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1 A Framework for Conceptual Case Studies for RFID-based B2C-Solutions

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1.1 INTRODUCTION

RFID has been in the focus of research for some time (Landt 2005). More visionary research analyses RFID from the perspective of an enabling technology for future visions of the Real-Time Enterprise or the "Internet of Things"(Furness 2005). Most work focuses on B2B-applications such as tracking and tracing solutions (Angeles 2005; Bose and Pal 2005), whereas research has not paid too much attention to consumer focused applications in a Business-to-Consumer setting.

The vision of Ubiquitous Computing weaving into everyday life and interconnecting everyday objects is not yet reached (Weiser 1991; Gershenfeld, Krikorian et al. 2004). There still is a gap between "everyday" application of UbiComp and the reality of RFID usage and the current applications of RFID (Davies and Gellersen 2002). Given that in the year 2006 there are hardly any working RFID-based consumer solutions on the market there are consequently no empirical data on success or failure available. Nonetheless there are several potentially fruitful areas of application. Early work in the area of consumer centric RFID applications focused on technical challenges (Römer, Schoch et al. 2003). But a technically perfect solution is not sufficient to develop marketable RFID-based B2C-solutions and successful business models - also strategic, organizational, and social as well as market related aspects have to be taken in consideration.

In this article we propose an integrated framework for the conceptual analysis and design of RFID-based B2C-solutions. It helps to systematically screen emerging ideas for new offerings and to derive design requirements at a very early stage. The consequent application of our framework therefore can help to reduce development cost, improve quality and market success.

In section two we highlight the specifics of RFID applications for consumers, explain the main idea of the framework and describe its different components. From these descriptions further questions are derived that allow an analysis of possible applications. In section three we consequently apply the framework to two areas of

potential applications for RFID-based consumer solutions. The article ends with a summary and gives an outlook on future research issues.

1.2 A FRAMEWORK FOR DESIGNING AND EVALUATING RFID CONSUMER APPLICATIONS

RFID in the consumer area is different compared to applications in B2B scenarios like supply chain management, logistics or production. Drivers for B2B applications are often efficiency, decrease of manual labour and human interaction, and cost reduction and have maximum demands on reliability, accuracy and speed. For consumer applications these requirements are in many cases less important. Fewer items have to be identified, cost reduction or efficiency increase are of minor importance. Much more, the user might be more lenient to sub optimal efficiency when new applications and services provide innovative benefits to him. On the other hand, the consumer has higher demands on usability, convenience, and design than an industry worker.

In the following we present a framework, which shall help researchers and practitioners to design, implement and deliver potentially promising, technically stable, socially acceptable and economically sustainable RFID-based B2C solutions. The framework considers the main characteristics of the B2C segment and provides a set of relevant questions which allow a structured and target-oriented design and evaluation of possible applications and business models.

Based on previous research on frameworks for business models (for an overview see e.g. (Krcmar 2003) or (Leimeister, Bantleon et al. 2002)) we develop an integrated framework. We adapt existing frameworks to our research problem by using an integrative business model approach consisting of several partial models.

The complete framework is illustrated in Figure 1. Each model includes assumptions, questions and leads to possible solutions. The answers found for each model influence all other models. Changes and new issues arising in one model make it necessary to iteratively revisit the other models and rethink and refine the assumptions and solutions found until a stable state is reached.

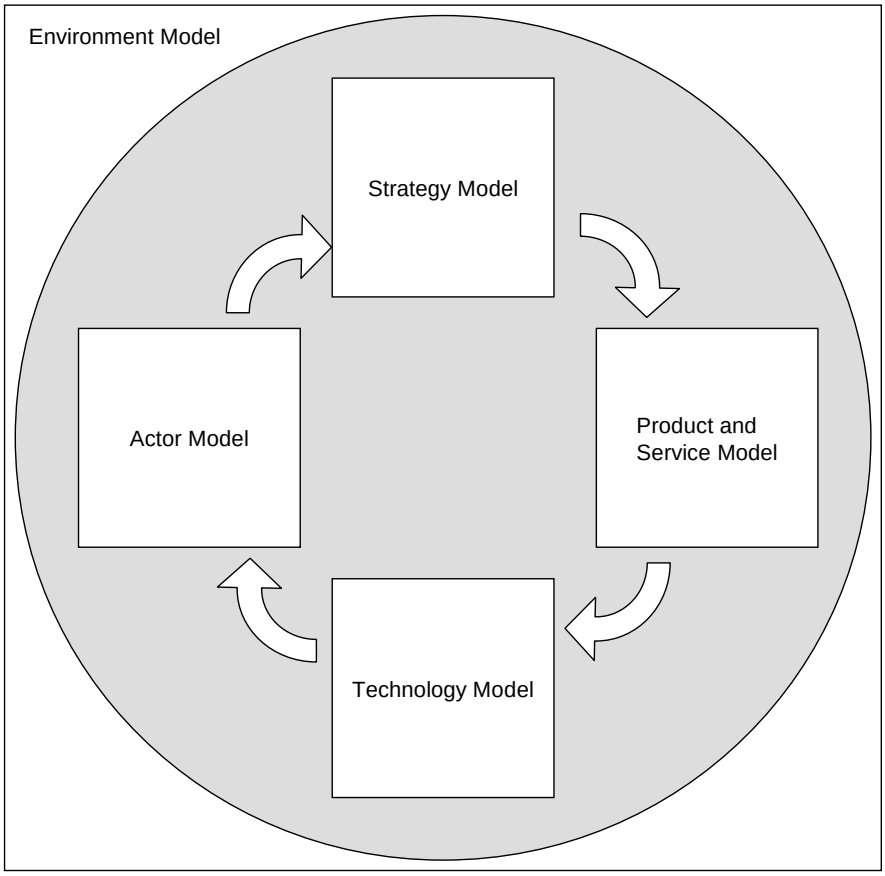

Figure 1: A Framework for Designing and Evaluating RFID Consumer applications

The development of economically successful and sustainable RFID-based solutions demands the consideration of all partial models and aspects described. The importance and detailed design of each partial model depends on the characteristics and current situation of the specific solution.
To avoid technological or market-related pitfalls we propose to use this framework already in very early development stages in order to derive requirements for the planned solution as well as for the organizational setting of development and deployment. For already existing applications the framework can be helpful for evaluation and improvement.

As Figure 1 shows, we have identified five different partial models to be relevant for our framework.

- The product and service model describes the basic idea of the RFID application focusing on the benefits it provides to the customer.
- The actor model contains the customer as central element and all other business actors involved in the product and service life cycle. The roles of the actors as well as the potential benefits they can expect are described.
- The technology model covers technological aspects associated to product, production, operation and usage on the sides of customer, producer, operator

and third parties. It also includes external factors as the future development of technologies.
- The strategy model considers market and competition aspects. It therefore contains major factors of Porters Five-Forces-Model such as competitors, market conditions, etc. (Porter 1980).
- The environment model encircles the four models described above. It includes all general conditions and external factors influencing the design of RFID applications which are not already part of one of the other sub models. The main components of the environment model are legal and social issues which have been identified to be crucial elements of business strategies in the context of internet economy offerings (e.g. (Porter, Billo et al. 2004)).

In the following we explain each partial model. First we point out main questions that have to be asked during the design phase. Second we propose guidelines for answering these questions for RFID based B2C solutions by focusing relevant aspects of this application area.

1.2.1 Product and Service Model

Relevant questions for the product and service model
- What is the basic idea of the service?
- Which benefits does the service provide to the consumer?
- What about usability and interfaces to the customer?

Basic idea and benefits
Main target by creating a new product or service is to satisfy a consumer need or solve a specific problem for the user. The benefits the service renders for the consumer should be well analyzed and must overcome his costs and efforts to use the service.

Interfaces and usability
The usage of an application based on RFID does not require that the user is aware of the underlying RFID system. Everyday actions can be turned into events that are detected and processed by an information system. Rather applications are part of ubiquitous computing scenarios where the environment of the user is pervaded with information technology and available human-machine-interfaces like desktop PCs, mobile devices or TV sets are used. Since today's homes and public spaces are far away from interacting smoothly and transparently with humans, the design of interfaces and their usability has to be considered when planning RFID based consumer applications. At the same time, the acceptance of ubiquitous technologies by the

consumer might be a challenge if he fears to loose control or is not trained or used to the new ways objects and information systems are interacting.

1.2.2 Actor Model

Summary of relevant questions for the actor model

- Who are the relevant actors and which benefits do they get?
- How is the value chain organized?
- Where and how are revenues generated?

Relevant actors and received benefits

The actor model considers stakeholders in an UbiComp application as well as in their individual utility function. Given that a business model can only be successful if it is beneficial for all parties involved, the crucial role of this partial model becomes evident. Independently from the type of RFID based applications, the offering must give a perceivable benefit to the consumers, out of which the applications acceptance and attraction results. The main service provider has the strategic task to optimize his operative marketing efforts according to his target group.

Organization of the value chain

Depending on the specific RFID application the organization of the value chain has to be determined. The roles of the different partners and their interaction have to be defined as well as the underlying processes and information flows. Main tasks are for example the tagging of goods, the provisioning of readers and other hardware or the provisioning of the UC service itself.

To enable RFID based applications, tags have to be applied to the item. Every player in the value chain and also the consumer himself might apply tags to items. Consumer applications can benefit from the fact that some items, for example drugs, apparel, and certain luxury goods are already tagged by manufacturers because of the usage of RFID in non-consumer settings.

To be able to use a RFID application the consumer must possess a RFID reader. This reader has to be connected to a device that allows using services interactively, for example a mobile phone, a computer, or a household or entertainment device. In some cases the needed information might be stored completely on the tag, but in many cases these data have to be meshed with other information sources available via a network connection. Since the cost of readers might be an introduction barrier, there are business models possible where the consumer buys subsidized readers and revenues come from the services he uses.

Also the provision of UC services can be realized by one provider or in interaction with partners that were involved in earlier stages of the value chain of the item as well as external partners.

The three examples described illustrate that it is not enough to specify the product or service for a successful application. Additionally the organization of the value chain and the task distribution between the business partners are decisive for the profitability of the business model. To make an application economically successful, there must be revenue streams to the service provider.

Revenues and utility functions
Benefits for players along the value chain arise not only out of the difference of direct costs and revenues associated with the RFID-based application. Rather the direct access to the consumer might be used for many marketing functions (Bruhn 2001): the original manufacturer of a good can use the application as direct channel to communicate with the customer from retention to recovery, e.g. to provide customer service or for cross selling of goods and services. RFID-based applications can extend the range of pricing models, e.g. price discrimination or pay-per-use (Coroama, Bohn et al. 2004).

1.2.3 Technology Model

Relevant questions for the technology model

- Which objects should be tagged and how should real world interaction be realized?
- How should the personal RFID infrastructure be designed?
- How is the application system provided and run?

The usage of RFID in the consumer market requires an infrastructure consisting of tagged items, readers, and information technology. Benefits come from solutions, products and services that were technically not possible without RFID or solutions that could not be offered efficiently. The basic technology for a RFID based consumer application consists of an information and communication technology (hardware) layer including objects, tags, readers, sensors, and actuators, and an information system layer including middleware, applications, and interfaces as software components.

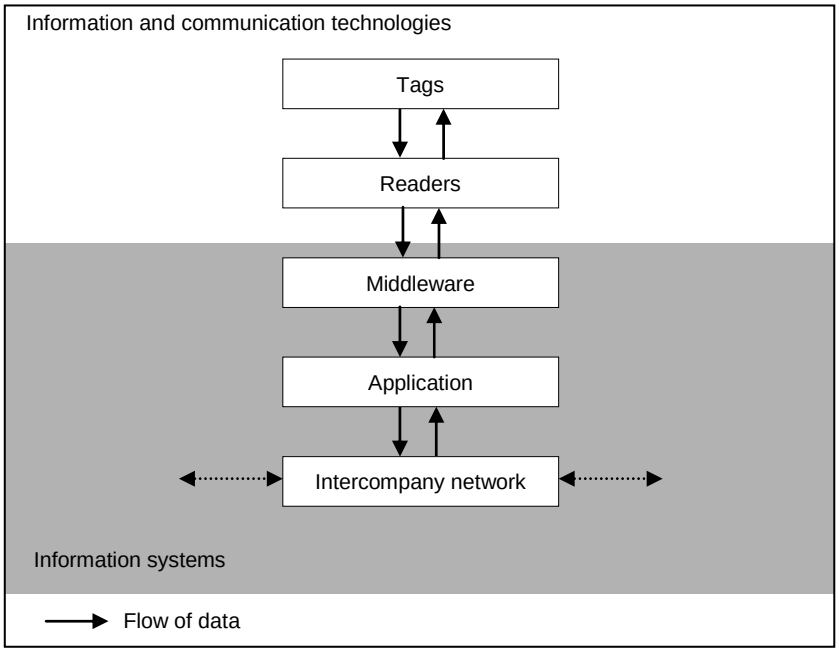

Figure 2: UbiComp system

Tagged objects and real world interaction

For RFID-based consumer applications, an object is a physical item, for example a product, or household item that is equipped with a tag. To identify persons, tags may be attached to an object the person possesses like clothes, phones or keys.

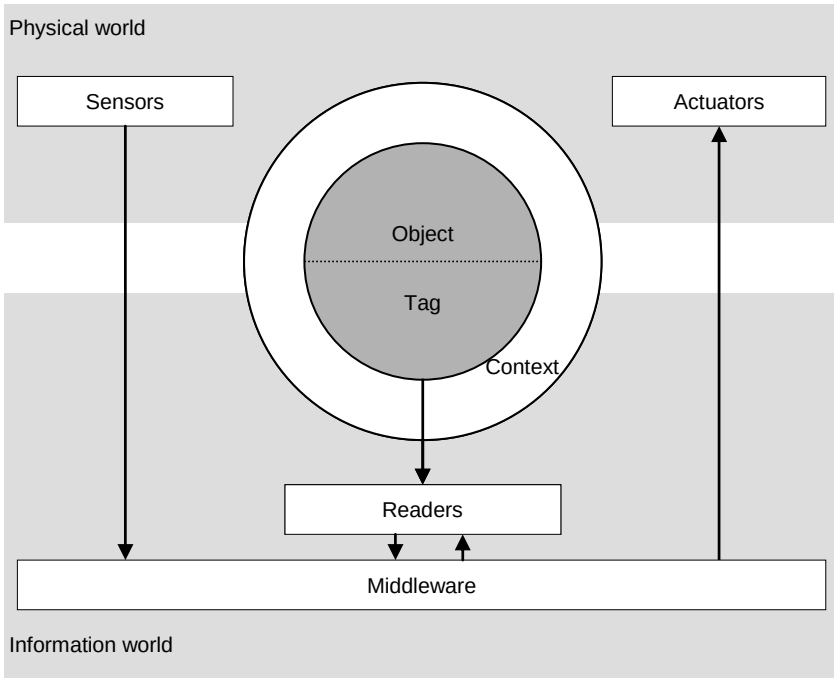

Figure 3: UbiComp as bridge between physical and information world

The RFID tag is attached to an object and stores data, where the most important information is a unique ID for the object. Material as metal or fluids influence communication and when items are hidden beneath other goods, stored in closets or cabinets, identification can be difficult. This is especially critical for consumer applications since the environment in which these applications should operate are in many cases less precisely defined than in industrial applications. The consumer might be not tolerant if an application does not function properly because one item is hidden beneath another.

Sensors gather information about the environment such as position, temperature, pressure, brightness, or moist (Dongwon, Young-Gab et al. 2005). Sensors can also collect information about the consumer in the area of health like pulse or blood pressure.

Actuators influence their environment physically. In a consumer environment, the controlled devices might be household appliances, media devices (like video or audio) or home automation systems.

To make information accessible to humans and make the potentials of UbiComp usable for improved convenience, productivity and efficiency, adequate human-machine interfaces must be designed. They have to present information and capture input in a usable way (Nagumo 2002), (Raskar, Beardsley et al. 2005). Existing interfaces can be PCs, TV sets or mobile devices.

Personal RFID infrastructure

The reader communicates on one side with tags, on the other side with a backend system. If RFID is used at home and in private settings, the environment and possible sources of interference are much less predictable than in an industrial setting. Installation and operation of readers has to be easy for the consumer and must cope with design issues and existing architecture. Portable readers could be integrated in mobile phones since they might not be accepted in the clumsy versions for industrial use available today. Electromagnetic radiation must also be re-examined if readers are used in a home environment.

The second component of the reader is the interface to the middleware. In industrial settings, middleware is used to cleanse raw data, coordinate multiple readers and shift data processing away from central systems closer to the locus where data is gathered. It performs data processing tasks like aggregation and filtering and makes the raw data from the reader usable by applications. A lot of raw physical events, which are not relevant for any application, are gathered by the reader, so strategies for distributing, filtering, aggregating and forwarding only relevant data are necessary. The middleware also takes part of the management of the infrastructure and

should hide problems on the communication layer (Krishna and Husak 2005), (Floerkemeier and Lampe 2005). In a consumer environment there are certainly applications that require fast responses and error-free detection but a lot of applications should have less hard requirements compared to industrial settings.

At the same time there is more flexibility required in a consumer setting because it is more likely that consumers want to update or change applications or use new or different applications. Generally, application life-cycles might be shorter than in industry. As readers, sensors, actuators and terminals are expensive a middleware could facilitate the use of the same (expensive) hardware by several services.

Application system
The application system, which is the IT system that runs the actual application might run as stand-alone system in the consumer environment, but for many scenarios the systems or part of it are offered by the service provider. Therefore a network connection is needed that connects middleware and local or remote application systems.

1.2.4 Strategy model

Relevant questions for the strategy model

- What is the relevant market niche and who are the customers?
- Where is RFID a substitute for existing solutions and where come dangers from substitutes from?
- Which suppliers are important for the planned RFID solution and how strong is their market position?
- Who are the possible competitors?
- Which entry barriers exist?

Market niche and market introduction
To make services economically successful, they do not only have to be technologically feasible but also marketable. Products which are build on a new technology might not start as commodity for everyone but have to be tailored for target groups with special benefits and interests, where consumers are as early adopters especially keen on new technology or suffer a high need. When the needed infrastructure both from a technical point of view (readers, tags, devices, connectivity) and an information systems point of view (information about items, electronic services, interfaces) becomes more widely available, applications might target a broader group of users. It is also clear that it easier to sell a RFID-based application to consumers that already have a RFID infrastructure at hand because of lower initial

costs (e.g. mobile services target mostly people with mobile phones; RFID-based services could target consumers with RFID-enabled mobile phones)

Substitutes
RFID is related to other identification technologies like barcodes or manual data input with advantages in automation and the seamless, not intrusive way of gathering information. Other wireless transmission technologies like Bluetooth, WLAN or ZigBee could also become substitutes as the technologies converge (Klym, Fine et al. 2006), especially for more expensive active tags and when sensors are involved.

Suppliers
Suppliers for RFID-based applications are not only manufacturers of tags and readers but also providers of information on tagged objects. Their bargain power to give out this information must be considered. Companies that have these resources available internally, i.e. when offering a service related to the own product, have advantages.

Competitors and Entry Barriers
For any product and service development it is relevant to identify existing and possible competitors. To evaluate the danger of potential entrants existing entry barriers have to be identified. In case of RFID applications entry barriers will be initially high as there are costs for hardware (tags and readers), the interfaces and processes to combine information from various are manifold and marketing must educate, inform and persuade the potential customer. Especially when applications have a social or communication component that builds on network effects it may be a long way to penetrate the market. Early applications thus have to provide benefits that overweight these costs. When the market becomes more mature, ubiquitous technology is common, e.g. in mobile phones and smart homes, and the infrastructure for the internet of things is working, providers of RFID-based service might focus on the information systems part of application development at much lower costs for market entry.

1.2.5 Environment Model

Relevant questions for the environment model

- Which standards are necessary?
- Which privacy and legal questions could arise in the context with the planned RFID based B2C application?

Standards

Technical standards reduce costs for connecting technical artefacts and eliminate barriers between application domains. Applications that build heavily on the interchange of information between different players like the Internet, EDI or some RFID applications need standards to operate. A household usually contains many different technical devices with different capabilities and requirements, where RFID is only one possibility of data interchange (Gershenfeld, Krikorian et al. 2004). Legal standards and regulations provide safety and security for the consumer, for example by limiting electromagnetic emission or promoting competition.

Privacy

Privacy and RFID is an intensively discussed phenomenon. Users fear that they private and public activities might be monitored and abused by companies or government (Galloway 2004). Successful businesses must handle this problem and implement legal and technological solutions. Proposed measures include the destruction or deactivation of tags by the consumer, encryption of data, or authentication (Bundesamt für Sicherheit in der Informationstechnik 2004). Most threats do lie in singular remote identification of goods (this information can also be acquired when watching a person i.e. when buying a good). More relevant is a possible mesh up of information on multiple goods, their history and a person. In general, active tags with a larger reading range are more sensitive than passive tags.

1.3 CONCEPTUAL CASE STUDIES FOR RFID-BASED B2C-SOLUTIONS

The integrated framework which we described in the previous section will be applied in the following for the analysis and evaluation of two RFID based B2C-solutions. To demonstrate the wide range of its applicability we choose two very different case studies.

- First, we look at RFID-based health applications for elderly people as a documented example from the literature. The example is based on a complex network of players and has high demands concerning the reliable, private, and secure exchange of information. It provides limited benefits to the consumer and has a complex user interface. Nevertheless, it shows very well the vision of ubiquitous computing and the technical possibilities.
- Second, RFID in the entertainment sector focuses on gaming, where tagged goods are especially manufactured and provide a new experience to the gamer. This case study is based on a project at the Munich Centre for Digital Technology and Management (CDTM) and illustrates potentials of RFID and the application of the framework. It was in contrast to the first case study constructed to include only a limited set of players with information

that is less critical. Consumer benefits and the business model were put in the focus, but the technical realization is complex and the feasibility not yet proven.

Both examples show the large range of ubiquitous computing applications in the consumer area and illustrate the framework.

1.3.1 RFID-based Health Solutions for the Elderly

The demographic change in society makes the consumer segment of people over 50 years especially interesting as customers. One area in which technology can support this group is health and wellness. Since less young people have to secure the retirement pensions and health care of an increasing number of older people the social security systems are changing. Social contacts in families and support for elderly people by their children or grand-children go down. Older people have specific needs which create demands in health care, monitoring, and barrier free or assisted living. Communication and information services have a positive effect on social integration, where local services can be designed more efficient using RFID. Ambient intelligence can be employed to facilitate assisted living. There are already prototypes for using RFID and sensor networks in the area of monitoring elderly (Loc, Melody et al. 2005).

This use cases concentrates on health care. It describes an application that focuses on elderly people which live at home and have to take drugs on a regular basis. The idea not the Smart Medicine Cabinet (SMC) (Siegemund and Florkemeier 2003; Gershenfeld, Krikorian et al. 2004) is already described and prototyped. The SMC is a medicine cabinet placed at home. It contains drugs and knows about the medication plan of the consumer. It can detect if correct drugs were removed at the correct time according to a medication plan and remind people by mobile device of their prescriptions. For the purpose of this case study, assumptions about the process and the value chain where extended compared to the original work.

1.3.1.1 Product and Service Model

Basic idea and benefits

The idea of the application is to monitor patients that have to intake drugs on a regular basis. Especially if the consumer has to take more than one kind of medication, perhaps several times a day or with complex prescription plans, the SMC can remind him to take all drugs at correct times.

Interfaces and usability
The drugs are stored in the SMC. When a drug is removed, the SMC detects this. A human-machine interface can raise a visible or audible alert when the patient forgets to take drugs in time or removes wrong drugs.

1.3.1.2 Actor Model

Relevant actors and received benefits
A pharmaceutics company manufactures the drug and applies the RFID tag to the package. The doctor or the pharmacist advises the patient how often and in which quantity he should intake the drug. Both are through the SMC able to provide a better service to their consumers, i.e. the patient. The improved service for the consumer may cause positive effects on brand image and reduce negative effects caused by patients' mistakes. Furthermore, there are extensions of the SMC thinkable that promote medical research. The SMC is a standalone product which does not need additional players or services to work. A network connection or information systems in the backend are also not required since all information reaches the SMC on the tags of the drugs or on the electronic health card.
Benefits for the consumer are certainly to receive notifications if she forgets to take a drug, Nevertheless, the patient has to stick exactly to the correct process, i.e. store all medication in the cabinet, take out the right dose, and put the drug back to the cabinet. If the patient is able to execute this process correctly at all times he might not really need the SMC.

Organization of the value chain
The pharmaceutics company has all necessary information like the name, ingredients, production charge, general information, adverse effects, etc. It tags the package of the drug and provides all or a subset of the data for health professionals and consumers. The health professional prescribes a drug and stores this prescription on an electronic health card. The consumer takes the drug and his health card to his SMC at home.

Revenues and utility functions
There are no additional costs that are created by the SMC neither for the manufacturer nor the health care professional. At the same time, there are no direct revenue flows. The patient has to buy the SMC, which may be subsidized by health insurance companies. The manufacturer of the SMC generates revenues by selling the SMC. Additional revenue streams, e.g. offering the service on a subscription basis or by enabling a feedback channel from the consumer to the drug manufacturer might be possible. If the SMC is extended as a central health hub in the household and additional services like monitoring of body functions, emergency detection or

medical research are embedded, this might provide additional revenues and utility to all players.

1.3.1.3 Technology Model

Tagged objects and real world interaction
The drugs are tagged by the manufacturer and are ready to use with the SMC. The SMC itself needs three interfaces: a RFID reader to detect the removal of drugs, an interface to communicate with the user and a reader to access the electronic health card. To acquire the medication plan, the cabinet communicates with this health card were the data is stored by the pharmacist or a health professional. As interface to the consumer a mobile phone or household appliances might be used.

Personal RFID infrastructure
The RFID infrastructure is integrated in the cabinet. The sharing of the (expensive) hardware with other applications in the household is not intended in the scenario and might be difficult due to the requirements posed on the design of the cabinet and the common demand to store drugs separated from other items.
The RFID reader can detect when a package containing drugs is removed out of the cabinet, but as long as not every single unit (i.e. every pill) is tagged, the SMC can not control the correct application rate.

Application system
The IT system contained in or connected to the SMC matches the medication plan and the actions of the user. Since all necessary information is obtained locally, no network connection to a backend system is necessary. An important requirement for this system is the correct detection when a drug is removed. This means that the SMC should neither identify the drugs incorrectly nor miss the event of a drug removal. To ensure this the SMC can give the consumer feedback about his detection and if necessary ask him to repeat his action.

1.3.1.4 Strategy Model

Market niche and market introduction
The application might be especially beneficial for the consumer if his prescription plans are complex with a number of different drugs that have to be taken at different times in varying doses. Furthermore, patients that have difficulties to remember their medication plan are in the target group.

If the health of elderly people is in a declining state, the costs for medical care and nursing homes are imposed on social security systems and damage welfare. Technical solutions for these problems might be expensive, but at the end the benefits can be large. Elderly people will be early adopters for some ubiquitous technology applications and other groups will follow later when prices decline.

Substitutes
The solution competes with a traditional approach where for the correct dose of each drug the patient has to take is prepared for each time of the day for several days in advance in small boxes in a casket. This solution is less flexible and offers no value added services but competes very well on the price.

Suppliers
Suppliers in this scenario are the drug manufacturers which have to tag their drugs and provide the corresponding information. Only if a sufficient number of drugs are tagged the applications makes sense for the consumer. Industry standards and agreements to roll out RFID on item level are not yet achieved, so the power of suppliers could be a major barrier for the success of this application.

Competitors and entry barriers
As long as it is not possible to gain exclusive access to the information provided by manufacturers and the prescription data stored on the health card the business model might be difficult to defend against competitors. An entry barrier certainly is the necessity of tagged drugs in a broad scale, which is not yet implemented today.

1.3.1.5 Environment Model

Standards
We assume that all drugs will come with RFID tags out of reasons that do not relate directly to the consumer segment. The pharmaceutics industry sees benefits for the usage of RFID in fraud prevention, price discrimination and tracking of production charges (Furness 2005). To be able to support drugs from different manufacturers the information stored on the tags has to be standardized. The SMS also has to access the medication plan of the patient. In this example we assume that all medication data is stored on an electronic health card.

Privacy
Privacy is especially in the area of health a serious concern. Since the application runs completely in the home environment, there are no additional privacy issues created by the usage of the application.

1.3.1.6 Evaluation

The application of our framework to the SMC case study shows strengths and weaknesses of this B2C-RFID concept. The proposed idea of the Smart Medicine Cabinet is as a prototype technological feasible, but especially the Product and Service Model and the Technological Model were helpful to identify critical points in the concept. The application of the Strategy Model in this case study could not be done in depth and stayed on the surface. The reason was that the original idea focused on technology and not on the business model so there was less input to analyze. Next steps would be to refine the idea of the SMC with the help of our framework, especially to go into more detail concerning the business part, if necessary to modify the already existing solution and to reapply the framework afterwards.

1.3.2 RFID in the Entertainment Sector

The usage of RFID and other ubiquitous computing technologies proposes interesting possibilities to extend the gaming experience (Björk, Holopainen et al. 2002). The technology allows to connect virtual and real world (Bohn 2004). Furthermore it enables advanced physical and social elements (Carsten, Timo et al. 2004; Leikas, Stromberg et al. 2006). RFID tags in clothes promote physical activity of the gamer (Konkel, Leung et al. 2004). Hardware manufacturers in this sector strive not only to provide better graphics and faster hardware, but also to offer new ways for human machine interaction (Nintendo 2006; Sony 2006). Additionally, the gaming sector is growing rapidly. By 2010, the worldwide video game market should grow to $46.5 billion, at an average 11.4% compound annual rate (PriceWaterhouseCoopers 2006), making it a relevant market for new technologies as RFID.

Gaming applications target a group of consumers which are open to new technologies and are willing to pay extra money for innovative gaming experiences. Since the system is closed with a controlled number of players and well defined existing hardware there are fewer questions on interoperability and standards than in other settings. If the value added by new gaming features, additional products and services is large enough to cover the costs, the entertainment sector might become a leading area for RFID based consumer focused applications.

1.3.2.1 Product and Service Model

Basic idea and benefits

In this case study the RFID based application focuses on massive multiplayer online games (MMOG) which put the player in a large virtual world where he experiences as a virtual character adventures together with other players over the

internet. In some of these games certain items are so valuable, that users trade these items for real world money (Kushner 2005).
The application could interlink the virtual and the real world by connecting an RFID reader to the PC or video console where the user plays the game with. Real world items are equipped with a tag, are recognized be the reader and their virtual counterparts appear in the game. The experience of the gamer is not only limited to what he sees on the screen but is extended to real items with a unique design and haptics. These items can be used as collectibles and design objects and therefore can be of value even when the user does not play the actual game. They can be traded with other gamers and bought and sold at offline stores or fairs.

Interfaces and usability
To create the connection between a real item and the game the user has simply to put the object near the gaming device with the reader. If the item is equipped with sensors these can be used to control more complex actions in the game, e.g. putting one object in another, moving an object, etc, making the usability of the game even higher and more natural compared to traditional input devices like a mouse. This could also enrich the gaming experience.
As an example, when the game plays in a medieval, fantastic world the user can find a sword with magic powers in the game. He can order a physical counterpart of this sword and when he puts the sword near the reader, his character equips this item. Additionally, sensors in the item can further enrich game experience. For example the sword player must hold the sword in his hand (pressure / temperature sensor) to use it or move it (movement sensor) to start certain actions. Furthermore, he can show this item to friends or trade it. In doing so, also the virtual sword is transferred to another game character.

1.3.2.2 Actor Model

Relevant actors and received benefits
RFID enabled game items are developed and created in close cooperation of the gaming device manufacturer and the game manufacturer since the game logic and software must be designed to support the interaction between real and virtual world. The provider of the UC service is therefore also the provider of the game. He extends his software product and gaming service with a physical good as product. PCs or game consoles need an RFID reader to be compatible to the service. As long as readers are not built in the standard version of the gaming device, the user has to buy a reader or to be able to use a shared reader in his household. Benefits for the game manufacturer include additional item sales but also higher customer lock-in and the potential perception of tangible products as more valuable com-

pared to mere intangible services by the consumer. Benefits for the consumer are an improved gaming experience.

Organization of the value chain
Items are tagged during manufacturing and the tags are primarily applied for the UC application and not to support production processes or logistics. Players can buy items in retail or online stores.

Revenues and utility functions
The costs the gamer pays for manufacturing, shipping, etc. are certainly high compared to the costs of the game, so gamers will order only items with a special value for them. The service provider earns money by selling tagged items and the original game, often as a subscription service. Additional utility is derived from improved marketing and stronger customer relations due to the physical, touchable nature of the items.

1.3.2.3 Technology Model

Tagged objects and real world interaction
The necessary infrastructure is not very complex since gamers buy the items with all necessary tags, sensors or actuators. The device that runs the game also provides adequate interfaces that the user is used to.

Personal RFID infrastructure
The reader should operate in a setting where the user normally plays games, e.g. in front of his computer or the TV. The reading range must be large enough to allow a convenient and comfortable playing of the game. When the game logic relies on real time actions that involve the real world items, the detection should be reliable and error free. Since the items are collectibles, life-term of tags should be long or mechanisms to replace defect tags must be offered. To share the costs of reader infrastructure between several games or applications, the middleware should support standard interfaces.

Application system
Online games already use central servers to support the interaction of many networked players in one shared world. They also check if users do not use hacks or modifications to cheat in the game. Where the game application, which is executed on the local device of the player, can handle the detection of the object and execute game actions related to RFID enabled items, the central system should check the validity of the tags and link it to the characteristics of the virtual item. Therefore

tags should be protected against modification or fraud. During production of the item a unique ID is designed and when shipped to the customer this ID is initialized with and connected to this single item. The corresponding information can be stored in the application system of the game and used by the game servers.

1.3.2.4 Strategy Model

Market niche and market introduction
The entertainment sector is an enormous market, where games have the largest share and are more important than the movie industry. RFID can be highly interesting for this area not only because of the size, but also because users are often open to technology innovations and cycle times are short, making new technology available to gamers. Moreover, games have left the virtual-only stage and integrate more and more real world elements, like other human gamers or when virtual items are sold for real money. As long as not all potential consumers have an RFID-enabled entertainment system at home, the service proposed in this case study could start as an add-on for heavy-users which are attracted by new features and are not afraid by high costs.

Entry barriers, substitutes, competitors and suppliers
The entertainment market and especially the market for gaming console is a quite close eco-system since the manufacturer of the console basically dictates which hardware its console is compatible with and who is allowed to produce applications around the platform. Thus competition, suppliers and substitutes are of lesser relevance in this setting.

1.3.2.5 Environment Model

Standards
Since the discussed case study is a proprietary solution in a limited area, standards for RFID tags and the underlying information is not important. If the gaming console should become a central hub for household and consumer related applications, existing standards should be considered.

Privacy
Privacy is minor relevance since objects seldom leave the home of the user and the communication range is limited to a few meters. The application has also positive impact on the social framework of the player, since collectibles and design objects invite to interact with people in person and face to face.

1.3.2.6 Evaluation

The framework proved to be valuable in the idea development and assessment for this case study. During the initial process of idea generation it helped us to focus, select, and sharpen the product and service idea. First, an application in a closed ecosystem with a limited number of players was chosen. Second, we picked a product and service with restricted requirements concerning privacy and security. Third, consumer benefits and market were considered more important than technological feasibility. The framework influenced the selection of all this criteria and paved the way for further prototyping and development steps.

1.4 CONCLUSION AND RESEARCH AGENDA

The application of the framework has proven to be useful for conceptual analysis and design of RFID-based B2C-Solutions. Compared to other early design approaches this framework allows a wholistic and market oriented view of potenital new RIFD-B2C applications. It thus derives some requirements that change the design significantly compared to other, rather technology-oriented design approaches. The framework is a tool to develop, assess and refine RFID applications in the B2C area. It is helpful to detect flaws and missing parts of a new concept systematically and to discover its weaknesses and strengths. Conceputal analysis of new Ubicomp-B2C applications following this framework can be a fast, economic and powerful approach for designing technologically stable, socially acceptable und economically sustainable and successful solutions.

Future research on B2C based RFID solutions should focus on methods, tools and processes for designing and delivering RFID-based B2C-Solutions, esp.:

- Support for detecting systematically potentially fruitful areas of application for RFID-based solutions
- Definition of adequate development processes for RFID-based solutions
- Systematic combination/bundling of RFID-based solutions with existing products and services

Furthermore this design framework requires empirical substantiation and it has to be examined how different models have to be adapted to different stages to the development funnel (Hayes, Wheelwright et al. 1988). This includes the definition of criteria for leaving the refinement process more precisely, i.e. when an idea is not feasible or when a stable status is reached.
Overall the B2C-Arena is a potentially very fruitful area of application of RFID and other Ubicomp-Technologies with more market potential than mostly recognised in research and practice today. Any research that helps developers to create successful solutions in this fast changing technological field is needed urgently and valuable.

1.5 LITERATURE

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