Thomas Sobottka
René Leitner
Wilfried Sihn

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METHODOLOGY FOR THE DEVELOPMENT OF RFID VALUE ADDED SERVICES TO IMPROVE SUPPLY CHAIN OPERATIONS

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Summary

Despite the potential of RFID technologies to improve supply chain operations and control, RFID projects – especially in production heavy sectors – are often restricted to basic recognition functionalities, leaving much of the vast potential to improve supply chain operations and control unharnessed. This paper aims at providing a procedure to identify advanced value added services based on the RFID technology, tailor made to companies' specific requirements. Considering all relevant processes the developed approach focuses on potential benefits from the RFID deployment throughout the supply chain. As a key element a case study for SMEs in the electronic component industry is presented.

Key words: *RFID, supply chain, value added services, SME*

1. INTRODUCTION

A major reason for the slow progress of the RFID (Radio Frequency Identification) technology in recent decades is the lack of emerging innovative applications that provide substantial added value, most prominently compared to the well established barcode. This paper is meant to address this central problem by describing a systematic procedure to improve the creative process of creating new application scenarios. Generally, the low level of RFID penetration in industrial environments contrasts with the significant potential and technical possibilities of the technology [1,2]. A similar situation can be observed concerning the level of sophistication of the majority of implemented RFID applications today. Their relative plainness – mostly mere barcode substitutions and simple identification tasks [3] – contrasts with the variety of additional functions enabled by RFID, ranging from dynamic memory, contactless recognition of objects and readability without a line of sight and bulk reading capability to connectability with other information technology. One of the main reasons given by potential users in the industry is the difficulty of identifying promising applications, followed by the problem of hardly being able to predetermine the economical impacts of implementing RFID systems.

Although there are numerous publications on RFID introduction projects – including both theoretical approaches and practical case studies – those works mainly focus on measuring the value and utility of RFID systems, while the very process of creating new application scenarios has not yet been dedicatedly investigated in the available literature. Hence this paper aims at developing a procedure to systematically identify the RFID applications generating additional value – other than mere identification of marked items – thus providing planners with an efficient universally applicable tool to find suitable elements of an RFID system in specific real life environments. This is meant to simplify, shorten and improve the results and quality of RFID projects.

The approach is designed under the premise of comprehensiveness – every area and division of a company should be considered a potential field for RFID applications – and openness towards the nature of the Value Added Services (VASs) provided by the technology. The latter is especially important, as new and special environments constitute the potential for finding previously unknown opportunities for technology applications. To achieve this, methods and tools available in other fields, in particular those from engineering are to be adapted to apply to the systematic search for VASs.

The paper is structured as follows: first, in a compact literature review the elements relevant for the envisaged concept – RFID, VASs and Supply Chain Operations – are briefly explained, followed by an overview of existing approaches to the development of new services, i.e. the Service Engineering concept. This is followed by a chapter on the concepts used to form the resulting VAS-search procedure, i.e. Service Engineering and morphological analysis. Based on these fundamentals, a procedure for the creation of RFID applications will be developed and the first, preliminary results of an application of the developed procedure in a case study will be presented.

2. FUNDAMENTALS AND LITERATURE REVIEW

In the following, basic terminology necessary for the precise description of concepts and methodology for the development of services, i.e. VASs, are defined. Additionally, concepts already available and presented in literature for the development of services are introduced und discussed briefly. These concepts are then used as the basis for developing a specific RFID VAS development procedure in the following chapters.

2.1 Definitions of RFID, Value Added Services and Supply Chain Operations

RFID is an Automatic Identification and Data Capture technology (AutoID), enabling the automatic identification of objects equipped with an RFID transmitter [4]. The characteristics of RFID, compared to other AutoID technologies, are the ability to identify objects via electromagnetic waves sent between RFID readers and transmitters (tags), transmitting information about the object from the tags to the readers. It is possible to identify multiple tags on multiple objects virtually simultaneously and some tags also enable changing the data saved on the tag memory.

While the basic functionality of RFID is the automatic remote identification of tagged objects, the technology offers a large variety of additional benefits and applications, utilizing the full range of technical capabilities and the versatility arising from a combination of the RFID technology with other information technologies, such as WLAN, Sensors and GPS modules. In this paper, these additional functionalities are referred to as *Value Added Services* provided by the application of the RFID technology.

In order to develop a toolset for the efficient creation of VASs, it is crucial that a proper *service* definition is assumed, including the characteristics and elements of services, which will then have to be systematically addressed by the to be developed procedure. Generally, services are defined as an intangible economic good characterized by the simultaneity of performance provision and consumption and the impossibility of saving and storing it. The integration of an external factor, i.e. the consumer, in the process also adds to the features distinguishing services [5]. From a constructional definition point of view, services consist of four elements: potential (i.e. the ability of the service provider to offer a service, constituted by human resources and auxiliary means), process (processes between service provider and consumer), result (status resulting from the effects of actions by the service provider on the consumer's side) and market (marketability and negotiations between service provider and consumer concerning services) [6]. In the context of RFID borne services, the concept of *hybrid products* has to be explained: hybrid products are services accompanying material products and are logically inseparable from the physical objects they complement. A typical example in the context of this paper would be an automatic goods receipt functionality provided by reading the RFID tags of incoming goods – this kind of service is dependent on the existence of an installed RFID system and is thus inseparable from it.

Supply Chain Operations, the designated object of the envisaged improvements through RFID applications, are the entirety of processes involved in the activity of creating value along the supply chain, from resources, via various production stages to the selling of finished products [7]. The main focus for the identification of VASs in this paper is on the manufacturing and distribution logistics and is not limited to in-house-logistics.

2.2 Available Concepts for the Development of Services

Traditionally, the development of services is considerably less covered by scientific publications than the development of material products [8]. The concepts that are available originate from (New) Product Development concepts (NPD) and can be divided into the New Service Development approach, which is decidedly marketing oriented [9], and Service Engineering, a concept focussing on an engineering perspective of the development of service products. The latter lends itself better to developing technology oriented services for RFID as the marketing component is not directly relevant for developing services provided by the application of the RFID technology based on their technical utility for the company.

3. METHODS AND CONCEPTS

All production and service development approaches are based on the fundamental principle of identifying demands and matching them against potentials of technologies or capabilities of service providers. For the purpose of this paper, the potential is being provided by the RFID technology while the demand equals the possible utility that can potentially be realised in companies using the technology. In the following, the methodology to form services, identified in the previous section, the RFID technology potential and a problem solving technique to be applied in the development process, i.e. morphological analysis, are introduced. These elements are considered to be the basic elements for the procedure developed in Chapter four.

3.1 Service Engineering concept

The discipline of Service Engineering – in literature also referred to as Service Design – is a multidisciplinary way of systematically generating and designing services, utilising methods and tools from engineering, business administration and other fields [10]. A morphological approach to Service Engineering is to combine the four aforementioned service elements with a set of engineering dimensions, constituting a scope of designing services. This framework is shown in Figure 1.

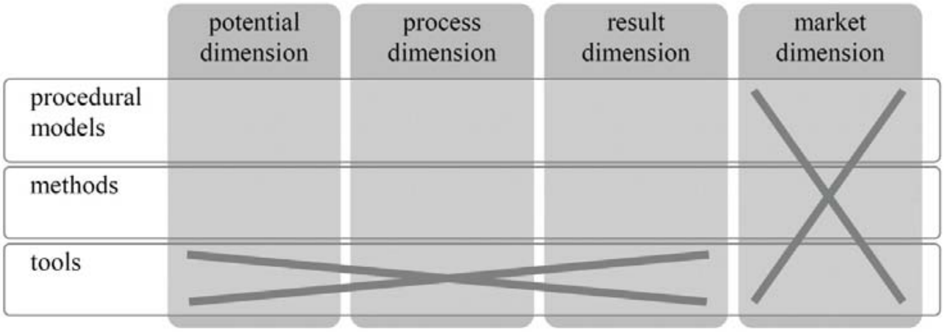

Fig. 1 Service Engineering framework by Bullinger – elements relevant for this study are marked

The procedural model is a set of phases (initialisation, analysis, concept, preparation and implementation phase) necessary to develop services. Methods in this context are described as techniques and instructions to achieve goals, while Bullinger et al. define tools as IT infrastructure to support the activities in the Service Engineering context.

The Service Engineering approach was originally designed to help create services for companies to offer and market. However, the nature of the RFID Value Added Services significantly differs from that assumption. RFID VASs and their design are not necessarily meant to create services for external parties but first and foremost to come up with services provided by the application of the RFID technology itself. That said, the utilisation of Service Engineering as a set of tools for systematically identifying and shaping services, like those envisaged in the context of RFID VASs in this paper, is still appropriate, due to the similarity of basic characteristics of both service views. It is possible to assume a "virtual service provider" in whose interest the services are developed. However, since the focus is entirely on conceiving possible applications for RFID – the VAS – a considerable share of the instruments of Service Engineering can be ignored. The "market" element of the service dimensions is among those negligible parts, as is the Service Engineering dimension "tools", as there is neither the necessity of marketing considerations and information technology supporting the services; at this point at least. If the VASs discovered by this adjusted procedure were later to be combined to form services a service provider would want to sell to his costumers, these elements had then to be added. The assumption of a "virtual" service provider appears sensible from another perspective: By its nature, RFID systems are an item of equipment companies invest in – yet the possession of elements of an RFID system do not in itself create benefits for the owner, other than the basic functionality of recognizing objects. The innovative ways of employing the technology in existing processes and even creating new value creating processes using RFID as an enabler are the key to utilising the capabilities of the technology. Thus, it is possible to assume a neutral service provider when shaping the way to conceive the services with the only goal of finding useful services for an available technology.

3.2 RFID potential and morphological analysis

The technology RFID offers a number of benefits or utilities, which in the course of an analysis phase of the Service Engineering procedural dimension can be matched with process requirements, company goals as well as current shortcomings and problems in existing supply chain processes. These benefits can be categorized into three dimensions, which are diagrammed in Figure 2 [11,12]:

- utility type
- time frame of utility realisation
- directness of the utility impact.

There are three utility types as follows:

- Automation-Effect: the substitution of manual operations due to automatically triggered operations and closing media gaps in the transmission of information
- Information-Effect: recording, retrieving, processing and distributing data, real time data availability
- Transformation-Effect: new processes enabled by RFID, e.g. decentralized material flow control.

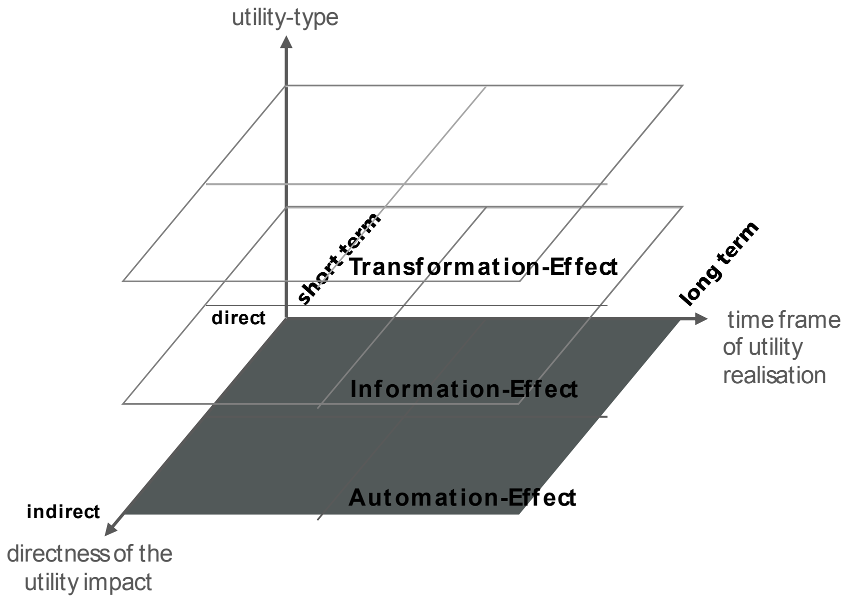

Fig. 2 Categories of RFID utility/benefits

The use of this open way of segmenting technology benefits provides planners with an idea of what kind of applications are possible without restricting their thinking to a set list of validated application scenarios. The visualisation of three possible dimensions of the RFID utility is also a preparatory step for applying the morphological analysis problem solving technique [13,14].

To develop the three-dimensional utility categorisation into a morphological box – Zwicky Box – it is necessary to parameterize each dimension. The utility type already consists of three dimensions, i.e. the three effects. Additionally, the timeframe of the utility realisation is categorized into “short-, medium- and long-term”, while the directness of the utility impact can assume the values “direct” and “indirect”, thus constituting a three-dimensional matrix with 3x3x2 (=18) cells – the morphological field. The resulting combinations of parameters have to be analyzed according to feasibility and sensibility. Eventually, the combinations deemed practical and probable have to be scrutinized in an effort to find possible applications.

This method will then support the innovation of services, which, given the still limited number of developed application scenarios, is an opportunity to further utilize the entire technology potential. However, in RFID projects, additional checking whether a list of well-established RFID scenarios, known to have generated a positive turnover in similar projects, might partially fit the application environment in question, is nevertheless certainly recommended.

4. RESULTS

This chapter is dedicated to the final development of the envisaged specific VAS creation procedure. It is based on an adaption of the Service Engineering concept and features a morphology-based technique to guide, structure and support the process of creating ideas for RFID VASs. The technique is based on the assumption that human thinking and perception are characterized by categorization processes – a notion commonly held in modern psychology [15]. Eventually, the newly developed concept is applied in a case study and the preliminary results are presented.

4.1 Resulting Procedure

The procedure is based on the Service Engineering framework in combination with a morphological analysis. In the first step, the combination of the service dimension "results" and the procedural dimension from Service Engineering have to be considered: Which steps have to be taken to define a process that delivers certain service results? At this stage the results themselves are not yet known since the service is not yet defined. Because this paper focuses solely on the identification of VASs, only the first three initial stages, initialisation, analysis and concept phase are of interest. The first contains the generating of ideas for services while the latter two are dedicated to the analysis of requirements, the evaluation of ideas and the drawing up of a basic description for the envisaged service. However, in this context, the generating of ideas and the analysis of requirements should be conducted simultaneously to streamline the activity of finding ideas, to structure this creative process and to ensure the relevance of its results. The methods of determining the requirements – needs, problems and envisaged processes from a manufacturing company's perspective that constitute the potential for an RFID system application – are not part of the subject of this study.

To structure the generation of ideas, the potential utility of RFID is converted into a morphological box – see Figure 3 – and subsequently matched with the said requirements portfolio. Example applications for every feasible combination have to be drawn up in team workshops, thus providing reference points for the creation of perhaps bolder and more innovative suggestions for RFID application scenarios. It is of crucial importance to involve both shop floor staff and management employees to allow for conceiving ideas from a variety of angles with the chance of receiving application suggestions of different nature.

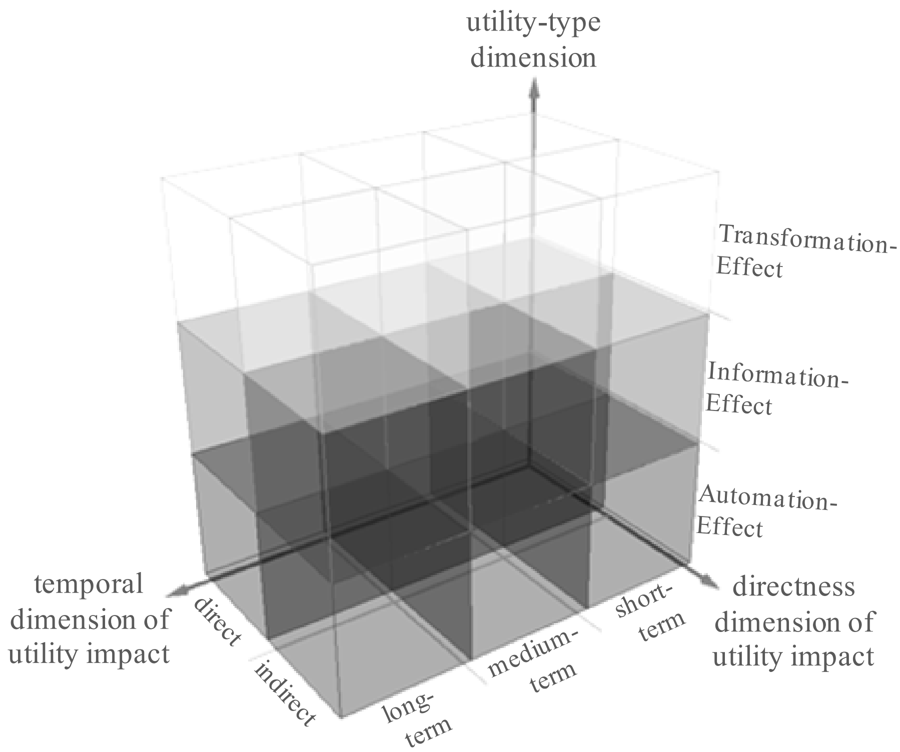

Fig. 3 Zwicky Box for RFID utility

It is important to note that the presented categorization is not based on the principle of proper sets, because the elements of the utility type dimension overlap partially. A combination of all three types of effects are for example equally important in constituting RFID applications associated with error reduction within processes, e.g. through avoiding human error in transferring and distributing data electronically, thus enabling new processes. In order to use these categories in a morphological analysis, the prototype view of categories is employed. It is based on the assumption that categories are represented by a prototype and recognizable through characteristic, central features rather than the existence of a set of single necessary features deterministically defining category membership – a probabilistic link between characteristics and affiliation with a category is established. Within this concept of categorization fuzzy sets are assumed, allowing for fuzzy boarders between elements of the sets [16]. Since this concept is considerably closer to describing the way the humans perceive objects than the proper set assumption – publications of the psychologists Rosch and Gleitman elaborate on the typicality effect of human perception and categorization, on which the fuzzy set concepts rest – it lends itself well to being utilized in a categorization of thought processes in the concept of generating ideas, i.e. in the procedure developed in this study.

After a list of ideas has been compiled in the course of team workshops the application options are evaluated regarding their feasibility. Following this, rough process outlines for the conceived VASs are produced to identify necessary process stakeholders, events and actions. This information is then used to design a draft solution for the technical application implementation, i.e. necessary components, and where to install the components. The data accumulated for each application option is then processed for an evaluation according to costs, chances of timely implementation and expected contribution to company/department goals. Enabling the project team to gradually increase the level of sophistication of the created application scenarios, these steps are re-run several times. The resulting incremental and iterative procedure is diagrammed in Figure 4.

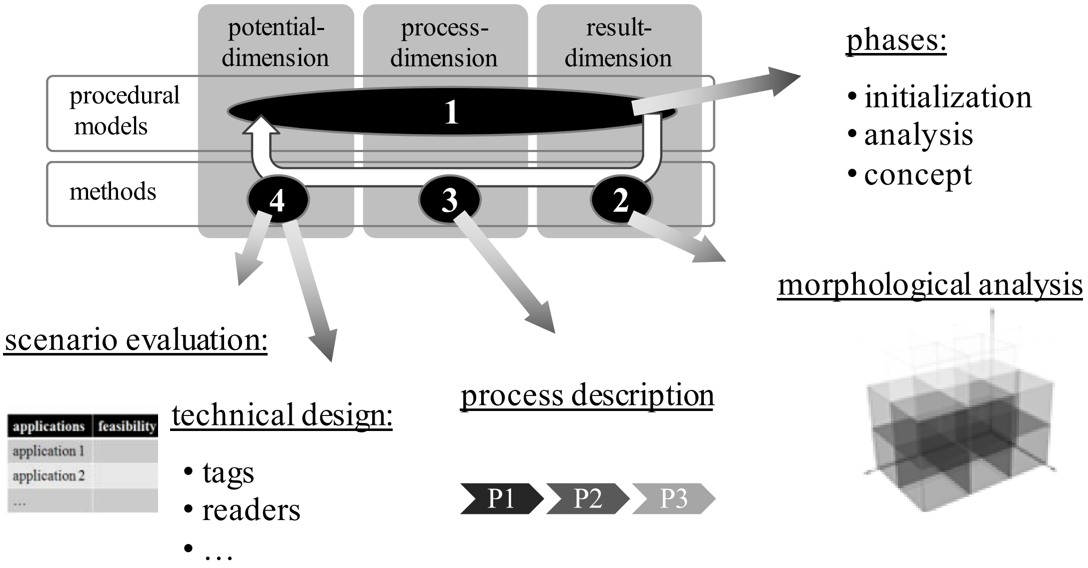

Fig. 4 Iterative procedure for the structured development of RFID VASs

The planned result of employing the outlined procedure is a comprehensive list of requirement specific RFID application scenarios, prioritized according to their utility for a specific company and specific application environment.

The premise of including the entire company in the investigation of RFID potentials leads to an increasing level of complexity for the task of finding promising applications with a growing company size and thus a larger number of processes. To cope with the complexity, the Supply Chain Operations Reference Model (SCOR) can be applied to segment the system of processes and prioritize important processes [17,18], e.g. processes associated with high costs, frequently used processes or processes spanning across the entire organizational structure, that are especially prone to the application of an AutoID technology. SCOR was developed by the Supply Chain Council as a diagnostic tool providing companies with a framework to systematically describe their activities. This concept lends itself well for the task of identifying all company processes and displaying them in a clear arrangement.

4.2 Case study findings

In order to detail the procedure for finding potential RFID applications, a case study in small and medium enterprises (SMEs) in the sector of electronic components production has been included in the research efforts. The value chains in this sector are characterized by short product life cycles, a high level of costumer specific products and the necessity to continuously increase production productivity induced by the pricing pressure resulting from a growing competition from Asian markets. Hence, the potential of increasing transparency and reduced response times within the value chain provided by RFID is especially promising for application environments within this sector. This circumstance is relevant even more for SMEs with their limited resources, which makes them more vulnerable to challenging market developments and hinders their access to technology like RFID, hence the SME focus of the case study.

The case study is part of an ongoing research project and thus no final results can be presented yet. However, the application scenarios that have so far been identified can be categorized into seven boxes in the morphological box developed above – the categorization is diagrammed in Figure 5. Direct, short term effects can be identified in association with the Automation Effect – mostly automatic reading of documents accompanying objects on their way through processes. Information gathered by an RFID system on the production floor and utilized to supply Production Planning and Control (PPC) systems with real time data on production order progress are an example for the medium and long term utilities originating in the Information Effect. Finally, a number of short- to long-term processes have been conceived of, e.g. new asset and container management systems in production logistics and returnable container systems with a decentralized, status dependent triggering of service processes enabled by applying RFID components. The latter can for example be applied to trigger container cleaning processes according to the actual cleaning state of a container. The demand oriented consumption of secondary processes constitutes savings potentials, e.g. regarding transport volumes and operating costs of a returnable container management system. These VAS examples can be attributed to the Transformation Effect and represent newly established processes.

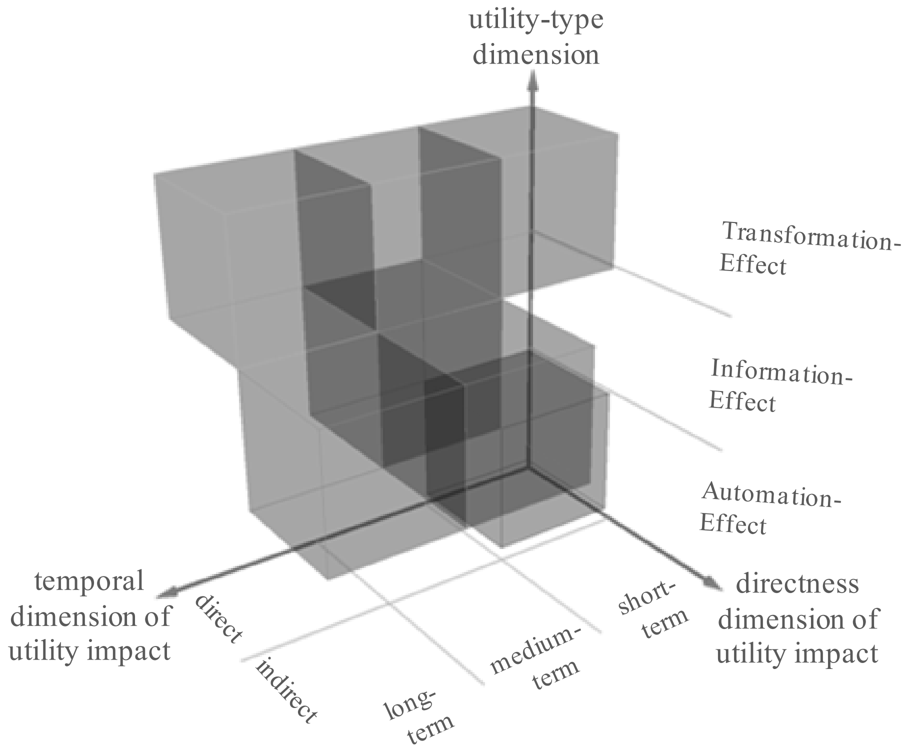

Fig. 5 Categorization of RFID applications identified in the case study

Despite the hitherto findings, this is not to say the combinations inside the morphological box that have so far not led to finding application scenarios are unlikely to hold potential for innovative options. On the contrary, it is more likely that trying to expand the area of utility combinations gathered so far is likely to produce rather more sophisticated applications utilizing more of the technology potential of RFID. Furthermore, this expansion would be tantamount to the widening of the portfolio of proper RFID applications, thus contributing to improving the profitability of these kinds of AutoID systems.

The procedure itself proved to be an efficient instrument in structuring and pacing the application identification process in the team work sessions with industry partners. However, convincing companies of the benefits of a thorough analysis of technology potential has turned out to be challenging. Most companies who participated in the case study so far have insisted on reducing the scope for applying the search procedure to a limited set of processes. This highlights the importance of communicating the benefits of a comprehensive investigation of processes across departments and organisational units regarding the resulting performance potential of RFID systems.

Another lesson to be learned from the current results is that in several cases the combination of RFID and barcode systems emerged as a promising solution in industry applications. As long as RFID tags are considerably more expensive than printed barcodes, for some tasks within identification systems that do not rely on the specific capabilities of RFID, e.g. dynamic memory, no line of sight necessary, greater robustness, it is economically sensible to use the barcode option. Due to the similarity of basic characteristics between both AutoID techniques, the procedure can still be applied with a minor adaption – in the technical design phase one of the technologies has to be selected according to the requirements of the identification task.

5. CONCLUSION

The procedure developed in this paper is a practically oriented approach of guiding the creative process of envisioning RFID applications in company specific application environments that is able to reduce the complexity of the task and provides participants in this process with a framework for an efficient investigation of the technology potential in actual industry settings. While other RFID implementation concepts hitherto have focused on the cost-benefit considerations, the given procedure contributes to the work dealing with the process of creating innovative VASs for this technology. In the course of a cases study the procedure has been successfully tested and confirmed its aptness in real life applications.

Further, more detailed research might focus on a technique for systematically finding application scenarios, i.e. VASs, associated with utility categories that have so far been left unharnessed. This would support the widening of the opportunities for an RFID system implementation. It is also conceivable that these newly found VASs would create synergies with already established VASs by requiring a similar technical implementation – this in turn would greatly improve the amortization of RFID system investments.

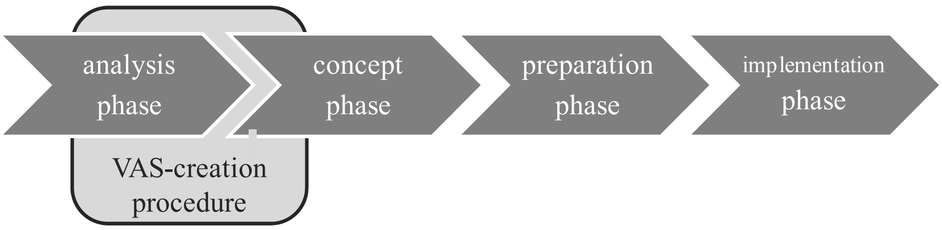

Fig. 6 Current work in the context of a comprehensive VAS development concept

Another potential follow-up research is the scope regarding an entire RFID implementation project. The current work focused solely on the creative process of identifying and creating new and innovative application scenarios for RFID, while preceding steps – an early analysis phase to identify the demands and goals of a company – that generate necessary input data for the described procedure have been ignored. The same can be said of the steps following the implementation and the early concept phase – those being the focus of this paper – of an RFID implementation project.

Thus, future work on the research project, in the course of which the presented case study has been conducted, is meant to integrate the developed search procedure into a universal RFID implementation concept. It is dedicated to provide SMEs with a practical guideline to efficiently and successfully conduct RFID implementation projects in order to benefit from the vast potential this technology has.

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Thomas Sobottka
Vienna University of Technology, Faculty of Mechanical and Industrial Engineering, Institute of Management Science, Theresianumgasse 27, Vienna, Austria

René Leitner
Wilfried Sihn
Vienna University of Technology, Faculty of Mechanical and Industrial Engineering, Institute of Management Science, Theresianumgasse 27, Vienna, Austria
Fraunhofer Austria Research GmbH, Division Production and Logistics Management
Theresianumgasse 7, Vienna, Austria