Scalable M2M Wireless Access System

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Abstract

NTT Network Innovation Laboratories is collaborating in developing a machine-to-machine (M2M) wireless access method in order to expand the ways of communicating with machines. This method utilizes a standard system of simplified management that improves communication quality by controlling the access points and wireless terminals from a network. This article outlines the system being developed and introduces the functions and requirements of the wireless access M2M method. In addition, we describe how the method realizes the rapid construction of a wireless access network using existing Wi-Fi home devices in a disaster area.

1. Background of M2M wireless access

In recent years, considerable attention has been focused on machine-to-machine (M2M) communication, which refers to communication between various devices and is not necessarily limited to home devices. This form of communication utilizes various types of information about the devices that network servers collect, store, and analyze. M2M communications is expected to create new value in areas ranging from health care, the environment, and ecology to security and safety. Wireless access systems for M2M communication play an important role these days as a means of accessing the devices. The 920-MHz frequency band (ARIB-STD 108) [1] became available in Japan at the start of 2012, and wireless access systems for this band have been attracting a lot of attention with an eye towards increasing their use in the future.

ZigBee has been established as an attractive standard for M2M wireless systems for the 920-MHz band because it can use multi-hop network topology and has relatively low power consumption characteristics. Zigbee private wireless systems allow users to set up facilities that they operate themselves. To utilize wireless local area networks (WLANs), which are also private wireless systems, users buy an access point (AP) and a wireless terminal (WT) and input an authentication key into them to establish authentication between them. This must be done for private wireless systems that request operational management on the part of each user. However, for M2M communication that must accommodate a huge number of WTs, this imposes a heavy burden on users who have to set the authentication manually for each individual WT. Another problem that arises is unstable communication quality due to interference between APs set up independently by many users. Yet another is that communication protocol requirements, e.g., IP (Internet protocol) or non-IP, differ according to users' purposes.

We aim to solve these problems without losing the benefits of the private wireless system by means of a scalable M2M wireless access system. This system is based on the standard method used in private wireless systems but has an added function that enables it to control the APs and WTs from a network. This makes it possible to avoid interference between APs and to concentrate on operational management.

The salient feature of the M2M wireless system we are developing is that it is scalable. This enables the sizes of cells in the cellular communication system to

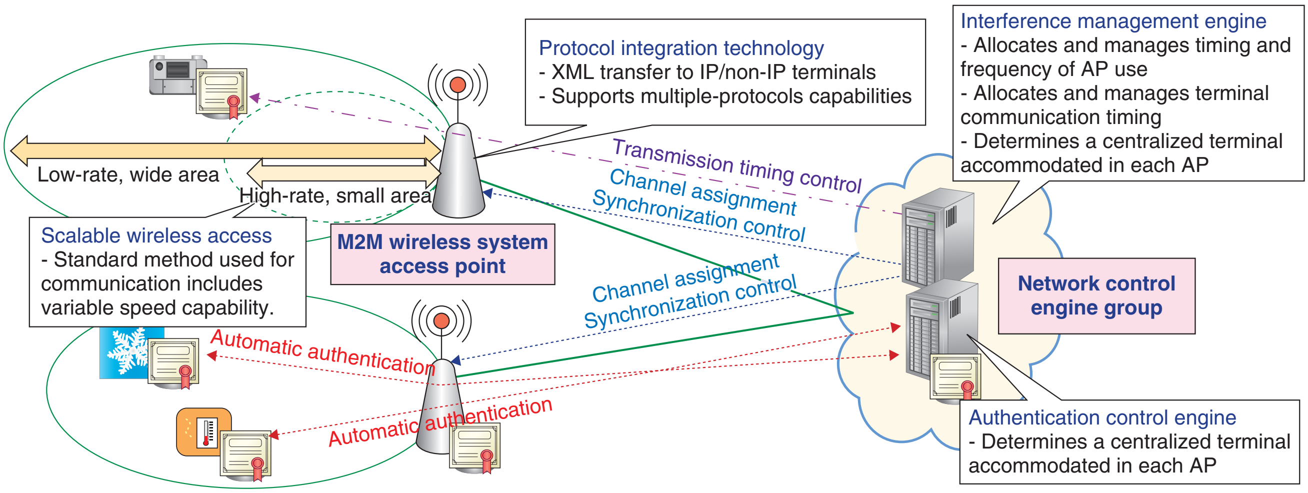

Fig. 1. Features of M2M wireless access.

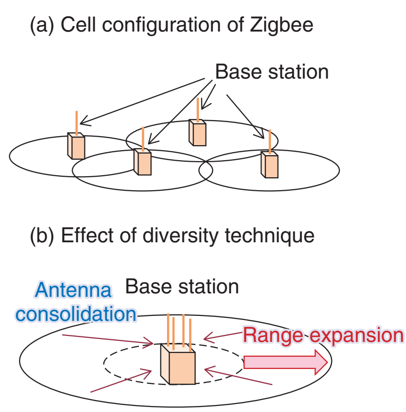

Fig. 2. Concept of diversity technique.

be flexibly designed from large to small by varying the cell size and communication speed according to demand. We also aim to establish multiple-protocol capabilities as the system's communication protocol, which will allow it to accommodate WTs using different protocols. Moreover, to achieve centralized control of APs and WTs from a network, we designed a WT that can be used without changing the connection settings to the APs when the WT moves among cells. This cooperative operation stabilizes the connection quality (**Fig. 1**). We aim to build an economical wireless system for M2M communication by using an AP that can use various commercial WTs made by the standard method.

2. Features of scalable M2M wireless access

2.1 Scalable M2M wireless access

Scalable M2M wireless access enables the communication range to be flexibly controlled by adjusting the transmit power and/or data rate. In outdoor environments, for instance, the communication range is about 1 km with 250 mW of transmit power and a 10-kbit/s communication rate. Moreover, the communication range can be approximately doubled by reducing the data rate to 1/10. In addition, as illustrated in **Fig. 2**, the communication range can be expanded without reducing the data rate by applying a diversity technique that consolidates antennas in the same location and combines their reception power levels.

In a non-line-of-sight environment between the transmitter and receiver, buildings often reflect signals, and this produces areas of weak received signal strength. In M2M communication where a fixed terminal position is assumed, a continuous communication failure known as fading frequently occurs as a result of this local degradation. It is therefore essential to develop a solution to combat the problem of fading.

The most common solution is to input a margin to compensate for the local degradation. However, in this solution, the margin limits the communication range. To solve this unique problem in M2M communication and to expand the communication range without reducing the data rate, we apply a diversity technique.

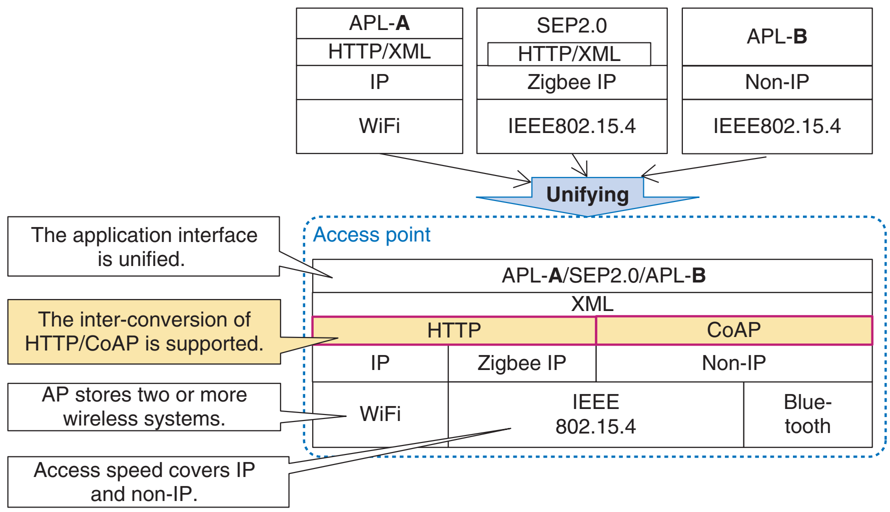

Fig. 3. Transparent XML transmission with HTTP/CoAP conversion function.

The application of diversity is generally limited in M2M communication because of its low signal-processing capability. Therefore, we developed a new method called *frequency offset transmitter diversity* that transmits only signals from two or more antennas at slightly different frequencies. This diversity method enables the communication range to be expanded by about 1.8 times using six transmitter antennas.

2.2 Multi-protocol correspondence of communication protocols

With respect to the communication protocol, an HTTP (hypertext transfer protocol)/CoAP (constrained application protocol) conversion function is mounted in an AP, and transparent XML (extensible markup language) transmission is achieved without being based on the protocol of a WT. Conventionally, the communication protocol is implemented using HTTP or an original system according to each application of M2M communication. This multi-protocol approach is intended to unify various protocols into the application interface of an XML base (**Fig. 3**). Although HTTP is usually used as a transfer protocol in IP connections, it is very difficult to achieve an IP connection and to mount HTTP into the low-performance terminals in M2M communication. Therefore, the IETF (Internet Engineering Task Force) has been advancing the standardization of CoAP in order to use it as a transfer protocol suitable for M2M communication. The main features of CoAP are that it is compatible with HTTP and that it reduces the required number of packet headers and sequences. These features make XML transmission possible at low-performance terminals for M2M communication. Supporting the HTTP/CoAP inter-conversion in an AP (Fig. 3) also enables the protocols to be unified into the application interface of an XML base to the WT of a non-IP connection. This enables users to develop applications without being base on the protocol of a WT.

2.3 Network-initiated authentication

M2M communication accommodates a huge number of WTs, and the connection setup needs to be established easily and securely between APs and WTs for authentication. Having to manually set individual WTs places an additional burden on users and should therefore be phased out or reduced as much as possible. WTs for M2M typically do not have any means of input (e.g., a keyboard or mouse), so the connection setup and authentication procedure for these terminals should be automated. In the system we are contemplating, a private-certification-authority server issues a digital certificate to a WT that contains a secure chip. After the power is activated, each WT automatically uses the certification server on the network to set up the connection with the AP for authentication. The tamper-resistant secure chip the WT contains provides a safe and secure wireless connection environment.

2.4 Centralized control with AP and WT from a network

Narrowband and limited frequency channels are

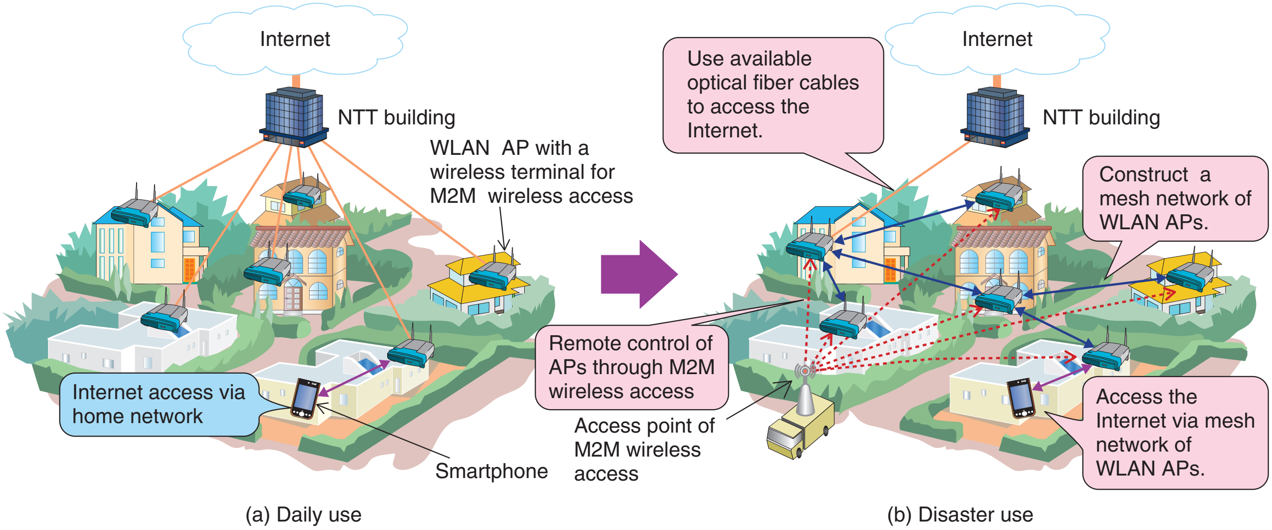

Fig. 4. Disaster recovery scenario using M2M wireless access.

used for M2M wireless access. An efficient approach to WT accommodation is for network-initiated management to coordinate the AP operation. For example, a cooperation scheme is needed where the network carries out synchronization between APs and allocates the frequency channel and communication timing to APs and WTs in order to prevent interference between adjacent APs and to enable the wide distribution of APs with fewer frequency channels. Another necessary scheme is one that ensures that data are transferred without fail, even though the currency of data may be limited to some extent. This is done by a function that distributes the WT's access timing in such a way as to prevent collision congestion when packet concentration is high in the network. This feature is suitable for M2M communication and could be effective for applications that do not require as high a degree of instancy as in human communications.

3. Disaster recovery solution using M2M wireless access

Smartphones with Wi-Fi capability have rapidly come into widespread use. They enable users to access the Internet outdoors via a cellular network and indoors via a home network, i.e., a WLAN. Consequently, the number of users who access the Internet with smartphones has recently been increasing. However, these access networks may not function in the event of a natural disaster such as an earthquake, so communication tools such as telephone and e-mail may not be available. In that event, users would have difficulty contacting relatives or gathering information about the disaster with these tools. To address this problem, in addition to restoring telephone services, it is important to construct new networks using existing Wi-Fi home devices, i.e., WLAN APs, to enable Internet access as quickly as possible. With this objective in mind, we are developing a prototype system that enables the rapid construction of a wireless access network by using M2M wireless access as a control link. This will make it possible for users to access the Internet with the Wi-Fi function on a smartphone, as shown in **Fig. 4**.

This system controls the Wi-Fi home (WLAN) APs attached to the M2M wireless terminal from the M2M AP installed by a carrier in a disaster area via an M2M wireless access link. Constructing relay links among the APs provides wide area coverage for communication around the area where the M2M AP is installed. Therefore, the system has two noteworthy features. The first is easy deployment. New APs and complicated settings done by engineers are unnecessary since APs for household use are used to construct the wireless access network for Internet access. The system also provides flexibility in establishing connections. For connection to the wireless access network, the system makes available access operations that any smartphone users can use, as well as those that only preregistered users can use. It should be noted that in either case, considerable discussion on the access operations is needed from the viewpoint of security. It is possible to access the Internet via optical fiber cables for household use if they have not been damaged in the disaster.

The second feature the system offers is flexible network management. When a disaster occurs, the number of available APs and the user distribution tend to vary from hour to hour. To deal with these variations, i.e., to accommodate a large number of users and handle a huge volume of traffic effectively, this system can control the network topology and assign the channel frequencies dynamically in accordance with the changes by using the M2M wireless access as a control link.

Finally, we mention the system's technical aspects. We are mainly developing two technologies relevant to this system under the national project; one is a means of effectively controlling data transmission of M2M wireless access in order to reduce overhead, since this access offers very low transmission rates ranging from several kilobits per second to several hundred kilobits per second. The other is technology to enable different WLAN AP devices to be controlled in a common manner.

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