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FUNCTIONALITIES AND INTEGRATION POSSIBILITIES OF MANUFACTURING EXECUTION SYSTEMS

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Abstract:
The paper is focused mainly on ERP and MES integration and is structured in the following way. Firstly the background on ERP and MES Evolution is presented. Then, MES functionalities are analyzed and a modified functionality model is suggested. After that a pertinent issues of ERP and MES are treated. In the final section will be discussed decisive findings and future trends of MESs, which are driven by RFID development.
Keywords:
Manufacturing management, process control, interface, standard

1. INTRODUCTION

The phenomena of globalization forces manufacturers to continuously improve their performance. In this context, manufacturing and operational excellence has become the key theme for the manufacturing companies. To improve their performance, most manufacturers apply methods and techniques which are focused on the elimination of non-value adding activities. Information systems can by supported in such programs or they can provide a complementary way of improving performance by increasing visibility on plant performance. Offered software solutions simultaneously close the gap between Enterprise Resource Planning (ERP) systems and production equipment control or SCADA (Supervisory Control And Data Acquisition) applications. Current ERP systems contain usually modules for material management, accounting, human resource management and all other functions that support business operations. In the past years, the role of ERP has been extended to cross-organizational coordination. Nowadays, as optimization of production activities is increasingly topical, a cooperation of ERP and Manufacturing Execution Systems (MES) becomes a serious concern of manufacturing managers. Manufacturing Execution Systems are IT solutions that support the primary production processes in a production plant. Nowadays, MES applications have become essential to support real-time production control as well as data collection and reporting, required improving production performance.

2. BACKGROUNDS OF ERP AND MES EVOLUTION

From a historical perspective, the infiltration of information technology into manufacturing technology was conditioned by the development and advancement of host mainframe computing in the 1950s and '60s. It gave manufacturers the ability to capture, manipulate, and share information and automate calculation and analysis in order to support design of increasingly complex and capable products. Simultaneously in the framework of manufacturing management an inventory control took on great importance and most of the software in the 1960s was developed for this purpose. Typically, inventory control was handled by tool called BOM (bill of materials) processors, which were used as a means to represent process plans. The focus shifted in the 1970s to Material Requirement Planning (MRP) as the complexity of manufacturing operations increased. This managerial instrument enabled financial managers both to view and control their business processes much more closely. The tools to automate business processes were enhanced by adding further functionalities to meet the increased requirements. Subsequently in the 1980s the term Manufacturing Resources Planning (MRP II) became popular. An MRP II presented extension of MRP functions to achieve integration all aspects of the planning and control of the personnel, materials and machines (Kimble & McLoughlin, 1995). Following solutions that are marked by acronym ERP were performed in the early 1990s. An ERP system can be defined as an integrated information processing system supporting various business processes such as finance, distribution, human resources and manufacturing (Choi & Kim, 2002). The newest version ERP II has been much publicized by the Gartner group (Mohamed & Fadlalla, 2005). Fundamentally, ERP II signals a shift in traditional ERP applications from focusing on internal data gathering and management process information to partners, vendors and customers externally via the Web (Farver, 2002). The overall view on evolution of ERP system is shown in Figure 1. Initially this concept attained a huge popularity among manufacturers, but as the scope of managed systems increased, the ERP system was not suitable for controlling activities on the shop floor level. For this purpose new tool of manufacturing management called Manufacturing Executive System was evolved and utilized during the 1990s. There is a more interpretation of MES depending on different manufacturing conditions, but the common characteristic to all is that an MES aims to provide an interface between an ERP system and shop floor controllers by supporting various 'execution' activities such as scheduling, order release, quality control, and data acquisition (MESA #6, 1997). In a context of the MES development and deployment it is important to point out that Manufacturing Execution Systems were originally designed to provide first-line supervision management with a visibility tool to manage work orders and workstation assignments. Consecutively, MES expanded into the indispensable link between the full range of enterprise stakeholders and the real-time events occurring in production and logistics processes across the extended value chain (McClellan, 2004).

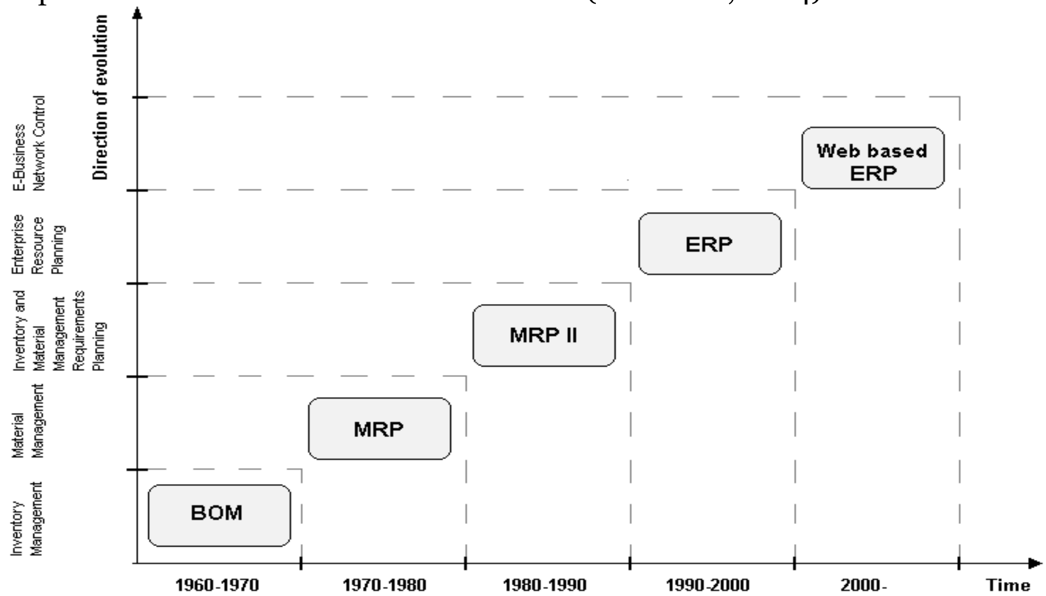

Figure 1. The evolution of ERP systems (Modrák, 2008)

3. VIEW ON MES FUNCTIONALITIES

A concept of Manufacturing Execution Systems is one of several major information systems types aimed at manufacturing companies. MES can be in simple way also defined as a toll for manufacturing management. The functions of an MES range from operation scheduling to production genealogy, to labor and maintenance management, to performance analysis, and to other function in between. There are several general models of typical MES functions that are principally divided into core and support functions (Kováč, et al, 2006). The core functions deal primarily with actual management of the work orders and the manufacturing resources. Other functional capabilities of MES may be required to cover support aspects of the manufacturing operations. According to McClellan (1997), the function parts pertaining to first group of functions include:

- Planning system interface
- Work order Management
- Workstation management
- Material movement management
- Data collection
- Exception management
- Inventory/materials.

The same author describes support functions as open system and simultaneously gives a picture of which other functions the MES should include:

- Maintenance management
- Time and attendance
- Statistical Process Control
- Quality assurance
- Process data/performance analysis
- Documentation/product data management
- Genealogy/product trace-ability
- Supplier management

MESA International presents another attitude to MES functionalities that is more or less based on the assumption of profitability to begin to deal with wider model of basic elements to ensure incorporating all-important functions into MES (MESA #2,1997). Accordingly MES would include functionalities such as:

1. Resource Allocation and Status
2. Operations/Details Scheduling
3. Dispatching production Units
4. Document Control
5. Data Collection/Acquisition
6. Labor management
7. Quality Management
8. Process Management
9. Maintenance Management
10. Product Tracking and Genealogy
11. Performance Analysis

A point of debate about MES functionalities also is connected with different types of manufacturing. Commonly, manufacturing can be divided to three types (Grover, 1987):

- Job Shop Production. The manufacturing lot sizes are small, often one of a kind.
- Batch Production. This category involves the manufacture of medium-sized lots of the same item of product. This type is called also discrete manufacturing.
- Mass Production. This is the continuous specialized manufacture of identical products.

Understandably, from automation point of view a discrete manufacturing presents much more complicate concept comprising of various technologies that are used to integrate manufacturing system to one another. One of specific models of MES functions is aimed to typical FMS (flexible manufacturing system) consisting of numerical controlled machining centers, automated handling systems for jobs and tools, automated storage/retrieval systems, auxiliary processing facilities, and set-up stations. Choi & Kim (2002) propose two-tier MES architecture suitable for bridging the gap between an FMS controller and ERP system. The two-tier MES consist of a main-MES in charge of main shop-floor operations and an FMS-MES in charge of FMS operations. The main MES is connected to the ERP system, and the FMS-MES is connected to the FMS controller. Then the overall structure of shop floor operations required for main-MES the following functions (Modrák, 2005):

- Customer Inquire Handling
- Received Order Handling
- Load/Process Control
- Engineering Change Orders Handling.

Consequently, structure of FMS operations pertaining to FMS-MES functions included:

- Retrieve detailed machining-process plans for the jobs
- Generate FMS machining schedule and send out NC-file transfer instructions and tool preparation instructions
- Download NC files and send out set-up instructions
- Tool presetting and installation
- Perform machining operations while collecting data.

In this connection functional requirements of MES might be identified without functional redundancy. Based on this comparison and common managerial experiences the following structure of MES functions depicted in Figure 2 is suggested. Obviously, the scope of operations or functions depends on number of subsystems, but the key functions remain unchanging in their essence. Because, there are no reference MES models that can be used for general manufacturing environments, overcoming of this aspect leads through the presentations of sample solutions by types of environment and other criterions. As example can be used approach to modeling three different management systems for maintenance, quality and production (Brandl, 2002) based on the S95 standard of ISA (ANS/ISA, 2000).

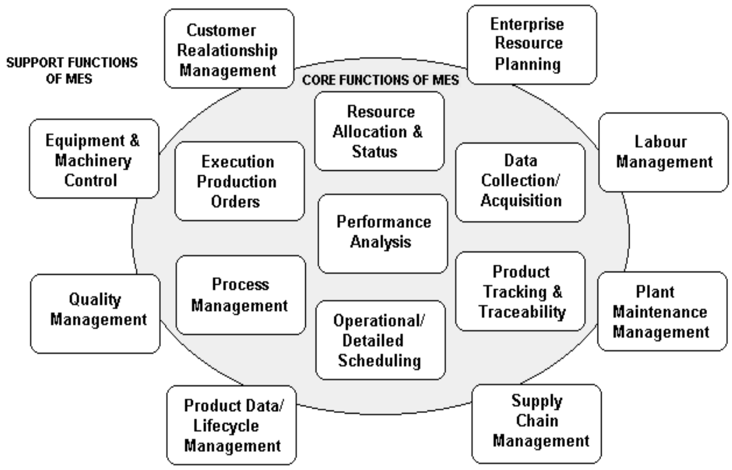

Figure 2. A MES functionality model

4. INTEGRATION OF ERP AND MES

Manufacturing execution systems besides their typical functions were developed and used also as the interface between ERP and process control, since it was generally recognized that ERP systems weren't scalable. The seamless connections often required skilled coding to connect to ERP and process control systems (Siemens Energy & Automation, Inc., 2006). Today, the availability of Web-based XML communications successfully bridges the gaps between MES and ERP systems. Built on XML, the B2MML (business-to-manufacturing markup language) standard specifies accepted definitions and data formats for information exchange between systems, and facilitates information flow and updates between ERP and manufacturing execution systems. It also instigated redefinition the role of the MES. The ISA SP-95 model (see Figure 3) breaks down business to plant floor operations into four levels.

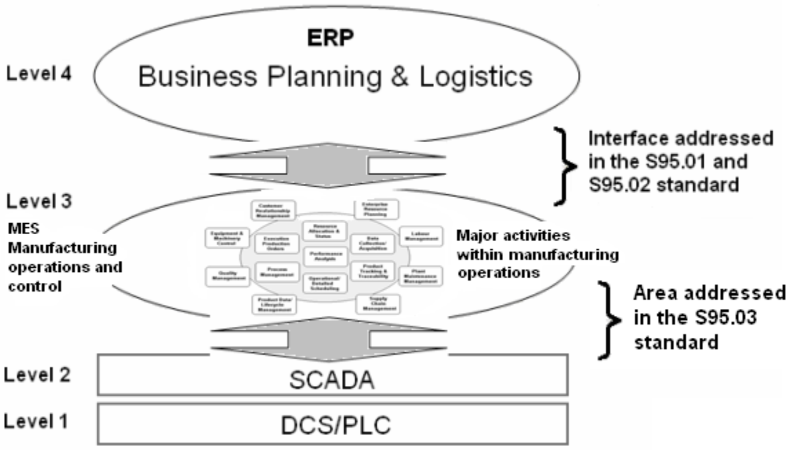

Figure 3. Position of MES in hierarchy of IT systems

Levels 1 and 2 include process control zone. MES layer consists of managerial and control functions depending on different types of manufacturing. Level 4 corresponds to the business planning and logistics.

The goal of ISA-95 standard was to reduce the risk, cost and errors associated with implementing interface between ERP and MES. The ISA-95 "Enterprise - Control System Integration" is a multi-part series of ANSI/ISA standards that define the activity models and interfaces between manufacturing functions and other enterprise functions. Parts 1 (Models and Terminology), parts 2 (Objects Attributes) and part 5 (Business to Manufacturing Transactions) define the exchange of production data between business and plant systems. B2MM provides a schema implementation of the ANSI/ISA-95 and represents an independent technology implementation of this standard. B2MML has been developed by The World Batch Forum (WBF) and adopted by players such as SAP and Wonderware. Coupled together, B2MML and ISA-95 permit designers to bridge ERP and MES systems by using B2MML XML vocabulary. In this concept, ERP functions and MES functions are divided by a horizontal line that is represented by B2MML XML documents (see figure 4).

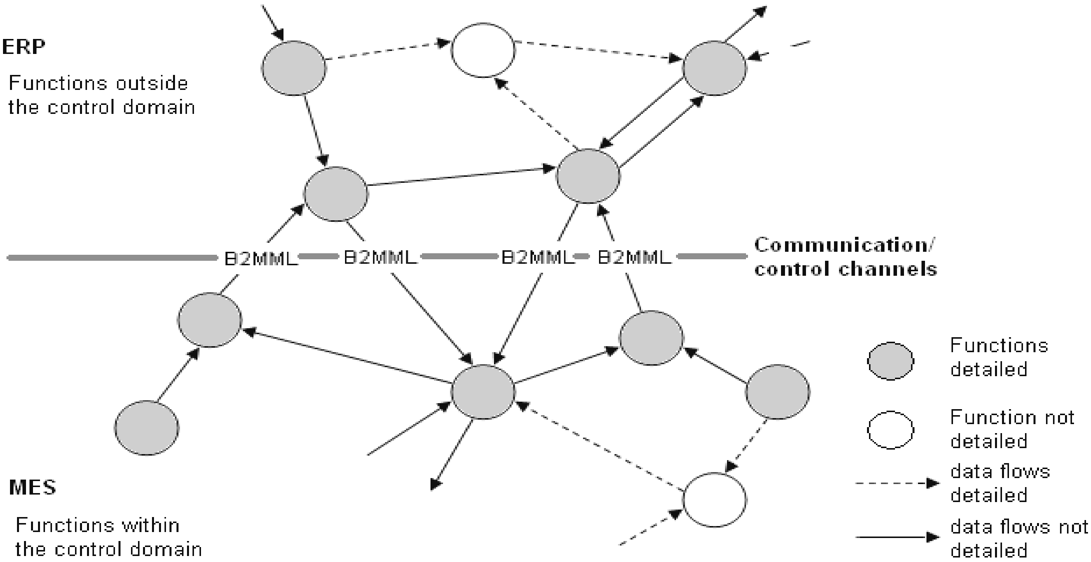

Figure 4. Model of data exchanging between MES and ERP using B2MML

Mentioned and other ISA standards significantly facilitate the implementation of integrated manufacturing systems. It is aimed to integrate ERP systems with control systems like DCS and SCADA. To support batch control level optimization, the standard S88.01 (ANSI/ISA, 1995) has been developed. It provides standard models and terminology for the design and operation of batch control systems. At the control level the key attribute is integration of all process information into one place. For this purpose are ordinarily used both a programmable logic controllers and SCADA software.

5. DISCUSSION AND CONCLUSION

According to Šešlija & Tešić (2006) an effectiveness of exploitation of new manufacturing technologies depends on the way how successful will be the synchronization of newly obtained data with both their ERP and MES systems. This challenge escalates as the RFID applications are increasing to a large number of products and facilities and as they include integration in broader Supply Chain Management systems. Besides that, MES are being viewed as critical in getting the most value out of existing investments in automation (Rockwell Automation, 2004). Speaking about MES role a frequent interest of manufacturers concerns a balanced scale of MES functionalities. As mentioned earlier, it depends on more factors. For instance, when an existing ERP system contains factory floor control functionality, then functionality model of MES has only supplement character. Scope of functionality is influenced also by changes in using automated identification (AID) technologies, which can have positive impact on the plant floor optimization. To this category of progressive AID technologies that have the potential to change the future in manufacturing, undoubtedly belongs Radio-Frequency Identification RFID. Mass use of this technology can bring significant rationalizations in the manufacturing automation in the future. This tendency indirectly confirms such IT players as Oracle, SAP, Microsoft and IBM, which are all accelerating efforts to meet the RFID challenge (Rockwell Automation, 2004). Then rules concerning manufacturing execution such as control, scheduling, routing, tracking, and monitoring must all be modified to collect as well as respond to new RFID-information. It is predicted that RFID will complement existing MES efforts in genealogy tracking. In this connection, according to Rockwell Automation, RFID could be used in varying scales, either locally or across the entire facility to provide visibility into incoming raw materials, work in process, production sequencing, packaging, palletizing, and warehousing operations as well as in the supply chain management.

In reality, majority enterprise information and control systems on different levels are developed and operated on incompatible technologies and based on heterogeneous architectures. On the other hand, today is ample standardized communication tools to achieve the successful integration of MES and ERP. From 'Siemens Energy & Automation, Inc.' view point of view 'an integrated system will show real returns: from the ability to monitor – in real time – key performance indicators on productivity, quality, yields, and throughput; to managing inventory locations and raw materials; through remediation processes to isolate and or rework nonconforming products'. One of expected directions of MES and ERP integration is synthesis of MES and ERP systems. It hopefully in future will simplify implementation issues of information system integration.

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