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Edition 2.0 2024-11

INTERNATIONAL STANDARD

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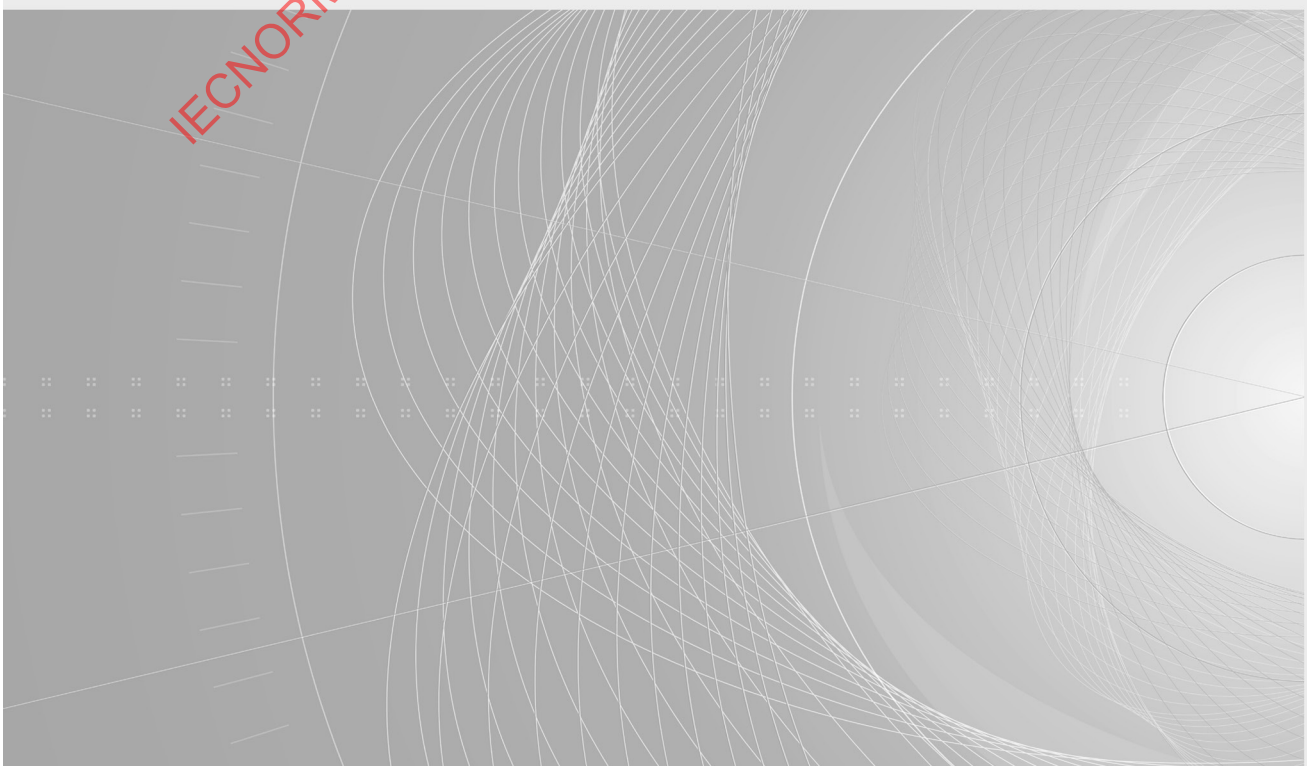
Active assisted living (AAL) reference architecture and architecture model – Part 1: Reference architecture



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

Part 1: Reference architecture

FOREWORD

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IEC 63240-1 has been prepared by IEC systems committee AAL: Active Assisted Living. It is an International Standard.

This second edition cancels and replaces the first edition published in 2020. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) clarifying the Introduction;
b) new terms and definitions have been added in 3.1;
c) adaption of terms according to the IEV in the whole document;

d) reference to ethical considerations of AI when applied in the AAL context has been added in Clause 5;

e) clarifying the description of AAL reference architecture in 6.3.1;

f) process to identify the needs on BAN, edge and cloud computing in the architecture perspective has been added in 6.3.2 and 6.3.3;

g) new figures have been added in 6.3.2 and 6.3.3;

h) reference to standards inventory has been added in 7.1;

i) clarification of 7.5;

j) Annex A has been added;

k) updated bibliography.

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

Draft	Report on voting
SyCAAL/322/CDV	SyCAAL/362A/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

IEC Systems Committee for Active Assisted Living (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.

The first edition of IEC 63240-1 was published in 2020. Since the publication of IEC 63240-1:2020, IEC SyC AAL has been collecting issues from a variety of sources including comments from IEC National Committees. At the September 2021 online meeting of IEC SyC AAL, it was decided to set up a process to identify the needs of body area network (BAN), edge and cloud computing in the architecture perspective. These items are considered in this document.

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 device 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 systems and the related regulations.

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

Part 1: Reference architecture

1 Scope

This document specifies the AAL reference architecture.

This document defines concepts and introduces terminology. It provides generic rules for designers of AAL systems and services with the aim to facilitate systems design and enable interoperability between components.

This document identifies safety, security, privacy, and other requirements for AAL systems such as usability, accessibility, and trustworthiness (reliability, resilience) and sets up a process to identify the needs on the body area network (BAN), edge and cloud computing in the architecture perspective.

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 terminology databases for use in standardization at the following addresses:

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

3.1.1
AAL device
device (IEV 151-11-20) used in an AAL system

EXAMPLE Examples are sensors and actuators that contain one or more components (functionality).

Note 1 to entry: External conditions and events include measurements of temperature, motion, and electrical conditions.

Note 2 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, wellbeing, personal comfort, and personal security and 3) devices that can serve as aggregators of personal data produced by the user of the device.

[SOURCE: IEC 60050-871:2023, 871-07-01]

3.1.2
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, 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.]

3.1.3
AAL platform backend system
AAL backend system
system that houses a number of components (and 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 the AAL gateways or AAL devices (e.g. firmware update) and components for interfacing with AAL information systems or other- information systems

[SOURCE: IEC 60050-871:2023, 871-07-04]

3.1.4
AAL application
AAL application and services
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, 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" and the note to entry has been omitted.]

3.1.5
AAL user
active assisted living user
person who uses or benefits from, or uses and benefits from, AAL devices, systems or services

[SOURCE: IEC 60050-871:2018, 871-02-05]

3.1.6
AAL service
active assisted living service
action or function of an AAL system creating an added value for customers

EXAMPLE An AAL service could comprise, for example

– configuration and maintenance of AAL systems,
– assistant systems to support the home environment.

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

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

3.1.7
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.

[SOURCE: IEC 60050-871:2023, 871-07-02]

3.1.8
consumer electronics, pl
CE
electronic devices designed to be purchased and used by end users or consumers for daily and non-commercial/non-professional purposes

Note 1 to entry: Consumer electronics are among the most commonly used form of electronic computing and communication devices.

3.1.9
information and communication technology
ICT
technology that comprises all devices, networking components, applications and systems that combined allow people and organizations to interact in the digital world

3.1.10
network connection
connection that comprises both local and wide area networks

EXAMPLE Network connection can comprise, for example LAN or internet.

3.1.11
interface
boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate

Note 1 to entry: This concept includes the specification of the connection of two devices having different functions.

[SOURCE: IEC 60050-871:2018, 871-04-18]

3.1.12
other-information system
<in AAL> collection of technical and human resources that provide the storage, computing, distribution, and communication for the information not specific to AAL services (IEV 871-01-04)

Note 1 to entry: An other-information system can include in part a health information system (HIS), of which examples include:

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

Note 2 to entry: It is possible that AAL care recipients' data need be shared with these 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 need be shared with the primary care physician's EMRs.

[SOURCE: IEC 60050-871:2023, 871-05-12]

3.1.13
edge computing
distributed computing (3.1.14) in which processing and storage takes place at or near the edge (3.1.15) where the nearness is defined by the system's requirements

[SOURCE: ISO/IEC TR 23188:2020, 3.1.3]

3.1.14
distributed computing
model of computing in which a set of nodes (3.1.16) coordinates its activities by means of digital messages passed between the nodes (3.1.16)

[SOURCE: ISO/IEC TR 23188:2020, 3.1.1]

3.1.15
edge
boundary between pertinent digital and physical entities, delineated by networked sensors and actuators

Note 1 to entry: Pertinent digital entities means that the digital entities which need to be considered can vary depending on the system under consideration and the context in which those entities are used.

[SOURCE: ISO/IEC TR 23188:2020, 3.1.2]

3.1.16
node
networked machine with processing and storage capabilities

[SOURCE: ISO/IEC TR 23188:2020, 3.1.5]

3.1.17
cloud service
one or more capabilities offered via cloud computing invoked using a defined interface

[SOURCE: IEC 60050-741:2020, 741-01-08]

3.1.18
cloud computing
paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand

[SOURCE: IEC 60050-741:2020, 741-01-07]

3.1.19
AAL home platform
IT platform offering AAL services, which is integrated in an existing home environment infrastructure

[SOURCE: IEC 60050-871:2018, 871-05-01]

3.1.20
home environment
environment within a home, including the totality of appliances [e.g. household technology, home network, furnishings]

[SOURCE: IEC 60050-871:2018, 871-03-02]

3.1.21
IT platform
hardware and software system in which application software is executed

EXAMPLE A combination of an operating system and hardware on which software is executed, a certain type of computer or computers of a certain architecture.

Note 1 to entry: In the AAL context an AAL IT platform is the interaction between hardware and software components used by an AAL application.

[SOURCE: IEC 60050-871:2018, 871-05-07]

3.1.22
home service
service which is offered in home environments

3.1.23
home and neighbourhood service
service which is offered in home environments and neighbourhood environments

3.1.24
AAL cloud application and service
AAL software application and service offered via cloud computing

3.1.25
AAL edge application and service
AAL software application and service offered via edge computing

3.1.26
AAL cloud platform
IT platform offering AAL services, offered via cloud computing

3.1.27
AAL edge platform
IT platform offering AAL services, offered via edge computing

3.1.28
device
material element or assembly of such elements intended to perform a required function

Note 1 to entry: A device may form part of a larger device.

[SOURCE: IEC 60050-151:2001, 151-11-20]

3.1.29
gateway
functional unit that connects two computer networks with different network architectures and protocols

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.

[SOURCE: IEC 60050-732:2010, 732-01-17]

3.1.30
personal health record
PHR
representation of information regarding or relevant to the health, including wellness, development, and welfare of a subject of care, which may be stand-alone or integrating health information from multiple sources, and for which the individual, or their authorized representative, manages and controls the PHR content and grants permissions for access by and/or sharing with other parties

[SOURCE: ISO/TR 14639-2:2014, 2.60]

3.1.31
electronic health record
EHR
repository of information regarding the health status of a person, in computer processable form, stored and transmitted securely, and accessible by multiple authorized users

Note 1 to entry: An electronic health record has a standardized or commonly agreed logical information model which is independent of electronic health record systems. Its primary purpose is the support of continuing, efficient and quality integrated healthcare.

Note 2 to entry: An electronic health record contains information which is retrospective, concurrent, and prospective.

[SOURCE: IEC 60050-871:2018, 871-06-01]

3.2 Abbreviated terms

AAL	active assisted living
ADL	activities of daily living
AI	artificial intelligence
BAN	body area network
IADL	instrumental activities of daily living
IoT	Internet of Things

4 General

AAL (active assisted living) was lacking an International Standard on a reference architecture to serve as a concept of the domain. The objective of this document is to give an overview for implementing concrete architectures for different families of AAL applications. The reference architecture defines design and implementation of, for example, communication and data flow between AAL components and how the architecture should be constructed.

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, where IoT is understood as being the possibility of connecting 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. 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.

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 key AAL requirements are safety, security, privacy, technical assistance, and additional requirements (e.g., resilience and reliability of the system).

Also, ethical considerations of AI when applied in the AAL context are required especially because of the human-centric approach (see IEC SRD 63416:2023).

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 needs of the user. AAL users can benefit from "smart", connected services in which AAL services are combined with services of other domains.

AAL systems are designed to assist people who need AAL services.

6 AAL reference architecture

6.1 Purpose of AAL reference architecture

The reference architecture defines concepts and introduces terminology on an abstract level. The reference architecture provides generic rules for designers of AAL systems and services with the aim to facilitate systems design and enable interoperability between components. The AAL reference architecture enables secure and interoperable AAL services (all AAL services, including end-to-end services) by describing the generic architecture. The purpose of the reference architecture is to develop a framework that provides an overall view on components and how they relate to each other, which enables users to fit use cases for AAL within the framework. Components can be actors, devices, and other building blocks. Thus, it describes connections between technical entities and associations of people to the technical entities.

The reference architecture is specific to AAL; however, it is not limited to current technological solutions and use scenarios.

6.2 Users of AAL reference architecture

Potential users of the AAL reference architecture are designers and developers of AAL systems and services, as well as manufacturers, procurers and all other stakeholders that are interested in an abstract framework that allows them to map their use cases.

Users should use the reference architecture during the development of use cases, AAL services, systems, or components, and to better understand how different components can be interconnected.

Users can develop guidelines for secure interoperability based on the reference architecture.

6.3 Description of AAL reference architecture

6.3.1 Description of conceptual AAL reference architecture

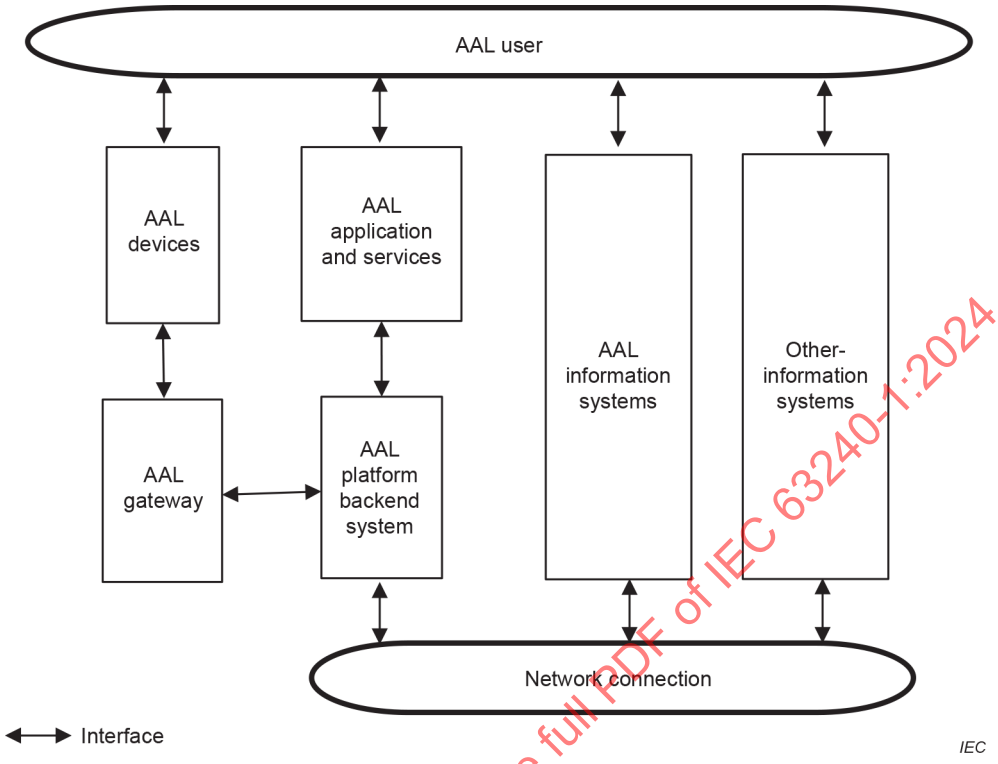

Figure 1 – Conceptual AAL reference architecture

Figure 1 depicts the AAL reference architecture on a conceptual level. There can be a user interface in every building block. It shows the flow of information from one building block to the next over defined interfaces of the reference architecture.

The AAL reference architecture consists of several building blocks. Building blocks are entities which are on their own or in combination with other entities capable of delivering AAL services. Building blocks are connected to each other by interfaces.

The four building blocks on the left hand-side of Figure 1, i.e., "AAL devices", "AAL gateway", "AAL platform backend system" and "AAL application and services", are intended for local AAL services. The other two building blocks on the right hand-side of Figure 1, i.e., "AAL information systems" and "other-information systems" are intended for remote services.

Therefore, AAL application and services (or AAL applications) refer to local services whereas AAL information systems are more of a cloud driven remote service.

"Network connection" connects the local services and remote services via a network. "Network connection" can be the Internet connection or connection via telephone. In some cases, it can be the intranet connection within a private network service.

See Annex A for examples referring to the conceptual level of AAL reference architecture.

6.3.2 Cloud and edge computing

In the future, solutions must be able to work even more closely together in order to reuse solutions that have already been purchased and installed and to combine data for completely new applications. This requires open platforms that can react dynamically to changes. In order to be able to dynamically add, update or exchange third-party offerings, whether hardware or software, as cost-effectively as possible, it is recommended that solutions be implemented on open semantic platforms (such as AAL backend systems). For this purpose, architectures should be set up in such a way that they can be implemented either without cloud services, or be combined with cloud services, or be purely implemented on the cloud side. As shown in Figure 2, AAL applications can be implemented on open platforms either in the home environment (3.1.20 / IEV 871-03-02) and/or using cloud services (3.1.17 / IEV 741-01-08). The latter implementation is known as cloud computing (3.1.18 / IEV 741-01-07). Edge computing (3.1.13) can be important in AAL applications where remote management of data and/or control is inadequate, for example, in terms of response time, privacy, security, and safety.

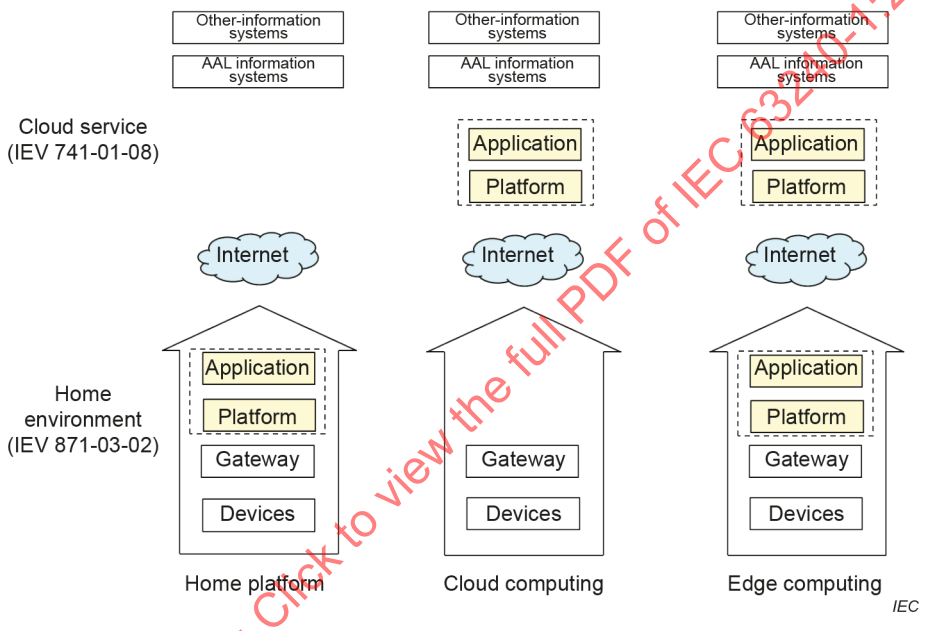

Figure 2 – Cloud and edge computing (conceptual)

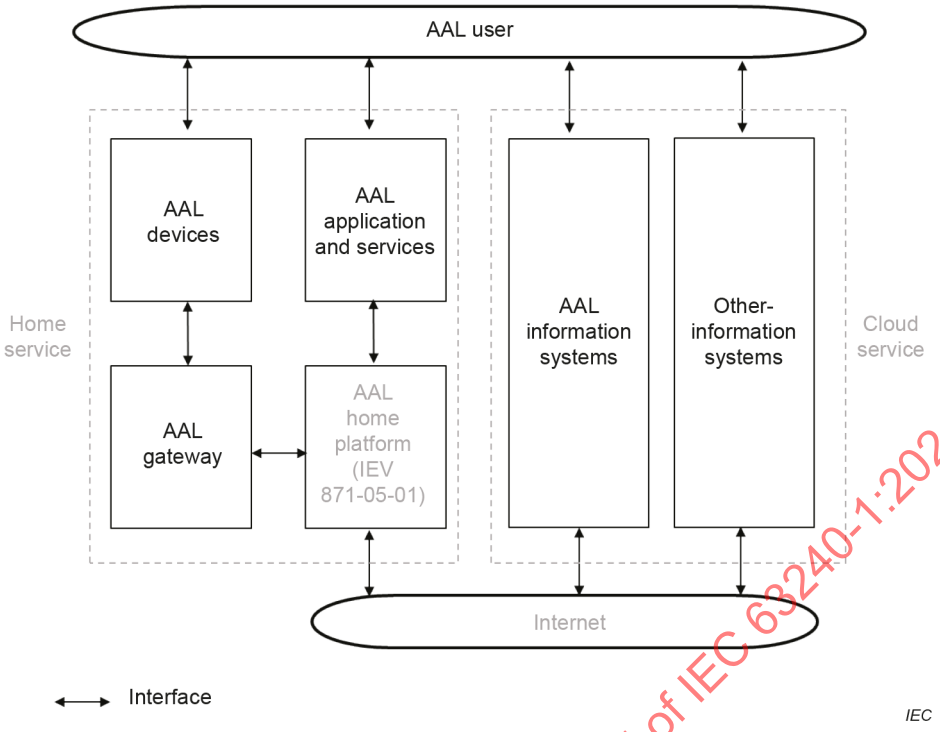

Figure 3 – AAL reference architecture: Home computing

Figure 3 depicts the AAL reference architecture for home computing. In this case, AAL home platform (3.1.19 / IEV 871-05-01) is the AAL platform backend system shown in Figure 1.

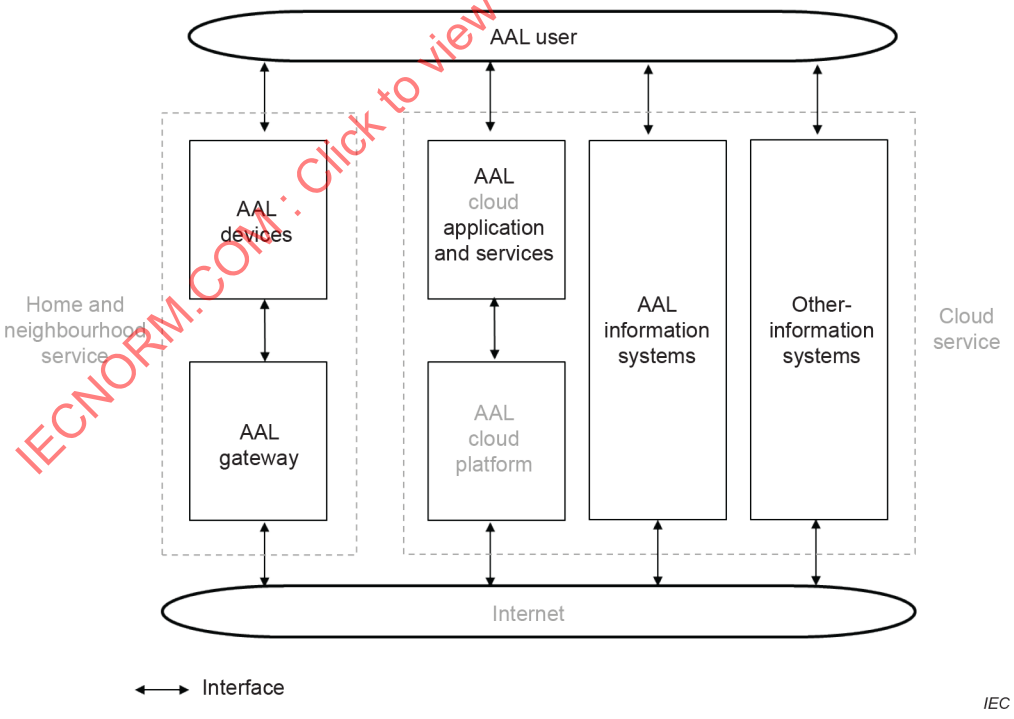

Figure 4 – AAL reference architecture: Cloud computing

Figure 4 depicts the AAL reference architecture for cloud computing. In this case, the AAL cloud platform (3.1.26) is the AAL platform backend shown in Figure 1 and implemented in the cloud service. AAL cloud application and services (3.1.24) are the AAL application and services shown in Figure 1 and implemented on the AAL cloud platform in cloud service. The AAL gateway is directly connected to the internet. In this cloud computing reference architecture, AAL devices and AAL gateway are not necessarily implemented only in a home environment (3.1.20) but can be part of a home and neighbourhood service (3.1.23).

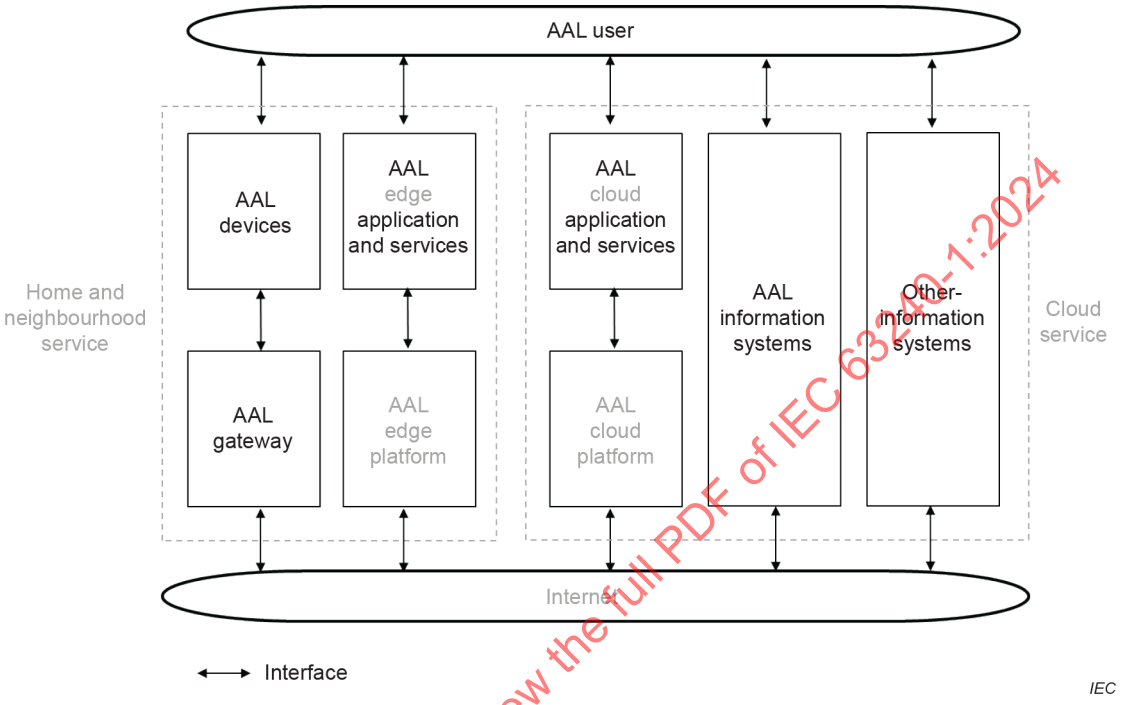

Figure 5 – AAL reference architecture: Edge computing

Figure 5 depicts the AAL reference architecture for edge computing. In this case, an AAL edge platform (3.1.27) is used as the AAL platform backend system in the home and neighbourhood service. AAL edge application and services (3.1.25) are implemented on the AAL edge platform and used as the AAL application and services defined in Figure 1 in the home and neighbourhood services. In the edge computing (3.1.13) architecture, AAL edge application and services coordinate their activities with AAL cloud application and services.

As shown in Figure 6, it shall be possible to connect AAL devices, including sensors and actuators, via different protocols so that products from different manufacturers can be integrated via an AAL gateway (including controller function, e.g., for protocol conversion).

In solutions that are implemented together both on the client and server sides, the data is mirrored via a server-side AAL gateway and can thus be evaluated on both sides, and services can also be implemented on both sides. On both the server and client side, it should be possible to connect several platforms with each other in order to implement cross-domain solutions (see Figure 6).

In addition, the architecture should enable scaling from the connected home to other buildings, and to the neighbourhood. Between the boundaries of these different domains, at the gateway and at all cloud connections, requirements particularly for a high level of security, for privacy protection, and for IT security shall be implemented (see Figure 7). See Clause 7 for security requirements in the context of AAL as well as further standards and national and international regulations in the context of security requirements (see also the "standards inventory mapping", a work in progress https://mapping.iec.ch/#/maps/97).

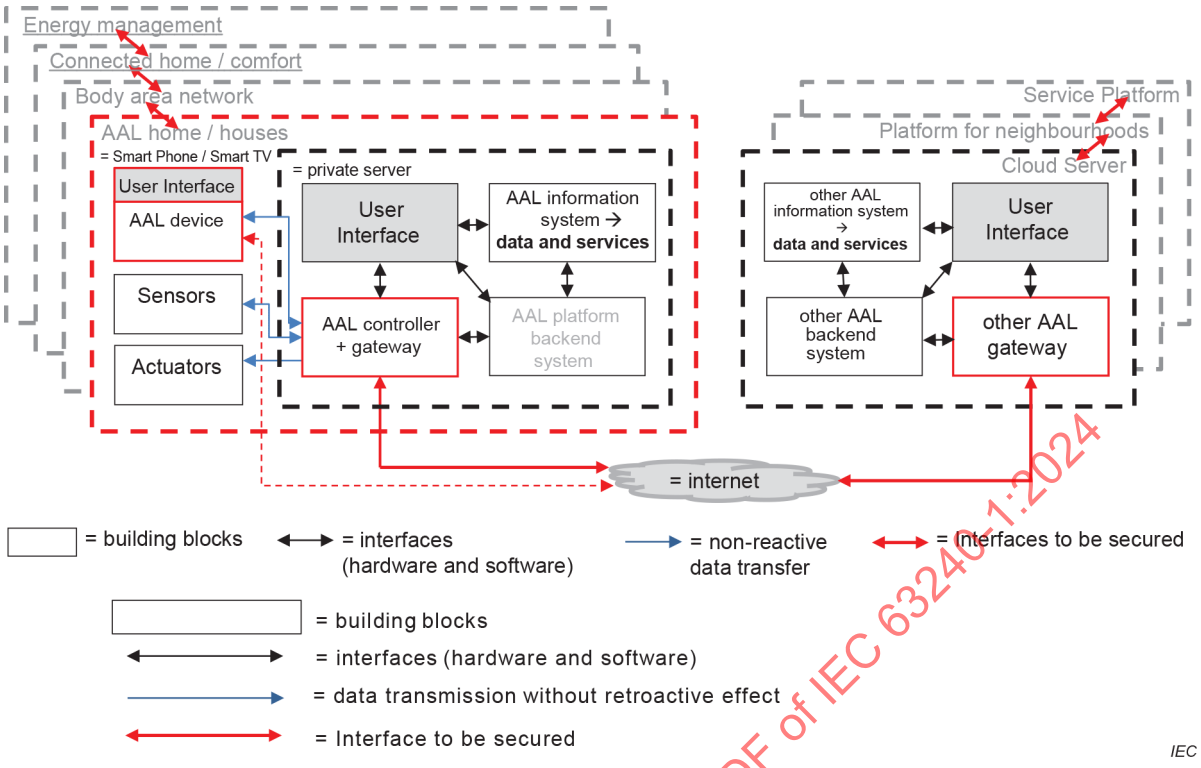

Figure 6 – Cross-domain solution

Software architectures should be built in such a way that they allow data to be merged across system boundaries in order to enable remote monitoring and interoperability. As societal needs change, it is possible that remote monitoring and interoperability will be required due to the necessity for social distancing caused by a pandemic or similar situation. Software architectures should also link with other domains such as transport, energy and water supply to ensure optimal reusability, extensibility and interoperability (see Figure 7).

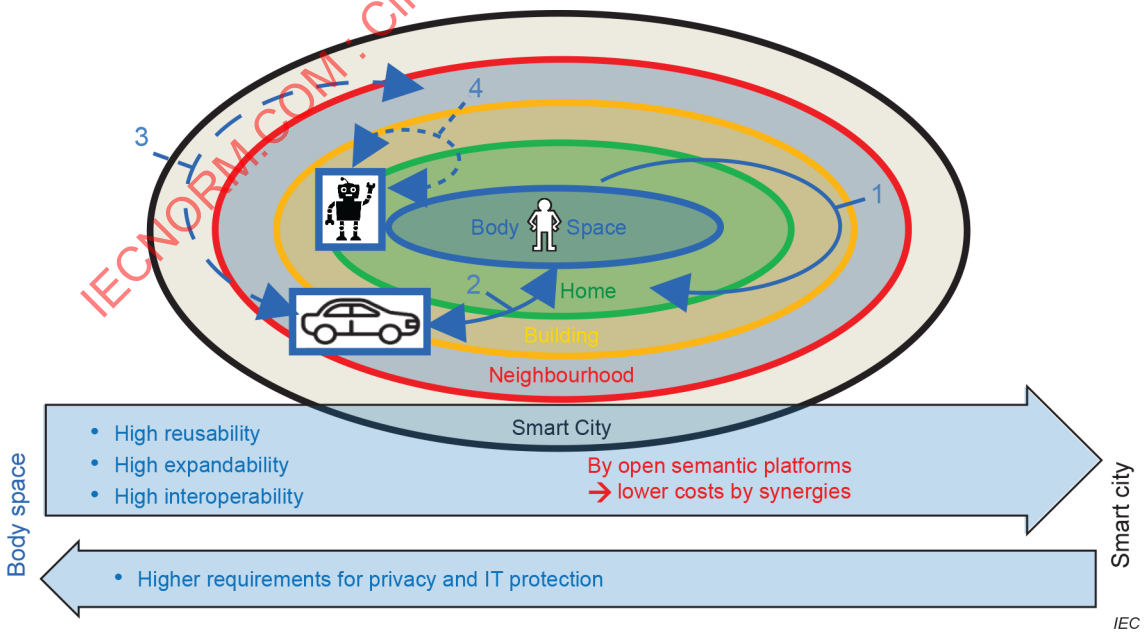

Figure 7 – Scalability and potential for savings

In the configuration shown in Figure 7, the user is considered to embody the body space. The body space (user) is mobile and can move within the home (see Figure 7) or outside home (see number 1 in Figure 7). The user can also go to another mobile space such as their car or public transport (see number 2 in Figure 7) and be on the move in other spaces (see number 3 in Figure 7). Here, too, there is a sharp distinction between the spaces due to privacy and IT protection. In this sense, a robot is also a mobile space that shall be able to communicate with the sensors and actuators of other spaces, such as the building or individual apartments (see number 4 in Figure 7), but also with the users. Otherwise, data across domain boundaries cannot be delimited in a secure way.

6.3.3 Body area network (BAN)

A body area network (BAN), also referred to as a wireless body area network (WBAN), a body sensor network (BSN) or a medical body area network (MBAN), is a wireless network of wearable computing devices. BAN devices can be embedded inside the body as implants, they can be attached to the body in a fixed position, or they can be devices carried in different positions, such as in clothes pockets, by hand, or in various bags.

While there is a trend towards the miniaturization of devices, body area networks consist of several miniaturized body sensor units (BSUs) called sensor nodes together with a single body central unit (BCU) called a hub. Larger decimetre (tab and pad) sized smart devices still play an important role in terms of acting as a data coordinator or data gateway and providing a user interface to view and manage BAN applications, in-situ.

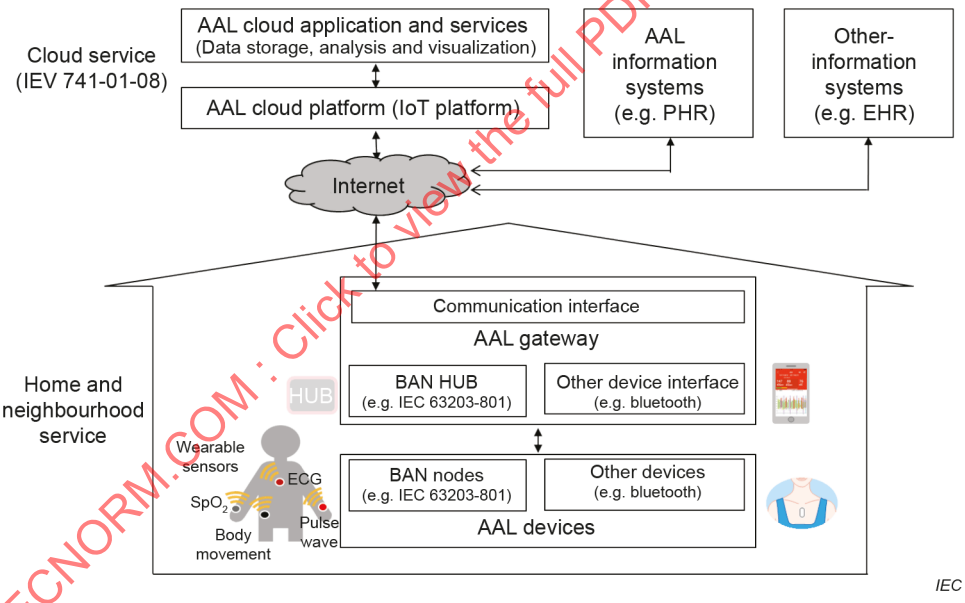

Figure 8 – Example of a BAN system (cloud computing at home)

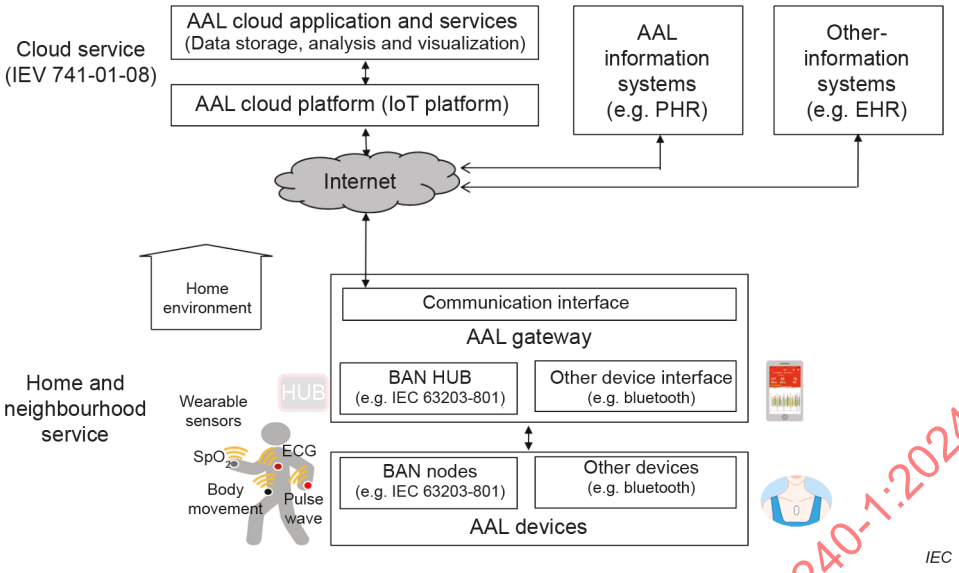

Figure 9 – Example of a BAN system (cloud computing outside the home environment, e.g., in the neighbourhood)

Figure 8 and Figure 9 depict examples of BAN systems in the cloud computing environment. The BAN can be operated both in the home environment (see Figure 8) and outside the home environment. As shown in Figure 9, it is possible to leave the home environment.

7 Security requirements in the context of AAL

7.1 General

Security and cybersecurity threats affect organizations, products, and services. Security measures now focus on response time from the time of the attack rather than on the risk of an attack. This need for a proactive response strategy is not likely to change in the foreseeable future. The traditional security defence strategy to layer one point-product tool over another has had to be rethought.

The development of intelligent immune systems in which enterprise security solutions work together to prevent and repair the damage cyberattacks can impose on an individual or on an organization is essential. The essence of this comprehensive approach to security shall be captured in the IEC SyC AAL standards inventory (see also "standards inventory mapping", work still in progress, available at https://mapping.iec.ch/#/maps/97). The IEC SyC AAL standards inventory can also be found in tabular form in the supporting documents section of the IEC SyC AAL home page:
https://www.iec.ch/dyn/www/f?p=103:252:114389371635500::::FSP_ORG_ID,FSP_LANG_ID:11827,25.

Figure 10 shows the security process within the context of AAL standards.