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AAL Service Performance Measurement Cube – Key Criteria for AAL New Service Development

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Abstract. The living environments of senior citizens are gaining in complexity with regard to health, mobility, information, support and behaviour. The development of Ambient Assisted Living (AAL) services in order to reduce this complexity is becoming increasingly important. The question is: What relevant criteria support the development, measurement and evaluation of business models of hybrid AAL services which have to be considered in an appropriate Performance Measurement Set? Within the EU funded research project DALIA (Assistant for Daily Life Activities at Home) a Service Performance Measurement Criteria (SPMC) Set has been developed and described. With the help of literature review and expert interviews relevant performance criteria were identified and described in the context of Analytic Hierarchy Process (AHP). In conjunction with an AAL business models scanning, a set of performance measurement criteria could be created. Discussion: The development and application of a specific AAL SPMC Set offers the possibility in a targeted and conceptual way advance the development of marketable AAL services. Here it will be important to integrate with software support the SPMC Set in the service development process of future marketable AAL applications. With the application of an adjusted AAL Service Performance Measurement Cube, the conceptual development of marketable AAL services can be maintained and relevant decisions can be supported.

Keywords: ambient assisted living, new service development, performance measurement, criteria set, business model

1. Transparency, Assistance, Automation and Empowerment through AAL Applications

1.1. Service Quality as an main Objective in Health Care and Social Care

The social and health care services in developed industrial nations are currently dominated by historical structures and processes as well as by changing objectives and earnings estimates. They are fast approaching resource limits that force the actors involved to make decisions regarding utilization, distribution and financing [1]. Further information asymmetries and information intransparencies as well as the increasing need for qualified health professionals to growing problems in the health care developed

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industrialized countries [2]. The aim therefore must be to adapt the entire continuum of care and support for older people in the physical, psychological and social dimensions of current and future requirements. One approach to greater transparency, assistance, automation and empowerment of supportive services for the elderly is the development and the use of AAL applications. In recent years the AAL area has been subject to constant change and constant development [3]. Considering the recent research projects and solutions in the development of AAL services, it is clarified that only a limited proportion has reached the stage of marketable realization and the commercial use or inclusion in the performance catalog of service providers [4]. The analysis illustrates the variety of causes for problems in the development of hybrid AAL services. Here, six different dimensions can be identified (environment, technology, customer, organization, methods, measurement) for consideration as part of a conceptual AAL service development [5].

Based on the identified challenges in the AAL service development, it is necessary to strive for improved achievement and outcome measurement by means of appropriate structures and processes as part of new service development [6]. In that regard, in the last years the application of a business model across all sectors [7] (or in the service sector a service model) has been developed [8]. A service business model is a business model that serves as a model description or blueprint of a hybrid service [9]. In addition to the resources needed and expected value creation, the necessary structures were described, analysed and strategically aligned. Here, the various external factors and requirements are described in addition to intense business-related perspective within the framework of a service business model. [10]. The aim is to enable an optimal fit between offered supply and realizable demand for quality, service, flexibility and cost [9]. One approach to visualize the different relevant structural dimensions is the service business model according to Osterwalder/Pigneur [11]. The different building blocks and their further consideration are product- or service-related information which supports a targeted development solution- and customer-oriented AAL service. As part of the social and health services for the specific AAL sector it makes sense to expand the original Osterwalder/Pigneur model with the dimensions of privacy, ethics and emotions [5].

The established methods and tools used in product development (e.g., blueprinting, stages of model development, push strategy) lead to insufficient results due to the special requirements of services [12]. Previous experiences in the field of AAL service development have shown that the successful introduction and establishment of new and innovative AAL services require a systematic development and design of services using appropriate methods and procedures (e.g., SWOT analysis, expert and user survey). Here a targeted and conceptual model enables a timely and economic approach to the development and establishment of marketable AAL service [13]. Particularly, the customer and system-related requirements have to be taken into account, which comprise the formative dimensions problem / idea, ethics / culture, organization / service, technology, economics, law, emotion and prototype [14].

1.2. Performance Measurement as a Challenge

It becomes clear that the current challenges in the social and health services will let a window of opportunity open up services for AAL solutions and AAL services. [15]. However, these require a request and demand design of conceivable AAL services [16]. The recent developments and research activities as well as the (non) establishment of related results suggest that in the past the focus was on technology-driven product

development (push perspective) [17]. In the future, we must also include more the customer or user perspective (pull perspective) in developments [18]. Furthermore, it is necessary to edit the respective requirements, interim results and objectives in detail by means of appropriate criteria and to present in a transparent and timely manner through meaningful indicators [17]. This leads to the following question: How should a suitable set of relevant criteria and indicators to support the development, measurement and evaluation of business models of hybrid AAL services be designed?

2. Methods

2.1. Analytic Hierarchy Process for Developing a SPMC Set

For the systematic and structured identification, prioritization and analysis of a suitable set of key criteria to support the development, measurement and assessment of business models of hybrid e-health services, the Analytic Hierarchy Process (AHP) provides a solution [19]. First, the overarching objective has been identified and defined. The derived operative objective, a Service Performance Measurement Criteria set for the AAL service development was formulated in the second step. The third stage of AHP based approach includes on the one hand the collection of possible influencing factors by literature search in relevant national and international databases (e.g., ScienceDirect College Edtition, SpringerLink, PubMed, Emerald collections, Thieme Connect) using targeted buzz words (e.g., business model, success factors, AAL , e-Health, customer satisfaction, etc.). In a first step, 148 criteria were identified. From these were 45 selected regarding the number of entries and on the basis of expert assessments. Secondly, the collected factors were analysed with respect to their significance and effect relationships by twelve experts and players from Austria (including service providers, users, developers, scientists) in the field of e-Health and AAL. The experts were chosen for their qualifications, work experience, focus on innovation and institutional affiliation. Furthermore, the meanings and descriptions of the 45 different criteria collected were connected with the research results. In the next two steps, the synthesis and evaluation of priorities and a review of the consistency of the evaluations were conducted in experts` discussions. This resulted in assigning 36 criteria to the 12 dimensions of the business model grid [20]. The seventh step involves the visualization of dependencies using an AAL Service Development Loom [20] and the outline of a Service Performance Measurement Cube for linking structure (business model grid) [21], process (service development process) [22] and results (Service Performance Measurement Criteria Set) [5]. The eighth step involves the identification and formulation of appropriate alternatives and operational measures.

2.2. Service Performance Measurement Criteria Set Development

The specific development of a Service Performance Measurement Criteria Set (SPMC-set) under the AHP was carried out in three iterative steps. In a first stage, the current situation (e.g. challenges) of AAL service development was identified and analysed. Based on these results, the identification and analysis of the target situation (e.g. customer requirements) were carried out. The third stage of development of a SPMC set includes the validation of the process and outcome measurement of the SPMC set based on exemplary AAL development projects, which are ongoing.

3. Results

3.1. Description of relevant Business Model Grid Dimensions

The complexity and lack of transparent services markets and emerging AAL services market requires a structured and conceptual approach in the development of hybrid AAL services [23]. Towards this end a business model grid provides a solution. A business model grid (also Business Model Canvas) is a structured template for the development of new or the documentation of existing business models. Through visiualization both the existing solutions as well as the development of future or alternative combinations and business models are possible. With regard to the peculiarities of the AAL market, the extension of the classic business model canvas by Osterwalder/Pigneur model (2011) to include the dimensions of privacy, ethics and emotions is presented [20]. The practical application of the grid has shown that the creative development process and the visualization of the results can be supported by further questions. Table 1 gives an overview of the twelve different dimensions of an AAL business model and the dimension-related issues.

In the context of a specific AAL service development, these questions should be discussed and answered decidedly. For example, in the business model dimension customer segments the question: Which customers (segments) are addressed by the proposed service? In relation to a possible AAL service arise a multitude of different customer groups (e.g. residents, patients, relatives, people with disabilities in the domestic environment, housing association, cardiac rehabilitation patients, health insurance, mobile care, rehabilitation facilities, assisted living, pharmaceutical companies, Workplace health promotion and so on.) that need to be investigated and analysed hereinafter in objectives, willingness to pay, utility. First from the collection of different information and linking the various dimensions of business model grid arise alternative applications / use and business cases and concrete operational AAL scenarios.

Table 1: Dimension of an AAL business model

Dimension		Deskription	Dimension		Deskription
1	Customer Segments	Customers have different needs and expectations with respect to the product/service and the provision of services . The segmentation in very homogeneous groups of customers enables targeted customer processing. The question is: Which customers (segments) are expected to be addressed by the service?	7	Value Propostion	The value proposition of a product is the core of the provider-customer relationship and aims usually at the solution or satisfaction of a customer´s problem or need. Value proposition promises an explicit benefit for the customer. The question is: Why should the customer make use of the service?
2	Revenue Sources	The sources of income are the inflow of income which the service provider/supplier receives and ensure success in the long term. The questions is: What types of services are paid to what extent and to what amount by the customer or cost unit?	8	Cost Structure	The cost structure includes and describes the total costs resulting from the offer as well as the provision of a service , arise. The question is: What are the relevant costs associated with the business model?
3	Comm-unication and Sale Channels	In connection with the provision of services at the point of service, there is an exchanges of information, data, products and resources between providers and customers through appropriate channels. The questions is: Via which channels do the exchange and communication of hardware/software, money, information, etc. takes place?	9	Key Ressources	Key resources include the most important capital goods which are required for the offer and provision of a service. The question is: Which resources (labor resources, labor, information, disposition) are needed for the provision of the service?
4	Customer Relationships	Customer relationships enable the reciprocal interaction between customers and suppliers. The question is: What kinds of customer relationships and customer contact are expected or offered ?	10	Key Activities	Key activities include the most important processes and sub-activities that are required as part of providing the service. The question is: Which processes and (sub-) activities are required or provided by the provision of the service?
5	Ethic	Ethics comprise society orientated and informal values (moral) of human activity and their evaluation. The question is: What are the ethical criteria which need be taken into account within the business model?	11	Privacy	Privacy includes securing the privacy of the customer (individuals or groups). In particular, in an increasingly automated and digitized world, personal data and information should be protected against the unauthorized access by third parties. The question is: Which data protection frame is connected to the business model and necessary players?
6	Emotions	Emotions of the customer are individual and subjective, which are based inter alia on different psychological experiences, priorities, social behavior and reactions. They influence buying behavior significant. The question is: Which desires and emotions services should provide?	12	Key Partner	Key partners are actors and networks that are required for the development and provision of the service. The question is: What external partners can be/are required or used concerning the provision of services?

3.2. Collection of relevant Performance Measurement Criteria

In addition to monitoring, developing and analysing the various dimensions of possible hybrid AAL services, it is necessary for their description, measuring and evaluation to identify, collect and analyse appropriate and meaningful criteria. As part of the conducted literature reviews, expert interviews (n = 12) and two creative workshops, 45 different performance measurement criteria were identified and described (see Table 2 and 3). In addition, naturally there are other criteria as well as monetary and non-monetary and qualitative and quantitative indicators available. Depending on their purpose they are conceivable and make sense. However, a final collection and presentation of criteria relevant for decision making purposes is beyond the scope of this work.

4. Discussion

4.1. Development of a Service Performance Measurement Cube

The added value of innovation and the benefits of a new service for the stakeholders concerned are significantly influenced by the associated which objectives, structures, processes and results. It is the combination of these different dimensions of quality of services may result in establishment on the market and sustainable service success. It is therefore necessary to describe transparently, to check and analyse the intermediate results during the complex and collaborative AAL new service development [6, 69, 70]. Here, the responsible players have to rely on an appropriate criteria and performance measurement system. A multi-dimensional and qualitative performance measurement system (PMS), serves as a control and documentation tool, which comprises a selected number of interrelated decision criteria and key figures. The aim is, through the use of appropriate instruments (e.g., EDV, cockpit, dashboard, reporting) to provide target-oriented, condensed, up-to-date, decision-relevant information. A winning pin end Performance Measurement by Service Performance Measurement Criteria Set is to see solutions in conjunction with the respective strategic objectives in the context of a targeted and conceptual product and service development of AAL and align them. It is

Table 2: Overview of relevant service performance measurement criteria of an AAL business model

Key Performance Criteria	*Description*
Level of Attention	Extent of perception by the customer regarding a product and/or vendor. Attraction and concentration count as indicators of the intensity and duration of attention. [24]
Break-Even-Analysis	Analysis of the breakeven point (break-even point), in which proceeds and costs of a product are equal. The profit margin is identical to the fixed costs. [25]
Protection of Privacy	Personal and health-related consumer data enable targeted and customized advertising and marketing opportunities. Therefore, these are always at the forefront by vendors and developers. It is important to ensure appropriate security as well on the supplier side. [26]
Privacy Policy	In conjunction with the digitization and the associated products and business models, the question arises about the privacy of customers in the processing of personal data . For this purpose, appropriate frameworks and guidelines must be observed(z.B. 95/46/EG). [27]
Data Security	A certain degree of information security refers to the characteristics products which store and process information. It is essential to ensure confidentiality, availability, integrity and protection against hazards or threats, prevention of economic damages, and minimizing risks. [28]
Distribution Network	Network and channels or processes by which the distribution and the sale of products between producers, suppliers and distributors through to the (end) customer take place. [29]

Table 3: Overview of relevant service performance measurement criteria of an AAL business model

Key Performance Criteria	*Describtion*
Personal Initiative	Personal initiative includes one's own initiative and the first steps to a responsible decision and action. [30]
Research and Developement (R&D) Cost Component	The use of resources of a company/consortium influencing the innovation success. Through external R&D-activities and a targeted management of research and development costs, better innovation performance is possible. [31]
R&D-Networking	For dealing with time-, content- and market-related challenges in the context of product development, it is important to develop appropriate solutions like simultaneous technological and market development, dynamic development of hybrid service bundles by means of networking by independent businesses. [32]
Horizontal and Vertical Integration	By grouping homogeneous players and functions (as well as upstream and downstream production levels) under a uniform management enables economies of scale and scope as well as optimizing the supply chain and networks with regard to common innovation successes. [33]
ICT-Infrastructure	Use of technology and structure in the field of information and communication. Factors such as distribution, interfaces, capacity or speed play an important role. [34]
Degree of Innovation	The level of innovation is a function that describe the cost-benefit ratio of the new product and previous solutions (state of the art). [35]
Interdisciplinarity	The use of different perspectives, approaches and methods from various disciplines with the aim of enabling future and successful innovations. [36]
Share of Investment / Return on Investment (ROI)	Profitability, the ratio of a profitability measure to the capital investment of an accounting period, measures the efficiency of product development and enables a comparison in competition. [37]
Purchasing Power	Monetary amount remaining per business entity after all fixed payment obligations were made, and which is available for potential buying decisions. [38]
Communication	The development of innovations dependents on the transfer and the exchange of information, knowledge, awareness or experience . It is important to develop and establish appropriate channels, methods and skills. [39]
Cooperation	Today the development of innovation requires targeted and purposeful interaction of two or more actors to achieve a common goal in a coordinated division of labor and resource allocation. [40]
Coordination	Consortium formation and systematic classification with regard to innovation and product development requires the control of players and projects and necessary strategically oriented activities. [41]
Debtors and Creditor Analysis	Overview and analysis of creditors, which means the suppliers and the debtors, the customer / company / products. [42]
Customer-/ User Integration	Customer involvement in entrepreneurial innovation projects aims at a reinforced market-based-view and is seen as an important factor for successful service development. The customer perspective is involved as a co-designer. [43]
Customer Acquisition	Status, planning and implementing targeted actions of customer acquisition. [44]
Customer Acceptance	Customer acceptance is the positive acceptance decision by the customer and includes, inter alia, aspects of the benefit assessment, the usability, the expectation of conformity, the costs and the context- and network effects. [45]
Customer Needs	The subjectively perceived lack of a business entity with the desire to eliminate these by demand and consumption. [46]
Customer Loyalty	Status, planning and implementing targeted actions of customer loyalty. [47]
Customer Authorisation	Customer or Consumer Empowerment aims to strengthen the customer or ownership and participation by the customer (regarding decisions, codetermination, participation in the development- and value creation process). [48]
Customer Profitability	Customer profitability, based on selected customer segments and groups, sets the acquisition costs in relation to revenues. [49]
Customer Satisfaction	The difference between customer expectations and satisfaction of needs is evidence of improvement and product innovation. [50]
Mass Suitability	Property of a product that makes this attractive and desirable for a larger number of customers / clients. [51]
Employee Qualification	The mix of qualifications of the employees determines the team- and personal working capacity , which is composed of professional and social skills, and should be controlled through strategic human resource development. [52]
Mobility	A sustainable mobility offers customers and stakeholders the movement in physical , geographic, social or virtual spaces. [53]
Modularity	The modular design of complete systems, forms standardized individual components with defined interfaces. The modular product design allows a higher system complexity and promotes product innovation. [54]
New Media	New media describe current and time-related new media technologies (e.g. Internet, blog, social networks, word of mouth) for information transmission and communication current or potential customers / clients. [55]
User Rating	The benefit assessment is a subjective assessment by the customer, whereby the benefits of a product are assessed in relation to the resources that has to spend the customer. [56]
Terms of Use	In conjunction with the general terms and conditions (e.g. directive 93/13 / EEC) it is necessary to protect customers from unfair contract terms. [57]
Patents	The development of products and thus of proprietary claims offer the opportunity to differentiate themselves from competitors and represents an increase in the value of the innovation or the product . Therefore, the number of patent applications is growing at a fast pace. Companies unable to process the patent information, are losing competitiveness. [58]
Personnel Costs	Personnel expense includes the costs incurred through the use of workers in the development and production process. [59]
Privacy	Privacy is that non-public area and need where, a human being undisturbed by others, lives out his human right to free development of personality. [60]
Product Quality	The product quality is composed of the dimensions of structure, process and outcome. This can be considered neutral, which means the sum of all characteristics of a product, as well as subjectively, which means the goodness of all the properties of a product. [61]
Self-determination	Self-determination includes the degree, the ability and the cognitive ability of customers to act in accordance with their own will, and to decide on their actions, behavior, and their body freely. [62]
Security Potential	Assistance systems and activity monitoring for the elderly are gaining importance and create a sense of security. [63]
Simulation	Simulation includes the analysis of complex systems. By means of an abstraction of the simulated system, different scenarios of product development and –variation are passed through, concerning structure, function and behavior by using specific parameters. [64]
Strategic Orientation	Medium- to long term planned objectives and approach of a company in terms of innovation, market and use of resources also includes the control of implementation incl. performance measurement. [65]
Time-to-Market	The lead time includes the time from product development to product placement on the market. In this period costs for the product arise, but it still generates no revenue. [66]
Use Case Building	The development and description of applications is the collection of visions and expectations for the technology and the user context. [67]
Willingness to Pay	Monetary amount paid for a product which a buyers or customers is willing to pay out of their income. [68]

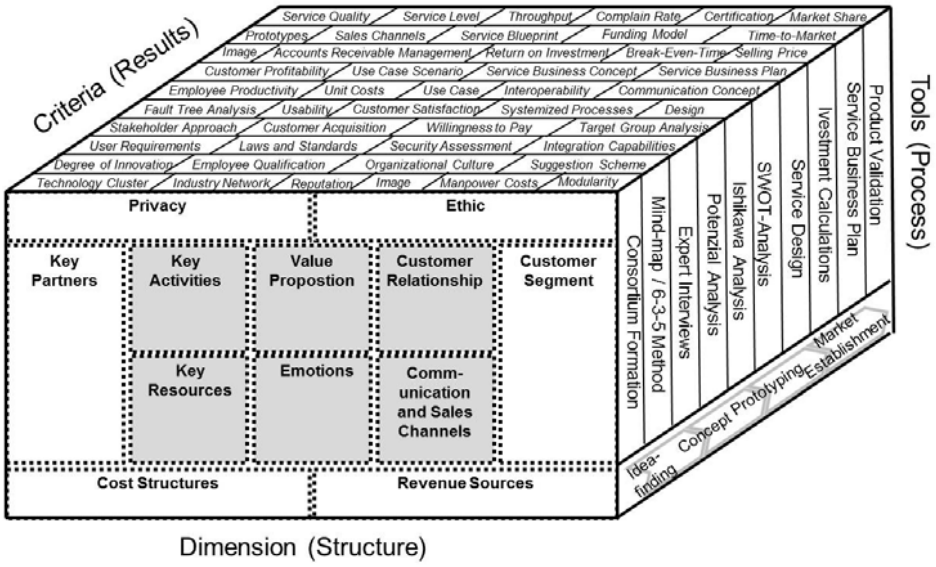

Figure 1: Service performance measurement cube for AAL service development

advisable to focus on selected key performance criteria. This results in a focused concentration on essential compliance levels and progress as well as on important goals and critical success factors in the context of AAL service development.

4.2. Evaluating the Spectrum and Validity of the SPMC Set

For the stakeholders, the development and application of an individual AAL Service Performance Measurement Cube creates the chance to drive forward the development of marketable AAL services in a targeted and conceptual way and to support relevant decisions. Therefore the service performance measurement cube can be used as a management tool in the AAL new service development process. For the future development of the SPMC set and their application in the context of the development of new services and service management of existing AAL applications, different challenges and research needs have to be identified. On the one hand it is necessary to evaluate the validity and reliability of the SPMC with further research and development projects [71]. Secondly, it is necessary to integrate the large number of different criteria and indicators by software support (for example, by means of e-Performance Measurement Cubes) practical and application-oriented in the new service development process of future marketable AAL applications [72].

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