WLAN QoS Power Save

Technology Reports

N902iL: FOMA/Wireless LAN Dual Terminal

NTT DoCoMo provides the FOMA N900iL as a FOMA/wireless LAN dual terminal for use with its PASSAGE DUPLE, and as its successor has developed the FOMA N902iL. This article describes the ease of operation of this new mobile terminal achieved as part of the expansion of existing functions and adding new wireless LAN functions to save power and ensure more efficient use of the wireless band.

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1. Introduction

Companies introducing the PASSAGE DUPLE, NTT DoCoMo's IP phone system, have increased following the release of the N900iL, and users are now demanding improvements to simplify the setting of complex wireless LAN parameters and the use of internal calls, as well as better key response.

The N902iL, FOMA/wireless LAN dual terminal (hereinafter referred to as the "N902iL") has been developed to further enhance its usability in response to these demands for improved functionality, and incorporates many improvements in using wireless LANs on a mobile terminal. These improvements are as follows.

- Compatibility with the 802.11g[*1] standard [1] of IEEE (Institute of Electrical and Electronics Engineers)
- Packet priority control in a mixed data/voice communications environment
- Increased call time (power-saving function)
- Band limit control for high voice quality
- Reduced voice communication handover time
- Simplified wireless LAN setup by the user

The N902iL was developed to ensure compatibility with the IEEE 802.11b[*2] standard [2] adopted by the N900iL, and for use in a mixed N902iL/N900iL environment, as well as a mixed IEEE 802.11b/g environment.

This article describes the new wireless LAN functions provided in the N902iL for improved efficiency in use of the wireless band, and power savings, and the new functions provided for easier use.

2. Overview of the N902iL and Network Services

2.1 Basic Specifications

Photo 1 shows the N902iL and **Table 1** shows its basic specifications. In order to improve processing speed and development efficiency, the hardware of the N902iL is based on the N902i and its software is based on the N902iS for greater speed in switching screen displays. Moreover, improvements made in phone book search and the layers of wireless LAN profile setup to ensure usability that is equivalent to or greater than that of the N900iL. In terms of wireless LAN functions, communication speed has been improved by adopting the IEEE 802.11g standard. Compatibility with Wi-Fi MultiMedia (WMM)[*3] has improved call quality and increased the maximum number of simultaneous calls possible, and powerful

Photo 1 N902iL

*1 **IEEE 802.11g**: A wireless standard defined by IEEE. Adopts the same 2.4-GHz frequency band as 802.11b (see *2) and supports a transfer rate of 54 Mbit/s. Differs from the 54 Mbit/s transfer rate of 802.11a, and is backward compatible with 802.11b.

*2 **IEEE 802.11b**: A wireless standard defined by IEEE. Adopts the 2.4-GHz frequency band and supports a transfer rate of 11 Mbit/s. Forward compatible with 802.11g (with the same 54 Mbit/s transfer rate).

*3 **WMM**: A standard specifying data priority processing and power-saving functions for Wireless Fidelity (Wi-Fi) to guarantee inter-connection between 802.11a/b/g products.

Table 1 Basic specifications of the N902iL

	N902iL	N900iL (reference)
Wireless frequency band	(FOMA) 2 GHz/800 MHz (Wireless LAN) 2.4 GHz	(FOMA) 2 GHz (Wireless LAN) 2.4 GHz
Size	106 × 51 × 25 mm	102 × 48 × 27 mm
Mass	123 g (approx.)	120 g (approx.)
Continuous call time	160 min. (approx.) –Voice 100 min. (approx.) –TV phone 250 min. (approx.) –VoIP*1	140 min. (approx.) –Voice 90 min. (approx.) –TV phone 160 min. (approx.) –VoIP*1
Continuous standby time	500 hours (approx.) –FOMA (static) 380 hours (approx.) –FOMA (moving) 400 hours (approx.) –VoIP*1 270 hours (approx.) –DUAL*1	350 hours (approx.) –FOMA (static) 270 hours (approx.) –FOMA (moving) 230 hours (approx.) –VoIP*1 150 hours (approx.) –DUAL*1
LCD	Main LCD - 2.5", 240 × 345 dots Rear screen LCD - 0.9", 120 × 30 dots	Main LCD - 2.2", 240 × 320 dots Rear screen LCD - 0.9", 120 × 30 dots
Main camera	1,250,000 pixels νMaicovicon®	1,000,000 pixels Super CCD Honeycomb
Wireless LAN system	IEEE 802.11b/g compatible	IEEE 802.11b compatible
Wireless LAN transmission speed	Maximum of 54 Mbit/s	Maximum of 11 Mbit/s

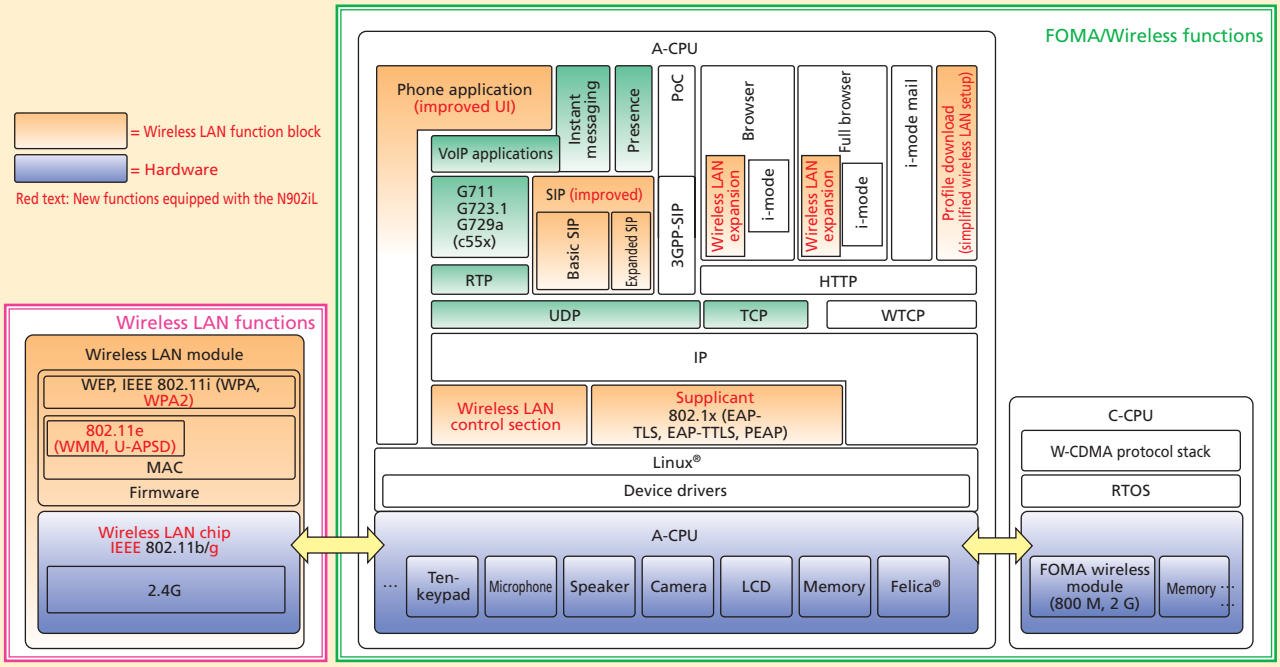
*1 Continuous call time and continuous standby time differ depending on wireless LAN conditions, as well as the N902iL and access point settings, etc.
ν Maicovicon®: A registered trademark of Matsushita Electric Industrial Co., Ltd.

communications encryption is implemented by adopting the IEEE 802.11i[*4] standard [3].

IEEE 802.11g area can be used in conjunction with IEEE 802.11b area, so a considerable capacity to establish areas for general-purpose use can be ensured. **Figure 1** shows the function blocks of the terminal. The expansion of functions of each module as shown in the diagram has improved the efficiency of developing new functions, which are shown in red.

2.2 Compatibility with Network Services

In addition to the PASSAGE DUPLE permitting use of FOMA/wireless LAN



3GPP-SIP: 3rd Generation Partnership Project-SIP
A-CPU: Application CPU
C-CPU: Communication CPU
EAP-TLS: Extensible Authentication Protocol-Transport Layer Security
EAP-TTLS: EAP-Tunneled TLS
MAC: Media Access Control
PEAP: Protected EAP
PoC: Push to talk over Cellular
RTOS: Real Time Operation System
RTP: Real-time Transport Protocol
UDP: User Datagram Protocol
UI: User Interface
WEP: Wired Equivalent Privacy
WTCP: Wireless TCP
Felica®: A registered trademark of Sony Corp.
Linux®: A registered trademark and trademark of Linus Torvalds in Japan and other countries.

Figure 1 Function blocks of the N902iL

*4 **IEEE 802.11i**: A security standard for wireless LANs defined by IEEE.

dual terminals, NTT DoCoMo developed the Business mopera IP Centrex service last year as an corporate IP phone solution, with which the N902iL is also compatible. **Figure 2** shows the system configuration using the N902iL, and examples of use. With the PASSAGE DUPLE, the company uses its Session Initiation Protocol (SIP)[*5] server IP-Private Branch eXchange (IP-PBX), and with the Business mopera IP Centrex service, NTT DoCoMo manages the SIP server (IP-PBX) in order to seamlessly use IP phones inside the company and FOMA outside. The N902iL enables a simple wireless LAN setup via the download profile using i-mode, even for such a complex system configuration as shown in the figure.

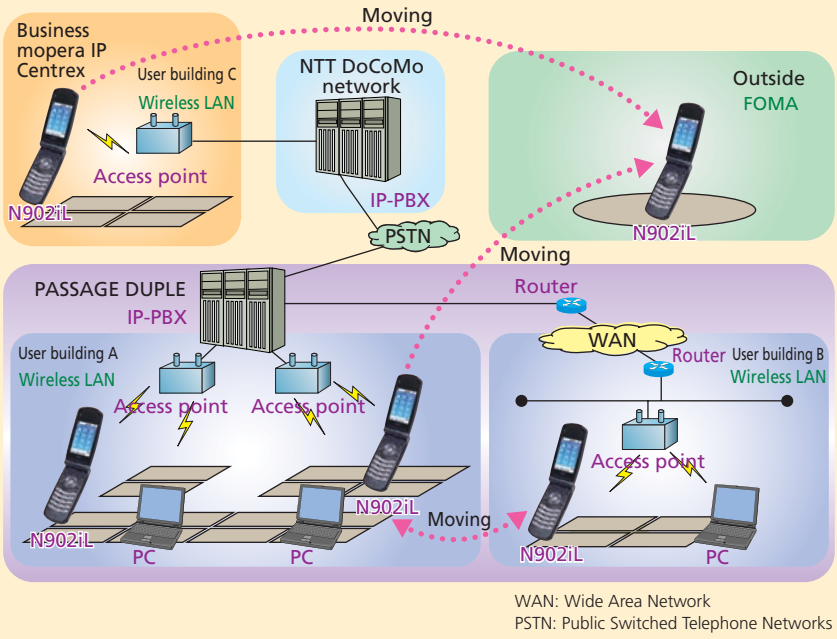


Figure 2 System configuration using the N902iL and usage examples

The phone book data storage service provided with the NTT DoCoMo network service has also been expanded, allowing SIP addresses in the phone book and URLs for the wireless LAN browser on the user mobile terminal to be backed up at the storage center.

3. Wireless LAN Function Details

The N902iL supports the following functions:

3.1 QoS Function

Experience has shown that a mixed environment of Voice over IP (VoIP)[*6] calls and data communications on a wireless LAN results in deteriorated call quality.

When data communications packets and VoIP call packets are mixed, the conventional packet transmission procedure specified under IEEE 802.11[*7] [4] provides equal transmission priority for both types of packets. Consequently, an opportunity to transmit VoIP packets may not be obtained, resulting in delays and packet loss. The N902iL incorporates a Quality of Service (QoS) function compatible with a more sophisticated WMM linked to access points in order to resolve this issue and ensure stable voice quality. **Figure 3** shows the QoS control in WMM.

1) Priority Setup

Priority is set for each data type of transmitted packet (by access category). The priority setup for the N902iL regarding sent packets (sent from the mobile terminal) sets voice and call control packets as the highest-priority voice data, with other packets set as best-effort data (Fig. 3 (a)).

2) Transmission Opportunity

Packets from the local terminal are sent beginning with those having higher priority (voice packets have more transmission opportunities) according to the setup for transmission opportunities from the N902iL and each access point, and held at each access point (Fig. 3 (b)).

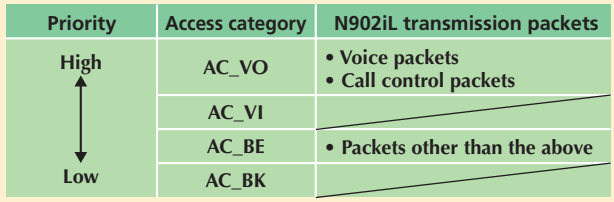
3) Transmission Timing

Contention Window (CW) size is set for each priority and packets with higher priority are sent first. Since the CW size provides a random aspect to transmission opportunities for each packet, the smaller the value, the easier transmission opportunities are acquired. In other words, the higher the priority, the smaller the value used (so that voice packets are sent before the data packets sent from devices such as PCs) (Fig. 3 (c)).

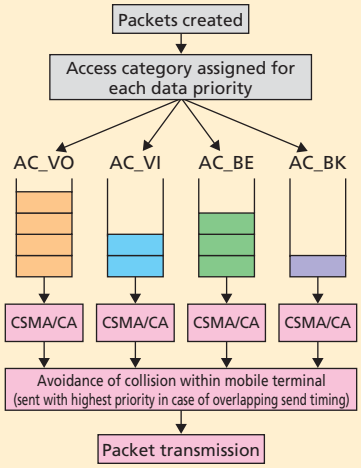
*5 **SIP**: A call control protocol defined by the Internet Engineering Task Force (IETF) for IP telephony, etc.

*6 **VoIP**: A technology for converting voice into packets and real-time transmission on an IP network using normal circuit switching.

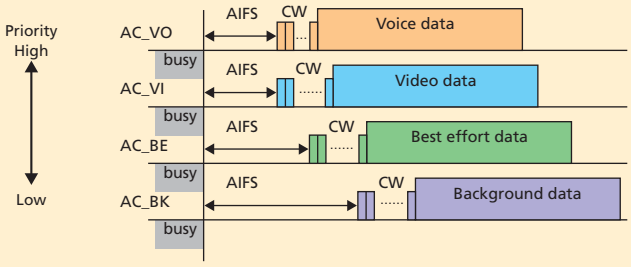
*7 **IEEE 802.11**: A wireless standard specified by IEEE. An international standard specifying the communications, wireless modulation, and power-saving methods forming the basis of wireless LAN communications.



(a) Priority setting



(b) Transmission opportunity



(c) Transmission timing

AC_VO: For voice
AC_VI: For video data
AC_BE: For best effort data
AC_BK: For background data
AIFS (Arbitration Inter Frame Space) : Frame transmission interval
CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) :
Control for transmission timing adjustment to avoid packet collision on a wireless network

Figure 3 QoS control

Unlike the case of sent packets, the access point evaluates the priority of received packets (received at the mobile terminal) and sets the transmission priority. That is, the access point sets priority in accordance with the Type of Service (ToS)[*8] value of the IP header received from the network, or the type of protocol.

The implementation of this function permits the transmission and reception of VoIP packets over a wireless section with greater priority than data packets, and provides high-quality calls in a mixed environment including data communications.

3.2 Power-saving Function

The power-saving function resolves the key issue of power consumption in mobile terminals with wireless LAN. This function reduces power consumption by placing the mobile terminal into sleep status when data is not being transmitted or received.

The N902iL adopts the Unscheduled-Automatic Power Save Delivery (U-APSD) power-saving function standardized in recent years under IEEE 802.11e[*9] [5]. U-APSD provides a superior power-saving function to minimize power consumption while maintaining communications quality.

Figure 4 shows the operation of the power-saving function. With conventional power-saving functions, the access point sends a beacon[*10] to report the presence or absence of data received from the mobile terminal, and then the data is transmitted and received accordingly. Therefore, the transmission and reception of data are concentrated immediately after the beacon, and when multiple mobile terminals communicate simultaneously, packets collide, often resulting in delays in VoIP communications. With the U-APSD function, data is received in conjunction with signals transmitted from the mobile terminal at any desired timing. This disperses the transmission timing, avoids the collision of packets, improves the efficiency of using the wireless band, and eliminates delays in VoIP communications. More-

*8 **ToS**: A field included in the header of an IP packet. Specifies the packet priority for QoS control.

*9 **IEEE 802.11e**: A standard for expansion of QoS security technology in wireless LANs defined by IEEE.

over, AWAKE time[*11] for the mobile terminal may be reduced to enable longer continuous call time. This dramatic effect is due to the fact that many more terminals are now associated with access points.

3.3 CAC Function

The Call Admission Control (CAC) function limits the number of mobile terminals able to make calls using a single access point. In communication using a wireless LAN, the higher the number of mobile terminals communicating simultaneously, the greater the wireless band congestion, resulting in transmission delays and packet losses. In VoIP communication, these delays and packet losses result in a considerable deterioration in voice quality. The N902iL supports the CAC function based on Traffic SPECification (TSPEC)[*12] to avoid this congestion and ensure high voice quality.

Figure 5 shows an overview of sending sequence using TSPEC. The mobile terminal sends an ADD TSpec (ADDTS) Request[*13] before transmission to request the access point for the wireless band needed to make the call. The access point sends an ADDTS Response[*14] indicating whether the wireless band may be used. Transmission for the mobile terminal is only possible when the access point issues permission for the call. Once the call is completed, the wireless band used is released upon the transmission of DELete TSpec (DELTS). If the wireless band cannot be used when requested due to congestion or other reasons, transmission by

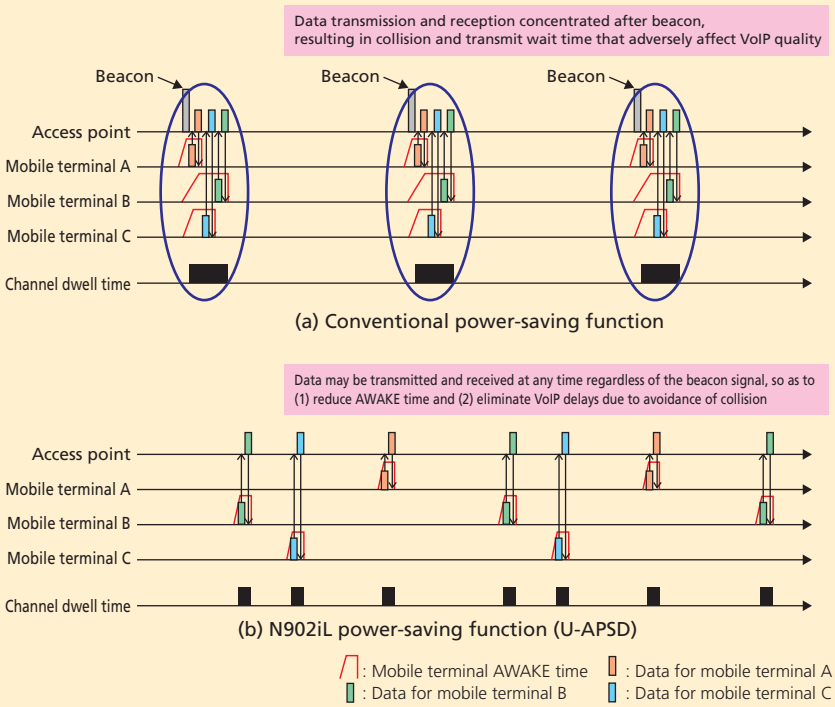


Figure 4 Operation using the N902iL power-saving function (compared with conventional function)

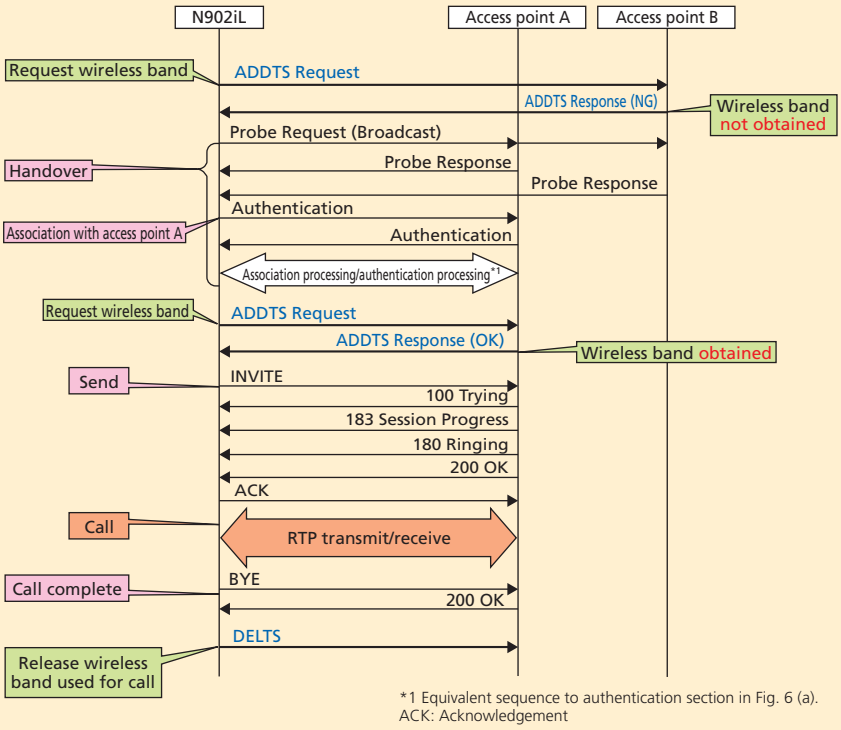


Figure 5 TSPEC sending sequence

*10 **Beacon**: Synchronized packet data sent at fixed intervals from an access point on a wireless LAN. Notifies the existence of an access point and the presence or absence of data to wireless LAN terminals within the range that the data is sent to.

*11 **AWAKE time**: The status of current consumption due to the transmission and reception of data during power-saving operation. Assumes Doze status when no data is transmitted or received in order to minimize current consumption.

*12 **TSPEC**: A method of band control defined in WMM. An access point manages the wireless band, and responses a communication request from the mobile terminal by notifying whether communication is possible. Prevents deteriorated communications quality relative to an increase in the number of communications devices.

the mobile terminal is refused and the system searches for another access point for which a wireless band is available.

Even if congestion occurs at an access point for a mobile terminal, these procedures permit the automatic selection of another access point through which a more satisfactory call is possible.

3.4 High-speed Handover

In VoIP communication using a wireless LAN, intermittent voice cutout may occur at handover, and thereby adversely affect quality. The N902iL adopts the Pairwise Master Key Security Association cache (PMKSAcache) function specified under IEEE 802.11i that enables high-speed handover to prevent cutout, even for calls made during movement between areas, and thus facilitates continuous high-quality communication. When a mobile terminal operates using Wi-Fi Protected Access 2 (WPA2)[*15] authentication, the access point and mobile terminal both hold the key required for authentication (hereafter referred to as 'PMK'). The PMKSAcache function reduces handover time by eliminating the need for authentication again for a previously associated access point.

Figure 6 shows the authentication sequence with WPA2 authentication at the handover destination when using/not using PMKSAcache.

Mobile terminals and access points create a PMK at WPA2 authentication. At normal handover, a PMK must be created again for the previously associated access point (Fig. 6 (a)). This entails more time

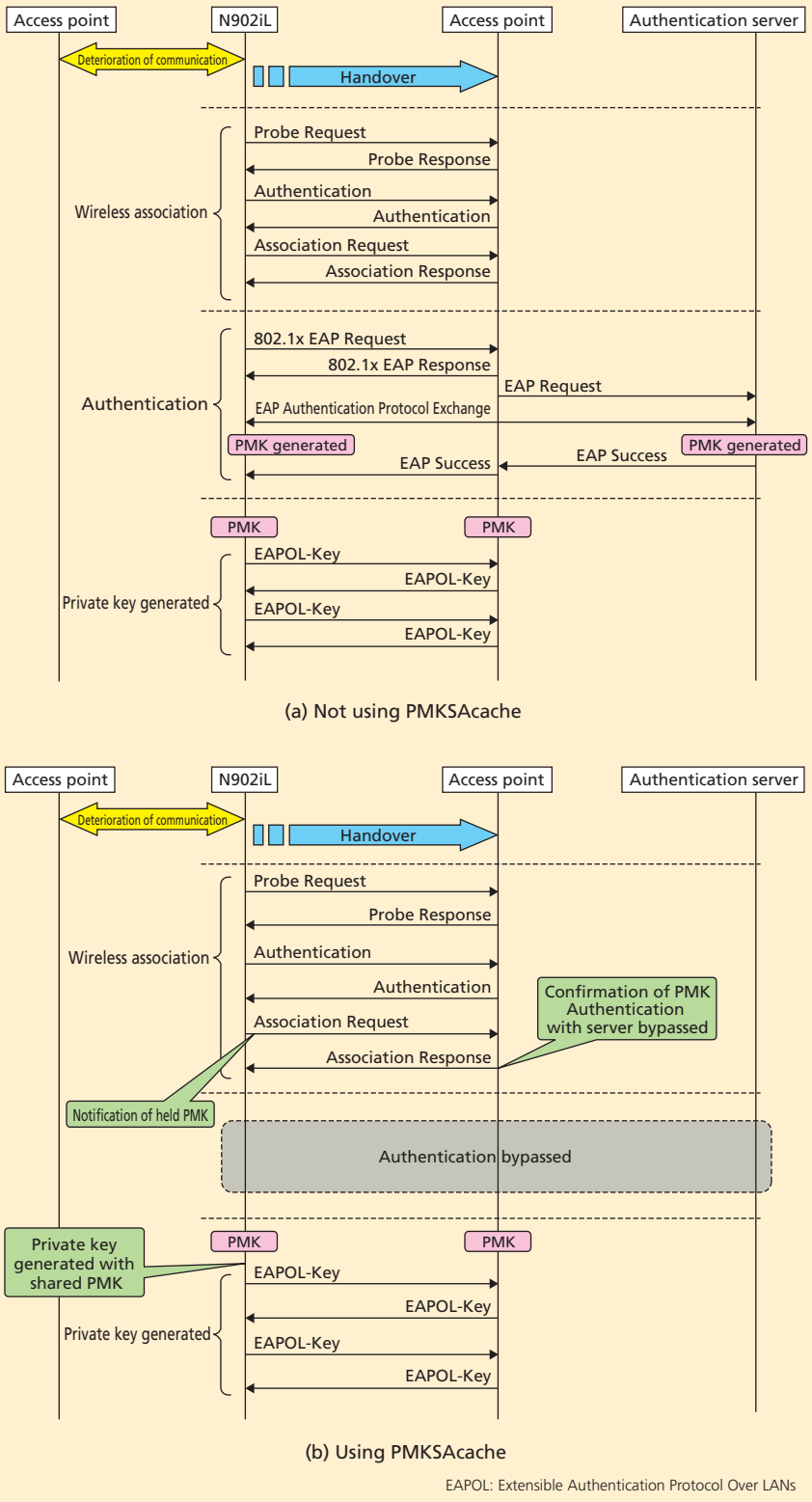


Figure 6 Authentication sequence at handover

*13 **ADDTS Request**: A communications request signal sent from the mobile terminal to the access point when using TSPEC.

*14 **ADDTS Response**: A response notifying a mobile terminal of whether the access point receiving an ADDTS request is able to communicate. Communication is permitted when a sufficient wireless bandwidth is available upon receiving the ADDTS request; otherwise, refusal is notified.

*15 **WPA2**: A standard for wireless LAN security in Wi-Fi. Compatible with 802.11i, and backward compatible with WPA.

required for authentication at handover, and may result in intermittent cutout.

When the PMKSAcache function of the N902iL is used, the PMK previously created is cached in mobile terminal memory, which can hold multiple PMKs. When associated on a wireless channel, the access point previously associated with WPA2 authentication is notified that the PMK is being held, and this allows the mutual authentication procedure normally conducted with the authentication server to be bypassed (Fig. 6 (b)). Handover time can consequently be significantly reduced, with less deterioration in call quality when changing areas.

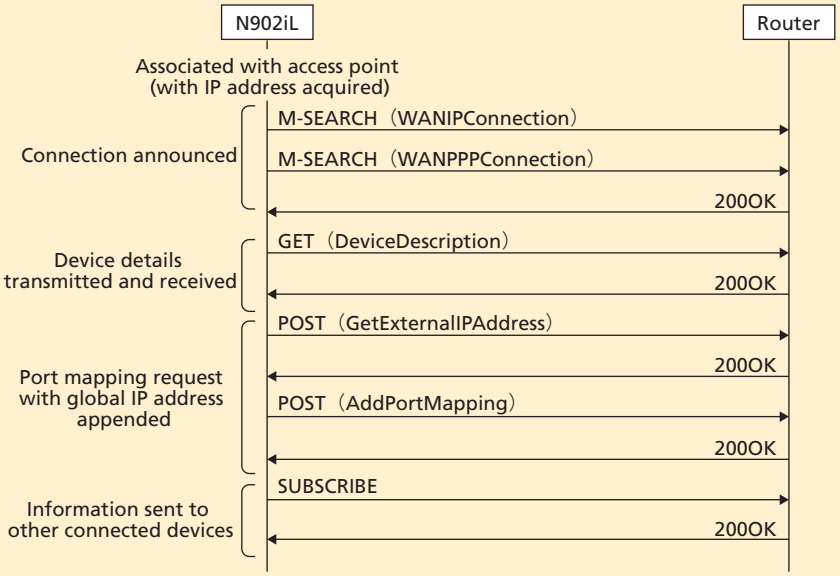


Figure 7 Basic operation of UPnP function

3.5 UPnP Function

VoIP communication using SIP also utilizes the transmission source IP address for the data part of packets. However, since part of the header is rewritten through router Network Address Translation (NAT)[*16] processing, the IP address does not match at the server, and therefore inhibits normal communication. The Universal Plug and Play (UPnP) function used with the N902iL enables VoIP communication by NAT traversal using port mapping requests.

Figure 7 shows the basic operation of the UPnP function. The mobile terminal acquiring the IP address notifies the device (router) on the network that the local terminal is connected, conducts a search to identify the router's location within the LAN environment, and issues a notification of capability (such as regarding which functions can be used between devices). The mobile terminal then issues a request to the router for appending a global IP address as the destination address, followed by a request for the router to recognize the global/local IP address and port number table for NAT traversal. Any changes in router status may be monitored by an updated connection status notification received from the router.

This function converts the address with the router and permits NAT traversal, even during VoIP communication on the mobile terminal (**Figure 8**).

4. Improvement of Usability

4.1 Profile Download Function

Connecting to a wireless LAN, performing VoIP communication, and browsing on the Internet, all require a large number of parameters to be set up on the N902iL. Although these parameters may be set up manually on the terminal screen, the complexity of this operation often results in setup errors that inhibit communication. Therefore, a facility to download the wireless LAN setup from the network is provided for the N902iL, so as to simplify setup by the user. In particular, the server administrator (typically the network manager) creates a wireless LAN setup file (profile), and users download this file via their browsers to simplify wireless LAN setup.

4.2 Expansion of Wireless LAN Browser Functions

The N902iL is designed for full browsing on a wireless LAN. Websites designed for PCs may be viewed on the terminal screen for faster Internet browsing than with the previous i-mode full browser function, but the handling of content appropriate to the mobile terminal's

*16 **NAT**: Conversion of packet IP addresses between two independent networks.

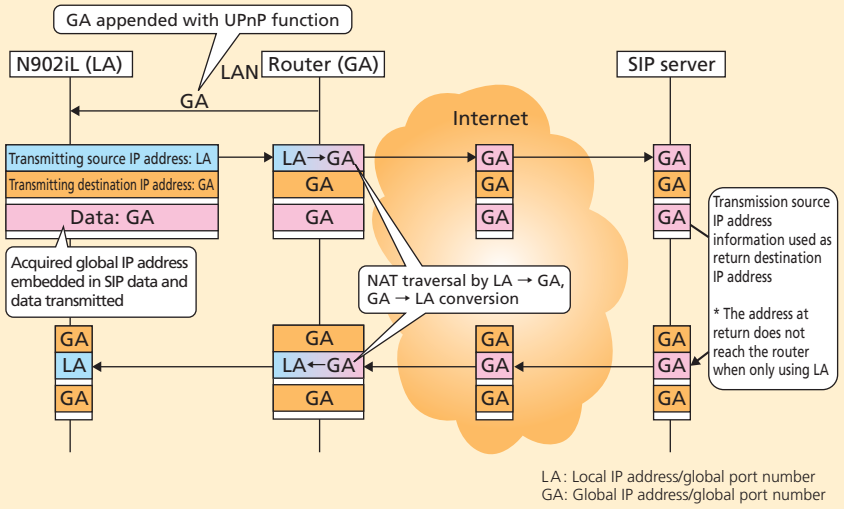


Figure 8 NAT traversal with UPnP function

capability must still be rationalized. A security policy equivalent to or better than Digital Rights Management (DRM)[*17] implemented with i-mode covers the handling and protection of content acquired via a wireless LAN. In particular, the N902iL restricts downloaded content using a filter for format type and data size. There are also limits applied to the redistribution of stored files—the N902iL checks downloaded content for total play time and expiry date to ensure that it can be replayed appropriately, and viewing restricted according to whether the User Identity Module (UIM) is inserted. **Table 2** shows the DRM conditions for handling downloaded content.

The characteristics of wireless LAN are also adopted for video replay to vastly increase the upper limit of 2 Mbytes for streaming replay on the N902iS to 400 Mbytes. This provides corporate users with more convenience and significantly higher capabilities, such as for storing demonstration videos on the server and viewing on the terminal screen via the Internet.

Table 2 DRM conditions for downloaded content

Menu items	Communication conditions	Download	Replay limits (i-motion/movies)	Redistribution limits	Viewing limits with UIM
i-mode full browser	FOMA communication (i-mode)	Possible	Yes	Yes	Yes
Wireless LAN full browser	Wireless LAN communication (UIM inserted)	Possible (equivalent to i-mode, except for some content)	Yes (equivalent to i-mode)	Yes (equivalent to i-mode)	Yes
	Wireless LAN communication (UIM not inserted)	Possible (equivalent to i-mode, except for some content)	Yes (equivalent to i-mode)	Yes (equivalent to i-mode)	No

5. Conclusion

As the successor to the N900iL, the N902iL has been developed as a mobile terminal offering a high level of convenience made possible by implementing such functions as the power-saving function for reduced power consumption and the QoS function for superior voice quality. New functions are now being investigated for use in further expanding the range of application of this device.

References

[1] Wireless LAN "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Amendment 4: Further Higher Data Rate Extension in the 2.4 GHz Band," IEEE Std 802.11g, 2003 Edition.

[2] Wireless LAN "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band," IEEE Std 802.11b, 1999 Edition.

[3] Wireless LAN "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Amendment6: Medium Access Control (MAC) Security Enhancements," IEEE 802.11i, 2004 Edition.

[4] Wireless LAN "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications," IEEE Std 802.11, 1999 Edition.

[5] Wireless LAN "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Amendment: Medium Access Control (MAC) Enhancements for Quality of Service," IEEE 802.11e/D13.0.

*17 **DRM**: A function for protecting the copyrights of digital content by restricting redistribution, preventing unauthorized copying, etc.