ValueApping: An Analysis Method to Identify Value-Adding Mobile Enterprise Apps in Business Processes

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Abstract. Mobile enterprise apps provide novel possibilities for the optimization and redesign of business processes, e.g., by the elimination of paper-based data acquisitioning or ubiquitous access to up-to-date information. To leverage these business potentials, a critical success factor is the identification and evaluation of value-adding MEAs based on an analysis of the business process. For this purpose, we present ValueApping, a systematic analysis method to identify usage scenarios for value-adding mobile enterprise apps in business processes and to analyze their business benefits. We describe the different analysis steps and corresponding analysis artifacts of ValueApping and discuss the results of a case-oriented evaluation in the automotive industry.

1 Introduction

As Apple released the first iPhone in 2007, the success story of mobile applications running on smartphones and tablets, so called mobile apps, began. In 2014, there will be over 138 Billion app downloads [1]. Nowadays, the majority of target users are consumers, but there is an increasing focus on mobile technology in enterprises. Mobile apps used in business are called mobile enterprise apps (MEA) and they are one of the top ten strategic technology trends for enterprises in 2014 [2]. The unique features of MEAs like intuitive touchscreen-based handling, anywhere and anytime usage as well as sensor capabilities enable a large spectrum of opportunities for new business models and novel business processes. The employment of MEAs can lead to higher productivity, higher employee satisfaction, integration of mobile process activities, elimination of paper-based data acquisitioning and ubiquitous information access [3].

Typically, the introduction of MEAs is realized in a technology-driven manner, which means MEAs are developed because it is technically feasible and fancy. However, a benefit from a business point of view cannot be guaranteed. In order to realize the business value of MEAs, the enterprise has to establish a mobile strategy. Thereby, a critical success factor is the business-driven identification and evaluation of value-adding MEAs based on a comprehensive analysis of the business process to be optimized. The goal is to identify process activities suited for MEAs and the deriva-

Recommended citation and copyright
Hoos, E.; Gröger, C.; Kramer, S.; Mitschang, B.: ValueApping: An Analysis Method to Identify Value-Adding Mobile Enterprise Apps in Business Processes. In: Enterprise Information Systems (ICEIS) 2014. Revised Selected Papers. Springer (2015)

The final publication is available at link.springer.com
http://dx.doi.org/10.1007/978-3-319-22348-3_13

tion of corresponding usage scenarios. This includes the analysis of business benefits of desired MEAs and their communication with the corporate management and the employees [4].

A key problem in the identification of value-adding MEAs is that the spectrum of new fields of application enabled by mobile apps in business is not yet well-understood, especially the conceptual differences compared to existing mobile IT systems like laptops have not been analyzed sufficiently. Furthermore, there is a methodological lack to systematically identify value-adding MEA usage scenarios. Previous methodologies consider mobile applications in general but do not focus on mobile apps and their unique features specifically [5–7]. Moreover, there is no clear picture of the business benefits of mobile app usage as these benefits comprise monetary and non-monetary factors [8].

To address these problems, we present ValueApping, an analysis method to identify value-adding MEA usage scenarios in business processes. It contains a criteria catalogue which combines technological and business-oriented aspects of mobile app usage and comprises several systematic analysis steps. By applying this method, it can be decided, which type of IT technology fits best to support a particular process activity. Moreover, ValueApping enables the analysis of the business benefits of a MEA usage scenario for a certain process activity.

The remainder of this paper is structured as follows: Section 2 characterizes mobile enterprise apps in general. Section 3 gives an overview of ValueApping including addressed requirements, analysis steps and the underlying analysis artifacts. Section 3 details on the analysis artifacts whereas the analysis steps are described in Section 4. An evaluation of ValueApping is presented in Section 5 based on a case-oriented application in the automotive industry. Section 6 reviews related work. Finally, Section 7 concludes the paper and highlights future work.

This paper represents a significantly revised and extended version of our work presented in [9]. In particular, we extend our method by several components for a business benefit analysis. Furthermore, we investigate the special characteristics of mobile enterprise apps compared to traditional mobile enterprise applications.

2 Mobile Enterprise Apps

In this section, MEAs are defined and characterized based on the term “mobile apps”. According to [10], mobile apps are applications running on smart mobile touch-based devices (SMTD) such as smartphones and tablets. Thereby, applications comprise all types of executable programs as well as browser-based web applications. MEAs are mobile apps used in business, whereas we specifically focus on mobile apps for employees. MEAs differ from traditional mobile applications running on mobile devices such as laptops, PDAs and mobile phones by the technical capabilities of SMTDs as well as the way they are developed, distributed and consumed which is known as the mobile ecosystem. Thereby, several technical and organizational challenges have to be addressed to leverage MEAs. These aspects are explained in the following.

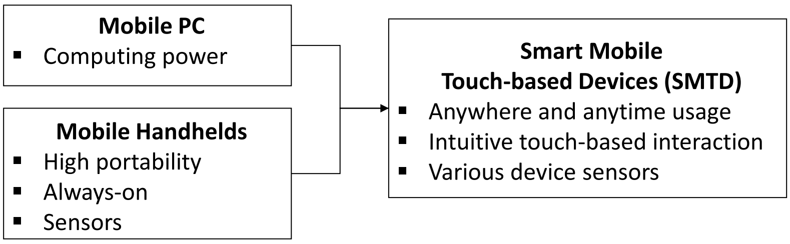

Fig. 1. Evolution of mobile devices

2.1 Mobile Devices and Technical Capabilities

Originally, there were two different types of mobile devices [11]: *Mobile PCs* such as laptops and *mobile handhelds* such as mobile phones and PDAs. Mobile PCs have similar capabilities as desktop PCs. In contrast, mobile handhelds are highly portable, always-on and they are equipped with various sensors, but they have limited resources such as computing power. The evolution of mobile technology lead to the combination of these two device types into smart mobile touch-based devices (SMTD) such as smartphones and tablets [12–15] as shown in Fig. 1. SMTDs are more and more replacing mobile handhelds and due to their increasing technical capabilities they are becoming an alternative to mobile PCs [14], as well. In contrast to mobile PCs, SMTDs are characterized by a unique feature set [10, 13–17] comprising anywhere and anytime usage, intuitive touch-based interaction as well as various device sensors like a GPS receiver. In the following, these features are discussed in detail.

Due to the mobile network, SMTDs allow for *anywhere and anytime usage*. This enables employee to access the enterprise back-end whenever it is required. Besides, the small and handy form factor of SMTDs leads to a higher portability. Moreover, SMTDs have no long boot process, because they are designed to be always on. This increases the reachability and working ability of the user.

Due to their touchscreen handling and multi-modal input capabilities, SMTDs enable an *intuitive touch-based interaction* using touch events and gestures [18]. This is more appropriate in mobile environments than the usage of mouse and keyboard. Due to the small screen size, the interaction design has to be tailored towards the functionality relevant for the task. We call this a task-oriented design. Moreover, the new interaction paradigm enables people who are generally uncomfortable with computers to interact with SMTDs without prior training [19]. In addition, sensors enable further input capabilities as described in the following.

SMTD are equipped with *various device sensors* including camera, GPS receiver, and accelerometer. They can be used for interaction as well as context sensing and enrichment. Regarding context sensing, sensors can be used for taking a photo, for voice recording, and for positioning. Furthermore, sensors can be used for interaction using voice commands or motion gestures. The camera can also be used for sensing the environment and in augmented reality application.

2.2 Mobile Ecosystems and Challenges to Leverage Mobile Enterprise Apps

Generally, mobile apps are part of complex mobile ecosystems which define the way apps are developed and distributed. A mobile ecosystem consists of the SMTD as a hardware component, the mobile operating system, native apps running on the operating system as well as a storefront and supplementary online services [20]. Google's Android, Apple's iOS, and Microsoft's Windows 8 are the three major mobile ecosystems competing nowadays. Each defines software development kits and user interaction guidelines as well as app store concepts to distributed mobile apps.

The unique features of SMTDs as well as the preexistence of mobile ecosystems lead to five core challenges to leverage MEAs according to [10]:

- *MEA Portfolio*: Systematic identification of usage scenarios for MEAs in business processes to derive value-adding MEAs and define a corresponding MEA portfolio.
- *MEA Development*: The development of MEAs is challenged by the requirements of high usability and restricted computing resources as well as limited network capacities [4]. In particular, a task-oriented interaction design is a critical success factor for usability. Moreover, the coexistence of different mobile ecosystems requires cross-platform development approaches.
- *MEA Infrastructure:* In order to distribute and manage MEAs, enterprises have to design company-internal app stores oriented towards apps store for consumers. Moreover, a unified device management is necessary, e.g., to define policies and control operating system updates across various types of SMTDs and mobile operating systems.
- *MEA Security and Privacy*: The use of MEAs poses new risks on privacy and security. Business-critical information has to be secured even in case of loss of SMTDs [21]. Moreover, personal data and context data on SMTDs have to be protected to avoid employee tracking.
- *MEA IT Architecture:* The use of MEAs on top of existing back-end IT systems requires an adaption and extension of the IT architecture especially with respect to the design of lightweight and context-aware back-end services.

With ValueApping, we address the MEA portfolio challenge by providing a systematic analysis method to derive value-adding MEA usage scenarios in business processes.

3 Requirements and Overview of ValueApping

In this section, we first define the requirements of an analysis method to identify value-adding MEA usage scenarios. Then, we give an overview of ValueApping and its parts.

3.1 Requirements

In order to identify value-adding MEA usage scenarios in business processes, for each process activity, the type of IT technology which fits best has to be selected. The technologies range from PCs as stationary IT technology and laptops as mobile PCs to SMTDs such as smartphones and tablets as a basis for MEAs.

The corresponding decision making process is complex, because there are several issues and requirements to consider. On the basis of shortcomings of existing analysis approaches (see Section 7), we identified the following three major requirements R_i our method has to address:

Potential of mobile technology (R1): A central question is whether there is a business benefit of using mobile technology. Generally, mobile technology can have two different effects on business processes [7]:

- Supporting existing mobility given by the process
- Enabling novel mobility in processes where none existed before

However, not every employment of mobile technology leads to an improvement of the business processes in terms of efficiency and effectiveness. Hence, activities that profit from one of the two effects have to be identified systematically.

Types of mobile devices (R2): There are a lot of different devices for mobile technology such as laptops, smartphones, tablets, PDAs, and mobile phones differing in hardware and software characteristics. In this work, we are considering the following types of mobile devices as described in Section 2.1:

- Mobile PCs like laptops
- Smart mobile touch-based devices like smartphones and tablets

Holistic point of view (R3): The combination of business-oriented and technology-oriented aspects avoids a purely technology-driven introduction of mobile technology. The latter typically focuses on porting existing back-end applications on mobile apps without a detailed business analysis. Besides, business aspects do not only refer to the mobility of process activities but further contextual factors like the elimination of manual data acquisition. In addition, not only aspects of the process activity but also infrastructural and organizational issues of the enterprise, e.g., the availability of a mobile network, have to be considered.

3.2 Overview of ValueApping

The purpose of ValueApping is to systematically analyze process activities with respect to their improvement potential using mobile technology in order to support enterprises in the decision which IT technology fits best. At this, ValueApping incorporates the above requirements and takes a holistic view on both technological and business-related aspects (R3), differentiates between SMTDs and mobile PCs (R1) and investigates both the support of existing mobility and the enablement of novel mobility in the process (R2). Process improvements can be determined according to the goal dimensions time, quality, and flexibility. The major result is a portfolio of analyzed process activities which are categorized according to the IT technology which fits best. On this basis, a business benefit radar chart for each process activity suited for SMTD support is derived. The radar chart represents the business benefits of a corresponding MEA usage scenario for the activity according to the goal dimen-

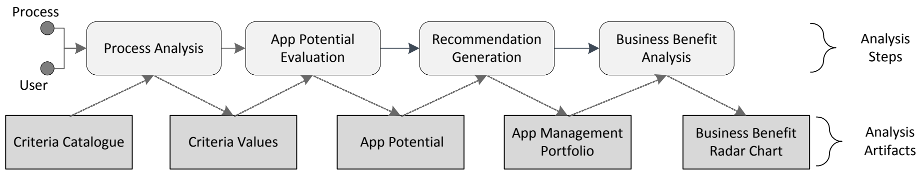

Fig. 2. Overview of ValueApping

sions. This provides a starting point to define corresponding MEA development projects and IT investments.

ValueApping is made up of two major parts, namely analysis steps and analysis artifacts (see Fig. 2). The analysis steps are executed in a sequence and create different analysis artifacts as input and output. Thereby, we distinguish between four groups of analysis artifacts, namely

- the criteria catalogue and criteria values,
- the app potential as a metric,
- the app management portfolio, and
- the business benefit radar chart.

The *criteria catalogue* reflects the different aspects for the usage of mobile technology in enterprises. The *app potential* is a metric to operationalize the improvement potential of each activity with respect to MEA. This means, the higher the app potential the more the activity can be improved using a MEA. The *app management portfolio* enables the classification and ranking of the activities according to the IT technology which fits best. The *business benefit radar chart* is based on a *business benefit breakdown structure*. It indicates on which goal dimensions the usage of a MEA has a positive impact for a particular process activity. The chart enables a comparison with other activities according to the goal dimensions and constitutes a graphical representation to easily communicate potential benefits.

ValueApping comprises four analysis steps, namely

- process analysis,
- app potential evaluation,
- recommendation generation, and
- business benefit analysis.

The two *starting points* represent different application variants of the method. The user point of view enables employees to validate improvement suggestions for selected activities across different processes. The process point of view considers improvements of an entire process including all activities.

Process analysis refers to a procedure to determine the value of each criterion in the criteria catalog. The input is the criteria catalogue and the output comprises a criteria value for each analyzed criterion. These values represent in turn the input for the *evaluation of the app potential.* The latter defines a procedure to calculate the app potential for each activity as a metric. Then, *recommendation generation* reveals the app management portfolio according to the app potential of each activity. On this basis, recommendations are deduced according to the IT technology which fits best for each activity in the portfolio. At last, the *business benefit analysis* step reveals the business benefits of corresponding MEAs for all process activities which are suited for SMTD support according to the app management portfolio.

4 Analysis Artifacts

This section describes the analysis artifacts, namely the criteria catalogue, the app potential, the app management portfolio, as well as the business benefit breakdown structure and radar chart.

Table 1: Criteria catalogue

Mobility of the activity		
		Actor: Mobility of the actor
		Task: Mobility of the task
Process		
	Relevance	
		Frequency: Number of execution
		Acuteness: Importance of performing the task immediately
	Current Information System	
		Digitalization: Potential of digitalization
		Devices: Possibilities to replace other devices with mobile touch-based devices
		Usability: Improvements of usability through mobile touch-based devices
		Sensors: Enrichment of the application through the use of sensors
Technology Requirements		
	Performance	
		Data Volume Transmit: Amount of data which have to be transmitted
		Date Volume Receive: Amount of data which have to be received
		Computing Power: Amount of computing power the application requires
		Presentation: Data representation on a small screen
		Type of Input: Structure of data input
	Software Quality	
		Availability: Availability requirements of the application
		Security: Security requirements of the application
Corporate Conditions		
	Individual	
		User: Acceptance of the user
		Management: Support of management to introduce mobile apps
	Organizational	
		Mobile Devices: Existence of mobile touch-based devices
		Guidelines: Guidelines limiting the usage of mobile touch-based devices
	Infrastructural	
		Data Communication: Availability of mobile networks

4.1 Criteria Catalogue

The criteria catalogue is based on multi-criteria analysis techniques. With these techniques, complex decision problems with multiple options and restrictions can be structured [22]. As a basis for the criteria definition, we conducted literature analyses [5–7, 23–28] Moreover, we carried out expert interviews with employees of a German car manufacturer to refine the identified criteria.

The criteria catalogue reflects the different aspects of mobile app usage in enterprises including the requirements R1, R2, and R3. The criteria are grouped into four categories: *mobility*, *process*, *technology requirement*, and *corporate conditions*. Each criterion has predefined ordinal values following a qualitative approach. In addition, some criteria are complemented by indicators to ease the determination of their value. Table 1 shows the structure of the criteria catalogue. In the following, an overview of the different categories and the corresponding criteria is given.

Mobility of the activity. This category includes two criteria: *task* and *actor*. These criteria consider the aspects given in R1. The criterion *task* is based on the definition of mobile processes given in [5] and has the predefined values of *high*, *medium* and *low*. The indicators are a stationary workplace, the uncertainty of the execution space, moving actor or multiple execution places. The uncertainty of the execution space emerges if the execution space is unknown at the start of the process or it differs in multiple instances of the process. For example, the value of the criterion *task* is *high*, if there is a high uncertainty of the execution space, a moving actor or multiple execution spaces. The value is *low* if the task is executed on a stationary workspace. This criterion investigates whether mobile technology can be employed to support existing mobility in the process. In contrast, the criterion *actor* considers if there is a benefit by enabling the location independent execution of a stationary activity. Therefore, the cross-process mobility of the actor is investigated on the basis of the definition of mobile workers given in [7] .The predefined values of the criterion *actor* are *high*, *medium* and *low*. The indicators are stationary workspace, mobile workforce, and frequent business trips. For example, the value is *high* if the actor is part of a mobile workforce, rarely at his stationary workspace or often on business trips.

Process. The category *process* considers aspects given by the process itself. This comprises, on the one hand, the effects of the improvement of the activity on the entire process and, on the other hand, the improvement potential of the underlying information system. Therefore, the category is divided into two subcategories: *relevance* and *current information system*. The category *relevance* contains the criteria *frequency* and *acuteness.* Based on these criteria, the impact on the process by improving the respective activity is analyzed. The criterion *frequency* refers to the frequency of execution of an activity. Thereby, it is not differentiated if the activity is executed multiple times in one process instance or if multiple process instance lead to frequent activity executions as the potential impact of the activity is higher the more often it is executed in general. The predefined values are *often*, *regularly*, and *rarely*. There are no concrete numbers as these depend on industry-specific process conditions. The subcategory c*urrent information system* considers the improvement potential regarding the current information system. The criteria are *digitalization*, *existence* *of devices*, *usability* and *sensors*. For instance, the criterion *sensors* investigates if the use of sensors has the potential to improve the activity, e.g., by taking photo of a situation instead of describing it textually.

Technology requirements. The category *technology requirements* analyzes technological aspects of the application used in the activity. They are deduced from [23–25, 28]. The category is divided into *performance* aspects and *software quality* aspects. The *performance* subcategory contains the following criteria: *Data Volume of send* and *receive*, *computing power*, *presentation* and *type of input*. With these criteria, the required performance can be matched with the different types of mobile technology. For instance, the criterion *presentation* refers to the characteristics of small screens. It is investigated if it is possible to present the data on small screens. Indicators are type of the data, e.g., text or picture, and number of data sets. The subcategory *software quality* refers to non-functional properties and contains the criteria *availability* and *security*. Security is one of the biggest barriers to introduce mobile technology in enterprises [10]. In this paper, *security* refers to data security which can be divided into confidentiality, integrity, authenticity, non-repudiation. The predefined values are *high*, *medium* and *low*. For the determination, the risks of violating each aspect have to be considered.

Corporate conditions. The category *corporate conditions* combines general organizational and technological conditions for the use of mobile technology in the enterprise. Thereby, aspects of mobile readiness as well as the context of the usage have to be considered [29]. Thus, the subcategories are *individual*, *organizational* and *infrastructural*. Individual considers the *user* and the *management* and their readiness to use and accept MEAs. For instance, the criterion *user* estimates if the users have a general affinity for mobile devices. Indicators are technical interests of the user and whether he already uses SMTDs. The predefined values are *high*, *medium* and *low*. If the value is *high*, then the possibility that the user would use the devices is high. The subcategory *organizational* refers to organizational aspects of the enterprises and includes the criteria *mobile devices* and *guidelines*. The criterion *mobile devices* investigates if the actor already employs mobile devices that he can reuse for other applications. Guidelines may prescribe, for instance, that in some restricted company areas mobile device are not allowed. *Infrastructural* contains one criterion, *data communication*. It represents the availability of mobile networks.

4.2 App Potential

The app potential is a metric representing the improvement potentials for a process activity when supported by a MEA. The app potential has two dimensions, *mobilization potential* and *app capability*.

The *mobilization potential* refers to the aspect whether a mobile execution of the activity is beneficial: the higher the mobilization potential, the higher the advantages of using mobile technology in general. The *app capability* refers to the question, whether the application supporting the activity is suited to be realized as an application on SMTDs.

In order to determine the app potential, the criteria of the catalogue are mapped to the two dimensions of the app potential. The numerical calculation is then based on scored and weighted criteria values as explained in Section 5.2.

The app potential metric enables the ranking and prioritization of process activities in a portfolio (see Section 4.3) and makes them comparable regarding their improvement potential using MEAs.

4.3 App Management Portfolio

The app management portfolio is based on portfolio analysis concepts. The latter are typically used for evaluating, selecting and managing research and development projects in order to make strategic choices [30–32]. We adapted these concepts to the evaluation and selection of process activities regarding mobile technology. The app management portfolio groups the process activities into four categories according to their mobilization potential and their app capability. The goal is to define action recommendations for each category. These recommendations focus on the type of IT technology which fits best for each category. The four categories are *flexible & easy-on-the-go*, *complex & mobile*, *legacy & fixed*, and *fancy & pointless*. The resulting portfolio is shown in Fig. 3. The higher the app potential of an activity, the more it is positioned further up on the right of the portfolio.

Activities in the *flexible & easy-on-the-go* category have a high mobilization potential and a high app capability. That is, process improvements are high when using apps for this activity. It is highly recommended to deduce a corresponding usage scenario for a mobile app. For instance, if a mobile worker needs current information of an enterprise backend system or has to record information on-the-go, these activities may be in the *flexible & easy-on-the-go* category. A corresponding app could not only provide mobile access but easily enrich the information by sensor data, e.g., photos, location, voice or video as provided by most smartphones. The recorded information can be transmitted directly to the backend instead of describing the situation textually on paper and transferring it manually.

The *complex & mobile* category is characterized by a high mobilization potential and a low app capability. That is, activities in that category can be improved, if their applications run on mobile devices. However, the application is not suitable for running on SMTDs due to, e.g., high performance requirements of the application.

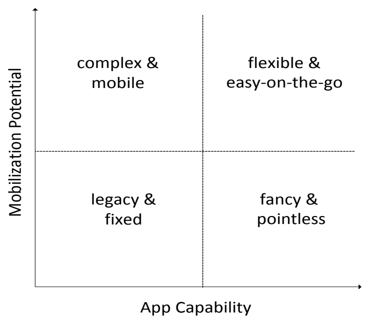

Fig. 3. App management portfolio

Hence, the actors of these activities should be equipped with laptops enabled to connect to the enterprise IT backend. For example, if a simulation model should be compared to the real world, the employee has to go to this area with his mobile device. Simulation needs a lot of computing power, hence a notebook might be suited. Writing a long report at the point of action is another example for a notebook application because writing a text on touchscreens is not appropriate.

Low mobilization potential and low app capabilities are the characteristics of activities positioned in the *legacy & fixed* quadrant. This implies that there are no improvements when using mobile technology. Thus, there is a clear suggestion to refer to traditional stationary technology like PCs.

The *fancy & pointless* category has low mobilization potential and high app capabilities. That is, it is possible to create an app for this application but the app does not add value, because the execution of the activity is not improved. For instance, an engineer might use an app for mobile product data management without having mobile tasks. Technology-driven approaches are in danger of producing apps for this type of process activities. Activities in this category should be supported by stationary IT technology although it is technologically possible to employ apps.

The boundaries of the quadrants can be varied according to the enterprise strategy. By default, boundaries are based on half of the maximum values for mobilization potential and app capability revealing quadrats of equal size. The numerical calculation of these values is described in Section 5.3 and the categorization of activities in the portfolio is detailed in Section 5.4.

4.4 Business Benefit Breakdown Structure and Business Benefit Radar Chart

The *business benefit breakdown structure* offers a mechanism to analyze the business benefits of MEA usage for a certain process activity. The structure is based on the three goal dimensions of process improvement, namely flexibility, time, and quality. For each dimension, we identified major business benefits which can be achieved by the usage of a MEA in a particular activity, e.g., a reduction of reaction times in the time dimension. It has to be remarked that we do not consider the cost dimension, because a profound cost analysis requires additional investment calculations regarding the use of information systems in organizations [33]. However, the benefits can be used as basis for a traditional cost-benefit analysis.

The benefits were identified on the basis of both a comprehensive literature study [26, 34–36] and a case-oriented investigation of mobile apps in the engineering domain presented in [37]. To determine, whether a certain benefit can be realized for an activity, we mapped related criteria of the criteria catalogue to each benefit. In the following, we give an overview of the business benefit breakdown structure with major benefits according to the three goal dimensions. Related criteria for each benefit are written in brackets.

Flexibility. In the context of ValueApping**,** flexibility means that the execution of the activity can be modified or adapted at process runtime.

- *Location independent task execution* (→ actor): Due to the anywhere and anytime characteristics, the actor is not restricted to perform the task in a specific place and is enabled to perform his work even on-the-go. Hence, this is determined by the criterion *actor*.

- *Task scheduling* (→ mobility of the task, availability): Different circumstances can necessitate a rescheduling of a task during mobile work. For example, a service engineer may receive an urgent service request while being at the customer. When he is able to access the required information relevant for the new task in the back-end system, he can reschedule his work immediately and reprioritize his tasks. Therefore, the corresponding criteria are *availability* and *task*.

Quality. Quality refers to the data quality in the process. A higher quality refers to fewer input errors as well as more precise information representation [38].

- *Reduction of input errors* (→ digitalization, usability): Due to digitalization, media breaks can be avoided, because the data are entered directly into the IT system. The corresponding criterion is digitalization. In addition, the intuitive touch-based interaction and targeted functionality of MEAs can avoid errors during activity execution in general. This benefit can be realized if the usability of the existing IT system is low. Thus, the corresponding criterion is *usability*.
- *Contextualization and enrichment of information* (→ sensor): Device sensors can be used to record data, which was not available before such as taking a photo or determining the geographic location of the user. This enables an informational enrichment by multimedia data as well as the additional contextualization of input data. The relevant criterion for this benefit is *sensor*.
- *Access to real time data* (→availability): Due to the mobile connection to the back-end system, the user can access current data and base his decision on up-to-date information. This is determined by the criterion *availability*.

Time: Time refers to the reduction of the entire lead time of the process. That is, the time from the start of the first activity until the end of the last activity of the process.

- *Reduction of activity execution time* (→ sensor, usability): Due to a higher usability and the sensor-based contextualization, the human computer interaction can be improved. For example, taking a picture is faster than describing a situation textually. Moreover, due to their strictly task-oriented user interface, MEAs only provide the functionality which is actually necessary to perform an activity in contrast to complex multi-functioned desktop applications. This leads to a faster execution of the activity, especially for untrained employees. Hence, the corresponding criteria are *sensor* and *usability*.
- *Reduction of waiting time* (→ actor, availability): MEAs increase the reachability and working ability of employees as described in Section 2.1. This is important, if the start of an activity depends on receiving an event from a back-end system. With a MEA the actor receives the notification of the event immediately and waiting times between process activities can be reduced. This benefit is determined by the criteria *actor* and *availability*.
- *Elimination of activities* (→ digitalization, sensor): One of the main optimization potentials of MEAs is the elimination of activities for paper-based data acquisitioning through digitalization. In addition, due to the integration of multiple IT func-

tions in one mobile device, further data processing activities can be eliminated, e.g., due to the integrated camera, it is not necessary to use a separate camera and transfer the data from the camera to the IT system. The corresponding criteria are *sensor* and *digitalization*.

On the basis of the benefit breakdown structure, the *business benefit radar chart* (see Fig. 4) aggregates the benefits for each analyzed activity according to the goal dimensions time, quality, and flexibility in a graphical manner. At this, the chart does not represent a detailed quantified statement but an indicator for the achievable benefits and can be used to relatively compare particular MEA usage scenarios of different process activities. The value for each dimension ranges between 0 and 1 and represents the proportion of achievable benefits compared to the maximum. The calculation of the values is detailed in Section 5.4.

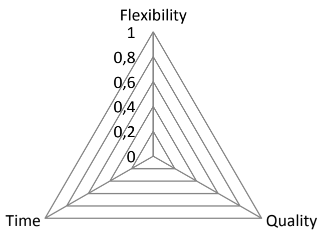

Fig. 4. Business benefit radar chart

5 Analysis Steps

In this section, the analysis steps of ValueApping are explained, namely process analysis, evaluation of app potential, recommendation generation and business benefit analysis.

5.1 Process Analysis

The process analysis refers to the application of the criteria catalogue and the determination of the criteria values for a given process activity. It comprises four analysis activities, one for each category of criteria. The entire procedure for process analysis is shown in Fig. 5.

The input for the activity *analysis of mobility* depends on the application variants. In the user-driven approach, the input is one activity whereas in the process-driven approach the input is the entire process. Then, each activity is analyzed by determining the values of the criteria from the category *mobility of activity*. To minimize the effort, there is a condition for early termination after the analysis of mobility: If no mobility is detected, then the analysis of the activity is terminated because mobility is the prerequisite for the use of mobile devices. No mobility is given, if the values of the criteria *actor* and *task* are both *low*.

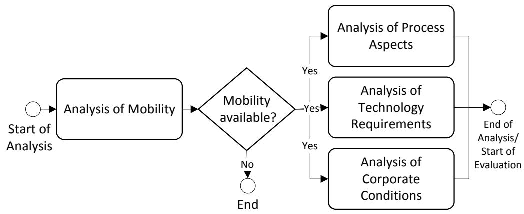

Fig. 5. Procedure and activities for process analysis

After this step, the activities for the *analysis of process aspects*, the *analysis of technology requirements* and the *analysis of corporate conditions* follow. Thereby, these activities are executed in parallel. The advantages of dividing the process analysis into four sub analyses are that the entire procedure is clearly structured and the results can be reused. For example, if two activities are executed in the same environment, the corporate conditions have to be analyzed only once and the results are used for both activities.

5.2 App Potential Evaluation

In order to evaluate the app potential, the criteria and their values have to be mapped to the dimensions of the app potential as explained in Section 4.2. For this purpose, the influence of the criteria on the dimensions has to be examined. For example, the criterion *task* in the category *mobility of the activity* has an influence on the mobilization potential due to the fact that a mobile task would benefit from mobilization. Hence, the criterion *task* is assigned to the dimension *mobilization potential* (D_{MobPot}). In contrast, the criterion *computing power* is assigned to the dimension app capability (D_{AppCap}), because this differentiates laptops from SMTDs.

The next step is to specify the concrete influence of a criterion value on the dimension it belongs to. Therefore, a scoring function $s(C = k_c)$ maps the ordinal value k_c of a criterion C to a numerical value. The scoring function is based on a scoring matrix as shown in Table 2. For example, if the criterion *actor* has the value *high*, then $s(Actor = high) = 3$ and in case the value is *low* it is $s(Actor = low) = 1$.

In addition, the influence of individual criteria on the app potential can be adapted by weighting each scored criterion C with weight w_c as in $s(C = k_c) * w_c$. The weighting enables enterprises to adapt the impact of the criteria according to their mobile strategy. For example, if data security issues are very important, such as with product data for manufacturing cars, the weight $w_{security}$ can be increased.

Table 2: Excerpt of the scoring matrix

Score	**3**	**2**	**1**
Task	High	Medium	Low
Actor	High	Medium	Low
Frequency	Often	Regularly	Rarely
...	....		

On this basis, the numerical values for the app potential of a process activity are calculated as follows:

$$AppPotential = (x_{AppCap}, x_{MobPot})$$
$$with$$
$$x_j = \sum_{C \in D_j} s(C = k_c) * w_c \quad (1)$$

5.3 Recommendation Generation

The step recommendation generation positions the activities in the app management portfolio and defines action recommendations for each portfolio category (see Section 4.3). Process activities are positioned according to their values for app capability and mobilization potential. For example, activities with the app potential (0,0) belong to the category *legacy & fixed*. The higher the app potential of an activity, the more it is positioned further up on the right of the portfolio.

Using this portfolio, the stakeholders can decide which activities should be supported by apps and prioritize corresponding development projects. Hence, the enterprise gets a structured overview about the app potential across various processes.

5.4 Business Benefit Analysis

In this step, the business benefits of MEA usage scenarios for activities located in the *flexible & easy-on-the-go* quadrant in the portfolio are analyzed based on the business benefit breakdown structure and the criteria (see Section 4.4): if one of the scored criteria values related to a benefit is larger than zero, we assume that this benefit is likely to be realized with the corresponding MEA. For example, the benefit *reduction of execution time* has the corresponding criteria *sensor* and *usability*. Hence, this benefit will occur if the value of the criterion *sensor* is *yes* or the value of the criterion *usability* is *medium* or *high*. For the business benefit radar chart, all scored criteria values for all benefits are then aggregated for each goal dimension. The calculation of the value v_i for each goal dimension GD_i is defined as follows:

$$v_i = \frac{\sum_{C \in \mathrm{GD}_i} s(C = k_c)}{\sum_{C \in \mathrm{GD}_i} \max s(C = k_c)} \quad (2)$$

$$with\ i \in \{flexibility, time, quality\}\ and\ 0 \leq v_i \leq 1$$

It is important to remark that the value of v_i does not denote the absolute quantified improvement of a goal dimension but enables a relative comparison of different MEA usage scenarios for certain process activities. For instance, $\mathrm{v}_{\mathrm{quality}} = 0{,}5$ does not represent an improvement of the process quality by 50% but, compared to another MEA usage scenario with $\mathrm{v}_{\mathrm{quality}} = 0{,}25$, the first has a higher impact on the quality dimension.

6 Case-oriented Evaluation in the Automotive Industry

As an initial evaluation, we applied ValueApping in a real case at a large German car manufacturer. At this, we used the method to analyze a concrete process in the engineering domain. In the following, we briefly describe the process and the analysis procedure and discuss major results.

6.1 Modification Approval Process

The modification approval process is part of the car development process. During the development of a car, a lot of change requests arise. For instance, the design of the seat is changed or another breaking system should be used. However, single changes have impacts on the whole car. For instance, it has to be checked whether the new seat design fits the car's interior. The modification approval ensures that the product data in the product data management (PDM) system is in a consistent state despite modifications. In general, a faster execution of the process is desirable to reduce development times.

For our analysis, a process description is needed. Therefore, we conducted interviews with the organizational owners of the process to get a high level overview of the process and deduce a simple process model. The process model is shown in Fig. 6. It consists of six sequential activities. The process starts if product data is modified. Product data comprises both product descriptions in terms of computer-aided-design models and the product structure in form of a bill of materials. When the modification is done, the engineer has to create a modification document including all relevant changes. Once the document is checked into the PDM system, the process starts. Then, the system forwards the document to various persons with different responsibilities following a pre-determined order. At first, the responsible person for this component, the creator himself or his boss, has to perform the *check modification record* activity. This includes checking the document for correctness and completeness. After that, the activity *verify packaging* is performed by the packaging manager. A package is a higher level component built from multiple parts. For example, the worker checks if there is an installation space collision, e.g., whether the new engine fits in the engine compartment. After that, the design validator performs the activity *verify design* to ensure data quality. Then, the activity *verify and approve modification* has to be executed by the technically responsible persons. First, the team lead has to give his approval and then the department leader approves as well. If the document received all required approvals, the documentarian performs the activity *create entries in PDM*. With that, the modification is completely documented in the PDM and the modification approval process finishes.

This simple modelling is sufficient for our analysis, because all other important aspects for mobile IT support, e.g., location and roles, are covered in the criteria catalogue. Yet, for further stages like the development of suitable apps for the process, the

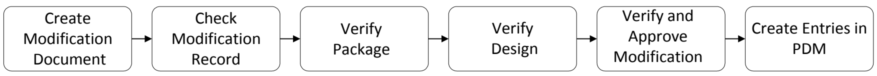

Fig. 6. Process model of the modification approval process

process model has to be extended by other process characteristics such as location, actors, business domains and resources [39, 40].

6.2 Method Application and Results

On the basis of the process model described above, we applied ValueApping in the process-driven approach in order to analyze the entire process. Thereby, we conducted interviews with process experts to determine the criteria values.

On this basis, we investigated the mobility of each activity according to the procedure described in Fig. 5. To this end, the criteria *task* and *actor* were used. We observed that all tasks have a low mobility. The reason is that they are all executed at the actor's stationary workspace. However, during the evaluation of the criterion *actor*, two groups of activities were identified. One group has actors with a low mobility and the other one has actors with a high mobility. The activities *create modification record document*, *check document*, *verify packaging*, *verify design*, and *create entries in PDM* have actors with a low mobility because they are most of their working time at their stationary workspaces. In contrast, the activities *check record* and *verify and approve modification* have actors who are rarely at their workplaces. Thus, according to the termination condition, we further analyzed only the activities from group two, *check record* and *verify and approve modification*, and skip process analysis for group one.

Our analysis results of these activities revealed that the values of the (sub) categories *process*, *performance,* and *individual* have a positive influence on the app potential of these activities, because the process is very important, so enhancement is beneficial for the enterprise and the performance requirements make it possible to run the application on SMTDs. In addition, employees and the corporate management welcome the usage of SMTDs. However, security requirements are a big challenge. Product data are highly sensitive and no unauthorized person should be able to access them.

After performing the app potential evaluation (see Fig. 7), two activities were positioned in the category *flexible & easy-on-the-go,* namely *check record* and *verify*

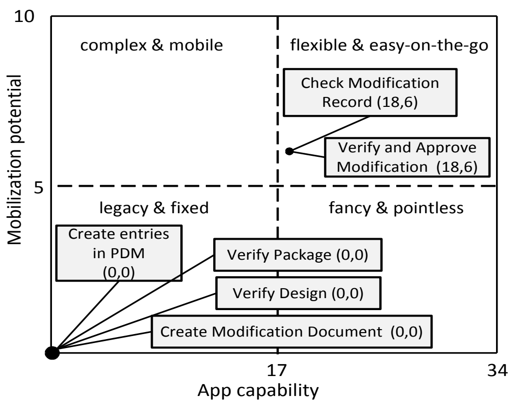

Fig. 7. App management portfolio of the modification approval process

and approve modification. For these activities, an app usage scenario was defined as a basis for the development of a concrete app within the car manufacturer, called ApprovalApp. The other activities *create entries in PDM*, *check package*, *check design*, and *create modification* cannot be improved through mobile technology due to a low mobilization potential.
The business benefit analysis for the ApprovalApp usage scenario revealed the following benefits:

- Location-independent task execution
- Reduction of waiting time
- Access to real time data

The resulting business benefit radar chart (see Fig. 8) reveals that the ApprovalApp improves flexibility, time, and quality of the modification approval process. Many actors of the *verify and approve modification* activity are senior managers. Hence, they are rarely at their stationary workplaces, most of the time they are on business trips and meetings. With the ApprovalApp, they are informed immediately if a new approval task occurs and they can perform the task right on-the-go. Furthermore, the decision can be made on the basis on up-to-date product data.

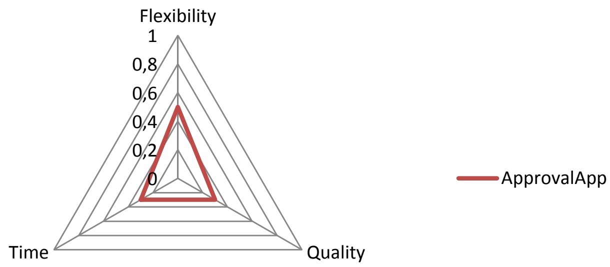

Fig. 8. Benefit Radar Chart of the ApprovalApp

6.3 Discussion

We discussed both the procedure of applying ValueApping as well as the concrete results for the modification approval process with experts on mobile technology within the industry partner and summarize major results in the following.

It was underlined that the strict structure and the systematic procedure of analysis steps make the results of ValueApping comprehensible and transparent. Moreover, it was emphasized that the portfolio-oriented visualization enables an easy communication and representation of the analysis results especially for corporate management. Before, various ideas for new MEAs were discussed within the industry partner without clear prioritization. The portfolio helped to get an overview of all analyzed activities and corresponding possibilities for new apps. This provided a sound basis for decision making and prioritization of investments in mobile technology. On the one hand, potential users could be convinced that their app ideas in the category fancy &

pointless should not be realized. On the other hand, IT responsibles developed a deeper understanding for a business-driven view on mobile technology.

With respect to the analysis steps, the termination condition was recognized as helpful because it decreased the analysis effort significantly. The approval modification process comprised six activities and the analysis of four was terminated using the termination condition. Yet, with respect to the criteria, additional indicators revealed to be helpful in order to precisely determine the value of each criterion. At this, more fine-grained values for some criteria like security and data volume would be helpful, too.

Considering the usage of MEAs in the modification approval process, the need for supporting the activities *check record* and *verify and approve modification* through a MEA was recognized by the industry partner. It was stated that an app has the potential to reduce execution times and enhance flexibility of the process significantly as highlighted by the business benefit radar chart.

7 Related Work

In this section, we give an overview of work related to our approach. A further qualitative evaluation of ValueApping based on a comparison with similar approaches can be found in our previous work [9]. For the discussion of related work, we differentiate three groups of work with respect to mobile technology in business processes.

The first group comprises work on the general potential and impact as well as the basic conditions for the use of mobile technology in business processes [26, 29, 34, 41]. These works discuss different high level aspects of mobile technology in enterprises such as benefits of mobilizing processes, transformational impact of mobile technology and mobile enterprise readiness. Yet, they do not address issues of a methodology to systematically realize the benefits of mobile technology.

The second group comprises concepts which are similar to our ValueApping method. Gumpp and Pousttchi propose a framework to evaluate mobile applications according to their potential business benefits [7]. The framework is based on the theory of informational added values and its application to mobile business. It constitutes a high level approach and misses the detailed analysis of processes to derive concrete usage scenarios. Gruhn et al. present a method called Mobile Process Landscaping to choose a suitable mobile application to enhance business processes [5]. The authors make use of typical return on investment concepts to analyze mobility in processes and evaluate different mobile applications. Yet, they neither incorporate technological aspects, e.g., the complexity of data input, nor do they focus on the specific characteristics of MEAs. Scherz defines criteria to identify mobile potential in business processes during a condition-analysis as part of a classical system analysis [6]. These criteria are divided into four categories, namely actor, process classification, data and information system as well as devices. Yet, mobile apps are not addressed specifically.

The third group of work considers the usage of mobile apps in enterprises [10, 42, 43]. They point out that apps have a great potential to improve business processes, suggest general application areas for apps and discuss selected app-oriented aspects, e.g., technical requirements for the IT back-end. Yet, they do not focus on an analysis methodology to identify concrete usage scenarios.

8 Conclusion and future work

In this work, we presented ValueApping, an analysis method to identify value-adding usage scenarios for mobile enterprise apps in order to improve business processes. ValueApping helps stakeholders to decide which type of IT technology fits best for a given process activity. It is based on a comprehensive criteria catalog to systematically analyze business processes and reveals an app management portfolio, which categorizes process activities according to their improvement potential using MEAs Furthermore, the business benefits of the resulting app usage scenarios are evaluated and represented in a graphical manner.

ValueApping can not only be employed to identify usage scenarios for one process. It can also be used to get a general view on mobile potentials of several processes in an enterprise in order to identify cross-process synergies and prioritize company-wide investments. On this basis, ValueApping enables both a systematic prioritization of IT investments in mobile technology and a transparent IT portfolio management as part of a mobile enterprise strategy.

Our future work comprises two aspects. On the one hand, we plan to implement ValueApping as a software tool to ease the application of the method, especially the determination of the criteria values. On the other hand, we want to extend ValueApping in order to apply it at the business modelling stage and determine usage scenarios for mobile enterprise apps during the initial design of a new business process.

ACKNOWLEGMENT

The authors would like to thank the German Research Foundation (DFG) for financial support of this project as part of the Graduate School of Excellence advanced Manufacturing Engineering (GSaME) at the University of Stuttgart.

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