Wireless Access Network System Using M2M Wireless Access for MDRU

Yoshitaka Shimizu, Yasuo Suzuki, Tomoaki Kumagai, and Kazuto Goto

Abstract

NTT Network Innovation Laboratories has been developing the Movable and Deployable ICT Resource Unit (MDRU) that enables us to quickly reestablish information and communication technology (ICT) services in disaster-stricken areas. In this article, we introduce a novel MDRU radio function that constructs a Wi-Fi access network quickly and flexibly around the MDRU by using machine-to-machine wireless access as the control link.

Keywords: M2M wireless access, remote control, Wi-Fi network

1. Introduction

Smartphones with Wi-Fi capability have rapidly come into widespread use. They enable users to access the Internet outdoors and indoors via wireless local area networks (WLANs). Consequently, the number of users who access the Internet with smartphones is increasing. We expect that there will be more and more opportunities to use Wi-Fi in the near future since a lot of Wi-Fi access points (APs) will be installed to strengthen connectivity prior to the 2020 Tokyo Olympic Games.

In view of the popularity and consequent importance of Wi-Fi, we must consider how to recreate Wi-Fi services after a disaster strikes. It is necessary to rapidly and flexibly deal with unexpected network failures such as those caused by the severing of optical fiber to Wi-Fi APs, which might occur after a disaster. For example, when several access links are broken and a network operator tries to recreate them by using Wi-Fi multi-hop connections such as wireless distribution system (WDS)*1 links, the corresponding Wi-Fi APs must be reset so as to establish multi-hop connections by linking neighboring APs to one another. Moreover, the conventional solution demands that users and administrators reset each AP according to the surrounding radio link situation. This is not easy, and it takes too long to reestablish Wi-Fi networks. To solve this problem, NTT Network Innovation Laboratories has been developing the Movable and Deployable ICT Resource Unit (MDRU) [1], which allows information and communication technology (ICT) services to be reestablished quickly in disaster areas. As a key MDRU wireless function, we are developing a system that enables rapid construction of a wireless access network by using machine-to-machine (M2M) wireless access*2 as the control link. This will make it possible for users to access the Internet via the Wi-Fi function of their smartphone.

*1 WDS: A wireless distribution system used to form multi-hop connections.

*2 M2M wireless access: A machine-to-machine wireless access system that is based on the standard method used in private wireless systems but has an added function that enables it to control the APs and wireless terminals (WTs) from a network.

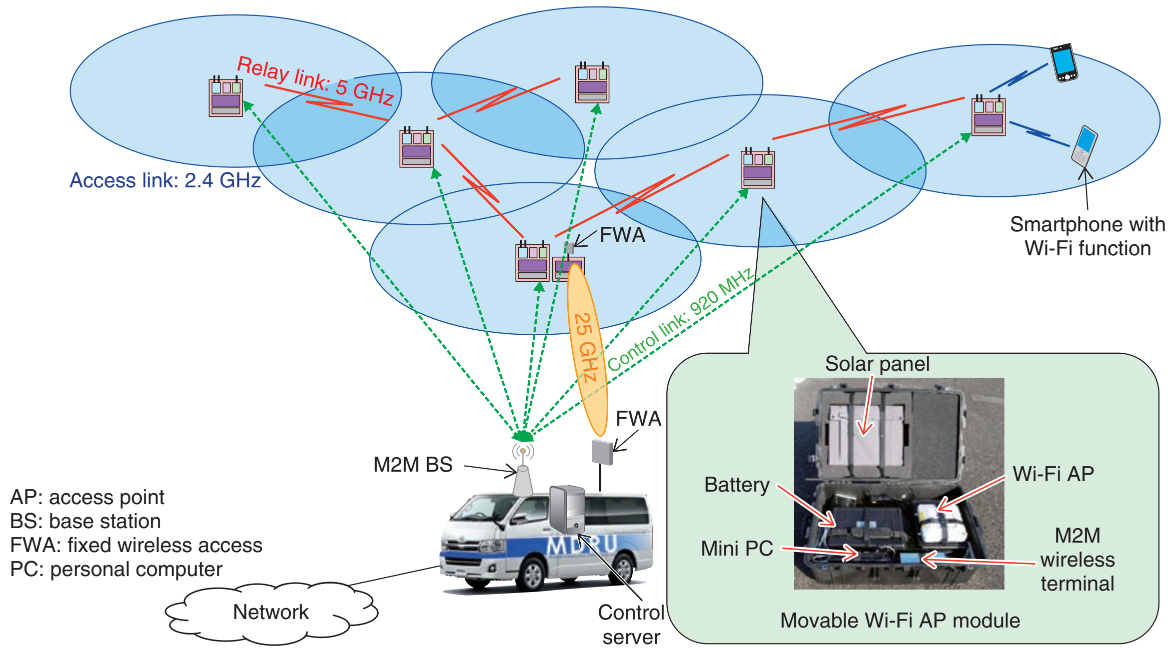

Fig. 1. Wireless access network system using M2M wireless access.

2. Wireless access network system using M2M wireless access as the control link

The wireless access network system using M2M wireless access is shown in **Fig. 1**. This system controls the Wi-Fi APs attached to the M2M wireless terminal from the M2M base station (BS) installed by a carrier in the 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 BS is installed. Therefore, the system has two noteworthy features. The first is easy deployment. The complicated Wi-Fi AP settings traditionally performed by engineers are unnecessary due to the remote control capability using M2M wireless access from the MDRU. The system also provides flexibility in establishing connections. If we try to cover the area by using only Wi-Fi APs, many Wi-Fi APs would be occupied by relay traffic. This would degrade throughput due to increases in the transmission delay and processing load. To avoid this situation, the system employs entrance links based on fixed wireless access (FWA)[*3] systems to reduce the number of relay Wi-Fi APs and to cover a wider area.

The MDRU prototype called the ICT Car has several modules such as an M2M BS module, a movable Wi-Fi AP module with solar panel and battery, and an FWA module with solar panel and battery. The Wi-Fi AP and FWA modules can be used even if the external power supply is down. After a disaster, the ICT Car arrives at the affected area, and these modules, transported by the ICT Car, are positioned up to 500 m away from the ICT Car. Since the remote control from the ICT Car is used to construct the Wi-Fi access network, we can reestablish the ICT environment [2] effectively and quickly with very few people.

3. Technical problems and solutions

If the MDRU is to control the Wi-Fi access network quickly and flexibly, it is essential that large numbers of WLAN APs be properly controlled in a short period by means of M2M wireless access. Unfortunately, M2M wireless access uses very low transmission rates ranging from several kilobits per second to several hundred kilobits per second in order to keep the transmission power of the WTs low and to achieve wide-area coverage, so it takes a comparatively long time to transmit the data to control the Wi-Fi APs and to transmit information from the Wi-Fi APs. To solve this problem, we need a means of effectively

*3 FWA: A system that enables a radio link to be connected between two points located far away from each other.

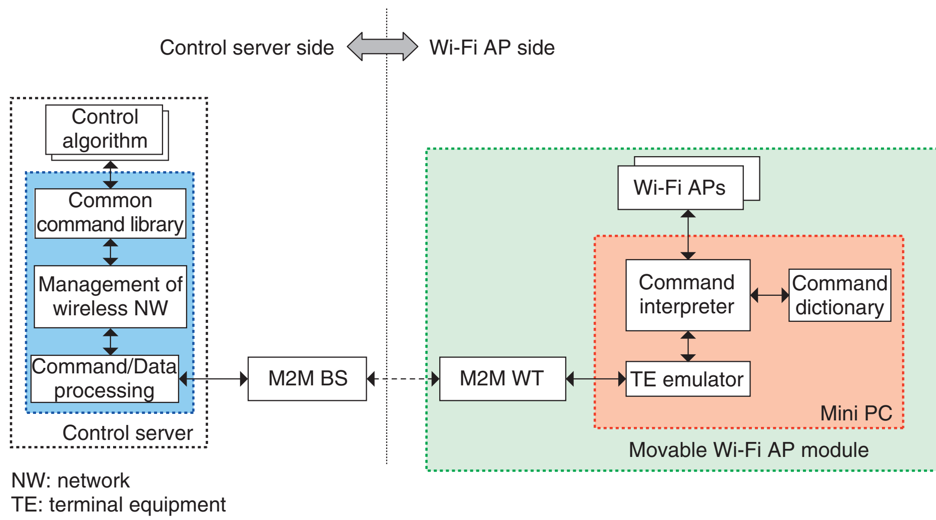

Fig. 2. Prototype platform.

controlling M2M wireless access. Moreover, we need to control a variety of Wi-Fi AP devices, but this is not easy to do since the devices may be from different vendors. We dealt with this by developing a software wrapper technology that enables different WLAN AP devices to be controlled in a common manner.

To assess the wireless access network system, we built a prototype platform as shown in **Fig. 2**. The platform consists of an M2M BS, a control server, and movable Wi-Fi AP modules including an M2M WT, a mini personal computer (PC), and Wi-Fi APs. To control the widest possible range of Wi-Fi AP devices, the control server has a specific command library with a set of common commands. When the operator issues a command to the Wi-Fi APs, the control server translates the control command into the corresponding common commands by referring to the library, and then sends the commands to the Wi-Fi AP modules via M2M wireless access. When the Wi-Fi AP module receives the commands, the command interpreter of the mini PC converts the commands into vendor-specific commands that correspond to the Wi-Fi device. The platform transmits only critical information in both the uplink and downlink in order to minimize the depletion of wireless resources and reduce the transmission delay. In the uplink, the only necessary information to control is extracted from the information acquired from the Wi-Fi AP in a command interpreter of the mini PC and then transmitted to the control server via M2M wireless access. In contrast, in the downlink, multiple vendor commands are assigned to a common command, which minimizes the number of control sequences passed to the Wi-Fi AP modules.

Table 1. Main specifications of M2M wireless access.

Frequency band	280-MHz band (Experimental purposes only)	
Transmission power	BS: 1 W	WT: 10 mW
Modulation scheme	π/4 –Shift QPSK	
Demodulation scheme	Uplink: coherent detection Downlink: differential detection	
Access method	TDMA/TDD	
Forward error correction	Convolutional coding (R = 1/2) / Viterbi decoding	

QPSK: quadrature phase-shift keying
TDD: time-division duplex
TDMA: time-division multiple access

4. Field experiments and evaluations

We conducted field experiments using our prototype platform at the Tohoku University campus. The platform employs the 280-MHz band, so we conducted field experiments using that band. We used eight different Wi-Fi APs from two vendors, Vendor A and B, in the experiments in order to evaluate the performance of our proposed system. The main specifications of M2M wireless access are listed in **Table 1**. First, we confirmed that the coverage area was over 400 m by actually controlling Wi-Fi APs that were positioned about 430 m from the MDRU.

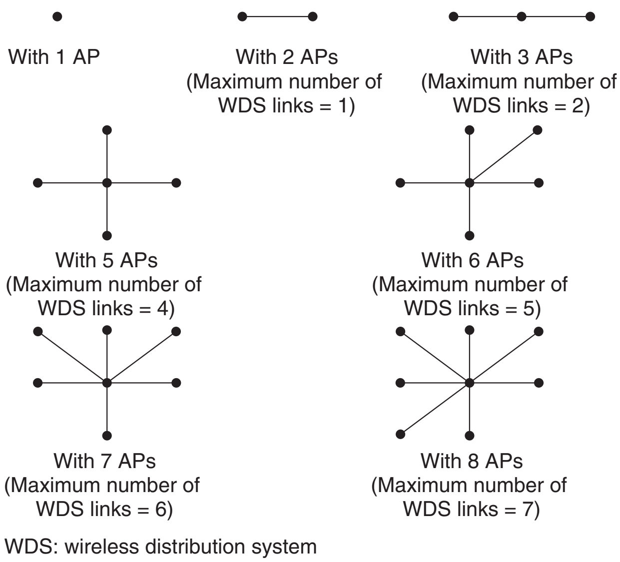

Fig. 3. Measured network topologies.

We evaluated how effective the transmission technique was by collecting wireless environment information of a Wi-Fi AP on our platform before measuring the transmission time. Without our technique, data capture took 167 s, and it took 147 s to transmit the data so gathered. With our technique, data capture took 68 s, and transmission took 45 s. The volume of information was reduced by 1550 bytes.

Next, we constructed a Wi-Fi access network using two kinds of Wi-Fi AP devices to find out whether or not our platform could control different Wi-Fi AP devices. The network topologies we implemented are shown in **Fig. 3**. We selected the topology in which the number of WDS links becomes the maximum given the number of Wi-Fi APs. We conducted wireless environment information collection, SSID*4 (service set identifier) setting, and WDS setting, and we also issued link confirmation commands in order to construct the Wi-Fi access network. The time taken to construct the Wi-Fi network versus the number of Wi-Fi APs is shown in **Fig. 4**. The results confirm that the common commands of our platform allowed different Wi-Fi AP devices to be controlled; moreover, a Wi-Fi access network with eight Wi-Fi APs was able to be constructed within 30 minutes. It is possible to shorten this time by adjusting the timer to wait for responses in the Wi-Fi module.

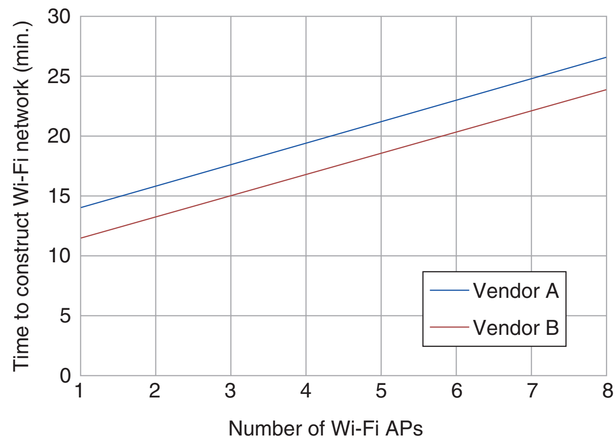

Fig. 4. Time required to construct Wi-Fi access network.

5. Future work

We plan to conduct additional field experiments using the 920-MHz band instead of the 280-MHz band in Japan as well as overseas [3] in order to evaluate the effectiveness of the system.

Acknowledgment

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*4 SSID: An identifier of Wi-Fi APs regulated by standardization.

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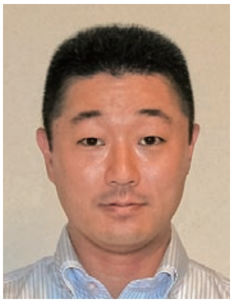

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