e-Collaboration for Ship repair Supply Chain Management

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Abstract

The current work focuses on the electronic collaboration among companies for the efficient execution of the shiprepair supply chain. The shiprepair supply chain is a dynamic environment that consists of collaborating companies, each one is specialized in a certain set of manufacturing activities. All these activities are interrelated and that are extremely complex to manage since the highest portion of the work is discovered during the actual repair work leaving very limited time to react and take decisions. In addition, the time to perform the repair of the ship is also constrained, since ships out of operation cause the loss of significant profits from the maritime companies. This work describes a web based software framework that enables the electronic collaboration among the companies that are working jointly for the repair of a ship.

1. Introduction

Supply chain management is a relatively new term, crystallizing concepts about integrated business planning, having been suggested by the academic community since 1950s [1]. Roughly speaking, strategic planning involves resource acquisition decisions to be taken over long-term planning horizons, tactical planning involves resource allocation decisions over medium-term planning horizons, and operational planning involves decisions affecting the short-term execution of the company's business [1]. At the strategic level, few decisions are made, but each decision takes a long time, and its impact is felt throughout the organization, while at the tactical planning and operational level many decisions are made, each requiring shorter time. The great number of decisions in the tactical and operational level is taken together in short time and though can have significant impact in the overall performance [2].

Operations in the Maritime Industry involve a large number of interrelated partners, with each performing manufacturing or distribution activities, thus forming a 'maritime supply chain'. Typical reasons for bringing these partners together may be a routine maintenance ship repair or an emergency situation that has arisen due to a ship accident at sea. In a routine maintenance case, the partners involved may be [3]:

the ship owner and/or the ship owner agent,
the shipyard and/or the shipyard agent,
the classification society, and
the shipyard suppliers.

These partners communicate among themselves by exchanging information related to the repair, while each plays his own 'role' adding his own value to the entire chain -the Value Added Chain [1]. The flow of information in the supply chain is established through the exchange of data related to the particular ship repair case. The entire business process is relatively complex for a number of reasons [3]:

The ship is at sea and has to send the repair related data in a fast, easy and reliable way to a large number of partners.
The repair work is not known from the beginning and a lot of repair items are identified during the inspection at the shipyard.
A large number of partners are involved in the repair, performing manufacturing and distribution activities.
The activities performed by the shipyard and by the shipyard suppliers are interrelated.

The shipyard is the main partner because it is involved in the work performed by its own personnel and the work of other partners, such as service and material suppliers, thus playing the key role on the execution of the whole business process [4].

There is a trend for the implementation of computer-based environments, to facilitate automated communication among the partners as described previously. Value-chain integration uses Internet technology to improve communication and collaboration among all parties within a supply chain [6]. According to Lancioni et al. the Internet fosters the integration of business processes across the supply by facilitating the information flows that are necessary to coordinate

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business activities. Using market mechanisms is less likely to generate a sustainable competitive advantage, but they might offer the opportunity to purchase some items at a lower price [7]. Although traditional electronic commerce such as EDI transactions have been conducted over proprietary value-added networks, new Internet-based electronic markets could include much larger numbers of buyers and sellers. The possibility of conducting business over the Internet is an area, which has received a great deal of attention recently [8]. Roberts and Mackay, in their case study, examined the opportunities of utilizing the Internet to support procurement-related processes, considering the impact of electronic commerce on the supply chain, in terms of customer service, lower costs, more efficient processes and improved supplier relationships [8]. Garcia-Flores at al. describe an on-going effort in developing an integrated framework for supporting supply chain management of process industries. In this contribution, retailers, warehouses, plants and raw material suppliers are modeled as a network of cooperative agents, each performing one or more supply chain functions. Interactions between agents are made through the common agent communication language knowledge query message language (KQML) and data is modeled using standard exchange of product model data (STEP) [9].

The need from a value chain integration software environment, is to be able to bring all the related partners together. Each partner uses his own system that supports its business. As a result, a large number of heterogeneous software systems must exchange data related to the business process. Due to the fact that each system uses a specific data storage mechanism, the direct exchange of data among these systems is not possible. This is the main reason for the slow execution of the business process and the reduced performance of the entire supply chain [3][4][5].

Research in [3] suggests the adoption of XML to enable the exchange of data over the Internet thus facilitating the integration of shiprepair companies and enables the communication of their information systems. In [4] a data modeling approach is suggested combining STEP and XML standards to support the data exchange among shiprepair companies. Finally, [13] suggests an hierarchical approach to model shiprepair activities and production facilities in the form of a software system.

2. Business Model

This work is based on a 'real life' ship repair scenario. We assume that a ship has to visit a shipyard for a planned maintenance. It is a typical situation that at least two partners will participate in the process: the shipyard and the ship owner. For this specific case study, we are going to discuss the concept of the collaboration only between these two partners, although the same ideas can be easily extended to more partners.

2.1. Business Process

The business process is as follows [4], as seen in Figure 1, in the form of a UML sequence diagram [10]. A similar model has been built to represent the interactions with the suppliers; the difference is that suppliers exchange information on delivery time instead of work plan that is the case for the subcontractors according to Figure 1:

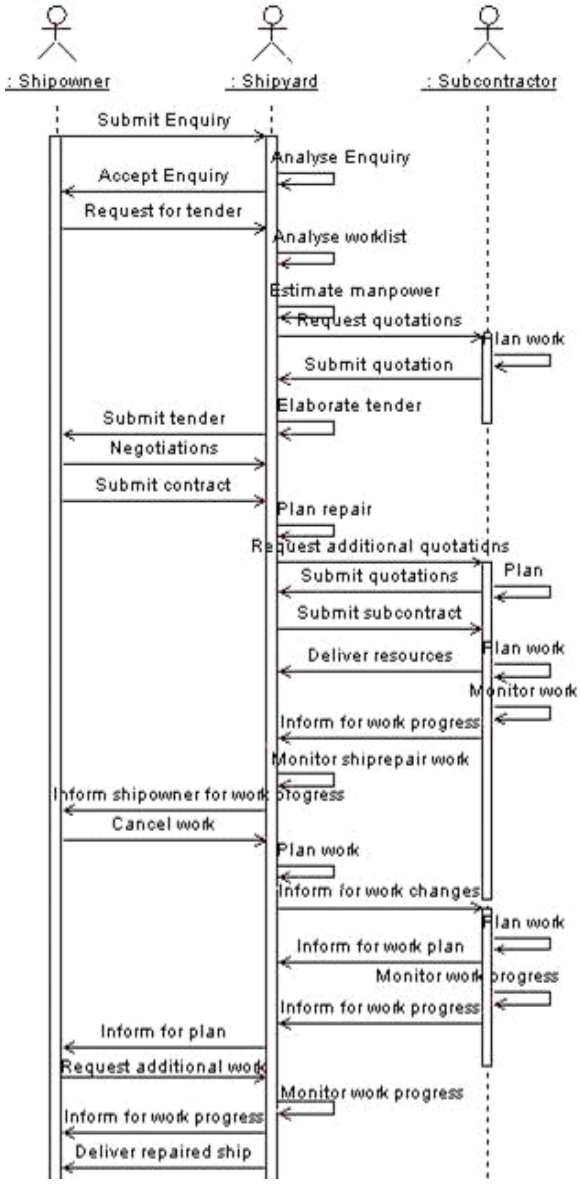


Figure 1. Shiprepair sequence of interactions

The ship owner submits an enquiry to the shipyard, giving abstract information about the repair, for example that it is a planned maintenance case. Additionally, a few details, such as the size and weight of the ship are given.

The shipyard then decides if they can do the work, if they have the appropriate equipment and if they have had previous experience with the ship owner.

If the shipyard wishes to proceed with the repair, then they ask for detailed information.

The initial work list is sent from the ship owner to the shipyard. Next, the shipyard performs an estimation of the work to be performed, based on the initial work list. In order to build the estimate, the shipyard makes an internal requisition for available personnel as well as for external supplies required for the ship repair. A set of quotes becomes available to the shipyard from the corresponding suppliers.

The shipyard produces a tender. The tender is actually a list of quotes on the work specification list that was initially provided by the ship owner.

The tender is forwarded to the ship owner to be processed which can be either accepted or sent back with comments.

Negotiations are reflected on the work list and on the prices.

Should the ship owner accept the tender. Then the initial contract is signed between the ship owner and the yard, according to an updated work list and tender.

The ship arrives at the yard and the repair work is initiated. During the repair, the work list is continuously modified so as to reflect the actual work done. New items are attached to the initial contract and some items are cancelled.

When the ship repair work has finished, the invoice is issued by the shipyard and is sent to the ship owner.

The major part of this scenario evolves around the use and modification of the work list, which changes constantly.

2.2. Data exchanges

Typically a shipowner contacts a number of shipyards in order to submit the Initial Work List and therefore shipyards accept a large number of enquiries that have to be evaluated. Even if both actors have software systems that allow them to process information quickly, it is still cumbersome to import all the necessary data into the existing systems.

A typical case is the entering of the work list into the shipyard's system. Nowadays this data entry is done manually taking time to be completed. The same happens for all the data exchanges between the shipowner and the shipyard. A small portion of the data exchanges between the shipyard and the shipowner during a typical ship repair is presented in Table 1 [4]. Considering the data exchanges between with the suppliers and the subcontractors, it is evident that the whole business process becomes very complex.

Table 1: Data exchanges in a typical repair scenario

FROM	TO	BUSINESS PROCESS
Owner	Yard	Submit enquiry.
Yard	Owner	Ask detailed information.
Owner	Yard	Submit initial work list specification.
Yard	Owner	Submit tender.
Owner	Yard	Submit requested changes to the work list.
Yard	Owner	Send invoice to owner

It is obvious that as the number of actors increases, the number of software systems that cooperate within the supply chain increases accordingly. Concequently, supply chains are characterized by dynamic relationships and that the systems participating in the process must be flexible in terms of the information that exchange. They have to be able to plug in-plug out to the process independently of the specific software systems that participate in the supply chain. Thus, we use an open standard that allows for seamlessly switch to another trading partner when necessary. Since we are trying to meet market demand, the systems must also be relatively simple and quick to set up [4]. These requirements are used as guidance for adopting the XML standard and integrate it inside the supply chain system.

3. Web based collaboration framework

The wide spread of Internet and technologies arising from it, offer a set of software tools that are suitable for the development a software framework that models, implements and facilitates the shiprepair supply chain. A 3 tier architecture was chosen for the development of the software environment. This approach involves a "Presentation" layer, an "Application" layer and a "Data" layer. The "Presentation" layer implements the "look and feel" of an application, the "Application" layer implements the business logic of the application and the "Data" layer manages the persistence of application information [11].

The implementation of the 3-tier architecture has introduced a new kind of applications the Web-Applications. In a Web-Application the "Presentation" layer is implemented by the web browsers that are also called thin clients. The programming languages used are the combination of HTML, CSS standing for Cascading Style Sheets and Javascript, which is commonly used for client-side validation and control over the look-and-feel of a page in dynamic HTML [11].

The "Application" layer is divided into sub-layers. The software technology used in application design and

development phase is mainly implemented in the "Application" layer of the web application. The "Application" layer is responsible for the interface with the "Presentation" layer, the transactions between modules of software code that represent business entities and finally the interface with the "Data" layer, which consists of Data Access Objects, implementing methods for "creating", "retrieving", "updating" and "removing" a business data from database as well as of Data Access Objects implementing business-specific methods, such as scheduling algorithms [2].

The "Data" layer is usually powered by a relational database server containing stored procedures and functions that are used to execute database server-side processes pertinent to data integrity, views that are an alternative choice for generating data reports to applications, some level of security that can be used as alias to hide physical structures of database tables and finally database tables that are used primarily for storing data [12].

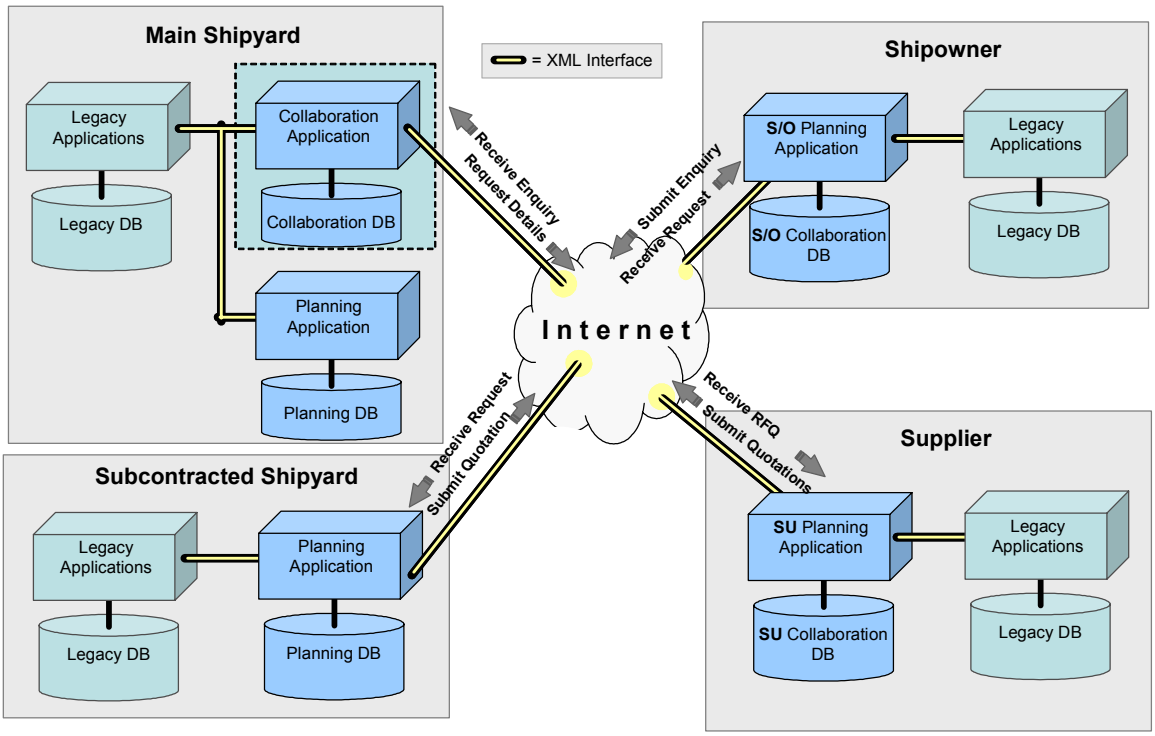


Figure 2. Software modules deployment

3.1. Software architecture framework

The web based software package, exhibits advanced communication and coordination characteristics and consists in two individual though complementary modules, the Collaboration module and the Monitoring and Planning module. Figure 2 demonstrates a generic cooperation scenario, where a shipowner submits an enquiry, the shipyard receives it and requests details, the shipowner then receives the request, in a similar way, requests and quotations are exchanged with suppliers and subcontractors via the Internet enabled software system.

The Collaboration Application with its central Collaboration Database is implemented and installed for data exchange and information sharing. Data from each partner that affect the other nodes of the supply chain are stored to the common database.

Delays in production of each partner affecting the overall supply chain orders is shared to other partners, thus allowing the adjustment of the production plans in each company. User-friendly forms are developed for this purpose supporting work coordination and data sharing. Finally, data exchange forms are implemented to facilitate data exchange among collaborating partners throughout the shiprepair business process.

The Monitoring and Planning Application with its local Monitoring and Planning Database is implemented and installed on each node of the supply chain. This software is used to plan the work and allocate the jobs to the production resources. Alternatively, commercial planning applications can be used and interfaced to the Collaboration module through the XML interfaces.

Selected planning data of each partner which he wants to make them available to the other partners are then merged to an overall distributed supply chain plan. The planning and monitoring database are integrated having their data synchronized, thus allowing the user to easily monitor and control the planned/ actual execution of the work.

Interfaces between the existing legacy systems and the modules of the system database are developed utilizing the XML standard, exploiting available data and avoiding duplicate data entry.

Concerning the deployment of the application, there is one instance of the Collaboration module, installed at the main shipyard that is running the shiprepair supply chain. All the supply chain partners have customized access to the Collaboration module workspaces, this means that the shipowner has his own workspace that allows him to access the data that are related to his business process. Similarly, the suppliers have access to their independent workspace and access data related to the orders where they are involved. Finally, the shipyard, as the operator of the supply chain has access to the information provided by all the ship-owners about the requested ship repairs, and also has access to the information submitted to all the suppliers and all subcontractors.

There is one instance of the Monitoring and Planning module that is available at each partner that manages Planning and Monitoring functionality. The Monitoring and Planning application can be used alternatively with available commercial planning applications.

The two modules namely the Collaboration and the Monitoring and Planning modules are parts of the same system therefore the have the capability to exchange data. The data are exchanged in the form of XML documents that enable the synchronization of the two modules.

Data from legacy applications are exchanged following the same paradigm, this means that after the identification of the data to be exchanged, the appropriate XML interfaces are implemented that enable the extraction of data from legacy databases.

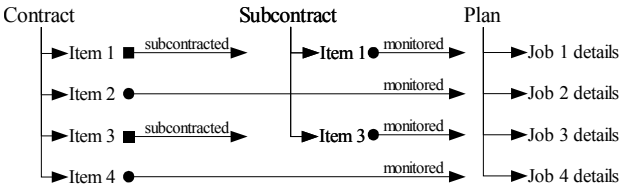


Figure 3. The multi-site planning and control model

Planning and monitoring is performed by each site independently, namely by the shipyard and its suppliers. The plan from each partner is facilitated through the allocation of tasks, to suitable resources, using various dispatching algorithms depending on the users' demands and policies (FIFO, SPT, EDD) [2][4][13]. Data from the shop floor are collected and are available for adjustments of the production plans. The allocation of the shiprepair tasks to the shipyard production departments is performed by utilizing a state of the art modeling approach, where a generic hierarchical model is used to model the facilities of the shipyard, while the allocation of the tasks is performed through the so-called release and assignment logic [4][13], resulting to a shiprepair production schedule. Following the same approach, the shipyard subcontractors produce a production plan for the tasks that they perform, and consequently, a production schedule is available for each company that participates in the shiprepair contract, according to Figure 3.

3.2. Results

The web based application was implemented in a number of shipyards and a series of real life workload as well as the interactions with the suppliers and subcontractors were modeled. A small part of the Gantt chart that demonstrates the schedule within one partner of the supply chain, specifically within a shipyard is in Figure 4.

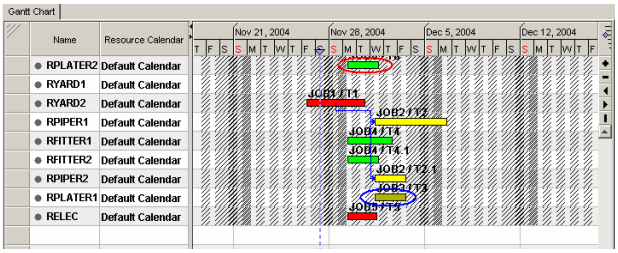


Figure 4. Scheduling of work within a supply chain partner

The Gantt chart is produced by the software system, which takes into account the manufacturing system model. This model is built using a hierarchical structure that considers information about the production facilities of the manufacturing system, such as production resources and resources availability, while in parallel it considers the workload to be scheduled [13].

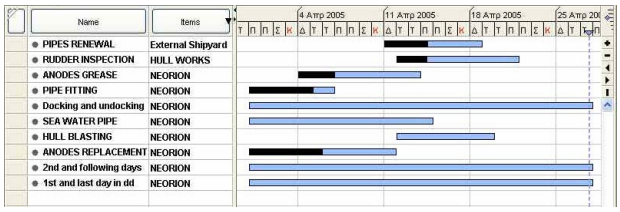


Figure 5. Supply chain plan

The scheduling information of each company is combined and merged in the form of a collaboration Gantt chart, and it is shared and accessible via the Internet. Changes in the schedule of each company is shared to the other companies that then can reschedule

their work to fit the changes. Also, the progress of the work is shared via the collaboration Gantt chart, and is visualised in the form of shaded bars, Figure 5.

4. Conclusions

Modern information technology was used in order to support the Ship repair Supply Chain within the maritime industry. A web based implementation was adopted to implement the electronic collaboration among the partners that participate before and during the execution of a ship repair contract. The current work demonstrates the feasibility of the developed approach and it is considered as a good approach to support communication efforts, while it improves the communication among the cooperating companies in a shiprepair contract.

Difficulties have appeared concerning the infrastructure of the shiprepair suppliers and subcontractors, which seem not to be ready yet to adapt high tech solutions due to the cost of internet connections and mainly due to lack of familiarization with use of computers. However it is believed that these burdens are only temporary and in the next years use of computers will be possible by everyone.

Test cases that were executed between shipyards and suppliers demonstrated significant savings of time; in particular the time that a shipyard needed to identify a supplier and submit him request for quotation until the quotation is finally sent back to the shipyard was around 40 minutes, taking into account that the system was used by untrained personnel. This procedure takes the same time in the case that the quotation involves more than one suppliers, since the requests for quotations can be sent to more than one suppliers at the same time. The same procedure, without the use of the suggested system and taking into account the fact that material suppliers are identified manually, consumes significantly more time to submit the request for quotations and get reply to more than one suppliers, this time was measured to be 2-3 times the one mentioned above, making it obvious that the suggested system ensures significant savings in time, leveraging cost reduction. Adding to the above the fact that an electronic version of the request and the quotation makes them searchable and available at any time very fast, makes it evident that there are significant savings in time and costs, proving the quality of the suggested system. Similar tests in other functions such as supply chain planning and monitoring demonstrated analogous results.

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