

Production planning and scheduling with material handling using modelling and simulation

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Abstract. Increase flexibility of manufacturing requires implementation of effective planning IT tools. Planning and scheduling problems traditionally consider the production resources as the only constraints. Since the raw material and intermediate transferring times are relevant in relation to the production times, it is required to model the material handling equipment and its activities. The problem of scheduling subject to manufacturing and logistical constraints based on data-driven models generation method is presented. A KbRS and FlexSim systems are used as a scheduling tool.

1 Introduction

Increase automation and flexibility of manufacturing systems which allow to take measures to adapt production systems to produce many variants of products in variable production batches, requires implementation of innovative and intelligent technologies and effective planning IT tools and techniques. The production planning and scheduling problems traditionally consider the production resources as the only constraints in the system [1]. Since the raw materials and intermediate products transferring times are relevant in relation to the production times, it is required to model the material handling equipment (especially in the automated material handling systems) and its activities in a scheduling process in the real industrial applications. The handling vehicles operations should be planned and synchronized with production resources operations. Thus, the production flow plans, configuration of manufacturing systems, scheduling and control, particularly at the operational level, should be developed in a way that ensures the optimal implementation of production orders in the context of constraints associated with both the manufacturing system as well as material handling equipment [1, 2, 3, 4]. Their mutual planning allows to determine the type, quantity, place and time of raw material and semi-finished products use, thus determining at the same time the transport, handling and storage operations, together

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with the accompanying information flow. Thus, the required changes in the area of organizing production preparation make it necessary to improve the flow of information and integration of decision support systems.

In the problem addressed in this paper, a scheduling and simulation systems integration based on data-driven semi-automatic simulation models generation method is presented. The proposed approach allow to eliminate the disadvantages associated with the traditional - expensive and time-consuming process of creating the simulation models. Methods of data mapping, data transformation and data exchange, between heterogeneous IT systems in the process of the simulation models generation have been used.

The presented method can become an efficient and effective tool to support the planning and verification of the production schedule subject to manufacturing and material handling constraints in the production system. Developed integration software module RapidSim allows for fast simulation model generation and conduct simulation experiments (with the visualization of the production processes flow) for rapid analysis of prepared schedule with regard to available quantity and the capacity of the material handling vehicles, the timetables, and the location and capacity of the material handling systems as well as.

A commercial software KbRS and FlexSim were used as a scheduling and simulation tool for testing the integration module. Developed RapidSim software has been applied to carry out the verification simulation experiments. Due to the use of the intermediate neutral data model, the integration module can be commercialized with any scheduling and simulation system which provide interfaces for data exchange (open system) and internal programming languages. Data and simulation models used in the verification experiments are provided as well.

The paper is organized as follows. Section 2 is devoted to presenting methods for semi-automatic generation of simulation models. Section 3 is devoted to the presentation of the practical implementation of the proposed solution. The production scheduling system KbRS used to support the process of generating production schedules and a brief description of the FlexSim simulation system with a practical example of its application are also presented. Finally, Section 4 presents our conclusions.

2 The integration of scheduling and simulation systems

The integration of scheduling and simulation systems is performed using the method of automating the process of creating simulation models based on the concept of Data-driven simulation model generation, which are now the largest group among the developed concepts [5, 6, 7, 8, 9] The simulation model is created automatically simultaneously with its parameterization based on specific data instances obtained automatically from the planning and scheduling system. Generating (creating) the models could therefore be performed by users without knowledge of how to build the simulation model. In this approach to build a simulation model does not require the use of standard computer simulation tools (usually specific modules of simulation systems), which are used in conventional "manual" approach, because the model is built automatically using data analysis methods and algorithms processing [5, 6, 10, 11].

The semi-automatic simulation model generation method based on parametric hybrid approach is proposed in this paper. It combines data mapping and data transformation methods with the concept of a neutral intermediate data model. This approach allows to generate a model for any method of production flow in the manufacturing system, based only on the data taken from scheduling system, for which between the manufacturing resources (deriving from the technological routing process flow in system) standard objects related to material handling equipment are created automatically.

Due to the fact that in the scheduling system (which is the source of the data used in the present method), no data regarding the specific parameters of internal transport are available (type, speed, acceleration, capacity, location, etc.), the objects imitating the behaviour of the material handling system must be generated with default parameters. A characteristic feature of the proposed approach to generate models in a semiautomatic way, is that the missing data and parameters for created material handling system objects can be introduced by the operator/planner (already within the target simulation computer software) in the last step before performing verification simulation experiments (Figure 1).

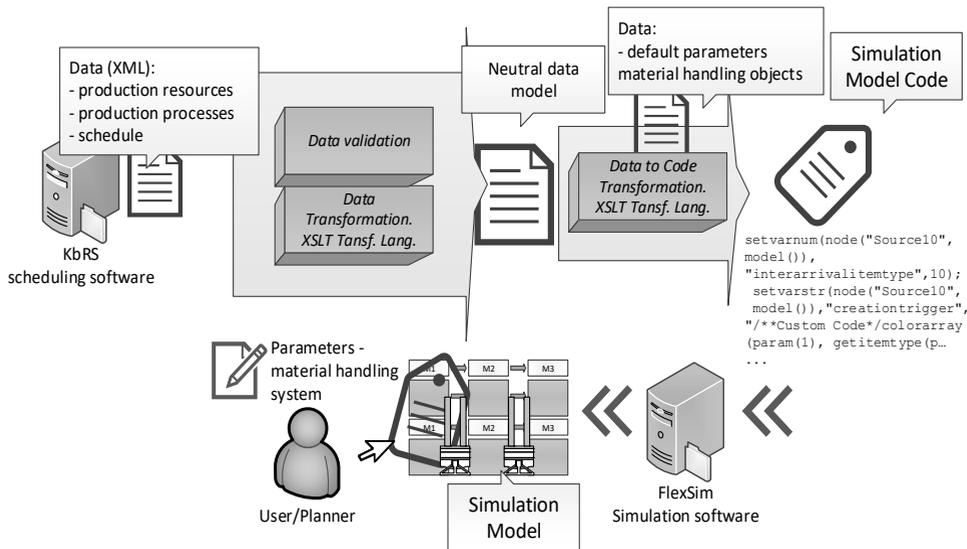


Fig. 1. Semi-automatic simulation model generation method.

The XML schema developed for the method of automating the process of creating of simulation models contains definitions of the XML document structure. The data structure defines the manufacturing system resources, i.e.: machines, interop, input and output warehouses, products, details of the production processes, i.e. technological routes, setup times and cycle times, as well as execution of production operations sequence data (production plans and schedules obtained from scheduling software). These data are obtained directly from scheduling system. The process of data transformation into input file for simulation systems is performed using XSLT processors (Extensible Stylesheet Language Transformations).

At the stage of transformation the data from the intermediate model are converted into script code using the data transformation method in the internal programming language of simulation systems (e.g. FlexScript for FlexSim system). The code contains script functions for creating a component objects of the simulation model, along with connections between them - and thus a complete simulation model. The instructions contained in the code also create information objects, i.e. tables contain data on the processing time of operations executed on resources, tables with resources work schedule, data on processes routes as a function of performing the connection between the respective atoms in the model, together with the corresponding objects of transport resources or other material handling system components. It also contains the parameters for the scenes and scripts enable the implementation of simulation and visualization processes, according to data contained in the information resources.

3 Practical implementation

Practical implementation of the presented method was carried out using a commercial scheduling and re-scheduling KbRS system and FlexSim simulation software. The process of data transformation (system integration) was carried out using RapidSim software, which is computerized implementation of the previously described methods.

3.1 KbRS scheduling system

The Knowledge based Rescheduling System (KbRS) is a production scheduling system dedicated for multiassortment production flow together with the best possible utilization of production resources and taking into account accepted evaluation criteria. The basis for determining production schedules are the production system data set, technological and organizational data (data describing the production processes) along with the data of production orders – routes, setup time, processing time, due dates, priorities, and the volume of production [1,11]. These data could come from many (often heterogeneous) sources of MRPII/ERP/CAPP systems. Due to the frequent gaps in information in existing databases, a part (or all) of the data can be entered into the system manually through a graphical user interface. After entering all the required data and defining input parameters the searching of available schedules is executed by two basic scheduling strategies: forward and backward. Schedules are generated by processes scheduling algorithms according to established common priority rules i.e. EDD (Earliest Due Date first), LDD (Latest Due Date first, LPT (Longest Processing Time first), SPT (Shortest Processing Time first) or Random, and set of the best solutions are saved. Production schedules are presented in form of the Gantt chart, an overview of evaluation indicators and analysis of individual schedules by other reports can be provided. The final decision on the selection and application of a schedule is taken by the planner.

3.2 FlexSim simulation software

FlexSim provides extensive support for building, analysis and verification simulation models developed by the FlexSim Software Products, Inc. FlexSim is fully customizable, graphically-oriented simulation software that integrates modelling, simulation and 3D visualization and animation in 3D object oriented drag-drop-connect environment. In FlexSim, discrete or fluid pre-defined modelling object are the most basic building element of a simulation and allows users to change the behaviour of objects, which can be parameterized at the stage of creating the model. The discrete objects (objects that create, send, store items awaiting processing, move items through the model, group and perform operations on products, etc.) are used to develop discrete-event simulation models where the model behaviour results from events that occur at discrete points in time [12]. Objects are available in the libraries of objects the extent corresponding to the possible uses of the various versions. Further provides mechanisms that import and export data and facilitate the analysis of data.

3.3 Illustrative example

The process of data transformation representing the computer implementation of the previously described integration methods was realized in the RapidSim software [8, 11]. The data transformation documents (XSLT) can be developed independently, so the software can be used for any scheduling and simulation systems. Input files to the RapidSim are XSLT documents constitute the definition of transformation functions for

data, also positioning RapidSim work parameters for data retrieved from computer systems which are subject to integration - in this case KbRS and FlexSim (Figure 2).

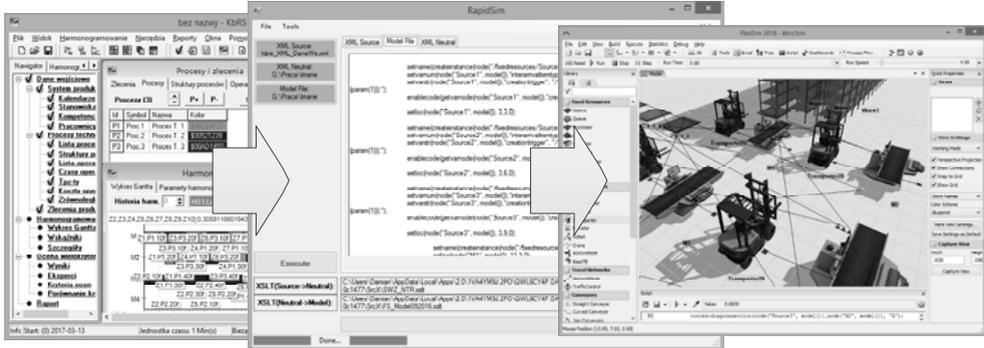


Fig. 2. RapidSim integration software.

Implementation of the process of simulation model creation consists of the following steps:

- loading the an XML document containing input data (KbRS - the results of scheduling),
- validation of the loaded XML document based on the definition of data models in the form of XML schemas,
- transformation of the XML document using a XSLT processor,
- generating a document (.mod) containing code in FlexScript (simulation model for FlexSim software),
- validation of the generated document.

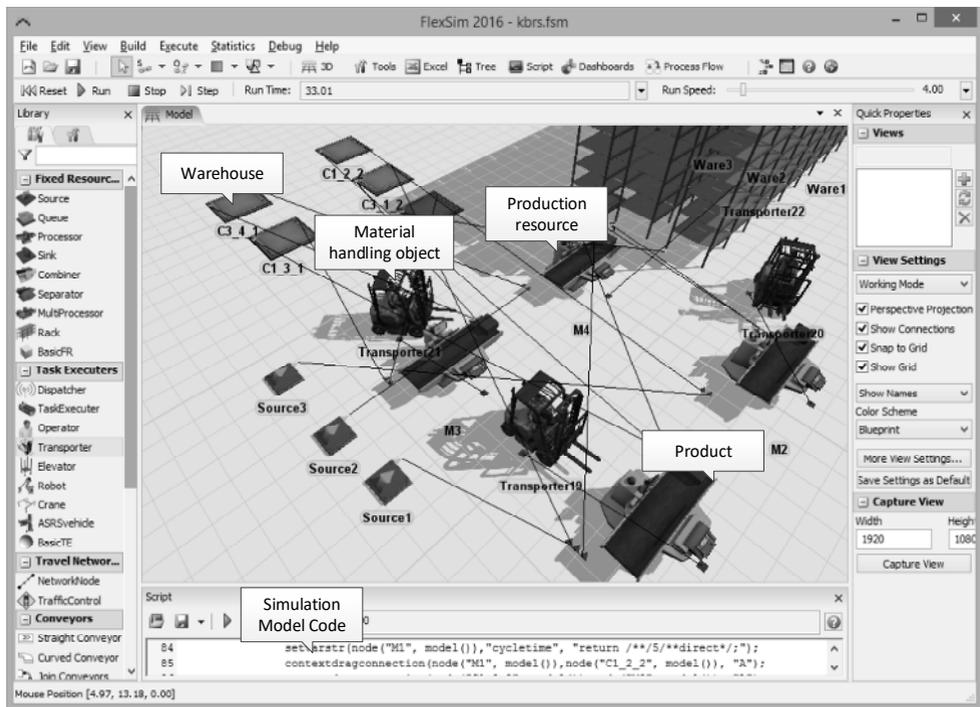


Fig. 3. Simulation model obtained from the generated script code.

Loading the resulting output document (MOD) in FlexSim software allows for automatic creation of a complete simulation model (Figure 2 and Figure 3), which is ready to carry out verification experiments, including the constraints related to material handling objects - analysis of available quantity and capacity of means of transport, timetables and potential hazards collisions.

Generated model, after setting the specific parameters for material handling objects, is ready to carry out simulation experiments. Performed simulations have confirmed the correctness and completeness of the connection in the generated automatically model.

4 Conclusions

The method of integration of scheduling and simulation systems proposed in the paper constitutes also data driven method of automatic generation of models for simulation systems, by eliminating the disadvantages associated with cost- and time-consuming process of building simulation models, can become an efficient and effective tool to support the planning and verification of production schedules subject to the material handling limitations.

The proposed RapidSim software solution enables, among others, to perform rapid analysis with regard to the available quantity and capacity of means of transport, timetable, and the location and storages. Thanks to its openness it may be commercialized with practically any scheduling system or simulation software. The subject of further work in this area will involve the expansion of the intermediate model data possible to obtain information concerning the other subsystems and manufacturing systems constraints.

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