Remote consultation system using hierarchically structured agents

Hiroshi Yajima[†], Jun Sawamoto[‡], and Kazuo Matsuda*

[†]Faculty of School of Science and Technology for Future Life, Tokyo Denki University, Japan
[‡]Faculty of Iwate Prefectural University, Japan
* School of Science and Technology for Future Life, Tokyo Denki University, Japan
yajima@im.dendai.ac.jp, sawamoto@iwate-pu.ac.jp

Abstract - In fields of technological innovation the speed of advance is fast, and while it is difficult for some people to keep up, there are few experts in new technologies. Since consultation is focused on a small number of experts, phenomena such as being unable to obtain sufficient information in a timely manner occur, and are one of the major reasons for the increasing social-technological divide. This paper proposes a 2-level hierarchical remote consultation system using two types of agent. The system possesses the features that through the responses to consultation made in advance by multiple agents, experts can focus on only complex questions, and consulter's waiting times are reduced. Its effectiveness is demonstrated experimentally.

Keywords: remote consultation system, agent, remote communication, expert, TV conferencing.

1 INTRODUCTION

Society has been aging in recent years, and service functions for poorly informed aged persons and patients will be sought. While the number of healthcare professionals is small, remote healthcare consultation which is efficient and yet maintains an appropriate level of service is being sought. In addition, while forms of employment are diversifying, models of employment such as the teleworking remote office are gathering attention. Further, in fields of technological innovation the speed of advance is fast, and while it is difficult for some people to keep up, there are few experts in new technologies. Since consultation is focused on a small number of experts, phenomena such as being unable to obtain sufficient information in a timely manner occur, and are one of the major reasons for the increasing social-technological divide according to which the benefits of advancing technology cannot be fully realized. Regarding policies for resolving this issue in society at present, research focusing on the theme of efficient remote communication support is important. In particular, support for fostering communication among disparate groups of fellow persons is essential.

So far, remote consultation systems have been conducted via TV conferencing and so on [1]–[4]. However, in such cases, it has been usual for consultation to be conducted with 1 consultee exclusively occupying the services of 1 expert. Regarding information sharing there are also remote conferencing systems [5] such as Skype. Functions for visualizing the topic of a discussion among its members in a shared manner have also been proposed. However, remote conferencing has been centered on discussions along a common theme among all members, and they are inefficient for situations in which experts possessing knowledge and information in a given field present solutions to laypersons lacking such information.

In order to solve these problems, this paper proposes a 2-level hierarchical consultation model using 2 levels of agent. The two types of agent established are Service Agent systems (SA) for the clients, and Supervisor Agent system (SVA) existing between the SAs and experts, who provide easily understood support by responding to requests for support from SAs in cases when they are able to do so, or otherwise forwarding the existing message history to experts. This system possesses the features that experts are able to focus on only complex questions, and in addition, consultees' waiting times are reduced.

2 PROBLEMATIC POINTS

2.1 Existing Remote Consultation

Remote consultation operations over the internet are increasingly tending towards communication among people from different cultures and institutions. This is because the internet generation, new technologies, new organizations and new establishments are being developed, constructed and disseminated on a daily basis, and it has become necessary to rapidly assimilate this flow.

In remote consultation, there are synchronous and asynchronous models. Synchronous models are those such as a telephone, where both parties exchange discourse during the same period of time. Asynchronous models are those such as email in which discourse may be exchanged without adopting a specific time period. Asynchronous models are mainly being applied by means of email, but with the rapid speed of business in the present day, there is an increasing need for synchronous models. The objective of this research is a synchronous remote consultation system over the internet among these kinds of disparate groups and individuals.

Figure 1 shows an example of an existing remote consultation system which has already been investigated [6], [7]. Basically, consultees initiate consultation from a convenient location, while on the other hand, a small number of experts oversee these consultations from a central office and respond to complex queries.

Remote consultation is currently being conducted in many fields. PC user support and so on, is widely active in general. Also, remote consultation has also come to be provided in financial and healthcare fields.
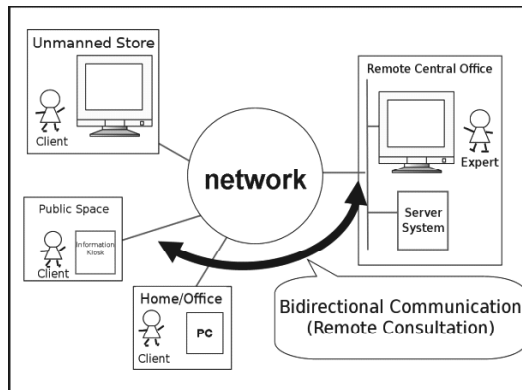
Figure 1: Existing model of a remote consultation system

Along with this model, the provider model has also diversified. At present, remote consultation services are being provided by email, homepages, TV, telephone, and models combining these technologies. However, services using asynchronous communication models such as email incur a time-lag between the receipt of a consultation and the response, so problems cannot be solved immediately. For reasons such as this, the telephone, with its synchronous communication model, is the main channel for the provider model of remote consultation services.

It is thought that the general flow of consultation may be broadly divided into 3 phases [6], and in this research the following definition is adopted (see Figure 2).
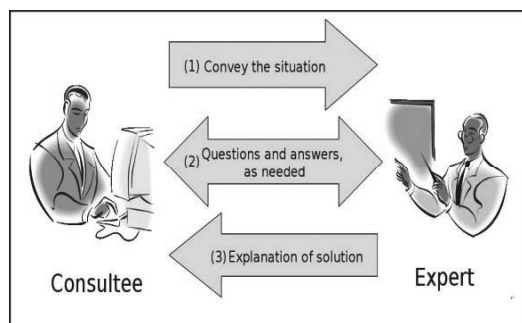

Figure 2: Phases of remote consultation

2.2 Problems With Existing Systems

Remote consultation has the following features (communication patterns). Basically, partners from different cultures (clients and experts) communicate as fellows. The disparate groups may include for example, a) groups of experts and laypersons, b) intradepartmental and interdepartmental staff groups, and c) groups of company staff and non-company persons, which thus constitute groups of people with different values, knowledge and objectives. People belonging to heterogeneous cultures often have different levels of knowledge, and the range and content of their basic assumptions also often differ, yielding obstacles to communication.

Also, the number of consultees is usually overwhelmingly greater than the number of experts, so if experts respond to

consultees on a 1-to-1 basis, the efficiency of consultation is poor.

3 SOLUTION STRATEGY

3.1 Concept

This paper proposes a formula for conducting remote consultation in which experts and agent systems are combined. Consultation is therefore first conducted between consultees and service agent systems (SA), and the SAs are supported by experts in the basic model proposed. This allows consultation to be conducted between consultees and agent systems, without the need for 1 to 1 consultation between consultees and experts.

Next, the multiple SAs seek support from the experts in cases when they are unable to respond themselves. However, when multiple SAs seek support simultaneously, experts must deal with multiple support requests at once. Agent system (SVA) with different functions (meta-knowledge and scheduling functions) is therefore placed between the experts and the SAs. By constructing the agent system in 2 layers (SVAs and SAs), consultation is made efficient. By including the SVAs, experts need only deal with a single SVA, rather than multiple SAs.

3.2 System Structure

The consultation model of this research is shown in Figure 3. Adopting this structure gives rise to the following advantages.

- The problem arising when multiple SAs directly request support from experts simultaneously, thus increasing the burden on experts and decreasing the efficiency of consultation, is avoided.

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- Also, the problem associated with consultee stress arising when multiple SAs send requests for support simultaneously, and one SA must wait for another SA's support to be concluded, thus increasing their consultee's waiting time, can be solved.

The function of each agent is as follows.

SA: conducting information exchanges with consultees. In this research, SAs question consultees regarding essential items and obtain their replies. When SAs are unable to respond themselves, these replies are forwarded to SVAs as requests for support. SA makes some questions to consultee in order to complete related documents.

SVA: providing support for experts, acting between the SAs and experts. When requests for support from SAs are within the range they can respond to, SVAs respond themselves, and in cases when they cannot respond, the requests are scheduled according to importance, and
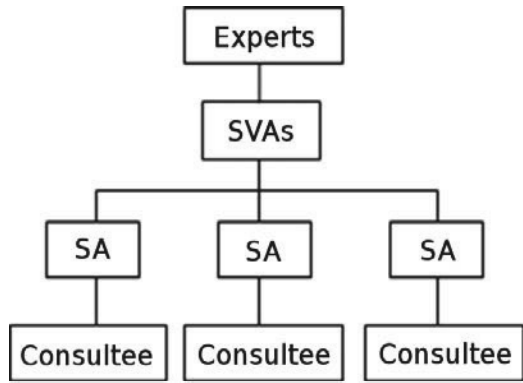
Figure 3: The model proposed in this research

presented to experts in an easily understood manner along with the message history to date. SVA answer request from SA using meta knowledge and expert's judge..

4   REMOTE CONSULTATION UTILIZING HIERARCHICAL AGENTS

4.1   Processing

The following procedure is proposed as a method for realizing the concept.

(1) Consultation is promoted between SAs and consultees. SAs ask questions of the consultees, and the consultees return their replies. Only the SAs respond during this process, without involving the experts.
When the consultees' replies are correct, the SAs present the next question.

(2) The SAs send the consultees' replies to the SVAs, and the SVAs process the data, presenting individual SA consultation cases to the experts. Under this process, the experts only observe the data reported to them.

(3) When replies from a consultee incur exceptional handling, SAs request support from SVAs, i.e., when the content of replies from consultees cannot be processed by SAs, SAs request support from SVAs.

(4) When requests for support received by SVAs can be handled using the meta-knowledge they maintain, they return replies to the SAs. When they are unable to reply themselves, the preceding message history is attached, and support is requested from the experts.

(5) Experts receiving requests for support send replies to the SVAs.

(6) Messages from the experts are sent, via the SVAs, to the SAs originating the requests, and presented to consultees. After receiving these messages, SAs resume questioning.

(7) When consultees are satisfied, consultations are concluded.

4.2   Specific Flow of Consultation

Existing consultation systems have mainly advanced using audio, but in this research, audio is not used. Consultation is conducted using a chat format in free text. The consultation advances as the agent poses questions to the consultee, and the consultee returns the answers, or asks questions. Then, when the consultee is satisfied, the final result is displayed at the consultee side and the consultation ends. The flow of consultation in shown in Figure 4.
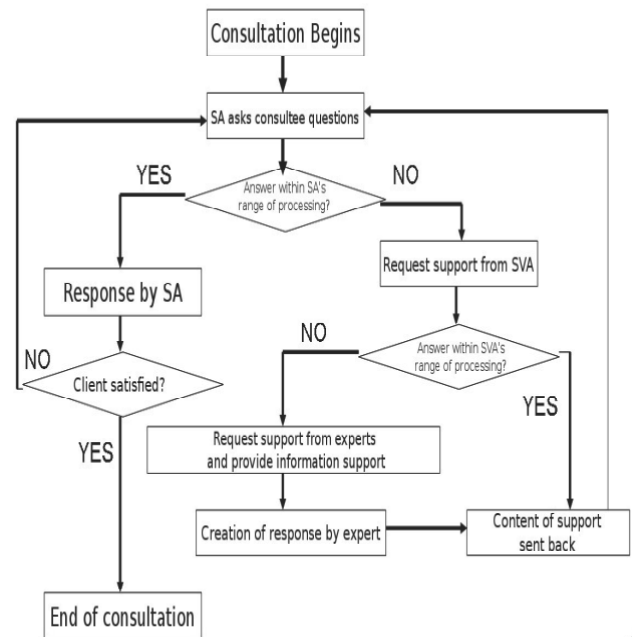

Figure 4: Flow of consultation

5   EXPERIMENTAL ASSESSMENT

5.1   Experimental Objectives

In the remote consultation system using agents, the case when SAs and SVAs are utilized, and the case when only SAs are utilized are compared and the variation in the burden on experts is ascertained. The number of consultees for each SA is taken to be 3.

5.2   Experimental Conditions

Condition 1 Consultation is conducted with an agent system in which 3 SAs respond to the 3 consultees. Experts respond to all of the requests for support from the SAs.

Condition 2 Consultation is conducted in a hierarchically structured system with an SVA added for the 3 SAs. SVA automatically reply when they are able to respond using their own knowledge, and send the problems to which they cannot respond, as requests for support along with the preceding message history, to experts.

Consultation is conducted using only text, without audio, in both Conditions 1 and 2.

Table 1: Results of the consultees' questionnaire

	Without SVAs	With SVAs
Smoothness of consultation	3.3	1.6
Level of concentration	3.3	2.6
Atmosphere	3	3
Reliability	2.3	2.6
Ease of consultation	2.6	2.3
Degree of stress	3.3	2.6
Level of satisfaction	3	2

5.3 Experimental Task

As a task, consultation was conducted regarding the bureaucratic procedures involved in registering for a new insurance policy. Consultees do not have any knowledge, and ASs have procedural knowledge, and SVA has exceptional knowledge.

5.4 Experimental Subjects

As experimental subjects, there were 1 expert and 5 groups of 3 consultees, making a total of 16 people. The subjects were students, and all had experience using a PC.

5.5 Experimental Results

(1) Data

In the experiments, as an indicator for measuring the burden on the expert, the expert's operating time was determined. The expert's operating time is shown in Figure 5. The average operating time of the expert in Condition 1 was 1570 seconds, and in Condition 2, it was 1150 seconds, so when SVAs were included, the result was a drop of about 27%. Also, the total number of messages to the expert was 245 in Condition 1, and 117 in Condition 2, so the result was a decrease of about 47%.

Regarding the consultees' waiting times, these were measured as the period during which they could not conduct their own operations, i.e., the processing time of each consultee's agent, and the expert's operating time. The experimental results are shown in Figure 6. The waiting time in Condition 1 is 915 seconds, and in Condition 2 it is 412 seconds. This result is a drop of about 57%.

(2) Questionnaire

A questionnaire was completed after the experiment, by both consultees and experts. The experiment was evaluated on a scale of 1 to 5 (1 was best, and 5 was worst). The results of the questionnaires are shown in Tables 1 and 2.

6 DISCUSSION

6.1 Expert's Operating Time

Looking at the expert's operating time, when SVAs are present the time is reduced in comparison to when SVAs are
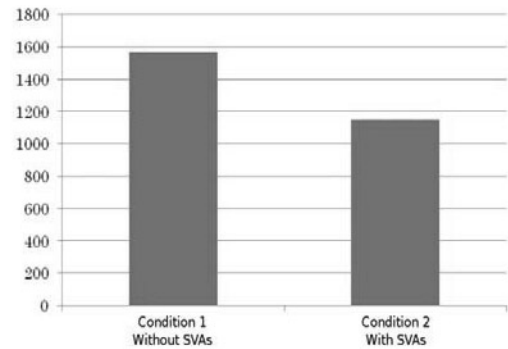

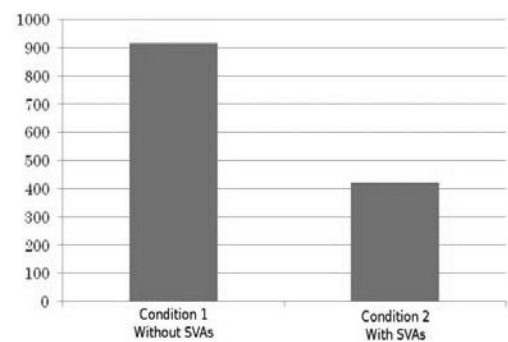Figure 5: The average operating time of the expert in each condition

Figure 6: Consultees' average waiting times in each condition

Table 2: Results of the experts' questionnaire

	With SVAs	Without SVAs
Ease of use	3	3
Ease of information acquisition	3	2
Level of concentration	2	3
Level of stress	2	3

not present. It was thus proven that the presence of SVAs reduces the expert's burden. From interview to expert, it made clear that using SVA, expert could concentrate to difficult questions from consultees.

However, there is a big difference in the reduction of the expert's messages by 47% as compared to the reduction of 27% in operating time. The content of the questions directed at the experts is therefore classified in Table 3. According to this data, it can be seen that when SVAs are present, there is a reduction in questions regarding phrasing which present, there is a reduction in questions regarding phrasing which do not require the experts long to answer, and an increase in other types of time-consuming question, particularly those regarding the service. According to the consultees' post-experiment questionnaire, consultation is smooth when SVAs are present, which means that there is an environment in which it is easy to ask questions. It was thus understood that while there are individual differences, making the consultation smooth may increase the consultees' motivation to ask questions.

Table 3: Total number of questions in each classification

Evaluation Items	Without SVAs	With SVAs	Average response time (seconds) with SVAs
1. Phrasing	77	62	17.055556
2. Price	30	32	31.875
3. Service	6	15	33.125
4. Personal circumstances	16	18	32

6.2 Consultees' Waiting Times

Looking at the results regarding the consultees' waiting times, the waiting times are reduced when SVAs are present, in comparison to the case when they are not. It was thus understood that consultees' waiting times may be reduced through the use of SVAs.

6.3 Questionnaire results

Looking at the results of the questionnaire, as shown in Table 1, the consultees' overall evaluation is increased when SVAs are present. In particular, the evaluation of the smoothness of consultation is very much increased. However, while the overall evaluation is increased, the evaluation of reliability is decreased. According to the post-experiment questionnaire, this means that there is a little resistance to the fact that the responses to questions come from a computer. It was thus understood that in contrast to the increase in the efficiency of consultation, there is a demerit in the sense that the reliability ends up decreasing.

Looking at the results of the questionnaire shown in Table 2, when SVAs are present the expert's ease of acquiring information is increased, so it can be seen that consultation has also been made easier for the expert. However, the evaluations of the degree of stress and level of concentration are decreased. This is thought to be related to the fact that the expert's operating time is decreased, so their free time is increased, which may affect their levels of stress and ability to concentrate.

7 CONCLUSION

This paper proposed a 2-level hierarchical remote consultation system with 2 levels of agent. The proposed system is established with SA agents who respond to clients, and SVA agents existing between the SAs and experts, who respond to requests for support from SAs when they are able, or if not, request support from an expert by sending an easily understood request along with the preceding message history. Experimental evaluations proved that the establishment of SVAs shortens experts' operating times, and that the system is applicable as a one-to-many remote consultation system.

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Hiroshi Yajima is currently a Professor of Tokyo Denki University , Japan. He received the B.E. and M.E. in mechanical engineering from Kyoto University in 1973 and 1975. He joined Hitachi Ltd in 1975. He received his PhD degree from Kyoto University in 1992. His research interests include systems engineering, human-interface design, knowredge-based system, and remote communication system. He is a member of IPSJ, IEEE.

Jun Sawamoto is currently a Professor of Faculty of Software and Information Science, Iwate Prefectural University, Japan. He received the B.E. and M.E. in mechanical engineering from Kyoto University in1973 and 1975. He joined Mitsubishi Electric Corporation in 1975. He received his PhD degree from Tokyo Denki University in 2004. His research interests include ubiquitous computing, human-interface system,multi-agent systems, and cooperative problem solving. He is a member of IPSJ, IEEE-CS, ACM.