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The Use Case and Smart Grid Architecture Model Approach

The IEC 62559-2 Use Case Template and the SGAM Applied in Various Domains

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If I have seen further it is only by standing on the shoulders of giants.

Sir Isaac Newton

Foreword

Recently, the development of systems and components has become more complex because systems from various domains are no longer kind of monolithic, but are more and more connected to other local ones or systems via internet-based communication. This leads to the fact that more and more interfaces between systems from different vendors arise. This raises the overall complexity of system integration from the requirements engineering point of view. The trend can be observed not only in domains like Smart Home, Smart Grid and Active Assisted Living, but also in industrial settings like factory automation. The development of system interfaces and the agreement on proper interoperability becomes more and more a cost driver in the development phase. With the upcoming convergence of various domains in the very scope of, e.g., the connection between Smart Home and Smart Grid, also different technical specifications and standards have to integrate in the system-of-systems environment. Individual domains have created individual data models, interfaces and pre-defined services based on common technologies like IP-based communications. But one particular challenge is to agree in a common way on the needed syntax and semantic of the data exchanged as well as the non-functional requirements, like timing, bandwidth or security. The design phase requirements process shall cover aspects, like technical standards and best practices on existing solutions.

Within the EU M/490 mandate, the German DKE has taken the initiative to bring forward a structured way of constructing and establishing sustainable processes for standardisation. One focus was to find a way of structuring requirements towards future standards in the scope of Smart Grids in an appropriate manner in order to facilitate the process for the heterogeneous stakeholders in the mandate. As one fundamental basis, the IntelliGrid Methodology for Developing Requirements for Energy Systems IEC/PAS 62559 was chosen as the methodological framework to create a process, a template and a repository to manage user requirements in the form of use cases from the various stakeholders in the mandate. Based on this work in the first phase of the mandate, a proper way to identify, in a holistic way, the requirements for future standards based on existing gaps for Smart Grids was created. Over the course of the two phases of the mandate, the use case methodology and the corresponding Smart Grid Architecture Model (SGAM) from the reference architecture group of the mandate has proven to be best practices for a structured requirements engineering process as well as initial architecture drafting in the Smart Grid domain. As various FP7, H2020 and national projects gained experience and provided feedback, it became apparent that the use case methodology can also be of benefit in other domains. Within the IEC TC 8 at first, later at the IEC SyC groups, the use case template, its serialisation as well as the envisioned use cases have been standardised for system-of-systems in various domains.

Within this contribution, the authors outline the need for this structured approach, provide first feedback from projects, how it can be applied, and provide the needed basic knowledge to apply the process in the context of projects. It is a very timely contribution for upcoming projects which are looking to apply this emerging standard in their daily operations.

Frankfurt
August 2016

Jessica Fritz
German DKE
Project manager Industry 4.0

Preface

The standardisation for complex systems and their interfaces has become more and more important in the last years; particularly due to the rapid development in the information and communication technologies. This development influences several domains in society and industry, like the Active Assisted Living (AAL), Smart Home/Building, Smart Grid, Smart City, Industrie 4.0 as well as the maritime sector. For this purpose, a standardised and holistic approach of requirements engineering for Smart Grid projects based on work conducted within the M/490 standardisation mandate from the European Commission has been developed. Over the last few years, this method has been established rapidly in Europe as the basic building block in the very scope of requirements engineering in the utilities sector with a focus on the operational technology. Based on the outcomes of the energy sector, this approach developed through the support of OFFIS – Institute for Information Technology has been standardised as the IEC 62559 series which describes a use case methodology for the requirements engineering of complex systems.

The authors present a canonical, structured way for users to apply these methods from international standardisation alongside a use case management repository and a three-dimensional visualisation for (Smart Grid) architecture models, which are provided as open software tools. The implementation of these tools has been done in the German project UC4AAL funded by the German Federal Ministry for Economic Affairs and Energy under grant agreement No. 01FS13028, and the European project DISCERN – Distributed Intelligence for Cost-effective and Reliable Solutions funded by the European Union Seventh Framework Programme under grant agreement No. 308913.

This book provides an introduction to the very fundamentals of the IEC 62559 Use Case Methodology, how it is related to the Smart Grid Architecture Model (SGAM), and how a holistic view for both, requirements engineering and architecture, can be achieved. In addition, the application in various domains outside the Smart Grid is motivated as the method can be applied to critical infrastructures or cyber-physical systems (CPS), respective system-of-systems (SoS) like AAL and Industrie 4.0 domains as well.

The authors hope that this book is useful as introduction in the overall Use Case Methodology and the application of architecture models for reference designation as well as a Use Case Management Repository in many prospective projects.

Oldenburg
August 2016

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Acknowledgements

The methods presented in this book from the *SpringerBriefs* series are a brief summary of work by various stakeholders over the course of several years. The original need of this approach dates back to the EPRI IntelliGrid program, since 2015 called the Information and Communication Technology Program. The first work dates probably back as long as 2004 with the documentation of hundreds of use cases over the years and the issue has come into daily practice with the complexity arising from the so-called Smart Grid projects. Thanks to this, the template has been recognised as a potential contributor to lower the complexity of integration costs and requirements elicitation. Standing on the shoulder of giants, the authors therefore would like to thank the original EPRI team and its subcontractors for bringing up a meaningful way to structure use cases in the domain. In addition, we would like to thank various collaborators on the EU M/490 mandate, mainly Johannes Stein from German DKE to bring up the topic of having sustainable processes and tools in standardisation to the SG-CG group, the IEC TC 8 and, later, IEC SyC Smart Energy to keep on working on the specifications and making the PAS into a standard. Various persons have to be named in this context, mainly the following in no particular order: Ralph Sporer, Rolf Apel, Jörn Trefke, Rafael Santodomingo Berry, Cyrill Effantin, Eric Lambert, Arnaud Ulian, Jessica Fritz, Andre Göring and many more. In addition, the authors would like to thank their partners from the DISCERN, UC4AAL, IES Austria and ELECTRA projects for providing valuable feedback on the use of the overall tool-chain. We hope that the content presented in this book helps to facilitate the use of the methodology presented and spread its use around the community.

Contents

Acronyms

AAL	Active Assisted Living
AALAM	Active Assisted Living Architecture Model
BAN	Building Area Network
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CG	Coordination Group
CIM	Common Information Model
CPS	Cyber-Physical System
DER	Distributed Energy Resources
DIN	German Institute for Standardization
DKE	German Commission for Electrical, Electronic, and Information Technology
DMS	Distribution Management System
DOCX	Word XML Document
DoD	Department of Defense
DSO	Distribution System Operator
EAM	Enterprise Architecture Management
EC	European Commission
EDIFACT	Electronic Data Interchange for Administration, Commerce and Transport
EMAM	Electric Mobility Architecture Model
EMS	Energy Management System
EN	European Standards
EPRI	Electric Power Research Institute
ETP	European Technology Platform
ETSI	European Telecommunications Standards
EU	European Union
EV	Electric Vehicle
FH	Applied Technological University
GWAC	GridWise Architectural Council

HA	Home Automation
HEMS	Home Energy Management System
HMI	Human Machine Interface
HTML	HyperText Mark-up Language
ICT	Information and Communication Technology
ID	Identifier
IDE	Integrated Development Environment
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IES	Integrating the Energy System
IHE	Integrating the Healthcare Enterprise
IIRA	Industrial Internet Reference Architecture
IMO	International Maritime Organization
INCOSE	International Council on Systems Engineering
IP	Internet Protocol
IREP	International Requirements Engineering Board
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
KNX	Connection for HA applications
KPI	Key Performance Indicator
kW	Kilowatt
M/490	Mandate 490
MAF	Maritime Architecture Framework
MHz	Megahertz
NIST	National Institute of Standards and Technology
NMEA	National Marine Electronics Association
OFFIS	Institute for Information Technology
OMG	Object Management Group
OSI	Open System Interconnection
PAS	Publicly Available Specification
PCC	Point-of-Common Coupling
PDF	Portable Document Format
PLC	Power Line Communication
RA	Reference Architecture
RAMI	Reference Architecture Model for Industry 4.0
RASSA	Reference Architecture for Secure Smart Grids in Austria
SCADA	Supervisory Control and Data Acquisition
SCIAM	Smart City Infrastructure Architecture Model
SG	Strategy Group
SGAM	Smart Grid Architecture Model
SG-CG	Smart Grid Coordination Group
SINTEG	Schaufenster intelligente Energie – Digitale Agenda für die Energiewende (in English “A German Digital Agenda for the Energy Revolution”)

SIP	Session Initiation Protocol
SME	Small and Medium-sized Enterprises
SoS	System-of-Systems
SSCC	Smart and Sustainable Cities and Communities
SyC	Systems Committee
TC	Technical Committee
TCP/IP	Transmission Control Protocol/Internet Protocol
TR	Technical Report
UC	Use Case
UCMR	Use Case Management Repository
UML	Unified Modelling Language
VTS	Vessel Traffic Service
WG	Working Group
XML	eXtensible Mark-up Language
XSD	XML Schema Definition
ZVEI	German Electrical and Electronic Manufacturers' Association

Chapter 1
Introduction to the Domains Smart Grid and Active Assisted Living

Abstract This chapter provides an overview on the definition of complex systems and their use in various domains. Its focus is on the domains Smart Grid and Active Assisted Living as well as on the motivation for the standardisation in such domains. In addition, an introduction for domain-specific modelling is given to demonstrate the support through the standardisation.

Keywords Architecture modelling · Requirements engineering · Use cases · Domain specific modelling · Stakeholder management

1.1 Motivation

The requirements engineering process and the architectural design for complex systems is one of the major challenges for the development of a Smart World in the near future as defined by most systems engineering experts [10]. A *Smart World* forces demographic, environmental, economic, political, and socio-cultural factors to be taken into account in order to make a step forward to an intelligent world with concepts like Smart Cities, Smart Grids, Active Assisted Living, Smart Home, and Industrie 4.0 alike [1]. For a Smart World, these systems have to interact and communicate with each other – ideally, cost-efficient, seamless, safe and secure. The communication between these systems and their components can be implemented e.g. with the TCP/IP protocol suite, i.e. the communication takes place via the Internet. This development is often coined the *Internet of Things* and describes a global infrastructure for the information society to enable interconnecting physical and virtual things based on existing and evolving information and communication technologies (ICT) [2, 8].

The diversity and heterogeneity of systems of a so-called Smart World makes it difficult to create a consistent requirements specification. The EU mandate M/490 for Smart Grids as a critical infrastructure to CEN, CENELEC and ETSI recognised this difficulty and developed a Use Case Methodology to support the requirements engineering process for complex systems as well as the standardisation [17]. In the first version based on the IntelliGrid work, the methodology has been adapted for Smart

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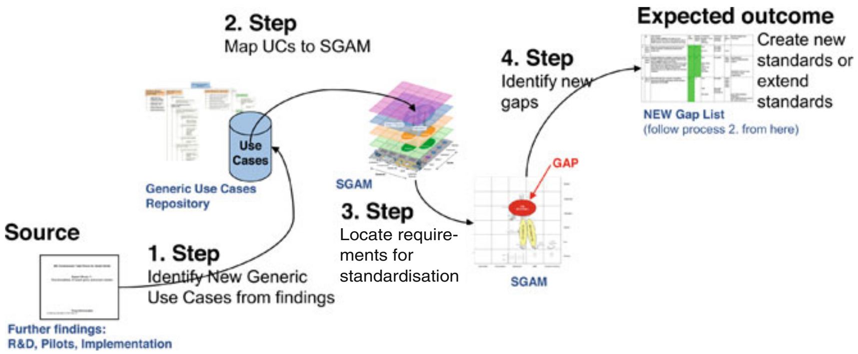

Fig. 1.1 Approach to find gaps in the existing standardisation landscape based on use case analysis (inspired by [22, 23])

Grids and, later on, extended and standardised by the International Electrotechnical Committee (IEC) for all kinds of complex systems [9]. The basic approach defined by the sustainable processes group in the mandate M/490 is depicted in Fig. 1.1 [4, 22, 23]. It describes a procedural process model to create and formalise solutions for the implementation of Smart Grid functionalities. The step after identifying new generic use cases (1. Step) is the development of an architecture model for the system-of-systems approach in order to visualise the use cases (2. Step) from various viewpoints. In the next process step, requirements are elicited and allocated (3. Step), that supports the identification of gaps in the system planning phase and general standardisation as well (4. Step). The standardisation organisations and their experts can only develop new standards when they know where to find gaps and which functionalities are required [23] and shall be supported by technical standards. New or refined standards are the results of this step. This approach (cf. Fig. 1.1) describes how to find gaps in the standardisation and starts the process for creating new standards or for extending existing standards based on the newly elicited requirements from the experts.

For supporting the approach defined in the EU mandate M/490, further methodologies and tools are defined [4]. The implementation of each step can be optimised by developing additional strategies, like e.g. a procedure to fill out a structured Use Case Template or an extension of the existing template with approaches from other domains, such as the IHE profiles from the health care sector (cf. Sect. 2.4). Additionally, the description of use cases and the visualisation in an architecture model can be tool-supported to prevent describing the same thing twice or executing similar transformations manually. Aim of this book is to give an overview on the existing procedures and tools for supporting this approach. The main focus lies on the creation of use cases and the mapping to the architecture model. The identification of gaps as well as the process to create new standards or extend standards are marginally considered.

Within this book, we provide a detailed introduction to the Use Case Methodology by the IEC 62559 in Chap. 2 and the application of the Smart Grid Architecture Model (SGAM) [3, 4, 13, 19, 20] as well as their relation to the use case description in Chap. 3. A tool-support of the Use Case Methodology and the SGAM is demonstrated in Chap. 4 and includes a short user manual of these tools. In Chap. 5, projects are introduced which use the Use Case Methodology as well as our tool-support. Additionally, this chapter includes an overview on further existing architecture models next to the SGAM. The book concludes with Chap. 6 and an overview on future work with the Use Case Methodology, Use Case Repository and reference designation architecture models.

1.2 Complex Systems – A Definition

As mentioned in the previous section, the approach of the EU mandate M/490 can be applied on complex systems from various domains, like the Smart Grid and Active Assisted Living (AAL). Both domains describe an environment for complex systems under development, whereby the description of use cases or requirements and the implementation of them are made difficult. For a successful development and implementation of such systems, a good systems engineering process is needed to recognise all relations and problems that can occur during the implementation. Systems engineering is an interdisciplinary approach [14]. It focuses on defining customer needs by documenting requirements and it requires an early implementation of functionalities in the development cycle while considering the complete problem, i.e. a structured development process from concept to production to operation is generated by various disciplines and speciality groups [11, 12]. In addition, systems engineering considers both the business and the technical needs with the goal of providing a quality product that meets the user needs [14]. The approach by the mandate M/490 complies with these definitions, it also describes an approach for a successful implementation of complex systems – in this case a Smart Grid system – with a relation to the standardisation [13].

The term *complex system* is used in the software and system development for systems which consist of connected various components or systems to achieve a common goal [2]. Hence, a complex system is also a *system-of-systems (SoS)*, i.e. the approach for the systems engineering can be applied on it as well. The US Department of Defense (DoD) defines SoS as *"a set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities"* [18].

Regarding this definition, the systems Smart Grid and AAL can be depicted as complex systems [21, 23, 24]. Smart Grids comprise all components of the current power grid, like power plants, generators, distributed energy resources (DER), loads, storages, etc. which are equipped with intelligent control units and sensors with the aid of Information and Communication Technologies (ICT) to network and control the power grid [22, 23]. Figure 1.2 shows a vision of the future Smart Grid from the

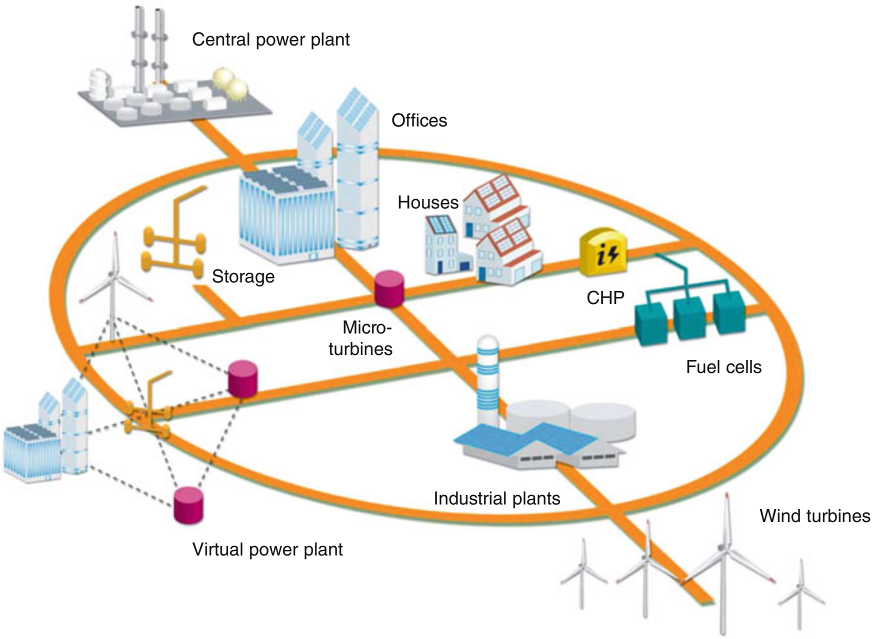

Fig. 1.2 The European union's Smart Grid vision (taken from [6, p. 18])

European Technology Platform (ETP) [6]. It demonstrates the network of various components in the Smart Grid, e.g. large electric storages can be found nearby the virtual and central power plants whereas large wind farms can be connected with industrial plants directly as well as with a storage or virtual power plant.

Challenges for the future Smart Grid are the integration of more variable generation of DERs and new storage options as well as the networking of various components via ICTs. Managing this process needs a distributed coordination intelligence and data aggregation management to involve producer and customer in a wise manner. In addition, the progress in the domains electric mobility, Smart Building, and AAL cannot be ignored and has to be involved in the planning and implementation of Smart Grids [22], i.e. the development of other complex systems has to be observed and managed as well. Thus, the approach of the EU mandate M/490 can be applied to other domains, like AAL which is considered in this book.

AAL systems are also mentioned as complex system by the German Standardisation Organisation DKE [24]. They mean assistance solutions in an everyday setting at home and on the move for every human independent from their age and health condition. Thereby, various vendors provide their products or systems for one solution in an AAL system, i.e. if persons want to install various systems in their household, it is important that these systems work together and can use the same sensors, so a high degree of adaptability and interoperability is reached [7, 24]. Figure 1.3 gives an overview on the functionality of an AAL environment, that has been developed

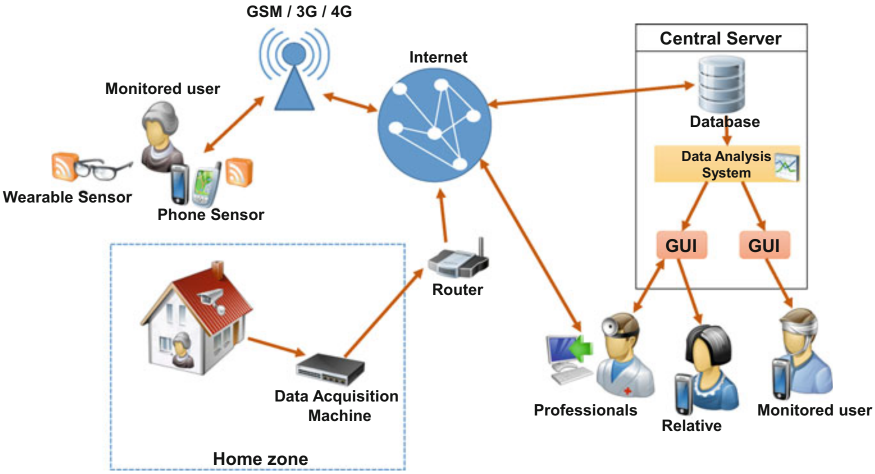

Fig. 1.3 AAL overview (inspired by the ENSAFE project [5])

in the project ENSAFE [5]. It demonstrates the environment of a household which is equipped with various sensors for monitoring its inhabitant. The recorded data is prepared by a Data Acquisition Machine and sent via the Internet to a central server which prepares the data for access by different persons, like doctors, relatives and the monitored person. Additionally, data of sensors, carried by the monitored user, is sent to the central server via Internet and is later considered for the data preparation.

The integration of various sensors and other devices is of the same difficulty as the integration of various components in the Smart Grid, i.e. same solutions should be used to solve challenges in different domains and possibly some challenges can be solved commonly, like energy savings and home safety (cf. the use case example in Sect. 2.3). Thus, we will consider the approach of the M/490 mandate within this book in more detail.

1.3 Domain-Specific Modelling

The approach presented in this book has several links to well established aspects from the overall system development. One very important aspect of system development is the requirements engineering where the elicitation of stakeholder requirements takes place. The Use Case Methodology mentioned in this book covers parts of an overall requirements engineering process [11]. The technique of use cases is a document-oriented way to make stakeholders formalise their requirements; therefore, different techniques exist. Further techniques in the requirements engineering process are interviews and observations which can be conducted both by the process of the system use to get real requirements given in the very context. As this is obviously very labour intensive, people opt for less time and work consuming approaches.

The original IEC 62559 Use Case Methodology was developed with a strong focus on power systems which can easily be seen from the requirements categories in the annex of the Use Case Template [16]. Many requirements classes are clearly motivated from a background in power system operation [15]. The template therefore covers a lot of domain-specific knowledge which helps to formalise the tacit knowledge embodied in the minds of the stakeholder. This tacit knowledge is usually very hard to elicit for a non-domain expert. As we aim to provide a very lightweight approach, the template can be either used in an interview-based approach where the requirements engineer does an interview and fills out the Use Case Template right on-site, later to be re-iterated and revised asynchronously. On the other hand, the template can also act as a questionnaire which is sent out to the respective stakeholder to be filled out in some kind of self-assessment. The design of the template helps in the particular scope that has been designed to cover information from the domain in terms of, e.g., non-technical requirements. In addition, it covers very little IT-specific methodological knowledge so it suits the diverse, mostly electrical engineering backgrounds of the stakeholders involved in power system projects very good. Therefore, the approach can be regarded both domain specific as well as non-domain specific from our point of view. While the original focus of the IntelliGrid project has been on power systems and their particular non-functional requirements, the approach has matured from the standardisation point of view and has been split into two main branches which shall be covered.

Within this book, we focus on the original work done on the basis of the EU M/490 mandate with the so called IEC 62559 series maintained originally by the IEC TC 8. Various parts have been defined as new work item proposals over time and this book provides insight on the most prominent one, the Use Case Template in the IEC 62559-2 part. Apart from this, other parts focus on the overall methodology for the elicitation and management process or the serialisation of the Use Case Template using XML to create an interoperable format which can be exchanged between various systems, e.g. use case management repositories which are also introduced in this book. Overall, the series covers the following parts as of today:

- IEC/PAS 62559 Ed. 1.0 IntelliGrid Methodology for Developing Requirements for Energy Systems, pre-merger project from IEC TC 8
- IEC 62559-1 Ed. 1.0 Use Case Methodology – Part 1: Concept and Processes in Standardization (by IEC SyC Smart Energy of now)
- IEC 62559-2 Ed. 1.0 Use Case Methodology – Part 2: Definition of the templates for use cases, actor list and requirements list
- IEC 62559-3 Ed. 1.0 Use Case Methodology – Part 3: Definition of Use Case Template artefacts into an XML serialized format
- IEC/TR 62559-4 Ed. 1.0 Methodology for developing requirements for energy systems – Part 4: Best Practices in Use Case Development for IEC processes and company projects

With the creation of the IEC System Committee on Smart Energy, the standards have been shifted from the IEC TC 8 and are now being maintained by the working groups from this new committee. In addition to this organisational change, a second standards series has been created which has a more narrow scope compared to the IEC 62559, the so-called IEC 62913 series which consists of the follow parts respective new work item proposals as of now:

- IEC/TS 62913-1 Ed. 1.0 Generic Smart Grid Requirements – Part 1: Specific application of the Use Case Methodology for defining Generic Smart Grid Requirements according to the IEC System approach
- IEC/TS 62913-2-1 Ed. 1.0 Generic Smart Grid Requirements – Part 2-1: Domains – Grid related domains, these include Transmission Grid Management, Distribution Grid Management, Microgrids and Smart Substation Automation
- IEC/TS 62913-2-2 Ed. 1.0 Generic Smart Grid Requirements – Part 2-2: Market related Domain
- IEC/TS 62913-2-3 Ed. 1.0 Generic Smart Grid Requirements – Part 2-3: Domains – Resources connected to the grid related domains, these include Bulk Generation, Distributed Energy Resources, Smart Home/Commercial/Industrial/DR-Customer Energy Management, and Energy Storage
- IEC/TS 62913-2-4 Ed. 1.0 Generic Smart Grid Requirements – Part 2-4: Electric Transportation Domain
- IEC/TS 62913-2-5 Ed. 1.0 Generic Smart Grid Requirements – Part 2-5: Domains – Support Functions related domains, these include Metering Management and Asset Management

One key element is the focus on Smart Grids instead of only power systems. In the US, the National Institute of Standards and Technology (NIST) has created relevant conceptual models for the Smart Grid after the IntelliGrid methodology came out, defining context in terms of generic system classes, interfaces, communication means and organisational views. On the other hand, the M/490 working group on Reference Architectures has created the SGAM which can be seen as a similar effort on European level. Those two main models, their scopes and systems are taken into account for the IEC 62913 series. The aforementioned parts deal with domain specific blue-print use cases for certain Smart Grid technologies and functions and structure them according to the new well-known domain models from NIST and the CEN, CENELEC and ETSI. Based on this, a more domain specific knowledge-based, structure according to the previous template will be provided with gold-standard domain knowledge ready-to-use for people familiar with the IEC 62559 series. The knowledge presented in this book also helps to deal with this future work from IEC.

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Chapter 2
Use Cases – The IEC 62559 Methodology

Abstract This chapter deals with the approach of use cases, their properties and a guideline for creating them. The Use Case Methodology and several different types of use cases are introduced. A standardised Use Case Template is presented and its usage is explained with help of an extensive example from the domain of Active Assisted Living. Additionally, the IHE process from the healthcare sector is presented as well as its common features and differences to the Use Case Methodology. Therefore, the standardised Use Case Template is extended through some aspects from the IHE process which provide a more detailed view on the actors' interfaces.

Keywords Architecture modelling · Requirements engineering · Use cases · Domain specific modelling · Stakeholder management

2.1 The Development Process

Use cases are first building blocks for projects in software engineering and describe the developed system and its functionalities in static as well as dynamic aspects. The static view is given through the presentation of actors that are related to the system, the dynamic view is described through the relation between actors and the system by use cases. A definition of *use case* is given in ISO/IEC 19505-2:2012 as follows.

> *A use case is the specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system.* – ISO/IEC 19505-2:2012 [10]

Thus, *actors* and their goals within the use case have to be identified as well as the way of proceeding which concludes in success or failure of these goals. The different outcomes of approaches depending on varying conditions or input is registered in *scenarios* with a distinct sequence of *steps*.

Usually, the needed information is provided by domain experts or prospective users of the designed system with diverse background knowledge and interests who do not always have a thorough technical understanding of their requirements. This material is often informal and the demands are presented in form of a short descriptive text, a so-called *user story* [19]. The task of the developers is now to combine those

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different points of view into a comprehensive standardised representation of a use case which allows a common understanding, base of discussion and possibly also an implementation by a programmer.

Over time, the developing process of a use case delivers results from rough proposals to highly detailed technical specifications. It starts with ideas, business needs and a collection of user stories for an approved project. After that, all necessary stakeholders and their demands have to be identified and sorted, constant feedback has to be adjusted accordingly. In the next step, the emerging use case requirements are formulated in detail and needed functions and technologies are clarified. With this information, specialists design technical specifications.

Detailed information about this process can be found in Chap. 3 of [18], as well as detailed in the following contributions [5, 7, 13, 16, 17].

2.2 The Use Case Methodology

For project management it is important to describe use cases and their functionalities in a structured and organised way. This process is called *Use Case Methodology* and is specified as a template in the standard IEC 62559-2 [8] by IEC TC8. The other three parts of the standard series IEC 62559 – Part 1, 3, and 4 – classify the proceeding with the Use Case Methodology as well as a possible tool-support. Additionally, XSD schemes are defined for an interoperable data exchange between various tools.

The full standard template has eight sections which are explained in detail in Sect. 2.3 below. The section titles in a short overview are

1. Description of the use case,
2. Diagrams of use case,
3. Technical details,
4. Step by step analysis of use case,
5. Information exchanged,
6. Requirements,
7. Common terms and definitions,
8. Custom information.

They provide information about the use case from different viewpoints. In a short standard version of the template, often only Sects. 1 and 2 are considered, this is called *Basic Version* of the Use Case Template.

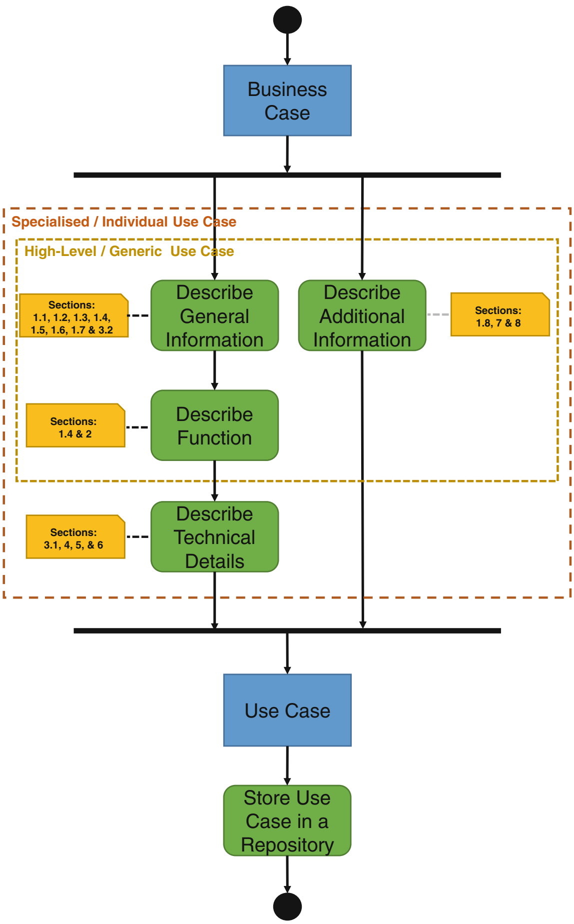
The building of use cases is usually based on an abstract *business case* with no technical details. A use case realises the description of the business goals in different layers of granularity and can be differentiated into *high-level use case*, *generic use case*, *specialised use case*, and *individual use case*. The distinction between those terms is determined by the purpose of the use case and its authors and follows a *top-down approach* or a *bottom-up approach*.

A *high-level use case* describes an innovative, abstract function but the actual technical implementation is not essential from this point of view. On its basis, *specialised use cases* can be developed and explain a tangible elaboration of the technical or functional details. Since the more general use case is created first in this course of action and the details are filled in later, this procedure is called *top-down approach*.

The *bottom-up approach* proceeds conversely and starts with explicit *individual use cases* which are created by organisations or diverse stakeholders of the project [14, 15]. They contain precise particulars for the realisation of the business case and quite possibly several of those individual use cases describe the same functions but with different means. From that compilation a *general use case* can be derived which entails a functional description without technical details for implementation. This perception characterises the *bottom-up approach*. Usually, such a general use case unifies many viewpoints and thus has a high acceptance rate among the stakeholders. Hence, it is often well-suited for a standardisation process.

The Use Case Methodology is displayed in Fig. 2.1, where also the differences in the use case types are illustrated. It can be roughly divided into four parts, *General Information*, *Function*, *Technical Details*, and *Additional Information*.

Fig. 2.1 Process of the Use Case Methodology



The *General Information* emerges from the business case information or from user stories and includes a unique identifier, explicit goals of the use case and the distinction from other use cases. The *Function* of the use case is described in plain-text fields and with diagrams. After that, the *Technical Details* focus on actors and the information flow with presentation of process sequences, data types and requirements. The *Additional Information* is collected in parallel to these other parts and helps to clarify terms and classify the use case.

Furthermore, Fig. 2.1 shows how these four parts are linked to the above-mentioned sections of the Use Case Template. It can be seen that not all sections have to be considered and especially the *Technical Details* can be neglected in high-level respectively generic use cases.

After the data is collected, it has to be stored in an accessible way for all involved persons. That can be a general SharePoint on a server for gathering PDF or DOCX files [6]. A practical alternative is an online repository implemented for creating, collecting, managing and evaluating use cases like the UCMR presented in Chap. 4 of this work.

2.3 Writing Use Cases

We describe the *Use Case Methodology* from the IEC 62559-2 [8] with an example of a behaviour monitoring system in the kitchen of a private household. The user story can be a short plain-text like the following example.

> *People with a mild cognitive impairment should live at home safely, in particular if they are alone at home. Therefore, a behaviour monitoring system in the kitchen of private households shall be implemented to support the person with mild cognitive impairments in their daily activities, like meal preparation, cleaning dishes or tiding the kitchen. For example, if the oven is switched on and the person leaves the house, the oven shall be switched off after five minutes automatically.*

Based on this concept, information has to be gathered and domain experts have to be consulted for the diverse sections of the template. This proceeding leads to the development of a fully completed template according to the IEC 62559-2 specifications shown below. After each explanation of the respective section in the Use Case Template, the table showing the according information for the behaviour monitoring example use case is displayed.

1 Description of the Use Case

The first section of the Use Case Template deals with the *description of the use case* where all general information about the designated goals of the use case is collected.

1.1 Name of Use Case

Section 1.1 of the template, *name of the use case*, provides a unique identification label as *ID* whose structure has to be agreed on for the respective project.

It further appoints a placement of the use case in the SGAM *area domains and zones* as explained in Chap. 3. Lastly, a precise descriptive *name of the use case* is presented. For our example, this part of the template is depicted below. The values for the keywords *SGAM.domains* and *SGAM.zones* can be found in Sect. 8 of the template.

Use case identification		
ID	***Area Domain(s)/Zone(s)***	***Name of use case***
Example-UC-AAL-01	SGAM.domains/SGAM.zones	Implementing a behaviour monitoring system in the kitchen of private households with an own energy storage

1.2 Version Management

A structured *version management* is listed in Sect. 1.2 of the template and can look like the following table. It entails a *version number* whose granularity has to be predetermined, the *date* of the submitted version and its *author*, a short documentation of the *changes* made in the respective version and an *approval status* defined for the project.

Version management				
Version no.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
0.1	6th December 2013	M. Eichelberg	Initial creation (General description with integration profiles)	Draft
0.2	26th May 2016	M. Gottschalk	Extended general description and added the technical part of the use case in Sects. 3 and 4	Draft

1.3 Scope and Objectives of Use Case

Section 1.3 of the template presents the *scope and objectives of the use case*. The *scope* describes the aims and boundaries of the use case in a short, precise text. The *objectives* are itemised in form of bullet points and a small headline. Also, possible *related business cases* are listed.

Scope and objectives of use case	
Scope	People with cognitive impairment shall be supported in their daily activities in the kitchen at home. These activities comprise the meal preparation with a stove, oven and microwave, cleaning dishes or tiding the kitchen. For these activities, various electronic devices (as mentioned above) are often needed. The usage of electronic devices can be dangerous if they are handled wrong or people forget that they have switched on device. Additionally, the household is equipped with an energy storage which should be used for the actions of the behaviour monitoring system to prevent a direct influence on the power grid, i.e. if devices are frequently turned on and off, like the kitchen light, only the energy storage is contacted by a smart meter.
Objective(s)	• Daily life support: Aim of the use case is to enable an independent life at home as far as it is possible. • People safety: Another objective is to reduce the number of accidents in households. • Saving costs: A behaviour monitoring system reduces the need of a daily visit by a care service. Additionally, electric devices are switched off when they are not needed.
Related business case(s)	• Improving safety aspects in own household • Supporting people with disabilities living alone • Stability of the power grid

1.4 Narrative of Use Case

Often the basis version of the Use Case Template comprises only the first two sections, hence the *narrative of the use case* in Sect. 1.4 of the template is quite important for the understanding of the process by the developer. The *short description* gives a brief overview of the use case and should be no longer than ten lines, whereas the *complete description* is a comprehensive longer narrative from user viewpoint about what happens *how*, *where*, *when*, *why*, and *under which assumptions*. It has to be written in a way that it can also be understood by non-experts.

Narrative of use case
Short description
A behaviour monitoring system in the kitchen of private households shall support people with cognitive impairments in their daily activities, like meal preparation, cleaning dishes or tiding the kitchen. For these activities, various electronic devices, actuators, sensors, gateways, and third-party applications are needed which exchange information to interact in dangerous situations with the people to prevent accidents. Otherwise, the behaviour monitoring system shall notify an external person if an accident happens and the inhabitant does not react. Electric devices of the behaviour monitoring system receive their power from the local energy storage which is loaded once per day.
Complete description
People, who are living alone at home and have diagnosed a mild cognitive impairment (i.e. an early form of dementia), need any support they can get in their daily activities, particularly when they prepare their meal and dangerous electrical devices, like an oven, are used. A behaviour monitoring system in the kitchen shall assume safety aspects to prevent accidents, like falls (because there is no light), a fire in the kitchen (because their meal is forgotten on the hot stove), or a water damage (because the water tap is not closed). However, it is important that behaviour monitoring systems do not affect the stability of the power grid by frequently turning electrical devices on or off The behaviour monitoring system is comprised of various actuators and sensors to detect dangerous situations and prevent accidents (falls, fire, and water damages); therefore, various scenarios can be defined. For example, if a person enters the kitchen, the behaviour monitoring system turns on the light automatically when there is not enough light. Slightly confused people, who forget to turn on the light, can go into the kitchen more safely. However, if the person still falls, an emergency call is executed. The meal preparation is a further part in which cognitive impaired people can be supported in the kitchen. If the person turns on the stove, oven or microwave and wants to leave the home, he or she should be notified that electrical devices in the kitchen are running. If this notification is ignored, these devices are switched off automatically After preparing a meal, people maybe want to wash their dishes manually. If they open the water tap and leave the kitchen, the washbasin may spill over. Thus, a sensor shall check how much water is in the washbasin and closes the water tap automatically before it spills over. These three activities in the kitchen are describing normal activities in a household of a person with a mild cognitive impairment who lives alone. The communication between sensors, actuators, and behaviour monitoring system shall happen wireless and without interventions of a person. Additionally, it is important that the power consumption of all devices can be compensated by a local energy storage for a day to support the grid stability. However, if the energy storage is defect or empty, all functionalities of the behaviour monitoring system are available by a common power connection.

1.5 Key Performance Indicators (KPI)

Key performance indicators (KPI) are classification numbers which have been appointed in the respective project and are described in Sect. 1.5 of the template. They have a unique *ID* and *name*, a *description* in form of a few sentences and, usually, they are associated to one of the above-listed use case objectives, which is stored in the field *reference to mentioned use case objective*.

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
kpi_01	Saving costs	The installation of a behaviour monitoring system shall reduce the costs for the human care by care services. It is calculated from the difference of the care service costs (per year) and the depreciation amount of the behaviour monitoring system.	Saving costs

1.6 Use Case Conditions

Section 1.6 of the template informs about *use case conditions*, more specifically about *assumptions* and *prerequisites* for the use case. Assumptions are general presumptions about conditions or system configurations. Prerequisites specify which requirements have to be met so that the basis scenario use case can be successfully accomplished. They often contain properties and states of actors or the condition of a triggering event.

If there are more than one assumptions or prerequisites, a greater number of tables has to be created.

Use case conditions
Assumptions
Connections to emergency call centres may be affected by national regulations.
Prerequisites
National regulations have to be captured completely before this kind of behaviour monitoring system can be implemented.

Use case conditions
Assumptions
Informed consent of user is required.
Prerequisites
The user consent has to be contractually specified.

1.7 Further Information to the Use Case for Classification/Mapping

All *further information to the use case for classification and mapping* is set in Sect. 1.7of the template. The *classification information* includes the *relation to other use cases* in the same project or thematic area. Possible relation types are for instance *include*, *extend*, *invoke*, or *associate*. The *level of depth* reflects the degree of specialisation of the use case. Although no common notation is settled, descriptions like *high level use case*, *generic*, *detailed*, or *specialised use case* are often used. *Prioritisation* helps to rate the use cases in a project from very important to nice-to-have with labels like *obligatory/mandatory* or *optional* which have to be agreed upon beforehand. Often use cases are applied to areas where restrictions by law or similar issues occur, so for purpose of generalisation the *generic*, *regional* or *national* relation has to be specified. The *nature of the use case* describes the viewpoint and field of attention like *technical*, *political*, *business/market*, *test*, etc. Finally, *further keywords for classification* can be entered at will in the last field of this part. They should follow a pre-described manner of notation, so that sorting and grouping use cases on behalf of these keywords is possible.

Classification information
Relation to other use cases
Behaviour monitoring system in private households (include) / Behaviour monitoring system in the living room (associate) / Loading an energy storage by a photo-voltaic system (associate)
Level of depth
Detailed Use Case
Prioritisation
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Process
Further keywords for classification
Behaviour monitoring system, fall detection, automatic regulation of electronic devices, smart metering

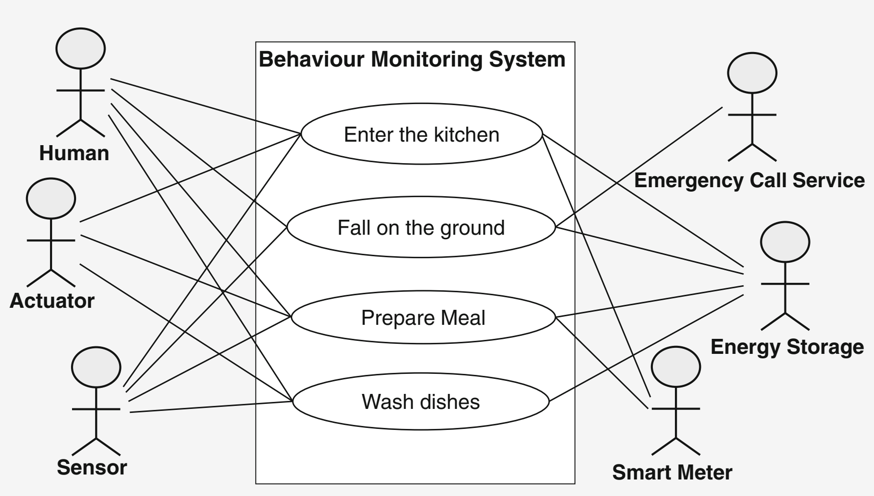
1.8 General Remarks

Any number of *general remarks* which do not fit in any other category may be inserted as bullet points in Sect. 1.8 of the template.

General remarks
• This use case does not claim to be exhaustive regarding the functionality of a behaviour monitoring system. • Example for a use case by using the IEC 62559 Use Case Methodology.

2 Diagrams of use case

In Sect. 2, of the template *diagrams of the use case* are displayed. Usually, UML use case, activity, and sequence diagrams help to provide a good understanding of the procedures of the use case. Any other kind of drawing is permitted, too.

Diagram(s) of use case


3 Technical Details

The *technical details* are dealt with in Sect. 3 of the template. They include *actors* in Sect. 3.1 and *References* in Sect. 3.2 of the template, respectively.

3.1 Actors

For a better overview, the actors can be sorted into groups according to their properties. For instance, in our example below we differentiate between the groups *Sensors* and *Actuators*. In other scenarios than the one described in Sect. 4 of the template, more actors can appear which can be added accordingly. If necessary, further grouping tables like *Gateways* or *Other Actors* have to be appended. For each *grouping*, a short *group description* is needed in form of a few sentences. Every actor needs a unique *actor name* and a remark about its *actor type* like *device*, *system*, or *human*. An *actor description* has to be provided as well as *further information specific to this use case* if necessary. It is recommended to use a separate table for each actor grouping as in our example below.

Actors			
Grouping		***Group description***	
Sensors		In this case, the sensor is an electrical sensor which, when excited by a physical phenomenon, produces an electric signal characterising the physical phenomenon (cf. IEC Electropedia: Sensor).	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Home automation sensor	Device	Summarises all sensors that can be used in households to support automated functionalities.	
Lux meter	Device	Measures light intensity and detects changes in the light conditions that are reported.	
Indoor localisation sensor	Device	Locates objects or humans inside a building using radio waves.	The radio waves do not exceed the permissible limits defined by the ITU.
Body area sensor	Device	Measures functions of the body (e.g. heart rate, blood pressure, temperature, etc.) and is a part of a wireless network of wearable computing devices.	
Water level sensor	Device	Measures the current water level in a wash basin.	
Power sensor	Device	Measures the current flow of an electrical device.	

Actors			
Grouping		***Group description***	
Actuators		In this case, the actuator is an electrical actuator that produces a specified movement when excited by an electric signal (cf. IEC Electropedia: Actuator).	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Home automation actuator	Device	Summarises all actuators that can be used in households to support automated functionalities.	
Water actuator	Device	Opens or closes a hydraulic valve of the water connection.	

Actors			
Grouping		***Group description***	
Other actors		A summary of all actors that are no sensors, actuators or gateways	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Inhabitant	Human	Describes the person who lives in the household.	In this case, a single household is considered.
Smart Meter	IED	Measures, collects, and controls the energy consumption of a household.	
Energy storage	System	A power capacitor intended to store energy and to release it within a very short time (cf. IEC Electropedia: Energy Storage).	The energy storage will be loaded by an own photo-voltaic system (at noon) or the house connection (at night).
Emergency Call centre	External system	Answers calls of the humans and redistributes information to other participants like hospitals or the fire brigade.	

3.2 References

In Sect. 3.2 of the template, the used *references* for background information are listed. They get a *number* or ID to refer to and the *reference type* like *publication*, *website*, *law/contract*, or *standard* is indicated. The *reference* gets a short descriptive label and the publication *status* (e.g. *draft*, *final*) is remarked upon. To enable the sorting through the references by importance, their *impact on the use case* is stated. Finally, the person or organisation which authored the respective reference document is noted in *originator/organisation* and, if available, a public weblink can be given in the field *link*.

References						
No.	***Reference type***	***Reference***	***Status***	***Impact on use case***	***Originator/ organisation***	***Link***
Electropedia	Website	IEC Electropedia		High	IEC	http://www.electropedia.org/

(continued)

References						
No.	***Reference type***	***Reference***	***Status***	***Impact on use case***	***Originator/ organisation***	***Link***
AAL-JP	Deliverable	AAL Joint Program: Action Aimed at Promoting Standards and Interoperability in the Field of AAL	Final	High	M. Eichelberg, L. Rölker-Denker, and A. Helmer	
Din EN 50090-1:2011	Standard	DIN EN 50090-1:2011 Home and Building Electronic Systems (HBES)	Final	High	VDE	
ZigBee	Standard	ZigBee Specification	Final	High	ZigBee Alliance	

4 Step by Step Analysis of Use Case

The *step by step analysis of the use case* in Sect. 4 of the template describes the possible scenarios of the use case with a distinct association to the use case narrative in Sect. 1.4 of the template. The scenarios should comply with the sequence diagrams in Sect. 2 of the template, so that every step describes one part of a communication or action. Apart from a normal success scenario, different failure scenarios or alternatives can be included to describe situations where preconditions are not satisfied or unwanted states are attained.

4.1 Overview of Scenarios

In Sect. 4.1 of the template, a tabular *overview of scenarios* is given. The *Scenario conditions* contain a consecutive *number*, where usually the normal scenario without failure cases is listed first. The scenario gets a distinct *scenario name* and a short precise *scenario description* in a plain text. The *primary actor* is the first actor appearing in the scenario at the incident causing the scenario to begin, called *triggering event*. The *precondition* indicates which terms have to be fulfilled for the scenario to be executed and the *postcondition* says which ones should be valid after the scenario. The postcondition can also specify whether a scenario has been successfully completed or not.

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
01	Enter the kitchen	A human enters the kitchen and the light is switched automatically on if it is needed. Therefore, a lux meter and an indoor localisation sensor provide data for the behaviour monitoring system for deciding whether the light has to be switched on or not. After this decision, the charging level of the energy storage is checked before it is used or a command is sent to load the storage (cf. Use Case *Loading an energy storage by a photo-voltaic system*).	Indoor localisa-tion sensor	Human enters the kitchen	The kitchen light is linked with a behaviour monitoring system.	Light is switched on, if it is necessary depending on the light conditions.
02	Fall on the ground	If the inhabitant falls in the kitchen, the behaviour monitoring systems inform an emergency call centre. An indoor localisation sensor provides the data of the current position and how long this position is kept. Due to this data, the behaviour monitoring systems decide whether it is a dangerous situation or not and makes an emergency call.	Indoor localisa-tion sensor	Human falls in the kitchen	The behaviour monitoring system has a link to external systems.	The emergency call centre has reached the inhabitants via phone or notified a rescue service.

(continued)

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
03	Prepare Meal	The inhabitant prepares his or her meal, and therefore, he or she turns on the stove. Then the inhabitant leaves the kitchen and a short time later the house without switching off the device. An indoor localisation sensor notifies the behaviour monitoring system about the leaving through the inhabitant. The behaviour monitoring system tries to notify the inhabitant that electrical devices are still running in the kitchen. If this notification is ignored, the stove is turned off in the next five minutes.	Indoor localisation sensor	Human leaves the home	The stove is connected with the behaviour monitoring system.	The stove is switched off.
04	Wash dishes	The inhabitant wants to clean his or her dishes and turns on the water tap and leaves the kitchen for a while. Thus, the inhabitant cannot notice when the wash basin is full. If the wash basin is full, a water level sensor sends a message to the behaviour monitoring system and a water actuator closes the water tap.	Water level sensor	Wash basin is full.	The wash basin has a water level sensor and is linked with the behaviour monitoring system.	The water tap is closed.

4.2 Steps – Scenarios

The scenarios listed above are described in more detail in Sect. 4.2 of the template, *Steps – Scenarios*. To make clear which scenario is dealt with in the respective table, the *scenario name* as in Sect. 4.1 of the template is entered in the headline. Below that, the steps of the scenario are listed in consecutive execution order with their *step number* and a triggering *event*. The event often just states that the last step has been performed successfully. Each step represents a process or activity which gets a unique *name* and a brief explanation of the procedure taking place in its *description*. The second half of the columns of this table deals with the information which are exchanged in the respective step. The *Service* addresses the nature of the information flow with the following possibilities.

GET (default): The information receiver obtains information from the information producer after an implicit request.
CREATE: The information producer creates an information object.
CHANGE: The information producer performs an update of the information at the information receiver's.
DELETE: The information producer deletes information of the receiver.
CANCEL/CLOSE: A process is terminated.
EXECUTE: An action or service is performed.
REPORT: The information producer supplies information of its own account.
TIMER: The actor which represents both information producer and receiver has to enforce a waiting period.
REPEAT: A number of steps has to be repeated until a break condition (stated in the field *Event*) is satisfied. The contemplated steps have to be added in parentheses.

The *information producer* and the *information receiver* are both actors from the actor list in Sect. 3.1 of the template. The *information exchanged* and *requirements* refer to the objects defined in Sects. 5 and 6 of the template, respectively. The corresponding IDs are sufficient here. Each scenario has its own table with this information. We only describe the first one of our example here.

Scenario			
Scenario name		***Enter the kitchen***	
No.	***Event***	***Name of process/activity***	***Description of process/activity***
01	Human enters the kitchen.	Indoor localisation in the kitchen	The indoor localisation sensor detects the entrance of the inhabitant into the kitchen and sends a signal to the behaviour monitoring system.
02	Behaviour monitoring system is notified.	Requesting the light conditions	After receiving a signal from the indoor localisation sensor, the behaviour monitoring system requests the light conditions from the lux meter.

(continued)

Scenario			
Scenario name		***Enter the kitchen***	
No.	***Event***	***Name of process/activity***	***Description of process/activity***
03	Lux meter is addressed.	Transmitting light conditions	The lux meter measures the current illuminances in the kitchen (luminous flux per unit area). This data is send to the behaviour monitoring system.
04	All data is collected.	Evaluating the data	The behaviour monitoring system collects the data from the indoor localisation sensor and the lux meter. Afterwards, the monitoring system evaluates the data and further data from the smart meter and the energy storage is collected (this process is described in another use case). Based on this, a signal for turning the lights on is created. Additionally, a signal to the energy storage is sent to use its energy.
05	Decision about the light condition has been made.	Sending signal to the actuator	The behaviour monitoring system sends a signal to the home automation actuator in the kitchen to switch the light on. This signal can differ from the default signal (cf. Sect. 7 of the template) that is sent each ten minutes and replaces the default signal until the behaviour monitoring systemcal culates a new signal.
06	Actuator has a signal.	Executes the instruction	The home automation actuator switches the light in the kitchen on.

Scenario (cont.)					
Scenario name		Enter the kitchen (cont.)			
Step no.	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Inf. exchanged (IDs)***	***Requirements (IDs)***
01	REPORT	Indoor localisation sensor	Behaviour monitoring system	I-01	Da-Pr-02, Co-Is-02, Co-Is-03
02	GET	Behaviour monitoring system	Lux meter	I-02	Co-Is-02, Co-Is-03
03	GET	Lux meter	Behaviour monitoring system	I-03	Da-Pr-02, Co-Is-02, Co-Is-03
04	CREATE	Behaviour monitoring system	Behaviour monitoring system	I-01, I-03, I-04, I-05, I-06	Da-Pr-02, Co-Is-03
05	CHANGE	Behaviour monitoring system	Home automation actuator	I-07	Co-Is-02, Co-Is-03
06	EXECUTE	Home automation actuator	Home automation actuator		

5 Information Exchanged

The *exchanged infomation* in the scenario steps is presented with a detailed description in Sect. 5 of the template. The *information ID* is used to refer to the respective information object and its *name* is a unique label for the main purpose of it. The *description* is an accurate plain text description as usual. Sometimes a requirement from Sect. 6 of the template has to be met for the information.

Information exchanged			
Inf. ID	***Name of information exchanged***	***Description of information exchanged***	***Req. ID***
I-01	Signal from the indoor localisation sensor	The indoor localisation sensor sends a signal to the behaviour monitoring system about the entrance or the leaving of the kitchen by the inhabitant. The signal is binary, i.e. only the values 0 and 1 exist (0 = leaving the kitchen, 1 = entering the kitchen).	Co-Is-04
I-02	Signal from the behaviour monitoring system	The behaviour monitoring system sends a signal to sensors to get current measurements.	Co-Is-04
I-03	Luminous flux per unit area	The measurements of the lux meter contain illuminance and irradiance values.	
I-04	Weather forecast information	The weather forecast information contains the periods in which the sun is shining.	
I-05	Room settings	The room settings is information which has to be configured for each room. These settings include the orientation of the windows and whether shutters are installed or not.	
I-06	Charge level of energy storage	The energy storage transfers its current charge level as a single value in percentage.	
I-07	Signal for light settings	The behaviour monitor sends a digital signal to a home automation actuator. The digital signal may have a value between 0 and 1 (0 = turns the light off, 0.1 until 1 = turns the light on (various brightness levels)).	

6 Requirements (Optional)

Section 6 of the template identifies the *requirements* needed in the range of the project. They are divided into *categories* with a unique *Category ID*. Each category gets a *name* and a short precise *description* and is supplied in a separate table. The requirements in each category have also an *requirements*

ID which is based on the ID of its category. Again, a *requirement name* and *requirement description* are provided.

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Da-Pr	Data protection	The private and data protection laws have a great influence on the application of a behaviour monitoring system in a private household. Thus, all relevant aspects of these laws for the use case are considered here.
Requirement ID	***Requirement name***	***Requirement description***
Da-Pr-01	Storage of vital parameter	Vital parameters have to be stored at the in-house NAS to prevent an external access by third-parties.
Da-Pr-02	Storage of sensor data	Sensors have to provide their measured data for at least one hour.
Da-Pr-03	Encryption of data	All data that leaves the household has to be encrypted with public-key cryptography.

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Co-Is	Configuration issues	Configuration issues reflect the typical, probable, or envisioned communication configurations that are relevant to a use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communication types, existing protocols etc. but only from the user's point of view (cf. IEC/PAS 62559 2008).
Requirement ID	***Requirement name***	***Requirement description***
Co-Is-01	Number of "end" entities or sources of data	Number of "end" entities or sources of data: significantly varied in different implementations.
Co-Is-02	Distance between entities	Distance between entities (for in-house entities): a few feet.
Co-Is-03	Location of information producer	Location of information producer (source of data): Building.
Co-Is-04	Elapsed time response requirement for exchanging data	Elapsed time response requirement for exchanging data: 1–4 milliseconds.

7 Common Terms and Definitions

Section 7 of the template contains *common terms and definitions* in a glossary. Each important *term* used in course of the project has to be followed by its *definition*.

Common Terms and Definitions	
Term	***Definition***
Mild cognitive impairment	An early form of dementia
NAS	Network Attached Storage
Default signal	The default signal for the home automation actuator is 0 (the light is turned off) after starting the behaviour monitoring system.
HA	Home Automation

8 Custom Information (Optional)

Optionally, *custom information* can be supplied in Sect. 8. It entails a *key* and its *value* and it has to be remarked to which *section* the pair refers.

Custom information (optional)		
Key	***Value***	***Refers to section***
SGAM.domains	Includes following domains: DER and Customer Premise	1.1 Name of use case
SGAM.zones	Includes following zones: Enterprise, Operation, Station, Field and Process	1.1 Name of use case

2.4 Extension with IHE-Profiles

In the eHealth domain, the initiative for *Integrating the Healthcare Enterprise (IHE)* has been founded to promote the integration of electronic information systems that support the delivery of modern healthcare [9]. It focuses on the standards-based exchange of authorised and relevant health information between hospitals, doctors, and various health services in the care of their patients. Integrating these systems, patients and healthcare actors can get an efficient access to necessary health information [9, 11, 12]. Organising and checking the information exchange between IT systems, applications and devices in healthcare is a complex process which is considered in the Sect. 2.4.1. The implementation of the IHE-process in the context of the IEC 62559-2 Use Case Template is shown in Sect. 2.4.2 carrying on the example of the use case in Sect. 2.3.

2.4.1 The IHE-Process

The *Integrating the Healthcare Enterprise (IHE)* initiative is a process as well as a forum which interacts on an international level to support and adopt interoperability standards for achieving an efficient access to health information for various actors [9, 11, 12]. The ISO/TC 215 develops healthcare specific standards which are complex and difficult to enforce. Hence, the IHE initiative defines IT standards for technical frameworks to implement the information exchange in the healthcare

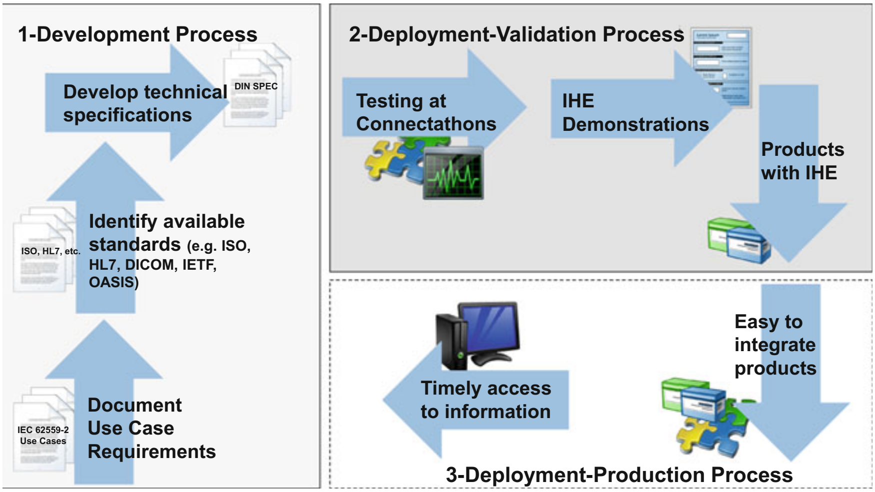


Fig. 2.2 The IHE development and deployment process (inspired by [9, 11])

sector. These IT standards are reviewed by a rigorous testing process wherein concrete implementations of the technical frameworks are made and checked, i.e. the IHE provides detailed implementation guides called *Integration Profiles*. Additionally, the IHE initiative organises educational sessions and exhibits to demonstrate the benefits of these frameworks for actors in the healthcare sector. This shall improve the adoption by the healthcare and technology industry as well as by doctors and patients [9, 11, 12]. Figure 2.2 depicts the IHE process which shows the development process for checking healthcare standards and becoming technical frameworks as implementation guidelines.

The IHE-process consists of three parts: *1-Development Process*, *2-Deployment-Validation Process*, and *3-Deployment-Production Process* [9, 11]. Based on the development process, the deployment process implements and checks whether components and systems are interoperable before the production begins. The *development process* starts with the description of requirements in terms of use cases; followed by the selection of standards and further documents (e.g. progress reports that implement one of the standards) to develop an implementation strategy. The process ends with the development of a technical specification – a detailed implementation guideline – for the use case and the selected standards. The *deployment-validation process* is based on the development process and starts with testing the technical specification. Therefore, various implementations of these profiles are used to exchange data between them; and hence, to demonstrate the interoperability between these independent implementations. If the interoperability of an implementation can be shown, the component is declared with the profile which is implemented. The *deployment-production process* describes the deployment of the components in the production of the healthcare sector. Aim of the IHE process is to reach an interoperable health IT environment through integrating components in all areas of the healthcare. After integrating components that have been through the IHE process, users can provide feedback to the functionality and the process, so that new requirements arise and the IHE process has to start from scratch.

The description of the IHE-process shows that it is a recurring process to reach a constant level of interoperable and up-to-date components. The continuous development in the IT and ICT leads to a rapid change in the application of components, interfaces, and software [1]. Thus, a standardised process about how to describe and check technical specification for single domains based on standards is necessary to enable an easy access to standards as well as markets [2]. Due to its importance and the fact that use cases have to be defined in the first step of the development process, the Use Case Methodology (cf. Sects. 2.2 and 2.3) is extended through integration profiles or rather the integration profiles are supported by the Use Case Methodology for getting a consistent use case description.

2.4.2 A Template for the IHE-Profiles

Each use case is depicted by at least one integration profile [2, 3], which describes the implementation of the use case based on existing standards and technical specifications. An integration profile consists of a sequence of steps that are described by single transactions which define the information exchange between two actors [12]. Actors are functional components of communicating IT systems within a healthcare information system environment [12], i.e. an actor cannot be a human like the actor in the use case description (cf. Sect. 3.1 within the Use Case Template). This demonstrates the more technical view of integration profiles in contrast to use cases. To link the Use Case Methodology and the IHE process, it is important that all actors are described in such a detail that they can be used in both approaches. Furthermore, the information exchange between actors is concreted through profile and message options within the integration profile. In this process, frequently, alternative implementations are considered to expand the range of application, e.g. to support cable-based and wireless networks [2].

Based on the work of the AAL Joint Program [4] and the IHE initiative,[1] a template for integration profiles similar to the structure of the Use Case Template (cf. Sect. 2.3) is developed. Hence, the numbering of the template starts with 9 to demonstrate its connection to the Use Case Template. In the following, the template of the integration profile is explained with the aid of the example from Sect. 2.3.

9 Integration Profiles

The Use Case Template is extended through a further Sect. 9 *Integration profiles* which describes the use case in a more technical way than the description of actors and scenarios in Sects. 3.1 and 4 of the Use Case Template.

[1]IHE Official Templates: http://wiki.ihe.net/index.php/Official_Templates.

9.1 Overview of Integration Profiles

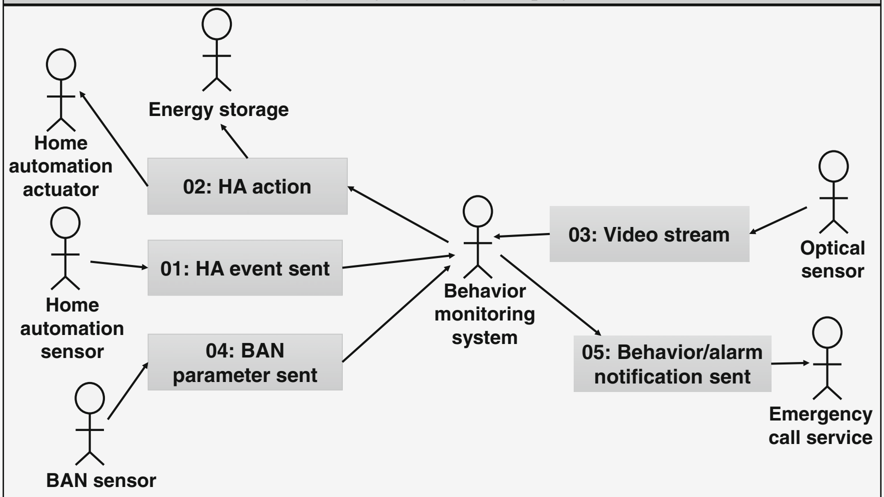
First of all, an *overview of integration profiles* is given in Sect. 9.1 of the template. This overview includes a *name* and a general precise *description* for the integration profile. Additionally, the description is extended by a description of the *high level process and data flow*, which gives an overview on the involved actors and their relations. Further, *ethical and legal considerations* are made to respect existing laws as well as humans needs.

Integration profiles			
Name	***Description***	***High Level Process and Data Flow***	***Ethical and legal considerations***
Behaviour monitoring	Dementia/cognitive impairment is a disease that often progresses slowly over many years. In order for the patient to maintain as much independence as possible, while preventing disease-related accidents, behaviour monitoring tries to identify the activities of the user at home to provide warnings in dangerous situations. This profile addresses the monitoring of the user's location and activities at home, combined with notifications to carers e.g. when the patient leaves/arrives at home. The profile also addresses the recognition of dangerous/unsafe situations and can be used to provide lighting-based indoor guidance for dementia patients.	A multitude of process and data flows are possible. Basically, all present sensors deliver sensor data to the behaviour monitoring system at an implementation-defined frequency. It is the task of the behaviour monitoring system to fuse this data and – based on context information about the sensor location, behaviour patterns of the user, etc. – derive information about recognised activities of daily living.	All collected data has to be considered as very sensitive personal data and is not allowed to beused out of the system. The behaviour monitoring system has to be protected from unauthorised access (independent of its localisation). A behaviour monitoring system cannot be installed and used without the informed consent of the user, or in the case of users who are unable to give informed consent, their legal guardians. It is furthermore desirable that the user has the ability to turn off the system temporarily.

9.2 Diagrams of the Integration Profile

The description of the integration profile is supported by diagrams in Sect. 9.2 of the template, *Diagrams of the integration profile*. These diagrams demonstrate an overview of the involved actors and their relations via transactions which describe the data exchange between actors. Additionally, a description for the diagrams is included.

Diagrams of the integration profile

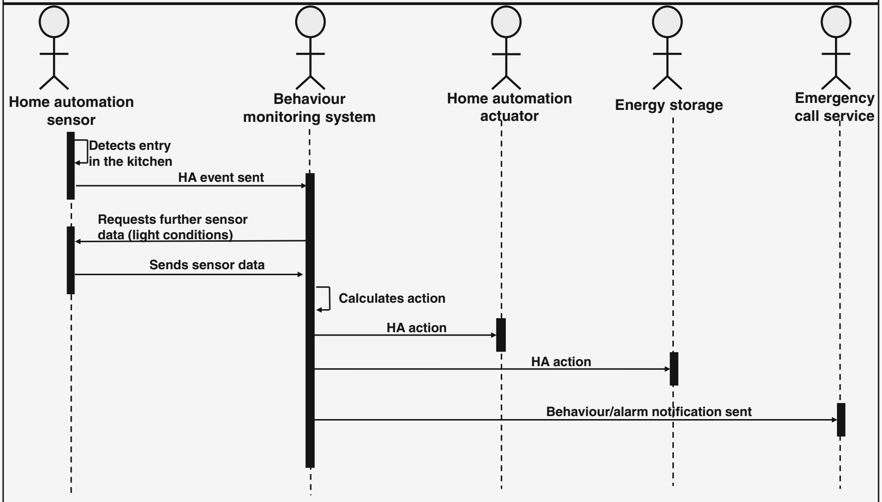


While at home, the location and activities of the user are monitored by means of ambient sensors. Since several sensor technologies are used for this purpose, the profile offers different options: for the home automation sensors like indoor localisation sensors, power sensors, and optical sensor (alternatively). The behaviour monitor receives and processes the sensor data and derives information about the activities to detect dangerous situations. At its own discretion, the behaviour monitor sends behaviour/alarm notification messages to an external emergency call centre. The information acquired by ambient sensors may be extended with information acquired by sensors worn on the body. Finally, the behaviour monitor may initiate actions of home automation actuators, in particular lighting and shutters.

9.3 Diagrams of the High Level Process and Data Flow

For describing the data exchange between actors in more detail, Sect. 9.3 of the template, *Diagrams of the high level process and data flow*, contains sequence or interaction diagrams to show which data has to be exchanged between which actors. Additionally, a description for the diagrams should be included.

Diagrams of the high level process and data flow



First, the indoor localisation sensor detects that the inhabitant enters the kitchen. A signal is sent to the behaviour monitoring system. Afterwards, the behaviour monitoring system requests further sensor data to calculate its decision whether the light is switched on or not. Then, the home automation actuator gets a command and, if a dangerous situation is detected, the emergency call centre is notified.

9.4 Profile Options

Section 9.4 of the template contains the *Profile options*. They show various implementation paths in which the vendor (alias inhabitant with a mild cognitive impairment) needs to choose between these two options, either a cable-based network (KNX option) or a wireless network (ZigBee Option) for connecting sensors in the behaviour management system. Each *actor* and its possible interface (alias *profile option*) is mentioned as well as the *optionality* of the interface. The optionality can be be *required*, *conditional*, or *optional*. Additionally, *notes* can be made for the interface, e.g. if an interface is conditional, alternatives are pointed out to the reader.

Profile options

Actor	***Profile Option***	***Optionality***	***Notes***
BAN sensor	ZigBee Option	required	
Behaviour monitoring system	Conventional option	conditional	Either “Conventional” or “universAAL” option shall be supported.
Behaviour monitoring system	universAAL option	conditional	Either “Conventional” or “universAAL” option shall be supported.

(continued)

Profile options			
Actor	***Profile Option***	***Optionality***	***Notes***
Behaviour monitoring system	ZigBee Option	required	
Energy Storage	KNX option	required	
Home automation sensor	ZigBee option	conditional	Either “ZigBee” or “KNX” option shall be supported.
Home automation sensor	KNX option	conditional	Either “ZigBee” or “KNX” option shall be supported.

9.5 Transactions – Integration Profiles

The description of single transactions which are part of an integration profile is done in Sect. 9.5 of the template *Transactions – Integration profiles*. This table is divided into two tables because of its size; hence, the field *name* and *transaction name* are shown twice. The *name* shows the corresponding integration profile for the transaction. The *transaction name* mentions the transaction and is followed by a general, precise *description*, a hint to *references* (cf. Sect. 3.2 of the Use Case Template), like standards and specifications, as well as the relevant *message options* (cf. Sect. 9.7 of the Use Case Template). Next, the involved actors are mentioned as *information producer* and *information receiver* to demonstrate the information flow between the actors. At this point, the information producer includes a decoder and a transaction initiator, and the information receiver contains an encoder and a transaction responder to enable the data exchange. For implementing the transaction, precise *requirements* are described from the actor and protocol perspective. Additionally, *security considerations*, which describe further, mostly technical or legal requirements for the transaction, are outlined.

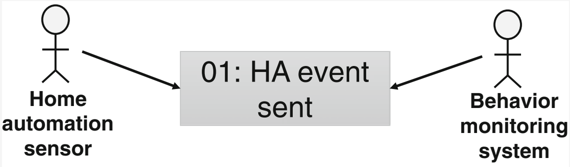
Integration profile					
Name:	Behaviour monitor				
Transaction Name	***Description***	***References***	***Message options***	***Information producer (actor)***	***Information receiver (actor)***
01: HA event sent	A home automation sensor uses this transaction to transmit sensor data to a behaviour management system that answers with an action using Transaction *02: HA action*. This transaction may be implemented using the wireless ZigBee option.	DIN EN 50090-1:2011, ZigBee	ZigBee Option	Home automation sensor	Behaviour monitoring system

Integration profile			
Name:	Behaviour monitor (cont.)		
Transaction Name	***Actor requirements***	***Protocol requirements (IDs)***	***Security considerations***
01: HA event sent	ZigBee operates either in the 868/915 MHz (Europe/North America) or in the 2.4 GHz frequency band. For the purposes of this transaction, the 868/915 MHz band shall be used with the ZigBee option.	Not applicable	The ZigBee protocol offers built-in security features: secure communications protecting establishment and transport of cryptographic keys, ciphering frames and controlling devices. ZigBee uses symmetric 128 bit keys to implement its security features. A key can either be associated to a complete ZigBee network (in which case it is used both on IEEE 802.15.4 MAC layer and on ZigBee network/application layer), or to an individual link (on ZigBee network/application layer). The negotiation of a link key requires a common master key, which – similar to a network key – is a shared secret that must be installed in all ZigBee devices of the network. One device in the ZigBee network acts as a "trust centre" that maintains the network key and master key, and can distribute link keys to devices on the network. The address of the trust centre and the master key should be pre-loaded to the ZigBee devices prior to installation, because otherwise this information had to be transmitted over the ZigBee network in unprotected form and might be recorded and exploited by an unauthorised eavesdropper.

9.6 Transaction Diagrams

The part *Transaction diagrams* in Sect. 9.6 of the template displays all actors which are involved in the transaction. A further description is not needed because this diagram shall be an extraction from the diagram in Sect. 9.2 of the template and the transaction is described in the previous Sect. 9.5.

Transaction diagrams



9.7 Message Options

Section 9.7 of the template *Message options* illustrates the message structure of the data exchange between actors, i.e. the mentioned profile options from Sect. 9.4 of the template are described in more detail. The *name* of the profile option is repeated and the process of the transaction of the *triggering event* as well as the structure of exchanged data and *message semantics* are described. Finally, the *expected action* is depicted and specifies the result after receiving the data and the next steps.

Message options			
Name	***Triggering event***	***Message semantics***	***Expected action***
ZigBee Option	The transaction is initiated by the home automation sensor whenever new sensor data needs to be transmitted. The transaction may either be sent periodically or be triggered by a physical event such as a switch being operated by the user or a presence detector detecting movement in its field of view.	This message makes use of the ZigBee Home Automation protocol, which is based on the ZigBee PRO (ZigBee 2007) protocol, and implements a wireless home automation network protocol over IEEE 802.15.4 personal area networks. ZigBee operates either in the 868/915 MHz (Europe/North America) or in the 2.4 GHz frequency band. For the purposes of this transaction, the 868/915 MHz shall be used. The behaviour monitoring system shall act as the ZigBee Coordinator of the ZigBee home automation network. The home automation sensor shall implement one of the device types and corresponding clusters specified in the ZigBee Home Automation application profile and use its client-side clusters to deliver sensor data to the behaviour monitoring system.	Upon receipt of the message, the behaviour monitoring system is expected to translate the sensor event to the UPnP SensorManagement protocol. Therefore, a mapping between the ZigBee protocol (ZigBee Home Automation device clusters) and UPnP SensorManagement has to be developed. This means that at the moment it is not possible to guarantee a common interface for sensors of the same type.

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Chapter 3
The Smart Grid Architecture Model – SGAM

Abstract Within this chapter, the development and the application of architecture models are introduced on the basis of the Smart Grid Architecture Model (SGAM). First, a definition and the purpose of this architecture model are described. Secondly, the connections to the Use Case Methodology and the IHE profiles are shown. Additionally, the use case example from Sect. 2.3 is demonstrated in the SGAM. Finally, the current status in AAL for an own Use Case Template and architecture model is discussed.

Keywords Architecture modelling · Requirements engineering · Use cases · Domain specific modelling · Stakeholder management

3.1 Definition and Purpose

The Smart Grid Architecture Model (SGAM) has been developed by the Smart Grid Coordination Group/Reference Architecture Working Group (SG-CG/RA) in the context of the European Commission's Standardisation Mandate M/490 [1] as a holistic viewpoint of an overall architecture in the Smart Grid domain [2]. The SGAM subsumes different perspectives and methodologies regarding the development and conceptualisation of the Smart Grid. Thus, it allows the visualisation of use cases and IHE profiles previously described in Chap. 2. Before these perspectives of the SGAM are described in more detail, the Grid Wise Architectural Council (GWAC), a model to structure the Smart Grid regarding interoperability aspects, is outlined. By using this model, several parts of the use cases and IHE profiles can be categorised for the Smart Grid design regarding concerns at levels spanning from economic and regulatory policy to the basic connectivity of systems artefacts. This procedure describes the first part of the SGAM.

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SpringerBriefs in Energy, DOI 10.1007/978-3-319-49229-2_3

3.1.1 *The Interoperability Stack*

The development of Smart Grids and AAL systems is mostly a step-by-step implementation because the current power grid as well as households cannot be exchanged overnight, i.e. the implementation of Smart Grids and AAL systems is a classic migration process. A *migration process* describes the transmission of functions from a legacy system to a new system without losing any functionalities [3], in our case from the power grid to the Smart Grid. Such a migration in the Smart Grid and AAL domain is a high-risk process and has to be managed on each level from the organisational to the technical view, i.e. interoperability has to be elicited on each level to achieve an easy integration of organisational and technical aspects [4]. The GWAC develops a structure for various interoperability levels, whereby organisational, informational and technical aspects are considered. Overall, the structure proposes eight interoperability layer, as shown in Fig. 3.1.

As mentioned above, the eight interoperability layers from the GWAC stack are divided into three sections: organisational, informational and technical. The *organisational* part helps to elaborate business functions and identify which parts of these functions lie outside the organisation boundaries. This yields the interoperability levels: *Economic/Regulatory Policy*, for recording political and economic objectives in policies and regulations, *Business Objectives*, for sharing strategic and tactical objectives between businesses, and *Business Procedures*, for a better understanding of the scope and task of a specified function [1, 2].

The *informational* part has the aim to transfer the organisational aspects into an appropriate information model. This part has the interoperability layers: *Business Context*, for a better understanding of the use of the information for a specific function,

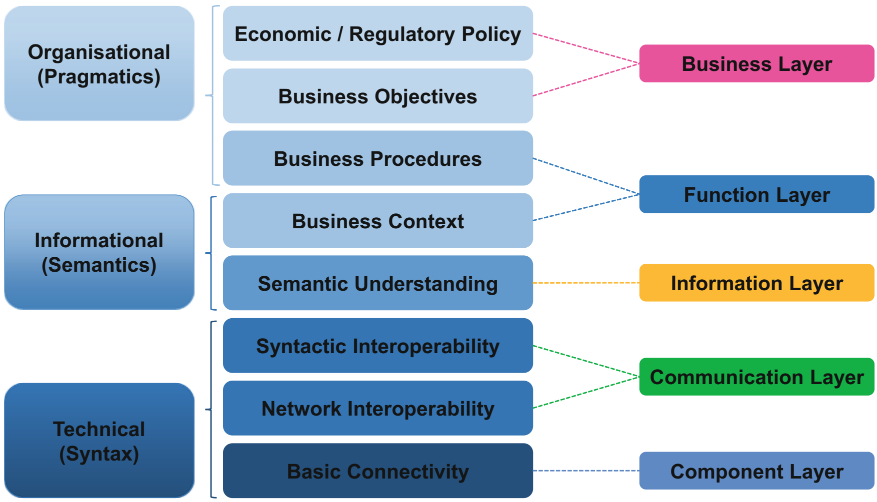


Fig. 3.1 Adoption of the GWAC stack in the Smart Grid architecture model

and *Semantic Understanding*, for a better understanding of the concepts contained in the message exchanged between systems [1, 2].

The *technical* part covers the basic connectivity needed to establish networked communication between distributed assets and applications within its lowest layers. This includes the following three interoperability layers: *Syntactic Interoperability*, for a better understanding of message data structures, *Network Interoperability*, for a standardised mechanism to exchange messages between multiple systems across various networks, and *Basic Connectivity*, for a mechanism to establish physical and logical connections between systems [1, 2, 5, 6].

Based on this layers, the SGAM has been developed for presenting Smart Grid functionalities on an interoperable manner.

3.1.2 Architectural Viewpoints to Smart Grid Use Cases

For visualising the use cases and IHE profiles, an architectural overview is needed which represents the various viewpoints described in use cases and profiles. In the context of the European Smart Grid Mandate M/490, the GWAC stack has been adopted for the Smart Grid domain to represent the content of the use cases according to the IEC 62559-2 template and the SGAM emerged [1]. As mentioned above, one perspective of the SGAM bases directly on the GWAC stack [7]. The five SGAM layers are derived from the eight layers of the GWAC stack. They are labelled *Business*, *Function*, *Information*, *Communication*, and *Component layer*. The relation between the SGAM and GWAC stack layers is also shown in Fig. 3.1. The detailed information of the SGAM layers are shown in Fig. 3.2, and they are explained by [1] as follows:

- The *Business Layer* depicts the business view regarding the information exchange within the Smart Grid. This view consists of regulatory and economic structures and policies, business models, and business portfolios as well as business capabilities. Further, it contains business processes for visualising business models and specific business projects to recognise and possibly to develop new models and projects, for instance single corporate goals like reducing the energy consumption.
- The *Function Layer* describes functions and services including their relations from an architectural view. These functions and services are derived from the business view and they are independent from involved actors and physical implementation in applications, systems and components, e.g. service platforms for the supplier change process.
- The *Information Layer* describes the used and exchanged information between actors (more precisely, systems and components). They include the information objects and their canonical data models which represent the common semantic for functions and services to enable an interoperable exchange, e.g. CIM and EDIFACT for the data exchange of grid and customer data.

- The *Communication Layer* demonstrates protocols and mechanisms for an interoperable data exchange between components regarding functions or services and the corresponding information objects or data models, e.g. via TCP/IP and PLC.
- The *Component Layer* describes the physical distribution of all components in the Smart Grid context. This includes systems/components, applications, power system equipment, protection and tele-control devices, network infrastructure and any kind of intelligent devices, e.g. wind farms, Smart Meters, and voltage sensors.

A single layer of the SGAM is a two-dimensional plane which considers, on the one hand, the domains as the electrical energy conversion chain from generation to consumption, and on the other hand, the hierarchical zones for the management of electrical processes from market to process. It can be said, that the Smart Grid distinguishes between the electrical process and information management viewpoints in general [5, 8]. These domains and zones are also shown in Fig. 3.2.

According to this concept, domains describe capacities which are physically related to the electric grid. The domains of the SGAM are explained by [1] as follows:

- The energy conversion chain starts with the *Generation* of electrical energy in bulk quantities, like fossil, nuclear, and hydro power plants, off-shore wind farms, large scale solar power plants; which are typically connected to the transmission system.
- The *Transmission* represents the infrastructure and organisation which distributes the electricity over long distances between generation and cities where it is used.
- The *Distribution* represents the infrastructure and organisation which distributes electricity directly to customers like households or SMEs.
- Distributed electrical resources (*DER*) represent small power plants which are directly connected to the public distribution grid, with a small-scale power generation technologies (in the range of 3 to 10.000 kW).
- The *Customer Premises* include normal consumers as well as producers in form of photovoltaic generation, electric vehicle storage, or micro turbines which are hosted to the distribution grid. The premises contain industrial, commercial and home facilities as consumers.

The zones describe the information management within the Smart Grid in a hierarchical manner. This concept considers the aggregation and functional separation in the power system management. Thereby, the data aggregation process concentrates data from the field in the station zone, and the functional separation means, that different functions are assigned to specific zones. For example, reasons for a functional separation are the specific nature of functions and various user philosophies. The basic idea of the zone concept is laid down in the *Purdue Reference Model* for computer-integrated manufacturing which has been adopted by the IEC 62264-1 standard for enterprise-control system integration [9]. This standard has been applied to the power system management and is described in the IEC 62357 standard as reference architecture for objects model services [10]. The zones of the SGAM are explained by [1] as follows:

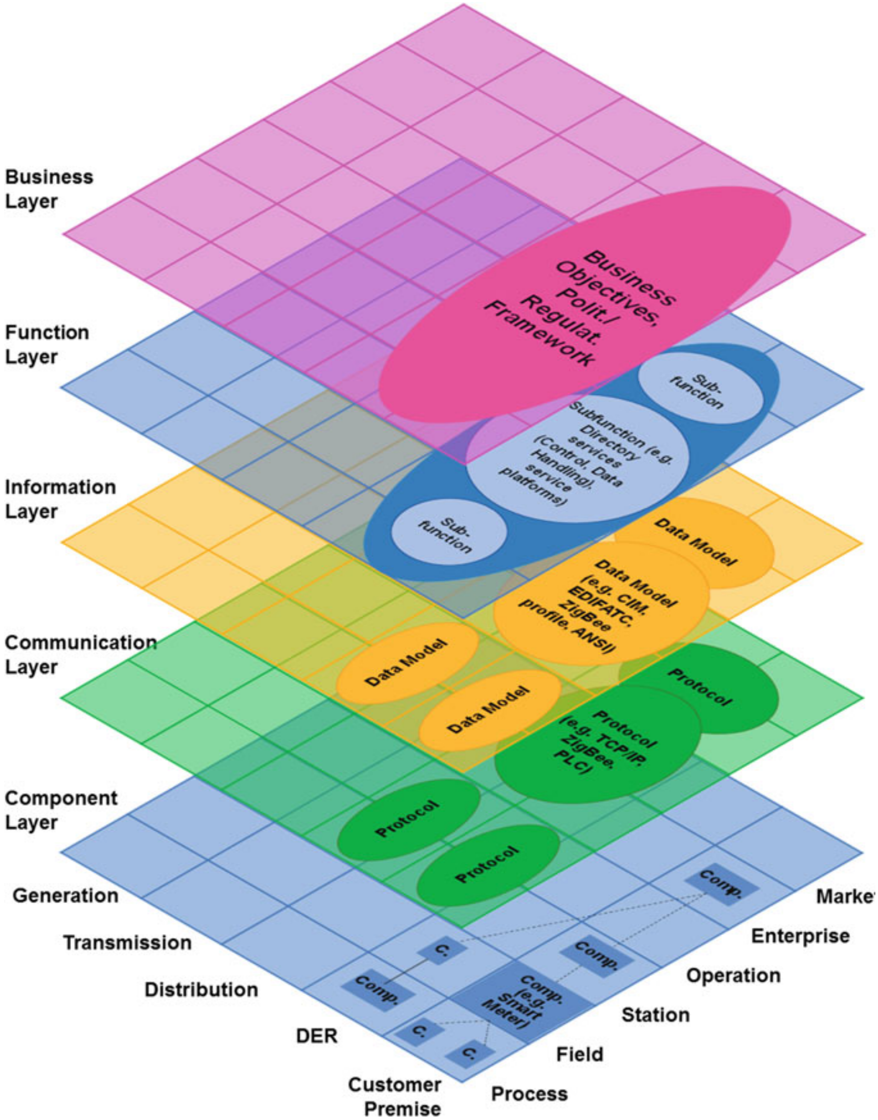


Fig. 3.2 The Smart Grid Architecture Model

- The *Process* includes physical, chemical and spatial transformations (e.g. electricity, solar, heat, etc.) of energy and the physical equipment that is directly involved, e.g. generators, transformers, cables.
- The *Field* includes the equipment to protect, control and monitor the process of the power system, e.g. controller and any kind of intelligent electronic device.
- The *Station* represents the aggregated level of the field zone, e.g. data concentrator, functional aggregation, and local SCADA systems.
- The *Operation* zone provides power system control operations in the respective domain, e.g. a distributed management system (DMS), an energy management system (EMS) in generation and transmission systems, as well as the management system for electric vehicle fleet charging.
- The *Enterprise* zone includes commercial and organisational processes, services and infrastructures for enterprises, e.g. asset management, logistic, customer relation management, billing and procurement.
- The *Market* reflects possible market operations along the energy conversion chain, e.g. energy trading.

Due to the connection of these three dimensions – layer, domains, and zones – the SGAM representation emerged and use cases according to the IEC 62559-2 template and some additional information, like the IHE profiles, can be visualised. Thus, the common understanding of Smart Grid functionalities can be improved through a visual representation.

3.2 Dependencies Between Use Cases and Architecture Models

As mentioned above, the SGAM depicts the visualisation of the use cases, and in our case, also the IHE profiles can be mapped to the SGAM. The mapping process and the allocation of each part of the use case description as well as the IHE profile is described in this section. Additionally, the use case example from Sect. 2.3 is transferred to the SGAM.

3.2.1 Mapping Process from Use Case to SGAM

During the mandate M/490, a process has been developed which describes the mapping process from a use case to the SGAM [1]. The mapping assists experts in detecting missing use case descriptions, since for instance an empty SGAM layer implies that there is no description for it in the use case. The mapping process can be done in three different ways which include the same process steps and end in the same representation; however, the sequence of the process steps vary. These mapping processes are the *top-down*, *bottom-up*, and *mixed-up* approach that are going to be

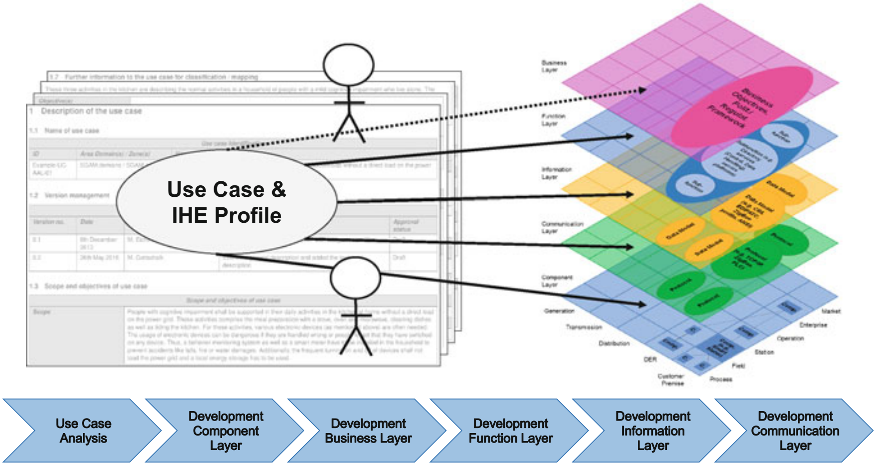


Fig. 3.3 Mapping process from Use Case to SGAM (inspired by [1])

introduced in this section. Figure 3.3 shows the *mixed-up* mapping process from the use case and IHE profile to the SGAM.

The mapping process, independent of this approach, always includes six steps. It starts with the use case analysis; this means, that the use case and the IHE profile are inspected by an expert (cf. Sect. 2.1). For the *mixed-up* approach, the expert begins with the development of the component layer, i.e. the involved actors and their relations are mapped on the component layer. They are defined by the steps within the use case and the transactions within the IHE profile. Thereby, the associations between actors represent a communication or a current flow. In the next step, the business layer is developed. This includes the allocation of business objectives and regulations to single steps from the component layer. In the use case description, these business objects and regulations are listed within the use case description and often business actors are used as representation which do not have a direct impact on the technical implementation; however, these actors can be used in steps as initiator or in the actor grouping as related actors to the use case. Thereafter, the function layer based on the business layer is created. On the basis of the information in the component, business and function layer, the information layer and then the communication layer are developed.

The *top-down* approach starts with the development of the Business Layer after analysing the use case and is followed by the function to the component layer in a sequential order. This approach is used if a high-level or generic use case is described, whereby the concrete implementation of the use case is unknown at the moment. The *bottom-up* approach is inverse to the top-down approach whereby it also starts with the use case analysis before the component layer is created. The bottom-up approach is useful for the representation of specified or individual use cases, that describe a concrete technical implementation which meets one or more business objectives.

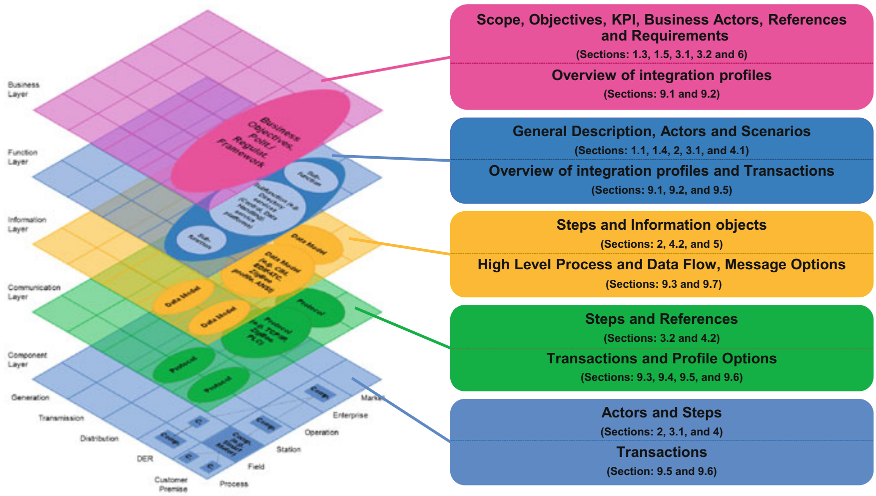


Fig. 3.4 Mapping Use Cases and IHE-Profiles onto the SGAM

To sum it up, the mapping process from the use case to the SGAM depends on the kind of use case; whereby the result of the mapping process should be the same independent of the approach because the steps executed are the same. However, the *top-down* approach is wiser for high-level and generic use cases and the *bottom-up* approach should be used for the specified or individual use cases. The *mixed-up* approach can be applied for all kinds of use cases and should support the experts through the view from the bottom and top at the same time during developing the function, information and communication layer.

3.2.2 Localisation of Use Cases and IHE Profiles

With the mapping process from use case to SGAM, the SGAM visualisation can be created; however, it does not describe which contents are shown on which layer. In this section, the content and its dependencies from the use case and IHE profile description which is mapped onto the layers, are demonstrated. In Fig. 3.4, the specific localisation of the use cases as well as the IHE profiles description in the SGAM is shown. The numbering of the sections conforms to the numbering of the use case and IHE profile template in the Sects. 2.3 and 2.4.

Starting top-down, the business layer depicts the content of the scope, objective, key performance indicator, actors, references, and requirements of a use case (cf. Use Case Template Sects. 1.3, 1.5, 3.1, 3.2 and 6) as well as the general description of the integration profile, which describes the general function, the high-level process and data flow as well as the ethical and legal considerations (cf. extended Use Case

Template Sects. 9.1 and 9.2). All these aspects describe business objectives, political and regulatory requirements which depict the reason for the development of use cases. Due to the use case type (high-level, generic, specific, or individual use case; cf. Sect. 2.2), some parts of the use case description cannot be applied to the business layer, like requirements which are not strictly necessary for high-level and generic use cases.

The function layer depicts the first layer for a concrete implementation to achieve the goals of the business layer. At this point, the considered parts of the IHE profile are the same as the parts of the business layer, but the viewpoint differs as a more solution-oriented viewpoint is chosen. The use case specification, the general description and diagrams, the actors list as well as the general scenario description (cf. Use Case Template Sects. 1.1, 1.4, 2, 3.1 and 4.1) from the use case description are relevant to extract single functions or sub-functions to achieve the business goals.

Next, the information layer is considered which depicts the information model for achieving occurring functions. The information objects are defined in Sect. 5 of the Use Case Template and their relation to the use case description is demonstrated in Sect. 4.2 as part of the steps. Additionally, the presentation in form of diagrams (cf. Use Case Template Sect. 2) supports the development of information models. Additionally, the IHE profile provides diagrams of the high-level process and data flow as well as message options for transferring structured data (cf. extended Use Case Template Sects. 9.3 and 9.7).

The communication layer depicts the way in which protocol data is transferred. In the Use Case Template, this part is described within the steps (cf. Use Case Template Sect. 4.2) which refer to the references in Sect. 3.2. The IHE profile goes into more detail as the implementation process is described in detail for an interoperable development of new components or systems functionality. The IHE profile provides diagrams for high-level process and data flow, profile options, transactions, and further diagrams to visualise transactions (cf. extended Use Case Template Sects. 9.3, 9.4, 9.5, and 9.6). These parts help to create a complete profile for the transaction between actors and they can be tested more easily.

On the lowest layer, the component layer, all actors and their relations are illustrated. This layer shows the physical connection via wired and wire-less communication links and current links which need a defined interface for an interoperable operation of these actors. The Use Case Template demonstrates actors and their relations in diagrams, actor groupings, as well as in scenarios and steps (cf. Use Case Template Sects. 2, 3.1 and 4). The IHE profile also describes the actors in diagrams and in the description of the transactions (cf. extended Use Case Template Sects. 9.5 and 9.6). With help of the Use Case Template and the IHE profile, the component layer can be filled. This supports the implementation process for detecting interfaces between actors and implementing the required functions and business goals.

In summary, each part of the use case and IHE profile template can be mapped onto the SGAM indirectly. This kind of visualisation helps experts to regard the use case and IHE profile at a glance. The more detailed information about actors, protocols, information models, etc. can be found in the use case description or the IHE profile.

3.2.3 Application of the SGAM

For a better understanding, the SGAM should be applied in this section. Therefore, the use case example *Implementing a behaviour monitoring system in the kitchen of private households with an own energy storage* from Sect. 2.3 is chosen and mapped onto the SGAM. This example is shown in Fig. 3.5. It demonstrates the SGAM layers, domains, and zones as described above.

On the business layer, the SGAM example shows the three defined business cases from the Use Case Template in Sect. 1.3 as well as the IHE profile which is related to this layer. These are the business objective *Stability of the power grid* and the regulatory aspects *Supporting people with disabilities living alone* and *Improving safety aspects in own households*. On the next layer, the function layer, general functions are named to achieve the business goals, these are *Home automation event sent*, *Home automation actions*, and *Behaviour alarm/notification sent*. The first two functions are derived from the transactions in Sect. 9.5 of the Use Case Template, because these transactions describe general functions for implementing various steps of the use case and serve the various business goals instead of a concrete actor of the component layer. The third function bases on the use case and scenario description in Sects. 1.4 and 4.1 of the Use Case Template. The information layer describes the data models which can be used to meet the mentioned functions. This layer bases on the data flow in Sect 9.3 and the message options in Sect. 9.7 of the template. The *ZigBee Home Automation application profile* is used to enable the automatic data exchange between various components and the behaviour monitoring system in a household. A more general description of the content is given within the steps and information objects of the Use Case Template in Sects.4.2 and 5. The communication layer demonstrates the protocols which are used for the data exchange within the AAL system. The applied protocols are mentioned in the steps (cf. Sect. 4.2 of the template) of the template and the transactions (cf. Sect. 9.5 of the template) and described in the reference part of the template in Sect. 3.2. On the lowest level, the component layer, all components which are involved in the use case and IHE profile as well as their relations are shown. The same actors appear in the description of steps in Sect. 4.2 of the template and transactions in Sect. 9.5. Additionally, diagrams which represents the use case and integration profile (cf. Use Case Template Sects. 2, 9.2, 9.3, and 9.6), demonstrate the communication and current flow between actors, and hence, they support the development process of the component layer.

This example demonstrates the complete mapping of a use case and an IHE profile onto a SGAM. It shows that the SGAM gives an overview on the use case and IHE profile description, whereas details for implementing the use case are described in the Use Case Template or in the integration profile.

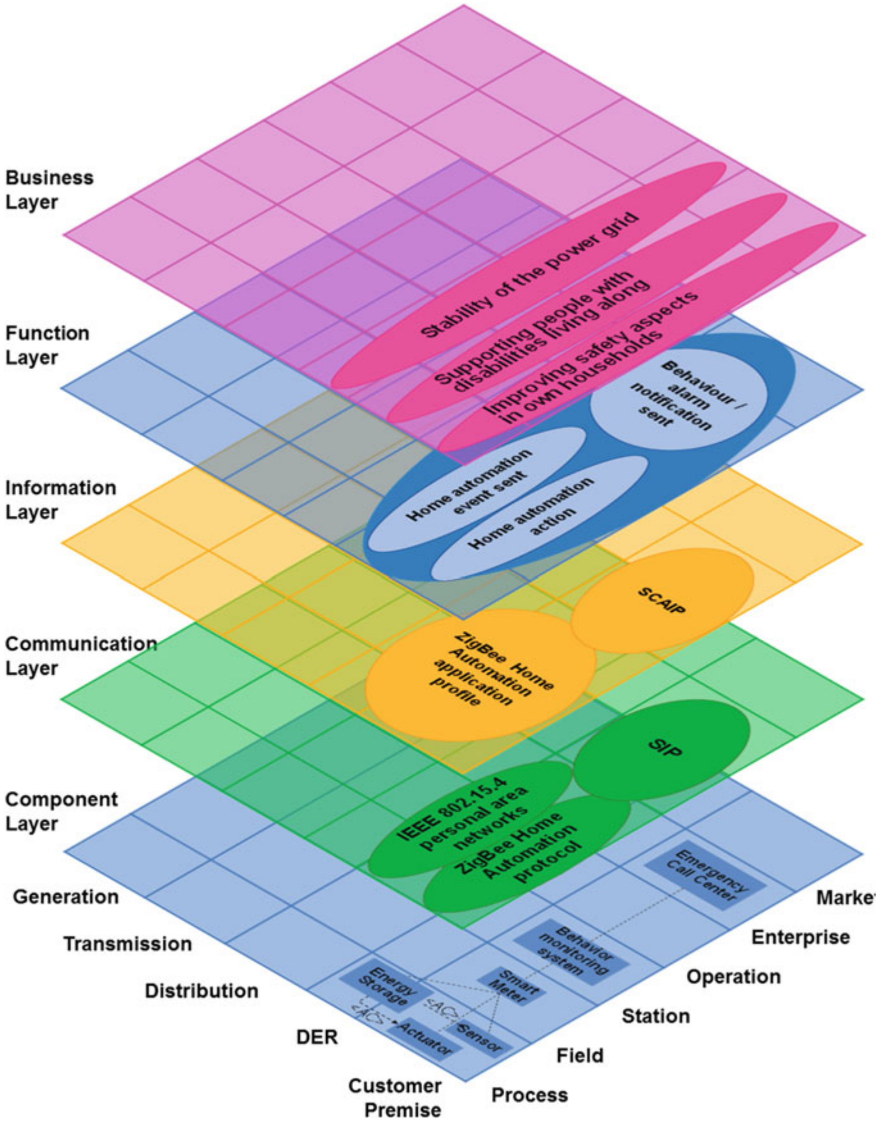


Fig. 3.5 SGAM example for the Use Case *Behaviour monitoring system in the kitchen of private households with an own energy storage*

3.3 Development in the Active Assisted Living Domain

Next to the IEC 62559-2 Use Case Methodology and the SGAM, a use case model by the IEC Strategy Group 5 Ambient Assisted Living (SG 5 AAL) has been developed to depict and analyse actors regarding their functionality and interoperability [11].

This use case model as well as their Use Case Template are introduced in this section to differentiate their approach from our extension of the IEC 62559-2 template (cf. Sect. 3.2). Therefore, our use case example *Implementing a behaviour monitoring system in the kitchen of private households with an own energy storage* is applied on the AAL Use Case Template and model.

3.3.1 The AAL Use Case Template

The use case model is introduced in the final report of the SG 5 AAL [12]. For the use case model, the IEC 62559-2 Use Case Template has been adapted and an own three-dimensional visualisation has been developed (cf. the use case model in Sect. 3.3.2). At this point, extensions from the AAL Use Case Template to the IEC 62559-2 Use Case Template are represented briefly.

In general, the AAL Use Case Template includes the same content as the IEC 62559-2 Use Case Template summarised [12]. The AAL Use Case Template is only divided into two part. The first part describes the use case, its actors, references, existing standards and issues, as well as relations to other known use cases. The second part visualises these descriptions. In the following, the AAL Use Case Template is described through the same example like in Sect. 2.3, i.e. the mentioned use case is expand from the example in [13]. Note: The use case example is not complete, it describes an extract of a use case.

1 Description of the Use Case

The first part of the AAL Use Case Template describes all information or rather refers to issues, constraints and standards to implement a use case from the AAL domain.

1.1 General

The *general* part hints the reader on the kind of use case to classify its complexity and difficulty as well as its area of application, the types *Critical System*, *Less Critical System*, and *Well-being System* can be chosen.

Critical System	*Less Critical System*	*Well-being System*
Yes	–	–

1.2 Name of Use Case

The *name of use case* is similar to the table with the same name in IEC 62559-2. An *identifier* and *name* are selected as well as the *domain* and *function* of the use case (cf. the domains and enablers in Fig. 3.6).

ID	*Domain role*	*Function*	*Name of use case*
Example-UC-AAL-01	Home	Home and building automation standards, Healthcare and Wellness	Implementing a behaviour monitoring system in the kitchen of private households with an own energy storage

1.3 Version Management

The *version management* is the same as the version management of the IEC 62559-2 Use Case Template, the *author*, *changes*, the *date* and the current *status* are captured.

Version no.	*Date*	*Name of author(s)*	*Changes*	*Approval status*
0.1	6th December 2013	M. Eichelberg	Initial creation (General description with integration profiles)	Draft
0.2	26th May 2016	M. Gottschalk	Extended general description and added the technical description	Draft

1.4 Basic Information to Use Case

The *basic information to use case* is a collection of references that describes the use case in general and its technical implementation.

Source(s)/Literature	*Link*	*Conditions (limitations) of use*
AAL Joint Program: Action Aimed at Promoting Standards and Interoperability in the Field of AAL by M. Eichelberg, L. Rölker-Denker and A. Helmer	http://www.aal-europe.eu/	Free available

1. 5 Scope and Objectives of Use Case

The first part in the table *scope and objectives of use case* describes the delimitation of the use case whereas boundaries and aims for the use case are captured.

Scope and objectives of use case and "AAL-Theme"
• Supporting in the following activities: meal preparation with a stove, oven and microwave, cleaning dishes, and tiding the kitchen. • Daily life support: Aim of the use case is to enable an independent life at home as far as it is possible. • People safety: Another objective is to reduce the number of accidents in households.

The second part gives some additional information about the range of application and the kind of implementation. Therefore, the aspects *maturity of use case*, *relation*, *view*, and *further keywords for classification* are considered in a short, concise manner.

Maturity of use case
Visionary
Generic, regional or national relation
Generic
View
Process
Further keywords for classification
Behaviour monitoring system, fall detection, automatic regulation of electronic devices, smart meter

1.6 Narrative of Use Case

The *narrative of use case* includes the *short* and *complete description* of the use case in a common way, like the description in the IEC 62559-2 Use Case Template. In this case, the description is not complete; however, it refers to the description in Sect. 2.3.

Narrative of use case
Short description
A behaviour monitoring system in the kitchen of private households shall support people with cognitive impairments in their daily activities, like meal preparation, cleaning dishes or tiding the kitchen. For these activities, various electronic devices, actuators, sensors, gateways, and third-party applications are needed which exchange information to interact in dangerous situations with the people to prevent accidents. Otherwise, the behaviour monitoring system shall notify an external person if an accident happens and the inhabitant does not react. Electric devices of the behaviour monitoring system receive their power from the local energy storage which is loaded once per day.
Complete description
People, who are living alone at home and have diagnosed a mild cognitive impairment (i.e. an early form of dementia), need any support they can get in their daily activities, particularly when they prepare their meal and dangerous electrical devices, like an oven, are used. A behaviour monitoring system in the kitchen shall assume safety aspects to prevent accidents, like falls (because there is no light), a fire in the kitchen (because their meal is forgotten on the hot stove), or a water damage (because the water tap is not closed). However, it is important that behaviour monitoring systems do not affect the stability of the power grid by frequently turning on or off electrical devices.
The behaviour monitoring system is comprised of various actuators and sensors to detect dangerous situations and prevent accidents (falls, fire, and water damage). For example, if a person enters the kitchen, the behaviour monitoring system turns on the light automatically when there is not enough light... *(Please proceed with Sect.* 2.3 *in Paragraph 1.4 Narrative of use case).*

1.7 Actors: People, Systems, Applications, Databases, the Power System, and other Stakeholders

The list of actors involved in the use case is demonstrated in the table *Actors: People, Systems, Applications, Databases, the Power System, and other Stakeholders*. Every kind of actor is described here, and also, technologies, like protocols or data models, can be mentioned here to facilitate the implementation process of the use case.

Actor name	*Actor type*	*Actor description*	*Used technology*
Home automation sensor	Device	Summarises all sensors that can be used in households to support automated functionalities	Indoor localisation sensor and body area sensor are used with the ZigBee Home Automation Protocol
Emergency call centre	External system	Answers calls of the humans and redistributes information to other participants like hospitals or the fire brigade	The call is initiate with the Session Initiation Protocol (SIP)

1.8 Issues: Legal Contracts, Legal Regulations, Constraints and others

Next to the actors involved, the issues like legal foundations and constraints have to be considered. This is done in the table *Issues: Legal Contracts, Legal Regulations, Constraints and others*, which gives an overview on laws as well as technical constraints.

Issue	*Impact of issue on use case*	*Reference*
Data protection law	Due to the high number of personal data collected, data protection laws have to be considered and the consent form has to be gathered	AAL Joint Program: Action Aimed at Promoting Standards and Interoperability in the Field of AAL, https://dejure.org/gesetze/BDSG

1.9 Referenced Standards and/or Standardisation Committees (if available)

In addition to the references in Sect. 1.4, of the template standards, standardisation committees, and their current status are listed which are relevant for implementing the use case.

Relevant standardisation committees	*Standards have to be considered in the use case*	*Standard status*
IEC system committee AAL	IEC 60050-871 Ed. 1.0	Draft
The ZigBee alliance	ZigBee specification http://www.zigbee.org/download/	Final

1.10 Relation with other known use cases

In most cases, a use case does not stand on its own, but it has various relations to other use cases. For example, the implementation of a use case can depend on other use cases or the extension of a use case by another leads to more functionalities than the implementation of both use cases regardless of each other.

Known use case	*Source*	*UC Status*
Behaviour monitoring system in private households	Include	Draft
Behaviour monitoring system in the living room	Associate	Draft

1.11 General Remarks

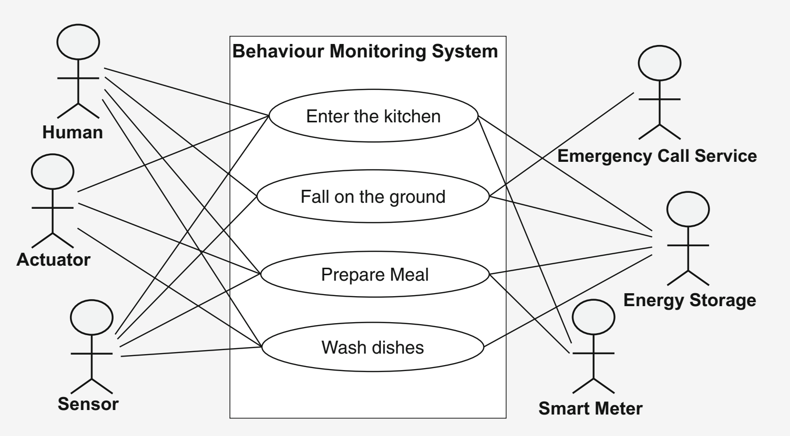
The first part ends with *General Remarks* to the use case. In this table, all information that does not fit in the previous parts is mentioned.

General remarks
• This use case does not claim to be exhaustive regarding the functionality of a behaviour monitoring system.
• Example for a use case by using the Use Case Methodology described by the SG 5 AAL.

2 Drawing or Diagram of Use Case

The second part of the AAL Use Case Template depicts the visualisation of the use case. Various drawings or diagrams, like use case and sequence diagrams as well as graph-based visualisations, can be used to illustrate boundaries and functionalities of the described use case.

Diagram(s) of use case



3.3.2 The AAL Architecture Model

The described AAL use case can also be visualised in the AAL model which has been developed by the SG 5 AAL. For example, the model with the use case example from the previous section is shown in Fig. 3.6. This model differs from the SGAM in many aspects. First of all, the use case model does not depict a reference architecture model. It only visualises the connections between actors of a use case from various viewpoints. Therefore, only four layers are considered to describe the use case functionality. In this case, the business layer is missing completely, because the aim of the use case model is to demonstrate actors, their domains and belongings to classify the use case, instead of realising business goals through a technical representation. Thus, the use case model shows all involved actors and their classification on the domains and enablers; additionally, protocols, data models, and functions as well as services which are needed to implement a use case are demonstrated in this model.

The layers are explained by [12] as follows:

- The *Semantic Layer* describes functions and services based on the underlying data which are realised by the use case.
- The *Information Layer* consists of the information model, data model, and data structure which are needed to exchange semantically well defined data.
- The *Communication Layer* describes protocols which are used by actors on the component layer to communicate with each other. Additionally, the network and connections in an AAL system are demonstrated, comparable to the seven OSI-layers [14].
- The *Component Layer* includes all actors which are needed to implement the use case. Therefore, physical devices and interfaces are defined as well as their connectivity by plugs and sockets.

Each layer is represented as a two-dimensional plane, that considers, on the one hand, the domains as an area in the AAL field, and on the other hand, the enablers which describe functions needed in an AAL system [12]. These domains and enablers are shown in Fig. 3.6.

The domains of the use case model describe the AAL environment and are explained by [12] as follows:

- The list of domains starts with *Global*, the biggest AAL environment. It describes all spaces outside a building as well as the public transportation system, e.g. parks, trains, streets.
- Public in-door spaces are described in the domain *Public buildings*, e.g. shopping centre, city halls, airports. Due to the different needs of people, the AAL environment has to be more generic than a system for one household which is adapted on individual needs.
- Another domain outsides is the *Personal vehicle*, e.g. cars, motor cycles, and electrical bicycles. This domain is not part of the home but the AAL system can be designed more customised than in the previous domains.

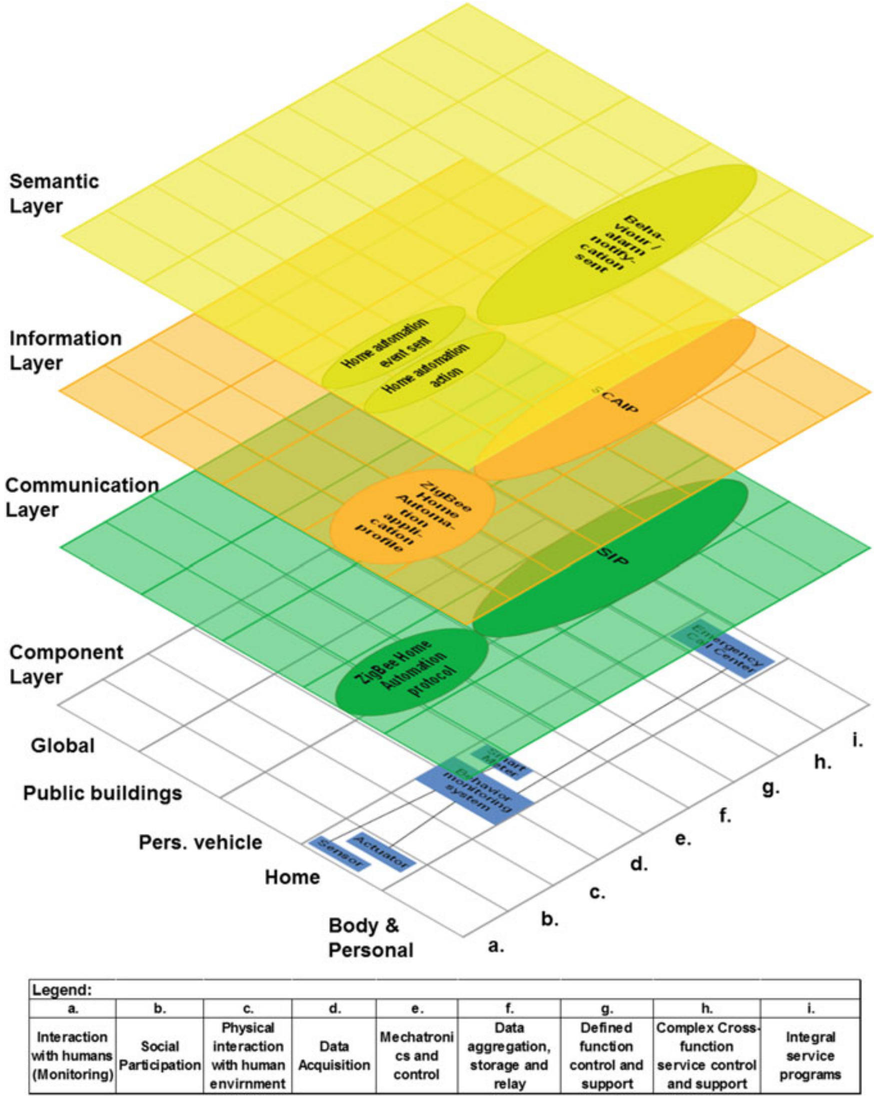


Fig. 3.6 Use Case Model from the AAL perspective (inspired by [12])

- The domain *Home* describes the spaces in which only a few people live who use the installed AAL system, i.e. a customised AAL system can be designed and installed. This kind of AAL system uses the home wireless network, routers, audio-video aids, TVs and so on for the daily life support in households.

- A more personal domain describes the domain *Body and Personal*. This domain includes AAL systems which are near around the body and can be controlled or executed by devices like smart phones, tables or body sensors.

The enablers of the use case model describe which kind of actors interact with each other and are explained by [12] as follows:

- The enabler *Interaction with humans (Monitoring)* describes the space for functionalities where a component or system directly interacts with a human, e.g. measurements in or on the body.
- On the next level, the *Social Participation* enabler describes the audio-visual interaction between humans or between a human and software, as well as the personal care, like shaving and feeding support.
- The physical interaction of AAL systems with the environment of the human is described in the enabler *Physical interaction with human environment (Assistance-System)*. It includes the machineries, like vacuum cleaner or actuators for switching the light.
- The enabler *Data acquisition* denotes the collection of all sensor data as well as the interface for entering data and further processing steps, e.g. to get the physical state of the environment like the temperature.
- For security aspects in the AAL environment, the enabler *Mechatronics and control* includes local control loops, e.g. to manoeuvre a wheel chair up the stairs.
- The content-agnostic data handling is described in the enabler *Data aggregation, storage and relay*. The recorded data is stored and prepared before it is communicated to external systems or services.
- The enabler *Defined function control and support* denotes digital and physical activities for supporting daily and simple functions, like sending a reminder for taking medicine or dispatching a task for the vacuum cleaner.
- On the next level, the enabler *Complex Cross-function service control and support* denotes tactical level coordination to perform more complex functions, e.g. the verification of the fridge content or the creation of a shopping list followed by printing this list for an assistant.
- The enabler *Integral service programs* describes functions or services for coordinating composed groups and services, e.g. external services like the emergency call centre which is linked with a rescue service to send help after the reception of alarms.

Our example in Fig. 3.6 shows the same actors on the component layer like the SGAM in Fig. 3.5 apart from the actors that are only related to the Smart Grid domain, like the energy storage, i.e. in this view only the AAL part is considered. Also, the used protocols, data models and functions are the same. However, the use case model does not depict a reference architecture for AAL systems or functions, because the connections between the domains do not have any correlations. But the visualisation in the use case model supports the allocation of existing standards to the defined use case [11]. Similar to the SGAM, actors or rather AAL components and their relations as well as their protocols and data models are demonstrated even in other regard.

For the future, the AAL Use Case Template is extended by the system committee, e.g. adding security and privacy requirements, conformity aspects and more detailed information about the interactions between actors (similar to the integration profiles). Additionally, an own architecture model for the AAL domain (AALAM) is going to be developed by the System Committee Active Assisted Living WG 2 to illustrate use cases and transactions in the form of an architecture for AAL systems [15]. Use cases from the AAL domain address other perspectives than use cases from the Smart Grid domain, so that an extended or rather a new kind of architecture model is needed. The AALAM provides such an architecture model. In its current state (version 0.9 – it is currently under discussion), the AALAM describes the AAL environment with domains, from complex system functionalities to single AAL technologies and services, and zones, from hardware and software components to enterprise application software [15]. In particular, the domains includes *Support Comfort, Well-being and Protection*, *Social Care and Social Interaction Assistance*, *Self-management of Health and Personal Care*, and *Medical Assistance*. The zone consist of *Sensor, actuator and device component*, *Software service component*, *Integration software and middle-ware system*, *Gateway to other systems and services*, *Information system*, *App and service cloud platform*, *User application*, and *Enterprise application*. The layers from the AALAM are based on the SGAM and AAL use case model layers (cf. Sects. 3.1.2 and 3.3.2). The layers are *Component Layer*, *Communication Layer*, *Information Layer*, *Function and Service Layer*, and *Organisation Layer*. On the *component layer*, all actors involved and its relations are shown. The *communication layer* demonstrates which protocols and techniques are used to exchange data between actors. The exchanged data is depicted on the *information layer*. The transactions for each actor are visualised on the *function and service layer*. Finally, the *organisation layer* describes components and business objective for the AAL functionalities.

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Chapter 4
Tool-Support – A Use Case Management Repository

Abstract In this chapter, the development of a Use Case Management Repository (UCMR) and a three-dimensional SGAM visualisation by OFFIS are introduced. Firstly, a part of the requirements specification and the functional design of the UCMR are shown. For this purpose, several functional and non-functional requirements for the UCMR are described as well as visualised by a functional design. Secondly, basic functions of the tool-support are illustrated by the previous use case example *Behaviour monitoring system in the kitchen of private households with an own energy storage*. The UCMR and the three-dimensional SGAM visualisation are depicted as screen-shots.

Keywords Architecture modelling · Requirements engineering · Use cases · Domain specific modelling · Stakeholder management

4.1 Requirements and Design

The described Use Case Methodology and SGAM approach by the mandate M/490 in Chaps. 2 and 3 can be tool-supported to facilitate the work with them. The Use Case Management Repository (UCMR) is such a tool. It is a web-application developed by OFFIS,[1] and it can be used for free.[2] Aim of the UCMR is the creation, management, and exchange of use cases as well as further related data for various projects, like architecture models, actor and requirement libraries. Regarding the described scope, the following functional requirements can be identified for the implementation of a UCMR:

1. The UCMR has to store data in a central repository.
2. The UCMR has to be implemented as a web-application for a barrier-free access for everyone.
3. The UCMR has to implement a login/logout function.

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[1]The development has been funded by the German Federal Ministry for Economic Affairs and Energy under Grant Agreement no 01FS13028, UC4AAL. Further information about the project is described in Sect. 5.1.

[2]For the registration in our UCMR, please visit: http://ucmr.offis.de.

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4. The UCMR has to implement a multi-user concept.
   a. The collection of use cases should be editable, managable, and analysable by several users at the same time.
   b. If a use case is edited, managed, or analysed, it has to be locked for other users to prevent editing; however, they can see the use case in read mode.
5. The UCMR has to implement a rights management.
   a. The administrator has to create accounts.
   b. The UCMR has to provide the following user rights: read, write, submit, and manage.
   c. The administrator has to assign the user rights for each project.
   d. The administrator has to be able to create accounts with different roles – e.g. reviewer, editor, and manager – with predefined rights.
6. The UCMR has to provide an import function for different kind of data within the UCMR.
   a. The UCMR has to import use cases as XML, DOCX and HTML file.
   b. The UCMR has to import use cases with diagrams as ZIP file.
   c. The UCMR has to import libraries as XML file.
   d. The UCMR has to import architecture models as XML file.
7. The UCMR has to provide an export function for different kind of data within the UCMR.
   a. The UCMR has to export use cases as HTML and XML file.
   b. The UCMR has to export use cases and their diagrams as ZIP file.
   c. The UCMR has to export libraries as XML file.
   d. The UCMR has to export architecture models as XML file.
8. Users have to be able to create new use cases in the UCMR.
9. Users have to be able to edit use cases in the UCMR.
10. Users have to be able to delete use cases in the UCMR.
11. Users have to be able to manage use cases in the UCMR.
12. Users have to be able to analyse use cases in the UCMR.
13. Users have to be able to create new library elements in the UCMR.
14. Users have to be able to edit library elements in the UCMR.
15. Users have to be able to delete library elements in the UCMR.
16. Users have to be able to manage library elements in the UCMR.
17. Users should be able to analyse library elements in the UCMR.
18. The UCMR should include a help function to facilitate the work with the tool.
19. The UCMR should include a search function to find keywords in use cases as well as in libraries.
20. The UCMR should include a glossary for each project.

These requirements show that there is a high relevance of the collaborative work and the data import and export functionality, to facilitate the work with this tool and to exchange data with external tools like MS Word and the SGAM Toolbox from the FH Salzburg [4]. Alongside these functional requirements, non-functional requirements have to be considered for an easy and comfortable use of the UCMR. For example, the server of the UCMR must have a high availability, so that people from different countries and time zones can use the UCMR at their usual time [7, 8]. Also, the time for data accesses on the repository has to be as short as possible to enable a smooth development process. Usability as well as security aspects are also important and requirements regarding these aspects shall be created, e.g. to check whether the contrast between the font colour and the background colour is high enough.

A general design of the UCMR is shown in Fig. 4.1. It summarises important requirements, like the import and export functionality as well as the possibility of a collaborative working environment.

First of all, the UCMR design demonstrates various data types, that can be imported and exported. It is possible to import single XML files as well as a set of XML files, which comprise use cases, libraries or architecture models. Additionally, use cases can be imported as HTML or DOCX files for importing the content and the layout. Use cases and single libraries can be exported as XML files, and additionally, use cases can be exported as HTML file for assigning the layout of the use case as well. The UCMR should be developed as web-application, so that different users can work with it at the same time with a common database. This allows a consistent use of the definition of single library elements, like actors and requirements as well as a fast exchange of use cases. The management of use cases in Fig. 4.1 means that use cases can be created, edited, ordered, analysed, and exchanged from various users, i.e. it depicts the collaborative approach. Due to this approach, communication outside the UCMR can be reduced because all users get the latest version of the

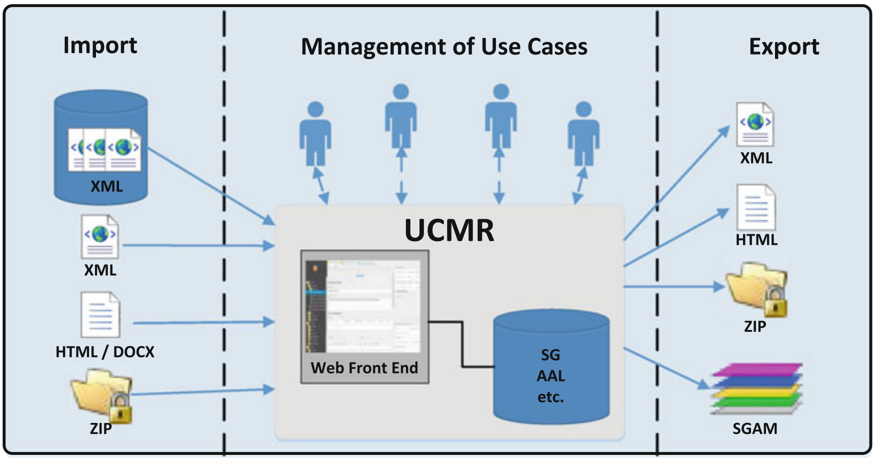

Fig. 4.1 Design of the UCMR

data from the UCMR [5, 6]. This works because use cases are centrally stored and each user has access to the latest data, which eliminates tedious and error-prone data exchange for use cases via Email.

4.2 Implementation

The mentioned requirements and the design have been implemented as web-applications by OFFIS. These include the UCMR and a three-dimensional SGAM visualisation which is linked to the UCMR, so that it can be used as one single tool. The implementation is continuously under development, so that more functions are going to be included, e.g. several user views and consistency checks within and between use cases. Earlier versions of the UCMR have been introduced at the *VDE Congress 2014* [1], the *AW4Cities Workshop 2015* on the World Wide Web [3], and the *Mensch und Computer 2015* conference [2], which demonstrates the ongoing development of the UCMR.

Figure 4.2 shows a screen-shot of our UCMR. On the left side the data within the UCMR is listed in a tree. The tree is highlighted to recognise the use cases and library elements of the project *Active Assisted Living*. Users can browse this tree and open single elements in a tab view which is shown on the right side in Figure 4.2. In this case, the use case with the identifier *Example-UC-AAL-01* is open and its content is shown in a new tab. Within the tab, the IEC 62559-2 Use Case Template is depicted. The content of the template is the same as the use case example in Sect. 2.3. Some differences between the use case view in the template and the UCMR exist, e.g. in the presentation of the use case relations as well as the scenarios and steps of the use case. The view of the use case relation within the UCMR is extended by a relation type (see at the top right in Fig. 4.2). The content of scenarios and steps is shown in single tabs in the UCMR (see at the left in Fig. 4.2) instead of in the tables like in the Use Case Template. This has the advantage that the content of scenarios and steps is clearly presented in one view, and additionally, the connections between use cases, scenarios and steps are shown in the tree on the left side of the UCMR.

For starting with the collaborative work, the administrator of the UCMR has to create new accounts and projects. Users are notified by the UCMR through an Email about their account with all relevant user data. Then each user can create use cases and libraries in their private space. If the administrator assigns the user to a project, the user is able to create, edit or manage use cases and libraries in this project. In Fig. 4.2, the project is named *Active Assisted Living*. This project includes six folders for the use cases and libraries: *Use Cases*, *Actors*, *Functions*, *Requirements*, *Transactions*, and *Open Submits*. The folder *Use Cases* can be divided in further folders to manage use cases from different topics. The elements of the other folders can be sorted and clustered via drag-and-drop. The folder *Open Submits* includes the use cases and library elements which have been shifted from another project to this one. Before these use cases and elements are part of the project, the administrator has to accept the submitted element.

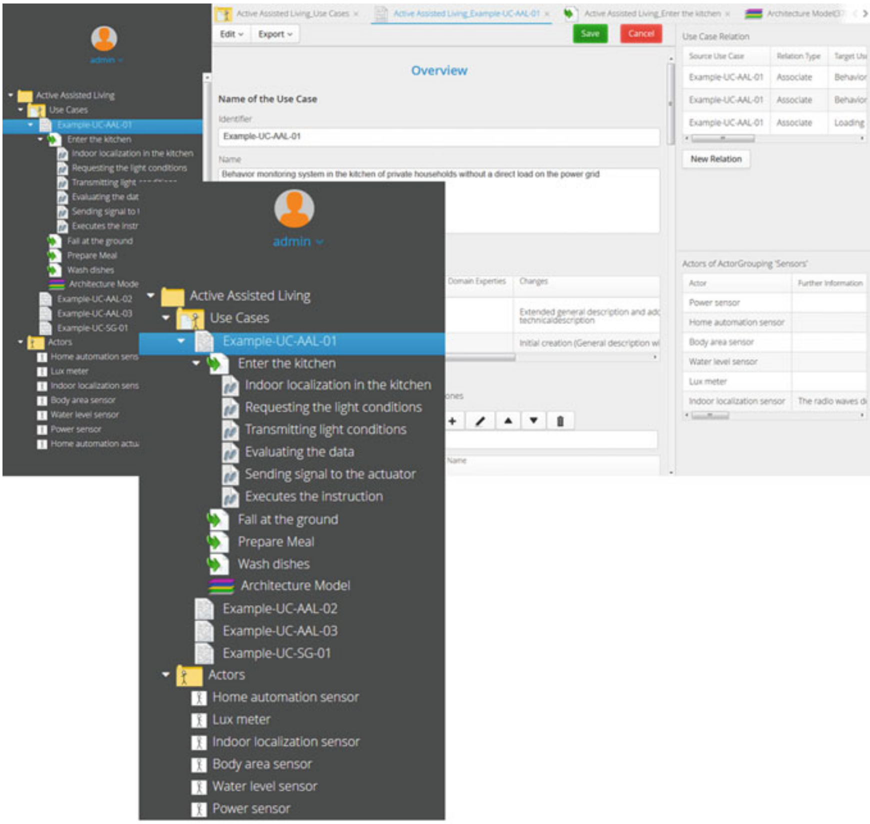

Fig. 4.2 Use Case Management Repository (UCMR)

Alongside the use case description, a visualisation of the use case in form of the SGAM (cf. Chap. 3) can be created [6]. For that, a web-based three-dimensional SGAM visualisation by OFFIS[3] has been created. This visualisation shows the connections between components, protocols, information models, functions, and business goals. At the moment, the creation of the SGAM visualisation has to be done in an external tool, like MS Visio or the SGAM Toolbox from the FH Salzburg [4], which can export the content as XML file. Our SGAM visualisation tool as well as the UCMR provide the import for various XML formats from the MS Visio template and the SGAM Toolbox. Additionally, architecture models from various domains, like electric mobility, Industrie 4.0 and maritime, can be imported and visualised in the three-dimensional visualisation tool. The SGAM visualisation tool is embedded in the UCMR to integrate the use case visualisation, so that the XML files from the UCMR are directly transferred and displayed. In the future, the XML file to

[3]Web-application for the three-dimensional SGAM representation: http://sgam.offis.de.

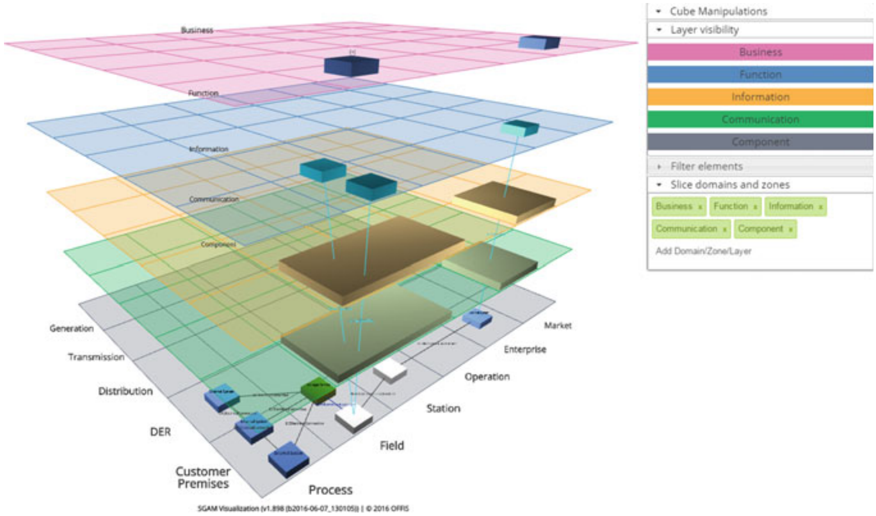

Fig. 4.3 Three-Dimensional SGAM visualisation

demonstrate the use case description as a SGAM is planned to be generated by the UCMR automatically without a detour through the MS Visio or the SGAM Toolbox. Figure 4.3 shows a screen-shot of the SGAM visualisation which is linked in our UCMR and demonstrates the use case example from Sect. 2.3.

The presentation of the SGAM in the web-application is similar to the SGAM visualisation described in Chap. 3. The interactive visualisation includes the five SGAM layers whose visibility can be switched on or off though selecting the layers on the drop-down menu within the web application to improve the readability of the other layers. On each layer, elements and their connections are shown which include further information from the use case description which are visible by a mouse-over. Further interactions with the SGAM, like the rotation about the X-axis and zoom-in, are significant advantages of a three-dimensional web-application to consider the SGAM from each side, so that all elements are visible and their information is accessible. Therewith, the SGAM visualisation enables the exploration from different perspectives of the architecture model. On the one hand, each domain and zone can be examined, and on the other hand, single layers of interest can be considered by different stakeholders.

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Chapter 5
Case Studies

Abstract Within this chapter, two projects are demonstrated as case studies in which the Use Case Methodology as well as the concept for architecture models are used with our tool-support. Additionally, further domains – Electro Mobility, Smart City, Maritime and Industrie 4.0 – are introduced that adopted the Smart Grid Architecture Model (SGAM).

Keywords Architecture modelling · Requirements engineering · Use cases · Domain specific modelling · Stakeholder management

5.1 Use Cases for Active Assisted Living (UC4AAL)

The German project *Use Cases als Basis zur interdisziplinären Konvergenz in Smart Grid und AAL – UC4AAL (Funding code: 01 FS 13028)* aims at the transfer and extension of the IEC 62559-2 Use Case Methodology (cf. Chap. 2) from the Smart Grid to the Active Assisted Living (AAL) domain. Therefore, these domains are considered in the context of complex and cross-domain systems as well as from the standardisation perspective (cf. Chap. 1). As mentioned in previous sections, the standardisation faces new challenges to gather and describe requirements for future complex systems e.g. to detect standardisation gaps (cf. Chap. 1). Supporting these challenges by the project UC4AAL is one of the main goals. The known vertical approach to describe a system's functionalities within one domain cannot be applied for Smart Grid and AAL (the top-down approach, cf. Sect. 2.2). On the one hand, the number of involved actors is too high, and on the other hand, ambiguous ideas of these systems make it difficult to specify general requirements. Thus, the vertical approach should be replaced through a horizontal approach, in which scenarios are described through the interaction between actors (the bottom-up approach, cf. Sect. 2.2). Scenarios allow a complete consideration and analysis of new systems in the area of standardisation. Prior experiences in E-Energy projects and discussions of the international IEC standardisation mandate M/490 show that the known Use Case Methodology from the IT sector can be used for the use case description in standardisation.

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Additionally, the transferability for the Use Case Methodology is checked as main goal of this project by including the domain AAL into previous work of the mandate M/490. Additionally, the concept of IHE profiles (cf. Sect. 2.4), which is a well-known methodology in the AAL sector, is included into the Use Case Methodology. For supporting use case description and administration for the large number of use cases as well as to allow use case analyses, an IT-Tool – the Use Case Management Repository (UCMR, cf. Sect. 4.1) – has been developed.

During the project, various use cases from the AAL Joint Program [4] have been described and included into the UCMR for demonstrating its functionality. These examples are used to perform test cases with various reviewers with different backgrounds to check and to improve the extension of the Use Case Methodology through the IHE profiles. Findings from this process are part of the development of the UCMR. The project results are described in the previous Sects. 4.1 and 4.2 as well as on the German conference *Mensch und Computer* [6]. Additionally, these results are applied on further complex and cross-domain systems, like Smart Cities [5, 7, 8]. This indicates that the Use Case Methodology and the IHE-process can be successful transferred to other domains.

5.2 DISCERN

The European project *DISCERN – Distributed Intelligence for Cost-effective and Reliable Solutions (Funding code: 308913)* aims to support Distribution System Operators (DSO) with services and tools that enable them to assess the optimal level of intelligence in their distribution network [3, 19, 20]. The basis of the overall concept of DISCERN is to utilise the experience of major European DSO with innovative technological solutions for a more efficient monitoring and control of distribution networks. The complementary nature of the demonstration sites with regard to specific challenges as well as technological and operational solutions serve as the main resource of DISCERN.

The knowledge sharing between the DSO is organised by use cases based on the IEC 62559-2 template, which are gathered and stored in the UCMR. These use cases describe solutions for monitoring and controlling the distribution network for future applications in the Smart Grid. During the knowledge sharing process, the DSO can take various roles: leaders, learners, and listeners; these roles describe the 3L concept of DISCERN [19]. A *leader* has good knowledge on a particular topic that has been implemented through the DSO, i.e. a DSO with this role shares its knowledge. A *learner* is a DSO which learns from the information provided by the leader. A *listener* studies the information provided by leaders and learners to check whether the implementation of a new function through the learner is successful. Based on this information, the listener decides whether this function and its implementation process can be realised for its own operation. Due to the classification in roles, use cases from different perspectives as well as technical specifications and alternatives can be created.

Next to the Use Case Methodology, the SGAM approach is applied in the project [18, 19]. For the described use cases, the conforming Smart Grid Architecture Models (SGAM) have been developed. Thus, the project has shown that use cases described by the IEC 62559-2 template can be transferred to the SGAM. Therefore, an XML schema has been developed which links elements from the use cases description with the components of the SGAM to enable a smooth transformation from the use case to the SGAM [18]. For collecting and visualising use cases and the SGAM, the tool-support described in the previous Chap. 4 is used. Due to the application of the tool-support, further ideas and comments are collected for developing the UCMR and the three-dimensional visualisation. Additionally, a broad acceptance from the users has been registered during the work with the tool-support [2].

5.3 Transfer to Other Domains and Future Application

In the last chapters, the architecture model for the Smart Grid domain has been explained (cf. Chap. 3), and additionally, concepts from the AAL domain about the use case model and the AAL architecture model are introduced (cf. Sect. 2.4). In this section, further (reference) architecture models from several domains are described [21] to give an overview on current application areas Electric Mobility [16, 22], Smart City [8], Maritime [9], as well as Industrie 4.0 and its legal aspects.

5.3.1 Electric Mobility Architecture Model (EMAM)

The domain *Electric Mobility* considers the application of electric vehicles in the Smart Grid as well as the connection between car, cable, pole, and point-of-common coupling (PCC). The architecture model is called *Electric Mobility Architecture Model (EMAM)* and an example is shown in Fig. 5.1. The layer concept is the same as for the SGAM (cf. Sect. 3.1.2). Thus, the layers are not explained in this chapter again. However, domains and zones are described briefly to demonstrate their links.

The EMAM has been developed as high-level model to demonstrate relations and connections between components from the electric mobility sector. The domains depict the energy conversion chain similar to the SGAM domains, however, in a more detailed manner from a consumer perspective. The zones demonstrate the connection between the electrical vehicle and its internal functionality with the power grid, the future Smart Grid. The domains are extracted from the German Standardisation Roadmap for Electromobility [23]; they are mentioned by [22] as follows:

- The *Distribution* represents the infrastructure and organisation which distributes the electricity to the customer, like households and SMEs.
- *Distributed Energy Resources (DER)* are small power plants which are directly connected to the public distribution grid with small-scale power generation technologies (in the range of 3–10.000 kW).

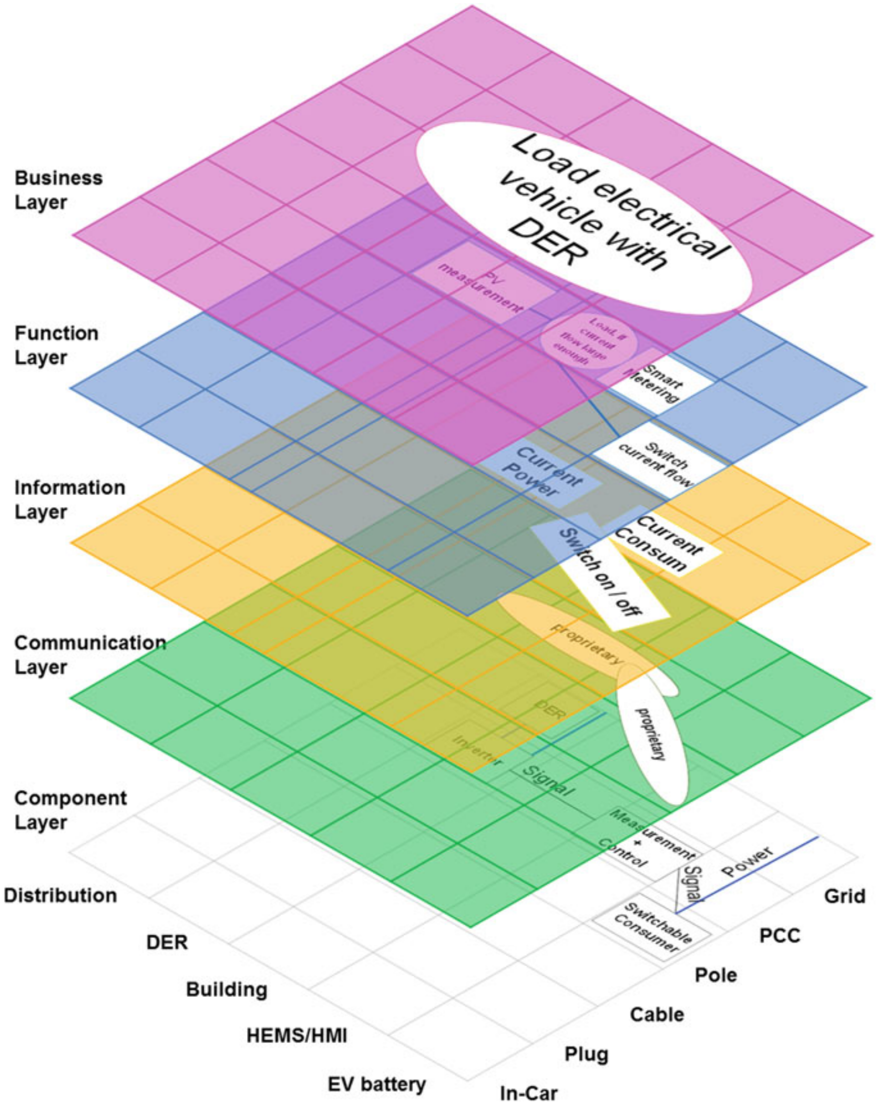

Fig. 5.1 Electric Mobility Architecture Model (EMAM)

- The energy distribution within a household or SME is demonstrated in the domain *Building*.
- The *Home Energy Management System (HEMS)/Human Machine Interface (HMI)* represents the control system for the energy distribution in households and SMEs.
- The *Electric Vehicle (EV) battery* stores the energy and can be located in an EV or a charging station.

The zones are also derived from the German Standardisation Roadmap [23] and are mentioned by [22] as follows:

- All components and systems within the EV are part of the zone *In-Car*, like control units, multimedia equipment, and navigation tools.
- The *Plug* describes the interface of the EV, which for example provides data about the battery level.
- The *Cable* represents the connection to transfer power and information between the EV and the charging station.
- The battery charger and the charging station are depicted as zone *Pole*, which is connected to the energy distribution system within households and SMEs.
- The interface between the pole and the power grid (distribution network) is described by the *PCC*. Thus, this zone supports the communication for services with external providers.
- The *Grid* represents the power grid where associations like virtual power plants or vehicle fleets act.

5.3.2 Smart City Infrastructure Architecture Model (SCIAM)

The Smart City Infrastructure Architecture Model (SCIAM) is shown in Fig. 5.2. It describes one particular new derivative from the original SGAM. First introduced and discussed in the German DIN/DKE Smart Grid Standardization roadmap for Smart Cities [24], it is a proposal based on the success of the original model of the SGAM. Instead of the business layer, a so-called *action layer* is proposed but not yet agreed upon [8]. Additionally, the zones are adopted from the SGAM, i.e. they cover a mostly hierarchical way of structuring physical locations. *Market*, *Enterprise*, *Operation*, *Station and Field* as well as *Process* form the zones axis. This list can be considered as a natural ordered list not being based on a bag principle. At this place, the layers and zones are not explained in more detail and we refer to Sect. 3.1.2 in which they are described for the SGAM.

For the SCIAM domains, a new axis has been developed. The SCIAM describes a model to visualise functions in a Smart City which affect more than one domain; thus, the domains for Smart Cities depict the different areas in cities which influence the quality of life, efficiency of urban operations and services, and competitiveness [13]. The domains are mentioned by [24] and depict the major areas of a Smart City are *Supply/Waste Management*, *Water/Waste Water*, *Mobility Transport*, *Healthcare/AAL*, *Civil Security*, *Energy*, *Building*, and *Industry*. These domains can be explained in a more detailed manner through further architecture models, like the SGAM (cf. Sect. 3.1.2) for *Energy*, the EMAM (cf. Sect. 5.3.1) for *Mobility Transport*, or the AALAM (cf. Sect. 3.3) for Healthcare/AAL. Thus, the SCIAM does not only demonstrate a single information flow but a number of various scenarios, like the implementation of smart traffic lights or the waste management for industry, which describe an information flow across multiple domains and can be demonstrated with this model.

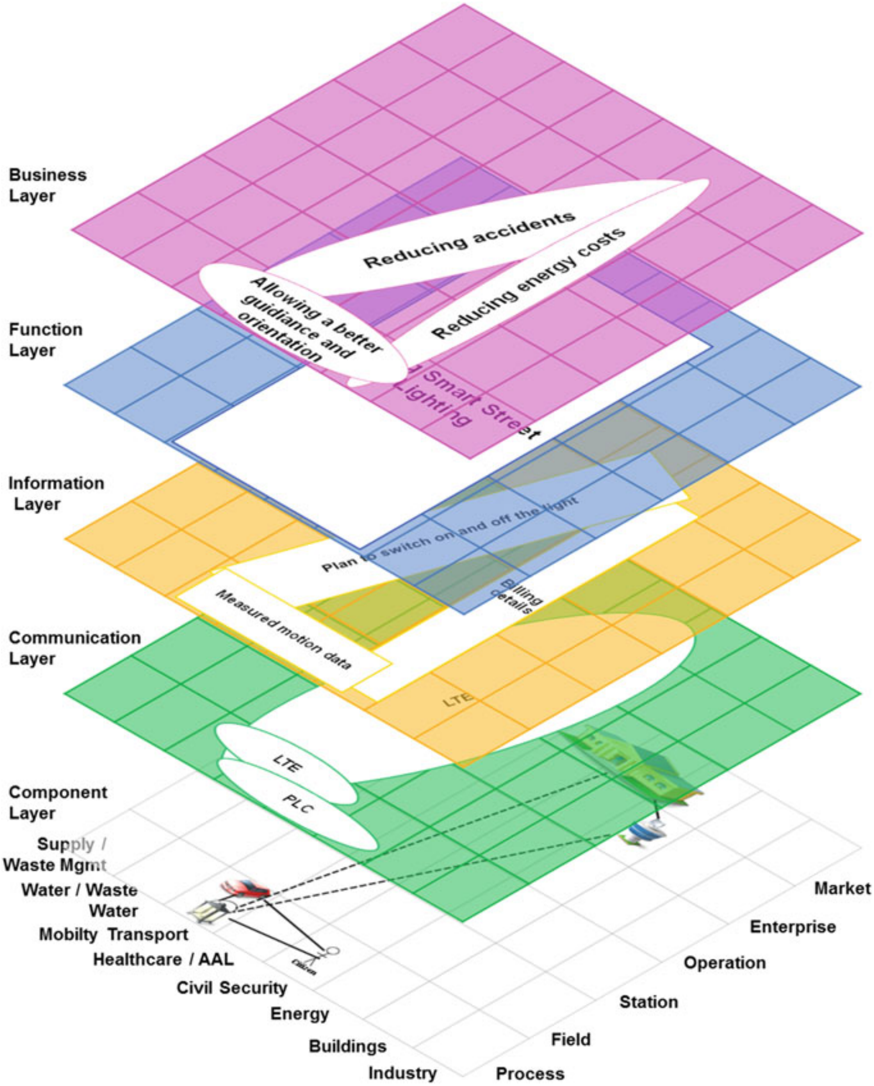

Fig. 5.2 Smart City Infrastructure Architecture Model (SCIAM)

Based on this initial proposal, a model has been developed and brought to attention of IEC SEG 1 as well as the SSCC-CG (Smart and Sustainable Cities and Communities) at European level. Looking at this model, it is apparent that a different granularity than in the SGAM is needed as the SGAM cube is at most one lane in the overall SCIAM scope. Therefore, the group has to develop a more high-level view on the use of the designation schema and limit itself to focus on the convergence aspects of individual domains in order to achieve synergies between them.

5.3.3 Maritime Architecture Framework (MAF)

The Maritime Architecture Framework (MAF) is shown in Fig. 5.3. It describes another derivation from the SGAM, this time in the maritime sector. The MAF has been discussed and developed during the project *EfficienSea2* as an architecture framework to depict information exchange between maritime actors and services

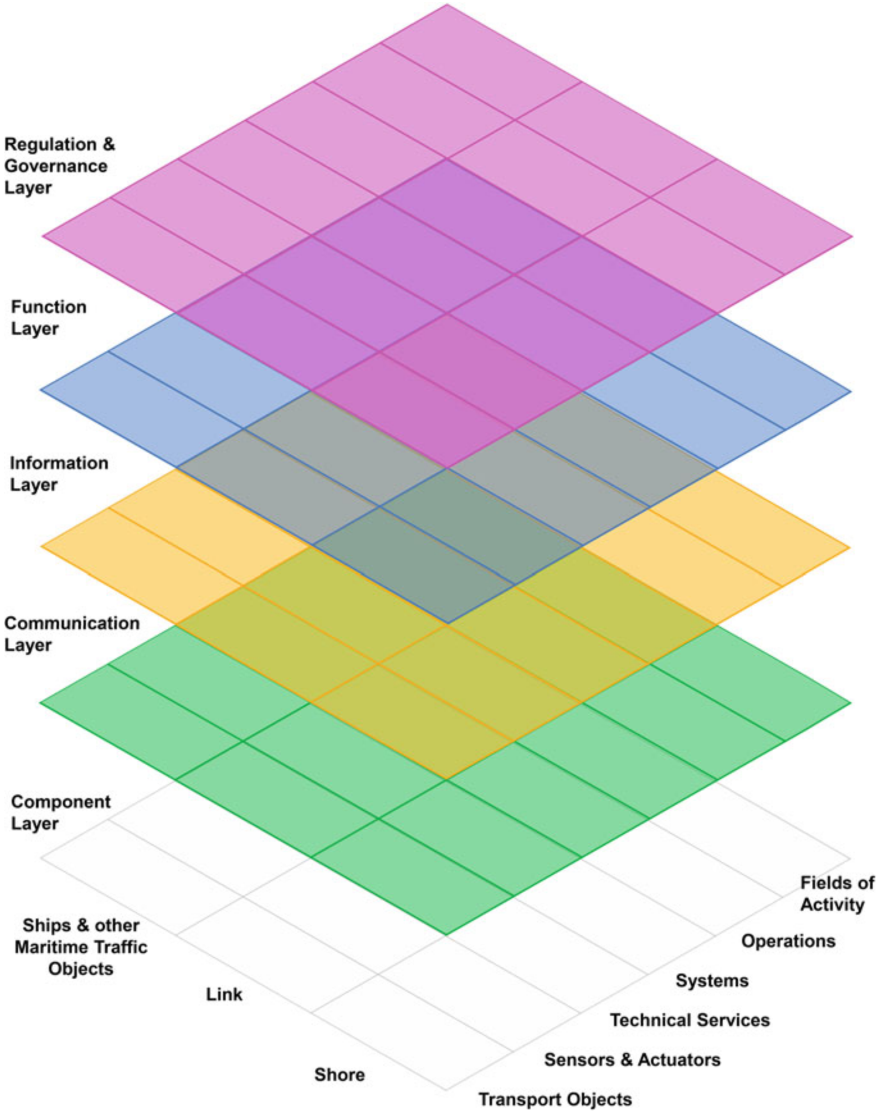

Fig. 5.3 Maritime Architecture Framework (MAF)

from a Maritime Cloud [17]. The *Maritime Cloud* is a framework which provides standardised protocols and functions for identity and role management, authentication, encryption, service discovery, and bandwidth efficient messaging in a geographic context for the maritime sector. Thus, the information exchange between the Maritime Cloud and further actors from the maritime sector has to be created interoperable. Actors are various software systems on-board, off shore as well as on shore, and personal devices, like smart phones and tablets.

The construction of the interoperability layer is analogous to the SGAM – apart from the *Regulation and Governance Layer* which replaces the *Business Layer* – hence, the layers are adopted and not explained at this place (cf. Sect. 3.1.2). For the domains and zones, new axes are developed that match the maritime sector. The domains are based on the International Maritime Organization (IMO) e-navigation strategy and divide the architecture into a ship-side and shore-side view [17, 25]:

- *Ships and other Maritime Traffic Objects* are actors which are at sea; these can be vessels, cargo or passenger ships.
- The *Link* describes the connection between actors from the ship-side to the shore-side with telecommunication methods and protocols. This includes actors like radio tower and transmission masts.
- Actors on the *Shore* are sea ports, docks, halls, and third-parties where ships land or which organise the shiploads.

Similar to the other architecture models, the zones describe the hierarchy and aggregation of management and control systems [17, 25]. The zones are:

- All components and systems which can execute a physical action are depicted in the zone *Transport Objects*, e.g. ship, crane, port, transmission masts.
- The zone *Sensors and Actuators* includes all components which are needed for receiving or sending data, like antenna, transceiver, ISO 11898, etc.
- Single services are shown in the zone *Technical Services*, e.g. IEC 61162 and NMEA (National Marine Electronics Association) 2000.
- Actors, information objects and protocols for operating and control services are displayed in the zone *Systems*, e.g. the vessel traffic service (VTS).
- In the zone *Operations*, the operating and control units from global, regional, national or local perspective are depicted, like the VTS centre.
- In the zone *Fields of Activity*, systems are described which support markets and eco systems along the maritime domain, e.g. a traffic message broadcast.

5.3.4 Reference Architecture for Industrie 4.0 (RAMI 4.0)

The Reference Architecture Model for Industrie 4.0 (RAMI 4.0) is the most sophisticated derivative of the SGAM as of today, developed by the German Electrical and Electronic Manufacturers' Association (ZVEI) [14]. Based on the German Industrie 4.0 concept, the main aspect is the re-use of the GWAC interoperability stack. In addition to *Business*, *Function*, *Information*, *Communication*, and *Asset* representing the *Component* layer, a new layer called *Integration* is introduced [21]. On the integration layer, components or systems are placed which display production plants without an own ICT interface as a virtual representation in the digital value chain [1, 15]. The further layers are explained in Sect. 3.1.2 for the SGAM. The RAMI 4.0 visualisation is displayed in Fig. 5.4.

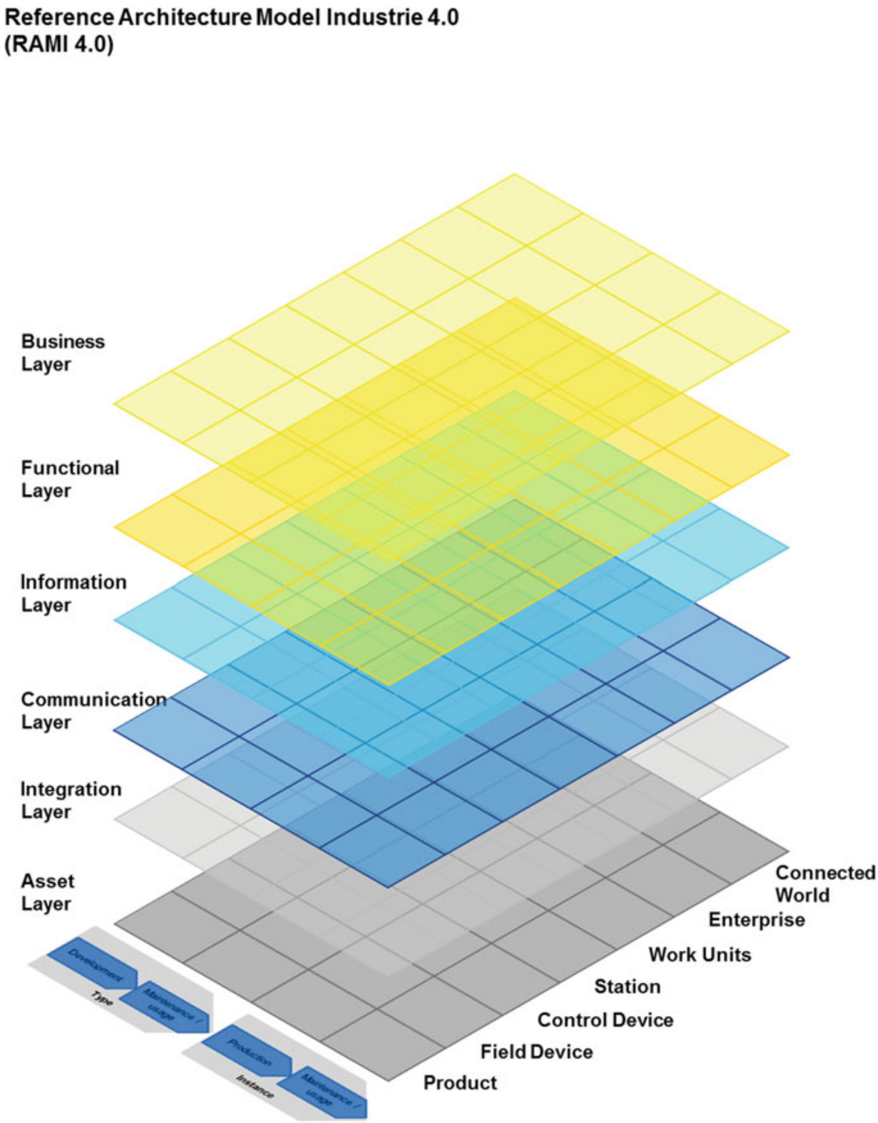

Fig. 5.4 Reference Architecture for Industrie 4.0 (RAMI 4.0)

The domain and zone axes are not custom taxonomies, but are based on the IEC 62890 value stream chain and the IEC 62264/61512 hierarchical levels, respectively. The *Domains*, as value stream chain [1], describe the life cycle of systems or products, and establish the distinction of:

- A *Type* is always created with the initial idea, i.e. a product comes into the *Development* as well as the *Maintenance/Usage* phase for testing the first samples.
- Products, that are manufactured industrially, are in the domain *Instance* which consists of the steps *Production* and *Maintenance/Usage*.

The distinction between *Type* and *Instance* is done to show whether the product is in the development (or rather prototyping) or production phase. The connections between plants and the data exchange can vary between these two phases so that the distinction makes sense. Additionally, if a product is improved by new functions, it is reported back to the development phase to produce prototypes before the actual production begins.

The *Zones*, as hierarchical levels, describe different functionalities inside a factory or a plant. These functions are complemented through the zones *Product* and *Connected World* to map the complete Industrie 4.0 environment [1, 14]. The zones are explained by [1, 11, 12] as follows:

- The *Product* describes the unit which is produced by a system or machine.
- For considerations within single machines and systems in factories, the zone *Field Device* is added which represents the functional level of an intelligent device, e.g. smart sensor.
- A *Control Device* describes a physical unit, that combines a mode selector, an adjuster for manual control of the actuating drive and a reference-variable adjuster for the controller.
- Complete machines and systems are illustrated in the zone *Station*.
- Dissimilar machines grouped together to produce a family of parts having similar manufacturing requirements are mentioned as *Work Units*.
- An *Enterprise* consists of one or more organisations sharing a definite mission, goals and objectives to offer an output such as a product or service.
- The zone *Connected World* depicts the interface to external firms, component suppliers and customers, etc.

The main purpose of the model is defined by ZVEI as follows: The model shall harmonise different user perspectives on the overall topic and provide a common understanding of relations between individual components for Industrie 4.0 solutions. Different industrial branches like automation, engineering and process engineering have a common view on the overall systems landscape. The SGAM principle of having the main scope of locating standards is re-used in the RAMI paradigms, also using it as a reference designation system.

The next steps for proceeding with the modelling paradigm is to come up with "101 examples" for Industrie 4.0 solutions in the RAMI, provide proper means for devices to be identified and provided discovery service modelling for those devices, harmonise both syntax and semantics and focus on the main aspect of the integration layer which is introduced in order to properly model the communication requirements in factory automation [15, 21].

5.3.5 Legal Reference Architecture for Industrie 4.0 (ju-RAMI 4.0)

As a co-evolutionary model to the aforementioned RAMI 4.0 model from the previous section, the so-called legal reference architecture model 4.0 (ju-RAMI 4.0 as by the German abbreviation) has been developed in the very context of the AUTONOMIK Industrie 4.0 funding scheme [10]. One of the aspects of having more and more complex systems interacting with each other is the separation of the individual organisations participating and operators of system-of-system parts. Legal aspects come into play in terms of liability for components, products and copyright for processes or solutions.

The ju-RAMI 4.0 aims at providing simple access to terms and wording used in the legal domain to lower the entry barrier for technical aspects to take into account legal risks and challenges at development time for the solution. One particular aspect is the visual representation of various dimensions of legal requirements in order to structure those aspects during the lifetime and -cycle of the product. Different legal domains (privacy, intellectual property, liability, etc.) are addressed and put in context with the original RAMI 4.0 reference designation system. While the model itself cannot address all legal issues from the jurisdictional point of view, it provides a useful visualisation of certain keywords for starting the discussion of various legal aspects of the product development phase as well as the inherent attributes of the intelligent product. As law is not a natural science but more or less interpreted, provided solutions can only hint to needed aspects to be discussed with legal departments. The authors claim to provide compliance barriers by defining risks and liability involved. This can lead to a better understanding of legal aspects of industrial internet solutions.

The axes of the ju-RAMI 4.0 are defined as follows. The vertical axis covers the defined and needed legal domains (like intellectual property rights, data protection law, workers protection law, civil rights, ...); the horizontal axis entails the actors participating in the development based on the original RAMI 4.0 model and clusters them in four areas of actors groupings. Finally, the third axis covers the risks involved when a certain legal requirement is not met. The authors suggest the following main advantages of the ju-RAMI [10]:

- Initial structures of the mapping of legal aspects and technical scope is provided.
- Initial overview on risks involved with the development as well as the operational scope is provided.
- Initial mitigation strategies to cope with risks identified in the model are included.

- Identification of legal processes to be followed to properly address the issues as product development and life cycle is given.
- One-stop-shop for glossary terms for partners with a more technical background exists.
- There are gap analyses for certain aspects which are arising from disruptive technological innovation like e.g. 3-D printing and corresponding rights to e.g. the shape models used for printing.

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Chapter 6
Future Applications of the Results from the EU Mandate M/490

Abstract Within this chapter, we outline the future application of the Use Case Methodology based on IEC 62559 and the Smart Grid Architecture Model (SGAM) as results from the EU Mandate M/490 to CEN, CENELEC and ETSI. Therefore, an overview of this book is given, in which all findings from this book are summarised. Additionally, next steps are demonstrated for applying the Use Case Methodology and the SGAM in the future.

Keywords Architecture modelling · Requirements engineering · Use cases · Domain specific modelling · Stakeholder management

6.1 Summary and Current Status of the Methodology Presented

As the title of the book series directly states, this book can only act as a brief introduction to the overall standards described in the context of use case management. Use cases or their agile version, the so-called user story, can only act as the first steps in the context of a meaningful requirements engineering process [15]. As the INCOSE Systems Engineering Handbook has already motivated, one important aspect in the overall system-of-systems development is the committed life cycle cost against the time dimension [5]. The cost to extract defects from the final product differs between the various phases. For the design phase, it may be three to six times as high as in the concept phase, for the develop phase even higher with twenty to hundred times the cost [10]. In addition, the complexity is rising but at the same time the technology acceleration leads to shorter overall time available for the development of the product and shorter time for coordination between the stakeholders involved. Combined with the fact that, being systems-of-systems (SoS) and inherently wicked, this is true for critical infrastructures, the need for a proper and meaningful requirements management process is obvious. With stakeholders from different domains participating, agreeing on terms, levels of interoperability and scopes of functions to be implemented is of highest relevance.

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The approach arising from the IntelliGrid project and extended by the IEC TC 8 as well as the IEC SyC based on the IEC 62559 Use Case Template helps to structure the early phase for domain-specific solutions for the power systems domain. As early as 2009 [13, 19], approaches existed to standardise the functional side of the Smart Grid projects emerging. The M/490 sustainable processes group has provided a lot of ideas and tooling to use the template not only as a file-based repository of word documents on a network drive, but to have a fully-fledged web-based Use Case Management Repository (UCMR) ready for various stakeholders in both standardisation and demonstration projects. Within this book, we have presented the Use Case Methodology as well as the requirements for a functional UCMR in the context of two domains, power systems as well as Active Assisted Living (AAL). While the UCMR provides a lot of information on the processes, dynamic aspects and non-functional aspects of the system, the static architecture with its various viewpoints has to be modelled in a different way to complement the use cases documented.

Therefore, the SG-CG group for reference architectures created the Smart Grid Architecture Model (SGAM) to model various viewpoints about Smart Grid solutions. Based on this reference designation system for the three dimensions value chain, utility organisation as well as technical interoperability layer, a static explosion drawing of a smart grid solution can be visualised; thus it provides a more differentiated view on the architectural dimension of the solution presented. The efforts of creating a common UCMR as well as creating the SGAM have been spent in parallel, making a harmonised meta-model based on the ISO 42010 standard necessary to properly coordinate between the work of the two groups [14]. Within this book, we have briefly presented results from the two working groups of the Smart Grid and AAL domain with a focus on the IEC 62559 Use Case Template [4]. As motivated, the information gathered in the template of the IEC 62559 provides meaningful input for functional as well as non-functional requirements on certain power system functions. While the sequence diagrams as well as the package diagrams from the UML mostly cover relevant aspects, the full potential of modelling with various viewpoints like business processes, data exchanged, information models and interfaces as well as involved physical assets is lifted with the SGAM. While it has originally been designed to cover only gap analysis for Smart Grid standards, it outgrew this purpose and has become the *lingua franca* for visualising Smart Grid solutions in research and development projects. Even though the mandate focused on the harmonisation of both methods into a single coherent tool-chain, still certain gaps had to be covered. This work is done within the IEC System Committee on Smart Energy, extending the previous work of the IEC TC 8 and their working groups on system aspects of power delivery. With the upcoming IEC 62913 series, it is going to be further harmonised and put in context with blue-print, generic Smart Grid use cases modelled in the corresponding template.

Based on the structured approach defined for the Smart Grid, a systems engineering effort can be defined, taking into account useful theory from this discipline [16]. System-of-systems have several characteristics in common which means the presented approach from the Smart Grid infrastructure domain can be applied with changes also in the scope of other system and cyber-physical system environments (CPS) like Industrial Internet, Smart City, Smart Home or AAL. The previous chapter has provided a short overview on how tailoring the methodology is done. Still, new applications of the models and methods in both requirements elicitation processes [7], security analysis [8, 20] as well as enterprise architecture management (EAM) [1, 17] level arise. The next section of this chapter elaborates more on the future as well as ideas which can fit the scope.

6.2 Future Work and Evolution of the Use Case and SGAM Methodology

The application in projects and the overall use of both the Use Case Methodology and the SGAM from the mandate M/490 is increasing. Based on the first large-scale projects conducted, as described e.g. with the FP7 DISCERN project in this book, studies using methods like the German study on the extension and costs of the national distribution grid [2], the Austrian RASSA project [6] and the upcoming German SINTEG (Schaufenster Intelligente Energie)[1] projects, the method and tools used get relevant feedback to be improved and customised to user demands. As this book has outlined, new initiatives aim for establishing new practices for both the Use Case Template as well as the architecture models.

Within this book, we provided an extension of the existing IEC 62559-2 template for the scope of AAL. One important aspect is the extension of the templates to cover the concept of IHE integration profiles. While doing the project, it has become clear that one large advantage of using the template is the agreement on common concepts and vocabularies. With people from various backgrounds participating in a project, one basic problem is to actually agree on formulating the problem to be solved [16]. When one part of the challenge is formulating the actual problem, due to the sheer complexity of the large scope, the heterogeneity of both the partners and their tacit views becomes much of a difficulty. As INCOSE has outlined, the costs of changing a solution and system during later stages increase dramatically compared to the early system development phases, the requirements phase is of utmost importance to the overall cost and time. With the template, the process becomes structured in terms of the glossary and technical views needed. In addition, non-technical requirements and standards which may never have been in the original scope as well as best-practices emerge from re-using existing IEC 62559 based use cases. The upcoming series IEC 62913 focuses on this, providing a link to the SGAM from the very start and taking into account the well-known technical reference models as well as the conceptual models [11] in the Smart Grid domain. Furthermore, this aligns the two methods into one single tool-chain, which has already been envisioned in e.g. [3, 9], and the corresponding tool-boxes based on the Sparx Enterprise Architect UML

[1] http://www.bmwi.de/DE/Themen/Energie/Netze-und-Netzausbau/sinteg.html.

tool. Future use is going to focus not only on the elicitation of the requirements but also on analysis of those requirements. Metrics are going to focus on interoperability scores, cost-benefit analysis or risk analysis [21]. Based on best-practices documented, maturity of solutions as well as migration paths can be identified and motivated [12, 18]; this is going to lead to further re-use of knowledge and help solving the issue of complexity as well as classification of problems occurring.

In addition to the alignment of the methods in the original scope, more effort is to be spent on the generic architecture reference designation models for interoperability architecture modelling [17]. The previous chapter already shows initial approaches which gain both national as well as international momentum. With viewpoints defined for various levels, providing a meaningful overview on a technical system solution becomes easier for the discussion of such a solution. With the upcoming harmonisation of the RAMI 4.0 model as well as the Industrial Internet Reference Architecture (IIRA), a new, possibly bigger scope than with the original methods is addressed. As Newton has once pointed out, "*if I have seen further, it is by standing on the shoulders of giants*", the original work still provides the very base due to the formalisation, the processes, tool design and serialisation formats provided.

6.3 The Approach in Context of the IREB Processes and Tool Recommendations

The methods described in this book are in line with well known requirements engineering processes as e.g. described in [10]. Different types of requirements elicitation techniques exist and can be utilised, as there are survey techniques, creativity techniques as well as document-centric and observation techniques. The use case approach is defined as a so-called support technique. In general, use cases focus on the external view of the system to be developed. Within this book, we have not defined how the requirements which are covered by the IEC 62559 template shall be elicited. The described approach focuses mainly on the phase of documenting requirements. As defined by the IREB (International Requirements Engineering Board), three main perspectives for requirements exist. The data, functional and behavioural perspective are all covered by the IEC 62559 template. In addition, the approach covers the documentation using natural language as well as conceptual models which is endorsed by IREB. Pohl and Rupp [10] provides both a meaningful reflection on the work presented for the domain specific approach in this book as well as a good introduction for a requirements engineering role in the context of the methods described in this book. One particular focus of Pohl and Rupp is on model-based requirements documentation which can as well be focused on in this context. The UCMR presented in this book also fulfils several of the requirements towards requirements engineering tools presented and discussed in [10]. The tooling presented has been developed with having a light-weight, office-software based tool with little costs in mind. One key aspect is the standardised interface as well as the XML-serialisation defined in the standard. This provides a possibility to implement various tools for this very data format, making specialised tools, e.g. based on UML tools like Sparx Enterprise Architect, Rational DOORS, or simulation tools as well as model-driven IDEs possible.

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