

Ambient Assisted Living e-services:  
Challenges to their ImplementationVivian Vimarlund<sup>1\*</sup> and Bertil Lindenfalk<sup>2</sup><sup>1</sup>Department of Computer and Information Science, Linköping University<sup>2</sup>Jönköping University, International Business School, Sweden

## Article Information

Received date: Apr 28, 2017

Accepted date: May 17, 2017

Published date: May 18, 2017

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Keyword Ambient Assisted living;  
e-services; Implementation

## Abstract

**Introduction:** Ambient Assisted Living (AAL) services are expected to foster economic, environmental, and social growth. Many different strategies are used today to create infrastructures that support effective implementation of e-services and facilitate the transition to an individual-centred system. However generic implementation of e-services that contribute to develop new alternatives to deliver social care and wellbeing services in AAL-environments has not yet taken place.

**Aim:** The purpose of this paper is to present an overview of the issues that influence the effectiveness of implementation of e-services in ambient assisted living contexts.

**Method:** The paper uses knowledge sampled in a report produced by one of the authors of this article for the Swedish Innovation Agency (VINNOVA) in Sweden, where issues related to implementation of IT-based applications and e-services were discussed as well as in data collected in two European projects connected to the Ambient Assisted Living (AAL) Programme in which strategies to implement e-services were studied and analyzed.

**Results:** The paper identifies ex-ante and ex-post enablers and concerns that are of importance at the moment to implement e-services in ambient assisted living contexts. The knowledge presented in this paper can be of importance for decision-makers, managers, and individuals who need to develop strategies that facilitate the implementation of e-services across a whole organization.

## Introduction

The next wave of Ambient Assisted Living (AAL) e-services is expected to contribute to reduce labour costs, diminish the delivery and distribution time of services, innovate and improve processes and routines, contribute to the improvement of quality and access to care, and, to engage the elderly and their next-of-kin, in decisions related to their own health and wellbeing [1-3]. In a context where there are a large number of challenges (because of the complexity of the stakeholders that AAL services demand), many different strategies are used to create infrastructures that support the effective implementation of e-services with the intention to facilitate the transition to an individual-centred system.

In Ambient Assisted Living (AAL) environments, research projects and R&D ventures characterized by trying to utilize consumer affordable technology to equip homes with a set of advances electronics, sensors and automated devices specifically designed for care delivery, remote monitoring and earlier detection of emergency cases to promote residential safety, and to increase quality of life of individuals [4,5]

Meanwhile there already exists a wide variety of devices and IT-based applications that could be applied in AAL contexts, such applications require a stable but flexible ecosystem in which, developers, decision makers, users and suppliers of services collaborate to implement solutions adapted to the needs and requirements of the users [6] that at the same time fulfill the main goals of AAL contexts. Namely to allow individuals to independently stay at home and access to the services they need to manage their everyday life, independent of age, socio-economic status or gender.

However, despite the increasing number of reports that indicate the potential improvements in efficiency which e-services can bring to the area of ambient assisted living [7], the sustainability and effectiveness of the implemented services has not yet being demonstrated. A considerable amount of research and projects has been performed mainly in artificial environments such as as research institutions or laboratory settings (living labs), rather than in real-world contexts [8,9]. The results have therefore been considered to have a questionable ecological validity and not be applicable to real-world settings [10].

Previous research has shown that there is a need to appropriately manage the implementation of the devices and services developed to overcome the challenges of complex ecosystems as AAL in which stakeholders belonging different interest groups are expected to interact [5,11] and, manage the services developed [12]. To our best knowledge there are few studies that expand knowledge

from adjacent areas, as for instance from the implementation of IT-based innovations in healthcare, education and transport, to the AAL area. To avoid failures in achieving the goals of AAL contexts, it is therefore important that we learn from experiences sampled in the past and that we identify issues that should affect the sustainability and the effectiveness of the use of e-services in complex ecosystems.

## Aim

The aim of this paper is to use previous knowledge sampled when implementing IT-based innovations in areas such as: healthcare, education and transport, to identify critical issues and challenges that the implementation of e-services in AAL contexts faces to effectively manage implementation processes. The knowledge sampled can be of importance for stakeholders that need to develop strategies that facilitate the adoption of IT-based innovations as e-services across smart homes.

## Method

First, we use previous knowledge sampled in a research report performed by the first author of this article, and published by the Swedish Innovation Agency, Vinnova, with the aim to describe issues that influence the successful implementation of IT-based innovations in the areas of healthcare, education and transport [13]. Second, we compare the outcomes of the report with risks areas considered of key relevance for the sustainability of implemented innovations in two AAL-research projects. The outcomes of the analysis are shown the main risks areas that influence the sustainability of the implementation of e-services in AAL-contexts.

The findings are then structured using a temporal framework of the issues, needs and specific request that implementation processes of e-services in AAL-contexts confront, which resulted in the emergence of two different perspectives: an ex-ante perspective and an ex-post perspective. The ex-ante perspective focuses on the plans and strategies that need to be made in advance in order to support the implementation process. The ex-post perspective highlights issues that need to be considered so as to support sustainability, and the adoption and integration of IT-based innovations, for instance, e-services in work-day routines. In the presentation of the outcomes we present issues that appear in both the previous research report [13] and in the two AAL-projects we participated. Whilst, issues of local relevance, that is to say, issues that only one of the EU projects discussed were omitted.

### The context of the AAL projects

The AAL FOOD project: The Framework for Optimizing the Process of Feeding (FOOD) project was aimed to provide the elderly (people over 65 years of age) with an environmental sensor-based service embedded in the white goods that collects information about the foods' habits and needs of the individuals to support them in their procurement, preparation, and consumption of food. A technical platform that supported the e-service was developed as an open-source solution with the aim to allow the possibility to integrate similar platforms and producers of other services in the future. Further, through a digital display embedded in the oven, it was possible to sample information about the oven temperature and to regulate, altered or shut down the oven if necessary. The service was piloted in the Netherlands, Romania, and Italy. In total, individuals

from 26 homes participated in the test and evaluation of the service. The individuals who tested the service were provided with a tablet that allowed them to control their white goods, and to also interact with other pilot participants in real time, sharing information about alternative recipes.

**The AAL HELICOPTER project:** The healthy life support through Comprehensive Tracking of individual and Environmental Behaviors (HELICOPTER) project aimed to support older adults (65+) in their daily routines for control and prevention of age-related diseases allowing them to maintain a relatively high degree of self-sufficiency at their homes. The service developed utilizes non-invasive sensors and used an algorithm (an id-identifier) that automatically sorted and analyzed the data collected at the individual level. Allowing in this manner to receive individual-based support and aid if needed. The service was tested with 38 participants in the Netherlands and in Sweden. The participants in the pilot were able to access and check information about their daily behavioural and habits progresses at the end of the project.

Both projects developed an open source platform based on JAX-WS, Glassfish, XML, SOAP, WSDL, HTML5, CSS3, and JavaScript, jquery library, jquery Mobile library and Phone Gap allowing access to the services anywhere at any time. The sensors used in both projects were described as "off the shelf" non-invasive sensors and incorporated into the technical platform developed at each of the projects, through the open standards mentioned above. In both projects, the sensors tested were developed and adapted by one of the SME companies that participate in the projects.

In both projects, data collected through the sensors were locally stored and saved on a home-PC placed in the individuals' residencies. In addition to this, every day aggregated data sampled through the sensors were synchronized with a server located at one of the project partners, namely the SME that developed the technical applications and that owned the server. This procedure facilitated to follow up the battery life of the sensors and the control of the continuity of online-accessibility of the information. In the HELICOPTER project, it was also possible to show individual information in forms of graphs i.e. quantity of sleep hours during a night, to analyze the importance of some habits for their well-being.

## Results

### Learning from the past

We learnt from the outcomes obtained in the Vinnova report [13] that the risks areas that can be associated with the implementation of IT-based innovations in areas such as healthcare, education and transport, can be categorised in terms of the time when the innovations are implemented and divided in two groups. Ex-ante and ex-post implementation. Ex-ante implementation issues are related to procurement and governance, while ex-post implementation issues are related to managerial and economic areas and their relevant to strategic plans, policies, and guidelines that reduce inefficiencies at the organizational level.

In Table 1, we present the main relevant areas of risks captured that influence the sustainability of the implementation of IT-based innovations [13].

**Table 1:** The main risk areas that influence the sustainability of the implementation of IT-based innovations in healthcare, education and transport.

Area/ temporal aspect	Issue	Needs	Specific requests
<b>Ex-ante implementation</b>			
<b>Procurement barriers</b>	Clear governance	Legal clarity	Document standards, access rights, rules for inter-operability and rules to be qualified as a supplier of e-health solutions
	Leadership	A strong guiding coalition and change champions	Cooperation and mutual understanding between stakeholders and leaders
	Effective Contracts	Contracts should clearly state the goals and objectives of the business relationship between a vender and customer.	Include an addendum in the contract to ensure the vendor meets all of their verbal commitments. Project vigilance and transparent communication that stimulate vendor engagement

**Ex-post implementation**

Area	Issue	Needs	Specific requests
<b>Management and reallocation of resources</b>	Change management and technical management process transformation	Reduce resistance to change due to inevitable changes in workflows	Create a management plan and execute it quickly to implement e-health innovation to prevent organizational changes that stimulate resistance.
	Don't call it a "pilot project", Consider using a rapid implementation	Avoid selection of units with a low volume of transfer as first mover and as good example to other units.	Give live support quickly to avoid failure of scale, including changes in hardware, software, policy user and contact information.
	Lack of funding and adequate governance	Adequate funds and adequate data sources	A detailed budget and a data pool including all of the necessary data
	Failed system performance	A continuous process which runs 24/7, all year long, and avoid maintaining obsolete applications	Develop certification criteria that support interoperability of innovations and apps.

**Comments**

Previous evaluation reports related to the implementation of IT-based innovations shown that some of the most relevant areas of concerns are: i) the importance of governance and leadership, ii) the need for effective contracts, and iii) the importance of policies that foster innovation. The complexity of the implementation processes and the huge number of previous failures are, unfortunately, findings that are repeatedly reported on several studies [14-16]. From the publications that were reviewed, we learn that there seems to be a mismatch between (i) what it is considered an effective approach for the implementation of IT-based innovations and (ii) the real-life effects that these implementation efforts have on organizations, users, consumers, and third parties. Further, the gap between expected effects and factual effects influences the sustainability of the use of the innovations and their organizational- and social effectiveness.

The implementation process and the implementation strategies of e-services in AAL-contexts are, nevertheless, similar to the implementation of IT-based innovations in other areas and in specific in the service sector. The context, in which e-services for ambient assisted living environments are implemented, is also complex in many aspects. Further, e-services in ambient assisted living contexts are expected to serve both consumers and producers and to improve the exchange of information between consumers and producers, and to support syntactic inter-operability, namely the possibility that multiple applications with multiple languages and interfaces communicate and cooperate for data exchange without geographical barriers to empower and to engage the elderly. The experience accumulated in the EU-projects we refer in this paper, shown that e-services in AAL environments are also influenced by a temporal dimension (ex-ante and/or ex-post implementation) and that these aspects can be of relevance for the efficiency and sustainability of the services (see Table 2).

**Table 2:** The main risk areas that influence the sustainability of the implementation of e-services in AAL- contexts.

Area/ temporal aspect	Issue	Needs	Specific requests
<b>Ex-ante implementation</b>			
<b>Stimulate innovation</b>	Scale innovations	Guidelines and policies	Willingness to pay for the e-services
<b>Create a structured approach to sustain co-creation of services</b>	Commitment of participants	Legal clarity and the limit of the responsibilities	Document standards, access rights, and rules for being qualified as a producer of e-services
	End-users satisfaction and acceptance	Policies and guidelines to include elderly end-users in the co-creation process	Describe the value-added of the involvement of end-users for the acceptance and adoption of the services
<b>Create an effective market</b>	Sharing of information	Cross-agency collaboration to share knowledge and experiences	Cooperation, reciprocal support, and mutual understanding between stakeholders and leaders
	Attract new producers	Protocols for smart houses	Accelerate the use of innovative e-services

Ex-post implementation

Area	Issue	Needs	Specific requests
Management and reallocation of resources	Management process transformation	Develop economic and societal business cases	Building facilities creating management plans manage IP and ensure syntactic inter-operability
	Creating a corporate identity	Linking complementary services	Create a public-private collaboration so as to develop an identity as an innovator
	Lack of funding and adequate governance	Make the process agile and rationalize administration	Capital investments, strategies to attract investors, tools to measure reimbursement; use of innovative business models

The outcomes of the analysis of the projects shown that the effective implementation of e-services in ambient assisted living contexts, faces similar challenges to the challenges that have been identified when IT-based innovations in sectors such as healthcare, education and transport are implemented. Issues related to economic profit, policies, social- and organizational innovations, management, the need for strategic investment and the importance of users' acceptance are core factors for success. However, the implementation of e-services in AAL-contexts demands the existence of evidence regarding the efficiency and effectiveness of the services, as well as the creation of living labs to support the co-creation of e-services in order to ensure sustainable and effective implementation strategies. Another interesting issue identified in the analysis of the projects, is that e-services for ambient assisted living contexts need to innovate managerial strategies and be open to cross-agency collaboration to ensure long-term sustainability of the implemented services. In addition to this, it is necessary to develop a corporate identify in which public- and private actors and end-users (the elderly) can share goals, knowledge, experiences, and even information about how to develop complementary services. An interesting output we obtained in the AAL projects included in this study, is the fact that the development of a corporate identity creates the feeling that the e-services have the value they are expected to add and bring to ambient assisted living environments and positive influences the willingness of the end-users to use and adopt innovative e-services.

Discussion

An e-service implementation process involves complexity and change with respect to several aspects. This process demands changes for the single individual, managers, stakeholders and third parties. Sustainable strategies for the implementation of e-services in ambient assisted living contexts can only be put into place once the services are a part of a corporate identity and when they add value at a cross-agency level. In this regard, it can be said that the implementation of e-services in ambient assisted living contexts differs from the implementation of IT-based innovations in other adjacent sectors, because the processes and strategies in the ambient assisted living context demand consideration for evidence, co-creation of the services between producers consumers and end-users, interoperability of solutions, and identification of the impacts they will bring at both the individual, social- and socio-economic level. Creating an enabling environment for the adoption of e-services in ambient assisted living contexts, implies consequently, high levels of innovativeness at the managerial-, organizational-, and market levels, as well as clear guidelines at the administrative-, managerial-, and financial levels.

It is therefore imperative that any new policies, new guidelines, or strategies directed towards the implementation of e-services in complex contexts and the ones ambient assisted living have, should consider the issues that are identified in this study. In further studies, it will be necessary to perform comparisons that measure the impact of the issues identified in the AAL-projects as important for to successful implement e-services in order to be able to develop effective implementation strategies. Standards approaches that do not consider ex-ante or ex-post issues do not match the challenges of complex environments with many different stakeholders, decision makers and users that need to match the demands from the both sides of the market, namely, producers and consumers of services.

Acknowledgements

This work was supported by VINNOVA and the European Commission through their support of the AAL programs.

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