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Cutting-Edge New-Media Technologies in Japan

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From the Editor

Innovation in computer and telecommunications technology is promoting the rapid informatization of Japanese society. Computers, ranging from very large general-purpose computers to very small computers and EWSs (Engineering Workstations), have been introduced into a wide range of fields according to their purposes. In particular, the proliferation of high performance PCs and other types of very small computers is promoting downsizing among business users, as well as informatization among individual and home users. However, the value of computers is reduced by half when used as stand-alone machines. In other words, downsizing can be achieved and an informatized society in the true sense of the word can be realized by constructing networks of computers that are connected not only by conventional means of communication, but by new means of communications, such as optical fibers and radio. In Japan, media that have appeared as a result of the progress in electronics technology are called "new media" as opposed to conventional media, such as newspapers, TV, and radio. Therefore, the term "new media" is used in a very broad sense, comprising radio media, such as teletex and HDTV, cable media, such as bi-directional CATV, videotex, TV phones, and video conferencing, as well as data recording media, such as video discs, CDs (compact discs), optical discs, and IC cards. Meanwhile, the progress of information technology is bringing about changes also in the field of databases, which used to center on numeric and character data. In other words, so-called multimedia databases in which a large variety of information, including voice, images, and video, is integrated are coming into wide use. Recently, hypermedia, which has the additional element of human logical thinking, has also become a topic. Thus, the importance of new media is constantly increasing. For this reason, the Japanese Government is forming various policies for promoting new media. For example, they support not only R&D in technological fields, but also concepts that, as applications, vitalize and promote the regional development of informatization. For example, MITI is promoting the New Media Community Concept, and has established the New Media Development Association as the main body to promote this concept. There are also others such as the Teletopia Concept of the Ministry of Posts and Telecommunications. The New Media Community Concept Project started in 1984. It is to designate cities in various parts of the country as model areas, and to realize an advanced informatization society by means of new media applications, such as bi-directional CATV, videotex and database services that fully utilize high speed communication lines such as optical fibers and satellite communications. This project aims, by these services, to decrease the information gap between regions.

Since 1984, Japan and Germany have held the Japan-Germany Forum on Information Technology in the two countries alternatingly. The Eighth Forum was held in May, 1993 in Weimar, Germany. The objective of this forum is to deepen mutual understanding and to promote exchange between the two countries in the information technology field by gathering leaders of the two countries in the fields of industry, academia, and government under one roof. The forum consists of a general meeting attended by all the participants where keynote speeches and the like are delivered, and three workshops on computers, new media, and semiconductors. Specialists in these fields give presentations at these workshops. At the Eighth Forum, as at all the preceding forums, about nine specialists each from Japan and Germany introduced the cutting-edge technologies of both countries. This issue of JIQ centers on the presentations made by the Japanese speakers at the New Media Workshop of the forum. These papers introduce the latest technologies in this field in Japan, and we hope that they will prove useful to our readers. We would like to express our gratitude to the Japanese speakers who readily approved publication of the papers in JIQ.

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Digital Cellular Systems and Services

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Introduction

Public cellular telecommunication services are now rapidly penetrating Japan. There were approximately 1.6 million cellular subscribers at the end of 1992. In order to accomodate increasing demand and to provide new services, development of digital cellular communication systems has been very active in Japan, as well as in Europe and North America.

In Japan, technical requirements for the digital cellular systems were deliberated and then reported by the Telecommunications Technology Council (TTC) in 1990. The first version of the detailed air-interface standard specifications **RCR STD 27** for the Personal Digital Cellular telecommunication system (**PDC**, once called JDC) was established by the Research and Development Center for Radio Systems (RCR) in 1991 (RCR STD-27B 1993).[1]

Based on RCR STD27, NTT Mobile Communications Network Inc. (**NTT DoCoMo**) developed equipments for the cellular infrastructure and mobile terminals with advanced hardware technologies.[2] The standard air-interface specifications and system performances were verified by field trial tests carried out in the urban areas of Tokyo and Yokohama in 1992. The initial commercial service started in the Tokyo area on March 25, 1993.

The PDC can provide various high quality enhanced services with efficient spectrum utilization by applying a newly developed full digital link control scheme and ISDN signaling systems.[3] Compact base station equipments and portable phones are available.

This paper presents the PDC standard specifications, system configuration, system features, and future evolution that will support new services.

PDC Standard

Since the frequency bands for existing analog cellular systems were already locked up, the PDC systems were assigned new bands: 800/900 MHz bands with 16 MHz × 2 bandwidth. 1.5 GHz band with 24 MHz × 2 bandwidth. 800/900 MHz bands are shared by two existing common carriers, while 1.5 GHz band will be utilized by two new common carriers.

Typical specifications of the PDC air-interface are shown in Table 1 compared with those of NADC and GSM standards. The modulation scheme is spectrum efficient π/4-QPSK so that the interleaved carrier spacing is 25 kHz. TDMA is employed as the multiple access method. The number of TDMA slots is 3 for full-rate (11.2 kb/s) speech CODECs, and will be 6 for half-rate (5.6 kb/s) speech CODEC that is now under standardization.

PDC employs diversity reception to improve receiver sensitivity and resistance to multipath fading. Thus, the mobile station output power can be reduced, and an adaptive equalizer may be removed. The diversity reception as well as voice operated transmission (VOX) saves battery power and makes the mobile station very compact.

Logical and physical channel structures are also defined in PDC to en-

Table 1 Typical Specifications of the PDC Air-Interface Standard

	PDC	NADC	GSM
Frequency Band	800 MHz & 1.5 GHz	800 MHz	800 MHz
Carrier Spacing	25 kHz Interleaving	30 kHz Interleaving	200 kHz Interleaving
Modulation	π/4-QPSK		GMSK
Multiple Access	3(6)ch TDMA		8(16)ch TDMA
Carrier Bit rate (CODEC)	42 kb/s (VSELP, 11.2 kb/s)	48.6 kb/s (VSELP, 13 kb/s)	270 kb/s (RPE-LTP, 22.8 kb/s)
Equalizer	Option	Mandatory	Mandatory
Diversity	Option	Option	-
Frequency Hopping	-	-	Option
Link Control	Fully Digital	Analog AMPS	Fully Digital

sure the "roaming" capability. A 3-layered signalling structure based on the OSI model is adopted to allow independent development of the transmission methods and control signals.

System Configuration

Figure 1 shows the system configuration of the NTT DoCoMo digital cellular network. As shown in the figure, this system comprises the mobile communication control centers (MCC), the base stations (BS), and the mobile stations (MS).

The MCC consists of D60 digital automobile switching system (D-AMS), speech processing equipment (SPE) for speech coding/decoding, and base station control equipment (BCE). By locating SPE in the MCC, the cost of MCC-BS links can be reduced considerably because one 64 kb/s link carries three 11.2 kb/s traffic channels.

The BS comprises modulation and demodulation equipment (MDE) and transmitter amplifier equipment (AMP). The BS becomes very compact by replacing the current massive multiple-carrier combiner with the multiple carrier amplifier. An existing analog BS with 3 sector cells and approximately 300 channel tranceiver requires 15 frame. Its digital cellular equivalent takes only 2 frames.

The volume and weight of the digital portable telephones are approximately 150 cc and 230 g. Power saving techniques such as VOX and efficient power amplifier enable longer battery life than is possible with analog sets.

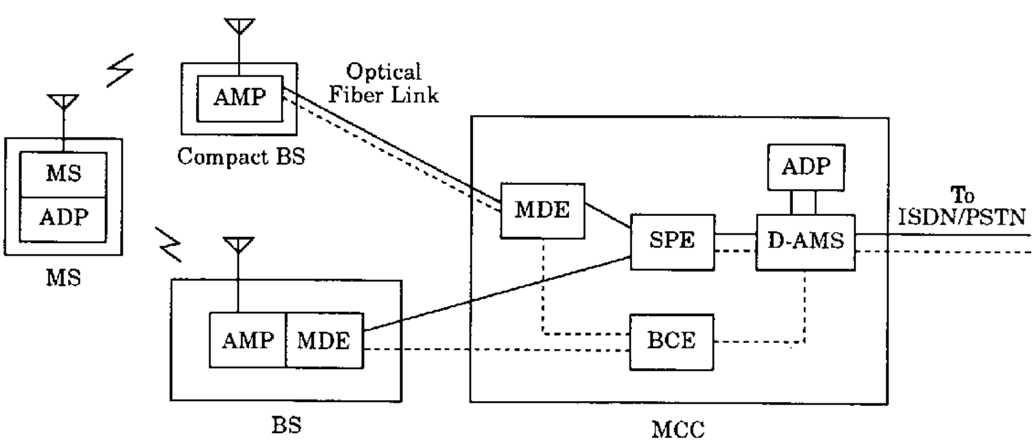

Figure 1 System Configuration

System Features

(1) System Capacity: The capacity of the PDC system is estimated to be 1.5 million for full rate speech CODEC users, and would be double using half rate one. The ultimate capacity of PDC with macro cell structure in Tokyo metropolitan area and throughout Japan is about 5 million and 10 million, respectively. Thus, PDC will fulfill the predicted demand in the year of 2000.

(2) Error-free FAX/DATA transmission: An adapter is provided at MS and MCC for converting between voice-band modem signal and 11.2 kb/s PDC-TCH data. Error-free facsimile signal transmission with less than 40 sec/page is achieved with the use of the high-throughput ARQ (**WORM-ARQ**: ARQ with Window-control Operation based on Reception Memory) transmission scheme. The widely used MNP modem protocol is also supported for data communications.

(3) Speech Quality/Security: The combined use of signal scrambling and encryption offers extremely high level of security and confidentiality without any deterioration of speech quality. Furthermore, the PDC can provide almost constant quality within an entire cell (up to 1 - 2% channel error rate).

Future Evolution

A half rate speech CODEC is now under standardization and will be introduced within a couple of years. Its quality is to be the same or higher as full rate CODEC with a reasonable increase of circuit complexity and delay time. The algorithm selection may be completed by this forum.

Unrestricted digital information services (8/64 kb/s), packet exchange services, short message/ location data services, and UPT services will be introduced near future.

Conclusion

The standard specifications and the system structure of PDC system have been discussed. NTT DoCoMo has started the initial commercial service with high quality, compact, and economical equipments. The next objectives are a half rate speech CODEC and various new services.

References

(1) "Digital cellular telecommunication system RCR standard," Research and Development Center

for Radio Systems (RCR) STD-27B 1993.

(2) M. Kuramoto, et.al., "System architecture for a TDMA digital mobile radio," 4th Nordic Seminar on DMR, 4.3, 1990.

(3) S. Onoe, J. Tajima, T. Utano, and N. Umeda, "Control channel structure for TDMA mobile radio systems," VTC'90, 1990.

Digital Cellular Network Technologies

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Abstract

Personal Digital Cellular telecommunication system (PDC) in Japan, developed under the specification No. STD-27 and issued by RCR (Research and Development Center for Radio systems in Japan), was introduced by NTT Do Co Mo in March, 1993.

This paper will discuss the network technologies adopted in the PDC system. In STD-27, an air interface between the base station and the mobile terminal was specified; however, the Protocols of the switching network, though the signaling system is based on CCITT No. 7, have not been specified. Those protocols of the switching network were commonly specified among Japanese operators; their standardization work has been executed by TTC (The Telecommunication Technology Committee). In the PDC system, many of the features and services have been considered and specified with new network technologies.

Summary

This paper consists of five chapters: 1) network configuration, 2) signaling structure, 3) control system, 4) system configuration, and 5) future trends.

(1) Network Configuration

There are three kinds of network structure for mobile telecommunication systems. The first one is that a total mobile system is operated as a part of fixed telephone subscribers connected to the PSTN network. The second one is that a mobile switch is provided in the PSTN and a mobile base station is operated as one of the subscribers. The third structure is that a PSTN switch is used for the mobile switch and each base station is operated as one of the subscribers.

Figure 1 shows an example of the telephone communications network. In this illustration, "SW" denotes the trunk communications networks, which are connected with each other by metal and/or fiber-optic cables, microwave, and satellite links.

This cable interconnection will be replaced by radio link in the future if the radio links prove to be more cost-effective than the wires, even taking into account the radio spectrum-related problems.

Figure 2 depicts detailed system configurations more concretely than in Figure 1. Basically, the difference in the system configuration between analog and digital radio communications systems is of no significance (here, the cellular system is referred to as MTS for convenience). The only difference is whether voice signals are modulated in analog or digital form at the air interface.

(2) Signaling Structure

When the concept of signaling structure for cellular system is discussed, there are two ways of thinking. Un-

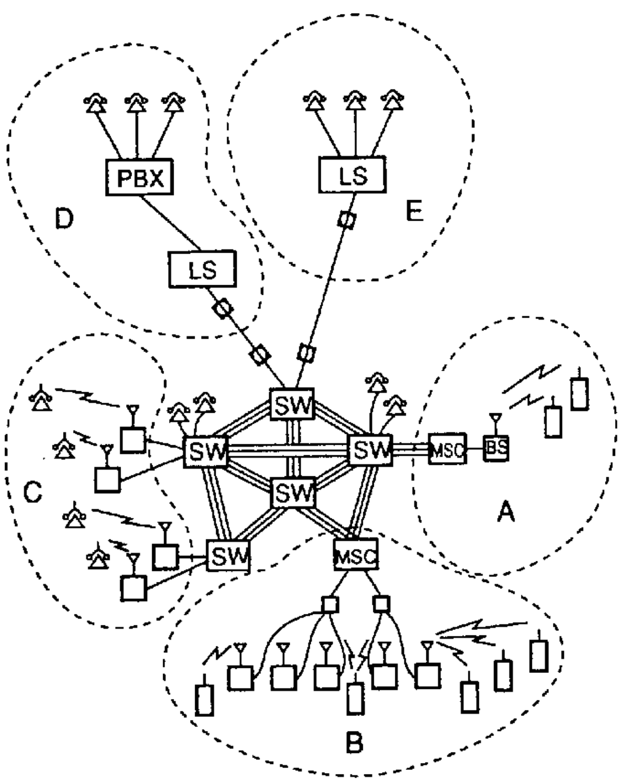


Figure 1 Network Configuration for Telephone Service

der the condition of specified air-interface, one is to specify the network interface, such as GSM, between the mobile switching center (MSC) and the base station controller (BSC) and between BSC and the base transceiver station (BTS). This enables multi-vender supply through integration of the best equipment provided by manufacturers. The other is to use an open interface, such as PDC, for the network to secure total economy, service flexibility and future expandability.

Figure 3 shows the signaling structure of the PDC consisting of three layers: Layer 1 for radio interface, Layer 2 for data retransmission and control, and Layer 3 for network management.

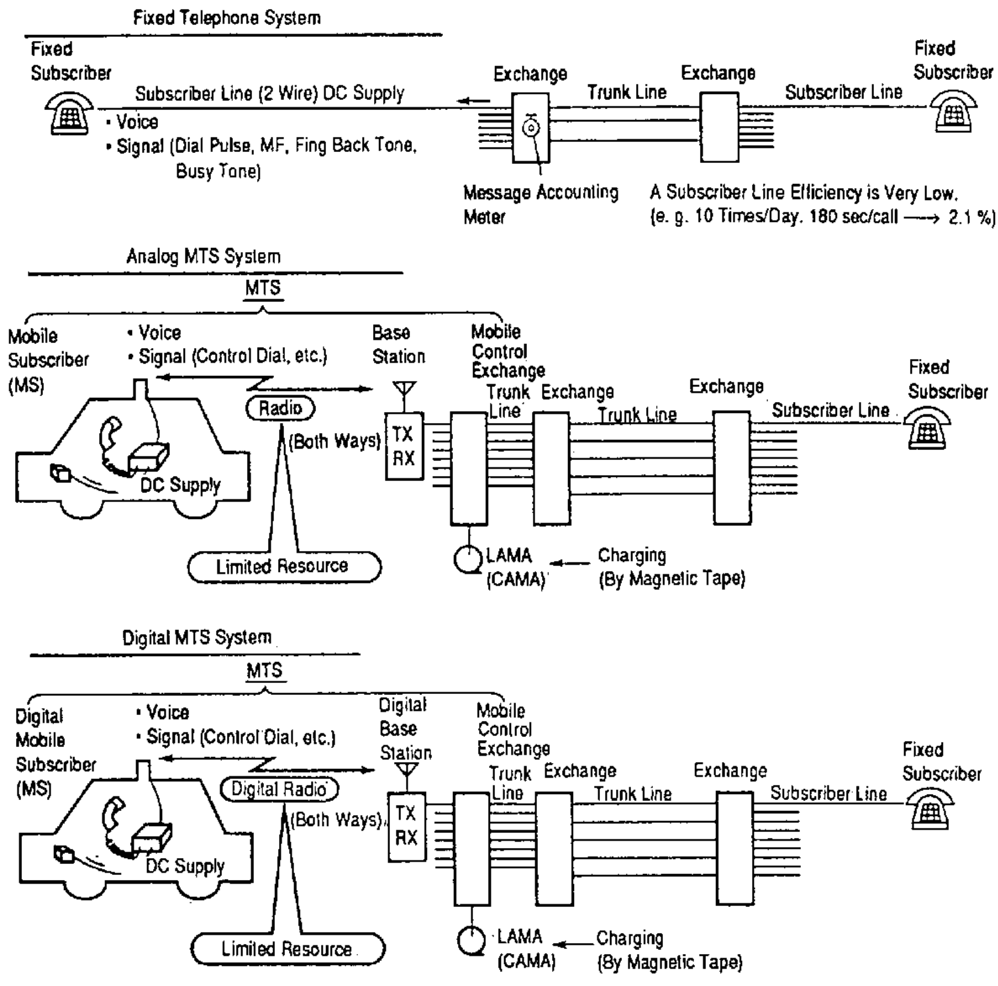


Figure 2 Comparison between Fixed and Radio Telephones

To realize efficient communications between each layer and minimize the total control time after a call occurs, system management is provided, connecting each layer. Figure 4 shows an example of the relation between the signaling structure and the PDC system configuration.

Concerning the interface of the PDC, the air interface is only specified by RCR STD-27 and the network interface between MSC, BSC and BTS is open.

(3) Control System

The control system is one of the important technologies for a cellular telecommunication system. It relates to system performance, investment cost and user services.

System performance is the efficiency of use of the radio spectrum, time delay for the traffic connection, time interval, and simplicity of the traffic control procedure. The PDC especially has the features of efficient use of the radio spectrum and simplicity in its traffic control procedures.

Some features of the control methods of the PDC differ from those of GSM.

(4) System Configuration

The system configuration of the PDC consists of two parts: a switching office and a base station. Depending on the system scale, a GMSC is provided separately from MSC in the

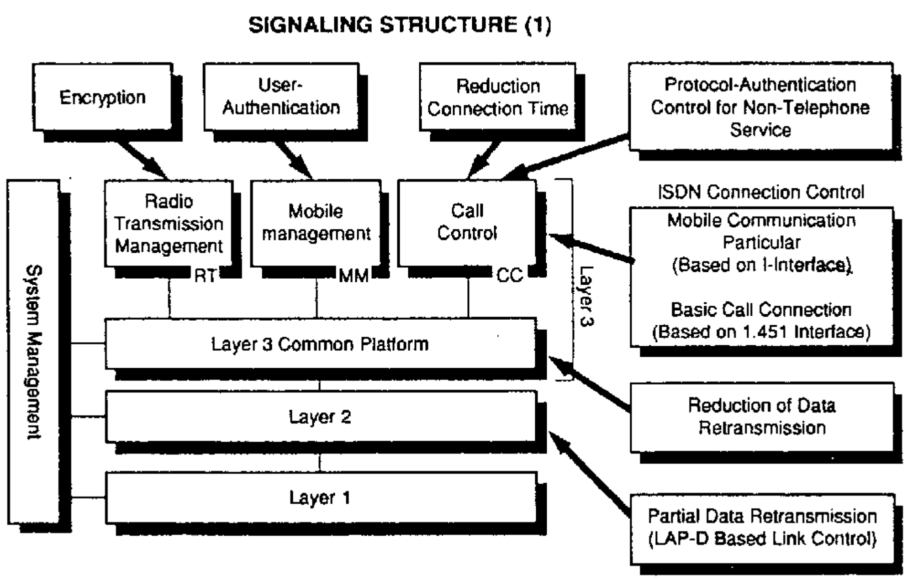


Figure 3 Signaling Structure (1)

switching office. The PDC has many features and services, supported by new network technologies. In urban areas, many base stations will be needed to increase the system's capacity. Optical fiber interface has been specified for micro-cell in the PDC STD-27.

Generally speaking, when the equipment or components of the system are designed under the specification, the compactness and economy of the system will depend on the simplicity of the specification. For example, more compact and more economical systems will be attained by fewer items of specification. The PDC aims at total economy of the cellular system by open interface not only at present but in the future with the estimation of an ultra-high integrated semiconductor.

Figure 5 shows an example of the system configuration of the PDC. Each operator can choose the most economical cellular system configuration, taking account of the user's service requirements.

Figure 6 shows an example of the basic configuration of the mobile switching center (MSC), consisting of four subsystems: the switching, processor, test console and application subsystems. The role of the switching subsystem is to act as an electronic switch for traffic channels, and the processor is for data processing and data memory. Depending upon the subscriber capacity, the processor can be expanded by the building block method. The application subsystem is the interface to the base station controller.

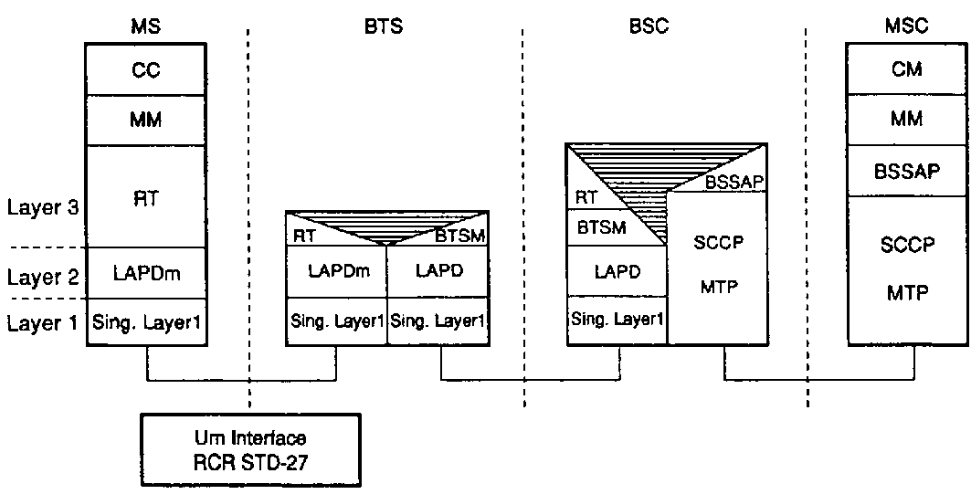
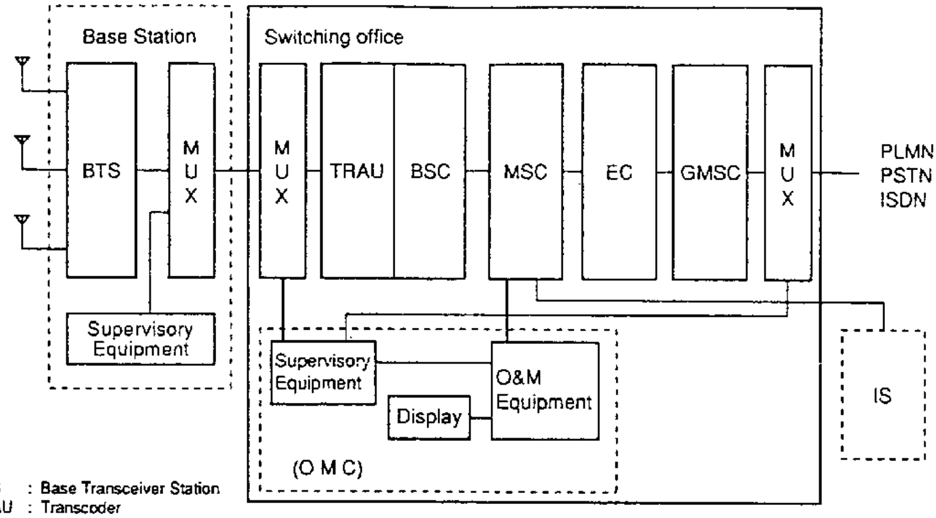
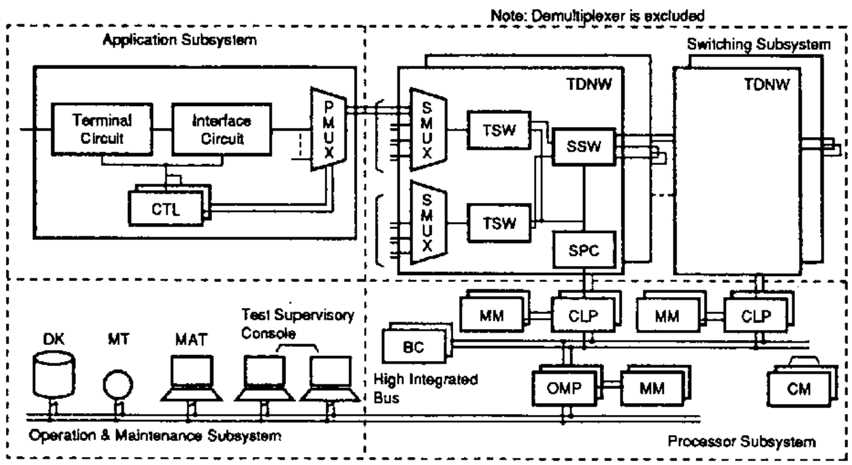


Figure 4 Example of Signaling Structure (2)



BTS : Base Transceiver Station
TRAU : Transcoder
BSC : Base Station Controller
MSC : Mobile Services Switching Center
EC : Echo Canceller
GMSC : Gateway Mobile Services Switching Center
OMC : Operation & Maintenance Center
MUX : Multiplexer
IS : Information System

Figure 5 Example of PDC System Configuration



BC : Bus Controller
CLP : Call Processor
CM : Common Memory
CTL : Controller
DKU : Disk Unit
MAT : Maintenance and Administration Console
MM : Main Memory
MTU : Magnetic Tape Unit
OMP : Operation and Maintenance Processor
PMUX : Primary Multiplexer
SMUX : Secondary Multiplexer
SPC : Speech Path Controller
SSW : Space Switch
TDNW : Time Division Network
TSW : Time Switch

Figure 6 Example of MSC Basic Configuration

The base station consists of the transceiver, whose function is conversion of the base band signal to/from radio signal, and the common amplifier, which simultaneously amplifies all radio signal channels of the same sector and supervisory equipment. In some cases, the base station controller is included.

The common amplifier is especially effective and valuable for reducing the number of racks configuring the base station.

Figure 7 shows the difference in transmitter configuration between the current analogue and the PDC system.

The common amplifier has excellent benefits for serving the dynamic channel assignment, downsizing and expandability because of its lack of frequency dominant devices such as bandpass filter in the output of each transmitter.

In order to amplify the multi-channel signals, super low distortion such as 60 dB IM and high power output should be required.

(5) Future Trends of the Digital Cellular System

Mobile communications will have the most important role in the informationalized society of the future. In the fixed network, the ISDN and Multimedia services have already started in the advanced countries, and are under study in many other countries.

The PDC is the most advanced digital cellular telecommunication system taking account of the future ISDN and Multimedia services in the personal communications age.

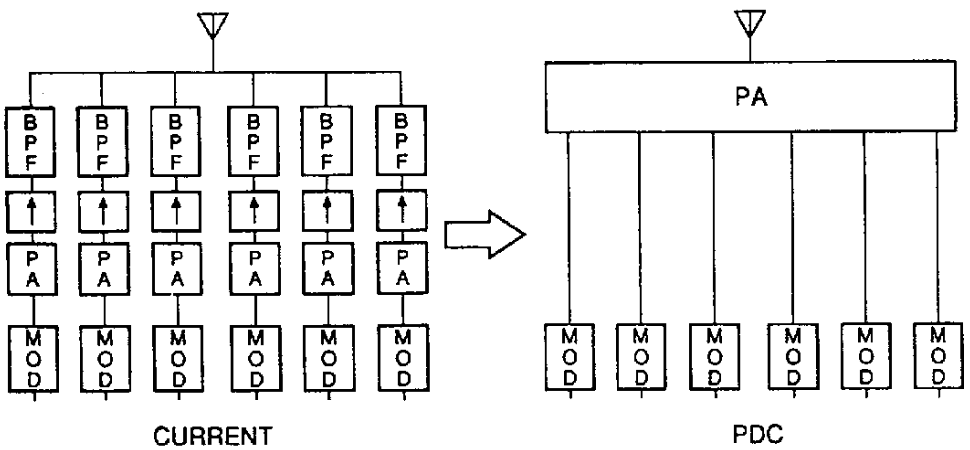


Figure 7 Common Amplifier of PDC (one example)

Also, in the future, an intelligent network, which manages the different kinds of mobile systems such as cellular, cordless, paging, and satellite systems, will be a key technology.

1) Network technologies

Figure 8 shows the one example of the future network configuration, called the "MCN" concept. In the future, various kinds of mobile systems will coexist and the harmonization of interfaces with the current network system will be required. The IN concept will be very valuable for integrating the various kinds of mobile services.

2) Base station technologies

In the future, in order to increase the mobile subscriber capacity within the limited frequency bandwidth, small, micro and pico cells will be needed and small portable type base stations will be required for total economy including the installation cost.

Figure 9 shows the trends of digital cellular systems and Figure 10 shows an example of an integrated base station including the approach radio link.

3) Personal Mobile Telecommunication

There are three kinds of digital cellular system: PDC, USDC, and GSM. Unfortunately no compatibility exists among them. But in the first step, by a technological breakthrough, compatible usage should be considered

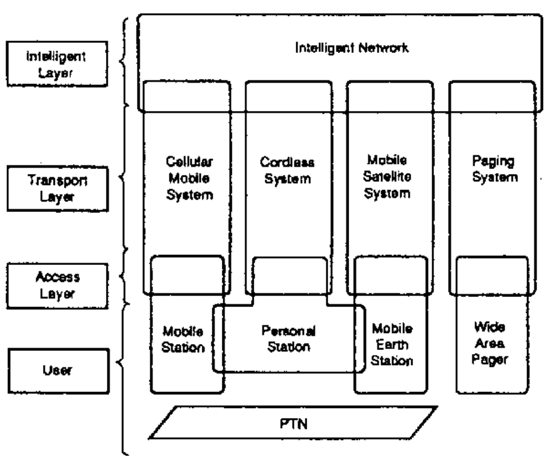


Figure 8 Structure of MCN (Mobile Communications Network)

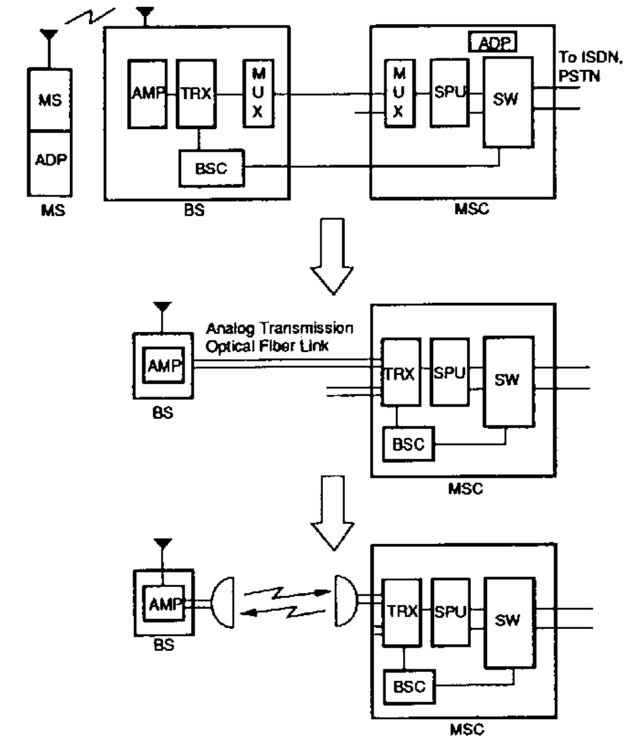


Figure 9 Trends of Digital Cellular System

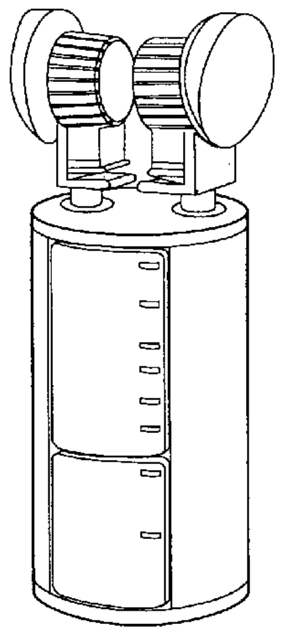


Figure 10 Integrated Base Station

for the end user's convenience.

As the second step, our final goal to the PCS (Personal Communications System) will be attained by FPLMTS (Future Public Land Mobile Telecommunication System).

The FPLMTS will be a global and personal mobile cellular system with the multimedia mobile services (See Figure 11).

(6) Conclusion

The PDC has been developed in Japan and includes enough functions for use worldwide.

The new network technologies adopted in the PDC will be applied to future mobile systems such as PCS and FPLMTS.

In conclusion,

1) The PDC is the user-oriented system with the most advanced technology.
2) The PDC is the most enhanced and efficient digital cellular telecommunication system.
3) The PDC is the best bridging system merging to the ISDN era.

References

A. Nakajima, M. Kuramoto, M. Yabusaki, (NTT Do Co Mo) "Intelligent Network Architecture for Personal Mobile Telecommunication", IEEE, ICUPC '92,12.6, September 1992.

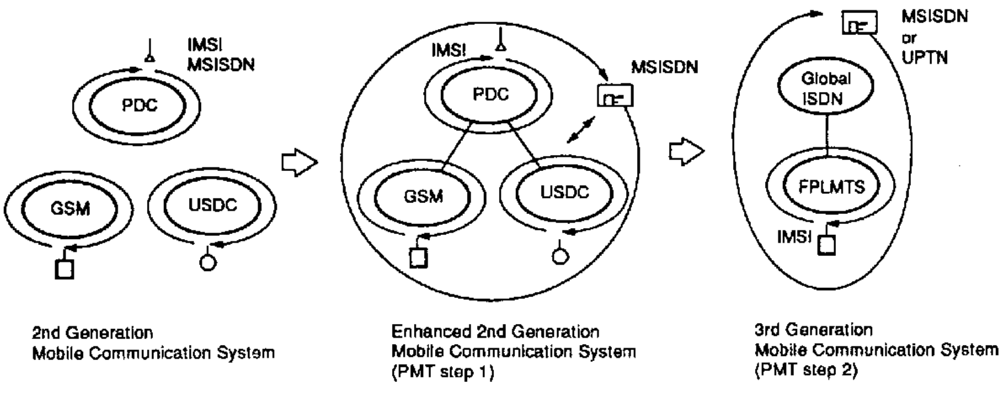


Figure 11 Steps towards Personal Mobile Telecommunications

Research and Development Center for Radio Systems
"Document on Digital Cellular Telecommunication System (JDC), July and August 1992"
"Document on Personal Digital Cellular Telecommunication System (PDC), March 1993"

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Digital Cellular Systems Technologies

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1. Introduction

In recent years, cellular mobile communication services using analog mobile radio systems based on FM radio technology have expanded to many countries and have shown a rapid increase in subscribers. To cope with growing demand, new digital systems were developed to help increase capacity and eventually replace the analog systems. The new systems, in which mostly TDM/TDMA access is used, include GSM in Europe, the personal digital cellular (PDC) telecommunication system in Japan, and D-AMPS in the U.S.

Japan's Ministry of Posts and Telecommunications assembled study groups and promoted the standardization of digital mobile radio systems. Cellular operators like NTT Mobile Communications Network Co. (DoCoMo) and manufacturers kept pace with these activities and designed the system, its equipment, and software. As a result, NTT-DoCoMo has brought the system into commercial service in the Tokyo metropolitan area starting from March '93.

Digital systems are attractive due to their efficient spectrum utilization, their potential for needing fewer and smaller components (both in the base station and the mobile terminals) making them less expensive, and their increased communication quality for voice, data, and image (FAX) services.

This paper discusses the major technologies used in digital cellular mobile communication systems. It features details on the radio-communication hardware technologies used in speech CODECs, high-power common amplifiers for cellular base stations, and portable phone units.

2. Speech CODEC Technology

The speech CODEC is an important technology for digital cellular systems. The Research and Development Center for Radio Systems (RCR) has standardized the vector-sum excited linear-prediction (VSELP) CODEC in Japan for full-rate (11.2 kb/s) systems.

Since such speech CODECs are not featured in analog systems, much R&D had to be carried out to realize devices that are both small and have low power consumption. Companies have developed dedicated DSPs using architectures optimized for considerations such as the CODEC algorithm and clock control.

Standardization work is now under way for a half-rate (5.6 kb/s) speech CODEC. When implementing algorithms more complex than VSELP, VLSI requirements become much more severe. Thus, the standard relies on the VSELP algorithm.

3. A High-power Common Amplifier for Cellular Base Stations

Size and cost effectiveness are the most important factors for base station components, since base stations are placed every 1 to 10 kilometers. Digital systems using low-bit-rate CODECs and TDM/TDMA can achieve larger capacities but still be smaller than analog systems. They are cost effective as well because integrated digital circuits can replace many analog components.

Analog systems have been plagued by their high cost, bulky antenna duplexer, and transmission and receiving equipment. Improving these components has been one of the challenges of cellular technology. One solution to this problem is to use common amplifier equipment in which a combined RF output from multiple low-power transmitters is boosted by a highly linear high power amplifier. To achieve the linearity required for the PDC system, a feed-forward distortion reduction circuit was developed. The common amplifier approach will likely be applied to GSM and analog systems, if the pass-band frequency and output characteristics can be tuned to the application requirements.

By using common amplifier equipment and other digital technology, the estimated size and weight of base station equipment can be reduced to less than one half of that of analog systems.

4. Mobile Terminals/Portable Phones

Both the baseband circuitry, such as the speech CODEC and the TDMA processor, and the RF section are affected by digitalizing the radio interface. The transmitter should satisfy conflicting requirements of high linearity and efficiency. The transmitter, the receiver, and the modem must additionally meet the requirements of TDMA regarding burst-mode operation.

TDMA allows receivers to detect the received-signal-strength-indicator (RSSI) signals used in different cells in idle time slots. A frequency synthesizer which switches much faster than those in analog systems enables subscriber-assisted fast handoff.

Figure 1 shows a simplified subscriber terminal configuration. Voice input is encoded in the VSELP CODEC. The output is fed to the TDMA processor to generate a data frame for transmission. The output modulates the carrier signal generated by the frequency synthesizer, is amplified in the transmitter, and then is fed through the duplexer to the antenna.

To implement diversity reception, a forward link signal is received by two antennas. Each signal is filtered and amplified, and the output signal is converted to an IF signal to be demodulated. The demodulated signal

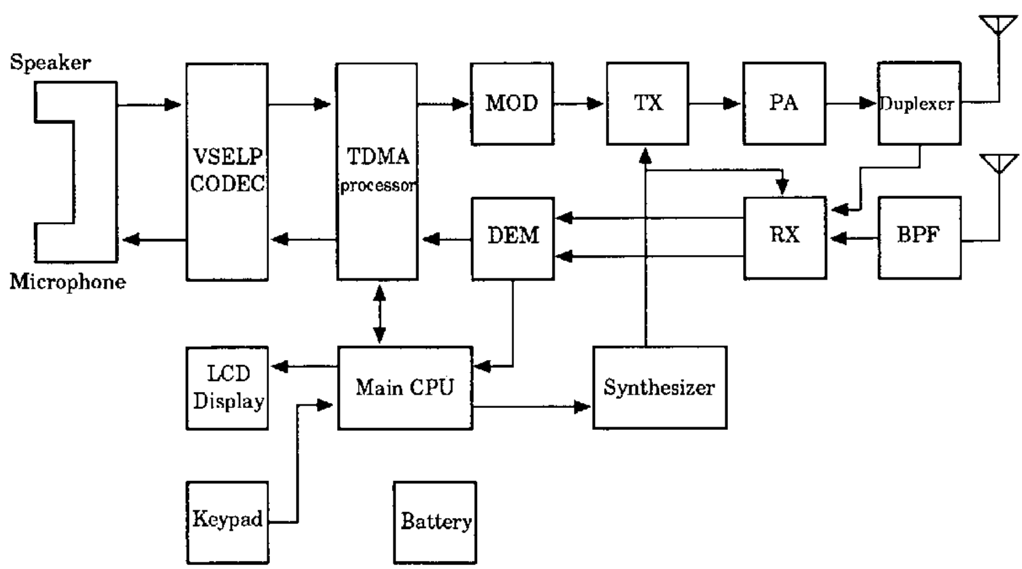

Figure 1 Configuration of Hand-held Terminal

is fed to the VSELP CODEC through the TDMA processor, where the voice signal is reconstructed. Individual sub-block circuitry is controlled by a dedicated main controller which deals with radio management, mobile management, and call processing. It also has a display and key-pad interface. All circuitry is driven by a suitable battery.

Various new technologies and LSICs have been developed for the digital cellular subscriber terminal. Digital cellular systems can be realized based on these technologies. A GaAs class-F power amplifier module has been developed with suitable linearity and high efficiency. A modulation baseband processor has been developed using the combination of a digital rolloff filter and a D/A converter. A direct-phase quantizing demodu-lator has been developed, where the received IF-signal phase is directly detected at symbol intervals. And a modem has been produced using CMOS to reduce power consumption. A synthesizer was developed using a Bi-CMOS process. The synthesizer can be made fully functional by combining the synthesizer IC with a voltage controlled oscillator.

The TDMA processor performs many kinds of layer-1 digital signal processing including random access control, frame synchronization, and transmission frame generation. Since the CPU in the TDMA processor has an active mode and a sleep mode, power consumption is minimized despite the highly integrated functions and high density.

The main CPU takes charge of call processing for layer-2 and layer-3 protocols. It is based on a 16-bit CPU core, including memories and some simple logic. The monitor program (RMT) installed is composed of macro procedures, interrupt procedures, and a task scheduler. When an event occurs, control is handed to the RMT so that the macro procedures can be executed. As in the TDMA processor, the CPU sleeps after command execution, and wakes up when an interrupt signal is received in order to reduce power consumption. These methods of reducing power consumption can aid in the design of any microcontroller that requires low power consumption.

Although a few years ago, the VSELP CODEC was considered a barrier to the realization of a digital cellular subscriber terminal, it has been successfully incorporated, due mainly to the development of this very low power DSP. Subjective estimation under deteriorating conditions confirmed that the speed quality had been improved.

To reduce the size of the subscriber terminal, it is necessary to assemble all the parts compactly. IC packaging and surface-mounted components are also important aspects of downsizing. To reduce size, a multilayer, ultrathin, printed circuit board has been developed. To conserve space in the layout, holes are not allowed to pierce through the board layers. The printed-circuit-board leadless chip-carrier package (PCLP) has been developed to enclose IC chips in a pit on the printed circuit boards surface. This enables high-density mounting and reduces weight. Another method to reduce size is the use of multi chip modules (MCM), where several chips are mounted both on and under board surfaces.

All these technologies enable the subscriber unit to have a volume of less than 150 cm^3-small and light enough to put in your pocket. The further progress of cellular phone technology will continue to contribute to these aspects of digital-subscriber-terminal construction.

5. Conclusion

This paper examined the pertinent technology being applied to radio-communication hardware for digital cellular mobile communication, especially those for speech CODECs, high-power common amplifiers for cellular base stations, and portable phones.

For a more complete view of digital systems, many other technologies must be mentioned. As the sphere of cellular technology continues to expand, digital systems will become the standard in mobile communication services.

References

(1) "Digital Cellular Telecommunication System RCR Standard," Research & Development Center for Radio Systems, STD-27B, 10 Dec. 1992.

(2) M. Kuramoto, et al., "An Outline of Digital Cellular Communication Systems," NTT Review Vol. 4, No. 1, January 1992.

(3) S. Uebayashi, et al., "Base Station Equipment Technologies for Digital Cellular Systems," NTT Review, Vol. 4, No. 1, January 1992.

(4) I. Shimizu, et al., "New Digital Mobile Radio Technologies," NTT Review, Vol. 4, No. 1, January 1992.

Personal Communications System -Evolution and Deployment-

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Abstract

As our information-aided society has grown, its communication structure has changed drastically. Third generation personal communications systems are being developed, where person-to-person connection should be able to be established. Furthermore, third generation systems should provide a variety of services dependent on personal preference. In this paper, we first propose a personal communications system that achieves the ultimate objectives of communications services. Second, we describe the service images and network architecture along with partitioning basic functionality. Finally, we focus on system deployment paying special attention to wireless access systems. The current status of personal phones, now known in Japan as the digital cordless phone, is shown.

1. Overview of PCS

The basic elements of personal communications are shown in Figure 1. The variety of media, the mobility, and the flexibility of services are essential benefits which will aid in promoting personal communications. Not only voice, but data and image service will be offered. As shown in Figure 2, personal communications will be enhanced to provide terminal mobility, personal mobility, and in the full-fledged stage, personalized accessibility.

The first priority will be to establish the physical layer with special attention to offering wireless terminal mobility. The handset must be small and light weight with long battery life, useable everywhere, and have a low to high degree of mobility so that a multilayered structure of radio cells can be used when accounting for limi-

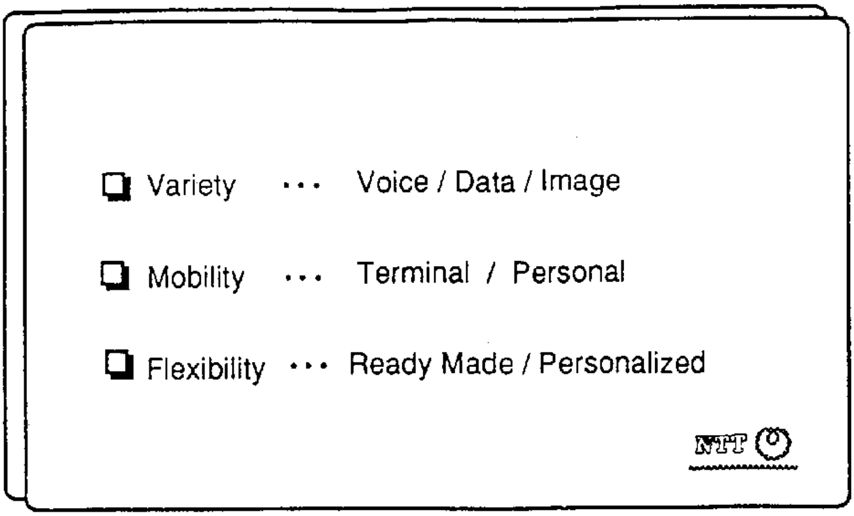

Figure 1 Basic Elements of Personal Communications

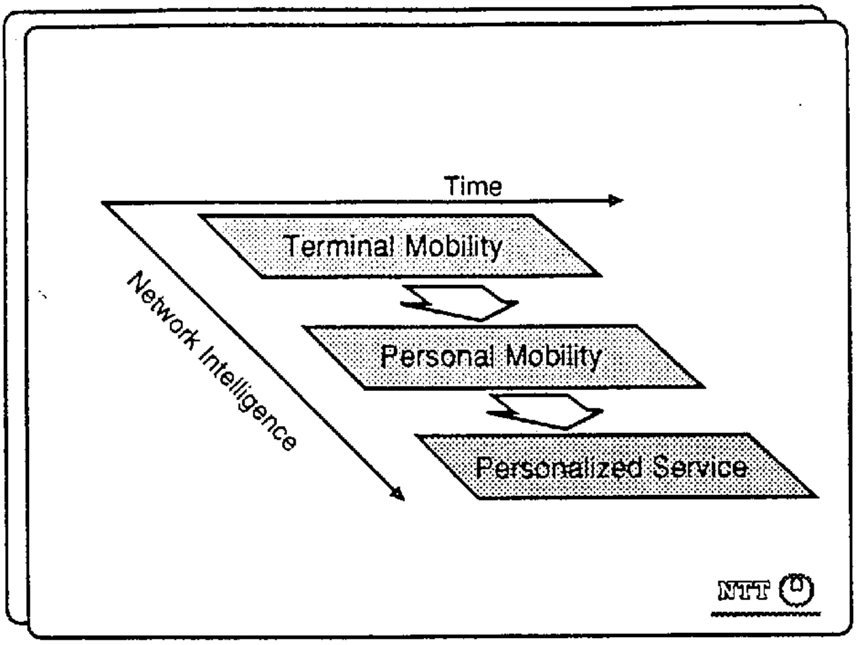

Figure 2 Deployment of Personal Communications

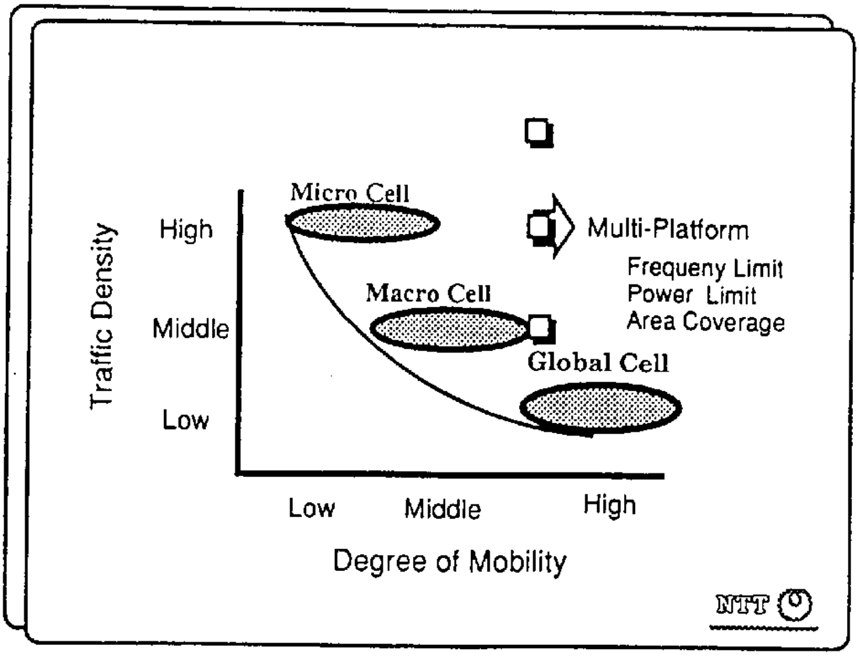

Figure 3 Multi-Platform for Terminal Mobility

Terminal Mobility

- Palm-top Handset with Long Battery Life
- Cordless
- Somewhat to Very Mobile

Personal Mobility

- Number Portability
- Billing to a Person

Roaming Capability

- Regional / Nationwide / Worldwide
- Public / Private System Compatibility

NTT

Figure 4 Terminal Mobility

tations on frequency, power and full area-coverage (See Figures 3 & 4).

Number portability and personal billing are essential for establishing personal mobility. Therefore, the personal communication number, which is logically derived, should be introduced. A person could have multiple personal telecommunication numbers depending on the propose of the line (i.e. business or personal).

At present no single network can provide full-scale personal communications in terms of variety, mobility, and flexibility. The capability to travel freely among networks is vitally important to guarantee a continuous connection.

2. Design Philosophy of Personal Communications

Design philosophy behind personal communications now being developed is shown in Figure 5.

(1) Integration of wired and wireless access

The personal communication system will provide communication despite

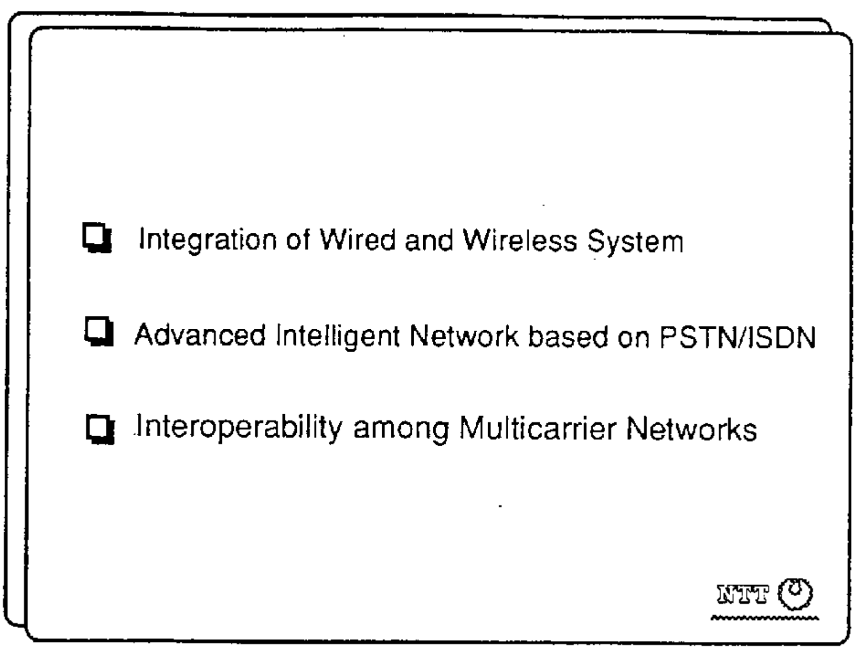

Figure 5 Design Philosophy of Network Architecture

location of users. It should guarantee both continuous wired and wireless access.

(2) Intelligent network based on the fixed public network

Deployment of personal communications should exploit the value of the fixed network to lower cost and speed introduction. Controlling intelligences should be added to the existing PSTN/ISDN to insure mobility and accessibility.

(3) Interworking with different networks

Interoperability or roaming capability among other networks is essential for guaranteeing continuous service. The point of interface (POI) between networks must be defined for traffic channel and signaling information.

3. Service Images

The basic service will connect a subscriber so that they can communicate instantly with anyone else anywhere by using a personal telecommunication number. Three requirements must be met: wired/wireless access, single number connection regardless of routing, and billing to a single person. The personal communication system can offer continuous service, if the networks have such information management functions as location registration, subscriber tracking exchange, and a logical communication number assigned to each subscriber. The service images are shown in Figures 6 & 7. Advanced services consist of "personalized" services that specifically respond to individual preferences. The service will be defined on the basis of the communication preferences requested by each subscriber with the personal telecommunication number. Several advanced services enhance the convenience for called parties. Thus, conventional calling-party oriented communications will evolve to assign equal importance to both the calling and the called parties. Examples of advanced services are shown in Figure 8.

4. Personal Communications Network Architecture

There are many functions that need to be established to provide personal communication services. Among others, location registration, number conversion, tracking exchange, flexible charging, large-scale databases, and security are the most important factors. These are shown in Figure 9.

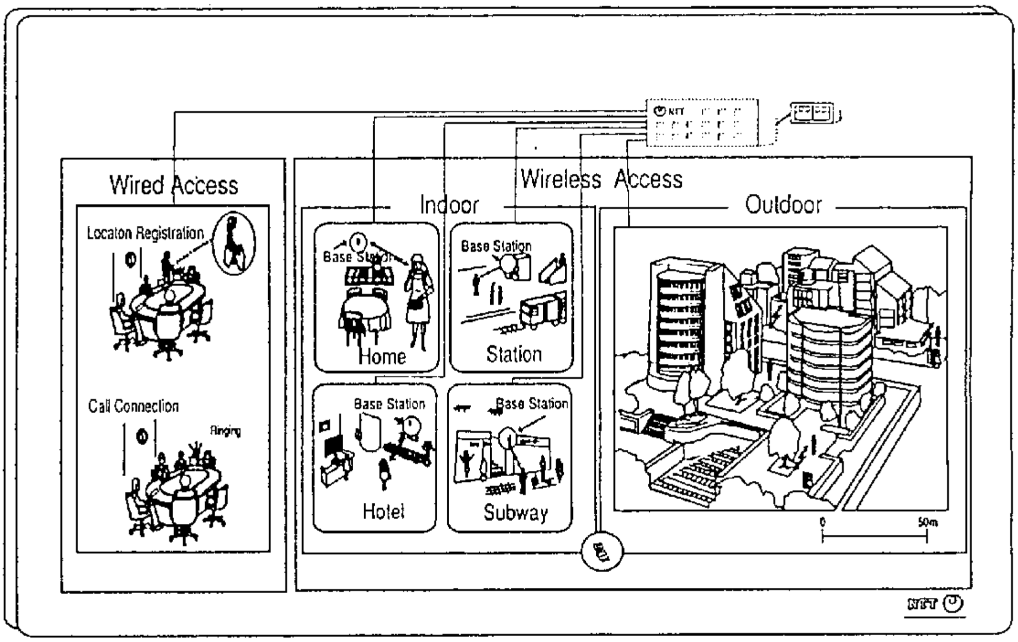

Figure 6 Basic Personal Communication Service Image

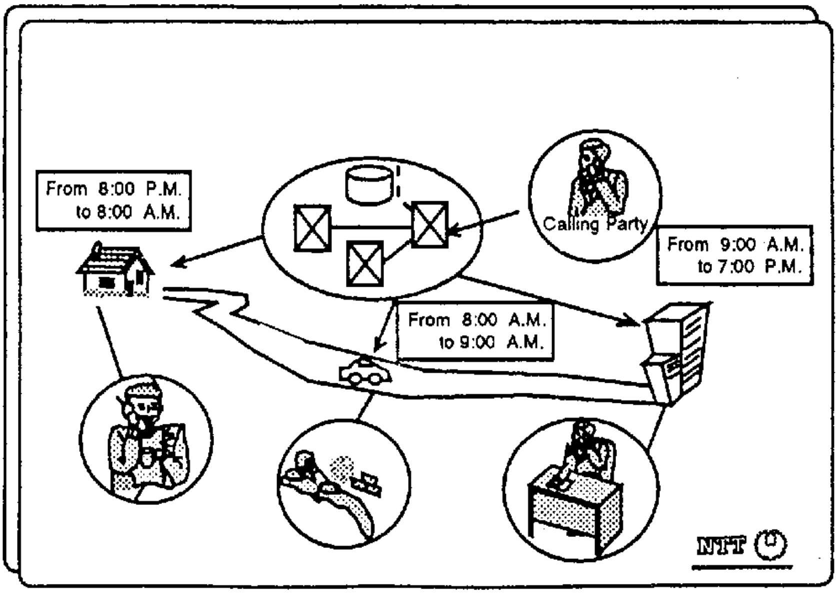

Figure 7 Scheduling Service Image

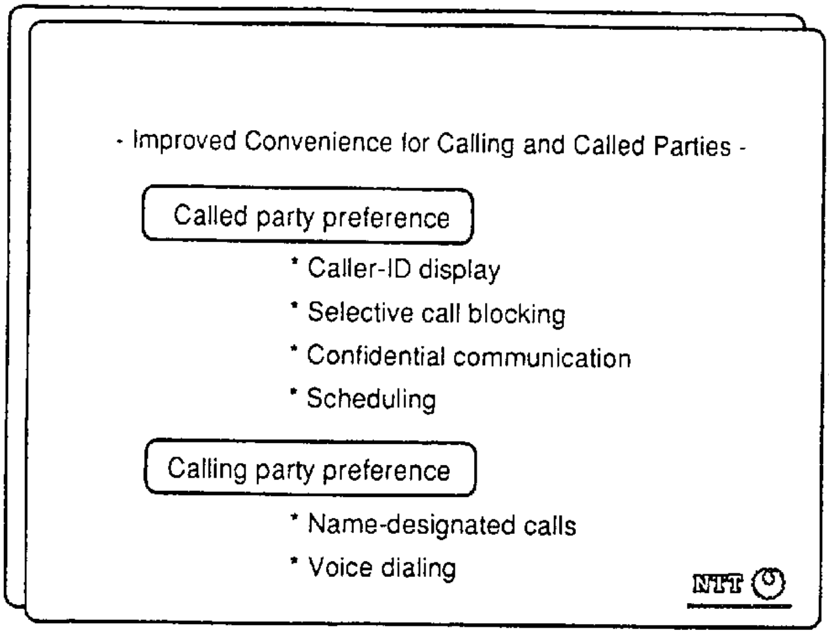

Figure 8 Advanced Personal Communication Services

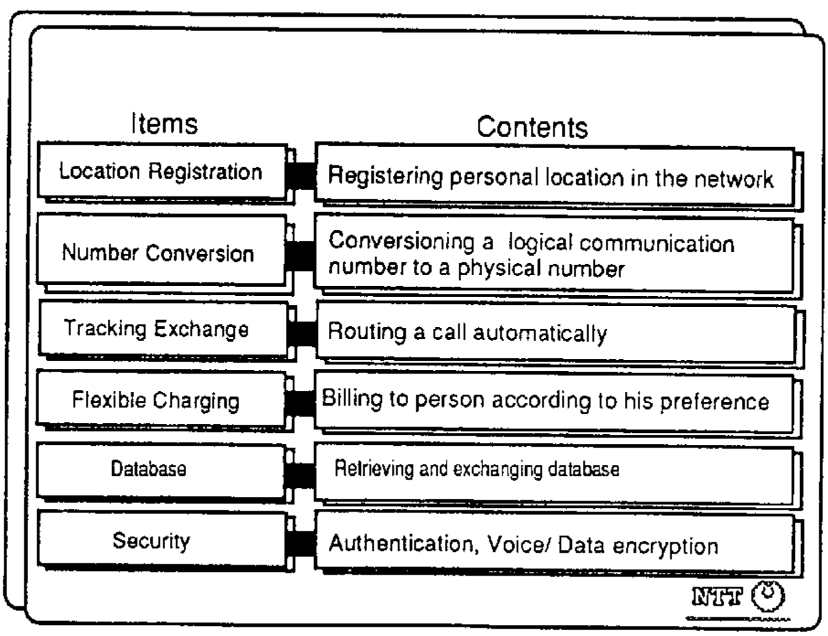

Figure 9 Required Functions for Personal Communication

The network architecture of the personal communication system is shown in Figure 10. The network is composed of the intelligence layer, transport layer, and access layer.

The upper intelligence layer consists of management control and the lower part consists of real-time service control, accessing large-scale databases. Personal information is memorized in the intelligence layer.

The transport layer is basically provided by the PSTN or ISDN. Its functions are to switch and transmit the subscriber information.

The radio access system is directly connected to the local exchange. The access layer has wired lines and radio access.

For the information signaling links, the PSPDN can be used for off-line and the common channel signaling network for on-line information.

5. Deployment of Personal Communications

The evolution of personal communications is based on enhancing fixed and wireless networks. Of the wireless systems, cordless systems with

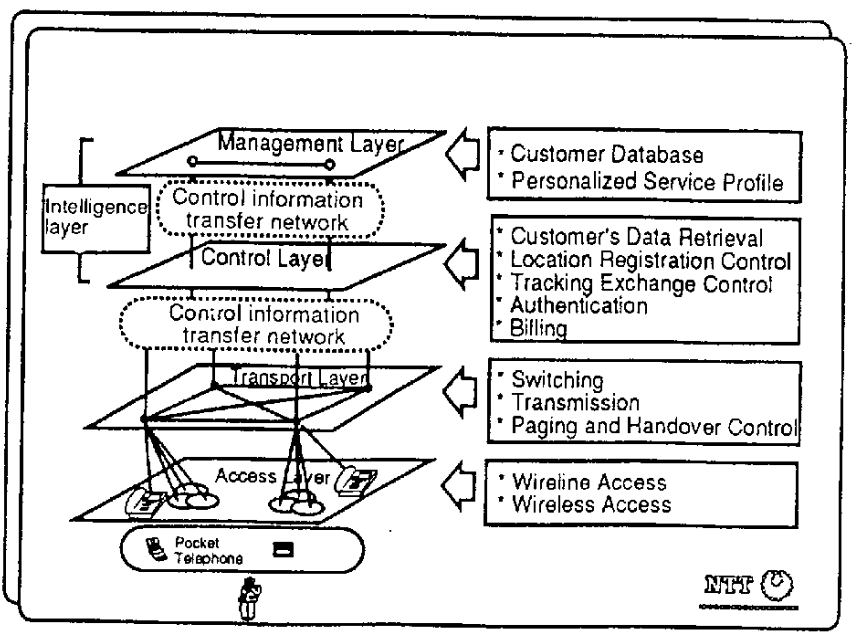

Figure 10 Personal Communications Network Architecture

fixed, advanced intelligence networks will play one of the most important roles, offering large capacity, cost-effectiveness, and excellent portability.

6. Personal Handy Phone

In Japan, a second-generation digital cordless telephone system has been introduced, offering new wireless services. This is called Personal Handy Phone (PHP). The aim of this system is to establish a common wireless interface for home, office, and public use as shown in Figure 11. This system will offer wireless access to the personal communications in the first phase.

The protocol structure consists of three phases. The first one is the link-channel establishment phase. The second is service-channel establishment phase. The last one is communications phase. The latter two phases are based on the OSI model as shown in Figure 12.

PHP system uses dedicated control channels, one for public use and the other for private use.

The major system parameters of the wireless interface are shown in Table 1. The access system is TDMA/TDD; four time slots are multiplied on a single carrier. The signaling rate is 384 kb/s, a reasonable speed if the average delay spread of 250 ns is taken into account.

Our PHP system is compared with CT-2 and DECT in Table 2. The DECT system is envisioned to provide offices with the ability to handle high-density traffic as well as data service, while the CT-2 system is a small traffic system for public and home use. The PHP system, however, is a medium traffic system for public, home, and office uses.

7. Conclusions

The concept of future personal communications is described. The basic ideas of its network architecture and system configuration, as well as several technical subjects are discussed. The proposed system introduces economically attractive and intelligent communications services at a large cost reduction and vastly increased capacity when established on the existing cellular mobile network.

8. Acknowledgment

The author would like to express thanks to Dr. K. Kohiyama, Director of Radio Communication Systems Laboratories for his helpful discussions and guidance.

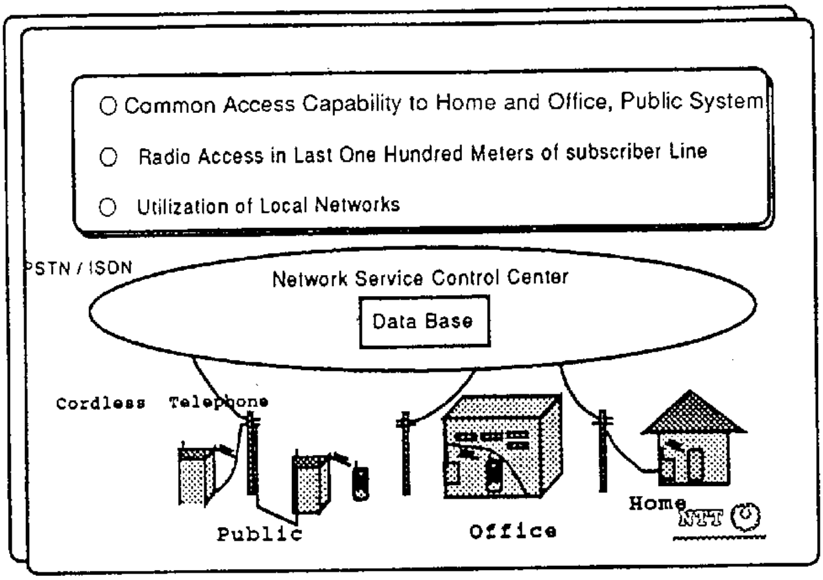

Figure 11 System Concept of PHP

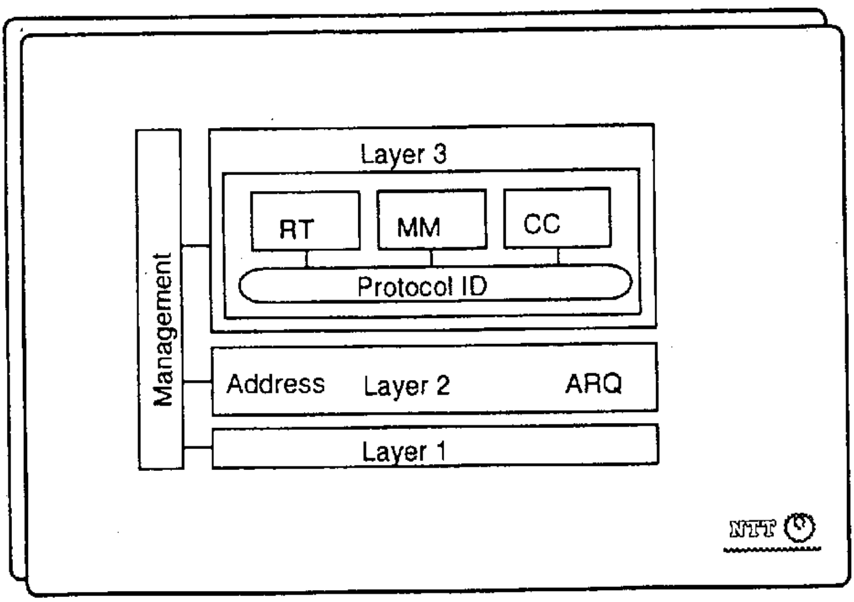

Figure 12 Layered Structure

Table 1 Major System Parameters of Wireless Interface

Frequency Band	1.9GHz
Access System	TDMA /TDD
Traffic Channels/RF Carrier	4
Modulation	$\pi/4$ - QPSK
Voice Codec	32 kbit / s ADPCM
Average Output Power (PS)	10mW (Portable Station)
Signalling Bit Rate	384 kbit/s
Carrier Spacing	300 kHz

Table 2 Comparison Between PHP and Oversea Systems

		PHP	DECT	CT-2
Country		Japan	Europe	England
Frequency Band		1.9GHz	1.9GHz	800MHz
Access System		TDMA (4cH)	TDMA (12cH)	FDMA (1cH)
Control Channel		Dedicated CC	Associated CC	Associated CC
Function	Incoming Call	○	○	×
	Hand Over	○	○	×
	Access Network	Digital / Analog	Digital	Analog
Uses	Public	○	△	○
	Home	○	△	○
	Office	○	○	△
Starting Time		1994/5	about 1994	1989
Evaluation		· Medium scale · High flexiblity	· High peak power · Vulnerability in daily spread	· Small Traffic System · Only Outgoing Call Capability

References

(1) D.C. Cox, "Universal Digital Portable Radio Communication," Proc. of the IEEE, vol. 75, pp. 436-477, Apr. 1987.

(2) T. Hattori, H. Sekiguchi, K. Kohiyama, and H. Yamamoto, "Personal Communication -Concept and Architecture-," IEEE International Conference on Communications, Apr. 16-19, 1990.

(3) J. Hoff, "Mobile Telephone in the Next Decade," Second Nordic Seminar on Digital Land Mobile Radio, Stockholm, Sweden, Oct. 14-16, 1987.

(4) P.A. Ramsadale, W.B. Harrold, "Future Personal Communications Systems," Fifth International Conference on Mobile Radio and Personal Communications, Dec. 1989.

(5) T. Hattori, A. Sasaki and K. Momma, "Emerging Technology and Service Enhancement for Cordless Telephone System," IEEE Commu. Mag., pp. 53-58, Jan. 1988.

(6) Report from Telecommunication Consultative Committee on "Technical Conditions of Personal Handy Phone."

Fiber-Optic Radio-Signal Transmission Technology

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1. Introduction

Personal communications will provide the ultimate in telecommunications services and enable anyone to communicate instantly with anyone else anywhere. The potential subscriber market is predicted to almost match the number of existing plain old telephone services (POTS) subscribers (1). Current development effort has focussed on microcellular radio, subcarrier multiplexing (SCM) fiber-optic transmission, and radio-spectrum-delivery switching technologies, since these are expected to be able to accommodate a large number of subscribers.

Optical subscriber loop systems using passive double-star (PDS) configurations are being developed worldwide to provide narrowband telecommunication and multi-channel video distribution services. This trend is expected to accelerate the transformation of local networks to optical configurations (2). However, the applicability of the PDS configuration to optical local-access systems for microcellular radio communications has only cursorily been studied (3).

This paper discusses SCM architectures suitable for fiber-optic radio-signal transmission systems. Technological barriers to the development of PDS fiber-optic local access systems for personal communications are also described.

2. Configurations

The configurations of fiber-optic radio signal transmission systems roughly fall into two categories: the single-star (SS) and the PDS. Optical fibers, which connect the central station (CS) to each base station (BS), are separately installed in the single-star configuration. On the other hand, the PDS configuration uses optical splitters between the central and base stations, decreasing the number of fibers converging on the central station by the splitting ratio.

2.1 Single-star configuration

The single-star configuration using the SCM technique, shown in Figure 1, has been well investigated. This yields robustness and flexibility to various traffic demands, because the spectrum delivery switch can assign any carrier and any timeslot of signals having frequency-division time-division multiple access with time-division duplex (FDMA/TDMA-TDD) to any base station (4). Although the single-star has several merits such as low optical transmission loss and no optical cross-talk nor interference, the optical link cost is higher than that of the PDS because of the increased number of fibers and optical devices required.

2.2 Passive double-star configuration

Figure 2 (a) shows a PDS system in which laser diodes are directly modulated by radio frequency (RF) signals. Different radio-frequency bands have to be assigned to each base station to avoid interference between nearby microcells. After optical fiber transmission, the individual signals are extracted by band-pass filters in the base station. Although the base-station equipment is simple using no frequency converters, broadband optical devices and electrical circuits are required.

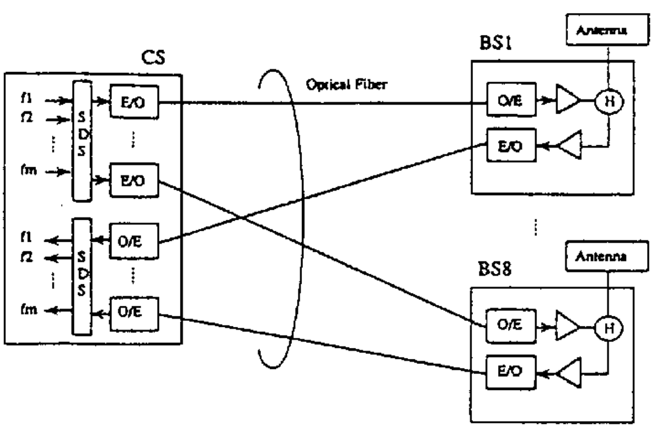
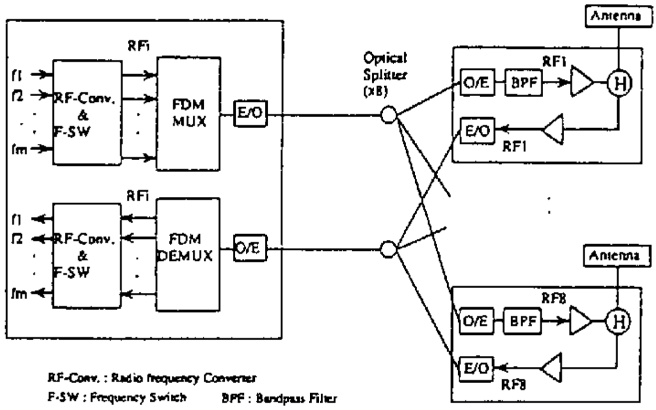
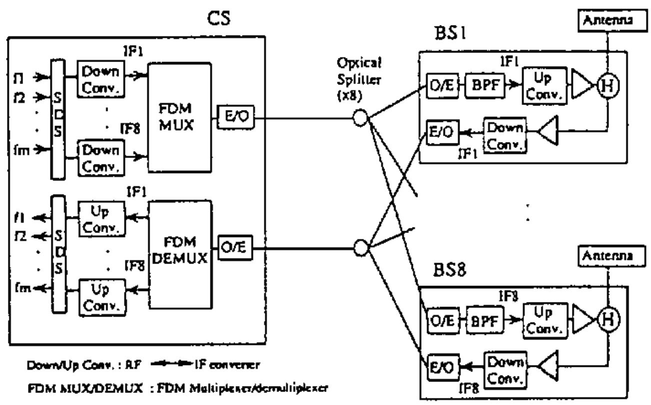


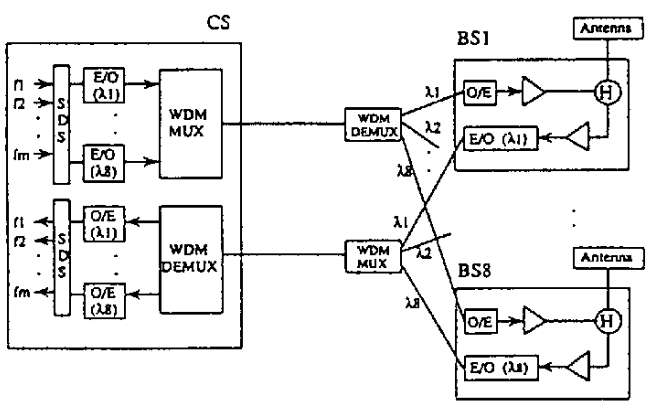
Figure 1 Single-star Configuration of a Fiber-Optic Radio-Signal Transmission System



(a) PDS-RF Scheme



(b) PDS-IF Scheme



(c) PDS-dense WDM Scheme

Figure 2 Various PDS Configurations of Fiber-Optic Radio-Signal Transmission Systems

PDS system shown in Figure 2 (b) uses an intermediate-frequency (IF) transmission scheme that predefines a different IF band for each base station. Incoming RF signals are converted into the base stations particular IF band before optical modulation. The bandwidth of the intermediate frequency is set to that of the air interface between the base station and portable terminals. Thus, this configuration has the same frequency reuse factor as the single-star. Frequency converters are required in both the central and base stations, but the broadband demands of the component optical devices are moderate.

Figure 2 (c) illustrates a PDS system that uses a dense-wavelength-division multiplexing (WDM) technique. Different wavelengths are assigned to each base station and WDM multiplexers and demultiplexers replace the optical splitters. This replacement minimizes the optical transmission loss of the PDS configuration because of the WDM multiplexers/demulti-plexers have lower attenuation than optical splitters. However, a method of precisely controlling the wavelength must be developed.

Table 1 compares the configurations, optical link cost, frequency reusability factor, network flexibility, and feasibility. The optical link cost of the PDS is generally half that of the single-star configuration. Because the intermediate frequencies and wave-

Table 1 Comparison of the Various Configurations of Fiber-Optic Radio-Signal Transmission Systems

	Single-star	Passive double-star		
		PDS-RF	PDS-IF	PDS-dense WDM
Optical link cost	1	~ 0.5	~ 0.5	~ 1
Frequency reuse factor	1	Less than 1/n	1	1
Network flexibility	Good	Bad	Good	Good
Feasibility	Easy	Difficult	Easy	Difficult
Comments	Near-term solution	Not applicable	Near-term solution	The best solution in the future

lengths are independent of which radio frequencies are used, the frequency reusability is high and a single-star configuration is logically achieved in the PDS-IF and PDS-dense-WDM configurations. It can be concluded that the single-star and the PDS-IF configurations are the best near-term solutions, since taking they can be easily realized using our present technology. The PDS-dense-WDM scheme is the best solution for future systems.

3. Fiber-Optic Radio-Signal Transmission Technology

When using subcarrier multiplexing for PDS access systems; two technological problems arise. The first is the difficulty of obtaining the same dynamic range offered by the single-star configuration and the second is the difficulty in suppressing optical beat noise in uplink transmission.

3.1 Dynamic range in uplink transmission

Because the radio-signal power received at the base station varies due to fading and the distance between the base station and portable terminals, a wide dynamic range is required for uplink communication in fiber-optic radio signal transmission systems. The dynamic range depends on the received optical power of the CS. Generally speaking, the total optical line loss of the PDS system is larger than that of the SS system due to the optical splitter loss. Dynamic range improvement is an important topic in development of PDS fiber-optic radio signal transmission systems.

The dynamic range is mainly restricted by the third-order intermodulation-distortion products caused by nonlinearities in directly modulated laser diodes. High carrier-to-noise ratios (CNRs) are difficult to obtain in conventional systems when small optical power is received, because the optical modulation index is limited by the laser diode's nonlinearity. On the other hand, very high CNRs can be obtained, even in regions receiving small amounts of optical power, by using signals in formats such as frequency modulation (FM) and pulse frequency modulation (PFM). By inputting constant signal power into the laser diode, the distortion generated by the diode's nonlinearity is suppressed and the carrier-to-noise ratio is increased due to the large optical modulation index. Therefore, converting the uplink signals from portable terminals into PFM or FM signals before optical modulation is an effective way to improve the dynamic range.

3.2 Optical beat noise

Besides shot noise and RIN (relative intensity noise), OBN (optical beat noise) produced by mixing different optical carriers at the photodetector in the PDS configuration may significantly restrict the dynamic range of the upstream direction (5). Figure 3 shows the experimentally measured RIN degradation caused by optical beat noise. This experiment used two optical sources: a 1.3-μm DFB laser diode with a linewidth of about 30 MHz and an Nd:YAG laser with a central wavelength of 1.319 μm and a linewidth of less than 5 kHz. The RIN peaks at the same frequency as the optical frequency differences (Δf = 1.8 GHz, 4.5 GHz and 17 GHz), that is, the difference in wavelength between the two optical sources. Cooper et al. reported that optical beat noise was negligible in PDS fiber-optic radio-signal transmission systems because of their narrow channel bandwidths (3). However, our experimental results indicate that, in this case, an optical frequency difference of more than 17 GHz is needed to suppress the noise. This means that it is necessary, even for narrow-bandwidth

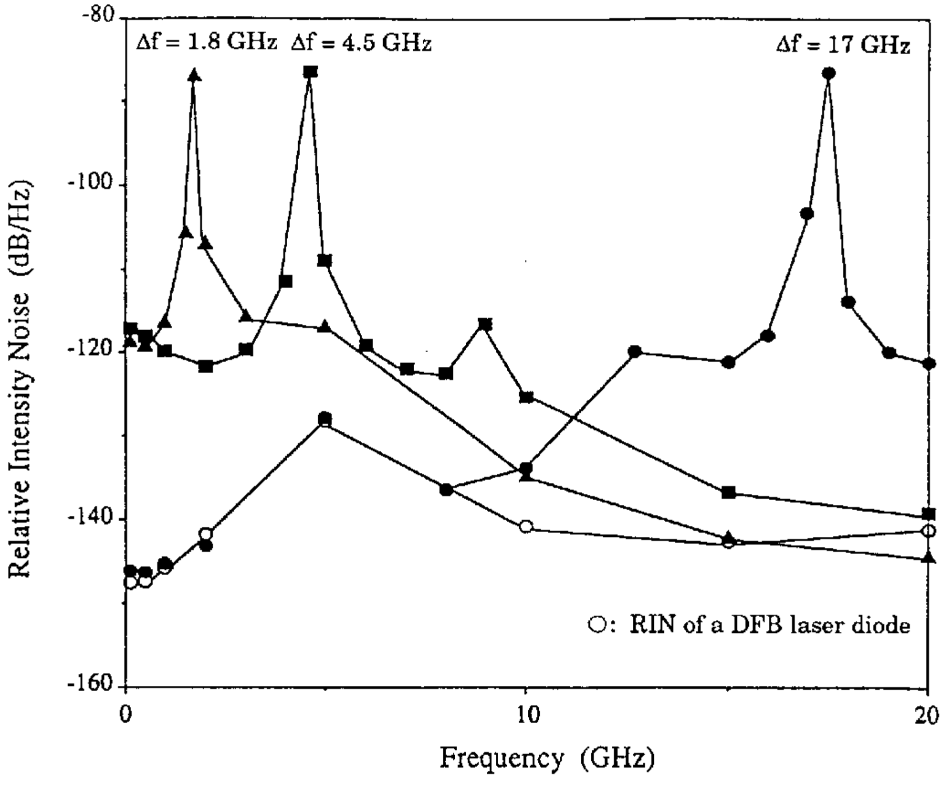


Figure 3 Experimental Results of RIN Degradation due to Optical Beat Noise

PDS systems, to control the wavelength spacing of optical sources in order to obtain a wide dynamic range.

The optical-beat-noise intensity mainly depends on the optical-source linewidth and wavelength difference. Possible OBN suppression methods are summarized in Table 2. When broad-linewidth optical sources such as super-luminescent diodes (SLD) and edge-emission light emitting diodes (E-LEDs) are applied, it is necessary to improve the linearity and high-frequency characteristics of the devices and to consider fiber chromatic dispersion which acts to limit the transmission distance. A superimposed modulation scheme can be used to reduce the optical beat noise because the laser diode's linewidth is broadened by sidebands that arise when superimposed signal has a higher frequency and modulation index than the original signals. However, it is felt that the superimposed modulation scheme may degrade the distortion characteristics of laser diodes.

Wavelength control methods are the most effective way of suppressing the optical beat noise. If the wavelength differences among optical sources are more than 0.1 nm, RIN degradation due to optical beat noise becomes negligible, as shown in Figure 3. Producing a DFB laser diode with this level of wavelength difference and using thermo-electronic control are

Table 2 Optical Beat Noise Suppression Techniques

Method		Point
Linewidth control	Broad-linewidth optical sources	- Linearity and bandwidhth - Transmission distance limitation due to chromatic dispersion
	Superimposed modulation	- Degradation of LD linearity
Wavelength control	Tunable LD	- Linearity and RIN
	LD array with different wavelength	- Small wavelength deviation of each LD
	Selection of single longitudinal mode LD with different wavelength	- High-yield productivity

the only ways to quickly realize wavelength control schemes. A tunable laser diode or an optical array device that integrates laser diodes of different wavelengths is indispensable in realizing wavelength control. In this case, continuous tunability is not needed but a broad range is required. Unfortunately, no existing tunable laser diode or laser-diode array are applicable to SCM transmission systems. Further progress in optical devices is needed before this scheme can be realized.

Figure 4 illustrates the best PDS configuration for personal-communication local-access systems. Intermediate-frequency transmission is utilized when downlinking to achieve a high frequency reuse factor and flexibility equivalent to that of the single-star configuration. Dense-WDM technology is applied to suppress the optical beat noise. A wavelength difference of more than 0.1 nm among optical sources are easily achieved by means of thermo-electronic control and conventional analog DFB laser diodes. PFM modulation is also used to get a wide dynamic range for link transmission. As shown in Figure 4, optical splitters are used to reduce the system cost. If a wider dynamic range is required, a WDM multiplexer can replace the optical splitter for the uplink and a dynamic range almost identical to the single-star configuration can be achieved.

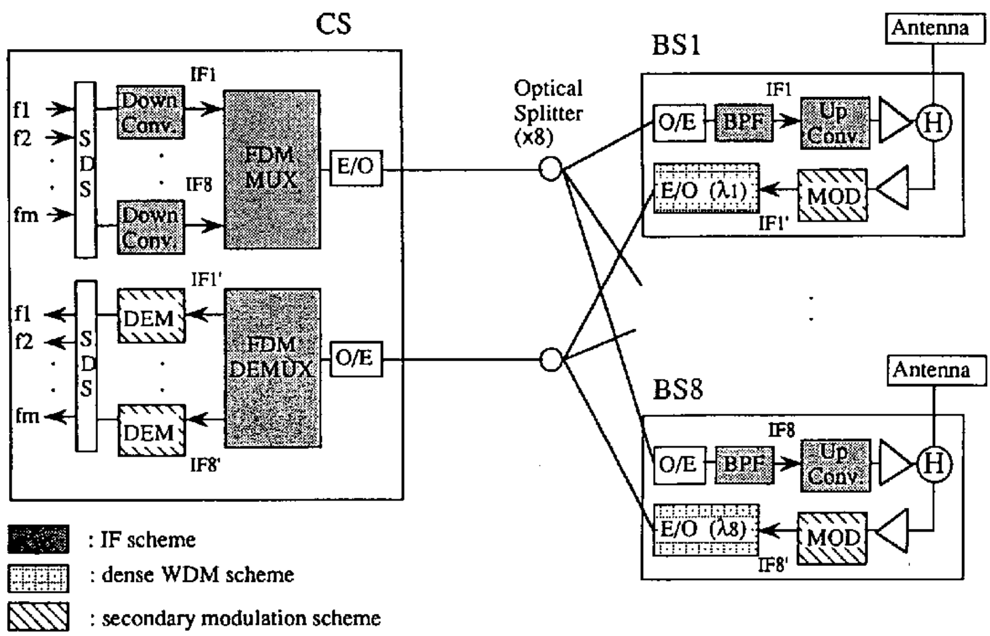


Figure 4 A PDS Configuration Suitable for Microcellular Systems

4. Conclusion

The architecture and technologies of several fiber-optic radio-signal transmission systems were described. The single-star and PDS-IF transmission schemes are superior near-term solutions, while dense-WDM technology promises to be the best solution for the future.

I concluded that the dynamic range of PDS must be improved. Possible solutions include pulse-frequency or frequency modulation and optical beat noise suppression. Further investigation of wavelength-control technology and tunable optical devices should be pursued.

Acknowledgements

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References

(1) T. Hattori, H. Sekiguchi, K. Kohiyama, and H. Yamamoto, "Personal Communication-Concept and Architecture," in Proc. ICC '90, pp. 1351 - 7, 1990.

(2) "The 21st-Century Subscriber Loop," special issue of IEEE Communications Magazine, Vol. 29, No. 3, 1991.

(3) A. J. Cooper, D. M. Smith, and R. P. Merrett, "CTPON-Cordless Telephone Services over a Passive Optical Network Using Fiber Radio Techniques," in Proc. ICC '92, pp. 91 - 6, 1992.

(4) H. Ohtsuka, R. Ohmoto, H. Ichikawa, M. Ogasawara, and T. Murase, "A Subcarrier Transmission Approach to Microcellular Systems," in Proc. ICC '92, pp. 82 - 6, 1992.

(5) C. Desem, "Optical Interference in Subcarrier Multiplexed Systems with Multiple Optical Carriers," IEEE J. Sel. Areas in Commun., Vol. 7, No. 7, pp. 1290 - 5, 1990.

Network Technology for Personal Communication

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Abstract

Universal personal telecommunication (UPT) is more than just a means of introducing "personal mobility" services into the public switched telephone network (PSTN). Revising the PSTN for universal personal telecommunication implies dramatic changes to the PSTN design framework. This paper focuses on these changes from three viewpoints: call control, Intelligent Network design, and UPT service.

1. Introduction

"UPT enables access to telecommunication services while allowing personal mobility." This is the opening sentence of the UPT definition in draft recommendation F.850. To provide personal mobility, network designers need to focus on three basic questions:

(1) How does the UPT number affect the PSTN call control schemes? Considering that a UPT number will play a future role as important as today's telephone number, it is important to reexamine three basic PSTN considerations - numbering, routing and charging - and discuss methods of UPT call control.

(2) What demands will UPT make on intelligent network (IN)? Clearly, by introducing UPT, an increase in the diversity of IN services will be required. This paper describes the two main requirements that need to be satisfied to prevent increase in complexity arising from UPT operations and outlines four technical proposals aimed at satisfying these requirements.

(3) What kind of UPT services are desirable to the user while being sufficiently cost effective for network service providers? This paper cites some examples of popular UPT services and introduces a recommended implementations.

2. UPT's Impact on PSTN Call Control

2.1 Basic principles

Numbering, routing, and charging are considered the three major design aspects of the PSTN. Their basic principles and the impact of UPT on their design can be listed as follows:

(1) Numbering

Trunk circuit selection (routing) is the design that best meets PSTN requirements. Whereas the telephone numbering plan is closely related to the subscriber's geographical location, a UPT number must be independent of location. Therefore, UPT assures free assignment of a UPT number, but at the same time, requires a routing mechanism that can manage the assignment efficiently.

(2) Routing

Being location-independent, UPT numbers cannot be utilized directly as a means of routing. As shown in

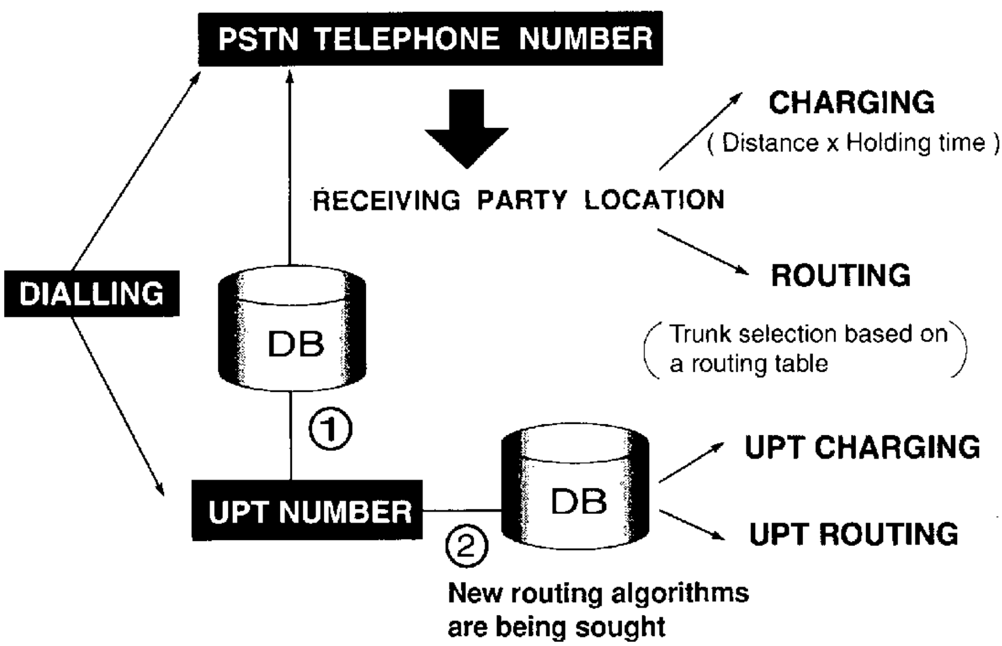

Figure 1 UPT Calling Routing

Figure 1, one way to solve this problem is to translate the UPT number into a destination telephone number. This method is now generally accepted and is also compatible with the trigger-table-based call control of the intelligent network. While being presently feasible, this method will probably be replaced in the future with a faster and more efficient PSTN routing algorithm.

(3) Calculating service charges

PSTN charges for the subscriber vary with call duration and communication distance. Distance information can be easily generated when using destination telephone numbers, but UPT numbers do not contain distance information. However, by translating the UPT number into a destination telephone number, the distance information is automatically calculated. Depending on the kind of services provided, alternate methods of calculating line charges will also be needed.

2.2 Examples of UPT call control

The degree to which the PSTN design must be restructured to accommodate the UPT protocols can be minimized by introducing a database that translates UPT numbers to destination telephone numbers. However, a better way to include new UPT services would be to enhance the service's capabilities by using a new algorithm. New algorithm should be considered because the UPT numbering scheme is still very basic and may not be able to accommodate new UPT services.

(1) UPT incall general routing model

Figure 2 illustrates the UPT incall general routing model, newly drafted in recommendation E.174. After receiving a UPT number, the serving exchange sends a query to the database, which then profiles UPT services to get a destination telephone number. Upon receipt of this number, the serving exchange routes the call to a destination node according to predefined (E170-3) routing principles. Determination of call control is generally regarded as the first step in establishing UPT services.

In this model, query overhead is not negligible, especially if considering global UPT service and providing a world-unique UPT number (such as the CC (UPT) + NDC (non-CC) + SN number described in "Scenario 3 - The global (country code-based) scheme" of the drafted recommendation E.168).

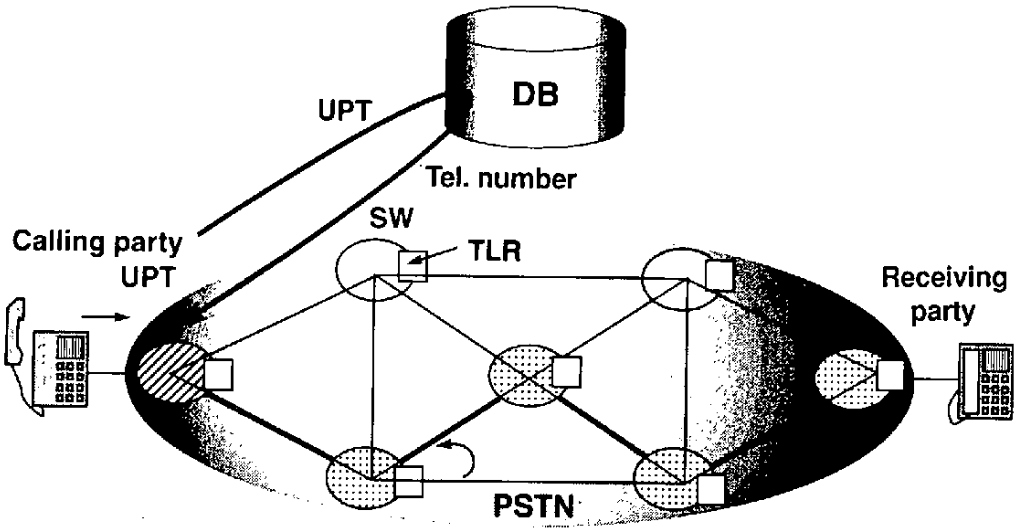

Figure 2 UPT Incall General Routing Model

Therefore, a new method of minimizing database query overhead is necessary.

(2) UPT database hierarchy

Generally speaking, calls are normally routed to geographically close locations; thus, database query overhead can be decreased by introducing a UPT database hierarchy. Most UPT calls can get a destination telephone number from a local database rather than a national or international one.

Hierarchical databases can handle most UPT queries, but sometimes access to several UPT databases is required to complete a query. Searching for a UPT number over several databases can be especially time consuming and expensive for global UPT service. To increase personal mobility, methods of decreasing the overhead of UPT number searching must be sought.

(3) Two-stage database querying

Figure 3 illustrates a proposal in which each UPT call has two stages of database query. The first is to a UPT directory database that trans-

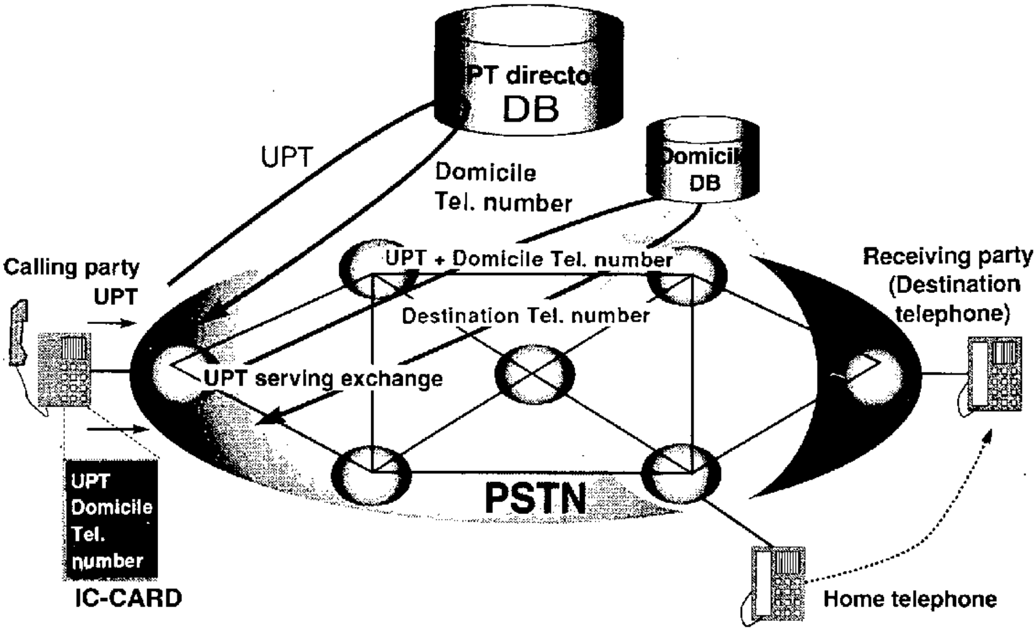

Figure 3 Two-Stage Database Querying

lates the UPT number into a domicile telephone number, while the second is to a domicile database where the destination telephone numbers can be checked against registered numbers. Key issues of this proposal are the following:

(a) Incall/outcall registration is done only at the domicile database, thus eliminating transaction traffic due to call registration.

(b) For the second query, the UPT serving exchange always directly accesses a domicile database (even in global UPT service). Therefore, this two-query method simplifies the UPT query sequence, a contribution that becomes significant for large UPT networks.

Furthermore, if a UPT device (defined in the drafted recommendation F.851 as a device that helps a user to interact with the UPT service) such as an IC card stores both the UPT number and the domicile telephone number, then the first query can be eliminated.

(4) Addition of an idle check sequence

In addition to other benefits, the introduction of the UPT will be a strong stimulus for improving PSTN call control. By adding an idle check sequence between the database and an ongoing telephone exchange, we can improve the performance of the UPT incall general routing model. This is particularly important because the UPT call-completion ratio is predicted to be lower than that of general telephone call if using comparable systems.

(5) Traffic-status-related routing

Another possibility for improving PSTN call control would be to introduce traffic-status-related routing. With this modification, when a UPT serving exchange sends a query to a database, the database would respond with routing information in addition to the destination telephone number. This routing information is generated by the database by referring to recent traffic data. The key advantage of this proposal is that it will allow location-specific traffic control to be communicated directly from a nearby database node.

3. Demands on Intelligent Network Architecture

3.1 UPT requirements

The intelligent network (IN) will be a new telecommunications software set aimed at providing a variety of new PSTN services. The IN will be capable of providing an environment for service creation. UPT's diversification of personalized services and location-free service will put a lot of demands on the ability to create new services. The two major requirements of this service creation environment are:

(a) Requirement A: Simple service creation and distribution

UPT service scenarios are generated within the service creation environment and then distributed to intelligent network databases. As the number of service scenarios increases, a simplified and automated mechanism of distribution will be necessary.

(b) Requirement B: Service scenario mobility

UPT allows personal mobility. This means that service scenarios should follow the user when they change their PSTN region. Therefore, service scenario should be compact and relocatable over the PSTN.

3.2 Key technical issues

To satisfy these two requirements, we propose the following:

(1) Message-interaction-based service sequence description language

Describing UPT services as a group of event series (that is, a set of message-exchange records [destination/order] and procedures) has advantages when adding or modifying UPT service scenarios. The compiler can easily check for message loss and nondeterministic actions (lack of blanching condition) by tracing old event sequences and newly added ones.

Furthermore, the integration of identical event sequences between old and newly added scenarios can be automatically processed. In this way, a revised UPT service scenario can be generated and distributed within the IN without relying on human intervention.

(2) Independent service scenario management

A particular service scenario should be managed independently of other service scenarios. As the number of UPT service scenarios increases, central management of all scenarios will be ineffective because the increase will make scenario management more complex and less efficient.

Independent management requires more UPT service-scenario memories for storage, but managing the scenarios will become significantly easier.

(3) Separation of core service functions and user-defined service functions

Service scenarios can be divided into two categories: core service functions are the principal network services provided by all PSTNs (services like dialling, ringing, connection, and charging), while user-defined service functions are a user's scenario-dependent functions, such as terminal type and the conditions under which a call is answered.

By separating the service functions into these two categories, UPT service can be better described because the categories limit the size of the amount of information necessary. A user sees only the UPT service scenario interface; the PSTN inner functional structure is a black box. On the other hand, a network designer sees only the interface; the user-to-user interactions can be processed by independent routines, such as a user-level negotiation services. Calls are processed by cojoining three service functions: the core, the user-defined, and the interfacing service functions.

(4) User-defined service scenario mobility

A user-defined service scenario is checked and then translated into a service scenario process. This process should be generated at the UPT node from where the user is requesting the service. The service scenario process enables the UPT service to cooperate with core call-processing objects. When a service is terminated, the service scenario object is removed.

4. UPT Services and Their Prospects

4.1 Popularity of UPT services

UPT is attractive because it improves and expands on current PSTN services. To gauge the effect of UPT, the Japanese Ministry of Posts and Telecommunications organized a study group in 1991. This study group proposed many UPT-based services and estimated the popularity of each by analyzing questionnaires answered by workers in industry and students. Some of the results from these questionnaires are shown in Figure 4. The names of the UPT services shown in the figure are not the same as those specified in the ITU-TS (previously called CCITT) documents. The study group concluded from this figure that UPT services can be characterized as follows:

(a) Two types of UPT numbers are utilized: a calling-party UPT number and a receiving party UPT number. Both types are necessary.

(b) One user should be able to have more than one UPT number, such as a business UPT number and a private UPT number.

(c) The service operation bottleneck occurs at incall/outcall registration. Thus, a UPT device that can aid in both UPT service management and in backing up UPT service operations is indispensable.

The most popular services as shown in this figure are caller name display, callee specified call, and calling UPT screening. However, chase call (A UPT number calling) and location display were not very popular.

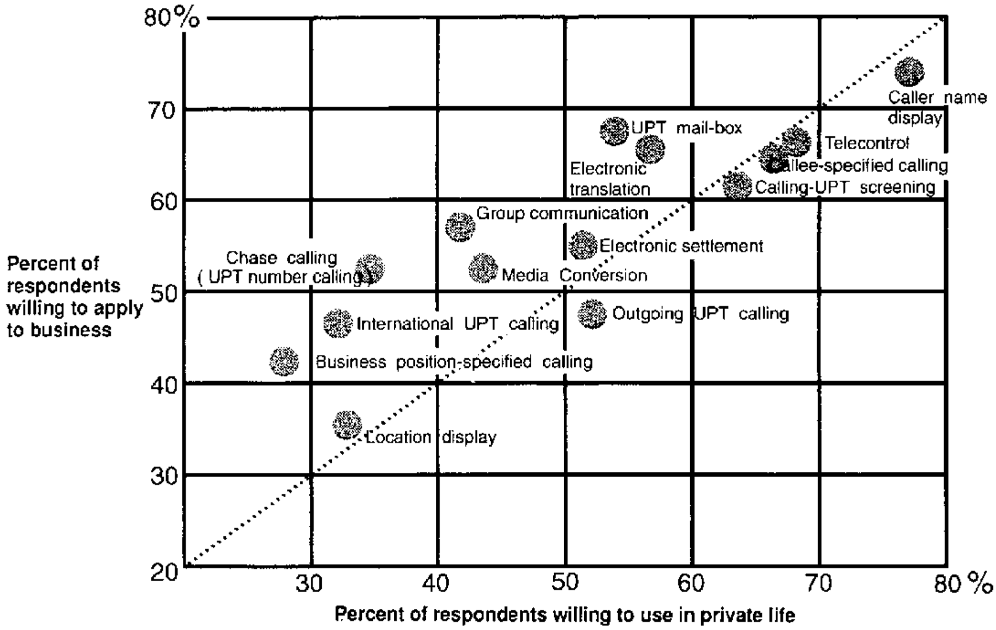

Figure 4 User Expectations of UPT Services

4.2 Private call

Private call ("Calling party identification presentation" in the terminology of F.851) is a UPT service that would ask the caller to identify themselves. The identification data (such as name, affiliation, and a photo) would be registered in the caller's UPT device. Upon viewing the information, the receiving party can decide whether or not to respond. By pushing a "busy" button, the receiving party can instead have the call transferred to an answering machine.

Private call has been implemented in our laboratory on a multimedia terminal that was remodeled by adding an ISDN interface and an IC-card reader/writer. The UPT device has an IC-card that can record caller information from the last ten UPT calls. The caller's information data is transferred in a D-channel packet. Our implementation indicates that the image data needs to be transferred using the B-channel because the D channel does not have enough throughput.

The private-call service is not expected to be an important UPT service. Rather, it should be regarded as an example that shows that UPT offers telecommunication services that are considerate of the receiving party, unlike normal telephone services, which are often considered an unwelcome invasion into the receiver's private life.

4.3 Automated starting and stopping of service

Another proposal is the automated starting and stopping of service. Suppose that a PSTN customer moves from Tokyo, Japan, to Weimar, Germany. In Tokyo, he put his UPT device into a UPT telephone and notified the telephone company that he would like to stop telephone service at his Tokyo address. After arriving in Weimar, he buys a UPT telephone from a local supermarket and finds a line port in his new house. After connecting the phone and inserting his UPT device into the telephone, messages from Deutsche Bundespost Telekom welcoming a new customer would appear on the display. The new subscriber could then order the telephone services he would like and send his UPT number, and without any delay, the user's UPT service would start in Weimar.

The advantage of this service is that the entire process can be automated. Since no human interaction is required, with a minimum effort telephone service can be stopped in Tokyo and restarted in Weimar. This service proposal assumes that the banking services are as efficient as the UPT transfer - both service providers will have to be able to be paid by the subscriber.

5. Conclusion

This paper discussed three viewpoints concerning universal personal telecommunication: the impact of UPT numbers on PSTN call control, the demands that will be placed on the intelligent network, and the characteristics of UPT service. In addition, several proposals were introduced to give the reader an idea of the freedom inherent in the UPT concept.

References

(1) J. Mizusawa, "Networking Architecture: Three Views," IEICE Transactions, Vol. E74, No. 11, pp. 3635-3644, November 1991.

(2) J. Mizusawa, "Experiences and Expectations of Introducing PSTN New Services in Japan," ITC Specialists Seminar, Proceedings of Late Papers, pp. 13-24, April 22-27, 1991.

(3) J. Mizusawa and M. Akiyama, "Intelligent Network Service Control with IC-CARD," Proceedings of Technical Sympo-

sium, ITU 6th World Telecommunication Forum, Part 2, Vol. 1, pp. 189-201, October 10-15, 1991.

(4) J. Mizusawa, "IC-CARDs and Telecommunication Services," ASIACRIPT'91 Abstracts, pp. 143-52, ASIACRIPT'91 November 11-14, 1991.

(5) J. Mizusawa, "Distributed Cooperative Processing for IN and its Prototyping System: TIPS," Conference Record 12-5, TINA'92, January 20-23, 1992.

(6) J. Mizusawa and A. Akiyama, "New Service Ideas and IN Technologies," Proceedings, pp. 195-210, Zurich Seminar, March 16-19, 1992.

(7) CCITT Draft Recommendation F.850, "Principles of Universal Personal Telecommunication (UPT)."

(8) CCITT Draft Recommendation F.851, "Universal Personal Telecommunication (UPT) - Service Description."

(9) CCITT Draft Recommendation E.168, "Application of E.164 Numbering Plan for UPT."

(10) CCITT Draft New Recommendation E.174, "Routing for Universal Personal Telecommunications (UPT)."

Development of DAta Radio Channel ("DARC") for Traffic Information Services

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1. Introduction

Most of the world's big cities are suffering chronic traffic congestion. Car drivers want real-time traffic information to avoid heavily congested roads. A new traffic information service using FM multiplex broadcasting is expected to be a promising solution. NHK has developed a new way to apply minimum shift keying (MSK) as an FM subcarrier called L-MSK. Multiple data channels can be accessed and it has a transmission capacity of 16 kbps. We call this channel "DARC" (DAta Radio Channel). DARC is compatible with RDS as developed by EBU, since they use different frequency bands. Transmitters and antennas that have been installed for FM broadcasting can be used without any modification, meaning DARC can be introduced at a low cost. In addition, the serviceable area of DARC are very large.

This paper describes the system, the L-MSK modulation method[2], the results of transmission tests, and the systems possible applications to traffic services.

2. Transmission System

2.1 System parameters

Figure 1 shows the baseband spectrum of DARC signal and Table 1 shows the transmission parameters.

2.2 FM multiplex broadcasting channel

In FM multiplex broadcasting, FM multiplex signals should be multiplexed using a carrier signal between 53 kHz

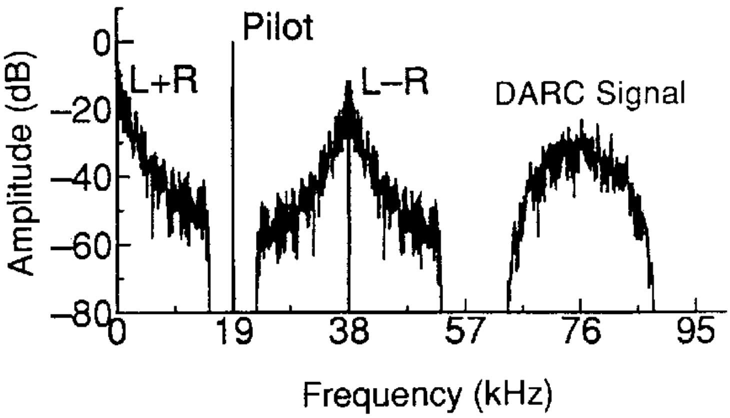
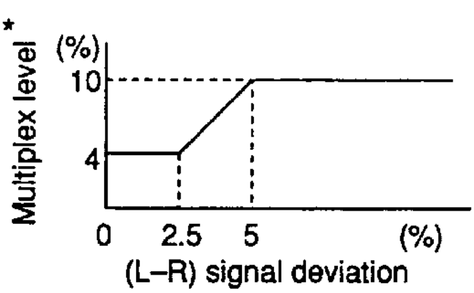


Figure 1 Baseband Spectrum of DARC

Table 1 Transmission Parameters

Modulation method	L-MSK
Subcarrier frequency	76 kHz
Bit rate	16 kbps
Multiplex level	4–10% *
Error correction code	(272, 190) product code



and 100 kHz. The degree of multiplexing should be kept as low as possible to preserve existing stereo sound.

In cases where there is multipath interference when receiving FM multiplex broadcasting signals, the resultant intermodulation degrades the signal-to-noise ratio of the stereo sound signals. However, interference between the stereo sound signals and the multiplexed digital signals can degrade the digital transmission characteristics. Any disturbance of the multiplexed digital signals by the stereo signals affects almost the entire multiplexable frequency band.

2.3 L-MSK (Digital modulation method)

The FM multiplex digital transmission characteristics affected by multipath interference depend on the modulation level of the stereo signals. Using a new modulation method, L-MSK, the degree to which the digital signals are multiplexed is controlled by the L-R signal level (left sound signal level minus right sound signal level). The basic modulation method is MSK which contains no information about the signal amplitude. Table 1 shows the control curve under L-MSK. L-MSK is the most powerful modulation method under real multipath receiving conditions.

2.4 Error correcting codes

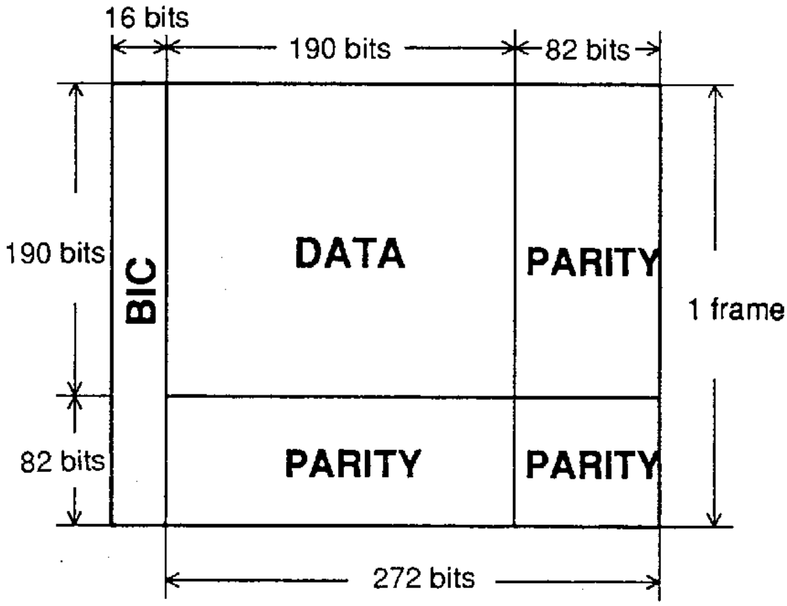
Computer simulations regarding methods of error correction have been carried out using error pattern data gathered in field tests. As a result, it has been revealed that the (272,190) product-code [3] is the best. Figure 2 shows the frame structure of DARC. The (272,190) code can correct about 11 bits of error per 272-bit block. The (272,190) code can be adapted to other digital systems, including teletext, protecting the scrambled data of cable TV, facsimile transmission, FM multiplex broadcasting systems for stationary reception, and optical memory card systems.

2.5 Decoding LSI

An initial prototype of the decoding LSI for DARC has been developed. The LSI demodulates L-MSK signals and accomplishes error correction using (272,190) code. While the LSI consists of 2 gate-array chips, a one-chip CMOS LSI is under development for practical use.

3. Transmission Test

Transmission tests were carried out to measure the performance of the 16 kbps DARC system in the area served by the NHK Tokyo FM station. All highways and main national roads



* BIC stands for block identify code.

Figure 2 Frame Structure

in the area were tested, a measured distance that totaled more than 1500 km. Transmission data was received without error during 90% of the measured time by carrying out error correction using the (272,190) product-code as previously mentioned.

Correct reception rate is defined as below.

$$\text{Correct reception rate} = \frac{\text{Number of correct pages received}}{\text{Number of all pages transmitted}}$$

Figure 3 shows the roads where reception rates of more than 95% can be obtained assuming one page to be 15 packets within the FM service area of the NHK Tokyo FM station. A correct reception rate of more than 95% can be achieved in one attempt within approximately 20 km of Tokyo Tower, where the transmission antenna is installed. By using three-time iterative transmission, a correct reception rate of more than 95% can be obtained in almost all of the service areas.

Figure 4 shows the iterative transmission effects. This figure shows the proportion of files received with a reception rate of higher than 95% in

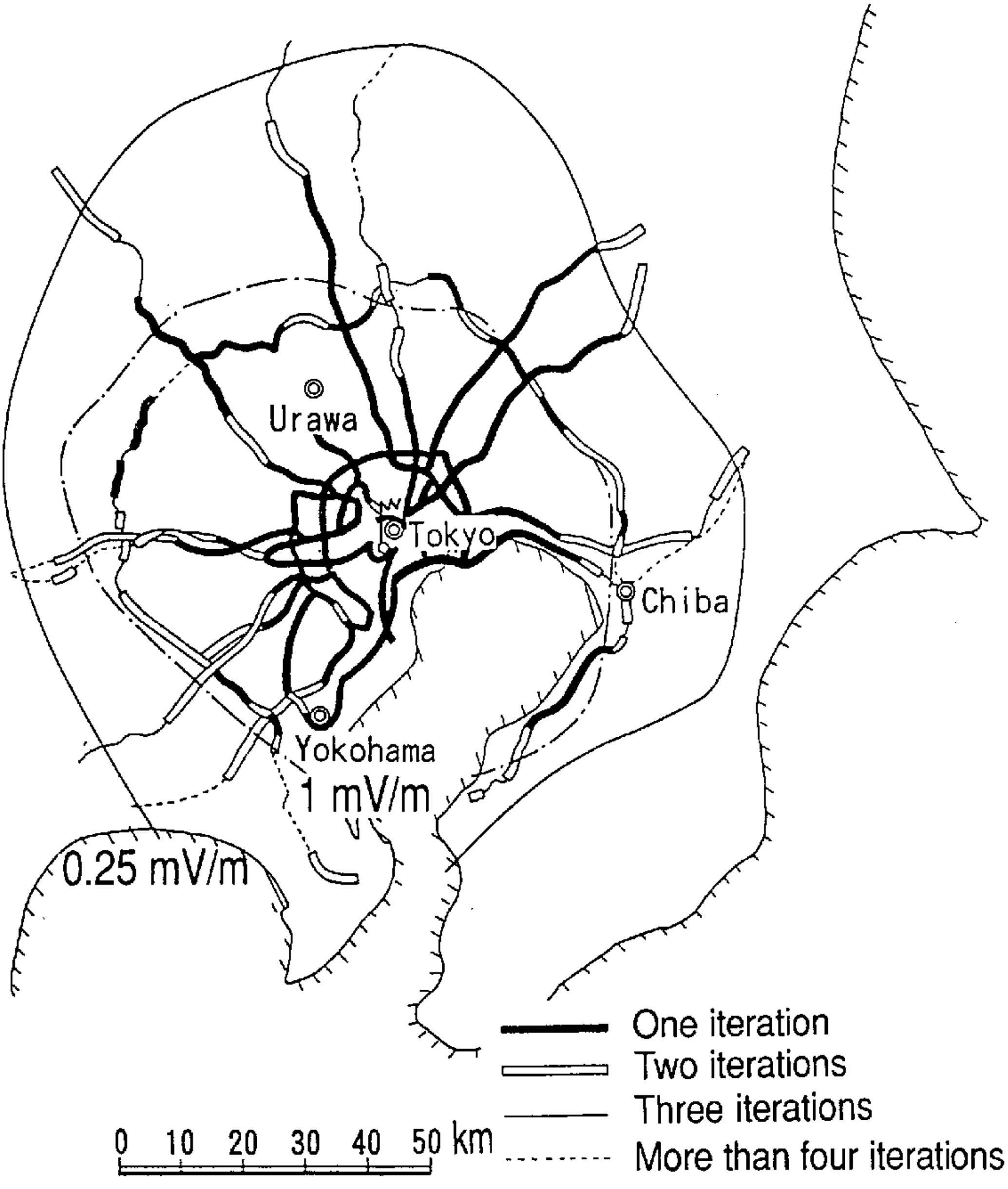


Figure 3 Routes having More than 95% Correct Reception Rate

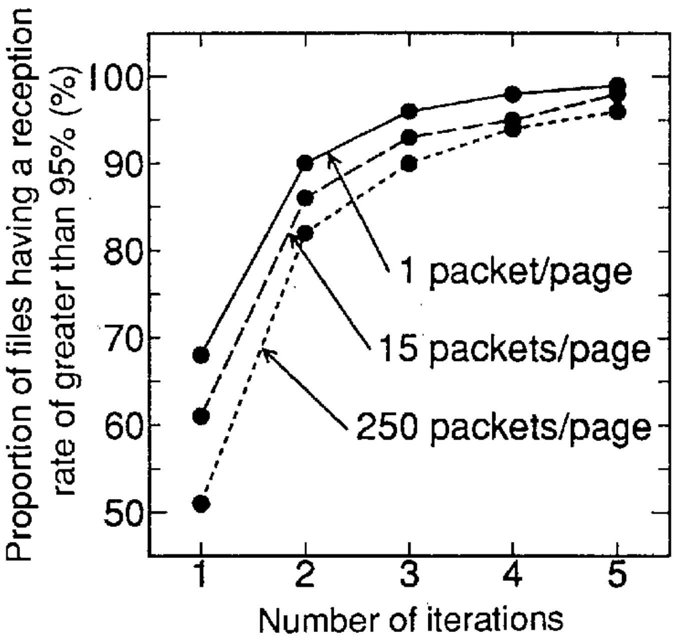


Figure 4 Iterative Transmission Effect

the FM service area. One file contains eight minutes of data. Assuming that the necessary reception rate for broadcasting services is at least 95%, the service is available to more than 90% of the FM service areas even with as many as 250 packets (1 packet = 22 bytes) just by using three iteration transmission and reception.

Figure 5 shows the reception rates of DARC as compared with that of RDS in several areas. Both are the reception rates of mobile receivers for files of approximately 350 bytes. Since the error correction code used in DARC is powerful, DARC is superior to RDS.

4. System Protocol

The Electrical Telecommunication Technology Council of Ministry of Posts and Telecommunications is deliberating on the system standard of the new FM multiplex broadcasting system in Japan. The system standard will be described in a manner following that of the 7-layer reference model for data broadcasting that is shown in CCIR Recommendation 807. Figure 6 shows an outline for the

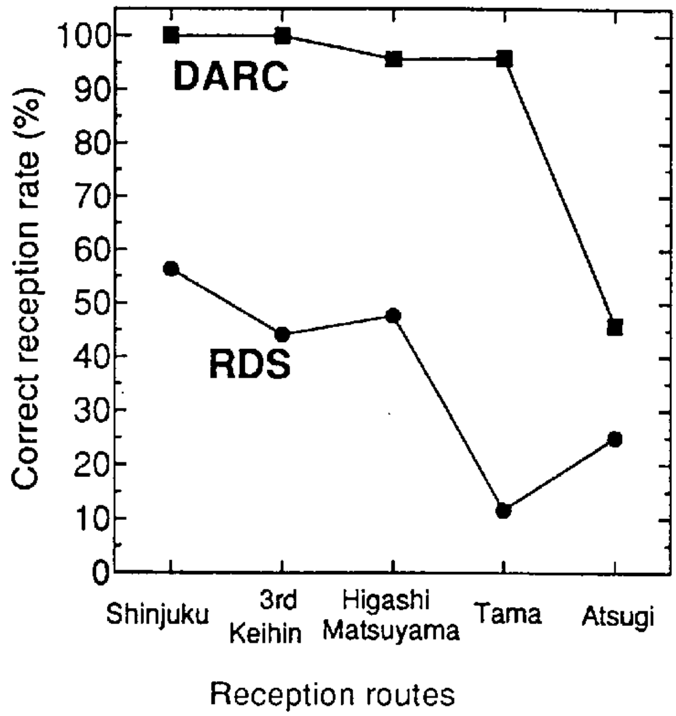


Figure 5 Comparison between RDS and DARC

system protocol of the DARC system. The protocol of layers 4, 5 or 6 is similar to that of the current teletext system in Japan.

5. Application to Traffic Information

5.1 Service areas of DARC

FM broadcasting covers 99.9% of Japan and 100% of the areas where traffic information is most needed. Therefore, FM broadcasting stations should broadcast detailed traffic information in their service areas so that drivers can tune into them.

For stations having a wide service area, the stations should broadcast traffic information for adjacent service areas to aid drivers.

5.2 Service images

Enhanced traffic information services will be gradually provided after the development of basic equipment such as devices for accurately gauging the speed of cars. Table 2 shows a service model divided into three levels. It is assumed that the service area is

Layer 7 Application	Traffic information service:	Congestion, traveling time, traffic regulation
	Teletext service:	News, weather forecast, town guide
	Additional data service:	Program-type, alternative frequencies
Layer 6 Presentation	Fundamental coding scheme:	Text code data unit (including Kanji)
		Geometric picture data unit
		Mosaic picture data unit
	Transparent coding scheme:	Traffic information data unit
		Color mapping data unit

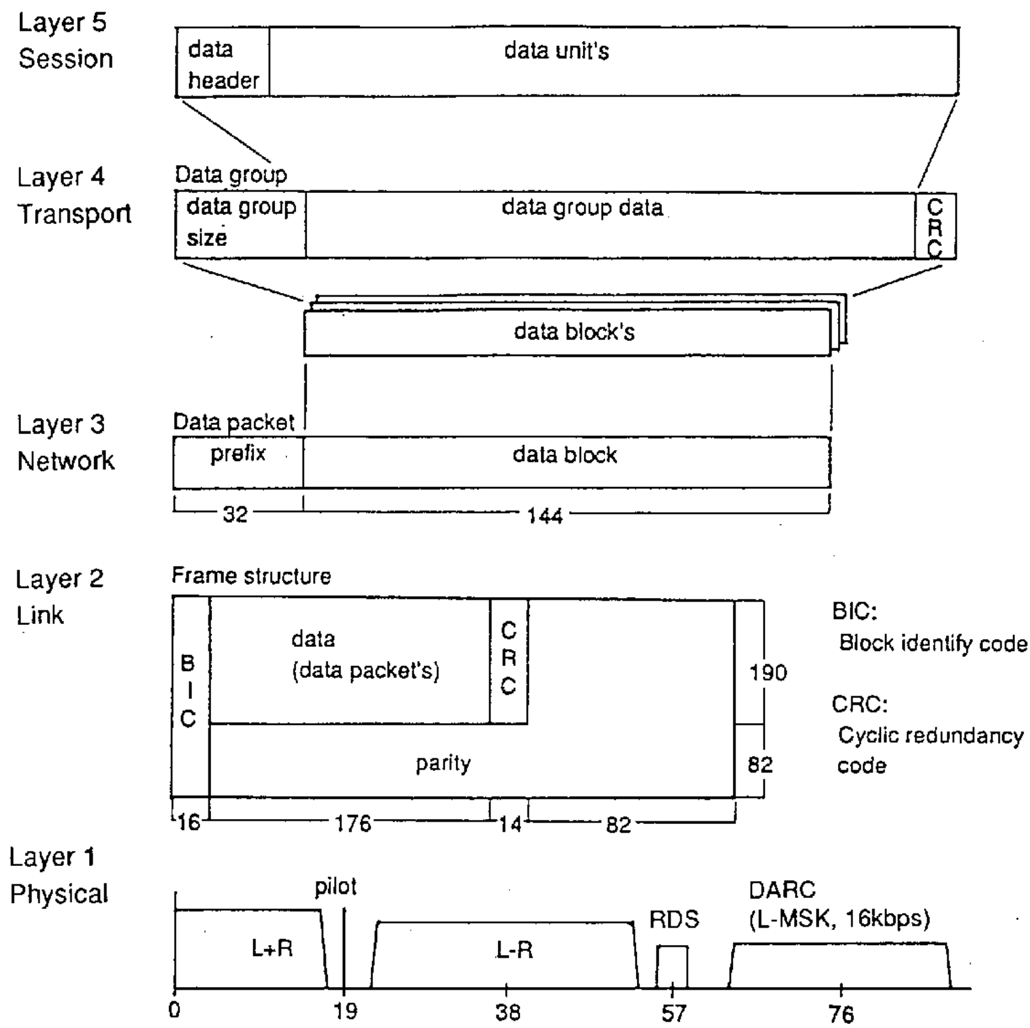


Figure 6 Outline for System Protocol

Table 2 Bit Rates Needed for Traffic Information Services

Service	Kind of information	Total data quantity	Transmission capacity*
Level 1	Text display (15 char. × 2 rows) Traffic jam in local area Highway information Traveling time Traffic regulation	18 kbyte	1 kbps
Level 2	Graphic display (248 × 196 dots) Level 1 text information Map of traffic jam	38 kbyte	2 kbps
Level 3	Graphic display CD-ROM maps Level 2 information Detail traveling time data	99 kbyte	5 kbps

*: Parity check bits for error correction not included. To include parity check bits, the total bit rate is 2.3 times that of transmission capacity.

Tokyo, where traffic congestion is the severest and 30% of all roads are jammed. The same traffic information is sent twice every five minutes. Even at the final stage of level 3, a transmission capacity of about 5 kbps is enough to broadcast sufficient information. Therefore, the remaining transmission capacity can be used for services other than traffic information, such as news, weather forecasts, stock market information, or paging.

Figure 7 shows an example of traffic information with a road map.

6. Conclusions

The Electrical Telecommunication Technology Councils of Ministry of Posts and Telecommunication is deliberating on the standard for a new FM multiplex broadcasting system to be used for traffic information service in Japan.

In Tokyo, traffic congestion can be avoided if 3% of the car drivers on ordinary roads and 13% on highways have accurate traffic information to steer them clear of congestion. An early introduction of timely, accurate traffic services is strongly needed for car drivers. Presently, there is a move

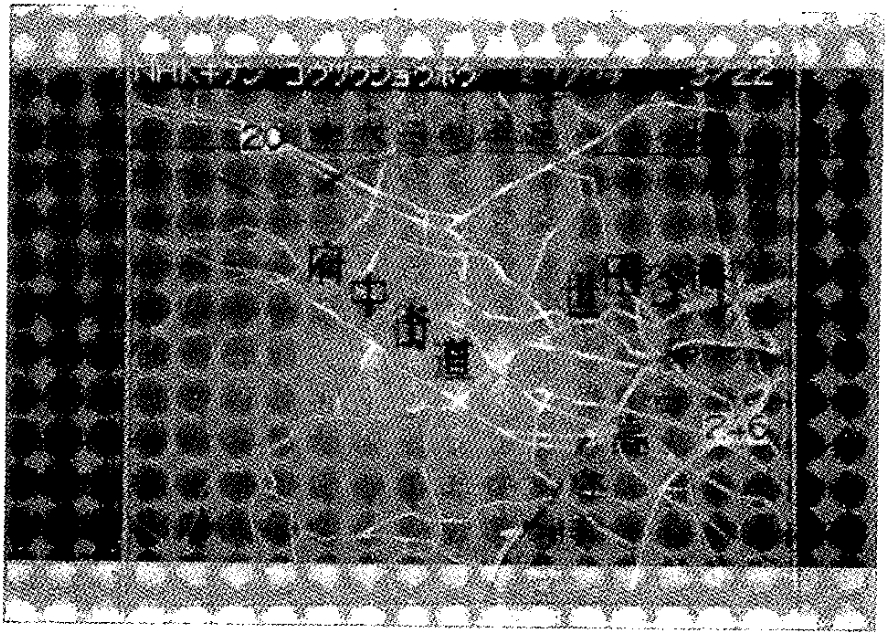


Figure 7 Traffic Information with Road Map

to combine some systems that have been individually developed, such as IVHS in the United States and VICS in Japan.

However, DARC has many advantages for use in traffic information services. No new radio band is needed, and wide service areas can be reached, running costs are low, and communications are reliable. We expected that DARC will play a vital role in future traffic information service.

Reference

(1) EBU, "Specifications of the Radio Data System (RDS) for VHF/FM Sound Broadcasting," Tech 3244-E, 1984.

(2) CCIR Document WP10/5 (1991), "A New Modulation Method of FM Multiplex Broadcasting for Mobil Receivers," 1991.

(3) O. Yamada, "Development of an Error-Correction Method for Data Packet Multiplexed with TV Signals," IEEE Trans. on Communications, Vol. COM-35, No. 1, pp. 1045-1055, 1987.

Recent Progress of DBS Mobile Receiver Technology

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1. Introduction

Japanese operational direct broadcasting satellites (DBSs), BS-3a and BS-3b, were successfully launched in 1990 and 1991. By the end of 1992, about five million Japanese subscribed to NHK (Japan Broadcasting Corporation) to receive this new TV broadcasting service. Eight-hour HDTV broadcasts were also started on a daily basis from November 1991.

One of the remarkable features of DBS lies in its wide coverage area. It is especially suitable for mobile reception when a vehicle moves from one terrestrial broadcast service area to another.

2. NHK's Activities Related to the Development of a DBS Mobile Receiver

Considering the prevalence of satellite broadcasting, NHK has been working to develop various types of mobile receivers for the DBS system for all modes of transportation.

Figure 1 shows the NHK's activities related to the development of DBS mobile receivers arranged in chronological order. The technology that was paramount to the development of the DBS mobile receivers is shown in Figure 2.

At present, NHK's major interest is to develop a reliable airborne DBS receiver.

3. Initial DBS Mobile Receiver

The first receiver developed by NHK was somewhat large with a flat antenna that could mechanically track

1987 Started 24-hour satellite broadcasting with BS-2b
1988 Started R&D on DBS mobile receiver
1989 Developed a DBS receiver for trains
1990 Launched BS-3a
1991 Developed a DBS receiver mountable on buses
1992 Developed a compact DBS receiver for cars
1993 Developed a prototype airborne DBS receiver

Figure 1 NHK's Development Activities of DBS Mobile Receivers

- High-efficiency active low-profile antenna
- Feeding line arrangement for circular polarization
- In-phase multiplexer capable of low carrier-to-noise operation
- An accurate tracking system for beam-pointing

Figure 2 Key Technology for Developing DBS Mobile Receivers

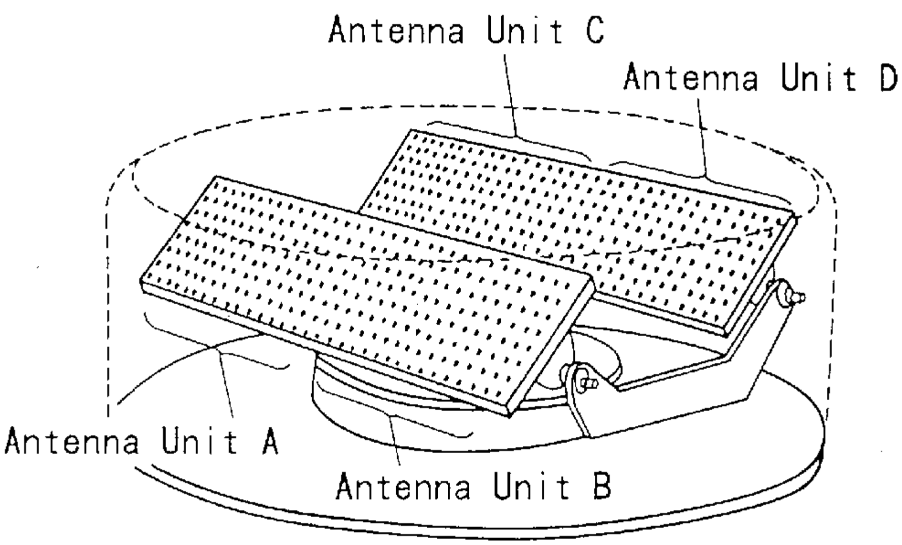

Figure 3 Schematic of the Initial Mobile Receiver

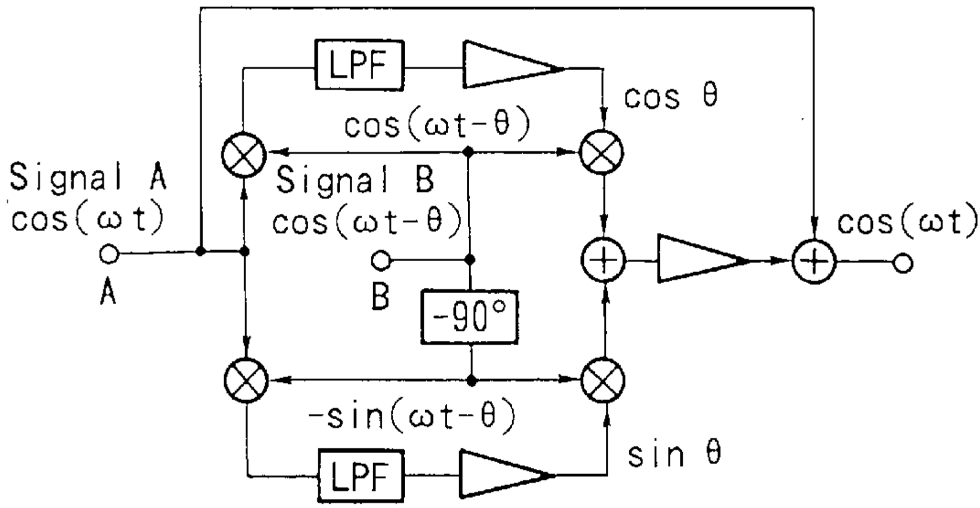

Figure 4 In-phase Combining Circuit for Initial DBS Mobile Receiver

both the azimuth and the elevation as shown in Figure 3.

An important circuit used in the DBS mobile receiver was the in-phase multiplexer. Of two kinds, the one shown in Figure 4 was initially used in the receiver. The vertical movement of the antenna required a large space under the radar dome (radome), making it too tall to be installed on the rooftop of a bus.

4. Bus-mountable DBS Receiver

An advanced model which was much smaller and lighter was designed and fabricated. As shown in Figure 5, it consists of eight microstrip-antenna subarrays with total of 512 radiating elements, eight low-noise converters, in-phase combiner circuits, electronic and mechanical tracking circuits, and some other mechanical tracking devices.

The block diagram of the mobile receiver is shown in Figure 6. In this model, a PLL in-phase combiner circuit, shown in Figure 7, was used. Specific features of this receiver are shown in Table 1.

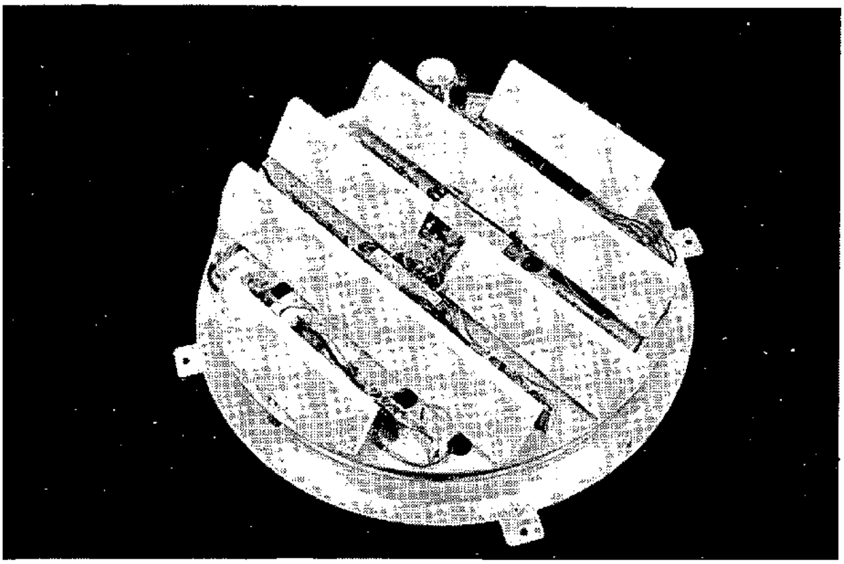

Figure 5 DBS Receiver for Buses

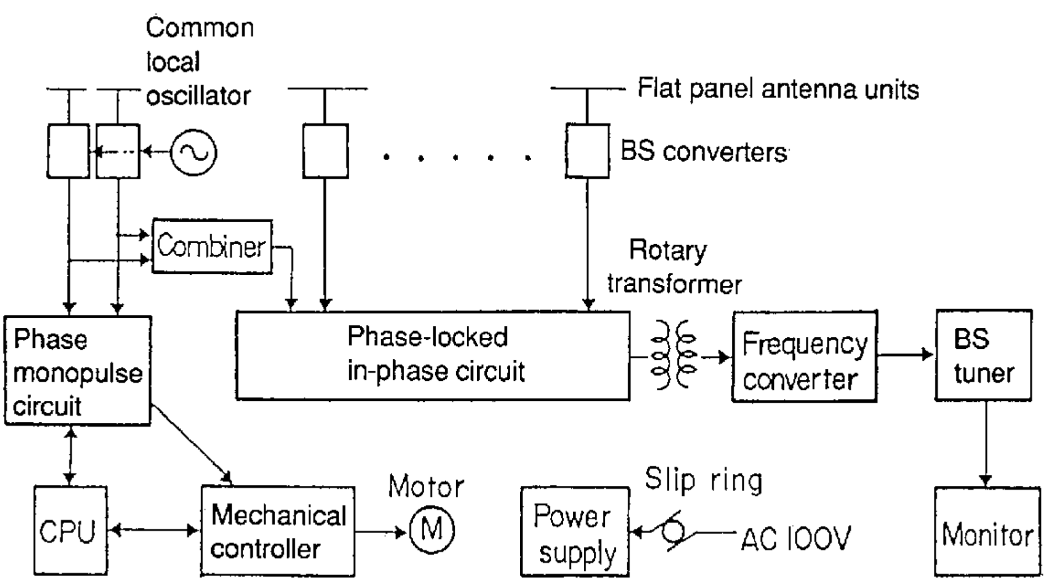

Figure 6 Block Diagram of the DBS Receiver for Buses

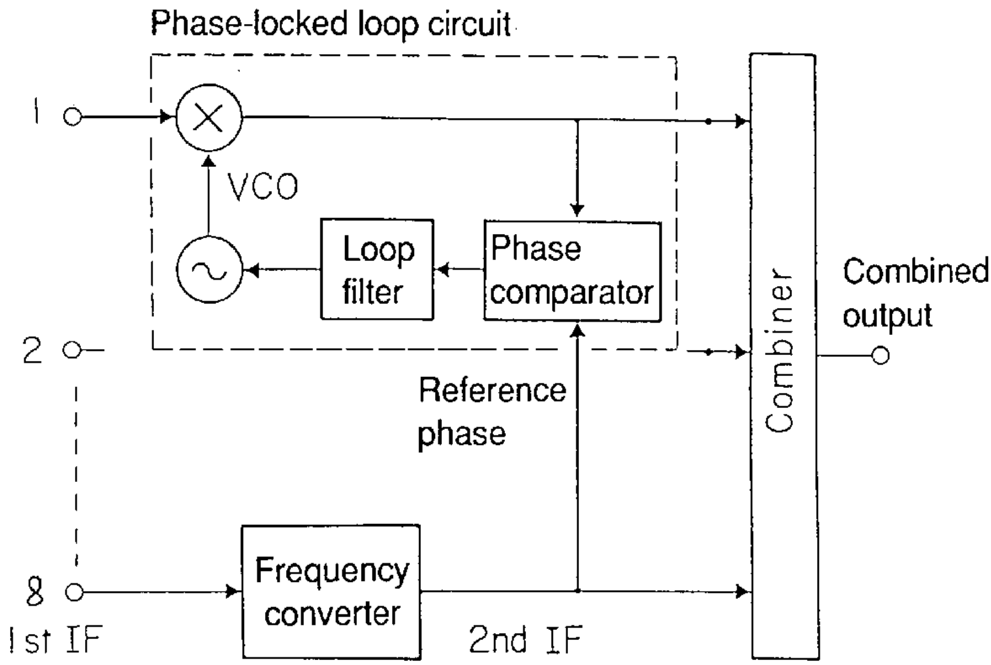

Figure 7 In-phase Combiner Circuit for Enhanced DBS Receivers

Table 1 Specifications of the Bus-mountable DBS Receiver

Size	20 cm in height, 70 cm in diameter
Weight	30 kilograms
Power consumption	100 W
Tracking	360° in-plane tracking (mechanical) ±10 degrees elevation (electronical)
Antenna gain	32.5 dB maximum
Transport	Bus

5. Car-mountable DBS Receiver

Ever since NHK rendered technical assistance in developing the first DBS receiver, we have made efforts to reduce the size and weight of the receiver.

We designed a compact feeding system for circularly polarized antenna elements that uses a single point feeding system. We have designed a subarray using active devices which have only two radiating elements along the vertical. Four subarrays constitute the entire antenna.

We have also succeeded in designing a new in-phase combiner circuit which can work at a very low signal-to-noise ratios (CNR).

Due to these developments and the recent improvement in the noise figure of the receiver, we have succeeded in reducing the size of the DBS mobile receiver dramatically as shown in Figure 8. The block diagram of this mobile receiver model is shown in Figure 9. Specifications of the receiver are shown in Table 2. It can receive a high-quality TV picture in the central part of Japan with a CNR of about 12 dB as indicated in Figure 10.

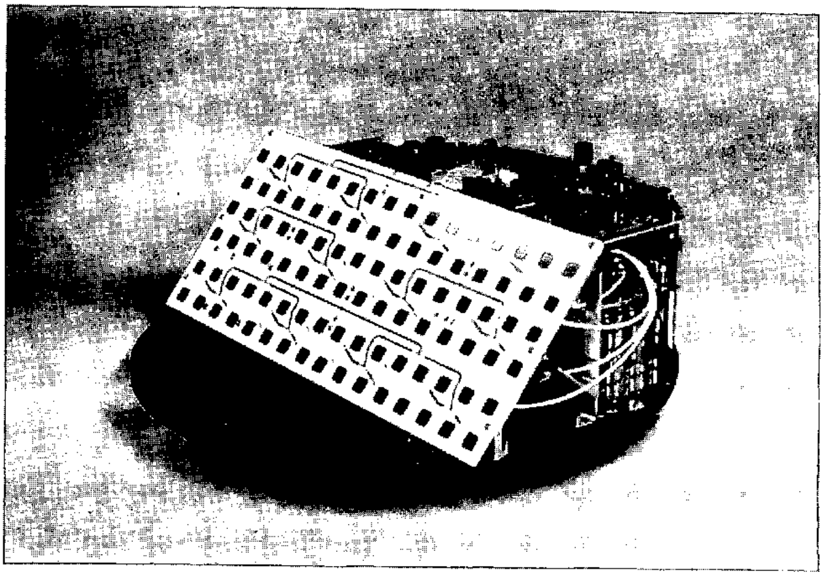

Figure 8 Compact DBS Receiver for Cars

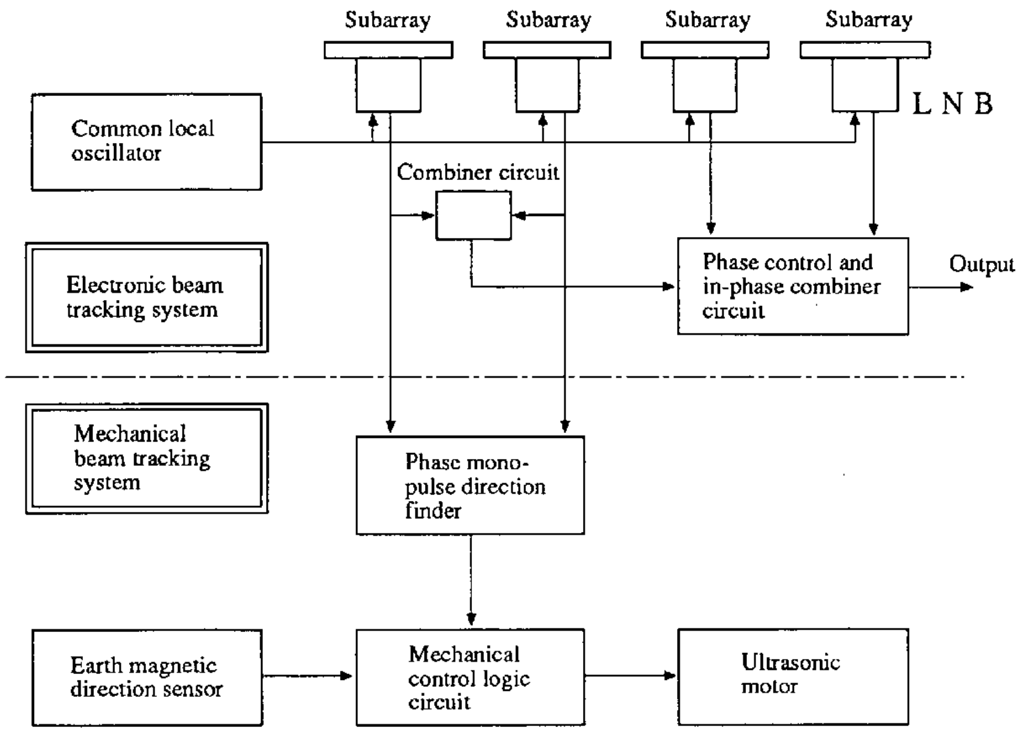

Figure 9 Block Diagram of the Compact Receiver for Cars

Table 2 Specifications of the Car-mountable Compact DBS Receiver

Size	15 cm in height, 35 cm in diameter
Weight	5 kilograms
Power consumption	40 W
Tracking	360° in-plane tracking ±20 degrees elevation
Antenna gain	27 dB maximum
Transport	Cars

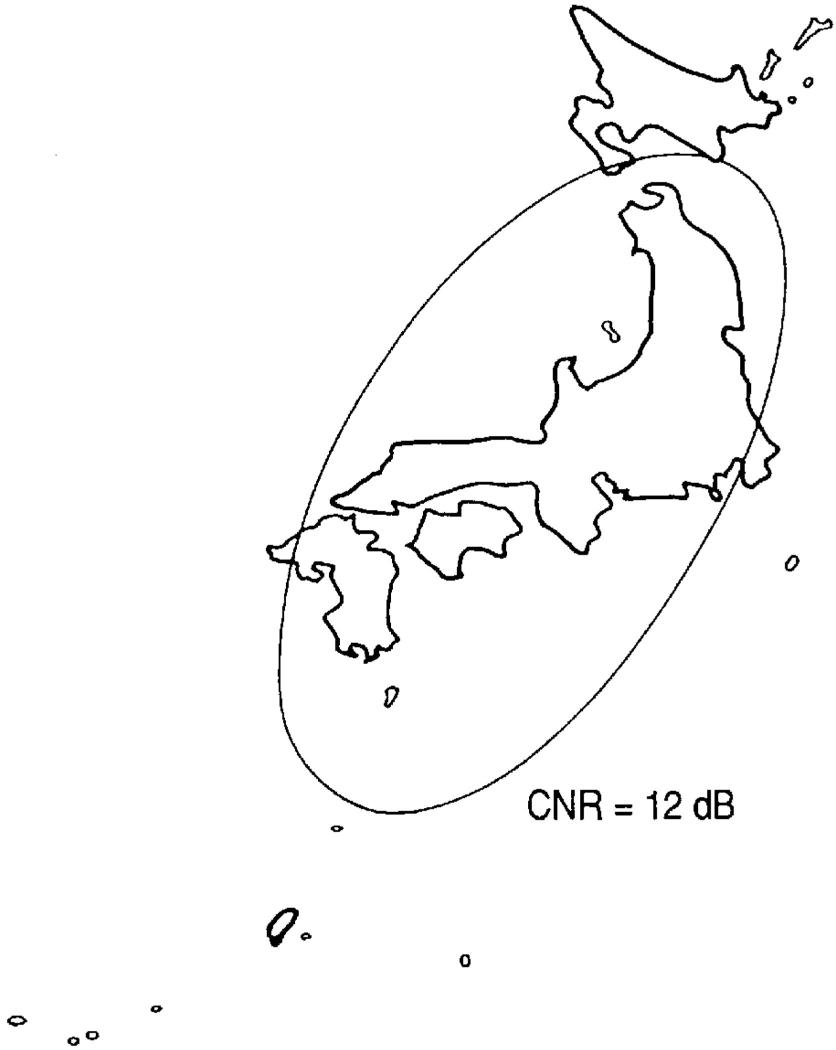

Figure 10 The 12 dB CNR Area under Clear Sky Conditions (Compact Mobile Receiver)

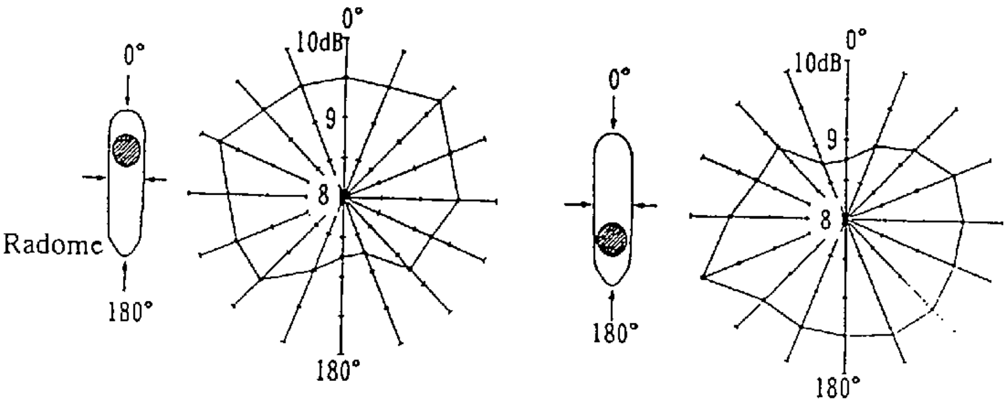

Figure 11 Transmission Characteristics of the Radome at 12 GHz (Measured Value in Terms of CNR)

6. Airborne Receiver for DBS

The final target of our research is to develop an airborne DBS receiver. The most important consideration in developing the airborne receiver is to find a suitable mounting place for the receiver. All the equipment outside the fuselage must withstand severe environmental conditions, and very low atmospheric pressure. After an in-depth study, we found a suitable installation site for the airborne receiver. Although unpressurized, the site can be covered by a radome of about 1.7 m in length, 45 cm in width, and 23 cm in height.

Electromagnetic wave transmission characteristics of the radome at a 12 GHz are shown in Figure 11. Using this figure, we concluded that two receivers should be a little larger than the one shown in Figure 8 and should be separated by about 70 cm to compensate for the angular variation in reception due to the radome.

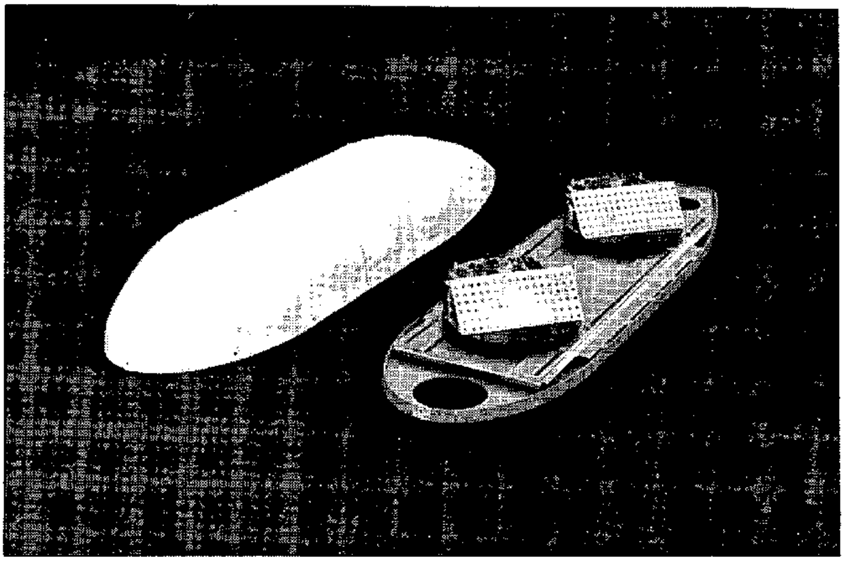

Figure 12 Breadboard Prototype of the Airborne DBS Receiver

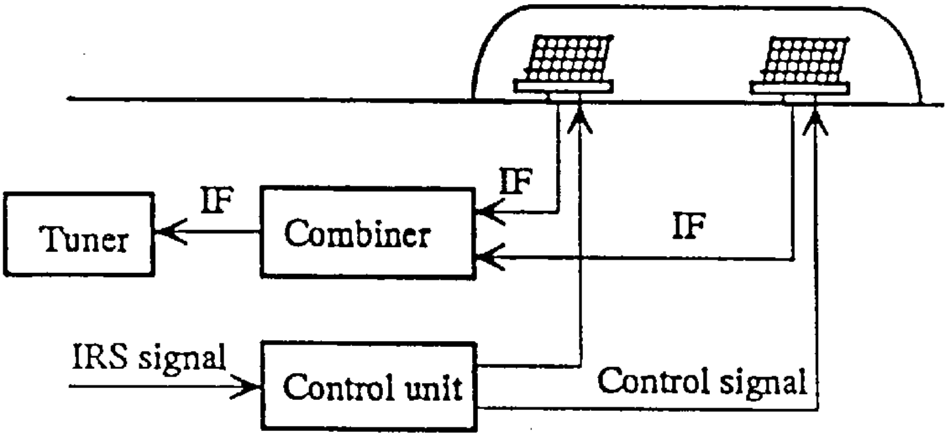

Figure 13 Block Diagram of the Airborne DBS Receiver

We have developed a breadboard prototype of the airborne DBS receiver as shown in Figure 12. The block diagram is shown in Figure 13. The two IF signals from the receivers are combined in-phase. An inertia reference signal produced by the aircraft is used to adjust the mechanical tracking of the antenna. A CNR of about 14 dB can be obtained for almost all of Japan.

7. Conclusion

NHK's development activities regarding the DBS mobile receiver have been presented in chronological order. Some of the receivers mentioned are already being used. For mobile receivers, the size of the receiver is crucial to determining its sensitivity and, thus, its usefulness to consumers. Any future increase in satellite power may enable the size of the mobile receiver to be reduced.

Spread-Spectrum Communications for Consumer Application

- Applications of Spread-Spectrum Communications in Japan -

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Keio University

1. Introduction

Spread-spectrum communications systems have had many applications, but because of their anti-jamming and anti-interception properties, they have mainly been military. Today, progress in communication devices is reducing the cost of such systems and giving us the possibility of nonmilitary applications.

Nonmilitary communications networks can be classified into two kinds, public-communication and consumer-communication, both of which seem very promising. Figure 1 shows the present divisions in nonmilitary communications networks; the public-communication networks' share of the market is much larger than the consumers' one. Figure 2 shows the predicted future share; the size of each market will become much larger, with consumer-communication networks becoming comparable with public-communication networks. The predicted progress of consumer communications is attributed to low cost, security from other users, unregulated design, and advantage to local and small-zone communications. Consumer communications has the most potential for growth in the future [1].

---

* Consumer-communication networks include LAN, WLAN, indoor communications, cordless telephones, communications for robots, remote control, data carrier, home communications, office communications, and factory communications.

However, several problems must first

be overcome, not only device design problems but also transmission line problems, since consumer-communication networks often have to employ poor transmission lines suffering from fading, low power transmission, interference, and interception. The key technology to overcoming poor transmission lines is spread spectrum. This paper describes the growing applicability of spread-spectrum communications to consumer communications in Japan.

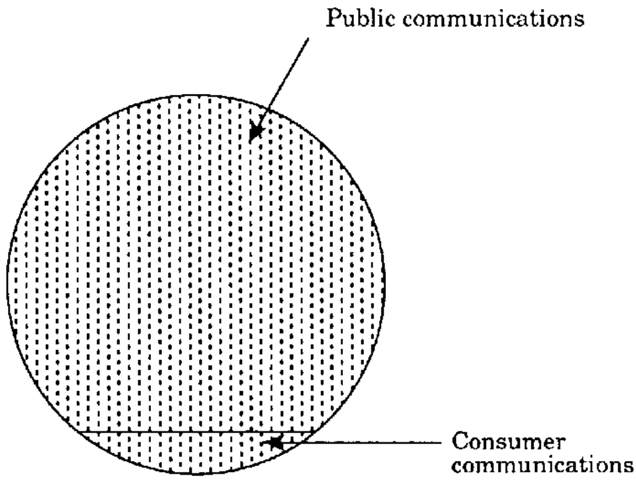

Figure 1 Present Division of Communication Networks

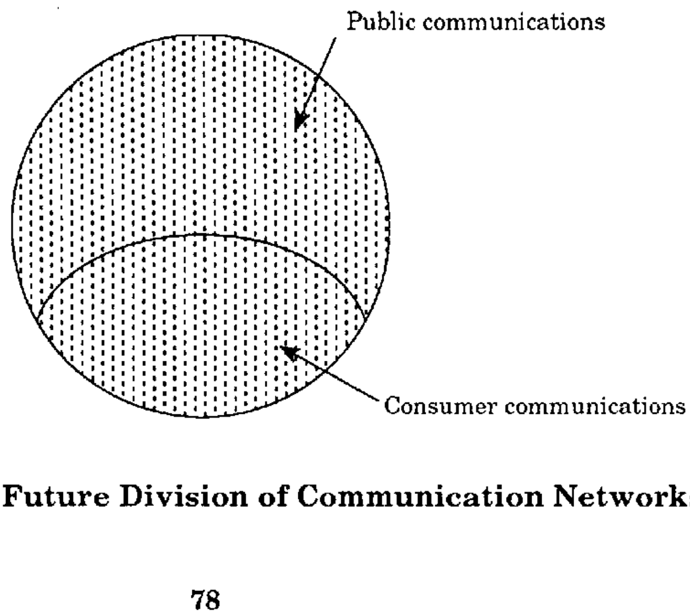

Figure 2 Probable Future Division of Communication Networks

2. Some Concepts of Spread-Spectrum Communications

Here we show the concept of spread spectrum.

Figure 3 shows a block diagram of a spread-spectrum communication system which uses a transmitter and a receiver. The data is filtered by a narrowband modulator and the resulting narrowband signal widely spread using the spreading code. The transmitted spread signal is despread by the same spreading code and the resulting narrowband signal is demodulated at the receiver.

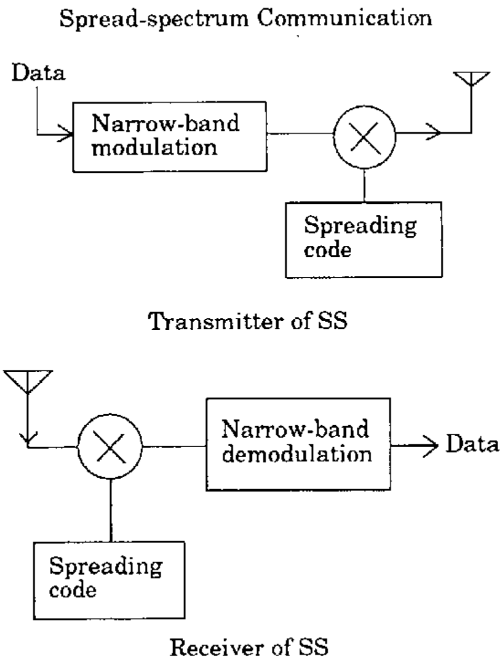

Figure 3 A Spread-Spectrum Communication System

Figure 4 shows a spectra schematic of the frequency transformations at the transmitter and receiver. Because the spread signal can be demodulated even in the presence of noise with a higher spectrum intensity than the signal means that other receivers without the same spreading code will have difficulty finding the signal. Thus the spread signal has resistance to interference.

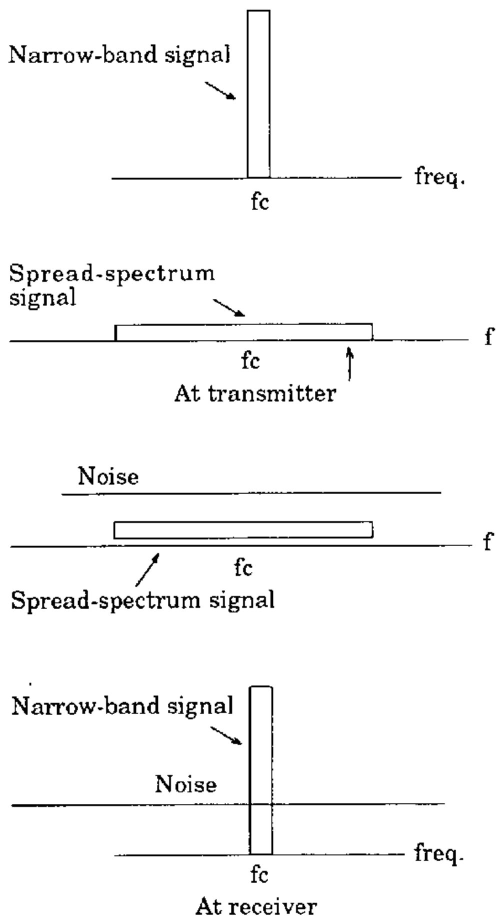

Figure 4 SS-Signal Spectra at Transmitter and Receiver

3. Spread-Spectrum Communications for Consumer Application

Consumer communications can be classified into two categories: wire communications and wireless communications. Here, we discuss only wireless consumer communications.

The most elegant application of the spread-spectrum method is in wireless communications, where multichannels, interference, and interception are present. We show here following examples: data carrier and radio remote control, ISM wireless LAN, personal communication, and vehicle-to vehicle communication and ranging.

3-1 Data carrier

The data carrier system is mainly used in factories where manufactured objects need to be automatically identified. As shown in Figure 5, data carrier systems usually consist of a controller unit, a read/write (R/W) head unit, and data carrier unit (tag) as illustrated by Figure 6. The controller and R/W units are fixed while the data carrier unit is mobile since it is attached to an object which is carried on a conveyor belt. Electrical power for transmitting data to the fixed R/W head unit is sent from the fixed head unit through the coupling coils. The transmission power is so small that the data transmission is

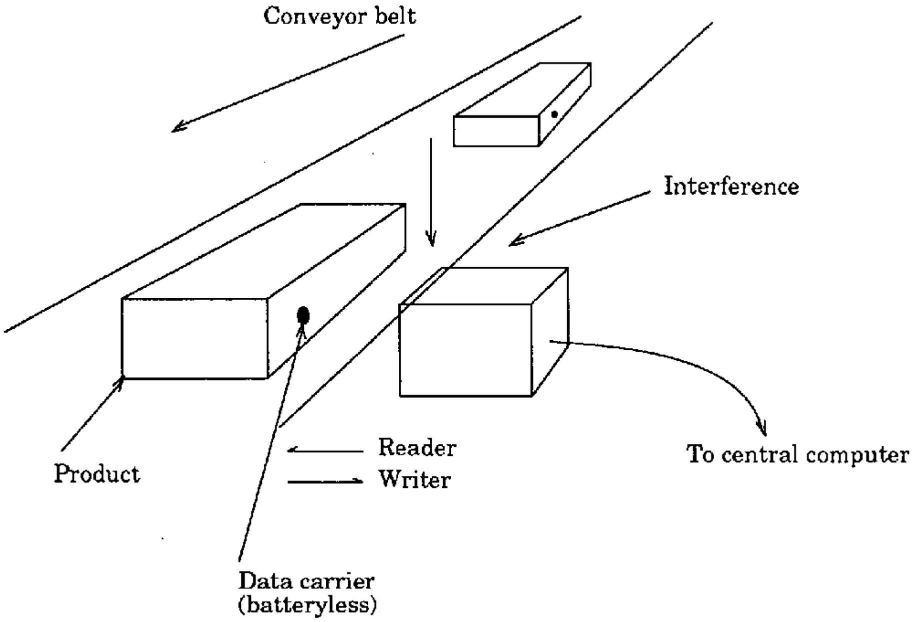

Figure 5 Data Carrier System in Factory

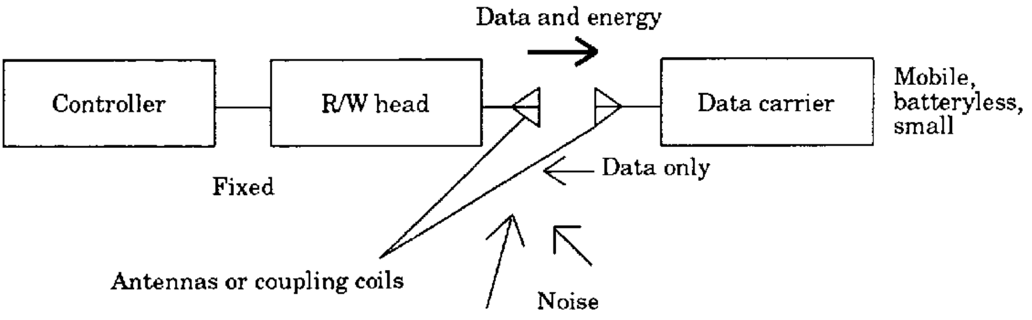

Figure 6 Blockdiagram of Data Carrier System

apt to be susceptible to noise such as clock noises generated by the processors in the controller and R/W unit. Clock noise does not have a uniform spectrum, but a spectrum consisting of lines. Spread spectrum modulation is robust against such noises.

3-2 Radio remote control

Radio remote control systems are widely used in factories, construction sites, offices and homes to control robots, cranes, and computers. These systems must be reliable, because a data transmission error may cause an accident. Since multichannel fading, interference, and noise degrade the transmitted signal of radio remote control systems, we propose using a DS/FH hybrid technique. Table 1 shows the specifications.

Table 1 Specifications of SS Radio Remote Control System

Term	Specification
Trans. power	Low power regulation
FH band width	5 MHz
Hopping number	15 (RS code)
Hopping freq.	4.88 kHz
DS processing gain	32
Modulation	FSK (m = 1)
Chip rate	6.4 μs/chip
Bit rate	4.88 kbps
Error control	1/2 convolutional code, Viterbi decoding, CRC
DS synch.	64 steps matched filter
FH synch.	DS synch. signal

3-3 ISM wireless LAN

Spread-spectrum communication has been allowed on industrial scientific, and medial (ISM) bands in the USA since 1985. One of them (2.4 GHz) has also been used for SS in Japan since the end of 1992. The maximum transmitted power is 260 mW, while the maximum bandwidth is 26 MHz. Many kinds of ISM WLAN systems whose standard transmission rate is 256 kbps will be sold this year, mainly by office-equipment, factory-equipment, and audio companies.

3-4 Personal communications

Spread-spectrum communications are thought to be a strong candidate for a future personal communication networks, because of its high-frequency efficiency, antifading, anti-interference, and anti-interception properties. The main issue is how to increase the number of multi-users. Here the key technology will be crosscorrelation cancellation as described in 4-2-2.

3-5 Vehicle-to-vehicle communication and ranging

To avoid accidents and to gain the ability to communicate with others while driving, a simultaneous communication and ranging system using spread-spectrum signals has been proposed (2). Figure 7 shows the concept of a system called the "boomerang transmission system." The transmitted spread signal from one car returns carrying the data modulated by another car. These spread-spectrum signals are not only useful for communications, but also for ranging.

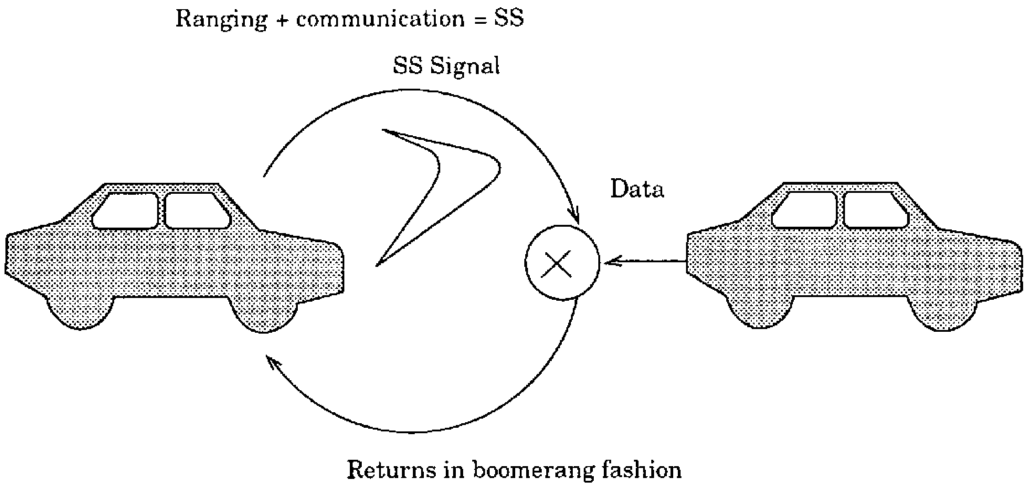

Figure 7 Boomerang Transmission System Using Spread-Spectrum Signal

4. Devices and Systems

4-1 SAW device applications

A difficult problems for spread-spectrum communication systems is how to synchronize the receivers decoder to the transmitted signal. The sliding correlator method is the simplest, but it needs a long acquisition time to synchronize. Matched filter and convolver methods need a much shorter acquisition time and SAW devices can be adapted to them.

4-1-1 Matched filters

Several companies are selling matched filters with a standard chip period of 127 MHz and a chip rate of 16 MHz.

4-1-2 Convolvers

Matched filters utilize a convolutional effect between the impulse response of the filter and the received pseudo noise signal. However, changing the pattern of the PN code to another pattern is difficult, because the pattern of the impulse response depends on the electrode pattern on the SAW filter's surface.

Using a convolver solves the problem, we can change a received PN code to another without any internal structural change by changing the external reference PN code. An SS convolvers can be fabricated with a 255 chip period and 66-MHz bandwidth.

4-2 Digital signal processing applications

Digital signal processors have been adopted in a lot of communication systems because of the stability, the variability of parameters, the flexibility, and the expansibility to new functions. They can also adopted in spread-spectrum communication systems.

4-2-1 Spread-spectrum block demodulator for packet SS transmission

Initial synchronization causes serious problems in SS packet radio networks, because each SS packet has to have a long preamble for the initial synchronization. This degrades the efficiency of the packet data transmission if conventional demodulation systems without memory function are employed. By using an SS block demodulator with a memory block to store a quasi-coherent-demodulated packet as shown in Figure 8, the received SS packet can be synchronized without using a preamble.

4-2-2 Crosscorrelation canceler

Crosscorrelations between multiuser-signals limit the multiple access user capacity in SS communications. By using a crosscorrelation canceler at a receiver (3), the number of the users can be increased.

5. Conclusion

Consumer communications will play an important future role and a key component will be the spread-spectrum method. Several examples that show the applicability of spread-spectrum communications to consumer communications in Japan were shown in this paper.

Advanced communication technology will be passed from the military to the civilian and from the public to the individual.

References

(1) M. Nakagawa and T. Hasegawa, "Spread Spectrum for Consumer Communications" IEICE Trans., vol. E74, No. 5, pp. 1093 - 1102, May 1991.

(2) K. Mizui, M. Uchida, and M. Nakagawa, "Vehicle-to-Vehicle Communication and Ranging System Using Spread Spectrum Technique (Proposal of Boomerang Transmission System)" IEEE

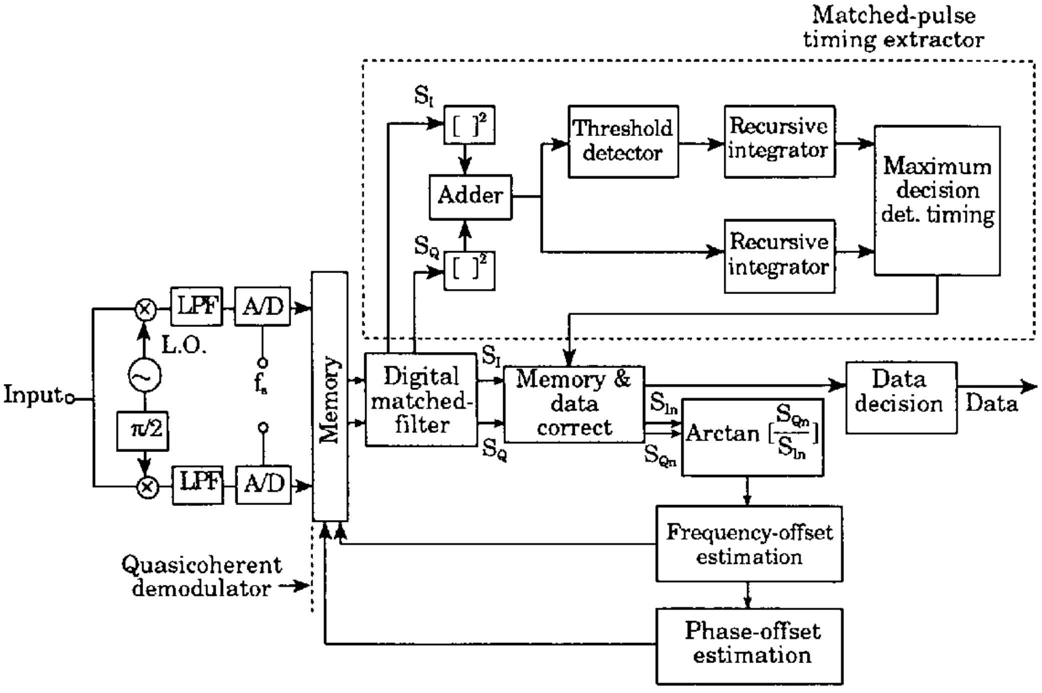

Figure 8 SS Block Demodulator

VTC (Vehicular Technology Conference) Report, pp. 335-338, May 1993.

(3) A. Kajiwara and M. Nakagawa, "Spread Spectrum Block Demodulator with High-Capacity Crosscorrelation Canceler" IEEE Globecom '91, 25 A4.1-4.5, pp. 0851 - 0855, Dec. 1991.

Current News

* Personal Computer Market Showing Recovery Trend

According to personal computer shipment statistics announced by JEIDA (Japan Electronic Industry Development Association), shipments during the 4th quarter of the 1992 fiscal year (January - March, 1993) totalled 688,000 units, up 6% over the same quarter of the preceding year. It was the first time in eight quarters that shipments had increased over the same quarter of the preceding year. The shipments for the whole year totalled 2,207,000 units, down 4% from the preceding fiscal year. Although yearly shipments have declined from the preceding year for two years in succession, JEIDA judges that the recession of the personal computer business has hit bottom.

In the 4th quarter of the 1992 fiscal year, domestic shipments of personal computers totalled 544,000 units, up 1% over the same quarter of the preceding year. It was the first time in six quarters that domestic shipments had increased. Exports in the same quarter totalled 144,000 units, up 31% over the same quarter of the preceding year. The increase in exports is accounted for by rapid sales growth in the American market, where low price competition is intensifying among manufacturers. The increase in domestic shipments is due to the fact that users, who have been observing price competition among domestic manufacturers from the beginning of 1993 onward, have judged that the price decline has stopped, and have begun to buy computers.

Concerning the future outlook for shipments, JEIDA predicts that the personal computer market will show an average annual growth rate of 7% until around 1996 because of the happy factor that the Government's new comprehensive economic policy includes installation of additional personal computers at primary, secondary and high schools, and because

LANs (local area networks) that connect personal computers will spread through medium-sized and small enterprises as well.

* Canon Enters Workstation Business in the U.S.

Taking the opportunity provided by the withdrawal of Next Computer, an American company in which Canon has 17% ownership, from the hardware business, Canon will recruit development engineers from this company and enter the workstation (WS) business. Canon will establish a new company in the U.S., develop high-speed workstations that use Next software, and market them under the Canon brand.

The new company will consist of fifteen engineers recruited from the hardware development section of Next Computer and staff dispatched from Canon. Details about the software selling rights and the hardware development license provided by Next Computer are being discussed.

The new model will have a RISC type microprocessor to which "Nextstep," Next Computer's original operating system (OS), will be transplanted. They plan to market the workstations for engineering, banking and academic computing next year. The processing speed of the model to be developed will be over 100 MIPS (1 MIPS = execution speed of 1 million instructions per second).

The new company will concentrate on development in the immediate future. Workstations will be manufactured and marketed by Canon's office machine manufacturing subsidiaries in the U.S. and partner manufacturers in Southeast Asia.

* JIPDEC Surveys Users' Investment in Informatization

JIPDEC (Japan Information Processing Development Center) summarized the results of their survey on users' attitudes toward informatization investment and strategic information systems (SIS).

Concerning changes in the level of informatization investment, 24.7% had experienced a decrease and 29.4% an increase, while investment had remained about the same for 43.9%. Contrary to the general view that informatization investment is sluggish due to the economic recession, the survey reveals that many enterprises show enthusiasm for informatization. However, the survey does not show the influence exerted by the suppression of informatization investment among financial institutions, because it makes no comparison in terms of monetary value.

The specific actions taken after reviewing informatization investment include "Cancellation or delay of hardware purchase or system development" (19.2%) and "Reductions in purchases of consumable supplies and in education and training expenses" (8.2%). These enterprises include those which answered that the amount of investments had not changed from the previous year. As for the attitude toward downsizing, 44.7% answered that they had begun downsizing already, while 52.6% answered that downsizing was being considered.

Concerning actions related to SIS, 91 enterprises (35.7%), including the 57 enterprises which already have strategic information systems in operation, are "taking concrete actions." This group had decreased by 10.6 points from the 1991 fiscal year. On the other hand, 58.8% answered that SIS-related action is "being considered, but no action has been taken yet," up 8.1 points.

Concerning the effects of informatization investment, the answers that it is "effective to some extent" or "quite effective" account for 83.9%, indicating that the effectiveness of investment is generally recognized. The reasons why attitudes toward investment have been revised and zest for SIS has decreased, in spite of this widely recognized effectiveness, seem to be that many users have judged it better to wait and see for a while because of rapid environmental changes, such as downsizing, and that the economic recession has lowered the priority of gaining a competitive advantage.

* Fujitsu Expands Tie-up with Siemens in General-purpose Computer Field

In June 1993, Fujitsu announced an agreement to expand a tie-up with Siemen of Germany in the general-purpose computer field. The section concerned is Siemens Nixdorf (SNI), Siemens' subsidiary in charge of computers. A processor to be developed by Fujitsu will be used in the successor models of the mid-size and small general-purpose computers which are the products of original development by SNI. SNI will design and manufacture CPUs using Fujitsu's processor as the nucleus. Fujitsu will adopt these CPUs for their own small general-purpose computers as well.

The two companies will jointly develop some OS functions for general-purpose machines. For example, they will combine their technologies to develop a function for operating a number of operating systems with one processor.

Until now, Fujitsu has supplied large general-purpose computers and supercomputers to SNI by OEM, and has granted licenses for UNIX OS for supercomputers. Small general-purpose machines to be developed under this tie-up are to be commercialized by 1996. Fujitsu estimates that they can decrease the hardware development cost for the next generation of small general-purpose machines by about half and that the development period can be shortened to two or three years as a result of this tie-up.

* Marubeni Begins Supplying Credit Information on Overseas Companies

Marubeni Telecom International, a subsidiary of Marubeni, has concluded an agency contract with MRC, a British international credit investigation company. Starting in July 1993, they will supply credit information on overseas companies as stored in MRC's database.

MRC is an international credit investigation company that started business five years ago. They are especially strong in information on marine transport, oil, and commodity exchange companies. Their database contains information on more than 40 thousand companies, mainly in Europe and the U.S.

Until now, Marubeni has utilized MRC's information for credit inquiry of their clients and business partners as a user. However, their subsidiary, Marubeni Telecom International, will now act as MRC's agency and supply information to Japanese companies. The information that will be made available includes a company's business and financial conditions in general, an evaluation by a third party in the industry, and MRC's own ranking and evaluation. The price for information ranges from 25,000 yen to 170,000 yen per company according to the type of information and the investigation time period. Data updating service, adding the latest information on companies which users have had investigated in the past, will also be available. Users may obtain information by facsimile or on-line operations using personal computers if they wish.

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