ISA-95 Tool for Enterprise Modeling

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Abstract— **Enterprise information modeling is one of the major challenges for system integration in Factory Automation. Different standards exist to model information. This paper describes ISA-95 Tool that is developed based on internationally-used industrial standard ANSI/ISA-95. The tool makes it easier to automatically integrate product information with a production system. Up to the knowledge of authors, so far only ad hoc solutions were developed following ISA-95, which were failing to support in general the modeling of manufacturing systems. The tool can be used for production order specifications. An overview on ISA-95, B2MML (Business to Manufacturing Mark-up Language) and structures as SIIS (Software Intensive Industrial System) are described in the paper, which are followed by tool description and case study.**

Keywords- B2MML; ISA-95; Enterprise modeling.

I. INTRODUCTION

The information flow in industrial systems grows in terms of amount and structural complexity. At the moment factory information system implementation follows ad hoc solutions that may be based on some of the standards, i.e. ISA-95 or CAMX [1], but lack to have an adequate tools support for information *modeling*. The developing tendency of industrial systems shifts towards SIIS where software essentially influences to the design, construction and deployment of these systems. GAO, known as U.S. Government Accountability Office, attributes the poor success degree [2] of building software intensive systems to the management [3], in detail, ERP (Enterprise Resource Planning) and MES (Manufacturing Execution System) levels. From modules to methodologies, from languages to services, during last two decades an extensive research is performed to interconnect different enterprise systems and refine the SDLC (System Development Life Cycle).

For example, SOA (Service-Oriented Architecture) is a paradigm developed for organizing and utilizing distributed capabilities under different ownership domains [4]; OPC was designed to provide a common bridge for Windows based software solutions and process control hardware; the mechanism of loose coupling keeps different part of one system maintained own functionalities with communicating through well-defined interfaces [5].

ISA-95 developed by the Instrumentation Systems and Automation Society (ISA) defines a complete functional model for enterprise-control use as a reflection of an organizational structure of functions which can be replaced addressing different demands of the enterprise.

Following ISA-95 standard, this paper presents a tool that allows modeling of enterprise information. The tool can be used to allow adaptation to any specific demands of the enterprise. The models can be extended. The tool is demonstrated on manufacturing line producing mobile phones, where it is used to represent order information.

The paper is organized as follows: next section gives short introduction to ISA-95 standard and B2MML that provides XML representation for ISA-95, which is important for interoperability of IT systems at factories. Third section describes the tool. The use case is presented in fourth section that is followed by conclusions.

II. THE ISA-95 STANDARD & B2MML

A. *The ISA-95 Standard*

ISA-95 is originally a US standard which has been adopted as an international one under IEC/ISO 62246. As currently envisioned, the ANSI/ISA-95 series will consist of the 5 parts under the general title, Enterprise-Control System Integration:

- Part1:Models and terminology
- Part2:Object model attributes
- Part3:Activity models of manufacturing operation management
- Part4:Object models and attributes of manufacturing operations management
- Part5:Business to Manufacturing transactions

The latest versions of Part 1, 2 and 3 are released on 2010 while part 4 and part 5 are still under standardization. In this article, second latest version of ISA-95 and B2MML (v4010) were selected as a stable combination for their compatibility.

As a structured standard, ISA-95 includes 3 main information areas of producing products, capabilities, and actual production. Besides, the standard provides a reference model for system organizing, allocating business to the different systems and information flow between systems [6].

UML (Unified Modeling Language) models are used in the development of the tools following ISA-95. The 9 object models, 86 objects and a whole set of attributes defined in ISA-95.00.02 are extensions to the information models defined in ISA-95.00.01.

The structure and the frame allow users of addressing own information inheriting the relationship between information blocks (known as classes in Object Models).

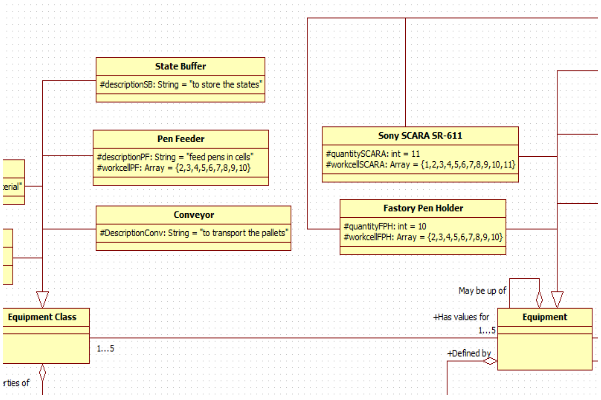

Figure 1. Part of Equipment Object Model for FASTory Line.

In an example of Equipment Object Model for the case study (Section IV), FASTory Line, the information of problem domain concepts such as “State Buffer”, “Pen Feeder”, “Conveyor” is well classified and the generalization between “Equipment Class” and them is also kept. In order words, standard UML models can be extended to fit the problem domain (Fig. 1).

The tool to be introduced in next part - “ISA-95 Tool” serves as an interface with all the classes beyond and under problem domain defined in ISA-95.00.02. In majority of the industrial systems, the problem domain consists of 4 models:

1) The personnel object model describes human resources defining different classes of personnel.

2) The equipment object model is structured similarly--the object model supports specifying requirements for different equipment classes.

3) The material model describes raw materials, intermediate products, and finished products.

4) A process segment is one step/task/unit of work that must be performed to complete a product.

The five other object models defined in ISA-95.00.02 beyond problem domain are production capability model, process segment capability model, product definition information model, production schedule model, production performance model.

B. B2MML

With a set of XML schemas written using the World Wide Web Consortium's XML Schema language (XSD), B2MML is treated as a complete XML implementation of ISA-95. The .xsd templates implement the data models in the ISA-95 standard. The final information carrier of ISA95-Tool will be an .xml file following B2MML’s .xsd template [7].

From the perspective of an SDLC, the link of support phase [8] in ISA-95 is still weak. This is reflected in the lack of tools and platform based on the standard. This stage of conceptualization greatly demands specific visualization to increase engineers’ efficiency on familiarizing and using this standard. Part III of this article depicts “ISA-95 Tool” as one solution addressing this demand.

III. INTRODUCTION TO ISA-95 TOOL

As mentioned in the previous part, there is a lack of visual-operating software as support phase for practical application of ISA-95`. The acknowledge degree still stays in the combination of models and attributes, which increases extremely the difficulty of application of the standard.

As one solution to the problem, “ISA-95 Tool” defines ”order” as the core concept and information carrier functioning in Manufacturing, Operation and Control level (level 3 in ISA standard family) and Business Planning and Logistics level (level 4 in ISA standard family) [9]. The process starts when the order is received from a customer and then transferred between system managers, analysts and operators. The process ends up with creating and transferring an .xml file to line controller that based on product needs should generate a production recipe. The recipe can be formalized in Business Process Execution Language (BPEL) [10].

However, system demands may vary from factory to factory and so not all models are necessary to keep the process running in a practical industrial use.

The first phase presented as a frame allows users to select models by their demands (Fig. 2).

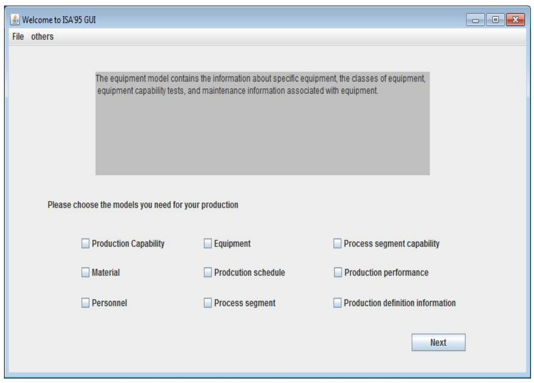

Figure 2. Model-selection phase of ISA-95 Tool.

The tool will list attributes and text fields under selected models (Fig. 3). The definitions of the attributes in the 9 models come from a minimum set of industry-independent information. The attributes are extensions to the object information model defined in ISA-95.00.01 and thus are part of the definition of terms. The attributes and models define interfaces for enterprise-control system integration.

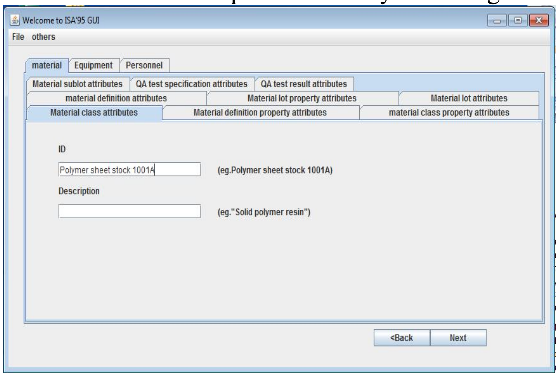

Figure 3. Attributes information phase of ISA-95 Tool.

An order list with information as Order ID and production start time can be created in third phase. A single cycle for all the operations in an order can be completed by pressing "Start" button (Fig. 4).

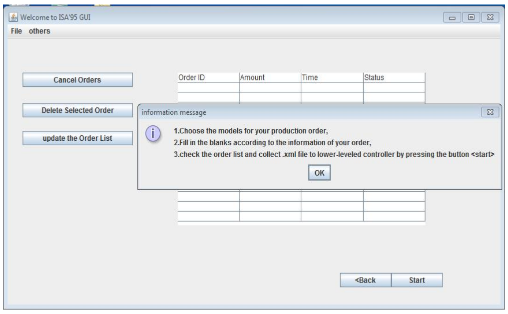

Figure 4. Order-checking phase of ISA-95 Tool.

After the operations cycle, an .xml file collecting inputs will be created by the tool and transferred to controllers at the production line level.

This is done by adding values to an existing .xml file template. As mentioned, from v02 of B2MML, .xsd files are available as part of the packages released by WBF (The Organization for Production Technology). The template here is created following .xsd file format. Little changes as adding root elements to .xsd files are required if the format transformation is completed by an xml software.

IV. Case Study: FASTory Line

A. *FASTory Line*

FASTory-Line is an assembly line used for research purposes in FAST Lab, Tampere University of Technology (Fig. 5). In order to simulate the production (due to costs reasons), drawings of components and products are created by robots. The main advantage is that, different drawings of components are used to simulate parts of the assembly and different colors for increasing the complexity of the systems as well as production customization. As a result, there is no need disassemble ready products, however the actual robots need to perform pick and place operation and follow unique sequence depending of the variant of the product.

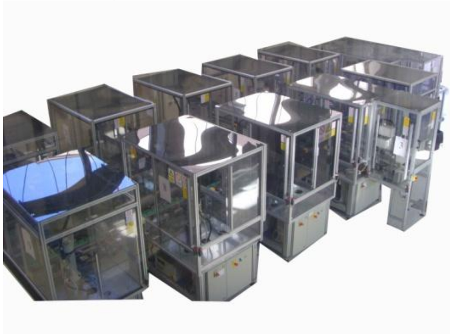

Figure 5. FASTory Line

The drawing consists of 3 components: frame, screen and keyboard, 3 different formats for each component and 3 different pen colors (red, green and blue) for each format thus the product has 729 variants altogether. All the drawing robots can take the task of drawing any part. It is also possible to make the complete mobile phone or finish only one part to bring larger flexibility of the line. The material to be used in the production will be paper and pens.

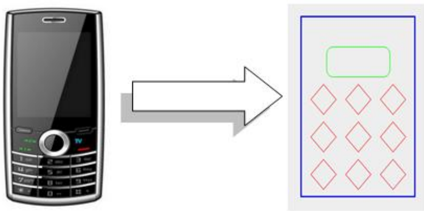

Figure 6. Cell-phone simulation.

B. *Modified version of "ISA-95 Tool"—"FASTory GUI"*

FASTory line is a typical production line with strong demands on models in problem domain, mainly for equipment model, personnel model and material model. The traditional solution with "ISA-95 Tool" is to choose problem domain models in first phase, to fill attributes forms in second phase before final order is created. However, a different scenario is presented below as an alternative solution.

"FASTory GUI" is developed as a modified version of "ISA-95 Tool" being optimized for FASTory Line. Starting from the action flow, the user set input by choosing radio button groups and making selections in combo boxes in the first phase (Fig. 7).

Instead of text-fields, the material information is represented directly in the form of component formats. The volume of the ink in different colors changes as the user chooses different cell phone formats and colors. The product segment information in accordance with the choice will be displayed in a table simultaneously.

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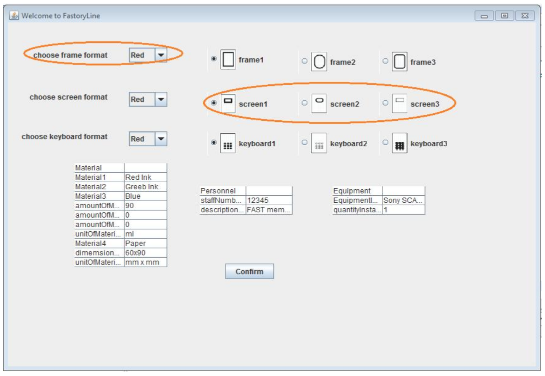

Figure 7. Cell-phone format selection phase of FASTory GUI.

After confirmation, the user can check the information as production segment rules, production schedules and even a preview of the cell-phone product (Fig. 8). The user adds orders list after the correction of the mistakes (if any).

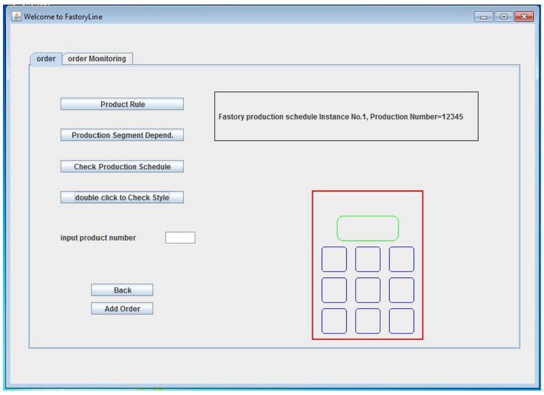

Figure 8. Production Segment Information phase of FASTory GUI.

The same as with "ISA-95 Tool", if the order does not reach the requirement, the user can delete unwanted order in monitoring tab or exit the procedure by cancelling the orders.

Also, an .xml file collecting user's choices and carrying order information will be created and transferred to line level controllers. Again, here an alternative method is presented instead of feeding values to .xml templates.

In an SIIS as FASTory Line, not all data are in top level of importance, which means only part of information can keep the system processes running. Another reason on reducing the amount of the information is that irrelevant elements, null elements and long headers increase workload and difficulty for line controllers on information analysis. Here a minimum set of elements are chosen from the template artificially and an example of this has been tested on FASTory GUI. An example of a part of the .xml code looks as follows:


```
<amount>99</amount>
<time>Tue Sep 20 12:58:58 EEST 2011</time>
<Formats>
<frameFormatColor="1">1</frameFormat>
<screenFormatColor="0">0</screenFormat>
<keyboardFormatColor="1">1</keyboardFormat>
</Formats>
```


As depicted in this scenario, the formats and colors are represented by integers in elements and attributes; the programming solution reduces the time needed analyzing and extracting information from files.

V. CONCLUSION

The ISA-95 standard is an important basis for the development connecting control system and enterprises. B2MML is selected as implementation language for the standard to allow interoperability of industrial IT systems. "ISA-95 Tool" allows visualization of the models and attributes staring from abstract concepts, refining and placing them into practical industrial use. FASTory tool is a specialized version based on "ISA-95 Tool" taking FASTory Line as a study case. It is also a good example of how "ISA-95 Tool" can be extended to fit factories, enterprises in different size and types as separate solutions, though it is already sufficient and powerful enough working as an independent tool.

The further development and research can focus on the modeling of production performance that can be checked after at least one single process segment and return information back to ISA-95 models. Thus an .xml file containing performance model information is needed and can be generated as a result of feedback information coming from line and low-level controllers. This addition will require some changes on current web service interface between the tool and the controllers of the line.

Another issue is that majority of targeted users of current software products on ISA-95 application are "solution architects", "analysts", and "engineers" but not the managers who do not have flexibility to update the model or change the schedule. This indirectly increases the operating requirement even if there are no problems other than the format and the access of the information. Thus an extra step could be added transferring created .xml file to .xls file. The format of an Excel table which avoids the specific knowledge requirements of B2MML is considered for the future work.

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