Spatiotemporal Analysis of Brussels Mobility Data with MobilityDB

Promoter : Esteban Zimanyi

BM Representative : Yacoubi Moaad

Student : Wassim Belgada

Table of Contents

Goals of the Work

- Add MobilityDB to Brussels Mobility's extensive range of tools
- Improving traffic management in Brussels with MobilityDB
- Detection of stationary vehicles
- Detection of low-speed vehicles
- Analysis of traffic light data (TLC)
- Analysis of ANPR camera count data (M-Cube)

Globals Standards

- GBFS (General Bike sharing Feed Specification)
  - Shared micro mobility availability (bike, scooter,...)
- GTFS (General Transit Feed Specification)
  - Static
  - Realtime
- MDS(Mobility Data Specification)
  - Companies <-> Local government
  - Shared mobility
  - Historical and RT

European Standards

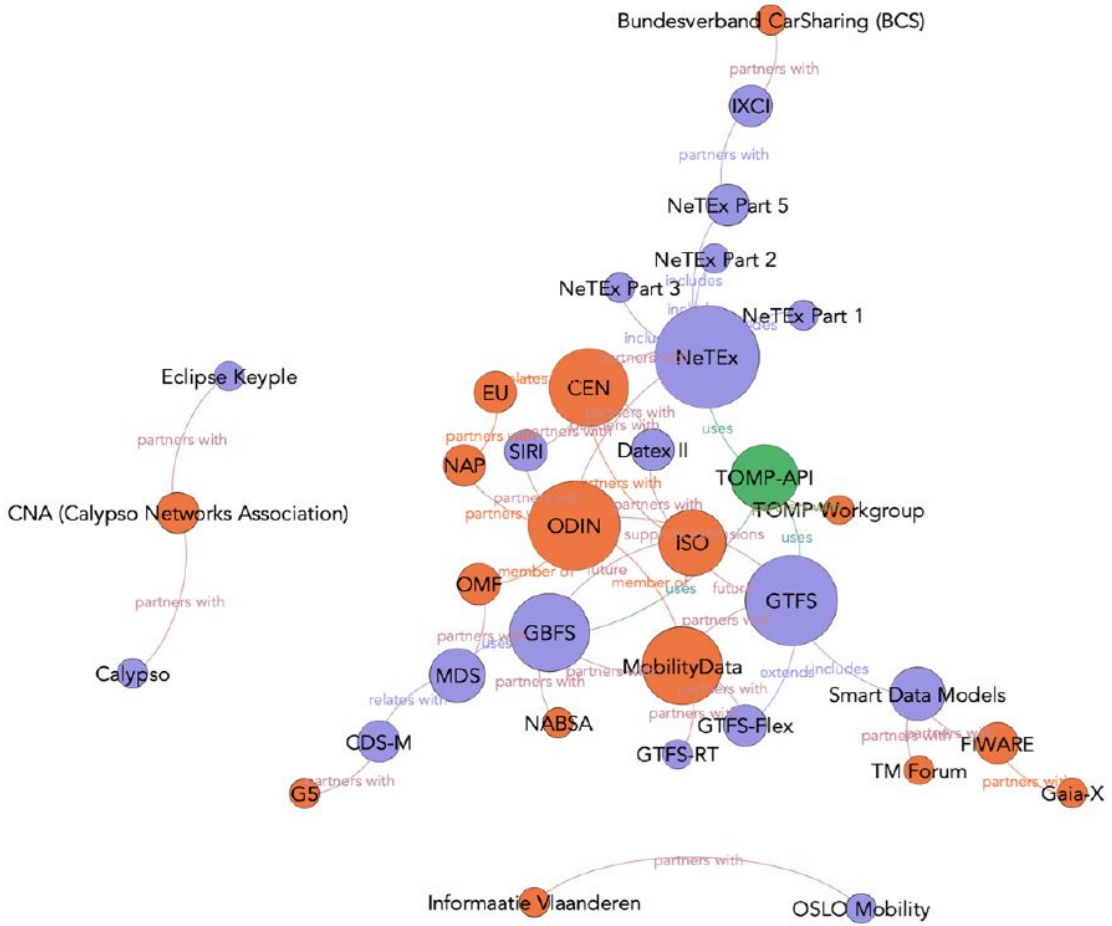
- Transmodel
  - CEN (Comité Européen de Normalisation)
  - Dictionary
- NeTEx (Network Timetable Exchange)
  - XML (Auto process with schema)
- SIRI (Service Interface for Real-time Information)
  - RT information about public and shared transport

Belgian Standards

- OSLO Mobility
  - Flemish gouvernement
  - Fast mapping from and to other standards

Other Standards

- DATEX II
  - CEN
  - State of the road
  - Communication between structures



source : MaaS Data Model Ecosystem

STIB Open Data Portal Services

GTFS

Le réseau STIB entier dans un format standard facile à utiliser.

Shapefiles

Dessinez nos lignes et arrêts sur une carte à l'aide des shapefiles !

Lignes & Arrêts

Tout savoir sur nos lignes et arrêts : noms, coordonnées GPS, ...

Position véhicules

Découvrez en temps réel la position de nos véhicules sur leur ligne.

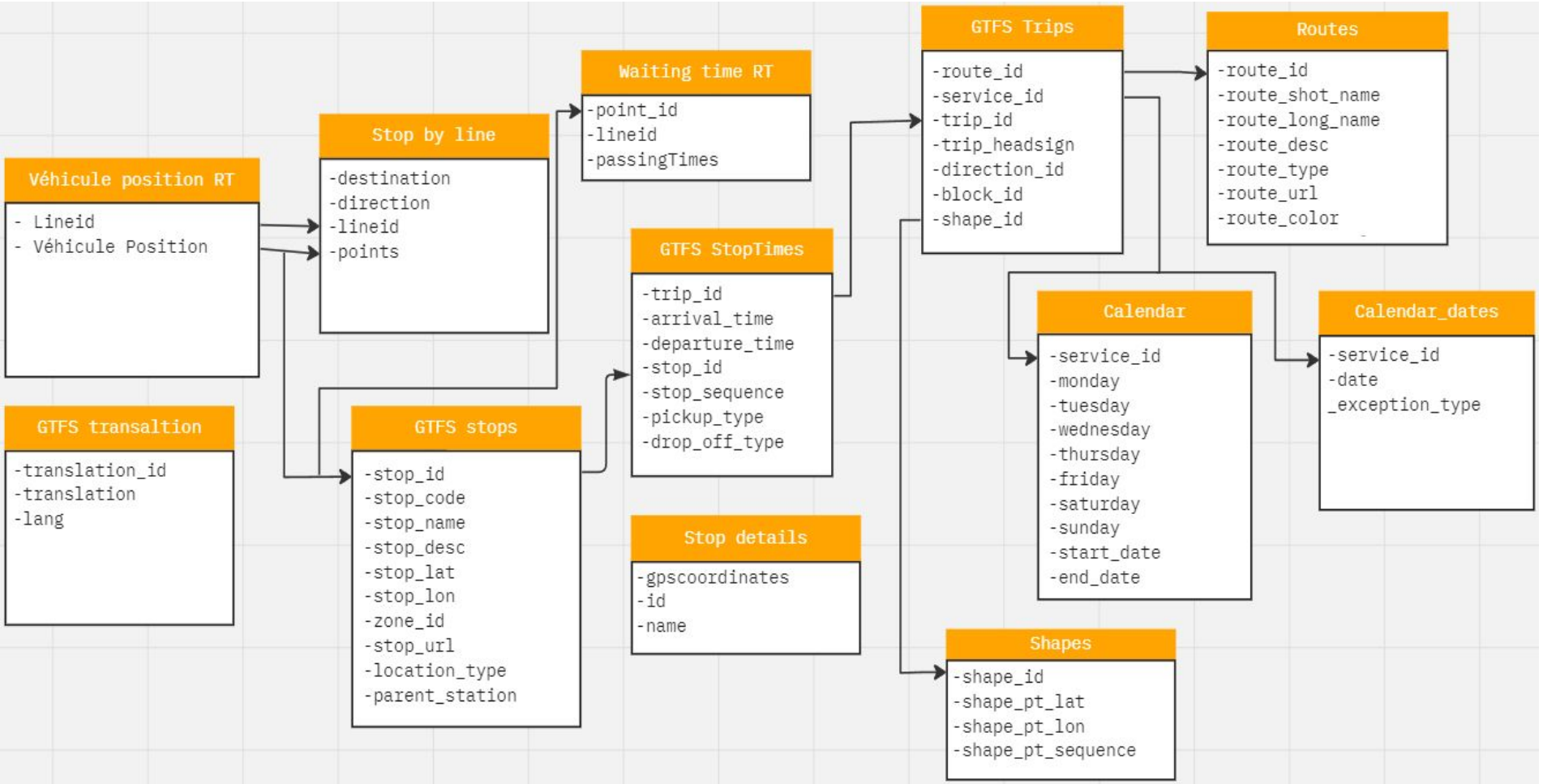
Temps d'attente

Dans combien de temps arrive un véhicule à l'arrêt ? Ce dataset vous le dit !

Messages voyageurs

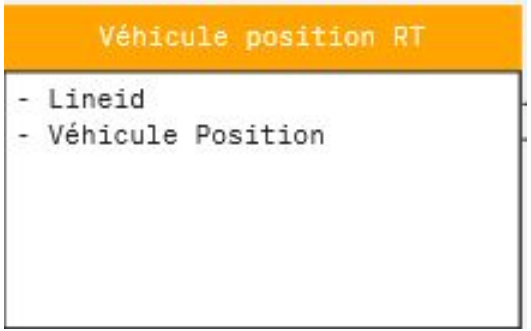
Informez les voyageurs en cas de perturbation sur le réseau.

STIB Open Data Portal Tables



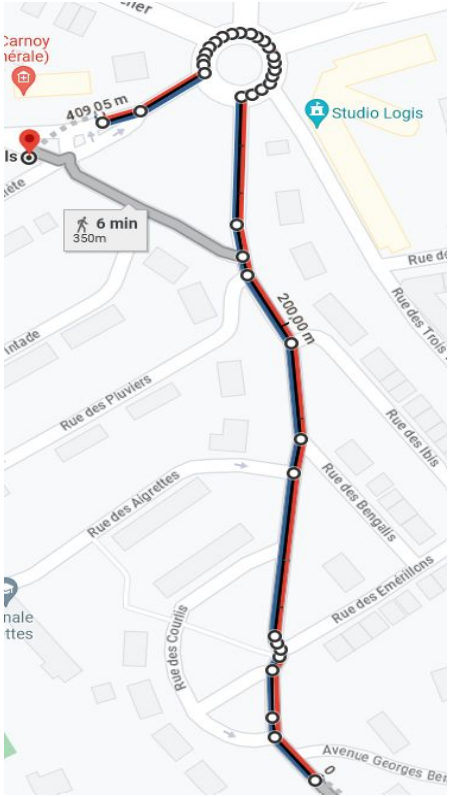
Real-time Position of Vehicles


```
{
    "total_count": 77,
    "results": [
        {
            "lineid": "12",
            "vehiclepositions": "[{"directionId": "9600",
            "distanceFromPoint": 0, "pointId": "1780"}, {"directionId":
            "1780", "distanceFromPoint": 0, "pointId": "9600"},
            {"directionId": "9600", "distanceFromPoint": 364, "pointId":
            "1780"}, {"directionId": "2247", "distanceFromPoint": 1455,
            "pointId": "1418"}, {"directionId": "9600", "distanceFromPoint":
            1612, "pointId": "1418"}, {"directionId": "1780",
            "distanceFromPoint": 4652, "pointId": "9600"}, {"directionId":
            "9600", "distanceFromPoint": 2579, "pointId": "3018"},
            {"directionId": "1780", "distanceFromPoint": 5, "pointId":
            "1270"}]"
        },
```

- Vehicle Positions :
  - directionID
  - distanceFromPoint
  - pointID

Real-time Position of Vehicles



	A	B	C	D
1	lineId	directio	anceFro	pointI
7316	17	9059	411	4313
7444	17	9059	411	4313
7466	17	9059	411	4313
7471	17	9059	232	4313
7520	17	9059	232	4313
7537	17	9059	201	4313
7637	17	9059	176	4313
7643	17	9059	141	4313
7799	17	9059	128	4313
7842	17	9059	128	4313
7871	17	9059	97	4313
7875	17	9059	46	4313
7919	17	9059	46	4313

GTFS stops

```
-stop_id
-stop_code
-stop_name
-stop_desc
-stop_lat
-stop_lon
-zone_id
-stop_url
-location_type
-parent_station
```

Stop details

```
-psCoordinates
-id
-name
```

- 4313 : LES 3 TILLEULS
- 4347 : MIRAVAL

Waiting Times in Real-time

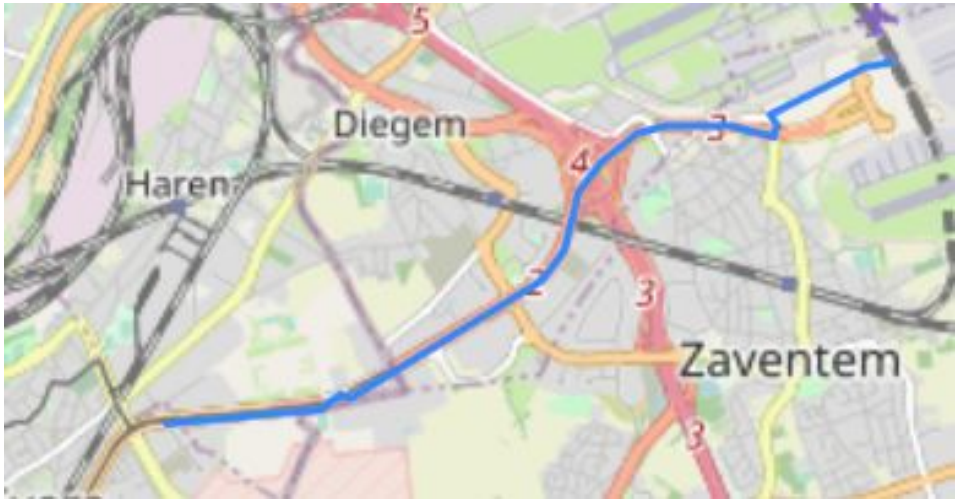

```
{
    "total_count": 3299,
    "results": [
        {
            "pointid": 6465,
            "lineid": "21",
            "passingtimes": "[{"expectedArrivalTime":
            "2023-10-12T12:20:00+02:00", "lineId": "21", "message": {"en":
            "End of service", "fr": "Fin de service", "nl": "Einde dienst"}},
            {"expectedArrivalTime": "2023-10-12T12:20:00+02:00", "lineId":
            "21"}]"
        },
```

Size of Data Sets

Data	20 seconds	1 minute	1 hour	1 day	1 month	1year
RT positions	37-60 Ko	111-180 Ko	6.7-10.8 Mo	160.8-259.2 Mo	4 Go-7.8 Go	48-93.6 Go
Waiting Times	1.15 Mo	3.46 Mo	208 Mo	4.75 Go	142.7 Go	1.67 To

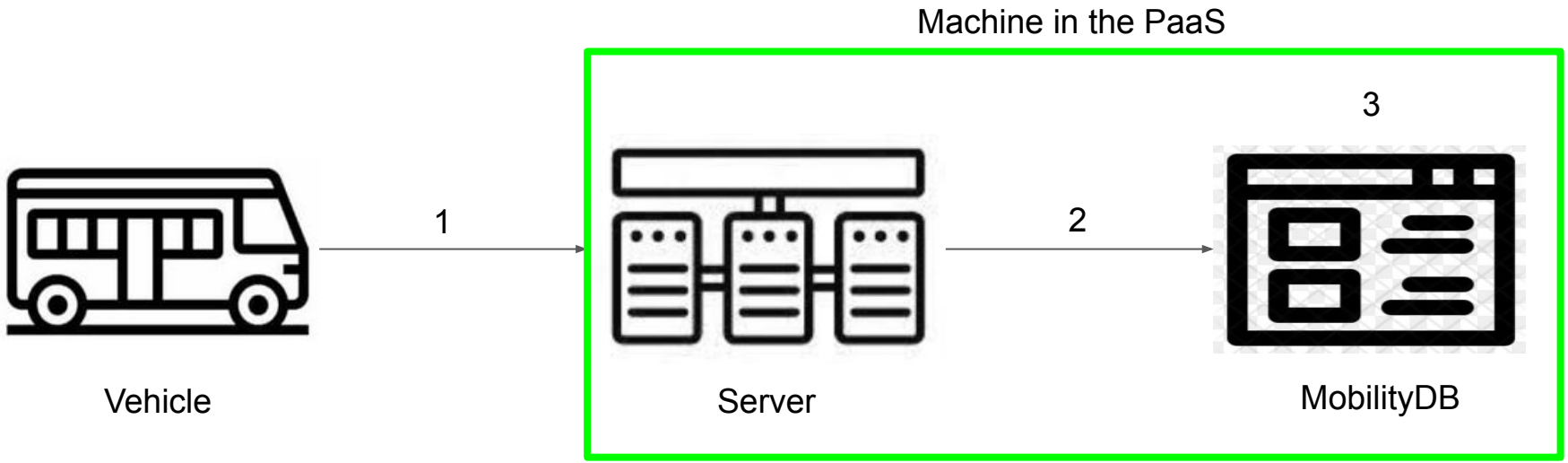
Conversion to Positions

- directionID : 1780
- distanceFromPoint : 150
- pointID : 3462



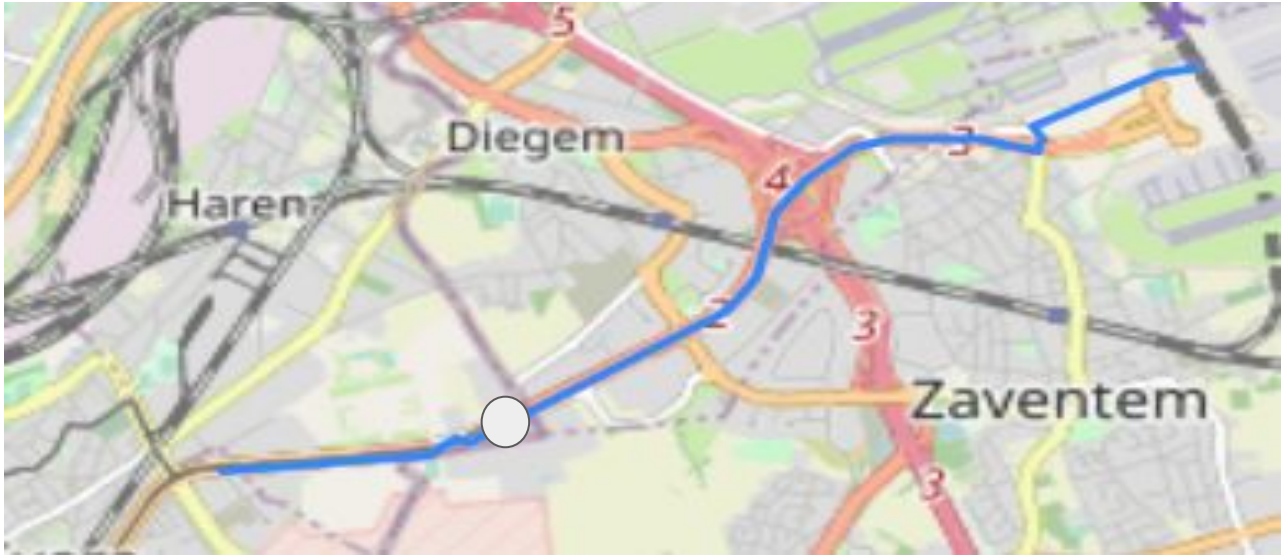
Where is the vehicle after 150 meters on the trajectory?

Interpolation



1 : Sends the position of all STIB vehicles (every 20 seconds) via the STIB ODP.
2 : Data collection by the server (PaaS machine)
3 : Calculate actual vehicle coordinate + add to trip

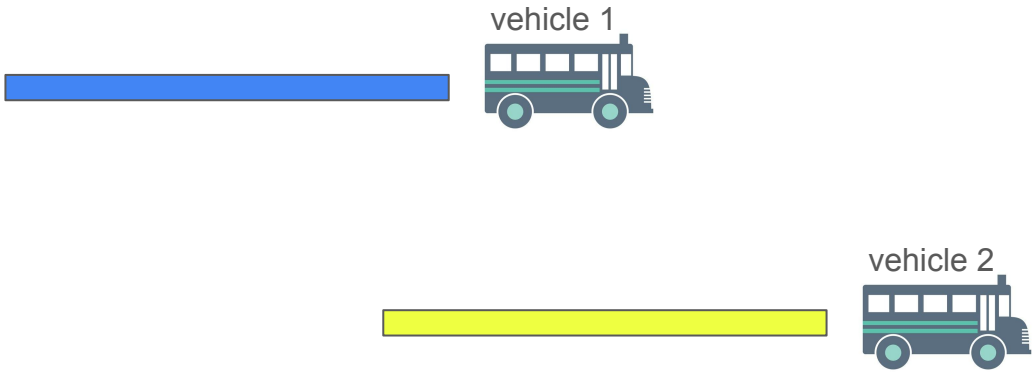
Better Data Understanding



	day date	lineid text	tripid text	directionid text	start_timestamp timestamp with time	end_timestamp timestamp with time	is_deviated boolean	current boolean	trip tgeompoint
1	2024-01-02	2	2_2	8763	2024-01-02 11:11...	2024-01-02 11:14...	false	false	[0101000020E6100000D3F6AFAC344911404EECA17DAC6C4940@2
2	2024-01-02	12	12_5	1780	2024-01-02 10:40...	2024-01-02 10:48...	true	false	[0101000020E6100000EA76F69507891140DA53724EEC6B4940@2(
3	2024-01-02	2	2_6	8382	2024-01-02 10:36...	2024-01-02 10:36...	true	true	0101000020E6100000240F4416695211400343 56B77A6E4940@20
4	2024-01-02	12	12_4	1780	2024-01-02 11:31...	2024-01-02 12:44...	true	false	[0101000020E6100000F9F36DC152ED1140B1F7E28BF6724940@2(
5	2024-01-02	2	2_4	8472	2024-01-02 13:21...	2024-01-02 13:24...	true	false	[0101000020E61000003FA88B14CA5211401EA9BEF38B6E4940@2(
6	2024-01-02	2	2_5	8763	2024-01-02 11:18...	2024-01-02 11:20...	false	false	[0101000020E6100000855FE1A5194C11400469204B2E6C4940@2(
7	2024-01-02	2	2_7	8472	2024-01-02 10:36...	2024-01-02 10:36...	false	false	0101000020E61000000EE509DADE4A11400DF52D863A6D4940@2(
8	2024-01-02	47	47_7	9784	2024-01-02 10:36...	2024-01-02 10:38...	true	false	[0101000020E6100000014D044D8F094114033535A7F4B744940@2(

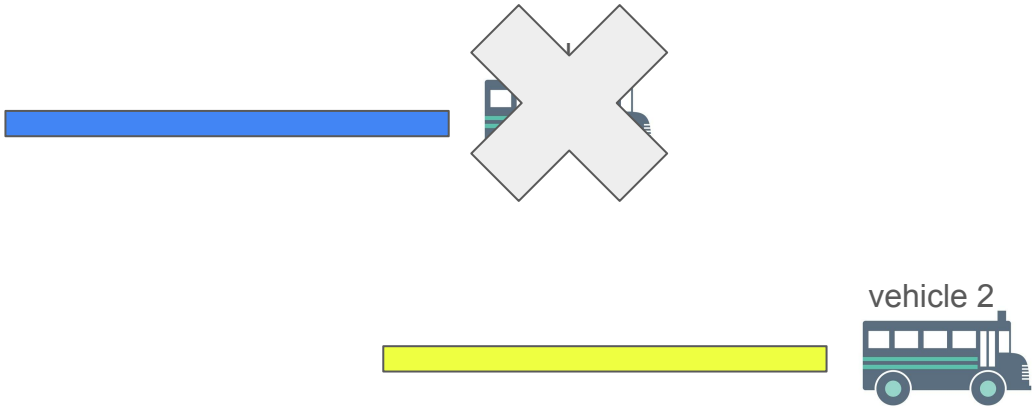
Difficulties

- Vehicle ID unkown
  - Complicated path construction



Difficulties

- Vehicle ID unkown
  - Complicated path construction



Difficulties

- Vehicle ID unkown
  - Complicated path construction

vehicle 1

Difficulties

- Vehicle ID unkown
  - Complicated path construction
- Some stops do not exit in the data
- Not all trip headsign have a shape

```
Query 1 returned no result for LineID: %s and pointID: %s for directionID: %s 55 2786 9943
Query 3 returned no result for LineID: %s and PointID: %s for DirectionID: %s 55 5803 529
Query 3 returned no result for LineID: %s and PointID: %s for DirectionID: %s 55 5361 529
Query 1 returned no result for LineID: %s and pointID: %s for directionID: %s 55 529 9943
Query 1 returned no result for LineID: %s and pointID: %s for directionID: %s 55 5362 9943
Query 1 returned no result for LineID: %s and pointID: %s for directionID: %s 55 5868 9943
```

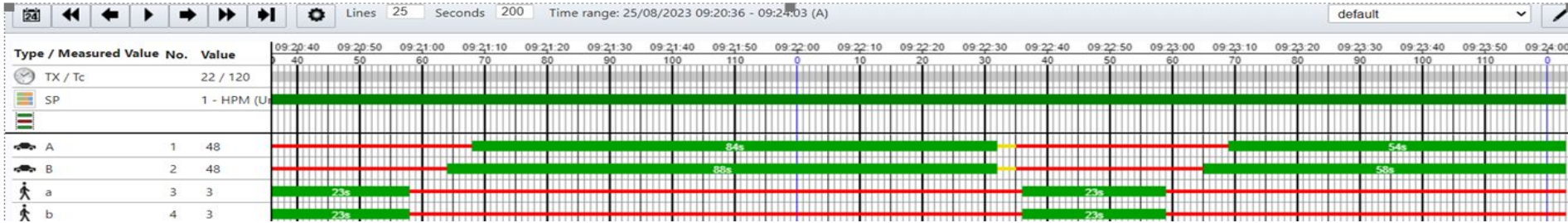
Difficulties

- Vehicle ID unkown
  - Complicated path construction
- Some stops do not exist in the data
- Not all trip headsign have a shape
- Deviations are not indicated in RT data
- New deviations do not exist in the data (2 years)

	route_short_name text	stopid text	trip_headsign text	shape_id text	trajectory geometry
1	1	1145	GARE DE L'OUEST	001m0045	0102000020E6100000A90200004165FCFB8CDB1140AF7C96E7C16B49408CA2073E06DB
2	1	1145	GARE DE L'OUEST	001m0063	0102000020E6100000760200001E37FC6EBAD51140E17CEA58A56C4940D93D7958A8D5

TLC and M-Cube Data

-TLC



Number of controllers accessible from the control centre : 315 / 610

-API requests

http://10.105.128.243:3000/api/rawData/signalgroups/SAB03?begin=1690848000

Identifier of the controller

timestamps of begin or end

Example of TLC Data

- Timestamp
- Value
- Offset
- Difficulty
  - Correspondence table :J2,J3,...
  - Server capacity

TLC and M-Cube Data

- TLC
- M3

- G3 : 330
- G5 : 70

+

Topic kafka

- Long lead times for coordination with two external entities Paradigm and Macq

Use Cases

- STIB Trips
  - More details for better filtering

	day date	lineid text	tripid text	directionid text	start_timestamp timestamp with time	end_timestamp timestamp with time	is_deviated boolean	current boolean	trip tgeompoint
1	2024-01-02	2	2_2	8763	2024-01-02 11:11…	2024-01-02 11:14…	false	false	[0101000020E6100000D3F6AFAC344911404EECA17DAC6C4940@2
2	2024-01-02	12	12_5	1780	2024-01-02 10:40…	2024-01-02 10:48…	true	false	[0101000020E6100000EA76F69507891140DA53724EEC6B4940@2(
3	2024-01-02	2	2_6	8382	2024-01-02 10:36…	2024-01-02 10:36…	true	true	0101000020E6100000240F441669521140034356B77A6E4940@202
4	2024-01-02	12	12_4	1780	2024-01-02 11:31…	2024-01-02 12:44…	true	false	[0101000020E6100000F9F36DC152ED1140B1F7E28BF6724940@2(
5	2024-01-02	2	2_4	8472	2024-01-02 13:21…	2024-01-02 13:24…	true	false	[0101000020E61000003FA88B14CA5211401EA9BEF38B6E4940@2(
6	2024-01-02	2	2_5	8763	2024-01-02 11:18…	2024-01-02 11:20…	false	false	[0101000020E6100000855FE1A5194C11400469204B2E6C4940@2(
7	2024-01-02	2	2_7	8472	2024-01-02 10:36…	2024-01-02 10:36…	false	false	0101000020E61000000EE509DADE4A11400DF52D863A6D4940@2(
8	2024-01-02	47	47_7	9784	2024-01-02 10:36…	2024-01-02 10:38…	true	false	[0101000020E610000014D044D8F094114033535A7F4B744940@2(

Use Cases

- STIB Trips
  - More details for better filtering
- STIB Alarms
  - Not moving or slowed down

Examples of Alarms

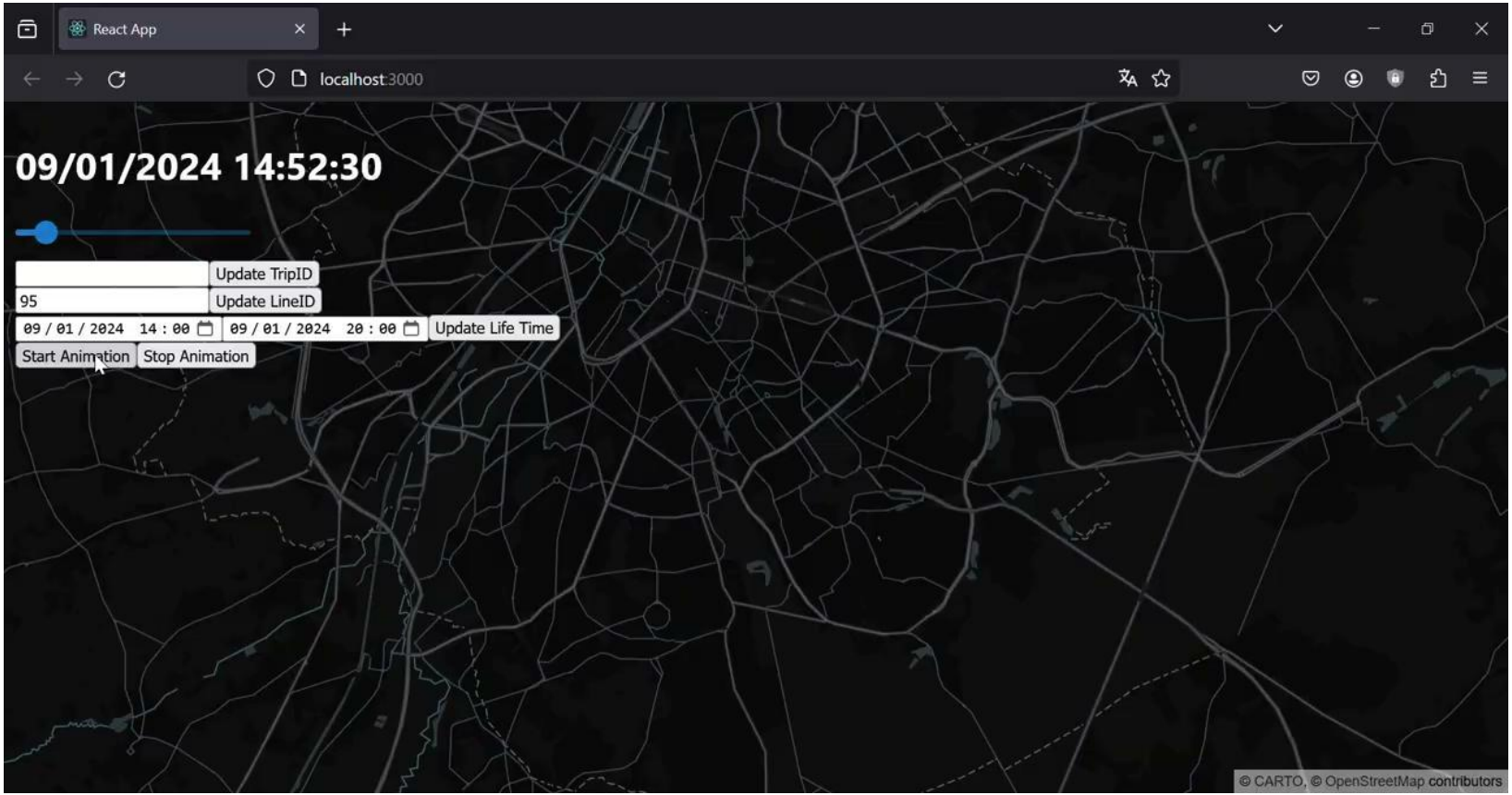

```
{
    "lineid": "95",
    "tripid": "95_15",
    "direction": "GRAND-PLACE",
    "transportType": "b",
    "position": {
        "x": 4.416161848211591,
        "y": 50.798619174166724
    },
    "startTime": "2024-01-09 17:23:26+01",
    "type": "SLOWED_DOWM",
    "description": "The vehicle has an average speed of 5 km/h since at least 5 minutes"
}
```

```
{
    "lineid": "50",
    "tripid": "50_6",
    "direction": "LOT STATION",
    "transportType": "b",
    "position": {
        "x": 4.298489,
        "y": 50.789893
    },
    "startTime": "2024-01-02 17:36:37+01",
    "type": "NOT_MOVING",
    "description": "The vehicle is not  moving since at least 5 minutes"
},
```

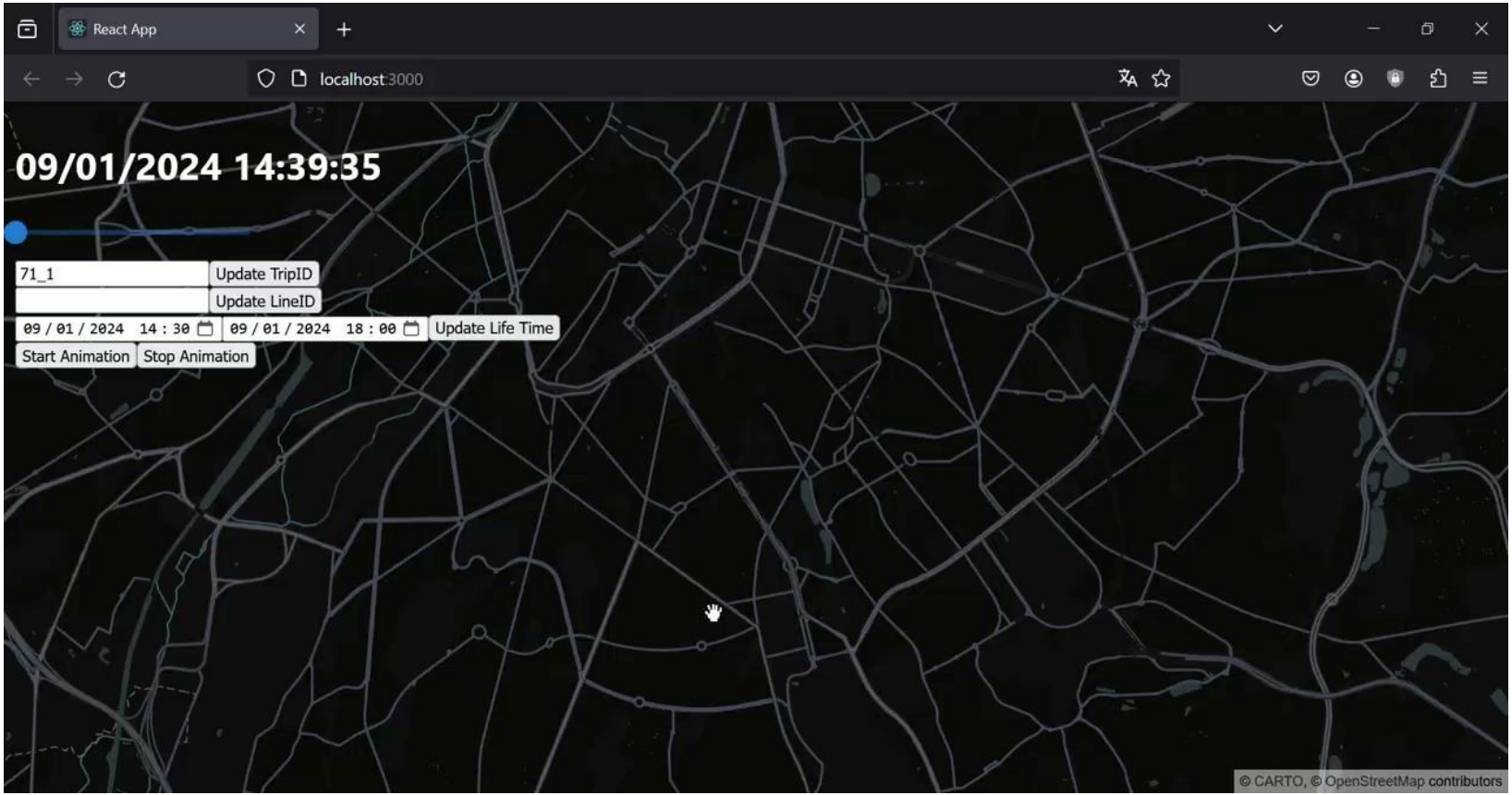
Use Cases

- STIB trips
- STIB alarms
- Visualisation tools
  - Historical
  - Near real-time

Historical Visualisation of Multiples Vehicles from Line 95

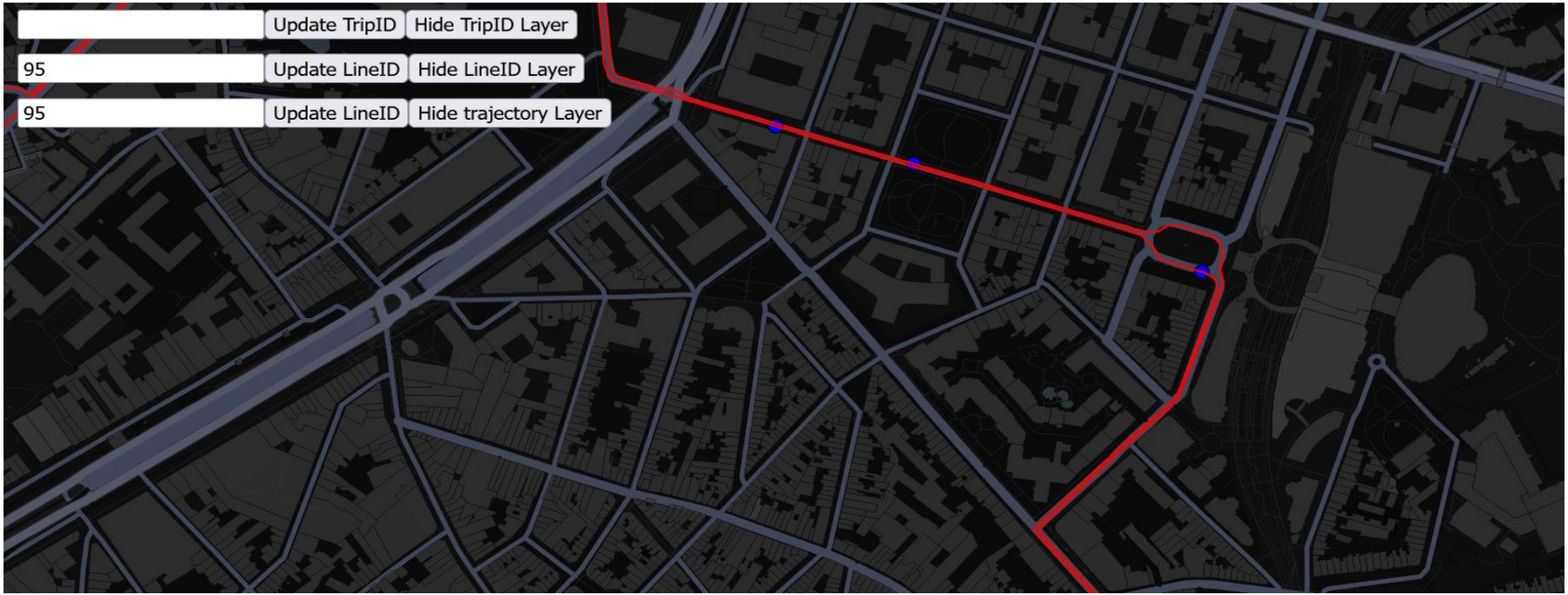


Historical Visualisation of one Vehicle from Line 71



Near Real-Time Visualisation of Vehicles of Line 95

Next Update


Update TripID
Hide TripID Layer
95
Update LineID
Hide LineID Layer
95
Update LineID
Hide trajectory Layer

Results

- STIB
  - STIB trips that allows multiples analysis depending on the user needs
  - STIB alarms that allows to have a better understanding of the actual state of the traffic
  - Visualization tool that allows a better comprehension of the data collected
- Setting up a source for ANPR camera count data
- Start of a collaboration to gain access to TLC data

Future Work

- Improved storage of STIB trips
- New alarms
  - Distance between 2 vehicles is less than 50 m
- Adding TLC data to the database
- Adding M-Cube data to the database
- New modules for the visualization tool
  - Visualization of TLC data
  - Visualization of M-Cube data
- New analysis of STIB trips