Batch Management in the Supply Chain

Charlotta Johnsson
System Architect
Siemens Orsi Automation S.p.A.
799 Corso Europa
16 148 Genoa
Italy
+39 010 3434 515
+39 010 380 309
charlotta.johnsson@siemens-orsi.com

KEY WORDS
Batch Management, Synchronization, Coordination, Component-based Architecture,
Supply Chain Management, ISA S88, ISA S95

ABSTRACT
Batch management systems are traditionally composed of two subparts, one assuring the creation and
configuration of the recipes, and the other assuring the execution of the recipes, i.e., driving the
equipments to make a product.
By reducing the total time needed for producing a product, the market can be reached quicker and more
money can (hopefully) be earned. Time to market is an important key competitive performance
indicator.
So, how can time to market be reduced?
The execution part of the batch management system must obviously work efficiently, but this alone will not be enough. Personnel, materials, scheduling and maintenance information sent from the ERP system must also be managed in an efficient way.

The problem is that traditional batch management systems are not intended to or capable of handling this information. Neither are they intended to handle information concerning warehouses, packaging or material receiving.

Rather than extending the batch management system beyond its core role, the importance of the MES system and its capabilities should be stressed. An approach based on the ideas and models presented in ISA S95 is believed to be successful. Dedicated cross industry components manage the functions that are decidedly non-batch.

Similar to a traditional batch management system that coordinates and synchronizes the recipe execution, a MES system should do the same for the functions of the components. Applying this approach, the batch management system can truly work in the context of the supply chain!!!
The physical hierarchy, Figure 1 (left), specifies that an enterprise can be divided in one or more sites, each site can be split in one or more areas, each area divided in several process cells etc, etc. The terminology used in Figure 1 for the physical hierarchy is that used within batch industries. The terminology used in discrete or continuous industries is somewhat different with regards to the lower four levels.

The functional hierarchy, Figure 1 (right), shows that the functions within an enterprise can generally be classified into three parts.

- The upper part of Figure 1 (right) represents all the functions generally managed by the Business Logistics system, i.e., by an ERP (Enterprise Resource Planning) System. Most of these functions are generally carried of at the Enterprise or Site level of the company.

- The lower part of Figure 1(right) represents all the control functions generally managed by the control system. The control system can be batch, continuous or discrete. For batch industries, the international standard IEC 61512 [2], also know under the name ISA S88 [3], applies. The batch control system manages the creation and execution of recipes. The functions taken care of by the batch control system act at the level of the process cell, unit, equipment module and control module.

- The middle part of Figure 1 (right) represents the Manufacturing Control System also known as the MES system (Manufacturing Execution System). The ISA S95 standard focuses upon the MES systems.

If the time-to-market is to be reduced, it is not enough to have a well functioning ERP system and a well functioning batch control system with an efficient batch execution engine and to connect the two of
them together. It is also necessary that information such as personnel, materials, scheduling and maintenance, i.e., information generated in the ERP system but not directly used within the recipe of a product, is managed in an efficient way.

Rather than extending the batch management system beyond its core role, the MES system should be designed to serve as a link between ERP system and the control system. The ERP system sends information to the MES system, e.g., scheduling information or information regarding personnel and materials. The MES system assures that the control system acts correctly with regards to this information. The control system, on the other hand, sends information to the MES system, e.g., logs, failure reports etc. The MES system filters this information and transmits parts of it to the ERP system.

The S95 standard presents a number of functions that are of relevance to a MES system, such as; scheduling, resource management (personnel, material and equipment), product definition management, production tracking, product analysis, production analysis, process analysis, etc, etc. All these functions must be represented and easily manipulated in a good MES system.

**MES SYSTEM**

The MES (Manufacturing Execution System) system can be based on the ideas and models presented in the standard ISA S95. It should take care of functions like scheduling, resource management (personnel, material and equipment), product definition management, production tracking, etc. Each function can be packaged in a component and the MES system can then manipulate these components. In order to express the sequential order in which the components should work, the use of a graphical language as a framework, is preferred.

**Components and Framework**

A component can be seen as a collection of related functionalities/tasks. The components expose their capabilities in terms of methods and events, see Figure 2.

![Figure 2: A component exposing methods and events.](image-url)
In order for the components to work together a framework, preferably containing a graphical language, is needed.

The task of the framework is to coordinate and synchronize the functionality exposed by the components, and to show this in an attractive and easily understandable way. This is done through a graphical language. The operator simply specifies the sequential order in which he/she would like the functionality of the components to be executed. An example of such a rule, referred to as a production operation, is shown in Figure 3. The production operation should be read from left to right. The first graphical element indicates the start of the rule and this element can be associated to an event. The second graphical element, which is the graphical element most frequently used in a production operation, is an element that calls a method of a component. It is referred to as method-caller. The production operation in Figure 3 contains one parallel and one alternative branch.

The operator can get information about the current execution status in the plant. The execution of a production operation is color-coded which means that the operator easily can see which steps have been executed and which step is currently executing.

**FUNCTIONS SEEN AS COMPONENTS**

All functions of relevance for the MES system can be packaged in, and treated as components. The S95 standard presents a number of functions that are of relevance for an MES system, see section 2 (Physical and Functional Hierarchies Within an Enterprise). Even though S95 does not speak about components, the functions can be implemented as such.

- personnel component
- material component
- scheduling component
- dispatching component
- etc

![Figure 3: A production operation.](image-url)
Even though the components needed in a MES-application focused upon batch processing, varies from one application to another, it is clear that the main important components in a S88 compliant batch solution are:

- recipe definition component
- batch execution component

These two components correspond to the two subparts found within a traditional batch management system.

**BATCH MANAGEMENT**

The two components in a S88 compliant MES solution for batch industries are the recipe definition component and the batch execution component.

The recipe definition component allows master recipes to be defined. This includes specifying a header, creating the procedure (graphical description), and specifying the formula and the equipment requirements, all according to the ISA S88 standard. An example of a procedure is shown in Figure 4. The procedure is composed of 4 unit-procedures, each unit-procedure is composed of a number of operations and each operation is composed by phases (not shown in the figure).

![Figure 4: A recipe with its procedure. The procedure consists of four unit-procedures](image)
The batch execution part assures the execution, i.e., it creates and starts the execution of control recipes, and it controls the execution and the interaction with the field. In order for the operator to get a good overview of the current executions in the plant, he/she can look at the color-coded procedure of the recipe to see the current execution status of a recipe.

In addition to the recipe creation and recipe execution, also batch recording is needed in a batch management system. The batch-recording part logs the execution of the batch, i.e., it logs the start and stop time of all phases/operations/unit-procedures in the recipe as well as the actual values of the associated parameters.

**The Batch System seen as a Component**

The MES system does not need to know the details of the batch control system, the batch control system can simply be seen as a component that it can manipulate by using the methods and events that the component expose. The method and the events are allowed to have parameters. When the MES system wants to send information to the batch system it simply uses a method call, on the other hand, when the batch system wants to tell the MES system something, it signalizes this by an event.

Examples of methods for the components are; start-a-recipe, pause-a-recipe, abort-a-recipe, create-nre-recipe, etc, etc.

There are three main ways in which the framework can interact with the batch components and thereby synchronize the execution of the batch component with that of other components. The three ways are; start a recipe, monitor the execution of a recipe, and detailed recipe synchronization, these are described within the paper Batch Processing in a Wider Perspective, see [4].

**A MES SCENARIO WITHIN BATCH PROCESSING**

Below follows an example of a combined MES and batch scenario. The terminology used complies with the terminology of the ISA S95.03-draft3 standard, [5].
A production schedule is sent from the ERP system down to the MES framework used in one area within an enterprise. The arrival of the file triggers a production operation at the area level to start. The production operation calls the scheduling-component that divides the production schedule into one or many detailed schedules. The detailed schedules, each one corresponding to the execution of one production operation at the cell level, are distributed to the dispatching-component of the relevant cells. The operator at the cell level sees the list of production operations to be executed, and he/she can use the dispatching-component to manually decide when to dispatch a production operation. The production operation at the cell level is used to coordinate the execution of the batch component with the execution of other components within the cell. When the work scheduled for one process cell is completed, a notification is sent back to the production operation at the area level. In this way the area production operation can synchronize the work performed by the different cells. Finally, when the entire production schedule has completed, a notification as well as a report of the production performance can be sent back to the ERP system. During the execution of a production operation, logging is performed, and location and status of materials are updated and stored, etc.

SUMMARY

Traditional batch management systems are not designed to manage functions such as resource management, material management, equipment scheduling, warehousing and packaging. These functions are critical to the efficiency of a batch manufacturing enterprise and are best addressed by a MES system. Rather than extending the batch management system beyond its core role, the importance of the MES system and its capabilities should be stressed. Each function, i.e., scheduling, materials, personnel, etc, can be packaged in, and treated as a component. The batch management system handles the traditional batch management tasks; creation and execution of recipes, whereas dedicated cross industry components manage the functions that are decidedly non-batch. In order for the components to work together a framework, containing a graphical language, is needed.

The graphical language within the framework resembles the recipe creation part of a batch management system. Very much as a traditional batch management system coordinates and synchronizes the execution of the recipe, so a MES system should do the same for the functions of the components. Applying this approach, the batch management system can truly work in the context of the supply chain!!!

REFERENCES