Study on Economical Structure of Safety Monitoring System by using Telephone for Elderly People Living Alone in a Rural Area

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Abstract: - The authours develop a new type of safety monitoring system which would reduce the initial cost and increase operability. A key feature of the system was that it used standard telephone terminals and computer telephony technology. The results of the experiment, carried out in Iwate and Aomori Prefectures in Japan, showed improved operability. This paper estimates the cost for an increasing number of users in the future. And this paper also discusses on some kinds of the system structures and proposes the most inexpensive structure.

Key-Words: - information system, safety monitoring system, social welfare system, computer telephony

1 Introduction

There are still many rural areas where elderly people are living alone without the information services provided by computers and the internet. In these rural areas, there are many social problems such as low birth rates, and aging and declining populations. The aim of our research is to provide useful but low cost information systems to ensure a safe, secure and comfortable life for elderly people in such rural areas.

This paper, a new successful safety monitoring system using telephone terminals and computer telephony technology is proposed. The prototype system structure is shown in the second section. Then, experimental results on the use of the system, carried out in Iwate and Aomori Prefectures, are shown in the third section. We obtained good results on its feasibility that it was comfortable to use and provided a feeling of safety for the elderly users and their supporting relatives. In the fourth section, we discuss three system models for the an increasing number of users in the future. And we also discuss the cost comparison of those system strucutre.

2 Prototype System structure

There are several types of safety monitoring systems, which can have the following typical elements.

(A) Sensor type: This type used infrared sensors, mechanical sensors (open/close door sensor, etc.), life monitoring (electric power, water or gas service monitoring sensor, etc.), appliances with a telecommunication function (for example, “i-pot” provided by the Zoujirushi Corporation, which is well known in Japan [1], etc.), human sensor (Doppler effect sensor, etc.), or surveillance cameras, etc. .

(B) Self Sending type: This type uses emergency information system or daily information sending system.

Various sensor systems (A) are produced by many production companies and can automatically send safety or activity information to the Social Welfere

Center (SWC) or their families. Several research papers on activity monitoring of the elderly at home have been published [2] [3] [4] [5] [6].

In this research, many sensors using telecommunication functions in the home or mobile phones with GPS functions in outdoor situations are used, and their experimental results are reported. Though they seemed to be very convenient because the user does not have to do anything, there are problems of frequent error detection, high cost and simply being uncomfortable to use because of the invasion of privacy. The cost problem is the most significant issue for elderly users and for rural governmental offices to administer in the field.

On the other hand, the Self Sending type (B) helps to solve the above problems. The emergency information system of this type (B) has a difficulty in that the user cannot use it in the case of an actual emergency, because the terminal may be located in a different place from where it is needed. For example, to ensure the safety of elderly people living alone in the Kawai village of Iwate Prefecture in Japan, an emergency call system was introduced by the government office. This system was introduced not only in the Kawai village but also in other areas in Japan. In this system, elderly people can send an emergency signal to the SWC by pressing the button on a telephone-type or a pendant-type terminal. However, there is a problem in that the system is not available in an emergency if the elderly person is unable to press the button [7].

Currently, such positive type systems tend to be difficult to expand because there are problems with error actions and resistance from elderly people due to privacy concerns [8]. Furthermore, the cost problems of the terminal and telecommunication fee remain.

When using a type (B) daily information system of the Self Sending type, a user can confirm his/her state daily. It has an acceptable low cost and seems to be superior to the conventional sensor type system from the viewpoint of the protection of privacy[9][10][11]. This type is an active system, which provides monitoring services for elderly people, and allows safety information to be sent by the elderly themselves. The privacy problem is minimal because they can inform on their state as and when they want to.

The Iwate Prefectural Council of Social Welfare is the head office for each city, town and village SWC located in Iwate Prefecture in Japan. It adopted the Self Sending type system using available telephones. The reason for using available telephones was that it has the lowest cost, virtually every user has a telephone, and it is easy for elderly people to use.

The prototype system structure is shown in Fig. 1. The system server has a voice server with a Voice IP board which converts analogue voice signals into digital packet signals. Each Voice IP board, which we adopted for the prototype system, has four telephone interfaces to connect to telephone lines. The system server has an automatic voice response function, which identifies the user by the telephone number and can respond by calling the user's name and providing short voice guidance. This appropriate automatic response is realized by using new computer telephony technology. By this function the user retains familiarity with the system.

When a user calls the recorded telephone number, the voice guidance says, "Hello (user's name) san". Then, it says, "How are you today? Push the number, please." If the user is fine, he/she will push the number 1 button of the telephone. If the user is not fine, he/she will push the number 2 button. If the user is bad, she/he will push the number 3 button. If the user wants to speak to a SWC staff member, he/she will push the number 4 button. After the user selects and pushes any button, the guidance makes an appropriate statement such as, "Thank you for sending the information, have a good day." The information is sent to the Web server located in the backend of the voice server. A manager of the SWC can confirm every user's state every day on the Web page. The Web server can send the information by e-mail to a nearby relative in the area and to family living elsewhere, if needed.

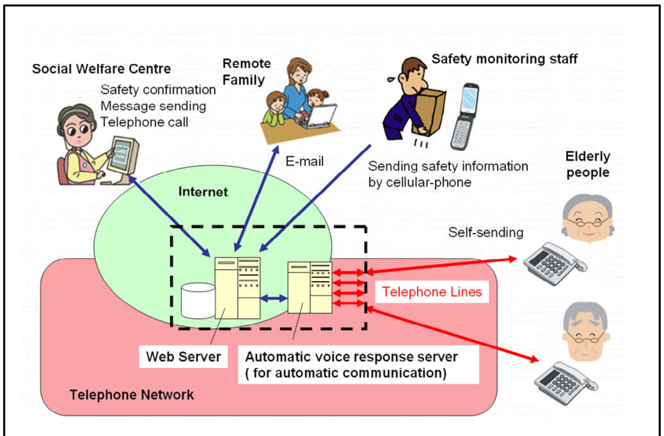

Fig.1 Prototype system structure

SWC operators can ascertain who is on the "Not yet communicated" users list. After a user on the list communicates his/her state, the user will then disappear from the list. The SWC manager only has to manage the users remaining on the list. This function is said to be very helpful for the SWC because the work load for confirmation of state is drastically reduced.

3 Experimental results

2.1 Feasibility

We developed the first prototype monitoring system in the period December 2008 to January 2009 and introduced it to five areas (SWC) in Iwate and Aomori Prefectures in Japan. Each area has four users, and the total number of first users was 20. They used the first prototype system from 6th to 18th February 2009.

After that, we sent a questionnaire to each user. From the response to the questionnaire we learnt that 13 users wanted to use it continuously, 5 users did not want to use it, and 2 users did not respond. We obtained encouraging and good results from the experiment.

After we had explained the system's advantages and how to use it to the 29 officers in each SWC in Iwate Prefecture, we ran a survey questionnaire on the system's use. Opinions of SWC officers on the introduction of the new system are shown as follows.

-"I considered using it actively this year": 5 (17.2 %)

-"I have not yet decided, but I have considered using it this year": 8 (27.6 %)

-"I am considered using it next year": 14 (48.3 %)

-"I have no plans to use it next year": 2 (6.5 %)

Over 93 % of the officers working in each SWC considered using the monitoring system in the next year (in 2011). The total number of areas involved (SWC) reached 11 and that of users reached 72 in March 2010.

2.2 Traffic of telephone calls

Fig.2 shows the total number of telephone calls from 1st June to 26th October 2009. Each vertical bar of the graph in Fig.2 represents the total number of calls per minute of every day in the experimental period (148 days). In this period, the average number of users per day was 64.6 and the 10 minute time slot with the heaviest telephone traffic named "Peak Time" was between 7:41 to7:50.

We have attempted to estimate the required number of telephone lines for the future size of the developed monitoring system. From the experiment mentioned above, the average number of users was 64.6 per day and the mean connection time, namely the speaking time, "ts", was 19 s. From the calculation results, we considered 10 users per one line was enough to keep the telecommunication quality[11].

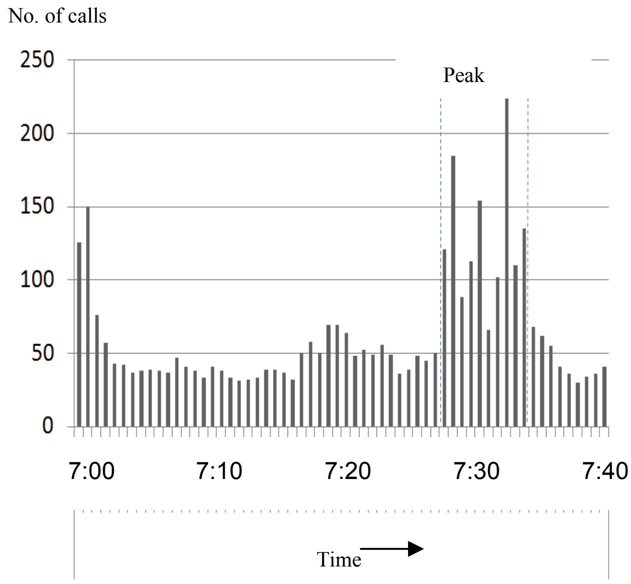

Fig.2 Number of telephone calls from 1 June to 26th October 2009

4 System models and discussion on cost

4.1 System models

The prototype system has a voice server with an IVR (Interactive Voice Response) card and a Web server. Voice IP board has a voice signal convert function to digital signal and an automatic voice response function by using computer telephony technology. There are some problems to manage the system that the Voice IP board and the management cost of the server is still expensive. Then, we propose other system models to solve the cost problem.

Fig.3 shows the current prototype mode (model A). The user's telephone call is sent to the Web server which has the IVR card via PSTN (Public Switched Telephone Network) directly. The user's safety information can confirmed by a client PC in each SWC via Internet.

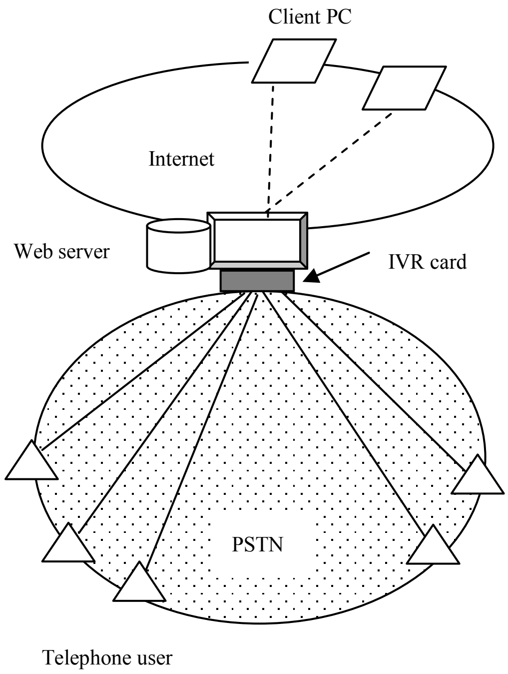

Fig. 3 Current prototype model (model A).

Fig.4 shows the next step model by using Asterisk technology (model B). Asterisk is free software that provides applications like PBX, VoIP gateway and IVR (Interactive Voice Response) function. We can relize the similar systm as the current prototype system without expensive IVR card by using Asterisk technology. In model B, it needs to use the VoIP gateway service because Asterisk server is a kind of

PBX for IP telephones in Internet, but usual users of the system use usual PSTN telephone terminal.

In model B, the expensive IVR card is not necessary and server management cost will be reduced because SWC are not responsible for all servers (Asterisk server, Web server and VoIP gateway service) . But, new cost problems of monthly cost for the rental servers and telephone fee of users arises. If the system size expands to wide area, the telephone fee will increase drastically. The sample of telephone call fee in Japan is shown in Fig.5. The figure shows the case with talking time of 60 sec and that of 40 sec. In both case, the call fee is increasing in communication distance of over 100 km.

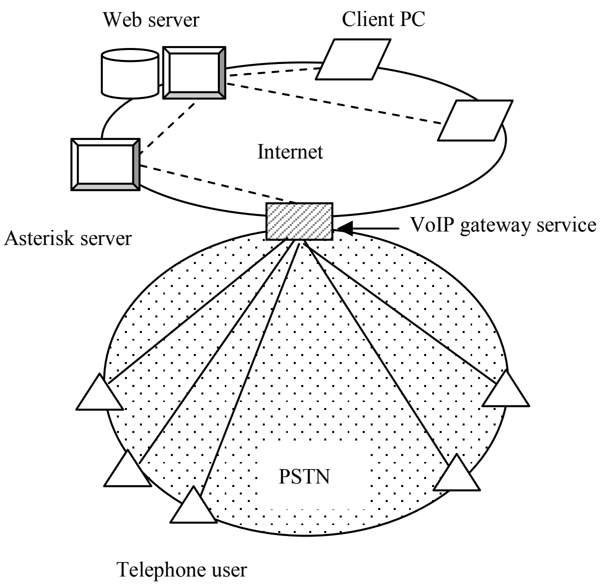

Fig.4 Model B by using Asterisk server.

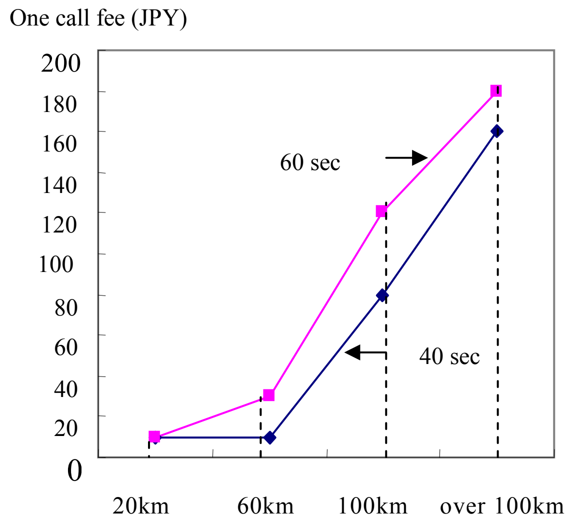

Fig.5 Sample of telephone call fee in Japan.

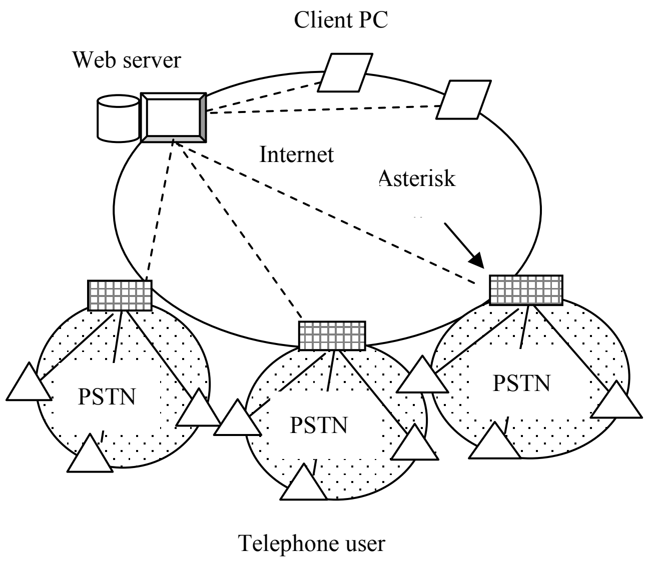

Fig. 6 Model C by using Asterisk appliance.

We propose another model C shown in Fig. 6 that uses Asterisk appliance to reduce telephone call fee. Asterisk appliance can provide small PBX service with low cost. When an Asterisk appliance is set in each SWC office, the distance between users and SWC will be in near PSTN area.

4.2 Cost comparison

In order to compare the cost of each model, we analyze the element of the each system structure. Required cost items for each model are shown in Table1.

In Table1, “Y” means “required” and “N” means “not required” item. As Client PC and Internet are required in every model, we do not consider them in the following cost comparison.

Table 1. Required cost items for each model.

Item (Cost symbol)		Model A	Model B	Model C
Initial Cost	Web server (W_s)	Y	N	N
	Client PC	Y	Y	Y
	IVR card(V_b)	Y	N	N
	Asterisk Appliance (A_a)	N	N	Y
Monthly Cost	Tele. Fee for SWC (T_c)	Y	Y	Y
	Tele. Fee for user (T_u)	Y	Y	Y
	Internet	Y	Y	Y
	VoIP GW service (V_g)	N	Y	N
	Asterisk rental server (A_r)	N	Y	N
	Web rental server (W_r)	N	Y	Y

The relative cost equation in each model can be expressed as follows,

Relative cost of model A is,

$$C_a = W_s+V_b \cdot N/10+N \cdot T_c \cdot M/10 +N \cdot T_u \cdot 30 \cdot M \cdot L_c, . \quad \text{--- (1)}$$

Relative cost of model B is,

$$C_b = (V_g \cdot N/10+A_r+W_r+N \cdot T_c/10+N \cdot T_u \cdot 30 \cdot L_c) \cdot M. \quad \text{---(2)}$$

Relative cost of model C is,

$$C_c= A_a \cdot N/100+(W_r+N \cdot T_c/10+N \cdot T_u \cdot 30) \cdot M. \quad \text{---(3)}$$

Here, N is number of total users (elderly users), M is time (unit is month), L_c is the cost coefficient depending on telephone line distance. If mean distance between telephone switching center and a user is L_m (km), $L_c = L_m \cdot 0.1$ (JPY/km) in Japan. Lm is depends on population density D of service area and it can be expressed in the case of random distribution as follows,

$$L_m = (2/3) \cdot (N / (D \cdot \pi))^{0.5} \quad \text{---(4)}$$

Equation (4) is introduced by using a simple model shown in Fig.7, where the population density D is constant in the area with radius R. We adopted D = 0.1 /km^2, for considering Iwate prefecture in Japan in following calculation.

In above equations, we assumed that 10 users are assigned per one telephone line of SWC [12], an Asterisk appliance has 10 ports and one month has 30 days.

We calculated the relationship between accumulated system cost and time for each model by using following samples of values.

W_s = 300, V_b = 200/line, A_a = 100/area,

T_c = 0.5/month & line for PSTN, 0.1 /month for IP,

T_u = 0.01 /time & user (it depends on distance),

V_g = 1 /month & line,

A_r = 20/month, W_r = 20/month.

Those values are set by considering current Japanese market price on each item.

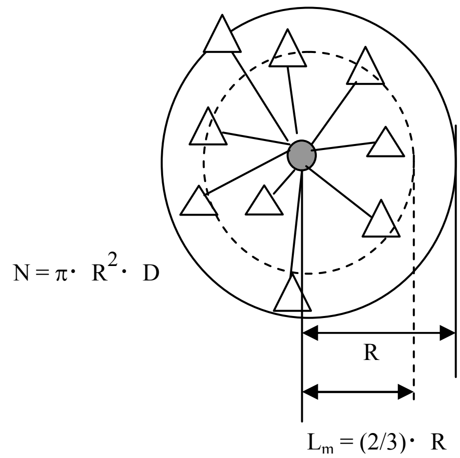

Fig. 7 Simple model to calculate the mean distance L_m between SWC and a user.

Fig. 8 (a), (b) and (c) show calculation examples in the case of N=40, N=80 and N=160, respectively.

From those examples, if number of users, N, is small value such as Fig.8 (a) (N=40), the cost of Model A will be the most inexpensive. If the number of users, N, is large value such as Fig.8(b), (c) (N=80, 160), the cost of Model C tend to be the most inexpensive.

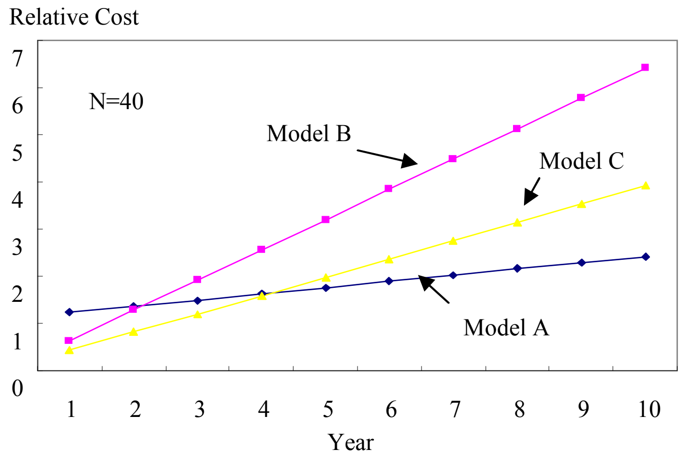

Fig.8 (a) Relative cost comparison in N=40.

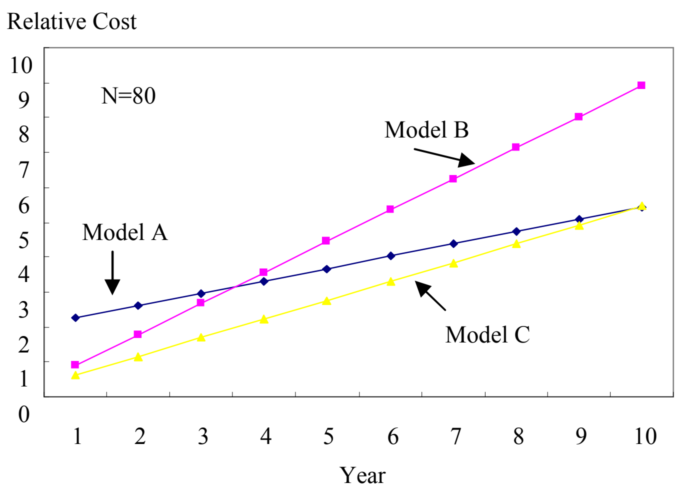

Fig.8 (b) Relative cost comparison in N=80.

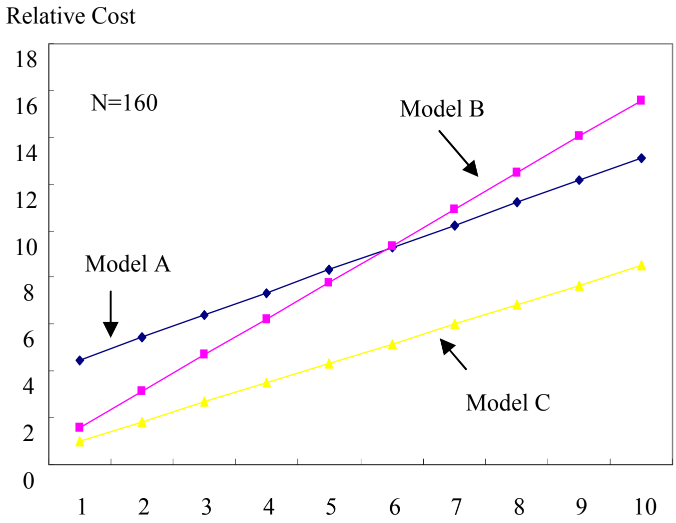

Fig.8 (c) Relative cost comparison in N=160.

5 Conclusion

This paper introduces a new type of safety monitoring system for elderly people living alone in a rural area. The feature of the systm is to use standard telehone terminals and computer telephony technology. The system would reduce the initial cost and increase operability and reliability compared with conventional sensor type systems.

The experimental results on the system feasibility, carried out in Iwate and Aomori Prefectures in Japan, showed improved operability. This paper estimates the cost for some kinds of the system structures. Based on cost calculation, using the system model using Asterisk appliance tends to realize the most inexpensive system.

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