BoloFence

Activity-aware geofencing platform

Report Highlights

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Introduction

Context-aware system

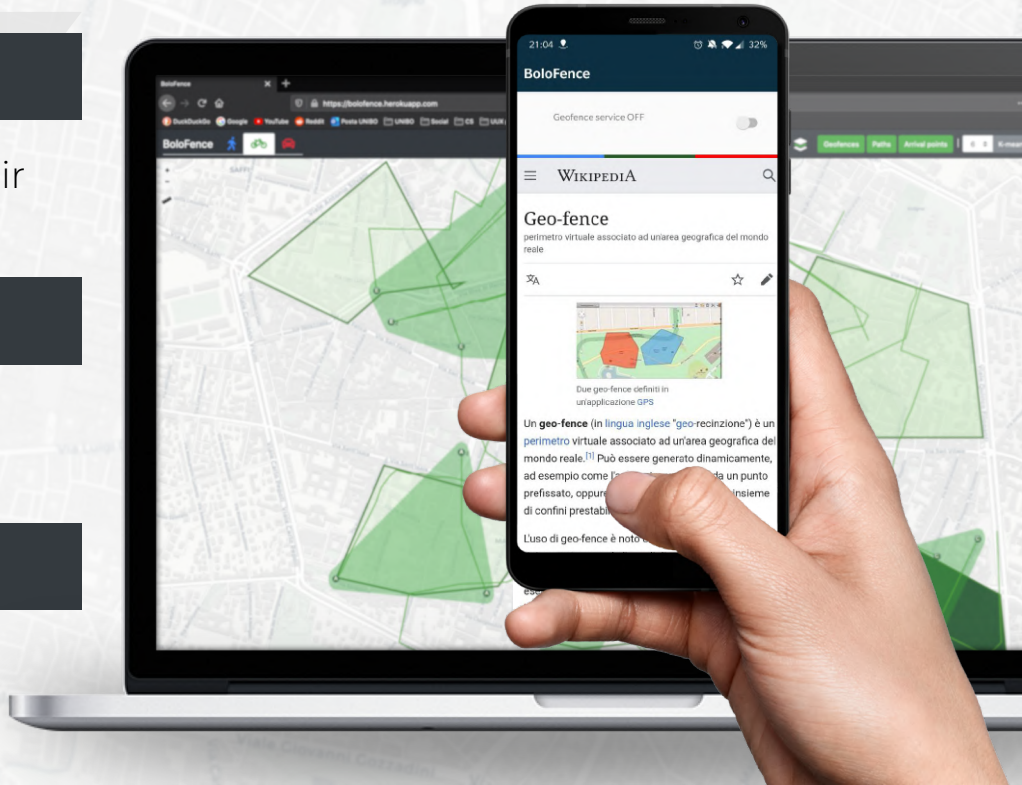
User's **location** is tracked according to their **mobility type** (walk, bike, car)

Geofence recognition

A **notification** is sent when a geofence is reached

Visualization and analysis

Web-app provides visualization and spatial data analysis tools



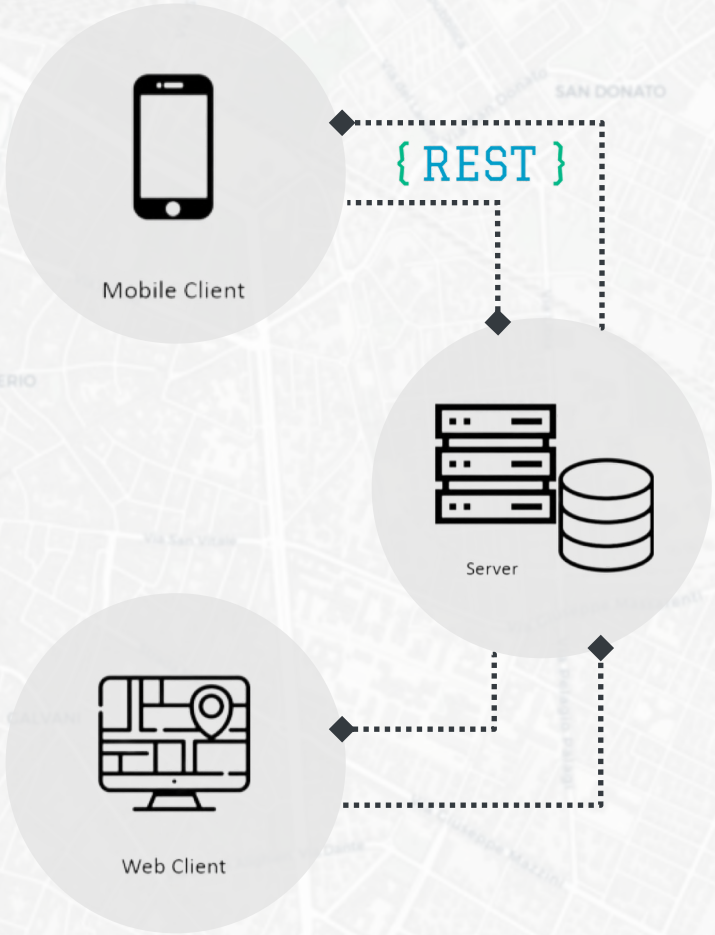
Architecture

Components

- **Android** client
- Server
- Web application

Client-server communication

- **REST**
- JSON POST request
- JSON response



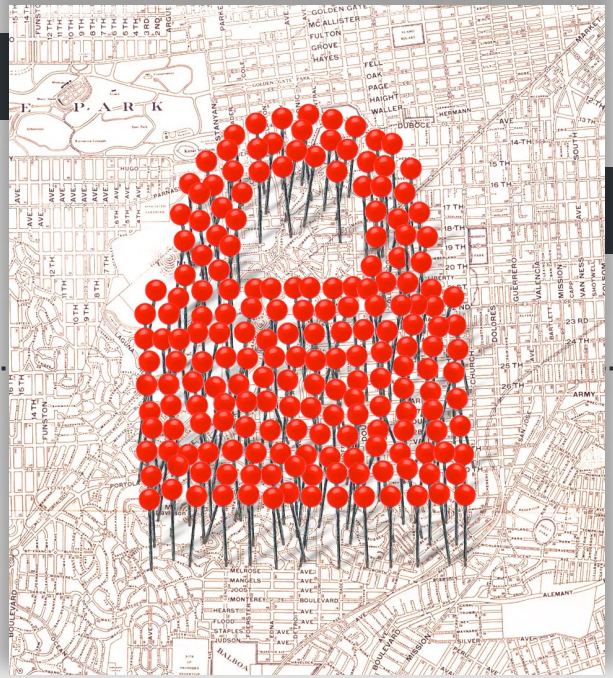
Data privacy

Perturbation

Coordinates are rounded in order to grant **cloaking**

Smart precision:
Geofence proximity: **~8m**
Else: **~40m**

Noising is applied before data is sent to server



Path updates

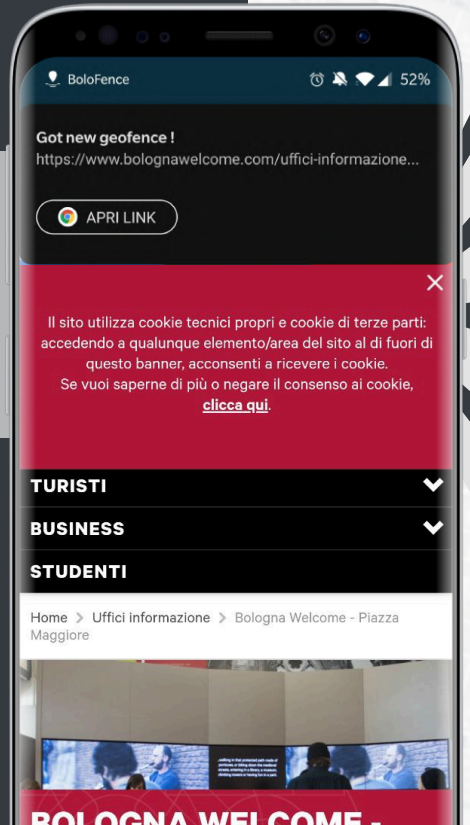
Each user session is identified by a single-use serial number **pseudonym**

When the client dismisses the service for a certain amount of time, an **id reset** occurs

System components

Client

Features



Path tracking

Coordinates are requested with **dynamic frequency**

Context awareness

Android activity recognition client provides a **mobility transition** awareness

Message notification

Notification is sent if, and only if a geofence is entered

Web content navigation

The UI includes a webview in order to allow **link browsing**

Design

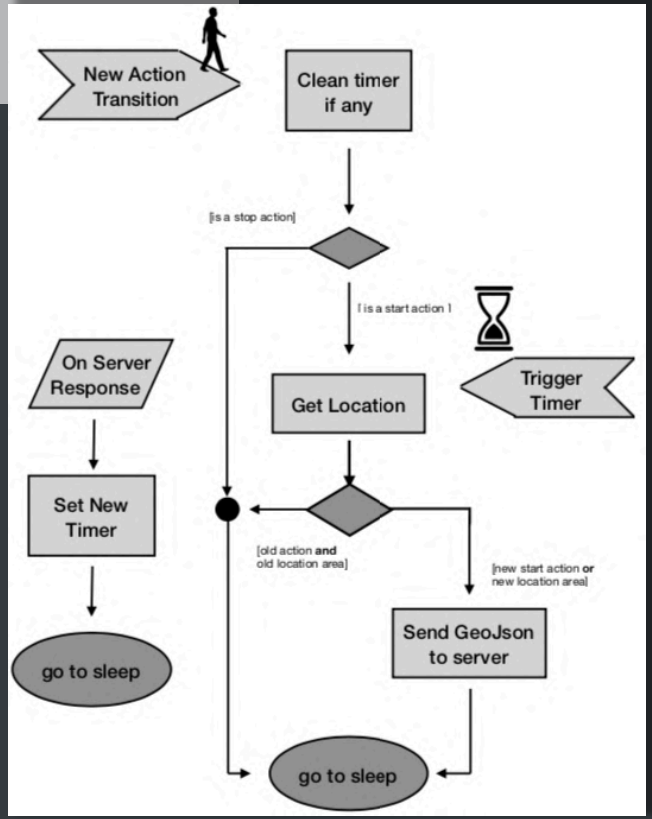
Path identifier

Tracking Service

- New action
- Timer trigger

Client-Server geoJSON exchange

Dynamic Time-To-Sleep



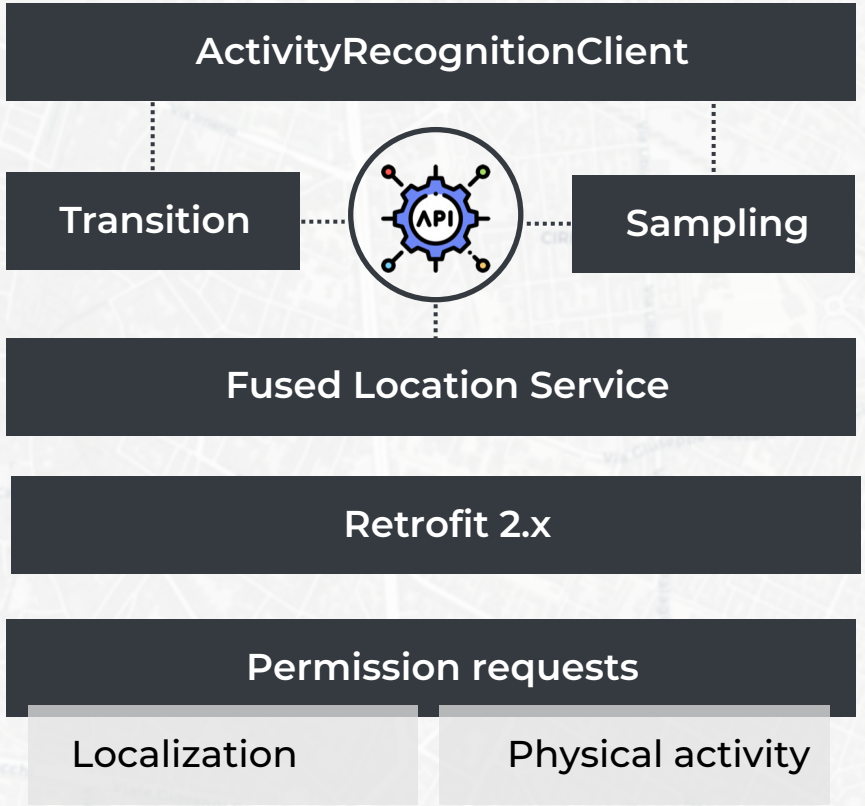
Implementation

Here's an example of our geoJSON Format:
Request

```
{"type":"Feature",
 "geometry":{
    "type":"Point",
    "coordinates": [ 11.355, 44.485 ]
       },
 "properties":{
        "activity":"walk",
        "pathId":32,
        "currentGeofence":"Giardini
           Margherita"
        }
}
```

Response

```
{   "pathId": 32,
    "timeToSleep" : "60.8346"
    "message" : "No new Geofence"
}
```



System components

Server

Design

CodeIgniter Framework

- **MVC** template
- **PHP** language
- Ease in setup and usage
- Leightweight

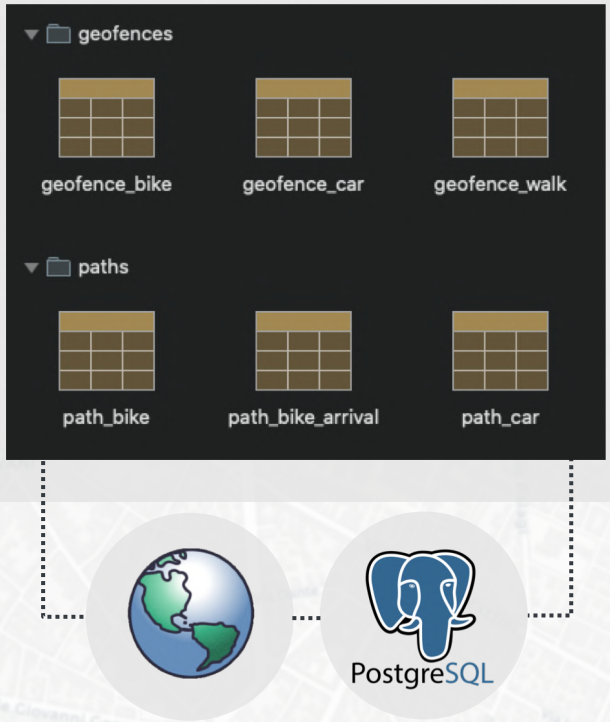
REST Library

- CodeIgniter **RestServer**
- **JSON POST** support

Database structure

Spatial data is stored in a **SQL-based** DBMS and exploits **PostGIS** spatial queries both for requests and pre-computation.

Indexes and materialized views are used for a better performance.



GEOFENCE
id
geom
message
intensity

PATH
id
geom
last_update

REST Service

1. geoJSON Request
   Validation process
2. pathID check
   Path update/creation
3. Geofence retrieval
   Compare current geofence
4. JSON Response
   Feedback

Request **Optimization**

Time-To-Sleep

A request occurs when a time-to-sleep expires.
It consists in an **underestimation** of time to reach the closest geofence.
A **minimum threshold** is set up in order to avoid too low timers.

How?

Time-to-sleep is computed by considering the **distance** to the closest geofence, the **average speed** of the related activity and driving limit in the center of Bologna.

5 km/h

15.5 km/h

30 km/h

System components

Web app

Features

Geofence areas

Colored polygons represent geofence and its traffic **intensity** for each activity.

Path lines

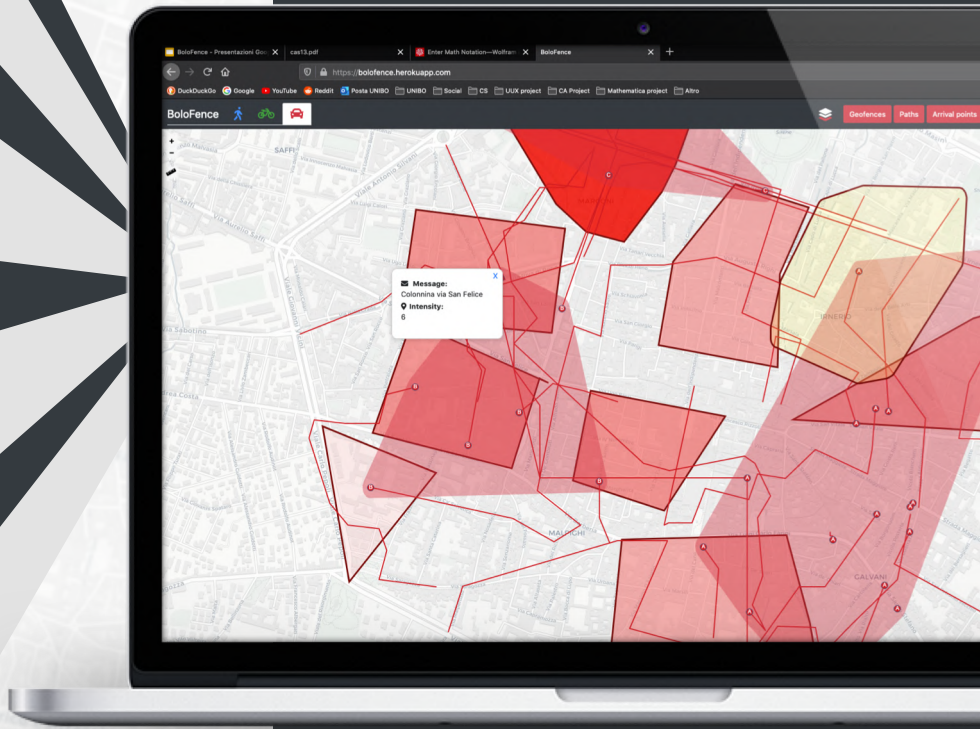
Path lines and arrival points represent users **trajectories**, for each activity.

K-means clustering

Dynamic k-means tool is available.

New geofence adviser

Personalized DBSCAN tool suggests the ideal area for a **new geofence**.



Visit now : https://bolofence.herokuapp.com/

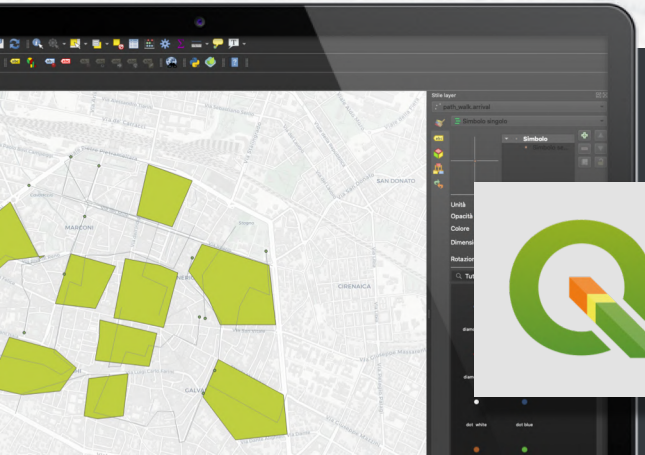
Design

- Project structure has been defined through **QGIS 3.10**;
- **qgis2web** plugin transformed it into html/js/css code that exploits **OpenLayers** library;
- The result has been integrated into the CodeIgniter project and **connected** to the database.

CodeIgniter

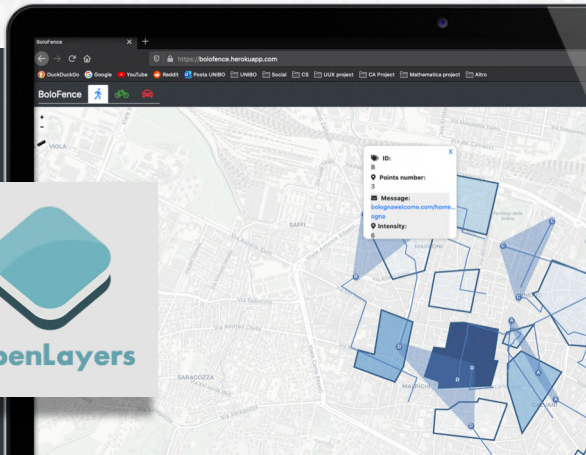
PostgreSQL

Bootstrap

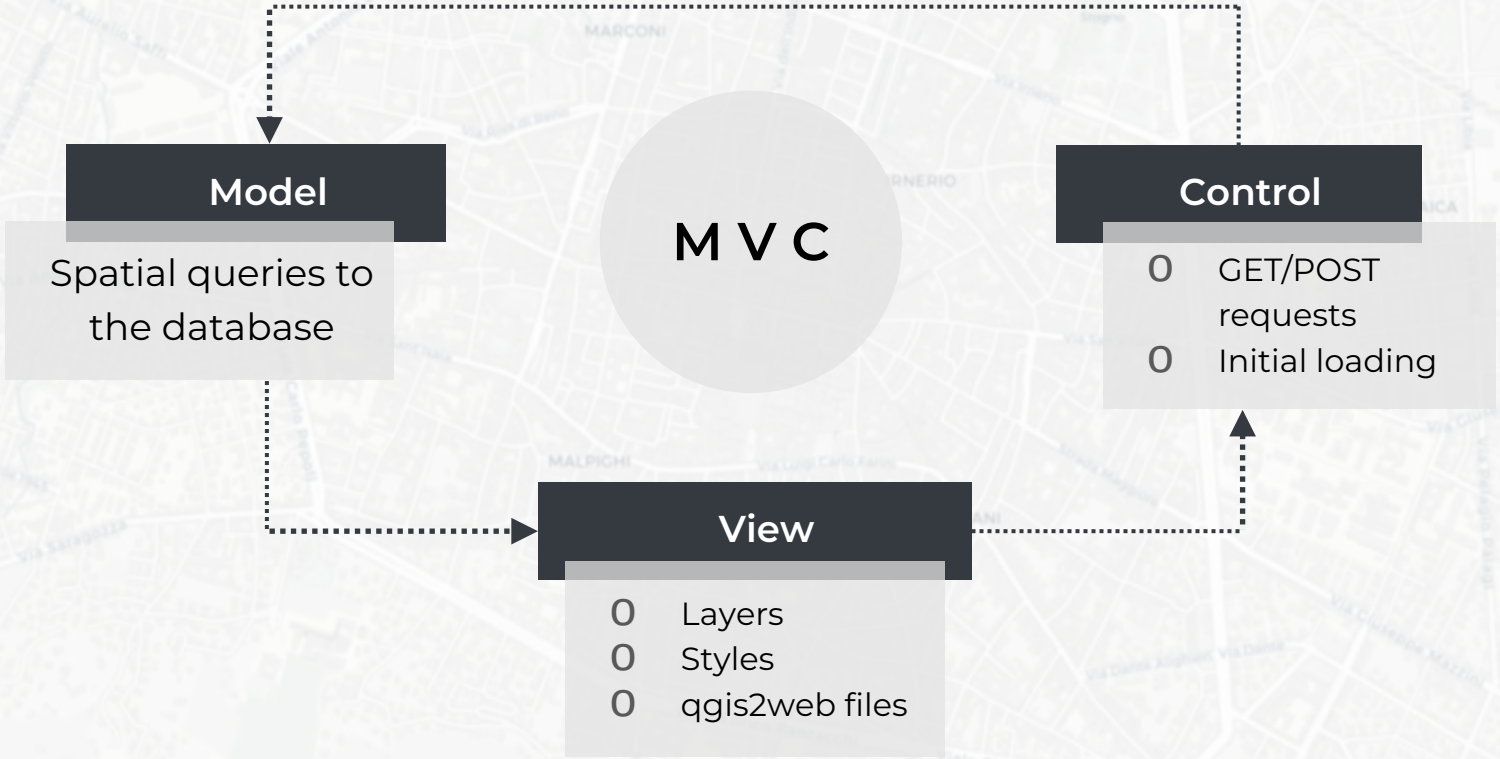


qgis2web

OpenLayers



Implementation



Geofence adviser

Generate tool **suggests** potentially the **ideal area** where a new geofence may have an high trigger rate.

1. Most relevant paths' points are retrieved by computing the **closest point** between each pair of paths
2. Distance between paths is tracked and the **eps value** is determined according to the **user percentile** value
3. **DBSCAN** algorithm is applied on the computed data
4. The cluster's shape with the **highest intensity** is returned

Testing and evaluation

The system has been tested both in a **real situation** and through **position emulator** (Lockito)

3.05 s

Avg. delay between real geofence entrance and notification

Lockito

17.33 s

Avg. delay between real geofence entrance and notification

Live testing

20.17 s

Activity recognition sampling/transition avg. delay

Live testing

24.11 m

Avg. Dev. between real geofence entrance and notification

Live testing

Conclusions

Results

The provided service accomplishes the given assignment and grants satisfactory **performance** and **reliability** in order to be used in real life situations.

Future works

- Activity recognition **ad hoc** API
- Trajectory prediction
- Ad hoc clustering algorithms