THE ROLE OF SIMULATION IN TRACKING MOBILE ASSETS USING AUTOMATIC IDENTIFICATION SYSTEMS

Swee Leong
Guodong Shao

Manufacturing Engineering Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899, USA

Nils Bengtsson

Production Modeling Corporation
Gullbergs Strandgata 36D
411 04 Gothenburg, Sweden

Abstract

A major aerospace company operates large factories that involve thousands of component parts, subassemblies, major subsystems, tools, fixtures, and material handling equipments to assemble commercial airplanes every day. They are considered mobile assets on the plant floor. These mobile assets are handled, moved and delivered in a coordinated, choreographed manner in order to sustain a steady and efficient operation. When any of these mobile assets are misplaced and lost on the vast assembly plant floor, mechanics and expeditors spend many hours walking around the plant floor looking for them. These missing assets have incurred human time and efforts, caused lost productivity, and have a huge impact on production costs and schedule. RFID technology and other smart devices are being considered to track mobile assets, not only to identify their whereabouts, but to monitor and manage their usage and inventory status. This paper describes how modeling and simulation technology and the Core manufacturing Simulation data (CMSD) specification are used to help assess the viability and business case justification of using RFID technology to track mobile assets on the plant floor. It also briefly describes continuing efforts and future tasks to use the CMSD specification in the case study.

Keywords:
interoperability, information model, interface standards, manufacturing simulation

1 INTRODUCTION

Simulation technology has been demonstrated to be an effective tool for improving the efficiency of manufacturing systems design, production engineering, operations, and maintenance. Simulation technology has been one of the most valuable technologies for providing decision making and evaluating manufacturing and business processes. An enterprise may gain a competitive advantage over its competitors by practicing and executing simulation and modeling technologies.

Various types of simulations being developed and executed in a manufacturing enterprise. These simulations include physical mock-ups, flight deck simulations, finite element analyses, dimensional verifications, numerical control machining verifications, computational fluid dynamics, digital electromechanical assembly modeling, ergonomics analysis, and other manufacturing process discrete event simulations (Banks et al. 2000).

Simulation and modeling technologies are a low-cost and efficient method for assessing and minimizing risks of change, streamlining manufacturing processes, validating production capabilities, and visualizing new automatic identification technologies. However, a consistent, generic, and reusable data integration specification does not exist in executing simulation projects for it requires significant effort when exchanging manufacturing process and simulation related data between manufacturing data sources, manufacturing applications, and simulation systems.

Researchers at the National Institute of Standards and Technology (NIST) have been working on a neutral interface standards development effort, titled “Core Manufacturing Simulation Data (CMSD) Information Model,” to address the interoperability between simulation systems and other manufacturing applications. The CMSD effort is under the guidelines, policies, and procedures of the Simulation Interoperability Standards Organization (SISO) (SISO 2009).

This paper describes how modeling and simulation technology and the CMSD specification are used to help assess the viability and business case justification of using RFID technology to track mobile assets on the plant floor. Section 2 describes the manufacturer's issue with misplaced manufacturing assets, the costs and efforts in searching and locating misplaced assets, and the potential benefits of deploying RFID technology to track these assets. Section 3 describes the proposed solution to address the issue. Simulation is used to assess the business case for using RFID technology to track manufacturing assets. Modeling assumptions, logic and initial simulation output will be discussed, and provides an overview of the CMSD information model used to serve as a neutral interface between production databases, other manufacturing systems, and simulation systems. Section 4 describes on-going tasks and efforts developing and demonstrating capability that could facilitate data-driven simulation based on the CMSD specification. Section 5 gives concluding remarks.

2 BACKGROUND/PROBLEM STATEMENT

A major aerospace company operates large factories and involves thousands of component parts, subassemblies, major subsystems, tools, fixtures, and material handling equipments to assemble commercial airplanes every day. They are considered mobile assets on the plant floor; and are handled, moved and delivered in a coordinated, choreographed manner in order to sustain a steady and efficient operation. When any of these mobile assets are misplaced and lost on the vast assembly plant floor, technicians and expeditors need to spend hours of time walking around the floor looking for them. These missing assets have incurred human time and efforts, created significant lost productivity, and caused a huge impact on production costs and schedule. RFID technology and other smart devices are being considered to track mobile assets, not only to identify their whereabouts, but to monitor and manage their usage and inventory status. Radio-Frequency Identification (RFID) devices are small electronic devices that consist of a chip and an antenna. The chip typically is capable of carrying 2,000 bytes of data or less. The RFID device serves the same purpose as a bar code; it provides a unique identifier for the manufacturing assets. The RFID device must be scanned to retrieve the identifying information. Most companies invested in RFID technology use the tags to track items within their plant floor; the benefits of RFID come when mobile assets are tracked. Research results from other industrial companies reported using RFID tracking system, the searching time could be reduced significantly. Additional issues and its relevance to simulation are summarized below:

Additional company issues:

- Lack of interoperability between manufacturing applications: Manufacturing Execution System (MES), material handling systems, inventory system, production database systems, tool crib application, gage laboratory application, and RFID tracking system.
- Manual data entry and manual tool calibration process produce error-prone data.
- Lack of visibility of calibrated tool status (e.g. out of calibration tools, expired tools) contributed to rework, warranty costs, and production delay.

Relevance to use modeling and simulation:

- Address manufacturing application interoperability by automating data entry. Ensure data accuracy by eliminating manual data entry.
- Improve productivity and efficiency of manufacturing by reducing data entry time.
- Improves visibility and monitoring of tool calibration status.
- Visualize/Simulate tool calibration status, monitoring, and tracking material flow, mobile assets on plant floor.

3 PROPOSED SOLUTIONS – SIMULATION SYSTEM

By applying simulation technique to problem analysis, conceptual modeling is the first step to take. An appropriate level of abstraction of details will simplify the complex real world problem. A decision on what details should be included in the simulation model and a mapping between the real world components and entities in simulation need to be specified. To Model everything is impractical and unnecessary, but a model that is too high level might not be sufficient for its intended purpose. The management team needs to have a clear requirement on what data are expected from the simulation run. Assessment of the data requirements for the simulation model also needs to be addressed and investigated before starting the modeling work. At the same time the data needs to be translated into a proper structure before used in the simulation model.

In this paper, the initial simulation model covered only the flow of the component parts from the internal storage location to the manufacturing line. Three possible scenarios for the delivery were considered: delivered on time, delayed delivery and lost delivery. The objective of the simulation model is to analyze the cost of searching and to compare it against the investment for RFID tracking systems. The results included the numbers of parts that are having problems and their impacts on search time. The raw data needed is located in an internal production database. A time based approach was used for the simulation.

A simulation of the company's material flow and delivery orders was modeled at NIST. The objective of the model was to evaluate the use of RFID technology to track mobile assets on the plant floor. The simulation enables the management to visualize the intensity of orders delivery to their respective delivery locations and the interacting activities on the plant floor. The results showed that parts were misplaced and many hours were spent in searching and locating the misplaced parts. Some parts were subsequently declared lost and had to be re-ordered. Figure 1 shows an overview of the simulation system. The raw data exist in a historical production database. Before the data can be imported into the simulation model, however, it needs to be processed and converted to an XML format according to the CMSD data structure (Johansson et al. 2007). The output of the simulation run (both animation and results) is useful to help managers of the company to make better decisions.

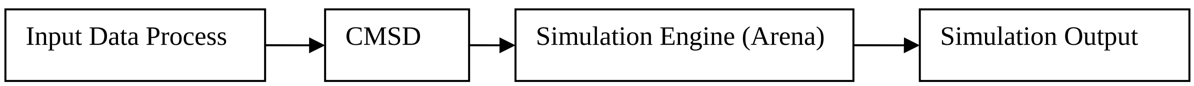

Figure 1: Simulation system overview

3.1Input Data Process

The input data for the simulation model came from a historical production information database. The data consisted of order number, request time, response time, text message, delivery location, and the product id. The data was first extracted from the database and saved in an Excel file. In order to convert the data into the CMSD structures, some data need to be processed. That includes extracting, sorting, removing, and editing the data records. VBA macro is used to structure the data and then write the data in an XML format according to the CMSD data structures (Microsoft 2009).

3.2 Core Manufacturing Simulation Data

Widespread and pervasive use of simulation and modeling technology has been limited in the manufacturing industry. To make this happened, a number of technical issues have to be addressed including information management, facilitate effective methodologies in creation and reuse of simulations, and enhance interoperability between manufacturing applications and simulation systems. NIST researchers, in collaboration with industrial partners, have been working on a standards development effort titled Core Manufacturing Simulation Data (CMSD) (SISO 2009) under the guidelines, policies, and procedures of the SISO (SISO 2008).

The CMSD specification describes a CMSD information model using the Unified Modeling Language (UML) (UML 2009) as the modeling language. The primary objective of this information model is to provide a data specification for efficient exchange of manufacturing life-cycle data in a simulation environment. The objective leads to:

- Foster the development and use of simulations in manufacturing operations
- Facilitate data exchange between simulation and other manufacturing software applications
- Enable and facilitate better testing and evaluation of manufacturing software
- Increase manufacturing application interoperability.

The CMSD information model addresses issues related to information management and manufacturing simulation development and provides a means to define information about many kinds of manufacturing objects. It facilitates the exchange of information between manufacturing-oriented simulations and other applications in manufacturing domains such as process planning, scheduling, inventory management, production management, and plant layout. The information model is not intended to be an all-inclusive definition of either the entire manufacturing domain or simulation domain. The model describes the essential or core entities in the manufacturing domain and the relationships between those entities needed to create manufacturing-oriented simulations.

The CMSD information model's UML representation has been organized using packages. UML packages, depicted as file folders, are UML constructs that can be used to organize model elements into groups. The CMSD information model consists of the following major UML packages:

- Layout
- Part Information
- Support
- Resource Information
- Production Operations
- Production Planning.

For more information and detailed definition about CMSD, see the referred article (SISO 2009). In this paper, only partially CMSD definitions are used.

3.3 Simulation Logic

The simulation logic focused on events after the parts had been delivery to their delivery locations. When time came to retrieve the parts, the mechanics could not locate some of the parts at their designated delivery locations. The model was developed using the historical best estimated search time for the misplaced parts by the plant floor personnel.

There are many different scenarios when a part is misplaced or lost in the process. A simplified version of simulation logic is showed in Figure 2. The logic provided three processing scenarios for a required part. In the first scenario, the part was delivered and retrieved at the designated delivery location. This is the normal scenario that would not required part searching by the mechanics and would not cause any delay for the production. The second scenario described the part was misplaced. Plant floor personnel and resources were needed to search for it, and the part could be found within a specified amount of time. The last scenario was that the part was misplaced and could be not found in a declared time limit. When that happened, the part was declared lost and needed to be reordered.

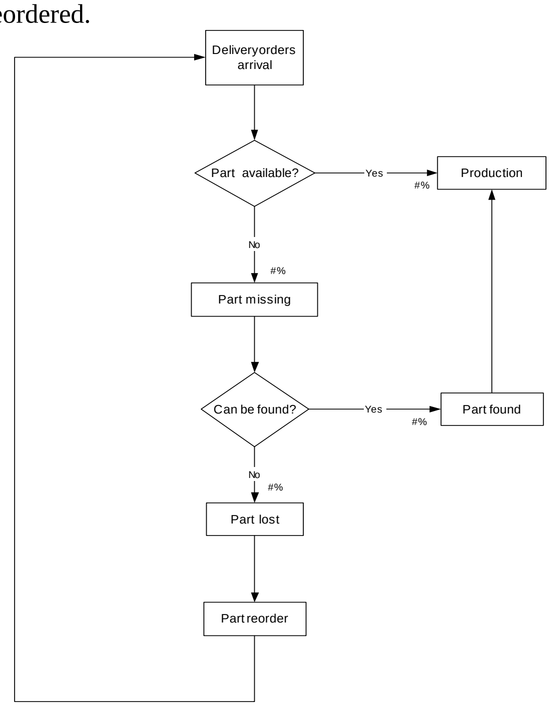

Figure 2: Schematic figure of search logic for different scenarios

The simulation tool selected for this project was Rockwell's Arena (Batat and Swets 2000). The simulation model includes main logic, delivery location logic, animation and statistics.

The main logic read the data from the XML file that was in CMSD structure, set all the attributes on the entity, and handled the delay time between different orders. The delay time was based on the time between two request times in the original delivery orders data. The user had the option to set a percentage of the total number of delivery orders that would have problems. The percentage was implemented in the overall logic by setting the attribute of affected delivery orders.

The delivery location logic handled all logic for setting the right statistics for the delivery locations, and also modeled the delivery time for the delivery order. The delivery time was based on the time between request time and response time in the original data.

Logic for the animation was used to display movement of the delivery orders from the pickup locations to the delivery locations in the simulation model. The animation was done at both the department level and the overall facility level for transportation between storage buildings.

The statistics of the simulation model contained data for both overall statistics and detailed statistics at each delivery location. Sample of the statistics covered were:

- Number of total delivery orders handled per month
- Total number of problem delivery orders per month
- Total number of problem delivery orders due to misplaced parts
- Search time of misplaced parts in labor hour
- A bar chart with number of delivery orders by product

3.4 Output Data Analysis

The result of the simulation was displayed in real time during the execution of the simulation model. Figure 3 presented a sample simulation output. The focus was on presenting the results using the company's local vocabulary to describe the output rather than a general description. Though the simulation could run for years with the data and based on assumptions representative of the process model, the results showed the total statistics for a period of one month. It gave an overview on the total number of delivery orders that have been handled in the simulation run and how successful the deliveries have been. It also gave the statistics on the total number of products that have been misplaced and lost, and the resultant production delays within the factory.

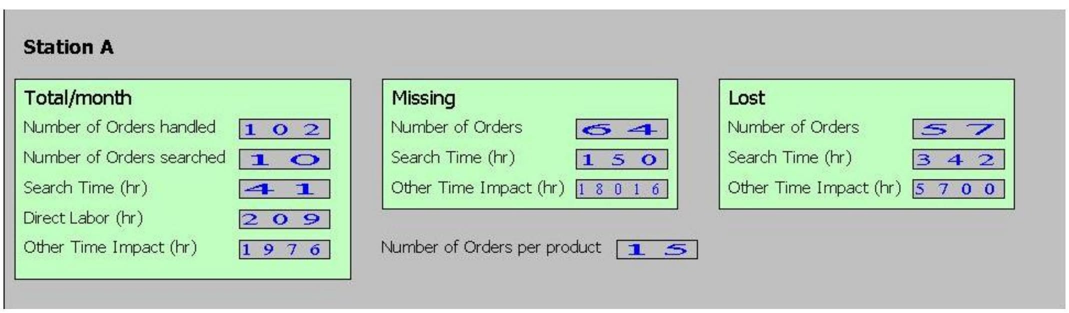

Figure 3: Sample output from the simulation model

Monthly statistical simulation results were captured in a Microsoft Excel spreadsheet. Customized graphs could be created from the Excel data. An example from the result in Excel was shown in Figure 4.

Non RFID			Orders		Orders Lost/Re-order Parts
Delivery station A			Missing/Found		
Total orders/mo	102		65		57
total orders/yr					
Search Time (hrs)	41		150		342
Direct Labor (hrs)	209				
Other Time Impact (hr)	1976		18016		5700

Figure 4: Sample output from the simulation model in Microsoft Excel

Both Arena and Excel reports gave the same data results. Arena displayed the current data for the simulation time while Excel stored simulation results in specified time intervals. The stored simulation results in Excel were used to analyzing behavior over time in the simulation model.

After every simulation run, a summary of the total number of good delivery orders and total number of problem delivery orders were captured and logged in Excel. The statistics was detailed at product level and the same information was displayed in the statistics part in Arena. The reason for data output in Excel was to allow further data processing and to create better charts with the results.

The output parameters were chosen to assist in the calculation of the as-is state of the system. These include capturing the total number of delivery orders processed, determining the number of misplaced orders, and computing both direct and indirect labor search time. A financial impact analysis can be estimated and compared that to the RFID investment.

Another result from the simulation model was the animation. The animation provided management with a realistic view of the plant floor activities. It showed the material traffic flow pattern and the speed at which orders were delivered to the stations that would help justified the implementation of RFID technology for tracking mobile assets on the plant floor.

4 FUTURE CMSD TASKS

Future tasks include providing capability that enables data driven simulation and automate the data input process to the simulation. Data storages need to be in a format which enables translations to a CMSD data structure. Network and data storage systems need to be accessible online to reach the latest version of data.

Ongoing effort is to enable data retrieval from many different data sources. Mapping tools will be available to translate the data from these sources to a CMSD format. The tool will include a distribution fitting algorithm for stochastic observations of input data. With such tool, the user of the application configures the mapping only once. Next time data is updated, the mapping configuration is automatically reused. In addition software vendors are encouraged to provide a CMSD application program interface to their applications using the XML-schema of CMSD (Leong et al. 2008).

5 CONCLUSION

Large manufacturing companies usually run a complex production operation that involves thousands of mobile component parts every day. When any of these mobile assets are misplaced and lost on the vast assembly plant floor, many labor hours and efforts are spent searching for them. These search efforts could cause significant lost of productivity and have a huge impact on production costs and schedule. By implementing RFID technology to track mobile assets, not only to identify their whereabouts, but to monitor and manage their usage and inventory status. This paper describes how modeling and simulation technology and the Core Manufacturing Simulation data (CMSD) specification are used to help assess the viability and business case justification for using RFID technology to track mobile assets on the plant floor. It also briefly describes continuing efforts and future tasks of using the Core Manufacturing Simulation data (CMSD) specification in the case study.

Disclaimer

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