An AAL Collaborative System: The AAL4ALL and a Mobile Assistant Case Study

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Abstract. The areas of Ambient Assisted Living (AAL) and Intelligent Systems (IS) are in full development, but there are still some issues to be resolved. One issue is the myriad of user oriented solutions that are rarely built to interact or integrate with other systems available in the market. In this paper we present the AAL4ALL project and the UserAccess implementation, showing a novel approach towards virtual organizations, interoperability and certification. The aim of this project is to provide a collaborative network of services and devices that connect every user and product from other developers, building a heterogeneous ecosystem. Thus establishing an environment for collaborative care systems, which may be available to the users in from of safety services, comfort services and healthcare services.

Keywords: Ambient Assisted Living, Ambient Intelligence, AAL4ALL, Active Ageing, Artificial Intelligence, e-Health, Intelligent Environments, Collaborative Networks, Sensor Platform

1 Introduction

Current United Nation (UN) population statistics [1] shows the evolution and growth trends changing rapidly, being expected in the near future a full reversion of the population distribution, age related. In fact, the UN states that the abrupt changes in the population evolution may become an international calamity if not dealt properly. The tendency occurring is the direct inversion of the teen-elderly ratio, being the tendency to greatly increase the number of elderly people. Furthermore, it is expected that in the year 2050 the elderly layer (60+) surpasses the young layer (0-15) [2].

This information stresses the investment on the services and products directed to the elderly. One issue is the shortage of specialized help, for instance, there is a lack of caregiving centres or domiciliary caregiving to all persons in need. The current demand of services greatly surpasses the offer available and in the future it is expected to be even more difficult to provide proper care. A different perspective is keeping people in their homes and providing them with specialized help.

That idea was the starting point of the Ambient Assisted Living (AAL) systems, being the aim providing people with technological resources that help them on their daily life. Currently there are numerous AAL projects [3] that provide help in many different ways, being services, devices or even humanoids, some being already available to the end-users.

A common issue with AAL projects, mainly due to the rapid development that is demanded, is that they are singular, meaning that they work by themselves and cannot be integrated with other systems [4–6]. Although it seems harmless, this issue quite serious. There are several implementation and operation issues that are resultant from it, and perhaps, a bigger issue that is user adoption of the technology.

Mostly what happens is that the AAL systems rely on their own knowledge, and the lack of established standards (from the community or organizations) constitutes a barrier to the interoperability. Furthermore, the AAL systems often rely on a panoply of concepts, ones in terms of software, others in terms of hardware to make everything work together, thus some compromises must be made.

Fagerberg et al. [4] presented an extensive overview about the latest developments of AAL projects, confirming that most of the developed projects stand alone in terms of interoperability. The authors affirm that there is more investment on the AAL area, being multiple projects addressing the same problems, without considering interoperability, due to several factors, such as development procedures, architectures and requirements guidelines.

Commercially, it is verified a large amount of services are interconnected, leading to a better usage and to information sharing between different platforms, enhancing the user profile of each service [7, 8]. Clearly there is an effort of the services providers to build an ecosystem that benefits all the participants.

This document is constituted by the following sections: section 2 presents the state of the art in terms of AAL ecosystems and previous attempts of building an ecosystem; section 3 presents the AAL4ALL project and the main lines of its architecture and structure; section 4 shows the UserAccess project, built to the AAL4ALL having as its aim the caregiver and relatives; finally, section 5 presents the conclusions and the future work.

2 AAL Ecosystems

As previously stated, what is occurring is the lack of viable business models that truly implement the needed interoperability [4–6]. In AAL projects interoperability comes in many forms, going from the sensor systems to the certification procedure. The following projects present a spectrum of approaches in terms of AAL ecosystems.

Norgall and Wichert [9] present an initial approach to the idea of an integrated environment. The universAAL project implemented an initial approach to interoperability, being the aim to provide an inexpensive platform so that users could benefit from low cost solutions. The initial approach was to implement conventional standards such as the IEEE 11073. This was the major issue with the universAAL project, as only one standard was insufficient to accommodate all features they proposed.

Memon et al. [10] presented the CareStore platform, being an AAL project the aim is to provide an system that is able to interact with all devices that are sold at their store. The authors provided a conceptual framework that is able to interact at different levels of communication between all the devices and services. This approach bridged the interoperability, integration, usability, security, and dependability features that an AAL platform must provide. This holistic perspective is built over the idea that several protocols have to be implemented, each one directed to the appropriate level of communication and security.

Lahteenmaki at al. [11] have presented an implementation that is not directly pointed to AAL but, with some level of adaptation, can serve as a starting point towards real communication protocols to medical environments. The ontologies created had the porpoise of establishing communication between medical services and external services that could be medical or not. Furthermore, the method of saving the data and the access procedures can be extrapolated to other systems as they are heterogeneous and can be ported to other solutions. The greatest contribution to the AAL was the implementation of this project on a real environment, thus proving that it is feasible to maintain communication between distinct spheres of action.

Walderhaug et al. [12] presents a discussion about the technological developments and the society needs, creating a dichotomy between the provision of quality technological services and the healthcare organizations standards. The authors emphasize the absence that a common system provokes, and how a group of singular services fail to present a useful or pleasant solution. Finally it is presented a framework with the aim of being a centralized system for information, resorting to ISO standards to comply with medical certification process.

These projects have provided information and technology to have a clear idea of what needs to be done to achieve an AAL ecosystem. It is easy to realize that the ecosystem must be based in ISO/IEEE standards and has to attend differently to each structure level, from the sensors to the logic reasoning.

3 AAL4ALL

The AAL4ALL [13] project is a Portuguese effort to construct an AAL ecosystem that shall serve as the standard for the future AAL projects. The project's consortium is constituted by academia and corporate partners, collaborating in ways that join the formal concepts with products that are already deployed in the market and adopted by people.

The AAL4ALL project has two main goals: to produce an AAL ecosystem and define a certification standard [14]. As it is expected, these two goals encompass various developments, going from the sensor systems to the high-level services, as seen in Figure 1. Therefore, the project must provide the design and architecture that structures and establishes a connection with every solution devised.

One of the AAL4ALL goals is to allow several distinct services to be connected to it. Not being limited to products developed internally, but to integrate all systems that bear an AAL4ALL certificate. Thus, other players, such as academia or industry, can build and integrate their devices to the system. Furthermore, one of the aims is to build a strong collaborative network. Virtual organizations (VO) and virtual environments (VE) are very interesting to this project, due to its own nature, of being fully ubiquitous and relying in external products providers to build solutions (whether hardware or software) to add value to the established systems.

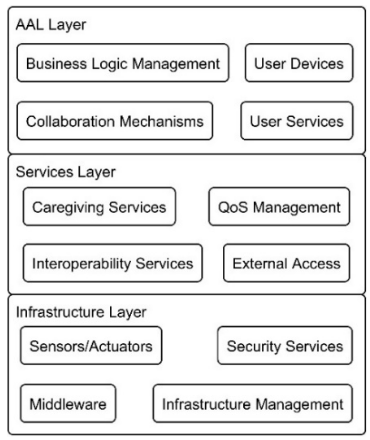

Fig. 1. Simplified diagram of the AAL4AAL layer architecture.

The AAL4ALL relies in two types of virtual organizations: architecture collaborative network and users' collaborative network.

The architecture collaborative network is established using heterogeneous devices and services, resorting to a transversal architecture backbone that is common to all solutions (hardware and software), communicating with a central system that is responsible for the verification of the whole organization.

The users' collaborative network is the related to the panoply of the users connected and sharing information in the platform. The main system only works by having a large amount of information and having one's personal sphere of people that is also connected to the system. Therefore, with a large community using the system more information is generated thus, the system becomes more efficient. Each user can be on their own environment, for instance, users in their homes and physicians on the medical centre, and collaborate as if they were in the same space, being one positive aspect the resources savings and the natural environment monitoring.

AAL project's have spheres of action that are constituted by the actors (the distinct users) and the global actions. For instance, a typical project's user is an elderly person that is being monitored and has devices and services available to help at any given task, but the life of a person is also constituted with connection to other people, like friends, relatives and caregivers.

Moreover, these people need different solutions to the ones presented to the elderly user, thus there is a necessity to allow distinct levels of interaction, keeping the system homogeneous. The key to this issue is personalization of the devices/services to each sphere, which requires a high level of interoperability of each service involved.

As showed in Figure 2, the AAL4ALL platform connects the several spheres of each actor, providing interoperability and connection between them. A leading aspect is the collaboration between all actors, considering that the help of the technological systems have boundaries and are finite [15–18]. For instance, although we can witness technological revolutions almost every day, there are only few systems that can truly monitor one that is outside its home. So, a natural solution is to resort to a caregiver that is constantly available to attend the actor monitored, but this solution causes another issue that is selecting a person for the arduous task of being always in alert. It is clear that only one person is unable to perform such activity alone, thus it must be considered that external services, such as caregiving services, must be used accessing the AAL4ALL platform to retrieve the actors' information. Keeping the user and the caregiver in mind the UserAccess project was created.

UserAcces is a platform in form of a service built for the AAL4ALL project, aiming for the assistance of the caregiver and the relatives of the user.

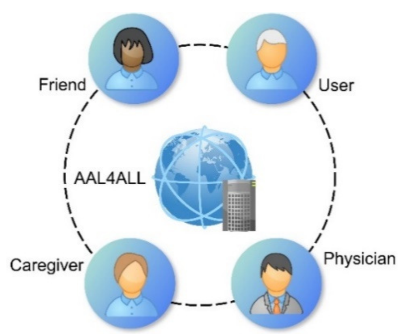

Fig. 2. Interaction of the different spheres.

4 User Access

The AAL4ALL ecosystem is composed of various services and devices, being most of them platforms on their own. The idea of such architecture was to provide an integrated service, which one could contract the solutions that sees fit, being assured that any product chosen works perfectly with all others. Therefore, several scopes were projected responding to the various user spheres, ones regarding the user and its direct monitoring, others monitoring the home, and others providing information. As presented before, the UserAccess [19, 20] platform was developed within the scope of the AAL4ALL project and, in simplified terms, consists in a platform that provides information about the actor being monitored. Corresponding to the information sphere, the UserAccess focuses the user monitored but it is not designed to be used by him/her, but by others that directly interact with them. Therefore, the UserAccess is a complementary service, in the perspective of the AAL4ALL, but plays an important role, as it relives the caregiver of arduous tasks, such as constant monitoring, allowing he/she to do other tasks of even monitor other users at the same time, providing a harmonious work schedule. One of the high-level goals is to create a collaborative platform here the actors can directly interact with each other by relaying information, send text and video messages, and schedule activities remotely. Therefore, conveying all information in only one place, thus the actor only has to interact with one service. This collaborative sphere is somewhat similar to a social network, although it lacks support to out-of-scope interaction, meaning that only discussions and interactions that are within the scope of the AAL4ALL theme are allowed. Currently the available information consists in health reports from the sensor system, current location and future activities.

In terms of interaction, the UserAccess has an ongoing development for deployment via web and mobile devices. The information consumption dictates the constant internet connection thus justifying the user method of access, as offline information soon becomes dated and invalid.

4.1 Architecture

In terms of architecture, the UserAccess is a server based platform, were all information passes. This procedure was opted due to the high volume of information that needs to be processed and the connectivity between all users, being the most effective way to overcome connection problems and devices overloading. Moreover, with the use of mobile devices, such as smartphones, their internal services can be retained and used to directly connect with other actors (by telephony or messaging).

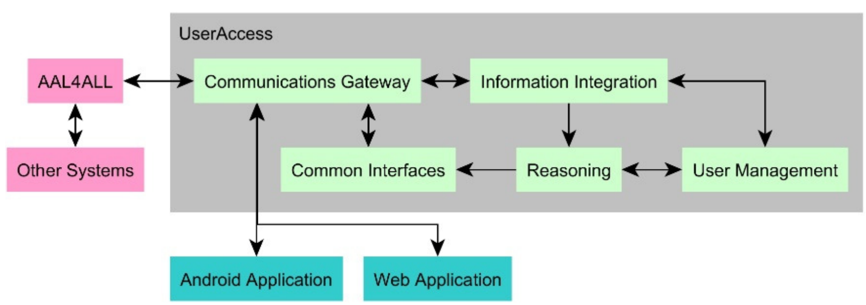

Fig. 3. UserAccess architecture overview.

This architecture also allows the development of the expected collaborative platform, being the information always accessible and distributed between all actors involved in a decision or task.

Figure 3 is the overview of the architecture, it is composed of five modules plus two user visual interfaces. The architecture is based on a multi-agent system, where every module has several agents in charge of different aspects of the module. This approach helps in terms of scalability and availability, making simpler to change options at the local level and update without downtime of the system.

The communication gateway provides the means to receive information from the AAL4ALL (more exactly from the AAL4ALL Node) and relay it to the next modules, using internal protocols based on XML and JSON formats.

Information integration module takes care of verifying the source of the information and checking it with the one present in the relational models. The UserAccess is open to any communication that follows its ontologies there is the necessity of knowing if the system possess the means to understand it. Also, the information that arrives is very distinct (in format and content) of the one that is present internally, thus it must be integrated in the system.

The reasoning is a vital part of the system, as it provide complex decisions in secure actions. For instance in terms of scheduling, if the user has already a task scheduled at a time that other user wanted to reserve the system can automatically respond that that time slot is occupied, or if it’s the user physician scheduling, the system can reserve that time and notify all people involve in the previous task that it is not happening. Thereon, the information is relayed to the user management module that updates that information on the AAL4ALL platform.

User management module treats the actor personal information, keeping updated his/hers likings and medical condition modulating the reasoning and providing extra information to the reasoning so that module can make better decisions.

Common interfaces module holds the information to be relayed back to the AAL4ALL platform. The reason why this module is separated from the information integration module is to keep the sent and receive procedures linear and non-blocked.

Finally, the android application and web application are the typical way of keeping the actors informed. Depending which actor is using (resorting to the user management module) the type of information and the content is changed.

4.2 Case Study

The UserAccess must be thoroughly tested before any real usage of the platform, as any information or action can result in unforeseeable results. The UserAccess is unable to change critical systems or choices, but the information delivered to the user can change the way that he/she acts, thus it is imperative that all systems are at least error free, and in the worst case scenario no information is showed.

With the current implementation of the UserAccess has already produced results, being the correct capture of information by the server and presenting it on a webpage and relaying it to the Android application, as showed in Figure 4. The ubiquitous nature of the system requires some features to be implemented differently from the common procedures, being scalability a theme that should be carefully considered.

The initial tests are very promising and it validates the work done until now, being the next steps to integrate other platforms. Furthermore, the information about the state of the sensor platform was correctly displayed, presenting warnings if the user exited his home and left something open, or if it pressed the panic button.

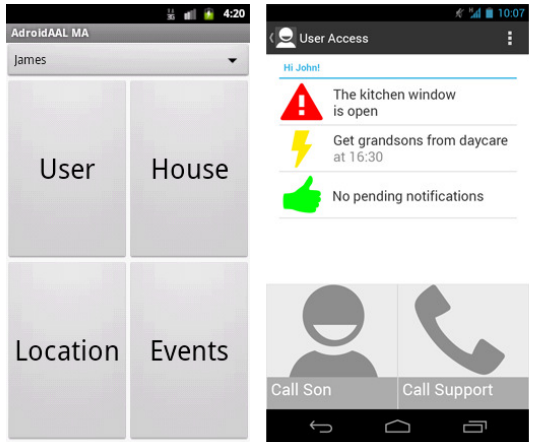

Fig 4. UserAccess Android Interface.

The scheduling is also a challenging theme, because of the inherent social interaction. We can safely assume that a great part of the tasks anyone does involves other people, and that make the process of scheduling much more complex due to the assumption of constraints of each party involved in the task. Let's assume the following scenario:

- Mario wants to play bridge with his friends Roger, Maria and Jack;
- To Mario Friday afternoon would be great;
- Roger can play Friday after 4 pm;
- Maria can play Friday until 5 pm;
- Jack can play Friday but only after 4:30 pm.

Thus there is a problem with the schedule that Mario suggested, as they cannot combine their tasks to play Friday.

This scenario shows how a simple task can be difficult to synchronize between all actors. Furthermore, we must consider the fact that each person has more than four friends and each one must be managed. We are used to schedule different tasks with different persons easily but we mind only our own schedule.

Another situation is the fact that some activities are more important than others, for instance, a medical appointment is more important than a game of bridge, and most of the time most of those tasks are not neatly scheduled. So, one issue that must be considered is the arrival of important tasks that overlap others that are already scheduled. There are two approaches to resolve this problem that can be used combined: actor hierarchy or actor preference.

The actor hierarchy consists in ranking the person that schedules the task according to the importance in the user's life, being task scheduled and others eliminated or reallocated. The problem with this approach is that it is quite inflexible, as the most used action is to schedule the one with priority and delete the others with least priority.

The actor preference is a modulated approach where the reasoning module can learn from the user's interactions and provide a hierarchy values that are more real. Furthermore, it allows interactive reallocation of the tasks that are overlapping and suggest times where all parties involved are in accordance.

Finally, the next step will be taken in a living lab that in the AAL4ALL project means collaboration with the Santa Casa da Misericórdia, which is a retirement home. The test will be proceeded with a small group (3 to 5) persons where it will be evaluated their reaction to the system and the reliability and usability. It is expected a large amount of results due to the time (1 month) and the exigency of the environment.

5 Conclusions

In this paper it was presented the AAL4ALL project and the UserAccess case study. The UserAccess is still in development, being most of the modules in the final stage, being the reasoning module the one that requires more effort and time, due to the its complexity. The system has also the web application and a basic Android application and is, currently, able to receive information from a sensor platform and generate valid information as well as warnings when a threshold is achieved. It is also able to receive multiple application connection and successfully connect users and share information about them, being in an initial stage of a collaborative environment.

In terms of future work, we are focusing in the reasoning module and provide visual interfaces' features so the users are allowed to direct communicate with the others. Furthermore, we plan to provide an easy way of integrating other devices with the UserAccess, by allowing the information integration module receive remote updates. Being the next step the deployment in a retirement home, and testing it in a controlled real scenario, testing the features and usability of the system. After this test the results obtained will be used to provide real information of the performance and the errors or shortcomings, being a final test planned to use all people in that retirement home, leading to the final stage of the project and the certification procedure of all services and devices.

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