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Abstract

Information sharing is a key prerequisite for supply chain collaboration. Most of the researchers in the area focus on establishing the information sharing benefits across supply chain. In spite of knowing its benefits most of the companies are reluctant practicing it. This may at least be due to the following challenge - information required for planning and scheduling is available in distributed applications and is owned by different partners in the supply chain. Decision makers need to sign in different applications and go to different web sites to manually collection information and make sense out of it. We found lack of research about information architecture for sharing information from distributed sources across the supply chain. As a result of this the purpose of this thesis has been to propose a design for information architecture for information exchange in supply chains.

In this thesis, we have conducted a case-study of quay allocation activities at the Vestbase supply base in Kristiansund, Norway. Vestbase is facing information integration issues from distributed sources. We have identified the information requirements for quay allocation regarding, who owns this information, where it is located and, what are the possible issues hampering the smooth flow of information across the supply chain. In this thesis, we have proposed a design of information architecture to achieve information integration into what may appear as a single application using “mashup” principles. Mashups are the fastest growing web application trend in the world right now.

An implementation of the proposed architecture will improve the planning and scheduling processes across the supply chain. Availability of information from proposed integrated tool will help managers to make decisions in less time.

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Chapter 1

1 Introduction

From the last two decades, supply chain management focus is shifted from an adversarial mindset towards collaborative mindset [1]. True cross company collaboration is to share information, develop joint strategies and synchronize operations. Donald et al (2003) describe cross company collaboration as “*It emerges when two or more firms voluntarily agree to integrate human, financial, or technical resources in an effort to create a new, more efficient, effective or relevant business model*”. Through cross company collaboration companies can establish joint plans and integrate processes to eliminate duplication and non productive redundancy. It is widely accepted that synchronized and coordinated supply chain leads to increased responsiveness and reduce uncertainty. Information sharing between the members of a supply chain is an important prerequisite for collaboration [2, 3]. Information sharing has a great impact on the performance of supply chain. Many researchers have proved that increased information visibility will improve the performance of a supply chain [2-4]. The benefits of information sharing includes higher sales, better understanding, better planning & forecasting, customer satisfaction, better utilization of resources and improved inventory management.

Information sharing across supply chains has been discussed and studied widely in recent years. “*However, we have little idea about how to obtain this information from adjacent supply chain players or independent third party organization*”[5]. It is also very important to know which information is important, where it is located in supply chain and how to share this information across supply chain in an effective and efficient way. Transparency of information flow is a major issue in supply chain. Information invisibility results in many logistical issues in the supply chain including:

- ✓ Planning and scheduling difficulties
- ✓ Efficient and effective allocation of resources
- ✓ Increment in operational cost

In our research we have conducted a case study about “Quay allocation process at Vestbase AS-Kristiansund Norway”. Vestbase is one of the supply base owned by NorSea group. Vestbase has been an important logistical hub for drilling activity that has moved into northern part of the North Sea. Vestbase with other services also provides terminal and quay facilities. Vestbase is facing some information sharing challenges related to efficient and effective handling of these quays. Vestbase personnel has to sign in different applications, and go to different web applications to manually collect information and try to make sense of it. Required information is not available at one place. Due to very short time between ordering and execution time, this information collection process from different sources results in many logistical issues.

Our primary objective is to design an information architecture for integrating information into single view from different sources. To do this we need to identify the appropriate types of information required for quay allocation e.g.

- ✓ Where this information is located?
- ✓ Who own this information?
- ✓ How much visibility gap is existed?
- ✓ What different technical and supply chain issues are stopping smooth flow of information across the supply chain?

We have adopted a research framework for designing information architecture shown in figure 1-1. We have look into this issue in five steps.

1. First, we have identified the information requirements for quay allocation and planning process.
2. Second, we have established information visibility gap between required and available information.
3. Third, we have identified the sources of required information across the supply chain i.e. who own this information. In this step we will try to find out technical characteristics of data available across supply chain.
4. Fourth, we have tried to find out possible root causes of information visibility gap both technical and supply chain issues.

5. Fifth, we have proposed a design of information architecture to integrate information from different sources into single view.

We are expecting that by facilitating information integration into a single view will improve planning and scheduling process across the supply chain. Our proposed solution will help managers to make better decision through getting information from one single integrated tool. Information sharing will help companies to provide better services to their clients. Information sharing can improve collaboration amongst the supply chain partners.

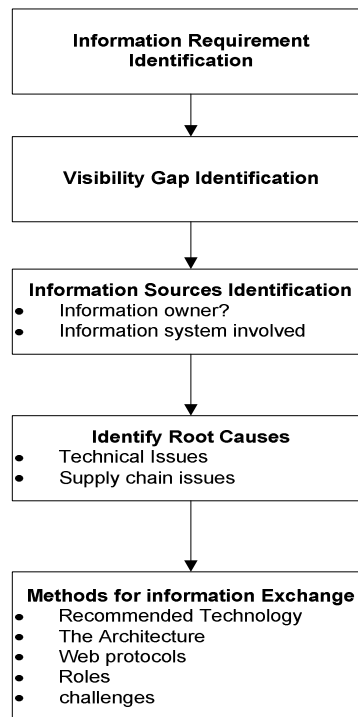


Figure 1-1: Research Framework for designing information architecture

The thesis is laid out as follows: In chapter 2, we review information as a key for supply chain performance, current information technologies available for information integration and information integration challenges both technical and supply chain. In chapter 3, we discuss our research methodology and tools used/proposed. In chapter 4, we discuss the oil and gas industry of Norway, NorSea group and Vestbase AS. In chapter 5, we discuss quay allocation and planning process in detail and find out information requirements, sources, visibility gap and reasons for invisibility. In chapter 6, we propose a design for the information architecture for this specific problem. In chapter 7, we conclude the benefits and improvements provided by implementing our design and propose issues for future research/work.

Chapter 2

2 Background

Information availability helps organizations to make better decision – and probably less errors. For making decisions organizations need data that is relevant, updated and correct. Information required may reside within the organization or maybe owned by one of the other supply chain members. By sharing such information within a supply chain the overall supply chain performance may improve. Many researchers have investigated the benefits of sharing information across supply chains and prove its benefits. In this chapter we will first discuss some important benefits the members of a supply chain can get by sharing information. Secondly, we will discuss information system practices in the supply chain. Third we will discuss technologies available for integrating information from different resources. Finally, we will explore supply chain and technical issues in integrating information from different information systems applications and resources.

2.1 Information: A key to supply chain performance

New information technologies, increasing pressure from customers on responsiveness, and globalization of operations and markets have made supply chain management a challenge and an opportunity[6]. Customer services are determined by overall effectiveness and efficiency from cooperation of all companies in the supply chain. “Competition is no longer one company against other companies, but one supply chain against other supply chain” [7]. Collaboration and integration amongst the companies in supply chain becomes more and more important, because every company has its own individual goals and rules that may, in some cases, conflict with other companies in the supply chain. As an example, Wal-Mart’s collaborative planning, forecasting and replenishment (CPFR) collaboration with their suppliers is a well-known success story. Information sharing allows Wal-Mart to outsource much of its inventory planning to suppliers who becomes responsible for monitoring inventory levels, planning replenishment, and suggesting new ideas to improve throughout [8].

Information sharing among the members of supply chain is an important prerequisite for collaboration [2, 3]. Information sharing has a great impact on the performance of supply chain. In supply chain two independent members can achieve common objectives by sharing information sharing. It promises win-win situation for the members involved. Type of information to share, how much to share, when to share and frequency of share are important factors to consider while sharing information across the supply chain. According to [2] successful information sharing is not only depends on right information with sufficient frequency, but also how the transferred information is used and implemented by the receiving company. Data must be shared specifically according to the receiver needs. Such data is often more valuable and will have greater impact on planning efficiency and performance in the supply chain.

Many researchers focused on what type of information needed to be shared and what kind of benefits will results in sharing such information. The phenomenon of demand variability amplification as we move upwards in the supply chain is known as bullwhip effect. Information sharing is regarded to be one of the key approaches for taming the bullwhip effect [9]. Paul, Denyse et al. investigate the links between different type of visibility and business performance by the using the concept of transparency[10]. They use Lamming et al. [11] transparency concept as a basis. According to Lamming et al. there are varying degrees of supply chain visibility or sharing of information between partners in a supply chain and refers to it as transparency. Lamming’s et al. categorization of the varying degrees of transparency is described in the Table 2-1.

	Opaque	Translucent	Transparent
Business case (information shared between two organizations)	For any of a variety of reasons, no information is shared between the parties; even operational day-to-day information is obscured	Outline information only is shared – interface conditions or partial data. This can be similar to “black box” collaborative design. If used tactically, it may be akin to cheating	Information is shared on a selective and justified basis. Development of information leads to shared knowledge and collaborative abilities

Table 2-1: The metaphor of transparency (Source: Lamming et al. (2001))

They demonstrate that development of transparency framework in a structured manner results in improvement in the supply chain. More accurate the information, the higher the transparency, but more the information deteriorates, the higher the obscurity.

2.2 Current Information systems and Information Sharing Practices

Information sharing and coordination among organization are central to producing comprehensive and practical approaches and solution to combating supply chain problems. Currently different organizations are using multiple types of information systems for multiple types of decision. These decisions can be varied in nature (e.g. strategic, managerial, and operational), duration (e.g. short term, long term), types (e.g. structured, unstructured and semi-structured) and scope (e.g. internal and external).

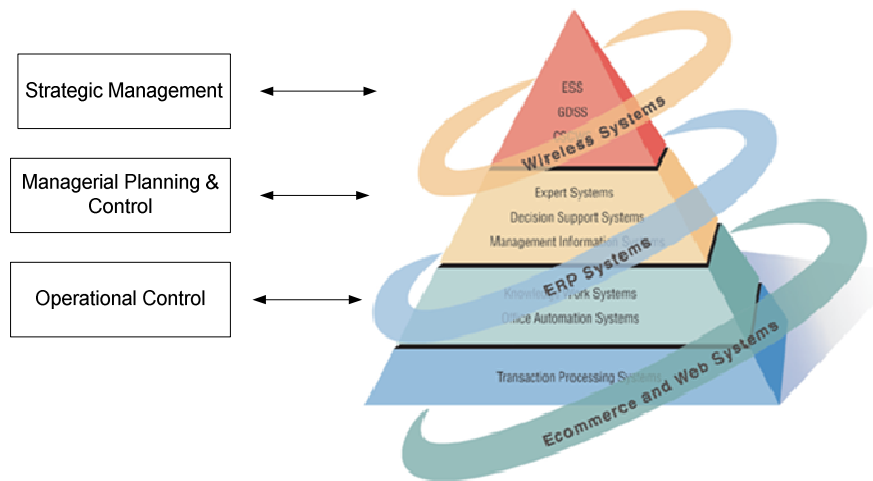


Figure 2-1: Systems practices at each organizational

For these multiple of types of decisions organizations are using different types of information systems. Transaction processing systems (TPS) are computerized systems that were developed to process large amount of data for routine business transactions such as payroll and inventory. These systems are used for structured decision making at operational level with in the organizations. At knowledge level of organization are two classes of systems. Office automation systems (OAS) support data workers, who do not usually create new knowledge but rather analyze information before sharing it within or outside the organization. Knowledge work systems (KWS) support professional workers such as scientist, engineers and doctors in their effort to create new knowledge. Management information system (MIS) supports a broader spectrum of organizational tasks than TPS, including decision analysis and decision making. A higher level class of computerized information systems is decision support system (DSS). Similar to MIS both depend on a database as a source of data. DSS helps decision making in all its phases.

Expert systems are a very high class of information system effectively captures and uses the knowledge of an expert for solving a particular problem experienced in an organization. When groups need to work together to make semi-structured and unstructured decisions, a group decision support system (GDSS) may offered a solution. When executives turn to computer they are often looking for ways to help them make decisions on the strategic level. Executive support systems (ESS) help executives organize their interactions with external environment by providing graphics and communication support.

In supply chain, decisions taken are usually classified as strategic, managerial, or operational. Strategic decisions are usually linked with company strategy and guide the design of the supply chain. Strategic decisions cover long horizons (3-5 years or more) and most of the time all partners in the supply chain are involved in it. Managerial decisions are taken on monthly, quarterly and annual basis. Operational decisions on the other hand are short term, and directly affect day to day activities. Managerial and operational decisions are made by independent player in the supply chain and cover internal functions of the organization.

During the last decade, many software packages have been developed to support decision making within and between partners in a supply chain. These tools have had a great impact on data acquisitions, storing, processing and information sharing across supply chain.

2.2.1 Enterprise Resource Planning (ERP)

During the 1990s the software support systems transited from manufacturing resource planning (MRP I and MRP II) to enterprise resource planning to illuminate the importance of planning and controlling all resources in manufacturing firm [12]. The term “Enterprise Resource Planning” was introduced by Gartner Group in 1990 and can be define as:

“A method for the effective planning and control of all resources needed to take, make, ship, and account for customer orders in a manufacturing, distribution, or service company” (APICS Dictionary ninth Edition).

This “ERP” term undoubtedly become a standardized type of software package. The ERP systems are based on the MRP systems, but cover more business functions. ERP systems are made for organizations of all sizes, different software vendors have focused on one or

more business sectors. All ERP packages consist of various modules cover different functions of an enterprise. One of the basic purposes of ERP system is not planning, but integration of traditional separated business functions through common database [13]. This common database may reduce the efforts and costs for storing and rationalizing redundant data [14]. Integrated nature of ERP systems is its potential to create processes that goes beyond the traditional functional borders of a company. According to Norris et al. ERP systems have other impacts on the organization as well [15]. He summarizes these in the following manner: “*What ERP really does is organize, codify, and standardize an enterprise’s business process and data*”. ERP implementation can help organization to replace complex, disparate, obsolescent systems, improve competitive performance, and improve the poor quality and visibility of information. ERP applications help organizations track customers, money, materials, assets, labor, utilization, etc.

Despite these potential benefits, ERP systems also had number of drawbacks. They are good for record keeping but not at intelligent decision making. They are meant for recording already occurred events. They can accommodate complex workflows, but lack the ability to adapt and restructure with changes in surroundings. While they integrate multiple business functions, they lack the ability to expand their scope to multiple enterprises. Accuracy of solutions provided by ERP systems depends on extent data in the database is accurate. Thus for optimal decision making, data must be accurate and real time.

2.2.2 Phone, Faxes & Emails

Despite the presence of sophisticated ERP systems and advancement in information sharing technologies, many organizations are still sharing information through ordinary methods of phone, faxes and emails, such as customers are registering orders on phones, delivery information is coming through emails, and inventory status is sharing through faxes. Information or data generated through these methods is difficult to integrate into the systems in practice. Storing and transmit of such information is very difficult.

2.2.3 Electronic Data Interchange (EDI)

In the past or in many companies even today information has been communicated within organization and between supply chain players through the use methods like letters, personal contacts, phones, messengers, and faxes. But the advent of internet has introduced

a new whole range of tools in this field. The internet quickly became the supply chain information transmission device of choice for exchanging forecasts, orders, inventory status, product updates, and shipment information.

Electronic data interchange (EDI) is a method for structured information transfers to provide a direct communication link between the information systems within separate business units. EDI implementation involves understanding EDI standards, communication link between partners, and available software. Common use of EDI is in sales, inventory management, order processing, distribution and financial management, etc. The usage of EDI system has the potential to increase productivity, improve channel relationships, and decrease operation costs. However, this type of connections is static and structured, and special expertise is required for both establishing and maintaining the communication links.

2.2.4 Extensible Markup Language (XML)

Extensible markup language (XML) is a flexible computer language that facilitates information transfer between wide ranges of applications and is readily interpretable by humans. XML is used for transferring data between different information systems, databases and web-browsers.

The Extensible Markup Language (XML) is a framework for defining markup languages. Compared to HTML, XML has no fixed collection of markup tags. The name “extensible markup language” is, in fact quite misleading [16]. It’s not only markup language that can be extended for other uses, but rather it is a common notation help to build other markup languages. XML is recommended by (W3C) World Wide Web consortium. It is an open standard.

Primary purpose of XML is to support sharing of structure data specifically on internet. XML will have a great impact on the way the data is exchanged on the web. Separation of content from presentation is an important feature which makes it easier to select and/or reformat the data. XML has been designed by keeping very simple and powerful principles in mind. It facilitates to develop any customized markup for any imaginable application domain. Technological changes have no effects due to platform independent characteristic of XML. XML is future of all structured information even for information stored in relational database

2.2.5 Sharing of Process Knowledge

Process knowledge such as product development processes, resource allocation processes, planning processes etc. are critical for a firm's performance. According to Hammer and Champy business process can be defined as "*A collection of activities that takes one or more kind of inputs and creates an output that is of value to the customer*" [17]. Modeling business process helped us in understanding how things are happening within the organizations. Uniform work processes improve predictability. Supply chain coordination can be improved by sharing processes knowledge with the members. For example by sharing forecasting techniques, production plans, inventory policies with the customers and the suppliers can improve over all supply chain planning and scheduling process.

In spite the benefits of sharing process knowledge, supply chain members are not ready to share work processes with the partners. They are afraid that by sharing process knowledge they will be more expose in front of their partners. Strong supply chain members can exploit their weaknesses.

2.2.6 Web Portals

A web portal is a unified way to integrate information from multiple sources. Web portals have significant supply chain implications. Web portal is an infomediary that facilitates horizontal and vertical information exchange between supply chain partners. Horizontal web portals cover many areas e.g. yahoo web portal. On the other hand vertical web portals focused on one functional area e.g. Stavanger tango workshop portal. Web based interface for the enterprise applications user is called Enterprise portal. Enterprise information portal or corporate portals provides a framework to integrate information, people and processes across the organization. It offers access to corporate databases, applications (including Web applications), and systems. This portal offers a common framework for exchanging information, including product information, design information, proposal request etc. Cross company exchange portal is designed to facilitate communication between firms that have common interests. Decentralized content distribution and management keeps the information always updated.

Portals are relatively an older technology designed as an extension to traditional dynamic web applications. The conversion process of data content into marked up web pages is

alienated into two steps. The first part is the generation of markup “fragments” and the second step is the aggregation of the fragments into pages. Portals can be hosted locally on portal server, or it can also be possible to host portlets remotely on another server.

2.2.7 Mashups

Mashups are an exciting genre of interactive Web applications that draw upon content retrieved from external data sources to create entirely new and innovative services. They are a hallmark of the second generation of Web applications informally known as Web 2.0[18]. The term mashup implies easy, fast integration, frequently done by access to open API's and data sources to produce results that were not the original reason for producing the raw source data. There are many types of mashups such as data mashups, business mashups and consumer mashups[19]. The potential uses of mashups are varied a lot.

From business point of view, it can help organizations to integrate all the information in single integrated application, which can help them to make decision with fewer uncertainties.

The ChicagoCrime.org website is a good example of what's called a mapping mashups. This is one the first mashups gain widespread popularity. User can interact with mashup site, such as how many crimes in particular area? What is the location of crime? How many get killed or injured?

Mashups are new exciting interactive web applications that retrieve content from external or internal data sources to create entirely new and innovative services. Mashups emphasis on active user participation. Mashups aggregate and stich together third-party data. Application of mashup in business setting is referred to as “Enterprise mashups”. Now tools are emerging to brign real mashup capabilities to consumers, business users, and IT professionals. From last few years, mashups are gaining popularity with its promise of easy data integration and rapid end user development. Users are looking for way to combine multiple data from multiple sources in a way to generate new insight, without the complexities, costs and risk of information. Users want to create tactical and opportunistic solution at their own with minimal technical skills. Mashups technologies have potential to satisfy users needs. Mashups enables users to create visualizations that improve understanding by adding context to the information.

2.2.8 Mashup Types

Now we will briefly discuss prominent mashup types.

2.2.8.1 Mapping Mashups

Mapping mashups interoperate with an online mapping service, such as those developed by Google or Yahoo, combining data with the mapping application's locating service[20]. Through online mapping services users can navigate most of the globe via a web interface. Online mapping services allow users to navigate most of the globe through a Web interface, available at varying levels of resolution through maps, satellite imagery, or a combination.

Introduction of Google Maps API plays an important role in the advent of mashups. It allows developers, hobbyists and others to mash all sorts of data onto maps. APIs from Microsoft (Virtual Earth), Yahoo Maps and AOL (Map Quest) shortly followed the trend.

2.2.8.2 Video and Photo Mashups

Photo hosting and social networking sites like Flickr with APIs has led to a variety of interesting mashups. Content providers have metadata associated with the images they host such as: when and where it was taken? Who capture it? Title of picture? Mashup designers can also mash photos with other information that can be associated with the metadata. For example display social networking graphs based upon common photo metadata (subject, timestamp, and other metadata).

2.2.8.3 Search and Shopping Mashups

Search and shopping mashups have existed before the term mashup was coined. Comparative shopping tools such as BizRate, PriceGrabber and Google's Froogle used combinations of business to business (B2B) technologies to aggregate comparative price data. To facilitate such mashups eBay and Amazon have released APIs for programmatically accessing their content.

2.2.8.4 News Mashups

News sources (such as BBC, New York Times) have used syndication technology like RSS and ATM since 2002 to disseminate news feeds related to various topics. Syndication feed helps user's to aggregate their own feeds and present them over the web. In this way users can create their own newspapers.

2.2.9 The Architecture

Now we are discussing technologies that are facilitating the development of mashups. Architecture of mashups comprised on following components those are logically and physically separated from each other. They are separated by both network and organizational boundaries.

2.2.10 The API/content providers

These are providers of contents being mashed. Through principles as ReST, Web services, and RSS / Atom provider exposed their contents to facilitate data retrieval. However, many data sources are still not exposing their API's. In this situation web sites like Wikipedia, TV guides doing this by a technique known as "Screen Scraping". Screen scraping can be defined as *"process by which a tool attempts to extract information from the content provider by attempting to parse the providers web pages, which were originally intended for human consumption"*[18].

2.2.11 Mashup Site

This is where mashups is hosted. Interesting thing is that on mashup sites only logic resides, it is not necessarily it is executed here. There are two ways of implementing mashups. One it can be implemented similarly to traditional web applications using server-side dynamic content generation technologies like Java servlets, CGI, PHP or ASP. Alternatively, mashed contents can be generated directly within the client browsers through client side scripting. Mashups created using this approach can be termed as rich internet application (RIA's), means more user interaction. RIA's are hallmark of "Web 2.0", the next generation of services available o the World Wide Web. The Google Maps API is intended for access through browser side JavaScript, and is a example of client-side

technology. Many mashups today's are using combination of both server and client side logic to achieve their data aggregation.

2.2.12 The Client Web Browser

This is where the application is rendered graphically and where user interaction takes place. Mashups often use client side logic to for assembling and composing mashed contents. Information can be integrated in many formats such as text, graphics, and videos.

2.2.13 SOAP and ReST

SOAP and ReST both are platform independent protocols for communicating with remote services. Client can use both the technique to interact with remote services without having knowledge of their platform implementation.

Originally Simple Object Access Protocols (SOAP) is now re-termed as Service-Oriented Access Protocols (or just SOAP) because it focused is shifted from object-based systems towards the interoperability of message exchange. SOAP is having two key components. The first is the use of XML message format for platform independent encoding. The second is message structure, which consist of header and body. SOAP API's for web services are described by WDSL documents. WDSL documents describe what operations a service exposes, the format of message, and how to address it. SOAP message typically communicate over HTTP transport. SOAP is useful when different services are being mashed.

ReST is an abbreviation for Representational State Transfer, a technique of web-based communication using just HTTP and XML. Its simplicity is differentiating it from SOAP and making it more attractive. Unlike the typical verb-based interfaces, ReST fundamentally supporting only few operations (i.e. POST, GET, PUT, DELETE), that are applicable to all pieces of information. ReST emphasis on pieces of information called resources. For example a resource record of quay is identified by URI, retrieved through a GET operation, updated by a PUT operation, and so on.

2.2.14 Screen Scraping

Lack of API's from content providers often force developers to employ screen scraping to retrieve information they are seeking. In scrapping process software tools are used to parse

and analyze content that was originally written for human consumption in order to extract semantic data structures representative of that information that can be used and manipulated programmatically [18]. For example XMLTV, a collection of tools that aggregate TV listing from all over the world.

Screen scrapping is normally considered an inelegant solution. The first reason is that, scraping has no specific contract between content providers and content users. Another reason is lack of sophisticated, re-usable screen scrapping toolkit software. The dearths of API's are available due to application specific needs of each individual scraping tool.

2.3 Information Integration Challenges

There is no doubt about the benefits of sharing information across supply chain. Many researchers have exerted their efforts to identify the potential benefits of information sharing from organizational and as well as supply chain point of view. Similar to other data integration techniques Mashups development is full with technical and social challenges that needed attention.

2.3.1 Technical Challenges

Information technology together with enterprise systems and electronic commerce have supported large-scale business transformations, and forced firms to change their structures and functionality as well as their business strategies. Information technological developments help organizations in developing, capturing, storing and transforming the digital information. IT advancement makes it possible to share information within different units of organizations as well as across the organizations. But still organizations are facing problems how to share information across the supply chain.

Today's organizations have multiple information systems for multiple purposes. While facing different information related problems organizations adopt information system that is best in resolving that problem. According to [21] while implementing ERP systems, companies were forced with two approaches: 1) to change the software to fit the organization or 2) to change the organization to fit the process. Another strategy is "best of breed" approach, in which organizations adopt ERP modules from different vendors to meet their goals. Themistocleous et al. in 2001 conducted a research on ERP and

application integration. They found integration extremely difficult. They suggest that it is better to fit ERP package rather than try to customize it [22]. Many organizations go for “best of breed” approach, and as a result, many autonomous applications co-exist in companies alongside ERP. These autonomous systems use different identifiers for goods, assets and processes. Exchange of information between these autonomous systems within the organization and across supply chain is difficult in terms of formats, security, privacy, roles and semantic integration.

While developing mashups developers are facing analogous challenges of deriving shared semantic meaning between heterogeneous data sets. Translation system between different dataset must be designed. During mapping reasonable assumptions have to be made (e.g. one data source have a model in which an address contains street-field, whereas another does not).

Missing and inconsistent data is another issue in mapping. Mashup designer may found that the data they want to integrate is not suitable for mapping. For example data entered by user might be inconsistent, using common abbreviations for names (e.g. “st_no” in one record and “street number” in another), making reasoning difficult.

Mashup developers might also contend with data pollution issues. This is a critical issue in enterprise mashups. How do I know the information available in a mashup is correct and updated? Data entered by user can be inconsistent, incorrect, or intentionally misleading. This can doubt the data trustworthiness and the value provided by the mashup.

Business infrastructure running today, especially in medium to large size organizations, are still mainly based on commercial software. Commercial software vendors are slow to provide support for enterprise mashup. Support for ReST, useful API's, support for RSS feeds and notification, mashup security solutions are lacking in commercial software. Enterprise has to do a lot at their own before mashups are commonplace in their organizations.

High numbers of product variants, customization and location based presentation have complicated product related information. What is the location of an item? Where it is heading? What is current status? Who own this item and when? are some of the product related information which organization need to store. Also stricter requirements on product life cycle management, traceability, after sales services and information management at

product level. All these requirements have increased quality and quantity of product related information. Different organizations are storing this product level information with different code. Barcodes, Universal Product Code (UPC) and Electronic product code (EPC) are methods in practice for storing product level information. Due to different design principles information sharing with different schemes is a big challenge.

Mashup developers and content providers will also need to discuss security issues. Who can access information? What role a user can perform while accessing mashups? Sensitive data is also required confidentiality. Mashup developers have to take care of this issue while mashing such data with other sources to not put it at risk. Identify will also be crucial for regulatory compliance.

2.3.2 Supply chain Challenges

Today supply chain has become a complex entity. Global competition, strategic nature of relationships had increase interdependencies amongst supply chain members. Length and depth of supply chain partners has increased the supply chain complexity. Anyone who wants to remain competitive is looking to source some portion of their goods from a low-cost provider. It means the supply chain is longer than ever and probably includes more participants than in the past [23]. A manufacturer may be using its own production plants or may have manufacturing contracts around the globe, may have its own distribution setup or using third-party 3PL providers. Challenge is shifting from internal efficiency to supply chain efficiency. It is not sufficient to improve internal operations if the external links are not up to the par [12]. This increase complexity of supply chain has making more difficult to share information. In addition to technical challenges there are some supply chains challenges are there to address.

One of the important supply chain challenge facing by mashup developers is the tradeoff between protection of intellectual property and consumer privacy versus fair-use and the free flow of information [18]. There is a chance that content providers who expose API's for data retrieval might found that their contents can be used in the manner they do not approve. It is an issue of trust between supply chain members.

Another issue is the awareness of the business value of mashups and their potential to solve business problems by providing faster access to the right information. In this

information age, many organizations still are not fully aware of benefits they can get by sharing information across the supply chain.

One another important issue is who will control this mashup in the supply chain. Who will catalog them, maintain them, support them and fix them when they break? One player in the supply chain or cross company team will control this. What will happen when some member will misuse information, or stop sharing information? This is an important challenge which supply chain will face while developing cross company enterprise mashup.

Modern organization management suggests decentralization is a good way to handle large organization. Decentralization gives right to person at spot to make decision based on his specialized knowledge and about his surroundings. However with decentralized control, the whole system may not achieve optimum performance when every individual members trying to optimize his performance. Most of the time each player in the supply chain creates its own information from its internal information systems and employ this in the planning and process executions. Status knowledge of adjacent players is unknown in this method. Behavior that is locally efficient can be inefficient from a global point of view [24]. This is beneficial only if such decisions do not require information from adjacent players. Such decisions are very few and very operational in nature. But in terms of strategic decision making information from both internal and external sources are required. This deficiency caused by decentralized control is expected to improve if each player of supply chain treats each other as strategic partners and share more information with each other.

Supply chains players are independent decision makers with different objectives and different information. They may not be willing to share information. The old saying “Information is power” holds true even in today’s business world. As a result, many players are unwilling to share information and perceived it as competitive disadvantage [8]. According to [25] extent of information sharing depends on company openness to sharing relevant information honestly and frequently.

In today’s business world, one company can be part of many supply chains. Role, size and level of business can vary from supply chain to supply chain. This issue makes it difficult for an organization to share its information in different supply chains with different information systems.

Sharing Information does not mean sharing all information with all partners in the supply chain, but rather relevant and meaningful. End-to-end visibility means “sharing of all relevant information between supply chain partners, also over echelon in supply chain” [26]. Organizations are still reluctant to share information with their adjacent members. They are not ready to trust their partners due to the fact that strategic information sharing can give an opportunity to misuse it in future. Still organizations are lacking in trusting on their supply chain partners to share information.

Chapter 3

3 Research Methodology

Many researchers have explored the benefits of sharing benefits across the supply chain. Some researchers have also focused on what type of information important to share. But the methodologies for sharing information across the supply chain is lacking in the literature. Our main objective of this research is to find out information requirements for quay allocation and planning process at Vestbase and design an information sharing architecture to share this information from distributed sources.

Selecting the right methodology is always a challenge for researcher. For scientific investigation right methodology help researchers to uncover the issue effectively. Once researcher chooses right methodology, the other issues are validity and reliability of research. These issues will be addressed in later part of this chapter.

3.1 Case Study

The issue on hand for our Master Thesis is “Design of an information architecture for information exchange related to quay allocation at Vestbase - Kristiansund”. The problem is discussed in more detail, in quay’s activity planning and scheduling process chapter. For the topic on hand we chose “case study” method. Case research has consistently been one of the most powerful research methods in operations management [27]. As the topic is an exploratory study, most researchers studied benefits of information sharing; very little work is done on issues related to methodology or architecture for sharing information. .

Meredith [28] cites some strengths of case study put forward by Bebensat et al. (1987):

- (1) The case method allows the questions of why, what and how, to be answered with a relatively full understanding of the nature and complexity of the complete phenomenon.
- (2) The case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon not at all understood.

And one most important reason for case study is that, Vestbase itself requested us to study their quay allocation problem and asking for possible solutions.

3.2 Research Framework

For conducting a research at Vestbase we have followed the framework shown in figure 1-1. We have conducted our research in five steps.

First we have identified the information requirements for quay allocation. In this phase we have conducted unstructured detailed interview with the management. We have also observed the process, and studied documents. As a result we developed business process model in Unified modeling language (UML). To validate our business process models design and information requirements findings, we showed these models and findings to the management. After management suggestions and correction we were able to develop information requirements for quay allocation process.

In second phase, we have identified that information visibility gap. For this purpose we developed information index table as shown in table 5-3. In this phase we have tried to identify what information is available, how much it is available, and who own this information.

In third phase, we have tried to identify the sources of information. Sources of information means where information is reside i.e. internal information systems, supply chain information systems, or web. We have divided quay allocation process into four phases i.e. ordering, planning, executing and finishing phase. We tried to find it out role of different information system in quay allocation process activities as shown in figure 5-3. This process really helped us in identifying the information sources and then we have included this information in our information index table. The role and functionality of each information system is discussed in detail in section 5.4.

In fourth phase, we tried to find out possible root causes of information invisibility. We have divided these causes into two categories: supply chain issues and technical issues. The purpose of categorizing these issues will help us in proposing better solution.

In the fifth and last phase, we propose information architecture for information exchange across supply chain. From our whole analysis we have identified that information required is available in pieces in different applications. Major issue is to integrate all these

information into single view. And also propose guidelines to resolve supply chain issues. For this purpose we have studied different information integration methods and technologies available in section 2.2. On the basis our understanding with current technologies we have proposed a possible architecture for information exchange across supply chain in chapter 6. For controlling purpose we have also proposed information roles, each member in the supply chain can perform.

3.3 Unified Modeling Language (UML)

Unified modeling language (UML) is widely used specification from Object management group (OMG). It's a way to model business process and data structured. It can also used in modeling application structure, behavior and architecture. OMG defines UML as "*The Unified Modeling Language (UML) is a graphical language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system. The UML offers a standard way to write a system's blueprints, including conceptual things such as business processes and system functions as well as concrete things such as programming language statements, database schemas, and reusable software components*" [29]. Unified modeling language helps in designing both the structural and behavioral models. There are seven types of diagrams in UML. But in our analysis we draw only two types of diagrams, one is business models diagrams to analyze the business processes and second we draw use case diagrams to define the roles of each member on information available.

3.4 Microsoft Visio

For designing the models and diagrams we have used Microsoft Office Visio Professional 2007. Microsoft Visio is a very easy tool to visualize, explore and communicate complex information. Microsoft Visio provides broad range of templates and one can draw any type of graph, table, charts, and models by using these templates. Microsoft Visio templates includes: business process flow charts, network diagrams, workflow diagrams, database models, and software diagrams. I am using this software for designing the models and diagrams since long. It is very user friendly and its support for multiple types of diagrams is very handy. Due to its support for UML diagrams and business process model diagrams, I felt comfortable to draw my diagrams in Microsoft Visio.

3.5 Database Design

For database designing we have used MySQL Workbench software version 5.0.30. MySQL Workbench is a visual database design application to design, manage and document database design. It is an open source software and available free of cost. It is very user friendly. MySQL workbench received “Product of the year 2009” award from developer.com in the category of database tools. The only reason to use this tool for database design is its simplicity and support for almost every database in practice today.

Chapter 4

4 Oil and Gas Industry

The use of oil and gas has long history spanning thousands of years. The growth of oil and gas has evolved over time and its various uses have also expanded and become an integral part of today's global economy. As oil and gas drives today's world economy[30]. Control and availability of oil and gas is an important issue for the sustainability of world industry. Many global, economical and political events led the oil world into shocks. Due to 1973 war in the Middle East, the first oil shock occurred. Second oil shocked occurred in 1979 as a result of political instability in Iran. These series of events led to escalating oil prices and a great deal of uncertainty concerning the world oil market [30]. Natural gas can be produced during oil production and it is called associated gas because it is associated with oil as it is extracted. Consumption of natural gas has been growing faster than oil, as it offers many environmental benefits.

In 2005, world oil consumption was estimated to 82.5 million barrels¹ per day and 2.7 trillion cubic meters of natural gas. Than it was estimated that world oil production could be sustained for another 41 years with current reservoirs of oil and with the same rate of production. The corresponding number of years for natural gas are 65 years [31].

4.1 Industry Structure

The petroleum² industry commonly divided into two sectors upstream and downstream. Upstream part of supply chain involves exploration, development, and production of oil and gas. In exploration phase, wells are drilled in search of an undiscovered pool of oil and gas. If reserves justify the investment of capital, some development work is carried out until commercial production can begin. Downstream phase covers transport, refining, petrochemicals, distribution, and retail.

¹ A barrel is 159 liters.

² The word "Petroleum" is used in this thesis to refer to oil and gas. Another commonly used term is "hydrocarbons".

Pipelines, tankers, trucks and trains, oil & gas companies, tanker operators, retail outlets, end consumers, 3PLs, supply bases, automation solutions providers, international organizations, national governments and policymakers are some of the key players in whole oil and gas logistic network. The logistics network is complex in nature, with the entities influencing and being influenced by each other.

4.2 Norway Petroleum Industry

Daniel Yergin in his award winning book on the world history of oil “*The prize: the Epic Quest for Oil, Money, and Power*” describes the discovery of oil and gas in North Sea as the “biggest play” so far in the history of petroleum and from an energy-strategy point of view. He thinks that this discovery was more significant than the findings in the Middle East, South America and Alaska. In the late 1950’s, very few people believed that the Norwegian Continental Shelf (NCS) might conceal rich oil and gas deposits. However, the gas discovery at Groningen in the Netherlands in 1959 demanded geologists to change their thinking on the petroleum potential of the North Sea [32]. With the Ekofisk discovery in 1969, the Norwegian oil adventure began to earnest. Production from the oil field starts on 9 June 1971. 2004 was a record year for petroleum production on the NCS. Norway is member of the International Energy Agency (IEA) but not of Organization of the Petroleum Exporting Countries (OPEC).

Norway is the world's third largest exporter of oil and gas [33]. Total oil production (including NGL and condensate) is about 2,8 million barrels per day and net gas production exceeds 3 trillion cubic feet a year. The first exploration well was drilled in 1966 and since then 1100 exploration wells have been drilled, proving 60 billion barrels out of recoverable resources. The average technical discovery rate is about 40 % [34]. The mean estimate for the undiscovered resources is 21 billion barrels out of recoverable resources, equivalent to the quantity that has been produced to date.

The NCS can be divided into three petroleum provinces; the North Sea, Norwegian Sea and the Barents Sea. These areas are differs in geology and exploration maturity. With highly matured and well-developed infrastructure for production and transportation, North Sea is leading. As far as numbers of fields are concern, Norwegian Sea is ahead. But deep-water fields are still un-explored. The southern part of Barents Sea has been successfully

explored, but eastern and northern parts are still unexplored, where geological data indicate large structures with petroleum potential.

Norway has a partly privatized energy sector, with government majority ownership of key company Statoil Hydro, formed recently from Statoil and the oil and gas interests of Norsk Hydro. Norway has mature and highly competitive upstream oil and gas segment, featuring most key national and international companies [35]. The downstream part of oil segment is small, open to competition and de-regulated. British Petroleum, Shell, Gas de France, Phillips Connoco and Esso are others oil companies working in Nor Sea.

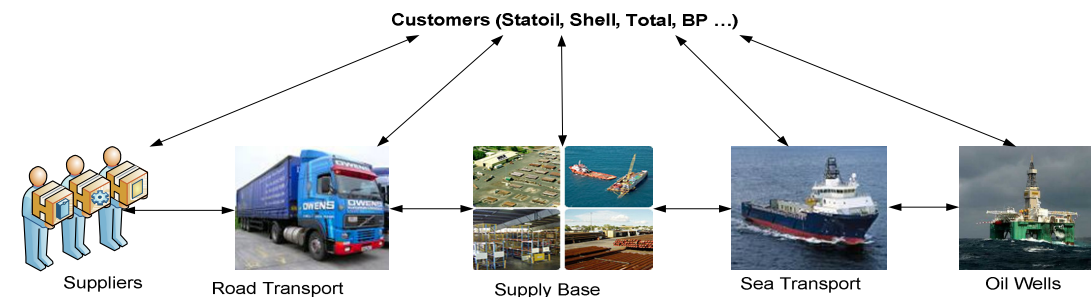


Figure 4-1: Norway Oil and gas upstream supply network

Norwegian petroleum industry consists of internationally competitive supply and service companies. Approximately 80,000 people are employed in the Norwegian petroleum sector, from exploration via development, production and operation to decommissioning, 60,000 of these are estimated to be directly involved in the supply and service industry.

4.3 Industry Trends/Issues

- Cost per unit of oil produced from fields in the tail production phase is rising. Spending must be cut to avoid early shutdowns with the attendant loss of valuable resources. The idea is to reduce offshore staffing. All administration activities will be moved ashore, but all jobs which physically need to be done offshore will remain there. Specialist will work on land, so that they can share their expertise between several developments and spend less time on travel – in other words, become more effective.
- E-operation requires new cooperation solutions, but the way these are implemented varies from company to company. They must identify for

themselves what is to be their main business and what they can leave to others. E-operations mean a closer partnership between operator and contractor. The two sides collaborate in joint operations center or virtual space where they share information in real time. Some of the most important challenges for the petroleum industry in adopting e-operations are:

- Willingness and ability to adopt
- Mutual trust and understanding
- Management commitment
- Technological support

When various disciplines need to work together to optimize oil and gas recovery from a field, a shared understanding of the issues will be important.

- Integrated operations (IO) entail a new operations practice on the NCS. IO can help in managing activities regardless of geographical distance, e.g. between offshore and land. IO requires assistance from other sectors including the ICT sector. Operator can make better and faster decisions by using ICT solutions. These ICT solutions use real time data to integrate work processes across disciplines and between organizations. In 2003, OLF (the Norwegian Oil Industry Association) designated a working team to conduct study on IO. This team came up with following potential benefits from IO:
 - As much as 8-10 percent increase in production
 - Up to 4-5 percentage point increase in recovery rate
 - Up to 30 percent reduction in operating costs compared to today's level.
- Many sources of oil do not require new exploration. Rather, what is needed to improve technology to get it. By the time field is abandoned, only one third of the oil in place may have been produced, leaving two third behind. New computer-based technologies are now making it possible for the oil industry to get more out of the remaining. It is estimated that about 125 billion barrels of additional oil can be made available from existing fields around the world utilizing proven technologies collectively known as “the digital oil field of the

future”. “The digital oil field of the future is a suite of technologies that allows producers to extract a larger percentage of the oil from a field at lower cost” [36].

4.4 NorSea Group

The NorSea Group is a private company established in 1965. With ten strategically located supply and support bases, NorSea and its associated companies offers the unique operating flexibility covering all offshore areas of Norway. NorSea meeting the industry’s most challenging requirements of high service level and cost effective solution through its competence, products and services. NorSea group dealing in wide range of products and services such as Supply base operations, Commercial terminal & Stevedore services, Supply chain management, Marine Logistics, Projects, and Infrastructure to 3rd part logistic provider.

NorSea Group, Associated Companies	
1. Helgelandsbase	2. Norbase
3. Polarbase	4. ITM
5. Tananger Eiendom	6. Idun Eiendom
7. Ledaal Invest	8. Vikan Næringspark

Table 4-1 : List of NorSea Group Associated Companies

In cooperation with the independent companies NorSea Group is providing “one stop supply & service center” at their supply bases. Service provided by supply bases includes offshore terminal, handling equipment, indoor and outdoor Storage, and Tank Farm for Dry and Wet bulk products, Gas & Oil.

NorSea Group, 50-100 % ownership:	
NorSea AS, Tananger	Maritime Logistic Services AS, Dusavik
NorSea AS, Dusavik	Coast Center Base (CCB), Bergen
AS Stordbase, Stord	
Vestbase AS, Kristiansund	

Table 4-2 : List of NorSea Group Supply Bases

4.4.1 HSEQ Policy

NorSea group planned and execute all their operations in accordance with the overall objectives for quality, health, safety and environment. NorSea group objective is to work according to a zero philosophy, which comprises: no damages or injuries, no environmental damages, no occupational illness and no quality defects. They are making it sure that all their behaviors and actions are governed by zero-damages philosophy. They are also motivating their employees to actively participate in improving HESQ. They are also encouraging their collaboration partners to ensure their HESQ-policy with their policy to achieve overall supply chain zero-damages philosophy.

4.5 Vestbase

Vestbase is one of the NorSea supply base. It is strategically situated, 3 kilometers from Kristiansund airport & helicopter terminal and 6 kilometers from downtown Kristiansund. Vestbase AS is 100% owned by NorSea Group AS , the leading national actor within harbor and base operations.

Over the years Vest base in Kristiansund has been an important location for all drilling activity that has moved into the northern part of the North Sea. Most of the supplies for the offshore oil and gas installation in the vicinity of Kristiansund are passing through Vestbase. In the development phase of Ormen Lange huge stocks of pipes and suppliers went through this supply base. Since then, Vestbase expand its facilities and starts providing broad range of services and activities. Huge supplies including heavy steel pipes, drilling equipment and lots of other heavy and very expensive stuff shipped from Vestbase to the deep waters of NorSea oil wells. The supply base operation is providing a full range of services including loading, unloading, storage and terminal facility. Heidrun and Draugen platforms are handled from the Kristiansund operation.

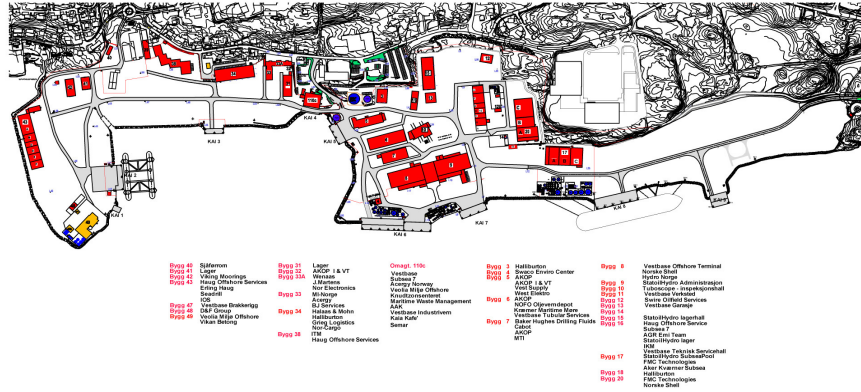


Figure 4-2: Maps and facilities at Vestbase (Source: official website of Vestbase)

Due to unique location, proximity to important infrastructure, modern facilities, a strong focus on safety, a large volume capacity as well as safe and efficient material handling made Vestbase a strategic choice of logistical partner for the companies involved in offshore related activities in Mid-Norway.

Further, the proximity of offshore installations and fields represents a clear advantage. Vestbase is also an industrial cluster with 60-70 companies established/represented. The platforms Draugen, Heidrun, Åsgard B, Njord, Kristin and the production vessel Åsgard A are supplied from Vestbase.

Chapter 5

5 Quay's Activity Planning and Scheduling Process

Vestbase terminal and quay facilities guarantee accessibility and capacity for bulk handling. Vestbase also handles large individual jobs. Vestbase strategy is to provide total concept that includes all the logistics-related tasks which must be solved at or from the base, for example efficient transport, shipping and customs solutions. Vestbase has substantial expertise within the core activities of terminal operations includes management, equipment coordination, purchasing, rig coordination and transport/forwarding.

Currently Vestbase is operating with total 9 quays. Some of these quays are designated for special handling like quay 2 and 8 are for water only and some quays are all purpose quays e.g. quay 6 (West) and 7. Detail of each quay with types of handling operations is available in table 5-1.

QUAY List	Length	Depth	Weight	Products Handling
QUAY – 1	12 m	6.3 m		Normaly not used by Vestbase at all. The only regular use it has is to reveive gravel and cement for the concrete supplier 'Vikan Betong'.
QUAY – 2	60m	10 m	10 m/t	Water
QUAY – 3	45 m	8.0 m	5 m/t	Water, Gas Oil
QUAY – 4	47 m	3.5 m	5 m/t	Water, Gas Oil - Currently closed due to construction work
QUAY – 5	50 m	7.3 m	5 m/t	Water, Gas Oil - Currently closed due to construction work
QUAY – 6 (W)	63 m	10 m	10 m/t	Water and Gasoil

QUAY – 6 (E)	63 m	10 m	10 m/t	Water , Gasoil, Baseolje, Cement/ Cilica , Barite, Bentonite, Drilling fluid(mud) , Brine , MEG, Slop All operations can handle at this port
QUAY – 7	63 m	7.3 m	10 m/t	Water , Gasoil, Baseolje, Cement/ Cilica , Barite, Bentonite, Drilling fluid(mud) , Brine , MEG, Slop All operations can handle at this port
QUAY – 8	100 m	21.4 m		Currently only for Water
QUAY – 9	40 m	10 m	10 m/t	Currently Water and LNG gas, In Futur Methanol Tank

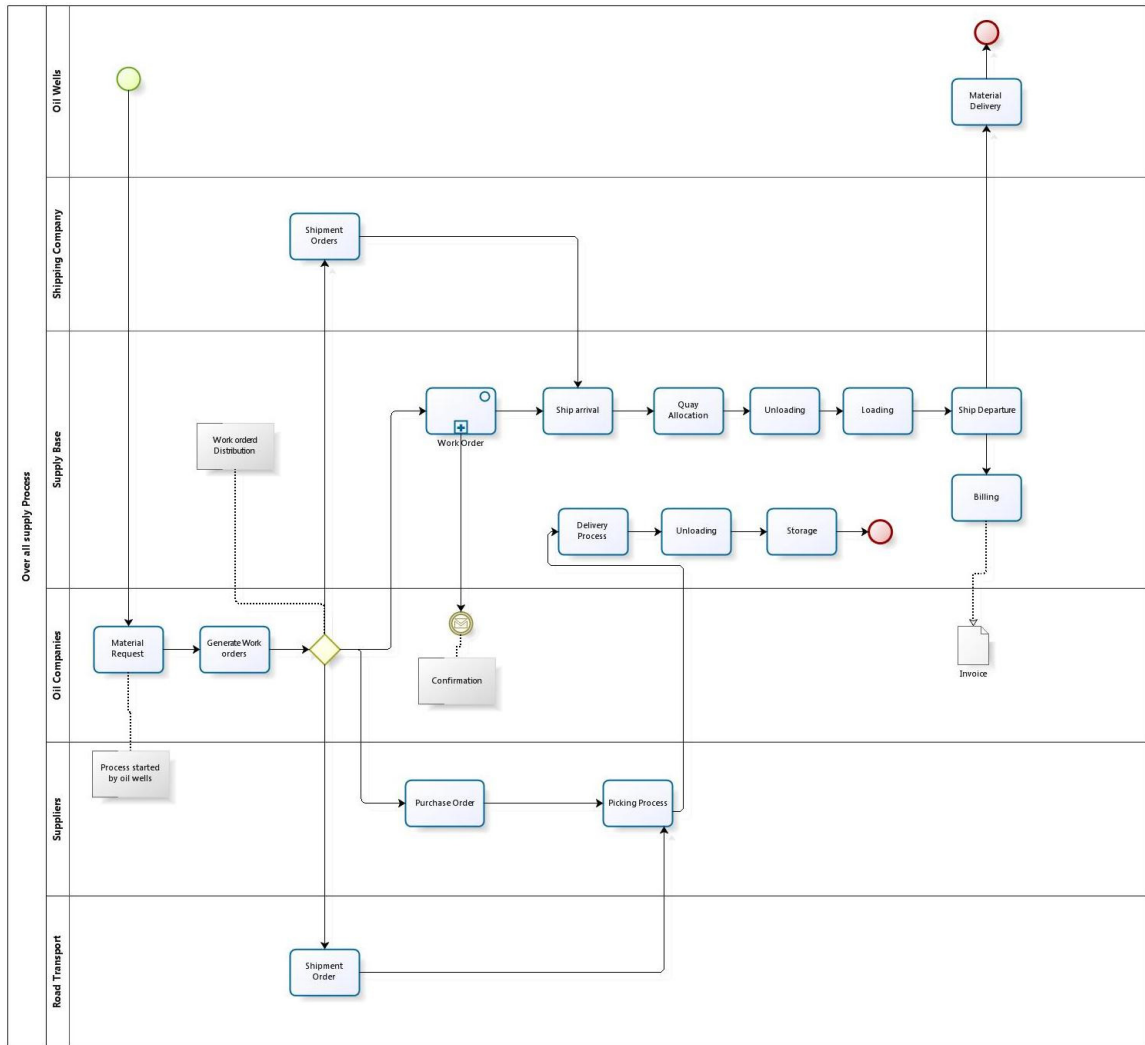
Table 5-1: Quay List and handling operation

Quay services provided by Vestbase are very important in terms of efficiency and effectiveness of supply base. The terminal-concept is tailor-made for the individual customer, where the efficient usage of existing facility, human resource and equipment in general is the basis. The service is targeted against customers which in periods (maintenance campaigns, projects etc.) needs total logistical support, or for suppliers which are not located in Mid Norway with own staff and products. The Terminal-department has also experience in coordinating and mobilizing various packages and larger constructions from other harbors both inland and abroad. Key elements within the terminal-concept are management, material coordination & handling, coordination of marine activity, purchase, offshore position as material coordinator, document control. The Terminal department provides different types of indoor storage facilities, and has necessary flexibility to provide cost optimized solutions for the customer.

5.1 Overall Supply chain workflows

Overall oil and gas industry upstream workflow is shown in figure 5-1. Workflow process is initiated by oil wells. If they need some products or want to send some products, they send a request to oil companies. After analysis of request oil companies generate work orders for possible players involved. For example, Material purchase order to suppliers, delivery orders from suppliers to supply base to road transport company, delivery order

from rig to supply base or supply base to rig to shipping company, quay allocation and loading and unloading order to supply base.



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Figure 5-1: Overall supply chain workflow diagram

Road Transport Company picked items from suppliers and delivered these items to supply base for storage. Supply bases received these items and stored them at particular place. All the items available at Vestbase are owned by oil companies. Supply bases are charging rent for their storage facility. When ship arrived against work order generated by oil companies, Vestbase allocate platform to that ship and perform loading and unloading activities as per request. Ship departs after finishing the job and delivered items to the oil rig. Vestbase sends invoices to the oil companies according to the work they perform for them.

5.2 Information Requirements for Quay Allocations

Handling and allocation operation of these quays are very important for Vestbase in-terms of customer satisfaction and efficiency. Cost effective terminal management, good allocation of quays to incoming ships will enhance ship owner's satisfaction and increase terminal productivity and results in higher revenues. Turnaround time of ship is important factor from Vestbase in-terms of efficiency and effective of terminal service. Turnaround time includes: ship waiting time for quay allocation after arrival, total time for unloading and loading and departure time. Therefore reasonable scheduling of quays and resource allocation are critical to efficiency of terminal services. Upon ship arrival different resources are required for unloading and loading operations including workers, quay cranes, yard cranes, truck etc. On time availability of information about work orders, what is going to be load, what is going to unload, when ship will arrive is important for Vestbase to make better plan for quay and resource allocation.

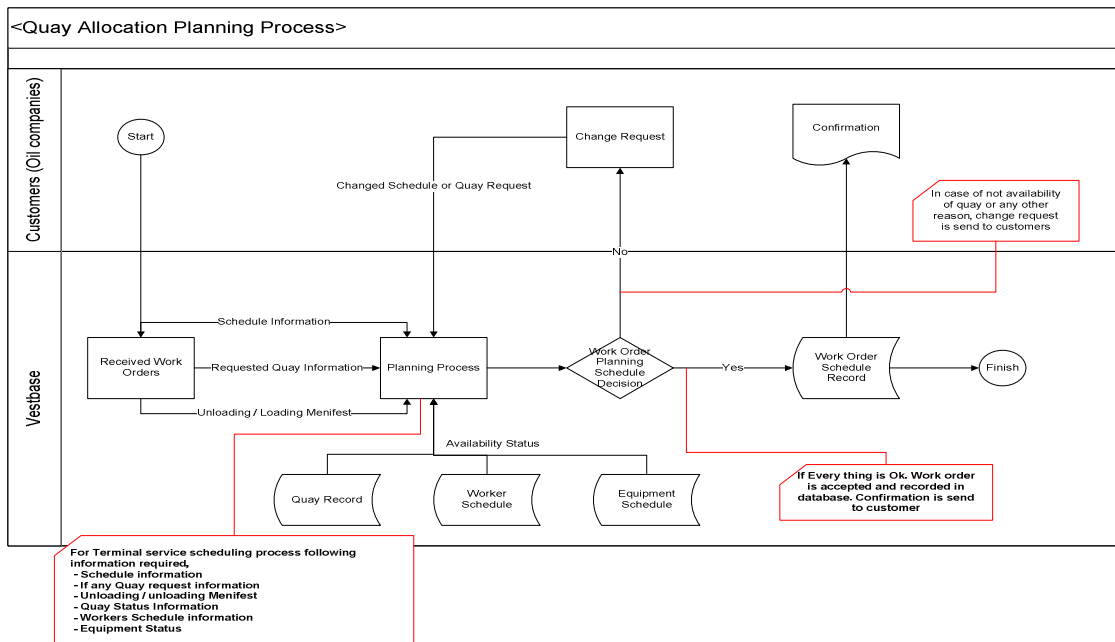


Figure 5-2: Quay Allocation process and Information Requirements

The figure 5-2 above shows quay allocation and activity scheduling process. Receiving of work orders from customers start this activity. After receiving this work orders Vestbase needs to plan and schedule this activity. This planning process includes allocation of quay, allocation of workforce and allocation of machines to carry out this activity on the required

date and time. For planning and scheduling this activity Vestbase needs following information:

- Schedule information
 - Task due date and time
 - Ship arrival time
 - Ship Departure Time
- If any quay request information
 - Many times customers requested particular quay for their upcoming task.
- Unloading and loading Manifest
 - Unloading Item Lists
 - Loading Items List
- Quay status information
 - Quay status on required date and time i.e. available or Busy
- Workers & Equipment schedule information
 - For handling quay operation Vestbase needs Equipment and work force to carry out this activity. For accepting the work order they need to check the status of their equipment and work force either they are available or already busy in some other task. List of equipment and work force category is available in table 5-2 below.

Employees Categories	Arbeidsleder, Base operator, Subsea, KranForer, TruckForer, Personell, Bulk, Teknisk Personals, Innleide, OCTG, Maskinforer
Equipment Category	Bukkeset, Casing Truck, Flak Dognleie, Hjullaster, Kran, Lofteteknisk Material, Stk. Pris, Tjenestebil, Trekkvogn, Truck

Table 5-2: Equipments and Workforce Categories

For finding the details of information required for quay allocation we have designed a database model (Appendix A). The database design is helped us in identifying the attributes of a particular information required. For example, loading list attributes like name of item, total weight, allowed weight, contents etc. On time availability of these information's are necessary for efficient and effective planning and scheduling process. If quay, workers and equipments are available on requested schedule then schedule has been made and confirmation is sent to the customers. In case if requested quay is not available

on due date and time then situation demands either change in requested quay or change in due date and time. For such changes Vestbase contacted their customers and ask for required changes. One more option Vestbase has to cancel already planned activity on requested quay and allocate particular quay for current activity. But Vestbase not always go for this option until unless it is required to do so.

5.3 Information Visibilities Gap

Vestbase is facing many information visibility challenges in quay activities planning and scheduling process. Unavailability of right information at right time results in lots of uncertainties including:

- Long waiting time for quay
- Ships Delays uncertainties
- Non-efficient allocation of quays
- Long turnaround time
- Inefficient uses of resources (workers and equipment)
- Many inter quays movement of ships

All these uncertainties are due to unavailability of right information. It is important for Vestbase to identify the issues stopping information flow within or across the supply chain. For this purpose we analyze the quay allocation system and identify information requirements for allocating quays efficiently and effectively. Then we tried to find out who own this information in the supply chain and either Vestbase have permission to access this information or not. Information index for quay allocation table 5-3 is describing current information visibility situation prevailing at Vestbase.

First information required for quay allocation and planning process is work order. Customer generates work order and sends it to supply base where activity will be carried out. Customers can register their work order though RMC online system. But still customers are sending work orders through phone, faxes and emails. Customer made many changes in the work order even after registering. According to Vestbase management even when activity is in execution phase, even then customers are sending new requirements. When this work order is coming via RMC system then Vestbase is in a position to have access on this information in digital format. But today only 80% customers are registering

their work orders through RMC and manifest are in PDF or in text file format. To provide customer flexibility today Vestbase is working with only one hour grace period between the order time and due time. Many times order from customer arrives in less than one hour.

Information Required	Owner	Information Systems	Access / Permissions	Visibility / Availability
Work Order	Customers	Customers information systems e.g. SAP at Statoil	Yes, if coming through RMC	<ul style="list-style-type: none"> ✓ Receiving through RMC, phone, faxes, email, ✓ Not always complete and updated information available ✓ Changing at nick of time ✓ Changing even during execution process
Manifest (what to unload / load)	Customers	Customer information systems	Not always available on time.	Changing all the time
Quays status	Vestbase	Outlook calendar	Yes	Complete information available
Customers Information	Vestbase	Agresso ERP	Yes	Available
Shipping Schedule	Customers, Shipping Company	information available through STATOILS VTMS and AIS (Shiplog) web	Yes	Available
Resources / equipment Information	Vestbase	RMC	Yes	Available
Resources Status	Vestbase	Google Earth (In development phase)	Yes	Available but not completely because project is in testing phase

Table 5-3 : Information Index for Quay Allocation

When customers register their work orders they also upload unloading and loading items lists called Manifests. Most of the times, while registering their orders customer are not providing manifests. In such cases customers send these manifests either through emails and faxes or Vestbase sends their own person for collecting these manifests. Customers know these manifest well before time but they are not sharing this information with the supply basis in time. Customers are also making changes in manifest very frequently.

Customers are allowed to propose some particular quay for carrying out their tasks. In such situation Vestbase need to know the status of that quay on requested date and time. Vestbase does not have any specialized system for handling such information. They are keeping this record in outlook calendar. But they have information about particular quay at specific date and time. If quay is available they accept the customer proposal otherwise they ask customers to change their requirement. Sometimes if order is big and important they can change the schedule of already allocated task at that quay.

Customer information is also important for quay allocation planning process. They kept this information in their Agresso ERP system. Customer information is important because they have different price contracts customers. There are three category of price contract: price per hour, fixed price and price per ton. Normally they have one year contract with their customers.

Shipping schedule is also very important in quay allocation and planning process. Which ship is coming, when it is coming, what is the current location of ship are some of the important information's required by Vestbase. They are using third party Shiplog system for generating such information. Statoil is one the big customer of Vestbase; they have provided access to Vestbase on their Shiplog system for such information.

Workforce and equipment status is also very important in quay planning process. Most of the times, customers delivered orders on very short notices, so Vestbase need to have this information available all the time. Currently Vestbase is using RMC system for managing this information and this system is providing real time information of resources available in the Vestbase.

5.4 Information system practices at Vestbase

Currently Vestbase is using multiple information systems for managing their internal operations. Present policy of adopting information system at Vestbase is not very strategic in nature. They select and adopt information system on activity to activity basis. They select information system while facing problem in particular domain without considering whole organization and supply chain. As a result they have multiple information systems working independently. We divide quay allocation process activity is four phases i.e. ordering phase, planning phase, execution phase and finishing phase. In these four phases Vestbase is using different information systems for different functions. Phase and activity wise use of information systems is shown in the figure 5-3.

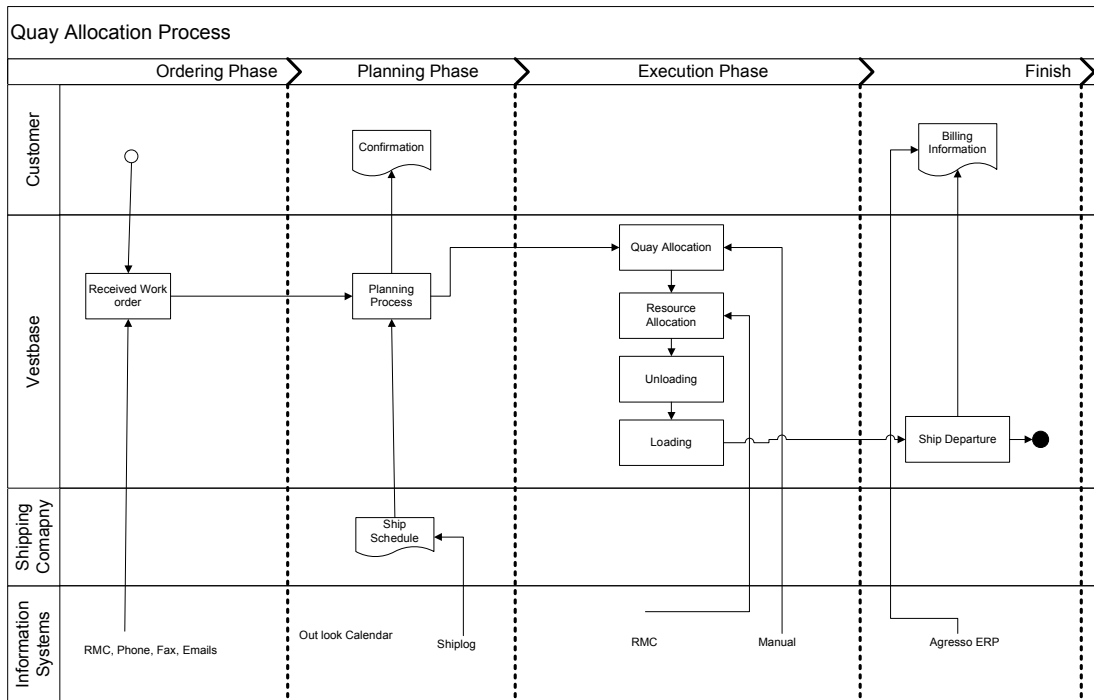


Figure 5-3: Information Index for Quay Allocation

The purpose of analysis quay allocation system is this way is to know the role of information systems in quay allocation and planning process activities. Which system holds what type of information? Can we integrate or share this information with others system? Or what activities Vestbase are performing manually? Other objectives are to identify the functionality and limitation of each system in practice at Vestbase.

5.4.1 RMC

For registering customers work orders Vestbase is using RMC system. This system is specifically designed for Vestbase and still in development phase. The main purposes of this system, is to register customer orders online and resource management. But currently only 80% customers today are registering work order online. Rests of the customers are sending their work orders though emails, faxes or telephones.

Customers can provide information about work orders such as work description, price category, task due date / time and they can also upload manifest (what is going to be unload and load). Vestbase have different price contracts with their customers on the basis of hourly price, fixed price and price per tons. RMC is also helping Vestbase in executing work orders. After starting the activity they can end, stop, hold or cancel that activity.

RMC is also keeping record of current status of resources available at Vestbase. With the help of this system they can calculate total activity time, total numbers of resources used including both workers and machines and total weight loaded and unloaded in the ship.

After completing the customer work orders RMC send data to Agresso ERP systems for billing. Ideally every work orders should have one unique ID in the Vestbase systems, but RMC and Agresso ERP are integrating properly that's why same work order exists in these two systems with different ID. RMC is still in development phase and Vestbase have clear intention to integrate information from this system to Agresso ERP in required mode.

5.4.2 Outlook Calendar

Currently Vestbase does not have any proper system for scheduling, planning and allocating quays. They are using Microsoft outlook calendar for scheduling quay allocations. They have expertise in the shape of skillful and experienced workers, who are managing quay allocation on activity to activity basis. They are drawing a chart for each quay on daily basis. This chart provides them information about at a specific quay and planned activity on that quay on daily basis.

Outlook calendar allows users to create different types of entities. One can note his/her appointment and can designate time slot for each appointment. Items in calendar can be viewed in different ways e.g. daily, weekly and on monthly basis.

Outlook calendar provides sharing facility to their users. User can share their schedules and appointment information with other users. But integrating information from outlook calendar into ERP system is difficult task. One can not apply query to get information about particular quay at particular time instead he need to open a full calendar and will check status manually.

5.4.3 Shiplog

Vestbase is using "Shiplog by Oddstol elektronikk" for fleet tracking. Shiplog has highly detailed sea charts gives user real time overview of all vessels. Shiplog permits user to identify zones to detect vessel's movement and ports of call. Shiplog is divided into two product groups: Shiplog Fleet and Shiplog Port. Shiplog Fleet gives a shipping company continuous overview of all vessels in the defined zone, as long as the vessels have Internet

connection (VSAT, Inmarsat C etc.). Shiplog Port gives an overview of all traffic in a harbor, and is a unique tool for harbor authorities, service companies and other industry related to ports of call. With Shiplog-link onboard, a vessel will send information regarding its position and data to the Shiplog server regardless of where it is in the world. Location information of all the vessels with AIS onboard is received by Port version. The users are allocated their own passwords and receive the information from vessels on the internet, via Shiplog server. Internet-based system makes it independent of what kind of computer you have or where you are. The only requirement is internet and you will therefore be able to use hand-held terminals such as laptops, PDA or 3G mobile phones.

Vestbase is using this system to monitor vessels movement in North Sea and using this information for planning and scheduling in quay allocation process. This system is working independently and Vestbase is using it for better scheduling. With the help of Shiplog Vestbase can monitor ships locations and can estimate how much time it will take to arrive at Vestbase. This information gives an opportunity to Vestbase to make reasonable plans for quay and resource allocations. Shiplog is working independently and not integrating information with main ERP system of Vestbase.

5.4.4 Agresso ERP

Agresso is Vestbase main ERP system. The main purpose of Agresso ERP is to handle accounting, invoicing and employee record. RMC sends customer work orders detail and quay activity detail i.e. numbers of hours machines used, total man hours and total loading and unloading weight for billing purpose. On the basis of this information Agresso calculate billing amount and then this bill has been sent to customers. These bills are sent to customers via faxes, emails or by postal service. Agresso ERP is not sharing information such as invoices with the customer's information systems. All customers, suppliers and employees records are stored in Agresso database. It means Agresso ERP is main data hub of Vestbase with data of all activities carried out there.

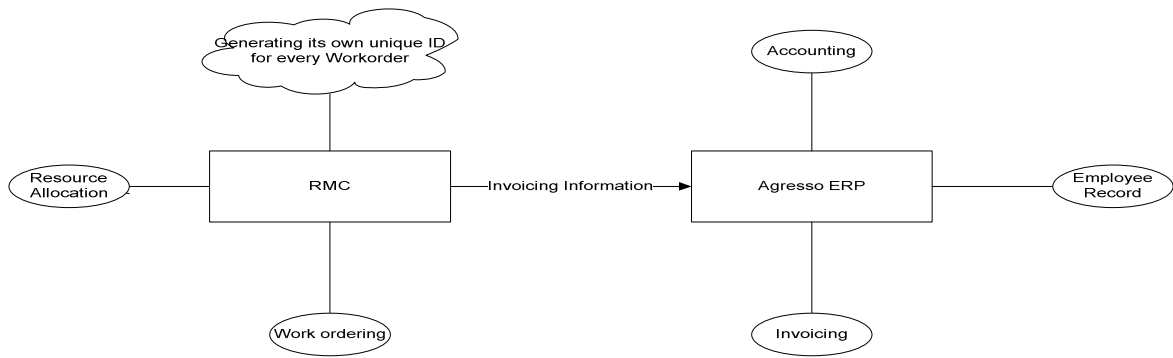


Figure 5-4: Interaction between RMC and Agresso ERP

Agresso core design pivots on an integrated data model, an information warehouse that provides intelligent availability of data throughout the system. Agresso architecture ensures the integrity of information across the enterprise in an “open” framework. Agresso offers a robust SOA. The technology leverages popular and readily available industry and open standards in relation to databases and operating systems such as Oracle, SQL server and MySQL as well Microsoft Windows, UNIX, Linux and IIS. Use of open XML standards, conformance to .Net technology and a choice of portal technologies allows companies to adapt their technology platform [37]. The technical architecture is acquiescent across a wide range of industry standards for interfacing, interoperability and integration.

With all these features, Vestbase is not getting best out of this system. Agresso ERP is working independently and not exchanging information with others systems available at Vestbase and systems available in supply chain.

5.5 Root Causes of information invisibility

After analysis of Vestbase quay allocation and planning process we have identified the possible root causes of information invisibility in Vestbase and across supply chain.

Upstream side of oil and gas sectors in Norway consists of many small and big supply chain partners. Exchanging information across supply chain is very difficult due to size and role of each player in the supply chain. Some players are very big and tried to influence on decision making process of small players. Some players are part of many supply chains, so it is difficult for them to opt different information sharing strategies in different networks.

There has been lots of research on information sharing benefits across the supply chain. But we have identified that there is still lack of awareness about information sharing benefits in Norwegian oil and gas industry. Statoil is a big player in whole supply chain. Statoil itself is not promoting information sharing culture across the supply chain. Overall oil and gas industry is lacking in culture of information sharing.

Vestbase is collecting information in bits and pieces from different resources. Required information is stored in different applications and owned by different members in the supply chain. Required information for quay allocation is not integrating into single view. So decision makers collecting pieces of information and then making decisions on the basis of their experience. Quality of decision depends on the information available at the spot.

Selection and adopting of information systems practices are not strategic in nature. Vestbase adopt information systems while facing problem in particular domain without considering whole organization and supply chain. This results in many independent information systems within the organization. These multiple systems are different in-terms of data format, security, privacy and semantic integration.

RMC system is particularly designed for online order registering. But customers are not using this system in proper way. While registering their work orders they normally did not upload manifest i.e. what is going to be load and unload. These manifests are either coming through emails, faxes or Vestbase needs to send a person for collection. Integrating information in such formats (e.g. paper, text, phone calls, PDF files) is difficult to share and difficult to store in databases. In this way it is not possible to get information from the systems like how much mud is going to be unloaded from ship in some particular task? How much water is going to be loaded in ship at particular date? Unavailability of such information cause planning and scheduling difficulties for Vestbase

Many customers today still are not registering their orders online through RMC. Their orders are coming through faxes, phones and emails. These orders are not immediately available in database for planning and scheduling.

Chapter 6

6 Proposed Information Architecture for Information Exchange

From analysis of quay allocation and planning process, we have identified that Vestbase is collecting information in bits and pieces from different resources. Required information is stored in different systems and own by different members in supply chain. People at Vestbase had to sign in different applications and go to different websites to manually collect information and then try to make sense of it. Required information for quay allocation is not integrating into single view. Quality of decision depends on the information available at the spot. Many times, there is very short time available for making decision and this manual information generation process results in many logistical issues including:

- Lots of internal movement of ships from one platform to another
- Long waiting time for ship after arrival to base for allocating platform
- Overtime payments to workers due to boat delays
- Boat delays can results in delay or cancellation of next allocating task on the same quay.
- Difficulties in allocation quay to next customers due to boat delays
- Resource allocation problem in odd timing especially on weekends and nights due to short grace period between ordering time and due time.
- Inefficient allocation of platform. If boat is dock on platform away from loading items results in increase internal traffic and increase operating cost.

Our main objective is how to integrate information from different sources into single view. This will help decision makers to collect information from one integrated tool and can make better quality decisions and can minimize the logistical issues listed above. For making information available at one location first we need to identify the information requirements for quay allocation and planning process.

In section 5.1 we have identified the information requirements for quay allocation and planning process. We are categorizing these information's into two categories: primary information and supportive information. This categorization will help us in prioritizing the information need.

6.1 Primary information

Primary information we can defined as “*Information compulsory for making decisions*”. Without primary information one cannot make decision. For example, Schedule information is primary in nature because if schedule is not available Vestbase cannot start even planning process. Another example is quay status information, if customer requested some specific quay and they don't have quay status information, it is not possible to confirm the customer order. So, primary information should be available for quay allocation and planning process.

6.2 Supportive Information

Primary information described above is facilitated by supportive information. With the availability of supportive information decision maker can make better plan with fewer uncertainties. For example, ship trip and planning data is supportive in nature. If Vestbase know this information they can plan better in-terms of quay allocation. Another example is Ship location information, if Vestbase know what is the ship current location they can estimates when ship will arrive at base. This information is really helpful in allocating resources for particular task and they can save overtime payments to their workers.

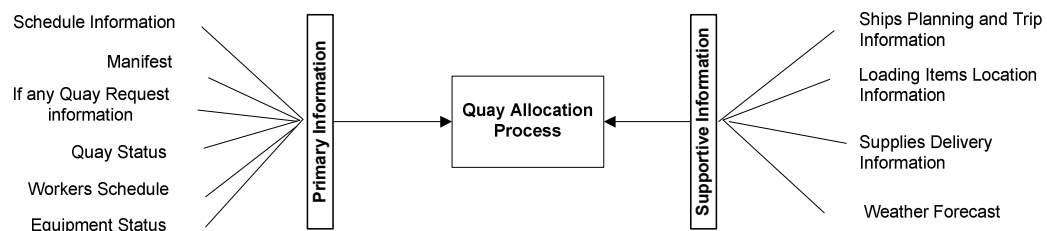


Figure 6-1 : Information Requirement Model for Quay Allocation Process

We have assumed that if primary and supportive information described above are provided to Vestbase they will be able to make their quay allocation and planning process more efficient and effective. We are expecting benefits such as:

- ✓ Reduction in Delays uncertainties
- ✓ Better scheduling
- ✓ Cost effectiveness
- ✓ Better utilization of resources
- ✓ Customer satisfaction
- ✓ Transparency

Now issue is how to integrate information required for quay allocation and planning process into single view from distributed sources. For integrating information from multiple sources we are proposing “Mashup” information architecture. Wikipedia defines mashup as *“It is a web application that combines data from one or more sources into a single integrated tool”*. In the context of an enterprise, we can define enterprise mashup as *“an application that results when a business user combines multiple sources of enterprise and public data with some visualization and interaction capabilities”*[38].

We are proposing an information architecture model of information exchange for Vestbase as shown in figure 6-2. Vestbase personnel need to sign in to several applications and go to different web sites to manually collect the information and then try to make sense of it. So our objective is to integrate all the information required by Vestbase for quay allocation and planning process into single view. We are proposing Enterprise mashups in which information from different sources will be available at single view.

6.3 Proposed Architecture

We have proposed a mashup that will be base on ReST with web or data sources. Data may be transmitted in XML format. This mashup will use a combination of both server and client side logic for data aggregation. We have also designed the client web browser views on the basis of our information requirements analysis of quay allocation and planning process.

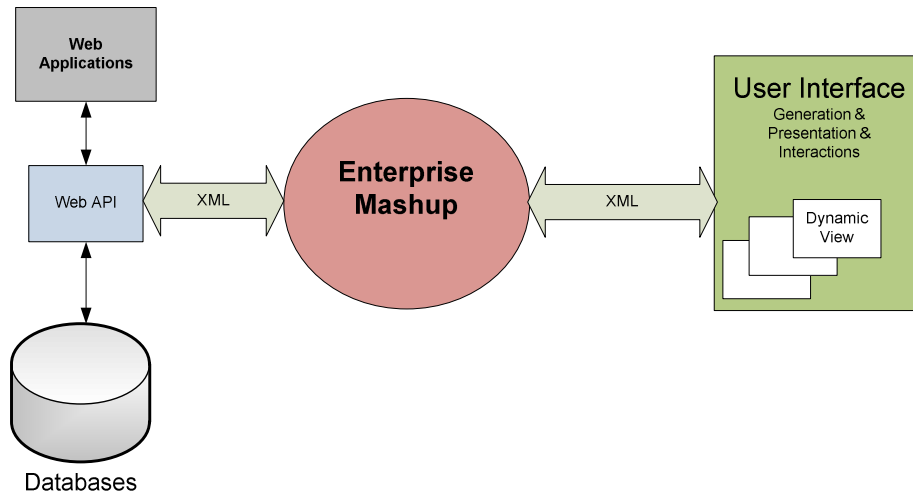


Figure 6-2: Proposed Information Architecture Model of Information Exchange For Vestbase

6.3.1 API / Contents

We are proposing that supply chain member should develop API's to expose their contents to the partners. We are not very sure either the current information systems applications have capabilities to expose their contents though API's or not. If not it should be done. Screen scraping is an alternative way to aggregate data in the absence of API's. But we will not recommend this due to lack of sophisticated, re-usable screen-scraping toolkit software. By developing standard API's for sharing contents it will easy to accommodate new members in the mashup.

6.3.2 ReST

Representational State Transfer (ReST) technique will be use to communicate on web. It is platform independent protocol for communicating with remote services. It is very simple and using XML as a data format and communicates over HTTP. Every object has a unique URI. By using GET operation of ReST we can get contents of that object. Then we can modify that object by using POST, DELETE and PUT operations. It is very easy to build, no toolkit required. It produces human readable results. Design methodology of ReST is very simple.

- 1- Identify resources to be exposed as service (e.g. quay status, ship trips and planning data etc.)

- 2- Define "Nice" URL's to address them
- 3- Distinguish between read-only (GET) from modifiable resources (POST, PUT, DELETE)
- 4- Identify relationships between resources correspond to hyperlinks that can be followed to get more details
- 5- Implement and deploy to web server

It emphasis on pieces of information called resources. ReST is useful while integrating resources. Because Vestbase is collecting information in bits and pieces from different sources, we think ReST is a good option for our enterprise mashup.

SOAP is an alternative option for communicating with remote services. But as compared to ReST it is complex in design methodology. It's a framework to deliver the necessary interoperability between message-based middleware tools across the entire industry. SOAP focus more on integrating design of distributed applications. There is lack of standard naming mechanism.

6.3.3 Data Aggregation Logic

As we know there are two ways to aggregate data in mashups: Web based and Server based. In web-based mashup content generated directly with in client browser through client side scripting. Both generation and modification executed in web browsers. In server-base, mashup analyze and reformat the data on server and then transmit to web browser in final form.

In our enterprise mashup, we are proposing combination of both the server and client side logic to achieve data integration. Location and Status information about ship and resource can be handled on client's browser using Google API. But information that requires complex queries on multiple data sources (such as quay schedule, manifest detail, total numbers of job on particular quay at particular data and time) requires computation that would be infeasible to perform within the client's web browser. Additionally, this option will provide more security. Members are not required to expose their database to internet and can avoid threats of viruses and data hacking.

6.4 Client's Web Browser

From Information requirements analysis for quay allocation and planning process in section 5.1 and 5.2, we have identified the primary and secondary information required for quay allocation process. On the basis of these information requirements we have designed some views.

6.4.1 Proposed Customer view

One view is for oil companies who create their order draft and send it to supply bases for approval as shown in figure 6-3.

The screenshot displays the 'Customer Work Order Creation Form' with various input fields and interactive elements. Key features include:

- Navigation Menu:** New order, Update, Order Status, Search, Statistics.
- Form Fields:** Company (Statoil), Address, Telephone, Post ntr/City, Requisition by, PO / ID, WBS, Boat Name (Island Challenger), Ship Compr., Item, Avd., Order Date / time, Due Date / time, Requested Quay, Work Description, Price Category (Hourly Price, Fixed price, Price per ton).
- Manifest Section:** Unload List, Load List, Additional Document (each with an Upload button).
- Utility Widgets:** Google Calendar (May 2009), My calendars (David Gallagher), Weather Maps.
- Map and Charts:** A map showing ship status and routes, and online charts showing ship status and ship routes plans.
- Callouts:** 'They can check Ship schedule and Loading items status to plan better for Task timings', 'They can requested quay status before Requesting that quay and can order Approval process time', 'Google calendar is an additional utility to Make order related appointments if any', 'They can check online weather status, and It can help in estimating ship delays', 'Online charts showing Ship status And ship routs plans'.

Figure 6-3: Propose Customer order creation form view

In this view we have tried to integrate both the primary and supportive information to help customers in creating draft. With the availability of these pieces of information on single web page, customers can draft their orders with fewer uncertainties. Supportive information such as quay status, ships schedule, ship routs information, and weather forecasts can help customers to draft their orders in better ways.

6.4.2 Proposed Supply base View

We have also tried to create view for supply bases for receiving word orders from customers and with the availability of both primary and supportive information they can improve their quay allocation and planning process. This view is shown in figure 6-4.

Supply Base Order Receiving & Planning Form

Company: Statoil Hydro ASA | Contact person: Ahmad Zubair | PO/ID: 12345 | WBS: Acary Eagle | Boat Name: Island Challenger

Comp	ID	Due Date	Reg. Date
Statoil Hydro A	146...	12.06.09 09:30	02.06.09 13:00
Statoil Hydro A	146...	12.06.09 09:30	02.06.09 13:00
Aker kvaerner.	146...	15.06.09 09:30	07.06.09 13:00
Total E&P No.	146...	12.06.09 09:30	02.06.09 13:00
Total E&P No.	146...	12.06.09 09:30	02.06.09 13:00
Haug Offshore.	146...	12.06.09 09:30	02.06.09 13:00
Haug Offshore.	146...	16.06.09 09:30	02.06.09 13:00
Haug Offshore.	146...	17.06.09 09:30	02.06.09 13:00
Haug Offshore.	146...	17.06.09 09:30	02.06.09 13:00

Reg Date/time: 02.06.09 13:00 | Due Date/time: 12.06.09 09:30

Confirmed by: Torimyr B. Taknes | TIT: +47 71 19 59 12

Buttons: Confirm, Hold, Update, Re submit, Cancel

Annotations:

- They can see the list of customer orders needing approval
- Google calendar is a good utility to create events and appointments
- They can see the weather forecast and can estimate ship arrival time for scheduling their resources
- They can read loading and unloading items list to plan how many resources required to do this task
- They can check quay, resources status and they can also see ships trip and planning information before accepting and scheduling

Figure 6-4: Proposed Supply base view for order receiving and planning process

In this view, we have tried to integrate real time supportive information such as quay status information, ship location and tour plan, resources location and status, manifests, and weather forecast information, so that supply bases can accept or reject work orders in no time. Currently there is very short time between ordering and due time, it will be really helpful supply bases to access all required information on single web page and can make better planning and scheduling decisions.

6.4.3 Proposed Workers and equipment status view

We have tried to create view for looking at workers and equipment status as shown in figure 6-5.

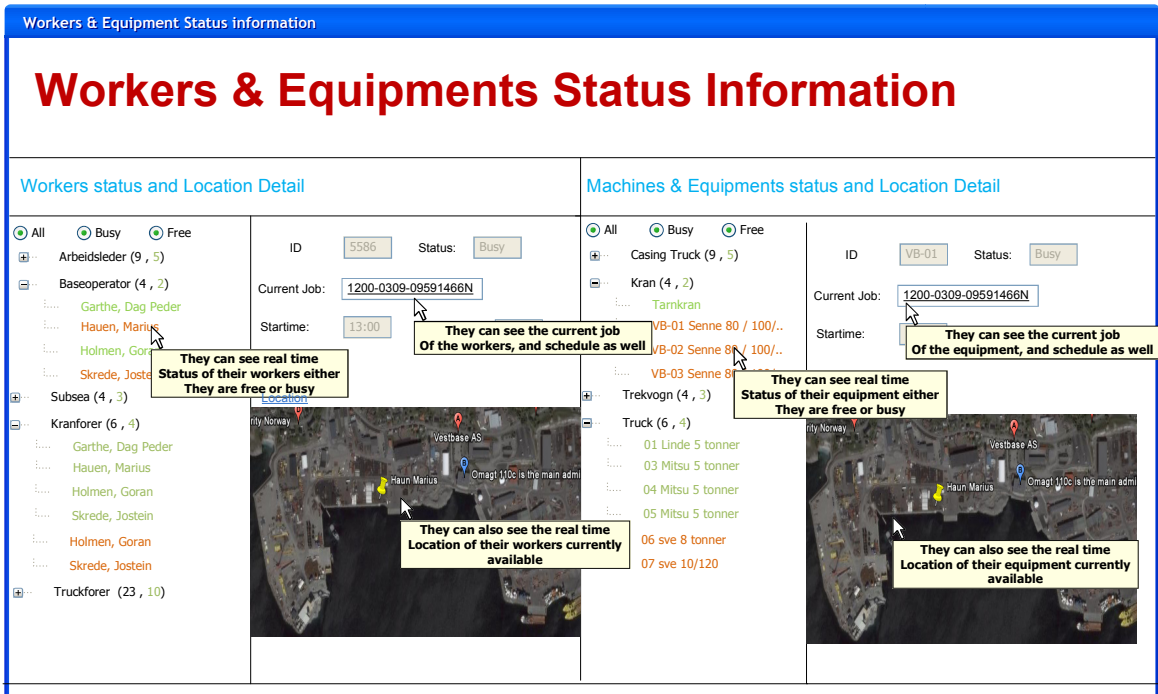


Figure 6-5: Proposed workers and equipment status view

This view will help supply bases to see real time status of their workers and equipments. This view will be linked with supply base view. While planning and scheduling work orders they can check the current and future schedule of their resources. This information will help them in better planning and scheduling.

6.4.4 Proposed Quay Status View

We have also tried to create view for checking real time status of any KAI as shown in figure 6-6. This view will be linked with both customer and supply base views to get status of requested KAI. This view will be automatically updated and will give real time information about KAI.

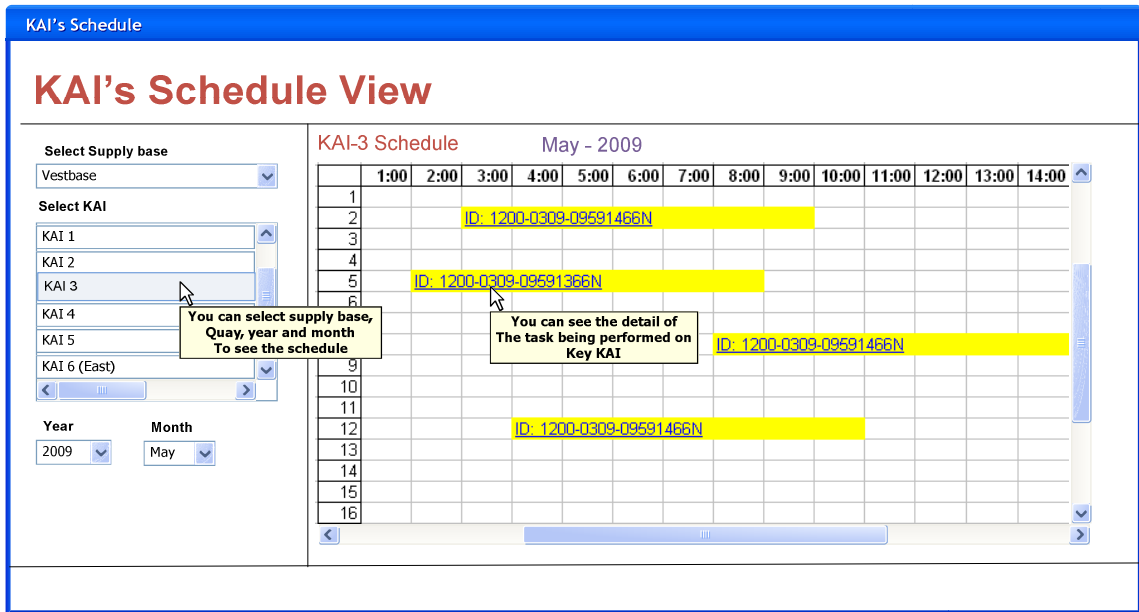


Figure 6-6: Proposed KAI status view

6.5 Proposed Mashup Roles

All the views in the mashup are role based views. Role based view means every user can perform different roles while accessing information available on these views. For example one user can only read the information, one can read and modify and other can view, modify and delete the information available on the view. So we need to define the roles of every user who can access information available on our enterprise mashup. These roles will vary from view to view. We have tried to define the roles user can perform on each view but it depends on the agreement between two members. Content provider will define the user roles that he can access the information through enterprise mashup. But we have tried to identify possible roles of users on each view we have designed.

6.5.1 Customer View Roles

Customers can create, modify, delete and submit their work orders. But supply bases can only read this information after the submission. They can access this information

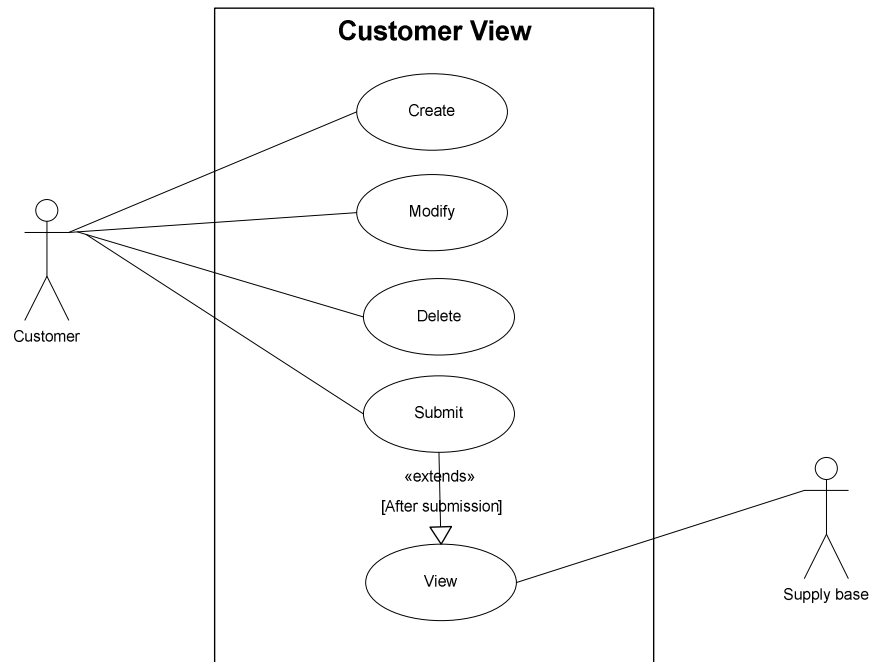


Figure 6-7: Customer View Roles

through the supply base view. Once customers submit their orders it is available in specified supply base view.

6.5.2 Supply base view Roles

Once customer submits their orders, information is available in supply base view for approval or scheduling. Supply bases can receives, approve, reject, hold and resubmit the customer orders. If customer demands some particular quay and that quay is not available on request date and time then supply base resubmit that work order for modification. Roles performed by supply bases on views are shown in figure 6-8.

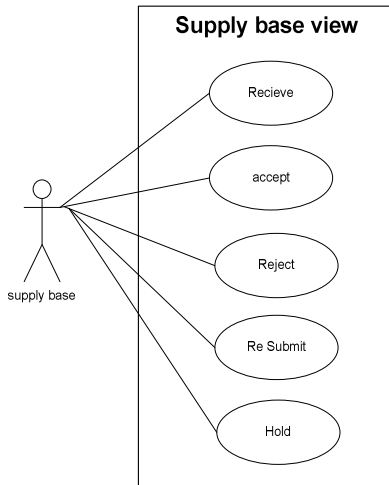


Figure 6-8: Supply base view roles

6.5.3 Quay status view Roles

Supply bases can view, create new schedule, update and delete the quay's information But Customer can only view this information while creating there orders. Supply bases can also

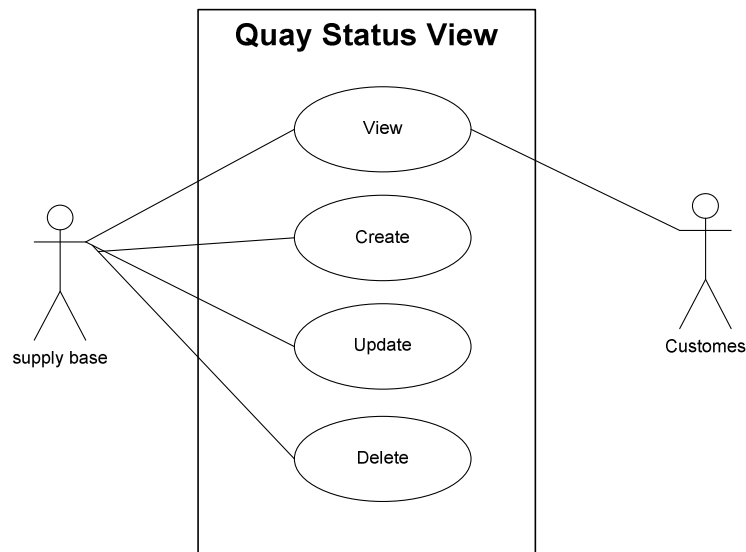


Figure 6-9: Quay Status View Roles

Access this information from supply base view to see the KAI schedule. This integrated information will help both the customers and supply base to make better plans.

6.5.4 Workers and Equipment Status view Roles

Only supply bases can have access on this view. While planning and scheduling customers orders they can view workers and equipment schedule on required date and time. This will help them in making better scheduling.

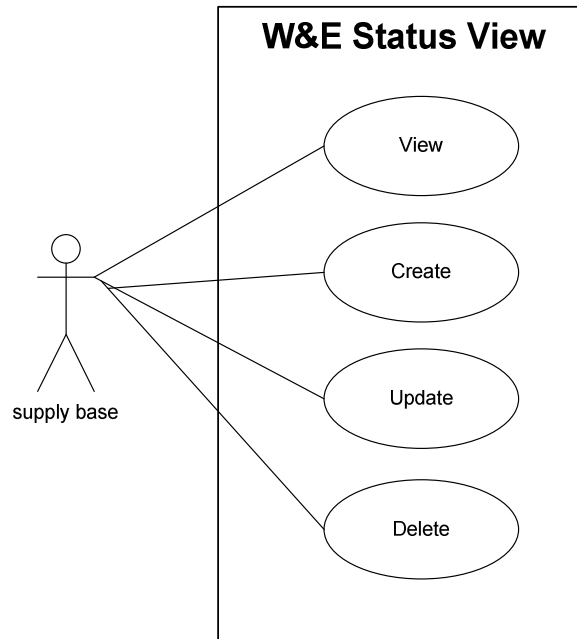


Figure 6-10: Workers and equipment status view roles

6.6 Challenges and Limitation

Supply chain partners are still not fully aware of information sharing benefits. Due to unawareness, they are unwilling to share their information. They do not trust each other and think that information sharing can be a disaster, if their partners misuse information providing to them.

We have identified the information requirements for quay allocation and planning process. This information is available in different information system applications. These systems are different from each other in terms of data format, roles and semantic integration. Integrating information from these systems is a big challenge.

Information system applications in practice across oil and gas industry supply chain are lacking in API's to expose their contents for different applications. Most of the

applications are based on commercial software. And software vendors are slow to provide support for enterprise mashups.

Security and privacy of contents on the enterprise mashup is also a very important challenge to handle. Who can access information, what roles one user can perform on the information available and stopping misuses of information are some of the related challenges. In case if some user misuses the information available will make it difficult for other partners to share information through enterprise mashup.

Quality of data contents available on the enterprise mashup is also a big challenge. It is very important to make it sure that contents available at enterprise mashup are in right format, correct and real time. Otherwise decisions made on the basis of information available at enterprise mashup will always be in doubt and discourage partners to rely on it.

The biggest challenge from our perspective is that who will manage this enterprise mashup. Who will finance, catalog information, support them, maintain them and fix them in case of problem. Manage and control by one player? Cross company team? This is a genuine challenge and important to discuss.

Chapter 7

7 Conclusion

The research presented in this thesis is part of an initiative to change the way information exchange across the supply chain. Here, we focus on the integration of information from different sources into a single view. The objective is to provide information integrated tool to decision makers, so that they can obtain required information from one point and can make better decisions in less time.

We began with a review of information as a key role in organizations planning and scheduling processes. We identified that information sharing is very crucial in collaboration across the companies. We evaluated current practices of information system applications across supply chain. We also analyzed the technologies available for integrating information from different sources. In our case-study we identified the information requirements for quay allocation and found that all required information already are available – but in different applications and owned by different members of the supply chain. We concluded that this information available in one place (or view) will improve the supply chain planning and scheduling process as well.

We then proposed a novel design of information architecture for exchanging information across the supply chain through “Enterprise Mashup”. Mashups are exciting interactive Web applications that draw upon content retrieved from external data sources to create entirely new and innovative services. This enterprise mashup is based on ReST to communicate with web or data sources. Data may be transmitted in XML format. This mashup will use a combination of both server and client side logic for data aggregation. We also present design for client web browser views on the basis of our information requirements analysis of quay allocation and planning process.

Convincing supply chain partners to open their systems for mashup will be big challenge. We have to ensure them that by sharing information with the adjacent supply chain partner will help to get better services in return. Organization should change their individual

thinking and start considering whole supply chain as one business unit. This will encourage them to consider other supply chain members as their business partners. Information sharing will help companies to provide better services to their clients. Willingness and trust need to be established amongst the supply chain partners to share information across the supply chain.

Applying the principal of mashup will help supply chain to work in more collaborative fashion. Under certain situations, trading partners might not wish to integrate their information – safety and privacy of information then becomes crucial to earning the trust of these trading partners.

In conclusion, this thesis outlines feasible and practical information architecture for this specific problem at Vestbase. The principles outlined in this thesis will for sure be implemented in many other businesses in the future. Our proposed architecture for this specific problem is easy to implement and very inexpensive as compared to other integrating solutions available.

Future Research

Today organizations are dealing with multiple autonomous information system applications. These applications are different from each other in terms of data format, privacy, authentication and semantic integration. We can conduct a research about “Implications of applying mashups with existing system applications”.

Business peoples are still not aware of how and where to begin with this tool. Understanding mashups and how to use the data is a problem. Future research should focus on developing better tools for businesses to easily create data mashups. Business world is lacking in mashup “Best practices”. We have to establish best practices.

Currently commercial software are lacking in support for mashups. We can quantitatively evaluate and compare the commercial software support for mashups.

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Appendix A: Database Design Model

Work order, resource allocation Work order detail Quay Allocation Ship statistics

Owen by Supply bases Own by customers Manual (No proper system) Shiplog

