

Research and Development of the “ZigBee” Short-Range Wireless Communication Standard

MURATA Tomomitsu, MATSUKA Mitsunobu, UENO Toshiyuki

Abstract

“ZigBee” is one of the key technologies supporting M2M private networks. It is a wireless communication standard that is available mainly in the U.S. Smart Grid market. Since it obtained a global first ZigBee product certification in 2006, NEC Engineering Ltd. is leading the industry in the development of ZigBee products and systems. This paper introduces aspects of R&D at NEC Engineering Ltd. by focusing on features of ZigBee; it also discusses the development of ZigBee products.

Keywords

wireless, communication, ZigBee, device, module, smart energy, smart grid, HEMS, application services, SIG-J

1. Introduction

NEC Engineering, Ltd. is a company of the NEC Group that manages a wide range of technical domains from ICT to networks and provides solutions and suitable devices in their support. Among them, a large number of achievements have been gained, particularly in developments related to the wireless communications technologies.

NEC Engineering markets ZigBee as part of a line of short-distance wireless communication modules and is also engaged in the development of supporting devices and systems.

Below, in section 2 we offer an overview and discuss trends in ZigBee R&D. In section 3 we describe efforts being made for the development of ZigBee devices, and in section 4 we introduce a service application platform that makes use of characteristic ZigBee solutions.

2. Overview of ZigBee

ZigBee is one of the global standards for short-distance wireless networking like the Bluetooth or NFC (Near Field Communication) standards. ZigBee research begun in 2001 by the ZigBee Alliance. Subsequently, at the end of 2004 the first standard “ZigBee 2004” was launched, for the first time being the latest version is “ZigBee PRO.”

In Japan, the ZigBee SIG Japan (SIG-J) was organized by sponsor businesses to conduct activities aimed at growth in the Japanese market and also at advancement of its specifications.

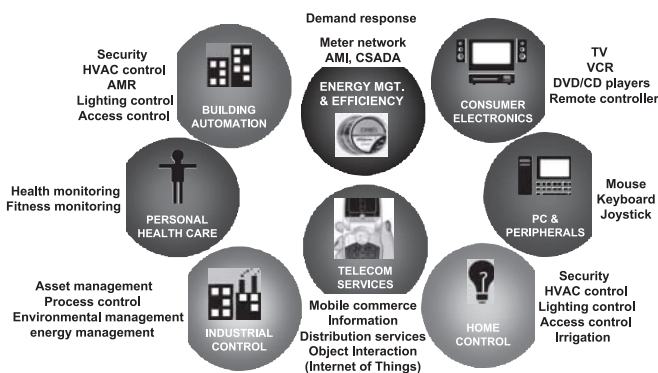
As a network, it is classified as a PAN (Personal Area Net-

work) but thanks to its supporting star, tree and mesh topologies it is capable of responding to various market needs.

The frequency band used in Japan is the 2.4 GHz band, it is used world-wide as well. Although the communication rate of 250 kbps is lower than other short-distance wireless communication standards, the most attractive features of ZigBee lie in its low power consumption and a low-cost installation capability.

2.1 ZigBee Markets

ZigBee is expected to be marketed in various fields of the M2M networks for industrial, commercial and home applications. Its main markets (range of application) are as shown in Fig. 1 .



* Source: ZigBee Alliance

Fig. 1 Representative ZigBee markets.

2.2 Configuration

The range of OSI (Open System Interconnection) reference models covered by ZigBee includes the network layers and the layers above. The IEEE 802.15.4 standard is applied to the physical layer and to the MAC layer (Fig. 2).

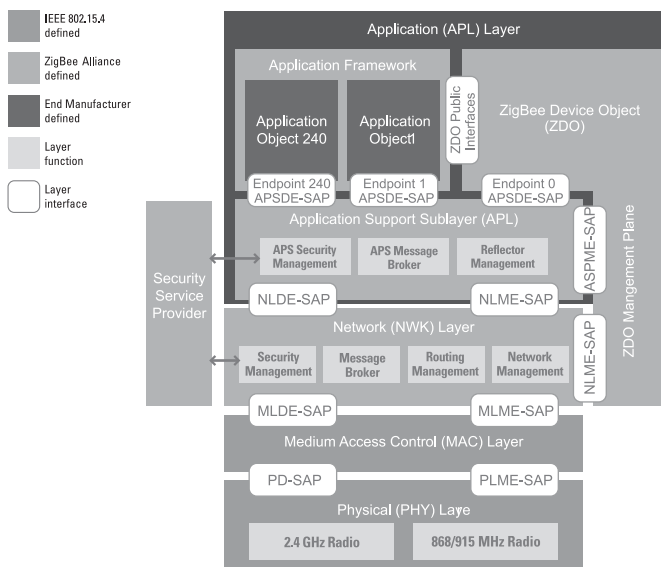
2.3 Defined Profiles

ZigBee defines an individual profile for each application. The main profiles include the following.

- ZigBee Home Automation (ZHA)
- ZigBee Smart Energy (ZSE)
- ZigBee Commercial Building Automation (CBA)
- ZigBee Telecom Service (ZTS)
- ZigBee Health Care (ZHC)
- ZigBee Remote Control (ZRC)
- ZigBee Remote Service (ZRS)

Among the above, the ZigBee Smart Energy (ZSE) profile is a control application for the home area that is attracting attention as an application of the M2M sensor network.

The ZSE was established as a solution to implement the HEMS (Home Energy Management System) based on the Smart Grid being developed in the USA and on other market requirements from Europe and Australia, etc.



* Source: ZigBee Alliance

Fig. 2 Configuration of ZigBee.

Its specifications were announced in June 2008. The main services of ZSE are as follows.

- Operational control of low-priority devices (sprinkler, pool pump, etc.) when power demand is high.
- Automatic adjustment of thermostat settings according to the power demand.
- Power-saving activities (visualization of power consumption on a display)
- High security by encryption of certificate based elliptic cryptography.

An example of the product application is the ZigBee smart meter that is becoming a mandatory installation in every home in certain areas. However, the current ZSE profile has been specified only for limited regions as described above, and does not always meet the circumstances of the Japanese market. Consequently, SIG-J is currently studying a ZSE profile suitable for the HEMS environment of Japan.

3. Device Developments

ZigBee as well as our other short-distance wireless communication device products are developed as modules so that customers can handle them and embed them in their own products easily and without technical knowledge of wireless communication systems.

The wireless communication module packages all the RF circuitry (including antenna) and control circuitry (microcomputer and peripherals) that are necessary for wireless communications. The module features a compact size and low power consumption that allows even operations powered by dry-cell batteries.

The wireless communication modules can roughly be classified into three types, each of which presents its own advantages and disadvantages for the specific needs of the user (Fig. 3). The following subsections discuss the differences between these three types of modules.

3.1 Standard Module

This product is equipped with the usual wireless communication functions such as the data communication function. In addition to the ZigBee module, we also provide modules based on independent standards in the 2.4 GHz/950 MHz bands (Photo 1).

This type of module is connected to the master board on

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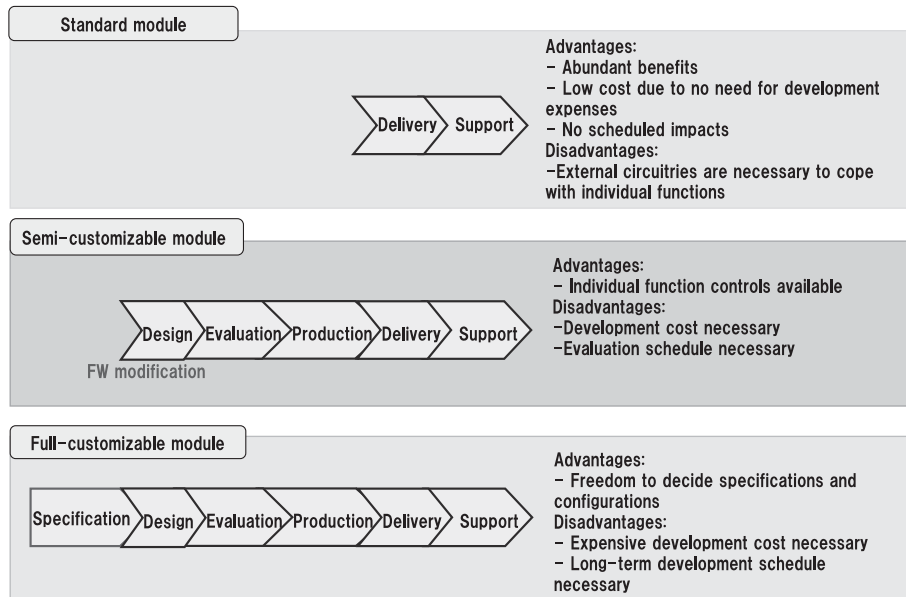


Fig. 3 Types of wireless communication modules.

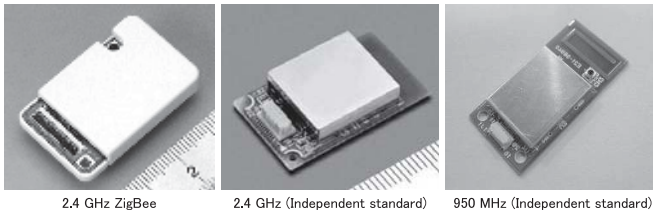


Photo 1 Standard wireless modules.

which it is mounted (belonging to the customer’s product) via a serial interface (UART). The current product (ZigBee 2004) offers the following functions.

- Data transmission/reception
- Power-save mode
- Network routing notification
- Network ping
- Network joining/leaving notification
- Power monitoring

In addition to the UART communication, this module also has I/O and A/D ports for connection with a large variety of sensors.

We also provide a low-priced starter kit for quick evaluation of wireless communication modules so that customers can develop wireless devices quickly and at low risk. As the product has already obtained certification under the Japanese Ra-

dio Laws, Japanese customers do not need to obtain certification of their products that mount this wireless communication module. The successful adoption of this product over a wide range of markets and business types ensures its safe use by the customers.

3.2 Semi-customizable Module

This module is provided by adding the equipment connection facilities and functions specific to each customer to the ZigBee platform (our platform firmware). This enables development at relatively low cost and over a short period because the functions can be packaged according to the needs of each customer and the targets of development are thus limited to the firmware (FW).

The representative product is a wireless communication module that is compliant to ZigBee PRO, which is the latest ZigBee standard (**Photo 2**).

This module is also compatible with the two ZigBee profiles of ZSE and ZHA and achieves a more compact size and lower power consumption than previous products. If the customer needs certification based on the Japanese Radio Law as for the standard module, we are ready to offer consultation and deliver the product after obtaining certification.

To ensure the high quality of the product, we perform the

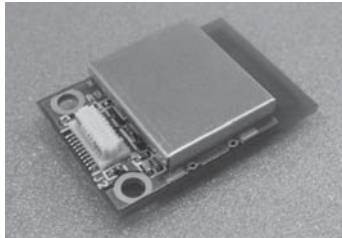


Photo 2 ZigBee PRO-compliant wireless module.

following evaluations in addition to the functional evaluation of the performance and profile.

- **Stability**

Although the number of home electric appliances assumed to be capable of being controlled by a ZSE is usually about 20 units, we evaluated the connections of 40 units to ensure stable operations with sufficient headroom in performance. To investigate the behavior at the performance limit we also confirmed connection evaluation of 100 units.

- **Interference with wireless LAN**

We have confirmed that the network can be started without problems by avoiding the channels used by wireless LAN communications.

3.3 Fully Customizable Module

In addition to the standard module featuring the best cost efficiency, we also develop and propose modules according to the specifications of each customer.

The custom modules that we develop can meet requirements that cannot be met with the standard modules. These are functional modules on which various sensors are mounted on a proprietary wireless communication platform as well as on the wireless communication block and those on which an antenna block is attached externally. Our custom development solutions include various wireless sensor devices, e.g., for measuring temperature/humidity, acceleration and GPS data.

4. ZigBee Service Application Platform

NEC is also developing "SmartWing," which is an M2M service application platform that is compatible with the ZigBee devices described above.

SmartWing provides applications in linkage with the "CONNECTIVE" M2M service platform, which is an asset of the NEC Group, as well as mounting an embedded common platform.

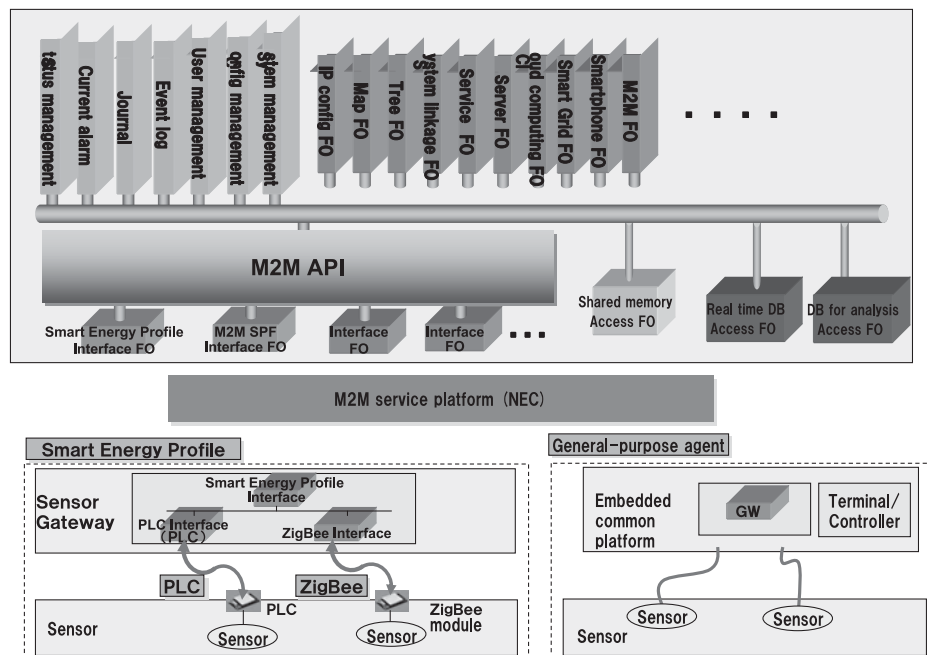


Fig. 4 Diagram of SmartWing architecture (Example applying ZigBee).

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Applications are mounted combining function objects (FOs). SmartWing provides abundant functions that have already been proven in actual operations, thereby allowing it to build high-quality applications (Fig. 4 , upper half). Development of new functions and the customization of existing functionalities are also easily achieved and can be made compatible with the defined profiles of ZigBee.

SmartWing quickly implements smart “visualization” and “management” for the ZigBee market. Its compatibility with various data formats in the market makes it capable of providing optimum CONNEXIVE-linked applications to the M2M market at a large scale.

Home appliance monitoring/control using smart power outlets is one example of a ZigBee service platform. This service builds a sensor network via smart power outlets using ZigBee and PLC (Power Line Communications) and notifies the user’s PC or mobile terminal (including Smartphone) of the home appliance power conditions, room temperature, etc. This allows the user to control remotely home appliances and to check their operating status (wattage, charges, etc.). The service is also capable of cutting the undesired power consumption of home appliances that are not in use in the home according to the demand responses to the power company.

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5. Conclusion

It is anticipated that ZigBee will be applied in a very wide range of fields thanks to its versatile features, which include compact size, low power consumption and flexible network configuration. NEC Engineering, Ltd. will continue R&D to meet market requirements for device services by continuing to lead ZigBee-compliant solutions in the core proprietary wireless communication technologies of the M2M-related fields.

*ZigBee is a registered trademark of ZigBee Alliance, Inc.

*Bluetooth is a registered trademark of Bluetooth SIG, Inc. (USA)

Reference

- 1) ZigBee Alliance website
<http://www.zigbee.org/>

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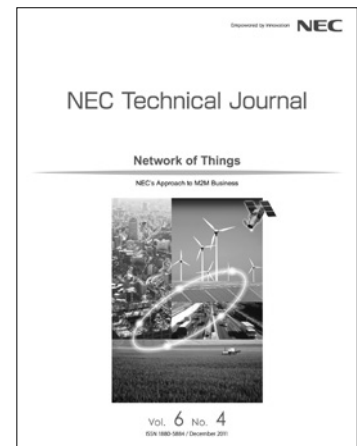
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