Modeling for Intermodal Freight Transportation Policy Analysis

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Introduction, Current Projects

Researchers in the Rochester Institute of Technology's (RIT) Lab for Environmental Computing and Decision Making (LECDM), in collaboration with the University of Delaware, are developing and applying a model to support policy analysis and decision support on freight transportation. The model, called the Geospatial Intermodal Freight Transportation (GIFT) model, is designed to enable an understanding of the dynamics and trade-offs between environmental, economic, and energy factors in the freight transportation system. GIFT integrates three types of models to characterize freight transportation so that decision makers and policy analysts can understand this complicated transportation system and assess the possible impact of their operational and policy decisions. The three model types are:

1. A geospatial-referenced network model integrating three distinct modes of transportation networks (road, rail, and marine highway) integrated by intermodal transfer facilities (ports, railyards, truck terminals) where freight can be transferred from one transportation mode to another,
2. Models of the environmental (carbon, particulate matter, etc.), energy consumption, and economic (operational cost and benefit) impact of freight transportation for each mode of operation and for intermodal transfer facilities,
3. Models of the current and possible future demand on the transportation networks, characterizing the originations, destinations, and flow volumes of goods movement across the transportation network.

Tying these models together is a network analysis engine, based on ESRI's ArcGIS Network Analyst, which evaluates the "cost" of traversing the transportation network and seeks minimum cost routes. The transportation networks' traditional attributes of traversal time and distance are augmented with attributes of environmental, energy, and operational costs. These additional attributes embody computations modeling the cost associated with different vehicles traversing those segments (different types of ships, locomotives, and trucks, and different operational profiles). We are now working to define multiple origination and destination sequences and flow volumes to scale up the cost impacts of traversing the network.

Given this computational infrastructure of intermodal transportation modeling, we can now provide a user interaction to help policy analysts and decision makers to understand the current transportation system and the impact of decisions and policy options on that system. We are working to provide a scenario management system where the analyst can define ranges of operations (ranges of flows, volumes, costs, environmental impacts, etc.) and the impact of policy decisions (environmental impact fees and rebates, infrastructure investment priorities, vehicle technology investments, etc.) on the behavior of the transportation system.

Our early work on GIFT focused on developing the model and applying it in basic policy analysis [1-3]. We are now addressing some applied software engineering challenges identified in our early work and enhancing GIFT for broader and more detailed policy analysis and decision support.

Software Engineering Research Needs

There are a number of needs and opportunities for software engineering researchers.

- Complex models and model integration: There are many sources of data and many models on transportation system characteristics, but they are often inconsistent, at different levels of aggregation, and with constraints on sharing and use. Further, the models are often implemented using different technologies and without a thought toward model integration. How does one manage the size, complexity, and diversity of models of transportation networks for multiple modes, operational characteristics of multiple types of vehicles, a wide diversity of operational profiles, and competing policy objectives and measures in sustainable economic, environmental, and social systems? How does one validate the data and relationships in light of the ever-changing nature of the natural and built environment? How does one integrate a system from data and modeling components that were not designed to work together?
- Human-Computer Interaction for understanding and decision support: The complexity of the range of analysis scenarios that must be considered results in a wide range of system behaviors that the decision maker must assess. More important, the decision maker and analyst must *understand* the behavior of the system as evident through the models. What kind of input and output interaction and visualization methods help the decision maker and analyst understand the range of possible futures, and how do they navigate through the simulated model outputs to develop a deep understanding and intuition of the behavior of the freight transportation system and the implications and opportunities available for their decisions? How do they understand the data, structural, and behavioral uncertainties and errors in their models so they can understand the limitations of the models and how those affect the validity of their analysis conclusions? How can analysts summarize the model and its results when capturing, explaining, and defending policy options with public and private policy decision makers?
- Software quality and development productivity: In multi-disciplinary research efforts, people are developing data and computation model software, but are not trained software engineers. Indeed, they often have little computing education. Yet their data and models are guiding critical decisions with potentially huge impact. How can we manage the data and software development effort to ensure high product quality and development/analyst team productivity? How can this be done in an environment with high turnover—students graduate, faculty join and leave the team, the models are developed for specific research questions then "abandoned," etc., and very few of these people are doing this as their dedicated full-time job (they take or teach classes, have multiple projects, etc.).

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