Data exchange between transport models, regional economic models and impact models, specifically designed to facilitate environmental impact evaluation

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Abstract

This paper presents the present status of the TRIP sub-project 2.3: Integrated Traffic, Regional Economic and Impact Models. It deals with the basic layout of the MERGE (Model for Exchanging Regionalised Geographic Entities) data conflation model and shows an example of the use of the MERGE model for transferring transport data to a regional economic model.

Introduction

TRIP (Centre for Transport Research on environmental and health Impacts and Policies) is a research collaboration financed by the Danish Environmental Research Programme. Within TRIP researchers from economics, geography, engineering and health undertake a number of projects dealing with the environment and personal transport (see www.akf.dk/trip for further details).

The TRIP sub-project 2.3: Integrated Traffic, Regional Economic and Impact Models has as objective [TRIP (2000)] "*Development of a system of data exchange between transport models, regional economic models and impact models, specifically designed to facilitate environmental impact evaluation.*" In order to fulfil the objective a consistent and accurate exchange of information between each type of model is needed. The handling of this task is assigned to the Model for Exchanging Regionalised Geographic Entities - in short: MERGE.

Other participants in TRIP 2.3 are Institute of Local Government Studies – Denmark (AKF), the Danish Road Directorate (Vejdirektoratet) and Institute of Geography – University of Copenhagen.

The TRIP MERGE model

As stated in the objective MERGE has to link a regional economic model, a traffic model and an impact model together into a decision-making tool by making procedures for transferring in- and output data between all the models. LINE from AKF has been chosen as regional economic model, LTM from the Danish Road Directorate has been chosen as transport model and TicMap/SEAM from DTU [Wass-Nielsen, M. & Hviid Steen, C. (2001)] as impact model.

A number of considerations have to be taken into account when trying to fulfil the systems objective. This paper focuses on two major considerations: Modularity and Consistency.

Modularity

The keyword in MERGE is model integration. First of all in the sense that MERGE has to integrate the LINE, LTM and TicMap/SEAM models in order to provide a tool for achieving the overall objective of TRIP Project 2.3.

But the integration of these models raised some questions that where not only relevant for the specific models in question but also has a more general application. This means, that some of the procedures to be developed in MERGE ought to be quite universal for model integration.

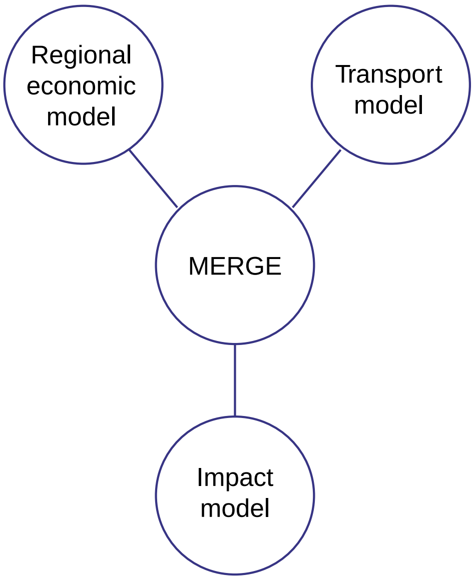
So instead of starting out making MERGE a specific tool for integrating the LINE, LTM and TicMap/SEAM models, the starting point was to make a more general approach to model integration (incl. data transfer) and from there on focus on the specific models for the TRIP Project 2.3.

This approach has the advantage, that if other (or better) models become available they can be utilised with less effort than if MERGE was specifically designed for the mentioned models. This is exactly the main aspect of model modularity.

The model modularity points in a direction of first developing/defining a special data-model for MERGE and subsequently developing the data-interfaces to the LINE, LTM and TicMap/SEAM models.

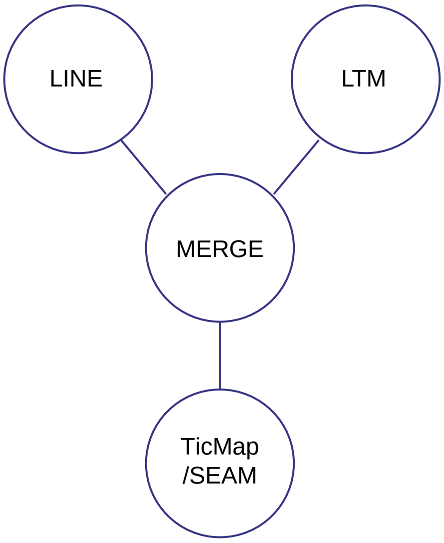
The modularity objective leads to a general structure of MERGE as illustrated in Figure 1.

Figure 1: General schematic structure of the MERGE modular structure.



With regard to the TRIP 2.3 project the schematic structure of the MERGE model in Figure 1 will be as in Figure 2.

Figure 2: Schematic structure of the specific MERGE modular structure for the TRIP project.



Consistency

Consistency is an important factor in model integration. The main objective of MERGE is, as previously stated, to provide data exchange between transport models, regional economic models and impact models. All three types of models rely to a certain extent on spatial distributed data, by not necessarily on data with the same spatially distribution. When integrating these models into a decision support system, it is important to ensure a common basis so that results and conditions to some extent are identical or at least consistent. It is especially important to be able to reproduce results and datasets.

It might sound simple, but if e.g. a model requires 50 zones, MERGE has to be able to generate this number of zones, preferable from any base dataset, under a number of different conditions e.g. equal number of inhabitants within the zone; equal area of the zones etc. At the same time it has to be possible to somehow keep track of where data originated from and giving some estimates of the accuracy of not only the original data, but also the generated data. This is commonly known as metadata (or data on data) and can be quite difficult to handle.

Generation of new datasets from an existing dataset is where geographical information systems (GIS) have been proven as a very powerful tool. Results and input data all have some kind of spatial attributes e.g. population data can be on a municipal or a parish level. It is not necessary that all the integrated models actually use the spatial reference but the spatial reference can be used in MERGE as a tool to generate and exchange datasets.

With regard to model integration, a GIS is however not an “out of the box” software. It is more like a toolbox with a lot of different tools but one still have to combine all the tools to make things work. In a GIS data can be organised topologically as Points, Lines or Polygons. This means that MERGE ideally has to handle all combinations of data transformation (conflation) between these three data-types. The MERGE data handling capabilities can be summarised as in Table 1.

Table 1: The MERGE data-handling matrix.

	Point	Line	Polygon
Point	**Point2Point**	**Point2Line**	**Point2Polygon**
Line	**Line2Point**	**Line2Line**	**Line2Polygon**
Polygon	**Polygon2Point**	**Polygon2Line**	**Polygon2Polygon**

Examples of use for the different conflationtypes could be:

- **Point2Point**: Conflation of e.g. centroids
- **Point2Line**: Linking of e.g. a zone centroid to a network
- **Point2Polygon**: Linking of e.g. a zone centroid to a zone polygon
- **Line2Point**: Linking of e.g. a network to a zone centroid
- **Line2Line**: Conflation of e.g. transport networks
- **Line2Polygon**: Linking of e.g. a network to a zone polygon
- **Polygon2Point**: Linking of e.g. a zone polygon to a zone centroid or a network node
- **Polygon2Line**: Linking of e.g. a zone centroid to a network
- **Polygon2Polygon**: Conflation of e.g. municipalities and parishes

Not all of the 9 types of conflation are equally important with regard to the TRIP project and some conflation types are more commonly used than others mainly because of the format that data are available in (e.g. **Point2Point)**. There are also some redundancies within the conflation types in Table 1. For instance will a **Point2Line** conflation often be made as a **Point2Point** conflation between the point and a node in the network.

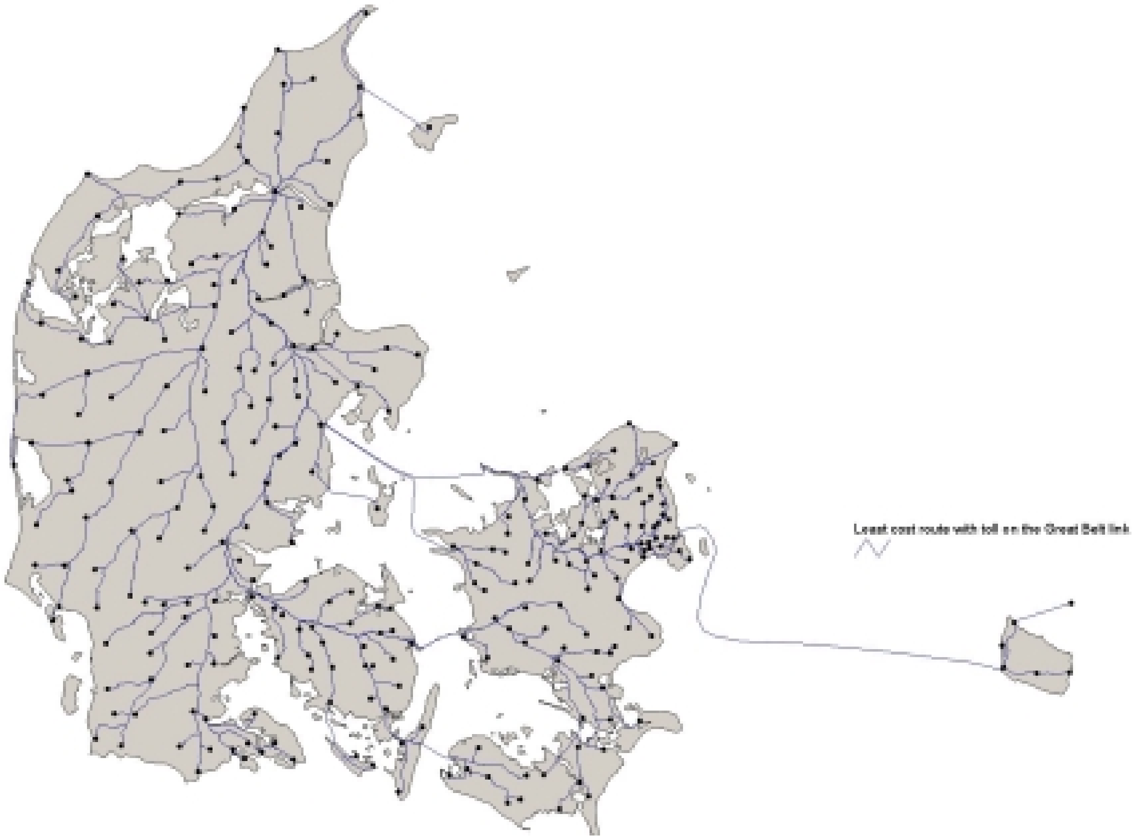
Present status and perspective

The present status of the TRIP project 2.3 is, that the data exchange procedures for the TRIP MERGE model between MERGE and LINE and between MERGE and TicMap/SEAM is completed and operational.

This part of MERGE has already been used to feed transport data to the LINE model and has shown to be an important improvement for the regional economic model. The use of MERGE made it possible to provide much more detailed transport data to LINE and at the same time to illustrate the data input graphical. The municipalities was linked to the network by **Point2Point** conflation polygon centroids and nodes in the network (this could also be described as **Polygon2Line** conflation).

An example of the calculation of the least cost route from Aalborg to all other municipalities in Denmark can be seen on Figure 3.

Figure 3. Least cost route from Aalborg to all other municipalities in Denmark with the present toll at the Great Belt link.



As it can be seen from Figure 3 the least cost route from Aalborg to municipalities in the northern part of Zealand and the Copenhagen area goes by Kattegat (with the actual pricing of time and driving cost). The competitive border between the ferries at Kattegat and the Great Belt link goes in a somehow horizontal line at the centre of Zealand.

As the purpose of the project was to evaluate a removal of the toll at the Great Belt link the same calculation was made without any toll on the fixed link.

Figure 4. Least cost route from Aalborg to all other municipalities in Denmark with no toll at the Great Belt link.

It can be seen from Figure 4 how the competitive border changes and makes it more attractive to use the Great Belt link. In this situation only a few municipalities on the northwestern part of Zealand are reached by use of the Kattegat routes.

Besides showing the route MERGE generates the necessary cost matrixes for the LINE model.

The final step of the TRIP 2.3 project is to integrate the data exchange to the transport model and to make an explorative example of the model framework. The explorative example will be an investigation of the regional economic consequences of a Road-Pricing scenario.

Literature

TRIP (2000): “TRIP 2.3: Integrated Traffic, Regional Economic and Impact Models”, Project description, TRIP 2000.

Wass-Nielsen, M. & Hviid Steen, C. (2001): ”Development of a MapInfo tool for mapping and analysis of traffic impacts – in Danish (Udvikling af et værktøj i MapInfo til kortlægning og analyse af trafikale effekter).