2006

Using RFID Technology in Collaborative Design of the Assembly Systems

Stevan Stankovski

Gordana Ostojić

Vukica Jovanović
Old Dominion University, v2jovano@odu.edu

Branislav Stevanov

FACTA UNIVERSITATIS
Series: **Mechanical Engineering** Vol. 4, N° 1, 2006, pp. 75 - 82

USING RFID TECHNOLOGY IN COLLABORATIVE DESIGN OF THE ASSEMBLY SYSTEMS

UDC 681.518:65.011.56

Stevan Stankovski[1], Gordana Ostojić[1], Vukica Jovanović[12], Branislav Stevanov[1]

[1]Faculty of Technical Sciences Novi Sad, University of Novi Sad, Trg D. Obradovića 6, 21000 Novi Sad, Republic of Serbia, stevan@uns.ns.ac.yu
[2]College of Technology, Digital Enterprise Center, Purdue University, 1419 Knoy Hall, N.Grant St.,West Lafayette IN 47907, USA

Abstract. *Modern production conditions require the application of the concept of distributing production. This approach means coordinative production in a number of small and middle size companies. Multiplex products, consisting of a number of parts, components, and modules are assembled in one function unit in one company, but they may not be manufactured in one place. Huge factory and production complex, which existed in our country, comprised all phases of product lifecycle, from the development of a concept solution to the assembly. Technology of product manufacturing, resource logistics, quality control, product testing and verification of product function characteristics all represented activities performed by specified departments. Designing and technology documentation was created on the basis of information given by the above mentioned departments. Today companies are specialized in partial technology processes. Hundreds, sometimes thousands of collaborative processes depend on workers interactions and communication in the product assembly phase. With an intensive coordination, all the manufacturing phases of one product design and technology documentation are produced, in digital form, on CAx workstation. The Product Lifecycle Management can be achieved by using specialized software solutions. Some of the solutions for the Product Lifecycle Management offer integrated portfolio for engineering design and production of products and services, which enables companies to create their own digital e-business projects.*

Key Words: *RFID Technology, Collaborative Design, Assembly Systems*

1. INTRODUCTION

The contemporary production conditions are demanding an application of distributed production concept because there is an enormous pressure on the manufacturers to comply with market changes and the continuous shortening of a product life cycle. Changes on the

Received June 19, 2006

factory floor are happening on a daily basis. Many manufacturing companies are searching for ways of dealing with this problem, by the creation of virtual enterprises, refining their supply chain or implementing eManufacturing principles to their factory floor. Besides, the expansion of enterprises through geographically distributed factory plants, administrative facilities, and sales offices has created the concept of distributed production systems.

In this paper, a suggestion was given, based on some ideas on the development of collaborative design in assembly systems. Some ideas are presented to respond to the technology challenges presented by this trend and the changing relationships between the different parts of a company (distributed project manager, distributed designers and information gathered from the factory floor).

2. Collaborative Design

2.1. Basic Concepts

Complex products, consisting of a number of parts, components, and modules are finally assembled in one functional unit in one company, but they all may not be manufactured in one place. Huge factory and production complexes, which existed in Serbia in the past, comprised all phases of product lifecycle, from the development of a concept solution to the assembly. The technology of the product manufacturing, resource logistics, quality control, product testing and the verification of product characteristics were the activities performed by specified departments. Design and technology documentation were created on the basis of information given by the above-mentioned departments.

Recent trends in computing environments and engineering methodologies indicate that the future engineering infrastructure will be distributed and collaborative, where designers, process planners, manufacturers, clients, and other related domain personnel will communicate and coordinate their activities by using a global web-like network. The designers use heterogeneous systems, data structures, or information models, whose form and content may not be the same across all disciplines. Hence, appropriate standard exchange mechanisms are needed for realizing the full potential of sharing information models.

The various applications are coordinated by a work flow management system, which acts as a project manager. They are connected to one another through a design network, which provides the infrastructure for high bandwidth communications. These applications retrieve design data and knowledge from a distributed design repositories and the evolving design (or designs) is stored in a database. This database provides various snapshots of the evolving design, with design artifacts and associated design rationale stored at various levels of abstraction. Finally, design applications communicate with other manufacturing applications through various networks, such as production, process planning, and user networks [1].

2.2. DVCDGIE System Architecture

Collaborative web design can be either a client-server based suite of tools to facilitate design activities and capture design rationale or e.g. usage of the VRML as a communication and visualization medium for evaluation of detailed designs. [2]

Some of the problems that can be made during the application of the distributed collaborative design are: heterogeneity, trust, awareness, interaction, overloads management, determination of access rights, system maintenance, and mutual understanding.

A concept, presented in this work, is the starting point of a future research project at the Institute for Industrial Systems in Novi Sad (Republic of Serbia). The Dynamic Virtual Collaborative Designing and Gathering Information Environment (DVCDGIE, see Fig. 1) is an idea for the collaborative design during the product development and assembly phase.

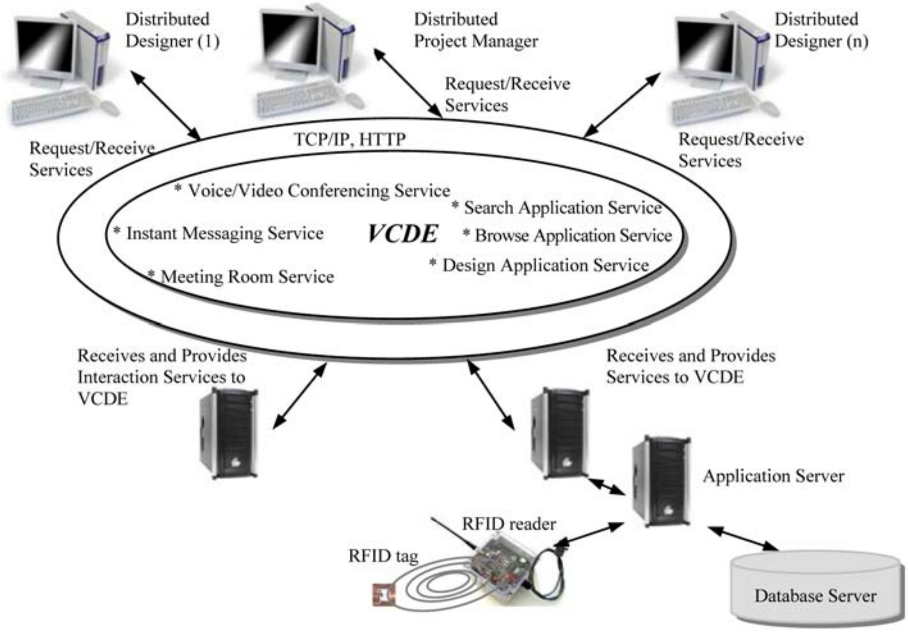

Fig. 1. DVCDGIE system architecture

Dynamic Virtual Collaborative Designing and Gathering Information Environment is a core of information system which needs to provide data structure for distributed project manager and distributed designers. There are many different ways of sharing the information. It can be either through instant messaging service, meeting room service or voice/video conferencing service. It is very important to enable the manager and the designers to share the data accurately and in the real – time. Any change in the product design, production and assembly or disassembly can lead to a completely different working procedure. The server which receives and provides interaction services to the VCDE must be able to support communication, even if the manager and the designers are located on distributed locations, or if they are working in different operational systems or have a different connection speed.

The other part of the VCDE has to provide for the application services. Those services are meant to function as a search application service, browse application service and design application service. The Application Server has to operate both with the RFID reader and the Database Server. The RFID reader would obtain the data from a RFID tag which is placed on a product and an application server would have to make an inquiry to a database server. Database server stores all the information needed for a product disassembly.

2.3. Collaborative Design in Assembly Systems

Manufacturing of complex products, like automobiles, aircrafts, is nowadays performed in a number of dislocated companies, stirred on principals of distributed production. In these conditions it is necessary to accomplish real-time communication between participants in all manufacturing processes in the entire product lifecycle.

In automobile industry changes in product design are frequent. The product is readjusted to special demands for a specific customer (color, conditioner, seats, etc.), and every product is unique. Design, management of production and assembly are very complicated and needs to be supported by modern computer technology solutions in order to achieve demanded quality, costs and delivery deadline. As production is done in distributed companies, it is necessary to achieve communication between designers, implemented at production control level of communication in the company.

2.4. RFID Technology

In assembly or disassembly, one of the most important things is a graphical representation which represents an explode state of a product. The other thing is assembly process, that is, the sequence of assembly operations and tasks needed to create a product from the base parts. Sometimes that information is not so available, and a product dismantling may mean the destruction of some subassemblies. Nowadays, when a sustainable development is getting more and more important, every company must take care of its products till the end of its lifecycle. It is very difficult to create a disassembly system for any kind of a product. It would be better if every company could trace its products and find out where they are at the end of a lifecycle and gather them at their own collection centers and disassembly them at the same time. Later, the company can also reuse this assembly parts as spare parts or as recycle materials. The explode state and assembly sequence can be stored at database sever; the RFID technology can be used to obtain the data needed for disassembly management.

Automatic identification technologies improve the data accuracy and acquisition of real-time information. Taking into consideration that the RFID systems enable automatic and contactless identification of the objects, more and more investigations of their application as an integral part of the automation production and logistics systems are conducted.

The RFID systems start with the two main components–RFID tags and an RFID reader. The RFID tags can be passive or active. The passive tags are energized only when they are in a reader's RF transmission field, while active tags are battery-operated and constantly emit an RF signal. The operation of an RFID data transmission is basically the same regardless of the type of a tag. When energized, the RFID tags emit a signal several hundred times per second. When it passes within the range of an RFID reader, the tag information is received by the host system. The host system then filters the multiple signals and begins processing the information.

With readers strategically placed throughout a warehouse, a distribution center or an assembly system, (see Fig. 2), the tag and its respective product or item is followed along its journey through the supply chain. The RFID tags can be read-only or read-writable. The read-writable tags allow the information stored on and emitted by the tag to be modified or rewritten during use. The passive read-only tags are the most affordable tag option available. They are also the most limiting, because their signal reach and data use are constrained. An important variant of the RFID tags is the Auto- ID tag, which is encoded with an electronic product code (EPC), a 96-bit unique naming scheme that can provide vast product detail. The EPC is currently the most common encoding scheme for warehouse and distribution applications. EPC tags can be active or passive, read-only or read-writable.

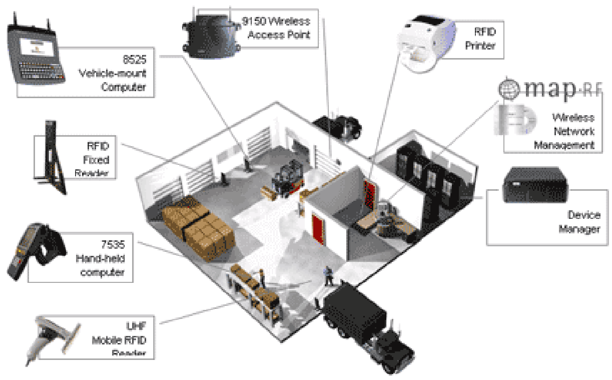

Fig. 2. Dislocated RFID readers

Most RFID data is simple. Unless a system is using sophisticated, expensive tags, all it gets is a serial number for the item, a time, and a location. RFID tags (transponders) – affixed to cases, pallets, cartons, products or their parts – begin to transmit radio frequency signals when in the read zone of a stationary or mobile reader (interrogator). The reader picks up the signal and decodes the unique EPC that identifies the name, class and serial number of the product.

This information is then matched with a record data in the host computer system and database application.

Fig. 3 illustrates the architecture of a general enterprise RFID solution.

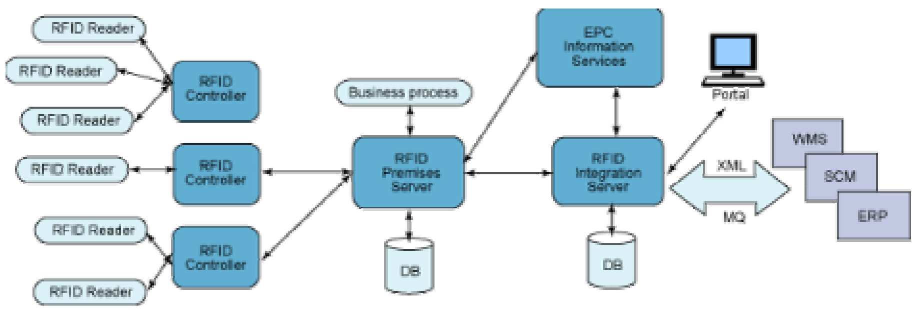

Fig. 3. Architecture of a RFID system [3]

The *RFID controller* supports the following functions:

- Connectivity, either synchronous or asynchronous.
- Software deployment, including device drivers, filters and aggregators, and dynamically loading software modules.

- Security, authenticating readers at the edge.
- Filtering, for such things as duplicates and noise and incomplete reads. Filtering is strictly local with no enrichment of tags and it is not persistent.

The RFID controller could find a place deployed in a store or a distribution-center environment.

The *RFID premises server* supports all the functions of the RFID controller, plus it adds persistence to store all incoming RFID events from the controllers. It acts as a controller for all the attached RFID controllers by passing commands and dates to the network of attached controllers using synchronous/asynchronous communication.

The premises server is the central access point for all RFID-related data at the local (store) level for network management. It also provides limited support for process management and it acts as a gateway into the EPC (electronic product code) Information Services that can be accessed either locally or remotely. As a gateway, it usually employs a straightforward HTTP or database lookup method rather than using a more complicated logic that could involve service federation or database joins.

It might also act as a gateway to the RFID integration server by sending and receiving commands and data from the server using synchronous/asynchronous methods.

Like the RFID controller, the premises server can also be deployed in a store or distribution center.

The *RFID integration server* supports the functions of the premises server. It also offers process integration, including sophisticated, cross-LOB or cross-enterprise process-management, driven application integration. Its data-integration capabilities include its ability to enrich RFID data from existing sources as well as the ability to cleanse and validate data.

Its ability to integrate business-to-business (B2B) processes means that it can offer the use of RFID-related data to partners along the supply chain. And, its ability to integrate various GUIs means that data from RFID sources can be displayed along with the data from other sources, whether new or existing [4].

Just like the premises server, the integration server is independent of the other components of the RFID architecture, making it possible for customers to select a wide range of software products to substitute for these servers, or even craft an implementation of their own.

This traditional vision of an RFID architecture is an enormously resilient and scaleable system, but it can be a daunting task for smaller enterprises, from convenience stores up to region-wide businesses, to implement.

As previously discussed, the architecture is huge, scaleable, and resilient, but not necessarily suitable for anything other than bigger companies. It's very expensive and complex for a start-up corporation or a convenience store. For those organizations, perhaps a lightweight RFID system is a better answer.

2.5. Product Database for Disassembly

To establish the data source for collaborative design we need to create a database. Since this is a simple database, we can use Microsoft Access to create it.

When planning a database, the first thing is to see which data we need for the process of collaborative design. The chosen data can be then organized into more tables and connected via primary keys. For every part we need to know: EPC, Part code, Material, Is the part base or not, Assembly sequence, Constraints – Align, Mate, or Insert, Part life cycle, Manufacturing date, Manufacturer.

For the materials we need information about ID of material and its name. For the manufacturer of a part we can use information about its name, address, phone number, email address and contact person.

Following the previously made plan about data that we need, there are three tables we need to construct in Microsoft Access: Table Parts, Table Materials, and Table Manufacturers (see Figure 4, 5 and 6, respectively).

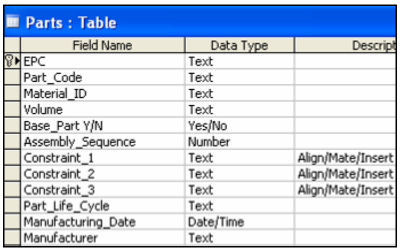

Fig. 4. Parts

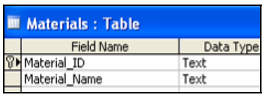

Fig. 5. Materials

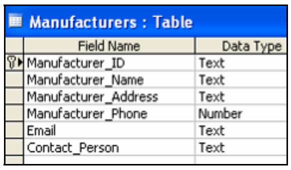

Fig. 6. Manufacturers

Foreign keys in the table Parts are Manufacturer and Material. We use them to create relations between the tables (see Fig. 7).

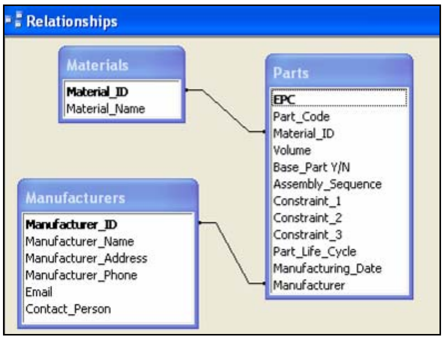

Fig. 7. Relationships among the tables

Once the database is constructed we can use it over the web via Macromedia Cold Fusion Application server.

For collaborative design we can use data by developing Cold Fusion application which can access the database server and use data from the existing database. Cold Fusion application collects the data from database server or some other data source, in our case RFID reader, and sends it to web server as an HTML document which is then presented to a distributed manager who originally made its request for the data.

To do this we configure our database as a data source for a Cold Fusion application. For a Microsoft Access database we can use either ODBC, or either OLE/DB drivers, to make a connection.

3. CONCLUSION

Modern means of a production management are completely dependent on the information technology and more than ever they relay on the web usage. Collaborative web enabled environment would be used on a daily basis for communication between product designers and engineers in disassembly process. This is getting more important due to frequent changes on the global market. RFID technologies can be really helpful in terms of sustainable development, regarding disassembly, recycling and re-usage. According to the WEEE Directive, certain measures must be taken into account in order to prevent waste, e.g. electrical and electronic equipment. All manufacturers should take care of the recycling of such equipment and reuse of its components by using the RFID technology to trace the products in all phases of their lifecycle. This paper gives a representation of one idea for collaborative design such as a DVCDGIE system.

REFERENCES

1. Fleig, J., Schneider, R.: The Link to the 'Real World': Information, Knowledge and Experience for Decision Making, in Shop Floor Control – A Systems Perspective, From Deterministic Models towards Agile Operations Management, edited by Scherer E., Springer, Cirih, 1998.
2. Baudin, M., Rao, A.: RFID Applications in Manufacturing, MMTI – Manufacturing Management & Technology Institute, 2000.
3. Junwei, C.: Lightweight RFID framework, DeveloperWorks, November 2004.
4. Medicke, J., Hall, B., Reed, B.: Manage business performance, DeveloperWorks, Jun 2004..

KORIŠĆENJE RFID TEHNOLOGIJE PRI TIMSKOM PROJEKTOVANJU MONTAŽNIH I DEMONTAŽNIH SISTEMA

Stevan Stankovski, Gordana Ostojić,
Vukica Jovanović, Branislav Stevanov

Savremeni uslovi proizvodnje zahtevaju primenu koncepta distributivne proizvodnje. Ovakav pristup podrazumeva koordiniranu proizvodnju koja se realizuje u brojnim malim i srednjim preduzećima. Složeni proizvodi, koji se sastoje iz velikog broja delova, komponenata i modula montiraju se u jednoj funkcionalnoj jedinici preduzeća, iako ne moraju svi biti proizvedeni u istom tom preduzeću. Velike fabrike i proizvodni kompleksi, na teritoriji naše zemlje, sadržali su sve faze životnog ciklusa proizvoda, od razvoja proizvoda do njegove montaže. Tehnologija proizvodnje, logistika, kontrola kvaliteta, testiranje proizvoda i verifikacija funkcionalnih karakteristika proizvoda bile su aktivnosti koje su se obavljale u posebnim sektorima. Projektovanje i tehnička dokumentacija realizovani su na osnovu informacija dobijenih od odgovarajućih sektora. Današnja preduzeća specijalizovana su za pojedine tehnološke procese. Stotine, a ponekad i hiljade timskih procesa zavise od interakcije između zaposlenih i komunikacije koja se ostvaruje u fazi montaže proizvoda. Intenzivnom koordinacijom svih proizvodnih procesa i procesa projektovanja i formiranja tehnološke dokumentacije u digitalnom obliku na CAx radnim stanicama Upravljanje životnim ciklusom proizvoda postiže se korišćenjem specijalizovanih softverskih rešenja. Pojedina rešenja za Upravljanje životnim cikusom proizvoda nude integrisani portfolio za projektovanje i proizvodnju proizvoda i usluge koje omogućavaju preduzećima kreiranje sopstvenih digitalnih e-business projekata.

Ključne reči: *RFID tehnologija, timsko projektovanje, sistemi za montažu.*