A NEED FOR AN INTEROPERABLE OPEN SOURCE MIDDLEWARE FOR AMBIENT ASSISTED LIVING APPLICATIONS
A Position Paper

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Abstract: Recent European population projections underlined demographic developments towards an ”ageing society”. A challenge of the future is ”ageing well at home” assisted by technology, while maintaining a high degree of independence, autonomy and dignity. Ambient Assisted Living technologies try to follow this objective by integrating intelligent assistance-systems in people’s homes. So in future there will be a high demand on AAL applications which should fulfil different needs of user groups and daily living scenarios. To speed up the development process and to make the applications more adaptive and flexible to special user needs a common middleware with standardised interfaces would be desirable. This should be an open-source middleware, which operates as an interconnection layer to the operating system and as basis for applications and services. Furthermore the implementation of different frameworks and standards is preferable to ensure the interoperability of different systems and overlapping domains in AAL. The open source approach can be essential to initiate a community of different stakeholders and to reuse software components with a common understanding on the implemented standards. The paper shows the need of such an interoperable middleware and gives recommendations of standards and frameworks to follow. The paper explains why the open source approach is a chance to fulfil the mentioned motivations. As a first approach the EU IST FP6 project MPOWER is introduced, which could be the basic fundament of such a middleware approach. It is an example for an open source service oriented platform providing encapsulated AAL and health related services.

1 INTRODUCTION

Within the next decades the European society will face serious demographic changes. Recent European population projections for 2008-2060 published by the European Office for Statistics underlined demographic developments towards an ”ageing society”. It is projected that from 2015 onwards, births will not outnumber deaths and hence population growth due to natural increase will cease. For this reason positive net migration will be the only population growth factor (Giannakouris, 2008).

The old age dependency ratio, which is defined as the population aged 65 years or older related to the population aged between 15 and 64 years, will be a particularly dynamic indicator. It is a reasonable projection that, on average for the EU-27 and if current trends prevail, the old age dependency ratio will approximately double during the next 50 years. This means that in 2050 a person of working age might have to provide for up to twice as many retired people as is usual today (Eurostat, 2008).

The social behaviour and lifestyles as well as the identity of the individual older person will change if current trends continue. With higher expectancies of life and rising retirement ages in European countries, the proportion of older people at work will increase as well as the number of elderly people participating actively in social life. Furthermore the number of elderly people living alone and of those who live under the average subsistence level will increase (AALIANCE, 2008). Although older people in the future will remain self-sufficient for a longer time, more people will need high intensity care in the end-of-life period and more people will need support in daily life operations prior to this phase due to more or less intense disabilities (European Commission, 2005).

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2 MOTIVATION

These demographic changes will lead to different challenges and opportunities of ageing society in Europe such as a growing number of older people who live by themselves and who are in need of care and a growing number of older people lacking basic financial and social resources who will have difficulties to obtain a minimum of health and care services. Facing these challenges and opportunities there exist opportunities, where technological and socioeconomic innovation can enhance the quality of life for older and impaired people. It is assumed that Ambient Assisted Living (AAL) technologies and services for elderly people can play an important role to solve some of the increasing future problems (AALIANCE, 2008). Information and communication technology (ICT) is believed to play a major role in order to help older individuals to improve their quality of life.

The following three areas of user needs are to be addressed as stated in (European Commission, 2007):

- Ageing well at work or "active ageing at work": staying active and productive for longer, with better quality of work and work-life balance with the help of easy-to-access ICT, innovative practices for adaptable, flexible workplaces, ICT skills and competencies and ICT enhanced learning (resp. e-skills and e-learning).
- Ageing well in the community: staying socially active and creative, through ICT solutions for social networking, as well as access to public and commercial services, thus improving quality of life and reducing social isolation (one of the main problems of older people in rural, scarcely populated areas, as well as urban areas with limited family support).
- Ageing well at home: enjoying a healthier and higher quality of daily life for longer, assisted by technology, while maintaining a high degree of independence, autonomy and dignity.

As can be seen there is a need for the development of AAL technologies to support elderly people in their daily life activities to enable them to live an independent life in the privacy of one's home as long as possible. This could help to cut the sharp increase in social costs caused by the ongoing demographic change. Ambient Assisted Living (AAL) technologies try to follow this objective by integrating intelligent assistance-systems in people's homes. Modern sensor-techniques and IT-based evaluation of data, i.e. behaviour pattern recognition algorithms, should support the safety of the inhabitants. In other words, current sensor events are compared to predefined or learned patterns and if the situation differs from normality alarms are triggered by the AAL-system at different levels (i.e. as a feedback to the care receiver, as an information for relatives or as an alarm to a nurse and/or a doctor).

AAL applications respectively technologies should be based on a middleware, which is open to the public and works as an intermediate layer between the operating system and the application itself. The middleware has to be adaptable in terms of services that can be implemented. Furthermore it should be flexible and freely configurable to satisfy user needs regarding the development of applications and user interfaces. Moreover it would be a good starting point for rapid development of applications and services. As a consequence the development process would be more cost- and time-efficient. A realisation as an open source project would help to spread it in a big community and a benefit would be more reliability and security in further development stages.
To ensure an interoperability and interaction of different AAL applications and systems standards should be the basis of all technologies. Furthermore the idea of open source software can enhance the coalescence of different approaches. Following ideas about standarization principles, open source approaches and generalization of interfaces and their interoperability are presented.

3 ONE MIDDLEWARE FOR APPLICATION DEVELOPER

There are a number of architectural characteristics that can be used as basis for reasoning about what might be considered appropriate quality attributes that can be measured. These include interfaces and layers, standards and data interoperability. Middleware provides an example of the layering principle. It separates the applications from the operating systems on which the applications run. As outlined in figure 1, middleware services are sets of distributed software that exist between the application and the operating system and network services on a system node in the network (Kasunic and Anderson, 2004).

An essential aspect of architecture is the establishment of technical standards. In general, standards define common elements, such as user interfaces, system interfaces, representations of data, protocols for the exchange of data, and interfaces accessing data

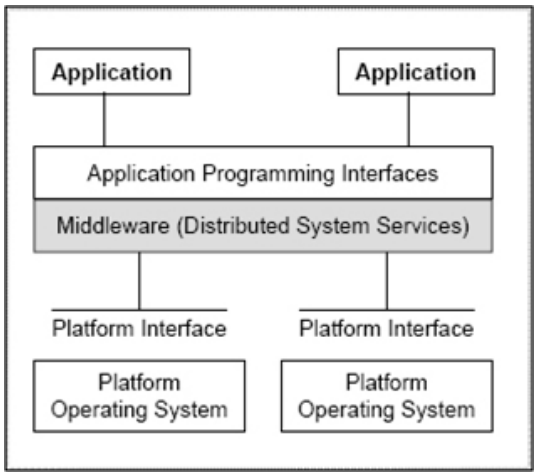

Figure 1: Middleware.

or system functions. Technical standards provide a number of advantages for the systems architect. With regard to interoperability, standards are important because they are accepted by multiple vendors, thereby increasing the likelihood that a collection of systems from diverse sources will be able to interoperate. It has become generally accepted by now that although standards are certainly beneficial, simple adherence to standards is not sufficient to guarantee interoperability. Even when there are accepted standards and compliant products, interoperability is facilitated but not assured as there are options within standards and different releases and versions of products.

4 INTEROPERABILITY IN AAL APPLICATIONS

Interoperability is the ability of different information technology systems and software applications to communicate, to exchange data accurately, effectively and consistently, and to use the information that has been exchanged. Important for interoperability is not only the syntactical interoperability of simply connecting devices and modules through sharing and exchanging. Specified data formats, communication protocols and the like are therefore fundamental. But also the semantic interoperability and therefore the ability to use and understand the exchanged information is important. Beyond the ability of two or more computer systems to exchange information, semantic interoperability is the ability to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by the end users of both systems. To achieve semantic interoperability, both sides must defer to a common information exchange reference model.

Services for the ageing and cognitively disabled do not and will not exist in isolation. The AAL domain consists of a large set of independently developed systems and services in existing environments. On top of the value of these individual systems additional value could be created by exchanging data between these systems or even aggregate the data in a system for analysis and to give proper feedback or alerts to relevant systems or users. These systems and services should be able to communicate with each other not only by exchanging data but also understanding each other's data. This can only be achieved by agreeing on a lot of issues in other words by using standards (AALIANCE, 2009).

The ageing society's conditions require that we rethink traditional models of care. One prominent aspect of new care models for this target group is the cooperation of different stakeholders in the care process. Stakeholders include the patient himself, his relatives and caregivers such as the general practitioner, hospital personnel, homecare personnel and insurance and social security departments as well. Healthcare systems are expected to maintain the continuity of care, shared care and the empowerment of patients in the management process. Many relevant systems and applications exist, that AAL services might need to interoperate with. Healthcare applications built around Europe use proprietary data formats and some systems are designed to interoperate with others based on standardized data formats, such as HL7 and CEN standards. Consequently an interoperability solution needs to be able to communicate with external parties in an agreed upon format, even though the internal system is based on proprietary formats.

So far we have experienced in many projects in the AAL domain that within one after the other project different proprietary solutions are developed. A lot of funded projects are like reinventing the wheel and so far no common sense on even some universal used modules or components with open and described interfaces can be found. Many working and already implemented solutions in residential house or smart home applications are generally proprietary solutions in the case of sensor networks, middleware implementations and even data formats and records. Of course interoperability and standardisation is already mentioned in every project proposal but a real guideline or state of the art for practical use is still missing. It seems like there is nowadays a situation in the AAL domain like in the eHealth domain years ago. Important will be to learn from this domain and to speed up the process of using interoperable and standardized systems and frameworks. Of course AAL is an

application domain with a lot of overlapping subdomains where so far there has not been a real need for interoperability. In the AAL domain there must be a interchanging of the e.g. eHealth domain, the home entertainment domain, the home automation domain, the household appliance domain and many more. The status quo in the AAL operation are conflicting versions of standards as well as conflicting implementations thereof. This is also caused by the fact that so far the existing standards, like the ISO/IEEE 11073 standards for domotic sensors, have not been used and implemented in many applications and cases. Thus there is no experience of e.g. missing parts or any other lessons learned from usage. There are not many examples to show how to implement these standards in practice. Of course there is also a lack of standards in some fields of AAL applications like for remote maintenance, terminology and ontology, emergency and alarming calls and procedures and in some extend middleware etc. And there is a lack of certification and also labelling processes of devices and modules in the AAL domain.

4.1 Using Standards and Frameworks

The structure shown in figure 2 presents four categories of standards relevant for AAL (AALIANCE, 2009). Starting from the bottom:

- Equipment and environmental standards (EES): these are standards agreed on in a large domain and sometimes imposed by regulation. Quite often they have to be followed if one wants to enter the market and processes to change them are very difficult. These standards are usually not ICT related but relate to environmental (e.g. EMC), quality (ISO 9001), safety, physical product properties (e.g. CE norms), manufacturing and installation processes. AAL products however have to comply with these standards but they will hardly be influenced by the AAL community. Some specific standards exist e.g. EN 50134 for social alarm systems, CENELEC Smart House and CENELEC TC 205 (HBES) for home and building electronic systems. A number of standards in this area will be mentioned but not explored in greater detail.
- Generic technology standards (GTS): these standards have often been developed by standard development organisations or industrial associations, which are either very broad associations like IEEE or more closed ones like W3C or UPnP, Bluetooth, or USB. Often multiple alternatives for certain technologies exist like Bluetooth, Zigbee, Z-wave for personal area or local area networks. For AAL one or sometimes more than one should be selected. If more than one is selected it might be necessary that an aggregating device supports more than one option at the same time. The influence of the AAL community on these standards might be in communicating specific needs from the AAL domain either on the standard itself or on profiles on top of these standards.
- Domain specific standards (DSS): these are standards for sub domains that are important for an integrated AAL solution. Examples of relevant sub domains are healthcare (with sub groups like: tele-monitoring, medication registries, electronic health records, personal health records), home control, home safety, home security, remote payment systems, etc. Sometimes generic technologies have specialisations for certain domains like the Bluetooth medical profile and the USB device class definition for personal healthcare devices. In this category the AAL community might give input to the standard development organisation for extensions.
- Specific AAL standards (SAS): these are standards specific to the AAL domain. There are very limited potential candidates available at the moment: data exchange standards and ontologies to enable the exchange and understanding of data between different subsystems for reasoning on this data and interacting with the users. Some of these standards might exist or are evolving in specific domains as e.g. healthcare.

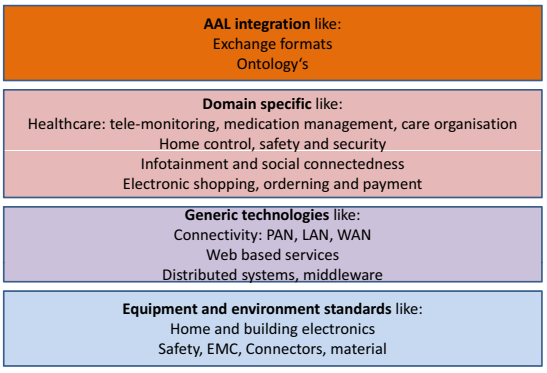

Figure 2: Standards relevant for AAL (AALIANCE, 2009).

Although the "Integrating the Health Care Enterprise" (IHE) (IHE - Integrating the Health Care Enterprise, 2008) started to implement the framework for health applications, the communication structure could be used as well for homecare applications for elderly and persons with dementia. This could be easily done because there are already structures for

point-of-care devices. The benefit would be the accordance to established standards and standard frameworks. It is obvious that there is a benefit because of already established point-of-care communications from the medical field (blood pressure, temperature etc.), which can be adapted. Of course the whole IT structure and the cross-enterprise-document sharing (XDS) defined in the IHE framework could handle personal health data and information, which could be, depending on the use cases, even important for medical help.

The ISO 11073 offers plug-and-play and a functional as well as a semantic interoperability between sensor systems and aggregation systems. In this standard all functions and use cases, which are defined for patient oriented health care and of course in some aspects for smart home for elderly, are already object orientated modelled. That means a so called domain information model is constructed where the device, the functionality, the measured data, settings, alarm functions, patient information and interfaces are defined. Furthermore there are codes for all information elements defined as ”nomenclature” (ISO/IEEE 11073-10101) and ”data dictionary” (ISO/IEEE 11073-10201). The communication standard POCT-1A is implemented in the ISO 11073.9 and is specialised for patient near point of care. In principle the functionality of POCT1-A could be realised by HL7, but the functional range of the HL7 structure is in some cases (single sensors) too high dimensioned. So it depends on the special functions to realize what should be realised on the sensor (according sensor often have a restricted hardware) and the local controller. Because of a clear defined message communication the unique interpretation of the standard is guaranteed. POCT1-A is a flaring of HL7 not a competition standard. The advantage of the CEN/ISO/IEEE 11073 is that it is the only comprehensive system of point-of-care medical device communication standards. The modality categories range from real-time operating medical equipment to point-of-care test devices. Wired as well as wireless IR and RF network technologies are supported. If healthcare providers and management organizations want point-of-care to record transparency of information, they must demand medical device interoperability. In addition the activity is regularly coordinated with other health information activities (HL7, NCCLS, IHE and DICOM) by the core development bodies.

The Continua Health Alliance can help to overcome the barriers of using standards. The Continua Health Alliance is a non-profit, open industry coalition of healthcare and technology companies joining together in collaboration to improve the quality of personal healthcare. With more than 200 companies around the world, Continua is dedicated to establish a system of interoperable personal health solutions with the knowledge that extending those solutions into the home fosters independence, empowers individuals and provides the opportunity to truly personalized health and wellness management (Continua Health Alliance, 2009). It is important to know that Continua is not developing standards but is recommending standards like the ISO/IEEE 11073 and is also providing a certification process to make the benefit of devices visible to the user. The benefit for AAL applications is that Continua has beside the scope on managing chronic diseases and fitness a scope on aging independently what could be used as a standardisation process for devices and applications in the AAL domain. Therefore more and more companies and technology providers but also research institutions from the AAL domain are joining the Alliance.

The implementation of standards and interoperability by using frameworks is not only a major issue concerning the usage of the open source services, it is also a major issue on private data protection. Recommendable are the frameworks provided by IHE (Integrating the Healthcare Enterprise) and HIMSS (Healthcare Information and Management System Society). As an example IHE provides a Basic Patient Privacy Consents (BPPC) mechanism to record the patient privacy consent(s), a method to mark documents published by XDS with the patient privacy consent that was used to authorize the publication and a method for XDS consumers to use to enforce the privacy consent appropriate to the use. The leadership of HIMSS, Health Level Seven (HL7), Integrating the Healthcare Enterprise (IHE) and the HIMSS EHR Vendors Association (EHRVA) have begun to work on this effort by establishing a coordinated set of activities that would provide an HL7 implementation guide and launch this new IHE domain called Patient Care Coordination with demonstrated interoperability of medical summary documents by January 2006.

4.2 The MPOWER Project

MPOWER has been an EU IST FP6 project (finished June 2009) with the objective to create a middleware platform that enables rapid development of novel smart house systems and applications. This platform should simplify and speed up the task of developing and deploying services for persons with cognitive disabilities and elderly. The approach has been to encapsulate the functionality by a service oriented architecture (SOA) and by using the model driven ar-

chitecture approach (MDA). To enable adaptivity and the possibility to integrate the middleware with external systems a requirement has been the implementation of existing standards and frameworks (HL7, ISO, CEN, IHE etc.). For demonstration purposes the implemented services are containing communication services, information services, management services, sensor services as well as security services.

As already mentioned MPOWER is based on SOA by using the web services WSDL and SOAP. Thus it is an interoperability enabler, as the web service front ends allows heterogeneous platforms to interoperate (e.g. .NET and Java). This is not enough as the messages, which can be exchanged by applications and systems, can be very different and there can be application policies (such as security) which need special interoperability requirements. To this end, we have designed a reusable interoperability architecture that encapsulates the interoperability components in such a way that changes in these components or the external systems they relate to are hidden from the rest of the MPOWER framework. For other MPOWER services the interoperability services look just like any other MPOWER service. The mechanism is to use a design pattern known as the message translation. We are not the first ones facing interoperability challenges. It is a reoccurring problem and therefore patterns exist that explain how one should design middleware components in order to achieve interoperability. We provide this pattern with its subpatterns and explain their relevance to MPOWER.

To see this middlware, which is implemented, used, maintained and expanded by different stakeholders, the MPOWER consortium provides all implemented services as open source (MIT license) under the Free-mpower project. It is hosted on SourceForge under http://sourceforge.net/projects/free-mpower/. Everyone is able and also invited to browse and acquire the source code, basic documentation to several services and the toolchain as well as the service deployment process, the handbooks as well as the open source toolchain itself and to submit requests. Members of the sourceforge project can also post code, make documentation and post pictures of e.g. running application GUIs. Provided services are for example security services, database management service (with init data), patient manager service, calendar service with reminder (HL7v3), patient information message board service, localisation service, frame sensor service (ISO/IEEE 11073) as well as alarming and notification services and many others. Of course documentation is provided for these services and the overall architecture.

As short term projects the usage of the free-mpower setup is thinkable for any student project, any proof of concept application or rapid prototyping. As long term projects the free-mpower project could be the basis for following European projects any commercial solutions or any application provider. For community building purpose, which is obviously a very important point for an open source project, a growing framework by using and adding service would be desirable.

MPOWER is an open source service oriented platform providing encapsulated AAL and health related services. It includes standardised smart house sensor interfaces (ISO/IEEE 11073), interoperable interfacing for legacy systems (CDA, HL7-HSSP) and external service connection (mobile alarming / reminding / communication), security services, social and information services (HL7). All results are shown in figure 3.

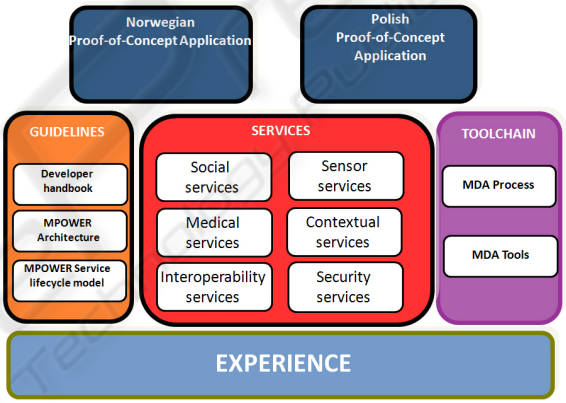

Figure 3: Results from the MPOWER project.

5 THE CHANCE OF OPEN SOURCE

To provide the services of a middleware and also software application modules as open source to the community, is a big advantage for projects and a subsequent use of the project results as well as it may ensure the usage of the platform and the consistency of the developments beyond the project runtime. On the other side it is important to be aware of the challenges and requirements of open source for the project and application developers.

At first the MIT License states explicitly the rights given to the end-user, including the right to use, copy, modify, merge, publish, distribute, sublicense, and/or sell the software. In detail the end-user are on the one hand the application developer, which may want to build applications based on the services, and on the other hand the care receiver who wants to use the ser-

vice including the application. In comparison to the GPL license the application developer is allowed to redistribute the modified software and an application which is an incentive for the professional application developer and can expand the usage of the services itself.

Another big advantage of open source services in the AAL context, which should be taken into account when talking about ethical issues, is the advantage of the transparency of the services and the code itself. Transparency is inherent to every release of open source code. The customers can see it and thus the vendor has no secrets.

But transparency also applies to vendor's operations. Vendors who are opaque on their strategy gain fewer benefits from a open source release of code. The most successful open source vendors are transparent on their strategies and the most successful open source customers are transparent in turn, being frank about their needs. Transparency, the need for it, the desire for it, extends outward from there. The advantage of the usage of open source in eHealth and AAL projects concerning the support of standards has been pointed out as a need by the member states of the European Union. There is a need to support actions that cover the development of standards addressing the interoperability of diverse systems and services and to explore in particular the possibilities of open source applications to achieve this objective. In this context, the need for future standards is clearly emphasized to solve interoperability concerns in a way that all stakeholders will benefit from the possible adoption of Open Source reference implementations for care services. In addition, an open and more free access to future and existing e-Health and general interoperability standards in the AAL and eHealth service providing should be recommended, taking inspiration from models such as the World Wide Web Consortium. The exchange of experience in the use of open standards and open source solutions among health administrations in Member States should be promoted (European Commission, 2004). Success in developing a European e-Health Area and AAL standard conform platform will draw on sharing best practices and experience across the Union, as systems are deployed and organizations redesigned. Open source applications play an important role in achieving interoperability (European Commission, 2004).

Maybe the biggest ethical issue when providing open source services in the AAL context is the issue of data privacy and data protection. This is very important because the services generally developed in AAL related middleware and application projects use medical and social relevant data which underlie special data privacy regulations.

The advantage of transparency of open source code and the possibility that any expert has the possibility to find security leaks and general mistakes in the code and can fix them, leads also to a high demand on secure software development and the integration of security services so that the transparency can not be misused. As a result of the transparency the application developer can fix and provide special data security, e.g. in the case of medical data treatment, and provide it as a business to user organization or private users.

The transparency of open source also gives the possibility to expand the functionality of the service or the application, which can be part of a business strategy, and to learn from the structure and interfaces of already implemented services.

A very important point concerning the usage of open source software components is the community, which uses and kind of maintains the project or at least can give assistance or support.

A main goal of AAL related projects developing open source middleware software components is to build a powerful community of application developers and users of the open source services and application. This can be any kind of possible stakeholders e.g. universities, national organizations, residential house operator etc. This will be important to guarantee maintenance of the services to provide good quality to the user and as well to set up and include perfect security mechanisms and to close possible security leaks. The attraction for developers to provide software components under the MIT license as open source may be that open source services under the MIT license are underlying the international valid copyright law. That means the provider of the services still holds the international copyright but is providing the sources as "it is".

In the social thinking of the gift economy, where valuable goods or software modules are given without any explicit agreement for immediate or future reward, the fact of providing a middleware for AAL applications makes sense to fulfil the aim of having a commonly used system. The gift economy is a more and more desirable thinking in western companies or by private persons, who are not essentially depending on a money exchange. Ideally, simultaneous or recurring giving serves to circulate and redistribute valuables within the community. Jordan Hubbard wrote in his article "Open Source to the Core" (although referring to it as a barter economy) and essentially describes a gift culture, where reciprocity is a broad community custom, rather than an explicit quid pro

quo (Hubbard, 2004): "The volunteer software engineers in the open source software community are far more likely to help those who have demonstrated their commitment to the success of the overall open source software development process."

6 CONCLUSIONS

There have been many research projects concerning a common middleware for AAL applications. There is a high demand on technical standards in the AAL domain but their is also a high activity defining standards going on. For future developments it will be important to reuse existing developments and to enhance or adapt them. In the future it will be important to have more and more applications with standardised interfaces and protocols implemented. These experiences can be used by standard organisations to adapt the documents to users' and developers' needs. We think that the open source approach can help a lot to spread a common sense a software and standard implementations.

The AAL domain should take the chance of reusing frameworks and standards from the medical domain because there is an overlap of this two domains. But more important is the fact that it should be avoided to make the same experience again and have an unsatisfying solution for the next years. Even in the medical domain their is still much to do when thinking of implemented standards of medical device communication or data exchange between different legacy systems. The AAL domain should use the already existing knowledge and base findings on it.
This will be very important because in the AAL domain their are also a lot of other fields where standards are missing and where the community should work on like standards for basic user needs evaluation, basic aspects of layout and designed user interfaces, basic standards for the demand on usability, standards on privacy data also for social data and basic standards for evaluation methodology.

The MPOWER project could be a basis for creating a community and to start a common implementation of an AAL middleware. The benefit is that it is easy adaptable and even some few services can be used as a standard and maybe integrated in other running AAL applications, because of its service encapsulation.

For the AAL community as a whole it will be a task to (AALIANCE, 2009):

- Increase the awareness on existing standards
- Demonstrate the advantage of collaborative and integrated applications and services based on using standards
- Develop and promote a reference model that gives guidance to product and service developers.

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