ZigBee Compliant Sensor Network

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Abstract

It will be necessary to acquire large amounts of information to enable smooth control, monitoring and information distribution in a ubiquitous society. This is why there are great expectations for wireless sensor network technologies which readily allow the sensing of multipoint connections and various types of sensors. We are proposing solutions that realize the ideal system using temperature/humidity sensors, acceleration sensors and triggered lighting control on the mesh network that is characteristic of ZigBee. And also the development of much-anticipated ZigBee-ready compliant wireless modules that offer low power consumption, low cost and advanced network configuration possibilities.
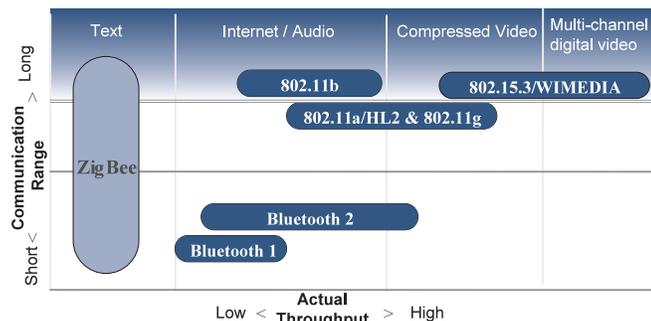
Keywords

wireless, low power consumption, low power wireless, sensor network, wireless sensor

1. Introduction

In recent years, expectations are great for low-cost, low power consumption, short-range wireless network communication technology for use in industrial equipment and home appliances in order to take in multi-type, multi-point sensor information. Typical conventional short-range wireless communication includes IEEE802.11a/b/g and Bluetooth the so-called "wireless LAN", with each offering different characteristics in terms of communication speed, power consumption, network configuration, communication range, and applicable to different applications. **Fig. 1** shows the transfer rate and communication range.

ZigBee was announced in December 2004 by the ZigBee Al-

liance as new short-range wireless communication standard offering low cost, low power consumption and flexible network configuration capabilities, and is categorized as a Personal Area Network (PAN). Over 300 firms are already participating in the ZigBee Alliance, and NEC Engineering has been a member from the spring of 2004. In addition to chip makers and network level middleware makers, a large number of manufacturers who are planning to ship ZigBee products in the future are also participants, such as our company. For the purposes of spreading ZigBee in the Japanese market, NEC Engineering has participated in the establishment of ZigBee SIG Japan, and has been active as a founding member.

2. ZigBee Outline

The basic layer structure of ZigBee can be roughly classified into the PHY layer, MAC layer and the network application layer.

The PHY layer and MAC layer is standardized using IEEE802.15.4, with the utilized frequency and modulation technique standardized in the PHY layer, and the authentication method, relay communication method and encryption method standardized in the MAC layer.

The network and higher layers are regulated by the ZigBee Alliance, stipulating the network topology management, network access and disengagement management, control methods for linkage to equipment functions, together with the topology as shown in **Fig. 2** and the 3 types of terminal functions.

Here is a brief explanation of each type of terminal function.

The PAN Coordinator is a terminal that manages the data for

> ZigBee handles control system (sensors, remote control, switches…)

> High reception sensitivity makes relatively long distances possible

Source: ZigBee Alliance

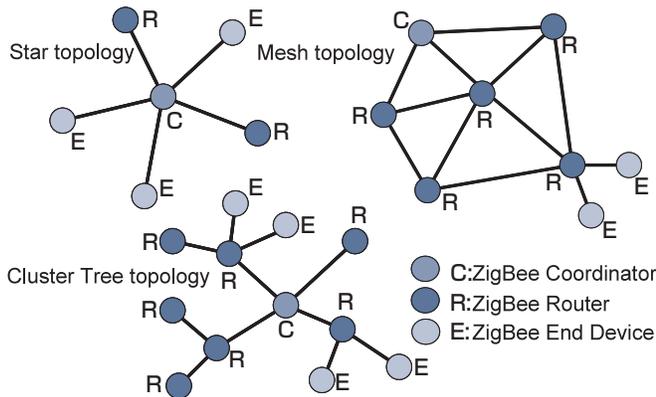Fig. 1 Transfer rate and communication range.

Fig. 2 Topology and 3 types of terminal functions.

the entirety of one local network. There is always one PAN Coordinator per one network, mainly for the purpose of establishing the network and managing the terminals that are participating in the network.

The Router is a terminal that has all standard functions, and serves to accept connection of end devices accessing the network, or to relay data from other equipment.

The End Device is a terminal with only the minimum necessary functions, dedicated to the processing of its own functions such as sensor control.

As for the network topology of ZigBee, two topologies of star topology and mesh topology are stipulated. The star topology consists of one PAN Coordinator and multiple Routers and End Devices, configured into communication channels in a star shape of 1-to-N. The mesh topology consists of a PAN Coordinator and Routers interconnected to other terminals in a web-like pattern, forming multiple communication channels. The data of each terminal is relayed like a bucket brigade, however if communication problems occur in a certain router the data is automatically detoured through another router to maintain communication. The cluster tree configuration is a combination of these two.

What's more, the profile is stipulated with ZigBee so the data and communication procedures used in the applications are standardized. As a result, compatibility between certified ZigBee equipment is guaranteed. Currently the "lighting profile" has already been decided, and other profiles such as for air conditioning and plant supervision are in the process of being decided.

3. Market Trend and Market Scale

As mentioned at the beginning, ZigBee has the potential for great demand in the fields of sensors, switches, etc., because of its low price, low power consumption, mesh network and relay communication capabilities.

In 2008 it is anticipated that the worldwide shipment of Zig-Bee chipsets will total 6 million dollars. Even if the unit price per chipset is $3 and the unit price per module is 1000 yen, this calculates into a global market worth 2 billion yen.

4. Activities of NEC Engineering, Ltd.

NEC Engineering's ZigBee business will allow response that corresponds to the needs of our customers.
・Supplying modules to equipment manufacturers as a module vendor
・Supplying terminals to SI vendors as an equipment manufacturer
・Proposing and constructing systems as an SI construction vendor

Using our standard module (which will be introduced later on) as the base platform, it is possible to offer customization and system construction according to the customer's system. As a result, from module supply to system development, we are able to offer the solution that a customer requires in a short timeframe and at low cost.

(1) Standard Module
Our standard module can process all network functions as well as wireless communication parts including the antenna. The customer can easily construct a ZigBee Network based system by connecting sensors, switches, lighting control circuits and such, to the input/output terminal of the module. A photo of the standard module is shown in **Fig. 3**.

Furthermore, we have created demo systems and modules with temperature/humidity sensors, etc., installed so that customers can understand the operation of the module, and are in the midst of developing sensor systems envisaging actual usage situations.

(2) Home Automation Demo
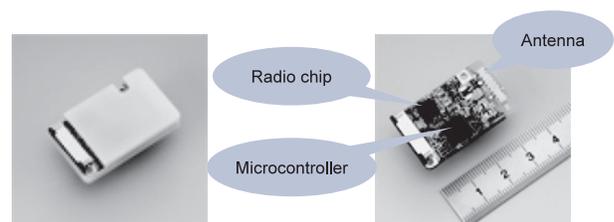**Fig. 4** is a demonstration which simulates usage in the home,

Fig. 3 Standard module.
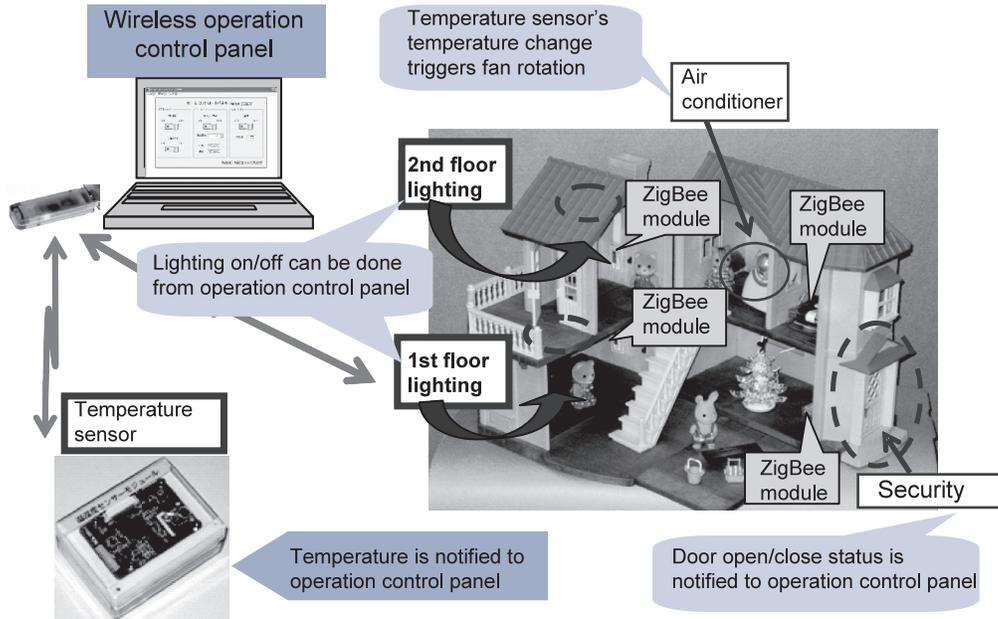
ZigBee Compliant Sensor Network

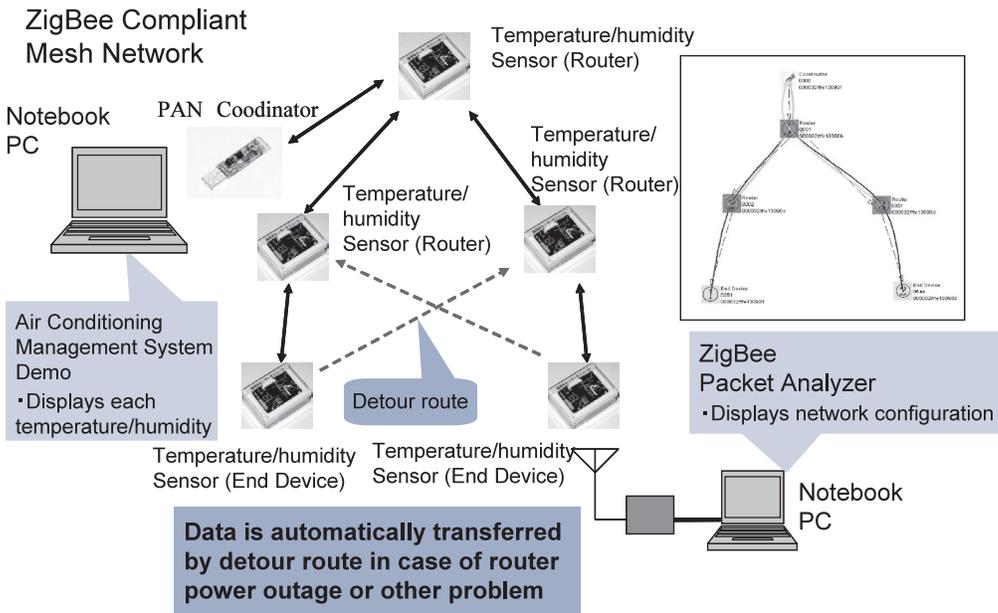Fig. 4 A demonstration which simulates usage in the home.

Fig. 5 Wireless temperature/humidity sensor network.

with multiple sensor modules and control modules placed throughout a model of a house. This represents how a wireless network can be used to achieve lighting control, automated air conditioning using temperature sensors, and basic

security that offers notification of doors opening/closing.
(3) Wireless Temperature/Humidity Sensor Network Demo
Fig. 5 shows how a USB type module connected to a PC becomes a coordinator, and a temperature/humidity sensor-

security
HVAC
AMR
lighting control
access control
BUILDING AUTOMATION

TV
VCR
DVD/CD
remote
CONSUMER ELECTRONICS

ZigBee
*Wireless Control that
Simply Works*

patient
monitoring
fitness
monitoring
PERSONAL HEALTH CARE

mouse
keyboard
joystick
PC & PERIPHERALS

asset mgt
process
control
environmental
energy mgt
INDUSTRIAL CONTROL

RESIDENTIAL/ LIGHT COMMERCIAL CONTROL
security
HVAC
lighting control
access control
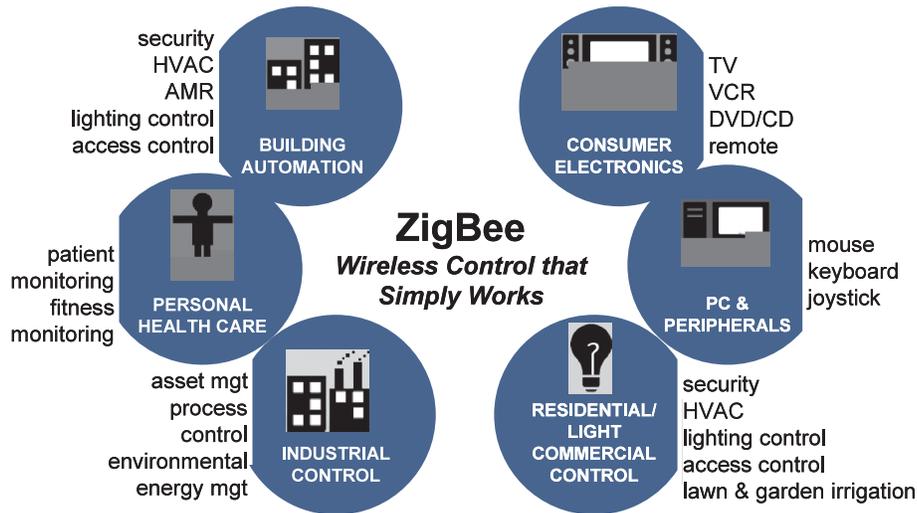lawn & garden irrigation

Fig. 6 Application fields of ZigBee.

equipped module acts as the router in the network, comprising a ZigBee mesh network.

With a mesh network, it is possible to construct a highly reliable wireless communication network because even if the module at a certain relay point develops problems the data can be automatically transferred through a different relay point.

5. Conclusion

The market for ZigBee, as shown in **Fig. 6**, has many potential fields of application, and we intend to move forward to the materialization of them through our activities.

In the future, we would like to continue promoting the spread of ZigBee by developing coordinators that can act as the gateway for other systems, further reducing module power consumption, further lowering the cost of module development, and creating a fuller lineup of sensor modules.

*ZigBee is a trademark of Koninklijke Philips Electronic N.V.
*Bluetooth is a trademark owned by Bluetooth SIG. Inc.

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