Application-Driven Product-Service System Configuration: Customer-Centered Strategy

Alexander Smirnov[1,2], Nikolay Shilov[1,2],
Andreas Oroszi[3], Mario Sinko[3], Thorsten Krebs[4]

[1] SPIIRAS, 14 Line 39, 199178 St. Petersburg, Russia
[2] ITMO University, Kronverkskiy pr. 49, 197101 St. Petersburg, Russia
[3] Festo AG & Co. Ruiter Straße 82, Esslingen, 73734, Germany
[4] encoway GmbH, Buschhöhe 2, Bremen, 28357, Germany
{nick, smir}@iias.spb.su;
{oro, sni}@de.festo.com; krebs@encoway.de

Abstract. Companies are currently forced to implement new production and marketing paradigms because modern markets are getting more and more saturated and commoditized. One of the trends is orientation to services. The paper investigates the problem of product-service system configuration in a customer-centered way and discusses how it has been solved. The paper shares the authors' vision of required improvements in business processes and information systems at the considered company related to life cycle management for product-service system configurations. Though the research results are based on the analysis of one company, the presented work can give significant input to achieve benefits for component manufacturers that tend to become system vendors in general.

Keywords: Product-service system, customer view, application view, information management, business process, information system

1 Introduction

Companies are currently forced to implement new production and marketing paradigms because modern markets are getting more and more saturated and commoditized [1, 2]. This equally applies to markets with long histories regarding type of products. There are many product manufacturers and vendors what results in extremely small rooms for new products. The markets are shrinking and companies striving for attracting and retaining customers see service provision as a new path towards profits and growth. As a result, they have to be very innovative in order to survive.

One of the trends is orientation to services. This opens a completely new world of business models allowing companies to transform from product suppliers to service providers or even to virtual companies acting as brokers. For example, Rolls-Royce instead of selling aircraft engines now charges companies for hours that engines run and takes care of servicing the engines [3]. Another famous example is Uber, that does not only provides taxi services, but it does this without actually owning cars and acts

Y. Hara and D. Karagiannis (Eds.): ICServ 2017, LNCS 10371, pp. 26–37, 2017.
DOI: 10.1007/978-3-319-61240-9_3

just as a connecting link between the taxi drivers and passengers. Timely changed business model can provide for a significant competitive advantage (e.g., the current capitalisation of Uber is about $68 billion, which is $20 billion higher than that of GM [4]).

Automation equipment production is not an exception. The carried out analysis of the business and information management processes related to an automation equipment producer shows that instead of offering separate products, the company now tends to offer complex products (which may consist of several other products), whole integrated systems and also software units using different services [5, 6]. Product-Service Systems (PSS) assume orientation on combination of products and services (often supporting the products) instead of focusing only on products. This paradigm fits well automation equipment producers, for which tight relationships with customers are of high importance. These tight relationships enable the possibility to get valuable equipment usage statistics, analyse use cases and get direct customer's feedback [7-9].

Besides the products themselves and services as standalone "products", a good way to create additional customer value is to provide the customer with PSS configuration possibilities. Both physical and software components are not used individually but in a greater context at the customer's site what means that integrated products, systems, and services as well as their valid combinations have to be considered all together. Running a set of components from an automation equipment manufacturer, for example, for the customer, it is of high value that the components do not fail. Service contracts for maintenance on a regular basis and maybe also on spare parts are only a few examples of how the product manufacturers can give added value to their customers.

The paper is based on the analysis and modification of the information management processes related to PSS configuration at the automation equipment producer Festo AG & Co KG. Festo is a worldwide provider of automation technology for factory and process automation with wide assortments of products (more than 30 000 – 40 000 products of approximately 700 types, with various configuration possibilities) ranging from simple products to complex systems (fig. 1).

Around the world, 61 Festo national companies and 250 regional offices in 176 countries ensure that advice, service, delivery quality and reliability precisely meet customer needs in all global industrial regions. Today, more than 300,000 industrial customers in 200 industry segments worldwide rely on Festo's problem-solving competency. It produces pneumatic and electronic automation equipment and products

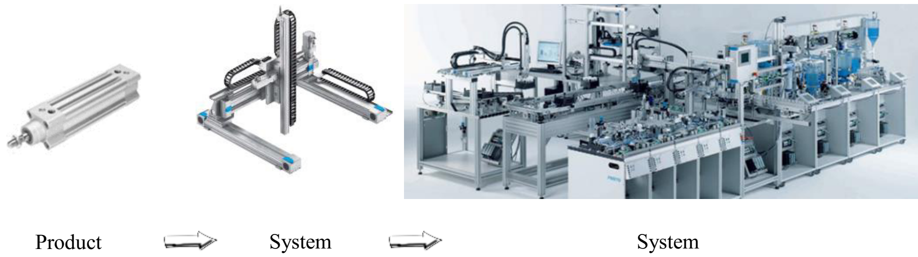

Fig. 1. Assortment range: from simple products to complex systems

for various process industries in 11 Global Production Centers and 28 National Service Centers.

The paper investigates the problem of PSS configuration information management in a customer-centered way and the way it has been solved. Implementing such an application-system view addresses the problem of designing the customer view on PSS selection, configuration and usage, i.e. defining customer's experience by "talking in a customer-understandable language" and addressing his/her application problems.

The paper shares the vision of the authors of required improvements in business processes and information systems at the considered company related to life cycle management for PSS configurations. Though the research results are based on the analysis of one company, the presented work can give significant input to achieve benefits for component manufacturers that tend to become system vendors in general.

The remaining part of the paper is structured as follows. The next section presents some ideas regarding modularization and configuration of services. Then, the approach is described followed by the pilot case study. Main findings of the carried out research are discussed in sec. 5. Some summarizing remarks are presented in the Conclusion.

2 Modularization And Configuration of Services

The fist, obvious difference when talking about selling products and services is that a product can only be sold once. Of course, you can make a contract for a larger number of that one product from which the customer gets a few on a regular basis. However, each individual product is manufactured and sold once. Services, on the other hand, can be recurring and rather long lasting. Basically, there are two different types of services:

- Point-of-sale (POS), which means that a service is a stand-alone product or is sold together with components or systems in a single quotation (as a PSS), and
- Contracts, which are long-term services for components or systems that are already in place at a customer site. Such long-term services are typically based on maintenance, which lowers the customer's risk of component or system failure. Maintenance contracts can also be agreed on for whole production environments, i.e. a running set of components and / or machines from potentially different vendors.

Next, there is a difference in how products and services are "produced". For tangible products, there typically is a defined way of how they manufactured. There are machines available for manufacturing, there are work plans describing how it is done, and there is a defined outcome. This means that such products are always the same. The same resources are used and the production costs are exactly the same for all products of the same product variant [10, 11]. The production is customer-independent. For service fulfillment there also is a defined way of how the work should be done. However, the exact way of how it is fulfilled varies every time it is done, because the situation of customer greatly influences how the service is fulfilled, e.g. the customer location is important. The fulfillment is customer-specific. Additionally, if the service is part of a PSS, then it belongs to some components or systems. The service itself will be different depending on the relevant products, their age, their usage, and so on.

These differences between product manufacturing and service fulfillment lead to different pricing strategies (fig. 2). For tangible products, the price is typically based on the production costs plus some margin. The price may also be country-specific, leading to a number of list prices, probably different because of currency rates or on the competition in the regarding countries. It is a rather new trend to use the value a product has for the customer as a source for pricing, e.g. leading to value-based pricing strategies. Still, usually specific characteristics of customers are used to group them, not to identify a single customer. Such groups may be the location, the time or the type of device used for product search. For services, the individual customer is also put into a group of persons that are similar in the sense of a list of characteristics. Regarding a Pareto-optimal approach, this can be an efficient approach since some customers are really similar in their behavior.

Car insurances are a good example of doing this: they group persons into groups based on their location and their history of previous accidents. However, when the car itself comes into play, the combination of customer and car is really individual.

The same holds for components and systems that are installed and running on customer sites. How old is that system? How frequently is it used? All these factors make pricing for service offers really difficult. Next to the service tasks themselves, additional information about serviced products/systems, their usage and about the customer are needed for a good calculation. When a company deals with the same customers over longer periods, it is thus a good idea to collect information about the "installed base" and about the planned and current usage. When well motivated, customers will accept a price that is based on measuring their individual behavior.

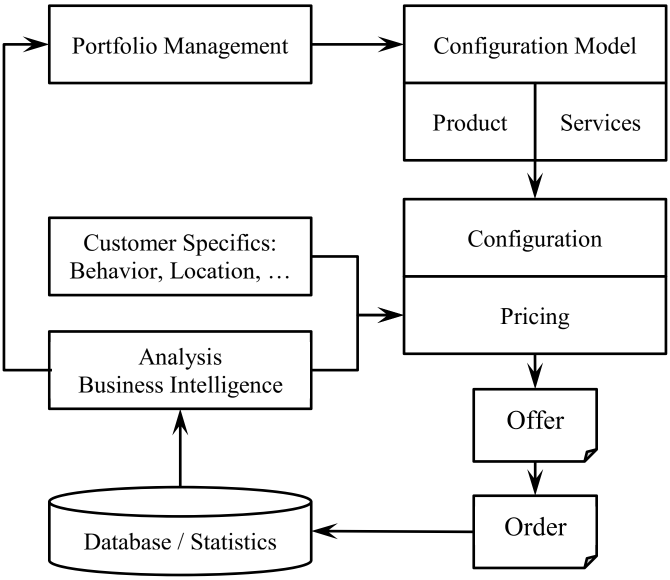

Fig. 2. PSS configuration and pricing specifics

3 Approach

The used gap analysis methodology was implemented through the following steps. First, the analysis of the current organisation of the information management was carried out. Then, the expert estimation of the company benchmark was done. Based on this, the comparison of the present and future business process and information management organisation was done resulting in creating corresponding process matrixes. This has made it possible to identify major gaps between the present and the future business organization, analyse these and define strategies to overcome these gaps.

Research efforts in the area of information management show that information and knowledge needs of a particular employee depend on his/her tasks and responsibilities. Different stages of the product lifecycle management processes in the company are associated with different roles like product managers, sales personnel and even customers. The representatives of different roles have different needs when interacting with an application like a PSS configurator. Product managers or a sales representatives, for example, know about the products and are able to configure by deciding on technical facts. A customer, on the other hand, may not know about the technical details of the company's products or even what kind of product he/she may use to solve his/her application problem. This is the reason why technical product details should be hidden from the customer under the application layer.

3.1 Application view

The complex PSS view comes from the application side. After defining the application area, configuration rules and constraints to the product are defined. They are followed by characteristics and product structure definition. Finally, the apps (software applications) enriching the product functionality or improving its reliability and maintenance are defined. The same applies to the sales stage.

As a result, implementing such application-constraints-system view addresses the problem of designing the customer view on product selection, configuration and processing (defining customer's experience, "talking in a customer-understandable language") [12, 13].

As it was already mentioned, based on the different complexity levels, the company's products can be classified as simple discrete components, configurable products or system configurations. The major goals are reducing the effort in producing products and reducing the time-to-delivery to the customer. Both goals should be reached by having less engineering activity (ETO) but more products that can be assembled based on a pre-defined modular system (ATO). In this sense, it is intended to make use of the "economies of scale". Products of different complexity require distinct handling in the process from request to delivery. Three levels of complexity are differentiated:

- **PTO – pick to order:** A product is order-neutrally pre-fabricated and sold as a discrete product. This means that no configuration is necessary to identify the correct combination of components. The different combinations already exist and for the customer it is a selection process rather than a configuration process. No order-specific production is required.

- **ATO – assemble to order:** The different components a product can be composed of are pre-fabricated but the correct combination of components is left open for order clearing process. The product itself is order-specifically produced from these existing components.
- **ETO – engineer to order:** A product is based on a known set of pre-fabricated components (like in the ATO scenario) but the specific customer need requires additional engineering activity. In this case new components need to be engineered, constructed and fabricated in order to fulfil a customer order and product the order-specific product.

Of course, the selection and configuration of these different types needs to be addressed accordingly. However, the customer should not be aware of this distinction. To the customer, the sales process should always “feel” the same.

As it was mentioned, different information needs of different roles (product managers, sales personnel, customers, etc.) are the reason to hide the technical product and service details under the application layer. In addition, the selection of the right product for solving the application problem can be based on a mapping between the application layer and a (hidden) technical product layer. In the optimal case, a customer does not notice whether he/she is selecting a discrete product, configuring a complex system, and so on.

As a result, the overall concept of customer-centric view on the products has been formulated as shown in fig. 3. It includes the introduced above new role of “System architect” responsible for the holistic view to the system and its configuration, description of its functionality and applications, and designing a customer view to it.

3.2 Changes in information systems

The changing requirements on business processes also induce changing requirements on information systems.

In today’s world, most companies do product specification with word documents or similar approaches. These documents are handed over to construction. Construction hands over other data, e.g. technical characteristics via PDM systems or CAD files, to manufacturing, and so on. At the time a sales channel is set up for the new product, the initial data from product specification is lost. Thus, a new requirement for effectively setting up sales configurators and after-sales support is a continuous database. Knowledge about the product’s application domain should be formally acquired already in the early phases of new product development. In this case, the data is available whenever needed in later steps of the product lifecycle process.

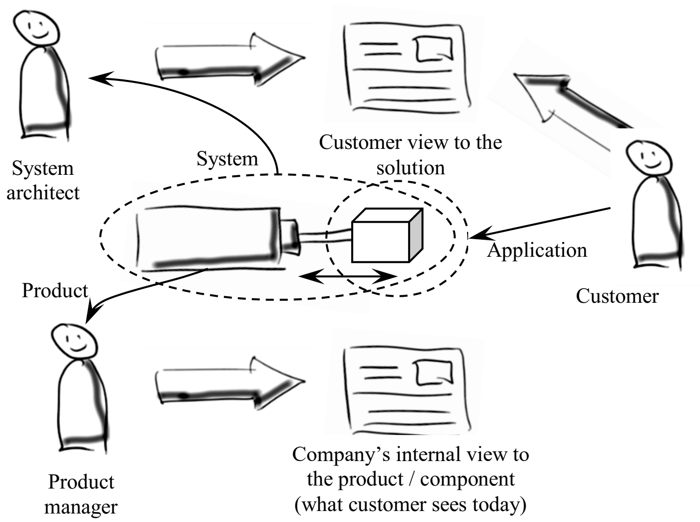

Fig. 3. The shift from the product view to the application view

Typically, the new product development process is structured in several milestones, such as design approval, technical approval or sales approval. During the entire life cycle, different roles work on product-centred data: product managers, engineers, controllers, marketing, sales personnel, and so on. Thus, either the relevant product data needs to be handed over – and potentially transformed – from a phase of the life cycle to later phases, or there is a single information system with which all the different roles carry out their daily work; every role on their specific view on a portion of the product data. In both cases, one of the major benefits for all concerned roles would be a seamless integration of all product life cycle phases within a comprehensive workflow.

A product-modelling environment must be capable of configuring modular product architecture. This means that using such an environment, it must be possible to reuse single product models in the scope of system configurations and assign product or system models to application knowledge. This requires the definition of well-formed product model interfaces to allow for modularity. Such interfaces enable a black-box approach, in which all products or modules implementing this interface can be chosen for the complex product / system; i.e. they become interchangeable. For the customer the complex details of product models on lower levels of the system architecture remain invisible. The customer decides based on the visible characteristics of the black-box.

Finally yet importantly, it is also important to support multi-user activities on the different parts of product, system and application models without losing track of changes and implication that such changes have.

4 Pilot case study implementing the developed approach

The developed approach has been verified on a pilot case for the Control cabinet product for selected customers. This is a complex product consisting of the cabinet itself housing a large number of different control elements, some of which are also complex products. Due to variety of components, its functionality is significantly defined by the software control system. Control cabinets are usually configured individually by company’s product managers based on the customer requirements since their configurations are tightly related to the equipment used by the customer.

Before the change, the customer together with the product manager had to compile a large bill of materials by deciding individually for every single component, in order to get the control cabinet. The customer would not be able to do this alone without assistance of the company’s representative who is an expert in the product range. Now, with a holistic customer-centric view to the control cabinet as to a single complex product including corresponding apps and software services, it can be configured and ordered as one product by the customer usually without assistance.

At the first stage, based on the demand history, the main requirements and components are defined at the market evaluation stage.

Then, at the engineering stage the components, baseline configurations based on branch specific applications as well as possible constraints are defined. The result of this is a source data for creating a cabinet configurator tool that makes it possible for the customers to configure cabinets based on their requirements online. At this stage, such specific characteristics are taken into account as components used, characteristics and capabilities of the cabinet, as well as resulting lead time and price (fig. 4).

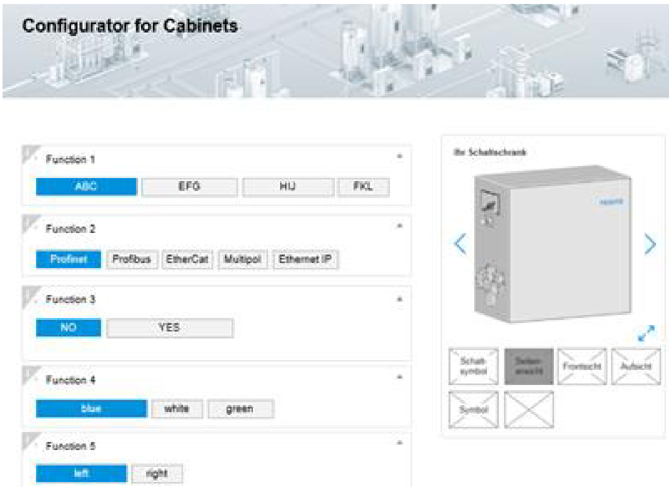

Fig. 4. Control cabinet configurator: an interface example

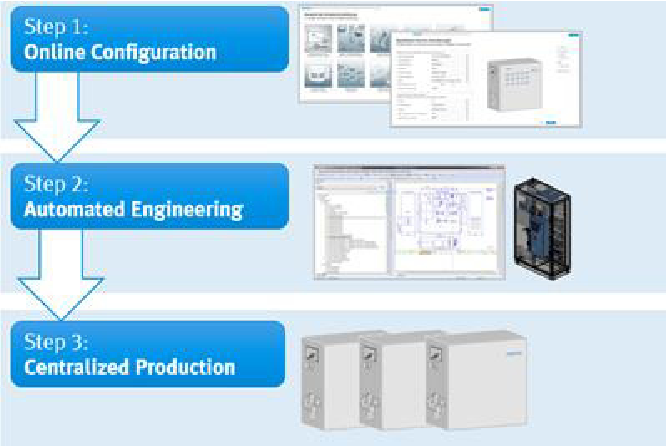

Fig. 5. Control cabinet: from online configuration to production

Based on the customer-defined configuration the engineering data is generated in an automatic (in certain cases – semi-automatic) way, which is used for the production stage. As a result, the centralized production of cabinets is based on the automatically generated engineering file (fig. 5).

The new business process made it possible to reduce the time from configuration to delivery from several weeks to few days (depending on the required components). The product maintenance is also significantly simplified due to the system-based view. All the data about this product (not only separated components) is available and can be used for modification of its configuration on customer's demand.

5 Findings

As a summarization of the findings of the described work, the following main strategies of the servitization processes have been identified:

1. Designing customer view on product selection, configuration and processing.

There are different types of users, like product managers, sales personnel or customers. These users have different needs when interacting with an application like a product configurator. The customer view and the company's internal view describe two contrary views addressing the intersection between the company's product diversity and the customer's individuality with a common goal: being able to guide a customer in selecting and configuring the right system for his/her application problem. At first sight, diversity and individuality seem to have a lot in common, but the goal behind each is rather distinct. It is important to analyse the customer's context (especially for offering services): system usage, customer's industry, who does the maintenance, country-specific regulations, etc.

2. Increasing system modularity / reusability in the context of PSS.

The structure of product combinations and systems needs to modularized. Comparable modules have the key ability to be used in multiple configuration contexts. This concerns not only products and components, but also product combinations and whole PSSs assuming building a multilevel PSS configuration model. Thus, a general PSS model architecture needs to be set up.

3. From business processes to IT and vice versa.

Though it is reasonably considered that the changes of business processes are the driver to changes in the corresponding IT systems, the experience has shown that it is not always the case. Having defined a general strategy, the company can try to implement some pilot particular IT solutions to support existing business processes or parts of them. If such solutions turn out to be successful, they could be extended and will cause changes in the business processes.

Besides the above strategies, some more particular findings with impacts on business processes and information systems can be identified as well.

The impacts on business processes include:

1. Aligning the business processes (improving interoperability and avoiding redundant tasks). When building a new configurator platform, it is important to align business processes like new PSS configuration together with the desired outcome. Doing so can help improving interoperability and avoiding redundant tasks e.g. in data maintenance.
2. Setting up sales and pricing strategies. While for tangible products, the price is typically based on the production costs plus some margin, pricing for services and PSS is difficult and requires development of new sales strategies.

The impacts on information systems include:

3. Homogenizing and standardizing master data (increasing master data quality; e.g. for being able to compare components, which are necessary to build partially defined combinations and PSSs).
4. Implementing tool support for the changed processes (supporting the improved business processes).
5. PSS needs to be defined. This includes data about components / machines, data about services, and about valid combinations of components and services.
6. Configuration of services needs additional knowledge sources.
7. Statistics need to be recorded and interpreted.

Impacts 6 and 7 are tightly related. Since software services are dealing with information, one has to provide such optimized and up-to-date information in order for services to operate efficiently as well as collect usage information to use it for further improvements and optimization. For a hardware system, the customer can tune parameters individually based on the particular usage. For services, if an extensive usage statistics is collected, some specific parameters can be offered to the customers in order to improve their production processes. The statistics can also be used for improvement of the company products and PSS. For example, a strategy that brings companies and their customers in a closer collaboration is innovation democratisation [14] standing for involvement of customers into the process of creating new products and services. This makes it possible for companies to better meet the needs of their customers.

6 Conclusions

The paper is concentrated on improving customer's experience in configuring and ordering for configurable PSS. The core idea is the change from the convenient for the company view of the products to the customer-friendly view from the system application perspective, which required an introduction of a new PLM role of "System architect". The developed business process and supporting information systems made it possible to implement the scenario of the automated production of the customer-configured control cabinet.

The presented work is an ongoing joint research, which is still in an intermediary step of implementation. So far, a pilot case for the control cabinet product has been implemented together with the CPQ (configure – price – quote) software vendor encoway GmbH. This configuration application is already in use for selected customers. The future work will include achieving automated production of other customer-configured PSS. The research is based on the company Festo AG&Co KG, however, the results can give significant input to achieve benefits for component manufacturers that tend to become system vendors in general.

Acknowledgements. The research was supported partly by project funded by grant # 16-07-00375 of the Russian Foundation for Basic Research and research Program I.5 of the Presidium of the Russian Academy of Sciences (State Research no.0073-2015-0006). This work was also partially financially supported by Government of Russian Federation, Grant 074-U01.

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