Improvements to WIPAS (Wireless IP Access System) for Application-area Expansion

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Abstract

Over the last year, we have developed new functions and improved construction technologies to further expand the application area of NTT's wireless IP access system (WIPAS). This article describes an adaptive modulation scheme, a minimum bandwidth guarantee function, a point-to-point communication system, improved radio zone design system, and better connectors, metal fittings, and waterproofing.

1. WIPAS

The wireless IP (Internet protocol) access system (WIPAS) was developed to provide broadband IP service primarily to SOHO (small office/home office) and mass users at an early stage. It is a point-to-multipoint 26-GHz-band fixed wireless access (FWA) system. **Figure 1** illustrates the services and **Table 1** gives their main specifications [1]. To further expand the application area of WIPAS, we developed the functions and technologies described in sections 2 and 3.

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2. Improved functions

2.1 Adaptive modulation scheme

The adaptive modulation scheme (**Fig. 2**) is automatically switched according to the transmission

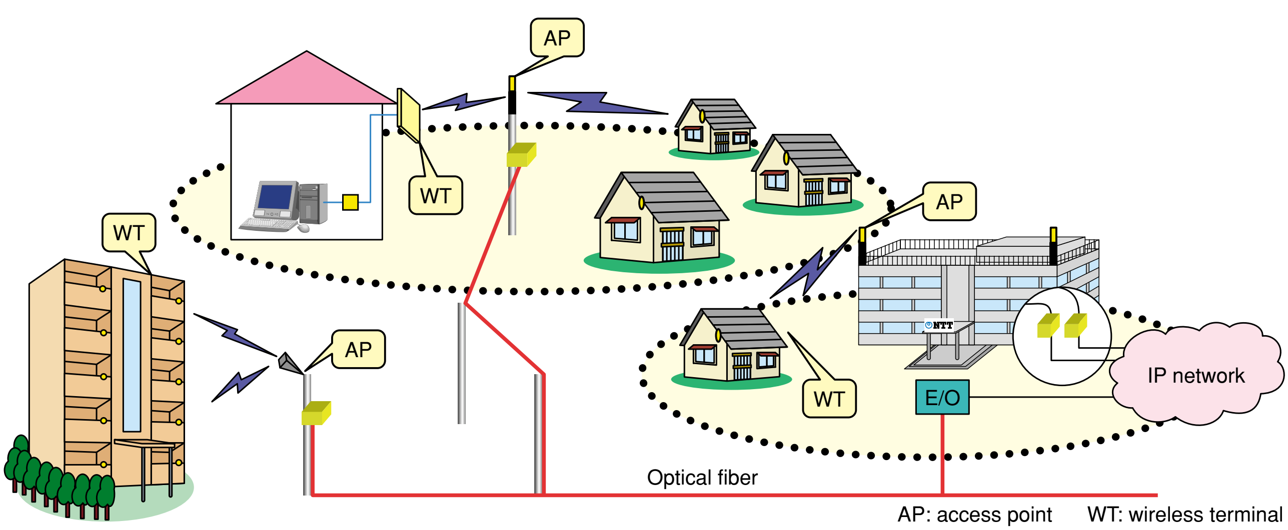

Fig. 1. Service concept.

Table 1. Main specifications.

Frequency band	26-GHz band
Modulation	QPSK,16QAM
Transmission	TDM/TDMA/TDD
Transmission capacity (Ethernet layer)	QPSK: 23 Mbit/s,16QAM: 46 Mbit/s
Number of WTs	Max. of 239 WTs per AP
QoS	Fairness assignment among WTs, Minimum bandwidth guarantee*
Others	Adaptive modulation function* Point-to-point communication function*

*: Recently developed

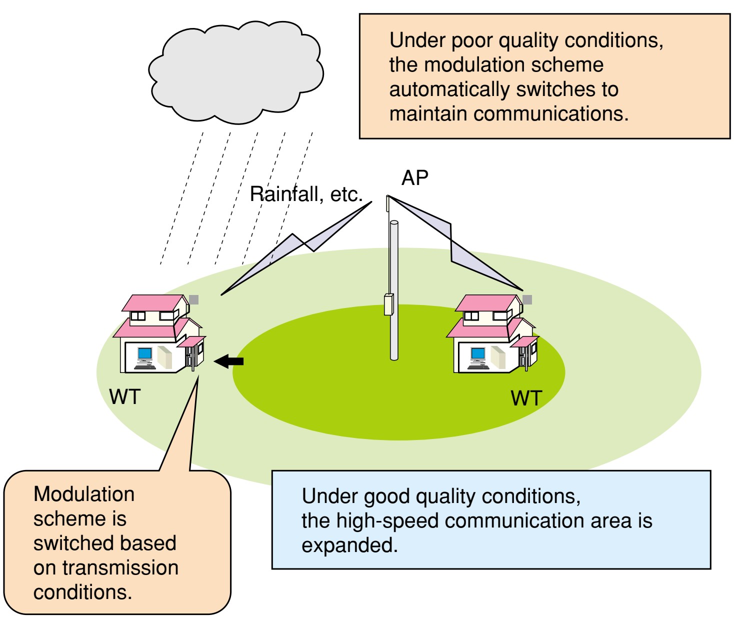

Fig. 2. Adaptive modulation scheme.

conditions of the wireless segment, so high-speed communications can be achieved when the transmission conditions are good. When rain causes deterioration in the transmission conditions, the modulation scheme is changed to the appropriate scheme, so stable communication is achieved. The current version of WIPAS can use two types of fixed setup: 16QAM (quadrature amplitude modulation) and QPSK (quadrature phase shift keying). The transmission distance for 16QAM is approximately 400 m. At this distance the yearly non-operational period due to rain attenuation is stated as being less than two minutes. However, in good weather, the transmission distance is 800 to 900 m, which is equivalent to that of QPSK under rainy conditions. Thus, the new adaptive modulation scheme that automatically switches between 16QAM and QPSK in the wireless segment according to the transmission conditions lets us expand the transmission distance to 800 to 900 m in good weather, while maintaining a peak speed of 46 Mbit/s.

Figure 3 shows the wireless frame format of WIPAS. The payload area of the wireless frame is partitioned based on the modulation scheme, and the wireless terminal (WT), which can communicate using a different modulation scheme, has a construction that allows mixing. The WT periodically measures the quality of the user data in the downward payload (16QAM), and reports the measurement results to the access point (AP). Based on the quality report received from the WT, the AP chooses the modulation scheme. At that time, if the quality degrades, the AP immediately switches to QPSK. If the quality level recovers, the AP switches back to 16QAM after verifying the stability a few times and verifying that there is no instability due to throughput degradation. The chosen modulation scheme reflects the allocation to the QPSK or 16QAM payload area. Since switching is accomplished by changing the area, the modulation scheme is switched without interruption [2].

2.2 Minimum bandwidth guarantee function

The minimum bandwidth guarantee function enables guaranteed-type services by adding a preferred bandwidth assignment function to the current version of WIPAS. It also enables services to be provided to a mixture of best-effort-type general users and guaranteed-type special users.

Table 2 shows the upward and downward payloads, which are independent of each other, for the guaranteed bandwidth set for each WT. **Figure 4** shows an example of bandwidth assignment. The guaranteed

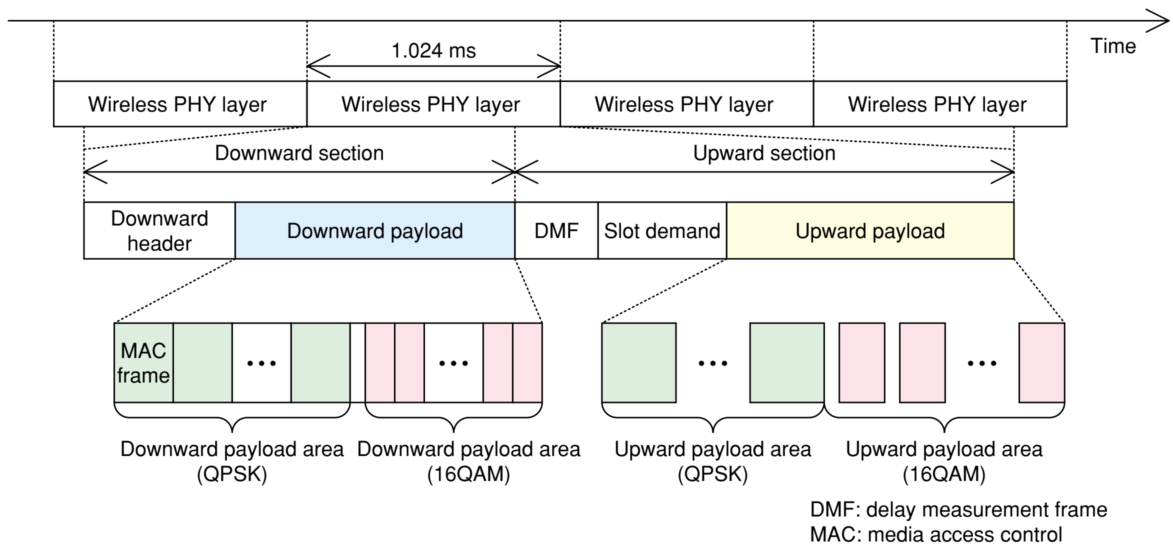

Fig. 3. Wireless frame format.

Table 2. Bandwidth guarantee assignment summary.

Downlink		Uplink	
Setting	Bandwidth guarantee	Setting	Bandwidth guarantee
0	Best effort	0	Best effort
1	1 Mbit/s	1	1 Mbit/s
2	2 Mbit/s	2	2 Mbit/s
3	3 Mbit/s	3	3 Mbit/s
4	4 Mbit/s	4	4 Mbit/s
6	6 Mbit/s	6	6 Mbit/s
8	8 Mbit/s	8	8 Mbit/s
10	10 Mbit/s	10	10 Mbit/s

bandwidth (red) is set so that it does not to exceed the allowed bandwidth; once it has been set, this bandwidth is completely guaranteed. The bandwidth to assign (blue) is calculated when the guaranteed bandwidth (red) is set. The bandwidth guarantee function does not assign the bandwidth in a fixed manner. If the requested bandwidth (yellow) is less than the guaranteed bandwidth (WT3, 4, and 8), then only the requested bandwidth is assigned, leaving some surplus bandwidth that can be reassigned to other WTs. Then, each of the remaining WTs is assigned its guaranteed bandwidth plus a fair share of the surplus. Thus, the bandwidth assignment is carried out in a flexible manner, which avoids wasting the wireless bandwidth.

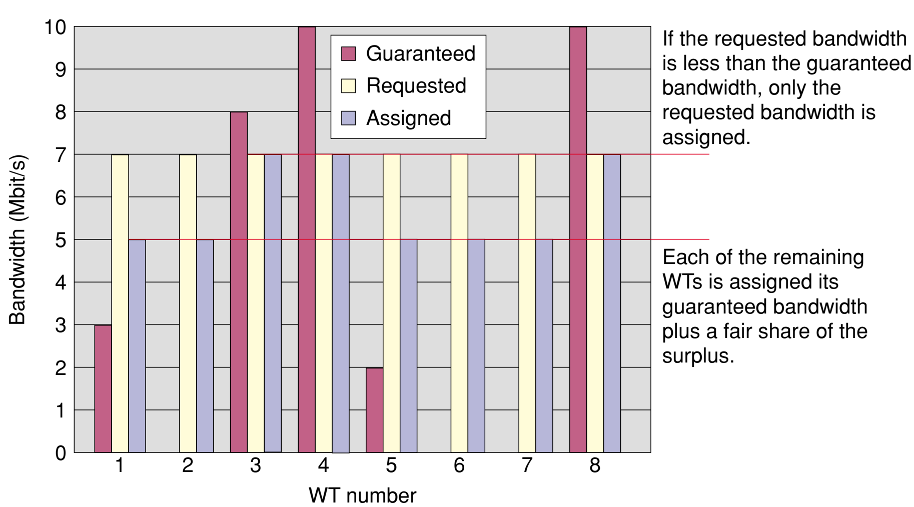

Fig. 4. Bandwidth assignment (example).

2.3 P-P communication system

Figure 5 illustrates the P-P (point-to-point) communications system. Two WTs are paired to achieve P-P communications simply and cost-effectively. This system can be applied to enterprise users and used to expand application areas such as entrance circuits to hotspot services. Furthermore, a maintenance function is implemented in the

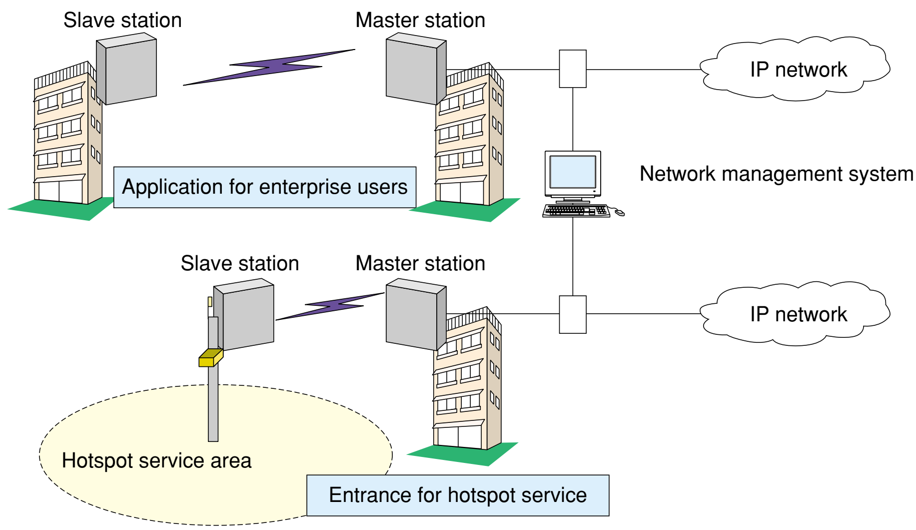

Fig. 5. P-P communication system.

Table 3. Main supervision and control items for P-P communication system.

		Master	Slave
Setting	Ethernet interface setting	○	○
	Time setting	○	—*1
Display	Equipment information (serial number, etc.)	○	○
	Equipment status	○	○
Control	Equipment reset	○	○
	Transmission on/off	○	—*2

*1: Slave station is synchronized to the time of master station.
*2: Slave station interrupts transmission when master station has a transmission interruption.

master station and remote operation of both stations is possible. This system uses the QPSK and 16QAM modulation schemes. The transmission capacities are 16 and 32 Mbit/s, respectively, and the upward and downward sections are allocated in the same fixed bandwidth.

Table 3 lists the main supervision and control items. Remote operation uses SNMP (simple network management protocol) and can perform functions such as setting up the two P-P stations, dealing with transmission interruptions, and performing resets.

2.4 Improved radio zone design system

Since WIPAS uses the 26-GHz frequency band, a guaranteed line of sight (LOS) is necessary between the AP and WT. The design system for establishing an AP station has an application to judge the degree of LOS considering the buildings surrounding the intended installation point. It can calculate the degree of LOS inside the simulation area and generate the AP-WT profile. This system is used to deploy WIPAS to cover a wide area. For this system, we verified that LOS calculation results agreed closely with actual LOS measurements. To achieve greater accuracy, the building and vegetation information used by the system should be improved. Therefore, we developed and implemented a function that easily obtains 3D data such as the shape and height of buildings and vegetation from a photograph taken from a comparatively high location. The photograph and map are displayed on the system's screen, and by plotting several reference points on the map and photograph, this function mutually links data such as positions. Next, by drawing ground features such as buildings and vegetation in the photograph, 3D data can be recognized on the map (**Fig. 6**). The addition of this function improved the reliability of the radio zone design

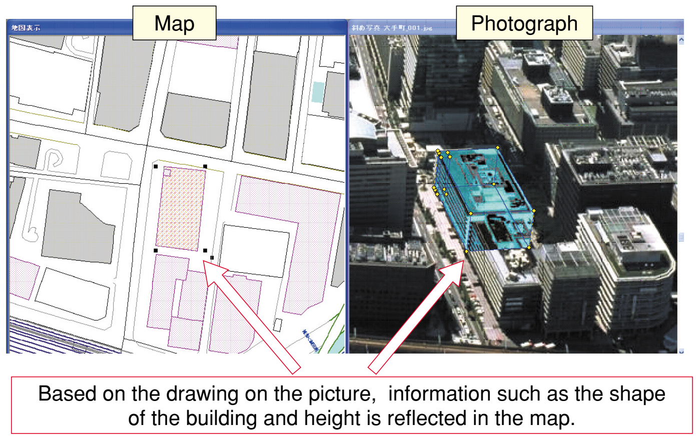

Fig. 6. Linkage of map/picture.

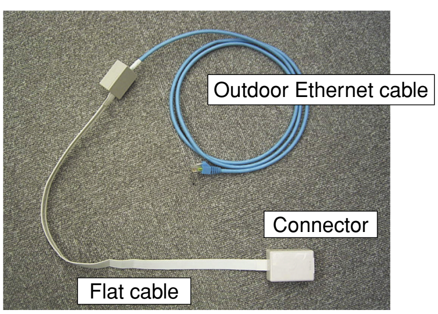

Fig. 7. Unit configuration (prototype).

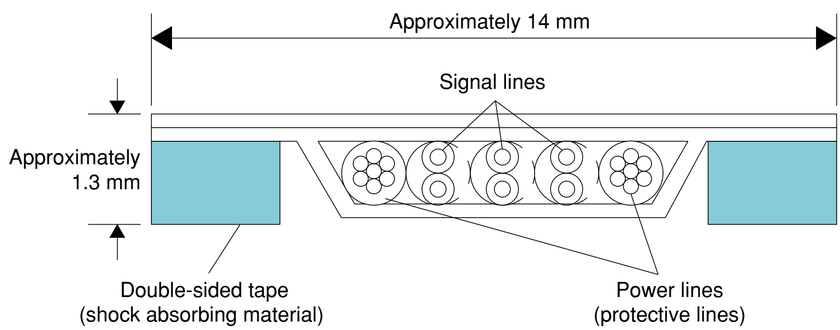

Fig. 8. Construction of flat cable.

results [3].

Furthermore, we improved the usefulness of the system by adding functions that readily search a building, register service conditions, and easily switch among the LOS figures.

3. Improved construction technology

3.1 Simpler connectors

To enable access through apartment windows without air-conditioning conduits, we developed a window-frame-gap traversing unit that has a flat cable section for the window frame. This unit comprises an outdoor Ethernet cable, a flat cable, and a connector to connect to an indoor cable (**Fig. 7**). As shown in **Fig. 8**, the flat cable is as thin as possible to allow it to pass through the gap between the window and the frame and it incorporates protective lines and shock absorbing material to enable it to withstand repeated impacts when the window is opened and closed. Even if the cable core is shorted, the user terminal is protected by a pulse transformer. The flat cable is fixed to the window frame using double-sided tape and reinforcement tape, as shown in **Fig. 9**.

Fig. 9. Example of the fixture of the developed flat cable on the window frame.

3.2 Smaller and lighter metal fittings for installing WTs

In response to requests from construction workers,

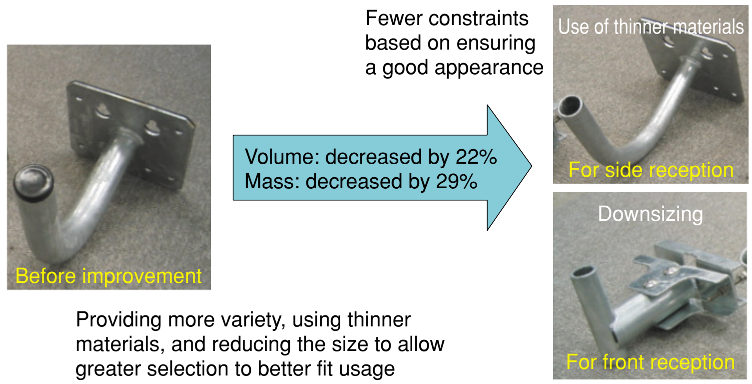

Fig. 10. Downsizing of the metal fittings.

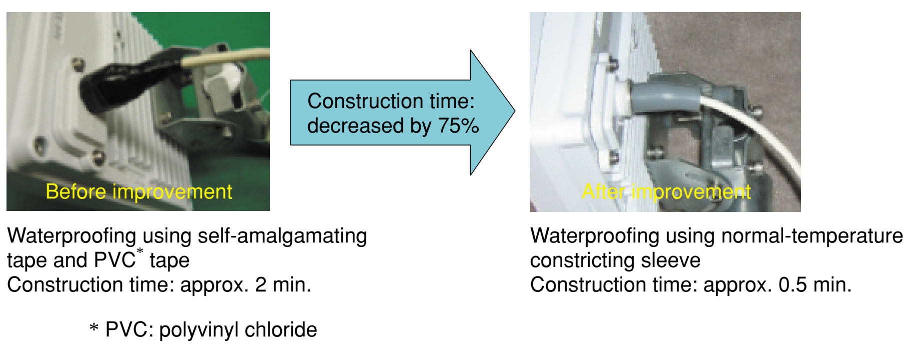

Fig. 11. Improvements in waterproofing.

users, etc., we reduced the size and weight of metal fittings for installing the WT. As shown in **Fig. 10**, the volume and mass of the installation metal fittings were decreased by 22% and 29%, respectively, while making efforts to improve the appearance and working efficiency.

3.3 Better waterproofing for WTs

To improve the waterproofing, we developed a normal-temperature constricting sleeve for the Ethernet cable used in conjunction with the WT. This enabled us to devise a simple waterproofing method. Compared with the current method of wrapping using self-amalgamating tape and PVC (polyvinyl chloride) tape, the new method reduces the work time to 25% while easily ensuring adequate waterproofing and achieving good work reproducibility (**Fig. 11**).

4. Concluding remarks

WIPAS was implemented in “IP data communication network service for specified areas” in July 2003. In December 2003, it was added to NTT’s B-FLET’s service menu. In the future, we plan to expand the service area using these newly developed technologies and investigate additional application areas.

References

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