - Statistical plots

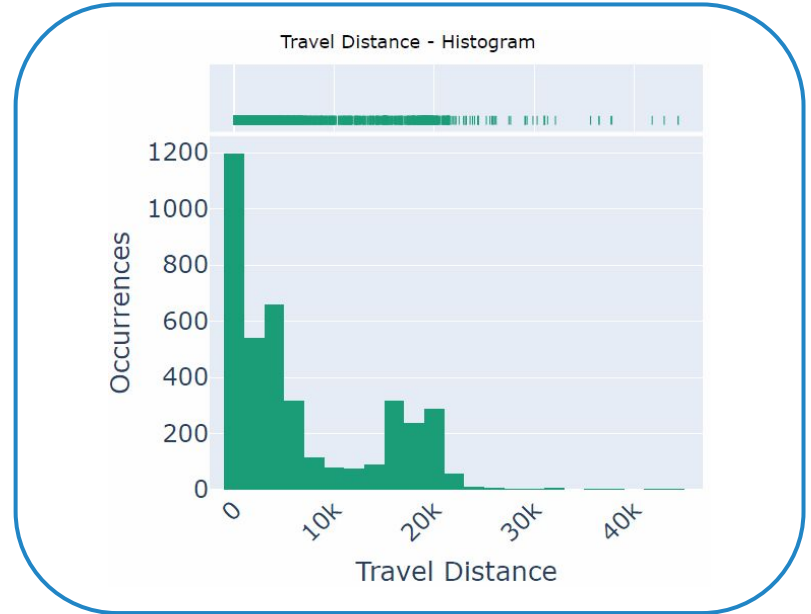
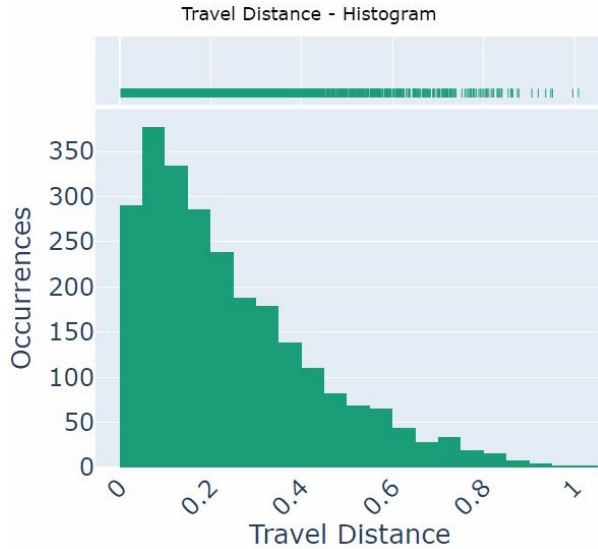
- **IoT-Obj:** Travel Distance Histogram



Shows on a histogram the Travel Distance metric obtained from the Processing module

# Use Case - Statistical plots

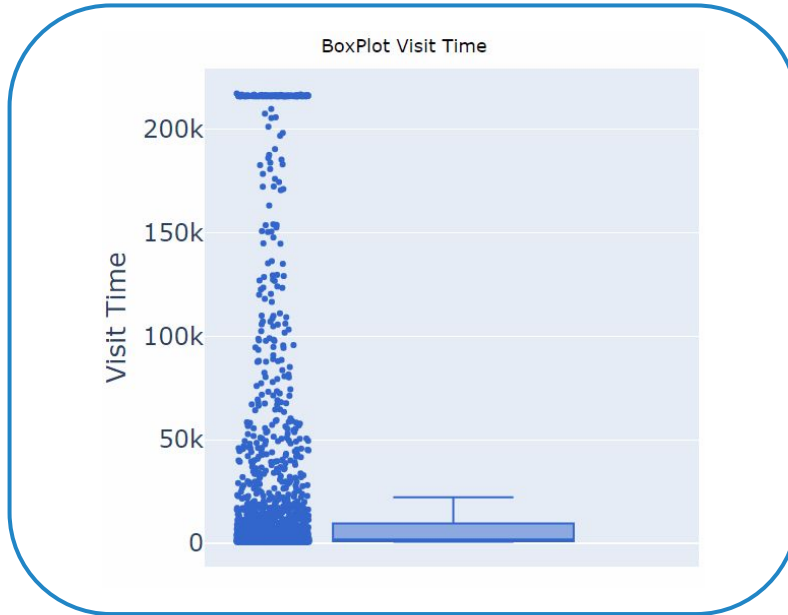
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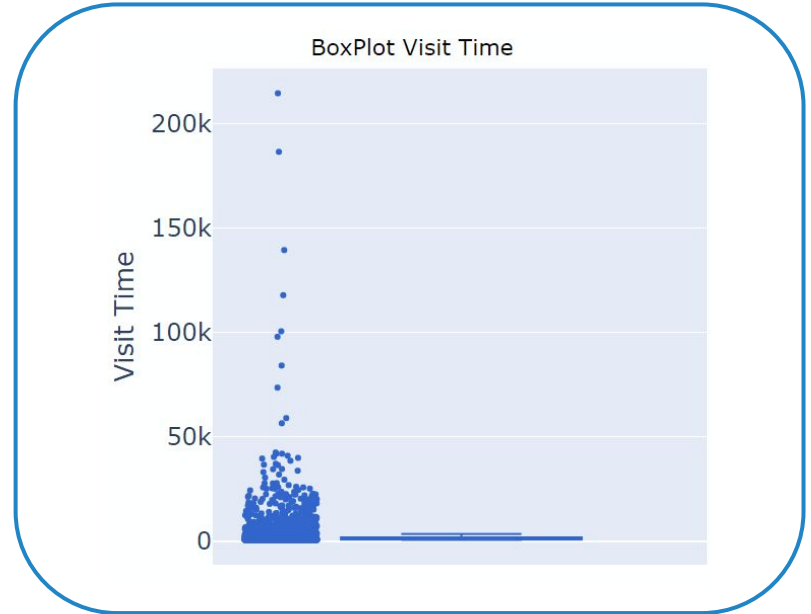
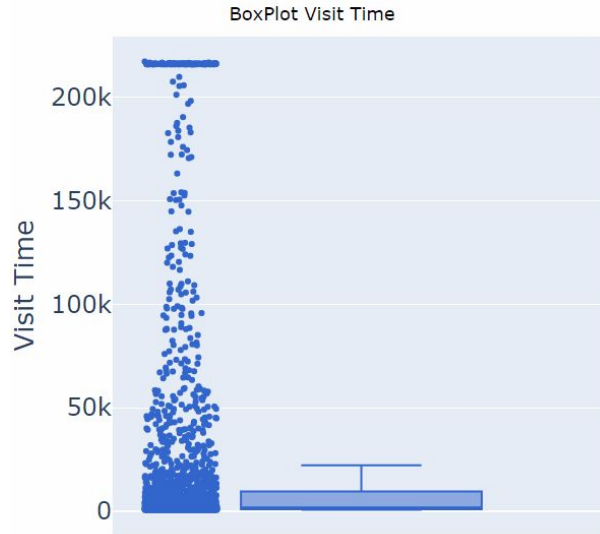
- **IoT-Obj:** Visit Time Boxplot



Shows on a box plot the Visit Time metric obtained from the Processing module

# Use Case - Statistical plots

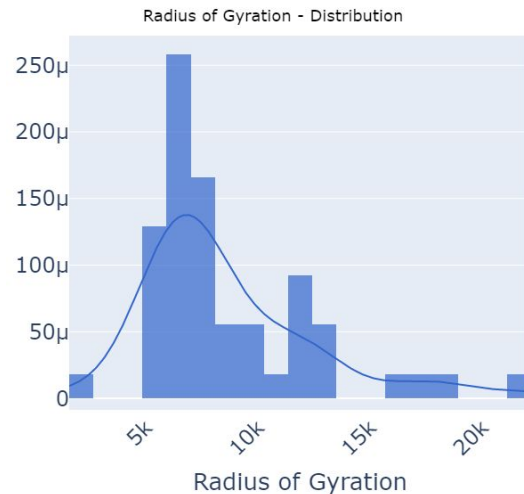
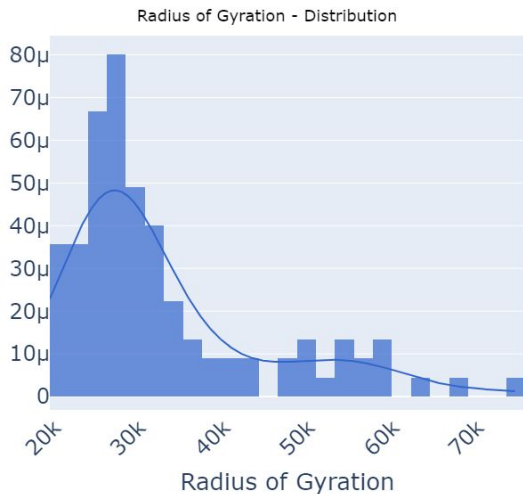
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# Use Case - Comparisons

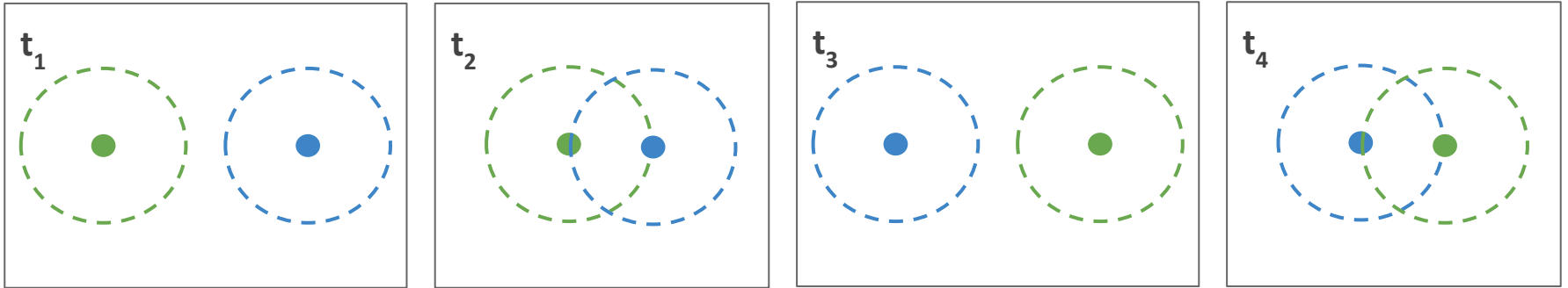
- **IoT-Obj vs SFCab: Radius of Gyration**



**Radius of Gyration** captures how much the points of the trajectory are far from their center of mass (here considered as homes).

## Use Case - Comparisons

- **IoT-Obj vs SFCab: Intercontact Time**

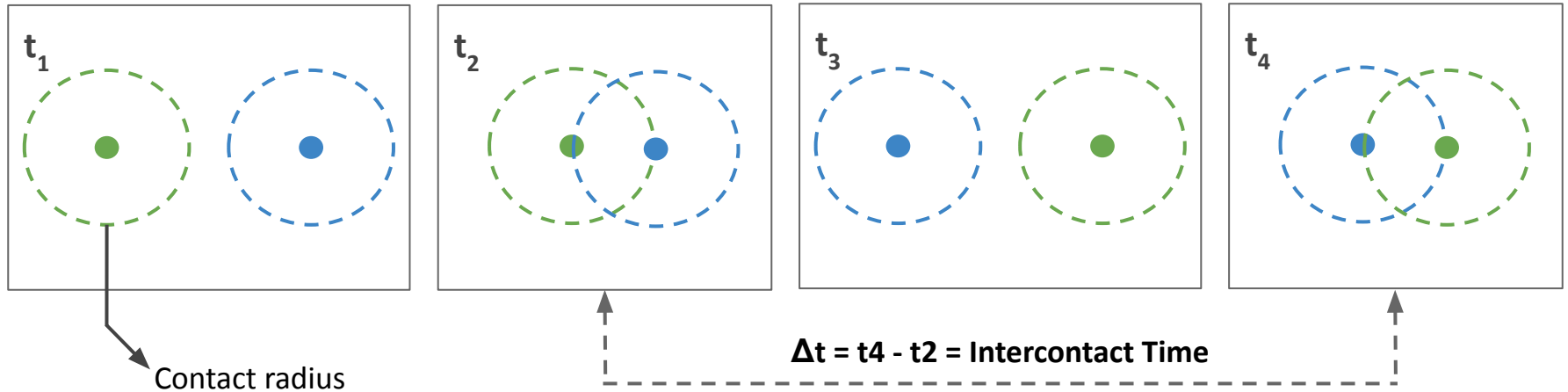


**Intercontact Time** is a social metric that captures the time interval between two consecutive contacts of a pair of nodes



## Use Case - Comparisons

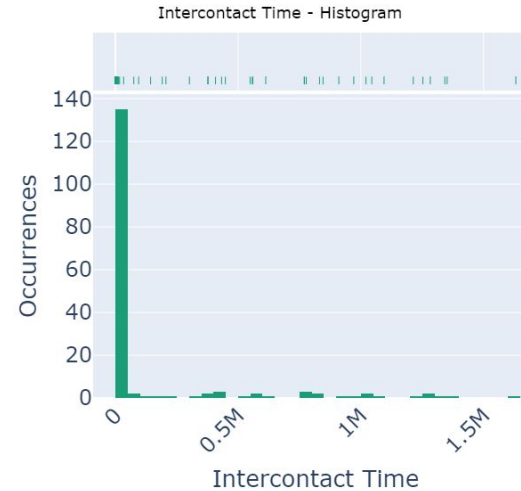
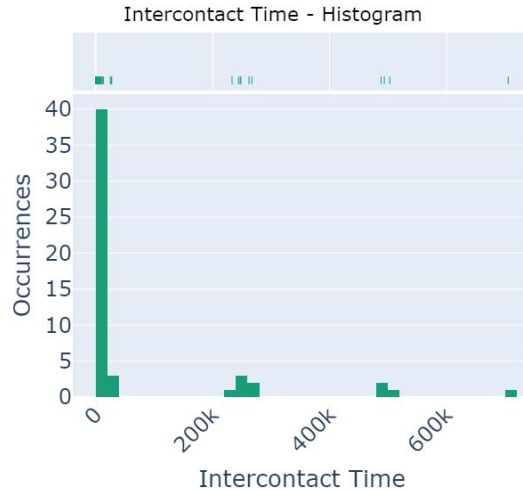
- **IoT-Obj vs SFCab: Intercontact Time**



**Intercontact Time** is a social metric that captures the time interval between two consecutive contacts of a pair of nodes

# Use Case - Comparisons

- **IoT-Obj vs SFCab: Intercontact Time**



**Intercontact Time** is a social metric that captures the time interval between two consecutive contacts of a pair of nodes

# MobVis Design - Web Application



## MobVis

A framework to easily visualize mobility data

[HOME](#) [DEMO](#) [PROJECT](#) [CONTACT](#)



### General instructions:

1. Upload the trace in CSV format via the "Upload" button;
2. Select metrics and configure parameters for processing (if not specified, parameters are set to a default value);
3. Select the plots to be generated;
4. Press the "Submit" button to start the procedures.



### Upload raw trace:

Drag and drop here  
or

Select from  
computer



### Configuration parameters:

# Conclusions

## • MobVis •

We presented a framework to work on data analysis solutions.

### Traces analysis

We demonstrated a use case comparing and analysing two different traces.



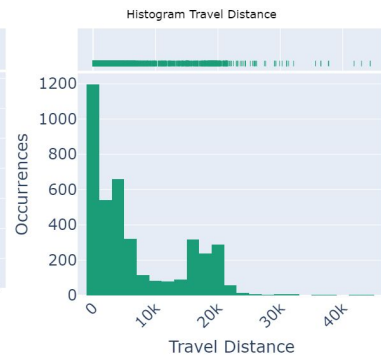
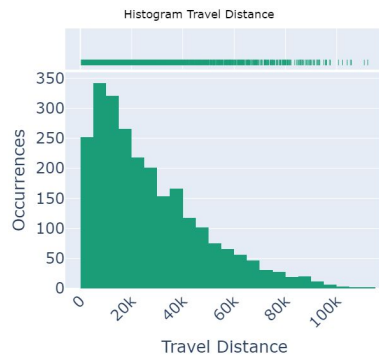
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# Future Work

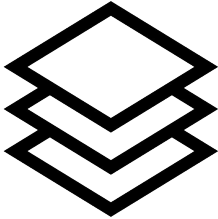


## New visualizations:

- Map overlay
- Bubble charts



# Future Work

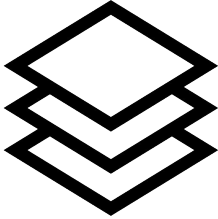


## New metrics:

- Average Speed
- Total distance



# Future Work



## Improvements:

- Better web version
- Reduced runtime





# Thank You!



[github.com/lucNovais/MobVis](https://github.com/lucNovais/MobVis)



[lucasnovais222@gmail.com](mailto:lucasnovais222@gmail.com)