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Collaborative Business Models for AAL-Services based on M2M-Communication

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***Abstract*— This paper presents first results of a project aiming to provide the requirements for enabling elderly people to stay longer in their flats or houses before moving to senior citizen's residences or nursing homes. Using market available devices an Ambient Assisted Living (AAL) system is developed for recording vital sign data. A minimal invasive radio transmission system and smart home sensors are installed. Data will be recorded, transferred and stored/managed in a private cloud-portal. On top of the recorded data a collaborative business model is developed enabling fair allocation of revenues. Data driven services will be developed and deployed. With the consent of the data owner (resident/client) data may be sold to external companies based on a data fair share concept. The compliance of data security policies will be achieved either by a data usage control system or by blockchain-based smart contracts.**

Keywords—Ambient Assisted Living; AAL-services; M2M-communication; collaborative business model; faire allocation; data fair share; data usage control; blockchain

I. INTRODUCTION

The term M2M-communication (machine-to-machine communication) has been established since years. Back in 2012 the Organization for Economic Co-operation and Development (OECD) expected for the future M2M-applications for health, transport, consumer electronics, energy use, and virtually every other sector with a very large amount of information to be generated. M2M-communication would enable the collection, enrichment and distribution of a wide variety of data. Some of these data would be generated by the public sector and used by the general public. Other data would be generated by private M2M-users and used by public organizations. M2M-communication was expected to allow companies to improve existing processes, by enabling remote monitoring, sensing and real-time updates, whereas before these were based on site visits, calls from customers, or monthly status reports. For the most part, this was seen to be incremental innovation, such as by cost reduction. However, new business models, enabled because processes can be implemented in ways never used before, were expected. Some examples of these new business models enabled by M2M-communication would be: pay as you drive insurance, digital content distribution or products as services [1].

In the aftermath beside numerous others the project M2M-Teledesk from the agricultural sector was developed by Gansemer et al. [2], where machines and the harvesting process are monitored by sensors collecting location data, machine data and harvesting data.

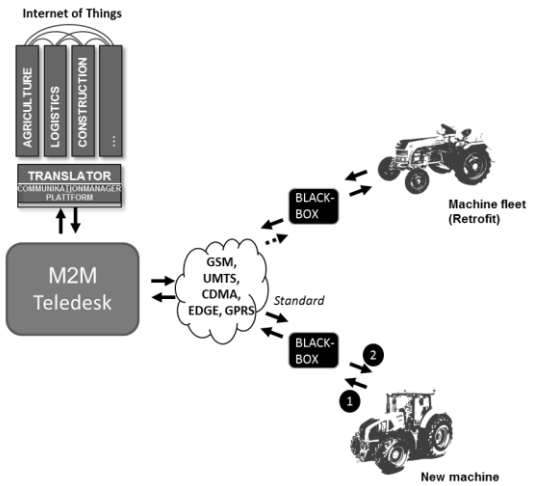

Figure 1. M2M-scenario of the agricultural sector including machines, transmission channels, a portal for hosting data and downstream service recipients [2]

Fig. 1 shows a typical scenario out of the agricultural sector as covered by M2M-Teledesk. Harvesting machines are equipped with sensors and a black box for communication. Machine data and harvesting data are collected by the sensors and transferred by the black box via other participating machines to a central portal (M2M-Teledesk). Data is transferred via public networks, either mobile or fixed. WLAN, GPRS, UMTS/HSDPA, LTE and Sub-GHz standards for on-field communication were selected and integrated into the communication module. To ensure data confidentiality and integrity communication channels are encrypted using certificate based public key infrastructure. Within the portal the collected data were stored and evaluated. Based on the evaluation a collaborative business model is developed by

offering the results as services to machine owners or to farmers [3].

The paper at hand will present first results of a project (Smart Service Power [1]) dealing with new types of collaborative business models together with a data fair share concept based on services resulting from M2M-communication in the area of ambient assisted living for elderly people.

II. Smart Service Power

The private sector represents an important area for wireless applications using M2M-communication. Within smart home systems houses and flats were equipped with sensors and actors enabling the owner to monitor and control window blinds, heatimg or even locks of doors. Moreover, sensorbased recording of data allows the recording and development of activity and behavour profiles. The project Smart Service Power aims predominantly to enable elderly people to live longer in their flats or houses before moving to a senior citizen's residence or a nursing home.

A. *The Ambient Asstisted Living (AAL) Scenario*

For smart care services the living environment is provided with market available recording devices for vital signs, a minimal invasive radio transmission system and smart home sensors.

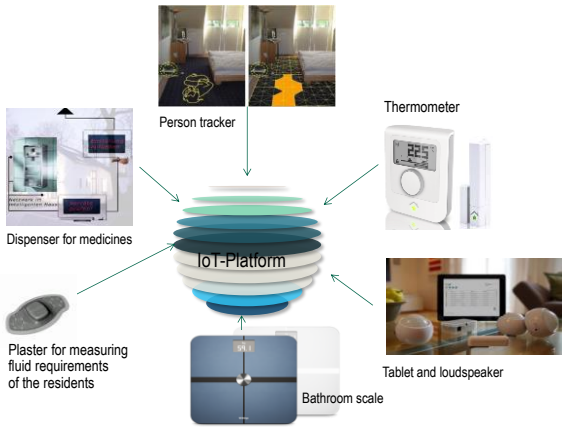

Figure 2. IoT-Platform with connected sensors and peripheral devices

Along with smoke alarms and motion detectors, sensors at doors, windows, light switches, refrigerators, oven, water taps up to special pressure sensors for determining the presence in bed can be installed. A fall detection system can find out, if the resident is collapsed and lies on the floor.

The software system recognizes deviations from the normal daily routine based on vital signs and activity data using big data methods.

Possibly dangerous situations may be derived and an action series started, e.g. dropping an emergency call or informing a service provider about an unusual change of situation in the flat. Detailed information about the present situation in the flat is provided on a tablet and allows starting a suitable reaction.

The core of the technical development is an open twodimensional IoT-platform, which integrates within the horizontal level the AAL, the care and emergency systems, from E-Health to Smart Home. On the vertical level, it integrates various gateways with the corresponding sensor technology, device management and integration, communication, data analysis, Big Data and Machine Learning. It also involves payment solutions, license management and connectivity solutions.

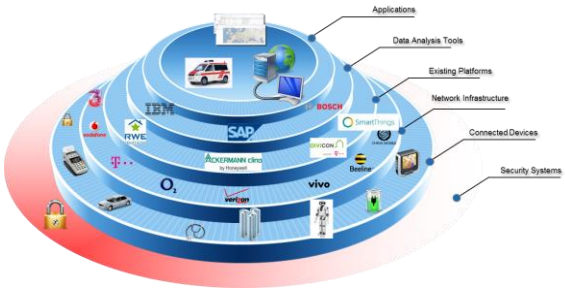

Figure 3. Integrating layers of IoT-platform

The IoT-platform includes several different security mechanisms which have to be configured carefully.

Part of the integrated platform is a user interface with different views for the individual target groups, which differ primarily by the granularity of the data. Doctors, relatives, emergency services, housing associations and the residents themselves - everyone needs a different view and a user interface that is oriented towards their needs. The elderly, for example need an age-appropriate graphical user interface, which can be operated simply and intuitively. The relatives, on the other hand, want information about what he or she has done all day. The emergency service is only interested in the fact that the person is lying on the ground and is not able to get up. The surface is equipped with a traffic light system, so that everyone can immediately recognize whether there have been any conspicuities.

B. *Business Models for AAL-applications*

In recent years a lot of AAL-systems have been developed in a prototypical manner. Almost none of these project could be launched sustainably. In most cases the reason was a lack of viable business models. An important aim of Smart Service Power is to investigate structures for profitable business models for the AAL sector.

On top of the technical application and the corresponding data described above services are generated resulting in business models. The value chain of such M2M-applications usually consists of several different players collaborating and contributing for providing services to endusers/customers.

[1] The project Smart Service Power is funded by the North-Rhine-Westfalian State Government (Germany) and the EU (EFRE).

A M2M-value-chain which is typical for the application domain of Smart Service Power is shown in Fig. 4.

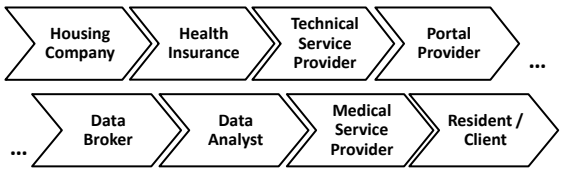

Figure 4. Typical value chain of AAL sector

Participants of the value chain are the housing company, which provides the flat or house, the health insurance, which provides financial means for the service, the technical service provider equipping the house or flat with sensors etc. The portal provider offers data storage and data management for recorded data. The data broker receives data released by the owner (patient/client) for further commercial usage. The data analyst develops algorithms and apps, which are able by examining the data to recognize specific conditions/situations of the client. The medical service provider will be informed for delivering a suitable action. The resident/client may also be given a response concerning his/her physical/medical status.

The value chain describes one of the essential parts of a business model, the participants. There are several more essential parts. One well-known method beside others for describing a business model for a single company is the Business Model Canvas (BMC) of Osterwalder and Pigneur [4]. Fig. 5 shows the essential compartments of the BMC.

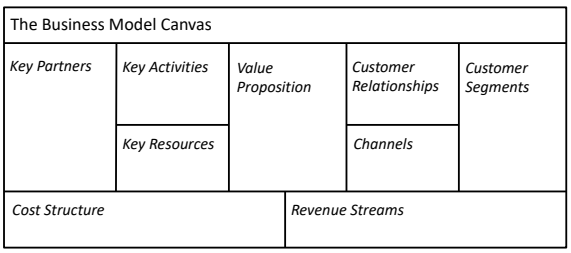

Figure 5. The Business Model Canvas (according to [4])

The Business Model Canvas consists of nine components. Key Partners, e.g. the value chain members presented in Fig. 4., work together to fulfill the Value Proposition, i.e. the services performed for the customers, who are described within the Customer Segment. Key Activities covers all activities necessary to perform the value proposition. Key Resources contains all necessary physical, intellectual, human and financial resources to execute the necessary activities. Channels comprises all communication channels the company uses to contact the customer. Customer Relationships describes the relations a company develops to its customers, e.g. personal support. Last not least there is the section Cost Structure with all costs arising while fulfilling the value proposition. Revenue Streams contains all revenues received, e.g. from customers for delivering the value proposition.

An exemplary graphical presentation of the Business Model Canvas for the AAL-scenario as used for the time being within the project Smart Service Power is shown in Fig.6.

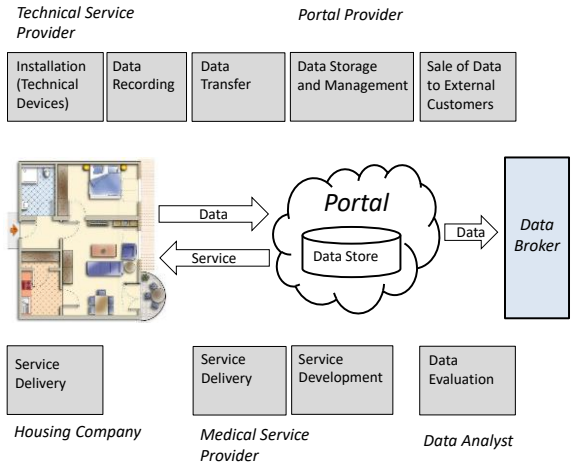

Figure 6. AAL-scenario of partners, activities and services used within project Smart Service Power (flat's grafic from [5])

Presented are key partners (technical service provider, portal provider, data analyst, medical service provider, housing company), key activities (technical installation, data recording, data transfer, data storage and management, data analysis, service development, service delivery and sale of data to external customers). Potential customers are the resident or client and/or his/her relatives and the external data broker, who buys data released by the resident or client, but also the medical service provider or the technical service provider. Key resources are the technical equipment of the flat or house (sensors etc.), the portal (data storage etc.), algorithms for evaluating the data and detecting conditions or events for delivering services. The value proposition to the resident/client or the medical service provider contains an information delivered after detection of specific situations and events, e.g. emergency situations. Other services to clients/relatives/medical service providers tentatively comprise continuous reports regarding the vital status, to external customers the sale of released data.

Revenue streams may include the fees the customers pay for specific services, the financial contributions of health insurance companies for medical services or the payment of external companies for received data.

In the first place The Business Model Canvas was developed as a model to describe all aspects of the business context of a single company in order to reach profitability. The AAL business scenario shows that several companies are involved and additional external stakeholders with financial contributions as health insurances etc. In order to reach a sustainable business model for the whole scenario it is necessary to introduce a

broader view on the whole scenario including several companies and external stakeholders. For these purposes the Business Model Canvas has to be extended. Fachinger et al. [6] are working on similar problems concerning sustainable business models for neighborhood networks. They are using meta business models including business models of several companies and external stakeholders. The external stakeholders may be communal offices or institutions.

C. Fair Collaborative Business Models and Data Fair Share

Even if we regard several contributing companies the 'meta business model' of the whole scenario owns a value proposition. For delivering this value proposition to the customers several partners have to collaborate. The question arises, how incoming revenues or other external financial contributions will be distributed to the collaborating business partners. If there is one dominant partner leading the value chain and choosing his partners, the question of allocating revenues does not appear as a problem. But if several partners having equal rights share the value chain and contribute to deliver a service to the customer/client, this question becomes more important. Are there methodologies for allocating revenues or cost savings between independent business partners fairly? And moreover, is there a suitable definition of the term 'fairly'?

There are several methods from accounting dealing with the problem of allocating costs, like indirect costing, transfer pricing etc., but they all show weaknesses, if it comes to fair allocation between independent business partners being on equal footing. A different, promising approach depicts the marginal principle of allocation, which may be used together with methods of cooperative game theory, e.g. Shapley-value or τ-value. Such methods have been applied in the past on scenarios in different industrial sectors, e.g. the transport/logistics sector [7] or the agricultural sector [3].

The project Smart Service Power shows a collaboration scenario of several partners on different value-added steps contributing with different cost structures. On the other hand customers remit for receiving services, and these revenues have to be allocated fairly. Since all services depend on data, the financial value of the data has to be investigated. Moreover, in the case that data are sold to an external data broker, the resident/client is entitled to receive a fair financial compensation for releasing his data (data fair share). Within this collaboration scenario the resident/client acts as a collaboration partner, because he provides his data, and as a customer, because he receives services. Similar considerations are valid for the medical service provider, the technical service provider and others.

D. Data privacy and Data Usage Control

The entire collaborative business model outlined above is based on the evaluation of data. Mostly these data is of highly sensitive and private nature. The sensors deliver profiles, which allow inferences onto the state of health and the personal lifestyle of the resident/client, i.e. the data is highly interesting for a lot of companies of the industrial, the insurance/financial or the service sector. One target of Smart Service Power is the consideration of privacy requirements of the resident/client. Exclusively, data will be recorded, which are necessary to deliver specific services to the resident/customer. It is up to the resident/client to decide, which of his data may be released for sale to external companies.

There are some approaches to secure a sophisticated data privacy, which allows to keep certain data private and release other data under definitive circumstances.

One approach is a data usage control system as described by Steinebach et al. [8]. The security framework IN^{2}UCE (Integrated Distributed Data Usage Control Enforcement) allows the exploitation of data usage control for practical purposes. The data owner is enabled to define and control precisely and finely granulated the data usage by security policies, e.g. which data may be used or under which circumstances and how often data may be read, copied or transferred.

Schuette and Brost [9] propose a mechanism to control the ways in which data may be processed, thereby limiting the information which can be gained from data sets to the specific needs of a service. They model data analytics as a data flow problem and apply dynamic taint analysis for monitoring the processing of individual records. A policy language is used to define how data is processed and enforce measures to ensure that critical data is not revealed.

Azaria et al. [10] present MedRec, a novel, decentralized record management system to handle electronic medical records, using blockchain technology. The system gives patients a comprehensive, immutable log and easy access to their medical information across providers and treatment sites. Leveraging unique blockchain properties, MedRec manages authentication, confidentiality, accountability and data sharing. Using blockchain technology the development of smart contracts is possible.

Within the project Smart Service Power the final decision concerning the methodology to be used is not taken yet.

III. RESUME

The project Smart Service Power is aiming to set up the basic requirements for extending the period of time elderly people can stay in their flats or houses before moving to senior citizen's residences or nursing homes. Technically market available recording devices for vital signs, a minimal invasive radio transmission system and smart home sensors will be used. Data will be stored and managed in a private cloud-portal. Services will be developed and deployed after detecting special events or conditions when evaluating the data. With the consent of

the data owner (resident/client) data can be sold to external companies.

The compliance of data security policies will be achieved either by a data usage control system or by blockchain-based smart contracts.

On top of the recorded data a collaborative business model is developed providing fair allocation of revenues cost savings and a data fair share concept. Standard business models like The Business Model Canvas will be extended to a meta business model integrating several service companies and external stakeholders.

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