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Edition 1.0 2020-11

INTERNATIONAL STANDARD

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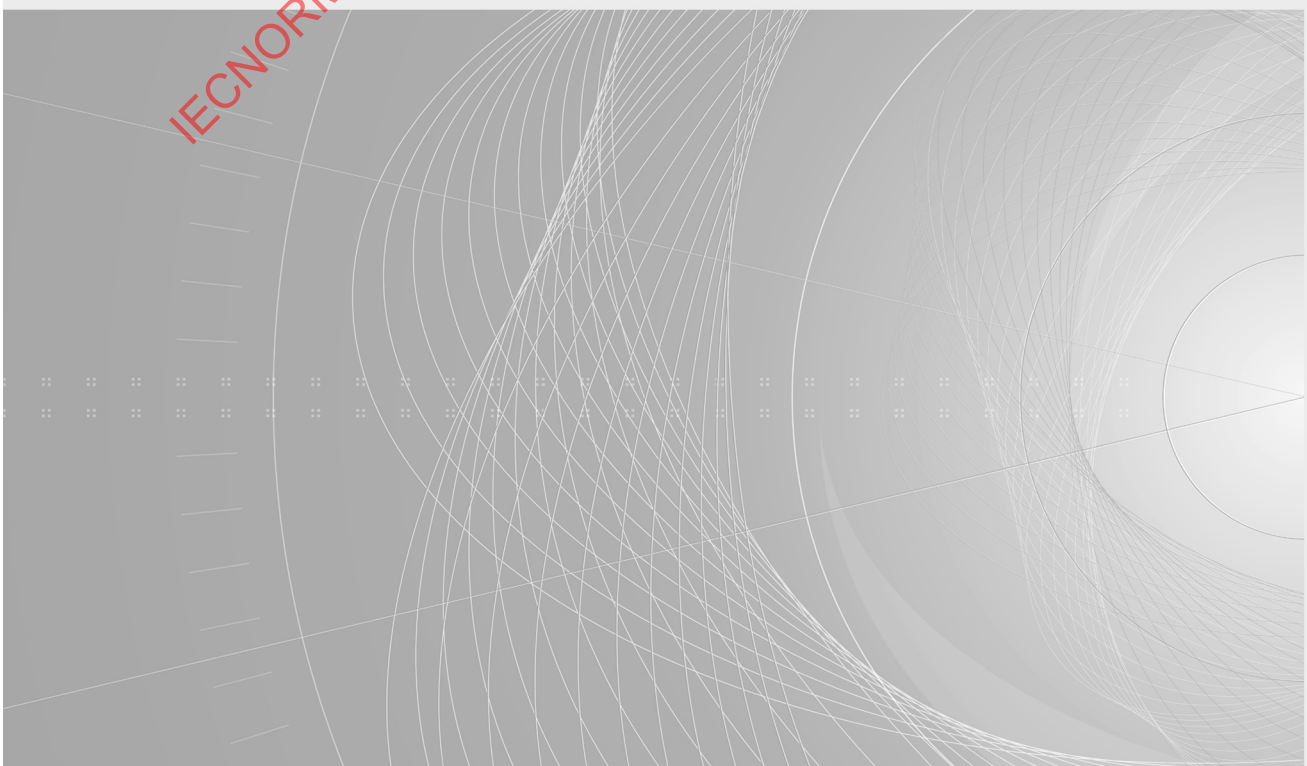
Active assisted living (AAL) reference architecture and architecture model – Part 2: Architecture model



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Active assisted living (AAL) reference architecture and architecture model – Part 2: Architecture model

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ACTIVE ASSISTED LIVING (AAL) REFERENCE ARCHITECTURE AND ARCHITECTURE MODEL –

Part 2: Architecture model

FOREWORD

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International Standard IEC 63240-2 has been prepared by IEC systems committee AAL: Active Assisted Living.

The text of this International Standard is based on the following documents:

Draft	Report on voting
SyCAAL/177/CDV	SyCAAL/191/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 63240 series, published under the general title *Active assisted living reference architecture and architecture model*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

IEC SyC AAL is developing an architecture model and a reference architecture for AAL to guide the development and deployment of AAL services and technologies. IEC 63240 consists of the following parts, under the general title Active assisted living (AAL) reference architecture and architecture model:

- Part 1: Reference architecture;
- Part 2: Architecture model.

This document provides information to ensure usability and accessibility from the earliest stages of design and provides guidance to developers on how to incorporate these requirements. Additional requirements such as security, privacy, and trustworthiness are introduced and considered.

This document captures the results the work of SyC AAL on architecture and interoperability. This document reflects contributions and discussions by SyC AAL experts, mirror committees and liaison members. This document also contains material gathered from reports and group output from the SyC AAL meetings in November 2015 (Tokyo), April 2016 (Wellington), October 2016 (Frankfurt), April 2017 (Beijing), September 2017 (Cleveland), December 2017 (Eindhoven), May 2018 (Tokyo), October 2018 (Seoul), June 2019 (Frankfurt) and October 2019 (Shanghai), as well as information obtained during various web meetings.

Experts from liaison organizations and the following national committees have contributed: CA, CH, CN, DE, GB, IN, JP, KR, NL, NZ, SE, US.

The target audience for this document includes the following stakeholders who have an interest in the AAL system:

- AAL users and service provider personnel who can learn about AAL user needs and how to operate AAL systems;
- consumer electronics and information and communication technology device manufacturers who want to understand AAL devices and interface and interoperability requirements;
- stakeholders who are interested in the usability, accessibility and performance of the AAL system as well as AAL operators who need to understand the system requirements;
- regulators who are responsible for developing and supervising AAL and related regulations.

ACTIVE ASSISTED LIVING (AAL) REFERENCE ARCHITECTURE AND ARCHITECTURE MODEL –

Part 2: Architecture model

1 Scope

This document specifies the AAL architecture model.

This document defines concepts and introduces terminology. IEC 63240-1 provides generic rules for designers of AAL systems and services with the aim to facilitate systems design and enable interoperability between components. This document provides a framework to analyse use cases on a common view and terminology, which is a foundation for communication to discuss the interoperability of the components of the AAL system. This document allows for the mapping of defined AAL use cases and supports the identification of interoperability issues and gap analysis of the standards.

This document also identifies safety, security, privacy, and other requirements for AAL systems such as usability, accessibility, and trustworthiness (reliability, resilience).

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
IADL
instrumental activity of daily living
human action that involves physical/social/cognitive skills related to independent living in addition to ADL

Note 1 to entry: IADL includes various actions: transportation, communication (i.e. use of telephone, emails), shopping, meal preparation, housekeeping, managing medications and managing personal finances.

Note 2 to entry: See also ISO/IWA 18:2016 [1], 3.3.

3.1.2
IADL assistance
assistance with instrumental activities of daily living

3.1.3
ADL
activity of daily living
most basic human action that involves physical self-maintenance ability

Note 1 to entry: ADL comprises the following six areas: transferring, bathing, eating, dressing, continence and grooming and toileting.

Note 2 to entry: See also ISO/IWA 18:2016 [1], 3.3.

3.1.4
ADL assistance
assistance with activities of daily living

3.1.5
AAL device
material element or assembly of such elements intended to perform a required function used in an AAL service (IEV 871-01-04).

Note 1 to entry: There are 1) medical devices (IEV 871-06-06), as defined by regulatory agencies, 2) personal health devices and sensors (IEV 871-04-29) for fitness, well-being, personal comfort and personal security and 3) devices which can serve as aggregators of personal data produced by the user of the device.

[SOURCE: IEC 60050-151:2001 [2], 151-11-20, modified – The term "device" has been replaced by "AAL device". In the definition, "used in an AAL service" has been added.]

3.1.6
AAL gateway
functional unit that connects two computer networks with different network architectures and protocols used in an AAL service (IEV 871-01-04)

Note 1 to entry: The computer networks may be local area networks, wide area networks, or other types of networks.

Note 2 to entry: Examples of gateways are a LAN gateway, a mail gateway used in an AAL service.

[SOURCE: IEC 60050-732:2010 [3], 732-01-17, modified – The term "gateway" has been replaced by "AAL gateway". In the definition and in Note 2 to entry, "used in an AAL service" has been added.]

3.1.7
AAL platform backend system
AAL backend system
system that houses a number of components (functionalities) in order to collect the data from AAL gateways or AAL devices directly over a wide area network connection, and that can also implement components for the remote management of AAL gateway or AAL device (e.g. firmware update) and components for interfacing with AAL information systems or other information systems

3.1.8
AAL applications and services
AAL application
program or application that interacts with the AAL users or within the network infrastructure to transmit or exchange data and information in the network

[SOURCE: IEC 61907:2009 [4], 3.1.13 – modified. The term in the source entry is "(network) service function". In the definition, "network users" has been replaced by "AAL users".]

3.1.9
AAL service
action or function of an AAL system creating an added value for customers

EXAMPLE 1 Configuration and maintenance of AAL systems.

EXAMPLE 2 Assistant systems to support the home and living environment.

Note 1 to entry: An AAL service can consist of several individual services.

[SOURCE: IEC 60050-871:2018 [5], 871-01-04]

3.1.10
AAL information system
collection of technical and human resources that provide the storage, computing, distribution, and communication for the information required by an AAL service (IEV 871-01-04)

Note 1 to entry: An AAL information system can contain various types of personal information.

Note 2 to entry: See http://whatis.techtarget.com/definition/IS-information-system-or-information-services [accessed 2020-10-20]. The definition is based on the first sentence in which "IS (information system) is the " was omitted and "all or some part of an enterprise" was replaced by "an AAL service (871-01-04)". Note 1 to entry was added.

3.1.11
other information system
collection of technical and human resources that provide the storage, computing, distribution, and communication for the information not specific to AAL services

Note 1 to entry: Health information system (HIS) can be part of another information system. Examples of HIS include

- electronic health records (IEV 871-06-01),
- primary care practice electronic medical records (EMRs),
- pharmacy systems, and
- laboratory information systems.

Note 2 to entry: It is possible that AAL care recipients' data need to be shared with other information systems. For example, in the context of an AAL care recipient who is suffering from chronic diseases and is monitored at home by a telemonitoring system, it is possible that a vital signs summary report needs to be shared with the primary care physician's EMR.

Note 3 to entry: See http://whatis.techtarget.com/definition/IS-information-system-or-information-services [accessed 2020-10-20]. The definition is based on the first sentence in which "IS (information system) is the " was omitted and "required by all or some part of an enterprise" was replaced by "not specific to AAL services". Notes 1 and 2 to entry were added.

3.1.12
actor layer
layer of an architecture model in which the content is derived from the use case information on actors

Note 1 to entry: Actors can be persons, technical components, or organizations that can be associated to domains (Levels of assistance: X-axis) relevant for the underlying use case. In the same manner the hierarchical zones (System component composition: Y-axis) can be identified indicating where individual actors reside.

Note 2 to entry: See CEN-CENELEC-ETSI Smart Grid Coordination Group, Smart Grid Reference Architecture, November 2012, 7.3.3.2. The definition has been derived from the first sentence in which "The content of the component layer is" has been replaced by "layer of architecture model in which the content is". Note 1 to entry was added.

3.1.13
communication layer
layer of an architecture model that describes protocols and actions for the interoperable exchange of information between the actors of a use case

Note 1 to entry: See CEN-CENELEC-ETSI Smart Grid Coordination Group, Smart Grid Reference Architecture, November 2012, 7.3.3.6. The definition has been derived from the first sentence in which "The emphasis of the communication layer is to describe" has been replaced by "layer of an architecture model that describes" and "the use case actors" has been replaced by "the actors of a use case". "mechanisms" has been replaced by "actions"

3.1.14
information layer
layer of an architecture model that describes the information that is being used and exchanged between functions, services and actors

Note 1 to entry: See CEN-CENELEC-ETSI Smart Grid Coordination Group, Smart Grid Reference Architecture, November 2012, 7.3.3.5. The definition has been derived from the first sentence in which "The information layer describes" has been replaced by "layer of an architecture model that describes" and "components" has been replaced by "actors".

3.1.15
function layer
layer of an architecture model that represents the functions described in the use cases

Note 1 to entry: See CEN-CENELEC-ETSI Smart Grid Coordination Group, Smart Grid Reference Architecture, November 2012, 7.3.3.4. The definition has been derived from the first sentence in which "The function layer is intended to represent functions and their interrelations" has been replaced by "layer of an architecture model that represents the functions described in the use cases".

3.1.16
stakeholder layer
layer of an architecture model to represent the different stakeholders involved in providing the applications and services described in the use cases

3.1.17
business layer
layer of an architecture model that represents the business models, including business objectives, economic and regulatory constraints

Note 1 to entry: See CEN-CENELEC-ETSI Smart Grid Coordination Group, Smart Grid Reference Architecture, November 2012, 7.3.3.3. The definition has been derived from the first sentence in which "The business layer is intended to host" has been replaced by "layer of an architecture model that represents" and "processes" has been replaced by "models". "services and organizations linked to the use cases" has been deleted.

3.2 Abbreviated terms

AAL active assisted living

ADL activities of daily living

IADL instrumental activities of daily living

IoT Internet of Things

4 General

New challenges are raised in system engineering due to the complexity of the AAL field. To cope with the specific characteristics and the individuality of demands of ambient intelligence, new approaches need to be adopted. These systems are demanding in matters of performance, time and quality as they answer to the needs of the elderly population. Moreover, they acquire awareness of the user's environment, the adjustability to its needs and the diversity of the provided services. The architecture model aims at the integration of different domains and systems.

Additionally, as interoperability has become a major issue in system development, standardization has emerged to manifest the compatibility between the system components. As of our knowledge, there is a lack of formulations, guidelines, rules and specifications in the context of AAL to guide the achievement of a common and optimum use of the architectural elements. The main purpose of the architecture model defined in this document is to provide a guide to analyse use cases on a common view and terminology, identify areas of possible lack of interoperability and allow for use case mapping and for conducting a standard gap analysis.

5 Relationship between IoT and AAL

AAL and IoT share a common technical architecture model and a technical "thing"-services-based framework with the emphasis on the AAL user who consumes or applies assisted living "thing"-related services. AAL is a specific use of IoT, if IoT is understood as the possibility of connectedness of things to each other. IoT is an enabler for other application systems and application domains. More specifically, it is an enabler for other "thing"-related services in these application systems and application domains.

AAL can be considered as one instance of a "human-centric IoT" approach. This means that the base for AAL is the IoT technical architecture, but specific or different requirements exist due to the user-centricity of AAL. In AAL, users include lay operators who are not IT professionals as users. There are also other IoT application domains that are human-centric such as the patient-centric medical thing-related services or healthcare thing-related services. All human-centric application domains differ from ordinary IoT services.

AAL is a human-centric use of IoT to create adapted localities (e.g. homes, points-of-care) with the aim of assisting humans. AAL is a human-centric domain at the point-of-care where services to people based on technical, IoT services are most commonly applied.

AAL utilizes IoT and designs thing-related services that serve the needs of an AAL user when interacting with the AAL cyber-physical system.

The AAL key requirements are safety, security, privacy, technical assistance and additional requirements (e.g. resilience and reliability of the system). These requirements can also apply to other domains where people play an important role such as the healthcare and medical domain.

Smart home and smart energy are domains in which domain-specific smart thing-based services are applied. "Smart services" of these and other domains should be interoperable and combined in processes which serve the need of the user of such "smart", connected services. AAL users can benefit from "smart", connected services in which AAL services are combined with services of other domains.

AAL systems are designed and implemented to assist people who are in need of AAL services realized by means of "things".

6 AAL architecture model

6.1 Development of AAL architecture model

6.1.1 Reference architecture and architecture model

As described in IEC 63240-1 [6][1], the AAL reference architecture (AAL RA) defines concepts and introduces terminology on an abstract level in the AAL systems. The AAL reference architecture also provides generic rules for designers of AAL systems and services with the aim to facilitate system design and enable interoperability between components.

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1 Numbers in square brackets refer to the Bibliography.

The AAL architecture model (AAL AM) provides a structured approach to analyse use cases on a common view and terminology and discuss the interoperability of the components of the AAL system. It allows for use case mapping and for conducting a standard gap analysis.

The AAL reference architecture and AAL architecture model give the framework to support the design of AAL system use cases with an architectural approach and provide the template to guide the development and deployment of AAL service and technologies.

6.1.2 The benefit of architecture model

The AAL architecture model has been inspired by the Smart Grid Architecture Model (SGAM) [7][8] and reference architecture model for Industrie 4.0 (RAMI4.0) [9]. The concept of a three-dimensional (3D) model (or cube model) adopted in SGAM and RAMI4.0 has been used in a structured approach for the architecture development. It allows depicting various interrelated aspects of system architecture and provides a set of concepts and viewpoints, as well as a method to map use case information. It is reported that the viewpoints of SGAM support the identification of interoperability issues and foster the awareness for interrelated aspects defined in various projects [8]

The AAL architecture model has been developed with the aim of taking the advantages in the three-dimensional model described above and further incorporating the people aspects of AAL.

6.1.3 Key decisions in AAL architecture model

The current version of AAL architecture model is the result of the work done on architecture and interoperability in SyC AAL. It is also closely related to the efforts on user focus in SyC AAL to define the use case template. One of the unique features of AAL architecture model is the x-axis "AAL levels of assistance" (also referred to as user domains in use cases) of the 3D model. In SGAM [7], this axis consists of "Domains" of energy conversion chain: Generation, Transmission, Distribution, etc. In RAMI4.0 [9], this axis represents "Product Life Cycle and Value Stream".

In AAL, modelling framework was initially investigated with reference to IEC 62559-2 [10] defined in SGAM environment and then adapted to consider the people aspects of AAL [11]. Specifically, it is necessary to consider the diversity, individuality and time-varying nature of the physical and mental conditions of people. For this purpose, SyC AAL decided to adopt "levels of assistance" to the x-axis (user domains) of AAL architecture model. "Levels of assistance" are defined in accordance with required support levels to cope with the deterioration of independence levels of people in life.

The y-axis "AAL system component composition" describes the interaction of devices and systems with services in the cloud. For y-axis, discussion was made as to which of the system component composition based description and the function and services based description is more appropriate. The former might be more important for system component providers, the latter might be more important for service providers. As a result of discussion, SyC AAL adopted system component composition based description for y-axis. This idea seemed more suitable for discussing interoperability and interface between system components such as physical interface (e.g. bus or path technology) and application programming interfaces of software components. There was also an opinion that defining devices and gateways as different component hierarchies is also important from a security point of view.

The z-axis "AAL model and process views" describes a coordinated set of viewpoints to depict different architectural aspects in AAL system. In SGAM, this axis consists of five "Interoperability Layers": component layer, communication layer, information layer, function layer and business layer. In AAL architecture model, another layer "stakeholder layer" was added between function layer and business layer. This layer has been inspired by the usage view of the Internet of Things Reference Architecture (IoT RA), where roles and relationships

of stakeholders such as service provider, service developer and user (human user/digital user) are discussed (see ISO/IEC 30141:2018 [12], 10.5). Also, Component layer in SGAM was renamed as actor layer in the AAL architecture model. This is because human actors (e.g. care recipients and care givers) in addition to the system components usually appear in AAL use cases.

6.1.4 Evolution of architecture model

It is expected to use the AAL architecture model framework to share information among projects that implement similar use cases with different technical solutions and to contribute to the development of AAL solutions. It is also expected to use this framework for standard gap analysis by the use case mapping.

The AAL architecture model described in this document has been verified and modified by the use case mapping trials in the development process. Since the new use cases will continuously appear in the AAL market, the architecture model should be reviewed and revised accordingly to meet these expectations.

6.2 Description of AAL architecture model

6.2.1 General

The three-dimensional model of AAL architecture model consists of the following three axes: AAL levels of assistance (x-axis), AAL system component composition (y-axis) and AAL model and process views (z-axis). See Figure 1.

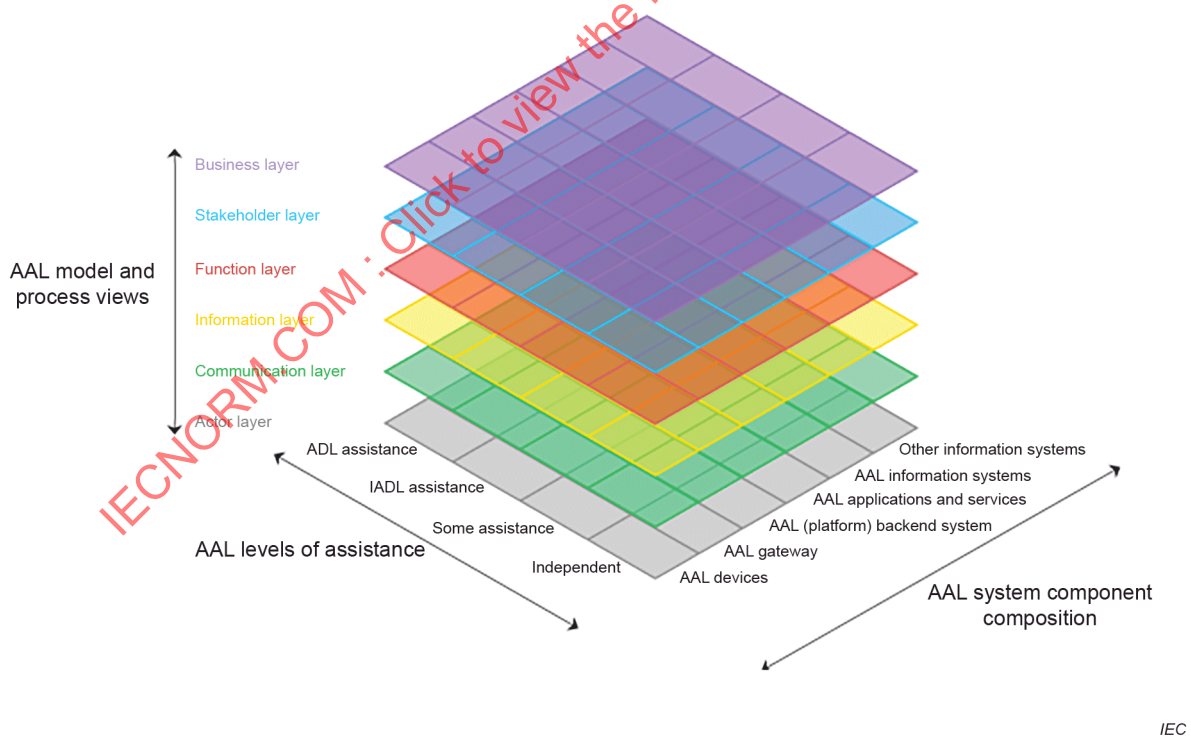

Figure 1 – AAL architecture model

6.2.2 X-axis: levels of assistance

6.2.2.1 Level 0: Independent

Level of assistance at which the AAL care recipient is not dependent on assistive technology (IEV 871-04-08)

NOTE 1 Assistive technology is used for comfort, wellbeing, wellness, fitness, entertainment or security.

6.2.2.2 Level 1: Some assistance

Level of assistance at which the AAL care recipient needs some assistance by assistive technology (IEV 871-04-08)

NOTE 1 Assistance can be needed at some points in time or continuously.

6.2.2.3 Level 2: IADL assistance

Level of assistance that involves physical/social/cognitive skills related to independent living in addition to ADL. This may include transportation, communication (i.e. use of telephone, emails), shopping, meal preparation, housekeeping, managing medications and managing personal finances.

6.2.2.4 Level 3: ADL assistance

Level of assistance which includes the most basic human activities like walking and moving around, going up a few steps of stairs, bathing (plus eating, clothing, continence, grooming).

6.2.3 Y-axis: AAL system component composition

6.2.3.1 AAL devices

See 3.1.5.

6.2.3.2 AAL gateway

See 3.1.6.

6.2.3.3 AAL (platform) backend system

See 3.1.7.

In the client-server model, the server is usually considered the backend.

Platform maybe a smartphone platform, a server platform or an IoT platform (IoT cloud service).

6.2.3.4 AAL applications and services

See 3.1.8.

6.2.3.5 AAL service

See 3.1.9.

6.2.3.6 AAL information system

See 3.1.10.

6.2.3.7 Other information system

See 3.1.11.

6.2.4 Z-axis: AAL model and process views

6.2.4.1 Actor layer (physical layer)

The actor layer describes all the actors and roles that interact, make decisions and exchange information with the AAL systems using the systems interface according to use case information. A different set of actors performing different tasks (e.g. visualization, data collection, data management) can be grouped in accordance with the AAL level of assistance and their roles and access to the system. The interaction will occur through the system interface (user interface). See Figure 2.

Hence, the actor layer in the use case documents can be used as the start point for the use case analysis and creation of the description of the other layers of the system such as functional, information, and communication layers.

This layer represents only the actors that have a direct benefit or use of the AAL systems. Indirect actors, such as system administrators, will be represented only at the stakeholder layer.

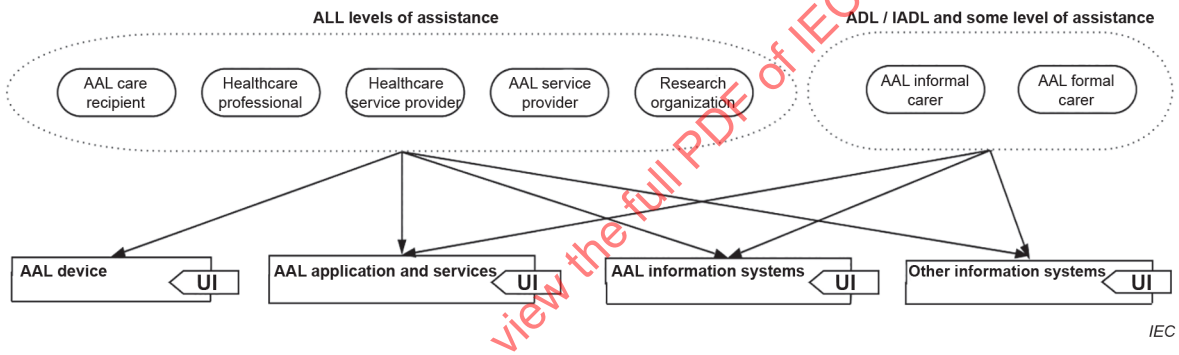

Figure 2 – Actor layer (physical layer) and the corresponding interfaces

6.2.4.2 Communication layer

The communication layer is responsible for how the data is transmitted from the device physical layer (source) over network communications to the physical layer of the receiving (destination). The layer describes which protocols are used to transfer data between different networks existing in the AAL ecosystem. See Figure 3.

This means that at this point it is necessary to determine what kind of communication is supported by the AAL devices and what capabilities are necessary for the AAL gateways to enable information to be available (or used, or shared, etc.) for the AAL devices, or AAL application and services, or AAL information systems, depending on the purpose of the AAL systems or services.

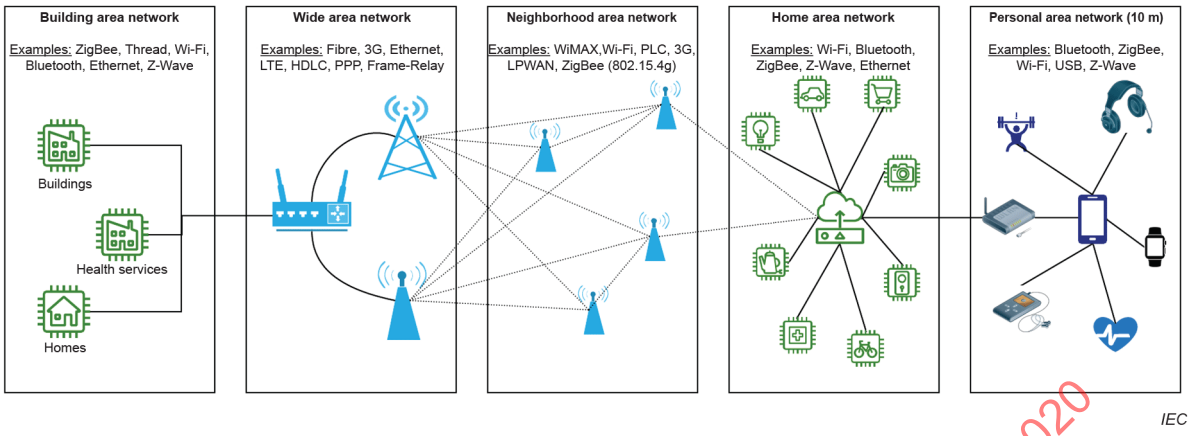

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Figure 3 – Communication layer with possible data transmission technologies

6.2.4.3 Information layer (data model layer)

This layer contains the data models that are going to be used in an AAL system or service. The data models that express the business point of view in terms of definition and format of the data and services. That is, it defines the structure of the domain, and how the information will be exchanged (or used, or shared, etc.) by the AAL devices, or AAL application and services, or AAL information systems, depending on the purpose of the AAL systems or services. Essentially, the data models can be used to describe three main aspects of the system: 1) the conceptual data model, 2) the logical data model, and 3) the physical data model. This layer can also contain the governance model representing the policies, standards and access control. See Figure 4.

This model can be represented in several ways and with several tools, such as an ontology, or a UML class diagram or conceptual diagram, an entity-relationship model, and so on.

The data can be transmitted using different types of protocols focused on what is transferred, and the format used to exchange the information using the networks described in the communication layer. Some examples of the protocols used are Health Level-7 (HL7), Fast Healthcare Interoperability Resources (FHIR), Extensible Markup Language (XML), among others.

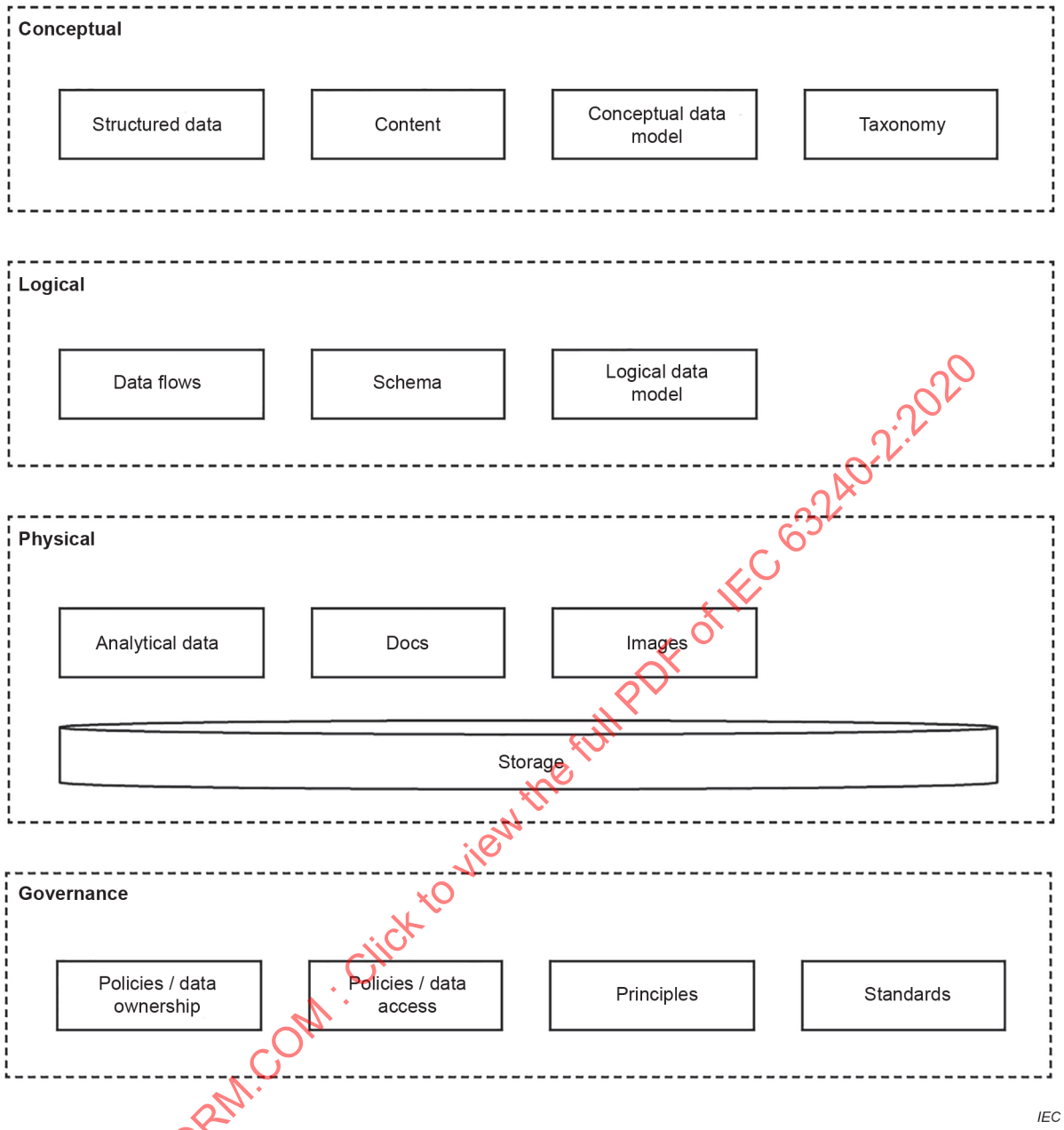

Figure 4 – Information layer (data model layer) describes the main aspects of the system

6.2.4.4 Function layer (functional layer)

On the functional layer of an AAL system or service are described the way the services are going to execute the necessary functions to concretize the stakeholders and actors needs for the business, by means of the specification of the functional data flows. Considering the current reference architecture model, these data flows are going to describe the necessary elements of the AAL system to obtain the data from AAL devices and AAL gateways until they are made available to the AAL platform, or AAL application and services, or AAL information systems, depending on the purpose of the AAL systems or services. See Figure 5.

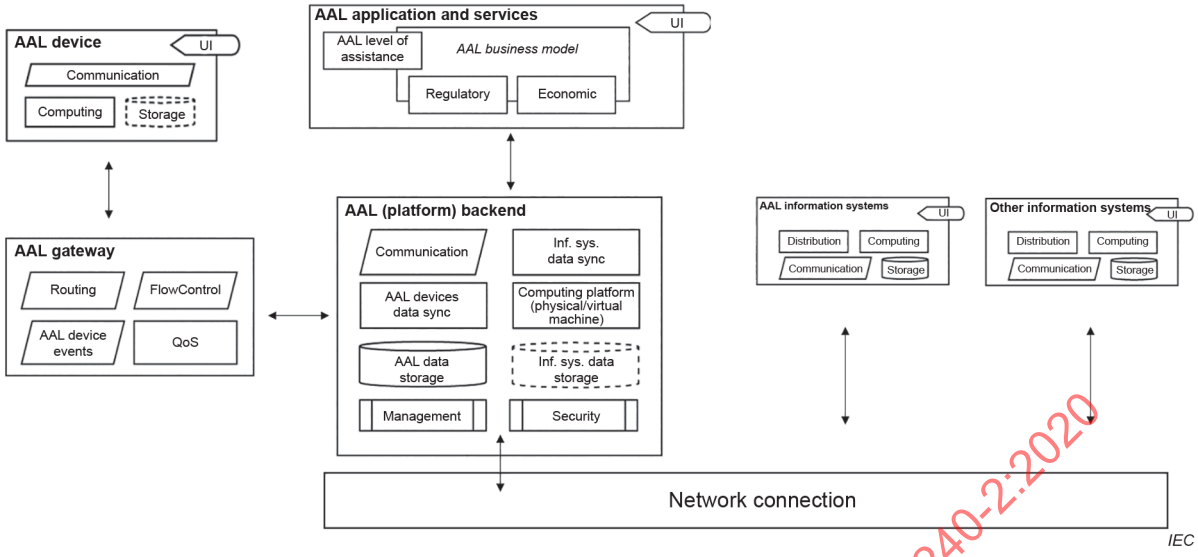

Figure 5 – Illustration of the function layer (functional layer)

6.2.4.5 Stakeholder layer

The stakeholder layer represents all roles that are involved in the AAL ecosystem or have a vested interest in its success or failure. The stakeholders can be divided according to their involvement in the final solution as external, connected and internal. See Figure 6.

- Internal - stakeholders who interact directly with the solution and have a direct benefit or action over the solution.
- Connected - other stakeholders within the ecosystem who might not interact directly with the solution, who benefit from it but generally host or control the project solution. They are directly involved in the success of the solution. They have an economic relationship: they can lose something with the failure of the project.
- External - represents the wider environment in which the solution operates. Populated with stakeholders who are outside of the ecosystem but who are still important and indirectly associated with the project. They are not functional beneficiaries.