Mobile Digital Assistants for Community Support

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■ We applied mobile computing to community support and explored mobile computing with a large number of terminals. This article reports on the Second International Conference on Multiagent Systems (ICMAS'96) Mobile Assistant Project that was conducted at an actual international conference for multiagent systems using 100 personal digital assistants (PDAs) and cellular telephones. We supported three types of service: (1) communication services such as e-mail and net news; (2) information services such as conference, personal, and tourist information; and (3) community support services such as forum and meeting arrangements. After the conference, we analyzed a large amount of log data and obtained the following results: It appears that people continuously used PDAs in their hotel rooms after dinner; e-mail services were used independently of the conference structure, but the load on information services reflected the schedule of the conference. Postquestionnaire data showed that our trial was considered interesting, although people were not fully satisfied with the PDAs and services provided. Participants showed a deep interest in mobile computing for community support.

The project reported in this article is intended to support, using mobile computing, increasingly diverse and amorphous groups of people. For this purpose, mobile computing services should change from applications based on point-to-point communication to those based on communitywide communication. Community mobile computing is feasible because the number of users of wireless communication services is rapidly increasing because of the falling prices of mobile terminals and cellular telephones. We show that mobile computing technology supports international conferences effectively and combines well with conventional desktop computing technology.

Internet access services are now popular at international conferences. Several tens of desktop terminals are usually provided at a conference site. However, the services are constrained in both space and time; the services are only accessible from terminal rooms during the daytime. However, the salient feature of mobile computing is that users can use their personal digital assistants (PDAs) anytime and anywhere. The challenge of this article is to apply mobile computing to an actual international conference and investigate its role quantitatively.

Previous work in computer-mediated communication was classified into two main categories (Mynatt et al. 1997): First is multiuser dungeons (MUDs) and casual meeting tools that support a virtual space where everybody can meet and talk. The other is MEDIASPACE (Bly, Harrison, and Irwin 1993), which is a hybrid of virtual and real spaces. Mobile computing, however, aims to amplify interactions in a real space and should therefore be classified in a third category.

Although internet access services are common at international conferences, no empirical study on them has been reported. Similarly, in the mobile computing literature, several papers have been published concerning technologies and applications, but no analysis on social interactions has been published (Weiser 1993). Human-computer interaction (HCI) researchers have expended substantial effort on multimedia communications and conferences for relatively small teams (Olson, Olson, and Meader 1995). Several reports address large groups in business applications (Sproull and Kiesler 1988), education (O'Day, Bobrow, and Shirley 1996), and home computing (Kraut et al. 1996). However, there is no report on mobile computing with a large number of users.

In this article, we first report the experiment called the Second International Conference on Multiagent Systems (ICMAS'96) Mobile Assis-

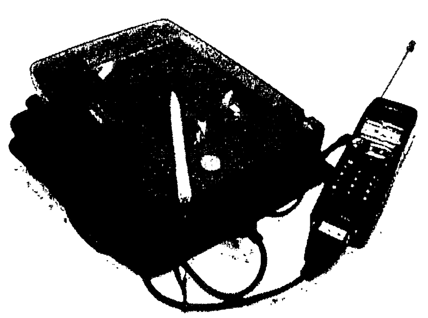

Figure 1. PDA with Telephone.

The goal of the ICMAS'96 Mobile Assistant Project was not only to support communication services such as e-mail but also to provide, through PDAs, a variety of information required at international conferences.

tant Project. This conference was held in Kyoto, Japan, from 9 to 13 December 1996. The project provided (1) e-mail and internet access services; (2) conference, personal, and tourist information services; and (3) forum and meeting arrangement services. In this experiment, about 100 personal digital assistants (PDAs) with wireless telephones were loaned to conference attendees without any charge to try out the system. To the best of our knowledge, this was the world's first application of mobile computing to community support.

By reducing the time and space constraints of desktop computing, mobile computing guarantees freedom of use of network services. As a result, the demand for various information services was clearly revealed. We show that mobile-computing technology supports international conferences effectively and combines well with conventional desktop computing technology.

ICMAS'96 Mobile Assistant Project

The goal of the ICMAS'96 Mobile Assistant Project[1] was not only to support communication services such as e-mail but also to provide, through PDAs, a variety of information required at international conferences (figure 1). PDAs were provided to about 100 people, roughly one-third the conference attendees. People could use them in the conference site, lobbies, and hotel rooms as well as outdoors.

Figure 2 describes an overview of the system configuration. The server machine was connected to the internet to provide e-mail exchange and information retrieval. The server system was programmed with TELESCRIPT, which is a language intended for agent-oriented mobile computing applications (White 1994). The client system was built on MAGICCAP OS running on MAGICLINK.[2] The server system was programmed with TELESCRIPT (White 1994),[2] a language intended for mobile computing applications. The client system was built on MAGICCAP OS running on MAGICLINK. Each client could connect with the server system used by wireless public telephone lines. The data-transmission rate of wireless lines on the physical layer was 9600 bits a second (bits/s).

The project became larger than we first expected. Thirty telephone lines were newly introduced and connected with the server machine placed at the conference site. We then found a serious communication problem between the PDAs and the server. Because mobile communication traffic in this experiment differed from typical telephone services, we found that the existing facilities were not enough to cover the demand. After negotiation with the local cellular telephone company, the situation was substantially improved by allowing several tens of calls from the conference site to be conducted simultaneously.

The project was announced to conference attendees beforehand so that they could apply for a PDA. We asked all participants to fill out a prequestionnaire together with the application form. At the conference registration desk, after the process of authentication and contract, the PDAs and the telephones were handed to the project participants.

Figure 3a shows a participant receiving a client system at the registration desk. The contract included permission to use log data for academic purposes. During the conference, a help desk was set up at the conference site to assist participants with various technical problems. Figure 3b depicts a participant using the service while he stands in the lobby of the conference hall. Figure 3c also depicts a participant using the service in the event hall where the conference was held. Figure 3d depicts the help desk. Figure 3e is a photograph taken during the excursion to Nara Historical Park, which was done as a part of the conference schedule. Help-desk staff also traveled to Nara Park during the excursion. After the conference, all PDAs and cellular telephones were returned without trouble.

To design the mobile digital assistant as an agent for community support, we first classified an individual's activities into the following three categories: (1) communicating with other people to share information, (2) interacting with the real world to determine his/her actions, and (3) understanding community activities to identify his/her role in the community. We then designed various functions to support these three types of activity and imple-

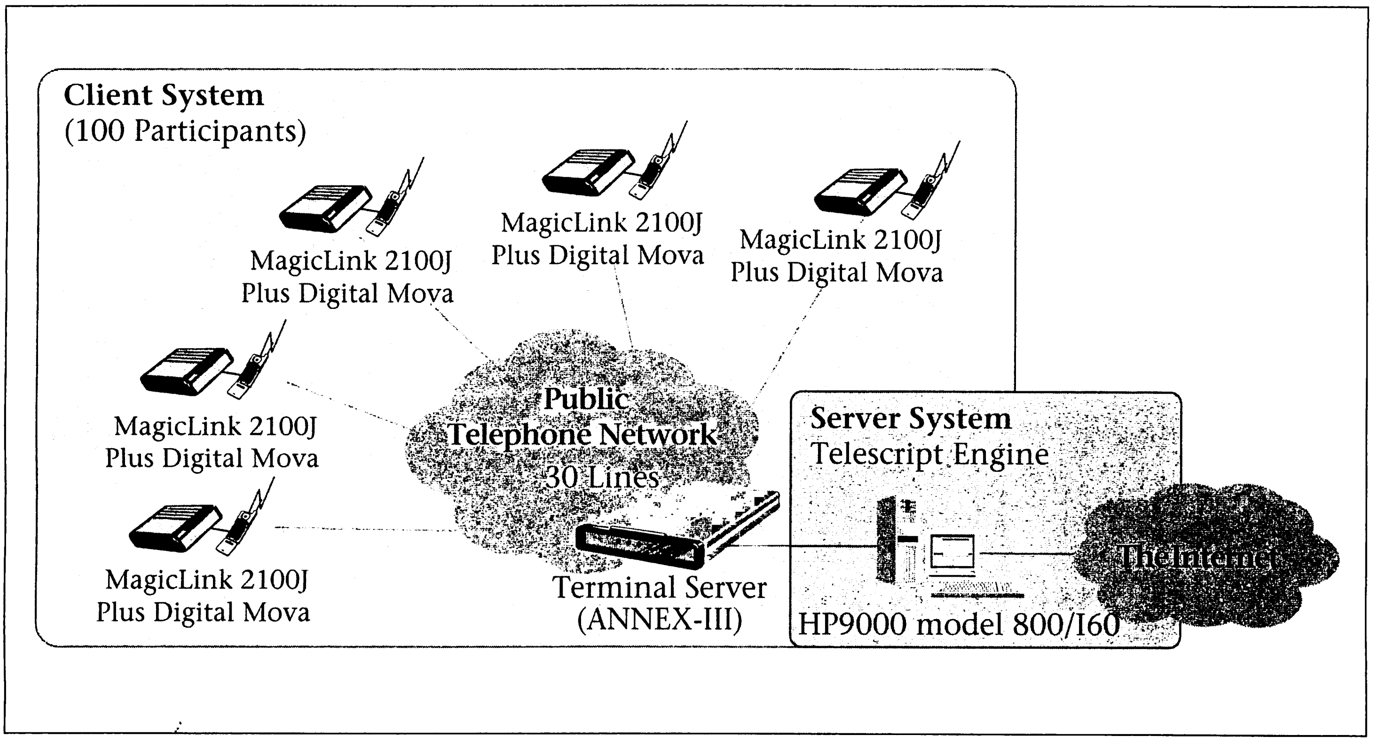

Figure 2. System Configuration.

mented (1) communication services, (2) information services, and (3) community services, as described in table 1. These services consisted of commercial services such as e-mail and various original services developed by about 20 engineers and students from NTT Information and Communication Systems Laboratories, Kyoto University, and the Nara Institute of Science and Technology. The original services given in table 1 were provided during the conference:

First, ACTION NAVIGATOR is a system that supplies tourist information and additional information to help the user make decisions.

Second, INFOCOMMON provides a weak information structure for human information sharing. The weak information structure connects various information media without defining the semantics rigorously.

Third, COMMUNITY VIEWER visualizes interactions among participants and provides a better view of community activities. Figure 4 shows the screen image of the opening index for selecting these services. Because most services were developed just for this experiment, we were able to embed enough codes to obtain log data such as the log for access to the server and changes in PDA output. We also asked all users to fill out a prequestionnaire and a postquestionnaire to find out about their usual computer environments and impressions of the project and the services provided.

ACTION NAVIGATOR: Supporting Action Making

We are always making decisions, such as selecting the restaurant when we eat out (Engel, Blackwell, and Miniard 1990). Typical tourist information services provide objective information such as name, telephone number, address, and business information when users request information.

However, depending on search conditions, they often return a large number of search results. In this case, the user has to choose the one he/she wants from this large amount of information. It is difficult to choose on the basis of objective information only. In general, when we make decisions, we often refer not only to objective information but also to subjective information, for example, recommendations of others or reviews in newspapers or magazines.

ACTION NAVIGATOR (Ohtsubo et al. 1998) supports decision making with subjective information from others coupled with a tourist information service. Figure 5 shows an example screen of ACTION NAVIGATOR. Information spots are displayed in the map of Nara city. Users could get detailed information on shops, restaurants, and so on, by clicking on the corresponding spot.

The subjective information in ACTION NAVIGATOR was based on answers to the following two

Figure 3. System in Use.
A. Registration desk. B. Lobby. C. Event hall. D. Help desk. E. Nara Park.

The subjective information in ACTION NAVIGATOR *was based on answers to the following two questions:*

(1) How often do users look at the detailed information for each information spot?

(2) Do users post news about this information spot?

questions: (1) How often do users look at the detailed information for each information spot? (2) Do users post news about this information spot? Each PDA counts the number of times that the user refers to the detailed information and sends this count to the server. The server gathers the number of references and calculates an evaluation value (we call it the *active level*) for each information spot.

When starting up ACTION NAVIGATOR, users are asked whether or not the system should update the active levels. When the user chooses to update these levels, the PDA communicates with the server to get the current active levels and changes the size of each information spot according to these levels. The active level took four values in this experiment. The information spot that has the highest active level (displayed as the biggest icon) is called the *hot-spot.*

We examined the accesses to the information spots. It appears that 50 percent of all accesses (furthermore, 80 percent of the first accesses) were to the top 7 percent of the hot-spots. The results show that the simple hot-spot mechanism effectively realizes social filtering of tourist information.

However, users did some decision making

Communication services		
	Send message	Messages are sent from PDAs to other participants or internet users through telephone lines.
	Receive message	Messages are received by PDAs from other participants and internet users through telephone lines.
Information services		
	Conference information	Session schedules and maps are stored in each PDA. Abstracts of presentations are provided through telephone lines.
	Personal information	COMMUNITY VIEWER provides participants' personal information stored in each PDA and visualizes the interactions among the participants through telephone-line transfer.
	Tourist information	ACTION NAVIGATOR provides information (stored in each PDA) such as shops and sightseeing spots.
Community services		
	Forum and meeting	INFOCOMMON helps users to exchange knowledge and ideas through shared card information through telephone lines. SOCIAL MATCHMATER provides a way to find other people who have similar interests.
	Statistics feedback	The current state of service use is shown in real time through telephone lines.

PDA = personal digital assistant.

Table 1. Services Provided.

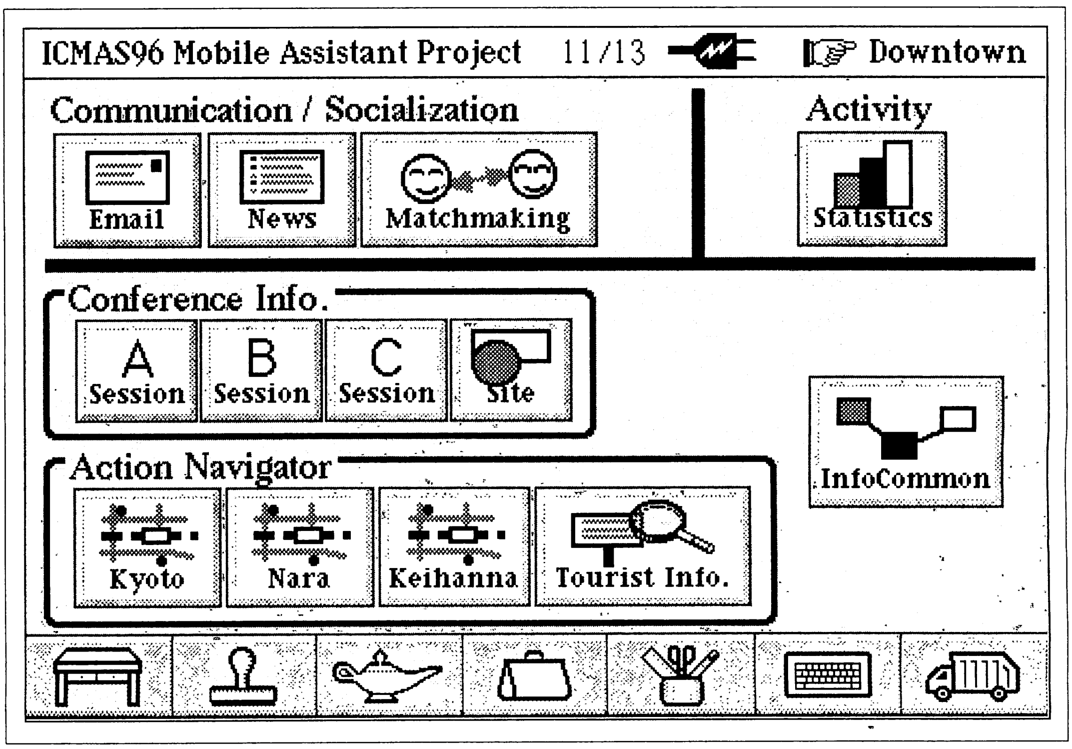

Figure 4. Opening Index.

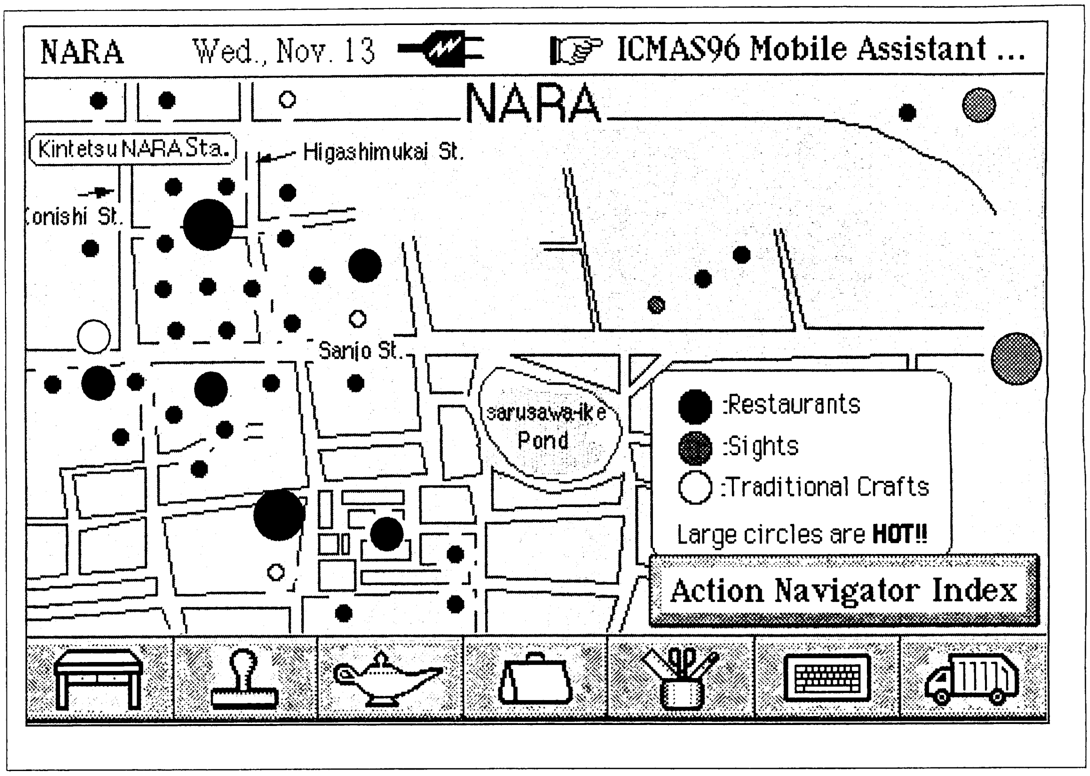

Figure 5. Screen Image of ACTION NAVIGATOR.

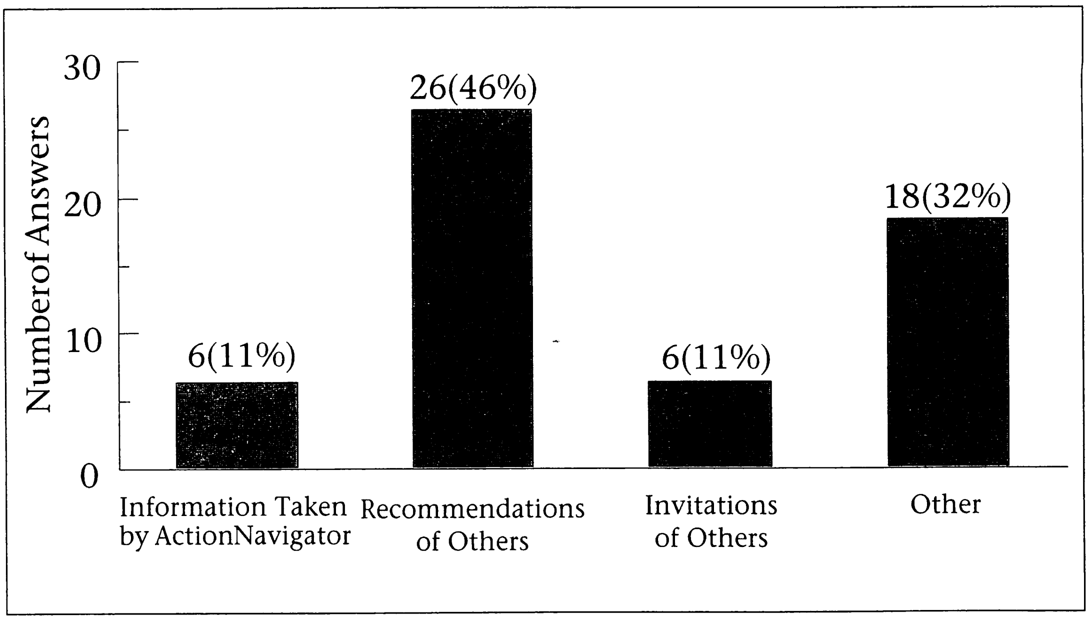

Figure 6. The Factor of Making Decisions.

during the conference independent of using ACTION NAVIGATOR. We asked users the following question in the postquestionnaire: "If you went to some restaurants or sightseeing, why did you select them?" Figure 6 shows the answers to the question. According to this chart, users' decisions depended on the recommendations of others: Individual preference of others takes an important role in making decisions. The result supports our policy of designing ACTION NAVIGATOR.

INFOCOMMON: Sharing Information among Participants

The effective use of tacit knowledge or nonlinguistic means of communication would be an

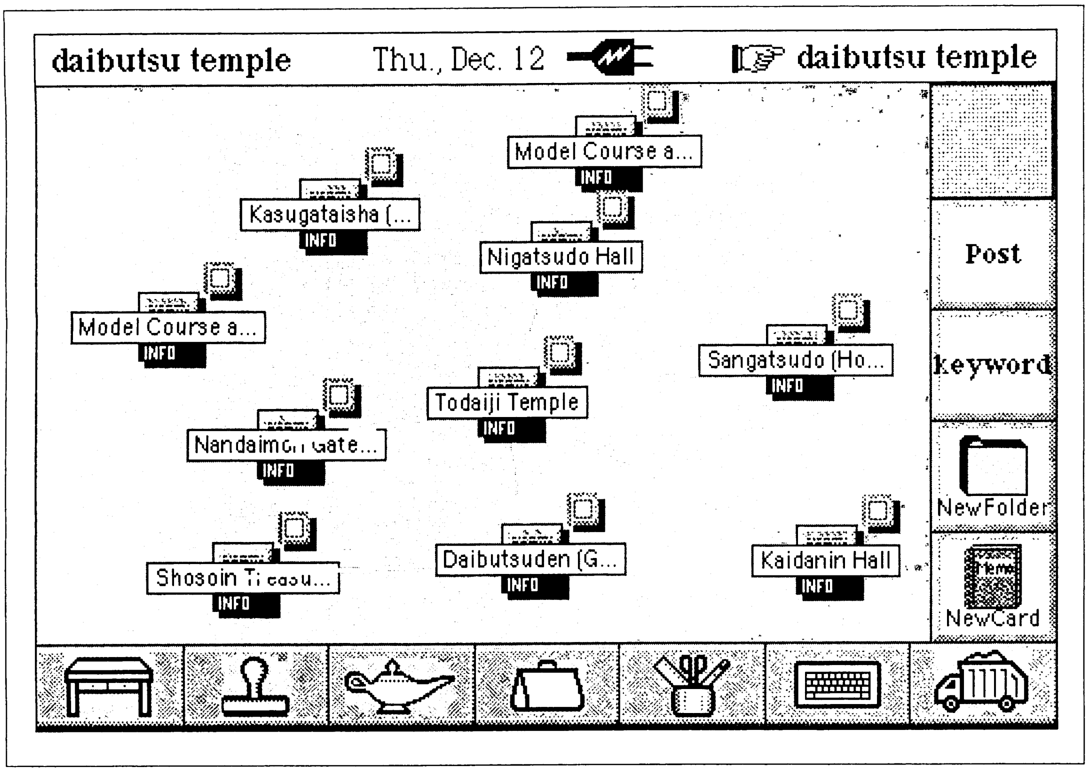

Figure 7. Screen Image of INFOCOMMON.

interesting issue in addition to unambiguous representation of information. It is not until recently that these issues have been addressed from computational points of view.

The basic assumption behind INFOCOMMON (Maeda et al. 1997) is that information sharing facilitates human interaction and group formation (Gaines and Shaw 1994). Talking about a common hobby might result in an academic discussion. To facilitate information sharing among participants, we used several design principles: First, we tried not to enforce any one particular concept. Instead, we allowed a lot of freedom in the use of terms and the structure of shared information and freedom to incorporate useful information from various viewpoints. Second, we made the information space a single seamless space, which releases the user from working with a rigid menu. Third, we enabled the user to build a personal information space where he/she can organize relatively small amounts of information, as desired (Nishida et al. 1995). This approach, we believe, makes shared information visible and encourages human interaction and community formation.

Technically, we propose a weak information structure for encoding shared information. The weak information structure connects a wide variety of information media, such as natural language text, hypertext, and images, without defining the semantics rigorously. By leaving ambiguity and vagueness in the representation, we can incorporate a wider variety of useful information into the information base, ranging from formal conference information to articles that might be useful in finding interesting restaurants or points of interest.

The information base of INFOCOMMON is a collection of information cards organized on this weak information structure. Representative keywords are automatically extracted from each information card. The collection of information cards is organized by shared keywords and predefined relations. Given a set of keywords, INFOCOMMON responds with the set of information cards connected to the keywords and provides a visual interface for retrieving and sending information cards. Figure 7 shows an example screen of INFOCOMMON. The relation between two information cards is displayed by a link. The result of retrieval is stored in the user's local information base where the user can rearrange the collection of information cards and add and remove nodes and links, as desired.

We analyzed how INFOCOMMON was used by log files and questionnaires. Figure 8a shows the answers to the question, "For what did you used INFOCOMMON?" Fifty-nine percent used the

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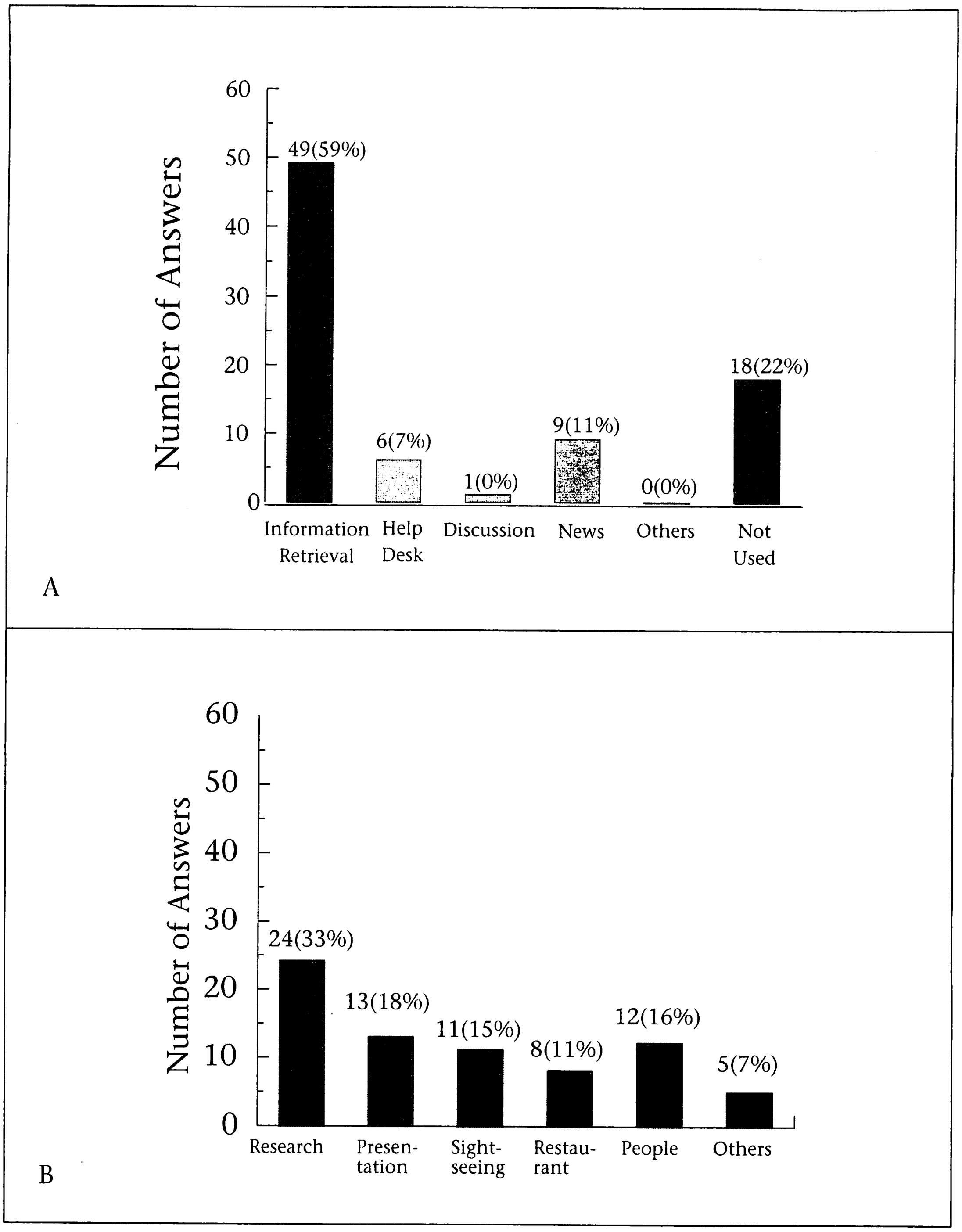

Figure 8. Use of INFOCOMMON.
A. Purpose. B. Topic.

system for information retrieval and 19 percent for information sending; sending comprises news, help desk, and discussion. The reasons INFOCOMMON was used for news "because keyword search was easy and useful" (14 persons), "because I found interesting topics in INFOCOMMON" (5 persons), and "because I had a question" (4 persons). We determined that INFOCOMMON added a new facility to the conventional news reader. Major reasons for the choice "didn't use" were "slow information retrieval" (8 persons) and "I couldn't connect to the server" (4 persons). These problems involve server response, so they can be corrected easily.

Figure 8b displays answers to the question, "For what topic did you use INFOCOMMON?" About search results, 81 percent felt that the search results were fine, and 51 percent answered that they were satisfied with INFOCOMMON. About the usefulness of INFOCOMMON for information retrieval and discussion, 55 percent answered that INFOCOMMON was useful for getting the information they needed. However, only 26 percent answered that it was useful for discussion. We feel that the five-day period was too short to form the kind of community in which people create many active discussions. We need to conduct a longer-term experiment to evaluate the usefulness of the system for discussion.

COMMUNITY VIEWER: Visualizing Community Activities

COMMUNITY VIEWER (Nishimura et al. 1998) provides the following three types of information: (1) personal profiles of conference participants and their interests; (2) static relations among the participants, as derived from the personal profiles; and (3) dynamic activities of the participants, including the ongoing process of community formation. The goal of COMMUNITY VIEWER is to support the formation of communities wherein people are willing to share their personal interests. At the first stage of community formation, personal profiles can help people in deciding whom to share personal interests with. Sharing knowledge (to know what other people know) and activities (to do what other people do) is also useful. Thus, the question is how to increase mutual interests, knowledge, and activities without infringing on people's privacy. This dilemma became a serious problem in designing COMMUNITY VIEWER because private communication takes a more important role in community support systems than in traditional groupware.

These types of information are provided in a unified framework called the *party room,* which is a virtual place for visualizing the activities of the community. To enhance the awareness of the community among the participants and protect their privacy, we introduced the new concept of *reflector icon.* We can observe the dynamic activities in the community by glancing over the room. Our party room has two display modes: (1) the overview mode that takes in the whole room and (2) the detailed mode that observes the activities of each individual. Figure 9a shows a typical screen image in the detailed mode.

Each icon can represent abstract information about personal activities without infringing on personal privacy. In the party room metaphor, the reflector icon is realized as a face mark (figure 9). One icon represents one participant of the community. In COMMUNITY VIEWER, people can easily access personal profiles by selecting reflector icons. A detailed profile is shown in figure 9b.

Several functions are provided to distinguish among individuals in the party room. Suppose you want to find those who work in research fields similar to yours. You can do this by specifying the appropriate keywords as search conditions. When the system finds the other participants who match the conditions, the color of the corresponding reflector icons change, and the icons move toward your icon. As a result, you can easily access the personal information as needed and determine to whom to send a meeting request.

The ongoing interactions in the community are visualized in the party room. The behavior of each icon reflects the current activity of the corresponding person in the following manner: In the default state, when a user is not interacting, his/her icon walks toward a randomly selected table to sit down in the party room. After staying at the table for a time, the icon leaves for a different table. When one interacts (sends a message, reads a personal profile, and so on) with others in the virtual party room, the corresponding icon behaves as if approaching and talking to others. As the degree of interaction increases, icons start to congregate, mirroring what is seen at parties. The length of time over which the icons associate is proportional to the degree of interaction between the people. Thus, users get the impression that people in the community are actively interacting, although the contents of the interactions are not displayed.

To realize this function, the system has to judge who is interacting with whom and to what degree. In the experiments, we used the number of accesses to the personal profile as the degree of interaction. In general, e-mail, telephone calls, meeting arrangement requests, and any other interaction can be considered to indicate the degree of interaction. Each PDA calculates how much its owner is interested in others and sends the information to the community server. The server accumulates all the information and sends a summary back to each PDA. To visualize personal characteristics in a community, the reflector icon changes its size according to run-time statistics. People can know who is attracting attention and who is currently active by observing icon size.

The goal of COMMUNITY VIEWER is to support the formation of communities wherein people are willing to share their personal interests.

Interaction Analysis

The challenge in this section is to investigate quantitatively the role of mobile computing in an actual international conference. To analyze

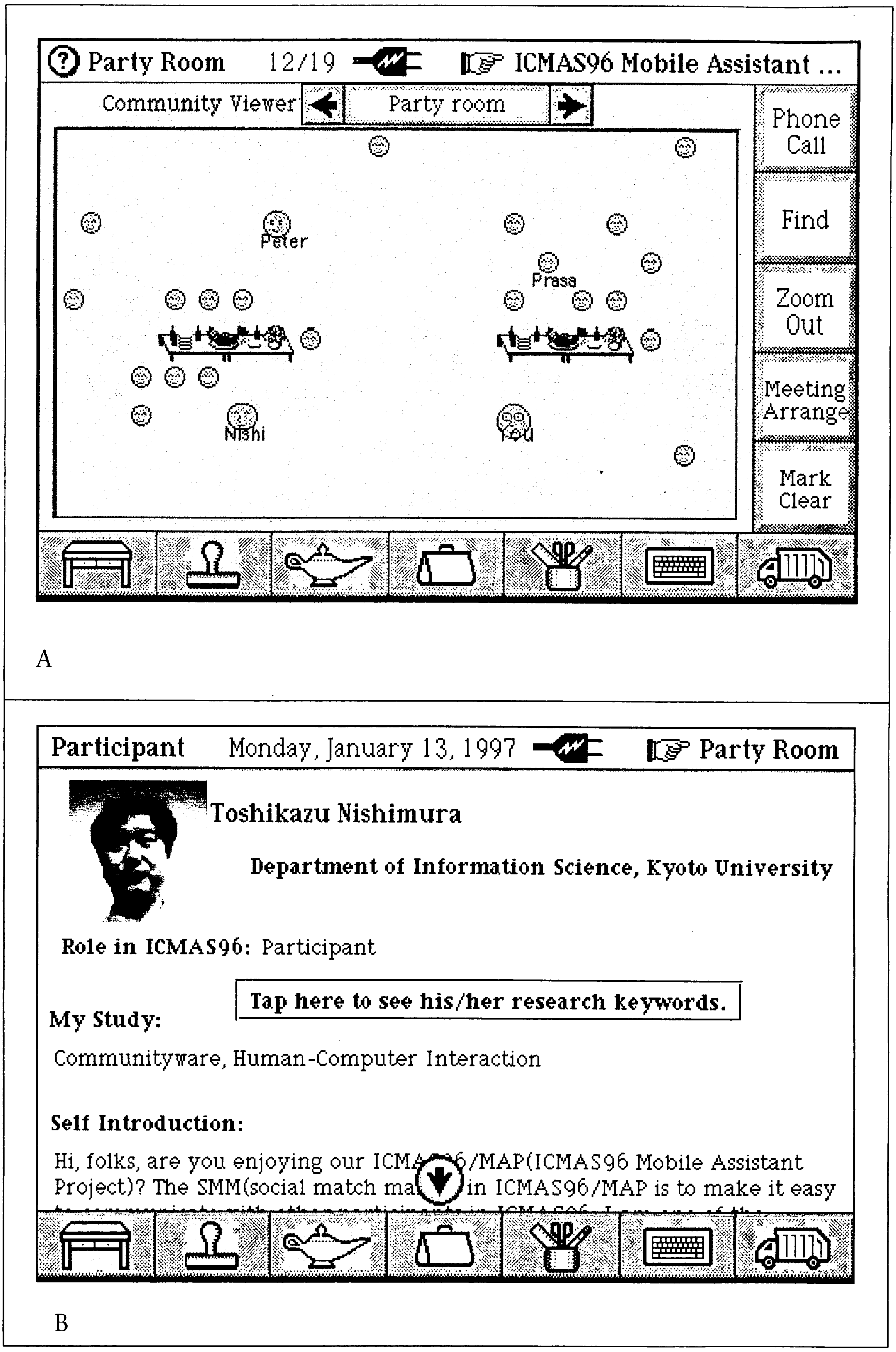

Figure 9. Screen Image of COMMUNITY VIEWER.

A. Party room. B. Personal profile.

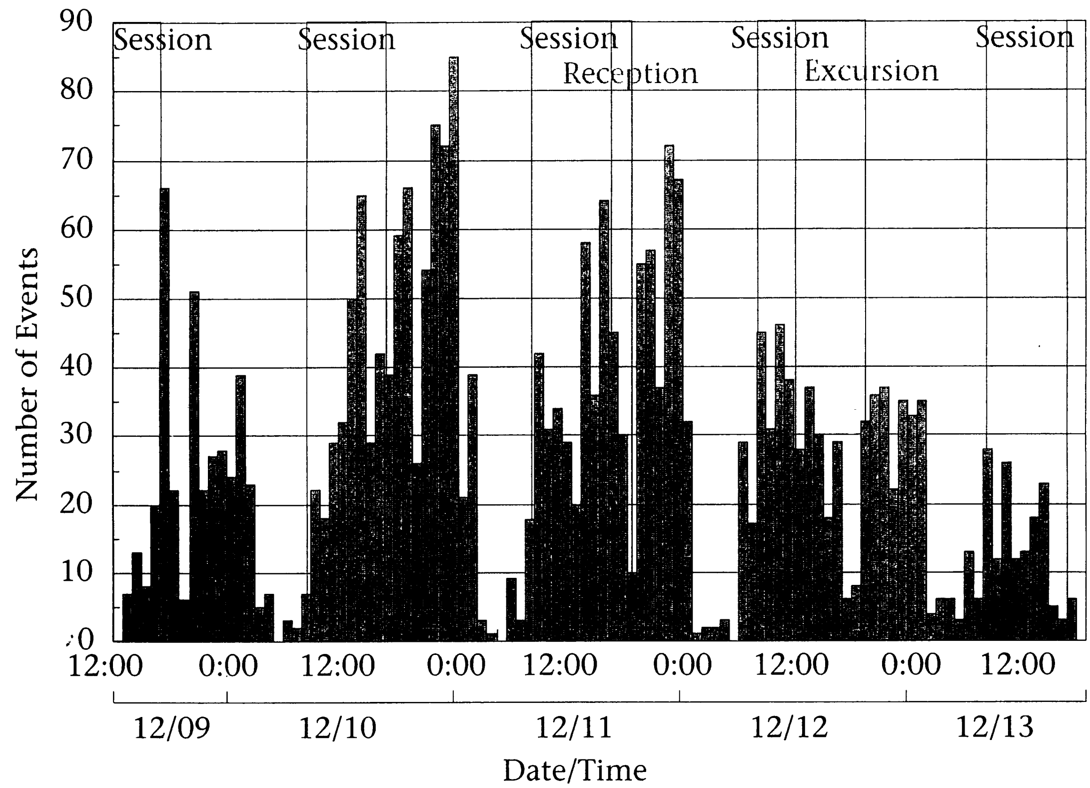

Figure 10. Use of Mobile Computing.

a large amount of noisy data, we were careful in selecting key data items. Our strategy for analysis of log data was to select data items that were independent of the provided software functions and implementations. In addition, we excluded the log data of project members and system operators to get accurate use results from true participants.

Our first goal was to determine how mobile computing is used in conferences and how its use differs from that of desktop computing. Figure 10 represents the overall activities during the conference. The x-axis indicates the hour, and the y-axis indicates the number of events within this hour. The first two days (9–10 December) were for workshops and tutorials, and the next three days (11–13 December) were for technical programs. The reception was held on the evening of 11 December, and the excursion to Nara Park was set for the afternoon of 13 December.

The following features can be observed in figure 10:

Continuous use: Except for the reception and excursion, the system was used continuously, even during technical presentations. People sometimes retrieved related information using PDAs while they listened to a presentation.

Midnight use: People used PDAs even after the conference, especially in their hotels after dinner. The highest peak in use, at midnight on 10 December, shows that PDAs are actively used just before the technical program starts.

Figure 11 shows the data for traffic on the third day, which showed the most typical traffic characteristic of the project. For purposes of comparison, it also shows the number of telephone calls made in one day on PASEO (Niwano et al. 1997), a multimedia communication market trial service provided by NTT Future Agent Network Inc., which also used MAGIC-LINK, the same PDA as in our experiment.

In PASEO, traffic peaked at 9:00 AM, noon, and 8:00 PM. These traffic peaks were because most users on PASEO had difficulty accessing the server during business hours. In the mobile assistant project, however, traffic dropped on the evening of the third day and the afternoon of the fourth day. These periods match the times

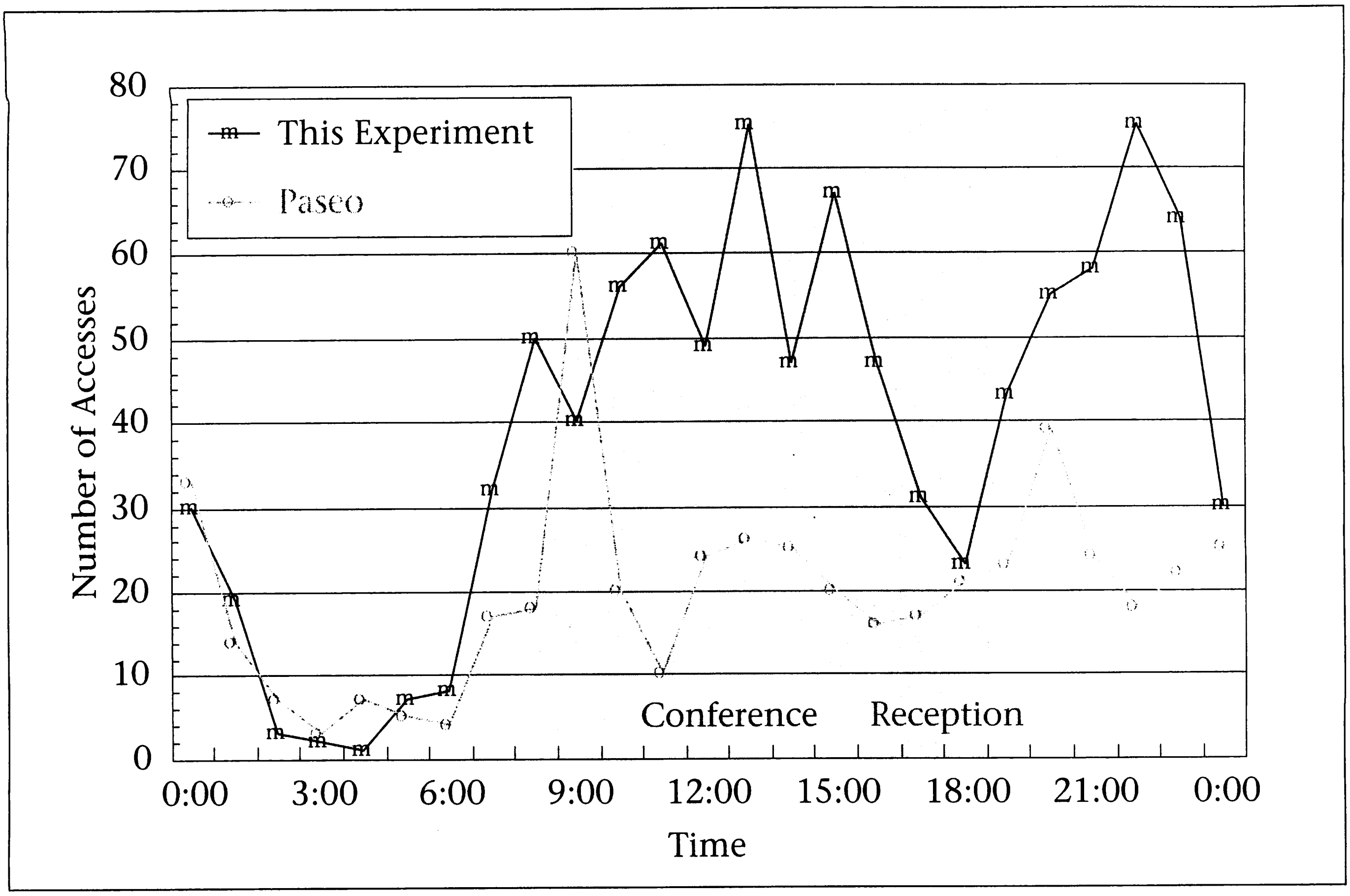

Figure 11. Number of Telephone Calls (comparison with PASEO).

for the conference reception and a postconference excursion, during which most users did not use their PDAs. Furthermore, the traffic peaked at midnight on each day. Except during the reception and excursion and in the very early morning, the system was used continuously. In this experiment, users could use their PDAs whether they had connected to the server, even during others' technical presentations. Traffic patterns on public services correlate with such things as hours of business, and the traffic pattern in this experiment correlates with the conference schedule. Thus, we learned that the use of a mobile computing system strongly reflects the users' situation.

Use of Services

We then analyzed the demands in international conferences by investigating how the services were used during the conference. Figure 12a describes the week's trend of participants' activity. The activity was low on 9 and 13 December because the PDAs were picked up and returned on these two days. At first glance, except for the first two days, activity was high at the beginning of the conference and gradually decreased toward the end. However, a structural trend exists as follows:

Demand for e-mail services was fairly steady during the conference. The number of related events (sending and receiving messages) was not dependent on the progress of the conference but, rather, on the number of PDAs in use.

However, the demand for information services changed dramatically. Conference information services were used most on 11 December, the start of the technical programs. The demand for personal information services was high at the beginning of the conference and slowly decreased thereafter.

Although the number of accesses was not large, the demand for statistics feedback showed a trend similar to that of personal information services: active use at the beginning of the conference with a slow drop-off thereafter.

Figure 12b shows the daily trend of participants' activity. The x-axis indicates three-hour blocks, and the y-axis indicates the sum of

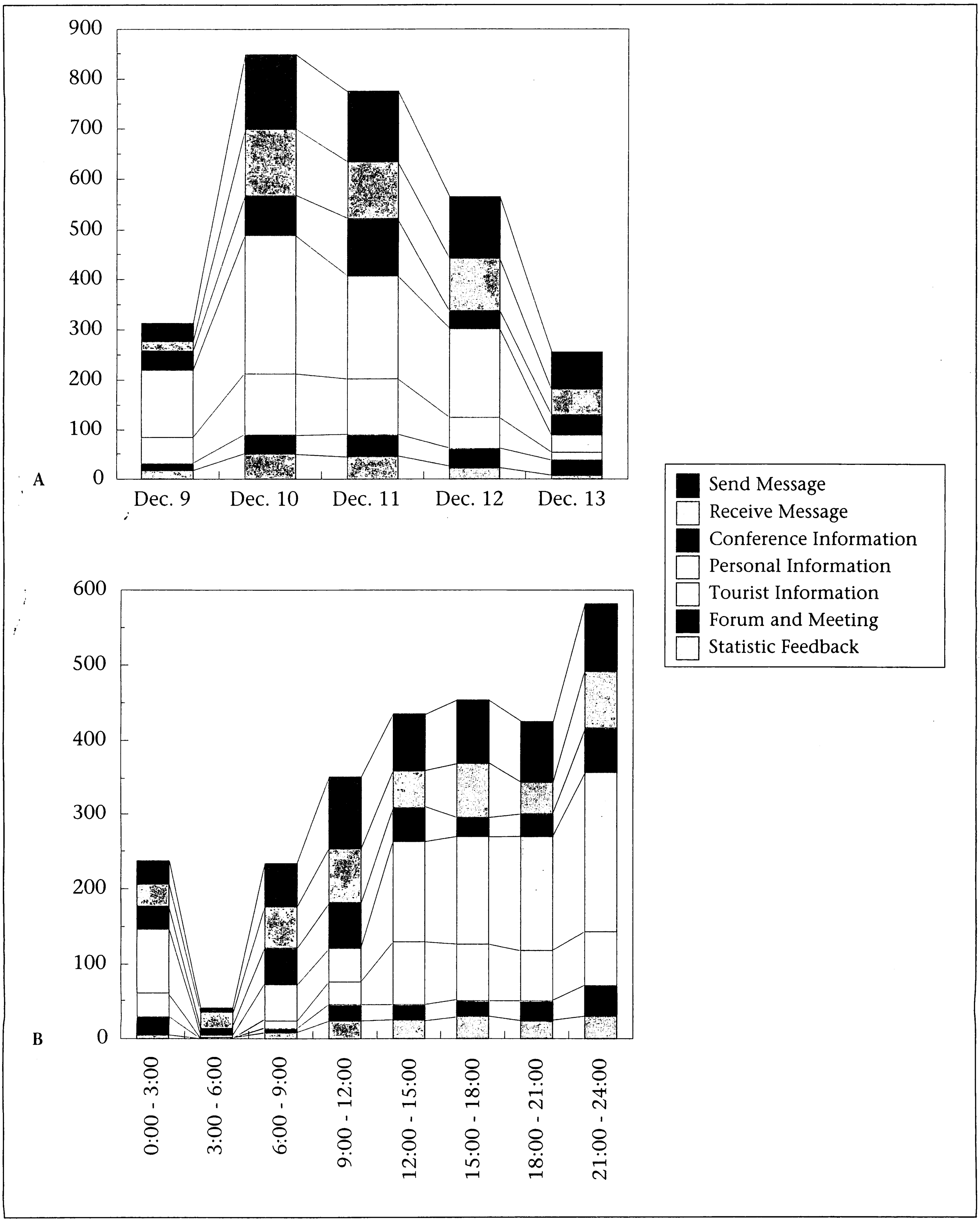

Figure 12. Use of Services.
A. Trend over the Entire Week. B. Daily Trend.

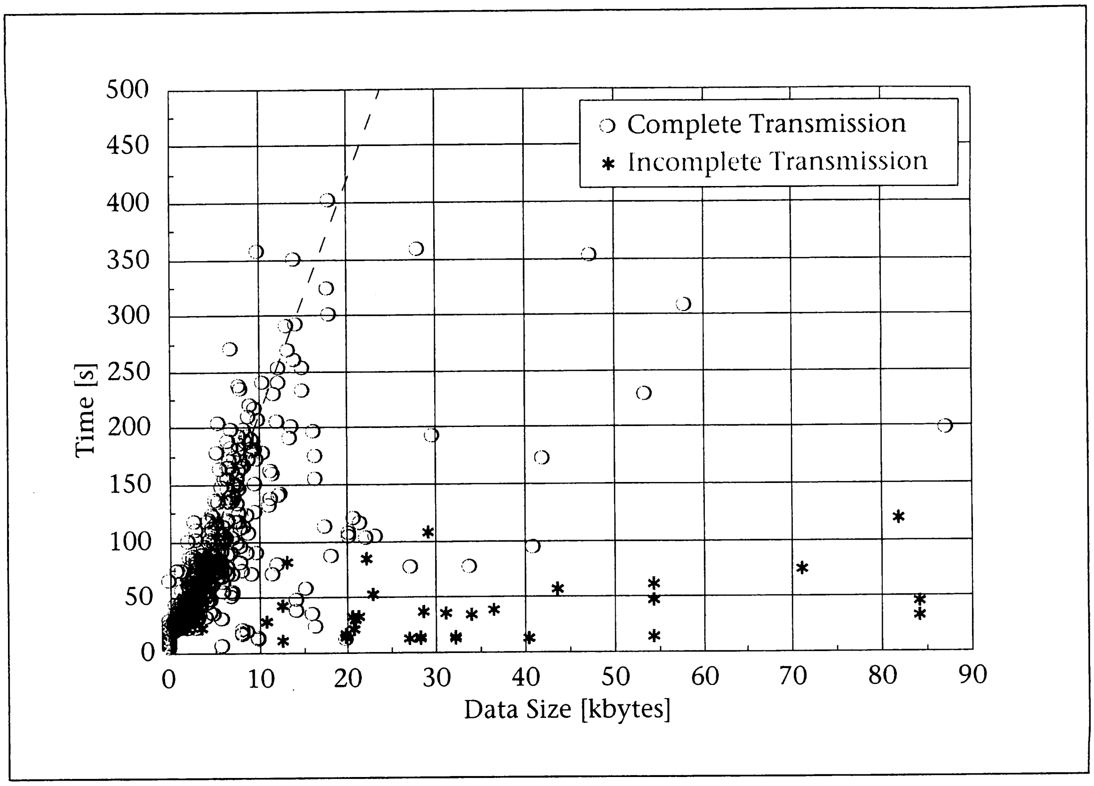

Figure 13. Data Transmission.

events that occurred within the corresponding time interval during the five days. The major results obtained from this figure are as follows:

Activity increased from morning to night. Lunch time did not affect the users' behavior, but dinner time (reception and excursion) substantially decreased their activity. A remarkable peak appears from dinner to midnight. E-mail services were used steadily all day. Messages from the internet were received all night.

Conference information was retrieved frequently in the morning and after dinner, but personal information was often retrieved in the afternoon and particularly after dinner.

In summary, the demand for e-mail services was steady, but that for information services was heavily dependent on the conference structure. In previous conference support, desktop computing primarily provided e-mail services so that users could continue their business at the conference site. Mobile computing, however, can support more conference-oriented information services. The results of log data analysis create the picture of people using their PDAs after dinner in their hotel rooms to get additional information on other people whom they met in the afternoon and make an action schedule for the next day.

Connection Refusal

We also tried to find the effects of the transmission rate and communication errors on mobile computing services. For e-mail, figure 13 shows the data-transmission rate.

In figure 13, points marked with an asterisk mean values for which the transmission had an incomplete status because of errors or user interruptions. In figure 13, the most important characteristic is the distribution of the data-transmission rate. Typically, the data-transmission rate on services using a wired local area network follows a normal distribution. The data-transmission rate in this experiment, however, has an offset distribution. Almost all measured points are concentrated around the line that defines an average data-transmission rate of 400 bits/s. Some points appear on the higher-rate side, but a few points appear on the lower-rate side. An average data-transmission rate of 400 bits/s is low compared with the 9600 bits/s of the physical layer on our mobile computing system. From these results (the low transmission rate and concentrated distribution), we estimate that in most cases of transmission in this experiment, the phenomena that caused a low-rate of transmission were transmission delay, bit error on the transmission layer, the retransmission of packets, and so on.

Comments from Participants

- It is a great initiative and I think it is the basis for the future mobile agent. I sometimes found it cumbersome; in general, if the communicational aspects improve, it will be of great value.

- It'll be more interesting if the participants use it more often. Less info, less news, less posting is not interesting.

- In general, the project is interesting and seems to have many possibilities. The concrete realization has many difficulties and problems. Besides those already mentioned, there have to be people doing first steps, i.e., posting news, inviting other people to discussion, meetings, etc. Without proving this initial start by yourselves, I do not think that much action will happen (I am also to blame, but it seems that nobody did anything, so I am not the only one.)

- I think the project is very interesting and potentially very important. The software should be enhanced, as well as the quality of the information, and the way it could be modified. The design of the user interface should be changed; it is not very clear how to use it.

- Unfortunately the interaction speed/ease was far too slow for me to use. It was much easier just to meet people and I could never get e-mail to work. I did not have time to visit the help desk to see what was wrong. Good idea but the speed wasn't useful for me.

- The project was nicely arranged and I appreciated being a part of it. I was very disappointed with the PDA for several reasons. First, I had to have a special address that people at home did not know about. Second, I really, really, missed standard tools like TELNET and FTP. Finally, If you were taking notes on talks, the only thing you could do with them was send them home by e-mail. It would have been nice to be able to create files that could be transferred, through FTP, to your home server.

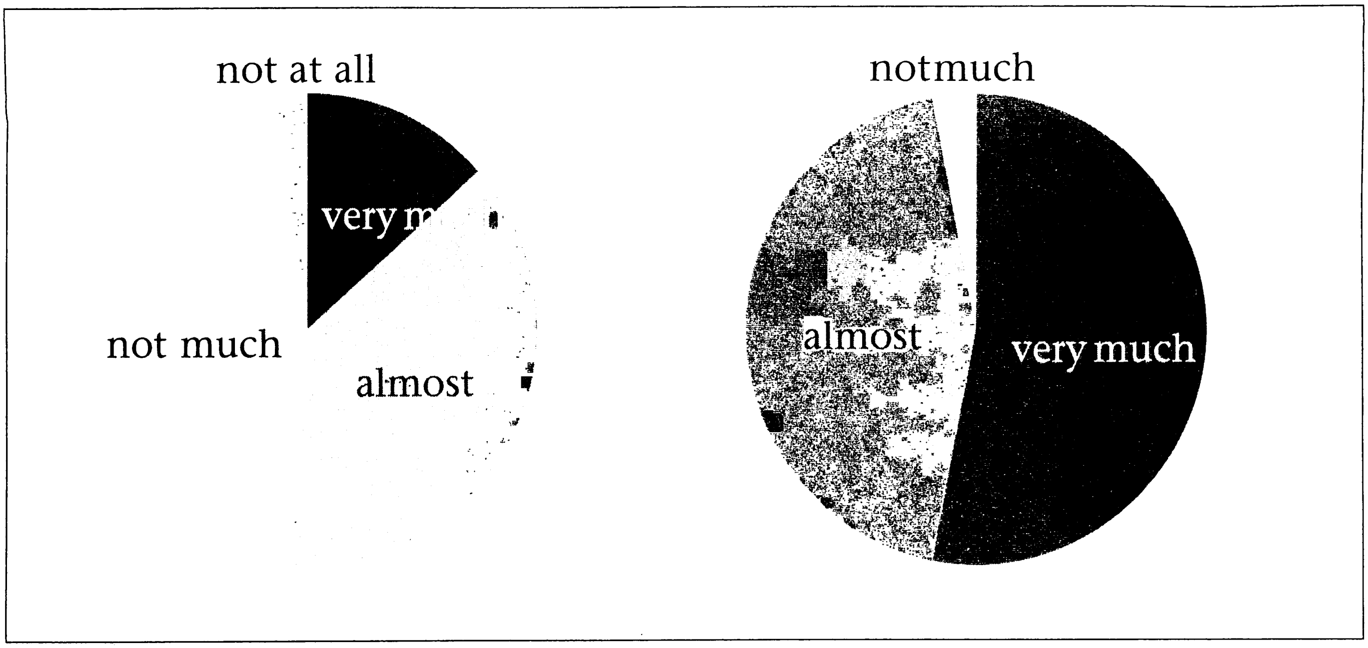

Figure 14. Questionnaire.

A. Satisfaction with services. B. Agreement to trials.

In questionnaires, users claimed that the data-transmission rate of communication with the server system was slow (transmission rate = 400 bits/s and setup time = 29 s; negotiation between modems = 23 s, and the time to establish PPP [point-to-point protocol] = 6 s).

Figure 13 shows that user interruptions occurred during the early stages of transmission. In this experiment, the total size of data to be transmitted and the amount transmitted to this point were shown on the client system. Thus, users were able to estimate the total time of transmission. If the user knew that transmitting data from the server would take a long time, he/she often interrupted the transmission.

Conclusions

Through the ICMAS'96 Mobile Assistant Project, we provided digital mobile assistants as agents for community support. The system was actually tested at an international conference, and the data collected are being analyzed.

The analysis of user behavior clearly illustrates the role of mobile computing in supporting international conferences. PDAs were continuously used not only at the conference site but also elsewhere after dinner. People used PDAs more often than desktop computing but for short periods only. E-mail services were used steadily and independently of the conference structure, but the peak of information services depended on the progress of the conference.

Important for the design of information services on mobile computing, we also found that users had a tendency to break the connection when they were forced to wait a long time for data transmission. Most users who had some error or interruption in transmission reconnected to the server system after a relatively long time.

We know that a single trial is not enough to obtain general conclusions. However, it is also true that large-scale experiments are not easy to repeat. To the best of our knowledge, no analytic reports have been published on conference support services, even for desktop computing. We believe it is valuable to share the results of our log data analysis with other researchers, who might perform similar experiments in the future.

Postquestionnaire data showed that our trial was considered interesting, although people were not fully satisfied with the PDAs and the services provided. (See the sidebar for more detailed comments from participants.) The participants showed a deep interest in mobile computing for convention support. This project was planned as a step toward a new research initiative on communityware (Ishida 1998).

Systems that are to be used in a community are more difficult to design than point-to-point communication services. They cannot be evaluated by the simple sum of the impression of the users. The effectiveness of such systems must be verified through experiments involving large numbers of people. Through real experiments, we expected to confirm what the role of mobile computing in social interactions among human communities is. Figure 14a indicates the degree of satisfaction with the provided services, and Figure 14b indicates the degree of agreement with this trial. It is notable that the project was widely accepted, although we could not completely satisfy all participants. People claimed that the terminal was heavy and inconvenient to carry, the speed of communication was slow, and so on. However, we can see that the users showed a deep interest in mobile computing for community support.

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Notes

1. A more detailed project report can be found in Nishibe et al. (1998).

2. Now, agent-oriented mobile computing languages are mainly based on JAVA, for example, AGLETS and ODYSSEY.

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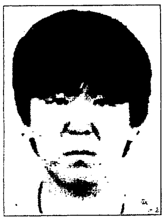

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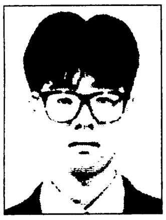

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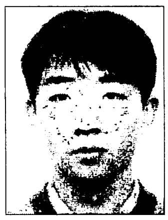

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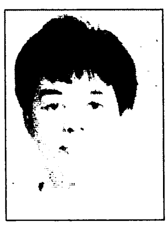

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