

Chapter 67

Large-Scale Agent-Based Models for Transportation Network Management under Unplanned Events

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ABSTRACT

The focus of this chapter is on issues surrounding the development and applications of large-scale agent-based traffic models. Following a brief overview of Agent-Based Modeling and Simulation (ABMS) applications in transportation modeling, the chapter proceeds to describe the authors' continued efforts and experiences with the development, calibration, validation, and application of a regional agent-based traffic model of the Buffalo-Niagara metropolitan area. The model is developed using the TRansportation ANalysis SIMulation System (TRANSIMS), an open-source, agent-based suite of transportation models. A unique feature of the chapter is its focus on unplanned or extreme events, such as severe snowstorms and major incidents on the freeways, and how the models may be calibrated and applied under such situations. The chapter concludes by summarizing the main lessons learned from the Buffalo case study and providing suggestions for future research.

INTRODUCTION

As an example of a complex adaptive system, the behavior of surface transportation systems emerges as a result of interactions among the human element, the physical system and the environment. These interactions result in a very complex,

dynamic behavior, which is very hard to predict. This is particularly true during emergencies, such as natural or man-made disasters, where the occurrence of the extreme event adds another layer of complexity and results in unexpected system performance. Given the complexity of predicting the emergent behavior of transportation systems,

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Agent-based Modeling and Simulation (ABMS) principles, and advanced simulation platforms, are needed for the analysis and evaluation of transportation performance during such events.

A quick review of the transportation research literature in the last twenty to thirty years may lead one to conclude that the application of ABMS principles and ideas in transportation modeling has a relatively long history. However, such a conclusion must be qualified by making the following observations. First, while the transportation community may not have always used the term “ABMS” to refer to models where agent-based modeling principles were utilized, such principles have been utilized to model both the transportation demand as well as supply sides. Second, until very recently, there has been a disconnection and lack of integration between agent-based transportation demand and agent-based supply models. Moreover, because the demand and supply models were often developed independently, the definition of agents between the demand and supply models is often inconsistent. Finally, very few modeling attempts have been aimed at using ABMS to model or understand the impact of extreme or unplanned events (e.g. a natural or man-made disaster such as an earthquake, a terrorist attack or a severe snow storm) on the transportation system.

This chapter will describe the authors’ continued efforts and experiences with the development, calibration, validation and application of a regional agent-based traffic model of the Greater Buffalo-Niagara metropolitan area. The model was developed using the TRansportation ANalysis SIMulation System (TRANSIMS), an open-source, agent-based suite of transportation models originally developed by Los Alamos National Lab (LANL), and one of the few models which offer a consistent definition of an agent throughout both the demand and supply side modeling phases. A unique feature of the current effort is its focus on unplanned or extreme events, such as severe snow storms and major incidents on the freeways, and

how the models may be calibrated and/or applied under such situations.

Specifically, the chapter is divided into the following sections. Section two provides a *very brief* overview of ABMS applications in transportation modeling on both the demand and supply sides. A subsection is included which describes previous research related to the application and calibration of agent-based transportation models to modeling extreme and unplanned events. Section three discusses the specific case of the development and calibration of the Buffalo-Niagara TRANSIMS model. Section four presents how the impact of inclement weather (specifically snow storms) on traffic flow was modeled and captured by calibrating TRANSIMS Cellular-Automata (CA) traffic simulation model. Section five then describes how the TRANSIMS model was used to study the impact of various freeway incident scenarios, as well as the compounded effect of these incidents and inclement weather, on the transportation system performance in the Buffalo Niagara region. The chapter concludes by summarizing the main lessons learned from the Buffalo case study, and provides suggestions for future research.

AGENT-BASED MODELING IN TRANSPORTATION

ABMS is a modeling paradigm that aims at “describing a system from the perspective of its constituent units” (Bonabeau, 2002). It is a “bottom-up” modeling approach which starts with the individual components of the system (i.e. agents) and defines their potential interactions. The macro-level behavior of the system then results from the myriad interactions among its constituent units. Toroczkai and Eubank (2006) define an agent as an entity that has the following properties:

1. An agent’s state as defined by a set of variables corresponding to the agent’s state space;

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