SEVENTH FRAMEWORK PROGRAMME SEVENTH FRAMEWORK PROGRAMME: PRIORITY 7.1B LARGE SCALE INTEGRATING PROJECT (IP)	IP project number 247950 Project duration: February 2010 – February 2014 Project coordinator: Joe Gorman Project Coordinator Organisation: SINTEF, Norway Strategic Objective: 7.1.b website: www.universaal.org UNIVERSAAL Universal Open Architecture and Platform for Ambient Assisted Living

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Release History

Release number	Date issued	Milestone*	eRoom version	Release description /changes made.
0.1	22.02.2013	PCOS proposed	2	Initial draft with content adapted from D1.3-D version. No further changes in structure.
0.2	18.05.2013	External proposed	5	Update content and maps to align concepts with Part III
0.3	09.09.2013	External revised	7	Updated content to address reviewer comments
0.4	5.11.2013	External Approved	8	Changes made by Project Coordinator, Joe Gorman, to improve clarity and precision.
1.0	18.11.2013	Released	10	TM release

* The project uses a multi-stage internal review and release process, with defined milestones. Milestone names include abbreviations/terms as follows:

- PCOS = "Planned Content and Structure" (describes planned contents of different sections)
- Intermediate: Document is approximately 50% complete – review checkpoint
- External For release to commission and reviewers;
- proposed: Document authors submit for internal review
- revised: Document authors produce new version in response to internal reviewer comments
- approved: Internal project reviewers accept the document
- released: Project Technical Manager/Coordinator release to Commission Services

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Executive summary

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The agreed definition for a reference model in universAAL is: “A reference model is an abstract framework **for understanding significant relationships among the entities of some environment**. It enables the development of specific reference or concrete architectures using consistent standards or specifications supporting that environment. A reference model **consists of a minimal set of unifying concepts, axioms and relationships within a particular problem domain**, and is independent of specific standards, technologies, implementations, or other concrete details.” [1]

In this document, the consolidated reference model for AAL is summarized in terms of a set of seven concept maps, of which one is serving as a root map, which provides a top-level understanding of an AAL ecosystem, and the other six analyze further related aspects at a second level of detail. These are about a basic understating of the term *service*, the domain-specific context of AAL services, the relationship with the AAL Space concept and the role of hardware and software components to enable them, as well as the most important stakeholders along with an introduction of the Reference Architecture term.

1 About this Document

This sub-part of D1.3 is dedicated to the description of the universAAL Reference Model. According to the definition provided in the introductive part of the deliverable, this reference model intends to provide a clear picture about the understanding of the AAL domain within the project as well as a broad understanding of the AAL domain.

It specifies a common view (and understanding) at the core set of domain and solution domain concepts and the essential interrelationships among them. Hence, it is already delivering a first analysis of the domain – although not with the same level of logical consistency of an ontology – that helps to also identify some of the important problems to be solved in AAL domain. In case of terms with several different, and sometimes even contradicting, interpretations in the literature, the reference model is additionally serving as means to clarify the AAL-specific notion of such ambiguous, but important, terms.

1.1 Relationship to other sub-parts of this deliverable

This document is one of the sub-parts of D1.3 as shown in Figure 1. It presents the universAAL Reference Model for AAL, which is one of the main results of D1.3. The introductive part of the deliverable provides supplementary info about how the results presented in this document have been achieved using which methods and tools. The Reference Architecture and the Concrete Architecture are logically built on this reference model and address issues identified here.

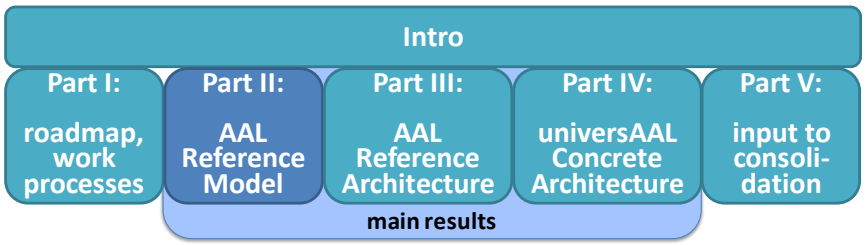

Figure 1: The AAL Reference Model within D1.3 deliverable

1.2 Relationship to other versions of this Part

In deliverable D1.3-A, we followed a consolidation approach by first collecting concepts from input projects and some relevant standards (see Part V) and then mapping and interrelating them to each other in order to obtain the first version of the universAAL reference model (cf. The procedure described in Part I). This has been done by building groups of concepts according to their interpretations which helped to reduce the number of concepts based on the identified overlaps in the different input projects and the chosen standards.

In version B of the document we decided to improve the reference model from D1.3-A, this time based on a top-down approach directly concentrated on the provision of a reference model, using concept maps as a visual tool[1]. A reference model should be "independent of specific technologies, implementations, or other concrete details" hence, the result of the second iteration achieved a drastic reduction of the number of concepts that possibly missed out many of the "unifying concepts, axioms and relationships" [1] within the domain of AAL[2] that were necessary "for understanding significant relationships among the entities" [1] in the domain.

[1] More specifically, the free software *IHMC CmapTools* from http://cmap.ihmc.us/.
[2] For instance, the business related stakeholders of AAL were not considered at all.

In version C of the document we made only a minor revision of the previous version. The main objective was the harmonization with the terminology used in other deliverables and the clarification of some ambiguities introduced for overused terms. A new concept map related to the AAL Application concept has been included to emphasize that AAL applications may consist of distributed software running on distinct hardware deployed in the environment and cooperating to implement AAL Services.

Version D of the document is introducing a major improvement in the context of alignment of terminology and simplification of concepts. The main objective was to minimize occurrence of technical aspects of presented concepts to make the document more attractive to non-technical readers. A new concept map related to the AAL Service Life-Cycle Management is also introduced to provide a comprehensive view of the AAL Services from business perspective.

In Version E of the document we improved the definition alignment with other parts of the deliverable, and made some detailed changes throughout to improve precision and clarity. We introduced some changes in a few concept maps (especially the AAL Stakeholders and AAL Reference Architecture) in order to fix some issues introduced in the previous version. Although most of the changes introduced in this version are by themselves fairly minor, they are spread throughout the document, and the sum of all the changes is such that we recommend that anyone who has read an earlier version should re-read this version in full. This version is the final release of the universAAL Reference Model for AAL.

1.3 Structure of this document

The structure of this document is very straightforward as it is just representing the reference model created out of the methods (just a brief overview is proposed at the end of this section), tools, and processes.

The Reference Model is described in full in the next section (Section 2). The description starts by introducing the root concept map, followed by subsections (2.x) on each concept presented in the root map. Each section is structured as follows. The concept map is followed by the table of definitions (which explain all terms used in the map) and concluded by details (which contains additional information difficult to present in the map or table).

1.4 Intended Audience

The intended audiences for the AAL Reference Model include at least the following groups:

- Anyone involved in the AAL business, or interested in becoming involved in it:
  - To understand the “standard” view, widely accepted by actors in the AAL domain, regarding basic concepts, stakeholders, relationships, assumptions and terminology in the AAL domain.
  - To understand ones potential role in the AAL business, and the business opportunities it offers.
- Architects and developers designing, identifying or developing a system located in the AAL domain;
- Anyone who wants to read the AAL Reference Architecture, to understand the basic concepts on which it is based.

2 The Reference Model for AAL

The agreed definition for a reference model in universAAL is: "A reference model is an abstract framework *for understanding significant relationships among the entities of some environment*. It enables the development of specific reference or concrete architectures using consistent standards or specifications supporting that environment. *A reference model consists of a minimal set of unifying concepts, axioms and relationships within a particular problem domain*, and is independent of specific standards, technologies, implementations, or other concrete details." [1]

A Reference Model is relevant to:

- create standards for both the concepts that inhabit the model and their relationships to one another
- break down a large problem space into smaller problems that can be understood, tackled, and refined → Developers who are new to a particular set of problems can quickly learn what the different problems are, and can focus on the problems that they are being asked to solve, while trusting that other areas are well understood and rigorously constructed
- improve communication between people
- create clear roles and responsibilities
- allow the comparison of different things: e.g., how well each of the candidate solutions can be configured to meet the needs of a particular business process

The Reference Model for AAL is formalized by using concept maps [3]. Concept maps provide an approach for knowledge representation similar to semantic networks that build semantic relations among concepts through a directed or undirected graph consisting of vertices, which represent concepts, and edges. One of the benefits of using concept maps is that the work can start with less formal constraints, increase (if required) the formalism gradually and eventually ends up with the formalism of ontology. Furthermore, even though they can apparently be considered just a simple tool, concept maps are a very expressive and powerful way for defining and representing knowledge. Simple relations or complex knowledge environments can be provided by using concept maps.

The graphical representation of concepts and their interrelationships within concept maps are intended to help different types of stakeholders to quickly gain a common understanding of the AAL domain. The view of the domain presented in this Reference Model, by means of these concept maps, has been produced through a consolidation process based on a careful analysis of work in the field.

In order to structure the AAL domain, a core set of concepts was identified reflecting a basic understanding of AAL systems, and described in a single concept map serving as the *root map*. Remaining concepts were then organized into a set of *subordinate concept maps* that provide more details in different directions at a second level. Some remarks should help to better interpret the concept maps before starting to present them in the following subsections:

- Top-level concepts are drawn as ovals and second-level concepts as rectangles.
- Reuse of top-level concepts in the related second level maps indicates the connection between the latter maps and the root map.
- Different colors are used to further group the concepts and add some traceability across the concept maps.
- Bold lines and fonts are used to highlight concepts of particular importance.

2.1 The Root Concept Map

The root concept map (Figure 2) presents the consolidated understanding of the AAL domain in a single picture using a small set of key concepts. Details about the concepts in the root concept map are presented in further sections as concept maps providing more precise definition for the related terms. All of them contain one or more concepts from the root concept map, with the corresponding color code, as a linking point. In this way it is evident how the root map and the detailed concept maps relate to each other.

Figure 2: The Root concept map of AAL domain

AAL Stakeholder	An individual, team, or organization (or classes thereof) with interests in, or concerns relative to the AAL domain (e.g. service providers, end users, authorities etc.)
AAL Service	A combination of software, hardware, and human resources that support people who need some assistance in carrying out everyday activities.
AAL Reference Architecture	Provides a common/standardized view of software architectural elements (building blocks) in the AAL domain.
AAL Platform	A set of hardware and software artifacts (standardized and compliant with the *AAL Reference Architecture*) that help developers and service providers with the provision of AAL Services (at all stages in the lifecycle, including design, development, deployment and execution).
AAL Spaces	Environments where people may need assistance (e.g.: homes, airports, railway stations, supermarkets and cars) with defined boundaries of hardware, software ,

	and human resources in the context of e.g. access control, multimodal user interfaces etc.
Software and Hardware Components	One or more pieces of computer software and/or special devices (sensors, displays, switches, controls for domestic appliances, … etc.) that – together with any relevant human resources – are used to provide AAL Services.

The AAL domain is all about the provision of *AAL Services* to end-users *(*e.g. Assisted Persons and/or Caregivers).

The *AAL Services* which take place in an *AAL Space* make use of *Hardware and Software Components* embedded in it. The cooperation between such distributed components in an *AAL Space* is facilitated by *AAL Platforms* that implement the *AAL Reference Architecture* in order to provide for resource sharing, and let users experience an integrated world easy to interact with based on natural communication.

2.2 AAL Stakeholders

This concept map shows the people/organisations involved in AAL, and how they relate to some of the concepts introduced in the Root Concept Map. It does not provide refined definitions of any of the concepts in the Root Concept Map – see later sections for that.

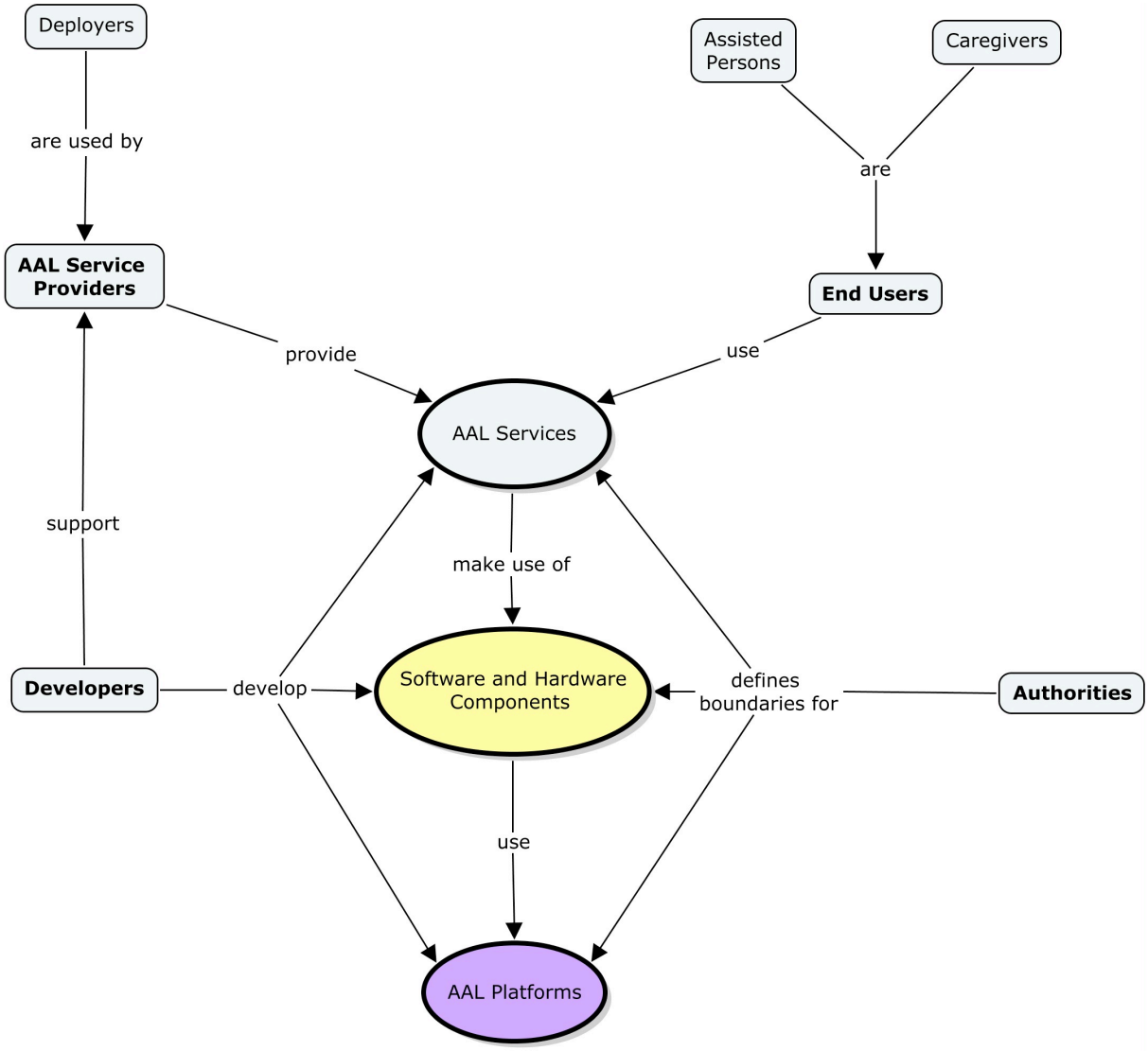

Figure 3: The AAL Stakeholders concept map

End Users	Non-technical group of AAL community members that directly benefit from *AAL Services* e.g. *Assisted Persons*, Professional Caregivers, Informal *Caregivers (such as: friends, neighbors, and family members*).
AAL Service Providers	Organizations that provide *AAL Services* to the *End-Users* by combining and publishing the resources provided by Developers.
Developers	People with technical skills in the design, production, testing and deployment of computer software and associated hardware (computers, sensors, actuators etc.) needed to provide *AAL Platforms* and *AAL Services*.
Deployers	People with technical skills, responsible for installation, configuration, customization, and maintenance of integrated AAL solutions

Authorities	Organizations and institutions that work in the economical and legal context of AAL thus having an impact on the overall *AAL Domain*

AAL Services are primarily intended to assist the elderly, people lacking in certain abilities, or anyone else needing support in carrying out the tasks of day-to-day living. We use the term *Assisted Person* to point out that people of any age may need assistance, not only elderly. *AAL Services* are also intended to help *Caregivers* help the *Assisted Persons*. They can be *informal* caregivers (i.e. people from the *Assisted Person's* personal network such as friends, neighbors, and relatives), or *professional* caregivers. The concept of *End Users* is used to indicate that these two categories of stakeholders are the people that require and use *AAL Services*.

The organizations that provide *AAL Services* to the *End Users,* acquire solutions provided by *Developers* and use technical services provided by *Deployers* are referred to as *AAL Service Providers*. *Deployers* are people in charge of equipping the environment with ICT technology, and installing the needed software to run the *AAL Service*.

All industries and companies that develop AAL solutions and technologies (hardware, software or both) are referred to as *Developers*. In this category we include *Hardware Developers* - producing devices and sensors; and *Software Developers* – implementing software services and applications.

The organizations and institutions that work in the economical and legal context of AAL are presented as *Authorities*. Examples are regional and national agencies working for the social-security, welfare and healthcare system, policy makers, and authorities in general. They are important in the AAL landscape, in ensuring funding for the services delivered and in defining the legal framework in which service provision can reach the target public. .

2.3 AAL Services

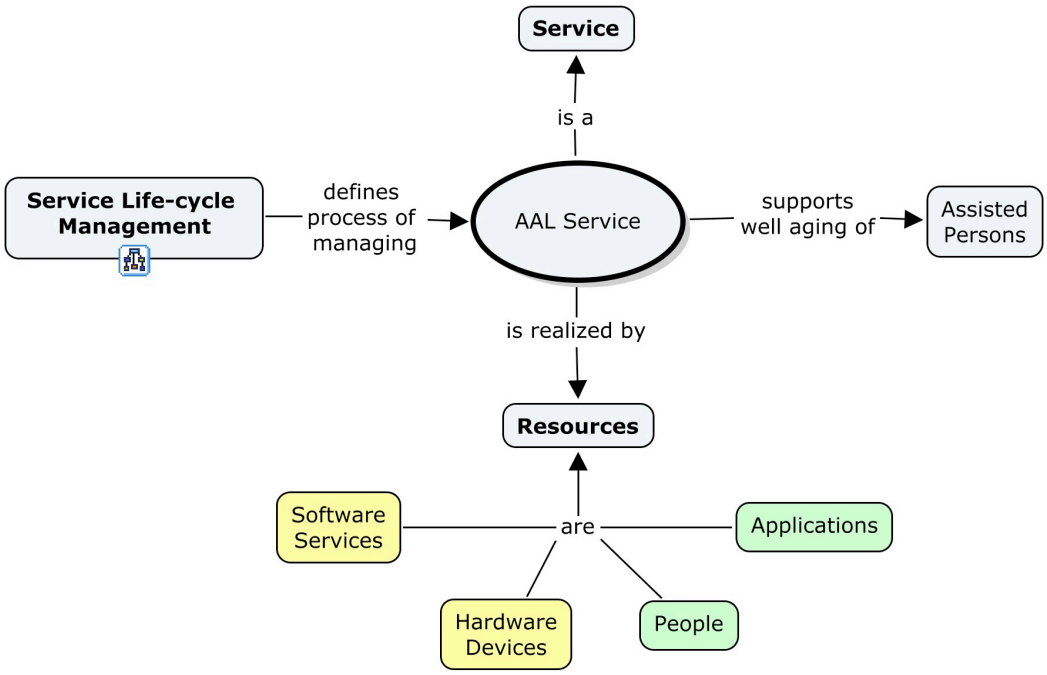

Figure 4: The AAL Service concept map

Service	An agreement between two entities (people, organisations or software components) whereby one carries out some actions or provides some material/information that is useful for the other. In its most general sense, "service" applies at the business/contractual level between two entities. If the two entities are software components, the term *software* service is often used.
Service Life-Cycle Management	Description of the operations carried out over an extended period of time to successfully design, deploy, operate and (maybe) finally terminate an *AAL Service*. Includes such processes as: Acquisition, Provisioning, Utilization, Removal etc.
Resources	Collective term for all the things needed for provision of an AAL Service.

An *AAL Service* (Figure 4) is a *Service* in the broadest, business oriented meaning of the term.

2.4 AAL Service Life-cycle Management

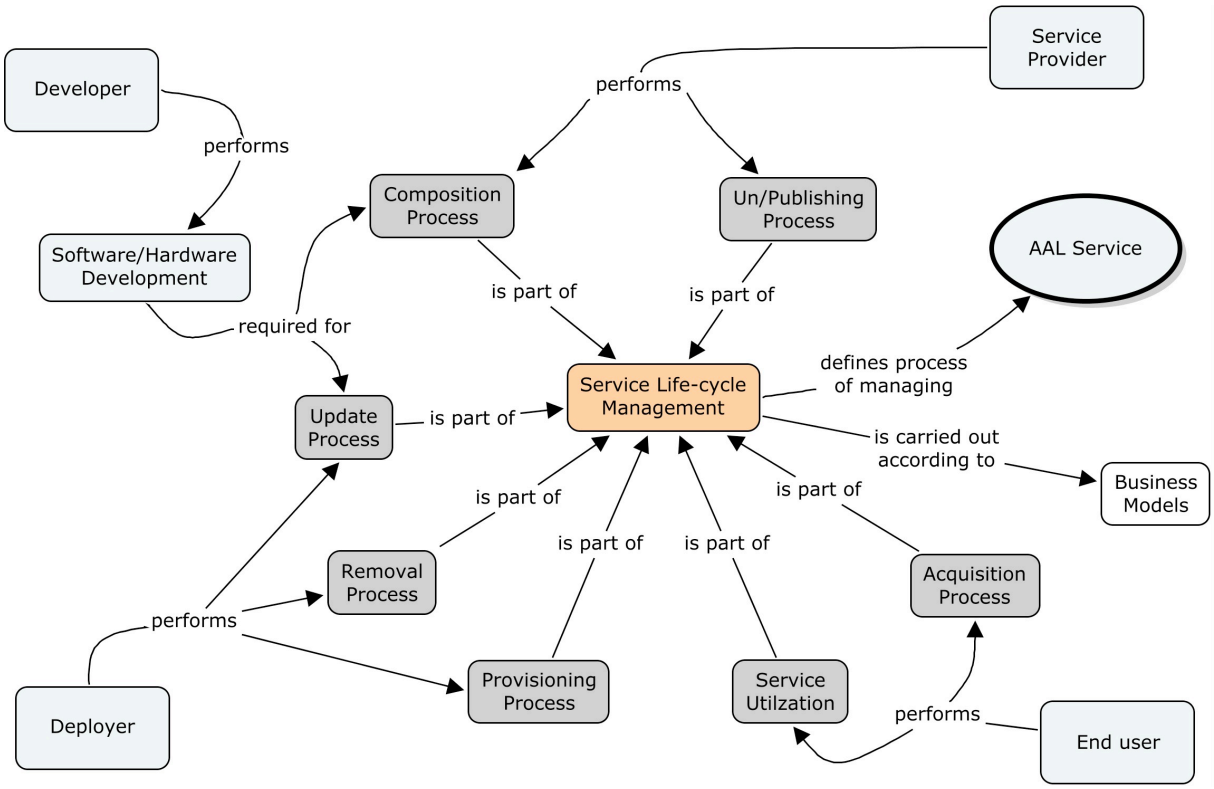

Figure 5: The AAL Service Life-cycle Management concept map

Note: The definitions below are sorted to follow the layout of the concept map (starting top-left, and working round clockwise).

Software/ Hardware Development	Creation of the technological parts of an *AAL Service*.
Composition Process	Process of combining interoperable resources into a functional entity, the *AAL Service* which deals with resolution of conflicts and dependencies between the used resources.
Publishing Process	Process of submitting the *AAL Service* which deals with placing it in the repository and its presentation to the *AAL Community* – defining terms of use, price etc.
Un-publishing Process	Process of withdrawing an *AAL Service* from the Repository. It could be triggered by the *AAL Service Provider* providing the *AAL Service*, a public *Authority* or the operators of the said repository.
Acquisition Process	Process of obtaining the rights to use an *AAL Service*. It includes concluding a contractual relationship between *End User* and *AAL Service Provider* typically involving payment of a fee (the price of *AAL Service*). This could be done by the *End User* (*Assisted Person*) or someone acting on his behalf (*Caregiver*)

Service Utilization Process	Process of direct use of the *AAL Service* by the *End User*.
Provisioning Process	Process of delivering the service resources to the *End User* and making them operable. It includes deployment of the software components onto the *End User*'s runtime platform(s), their configuration and customization. If the *AAL Service* involves hardware components they are also delivered, connected and configured to operate with the End User's *runtime platform(s)*.
Removal Process	This process is the opposite of Provisioning. It includes removal of the software parts of the *AAL Service* from the runtime platforms of the *End User* and takes steps to ensure the return of any rented hardware equipment to its owner(s). As a result, any contractual agreement between *End User* and *AAL Service Provider* of the *AAL Service* being removed is made void.
Update Process	Process of delivering changes in the *AAL Service* to the *End User*. It includes development and provisioning of software components, replacement of defect or malfunctioning hardware equipment, changes of the terms of involvement of the human resources etc.

Service Life-cycle Management describes the processes related to creation of an *AAL Service*, its delivery to the assisted person, utilization and removal. It supports one or more Business Models. This section presents the overall description of the individual processes and points the involvement of the different stakeholders.

As described previously, an *AAL Service* is a composition of multiple resources. The development of software and hardware components is performed by *Developers*. The resulting components are typically marketed, published on the web and in a software repository. Software components are described with metadata: some additional information, like a description, conditions of use, requirements and dependencies, license agreement etc.
The role of the *AAL Service Provider* is to perform the *Composition and Publishing Process;* that's the act of collecting, publishing and marketing interoperable resources into a functional entity, the *AAL Service*. The *AAL Service Provider* in turn provides additional information describing terms of use, requirements, payment options and price, contact data etc.

The *Acquisition* of *AAL Service* is the process in which *End Users* declare interest in a specific *AAL Service* and express consent to the terms and conditions of use (i.e. usage agreement). They may enter into contractual relationships with the provider of the *AAL Service* and, if necessary, pay the price entitling them to obtain and use the Service. On the other hand, if stated in the usage agreement, the *AAL Service Provider* may be bound to provide the service, update and support it with limited or no charge.

As a result of *Acquisition*, the *AAL Service* is delivered to the end user. This is done by the *Provisioning process*. This is the process where the software component of the *AAL Service* is deployed in the *AAL Space* of the *End User,* configured and initialized; the hardware components (if any) are delivered, configured and made available in the *AAL Space*; the *Human Resources* (if any) are introduced to the *End User*. This process is performed by a *Deployer*, who also demonstrates the use of the *AAL Service* to the *End User*.

After successful *Provisioning* of the *AAL Service,* the *End User* can start using it. This is the process of *Utilization*. In some cases *Utilization* is bound to charging (determining what should be paid) and payment for the service, as stated in the Usage agreement.

An important part of *Service Lifecycle Management* is the process of modification and *Update* of a Service. This includes update of the conditions of use, update of the software part (related to the subsequent *Provisioning* of the updated component), replacement of devices or human resources. These changes could be done with or without the explicit consent of the *End User*. The *Development* of the updated software component is done by a *Developer* and the actual *Update* may require the involvement of a *Deployer*.

The final stage of *Service Lifecycle Management* is the process of *Removal* of the *AAL Service* from the *AAL Space*. This includes de-installation of the installed software components from the *AAL Space*, return of any borrowed hardware and the end of the contractual relationship between the *End User* and the *AAL Service Provider*.

The *AAL Service Provider* can withdraw his Service from the market. This is done by *Unpublishing* the Service from AAL Public Repositories. This results in the Service not being available any more to end users. *Unpublishing* may trigger *Removal* of the Service from the premises of *End User*'s, and thus lead to discontinuation of the support provided by the *AAL Service Provider*. But note that this does not necessarily happen: it is possible to unpublish a service, but keep it active for existing users.

2.5 AAL Spaces

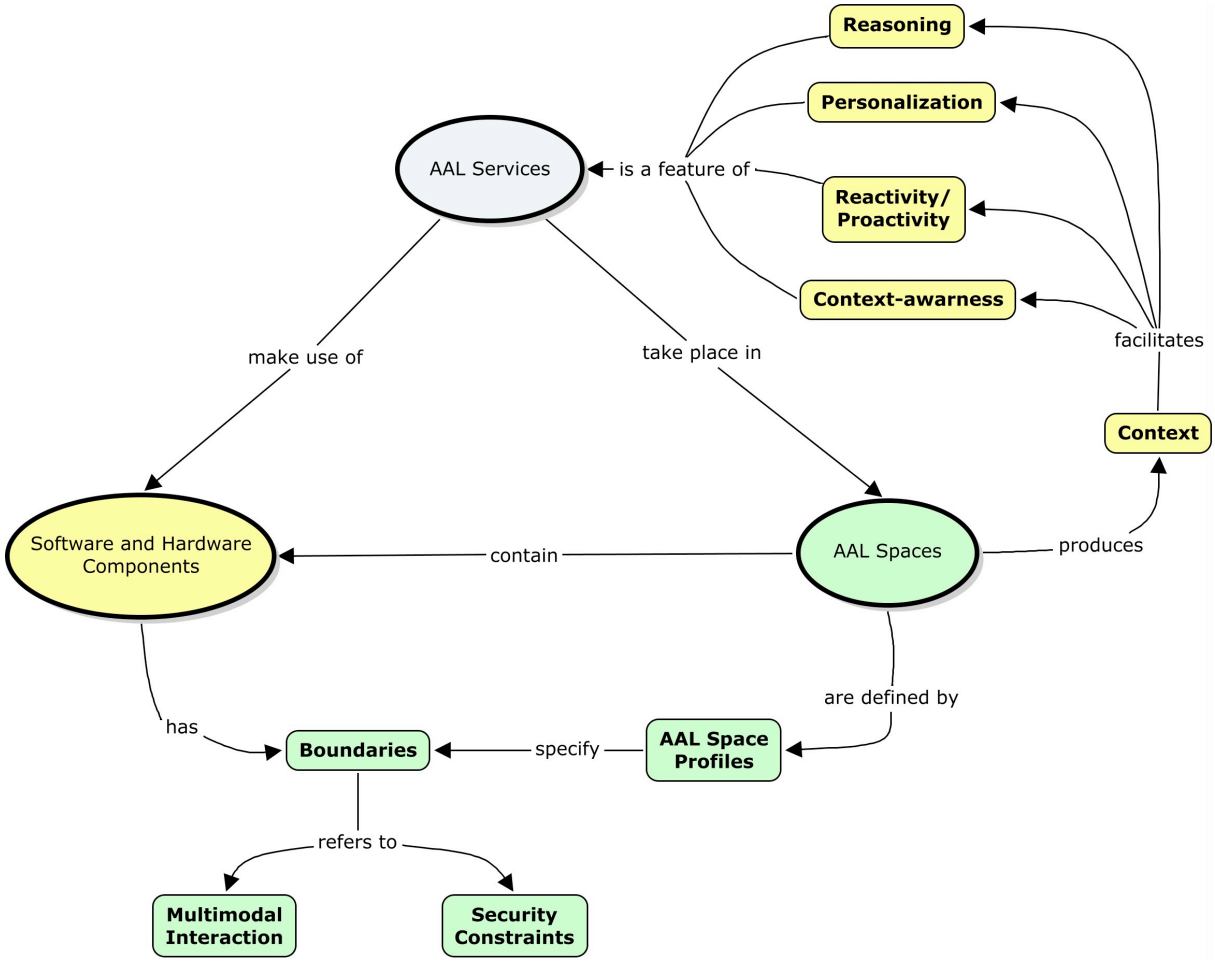

Figure 6: The AAL Space concept map

Context	Context is data produced by the AAL Space that can be shared within AAL Services. This data can be related to the characteristics and states of the physical environment of the AAL Space, including its users, and/or the properties and states of hardware/software components contained in the AAL Space
Reasoning	The capability of AAL Spaces to generate new knowledge by making calculations and applying logic, using one or more pieces of basic context data and/or other new knowledge already generated by reasoning. New knowledge generated in this way can be used to enhance AAL Services with advanced features.
Context-awareness	The capability of *AAL Spaces* to extract and understand context data in order to adapt and enhance services to a wide variety of contextual circumstances.
Personalization	The capability of *AAL Spaces* to incorporate knowledge about the characteristics, capabilities and preferences of individual human users interacting within its boundaries.
Reactivity	The capability of *AAL Spaces* to automatically react upon the occurrence of

	certain situations in an adaptive way.
Pro-activity	The capability of *AAL Spaces* to automatically perform actions in advance that are anticipatory and aim at getting prepared for future situations.
AAL Space Profile	Description of an *AAL Space* containing: definition of mandatory and/or optional software and hardware components as well as attributes of *AAL Space*.
Boundaries	A set of limitations, which are specified for particular software and hardware components embedded in AAL Space.
Multimodal Interaction	Performing the interaction with the *End Users* using multiple channels in parallel, possibly with a hybrid mix supporting different modalities (e.g. voice, gestures, graphical user interface etc.)
Security Constraints	Access control constraints specifying which resources (software, hardware, human) are capable of performing interaction in the boundaries of a particular *AAL Space.*

Each AAL Space is a logical environment, deployed over a physical space, in which AAL Services can establish communication with each other and with platform contextual information in a seamless manner. The AAL Services use platform communication facilities that do not require knowledge of the physical node and position in space in which they are being executed. The AAL Services provided are oriented to a specific human user (the Assisted Person), or set of users who are present in the space, and use whatever human-computer interfaces are deployed across the space.

The most typical AAL Space is the home of an Assisted Person, but other scenarios are possible in which an AAL Space can be set up in supermarkets, health care centres, hospitals, airports... Many different combinations of users, physical places, devices, networks and connections among them are possible, but in all cases the AAL Space is what delimits the boundaries inside which services and context are shared in order to facilitate a concrete user´s experience in that space.

The AAL Space boundaries are delimited by the security constraints, interface definitions and environment restrictions stipulated in its AAL Space Profile.

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2.6 Software and Hardware Components

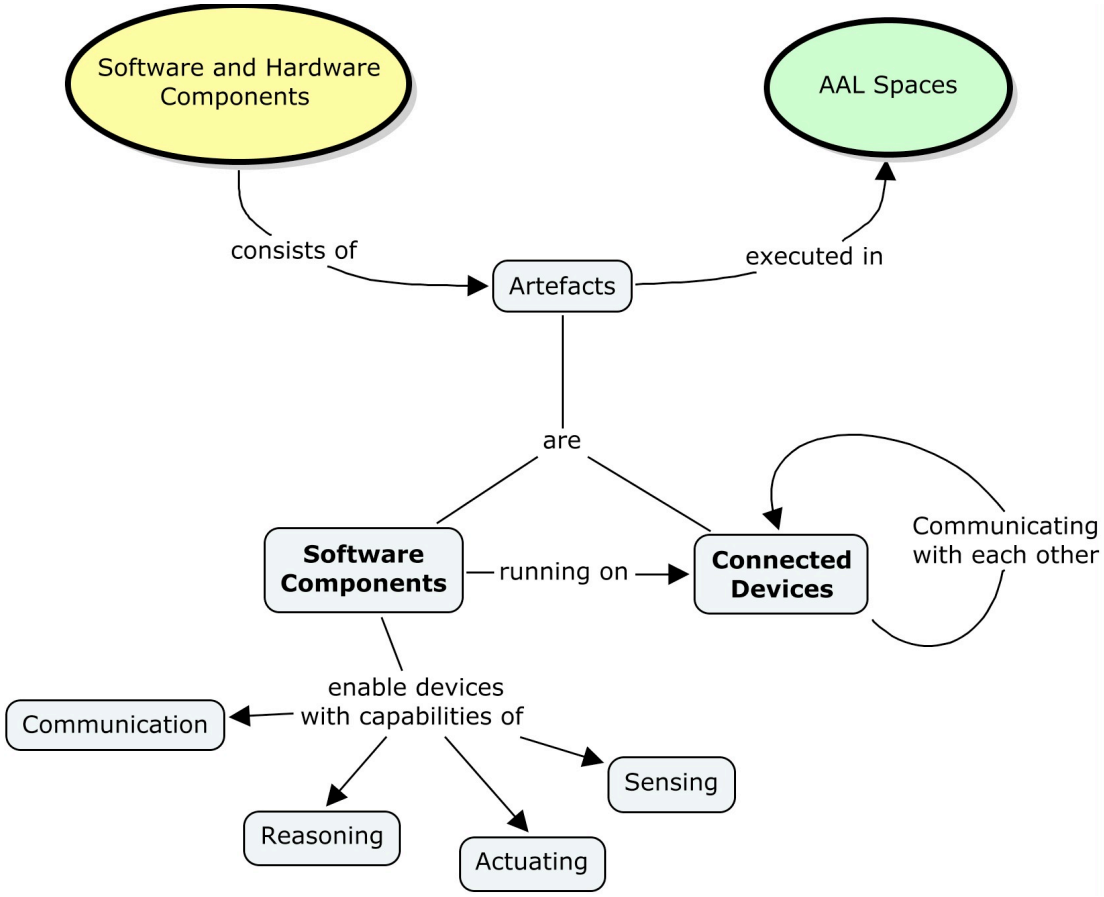

Figure 7: The Software and Hardware Components concept map

Connected Device	A device with capabilities of performing communication with other devices. May embed other atomic devices like actuators (devices that can cause changes in the physical world e.g. manage the lights in the room etc.) or sensors (a device that realizes a sensing channel by capturing info from the physical world).
Software Components	A set of software artifacts that provide the means of accessing and controlling the functions provided by Connected Devices, and/or extend these in some way.

The concept of Software and Hardware Components (described in Figure 7) represents the significant role of both software and hardware elements in the AAL domain. These artifacts are executed inside *AAL Spaces* in accordance with particular profiles and boundaries defined by them. Furthermore, *Software Components* running on *Connected Devices* provide them with such features as: *Communication*, *Reasoning*, *Sensing*, and *Actuating*. The exact specification of which *Software Components* (and for which Connected Devices) should be embedded in an *AAL Space* is specified directly by the AAL Space Profile. By using profiles *Software* and *Hardware Developers* do not need to know the actual configuration of the final installation, and development tools can automatically provide the set of specific software packages for the profile they are targeting.

2.7 AAL Platforms

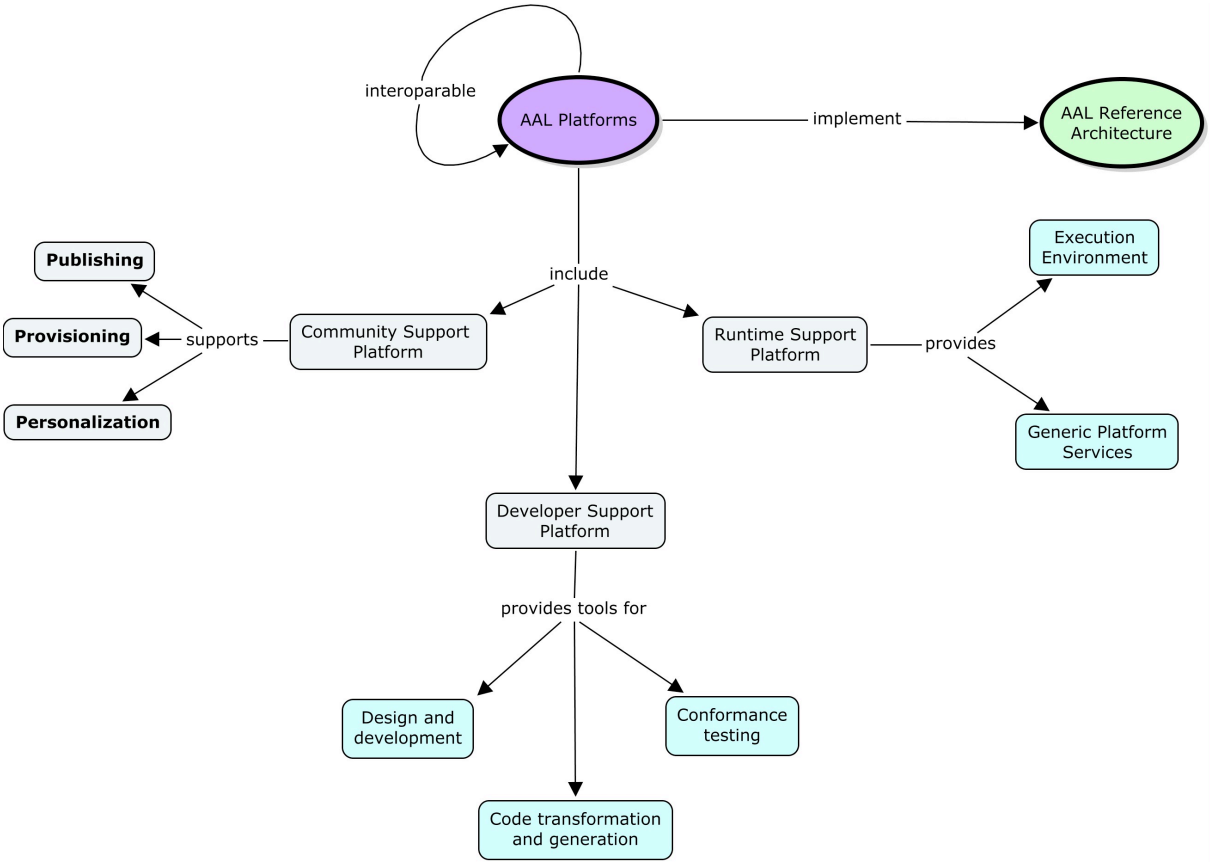

Figure 8: The AAL Platforms concept map

Developer Support Platform	A suite of software resources and tools for supporting the software developer during the process of developing software artifacts (either AAL Services or new full AAL Platforms themselves).
Community Support Platform	A suite of software facilities and technological infrastructures to assist end users, service providers and developers in community-building. It also includes facilities for publishing, provisioning, searching, discovering and managing AAL Services, and their deployment into AAL Spaces.
Runtime Support Platform	Implementation of the *Execution Environment* that is responsible for the integration and interoperability of software components in the Assisted Person´s space, and for facilitating communication amongst them.

Figure 8 presents the concept map containing basic concepts describing *AAL Platforms*. The set of three support platforms (Developer, Community, and Runtime) presented in this document is consistent with the *AAL Reference Architecture*. The three support platforms can communicate with each other in order to provide coordinated functionalities valuable to the *AAL Stakeholders*.

The *Developer Support Platform* gives *Developers* tools for modeling, implementing, testing and promoting their *AAL Applications*. These could include extensions to existing IDE (Integrated Development Environment) such as Eclipse. The *Deployers* will find tools helping them to install,

configure and manage the *AAL Services,* locally or remotely. Working together with the *Runtime Support Platform*, The *Developer Support Platform* provides tools for personalization of the *AAL Services* and their adjustment to the specific needs and preferences of individual *Assisted Persons*.

The *AAL Community Support platform* enables sharing of *AAL Services* among *Stakeholders*, helps regulate the business relations between *Stakeholders,* and helps the delivery (deployment) of the *AAL Services* from a remote repository to the target (*Runtime Support*) platform for consumption by end users. This is achieved with tools and facilities like forums and repositories to put *Developers*, *Deployers* and *Service Providers* in touch, together with store-like back-ends for the publication of the resulting *AAL Services* to be discovered and purchased by end users.

The *AAL Runtime Support Platform* hides the distribution of the system and heterogeneity of its nodes, providing a unified runtime environment for execution of *AAL Services*. The *Runtime Support Platform* also provides *Generic Platform Services* that offer core system functionalities like context data management, user interaction management, security etc.

2.8 Reference Architecture

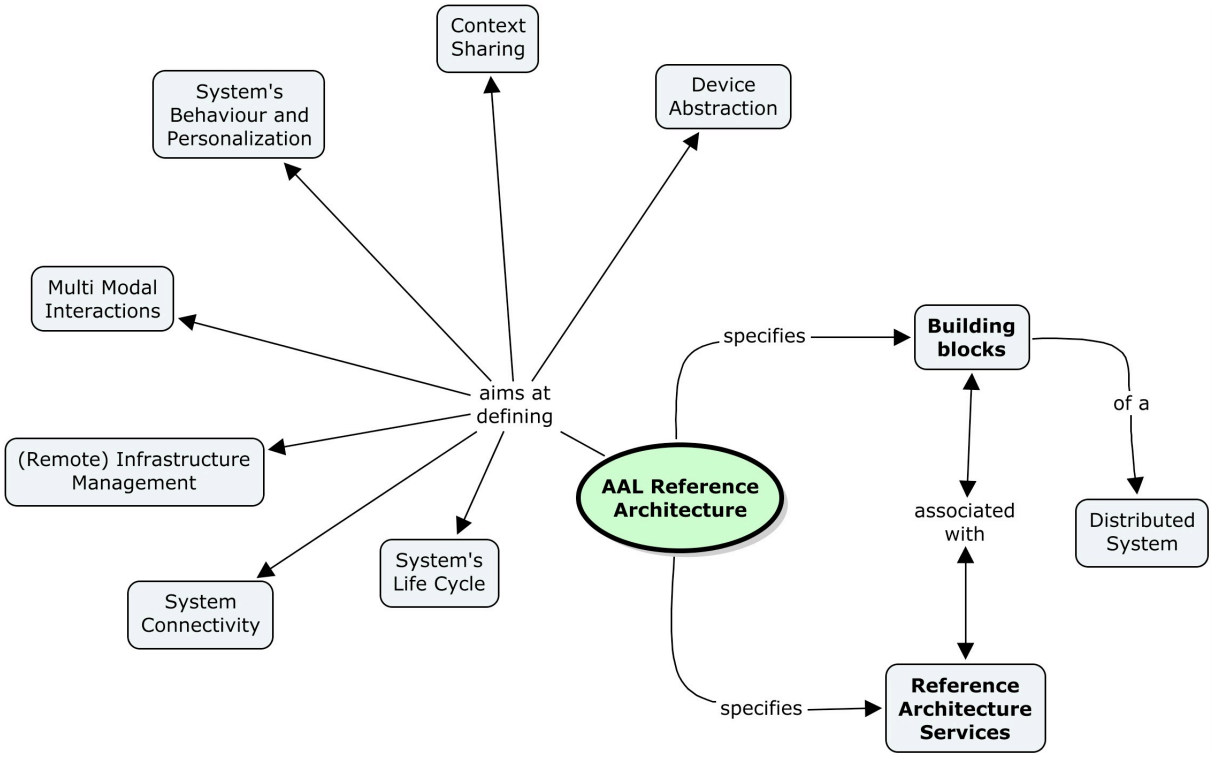

Figure 9: The AAL Reference Architecture concept map

Building blocks	Core elements of the *AAL Reference Architecture* defined as functional entities providing some key functionality specified by the architecture (e.g. discovery and pairing of devices, abstraction of device implementation specifics, handling of context information, service brokerage, manageability, security, service life-cycle and many others).
Reference Architecture Services	High level services providing a cohesive set of functions that are exchanged among stakeholders and provided tangible benefits to them.

The *AAL Reference Architecture* provides a high-level model of the class of ICT-based systems used in the AAL domain. It describes the AAL business domain in the form of ICT architectures in a technology agnostic way. It is intended to be used as the basis for concrete architectures that facilitate the realization of AAL Services making use of specific technological solutions.

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