A Framework for Dynamic O-D Matrices for Multimodal transportation: an Agent-Based Model approach

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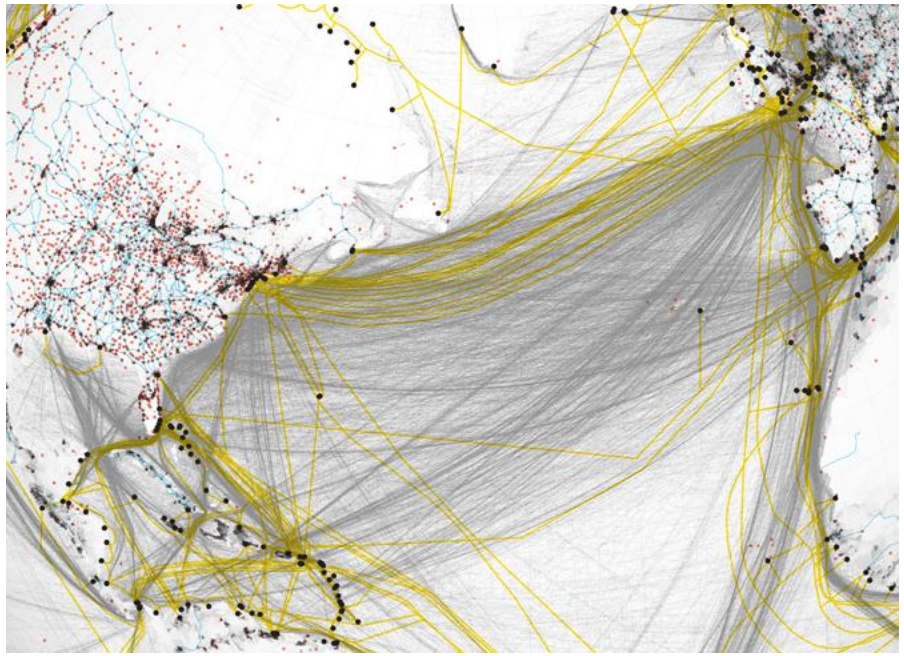


Introduction

Introduction

Mobility and commuting

Very Expensive
Highly Polluted
Time Wasting

Solution

A simulation model of the Four Step Model using an agent Based Model (ABM) is proposed

Steps

Multi-Modal Transport Network
Economic Analysis

Introduction

An agent-based model

simulates the actions and interactions of autonomous agents to assessing the effects

on the system as a whole. They can be a handful tool for combining different models in one.

Major Steps

Calibration – *"data fit"*
Verification – *"building the system right"*
Validation – *"building the right system"*

Introduction

Overview, Design and Details Protocol

Volker Grimm

Why?

The primary purpose of ODD is to make writing and reading model descriptions easier and more efficient.

How?

Attempts to create a generic format and a standard structure by which all ABMs could be documented.

Overview	1. Purpose 2. Entities, state variables and scales 3. Process overview and scheduling
Design Concepts	4. Design concepts a. Basic principles b. Emergence c. Adaptation d. Objectives e. Learning f. Prediction g. Sensing h. Interaction i. Stochasticity j. Collectives k. Observation
Details	5. Initialization 6. Input data 7. Submodels

Transportation Network

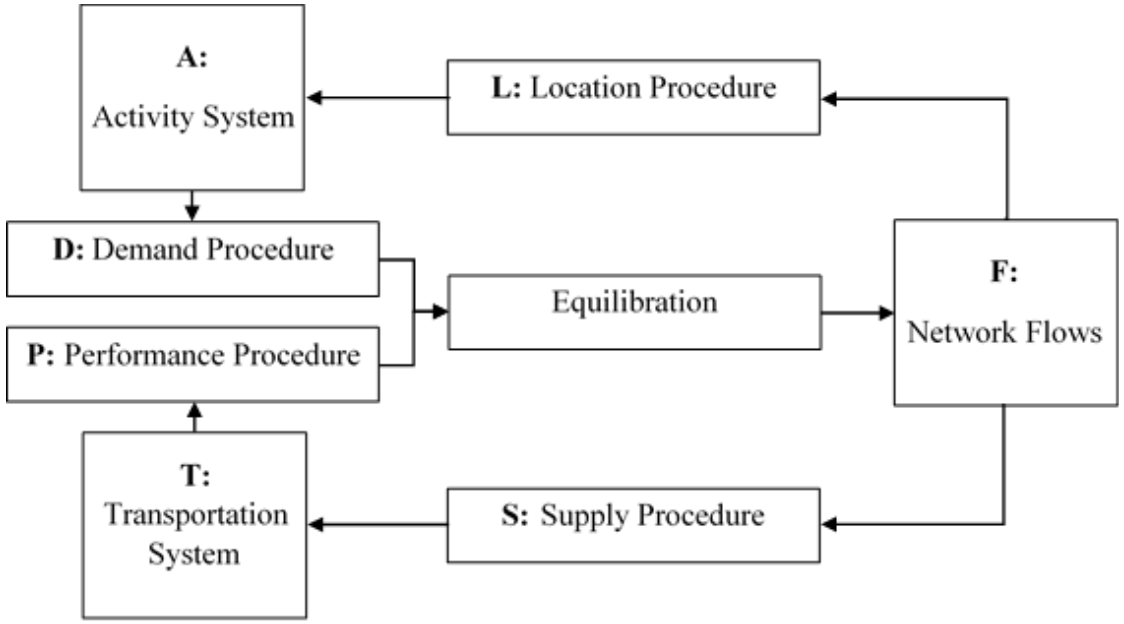
Transportation Network

Transportation System Analysis Framework

Manheim and Florian work

Transportation System T
is defined as the transportation infrastructure and services elements.
Inputs to performance procedures P.

Activity System A
defined as everything else (e.g. endogenous factors).
Inputs to demand procedures D.



Transportation Network

Four Step Model - FSM

McNally and Ortuzar

1. Trip Generation

Total daily travel is loaded in the model system

2. Trip Distribution

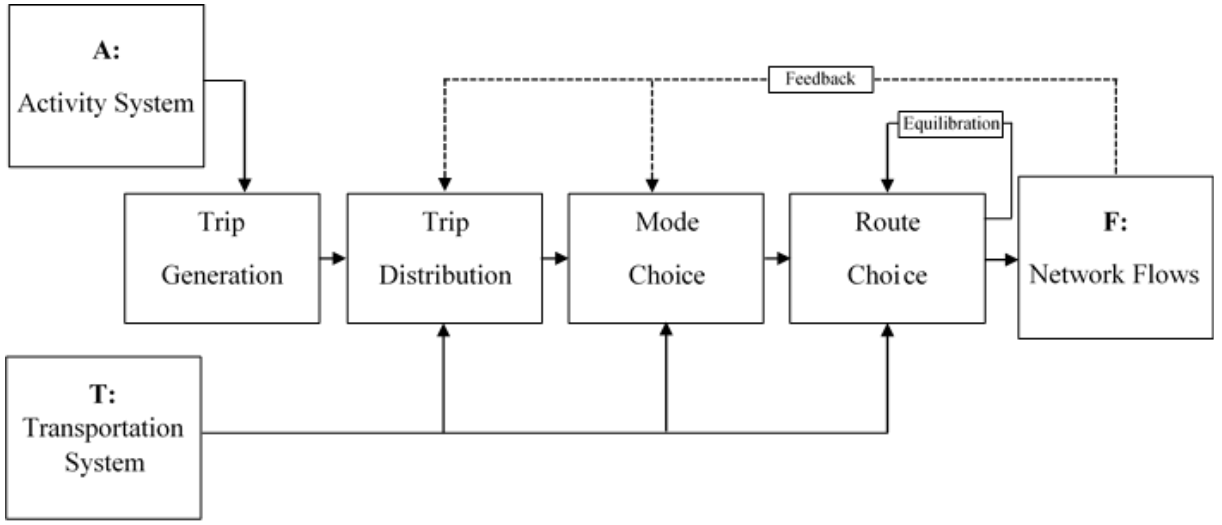
Destination is made that generates a trip matrix

3. Mode Choice

Factors the trip tables to produce mode trip tables

4. Route Choise

Allocates trips between an origin and destination by a particular mode to a route



Transportation Network

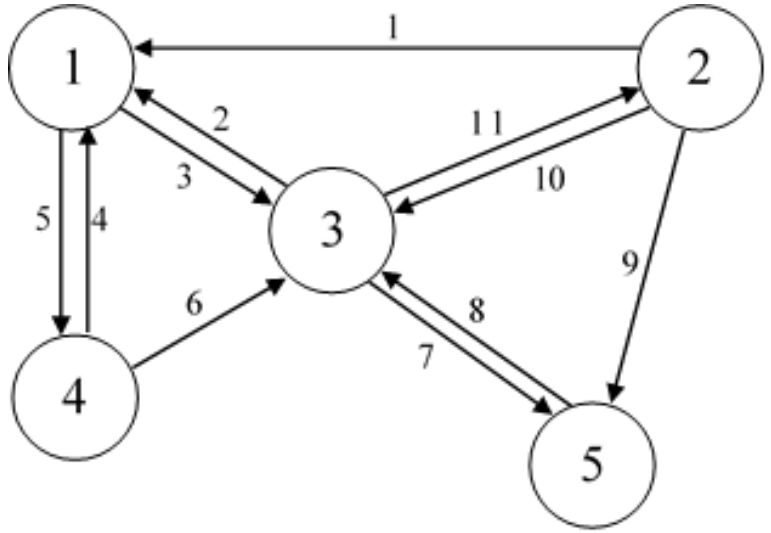
Network Representation

Sheffi

The link relationship with the capacity and the volume expresses in a function called the BPR function (Bureau of Public Roads, 1964). This function works as follows

$$\left[\quad — \quad \right]$$

is the average travel time for a vehicicle on link ,
is the free-flow time, and is the *practical capacity* of the link .



Framework for Agent Based Transportation Model (ABTM)

Framework for ABTM

1. Structure

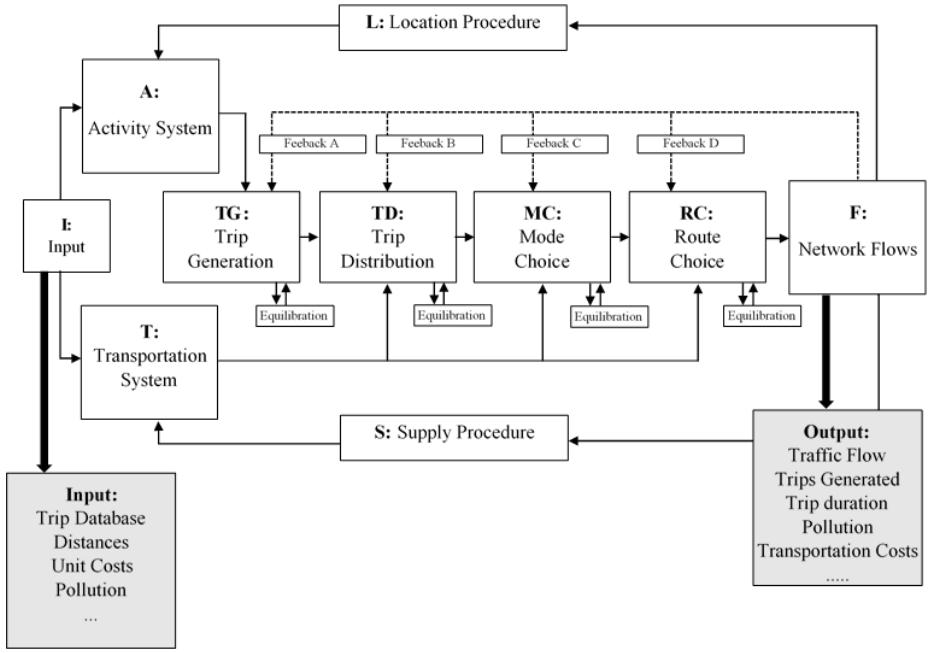
The structure must follow the updated version of the ODD protocol. This acts as an underlying code structure being easier for new models to be built-in or to expand the current model.

2. Tools

This model works under the NetLogo agent-based simulation environment.

3. General Framework

This approach combines the different transportation models used to analyze the transportation system with an agent-based paradigm.



Framework for ABTM

4. Models

In this Framework, a combination of transportation models is proposed. The one underlying the model is the FSM.

Variables		
A:	Activity System	Defines the Activity System within the city.
L:	Location Procedure	Location Procedure gives the location and the situation of each agent travelling in the network.
T:	Transportation System	The Transportation System is the network the model will work on.
S:	Supply Procedure	The Supply Procedure is the characteristics of that Transportation System.
F:	Network Flow	The Network Flow is the output of the simulation Here we can extract information to adjust the model.

Functions		
TG:	Trip Generation	The Trip Generation will decompose the Activity System in trips that will be assignment in the next step.
TD:	Trip Distribution	Here all the trips generated in the last will by distributed in all the nodes of the network.
MC:	Mode Choice	The Mode Choice will analysed for each agent is preference and assign a transportation mode.
RC:	Route Choice	The Route Choice will give the agent a route / a path to follow and the agent will go under that path.

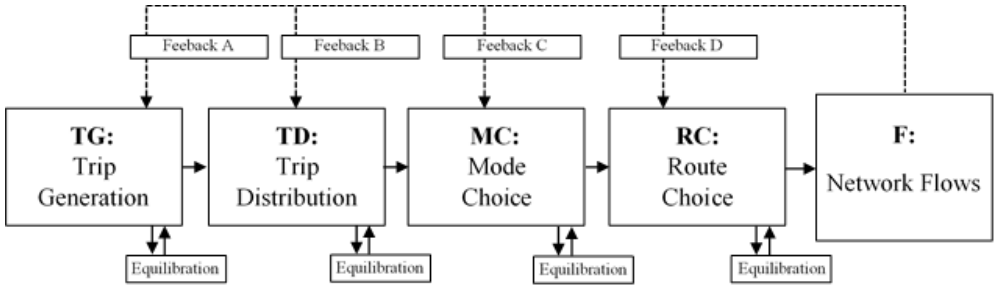
Control / Flow	
Input	Anything can act as input variables: from network characteristics to population characteristics.
Output	Depending in the study objective, the Model Output must be adjusted to reflect that need.
Feedback	This is a control measure that only work in a day-to-day Dynamics.
Equilibration	Each function will have an equilibrium that will work as stabilizer for the all model.

Framework for ABTM

5. Model Flow and Techniques

The four functions works in a sequential way.

The feedback parameters A, B, C and D serves as an input for the TG, TD, MC and RC. Those parameters works as a day-to-day updating and a historical demand.



Framework for ABTM

6. Visualization

The model must be practical and useful for the community.

First Implementation

Implementation

1. Purpose

A simulation model of the FSM using an ABM is proposed. In this implementation, we developed a within day dynamics (24-hour).

2. Entities, state variables and scales

Each agent can have two strategies:
the shortest way (yellow_drivers) or
the fastest way (red_drivers).
The model is a 30 x 20 patches world
in which each patch represents 1000 sq meters.
Each tick represents one-minute simulation and so 1440 ticks represents a 24-hour process.

The state variables	
to-node-car	the node each agent is going to
from-node-car	the node each agent comes from
current-node	the node the agent is
who	which identifies the agent number
drivers_ratio	splits the agents strategies
velocity_delta	random number to increase speed
v	agents velocity

Implementation

3. Process overview and scheduling

Willing-to-travel -> setups the agents' will to travel during a 24-hour process.

Inter-arrival-time -> defines the parameter for the Poisson distribution.

Reproduce -> procedure ensures that new agents' have the same drivers' characteristics.

Count-turtles-on-links -> is a procedure that counts all the agents' in each link.

Create_link_volumes -> uses the last procedure to update the behavior of each agent.

Report -> the network calculates the total drivers (*Calculate_total_drivers*)

the time to travel (*Calculate_time_travel_drivers*) for all the agents

the average travel time (*Calculate_average_travel_time*) for each agent.

Implementation

4. Design concepts

Emergence - The main output is the average speed and the agents' travel time.

Objectives – *yellow_drivers* tries to achieve the shortest path and the *red_drivers* the fastest one.

Sensing - Agents' perceive their status and the agents around them, so agents can adapt their velocity to the current network condition.

Stochasticity - this model has not real data therefore, the type (drivers_ratio),number (*num-drivers*), and time (*inter-arrival-time*) are modelled using random distribution or a Poisson distribution.

Observation - The time to travel, the number of agents created and the average travel time.

Implementation

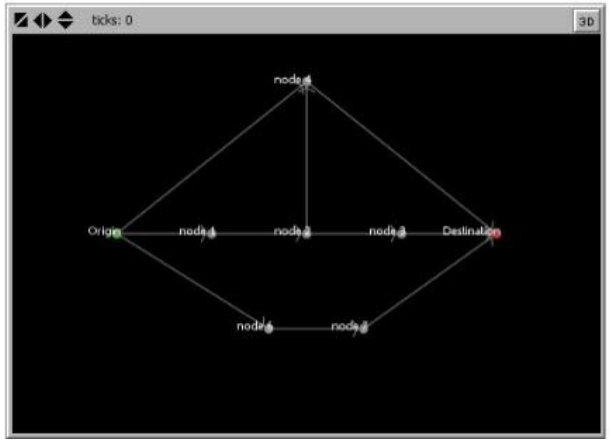
5. Initialization

Seven nodes plus one origin and one destination defines this network.

With this links and nodes, four paths connects the network. We divided the links in two, CCL (City Center Links) and HL (Highway Links) and four paths:

1. (link_6 -> link_7) and (origin -> node 4 -> destination) -> length 25.61 patches
2. (link_1 -> link_2 -> link_3 -> link_4) and (origin -> node1 -> node 2 -> node 3 -> destination) -> length 20 patches
3. (link_1 -> link_2 -> link_5 -> link_7) and (origin -> node1 -> node2 -> node 4 -> destination) -> length 30.81 patches
4. (link_8 -> link_9 -> link_10) and (origin -> node5 -> node6 -> destination) -> length 23,04 patches

Link	Owns
Link_1	origin -> node 1
Link_2	node 1 -> node 2
Link_3	node 2 -> node 3
Link_4	node 3 -> destination
Link_5	node 2 -> node 4
Link_6	origin -> node 4
Link-7	node 4 -> destination
Link_8	origin -> node 5
Link_9	node 5 -> node 6
Link_10	node 6 -> destination



Implementation

6. Input data

The agent velocity was developed with the help of the BPR function. Each agent have their velocity adjusted to link volumes.

7. Submodels

Model 1 - The model that updates the velocity of each driver. It relates the maximum capacity for each link with the current-flow.

Model 2 - The other submodel is the route/path choice. It works as follows: an agent when reaches a node calculates the distance to the next node or the time to the next node.

The *inter-arrival-time*

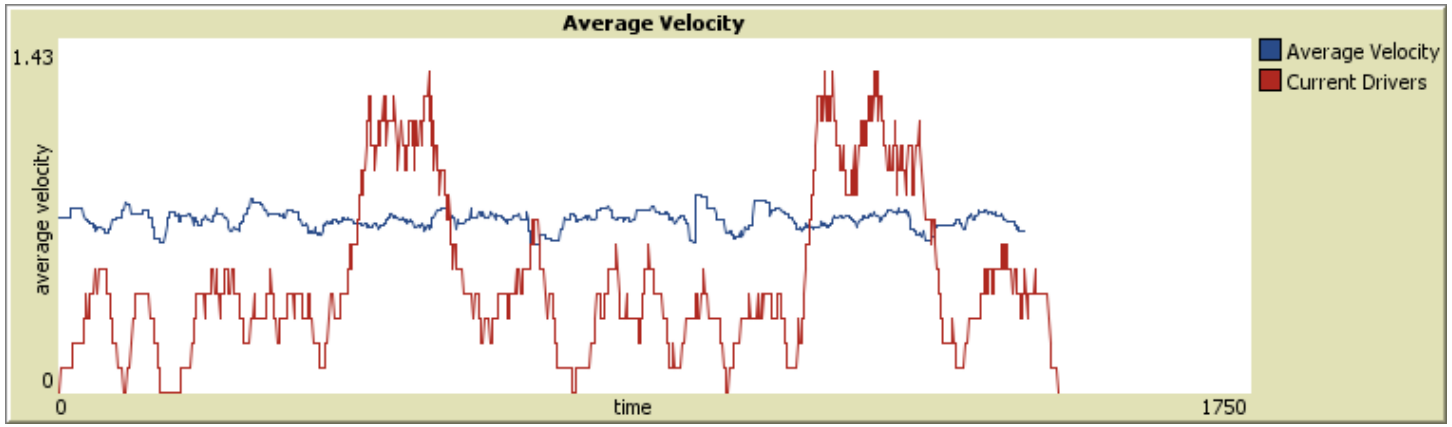
Hour	Ticks	Parameter
00:00 - 6:59	0 - 419	10
07:00 - 10:59	420 - 559	2
11:00 - 14:59	560 - 899	10
15:00 - 17:59	900 - 1079	10
18:00 - 20:59	1080 - 1259	2
21:00 - 23:59	1260 - 1440	10

City Center Links								Highway Links							
Volume	V	VD	Vel Range	Volume	V	VD	Vel Range	Volume	V	VD	Vel Range	Volume	V	VD	Vel Range
25	0	0,1	0km/h - 6km/h	12	0,5	0,1	30km/h - 36km/h	25	0,2	0,2	12km/h - 24km/h	12	0,7	0,2	42km/h - 54km/h
24	0	0,1	0km/h - 6km/h	11	0,5	0,1	30km/h - 36km/h	24	0,2	0,2	12km/h - 24km/h	11	0,7	0,2	42km/h - 54km/h
23	0	0,1	0km/h - 6km/h	10	0,5	0,1	30km/h - 36km/h	23	0,3	0,2	18km/h - 30km/h	10	0,7	0,2	42km/h - 54km/h
22	0	0,1	0km/h - 6km/h	9	0,5	0,1	30km/h - 36km/h	22	0,3	0,2	18km/h - 30km/h	9	0,7	0,2	42km/h - 54km/h
21	0	0,1	0km/h - 6km/h	8	0,5	0,1	30km/h - 36km/h	21	0,3	0,2	18km/h - 30km/h	8	0,7	0,2	42km/h - 54km/h
20	0,1	0,1	6km/h - 12km/h	7	0,5	0,1	30km/h - 36km/h	20	0,3	0,2	18km/h - 30km/h	7	0,7	0,2	42km/h - 54km/h
19	0,1	0,1	6km/h - 12km/h	6	0,5	0,1	30km/h - 36km/h	19	0,4	0,2	24km/h - 36km/h	6	0,7	0,2	42km/h - 54km/h
18	0,3	0,1	18km/h - 24km/h	5	0,6	0,1	36km/h - 42km/h	18	0,4	0,2	24km/h - 36km/h	5	0,7	0,2	42km/h - 54km/h
17	0,3	0,1	18km/h - 24km/h	4	0,6	0,1	36km/h - 42km/h	17	0,4	0,2	24km/h - 36km/h	4	0,7	0,2	42km/h - 54km/h
16	0,3	0,1	18km/h - 24km/h	3	0,6	0,1	36km/h - 42km/h	16	0,5	0,2	30km/h - 42km/h	3	0,7	0,2	42km/h - 54km/h
15	0,3	0,1	18km/h - 24km/h	2	0,6	0,1	36km/h - 42km/h	15	0,5	0,2	30km/h - 42km/h	2	0,7	0,2	42km/h - 54km/h
14	0,3	0,1	18km/h - 24km/h	1	0,6	0,1	36km/h - 42km/h	14	0,5	0,2	30km/h - 42km/h	1	0,7	0,2	42km/h - 54km/h
13	0,3	0,1	18km/h - 24km/h	0	0,6	0,1	36km/h - 42km/h	13	0,5	0,2	30km/h - 42km/h	0	0,7	0,2	42km/h - 54km/h

First Insights

First Insights

The standard parameters are *drivers_ratio* = 0.5, *velocity_delta* = 0.10, *num-drivers* = 1.0.

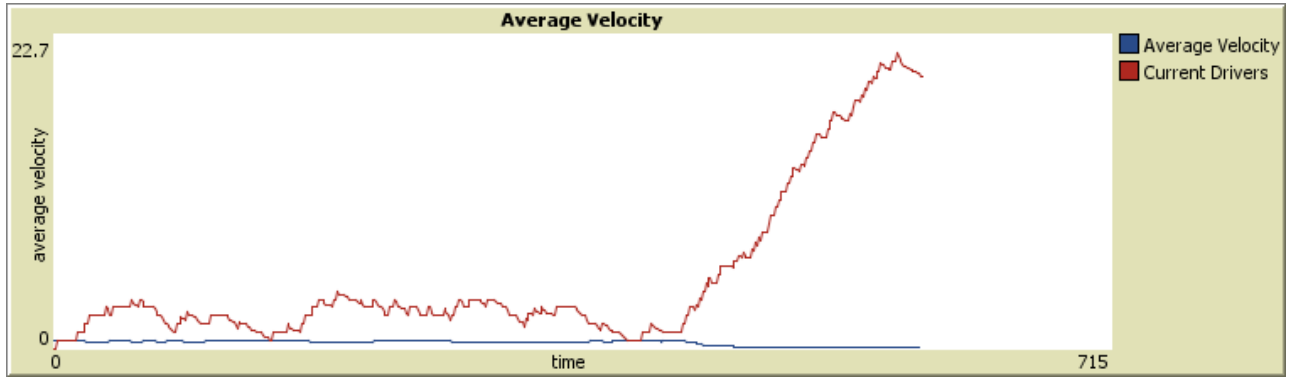


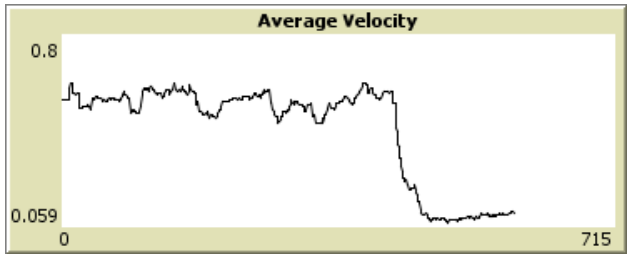
For 197 drivers, 97 red_drivers and 100 yellow_drivers, a total travel of 6553 ticks with a 33.27 minutes average travel time was record.

First Insights

In this experiment only agents with the shortest path strategy are used, so they only travel in the City Center Links.

The parameters are drivers_ratio = 1.0, velocity_delta = 0.10, num-drivers = 5.0.





Conclusion
Future Work

Conclusions

Framework

Can be used as a decision support tool with real application data;
Open model;
Simplify the transport measures and analysis;
Fast simulation tool.

First Implementation

The first results points to the model usefulness. The main model objective, in the first stage, is to prove the agents can change their status and adapt to current traffic conditions. More, the agents can also have different strategies to reach their goal.

Future Work

The next steps we will adopt learning, multi-modal network, expand the network and improve the output data/variables.

1. Learning will work as a variable that will store the agent's experiences so they can change their present behavior;

2. The multi-modal network, we will create agents that will act as bus;

3. Finally, we will expand the network, by creating a meso/macro implementation of Porto city. (implementation of GIS and R);

4. In this model, we extract only some relevant data, the data we needed to perform this analysis. However, in future implementations, other input and output data is also possible to module. (e.g pollution, transportation costs, etc..).

Thanks !