

CAPTURING, MANAGING AND SHARING PRODUCT INFORMATION ALONG THE LIFECYCLE FOR DESIGN IMPROVEMENT

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ABSTRACT

In today's mature markets, customers increasingly expect the highest quality of physical products and related services. The actual shift from a product perspective to an integrated perspective on product service systems brings the entire product lifecycle of individual products into focus. Accordingly, an emphasis has to be placed on how to actively capture, manage and share product lifecycle information and data. Information and data, especially describing the actual use of a product and/or service, is considered highly valuable for different stakeholders. Of those stakeholders, the ones involved in design and development (BOL) of products and services can profit most from item specific usage information and data. As a concept supporting this tasks of managing and sharing product lifecycle information, the so-called Product Avatar represents an interesting approach to administrate the communication between Intelligent Products and their stakeholders along the product lifecycle. In this paper, the Product Avatar concept and related topics are briefly introduced. Following, a case study of a real life example of a leisure boat lifecycle is presented. Based on this case study, a stakeholder analysis is conducted focusing on how the most influential stakeholders of the product/service, especially during the BOL phase (design), may profit from advanced product lifecycle based information management through the Product Avatar.

1 INTRODUCTION

In today's globalized and mature markets, customers increasingly expect physical products and related information of the highest quality. New developments bring the entire product lifecycle into focus, and with it an increased sensibility regarding issues like energy consumption, sustainability, etc. Accordingly, when developing new products and improving existing products and services an emphasis must be placed upon approaches on how to effectively capture, actively manage and share product lifecycle information and data.

The so-called Product Avatar [HRT06] is an approach which enables communication between Intelligent Products amongst each other and their stakeholders. After its initial introduction as a technical concept, the Product Avatar now revolves around the idea of individualized digital counterparts functioning as targeted digital representations of products; thus enabling stakeholders to benefit from value-added services built on product lifecycle information generated and shared by Intelligent Products [WHT12].

During the Middle-of-Life (MOL) phase of a product, a broad variety of data, and consequently information, can be captured, communicated and stored. The ready availability of this item-level information creates potential benefits for processes throughout the product lifecycle. In the Beginning-of-Life phase (BOL) of the product lifecycle specifically, opportunities are created to continuously improve future product generations by considering item-level MOL information in design, development and manufacturing processes. However, in order to make use of this information, its selection and presentation must be individualized, customized and presented according to the

stakeholders' requirements. For example, in the case of design processes, this means taking the needs of design engineers into account; during manufacturing, the production planner. In this paper, first the Product Avatar and its three fundamental pillars are introduced. Subsequently, how product lifecycle information can be utilized to support stakeholders such as designers and users during the BOL phases is illustrated. This is elaborated on using a real life example of a leisure boat lifecycle to demonstrate the feasibility of the theoretical concept.

2 THE PRODUCT AVATAR CONCEPT AND ITS THREE PILLARS

The Product Avatar concept describes a distributed and decentralized approach to the management of relevant, item-level information throughout a product's lifecycle [HRT06]. At its core lies the idea that each product should have a digital counterpart by which it is represented towards the different stakeholders involved throughout its lifecycle. In the case of Intelligent Products, this may also mean the implementation of digital representations towards other Intelligent Products. Consequently, the Avatar concept deals with establishing suitable interfaces towards different types of stakeholder.

The Product Avatar concept builds on the following three pillars:

- Product Lifecycle Management (PLM)
- Intelligent Products
- Collaboration of Stakeholders

In the following, the three pillars and the Product Avatar itself are described in more detail.

2.1 Product Lifecycle Management

Literature broadly differentiates marketing and production engineering perspectives towards the product lifecycle [S09]. The marketing perspective tends to adopt a sales-oriented view, in which the lifecycle is divided into the introduction, growth, maturity, saturation and degeneration of a product. The product is not seen as a physical thing but only in terms of the degree of its economic success [MBK03]. The production engineering perspective used here follows [KBX03]. Here, the processes related to the development, production and distribution of the product are arranged into the BOL phase. A product's utilization, service and repair are labeled MOL. Reverse logistics take place in the End-of-Life (EOL) phase. Closed-loop PLM describes an approach to PLM which facilitates the closing of information loops between the individual phases of the product lifecycle [JKX07]. It aims to achieve a pervasive availability of relevant product information at any point in the product lifecycle. Furthermore, the concept deals with closing information loops between different IT layers, from the data acquisition, through middleware and knowledge transformation layers to the business application layer. In order to do so, the concept proposes different methods of applying information technology [FBD97; HHT10; JKX07; K11; JSK07]. With Closed-loop PLM, a paradigm shift from „cradle to grave” to “cradle to cradle” is put forward [PM09].

In principle, every product has a lifecycle. Manufacturers are increasingly becoming aware of the benefits inherent in actively managing those lifecycles of their products and/or services [S09b]. At the same time, today's products are becoming increasingly complicated. For example, the amount of component parts is increasing over most domains. Simultaneously, development, manufacturing and usage cycles are accelerating [S09b] and production is being distributed geographically. These trends highlight the need for innovative concepts for structuring and handling product related information efficiently throughout the entire lifecycle.



Figure 16: Phases of the Product Lifecycle

PLM expands on the concept of Product Data Management (PDM) to include information generated and used beyond design and manufacturing [PP08; FTJ11]. Besides merely handling product and

process related data, PLM also has to take into account the interdependencies of information and communication between all of the stakeholders involved in the product lifecycle.

Common graphical representations of the product lifecycle encompass the previously introduced three phases –BOL, MOL and EOL –arranged either in a circle or in a linear form (see Fig. 1). The linear form represents the product lifecycle “from the cradle to the grave”. Applications are making use of modern technological advances. So does e.g., the social web offer a number of opportunities for item-level PLM as Web 2.0-based product information acquisition could contribute to the improvement of the quality of future products [MB11; GY11].

In the next subsection, Intelligent Products are introduced as they are closely tied to closed-loop PLM from an information and data management perspective.

2.2 Intelligent Products

In this subsection, the so-called Intelligent Products (also known as smart products) are briefly introduced as they are more and more considered a necessity for successfully item-level PLM application. As mentioned before, closed-loop PLM relies on the pervasive availability of information throughout the product lifecycle in order to fulfill its aims. This is especially difficult in the MOL and EOL phases of the product lifecycle where, unlike in BOL processes such as design, manufacturing and sales, little data is collected in an organized manner. The Intelligent Product” concept can support closed-loop PLM by providing a means to collect and communicate product data throughout the entire lifecycle. Intelligent Products are physical products which may be transported, processed or used and which comprise the ability to act in an intelligent manner. McFarlane et al. define the Intelligent Product as “a physical and information based representation of an item [...] which possesses a unique identification, is capable of communicating effectively with its environment, can retain or store data about itself, deploys a language to display its features, production requirements, etc., and is capable of participating in or making decisions relevant to its own destiny.” [MSC03] The degree of intelligence an Intelligent Product may exhibit varies from simple data processing to complex pro-active behavior [KHF03]. Intelligent Products can make use e.g. of RFID, sensors and embedded computing throughout their lifecycles in order to collect data for example about their usage, service, maintenance, upgrading, decommissioning and disposal. They thus can contribute significantly to closing the information loops throughout the product lifecycle and are fundamental to a holistic implementation of Closed-loop PLM in many types of product.

After in the previous subsection the first two pillars PLM and Intelligent Products were elaborated, in the following the stakeholders and their collaborative nature along the lifecycle is briefly introduced.

2.3 Collaboration of Stakeholders

After the basic understanding of the two pillars PLM and Intelligent Products have been introduced, stakeholders and their collaboration are presented as the third pillar.

In this case, stakeholders are understood as all parties that interact with or have an interest in a product and/or service along its lifecycle. This corresponds with the definition by [AK08] which defines stakeholders as persons or groups who have interests or claims towards a project or enterprise and are affected by decisions and actions. Stakeholders can influence project decisions to a varying degree, which may affect the project positively or negatively. Stakeholder’s acceptance is essential for the success of a project [AK08; Z12]. When we apply that to the previously mentioned understanding within the product lifecycle setting, it becomes apparent that an understanding of the different stakeholders and especially their demands and requirements may be an essential tool for promoting a successful product and/or service.

In order to derive the requirements and demands of ones stakeholders, there are several tools and approaches for a stakeholder analysis available [S00]. However, there is no direct comparison available which of those approaches is the most successful [M06]. In the following case study an approach is used comparing the different stakeholders based on their influence and influenceability in a matrix. This is explained in more detail in the respective section.

Today, companies are not conducting business on their own or isolated from others during manufacturing, distribution etc. (BOL). During the usage phase this stands true as well. The user collaborates with a varying number of other stakeholders, starting from the manufacturer to the service provider to the insurance company (MOL). And during the EOL, there are stakeholders like the retail company looking for a following owner, the dismantling company, stripping the product for parts or others involved. All of them are in some way or another interdependent across lifecycle phases. A simplified example to illustrate the issue is the following: information of the service provider (MOL) essential for a successful sale of the retailer during the EOL phase.

2.4 Product Avatar

Closed-loop PLM and Intelligent Products together provide the conceptual and technological basis for a holistic management of item-level product information throughout the product lifecycle. The stakeholders in the product lifecycle are heterogeneous and have very different requirements towards the selection, presentation and use of product lifecycle data. They include product designers, manufacturers, sellers, maintenance staff, service providers, recycling operators and, of course, the actual owner of the product in question. Consequently, a single interface to closed-loop PLM data is not viable and a more flexible approach is required. A Product Avatar is a distributed approach to the interaction with and management of item-level product lifecycle information [HRT06]. It can be understood as a digital counterpart or set of digital counterparts, which represents the attributes and services of a physical product towards the different stakeholders involved in its lifecycle. This means a Product Avatar presents different interfaces and delivery channels depending on who uses it and how. Stakeholders such as owners, producers, designers may interact with the Product Avatar e.g. via dedicated desktop applications, web pages, or mobile “apps” tailored to their specific information, service and interaction needs. Product Avatars can also interact with other Product Avatars. This can be facilitated, for example, by means of web services, software agents, common messaging interfaces such as QMI, or a combination of these. This paper focuses on the former type of interaction between human stakeholders and Product Avatars [WHT12].

Before the design and development of the Product Avatar for a specific Intelligent Product, requirements need to be elicited and analyzed regarding how, by which channel, and for whom the digital counterparts need to be made available. This necessitates considering each stakeholder individually, as they each have their own individual requirements and preferences. In order to achieve a high level of acceptance for a Product Avatar with leisure boat owners, it needs to be designed taking into account interaction channels and paradigms they are already comfortable with and have come to expect. At the same time, European boat builders are seeking to expand their target market to attract the younger generations who have grown up with the Internet – the so-called “digital natives”. Amongst other considerations, these two factors make Social Network Services such as Facebook an interesting channel for interacting between boat owners and Product Avatars.

Social Network Services such as Facebook boast user bases, which are already familiar with their design, functionality and interaction paradigms. Furthermore, the service is an accepted communication tool, which is used anytime, anywhere via a plethora of different devices both stationary and mobile. The Product Avatar concept is, in essence, inherent to these tools – users of Social Network Services interact with “avatars” of other users as a matter of course. Thus, it seems a small step for boat owners who already actively participate in Social Network Services to also interact with their boats and the services, which augment it through the same channel.

In summary, designing a Product Avatar which uses a popular Social Network Service as its interaction channel and conforms to that network’s interaction paradigm promises to help users interact intuitively with it and thus enhance user acceptance, immediately leverage the user base for potential new value-added services augmenting the product, and leverage the in-built multimodality and mobility for anytime, anywhere interaction with the Product Avatar.

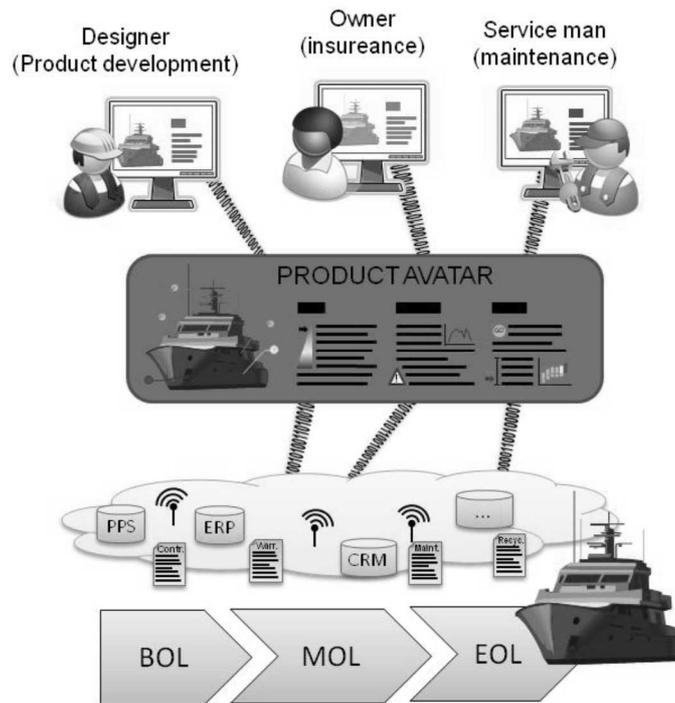


Figure 2: Digital representation of a product through a Product Avatar [HWT13]

3 CASE STUDY

In order to better illustrate the feasibility of the theoretical Product Avatar concept, a short introduction of an example based on a real case will be given in this section. The use case within this paper is set in the European leisure boat industry. The case study is based on a EU funded project BOMA. The BOMA consortium was driven by leading European boat manufacturers supported by leading research and industrial partners in the fields of Product Lifecycle Management and Intelligent Products. BOMA developed services addressing intelligent maintenance, sustainability, upgrades and the used boat market. These services improve all phases of the leisure boat lifecycle from enhancing design processes with knowledge from the entire lifecycle, through the usage phase applying intelligent maintenance concepts and technologies to improve safety, reliability and quality to the end-of-life phase by empowering sustainability issues such as increased reusability, refurbishing and reuse of used boats and components parts as well as their ultimate retirement [BOMA14].

Leisure boat manufacturers have previously focused on the improvement of their products' quality to remain competitive in the market. However, with the recent, drastic downturn in the boat market they increasingly recognize the need to additionally emphasize both the after-sales market and their customers' demands for products that are easy in upkeep, environmentally friendly and which offer added-value services to enhance their boating experience.

This is especially true for SME (Small and Medium Enterprise) boat manufactures, for whom the current crisis in the European boat market constitutes an existential challenge. Servitization offers these SMEs the opportunity to create revenue streams on top of and parallel to their traditional business strategies. Many already offer services related to boats, for example upgrades to previously sold boats, maintenance and winter storage. However, they have hitherto neither focused their business on nor have they implemented specific concepts or enabling technologies for these service offers. Experience in applying these concepts is already available in comparable sectors such automotive or ship-building. As of today, however, no attempt has been made to transfer that experience to the leisure boat sector.

3.1 Stakeholders of the leisure boat lifecycle

Leisure boats are complex, high-value consumer products, which lend themselves easily to servitization due to their inherent characteristics. They are often produced in small series, designed or

made to order and often unique. Maintenance plays a key role in safety and ownership costs, the products can be in use for a considerable time, and finally, sustainability issues are potential key advantages on the market. Many stakeholders in the leisure boat lifecycle besides the manufacturers and owners can profit from the Product Avatar approach to servitization presented here. They include designers and manufacturers (which are both often part of the OEM), boat yards, retailers, maintenance providers, insurance providers, suppliers, user (assumed to be the owners in this case), and in the case of the application of digital services, the platform.

3.2 Stakeholder analysis of leisure boat lifecycle

Looking at the stakeholders of the leisure boat lifecycle introduced in the previous subsection, it is important to understand their impact and influence on the project, product or service, and at the same time the influence of the project, product or service on them. In order to structure the different stakeholders, a stakeholder analysis was conducted. The goal was to identify the stakeholders which are most important concerning the effective utilization of lifecycle data and information by the Product Avatar.

The approach chosen is based on [M06; Z12] and focuses on placing the different stakeholders in a preset matrix where one axis determines the influence of the product/service on the stakeholder and the other axis shows the influence of the stakeholder on the product/service. It is assumed that stakeholders with high scores in both categories are considered the most important and called playmakers, and are thus focused on in the following.

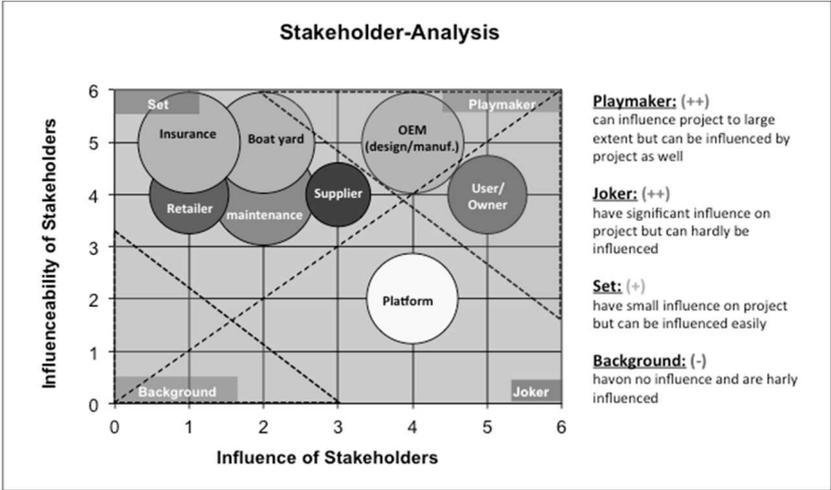


Figure 17: Stakeholder analysis of leisure boat lifecycle

As shown in Fig.2, the OEM, comprised of designers, manufacturers and the users/owners are the playmakers when it comes to utilizing lifecycle data and information of leisure boats by the Product Avatar. Even so, the OEM also includes manufacturing, in the following the main focus is laid on product development/design.

3.3 Benefit for BOL stakeholders: OEM (designer/manufacturer)

Looking into the impact MOL lifecycle data and information can have on designers during the BOL phase, it is apparent that improving the designers understanding of the condition of the boats in use and their customers’ behavior allows them to design boats on the principle of “fact-based design”.

The MOL “usage” data is generated by technology already available on most boats, such as sensors built into motors, geographical information generated e.g. by navigation systems, and electronic systems already connected to the on-board NMEA³ bus. Additional data, such as hull stress,

³ National Marine Electronics Association standards for communication between marine electronics: NMEA 0180, NMEA 0182, NMEA 0183 and NMEA 2000.

acceleration and alignment information, was captured by UMGs⁴ and managed and distributed using a closed-loop PLM platform [WHT14]. This data was then called up by boat designers and manufacturers via a Product Avatar implemented upon the closed-loop PLM platform.

Having this information and data available allows the designers to base their work on more accurate requirements and reduce the often-necessary “estimation” and resulting over engineering. One example is the actual usage of a leisure boat hardly ever makes use of the powerful engines build in and is rather driven slowly in close proximity to the harbor.

3.4 Benefit for BOL stakeholders: user/owner

Of the two stakeholders identified as being most important for the objective, the users/owners of the product/service are deemed to profit more in the other phases of the lifecycle. Users may profit significantly from additional information and services based on that during the usage phase (MOL) (e.g., by connecting with their boat through Social Network Services [WHT12]) and during the end of life (EOL) (e.g., by being able to provide continuous prove of the boats state for next user). In the BOL phase the benefit is mostly interdependent with that of the OEM, as the user profits from design improvements based on the actual usage of the user. Another potential advantage may be that the user can be involved in the design process at an early stage through the Product Avatar. Being a digital representation of the boat, the user can follow the design and manufacture and maybe even make decisions during those phases based on his or her preference.

4 CONCLUSIONS AND OUTLOOK

In conclusion, it can be said that the Product Avatar concept presents significant benefits to (selected) stakeholders by capturing, managing and distributing lifecycle information. In this case, the focus was on the utilization of MOL usage data during the BOL. In order to identify the relevant stakeholders during the BOL phase of the presented case study, a stakeholder analysis was conducted. Following this analysis, the resulting benefits for the identified "most important" stakeholders were briefly discussed.

Overall, with the fast-paced developments in sensor technology and ICT, the opportunities to utilize the treasure of usage information and data at different times during the lifecycle steadily increase. With more available information, the resulting services and business opportunities will develop.

However, there are also limitations to be considered. Among those are data security and privacy issues which must be taken seriously. Furthermore, the more data and information that is available, the more important it becomes to develop solid solutions to efficiently manage it. Identifying the relevant information for specific stakeholders will become an increasing challenge. In the future it will become impossible to handle the data streams manually. Machine learning, artificial intelligence or data mining approaches will increase in importance.

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⁴ Custom-built Universal Marine Gateways (UMGs) comprising of low-cost, single board computers capable of acquiring, processing and communicating lifecycle data from arbitrary sensors.

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