E-mail-based Telemonitoring System of Television's Operating State for Elderly Persons Living Alone

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1. Introduction

The number of elderly people living alone at home is increasing rapidly as the aged population increases in Japan [1]. Since the incidence of disease and injury increases with aging, remotely located families become anxious about the safety of elderly parents who conversely are eager for information about their remotely located families. Families and parents can communicate by telephone or e-mail, but frequent communication may cause emotional stress on one side or the other, or both. Ideally, an automatic check of daily activities and health status of elderly parents would help both sides without stressing either.

Changes in the behavioral activity of elderly people living alone at home may be an indicator for the assessment of their functional health status [2]. We propose that a television's operating-state (TVOS), *i.e.*, whether a television (TV) is turned on (TV-on) or off (TV-off), can express the consistency of the rhythms of the long-established everyday rituals of a dweller [3]. To improve the relationship between families and elderly parents who live far apart, we have developed a telemonitoring system using the TVOS [4]. In the previous telemonitoring system,

we employed the free software Cygwin and installed it in the Microsoft Windows® operating system (OS) to enable us to use UNIX commands on the Windows® OS. Cygwin installation requires computer skills and one hour of installation time, and the program occupies a large amount of hard disk space. These problems might prevent the telemonitoring system from becoming widespread. The aim of the present study, therefore, was to develop a novel system that monitors the TVOS by utilizing e-mails to solve the problems of the previous system.

2. E-mail-based telemonitoring system

Fig. 1 shows a schematic illustration of the whole e-mail-based telemonitoring system, which consists of a sensor section, a signal transmission section, a PC connected to the Internet at an elderly person's end (EPE), a server computer, and a PC connected to the Internet at a family's end (FE). In the sensor section, a current sensor is attached to the power line of a TV. The current sensor produces an AC voltage signal, which is amplified, rectified, and sent through a smoothing circuit to obtain a DC voltage that indicates TV-on or TV-off. An infrared sensor for a remote
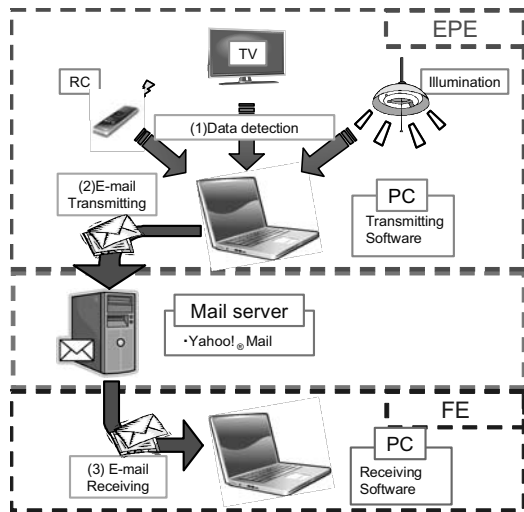
Fig. 1 Schematic illustration of e-mail-based telemonitoring system. EPE: elderly person's end; FE: family's end.

controller and a visible light sensor are also available in the system. Those signals are sampled every two seconds.

Before we install the telemonitoring system, we get an e-mail account in a server computer of free e-mail service, for instance Yahoo!®. In the TVOS transmission based on e-mail, the TVOS data must be kept private, as it includes personal information. In our previous system, we used secure shell (SSH) with two secret keys which were exchanged between PCs each other. In e-mail-based telemonitoring system we introduced Blowfish, a common key cryptosystem. In this study, we used a 64-bit secret key that was generated by Blowfish, and the text data of the TVOS was enciphered by the secret key. The enciphered TVOS data was attached to an e-mail and sent to the FE PC as follows. The e-mail sender, Blat free software, in the EPE PC is activated only when TVOS changes from its previous condition. Blat attaches

the current TVOS data to an e-mail and sends it to the server. The e-mail receiver, Mozilla Thunderbird free software, in the FE PC checks the server every minute and downloads any new mail. The FE PC restores encrypted data to its original form of text data. Table 1 shows a comparison of the functions between the previous system and the e-mail-based-system.

Table 1. Comparison of the functions between the previous system and the e-mail-based system

	Previous	E-mail
Sensors	(1)TV, (2)Remote controller	(1)TV, (2)Remote controller, (3)Illumination
Interface	USB-I/O	USB-I/O
Data acquisition	Real time	Real time
OS for PC	Windows XP®	Windows XP®
Data transmission	Pear to pear, Cygwin	Pear to pear, Free mail
IP address	Fixed IP or dynamic DNS	DHCP available
Security for data transmission	SSH	Blowfish
Data display	Graphic	Graphic

3. Results

3.1 System installation

We installed both the previous data transmission system and the developed e-mail-based one on a computer (Compaq nx6310, hp: CPU, Celeron® M 1.73 GHz; Memory: 512MB; Hard disk: 60GB; OS, Microsoft Windows® XP Professional SP2). We measured installation time, system occupation capacity in the hard disk, and port restriction changes. The results are shown in Table 2. The installation time of the e-mail-based system was 80% shorter than that of the previous system. The hard disk occupation capacity of the e-mail-based system was 98% smaller than that of

the previous system. Moreover, the e-mail system requires no port restriction changes. As the e-mail-based system has these advantages, people can install this system easily and the telemonitoring system can become widespread.

Table 2. Comparison of the installation between the previous system and the e-mail-based system

	Previous	E-mail
Installation time (min)	74	15
HD occupation capacity (MB)	1,500	25
Port restriction changes	22 port open	Unnecessary

3.2 Trial

Four families, two parents-children pairs, participated in this trial. Before beginning the study, we explained the purpose of this study to the subjects and the subjects gave us written informed consent to participate in the study.

We opened four free Yahoo!® e-mail accounts and installed the e-mail-based telemonitoring system of TVOS in each home. Changes in the TVOS were monitored for over four weeks without any trouble. The data obtained from the e-mail-based system corresponded well to the results of interviews with the subjects.

The pattern of TVOS varied in each subject. However, the pattern of TVOS had a few peaks which reflected the consistency of the daily TVOS in all subjects.

4. Discussion

The e-mail-based telemonitoring system developed in this study had the same function as the previous system. Moreover, the

visible-light-sensor data was also obtained. The e-mail-based telemonitoring system was easy to install, as shown in Table 2. We hope that this telemonitoring system becomes widespread.

The trial showed that the consistency of the daily rhythms of the TVOS and the different pattern of TVOS by day of the week. The TVOS reflects a living condition of the elderly person living alone at home. This system does not directly monitor the behavioral activity of elderly people living alone at home, but if deviation from the consistency of the rhythms of the TVOS and the visible-light-sensor data appears, the family living distant from the elderly person can detect a significant disruption of daily habit and take measures to find out what caused the disruption.

Acknowledgments

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