MATSim User Meeting 2025:
Urban Traffic Simulation in the City of Nouakchott Using MATSim

Mohamed Abderahman
mohamed.mohamedelmoctar@univ-tours.fr

Supervised by:
LIFAT – Ameur Soukhal, Emmanuel Neron
ESP – Mohamed Aly Louly
SUPNUM – Cheikh Dhib

Plan

1. Context
2. Problem Statement and Objectives
3. Assessment of the Existing Transport System in Nouakchott
    1. Data Formatting and Integration
    2. Visualization
4. Future Work and Improvements

Context: Characteristics of the urban environment

- Urban structure :
  - Population density by neighborhood
  - Zone types: residential, commercial, industrial, administrative
  - Points of interest: schools, hospitals, markets, etc.
- Infrastructure and mobility:
  - Transportation network: roads, bus routes, stops
  - Means of transport used: private car, cab, bus
  - Areas well / poorly served

Context: Mobility Data and Planning

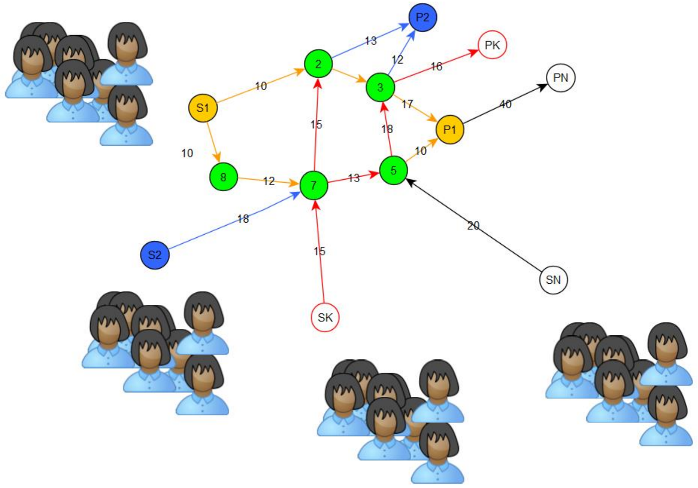
- Data Available/Simulated:
  - Origin-destination matrices
  - Ridership data, Individual users and collective users
- Public Transport Planning:
  - Extension projects: new lines or routes,
  - Sustainable mobility plan:
  - Objectives: Adapt supply to demand.
  - Management: Schedules, frequency, and fleet sizing (number of buses, capacity, and availability).
  - Planning new routes

Context: Background

- With the city’s growth and the expansion of the private vehicle fleet, the transport network requires a redesign and improved planning for public transportation, aiming to:
  - Improve quality of service (QoS)
  - Facilitate traffic flow and reduce urban congestion
  - Minimize environmental impact
- This revision may involve the construction of new network segments or capacity adjustments on specific links.
- It must be based on accurate data regarding transport demand and the resources available to public transport operators.

Problem Statement and Objectives

- The objective of the simulation is to identify areas of the transport network that require improvement due to the city's significant growth.
- As urban expansion increases travel demand and pressure on existing infrastructure, the simulation helps pinpoint the most critical segments in need of redesign, expansion, or capacity adjustment



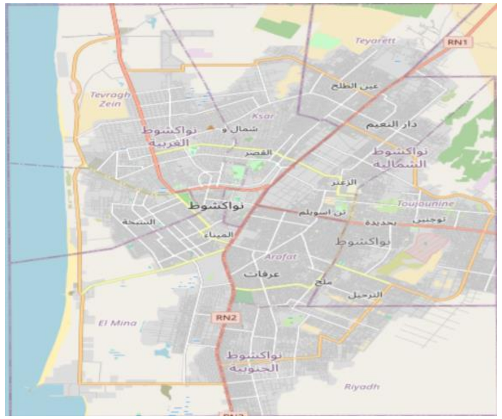
Assessment of the Existing Transport System in Nouakchott

Transport public bus

$$D\_p = \begin{bmatrix} d_{1,1} & \cdots & d_{1,n} \\ \vdots & \ddots & \vdots \\ d_{n,1} & \cdots & d_{n,n} \end{bmatrix}$$

$$D\_v = \begin{bmatrix} d_{1,1} & \cdots & d_{1,n} \\ \vdots & \ddots & \vdots \\ d_{n,1} & \cdots & d_{n,n} \end{bmatrix}$$

Time table



Network

- Demand origin-destination D_p and D_v :
  - D_p: person requesting public transport from one point to another.
  - D_v: personal vehicle requesting travel within the city from one point to another

Data Formatting and Integration

- ❑ Transport network in the city (as a graph)
  - ❑ Modelled as a graph: nodes = intersections, edges = road segments
  - ❑ Includes key information: capacities, speed limits, traffic direction and types of lanes

- ❑ Public transport data
  - ❑ Bus lines
  - ❑ Public transport schedule
- ❑ Mobility demand
  - ❑ Represented as individual travel plans (origins, destinations, departure times, travel purposes, transport mode)

- ❑ Vehicle fleet in the city
  - ❑ Information on the types of vehicles (cars, buses, trucks) including their number, engine type, and emission standards
  - ❑ Especially useful for environmental impact assessments (emissions, fuel consumption)

Data Formatting and Integration: network and transit supply

- OSMOSIS:
  - converts (network.osm.pbf) data to network.osm compatible with pt2matsim
- Pt2GTFS:
  - Converts:
    - GTFS data
    - Network.osm
  - To :
    - network.xml
    - transitSchedule.xml
    - transitVehicles.xml

Data Formatting and Integration: demand

Work station:

Point 1: 5000 persons
Point 2: 7000 persons
Point 3: 6000 persons
………….. : …………
………….. : …………
………….. : …………
………….. : …………
Point 30: 4000 persons

Home Station:

Point 1: 5063 persons
Point 2: 6732 persons
Point 3: 495 persons
………….. : …………
………….. : …………
………….. : …………
………….. : …………
Point 1000: 6874 persons

Data Formatting and Integration: demand

Table. 1: Matrix Origins and destinations

Origins \ Destinations	1	2	..	..	30	Total Origins
1	..	..	..	..	..	O_1
2						O_2
..						..
..						O_i
						..
1000						O_{1000}
Total destination	D_1	D_2	D_j	..	D_{30}	

$$\sum_i N_{ij} = D_j$$

$$\sum_j N_{ij} = O_i$$

O_i et D_j are known whereas N_{ij} is unknown

Data Formatting and Integration: Demand

Completion of the Origin-Destination Matrix:

- For all work locations, we assume that the attraction factor for a person to travel to a given location is the number of people working at that location divided by the total population.
- Taking into account the inverse of the distance between residential and work locations.
- The probability that a person travels from residence location *i* to work location *j* is calculated using the following formula:

$$p_{i,j} = \frac{fa(j) * \frac{1}{distance(i,j)}}{\sum_j (fa(j) * \frac{1}{distance(i,j)})}$$

with $fa(j)$ the attraction factor of location j

Data Formatting and Integration: Demand

Matrix adjusting:

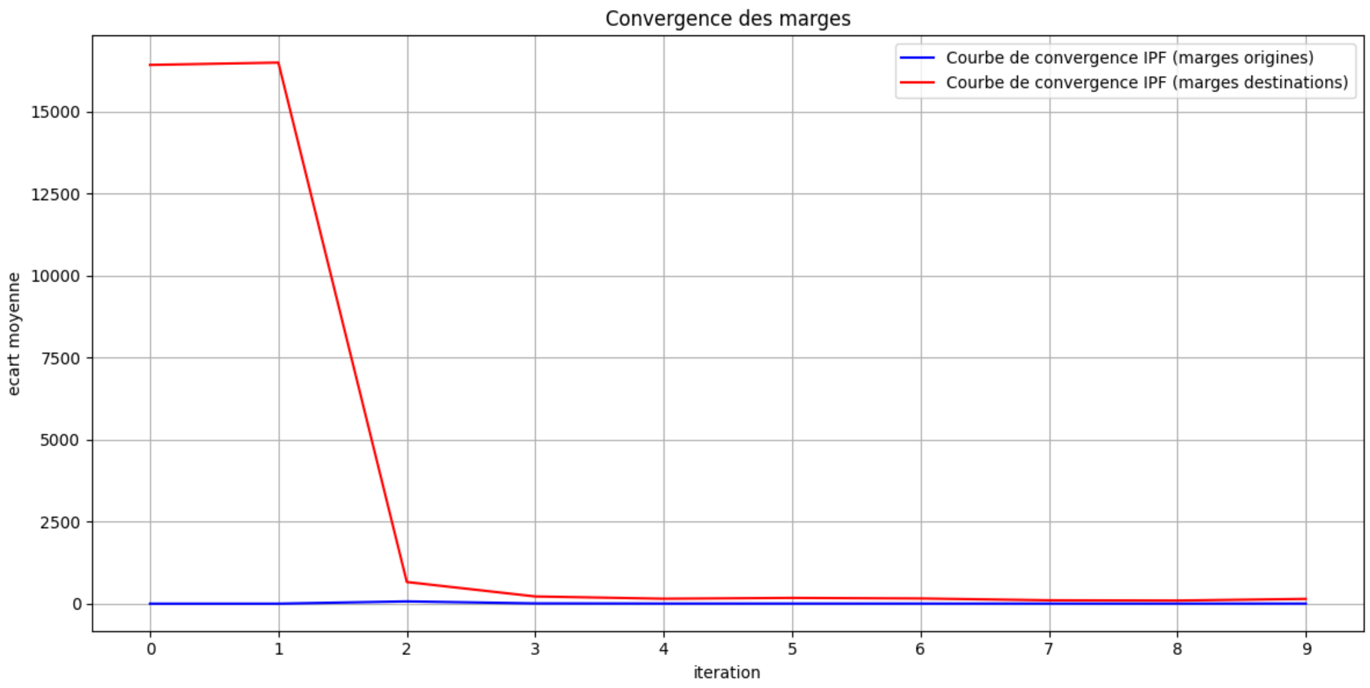
- **To ensure consistency with the marginal totals** (i.e., the number of people in each residence and work location), the **Iterative Proportional Fitting (IPF)** method is used
  - This allows us to construct the trip matrix dep
- At first iteration : $dep_{i,j} = p_{i,j} * O_i$ then $dep_{i,j}$ represents the number of people who travel from location i to location j, $p_{i,j}$ represents the probability to travel from location i to location j and O_i total number of people residing at location i
- ITF:
  - At each iteration I: $\boldsymbol{dep_{i,j,I} = \frac{dep_{i,j,I-1}}{\sum_{i=1}^{1000} dep_{i,j,I-1}} * O_i}$

  Then $$\boldsymbol{dep_{i,j,I} = \frac{dep_{i,j,I}}{\sum_{j=1}^{30} dep_{i,j,I}} * D_j}$$

  where $\boldsymbol{D_j}$ is the total of people working at j and $\boldsymbol{O_i}$ is the total of people living at **i.**

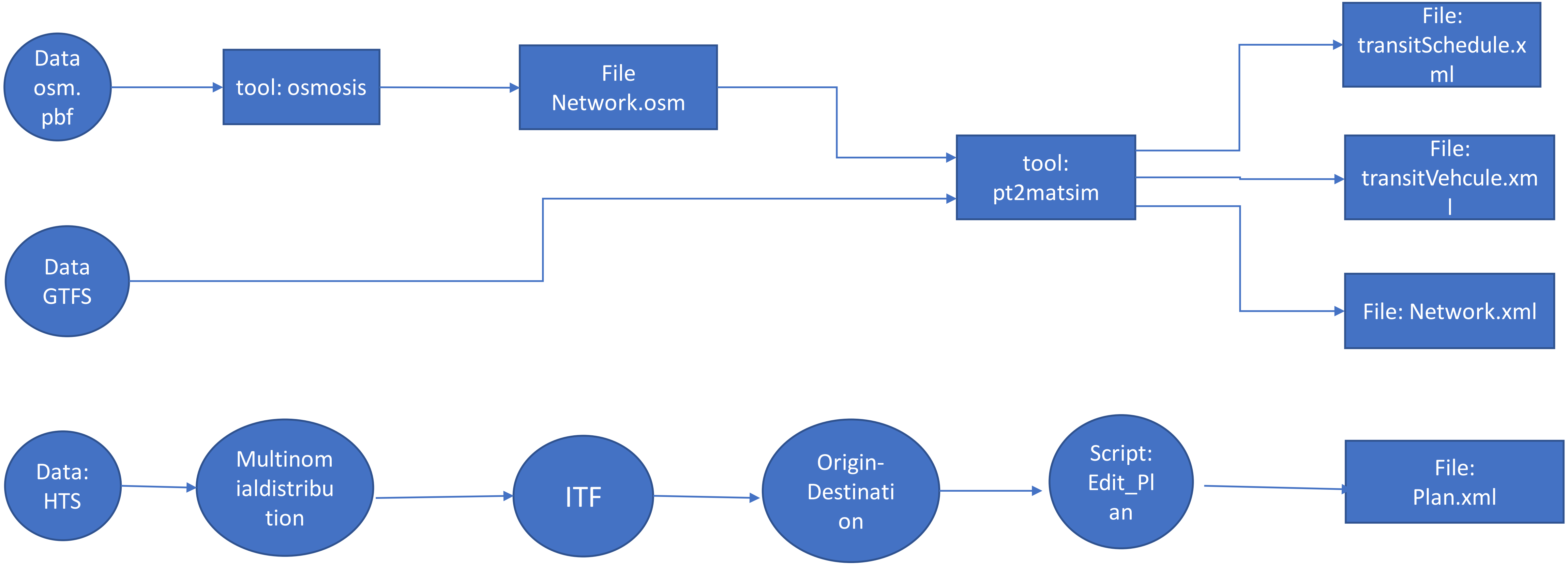
Data Formatting and Integration: Demand

The evolution of the adjustment

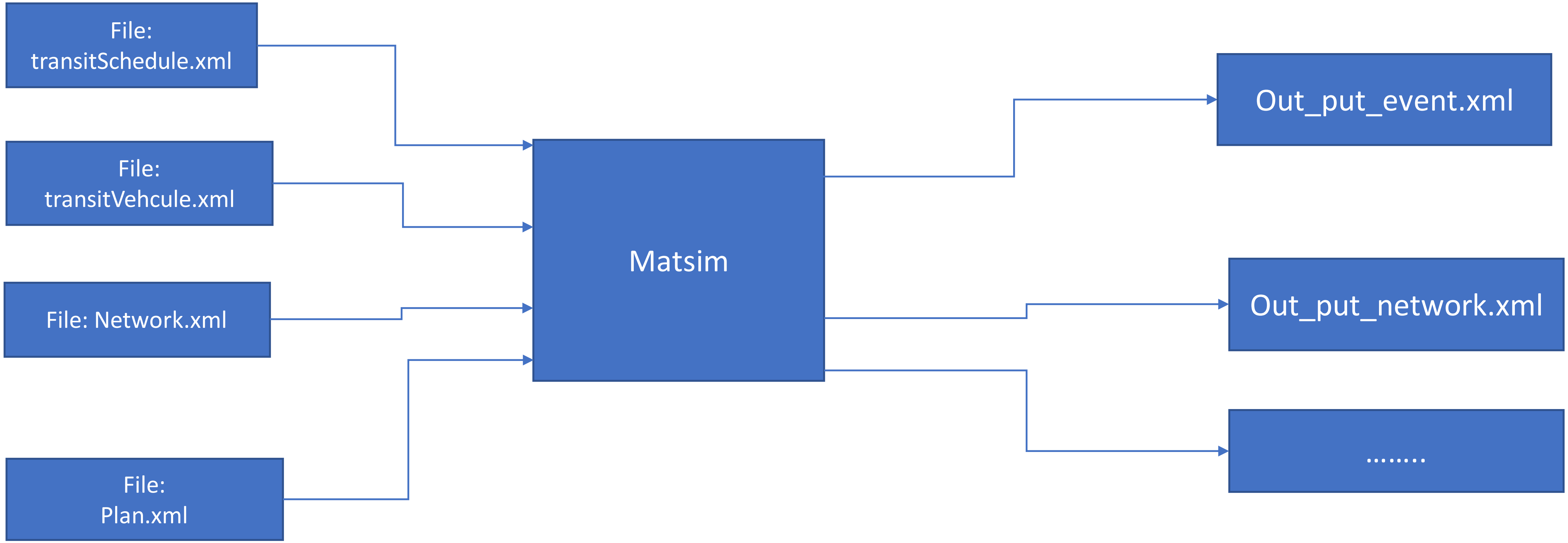


- The row totals converge rapidly from the first iteration, thanks to the initial attraction formula, guarantees consistency with the original totals.
- Column consistency, on the other hand, only begins to improve from the second iteration onwards, as the algorithm initially adjusts only the rows

Data Formatting and Integration: Data Intégration Processus



Traffic Simulation with MATSim



Visualisation

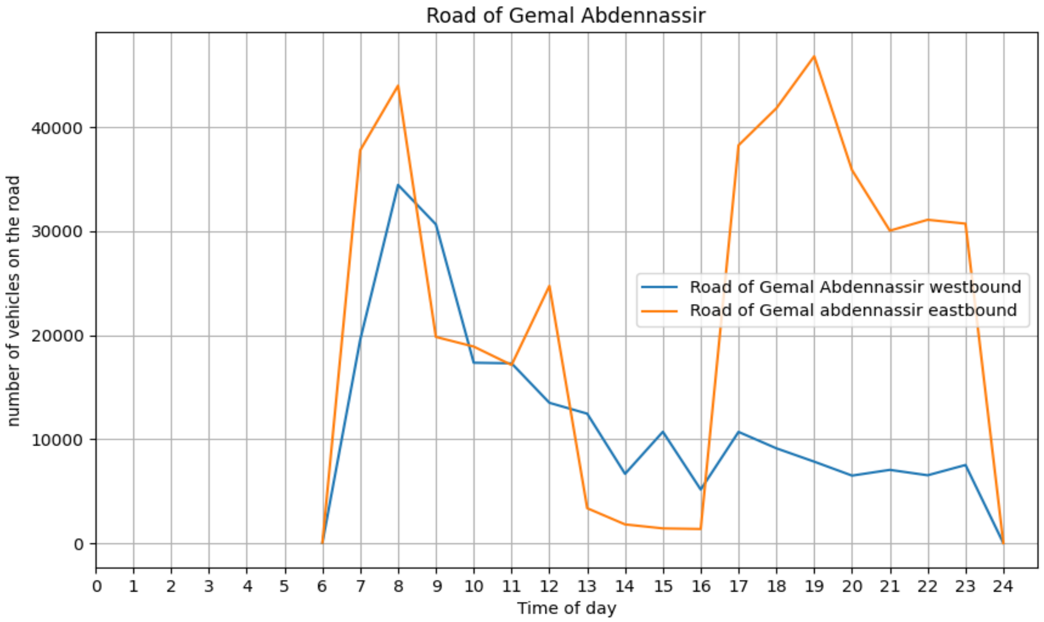
- ❑ Visualize traffic behavior
  - ❑ Identify areas of congestion
  - ❑ Observe peak-hour flows
- ❑ Detect segments in need of improvement
  - ❑ Define the set of arcs to be added or modified

Visualisation

Network state at 06:30:00

Simunto MATSim

A main road during the day



Future Work and Improvements

- Collect more real-world data
  - Improve accuracy and realism of simulation input data.
- Re-run the simulation with updated data
  - Ensure better representation of real mobility patterns.
- Compare simulation results with traffic count data
  - To validate and assess model quality.
- Integrate calibration and emission modules
  - To improve accuracy and environmental impact analysis.

Thanks