AAL Joint Programme

Action Aimed at Promoting Standards and Interoperability in the Field of AAL

Deliverable D5

Final Report

Editors: Marco Eichelberg, Lars Rölker-Denker
Date: 2014-07-02
Status: Final Version

Action Aimed at Promoting Standards and Interoperability in the Field of AAL –
Deliverable D5: Final Report

Report for Ambient Assisted Living Association, Brussels
Date July 2014
Author(s) Marco Eichelberg
Lars Rölker-Denker
Responsible Administrator: AAL Association Brussels
Project Name: Action Aimed at Promoting Standards and Interoperability in the Field of AAL

Publisher:
Ambient Assisted Living Association
Rue de Luxembourg, 3, 2nd floor
B-1000 Brussels, Belgium
Phone +32 (0)2 219 92 25
email: info@aal-europe.eu

About Ambient Assisted Living Association: The Ambient Assisted Living Association (AALA) is organizing the Ambient Assisted Living Joint Programme (AAL JP). The AAL JP aims at enhancing the quality of life of older people and strengthening the industrial base in Europe through the use of Information and Communication Technologies (ICT). Therefore, the AAL JP is an activity that operates in the field of services and actions to enable the active ageing among the population. The programme is financed by the European Commission and the 22 countries that constitute the Partner States of this Joint Programme. See more at: http://www.aal-europe.eu/.

Editors

Name	Surname	E-Mail
Rölker-Denker	Lars	Lars.roelker-denker@offis.de
Eichelberg	Marco	eichelberg@offis.de

Version History

Date	Editor	Change
2014-03-03	Eichelberg	Initial version created
2014-03-04	Eichelberg	Sections 2 and 3.1 populated
2014-03-10	Eichelberg	Section 3.2 populated
2014-03-12	Eichelberg	Sections 4.2, 4.3 and 5 populated
2014-03-18	Eichelberg	Sections 3.3, 5.5 populated
2014-03-18	Eichelberg	Executive summary written.
2014-05-20	Eichelberg	Added colophon, updated actor/transaction diagram for integration profile 5. Merged comments/fixes from KM into document. Proof-read the document.
2014-06-03	Eichelberg	Revised executive summary
2014-07-02	Eichelberg	Final updates to reflect final text of Deliverables D2 and D7

Table of Contents

1 Executive Summary

Ambient Assisted Living (AAL) can be described as *concepts, products and services that combine new technologies and social environment to improve the quality of life for people in all phases of life*. AAL uses assistive technology to keep people at work productive and healthy, to keep people at home healthy, independent and integrated, and to improve the delivery of care where and when needed. AAL systems consist of a combination of products and components from various industrial sectors, and their operation requires an "ecosystem" of service providers for planning, installation, maintenance, operation and service provision. Furthermore, it is of key importance that AAL systems are "future-proof", i.e. can be extended and maintained over a longer period of time, growing and adapting to the changing needs of the user. This can only be achieved with modular solutions, where components can be combined in a flexible manner. This requires *standardized* interfaces between systems and system components, a property called *"interoperability",* i.e. the ability of components to work together in a seamless manner. It can be argued that interoperability is a key requirement for the success of AAL solutions on the market.

This report summarizes the work and results of the AAL Joint Programme *"Support Action Aimed at Promoting Standards and Interoperability in the Field of AAL",* which has been running from July 2013 to spring 2014. The goals of this support action were two-fold: 1. to make existing standards more easily accessible by identifying use-cases covering the topics of all six calls of the AAL JP published to date and by mapping technical standards to these use-cases such that the result provides guidance on the use of standards for the AAL community; 2. To raise the awareness of existing standards in the field of AAL by organising two workshops and inviting partners of the AAL JP projects and the wider AAL community.

1.1 Use Cases and Integration Profiles

The approach followed in this support action is similar to the approach employed by IHE or the Antilope project: we collected, and then selected the most important use cases, we formalized use cases by identifying actors, transactions, process and data flow, and we mapped transactions to communication standards (and options where necessary). The resulting integration profiles were documented in a structure similar to that of IHE integration profiles and Antilope use cases. For each call topic of the AAL Joint Programme, at least one high-level integration profile (i.e. an integration profile without a mapping of the transactions to standards) was devised, and for four of them the transactions were also defined in detail.

Many AAL projects have tried to describe their vision of ambient assisted living in the form of a "use case" or "storyboard", i.e. the story of a fictitious user of the AAL system to be developed. These storyboards form the starting point for the development of integration profiles. More than 300 of such use cases have been collected from deliverables of AAL Joint Programme projects, public deliverables of FP6/FP7 AAL research projects, the "ICT & Ageing Scenarios published by the BRAID project, the AALIANCE roadmap, and the Antilope use cases (which are based on the eHealth European Interoperability Framework). The use cases were documented in a structured manner using a template devised by IEC Strategic Group 5 "Ambient Assisted Living". The public part of this "collection" has been made available in Deliverable D7.

In order to systematise and analyse the collection of storyboards (or use cases), a number of keywords were assigned to each use case to describe the main purpose of the AAL system described there, the stakeholders involved in the scenario, and key enabling technologies used. For this purpose, a multi-dimensional, hierarchical taxonomy for indexing the texts was developed, using the following dimensions: body function addressed by the AAL system; activities and participation supported by the AAL system; functionality of AAL systems addressing the workplace;

stakeholders appearing in the use case; purpose of the system (other than supporting body function or activities/participation); key enabling technologies used. The full set of keywords can be found in Deliverable D2, section 2.2.

For each of the six call topics of the AAL Joint Programme, a list of keywords matching the respective call topic were identified, and the number of use cases that had been assigned each keyword was determined. Keywords appearing in many use cases thus represent system functions or body functions/activities supported by many of the AAL systems described in the use cases, and, therefore, are arguably a good basis for work towards a standardization of use cases as they cover the most frequent themes and project goals. Therefore, for each call topic the most frequently used relevant keywords were chosen, and all use case texts related to these keywords were re-examined with the goal of condensing them into a new, “representative” use case. For this purpose, the individual assistive functions appearing in the use case texts, such as for example “behaviour monitoring”, “fall detection”, “indoor localization”, “intelligent calendar”, “outdoor pedestrian navigation” etc. were identified and also sorted by frequency of appearance, to identify the most common ideas on assistive functions for each call topic. These were then used as a basis for the selection of the key topic of each representative use case. The narrative texts of all representative use cases can be found in section 3.1.3 below, and the full set of representative use case is available in Deliverable D2. The titles of the representative use cases are:

- UC R01: Behaviour Monitoring
- UC R02: Calendar Service
- UC R03: Social Interaction with Smart TV
- UC R04: Shopping and Nutrition Planner
- UC R05: Mobility Assistant
- UC R06: Personal Trainer
- UC R07: Environmental Health Monitoring and Alarms at Work

The next phase of the project comprised the process of defining “high-level integration profiles” for all representative use cases. In this phase, a semi-formal description showing systems and system components (“actors”) and interactions between these components (“transactions”) was derived from the representative use cases. The idea of modelling an integration profile is to only identify components based on a specific function that they contribute to the overall system, components that could be implemented as a separate product (software or hardware). The internal functionality (e. g. algorithms, user interface concept) of an actor is not considered in an integration profile – an actor is considered as a “black box”, only the interfaces of which are defined. Once the actors and transactions are defined, the high-level process and data flows are defined as a series of UML sequence diagrams showing alternative sequences of events and the involved process and data flows. As a rule of thumb, not all possible sequences of events can be described, but the most important – both regular and irregular – sequences should be described, including the expected behaviour of the actors. The results of this phase are seven “high level integration profiles” corresponding to the seven representative use cases.

The full integration profile definitions including explanations can be found in Deliverable D2, chapter 4. Below, only a single actor-transaction diagram for the first integration profile is reproduced as an example. The corresponding diagrams for all high-level use cases are shown in section 3.1.4.

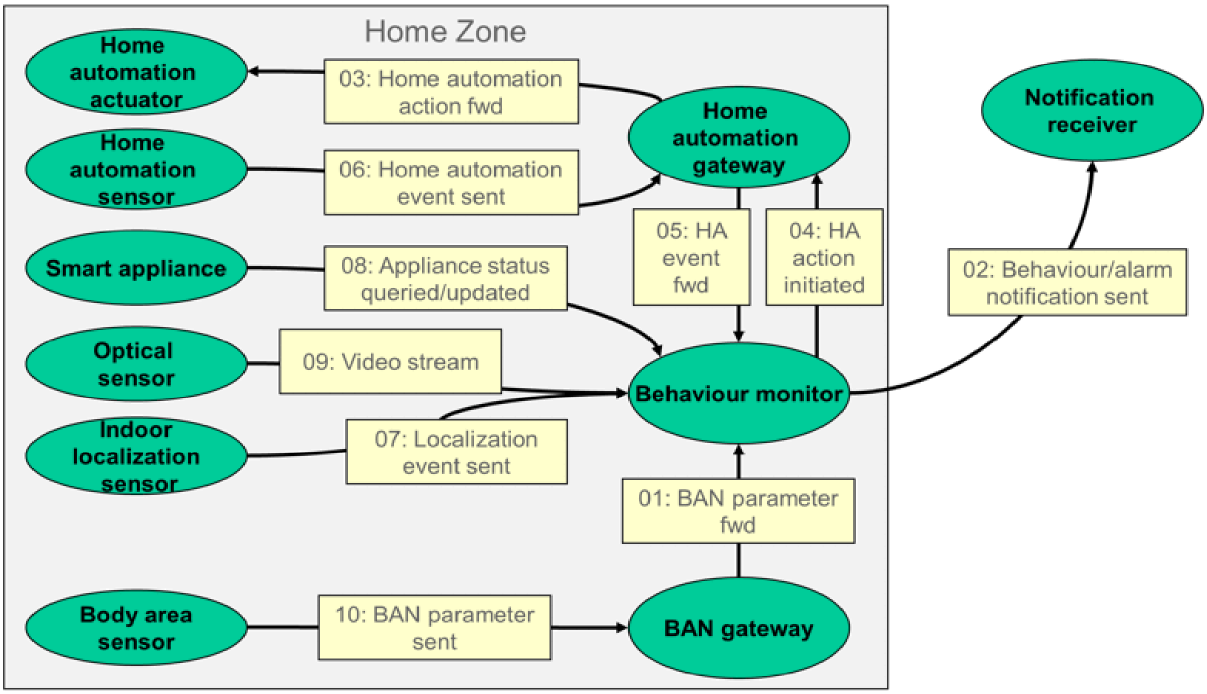

Figure 1: Behaviour Monitoring: Actors and Transactions

In the final phase of the technical work, a mapping to communication protocol standards was defined for each transaction of the integration profiles 1 and 5-7. These profiles were chosen such that components of the major domains of relevance for AAL (medical devices, home automation, communication with external parties outside the user's home) are involved. This mapping follows the structure of transaction definitions in the IHE Technical Frameworks. The following transactions were modelled in detail:

- Transaction 01: BAN parameter forwarded, based on the Continua design guidelines
- Transaction 02: Behaviour/alarm notification sent, based on SCAIP
- Transaction 03: Home automation action forwarded, based on KNX or ZigBee
- Transaction 04: Home automation action initiated, based on Universal Plug and Play
- Transaction 05: Home automation event forwarded, based on Universal Plug and Play
- Transaction 06: Home automation event sent, based on KNX or ZigBee
- Transaction 07: Localization event sent, Web service using the GPS Exchange Format
- Transaction 08: Appliance status queried/updated, based on CECED CHAIN
- Transaction 09: Video stream, based on ONVIF specifications
- Transaction 10: BAN parameter sent, based on the Continua design guidelines
- Transaction 25: PHR extract exported, based on IHE XPHR.

The critical part in the definition of transactions is the choice of communication protocol and content standards that together cover all seven layers of the ISO/OSI reference model. There is no simple way of guaranteeing that the best choice has been made, and the example of IHE shows that only implementation experience tells – often after a few years – whether or not a choice was appropriate. Furthermore it is well possible that for certain transactions no existing standard can be identified. In the transactions listed above, this affects transaction 07 "Localization event sent": no standard for the communication of indoor localization information could be identified during the work in this support action, instead a proposal for a simple protocol based on web services and a well-known specification for representing GPS coordinates was developed. For many of the transactions that were not modelled in detail in this support action, it is rather doubtful whether suitable standards exist, e.g. for shopping lists, the placement of shopping orders, whether forecast queries, reporting on activities of daily living recognized etc.

A final issue to be considered in the definition of transactions is the prevalence of competing, incompatible standards in fields where it may not be acceptable to choose a single standard and exclude all others. Examples for this problem include field buses for home automation, where at least three standards (KNX, LON, BACnet) cover large parts of the market and various newer competitors are also of relevance since they focus on wireless retrofittable technology (e. h. EnOcean, Zigbee, Z-Wave). In Transactions 03 and 06 this has been modelled by offering two alternative implementation paths (profile options): either a cable-based network (KNX) or a wireless network (ZigBee), where only implementations of the same option can be expected to interoperate. A similar choice must be made by implementers of Transaction 10, which is based on the Continua design guidelines. These offer different, incompatible options for connecting a sensor worn on the body to a mobile device: "conventional" Bluetooth based on the Health Device Profile, "low energy Bluetooth, which is arguably superior because of its lower energy consumption, but supports much fewer types of sensors and is not compatible, and cable-based connection using USB.

Finally, the integration between IT systems in the profiles has always been modelled in two alternative ways: Once using "conventional" syntactic interoperability standards such as UPnP or IHE transactions, and once using the universAAL middleware platform, which implements "semantic" interoperability based on the use of common ontologies, and offers interoperability at a different layer (API instead of wire protocol).

1.2 Workshops

The support action carried out two workshops: the workshop "Future-proof AAL Systems: from visionary use cases to standardised integration profiles" held on 19 November 2013 in Brussels, and the two-day conference on AAL and interoperability entitled "MACSI 2014: Managing AAL Complexity through Support for Interoperability" on 19/20 February 2014 in Brussels, which was a common activity with the EU projects universAAL, ReAAL, and Engaged.

The first workshop focussed on the dissemination of preliminary results of the support action (as available by November 2013) and discussions on how modularity and interoperability in AAL systems can be achieved, in the form of a "speakers' corner". The agenda was complemented by an external keynote on AAL and interoperability from the view of an industrial player. 31 persons participated to this workshop – this was the maximum number possible given the available room, but of course only represents a relatively small part of the AAL projects and companies active in the field of AAL. A summary of the workshop introduction and the invited keynote are available in section 3.2.2.

The discussion in the speakers' corner showed that privacy concerns are still an open topic in the AAL community. Hence, the IHE Profiles can – and have to be adapted to the European privacy requirements. It became clear that standardized AAL profiles have to reflect the market on one hand but have also to be very flexible to react to current developments of fast evolving AAL techniques on the other hand. As a consequence the standards should be specified as fine grained modules that reflect very basic transactions and are easy to implement for vendors. This enables vendors to spare time, when they adapt these standards in their products. Open standards that are available free of charge reduce the barrier for implementation as Open Source Software projects. This is also important for the vendors, because they are able to focus on their own applications. They can use already existing software components to implement them, without the need to implement every driver on their own. As long as the standards support their own business model the result will be a better market penetration for standardized AAL components.

Feedback was collected from the workshop participants using a feedback form. The workshop was overall rated rather positively by the participants, with all questions related to workshop organization and knowledge transfer receiving a dominant result of “very good” or “good”. The participants very much valued the opportunity to do networking during the lunch and coffee breaks, and also rated the discussion as very positive. The questionnaire also asked the participants to rate the benefit they perceive from the individual sessions / presentations. All sessions were rated rather positively, with “valuable” or “informative”, and there is no session that would show a significant accumulation of “less relevant” ratings. Some organisational shortcomings (primarily related to the registration process) were identified and taken into account for the second workshop.

In summary, a number of new opportunities were identified during the workshop. First of all, useful comments on the transactions and standards chosen were given by participants and used to further refine the integration profiles. Another important topic in the discussion was that currently integration profiles do not discuss *non-functional aspects*, with the exception of security requirements. AAL technology should not be discussed without keeping non-functional aspects such as ethical and privacy requirements of the system in mind. The structure of the integration profiles developed by this support action was, therefore, extended with a section on ethical and privacy considerations. Finally, one topic discussed that is not addressed by the support action is the issue of *standardised human-machine interface descriptions* that enable modular, individualised user interfaces adapted to the limitations and needs of each individual user. User interfaces are a topic that is deliberately ignored in IHE-style integration profiles, which focus on the machine-to-machine interfaces only. However, the point can be made that a similar approach could be adopted for “user interface integration profiles”, based for example on the technical work of the URC/Cloud4All or the AALuis project, both of which were represented in the workshop. Such a work would add an important additional “layer” for addressing the challenges of modularity and interoperability.

The second workshop was held on 19 February 2014 in Brussels. To achieve more impact along all stakeholder groups the projects of universAAL, ReAAL, Engaged and the AAL JP action decided to co-organise a two-day conference on AAL and interoperability, entitled “MACSI 2014: Managing AAL Complexity through Support for Interoperability”. This conference was held on 19/20 February 2014 in Brussels. This workshop was intended to raise awareness among the workshop participants about the need for interoperability in the field of AAL. This was achieved by the plenary sessions with keynotes from all relevant stakeholders, including industry (NICTIZ, DALLAS), European Commission, EIP AHA, standardisation bodies (represented by IEC SG 5) and end-user perspective (AGE).The dissemination part included an overview of the visionary use-cases that are the starting point for most projects, and the presentation of a methodology for formalising such use-cases into modular design guidelines called “integration profiles”. A summary of the presentations given during this workshop can be found in section 3.3.2. Finally it was intended to gather feedback from the participants on interoperability issues to influence the final project results. For this reason a speaker’s corner was put on the agenda. Due to the co-organisation of the event by 4 projects, there was a common invitation and registration process. 58 persons participated to the workshop, 29 of them to the supply side track (AAL JP) and 29 to the demand side track.

The workshop sessions organised by the support action each contained an interactive discussion element (“speakers’ corner”), allowing the workshop participants to discuss the workshop contents after listening to the presentations. Topics discussed included the creation of a community effort listing all standards and standardisation efforts of relevance for AAL, the development of an “interoperability by design” guideline that explains to researchers and developers on how to make sure that a system is interoperable, and the creation of a collection of success stories about projects that have successfully developed and deployed interoperable solutions based on standards. Participants discussed which organisation could take over responsibility for the further development and maintenance of integration profiles for AAL and identified IHE, Continua and IEC as possible “candidates”. Participants expressed their opinion that the AAL JP should not easily accept any more new platform developments in proposals; new projects should use existing platforms, or in case of new platforms, clearly explain the progress beyond the state of the art. It was also suggested that project proposals should explain the project’s impact on interoperability. The workshop participants were then asked to rate which integration profile should next be worked out in detail. The three profile proposals that received the highest number of votes were “Behaviour Monitoring”, “Assistive Robots”, and “Safety, data security and privacy of home”. The participants were also asked to rate which integration profile should be implemented as reference implementation. The highest number of votes was given to Integration Profile 01: Behaviour Monitoring, Integration Profile 06: Personal Trainer, and Integration Profile 03: Social Interaction with Smart TV.

Again, feedback was collected from the workshop participants using a feedback form. The participants rated the workshop rather positively overall, with the exception of the catering, which received more “fair” votes than “good” or “very good”. All presentations were rated rather positively, with “valuable” or “informative”, with the presentations about the results of the support action receiving in general better ratings than the plenary session presentations. Given the number of registrations for the workshop, which met the expectations of the organisers, and the overall positive feedback of the participants the efficacy of the workshop can certainly be rated as satisfactory, although some participants missed the workshop. The participants were introduced to the importance of modularity/interoperability through the opening sessions with invited talks, representing the political, industrial and standardisation point of view. However, with 29 participants in the AAL JP workshop and 58 participants to the whole event, only a relatively limited percentage of the projects and companies active in the field of AAL have been reached – even if the workshop participants have raised awareness for this topic, there are still many projects and organisations that have not been reached. Furthermore, 13 registered participants did not show up at the workshop without withdrawing their registration, thus blocking limited seats that might otherwise have been given to other participants.

The new opportunities identified during workshop were the most interesting integration profiles to work out in more detail, and the integration profiles voted by the participants to be most relevant for reference implementation (see above). The majority of the participants voted that integration profile 01 “Behaviour Monitoring” should be selected for a reference implementation. This is certainly a good idea, since behaviour monitoring is on the one hand one of the core topics of AAL and on the other hand combines multiple kind of technologies from hardware (stationary sensors, mobile sensors, gateways, home network) and software (sensor abstraction, interpretation of sensor data). Finally, one idea discussed by the participants was a collection of use cases in the sense of recommendations for implementing standards and which standard works well or not for a certain AAL problem. This would need some kind of moderated online platform where standards and AAL scenarios can be linked together and discussed.

1.3 Analysis of the Support Action

Participation to both workshops was satisfactory in terms of the number or registrations, which in both cases was close to the pre-defined number of seats available. In total, 36 participants from AAL-JP projects, representing 29 distinct AAL-JP projects participated to the workshops, with relatively little overlap in participation between workshops. While the numbers are satisfactory given the space and discussion time available during the workshops, only about 20% of the ca. 150 AAL-JP projects – past and present – have been reached.

The overall positive feedback received from the participants of both workshops gives rise to the expectation that the awareness for the importance of standards and interoperability in the design of AAL systems has increased among the workshop participants. The discussions showed that the approach to interoperability proposed by the support action (use-case based integration profiles) was not criticized at all – the discussions rather looked at how to further improve and complement the approach. To which degree the workshops will influence the future work of the participants and the projects represented is unclear, though.

The authors believe that the technical work done in this support action has achieved significant progress towards supporting standards-based interoperability in AAL. The analysis of the use case collection has for the first time provided suggestions for use cases suitable for standardization as an integration profile based on a quantitative analysis of the ideas ventilated in the use-case scenario texts written by AAL project participants from the AAL Joint Programme, EU FP6 and FP7. Furthermore, while the applicability of "integration profiles" to the AAL sector has been discussed as an idea at least since 2008, the work performed in this support action is – to the knowledge of the authors – the first attempt to really develop a set of comprehensive integration profiles for AAL use cases. The availability of a tangible set of integration profile proposals makes it much easier to promote the general idea behind this approach, as underlined by the significant interest the results of the project have found in the standardization "scene" (DKE in Germany, NICTIZ in the Netherlands, IEC Strategic Group 5 on international level – a presentation of the results of this project to IEC SG5 was given during their meeting in Brussels on 11 March 2014).
However, it is clear that the results of this support action can only be a first step in achieving interoperability in AAL.
The most important steps that need to be taken in the future are: further development, improvement and eventually formal standardisation of the integration profiles; further dissemination; and providing Implementation support through reference implementations, test tools etc. Finally, a certification programme, as offered by the Continua Health Alliance, might help customers to make better informed choices when selecting products, based on an independent validation of the product properties. However, for AAL such a certification programme is certainly rather a long-term goal.
In summary, we believe that this support action has provided useful contributions for addressing the challenge of standards and interoperability in AAL, but more work (by various actors) will be needed to fully achieve the goal of an interoperable ecosystem of AAL products, components and services. Practical suggestions for the next steps are discussed below.

1.4 Recommendations for Future Work

The following paragraphs contain practical recommendations for future work to follow-up on the results of this support action:

- **Interoperability as required topic for future AAL-JP projects:** We recommend to make it a contractual requirement for future AAL Joint Programme projects to address the issue of interoperability in an appropriate manner. As part of a project proposal, consortia could be required to write a section about "standards and interoperability", explaining which standards are of relevance for their topic, which ones they are aiming to implement, and how they plan to achieve an interoperability with other systems. As part of the description of work, one task resulting in one deliverable could be required that examines this topic in more depth during the course of the project. There may actually be good reasons for a project to not use available standards for a certain task, but this should have to be justified.
- **Further development of integration profiles:** Further development, improvement and eventually a formal standardization of the integration profiles developed by this support action is

needed in order to refine and complete the existing specifications; cover further use cases; achieve consensus about the profile specifications among stakeholders; and publish the integration profiles as a formal (industry or de-jure) set of standards. This work is the “core business” of standards bodies like CENELEC or IEC, and of industry standard committees such as IHE and Continua. The question is which organization would be willing to take up the work such that the outcome from the perspective of the AAL community is maximized. In terms of priority, the following indications can be given: 1. The biggest “missing link” to make the first integration profile interoperable is the mapping between the home automation standards (KNX and ZigBee) and the Universal Plug and Play Sensor Management specification. 2. Working out the transactions not defined in detail by this support action would make the remaining integration profiles implementable. 3. Developing integration profiles for further AAL use cases.

- **Reference implementation and test tools:** The success of integration profiles can be greatly enhanced by providing reference implementations for the transactions involved, preferably under an open-source license, and test tools that help developers assess the conformance of their implementations. Funding such implementations, to be published under a permissive open source license such as the BSD license, has shown to accelerate implementation of the related standards or profiles. Both IHE and Continua, and also other standards bodies like the DICOM committee, have funded such developments in the past. The development of test tools should be linked to the development of a reference implementation of a transaction, since a test tool will typically be closely related to an implementation of the underlying transaction, and its implementation requires the same knowledge.
- **Work on user interface modularity:** Standardised human-machine interface descriptions that enable modular, individualised user interfaces are an important topic that has not been addressed in the integration profiles developed by this support action, which like their IHE and Antilope counterparts focus on the machine-to-machine interfaces only. However, the point can be made that a similar approach could be adopted for “user interface integration profiles”, based for example on the technical work of the projects Universal Remote Console (URC, http://www.openurc.org/), Cloud4All (FP7) and AALuis (AAL-JP call 3). This work could perhaps be initiated by a different support action similar in scope and size to this one.
- **Collaboration between AAL JP and AAL Standardisation Bodies:** Standards and interoperability are an important topic for the further development of the AAL sector. The AAL Joint Programme –with its wealth of projects and topics, but also with the results of this support action – can certainly contribute important knowledge and experience to the international AAL standardization process, which is currently starting with the formation of an AAL Systems Committee by the IEC. On the other hand, this would be an opportunity to make sure that the needs of European AAL researchers and SMEs active in the AAL Joint Programme with regards to standards and interoperability get heard – and addressed – by standardization. We, therefore, recommend that the AAL Joint Programme becomes a member in the IEC Systems Committee on AAL to be founded in 2014. At the same time, it should be clarified if a representative from the standardization can perhaps become member of an advisory boards to the AAL Joint Programme, to make sure that interoperability and standards related topics are properly represented in future calls and projects.

2 Introduction

In May 2013, the AAL Joint Programme published a call for tenders for an "Action Aimed at Promoting Standards and Interoperability in the Field of AAL", i.e. a small project with a duration of about 6 months, starting in Summer 2013. The goals of this Action were defined as follows:

- **Make existing standards more easily accessible through use-cases:** Identify a set of use-cases covering the AAL domain, in particular covering the topics of all six calls for proposals published by the AAL JP until 2013; identify and match existing technical standards to these use-cases that can help promote interoperability; analyse these existing technical standards and provide guidance on their use for AAL JP projects and the wider AAL community.
- **Raise awareness of existing standards in the field of AAL:** Based on the use-cases, raise awareness of existing standards in the field of AAL by organising two workshops, including partners of AAL JP projects (all 6 calls) as well as the wider AAL community, i.e. stakeholders active in the field of AAL but not funded by the AAL JP (including all potential future applicants).

This document is the final report that summarizes the activities and results of this support action, analyses its effectiveness, and provides recommendations on future activities in this field.

2.1 Background

Ambient Assisted Living (AAL) can be described as *concepts, products and services that combine new technologies and social environment to improve the quality of life for people in all phases of life*. Its proponents see AAL as an important "building block" for addressing the challenges of the demographic change in most industrial countries (the so-called "aging society"), by using assistive technology to keep people at work productive and healthy, to keep people at home healthy, independent and integrated, and to improve the delivery of care where and when needed. Essentially, AAL uses technology combined with social services to extend the part of life where people are productive (at work) and independent (at home), and also to improve the quality of life for people in need of care (e. g. with chronic diseases.) Many AAL systems explicitly address older people as main user base, although the vision of AAL applies to all people with special needs.

Much research has taken place in this field over the last 10 years in Europe, and while significant progress has been achieved, the transfer of research results into wide-scale adoption is only starting to emerge (e. g. the ReAAL project, http://www.cip-reaal.eu). One reason for this fact is certainly the complexity of the topic, both in terms of technology and business models / logistics.
AAL systems consist of a combination of products and components from various industrial sectors (including medical technology, home automation, telecommunications and consumer electronics) and vendors, and their operation requires an "ecosystem" of service providers for planning, installation, maintenance, operation and service provision. Furthermore, as AAL technology is still rather expensive, it is of key importance that AAL systems are "future-proof", i.e. can be extended and maintained over a longer period of time, growing and adapting to the changing needs of the user. There is a very large variety of user need among older people, and at this time no vendor can offer a "one size fits all" product. This can only be achieved with modular solutions, where components (sensors, actors, but also complete AAL systems) can be combined in a flexible manner, just like Lego® building blocks. This becomes only possible with standardized interfaces between systems and system components, a property called "interoperability", i.e. the ability of components to work together in a seamless manner. It can be argued that *interoperability is a key requirement for the success of AAL solutions on the market*. A standardization of functions and interfaces simplifies the comparison of products or components before purchase, combinability during installation, exchangeability during maintenance, and retrofitting during extension of a system. The primary beneficiaries of such flexibility are, therefore, the users at the end of the value

chain, since a better comparability and exchangeability of components leads to more choice, more competition and, consequently lower prices. However, also vendors benefit from interoperability since they can flexibly combine their products and components with components from third parties to offer functionality not available in their own product range.

The issue of interoperability must be addressed on multiple layers. In the communications interface between two systems or system components, the network layer, message layer (syntax) and semantics layer as well as service interoperability from a user perspective can be distinguished, roughly following the layers of the ISO network reference model. If one considers the complete AAL ecosystem including the service aspects, interoperability is also required on a legal, process and policy layer. The “usual” approach to achieving interoperability is to reach consensus across the parties and vendors involved about the interfaces between systems and system components on the different levels, including both “hardware” interfaces between sensors, actors, and IT components on one hand, and “software” interfaces between software components (services) on the other hand. Such consensus is most often codified into standards (both legal and industry standards.) A multitude of such standards that are readily applicable to the “AAL world” exist already, covering all kinds of communication protocols. A repository created by the AALIANCE2 project[1] references more than 400 standards of relevance for the AAL sector. To some degree, this large body of standards creates a new problem: Which ones are relevant for a particular application or use case? Which standards are the best choices? Furthermore, most communications and network standards have been defined as “toolkits” that can be used to implement interoperable interfaces for many different use cases. In order to guarantee a wide applicability, many standards offer multiple “services”, “options” or “profiles” – typically only devices supporting the same service, option or profile are interoperable. As an example, two devices implementing both a wireless Bluetooth interfaces are not interoperable if one system implements the “health device profile”, and the other one implements the “serial port profile”, both profiles frequently used with medical sensors. Furthermore, a single standard will rarely cover all requirements needed to guarantee modularity and interoperability of the systems and components involved in a complete use case or application scenario. In this case, usually components from multiple standards need to be combined. In summary, communication standards are *necessary* for interoperable solutions, but they are not *sufficient*.

An approach that has been developed over the last 15 years to address this problem is the concept of so-called “*Integration Profiles*”. Integration profiles do not attempt to replace communication standards, but to close the gap between the individual communication standards, and the overall use case. Unlike communication standards, which try to support many different use cases, integration profiles are designed for one single use case: they describe the use case (application scenario) from a user perspective, identify the systems/components needed to implement or support the use case, and then enumerate the communication interfaces between the systems and components. Finally, the communication standards (and options, if needed) to be used for each interface are defined. From an implementer’s perspective, integration profiles can be seen as design guidelines or standards-based “cook books” describing how to implement a certain use case in a way that ensures interoperability from a user perspective. The following existing organizations develop integration profiles (for different industry sectors), although not all of them actually call their specifications “integration profile”:

- The Integrating the Healthcare Enterprise (IHE) initiative (www.ihe.net) has since 1998 developed and published about 100 integration profiles as part of their “technical frameworks”. Most of this work is focused on the integration of IT systems within hospitals, but there are some profiles addressing the exchange of health information between health professionals or between patient and health professional. Furthermore, the IHE “Patient Care Devices” domain develops

[1] http://nero.offis.de/projects/aaliance2/start

integration profiles describing how data from vital parameter sensors can be exchanged over local area or wide area networks, and these profiles may serve as "building blocks" in AAL scenarios. The most interesting integration profiles from an AAL perspective are the "XD* family" (XDS, XDR, XDM) and MHD, the Patient Care Coordination document formats (in particular XPHR) and the Patient Care Devices profiles.

- The Continua Health Alliance (www.continuaalliance.org) annually publishes the Continua Design Guidelines, which can also be considered a set of integration profiles. The guidelines cover the fields of health and fitness, chronic disease management and living independently, and are thus of immediate relevance to the AAL domain. It should be noted that Continua is closely collaborating with IHE and HITSP (see below).
- The Healthcare Information Technology Standards Panel (HITSP, www.hitsp.org) is a U.S. specific initiative that aims at harmonizing and integrating standards that will meet clinical and business needs for sharing information among organizations and systems in the healthcare sector. HITSP publishes a comprehensive set of specifications that are freely available and, on a technical level, mostly based on the work done by IHE and Continua. The HITSP Interoperability Specifications describe many use cases and contain very useful high-level information that is mapped to requirements and, from there, to a selection of standards.
- The Digital Living Network Alliance (DLNA, www.dlna.org) develops interoperability profiles for multimedia applications, based on UPnP, and offers a certification program for compliant products. More than 18,000 different products have been certified, and there is an installed base of ca. 440 million certified devices. The DNLA Networked Device Interoperability Guidelines have been published as IEC 62481.

In the eHealth sector, the epSOS project (http://www.epsos.eu/) and the Antilope project (www.antilope-project.eu) have both adopted this approach. Finally, the German project RAALI ("Roadmap AAL Interoperability") should be mentioned: RAALI has developed an approach for describing integration profiles that is specifically adapted to the needs of the AAL domain, and is inspired by the international standards IEC 61131-3[2] and IEC 61499-1[3]. This approach is currently being published in Germany as a multipart "VDE application guide" (which essentially is a national pre-standard) VDE-AR-E 2757-6-1 Ambient Assisted Living (AAL) – Representation of integration profiles – System planning point of view and VDE-AR-E 2757-6-2 Ambient Assisted Living (AAL) – Conceptualisation of integration profiles. Unlike the IHE profiles, the RAALI approach can also describe interfaces that continuously deliver data (such as analogue sensor output), whereas IHE profiles implicitly assume event-driven communication where a real-world event triggers the transmission of a message over an interface. However, for sake of easier integration with the work being done in epSOS and Antilope, in this support action the IHE approach for modelling integration profiles was chosen. The technical approach and the results are described in more detail in section 3.1.

3 Summary of the Support Action

The support action started with an "inception phase" in which the approach to the technical work and the goals of the dissemination activities were defined in detail. The results of this phase, as amended during the inception meeting with the AAL association, were document in Deliverable D1 "Inception Report", which served as a "description of work" for the support action. In brief, the goal of "making existing standards more easily accessible through use-cases" was addressed by the technical work, which is summarized in section 3.1, and has resulted in Deliverable D2 "AAL Use Cases and Integration Profiles". The goal of "raising awareness of existing standards in the field of

[2] IEC 61131-3: 2013 Programmable controllers - Part 3: Programming languages
[3] IEC 61499-1: 2012 Function blocks – Part 1: Architecture

AAL" was addressed by the preparation and performance of two public workshops, to which participants from all AAL Joint Programme projects were invited. During the workshops the technical work of the support action was presented and the participants' experiences and problems with standards and interoperability were discussed. The workshop results are summarized in sections 3.2 and 3.3.

3.1 Use Cases and Integration Profiles

This section summarizes the technical work of the support action on collecting and analysing use cases, deriving representative use cases and formalizing these into so-called integration profiles. The full results of this work are available in the public Deliverable D2: "AAL Use Cases and Integration Profiles", so this section is only a brief summary.

The approach followed in this support action is similar to the approach employed by IHE or the Antilope project: we collected, and then selected the most important use cases, we formalized use cases by identifying actors, transactions, process and data flow, and we mapped transactions to communication standards (and options where necessary). The resulting integration profiles were documented in a structure similar to that of IHE integration profiles and Antilope use cases. For each call topic of the AAL Joint Programme, at least one high-level integration profile (i.e. an integration profile without a mapping of the transactions to standards) was devised, and for four of them the transactions were also defined in detail. The AAL-JP call topics were: "Prevention and Management of Chronic Conditions"; "Social Interaction"; "Independence and Participation in the Self-Serve Society"; "Mobility"; "(Self-)Management of Daily Life Activities at Home"; and "Occupation in Life".

3.1.1 Collection of Use Cases

Many AAL projects have tried to describe their vision of ambient assisted living in the form of a "use case" or "storyboard", i.e. the story of a fictitious user of the AAL system to be developed. These storyboards form the starting point for the development of integration profiles. The following example is taken from the BRAID collection of "ICT & Ageing Scenarios" [Bra2011]:

> Thomas is a 70 years old person that despite his age feels healthy and eager to remain active as long as possible. Unfortunately, ten years ago, Thomas suffered a car accident that besides immediate severe injuries also left him with permanent ones, namely the need of having daily oxygen breathing and the need to use a wheelchair for the rest of his life.
>
> Along with other sensors and equipments Thomas wheelchair makes use of sonar technology to detect obstacles and modify his driving commands to ensure that the platform does not collide with any obstacle. Also the smart wheelchair is equipped with robotic manipulators, which can be used to manipulate common household objects.
>
> With the aim of improving his quality of life, Thomas installed at his home a system that manages the quality and quantity of oxygen that is needed. Also, in order not to be dependent from others for transportation, Thomas managed to buy a car adapted to his health condition. When Thomas arrives at home, and as his car is equipped with an automated parking system, he manages to activate the system relieving him from many difficult manoeuvres. When the car stops, it begins the procedures to un-dock the smart wheelchair and starts moving towards the house. Through the control panel of his smart wheel chair, Thomas can activate the oxygen system so that shortly after he can start to receive the necessary dosage of oxygen.

A total of 332 such use cases have been collected from a number of sources, including deliverables of AAL Joint Programme projects, public deliverables of FP6/FP7 AAL research projects, The collection of "ICT & Ageing Scenarios published by the BRAID project, The AALIANCE roadmap, the Antilope use cases (which are based on the eHealth European

Interoperability Framework). The use cases were documented in a structured manner in a Wiki system using a template devised by IEC Strategic Group 5 “Ambient Assisted Living”. The public part of this “collection” has been made available in Deliverable D7.

3.1.2 Keywords for the Analysis of Use Cases

In order to systematise and analyse the collection of storyboards (or use cases), a number of keywords were assigned to each use case to describe the main purpose of the AAL system described there (such as compensation of a certain physical function loss, support of activities or participation, security/safety functions etc.), the stakeholders involved in the scenario, and key enabling technologies (such as indoor location services, robotics, home automation etc.) appearing in the scenarios. For this purpose, a multi-dimensional, hierarchical taxonomy for indexing the texts was developed, using the following dimensions:

- User-centric keywords:
  - Body function addressed by the AAL system (based on the WHO ICF classification)
  - Activities and participation supported by the AAL system (also based on WHO ICF)
  - Functionality of AAL systems addressing the workplace
  - Stakeholders appearing in the use case
- Technical keywords:
  - Purpose of the system (other than supporting body function or activities/participation)
  - Key enabling technologies used

The full set of keywords can be found in Deliverable D2, section 2.2.

3.1.3 Analysis of Use Cases by AAL-JP Call Topic

For each of the six call topics of the AAL Joint Programme, a list of keywords matching the respective call topic were identified, and the number of use cases that had been assigned each keyword was determined. Keywords appearing in many use cases represent system functions or body functions/activities supported by many of the AAL systems described in the use cases, and, therefore, are arguably a good basis for work towards a standardization of use cases as they cover the most frequent themes and project goals. Therefore, for each call topic the most frequently used relevant keywords were chosen, and all use case texts related to these keywords were manually re-examined with the goal of condensing them into a new, “representative” use case. For this purpose, the individual assistive functions appearing in the use case texts, such as for example “behaviour monitoring”, “fall detection”, “indoor localization”, “intelligent calendar”, “outdoor pedestrian navigation” etc. were identified and also sorted by frequency of appearance, to identify the most common ideas on assistive functions for each call topic. These were then used as a basis for the selection of the key topic of each representative use case. Each representative use case was then also written using the IEC SG5 template structure (which has a narrative text at its core), and also a technical description of each representative use case was developed. The full representative use case can be found in Deliverable D2, section 2.4. Below, only the narrative texts for the seven representative use cases are reproduced:

- **UC R01: Behaviour Monitoring:** Jane Miller is an 85-year old lady who still lives independently in her own apartment. Since her husband has passed away a few years ago she lives alone. Her children live some 50km away, close enough to see her once or twice a week, but not every day. Despite several chronic diseases that require her to take many different drugs three times a day, she is doing relatively well. However, recently she has started to forget things and make mistakes that were unheard of before. The family doctor has diagnosed her with a mild cognitive impairment, i.e. an early form of dementia that may or may not worsen over time. A few months ago she switched on the cooker, forgot about it, and went shopping. The cooker caused a fire in the kitchen that could well have burned down the house - fortunately it was discovered and extinguished quickly, before serious damage could occur. Since then her family is worried that a similar accident has happened, and with her consent had a “behaviour monitoring” system installed in her home. The system consists of several sensors that are mounted to the walls, and a small computer that processes the sensor data. Most of the time the system is silent, but it monitors her activities and notifies her if something that is potentially dangerous, happens. Last week she again started cooking, but since the water took rather long to boil, she went to the living room, switched on the TV, and forgot about the kitchen. 15 minutes later the system displayed a message on the TV reminding her of the cooking water. When she opens the front door in order to leave the house, the system reminds her if windows are still open, electrical appliances in the kitchen still switched on, etc. There is also a new switch next to the front door that allows her with one press to bring the house into a “safe” configuration, with everything switched off and electrical lighting reduced to a safe minimum. Should she ever fall at home, and not be able to get up, then the system would automatically notify an emergency call service, which would then first try to call her on the phone, and then send somebody to look after her. The system can be extended with some sensors worn on the body, in which case the fall detection would also work outside, but she prefers not to use this at the moment. Finally, the system recognizes when there are changes in her daily activity patterns that indicate an increased need for support, such as an overall reduction of physical activity, or lack of certain activities of life, such as cooking. In this case a notification would be sent to her daughter, who could then look for appropriate support.

- **UC R02: Calendar Service:** Jane Miller is an 85-year old lady who still lives independently in her own apartment. Since her husband has passed away a few years ago she lives alone. Her children live some 50km away, close enough to see her once or twice a week, but not every day. She has recently been diagnosed with a mild cognitive impairment, i.e. an early form of dementia that may or may not worsen over time. Since she tends to forget things, such as taking her medicine, and because she knows that maintaining social and physical activity is important to keep her independent as long as possible, she has agreed with her family to have a calendar service system installed in her home. The calendar service regularly scans the internet for community events in her city that she might be interested in and suggests these to her. If she agrees, a reminder is automatically added to her calendar. The system also retrieves the weather forecast and, if there is good weather, suggest to her to take a walk outside if she has not left her home for too long. Perhaps most importantly, the system reminds her to take her medicine three times a day. The system is coupled with a drug dispenser that is filled every week by her daughter, and a reminder is generated by the calendar whenever she forgets to take the next box of pills out of the dispenser when it's time. Should she still forget to take her medicine despite the reminders, a notification would be sent to her daughter after two days, who could then see what the problem is. The events on her personal calendar are kept in “the cloud” - in her case, on Google calendar, so that also her daughter can create entries and reminders there. Finally, since she also has a “behaviour monitor” installed in her home, that system is coupled with the calendar and notifies the calendar service about the activities of daily living (such as the morning toilet, bathing, cooking, eating etc.) that were recognized by the system. Should her mental impairment worsen to an early form of dementia, the system would also remind her of activities of daily living she might have forgotten (such as brushing her teeth, opening the windows from time to time to let in fresh air, or simply the fact that it's time for the next meal). Fortunately, she does not need this functionality yet, but she understands that this will make it possible for her to live at home independently for a longer time than without this technology, should her condition worsen.

- **UC R03: Social Interaction with Smart TV:** Peter is an 83 year old person living in the suburbs of a big German city. His wife died 4 years ago and his son Michael has moved to another city about 200 km away. He is suffering from lung cancer, frailty and is not good on feet anymore. In the past he never got used to computers and mobiles but since the new generation of smartphones and tablets with touch screen have been available, he is keener on technology. In addition he owns a new smart TV with some additional functions like video conferencing, internet browsing and online gaming. His smart phone is connected to the TV and can be used as remote control, game controller but also has a “panic button app” installed, which he can use in emergency situations inside and outside his home. A nursing service nearby is hosting this service. Peter loves to use video conferencing in the evening to chat with his son Michael and his wife Julia as well with his three grandchildren. Sometimes he calls his good friend Horst who has moved to Spain, and they talk about the good old times or play cards. Today Peter has a video call with his general practitioner to talk about his latest lab results. Since there is no need for any other examination they both agreed on this video call. After the call Peter decides to buy some food in the supermarket up the road. He picks up his walker and uses the elevator. As the weather is very good today, he takes the route through the park. While he is walking along the little lake he is feeling dizzy and he decides to take a rest on his walker. He takes out his smart phone and presses the panic button. After a few seconds a carer responds his emergency call. As the smart phone has a localisation application installed, the carer can see where Peter is and speaks to him. Since Peter is complaining of dizziness and seems to start panicking, the carer sends out an ambulance to pick him up. As he is already feeling better by the time the ambulance arrives, they bring him back home. With the help of his smart TV he orders his food from the supermarket's shopping service. In the evening Peter calls his son Michael and tells him about the incident in the morning. Michael decides to give his father a visit at the weekend.
- **UC R04: Shopping and Nutrition Planner:** Michael is 72 years old, lives on his own and suffers from mild cognitive impairment (MCI). Due to MCI he often has problems with healthy nutrition and related shopping tasks. A few weeks ago his son Klaus installed the new shopping assistant on Michael’s smart TV and mobile phone. The shopping assistant can be used for home shopping as well as for the assistance of normal shopping. There are also some upgrades available, one is on malnutrition and one with reminder functions. Michael is able to plan his shopping trip with the smart TV sitting on the couch or with his smart phone at any place. The shopping assistant recommends more fruits for Michael and put some apples and bananas on his shopping list. The system also knows that the stock of sparkling water is running out. As Michael is not able to carry heavy beverage crates any more the system sends an automated order to the next beverage store. As Michael is not leaving his home (a door contact is monitoring the front door) the shopping assistant reminds him for his shopping trip. Michael leaves his home and the shopping assistant on standby to navigate if Michael is leaving his normal route for a longer period of time. In case of bad weather or feeling discomfort Michael can use the home shopping application out of his living room. The home shopping application includes several regional providers of food, clothes and other articles of daily use. Michael places his order in the system and, depending on time of the day, up to 6 hours the items are delivered.
- **UC R05: Mobility Assistant:** Clara is a very active person. She uses her free time for long walks in the “hood” like it’s been called by her grandchildren. She loves these excursions, because they make her feel strong and independent even though she uses her beloved walker. Although the nice Doctor Hibbert told her that walking is very healthy and that she should walk as long as she likes. To view the change of the seasons had always been fascinating her. But in this year’s autumn as leafs changed their colours she forgot to drink enough before her walk and became a little disoriented and also felt a weakness in her legs. She began to ask herself what would happen if she would have slipped and fell so far away from home. Clara discusses

her concerns with her son-in-law Jerry. He is in the computer business and tells her about a new device that she can use to “update” her current walker. Jerry explains that this convenient “mobility assistant” can be easily attached to her walker. The device shows a big red button which she can press if something happens and that she will get help immediately. Clara thinks that this is a nice and easy to use thing, but normally she has a sharp mind and is not like other “old” people who forget everything. So she tells Jerry that this button is ok, but it won’t help her, if she would be unconscious and could not get up to press it. Jerry smiles as if he anticipated her thought. He tells her that this special assistant has the ability to detect dangerous situations and would call an emergency contact immediately. Even more, this small thing is also able to record vital parameters like the machines in Doctor Hibbert’s office. Clara is impressed but also a little bit sceptical how Doctor Hibbert would know about this information, when she is not in her office. Although she is an independent person who does not want that the Doctor sees all of her medical information without asking her. Jerry tells her that she is absolutely right to have her privacy whenever she wants. He explains to her that the assistant would communicate this medical information only to a thing called “Personal Health Record” which is like a safe for her data. Only, if she decides to show some of her data to Doctor Hibbert this thing would transfer it to him. She even can control it with her old but well-known TV remote control. Clara is convinced and curious about this new thing. She rejects Jerry’s offer to bring her to the store happily, as she wants to walk there by herself.

- **UC R06: Personal Trainer:** Frieda has become a little fragile in the last years. She feels that it is harder to be really active during the day. Many household activities slowly became a big burden for her. Her Doctor said that she should continue her activities as long as she can. So, the doctor gave her a little device that she wears on her wrist and that tracks her physical activity. Her Doctor also gave her a small box which is connected to her TV. She doesn’t know anything about this technical stuff, but her son Hubert installed the box for her. Hubert told her that the box helps her to get help whenever she needs it. The box also shows her videos with little tricks which she can apply to simplify the performance of household activities and her activities of daily living (e.g. dressing herself). It also suggested special workout training. She already bought herself a bicycle ergometer which she can now use to drive her personal training plan. Also, the box plays some small games with her, which is exhausting but fun. She tried this stuff a few months and soon she realized that she became fitter and even more secure when she performs her daily activities.
- **UC R07: Environmental Health Monitoring and Alarms at Work:** Manuel works auxiliary industries for a medium size paint shop producing parts for the automotive industry. He is responsible for clamping and releasing parts from the fixation for the powder coating machine. As he just working on another part the red lights begins to flash and a siren signal occurs. One second later his mobile emergency device which is mounted to his belt also begins to vibrating and beeping. The environmental sensors have detected a dangerous concentration of air pollution in his area. Despite his protection clothing and mask he immediately leaves the polluted area. Doors and windows are automatically opened to release the polluted air. Manuel waits in the break room until the dangerous situation is over. He suddenly feels dizzy and his sensor vest with an integrated ECG detects ventricular fibrillation. Since Manuel had myocardial infarction (vulg. heart attack) in the past, he is additionally equipped with this device. His mobile emergency device immediately sends an alarm message to the work fire service including Manuel’s current location. They soon arrive to the break room and give first aid until the emergency physician arrives.

3.1.4 Process of Defining Integration Profiles

In this phase, a semi-formal description showing systems and system components (“actors”) and interactions between these components (“transactions”) was derived from the representative use

cases. The idea of modelling an integration profile is to only identify components based on a specific function that they contribute to the overall system, components that could be implemented as a separate product (software or hardware). The internal functionality (e. g. algorithms, user interface concept) of an actor is not considered in an integration profile – an actor is considered as a “black box”, only the interfaces of which are defined.
While in the eHealth sector this concept has been used with much success for the last 15 years, one significant difference of AAL is that no established product base exists in the AAL market. For example, the boundaries of an actor in one of the IHE integration profiles typically follows established product categories: An IHE “Admission/Discharge/Transfer” actor is typically a functionality offered by Hospital Information Systems, an IHE “Order Filler” actor is typically identical to a departmental information system such as a Radiology Information System, and an IHE “Image Manager” is typically the archive component of a PACS (picture archiving and communications system). In contrast, in AAL it is not yet completely clear where the boundaries of products and product components will be. As an example: Will sensors such as presence detectors or temperature sensors be implemented as simple components transmitting their measurements over an analogue line or simple protocol (e.g. Bluetooth serial port profile), or will there be a computing node combined with each sensor, such that each sensor becomes an intelligent “node” in a partly or fully distributed sensor network? The Continua Design Guidelines [Con2012] are based on the first approach and the universAAL middleware system [HMH+2011] on the second one. This is a decision that needs to be taken for the definition of an integration profile, and, therefore, will necessarily reduce implementation choice. For the integration profiles to be developed during this support action, both approaches were worked out as alternative options of the integration profile.
Once the actors and transactions are defined, the high-level process and data flows are defined, for example as a series of UML sequence diagrams showing alternative sequences of events and the involved process and data flows. As a rule of thumb, not all possible sequences of events can be described, but the most important – both regular and irregular – sequences should be described, including the expected behaviour of the actors. The results of this phase are seven “high level integration profiles” corresponding to the seven representative use cases. For each profile, the following information is defined:

- Rationale: introduction, purpose and scope
- Actors and transactions
- Profile options (optional features and alternative implementation paths)
- High-level process and data flow
- Ethical and legal considerations

The full integration profile definitions including explanations can be found in Deliverable D2, chapter 4. Below, the actor-transaction diagrams for the seven integration profiles are reproduced in order to provide an overview of the profiles (Figure 2 to Figure 8):

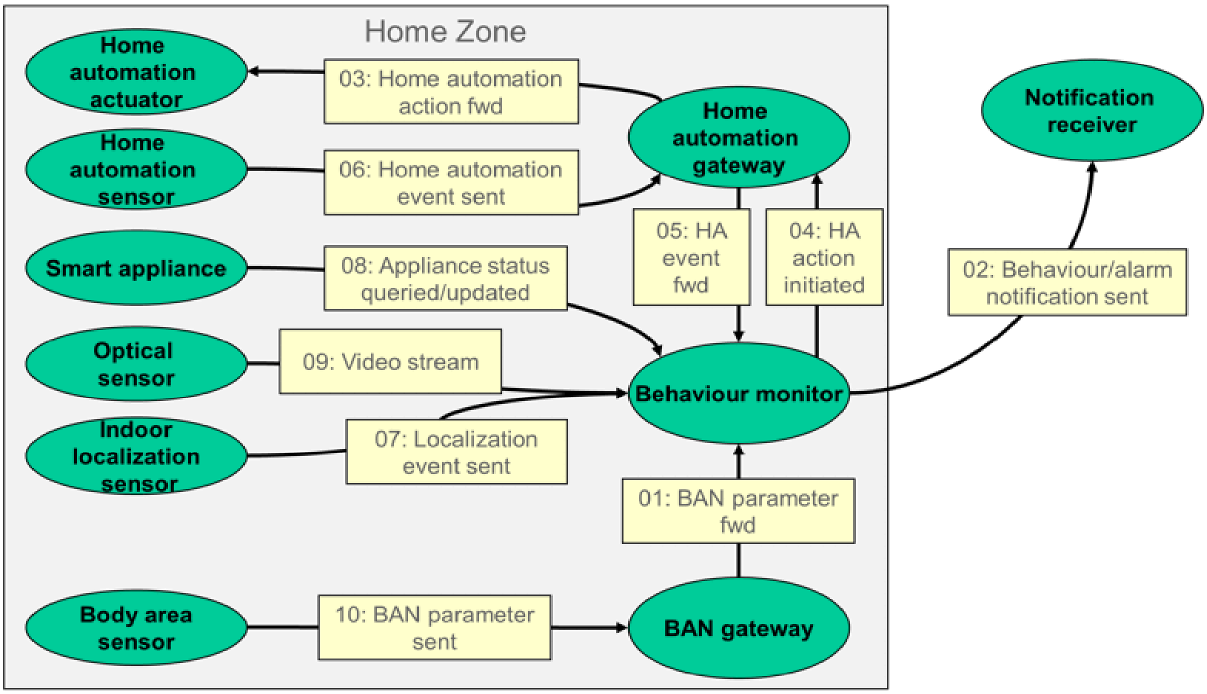

Figure 2: Behaviour Monitoring: Actors and Transactions

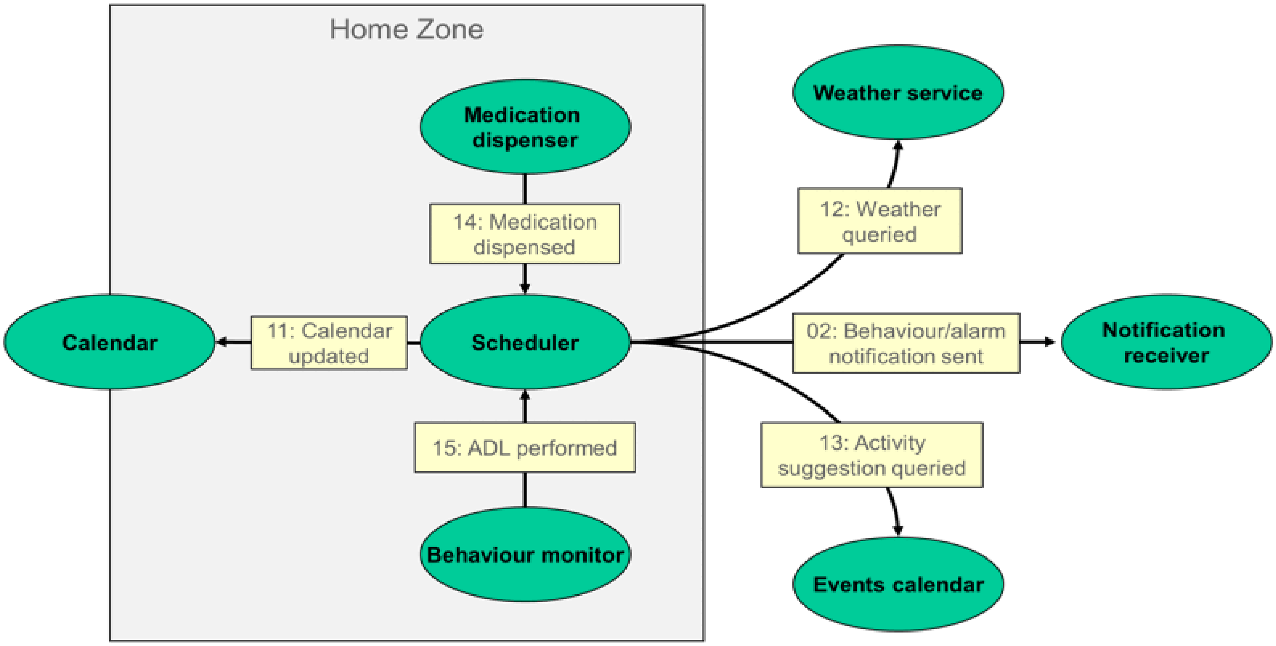

Figure 3: Calendar Service: Actors and Transactions

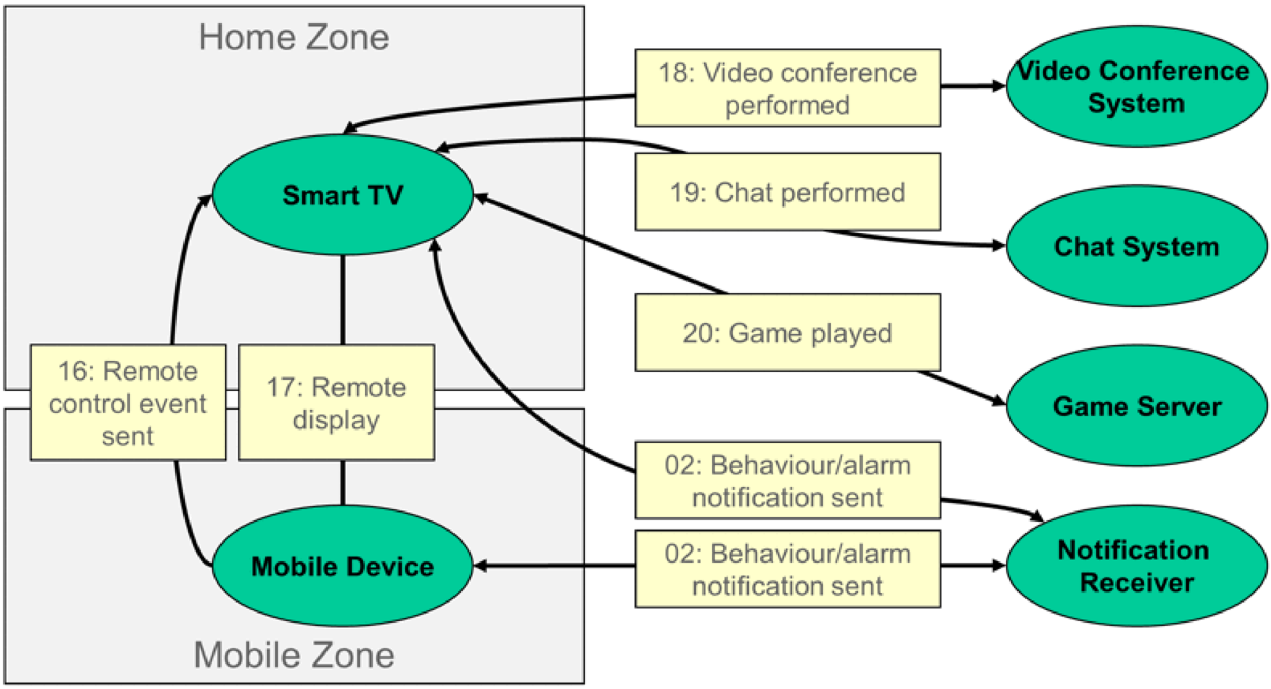

Figure 4: Social Interaction with Smart TV: Actors and Transactions

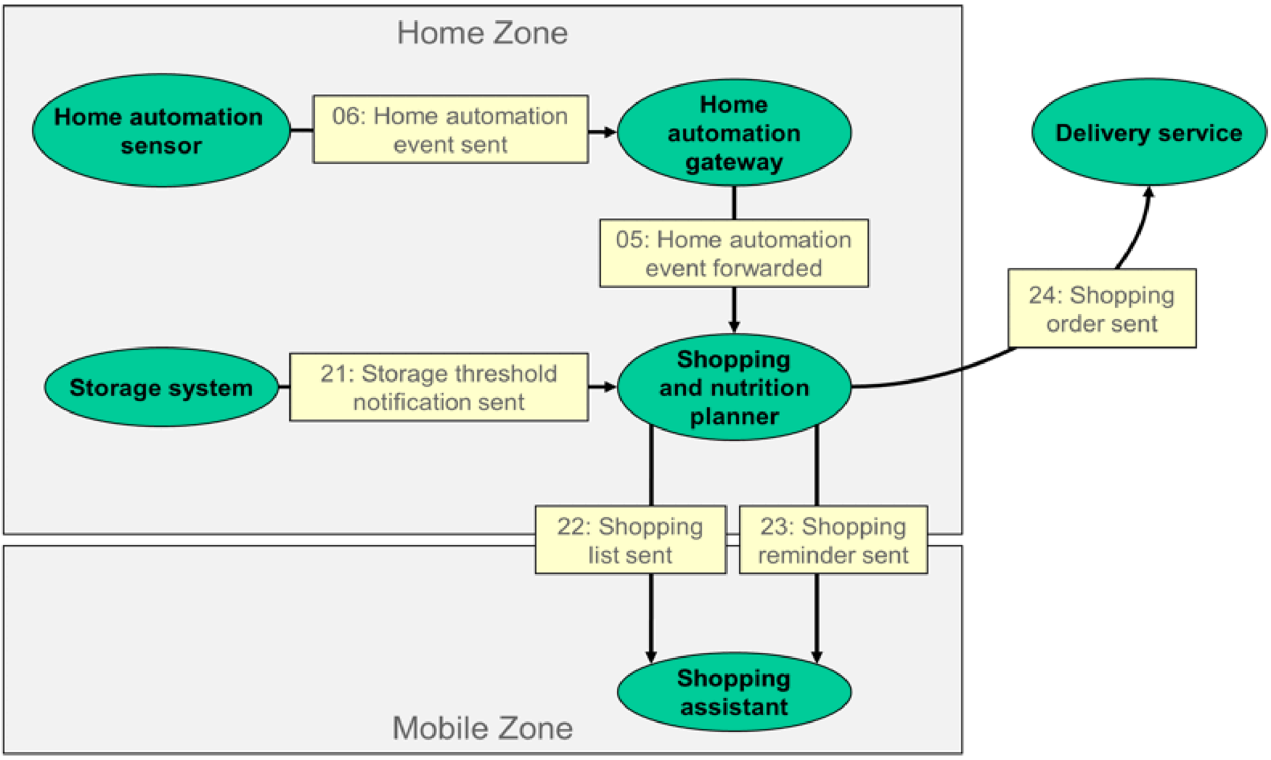

Figure 5: Shopping and Nutrition Planner: Actors and Transactions

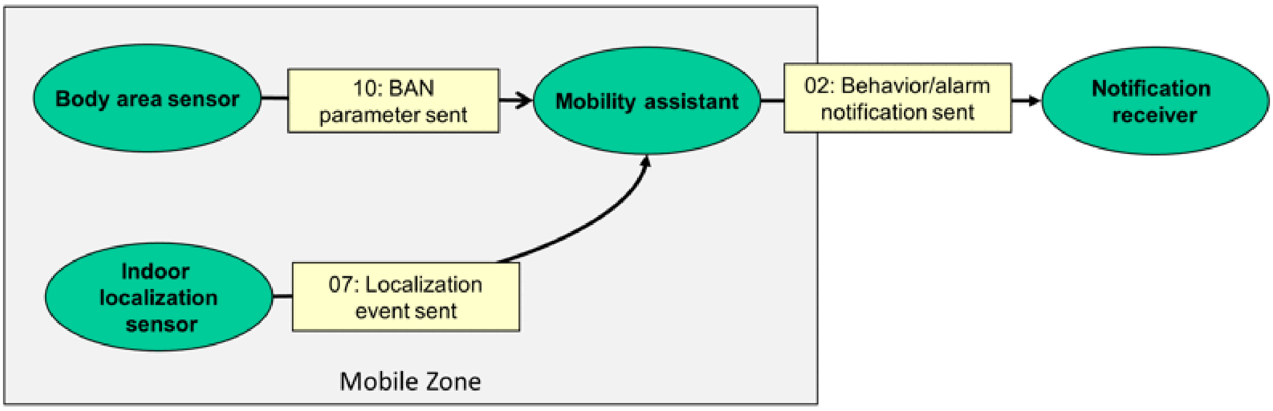

Figure 6: Mobility Assistant: Actors and Transactions

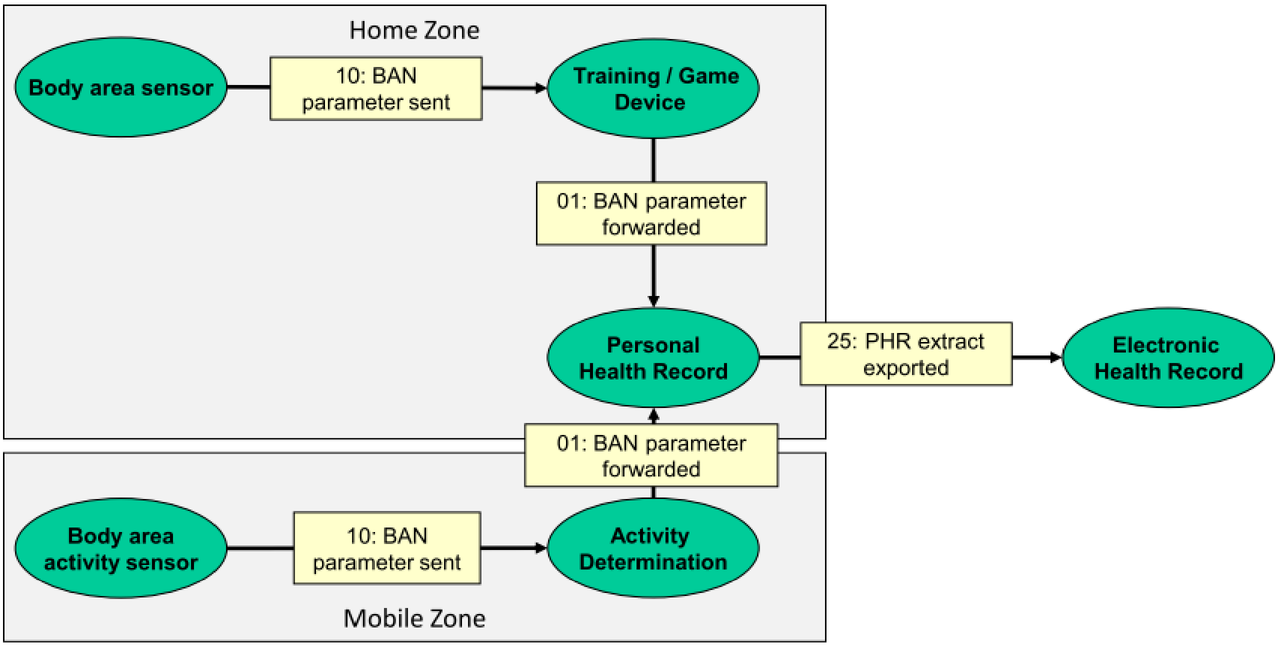

Figure 7: Personal Trainer: Actors and Transactions

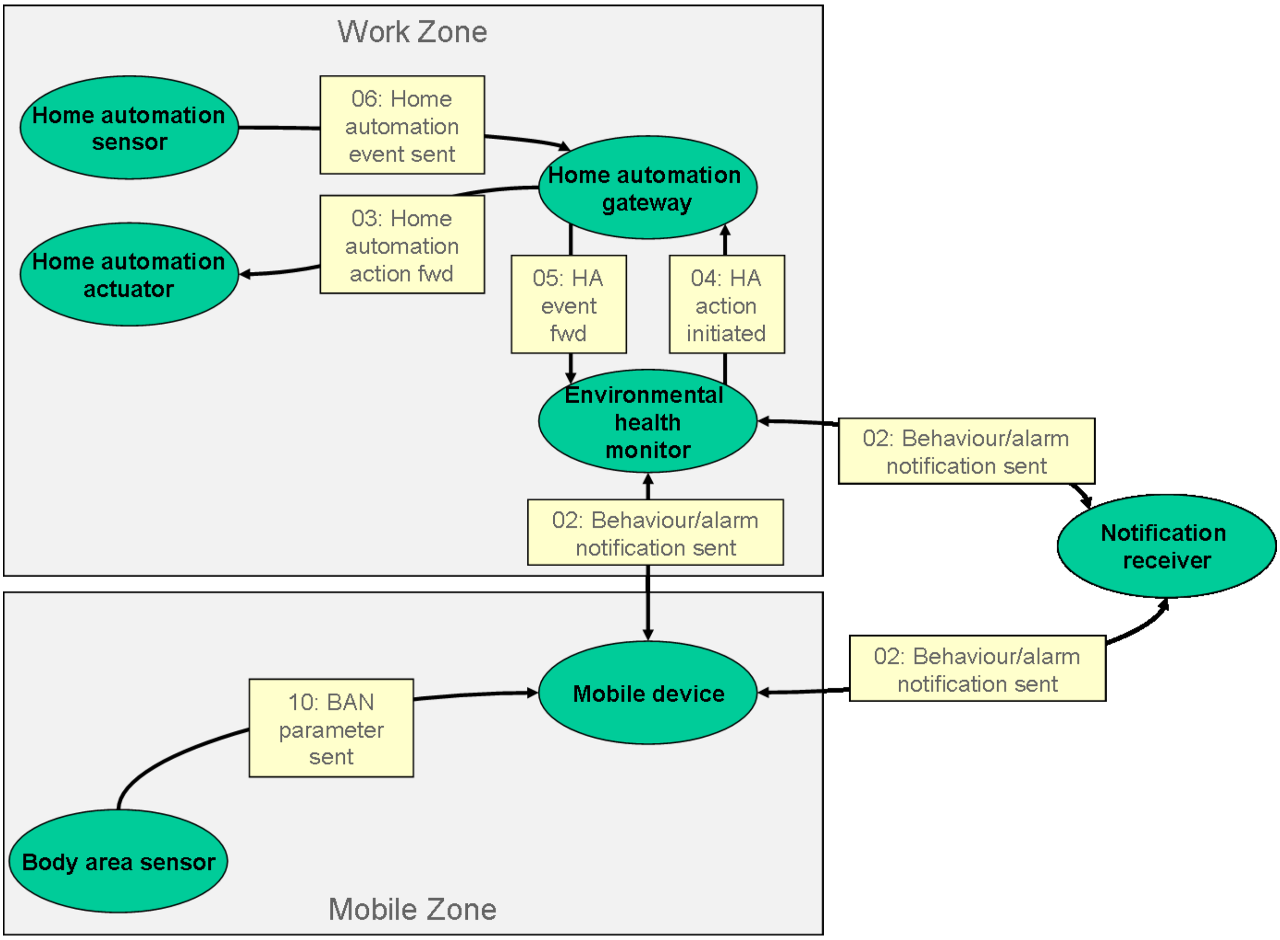

Figure 8: Environmental Health Monitoring and Alarms at Work: Actors and Transactions

3.1.5 Mapping to Standards and Options

In this final phase, a mapping to communication protocol standards was defined for each transaction of the integration profiles 1 and 5-7. These profiles were chosen such that components of the major domains of relevance for AAL (medical devices, home automation, communication with external parties outside the user's home) are involved. This mapping follows the structure of transaction definitions in the IHE Technical Frameworks:

- *Scope*: A brief scope statement describing the purpose of the transaction
- *Use Case Roles*: A UML use case diagram showing the actors involved in the transaction, followed by a brief description of the role performed by each actor.
- *Referenced Standards*: A list of references to the standards that are used to define the transaction.
- *Interaction Diagram*: A UML sequence diagram showing the messages involved in this single transaction. For each message, separate subsections define the following properties of each message exchange:
- *Trigger Events*: Circumstances under which this message is transmitted
- *Message Semantics*: Detailed description of the message, including additional requirements that go beyond the minimum set of requirements defined by the standards in terms of options and optional fields that need to be supported by the sender or receiver for this particular message in the context of this transaction and trigger event.

- *Expected Actions*: Colloquial description of the actions expected by the involved actors upon transmission of the message.
- *Protocol Requirements*: Additional requirements on the implementation of the communication protocol standards that are common to all messages of the transaction can be enumerated in this optional section.
- *Actor Requirements*: Actions expected by the involved actors upon execution of the message (i.e. behaviour that is related to the complete transaction and not individual messages) can be described in this optional section.
- *Security Considerations*: In this optional section, security considerations concerning the transaction, such as additional requirements when executed over a public network, logging requirements etc. can be described in this section.

The following transactions were modelled in detail (for each transaction below the main standard chosen as the communication protocol is given):

- Transaction 01: BAN parameter forwarded, based on the Continua design guidelines [Con2012]
- Transaction 02: Behaviour/alarm notification sent, based on SCAIP [Sca2012]
- Transaction 03: Home automation action forwarded, based on KNX (EN 50090) or ZigBee [Zig2013]
- Transaction 04: Home automation action initiated, based on Universal Plug and Play [Upn2013]
- Transaction 05: Home automation event forwarded, based on Universal Plug and Play
- Transaction 06: Home automation event sent, based on KNX or ZigBee
- Transaction 07: Localization event sent, Web service using the GPS Exchange Format [GPX]
- Transaction 08: Appliance status queried/updated, based on CECED CHAIN (EN 50523)
- Transaction 09: Video stream, based on ONVIF specifications [Onv2013]
- Transaction 10: BAN parameter sent, based on the Continua design guidelines
- Transaction 25: PHR extract exported, based on IHE XPHR [IHE09].

The critical part in the definition of transactions is obviously the choice of communication protocol and content standards that together cover all seven layers of the ISO/OSI reference model. There is no simple way of guaranteeing that the best choice has been made, and the example of IHE shows that only implementation experience tells – often after a few years – whether or not a choice was appropriate. Furthermore it is well possible that for certain transactions no existing standard can be identified. In the transactions listed above, this affects transaction 07 “Localization event sent”: no standard for the communication of indoor localization information could be identified during the work in this support action, instead a proposal for a simple protocol based on web services and a well-known specification for representing GPS coordinates was developed. For many of the transactions that were not modelled in detail in this support action, it is rather doubtful whether suitable standards exist, e.g. for shopping lists, the placement of shopping orders, whether forecast queries, reporting on activities of daily living recognized etc.

A final issue to be considered in the definition of transactions is the prevalence of competing, incompatible standards in fields where it may not be acceptable to choose a single standard and exclude all others. Examples for this problem include field buses for home automation, where at least three standards (KNX, LON, BACnet) cover large parts of the market and various newer competitors are also of relevance since they focus on wireless retrofittable technology (e. h. EnOcean, Zigbee, Z-Wave). In Transactions 03 and 06 this has been modelled by offering two alternative implementation paths (profile options): either a cable-based network (KNX) or a wireless network (ZigBee), where only implementations of the same option can be expected to interoperate. A similar choice must be made by implementers of Transaction 10, which is based on the Continua design guidelines. These offer different, incompatible options for connecting a sensor worn on the

body to a mobile device: "conventional" Bluetooth based on the Health Device Profile, "low energy Bluetooth, which is arguably superior because of its lower energy consumption, but supports much fewer types of sensors and is not compatible, and cable-based connection using USB.
Finally, the integration between IT systems in the profiles has always been modelled in two alternative ways: Once using "conventional" syntactic interoperability standards such as UPnP or IHE transactions, and once using the universAAL middleware platform, which implements "semantic" interoperability based on the use of common ontologies, and offers interoperability at a different layer (API instead of wire protocol).
For a discussion on the "lessons learned" from this work, see section 4.3 and chapter 5.

3.2 First Workshop

This section summarizes the findings of the first workshop "Future-proof AAL Systems: from visionary use cases to standardised integration profiles" held on 19 November 2013 in Brussels.

3.2.1 Workshop Preparation

The first workshop focussed on the dissemination of preliminary results of the support action (as available by November 2013) and discussions on how modularity and interoperability in AAL systems can be achieved, in the form of a "speakers' corner". The agenda was complemented by an external keynote on AAL and interoperability from the view of an industrial player.
The workshop invitation was initially sent to representatives from all AAL-JP projects (calls 1 to 6) and to the standardization bodies of relevance for AAL (national, European and international). A second set of invitations was sent to AAL researchers outside the AAL Joint Programme, and to industry participants. Invited researchers were from the fields of informatics, nursing science, microelectronics, electrical engineering, medical engineering, medical informatics and economics. Industry partners were invited from the fields of telecommunications, medical engineering, consumer electronics, home automation and other related branches. Overall 122 invitations were dispatched to individual persons from all these organisations and companies. Finally the invitation was distributed via social media postings in AAL-related groups on LinkedIn, AAL related mailing lists of the DKE, and posted on multiple websites (AALIANCE2, OFFIS).
31 persons participated to the workshop, 4 further registered participants fail to appear due to traffic disruptions or other last-minute business matters. The composition of the participants in detail was: 19 AAL JP participants, 5 external participants, 1 keynote speaker, 3 organizers / speakers, and 3 AALA representatives.

3.2.2 Workshop Documentation and Results

3.2.2.1 Workshop Introduction

The workshop introduction set the frame of reference for the workshop by defining the themes "AAL", "modularity/interoperability" and "standards" and highlighting the challenges that AAL researchers and developers are facing in these fields.
The presentation started by defining AAL as "concepts, products and services that combine new technologies and social environment to improve the quality of life for people in all phases of life". AAL can be seen as one important "building block" for addressing the challenges of demographic change ("aging society"), by keeping people at work productive and healthy, by keeping people at home healthy, independent and integrated, and by improving the delivery of care where and when needed. The vision of Ambient Assisted Living, as framed by the AALIANCE2 project, is shown in Figure 9: With increasing age of life, the physical and cognitive capabilities of a person naturally decline, due to the aging process, but also due to diseases. The first goal of AAL, "AAL4prevention", is to delay the onset of physical and cognitive decline by offering or supporting

prevention (e. g. monitoring, fall prevention, healthy lifestyles). The second goal, "AAL4support and compensation" is to reduce the effects of declining capabilities and to slow down the decline by offering compensation and support tools for cognitive and physical activities such as mobility support devices, technological aids for reduced hearing and vision etc. Finally, the third goal, "AAL4independent & active ageing" is to improve the quality of life of older adults despite a reduction of their physical and cognitive capabilities by supporting social inclusion, improving conditions at work, but also at leisure, offering entertainment etc.

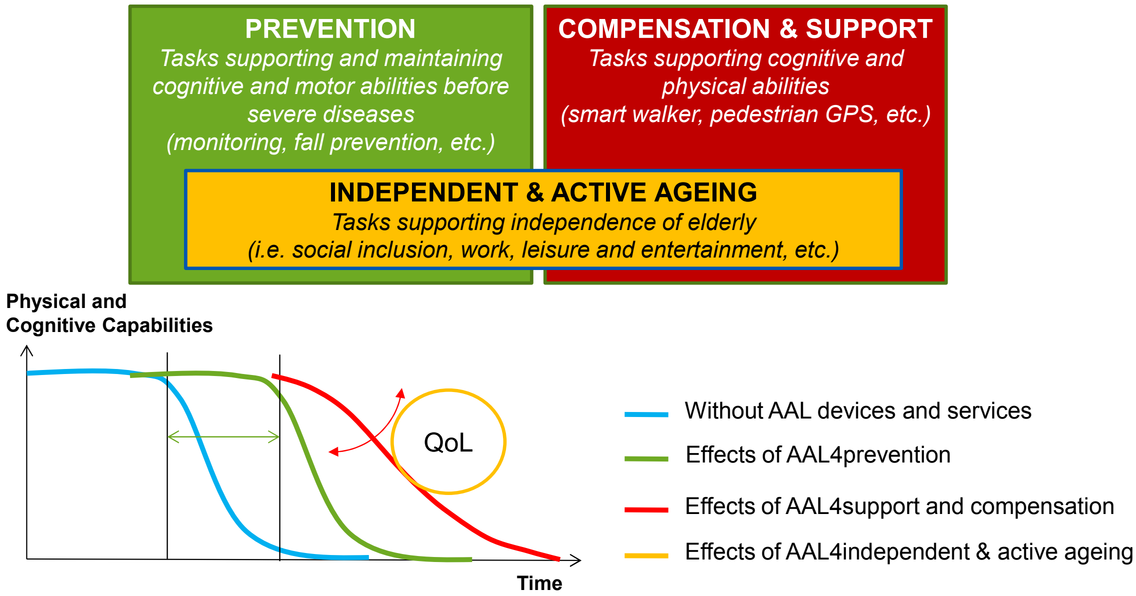

Figure 9: Vision of Ambient Assisted Living (Source: AALIANCE2 project)

When designing AAL systems, system developers are facing a number of challenges. The first challenge is that from a customer perspective it is of key importance that a (relatively expensive) AAL product is "future-proof", i.e. can be maintained over several years and can be extended to grow and adapt to the changing needs of the user. There is a very large variety of user need among older people, no "one size fits all" product, and needs change over time, depending on the decline of physical and cognitive abilities as outlined above.

A second challenge is the integration of an AAL system with the local infrastructure: Most of the houses that will be used in the next 50 years have already been built, which means that AAL systems must be installable in existing homes/apartments, since they would otherwise lose the large majority of potential customers. As an example, if a home is already equipped with home automation, it will not be acceptable to replace the home automation with a different system just because the AAL system only supports one specific home automation bus. Furthermore, AAL systems offering human services must integrate with local service providers (e. g. taxi services, delivery services etc.), which requires adaptation of the system at least for each city/region.

These challenges can only be addressed by "modularity", i.e. systems where sensors, actors and complete subsystems can be combined as needed – just like Lego building blocks can be combined in many different ways. In technical systems, such a level of modularity can only be achieved with standardised interfaces between systems and system components, a property that is called "interoperability". Interoperability is, therefore, a key requirement for the success of AAL solutions on the market.

Within the system architecture, interoperability must be addressed on multiple layers: components and subsystems must be able to exchange bits and bytes (network); to exchange well-formed messages (syntax); to correctly understand the information (semantics); and to correctly provide the desired services to the user (user perspective). It should be noted that the levels are interdependent, i.e. semantic interoperability cannot be achieved without syntactic interoperability. Addressing these layers required agreement across vendors of the different components and subsystems about interfaces between sensors, actors, and IT components, but also about interfaces between the software components (services). Standards (both official standards and industry standards, also called “publically available specifications”) are the most appropriate means for this purpose, and fortunately for the AAL sector a multitude of standards already exist that can readily be used in the design of AAL systems. The AALIANCE2 project has assembled a list (“Repository of Standards”, http://nero.offis.de/projects/aaliance2/) that names more than 500 standards that are of relevance for AAL. However, the large number of available standards creates new challenges: It is everything but trivial for a system architect to decide which of the hundreds (or perhaps thousands) of standards are applicable and relevant for a specific project or product. Furthermore, there are still several areas within AAL for which there is no standard yet – one example is a generic web service standard that could be used to perform order management (e. g. call a taxi or a delivery service) in the B2C (“business to customer”) market in which AAL is located. Missing standards force every developer to “re-invent the wheel” and develop a proprietary solution that will be incompatible with all other solutions developed in parallel by others. Finally, there is also the problem of rivalling standards. While in theory only one standard should exist for each technical problem or interface, in fact there are often rivalling standards with overlapping scope, so that for a single problem several alternative, incompatible choices exist in the world of standards. A good example is home automation, where a multitude of competing standardised buses and wireless protocols exist (e.g. KNX, LON, BACnet, ZigBee, EnOcean or Z-Wave). This also causes problems for a system developer: supporting all standards is likely to be too expensive (in terms of required effort and system components), but selecting any single standard may cause the system to lose a significant share of the market (e.g. because it then is incompatible with homes that have an infrastructure based on another standard). When possible, a software abstraction layer that permits such interfaces to be easily replaced, such that different versions of a product can be produced with little effort, is a good solution where possible, but may not always be possible.

The workshop presentation ended with summarizing the goals of the workshop: The first goal is to discuss how modularity and interoperability in AAL systems can be achieved: by starting from the user’s perspective, analysing the visions and use cases of current AAL projects and then selecting common themes addressed by many projects that seem suitable for standardisation. These common use cases can then be formalised into modular design guidelines (so-called “integration profiles”). The second workshop goal is to discuss the problems that participants have experienced with regard to modularity, interoperability and standards: practical problems, experiences and questions.

3.2.2.2 Invited Keynote: AAL and Interoperability

The keynote speaker for the workshop was Mr Klaus from the Innovation Laboratories from the Deutsche Telekom (Berlin, Germany). Deutsche Telekom is a big phone company that participated in many AAL-projects. The company develops a product called QIVICOM, which is a hard- and software platform for smart home and AAL services. The platform combines functionality from the home automation domain, such as “Leaving the house” (turns off all electric devices) up to integrated, bookable services such “Meal on wheels”.

Mr Klaus talked about AAL, which is defined by the Telekom as AAL = Technology + Services. His presentation focused on the current and future situation from a vendor’s perspective. He stated that AAL will soon become reality, but is not ready yet. In his personal view the AAL market is service-centric in difference to the smart home market, which is user-centric. He emphasised interoperability and the current lack of business models as main challenges.

Mr Klaus said that in regard to interoperability, first steps have been made by the definition and success of basic standards and consortia, such as UPnP and the OSGi Alliance. He showed the

AAL Home Gateway that was introduced in the Smart Senior Project and explained that the usage of the underlying standards led to a standardized execution environment, which covers the needs of AAL and integration in the medical domain.
Afterwards, Mr Klaus talked about the second challenge: the AAL business models or services. He started with an abstract view of how a business involves different partners in the complete value chain from suppliers up to the customers. The smart senior project used this abstract view as basis to perform the business modelling for the AAL domain. The results showed the different opportunities for the participating companies. Device manufacturer, system provider, provider of social services, platform provider, and telephone provider were identified as key providers. Mr Klaus showed that the AAL- platform has been successfully used together with the connected services in a residence for elderly people in Sarstedt, Germany.
He summarized that most of the interoperability and business model challenges have been solved through the integration of different service providers and partners on the basis of a technical integration by the QIVICOM platform of his company.

3.2.2.3 Workshop Presentations

The workshop presentations are not reproduced in this document, since they only represent an initial version of the work that has been published in Deliverable D2 "AAL Use Cases and Integration Profiles".

3.2.2.4 Summary of the Speakers' Corner on AAL and Interoperability

The discussion in the speaker's corner showed that privacy concerns are still an open topic in the AAL community. Hence, the IHE Profiles can – and have to be adapted to the European privacy requirements. It became clear that standardized AAL profiles have to reflect the market on one hand but have also to be very flexible to react to current developments of fast evolving AAL techniques on the other hand. As a consequence the standards should be specified as fine grained modules that reflect very basic transactions and are easy to implement for vendors. This enables vendors to spare time, when they adapt these standards in their products.
Open standards that are available free of charge reduce the barrier for implementation as Open Source Software projects. This is also important for the vendors, because they are able to focus on their own applications. They can use already existing software components to implement them, without the need to implement every driver on their own. As long as the standards support their own business model the result will be a better market penetration for standardized AAL components.

3.2.3 Workshop Analysis

During the workshop, a feedback form was given to all workshop participants, and they were asked to fill-in and return the form by the end of the workshop. Out of 23 participants (not counting the speakers/organizers of the workshops and AALA representative), 18 (that is, 72% of the participants) returned a filled-in form.
The workshop was rated positively from the perspective of the participants, with all questions related to workshop organization and knowledge transfer receiving a dominant result of "very good" or "good". It seems that the participants very much valued the opportunity to do networking during the lunch and coffee breaks, and perhaps somewhat surprisingly given the limited time for discussion also rated the discussion as very positive. One participant noted that the workshop contents were not oriented on his/her needs, whereas the majority seems to have been happy with the topics, the complexity, knowledge transfer and personal support (i.e. possibility to raise questions).
The questionnaire also asked the participants to rate the benefit they perceive from the individual sessions / presentations. All sessions were rated rather positively, with "valuable" or "informative",

and there is no session that would show a significant accumulation of “less relevant” ratings. It is interesting to note that each session / presentation was rated by some participants as the most interesting one. The highest rating for the “formalising use cases” presentation does not come as a surprise, since the “welcome and introduction”, “use case collection” and “formalising use cases” presentations build up on each other, with the most recent results of the Action presented in the latter presentation.

Finally the questionnaire asked the participants whether or not they could recommend participation to a similar workshop to their colleagues and partners, and whether or not they would be interested in participating to the follow-up workshop in February 2014. Out of 18 questionnaires returned, 16 participants would recommend participation to a similar workshop, and 15 were interested in participating to the follow-up event in 2014. The questionnaire ended with a block where comments, suggestions and questions could be noted. The comments received highlighted the value of the networking opportunities of the workshop and pointed out some weaknesses of the registration procedure that were taken into account when preparing the second workshop.

3.2.3.1 Efficacy of the Workshop

Given the number of registrations for the workshop, which was higher than expected and filled the room to the available maximum, and the overall positive feedback of the participants the efficacy of the workshop can certainly be rated as satisfactory. The participants were introduced to the importance of modularity/interoperability through the introduction and the invited talk, which offered the perspective of a big industry player on this topic, and the work of the Action on Standards and Interoperability was presented and discussed.

The workshop format (10:00-16:00, with generous lunch break for networking) was rated very positively by the participants. many of whom could arrive in the morning and depart in the afternoon of the workshop day. However, this format offered only 4:15 hours effective workshop time (not counting breaks), and this limited the time that could be devoted to each topic. It was, therefore, not possible to present and discuss several integration profiles in detail (which limited the feedback participants could provide), and the “speaker’s corner” block was too short to really discuss the practical experiences of the AAL-JP project participants, which is unfortunate. It is questionable, though, whether a longer workshop would have improved efficacy, as it would certainly have reduced the number of registrations.

Finally it should be noted that with 25 participants only a relatively limited percentage of the projects and companies active in the field of AAL have been reached – even if the workshop participants have raised awareness for this topic, there are still many projects and organisations that have not been reached.

3.2.3.2 Difficulties and Missed Targets

One organizational problem of the workshop was the short time between the notification of registered participants, and the workshop, which was only two weeks. Two participants with good cause remarked that it is difficult to organise travel on such short-term notice, and flight tickets are more expensive if bought so shortly before flight. Furthermore, feedback on the technical work might have been more insightful if the material (such as the workshop slides) would have been sent to the participants before the workshop. Both problems were taken into account during the preparation of the second workshop.

3.2.3.3 New Opportunities

The following new opportunities were identified during the workshop:

- *Non-functional requirements in integration profiles:* One important topic during the discussion of the “integration profiles” approach is that currently integration profiles do not discuss non-functional aspects, with the exception of security requirements. While this may be appropriate to the eHealth sector, the proponents of this argument in the discussion certainly have a point: AAL technology should not be discussed without keeping other non-functional aspects such as ethical considerations, privacy and (perhaps) availability / reliability of the system in mind. It might, therefore, be useful to extend the structure of integration profiles (as defined by IHE and the Antilope project) for use in AAL to add a section on non-functional requirements, instead of a section focusing exclusively on security, which is only part of the non-functional requirements. This was taken into account during the development of the integration profiles in this support action, where one section on ethical and privacy considerations was added. Availability and reliability requirements can be addressed in the “security considerations” section that each integration profile also contains.

- *Improvement of draft integration profiles:* The shortage of time prevented an in-depth discussion of the individual actors/transactions and standards proposed for the integration profiles presented. However, some useful comments were received and were merged into the final profile. Furthermore, Dr. Marco Eichelberg in the week after the workshop repeated the presentation about “formalizing use cases” for the German DKE working group STD_1811.0.12 “AAL interoperability”, which he chairs, and received further useful input from technical experts that was merged into the profiles.
- *Standardising user interface modularity:* One topic that was discussed during the workshop and that is not addressed by the Action on Standards and Interoperability is the issue of standardised human-machine interface descriptions that enable modular, individualised user interfaces adapted to the limitations and needs of each individual user. User interfaces are a topic that is deliberately ignored in IHE-style integration profiles, which focus on the machine-to-machine interfaces only. However, the point can be made that a similar approach could be adopted for “user interface integration profiles”, based for example on the technical work of the URC/Cloud4All or the AALuis project, both of which were represented in the workshop. Such a work, which is clearly beyond the scope of this Action, would nevertheless add an important additional “layer” for addressing the challenges of modularity and interoperability.

3.3 Second Workshop

This section summarizes the findings of the second workshop, held on 19 February 2014 in Brussels. To achieve more impact along all stakeholder groups the projects of universAAL, ReAAL, Engaged and the AAL JP action decided to co-organise a two-day conference on AAL and interoperability, entitled “MACSI 2014: Managing AAL Complexity through Support for Interoperability”. This conference was held on 19/20 February 2014 in Brussels.

3.3.1 Workshop Preparation

The second workshop focussed on the dissemination of the outcomes of the support action on how modularity and interoperability in AAL systems can be achieved. It was intended to raise awareness among the workshop participants about the need for interoperability in the field of AAL. This was achieved by the plenary sessions with keynotes from all relevant stakeholders, including industry (NICTIZ, DALLAS), European Commission, EIP AHA, standardisation bodies (represented by IEC SG 5) and end-user perspective (AGE).The dissemination part included an overview of the visionary use-cases that are the starting point for most projects, and the presentation of a methodology for formalising such use-cases into modular design guidelines called “integration profiles”. Finally it was intended to gather feedback from the participants on interoperability issues to influence the final project results. For this reason a speaker’s corner was put on the agenda.

Due to the co-organisation of the event by 4 projects, there was a common invitation and registration process. For this reason the following figures are not only focussing on the AAL JP workshop, but on the whole conference. The workshop invitation was sent to representatives from all AAL-JP projects (calls 1 to 6) and to the standardization bodies of relevance for AAL (national, European and international). The announcement of the overall conference was, furthermore, published on the web (http://www.cip-reaal.eu/press-room/events/macsi-2014/) and announced through the dissemination channels of the other co-organizing projects universAAL, ReAAL and ENGAGED. Invited researchers were from the fields of informatics, nursing science, microelectronics, electrical engineering, medical engineering, medical informatics and economics. Industry partners were invited from the fields of telecommunications, medical engineering, consumer electronics, home automation and other related branches. Overall 122 invitations were dispatched by OFFIS to individual persons from all these organisations and companies. Finally the invitation was distributed via social media postings in AAL-related groups on LinkedIn, AAL-related mailing lists of the DKE, and posted on multiple websites (AALIANCE2, OFFIS).

58 persons participated to the workshop, 29 of them to the supply side track (AAL JP) and 29 to the demand side track. Finally, the composition of the participants in detail was: 16 AAL JP participants, 27 external participants, 6 invited speakers and keynotes, 7 organizers/speakers, and 2 AALA representatives. Three participants representing national and international standardisation bodies registered to the workshop: one person for the German DKE, one person for IEC Strategic Group 5 and one person for the Dutch NEN.

3.3.2 Workshop Documentation and Results

3.3.2.1 Introduction and Motivation (Plenary Session)

The overall conference stood under the topic of “Managing AAL Complexity through Support for Interoperability”. First of all Dr. Wichert (Fraunhofer AAL Alliance) and Dr. Eichelberg (OFFIS) introduced the topics of the day and some organizational content. The session then started with the presentation of Mr. Gazoulis (European Commission). His talk introduced and motivated the topic of interoperability and highlighted its importance for the “new paradigm of ageing”. This paradigm defines ageing as a chance, instead of a burden for the future. To reach this goal, the European commission funds and optimizes its research activities with the target to “enable citizens to live longer independently in good health”. One of these activities is the Action: “Interoperable ICT solutions for independent living & active ageing”, where research institutes work together with advocacy organizations, health providers, care providers and the industry. Mr. Gazoulis introduced different action groups who build the basis to reach a large scale of European citizens. One of the limiting factors is the lack of interoperability and standards of the resulting solutions. Mr. Gazoulis also strengthened the development of open solutions, which would lead to a better user acceptance, better return of investment and better business models. He also gave an overview of funded projects in the area of AAL and picked out the REAAL Pilot Project which involves more than 7000 users. During this project the benefits of interoperable and open solutions will be measured. His summary underlined that interoperability and open solutions are the key factors to success in the next research funding programmes.

The next presentation was held by Mr. Kung (TRIALOG), who is a member of the coordination team of the European Innovation Partnership on Active and Healthy Aging’s C2 Action Group. At the beginning, he introduced the issues of the AAL domain, such as the big diversity of users and providers. This requires AAL solutions to learn from other ICT enabled business sectors. Interoperability should at least lead to a coexistence of different applications on a shared platform. Mr. Kung stated that the actors in the “innovation ecosystems” have to “practice interoperability” to gain the critical mass in the independent living market. He also highlighted the current achievements, which are mainly based on a better networking across Europe and a contribution to existing standards, as well as repositories for Interoperability specifications and associated product references, evidence of interoperability, and evidence of consensus. The C2 approach uses use case interoperability scenarios, which have been developed by the BRAID project to define

interoperability profiles. Afterwards Mr. Kung explained the commonalities between the C2 approach and the IHE approach.
The third presentation of this session was held by Mr Tazari on behalf of MS Arndt (Orange), who is the chair of ETSI SmartM2M. The presentation motivated the topic with the missing interoperability in the Internet of Things on different layers (Device Connectivity, Transport, Service layers and Network Platforms, Data models and Business applications and Information Systems. The presentation highlighted that the standards used have to be open to be successful. Afterwards the platform vision of the telecommunication industry was explained, which is based on a common layer that includes infrastructure, environments and network elements. The M2M standard for service platforms was introduced, which is an open architecture for the data exchange inside a network. As an extension of the AAL and smart home topic the presentation gave the audience a glimpse at the bigger scale topic: “Smart City”.
The next speaker was Janina Laurila-Dürsch from the German standardization organization DKE, who also represented the IEC Strategic Group 5 “AAL”. Her presentation was about “interoperability from the standardization point of view”. After the introduction of her institute, she showed the advantages and challenges of the standardization process. Currently, IEC is working on standardization efforts in the field of AAL. They have constituted three groups: “Status”, “Modelling”, and “Data Security”. These groups determined the current status of the field, developed templates for use cases and worked on security questions in this field. Finally, the speaker pointed out that interoperability is the key factor for the success of AAL-solutions in the market.
The last speaker in this session was Mister Abeloos (European Commission), who presented eHealth Interoperability from the perspective of the EU. He began with the presentation of the legal framework for standardization in the EU and explained the main goals of the current politics. As the outcome of a concrete study, 7 IHE profiles have been chosen for identification. Mr. Abeloos introduced the epSOS project as an example of cross-border interoperability inside the EU with 17 involved piloting countries. He pointed out that the EU commission is currently investigating the possibilities of the SNOMED CT terminology and also introduced the SemanticHealthNet project, which bundles a large consortium to focus on the medical use cases chronic heart failure and cardiovascular prevention. His presentation ended with a short overview of related EU projects.

3.3.2.2 AAL Use Cases: Overview and Analysis

After a brief introductory presentation (an updated version of the presentation described in section 3.2.2.1), the session started with the methodology of the use case collection: Many AAL projects have tried to describe their vision of ambient assisted living in the form of a “storyboard”, i.e. the story of a fictitious user of the AAL system to be developed. These storyboards form the starting point for the development of integration profiles. The search was performed by text-skimming with Adobe Acrobat Professional. As the terms use case, scenario and storyboard are used in different ways; the decision was to search for all terms. The search terms (with some variations in spelling) were: “use case”; “use-case”; “scenario”; “storyboard”; “story board”; “story-board”. Storyboards were collected from the following sources:

- Deliverables of AAL Joint Programme projects.
- Public Deliverables of FP6/FP7 AAL research projects
- The collection of “ICT & Ageing Scenarios published by the BRAID project (Bridging Research in Ageing and ICT development). This is a booklet with a collection of scenarios from different perspectives called “life settings”. These four settings are independent living, health and care in life, occupation in life, and recreation in life.
- The AALIANCE roadmap, published in 2010, describes different scenarios in the home environment, mobile settings, community settings and working environments. In addition,

enabling technologies and functions (sensing, reasoning, acting, interacting, and communicating) are defined.

- The recently started Antilope project (Adoption and take up of standards and profiles for eHealth Interoperability) has defined ten use cases, two of which are of interest for the AAL community.

The overwhelming results were 325 storyboards collected in the repository. They were collected by using the IEC SG 5 template for collecting use cases. These storyboards have been analysed and tagged with the keywords. The keyword list is explained in detail in Deliverable D2 “AAL Use Cases and Integration Profiles” and was introduced in the presentation by briefly showing categories and then directly explaining the results and numbers analysed. The keyword taxonomy defines several axes. For each axis the most frequently occurring topic in the use case collection was identified:

- *Body Function:* This category focuses the type of function loss which is addressed by the system. The most recognized keyword in this category was “Mental body function”, with 86 related use cases.
- *Activities and participation:* This category focuses the type of activity is supported by the system. The most recognized keyword in this category was “Human communication”, with 133 related use cases.
- *Intended purpose:* This category focuses the type of intended purpose of the system, like safety, security and comfort. The most recognized keyword in this category was “Alert communication”, with 72 related use cases.
- *Stakeholders:* This category focuses which stakeholders interact with the system. The most recognized keyword in this category was “Relatives”, with 103 related use cases.
- *Key enabling technologies:* This category focuses which KETs are used by the system. The most recognized keyword in this category was: (Human) communication functions, with 194 related use cases.

From colloquial use cases to abstract system functions

The way from the collected colloquial use cases to more abstract system functions was demonstrated by call topic 1 “Prevention and Management of Chronic Conditions”, the most frequent keyword was “mental body functions” with 53 hits. A closer look at the „Mental Health“ use cases showed that actually two rather different types of mental problems are addressed: dementia (50 hits) and depression (3 hits). Since dementia and depression will need different kinds of support and assistance, the focus was turned on the use cases related to dementia and the described assistive functions. Some kinds of assistance are mentioned frequently or a few times, some appeared only in a single use case. The following assistive functions occurring in multiple dementia related scenarios and were briefly introduced:

- Behavioural monitoring, i.e. recognition of ADLs (10 hits): a system that monitors the behaviour of the user, recognises the activities of daily living (ADLs) and potentially dangerous situations and, if need be, informs carers or raises alarms.
- Calendar with reminders (8 hits): a system that reminds the user of appointments, activities of daily living, and medication.
- Medication reminder/dispenser (6 hits): a system that monitors the medicine taken from a dispenser and reminds the user if medicine is not taken in time.
- Social network for informal carers, including tutorials/webinars (5 hits): a social network where informal carers can connect with each other, share experiences, in some cases also ask advice from professional carers. The systems often also offer tutorials/webinars for informal carers.
- Outdoor mobility assistant with “panic button” (5 hits): a navigation system for pedestrians, partly with support for using public transportation. The systems usually offer a “panic” button that can be pressed when the user feels lost. In this case a connection to an informal or formal

carer is established and the position of the user is transmitted, so that the carer can guide the user home, or organise other means of transport.

The analysis showed that some functions are closely linked to behavioural monitoring and to the calendar with reminding functions so "behaviour monitoring" and "calendar" were used together with some of the related themes as foundation for formalising AAL systems for dementia patients.

3.3.2.3 Achieving Interoperability through Integration Profiles

This presentation continued from where the presentation of the use case collection ended: the analysis of use cases has shown that although AAL is a very broad field of research, with hundreds of use cases and many different topics, certain topics appear over and over again, hinting that these might be the most promising topics for a first attempt at achieving interoperability. In particular, an analysis of the use cases related to dementia shows that "behaviour monitoring" and "calendar" with some of the related themes seem to be good choices as a foundation for formalising AAL systems for dementia patients.

The goal of the formalisation of the abstract assistive functions from the use cases is to produce a modular architecture describing the systems / system components involved, and the interfaces between systems and components. The approach follows a concept developed in the healthcare IT sector about 15 years ago: "integration profiles" as defined by the "Integrating the Healthcare Enterprise" (IHE) initiative. IHE is a non-profit initiative, founded in 1998, promoting and supporting the integration of IT systems in the healthcare enterprise. Within IHE, users and vendors work together to identify and design solutions for integration problems, based on a well-defined process with annual cycles: users identify key workflows (use cases) where integration problems exist, technical experts then research and select standards to specify a solution, which is reviewed and published as the "IHE Technical Framework". Industry is then invited to implement these specifications and to perform cross-vendor testing at an annual test event called the "Connectathon", finally successful integrations are shown at trade shows. IHE integration profiles describe IT-related real-world problems (use cases, scenarios) and define a solution based on "actors" and "transactions": actors describe the systems / components that are involved (based on their functionality); transactions describe how the actors interact based on standards. The transaction definitions try to define very precisely how actors communicate: Within a given communication standard, which messages to use and which of the message fields are mandatory and which are optional (IHE often defines additional requirements beyond the requirements posed by the standard itself to make sure that the message contains all information needed in the very specific context described in the profile.) Furthermore, the required sequencing of messages, the transport protocol (in the case of message standards that offer bindings to multiple transports), the integration of data models between multiple standards needed within one profile (e.g. mapping of fields from ISO/IEEE 11073 to HL7 V2.6), and national specificities are defined and documented in a comprehensive implementation guide, the IHE technical framework, which is not a standard as such, but a set of "application profiles" for existing standards. Such a "rule book" can be the basis for the development of test tools (as IHE extensively does) or a certification programme (as offered by the Continua Health Alliance, which follows a very similar development model.) The structure of an integration profile is well-defined, always consisting of the following sections:

- *Rationale:* introduction, purpose & scope
- *Storyboard:* narrative description of the use case
- *Actors and transactions (diagram), options:* this is a graphical, semi-formal description showing systems and system components ("actors") and interactions between these components ("transactions"). The idea is to identify components or systems as actors based on the specific function that they offer, which could be implemented as a separate product (software or hardware). The internal functionality (e. g. algorithms) of an actor is not described ("black box"),

and human-machine interfaces are not shown. Transactions are the interfaces the system/component needs to implement in order to be interoperable with other systems/components based on the same integration profile. Profile options describe alternative implementation paths or optional extensions within a profile.

- *High level process and data flow:* Once actors and transactions are defined, the high-level process and data flows are defined, for example as a series of UML sequence diagrams showing alternative sequences of events and the involved process and data flows. As a rule of thumb, not all possible sequences of events can be described, but the most important – both regular and irregular – sequences should be described, including the expected behaviour of the actors.
- *Transaction definitions:* Transaction definitions are the most complex part, as they define the mapping to standards. IHE uses a rather elaborate structure (7 sections) to describe them:
  - Scope: A brief scope statement describing the purpose of the transaction
  - Use Case Roles: UML use case diagram, brief description of actors' roles
  - Referenced Standards: Refs to the standards used to define the transaction.
  - Interaction Diagram: UML sequence diagram showing the messages involved in this single transaction. For each message, separate subsections specify *Trigger Events*: Circumstances under which message is transmitted; *Message Semantics*: Detailed description of the message, including required fields and options exceeding the standard's requirements; *Expected Actions*: Actions expected by the actors involved upon transmission of the message.
  - Protocol Requirements: Additional requirements on the implementation of the communication protocol standards that are common to all messages of the transaction. (optional)
  - Actor Requirements: Actions expected by the involved actors upon execution of the transaction (i.e. behaviour that is related to the complete transaction and not individual messages). (optional)
  - Security Considerations: Security considerations concerning the transaction, such as additional requirements when executed over a public network, logging requirements etc. (optional)

This structure was presented in detail on the example of the *Behaviour Monitoring Integration Profile,* which is described in Deliverable D2 "AAL Use Cases and Integration Profiles". The presentation then gave an overview of further profiles, which the Action on Standards and Interoperability have been developed. The goal was the development of the most important AAL high-level integration profiles. A high-level integration profile is essentially a complete profile except the definition of the transactions (i.e. the mapping to standards). Four of these integration profiles have been worked out in full detail (including transactions). As an additional option, alternative transaction definitions based on the universAAL middleware architecture have been defined. The further integration profiles presented were:

- *Social Interaction with Smart TV:* This profile uses a Smart TV for supporting social interaction, since TVs are widely used and accepted. The Smart TV can be used as a central communication unit at home. It offers communication through video conferencing, chat or even online gaming. The Smart TV can be controlled via a classical remote control unit or a remote control application installed on a mobile device (smartphone, tablet PC) offering additional functions such as a remote display.
- *Personal Trainer:* Amyotrophia and cardiovascular weakness are big challenges in older adults, leading to fragility and a reduction of physical activities, and in the end in a reduced ability to perform activities of daily living. Physical exercise is important. The Personal Trainer is a system that tracks the physical activity of the user and combines this data with medical information to

create a personalized training plan and to offer learning media like video tutorials to the user. Physical activity is measured using an accelerometer connected to an “activity determination module” (e.g. smartphone app). The Training / game devices (e.g. a bicycle ergometer or an interactive computer game that involves physical activity) can be used to perform an individualized physical training. Depending on the training modality the user can also wear body area sensors that record vital signs (e.g. heart rate, SpO2), which are used for the short-term adaptation of the training plan. The collected information can be forwarded from the PHR to the health practitioner’s EHR.

- *Environmental Health Monitoring and Alarms at Work:* This integration profile introduces a combination of building automation components and mobile devices for detecting dangerous situations and emergencies regarding workers’ health. It belongs to the AAL at the workplace topic. This profile uses a building automation system with sensors and actuators, connected to a corporate infrastructure. This infrastructure consists of environmental sensors that are not common in the domestic environment, e.g. for detecting air pollution or gas leaks. In case of an emergency, this information is simultaneously forwarded to the workers in the affected areas and to emergency services. The workers carry mobile emergency devices with them to receive these alerts. These devices can be enriched with body area sensors for recording vital parameters if the worker has a known disease.

In conclusion, Integration Profiles help to close the gap from a high-level use case to a modular specification enabling interoperable implementations. The AAL-JP Action on Standards and Interoperability has published seven high-level integration profiles covering all 6 AAL-JP call topics and fully detailed transactions for four of these profiles. The work does not end there, though. This can only be the starting point for:

- Refining the profile definitions
- Defining further integration profiles for the most important use cases.
- Implementing the profiles in prototypes and products.

This will only happen if many stakeholders from research, industry and standardisation take up this work and continue from here.

Furthermore, it should be noted that in AAL it is not yet completely clear where the boundaries of products and product components will be: will sensors be implemented as simple components only transmitting their measurements (“Continua approach”), or will there be a computing node combined with each sensor, such that each sensor becomes an intelligent “node” in a partly or fully distributed sensor network (“universAAL approach”)? Only time will tell, however, this will affect definition of the transactions of AAL integration profiles.

Finally, if we follow the example of IHE, the success of Integration Profiles is based not only on the specifications, but on a comprehensive process:

- Development of test tools that allow developers to test their prototypes and products for compliance with the integration profiles
- Regular cross-vendor testing events to validate practical interoperability
- Dissemination (e.g. public demonstrations) to create “market pull” for solutions based on integration profiles
- Certification or vendor self-declaration of product conformance to a profile (example: “product X version Y implements the ‘behaviour monitoring’ profile as actor ‘home automation gateway’ with ‘KNX option’”).

This is clearly a long way to go, but it would really help to create a market of modular, future-proof AAL systems.

3.3.2.4 Summary of the Speakers' Corners on AAL and Interoperability

The sessions presented in sections 3.3.2.2 and 3.3.2.3 each contained an interactive discussion element ("speakers' corner"), allowing the workshop participants to discuss the workshop contents after listening to the presentations. It was also intended by the organisers to include further topics addressing interoperability such as the usage and acceptance of standards or middleware, and daily problems occurring in the context of interoperability and the way of solving them.

With regard to *further (or better) ways of analysing the contents of the use case collection*, the following ideas were discussed: one could represent the use cases as "situations" that can be depicted with pictures graphically explaining each function of a system; use cases could be analysed with regard how realistic their implementation is and which are the gaps concerning interfaces, plugs and standards; it would be useful to identify overlap between use cases and point out different approaches to solving the same problem; use cases could also be used for educational purpose to make people understand of what topics are discussed in the AAL research scene.

On the topic of *facilitating the use of standards,* it was discussed that even within standardisation committees the knowledge about which other groups and committees are there and what each group is working on is quite limited – even more so in the general research scene. This calls for a community effort listing all standards and standardisation efforts of relevance for AAL, and the practical relevance each standard has on the different national markets. It was also suggested to let users rate standards they have used in the manner of a social network. The concept of "integration profiles", which map use cases to standards, was also seen as contributing towards this goal, perhaps with the addition of middleware platforms providing ready-to-use implementations of the most important protocol standards. It was furthermore suggested to develop an "interoperability by design" guideline that explains to researchers and developers on how to make sure that a system is interoperable. A collection of success stories about projects that have successfully developed and deployed interoperable solutions based on standards was also proposed.

At the end of the first "speakers' corner" all participants were asked to write down further research questions on the use case database. The answers were clustered to into groups and rated at the end of the workshop, in the following order: Best Practice (12 votes), Gaps (9 votes), Public Database (9 votes), Technological change (6 votes), Accessibility (4 votes), Integration Profiles (3 votes), Overlap of Use Cases (2 votes), Better/deeper use cases (0 votes).

In the second session's speakers' corner, the question was discussed *who should be responsible for the future development and maintenance of AAL related integration profiles*. It was stated that whatever organization takes over this task, it has to be a strong organization that can achieve significant impact. Furthermore it was discussed that it is not possible to treat the AAL sector completely different from the health sector, because many AAL solutions ultimately need to be integrated with the IT infrastructure of the professional health care sector. Therefore, both IHE and Continua could be possible candidates for such an organization. IEC was also discussed as an option, but here the Systems Committee on AAL first needs to be started and become operational.

With regards to considering interoperability during proposal planning and writing, it was discussed that the AAL JP should not easily accept any more new platform developments in proposals; new projects should use existing platforms, or in case of new platforms, clearly explain the progress beyond the state of the art. It was also suggested that project proposals should explain the project's impact on interoperability. However, it was noted that interoperability will ultimately only be achieved if this matches the business strategy of the underlying product and market and one has to take into account that – important as it may be – interoperability is only a secondary goal, user empowerment and system functionality will always come first.

When asked to propose topics for further integration profiles beyond the set developed by the support action, the following topics were suggested: Safety, data security and privacy of home; Chronic Heart Failure; Assistive Robots; and Medical Data Visualisation.

The workshop participants were then asked to rate which integration profile should next be worked out in detail (including both the profiles developed by the support action, and the proposed new profiles mentioned above). The voting results were as follows: Integration Profile 01: Behaviour Monitoring (13 votes); Assistive Robots (8 votes); Safety, data security and privacy of home (7 votes); Integration Profile 03: Social Interaction with Smart TV (6 votes); Integration Profile 05: Mobility Assistant (5 votes); Integration Profile 07: Environmental Health Monitor (5 votes); Integration Profile 06: Personal Trainer (4 votes); Integration Profile 02: Calendar Service (1 vote); Integration Profile 04: Shopping and Nutrition Planner (1 vote), Chronic Heart Failure (0 votes); (Medical Data Visualisation: 0 votes).

Finally, the participants were asked to rate which integration profile should be implemented as reference implementation. The voting results for this question were as follows: Integration Profile 01: Behaviour Monitoring (14 votes); Integration Profile 06: Personal Trainer (9 votes); Integration Profile 03: Social Interaction with Smart TV (8 votes); Safety, data security and privacy of home (8 votes); Integration Profile 05: Mobility Assistant (4 votes); Integration Profile 07: Environmental Health Monitor (2 votes); Assistive Robots (2 votes); Integration Profile 02: Calendar Service (1 vote); Integration Profile 04: Shopping and Nutrition Planner (0 votes); Chronic Heart Failure (0 votes); Medical Data Visualisation (0 votes).

3.3.2.5 Perspectives (Plenary Session)

The fourth session of the workshop program dealt with the perspectives of interoperability. Three presentations were given. The start was made by Vincent van Pelt (NICTIZ) from the Netherlands with his talk about the Antilope EU project. He started with an overview of the European countries that are involved in the validation of the project results. The project delivered the "Refined eHealth European Interoperability Framework (eEIF)", which contains a set of use cases, integration profiles and templates as well as testing guidelines and guidelines for the labelling and certification. These results are implementation-agnostic and can be used in different scenarios. Mr. van Pelt stated that modularity was very important in Antilope and he showed that the use cases consisting of functionality modules, which can be implemented with interoperability profiles like IHE or Continua, independently. These interoperability profiles use existing standards to specify the exact technical implementation. He finished his presentation with the message that interoperability requires a shared definition of interoperability levels, terms and use cases.
As second speaker, Mr. Worsley (UK Technology Strategy Board) gave a presentation about interoperability in the UK DALLAS project ("Delivering Assisted Lifestyles Living At Scale"). He explained the challenges on large scale AAL-projects. He highlighted the interoperability challenge between the businesses to consumer market. The idea of the DALLAS project is to improve interoperability by facilitating the integration of health, social care, housing, and consumer purchase models. The developed reference system uses a PHR system to exchange health data

over long distances with other IT systems. Mr. Worsley introduced some results of the project and gave an overview about the APIs which have been developed in it.

The final speaker in this Session was Mr. Reiner Wichert (Fraunhofer AAL Alliance). He started with an overview about the complex European AAL research innovation landscape and showed that the consolidated efforts were bundles in the universAAL Project, which is a common open platform for AAL-applications. He also introduced the Lecce Declaration on AAL Market Breakthrough, which was signed by 200 organizations. The ReAAL project tries to implement the breakthrough by the real life deployment of AAL components for 7000 users in 9 different European countries. He finished his presentation with an appeal to work together for one good share AAL platform.

3.3.3 Workshop Analysis

During the workshop, a feedback form was given to all workshop participants, and they were asked to fill-in and return the form by the end of the workshop. Out of 43 participants (not counting the invited speakers, organizers of the workshops and AALA representatives), 25 (that is, 58% of the participants) returned a filled-in form.

The workshop was rated positively from the perspective of the participants, with all questions related to workshop organization and knowledge transfer receiving a dominant result of "very good" or "good". Catering is the only category where "fair" marks are the most frequent ones (11 out of 25) – certainly many participants would have preferred a warm lunch, as opposed to sandwiches, but this was not possible due to budget restrictions.

The questionnaire also asked the participants to rate the benefit they perceive from the individual presentations of sessions 1-3 (i.e., the first workshop day). All presentations were rated rather positively, with "valuable" or "informative", with the presentations about the results of the support action receiving in general better ratings than the plenary session presentations. When asked about the most interesting presentation, the highest rating (12 votes) was assigned to the presentation "Achieving Interoperability through Integration Profiles", followed by the other topics of the AAL-JP sessions: AAL Use Cases: Overview and Analysis (8 votes), Speakers' Corners (5 and 7 votes, respectively).

3.3.3.1 Efficacy of the Workshop

Given the number of registrations for the workshop, which met the expectations of the organisers, and the overall positive feedback of the participants the efficacy of the workshop can certainly be rated as satisfactory, although some participants missed the workshop. The participants were introduced to the importance of modularity/interoperability through the opening sessions with invited talks, representing the political, industrial and standardisation point of view.

The two-day workshop format with the AAL JP part on one day (14:15-17:45, with generous lunch break for networking) was rated very positively by the participants, giving the AAL JP participants the opportunity whether to stay only for the first day (arrive in the morning and depart in the afternoon of the workshop day) or to stay both days. Fortunately the majority of the AAL JP participants took the opportunity to attend both days, there was only one participant declaring in the feedback form that a two day workshop was too long. However, this format offered only 3:00 hours effective AAL JP workshop time (not counting breaks), meaning 1:15 minutes less than the first workshop, but effectively both workshops had the same for time presenting the outcomes of this support action, since there was no separate keynote in the AAL JP workshop block as there had been during the first workshop). This limited the time that could be devoted to each topic and it was, therefore, not possible to present and discuss several integration profiles in detail (which limited the feedback participants could provide), and the "speaker's corner" block was too short to really discuss the practical experiences of the AAL-JP project participants, which is unfortunate. This lack of time could be compensated by a more interactive concept during the speaker' corner,

giving the participants the ability to write down comments on moderating cards. It is questionable, though, whether a longer workshop would have improved efficacy, as it would certainly have reduced the number of registrations.
Finally it should be noted that with 29 participants in the AAL JP workshop and 58 participants to the whole event, only a relatively limited percentage of the projects and companies active in the field of AAL have been reached – even if the workshop participants have raised awareness for this topic, there are still many projects and organisations that have not been reached.

3.3.3.2 Difficulties and Missed Targets

Unfortunately 13 participants did not show up at the workshop without withdrawing the registration. This is unsatisfying in two ways: on the one hand these participants blocked limited seats and might have hindered other persons from attending the workshop (fortunately this did not happen because there were no short-term registrations to be rejected). On the other hand the catering had to be paid for all registered participants, meaning that the organisers had to pay catering fees for persons not showing up. There is not really a solution for this kind of problems other than taking a registration fee, which may increase the reliability of a registration but may also prevent even more people from not registering, and would be a significant additional organisational effort.

3.3.3.3 New opportunities

The following new opportunities have arisen from the workshop:

- *Next integration profiles to work out in detail:* The intention of this discussion topic was to identify which integration profile should be worked in detail like the presented integration profiles 01 "Behaviour Monitoring" with complete high level data flow and referenced transactions. Interestingly, the majority of the participants (13 votes) voted for integration profile 01. There are two possible explanations. The first explanation is that the presented work was not detailed enough and the participants wanted more information. The second explanation is that the formulation of the question was misleading. The integration profiles on the following ranks are Assistive Robots, Safety, Data Security and Privacy of Home, and Integration Profile 03: Social Interaction with Smart TV. This would require an analysis of the use case database (use case collection) on assistive robots and safety/security issues. 49 use cases on robotics are already in the database. Safety might include issues like fall detection (21 use cases) and alert detection (65 use cases), security might include access control (30 votes), intruder alert (1 vote).
- *Integration profile for reference implementation:* The majority of the participants voted that integration profile 01 "Behaviour Monitoring" should be selected for a reference implementation. This is certainly a good idea, since behaviour monitoring is on the one hand one of the core topics of AAL and on the other hand combines multiple kind of technologies from hardware (stationary sensors, mobile sensors, gateways, home network) and software (sensor abstraction, interpretation of sensor data).
- *Best practice collection:* One idea of the interactive part was a collection of use cases in the sense of recommendations for implementing standards and which standard works well or not for a certain AAL problem. This would need some kind of moderated online platform where standards and AAL scenarios can be linked together and discussed.

4 Analysis of the Support Action

4.1 Workshop Participants

Participation to both workshops was satisfactory in terms of the number or registrations, which in both cases was close to the pre-defined number of seats available. In the second workshop, the number of participants from AAL-JP projects was smaller than in the first workshop, though, with more participants from “outside” the AAL Joint Programme. In total, 36 participants from AAL-JP projects, representing 29 distinct AAL-JP projects participated to the workshops, with relatively little overlap in participation between workshops. Participation included 3 projects from Call 1, 5 projects from Call 2, 4 projects from Call 3, 4 projects from Call 4, 11 projects from Call 5 and 2 projects from Call 6. The high share of Call 5 projects is not surprising as these are mainly the currently running projects, with Call 6 projects only starting now.

While the numbers are satisfactory given the space and discussion time available during the workshops, only about 20% of the ca. 150 AAL-JP projects – past and present – have been reached.

4.2 Workshop Effectiveness

The overall positive feedback received from the participants of both workshops gives rise to the expectation that the awareness for the importance of standards and interoperability in the design of AAL systems has increased among the workshop participants. The discussions showed that the approach to interoperability proposed by the support action (use-case based integration profiles) was not criticized at all – the discussions rather looked at how to further improve the approach (e.g. by adding a coverage of ethical issues related to each profile) and which important aspects (such as user interface integration and usability) are not covered by the approach and need to be addressed by complementary work. To which degree the workshops will influence the future work of the participants and the projects represented is unclear, though.

Both workshops offered generous breaks for networking among participants, and this was confirmed to be very useful by the participants, and should be repeated if future events of this kind should be planned in the future. However, a side-effect of this arrangement was that the time that could be devoted to a discussion of the experiences (both successes and failures) of the workshop participants in using standards in the projects and product developments, and in achieving interoperability, was rather limited. While the “speakers’ corner” sessions provided useful feedback on the technical work performed by the support action, the exchange of experience between participants during these sessions was limited. This would, however, have required much more time, and it is questionable if workshop participation would have been as good if the workshops had been significantly longer.

4.3 Effectiveness of the Support Action

The authors believe that the technical work done in this support action has achieved significant progress towards supporting standards-based interoperability in AAL. The analysis of the use case collection has for the first time provided suggestions for use cases suitable for standardization as an integration profile based on a quantitative analysis of the ideas ventilated in the use-case scenario texts written by AAL project participants from the AAL Joint Programme, EU FP6 and FP7. Furthermore, while the applicability of “integration profiles” to the AAL sector has been discussed as an idea at least since 2008, and projects such as RAALI have worked on a methodology for writing integration profiles for AAL [WBK+13], the work performed in this support action is – to the knowledge of the authors – the first attempt to really develop a set of comprehensive integration profiles for AAL use cases. The availability of a tangible set of integration profile proposals makes it much easier to promote the general idea behind this approach, as underlined by the significant interest the results of the project have found in the standardization “scene” (DKE in Germany, NICTIZ in the Netherlands, IEC Strategic Group 5 on international level – a presentation of the results of this project to IEC SG5 was given during their meeting in Brussels on 11 March 2014).

However, it is clear that the results of this support action can only be a first step in achieving interoperability in AAL. The most important steps that need to be taken in the future are:

- *Further development, improvement and eventually formal standardisation of the integration profiles:* Not all transactions identified in the integration profiles designed during this action have been worked out in detail. The selection of standards for each transaction – and the creation of standards where gaps are identified – is a significant effort that is needed to make all integration profiles implementable. Certainly the set of seven integration profiles as devised by this action is also not the full set that is needed. In detail, the following issues have been noted during the development of the integration profiles:
  - *Gaps in the standards landscape:* There seems to be no standard message format for transmitting GPS-based location information suitable to indoor location tasks as used in several integration profiles. Furthermore, the authors are not aware of any standards that would be suitable to implement the transactions “weather queried”, “medication dispensed”, “ADL performed”, “storage threshold notification sent”, “shopping list sent”, “shopping reminder sent”, and “shopping order sent”. While some of these transactions could be implemented in a straightforward manner using web services, no standards for this purpose seem to exist. The transmission of orders in a business-to-customer setting (B2C) is a more complex problem, since it involves creating an electronic process for of a legally binding contract, i.e. the order placed.
  - *Mapping between standards:* In some integration profile, a set of data is received by an actor using one standard, and forwarded using a different standard. One example is the transmission of vital parameters, which are received by a gateway device such as a smartphone using ISO/IEEE 11073, and forwarded over a wide-area connection to a receiving system using HL7 messages. Another example is the home automation gateway, which receives sensor events using a home automation field bus such as KNX or Zigbee, and forwards the information using a TCP/IP based protocol, namely Universal Plug and Play. In all such cases a careful mapping between the data elements in the different standards is needed. While such a mapping is available for the field of vital parameters, where this has been developed by the Continua Health Alliance, no such mapping is available in the home automation field. This is a considerable technical challenge, but would arguably solve the problem of the fragmentation of the home automation market from the perspective of an AAL system designed, since only an interface to a home automation gateway would have to be implemented, which in turn would translate sensor data and actuator commands to the home automation field bus protocol used in the local installation of the customer.
- *Dissemination:* As written above, only 20% of the AAL JP projects have been reached by the workshops of this support action. A continuous dissemination effort will be needed to make sure that researchers and developers of AAL solutions are aware of the available approaches for addressing interoperability.
- *Implementation support:* While integration profiles per se are useful (if worked out in sufficient detail to be technically implementable in an interoperable manner), the experience of the eHealth sector has shown that more is needed: *Reference implementations* (preferably open source) help developers to understand how certain transactions can be implemented, *test tools* support developers in validating the conformance of their implementations with the integration profile and the standards used in each transaction, and *cross-vendor testing events* such as the IHE connectathon allow implementers to gain practical experience with the interoperability (or non-interoperability) of their systems before market deployment. Finally, a *certification programme,* as offered by the Continua Health Alliance, might help customers to make better informed choices when selecting products, based on an independent validation of the product properties. However, for AAL such a certification programme is certainly rather a long-term goal.

In summary, the authors believe that this support action has provided useful contributions for addressing the challenge of standards and interoperability in AAL, but more work (by various actors) will be needed to fully achieve the goal of an interoperable ecosystem of AAL products, components and services. Practical suggestions for the next steps to be taken are discussed in the following section.

5 Recommendations for Future Work

The following sections contain practical recommendations for future work to follow-up on the results of this support action.

5.1 Interoperability as required topic for future AAL-JP projects

From the perspective of a researcher starting a new, technology-based research and development project, “interoperability” is an onerous topic, because it required additional consideration, development work, and is of little use during the development and trial phase of a project – this is a similar situation as with exploitation plans or the development of a business model, which many researchers are hesitant to address from the very beginning of a project. On the other hands, projects not considering the importance of interoperability are as likely to fail in the commercialization of their results as projects that ignore the business perspective. While workshops such as the ones performed by this support action may help in raising awareness among researchers and developers, workshops alone will not be sufficient.

We recommend, therefore, to make it a contractual requirement for future AAL Joint Programme projects to address the issue of interoperability in an appropriate manner:

- As part of a project proposal, consortia could be required to write a section about “standards and interoperability”, explaining which standards are of relevance for their topic, which ones they are aiming to implement, and how they plan to achieve an interoperability with other systems.
- As part of the description of work, one task resulting in one deliverable (report) could be required that examines this topic in more depth during the course of the project. Topic that should be covered in such a report include: software infrastructure (such as middleware used); interfaces between system components; interfaces with other AAL systems in the same apartment or owned by the same user; interfaces with external actors, such as service providers, and their respective IT infrastructure; and modularity/extensibility of the system.

There may actually be good reasons for a project to not use available standards for a certain task, so the requirement should not be that standards *must* be used whenever possible. The idea is rather that the use of standards should be the “default”, and that projects should have to explain the reasons for not using them.[4]

5.2 Further development of integration profiles

As described in section 4.3, further development, improvement and eventually a formal standardization of the integration profiles developed by this support action is needed in order to

- refine and complete the existing specifications,
- cover further use cases,
- achieve consensus about the profile specifications among stakeholders,

[4] This recommendation has in part been implemented already. The current draft call for proposals for AAL-JP 2014 mentions the following prerequisite for project proposals under this call: “Solutions should be based on existing standards in order to improve interoperability and avoid "lock-in". The use of a non-standard solution must be appropriately justified and is only acceptable if a relevant standard does not exist. Contribution to development of new standards is welcome.”

- publish the integration profiles as a formal (industry or de-jure) set of standards.

This work could be considered as the "core business" of standards bodies like CENELEC or IEC, and of industry standard committees such as IHE and Continua. The question is which organization would be willing to take up the work such that the outcome from the perspective of the AAL community is maximized. Since standardization in the field of AAL is only starting at this point in time, it would be premature to suggest one organization to take up this work. It should be avoided, however, that no follow-up to this action takes place just because everybody hopes somebody else will take up the work.

In terms of priority (top priority first) and effort, the following indications can be given (note, however, that all effort estimations are rather vague):

- The biggest "missing link" to make the first integration profile interoperable is the mapping between the home automation standards (KNX and ZigBee) and the Universal Plug and Play Sensor Management specification. Such a specification should ideally be provided by the UPnP Forum, but could be developed by any group intimately familiar with the underlying standards, KNX, ZigBee and UPnP. The effort required would be in the order of a few (2-4?) person months.
- Working out the transactions not defined in detail by this support action would make the remaining integration profiles implementable. The effort for this task strongly depends on the gaps in the standards landscape. Just addressing the remaining transactions on a technical level could perhaps be done with an effort of 2-3 person months; however, following up with the various standardisation bodies to make sure that the gaps in the standards landscape are closed in the form of official standards will take years, and more effort (mainly for committee work and travel).
- Developing integration profiles for further AAL use cases is a secondary task, as long as the first ones are not fully complete and actually implemented. This task may be revisited once the current projects working on AAL solutions for supporting occupation in life have reached greater maturity (e.g. in 1-2 years), since this topic is only weakly covered so far. The effort for developing a few integration profiles for AAL at the workplace will also strongly depend on the possible gaps in the standards landscape, but may be estimated in the order of 3-6 person months.

5.3 Reference implementation and test tools

The success of integration profiles can be greatly enhanced by providing reference implementations for the transactions involved, preferably under an open-source license, and test tools that help developers assess the conformance of their implementations. Funding such implementations, to be published under a permissive open source license such as the BSD license, has shown to accelerate implementation of the related standards or profiles. Both IHE and Continua, and also other standards bodies like the DICOM committee, have funded such developments in the past.

Since each integration profile typically contains a number of transactions, and transactions are re-used in multiple integration profiles, it would be more useful to fund the development of reference implementations for set of transactions based on the same underlying standard, rather than funding the implementation of one integration profile. Priority should be given to transactions using base standards that have a high market acceptance (such as the home automation transactions) over transactions using little-known standards (such as the SCAIP standard for social care alarms). The effort will significantly depend on the complexity of each standard/transaction and the availability of open source libraries on which each implementation project can build, so no estimation can be provided in this document.

The development of test tools should be linked to the development of a reference implementation of a transaction, since a test tool will typically be closely related to an implementation of the underlying transaction, and its implementation requires the same knowledge. Implementations published under a permissive open source license (such as BSD) would allow AAL JP projects to use the reference implementations in their development, even if that development later leads to a product – something that would be problematic if “copyleft” licenses like the GPL were used.

5.4 Work on user interface modularity

One important topic that came up during the first workshop (see section 3.2) is user interface modularity, or more precisely the issue of *standardised human-machine interface descriptions that enable modular, individualised user interfaces adapted to the limitations and needs of each individual user*.

User interfaces are a topic that is deliberately ignored in the integration profiles developed by this support action, which like their IHE and Antilope counterparts focus on the machine-to-machine interfaces only. However, the point can be made that a similar approach could be adopted for “user interface integration profiles”, based for example on the technical work of the projects Universal Remote Console (URC, see http://www.openurc.org/), Cloud4All (FP7) and AALuis (AAL-JP call 3). This work could perhaps be initiated by a support action similar in scope and size to this support action.

5.5 Collaboration between AAL JP and AAL Standardisation Bodies

The support action has clearly shown that standards and interoperability are an important topic for the further development of the AAL sector. Furthermore, the AAL Joint Programme –with its wealth of projects and topics, but also with the results of this support action – can certainly contribute important knowledge and experience to the international AAL standardization process, which is currently starting with the formation of an AAL Systems Committee by the IEC. On the other hand, this would be an opportunity to make sure that the needs of European AAL researchers and SMEs active in the AAL Joint Programme with regards to standards and interoperability get heard – and addressed – by the standardization. We, therefore, recommend that the AAL Joint Programme becomes a member in the IEC Systems Committee on AAL to be founded in 2014. At the same time, it should be clarified if a representative from the standardization can perhaps become member of an advisory boards to the AAL Joint Programme, to make sure that interoperability and standards related topics are properly represented in future calls and projects.

6 Literature

[Bra2011] BRAID Project (2011). ICT and Ageing Scenarios.
Online: http://www.braidproject.eu/sites/default/files/Ageing_scenarios.pdf

[Con2012] Continua Health Alliance (2012). Continua Design Guidelines, Version 2012.
Available on request from http://www.continuaalliance.org/products/design-guidelines

[GPX] GPS Exchange Format (GPX) 1.1 Schema Documentation,
Online: http://www.topografix.com/GPX/1/1/

[HMH+2012] Hanke S, Mayer C, Hoeftberger O, et al (2011). universAAL – An Open and Consolidated AAL Platform. Ambient Assisted Living 2011, pp. 127-140

[IHE09] IHE IT Infrastructure (ITI) Technical Framework Volume 2 Appendix V, Revision 6.0.
http://www.ihe.net/Technical_Framework/upload/IHE_ITI_TF_6-0_Vol2x_FT_2009-08-10.pdf

[Onv2013] ONVIF Core Specification, Version 2.4.1 (2013)

[Sca2012] Social Care Alarm Internet Protocol (SCAIP) Specification 2012-09-18, Online: http://www.sis.se/PageFiles/12476/CEN-f%C3%B6rslag/c069_2013.pdf

[Upn2013] SensorManagement Architecture Overview for UPnP Version 1.0, UPnP Forum, 2013

[WBK+13] Welge R, Busch BH, Kabitzsch K, Laurila-Epe J, et al. Representation of Integration Profiles using an Ontology. Reiner Wichert, Helmut Klausing (eds.) Ambient Assisted Living: Advanced Technologies and Societal Change, 2013 (in print)

[Zig2013] ZigBee Alliance, ZigBee document 05-3520-29, ZigBee Home Automation Public Application Profile