Energy@Home Technical Specification

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Revision: 1.1
Status: Version 0.7

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1 Foreword

Energy@home is a collaborative project between Electrolux, Enel, Indesit Company and Telecom Italia.

The aim of the project is to develop a communication infrastructure that enables provision of Value Added Services based upon information exchange related to energy usage, energy consumption and energy tariffs in the Home Area Network (HAN). The project envisions a protocol that shall be used to build an integrated platform to allow cooperation between the main devices involved in residential energy management:

- The **Electronic Meter**, responsible for providing certified metering data. The meter shall be interfaced via a new-generation device called Smart Info to enable communication with the telco infrastructure and the household appliances;
- The **Smart Appliances**, able to cooperate in order to adjust power consumption by modifying their behavior, while preserving the quality of service and user experience;
- The **Smart Plugs,** able to collect metering data and to implement a simple on/off control on the plugged energy loads other than Smart Appliances;
- The **Home Residential Gateway**, which acts as the central coordinator of the entire home. It allows data exchange between the devices operating in the Home Network, in the Home Area Network, and in the Internet;
- The **Customer Interfaces**, i.e. all the devices used by the customer to monitor and configure his/her energy behavior.

These actors identify the main categories of devices in the Home Domain, without any limitation to the possibility for a device to implement functionalities from more than a category. As an example, an advanced Smart Appliance, provided with a rich user interface, could also implement functionalities typical of a Customer Interface. In the same way, a personal computer might be considered a Smart Appliance from the protocol point of view if it was able to behave like a white good within the HAN.

From a **functional point of view**, Energy@Home envisions a system that can provide users with information on their household consumption directly on the display of the appliance itself, on the smart phone or on their computer. It is expected that, through easy access to information on consumption and through the possibility of downloading custom applications, consumers will be able to use their appliances in a “smart” way by enhancing the energy efficiency of the entire house system. For instance, Smart Appliances can start functioning at non-peak (and therefore less expensive) times of day as well as they can cooperate to avoid overloads by automatically balancing consumption without jeopardizing the proper execution of cycles.

The project is a further step towards the development of the so-called "**smart grid**", that, in the future, will allow continuous real-time two-way information exchange between utilities and appliances in the houses to enable each customer to “self-manage” his/her energy behaviors depending on power supply availability and prices.

The first deliverable of the project was the "Energy@Home Use Cases" document, where the system architecture was presented together with reference application scenarios. In the document, different type of services were defined, taking into account incremental levels of interoperability in order to provide customers with different levels of service, starting from simple awareness, until the achievement of a fully integrated Energy Management system. The first release of the Use Cases was identified taking into account the experience of the partners involved in the project and constitutes the initial set of functionalities that shall be addresses by Energy@Home and that are the subject of this technical specification document. Further versions of the document are envisaged during the development of the project, whenever partners shall identify the chance to implement supplementary categories of services for customers also taking into account additional experiences and points of view.
The project goal will be pursued through the following plan of milestones:
M1. identification of use cases relevant to the protocol and definition of the system architecture;
M2. definition of the protocol by leveraging existing standards and integration of partner's devices to implement a system prototype;
M3. assessment of the protocol and of the prototypes interoperability
M4. proposal of a pilot market test which will involve selected customers throughout Italy.

This document is the second deliverable and represents also the second milestone of the Energy@Home project. It reports the technical specifications of the HAN protocol that supports the Energy@Home use cases.

Information in this document is preliminary and subject to change, however anyone is encouraged to review and provide comments at the following e-mail addresses:

enhome-comments@avalon.tilab.com
comments@energy-home.it

Energy@Home is now starting a validation phase of these technical specifications by encouraging to carry out field trials that are based on these specifications. Energy@Home reserves the right to publish future versions of these specifications without any prior notice.

Companies' Profiles

Enel is Italy's largest power company, and Europe's second listed utility by installed capacity. It is an integrated player which produces, distributes and sells electricity and gas. Further to the acquisition of the Spanish utility Endesa, Enel has now a presence in 23 countries with over 95,000 MW of net installed capacity and sells power and gas to around 61 million customers. Enel was the first utility in the world to replace its 32 million Italian customers' traditional electromechanical meters with modern electronic devices that make it possible to take meter readings in real time and manage contractual relationships remotely. This innovation has enabled Enel to implement time-of-use electricity charges, which offer customer savings for evening and weekend electricity use, an initiative that has attracted interest from many utilities around the world, especially in Spain where Enel's subsidiary Endesa is about to install 13 million electronic meters to its customers.

Electrolux is a global leader in household appliances and appliances for professional use, selling more than 40 million products to customers in more than 150 markets every year. With a culture of passion for innovation, customer obsession and drive for results, the company uses thoughtful design and extensive consumer insight to meet the real needs of consumers and professionals. Electrolux products include refrigerators, dishwashers, washing machines, vacuum cleaners and cookers sold under esteemed brands such as Electrolux, AEG-Electrolux, Eureka and Frigidaire.

Indesit Company is one of the European leading manufacturers and distributors of major domestic appliances (washing machines, dryers, dishwashers, fridges, freezers, cookers, hoods, ovens and hobs). It is the undisputed leader in major markets such as Italy, the UK and Russia. Founded in 1975 and listed on the Milan stock exchange since 1987, the Group posted sales of €2.6 billion in 2009. Indesit Company has 16 production facilities (in Italy, Poland, the UK, Russia and Turkey) and 16,000 employees. The Group's main brands are Indesit, Hotpoint-Ariston and Scholtès.

Telecom Italia is an integrated telecommunications company that operates mainly in Europe, the Mediterranean basin and South America. It is a major Italian enterprise and a key European strategic ICT player. Driven by technological innovation and a commitment to service excellence, Group companies operate in fixed-line and mobile telecommunications, Internet & Media, Information Technologies.

1.1 Scope

The scope of this document is the Home Area Network (HAN) and its aim is the specification of the HAN protocol that supports Energy@Home use cases.
At this very moment an international standard of a functional profile covering all the defined Energy@Home (**E@H**) use cases does not exist.
This document is based upon [R8] and it aims at proposing a new ZigBee Profile, leveraging on both the functionalities of ZigBee-based application specification (profiles [R2]-[R5]) and CENELEC interworking specifications ([R6]-[R7]), to cover the E@H use cases.
The E@H protocol has been defined as a ZigBee profile leveraging on both ZigBee Home Automation and ZigBee Smart Energy features (cluster and devices) whenever possible. The profile has been designed to be potentially mapped as an extension of existing standard Public profile.

1.2 Version conventions

The E@H specification follows a convention commonly used by other standard such as Bluetooth and ZigBee.

- **0.7 Specification Completed**
  The 0.7 Specification is the first feature complete version suitable for implementation. The specification is considered stable enough to start the implementation and preliminary testing phase.
- **0.9 Specification Completed**

The 0.9 Specification has resolved comments coming from the first run of the testing phase and there is a test plan in place.

- **1.0 Specification Completed**
  The 1.0 Specification, test plan are completed and implementations have been tested. Testing logs and a test summary are available for review.

1.3 Related Documents

[R1] Energy@Home project, *"Energy@Home Use Cases"*, Rev. 1.2, April 23, 2010.
[R2] ZigBee Application Framework Working Group, ZigBee document 075123, *"ZigBee Cluster Library Specification"*, October 19, 2007.
[R3] ZigBee Standards Organization, *"ZigBee Home Automation Public Application Profile-Version 1.1"*, February 8, 2010.
[R4] ZigBee Technical Steering Committee (TSC), ZigBee Document 053474r17, *"The ZigBee Specification"*.
[R5] ZigBee Standards Organization, ZigBee document 075356r14, *"ZigBee Smart Energy Profile Specification"*, May 29, 2008.
[R6] BSI British Standards, document BS EN 50523-1:2009, *"Household appliances interworking - Part 1: Functional specification"*, July 2009.
[R7] BSI British Standards, document BS EN 50523-2:2009, *"Household appliances interworking - Part 2: Data structures"*, July 2009.
[R8] Indesit Co, *"Use Cases: Smart Appliances Requirements and Data Structures "*, Rev. 1.0, March 22, 2010.
[R9] Indesit Co, Telecom Italia, *"Energy@Home, ZigBee and EN50523"*, Rev. 1.0, March 22, 2010.
[R10] ZigBee Standards Organization, ZigBee document 075356r15 *"ZigBee Smart Energy Profile specification"*, Rev. 15 December 1, 2008.

2 System Architecture

2.1 Protocol Basics

The ZigBee application architecture is presented in [R4]. The specific E@H devices can be implemented leveraging on one or more Application Objects (each one relying on its own communication Endpoint), belonging to the ZigBee Application Framework.
ZigBee application objects include a collection of clusters, i.e. a related group of commands and attributes, which together define an interface to specific functionality.

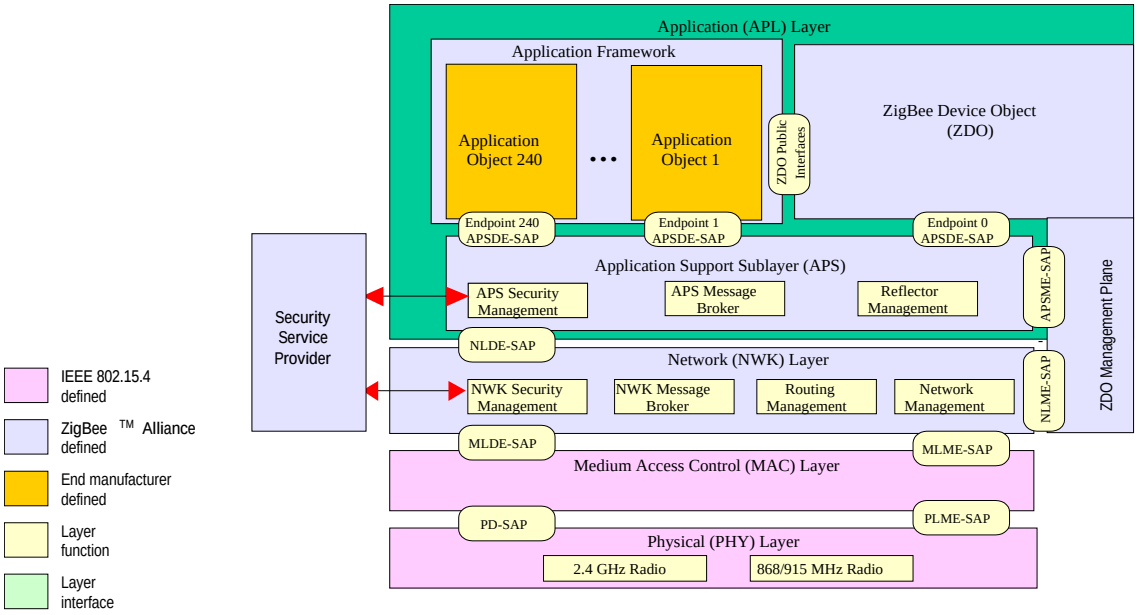

Figure 1 – The ZigBee application architecture[1].

2.2 Energy@Home Networking

Smart Appliance connectivity is expected to become a standard functionality in the next future. This will enable innovative services through an evolution from the current stand alone appliance to the future Smart Appliance. In the scope of E@H project, connectivity and digital domain computation will enable in-house smart power management.

To this purpose, the adoption of several communication protocols, either wired or wireless, has been proposed (Konnex, LonTalk, Ethernet, etc.). ZigBee RF transmission promises to be a feasible

[1] ZigBee Architecture as described in [R4], ZigBee Alliance® Copyright

solution: it is cost-effective and it is getting even less expensive over time; at the same time it provides the flexibility of a wireless communication and benefits of the worldwide standardization of application profiles. Hence, in the following, ZigBee is referred as the HAN communication technology (see Figure 2 below).

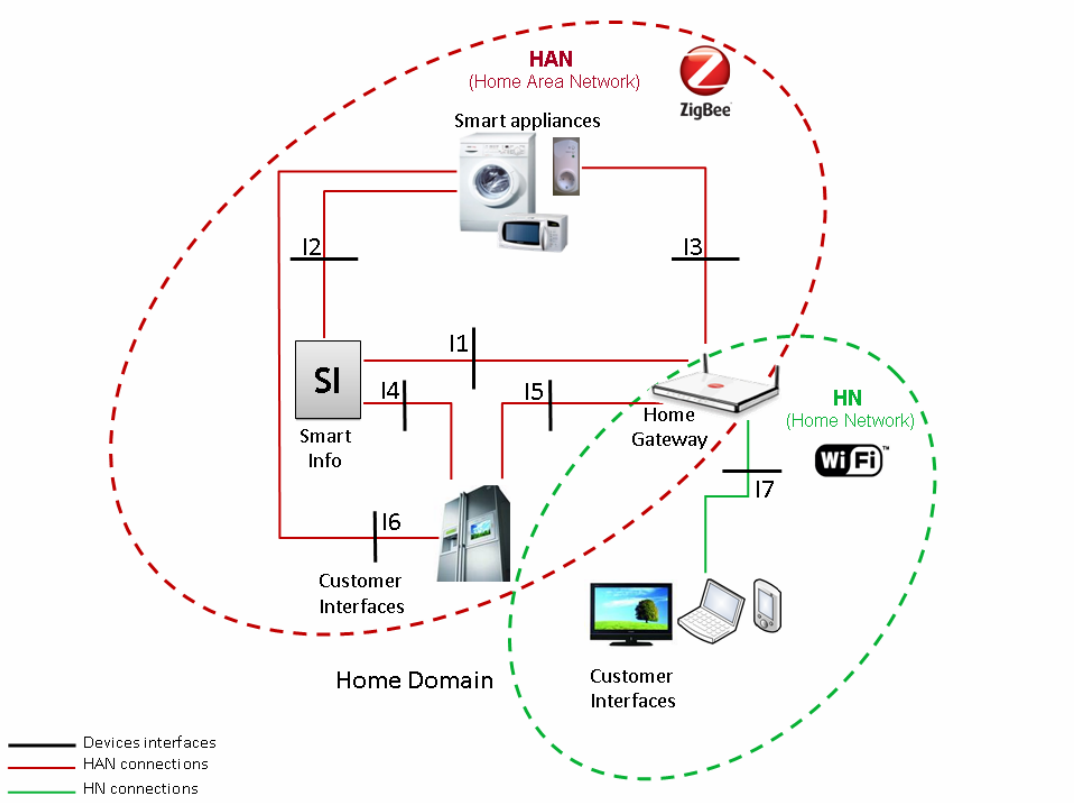

Figure 2 – HAN and HN connections.

The figure represents the user's Home Domain that includes both the HAN and the HN. In this domain all the home devices (i.e. Smart Appliances, Smart Plugs, Home Gateway, Smart Info and Customer Interfaces) can cooperate through some communication mechanism as specified in these technical specifications.
In the figure the Smart Info is the device that enables the Electronic Meter of the DSO to communicate with the HAN, while the Home Gateway is the telco broadband residential gateway with the extended functionality of gateway between the HAN, the HN and the WAN (i.e. broadband connection to internet). All the depicted interfaces are logical ones and are expected to be implemented through the communication technology specified in this document.

3 Sequence Diagrams

This section reports a set of sequence diagrams that show the possible interaction between E@H devices.

3.1 Control modes

The interactions between the Energy@Home devices can be operated in two different control modes, depending on how each device is willing to participate to the overall system control operation:

- Operating mode without E@H control (**E@H control disabled**): this is a special case of awareness, and it is described in section 3.4.1.2 of the document
- Operating mode with E@H control (**E@H control enabled**)

Selection of the control mode has to be harmonized by the functional controller (e.g. the Home Gateway), how that is done and how it is selected by the user is implementation specific and is outside the scope of these specifications: for instance a special button on the appliance might be used or, alternatively, a special function on the Central User Interface, or some other mechanism, may be adopted depending on the implementation.

3.2 Startup and discovery

The device association and discovery procedures are dependent on the underlying protocol used (see chapter 4 for mapping of Energy@Home into the ZigBee protocol). However, the general Startup procedure shall follow the steps listed below:

1. Home Gateway present:
    - The Home Gateway opens the network (i.e. enable other device joining the HAN);
    - The Home Gateway manages the authorization and authentication of the new HAN devices willing to join the E@H network;
    - The services offered by the HAN devices shall be automatically discovered using the underlying protocol service discovery procedures: the E@H devices shall then detect the addresses of the devices they are required to communicate to;
    - an auxiliary mechanism for enabling the configuration of the HAN by using an interface exposed by the Home gateway should be supported as well;
2. Home Gateway NOT present:
    - Since the Home Gateway is not available, the admission procedure should be managed by another device, responsible for the authorization and authentication of the new HAN devices willing to join, which shall provide user with a user-friendly interface; alternatively, if no user interface would be supported by this device, a pairing mechanism with the other HAN devices shall be enabled (such as button pressed or other peering techniques).

An example of sequence diagram for Smart Appliance and Smart info joining a Home Gateway is reported in Figure 3.

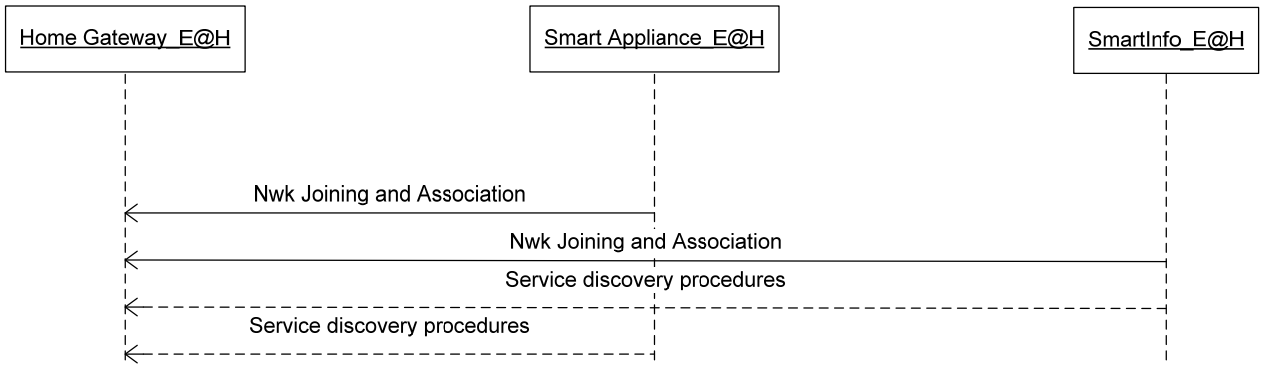

Figure 3 – Startup and discovery procedure.

The service discovery procedure shall leverage on the procedures defined by the communication protocol (for ZigBee see paragraph 4.8)

3.3 Customer Awareness

3.3.1 Visualization of current energy, power and price data

These sequences of messages represent a possible implementation of the scenario 1 as it has been described in [R1]. The energy, power and cost information should be distributed on the E@H network using the procedures depicted in Figure 4. In case the Home Gateway is operating in the E@H network it shall acts as a mirror for the information to the other devices on the HAN: that means that the Home Gateway shall maintain up to date data related to energy, power, and energy cost (if required), associated to each device as well as metering data from the Smart Info related to home global consumption. The devices willing to access this information should access the mirrored information in the Home Gateway. That mechanism provides the following main advantages:

- it enables sleeping devices in the network: since devices may sleep in the network, the Home Gateway (always-on device) should buffer the data to be retrieved by the other devices in the HAN;
- it reduces the need of broadcast messages enhancing the performance in case of wireless E@H network: the mirroring feature on the Home Gateway enables the other devices to communicate in unicast to the gateway itself, reducing the need of the broadcast messages in the HAN (typically considered unreliable mechanism for the wireless HAN).

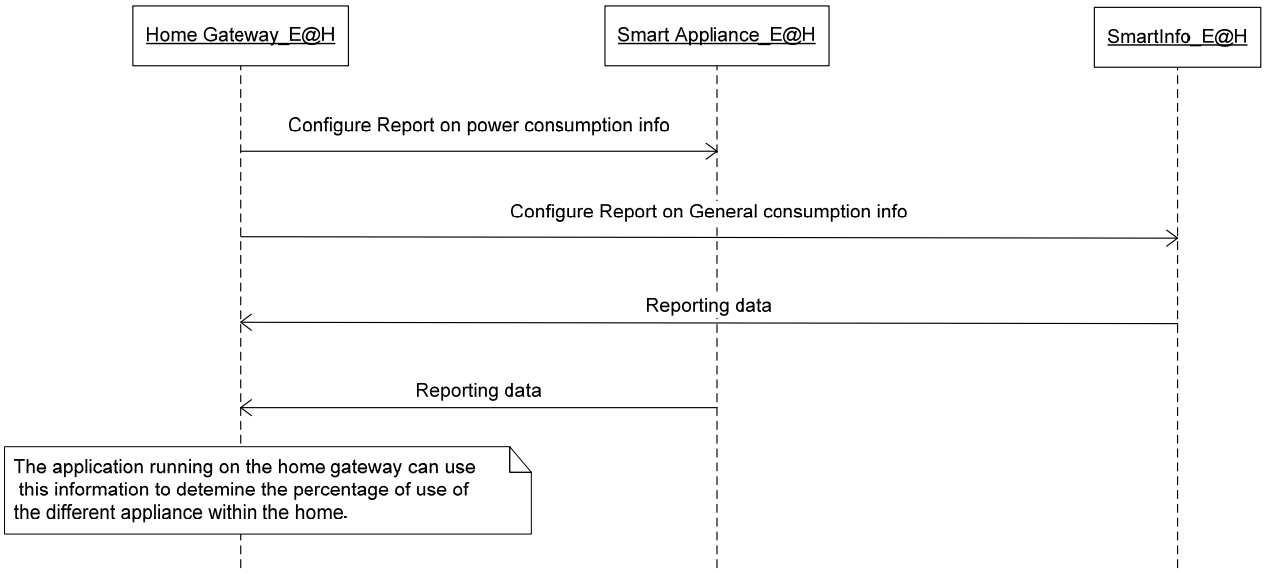

Figure 4 – configuration of energy, power, and price reporting procedure.

3.4 Appliance regulation

3.4.1 Home Domain Overload management and Optimize energy cost in case of multi-tariff contract (scenario 5 and 6)

Referring to [R1] the following considerations and descriptions concern the scenario 5 and scenario 6 (control of power peak and optimization of the energy use). The two scenarios are grouped because they present lots of similarities.
These two scenarios, in fact, imply that the Smart Appliance, in order to perform its main functions (washing, cooking, …), has to interact both with the Home Gateway, the Smart Info and the User.

The description of these interactions is divided into three sections:

- **COMMON**
- **SET-UP (or SELECTION)**
- **OPERATIVE**

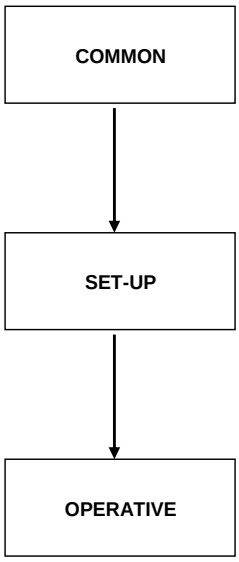

Figure 5 – Section sequence.

3.4.1.1 COMMON section description

This section concerns with the messages related to the whole system, such as the total instantaneous power (measure in kW) currently used in the house or the tariff profiles.

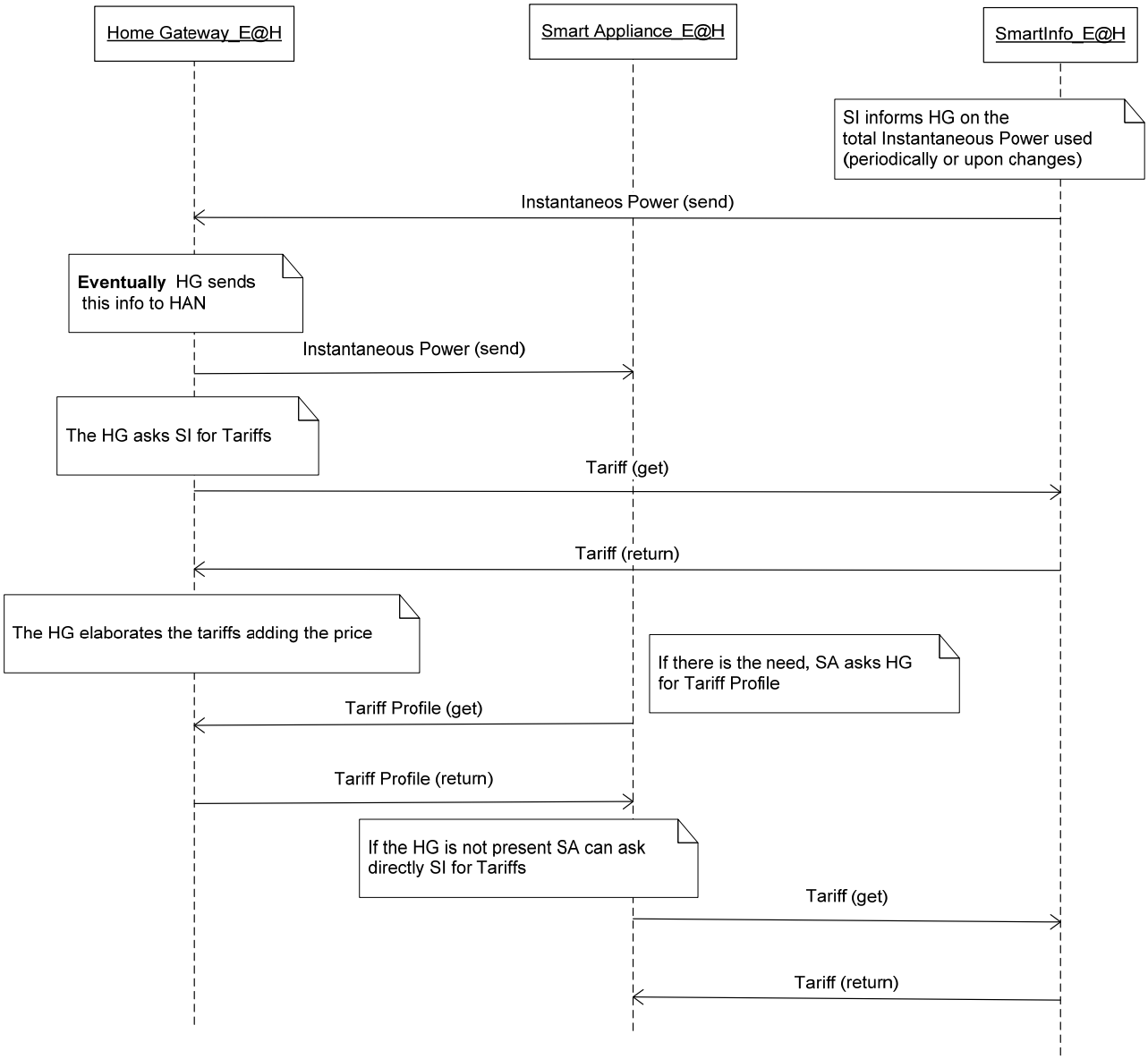

Figure 6 – COMMON section messages exchange

This information will be sent periodically or when a significant event occurs (e.g. when power consumption changes by more than a specified quantity). Warnings coming from the Smart Info device to the E@H network (such as power overload risk) are described in paragraph 3.4.1.3.

3.4.1.2 SET-UP section description

This section concerns with the set up or the selection of the user preferences when the Smart Appliance is required to operate. Depending on the options selected by the user, the behavior of the machine is different.
The information exchange is here described, not the functionality of the machine: it will be up to the implementation to define if and how to show some information or how the machine should act (e.g. showing a message asking a user to wait or blinking LEDs).

The user switches on the machine, then selects the machine function (e.g. cycle program) and finally request to start the appliance.

3.4.1.2.1 Energy@Home Control Disabled

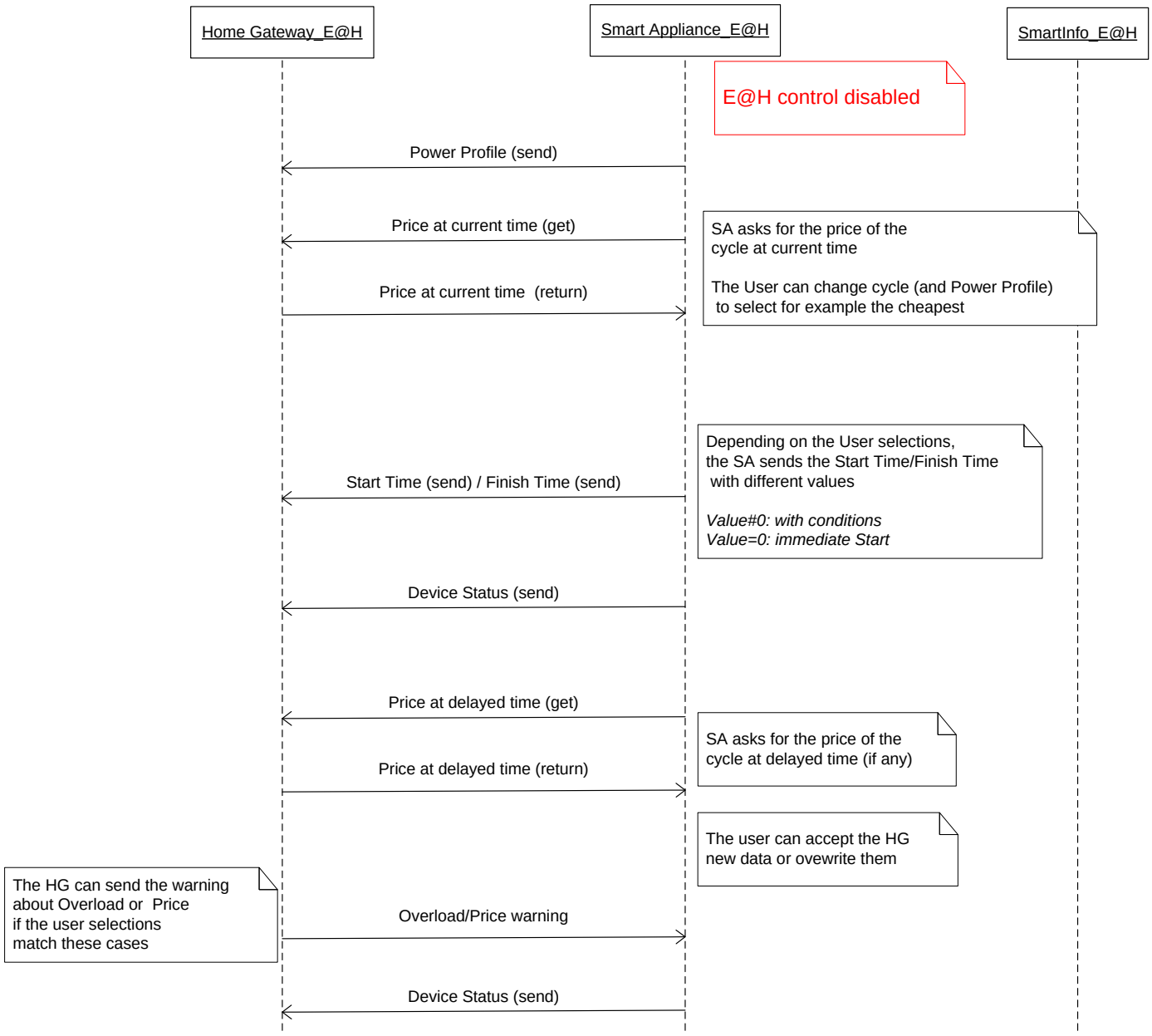

Figure 7 – E@H Control Disabled sequence diagram

3.4.1.2.2 Energy@Home Control Enabled

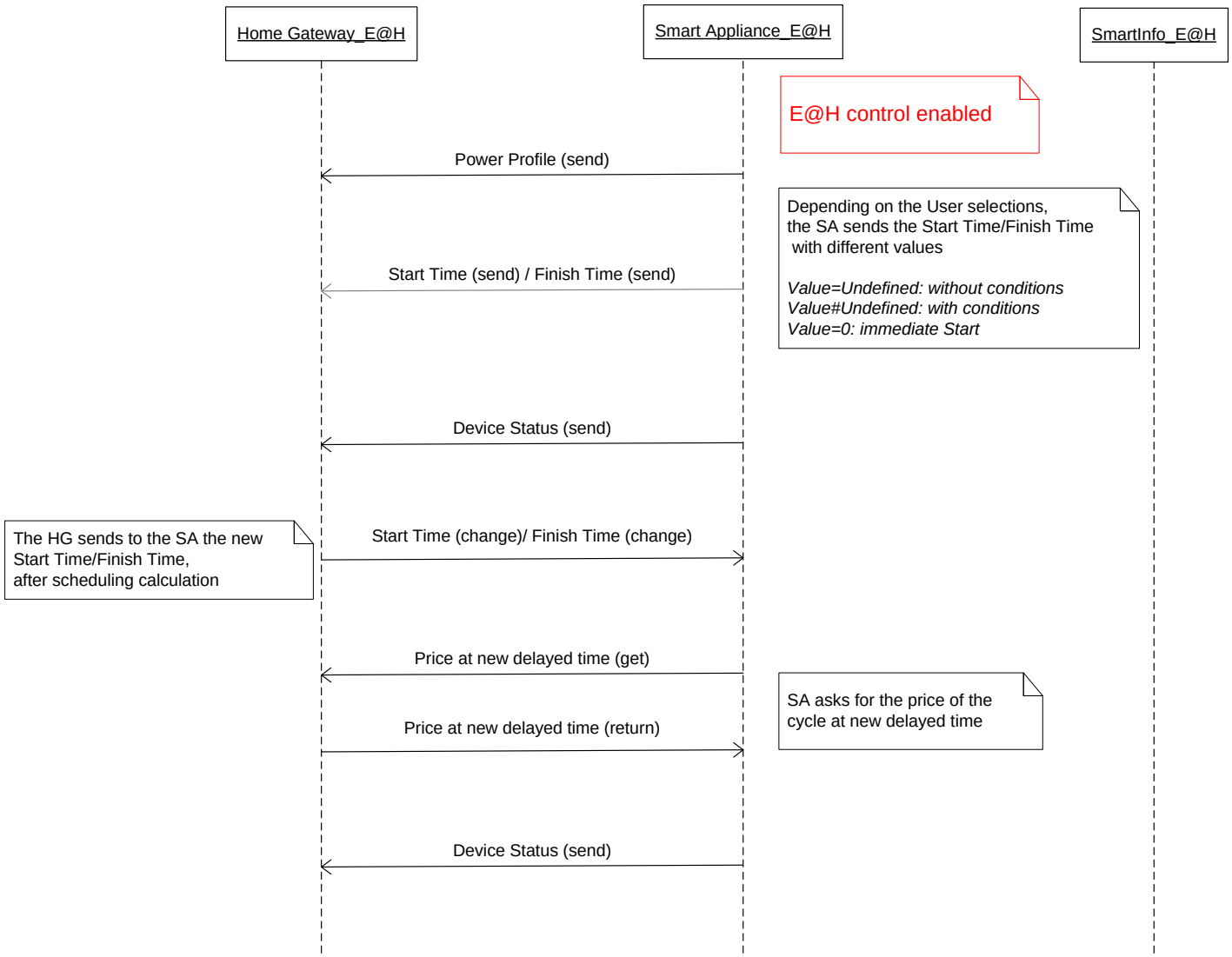

Figure 8 – E@H Control Enabled sequence diagram

Please note in the sequence diagram that Start Time message coming from the appliance has to be intended as optional in case of Value=Undefined (without condition); in this case the E@H control scheduling and price calculation should be operated considering the result of the optimization (and not intended as immediate start requested by the appliance).

3.4.1.3 OPERATIVE section description

Overload condition. When the total instantaneous power used by the house (measured in kW and described by the attribute *InstantaneousDemand* in case of ZigBee) exceeds the contractual limit (described by the attribute *DemandLimit*), the SI starts to send periodically to the HG (e.g. every 60 seconds) an "Overload Warning" alarm. This alarm will be reset by sending once the "End of Overload Warning" message when the total instantaneous power returns below the limit. The HG forwards the warnings to the SA upon receiving them.

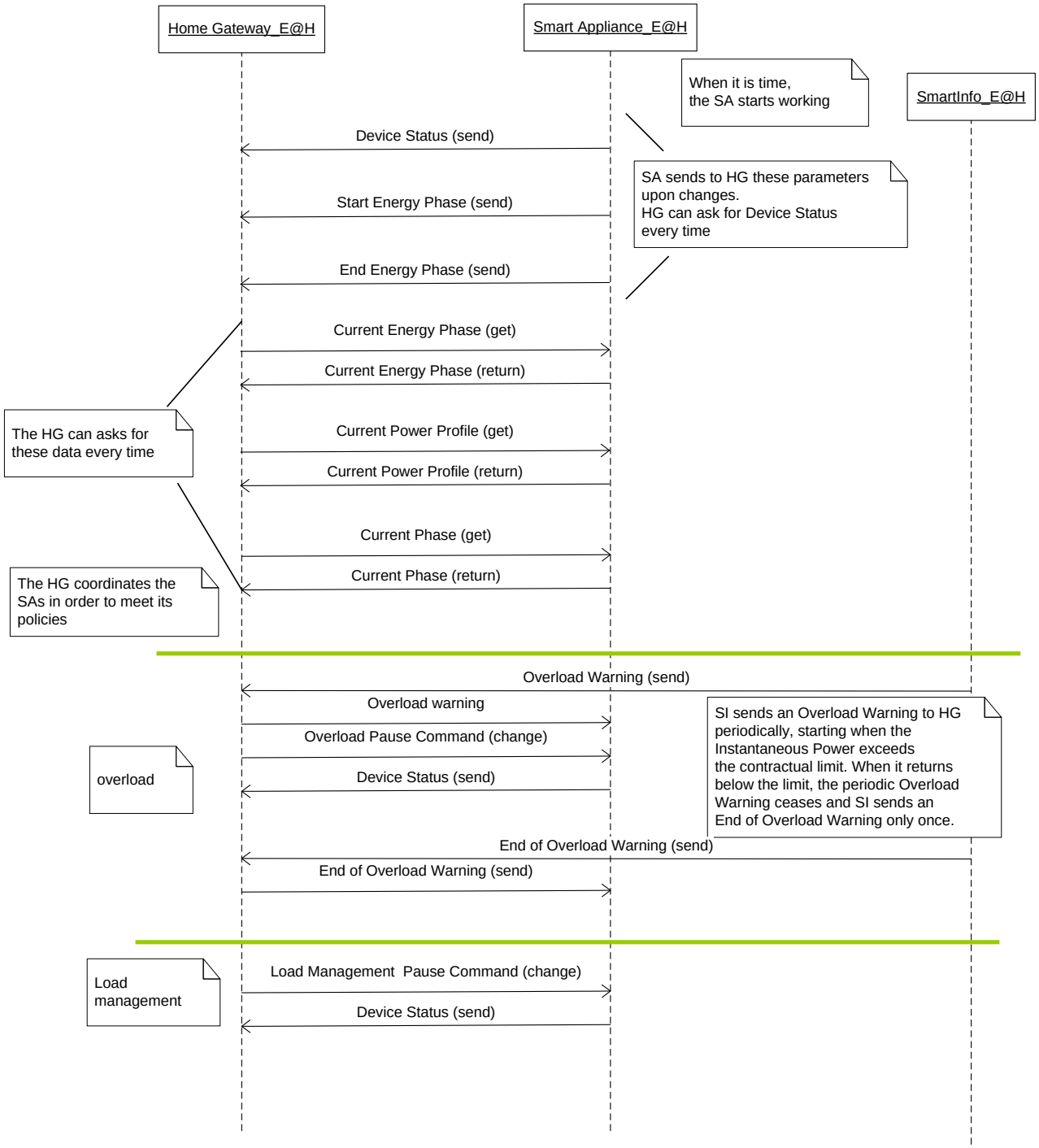

Figure 9 – OPERATIVE section messages exchange

4 Energy@Home ZigBee protocol specification

The E@H features defined in this document extend the HA and SE ZigBee profiles in order to build a new class of devices, i.e. White Goods for Energy@Home. The extension of the standard profile requires the introduction of new clusters needed to satisfy all the requirements of Energy@Home use cases.

4.1 ZigBee Profile ID

Energy@Home Profile ID = 0xC23C.
Energy@Home reserves the right to change the value of ProfileID as a result of the integration of these specification within future versions of ZigBee public profiles, in particular HA (ProfileID= 0x0104) or SE (ProfileID= 0x0109).

4.2 ZigBee Stack Profile

Products that are compliant to this specification shall use stack profile number 0x02 (ZigBee PRO). In addition to the requirements specified in [R3], the fragmentation support is recommended for this application profile.

4.2.1 APS Fragmentation Parameters

When using clusters requiring fragmentation (see cluster definitions) there are application settings from the APS IB that must be defined by the application profile. These parameters are to be set as shown in Table 1 - APS Fragmentation Parameters.

Parameters	Identifier	Type	Value	Description
apsInterframe Delay	0xc9	Integer	50	Standard delay in milliseconds between sending two blocks of a fragmented transmission
apsMaxWindowSize	0xcd	Integer	1	Fragmentation parameter – the maximum number of unacknowledged frames that can be active at once

Table 1 - APS Fragmentation Parameters.

In addition the Maximum Incoming Transfer Size Field in the Node descriptor defines the largest ASDU that can be transferred using fragmentation. For the HA Profile the default value shall be set as described in [R3]. Maximum ASDU size allowed is specified in [R4] and dictated by solution needs and RAM capacities of the communicating devices.

4.3 Other E@H Requirements and Best Practices

4.3.1 Preferred Channels (11, 14, 15, 19, 20, 24, 25)

When forming a new network, or scanning to join a network, E@H devices should perform channel scans using the above channel mask before scanning the rest of the channels in order to avoid the most commonly used WiFi channels. This is to improve the user experience during installation (quicker joining) and possibly improve bandwidth (on average).

4.3.2 Broadcast Policy

It will be detailed in Version 0.9[2]

4.3.3 Frequency Agility

E@H devices shall support frequency agility as defined in ZigBee Specification [R4].

4.3.4 Key Updates

E@H devices shall support "common security model" (i.e. default preconfigured Trust Center link key shall be used to transfer network key if no specific Trust center link key is set through out-of-band mechanism to the E@H device). Network key updates should be limited due to the possibility of end devices missing two key updates.
It is strongly encouraged that key updates should only be initiated by the user via interaction with the Trust Center. Auto updates of security keys pose the risk that battery operated devices will miss two key updates and need to be re-commissioned.

4.3.5 Return to Factory Defaults

In support of a return to factory default capability, E@H devices shall implement the ZDO Management Leave server service. When invoked with a unicast address and the DeviceAddress set to NULL=0x00000000, the device shall implement a NWK Leave. When invoked with a broadcast address and the DeviceAddress set to NULL=0x00000000, the device shall wait the broadcast timeout period to allow the message to propagate through network, then the device shall implement a NWK Leave. Prior to execution of the NWK Leave in either case, processing in the device shall ensure all operating parameters are reset to allow a reset to factory defaults.

4.4 Device Descriptions

[2] Appliance Control & Monitoring could require broadcast transmissions. Frequency and opportunity will be defined in version 0.9.

Device descriptions are summarized in Table 2. The reserved values shall not be used until the profile defines them.

	Device	Device ID
Smart Energy	Energy Service Portal (Home Gateway)	0x0500
	Metering Device (Smart Info)	0x0501
	In-Premise Display	0x0502
	Load Control Device (Smart Plugs)	0x0504
Household appliances	White Goods[3]	0x0A00
General	Range Extender	0x0008
	Reserved	Others

Table 2 – Devices Specified in E@H Profile.

4.5 ZigBee Cluster Library

The E@H devices utilize both the clusters specified in the ZigBee Cluster Library [R2] and in the SE and HA [R3] specification whenever possible. The implementation details for each cluster are given in the relative ZigBee specifications. Further specification and clarification are given in the this document where necessary.
The ZCL provides a mechanism for clusters to report changes to the value of various attributes. It also provides commands to configure the reporting parameters. The attributes that a particular ZCL-defined cluster is capable of reporting are listed in the ZCL specification as well.

4.6 Cluster List and IDs

The clusters used in this profile are listed in Table 3.

Functional Domain	Cluster Name	Cluster ID
General	Basic	0x0000
General	Identify	0x0003
General	Groups	0x0004
General	Scenes	0x0005

[3] Energy@Home reserves the right to extend this device list by enumerating each specific white good, including complete appliance list and/or "combi" devices.

General	On/Off	0x0006
General	Alarms	0x0009
General	Time	0x000A
Measurement & Sensing	Temperature Measurement	0x0402
E@H Clusters	Appliance Identification	0x0A00[4]
E@H Clusters	Appliance Control	0x0A01
E@H Clusters	Appliance Events and Alerts	0x0A02
E@H Clusters	Appliance Statistics	0x0A03
E@H Clusters	Appliance Power Leveling	0x0A04
E@H Clusters	Power Profile	0x0A05
E@H Clusters	SmartInfo Identification	0x0A06
Smart Energy	Price	0x0700
Smart Energy	Demand Response and Load Control	0x0701
Smart Energy	Simple metering	0x0702
Smart Energy	Message	0x0703

Table 3 – Cluster Used in theE@H specification.

4.7 Commissioning and security

The startup procedure of the network shall involve the following steps:

1. the network shall be opened by the Home Gateway (i.e. enable permit joining to the routers of the network);
2. each device shall join the network by using a unique TC link key (i.e. same key on the products and the home gateway derived with Hash specified in Smart Energy 1.0 - Matyas-Meyer-Oseas hash function); the TC link key shall be derived from Serial/bar code or other products code (e.g. 2D barcode);
3. the TC link key shall be configured on the home gateway or portal controlling the gateway and derived by the registration of the product code.

The devices will then receive a network key according the common security mode specified in ZigBee (network key encrypted with the TC link key). The network key may change over time according to the security policy of the Home Gateway. If losing synchronization with the proper key the devices shall be able to rejoin using the TC link key.

No APL link keys are required to be used among the devices to access the information in the E@H network.

[4] Cluster ID: All 0Axx cluster ID should be harmonized with ZigBee public cluster ID as a result of the possible integration of these specification within future versions of ZigBee public profiles.

4.8 Best practices for Service Discovery

4.8.1 Commissioning modes

Three different commissioning modes are typically discussed within the ZigBee specification (see [R3]):

- A-mode (automatic mode), which involves automatic commissioning of devices. The A-mode generally allows for minimal (or no) human intervention.
- E-mode (easy mode), which involves the use of buttons or other physical mechanisms on devices to direct devices during commissioning. The E-mode allows for simpler end-user or professional installer commissioning. It usually targets small installations (maximum size: typical home).
- S-mode (system mode), which involves the use of external tools and are typically used by expert installers. The S-mode represents the most complex form of commissioning and includes the highest level of human intervention. It usually targets larger installations such as commercial premises and high-end residential environments.

All E@H devices must support E-mode. E-mode commissioning may be a simple button press or may involve a separate low-cost commissioning tool (like a remote control). The device can use some form of automatic behavior for instance joining the network upon Power up, but shall still provide the means for the end user to commission the device. S-mode (e.g. using commissioning operated by an interface exposed by the Home gateway) should be possible.

4.8.2 Pair devices

The operation of pairing E@H devices may be operated using ZigBee End Device Bind Request as defined in [R4]

Example: a user would like to pair two devices (for example, a Smart Appliance and a Home Gateway). A button on each device is pressed and the “pairing” is done using the end device bind request. It is required that the Coordinator includes the “bind manager”/End device response. The Bind manager uses the ZDP bind/unbind request to create the source binding in the devices. If a device does not include buttons, a specific interface (e.g. web interface on the Home Gateway) should be used to initiate the same function by sending a telegram to the device (i.e. by emulating a button press).

EndDeviceBindTimeout parameter shall be set to 60 seconds. This is the timeout value for end device binding.

4.9 Device Specifications

4.9.1 Common clusters

Support for certain clusters is common to all devices in this profile extension. The clusters shown in Table 4 shall be supported by all devices in this profile as mandatory or optional according to the designation given here. Individual device descriptions may place further restrictions on support of the optional clusters shown here.

Server Side	Client Side
Mandatory	
Basic *	*None*
Optional	
Identify *	*None*

Table 4 – Clusters Common to All Devices.

Legend
* = ZigBee standardized clusters
** = CENELEC derived data structures mapped into ZigBee ZCL style clusters
*** = E@H specific clusters

4.9.2 Energy Service Portal

The Energy Service Portal device performs home control and monitoring activities. It is executed on a Home gateway who is able to collect energy data, from the Smart Info and from the user's appliances, and to publish them in the HN and WAN.

4.9.2.1 Supported Clusters

In addition to those specified in Table 4 the ESP device shall support the clusters listed in Table 5.

Server Side	Client Side
Mandatory	
Message	
Price	
Demand Response/Load Control	
Time	
Optional	
Simple Metering	Simple Metering
	Price
*All additional client clusters defined for White goods and Smart Info****	*All additional server clusters defined for White goods and Smart Info****

Table 5 – Clusters Supported by the ESP (Home Gateway).

Legend
* = ZigBee standardized clusters
** = CENELEC derived data structures mapped into ZigBee ZCL style clusters
*** = E@H specific clusters

4.9.3 Metering Device (Smart Info)

The Smart Info device represents a metering device (e.g. electricity, gas, water, heat, etc.). Depending on what is being metered, the device may be capable of immediate (requested via polling) reads or of autonomous periodic readings (sent via push mechanism). A Metering end device may also be capable of communicating certain status indicators (e.g. battery low, tamper detected).

4.9.3.1 Supported Clusters

In addition to those specified in Table 4 the Smart info device shall support the clusters listed in Table 6.

Server Side	Client Side
Mandatory	
Simple Metering*	
SmartInfo identification***	
Optional	
	Time*
	Prepayment*
Price*	Price*
	Message*

Table 6 – Clusters Supported by the Metering Device (Smart info).

Legend
* = ZigBee standardized clusters
** = CENELEC derived data structures mapped into ZigBee ZCL style clusters
*** = E@H specific clusters
In case the Smart Info cannot provide price information, the use of Price Cluster as defined in [R10] could be limited to the provision of time-of-use (TOU) intervals by using the Get Scheduled Prices without specifying the actual price. In this case the in *Publish Price Command* Payload the *Price* field will be always 0, and the *Price Tier* field specify the current tier name.

4.9.4 White Goods

White Goods devices can participate in home control and monitoring activities. Moreover, White Goods could provide data related to device usage (statistics) and participate in in-home energy management activities.

4.9.4.1 Supported Clusters

In addition to those specified in Table 4 the White Goods device shall support the clusters listed in Table 7.

Server Side	Client Side
Mandatory	

None	Price*
	Time*
Optional	
	Power Profile***
Appliance Identification**	
Appliance Control**	
Appliance Events and Alerts**	
Simple Metering*	
Appliance Statistics**	
Alarms*	
	SmartInfo identification***

Table 7 – Clusters Supported by the White Goods Devices.

Legend
* = ZigBee standardized clusters
** = CENELEC derived data structures mapped into ZigBee ZCL style clusters
*** = E@H specific clusters

4.9.5 Load Control Device (Smart Plugs)

Smart Plugs can participate in home monitoring and control activities. Smart Plugs could provide information about instantaneous power and energy consumption. The detailed description of the used Simple Metering cluster attributes is reported in 6.4. The Smart Plugs can also be controlled by using the On/Off cluster.

Server Side	**Client Side**
Mandatory	
	Demand Response/Load Control*
	Time*
Optional	
On/Off*	Price*
Simple Metering*	

Table 8- Clusters Supported by theLoad Control Devices.

5 Energy@Home Use Cases and Smart Appliances

Several use-cases have already been defined [R1], relying on HAN and HN connectivity. Each use case requires the implementation of several functions (e.g. product identification, statistics collection, alert management, etc.). The following table includes all the interesting tasks with a preliminary mapping with already defined ZigBee clusters and/or CENELEC appliance interworking functional blocks. See [R8] and [R9] for more details.

Scenario	E@H feature requirement	Coverage in ZigBee	Coverage in EN50523
1	Visualization of current energy and power data + cost.	ZigBee Cluster Library *i) Simple Metering Cluster* *ii) Price Cluster*	Not supported
2	Visualization of historical data.	ZigBee Cluster Library *i) Simple Metering Cluster*	Potentially *COLLECT DIAGNOSIS DATA MID* can be used
3	Alarm	ZigBee Cluster Library *i) Alarm Cluster*	*SIGNAL EVENT/STATE MIDs* which support Alert Event OID management
4	Other energy information	ZigBee Cluster Library *i) Message Cluster*	Not supported
5	Home Domain Overload management	ZigBee Cluster Library *i) Simple Metering Cluster* *ii) Demand Response&Load Control Cluster*	*EXECUTE COMMAND MIDs* and *SIGNAL STATE MIDs* covers statements and status of SA
6	Optimize energy cost in case of multi-tariff contract	ZigBee Cluster Library *i) Simple Metering Cluster* *ii) Price Cluster*	Not supported
7	Demand response	ZigBee Cluster Library *i) Price Cluster* *ii) Demand Response&Load Control Cluster*	*EXECUTE COMMAND MIDs* covers statements to SA

Table 9 – Mapping between ZigBee clusters and/or CENELEC appliance functional blocks

According to the preliminary analysis, the E@H use-cases could be fulfilled implementing several functions embedded into a single Application Object as depicted in Figure 10. The same figure reports also the potential correspondences between ZigBee and CENELEC concepts/terminology which will be deeply analyzed in the next paragraphs.

The clusters implemented in the Smart Appliances could leverage on the ZigBee Home Automation (HA) profile. Essential HA or SE clusters, related with electrical appliances functionalities, are implemented (e.g. Identify, Basic, Group, etc.). The same end-point includes clusters, derived from Smart Energy profile, which will be added to monitor electrical appliance energy consumption (e.g. Simple Metering cluster).

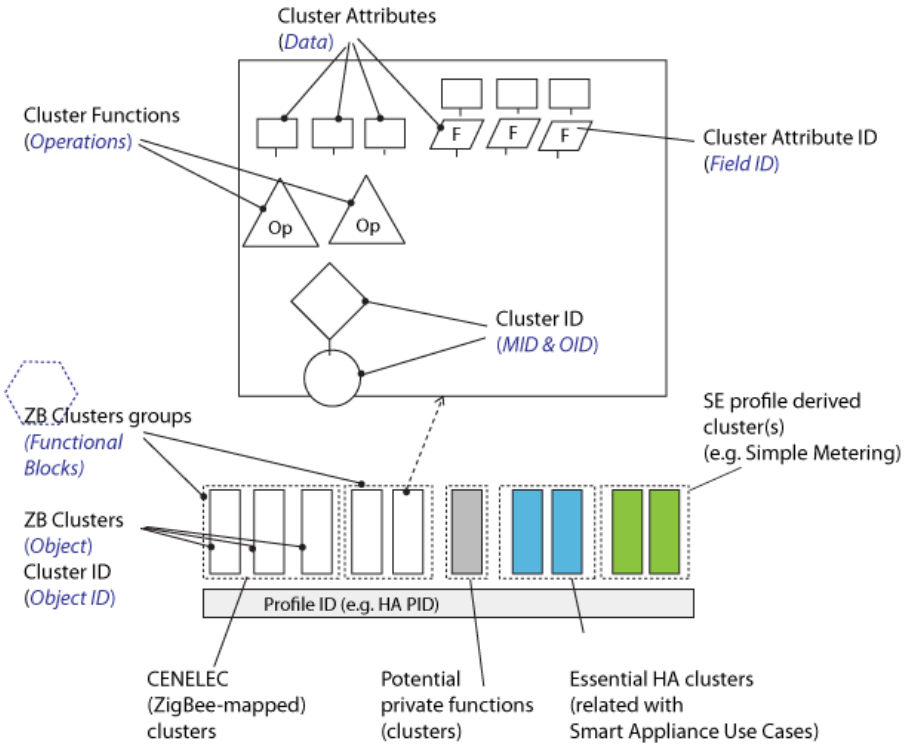

Figure 10 - Architecture of Smart Appliance ZigBee application layer and CENELEC mapping on ZigBee protocol.

CENELEC functionalities [R6]-[R7] , not covered by existing ZigBee clusters and useful for E@H project, are implemented in private (potentially, in a near future, public) dedicated clusters. Moreover, manufacturer specific tasks could be embedded in a private cluster as well.

The ZigBee Alliance provides a Cluster Library (ZCL) [R2] which is intended to act as a repository for cluster functionality that is developed by ZigBee. A developer implementing a profile should use the ZCL to find relevant cluster functionality that can be incorporated into the new, even if private, profile. This also allows ZigBee profiles to be developed with more of an object oriented style approach.
Throughout the ZCL, a client/server model is employed. Typically, the entity that stores the attributes of a cluster is referred to as the server of that cluster and an entity that affects or manipulates those attributes is referred to as the client of that cluster. However, if required, attributes may also be present on the client of a cluster.
The E@H-defined clusters described below follow, as much as possible, the ZCL approach.

Potentially, Smart Appliances could be configured as a new device in the E@H profile, i.e. generic "White Goods" device or more detailed sub-categories, as depicted in the following (i.e. according to CENELEC specifications).

5.1 CENELEC Interworking Concepts Mapping

In the following table, a potential mapping of CENELEC networking concepts on ZigBee protocol is proposed. The mapping is represented in Figure 10

Concepts	ZigBee Protocol Mapping
OID	Cluster ID
OID Data	Cluster attributes
MID value field	ZB cluster command with data parameter field
MID individual transmission	ZB individual transmission
MID group transmission	ZB group transmission or, alternatively, individual transmission to all linked devices
MID broadcast transmission	ZB broadcast transmission
Functional Block	Group of clusters

Primitives	Addressing	ZigBee Protocol Mapping
Change value primitive	Individual	Individual Write request ("*Write attributes*" command, Command Identifier Field Value: 0x02) on ZB attribute
	Group	Group Write request on ZB attribute to linked devices
	All	Broadcast Write request on ZB attribute to all devices
Get value primitive	Individual	Individual Read request (*"Read attributes"* command, Command Identifier Field Value: 0x00) on ZB attribute
	All	Broadcast Read request on ZB attribute
Return value primitive	Individual	Individual *"Read attribute response"* command (Command Identifier Field Value: 0x01) related to read ZB attribute
Send value primitive	Individual	Individual Report attribute request (*"Report attributes"* command, Command Identifier Field Value: 0x0a) on ZB attribute
	Group	Individual Report attribute request to linked devices
	All	Individual Report attribute request to linked devices

6 Cluster Definitions

In the following, preliminary specifications of some extra HA clusters are reported. These clusters are not included into the current Home Automation Profile and are needed to fulfil the E@H use cases. They are mostly derived from the Cenelec standard; since the EN50523 does not cover all the needed functionalities, some extensions has been introduced.
The description includes data organization as well as cluster commands. Further revisions are expected.

6.1 Appliance Identification Cluster

6.1.1 Overview

Attributes and commands for determining basic information about a device and setting user device information.
The Appliance Identification Cluster is a transposition of EN50523 “Identify Product” functional block.
Note: Where a physical ZigBee node supports multiple endpoints it will often be the case that many of these settings will apply to the whole node, that is they are the same for every endpoint on the device. In such cases they can be implemented once for the node, and mapped to each endpoint.

6.1.2 Server

6.1.2.1 Dependencies

None.

6.1.2.2 Attributes

For convenience, the attributes defined in this specification are arranged into sets of related attributes; each set can contain up to 16 attributes. Attribute identifiers are encoded such that the most significant three nibbles specify the attribute set and the least significant nibble specifies the attribute within the set. The currently defined attribute sets are listed in Table 10.

Attribute Set Identifier	Description
0x000	Basic Appliance Identification
0x001	Extended Appliance Identification
0x002-0xfff	Reserved

Table 10 – Appliance Identification Attribute Sets.

6.1.2.2.1 *Basic Appliance Identification Attribute Set*

The Basic Appliance Identification attribute set contains the attributes summarized in Table 11.

Identifier	Name	Type	Range	Access	Default	Mandatory/ Optional	Reportable
0x0000	BasicIdentifi	Unsigned 56-	(length: 7	Read only	-	M	No

cation bit integer octets)

Table 11 – Attributes of the Appliance Identification Attribute Set.

6.1.2.2.1.1 BasicIdentification Attribute

BasicIdentification is 56-bit bitmap (7 octets) and contains the basic appliance identification.
BasicIdentification is mandatory and must be included as part of the minimum data set to be provided by the household appliance device.
The following table provides attribute content specification.

Attribute Name	Field	Bits
BasicIdentification	Company ID	0x00-0x0f
	Brand ID	0x10-0x1f
	Product Type ID	0x20-0x2f
	Spec. Ver.	0x37-0x30

Table 12 - Basic Appliance Identification content specification.

Company ID and Brand ID fields content could be se according to [R7], Table 5.
The following table provides Product Type IDs field content, again according to [R7] (see Table 6).

Device (Appliance)	Product Type ID
White Goods	0x0000
Dishwasher	0x5601
Tumble Dryer	0x5602
Washer Dryer	0x5603
Washing Machine	0x5604
Hobs	0x5E03
Induction Hobs	0x5E09
Oven	0x5E01
Electrical Oven	0x5E06
Refrigerator Freezer	0x6601

Table 13 – Product Type IDs.

6.1.2.2.2 *Extended Appliance Identification Attribute Set*

The Extended Appliance Identification attribute set contains the attributes summarized in Table 14.

Identifier	Name	Type	Range	Access	Default	Mandatory/Op	Reportable

						tional	
0x0010	CompanyName	Octet String	0 to 16 Octets	Read only	“1, 0x00”	O	No
0x0011	CompanyId	Unsigned 16-bit integer	0x0000-0xffff	Read only	0x0000	O	No
0x0012	BrandName	Octet String	0 to 16 Octets	Read only	“1, 0x00”	O	No
0x0013	BrandId	Unsigned 16-bit integer	0x0000-0xffff	Read only	0x0000	O	No
0x0014	Model	Octet String	0 to 16 Octets	Read only	“1, 0x00”	O	No
0x0015	PartNumber	Octet String	0 to 16 Octets	Read only	“1, 0x00”	O	No
0x0016	ProducRevision	Octet String	0 to 6 Octets	Read only	“1, 0x00”	O	No
0x0017	SoftwareRevision	Octet String	0 to 6 Octets	Read only	“1, 0x00”	O	No
0x0018	ProductTypeName	Octet String	2 Octets	Read only	“0x00, 0x00”	O	No
0x0019	ProductTypeId	Unsigned 16-bit integer	0x0000-0xffff	Read only	0x0000	O	No
0x001A	CECEDSpecificationVersion	Unsigned 8-bit integer	0x0000-0xffff	Read only	0x10	O	No

Table 14 – Attributes of the Extended Appliance Identification Attribute Set.

6.1.2.2.2.1 CompanyName Attribute

CompanyName is a ZCL Octet String field capable of storing up to 16 character string (the first Octet indicates length) encoded in the UTF-8 format. Example Company Name labels are “Electrolux”, “Indesit Company”, “Candy”. The complete list of valid labels is defined in [R7], Table 7.

6.1.2.2.2.2 CompanyId Attribute

CompanyId is 16-bit in length unsigned integer which defines the appliance company identifier. The complete list of valid company identifiers is defined in [R7], Table 7.

6.1.2.2.2.3 BrandName Attribute

BrandName is a ZCL Octet String field capable of storing up to 16 character string (the first Octet indicates length) encoded in the UTF-8 format. Example Brand Name labels are “Rex”, “Ariston”, “Hoover”. The complete list of valid labels is defined in [R7], Table 7.

6.1.2.2.2.4 BrandId Attribute

BrandId is 16-bit in length unsigned integer which defines the appliance brand identifier. The complete list of valid brand identifiers is defined in [R7], Table 7.
Note that Brand Ids and Company Ids are independently defined. The advantage is that one brand of one producer may have the same id as a brand name of another producer.

6.1.2.2.2.5 **Model Attribute**

Model is a ZCL Octet String field capable of storing up to 16 character string (the first Octet indicates length) encoded in the UTF-8 format. *Model* defines the appliance model name, decided by manufacturer.

6.1.2.2.2.6 **PartNumber Attribute**

PartNumber is a ZCL Octet String field capable of storing up to 16 character string (the first Octet indicates length) encoded in the UTF-8 format. *PartNumber* defines the appliance part number, decided by manufacturer.

6.1.2.2.2.7 **ProductRevision Attribute**

ProductRevision is a ZCL Octet String field capable of storing up to 6 character string (the first Octet indicates length) encoded in the UTF-8 format. *ProductRevision* defines the appliance revision code, decided by manufacturer.

6.1.2.2.2.8 **SoftwareRevision Attribute**

SoftwareRevision is a ZCL Octet String field capable of storing up to 6 character string (the first Octet indicates length) encoded in the UTF-8 format. *SoftwareRevision* defines the appliance software revision code, decided by manufacturer.

6.1.2.2.2.9 **ProductTypeName Attribute**

ProductTypeName is a 2 Octet in length String field which defines the appliance type label. Example ProductTypeName labels are “WM”, “RE”, “GO”, respectively for Washing Machine, Refrigerator and Gas Oven. The complete list of valid labels is defined in [R7], Table 8.

6.1.2.2.2.10 **ProductTypeId Attribute**

ProductTypeId is a 16-bit in length unsigned integer which defines the appliance type identifier. The structure and complete list of valid *ProductTypeId*s is defined in [R7], Table 7.

6.1.2.2.2.11 **CECEDSpecificationVersion Attribute**

CECEDSpecificationVersion is a 8-bit in length unsigned integer which defines the CECED reference documentation. Compliance and certification of appliance communication capabilities can be defined according to the following table (see [R7], Table 10).

Specification Version	Value
Compliant with v1.0, not certified	0x10
Compliant with v1.0, certified	0x1A
Compliant with vX.0, not certified	0xX0
Compliant with vX.0, certified	0xXA

Other values	Reserved

Table 15 – CECED Specification Version.

6.1.2.3 Commands Received

No cluster-specific commands are received by the server.

6.1.2.4 Commands Generated

No cluster-specific commands are generated by the server.

6.1.3 Client

6.1.3.1 Dependencies

For the alarms functionality of this cluster to be operational, the Alarm cluster server shall be implemented on the same endpoint.

6.1.3.2 Attributes

The Client cluster has no attributes.

6.1.3.3 Commands Received

No cluster-specific commands are received by the client.

6.1.3.4 Commands Generated

No cluster-specific commands are generated by the client.

6.2 Appliance Control Cluster

6.2.1 Overview

This cluster provides an interface to remotely control and to program household appliances. Example of control is Start, Stop and Pause commands.
The status read and set is compliant to the EN50523 “Signal State” and “Execute Command” functional blocks. Appliances parameters (e.g. Duration and Remaining Time) have been added, since they were missing from the original specs.

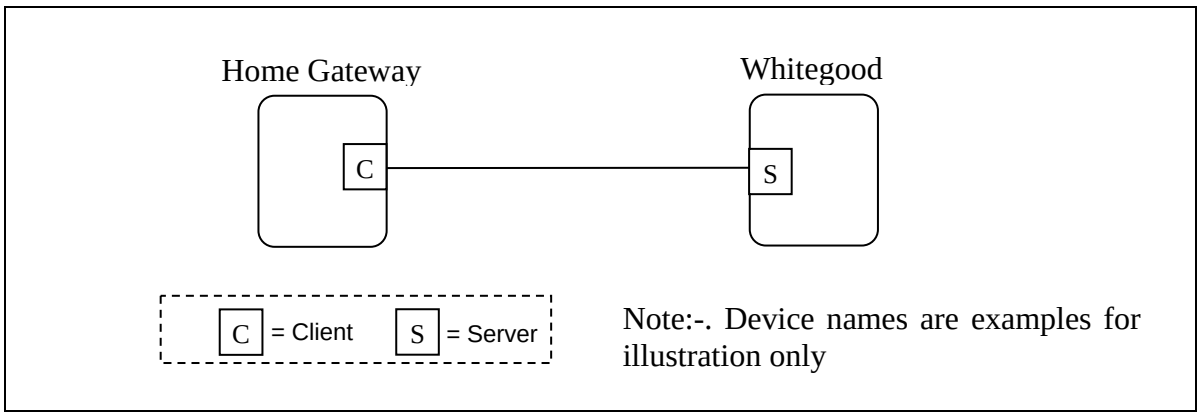

Figure 11 – Appliance Control Cluster Client Server Example.

Note: Where a physical ZigBee node supports multiple endpoints it will often be the case that many of these settings will apply to the whole node, that is they are the same for every endpoint on the device. In such cases they can be implemented once for the node, and mapped to each endpoint.

6.2.2 Server

6.2.2.1 Dependencies

For the alarms functionality of this cluster to be operational, the Alarm cluster server shall be implemented on the same endpoint.

6.2.2.2 Attributes

For convenience, the attributes defined in this specification are arranged into sets of related attributes; each set can contain up to 256 attributes. Attribute identifiers are encoded such that the most significant byte specifies the attribute set and the least significant byte specifies the attribute within the set. The currently defined attribute sets are listed in Table 16.

Attribute Set Identifier	Description
0x00	Appliance Status
0x01	Appliance Functions

0x02-0xff	Reserved

Table 16 – Appliance Control Attribute Sets.

6.2.2.2.1 *Appliance Status Attribute Set*

The Appliance Status attribute set contains the attributes summarized in Table 17.

Identifier	Name	Type	Range	Access	Default	Mandatory/ Optional	Reportable
0x0000	ApplianceStatus[5]	8-bit Enumerator	0x00-0xff	Read only	0x00	M	No
0x0001	RemoteEnableFlags	Unsigned 8-bit integer	0x00-0xff	Read only	0x00	M	No
0x0002	ApplianceStatus2	Unsigned 24-bit integer	0x000000 -0xffffff	Read only	0x000000	O	No[6]

Table 17 – Attributes of the Appliance Status Set.

6.2.2.2.1.1 **ApplianceStatus Attribute**

ApplianceStatus represents the current status of household appliance.
ApplianceStatus is mandatory and must be included as part of the minimum data set to be provided by the household appliance device.
ApplianceStatus is update continuously as appliance state changes.
The following table provides state defines (see [R7], Table 2).

Enumeration	Value	Description
Reserved	0x00	Reserved
OFF	0x01	Appliance in off state
STAND-BY	0x02	Appliance in stand-by
PROGRAMMED	0x03	Appliance already programmed
PROGRAMMED WAITING TO START	0x04	Appliance already programmed and ready to start
RUNNING	0x05	Appliance is running
PAUSE	0x06	Appliance is in pause
END PROGRAMMED	0x07	Appliance end programmed tasks
FAILURE	0x08	Appliance is in a failure state
PROGRAMME INTERRUPTED	0x09	The appliance programmed tasks have been interrupted
IDLE	0x0a	Appliance in idle state
RINSE HOLD	0x0b	Appliance rinse hold
SERVICE	0x0c	Appliance in service state
SUPERFREEZING	0x0d	Appliance in superfreezing state
SUPERCOOLING	0x0e	Appliance in supercooling state
SUPERHEATING	0x0f	Appliance in superheating state

[5] The Appliance Status attribute is reportable (both periodically and on event basis).

[6] No reportable is used for the Appliance states since dedicated command is used (see 6.2.2.3.2)

ENABLE ENERGY CONTROL	0x10	Enable energy management of the appliance
DISABLE ENERGY CONTROL	0x11	Disable energy management of the appliance
Reserved	0x12..0x3f	Reserved
Non standardized	0x40..0x7f	Non standardized
Proprietary[7]	0x80..0xff	Proprietary

Table 18 – Appliance Status Values.

6.2.2.2.1.2 RemoteEnableFlags Attribute

RemoteEnableFlags represents the current status of household appliance correlated with remote control.
RemoteEnableFlags attribute is mandatory and must be included as part of the minimum data set to be provided by the household appliance device.
RemoteEnableFlags is update continuously when appliance state remote-controllability changes.
The following table provides details about flags organization (see [R7], Table 2).

Bit range	Function	
0..3	Remote Enable Flags	
	Value	**Enumeration**
	0x0 0x7 0xf 0x1. 0x2..0x06, 0x8..0xe	DISABLED TEMPORARILY LOCKED/DISABLED ENABLED REMOTE CONTROL ENABLED REMOTE AND ENERGY CONTROL Reserved
4..7	Device Status 2 Structure	
	Value	**Enumeration**
	0x0 0x1 0x2 0x3..0xf	PROPRIETARY PROPRIETARY IRIS SYMPTOM CODE Reserved

Table 19 – Remote Enable Flags Values.

6.2.2.2.1.3 ApplianceStatus2 Attribute

ApplianceStatus2 represents a detailed definition of Appliance state. If optionally provided, *ApplianceStatus2* is update continuously as appliance state change.
This attribute contains Non-standardized or Proprietary data. In the case of IRIS Symptom Code (see 6.2.2.2.1.2), 3 bytes representing the 3 digit encoding is provided (possibly complemented with proprietary bytes).

6.2.2.2.2 *Appliance Functions Attribute Set*

The Appliance Functions attribute set contains the attributes summarized in Table 20.

[7] Reserved, Non Standardised and Proprietary from CECED naming conventions.

These attributes control the Appliance cycle parameters. Each of them, as described below, corresponds to an Appliance internal status configuration.

Identifier	Name	Type	Range	Access	Default	Man. /Opt.	Reportable
0x0100	StartTime	Unsigned 16-bit integer	0x0000 – 0xffff	Read Only	0x0000	O	No
0x0101	FinishTime	Unsigned 16-bit integer	0x0000 – 0xffff	Read Only	0x0000	O	No
0x0102	Duration	Unsigned 16-bit integer	0x0000 – 0xffff	Read Only	0x0000	O	No
0x0103	RemainingTime	Unsigned 16-bit integer	0x0000 – 0xffff	Read Only	0x0000	O	No

Table 20 – Attributes of the Appliance Functions Set.

6.2.2.2.2.1 StartTime Attribute

StartTime attribute determines the time (either relative or absolute) of the start of the machine activity. Default format for Oven devices is absolute time. The default format for other appliances is relative time.
The following table provides details about time encoding which is used for *StartTime* attribute organization.

Bit range	Function	
0..5	Minutes ranging from 0 to 59	
6..7	Time encoding	
	Value	**Enumeration**
	0x0 0x1 0x2..0x3	RELATIVE ABSOLUTE Reserved
8..15	Hours ranging from 0 to 255 if RELATIVE encoding is selected 0 to 23 if ABSOLUTE encoding is selected	

Table 21 – Time Encoding.

6.2.2.2.2.2 FinishTime Attribute

FinishTime attribute determines the time (either relative or absolute) of the expected end of the machine activity. Default format for Oven is absolute time. The default format for other appliances is relative time.
FinishTime Attribute exploits time encoding reported in Table 21.

6.2.2.2.2.3 Duration Attribute

Duration attribute determines the time, in relative format, of the expected duration of the machine activity.
FinishTime Attribute exploits time encoding reported in Table 21.

6.2.2.2.2.4 RemainingTime Attribute

RemainingTime attribute determines the time, in relative format, of the remaining time of the machine cycle.

6.2.2.3 Commands Received

The command IDs for the Appliance Control cluster are listed in Table 22.

Command Identifier Field Value	Description	Mandatory/Optional
0x00	Execution of a Command	M
0x01	Signal State	M
0x02	Write Functions	O
0x03	Load Management Pause	O
0x04	Overload Pause	O
0x05-0xff	Reserved	-

Table 22 – Received Commands IDs for the Appliance Control Cluster.

6.2.2.3.1 *Execution of a Command*

This basic message is used to remotely control and to program household appliances. Examples of control are START, STOP and PAUSE.

6.2.2.3.1.1 Payload Format

The Execution of a Command payload shall be formatted as illustrated in Table 23.

Octets	1
Data Type	8-bit Enumerator
Field Name	Command Identification

Table 23 – Format of the Execution of a Command Payload.

6.2.2.3.1.1.1 Payload Details

The **Command Identification** field: the command identification is an 8-bits in length field identifying the command to be executed. The enumeration used for this field shall match the following table.

Enumeration	Value	Description
Reserved	0x00	Reserved
START	0x01	Start appliance cycle
STOP	0x02	Stop appliance cycle
PAUSE	0x03	Pause appliance cycle
START SUPERFREEZING	0x04	Start superfreezing cycle
STOP SUPERFREEZING	0x05	Stop superfreezing cycle
START SUPERCOOLING	0x06	Start supercooling cycle
STOP SUPERCOOLING	0x07	Stop supercooling cycle

DISABLE GAS	0x08	Disable gas
ENABLE GAS	0x09	Enable gas
ENABLE ENERGY CONTROL	0x0a	Enable energy management of the appliance
DISABLE ENERGY CONTROL	0x0b	Disable energy management of the appliance
Standardized (TBD)	0x0A..0x3f	Standardized (TBD)
Non standardized	0x40..0x7f	Non standardized
Proprietary[8]	0x80..0xff	Proprietary

Table 24 – Command Identification Values.

6.2.2.3.1.2 Effects on Receipt

On receipt of this command, the appliance shall execute the command given in the Command Identification field. The device application shall be informed of the imposed command (and potential personalized tasks could start, e.g. by means of a message to appliance Main Board controller).
After the command execution, the appliance shall generate a Signal State Notification with the new appliance state.

6.2.2.3.2 *Signal State Command*

This basic message is used to retrieve Household Appliances status. This command does not have a payload.

6.2.2.3.2.1 Effects on Receipt

On receipt of this command, the device shall generate a Signal State Response command (see 6.2.2.4.1).

6.2.2.3.3 *Write Functions Command*

This basic message is used to set appliance functions, i.e. information regarding the execution of an appliance cycle. Condition parameters such as start time or finish time information could be provided through this command.

6.2.2.3.3.1 Payload Format

The Write Functions command frame shall be formatted as illustrated in Table 25.

Octets	Variable	Variable	...	Variable
Field Name	Write Functions record 1	Write Functions record 2	...	Write Functions record *n*

Table 25 – Format of the Write Functions Command Frame.

Each Write Functions record shall be formatted as illustrated in Table 26.

[8] Reserved, Non Standardised and Proprietary from CECED naming conventions.

Octets	2	1	Variable
Data Type	Unsigned 16-bit integer	8-bit Enumerator	Variable octets
Field Name	Function I identifier (i.e. Attribute Identifier)	Function data type	Function data

Table 26 – Format of the Write Functions Record Field.

6.2.2.3.3.1.1 Payload Details

The **Function identifier** field: the Function Identifier is 16-bits in length and shall contain the identifier of the function that is to be written.
The **Function data type** field: the function data type field shall contain the data type of the attribute that is to be written.
The **Function data** field: the function data field is variable in length and shall contain the actual value of the function that is to be written.

6.2.2.3.3.2 **Effects on Receipt**

On receipt of this command, the appliance shall set the function given in the Function identifier field. The Function identifier is actually changed only when the appliance internal functions have been changed.
If attribute reporting is configured on some function attributes, an attribute reporting command is generated when the internal appliance functions is actually modified.

6.2.2.3.4 *Overload Pause Command*

This basic message is used to pause the household appliance as a consequence of an imminent overload event.

6.2.2.3.4.1 **Payload Format**

The Overload Pause Command payload shall be formatted as illustrated in Table 27.

Octets	2	2
Data Type	Unsigned 16-bit integer	Unsigned 16-bit integer
Field Name	Duration in minutes (M)	Pause Start Time (M)

Table 27 – Format of the Overload Command Payload.

6.2.2.3.4.1.1 Payload Details

The **Duration in minutes** field: Duration of this event in number of minutes. Maximum value is 1440 (one day). A duration of 0xffff is a special value denoting an unlimited pause command.

The **Pause Start Time** field: 2 bytes representing when the pause event is scheduled to start. A pause start time of 0x0000 is a special time denoting “now”. See Table 21 for the encoding of the time.

6.2.2.3.4.2 **Effects on Receipt**

On receipt of this command, the appliance shall pause its operations for a number of minutes specified in the Duration in minutes field. Moreover, the server should acknowledge the received command, generating a Load Management Acknowledge Command, (see sub-clause 6.2.2.4.3).

6.2.2.3.5 *Energy Phase Pause Command*[9]

This basic message is used to pause the household appliance operations as a consequence of a programmed load balancing event, i.e. a pause between two energy phases (see Power Profile Cluster).

6.2.2.3.5.1 Payload Format

The Energy Phase Pause Command payload shall be formatted as illustrated in Table 28.

Octets	**2**	**0/1**	**0/1**
Data Type	Unsigned 16-bit integer	Unsigned 8-bit integer	Unsigned 8-bit integer
Field Name	Duration in minutes (M)	PowerProfileID (M)	EnergyPhaseID (M)

Table 28 – Format of the Energy Phase Pause Command Payload.

6.2.2.3.5.1.1 Payload Details

The **Duration in minutes** field: Duration of this event in number of minutes. Maximum value is 1440 (one day). A duration of 0xffff is a special value indicating an unlimited pause command.

The **PowerProfileID** field: PowerProfileID field represents the identifier of the specific profile (see the Power Profile Cluster) which requires the interruption of operations.

The **EnergyPhaseID** field: EnergyPhaseID field represents the identifier of the specific energy phase among the selected PowerProfileID (see the Power Profile Cluster) which requires the interruption of operations.

6.2.2.3.5.2 Effects on Receipt

[9] The implementation of the Energy Phase Pause Command requires Power Profile Cluster implementation. TB added to Dependencies sub-clause.

On receipt of this command, the appliance shall pause its operations for a number of minutes specified in the Duration in minutes field. Moreover, the server should acknowledge the received command, generating a Load Management Acknowledge Command, (see sub-clause 6.2.2.4.3).

6.2.2.4 Commands Generated

The command IDs generated by the Appliance Control server cluster are listed in Table 29.

Command Identifier Field Value	Description	Mandatory/Optional
0x00	Signal State Response	M
0x01	Signal State Notification	M
0x02	Load Management Acknowledge	O
0x03-0xff	Reserved	-

Table 29 – Generated Commands IDs for the Appliance Control Cluster.

6.2.2.4.1 *Signal State Response Command*

This basic message is used to return household appliance status, according to Table 18 and Table 19.

6.2.2.4.1.1 Payload Format

The Signal State Response Command payload shall be formatted as illustrated in Table 30.

Octets	1	1	0/3
Data Type	8-bit Enumerator	Unsigned 8-bit integer	Unsigned 24-bit integer
Field Name	Appliance Status	Remote Enable Flags and Device Status 2	Appliance Status 2

Table 30 - Format of the Signal State Response Command Payload.

6.2.2.4.1.1.1 Payload Details

The **Appliance Status** field: the data field is a 8 bits in length enumerator identifying the appliance status. The enumeration used for this field shall match the specifications in Table 18.
The **Remote Enable Flags and Device Status 2** field: the data field is a 8 bits in length unsigned integer defining remote enable flags and potential appliance status 2 format. The unsigned integer used for this field shall match the specifications in Table 19.
The **Appliance Status 2** field: the command identification is a 24 bits in length unsigned integer representing potential non-standardized or proprietary data.

6.2.2.4.1.2 Effects on Receipt

On receipt of this command, the device is informed of a Household Appliance status.

6.2.2.4.2 *Signal State Notification Command*

This basic message is used to return household appliance status, automatically when appliance status changes.

6.2.2.4.2.1 Payload Format

The Signal State Notification Command payload shall be formatted as illustrated in Table 30.

6.2.2.4.2.2 Effects on Receipt

On receipt of this command, the device is informed of a Household Appliance status.

6.2.2.4.3 *Load Management Acknowledge Command*

This basic message is used to acknowledge the reception of either an Overload Pause Command or a Energy Phase Pause Command.

6.2.2.4.3.1 Payload Format

The Load Management Acknowledge Command payload shall be formatted as illustrated in Table 31.

Octets	1
Data Type	8-bit Enumerator
Field Name	Load Management Acknowledge

Table 31 – Format of the Load Management Pause Acknowledge Command Payload.

6.2.2.4.3.1.1 Payload Details

The **Load Management Acknowledge** field: the data field is a 8 bits in length enumerator identifying the Load Management Command acceptance or potential error conflictions. The enumeration used for this field shall match the specifications in CECED.

Enumeration	Value	Description
Reserved	0x00	Reserved
PAUSE_ACCEPTED	0x01	Either Overload Pause Command or Energy Phase Pause Command correctly received and scheduled for execution
PARAMETERS_ERROR	0x02	Error in pause schedule packet request
INVALID_DURATION	0x03	Invalid Duration
INVALID_POWER_PROFILE_ID	0x04	Invalid PowerProfile ID
INVALID_ENERGY_PHASE_ID	0x05	Invalid Energy Phase ID
Proprietary	0x06..0xff	Proprietary

Table 32 - Command Identification Values.

6.2.2.4.3.2 Effects on Receipt

On receipt of this command, the device is informed of a pause command correct reception.

6.2.3 Client

6.2.3.1 Dependencies

For the alarms functionality of this cluster to be operational, the Alarm cluster server shall be implemented on the same endpoint[10].

6.2.3.2 Attributes

The Client cluster has no attributes.

6.2.3.3 Commands Received

The client receives the cluster specific commands generated by the server (see 6.2.2.4).

6.2.3.4 Commands Generated

The client generates the cluster specific commands received by the server (see 6.2.2.3), as required by the application.

[10] TBD.

6.3 Appliance Events and Alerts Cluster

6.3.1 Overview

Attributes and commands for transmitting or notifying the occurrence of an alert event such as alarm, fault or warning.
It is based on the "Signal event" syntax of EN50523 and completed where necessary.

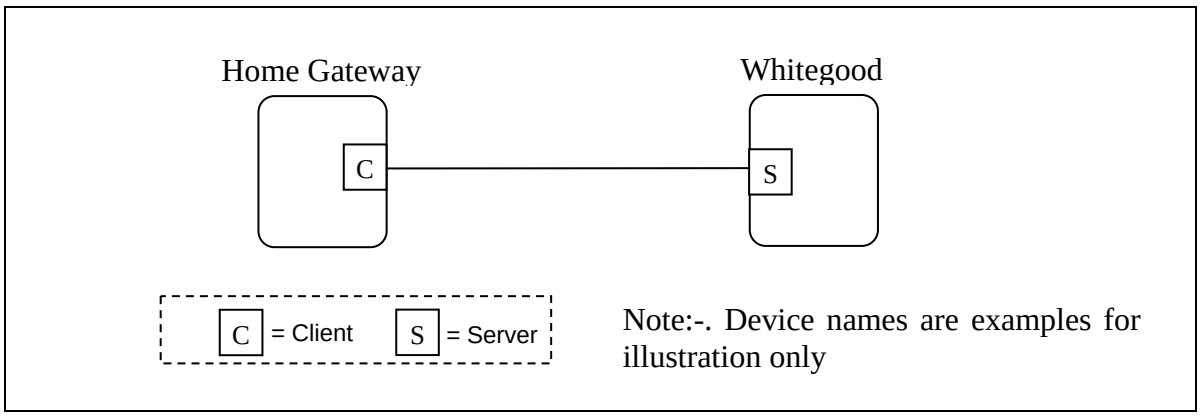

Figure 12 – Appliance Control Cluster Client Server Example.

Each event is described through three fields:

- An event identification value;
- A category: either WARNING, or DANGER, or FAILURE.
- A presence/recovery flag. Either the event has been detected, or the alert has been recovered.

6.3.2 Server

6.3.2.1 Dependencies

None.

6.3.2.2 Attributes

For convenience, the attributes defined in this specification are arranged into sets of related attributes; each set can contain up to 256 attributes. Attribute identifiers are encoded such that the most significant byte specifies the attribute set and the least significant byte specifies the attribute within the set. The currently defined attribute sets are listed in Table 33.

Attribute Set Identifier	Description
0x00	Appliance Warning and Faults
0x01-0xff	Reserved

Table 33 – Appliance Events and Alerts Cluster Attribute Sets.

6.3.2.2.1 *Appliance Warning and Faults Attribute Set*

The Appliance Warnings and Faults attribute set contains the attributes summarized in Table 34.

Identifier	Name	Type	Range	Access	Default	Man./ Opt.	Reportable
0x0000	ApplianceEvent List	Array of *n* Unsigned 24-bit integer	-	Read only	*n* x (0x000000)	M	No

Table 34 - Attributed of the Appliance Warnings and Faults Set.

6.3.2.2.1.1 **ApplianceEventList Attribute**

The *ApplianceEventList* attribute provides indicators reflecting the current warning and fault conditions of the electrical appliance.
ApplianceEventList is mandatory and must be included as part of the minimum data set to be provided by the household appliance device.
This attribute is an Array of *n* elements, with $n \geq 1$ (plus the zero-th element).
Each element is a 24-bit in length unsigned integer, representing a warning or fault condition. The behaviour causing the setting presence or recovering from a warning/fault condition is device specific. In other words, the application within the electrical appliance will determine and control when these fields are set or recovered.
The zero-th element is a 16 bit unsigned integer, holding the number of elements contained in the array, which may be zero. If the zero-th element contains 0xffff, the array is considered invalid / undefined.
The following table represent the array structure of *ApplianceEventList* attribute.

Attribute field	Type	Name	Range	Access	Default	Man. /Opt.	Reportable
0	Unsigned 16-bit integer	Number of elements	0x0000 – 0xffff	Read-only	0x0000	M	No
1	Unsigned 24-bit integer	EventStructure-1	0x000000 – 0xffffff	Read-only	0x000000	M	No
2	Unsigned 24-bit integer	EventStructure-2	0x000000 – 0xffffff	Read-only	0x000000	M	No
...	...	...	...	...	...	...	No
n	Unsigned 24-bit integer	EventStructure-*n*	0x000000 – 0xffffff	Read-only	0x000000	M	No

Table 35 - Array Structure of *ApplianceEventList* Attribute.

The organization of each array elements (EventStructure-*i*) is reported below.

Bit range	Function	
0..7	Event/Alert id	
8..11	Category	
	Value	**Enumeration**
	0x0 0x1	Reserved WARNING

	0x2 0x3 0x4 – 0xf	DANGER FAILURE Reserved
12..13	Presence recovery	
	Value	**Enumeration**
	0x0 0x1 0x2 – 0x3	PRESENCE RECOVERY Reserved
14..15	Reserved (set to 0x0)	
16..23	Non-standardised or proprietary	

Table 36 - Array Elements Organization.

The following enumerations are used in order to represent appliance warning and fault conditions contained into Appliance Warnings and Faults attribute set.

Enumeration	Value	Description	Category
Reserved	0x00	Reserved	-
Reserved	0x01 – 0x3f	Reserved for standardised events	-
Reserved	0x40 – 0x7f	Reserved for non-standardised events	-
DOOR LOCKED	0x80	Door does not unlock	WARNING
H2O MISSING	0x81	Water missing or water tap closed	WARNING
Reserved	0x82 – 0x90	Reserved for future use	-
MAINBOARD FAULT	0x91	Appliance Main board fault	FAILURE
MOTOR FAULT	0x92	Appliance Motor fault	FAILURE
TEMPERATURE SENSOR FAULT	0x93	Temperature sensor fault	FAILURE
PRESSURE SWITCH FAULT	0x94	Pressure switch fault	FAILURE
DRAIN PUMP FAULT	0x95	Appliance in idle state	FAILURE
Reserved	0x96	Reserved for future use	-
HEATER FAULT	0x97	Appliance rinse hold	FAILURE
Reserved	0x98 – 0x99	Reserved for future use	-
SPIN FAULT	0x9a	Appliance in service state	FAILURE
Reserved	0x9b – 0xff	Reserved for future use	-

Table 37 - Household Appliance Warning and Fault Enumerations for a Washing Machine.

6.3.2.3 Commands Received

The received command IDs for the Appliance Events and Alerts Cluster are listed in Table 38.

Command Identifier Field Value	Description	Mandatory/Optional
0x00	Get Events and Alerts	M
0x01-0xff	Reserved	-

Table 38 - Received Commands IDs for the Events and Alerts Cluster.

6.3.2.3.1 *Get Events and Alerts Command*

This basic message is used to retrieve Household Appliance current events and alerts.

6.3.2.3.1.1 **Payload Format**

This command does not have a payload.

6.3.2.3.1.2 **Effects on Receipt**

On receipt of this command, the device shall generate a Get Events and Alerts Response command (see 6.3.2.4.1).

6.3.2.4 Commands Generated

The generated command IDs for the Appliance Events and Alerts Cluster are listed in Table 39.

Command Identifier Field Value	Description	Mandatory/Optional
0x00	Get Events and Alerts Response	M
0x01	Events and Alerts Notification	M
0x02 - 0xff	Reserved	-

Table 39 - Generated Commands IDs for the Appliance Events and Alerts Cluster.

6.3.2.4.1 *Get Events and Alerts Response Command*

This message is used to return household appliance current events and alerts.

6.3.2.4.1.1 **Payload Format**

The payload shall be formatted as illustrated in Table 40.

Octets	1	3	...	3
Data Type	Unsigned 8-bit integer	Unsigned 24-bit integer	...	Unsigned 24-bit integer
Field Name	Events Count[11]	Event structure 1	...	Event structure *n*

Table 40 - Format of the Get Events and Alerts Response Command Payload.

6.3.2.4.1.1.1 Payload Details

The **Events Count** field: the data field is a 8 bits in length unsigned integer, containing the following event structures count and events structure type.
The following table provides details about Events Count and Structure field organization.

[11] Even if the *ApplianceEventList* array number of element field is 16-bit in length, the actual content is limited to 0x000*n*, where, in actual implementations, n is lower than 255 (except for the invalid condition, 0xffff). Then, the notification of the Event count is mapped to a single byte (following appliance interworking specifications [R6]-[R7]).

Bit range	Function	
0..3	Number of Events and Alerts n.	
4..7	Type of event.	
	Value	**Enumeration**
	0x0 0x1..0xf	UNSTRUCTURED Reserved

Table 41 – Events Count organization.

Each **Events Structure** field shall be formatted as illustrated in Table 42.

Bit range	Function	
0..7	Event/Alert id	
8..11	Category	
	Value	**Enumeration**
	0x0 0x1 0x2 0x3 0x4 – 0xf	Reserved WARNING DANGER FAILURE Reserved
12..13	Presence recovery	
	Value	**Enumeration**
	0x0 0x1 0x2 – 0x3	PRESENCE RECOVERY Reserved
14..15	Reserved (set to 0x0)	
16..23	Non-standardised or proprietary	

Table 42 – Events Structure organization.

6.3.2.4.1.2 Effects on Receipt

On receipt of this command, the device is informed of a Household Appliance warning and fault occurrence.

6.3.2.4.2 *Events and Alerts Notification Command*

This message is used to notify the current modification of warning and/or fault conditions.

6.3.2.4.2.1 Payload Format

The payload shall be formatted as illustrated in Table 43.

Octets	1	3	...	3
Data Type	Unsigned 8-bit integer	Unsigned 24-bit integer	...	Unsigned 24-bit integer
Field Name	Events Count	Event structure 1	...	Event structure n

Table 43 - Format of the Get Events and Alerts Response Command Payload.

6.3.2.4.2.1.1 Payload Details

See 6.3.2.4.1.1.1.

6.3.3 Client

6.3.3.1 Dependencies

None.

6.3.3.2 Attributes

The Client cluster has no attributes.

6.3.3.3 Commands Received

The client receives the cluster specific commands generated by the server (see 6.3.2.4).

6.3.3.4 Commands Generated

The client generates the cluster specific commands received by the server (see 6.3.2.3), as required by the application.

6.4 Simple Metering Cluster

6.4.1 Overview

The Simple Metering Cluster provides a mechanism to retrieve usage information from Electric metering devices applied to / embedded into a white good appliance; it is fully copied from ZigBee Smart Energy Profile.
Detailed description of Simple Metering Cluster is reported in [R5].
In the following, a selection of relevant attributes and information are reported, which are useful to include energy metering functionality into electrical appliances. We report here the Simple Metering for the sake of the reader.

6.4.2 Server

6.4.2.1 Dependencies

Subscribed reporting of Simple Metering attributes.

6.4.2.2 Attributes

For convenience, the attributes defined in this specification are arranged into sets of related attributes; each set can contain up to 256 attributes. Attribute identifiers are encoded such that the most significant Octet specifies the attribute set and the least significant Octet specifies the attribute within the set. The currently defined attribute sets are listed in [R5].
Simple Metering Cluster include the following attribute sets.

Attribute Set Identifier	Description
0x00	Reading Information Set
0x01	TOU Information Set Defined in [R5] but Not Implemented
0x02	Meter Status
0x03	Formatting
0x04	ESP Historical Consumption
0x05	Load Profile Configuration Sets Defined in [R5] but Not Implemented
0x06	Supply Limit
0x07-0xff	Reserved

Table 44 – Simple Metering Attribute Sets.

6.4.2.2.1 *Reading Information Set*

The Reading Information Set attributes provide a remote access to the reading of the Electric metering device. A reading must support at least one register which is the actual total summation of the delivered quantity (i.e. kWh).
Please note: In the following attributes, the term "Delivered" refers to the quantity of Energy that was delivered to the customer from the utility. Likewise, the term "Received" refers to the quantity of Energy that was received by the utility from the customer.
The following table includes a selection of attributes related to white good applications.

Identifier	Name	Type	Range	Access	Default	Man. /Opt.	Reportable
0x0000	CurrentSummationDelivered	Unsigned 48-bit Integer	0x000000000000 to 0xffffffffffff	Read only	-	M	Yes
...							
0x0006	PowerFactor	Signed 8-bit Integer	-100 to 100	Read only	0x00	O	No
...							

Table 45 – Reading Information Attribute Set.

6.4.2.2.1.1 CurrentSummationDelivered Attribute

CurrentSummationDelivered represents the most recent summed value of Energy [..] delivered and consumed in the premise.
CurrentSummationDelivered is mandatory and must be provided as part of the minimum data set to be provided by the metering device.
CurrentSummationDelivered is updated continuously as new measurements are made.

6.4.2.2.1.2 PowerFactor Attribute

PowerFactor contains the Average[12] Power Factor ratio in 1/100's. Valid values are 0 to 99.

6.4.2.2.2 *Meter Status Set*

The Meter Status Attribute Set is defined in the following table.

Identifier	Name	Type	Range	Access	Default	Man. /Opt.	Reportable
0x0200	Status	8-bit BitMap	0x00 to 0xff	Read only	0x00	M	Yes

Table 46 – Meter Status Attribute Set.

6.4.2.2.2.1 *Status* Attribute

The *Status* attribute provides indicators reflecting the current error conditions found by the metering device. This attribute is an 8 bit field where when an individual bit is set, an error or warning

[12] CCB CC-931 [SE]

condition exists. The behavior causing the setting or resetting each bit is device specific. In other words, the application within the metering device (here, an electrical appliance which include a power meter device) will determine and control when these settings are either set or cleared. Table 47 lists the mapping of the bit:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Service Disconnected Open	Leak Detect	Power Quality	Power Failure	Tamper Detect	Low Battery	Check Meter

Table 47 - Mapping of the *Status* Attribute.

The definitions of the Status bits are:
Service Disconnect Open: Set to true when the service have been disconnected to this premise.
Leak Detect: Set to true when a leak have been detected.
Power Quality: Set to true if a power quality event have been detected such as a low voltage, high voltage.
Power Failure: Set to true during a power outage.
Tamper Detect: Set to true if a tamper event has been detected.
Low Battery: Set to true when the battery needs maintenance.
Check Meter: Set to true when a non fatal problem has been detected on the meter such as a measurement error, memory error, self check error.

6.4.2.2.3 *Formatting Set*

The following set of attributes provides the ratios and formatting hints required to transform the received summations, consumptions or demands/rates into displayable values.

Identifier	Name	Type	Range	Access	Default	Man. /Opt.	Reportable
0x0300	UnitOfMeasure	8-bit Enumerator	0x00 to 0xff	Read only	0x00	M	No
...							No
0x0303	SummationFormatting	8-bit BitMap	0x00 to 0xff	Read only	-	M	No
0x0304	DemandFormatting	8-bit BitMap	0x00 to 0xff	Read only	-	O	No
...							No
0x0306	MeteringDeviceType	8-bit BitMap	0x00 to 0xff	Read only	-	M	No

Table 48 – Meter Status Attribute Set.

6.4.2.2.3.1 **UnitofMeasure Attribute**

UnitofMeasure provides a label for the Energy being measured by the metering device. The unit of measure apply to all summations, consumptions/profile interval and demand/rate supported by this cluster. Other measurements such as the power factor are self describing. This Attribute is an 8 bit enumerated field. The bit descriptions for this Attribute are resumed in the following table and fully described in [R5], Table D.17.

Values	Description
0x00	kW (kilo-Watts) & kWh (kilo-WattHours) in pure Binary format
[…]	
0x80	kW (kilo-Watts) & kWh (kilo-WattHours) in BCD format
[…]	

Table 49 – *UnitOfMeasure* Attribute Enumeration.

6.4.2.2.3.2 SummationFormatting Attribute

SummationFormatting provides a method to properly decipher the number of digits and the decimal location of the values found in the Summation Information Set of attributes. This attribute is to be decoded as follows:

- Bits 0 to 2: Number of Digits to the right of the Decimal Point.
- Bits 3 to 6: Number of Digits to the left of the Decimal Point.
- Bit 7: If set, suppress leading zeros.

This attribute shall be used against the following attributes:

- *CurrentSummationDelivered*
- *[…] See [R5]*

6.4.2.2.3.3 DemandFormatting Attribute

DemandFormatting provides a method to properly decipher the number of digits and the decimal location of the values found in the Demand related attributes. This attribute is to be decoded as follows:

- Bits 0 to 2: Number of Digits to the right of the Decimal Point.
- Bits 3 to 6: Number of Digits to the left of the Decimal Point.
- Bit 7: If set, suppress leading zeros.

This attribute shall be used against the following attributes:

- *[…] see [R5]*
- *InstantaneousDemand*

6.4.2.2.3.4 MeteringDeviceType Attribute

MeteringDeviceType provides a label for identifying the type of metering device present. The attribute are enumerated values representing Energy, Gas, Water, Thermal, and mirrored metering devices. The relevant enumerations are reported below whereas all defined values are represented in [R5], Table D.18.

Values	Description

0	Electric Metering
[…]	[…] See [R5] for further details

Table 50 – *MeteringDeviceType* Attribute Enumerations.

6.4.2.2.4 *ESP Historical Consumption Set*

The ESP Historical Consumption Set is defined in Table 51

Identifier	Name	Type	Range	Access	Default	Man. /Opt.	Reportable
0x0400	Instantaneous Demand	Signed 24-bit Integer	0x000000 to 0xffffff	Read only	0x000000	O	Yes
[...]							

Table 51 – ESP Historical Consumption Set.

6.4.2.2.4.1 InstantaneousDemand Attribute

InstantaneousDemand represents the current Demand of Energy […] delivered or received at the premise. Positive values indicate Demand delivered to the premise where negative values indicate demand received from the premise. *InstantaneousDemand* is updated continuously as new measurements are made. The frequency of updates to this field is specific to the metering device, but should be within the range of once every second to once every 5 seconds. In the E@H context, the *InstantaneousDemand* attribute describes the total power used by the entire house at a given instant in time, and it is measured in KW.

6.4.2.2.5 Supply limit Attribute set

See ZigBee Smart Energy rev15 specification. *DemandLimit* is used to set the limit for the *IstantaneousDemand*.

The *AlarmMask* attribute specifies whether each of the alarms listed in is enabled. When the bit number corresponding to the alarm code is set to 1, the alarm is enabled, else it is disabled. Bits not corresponding to a code in the table are reserved. When the Alarms cluster is implemented on a device, and one of the alarm conditions included in this table occurs, an alarm notification is generated, with the alarm code field set as listed in the table Alarm code attribute shall be added as manufacturer specific attribute to the Simple metering cluster as described in SE 1.0 specification, in order to manage the alarm related to the power overload as listed in the following table :

AlarmMask Attribute Bit Number	Alarm Code	Alarm condition
0	0	*InstantaneousDemand* over *DemandLimit* (Power overload condition)
1	1	*InstantaneousDemand* below *DemandLimit* (back to normal operating

		condition)
2-7	-	Reserved

Table 52- Values of the *AlarmMask* Attribute.

6.4.2.3 Server Commands

6.4.2.3.1 *Commands Received*

The Server cluster support cross-cluster commands, i.e. can receive Read Attribute, and Read Reporting Configuration commands.

6.4.2.3.2 *Commands Generated*

The Server cluster support cross-cluster commands, i.e. can generate Read Attribute Response, Report Attributes and Read Reporting Configuration Response.

6.4.3 Simple Meter Application Guidelines

6.4.3.1 Attribute Reporting

Attribute reporting may be used for sending information in the Reading Information, [..] Meter Status [..] attribute sets.

6.4.3.2 Metering Data Updates

The frequency and timeliness of updating metering data contained in the Simple Metering Cluster Attributes and Profile Intervals is up to the individual Metering device manufacturers capabilities. As a best practice recommendation, updates of the metering data should not cause delivery of the information to end devices more often than once every 30 seconds. End devices should also not request information more often than once every 30 seconds.

6.5 Power Profile Cluster

6.5.1 Overview

This cluster provides an interface for transferring power profile information from a device (e.g. Whitegood) to a controller (e.g. the Home Gateway). The Power Profile transferred can be solicited by client side (request command) or can be notified directly from the device (server side).

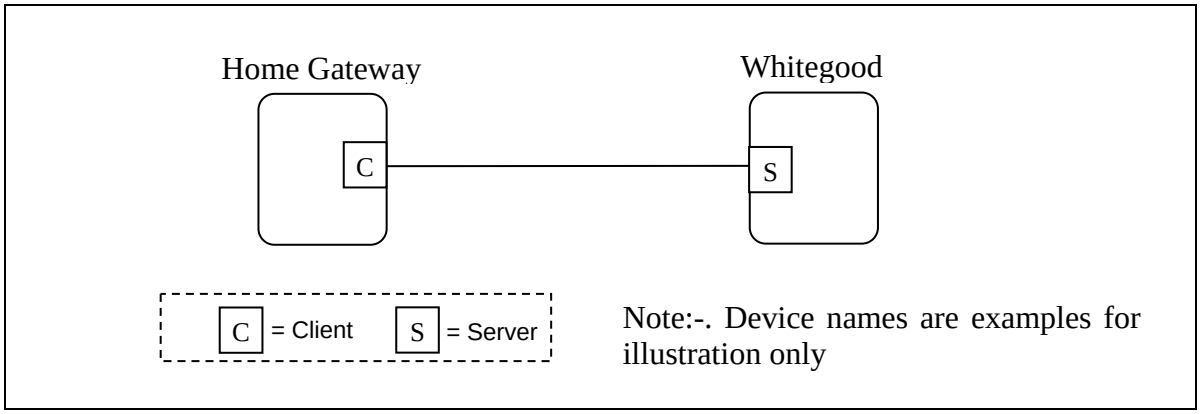

Figure 13 – Typical Usage of the this cluster.

6.5.2 Server

6.5.2.1 Dependencies

Appliance Control Cluster for the parts regarding the status notification and power management commands. Other specific clusters for actuation for devices different than Smart Appliances.

6.5.2.2 Attributes

The currently defined attributes for this cluster are listed in Table 53. The following attributes represent the parameters for each Power profile's phases.

Identifier	Name	Type	Range	Access	Unit	Default	Mandatory / Optional	Reportable
0x0000	TotalProfileNum	Unsigned 8-bit integer	0x01 – 0xfe	Read Only	-	-	M	No
0x0001	CurrentPowerProfile	Unsigned 8-bit integer	0x01 – 0xfe	Read Only	-	-	M	No
0x0002	CurrentEnergyPhase	Unsigned 8-bit	0x01 – 0xfe	Read Only	-	-	M	No

		integer						

Table 53 – Attributes of this cluster.

6.5.2.2.1 *TotalProfileNum Attribute*

The *TotalProfileNum* attribute represents the total number of profiles supported by the device.

6.5.2.2.2 *CurrentPowerProfileAttribute*

The *CurrentPowerProfile* attribute represents the identifier of the last power profile requested or notified by the device.

6.5.2.2.3 *CurrentEnergyPhase Attribute*

The *CurrentEnergyPhase* attribute represents the identified of the current energy phase of the last power profile notified by the device.

6.5.2.3 Commands received

Table 53 lists cluster specific commands which are received by the server.

Command Identifier Field Value	Description	Mandatory / Optional
0x00	*PowerProfileRequest*	M
0x01	*ReadCurrentProfiles*	M
0x02	*GetPowerProfilePriceResponse*	M

Table 54 - Cluster specific commands received by the server.

The *PowerProfileRequest* Command is generated by a device supporting the client side of the Power Profile cluster in order to request the Power Profile of a server device. It is possible to request all profiles (without knowing how many Power Profiles the server has) or to request a specific *PowerProfileID*.
In the case of multiple profiles the server shall send multiple messages, one for each Power Profile.
If the profile is already running, the *ExpectedDuration* and *Energy* fields of the first phase represent the time and energy-to-end of the energy phase in execution, followed by the data representing the remaining phases.

6.5.2.3.1.1 Payload format

The *PowerProfileRequest* Command payload shall be formatted as illustrated in Table 55.

Octets	1
Data Type	Unsigned 8-bit integer
Field name	PowerProfileID

Table 55 - Format of the *PowerProfileRequest* command Payload.

6.5.2.3.1.1.1 Payload details

The payload of the *PowerProfileRequest* command carries the fields defined in Table 55.
The *PowerProfileID* field specifies which profile (among *TotalProfileNum* total profiles number) is requested. The special value 0x00 of this field does not refer to a particular profile; if 0x00 value is received, the device should send details related to all the available profiles.
The *PowerProfileID* field cannot be greater than *TotalProfileNum.*

6.5.2.3.1.2 When generated

This command is generated when the client side of the Power Profile cluster (e.g. a Home gateway device), needs to request the power profile to a device supporting the Power Profile cluster server side (e.g. Whitegood).

6.5.2.3.1.3 Effect on receipt

The device that receives the *PowerProfileRequest* command shall reply with a *PowerProfileResponse* if supported. If the command is not supported the device shall reply with a standard ZCL Default response with status UNSUP_CLUSTER_COMMAND 0x81 (as from ZCL specification).
If the requested profile data are not available, the device shall reply with a standard ZCL response INVALID_VALUE 0x87 (according to ZCL specification).

6.5.2.3.2 *ReadCurrentPowerProfiles Command*

The ReadCurrentPowerProfiles Command is generated in order to retrieve the identifiers of current Power Profiles. This command does not have a payload.

6.5.2.3.2.1 Effects on Receipt

On receipt of this command, the device shall generate a *Read Current Power Profiles Response* command (see 6.5.2.4.2).

6.5.2.3.3 *GetPowerProfilePriceResponse Command*

The*GetPowerProfilePriceResponse* command allows a device (client) to communicate the cost associated to the selected Power Profile to another device (server) requesting it.

6.5.2.3.3.1 Payload format

The *GetPowerProfilePriceResponse* Command payload shall be formatted as illustrated in Table 56

Octets	1	2	4	1
Data Type	Unsigned 8-bit integer	Unsigned 16-bit integer	Unsigned 32-bit integer	Unsigned 8-bit integer
Field Name	Power Profile ID	Currency	Price	Price trailing Digit

Table 56 - Format of the GetPowerProfilePrice command.

6.5.2.3.3.1.1 Payload format

PowerProfileID

The *PowerProfileID* field is an 8-bit unsigned integer representing the identifier of the specific profile described by the Power Profile.
This is typically a sequential and contiguous number ranging from 1 to *TotalProfileNum*.

Currency

The *Currency* field is an unsigned 16 bit integer identifying the local unit of currency used in the price field. This field is thought to be useful for displaying the appropriate symbol for a currency (i.e.: $, €). The value of the currency field should match the values defined by ISO 4217.

Price

The *Price* field is an unsigned 32 bit field containing the price of the energy measured in base unit of Currency per Unit of Measure (as described in the Simple Metering Cluster, see [R10]) with the decimal point located as indicated by the Price Trailing Digit field when the energy is delivered to the premise.

Price trailing digit

The price trailing digit field is an 8-bit unsigned integer used to determine where the decimal point is located in the price field and to indicate the current pricing tier as chosen by the commodity provider. The Trailing Digit indicates the number of digits to the right of the decimal point.

6.5.2.3.3.2 When Generated

This command is generated when the command *GetPowerProfilePrice* is received. Please refer to sub-clause 6.5.2.4.5 .

6.5.2.3.3.3 Effect on receipt

On receipt of this command, the originator is notified of the associated cost of the requested Power Profile, calculated by the Power Profile server side.

6.5.2.4 Command Generated

Table 56 lists the cluster specific commands sent by the server.

Command Identifier Field Value	Description	Mandatory / Optional
0x00	*PowerProfileNotification*	M
0x01	*PowerProfileResponse*	O
0x02	*ReadCurrentProfilesResponse*	M
0x03	*GetPowerProfilePrice*	O
0x04	*PowerProfilesStateNotification*	M

Table 57 - Cluster specific commands sent by the server.

6.5.2.4.1 *PowerProfileNotification Command*

The *PowerProfileNotification* Command is generated by a device supporting the server side of the Power Profile cluster in order to send the information of the specific parameters (such as Peak power and others) belonging to each phase.

6.5.2.4.1.1 Payload format

The *PowerProfileNotification* Command payload shall be formatted as illustrated in Table 58.

Octets	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**
Data Type	**Unsigned 8-bit integer**	**Unsigned 8-bit integer**	**Unsigned 8-bit integer**	**Unsigned 8-bit integer**	**Unsigned 8-bit integer**	**Unsigned 16-bit integer**	**Unsigned 16-bit integer**	**Unsigned 16-bit integer**	**Unsigned 16-bit integer**
Field name	*TotalProfileNum*	*PowerProfile ID*	*Num of Transferred Phases*	*Energy PhaseID*$_1$	*Macro PhaseID*$_1$	*ExpectedDuration*$_1$	*Peak Power*$_1$	*Energy*$_1$	*Max ActivationDelay*$_1$

Octets	**…**	**1**	**1**	**2**	**2**	**2**	**2**
Data Type	**…**	**Unsigned 8-bit integer**	**Unsigned 8-bit integer**	**Unsigned 16-bit integer**	**Unsigned 16-bit integer**	**Unsigned 16-bit integer**	**Unsigned 16-bit integer**
Field name	…	*Energy PhaseID*$_n$	*Macro PhaseID*$_n$	*ExpectedDuration*$_n$	*PeakPower*$_n$	*Energy*$_n$	*MaxActivationDelay*$_n$

Table 58 - Format of the *PowerProfileNotification* command Payload.

6.5.2.4.1.1.1 Payload details

The payload of the *PowerProfileNotification* command carries the fields defined in Table 58. If multiple phases are transferred within a single *PowerProfileNotification* command (i.e. *Number of Transferred Phases* greater than 1), the parameters of the other phases (*PhaseID*, *ExpectedDuration*, etc) should be carried in the payload. Each phase has a fixed number of parameters and the total length is 10 octets, so that the total length of the payload could be calculated with the following formula:

*Total Payload Length = 1 + 1 + 1 + (Num of Transferred Phases * 10)*

TotalProfileNum

See sub-clause 6.5.2.2.1 reporting the *TotalProfileNum* attribute description.

PowerProfileID

The *PowerProfileID* field represents the identifier of the specific profile described by the Power Profile.
This filed contains a sequential and contiguous number ranging from 1 to *TotalProfileNum*.

MacroPhaseID
The *MacroPhaseID* field represents the identifier of the specific phase (operational-displayed) described by the Power Profile.
This reference could be used in conjunction with a table of ASCII strings, describing the label of the functional phase. This table is not described in the contest of the Power Profile because it may be not functionally linked with energy management.

EnergyPhaseID
The *EnergyPhaseID* field indicates the identifier of the specific energy phase described by the Power Profile.
This is a sequential and contiguous number ranging from 1 to the maximum number of phases belonging to the Power Profile.

ExpectedDuration
The *ExpectedDuration* field represents the estimated duration of the specific phase. Each unit is a minute.

PeakPower
The *PeakPower* field represents the estimated power for the specific phase. Each unit is a Watt.

Energy
The *Energy* field represents the estimated energy consumption for the accounted phase. Each unit is Watt per hours. The Energy values fulfills the following equation:

$$Energy \leq PeakPower(Watt) * ExpectedDuration(sec).$$

MaxActivationDelay
The *MaxActivationDelay* field indicates the maximum interruption time between the end of the previous phase and the beginning of the specific phase. Each unit is a minute.
The special value 0x0000 means that it is not possible to insert a pause between the two consecutive phases.

6.5.2.4.1.2 When Generated

This command is generated when the server side of the Power Profile cluster (e.g. a Whitegood device), need to send the representation of its power profile to a controller device supporting the Power Profile cluster client side (e.g. Home Gateway).

6.5.2.4.1.3 Effect on receipt

The device that receives the *PowerProfileNotification* command shall reply with a standard Default response if requested in the ZCL header of the *PowerProfileNotification* command.

6.5.2.4.2 *PowerProfileResponse command*

This command is generated by the server side of Power Profile cluster as a reply to the *PowerProfileRequest* command. If the reception of *PowerProfileRequest* command is not supported the device shall reply with a standard ZCL Default response with status UNSUP_CLUSTER_COMMAND 0x81 (as from ZCL specification).
If the profile data requested are not available, the device shall reply with a standard ZCL response INVALID_VALUE 0x87 (as ZCL specification).

6.5.2.4.3 *Payload format*

The *PowerProfileResponse* Command payload shall be formatted as illustrated in (same as *PowerProfileNotification* command).

6.5.2.4.3.1 Payload details

The payload of the *PowerProfileResponse* command carries the fields defined in Table 58 (the same as *PowerProfileNotification* command).

6.5.2.4.3.2 When generated

This command is generated when the client side of the Power Profile cluster (e.g. a Home gateway device), need to request the parameters of a specific phase (or phases) of its power profile to a device supporting the Power Profile cluster server side (e.g. Whitegood).

6.5.2.4.3.3 Effect on receipt

The device that receives the *PowerProfileResponse* command shall reply with a standard Default response if requested in the ZCL header of the *PowerProfileResponse* command.
The device that receives the *PowerProfileResponse* command shall reply with a standard ZCL Default response with status UNSUP_CLUSTER_COMMAND 0x81 (as from ZCL specification) if the reception of this command is not supported.
If the profile data requested are not available, the device shall reply with a standard ZCL response INVALID_VALUE 0x87 (as ZCL specification).

6.5.2.4.4 *ReadCurrentPowerProfilesResponse Command*

The *ReadCurrentPowerProfilesResponse* command allows a device (server) to communicate its current Power Profile(s) to another device (client) that previously requested them.

6.5.2.4.4.1 Payload format

The *ReadCurrentPowerProfilesResponse* Command payload shall be formatted as illustrated in. Table 59

Octets	**1**	**3**	**3**	**...**	**3**
Field Name	Power Profile Count	Power Profile record 1	Power Profile record 2	...	Power Profile record *n*

Table 59 – Format of the Read Current Power Profiles Response Command Frame.

Each Power Profile record shall be formatted as illustrated in Table 60.

Octets	1	1	1
Data Type	Unsigned 8-bit integer	Unsigned 8-bit integer	8 bits enumeration
Field Name	Power Profile ID	Energy Phase ID	PowerProfileState

Table 60 – Format of the Power profile Record Field.

Payload details:

Power Profile Count

The number of Power Profile ID requested by the *ReadCurrentProfiles* command.

Power Profile Record

This recors support the following fields:

- Power Profile ID: the identifier of the Power Profile as requested;
- Energy Phase ID: The current Energy Phase ID of the specific Profile ID;
- PowerProfileState: an enumeration field representing the current state of the Power Profile (see Table 61 and see Figure 14).

Enumeration	Value	Description
POWER_PROFILE_STARTED	0x00	The whole power profile is started
RUNNING	0x01	An energy phase is running when the request is received
ENERGY_PHASE_ENDED	0x02	The current energy phase is terminated
ENERGY_PHASE_STARTED	0x03	The current energy phase is started
WAITING_TO_START	0x04	The Power Profile is in between two energy phases (one ended, the other not yet started)
POWER_PROFILE_ENDED	0x05	The whole Power profile is terminated
Reserved	0x06-0xff	Reserved

Table 61 – PowerProfileState enumeation field.

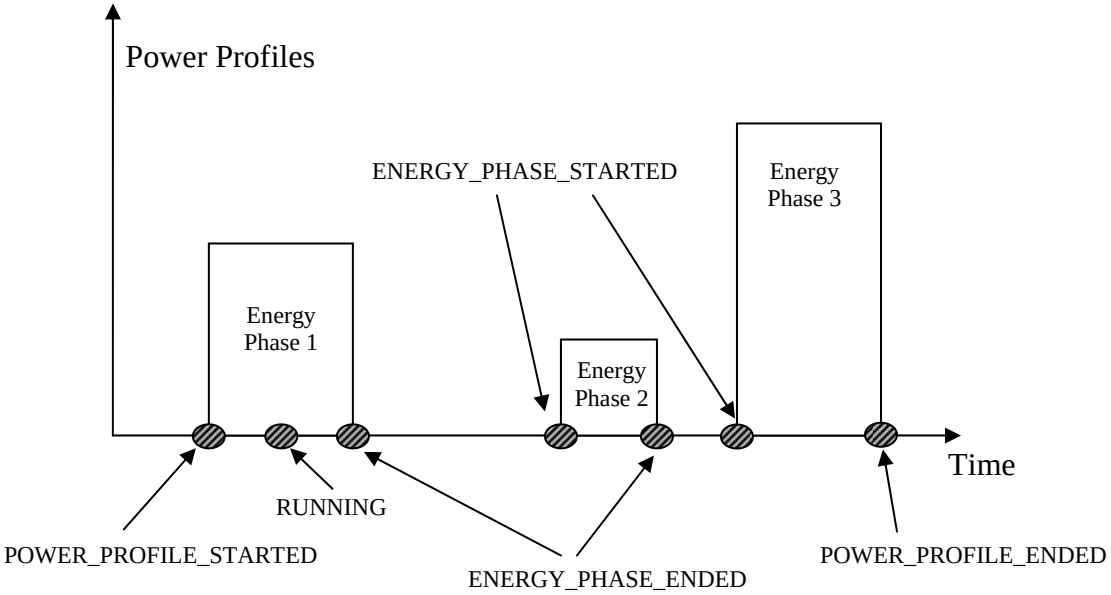

Figure 14 – Power profile states

6.5.2.4.4.2 When Generated

This command is generated when the command *ReadCurrentPowerProfilesResponse* is received. Please refer to sub-clause 6.5.2.3.2.

6.5.2.4.4.3 Effect on receipt

On receipt of this command, the originator is notified of the results of its Read Current Power Profiles attempt (i.e. receives the Power Profiles currently running in the server device).

6.5.2.4.5 *GetPowerProfilePrice Command*

The *GetPowerProfilePrice* Command is generated by the server (e.g. White goods) in order to retrieve the cost associated to a specific Power profile. This command has the same payload as the *PowerProfileRequest* command (see Table 54)

6.5.2.4.5.1 Effects on Receipt

On receipt of this command, the recipient device shall generate a *GetPowerProfilePriceResponse* command (see 6.5.2.3.3).

6.5.2.4.6 *PowerProfileStateNotification Command*

The *PowerProfileStateNotification* Command is generated by the server (e.g. White goods) in order to update the state of the power profile and the current energy phase. It has the same payload as the *ReadCurrentPowerProfilesResponse* command but it is an unsolicited command.

6.5.2.4.6.1 Effects on Receipt

On receipt of this command, the recipient device will update its information related to the PowerProfile of the device (e.g. it will update the estimation of the durations of the Power Profile's energy phases with the actual data).

6.5.3 Client

6.5.3.1 Dependencies

None

6.5.3.2 Attributes

The client has no attributes.

6.5.3.3 Commands Received

The client receives the cluster specific response commands detailed in 6.5.2.4.

6.5.3.4 Commands Generated

The client generates the cluster specific commands detailed in 6.5.2.3, as required by the application.

6.6 SmartInfo Identification Cluster

6.6.1 Overview

Attributes and commands for determining advanced information about utility metering device.

Note: Where a physical ZigBee node supports multiple endpoints it will often be the case that many of these settings will apply to the whole node, that is they are the same for every endpoint on the device. In such cases they can be implemented once for the node, and mapped to each endpoint.

6.6.2 Server

6.6.2.1 Dependencies

None.

6.6.2.2 Attributes

For convenience, the attributes defined in this specification are arranged into sets of related attributes; each set can contain up to 16 attributes. The currently defined attribute sets are listed in Table 10.

Attribute Set Identifier	Description
0x000	Smart Info Identification
0x001-0xfff	Reserved

Table 62 – Smart info Identification Attribute Sets.

6.6.2.2.1 *Smart Info Identification Attribute Set*

The Smart Info Identification attribute set contains the attributes summarized in Table 63

Identifier	Name	Type	Range	Access	Default	Mandatory/ Optional	Reportable
0x0010	CompanyName	Octet String	0 to 16 Octets	Read only	“1, 0x00”	M	No
0x0011	Model Type ID	Unisgned 16-bit integer	0x0000-0xffff	Read only	-	M	No
0x0014	Data Quality ID	Unisgned 16-bit integer	0x0000-0xffff	Read only	-	M	No
0x0015	Customer Name	Octet String	0 to 16 Octets	Read / Write	0x0000	O	No
0x0016	Model	Octet String	0 to 16 Octets	Read only	“1, 0x00”	O	No
0x0017	PartNumber	Octet String	0 to 16 Octets	Read only	“1, 0x00”	O	No
0x0018	ProducRevision	Octet String	0 to 6 Octets	Read only	“1, 0x00”	O	No

0x001A	SoftwareRevision	Octet String	0 to 6 Octets	Read only	"1, 0x00"	O	No

Table 63– Attributes of the Smart Info Identification Attribute Set.

6.6.2.2.1.1 Company Name Attribute

CompanyName is a ZCL Octet String field capable of storing up to 16 character string (the first Octet indicates length) encoded in the UTF-8 format. Company Name defines the meter manufacturer name, decided by manufacturer.

6.6.2.2.1.2 Meter Type ID Attribute

Meter Type ID defines the Smart Info installation features, decided by manufacturer.
The following table provides Meter Type IDs field content.

Device	Meter Type ID
Utility Primary Meter	0x0000
Utility Production Meter	0x0001
Utility Secondary Meter	0x0002
Private Primary Meter	0x0100
Private Production Meter	0x0101
Private Secondary Meters	0x0102
Generic Meter	0x0110

Table 64– Meter Type IDs.

6.6.2.2.1.3 Data Quality ID Attribute

Data Quality ID defines the Smart Info Simple Metering information certification type, decided by manufacturer.
The following table provides Data Quality IDs field content.

Device	Meter Type ID
All Data Certified	0x0000
Only Instantaneous Power not Certified	0x0001
Only Cumulated Consumption not Certified	0x0002
Not Certified data	0x0003

Table 65– Data Quality IDs.

6.6.2.2.1.4 Customer Name Attribute

CustomeName is a ZCL Octet String field capable of storing up to 16 character string (the first Octet indicates length) encoded in the UTF-8 format.

6.6.2.2.1.5 Model Attribute

Model is a ZCL Octet String field capable of storing up to 16 character string (the first Octet indicates length) encoded in the UTF-8 format. *Model* defines the meter model name, decided by manufacturer.

6.6.2.2.1.6 PartNumber Attribute

PartNumber is a ZCL Octet String field capable of storing up to 16 character string (the first Octet indicates length) encoded in the UTF-8 format. *PartNumber* defines the meter part number, decided by manufacturer.

6.6.2.2.1.7 ProductRevision Attribute

ProductRevision is a ZCL Octet String field capable of storing up to 6 character string (the first Octet indicates length) encoded in the UTF-8 format. *ProductRevision* defines the meter revision code, decided by manufacturer.

6.6.2.2.1.8 SoftwareRevision Attribute

SoftwareRevision is a ZCL Octet String field capable of storing up to 6 character string (the first Octet indicates length) encoded in the UTF-8 format. *SoftwareRevision* defines the meter software revision code, decided by manufacturer.

6.6.2.3 Commands Received

No cluster-specific commands are received by the server.

6.6.2.4 Commands Generated

No cluster-specific commands are generated by the server.

6.6.3 Client

6.6.3.1 Dependencies

None.

6.6.3.2 Attributes

The Client cluster has no attributes.

6.6.3.3 Commands Received

No cluster-specific commands are received by the client.

6.6.3.4 Commands Generated

No cluster-specific commands are generated by the client.

7 Glossary - Terms and Abbreviations

Term	Description
AG	See HG
Appliance Power Profile	The Appliance Power Profile is a data structure containing information about the energy consumption of an appliance (load profile related to its cycles) and some other useful information for load shifting or load shedding its usage.
APL	ZigBee Application Layer
APS	ZigBee Application Support Sublayer
ASDU	ZigBee Application Service Data Unit
CEMS	Community Energy Management System: aggregator
Customer Interfaces	An appliance or Smart Info User Interface extension. Its goal is having a remote, more verbose, portable, remote, user friendly, configurable device. It could be a physical device or, more commonly, it is only a logical component, which can be visualized by a PDA, a pc or a Smart Phone (connected in the HAN or HN). Typical implementations are through Web pages or custom software written for each of these devices.
Demand Side Management	Demand side management (DSM) entails actions that influence the quantity or patterns (load profile) of use of energy consumed by end users, such as actions targeting reduction of peak demand during periods when energy-supply systems are constrained. Noticeably techniques are load shifting and load shedding.
DSO	In electrical power business a Distribution System Operator is an operator that carries and delivers electricity to the consumer from the TSO's distribution lines.
Energy Cost Algorithm	Algorithm, to obtain the price of energy at a given time (e.g. € per kWh from 08:00 to

	19:00) replicating the conditions applied by the Energy Retailer. The Energy Cost Algorithm to get the price could be quite complex, and, in any case, defined by each Energy Retailer. The Energy Cost Algorithm shall receive as inputs a Power Profile, either actual or estimated, and all the needed metering data.
Energy Regulation Algorithm	Energy Regulation algorithm is any procedure which defines the strategy for coordinating Smart Appliances behavior, in order to reach energy consumption or cost optimization and to guarantee the overall performance of the system, using as inputs the global energy consumption, its cost, Appliances Power Profile and their status. Main control techniques involved in the Energy Regulation algorithm are load shifting and shedding .
Energy Retailer	Companies that participate in the retail energy market providing a service (energy) to the end user.
HA	ZigBee Home Automation Public Application Profile (see [R3])
HAN	A home area/automation network is a residential local area network, usually characterized by low throughput. It is typically used for communication between devices within the home such as sensors, smart plugs, smart thermostats and household appliances. It can be a Wireless network (e.g. ZigBee) or wired (e.g. Power Line Communication). This is often referred to as PAN (Personal area network)
HG	Home Gateway: it is the gateway between the HAN, the HN and the WAN (e.g. internet). It is able to interface Smart Appliances and Customer Interfaces through the communication protocol(s) used in the HAN and HN (ZigBee, WiFi, etc.) and to provide a broadband connection to internet (usually via a standard ADSL connection). Moreover, the Gateway is able to collect energy data, from the Smart Info and from the user's appliances, and publish them in the HN and WAN.

Home Domain	It identifies a boundary of the wired/wireless communication system (HAN and HN), covering Smart Appliances, Customer Interfaces, Smart Info and Home Gateway. This boundary is usually the customer's House.
Home Domain Overload	Condition which takes place when aggregated home load exceeds a given power limitation. Power limitation can be determined by different causes according to the regulation in place. For example, in South Europe countries, domestic connections are subject to a maximum contractual power (eg. 3kW). Note that maximum contractual power limitation process is managed by the Meter, which is the only actor entitled to sense threshold exceeding and to perform needed action. In some circumstances, the Meter will open the breaker immediately, without emitting any alarm. In other countries, the limitation is imposed by physical limitation of the home equipment and apposite safety devices are installed to prevent the overload.
Home Energy Monitor	A Home Energy Monitor is a device providing the consumer a prompt and convenient feedback on electrical (or other) energy use. These devices may also display cost of energy, estimates of greenhouse gas emissions, near real time consumption of some electrical loads inside the house. Usually its display is remote from the measurement point and portable inside the house, communicating with the sensor/Home Electricity Meter using a wired (e.g. power line communications) or wireless methodology.
HN	A home network is a residential local area network, typically characterized by high throughput. It is used for communication between digital devices typically deployed in the home, usually personal computers, printers, gateways. The home network can be wireless

	(e.g.Wi-Fi) or wired (e.g. Ethernet).
Load Profile	Load profile is the variation in the electrical load versus time. A more specific definition is the Power Profile, which takes into account the power used by the load.
Load Shedding	Energy utilities' method of reducing demand on the energy generation system by temporarily rationing distribution of energy to different geographical areas; this can be done by forcing the switch off of some electric loads in the grid or by reducing the power consumption of some of those (thus altering their load profile). The most drastic kind of load shedding are rolling blackouts, the last resort measure used by an electric utility company in order to avoid a total blackout of the power system. Smart Appliances could significantly help to avoid these last resort measures, reducing temporarily their power consumptions: load shedding could be performed by the appliance control logic itself changing its power consumption profile (load profile) during its working operations . This action implies an information coming from the Utility through the Smart Grid to the Smart Appliance in order to to signal the need, carrying usually also a severity level. Their performances should not be greatly or noticeably affected by the load shedding operation. It belongs to the Demand Side Management techniques.

Load Shifting	Load Shifting is an electric load management technique that aims to shift the pattern of energy use of a device (load profile), moving demand from the peak hours to off-peak hours of the day. It belongs to the Demand Side Management techniques. In the Smart Appliance context, the load could be each single electric load of the appliance or, more generally and commonly, the overall working cycle of the appliance (which consists of a complex sequence of activation of those single loads, in order to achieve the needed performance of the machine).
MID	CECED Message Interaction Description
OID	CECED Object Identifier
Peak Demand or Peak Load	Peak demand or peak load are terms used in Demand Side Management describing a period in which electrical power is expected to be provided for a sustained period at a significantly higher than average supply level. Peak demand fluctuations may occur on daily, monthly, seasonal and yearly cycles.
Power Profile	Power profile is the variation of power consumption of an electrical load versus time, thus specifying the [[Load Profile]] concept. It will vary according to customer type (typical examples include residential, commercial and industrial), temperature and holiday seasons. In the Smart Appliances context, the more specific concept of Appliance Power Profile is used.
SE	ZigBee Smart Energy Profile Specifications (see [R5])
SI	Smart Info: is the element, provided by the DSO, which provides energy information into the HAN. Published data are a sub-set of those already available inside the Home Electricity Meter, hence the Smart Info acts like a proxy of

	the meter
Simplified Tariff Profile	It is a simplified structure of the energy tariff offered to the client by the Energy Retailer. The content of the Simplified Tariff Profile is a sequence of time slots for a configurable amount of time (e.g. the next 24 hours) and the correspondent price (in euros per kWh) for each time slot. The actor that provides the Simplified Tariff Profile shall autonomously take into account all the relevant factors that influence the tariff, such as current time or differences between working and holiday days.
Smart Appliance	It is an appliance connected in the HAN and equipped with some intelligence to cooperate with the other home actors in order to provide new services to the consumer, like for instance energy consumption awareness, demand response,.... The Smart Appliance plays an active role in the home system complying with the system policies, satisfying the user whishes and always assuring its best performance. Most of these technologies imply some information transfer from the Smart Grids to the Smart Appliance (thus a communication channel within the HAN and outside the Home Domain) and an additional control and supervision logic (inside and/or outside the appliance).
Smart Info	Device that enables communication between the electronic meter and the HAN.
Smart Plug	Device provided with a HAN interface (e.g. ZigBee) that typically has a power meter able to calculate the power/Energy consumption of the connected load and is typically provided with a Relay that can be used to remotely power on/off the load.
TOU	Time of Use
TC	ZigBee Trust Center
TSO	Transmission System Operator. In electrical power business, a transmission system operator (TSO) is an operator that transmits electrical power from generation plants to regional or local electricity distribution operators (DSO).

WAN	Wide area Network: it is a computer network that covers a broad area (i.e., any network whose communications links cross metropolitan boundaries) This is different than personal area network (PANs), Local area network (LANs) which are usually limited to a room, building, campus respectively.
ZCL	ZigBee Cluster Library

Editors

Contributions were made to this document from the following members:

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Change history

The following table shows the change history for this specification.

Revision	Description
0.1	Original version from Indesit Company.
0.2	Version modified by Telecom Italia and Indesit Company after discussion in E@H conf call: introduced other E@H devices, grouped White Goods, defined general outline of the document
0.3	Version modified after technical Meeting in Fabriano: added commissioning and security procedures. Added Range Extender compatible with other profiles
0.4	Version modified after the discussion in conference calls: added sequence diagram and text for awareness; completed Load control device (smart plugs) cluster description
0.5	Version modified after the discussion in conference calls: moved all the appliance identification functionalities to E@H cluster Appliance Identification
0.6	Version modified after the discussion in conference calls: added power profile cluster description and harmonized with other references. Fixed styles in heading all over the document
0.7	Version modified after the discussion in conference calls: defined distinct commands for overload pause and scheduled energy phase pause. Fixed styles in figures, tables and captions, up to paragraph 6.5.
0.8	Version modified during Meeting in Milano; fixed Smart Info use of clusters; added SmartInfo identification cluster; reviewed Power Profile cluster according toe Milano's discussion (added Get Price command and State notification command). Sequence diagram completed. Modified according to some editorial comments received by Steering

	Committee (disclaimer, glossary).
0.9	Minor editorial typos fixed. Text cleaned up. Added details on disclaimer text after feedback from IPR group.
1.0	Minor editorial typos fixed. Text cleaned up. Power Profile Cluster text revised. Appliance Event and Alerts Cluster attribute structure revised. Appliance Control "Execution of a Command" Energy enumerations added. Merged also with comments received from Enel and Electrolux (completed sequence diagrams with Overload warning, added references to reportable attributes in the cluster tables).
1.1	Power Profile state review. Minor editorial changes all over the text. Added clarification on conventions of CECED. Smart Info changes on Price cluster and clarification of its use.

Table 66 – Document revision change history.