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COMMUNICATION WITHIN AN INTEGRATED BATCH CONTROL

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Abstract. This work is based on general area of batch control. The control of batch production is a complex problem as it includes features of the continuous and discrete world. Integrated framework for coordinating operational tasks in industrial plants promises good solution. In this way unified control is possible. Integrated framework has to deal with integration of various problem-solving methodologies, with synchronization to continuously changing environment and with the definition of the information flow. The main consideration of this work is the formalization of the information flow. International Society of Automation (ISA) introduced standards to control batch productions and to help integrating the control. The integrated batch control system that is being developed by the group of CEPIMA from UPC is made up of various components where each generates and requires information to perform different functions. In this work a communication schema for this integrated control system is proposed. This schema is determined based on XML messages, which are defined based on World Batch Forum (WBF) recommendations.

1 Introduction

In many production environments (chemical, pharmaceutical,...) batch processing is preferred as it enables more flexibility and therefore can easily accommodate the market fluctuations of the product. The primary characteristic of batch production is that all components are completed at a workstation before they move to the next one. The control of batch processes poses difficult issues because these processes combine features of the continuous world as well as the discrete one. As a consequence a comprehensive model of such hybrid systems has to include both discrete event and continuous aspects.

Until now the control systems in production plants were strictly structured hierarchically into several levels, each operating on a different time scale. Each of those systems (regulatory control, fault detection, supervisory control, planning and scheduling,...) were implemented individual, using many different techniques. The main reasons for this were technological limitations. However, present-day's computer systems have been improved pretty much and many of those limitations are not present any more. Consequently the usage of integrated framework for coordinating operational tasks in industrial plants is now possible [8]. Integrated framework has to deal with integration of various problem-solving methodologies, with synchronization to continuously changing environment and with the definition of the information flow. The main consideration of this work is the formalization of the information flow.

In 1995, International Society of Automation (ISA) introduced S88 standard for batch control systems. However, carefulness is needed in order to deal with the complexity of batch processes and to meet the high-quality requirements of control software for batch-process control according to the ISA standards [1]. Those standards may be used to define representation of data and in this way the problems of heterogeneous components integration can be solved. Data representation can be a complex structure, defined as an object where data specified compose the object and the methods to manage it. Within this work communication should be defined based on XML (eXtensible Markup Language) messages and should be synchronized in a common distribution system. XML messages were defined based on the World Bach Forum (WBF) [11] implementation of standards ISA-95 [10] and ISA-88 [2, 3, 4, 5, 6].

2 Standards for Integrated Batch Control

The work is based on general area of batch control. Batch manufacturing factories produce an intermediate variety of products in intermediate volumes [7]. In batch production, a recipe that contains all requisite information for manufacturing the product, determines the products processes. In batch processes it is supposed there are three different types of control: basic control, procedural control and co-ordination control. There exists standards to control batch productions and helps integrating the control. As mentioned one of the main concerns of the integration of such a complex systems is the definition of information flow.

ANSI/ISA 95 family of standards (ISA-95) [10], known internationally as IEC/ISO 62264, is a method described in several documents. These contain models and terminology to be used to analyze an individual manufacturing company and to integrate the enterprise and control systems. ISA-95 can be applied into different categories. It can be used as an analysis tool, as a basis for developing software with MES functionality and can be used for standardized information exchange between enterprise and control systems.

ANSI/ISA 88 family of standards (ISA-88), known as IEC 61512 and developed for batch control, consists of more parts where each has its own specific subjects, but they are closely related. Part one [2] consists of a consistent set of models and terminology concerning batch processes. Three kinds of models are combined: physical hierarchy model, procedural model and recipe model. Part two [3] consists of data structures and a graphical language for displaying recipes and part three [4] deals with enterprise wide representation of recipes. Part four [5] defines the reference module for batch production records and part five [6] defines implementation models and terminology for modular equipment control based on the part one equipment control concepts

The WBF forum has developed XML schemas based upon the ISA-88 and ISA-95 families of standards. *Business To Manufacturing Markup Language* (B2MML) is an XML implementation of the ISA-95 standard and *Batch Markup Language* (BatchML) is an XML implementation of ISA-88 standard. B2MML and BatchML consist of a set of XML schemes written using the World Wide Web Consortium's XML Schema language (XSD) that implement ISA-95 and ISA-88 standard. In the latest release, V0401 [11], BatchML schemas have been integrated into the B2MML namespace and BatchML now uses the B2MML common and extension files. A definition of all data types and all elements is given in this way. Elements are also defined for each possible element of exchanged information what provides a very fine level of granularity for exchanged information.

3 Case study

The integrated batch control system that is being developed by the group of CEPIMA from UPC is made up of various components where each generates and requires information to perform different functions [9]. These components handle various aspects of the process control within the flexible system to support decisions. All these components have to be able to exchange information and to coordinate their implementation in order to operate as an integrated application. Components of the integrated system and the information flows are depicted in the Figure 1.

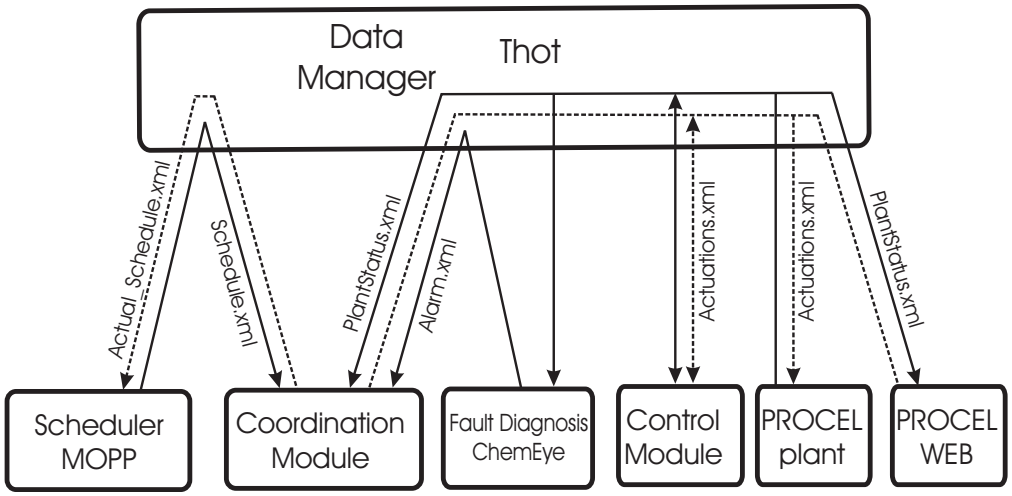

Figure 1: Components of the integrated system and the information that flows through the system (XML messages).

In the following all these components will be briefly described, where the main stress will be given in the discussion about the information flow within this integrated system.

All the communications are done trough the data manager *Thot* which supports the exchange of information between modules located on the same processor board and also between modules located on different boards connected through the network.

This integrated control system is being implemented in the pilot plant *PROCEL* that has been built at the CEPIMA department. The pilot plant contains three glass reactors, connected with network of pipes, pumps and valves. The plant is used as a test platform to investigate different issues (Co-ordination control, information system integration and online operation and control in closed loop). At this place also a study was performed to renovate the system. Some sensors and actuators would need to be changed in order to be able to use them with the multipoint serial communication RS-485 which could later be connected to the computer via, e.g., USB port.

The *MOPP* planner generates and sends a production plan. *MOPP* is a toolbox for planning and scheduling of tasks in batch chemical processes. The tool can receive orders that have to be performed and data about the available equipment. Different algorithms can be used/implemented to build schedules. The results are shown in Gantt chart. Plug-in *ThotMOPPBridge* has to be included within the *MOPP* toolbox to enable the communication with other modules. The output of the MOPP is a production schedule which is passed to the integrated control system as an XML message *Schedule.xml*. Data transmitted with this message are defined with ISA-95 and ISA-88 standards

and here the data structure implemented by the WBF is incorporated. The formal description of XML message structure is defined by the XML Schema Definition (XSD). XSD definition of a batch list model is presented in the Figure 2.

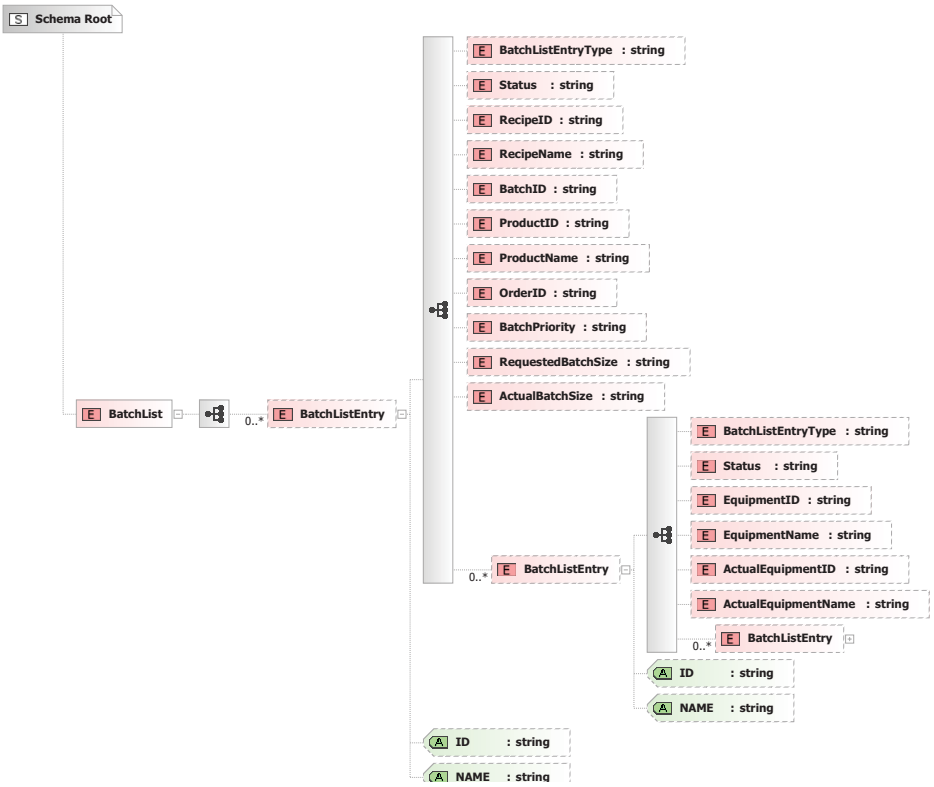

Figure 2: XSD definition of a batch list model used to define *Schedule.xml* message.

A batch list contains the list of batches for a process cell. This may be a list of batches to be added to the cell, the list of batches currently scheduled in the cell, or the list of batches currently scheduled and completed in the cell. A Batch list entity is represented in a *BatchListEntry* element. A batch list entry corresponds to a single batch. A batch list entry contains information about the starting conditions, scheduled times, actual times, scheduled batch size, actual batch size, and equipment binding.

This plan is later translated by the *Coordination module* into control actions. *Coordination module* played the main role in this work as the most communications are done with this module. Besides defining the control actions it has to supervise the units (control the activities related to the recipe control) and it receives the data about the plant status. Based on this data this module recalculates the control actions and inform *MOPP* planner about the actual schedule. During this work first this module had to be refined. The function which reads the XML message and writes it to the Data model was rewritten using Abstract Data Type (ADT). In this way messages from *MOPP* (*Schedule.xml*) can be read directly via data manager *Thot*. Similar the communication is done also in the opposite way, where *Coordination module* informs *MOPP* planner about the actual development of the plan (*Actual_Schedule.xml*). It is a copy of a schedule where data about actual start times, end times, etc. are added.

Coordination module is defining messages indicating the actions that must be implemented in the plant (*Actuations.xml*). Those messages are sent to the *Control module* which is still under development. *Control module* perform lower level of the coordination control. It receives information directly from the plant and based on that make basic control of specific equipment and execute procedural control. *Control module* also informs the integrated control system about the current state of the plant (*PlantStatus.xml*). In the case of anomalous situation (e.g., unit has failed) *Fault Diagnosis system* detects that and sends an alarm to *Coordination module* (*Alarm.xml*).

The *PROCEL WEB* is web interface used to control and supervise the plant, i.e., SCADA system. Using this interface the plant status can be visually supervised. Besides this, it can also be used to change the plant settings and thus enables the manual control of the plant.

4 Conclusions

In this work the communication schema for integrated control is proposed which is a prerequisite for the unifying control (optimization) of a batch system. Within this schema all possible information is available to all control levels. Some information is not necessarily related to some parts and new models can be built to exploit it.

Communication schema is being developed with regard to the standards for batch control systems (ISA-88 and ISA-95). This schema is determined based on XML messages, which are defined based on World Batch Forum (WBF) recommendations. The main advantage using those standards is the interoperability of different software tools from different vendors what enables the integrated control of batch systems.

5 References

[1] Godena N.: *A new proposal for the behaviour model of batch phases*. ISA Transactions, (2008).

[2] Int. Soc. for Measurements and Control: *ANSI/ISA-88.01-1995. Batch Control Part 1: Models and Terminology*. ISA Society, 1995.

[3] Int. Soc. for Measurements and Control: *ANSI/ISA-88.00.02-2001. Batch Control Part 2: Data Structures and Guidelines for Languages*. ISA Society, 2000.

[4] Int. Soc. for Measurements and Control: *ANSI/ISA-88.00.03-2003. Batch Control Part 3: General and Site Recipe Models and Representation*. ISA Society, 2003.

[5] Int. Soc. for Measurements and Control: *ANSI/ISA-88.00.04-2006. Batch Control Part 4: Batch Production Records*. ISA Society, 2006.

[6] Int. Soc. for Measurements and Control: *ANSI/ISA Draft 88.00.05. Batch Control Part 5: Implementation Models & Terminology for Modular Equipment Control*. ISA Society, 2008.

[7] Jovan V.: *The Specifics of Production Scheduling in Process Manufacturing*. Electrotechnical Review, 69(5) (2007), 305–310.

[8] Power Y., and Bahri P.A.: *Integration techniques in intelligent operational management: a review*. Knowledge Based Systems, 18:2–3 (2005), 89–97.

[9] Puigjaner L., Nougués J.M., and Espu na A.: *Integrated batch control. En: The Integration of Process Design and Control*. Elsevier, Amsterdam, 2004, 501–532.

[10] Scholten B.: *The road to integration: A guide to applying the ISA-95 standard and manufacturing*. ISA Society, 2007.

[11] World Batch Forum: *B2MML BatchML V0401*. Available online via *http://www.wbf.org* (2008).