Integration of Mobile Device Features in Product Data Management Systems

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Abstract. Mobile devices have evolved rapidly in recent years and have become an everyday commodity. The young mobile PLM market is still in its infancy. At present, companies have covered their business processes with stationary workstations while mobile business applications have limited relevance and have been used to a limited extent. Companies can cover their overall business processes more time-efficiently and cost-effectively when they integrate mobile users in workflows. Mobile device features have the potential to significantly support the product development process through interactive user interactions and make them more effective. Moreover, entirely new workflows can be defined and established by considering mobile situations in business processes, which were excluded from the outset in the stationary context. This paper presents a novel approach for the usage of mobile device features in PDM systems to enhance user experience through novel interaction methods.

Keywords: PDM · Mobile device feature · Architecture · Product development

1 Introduction

The number of product variation on the world-wide market has increased significantly over the last few decades that consumers can easily find a broad range and assortment of goods [1, 2]. Nowadays, customers have better access to information resources related to consumer products than 20 years ago. Detailed product features, competitive market exchange, and consumers who share their experiences with others are no longer obstacles. Compared to earlier years, this results have been changed in several significant ways. The consumer behavior has been less continuous and unstable than before. Consumer behavior has been changed in such a way that customers increasingly expect a product experience. It is equally important for the consumer to be able to identify with the product, because it is not only a product, but also offers valuable experiences. Through this shift, partly as a result of an improved market transparency, the power of the consumer has been expanded, so that companies must respond more to customer needs and thereby being found difficult to build a loyal consumer base who tends to switch faster the product and therefore the manufacturer. In order to ensure customer loyalty, on the one hand the company must have a high level of innovation capability to place new ground-breaking products and solutions with unique

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characteristics on the market and on the other hand it is essential to offer new products to the global market in even shorter intervals. A high pace of innovation and the constant shortening development cycles of products have become major challenges for companies and their employees. Whereas previously decisions were made only in the late phases of the product life cycle, this has been postponed due to cost savings, shorten the product development, and production in an earlier phase of the design and construction process [3]. Employees must be assisted by their company in their task to provide a permanent access to appropriate information over the entire product life cycle at the suitable time in the right place and in the appropriate form where they are needed [4]. The quantity of information is not important, but rather a purposeful provision of information for the respective mobile context of the person to fulfill and support them in their tasks. However, this implies a deeper connection between the different stages of a product life cycle having a huge impact on other stages. To achieve this for PDM activities in mobile situations, totally new approaches for collaboration and interaction must be innovated and developed with the support of the all product lifecycle stages. An improved collaboration with the appropriate stages could be achieved if a better supply and contribution of information takes place. When a timely and up to date data supply is established quickly, the areas can start to plan more effectively the next steps, which shorten the follow-up process and the product quality. In this context, the importance of information quality in PLM must be taken into account and is discussed from a production process perspective [5]. This paper presents a novel approach of mobile device feature (MDF) usage for PDM systems as well as identifies and discusses MDF pattern. Different integration approaches for MDFs are presented and discussed with related limitations. This paper is organized as follows: Sect. 2 analyzes and evaluates currently used MDF techniques within the PDM field. Sections 3 and 4 present the methodical approach considered for the MDF integration as well as differentiate the terms for this work. Section 5 identifies MDF pattern whereas Sect. 6 presents and discusses the integration approaches. Sections 7 and 8 presents an industrial use case and discusses the limitations. Finally, in Sect. 9, conclusions and suggestions for further research are formulated.

2 Related Work

In the field of Knowledge Management, research about user's context and presentation of content in the mobile environment has been performed as determined in [6, 7] as well as proposed knowledge framework in [8]. Nevertheless, both approaches are limited to the semantic collaboration and content presentation. An approach for the integration of powerful hardware features in a generic way is still missing and is presented in this work. Methods focusing only on different types of mobile applications have their limitations. The implementation of business applications designed for various mobile operating systems is very time-consuming and expensive, thus it is difficult to develop such application as well as implement process changes in a short time interval. Today, those native business applications have to be individually designed and implemented for each mobile operating system and for each business process. Moreover, the diversity of platform specific user interfaces was examined in [9]. The usability across all platforms for operational purposes on the basis of native applications is difficult. In a business environment it is important to access company-specific functions and processes using a unified way. Different user interfaces would negatively affect the productivity of the mobile user when they change the device platform. This point of view is supported by a survey performed by Page in 2013 that users ask about apps more than they ask about the device specification [10]. Another aspect is the delivery of native business applications, because it is unusual to distribute company specific and internal software through application distribution platforms such as *Google Play* or *Apple's App Store* which are primarily designed for end-consumers. PDM applications are generally made for a selected circle of people who participate in the product lifecycle. Native business applications on mobile devices are characterized by a wide variety of platforms, and also by limitation of simultaneous updates on all mobile devices at the same time. Web applications would solve the problem of updating, because they are browser-based largely executed on the server side, but they provide only limited access to hardware features. So far, it can be hard to combine the respective advantages of native business apps and web apps together for PDM, i.e. to model and manage various business processes centrally and to create dynamically new business processes considering mobile features. The classic mobile support for employees can be realized especially in areas where value added related tasks need to be provided in an environment characterized by mobility [11]. In addition, opportunities exist to increase the capability and efficacy through the integration between physical objects in the real world and business information systems [11] to cover existing PLM workflows for mobile users. The overarching objective was already defined at a general and abstract level for the Internet of Things in order to provide additional information for the realities and to minimize information gaps [12]. In the field of CMMS[1], there are already approaches of a web-based communications between mobile devices and maintenance systems. Such approach is described in [13] as a multi-tier architecture, which is based on CMMS and DSS[2] web services. This paper has simulated a corrupt bearing, which sensor data was read from the machine and stored for data acquisition as well as signal analysis in the database. Mobile users remotely access the results through the middleware layer. In this context, a bridge between the field of PLM and CMMS/SLM[3] would be beneficial.

3 Methodical Approach

Firstly, it is essential to identify and delimit the different contexts of MDF usage and subsequently understand their interactions and relationships. The contexts *Users*, *Software*, and *Business* could be identified (see Fig. 1).

[1] Computerized Maintenance Management System (CMMS) describes the logical support of maintenance procedures for products and product-related components.

[2] Decision Support System (DSS) describes a software-based system for operational and strategic decision-making.

[3] Service Lifecycle Management (SLM) deals with the lifecycle administration and control for product service activities.

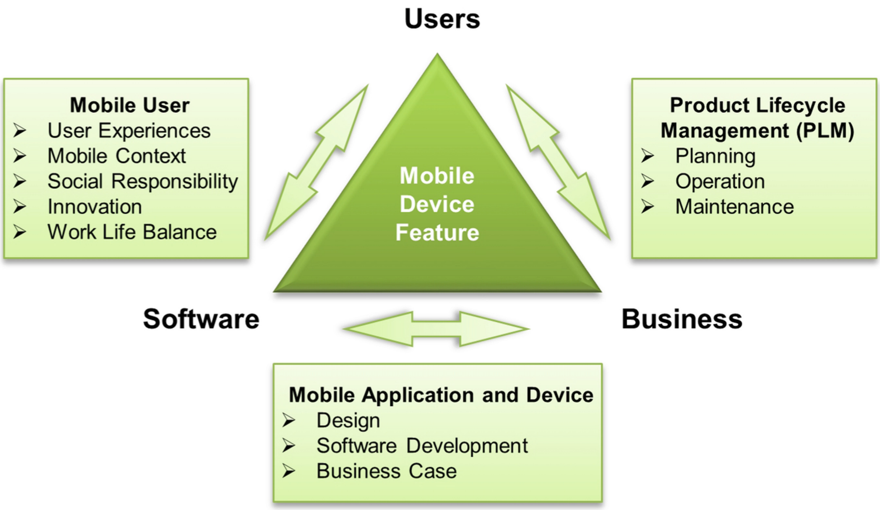

Fig. 1. Contexts of mobile device features

Firstly, the *User* context focus on mobile users who interact in a mobile context. This context can be divided into three sub-areas. The *technical level* describes the challenges of the user dealing with mobile devices. The main focus is set on the user who has developed a corresponding behavior due to the technical circumstances. The *social level* represents the acceptance of the mobile user to communicate because of the technical capabilities of a device. Finally, the personal needs of the mobile user are investigated on the *human level* in order to achieve a high user acceptance of the mobile device. Secondly, the context of *Software* has to deal with the technical integration part which has a wide range of mobile operating systems and MDFs. Mobile applications are dependent on the particular mobile platform, so that the development requires enormous efforts to ensure a consistent user experience across all mobile platforms. The variety of mobile platform and device types represent the wide spectrum of mobile technologies which satisfy different uses depending on the context and can be used at various locations. Finally, the *Business* context is dealing with different PDM providers with partly proprietary components. Traditional worker's desk of engineers participating in the lifecycle, has mainly a local workstation in the office. This workstation is used to handle all engineering tasks and decisions from a single point. Once an engineer leaves the workspace, a contribution of new information is no longer possible and all important product data are limited accessible if it has not been printed or noted. Therefore, product information can only be consumed unless it has been selected before. Any new generated information which is related to the lifecycle can only be transferred to the PDM backbone when the engineer returns to the workplace. Here, new knowledge could be lost when information has been only communicated verbally between the persons or written down on a piece of paper. In addition, new updates will be reported back to the lifecycle after a time delay. Other persons involved in the lifecycle could access the updated status only after a certain time. Incorrect product information can cause in such situations additional costs for the company and delays in the lifecycle. Such impacts could have a negative effect on the competitiveness of the company. In a study published by the Institute of Mechanical Engineering (ITM) at the Ruhr University Bochum in cooperation with IBM was identified as the primary potential benefits in the product lifecycle, the increase of the process efficiency through faster data distribution, data access, data search as well as less repeated re-entry of the same data [14]. Such situations of missing or invalid product information can be avoided by mobile solutions and also improve the productivity of the business because new updates are immediately available for other persons involved in the product lifecycle.

4 Mobile Device Features

Currently there is not clear understanding what MDF stands for. MDFs represent capabilities and services of a mobile device in order to generate added value for the user. For example, using the smartphone camera to scan the barcode of a book to query additional information about author. Conventional mobile phones offer only basic functionalities like phone to each-other and save contacts on a SIM card, while feature phones provide advanced capabilities such as camera and web browser. However, feature phones do not provide the width range of capabilities as smartphones. Smartphones are considered as high-end devices because the higher purchase price compared to low-end feature phones warrant additional hardware feature and thus better hardware equipment. In addition, feature phones are mainly provided with a restricted manufacturer-specific proprietary firmware. However, smartphones provide a mobile platform with an extensive API that allows the provision of own mobile applications. In addition, the API integration to access hardware-specific features of the mobile platform is more efficient. Initially, a clear distinction and definition for the terms hardware feature, software feature and Mobile Feature are carried out. A hardware feature represents a hardware-specific technical capability which is not supplied by the mobile platform, but managed and controlled. For example, a camera consisting of a lens, image sensor and other components. A software feature is an ability that is completely provided by logical software-based components. This type of capability does not require hardware specific characteristics, such as a pocket calculator or a file manager. At work, a mobile feature is seen as an abstract element, which is derived and composed from hardware-specific and software-based capabilities. However, it is not necessarily required for a mobile feature to be derived from both types of capability. Table 1 illustrates this aspect.

Table 1. Mobile device feature examples.

Example no.	Mobile feature	=	Software feature	+	Hardware feature
1	Object identification	=	Object recognition	+	Camera
2	Person localization	=	Personal identification	+	GPS
3	Language assistant	=	Speech recognition	+	Microphone
4	Authenticator	=	Fingerprint recognition	+	Fingerprint sensor

5 Mobile Device Feature Pattern

PDM concepts cover a variety of application scenarios differing from the respective industry and individual customer requirements. Customers describe abstractly formulated user stories about what functions and features the software is supposed to provide. The user story must be described in an adequate level of detail to derive the corresponding use cases, requirements, and finally to identify patterns. Subsequently, the patterns are described and assigned into various categories. From the variety of application scenarios, eight primary groups were derived and abstracted (see Fig. 2). These abstracted application scenarios cover most of typical scenarios from the PDM domain and can contribute added value to the mobile PDM sector. The groups are composed mainly by activities (verbs) that express an action or a state of an object. Accordingly, objects can be *observed*, *identified*, *analyzed*, *located*, *examined* as well as objects can *collaborate* and information over objects can be *contributed*. However, the grouping can also be organized from the feature perspective and therefore a distinction into three groups takes place: (1) a feature interacts with the user independent from foreign components, (2) a feature works within a dependent component (e.g. workflow) as well as (3) a feature works independently and automatically from other components without user interactions. The classification by object activity appears to be more suitable.

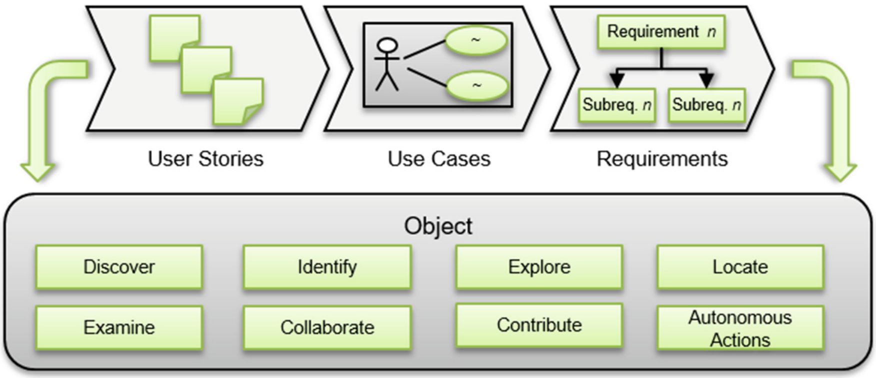

Fig. 2. Groups of MDF pattern

6 Mobile Device Feature Integration Approach

The MDF integration can be accomplished by different options (see Fig. 3). The first option describes the direct integration of mobile features in the PDM system. In this case, the mobile device features are called directly. The control and management of the mobile devices and associated features for all device classes takes place directly in the PDM system. However, this integration type is problematical in two respects. On the one hand the core competence of the PDM is the provision of product development data across all product lifecycle phases and not the control and administration of MDFs

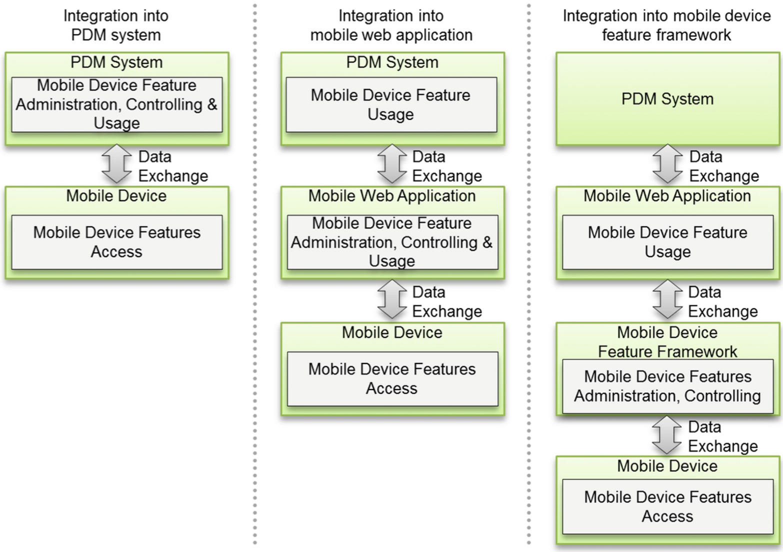

Fig. 3. PDM integration options for mobile device features

for all mobile device classes, and on the other hand, rapid technological leaps in mobile ICT sector represent an enormous challenge for PDM manufacturers. The second option pursues the notion of an outsourced control and management competence into the mobile web application. This option prevents potential problems with configurations and customizations of the PDM system. However, the basic problem with this method is that all mobile web applications possess these competencies of MDF control and no overall coordination of various feature-enabled mobile web applications exist. Furthermore, additional expenses arise for the feature logic development and maintenance in the web application. The third option favored a framework for the integration of MDFs. The competences of the framework include administrative tasks of the feature control, assignment and provision the MDFs for various mobile web applications and PDM modules.

7 Industrial Use Case

This paper has applied the presented approach by a case study of developing a web-based mobile application to query the PDM data of an 'Issue' object and using MDFs to perform object-related tasks (see Fig. 4). Based on the patterns, the mobile user can perform various object interactions such as *View*, *Navigate*, *Capture*, *Localize*, and *Identify* through the MDF support. Conventional input devices (e.g. soft keyboard of the mobile device) are no longer compulsory to interact with digital objects in the PDM world. All context-related interactions with the object are performed for the current user context. The interaction is not limited to a specific object types, but can be used for all objects in the PDM system and other software systems.

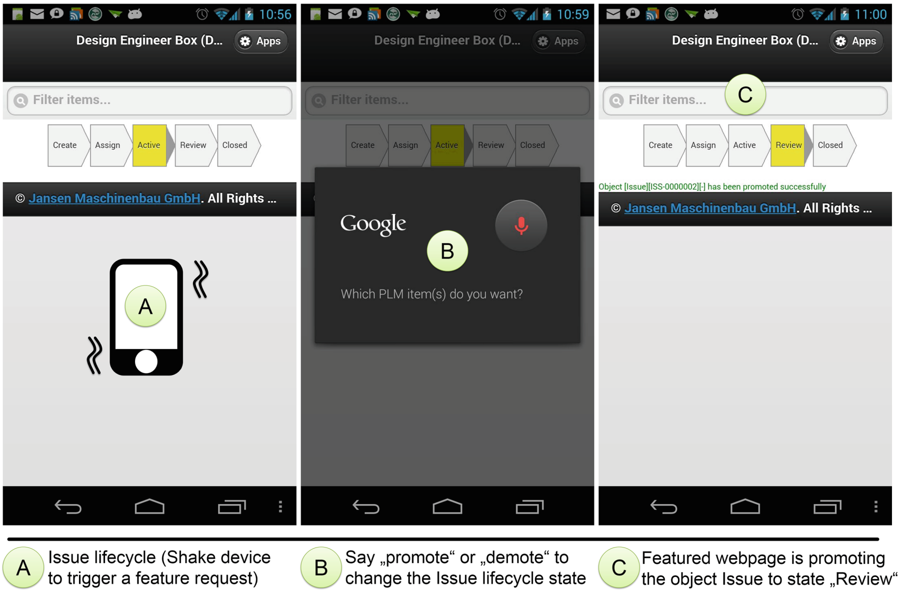

Fig. 4. Interaction with PDM objects using acceleration sensor and voice recognition as MDFs

8 Limitations

The MDF usage in PLM provides not only benefits, but also have some limitations:

1 The technological progress requires a continuous reconsideration of MDFs. Serious changes can be observed particularly in the mobile sector, because new device classes are pushed in the market in short time intervals and new technological standards are being set. Mobile platforms are strongly affected because the support is completely discontinued after a few years. The missing technological adaptation of implemented software to new technologies would ultimately lead to unsupported configurations in newer software versions as well as incompatibilities may result in various infrastructure components. However, the business logic would not be affected, because the business logic is isolated from the mobile devices and operates independently.

2 The social interactions can take an influence on the social relationship of people. The nature of the social interactions and its impact on the social relationship may have country or region-specific reasons. Thereby, social aspects addresses the privacy, user context, and cultural needs which plays another important role for the user acceptance of MDFs. The behavior of the mobile user is deeply rooted into the culture and linked to social aspects. Cultural aspects are often not sufficiently taken into account in mobile software. The perception of cultural backgrounds is complex, because the patterns differ in a high degree from culture to culture. Thereby, the privacy of every culture is more or less pronounced. Cultural aspects are

comprehensive and diverse. Therefore, a more detailed and country-specific research that captures the relevant cultural aspects are required.

3 The MDF usage also places demands on mobile networks such as network reliability, system availability, standardization, costs for transport of mobile data, and communication encryption. Most of the developed country fulfill the demand but there is a gap particularly in rural regions and developing countries.

9 Conclusions and Future Works

This paper has presented an approach for the integration of MDFs in PDM systems to close the gap in the interaction of objects between the real objects and digital PDM objects. The suggested approach provides significant advantages for mobile users in the interaction with PDM information but also other software systems such as ERP and CMMS. For many years, PDM-related tasks have been performed exclusively on stationary workstations. By introducing new classes of mobile devices, the mobile revolution began ultimately, which led that long-established patterns of thought and behavior were broken and existing processes have been accordingly revised or completely redefined. Existing processes have been accordingly revised or completely redefined. This meant that mobile situations could be considered now and will not be excluded from the outset anymore. The mobile revolution has initiated a change that defines new standards in the communication and interaction between people in various industrial fields. MDFs are insufficiently used for industrial purposes. However, the market demands that companies of various industrial sectors increase steadily the innovativeness and the efficiency of processes and operations so that products in a wide variety can be pushed in the market in ever shorter development cycles. Companies that do not bow to the market conditions lose competitiveness and will quickly fall behind. In order to prevent this case, free space for creativity and innovation must be given to employees. Since most creative ideas and inspirations arise spontaneously and are first discussed by the employees in the collective, MDFs support the employee in the media communication and interaction in mobile situations. In addition, data is collected mainly through manual input forms that have not been optimized for mobile applications. Furthermore, user-specific contexts are neither perceived nor taken into account in the application. MDFs assist users in this situation in the data acquisition and consummation over all stages of the product lifecycle through innovative data interactions and context-sensitive information. The specific problem lies in a missing generic possibility to integrate features for PDM systems. The fact that the majority of mobile PDM applications have been implemented proprietary and natively, a unified and cross-system look ahead approach was missing to solve this problem. Therefore, it was necessary to develop an approach that takes into account the various aspects of the mobile feature integration from a generic perspective. Only such an innovative and holistic approach provides the possibility to integrate mobile features for all phases of the product lifecycle and to avoid isolated solutions in form of individual native implementation in context of mobile PDM applications.

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