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INTERNATIONAL STANDARD

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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

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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

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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

FOREWORD

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International Standard ISO/IEC 15067-3-3 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

The list of all currently available parts of the ISO/IEC 15067 series, under the general title *Information technology – Home electronic system (HES) application model*, can be found on the IEC and ISO websites.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

The text of this standard is based on the following documents:

FDIS	Report on voting
JTC1-SC25/2899/FDIS	JTC1-SC25/2907/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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 a high-level model of interacting energy management agents (EMAs). These EMAs provide automated demand-response services in a residential community or a building consisting of multiple apartments. This document extends the energy services for residential homes specified in ISO/IEC 15067-3.

Interacting EMAs provide coordination among EMAs to offer improved energy management and overall efficiency. Each EMA enables the allocation of energy among appliances and switching energy sources from grid to local generation or storage according to consumer preferences. This document specifies the structure and interfaces among EMAs. In this model, EMAs may have a hierarchical interacting structure and/or mesh interacting structure. One EMA connected to the home area network controls and coordinates with other EMAs connected to other home area networks or with supplemental EMAs in the cloud.

Typical smart energy services may include integrated energy management for multiple energy systems, energy sharing and trading within the community, energy information sharing for more efficient energy usage, etc. These energy services offer benefits in electrical energy management.

The intent of these models is to accommodate flexible and efficient energy management. Interacting EMAs enable the allocation of energy among houses in a community and appliances within houses, and the choice of energy supplies from local and/or external sources. External sources may be public utilities or other suppliers. Local sources may include local power generators and storage devices. Distributed EMAs extend these capabilities to an environment with multiple houses and apartments.

Based on this model, a specification of a mechanism for interoperability among EMA products from different manufacturers will be proposed as an additional subpart of ISO/IEC 15067.

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

1 Scope

This part of ISO/IEC 15067 specifies a high-level architecture and a set of models for a demand-response energy management system with multiple interacting EMAs in a home or community housing (such as one or more apartment buildings or a campus of houses). These models specify the structure among multiple EMAs, which can be arranged in a mesh or hierarchical structure. This document builds upon ISO/IEC 15067-3.

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*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

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

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

3.1.1
client EMA
EMA that acts as a client to another EMA

3.1.2
service provider
business that provides demand-response services as specified in ISO/IEC 15067-3

3.1.3
distributed energy resources
DER
energy generation and storage resources possibly supplied by non-utilities and customers

Note 1 to entry: As used in this document, this term applies to resources inside a home or building.

3.1.4
energy management agent
EMA
set of control functions that manage energy consumption as an agent for the customer

Note 1 to entry: An energy management agent (EMA) is specified in ISO/IEC 15067-3.

3.1.5
HES gateway
residential gateway that conforms to ISO/IEC 15045-1 and ISO/IEC 15045-2

3.1.6
residential community
one or more multi-dwelling buildings or housing units for the purpose of residence

Note 1 to entry: A typical residential community is an apartment building. The residential community may contain a public common use area with a community energy system and a private use area in homes, each with an HES energy system.

3.1.7
server EMA
EMA that acts as a server to other EMAs

3.1.8
smart energy management appliance
home appliance equipped with built-in energy management agent components that provide energy management capabilities for demand-response

3.1.9
supplemental EMA
EMA located outside of the home or building

3.2 Abbreviations

iEMA	interacting energy management agent
EMA	energy management agent
EV	electric vehicle
DER	distributed energy resources
DR	demand reponse
HAN	home area network
HES	home electronic system
ID	identity
SP	service provider
SSL	secure sockets layer
TV	television
WAN	wide area network

4 Conformance

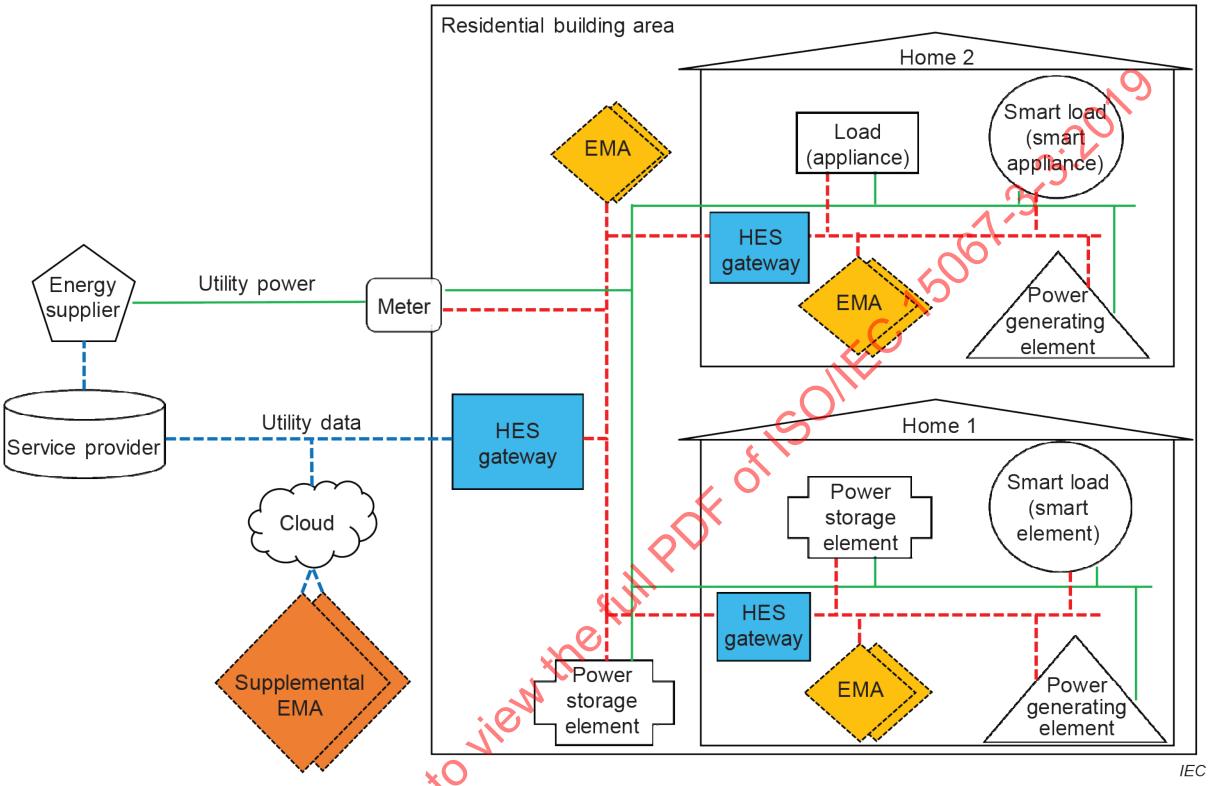
Implementations of an energy management system with multiple EMAs shall conform to one of the two logical models specified in Clause 5. The chosen model shall conform to one of the two topology models specified in Clause 6.

If there is a supplemental EMA in the cloud, all data flowing into the residential community from the supplemental EMA and/or from the residential community into the supplemental EMA shall pass through an HES gateway located in a residence or serving the entire community.

5 Energy management agent for home or residential community

5.1 Overview for home or residential community

Figure 1 shows an example of a physical energy management system in a single community domain that includes multiple private residential homes and common spaces in a residential community. In some cases, one or more EMAs may be physically located in a home and one or more supplemental EMAs in a cloud.



NOTE 1 The HAN networks are shown with a dashed line in red; the WAN network is shown with a dashed line in blue; the power line is shown in solid green.

NOTE 2 The shapes within Figure 1 are explained in 5.2.

Figure 1 – Example of an energy management system in a building with two homes

The configuration shown in Figure 1 consists of multiple interacting EMAs in the homes and supplemental EMAs in the cloud for two reasons.

1) One reason is that it may be advantageous to assign responsibilities for a subset of appliances to different EMAs within one home. For example, one EMA may be assigned to a washing machine, refrigerator and TV, another EMA assigned for lighting, heating and air-conditioning, and another EMA assigned to electric vehicles, local power generators and storage devices.
2) The other reason is that EMAs may coordinate energy management among multiple homes within a residential community to optimize desired parameters, such as cost and comfort.

5.2 System architecture for an energy management system with multiple EMAs

ISO/IEC 15067–3:2012, 5.1 introduces the HES energy management model. The model shows the system architecture and interrelationship among the elements.

This document extends ISO/IEC 15067-3 for installation of multiple EMAs within a house, multiple houses in a community, an apartment building or a campus of apartment buildings.

Figure 2 shows the extended model of a home or a community energy management system with multiple EMAs. The system may be extended to manage multiple EMAs in a home and supplemental EMAs in the cloud.

At least one EMA is located on a home area network. Supplemental EMAs may be located in the cloud.

The models specified in this document are organized into one of the following topologies:

- local EMA topology model (multiple EMAs within a home);
- hybrid EMA topology model (multiple EMAs in the home and supplemental EMAs in the cloud).

Figure 2 shows the system architecture and interrelationship among the elements. The framework is very similar to the HES model using an EMA. Within this figure, the rectangle box in blue represents the HES gateway. The circles represent power-using smart appliances that can communicate via a home area network (HAN). The rectangular shapes represent appliances that are not able to communicate. The octagonal shape represents a power conversion device. The cross shapes represent power storage devices. The triangle shapes represent DER power-generating devices. The rectangle with a curved corner represents the utility elements such as a meter. The diamond shape represents the controller element (e.g. EMA, sensor or DR switch). The pentagon shape represents the energy supplier, such as the utility, transmitters, and distributors.

NOTE Elements of the HES model are specified in ISO/IEC 15067-3.

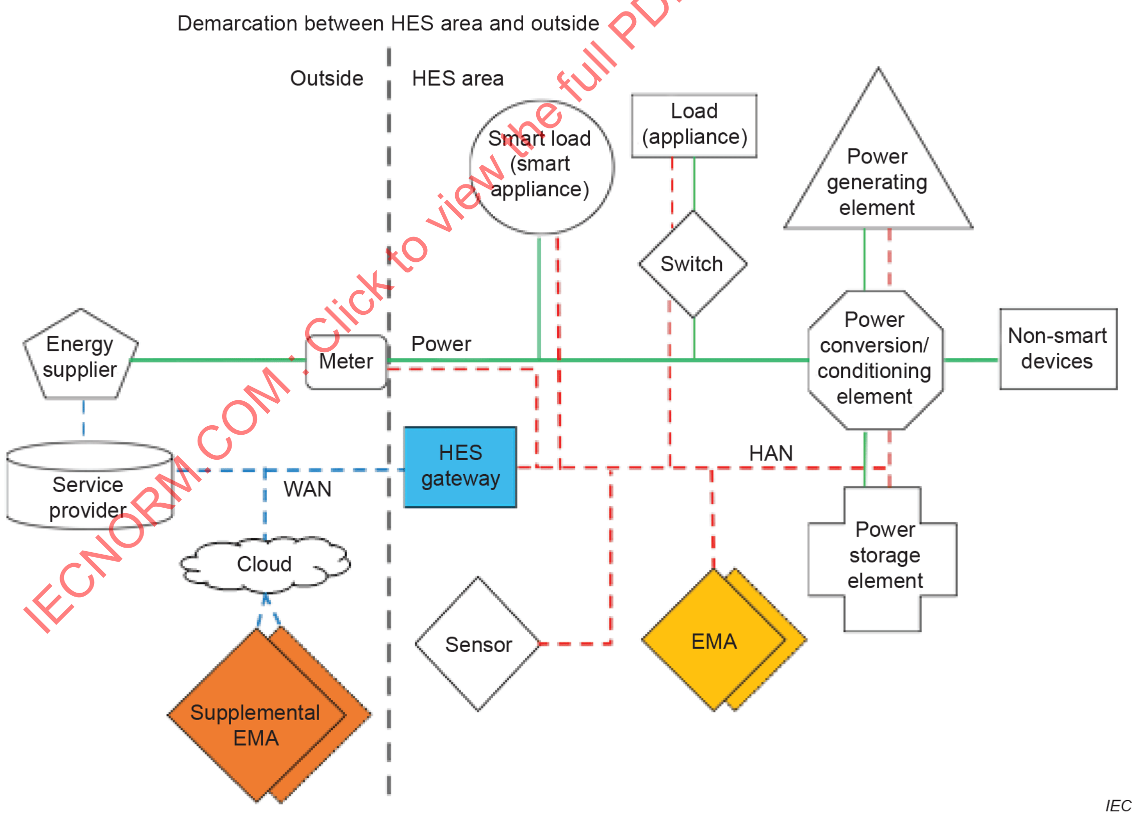


Figure 2 – System architecture of an energy management system for a home with multiple EMAs

5.3 Interacting energy management agents

ISO/IEC 15067–3:2012, 6.3.1 introduces the EMA. The EMA enables the allocation of limited energy (or a limited budget for energy) among appliances or the switching of energy sources from local generation or battery according to consumer preferences.

The EMA functions are extended from ISO/IEC 15067-3 to support multiple EMAs. An EMA allocates energy for appliances in the corresponding service area. The EMA can be extended to interact with other EMAs in different locations to optimize energy consumption and generation. The EMA performs specialized interacting functions by applying complex algorithms to exchange data among EMAs and devices, for example, for energy consumption targets, cost of energy, usage data, and budget for appliances, distributed energy resources (DER), and EMAs under the management of the community.

There are two options for the design of interacting functions among EMAs: hierarchical interacting design and mesh interacting design. In a hierarchical interacting design a centralized EMA coordinates and allocates energy consumption and generation among multiple EMAs in different locations. Among multiple EMAs within a domain, one becomes a server and the others remain clients in a distributed architecture. The server EMA provides demand-response optimization through the interaction of multiple client EMAs. The server and client EMAs are technically the same except for the logical relationships. A server or client EMA may supervise energy allocation among devices with or without an intervening EMA.

In a mesh interacting design, each EMA allocates energy consumption of appliances in the corresponding service area. Each EMA includes an algorithm to manage energy. EMAs are able to co-operate autonomously and interact with each other to optimize control. For instance, the optimization can be done by controlling the operation of smart appliances, local power generators and storage devices via interactions with other EMAs. To support these interactions, each EMA provides a common communications interface.

Figure 3 shows the model of hierarchical interacting EMAs, where EMAs can be divided into two types: the server EMA and the client EMA. The server EMA for energy management included in Figure 3 is a specialized controller that coordinates and allocates energy consumption and generation among multiple client EMAs. The client EMA enables the allocation of energy among smart appliances by switching energy sources from grid to local generation or modifying the operation of energy sources.

Figure 4 shows the model of mesh interacting EMAs, where each EMA can be a server EMA as well as a client EMA. The EMA interacts with other EMAs to coordinate energy consumption and generation.

Figure 5 shows a combination of hierarchical interacting and mesh interacting approaches to coordinate energy consumption among EMAs and/or to allocate energy consumption of smart energy management appliances.

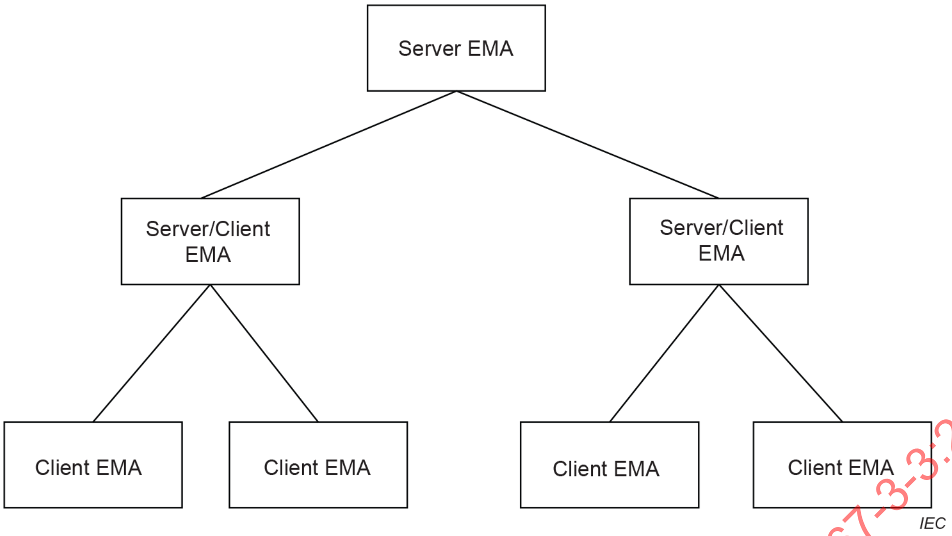


Figure 3 – Example model of hierarchical interacting energy management agents

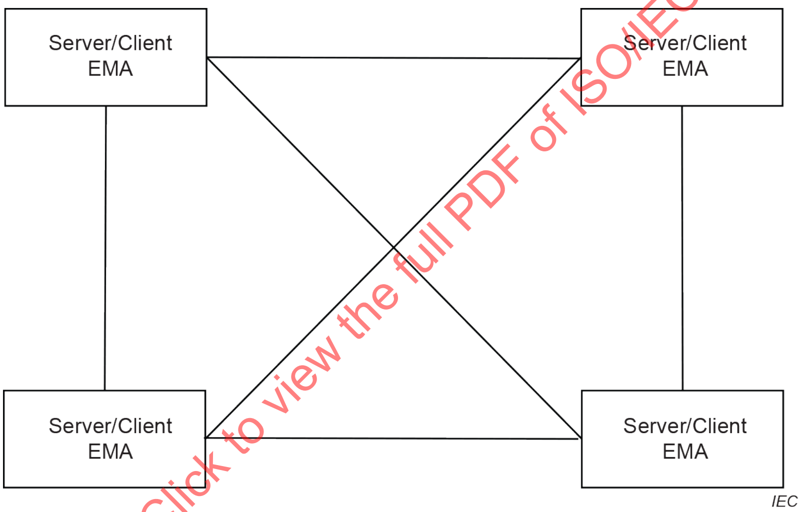


Figure 4 – Example model of mesh interacting energy management agents

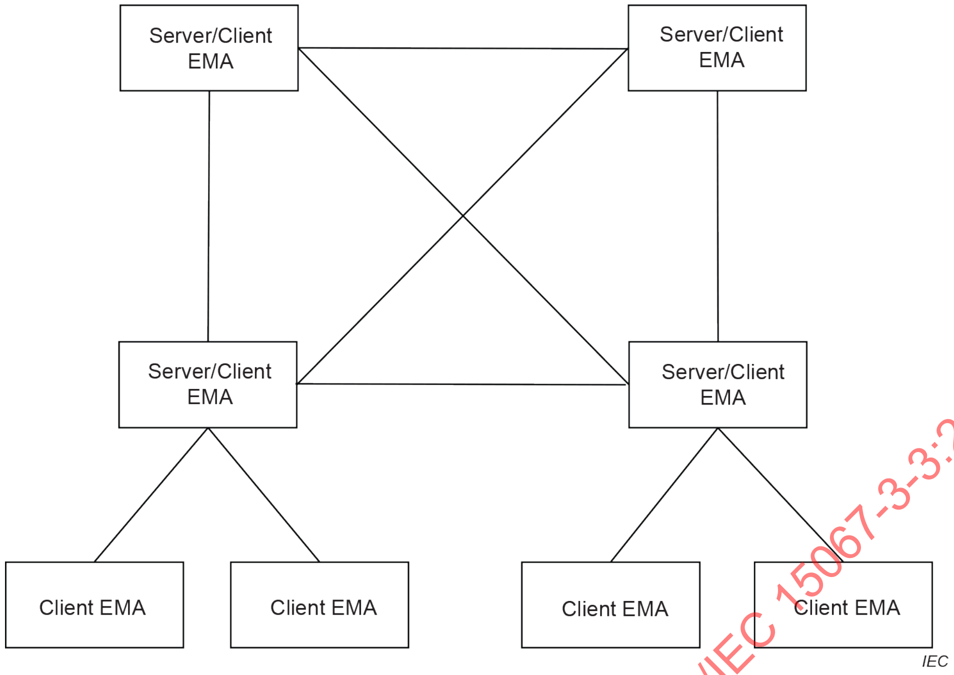


Figure 5 – Example model of mixed hierarchical and mesh interacting energy management agents

The interfaces to energy service providers and appliances are outside the scope of this document. Use cases and service scenarios for a hierarchical interacting approach and a mesh interacting approach are described in Annexes A and B, respectively.

6 Topology of energy management systems

6.1 Overview of topologies

The EMA can be modelled as two topology types depending on the physical location of the EMAs: local EMA topology model and hybrid EMA topology model.

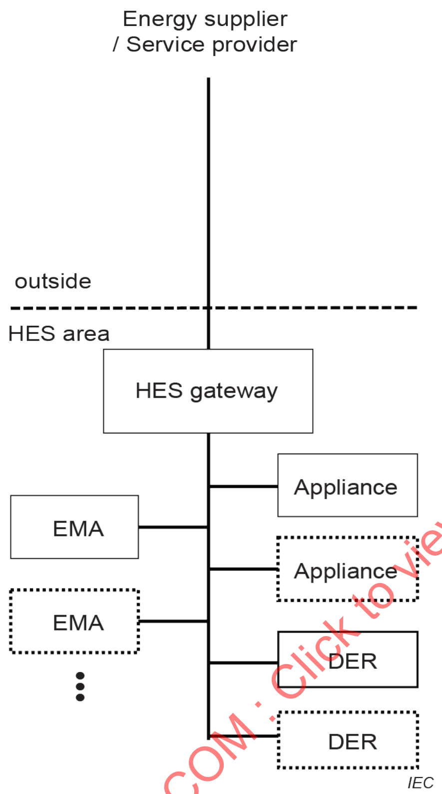
- In the local EMA topology model, all the EMAs are located within a home or a residential community.
- In the hybrid EMA topology model, the EMAs are located within a home, and one or more supplemental EMAs are in a cloud. EMAs on a HAN may interact with appliances in a home or a residential community.

NOTE 1 Multiple EMAs can be used when there are multiple energy subsystems inside a home or a residential community. For example, a wind turbine, local power generators and a battery may be combined into a subsystem and controlled by a DER EMA acting as a smart DER. A washing machine, refrigerator and TV may be combined into a subsystem controlled by an appliance EMA. A lighting, heating and air-conditioning system may be combined into a subsystem controlled by a facility EMA.

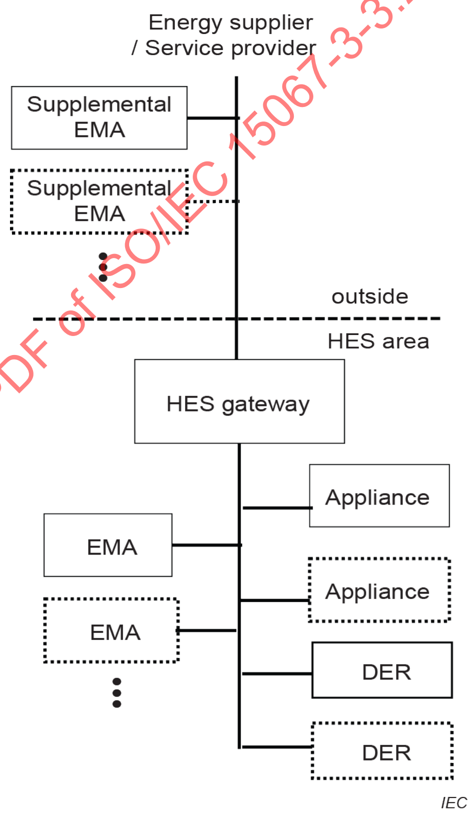
NOTE 2 In a home or a residential community with multiple EMAs, EMAs are divided into two types depending on the physical location: the local type and the cloud type. The local type is an EMA within a home or a residential community where an EMA controls the appliance according to the algorithm installed in the EMA. The cloud type has the remote control capability with one-way or two-way communication functions, and the cloud-based supplemental EMA controls the operation of selected devices remotely through the EMA from outside the home. To implement local or remote load control, EMAs send control signals to interrupt the operation of selected appliances to the EMA via the HES gateway within a home or from outside the home.

Figure 6 shows the EMA models with two topologies that illustrate the physical locations of the EMAs. Models that meet these requirements may be compared in terms of control functions, communication interfaces and other relevant factors such as cost and availability. These topologies of the models are described in 6.2 and 6.3, and include benefits for various energy management services.

a) Local EMA topology model
   1) Implement multiple EMAs depending on the capabilities of the appliances.
   2) Coordinate energy management among EMAs to optimize energy management and overall efficiency.
   3) Provide automated failover service from continuous energy management.
b) Hybrid EMA topology model
   1) Integrate EMAs with supplemental EMAs in the cloud.
   2) Balance the functionalities between the EMAs and the supplemental EMAs based in the cloud.
   3) Improve computing resources by complementing EMAs with supplemental EMAs based in the cloud.



a) Local EMA model



b) Hybrid EMA model

Figure 6 – Topology models for a system of interacting EMAs

6.2 Local EMA topology model

Case 1 is a topology model of one or more EMAs based on a tree, bus or mesh topology in a home or a residential community. The basic physical system model of a bus topology is illustrated in Figure 7.

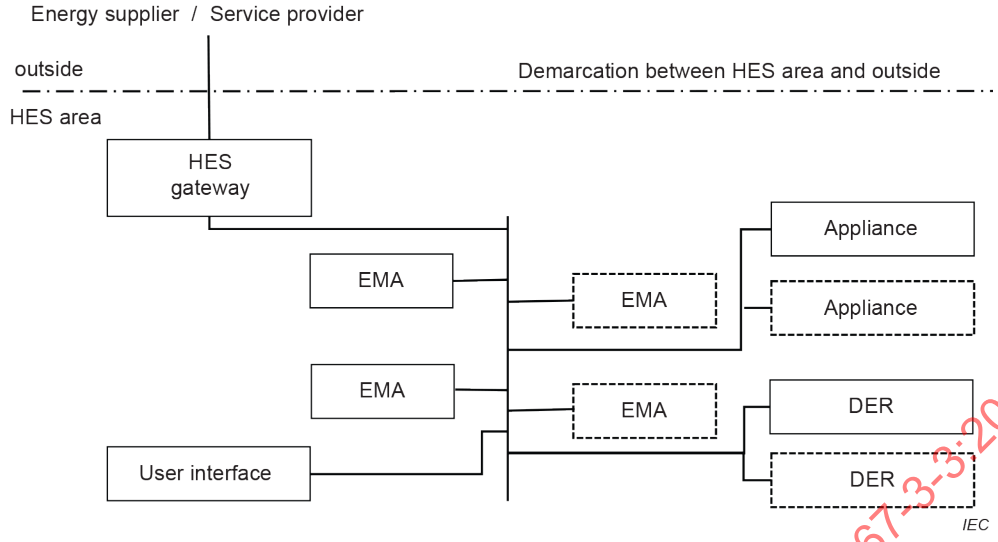


Figure 7 – Physical topology example of local EMA topology model

When a single EMA is used, this model is equivalent to the HES energy management model specified in ISO/IEC 15067–3. The EMA in the dotted line indicates that more than two EMAs may be installed, and EMAs may have a different topological configuration. A home may contain one or more EMAs in a hierarchical interacting structure or in a mesh interacting structure. For an apartment building, an EMA may be installed in each residence to manage loads in accordance with the topology of the apartment.

6.3 Hybrid EMA topology model

In the hybrid EMA topology model, EMAs are located inside a home as well as supplemental EMAs in the cloud linked via a secure network. The topology may be any combination of the EMA topology and the supplemental EMA in a cloud topology in a hierarchy. The physical topology for hybrid EMA topology model is illustrated in Figure 8.

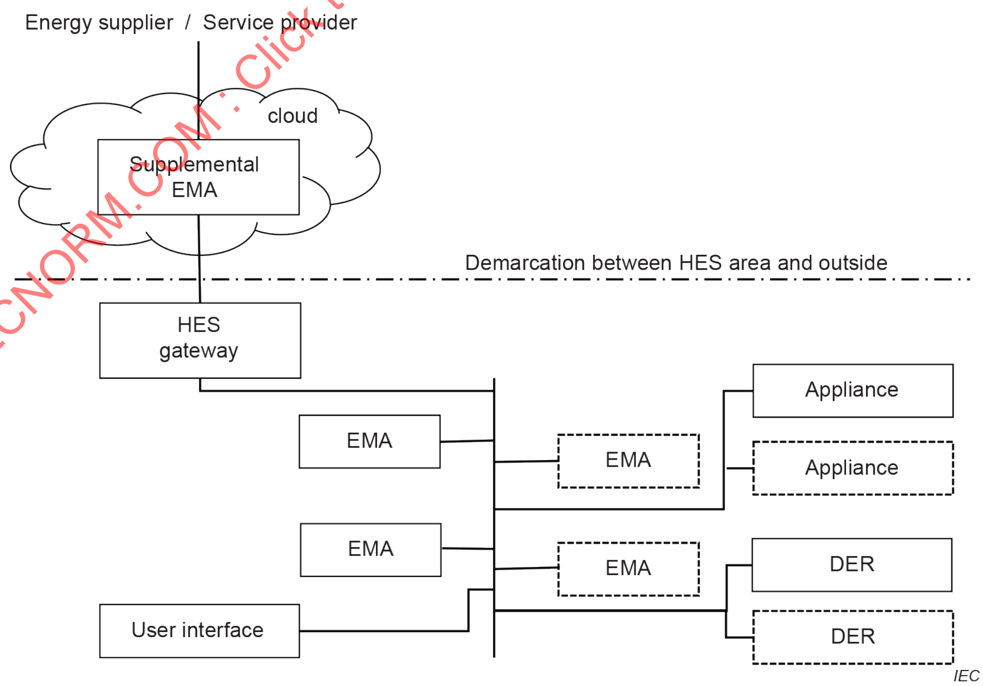


Figure 8 – Physical topology example of hybrid EMA topology model

This is a combined model of EMAs and supplemental EMAs in the cloud. Supplemental EMAs receive information such as real-time power demand and supply status, electric rate criteria, load reduction and event messages from utilities and send demand-response signals to EMAs located inside the home. EMAs inside a home provide automatic demand-response service to control target appliances and DER based on assigned power demand and rate criteria. Supplemental EMAs receive power consumption status from EMAs in the home. The supplemental EMA can calculate energy saving amounts compared to prior usage and report to the utility. According to the utility programme, incentives may be provided to the customer, and overall power demand and supply status may be calculated. In addition, EMAs may provide automatic demand-response inside homes.

Annex A
(informative)

An energy management system with multiple energy management agents

A.1 Use cases for energy management systems with multiple energy management agents

Annex A shows some use cases to support the architecture of energy management systems with multiple EMAs in homes or residential communities.

Figure A.1 depicts a conceptual model of an energy management system with EMAs for a home. As shown in this figure, EMAs are divided into four types: appliance EMA, facility EMA, meter EMA and DER EMA. The appliance EMA interacts with one or more appliances, such as a washing machine, refrigerator, and/or TV. The appliance EMA controls the appliance through one-way or two-way communication functions according to the algorithm installed in the EMA. The facility EMA interacts with lighting, heating and air-conditioning facilities. The meter EMA communicates with the electric meter to gather consumption data, such as whole-house or appliance usage. The DER EMA model is for wind turbines, local power generators and local storage systems. The DER EMA in this model has higher intelligence than the appliance/facility/meter EMAs because it processes demand-response signals, such as price or event notices. These EMAs may be considered as smart energy management appliances with the EMA functionality inside.

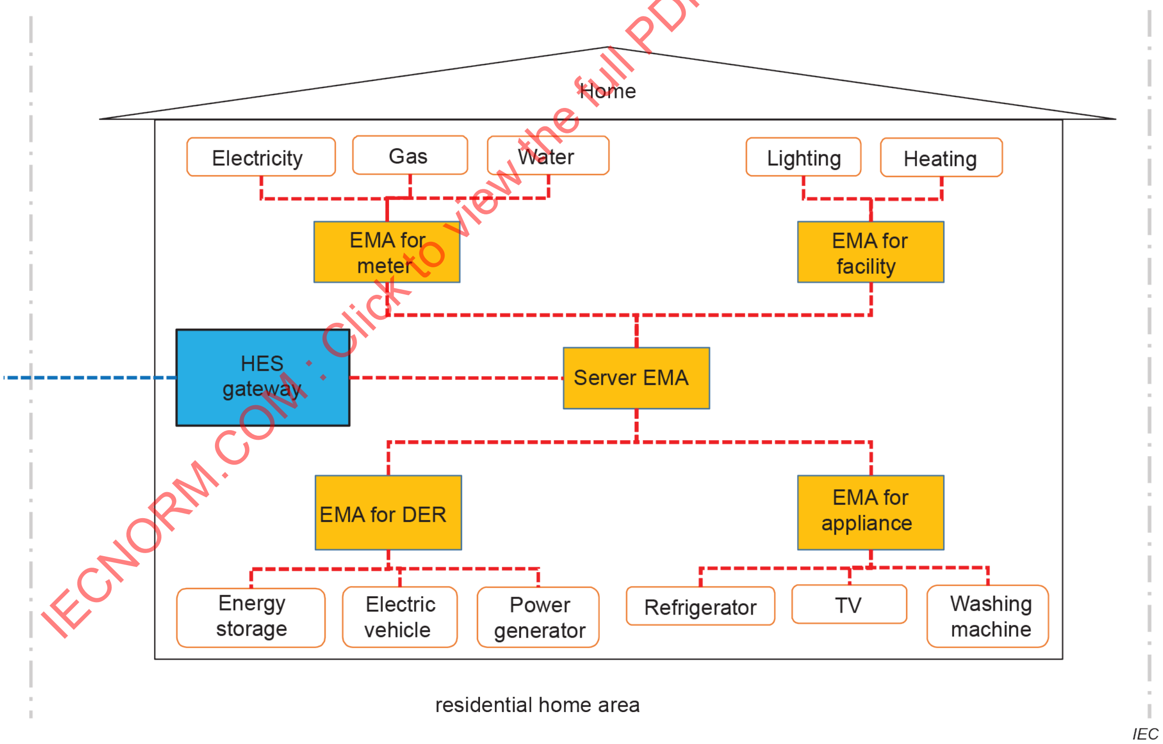


Figure A.1 – Example of local EMA topology model for a home

Figure A.2 depicts a conceptual model of an energy management system with EMAs for a residential community. As shown in this figure, a residential community can be divided into multiple home areas and a set of public common areas. Each EMA may communicate with other EMAs via the community gateway in a hierarchical manner.

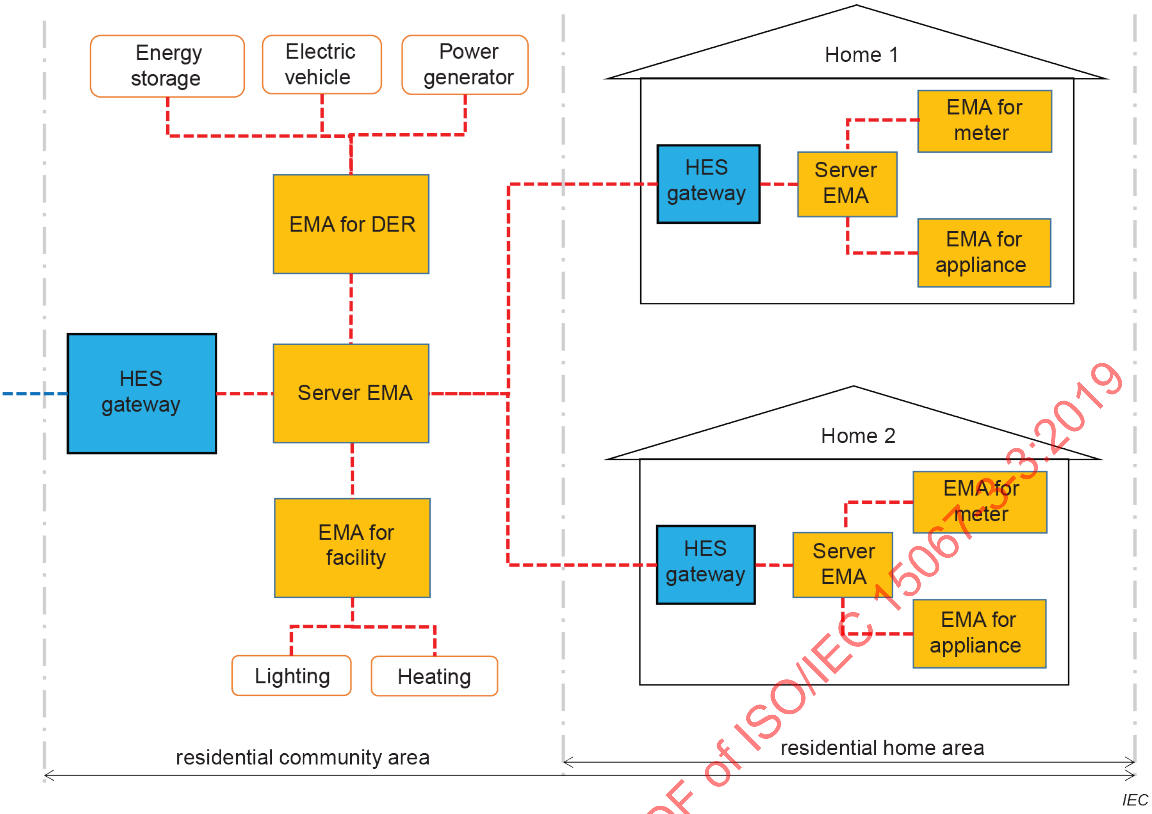


Figure A.2 – Example of local EMA topology model for a residential community

Figures A.3 and A.4 depict a conceptual model of an energy management system with a hybrid EMA for a home and a residential community, respectively. As shown in these figures, the utility and customers interact through the grid, and the HAN EMA co-operates with the cloud-based supplemental EMA. The supplemental EMA is a collection of computing entities with memory and storage. The supplemental EMA communicates with EMAs via the HES gateway using a secure communication channel.

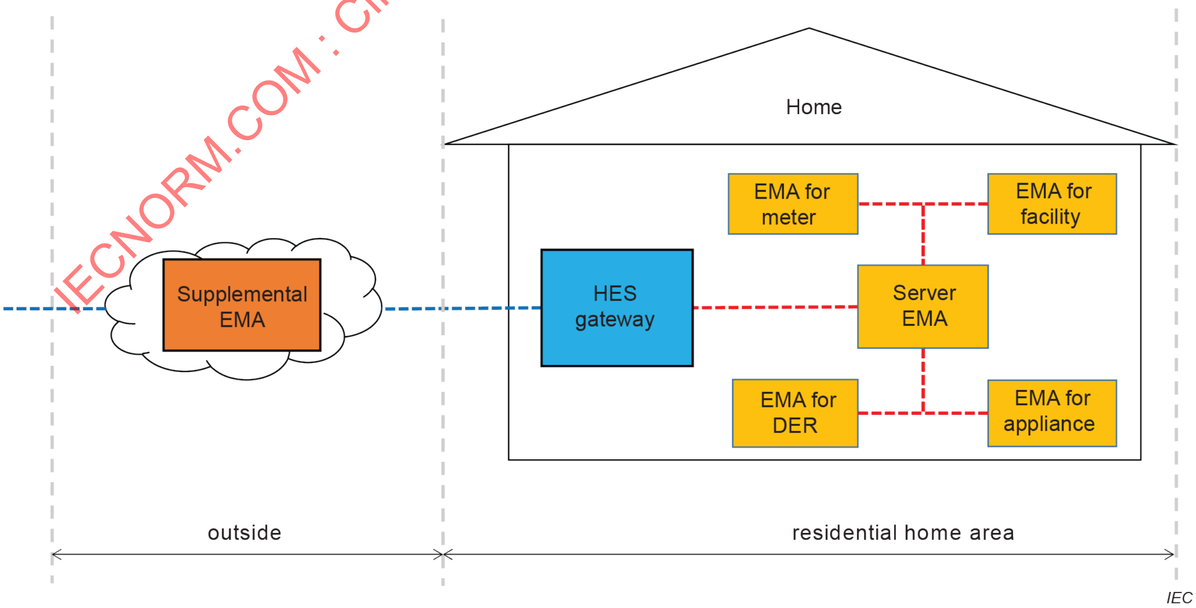


Figure A.3 – Hybrid EMA topology model example for a home

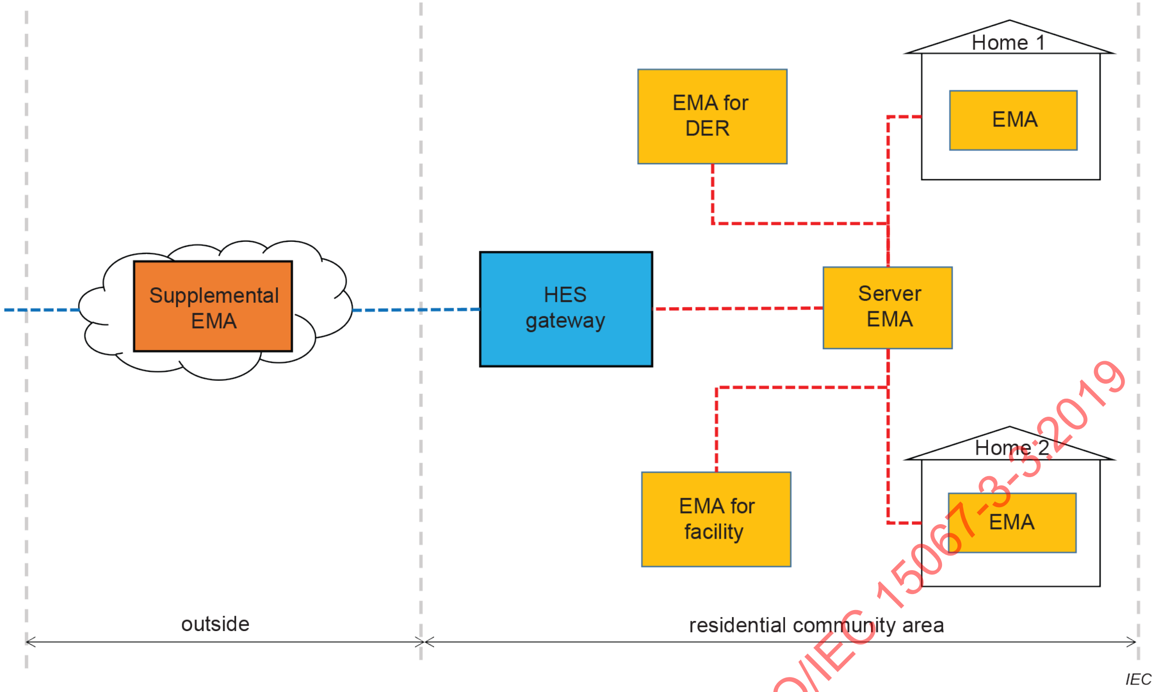


Figure A.4 – Hybrid EMA topology model example for a residential community

In the residential community or HES environment, one EMA or a combination of multiple EMAs participates in performing energy management to optimize customer costs by managing consumer demand (e.g. how much electricity is consumed during a specified time interval by end-devices, such as water heaters, air-conditioners and appliances). The more innovative methods of load control can be designed to optimize consumer demand by switching energy sources from grid to DER, such as local generation or battery, according to consumer preferences. Each EMA manages consumer demand and the use of DER in the corresponding service area, which also interacts with the other EMAs through the communications infrastructure in a distributed fashion (i.e. interacting EMAs).

The energy management system with multiple EMAs has the potential for significant energy savings and cost reduction for energy. Moreover, the energy management system with multiple EMAs offers desirable benefits, such as fault tolerance, reliability, and ease of installation and maintenance. These benefits help the consumer to make smart choices at the retail level according to market conditions with limited or advance notice to customers.

The benefits of the energy management system with multiple EMAs are summarized as follows.

- Improved system performance: Performance when processing loads is improved because multiple EMAs allow these loads to be distributed.
- Improved fault tolerance: A failure of a single EMA does not cause the entire HES system to fail. If an EMA has a problem, it can be resolved by EMA reconfiguration algorithms that make sure another EMA takes over the appliances covered by the failed EMA.
- Reliability: The influence of a failure can be limited to a single functional unit, which results in increased system reliability.
- Excellent expandability: System expansion can be accelerated in parallel since the development work of each functional unit is performed with an EMA by an EMA.
- Maintenance: Maintenance functions can be localized to a single EMA.

A.2 Demand-response functionality of interacting EMAs

The EMA functions are extended from ISO/IEC 15067-3 to support interacting EMAs. When a utility determines a mismatch between the supply and demand for power, a utility or other service provider (also called "third-party supplier") of energy management services may choose one or more of the demand-response methods, such as direct control and local load control. The utility may also use indirect load control methods facilitated by EMAs, where the price of electricity at the retail level varies according to market conditions.

For HES energy management, the utility or other service provider performs demand-response methods that use incentive-based and indirect methods via EMAs. The utility sends messages related to electricity supply (called the “utility data”) to influence EMAs to make choices about the operation of appliances. Such utility data may contain energy costs (e.g. pricing data or a penalty for exceeding a budget consumption amount) that indicate at least two different states corresponding to the electricity price: time-of-use pricing (e.g. pricing data) that specifies a static rate at specified times or real-time pricing. The utility data may also include an event notification about pending supply limitations. The EMA combines this information with stored data about appliance power requirements, DER output and customer information, and sends control signals to modify the operation of end-devices such as water heaters, air-conditioners, etc. The customer can enter preferences for appliance operation and budget limitations for electricity expenditures. Unless overridden by the customer, the EMAs enable automated demand-response by determining how and when to operate appliances and DER based on the cost of energy and the energy requirements of the appliances, DER and user inputs, among others. The EMA may report the electricity usage data to the utility.

The extended functions of the interacting EMA model are illustrated in Figures A.5 and A.6, which illustrate a hierarchical interacting approach and a mesh interacting approach, respectively. In a hierarchical interacting EMA environment as shown in Figure A.5, multiple EMAs solve the demand-response optimization problem through the coordination of energy consumption. The EMAs may act as an agent that performs specialized computing functions by receiving the electricity rate data from the utility and applying sophisticated software algorithms to determine which appliances and DERs to operate and when. To make choices about appliances and device operations, one becomes a server EMA and the others remain as client EMAs. The server EMA provides an automated demand-response by allocating limited energy (or a limited budget for energy) among multiple client EMAs, and distributes the limited budget of energy, including the cost of energy (e.g. a limited budget, pricing data for energy and event notification), to the client EMAs through the recommended interface between EMAs. The client EMA allocates energy consumption and generation among those appliances and DERs that it manages. The client EMA may also report the electricity usage data to the server EMA. The user inputs should be primarily preferences for home activities that involve energy-consuming devices.

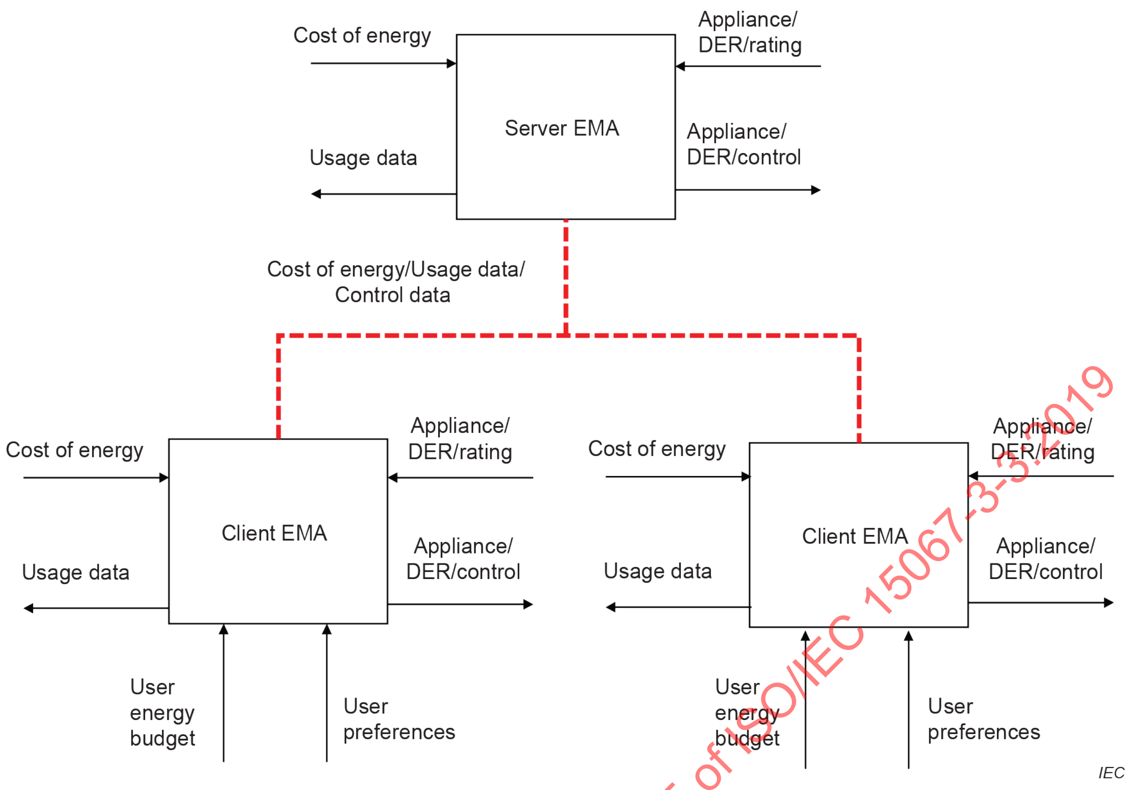


Figure A.5 – Function of hierarchical interacting energy management agents

In the mesh interacting EMA environment as shown in Figure A.6, EMAs add flexibility to accommodate how appliances respond to price changes with distributed control and controllability for coordinating multiple EMAs. The coordination of the EMAs could be extended to exchange energy related information among EMAs in order to optimize energy allocation. The interactions of the EMA are illustrated in Figure A.6. The EMA interactions may be extended to manage on-premises energy resources and power conditioning or conversion subsystems. Based on the information, the EMA decides how and when to operate appliances, DER and user inputs. Parts of or all the functions of the EMA can be delegated to other EMAs located above or below in the hierarchy.

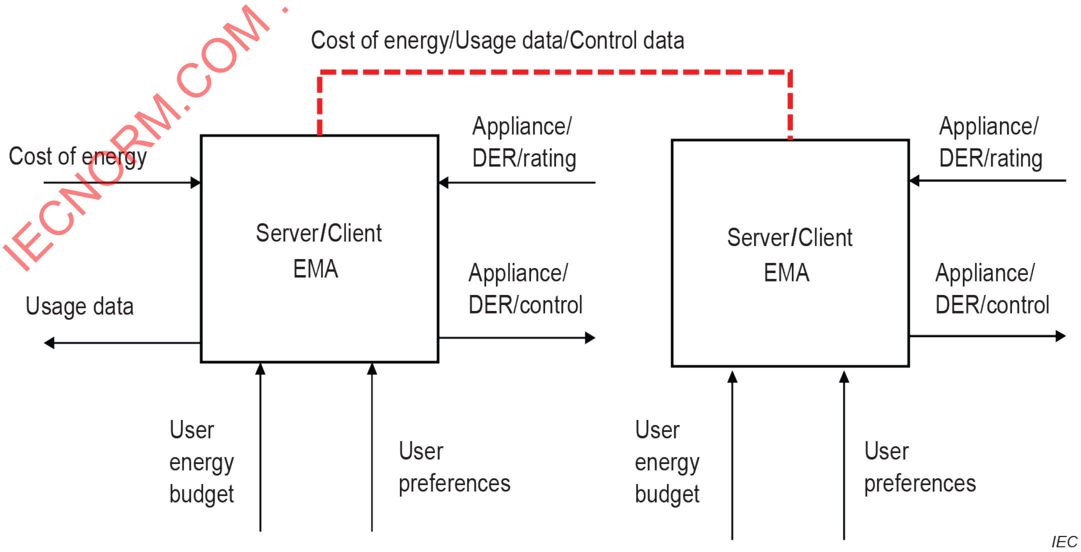


Figure A.6 – Function of mesh interacting energy management agents

A.3 Communication capability among EMAs

Two-way communication capabilities are involved in the interactions among EMAs. The communication capabilities specify control commands, status reports or price of energy data to be exchanged in the HES energy management system model. These data enable the demand-response in cooperation with multiple EMAs, allow the allocation of limited energy among EMAs and reveal energy usage by residential appliances. These data can be represented by a variety of messages between EMAs. The message contents given in a) to c) will be chosen according to the needs of a specific implementation in the HES energy management system model. Not all EMAs can or will support the contents of each message.

The communications between EMAs may be secured by some security standards such as Secure Sockets Layer (SSL). Data includes the cost of energy data, a limited budget for energy, control data, and the electricity usage data shown in Figures A.5 and A.6.

a) The cost of energy data:
   1) current price and the time-of-use pricing (including anticipated duration) that specifies a specific rate for a specified time;
   2) real-time pricing that may include advanced notification of price changes, such as one or more hours up to one day ahead of pricing;
   3) power restrictions such as level of consumption, remaining electric power and energy generation for a specific duration;
   4) peak and off-peak rates that change with appropriate notice;
   5) times for peak and off-peak rates, multiple-rate levels, such as time periods for low rates, medium rates, high rates and emergency rates;
   6) electricity rate information data suggesting operating modes and costs that will save money.
b) Control data:
   1) maximum power availability and the time allowed to shed loads;
   2) an emergency notice that supplies are limited (e.g. power deficit) and that a specific level of power consumption should not be exceeded;
   3) a request to reduce average power consumption by a stated percentage or the allocation of limited energy;
   4) acceptance or rejection of the power reduction within the specified time to limit a budget of energy.
c) Usage data:
   1) aggregated energy consumption for the home and/or building;
   2) status report, including static information, historical information, device operating status and customer acceptance or rejection of load control and the reason, if available;
   3) power consumption statistics reported by an EMA for load planning purposes;
   4) power recording and upload data accumulated by the EMA;
   5) energy generated or stored locally.

The data originated from the utility or the service provider will be exchanged between EMAs using a secure link. The level of security entails authentication to confirm that the data are from the real source and have not been altered during transmission. It is not necessary to encrypt such data since the data are public. However, the customer usage data will be encrypted to preserve customer privacy.

The interaction among EMAs should not be externally manipulated or observed by an energy service provider. Service scenarios for energy management in a residential community implementing HES are described in Annex B. Distributed load control implemented in an EMA combines local and direct load control features with greatly increased flexibility and customer control to accommodate time-varying prices that change dynamically. The specification of the user interfaces for configuring EMAs are outside the scope of this document.

Annex B
(informative)

Service scenarios of an interacting energy management agent

B.1 A service scenario of hierarchical interacting energy management agents

Clause B.1 specifies a service scenario to support DR applications with hierarchical EMAs.

In this scenario, a server EMA performs demand-response optimization. The server EMA appears as a black-box information system, which implements demand-response optimization and reports to the utility. In this scenario, the server EMA negotiates energy prices with client EMAs within a building. The energy service provider is not involved in these negotiations. In this scenario, the utility does not directly interact with the customers' appliances but sends a demand-response request to the server EMA with the following parameters: the power deficit, the price and the maximum incentive price.

Figure B.1 illustrates the logical message flows of a hierarchical interacting EMA to support DR application services in a hierarchical EMA environment. The energy service provider will present an offer for a quantity of power (usually in terms of power reduction) with price terms. An iterative process between server EMA and client EMA should result in a minimal possible price while achieving the necessary load reduction, thus converging to optimality. The server EMA will report acceptance of the offer to the utility. Figure B.1 shows a successful negotiation among the EMAs and a subsequent reporting to the energy service provider about accommodating a demand-response interaction.

The following messages specified in Table B.1 may be used for control, status/usage or cost of energy data to be exchanged among the logical components (i.e. server EMA, client EMA) in a hierarchical interacting EMA system model for energy services. Information shown in Table B.1 is referenced in Figure B.1. The sequence of messages in Table B.1 is not specified. An example sequence is shown in Figure B.1.

a) The control data
   1) Command: DR control, event notification.
   2) Response: accept/deny.
b) The cost of energy data
   1) Command: initial price, incentive price, bargaining price.
   2) Response: acknowledgement, accept/deny.
c) The usage data
   1) Billing, status report, usage data.

The message set described in Clause B.1 does not imply that all components may or shall support the features of the message. This information is used to implement a hierarchical interacting EMA system and energy management service. It provides a bounded set for messages to support interoperability among the logical components of hierarchical interacting EMAs.

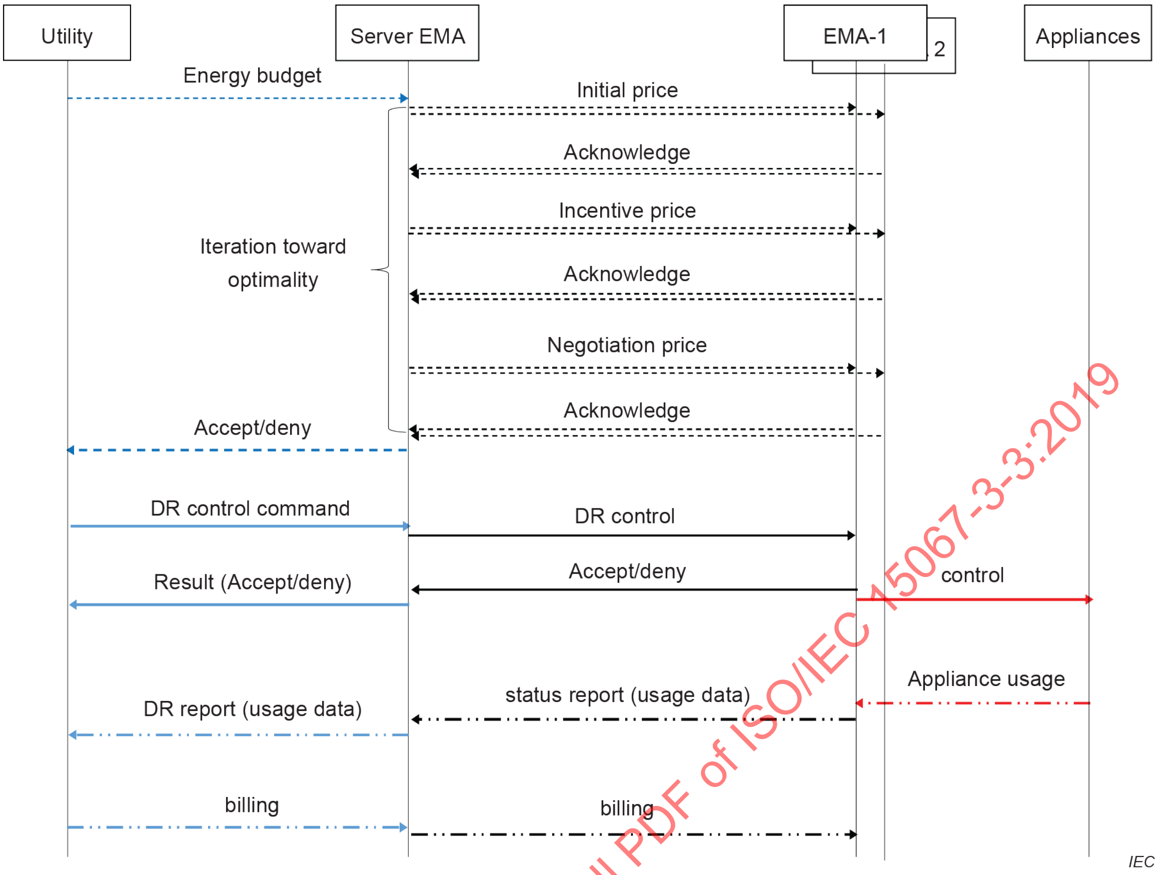


Figure B.1 – EMA to EMA interaction model in a hierarchical interacting EMA environment