Development of Wireless IP Access System (STEP 2) in the 26-GHz Band

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Abstract

To provide fast Internet services to areas where it is difficult to lay optical fiber cables for an access network, NTT developed a Wireless IP Access System (WIPAS STEP 1), which is a point-to-multipoint fixed wireless access system using the 26-GHz frequency band that provides a best-effort IP service. WIPAS combines wireless technology with an optical network and complements FTTH (fiber to the home) service. This article describes the second-generation WIPAS called STEP 2, which has twice the transmission rate of STEP 1 while being much more compact. It overviews the concepts and technologies of the STEP 2 system.

1. Wireless IP Access System

High-speed Internet access over optical fiber, ADSL, CATV, etc. has become rapidly available in recent years. Yet there are still many users who cannot obtain broadband access because of the difficulties of deploying fiber-optic cable or simply because services have not been made available in their areas due to cost considerations. With the goal of providing high-speed Internet access to these previously inaccessible pockets of users, the Access Network Service Systems Laboratories developed a Wireless IP Access System (WIPAS) STEP 1 [1]. WIPAS combines wireless technology with an optical network and complements the FTTH (fiber to the home) service. STEP 1 services began in September 2002 when NTT EAST and WEST added them to their B–FLET'S service menus.

To increase the transmission rate and reduce the size of the wireless equipment, we developed WIPAS STEP 2 (Fig. 1). It is a point-to-multipoint Fixed Wireless Access (FWA)*1 system using quasi-millimeter-waves in the 26-GHz band, one of the fre-

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*1 In FWA, both the access point and wireless terminal are fixed.

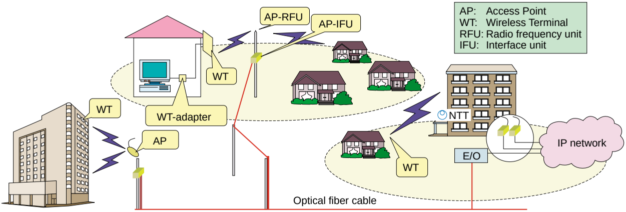

Fig. 1. Wireless IP access system.

quencies (22, 26, and 38 GHz) allocated to FWA services in Japan. Figure 2 shows the channel plan for WIPAS. This system comprises wireless terminals (WTs) installed on customer premises (typically attached to the balcony or outside wall) and access points (APs) installed on telephone poles and building rooftops. An AP is connected to the core network by an optical fiber cable. A WT incorporates an antenna, radio frequency (RF) module, baseband processing modules (modulation/demodulation, TDMA, MAC processing, and so on), and a WT adapter that functions as an interface to a personal computer. An AP comprises a radio frequency unit (AP-RFU) that incorporates an antenna and RF module and an interface unit (AP-IFU) that incorporates baseband processing modules and a core network interface. The main specifications of this system are given in Table 1.

The maximum wireless transmission rate of this system is 80 Mbit/s, and the maximum Ethernet frame transmission rate is 46 Mbit/s. This system provides a best-effort type IP service, and the wireless bandwidth is shared fairly among the WTs that are connected to the same AP. The AP dynamically allocates the bandwidth to WTs corresponding to the demand of each WT and uses a round-robin algorithm for allocation processing. VLAN*2 (IEEE802.1Q) [2] is used as the protocol for this system, and all IP packets are transmitted transparently between WTs and the AP. Figure 3 shows the WIPAS protocol stack.

Some FWA systems in Japan use IEEE802.11b [3] (2.4-GHz band). The equipment costs of these FWA systems are low, but such systems suffer unstable link quality because they use industrial, scientific, and

*2 VLAN is a network technology that organizes and manages virtual networks without physical cable connections.

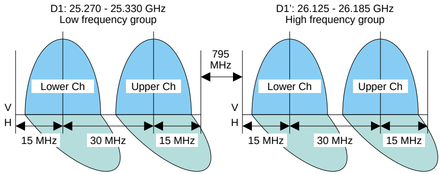

Fig. 2. Channel plan for WIPAS.

Table 1. Main specifications of WIPAS STEP 2.

Frequency	26-GHz band
Modulation	QPSK/16QAM
Transmission	TDMA/TDD
TX capacity	For wireless: 40 Mbit/s (QPSK), 80 Mbit/s (16QAM) For Ethernet: 23 Mbit/s (QPSK), 46 Mbit/s (16QAM)
TX power	AP: 14 dBm (QPSK), 11 dBm (16QAM) WT: –6 to 14 dBm (QPSK), –9 to 11 dBm (16QAM) (auto power control: 0.5-dB step)
Antenna	AP: Omni, Sector (90 degrees), Horn, Cassegrain WT: Flat
User interface	10 Base-T/100 Base-TX (full/half duplex)
Network interface	100 Base-FX or100 Base-TX (full/half duplex)
MAC processing	VLAN (IEEE802.1Q)
TX distance	Approx. 700 m (QPSK), 400 m (16QAM)
Number of WTs	Max. 239 WTs per AP
Downtime	Less than 2 minutes per year

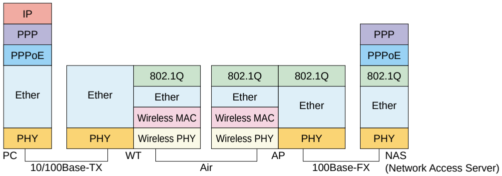

Fig. 3. Protocol stack.

medical (ISM) bands. Because WIPAS uses the 26-GHz band, which FWA services are permitted to use, there is no interference from other wireless services. FWA systems that use the 5-GHz band will begin services soon. These systems are based on IEEE802.11a, and the transmission rate is up to 36 Mbit/s. WIPAS STEP 2 surpasses the 5-GHz FWA systems in maximum transmission rate with the same equipment cost.

2. New features of STEP 2 system

WIPAS STEP 2 has four major improvements over the STEP 1 system.

(1) In addition to QPSK (quadrature phase shift keying), it also uses 16QAM (quadrature amplitude modulation) for modulation .
(2) WT-RFU and WT-IFU are unified.
(3) It can select either the upper or lower channel in the AP-RFU and WT equipment.
(4) It also supports point-to-point communication.

The use of 16QAM raises the maximum wireless transmission speed to 80 Mbit/s, twice that of the STEP 1 system. The WTs are made significantly smaller and easier to produce by integrating WT-RFU and WT-IFU. Because the AP-RFU and WT equipment have a polarization option (vertical or horizontal polarization), users can select one of four channels in the STEP 2 system. The STEP 2 system can be used to connect an AP to a core network instead of optical fiber cable using point-to-point mode.

3. Increased transmission rate

Figure 4 shows the frame format of the STEP 2 system. If QPSK is used for modulation, the wireless transmission rate is 40 Mbit/s, because one symbol*3 (the symbol rate is 20 Msymbol/s) can carry two bits of information in QPSK. If 16QAM is used, the air transmission rate is 80 Mbit/s, because one symbol can carry four bits of information.

The 16QAM modulation is only used in payload fields for safety concerns pertaining to equipment control (QPSK is more robust against C/N+I*4 degradation than 16QAM). The maximum Ethernet frame

*3 A symbol is an information unit that is transmitted over the base clock of a wireless signal and can multiplex a few bits of data by means of modulation.

*4 C/N+I: The ratio of carrier power to noise plus interference.

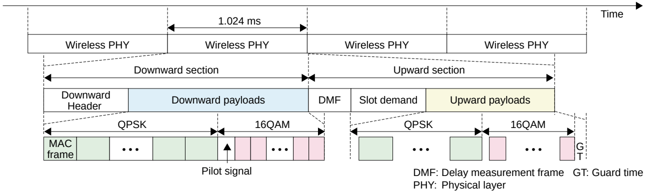

Fig. 4. MAC frame format.

transmission rate is 46 Mbit/s, if 16QAM is only used for payload modulation and all payloads are allocated to the downlink. If all payloads are allocated to the uplink, the transmission rate is 31 Mbit/s.

4. Wireless terminal technologies

To unify the WT-RFU and WT-IFU, we developed i) a one-chip application-specific integrated circuit (ASIC) that handles modulation/demodulation, MAC processing, and TDMA control, ii) a surface-mount microwave monolithic IC (MMIC) for the RF modules, and iii) a slotted-waveguide-array flat antenna [4].

Unifying the baseband modules into a one-chip ASIC reduced the WT equipment size and cost and improved device reliability. The MMICs consist of a high-power amplifier, low-noise amplifier, and up and down converters. Their surface-mounting design reduces the equipment manufacturing cost because they can be installed without special manufacturing processes.

We developed a slotted-waveguide-array flat antenna with the RF and baseband modules and power-supply circuit on its rear side to reduce the size and cost of the WT equipment. The flat antenna has a narrow beamwidth of 4° to obtain a high antenna gain. Table 2 gives the antenna specifications. Figure 5 shows the appearance of the WT and compares the STEP 1 and 2 systems.

We developed a WT-adapter having a PC interface, power supply, and alarm indication. It connects to the WT and user PC via Ethernet cables. Vacant cores within the Ethernet cable are used to supply power to the WT.

5. Access point technologies

We reduced the size of the AP-IFU (size: 27 × 32 × 16 cm, weight: 6.5 kg) by using two ASICs for the

Table 2. Antenna specifications of WIPAS.

	AP			WT
Type	Omni	Sector	Horn	Flat
Directivity	H plane: Omni directional V plane: Fitting cosec^2 curve	H plane: Beam width: 90° V plane: Fitting cosec^2 curve	Beam width: 90° × 90°	Beam width: 4°
Gain	6.0 dBi	12.0 dBi	5.5 dBi	31.5 dBi
Polarization	V or H	V or H	V and H	V and H
V.S.W.R.	Up to 1.5			
XPD	Greater than 20 dB			Greater than 25 dB

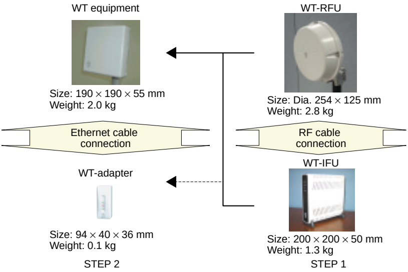

Fig. 5. Appearance of wireless terminal.

Size: 275 × 325 × 160 mm
Weight: 6.5 kg

STEP 2

Size: 330 × 380 × 380 mm
Weight: 14 kg

STEP 1

Fig. 6. Appearance of AP-IFU.

Omni/90 degrees sector type
Size: Dia. 150 × 600 mm
Weight: 7.0 kg

Horn/Cassegrain type
Size: Dia. 254 × 125 mm
Weight: 2.9 kg

Fig. 7. Appearance of AP-RFU.

baseband processing. One, which is commonly used in WTs, functions as a modem, and the other performs TDMA control and MAC processing. Figure 6 shows the appearance of AP-IFU and compares the STEP 1 and 2 systems.

In the AP, we separated the AP-RFU from the AP-IFU in the same way as in the STEP 1 system, because different AP-RFU antennas are used to suit the service type. For example, an omni-directional antenna with a 360° horizontal directional pattern is used for services in residence areas without high-rise buildings (Table 2). A horn antenna with a 90° × 90° directional pattern is used for services targeted at occupants of apartment or office buildings because these users are widely spread both horizontally and vertically. On the other hand, a Cassegrain antenna with a 4° pattern is used for a wireless entrance system. The appearance of the AP-RFU is shown in Fig. 7.

6. Equipment installation

The equipment is now small enough to be mounted on telephone poles or customers homes (e.g., balconies or outside walls). Figure 8 shows a photograph of the equipment and installation.

7. Conclusion

NTT has improved Wireless IP Access System (WIPAS). The STEP 2 system is designed for home and SOHO (Samll Office Home Office) users in areas where it is difficult to lay optical fiber cables. It uses the 26-GHz frequency band and has a transmission capacity of 80 Mbit/s. Compared with the previous version (STEP 1), we reduced the wireless terminal cost by employing MMICs and ASICs in the radio frequency and baseband modules, respectively.

Services based on this system will commence this year. In the future, we will add quality-of-service and adaptive modulation functions and develop a wireless repeater.

References

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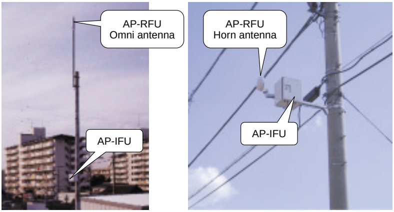
(a) Wireless terminal



(b) Access point

Fig. 8. Equipment installation.

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