Winter 12-4-2009

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Abstract

Product lifecycle management is a concept for managing product related information. Besides product related information decision-makers urge processed information of other types as well. A solution for managing this kind of business information is business intelligence. In this paper is studied how business intelligence framework could be utilized in the context of product lifecycle management in order to refine information for better decision-making. The study is based on theoretical findings of business intelligence as a solution for product lifecycle information management challenges. As a conclusion the paper points out how business intelligence, and especially business intelligence tools, e.g. data warehousing and data mining, are efficient way to refine information products in order to support decision-making.

Keywords: product life cycle management (PLM), business intelligence (BI), information product, data warehousing, data mining

Introduction

PLM (Product Lifecycle Management) is a systematic and controlled concept for managing product related information and knowledge, and products, taking into consideration the whole product lifecycle (design, manufacturing, using, maintenance, recycling and disposal -cycle) [1]. The benefits gained by using PLM in the different separate phases of product lifecycle are proved by many sources, but utilizing product information together with other information types (like customer information) sets challenges for the lifecycle management (see e.g. [2]). Combining information from different sources is also a remarkable opportunity for organizations, for example, combining historical information of maintenance to predicted customer needs would ease the decisions of product customization. Besides the importance of utilizing customer information during the whole lifecycle, utilizing information from multiple different operational sources and the sharing of information to support the decision making are emphasized from product lifecycle management point of view.

In today's highly networked business environment, various business functions are dispersed throughout different business units that many times cross organizational boundaries, forming complex and volatile relationships [3]. Product data management (PDM), and applications and functions, like enterprise resource planning (ERP) and customer relationship management (CRM), urge for a large amount of data, which presents many challenges to organisations' information gathering and sharing [4]. Products generate large amounts of information through life cycle. There are several possible viewpoints to issue, e.g. intra organisational, extra organisational and life cycle viewpoints. Common themes to those views are the amount of information, crossing boundaries, form of information and collaboration between different phases of product lifecycle.

The purpose of this study is to find out how business intelligence framework could be utilized in the context of product lifecycle management in order to refine information for better decision making. The study is approached through theoretical consideration about central information management- related product lifecycle management and the challenges it faces and brings forward. One useful solution for problems of information management in PLM is business intelligence, especially BI solutions e.g. data warehousing and data mining. Based on the theory the study is expanded to consider the practical examples of PLM and BI complementing each others. These practices are studied from the business intelligence perspective. The main contribution by this study is to see how PLM information or PDM can be refined through BI process. Contribution is mainly theoretical, yet there are some empirical findings too. Authors seek to find new lines in the field of PLM research. Aim is to provide non-conclusive results.

This paper points out how information products could be processed from organisations' operational systems to serve the information management in PLM. The research also indicates what type of business intelligence solutions could be utilized to ease the information management in PLM. The key finding in the paper is that business intelligence framework is a useful and novel concept when managing product lifecycle information. Especially, when sharing analyzed information to decision makers through different phases of product

lifecycle. The paper gives, in addition to descriptive results, some practical points how BI can leverage PLM process.

Generation of product lifecycle information

The ultimate goal in managing product lifecycle information is to control and steer product-related information creation, handling, sharing and storing during the whole life cycle [1]. Managing product information is challenging, like stated above. One reason is the variety of the length of product life cycles within in the individual organizations. For example, in car industry product unit's life cycle is generally longer than life cycle of product model, while in some services might be consumed in shorter time than the life cycle of product models are. In both cases demands for information management are exacting though the life cycle differs. In services the need for information is rapid and more ad hoc while in longer life cycles the accessibility of information years hence is relevant. Stark [5] elicits also challenges like large volumes of data, globalization, mass customization and personalization, knowledge management, new customer requirements, and the variety of different information system applications that all affect to the modern-day product and onward to containing the whole lifecycle.

Though the focus of the paper is on the challenges concerning the whole lifecycle it is essential to understand how product lifecycle is formed. Despite the variety of duration of product life cycles within in the individual organizations some equal phases of product lifecycles can be found. These phases are presented in the figure 1 which is one model of product lifecycle (c.f. [6]). The distinguished phases are design, manufacturing, packaging and distribution, use, service and maintenance, reuse and recycling and disposal. As concluded from the phases there could be many interfaces during product life cycle. For example, companies that manufacture mobile phones have multiple numbers of clients and many different interfaces to suppliers and subcontractors, but companies that prepare paper machines typically have only few clients who participate intensively in the whole manufacturing process.

As stated above, information is generated in each stage in product lifecycle. Information consists of two information modes. The first mode is related to product, i.e. how it is designed etc. The first mode can be documented in order to be passed forward or backward in life cycle, but some of it remains undocumented in each stage. First mode information accumulates in

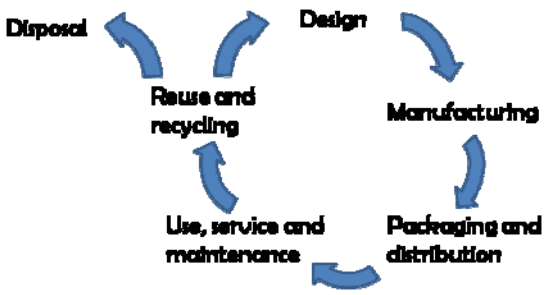

Figure 1. A Product life cycle (c.f. [6])

organizational depositories, yet some of it is remitted to earlier stages. Second mode of information is local, i.e. it is generated in each stage and there is no indented way to pass it forward or backward. In either modes information can be product-specified, life cycle specified or metadata that describes product or life cycle information.

Challenge to information management is how put up a setting that allows efficient analysis of both information modes. Despite of the type of the mode amount is the most obvious challenge. Efficient information management requires depositories, information structure and analytical tools. Different boundaries challenge at least migration of information. Boundaries can be organizational or system related, but if there are difficulties to return or pass forward information the leverage of information management is compromised. Putting focus on efficient product lifecycle management also collaboration between different lifecycle stakeholders is required, therefore form of information and metadata are also important.

In practice challenges occur especially in discontinuation. Discontinuation in organizations causes loss of relevant knowledge, and begets urge for information in order to resume knowledge. From the customer perspective discontinuation can be caused e.g. by change in clientele. Change in clientele puts focus on information value chain and information mediating practices. If there is no shared context for mediating information e.g. same information systems or unitary information boundaries, information cannot be mediated or it is costly. Problems caused by impotent or inefficient product information management affect also the "real" product process. For example, if critical information on use of a machine is not supplied to use, service and maintenance –phase critical and costly errors may occur. Another example is that if end users cannot give feedback to design phase, suppliers' competitive advantage is in jeopardy.

It is obvious that other information than just product-related information is generated during product life cycle. According to Kalakota and Robinson [7] organizations need to continuously observe customers, suppliers and markets, and to combine the relevant business information to data

from their existing and potential customer depositories to invent added value to their offerings. According to Sääksvuori and Immonen [1] and Stark [5] product lifecycle management is one solution for managing the information related to organisations' offerings. But Stark [5] continues by saying that PLM is just product-focused, not the customer, or the supply chain, or the organisations' information systems. Still, one important reason for managing business information is the linkage of the collected information and the business-critical systems and processes like ERP and CRM systems and also the tools to process the information. It seems that managing product lifecycle information needs a process alongside to manage the whole business information.

Business intelligence framework

Business intelligence (BI) is a one solution for managing the business information. Many authors, like Pirttimäki [8], define business intelligence as a dualistic concept. The concept refers to the refined information and knowledge, and the process. According to Pirttimäki [8] refined information and knowledge means information about organisation's business environment, an organisation itself, and its state in relation to its markets, customers, competitors, and economic issues. The process, on the other hand, "produces refined information and knowledge (information products) for the management and decision-makers". To put it brief BI can be defined as a framework for refining information to knowledge and a framework for refining data masses to information products utilized in operations and decision making.

Business intelligence is a wide concept which takes into account other viewpoints beside those related to product information. Business intelligence could be divided to fields like customer intelligence, marketing intelligence, competitive intelligence and counter intelligence [9] [10]. Competitive intelligence is the closest term if compared to business intelligence. It is continuous scanning of the environment, collecting outside information about competitors' strategies, customer or supplier activities and market changes and analyzing information to provide refined information, information products, to decision-makers (see e.g. [10] [11]). Customer and marketing intelligence, on the other hand, refer to management of narrower type of information, like product information. Counter intelligence is about preventing other organizations to gather and collect intelligence of our organization [12].

Business intelligence does not have generally accepted conception and, besides above mentioned definitions, sometimes it has divided to discuss either organization's internal or external information. However, in this study the concept of business intelligence does not refer just to internal or external information, and neither to any specific information type. BI refers to the processes, techniques and tools which support faster and better decision-making. The main task of business intelligence processes and activities is to refine, analyze and manage large amounts of information related to business and business environment and provide the decision makers the easy access to processed information. Processed information is various types of information products, e.g. monthly sales reports, analysis of organisations' market situation, analysis of customer needs, and information about subscriptions, product configurations and after-sales activities.

Business intelligence is a process which reduces the need of analysis and ease information sharing. An example of BI processand its phases is seen in the figure 2. Figure is based on many different sources, like Vitt et al. [13], Vuori [14], Gilad and Gilad [15], Choo [16]. The framework takes into account the both views stated above: refining information to knowledge and refining data masses to information products.

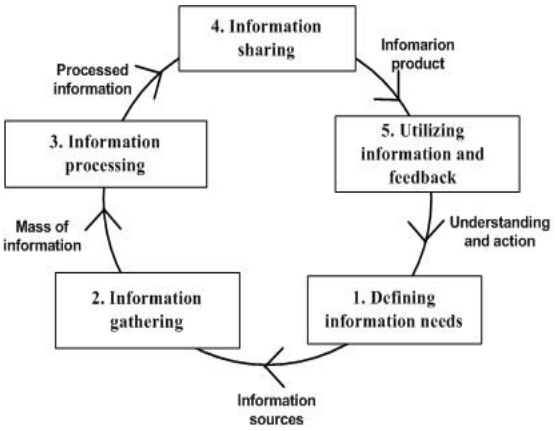

Figure 2. Business information process

The process starts with definition of information needs. Information needs composed of changes and uncertainties between organisation's industry, strategy and operational environment have to be defined so the needs can be satisfied as well and efficiently as possible. Decision-making seek information and knowledge but false and unless information just harms decision-making. It is important to find out the proprietary information, focus on gathering, analyzing and sharing it in right form, to right people in right time.

Based on the definition of information needs the specified information sources act as a foundation for gathering the expedient information or data. Organisation's information sources can be external, like competitors and customers, or internal, like operational databases. Based on scale and range of

needed information organizations must decide how tightly they want observe for example changes in markets or behavioral of customers and store the results to organisation's depositories. From the perspective of product or life cycle information there is large variety of data or information sources. Each phase of lifecycle produces relevant, and especially irrelevant, information. Challenge is how to refine most essential out of relevant information. Moreover, each phase has unique requirements for type of information, e.g. design has different need compared to aftersales.

After information gathering the information must be analyzed and processed to some compact form. Collected information (mass) is assessed and connected to information that is already known. Analyzed information is formed by utilization of business intelligence solutions. During the phase information is generated to form of information products which are equivalent to needs of decision-makers. Though, existence of information and information products is not enough. To achieve decision-makers, information must be shared to satisfy the needs of decision-makers. For instance, sales needs detailed information on product versions to be passed forward to customers. Opposite information flow from customer needs to reach manufacturing and design as if there is something to be developed.

Information gets its final meaning when it is utilized. In the final phase of business intelligence process information is adapted to practice in problem solving and decision making situations. By utilizing information and knowledge is formed new information and understanding, and by adjusting operation of organizations the business intelligence cycle starts over. Business intelligence must be in connection with organizations other processes

Common for all processes made by above mentioned authors is the result of the processes. The purpose is to produce insights, visions and knowledge for decision makers. In this study the authors emphasize the meaning of information products. Information products are the key elements of sharing relevant information for decision makers. Examples of information products are regular reports and announcements of organisation's market situation, analysis of product offerings, strategic analyses of competitors and organisation's intranets. Information products are important means in information sharing but they also act as information sources. Typical characteristics for good information products are ease of use, relevance of the information, flexibility and time and cost savings. The greatest benefit of information products, and of utilizing business intelligence, is gained when the right and qualified information is delivered for supporting decision-making [17].

Business intelligence must be connected to other business processes of organisations, because by separating it from every day operations high quality information, information products, do not bring value to decision-making. In the business intelligence process described above, data warehouses and the other tools, for example mining and analyzing tools, are in essential part in getting the right information to the right people. The tools, such as data warehouses, support the different stages of business intelligence as efficiently as possible. The tools are a part of the business intelligence process in which the data and information are processed into knowledge and intelligence based on the needs of the decision makers. Some authors, like Turban et al. [18] define business intelligence as an umbrella term that combines different tools, applications and methods.

Business intelligence tools in refining product lifecycle information to the form of information products

Nowadays business managers come face to face with the problem of having less and less time to make rational decisions with the over-abundance of the information available in various sources. BI solutions, e.g. search and reporting systems, online analytical processing, executive information systems, data warehousing and data mining, enable sharing the relevant and analyzed information through the product lifecycle for the whole personnel at the right time and at the proprietary way. Myllärniemi and Väisänen [19] indicate that organisations have needs to allocate the resources for facilitating information availability in decision making. There are also many examples in literature about different successful BI-solution implementation where organisations have gained remarkable benefits by allocating resources to support decision making, (see e.g. [18] [20] [21] [22]). Based on the literature the collaboration of concepts of product lifecycle management and business intelligence are not widely studied though, business intelligence as solution for resolving challenges of a single phase of product lifecycle is. In this paper, however, business intelligence is discussed as a solution for the challenges related to whole product lifecycle information management pointed out earlier on the text.

It is obvious that decision-makers need to know what their organisations' problems are and what actions they need to do to solve those unwanted situations. But more important than to know what has happened is to know what will happen next. The evolution of business intelligence tools supports this kind of shift from reactive decision-making to proactive one. The evolution is from query and reporting towards data mining [23]. Efficient utilization of data mining tools coupled with

utilization of data warehouses, i.e. data warehousing, allows correctly and efficiently use of data to support organisations' decision-making.

Data warehousing is a collection of different decision-supportive systems that help managers to structure and analyze this information better in order to make better and faster decisions. Data warehousing is based on the use of data warehouses (or databases) and a series of different tools to provide the right information for the decision makers [10]. While data warehousing contains the whole process of data handling in the organizations, data warehouses are more like repositories of data; solutions for many organizations for managing and storing their collected business information. Manning [24] describes data warehouse as a repository of current and historical data of potential interest collected from various sources for the purpose of providing management information.

It is important to notice that the data warehouses need to be capable of providing the data in an understandable form to various front-end tools for reporting and analysis. As stated above, data warehousing is more than just technical aspects of databases. Continental Airlines is an illustrative example of how both organizational and technical aspects of data warehousing must be taken into account when talking about successful data warehousing solutions. [21] Their real-time business intelligence solution implementation, which in their case was strongly related to data warehousing, has gained global visibility and recognition. Another good example of successful data warehousing implementation is Wal-Mart's Collaborative Planning, Forecasting and Replenishment (CPFR) model [20]. The CPFR model allows Wal-Mart to share data and analyze it in collaboration with their suppliers providing added value to their supply chain management processes. These cases, among many others, support the importance of data warehousing in processing information products, and thus, our paper. Especially, the Wal-Mart case indicates data warehousing as a solution for breaking the boundaries between organization and it partners. More potential benefits of data warehousing is proposed by Watson et al. [25] and Myllärniemi & Väisänen [19] which are similar to characteristics of information products:

- Time savings for data suppliers and system users
- More and better information
- Better decisions
- Improvement of business processes
- Support for the accomplishment of strategic business objectives
- better information faster
- combining data from different sources
- ability to make the right decision
- focused resources

From data warehouses the information is processed to the decision makers mainly by using information processing methods like OLAP and data mining [19]. OLAP is a fast, intuitive to use and easily decipherable ad hoc method enables users to create on-demand reports and queries [26]. It is one of the most commonly used information processing method among organizations, but it is not as analytical tool as, for example, data mining. One theoretical advantage of data mining over OLAP is the fact that the analyst does not necessarily have to have any kind of prior knowledge about the data. Still, the previous surveys indicated that managers prefer to conduct information processing with a more "human touch" instead of computer-generated algorithms. This calls for more flexible ways of viewing the data.

Earlier studies [19] [17] suggest that organizations are shifting from traditional information analysing methods towards faster and more multifunctional and -dimensional analysing tools, like data mining. Data mining is a process that utilizes statistical, mathematical and artificial intelligence techniques to extract and identify useful information from large databases. Data mining tools look for hidden patterns that can be used to predict future. [26], [27] It discovers previously unknown relationship among the data. For example, While OLAP answers only to questions you are certain to ask, data mining brings answers to unpredictable questions; to questions you would not think of asking [26].

Data mining tools and techniques are used to reach better understanding of customers and organisations' own operations [26]. The point is to analyze massive amounts of data, for example customer information, to find out customer behavior and to identifying new products and features [28]. As a result of this kind of activity is mode of information, information products, that organizations apply to new customers, products, services or transactions to better understand how they should respond to them [27].

Data mining has been found useful in retailing and sales operations but also in manufacturing and production phases [26]. In the following cases of Credit Suisse and Highmark, Inc. data mining is utilized in forming information of organisations' fairly large customer-related databases. Credit Suisse used data mining methods to determine their customer value and product buying probability. By data mining methods they generated knowledge about their customers buying a certain core products. This knowledge they utilized in product marketing campaign. [22] The success of Credit Suisse is based on utilization of data depositories and actively gathering the customer information. In Highmark,

Inc. case the use of data mining methods relates to the even massive amount of data gathered from their clients. Highmark, Inc. is a health care organization that exploits data mining in
analyzing patient data for achieving cost savings and efficiency to their operations. [18]

When using data mining tools, or any other business intelligence tool, the absolutely value is not the location of used information. The most important is that the processed information supports decision-making. Decision-makers need relevant, real-time and coherent information like in the cases described above.. In PLM concept the emphasis is on product information which narrows information sources and, thus, scale of information. In BI process information is processed by utilizing information from internal and external sources, like stated above. This is one of the most remarkable benefits of business intelligence compared to product lifecycle management; the information is not local. In the next figure information sources are linked to product lifecycle concept by utilizing business intelligence process. The figure summarizes the idea of the paper of linking business intelligence to product lifecycle management.

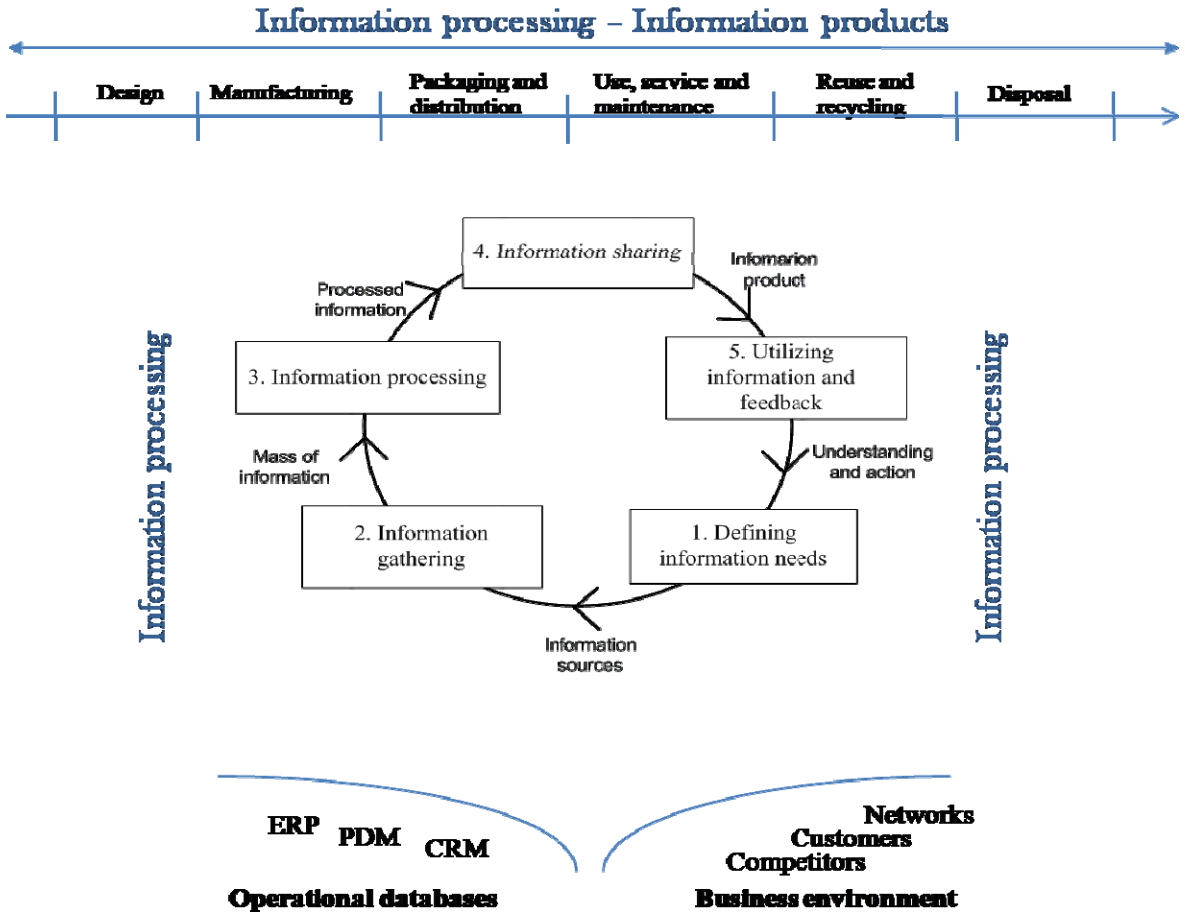

Figure 3. Information processing in product lifecycle concept

Based on the discussion of the paper, it could be said that in traditional product lifecycle information management, for example, CRM is only concentrated to collecting information from phases like services. In this framework business intelligence is spread to all organization levels to contain the whole lifecycle. Information is processed in two levels: it is processed from operational databases, like PDM, and from business environment to support decision-making in phases of product lifecycle, but it is also processed from one product lifecycle phase to another. As a result from information processing, either from the depositories or between different phases, is an information product. Information products enable not just top management but also lower-stage employees to access and manage information. Business intelligence is a solution for transferring information from, for example, CRM systems to units that traditionally are not supposed to use that kind of information. Information products are expression of how information process, like BI process, is linked to product lifecycle management. Information product

can also seen as aided sense-making, i.e. analysis is already done.

Conclusions

Based on this research, it is obvious that business intelligence could leverage product lifecycle management. Especially, BI tools, like data warehousing and data mining, could offer remarkable benefits if compared to traditional product information management, for example, BI tools enable multiple ways to analyze and, more important, to process information. On the other hand, the tools enable sharing information products across the lifecycle. The tools discussed in this paper are not just for gathering and processing data and information for the needs of historical reporting. For example, data mining could be used in forecasting and simulating future potential.

As a conclusion, it could be stated that utilizing business intelligence tools organizations could integrate information management processes, like business intelligence process, to their lifecycle management. Besides product information, organizations generate multiple other types of information that need to be processed and shared to the all phases of product lifecycles. As a result of business intelligence processes information products are the expression of this integration. Information products minimize discontinuation and migration of information.

Though the concept of business intelligence is emphasized lately and organizations have recognized the benefits business intelligence could offer, it is not a novel concept. Organisations have always gathered information about customers and products and used it for refining their offerings. But by more effective utilization of, for example, business intelligence tools, organizations could get more relevant and coherent information for decision-makers.

This paper presented the results of a theoretical study for future empirical researches about linkage of business intelligence and product lifecycle management. This study described how business intelligence framework could be utilized in the context of product lifecycle management in order to refine information for better decision making. This research brought up the issue of the underlying potential of data warehousing and data mining in product lifecycle information management. Though the study was mainly theoretical, the results show that there is a need for a larger research. The results indicate that the business intelligence and the tools are efficient in refining information and forming information products. Especially, in organizations where challenge is to process information from gathered data masses in order to, for example, provide better services to clientele utilizing business intelligence is a solution. The results motivate for a more pragmatic study of connecting these two concepts together. In further studies the authors aim to study how Finnish manufacturing companies actually use information processing methods in a product lifecycle management concept, and how business intelligence tools could intensify the forming of information products.

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