Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 4 (2014) 213 – 227

Transportation Research Procedia

www.elsevier.com/locate/procedia

Mobil. TUM 2014 "Sustainable Mobility in Metropolitan Regions", May 19-20, 2014

A Framework for a Multimodal Transportation Network: an Agent-Based Model Approach

Nuno Monteiro[a]*, Rosaldo Rossetti[b], Pedro Campos[a], Zafeiris Kokkinogenis[b]

[a]*Porto University, Economics Department, Porto, Portugal*
[b]*Porto University, Enginnering Department, Porto, Portugal*

Abstract

Mobility and commuting in metropolitan areas are very expensive, highly polluted and time wasting. The Four Step Model (FSM) is the key model to analyze a Transportation Network. However, being the FSM a combination of several models, combining them in one model have rarely been applied. To deal with this problem an Agent-Based Model (ABM) is proposed. An ABM uses the metaphor of autonomous agents and so, they can be a handful tool for combining different models in one. Therefore, this model can be used as a tool for simulation and integrate the FSM in one model. Here we present the preliminary results of this approach.

Selection and peer-review under responsibility of Technische Universität München

Keywords: Multimodal Transportation; Multimodal Network Design Problem; Agent-Based Models; Intelligent Transportation Systems; Four Step Model; Transport Analysis

1. Introduction

There are different motivations behind this work. The first one is the application of Agent-Base models, a nascent type of models in urban studies. The second is that research in Intelligent Transportation System and Future Cities has been increasing in the last years.

Our research problem is that commuting in metropolitan areas is very expensive, highly polluted, time wasting and there is no real car alternative. It is expensive and polluted due to the large sparse cities that make the commuting longer and expensive. There is no real car alternative because public transportation lack in quality and time management to reach all people needs.

* E-*mail address:* 120414020@fep.up.pt

Selection and peer-review under responsibility of Technische Universität München
doi:10.1016/j.trpro.2014.11.017

To analyze the transportation network we adopted the Four Step Model (FSM), described in McNally (2000). The FSM is a framework model developed that functions like an iteration model with four steps Trip Generation, Trip Distribution, Mode Choice and Route Choice

To solve the research problem we propose a simulation model of the FSM using an Agent Based Model (ABM). Although combined models integrating all of the four stages were developed, they rarely applied in practice. Therefore, this model act as a tool for simulation and prediction interactions between infrastructures changes, public transportation investments, and endogenous traffic effects in a daily basis.

We aim at creating dynamic Origin-Destination Matrices (O-D matrices) and Multi-Modal Transport Network (MMTN). Studying dynamic O-D matrices can provide the FSM with real-time demand that reflects the actual traffic situation and MMTN combines several transportation methods.

To solve the problem we divided the methodological approach in three phases. First, we develop a methodological framework for ABMs regarding the FSM and the MMTN. This framework is built with the ODD protocol (Overview, Design concepts and Details protocol) in Grimm (2006). The ODD is a generic format and a standard structure by which all ABMs. In the second phase, one must combine the different models used to analyze a transportation and expand the network. Finally, we analyze and calibrate the model that must be simple to understand so that it can be useful for decision process.

2. Agent-Based Models

Models are simplifications of reality. They are theoretical abstractions that represent systems. Batty (2009) identify and highlight essential features crucial to move from theory and to applications.

Agent-Based Simulation uses the metaphor of autonomous agents and Multi-Agent Systems as the basic model conceptualization. They are an evolution of Cellular Automata (CA). This means that a model consists of interacting agents situated in a simulated environment thus and agents may correspond to cities, blocks, platoons, households, individual travelers (drivers), vehicles, sensors, traffic signals, etc. In addition, elements of the environment may be agents as highlighted in Portugali (2000).

One reason for the popularity of agents and Multi-Agent Systems are the advances in computers, which are more distributed, open, large, and heterogeneous, Bazzan (2013). Managing interactions among autonomous entities with increasing interdependencies has been one of the biggest motivations for distributed artificial intelligence and for MAS.

Traffic simulation represents a prominent application for modelling and simulation in Bazzan (2013). It supports complex urban and transport planning but their utility depends on adequate calibration, verification, and validation.

Calibration provides values for unknown parameters. Verification and validation means the correctness of model construction and the truthfulness of a model with respect to its problem domain, respectively. In other words, “verification means building the system right, and validation means building the right system” in Parker (2003).

These three aspects motivated the ODD protocol, Grimm (2006). The primary purpose of ODD is to make writing and reading model descriptions easier and more efficient.

At table one, we present the seven elements of the original and updated ODD protocol, as seen in Grimm (2010).

Overview

The first phase, Purpose, defines that every model has to start from a clear question, problem, or hypothesis.

The next one is the Entities, State Variables, and Scales. An entity is a distinct object that behaves as a unit, and defines a set of attributes that can contain numerical or behavioral strategies, Huse, et al. (2002). A state variable traces how the entity changes over time. Scales describes a spatial or temporal variable that explains the amount of space and time represented in the simulation.

The Process Overview and Scheduling defines the order and names of the model’s processes. This is relevant due to different scheduling process can have a very large effect in the model outputs, Bigbee, et al. (2006) and Caron-Lormier (2008).