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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Frameworks and functional architecture models

Energy saving using smart objects in home networks

Recommendation ITU-T Y.2064

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Recommendation ITU-T Y.2064

Energy saving using smart objects in home networks

Summary

Recommendation ITU-T Y.2064 describes requirements and capabilities for saving energy by using smart objects in home networks. It also presents the functional architecture of key components for saving energy through home/building automation.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2064	2014-01-13	13	11.1002/1000/12071-en

Keywords

Energy saving, home network, smart object.

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Energy saving using smart objects in home networks

1 Scope

This Recommendation describes requirements and capabilities for saving energy by using smart objects in home networks. It develops the functional architecture of key components for saving energy through home/building automation. This Recommendation covers the following:

- general overview for saving energy by using smart objects in home networks
- requirements and capabilities for saving energy by using smart objects in home networks
- functional architecture for saving energy by using smart objects in home networks.

This Recommendation considers the fixed home environment such as residential buildings, and it also considers aspects of the mobile environment relating to the home such as networked electric vehicles (EVs) which support ubiquitous networking among smart objects.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T X.1111] Recommendation ITU-T X.1111 (2007), *Framework of security technologies for home network.*

[ITU-T Y.2002] Recommendation ITU-T Y.2002 (2009), *Overview of ubiquitous networking and of its support in NGN.*

[ITU-T Y.2060] Recommendation ITU-T Y.2060 (2012), *Overview of the Internet of things.*

[ITU-T Y.2062] Recommendation ITU-T Y.2062 (2012), *Framework of object-to-object communication for ubiquitous networking in next generation networks.*

[ITU-T Y.2281] Recommendation ITU-T Y.2281 (2011), *Framework of networked vehicle services and applications using NGN.*

[ITU-T Y.2291] Recommendation ITU-T Y.2291 (2011), *Architectural overview of next generation home networks.*

[ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 context [ITU-T Y.2002]: The information that can be used to characterize the environment of a user.

NOTE – Context information may include where the user is, what resources (devices, access points, noise level, bandwidth, etc.) are near the user, at what time the user is moving, interaction history between person and objects, etc. According to specific applications, context information can be updated.

3.1.2 object [ITU-T Y.2002]: An intrinsic representation of an entity that is described at an appropriate level of abstraction in terms of its attributes and functions.

NOTE 1 – An object is characterized by its behaviour. An object is distinct from any other object. An object interacts with its environment including other objects at its interaction points. An object is informally said to perform functions and offer services (an object which makes a function available is said to offer a service). For modelling purposes, these functions and services are specified in terms of the behaviour of the object and of its interfaces. An object can perform more than one function. A function can be performed by the cooperation of several objects.

NOTE 2 – Objects include terminal devices (e.g., used by a person to access the network such as mobile phones, Personal computers, etc.), remote monitoring devices (e.g., cameras, sensors, etc.), information devices (e.g., content delivery server), products, contents, and resources.

3.1.3 ubiquitous networking [ITU-T Y.2002]: The ability for persons and/or devices to access services and communicate while minimizing technical restrictions regarding where, when and how these services are accessed, in the context of the service(s) subscribed to.

NOTE – Although technical restrictions to access services and communicate may be minimized, other constraints such as regulatory, national, provider and environmental constraints may impose further restrictions.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 smart object: An object which is aware of its characteristics, context and situation. It shares and processes information, such as its identity, current location, physical properties and the information it senses from its surroundings, while performing object-to-object communications.

NOTE – [ITU-T Y.2002] and [ITU-T Y.2062] provide details of object-to-object communication.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BAN	Building Area Network
BAS	Building Automation System
BEMS	Building Energy Management System
DR	Demand Response
EMS	Energy Management System
ESI	Energy Service Interface
EV	Electric Vehicle
FMS	Facility Management System
GHG	Greenhouse Gas
H2G	Home to Grid
HAN	Home Area Network
HEG	Home Energy Gateway
HVAC	Heating, Ventilating and Air Conditioning
ICT	Information and Communication Technology

IoT	Internet of Things
IP	Internet Protocol
IT	Information Technology
ITS	Intelligent Transport System
QoS	Quality of Service
V2G	Vehicle to Grid
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The keywords "is prohibited from" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The keywords "is not recommended" indicate a requirement which is not recommended but which is not specifically prohibited. Thus, conformance with this Recommendation can still be claimed even if this requirement is present.

The keywords "can optionally" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option, and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

6 Overview of energy saving using smart objects in home networks

Home networks [ITU-T Y.2291] provide packet-based transfers (in particular support of Internet protocol (IP)) and user access to a wide range of services and applications in a seamless environment, using multiple broadband and quality of service (QoS)-enabled transport technologies. They support automatic discovery and management of fixed and mobile terminals to the home network.

Energy issues such as low-power consumption are central to the ubiquitous network environment [ITU-T Y.2002] of the Internet of things (IoT) [ITU-T Y.2060]. For devices which constrain and minimize energy consumption, there are significant efforts being made to implement autonomous smart objects and to develop their applications which relate to energy issues. Home networks play an important role in interconnecting smart objects with the Internet.

In the ubiquitous network environment, everything is becoming connected. Therefore, a network has evolved from being primarily a source of information to being the platform for all types of applications. Smart and connected communities using the "connecting to anything" capability of ubiquitous networking [ITU-T Y.2002] play an important role in applications and services. Therefore, one of the core applications for interdisciplinary fusion services that this Recommendation focuses on is the requirements and key functionalities for saving energy using smart objects through combining information technology (IT) and other technologies (e.g., from energy related industries) in home networks.

Figure 1 depicts energy saving using smart objects; it shows a diagram of home networks with examples of smart objects. In the fixed home environment (e.g., residential buildings), objects such as energy saving systems, smart meters and home automation controllers, are used for energy management. In the mobile environment (e.g., networked EVs), objects such as devices for navigation and/or safety are used for saving energy.

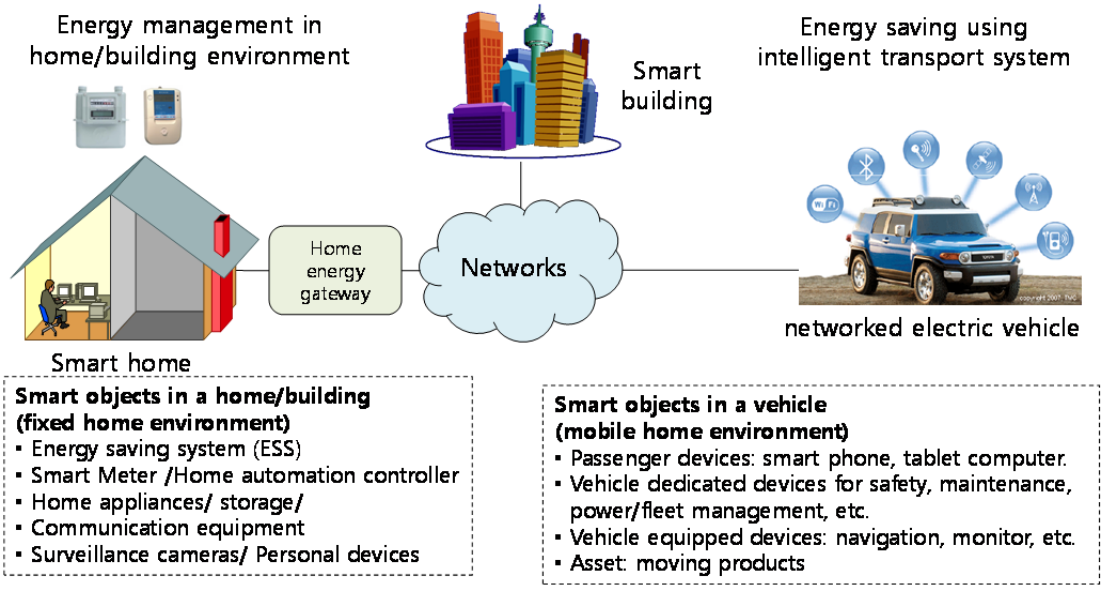

Figure 1 –Energy saving using smart objects in home networks

"Smart homes/buildings" represent a suite of technologies used to make the design, construction and operation of buildings more efficient; they are applicable to both existing and new-build properties. Building automation systems (BAS) including building management systems are important components which run heating and cooling systems. Data from these systems can be used to identify additional opportunities for efficiency improvements. As information and communication technology (ICT) applications become more sophisticated, the range of building automation system functions will expand.

Building system engineering supported by intelligent and networked room and building controllers (lighting, sun protection, heating, ventilation and air conditioning (HVAC), as well as other building engineering systems) contribute significantly to conservative and requirement-based energy use.

Various concepts and approaches are possible in the optimization of energy efficiency in homes/buildings; in this context, the use of intelligent building control provides a proven and interesting alternative or addition that is clearly set apart by its convincing cost-benefit ratio.

Automotive transport represents one of the main sources of greenhouse gas (GHG) emissions, but the wide-spread availability of ultra-high-speed broadband access, with ubiquitous provision of services, would enable multiple tasks to be achieved simultaneously with minimum power consumption. ICTs can be applied to transport through the development of intelligent transport systems (ITS). Although the main focus of ITS is on the safety, management and efficiency of transport systems, ITS can also be used to reduce their energy consumption.

7 Requirements and capabilities for saving energy using smart objects

7.1 High-level requirements

In home networks, there are the following high-level requirements for saving energy using smart objects:

- Home networks are required to support networking using various communication protocols and interfaces.
- Home networks are required to deliver energy consumption information and other information for customers, on demand.
- Home networks are required to store the most recent energy-consumption readings.
- Upon the request of authorized persons/organizations, home networks are required to provide periodic energy monitoring information.
- Home networks are required to support energy-related details/changes when they are being managed remotely (e.g., meter status, activation/de-activation capability, error messaging, fraud detection).
- Home networks are required to support any tariff changes that have been made remotely through interaction with the utility company.

7.2 Requirements of key components in home networks

7.2.1 Requirements for home energy gateway

The home energy gateway (HEG) offers features for collecting power consumption data over home networks with multiple access interfaces from appliances, controlling power activation, and communicating with utility networks, as well as communication network operators.

NOTE – HEG is a set of functions consisting of gateway functions and functions required for Smart Grid applications to control and manage Smart Grid services in customer premises.

The requirements for the HEG are as follows:

- An HEG is required to support various kinds of communication interfaces:
  - multiple communication access interfaces (e.g., WiFi, ZigBee) in a home;
  - a communication interface for remote control/readout outside a home;
  - the interconnection between home and utility companies/ communication network operators.
- The HEG is required to support authentication and authorization of all equipment in a home, including an electric vehicle (EV).
- The HEG is required to support the monitoring of energy consumption of home appliances, the analysing of information and the learning of usage patterns:
  - collecting power consumption data from various appliances;
  - the management of electric power load in the house, including EV energy consumption control based on the EV charging status.
- The HEG is required to detect and raise the alarm of an abnormal/emergency situation.
- The HEG is required to support charging/billing control.
- The HEG is required to support display control.
- The HEG is recommended to support device control and management:
  - control menus to control appliances
  - activation and deactivation of appliances.

7.2.2 Requirements for electric vehicles

For saving energy, the requirements for EVs are as follows:

- The networks for EVs are required to support vehicle communications [ITU-T Y.2281] including vehicle to vehicle (V2V), vehicle to infrastructure (V2I), vehicle to grid (V2G) in mobile environments.
- The networks for EVs are required to support charging/billing:
  - Smart charging: the vehicle charges its battery at a variable rate. It always tries to balance the vehicle owner's needs, the battery's demands and the grid operator's wishes.
  - Smart billing: it makes paying for the energy used convenient to the car owner and it enables advanced services and new business models.
- The networks for EVs are required to support interworking with several grid interfaces, e.g., V2G and home to grid (H2G).
- The networks for EVs are required to support the remote management of battery charging.
- The networks for EVs are required to support mobile networking and services concerning a networked EV.
- The networks for EVs are required to support new applications' combined telecom services and energy-related services.

7.3 Required capabilities for saving energy

The following are required capabilities for saving energy:

- energy-consumption monitoring and control
- intelligent power consumption monitoring application
- device virtualization environment
- web-based information processing
- personalized service creation
- secure and privileged access
- identity-based user management
- IP connectivity.

The following describes essential capabilities for customers in their home/building:

- home/building energy automation;
- energy management (including control and logging);
- renewable energy management (store, manage and integration);
- support electric vehicles charging;
- manage home appliances;
- home area networking and management;
- supports load control: a load control device (e.g., smart appliance, pool pump controller, energy management system (EMS), etc.) has the capability to reduce the peak power consumption of the equipment under its control.

8 Functional architecture for energy saving using smart objects

8.1 Configuration of home networks

There are important components of home networks. A residential building is comprised of an HEG to control the electricity, home appliances with energy-measuring sensors, smart meters (e.g., electricity meter, gas meter, etc.), display and a set-top box. A non-residential building is comprised of a building energy management system (BEMS) for managing building facility and component operation, focused especially on energy, BAS, HVAC, facility management system (FMS), and in-building infrastructure with sensing, metering and controlling components. Additionally, an EV, charging system (i.e., storage battery) and a parking system are considered for both homes and buildings.

Figure 2 shows the physical configuration of home/building networks with outdoor networks. Specifically, an energy service interface (ESI) in home/building networks refers to the interface between the home/building domain and outdoor networks. This interface can be a simple logical device within an HEG in a home/building network.

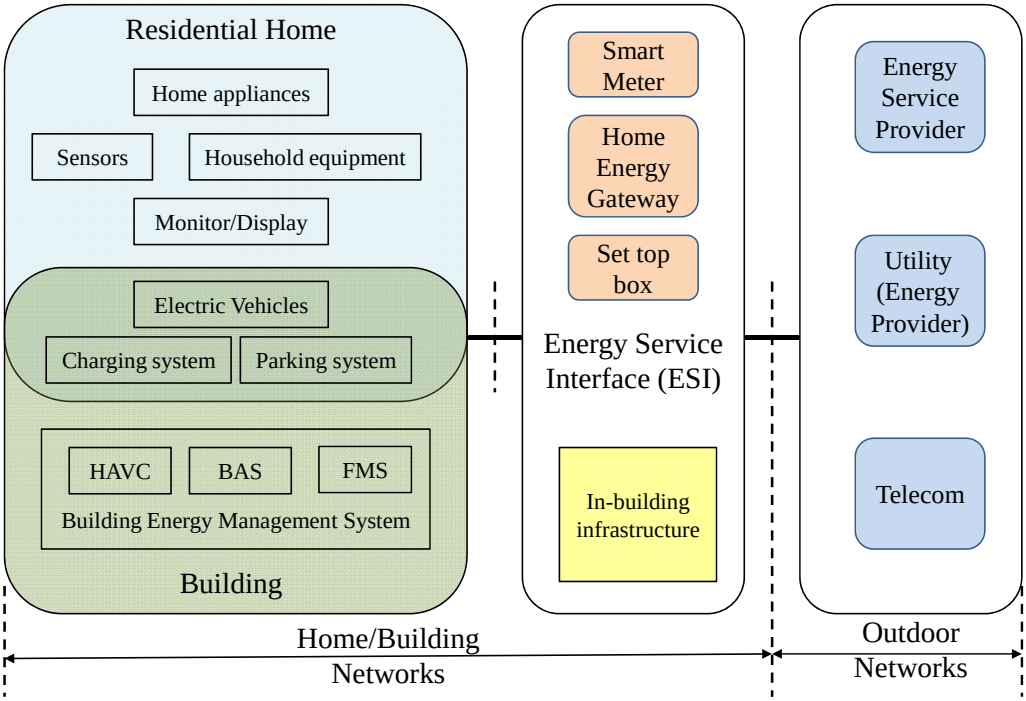

Figure 2 – Physical configuration of home networks (residential building and non-residential building) with outdoor networks

An HEG has the following functionalities:

- support of multiple communication interfaces (e.g., WiFi, ZigBee, etc.);
- interconnecting between home and utility companies/communication network operators;
- authentication and authorization of all home equipment including an electric vehicle;
- monitoring of energy consumption of home appliances, analysing information and learning usage patterns;
- detecting and raising the alarm of abnormal/emergency situations;
- charging/billing control;
- display control.

8.2 Functional architecture in home/building for saving energy

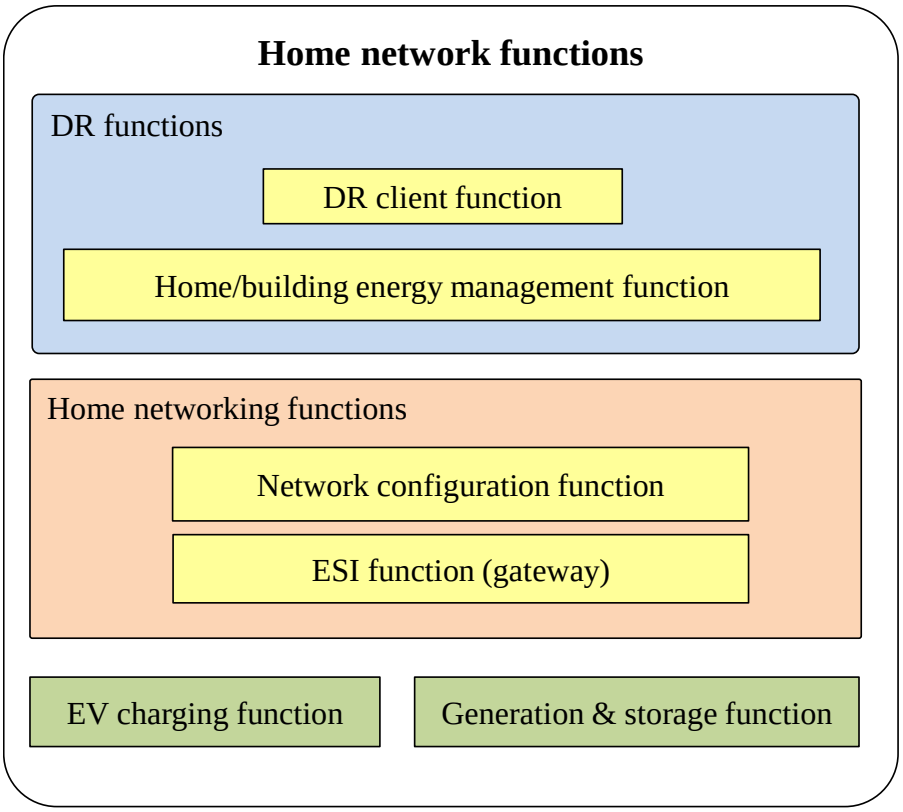

Figure 3 – Functional architecture for home network functions to support energy saving

A home network function group consists of the following functions: energy demand response, home/building energy management and automation, local energy generation and storage, and EV charging. It interacts with a DR application for dynamic pricing information, it controls energy usage of home appliances and in-building equipment.

NOTE – A home network function group can also interact with energy control functions which are located in outdoor networks for distribution capacity management and two-way energy transmission. It is out of the scope of this Recommendation.

- **DR functions***:* This function group covers all operations in the home/building domain for energy saving applications where the users interact with the service provider domain connected with outdoor networks.

DR client function: This function supports subscription to the service and dynamic pricing information and enables the management of energy consumption per users' needs while supporting metering information retrieval.

Home/building energy management function: This function monitors the energy consumption of appliances and dynamic pricing information, in order to control appliances, and generation and storage devices, through the interactions with users in the home/building domain. This function also provides notification of power outage to utility companies, and responds to mitigation and recovery signals during a scheduled or unscheduled energy outage.

- **Home networking functions***:* This function group provides a communications function in the home/building through a home area network (HAN) and building area network (BAN), respectively. These networks interconnect all appliances and equipment, EMS, EV charging stations, generation and storage facilities, and meters.

  - Network configuration function: This function manages equipment that joins and leaves the network. It supports by authenticating the members, authorizing the operations they could perform, and the information they could send and receive, and maintains encryption key information.
  - ESI functions: This function gates information in/out of HAN/BAN like a firewall and performs other functions which provide bi-directional logical interface that supports the communication of information between energy automation and other entities located in outdoor networks.
- **EV charging function***:* This supports managing the charging rate and billing information of an EV to support energy saving applications.
- **Generation and storage function**: This function manages the facilities for local energy sources. It interacts with the EMS for the switching of power for consumption in the home/building domain. It also interacts with the home/building energy management function to efficiently manage energy usage.

NOTE – This Recommendation does not consider all functions which support energy savings for various home environments. In particular, any additional functions for networked EVs can be added.

9 Security considerations

Security considerations for home networks should be in accordance with the security requirements given in [ITU-T X.1111] and [ITU-T Y.2701].

Appendix I

Use cases for saving energy through home automation and building energy management

(This appendix does not form an integral part of this Recommendation.)

This appendix describes various use cases for saving energy through home automation and building energy management.

I.1 Energy saving through home automation

For saving energy, the more detailed cases in home networking environments are considered. The following shows more specific cases for saving energy through home automation [b-AIM project].

- **Case 1 for residential users**

  Local users can interact with the system to perform a set of operations for intelligent power management services for autonomous energy preservation. The operations include the monitoring of energy use, the personalization of energy use and gateway maintenance.

- **Case 2 for utility companies**

  For a metering service for energy planning;, some components allow the metering system to exchange information with the power distribution network operator.

- **Case 3 for communications network operators**

  For remote monitoring and management, the users can monitor and control the power consumption of their homes remotely while moving outdoors.

  NOTE – In this Recommendation, two cases (Case 1 and Case 3) are considered for saving energy using smart objects.

I.2 Energy saving through building energy management

BEMS is a system technology for managing the building facility and component operation focused especially on energy. To improve energy efficiency, it is anticipated that various energy saving services are provided in the building domain [b-ITU-T FG-Smart]. The following is a list of use cases for saving energy using BEMS.

- **Dynamic pricing and metering information transfer**: To enhance the efficiency of electrical power usage and provide detailed energy usage in a building. The BEMS monitors and manages electric usage for building operation and maintenance based on the input dynamic pricing information and the usage information provided.
- **Demand response message transfer**: After receiving the message to reduce energy demand by the consumer when reaching peak demand, the BEMS is able to control electricity usage in the building based on a BEMS energy management algorithm and policy.
- **EV information transfer and EV's electric charge and discharge**: Based on the information of an EV's state such as its storage state or operating schedule, the BEMS is able to control an EV's electric charge and discharge in order to optimize energy usage by the EV.

Bibliography

[b-ITU-T FG-Smart] Smart-O-31Rev.7 (2011), *"Use cases for Smart Grid"*.

[b-AIM project] AIM Deliverable 4.1.1 (2009), *Use-cases design report*.

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