IEICE Communications Society GLOBAL NEWSLETTER *Vol. 9*
Contents

International Activities of IEICE Communications Society

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Introduction

The IEICE Communications Society (CS) has been promoted several international activities for the benefit of both domestic and overseas members. The improvement of such services will also increase overseas membership and consequently activate our Society. I will survey current status of the activities.

Overseas Membership

The current number of CS overseas memberships is around nine hundreds. One third of them are Regular Members and the others are Associate Members and Student Members. Overseas Member Development Program (OMDP) supports members from countries/ areas of Asia, Africa, Central and South America by discounting membership fees. Most of the overseas memberships come from Asia. CS is working together with the IEICE International Affairs Committee, which has five Overseas Area Representatives [1] .

Sister Society Agreements

IEICE-CS has Sister Society Agreements with IEEE ComSoc [2] from 1998, Korea Institute of Communication and Sciences (KICS) [3] from1999, and Mongolian Communications Union (MCU) [4] from 2003. The agreements address:

- Dual membership for each Society member
- Cooperation regarding membership promotion
- Technical co-sponsorship in conferences

International Conferences

The CS sponsors, cosponsors and supports many conferences in the area of communication. In this year, EMC'04 and ISAP'04 are sponsored by CS, and OECC2004 is cosponsored. ISADS2005, CLEO-PR/ICQE 05 and ISAP05 will be cosponsored by CS next year.

Global News Letter and eNews

The Global News Letter started from 2002 to improve communication with overseas members. The CS eNews mailing service starts from this year. The eNews timely provide useful information to members such as links to the latest Transaction and call for papers.

Paper Submission

Figure 1 shows the number of paper submission by countries in 2003. Domestic papers occupy only 27 % of the total number, and the rest are from overseas. Papers from Asia countries except Japan are more than 60 % and Korea represent the highest contributor.

As a result, the total number of accepted papers shown in Fig. 2 is increasing. It almost doubled in the last five years. We hope this increase results in the increase of CS membership.

Conclusion

We should consider growing interest in our Society from overseas areas. The CS will continue to improve international services and activities.

[1] http://www.ieice.org/eng/overseasarea.html
[2] http://www.ieice.or.jp/cs/DM/ComSoc_SSA.pdf
[3] http://www.ieice.or.jp/cs/KICS/KICS_SSA.pdf
[4] http://www.ieice.org/cs/GNL/GNLvol6.pdf

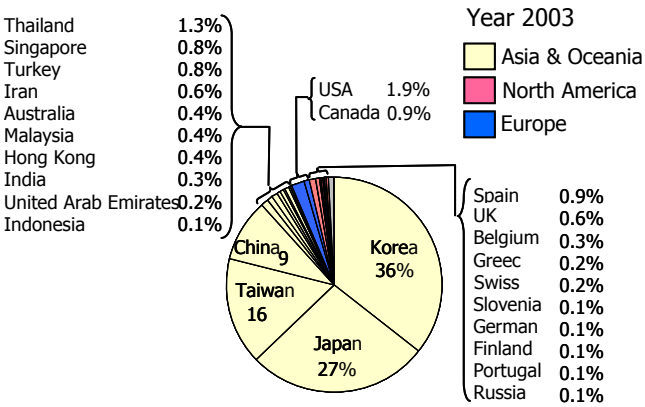

Fig. 1 Submission for Trans. on Commun.

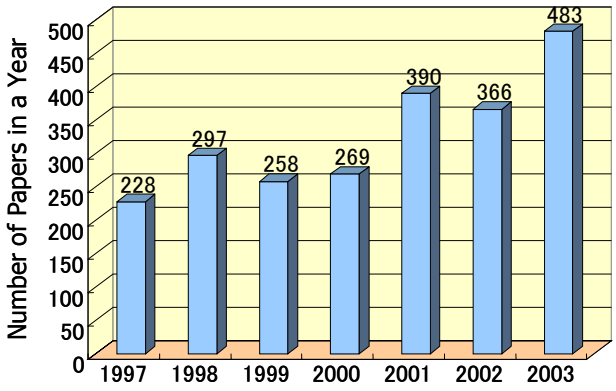

Fig. 2 Number of papers in Trans. on Commun.

Annual Report of Technical Committee on Network Systems

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Introduction

This report covers the annual activities of The Technical Committee on Network Systems (NS). We describe activity at the monthly technical meetings, recent research topics of the committee, and research award for 2003.

2. Technical meetings

As a rule, this Technical Committee holds 10 two-day technical meetings each fiscal year. Table 1 shows the schedule of from April 2004 to March 2005, consisting of nine technical meetings and one workshop. Several of these are co-sponsored by the RCS (Radio Communication Systems), CS (Communication Systems) and IN (Information Networks), TM (Telecommunication Management), CQ (Communication Quality), PS (Photonics in Switching), and OCS (Optical Communication Systems) committees. In addition, the April technical meeting is co-sponsored by the ITC (International Teletraffic Congress) Japan Committee chaired by Professor Konosuke Kawashima of the Tokyo University of Agriculture and Technology.

Recently presented papers center on technologies that support traffic control/measurement, multicasting, ad-hoc networking, and mobile networking. At each technical meeting, we host lectures by invited speakers who are experts in their fields. During this fiscal year, we have also had guest lectures on ubiquitous networking, traffic control for routers, VPN, and other topics. From June 2003, we started to foster the work of young researchers who have presented papers at technical meetings, by inviting them to give a follow-up talk some months later. We call these "encouragement lectures." We invited 16 young researchers to give such lectures in the past year, and are going to continue this system. Moreover, Figure 1 shows the number of papers presented at our meetings in recent years. This figure shows that the number is in general increasing.

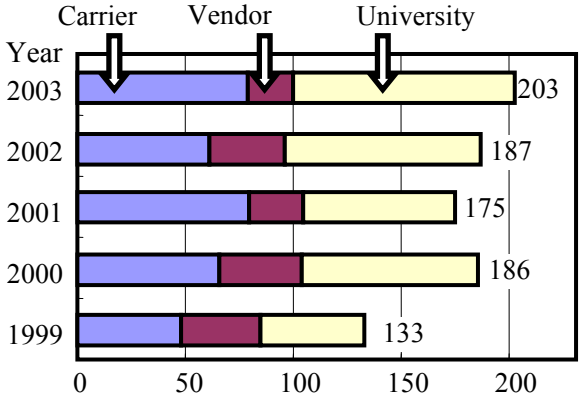

Figure 1: Changes in the numbers of papers presented in technical meetings.

Tabel 1: Technical meeting schdule

Date	Place	Themes	Co-organizer
April 22-23.	Kyoto Univ. (Kyoto)	Traffic	ITC Japan Committee
May 20-21	Ibaraki Univ. (Ibaraki)	Next generation networks, SIP, presence	
June 10-11	Akita Univ. (Akita)	CDN, multicasting	
July 15-16	Hiroshima Int. Univ. (Hiroshima)	Mobile networks	RCS
Sep. 2-3	Tohoku Univ. (Miyagi)	Active networks, IP-VPN, Security, P2P	IN, CS
Oct. 21-22	Toyama Pref. Univ. (Toyama)	Networking technology for the ubiquitous era	
Nov. 18-19	Mitsubishi Electric (Kanagawa)	Performance, quality of service	TM
Dec. 16-17	Not decided (Kyushu)	Photonic networks, photonic routing	PN
Jan. 27-28	Kagoshima Univ. (Kagoshima)	Photonic IP networks, photonic nodes	OCS
Mar. 3-4	Zanpa Royal Hotel (Okinawa)	NS/IN Workshop	IN

3. Research Award 2003

The Technical Committee selected the recipients of Network System Research Award from among papers at monthly technical meetings from January 2003 to December 2004. The award is presented to the authors of the three or four most excellent papers of every year. Figure 2 shows last year's recipients, at the IN/NS Workshop, held in Okinawa in March 2004. The abstracts of papers for which the award were received in 2003-2004 are shown below.

Katsuya Minami, Hideki Tode, and Koso Murakami, "Design of Buffer Controller of the Internet Router for Flow-Based High Quality Communications"

As multimedia and high-speed traffic become more popular on the Internet, the various traffic requiring different qualities of service (QoS) must co-exist. In addition, classified services have come into wide use. Today's Internet environment requires routers to perform control mechanisms in order to guarantee various QoSs. For the QoS guarantee mechanism, the packet scheduling algorithm to decide the output order from the buffer has been widely researched, e.g. WFQ (Weighted Fair Queueing), WRR (Weighted Round Robin) and CBQ (Class Based Queueing). However, it is difficult for the Internet router to realize QoS guarantee by using only these scheduling algorithms, because newly arriving high-priority packets can no longer be stored in the buffer when the buffer load is high and the buffer space is full. As the packet discarding discipline, many algorithms for the congestion avoidance are proposed, e.g. RED (Random Early Detection) and FRED (Fair RED). Although these algorithms can improve the throughput of Best-Effort traffic using TCP, it is difficult for routers to guarantee QoS of the real-time traffic unless proper scheduling algorithm is implemented. Namely in order to provide better QoS for each flow, several intelligent buffer controls must be combined each other, such as packet scheduling discipline and packet discarding discipline.

In this paper, we propose a smart buffer management scheme for the Internet router that uses hierarchical priority control with port class and flow level. The proposed scheme performs the priority control by cooperating with following three mechanisms; the assignment of "basic volume" (ideally allocated buffer volume per flow), the pushout mechanism and hierarchical WRR. Furthermore, since the proposed scheme must operate at very high speed, we propose several design policy for high speed operation and the hardware implementation is performed in VHDL (VHSIC Hardware Description Language) code. Implementation results show that the proposed scheme can scale with high-speed link, achieving the maximum rate of 8.0 Gbps using the 0.18 um CMOS technology. Future works include the performance evaluation of the fairness of flows and the improvement of the proposed scheme intended for more high-speed and compact hardware implementation by the introduction of pipeline technique.

Takahiro Murooka, Masashi Hashimoto, and Toshiaki Miyazaki, "High Time-resolution Traffic Monitoring System"

We would like to introduce high time-resolution traffic monitoring system. This system is capable of evaluating quality real-time data for video and audio streaming services. The user can observe the traffic shape changes in detail overtime by using on oscilloscope style display trace.

The features of the system are:

High time-resolution. The traffic is sampled every one millisecond (ms), which is adequate for observing its characteristic shape.

Traffic-flow selection. A series of individual telecom packets could be selected from the line of traffic according to their attributes.

Real-time data plotting and storage. Periodically traffic samples appear on a display and are saved in a storage device in real-time.

The high time-resolution and the real-time traffic plotting function of our system are unique features that have never before been used in any other traffic monitoring system.

The time resolution is the most important element of these features and is determined by a balance between the behavior of the streaming source media's and the network line bandwidth. For example, NTSC video is equivalent to almost 30 still-frames (images) per second. High-quality video streaming services aim to support this frame rate at least. Every still-frame must be transferred within 33 ms. We can therefore observe and evaluate their behavior by using one ms traffic sample.

From the network bandwidth perspective, however, we need a statistically meaningful number of packets to measure traffic volume. The Giga-Bit-Ethernet (GBE) can transfer a large datagram in about 12 microseconds (μs). If we sample a GBE line every 10μs we can observe the datagram, but not the traffic rate. This sample period is too short to observe the traffic rate. Accordingly, we chose one ms as the traffic sample interval.

We evaluated the effect of the monitoring system by using real network applications. The system can clearly represent the differences in the streaming application's traffic shape which can not be seen with conventional traffic monitoring systems that feature one second as the time resolution for monitoring traffic shape. In addition, the monitoring system with its time resolution could make an impact on traffic management.

Yuichi Ishikawa, Norihito Fujita, and Atsushi Iwata, "User-customized Network Services Provided by Multi-Layer DNS"

We propose a new network service architecture for creating a user-customized network environment. So far connectivity and reliability have been regarded as a

main SLA in a current network, and various kinds of user requirements have not been able to be sufficiently handled due to limited equipment functionality for a per-user customization. To solve this problem, we propose Multi-Layer DNS which extends current DNS to enable to customize per-user network environment based on such contextual information as users' attributes and service providers' policies. DNS is used as a base protocol because of its flexibility and scalability (i.e., a flexible name binding from application specific information to network level control and a scalable distributed server architecture).The proposed Multi-Layer DNS provides two remarkable functionalities:

(i) per-user customized name resolution by cooperating with user authentication system and (ii) per-user configuration of routers/switches' routing table. ML-DNS server prototype is also developed to evaluate its performance, especially its detailed implementation technique which significantly reduces the overhead of proposed per-user customized name resolution.

Fukami Tadayoshi, Takuya Asaka, and Tatsuro Takahashi, "Method of Estimating Short- Interval Traffic Distribution considered Long-Term Traffic Fluctuations"

Realizing short-interval-traffic behavior is important for network performance management. However, complications of collecting short-interval traffic data from routers, for example, the possibility of heavy loads on the routers and the inaccuracy of measurement in a short polling interval make difficult to measure short-interval traffic volumes. To resolve these disadvantages, EMSIT has been proposed as a method for the estimation of short-interval-traffic distributions. This method estimates short-interval traffic distributions on the basis of data in MIB (Management Information Base) data, where information on traffic volume is collected in cycles of several minutes.

In this paper, we propose EMSIT-LD as a new method of estimation that is based on the EMSIT, but is more strongly applicable to the estimation of long-term-traffic dynamics. The EMSIT-LD uses traffic trends measured over the previous couple of hours to estimate current short-interval traffic distributions. EMSIT-LD allows us to estimate the distributions, which was impossible with the original EMSIT method. Results of simulation results and numerical examples successfully demonstrated its performances.

4. Future Plans

The Technical Committee has began to plan a special edition of the IEICE Transactions on Communications B covering networking technology for the ubiquitous era, which will be one of the key applications in the era of broadband services. The call for papers will be issued in the second half of this year. The Program Committee, which has 10 members, is chaired by Mr. Takashi Hanazawa of NTT, is the former chair of the Technical Committee. This feature edition will be published in November of 2005.

In addition, the Technical Committee will organize two special events: an Open Symposium on "Metro Network Technologies and Their Future Issues" at the IEICE Society Conference in September 2004 and an English-language session on "Network Controls for High-Quality Communications" at the IEICE General Conference in March 2005.

In addition, in order to ensure the production of a large number of high-quality papers in our technical field, we will continue to organize the IEICE Transactions on Communications B.

(For more information, please see our home page.
URL: http://www.ieice.org/cs/ns/)

Figure.2: Research award recipients and former NS chair Mr. Hanazawa.

Report on the 20th IN/NS Workshop in Okinawa

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Workshop Secretariat, NTT

1. Introduction

The 20th IN/NS Workshop was held from 3-5 March 2004 at Bankoku Shinryokan in the north part of the Okinawa islands. Established as the main convention center for the 2000 Kyushu-Okinawa G-8 Summit, it is located in a beautiful seaside setting and we all enjoyed the nature of Okinawa. The workshop was organized and supported by the technical groups on information networks (IN) and network systems (NS) in the IEICE Communication Society.

The theme of this workshop in was "Post IP networks -The future information networks and society-" More than 150 participants enjoyed interesting talks by experts in various fields.

2. Workshop Overview

Lectures were given by six specialists who are playing active rolls in various fields. Afterwards, a panel discussion was held by all.

Below is a summary of each lecture.

- Dr. Tomohiro Kudo (NIAIST), "Grid and Networks": Some advanced grid applications such as a Gaussian portal system were introduced and the requirements for next-generation networks for the grid were presented.
- Dr. Atsushi Iwata (NEC), "Next generation packet networking architecture": A technology overview for the Internet was presented and Global Open Ethernet architecture was proposed.
- Dr. Naoaki Yamanaka (NTT), "All optical network and standardization of GMPLS": The activities of the Photonic Internet Lab. (PIL), which aims to achieve global standard photonic-GMPLS protocol were introduced.
- Dr. Fumio Watanabe (KDDI), "Future mobile networks": An overview of next generation mobile network "Beyond IMT-2000" was given. Issues for future network such as security and QoS were also discussed.
- Mr. Takechika Tsurutani (Future Institute Corp.), "Network for knowledge oriented society": The impact of network innovation on human society was presented.
- Professor Masakatsu Kaneko (Univ. of Electro-Communications), "For a design strategy of new network society -introducing the concept of 'ars'": The concept of "ars" in the design strategy of information systems was introduced.

3. Panel Discussion

Hirohiko Sato (NTT), the general chair of the workshop organized the panel discussion. The following topics were discussed.

- An open and heterogeneous network like the Internet has serious security issues. The next-generation network must overcome these issues.
- IPv6 is one technology for the next-generation network. The huge address field of IPv6 will be useful for grid applications.
- We must consider the relationship to existing telephone services and broadcasting services when discussing the next-generation network.
- Etc.

Fig. 1 Panel members

4. Conclusion

The workshop was a big success. We hope that the discussions in the workshop will be helpful to all participants in their R&D work. The next workshop will be held 2-4 March 2005, again in Okinawa. Details will appear on NS and IN Web pages. See you again in Okinawa!

Acknowledgements

The authors would like to thank all organizing committee members, especially H. Ibe (Toshiba), N. Watanabe (Fujitsu), T. Mizukami (Oki), K. Kusama (Hitachi), and T. Kawakubo (NEC) for their efforts to make this workshop a success.

Optical Wireless Communications Using Multiple-Subcarrier Modulation

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Abstract— **This article overviews optical wireless communications using multiple-subcarrier modulation (MSM). The basic principles and characteristics of the optical wireless communications using MSM are presented. The optical wireless systems using MSM are explained where some block codes that convert information bits to be transmitted to the symbol amplitudes of subcarriers are used to increase the minimum value of the multiple-subcarrier (MS) electrical waveform. The MSM optical communication systems using subcarrier signal point sequences (SSPS) that can improve the power efficiency of the MSM systems are also explained. The performance of the MSM optical communication systems are presented in the intensity-modulation with direct-detection (IM/DD) channel without dispersion.**

Keywords—**Multiple-Subcarrier Modulation, Optical Wireless Communications, SCM, Scintillation, Block Code, Subcarrier Signal Point Sequence**

I. Introduction

Recently, multicarrier modulation (MCM) has attracted much attention in many fields, such as, wired and wireless electrical and radio frequency (RF) communications, optical fiber communications, optical wireless communications, and so on. In MCM, multiple data streams are modulated onto different carriers at different frequencies. In the electrical and RF communications, orthogonal frequency division multiplexing (OFDM) has attracted much attention [1]. OFDM has been used or has been under consideration in many applications, such as, digital TV, local area networks (LAN's), asymmetric digital subscriber line (ADSL), next generation mobile communications, that is, the fourth generation (4G), and so on. In the optical fiber communications, subcarrier multiplexing (SCM) is a popular technique [2]. In SCM, multiple signals are multiplexed in the RF domain and transmitted by a single wavelength. A major application of SCM in optical fiber systems is the analog cable television (CATV) distribution. Since SCM can be implemented at low-cost, it has been applied to transmit multichannel optical signals using direct-detection (DD) for LAN's.

In optical wireless communications, multiple-subcarrier modulation (MSM) has attracted much attention, because it can realize high-speed communications without equalization [3]. Note that MSM is referred to as SCM in the field of optical fiber networks. MSM can be more bandwidth-efficient than single carrier modulation, such as on-off keying (OOK) and M-ary pulse position modulation (PPM). The multiple subcarrier (MS) electrical signal may be modulated onto the optical carrier using intensity, frequency or phase modulation. Most current practical MSM systems use intensity-modulation with DD (IM/DD) owing to its simple implementation. The IM/DD MSM systems are attractive, because the use of several narrow-band subcarriers promises to minimize intersymbol interference (ISI) on multipath channels, and because MSM can provide immunity to fluorescent-light noise near d.c..

The main drawback of the IM/DD MSM systems is poor optical average power efficiency. This arises because the MS electrical signal is a sum of modulated sinusoids and thus takes on both negative and positive values. Optical intensity (instantaneous power) must be non-negative. Hence, a d.c. bias must be added to the MS electrical signal to modulate it onto the intensity of an optical carrier.

In the MSM systems, the block coder maps the information bits to be transmitted to the symbol amplitudes modulated onto the subcarriers. Some block codes have been proposed for the MSM optical wireless systems to reduce the d.c. bias and to improve the power-efficiency of the MSM systems [4][5]. In the conventional MSM systems, one symbol is transmitted with one subcarrier, while in the MSM system using subcarrier signal point sequences (SSPS), one symbol is transmitted with multiple subcarriers, which means that each symbol is composed of signal points on some subcarriers [5]. This technique has been shown to be effective to reduce the d.c. bias and to improve the power-efficiency of the MSM systems.

II. MSM Optical Communication System

MSM is a scheme where multiple signals (subcarriers) are multiplexed in the electrical domain, which modulates a single optical carrier (wavelength) [3]. High-speed single-carrier modulation schemes, such as OOK and M-ary PPM, are wideband signals and thus suffer from ISI due to multipath dispersion when the symbol rate exceeds about 10 Mbaud [6]. In MSM the symbol rate of each subcarrier is lower than that of a single-carrier with the same total bit rate. Thus, MSM experiences little distortion and has no need of equalization. MSM has the other advantage that it can exploit the microwave devices that are more mature than optical devices; the stability of microwave oscillator and the frequency selectivity of a microwave filter are much better than their optical counterparts. In addition, the low phase noise of RF oscillator makes coherent detection in the RF domain easier than optical coherent detection, and thus advanced modulation formats can be applied easily.

Fig. 1 (a) and (b) depicts the transmitter and receiver design used in the MSM transmission scheme with quadriphase-

shift keying (QPSK). The transmitter uses a set of N subcarriers $\{\omega_n, n = 1, \ldots, N\}$. During each symbol interval of duration T, it transmits a vector of K information bits. A block coder maps a vector of K information bits to a corresponding vector of symbol amplitudes. Since the MSM signal $s(t)$ can be positive or negative, the transmitter adds a baseband bias signal $b(t)$ so that the MSM signal is nonnegative. In general, $b(t)$ is the sum of a constant and a baseband pulse-amplitude modulation (PAM) signal. Considering a rectangular transmit pulse shape and the subcarrier frequencies $\omega_n = n\frac{2\pi}{T}$, $n = 1, \ldots, N$, the average optical power just depends on the bias signal [4].

If we choose the bias signal properly, we can decrease the average optical power. There are two biasing schemes: a fixed bias and a time-varying bias. When using a fixed bias, we use one that has the same magnitude as the smallest value of an MSM signal. When using a time-varying bias, we use the smallest allowable symbol-by-symbol bias. Note that the average optical power with time-varying bias scheme is generally smaller than that with fixed bias scheme.

A. Block Codes for MSM Optical Communication System

In the MSM systems, the block coder maps the vector of K information bits to be transmitted to the vector of symbol amplitudes modulated onto the N subcarriers. Some block codes have been proposed for the MSM optical communication systems to improve the power efficiency of the MSM systems [4]. We will briefly explain some block codes.

A.1 Normal Block Code

Under the normal block code, all N subcarriers are used for transmission of information bits. Hence, the number of vectors of symbol amplitudes is $M = 2^{2N}$ and the number of information bits per MSM symbol is $K = 2N$ for QPSK. Each information bit can be mapped independently to the corresponding symbol amplitude. At the receiver, each detected symbol amplitude, i.e., each component of the vector of the symbol amplitudes can be mapped independently to an information bit.

A.2 Reserved-Subcarrier Block Code [4]

Under the reserved-subcarrier block code, L subcarriers are reserved with the goal of maximizing the minimum value of the MSM electrical signal $s(t)$, thereby minimizing the average optical power. Hence, in this case, $M = 2^{2(N-L)}, K = 2(N-L)$ for QPSK. In the reserved-subcarrier block coding, we encode an information bit vector by freely choosing the symbol amplitudes on the unreserved subcarriers. We then choose the symbol amplitudes on the reserved subcarriers to maximize the minimum value of the MSM electrical signal over the symbol interval. For each choice of N and L, there exists an optimal set of reserved subcarriers, though this set is often not unique.

A.3 Minimum-Power Block Code [4]

Under the minimum-power block code, no fixed set of subcarriers is reserved, but $L > 0$ subcarriers are reserved for maximizing the minimum value of the MSM electrical signal $s(t)$. Under the minimum-power block code, $M = 2^{2(N-L)}, K = 2(N-L)$ for QPSK. For a given N and L, the average optical power under the minimum-power block coding always lower-bounds the average optical power requirement under the reserved-subcarrier block coding.

TABLE I
SUBCARRIER SIGNAL POINT SEQUENCES (SSPS) (N=3, K=3, 8PSK)

No.	Input Bits			SSPS			Bias [V]
1	0	0	0	0	0	0	1.3156
2	0	0	1	3	6	1	1.3156
3	0	1	0	6	4	2	1.3156
4	0	1	1	1	2	3	1.3156
5	1	0	0	4	0	4	1.3156
6	1	0	1	7	6	5	1.3156
7	1	1	0	2	4	6	1.3156
8	1	1	1	5	2	7	1.3156

B. MSM Optical Communication Systems with Subcarrier Signal Point Sequences (SSPS) [5]

In the conventional MSM optical systems, one symbol is transmitted with one subcarrier, while in the MSM system with subcarrier signal point sequences (SSPS), one symbol is transmitted with multiple subcarriers, which means that each symbol is composed of signal points on some subcarriers.

At the transmitter in the MSM systems with SSPS, each SSPS consisting of N points is selected according to input data. The SSPS having the largest minimum value and the largest Euclidean distances are used, so that the required d.c. bias is minimized and the error rate performance is improved. Each subcarrier has a respective signal point selected according to the information data. The selected sequence is mapped to the corresponding signal point of each subcarrier. The receiver detects the transmitted symbols based on the maximum likelihood sequence estimation (MLSE). According to the Euclidean distance between the received SSPS and the locally generated SSPS, the detector selects the signal point sequence that shows the minimum value of Euclidean distance as the transmitted symbol. The MSM systems with SSPS using 2^K sequences can transmit K bits by one MSM-SSPS symbol.

Table 1 shows a set of SSPS and the bias values for three subcarriers ($N = 3$) where each signal point of which corresponds to a signal point of 8PSK signal constellation. In this table, 8 SSPS's having a minimum bias value of 1.3156 have been selected from all the possible sequences 8^3.

III. PERFORMANCE ON IM/DD CHANNEL WITHOUT DISPERSION

In this section, we show the bandwidth and power requirements of the MSM systems with some block codes, comparing them to the single-carrier system with OOK. For each scheme, R_b represents the information bit rate and B represents the total electrical bandwidth required at the receiver. The required bit error probability is set to 10^{-6}. For comparison, the required power is normalized with that of OOK at the same bit rate R_b. The system using OOK with rectangular pulses of duration T and the symbol rate of $1/T$ is considered as a reference system.

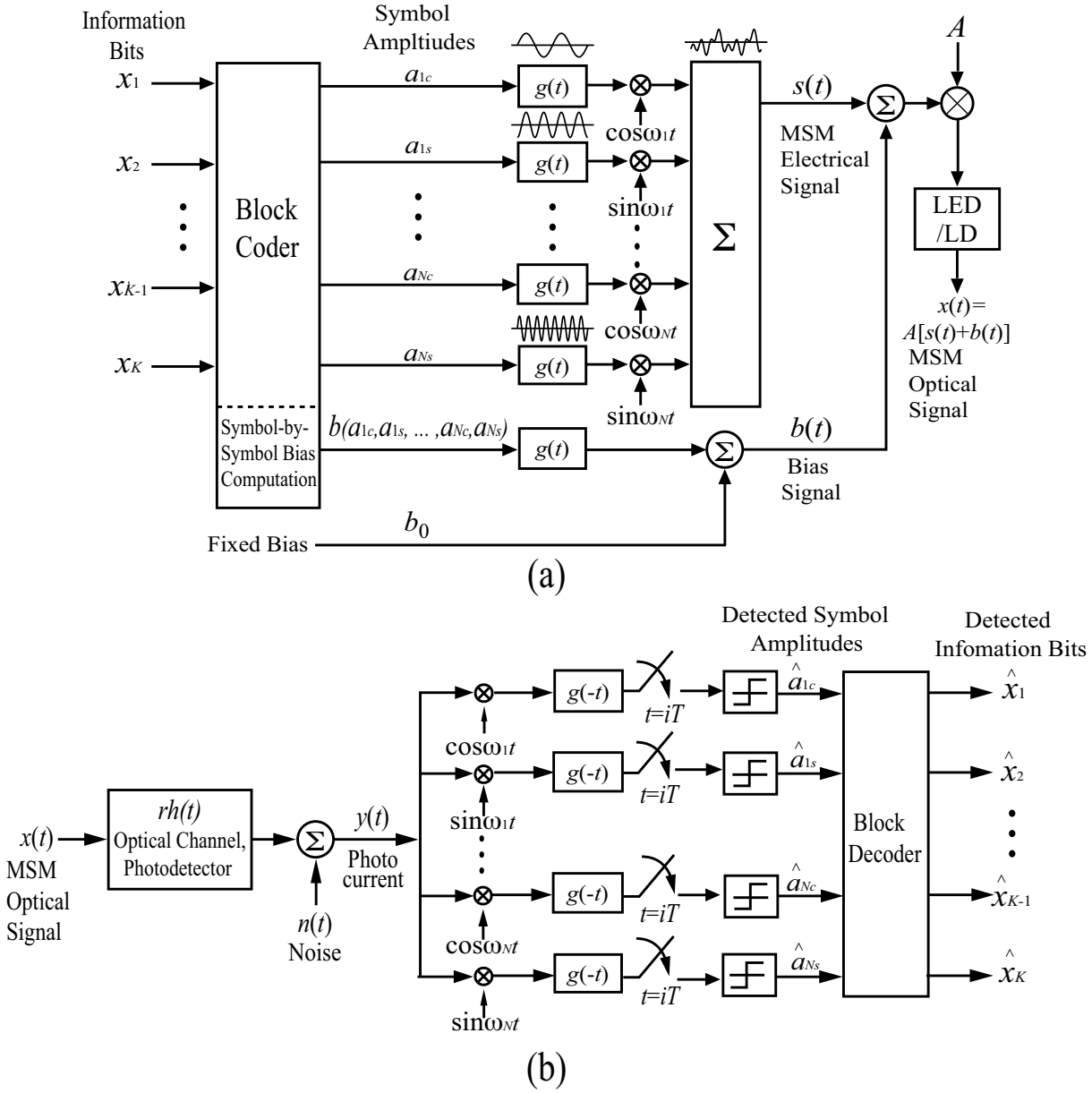

Fig. 1. Multiple subcarrier modulation (MSM) system where QPSK is assumed in this figure: (a) transmitter and (b) receiver

The electrical bandwidth requirement is given by

$$B = (N + 1)/T. \tag{1}$$

The number of subcarriers is set to $1 \leq N \leq 8$ in all the systems, because in the optical wireless communications, eye safety and power consumption limit the available average optical power and thus the number of subcarriers should be kept small. The number of reserved subcarriers L is set to $L = 1$ in the MSM system with the reserved subcarrier block coding (Reserved-MS). As for the bias signal, the fixed bias and the time-varying bias are used for all the systems.

A. Normalized Power Requirement Versus The Number of Subcarriers

We compare the performance in terms of the number of subcarriers, because it affects the required speed of the demodulation electronics, and also influences the multipath immunity of the signal.

Fig. 2 shows the normalized power requirement versus the total number of subcarriers for the systems with binary-phase shift keying (BPSK) and (a) fixed bias and (b) time-varying bias. The normalized power requirement of the MSM-SSPS is smaller than those of the MSM systems with the normal block code (Normal-MS), the reserved subcarrier block code (the Reserved-MS), and the minimum power block code (Min. Power-MS) for all N and both the biasing schemes. Comparing the performances with both the biasing schemes, the per-

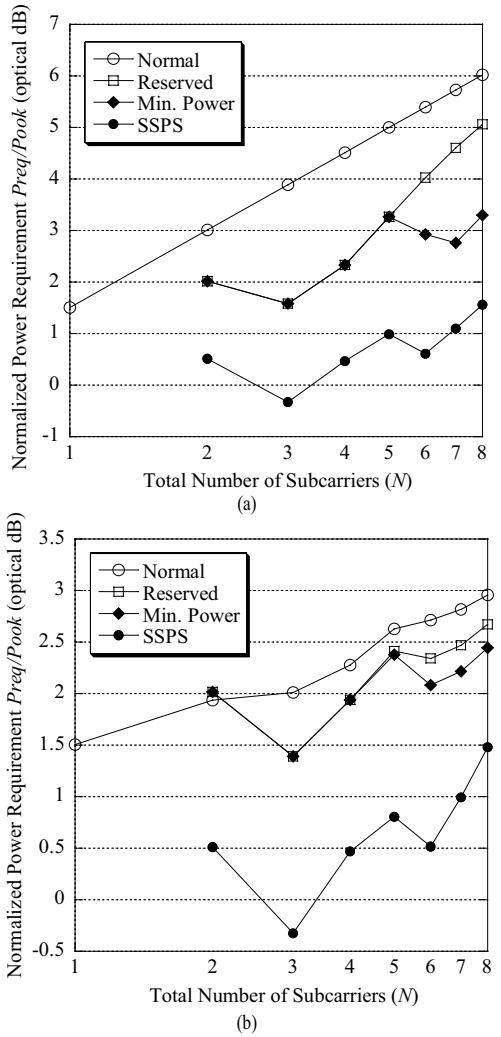

Fig. 2. Normalized power requirement versus the number of subcarriers for the systems with BPSK, (a) the fixed bias, (b) the time-varying bias

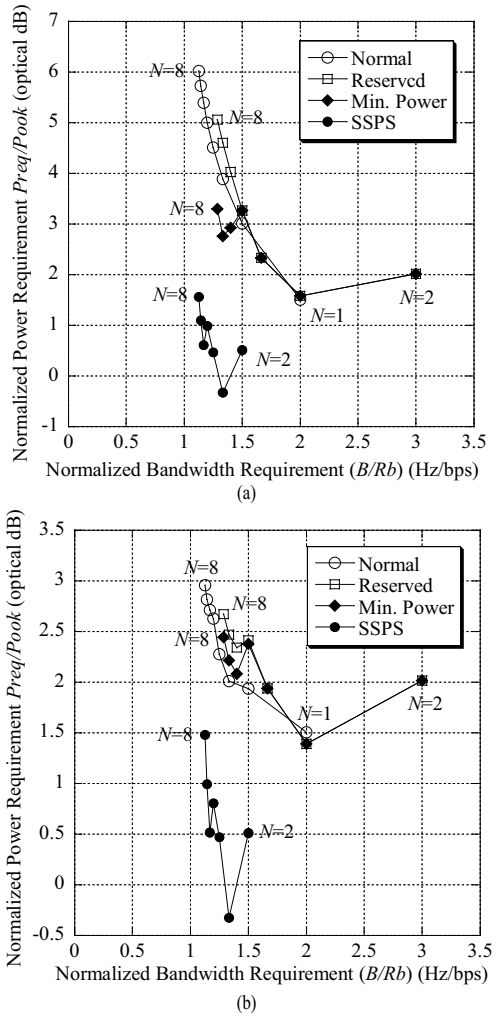

Fig. 3. Normalized power requirement versus normalized bandwidth requirement for the systems with BPSK, (a) the fixed bias, (b) the time-varying bias

formance of the system with time-varying bias is better than that of the system with fixed bias. As shown in this figure, the MSM systems are less power-efficient than the single-carrier systems with OOK. However, the MSM systems are well suited for transmission of multiplexed bit streams from a base station to some receivers. Through simultaneous transmission of several narrowband subcarriers, the MSM systems can enable very high aggregate bit rates without requiring equalization to overcome ISI. Moreover, the SM and the MSM systems can achieve much greater immunity than OOK or M-ary PPM to near-dc noise from fluorescent lights.

B. Normalized Power Requirement Versus Normalized Bandwidth Requirement

We also compare the performance in terms of the bandwidth requirement, because it is a measure of the electrical bandwidth required to pass the electrical signal resulting from direct detection

Fig. 3 shows the normalized power requirement versus the normalized bandwidth requirement for the systems with BPSK and (a) fixed bias and (b) time-varying bias. The MSM-SSPS can reduce the normalized power requirement large at the same normalized bandwidth requirement as other systems. Comparing the performances with both the biasing schemes, the performance of the system with time-varying bias is better than that of the system with fixed bias. As shown in this figure, the MSM systems are less bandwidth-efficient than the single-carrier systems with OOK or M-ary PPM. This is because the BPSK subcarrier used here requires twice the bandwidth of an OOK signal.

IV. Conclusions

This article has outlined the basic principles and characteristics of the multiple subcarrier modulation (MSM) techniques in optical wireless communications. Although the general MSM systems are not as power-efficient as single carrier systems, the MSM system using subcarrier signal point sequences (SSPS) was presented to improve the power efficiency of the MSM systems. MSM can also effectively improve the bit error probability in atmospheric optical communications [7], [8], though it is not shown in this article. Therefore, the MSM techniques are shown to be attractive in optical wireless communications.

REFERENCES

[1] J. A. C. Bingham, "Multicarrier modulation for data transmission: An idea whose time has come," *IEEE Commun. Mag.*, vol. 28, pp. 5–14, May 1990.

[2] T. E. Darcie, "Subcarrier multiplexing for lightwave networks and video distribution systems," *IEEE J. Select Areas Commun.*, vol. 8, pp. 1240–1248, Sept. 1990.

[3] J. M. Kahn and J. R. Barry, "Wireless infrared communications," *Proc. IEEE,* vol. 85, pp. 265–298, Feb. 1997.

[4] R. You and J. M. Kahn, "Average power reduction techniques for multiple-subcarrier intensity-modulated optical signals," *IEEE Trans. on Commun*, vol. 49, pp. 2164–2171, Dec. 2001.

[5] S. Teramoto and T. Ohtsuki, "Multiple-subcarrier optical communication systems with subcarrier signal point sequence," IEEE Global Telecommunications Conference (GLOBECOM2002), pp. 1845–1849, Taipei, Taiwan, Nov. 2002.

[6] J. B. Carruthers and J. M. Kahn, "Multiple-subcarrier modulation for nondirected wireless infrared communication," *IEEE J. Select Areas Commun.*, vol. 14, pp. 538–546, Apr. 1996.

[7] W. Huang, J. Takayanagi, T. Sakanaka, and M. Nakagawa, "Atmospheric optical communication system using subcarrier PSK modulation," Trans. of IEICE, Vol. E76-B, No. 9, pp. 1169–1176, Sep. 1993.

[8] T. Ohtsuki, "Turbo-coded atmospheric optical communication systems," IEEE International Conference on Communications (ICC2002), pp. 2938–2942, New York, USA, April, May 2002.

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From Editor's Room

● Society Conference in Tokushima

The IEICE Communications Society Conference is coming. The next conference is held in Tokushima from September 21(Tue.) to 24(Fri.).

Have you ever been to Tokushima? I suppose this is a rare chance to visit Tokushima. I have been to Tokushima once for a wedding ceremony of my colleague. I acted the matchmaker (nakoudo) at the wedding for the first time. So Tokushima holds fond memories for my wife and me.

Perhaps you know Tokushima as the place of Awaodori dance. The Awaodori will be held from August 11th to 16th this year. We cannot see this, but we can visit Awaodori-kaikan, where we can see the costumes, instruments, etc. at the museum, and enjoy the dance at the determined time at the hall.

Tokushima may remind you of sudach that is a kind of citrus fruit. My friend in Tokushima sent me a box of sudachi once. Most of you will use sudachi as an accent of taste for sashimi, hiyayakko, baked fish, etc. with soy sauce. Of cause it's a good choice, but I found sudachi fits shochu perfectly. September is the best season of fresh sudachi. Please enjoy sudachi-hi after your presentation at the conference.

It is not well-known but I like cloth of Tokushima. It is simle and idylic. I displayed the cloth on a wall of my room. I forgot the name of the cloth. Please visit a cloth shop, if you are interested in smoky brown or gray earthy feeling cloth.

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Call for papers

Special Section on 2004 International Symposium on Electromagnetic Compatibility

The IEICE (Institute of Electronics, Information and Communication Engineers) Transactions on Communications announces a forthcoming Special Section on " **2004 International Symposium on Electromagnetic Compatibility** " to be published in **August 2005**.

As the development of the advanced information society, various electrical and electronic equipment applied with digital techniques as well as information and communication equipment are widely used for the industry and also in the home. In addition, many radio communication systems such as mobile phones and wireless LAN have become popular in the world. Moreover, continuous technical development has been done toward the realization of the Ubiquitous Network Society. In this background, the technology achieving electromagnetic compatibility (EMC) should be developed to maintain the quality of these equipment and the systems, and many engineers are working on these problems. The EMC'04 International Symposium sponsored by IEICE in Sendai in June 2004 discussed many related problems.

The intention of this special issue is to promote the development of EMC technologies, which are increasing in importance. This special section presents the problems concerning EMC technologies, for example measurement, test, evaluation, simulation, design, and countermeasure methods. We call for papers from domestic and overseas engineers, and strongly encourage the submission of papers to be presented at **EMC'04 Sendai**.

1. Scope

The major topics are listed below, but are not limited to

- EMC measurement method
- EMC test method
- EMC evaluation method
- EMC simulation method
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- EMC countermeasure method

2. Submission Instructions

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In this special issue, electronic submission is adopted. Prospective authors are requested to follow carefully the submission process described bellow.

1. Submit a paper using the IEICE web site http://review.ieice.org/regist_e.wbt. The acceptable format of the file is PDF file. Other any files and the e-mail submission are **Not** acceptable. Authors should choose the "[Special-EB] 2004 International Symposium on Electromagnetic Compatibility" as a "Type of Issue/Category of Transactions" on the online screen. Do **not** choose "[Regular-EB] Communications".
2. Two sets of the hard-copy manuscript including the figures and tables, should be sent by postal mail to the following address together with "**Copyright Transfer and Page Charge Agreement"** and "**Confirmation Sheet of Manuscript Registration**" which are created automatically on the online screen after registration. Please mark "Special Section on International Symposium on 2004 Electromagnetic Compatibility" on the envelope.
3. The deadline for submission is **November 15, 2004.**

Manuscripts and all inquires should be sent to:

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3. Special Section Editorial Committee

4. Notes

A few invited papers will be included in the special issue. Authors of all papers, including authors of invited papers, will be requested to pay the usual page charges covering the partial cost of publication. 100 copies of reprints will be provided.