Proceedings of the 9th ASME Engineering Systems Design and Analysis Conference
ESDA 2008
July 7-9, 2008, Haifa, Israel

ESDA2008-59477

AN APPROACH FOR AN AUTOMATED AND MARKET-DRIVEN OPTIMISATION OF PRODUCT RANGES AS PART OF THE PRODUCT LIFECYCLE MANAGEMENT (PLM) FRAMEWORK

Christian-Andreas Schumann*
Institute of Management and Information
christian.schumann@fh-zwickau.de

Andreas Rutsch
Institute of Management and Information
andreas.rutsch@fh-zwickau.de

University of Applied Sciences Zwickau
Dr.-Friedrichs-Ring 2A
D-08056 Zwickau, Germany

ABSTRACT

From the perspective of systems theory, looking at a defined product range of a company, it is possible to describe the main influences as well as restrictions from the market on it. After figuring out, which of those variables are specific, measurable, attainable, realistic, and timely, there is the potential to create sensed values for a "market-driven optimization of product ranges"-feedback loop. The controller of the circuit affects the reference to become the optimal product range for the customer. Therefore a second model or subsystem is needed, which commits the optimum product range in respect to economic interests of the quoting company. Changes in market demands will have, under the restrictions of intra-corporate economic targets, direct effect on the product ranges. Prior achieving that interlinking between market and product, the controller and its functions need to be determined. Rules have to be developed and evaluated in relation to proper feedback on market demands.

The whole system will be prototypical implemented based on an integrated enterprise information system, including Computer Aided Design (CAD), Product Data Management (PDM), Part Management (PM), Enterprise Resource Planning (ERP), and E-Commerce (EC) subsystems. The feedback loop stated, will be the core of the system in the PLM framework. The main impact of the loop will be on the product data model, especially its requirements to definition.

INTRODUCTION

The decision to enter new markets or sales channels becomes relevant for more and more final manufacturers. The general conditions, they have to cope with, especially in the electronic markets, are totally diverse from the common channels of sales. The achievement of process optimisation and improvement in total process time by using electronic markets should finally lead to shorter times of delivery. Today this corollary is mostly disregarded and therefore not implemented in business concepts of final manufacturers. Reducing lead times while getting orders via electronic sales channels is a crux for almost every manufacturer, especially in job order manufacturing, because so far there is no connection between electronic order, job entry, and job handling to shorten lead times. The total process time for an electronic order is only reduced till it is placed and hence limited on customer's processes. To come up with an approach in changing the described state-of-the-art is the aim of this paper.

PROCESS APPROACH FOR THE FURTHER INFORMATION SYSTEM DEVELOPMENT

The growing complexity of the business relations and procedures, generated by increasing internationalisation, division of labour, stress of competition and costs, in a globalised world forces the management to orientate itself to the optimisation of the total process instead of improving parts of it. [1] This kind of orientation requires modelling, analysing, and realisation of the entire business process. The enterprise informatics is compelled to fulfil the needs of the whole business processes, which are composed of a sequence of activities serving the generation of products or services. The consequence is to reconsider the enterprise processes fundamentally and to redesign the main processes radically.

* Professor and author of correspondence

The method is called business process reengineering. [2] The sequence of the processes begins with the relation to the customer and will end with the satisfaction of his needs. The holistic view of the business processes includes different kinds of sub-processes such as customer-related, product-oriented or service-oriented processes. [3] In the last years with this in mind several strategies and concepts such as supply chain management, Customer Relationship Management (CRM), and total quality management were developed. All the new approaches zero in on the improvement of the main processes including order processing, order-to-payment procedures, product development and marketing, controlling and enterprise development. Thereby, the information technology is the key driver as supporter, integrator, and enabler in this framework. [4]

The business strategy determines the global framework such as enterprise structure, business fields, and operating area. The process management defines the organisational units, the business processes and their performance. The information management services and supports the processes in detail. [5] The management is enabled to use the resulting form of e-business for the further integration of processes as well as information systems. One form soars up to the business intelligence defined as integrated, firm-specific, IT-based, holistic approach for the business decision support service. [6]

Other related developments generated by the new process view lead to

- integral information management, which focus on the development of integrated information systems, [7]
- information management systems including the perspective of the integration of marketing, manufacturing, financial, and human resource information systems, [8]
- company-wide data management concerning the development of consolidated information resources for the enterprise, [9]
- and the customer knowledge management as an anticipation of the future changes. [10]

The methods of the process-guided development of information systems are based on the mentioned process reengineering of business processes as well as information systems. They are characterised by the sequence of process analysis, process redesign, process safeguard, and process implementation. [11] The future information system architecture will be increasingly dominated by the design of complex and integrated enterprise processes. That is why, new concepts, for instance of product development, are characterised by highly integrated electronic means, methods, and procedures. In this way, customers are incorporate in so-called communities of practice to increase the product value of their customers. [12] The main idea is to customer-centralise all processes and applied information system utilities in order to generate user innovation for extraordinary user product value. [13]

User interfaces in the e-business environment, which serve as windows of market access, are the conclusion. The customer should get the chance to realise an optimised access to the product innovation, its development, product administration, and product distribution by integrated information and data system solutions. Along the first part of the product lifecycle, from the product design to the product provision, the customer needs an integrated system of subsystems supporting the holistic processes. It follows that the information system integration is increasing enormously. That will lead to a coordinated and modular architecture of products, processes, and organisational knowledge. [14]

E-COMMERCE AND ITS INFLUENCE ON NEAR-TERM PRODUCT DEVELOPMENT

The globalisation influences the technological change and the spatial organisation of the economic activities [15] of large-scale companies as well as increasingly of Small and Medium sized Enterprises (SME).

E-business concerns the development as well as the partly respective complete support, processing, and maintenance of performance exchange processes by electronic networks. Those processes are procedures including the transfer of material and immaterial goods and services into compensatory accounts. The main objective of the performance exchange processes from the viewpoint of an organisational participant is the sustainable yield bringing performance creation. [16] E-commerce is, beside e-information, e-education, e-communication, and e-collaboration, a subset of e-business. It concerns performance exchange processes of development, brokering, and conclusion of commercial transactions among business units by electronic networks. [16]

The main objectives of e-commerce are the increase of efficiency, the decrease of costs, and the user-friendliness of any commercial transaction. EC is an interesting alternative especially for SME with limited resources for the opening of new markets to improve the market access on different ways. [16] But EC is also a tough challenge due to high expectations especially with respect to lead times. E-commerce should finally lead to more customer impact on the up-to-date near-term product development.

E-commerce is often underestimated in its impact on old-fashioned commercial operations. So many companies are fatally wrong in facing the e-commerce challenge not until they participate in electronic markets. Especially the SME are characterised by a huge backlog in the recognition of the actual market situation. The conditions of the producer, the market, and the customer are essential for defining an e-commerce strategy. The star role approaches the key accounts. The e-commerce strategy should adhere to the specific conditions of the key accounts. Respecting arbitrage it is important to define different EC approaches depending especially on the interaction in pricing of neighbouring regions.

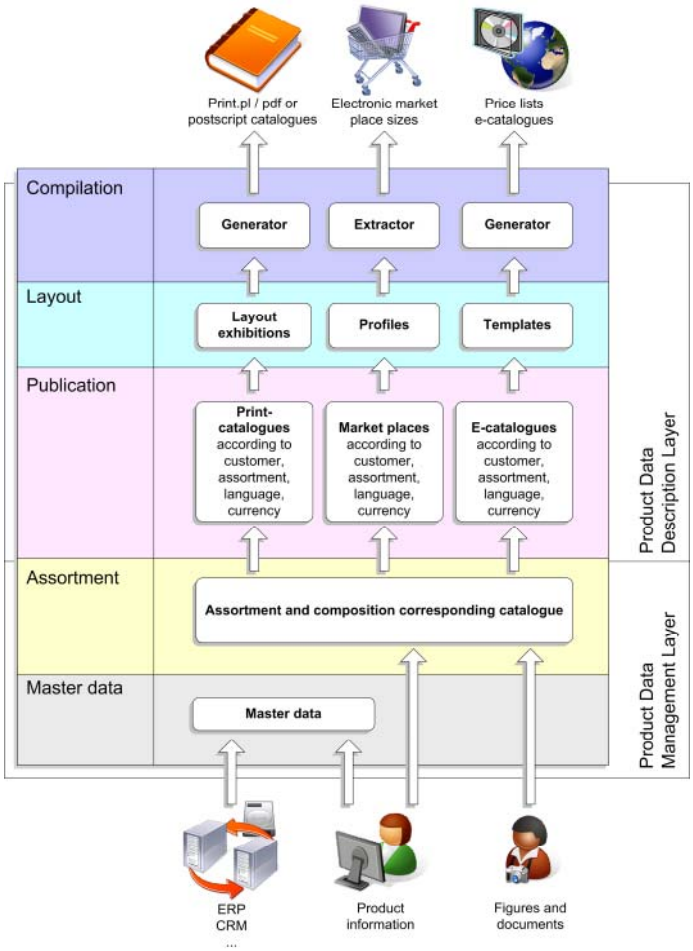

Figure 1: A multichannel e-commerce architecture

Therefore the development of a product-oriented information system must also include an integrated data and information management for multichannel e-commerce systems (Figure 1). It is essential in consideration of the international competition to close the gap in EC strategy by the SME.

CONCEPT FOR CONTROLLING THE EMERGING COMPLEXITY BY INTEGRATION

Each enterprise needs a general concept for the provision of the right data and information, supporting electronic and non-electronic commerce activities. [17] The concept has to consider a wide range of commercial activities, methods, and tools. Typically, it includes catalogue data demands, customer intranet access specifics, and e-shop requirements in the form of data supply. Those are mainly presented as one-way, a passive kind of customer support via prepared, static data descriptions.

Another, more complex case is the use of product configurators. They include the customer-related design of the product configuration and as a result the dynamic change of the data and data structures. If the producer offers customer-depended manufacturing of products as unique specimen, he has to organise an active, bidirectional linking of the information and data flow between the enterprise data sources and systems, and the commercial support systems. The product configurators support capabilities such as guided selling, guidance of the user to recommended options, presentation of alternative features and options, constrained choices based on compatibility rules, display of price, lead time and availability, support of complex calculations and access to engineering algorithms, etc.. It is necessary to develop a network concept of data exchange between the data source systems and the distribution channels.

There are different classes of data sources and data source systems. The first and main class is the product data master class. It implies the product description by product attributes and behaviours. Usually, the source systems are product describing systems such as CAD systems and animation systems in interaction with sub domains of the product management systems such as ERP and PM systems. The second one is the product data relation class. It consists of the description of the assortments and compositions of groups of products configured for special application cases. The data sources are available in correspondent systems such as sub domains of the PM systems, ERP systems, and product configuration systems.

The concept of a multichannel solution for the e-commerce is based on the multi layer architecture. The two kernel layers for the multichannel e-commerce sources are the PDM layer and the product data description layer. The PDM layer contains the integrated data base as a single product information source and should be media-neutral. [18]

It can be realised as a centralised data base system or as an integrated, distributed data base system. In any case it should have a unified data base management system. The PDM layer is linked to the main enterprise information systems such as ERP System, CRM System, various Computer-Aided Systems (CAX), Controlling System, etc. by special interfaces. The product data description layer involves the different opportunities for publishing product data as customer information.

In principle, the part management and the related PDM systems are able to support the unidirectional as well as the bidirectional exchange of data from the data source systems in the enterprise to the commercial support systems. Recently, the problem is the availability of the required interfaces for bidirectional data exchange of the software packages in practice. The problem is that the prevalent unidirectional data flow is only appropriate for the quasi static data support of multichannel e-commerce systems. It allows only the variation of e-commerce data set in the framework planned ahead by the sales management and realised by using the links to the data sources as well as the media-neutral data base for the multichannel e-commerce.

The effort of offering the customer a wide range of options, alternative choices, and related short lead times usually requires bidirectional relations between the data source systems of the enterprise, the PM and PDM systems, and the

multichannel e-commerce system including special applications such as product configurators. The task is much more complex but enables the sales management of the enterprise to achieve better competitiveness in customer-dominated markets.

ONWARDS AN INTEGRATED CORPORATE INFORMATION SYSTEM

At first, the data supply of the customer by the e-commerce system takes place by a unidirectional information service with quasi static data structures. If the customer changes the parameters over the available limits, the e-commerce system will need the access to more data in the required context and volume enclosed in the enterprise internal data layers and sources. The establishment of a dynamic interaction loop between sales and product data support is needed to better fulfil the fluctuating customer demand. [19]

Recently, SME have usually neither a multichannel e-commerce system nor an integrated enterprise information system and more than ever no complex solutions for the bidirectional, dynamic data exchange between the data source system and the sales system. The result of analysing the state-of-the-art on behalf of a company as a European market player was the description of the important e-commerce channels. Data source systems including CAD and ERP were located. The current status was listed in a data source and flow map. It is the prerequisite for the replacement of the auxiliary solution by implementing a PM and PDM system. The existing inhomogeneous classic as well as IT-solutions for the distribution have been replaced by an integrated system as follows. [9] [20]

Figure 2: Laboratory architecture

The knowledge about the different internal and external data requirements, layers, systems, and sources was the basis for developing a model for an integrated approach. Several related functions and systems were involved in the integrated information system. The basic layer is dominated by the data source systems such as CAD and ERP, the intermediate layer is shaped by the PM and PDM systems, and the outlet layer will be characterised by the multichannel e-commerce system. [21]

Based on the international state-of-the-art a first step, by using standard software and data base systems, onwards an integrated corporate information system has been made. A laboratory (Figure 2) at the Zwickau Institute of Management and Information has been set up. While a nearly complete set of corporate information systems is implemented, one of the first conclusions of research was just to use a subset (Figure 3) to reduce the complexity of the system. The ones not taken into account in the first place will be included within the future steps of research.

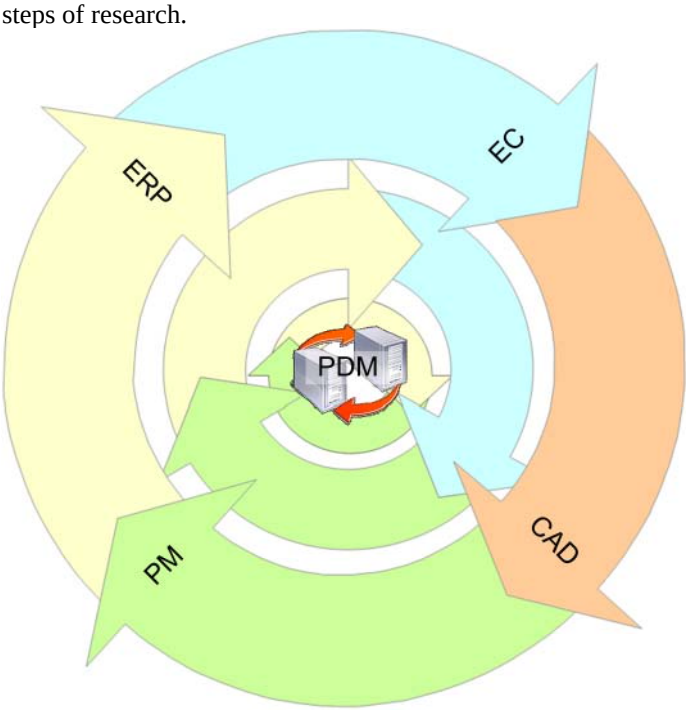

Figure 3: Steps of research and implementation

The elements of the inner loop (PDM, ERP, and PM) are used in the primary step, because they include the main functions needed to design a proprietary feedback loop.

THE INNER LOOP (FIRST STEP)

The catalogue software eCATALOGsolutions from CADENAS was used to create a Sales Product Data Model (SPDM) which includes geometric as well as product information data. The model is packed in a configurator to give the customer some scope for design. A plate is used as a sample which could be selected from different default dimensions. In Addition the customer has the opportunity to position a specified quantity of through-holes on the plate's surface. The through-hole represents one to-be defined machining feature known from

ISO 10303-224:2006. After the SPDM is defined it is made available for the customer within PARTsolutions. The customer can create a configuration which satisfies his requirements. After doing so a bill of materials (BOM) is generated. It consists of the to-be treated part (e.g. plate) and the defined through-holes also mentioned as single positions. The description of the through-holes in the BOM gives a clear understanding where the holes need to-be positioned for production.

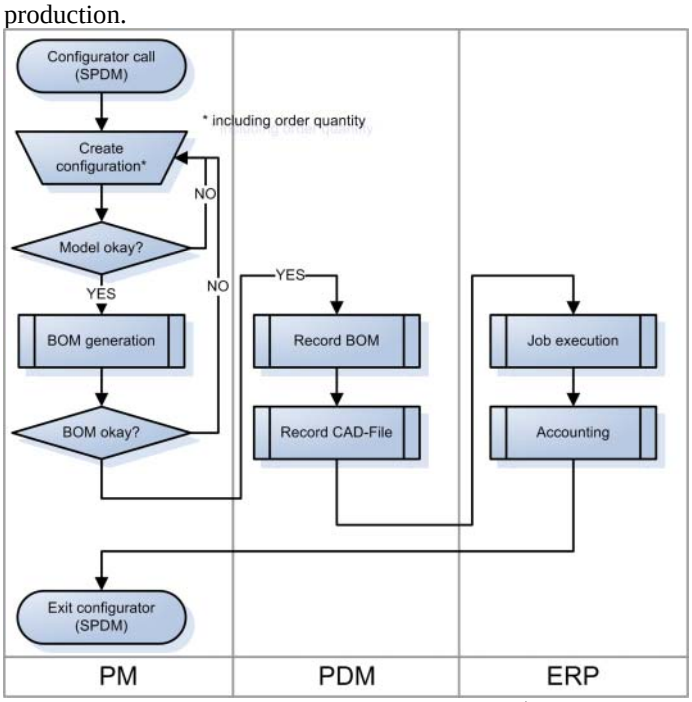

Figure 4: Unidirectional flow-chart (1st step)

After the customer deployed the order within the PM-system a routine saves the BOM customer-related into the PDM data base. Normally in this procedure an e-commerce or shop-system should be involved, for instance to handle customer information and access. This should not be the case in our primary step of evaluation. The evaluated PM system offers also the opportunity to save the configuration being made in different CAD-formats via native data export. The drawings now available for production enable to think about more complex machining features to-be defined by the customer for future configurators.

Primarily based on the BOM and the included order quantity the ERP-system initiates the costumer-based job execution in the production. Also the customer data passes the interface and is ready for accounting. Job execution in an automated way is possible, because the ERP system knows the through-hole as a material position. This position is directly linked with the corresponding resource (drilling machine). This static chaining will be replaced in the next steps.

A summary of the order process mentioned and achieved so far is shown in Figure 4 as flow-chart.

The first part of the inner “market-driven optimization of product ranges”-feedback loop has been created. The next challenge is in getting a direct feedback from the ERP system into the SPDM, initially defined at the setup of the system. Economic metrics have to be evaluated or defined, which affect the loop primarily in relation to cost optimization of the production involved. Closing the first or inner loop by implementing bidirectional interfaces provides the basis for the next step. It contains the implementation of a new customer interface in the form of an EC system. The EC system offers the opportunity to gain more customer-metrics beyond the SPDM. Those metrics are known as e-metrics. [22] The SPDM could be deeply optimized with respect to customer requirements using SPDM-customer data (a selected order) and e-metrics in the first stage of expansion of the loop or system.

SUMMARY

The e-commerce scene of SME will be dominated by integrated enterprise information systems in the near future. It is necessary to analyse and describe the business processes and models of the future e-commerce scenarios for SME. Their requirements influence the planning and design of the information flows and data support systems strongly. Especially, the use of PM and PDM systems as intermediate connectors in integrated enterprise information solutions will enormously increase within the next years.

This is the only way for SME to preserve the competitiveness in the procedure of dynamisation and globalisation. The unidirectional solution is implementable by the existing standard software and interfaces. The bidirectional, dynamic data flow requires add on activities for completion of the available systems enabling the directed access of multichannel e-commerce systems to the enterprise data sources in integrated information systems of SME.

REFERENCES

[1] Grebenstein K, Schumann CA et al (2003) Globale IT-Infrastruktur für die interkulturelle Kommunikation. In: Bleich S (ed) Kommunikation in der globalen Wirtschaft. Lang, Frankfurt am Main

[2] Richter-von Hagen C, Stucky W (2004) Business-Process- and Workflow-Management. Teubner, Wiesbaden

[3] Wilhelm, R (2007) Prozessorganisation, 2nd edn. Oldenbourg, München

[4] Melzer-Ridinger R (2002) Online-gestützte Geschäftsprozesse. In: Pepels W (ed) E-Business-Anwedungen in der Betriebswirtschaft. Neue Wirtschafts-Briefe, Herne

[5] Gadatsch A (2003) Geschäftsprozessmanagement, 3rd edn. Vieweg, Wiesbaden

[6] Kemper HG, Mehanna W, Unger C (2004) Business Intelligence. Vieweg, Wiesbaden

[7] Schönsleben P (2001) Integrales Informationsmanagement, 2nd edn. Springer, Berlin

[8] McLeod R (1995) Information Management Systems, 6th edn. Prentice-Hall, London
[9] Dippold R, Fedtke S (2001) Unternehmensweites Datenmanagement, 3rd edn. Vieweg, Wiesbaden
[10] Aebi R (2000) Kundenorientiertes Knowledge Management. Addison-Wesley, München
[11] Steinbuch PA (1998) Prozessorganisation – Process Reengineering – Beispiel R 3. Kiehl, Ludwigshafen
[12] Zboralski K, Gemünden HG (2004) Die Integration von Kunden in Communities of Practice. In: Herstatt C (ed) Produktentwicklung mit virtuellen Communities. Gabler, Wiesbaden
[13] Schreier M (2004) Toolkits for User Innovation and Design. In: Herstatt C (ed) Produktentwicklung mit virtuellen Communities. Gabler, Wiesbaden
[14] Sanchez R (2003) Product, Process, and Knowledge Architectures in Organisational Competence. In: Sanchez R (ed) Knowledge management and organizational competence. Oxford University Press, Oxford
[15] Dunning JH (1998) Globalization, Technological Change and the Spatial Organization of Economic Activity. In: Chandler AD (ed) The Dynamic Firm. Oxford University Press, Oxford
[16] Wirtz BW (2000) Electronic Business. Gabler, Wiesbaden
[17] Schumann CA, Kassel S, Tittmann C, Grebenstein K (2004) AI-based Integration of Business Intelligence and Knowledge Management in Enterprises. In: Mercier-Laurent E (ed) The Symposium on Professional Practice in AI : 1st IFIP Conference on Artificial Intelligence Applications and Innovations (AIAI2004) as part of the 18th IFIP World Conference. Toulouse
[18] Schumann CA, Rutsch A (2006) Multichannel E-Commerce System for SME as European Market Player. In: Proceedings 41st Annual Assembly of the Latin American Council of Management Schools CLADEA 2006. Montpellier
[19] Hering E, Draeger W (1995) Führung und Management. VDI-Verlag, Düsseldorf
[20] Schumann CA, Rutsch A et al (2007) Directed Access of Multichannel E-Commerce Systems to Data Sources of Integrated SME Information Systems. In: Proceedings 14th European Concurrent Engineering Conference (ECEC) 2007. Delft
[21] Vernadat FB (1996) Enterprise Modeling and Integration. Chapman & Hall, London
[22] Sterne J (2002) Web metrics. Wiley, New York