SOFTWARE DEVELOPMENT PLATFORM FOR INTEGRATED MANUFACTURING ENGINEERING SYSTEM


Abstract:
This paper will focus on the concept of how to reduce the complexity of connectivity in an integrated manufacturing engineering system using Enterprise Service Bus (ESB) approach. Software platform is developed for designing and implementing the interaction and communication between mutually interacting software subsystems and modules for manufacturing engineering systems. The developed approach enables a manufacturing engineering systems to make use of a comprehensive, flexible and consistent integration and to reduce the complexity of the applications being integrated.

The main objective of the current study is to analyse ESB systems and integrate the data and activities considered with products, supply chain and shop-floor management processes.

Key words: enterprise service bus, e-manufacturing, integrated manufacturing management systems, computer integrated manufacturing.

1. INTRODUCTION

The increasing competitiveness in global and local markets highlights the importance of design, quality, productivity, multi-company collaboration, optimal price levels and production process predictability. The manufacturers are now under pressure to keep and increase their places in the market. To improve their ability to innovate, bring products to market faster, and reduce manufacturing bottlenecks, the manufacturers have been improving their product development and management abilities. In the recent years has been seen growing investments in the area of integrated manufacturing management systems.

Modern companies cannot take success for granted by living on their existing niche. They are forced to develop and modify the products and management systems constantly. This requires them to cope with high dynamics and continuously adapt to changing environments. Every situation the business company faces an enormous tasks.

It needs to perceive large numbers of external stimulations to support management decisions and effective the information flow through the company. An effective enterprise behavior relies on mapping perceived patterns of stimulations to the right set of actions. This requires a number of non-trivial and highly sensitive mappings, which is the complexity that every enterprise has to handle [1-2].

2. INTEGRATED MANUFACTURING ENGINEERING SYSTEM

With emerging applications of internet and communication technologies, the impact of e-intelligence is forcing companies to shift their manufacturing operations from the traditional factory integration philosophy to an e-factory philosophy. According to [3,4] there is a tight integration of:

a) e-Business (SCM, technology infrastructure, CRM, dynamic decision making);

b) e-Manufacturing (outsourcing, collaborative planning, technology structures, real-time information);
c) e-Maintenance (predictive technologies, information pipeline, real-time data) [5].

In Fig. 1 there is presented the integrated manufacturing management system structure, used in IMECC applications. It integrates the information considered with the products, resources in the manufacturing network and manufacturing planning environment.

The main objective is to integrate the data and activities considered with products (product families), supply chain and shop-floor management processes. There is possible to have real life information from the products, about the technological capabilities, costs and available resources inside a company but also in a agreed amount inside a group of companies /cluster/. The system gives the possibilities for flexible communication between the companies and customers but also between the companies and subcontractors (partners).

Technological resources of the companies are described inside the system TECHNOL, which main functions are described on the Fig.1. Additionally TECHNOL could use the functionality of the technological expert system TEXPERT, which gives advices for selection the most suitable manufacturing method, about the alternative manufacturing processes or cooperation possibilities between the companies. The methodology of estimation of working place performance in a certain workplace is given in [6].

Supply chain knowledge is linked with various PDM, PLM, and/or ERP systems for carrying out manufacturing planning and scheduling operations for the product and/or group of products [3,8].

The main objectives of the integrated manufacturing concept are to:
- maximize the availability and flexibility;
- assure reliability and maintainability;
- synchronize the customers and supplies (companies) and/or supplies and subcontractors;
- gather and use the knowledge for more effective management;
- optimising the utilization of technological resources.

The framework given in a Fig.1. gives us the possibilities for having various manufacturing information inside the company but also sharing the necessary information between the companies. With this framework in place a general information (existing technological resources, the capabilities of the resources, most suitable methods for machining, etc) could be easily divided between the companies and critical information can be easily linked back to the corporate business systems enabling a real time view of plant operations.

At the current time in the networking manufacturing three main information flows are under the control:
- offering and order management information flow;
- resource utilization and sharing information flow;
- manufacturing planning information flow.

The real time connection into manufacturing gives to the enterprises more accurate view of ATP (available to promise) and CTP (capable to promise) information. This becomes essential in supporting an e-business/e-manufacturing strategy, as a company must have a real-time view of its ability to fulfil customers orders.

For realizing e-Business or e-manufacturing loops virtually every enterprise must cope with information system integration. There are three main pillars what is necessary to fit together [9]:
- XML is a data format – a tag-based language for representing data;
- Web Services are methods – a set of standard techniques for requesting and providing services;
- SOA is a Framework – an architecture to communicate with other systems.
3. SYSTEM ARCHITECTURE

In IMECC’s integrated manufacturing engineering system’s architecture is based on service based architecture that uses events as triggers. This architecture is called SOA 2.0 or Event-Driven SOA, which is a form of service-oriented architecture (SOA), combining the intelligence and proactiveness of event-driven architecture (EDA) with the organizational capabilities found in service offerings. In Fig.2 is brought out the schema of combined SOA and EDA.

For IMECC’s integrated manufacturing engineering system also processing Complex Events is required (Complex Event Processing – CEP), it is noted that CEP can get maximal use from SOA \[10\].

Event-driven architecture (EDA) is perfectly suited by its nature to support automatic data synchronization mechanisms in redundant environments while maintaining loose coupling \[11\].

![Combined SOA and EDA](image)

Complex Event Processing means evaluating and analysing events and therefore registration complex events as simple events in certain timeframe. CEP is
being used for recognizing abnormalities, threats and opportunities. It is also possible to deliver more complex business logic through CEP.

The backbone of SOA in event-driven enterprises is the Enterprise Service Bus (ESB), which combines messaging, data transformation and intelligent routing services to connect distributed applications across an enterprise while assuring reliability and transactional integrity [12].

In this project was used the Enterprise Service Bus (ESB) approach for enterprise integration backbone and to treat IMECC’s integrated manufacturing engineering system’s stand-alone modules as one of Integrated Resources. To realise ESB approach the Mule ESB was used. Mule ESB is a lightweight Java-based enterprise service bus (ESB) and integration platform that allows developers to connect applications together quickly and easily, enabling them to exchange data. Mule ESB enables easy integration of existing systems, regardless of the different technologies that the applications use. Integrated manufacturing engineering system’s detailed architecture schema is brought out in Fig.3 and IMECC manufacturing engineering system prototype general architecture schema in Fig.4.

![Diagram of MULE ESB](image1)

**Fig. 3. Integrated manufacturing engineering system’s detailed architecture**

![Diagram of Integration Layer](image2)

**Fig. 4. General architecture of integrated manufacturing engineering system prototype**
Web-based manufacturing management modules are integrated through Mule as company’s other resources. Event processing is done by BPEL engine, that is integrated with Mule ESB using BPEL workflows as event processing rules.

4. MESSAGE MODEL

Existing business software applications are not interoperable because they use proprietary data models and message sets for business-to-business (B2B) communication, industry consortia and standards development organizations (SDOs), such as the Automotive Industry Action Group, have responded to this problem by publishing standard messages for interoperable B2B data exchanges, their approach has several shortcomings that impede standards adoption \[13\].

The REA model is much better than any competing semantic model for multi-company supply chain collaboration. The Internet as a means of coordination is driving supply chain collaboration very quickly, but there is no accepted standardized semantic model that can actually encompass all supply chain activities \[14\].

As a semantic web, REA can link economic events together across different companies, industries and nations. The links are activity-to-activity or agent-to-agent or person-to-person, not just company-to-company. This means each individual in a REA supply chain can be linked directly to each other individual.

Adopting an all-embracing ontology as a basis for sharing meaning, and as a foundation over which to build up information and knowledge exchanges, remains a very unlikely scenario, since in practice, multiple ontology’s and schemas will be developed by independent entities \[15, 16\].

We suggest to use REA principles for all sub-domain and company specific ontology’s. These sub-ontology’s are mapped with IMECC’s top-level ontology to provide central definition to events, that should be discoverable outside one subsystem or company.

5. CONCLUSION

During the work optimized concept of reducing the complexity of connectivity in an integrated manufacturing engineering system event driven architecture combined with SOA approach based on Enterprise Service Bus (ESB) is described. Software platform is developed for designing and implementing the interaction and communication between mutually interacting software subsystems and modules for manufacturing engineering systems. Subsystems and modules of IMECC’s integrated manufacturing engineering systems are handled as company’s other internal resources and connected through ESB.

Event development and management is based on BPEL workflows and event processing is achieved with BPEL engine integrated with ESB. For better connectivity between different companies and sub-systems we use ontology’s and ontology mapping between sub-domain ontology’s. Ontology’s are based on REA concept, to provide overall model for defining events and related resources and actors.

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7. REFERENCES


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