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IMPLEMENTATION OF AN ADAPTIVE SIMULATION MODEL IN PLANT SIMULATION ENVIRONMENT

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I. INTRODUCTION

Simulation modelling has an increasing importance and fields of application. In this paper we focus on a restricted view: modelling of material flow systems. This can be divided further into two areas:

- modelling of the physical flow of bulk materials, such as liquids, gases and solid bulk materials. In these models the analysis focuses on the physical characteristics of the flow, such as flow profile and trajectory.
- modelling material flow of bulk materials and unit loads from the logistic aspects. In this case the modelling concentrates on the materials flows' implementation on the required time and spatial relations, using the available devices of material handling and transport.

In the further discussion only the second type of models will be addressed. Material flows of products, parts and other goods in the production and in the associated logistic operations generally make up complex systems. In order to cope with the complexity during analysis and system control intelligent software system components are needed. Many see it the only way to analyze complex systems [1]. Simulation software are more and more frequently used as a base platform for this purpose. These require implementation of a simulation model, which is digital mapping of the real material flow system. This digital model enables multiple tasks such as emulating the system, making predictions for the future operations, evaluating control strategies and optimization.

There are growing requirements on the simulation models regarding adaptivity to the altering modelled system. This resulted in new structures, the so called adaptive simulation models. This paper aims to summarize latest trends and challenges of the area and presents a concrete example.

II. SOME TRENDS AND CHALLANGES IN ADVANCED SIMULATION MODELLING

As mentioned before, it is a key issue that the simulation model contain realistic values. As the modelled system is changing over time, the model should follow it as well. Adaptive simulation methods build up advanced modelling tools for this problem. In adaptive models (similar as the DDDAS, see [2]), properties are subject to continuous adaptation. Necessary information comes directly from the modelled

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system. The model is adapted using this information in defined time interval. Generally there are three ways of adaptation. The most common way is to change the adaption of the model's behavior on receiving different input. A more demanding solution is to change operational rules and parameters in the model (these adaptions are without changing the static structure of the model, example see in [3]). The most complex task among the adaptations is the so-called structural adaptation. During this the model recognizes via data exchange, changes in the modelled system/processes and adapts the DES model structure. There is a good example model on it which applies ontologies in order to be able to develop itself from components [4]. In [5] the authors point out that the formerly mentioned automatic model adaptation (and in the initial phase even model generation) process is largely supported, if such simulation components are selected which are can be matched directly to the components of a formal modelling language. Figure 1 presents an example on it from our formal research, comparing a duly generated simulation model and a Petri net representation.

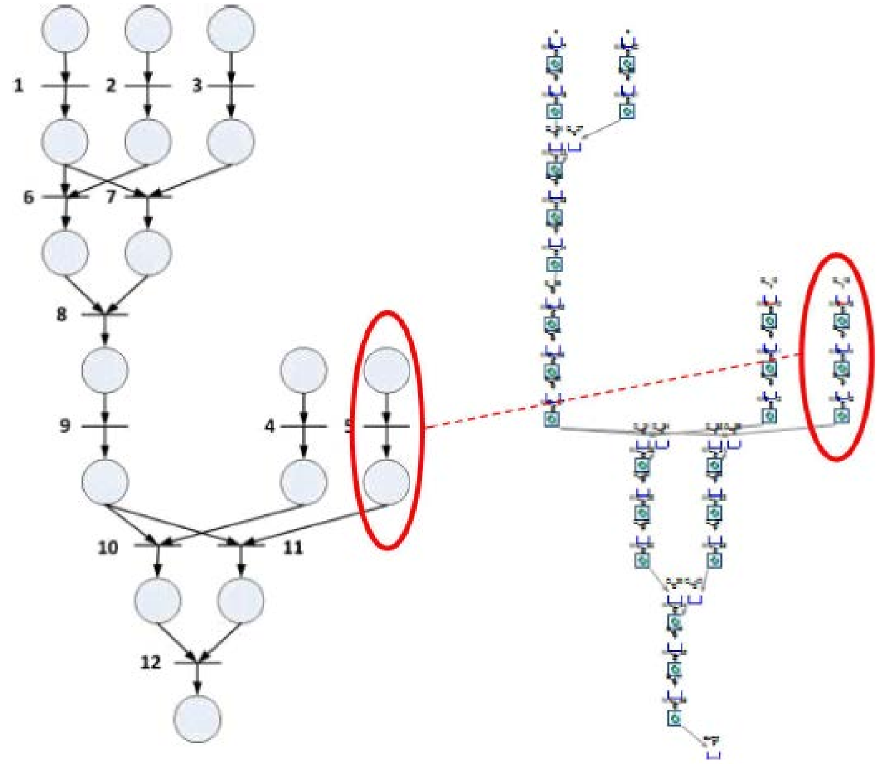

Figure 1
Comparison of a Petri net formal representation
(left) and a Simul8 model (right) [5]

From the rising number of publications we concluded that adaptive models getting more and more importance in the rapidly changing material flow systems. This modelling method not only supports models for the traditional forecasting task but it also enhances applicability in emulations even for altering systems.

There are however challenges as well. Wenzel in his paper [6] presented development areas in the areas of production and logistics using the "Gartner Hype Cycle". In this area adaptive simulations, which are closest to the category called

„Automatic model generation“ nearing the “Peak of inflated expectations”. That means in the next time the “Trough of disillusionment” is coming.

Therefore it is an important issue to solidify the modelling approaches in the future period. The model presented in the next sections is a complex, but at the same time a highly formalized representation.

III. INTRODUCTION OF THE IMPLENTED ADAPTIVE SIMULATION MODEL IN TECNOMATIX PLANT SIMULATION

As an answer to the previously mentioned challenges, a novel model structure has been proposed by us. The general concept has been described in [7]. In the current paper only the most important characteristics are repeated, supplemented by the description on the implementation in Tecnomatix Plant Simulation software environment.

The new model is presented using an example material flow system (see Fig. 2.). In this a single material handling machine (a simple transport vehicle) moves the materials in a loop structure which connects buffers (Node 1…6). Node 1 is the overall input of the system, Node 2,3,5,6 are temporary buffers and Node 4 is a dedicated buffer for the single technological machine. In the model first the transport vehicle moves the necessary 4 type of materials into the buffers. During this the machine is being prepared for Machining task 1. After the preparation phase, the materials of Machining task 1 are transferred to Node 4 for production. After finishing Machining task 1, preparation of the next Machining task starts and materials of this task are being transported to Node 4. The process is quite simple to remain perspicuous but include dependencies which can demonstrate the advantages of the new model.

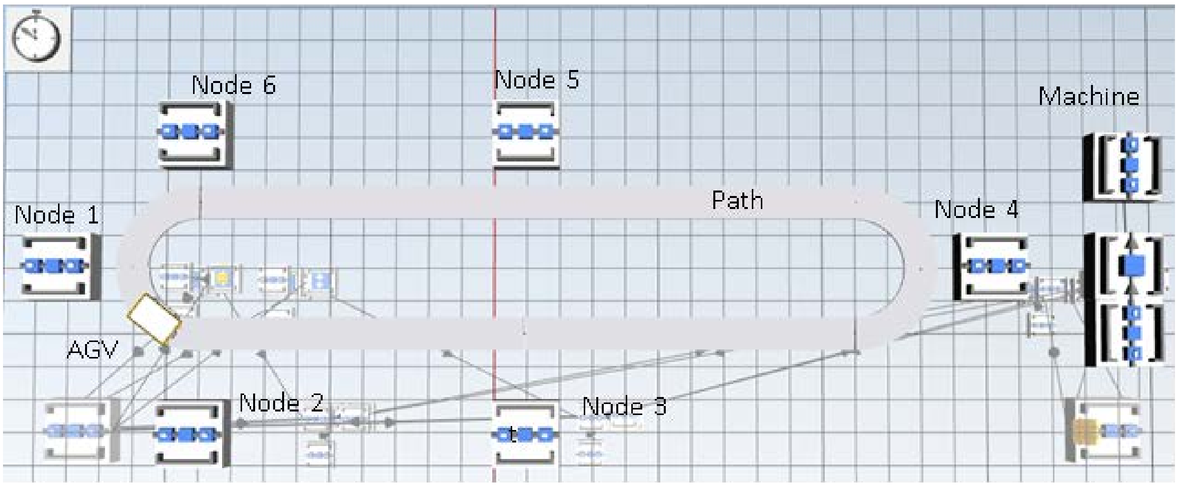

Figure 2
Layout of the material flow system [7]

The model has been implemented in Plant Simulation software environment. A detailed and explanatory description on the elements mentioned below can be found in [8]. The “Path” in Figure 2 is a consecutive loop structure from Track elements. Start and End positions of the Track elements are located at the Nodes, which are modelled as Buffer elements. These are just holding passively the materials, the loading and unloading are carried out using the Exit Controls of the Track elements. The material handling machine is modelled using a Transporter element, which is created in the Init phase of the EventController of the modelling frame. The machine is modelled by an input Buffer, which obtains a mobile object (MU) at the start of a machining process. The machine itself is a SingleProc element, implementing the necessary time delay, which models preparations and machining phases. Further it deletes the necessary MUs from the Node 4 buffer.

Viewing Figure 2 it gives a good overview on the layout but not on the processes, as these are given in a TableFile. There would have been another modelling approach to model the process itself (similar as in Figure 1.), but that way we would have lost the overview of the layout.

In order to unify the two modelling perspectives following new type of simulation model has been proposed.

It was named as the Jellyfish model. The General concept of this modelling approach as mentioned before has been presented in [7]. As the most important issue it must be highlighted that this concept successfully unifies the layout and process type simulation models.

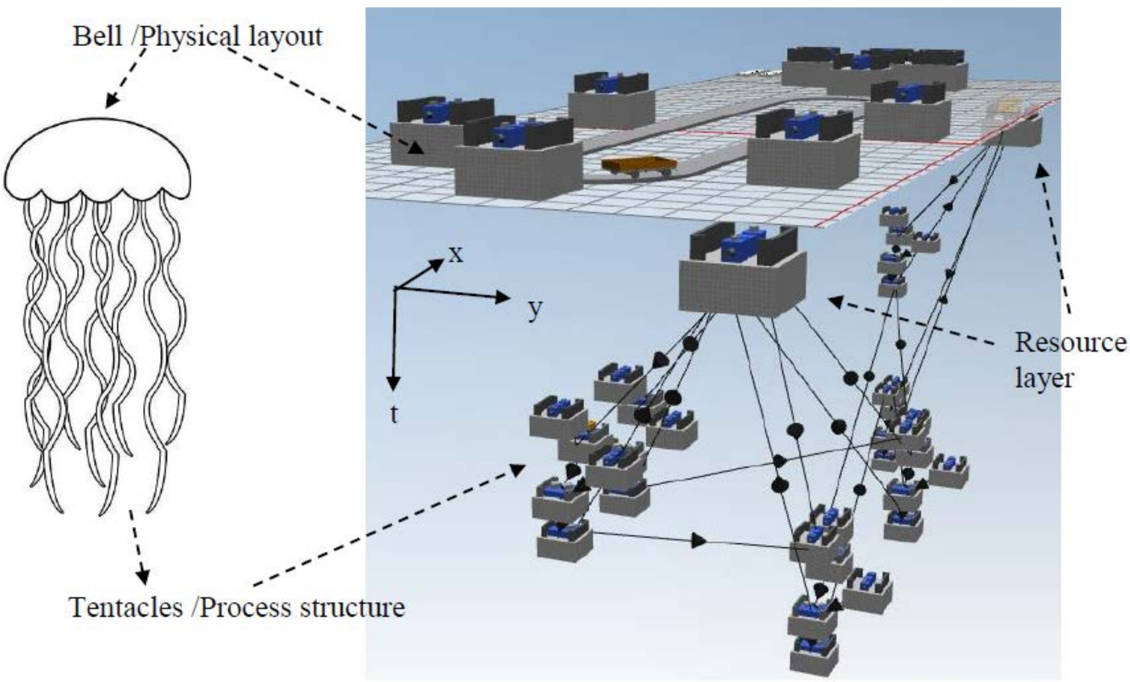

Figure 3
General construction of the "Jellyfish" model [7]

The name comes from the structure of the model as it is composed of two main parts like the marine animal. The upper "bell" represents the physical layout of the modelled system with all the machines, transporters, buffers; the technological and material flow components. This is a realistic model of the real system, handling alone all the mechanical and logical constraints. Thus this part is a layout type simulation model. Comparing to the latter, the main difference is that in former models the processes are defined in codes, databases or when it was necessary were modelled by separate modelling objects, which were placed in the same modelling plane. It should be remarked that the previously demonstrated example can be constructed in other software environment, provided it is able to handle 3D position of simulation objects.

In our approach the processes are represented in the 3D space of the downwards projection of the layout. That means the model is interpreted in a (x, y, t) coordinate system, which is common for the description of planar motions. As later processes are located more distant from the plane of the physical layout the axis “t” points downwards.

Each process is composed of a special structure of elements. The signals from the processes which are preconditions of the actual one arrive into Buffer elements (1). If all preconditions are met (each Buffer has one MU in it), the process starts, if the physical resource is available (2) as well. The process running element (4) is modeled as an Assembly element as it collects signals (virtual objects) from the preconditions and from the availability of the resource. As soon as the physical system has executed the process it places an MU into the feedback on completion Buffer (5). If the process duration is independent from the physical layout then this Buffer (5) can be omitted, and the (4) Assembly has an inner time delay. In either way the information flows further into the process completed Assembly element (6). Finally the information forwarding on completion, which is a DismantleStation element leads the MUs to the precondition side of consequent processes. The processes are located in the (x, y) plane at a position where the process starts (e. g. starting point of a movement).

It should be underlined that the process structure and the connections can be created automatically from programming code at the start of the simulation.

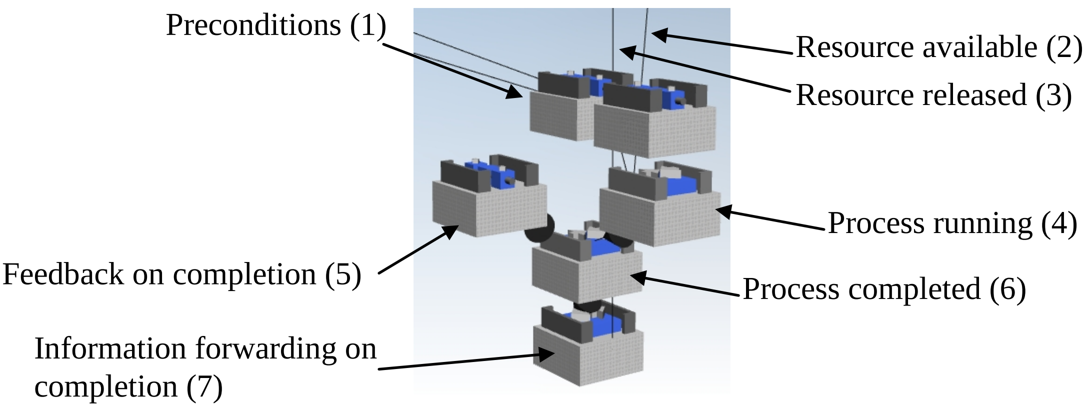

Figure 4
Model of a single process [7]

Between the physical layer and the processes the resource availability layer is located. It helps controlling the processes from executing parallel multiple processes which require the same resource. These are modelled in Plant Simulation as simple Buffer elements. Having an MU in the Buffer means that the corresponding Resource is free and operational.

IV. SUMMARY

This paper presented a concrete adaptive simulation model using a new modelling concept. We found that this has several advantages, such as good visualization, and the ability to be structurally adaptable, if e.g. the processes, and dependencies are changing. Further, this approach enables new possibility in the methodology of model analysis. Having a graph model of the processes such methodology like ontology matching could be applied. These methods enable recognition of typical process patterns in the actual process flow thus enhancing the analysis possibilities.

Summarizing the above advantages, the proposed model gives an easy to overview and standardized way for presenting complex material flow processes. It supports human analysis and adaptation without becoming over-complicated.

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