Improving Business Processes through Mobile Apps
An Analysis Framework to Identify Value-added App Usage Scenarios

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Abstract: Mobile apps offer new possibilities to improve business processes. However, the introduction of mobile apps is typically carried out from a technology point of view. Hence, process improvement from a business point of view is not guaranteed. There is a methodological lack for a holistic analysis of business processes regarding mobile technology. For this purpose, we present an analysis framework, which comprises a systematic methodology to identify value-added usage scenarios of mobile technology in business processes with a special focus on mobile apps. The framework is based on multi-criteria analysis and portfolio analysis techniques and it is evaluated in a case-oriented investigation in the automotive industry.

1 INTRODUCTION

With the rise of smartphones and tablets, a new type of software called mobile apps has established itself in consumers' life. Mobile apps provide an easy-to-use, touchscreen-based handling and can be used anytime and anywhere (Clevenger, 2011). The employment of mobile apps in enterprises creates new possibilities for business process improvement, e. g., by the elimination of activities for paper-based data collection. Hence, enterprises are more and more equipping employees with a variety of mobile devices to enhance productivity (Unhelkar and Murugesan, 2010). To this end, the enterprise has to decide which type of IT technology fits best for each process activity. As illustrated in Figure 1 three types of IT technology can be distinguished in general:

- PCs as stationary IT systems
- Laptops as mobile IT systems
- Smartphones and tablets as mobile touchscreen-based devices

In general, the usage of these types may differ for each activity in a process. The corresponding decision making process is complex, because there are many issues and requirements R_i to consider, especially the following:

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 (Gumpp and Pousttchi, 2005):

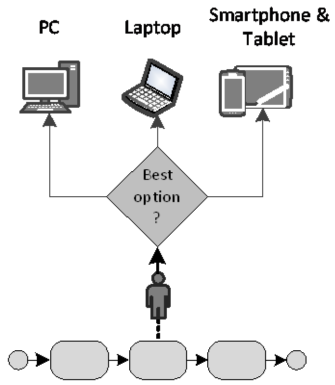

Figure 1: Which IT technology fits best for executing this activity?

- Supporting 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.

Type 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:

- Mobile PC like laptops
- Mobile touch-based devices like smartphones

In contrast to mobile PCs, mobile touch-based devices have special features e. g., sensors like GPS and camera, touch-based user interface, mobile radio, and a purpose-build operating system. Therefore, mobile devices target different application scenarios.

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 existence of a mobile network, have to be considered.

In the following, examples are given to illustrate the complexity of these issues in the decision making process.

Motivating Examples. With respect to the business potential (R1), the question "is it suggestive to mobilize an existing enterprise application?" cannot be answered in general. Mobilization of an application means, that the application can be accessed using mobile devices. For example, enterprise resource planning data can be accessed by different IT systems in order to check actual stock levels. However, not in every scenario a mobile application is sufficient. We illustrate this point in three exemplary scenarios: In the first scenario, a sales man needs information about current stock levels on-site at the customer. In this case, mobile technology is beneficial because he can access the data during his customer visit. In another scenario, if an office worker needs this information, a benefit of mobilization is questionable because stationary IT technology may be sufficient. In the last scenario, a manager has to verify the ordering of parts. He can do this at his stationary workspace using a PC as the activity itself does not involve mobile aspects. Yet, he is regularly on business trips and thus process execution is delayed until he returns and verifies open orderings. For this purpose it would be beneficial to verify orders on-the-go when being out of office using mobile technology.

A further challenge is to choose between the different types of mobile technology (R2) in the above scenarios. For example, the worker has to input data including a description of the situation. The structure of data input as well as the required computing power have to be analysed in order to select a suitable mobile technology. For instance, if computing capacity is critical, a notebook is more appropriate than a mobile touch-based device. Moreover, organizational aspects, e. g., compliance regulations, have to be considered in a holistic view (R3).

Contribution and Paper Outline. In this paper, we present a holistic analysis framework for the goal-oriented use of mobile technology in business processes to identify value-added usage scenarios of mobile technology with a special focus on mobile apps. The framework comprises a systematic methodology using multi-criteria analysis and portfolio analysis techniques and considers all above requirements (R1-R3).

The remainder of this paper is structured as follows: Section 2 gives an overview of the framework including the analysis methodology and the underlying analysis artifacts. Section 3 details on the analysis artifacts and the analysis methodology is described in Section 4. A proof of concept of the framework is presented in Section 5 based on a case-oriented application in the automotive industry. Related work and a comparative evaluation are discussed in Section 6. Finally, Section 7 concludes the paper and highlights future work.

2 ANALYSIS FRAMEWORK

In this section, we first give an overview about the analysis framework. After that, we discuss the potential improvements of business processes according to the goal dimensions cost, time, flexibility and quality when using mobile apps.

2.1 Overview

The purpose of our framework 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. Improvements refer to enhancements of both the efficiency of a process, e. g., by a faster execution, and the effectiveness, e. g., by elimination of paper-based data collection to improve data quality. The major result is a portfolio of

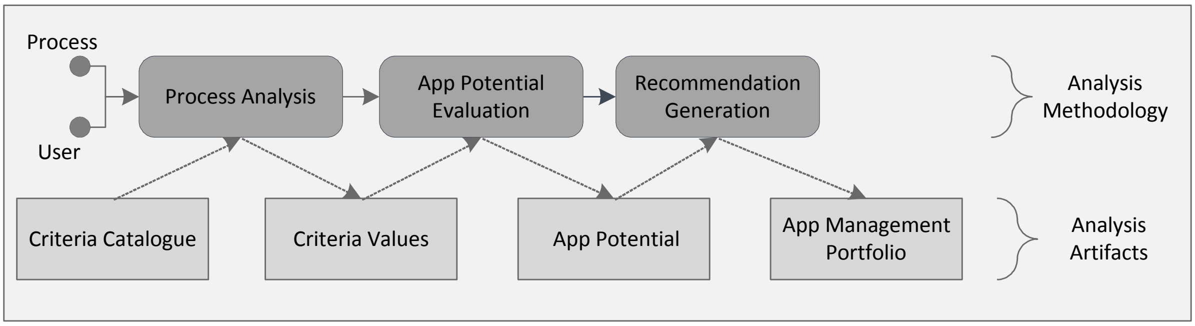

Figure 2: Analysis Framework to improve Business Processes using mobile apps

analyzed activities which are categorized according to the IT technology which fits best. This provides the basis to deduce value-added usage scenarios and to define corresponding development projects and IT investments.

The framework is made up of two major parts, the analysis methodology and the analysis artifacts (see Figure 2). The analysis methodology describes the execution sequence of analysis activities which require and create different analysis artifacts as input and output. Thereby, we distinguish between three groups of analysis artifacts, namely

- the criteria catalogue and criteria values,
- the app potential as a metric and
- the app management portfolio.

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 mobile apps. This means, the higher the app potential the more the activity can be improved using mobile apps. The *app management portfolio* enables the classification and ranking of the activities according to the IT technology which fits best.

The *analysis methodology* comprises two starting points and three activities, namely:

- Process Analysis
- Evaluation of App Potential
- Recommendation Generation

The *starting points* represent different application variants of the framework. 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 as a metric. At last, *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.

2.2 Goal dimensions of process improvement

The goal of our framework is to improve business processes regarding efficiency and effectiveness. These improvements can be evaluated with respect to four goal dimensions, namely time, cost, quality and flexibility (Reijers and Mansar, 2005). In the following, the potential improvements of business processes through the usage of mobile technology are discussed according to these goal dimensions.

Time. The execution time of the process can be reduced due to the anywhere and anytime characteristics of mobile touch-based devices. For instance, the delay between two activities can be minimized, because the actor of the activity can receive and perform the task immediately and independently from his location, that is, the actor has not to go back to his stationary work place to perform the task. Furthermore, activities may be entirely eliminated, for example, when they solely focus on paper-based data acquisition.

Quality. Mobile touch-based devices can increase the quality of the activity, e. g., by avoiding media breaks and corresponding transmission errors. Furthermore, due to new sensor technologies, the quality of the data increases. For instance, taking a picture is more meaningful as describing a situation textually or recording the location via GPS is more precise than a textual location description. In addition, through the easy-to-use and intuitive touch-screen handling, the usability of the application is increased and can avoid input errors.

Flexibility. Flexibility can be increased by the use of mobile touch-based devices, because the actor can perform the task anytime and independent from his location. For example, with mobile apps the employee can answer his email not only on his stationary work place but also in a train or at the airport.

Cost. The impact on costs has two sides: On the one hand, the usage of mobile apps increases costs by purchasing mobile touch-based devices and establishing a corresponding IT infrastructure. On the other hand, purchasing costs may amortize over the time due to shorter execution times, higher quality or increased flexibility as explained above.

To sum up, mobile apps provide significant potentials for the improvements of business processes regarding time, quality, flexibility and cost. Our framework aims at leveraging these potentials by a holistic analysis of business processes. It has to be remarked, that a profound analysis of the cost dimension requires additional investment calculations regarding the use of information systems in organizations (Ward and Peppard, 2002). Hence, our framework focuses on the dimensions time, quality and flexibility and can be extended by cost analysis concepts.

3 ANALYSIS ARTIFACTS

This section describes the analysis artifacts of the framework, namely the criteria catalogue, the app potential, and the app management portfolio.

3.1 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 (Cansando *et al.*, 2012). As a basis for the criteria definition, we conducted literature analyses (Forman and Zahorjan, 1994; Gruhn and Köhler; Gumpp and Pousttchi, 2005; Krogstie, 2001; Murugesan and Venkatakrishnan, 2005; Nah *et al.*, 2005; Sarker and Wells, 2003; Scherz, 2008; Wasserman, 2010). Moreover, we carried out expert interviews with employees of a

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

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 (Gruhn *et al.*, 2007) 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 (Gumpp and Pousttchi, 2005). 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 on 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 (Forman and Zahorjan, 1994; Krogstie, 2001; Murugesan and Venkatakrishnan, 2005; Wasserman, 2010). 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 (Gröger *et al.*, 2013). 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 (Basole, 2005). Thus, the subcategories are *individual*, *organizational* and *infrastructur-*

al. Individual considers the *user* and the *management* and their readiness to use and accept mobile apps in the enterprise. 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 mobile touch-based devices. The predefined values are *high*, *medium* and *low*. If the value *high* is true, 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.

3.2 App Potential

The app potential is a metric representing the potential of improvement for a process activity when supported by mobile apps. 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 is, 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 app on mobile touch-based devices.

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 4.3.

The app potential metric enables the ranking and prioritization of process activities in a portfolio (see Section 3.3) and makes them comparable regarding their improvement potential using mobile apps.

3.3 App Management Portfolio

The app management portfolio is based on portfolio analysis concepts. The latter are typically used for evaluating, selecting and managing research&development projects in order to make strategic choices (Bohanec *et al.*, 1995; Mikkola, 2001; Killen *et al.*, 2008). We adapted these concepts to

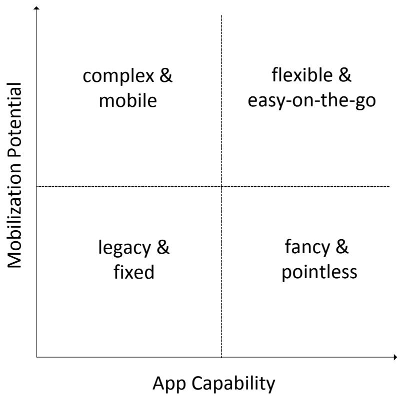

Figure 3: App Management Portfolio

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 Figure 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 actual 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 the most smartphones. The recorded information can be transmitted directly to the backend instead of describing the situation textually on a 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 mobile touch-based devices due to, e. g., high performance requirements of the application. Hence, the actors of these activities should be equipped with laptops being able 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 4.3 and the categorization of activities in the portfolio is detailed in Section 4.4.

4 ANALYSIS METHODOLOGY

This section explains the activities of the analysis methodology including its application variants.

4.1 Application variants

The methodology has two possible starting points, which enable two different applications variants, namely the process-driven and the user-driven variant. In the *process-driven variant*, the analysis is initiated by the person who is responsible for the process, the process owner. The goal is to improve the whole process. Hence, all activities of the selected process are analyzed and as a result positioned in the portfolio. The *user-driven approach* considers the fact that through the consumerization of IT and the bring-your-own-device paradigm more and more workers have their own ideas of improving their work using mobile apps (Clevenger, 2011). Thus, in the user-driven variant, the analysis is initiated by the worker in order to improve process activities which he takes part in. Thereby, only the activities selected by the worker are analyzed. In this way, workers can justify or validate whether their ideas for mobile apps are valuable from a business point of view. The user-driven variant incorporates end users and their creativity in the decision process but further synergies across an entire process may not be identified. Hence, the results of the two variants should be combined when applying the framework.

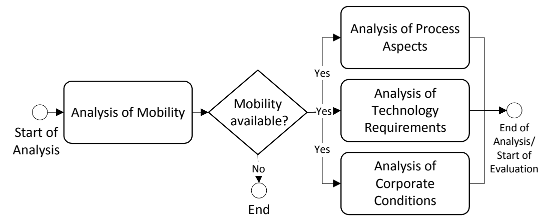

Figure 4: Procedure and activities for process analysis

4.2 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 Figure 4.

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*.

After this step, the activities for the *analysis of process aspects*, the *analysis of technology requirements* and the *analysis of the cooperate conditions* follow. Thereby, these activities are executed in parallel. The advantages of dividing the process analysis into four subanalyses 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.

Table 2: Extract of the scoring matrix

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

4.3 Evaluation of App Potential

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 3.2. 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 mobile touch-based devices.

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.

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

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

4.4 Recommendation Generation

The step *recommendation generation* positions the activities in the app management portfolio and defines action recommendations for each portfolio category (see Section 3.3). 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 CASE-ORIENTED PROOF OF CONCEPT

As an initial proof of concept, we applied our framework in a real case at a large German car manufacturer. At this, we used the framework to analyse a concrete process in the engineering domain. In the following, we describe the process and the analysis. At the end, we discuss the results.

5.1 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 about the process and deduce a simple process model. This deduced process model is shown in Figure 5. 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

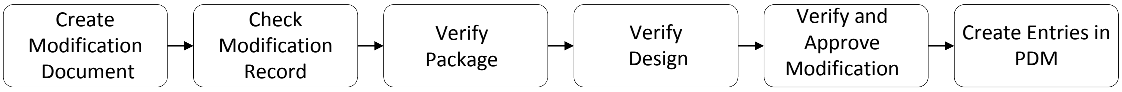

Figure 5: Process model of the modification approval process

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 build of multiple parts. For example, the worker checks if there is an installation space collision, e. g., whether the new engine fits in the bonnet. 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 process model has to be extended by other process characteristics such as location, actors, business domains and resources (Gao and Krogstie, 2012; Gopalakrishnan *et al.*, 2012).

5.2 Framework Application and Results

On the basis of the process model described above, we applied our framework according to the analysis methodology shown in Figure 2. We used the process-driven approach in order to analyse the entire process. For the first step, 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 Figure 4. Therefore, the criteria *task* and *actor* are 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 work spaces. Thus, according to the termination condition, we further analysed 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 reveal that that the values of the (sub)categories *process*, *performance requirement,* and *individual* had 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 mobile touch-based devices. In addition, workers and management welcome the usage of mobile touch-based devices. However, the big challenge are security requirements. Product data are highly sensitive and no unauthorized person should be able to read them.

After performing the app potential evaluation (see Figure 6), two activities were positioned in the category *flexible & easy-on-the-go,* namely *check record* and *verify 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. 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.

5.3 Discussion

We discussed both the procedure of applying our framework as well as the concrete results for the

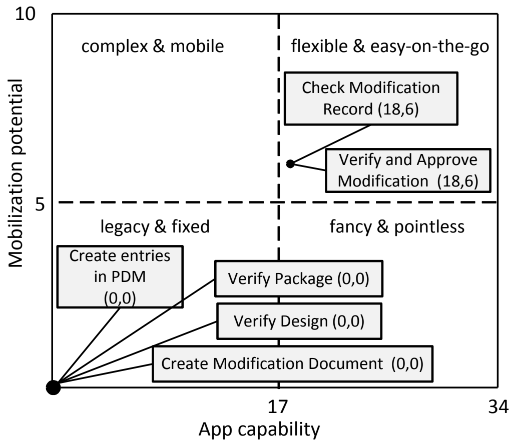

Figure 6: Portfolio of modification approval process

modification approval process with experts on mobile technology within the industry partner.

It became clear that the strict structure and the systematic procedure to apply the framework make the results comprehensible and transparent. Moreover, it was emphasized that the portfolio visualization enables an easy communication and representation of the analysis results especially for corporate management. Before, various ideas for new mobile apps 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 methodology, 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 mobile apps in the modification approval process, the need for supporting the activities *check record* and *verify and approve modification* through a mobile app 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.

6 RELATED WORK AND COMPERATIVE EVALUATION

In this section, we discuss related work and present a qualitative evaluation of our framework based on a comparison with similar approaches.

6.1 Related Work

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 (Basole, 2004; Basole, 2005; Gebauer and Shaw, 2004; Nah *et al.*, 2005). 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 framework. (Gumpp and Pousttchi, 2005) propose a framework to evaluate mobile applications according to their potential business benefits. 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 deduce concrete usage scenarios. (Gruhn *et al.*, 2007) present a framework, called Mobile Process Landscaping, to choose a suitable mobile application to enhance business processes. 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 mobile apps. (Scherz, 2008) define criteria to identify mobile potential in business processes during a condition-analysis as part of a classical system analysis. 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 (Lunani, 2011; Gröger *et al.*, 2013; Clevenger, 2011). They point out that apps have a great potential to improve business process, 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.

6.2 Comparative Evaluation

We qualitatively evaluate our framework against the most similar approaches, namely Mobile Process Landscaping (MPL) (Gruhn *et al.*, 2007) and Identification of Mobile Potential (IMP)-Analysis (Scherz, 2008) described in the last subsection. In addition to the requirements (R1-R3), the following criteria are examined as well:

- *Analysis effort* to execute the approach
- Addressed goals of the approach according to *goal dimensions*
- Existence of a *cost-benefit analysis* in the approach

The results are represented in Table 3. The evaluation against R1 shows that the MPL does not consider the two effects of mobile technology, namely enabling and supporting of mobility. This is the case, because they define a mobile process through the distribution of the task and do not regard the mobility of the actor as an additional enabling factor. Besides, the table shows that only our framework considers different types of mobile devices and corresponding mobile apps according to R2. However, this is an important requirement because, due to their special characteristics, mobile touch-based devices create new possibility to enhance business process as discussed in Section 2.2. The criteria defined in the IMP-analysis and in our framework consider business and technology aspects according to R3. In contrast, MPL focuses on criteria with business aspects only. However, technical aspects are partially considered in the further investigation of the method.

The comparison of the approaches regarding the addressed goal dimensions shows that the goal of MPL is to reduce process cost. In contrast, our framework and the IMP-analysis consider the goal dimensions time, flexibility and quality whereas the IMP-analysis additionally includes cost aspects. Another difference between the approaches is the analysis effort: our approach needs a small analysis effort because it is limited to the design of a simple

Table 3: Comparative analysis of the approaches Mobile Process Landscaping MPL (Gruhn *et al.*, 2007), Identification of Mobile Potential (IMP)-Analysis (Scherz, 2008) and the analysis framework present in this work.

	MPL	IMP-Analysis	**Our Framework**
R1	-	+	**+**
R2	-	-	**+**
R3	-	+	**+**
analysis effort	high	high	**low**
goal dimensions	cost	all	**all, but cost**
cost-benefit analysis	yes	yes	**no**

process model and the determination of the criteria values including termination conditions, whereas MPL and the IMP-analysis are based on a complex process model. The missing of the cost-benefit analysis is the main drawback of our approach in comparison with the other approaches. However, performing a cost-benefit analysis is not the aim of our framework, which is designed to be applicable in a simple way and with a low analysis effort. Yet, it provides the basis for a comprehensive cost-benefit analysis. Finally, a limitation of all approaches is that the person who performs the analysis needs a deep understanding in business processes and the potential of mobile technology in order to achieve valid results. This is why we suppose an assisting application, e. g., a mobile app, to ease the application of our framework.

7 CONCLUSION AND FUTURE WORK

In this work, we presented an analysis framework to identify value-added usages for mobile apps in order to improve business processes. The analysis framework assists stakeholders to decide which IT technology fits best for given process activities. It comprises a systematic methodology to analyze business processes from a user or a process point of view and reveals a portfolio, which categorizes process activities according to their app potential. This enables a systematic and transparent procedure to identify value-added usage scenarios for mobile apps and to prioritize IT investments in mobile technology.

Our framework can not only be used 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.

There are three major parts for future work: First, we plan to apply the framework in other process domains to further refine the criteria. Second, in order to facilitate the application of our framework, we plan to implement it as a software tool to support the determination of the criteria values and the creation of the app management portfolio. Third, we want to extend our framework in order to apply it not only a posteriori on existing business processes but a priori during business modelling of a new process, as well.

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