Development of an Economical Access Point and Peripheral Equipment for an Advanced Wireless Access System

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Abstract

NTT Access Network Service Systems Laboratories have developed an economical access point for the Advanced Wireless Access system. We have also developed a mobile terminal capable of interoperation between equipment from different vendors.

1. Introduction

A broadband wireless access system utilizing the 5-GHz band, called HiSWANa (High Speed Wireless Access Network type a) [1], has been attracting attention as a system that can simultaneously provide two key advantages for a variety of office, home, and public usage scenarios. The first is broadband characteristics suitable for multimedia communications such as real-time video streaming, and the second is terminal mobility, the most important feature of wireless communications. This system provides a data transfer speed of 20 Mbit/s or more, terminal mobility up to walking speed, seamless connections between private and public areas, flexible band assignment according to service type, and security functions including authentication and privacy.

NTT Access Network Service Systems Laboratories have developed an Advanced Wireless Access (AWA) system based on the HiSWANa standard. This system was placed on the market in March 2002 [2]. More recently, we have developed an economical access point (AP) to achieve a more compact and lower-cost AWA system and have also developed a mobile terminal (MT) capable of interoperation between equipment from different vendors. This article introduces the technical features of this AWA system.

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2. Development concept and equipment overview

To make the equipment compact and inexpensive, the circuit scale must be reduced, key functions must be integrated using LSI circuitry, and equipment and enclosure structures must be optimized taking into account heat radiation and other factors. Therefore, we took the following measures.

Reduction of transmission/reception circuit scale

Initially, we achieved transmission/reception diversity by equipping the AP with two antennas and two transmitter-receiver units [3]. The purpose of incorporating this function was to cope with abrupt variations in received signal power caused by shadowing and fading as well as to simplify the MT circuit configuration. However, transmission/reception diversity for controlling every subcarrier in an orthogonal frequency division multiplexing (OFDM) signal requires considerable signal processing plus additional circuitry, which can have a significant effect on cost. For this reason, we subsequently chose a selective-diversity scheme featuring only one transmitter-receiver unit with switching performed between the two antennas every MAC (media access control) frame. This approach significantly reduced the circuit scale (Technical aspects are described below).

FPGA circuit reduction

Initially, we used a field programmable gate array (FPGA) to test the processing of functions on the data-link and network layers. It forms logical circuits by software, so it is expensive compared with an LSI device. To reduce the scale of this FPGA, we therefore implemented most of those functions in LSIs except for a few such as packet processing (segmentation and reassembly: SAR).

Power supply section

In general, most base station equipment in mobile communication systems uses built-in power supplies allowing installation in various types of environments such as on poles, walls, and ceilings. This means, however, that different power-supply voltages must be used inside the same equipment to handle radio-frequency circuits, signal-processing circuits, *etc*. This, in turn, requires countermeasures against the effects of electromagnetic induction and heat radiation, which increase equipment size. To deal with this problem, we decided to separate the AP's power-supply section into an AC/DC section and a DC/DC section and to separate the AC/DC section from the main unit as is usually done in portable terminals like notebook computers. Furthermore, to support a range of power-supply voltages (AC100-240V), we designed the AC/DC section so that commercial products can be utilized.

Enclosure section

Initially, despite the fact that the system was intended only for indoor use, we used a highly airtight structure to avoid the harmful effects of moisture and dust particles. We consequently used a method for recirculating air inside the equipment to remove heat emitted from the power-supply section and other components. Unfortunately, this increased the equipment volume. For the current enclosure, therefore, we replaced the airtight structure by one designed to radiate heat and introduced slits in the bottom and back panels.

Figure 1 shows external views of the AP and MT used in our current AWA system. Compared with the initial design, we reduced the equipment volume by 30% (from 2800 to 1800 cc) and cost by about 60%.

3. Main specifications

Table 1 summarizes the main specifications of the AWA system. The basic specifications are compliant

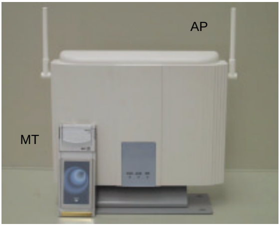

Fig. 1. AP and MT of this AWA system.

Table 1. Main specifications.

Frequency	5.15–5.25 GHz
Modulation method	Coded OFDM (52 subcarriers, 64-point FFT)
Error correction	Convolution coding, Viterbi decoding
Transmission power	10 mW/MHz EIRP or less
Transmission modes	BPSK r=1/2 (6 Mbit/s), BPSK r=3/4 (9 Mbit/s), QPSK r=1/2 (12 Mbit/s), QPSK r=3/4 (18 Mbit/s), 16QAM r=9/16 (27 Mbit/s), 16QAM r=3/4 (36 Mbit/s)
Link adaptation	6–36 Mbit/s (transmission mode switching threshold PER = 10^{-2})
QoS classes	Class 1: GBR with ARQ (min. bandwidth guarantee) Class 2: CBR with ARQ (bandwidth guarantee) Class 3: CBR without ARQ (low-delay guarantee)
Area radius	About 100 m
Simultaneously connected MTs	50 per AP
MAC control	TDMA-TDD, DSA (Dynamic Slot Assignment)
Interfaces	AP: 10BASE-T/100BASE-TX MT: PCMCIA (32-bit Card-Bus)
Security	DES (56 bit)
Authentication modes	AP and NW authentication
Supported OS	Windows 98SE/Me/2000/XP

with the HiSWANa standard. Among these specifications, the number of MTs that can be simultaneously connected to one AP is 50 taking into account the cost of AP's internal memory and CPU, for example. Three quality of service (QoS) classes can be provided for AP-MT connections. Class 1 is a guaranteed bit rate (GBR) service to ensure a minimum bandwidth assignment for each MT while keeping best-effort type communication. Classes 2 and 3 provide a constant bit rate (CBR) service based on user declaration. Class 3, in particular, makes no attempt to retransmit packets by ARQ (automatic repeat request) even when data errors occur on the radio link in order to minimize the data transmission delay. The user can specify which of these QoS classes to use from a personal computer connected to the MT.

4. Transmission/reception diversity technology

In general, when one reduces the size and cost of equipment, the system performance deteriorates in conjunction with reduced functions. In the current design, we minimized this deterioration using new transmission/reception diversity technology [4].

Requirements

The aim of the AWA system is to provide seamless services without having to specify the usage environment, whether it is a public service at a train station, airport, hotel, *etc*., a wireless LAN in an office, or simply home use. Public and office use both need high-performance scheduling and diversity functions in the AP to efficiently accommodate many users. On the other hand, for home or SOHO (Small Office Home Office) use, the usage area is small, so the hardware configuration should be simple to make the system as small and inexpensive as possible.

In a wireless environment on the home and SOHO scale, we expect the Doppler frequency to be low and deterioration in packet error rate (PER) characteristics due to the effects of shadowing and fading to continue across several MAC frames. Although random packet errors on the radio link can be compensated for by ARQ, resending packets during a burst of packet errors will minimize any improvement in PER characteristics. As a result, from the user's viewpoint, service characteristics will depend on PER characteristics after a limited number of attempts to retransmit packets. This calls for an effective ARQ function together with a simple configuration to make an economical AP.

Cyclic-antenna-switching diversity

In response to the above technical issues, we developed selective diversity technology that sends and receives radio signals by periodic switching of antennas. This diversity technology features multiple antennas for one transmitter/receiver unit and periodic switching among these antennas every MAC frame. It can compensate for burst packet errors that occur in home and SOHO scenarios characterized by a low Doppler frequency and a relatively smoothly changing signal-propagation environment. In other words, by randomizing the burst errors that occur on the radio link by means of the diversity function and compensating for random errors by ARQ, we can reduce the correlation between MAC frames associated with packet errors at the time of retransmission. As a result, the degradation of system performance that accompanies circuit simplification can be minimized.

Figure 2 shows computer simulation results (16QAM, r=3/4). Since 20-dB-SW-div case shows better characteristics than 20-dB-without-div case and almost coincides with the 23-dB-without-div case, it can be said that our cyclic-antenna-switching type of selective diversity achieved a diversity gain of about 3 dB.

5. Development of a mobile terminal for interoperability

To promote the spread of the AWA system, it is important that interoperability specifications are

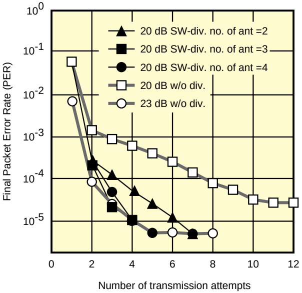

Fig. 2. Effect of cyclic-antenna-switching diversity (SW-div).

Fig. 3. MT capable of interoperability (45cc~).

established so that equipment developed by different companies can be mutually connected. Thus, in addition to improving AP economy, we have also drawn up interoperability specifications and developed an MT that can be connected with our economical AP. Figure 3 shows an external view of this MT.

References

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