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INTERNATIONAL STANDARD

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Information technology - Home Electronic System (HES) application model - Part 3-30: Energy management agent functional requirements and interfaces

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INFORMATION TECHNOLOGY – HOME ELECTRONIC SYSTEM (HES) APPLICATION MODEL –

Part 3-30: Energy management agent functional requirements and interfaces

FOREWORD

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

Draft	Report on voting
JTC1-SC25/3203/FDIS	JTC1-SC25/3218/RVD

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

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, and the ISO/IEC Directives, JTC 1 Supplement available at www.iec.ch/members_experts/refdocs and www.iso.org/directives.

A list of all parts of the ISO/IEC 15067 series, published under the general title *Information technology – Home Electronic System (HES) application model*, can be found on the IEC and ISO websites.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This document specifies energy management agent (EMA) functional requirements and interfaces for interconnected energy management agents in a house, an apartment complex, or a residential community with multiple EMAs. It supports energy management by facilitating interactions among EMAs, appliances, consumer electronics, distributed energy resources (DER) and electric vehicle (EV) chargers. These EMA functional requirements and interfaces complement the reference model for interconnected EMAs specified in ISO/IEC 15067-3-3. The EMA interfaces identify interactions and information exchanges for energy management applications. The goal of this document is to specify a framework for multiple EMAs to provide energy management co-operatively by using communication protocols that link devices participating in energy optimization, transactive energy (TE), and demand response (DR) programmes, subject to constraints such as a consumer's budget for energy or goals for reducing greenhouse gas emissions.

This document explains a high-level view of the EMA functional requirements and reference interfaces in energy environments beyond the traditional public utility. Such energy environments include energy supplies from DER and TE sources. DER encompasses supplies from wind turbines, solar panels, and other local power generators, plus storage equipment (stationary and mobile batteries). Also, the EMA can assist the prosumer (a consumer who also produces power) in buying or selling TE.

As specified in ISO/IEC 15067-3-3, the EMA can interact with other EMAs, smart appliances, DERs or other consumer products. Interacting EMA are anticipated to be important for apartment complexes with multiple apartments and possibly multiple houses or buildings on a campus. ISO/IEC 15067-3-3 accommodates an EMA per apartment, per building, per campus, and possibly a cloud-based EMA. Options for interconnecting EMAs to create an EMA framework (EMF) are specified.

This document and related standards accommodate flexible and efficient energy management by co-ordinating and optimizing energy consumption and generation within a residential community consisting of houses and apartments. The ISO/IEC 15067-3 series enables automated energy management including optimal load control for allocating energy consumption and generation among multiple products in a house or a small building. The co-ordination among products offers improved energy management applications and overall efficiency according to goals set by the occupants. Multiple EMAs organized according to this document will be especially useful as DER proliferates with fluctuating energy generation and storage.

INFORMATION TECHNOLOGY –
HOME ELECTRONIC SYSTEM (HES) APPLICATION MODEL –

Part 3-30: Energy management agent functional requirements and interfaces

1 Scope

This document specifies functional requirements and reference interfaces for interconnected energy management agents (EMAs) based on the model for an EMA specified in ISO/IEC 15067-3 and the model for multiple interacting EMAs specified in ISO/IEC 15067-3-3. This specification supports energy management by facilitating interactions and information exchange among EMAs and appliances, consumer electronics, heating, ventilation, and air conditioning (HVAC) equipment, water heaters, distributed energy resources (DERs), electric vehicle (EV) chargers, and other loads supplied by public and local power sources in a house or an apartment complex. Local power sources can use DER, which can include, but are not limited to, wind turbines, solar panels, and storage (stationary and mobile). EMAs specified with these functions and interfaces can assist the consumer in responding to price-varying public power and buying or selling transactive energy (TE).

This document specifies framework methods for EMAs to co-ordinate the delivery of energy management applications, and the reference interfaces facilitate a communications protocol among interacting EMAs. These linked and interacting EMAs provide energy optimization and conservation within constraints such as a consumer's financial budget and goals for greenhouse gas reduction, while supporting programmes as diverse as TE and demand response (DR).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 15067-3:2012, *Information technology – Home Electronic System (HES) application model – Part 3: Model of a demand-response energy management system for HES*

ISO/IEC 15067-3-3:2019, *Information technology – Home Electronic System (HES) application model – Part 3-3: Model of a system of interacting energy management agents (EMAs) for demand-response energy management*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 15067-3:2012, ISO/IEC 15067-3-3:2019 and the following apply.

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

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

3.1.1
client EMA
cEMA
energy management agent (EMA) that acts as a client to another EMA

[SOURCE ISO/IEC 15067-3-3:2019, 3.1.1]

3.1.2
server EMA
sEMA
energy management agent (EMA) that acts as a server to other EMAs

[SOURCE ISO/IEC 15067-3-3:2019, 3.1.7]

3.2 Abbreviated terms

AI	artificial intelligence
AMI	advanced metering infrastructure
API	application programming interface
cEMA	client EMA
DER	distributed energy resources
DR	demand response
EMA	energy management agent
EMF	EMA framework
EV	electric vehicle
HAN	home area network
HES	home electronic system
HVAC	heating, ventilation, and air conditioning
MAS	multiple agent system
REST	representational state transfer
sEMA	server EMA
TE	transactive energy

4 Conformance

Implementations of an energy management system with multiple EMAs shall conform to one of the EMA configuration options in Clause 5 and to the functional requirements and reference interfaces specified in Clause 6.

5 Configuration of multiple energy management agents in a residential community

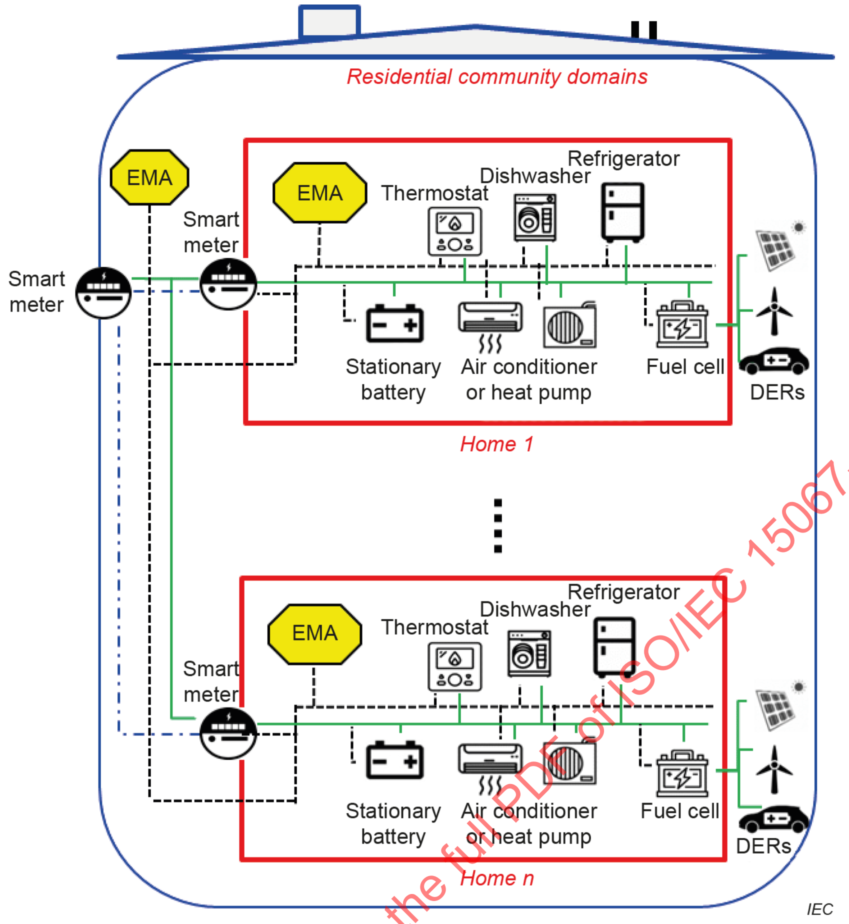
5.1 Overview

ISO/IEC 15067-3:2012 specifies the model of a generic energy management system and specifies the EMA for a house or a unit in an apartment complex. Communicating EMAs in an apartment building, a residential community house or a small building are introduced in ISO/IEC 15067-3-3:2019. These EMAs communicate with each other in an EMA framework (EMF) to optimize energy management among these houses and units (apartments). Figure 1 shows a generalized EMF configuration for houses in a residential community. The EMF configuration shown in Figure 1 is enabled by the EMAs in each house and the EMA serving the community, all acting co-operatively to provide energy management for each house and for the community. EMAs interface with DERs, EVs, and smart appliances (e.g. thermostat, dishwasher, air conditioner, and heat pump) to optimize energy management within constraints set by the consumer. Such constraints are personalized by the consumer and can include a cost budget, limits on greenhouse gas emissions and reduction in the carbon footprint of the house.

An EMF can also be integrated with a metering system as illustrated in Figure 1. Smart meters perform automated meter readings and communicate with an advanced metering infrastructure (AMI) of a utility or energy service provider. The AMI network shown in the network is separate from other networks because it is often proprietary to a meter manufacturer. Smart meters can provide utility and consumption data useful for EMAs to management energy within a home or apartment complex.

In some regions, customers with excess wind and solar power can sell the excess to the local utility. Some are paid the retail rate for energy; others are paid a special "feed-in tariff" rate. Such customers who also produce power are called "prosumers". As reported in ISO/IEC TR 15067-3-7 and ISO/IEC TR 15067-3-8, there is considerable research into the development of markets and technologies for prosumers to sell excess wind and solar power to neighbours via a local microgrid or the distribution grid. The process that includes a market and technologies for prosumers to sell and buy power among themselves, to an aggregator or a public utility is called transactive energy (TE).

TE is enabled by a local trading market for power with a bid-and-ask mechanism for power to be delivered now or at a specified future time. However, this is a constrained market because power must flow from source to load over wires that have capacity limits. Therefore, controls are needed to manage power flows on a local basis. The EMA could be programmed both for TE bidding and for managing power flows from the TE supplier to the TE customer's appliances, EVs, and storage devices. The EMAs can buy and sell energy to a local utility or to other prosumers (subject to local regulations), as described in ISO/IEC TR 15067-3-7 and ISO/IEC TR 15067-3-8.



NOTE The home area networks (HANs) are shown with dashed lines in black, and the power line is shown in solid green.The metering data communication network is shown with the dotted dash line in blue.

Figure 1 – Example of interconnected EMAs in a residential area

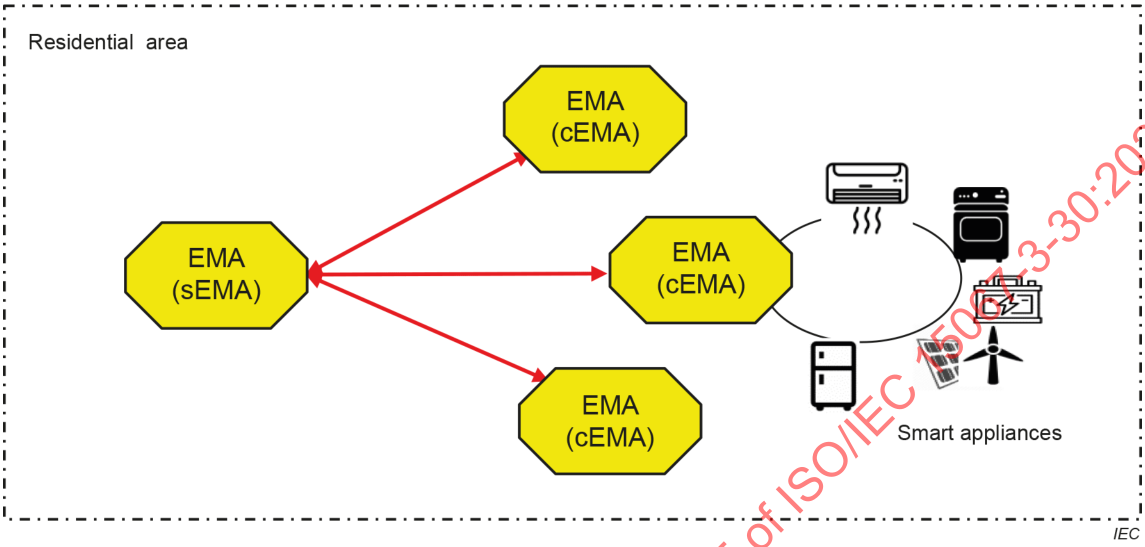
Within a residential community, the EMF shall orchestrate EMAs with diverse energy systems in either a hierarchical or distributed configuration. In a hierarchical configuration, a centralized EMA coordinates and allocates energy consumption and generation among multiple EMAs in different locations. In a distributed design, each EMA allocates energy consumption of appliances in the corresponding service area. Each EMA specifies an algorithm that carries out various approaches to solving the same problem.

5.2 Hierarchical EMA configuration for home or residential community

The logical arrangement of EMAs shall be configured either in a hierarchical structure or a distributed structure as specified in 5.3. EMAs can communicate with other EMAs from other residential homes or buildings to optimize energy management across the residential community or apartment complex.

Figure 2 shows a logical hierarchical configuration in a residential area. In this configuration, the EMA that acts as a server to other EMAs is called the server EMA (sEMA). An EMA that is served by the sEMA is called a client EMA (cEMA). An EMA can function as an sEMA as well as a cEMA. The message sets between the sEMA and cEMAs are not specified in this document. The communications protocol may use HES standards such as ISO/IEC 10192-3, ISO/IEC 14543-3-x, ISO/IEC 14543-4-x, and ISO/IEC 14543-5-x.

To provide distributed energy management data (prices, TE data, DR data, etc.) for the community, the sEMA shall communicate with cEMAs in the community, which is specified in ISO/IEC 15067-3-3. The cEMA can control (on/off) or set the operating mode of appliances based on the signal received from the sEMA according to the programme chosen by the consumer for energy management.



NOTE 1 End-to-end encryption can provide cybersecurity protection between two communication partners, if required.

NOTE 2 The red arrows in Figure 2 can be implemented within a home or residential community area.

NOTE 3 The red arrows indicate HAN networks.

NOTE 4 The arrows are logical connections.

Figure 2 – A hierarchical configuration in a residential area

5.3 Distributed EMA configuration for home or residential community

The logical arrangement of EMAs shall be configured either in a distributed structure or a hierarchical structure as specified in 5.2. The distributed EMF configuration provides co-ordination among EMAs to offer improved energy management and overall efficiency. Each EMA enables the allocation of limited energy among appliances and enables switching energy sources from grid to local generation or storage according to consumer preferences.

Figure 3 shows a distributed configuration where each EMA allocates energy consumption by appliances in the corresponding service area. The EMA works in conjunction with DERs (e.g. local generation or storage) that supply power. The EMA functions co-ordinate energy consumption and generation among multiple EMAs in different locations. The EMA functions can be further extended to manage on-premises DERs and power conditioning and conversion subsystems.

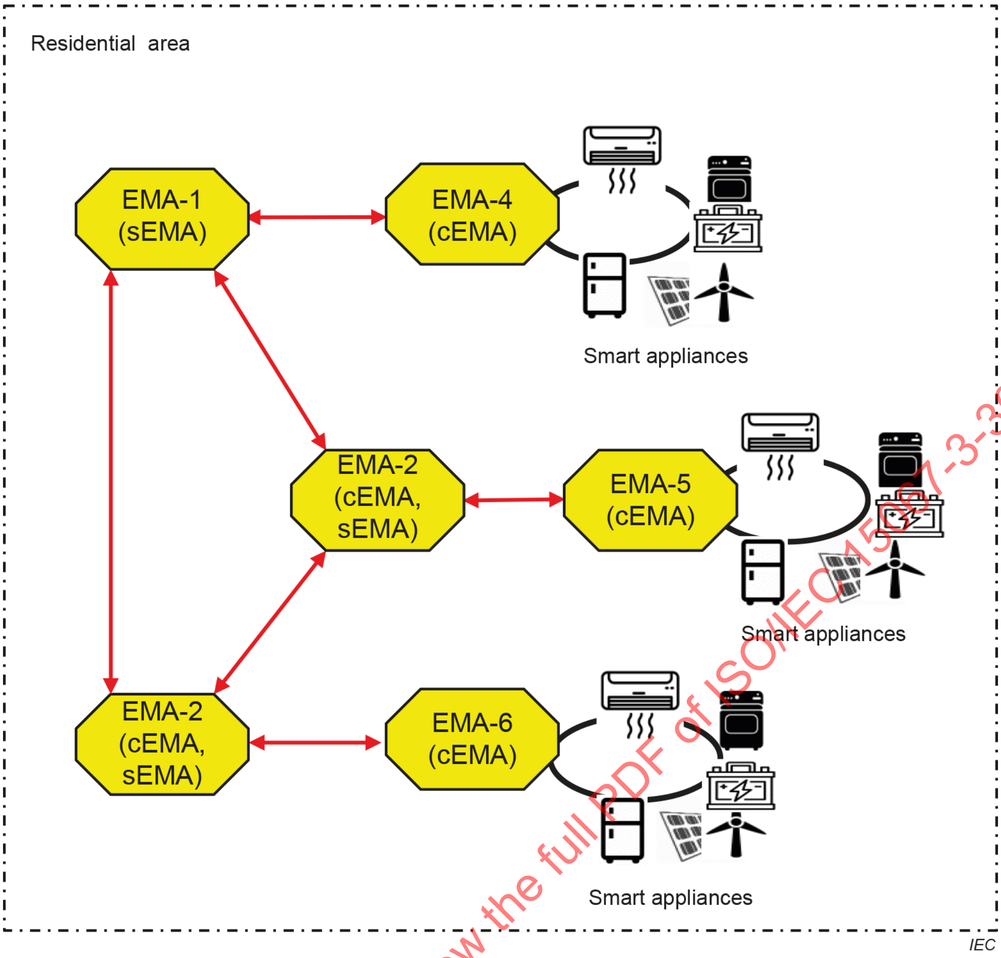


Figure 3 – A distributed EMF configuration in a residential area

6 EMA functional requirements and reference interfaces

6.1 Overview

Each interconnected EMA shall support the functional requirements and reference interfaces specified in this Clause 6 to ensure interaction and connectivity among EMAs, smart appliances, DERs and other consumer products. Figure 4 illustrates a reference model with four functional requirements and four interfaces for an EMA. The EMA reference model shall consist of the following functional requirements and reference interfaces.

The functional requirements for energy management are

a) load forecasting,

b) optimization and decision-making,

c) monitoring, and

d) control of the underlying energy systems.

The load forecasting and optimization functions can offer autonomous decision-making according to customer needs. The monitoring and control functions enable the EMA to allocate limited energy by providing advanced energy management and support for legacy demand-side management and DR programmes.

The interfaces provide connectivity for co-operative energy management among EMAs. The interactions make mutually beneficial decisions for co-ordinated energy management services through the integration of emerging technologies shown in Annex A. These interfaces are:

1) southbound interface, the logical connection for data and control exchange between an EMA and energy devices;
2) northbound interface, the logical connection for information exchange between an EMA and energy services that facilitate the operation of the EMA;
3) eastbound interface, the logical connection to enable co-ordination among multiple EMAs using the same communications protocol in a home or apartment complex; and
4) westbound interface, the logical connection to enable co-ordination among multiple EMAs using different communication protocols in a home or apartment complex.

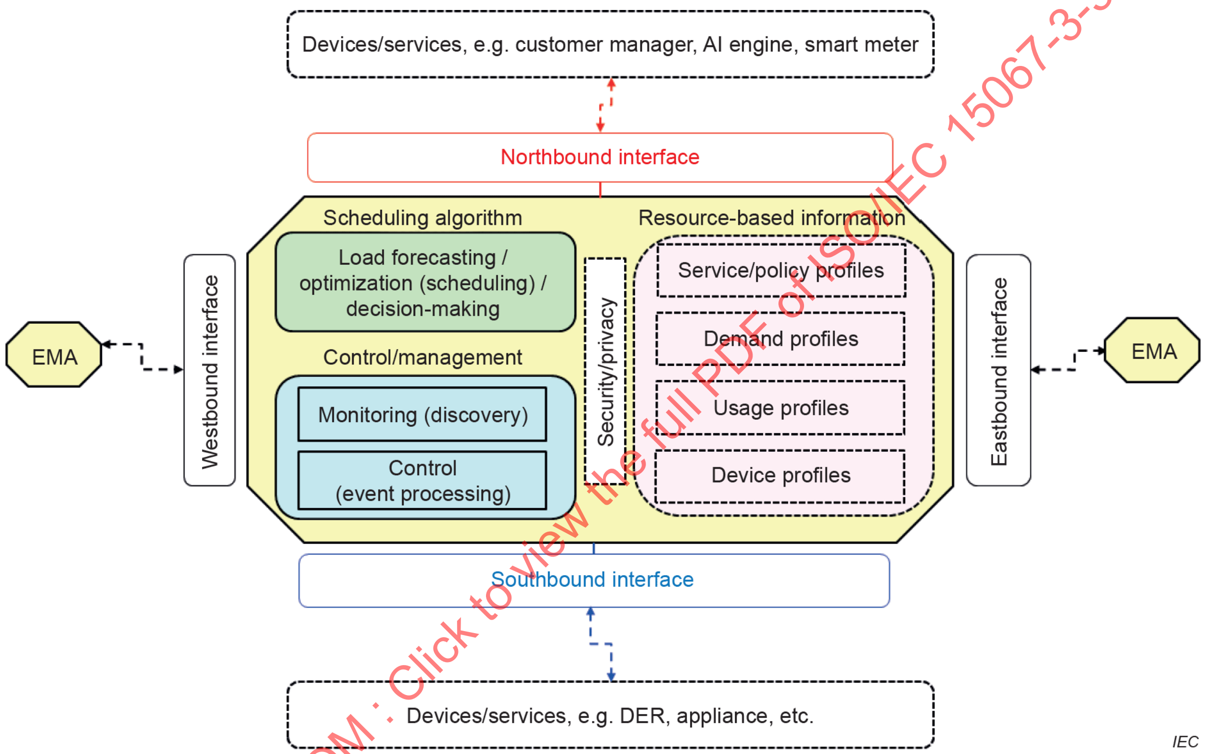


Figure 4 – An EMA reference model with four functional requirements and four reference interfaces

6.2 Functional requirements

EMA functional requirements comprise a scheduling algorithm, a control and management capability, security and privacy protection, and resource-based information. The scheduling algorithm runs an optimization function using artificial intelligence (AI) for optimizing energy allocation. The forecasting function predicts the potential future demand to plan optimal times for various operations. The scheduling function can recommend a control sequence and the available time for the operation. The decision-making function turns on and turns off the underlying energy systems according to this sequence. Contingency analyses of the information allow for close prediction of state changes, exceeding limits, and state estimation of stability in emergencies. Consumer preferences (e.g. for temperature, humidity, and electricity cost) are important for achieving an effective control sequence and operation time.

The control and management function enables energy-related discovery, monitoring, control, and event processing functions by effectively balancing energy consumption or generation and consumer preferences. The discovery function facilitates installation, configuration, and maintenance without requiring professional help. The monitoring function gathers disaggregated energy consumption data from individual devices at regular intervals or on demand. The state of the system, such as indoor humidity, temperature, and light level, and consumers' historical usage data related to various appliances are obtained from the customer manager. The customer manager provides power measurements from appliances (where available) and user interface data. The control function enables remote, programmable, and supervisory control of devices (e.g. actuation and reconfiguration). The event processing function detects extreme conditions of operational anomalies, such as failure, time/frequency skew, and outages, and performs necessary remedy control reactions in response to events.

The security and privacy functions authenticate all control data and transactions for protection. Privacy protection functions prevent the disclosure of personal profiles of consumers. The security protection function protects the control system and blocks third parties without explicit consent.

The resource-based information is a repository of the service policy, energy demand, energy usage, and device profiles recorded by the EMA. The service policy profiles are maintained for customer goals, preferences, budgets and constraints. The demand profiles maintain active energy load patterns for the appliance operating cycles. The usage profiles maintain current energy usage and consumers' historical energy usage data. The device profiles maintain the device inventory about the types and states of all measured devices, power capacity, and other relevant data. These profiles help obtain energy flow patterns based on consumer preferences.

NOTE This document specifies functional requirements and reference interface model for the EMA. The specific protocols and interworking architectures for other functional entities through the interface are specified in other documents.

6.3 EMA interfaces

6.3.1 The four EMA interfaces

As shown in Figure 4, the EMA shall include up to four logical interfaces to provide connectivity. The northbound and southbound interfaces shall be included in all EMAs. The eastbound interface shall be included in EMAs that are interconnected in a house or apartment complex using the same communication protocols. The westbound interface shall be included in EMAs that are interconnected in a house or apartment complex using different communication protocols. Reference models for these interfaces are specified in 6.3. Information about specific communication protocols applicable to the interfaces is described and specified in other documents as explained.

Any communications between the EMA and a device on a HAN that is not directly connected to the EMA can use a gateway for HAN-HAN translation.

6.3.2 The southbound interface

The southbound interface enables the EMA to collect information and deploy relevant control data from and to the underlying energy devices (smart appliances, DERs, controllers, etc.). The protocols for this interface are specified in other standards such as ISO/IEC 10192-3, ISO/IEC 14543-3-x, ISO/IEC 14543-4-x, and ISO/IEC 14543-5-x. For example, the EMA can collect energy data (load state, duration, energy storage capacity, etc.) from appliances or DERs. If an appliance accepts the remote control, then EMA can send the control commands or prices to the appliances to support load control.

6.3.3 The northbound interface

The EMA shall exchange information with services such as an AI engine through the northbound interface or standard application programming interfaces such as IEC 61850 series. For example, the forecasting function in the EMA consolidates the energy consumption or generation information and policy from and to an AI engine, where the AI engine could be located within the EMA (an internal AI engine) or in the cloud (an external AI engine). The AI engine can perform multiple processes such as energy load prediction, energy generation prediction, and energy market demand prediction in determining energy allocation. The AI engine enables the EMA to reduce energy consumption or to raise energy efficiency in a house, apartment, residential building, or housing community. The AI engine processes data based on customer inputs via a user interface for appliance usage, energy budget and other goals. The customer manager also consolidates the maintenance data (where available) from and to the EMA.

Data for an AI engine shall be exchanged through application programming interfaces (APIs). A universal and standardized API or protocol does not exist, but this interface can be implemented by representational state transfer (REST) APIs. The APIs support request and response messages. Every request message, either by a browser or application, sends header information and payload every time to get the response from a customer manager. Standardization should be considered for common scenarios, protocols and data models based on the type of application information exchanged. For example, a customer manager would be a REST server and the EMA would be a REST client. Through the interface, an EMA can retrieve metering data, operation policy or weather information from the server. The EMA can be a REST server for a customer manager client. In this scenario, the EMA provides energy consumption data or load status to a customer manager.

NOTE With the northbound interface functionality, a customer manager can be implemented with one of two alternatives: common user interface in an EMA or as a separate device. Through the interface, a customer manager can configure, monitor and modify EMA functionalities such as an energy budget, event notification, scheduling policy, etc.

6.3.4 The eastbound interface

The eastbound interface supports co-ordination among EMAs (called "orchestration"). Using this interface, the EMA communicates with other EMAs in the same apartment or home. This interface serves as an orchestration interface to build a multi-agent framework and allows the exchange of relevant information and control data between EMAs for co-operative energy management. For distributed energy management provisioning of prices and event notices in the residential area, communications protocol may use HES standards such as ISO/IEC 10192-3, ISO/IEC 14543-3-x, ISO/IEC 14543-4-x, and ISO/IEC 14543-5-x.

6.3.5 The westbound interface

The westbound interface interconnects EMAs using different communication protocols. Interconnected EMAs can use different protocols or communicate with devices on different HANs. In homes and residential area, the EMA can, for example, use an IEC 62746-10-1 protocol for price and event data. Essentially, the EMA provides protocol translation of data and information between the westbound and eastbound interfaces. Using the protocol translation between these two interfaces, both domains are seamlessly interconnected to provide co-operative energy management. To support legacy DR load control, a service provider can send DR event or price signals (i.e. DR messages) to the EMA.

Annex A
(informative)

Emerging challenges in EMAs

A.1 General

Recently, significant advances have been made in emerging technologies that help EMAs. Figure A.1 summarizes seven emerging challenges associated with EMAs, which can progressively accelerate the deployment of EMAs if accepted by the market.

A.2 Integration with smart appliances

EMAs can be integrated with smart appliances, such as refrigerators, washing machines, tumble dryers, dishwashers, and other consumer-heating ventilation and air-conditioning products. An EMA can perform autonomous decision-making related to energy as a smart butler. The EMA obtains user preferences, energy consumption targets, cost of energy, budget, and comfort level. It also analyses electricity consumption patterns and human living behaviours. Using the EMA, the EMA-integrated appliances provide optimal schedules to customers based on power usage patterns as well as user preferences. The EMA-integrated appliances also can advise the user on an optimum schedule for appliance operation and further advise the user of the cost impact of overriding the schedule.

A.3 Integration with artificial intelligence

Artificial intelligence (AI) techniques involve learning, forecasting, and decision-making. AI-based learning techniques enable EMAs to learn energy preferences and comfort levels to meet user demands. AI-based forecasting techniques enable energy-related forecasting that includes uncertainty parameters. AI-based decision-making enables the balance of energy consumption and consumer comfort levels without consumer intervention in a nonintrusive way. Thus, an AI-integrated EMA reduces the burden on the consumer to control and optimally manipulate all appliances continually. The AI-integrated EMA also reduces electricity cost while satisfying user demands. A detailed understanding and implementation of interfacing with AI functions is a relatively new concept. However, standardization of the interface is essential for any vision of future AI-integrated EMA solutions.

A.4 Integration with big data

EMAs can be integrated with aggregated energy data (so-called "big data") gathered from the generation, transmission, distribution, and consumption in the smart grid infrastructure. These big data contain substantial valuable patterns of energy production and consumption in the operation and management of energy systems. By analysing the electricity patterns, EMAs can shift some electricity consumption to off-peak hours and enable energy production at peak hours. Customer privacy can be protected when EMAs are located in homes and buildings and are programmed not to share customer data with cloud-based processors.