Title: Modeling for Local Impact Analysis

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Abstract

Under this project we are developing regional traffic simulation models for the Los Angeles/Long Beach area that will allow us to model the local traffic flows and estimate impacts of existing freight flows as well as impacts of policy interventions or of warehouse distribution and land use changes.

INTRODUCTION

The Los Angeles/Long Beach area is an important region for freight as it involves the twin ports of Los Angeles and Long Beach that generate a lot of freight traffic and warehouses and freight hubs that serve the Metropolitan Los Angeles as well as adjacent counties. There is a high concentration of freight traffic in the local region near the Los Angeles/ Long Beach ports. The way freight is consolidated and distributed affects what is going on within the terminals and roadway network. Land use changes in particular the spatial pattern of warehousing and distribution as well as policy interventions may also have a big impact on the consolidation and distribution of freight traffic. Developing traffic simulation models would allow us to evaluate these impacts as well as other scenarios on the freight transport. Simulation traffic flow models will allow us to test if scenarios and evaluate proposed changes for benefits and impact before actual implementation which may prove to be costly. Due to the availability of fast computers and software tools, traffic flows on the transportation network can be accurately simulated to capture steady state but more important dynamic effects.

PROJECT OBJECTIVE

The aim of this project is to develop traffic simulation models for the Los Angeles/Long Beach region. The objectives of this research includes: (1) development of regional traffic simulation test bed consisting of port terminal model, macroscopic and microscopic models of road network; (2) Use the developed models to estimate the impact of land use changes on freight traffic distribution; (3) Evaluate other scenarios related to policy interventions and new technologies.

PROJECT DESCRIPTION

The use of high fidelity simulation models is an effective low cost approach for studying a wide range of transportation problems without distracting any of the current operations and practices. It allows us to identify what has the potential to work and what will have a spillover effect in the transportation network, which is often the case when approaches to alleviate congestion in one area simply transfer it to another area. Our focus is freight transportation and in particular freight transportation in a metropolitan area where congestion puts additional constraints and different modes of transportation interact in a way that is not always clear. The use of high speed computers and software tools allow us for the first time to develop complex simulation models that mimic the real system with levels of accuracy not achieved before by the use of simpler models. Our focus area is Los Angeles/Long Beach metropolitan area that includes the twin ports, inland ports, warehouses etc. and a complex road and rail networks that are shared with passengers. Our task is to develop a suite of models that include the terminals and road network, which can accurately simulate the flow of trucks. Such models once validated with real data can be used to evaluate the impact of different scenarios due to policy, land use changes, new technologies etc. on the flow of freight within and outside the terminals but also on the flow of traffic on the road network in general. We will interact with the research group of Professor Giuliano, which will provide the scenarios to be evaluated. We should note the granularity of the models will very much depend on the scenario to be tested and for this reason we are developing both macroscopic and microscopic traffic models. The macroscopic models allow us to model a much bigger road network as the emphasis is on flows without encountering any computational and significant scaling issues. The microscopic models are used for smaller areas as in these models that dynamics of each vehicle are simulated and we are able to look into individual vehicle acceleration/deceleration and speed profiles as it interacts with other vehicles. In addition to these two classes of models we also develop a terminal cost model that examines the impact on the cost to the terminal operations as a result of a certain change in the freight transportation chain or road network. Furthermore an emissions model integrated with the microscopic model can count the individual vehicle emissions and fuel consumption and allow us to evaluate the impact to the environment of any proposed changes.

RESEARCH APPROACH

The up to date project progress includes the following:

Development of Port Model:

One of the difficulties in combining a terminal model with the road network to operate together in real time as well as interact with other modules such as the environmental model/emissions model, terminal cost model is to describe these models in a programming language that makes it easy to interface each model in a continuous manner. For this reason we developed an object-oriented, event-based terminal simulation module implemented with the C++ programming language based on our previous terminal model. It realizes high degree of continuous data exchange and software integration with the traffic simulation module via COM interface.

The design of this terminal module is shown in Fig. 1 that includes a terminal object and other three objects used to generate truck input & output, ships and trains. This terminal module provides a complete simulation environment where a lot of simulation parameters are able to be set such as inbound/outbound gate processing times, ship and train arrives, inflows and outflows of storage yards, yard capacities, etc. Various methods are supported for configuring the truck arrival: 1) setting the truck arrival distribution parameters in the user interface; 2) importing a truck log file that stores truck arrival quantities with respect to simulation time as simulation input; 3) obtaining truck arrivals from traffic simulation module via COM interface automatically. The terminal simulation module provides time dependent and cumulative graphs of any variable of interest within the terminal at the end of the simulation. With a developed terminal cost model we can evaluate the impact on terminal operation costs of different scenarios. The use of C++ and object classes makes the model computationally efficient, expandable and reconfigurable. We have finished the coding of simulation part and tested its integration with traffic simulation module via COM interface.

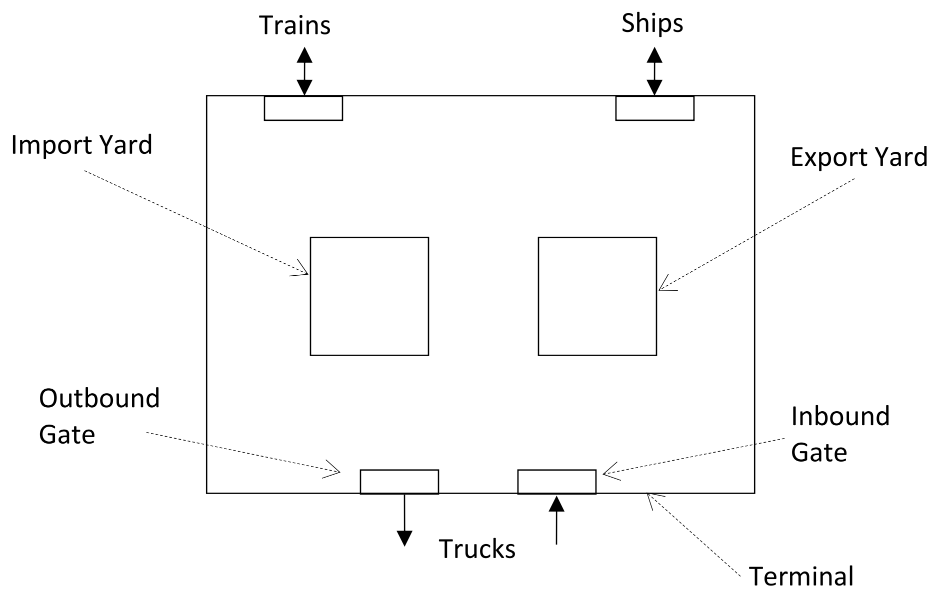

Fig. 1 Design of Terminal Module

We also designed and developed the user interface for the terminal simulation module with C++ as shown in Fig. 2 and 3. With the user interface, it will be convenient to configure the port parameters and information in objective simulation scenario such as ship schedules, train schedules, yard information etc. In addition, the simulation outputs can be displayed in the user interface. Currently we are working on integration of developed user interface with the finished simulation part. After that we will integrate the developed terminal module with the cost model.

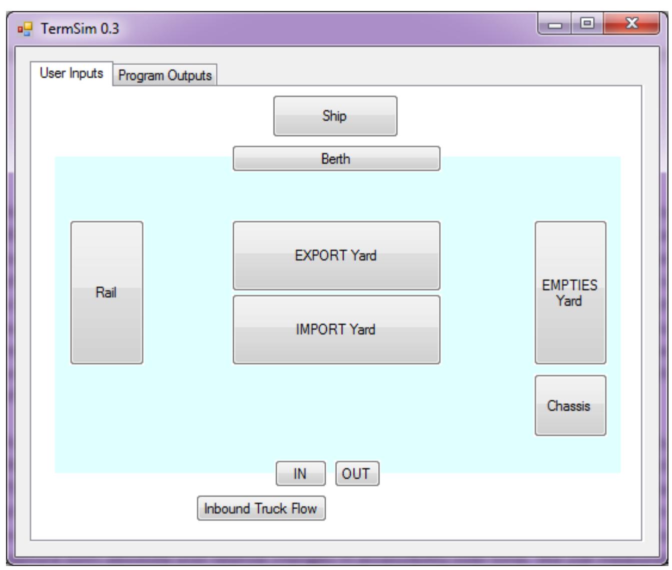

Fig. 2 User Interface of Terminal Module – Main Window

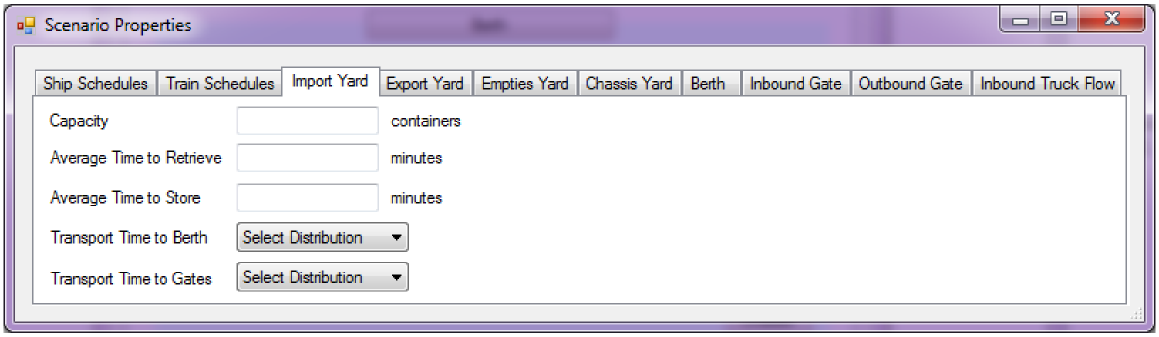

Fig. 3 User Interface of Terminal Module – Scenario Properties

Development of the Microscopic Traffic Simulation Model: The traffic simulation module models the microscopic traffic flows on the roadway network around the port area. This module is built based on the traffic simulation software VISSIM. We first developed a microscopic simulation model of one selected area including more than 100 intersections (15 of them are signalized) as shown in Fig. 4. In this microscopic model we implemented network coding including links, connectors, intersection controllers (stop signs and signal controllers), dynamic assignment etc. to evaluate the traffic flows in the area. This microscopic model has been used to evaluate the impact of traffic signal control with truck priority successfully, in which we realized the integration of our traffic simulation model and the vehicle emission model CMEM (Comprehensive Modal Emission Model) developed by the University of Southern California, Riverside.

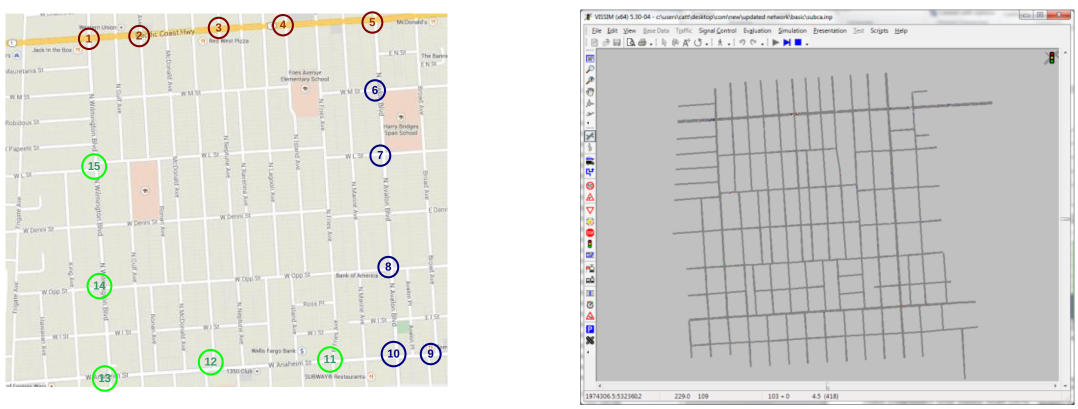

Fig. 4 Micro-Simulation Traffic Model of a Selected Area

Based on the development and usage of the selected area simulation model, we expanded the model to a large scale simulator in Fig. 5 having both freeways and local streets of the LA/LB port area. We also finished the simulator coding of the large scale simulator as in the simulator of Fig. 5. We are working on the coding of traffic inputs and dynamic assignment module in order to evaluate the traffic flows of the entire studied port area.

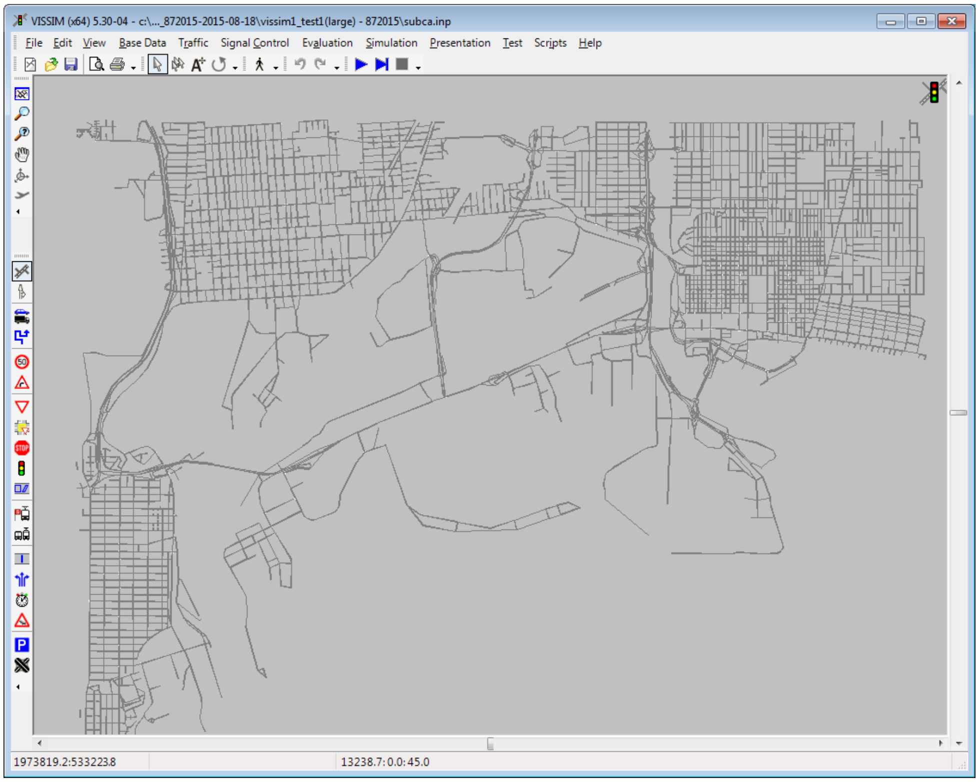

Fig. 5 Micro-Simulation Traffic Model of LA/LB Port Area

Macroscopic Traffic Model for the region of study: The current area covered by the macroscopic road network model is shown in Fig. 6 below. All the link information is added together with traffic light information, delays etc. We are having meetings with the Ph.D. student of Price school to discuss the proposed scenarios of warehouse dynamics to be evaluated and the corresponding demands for the traffic simulator such as model scale and required simulation outputs. We decided to select an experiment area such as Fig. 6 to evaluate the proposed approaches and the scenarios in the experiment region. In order to validate this macroscopic model, we designed an example scenario in Fig. 7 in which we studied the freight traffic routing methodology among three port terminals and six different destinations. We run a series of experiments of different traffic conditions and demand loads. The results showed that this model is ready for evaluation of more complex scenarios. We are adding more destinations based on the spatial data of warehousing which will make us to study the freight traffic among these warehouses and port terminals under different traffic conditions.

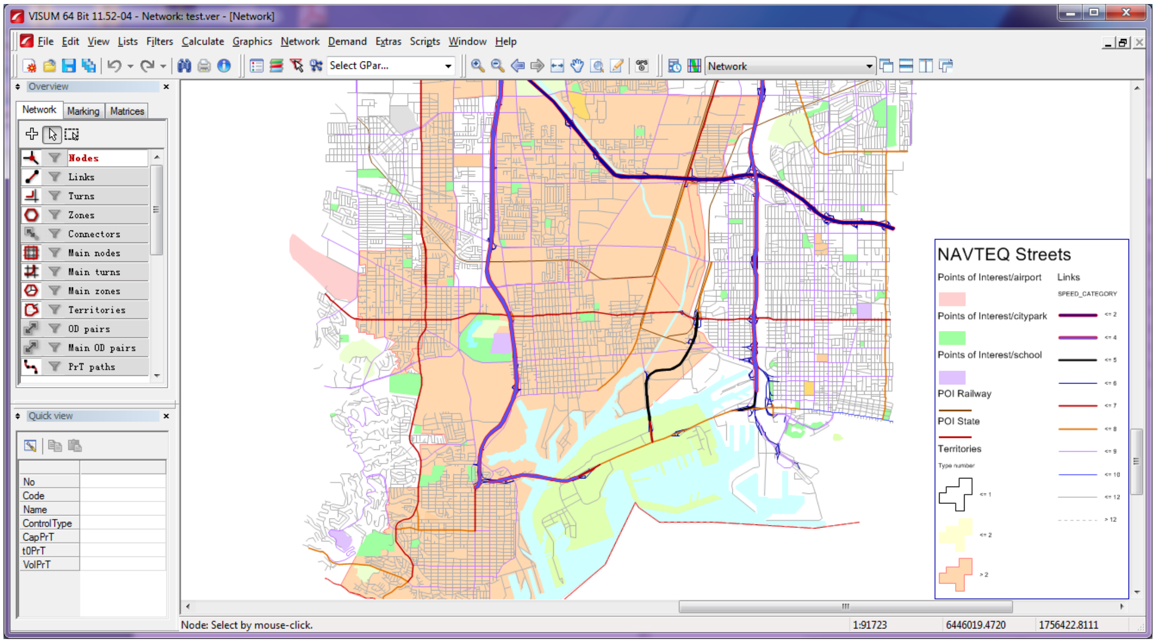

Fig. 6 Macroscopic Model Area

Fig. 7 An Example Scenario

In addition we expanded the above network to a larger scale network in Fig. 8 through working with Professor Giuliano's group. Since the macroscopic traffic model converting from the GIS data provided by Professor Giuliano's group only has the network coding, we are working on automated instead of manual approaches that allow us to implement the simulator coding besides the network coding in an effective way due to the very large scale of this model. Once done we plan to test our scenarios and approaches to the entire macroscopic model shown in Fig. 8.

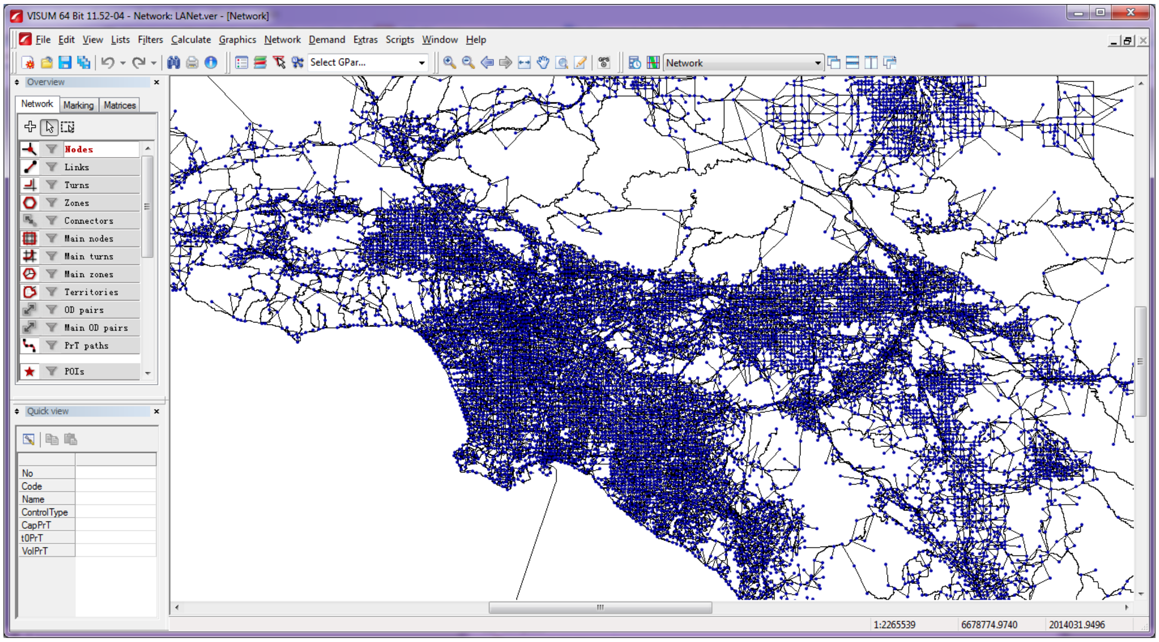

Fig. 8 Macroscopic Model of Larger Area

DATA

We use the Los Angeles/Long Beach port region as our case study area since it is a major trade hub.

Data sources

Our data includes population, employment, warehousing and transport system characteristics. We are working with Professor Giuliano's group to collect all possible data.

ANALYSIS AND RESULTS

For the microscopic model, we finished the simulator coding of the large scale simulator as in the simulator of Fig. 2 and we are working on the coding of traffic inputs and dynamic assignment module in order to evaluate the traffic flows of the entire studied port area.

For the macroscopic model, we finished the network topology model and are working on automated approaches to implement the simulator coding besides the network coding due to the extreme large scale of this model.

CONCLUSIONS

We developed several traffic simulation models for the Los Angeles/Long Beach region that will allow us to estimate impacts of existing freight flows as well as impacts of policy interventions or of land use changes.

Acknowledgment

This research is supported by the Volvo Research and Educational Foundations through the MetroFreight Center of Excellence, METRANS Transportation Center, University of Southern California. Data was provided by Professor Giuliano's group. All errors and omissions are the responsibility of the authors.

The following publications use the models developed under this project for freight routing, traffic light control with truck priority and traffic flow prediction demonstrating their use as well as their effectiveness in evaluating the impact of different scenarios and approaches for freight transportation.

PUBLICATIONS

1. Y. Zhao, P. A. Ioannou, M. M. Dessouky, "A Hierarchical Co-Simulation Optimization Control System for Multimodal Freight Routing", 2017 IEEE 20th International Conference on Intelligent Transportation Systems, Yokohama, October, 2017.

2. Y. Zhao, P. A. Ioannou, M. M. Dessouky, "Dynamic Multimodal Freight Routing Using Co-Simulation Optimization Approach", 2017 METRANS International Urban Freight Conference (I-NUF), Long Beach, October, 2017.

3. Yanbo Zhao, Petros Ioannou, "A Traffic Light Signal Control System with Truck Priority", 2016 IFAC Symposium on Control in Transportation Systems, Istanbul, Turkey, 2016.

4. Afshin A., R. Rajabioun, P.Ioannou, 'Traffic Flow Prediction for Transportation Networks with Limited Traffic Data,' IEEE Transactions on Intelligent Transportation Systems, appeared in April 2015.

5. Afshin A., and P.Ioannou, 'Optimization Strategies for Resilient Freight Transport and Sustainability' Proceedings IEEE Conference on Decision and Control, Los Angeles, Dec. 2014.