FOMA (R) /Wireless LAN Dual Terminals, Wireless LAN Technology

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Abstract

FOMA (R) /wireless LAN dual terminals are dual-phone terminals that support both the 3G mobile phone and IP phone capabilities that use wireless LAN as the IP phone interface. This paper is intended to introduce the issues involved in the incorporation of wireless LAN in a mobile terminal as well as the main component technologies necessary for securing an IP phone service of satisfactory transmission quality. It will also discuss future perspectives such as the seamless service and broadband initiatives.

Keywords

wireless LAN, IP phone, VoIP, QoS, handover, security, seamless

1. Introduction

Up till now, mobile terminals have been fabricated with the aim of benefiting from services by connection to a network provided by a telecommunications carrier. However, as the needs for using various services at low cost on existing open IP networks have recently been increasing, we decided to incorporate wireless LAN into the mobile terminals. Wireless LAN is an advanced communication system with a high transmission speed and a high affinity to IP networks and in support of this strategy we proceeded to advance our R&D to improve the IP phone functions and the services based on the SIP protocol.

Our R&D has already made it possible for us to develop several FOMA/wireless LAN dual terminals (FOMA N900iL/N902iL) equipped with 3G mobile phone and IP phone capabilities, N900iL, which is an IEEE802.11b compliant model released in November 2004 and N902iL, an IEEE802.11b/g compliant model released in February 2007.

Fig. 1 shows the settings in which the FOMA/wireless LAN dual terminals can be used. A single terminal may be used as an intercom phone using IP phone functions in the office and as a FOMA mobile phone outside the office. These terminals provide full browsing capabilities as do the services using the IP network. Due to recent trends such as the dissemination of household wireless LAN routers, an increase in the number of hot spots in which wireless LAN is available and the plan to make wireless LAN access services available in the *Shinkansen* bullet trains, it is expected that the settings in which wireless LAN is used will expand more and more in households,urban environments and in moving trains.

Fig. 1 Settings in which the FOMA/wireless LAN dual terminal is used.

At the time the FOMA/wireless LAN dual terminal was initially developed, wireless LAN had already been disseminated but there had been almost no example of its being embedded in equipment, such as in the mobile phone. We therefore had to prepare various improvements and studies in order to effectively package the wireless LAN function. In section 2 below, we will introduce these improvements by focusing on the key technologies.

2. The Wireless LAN Key Technologies

The following sections discuss the main issues in embedding

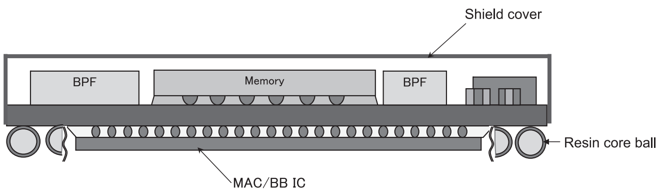

Fig. 2 Model diagram of cross-section of wireless LAN module.

wireless LAN in the mobile terminal, such as the packaging area, power consumption and the key technologies for achieving the requisite quality for VoIP (Voice over IP) communications.

2.1 Packaging Technology

Since the size of the mobile phone terminal is one of the key factors determining its marketability, it has been necessary for us to maintain an equivalent size to the previous terminals even after the wireless LAN function is incorporated. The studies that we conducted for this purpose included the size reduction of the wireless LAN module, review of the motherboard packaging layout and review of the interface between the wireless LAN module and the host CPU (hereinafter referred to simply as the CPU).

As an example of the module size reduction, **Fig. 2** shows the model diagram of a cross-section of the wireless LAN module used with the N902iL. By mounting the components on both the top and bottom sides of the module board, a size reduction to 10.5mm × 10.5mm × 1.8mm (thickness) has been achieved. This module is also equipped with a filter for preventing mutual interference between the mobile phone and the wireless LAN and a diversity circuit for stabilizing the reception performance. Although these measures increase the number of components and are disadvantageous from the point of view of size, we have decided to adopt them in order to improve the quality of the IP phone.

To decrease the wiring space on the motherboard and increase the freedom of packaging, we adopted the serial interfaces (SPI, SDIO) for interfacing between the wireless LAN devices and the CPU in place of the previously popular parallel interfaces. In addition, we also reviewed the motherboard layout in order to increase the packaging density.

We believe that a future major issue will be how to decrease component heights in order to meet the expected increased need to decrease the terminal thickness.

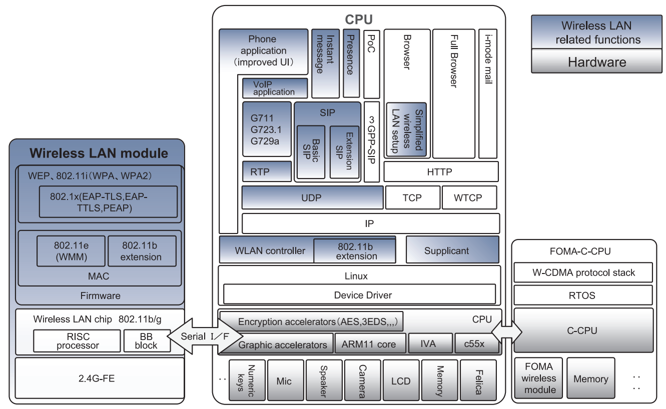

Fig. 3 Software and hardware configurations.

2.2 Power Saving Technology

Since wireless LAN uses the CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) as its access method, its power consumption is determined mostly by the time taken for the reception operation. Therefore, we have selected the wireless LAN devices by placing importance on low reception power and low power consumption during dozing status in the power-saving mode. The dozing power consumption is a particularly important factor, so we switched the operation clock to a lower speed in order to reduce the power consumption to the level of a few hundreds of microwatts.

Fig. 3 shows the function allotments between the wireless LAN module and the CPU. The control of the wireless LAN is allotted between the wireless LAN module and the software in the CPU. In order to reduce power consumption, the CPU and wireless LAN module are controlled so that they transit to the power-saving mode asynchronously. For example, the wireless LAN module transits to the waking status periodically at the timing of the beacon in order to secure synchronization with the AP (Access Point) but the CPU is controlled to maintain the sleeping status when the wireless LAN does not communicate data and no other task is necessary. The mounted software also takes into consideration the switching of the optimum wake transition interval (Listening interval) according to the operation mode (standby, talk) and the functions that the AP supports.

Fig. 4 shows examples of three operation modes. Fig. 4(a) is the operation in standby mode, in which power consumption is reduced by extending the waking interval to the interval of DTIM (Delivery Traffic Indication Message) and the beacon receptions are interlaced. Fig. 4(b) is the operation in

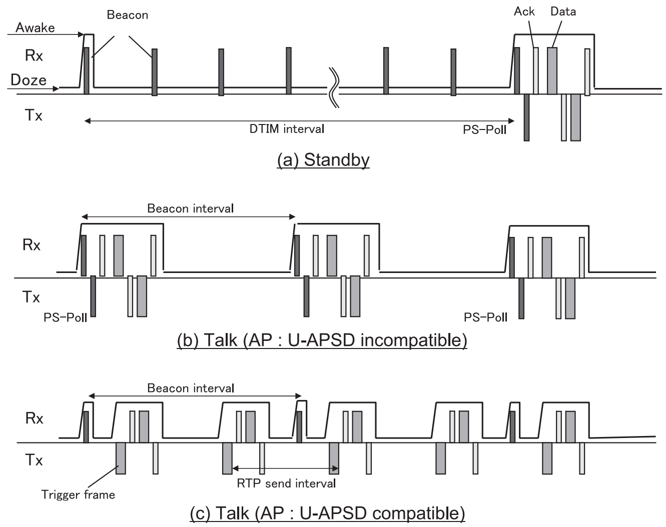

Fig. 4 Examples of power-save controls.

talk mode, in which the waking status is switched at the interval of the beacon to prevent the audio delay and data is exchanged using the PS-POLL (Power Save POLL) packets. Also power consumption can be reduced during talk mode by transiting the module to the dozing status in case no data is exchanged. Fig. 4(c) is also an operation in talk mode, but it differs from the operation in Fig. 4(b) in that it shows the case in which the AP is U-APSD (Unscheduled Automatic Power-Save Delivery) compatible. U-APSD enables data exchange at the RTP interval asynchronously with the beacon, so it is more advantageous for the quality of communication than the operation in Fig. 4(b). In addition, it does not need the PS-POLL packets for data reception so it is also advantageous in terms of power consumption compared to the operation in Fig. 4(b).

Furthermore, to save power in the out-of-service area, the interval of AP search is gradually increased with time elapse.

The measures described above allow the N902iL to achieve the performance shown in **Table 1** .

2.3 QoS

The QoS control is essential for securing the requisite quality for IP phone communications. The QoS controls for wireless LAN include the priority control and the bandwidth control.

Fig. 5 shows the principles of the priority control. In this figure, the waiting time from completion of transmission from a nearby terminal until transmission becomes ready (AIFS + CW) decreases as the priority increases, so that packets with

Table 1 Performance of N902iL.

Talk time	FOMA	Approx. 160 min.
	WLAN	Approx. 250 min.
Standby time	FOMA single	Approx. 500 hr.
	WLAN single	Approx. 400 hr.
	DUAL (FOMA/WLAN)	Approx. 270 hr.

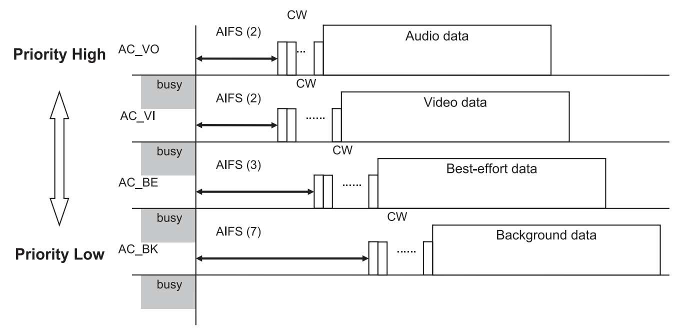

Fig. 5 Priority control.

high priority can be transmitted as a priority over other packets. The VoIP packets are assigned the highest priority to minimize delays in transmission. In the case of the bandwidth control, the process is performed using an action frame that is specified as an option in WMM (Wi-Fi Multimedia). With this method, the terminal can request the required band to the AP using the action frame and when this is permitted, can hold stable communication using that bandwidth.

2.4 Handover

A smooth handover for the prevention of momentary interruption is also important for the requisite quality of VoIP communications. The software mounting method that we have adopted for securing smooth handover searches the candidate AP according to the radio wave strength in advance and also sends voice packets, even during the candidate AP search in order to prevent momentary voice interruptions.

In addition, the terminal also supports a function for caching the authentication key when the WPA2 (Wi-Fi Protected Access 2) security system is used. This makes it possible to omit authentication in handover to a previously used AP and therefore reduce the handover time.

Table 2 Security system of N902iL.

Security	Encryption method	Authentication method
802.1x authentication	WEP	EAP-TLS EAP-TTLS(PAP, CHAP) PEAP(MS-CHAPv2, EAP-GTC)
WPA	CCMP(AES),TKIP*	EAP-TLS EAP-TTLS(PAP, CHAP) PEAP(MS-CHAPv2, EAP-GTC) WPA-PSK
WPA2	CCMP(AES),TKIP*	EAP-TLS EAP-TTLS(PAP, CHAP) PEAP(MS-CHAPv2, EAP-GTC) WPA2-PSK

*1: CCMP>TKIP priority is adopted when AP presents multiple options.

2.5 Security

Early wireless LAN systems had a security problem due to the weakness of the WEP (Wired Equivalent Privacy) used in encryption but this issue was solved by standardization of IEEE802.11i. The M902iL is packaged with a security system compliant to WPA/WPA2, which has been established based on IEEE802.11i by WFA (Wi-Fi Alliance). **Table 2** shows the supported security systems. In addition, WPS (Wi-Fi Protected Setup,) which has recently been standardized as a system enabling the automatic setting of the most powerful security system is also packaged.

2.6 CWG–RF (Converged Wireless Group RF)

The mutual suppression characteristic during simultaneous use of FOMA and wireless LAN is an important factor with the FOMA/wireless LAN dual terminal. We took account of the need to minimize this and succeeded in obtaining the first certification globally of the CWG-RF testing by Wi-Fi and CTIA (Cellular Telecommunications & Internet Association).

3. Future Perspectives

The FOMA/wireless LAN dual terminal has enabled the parallel use of mobile phones and IP networks. The user should for the present be conscious of the network he or she uses, but in the future it will be desirable that the optimum communication channel is selected automatically from the perspectives of quality and cost so that the user may benefit from the services seamlessly and without being aware of the network being used.

One of the R&D projects that we are conducting for implementing seamless services is that of VCC (Voice Call Continuity), which is being standardized at 3GPP and is being researched mainly by the NEC Central Laboratories (System Platforms Research Lab, NEC Laboratories Europe). VCC is the technology for seamless handover between a 3G voice call based on circuit switching and VoIP via wireless LAN, etc. The results of the study were demonstrated at 2007 3GSM World Congress. As another advance, we are also preparing to make the SIP protocol compatible with the NGN (Next Generation Network,) which is to be implemented in the future.

The FOMA/wireless LAN dual terminal has been used mainly in corporate extension intercom systems but we are planning to expand the scenarios of its use to households, etc. based on the technologies that we have introduced up to the present.

A typical scenario for household use would be the reception of movie streaming by accessing the Internet.

As it is expected that the need for the stress-free utilization of rich multimedia contents will grow further, we are also planning to advance studies for broadening the wireless LAN bandwidth (IEEE802.11a, 11n) and improving the processing capabilities of CPUs, etc.

4. Conclusion

In the above, we introduced our current efforts related to the key element technologies for wireless LAN in the FOMA/wireless LAN dual terminal. In the future, we will improve these technologies further at the same time as developing relevant seamless and broadband technologies in advance. This strategy will be aimed at the development of mobile phone terminals that allow everyone to enjoy rich and seamless multimedia services anytime and anywhere.

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