Analysing and Enhancing Business Processes and IT-Systems for Mobile Workforce Automation - A Framework Approach

Volker Gruhn
University of Leipzig
Department of Computer Science
Chair of Applied Telematics / e-Business
Klostergasse 3, 04109 Leipzig, Germany
gruhn@ebus.informatik.uni-leipzig.de

André Köhler
University of Leipzig
Department of Computer Science
Chair of Applied Telematics / e-Business
Klostergasse 3, 04109 Leipzig, Germany
koehler@ebus.informatik.uni-leipzig.de

Abstract

Mobile B2E-applications (business-to-employee) can add significant value to a company's business, when large workforce divisions are involved in the execution of certain business processes. From a technical point of view, the major issues are solved (e.g. solutions for connectivity, broadband mobile networks, synchronization mechanisms, secure protocols etc.). But from a business point of view there is a lack of methodology regarding the alignment of technical solutions to the business needs. As companies face a continuously faster change in business models, legal constraints and customer needs, highly flexible systems are needed to react to changing business processes. Furthemore, the introduction of new mobile systems is often a technology-driven process, pushing the alignment of software and systems to the highly specific, fast changing business needs into the background. This paper introduces a framework summarizing the findings from earlier research and case studies related to this topic. The framework consists of a general reference process for mobile work and of a model explaining influencing factors, optimization goals and their relationships for mobile processes. The framework can be applied for process modeling, simulation and optimization as well as for requirements analysis and return on investment calculations.

Keywords

Mobility, Information Systems, Business Process

1 Introduction

Mobile applications can mainly be distinguished into three different types. *Mobile B2C-applications* (business-to-customer) are used to provide services to a company's customers on their mobile devices. Such services mostly are offered for sales or information purposes. *Mobile B2E-applications* (business-to-employee) are used to connect mobile workers to the company's back-end systems, respectively to provide access to information systems on the road. *Mobile M2M-applications* (machine-to-machine) are used to transfer information automatically collected by a mobile or a stationary machine to the company's information systems. Actually, these applications are not mobile in the sense of supporting mobile people but often replace such mobile processes (e.g. B2E-processes).

In this paper, the focus is put on mobile B2E-processes (in the following: *mobile processes*). Since the availability of mobile broadband networks and the reduced costs for mobile devices, companies with large divisions of mobile employees (e.g. service technicians, sales representatives, healthcare services) can use mobile applications to gain access to corporate applications and databases at the point of service (POS). Therewith better coordination of mobile employees, rapid task assignment, the avoidance of error-prone format conversion, instant access to customer data and many more becomes feasible [8], [16].

The aim of this article is to show that due to several characteristics caused by the workers mobility, a general industry-independent mobile process can be established allowing to describe most of todays mobile processes. Furthermore, the most frequent characteristics of mobile work are described, which can be used to refine the general process. The findings are summarized in a framework, that can be applied for process modeling, simulation and optimization as well as a basis for requirements analysis and return on investment calculations. This paper is organized as follows: Section 2 gives an overview about the related work. Section 3 describes the developed framework through explaining the reference work process (3.1), influencing factors on the process (3.2, 3.3), optimization goals (3.4), example cases (3.5) and the framework usage (3.6). Section 4 draws a conclusion and gives an outlook to further research.

2 Related Work

The changes for the discipline of software engineering when developing systems for mobile environments are discussed in [19]. The authors state that ”mobility represents a total meltdown of all stability assumptions [...] associated with distributed computing”. A comprehensive overview of software engineering for mobile systems is given, regarding issues like models, algorithms, applications and middleware to solve in the future.

The concept of mobility is analysed by [9]. Usually, in the context of mobile applications and mobile workforces the term mobility is used in the meaning of *spatial mobility*. Kakihara and Sorensen expand this concept to *temporal* and *contextual mobility*. Amongst others, *temporal mobility* describes the fact that ”it is no longer strictly necessary to share the same time period exclusively with a particular person or group” [9]. In other words, the term describes the absence of temporal constraints through the use of mobile technologies. Beyond, *contextual mobility* is given when contextual constraints for a certain task of a mobile worker can be avoided, e.g. when he carries the necessary information to the place of task completion. This work gives an excellent analytical basis for further work on the mobility concept.

The concept of mobility is also subject of [22] where user mobility is distinguished into *personal* and *terminal mobility*. The paper gives an overview about recent developments on OSI network levels for improving terminal mobility, i.e. connectivity. Moreover, the authors present an integrated personal mobility architecture which supports personal mobility. This architecture aims at context preservation during device or network changes. On the basis of these key factors, concrete implications for the design of mobile systems in general are given. The particular importance of context is also subject of [6]. Different types of contexts in mobile environments like the infrastructure context, the system context, the domain context and the physical context are discussed. On this basis, a design framework for mobile systems is presented, that can be used to develop *models of space and awareness* and to deduce requirements for software architectures. [17] also present results regarding the basic concept of mobility. They present a study where different aspects of mobile work in general are examined. The four key factors identified for mobile work are *the role of planning*, *working in dead time*, *accessing remote resources* and *monitoring distant activities*.

A number of recent publications show that efficiency and effectiveness of business processes can be improved through the use of mobile technologies. A case study shows examples for mobile business processes from Sweden and the Netherlands [23]. After stating that benefits of mobile technology are hard to quantify, the authors deduce certain propositions from their case studies. The first proposition is that a benefit is given when coordination is required for actors who are difficult to locate. The second proposition is that the benefit of a mobile solution is the avoidance of opportunity costs which occur due to not being able to coordinate actors. However, to examine such opportunity costs will likely be difficult. Furthermore, there are more advantages in mobile solutions than just coordination of mobile actors, e.g. the avoidance of error-prone format conversions or just-in-time data supply. [4] also adress the introduction of mobile systems in the construction industry with particular focus on the mapping of business processes. The presented methodology consists of the four steps *identify ten processes*, *map out the as-is-process*, *map out the to-be-process*, and *select four processes*. The method is evaluated with site engineer processes.

A business process analysis for the electricity industry is presented in [10]. The authors show a method for identifing and modeling selected business processes for a certain goal. The method consists of a knowledge model, a goal submodel and a process submodel containing actors, roles, activities and resources. Based on these tools, the concrete goals and process models for a company can be created, followed by an analysis of these results. Another case study presents results from an analysis of mobile police work [18]. The authors recommend to strongly focus on the type of mobility when dealing with mobile workers in order to design the right mode of interaction. Further, the distinction between structured and unstructured work is recommended when designing mobile systems. Further case studies show significant improvements for mobile business processes, e.g. for energy supply workers [21], [3], [7], for medical services [21], [1], [2] and for salesforce divisions [5], [3], [13], [21].

[24] report about a similar appraisal. They provide an analysis framework focusing on assessing the design approach of mobile workforce solutions. Within this analysis framework, the four perspectives *thinking*, *controlling*, *working* and *modeling* are distinguished. The *thinking perspective* includes engineering aspects like network infrastructures and middleware (called *hard thinking*), as well as communication aspects with involved actors and the mobile workforce (called *soft thinking*). The *controlling perspective* deals with the way the project and processes are managed. The *working perspective* describes how business engineers try to create solutions for the workforce problem, as well as the information system design. The *modeling perspective* consists of conceptual and empirical modeling of business processes and application prototyping. Although this

framework contains certain important aspects for the modeling of mobile IT solutions, no details are given for conducting the mentioned steps from the four different perspectives. [15] present an analysis of requirements for mobile systems within the construction industry. Starting from defined situations, the information needed on site, the information created on site and the involved people are identified. Furthermore, core business functions for specific problem situations are developed. In [20] a model for assessing the readiness prior to IS investment is described. [16] present results from a case study with a utility company. On the basis of interviews with the company's employees, the authors developed a means-ends objective network that can be used to increase the value of a mobile application. There are six fundamental objectives a company tries to reach through the use of a mobile application. Beyond, there are numerous mean objectives that must be fulfilled in order to reach a fundamental objective. This work could be very helpful for achieving a company's objective by implementing mobile applications.

An interesting approach to a process-centered IT return on investment (ROI) analysis is described in [14]. The authors report about a case study where an IT ROI is calculated for a business process from the banking industry. According to their experiences they propose a seven phase model in order to calculate the ROI. [11] proposes an approach to evaluate e-Business information systems projects in order to calculate IT payoff. The approach focuses on traditional measures for IT payoff and their linkage to technology questions. The current research questions regarding IT investment payoff in e-Business environments are raised in [12]. The authors propose directions for future research in this field, namely *metrics*, *environment*, *technology* and *process*.

3 A Generic Reference Model for Mobility in Business Processes

As described in section 2, a number of papers and case studies report about successful implementations of mobile systems in different business contexts. Based on this research as well as on the authors experiences from similar projects, a couple of repeatedly recurring process and system characteristics can be observed. In the following, these characteristics are described and a reference model for mobile business processes is built. This model can be used for different purposes when analyzing and designing mobile business processes and systems (see section 3.6). Amongst others, such purposes could be a process analysis for optimization potentials, a requirements analysis for mobile systems or a return on investment analysis for mobile systems.

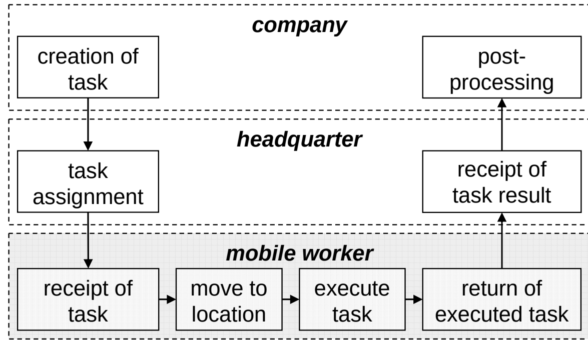

Figure 1. General mobile process.

3.1 General Mobile Work Process

As stated above, along with a wide range of case studies a typical mobile work process can be observed, which is at a certain level of abstraction the same process spanning different companies and industries. This derived general mobile work process is shown in Figure 1. The process is based on the assumptions, that four major components exist:

- An company, that requires the execution of defined mobile tasks.
- A group of mobile workers (mobile workforce).
- A headquarter, that coordinates mobile workers and tasks.
- A task-centered work process of the mobile worker.

The process works as follows: The company creates tasks and sends them to a headquarter, that coordinates its mobile workers. The headquarter receives tasks from the company and sends each to an appropriate worker. The worker receives the task, moves to the specified location, executes the task and returns the task result back to the headquarter. The headquarter receives the task result and sends it to the company, where following processes can be initiated.
There might be some special mobile work processes that do not follow this model, but as a result from analyzing the related work, case studies and reports, this model could be applied for the vast majority of mobile work processes. The headquarter and the mobile workforce are not necessarily required to be part of the company, but could be external service providers as well. However, the above described process is a very simplified process, prescinding from any detail or variant. But the nature of mobility brings certain opportunities as well as constraints when modeling a more detailed process. Analyzing these, the authors could identify typical factors influencing the process design. They can be distinguished into factors caused by the *organizational structure* and the *business model*, and into factors caused

by the use of *information technology*. Furthermore, certain general *optimization goals* could be observed when redesigning such processes or implementing mobile systems. The influencing factors as well as the optimization goals are shown in Figure 2 and will be described in the following.

3.2 Influencing Factors due to Organizational Structure and Business Model

The main influencing factors that arise due to the organizational structure and the business model of the company are *worker* and *task*. Both influencing factors as well as their effects for the above described process are explained as follows.

3.2.1 Worker A first distinction can be made through the assumption that the company's mobile workforce is not a volume of unique subjects but workers with different *skills*. Correspondingly, a task could require specific skills from the executing worker. Furthermore, a mobile worker could be associated with a certain geographically *area*, that he can not leave or just at higher costs. Beyond, the company's mobile workforce could be temporarily extended by subcontractors, which might e.g. result in higher *costs* for task completion.

The *autonomy* of the mobile worker might be considered if he is allowed to reject a task assigned by the headquarter. In this case, the headquarter needs to regard this fact during the task planning. This could be especially important while subcontractors participate. Related to the autonomy aspect, the types of *task handling* can be distinguished into sequential and parallel ones. Sequential task handling means the need for closing the current task before the next can be started, even if the task could not be completed. In this case, the headquarter could later assign the same task to the same worker or another. Parallel task handling allows the worker to choose from a couple of tasks to complete, in particular to restart the processing of a task at a later time.

3.2.2 Task The majority of mobile tasks might be of simple nature and can be completed by a single worker in a short time. But some tasks may require the *cooperation* with several specialist. Two major kinds of cooperation are particularly important: sequential cooperation (multiple mobile workers execute the task in a defined order) and team cooperation (multiple mobile workers execute the same task at the same time or ad hoc in undefined order).

The highest flexibility for planning and executing a task is given when no *time restriction* exists. But often a task is associated with a deadline until it has to be completed. Even more restrictive is a task with a fixed execution date (e.g. appointment). Furthermore, it can be necessary to fulfill a task immediately.

One way of task allocation is assigning a single task to a single worker. Another way is to assign a couple of tasks (e.g. for a day) to a single worker. The *type of assignment* has amongst others influence on the frequency of communication between worker and central.

3.3 Influencing Factors due to Mobile Information Technology

The type of support for mobile workers with information technology can mainly be distinguished into *coordination systems* and *information systems*. A coordination system is used to build schedules and plan routes under certain optimization goals. Furthermore, the system is often used to submit tasks and control worker and task state. An information system is necessary to connect the mobile worker with the company's systems in order to supply him with the needed data and functionality at the point of action. The information system is often used to retrieve, manipulate and store necessary information. As noticed in the analysis of the above mentioned case studies, often mobile systems realize both functionality in one physical system. However, the separation of both aspects is helpful when analyzing processes and designing systems.

3.3.1 Coordination System Using a coordination system, several opportunities for the process design are arising. One opportunity is to realize the *information flow to the headquarter*. The coordination system could therefore permanently transmit the actual geographical location of the worker as well as the actual worker or task state to the headquarter. This information could be used for ad hoc planning and task assignment. Furthermore, the *information flow to the worker* can be supported. This is often the main purpose of the coordination system, as it delivers tasks to the mobile worker.

The coordination system consists of two major parts. The headquarter-part of the system is used to realize the functions

- assign task to worker,
- plan routes,
- control workers load and state,
- control task fulfillment,
- receive task from worker

and many more. The workers-part of the system usually realizes the functions

- receive new tasks,
- manage current tasks and

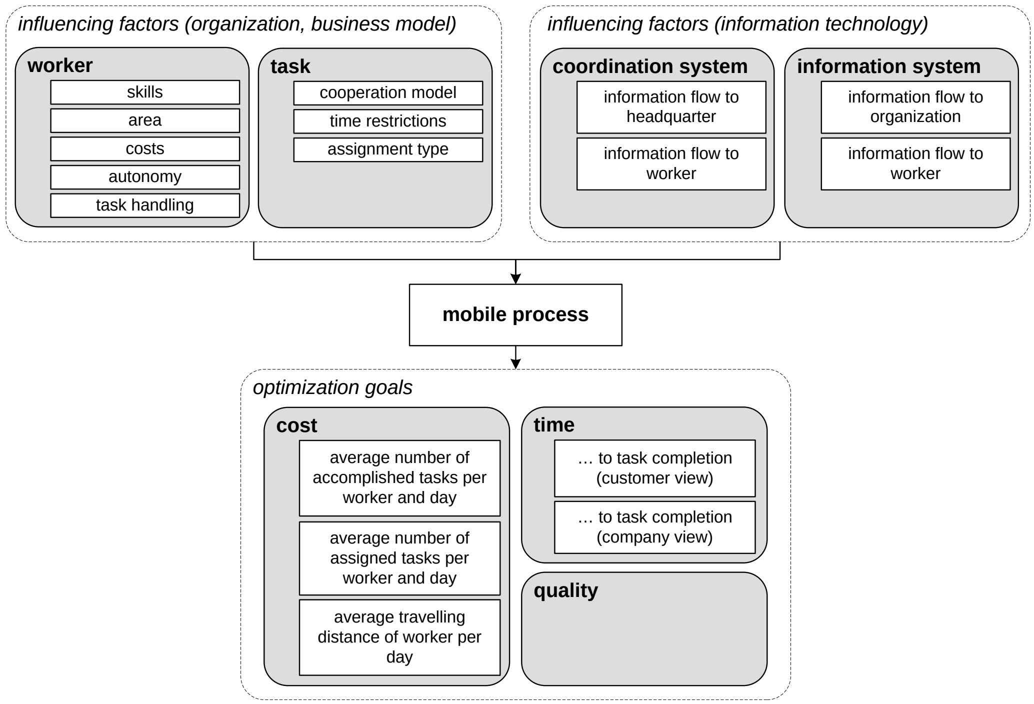

Figure 2. Influencing factors and optimization goals.

- send tasks to headquarter.

An extended function of the system could be e.g. to send the GPS coordinates of the workers current location to the headquarter permanently for real time planning purposes.

Beyond, coordination systems can be distinguished regarding their *connectivity* into (always) online systems, where workers are connected nearly constantly with the headquarter via a mobile network, and offline systems, where workers have to move to fixed points (e.g. home office) in order to synchronize their applications with a central server at the headquarter.

3.3.2 Information System An information system can be used to provide access to data and applications to mobile workers on the road. It focusses on the support of fulfilling the tasks of the worker. The first major function is to support the *information flow to the worker*. The more complex a task is, the likelihood of needing unpredictable information at the point of action increases. Information systems can used to provide such information to the mobile worker whenever he needs it, avoiding costs and time for aquiring the information, e.g. in the office, and returning to the point of action. The second major function is to support *information flow to the organization*. If the task requires the aquisition of information, the system can realize the electronic gathering and (online) submission to the headquarter. Thus, a faster processing of aquired data, avoiding media breaks, plausibility checks and many more can be realized.

As described for coordination systems, information systems can be distinguished regarding their *connectivity* into (always) online systems, where workers are connected nearly constantly with the company via a mobile network, and offline systems, where workers have to move to fixed points (e.g. home office) in order to synchronize their applications with a central server at the company.

3.4 Optimization goals

As above stated, mobile processes are task-based and principal/agent-oriented. Different process variants occur due to different influence factors. When introducing or changing mobile systems (for coordination and/or information purposes) within such a process, the company aims at achieving certain optimization goals with that investment. An optimzation goal always belongs to one of the categories *cost*, *time* or *quality* referring to the process outcome.

Typical cost optimzation goals are to increase the *average number of accomplished tasks per worker and day*, to increase the *number of assigned tasks per worker and day* and to lower the *average traveling distance of worker per day*. Typical time optimization goals are to decrease the *average time until task completion*, distinguished into the customer and the company view. For both categories more goals are conceivable.

Whereas these are quantitative measures, the quality category contains normally company- and process-specific qualitative measures regarding the process outcome. These could be e.g. the avoidance of preparing and concluding processes, the avoidance of recurrent visits and the ability to immediately and fully provide the requested information at the point of action.

3.5 Case Examples

Table 1 summarizes the above explained influencing factors. For each influencing factor the characteristics as well as their typical values are shown. Furthermore, examples for the most characteristics are given, which are explained as follows.

3.5.1 Taxi Driver The first example for the application of the above described model is the case of a cab company. The assumption is, that an innovative coordination system as described in [23] is applied. The taxi central knows the exact location of each taxi driver as well as the current transport status. When a customer orders a taxi at the central, the nearest taxi is idenitified automatically via a GPS system. The driver gets the offer to take this ride with the option to reject or accept. If he accepts the task, he is supposed to fulfill it immediately. Table 1 shows the case matching the model explained above (case indicated by '1').

3.5.2 Accident Assessor The second example is taken from the insurance industry. If a car accident with a customer involvement happens, usually an accident assessor will examine the car damage in order to define the maximum repair costs. The insurance company's headquarter collects the customers claim notifications on a daily basis and plans the assessors task list for the next day. One assessor has a defined geographically area where he can accomplish tasks at defined costs and time. When he starts a task he drives to the damaged car (often at customers home or at garage). He assesses the claim, writes a report and sends the reports to the headquarter at the end of day. Table 1 shows the case matching the model explained above (case indicated by '2').

3.5.3 Emergency Worker The last example is one with most unstructured und often not scheduleable work processes. In case of an emergency, the headquarter gets informed by phone calls. It assigns tasks to its emergency workers (firemen, ambulance, police etc.). At the place of emergency the different workers need to cooperate, depending on their skills and tools available (e.g. extinguish fire, remove objects, medicate casualties). Table 1 shows the case matching the model explained above (case indicated by '3').

3.6 Framework Usage

In the following, possible usage scenarios for the framework described above are explained.

3.6.1 Understanding Objectives, Constraints and Variablity The model illustrated in Figures 1 and 2 shows the essentials when trying to understand the interdependencies between mobile business processes and mobile technologies. In the center of the model resides the *mobile process*, producing an outcome with worth for the company. The constraints determining the process outcome are given through the organizational structure and the underlying business model as *influencing factors* (see the box in the upper left corner). The process outcome is produced under these constraints and is characterized by management ratios or *optimization goals* (see the box at bottom). This means, that the company constantly produces the process outcome under the given constraints but aims at improving the optimization goals. The variable part in this model to achieve this objective is the support with information technology (changes in organizational belongings or business development could also lead to this goal, but are not in the scope of this paper). Thus, two major conclusions can be drawn. First, when the supporting information technology is about be improved or to be introduced in the process, resulting changes in the optimzation goals have to pointed out clearly. Second, the applied information technology need to thoroughly consider the given organizational and business constraints. Aspects of both conclusions are explained in the following.

3.6.2 Calculating Return on Investment As the introduction of information technology is always an investment for the company, the profitability has to be proven before a management decision can take place. To support this, the model can be used to support the calculation of the mobility-specific management ratios. A simulation of the mobile process can be helpful in order to calculate the ratios under certain different constraints (see section 3.6.4).

3.6.3 Requirements Analysis When analysing the requirements of the mobile process for supporting information technology, the model can help as it shows the most typical constraints due to organizational structures and business models. Furthermore, it helps to distinguish between information and coordination aspects, showing typical functions to realize for mobile environments.

3.6.4 Process Modeling, Simulation, Optimization With a detailed modeling of the mobile process, several goals can be achieved. First, modeling the process is a crucial base for calculating the return on investment as well as

influencing factor	**characteristic**	**possible value**	**example**
worker	skills	*process-dependent*	2, 3
worker	area	*process-dependent*	1, 2, 3
worker	costs	*process-dependent*	
worker	autonomy	no autonomy	2, 3
		can reject task	1
worker	task handling	sequential	1, 2, 3
		parallel	
task	cooperation model	requires single worker	1, 2
		requires team sequentially	3
		requires team cooperatively	3
task	time restrictions	no restrictions	
		execution immediately	1, 3
		has deadline	
		has fixed execution date	2
task	assignment type	assign single task	1, 3
		assign task list	2
coordination system	information flow to HQ	no information flow	2
		transmit workers actual location	1, 3
		transmit workers actual task state	1, 3
coordination system	information flow to worker	no information flow	
		task (-list) update	1, 2, 3
coordination system	connectivity	no system used	
		fixed point synchronization	2
		(always) online connection	1, 3
information system	information flow to worker	*process-dependent*	2, 3
information system	information flow from worker	*process-dependent*	2, 3
information system	connectivity	no system used	1
		fixed point synchronization	2
		(always) online connection	3

1 – taxi driver 2 – accident assessor 3 – emergency worker

Table 1. Influencing factors on process and system design.

for the requirements analysis. The modeled process can further be used for e.g. simulation purposes in order to identify whether changes to technology have desired effects. Parameters for the simulation are given through the above explained reference model. Thus, it gives a clear frame for process modeling, simulation and optimization purposes.

4 Conclusion and Outlook

This paper presented a framework for the domain of mobile business processes and related systems. The aim of the framework is to summarize the findings from previous work related to research and case studies regarding mobility. The framework can be used for different purposes in conjunction with B2E-processes and -applications, e.g. calculating ROI and supporting requirements analysis as well as the modeling, simulation and optimization of processes. It consists of a general mobile work process as well as of a model describing the relationship between the work process, influencing factors and optimzation goals.

Further research is necessary to increase efficiency and impact of mobile information technology for mobile business processes. From a technical point of view, the major issues are solved (e.g. solutions for connectivity, broadband mobile networks, synchronization mechanisms, secure protocols etc.). But from a business point of view there is a lack of methodology regarding the alignment of technical solutions to the business needs. As companies face a continuously faster change in business models, legal constraints and customer needs, highly flexible systems are needed to react to changing business processes. The authors see a great demand for process simulation, considering current and future changes in organizational, business and technological constraints. As this is an optimization problem with multiple optimization goals and a large variety of input parameters, the process modeling and simulation with Petri nets could lead to a convenient solution. Further research on this topic is planned.

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References

[1] E. Ammenwerth, A. Buchauer, B. Bludau, and R. Haux. Mobile information and communication tools in the hospital. *International Journal of Medical Informatics*, 57(1):21–40, 2000.

[2] J. E. Bardram and C. Bossen. Moving to get ahead: Local mobility and collaborative work. In *Proceedings of the Fifth European Conference on Computer Supported Cooperative Work (ECSCW2003)*, pages 355–374, 2003.

[3] S. J. Barnes. Wireless support for mobile distributed work: A taxonomy and examples. In *Proceedings of the Proceedings of the 37th Annual Hawaii International Conference on System Sciences (HICSS'04) - Track 3 - Volume 3*. IEEE Computer Society, 2004. 962935 30078.1.

[4] S. Bowden, A. Dorr, A. Thorpe, and C. J. Anumba. Mapping site processes for the introduction of mobile IT. In *ECPPM '04: eWork and eBusiness in Architecture, Engineering and Construction*, pages 491–498, The Netherlands, 2004. A.A. Balkema Publishers.

[5] T. Brodt and R. Verburg. Managing mobile work - insights from european practice. *New Technology, Work and Employment*, 2007. University of St.Gallen - Alexandria Repository [http://www.alexandria.unisg.ch/EXPORT/OAI/server.oai] (Switzerland) ER.

[6] A. Dix, T. Rodden, N. Davies, J. Trevor, A. Friday, and K. Palfreyman. Exploiting space and location as a design framework for interactive mobile systems. volume 7, pages 285–321, New York, NY, USA, 2000. ACM Press.

[7] V. Gruhn, A. Khler, and R. Klawes. Modeling and analysis of mobile service processes by example of the housing industry. In W. M. v. d. Aalst, B. Benatallah, F. Casati, and F. Curbera, editors, *Proceedings of the International Conference on Business Process Management (BPM 2005)*, LNCS 3649, Nancy, France, 2005. Springer.

[8] V. Gruhn, A. Köhler, and R. Klawes. Modeling and analysis of mobile service processes by example of the housing industry. In W. M. van der Aalst, B. Benatallah, F. Casati, and F. Curbera, editors, *Business Process Management*, pages 1–16. Springer LNCS 3649, 2005.

[9] M. Kakihara and C. Sorensen. Expanding the 'mobility' concept. volume 22, pages 33–37, New York, NY, USA, 2001. ACM Press.

[10] E. V. Kavakli and P. Loucopoulos. Goal-Driven Business Process Analysis - Application in Electricity Deregulation. In *CAiSE '98: Proceedings of the 10th International Conference on Advanced Information Systems Engineering*, pages 305–324, London, UK, 1998. Springer-Verlag.

[11] V. F. Kleist. An approach to evaluating e-business information systems projects. *Information Systems Frontiers*, 5(3):249–263, 2003.

[12] R. Kohli, S. A. Sherer, and A. Baron. IT Investment Payoff in E-Business Environments: Research Issues. *Information Systems Frontiers*, 5(3):239–247, 2003.

[13] A. Kornak, J. Teutloff, and M. Welin-Berger. *Enterprise Guide to Gaining Business Value from Mobile Technologies*. John Wiley and Sons, 2004.

[14] C. S. Leem, C. Y. Yoon, and S. K. Park. A Process-Centered IT ROI Analysis with a Case Study. *Information Systems Frontiers*, 6(4):369–383, 2004.

[15] A. May, V. Mitchell, S. Bowden, and T. Thorpe. Opportunities and challenges for location aware computing in the construction industry. In *MobileHCI '05: Proceedings of the 7th international conference on Human computer interaction with mobile devices & services*, pages 255–258, New York, NY, USA, 2005. ACM Press.

[16] F. F.-H. Nah, K. Siau, and H. Sheng. The value of mobile applications: a utility company study. *Communications of the ACM*, 48(2):85–90, 2005.

[17] M. Perry, K. O'hara, A. Sellen, B. Brown, and R. Harper. Dealing with mobility: understanding access anytime, anywhere. volume 8, pages 323–347, New York, NY, USA, 2001. ACM Press.

[18] D. Pica, C. Sorensen, and D. Allen. On Mobility and Context of Work: Exploring Mobile Police Work. In *HICSS '04: Proceedings of the Proceedings of the 37th Annual Hawaii International Conference on System Sciences (HICSS'04) - Track 3*, page 30081.3, Washington, DC, USA, 2004. IEEE Computer Society.

[19] G.-C. Roman, G. P. Picco, and A. L. Murphy. Software engineering for mobility: a roadmap. In *Proceedings of ICSE '00*, pages 241–258, New York, NY, USA, 2000. ACM Press.

[20] Y. Saleh and M. Alshawi. An alternative model for measuring the success of IS projects: the GPIS model. *Journal of Enterprise Information Management*, 18(1):47–63, 2005.

[21] R. Schierholz, L. Kolbe, and W. Brenner. Strategy alignment of mobile solutions in customer-oriented processes. *Wirtschaftsinformatik*, 47(1):17–24, 2005.

[22] B. Thai, R. Wan, A. Seneviratne, and T. Rakotoarivelo. Integrated personal mobility architecture: a complete personal mobility solution. volume 8, pages 27–36, Hingham, MA, USA, 2003. Kluwer Academic Publishers.

[23] H. van der Heijden and P. Valiente. The value of mobility for business process performance: Evidence from sweden and the netherlands. In *European Conference on Information Systems (ECIS)*, 2002.

[24] Y. Wang, E. van de Kar, and G. Meijer. Designing mobile solutions for mobile workers: lessons learned from a case study. In *ICEC '05: Proceedings of the 7th international conference on Electronic commerce*, pages 582–589, New York, NY, USA, 2005. ACM Press.