WEB-BASED SERVICE FOR THE INTEGRATION OF SIMULATION AND VISUALIZATION

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ABSTRACT

This article demonstrates the implementation and integration of a web-based service for the visualization of simulation models and their dynamics within the scope of logistics education at universities. Therefore, a survey of applications of visualization in simulation-based analysis of logistic systems as well as the utilization of web-based services in logistics planning is given. Both the technical realization and the definition of semantic dependencies as mapping rules or restrictions are discussed in detail. Finally, the results of a first validation and the future development are presented.

INTRODUCTION

The tasks of logisticians deal with the various problems of planning, control and monitoring of worldwide linked supply and production networks. The tasks touch all levels of enterprise hierarchy, from strategic level comprising location planning, organization or logistics controlling to operational level of material flow functionality, e.g. packing, materials handling, warehousing, transhipment. The logistician is not only challenged to operate logistics systems but also to analyze, to plan and design as well as to improve them continually. Therefore, in particular model-based analytical methods as process analysis and simulation are playing a decisive role. On the one hand these methods based on their abstraction allow for focusing on the crucial tasks of planning, on the other hand for experiments of dynamics of great logistic networks as well as for comparison of different planning variants.

To prepare logisticians for the increasing use of IT technology in industrial practice, consequent integration of web-based e-Learning including corresponding multi-medial elements in education is necessary. Thus, discipline spanning competences are supported by new forms of communication. By strong linkage of inter-disciplinary areas the understanding of various dependencies and interrelations is raised and the previous knowledge range is expanded to a location and time independent usable knowledge pool of logistics.

Due to limited time and funding academic education and training is mainly performed as lecture and/or seminar. These events only allow for a description and short demonstration of modelling and simulation tools. The complex tool functionality cannot completely be demonstrated and communicated. In this context the application of new media has a lasting effect. Besides the utilization of multi-media techniques for a more appealing presentation and intuitive imparting of knowledge the utilization of the World Wide Web (WWW) is playing a more and more important role for the education and training at universities. Dealing with individual web-based courses students can learn independently from time restrictions and location. Additionally, students can complete and extend their knowledge to their own interests browsing the complete knowledge database of the web-based education and training system. Relating to simulation students can find out their own way to apply the basic methodology and handle complex tools.

The inter-disciplinary approach of simulation methodology and the corresponding utilization of different methods as data acquisition and static analysis to 3-D visualization make the focusing on primary creative planning process necessary. This includes the analysis of the problem with implicit derivation of research goals, the modelling and validation of planned processes as well as experiments and result analysis on basis of simulation models (VDI 2000). In particular within the scope of model validation and the evaluation of dynamics the visualization (3-D animation, charts and diagrams) keeps on representing a crucial part for the creation of modules for education and training for simulation within logistics (VDI 2003).

Considering the mentioned conditions the development of an internet-based service for the automatic creation of animated Virtual Reality (VR) scenes on basis of simulation models and their dynamics description represents a reasonable solution. This enables the student to utilize a high-sophisticated realistic representation of the simulated system without specific knowledge about computer-based 3-D design.
Requirements to be derived for the utilization process, transformation rules and the technical realization are discussed in the following two chapters. Finally, the

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concrete realization of the web-based service to provide 3-D visualization in academic education is described.

FROM PROCESS DEFINITION TO SIMULATION AND VISUALIZATION

The utilization of visualization in simulation includes both static and dynamic form. For example, static visualization shows content of simulation database as well as status and results of the experiment process as tables or graphs. The student gets information about structure of the model and key performance indicators but no information about the dynamics of the model. In particular the knowledge of dynamic coherences within simulation models lets the students recognize and understand occurring effects. Additionally, dynamic visualization gives students an insight in the dynamics of the process by animation and thus makes complex issues much easier to understand.

Generally, visualization improves the understanding of the model and sets the basis for a common communication between all persons involved (Wenzel at al. 2004). The goals of visualization differ according to the phase of the simulation study as well as the target group and focus on the one hand on the cognition enhancement (e.g. during validation and analysis) and on the other hand on the knowledge mediation (e.g. for presentation).

The automatic creation of a dynamic 3-D scene includes the transition from process modelling over simulation to 3-D visualization and the implicitly changing of modelling paradigms (process-oriented model, structure-oriented simulation, close to reality visualization). For the realization several requirements and restrictions have to be taken under consideration.

In this context the descriptive process model is based on the specification of parameterisable elementary operations. By arranging and parameterising these elementary operations the logistics process could be described (Neumann 2004). In this concrete application the transition into a simulation model is not supported in a technical way because the utilization of a common commercial software tool was intended. To ensure an appropriate transformation of the process description into a simulation model specific mapping rules and restrictions can be used. The transition of the simulation model into an animated Virtual Reality scene is supported per automatism. The automatic transformation of the simulation model into a VR scene and the transmission of the dynamic flows into animation of the scene have special influence on the technical basis. Based on the selected simulation tool and its non-proportional scaling modelling technique as well as the use of abstractions, mapping rules and restrictions as well as the specification of a specific system technology for the close to reality visualization are necessary for an appropriate transformation. The concrete measures for this are described in chapter Web-based SimVis Service.

WEB-SERVICES

On the field of mechanical and plant engineering apart from their technical features capital goods are increasingly assessed according to their contribution to the solution of the problem. Thus, manufacturers of production and logistic systems expand their technically orientated product spectrum with additional (value-added) services, which increase the efficiency during the ramp-up and the operation processes of complex systems significantly (Hellmann et al. 2003). The World Wide Web is the ideal platform to implement a service process and to make this service available to customers.

For example, the web-based use of simulation and 3D-visualization as a value-added service of logistics system planning and tender generation forms the common, consistent and confidence-building discussion basis for all people involved in the planning process (Hellmann, Jessen and Wenzel 2003). It prevents possible deficits and misinterpretations and allows the integration of system planner as well as customers during an early project phase. Herewith the users are offered a convenient access to advanced planning techniques. Users don't have to invest in expensive simulation and visualization tools since the tools are utilized as part of the web-based service. Additionally, a well-defined process of the individual service simplifies the usage of simulation and visualization techniques by focussing on fundamental information and reduces effort for planning and tool-specific staff training and education.

Students are the future user of advanced simulation and visualization techniques. Thus, web-based services also lend themselves to students' training and education at universities (Neumann 2005). Lecturers expand their spectrum of lectures and seminars with additional (value-added) services, which increase the efficiency and effectiveness of learning about complex issues significantly. Students are enabled by the services to design their own (additional) training program usable at any time at any location.

Besides creation of organizational conditions and definition of service processes, a suitable IT infrastructure is needed to implement web-based services for academic training and education. The basic technology to set up web-based services is available and worldwide utilized, standards for services are defined. For example, IBM, BEA and Oracle provide comprehensive IT platforms including specific functionality for authentication, authorisation, security; web-portals etc. and – last but not least – to set up web-based services.

WEB-BASED SIMVIS SERVICE

From technical point of view the SimVis service is divided into three main components: the user interface, the service platform and the processing kernel (see Figure 1). The user interface was realized based on common web technology, so that the user does not need additional software. To upload the necessary input data, a model file and a so-called trace file, the user is provided with a convenient web-interface. The model provides the necessary information about the model structure (principle component layout, technical parameters, topology, etc.) for the automatic generation of the VR scene. The trace file provides a summary of all state changes which have occurred during simulation run and is used for adding dynamics of simulation into the VR scene. Furthermore, a valid email address for dispatching different status information and the transmission of the result has to be specified. The result, an animated Virtual Reality Modelling Language (VRML) scene, can be viewed with a generic internet browser after the installation of a free VRML plug-in.

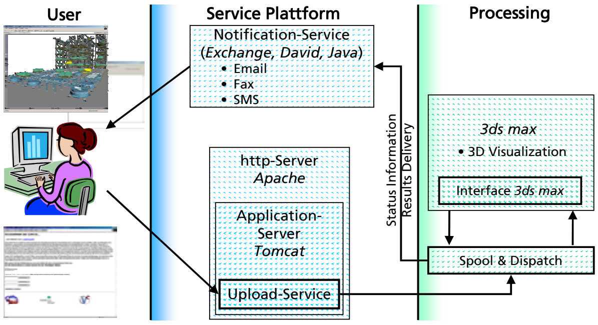

Figure 1: SimVis-Process and Technical Details.

The central service platform consists of application server (including web server) and notification component. The application server provides an upload service for the transfer of necessary input files from the user to the processing kernel as well as a verification of the email address which defines the target for sending the service results. To obtain an implicit, but very rudimentary access control, the web service checks authentication and authorisation by the unique IP-Address of the calling server of the e-Learning-environment. Moreover, the service platform comprises a notification service, which uses existing infrastructure as MS-Exchange, DAVID or any POP email server for messaging. This service is used for the transmission of status information and the delivery of the results.

The processing kernel consists of a spool and dispatch component and an intrinsic processing unit. The spool and dispatch component receives the task, puts it into a queue, and delivers status information as well as results of the task. The intrinsic processing component is realized as extension of a professional 3D modelling and visualization tool. The selected tool 3ds max by Discreet provides a script language which has been used for the development of the automatism for transformation of simulation models into 3-D scenes. The transformation process is supported by a component library, which has been developed by Fraunhofer IML. It consists of parametrisable graphical elements representing typical material handling elements. In addition, the dynamics of simulation defined as trace file is automatically transformed into the animation of the scene. At last the animated scene is exported format-optimized into a VRML file and delivered to the user.

To ensure an adequate, close-to-reality visualization of the simulation model several restrictions and implicit mapping rules have to be specified. Basically, these rules define a pre-selection of graphical elements as representatives of simulation elements and their positioning in animation scene as well as standard behaviour of the graphical elements based on simulation events. In case of the selected discrete-event simulation tool DOSIMIS-3, additional mapping rules have to be defined, which concerned the avoidance of typical abstractions in the non-proportional scaled simulation modelling. For example non-straight-line transportation processes (curves, turn-table, etc.) must be explicitly modelled (see Figure 2). This could be perfomed either by using several elements or by an explicitly curve modelling using the conveyer element. A purely graphic modelling by using the logical building blocks linkage could not accordingly be visualized, because this information is not specified in the model file.

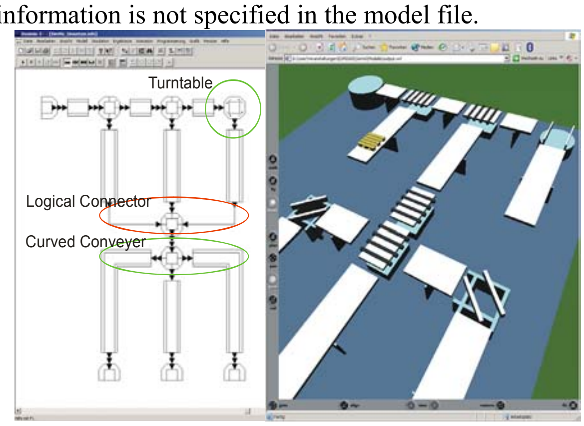

Figure 2: Example for Restrictions in DOSIMIS-3.

In the sense of documentation and user guidance both the mapping rules for the manual transition between process and structure modelling as well as the automatic transition between structure modelling and visualization are described in a table (see Figure 3).

Logistics Operations	Process	DOSIMIS-3	Visualization
Change Location		SST FST VTW	
Keeping		LAG SST LFP	
Combining		MON	
Add Information		AST MON	

Figure 3: Mapping Table for Transformations.

UTILIZATION OF THE SIMVIS SERVICE

In addition to the description of the component-based process design (Neumann 2005) this chapter shows an illustrative example for the utilization of the SimVis service. Starting with a task description and the process model on the basis of elementary material flow elements this section focuses on the modelling of a suitable simulation model by concerning restrictions and mappings as well as the automatic transformation into a dynamic VR-Scene by the SimVis service.

Task Description:
As an example for a component-based process design following task should be given: to define an efficient material flow for the production of a merchandising product, a football with the print of an emblem of one of three different soccer-clubs. For this, on average every 20 s with a deviation of 3 s the system source produces 4 plain footballs as batch entering the system on a loading aid. The footballs need 40 s to be printed, 40 percent of the balls with the emblem of Club A, 30 percent with Club B and 30 percent with Club C emblem. 10 percent of the printed balls are checked, 3 percent of them again leave the system as rejections. The subsequent packaging needs 40 s. At this stage the balls get unique identifier. In the shipping area batches of 4 balls of Club A, 3 balls of Club B and 3 balls of Club C each have to be assorted which finally leave the system.

Process Model:
First, starting with the task description the central useful and supporting processes are identified and described within an approximate process chain model. The *useful processes*, planned processes directly participating in the creation of value for the customer, comprise accordingly to VDI 3600 (VDI 2001) processing, assembly, packing, development, conditioning, designing et al. The *supporting processes* are planned processes which support the execution of the useful processes as transporting, storing, checking, order placement and acceptance, buffering and transhipping. In contrast *blind processes* are processes like checking back, waiting times, searching for parts, etc., and *error processes,* reject production, over-storage of goods, faulty commissioning, delivery to wrong consignee, etc. Main goal of a planning process is to avoid blind and error processes as well as to minimize the supporting processes. As second step the process chain model is detailed and the single process elements are parameterised accordingly to the task description (see Figure 4). For this, different kinds of influencing the process chain or the parameters like omission, combination, replacement or paralleling of process steps are possible. The strategic goal is the increase of value-creating share while minimising the process costs (Kuhn 1995).

Simulation Model:
As next step based on process description using mapping rules and taking defined restrictions into account the process chain model is manually transformed into a simulation model which allows the investigation of dynamic system behaviour as simulation experiment. For modelling, the simulation tool DOSIMIS-3 (DS3) was utilised. Here, defined mappings and restrictions have to be considered by the modeller in terms of subsequent visualisation (see mappings in table 1 and simulation model in figure 5).

Process	**DOSIMIS-3 Element**
Source	Source
Opening OR-Connector	Distributor
Printing	3 Conveyers, 3 Workstations
Closing OR-Connector	3 Conveyers, 1 Combining Station

Table 1: Mapping Table Process–DOSIMIS-3.

The parameterisation of simulation elements is done accordingly to the process chain modelling. Fixed data of the process model could be used, e.g. inter-arrival time, process time and distributions. Additionally, 2 m/s are defined as standard speed of transportation and 1.2 m as standard length of a pallet place (length of euro-pallet).

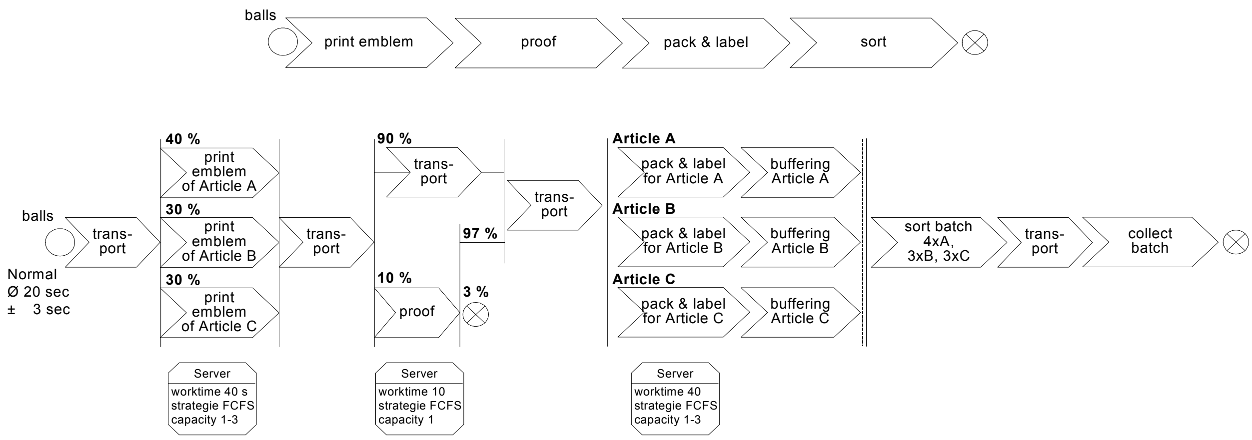

Figure 4: Process-Chain model.

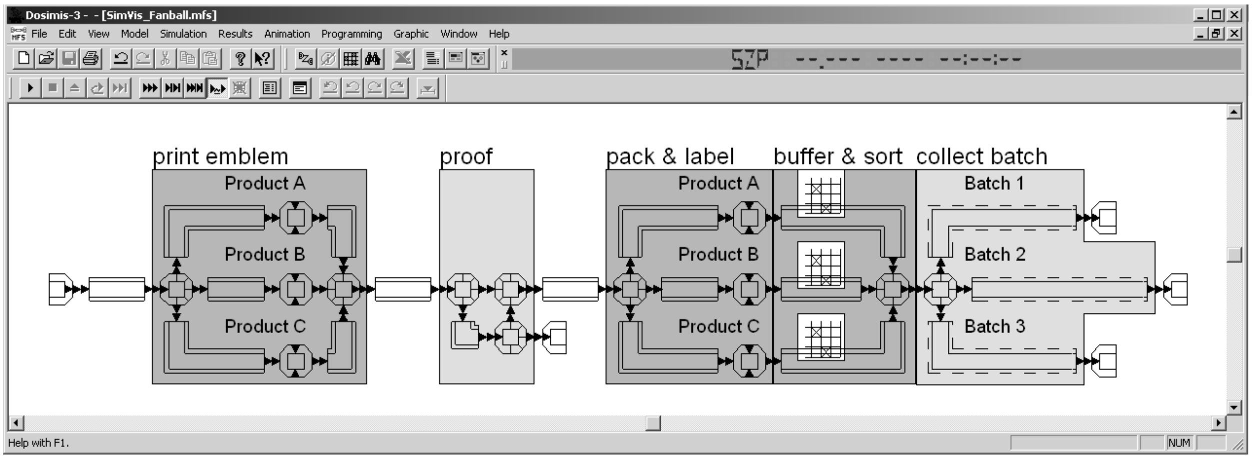

Figure 5: DOSIMIS-3 simulation model.

Visualization Model:
The visualisation model is automatically created by the SimVis service (see previous chapter for description). For this, accordingly to mappings and restrictions a static visualisation model is generated from the DS3 model. Subsequently, the dynamics information is extracted from simulation model and added to the animation scene. Finally, the animated scene is exported as VRML file (Virtual-Reality-Modelling-Language according to ISO/IEC 14772-1:1997 Standard) to show it on standard (mostly freely available) VRML viewer.

The intrinsic processing unit of the SimVis service generates *3-D scenes* based on completely defined error-free DS3 models considering implicit mappings and assumptions. In this example material flow using euro-pallets is supposed, i.e. sizes (length, width) of all graphical elements are related to standard size of euro-pallet (1.2m x 0.8m). For this, a library of parametrisable, adaptable and re-usable graphical animation elements for the professional modelling and animation tool 3ds max by Discreet has been built up. The elements represent real system components based on geometry and behaviour model and are used for quick and flexible 3-D modelling and animation of logistics and production systems. Using information of the DS3 model file as simulation element positions and directions as well as length and specific element type, the processing unit selects animation elements from the library and arranges them within the 3-D scene. Because of the non-proportional scaled DS3 models a grid (1.2m x 1.2m) is defined for the generation of the 3-D scene. The animation elements as representations of each DS3 element are selected from the library, positioned considering the grid structure and parameterised accordingly to an implicit mapping table and possibly on basis of technical attributes, e.g. a conveyor with its exact conveying distance.

The *transfer of dynamics* from simulation model to animation utilises the information of the event list represented by the trace file. It has to be pointed out that there is a fundamental difference between the discrete-event-based descriptions of dynamics of simulation and the activity-based description of animation. Events only describe single points in time. Activities define a period with starting point and duration. Thus, a translation process has to be defined, which based on event information generates a dynamics description, e.g. creation of pallet movement activity based on start and end event of a conveyor in simulation. Within the scope of the SimVis service this task is performed by a translator individually configured for DS3 and 3ds max.

When the dynamics are transferred from simulation to animation the completely animated scene is available in 3ds max. Potential export formats are picture, movie and accessible Virtual-Reality scene. Within the scope

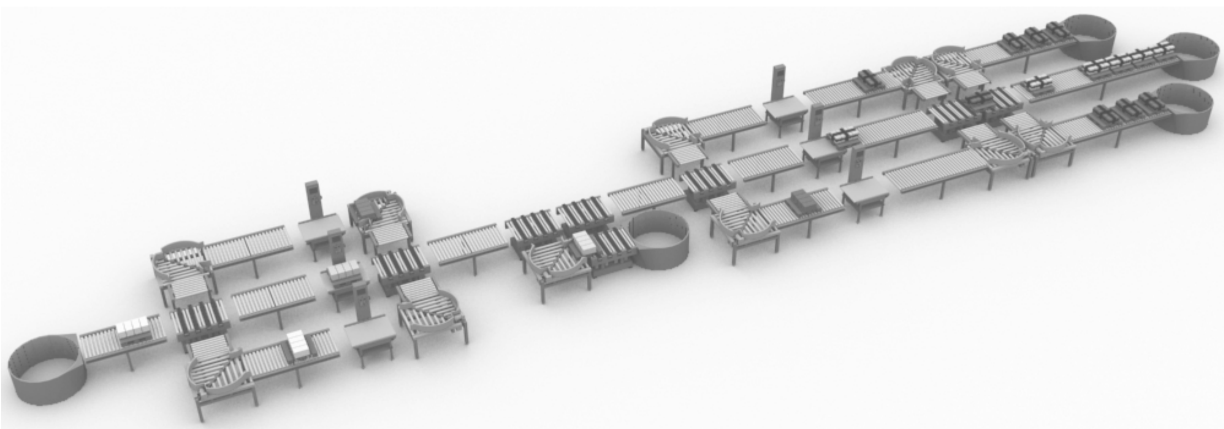

Figure 6: Visualization model.

of the SimVis service an animated *VRML file* is generated. Several measures improve the quality of the resulting file as polygon reduction, element referencing, file size compression etc. Finally, this file is sent to the user by email.

VALIDATION AND FUTURE PROSPECTS

The application of web-based services for the visualization of simulation models within the scope of academic education has demonstrated that particularly the application of the service for model validation and presentation of simulation results has been highly accepted by the students. However, default mapping rules and restrictions limited the work of the students with the service. Disregarding the mapping rules, transferring incomplete models by the students and a few deficiencies in error handling causes breakdowns of the web-based service. To fix the deficiencies, additional technical measures making the service stable regarding hardware, software bugs as well as handling errors including bug-reporting, have been taken. Additionally, the defined restrictions and mapping rules are permanently improved in order to increase the modelling flexibility. For further validation the utilization of the service is planned within the scope of other tutorials and workshops. By doing this, the service is evaluated within a different context and proved for other planning tasks. The goal is a generalized service.

ADDITIONAL INFORMATION

Additional information can be found under <http://www.logedugate.de>.

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