1. Executive Summary

This public report provides key information about the universAAL project (FP7 project number 247950).

The contextual background of the project is the recognition of the importance of open platforms to facilitate development of services for AAL (Ambient Assisted Living), and the need to consolidate earlier work in this area.

The report provides brief descriptions of the main technical results of the project, which are: an AAL Reference Architecture, an Execution Platform (intended to become a standard), tools to assist developers, the "uStore" (a web-based marketplace for AAL services), and a set of sample AAL services.

The report also provides an overview of the three main mechanisms that have been put in place to promote widespread adoption of project results: the ReAAL project (applying universAAL results in real life with large numbers of end-users), AALOA (the AAL open association), and universAAL training (to facilitate use of the results by novices).

Finally, the report provides contact information and links to websites where further information, and the results themselves, can be obtained.

2. universAAL Project Context and Objectives

The following page describes the motivation for the universAAL project, the context in which it arose, and its overall objectives.

The potential benefits of Ambient Assisted Living (AAL) solutions are already clearly recognised, and societal trends indicate that they will be attractive to a large and increasing number of people. But uptake of such solutions has so far been limited. The universAAL project aimed to reduce barriers to adoption and to promote the development and widespread uptake of innovative AAL solutions. This would benefit end-users (i.e. elderly people and people with disabilities, their carers and family members) by making new solutions affordable, simple to configure, personalise and deploy. It would benefit solution providers by making it easier and cheaper to create innovative new AAL services or adapt existing ones using a compositional approach based on existing components, services and external systems.

The top-level objectives of universAAL were:

- To provide a standardised **open and scalable technological platform** that facilitates the development and deployment of a broad range of AAL services
- To carry out support activities promoting **widespread acceptance and adoption** of the platform.

universAAL was the only IP funded in a call (see table for details) where EC was requesting a consolidated AAL platform to become a reference for building innovative AAL Services. The project has produced an open platform that makes it technically feasible and economically viable to develop AAL solutions. The project had a vision that it should be as simple for users to download and setup AAL services as it is to download and install software applications on a modern operating system. To this end, universAAL developed a one-stop-store, uStore, for providing plug-and-play AAL applications and services that support multiple execution platforms and can be deployed to various devices and users. Finally the allocation of local human resources is also supported in the store.

The project was built on the legacies of a number of EU projects devoted to the production of AAL software infrastructures (including PERSONA, Amigo, GENSYS, OASIS, SOPRANO and MPOWER), consolidating the results from these where feasible and carrying out new development where necessary. The consortium was built of major industrial and research players in the field, including key participants from earlier projects. It started out with 17 partners and grew to 21 partners during the project period. Further details about the project and consortium can be found at: http://www.universaal.org.

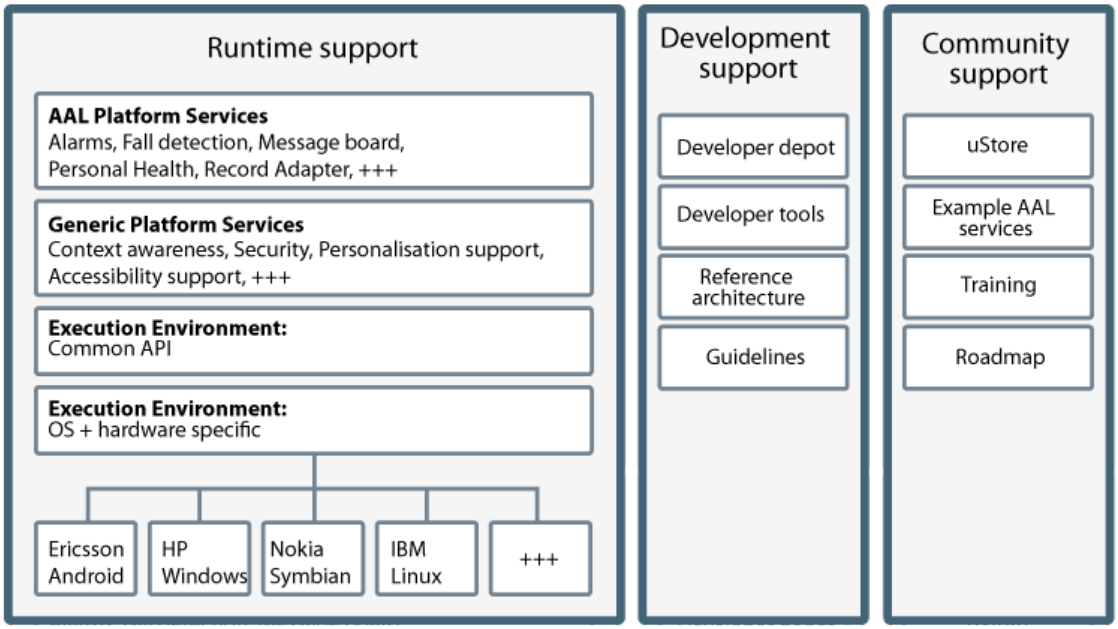
Full Name	UNIVERsal open platform and reference Specification for Ambient Assisted Living
Free Keywords:	Consolidated European AAL platform, runtime support, AAL services, development tools, community building and standarization
Funded under:	7th FWP (Seventh Framework Programme) FP7-ICT-2009-4 - Objective 7.1b
Area:	ICT-2009.7.1:ICT & Ageing
Project reference:	247950
Contract type:	Large-scale integrating project (IP)
Coordinator:	STIFTELSEN SINTEF
Starting date:	1st February 2010
Duration:	48 months
Total Budget:	14,921,304 €
Funding:	10,775,000 €

3. Main Scientific and Technical Results

The following page provides an overall summary of the results of the project. This is followed by 1-2 page summaries of each individual result.

Summary of results

The main result of the project is the universAAL *platform*, the name given to a set of mechanisms offering support on three main axes: at runtime, for developers and to support the emergence of an AAL community and marketplace.



For *runtime support*, the platform provides a software **execution platform** intended to become a standard for execution of AAL services, providing an abstraction layer hiding the details of underlying operating systems & devices, and supplying re-usable components that facilitate development of new services.

For *development support*, three key elements of the platform are a reference architecture, the developer depot, and the developer tools. The **AAL reference architecture** provides a "template" on which the concrete architectures of future AAL systems can be based – providing a standard approach intended to facilitate interoperability while not excessively constraining architectural decisions. The **developer depot** provides a location where the developer can find all resources needed to start development on top of the platform, including software components, documentation and tools. The **developer tools - AAL Studio** provide an integrated development environment that makes development of universAAL applications easier and more effective.

The universAAL **uStore** concept forms one of the key elements of *community support.* Inspired by Apple's "App Store", it provides an online one-stop-shop where service providers can publish their services and where potential users can find, purchase, download and deploy them. A set of **AAL services** was developed in the project, that have a dual role as examples of useful AAL services for elderly users, and as examples for developers that illustrates different aspects of the platform. Another element of the community support is the **universAAL Control Center** that provides a tool for deployment, configuration and personalisation of AAL services. The **universAAL training** material and events helps the developer community to get started learning about the universAAL platform.

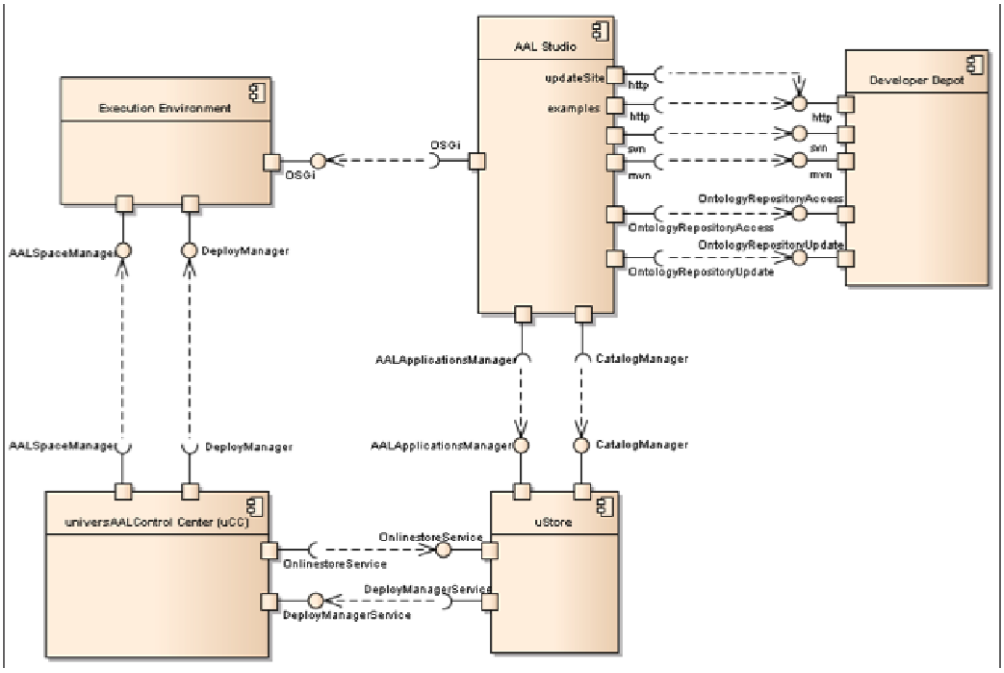
For the further development of the platform, universAAL has been active in forming the **AAL Open Association (AALOA)**. AALOA is the new home of the universAAL platform now after the project has been completed.

In the following pages, you will find more information about each of the main results (shown in bold in the text above). All the main project results are openly available and described in more detail in the project deliverables at: http://www.universaal.org/index.php/en/about/about-deliverables

AAL Reference Architecture

The universAAL project has produced a set of results that define an AAL reference architecture and related results:

- Reference Use Cases provides a detailed overview of stakeholders in the AAL domain, and defines a set of high-level use cases for the main stakeholder categories.
- Reference Requirements define requirements for the AAL Reference architecture.
- AAL Reference Model is defined as a set of concept maps for the AAL domain. The root concept map is shown in the first figure below.
- AAL Reference Architecture defines a high level architecture that supports the concepts of the AAL Reference model. It includes stakeholders, tools, and platform interfaces from runtime, development, and community perspectives. The reference architecture is defined independent of technologies, protocols, and products.
- universAAL Concrete Architecture describes the architecture of the universAAL platform. The concrete architecture is one realization of the AAL Reference Architecture, and adds details for the main components of the platform with their main interfaces and interactions.



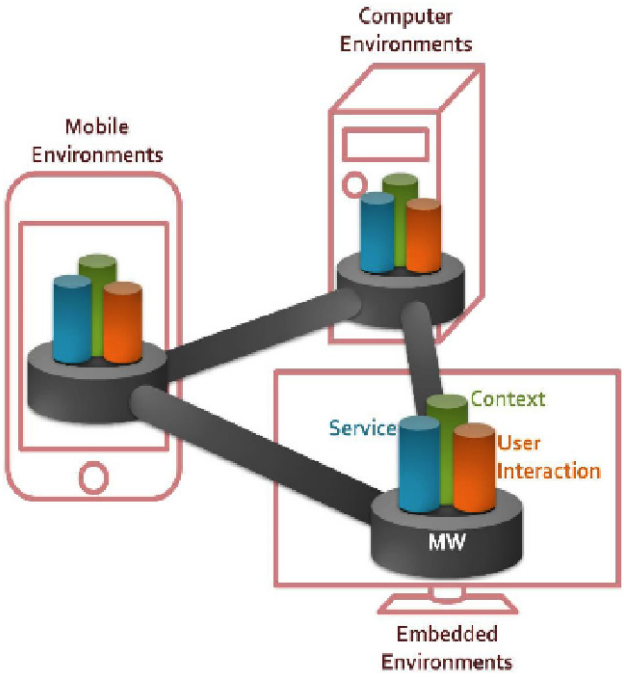
The overall concrete architecture of universAAL (shown in the figure above) supports the lifecycle of AAL applications and services, from their development to publishing, bundling in AAL services, and purchase and deployment to the end-users environment. The following are the main components:

- Execution Environment is the runtime platform needed in order to run universAAL applications.
- Developer Depot is the site where the developers can find all required resources to get started with development on universAAL, including download of the AAL Studio, execution platform, source code, and documentation. The Developer Depot is available at: http://depot.universaal.org/
- AAL Studio is an Eclipse based application development environment, consisting of tools that support the development of applications and components based on the universAAL execution environment.
- uStore is an application and service store where application developers can publish their applications, and service providers can bundle the applications with hardware and human resources to offer complete AAL services to end users. uStore is available at: http://ustore.universaal.org/
- universAAL Control Center (uCC) is a tool for local deployment and configuration of services acquired from the uStore.

More details about each of the main components are found in the next pages.

Execution Platform

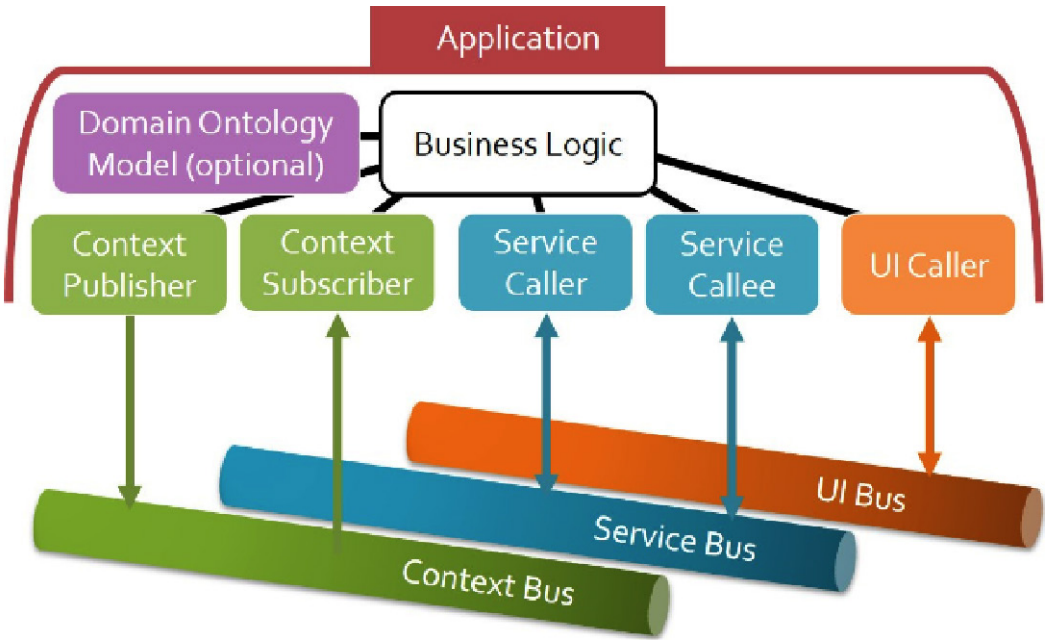
The universAAL execution platform supports the execution of AAL services. The platform is built with focus on supporting services that require several nodes to form a logical environment called an AAL Space. The following figure shows an AAL space consisting of 3 nodes – e.g. a mobile phone, a computer, and a TV (embedded system). Each of the nodes in the AAL space runs an instance of the middleware that forms the foundation of the universAAL execution environment. The middleware hides the distribution and heterogeneity of the devices.



Components and AAL applications communicate with each other through the busses provided by the universAAL middleware. As shown in the next figure, three busses are defined:

- The context bus is an event-based communication channel that is used to publish and to subscribe to context information. Context Publishers send context events over the bus when the state of the environment and/or assistive service change, while Context Subscribers register with the bus to receive the events they are interested in and handles such events.
- The service bus is a call-based communication channel used to invoke services. Components and applications that offer a service take the role of Service Callee, and register a description of the services they can provide with the with the service bus. Components and applications in the role of Service Caller sends requests for services over the bus, and the service bus tries to match the requests with registered services to find which service callee(s) to forward the request to.
- The UI bus is used to create user interfaces. The component or application that takes the IO Caller role provides only an abstract description of the user interface to the UI bus. The UI Bus takes the decision on where and how to present the concrete user interface.

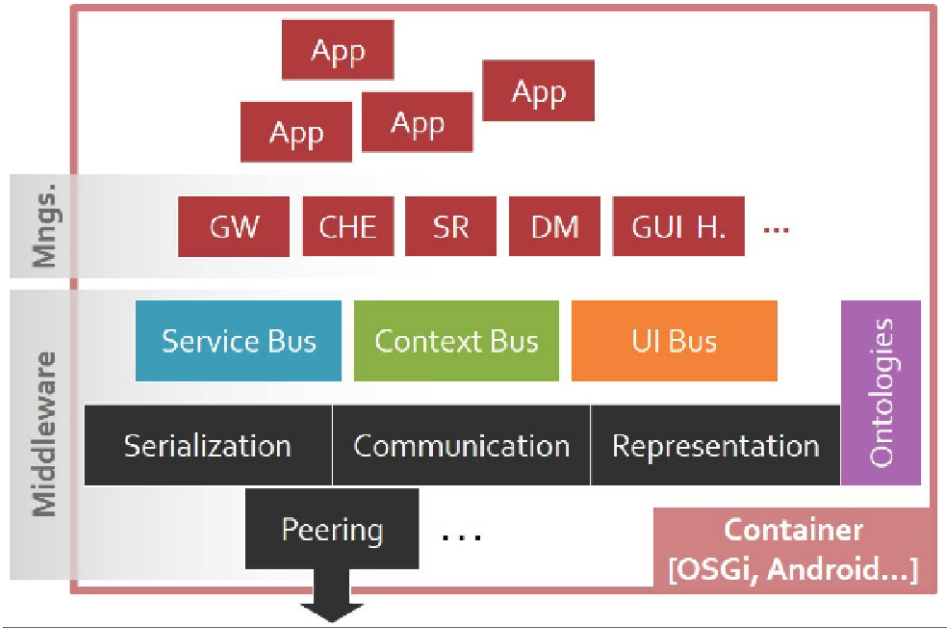
The requests that are sent over the busses are formulated semantically based on shared ontologies. This means that the components/applications do not need to know the syntactic interfaces of each other to interact. However, they require well-thought-out strategies for fault tolerance, as there are no guarantees that the dynamic resolution of dependencies through the mediators will actually be successful.



On top of the middleware the platform provides a set of components called managers, which provide important functionality (see next figure). Some of these will always exist on only a single node in the AAL space, while others can be present on all nodes. Through the busses, AAL applications and managers can communicate independent of their distribution in the AAL Space. The information exchanged on the busses is expressed using domain ontologies, and are transmitted on the busses using RDF (Resource Description Framework).

The universAAL middleware is implemented in Java, with realizations on two containers:

- OSGi: The main universAAL implementation based on Java 5, and uses OSGi as the primary container. The execution platform consists of a set of OSGi bundles, and also managers and applications consist of OSGi bundles.
- Android: For mobile devices, universAAL have supports Android. The native Android implementation of universAAL is somewhat limited compared to the OSGi version, and uses an approach where regular Android applications are annotated for use with the Android version of the universAAL middleware.



Developer Depot

The Developer Depot Server hosts resources needed for developers of AAL applications to get started developing using universAAL. The Depot aims at providing a powerful archive for developers embracing the universAAL platform. The Depot provides common repository functionality such as upload, download, search, and removal of binary and source code resources (depending on level of access). The developer will interact with the Depot either accessing the server directly or by using tools in the AAL Studio that interact with the Depot.

While the Developer Depot hosts the official platform, examples and documentation, it is not intended as a general hosting facility for community open source AAL applications. The Depot do however provide a facility that will list universAAL compliant open source community projects, with structure description of the projects and links to where they are hosted.

The Depot uses the Sonatype Maven Nexus Repository (http://www.sonatype.org/nexus/) open-source edition as the implementation for the binary resource facilities of the Developer Depot Server. By using a Maven server such as Nexus, we also enable transparent access to the platform binary distribution from the AAL Studio environment, so that for projects set up by the AAL Studio tools required libraries are automatically downloaded during build.

The Developer Depot is available at: http://depot.universaal.org/

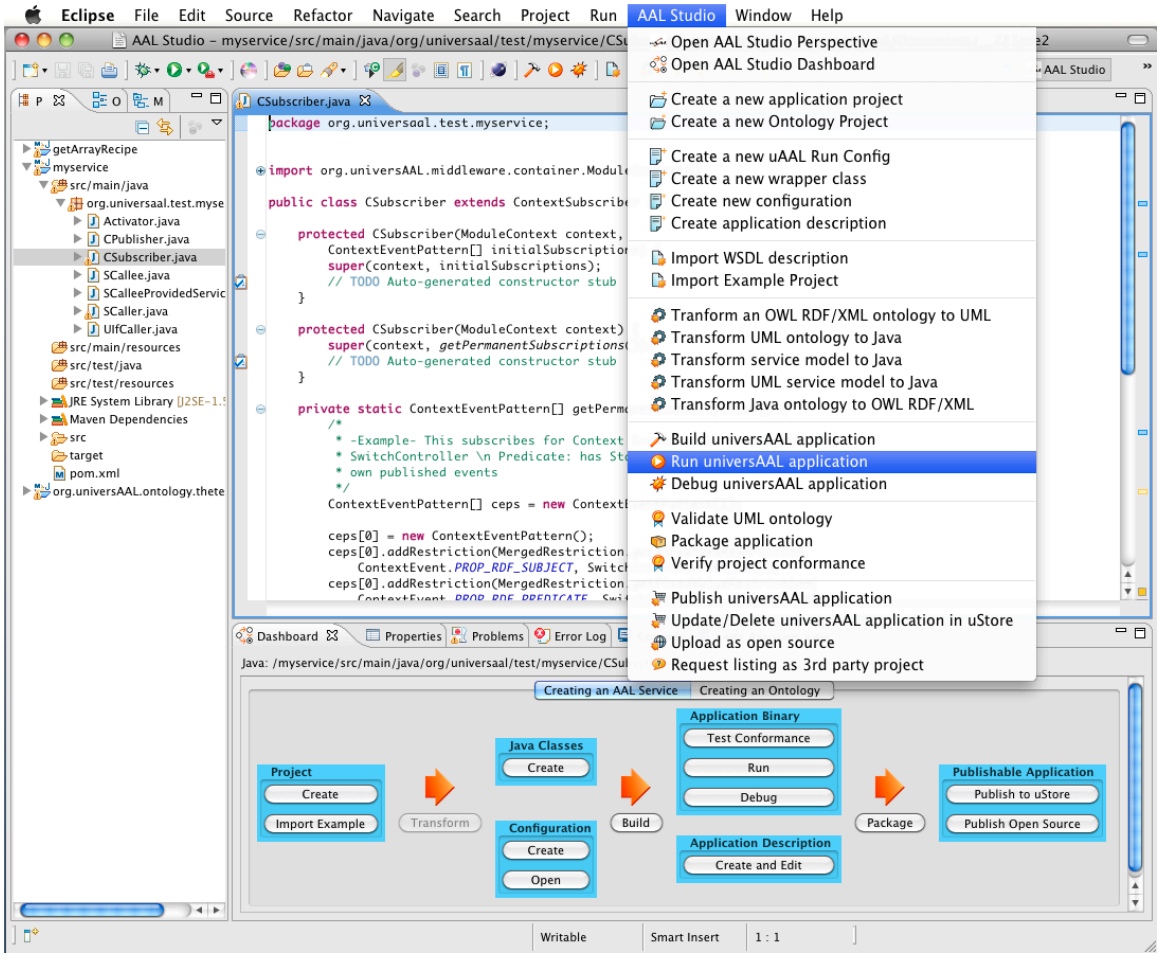
Developer Tools – AAL Studio

The AAL Studio provides an integrated development environment based on Eclipse for building applications and components using the universAAL execution platform. The AAL Studio makes it easier to get started with the AAL application development, and make some of the development tasks more efficient. Also, it gives easier access to the resources from the Developer Depot needed by the developer.

The AAL Studio tools created by universAAL are implemented as Eclipse plug-ins and provide integration with other AAL Studio tools (3rd party and those developed in universAAL). Also, some of the AAL Studio tools integrate with the server-side tools of universAAL (Developer Depot server and uStore). While development of universAAL compliant applications and components can be done in any Java development using the libraries of the universAAL execution platform, use of the Eclipse with the AAL Studio tools is recommended because it simplifies the development.

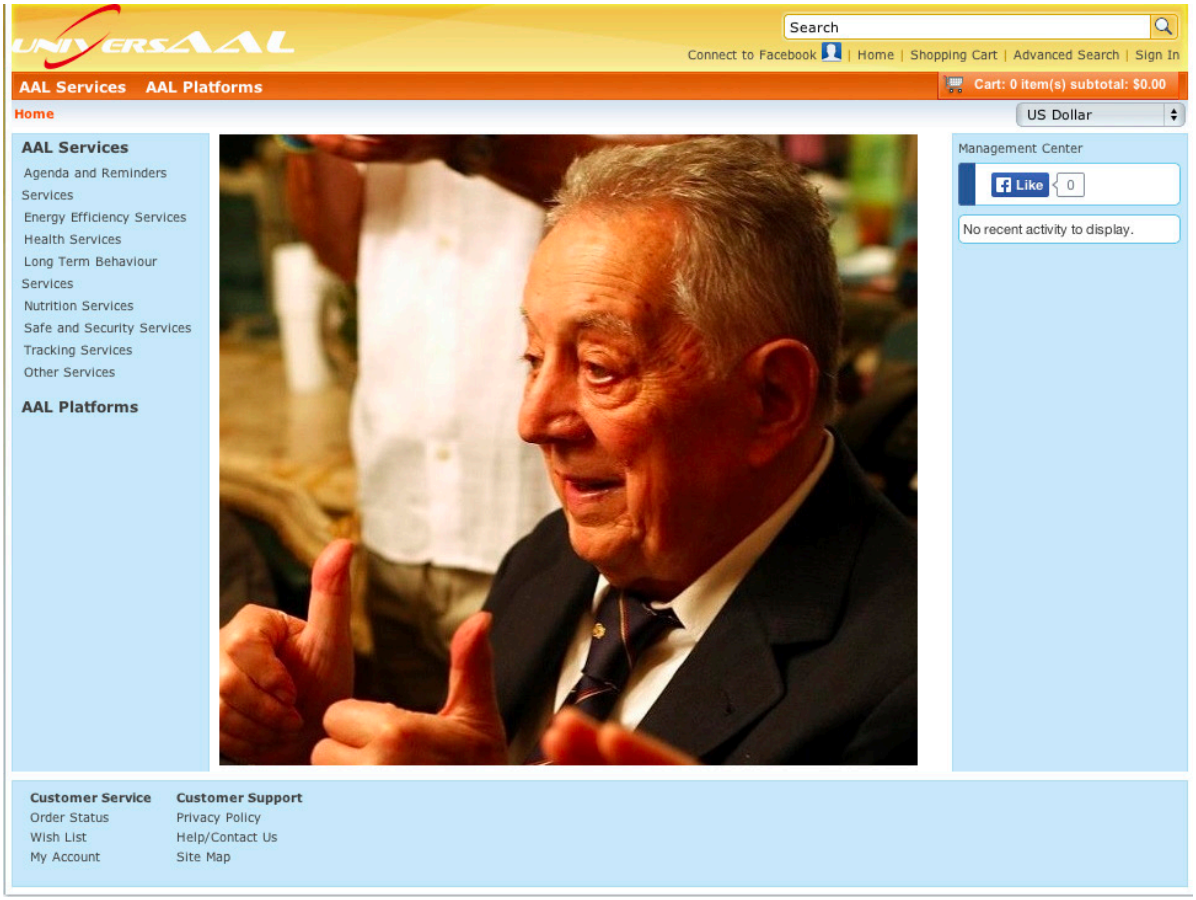
Among the tools AAL Studio includes are:

- wizards for creating new development projects and resources
- views supporting the development process and for browsing and using elements of ontologies
- modelling support for ontologies and services
- transformations that generate source code and other development resources from models
- support for building and running AAL applications from the development environment
- packaging and publishing support that prepares and publishes applications at the uStore



uStore

uStore is the one-stop-shop for universAAL services of all kinds: software, hardware and human resources. Service providers and developers can offer their services on uStore, while beneficiaries are able to find the most suitable service for their profile, needs, environment etc. The innovation of uStore is the creation of a one meeting point for all the stakeholders. The goal of uStore is to speed up the adoption and spreading of AAL Services by making it easier and more comfortable for the users to get the services they are looking for.



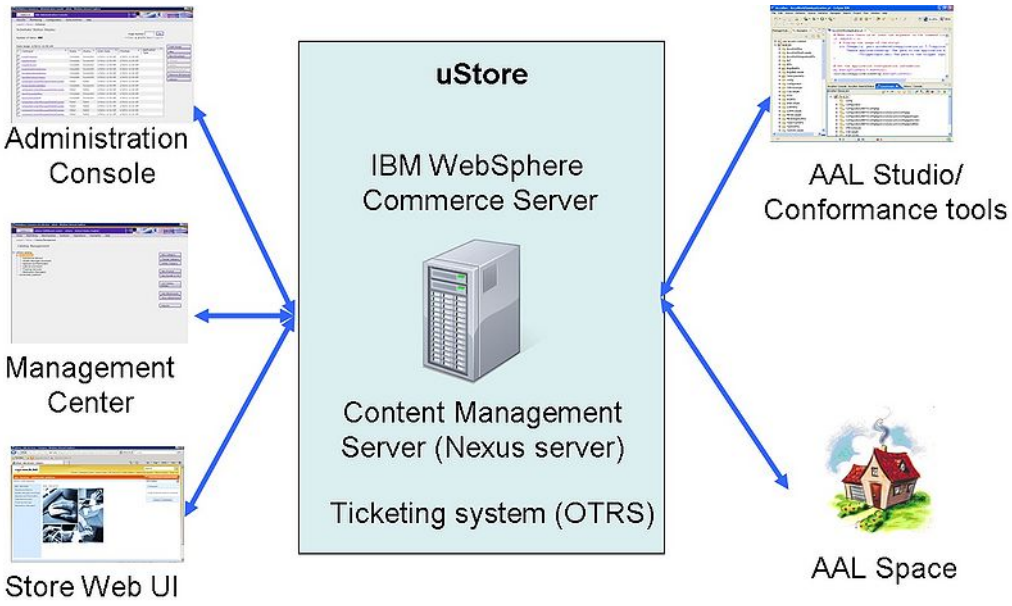
uStore provides the market place and community support part for the universAAL platform, including the following functionality:

- **uStore allows services providers to offer their AAL Services:** Service Providers (e.g. municipalities, integrators, private organizations and, individuals) can offer their services in uStore; thereby making them available to end users and other interested parties. A Service Provider can follow-up the service offering by using the uStore service management capabilities.
- **uStore allows users to easily find and acquire AAL services:** End users (elderly person and caregivers) can easily look for and acquire AAL services matching their specific needs. Searching for suitable services is supported by various context-aware search mechanisms, with filtering and ordering. Acquiring a service includes support for service negotiation and support for deployment of the service.
- **uStore supports exploitation of different business models:** AAL solutions offered in uStore can be acquired for free by its consumers or by paying according to business model that was defined by a solution provider. Therefore, a management framework of uStore services supports various and customizable business models, including wizards, license editing etc., that may be applied on all available services.

- **uStore allows capturing and utilizing user feedback:** uStore provides a user friendly and extendible mechanism for communication between users and providers. It provides a standard feedback form for collecting the users' comments, ranking and feedback of service and/or provider. Additionally the service providers may use the uStore tools to create a customised feedback form (polls, questionnaires etc.) that matches the specific aspects of the offered service. The users can communicate directly with the service providers or use the uStore ticketing system to report problems

From a technical point of view, uStore is an eCommerce platform that is customized to the unique requirements and use cases of universAAL as a one-stop-shop for AAL services. The core component of uStore is an eCommerce solution of IBM, WebSphere Commerce, which provides the ability to conduct commerce and specifically assist in publishing and purchasing AAL services. The built-in wizards for social commerce provide the interaction among all the involved stakeholders and help to establish an online community around uStore.

This figure describes the uStore architecture. It covers the interactions between the inner components of uStore and the interactions of uStore with other universAAL tools such as the AAL studio and the universAAL runtime platform.



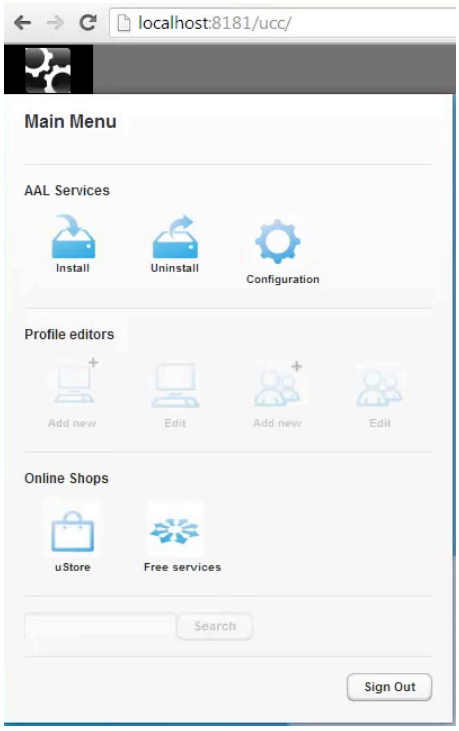
universAAL Control Center

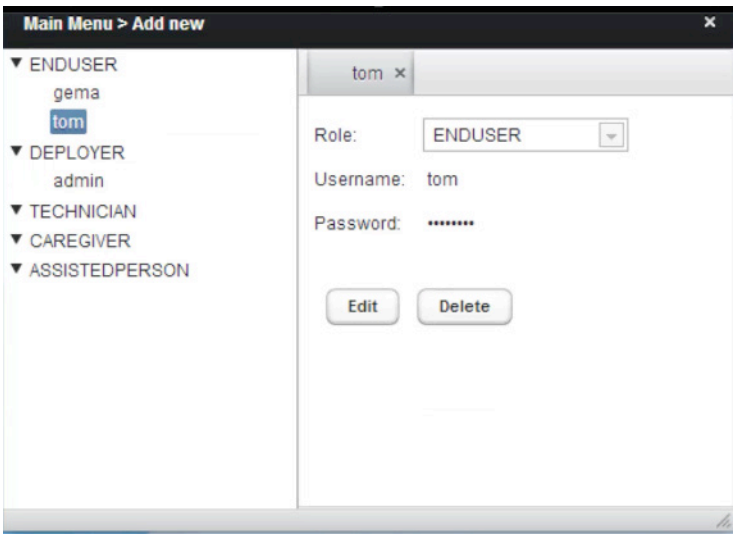
The universAAL Control Center (uCC) supports an easy integration of uAAL services provided by the uStore into the AAL space and its different nodes. This tool focuses on deployers (case manager, technician) and partly the end user. Developers of services and platform components can also use this tool suit mainly for testing purposes.

The uCC supports the integration of new AAL services into an AAL environment. By "integration" we mean all steps that must be done to get the new AAL service (application, hardware, human resources) working in the AAL space. This integration process starts after the identification of the needs an AAL service can solve. The first step is to search for a fitting AAL service in the uStore. Next the new service is simulated in the AAL space. After the successful simulation the process in the uStore is finished by buying and downloading the AAL service. Inside the AAL space the installation, configuration and personalization are the next steps. The integration process ends with continual maintenance of the AAL service and the AAL space.

uCC reduces the time and the complexity of the integration process for new uAAL services. The main benefits provided by uCC are:

- Easy installation, customization (configuration, personalization) and maintenance of AAL services and its parts. Also, all functionalities are available remotely.
- Easy extensible to own needs be plugins
- Supports developers in pre-integration process





AAL Services

The main objective of the universAAL project was to make it technically feasible and economically viable to conceive, design and deploy innovative new AAL services. To evaluate that the universAAL platform reached these goals, a set of applications was built based on the execution platform and using the development tools. These applications are known as AAL Applications in universAAL, while the complete experience offered to users through the usage of universAAL platform, involvement of other technical and human resources, and oriented to support the daily life of elderly people are called universAAL AAL services. The set of AAL services implemented in universAAL was selected in order to cover a wide set of reference requirements for AAL services, and contain different technical challenges that the underlying platform has to face.

The AAL services described below are available in open source, and thus are valuable examples for developers that want to create new services based on the universAAL platform.

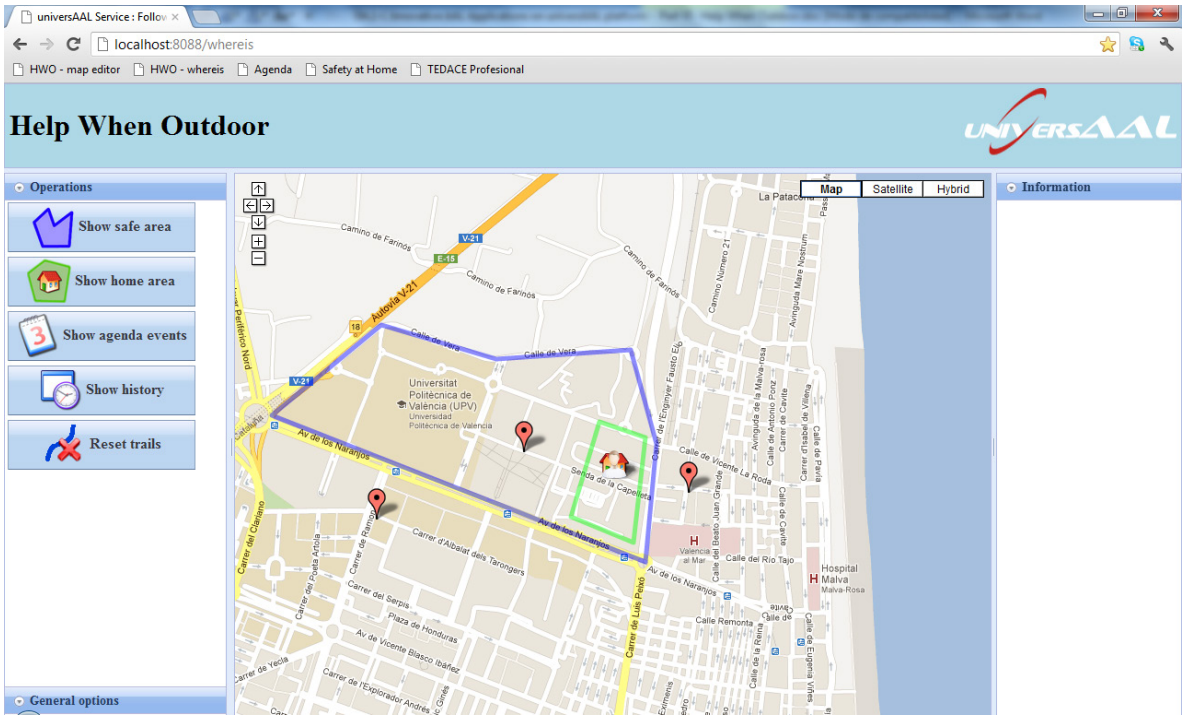
Health Management AAL Service. This service implements functionalities that help elderly people, their relatives and professionals in health care to manage chronic diseases (such as heart failure) of the elderly. The service allows the user to realize and to control the monitoring of his/her vital signals while doctor can interact with the patients and control their progress.

Nutritional Advisor AAL Service. This service helps to manage the nutritional aspects of the elderly by implementing mechanisms to increase the communication between the professional and the elderly (reminders, recommendations and tips, questionnaires...). It provides weekly menus, nutritional questionnaires and advices to help assisted person to maintain healthy nutritional habits. The service is personalized, taking into account the personal profile of the assisted person where his/her health status (diseases, medications, allergies etc.) and eating preferences are detailed.

Agenda AAL Service. This service deals with managing reminders for the elderly person. It offers interfaces to social networks and other common tools in order to facilitate that relatives participate in the management of reminders helping them to better manage the needs of the elderly. This service is important because it offers internal services to other AAL Services who need to remind things to the user. This is done thanks to the internal functionality to the platform to share common services through a common semantic framework.

Safety and security at home. This service deals with the usage of local infrastructure at home to implement a mechanisms that is able to be controlled by an elderly, related to security aspects when the people is at home. It also connects to relatives and professionals when emergency situations arise.

Help when outdoors. This service is built to demonstrate the capacity of universAAL to run in portable devices (like Android devices) and to coordinate with a local infrastructure running at home thanks to universAAL gateways. It helps the user to feel safer when leaving home by detecting risky situations and offering potential solutions to the user.



Long Term Behaviour Analyzer. This service models the behaviour of a person thanks to the massive acquisition of information in their daily environment, and then it is able to compare models to detect trends in the evolution of certain important behaviours to measure the quality of life of an elderly person: mobility, social networking/isolation, health parameters, etc.

AALffiency. This service is oriented to demonstrate the capacity of the universAAL execution framework to support services from other domains by sharing the same physical and logical infrastructure. This other domain is the Energy Efficiency, which is a concept that is becoming more and more important in daily life management of people. The idea is to demonstrate the capacity of universAAL to survive and adapt itself to existing infrastructures in order to increase its opportunities of adoption. Editor: TSB.

Food and shopping. Older people find difficulties in keeping track of their food supplies, needs and shortage of them. This is happening because it is not an easy task to know what their fridge or their storage area contains. And it is even more difficult to find out what items they should buy in advance. By using such service, users can feel more confident and relieved knowing that the system is able to handle all this information, and create the correct shopping lists, on behalf of them.

Medication manager. Medication is a critical matter for elderly people. Almost every elderly person has to manage this aspect, moreover when they have to take not only 1 pill a day but probably some more. Reminding part is important and connection to health management service will be provided to provide a complete solution based over universAAL.

4. Potential Impact: Mechanisms for Dissemination and Exploitation

The project uses three main mechanisms as its strategy for bringing about widespread adoption of project results, as follows:

1. *ReAAL – a new project that has as its main aim to use universAAL results in real-life settings with large numbers of end-users. This will demonstrate the benefits of universAAL and so encourage adoption. The project was initiated during the last year of universAAL, by a subset of universAAL partners.*
2. *AALOA – the AAL Open Association. While it was members of the universAAL project who took the initiative to form this association, its membership and composition encompasses the wider AAL community. One of its activities involves promotion of universAAL.*
3. *universAAL training – Training materials and course modules were developed during the project. These play an important "enabling" role: developers wishing to use universAAL results can efficiently learn what they need to know to use the results effectively.*

Each of the above is presented in more detail in the following pages.

The ReAAL Project

The following description is extracted and slightly adapted from the ReAAL project website at: http://www.cip-reaal.eu/home/

Roll-out with 7000 users in real life: Active & Independent Living applications to be built using the open service platform universAAL

Whether health, safety, comfort, social integration or support of mobility – assistance might be needed in any possible aspect of daily life. From an investment point of view, the AAL market should allow individuals in danger of losing independence to pick the set of applications and services of Ambient Assisted Living (AAL) over time in conjunction with actual needs, as they arise. Open platforms are supposed to be the enabler for such gradual system evolution and support products and services to become more affordable, future-proof, adaptable, and accessible.

ReAAL investigates these assumptions via a number of pilots, each with a different focus. If the platform's usefulness can be shown and the related technical knowledge is spread to an associated community of interest, a self-organizing AAL ecosystem will emerge, from which diverse stakeholders will benefit: application and technology vendors, service providers, public authorities and policy makers, sponsors, and the consumer masses, foremost those people who wish to be able to avoid dependency on nursing homes, preferring to continue to live independently in their own homes.

In search of answers...

At least since the community activity known as The Lecce Declaration, a central question is haunting the minds of many AAL stakeholders: *Will open platforms be able to help achieving AAL market breakthrough?*

The strategy in ReAAL for answering this question is based on the investigation of the following more tangible questions:

- What are the key selling points of open platforms?
- What is the evidence that those features are fulfilled by a certain platform (in this case universAAL) in reality?
- What are the costs for the different stakeholders to adopt universAAL?
- What is the evidence that the costs pay off?

The ReAAL project will:

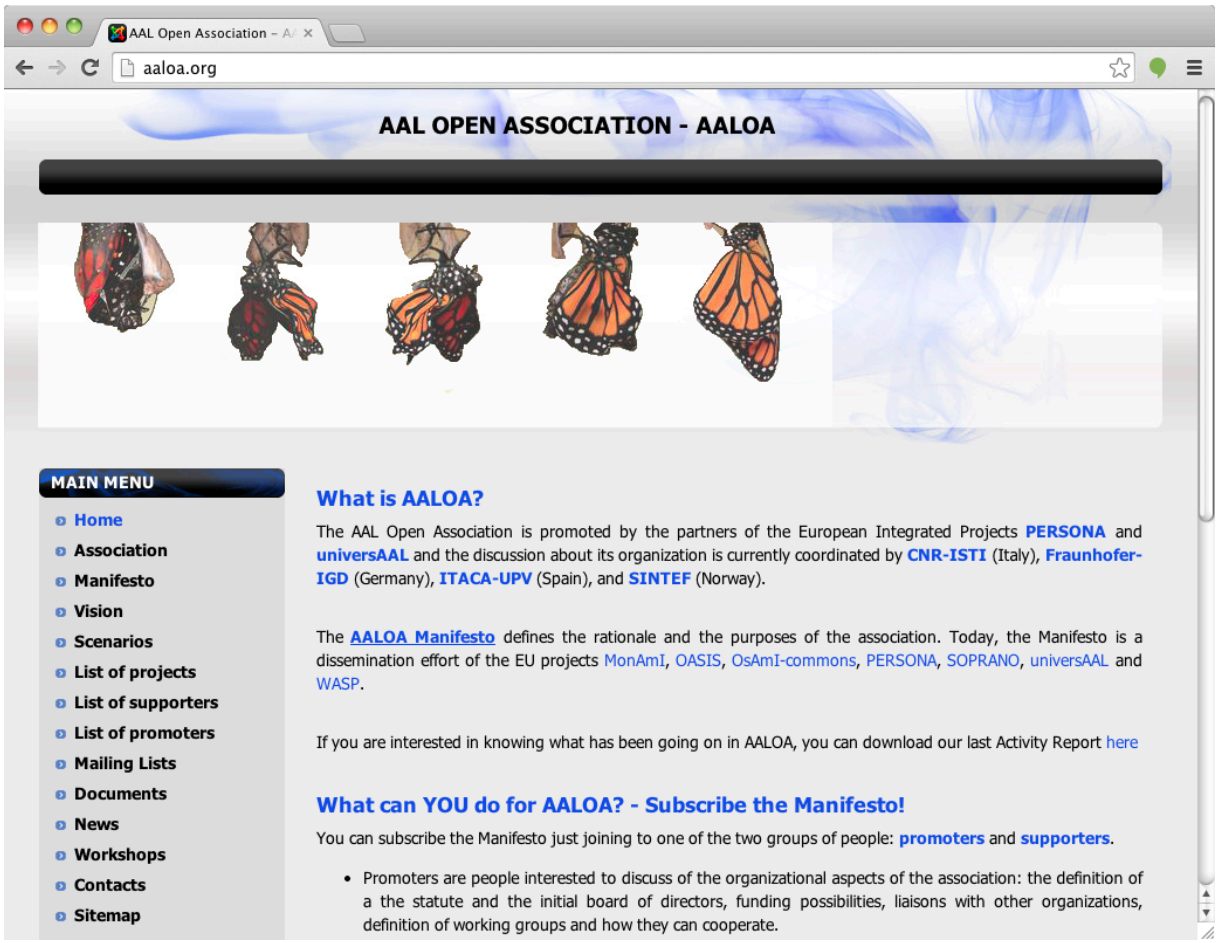
- validate the role of common open platforms in putting interoperability standards in place
- measure the related socio-economic impact
    - a multidimensional evaluation framework will allow to consider the ethical, legal, market, quality of life, and user experience impacts in addition to the socio-economic impact
- analyse the effectiveness of pilots' value chains and derive replication guidelines
- publish findings and recommendations, esp. lessons learned and best practices on technical and organisational aspects of deployment and public procurement, in a public knowledge portal to serve as the ultimate reference for future roll-outs

The AAL Open Association (AALOA)

An important part of the community building approach in universAAL has been to help creating AALOA, the AAL Open Association. The initiative to AALOA was taken by Persona and universAAL, with the aim of reducing fragmentation in the research efforts and realizing the impact of Ambient Assisted Living (AAL) in positively influencing the lives of elderly people. The main aim of universAAL in this activity has been to further the development of the universAAL platform after the project end, in January 2014. The reason is that the results of the universAAL project: the infrastructure, the software and the documentation produced by universAAL will make sense if they are inherited by some organisation that is able to back them with legal support, to improve them, have them evolve and to advertise them so that they can become a standard in AAL and related fields. This organisation must be independent of other organisations such as companies and public or private bodies, and will need to gather the attention of stakeholders and involve the highest possible number of them at all levels:

- At the technical level, it must necessarily involve developers and academics with a vision for the future who would guarantee the further development of the universAAL platform at a cutting-edge level.
- At the marketing level, it needs to involve companies, which will provide guidance as to the market needs and which will be the primary consumers of the organisation's products.
- At the policy level, it needs to involve public and private bodies that are in any way related to the needs of older or impaired people and their caregivers.

The AALOA web site is available at: http://aaloa.org



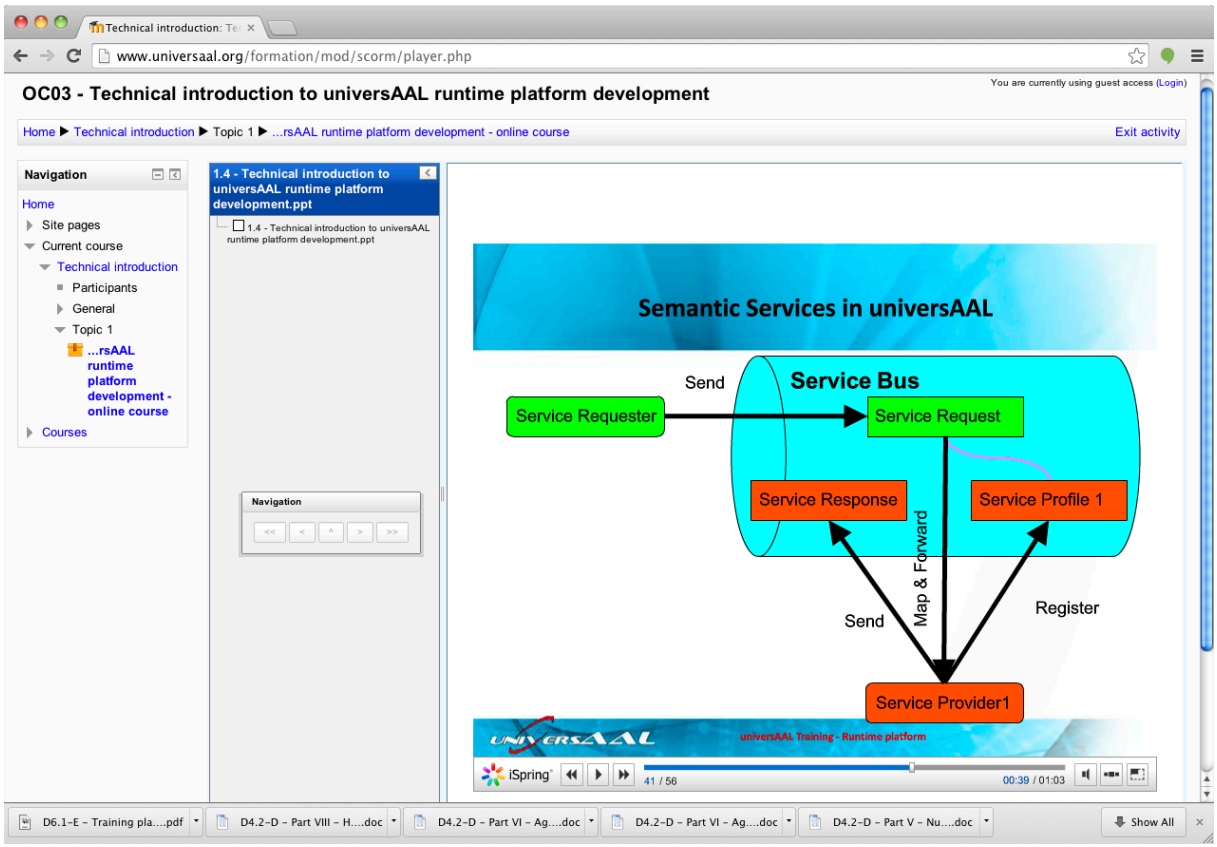
universAAL training

To make it easier for developers to get started using the universAAL platform, and to promote widespread adoption of the platform, the universAAL project developed training material and events for developers. During the project, a set of external training events was organized. In total, 235 trainees participated on the 20 main universAAL face-to-face training events that was organised worldwide. Besides workshops organised in parallel with the universAAL Open Day events, several training workshops aligned with important AAL events and on-demand training workshops at consortium locations were also organised.

The course materials are now available for use by any potential new users of project results, and indeed have already been used extensively in the ReAAL project mentioned above.

The basic work unit of training in universAAL project is called training module and it is defined as a group of training materials which address single learning objective by using single training method. A total of 42 training modules have been prepared and are available also for online training. Each training module is usually composed of various different material types (i.e. slides and source code) and can have several variations of materials (variation in duration or delivery type). Materials include presentations, videos, documents, online material, exercises, source codes, and other materials. There were around eighteen training modules created for internal trainings and more than fifty training modules created for external trainings. External training modules are grouped under ten different high-level training topics. Training topics are top-level abstraction training concepts and are only considered as organizational unit of work for planning and development of training materials.

The training material is available from: http://www.universaal.org/formation/



5. universAAL Website and Contact Information

Project Website

Project website: www.universaal.org

Developer depot website: depot.universaal.org

Website of the AALOA association being established by the project: www.aaloa.org

Access to open source results

The main results of the universAAL project are available as open source. The final release versions of the source code of the execution platform, AAL Studio, universAAL Control Center and the uStore[1] can be downloaded from: http://www.universaal.org/index.php/en/download/downloads

The latest version of all the source code, including the above and the AAL Services and other examples are available from the repositories at: depot.universaal.org

Access to open deliverables

More details about the universAAL results can be found in the open deliverables that are available from: http://www.universaal.org/index.php/en/about/about-deliverables

Consortium and Contact Information

For further information on the project, please contact:

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[1] uStore is built on top of IBM WebSphere Commerce product. While the universAAL-specific extensions are open source, a license for WebSphere Commerce is required in order to set up a new uStore server deployment.