Agent-based simulation of transportation nodes

Assoc. Prof. Antonín Kavička, PhD.
Jan Perner Transport Faculty
University of Pardubice, Czech Republic

Assoc. Prof. Valent Klima, PhD.
Ing. Norbert Adamko
Faculty of Management Science and Informatics
University of Žilina, Slovak Republic

Conclusions

Due to the extremely high financial impact, planning and optimisation of infrastructure or resource schedules, as well as rationalisation of managerial procedures in transportation nodes should not be executed without thorough and objective examination of consequences, adopted decisions could have on the node.

Transportation node is a highly complex dynamic system – there exist complicated relationships between its entities, service processes are highly dependent on each other and many of them are of stochastic nature. The complexity of the nodes and their operation is the main reason why we consider experimenting with simulation model of node's infrastructure and its operation to be the most effective way to examine consequences of decisions taken.

It is obvious that simulation model of such a complex node is also very extensive and complex. Creation of the model and its reasonable utilisation are possible only if two conditions are met: The first condition being sufficient computational power of the computer used for experimenting with the model. The development of computer performance in recent years gives us some reasons to be optimistic in this field. Second condition to be met is the application of simulation model architecture, which permits to design and implement the complex model in a way that it is still understandable, maintainable and flexible enough. Simulation architectures of this kind are nowadays subject of intense research efforts. Presented architecture ABAsim as well as simulation tool Villon (which was developed using this architecture) are examples and proofs of the fact that the research in this field is not purely theoretical one, but also delivers practically usable results and tools.

Based on our experience with ABAsim architecture, we can point out few of its advantages and features:

- The structure of simulation model is very close to the structure of the system being modelled, especially considering the organisation/hierarchy of management units. This feature is of high benefit to the designer of the simulation model, and also makes the communication with customer much easier.

- Straightforward model decomposition and reusability of sub-models, agents and components.
- Simple and natural integration of human into the simulation model. Human can take the role of an autonomous agent or one of its components (either of advisory, sensory or managerial type)
- Support for creation of universal and flexible simulation models rather than single-purpose models. It is natural to develop libraries of alternative components, agents and models, which can later be used in the simulation scenario definition to configure required version/alternative of simulation model. The designer is able to modify:
  - executive properties of an agent (by selecting its effectors)
  - decision properties of an agent (by selecting alternative informers and solvers from predefined set)
  - control and management strategies of an agent (by choosing one of various variants of manager‘s „brain“)

  or
  - modelling of complete parts of simulated system (by selecting alternative agents and sub-models)
- Means for the experimenter to define model configurations and simulation scenarios using editors without the need for program source code modifications (e.g. using Petri net editor of CASE tool, which is in development).
- Support for integration of models into networks, i.e. support for development of models of networks and also networks of models.

Since used paradigm of message oriented simulation architecture qualifies the utilisation of distributed simulation models, ABAsim architecture is currently being adapted to support distributed execution of simulation models [Adamko 2005].

Even thought simulation tool Villon was originally designed for simulation of marshalling yards, chosen agent based approach provides natural ways to extend its abilities by new functions (adding new agents). Continuous augmentation of Villon by adding support for simulations of different type of nodes (including nodes with road transportation) demonstrates this fact. Villon was used in real-life consultancy practice to solve various types of problems in different type of nodes, and its utilisation always brought high financial profit.

Changes in railway network organisation in Austria and Switzerland required a few smaller marshalling yards to be closed and other, bigger and more productive yards to be modernised and extended, in order they are able to handle trains from the closed yards. Linz VBf Ost [Study Linz 1999] [Kavička et al. 1999], Wien ZVBf [Study Wien 2001] or Swiss Basel can be given as an example, where Villon was used to examine problem solutions related with planned increase of input traffic flows. Similar situation was encountered in simulation study of German yard Hamburg Alte Süderelbe. In the case of revitalisation of yard Žilina–Teplička, Villon was used to support design process of new marshalling yard. In German marshalling yards Hagen Vorhalle and Oberhausen-Osterfeld, simulation in Villon was used to verify different variants of technical modernisation of these yards.

Villon was also used to develop simulation models of two Chinese yards in Mudanjiang and Harbin. These studies exhibited the flexibility of the tool in the ability to model quite different technological procedures and custom practices [Xu et al. 2003].

The tool Villon, enhanced with the capability to model manipulation processes, was used to solve various problems at factory sidings of chemical giant BASF Ludwigshafen, paper producer SCA Laakirchen, steelworks VOEST Alpine in Linz and car producer Volkswagen in Bratislava.

Design of infrastructure and verification of operational procedures were the fields in which Villon was utilised during the project for German newly designed train care centre near city of Ulm. Besides the solution of problems related with the configuration of tracks, Villon was also utilised to help find the best placement of various service modules of the train care centre (e.g. inside and outside train set cleaning, refuelling stations, repair shops, etc.).

Versatility of simulation techniques in emphasised by the fact that once built and validated simulation model of a node can be repeatedly utilised to solve various types of problems [Adamko et al. 2002]. For example simulation model developed to support optimisation of the extent of node's reconstruction can later be used during the real reconstruction to solve operational problems caused by construction.