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QM4AAL: QUALITY MODEL FOR AMBIENT ASSISTED LIVING SYSTEMS

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Abstract

In this technical report we presented the QM4AAL, a Quality Model for Ambient Assisted Living (AAL) systems. The QM4AAL was constructed based on empirical evidence found in software systems and reference architectures (RAs) in the AAL domain. Such model offers more than 150 requirements for quality attributes (QAs) that AAL systems must address. The QM4AAL details QAs requirements for AAL systems' constituents (e.g., personal health records systems, activity monitoring systems, or health status monitoring systems). Moreover the model considers adaptive (e.g., self-managing, self-configuring, situation-aware) and static properties at describing QAs requirements for AAL systems and their constituent systems. In this perspective, the QM4AAL serves as a knowledge base to support practitioners at identifying QAs requirements for their projects. As future work, expert assessment and inclusion of more QAs requirements for AAL systems' constituents will be introduced in the QM4AAL.

Contents

Chapter 1

Introduction

The development of quality AAL systems carries significant challenges because the heterogeneity of their constituent systems, their adaptive properties, the variety of stakeholders involved in their creation. In this context, we proposed a Quality Model for AAL systems, named QM4AAL, in order to support the development and assessment of such systems.

Our model differs from previous works in the following aspects: (i) QM4AAL contains the QAs that have been considered as important by software systems and reference architectures in the AAL domain. Moreover, such QAs are represented as an specialization of the standard ISO/IEC 25010; (ii) QM4AAL offers description of QAs requirements of AAL systems constituents, e.g., health status monitoring systems or PHR systems; (iii) QM4AAL relates QAs requirements with adaptive properties of the AAL systems, which have not been studied until now; and (iv) QM4AAL considers stakeholders at defining QAs requirements.

The remainder of this technical report is organized as follows. Chapter 2 presents the theoretical background to understand concepts of AAL systems and Quality Models. Methods used to create and assess the QM4AAL are presented in Chapter 3. The QM4AAL is detailed in Chapter 4. Definitions of QAs requirements for adaptive and static properties are described in Chapters 5 and 6, respectively. Finally, in Chapter 7 final considerations and future work are introduced.

Chapter 2

Background

In this section important characteristics of AAL systems are presented. Additionally, the standard ISO/IEC 25010 is described.

2.1 Ambient Assisted Living systems

The mission of an AAL system is to assist elders and disabled people in their daily activities, e.g., monitoring health status, supporting in rehabilitation activities, social inclusion, assisting in emergency situations, reminding medications, cooking, dressing, and connecting with relatives and medical staff. In this context, AAL systems can be seen as a System-of-Systems (SoS), this is, a complex system composed by different constituent systems. Constituent systems have their own mission, operate independently from others systems, and contribute to achieve the general mission of the AAL system. Important AAL systems' constituents can be:

- Activity monitoring systems, whose mission is to assist persons in normal daily life activities at home, such as, dressing, cooking, entertainment, exercising, and reminding important dates.
- Health status monitoring, which have the mission of monitoring people?s health condition, through sensed information, looking for anomalies or out of pattern behaviors. Such systems can be developed to monitor chronic diseases such as, Alzheimer, cardiovascular, diabetes, and hyperthension. The monitoring can be performed either at home or outdoors.
- Personal Health Records (PHR) systems, which capture health data entered by patients and provide information related to the care of those patients. PHR include

tools to help patients take a more active role in their own health. In part, PHRs represent a repository for patient data, but PHR systems can also include decision-support capabilities that can assist patients in managing chronic conditions [34].

- Human Computer Interaction (HCI) systems, whose mission is to facilitate elders interaction with the AAL system and its constituents systems.

- Coordinator systems, which communicate constituent systems in order to achieve the global mission of the AAL system.

2.1.1 Adaptive properties

Moreover, AAL systems are considered as a self-adaptive systems, i.e., software systems that adapt its own behavior in response to changes observed by the system, such as end-user input, external hardware devices and sensors, interaction with its constituent systems, or emergency situations detection. Adaptations can occur in different levels and with different purposes. Salehie and Tahvildari [35] establish a hierarchical set of adaptivity properties, such as illustrated in Figure 2.1.

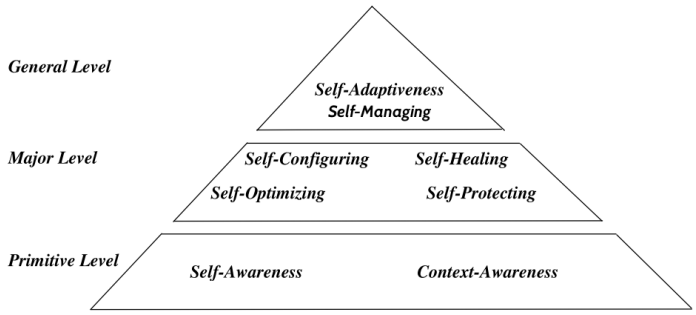

Figure 2.1: Taxonomy of adaptive properties. Adapted from [35].

- **General level**: Self-adaptivity and Self-managing are considered the most general properties, which are decomposed into major and primitive properties at two different levels.

- **Major level:** Four properties are considered in this level:

  - Self-configuring: is the capability of reconfiguring automatically and dynamically in response to changes by installing, updating, integrating, and composing/decomposing software entities.

  - Self-healing: is the capability of discovering, diagnosing, and reacting to disruptions. It can also anticipate potential problems, and accordingly take proper actions to prevent a failure.
  - Self-optimizing: is the capability of managing performance and resource allocation in order to satisfy the requirements of different users.
  - Self-protecting: is the capability of detecting security breaches and recovering from their effects.

- **Primitive level:** Three properties are considered primitives:
  - Self-awareness: means that the system is aware of its self states and behaviors. This property is based on self-monitoring which reflects what is monitored.
  - Context-awareness: means that the system is aware of its operational environment, i.e., context.

2.1.2 AAL systems stakeholders

A software system stakeholder is any people, organisations, system (or parts of it) who is affected by the system functionality and who have a direct or indirect influence on the system requirements. In the context of AAL systems, Huch [15], describes the following categories of stakeholders:

- Primary Stakeholders: They are private users of AAL system, e.g., senior and impaired citizens, or private caregivers, which are usually family members or relatives.
- Secondary Stakeholders: They are professional users of AAL systems. Members of this group have a Business-to-Commerce (B2C) relation with the primary stakeholders, i.e. they sell AAL services to patients. Moreover, they have a Business-to-Business (B2B) relation with tertiary stakeholder, i.e. they buy AAL systems from suppliers.
- Tertiary Stakeholders: They are suppliers of AAL systems, e.g., research organisations, enterprises with a business in tele-medicine or tele-care (e.g. Bosch, Philips, Tunstall), or providers of the IT infrastructure (e.g., Networks and databases or small and medium sized enterprises).
- Quaternary Stakeholders: They are supporters of AAL systems, e.g., policy-makers, social (and private) insurance companies, employers, public administrations, standardisation organisations, or civil society organisations.

2.2 The ISO/IEC 25010 quality model

The ISO (International Organisation for Standardization) and the IEC (International Electrotechnical Commission) in 1991 proposed the international standard ISO/IEC 9126 [10], and as its successor, in 2011, the set of international standards denominated ISO/IEC 25000: SQuaRE (Systems and software Quality Requirements and Evaluation). SQuaRE defines the ISO/IEC 25010 [11] and the ISO/IEC 25012 [12] standards that establish quality models for computer systems and software products, quality in use, and data. Figure 2.2 illustrates the standard ISO/IEC 25010. Specifically, such standard defines: (i) a "software product quality model" composed of eight characteristics (i.e., functional suitability, reliability, performance efficiency, usability, maintainability, security, compatibility, and portability), which are further subdivided into sub-characteristics measured internally or externally; (ii) a "system quality in use model" composed of five characteristics (i.e., satisfaction, effectiveness, freedom from risk, efficiency, and context coverage), which are further subdivided into sub-characteristics measured when a product is used in a realistic context of use.

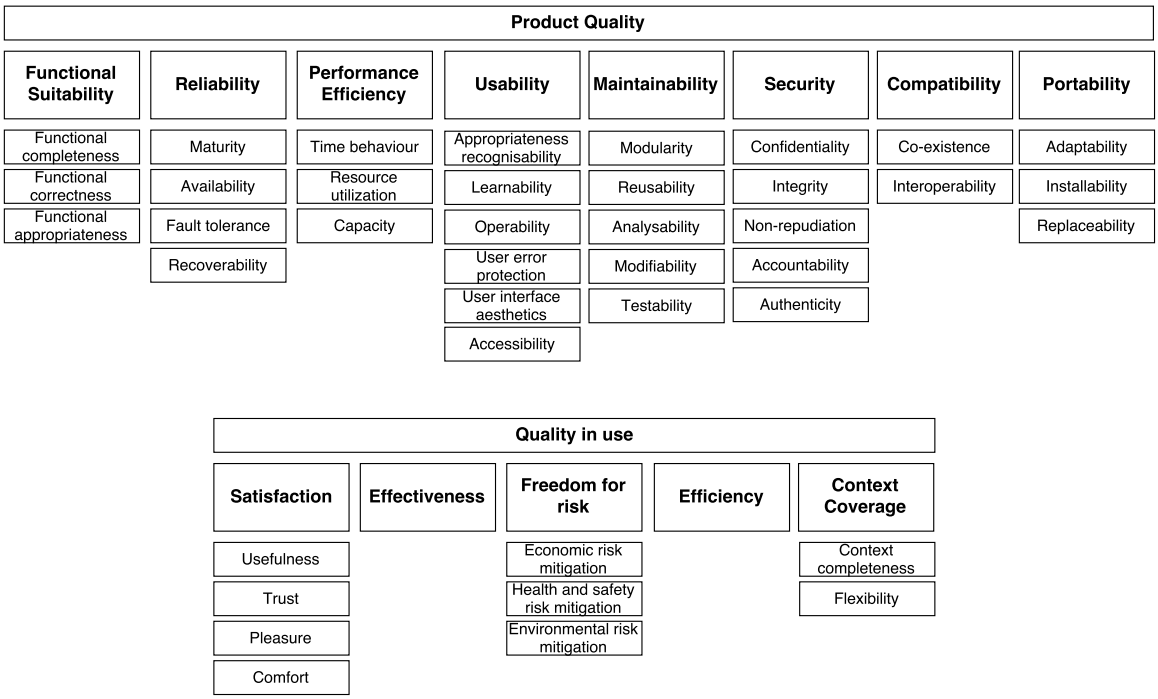

Figure 2.2: Standard ISO/IEC 25010. Software product quality model and system quality in use model. Adapted from [11].

2.3 Quality in Healthcare and AAL systems

Several works are focused on analysing quality attributes in healthcare systems, [19] provide a catalog of non-functional requirements (NFRs) and highlight several NFRs (i.e., communicativeness, confidentiality, integrity, performance, privacy, reliability, safety, security, traceability, and usability) as the most frequently considered in this domain. In a similar effort, [20] establish a model to meet quality requirements for asynchronous store-and-forward telemedicine systems. In this work, they defined context completeness, flexibility, time behavior, resource utilization, capacity, co-existence, and interoperability as the most important attributes that such systems must have. Concerning mobile health systems, [23] identified reliability, availability, efficiency, and privacy as the prominent quality characteristics for health services provided over mobile platforms.

Recently, [21] identified the most studied and used quality characteristics in e-Health systems, following a two-step process. First, they selected two categories of quality characteristics from the ISO/IEC 9126 standard: (i) External/Internal Quality: These characteristics were functionality, suitability, usability, accessibility, reliability, maintainability, continuity, efficiency, and portability. For the functionality characteristic, the sub-characteristics were security, interoperability, accuracy, and compliance; and (ii) Quality in use: Characteristics to measure the effect of using e-Health systems in a specific context. In this category, the quality characteristics were safety, effectiveness, satisfaction, and productivity. Second, they conducted a systematic literature review to identify the level of importance of each quality characteristic in such systems. As a result, functionality, effectiveness, and safety were identified as the most used to develop e-Health systems.

A similar research was made by [22], who evaluated the effects of software quality characteristics and sub-characteristics on the healthcare indicators: user satisfaction, quality of patient care, clinical workflow and efficiency, care providers communication and information exchange, patient satisfaction, and care costs. The most important health quality indicators in relation to software quality characteristics were established based on a literature review. As contribution, the study of Aghazadeh et al. proposes a model based on ISO/IEC 9126 standard that establishes relations between software quality characteristics and health quality indicators. Relations were evaluated through expert opinion analyses. Some important findings were: (i) software functionality affects directly the quality of patient care; (ii) clinical workflow is influenced by the software efficiency; (iii) communication is affected by software maintainability; (iv) usability and efficiency influence on patient satisfaction; and (v) care costs are affected by software maintainability, efficiency, and reliability.

Regarding AAL services, Bitelli et al. [24] offer a model to assess the quality of assistive interventions. Other works have listed important quality attributes for AAL systems,

such as, Memon et al. [17] and Omerovic et al. [18]. Moreover, a taxonomy of QAs, based on the standard ISO/IEC 9126, for AAL systems have been proposed by Schneider et al. [33], named OptimAAL. Such taxonomy establishes reliability as one of the most important QAs for AAL systems. OptimAAL presents the reliability attribute as dependent from the attributes: availability, safety (or freedom for risk in the standard ISO/IEC 25010), integrity, and maintainability. Hence, OptimAAL states that a reliable AAL systems must be: (i) available, in other words, be prepared to be used when it is needed; (ii) reliable, to ensure adequate continuity in the provision of its services; (iii) safe, in terms of possible catastrophic consequences in the use of the system; (iv) integer, to ensure that there are no unacceptable system changes; and (v) maintainable, to be easy to make adjustments and repairs. Moreover, OptimAAL details metrics to measure the quality of AAL systems regarding those quality attributes.

Despite the increasing effort to improve the quality of AAL systems, there is a lack of quality models to assess such systems, which in turn consider important characteristics of such systems: adaptive properties, constituent systems, stakeholders, and relation among QAs.

Chapter 3

Establishing and Assessing the QM4AAL

Figure 3.1 shows the activities followed to establish and assess the QM4AAL. First, in order to obtain evidence of which are the QAs most considered at developing AAL systems, we conducted a systematic mapping study [14] following the guidelines provided by Kitchenham and Charters [16]. We analyzed 17 studies that described which QAs were important for their systems, and as result we identified 97 QAs for AAL systems that can be consulted in Appendix B.

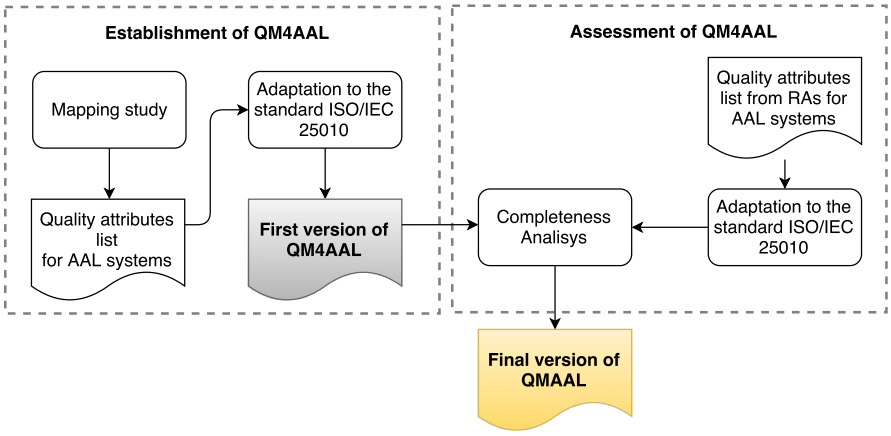

Figure 3.1: Method to establish and assess the QM4AAL

The second activity was the adaptation of the 97 QAs to the standard ISO/IEC 25010 [11]. This activity was necessary because it was not found homogeneity at defining the QAs by the studies. Thus, to establish a standardized set of QAs, we defined and conducted the process presented in Figure 3.2. This process aims to map the 97 QAs into quality characteristics or sub-characteristics specified by the ISO/IEC 25010 standard.

3.1 Adaptation process

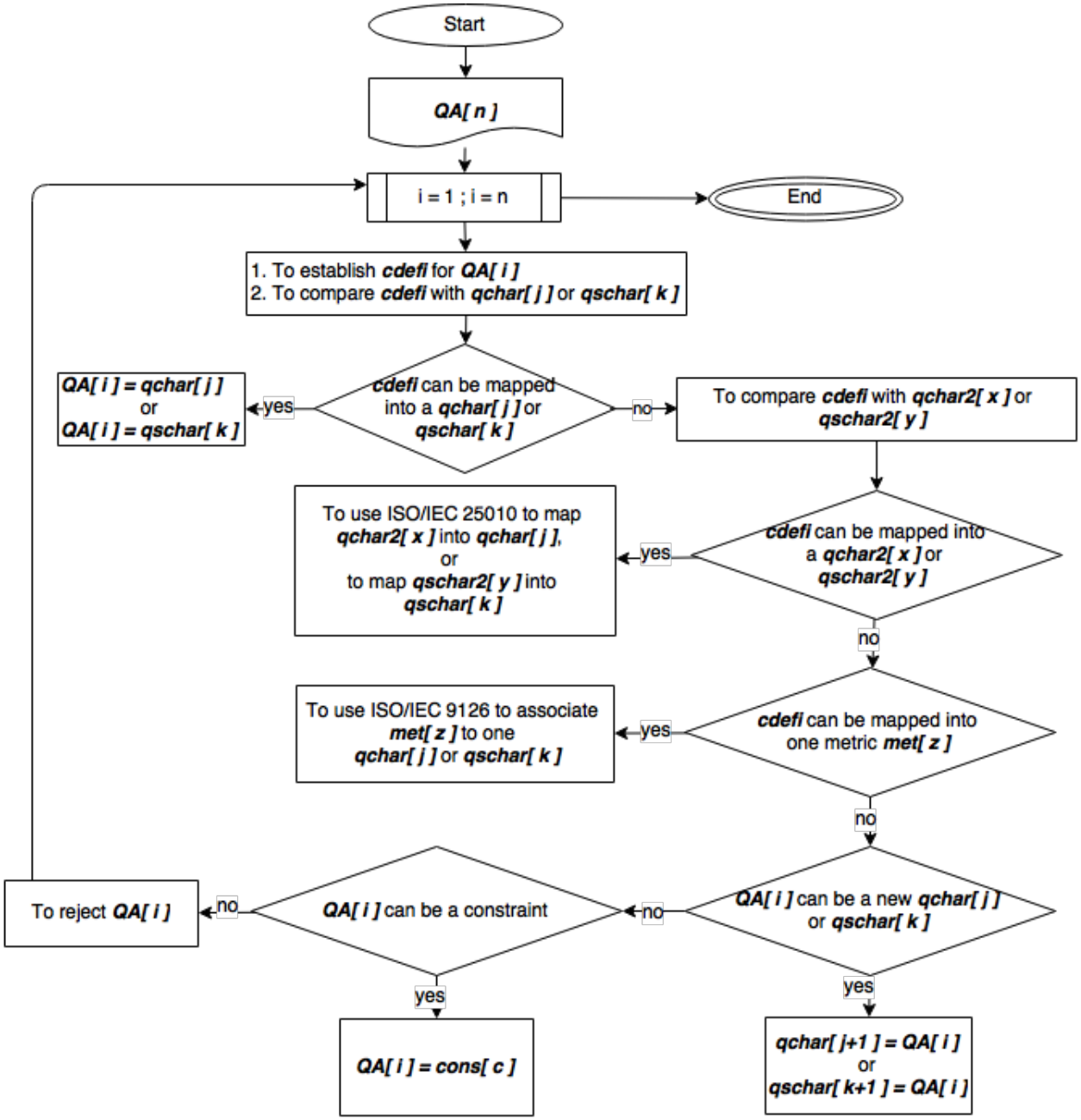

Figure 3.2: Process to adapt QAs to the standard ISO/IEC 2510. Source: [14]

For each quality attribute, QA_i, its definition $cdef_i$ is extracted based on the primary studies that address QA_i. Next, $cdef_i$ is compared to definitions of quality characteristics $qchar[j]$ or sub-characteristics $qschar[k]$ provided by ISO/IEC 25010. If $cdef_i$ matches

(or it is similar) to a definition of $qchar[j]$ or $qschar[k]$, QA_i is considered as part of ISO/IEC 25010 standard. Otherwise, $cdef_i$ is compared to definitions of quality characteristics $qchar2[x]$ or sub-characteristics $qschar2[y]$ provided by ISO/IEC 9126. If there is a direct match between the $cdef_i$ and $qchar2[x]$ or $qschar2[y]$, Annex A[1] of ISO/IEC 25010 is used to map quality characteristics of ISO/IEC 9126-1 into ISO/IEC 25010. If the $cdef_i$ is not considered as characteristic of sub-characteristic of any of the standards, $cdef_i$ is compared to metrics $met[z]$ for characteristics or sub-characteristics of ISO/IEC 9126. If QA_i is considered as metric $met[z]$, Annex A is used again to associate $met[z]$ to the correspondent characteristic or sub-characteristic into the ISO/IEC 25010. In any other case, QA_i is considered as a new quality characteristic $qchar[j+1]$ or or sub-characteristic $qschar[k+1]$. Finally, if QA_i is not considered as (sub)characteristic or metric of ISO/IEC 25010 nor as a new (sub)characteristic, it is checked if QA_i can be classified as a constraint. Otherwise, QA_i is not considered as a QA relevant to the AAL domain.

3.2 Preliminary version of QM4AAL

As result of conducting the adaptation process, a previous version of the QM4AAL was obtained, such as presented in Figure 3.3.

3.3 Completeness Assessment of QM4AAL

The QM4AAL was under a completeness evaluation in order to ensure that it comprises all (or the majority of) the QAs for AAL systems. Because AAL systems are complex systems constituted by other well-known systems such as, tele-monitoring, eHealth, tele-medicine, Personal Health Records (PHR), Information Health Records (IHR), and smart environments, we decided to use the information on QAs contained in the reference architectures (RAs) established for AAL systems. In short, a RA is a generic type of software architecture that achieves well-recognized knowledge of specific domains (e.g., AAL), which promotes reuse of design expertise and facilitates the development, standardization, and evolution of software systems. Moreover, a RA captures the essence of architectures of similar systems, and provides a common lexicon and taxonomy, a common architectural vision, and the modularization and the complementary context [5]. Examples of RAs established for AAL are presented in [13]. Utilizing RAs as source of information, we can identify all important QAs for all possible AAL systems.

[1]Section 3.7 - Relationship between the models. Online: `https://www.iso.org/obp/ui/\#iso:std:iso-iec:25010:ed-1:v1:en`

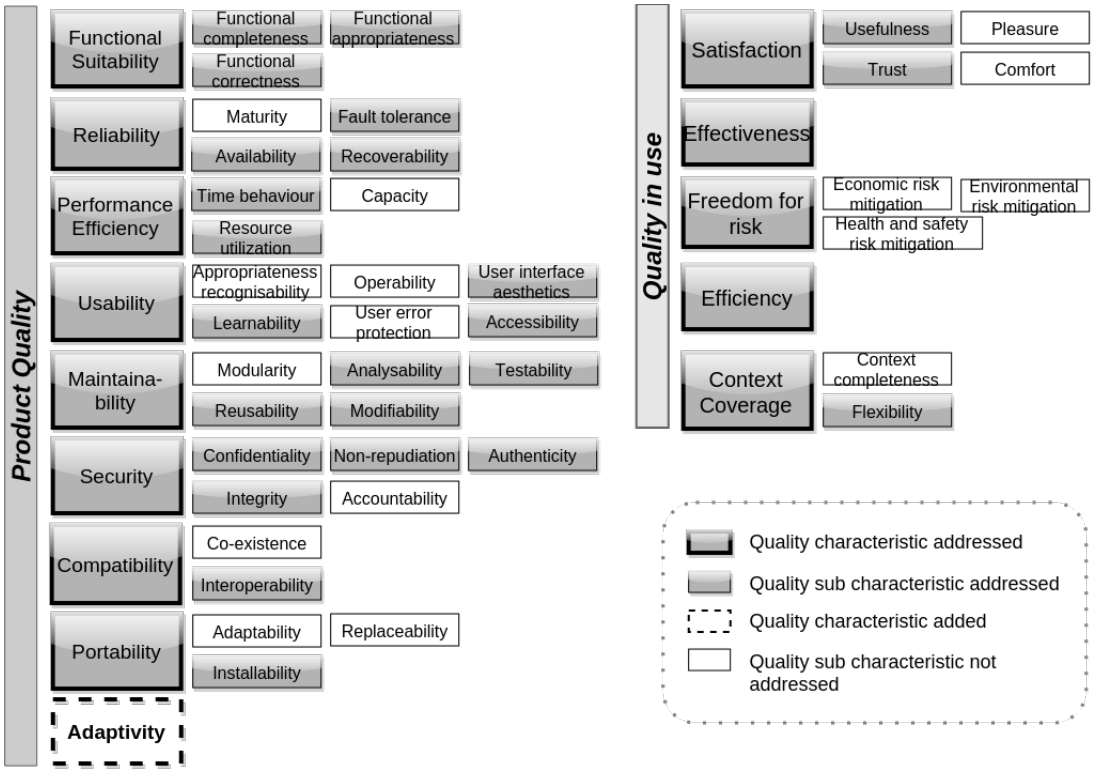

Figure 3.3: QM4AAL's preliminary version.

Hence, as first step of the completeness assessment, we extracted information on QAs described in the RAs: [25, 26, 27, 29, 28, 30, 31, 32]. As result we obtained a broad list of QAs (See Appendix C) that were through the adaptation process presented in Section 3.1. As a final activity we made a completeness analysis, mapping the set of QAs obtained from RAs into the first version of QM4AAL to detect missing QAs. As result, were added QAs to the QM4AAL as showed in Figure 3.4 .

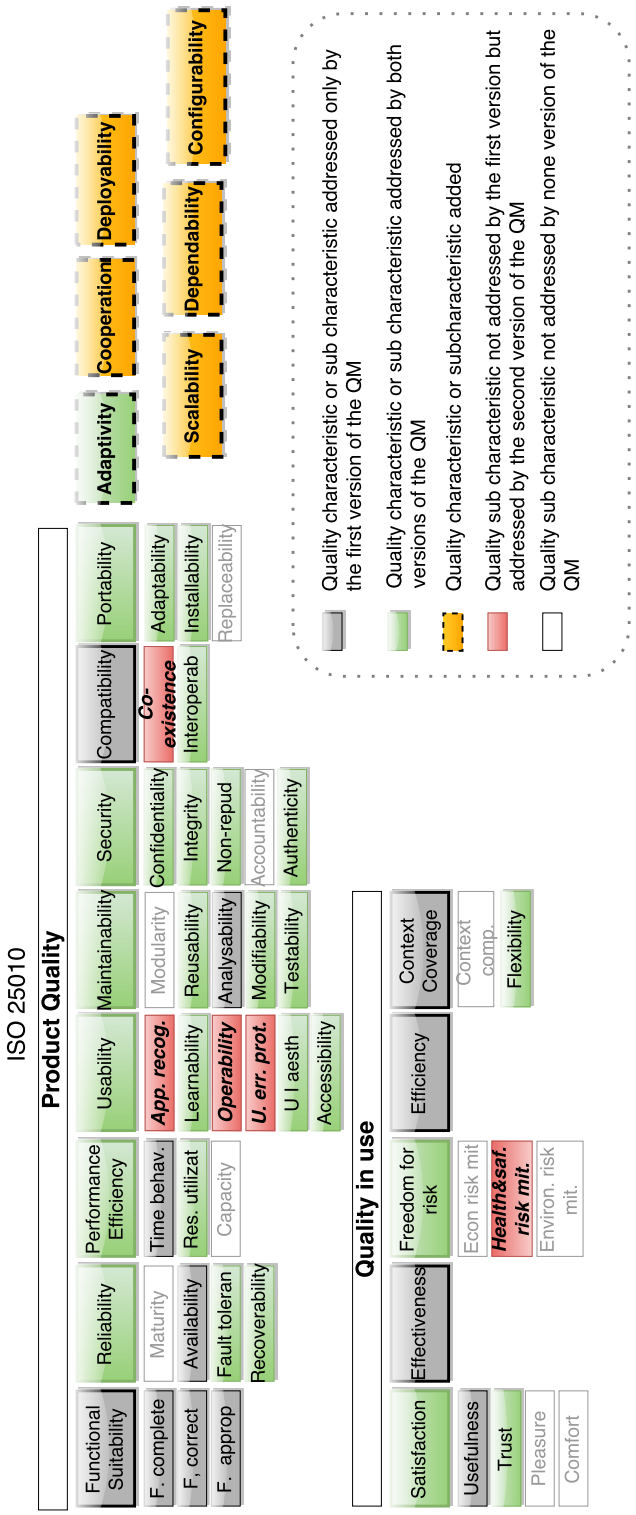

Figure 3.4: QM4AAL's attributes.

Chapter 4

The Quality Model for AAL systems

The QM4AAL is composed by three dimensions, such illustrated by Figure 4.1.

AAL system constituents: This dimension represents all possible constituent systems that can compose the AAL system. Examples of constituent systems were introduced in Section 2.1;

Adaptive or static properties : Adaptive properties must be achieved in run-time and imply dynamic modifications during the system's life cycle. Most of adaptive properties are not be established at system's design time, but at executing time. Adaptive properties were introduced in Section 2.1. Meanwhile, static properties can be addressed at design time and do not require modifications after the system's deployment.

Quality Attributes: This dimension is represented by the set of QAs exposed in Figure 3.4. In Appendix A we present each QA using definitions given by the standard ISO/IEC 25010 [11].

4.1 Documenting QAs requirements for AAL systems

The QM4AAL establishes the QAs requirements for the AAL/constituents systems, considering both adaptive and static properties. For that, the following template is used:

- **Adaptive property**: It describes the adaptive property that must be achieved by the AAL system or their constituents, e.g., self-configuring or situation-aware. If none adaptive property is determined here, then, it is supposed that the property is static.

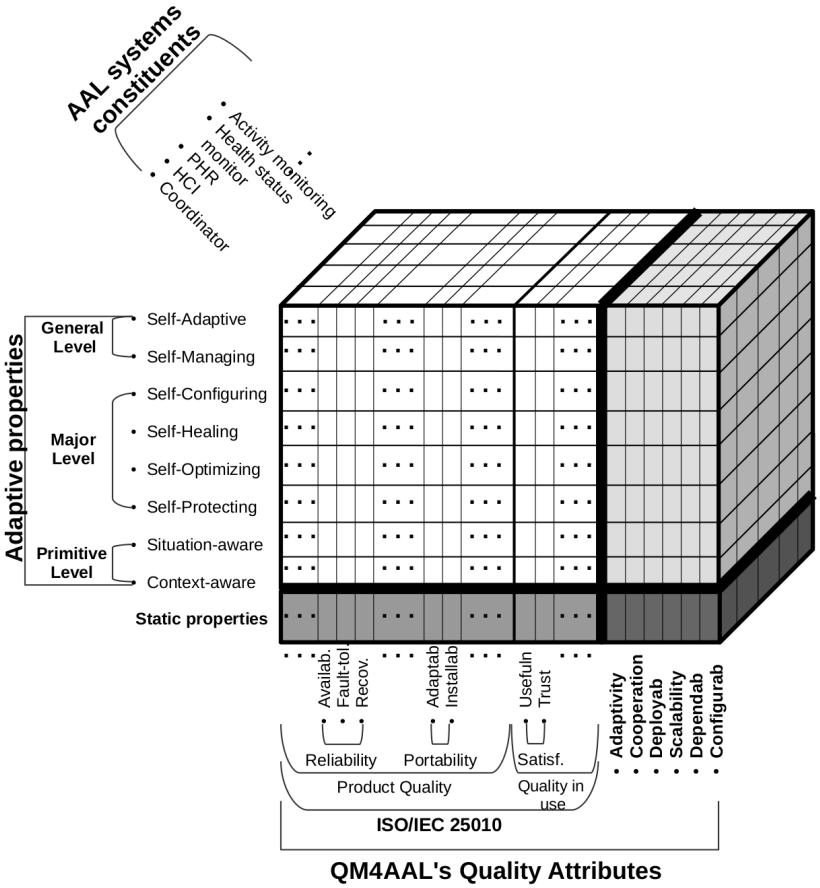

Figure 4.1: Three dimensions of QM4AAL.

- **Constituent:** Here, the system that requires achieve the adaptive/static property is specified.
- **Quality Attribute:** In this field, the QA that need to be addressed by the AAL/constituent system to achieve the adaptive/static property is detailed.
- **Stakeholders:** This field lists the stakeholders that are interested in the achievement of the adaptive/static property. Here, both stakeholders categories or AAL/constituents systems can be placed.
- **Related QAs:** Here, other QAs that could be directly related with the achievement of the adaptive/static property and with the QA requirement are listed.
- **Description:** The QA requirement is detailed in this field.

The QM4AAL contains more than 50 QAs requirements for adaptive properties and more than 100 QAs requirements for static properties of AAL/constituents systems. Both adaptive/static QAs requirements are presented in Sections 5 and 6, respectively.

Chapter 5

Adaptive properties requirements of AAL systems

5.1 General Level properties

5.1.1 Adaptive property: Self-Adaptive

Constituent: Activity monitoring system

Quality Attribute: Adaptivity

Stakeholders: Primary users

Related QAs: Usability

Description: The system must provide adaptation to user profiles (e.g., age, health status), preferences (e.g., on body sensor, wristwatch sensor, pedometer integrated into shoes) an to the desired information to be processed.

Constituent: HCI system

Quality Attribute: Adaptivity

Stakeholders: Primary and secondary users

Related QAs: Satisfaction

Description: The system must alter its interaction during run-time to meet user requirements and preferences during the interaction.

Constituent: Coordinator system

Quality Attribute: Cooperation

Stakeholders: AAL system

Related QAs: Integration, interoperability

Description: The system must offer cooperation among constituents, starting both on a user-triggered basis, as well as, as a result of an autonomous decision of the coordinator itself.

5.1.2 Adaptive property: Self-Managing

Constituent: AAL system

Quality Attribute: Configurability

Stakeholders: AAL system constituents

Related QAs:

Description: The system must provide update and delete function for applica-tionssystem componentsconstituentsservices

Constituent: AAL system

Quality Attribute: Deployability

Stakeholders: AAL system

Related QAs: Efficiency

Description: The system must support the deployment of services reducing deployment time and costs.

Constituent: AAL system

Quality Attribute: Usability

Stakeholders: AAL system

Related QAs: Configurability, adaptability, flexibility

Description: The system must have a simple configuration process, guided by a wizard if appropriate, and carefully designed so as not to be boring or annoyingly long. The configuration process must take explicit advantage of any modern device (e.g., smart-phone, tablet, smart tv, gaming consoles) that users might have.

5.2 Major Level properties

5.2.1 Adaptive property: Self-Configuring

Constituent: AAL system

Quality Attribute: Adaptivity

Stakeholders: AAL system

Related QAs: Scalability

Description: The system must have self-adaptable capacity, this means, it must be able to change system configuration related to scalability in a semi-automatic way.

Constituent: AAL system

Quality Attribute: Adaptivity

Stakeholders: AAL system

Related QAs: Integration

Description: The system musst add plug-and-play constituents systems that are automatically detected and integrated in a dynamic way.

Constituent: AAL system

Quality Attribute: Adaptivity

Stakeholders: AAL system

Related QAs: Usability

Description: The system must be customizable and reconfigurable at runtime to fit personal user needs in the best way possible.

Constituent: HCI system

Quality Attribute: Configurability

Stakeholders: Primary and secondary users

Related QAs: Flexibility, adaptivity

Description: The user's interaction with the system must be easy to configure and adaptable to various changing parameters in the environment.

Constituent: AAL system

Quality Attribute: Configurability

Stakeholders: Primary and secondary users

Related QAs: Operability, accessibility, usability

Description: The system must offer the possibility to users to access, configure, and administer relevant parts or properties of deployed services.

Constituent: AAL system

Quality Attribute: Configurability

Stakeholders: AAL system

Related QAs: Scalability

Description: The system should propose different scalability configurations, which could be dynamically changed according to changes of systems size and its topology.

Constituent: AAL system

Quality Attribute: configurability

Stakeholders: AAL system

Related QAs: Reliability

Description: The system should be capable of adapting to changed reliability of subsystems over lifetime, and provide different levels of reliability of the communication services.

Constituent: AAL system

Quality Attribute: Configurability

Stakeholders: AAL system

Related QAs: Integration

Description: The system must add new sensors and actuators without rebooting.

Constituent: AAL system

Quality Attribute: Configurability

Stakeholders: AAL system constituents

Related QAs: Integration

Description: the system must provide a plug-and-play mechanism for automatic constituent detection. The user should have the possibility to add plug-and-play systems that are automatically detected and integrated in a dynamic way.

Constituent: AAL system

Quality Attribute: Configurability

Stakeholders: AAL system

Related QAs: Adaptivity, usability.

Description: The system must be customizable and reconfigurable at runtime to fit personal user needs int he best way possible.

Constituent: HCI system

Quality Attribute: Scalability

Stakeholders: AAL system

Related QAs: Integration, adaptability, usability

Description: The system must add new UI components at any time without the need to restart itself.

Constituent: AAL system

Quality Attribute: Flexibility

Stakeholders: AAL system

Related QAs: Configurability, scalability

Description: The system must apply different system configurations in order to choose what kind of scalability should be used.

Constituent: AAL system

Quality Attribute: Integration

Stakeholders: AAL system

Related QAs: Installability, deployment

Description: The system must integrate easily new applications.

Constituent: AAL system

Quality Attribute: Integration

Stakeholders: Primary and secondary users

Related QAs: Usability, adaptivity, adaptability.

Description: The system must adjust itself and the integrated applications/systems, to the special needs of the end users.

Constituent: AAL system

Quality Attribute: Integration

Stakeholders: Primary and secondary users

Related QAs: Adaptivity

Description: The system must allow the possibility to the user to add plug-and-play systems/components/sub-systems that are automatically detected and integrated in a dynamic way.

Constituent: AAL system

Quality Attribute: Interoperability

Stakeholders: AAL system

Related QAs: Configurability

Description: The system must provide discovery and self-configuration mechanisms based on a local database of known device profiles that maintains appropriate data exchange specifications.

Constituent: AAL system

Quality Attribute: Maintainability

Stakeholders: AAL system

Related QAs: Scalability, configurability

Description: The system must provide an easy management of the scalability configuration, even in large, distributed and heterogeneous systems.

Constituent: Coordinator system

Quality Attribute: Modifiability

Stakeholders: Primary and secondary users

Related QAs:

Description: The system must support dynamically-modifiable, user-definable policies, inspectable and readable by any user in a clear human-understandable format, so that policies may be easily reviewed, integrated, and replaced at any time both locally and remotely.

Constituent: AAL system

Quality Attribute: Operability

Stakeholders: AAL system

Related QAs: Configurability

Description: The system must manage AAL spaces remotely. The system must provide a way to create and destroy an AAL space as well as a way to merge existing AAL spaces.

Constituent: HCI system

Quality Attribute: Operability

Stakeholders: Primary and secondary users

Related QAs: Usability

Description: The system must support configuration of sensor sand actuators by a common API and users interfaces.

Constituent: AAL system

Quality Attribute: Operability

Stakeholders: AAL system

Related QAs: Integration

Description: The system must allow for adding new sensors and actuators to the system without rebooting the system.

Constituent: AAL system

Quality Attribute: Operability

Stakeholders: AAL system

Related QAs: Integration

Description: The system must provide services and tools to support the configuration of new software, hardware and services.

Constituent: Middleware system

Quality Attribute: Operability

Stakeholders: AAL system

Related QAs: Configurability

Description: The system must reload the history state of a subsystem/constituent in situ or remotely.

Constituent: AAL system

Quality Attribute: Portability

Stakeholders: Primary user

Related QAs: Usability, interoperability

Description: The system must execute the local configuration process exploiting smart tvs, gaming consoles, and personal computers available in the home, as well as other more pervasive devices like smart-phone and tablet (via suitable apps or ad hoc web sites), as well as via a voice menu system able to guide the user towards the desired configuration in a natural and familiar way.

Constituent: AAL system

Quality Attribute: Testability

Stakeholders: AAL system constituents

Related QAs: Fault-tolerance

Description: The system must provide a testing mode where individual components can be provided with input messages in order to control it, and output messages can be observed, even in case the subsystem/constituent is already integrated.

5.2.2 Adaptive property: Self-Healing

Constituent: AAL system

Quality Attribute: Adaptivity

Stakeholders: AAL system

Related QAs: Resource utilization

Description: The system must be able to adapt not only in case of system shrink. It should automatically allocate resources at runtime to support system functionalities with higher priorities.

Constituent: AAL system

Quality Attribute: Recoverability

Stakeholders: AAL system

Related QAs: Freedom for risk, reliability

Description: The system must define measurements for disaster recovery.

Constituent: AAL system

Quality Attribute: Fault-tolerance

Stakeholders: AAL system

Related QAs:

Description: The system must discover errors and failing components/systems and perform corrective actions, e.g., restart failing or erroneous components/systems.

5.2.3 Adaptive property: Self-Optimizing

Constituent: AAL system

Quality Attribute: Adaptivity

Stakeholders: AAL system

Related QAs: Resource utilization

Description: The system must be able to adapt not only in case of system shrink. It should automatically allocate resources at runtime to support system functionalities with higher priorities.

Constituent: AAL system

Quality Attribute: Resource utilization

Stakeholders: AAL system

Related QAs:

Description: The system must allocate different resources to different applications/systems, according to their importance.

Constituent: AAL system

Quality Attribute: Resource utilization

Stakeholders: AAL system

Related QAs: Scalability

Description: The system must allow for scalable allocation of resources, must guarantee the allocation of resources during execution, and must ensure that components/system do not exceed resource boundaries, if required by an application (also real-time requirements).

Constituent: AAL system

Quality Attribute: Scalability

Stakeholders: AAL system

Related QAs: Flexibility, configurability

Description: The system must apply different system configurations in order to choose what kind of scalability should be used.

Constituent: AAL system

Quality Attribute: Scalability

Stakeholders: AAL system

Related QAs: Performance

Description: The system must ensure the performance offered by delivered services in runtime, with respect to increasing numbers of nodes, users and services.

5.2.4 Adaptive property: Self-Protecting

Constituent: AAL system

Quality Attribute: Fault-tolerance

Stakeholders: AAL system

Related QAs: Freedom for risk

Description: The system must avoid the failures propagation to other components/systems.

Constituent: AAL system

Quality Attribute: Fault-tolerance

Stakeholders: AAL system

Related QAs:

Description: The system must provide protection mechanisms within the architecture to handle software errors.

Constituent: AAL system

Quality Attribute: Integrity

Stakeholders: AAL system, primary and secondary users.

Related QAs: Freedom for risk, security, trust.

Description: Each system constituent must detect data modifications and prevent unauthorized modifications. This applies specifically to service user data, sensor data and commands sent to actuators, but could also apply to some extent to private communications between end-users.

5.3 Primitive Level properties

5.3.1 Adaptive property: Situation-aware

Constituent: Context management system

Quality Attribute: Adaptivity

Stakeholders: AAL system constituents

Related QAs:

Description: The system must integrate context reasoning algorithms to derive useful and valuable information.

Constituent: Activity monitoring system

Quality Attribute: Adaptivity

Stakeholders: Primary user

Related QAs:

Description: The system must recognize patients activities based on motion pattern models.

Constituent: AAL system

Quality Attribute: Maintainability

Stakeholders: AAL system, tiertiary users

Related QAs: Fault-tolerance

Description: The system must have a diagnostic service that must have an holistic view of the system, so that correlated failures and anomalies can be detected.

5.3.2 Adaptive property: Context-aware

Constituent: HCI system **Quality Attribute:** Adaptability **Stakeholders:** Primary user **Related QAs:** **Description:** The system must allow changes in order to meet user requirements and preferences prior to the start of the interaction.

Constituent: Context management system **Quality Attribute:** Adaptivity **Stakeholders:** Primary and secondary users **Related QAs:** **Description:** the system must provide context information to final user so that they can dynamically adapt to situation changes.

Constituent: Context management system **Quality Attribute:** Adaptivity **Stakeholders:** AAL system constituents, and primary and secondary users **Related QAs:** **Description:** The system must provide context information to other systems/services to adapt themselves according to the needs, preferences and situation of the user.

Constituent: Context management system **Quality Attribute:** Scalability **Stakeholders:** AAL system **Related QAs:** Integration **Description:** The system must allow the integration of several different context reasoning mechanisms based on different algorithms types.

Constituent: Context management system

Quality Attribute: Reliability

Stakeholders: AAL system

Related QAs:

Description: The system must handle uncertain and imprecise context information.

Constituent: Context management system

Quality Attribute: Reliability

Stakeholders: AAL system

Related QAs:

Description: The system must provide means for resolving conflicting context information coming from different context sources.

Constituent: AAL system

Quality Attribute: User error protection

Stakeholders: AAL system and primary user

Related QAs: Freedom for risk

Description: The system must have user interfaces capable to provide short and understandable feedback to the user. Whenever possible, actions performed by user shall be reversible.

Chapter 6

Static properties of AAL systems

6.1 Accessibility requirements

Related QAs: Usability

Constituent: AAL system

Stakeholders: Primary user

Description: An user must be capable to interact easily with the system to avoid reluctance with the system.

Related QAs: Usability, trust

Constituent: Activity monitoring system

Stakeholders: Primary user

Description: systems must offer accessible and easy to use user interfaces for elders, so they can easily understand when there is a risky situation.

Related QAs: Usefulness

Constituent: Activity monitoring system

Stakeholders: Primary user

Description: The system must provide easy accessibility to services through Internet connections.

Related QAs: Configurability

Constituent: Activity monitoring system

Stakeholders: Secondary user

Description: The system mus be easy to set up the personal profile of patients.

Related QAs: Understandability

Constituent: Activity monitoring system

Stakeholders: Secondary user

Description: The system must have UI accessible, while the information provided must be presented in a manner that is easy understandable by other people.

Related QAs: Operability

Constituent: Activity monitoring system

Stakeholders: Primary and Secondary users

Description: The system user interface must be self-guiding for users that want to transmit data.

Related QAs: Pleasure

Constituent: Activity monitoring system

Stakeholders: Primary user

Description: The system UI must be fully accessible. The system must offer their services to people with severely impaired eye-sight, cognitive level of functioning, or middle cognitive impairment elders.

Related QAs: Configurability

Constituent: Coordinator system

Stakeholders: Primary user and secondary user

Description: The system must be accessible and easily configurable by the (non-expert) user both locally and remotely.

6.2 Adaptability requirements

Related QAs: Interoperability, portability, integration

Constituent: health status monitoring system

Stakeholders: AAL system

Description: The system must employ an adaptable, wearable gateway device to harvest data from a variety of holters, wearables and biosensors.

Related QAs: Portability, comfort

Constituent: AAL system

Stakeholders: Primary and secondary users.

Description: The system must define a comfortable way to adapt it to wide variety of different end user needs.

Related QAs: Accessibility, integration.

Constituent: AAL system

Stakeholders: Primary and secondary users.

Description: The system must provide services and tools to support the personalisation of new software, hardware and service.

6.3 Adaptivity requirements

Related QAs: Usability

Constituent: HCI system

Stakeholders: primary user

Description: The system user interface must incorporate features for coping with access impairments and capability changes due to ageing.

6.4 Authenticity requirements

Related QAs:

Constituent: AAL system

Stakeholders: AAL system

Description: The system constituents must identify and authenticate an entity (i.e., human users and other systems or components) that wants to use them.

Related QAs: Usability

Constituent: AAL system

Stakeholders: AAL system

Description: The system must provide mechanisms for authentication that improve usability (e.g., single-sign-on) or multiple security levels of authentication with different confidence levels (initially basic but when required more reliable authentication).

Related QAs:

Constituent: AAL system

Stakeholders: AAL system

Description: The system must provide access control mechanisms aware of the context, e.g., prevent leaking detailed information in situations where less detailed information would have sufficed.

Related QAs: Authorization

Constituent: AAL system

Stakeholders: AAL system

Description: The system must authenticate and authorized entities in the multi-user settings.

Related QAs:
Constituent: AAL system
Stakeholders: AAL system
Description: The system must certify each constituent system individually.

6.5 Availability requirements

Related QAs: Security
Constituent: AAL system
Stakeholders: AAL system
Description: The system must provide mechanisms to prevent malicious attackers and denial-of-service attacks must be implemented.

6.6 Co-existence requirements

Related QAs:
Constituent: Coordination system
Stakeholder: Primary user
Description: the coordinator system must interact with the main social networks (e.g., twitter, foursquare, facebook, google+) either directly or, more likely, via some ad hoc proxies ? agents, in the MAS terminology and perspective.

6.7 Confidentiality requirements

Related QAs: Security

Constituent: AAL system constituents

Stakeholders: AAL system

Description: Each part of the system (constituents) must be aware of maintaining confidentiality of identifiable data, including controls on storage, handling, and sharing of data.

Related QAs: Integrity

Constituent: AAL system constituents

Stakeholders: AAL system

Description: System constituents must protect data storage or communication to ensure confidentiality and integrity of this data.

Related QAs: Reliability, security

Constituent: AAL system

Stakeholders: AAL system, tertiary users

Description: The system must have reliable means for authentication, secure transmission method, secure server environment and application, and deployment of security policies covering, e.g., management and maintenance processes.

6.8 Configurability requirements

Related QAs: Portability, flexibility, adaptability, usability

Constituent: AAL system

Stakeholders: Primary and secondary users

Description: The system must provide services and tools to support the configuration of new software, hardware, and services. The configuration mechanisms must be easy to manage also for relatives with little or no technical knowledge, this would enhance acceptance of the system.

Related QAs: Portability, flexibility, adaptability

Constituent: AAL system

Stakeholders: tertiary users

Description: The system must provide services and tools to support the configuration of languages by application developers to clearly specify how and what parts of an application can be configured.

Related QAs: Maintainability

Constituent: AAL system

Stakeholders: Tertiary users

Description: The system must allow to service deployers, service providers, administrators the possibility to access, configure and administer relevant parts or properties of deployed services.

6.9 Dependability requirements

Related QAs: Trust, reliability, faul-tolerance, safety

Constituent: AAL system

Stakeholders: AAL system

Description: The system must support the delivery of services that can justifiably be trusted, where the service is the intended behavior of the system. The system must be resilient with respect to unanticipated behavior from the environment or of constituents (e.g., transient and permanent hardware faults, design faults).

6.10 Deployabiliity requirements

Related QAs:

Constituent: AAL system

Stakeholders: AAL system

Description: The system must be simply deployed by being independent from the underlying hardware or operating systems.

Related QAs:

Constituent: AAL system

Stakeholders: AAL system

Description: The system must define protocol and infrastructure for easy deployment of services.

6.11 Easy interaction requirements

Related QAs: Usability

Constituent: HCI system

Stakeholders: Primary and secondary user

Description: The system must support multi-modal user interaction.

6.12 Efficiency requirements

Related QAs:

Constituent: AAL system

Stakeholders: AAL system

Description: The system must implement efficiently both local and distributed transactions.

Related QAs:

Constituent: AAL system

Stakeholders: AAL system

Description: Data structures used for storing data in the system must be efficiently designed in the context of representation and serialization.

Related QAs: Usability

Constituent: UI framework

Stakeholder: Primary and secondary users

Description: the system must provide highly responsive user interfaces

6.13 Fault-tolerance requirements

Related QAs: Usability, Pleasure

Constituent: AAL system

Stakeholders: AAL system

Description: The system must ensure proper levels of service and experience quality through various fault-tolerance mechanisms.

Related QAs: Performance

Constituent: AAL system

Stakeholders: AAL system

Description: The system must guarantee the lower bound on the communication bandwidth, upper bounds on the latency and jitter must be determinable.

Related QAs: Reliability

Constituent: AAL system

Stakeholders: AAL system

Description: The system must be capable to tolerate the failure of individual devices and interconnects.

Related QAs:

Constituent: AAL system

Stakeholders: AAL system

Description: The system must identify assumptions to define the type and frequency of faults that the system has to be able to tolerate.

Related QAs: Performance

Constituent: AAL system

Stakeholders: AAL system

Description: The system architecture must assure a known, bounded and minimal start-up time of system components/systems.

Related QAs:

Constituent: AAL system

Stakeholders: AAL system

Description: The system architecture must provide an error-detection mechanism to distinguish between transient and permanent faults.

6.14 Flexibility requirements

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: The system must guarantee a high-level of flexibility in the distribution of functionalities.

Related QAs: Efficiency

Constituent: AAL system

Stakeholder: AAL system

Description: the system must offer language configuration, intended as the set of commands usable to control the configuration process, linguistically expressive and efficient.

Related QAs: Compatibility

Constituent: AAL system

Stakeholder: AAL system

Description: The system must support both local ? exploiting available appliances such as smart tvs, wall screens, touch screens, gaming consoles, voice systems - and remote access - via text messages, short messages, voice messages, apps, wizards, web sites, etc.

Related Qas: Configurability, scalability

Constituent: AAL system

Stakeholder: AAL system

Description: The system must apply different system configurations in order to choose what kind of scalability should be used.

6.15 Freedom for risk requirements

Related QAs: Reliability

Constituent: PHR and HIR systems

Stakeholder: AAL system

Description: The system must offer reliable data to base diagnosis and health decisions.

Related QAs:

Constituent: AAL system

Stakeholder: Primary users

Description: The system must protect users against any physical, social, financial, or other type of damage.

Related QAs: Reusability, Integration

Constituent: AAL system

Stakeholder: AAL system

Description: The system must allow the possibility to use subsystems/constituents with different levels of criticality within the AAL system.

6.16 Integration requirements

Related QAs: Portability

Constituent: Coordinator system / middleware

Stakeholder: AAL system

Description: The system must integrate information from distributed and heterogeneous sensor and data sources.

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: The system must integrate communities and social networks, both as a means to exchange data.

Related QAs: Extendibility

Constituent: Context management system / Coordinator system

Stakeholder: AAL system

Description: The system must allow for integration of several different context reasoning mechanisms based on different algorithm types.

Related QAs:

Constituent: UI framework

Stakeholder: AAL system

Description: The framework must combine the input from multiple devices into one in-put representation (input fusion) and to split one output representation into the output to multiple devices (output fusion) in a meaningful way.

Related Qas: Compatibility

Constituent: AAL system

Stakeholder: AAL system

Description: The system must support the integration and invocation of remote web services, i.e., remote web service shall be able to interact with local services and vice-versa.

Related QAs: Interoperability

Constituent: AAL system/middleware

Stakeholder: AAL system

Description: the system must allow inter-component/system communication infrastructure that enables remote procedure calls between decoupled and distributed components/systems that hide possible underlying different communication protocols.

Related QAs:

Constituent: AAL system / middleware

Stakeholder: AAL system

Description: The system must hide the distribution of components/systems. Inter-component communication infrastructure shall hide possible distribution of components in intercomponent communication.

Related QAs:

Constituent: AAL system / middleware

Stakeholder: AAL system

Description: The system must have an inter-component communication infrastructure that decouples communicating components by some intermediary.

Related QAs: Scalability, interoperability

Constituent: AAL system

Stakeholder: AAL system

Description: The system must facilitate the integration of arbitrary numbers of sensors, actuators, control units, appliances, and application/systems into the system.

6.17 Integrity requirements

Related QAs: Confidentiality

Constituent: AAL system

Stakeholder: AAL system

Description: system constituents must protect data storage or communication to ensure confidentiality and integrity of this data.

6.18 Interoperability requirements

Related QAs:

Constituent: AAL system

Stakeholder: Tiertiary users

Description: The system must use open standards to facilitate the openness of the platform and thus must be supported.

Related QAs:

Constituent: AAL system

Stakeholder: Tiertiary users

Description: The system (services) infrastructure must support semantic service matchmaking, which is a core part of any system that provides for semantic interoperability.

Related QAs:

Constituent: AAL system

Stakeholder: AAL system Description:The system must allow interoperability with sensing devices.

Related QAs:

Constituent: Middleware

Stakeholder: AAL system

Description: The system must obtain and integrated view of the world state that is relevant.

Related QAs: Co-existence

Constituent: Middleware

Stakeholder: AAL system

Description: The system must provide connectivity to heterogeneous sensor devices and other data sources.

Related QAs:

Constituent: AAL system / Ontology

Stakeholder: PHR system

Description: The system must use common vocabularies (e.g., ontologies such as ONKI) covering both clinical and non-clinical contents in order to achieve semantic PHR interoperability.

Related QAs:

Constituent: AAL system / Ontology

Stakeholder: AAL system

Description: The system must allow semantic interoperability between applications/systems and services.

Related QAs:

Constituent: Coordinator system

Stakeholder: tiertiary users

Description: The coordinator system must be based on open communication protocols, so as to be interoperable with potentially any appliance from any vendor.

Related QAs: Security

Constituent: Coordinator system

Stakeholder: AAL system and other coordinator systems

Description: The coordinator system must be able to interoperate and cooperate with other users' coordinators installed in other houses to exchange best practices, users policies and other relevant information ? provided that an adequate security model is set up and the proper permissions are granted.

Related QAs: Integration

Constituent: AAL system

Stakeholder: AAL system

Description: The system must allow external interoperability, this is, it must integrate external and legacy services/systems and modules

Related QAs: Integration, co-existence

Constituent: AAL system

Stakeholder: AAL system

Description: the system must support the timely and time-dependent combination of data-streams that originate from existing different devices.

6.19 Learnability requirements

Related QAs:

Constituent: UI framework

Stakeholder: Primary and secondary users

Description: the system must offer user interfaces predictable and easy to learn.

6.20 Maintainability requirements

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: The system must provide services and tools to support the installation of new software, hardware and service into the AAL space and to install pre-compiled software modules

Related QAs: Modularity

Constituent: AAL system

Stakeholder: AAL system

Description: the system design must be highly modular and extensible for facilitating maintenace and administration.

Related QAs:

Constituent: AAL system

Stakeholder: primary and secondary users

Description: The system must allow a technical support personnel to the users easily maintain the system after the deployment (i.e., to monitor state of the system, to identify exceptions or faults).

Related QAs: Evolution

Constituent: AAL system

Stakeholder: AAL system

Description: the system must provide long-term support of evolving environments.

Related QAs: fault-tolerance

Constituent: AAL system

Stakeholder: AAL system

Description: The system must offer ease maintenance through identification of faulty systems.

Related QAs: Modifiability

Constituent: AAL system

Stakeholder: AAL system

Description: The system must provide replacement of commodities goods and old or broken hardware components.

Related QAs: fault-tolerance

Constituent: AAL system

Stakeholder: AAL system

Description: The system architecture must support the identification of faulty systems/sub-systems for maintenance.

Related QAs: fault-tolerance

Constituent: AAL system

Stakeholder: AAL system

Description: The system architecture must provide error-detection mechanisms to distinguish between transient and permanent faults.

Related QAs: portability, usability

Constituent: AAL system

Stakeholder: primary user

Description: The system must be clearly uncoupled from the user's natural language, both to easily support any user's nationality (even simultaneously) and to preserve the underlying layer from changes in the users' natural languages.

6.21 Non-repudiation requirements

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: the system must to trace back every action on sensitive assets to the person or system component that performed it (e.g., to deal with misuse that could not be prevented with technical security mechanisms).

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: The system must to trace back actions on sensitive assets to the human or system component that was responsible for this action.

6.22 Performance efficiency requirements

Related QAs: Resource utilization, co-existence

Constituent: AAL system / middleware

Stakeholder: AAL system

Description: the system architecture must ensure that individual subsystems/constituents cannot dominate/block shared communication resources.

Related QAs: Reliability

Constituent: AAL system

Stakeholder: AAL system

Description: The system architecture must support the calculation of the worst-case execution time (WCET) of software modules with feasible effort.

6.23 Privacy requirements

Related QAs: Security

Constituent: AAL system

Stakeholder: AAL system

Description: the system must guarantee its secure operation and prevent the abuse of person-related information.

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: System services mus be certified at manage person-related information.

Related QAs: Trust, satisfaction

Constituent: AAL system

Stakeholder: AAL system

Description: The system must protect users private data and respect the user's privacy, in order user feels assured.

Related QAs:

Constituent: PHR and HIR systems

Stakeholder: primary user

Description: The system must protect sensitive health information to avoid that patients information be used for other purposes (e.g., to publish in social networks the health status of the patient). Unauthorized access to health information must be prevented.

Related QAs: non-repudiation

Constituent: PHR and HIR systems

Stakeholder: primary user

Description: the system must provide mechanisms to prevent unauthorized profiling in order to prevent leaking of information about who is using which service or leaking information between services.

6.24 Reliability requirements

Related QAs:

Constituent: AAL system

Stakeholder: Primary and secondary users

Description: The system and its constituents must manage personal and health-related information in a reliable way.

Related QAs: fault-tolerance

Constituent: AAL system

Stakeholder: AAL system

Description: The system must be highly reliable to address the distinct and measurable impact of possible failure.

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: The system must offer mechanisms to ensure a proper execution of components/constituents and application.

Related QAs:

Constituent: AAL system (middleware)

Stakeholder: AAL system

Description: The system communication infrastructure must provide prioritization of messages to ensure transfer of emergency related messages.

Related QAs: performance

Constituent: AAL system (middleware)

Stakeholder: AAL system

Description: The system must guarantee for the message exchanged between systems: a) the lower bound on the communication bandwidth, b) the upper bounds on the latency, and c) the jitter must be determinable.

Related QAs:

Constituent: Aal system (middleware/communication infrastructure)

Stakeholder: AAL system

Description: The system architecture must provide different levels of reliability of the communication services.

Related QAs: Fault-tolerance

Constituent: Fault tolerance mechanisms

Stakeholder: AAL system

Description: Fault-tolerance mechanisms must be capable of adapting to changed reliability of subsystems/constituents over lifetime.

Related QAs: Fault-tolerance

Constituent: AAL system

Stakeholder: AAL system

Description: The system must provide replicas and voting mechanisms (e.g., triple-modular redundancy) shall be provided for error detection and error masking.

Related QAs: Fault-tolerance

Constituent: AAL system

Stakeholder: AAL system

Description: The system must assure replica determinism for replicated components (e.g., replicated components are in the same state and produce the same output within a defined interval of time).

Related QAs: Authentication, confidentiality

Constituent: PHR system

Stakeholder: AAL system

Description: The system must provide reliable authentication to improve the confidentiality of the handled health-related information.

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: The system must be robust, an for that the system's gateway must operate as a local cache for harvested data.

Related QAs: Trust , fault-tolerance

Constituent: AAL system (AmI system or context management system?)

Stakeholder: AAL system

Description: The system must minimize Mean Time Between Failures (MTBF) and guarantee minimum system functionality for core services (e.g., health services, traffic services).

6.25 Reusability requirements

Related QAs: Extendibility

Constituent: AAL system

Stakeholder: Tiertiary users

Description: The system must easily extend service/system capabilities and reuse existing components/systems.

6.26 Satisfaction requirements

Related QAs: Usability

Constituent: HCI system

Stakeholder: primary user

Description: The system must make easy and natural for the user to express high-level goals, desires and preferences.

6.27 Scalability requirements

Related QAs: Reusability, Maintainability

Constituent: AAL system

Stakeholder: AAL system

Description: The system must easily extend service /systems capabilities and reuse existing components/systems.

Related QAs: Usability

Constituent: AAL system

Stakeholder: Primary and secondary user

Description: The system must allow the use of its different devices across it services.

Related QAs: Integration

Constituent: AAL system

Stakeholder: AAL system

Description: the system must provide a shared communication infrastructure to ease integration of new components and hardware, using plug-and-play approach and automatic detection and integrated.

Related QAs:

Constituent: context management system

Stakeholder: AAL system

Description: The system must allow the integration of several different context reasoning mechanisms based on different algorithms types.

Related QAs:

Constituent: AAL system

Stakeholder: primary and tertiary users

Description: The system must support large numbers of primary and secondary users.

Related QAs:

Constituent: PHR system

Stakeholder: tiertiary and quaternary user

Description: The system must be open source to have international visibility and partners, which are important concerns for the evolution of a global scale health ecosystem.

Related QAs: reliability

Constituent: Coordinator system

Stakeholder: AAL system

Description: The coordinator system must be designed in such a way to prevent the risk of creating bottlenecks ? that is, it should be logically central, but possibly distributed at the implementation level if appropriate.

Related QAs: Performance

Constituent: AAL system

Stakeholder: AAL system

Description: Large systems must add proportional amount of resources for maintaining performance metrics on the same level.

6.28 Security requirements

Related QAs: Authentication

Constituent: AAL system

Stakeholder: AAL system

Description: The system must implement access control mechanisms for collected data (e.g., by employing fingerprint authentication for the user).

Related QAs: Privacy

Constituent: AAL system

Stakeholder: AAL system

Description: The system must guarantee its secure operation of the and prevent the abuse of person-related information.

Related QAs: Protection

Constituent: AAL system

Stakeholder: Tiertiary users

Description: The system must provide content protection addressing encryption mechanisms of the information, in addition to the connections protected by the https protocol.

Related QAs: Trustability

Constituent: PHR system

Stakeholder: primary, secondary, and tiertiary users

Description: The system must provide trust between the communication services by establishing agreements between the PHR service providers.

Related QAs:

Constituent: HCI system

Stakeholder: primary and secondary users

Description: the system must protect the user interface of services due to users have full control on the PHR information.

Related QAs: Privacy

Constituent: AAL system

Stakeholder: AAL system

Description: The system must provide and enforce privacy and security in health-care by technological means (e.g., providing secure communication, secure storage, and access use and disclosure control).

6.29 Testability requirements

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: The system architecture must support testability (e..g., design testing, system-integration testing, manufacturing testing and assembly testing).

Related QAs:

Constituent: AAL system

Stakeholder: AAL system

Description: The system architecture must support the establishment of error containment regions, where errors can be detected with defined error-containment coverage.

Related QAs: fault-tolerance

Constituent: AAL system

Stakeholder: AAL system

Description: The system must detect application-independent failures modes (e.g., communication errors) by providing systematic diagnostic methods.

6.30 Trust requirements

Related QAs:

Constituent: AAL system

Stakeholder: primary users

Description: The system must use trust and reputation mechanisms to increase trust by users, e.g., in payment transactions.

Related QAs: usability

Constituent: PHR system

Stakeholder: primary user

Description: The system must be trust to improve its usability.

Related QAs: reliability

Constituent: health monitoring system

Stakeholder: secondary users

Description: The system must ensure trust to the data measured by patients or consumers that will be used by professionals to monitor the health-status of patients.

Related QAs: protection

Constituent: AAL system

Stakeholder: AAL system

Description: The system must be trustworthy and thus protect personal information.

6.31 Usability requirements

Related QAs: Accessibility

Constituent: AAL system

Stakeholder: primary user

Description: The system mus consider accessibility and usability when designing user interfaces for elderly.

6.32 User interaction requirements

Related QAs: usability

Constituent: AAL system

Stakeholder: primary user

Description: The system must facilitate the explicit user interaction with it while separating the presentation mechanisms from application logic and supporting multimodality in an ensemble of devices distributed at different locations.

6.33 User Interface aesthetics requirements

Related QAs: usability, portability, integration

Constituent: UI framework

Stakeholder: primary users

Description: The system must support a consistent look and feel between different interfaces and applications of the different constituents.

Related QAs: usability, portability, integration

Constituent: HIC system

Stakeholder: primary users

Description: The system must use consistent colours, shapes and symbols together with natural language and vocabulary familiar to the user.

Related QAs: usability, portability, integration **Constituent:** UI framework **Stakeholder:** primary users **Description:** The system must use specific usability standards for the appropriate focus group (assisted persons).

Chapter 7

Final Considerations

The development of quality AAL systems carries significant challenges because the heterogeneity of their constituent systems, their adaptive properties, and the variety of stakeholders involved in their creation. In this perspective, the QM4AAL offers a repository of QAs requirements for both AAL systems and their constituents systems.

Moreover, the three-dimensional structure of the QM4AAL allows to represent QAs requirements for AAL systems' constituents in a way that such representation be a QM specific of the constituent system. Hence, such QM permits the definition of adaptive properties, stakeholders, and related QAs for each constituent systems. As an example, figure 7.1 illustrates the structure of a QM for a health status monitoring system. In this context, the QM4AAL can be used to define and assess both AAL systems as a whole, as their constituent systems as independent systems.

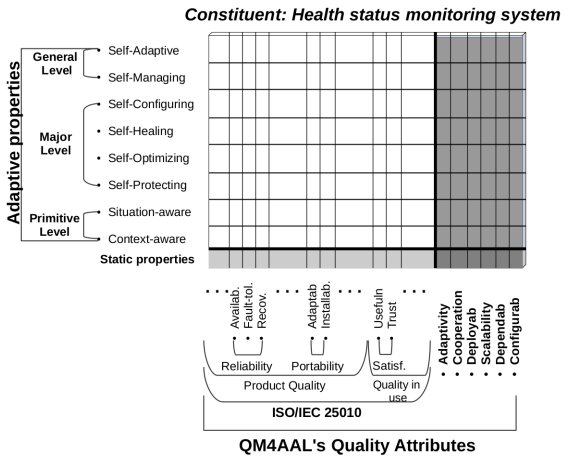

Figure 7.1: QM for the AAL system's constituent: health status monitoring system.

Future work

We are aware that the QM4AAL needs important improvements that will be carried out as future work. In the QM4AAL next versions more constituent systems will be considered, e.g., tele-medicine, nutritional, and rehabilitation systems. Moreover, the QM4AAL will be under experts assessment of both ITC and medical area, in order to prioritize QAs. Finally, the QM4AAL will be used to create a reference architecture and software systems to evaluate its correctness.

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Appendix A

Quality attributes definitions

In this appendix we present the definitions for quality attributes. Such definitions were extracted from the standard ISO/IEC 25010 [11]. Moreover, we define those QAs that are not comprised by the standard.

ISO/IEC 25010 QUALITY ATTRIBUTES DEFINITIONS			
PRODUCT QUALITY	**FUNCTIONAL SUITABILITY**	***Functional suitability***	*degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions*
		Functional completeness	degree to which the set of functions covers all the specified tasks and user objectives
		Functional correctness	degree to which a product or system provides the correct results with the needed degree of precision
		Functional appropriateness	degree to which the functions facilitate the accomplishment of specified tasks and objectives
	RELIABILITY	***Reliability***	*degree to which a system, product or component performs specified functions under specified conditions for a specified period of time.*
		Maturity	degree to which a system meets needs for reliability under normal operation
		Availability	degree to which a system, product or component is operational and accessible when required for use
		Fault tolerance	degree to which a system, product or component operates as intended despite the presence of hardware or software faults
		Recoverability	degree to which, in the event of an interruption or a failure, a product or system can recover the data directly affected and re-establish the desired state of the system
	PERFORMANCE EFFICIENCY	***Performance efficiency***	*performance relative to the amount of resources used under stated conditions*
		Time behaviour	degree to which the response and processing times and throughput rates of a product or system, when performing its functions, meet requirements
		Resource utilization	degree to which the amounts and types of resources used by a product or system when performing its functions meet requirements
		Capacity	degree to which the maximum limits of a product or system parameter meet requirements
	USABILITY	***Usability***	*degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*
		Appropriateness recognisability	degree to which users can recognize whether a product or system is appropriate for their needs
		Learnability	degree to which a product or system can be used by specified users to achieve specified goals of learning to use the product or system with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use
		Operability	degree to which a product or system has attributes that make it easy to operate and control
		User error protection	degree to which a system protects users against making errors
		User interface aesthetics	degree to which a user interface enables pleasing and satisfying interaction for the user
		Accessibility	degree to which a product or system can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use

ISO/IEC 25010 QUALITY ATTRIBUTES DEFINITIONS			
PRODUCT QUALITY	MAINTAINA- BILITY	***Maintainability***	*degree of effectiveness and efficiency with which a product or system can be modified by the intended maintainers*
		Modularity	degree to which a system or computer program is composed of discrete components such that a change to one component has minimal impact on other components
		Reusability	degree to which an asset can be used in more than one system, or in building other assets
		Analysability	degree of effectiveness and efficiency with which it is possible to assess the impact on a product or system of an intended change to one or more of its parts, or to diagnose a product for deficiencies or causes of failures, or to identify parts to be modified
		Modifiability	degree to which a product or system can be effectively and efficiently modified without introducing defects or degrading existing product quality
		Testability	degree of effectiveness and efficiency with which test criteria can be established for a system, product or component and tests can be performed to determine whether those criteria have been met
	SECURITY	***Security***	*degree to which a product or system protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorization*
		Confidentiality	degree to which a product or system ensures that data are accessible only to those authorized to have access
		Integrity	degree to which a system, product or component prevents unauthorized access to, or modification of, computer programs or data
		Non-repudiation	degree to which actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later
		Accountability	degree to which the actions of an entity can be traced uniquely to the entity
		Authenticity	degree to which the identity of a subject or resource can be proved to be the one claimed
	COMPATIBILITY	***Compatibility***	*degree to which a product, system or component can exchange information with other products, systems or components, and/or perform its required functions, while sharing the same hardware or software environment*
		Co-existence	degree to which a product can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product
		Interoperability	degree to which two or more systems, products or components can exchange information and use the information that has been exchanged

ISO/IEC 25010 QUALITY ATTRIBUTES DEFINITIONS			
PRODUCT QUALITY	**PORTABILITY**	***Portability***	*degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another*
		Adaptability	degree to which a product or system can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments
		Installability	degree of effectiveness and efficiency with which a product or system can be successfully installed and/or uninstalled in a specified environment
		Replaceability	degree to which a product can be replaced by another specified software product for the same purpose in the same environment
QUALITY IN USE	**SATISFACTION**	***Satisfaction***	*degree to which user needs are satisfied when a product or system is used in a specified context of use*
		Usefulness	degree to which a user is satisfied with their perceived achievement of pragmatic goals, including the results of use and the consequences of use
		Trust	degree to which a user or other stakeholder has confidence that a product or system will behave as intended
		Pleasure	degree to which a user obtains pleasure from fulfilling their personal needs
		Comfort	degree to which the user is satisfied with physical comfort
	EFFECTIVENESS	***Effectiveness***	*accuracy and completeness with which users achieve specified goals*
	FREEDOM FOR RISK	***Freedom for risk***	*degree to which a product or system mitigates the potential risk to economic status, human life, health, or the environment*
		Economic risk mitigation	degree to which a product or system mitigates the potential risk to financial status, efficient operation, commercial property, reputation or other resources in the intended contexts of use
		Health and safety risk mitigation	degree to which a product or system mitigates the potential risk to people in the intended contexts of use
		Environmental risk mitigation	degree to which a product or system mitigates the potential risk to property or the environment in the intended contexts of use
	EFFICIENCY	***Efficiency***	*resources expended in relation to the accuracy and completeness with which users achieve goals*
	CONTEXT COVERAGE	***Context coverage***	*degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in both specified contexts of use and in contexts beyond those initially explicitly identified*
		Context completeness	degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in all the specified contexts of use
		Flexibility	degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in contexts beyond those initially specified in the requirements

OTHERS QUALITY ATTRIBUTES DEFINITIONS	
Adaptivity	degree to which a product or system can effectively and efficiently be adapted in run-time for different or evolving hardware, software or other operational or usage environments
Cooperation	degree to which a product or system can exchange requests among classes and instances in order to achieve some goal.
Deployability	addresses how reliably and easily software can be deployed from development into the production environment.
Scalability	ability to handle increased workload by repeatedly applying a cost-effective strategy for extending a system's capacity.
Dependability	Measure of the degree to which an item is operable and capable of performing its required function at any (random) time during a specified mission profile, given item availability at the start of the mission. Reliability, availability, and maintainability are aspects of dependability.
Configurability	Addresses how hardware and software of an information processing system are organized and interconnected.

Appendix B

List of quality attributes from AAL software systems

Table B.1 lists the 97 quality attributes that were found at conducting the systematic review about quality attributes and quality models for AAL software systems [14]. Columns from S1 to S17 represent the primary studies analyzed to extract the information on QAs for AAL systems. For more information on studies please referred to [14].

Table B.1: List of quality attributes

ID	Attributes	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	(#)	(%)
1	**Safety**	1	1	1	1		1						1	1		1	1	1	9	52,9
2	**Security**	1		1	1	1	1		1				1			1		1	9	52,9
3	Usability	1	1		1					1				1	1	1	1	1	9	52,9
4	Availability	1		1					1	1	1	1	1					1	8	47,1
5	Efficiency			1	1	1	1						1	1				1	7	41,2
6	Reliability					1	1				1			1		1	1	1	7	41,2
7	Accuracy							1		1	1	1				1		1	6	35,3
8	Robustness	1		1					1			1				1	1		6	35,3
9	Maintainability						1						1	1			1	1	5	29,4
10	Accessibility		1		1										1			1	4	23,5
11	Adaptivity	1	1	1														1	4	23,5
12	Confidentiality							1	1		1		1						4	23,5
13	Integrity								1		1		1					1	4	23,5
14	Resource consumption	1					1						1					1	4	23,5
15	Timeliness	1		1				1			1								4	23,5
16	Effectiveness				1	1								1					3	17,6
17	Extensibility	1		1													1		3	17,6
18	Installability						1					1						1	3	17,6
19	Natural, anticipatory HCI[1]	1	1	1															3	17,6
20	**Performance**								1	1						1			3	17,6
21	Usefulness				1					1							1		3	17,6
22	User acceptance		1									1				1			3	17,6
23	Acceptability				1													1	2	11,8
24	Adaptability															1	1		2	11,8
25	Adequacy for small devices						1											1	2	11,8
26	Certainty							1			1								2	11,8
27	Changeability						1											1	2	11,8
28	Communication overhead						1											1	2	11,8
29	Ease of use					1											1		2	11,8
30	Encryption						1											1	2	11,8
31	Flexibility		1														1		2	11,8
32	Heterogeneity		1	1															2	11,8
33	Integrability		1									1							2	11,8

Continued on next page

[1]Human Computer Interaction

Table B.1 – *Continued from previous page*

ID	Attributes	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	(#)	(%)
34	Interoperability																1	1	2	11,8
35	Learnability				1													1	2	11,8
36	Portability													1			1		2	11,8
37	Presence of SPoF[2]						1											1	2	11,8
38	Privacy															1	1		2	11,8
39	Productivity				1									1					2	11,8
40	Profile definition						1											1	2	11,8
41	Recoverability						1											1	2	11,8
42	Safety pattern usage						1											1	2	11,8
43	Satisfaction				1									1					2	11,8
44	Suitability		1							1									2	11,8
45	User role						1											1	2	11,8
46	Analysability												1						1	5,9
47	Authentication										1								1	5,9
48	Awareness					1													1	5,9
49	Compatibility with standards																1		1	5,9
50	Completeness										1								1	5,9
51	Conformity												1						1	5,9
52	Context consistency										1								1	5,9
53	Context correctness										1								1	5,9
54	Contextual knowledge																	1	1	5,9
55	Data volume										1								1	5,9
56	Delay time										1								1	5,9
57	**Dependability**																	1	1	5,9
58	Development time and cost															1			1	5,9
59	Ease of maintenance															1			1	5,9
60	Evolvability																1		1	5,9
61	Extrapolation											1							1	5,9
62	Feasibility									1									1	5,9
63	Fulfilment					1													1	5,9
64	Functionality													1					1	5,9
65	Generality									1									1	5,9
66	Identification									1									1	5,9

Continued on next page

[2]Single Point of Failure

Table B.1 – *Continued from previous page*

ID	Attributes	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	(#)	(%)
67	Information processing																1		1	5,9
68	Interface compatibility															1			1	5,9
69	Invisibility															1			1	5,9
70	Manageability																1		1	5,9
71	Modifiability												1						1	5,9
72	Multi user									1									1	5,9
73	Obtrusiveness or integration																1		1	5,9
74	Personalization					1													1	5,9
75	Precision								1										1	5,9
76	Proceeding speed					1													1	5,9
77	Quality of data																	1	1	5,9
78	Relevance		1																1	5,9
79	Replicability																1		1	5,9
80	Responsiveness					1													1	5,9
81	Reusability																1		1	5,9
82	Run-time behavior												1						1	5,9
83	Scalability											1							1	5,9
84	Self-configuration	1																	1	5,9
85	Self-maintenance	1																	1	5,9
86	Self-optimization	1																	1	5,9
87	Stability												1						1	5,9
88	Sustainability																1		1	5,9
89	Testability												1						1	5,9
90	Time accuracy											1							1	5,9
91	Trustfulness				1														1	5,9
92	Universal access														1				1	5,9
93	Universality				1														1	5,9
94	Unobstrusiveness															1			1	5,9
95	Upgradability																1		1	5,9
96	User centric									1									1	5,9
97	User's autonomy															1			1	5,9
Total by study		13	10	10	13	10	16	4	7	11	13	9	14	10	3	16	22	28		

Appendix C

List of quality attributes from Reference Architectures for AAL systems

QA ID	QA	PSCI	AmIRA	FeelGood	OASIS	Continua	Persona	Butlers	UniversAAL	(#)
QARA001	Ability of easy integration								1	**1**
QARA002	Accessibility				1			1	1	**3**
QARA003	Accountability					1				**1**
QARA004	Accuracy		1							**1**
QARA005	Adaptability	1							1	**2**
QARA006	Adaptation				1		1			**2**
QARA007	Adaptivity				1		1		1	**3**
QARA008	Adequacy for small devices				1					**1**
QARA009	Assurance					1				**1**
QARA010	Authentication								1	**1**
QARA011	Authorization					1			1	**2**
QARA012	Availability					1			1	**2**
QARA013	Awareness						1			**1**
QARA014	Changeability				1					**1**
QARA015	Compliance to standards								1	**1**
QARA016	Composability						1			**1**
QARA017	Confidentiality								1	**1**
QARA018	Confidentiality in the infor.			1		1				**2**
QARA019	Configurability								1	**1**
QARA020	Context awareness		1					1	1	**3**
QARA021	Cooperation							1		**1**
QARA022	Data authenticity					1				**1**
QARA023	Data quality					1				**1**
QARA024	Dependability								1	**1**
QARA025	Deployability								1	**1**
QARA026	Device authenticity					1				**1**
QARA027	Disaster recovery		1							**1**
QARA028	Easy development								1	**1**
QARA029	Easy interaction								1	**1**
QARA030	Efficiency								1	**1**
QARA031	Encryption mechanism				1					**1**
QARA032	Extendibility		1						1	**2**
QARA033	Fault tolerance								1	**1**

QA ID	QA	PSCI	AmIRA	FeelGood	OASIS	Continua	Persona	Butlers	UniversAAL	(#)
QARA034	Flexibiity						1	1	1	**3**
QARA035	Heterogenity						1			**1**
QARA036	Identification								1	**1**
QARA037	Installability				1				1	**2**
QARA038	Integration		1				1	1	1	**4**
QARA039	Integrity					1			1	**2**
QARA040	Intelligent							1		**1**
QARA041	Interaction							1		**1**
QARA042	Interoperability	1	1	1	1	1	1	1	1	**8**
QARA043	Learnability								1	**1**
QARA044	Maintainability		1	1					1	**3**
QARA045	Modifiability							1		**1**
QARA046	Modularity		1							**1**
QARA047	Natural interaction						1			**1**
QARA048	Non-repudiation					1			1	**2**
QARA049	Operability								1	**1**
QARA050	Patient safety					1				**1**
QARA051	Performance		1				1		1	**3**
QARA052	Personalization				1					**1**
QARA053	Portability		1					1		**2**
QARA054	Privacy		1	1		1			1	**4**
QARA055	Quality of service								1	**1**
QARA056	Relevance		1							**1**
QARA057	Reliability	1				1			1	**3**
QARA058	Reliable authentication			1						**1**
QARA059	Resource management								1	**1**
QARA060	Reusability								1	**1**
QARA061	Richness						1			**1**
QARA062	Robustness	1	1							**2**
QARA063	Safety								1	**1**
QARA064	Satisfaction							1		**1**
QARA065	Scalability	1	1	1			1	1	1	**6**
QARA066	Seamless connectivity				1					**1**

QA ID	QA	PSCI	AmIRA	FeelGood	OASIS	Continua	Persona	Butlers	UniversAAL	(#)
QARA067	Seamlessly						1			**1**
QARA068	Security	1	1	1		1				**4**
QARA069	Security profile definition				1					**1**
QARA070	Self-adaptive		1							**1**
QARA071	Self-configuration		1							**1**
QARA072	Simplicity					1		1		**2**
QARA073	Testability								1	**1**
QARA074	Trustability		1	1		1				**3**
QARA075	Trustworthy	1								**1**
QARA076	Ui aesthetics								1	**1**
QARA077	Unauthorized modifications					1				**1**
QARA078	Understandability							1		**1**
QARA079	Usability		1		1			1	1	**4**
QARA080	Usefulness								1	**1**
QARA081	User authenticity					1				**1**
QARA082	User error protection								1	**1**
QARA083	User interaction						1			**1**
Total by study		**7**	**19**	**8**	**12**	**19**	**14**	**15**	**41**	

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