Challenges in the Development of Mobile Applications in Industrial Field Service

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Abstract

Utilizing mobile applications in the area of industrial field service promises several benefits, especially improved process support providing tailored service information and presenting it in an ad-hoc manner. The suggested approaches up to now are more or less beneficial or can't be applied in this area at all due to some assumptions that can't be perpetuated in most cases.

In this paper, we describe the results of our evaluation of current approaches in the development of mobile applications. We discuss inhowfar these approaches can be used in industrial field service arguing their pros and cons. Based on the results of our case studies, we give some advices regarding which of the presented approaches are less suitable for industrial domains and which should be considered for further investigation.

1 Introduction

Changing business environments, technological progress, and an aging workforce are some of the challenges that have to be faced in the industrial field service area. Especially in high wage countries, we observe some important developments that will influence the future service organizations and processes:

- There will be an increasing influx of non-experts into the workforce. As a consequence there will be an increased necessity to support service personnel with information and knowledge.
- Competition will increase cost-pressure on service units, with the consequence that mobile work must be performed more effectively and efficiently.
- Products and solutions will become more complex, with the consequence that field service engineers will require context-specific information and knowledge support.
- Partnerships for after-sales services will increase, i.e., personnel of external firms will cover some service tasks. Since they will not necessarily be familiar with the installed products, focused information to perform service specific tasks will have to be provided on an ad-hoc basis.

2 Misassumptions, Leaking Domain Knowledge, and Desirable Developments

The capability to provide tailored information support and usability is one of the great opportunities and challenges in the area of industrial field service applications. Mobile and context-sensitive applications seem to be the right choice to fullfil these requirements. A main characteristic of this kinds of applications are their dynamics, which require that the restricted resources of the mobile device on which such applications are executed are used efficiently. The reason is that the current context of the user, such as the present location, decides on the available services.

In the following sections, we describe some challenges and inapplicable assumptions that are often made with respect to the development of mobile applications that also have to be used in industrial field service applications.

2.1 Positioning

The Global Positioning System (GPS) [5] can be used for the recording of the current location of the mobile device or the user. Although GPS has gained wide acceptance out-of-doors, there are different approaches, which try to cover the areas in which GPS does not (reliably) work due to missing intervisibility. Therefore, different projects try to use other existing communication infrastructures, such as GSM radio masts, WiFi or Bluetooth access points, etc. (cf. [17], [1], [11], [2], [18], [6] and others).

However, procedures that are based on WiFi or Bluethooth can't be applied in industrial field service since the worker neither have any access to the customers internal communication infrastructure nor is allowed to establish it's own. A network-supported determination of service technicians' positions, or more precisely the positions of their mobile devices, is possible with using GSM or UMTS. These technologies provide a cellular phone network consisting of segments with different kinds of sizes. Especially in urban agglomerations, these segments have a radius between 100 and 1000 meter which equals the accuracy for localization ([16], [13]). Even though these values would be sufficient for a position determination it must be paid attention to the downside which can be critical for a usage in field service processes. The disadvantages are segments of a far bigger size which are more common rural areas and have a radius of about 35 kilometers ([7]). Since it is more likely that industrial plants are located in these rural areas a huge sacrifice in localization accuracy might be the case. Furthermore, legal restrictions as well as company's internal directives may also lead to limited availability of positioning information even if it can be technically realized.

2.2 Enhanced Input/Output Capabilities

As already mentioned, providing tailored information to a service engineer is one of the challenges that have to be faced. But even if this information is available, accessing it might be a problem. Having both hands full with service tools makes it difficult to access service instructions and manuals. Approaches, like augmented reality are promising but can't be applied in real life scenarios yet due to the limited resolution of displays and the restrictions of available wireless communication technologies, like limited bandwidth and high latency.

Additionally, industrial service processes may require a large input of data like diagnosis results or service reports and thus, presuppose convenient input capabilities. On the other hand, the results of diagnostics routine may produce extensive data that have to be visualized on the mobile device.

Therefore, we evaluated some of the existing approaches regarding their applicability in the area of industrial field service.

2.3 Case Study

In-between a myriad of alternative input technologies and techniques to keyboard-based input exists. Solutions based on data input using pens require too much time for the input of text-intensive tasks to provide a real alternative to a keyboard. Handwriting recognition might provide an appropriate solution. In several cases it can only be applied if it is able to recognize the user's handwriting fast and achieving sufficient results to a large extent. The approach driven by Palm Pilot where a user has to learn the device's abbreviations to get his handwriting recognized wouldn't be accepted by the users. So, general problems in this domain are the limited resources provided by the mobile devices as well as the restricted area of a touch-sensitive display that can be used for user input. The steadily increasing processing power of mobile devices together with the ongoing improvement of handwriting recognition may lead to reasonable solutions in the future.

Improvement of keyboard-based input facilities provides another interesting area of advancement. Some field workers are well skilled in utilizing computer keyboards and use them more efficiently than handwriting. In this area, several improvements regarding user's input capabilities had been suggested in the past, e.g., one-handed keyboards [10], wrist-mounted keyboards [4], or even utilizing an invisible keyboard ([8], [12]). However, the usage of one-handed keyboards require additional training and thus can't be applied in the daily service business. Invisible keyboards sound promising. However, this technology needs some improvements regarding the quality of input recognition before it can be applied in industrial field service. Nowadays, wrist-mounted keyboards seem to strike a balance between enhanced input capabilities and required experience.

The speech-data convergence strikes a balance between new input/output capabilities and the limitations of existing communication technologies. It fosters advanced input capabilities by using voice control and auxiliary output facilities like text-to-speech at the same time. Voice-based input approaches present another alternative for enhancing user input capabilities. They might be suitable for certain kind of mobile industrial applications. However, in most cases, the service engineers' work place is considered to be noisy or for safety reasons requires that at least one of his ears is able to listen to the conditional environment. Anyone, who already tried to use his cell phone in a discotheque-a similar environment with respect to the level of noise-will confirm that it is hard to use. Furthermore, speech-recognition often requires an increased CPU usage and is related to additional power consumption, thus limiting the device's usage.

Specialized types of output-devices, like head-mounted displays are expensive and provide only limited resolutions. Furthermore, a network connection is often a prerequisite in many cases–a requirement that can't be ensured in industrial field service scenarios. Therefore, they can be applied in some specific cases only. Utilizing context-sensitive applications, however, can provide some additional benefit. Here, the output on the mobile device can be adjusted if context information is available, e.g., if it is noticed that the service engineer is just situated in a moving vehicle. In this case, the device could switch over from the default output on the display to an optional acoustic output.

We developed a case study to evaluate the general applicability of some of the alternative input/output capabilities with regard to the utilization in industrial field service. In this study we asked 20 service engineers from Germany and United Arab Emirates to provide us some feedback about the suitability of:

- One-handed keyboard,
- Wrist-mounted keyboards / devices,
- Handwriting input capabilities, and
- Voice-operated input capabilities.

In the questionnaire, we asked the service engineers inhowfar these devices and input techniques would provide the necessary functionality to execute all parts of their jobs. The handwriting input capability came off well: 78,95% of the respondents think that this input technique provides the most potential for interaction improvement. The remaining input devices and techniques under investigation, namely one-handed keyboard, wrist worn computer and voice-operated input performed balanced (cf. Table 1).

Device / Input Technique	Appropriate	
	Yes	No
One-handed keyboard	45,00%	55,00%
Wrist worn computer	50,00%	50,00%
Handwriting input[1]	78,95%	21,05%
Voice-operated input	50,00%	50,00%

Table 1. Appropriateness of the Devices and Input Techniques for Field Service Utilization

Additionally, we asked them inhowfar the one-handed keyboard and the wrist worn computer could be a suitable replacement for their laptops. The results of our case study show that both of them can only be utilized as an addition to the laptop used by the service engineers (cf. Table 2). However, the wrist worn computer performs slightly better (26,32%) compared to the one-handed keyboard (10%) with respect to the general potential of both devices.

According to the results of our case study, the capability for handwriting input would facilitate the daily work in industrial service environment much more than voice-operated input (cf. Table 3). One reason for this outcome commented by the service engineers are noisy work places and environments.

[1]Only 19 service enginners answered this question.
[2]Only 19 service enginners answered this question.
[3]Only 18 service enginners answered this question.

Device	Laptop Replacement		
	Yes	No	Addition
One-handed keyboard	10,00%	25,00%	65,00%
Wrist worn computer[2]	26,32%	10,53%	63,16%

Table 2. Suitability of the Devices as Laptop Replacement

Input technique	Assistance / Ease of work	
	Yes	No
Handwriting input	80,00%	20,00%
Voice-operated input[3]	66,67%	33,33%

Table 3. Assistance / Ease of work

According to the comments of the service engineers, they believe that all of the presented approaches would require more interaction with the system and thus would be too time consuming. The general doubts regarding the usage of these devices listed by the service engineers were related to the restrictions of mobile devices like limited computational power, memory, and storage capabilities as well as limited size of the display. Additionally, there was some skepticism about drawing capabilities provided by PDA's and wrist-mounted devices. The utilization of handwriting and voice-operated input capabilities strongly depend on the environmental factors, e.g., dirty and wet working environment, noise level in an industrial plant etc.

Furthermore, the utilization of exsiting tools, availability of legacy hardware interfaces like serial port interface as well as sufficient system resources (computational power, memory, storage etc.) reflect some of the requirements that must be also fulfilled.

2.4 Enhanced Sensing Capabilities

Consumers' requirements in the area of mobile phones lead that many additional features had been included into these devices. Many of today's mobile phones integrate the functionality of cameras, MP3-players, radios, navigation systems etc. in-between thus providing a universal device.

This approach should also be facilitated in the area of industrial field services for providing advanced identification and labeling technologies. Advanced identification and labeling combines conventional product identification techniques, like nameplates and bar codes, with Radio Frequency Identification (RFID)-based tags. RFID is identification, labeling, and data collection technology that uses radio-frequency waves to transfer data between a reader and an RFID tag placed on an item. Due to their small size, products can be retrofitted with RFID tags containing information such as serial number, ID, service history etc. A service engineer can use an RFID reader to retrieve data stored in RFID tags. Today, RFID readers that are equipped with Bluetooth allow connectivity with other mobile devices such as a service engineer's laptop or tablet PC.

Bar codes act as a widely-used approach to represent information in a machine-readable manner. Besides one-dimensional (1D) bar codes also known as linear codes, such as the widely known EAN-13 code that is used worldwide for marking retail goods, two-dimensional (2D) bar codes (also known as matrix codes) recently gain more popularity. There is a myriad of different matrix code formats, e.g., the Datamatrix code, Aztec code, and Quick Response (QR) codes. Integration of such features in a "service-oriented" mobile device has been neglected yet. Providing a "universal" mobile service device would help to increase productivity. Utilizing many devices, e.g., laptop, signature pad, mobile phone, RFID reader, bar code reader etc. require that they are on-hand. In this case, the service engineer has to provide a lot of devices as well as corresponding utilities, e.g., power supply and data cables, rechargers and so on. Some of them could be forgotten at home or at office leading to the problem that he must return wasting time. The development of a "universal service device" that provides various scanning features, like RFID, recognition of various bar codes as well as additional capabilities present a reasonable solution to this problem. Some of the mobile device producers discovered some of these challenges in-between, e.g., Samsung developed a single-chip RFID reader for mobile devices [9]. Besides the current development in the area of mobile devices, providing a universal mobile service device that supports all needed features will remain a challenge.

3 Utilizing Mobile Applications in Industrial Field Service

In the initial phase of our project, we gathered major requirements for a mobile application utilized to improve industrial service processes. Here, aspects like capability to work online as well as offline, input of large number of data, and visualization of prior service report information gathered from various information systems were of major interest. Additionally, many of the service engineers already use laptops to run diagnosis and testing tools. Furthermore, the results of our case studies presented in section 2.3 indicate that the service engineers prefer using their laptops and accept another devices as an addition only. According to their remarks in our questionnaires, they still feel that the performance and the storage of the mobile devices are insufficient. Despite the ongoing further development and improvement of mobile systems, there will remain a discrepancy between them and their static counterparts [14].

For these reasons, we decided to concentrate on a mobile application that can be executed on an ultra mobile PCs (UMPC), tablet PCs or even regular laptops in our study since only these kinds of devices fully support the required input and output capabilities.

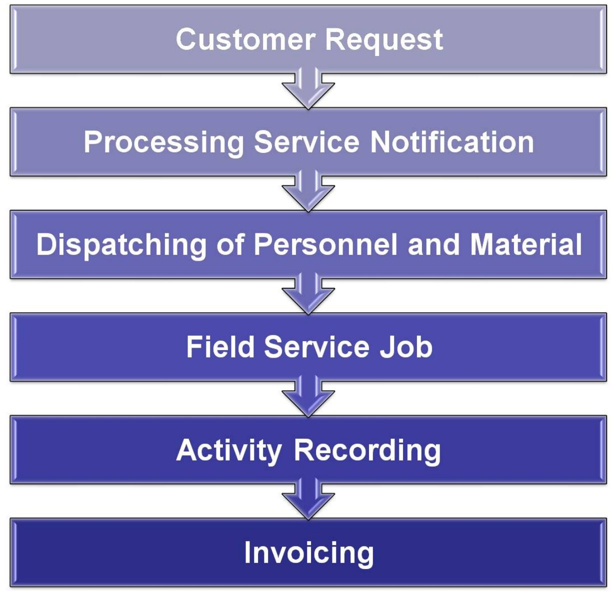

Figure 1. Typical Service Process

In a second step, we evaluated existing commercial field service applications regarding their suitability to meet our general requirements. Based on this evaluation, we decided to take a closer look at one of them. Therefore, we developed a usability study based on the usability guidelines described by DATech [3] to check inhowfar this standard software meets the expectations of the potential users.

In this study, seven of the later users made a preliminary evaluation of the software. It is important to say, that they already use rudimentary mobile software to fulfill their tasks. However, the new software provides several new enhancements improving the service processes in general. After installation of the software on the users' devices, an introduction how to use it has been given. Afterwards, the users performed multiple service scenarios to test the software. We used a typical service process (cf. Figure 1) as well as some variants and potential improvements in these scenarios (cf. [15] for further details with regard to the service process description). Finally, the users answered a questionnaire based on the guidelines presented in [3]. As a result of the study, we were able to derive about fifty new and very detailed requirements regarding the usability of the mobile field service software (cf. Table 4 for an overview).

Category	#
Core functionality	22
Information systems integration	16
Data input capabilities	8
Data output capabilities	7
User guidance	6

Table 4. Overview of Derived Requirements

4 Conclusions

In this paper, we have presented some challenges and misassumption according to current approaches with respect to the development of mobile applications if they should be considered to be used in the area of industrial field service. We showed which general requirements should be fulfilled and discussed why some of the current approaches still can't close the gap between existing systems and the necessity to provide major improvements to support field service personnel to fulfill their tasks. Additionally, we discussed which approaches in the development of mobile applications provide some potential to be applied in the area of industrial field service. According to the results of our case study, a laptop / tablet PC are the most preferred devices in industrial field service since they provide the best mix of performance, required input/output capabilities, software tools and connectivity support. Enhancing existing applications by supporting handwriting capabilities seems to be the most promising approach nowadays.

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