The Challenge of Identifying Value-Creating Ubiquitous Computing Applications

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ABSTRACT
Ubiquitous computing (UbiComp) applications involve large numbers of non-traditional networked computing devices which are often mobile and/or equipped with sensors to collect data. So far there is only limited knowledge on the impact of these technologies on business processes and how these applications can create value. In this paper we consider challenges for identifying value-creating UbiComp applications. For the individual challenges we provide examples from projects on industrial applications of UbiComp technologies in which we were involved. We conclude that companies can pursue two distinct strategies of dealing with these challenges, one aimed at incremental, the other one at more radical innovations.

Keywords
Business applications, innovation adoption, ubiquitous computing, value creation

INTRODUCTION
To date, there is no widely accepted definition of ubiquitous computing (UbiComp). One can probably say that applications based on UbiComp technologies involve large numbers of non-traditional networked computing devices which are often mobile and/or equipped with sensors to collect data [10].

This paper focuses on business applications. One of the main capabilities of UbiComp technologies in the context of business applications is their potential to reduce media breaks between the physical world and information systems [10]. This provides the opportunity for a more accurate, timely and detailed representation of the real world in information systems.

As UbiComp technologies start to become mature [11], commercial applications gradually become feasible [10]. There are already a number of UbiComp business applications which are in pilot phases or already available on the market. However, so far there is only limited knowledge on the impact of UbiComp technologies on business processes and how applications based on these technologies can create value for companies. Davies and Gellersen [6] mention economic concerns as one of the inhibitors for deploying ubiquitous systems.

We believe there is no general answer which UbiComp applications are value-creating. Companies that want to invest need to determine the value of a UbiComp application on a case by case basis. If companies have difficulties to identify promising applications, this can delay the adoption of these technologies.

LITERATURE REVIEW
In this section we look at selected research on evaluation and valuation. Findings from this research are used to derive the framework that we propose below.

The selection of an appropriate evaluation method, e.g. for a UbiComp application, depends on the application type. There are different taxonomies for classifying information technology applications (e.g. [9, 13]). According to Farbey et al. [9], the complexity of evaluation and the degree of risk and uncertainty is higher when e.g. an investment in an IT infrastructure is evaluated compared to an application for automating a process. However, at the same time, the potential benefits become higher. Often, the term intangible benefits is used to refer to benefits that are hard to quantify (either in monetary or non-monetary terms). As we use the term here, benefits are intangible if they can not be expressed in monetary terms. According to our understanding, value is created when the returns from an investment exceed the cost of capital (see e.g. [4]). Monetary evaluation – or valuation – can be conducted at different levels, ranging from market, firm, work group, business process to individual [5].

Chircu and Kauffman [3] suggest a limits-to-value framework for IT investments. The authors distinguish two types of barriers that make it difficult for companies to benefit from an investment in information technology. The initial sources of value (or value flows) may not be fully realizable due to valuation barriers that depend on the industry and organizational factors. This includes e.g. compatibility issues with current systems and organizational characteristics such as existing work processes. The potential value that remains after the

valuation barriers are taken into account may be further diminished by so called conversion barriers which include limited resources, knowledge or actual use of the system.

CHALLENGES FOR IDENTIFYING VALUE-CREATING UBICOMP APPLICATIONS

Our research question is as follows: What are the challenges in identifying value-creating UbiComp applications?

We propose four challenges which complicate the identification of value-creating UbiComp applications: the network challenge, the constraints challenge, the implementation challenge, and the valuation challenge.

The challenges were encountered in industrial projects on business applications of UbiComp technologies. Based on the literature review, we suggest a framework which incorporates the challenges. To provide evidence for the relevance of the individual challenges, we present examples from selected projects. The projects were conducted during an ongoing research initiative. Apart from the authors, the projects involved people from a number of companies and selected other researchers at different stages.

The framework proposed here uses ideas from the model presented by Chircu and Kauffman [3], although its intention is different. Our focus is on the challenges for identifying value-creating applications, both ex-ante and ex-post, whereas Chircu and Kauffman focus on the barriers that prevent the sources of value from being fully realized, independent from their visibility. The terminology we use is therefore different. Our framework furthermore incorporates findings from the research discussed above regarding the level of analysis, types of application and intangible benefits. Figure 1 provides an overview of the framework.

The projects listed below are used to illustrate the relevance of the individual challenges:

- For an industrial consortium, we developed an internet-based tool that allows users to estimate the financial impact of using RFID technology in the supply chain. The calculator considers pallet, case, and item level tracking.
- We are involved in a project with a software vendor and a number of other companies in which data from vending machines is integrated in an ERP system. The data is gathered by sensors and transferred via the GSM network. Among others, the project aims at improving product availability and decreasing maintenance cost by allowing timely and event-based refill and maintenance processes.
- For a car manufacturer, it was analysed whether RFID tags attached to certain spare parts could improve supply chain performance in the company's spare parts business. With the solution, the car manufacturer intends to improve the efficiency of handling incoming deliveries and to increase the accuracy of information on actual deliveries and inventory levels.
- For a pharmaceutical company, we examined a solution that monitors the compliance of patients with chronical illnesses in taking their prescribed medication. By increasing compliance of these patients, pharmaceutical companies hope to increase sales e.g. by reducing the churn rate. The solution uses Bluetooth and GSM technology for data communication. To illustrate the concept, a demonstrator was built as part of the project.
- A large European retailer tests different technologies in one of its supermarkets, among them RFID technology. In this test, RFID tags are used to track the movement of cases and pallets from the distribution center to the store and from the backroom of the store to the shop floor. Furthermore, a number of products are tagged at item level. This allows to track products also on the shelves. We already conducted site visits and are currently setting up a project to analyze the implications of using RFID tags within the supply chain for current processes and information systems.

In the following, the individual challenges are discussed.

UbiComp applications often involve more then one

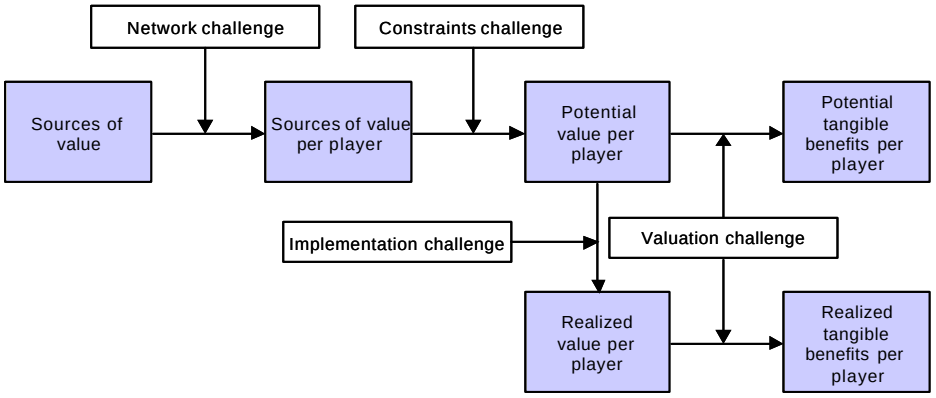

Fig. 1. From sources of value to tangible benefits per player: Challenges in identifying value-creating UbiComp applications

company. The network challenge refers to the issue that generally companies will not invest in an application unless they see a positive value for themselves. An analysis at the network level may indicate high sources of value. However, this is only a necessary, but not a sufficient criteria. Relevant is the level of the individual company. An example for the relevance of the network challenge is the introduction of RFID technology in retail supply chains. Retailers such as Wal-Mart expect to benefit from the use of RFID tags to track pallets and cases and are working on introducing the technology [2]. They thereby implicitly expect that their suppliers pay for – at least large parts of – the tags. If retailers had to pay for the tags, the results from our calculator indicate that their net present value from an investment can turn negative. Suppliers may initially not be willing to introduce RFID technology unless they expect their gains to exceed their cost. A solution needs to be found so that every player in the supply chain agrees to use RFID.

Constraints challenges are issues which inhibit that the entire sources of value can be realized. This can be existing systems, processes, etc. Constraints challenges are similar to valuation barriers introduced in Chircu and Kauffman's limits-to-value framework [3]. Specifically for Ubicomp applications, Davies and Gellersen [6] mention technical challenges as well as social and legal issues (e.g. privacy and data security). These aspects can become major constraints. Due to these challenges there is only a certain part of the value sources available to a player, which is called the potential value. In the project with the software vendor where data from vending machines is gathered remotely, we analyzed the potential value of detailed information on demand, product availability, machine status etc. for one specific vending machine operator. As we discovered, current processes prevent some of the value sources from being realizable. The company has defined fixed routes that specify which vending machines are refilled at what dates. Furthermore, there is already a system in place to manage product availability. Sales data for each slot in a vending machine is registered, and refill intervals and levels are defined based on this information. A main issue in defining a tour is minimizing the time personnel needs for getting from one vending machine to the next. There is no system in place that allows for dynamic routes to be defined based on product availability in certain vending machines. Such a system would have to take information from roughly ten thousand vending machines into account which are serviced by about 30 employees. These constraints currently inhibit the company from using the data in order to achieve higher product availability.

As the term already indicates, implementation challenges become relevant when a company starts to implement a solution. Limited resources, knowledge or low actual use of the system after the implementation is finished diminish the realized value. Implementation challenges are similar to the conversion barriers introduced by Chircu and Kauffman [3]. In the above mentioned project with a car manufacturer, the potentials of RFID technology for product tracking in the spare parts business look promising, but there are no standard solutions available so far. Introducing this technology still requires a company to invest resources to solve a number of generic issues, e.g. regarding the selection of appropriate tags, positioning of antennas, and integration into legacy systems. Experience from other pilots has shown that there is still a need for a lot of testing with RFID technology [1]. Companies that follow later may profit from this knowledge. Therefore, some players are reluctant to adopt early. Delays in implementing a solution reduce the potential value as (a) cash flows are delayed in time and (b) an initial competitive advantage may be lost.

Valuation challenges refer to the problem of determining the tangible benefits from a project. Valuation challenges are present at two distinct points in time. Ex ante, which means before a decision to go ahead with an investment is made, and ex post, i.e. after the solution is implemented. In our project with the pharmaceutical company, the system would have required the co-operation of doctors, pharmacists, and patients. Their willingness to co-operate was hard to judge, and we were not able to determine ex ante with reasonable accuracy (a) whether a monitoring solution would be able to increase compliance and (b) what value would hereby be created, e.g. by reducing the churn rate. The potential benefits of the application thus remained intangible.

It can also be difficult to determine ex post whether a solution is value-creating. Some UbiComp applications (e.g. the use of RFID technology for tracking products in a supply chain) focus on increasing the efficiency of gathering data (e.g. by automating the delivery verification process) or avoiding the negative impact of inaccurate or imprecise data (e.g. on product availability). A common approach is to conduct a pilot project to see whether the potential benefits are really achievable. However, processes in a pilot can often not entirely reflect actual processes. In the demo store set up by the large European retailer mentioned above, the work routines are somewhat artificial (e.g. cases are manually tagged before shipment from the distribution center). This makes it difficult to measure e.g. whether RFID technology really increases labor efficiency.

CONCLUSIONS

In this paper we have presented four challenges in identifying promising business applications of UbiComp technologies: the network, the constraints, the implementation, and the valuation challenge. These challenges are not unique for Ubicomp applications. However, some of the challenges – the network challenge, the constraints challenge, and the ex post valuation challenge – are from our point of view of specific relevance for UbiComp applications.

The network challenge occurs when more than one company is involved in an application. This is frequently the case with business applications of UbiComp technologies. The question of appropriate business models is far from being solved for a lot of scenarios [6]. Further examples of complex scenarios involving UbiComp technologies where the business model might not be obvious can e.g. be found in Fano and Gershman [8] and Tarasewich and Warkentin [12].

The constraints challenge deals with the limitations in achieving the value sources due to e.g. compatibility issues with existing processes or systems. One of the main challenges for UbiComp applications is putting the information that can be gathered into use. New kinds of application logic may be needed in order to benefit from the additional data. For example, what needs to be changed in an ERP systems when a company wants to benefit from the ability to track each individual product as it moves through the supply chain?

The ex post valuation challenge refers to the problem of measuring the value that is supposed to be created by an application. Even when benefits may be tangible ex ante, they can be difficult to observe and may only show when the performance before and after the solution was implemented is compared over a longer time period. For new technologies such as UbiComp technologies, it might take some time to prove that tangible results are delivered.

The fact that it is challenging to identify value-creating UbiComp applications has certain implications for the adoption of UbiComp applications. The previous comments seem to suggest a strategy of focusing on incremental improvements and quick wins. Companies may decide to go ahead with applications based on UbiComp technologies which only involve a few players. They may initially focus on applications which do not require extensive changes to existing systems and which are consistent with existing processes. Furthermore, companies may prefer applications with tangible benefits that can easily be observed after implementation. However, there might be an alternative to this strategy. Up to a certain degree a company may be able to improve its evaluation process. A good understanding of the challenges can lead to a higher chance of correctly identifying value-creating applications that are radical in nature rather than provide incremental benefits. Knowledge seems to play an important role for this strategy to work. Depth of knowledge – as well as company size – has a positive impact on the adoption of radical innovations [7]. Companies that want to pursue this strategy may e.g. engage in industry initiatives, collaborate with other companies, develop internal resources, conduct extensive pilots, and seek close contact with academic institutions.

ACKNOWLEDGMENTS

Large parts of this paper have been funded by the M-Lab (www.m-lab.ch), a joint research initiative of ETH Zurich and University of St. Gallen, Switzerland in co-operation with the Auto-ID Center at the Massachusetts Institute of Technology, Cambridge, USA. M-Lab works with several international companies on business applications based on ubiquitous computing technologies.

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