A WIRELESS VOICE/DATA COMMUNICATION SYSTEM IN A LARGE HOSPITAL

Eisuke Hanada
Department of Medical Informatics, Shimane University hospital, Izumo, 693-8501, Japan

Takato Kudou
Department of Electric and Electronic Engineering, Faculty of Engineering, Oita University, Oita, 870-1192, Japan

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Abstract: Computer systems, often called hospital information systems (HIS), have been installed in most large Japanese hospitals for administration of the basic medical information of patients, for making entries on medical charts, and for prescribing medication. In almost all cases, HIS have a server/client type structure, with the servers and client terminals connected with a LAN. For voice communication among the hospital staff, a landline telephone is often used. Fixed-line call systems (nurse call systems) are used for communication between patients and nurses. The potential demand for the introduction of wireless communication devices for data/voice communication into hospitals is high because of the promise of savings these technologies bring by improving patient service and labour efficiency. However, because of guidelines made to reduce problems that might be caused by electromagnetic interference (EMI) with medical electric devices and administrative fears about potential problems, the introduction of these systems has, until recently, been shelved in almost all cases. Because in recent years it has became possible to control the electromagnetic waves emitted by mobile communications apparatus and to protect against the possible occurrence of EMI, the number of hospitals introducing such wireless communication has grown. We report a case of a university hospital in which data and voice wireless communication have been safely and efficiently introduced

1 INTRODUCTION

Computer system installation is progressing rapidly in Japanese hospitals. Computer systems designed for storing the basic medical information of patients, for making entries on medical charts, for information retrieval, and for the prescription of medication have been installed in most hospitals with 600 or more sickbeds. Usually called a hospital information system (HIS), most have a server and client type structure. Many types of systems exist in which servers located in a special hospital server room communicate with client terminals in consultation rooms or nurse stations by way of a LAN using TCP/IP.

Voice communication among hospital staff members, however, is often still done with fixed, landline telephones. A fixed-line call system is usually used for communication between a patient and a nurse in which the patient pushes a button on the sickbed and a lamp on the indicator panel in a nurse station lights up. An intercom may also be used by which a nurse can talk with the patient who pushed the button. This system is usually called a "nurse call system."

The potential demand for the introduction of wireless communication devices for data/voice communication into hospitals is high because of the promise of savings these technologies bring for improving patient service and labour efficiency (Nelson, 1999). However, because of reports since 1993 of problems caused by electromagnetic interference (EMI) with medical electric devices and guidelines enacted in many countries to protect against such interference, the introduction of such systems has been shelved in almost all hospitals.

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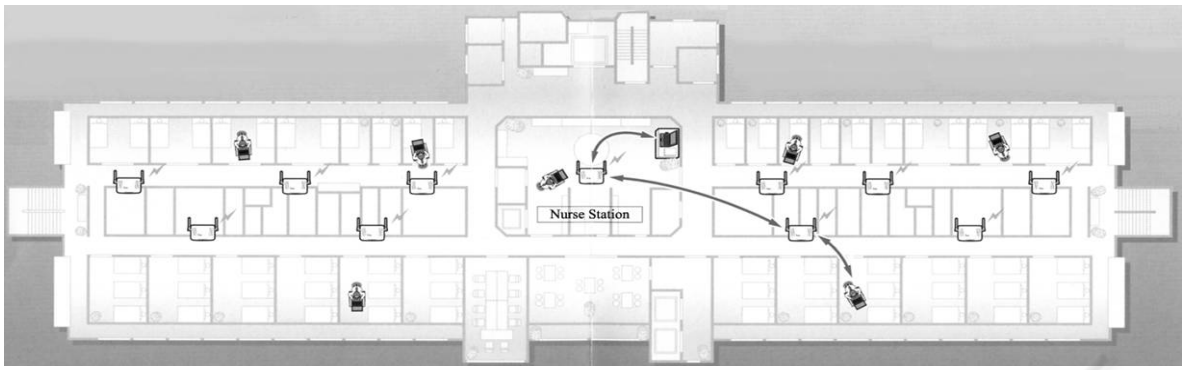

Figure 1: An image of the location of access points in one floor

Since in recent years it has became possible to control the electromagnetic waves emitted by mobile communications apparatus and to protect against the possible occurrence of EMI, the number of hospitals introducing such wireless communications has grown. In this paper, we report a case of a university hospital in which wireless communication have been safely and efficiently introduced. (hereafter termed the target university hospital). The target university hospital is described in section 2.1. Wireless data communication is reported in section 2.2, followed by wireless voice communication for staff and patients in section 2.3. Finally, the needs and effectiveness of in hospital wireless communication are discussed.

2 INTRODUCTION OF WIRELESS COMMUNICATION IN A UNIVERSITY HOSPITAL

2.1 Outline of the target university hospital

The target university hospital is located in western Japan, has 21 specialised departments, 616 beds, and about 300 doctors and 350 nurses. The target university hospital has one ward building with 12 wards of about 50 beds each, an ICU and an NICU. A special ward is only for children and another is only for psychiatric patients. Also, one ward is designated for women only. Although there are some private rooms, most accommodate from 2-6 persons. Each ward has eight to ten daytime and two or three night nurses. A minimum of one doctor is required to be stationed at each ward at all times to perform required medical treatment, but usually more than one is on duty

2.2 HIS wireless data communication

The HIS of the target university hospital consists of 44 servers and 512 client terminals. Of these, 60 client terminals are connected with servers using wireless LAN. These terminals are limited to use in the wards by the medical staff. The specification of the adopted wireless LAN is IEEE802.11a for the following reasons.

Apparatus that emit electromagnetic waves in the 2.45GHz band, such as heaters, and microwave ovens, are often found in hospital wards. The data transfer rate is higher than that using IEEE802.11b and 11g.

Eleven access points are located in each floor, as shown in Fig.1. For the access point, we adopted the AP-5100 (ICOM Inc., Fig. 2).

Figure 2: AP-5100 in a ward corridor

Because the security of personal information important, to prevent electric wave interception the SSID value is changed on each floor and connection attempts using the “Any” setting of the SSID are refused.

The AP-5100 has adopted OCB AES (128 bits) as a cipher system, and high-speed encryption and decryption are possible. Also, a connectable Media Access Control (MAC) address can be registered into each access point. Therefore, if PCs other than terminals permitted to be connected are used in any ward, they cannot be connected to the hospital LAN. Furthermore, to prevent unauthorised entry into the HIS, authentication with ID and a password is has been added and all communications are logged.

In addition to uploading and input of patient information at bedside, patient checks using barcode scanning and review of medical treatment charts can be done on this system. Not only is medical efficiency improved, but the system also protects against input failures and input mistakes by eliminating the need to move from bedside to the fixed terminals in the nurse station. Also, because reference to required medical information is possible at the bedside, it is also useful from the aspect of improvements in the safety of medical treatment. Moreover, messages and directions previously were written on memorandum pads and passed by hand among the staff, resulting in personal information being seen by many people. The protection of personal information is improved through the use of this system**.**

2.3 Mobile voice communication

2.3.1 Mobile voice communications between staff members

In the target university hospital, both landline telephones and the Personal Handy-phone System **(**PHS**)** are used for voice communication between staff members. PHS is a totally digital mobile communication system with low output power (Hanada, 2000) developed in Japan, and its use is spreading in China and Southeast Asian countries. The frequency of the electromagnetic signal used by PHS is in the 1.9GHz band, and the output of a terminal is a maximum of 80mW. When the distance from a base station to a terminal is about 100m, the output of the base station can be reduced to as low as 160mW. Almost no EMI with medical electric devices by the electromagnetic signals emitted by a PHS terminal was found in investigations by EMCC of Japan (EMCC, 1997) and the Ministry of Public Management, Home Affairs, Posts and Telecommunications of Japan (MPHPT, 2002).

In many large Japanese hospitals, not only in university hospitals, nurses using PHS instead of the traditional nurse call system terminal can respond to calls from patients immediately, even when out of the nurse station, thus increasing efficiency, improving patient service, and raising the level of medical safety.

Figure 3: A PHS terminal used in the target university hospital

Besides this, doctors working in the target university hospital have access to a public PHS terminal (WILLCOM, Inc., Fig.3), the cost effective "Anshin-da-phone" service with limited functions. In this system, calls can be received freely, but a limit is set at three numbers, designated by the subscriber, that can be called. As seen in Figure 3, a red strap is connected to the PHS terminal to serve notice that the terminal has been registered for use in the hospital. The use of PHS makes it unnecessary for nurses and pharmacists to physically search for a doctor, and makes it possible to quickly ask questions and receive the necessary feedback.

To determine the effectiveness of the PHS system for doctors, the number of calls received on a fixed-line telephone in a ward was compared for one week before and after the introduction of PHS. Results are shown in Table 1.

Table 1: Number of calls received on weekdays (5 days) before and after the introduction of PHS

Section	Calls before introduction	Calls after introduction
Wards	1216	588
Visitor sections	458	356
Other sections	116	212
Total	1790	1126

As shown in Table 1, the total number of calls received at wards was reduced by more than half. However, the number of calls received at the other sections increased, possibly because even though PHS emits a safe level of electromagnetic signals, carrying such phones into surgical rooms is forbidden.

2.3.2 Mobile communication as a service for patients

The target university hospital permits the use of cellular phones by outpatients, inpatients, and visitors to unrestricted zones. In Japan, 85,500,000 or more cellular phones are now in use, with 75% or more people having a cellular phone (TCA, 2004). Many people have become so dependant on them that a syndrome called "cellular-phone dependence" has been coined for people who cannot live without them. Also, the use of cellular phones in business is widely promoted as they are now recognised as being indispensable for doing business. Due partly to the above factors, the demand for communication using cellular phones by both outpatients and inpatients is growing. Especially for inpatients, the free use of a phone can decrease stress and the sense of isolation caused by hospitalisation, thus raising the Quality of Hospital Life (QOL). Other factors may account for some of the increased demand for cellular-phone use. For example, no reports of malfunction of medical devices have been seen in recent years. The third generation mobile phone systems, which reduced the electric wave output have become popular. Also, medical devices have improved protection against electromagnetic waves.

The target university hospital defined criteria for cellular phone use, with reference to experimental results (EMCC, 1997, Hanada, 2000, MPHPT, 2002) as shown in Table 2, and permitted the use of cellular phones in limited areas from January, 2004.

Table 2: Conditions for cellular-phone use in the target university hospital

- Cellular phones can be used only in a visitor lobby, a single bed sickroom, and in dining rooms.
- The medical staff can use cellular phones at nurse stations and in conference rooms
- Cellular phone use is not allowed within 50cm of medical devices
- Patients connected to medical devices are prohibited from using cellular phones
- After a set time for turning out sickroom lights, the use of cellular phones is prohibited
- Staff members are not allowed to use a cellular phone during rounds, while walking, or during explanations to patients or their family.

In the target university hospital, these rules are widely displayed and are specified in the hospital guidelines. The co-operation of patients and staff members has been requested, and no interference with medical devices has been observed since these rules were put in effect.

3 DISCUSSION

In Japan, other than the target university hospital there are no hospitals with more than 600 beds using wireless communications for both data and voice communication. This is because restriction of cellular phone use is economically cheaper and responsibility can be avoided by hospital administrators who fear EMI and who do not want to take the measures necessary to mitigate against EMI. However, by keeping cellular phones away from medical devices and by using mobile phones or wireless LAN apparatus with weak electromagnetic wave output, it is possible to stop or minimise EMI with medical devices, as shown by previous experimental results (Hanada, 2000, Hanada, 2004).

In Japanese hospitals, long periods of time spent in treatment as an outpatient has been a big problem. Also, inpatients have, in many cases, been restricted from communicating with persons outside the hospital. The dissatisfaction of both groups has grown. Recently, the Japan Council for Quality Health Care (JCQHC) has been asked for a ruling about cellular-phone use in hospitals. The JCQHC has made standards and checks hospitals for compliance. Japanese hospitals that have been checked for evaluation of clinical function have felt the evaluations were fair. The newest version of the JCQHC standards require that a space be designated in which cellular phone use is permitted or that an alternative communication means be in place if the institution wishes to meet the evaluation standards (JCQHC, 2005). Such evaluation is not mandatory, but permission for cellular-phone use taking into account these factors has resulted in improvements in service to patients.

Before mobile communications systems were installed in Japanese hospitals, many telephone calls searching for doctors were placed, which took quite a lot of time. Because secretaries and office personnel are seldom hired to work in wards in Japanese hospitals, there are many cases in which nurses receive calls that require administrative work, reducing their ability to complete their nursing responsibilities. For example, when a pharmacist in the pharmacy has a question about a prescription, it is necessary to contact the doctor concerned for confirmation of the prescription and correction, if necessary. However, in large hospitals, because the pharmacists in many cases work in places distant from doctors, the pharmacists do not have the means to know the current location of each doctor. Therefore, they had to call various wards or consultation rooms.

Doctors working in Japanese university hospitals in the past, in many cases, received emergency calls through a pager. However, a pager has only a message receiving function and can not place calls, and the caller can not know whether the doctor has read the message. Therefore, they are not suitable for communications that require immediate reply. This is the same with communications using E-mail. Furthermore, public pager service in Japan will be stopped within the next year.

Installing wireless communication will result in fore timely communication, which will result in significantly improved medical safety. For example, when a pharmacist has a question concerning a prescription, drugs can not be given to the patient until the question has been answered. Also, the immediate communication gives nurses more time for providing direct nursing care. This results in fewer patient accidents and quicker response times when patients have a sudden change in their disease course.

Unrestricted mobile voice communication not only may become the cause of EMI but may cause conflict due to the noise generated by a telephone call or may result in medical accidents due to a lack of attentiveness. Therefore, limiting the areas in which phones are allowed is important for the purpose of preventing EMI, controlling noise, and preventing medical accidents (Hanada, 2005).

In Japan, some hospitals do not have wireless communication, but place a computer that serves as a joint use terminal for business use and for patient service at each bed. However, when taking into account other factors, such as multi-patient sickrooms, the fact that some patients are not notified of their precise diagnosis, that the user authentication of these systems depends only on an ID and a password, and that the cost of installing a terminal at each bed is extremely high, these systems may not be viable. Other methods of providing Internet terminals as a patient service may be better from the standpoints of both economics and patient privacy.

To prevent the leakage of personal and hospital information, it is necessary to take all possible physical means available, but user education, especially the education of the medical staff, is the most important aspect.

4 CONCLUSION

A system for wireless voice/data communication in a university hospital was shown. In many hospitals, wireless communications have not been introduced for fear of the possibility of EMI. Aimed at realising the benefits of cost efficient information sharing and instant communication while insuring medical safety, wireless data transmission and mobile voice communication with low output power systems will be widely used in the future as they become evermore efficient, useful, and safe in the medical environment.

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