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*.

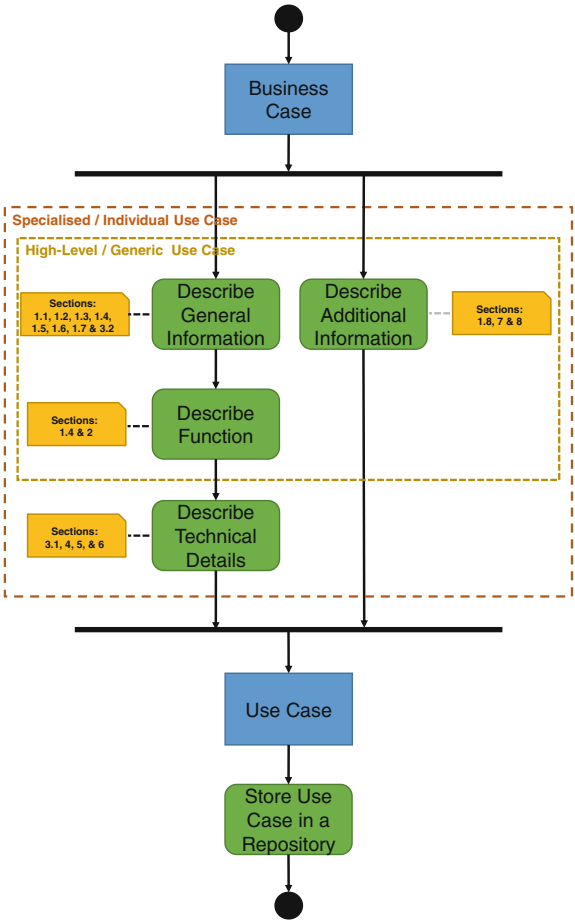


Fig. 2.1 Process of the Use Case Methodology

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

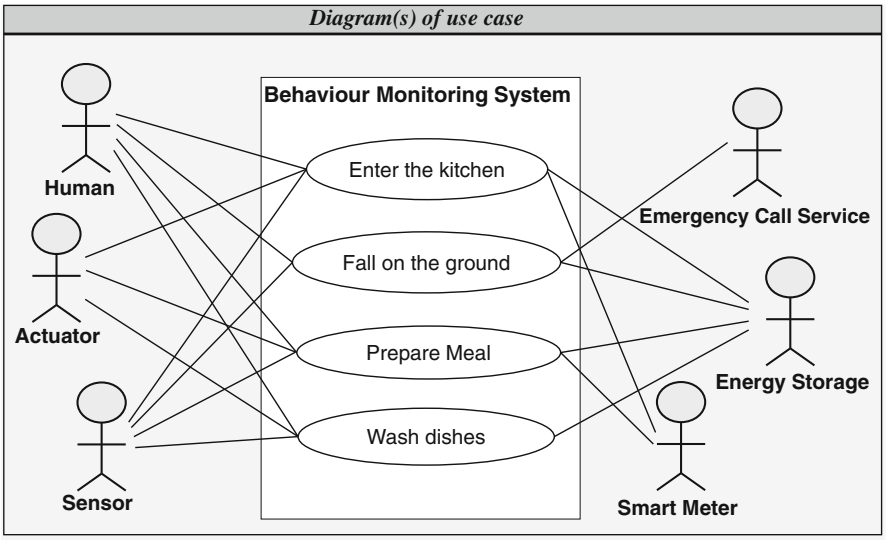
1.8 General Remarks

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.



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/

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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 localisa-tion 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

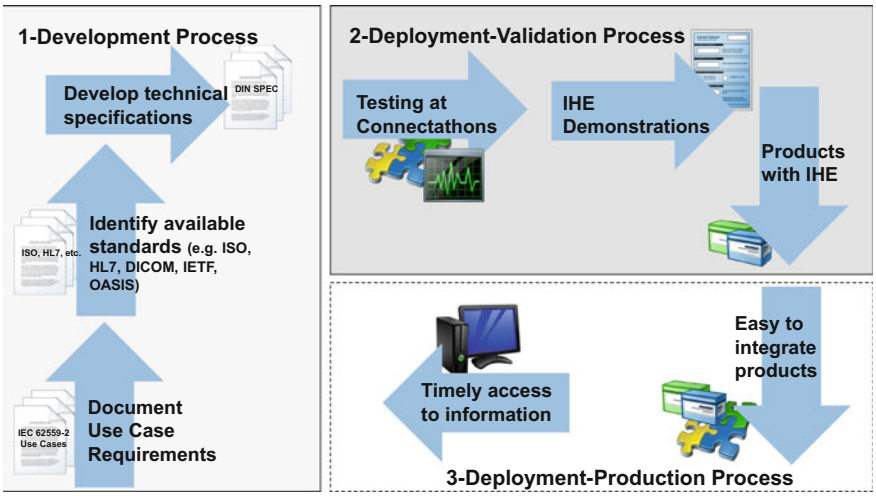


Fig. 2.2 The IHE development and deployment process (inspired by [9, 11])

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

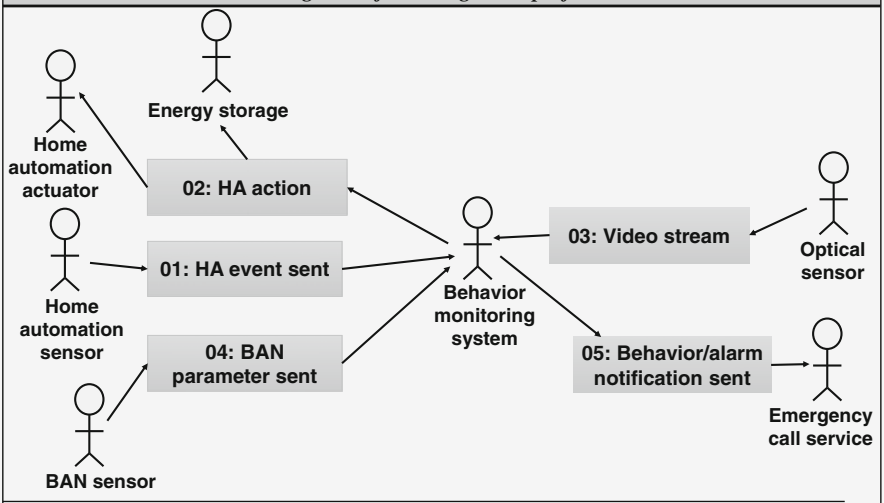
First of all, an *overview of integration profiles* is given in Sect. 9.1 of the template. This overview includes a *name* and a general precise *description* for the integration profile. Additionally, the description is extended by a description of the *high level process and data flow*, which gives 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.

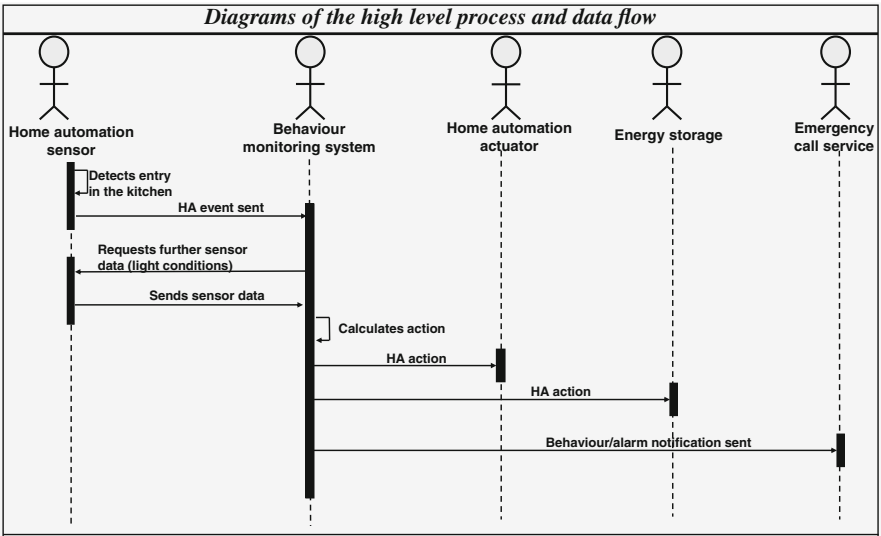
Diagrams of the integration profile



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.



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

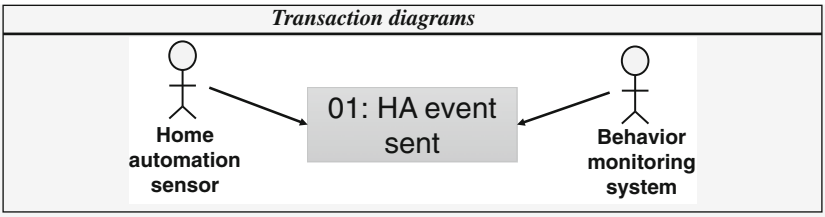
The description of single transactions which are part of an integration profile is done in Sect. 9.5 of the template *Transactions – Integration profiles*. This table is divided into two tables because of its size; hence, the field *name* and *transaction name* are shown twice. The *name* shows the corresponding 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.



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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