M-Lab – The Mobile and Ubiquitous Computing Lab

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The Financial Business Case for Ubiquitous Computing Business Applications

Abstract

Ubiquitous Computing (UbiComp) applications involve large numbers of non-traditional networked computing devices which are often mobile and usually equipped with sensors to collect data.

The goal of this paper is to develop a framework for evaluating the financial impact of UbiComp business applications. So far there is no clear understanding which applications might be financially feasible.

We identify five generic business applications in which UbiComp technologies can create value and some potentially important value and cost drivers. We also propose a model for calculating the financial value for these applications.

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1 Introduction

1.1 Ubiquitous Computing

The idea of ubiquitous computing (UbiComp) has been around for more than ten years [Weiser, 1991][1]. To date, there is no widely accepted definition of UbiComp. UbiComp applications frequently have the following characteristics [Fleisch, 2002]:

- UbiComp applications involve very high numbers of non-traditional networked computing devices which are usually equipped with sensors to collect data from their environment.
- Most of the devices are mobile, and the tasks they perform depend on the geographical location or the neighborhood of other devices.
- The large number and the often invisible device interfaces require new forms of interaction between humans and computers.

Development was mainly technology-driven until recently [Fleisch, 2001]. As new technologies develop and mature [Mattern, 2001], commercial applications gradually become more feasible [Fleisch, 2001]. Our research focuses on business applications rather than the more intensely studied areas of home or office automation. There are already a wide range of UbiComp business applications, which are in pilot phases or already available on the market. Imagine a supply chain in the consumer goods industry in which all products can automatically be identified on item level. This becomes possible when a Radio Frequency Identification (RFID) tag is attached to every single product. The tag is read e.g. when the product enters or leaves a warehouse or is sold at the supermarket. This gives a new quality of information visibility in the supply chain in addition to the one recommended by [Lee et al., 1997]. Other examples of UbiComp business applications include applications that continuously track the location of products or remotely monitor blood pressure for patients that suffer from heart disease or take part in clinical trials. Benefits of UbiComp business applications include e.g. reduced theft, increased security

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1 Large parts of this paper have been funded by the M-Lab (www.m-lab.ch), a joint research initiative of ETHZ and HSG in co-operation with the Auto-ID Center at MIT. M-Lab's practical research partners include Novartis, Paul Hartmann, SAP, SAP SI, Swisscom Mobile, UBS and Volkswagen.

as well as counterfeit protection. Applications can be found in industries such as consumer goods, automotive, health care as well as financial services.

There are initiatives that are currently developing standards for UbiComp business applications. The Auto-ID Center, which started at MIT, Cambridge, USA is creating an infrastructure in co-operation with its corporate partners. It recommends standards regarding the unique identification of objects, the linking of the object identifier to the data stored on the object, as well as a language to specify the data about an object. [Sarma et al., 2000] Another approach has been taken by Hewlett-Packard Laboratories. In their CoolTown project, they propose a way of uniquely identifying real world objects and linking them with virtual applications and services [Kindberg, 2001]. Both approaches are based on and refer to existing Internet standards. The Auto-ID Center envisions that the data generated is stored in special servers and can be accessed by multiple business applications [Sarma et al., 2000]. To our knowledge the CoolTown project does not address this issue.

The Auto-ID Center has formed a working group dedicated to build business cases and calculate financial benefits. The focus is mainly on supply chain management in the fast moving consumer goods industry. The M-Lab, a joint initiative of University of St. Gallen (HSG) and Swiss Federal Institute of Technology Zurich (ETHZ), Switzerland, aims to find business applications within the above mentioned area. Identifying feasible business ideas for the partner companies supported by financial considerations is part of the effort [Fleisch, 2001]. Among the seven founding partners almost all express the wish for estimating the financial feasibility early in the process before making any major decisions.

Questions about the financial impact play an important role in the decision making for undertaking projects in information systems [e.g. Willcocks, 1996; Hitt, Brynjolfsson, 1996]. To promote the use of their software a number of software vendors [Peoplesoft; Plumtree; SAPa; SAPb] and some consultancies [Gartner] offer tools on their websites to calculate the financial impact of decision to invest in new information technology such as human resource management systems, portals, supply chain management and customer relationship management systems.

Initial research already exists on benefits of UbiComp applications such as the use of RFID tags for automatic identification and data collection in the supply chain of consumer goods [Agarval, 2001]. However, we see a need for further research on a wider range of UbiComp applications to develop an understanding which UbiComp applications might be financially feasible.

1.2 Barcodes and UbiComp Business Applications

Some applications which fall under the set of generic UbiComp business applications we are to introduce can be seen as extensions of existing barcode applications where barcodes are substituted by RFID tags. This is true for tracking & tracing applications. A common example for tracking & tracing are the EAN or UCC standard barcodes on logistics or trade units used e.g. for stock picking or verification of deliveries in combination with despatch advices that can be sent via EDI [ECR Europe, 2000]. Another example is the 2-dimensional barcode schema used by UPS [Osman, Furness, 2000]. One can also argue that the use of barcodes on trade items such as consumer goods scanned at the point of sale [Little, 1991] are a self service application in our set of generic applications because the inventory data can automatically be updated and there is no need any longer to type in the prices.

The initial financial business case for barcodes in the grocery industry was based on labour cost reduction by speeding up the check out process [Little, 1991]. The grocery industry required an amortisation time of less than two and a half years [Seideman]. The discovery and realisation of the more intangible benefits based on the data generated depended on new measurements, theories and applications that were only developed later on [Little, 1991]. One challenge which had to be overcome was getting the right information out of a waste amount of data. Although a lot of work has been done in this field this challenge still exists. [Baron, Lock, 1995]

1.3 Aim of the Paper

The aim of this paper is to develop a framework for evaluating the financial impact of UbiComp applications. Our research concentrates on business applications rather than the more intensely studied domains of home or office automation. Our framework is based on the assumption that UbiComp business applications show enough similarities to be analysed within a single basic model. The framework consists of a description of the context in which the framework can be used, a set of generic UbiComp business applications, a calculation model, and a five-step process for applying the framework.

The calculation model assesses the major value and cost drivers which allow to calculate the financial value for a set of generic UbiComp business applications. We define a driver as a main factor that influences an outcome.[2]

After the output of the model is prepared for the decision committee that decides on the realisation of the proposed project, we call this the financial business case. According to [Hogbin, Thomas, 1994; pp. 10-11] the financial business case shows the monetary impact of a proposed project and is part of the business case which provides the rationale for the investment.

The paper aims to provide answers to the following questions: Which business problems can be solved by UbiComp technologies? What are critical value and cost drivers? How can the financial value of UbiComp business applications be quantified? As the model is intended to be used to prepare financial business cases for real projects we also consider questions such as: Why do we need a financial business case? What are the business requirements for a financial calculation model? How is the financial business case integrated into the business case? How do we treat intangible benefits and financial risks?

1.4 Target Audience

This paper is directed towards practitioners in companies that are investigating ways to improve certain business processes and researchers in the area of UbiComp. When looking at the generic applications we present, practitioners might identify potential applications based on UbiComp technologies within their company. In this case, we want to provide them with a means to come up with an initial idea of the financial impact of these applications that helps them in preparing the business case for such an application.

For researchers, the paper specifies a set of generic business applications using UbiComp technologies in the area of UbiComp for the first time and looks at the range of generic UbiComp business applications from a financial perspective. The proposed generic applications, benefits, value and cost drivers etc. may now be tested, potentially refined and quantified if applicable.

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2 [Copeland et al., 1996; p. 44] use the same term.

1.5 Structure of the Paper

This paper starts with a short review of valuation methodology which we use as a frame of reference for the calculation model. We proceed with a look at the financial business case. This gives us the context in which the calculation model is applied. Then follows a description of the generic UbiComp business applications we have found. For one generic application we exemplary list the relevant value and cost drivers as well as intangible benefits. We propose a calculation model and a five-step process to value UbiComp business applications. A case study is presented where the calculation model and the five-step process have been applied. The paper closes with the limitations of the calculation model, a discussion of the findings and areas for further research.

2 Frame of Reference for Calculation Model

We want to introduce some concepts from financial theory which form the frame of reference for our model. Net present value (NPV) is generally regarded the appropriate way of calculating the value of an investment[3] [Kaplan, 1986; Copeland et al., 1996; p. 72, 75]. Thereby estimates of future cash flow are generated and then discounted by using a risk-adjusted discount rate, the cost of capital.[4] The cash flow and cost of capital estimates can either be expressed in nominal or real value. An investment is favourable and creates value if the NPV is greater than zero. [Copeland et al., 1996; p. 73, 75, pp. 153-154] If resources are limited and not all projects with a positive NPV can be implemented the projects are chosen that maximise the total NPV given the constraints.

As future cash flows are uncertain it may be reasonable to define a number of scenarios, i.e. consistent possible outcomes, with possibilities attached to each scenario[5]. The final result is obtained by calculating the expected value.

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3 The discussion of limitations of alternative dynamic methods such as internal rate of return or static methods such as amortisation time is beyond the scope of this paper.

4 In the last couple of years other ways of calculating the NPV have emerged which focus on value added (such as Economic Value Added [Stewart, 1991]). These concepts use a different way of calculation but, other things being equal, arrive at the same result [Copeland et al., 1996; p. 135].

5 The consistency of possible outcome is the reason why we prefer scenario analysis over simple sensitivity analysis as proposed e.g. in [Anandarajan, Wen, 1999].

[Copeland et al., 1996; p. 215] This is theoretically based on microeconomic decision theory where the utility function is equal to the monetary value.

In recent years option pricing theory has been discussed for valuing real assets. [Kambil et al., 1993] use option theory to value investments in information technology. An option can be defined as "[t]he privilege (acquired on some consideration) of executing or relinquishing, as one may choose, within a specified period a commercial transaction on terms now fixed [...]" [Oxford English Dictionary]. Options in real assets occur e.g. when at a certain point in the future a decision can be made whether to abandon or postpone a project based on the then realised scenario. However, to apply these models usefully, a portfolio of traded UbiComp companies would be necessary to allow for the construction of a continuous risk-neutral portfolio as well as to get an estimate of volatility. [Amram, Kulatilaka, 1999; pp. 52-54] Since this is not available, we cannot apply option-pricing theory.

The financial impact can be calculated at different levels, ranging from country, industry, organisation, group to individual [Chan, 2000]. As the changes which happen through the use of UbiComp have a direct impact on specific tasks within processes we regard processes (which are likely to be on the group level) as the appropriate level of analysis.[6] According to [Österle, 1995; p. 19] processes are built up of a series of tasks which produce a certain output.

We regard it as appropriate to look at UbiComp applications as described above as information systems that use UbiComp technology. Information systems offer certain functions that assist in performing or perform certain tasks and can be defined as systems that generate and manipulate data, perform routine or more complex planning tasks and provide information for decision making [Scheer, 1988; pp. 1-2]. This is in line with our understanding of the functions UbiComp business applications provide.

6 [Tallon et al., 2000] also promote looking at investments in information systems at a process level as they see this as a means for a comprehensive approach towards assessing the value creation of information systems. [Belcher, Watson, 1993] in general recommend to assess benefits at the level where they occur.

3 Research Method

To answer the research questions we have used (a) a literature review on valuation, on the assessment of investments in information systems, and on UbiComp, (b) a database of UbiComp case studies, (c) selected material on business concepts such as supply chain management, and (d) experience from projects on mobile and ubiquitous computing with partner companies in the M-Lab.

Based on the results of (a)-(c) we prepared an initial framework consisting of a description of the context in which the framework can be used, a set of generic UbiComp business applications, a calculation model[7], and a five-step process for applying the framework. The generic applications were derived by going through the database of applications set up by M-Lab. A new one was added if it was not possible to subsume the specific application under the generic applications identified until then. Main criteria was whether the process tasks performed by the specific application were similar to the already identified ones.

With regard to (d), the framework was then presented to five of our partner companies during the M-Lab workshop (I/02) followed by a 1,5 h group work in small teams where the participants applied the framework on a selected application. After the presentation and again after the group work we collected feedback on the framework on flipcharts. The workshop was held on February 14 and 15, 2002 in Würzburg, Germany.

The framework was then used in a case study. Case studies are useful in exploratory research, e.g. to get an initial understanding of a new situation [Sekaran, 2000; pp. 123-124]. For this case study we worked with a UbiComp solution provider that specializes in RFID technology[8]. A detailed description of how we applied the framework is given when the case study is presented. The results of the case study were handed over to the company for checking before publication. Additionally, we looked at other projects the company had

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7 According to the [Oxford English Dictionary] a model can be defined as "a simplified or idealized description or conception of a particular system, situation, or process [...] that is put forward as a basis for calculations, predictions, or further investigation".

8 To protect confidentiality we are not allowed to disclose the name of the company. The authors would like to thank the management for its support.

realised and checked whether they fit into the set of generic applications we propose. We also discussed the framework with two people from the company during a one-day company visit on February 20, 2002.

4 The Financial Business Case

4.1 Reasons for Financial Business Case

There are several reasons mentioned for calculating a financial business case. It forces the business case team to precisely state the benefits of the project based on operational measures derived from the company's strategic goals[9] [Norris, 1996] and assists a rational approach to decision making [Toraskar, Joglekar, 1993]. [Hogbin, Thomas, 1994; p. 7] argue that the process of discussion the benefits is of similar importance as the actual outcome. Getting the project proposal approved, which may require a financial business case to be included, is often considered a necessary step before entering the next project phase (e.g. pilot phase) [Hogbin, Thomas, 1994; p. 121; Norris, 1996]. The financial business case can also be used in later stages to evaluate the project results against expectations, as it is not guaranteed that a promising project is executed well[10] [Gunasekaran et al., 2001; Norris, 1996; Peters, 1996].

4.2 The Context for Preparing a Financial Business Case

In our understanding the financial business case is part of the business case. To prepare the business case a dedicated team, the business case team, is usually selected. There are a number of steps before a financial value can be attached to a project [Hogbin, Thomas, 1994; p. 121; Norris, 1996].

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9 This may also lead to a closer examination of the organisational changes (process, structure, etc.) associated with the project. Senior managers who were asked some years ago what they considered to be the "top ten" most common causes of project failure ranked vague statement of benefits as number one cause (95% occurrence), followed by underestimation of the extend and scale of organisational change costs (95% occurrence) [CIE Survey, 1990; quoted in Norris, 1996].

10 [Davern, Kauffman, 2000] elaborate on so called convergence contingencies that influence the amount of value that can be realised from a project compared to its potential value.

	Surveillance / Monitoring	Positioning / Identification	Product information	Tracking and tracing	Self service	New services / products
Supported process tasks	Product regularly checks its functionality and collects data Central system performs remote updates (e.g. software) User can locally access all relevant information	Product reports locations Product identifies itself and starts transaction / update of information	User can access information about product (production details, etc.) User can directly manipulate data	Product (or reader) reports location Worker can locally access tracking data and further information about history and other information	Product gathers information Product (or reader) automatically starts transaction	[to be defined on a case by case basis]
Focus	Data gathering using sensors	Reporting of location	Information access for user	Following product over time	Automatic trigger for transaction	[to be defined on a case by case basis]

Figure 1: Generic Applications with Supported Process Tasks and Focus

The financial business case itself is not sufficient to justify a project proposal[11] [Hogbin, Thomas, 1994; p. 12; pp. 188-191]. Often the need is stated to align the project goals with company strategy[12] [Hogbin, Thomas, 1994; p. 110; Peters, 1996; Tallon et al., 2000; Willcocks, 1996]. As resources such as capital and labour are scarce, projects compete for the allocation of scarce resources. [Wetherbe, 1993] proposes a four-stage model of management information systems planning which can also be applied to more general investments in information systems. It starts with strategic planning using planning methods such as competitive strategy and customer resource life cylce, followed by organisational information requirements analyses using methods such as critical success factors. In the third step, resource allocation, methods such as return on investment analysis are used. The fourth step consists of project planning using gantt charts and others. Strategic goals may be broken down into operational measures using balanced scorecards [Kaplan, Norton, 1992].

11 [Hogbin, Thomas, 1994; p. 157] propose the following main sections for a business case: project objectives (including project scope), requirements, systems solution and alternatives, constraints and risks, costs, tangible and intangible benefits, financial assessment. They believe that e.g. risk assessment is of similar importance as the financial business case and name project size, project structure and procedure, application and technology complexity, operational impact, and commitment of management as criteria to be considered for a risk assessment [p. 190].

12 The same alignment is demanded for strategy and information systems in general. [Österle, 1995; p. 21] links strategy and information systems via processes.

Surveillance & Monitoring	Positioning & Identification	Product information	Tracking & tracing	Self service	New services / products
Monitoring of vending machines	Fleet management	Parts identification for reordering	Baggage tracking at airports	Self check out in supermarkets	[to be defined on a case by case basis]
Temperature monitoring for pharmaceuticals	Location based car insurance premiums	Alignment of delivery with EDI message	Cargo tracking at ports	Decentralised croduction control	
Remote patient monitoring	Locating of finished goods	Information access for maintenance	Parcel tracking	Parts replenishment	
Monitoring of train waggons	Call routing to nearest phone			Access control	
	Locating of nearby friends			Automatic toll collection	
				Weight based waste billing	

Figure 2: Examples for Generic Applications

Other authors such as [Gunasekaran et al., 2001; Hogbin, Thomas, 1994; p. 109; Norris, 1996; Peters, 1996] advocate similar approaches towards preparing for decisions on investments in information systems and propose a similar positioning for the financial business case in the process.

4.3 Tangible and Intangible Benefits

By looking at the benefits of investments, authors often distinguish between tangible and intangible benefits. Whereas tangible benefits can easily be transferred into monetary values, intangible benefits are harder to grasp. Benefits can be seen as intangible e.g. if there is a complex causal chain between the functionality the system provides and a monetary value derived from the functionality, or if they might materialise only in the medium to long term future where it does not seem feasible to make assumptions[13]. Due to these reasons it is difficult to arrive at a meaningful quantification in money terms. The extent to which tangible and intangible benefits are prevalent differs by type of information system. Systems aiming at internal efficiency are likely to have the highest proportion of tangible benefits. On the other side investments in IT infrastructure and strategic systems are likely to have a high proportion of intangible benefits. [Whiting et al., 1996]

13 Another reason presented by [Whiting et al., 1996] is that the cost associated with quantification outweigh the benefits. The description given for intangible benefits considers all benefits that are not quantified in monetary terms as intangible benefits. However, some of the measures may be qualitative, others quantitative non-financial measures.

Value drivers (included in calculation)	Cost drivers (included in calculation)	Intangible benefits (not included in calculation)
▪ *Automated check of status** ▪ *Reduction of checking errors* ▪ *Local access to gathered status and other data* ▪ *Reduction in incorrectly assumed failures* ▪ *Increase in detected failures** Overall value driver ▪ Time for project realisation and project life time* ▪ Cost of capital ▪ Probability of success and failure and additional potential	▪ Cost (ongoing) for tags and mounting ▪ Maintenance cost* ▪ Exception handling One time cost ▪ Cost of implementation* ▪ Cost of installation* ▪ Cost of training and process changes* ▪ Cost of pilot phase ▪ Cost of hardware and software ▪ Cost of readers* ▪ Cost of initial set of tags and mounting*	▪ *Increase in availability* ▪ *Increase in security* ▪ *Increase in trust* ▪ *Detection of rocess / process improvements*

Please note: *Italic* letters indicate drivers and intangible benefits that are specific for a generic application.

Figure 3: Surveillance & Monitoring: Value and Cost Drivers and Intangible Benefits

Failure to capture intangible benefits is sometimes made responsible for short-term orientation and inability to proceed with potentially valuable projects [Whiting et al., 1996; Toraskar, Joglekar, 1993]. This argument is then used to label the use of cost benefit analyses as inadequate for assessing investments in information systems [Kaplan, 1986; Toraskar, Joglekar, 1993]. [Toraskar, Joglekar, 1993] argue that this view results from a lack of understanding of cost benefit analysis. Citing seven criticisms against the use of cost benefit analysis they offer remedies for all of them and conclude that, if implemented appropriately, cost benefit analysis is very much appropriate as a basis for decision making on investments in information systems. Efforts should be made to quantify intangible benefits in monetary terms as good as possible keeping in mind and stating explicitly that these are only reasonable estimates. Similar statements can be found in [Hogbin, Thomas, 1994; p. 11; Kaplan, 1986]. However, finally there might still be some intangible benefits that do not lend itself even to rough estimates [Kaplan, 1986].[14]

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14 Further down we will see how intangible benefits can be integrated into the financial business case.

Value drivers (included in calculation)	Cost drivers (included in calculation)	Intangible benefits (not included in calculation)
▪ *Reduction of loss** ▪ *Automated location information** ▪ *Reduction of capacity*	▪ Cost (ongoing) for tags and mounting* ▪ Maintenance cost* ▪ Exception handling	▪ *Complete visivibility of location* ▪ *Increase in security* ▪ *Increase in customer loyalty / demand*
Overall value driver ▪ Time for project realisation and project life time* ▪ Cost of capital ▪ Probability of success and failure and additional potential	One time cost ▪ Cost of implementation* ▪ Cost of installation* ▪ Cost of training and process changes* ▪ Cost of pilot phase ▪ Cost of hardware and software ▪ Cost of readers* ▪ Cost of initial set of tags and mounting*	

Figure 4: Positioning & Identification: Value and Cost Drivers and Intangible Benefits

4.4 Project Approval

After the business case team has prepared the business case for the decision committee for approval, the decision committee faces the task of questioning the business case of which the financial business case is one part. Regarding the importance of the financial business case [Norris, 1996] offers some insight. He distinguishes between six types of investments in information systems. Of these, three are relevant for UbiComp applications, namely systems for efficiency, effectiveness and business redesign. For all types of applications the financial business case influences the decision. Questioning the validity of assumptions and estimates of parameters is the main issue. The importance of the financial business case is highest for systems aimed at improving efficiency. It decreases for systems for effectiveness and business redesign. Simultaneously the importance of business judgement increases. This judgement, finally performed by the decision committee, is concerned with intangible benefits on a strategic level such as value of claimed benefits for the entire business or the system's impact on the company and the market. Similarly, [Hogbin, Thomas, 1994; p. 194-198] offer a set of seven criteria the business case must meet. Financial feasibility is only one of the criteria, the other criteria being more related to strategic alignment and risks.

Value drivers (included in calculation)	Cost drivers (included in calculation)	Intangible benefits (not included in calculation)
▪ *Direct access to information** ▪ *Availability of information** ▪ *Reduction of wrong use** ▪ *Prove of ownership* ▪ *Prove of origin** Overall value driver ▪ Time for project realisation and project life time* ▪ Cost of capital ▪ Probability of success and failure and additional potential	▪ Cost (ongoing) for tags and mounting* ▪ Maintenance cost* ▪ Exception handling* One time cost ▪ Cost of implementation* ▪ Cost of installation ▪ Cost of training and process changes* ▪ Cost of pilot phase ▪ Cost of hardware and software ▪ Cost of readers* ▪ Cost of initial set of tags and mounting*	▪ *Enhanced product communication* ▪ *Increase in security* ▪ *Increase in trust* ▪ *Increase in customer loyalty / demand*

Figure 5: Product Information: Value and Cost Drivers and Intangible Benefits

5 UbiComp Business Applications

After having examined the financial business case for information systems in general, we now want to look specifically at UbiComp business applications. We have identified five generic UbiComp business applications: surveillance & monitoring, positioning & identification, product information, tracking & tracing, and self service. These generic applications can be found in industries such as consumer goods, automotive, health care, and financial services. They are shown in figure 1 including the process tasks that are supported by UbiComp technology[15]. Figure 2 gives a number of examples for each generic application. For each generic application we propose a number of relevant benefits[16].

15 There is one additional generic application called new products / services indicating that there might be UbiComp business applications which do not fit into one of the five generic applications.

16 [Norris, 1996] offers an example for a systematic approach to identifying business benefits.

Value drivers (included in calculation)	Cost drivers (included in calculation)	Intangible benefits (not included in calculation)
▪ *Improved product availability* ▪ *Improved security of products** ▪ *Automated proof of delivery** ▪ *Eliminating stock verification** ▪ *Reduction in inventory level* ▪ *Decrease in products rejected** ▪ *Local access to gathered position and other data* Overall value driver ▪ Time for project realisation and project life time* ▪ Cost of capital ▪ Probability of success and failure and additional potential	▪ Cost (ongoing) for tags and mounting* ▪ Maintenance cost ▪ Exception handling* One time cost ▪ Cost of implementation* ▪ Cost of installation ▪ Cost of training and process changes* ▪ Cost of pilot phase ▪ Cost of hardware and software ▪ Cost of readers ▪ Cost of initial set of tags and mounting*	▪ *Complete visibility and tracebility of products* ▪ *More responsive production* ▪ *Reduced order cycle time* ▪ *Improved forecast accuracy* ▪ *Mass customisation*

Figure 6: Tracking & Tracing: Value and Cost Drivers and Intangible Benefits

The benefits may either be quantifiable in monetary terms (and thus become value drivers) or intangible benefits. Value and cost drivers as well as intangible benefits are shown separately for each generic UbiComp business application in figure 3-7[17]. There are a number of value drivers which can not be attributed to specific generic applications, e.g. value drivers such as additional potential for application due to experience gained or years of usage. The same is true for all cost drivers such as project cost, software and hardware, maintenance, training, and change management. Hence these drivers appear in all generic applications.[18] The figures include for each generic application the value and cost drivers we regard in general as potentially decisive for the financial value (marked with an asterisk), although this may vary by application. It is important to note that the benefits and cost are marginal, i.e. benefits and cost that accrue in addition to the currently existing process.

17 For a certain application some benefits may have to be interpreted slightly different to be applicable. Additionally, some value drivers or intangible benefits might not be relevant, or some value drivers are relevant but intangible (and vice versa).

18 There is no explicit distinction between direct and consequential cost as the idea of activity based costing is favoured as proposed in [Kaplan, Cooper, 1998].

Value drivers (included in calculation)	Cost drivers (included in calculation)	Intangible benefits (not included in calculation)
▪ *Automated transaction** ▪ *Higher accuracy** Overall value driver ▪ Time for project realisation and project life time* ▪ Cost of capital ▪ Probability of success and failure and additional potential	▪ Cost (ongoing) for tags and mounting* ▪ Maintenance cost ▪ Exception handling One time cost ▪ Cost of implementation* ▪ Cost of installation* ▪ Cost of training and process changes* ▪ Cost of pilot phase ▪ Cost of hardware and software ▪ Cost of readers* ▪ Cost of initial set of tags and mounting*	▪ *Increase in capacity* ▪ *Reduction in process complexity* ▪ *Increase in flexiblitiy* ▪ *Increase in customer loyalty / demand*

Figure 7: Self Service: Value and Cost Drivers and Intangible Benefits

6 The Calculation Model

The calculation model uses NPV calculation, expected return and the real options idea (in the form of scenario analysis) to derive a result. The model aims for supporting the calculation of a monetary value for a proposed project using UbiComp technology, based on the range of generic UbiComp business applications we have introduced above, taking into account the most important value and cost drivers over the entire life time of the solution, with the possibility to adapt the model to individual specifics and constraints.

There are a number of requirements on the model resulting from the fact that the model is to be used within companies, namely within the M-Lab partner companies. The requirements include simplicity and ease of use, transparency, decision support, adaptability, orientation on project phases, and suitability. For our own research main requirements are the ability to generalise results and theoretical correctness. Simplicity and ease of use have a strong influence on the number of inputs that can be requested from a user. Other models we have looked at use between 5-10 [Peoplesoft; SAPa; SAPb], 40-50 [Gartner] and >100 inputs [Plumtree] to derive a result. We have to decided to use approximately 30-40 inputs and an additional 3-5 assumption.

For the quantification of each value and cost driver a set of parameters is used. For an illustration see figure 8. The parameters are either inputs (i.e. data to be entered by the user) or assumptions made initially (e.g. discount rate). Inputs are either quantitative non-financial (e.g. number of tagged items per year) or quantitative financial inputs (e.g. price of tagged item). If possible we prefer non-financial inputs as we believe these are more directly observable in processes. Inputs and assumptions are transferred into the value for a driver usually by using basic arithmetic[19].

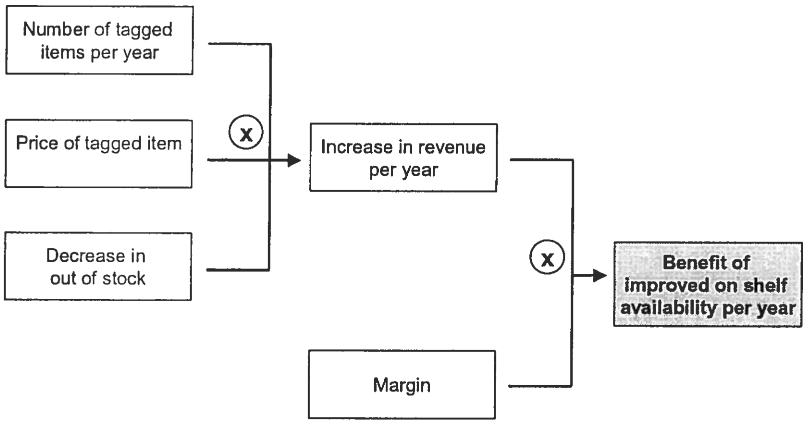

Figure 8: Schematic Calculation for Value Driver "Improved Product Availability"

The model is based on the idea that the project consists of three phases and that two decisions at distinct points in the project have to be made before it is implemented. The first one is the decision to examine the project proposal further. This is the decision for which the framework presented here may be useful. We assume that the following step is a pilot project. After the pilot phase a decision is made whether to continue with the project or not. We consider three possible scenarios for the pilot phase:

19 After an initial result is derived the assumptions can be relaxed or additional benefits or ways to calculate the benefits or cost might be applied, if applicable.

- In the base case, the pilot phase was successful, the benefit and cost estimates prove realistic and the project is realised as planned.[20]

- In the best case, the insights gained in the pilot show additional application potentials in other areas. These projects are initiated, and e.g. the experience gained, or the systems and procedures in place reduce implementation costs.

- In the worst case, the pilot fails and the project is not realised.

For each of these scenarios a NPV can be calculated, using an estimate of the cost of capital for discounting. All numbers are pre-tax. Based on the inputs for probabilities for each scenario an expected NPV for the project as of today is calculated. The resulting model is schematically depicted in figure 9.

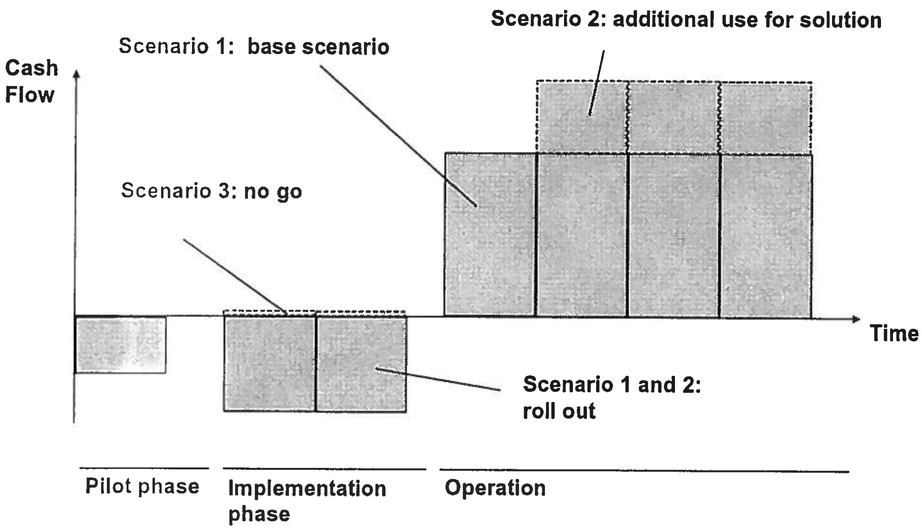

Figure 9: Schematic Model of NPV calculation

20 This assumes that the NPV for the base case is greater than zero.

7 A Five-Step Process for Applying the Calculation Model

For applying the model we propose a five-step approach that is shown in figure 10. Before the model is applied, a business case should at least be outlined. The business idea generation method proposed by [Gross, 2002] and the RFID feasibility check by [Floerkemeier, 2002] may have been used.

From our point of view four of the five steps are plausible and do not need further explanation. We believe the fourth step, check for plausibility and perform sensitivity analysis, needs a more detailed examination. For the sensitivity analysis some parameters are varied to show how individual drivers and the NPV change. We propose to test for sensitivity of individual parameters at least for those drivers that are most substantial (e.g. by testing when the value of the application turns negative). This may e.g. give an idea of the parameters that have to be closed monitored during implementation and hence provides a way of addressing the financial risk during implementation[21]. The plausibility check is a little more demanding. It requires to check the underlying assumptions for all inputs, something which is to be done by the decision committee as well. The plausibility check is especially important if the result of the calculation is a negative NPV. In this case one might look for the intangible benefits that are included in the business case. The business case team (and later the decision committee) may consider whether the intangible benefits are likely to be substantial enough to make the NPV greater than zero[22].

21 Here the term risk is used only in its negative meaning, whereas as in real options uncertainty and the associated risks can be positive [Amram, Kulatilaka, 1999; p. 8, 15]. This is also true for scenario analysis.

22 Typical examples of intangible benefits might include increases in flexibility and quality, or learning [Kaplan, 1986]. To a certain extend we try to capture these concepts in our model e.g. by allowing for scenarios and proposing the above mentioned way of dealing with intangible benefits, although probably not to the full extent. Please note that the list of intangible benefits can also contain drivers which the business case team or the decision committee might not feel comfortable with to estimate and which therefore are not included in the calculation model.

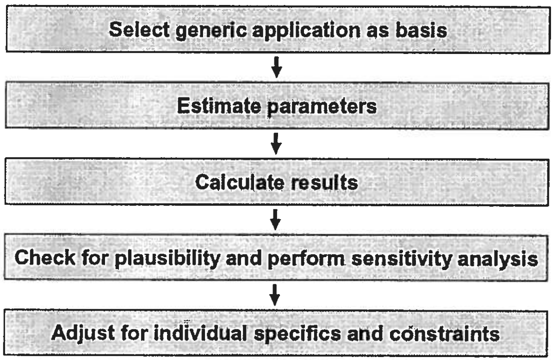

Figure 10: Five-step process for deriving the financial business case

The final results are then prepared in a way that the business case team can easily communicate them to the decision committee. It is highly likely that the results provide only a rough approximation of the value. Having this in mind [Kaplan, 1986; p. 92] states that managers need not follow accountants who “prefer being precisely wrong to being vaguely right”.

8 Initial Findings

8.1 Findings from Workshop with Partner Companies

We now want to present some initial findings from discussing and applying the framework with companies, starting with the workshop with our M-Lab partner companies where the framework was presented and discussed in a group work.

The workshop gave us the impression that the framework fulfils the requirements to be applied in UbiComp projects within companies. Similar to our view, our partner companies do not regard a financial business case alone as sufficient for approving a project. Based on the comments we extended the description of each generic UbiComp application by marking the potentially most critical parameters for each generic application. Four of the five companies that gave feedback to the framework stated that they would talk to two or three people with relevant expertise within their organisation in order to get an idea of the magnitude of benefits and costs for a certain project proposal. The same four companies would spend about one day for preparing the financial business case as basis for approval of a pilot project[23]. The level of detail required by the calculation model was regarded as sufficient to prepare a financial business case, as often there is no data available on which to base more detailed estimates.

8.2 Findings from Company Visit and Case Study

During a one day company visit to a UbiComp solution provider we analysed a number of projects the company had realised and prepared a case study for one of its projects.

When looking at the kind of projects the UbiComp solution provider has realised we could fit them into three of the generic applications: tracking & tracing, surveillance & monitoring, and product information. Hence, there was no need to change our initial categorisation. For tracking & tracing we present a more detailed case study below. An example for a surveillance & monitoring application is cool chain monitoring, e.g. in supermarkets using the built in temperature sensor in the RFID tag. Product information applications rest on the built in memory with read/write capability in the tag in which information on the product can be stored and retrieved.

The case study on tracking & tracing we present here is based on the results of a pilot project for tracking racks for specific parts in the automotive industry[24]. The racks circulate in a closed loop between a car manufacturer's production and assembly sites. The racks can be used for several years and are usually bought once, e.g. when a new car model is introduced. Main problems within the current situation are the high investment cost in racks, production delays due to missing racks, and loss of racks. Currently, more racks are circulating than needed to avoid expensive production delays. As the racks can be stored at different locations within each site, racks get frequently lost. If no racks are available, special one-time racks can be used. However, these are more expensive than the reusable racks.

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23 The exception was a partner company that is focusing more on a solution for the consumer market. Here, they see a need for a more detailed analysis, based e.g. on surveys or focus groups.

24 Due to confidentiality reasons we are not allowed to provide a more detailed description of the solution or values for individual drivers.

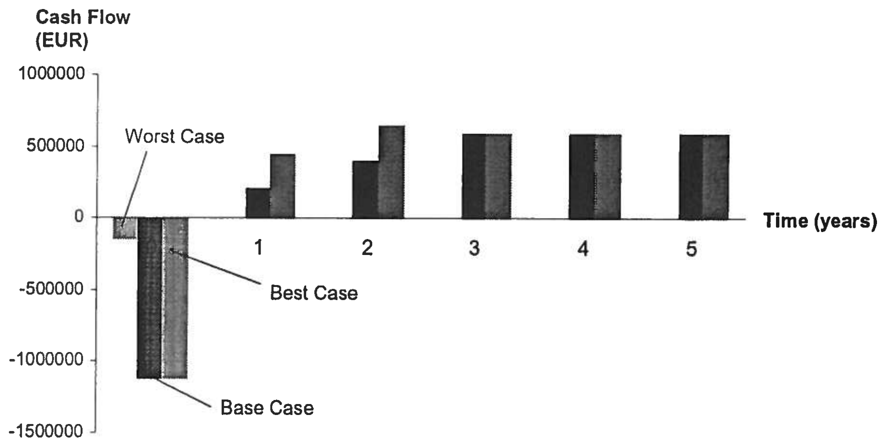

Figure 11: Cash Flow over Project Life Time

The pilot project was mainly aimed at showing the technical feasibility of the proposed solution. The solution uses active RFID tags. Technical feasibility in this case is mainly concerned with the read rate in a metallic environment. In contrast to applications which require a read rate of as close to 100% as possible to become feasible, a read rate of 97-99% is sufficient as items are identified several times during circulation. Based on the results from the pilot project the car manufacturer has gained a rather clear understanding of the associated cost drivers regarding e.g. tag and reader cost, installation and implementation cost. However, as only a limited number of racks was tracked, the benefits could only be observed to a limited extend. For example, the car manufacturer may, from our point of view, not be able to reduce production delays that result from missing racks before the solution is fully operative. The car manufacturer therefore had to make reasonable assumptions for the input parameters.

For preparing the financial business case we followed the proposed five-step approach. The application clearly falls under tracking & tracing in our set of generic applications (step 1). This provided us with a set of value and cost drivers and intangible benefits as a starting point for going trough the data.

We gathered the inputs based on the available data (step 2). As the company was interested in gaining a tailored calculation model and result without spending time on applying the generic model for tracking & tracing, we made some changes to the generic model while collecting the inputs.

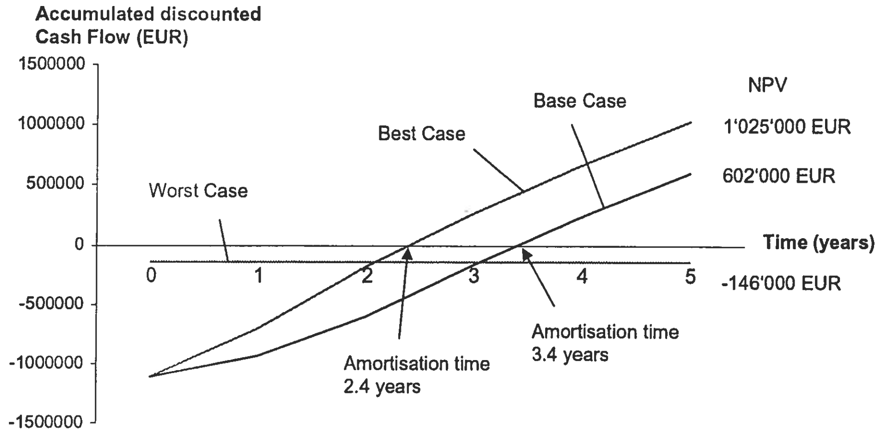

Figure 12: Discounted Cash Flow over Project Life Time for Three Scenarios

Essentially this means we performed step 5 simultaneously to step 2. The changes we made to the generic model were as follows: The value driver "reduction in inventory level" was interpreted as reduction in investment cost for racks; "improved product availability" as reduction in cost of production delays; "eliminating stock verification" as reduction in searches for racks. An additional driver, "reduction in special transport or special packaging", was added. The value driver "decrease in products rejected" was considered irrelevant, and the value driver "local access to data" was treated as an intangible benefit.

The data available was sufficient to calculate the one time cost except for the implementation, process change and training cost. A person involved in the project estimated these parameters. The data available also contained a static base case scenario of the benefits for a one year period. Based on this data the car manufacturer had calculated an amortisation time of less than one year. There was no amount for ongoing cost so we included estimates for these (e.g. maintenance, exception handling). As the car manufacturer had applied a static view on the project there was also no specification of the expected project life time. We assumed five years which occur as prudent to us as this is in the range of the average production time for a car and is also still below the life span of the battery in the active tags. We assumed a time frame of one year before the solutions goes live and allow for three years before the system becomes fully operative. Finally we made some assumptions regarding the likelihood of success. The assumptions were all discussed with the above mentioned person familiar with the project. Although a pilot project was already conducted, due to the focus on technical feasibility we regard it as reasonable to assume a scenario for failure. The company might e.g. detect during implementation that it might not be able to realise the benefits based on the tracking & tracing information that it had expected and therefore abandon the project. The positive scenario reflects the potential international roll-out of the solution for this specific type of racks and assumes a reduction in one time cost if the solution is rolled out internationally. This possibility was already discussed at the car manufacturer. The changes and amendments we made to the car manufacturer's data all increased the one time cost and decreased the net benefits (i.e. benefits minus recurring cost) for the base case, so the amortisation time increased.

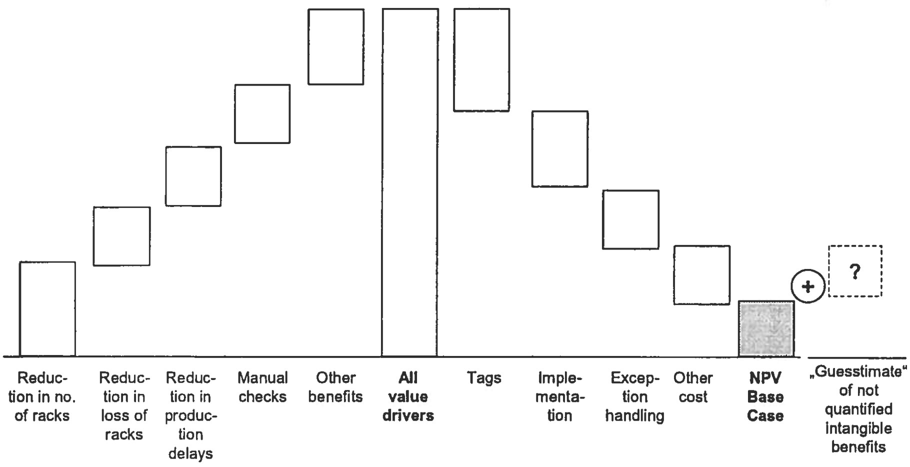

Figure 13: Discounted Values for Most Important Value and Cost Drivers by Amount

When gathering the inputs by analysing the data and discussing with the UbiComp solution provider, we learned that not all information may be available or can be estimated at the same level of granularity. Therefore in some cases the value drivers were not calculated but directly taken as lump sums (e.g. software cost).[25]

25 In general, this practice might be used for amounts which are assumed not to be substantial as the effort needed to derive the data might not justify the result. For more substantial amounts however, we regard it as important that the assumptions that lead to a certain value are transparent and people have the chance to question or discuss these assumptions.

After having gathered all inputs, we calculated the value (step 3), compared the results with the initial data and checked the results for plausibility (step 4). During the company visit no sensitivity analysis was conducted. This was added after the company visit. The results of the calculation model are shown in figure 11-13.

The application shows a positive NPV for the base case and the best case. The discounted value of benefits over the life of the project for the base case totals EUR 4'327'000 compared to one time investment cost of EUR 1'121'000 and recurring cost of EUR 2'604'000. This results in a NPV of EUR 602'000 for the base case. The expected NPV taking all three scenarios into account is EUR 580'000. The most important value drivers in our calculation are reductions in number of racks, loss of racks and production delays as well as less manual checks. The most important cost drivers are cost of tags, implementation and exception handling.

Figure 14 shows the results of the sensitivity analysis. The sensitivity analysis reveals e.g. that if the solutions only runs three years instead of five years as envisioned, the NPV becomes negative. The same is true if the realised reduction in the number of racks needed is only 2% instead of 5% as expected.

We believe these figures, combined with a table of parameters used for the calculation and a list of the intangible benefits (which are by definition not included in the calculation), provide a meaningful way for the business case team to present the financial business case, as part of the business case, to the decision committee.

Parameter	Input value*	NPV (in EUR) Base Case	NPV (in EUR) Expected return
Project life time (years)	5	602000	580000
	4	238000	288000
	3	-164000	-33000
Cost of tags (EUR)	25	602000	580000
	30	338000	368000
	35	74000	157000
	40	-191000	-55000
Reduction in no. of racks (in %)	5	602000	580000
	4	352000	380000
	3	108000	184000
	2	-132000	-8000
Reduction search cost (EUR/year)	125000	602000	580000
	0	239000	289000
Reduction in loss of racks (%/year)	1	602000	580000
	0,5	239000	289000
	0	-125000	-2000
Reduction in manual checks (hours/batch size)**	24	602000	580000
	12	239000	289000
	0	-125000	-2000
Reduction in production delays (%)**	10	602000	580000
	5	239000	289000
	0	-125000	-2000

data rounded
* bold indicates initial value
** own estimate; no detailed data available

Figure 14: Sensitivity Analysis for Selected Parameters

9 Limitations of the Calculation Model

The calculation model has some limitations. It focuses only on a monetary value and requires the quantification of hard to quantify factors in the future. It assumes that the project is consistent with strategy (as mentioned before) and technologically as well as organisationally feasible. We have tried to limit this shortcomings by stressing the importance of the business case of which the financial business case is a part. Controlling benefits and costs as well as risks plays an important role if the project is to be realised.

The fact that generic applications are defined using a fixed set of inputs and a number of assumptions might introduce inaccuracy by abstracting too much from the specific circumstances of each case. It is hard to argue against that. However, in the longer run experience that is gained from applying the same model several times may increase the accuracy of forecast for projects to come. This experience would not be gained if the financial business case were calculated on a case-by-case basis.

Accuracy is further limited due to the fact that the calculation is done before detailed concepts for the solution have been worked out and benefits can be accurately estimated. Given that the business case is prepared in an early project phase just to get an approval to further elaborate the project proposal, this is inevitable and not specific for our model.

There is a risk that the business case team preparing the financial business case is biased, most likely in favour of the potential application [Toraskar, Joglekar, 1993]. This is likely to result in a biased assessment of the critical value and cost drivers. The bias may be reduced by ensuring that e.g. a person which is familiar with the process, but so far has not been involved in the project and is not affected to a major degree by the project does the calculation. An eventual bias may also be detected by the decision committee when it questions the critical inputs and assumptions.

We assume that the decision committee can make a reasonable informed decision on the implementation after the pilot phase. However, the pilot phase might only show the technical, not the financial feasibility of the proposed applications as the setting is too far removed from real operations to gather any relevant data, especially on benefits. This view is supported by discussions with an institution that is currently conducting a pilot project.[26] In these instances, we propose to individually adjust the model. It may then include e.g. four phases and distinct scenarios for both the technical pilot and the following phase. Before the technical pilot is started, after it has been conducted and after the following phase, a decision is made on how to proceed.

From a slightly more theoretical point of view, inaccuracy might be introduced when the calculation model is used within companies. We suspect that some companies when applying the calculation model may not distinguish between nominal and real values. They might use a nominal risk-adjusted cost of capital instead of a real (i.e. inflation adjusted) risk-adjusted cost of capital. In our model however benefits and cost are not inflated, i.e. real values are assumed. As we believe the amortisation time to be rather short this is unlikely to lead to major distortions in results. We also tolerate these potential distortions

[26] Unfortunately we are not allowed to disclose the name of this institution.

for the sake of simplicity and ease of use. We believe it is easier to discuss benefits and cost with people in real terms (i.e. today's prices) and discount rates in nominal terms.

As mentioned above we only look at marginal benefits and cost compared to the current process. This implicitly assumes that the current process can continue without changes. As [Kaplan, 1986] indicates it is more likely that the current practice is not sustainable. In this case we are likely to understate the financial value of the proposed project.

As our focus is on UbiComp business applications, there is a risk that we might limit our investigation to process improvements using UbiComp technology. Thereby we might not identify the best alternative, i.e. the one with the highest NPV, which potentially may be one without any new technology at all.

There is a final point of acceptance in real projects, especially within our partner companies. We can not yet judge this as of today. We know, however, that our partner companies have asked for such a model. We have addressed this issue of acceptance by taking into account main requirements as listed above. Whether the calculation model is finally used, remains to be seen.

10 Conclusions and Further Research

In this paper we have identified five different generic UbiComp business applications by looking at the applications that are currently available or that are at least in a pilot stage. Assuming that companies explore all opportunities that seem financially feasible (and that we did not miss any major types of applications), these can be seen as the ones where UbiComp technologies can currently create value. However, it is unlikely that this set of generic applications is stable. We expect new types of applications to appear over time as e.g. new ways to use the data that is generated are developed. When drawing a parallel between barcodes and UbiComp business applications, one may assume that initially applications are realised that focus on short term tangible benefits and do not heavily rely on sophisticated data analysis to provide results.

We have tried to find out the most important cost and value drivers for UbiComp business applications. When looking at the results of the case study and the drivers for the generic applications, there are no clear answers yet, but we start to see some patterns. It is likely that only a number of value and cost drivers are decisive. On the benefit side, labour cost savings are of high importance as well as costs that are resulting in the total loss of items (e.g. theft, destruction, loss) in contrast to a loss of only the margin (e.g. when items are out of stock). In some cases there may be single benefits (e.g. counterfeit protection, reduction of production delays) that justify the use of UbiComp technologies. On the cost side, the devices that are attached to the items are a major cost driver. This is likely to change somewhat if volumes e.g. for low cost passive RFID tags increase. Additionally, implementation cost can be substantial. Another potentially important cost driver has to do with those cases in which the data is not transmitted (e.g. when a tag could not be read) or transmitted incorrectly. In these cases cost for exception handling can occur.

We have proposed a framework for calculating the financial impact of ubiquitous computing business applications. The framework is based on the assumption that business applications featuring ubiquitous computing possess enough similarities to define a limited number of generic applications that can be analysed within a single model to derive a financial business case. Given the research on business applications we have done so far, we believe that this is still reasonably to assume. We have argued that the financial business case is not sufficient to justify an investment. However, we believe a company that is thinking about investing in a UbiComp application should at least try to get a rough idea of the financial impact of its decision.

Currently the ideas presented here are based on a limited set of cases. The presented value and cost drivers as well as intangible benefits need to be tested in several case studies for each generic application. This may help to more clearly define the processes in which UbiComp technologies can create value and how this value is created. Further case studies may also be longitudinal to check how companies were able to realise the identified potential benefits and costs. Researchers may also look at whether they can identify more or different types of generic applications. It may also be worthwhile to look at UbiComp business applications from the perspective of innovation adoption. Apart from the financial feasibility we already have anecdotal evidence that there are other factors (both individual and organisational) which influence whether a project based on UbiComp technologies is realised. A better understanding of these factors would not only be valuable from a research perspective but also for companies that want to realise the potential of UbiComp now.

Going forward we aim to apply the model in a number of projects with our partner companies and prepare case studies for these projects. After that, it might become necessary to adjust or extend the number of generic applications, to refine the inputs needed, assumptions made and the way the financial impact is calculated. These case studies may provide same initial empirical insights in the specific kinds of business problems, i.e. processes and tasks and conditions under which UbiComp business applications provide the highest value. This may at least provide some further anecdotal evidence on the value creation potential of UbiComp business applications and help to define more clearly the achievable benefits. If some of the projects we are to look at are finally realised, we then have the chance to compare estimated with realised benefits and costs. This may again help to understand the benefits in more detail and provide a basis for cost estimates that can be used for future projects.