DTV FeliCa Bluetooth

Technology Reports

Special Articles on Technology toward Further Diversification of Life-Style Mobile

Key Mobile Terminal Technologies for Expanding the Scope of Life-Style Mobile

Mobile phones, known as simply, "Keitai", and are now also including support for a variety of services like One Seg, Osaifu-Keitai (e-cash), Imadoco location search and Passage Duple. These new functions help expand the scope of NTT DoCoMo's business, and make mobile phones even more useful for users by linking them with various peripheral devices and non-cellular networks. In this article we describe the current state and future directions for some of the key technologies used to make these services possible.

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1. Introduction

Mobile terminals have been able to connect and communicate with peripheral devices for some time through Universal Serial Bus (USB) and infrared interfaces, but recent advances have added One Seg and Global Positioning System (GPS) functions and ability to connect to wireless LAN and other entities using interfaces like FeliCa®*1 and Bluetooth®*2 (**Figure 1**).

These key technologies are advancing rapidly in the world. Contactless-card services like Suica®*3 and PASMO®*4 are already in the main-stream with sales

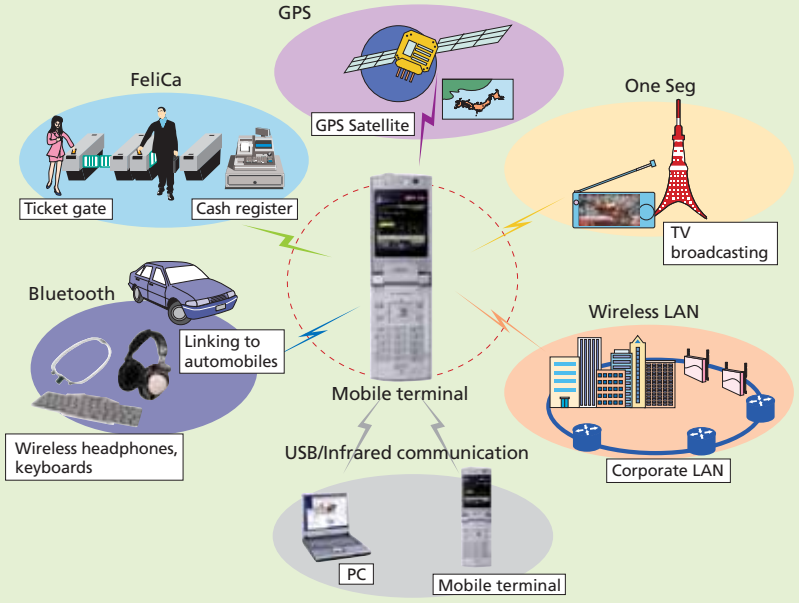

Figure 1 Expansion of mobile terminal peripheral technology

*1 **FeliCa®**: A registered trademark of Sony Corp.
*2 **Bluetooth®**: A registered trademark of Bluetooth SIG Inc. in the United States.
*3 **Suica®**: A registered trademark of the East Japan Railway Company.
*4 **PASMO®**: A registered trademark of the Pasmo Corporation.

exceeding 30 million cards, and digital television is expanding rapidly, as LCD television sales climb and analog broadcasting is scheduled for termination in 2011.

With broadband being available on fixed phone lines, household wireless LANs are also becoming common, and recently not only PCs, but even portable game devices are equipped with wireless LAN capabilities. One Seg and Bluetooth have also been very active in the mobile communications industry, with over 1.5 billion Bluetooth-supporting devices delivered, particularly overseas, since 1998 [1], and over half of all delivered terminals equipped with One Seg receivers as of November, 2007 [2].

NTT DoCoMo has been steadily pushing to include these technologies as standard features, with Mobile FeliCa (Suica) in the FOMA 901i series, Personal Navigation (GPS) in the FOMA 903i series and One Seg functions in the FOMA 905i series. Mobile terminals are becoming essential tools in daily life and are continuing to expand into broader areas of users' work and life by applying these key technologies in various situations.

In this article, we look at the current state and future directions of One Seg, i-mode FeliCa, GPS, Bluetooth and wireless LAN—key technologies that are expanding the range of Life-Style Mobile.

2. Expanding the Lifestyle Infrastructure with One Seg Keitai

One Seg is a service that uses part of a digital terrestrial television broadcast channel in a way that is accessible to compact and mobile devices. The service uses only one of the 13 segments of the 6 MHz band allocated to each broadcast channel, keeping the amount of information relatively small so devices like mobile terminals with limited processing power and resources can receive and process the signal.

2.1 Implementing One Seg Receivers into Mobile Terminals

After the FOMA P901iTV, which was the first terminal to incorporate a One Seg receiver, NTT DoCoMo has continued to add One Seg capability to other terminals, gradually making it a standard mobile terminal feature.

Initially, mobile terminals with a One Seg receiver tended to be quite large, due to the extra components: the tuner, IC of the One Seg signal processor, One Seg antennas, additional memory and a higher-capacity battery required to ensure practical viewing times.

However, with advances in manufacturing processes, higher-density components, reduction in the size of system Large Scale Integration (LSI) and tuner components and reduced power consumption, it become possible to develop a compact, long-playing One Seg receiver, and the number of devices supporting One Seg began to increase.

The FOMA P903iTV and FOMA P905iTV incorporate both a whip antenna and an internal antenna, which can be used to increase the accuracy of the received signal through diversity combining. They can achieve a more stable picture over a wider range; particularly while in motion or under difficult reception conditions like urban areas with many buildings and other obstacles.

2.2 Linking One Seg with Communications Functions

One Seg has the particular feature of allowing users to watch bright, clear television anywhere and any time on small devices like mobile terminals, as well as being able to receive data broadcasts at the same time.

With data broadcasting, the mobile terminal can also access Websites on the Internet using its i-mode communications features, providing many new opportunities for services linked to television watching. For example, shopping and other information related to the program being watched can be retrieved, viewers can participate in quiz programs, or items introduced on a program can be purchased. In this way, watching television on the mobile terminal is not a simple, passive activity, but becomes interactive communication.

2.3 Linking One Seg with Osaifu-Keitai Features

In order to create new business using the FOMA 905iTV terminals, NTT DoCoMo developed a broadcast ToruCa (coupons) feature, linking the ToruCa with One Seg and Osaifu- Keitai functions.

ToruCa is a service that supports distribution of coupon and membership-card information, conventionally been distributed on paper, in electronic form. Users can retrieve, store and display items like restaurant coupons on their mobile terminal, and exchange them with their friends through e-mail or other external interfaces.

The broadcast ToruCa function allows ToruCa to be distributed through One Seg data broadcasting as well as through Websites and reader/writer devices at the point-of-sale. They can be retrieved and stored automatically by simply watching a television program.

ToruCa are distributed as Broadcast Markup Language (BML) content in the data broadcast. The data broadcast is processed by the BML browser[*5] and automatically stored in the terminal. The same processing is also done when viewing the broadcast in full-screen mode.

ToruCa distributed through One Seg are limited to about 200 bytes, but more-detailed data such as shop photos or maps can be provided by including a Website URL in the data.

New services, delivering ToruCa with additional information related to a program-products, recipes, store information, maps, coupons, or event tickets—can be created for use in various situations, and are only possible at NTT DoCoMo through integration of One Seg and Osaifu-Keitai with this new feature (**Figure 2**).

ToruCa can also be exported as e-mail attachments or using external interfaces, providing even more communication opportunities as users redistribute information gained from television programs to their friends.

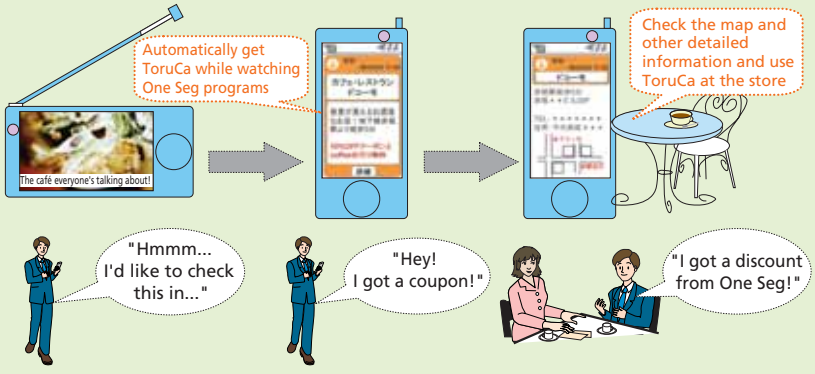

Figure 2 Linking One Seg with Osaifu-Keitai

3. Diversification of i-mode FeliCa

Contactless IC card technology, as in the widely known Edy®[*6] and Suica cards, use power from the reader/writer-device RF signal to power the IC on the card, and also to communicate with the card over distances of a few centimeters. FeliCa, the technology used in Edy and Suica cards, is common mainly in Asian countries including Japan and Hong Kong, but there are other common international standards, including the International Organization for Standardization/International Electrotechnical Commission standard 14443 (ISO/IEC 14443), Type A and Type B. FeliCa is able to process transactions between reader/writer and card very quickly, using efficient mutual authentication and communication techniques, so it is well suited to situations like crowded ticket gates.

NTT DoCoMo has realized i-mode FeliCa (hereinafter reffered to as "FeliCa"), linking FeliCa functionality with i-mode services. Since NTT DoCoMo launched its first FeliCa-equipped Osaifu-Keitai in 2004, the number of restaurants, convenience stores and transportation methods supporting Osaifu-Keitai payments has increased rapidly.

It has been difficult to equip ultra-thin

*5 **BML browser**: Software for displaying and executing content written in BML, a page description language for data broadcasting.

*6 **Edy®**: A registered trademark of Sony Financial Corporation.

mobile terminals with FeliCa, because of the space required for the FeliCa antenna, but as of fall, 2007, many ultra-thin mobile terminals also support FeliCa, and it is becoming an essential mobile terminal feature. In 2004, approximately 20% of FOMA terminals were equipped with FeliCa, but as of 2007, over 70% are Osaifu-Keitai.

With the spread of Osaifu-Keitai, measures to prevent the unauthorized use of the IC card functions in case the terminal is lost or stolen are also being taken to ensure a safe and secure environment for Osaifu-Keitai use (**Figure 3**).

With the introduction of the FOMA 903i series, new services are being offered which make use of new mobile FeliCa IC chips (hereinafter reffered to as "FeliCa chip") with additional functionality. The main new functions of these FOMA 903i series and later mobile terminals are described below.

3.1 Contactless IC Card Reader/Writer Functions

Data on the FeliCa chips has generally been read and written by reader/writer devices at ticket gates and cash registers, but as of the FOMA 903i series, the mobile terminal itself is a reader/writer, and is able to read and write other IC cards. The mobile terminal can now send commands and receive responses from other contactless cards through the FeliCa antenna in the terminal, use reader/writer-enabled i-appli, and read or write to the unauthenticated area of external contactless IC cards in FeliCa-conforming contactless communication.

As an example, a contactless IC card could be attached to a poster, and the information on the card read by mobile terminals, for a service providing additional related information (e.g., for an event poster, the name of the event, event times, a URL providing details, etc.).

3.2 iC Transmission Functions

The iC transmission function uses FeliCa technology to allow contactless data communication between mobile terminals. Two terminals can exchange data by sending and receiving a sequence of commands through the reader/writer described in the previous section. Upper protocol layers use the existing OBject EXchange protocol (OBEX™)[*7], helping to reduce development costs, and also allowing the same sorts of data exchange as are possible using infrared communication. As an example, only ToruCa less than 200 bytes could be received from a reader/writer with the FOMA 902iS series, but with the FOMA 903i series, ToruCa up to 100 kB can be transmitted between two mobile terminals through the FeliCa interface by simply placing them beside each other. The data-transmission operations are also very simple: to send a ToruCa or phone book entry, the sender initiates the transaction, and the receiver can receive the data by simply placing the terminal near the transmitting terminal.

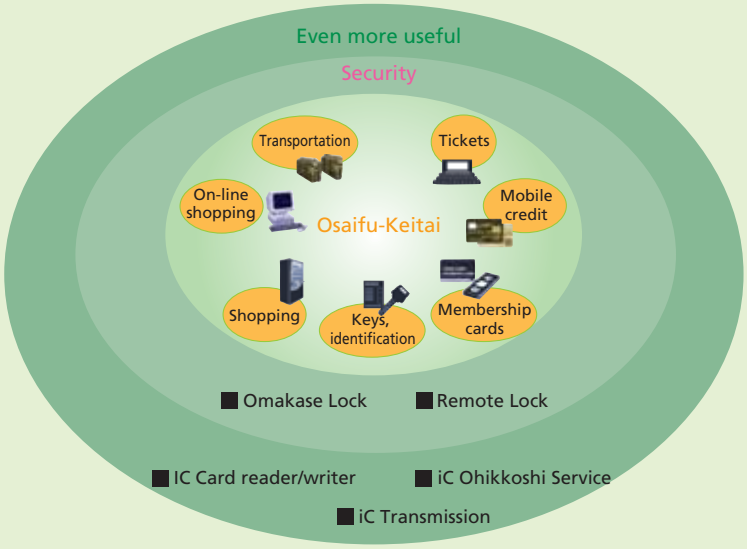

Figure 3 Diversification of i-mode FeliCa

*7 **OBEX™**: A communications protocol for exchanging objects standardized by the Infrared Data Association (IrDA) and a trademark of that organization.

3.3 Data Transfer Functions

It has been possible to move FeliCa data (e-money, membership data, etc.) from one mobile terminal to another when changing mobile terminal or having repair work done, but as of the FOMA 903i series, a new iC Ohikkoshi Service is supported, allowing IC card data from multiple IC card service providers to be moved all at once.

Individual IC card service providers have had their own services for moving IC card data from one terminal to another with earlier terminals, but these required separate user operations for each IC card service.

With the iC Ohikkoshi Service, users with a lot of IC card data can use the service, and those with only a small amount can used the earlier services if they desire, providing more choice for users, depending on their usage conditions.

4. Location-based Services Expanded through GPS

4.1 GPS Positioning Technology

GPS is a system for determining location using satellite signals, first developed by the American Department of Defense in the 1970s. GPS operates using about 30 satellites orbiting at an altitude of 20,000 km, each completing one orbit in approximately 12 hours. Terrestrial GPS receivers receive the signals emitted by several GPS satellites, and calculate the distance to the satellite based on measurements of the time taken for the signal to arrive, and then the position of the receiver based on these distances and the coordinates from each GPS satellite.

The GPS satellite coordinates (orbit data) required for GPS positioning can all be received from the satellites, but some time is required to receive all messages (30s to several minutes). Because of this, most terminals incorporating GPS use "Assisted-GPS" (A-GPS), a method that is able to provide measurements much more quickly by acquiring orbit data through faster means such as the mobile phone network.

4.2 Implementing GPS Receivers into Mobile Terminals

NTT DoCoMo began equipping FOMA terminals with A-GPS-capable receivers in October, 2005, and GPS receivers are a standard feature on FOMA 903i series and later terminals. Using the latest manufacturing processes for LSI chip/ Radio-Frequency Integrated Circuits (RFIC)[*8] and System on a Chip (SoC)[*9], we have achieved low power consumption, small size and low cost. This has helped increase the share of GPS-equipped DoCoMo mobile terminals from 20% in 2006 to 30% in 2007.

Also, improvements in positioning performance, including accuracy (location correctness), speed (time required to take a measurement) and coverage area have made the feature much more useful for users. Later-model FOMA terminals have more-sensitive GPS receivers that work over a wider range, can make better use of GPS signals reflected from buildings and other objects for better accuracy, have optimized measurement algorithms and can better evaluate whether measurements are valid. Speed and accuracy of measurements continue to improve with each new series due to these factors.

NTT DoCoMo is also improving the accuracy of location measurements made without GPS, using our base-station locations. By implementing a function to switch seamlessly between GPS and base-station positioning, the best positioning result for the current environment can be provided to the user, further improving usefulness of this feature.

4.3 Infrastructure for Location-based Services

The first location-based services offered on FOMA terminals were the i-Area and Open i-Area, which used the location of the current base-station, and was a relatively rough location (area). This only allowed searches such as for nearby shops and restaurants.

Then, as mentioned above, a positioning service for mobile terminals with GPS receivers and using the FOMA network was introduced in October, 2005. Initially, this offered only a function to check and the terminal's current location accurately on a map or give directions to a specific location. Then from March, 2006, location notification and location provision functions (Imadoco Search, Keitai-Osagashi Service, etc.) were launched to

*8 **RFIC**: A general term for Integrated Circuits (IC) processing Radio-Frequency (RF) signals.
*9 **SoC**: Integration of all functions required for a system on a single semiconductor chip.

provide location information to third parties and allow third parties to search location data (**Figure 4**). Enhancements to notification of location information for emergency calls (dialing 110/ 118/ 119) can now also provide caller position information when these numbers are dialed. Emergency facilities (police, coast guard and fire) can also look up the caller position, helping them to respond more quickly and appropriately to the situation.

These types of services based on a positioning information infrastructure are much anticipated, and we look forward to further expansion of the location-based services.

5. Linking to Various Devices with Bluetooth

5.1 Characteristics

Bluetooth is a short-range wireless technology that uses spread-spectrum techniques in the 2.4 GHz band, and is internationally standardized by the Bluetooth Special Interest Group (SIG). It has data-transfer rates of up to 3 Mbit/s (using Bluetooth 2.0+Enhanced Data Rate (EDR)[*10]), over distances up to 100 m, and is particularly noted for two features: its low-power-consumption design oriented to mobile devices, and regulation of various profiles. Profiles provide separate, optimized regulation for each of the various applications a Bluetooth device may use, so that devices can use a profile if both support it (e.g., a phone supporting the hands-free profile[*11] can use the hands-free functions of a Bluetooth device such as a headset if it also supports the profile).

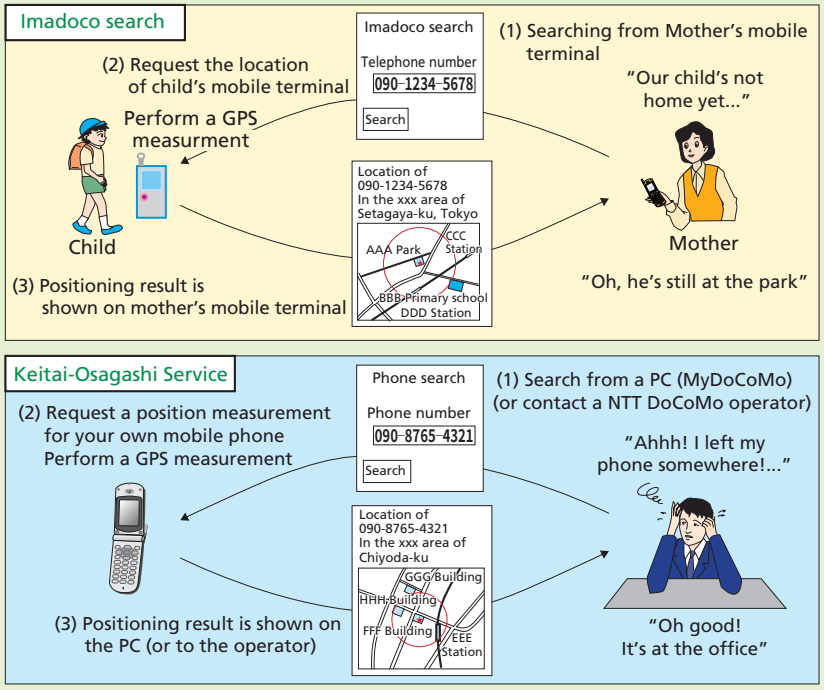

Figure 4 Examples of location-based services

5.2 Purposes of the Bluetooth Implementation in Mobile Terminals

The purpose of implementing Bluetooth technology in mobile terminals is to improve usability and expand the range of usage scenarios by allowing wireless connectivity with various peripheral devices.

Mobile terminals can be developed further to support features that would be very difficult to implement within a compact device by linking with peripheral devices.

5.3 Bluetooth Market Trends

Bluetooth-equipped devices such as mobile terminals, car navigation systems, PC peripherals (keyboards, etc.) and headsets have become much more common in recent years. These devices are being used in a wide variety of situations, from data transmission, hands-free telephony and listening to music, to extended I/O and local communication head-to-head games (**Figure 5**).

Using mobile terminals with a hands-free headset has become particularly popular in overseas markets, and almost all mobile terminals are equipped with Bluetooth. The market is set for expansion in Japan as well, with regulations for using

*10 **Bluetooth 2.0+EDR**: A Bluetooth version featuring high-speed EDR functions, and theoretically capable of speeds up to 3 Mbit/s.

*11 **Hands-free profile**: A profile that allows hands-free use of a telephone; for use with headsets or car-navigation systems.

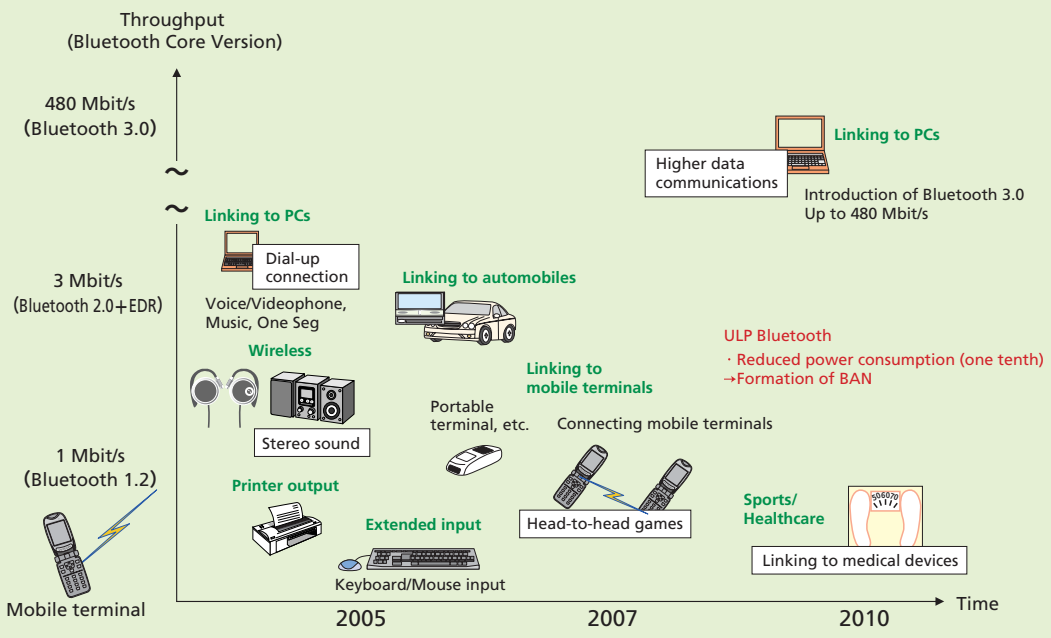

Figure 5 Bluetooth scenarios and new functions possible with increased speed

phones in vehicles, and expectations that use of music players with wireless output will increase.

5.4 Future Developments for Bluetooth

With the introduction of Ultra-Low-Power (ULP) Bluetooth[*12] (around 2009), power consumption is expected to be even further reduced (one 10th) so that tools supporting ULP Bluetooth and running on a single button battery will be possible. This will allow further size reductions on Bluetooth modules, making it easy to attach them to shoes or clothing. Because of this, they are expected to be used widely for Body Area Network (BAN)[*13] applications, and make it possible to link mobile terminals with products in the sports and healthcare fields.

At the other extreme, introduction of Bluetooth 3.0[*14] (around 2010) is expected to improve throughput (up to 480 Mbit/s) using Ultra Wide Band (UWB)[*15] techniques at the physical layer, allowing higher-volume external I/O such as video content (Fig. 5).

6. Seamless Communication on Mobile Terminals

6.1 Wireless LAN (IEEE 802.11)

Wireless LAN is usually associated with high-speed, short-range communication in environments like offices, but recently it is being used more and more for applications like peer-to-peer games as well.

Wireless LAN conforms to the IEEE 802.11[*16] standards for unregulated, unlicensed wireless systems. When initially standardized, the maximum data rate was 2 Mbit/s, but the standard has progressed with IEEE 802.11b up to 11 Mbit/s, and IEEE 802.11a and IEEE 802.11g to 54 Mbit/s. A further increase is planned with the standardization of IEEE 802.11n (100-300 Mbit/s) in 2009 (**Figure 6**).

6.2 iL Series Mobile Terminals Supporting Wireless LAN

Following development of the IEEE 802.11 standards, NTT DoCoMo has

*12 **ULP Bluetooth**: A simplified protocol design that is able to achieve power consumption that is 10% that of conventional Bluetooth. It is being developed for use in applications, such as sensors, that require extremely low power consumption. Currently under consideration for standardization by Bluetooth SIG.

*13 **BAN**: A very short-range wireless network intended for medical or healthcare purposes used mainly for devices attached to the body (wearable devices) or implanted in the body (implantable devices).

*14 **Bluetooth 3.0**: The next generation Bluetooth specification, now under consideration by Bluetooth SIG. Uses UWB (see *16) conforming to the Wimedia standard at the physical layer, with a maximum throughput of 480 Mbit/s. Wimedia is an intermediate abstraction layer for UWB between the physical and application layers, providing communication for both, proposed by the non-profit industry organization, the Wimedia Alliance.

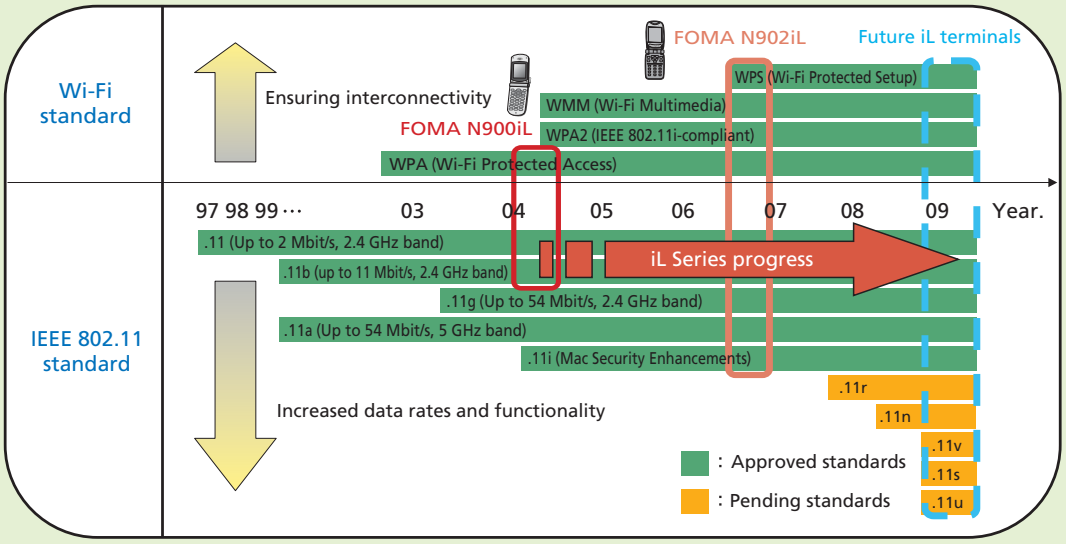

Figure 6 Future developments for wireless LAN functions

developed the FOMA N900iL and FOMA N902iL terminals, which are dual FOMA/wireless LAN terminals linking wireless LAN and FOMA services, support IP technology important for data communication, improve data throughput, and provide seamless communication depending on the reception.

The FOMA N900iL was developed as a Voice over IP (VoIP)[*17] terminal equipped with IEEE 802.11b wireless LAN and supporting the "Passage Duple" corporate IP telephony system. It was introduced in November, 2004 as an alternative terminal for the corporate telephony system. In February, 2007, the FOMA N902iL was developed, supporting the IEEE 802.11g standard, in order to increase the number of users supported by an access point. In addition to high-speed communication, the FOMA N902iL supports Wi-Fi MultiMedia (WMM)[*18] providing improvements in voice quality and talk time, IEEE 802.11i compliant Wi-Fi Protected Access 2 (WPA2)[*19] for improved security, and Wi-Fi Protected Setup (WPS)[*20], making wireless LAN device setup much easier. Besides these measures, voice and connectivity were further improved by implementing schemes to prevent concentration of traffic on an access point, and various other improvements to usability were made, such as a voice codec negotiation scheme to ensure connectivity with various VoIP terminals.

The FOMA N902iL is a terminal for "Passage Duple," but it is not only for corporate use. It has also been used to provide hotel services for guests. Each hotel room is equipped with a FOMA N902iL as room phone, which guests can use for internal and out-going calls while in the hotel. They may also take the mobile terminal out of the hotel and use it like a regular mobile terminal if they choose to use that service. All staffs are also provided with these mobile terminals, linking them more closely with the instant messaging and presence functions, and helping them to provide more attentive guest support.

6.3 Technical Developments with Wireless LAN

In recent years, standardization of wireless LAN technology has advanced

*15 **UWB**: Ultra-wide-band wireless technology. Features include low-output, low power-consumption and radar functionality.
*16 **IEEE 802.11**: An international standard for wireless LAN defined by the IEEE.
*17 **VoIP**: A technology for converting voice into packets and the real-time transmission on an IP network using normal circuit switching.
*18 **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.
*19 **WPA2**: A standard wireless LAN security method for Wi-Fi. Complies with IEEE 802.11i and backwards compatible with WPA.
*20 **WPS**: A standard for simplifying the process of setting up connection and security settings on wireless LAN devices.

beyond its focus on data communications for PCs to a wider range of applications, also taking VoIP for applications like the Passage Duple service into consideration. IEEE 802.11r, scheduled for standardization in June, 2008, deals with high-speed hand-over, which is useful for VoIP. After that, IEEE 802.11u (2009) will deal with handover between FOMA and wireless LAN networks, and IEEE 802.11s (2009), will deal with mesh networks. IEEE 802.11s is a wireless multi-hop connection technology which will allow data transmission via ad hoc communication[*21] between mobile terminals, making it easy to build wireless LAN areas. It will be necessary to select new technologies from among these, to incorporate into future iL terminals in order to bring the best new features to users (Fig. 6). For example, a terminal equipped with IEEE 802.11s functionality could possibly use other nearby terminals to relay and enable emergency communications even in areas where there is no FOMA network coverage (**Figure 7**).

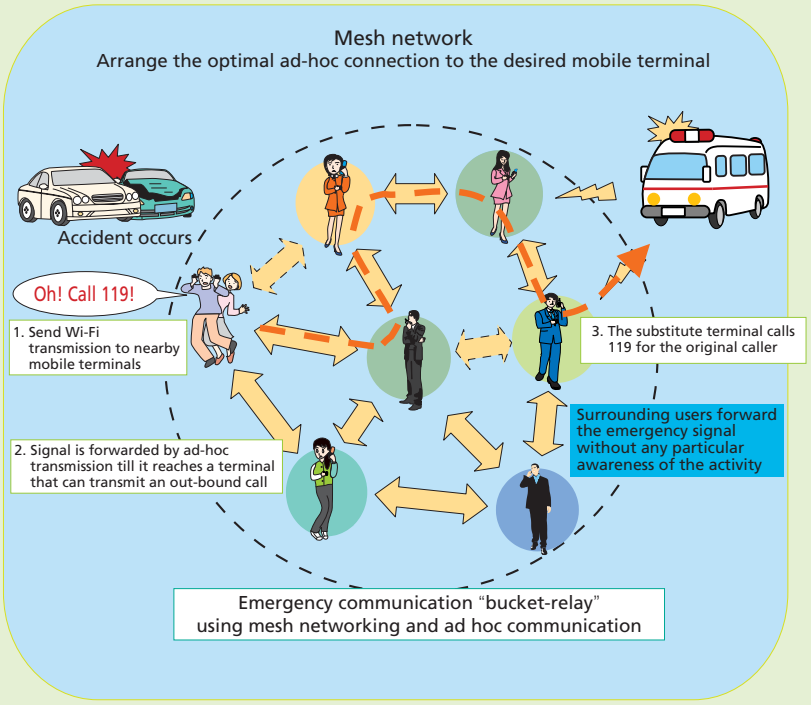

Figure 7 Services envisioned using mesh networks

6.4 Future Wireless LAN Services

Till now, the main requirement of wireless networks was a high data transfer rate, but there will be increasing demand for a variety of additional functions and services in the future. For example, Digital Living Network Alliance (DLNA)[*22] functionality together with wireless LAN capabilities would allow mobile terminals to be linked to other DLNA devices. TV programs recorded on a Hard Disk Drive (HDD) recorder could be viewed easily on the mobile terminal from anywhere in the home or other home electronics could be controlled remotely from the terminal. It will also be important to add support for IP broadcasting services[*23], which are expected to take off soon. NTT DoCoMo is continually advancing use of wireless LAN technologies and will continue to produce new services only possible on mobile terminals.

7. Conclusion

In this article we have presented the current state and future expectations for One Seg, i-mode FeliCa, GPS, Bluetooth and wireless LAN—key technologies that will contribute to expanding the scope of Life-Style Mobile in the near future.

There are many other promising peripheral mobile terminal technologies, each with their particular characteristics; connecting to different systems and sharing different services. Some of these are already in use, like infrared and USB, while others, such as Wireless USB[*24], are still to be developed and incorporated into products. Considering the increasing competition among network operators, new entrants in the market like Mobile Virtual Network Operators (MVNO), and

*21 **ad hoc communication**: Direct data communication between mobile terminals without going through a network. Used for Felica, Bluetooth and wireless LAN technologies available.

*22 **DLNA**: An organization of manufacturers in the fields of information appliances, mobile terminals and PCs that promotes activities for standardization to ensure interconnection in the digital age and establish technical specifications. A DLNA function is one which conforms to standards defined by this organization. Home electronics supporting DLNA functions can be linked and used together.

*23 **IP broadcasting service**: A broadcasting-like service offered using the Internet protocol. Can be viewed/listened-to on regular televisions and radios using a special device.

*24 **Wireless USB**: A wireless technology for PCs. Makes the wired USB interface wireless based on UWB technology.

entrants gaining footholds in the market from other fields like mobile terminal or OS, it will be even more important to continue to provide terminals with new and improved functionality. It will be difficult to incorporate more features into mobile terminals considering their limited size and capacity, but it will be smaller and lighter terminals will be possible with integration technologies like one-chip CPUs (**Figure 8**). Also, by collaborating with other businesses to expand into new business areas, we will continue to expand the range of applications and to build a lifestyle infrastructure. NTT DoCoMo is continually studying new mobile terminal technologies, adopting and eliminating them and closely following developments within the industry.

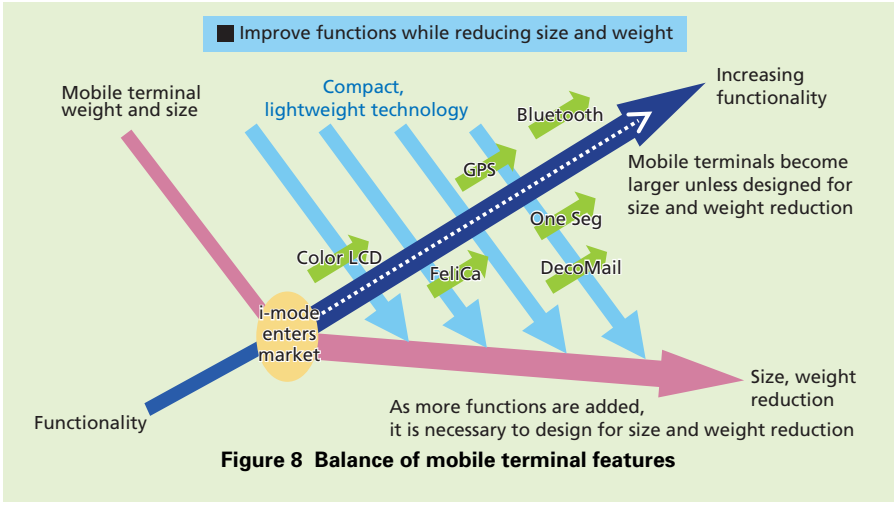

Figure 8 Balance of mobile terminal features

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