IMPLEMENTATION OF AN AUTOMATED EXCHANGE SYSTEM FOR CONSTRUCTION, SIMULATION, AND VISUALIZATION TOOLS

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ABSTRACT

The automated and semi-automated generation of material flow simulation models is discussed for decades. With AutomationML (AML) an open, object-oriented, XML-based storage and Exchange format is given, which in addition will allow an exchange between visualization, construction, and simulation tools. The application of AML within the different tools promotes a consistent design within the product- and production process of production and intralogistics systems. The neutral Exchange format will be allowed to pick up the different core functions of tools as well as their proprietary interfaces. The aim of the research project „ADEX - AutomationDataEXchange“ is the development of this single, digital planning methods and tools by AML. Open source automated import and export solutions of different tools will be developed.

KEYWORDS

Automated and semi-automated model generation, AutomationML, operative simulation construction and visualization

1. INTRODUCTION AND PROBLEM STATEMENT - ADEX

Due to increasingly shorter product life cycles emphasis in factory planning increasingly on the adaptability of production and logistics processes. The conversion and competitiveness of a factory can be improved by flexible production and logistics processes, as well as variable plant and facility planning. The use of digital tools consisting of under simulation, visualization and design - based factory planning and has a positive effect on the entire product creation process, as part of the product life cycle. The aim of the research project „ADEX - AutomationDataEXchange“ is the development of uniform, digital planning methods and tools for a consistent design within the Produkt- and production process of production and intralogistics systems. The core task of the „ADEX“ project is the development and testing of an automatic

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Exchange System (AES) between visualization, design, and simulation tools. Here the lossless and accelerated conversion and modelling within the various tools in the focus (s. Fig. 1).

![Diagram of Automatic Exchange System (AES)](image)

**Fig. 1: Structure and function of all components in conjunction with the AES**

The reason of the different core functions of each tool, as well as their proprietary interfaces, leads to develop open source automated import and export solutions. Following advantages arise from the use of an automatic exchange system:

- Existing simulation, visualization, and construction tools in the company remain in place, this will prevent costly new investments
- Productivity and cost reduction can be achieved by the use of AES, combining the individual duels advantages of tools
- Visualization, modeling, and simulation of real-world intralogistics systems accelerates, reducing the largely manual and costly effort in creating a new model

The core task of the ongoing implementation phase is the detailed development of the automatic Exchange System (AES). The focus this first in the data exchange of visualization and simulation tool.
2. STATE OF THE ART AND SCIENCE

Automated / Semi-Automated Model Generation

The automated or semi-automated generation of material flow simulation models is discussed and developed for two decades. First approaches coming from LORENZ AND SCHULZE [1], which generate layout-based models or SAN PEDRO [2], whose approach uses structural as well as data from a PPS system to generate models. A first classification of automatic model generation approaches provided by ECKHARDT [3]. Distinguished are parametric, structural and hybrid approaches. Parameters in parametric approaches are the selection and configuration of standard simulation modules. However structural approaches based on the structure of imaging system which are primarily represented by CAD data. Another way to classify is the morphological box of STRAßBÜRGER [4]. Based on this ADEX can be classified as follows:

- Application: planning-accompanying (tactical)
- Focused trades: Conveyor technology
- Degree of automation: auto part
- Approach: direct generic structure
- Support creation of model
- Interface: Text and XML-based

Other approaches for continuous digital planning and control describe the enterprise application integration (EAI) and service oriented architecture (SOA). The EAI represents integrated business processes along the value chain. Enterprise applications of from different generations and architectures can therefore interact over a common network [5], [6]. The SOA describes a method that encapsulates from existing computer components such as databases, servers, and sites in services and coordinated, thus the services provided are summarized to higher services and provided other services of the organization [7], [8]. Goals are the long-term costs in the development of the production plans and a greater flexibility of business processes through the reuse of existing services. Reduces the costs of future developments, since all necessary services are already available and only who combines them-the must. The reason for the sluggish development is the high demands on data security, continuity of the tool development and unsafe systems and product development processes [9], [10]. Model generation was increasingly published automatically to the topic in the context of discussions about the „digital factory“. In this context, STRAßBÜRGER [4] identified the implementation of control and routing strategies as well as of complex system behavior as automated model generation. For this purpose he leads various reasons. On the one hand, control rules can be integrated by the Scheduler often not within the layout tools in the planning data, on the other hand often corresponding to the layout designer’s competence for determining the control rules are missing.
ROOKS [11] suggests to create the missing information within the digital process planning and merge with the layout data. Module-oriented simulators, 10-30% of the control and routing strategies not through a direct parameterization of the standard modules are depicted [4]. A manual modelling is needed to implement this complex system process, which is typically performed by scripting languages. The automatic generation of such logic is hardly feasible with the scripting languages of the most simulators [4]. When the automated model generation, which can be also called „data-driven model generation“ [12], the origin and the type of information plays an essential role. SDX and CMDS are known data standards, previously used for the automatic model generation. The SDX-format of Siemens serves exclusively provides layout information. With the open, XML-based cmd-format layout - as well as process-related information can be transmitted. [4] The issue of the representation of complex behavioral logic is not completely solvable but also with this (cf. Bergmann and STRAßBURGER [13] and BERGMANN [12]). With the AutomationML used in the ADEX project there is another data standard for the automatic model generation, this is described in more detail in the next chapter. ADEX can be classified in the field as another approach to partially automated model generation. The issue of control processes is up to that point but not yet conceived, to consider it as resolved.

**AutomationML**

AutomationML (AML) is an open, free available, object-oriented, XML-based storage and Exchange format, which is developed by the AutomationML e.V.. AML serves the exchange of engineering data between heterogeneous tools of the „digital factory“. Goal of AutomationML e.V. is to reduce it, since they account for a significant share of the cost of engineering and the transfer costs. [14] So far, topology, geometry, kinematics and behavior of system components can be described with AML (s. Figure 2).

The hierarchical picture of the topology of the subject of the planning is carried out by means of CAEX (computer aided engineering Exchange). The CAEX library concept includes three types of library [16]:

- The SystemUnitClass library is a catalog of concrete physical or logical system objects or their combination. Attributes, interfaces and nested internal elements and their compounds are assigned to the elements.
- The RoleClass library defined abstract physical or logical system objects, regardless of the actual technical realisation. Roles describe the functioning of investment properties.
- The InterfaceClass library describes the kind of interfaces between the system objects. Who illustrated the relations between investment objects.
Geometry and kinematics can be associated with individual system components through COLLADA files. Also is the control that is defined with the PLCopenXML or the behavior referenced AML is adaptable and flexible; it offers the possibility to include other XML formats. [15] AutomationML also has an inherent distributed data structure. The information is instead of a monolithic XML document stored as separate documents. The reusability of individual system components and the development of element libraries will be easier. [16]

3. CONCEPTATION AND IMPLEMENTATION

   Automatic Exchange System (AES)

The automatic exchange system is defined by a system of figure rules and an associated user interface. Within the Exchange system, the model element to be transmitted is evidenced with existing or new role profiles of the AutomationML roles library for this to be developed. This goal is a uniform model generation within the various tools. Should there be for the assignment of the different models in the different tools conflicts this can be fixed separately through an interface through a manual selection. In addition to the transmission of model elements it is important to describe their attributes such as capable of taking over transport direction, speed, and more status descriptions. Furthermore, the relationships between the elements must be transferred. The conceptual design of the interfaces for the import and exporter of
visualization simulation was carried out in the initial phase of the project. For this purpose the parameter to be transferred were analyzed and compared to the available interfaces. The approach of an open source standards about the AML function excludes the existing interface packages and libraries available for exchanging data. Goal is to realize independent modeling of closed software packages across. Thus, a cumbersome and often time-consuming and error-prone new modeling will be reduced. The core task of the ongoing implementation phase is the detailed development of the automatic Exchange System (AES). The focus is first in the combination of visualization and simulation tool.

*Data transfer from the taraVRbuilder to Plant Simulation*

The visualization software „taraVRbuilder“ from the tarakos company already has an AML exporter. When exporting, the modulated in „taraVRbuilder“ objects with their parameters and relationship as AML file is stored. Then, the AML file is processed by the rule interpreter. Based assignment to one of the predefined AutomationML RoleClass is the function of an object. The RoleClass is in turn associated with a „Plant Simulation“ block. This ensures that different objects with similar functionality in „Plant Simulation“ are made identical. Tape, rollers, chain conveyors of „taraVRbuilder“ is interpreted as „Plant Simulation“ conveyor belt, for example, all of them. A general representation of the solution for the import and export of the and in the simulation tool is illustrated in Figure 3.

![Diagram](image)

**Fig. 3: Function and structure of import and export**
The conceptual design of the importers to „Plant Simulation“ was influenced by the demand for generality. Aim is the project of ADEX the developed AAS of all „Plant Simulation“ users license independently to provide. Interfaces that are available only through the purchase of „Professional“ or interface package licenses available were not taken into account accordingly. The file interface is imported to „Plant Simulation“. In addition, the structured text file can be processed by other simulators (e.g. ExtendSim, AnyLogic). The extensibility of ADEX on these simulators is project intended to link heterogeneous planning tools by the AES.

Automated model generation

The automated or partially automated model generation uses a standardized „Master model“. This includes a user interface and methods which run the model generation. A text file can be selected by the user interface shown in Figure 4. By pressing a button, the model generation is raised. Also can the „Model“ reset, stored or a simulation run is started and stopped. The user interface will be expanded later in the project to export functions.

Fig. 4: User interface of the importers in the simulation tool

The model generation is implemented in a „Plant Simulation“ method (s. Code 1). To create a static element of the system is to next from the text file, the standardized type of object selected. The method jumps to the part of the codes defined for that object type and executes it. At the beginning, the parameters of the object are read out and stored in variables.
Typical parameters are:

- Object name
- ID
- x-/y-Position
- Angle of rotation
- Object-specific attributes such as length, width, speed, time consumption
- In- und Output-ID

Then, the material flow object insert according to the x-/y-position in the model network. It follows the naming, labelling and parameterization by defining the attributes of the material flow object. Finally, the material flow object according to the in- and output-ID is connected to the already existing predecessors and successors by edges. Should any information about in- or output-ID be present in the record, is automatically a source or sink created.

OPEN textfile
READ objecttype
WHILE NOT textfile.end
  CASE objecttype OF
    CASE "conveyor"
      READ: name, ID, length, width, speed, capacity, angle, x-pos., y-pos., input-ID, output-ID
      CREATE conveyor AT x-pos., y-pos.
      SET name, ID, length, width, speed, capacity, angle
      IF input-ID <> ""
        CONNECT TO input-ID
      ELSE
        CREATE source AND CONNECT TO source
      END IF
      IF output-ID <> ""
        CONNECT TO output-ID
      ELSE
        CREATE sink AND CONNECT TO sink
      END IF
    END CASE
    CASE "curve"
      ...
  END CASE
ENDWHILE
CLOSE textfile

Code 1: Model generation in Plant Simulation
The implementation of a visualization model shows as an example the simulation tool automatic exchange system using the source code from the formatted text file in Figure 5. The prototypical example of a first option of automatic generation of model outlines the potential but also the limits of development. So far, simple conveyor systems from straight -, curve conveyor belts, turntables and individual stations can be modelled automatically. More material flow objects are to follow soon. Discussed the advisability and possibility of user-defined „Plant Simulation“ automatic generate and parameterize is currently. Fundamentally the elements would have to can be read by user-defined class libraries. With both the new object types, with the existing roles would be to link and a way should be found to address the attributes of those objects.

A custom object is implemented by a subnetwork. These can include several standard modules and methods. It is questionable what parameter as the object attributes set are or whether the attributes are passed through methods on the objects. The latter would be equivalent in the implementation of an automatic search and modification of the code of methods. Another step is the generation of moving material flow objects with attributes and corresponding work plans. The exchange of data will be identical to the static material flow objects. The control and routing of moving objects through the material flow system on the basis of the work plans must be even conceived.
4. CONCLUSION

The development here described „ADEX“ represents a first development for the automatic, open source, and free assembly model creation and transmission between different tools. This corresponds to the requirements for an integrated planning tool. It is created to feed individual AML libraries for simulation, visualization and design of repeated use one way. The development will help to facilitate the exchange of information and model components by combining different tools. The first results show that the implementation is successful possible. These used no proprietary software solutions. With the possibility to combine the model creation within the different tools in the future, it may be possible to produce accurate and fast models from a single source. This avoids costly, error-prone and time-consuming rebuild model. The previous level of conceptual design and implementation is the basis for the timely implementation of the automatic generation of another static material flow objects. To do this, yet the attributes to be transferred and the structure of the text file must be matched. The parallel development of the automatic model generation for AutoCAD is a similar pattern. Interfaces, such as ActiveX and .NET are available in AutoCAD without additional licenses. Thus, the information from the AML file can be directly read and processed. Up here, the static material flow objects are represented by simple geometric body. Problematic the request can be custom „blocks“ also here automatically parameterize.

The development described is a first step for the automatic model creation. This meets the requirements for a planning tool that is integrated and automatable. It is now possible to create individual and joint AML libraries for simulation, visualization and design, to share and to use repeating. Further steps are the increasing detail and standardization of automated Exchange System. In addition, the greater dynamism in production is user-defined material flow objects in the simulation tool in the foreground. This involves identifying the building blocks as well as their linkage with existing roles and the necessary parameterization. In the future, also the question of the implementation and delivery of work plans and thus accompanied by in-depth control and routing of the elements in the simulation tool should be explored.

5. BIBLIOGRAPHY


