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Supporting the awareness of shared interests and experiences in communities

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In this paper, we propose a notion of facilitating encounters and knowledge sharing among people having shared interests and experiences in museums, conferences, etc. In order to show our approach and its current state, this paper presents our project to build a communityware system situated in real-world contexts. The aims of the project are to build a tour guidance system personalized according to its user's individual contexts, and to facilitate knowledge communications among communities by matchmaking users having shared interests and providing real and/or virtual places for their meetings. In this paper, we first show PalmGuide, a hand-held tour guidance system. After that, we show two systems designed to increase the level of "community awareness". One is called Semantic Map, a visual interface for exploring community information, such as exhibits and people (focusing on exhibitors and visitors). The other is called AgentSalon, a display showing conversations between personal agents according to their users' profiles and interests.

1. Introduction

In this paper, we propose a notion of facilitating encounters and knowledge sharing among people having shared interests and experiences in museums, conferences, etc. In order to show our approach and its current state, this paper presents our project to build a communityware system situated in real-world contexts.

With the advances of global computer networks like the Internet and mobile computing, human communications have gone beyond temporal and spatial limitations. Previously, research into groupware was triggered by advances in local area networks. Recently, many researchers have been attracted to communityware, a type of software that allows a large decentralized group of people to form communities, share preferences and knowledge and perform social activities (Ishida, 1997).

In Table 1, we make a comparison between groupware and communityware by considering our intentions. Unlike previous research on groupware, which has mainly supported the collaborative work of already-organized people with shared goals, communityware is for more diverse and amorphous groups of people sharing interests and preferences, not obvious goals. In communityware, the objectives and benefits of any activity are not centralized, but distributed. The essence of activities changes from finding solutions to finding issues to be solved. The interests and volunteering mind-sets

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TABLE 1
Comparison between groupware and communityware

	Groupware	Communityware
Background	Local area network	Global area network, e.g. Internet
Target group	Already-organized group	Community: diverse and amorphous group
Objectives, benefits	Shared, centralized	Individual, distributed
Target task	Solution (collaborative work)	Discovery (encounter with knowledge and people)
Shared properties	Goal, duty, reward	Interest, commitment, volunteer

of the participants empower these activities, rather than a sense of duty or direct rewards.

In investigating how to create communityware situated in real-world contexts, we have chosen exhibition-type applications such as museums and open house events at research laboratories. The reason for this choice is that these are places where knowledge is accumulated and/or conveyed to people by seeing, touching and experiencing actual exhibits, and where exhibitors, as specialists, provide knowledge to visitors with diverse interests and viewpoints.

The aims of the project are to build a guidance system personalized according to its user's individual context, and to facilitate knowledge communications among communities by matchmaking users having shared interests and providing real and/or virtual places for their meetings (Sumi, Etani, Fels, Simonet, Kobayashi & Mase, 1998; Sumi & Mase, 2000).

Figure 1 shows an overview of our system.

Tour navigation. Users carry their own PalmGuide devices, which are hand-held guidance systems, during the tour. Each PalmGuide manages its owner's profile and visiting records accumulated so far and recommends exhibits according to his/her current situation (location and time) and interests. The owner can browse the information of the recommended exhibits on PalmGuide.

Exhibit display. The user can obtain a personalized explanation of each exhibit by connecting PalmGuide with exhibit displays set at individual exhibit sites.

Personalization of exhibit. Using the personal contextual information accumulated by the guide agent enables the personalization of experience-type exhibits. In the example shown in Kadobayashi and Mase (1998), an animation character, i.e. a user's guide agent, migrates from the user's personal digital assistant (PDA) into the demo screen and automatically changes the course of the demo according to the user's personal interests.

Information kiosk. Our information kiosks are connected with servers via a LAN, and enable visitors to access accumulated community information. In order to increase the level of "community awareness" among people involved in an exhibition, the kiosks provide users with services such as visually showing the relationships between visitors and exhibitors according to their interests and touring histories. The community services on the kiosks are almost identical to offsite services provided via the Internet. However, in the case of the kiosks, we can offer more sophisticated services situated in

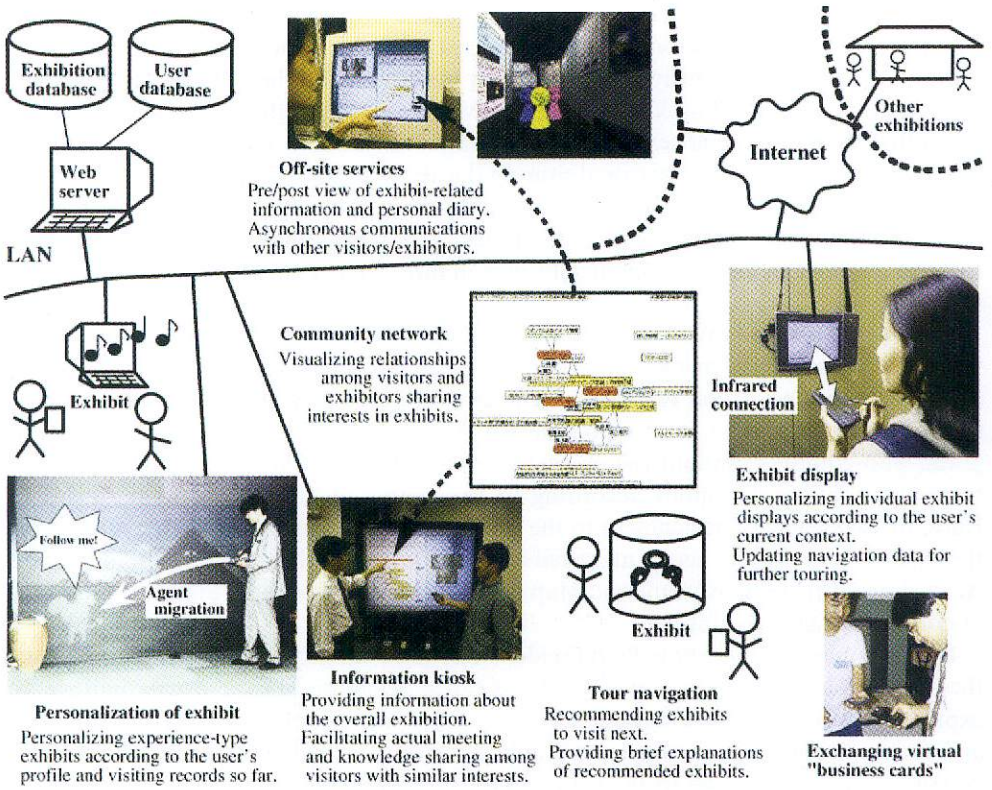


FIGURE 1. System overview.

location and time, e.g. highlighting information related to the present exhibit. Moreover, the kiosks have the potential to facilitate actual face-to-face meetings between visitors with shared interests at the exhibition site, like AgentSalon, a system described in this paper.

Exchanging of virtual business cards. Users can exchange virtual "business cards" by turning their PalmGuides towards each other. The exchanged data includes only user IDs, which are recorded with the time they exchanged the cards. However, once the data is combined with the community information space, the users can easily access the personal Web pages of people with whom they have exchanged "business cards" and learn their interests in the exhibition. Since the community information can continuously grow after the "business card" exchanges, the users can always access updated information.

Off-site services. Potential visitors can preview exhibit-related information at their homes/offices beforehand. As will be described later, we provide users with Semantic Map, a tool for visually exploring exhibit-related information. Each user's behaviour when using Semantic Map, such as keyword selection, is used to quantify the user's preferences, which will then be exploited for the personalization of the user's guide agent while he/she actually tours an exhibition site. In this framework, the authors' group has also been developing a question-answering system for the personalized

preview of exhibit-related information (Sumi, Sumi, Mase, Nakasuka & Hori, 1999) and a shared virtual exhibition space with 3D graphics for virtually revisiting an exhibition and synchronously/asynchronously meeting with other people having shared interests (Ko, Sumi, Choi & Mase, 1999). Moreover, since the infrared connections between PalmGuide and exhibit displays or information kiosks leave electronic "footprints", we can make personal touring diaries. We can insert the personal touring records and an abundance of information existing in cyber space (such as Web pages related to individual exhibits) into the diaries. This means that touring behaviours in the real world can help automatically personalize (gather and filter) the huge Web space.

Community network. We believe that providing people involved in an exhibition with visualized community networks, by structuring all users' contextual information accumulated in the actual exhibition, will help to create new encounters among users sharing interests and to form communities. The community network's structure is a graph whose nodes represent visitors, exhibitors, and exhibits and will have connections between people and exhibits according to the degree of attachment to the exhibits. Here, by the degree of attachment to the exhibits, we mean exhibitors being involved in the exhibits and visitors being interested in them, i.e. rating them highly on PalmGuide. Accordingly, the users of Semantic Map can discover partners who might be interested in collaborating in the future.

In this paper, we first show PalmGuide. After that, we show two systems to increase the level of "community awareness". One is called Semantic Map, a visual interface for exploring community information, such as exhibits and people (focusing on exhibitors and visitors). The other is called AgentSalon, a display showing conversations between personal agents according to their users' profiles and interests.

2. PalmGuide: personal tour assistant

A user of our system carries PalmGuide, a hand-held guidance system, while touring an exhibition. PalmGuide runs on PalmOS PDAs. When starting to use it, a user selects an agent character from among eight characters that we prepared beforehand. The character representation is intended to have the agent increase the believability, consistency, and transparency of services, by having the agent show up on PalmGuide as well as on the exhibit/kiosk displays when the user connects his/her PalmGuide to them.

Figure 2 shows an example display of PalmGuide. The user can hierarchically browse dates, sessions, individual exhibits, and their abstracts and exhibitors. The guide agent running on PalmGuide provides the user with tour navigation information, such as exhibit recommendations, according to the user's context, i.e. personal interests and temporal and spatial situations. This agent keeps its user's personal profile and touring records, which are used for personalizing the presentation of individual exhibits and matchmaking with other users having shared interests and touring records.

PalmGuide can communicate with exhibit displays by infrared communications. The agent can migrate to and provide personalized guidance on individual exhibit displays or information kiosks that are ubiquitously located in the exhibition site (Figure 3). It

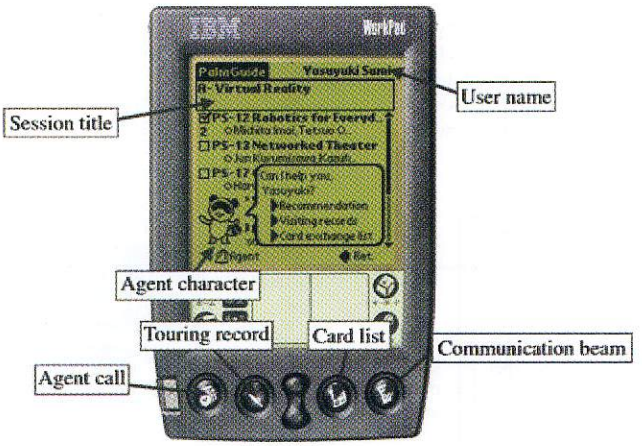


FIGURE 2. PalmGuide display.

manages its user's personal data (user ID, touring history, personal interests, etc.), which is conveyed to an exhibit display when the user turns PalmGuide towards the display. The individual exhibit displays are then personalized for presentation based on the user's context, e.g. expert or novice, much interest or not much interest, English or Japanese, etc. Migrated agent characters are visualized with the Microsoft Agent platform.

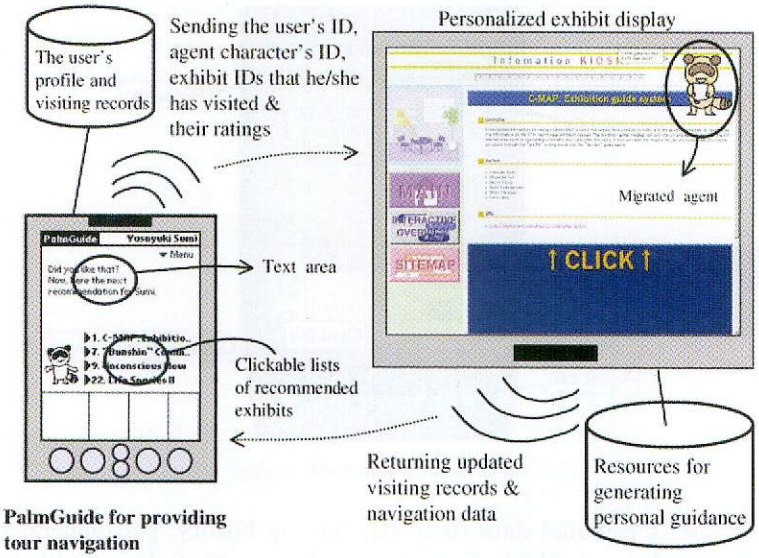
Connecting PalmGuide with exhibit displays via infrared communications updates the user's visiting history. This architecture allows us to capture the visiting histories of users without employing special methods, such as location detection devices. The updated history of a user renews the personal guidance information, e.g. exhibit recommendations, on PalmGuide.

On PalmGuide, the user can rate individual exhibits that he/she has visited so far (Figure 4). The ratings improve the precision of the exhibit recommendations by the guide agent. That is, exhibits sharing keywords with exhibits rated highly by the user are highly recommended, and exhibits sharing keywords with exhibits rated lowly are lowly recommended. The ratings are also used for building community networks. That is a high rating for a certain exhibit by the user is represented as a link between the user and the exhibit on community networks; this is described next.

3. Semantic Map: visual explorer of community information

We built Semantic Map as a visual interface for exploring community information accessible via the Internet and on information kiosks located in exhibition sites.

We believe that providing people involved in an exhibition with visualized community networks, by structuring all users' contextual information accumulated in the actual exhibition, will help to create new encounters among users sharing interests and to form communities. The community network's structure is a graph whose nodes represent visitors, exhibitors, and exhibits and will have connections between people and exhibits according to the degree of attachment to exhibits. Accordingly, the users of



(a)

(b)

FIGURE 3. Agent migration form PalmGuide to an exhibit display: (a) personalization of an exhibit display with PalmGuide connections; (b) an exhibit display in use.

Semantic Map can discover partners who might be interested in collaborating in the future.

The Semantic Map illustration shown in Figure 5 graphically displays the relationships between exhibits presented in the open house of the authors' laboratories. The rectangular icons in the graph signify exhibit titles and the oval icons signify keywords or participants (including exhibitors, i.e. researchers, and visitors). The keywords are technical terms characterizing the contents of the exhibits, which were previously extracted from outline texts prepared by the exhibitors. This Semantic Map provides the users with graphs, with links between exhibit icons and keyword/

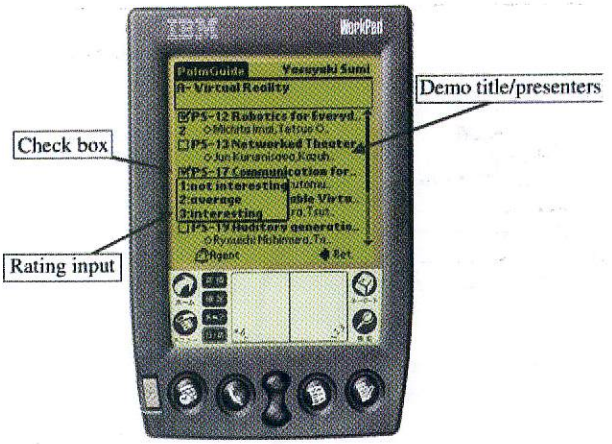


FIGURE 4. Personal ratings of individual exhibits on PalmGuide.

participant icons, which, in turn, helps the users to browse the information space of the exhibition.

However, since the number of keyword/participant icons is huge, a graph that includes all of these keyword/participant icons is unable to provide useful visualization. Therefore, we have adopted a method whereby only the keyword/participant icons selected by the user are displayed based on his/her interests. As a result, the graph of Semantic Map can be structured based on an individual user's interests. For example, if a user selects the keyword "agent", he/she can view a partial graph formed with only "agent"-related papers. If the user selects other keywords, Semantic Map restructures the graph based on the corresponding viewpoint.

The guide agent keeps the selected keywords/participants as a part of its user's mental context, and uses the data for the personalization of Semantic Map whenever the user accesses an information kiosk.

The exhibit icons and participant icons have links with related Web pages, e.g. project pages, personal home pages and automatically generated touring diaries. Therefore, Semantic Map can be used as a visual interface for exploring the information spaces of exhibitions, conferences, etc.

Semantic Map facilitates its user's associative exploration of huge information spaces. In the example of Figure 5, when a user clicks the "*exhibit A*" icon with the right button of the mouse, Semantic Map provisionally shows all of the keyword/participant icons having links with *exhibit A*, including hidden icons. Therefore, the user can check for the existence of unknown keywords and participants related to an exhibit that he/she is interested in. By moving the mouse while continuing to push the right button and releasing the button on one of the provisionally appearing keyword/participant icons, the user can select a new keyword/participant icon. In the example, the icon of *participant C*, who expressed his interest in *exhibit A*, is selected. Semantic Map then shows not only the icon of *participant C* but also other exhibit icons that *participant C* expressed an interest in. Accordingly, the user can notice not only that *participant C* has a shared interest in *exhibit A* but also that he has an interest in other exhibits that the user himself/herself had not noticed yet.

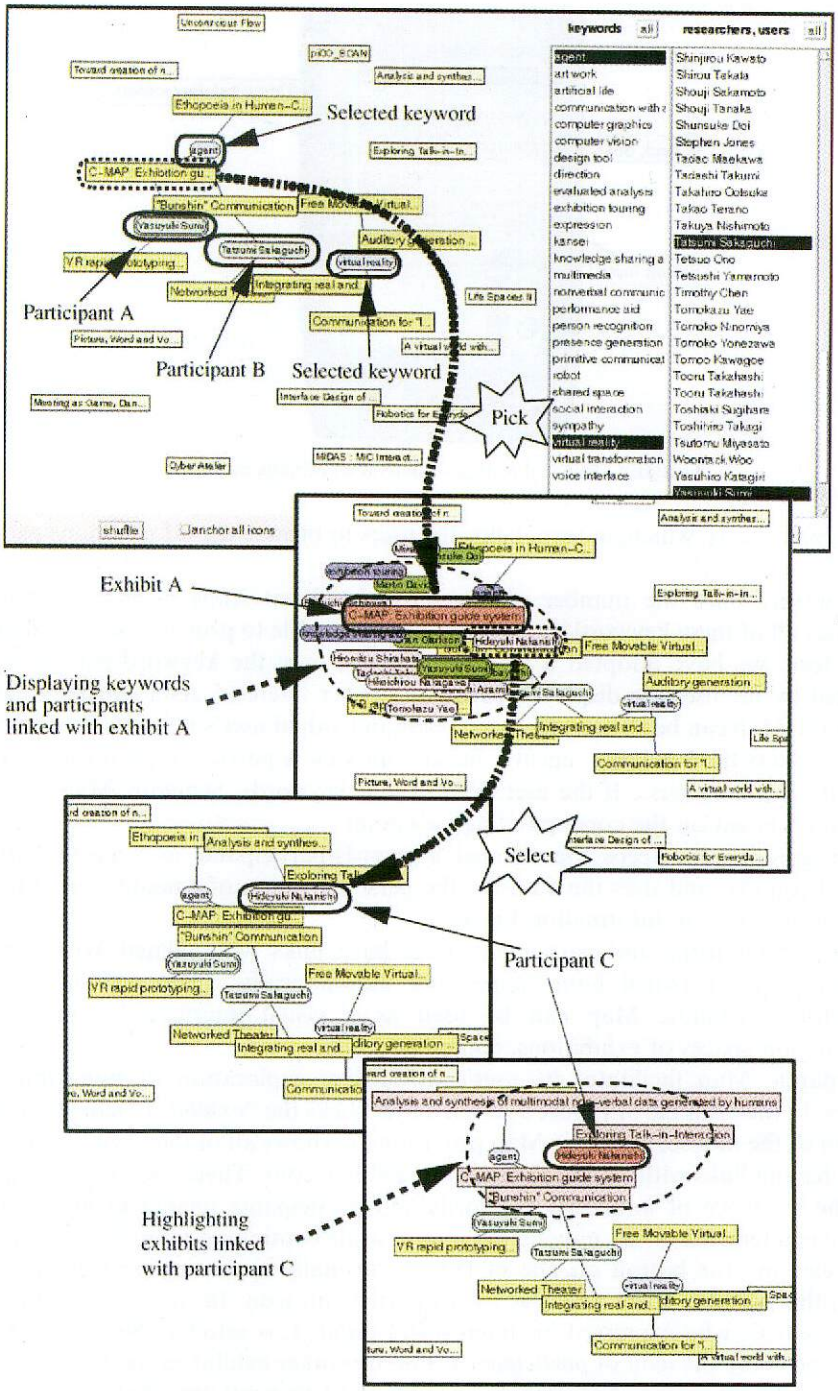


FIGURE 5. Visual exploration of community information with Semantic Map.

Although Semantic Map has lists of keywords and participants as shown in the figure and its user can select interesting keywords/participants from the lists, these lists can become useless if the information space consists of huge numbers of exhibits and participants. In such cases, the associative method presented here encourages human interest-driven information exploring.

4. AgentSalon: facilitating face-to-face conversations

AgentSalon (Sumi & Mase, 2001) is a system that facilitates face-to-face knowledge exchange and discussion between users by tempting them to chat with prompting by their personal agents, which maintain their personal interests and experiences. We prototyped AgentSalon as a kind of information kiosk that is assumed to be located in a meeting place of an exhibition site, with a large touch panel screen. AgentSalon has a big display for use by two to five users simultaneously.

The following is an AgentSalon scenario.

(1) Personal guide agents on the PalmGuide of individual users migrate to AgentSalon with their users' personal information and are displayed as animated characters.
(2) The migrating agents share their users' visiting records and interests and detect common as well as different parts in this information.
(3) Based on the above results, the agents plan and begin conversations in front of the users. By observing the conversations, the users can efficiently and pleasantly exchange information related to an exhibit.
(4) Because AgentSalon can access community information, such as the information on each exhibit and other users' personal information via networks, users can browse detailed information about the exhibits or users that are referred by agents.

As Figure 6 illustrates, AgentSalon consists of the following three components.

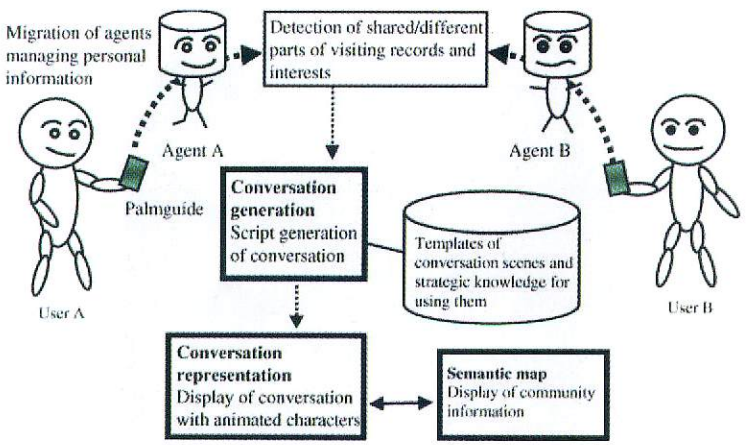


FIGURE 6. System architecture of AgentSalon.

Conversation generation. This component generates scripts of *interesting* conversations using personal information managed by agents. This is a knowledge-based system having utterance templates and strategic rules to tailor scripts depending on the context.

Conversation representation. According to the generated scripts, this component controls and represents the utterances and behaviours of animated agents by using Microsoft Agent. The streams of conversations, entrance and exit points of agents, and simple interaction with users are controlled by JavaScript.

Semantic Map. This is a visual interface for browsing community information accumulated in a Web server. It shows the semantic relationships between exhibits and the people involved with them and helps a user to associatively explore large information spaces according to his/her interests.

The goal of the conversation generation component, which is the main part of AgentSalon, is to generate scripts of *interesting* conversation based on personal information managed by agents in the salon. In order to achieve this goal, we have implemented a knowledge-based system to plan conversations by authoring reusable templates of conversations, and the strategic rules to use them.

We call comparatively independent and reusable sets of utterances "scenes". Conversation planning is triggered by the entrance of a new agent, accompanied by the display of one or more scenes. The exit of the agents from the salon is done on users' demand by touching the animated agents on the display.

The rules of script generation can be classified as follows:

Object rules. These are rules to make scenes by filling scene templates with the personal information (e.g. user name, exhibit title, parametric numbers, etc.) on hand.

Meta rules. These are strategic rules to select templates and object rules in order to make more effective conversation to stimulate the users' meeting. They include editorial rules to smooth the stream of the whole conversation when combining several scenes.

AgentSalon runs on Microsoft Internet Explorer. The animated agents are displayed on the top of Semantic Map using Microsoft Agent. The display is a touch panel, so users can manipulate Semantic Map with their fingers and interact with their agents. Figure 7 shows AgentSalon being used by two people.

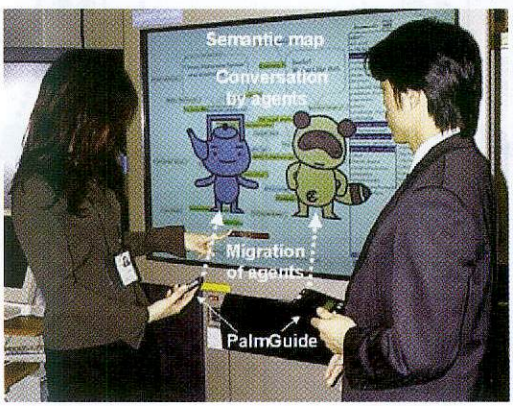


FIGURE 7. AgentSalon in use.

In the current implementation, when a certain agent enters the salon, its user's icon appears in Semantic Map. At the same time, the icons of the exhibits that he/she has visited and evaluated as *interesting* appear and are linked with his/her icon. Therefore, the current implementation visualizes relationships (overlaps and differences) between touring experiences and the individual interests of users.

The following provides an example of conversation scenes performed by agents.

- Suppose that a *user A* has visited *exhibits 1*, *2*, *3* and *4*, and a *user B* has visited *exhibits 2*, *4*, *5* and *6*. In this case, their agents will notice that the users have commonly visited *exhibits 2* and *4*, i.e., they share some interests in exhibits. Therefore, *user A*'s agent recommends *exhibits 1* and *3* to *user B*, and *user B*'s agent recommends *exhibits 5* and *6* to *user A* (see Figure 8).
- When two users' evaluations of a commonly visited exhibit are different (e.g. *user A* is interested in *exhibit 1*, but *user B* is not), their agents prompt a discussion about the exhibit. For example, the agent of *user A* says "*Exhibit 1* was interesting!", and then the agent of *user B* replies "Really? We didn't like it." By observing the dialog, *user A* and *user B* can know that they have differing opinions about a shared experience (i.e. visiting *exhibit 1*), which efficiently leads them into a stimulating discussion (see Figure 9).
- The salon agent has a more global view on Web resources than other agents belonging to individual users. When no events (e.g. no new agent entries) happen for a while, the salon agent offers a topic, such as pointing to the most popular exhibit among all PalmGuide users (see Figure 10).

5. Experiments and evaluation

Based on the architecture described in this paper, we prototyped a guidance system and provided it to participants at academic society conferences in 1999, 2000 and 2001, and at our laboratory's open house in November 1999. Here, we show the results of an experiment of our guidance system at an academic conference from July 4th to July 7th, 2000.

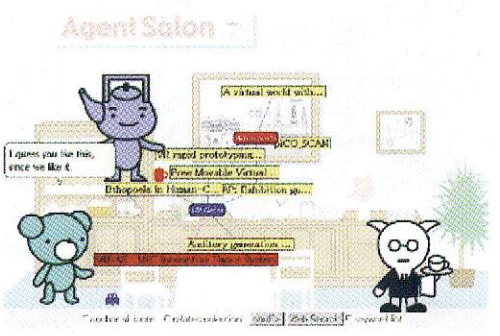
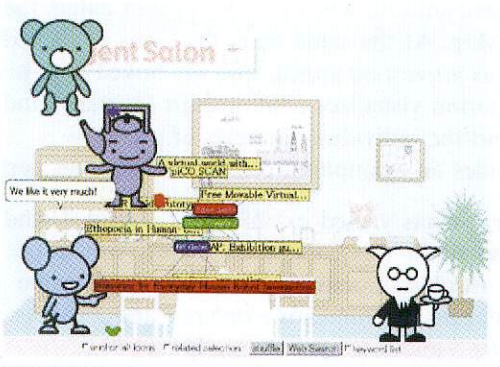
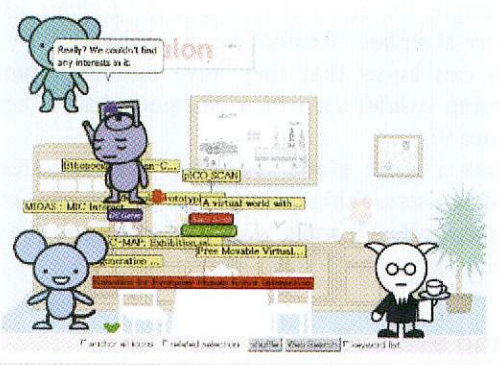


FIGURE 8. Example scene of AgentSalon (1): Mutual recommendations.



(a)



(b)

FIGURE 9. Example scene of AgentSalon (2): Stimulating discussion.

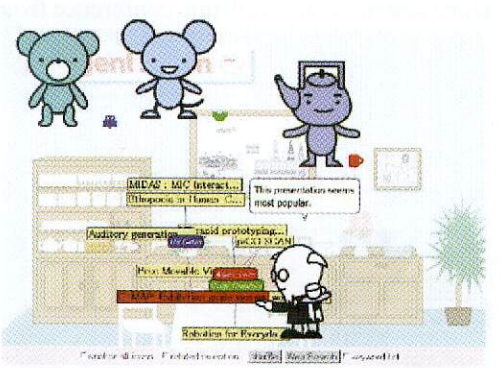


FIGURE 10. Example scene of AgentSalon (3): A topic being provided by the salon agent.

We provided the conference participants with onsite services using a hand-held guidance system, i.e. PalmGuide, and kiosks and off-site services using the Web. The services consistently covered an on-line preview service by the Web; personal guidance

and knowledge-sharing support among the participants at the conference site; and an online service after the conference.

The conference was held for 4 days and had about 250 presentations (oral presentations and demos) and about 600 participants. Our system was used by not only the onsite participants but also on-line sign-up users. We registered 479 presenters as users of the system beforehand. In addition to these users, 136 people signed up for our services in the 2-month period after we started our on-line service just before the conference. Even a year after the conference, the number of sign-up users continues to increase.

Figure 11 shows the overall activities of our off-site services. The x-axis indicates the date and the y-axis indicates the numbers of sign-ups and user logins. Note that the

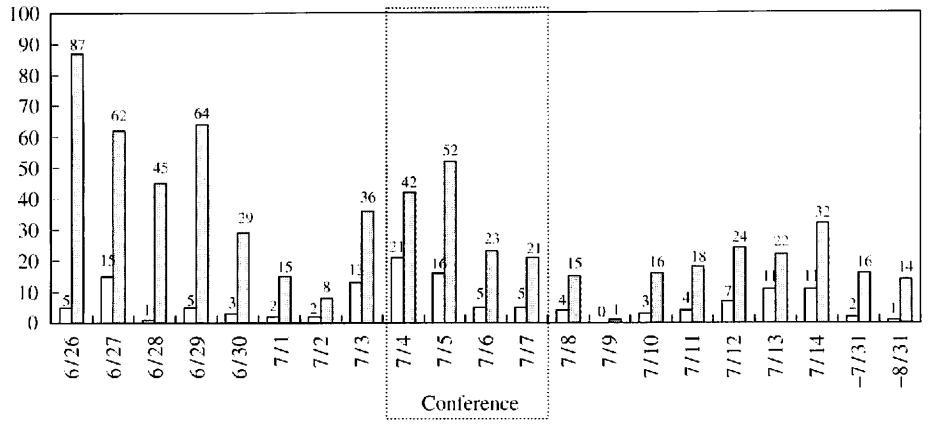


FIGURE 11. User sign-up and login to our off-site services: □, sign-up; □, login.

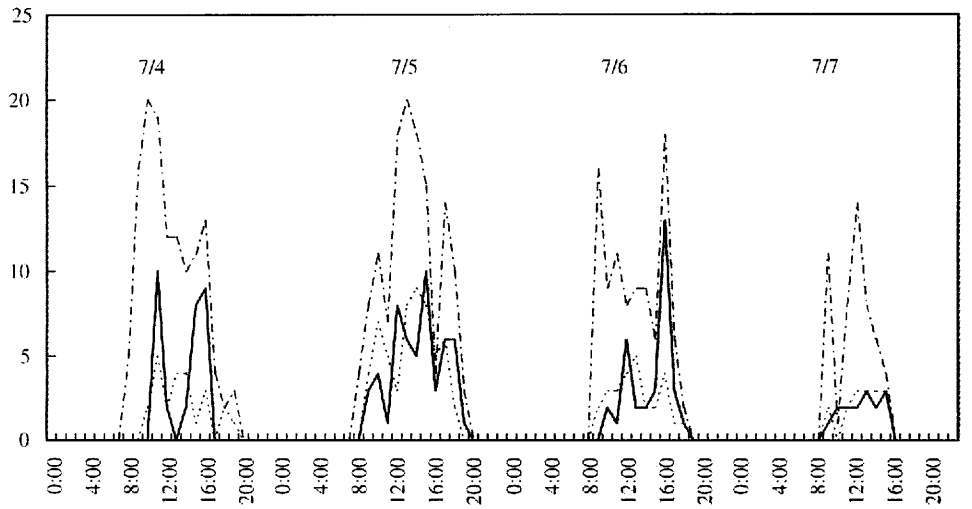


FIGURE 12. Utilization of kisoks located at a conference site. –·–·–, use of kiosk without PalmGuide; ——, use of kiosk with PalmGuide; ····· Use of AgentSalon.

login count before the conference is larger than that during the conference; this indicates that online services provided by the Web have considerable potential to facilitate "warming-up" activities among participants before social events.

We located four kiosk terminals and one AgentSalon terminal at the conference site. PalmGuide was used by 65 participants. Figure 12 shows the utilization rates, i.e., kiosk access with PalmGuide, kiosk utilization without PalmGuide, and AgentSalon utilization. The x-axis indicates the hours during the conference period and the y-axis indicates the user access count.

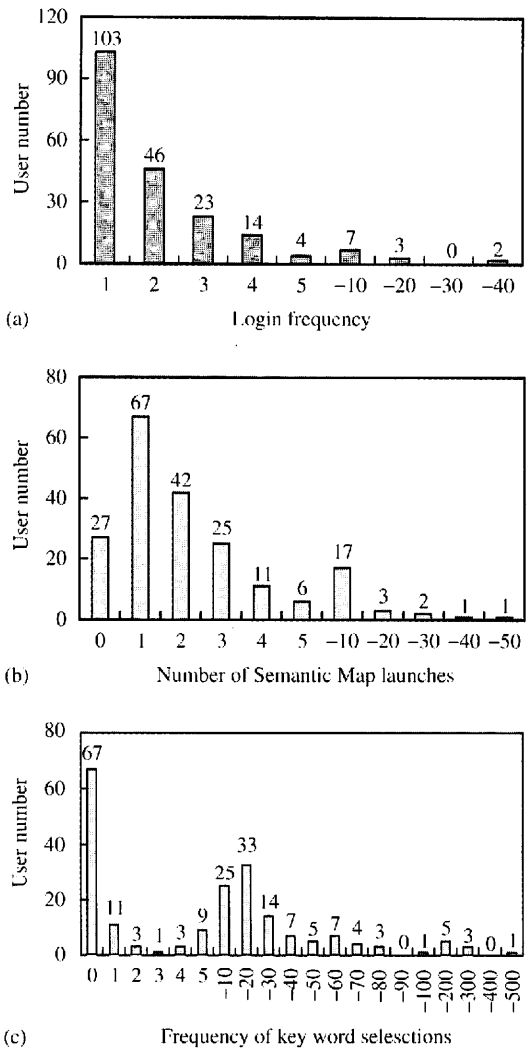


FIGURE 13. Utilization of off-site services: (a) login; (b) launching Semantic Map; (c) keyword selection on Semantic Map.

TABLE 2
User distribution of AgentSalon accesses

Access count	0	1	2	3	4	5	6	7	8	9–13	14	15
User number	25	15	10	4	4	2	1	1	1	0	1	1

TABLE 3
The number of users per session

User number	1	2	3	4	5
Number of sessions	40	14	8	4	3

Figure 13 illustrates the utilization of our off-site services. Figure 13(a) shows the user distribution of logins to the off-site services. While about half of the users logged in only once, some of the users logged in about 40 times over two months. The most utilized off-site service was Semantic Map, for browsing conference information such as papers and presenters. Figure 13(b) shows the utilization of Semantic Map. Most of the users launched Semantic Map a few times. Surprisingly, there were users who launched it more than 30 times over the two-month period. In order to gain a more in depth view of the users' utilization of Semantic Map, let us look at the number of keyword selections on Semantic Map in Figure 13(c). On Semantic Map, a user can select keywords for exploring conference information. Therefore, the frequency of keyword selections can be regarded as the user's activity while using Semantic Map. In our case, since one third of all users never selected a keyword, we can say that there were not a few users who launched Semantic Map without any specific aim. On the other hand, we can also observe a gentle peak around 20 times, meaning that most of the users understood and reasonably used Semantic Map. Some very active users made more than 100 keyword selections. According to our records, the most active user used Semantic Map before the conference (for only 8 days).This implied that Semantic Map functioned well for previewing the conference.

Next, let us see the utilization of AgentSalon. Table 2 shows the user distribution of AgentSalon accesses. The table shows that 40 of the 65 PalmGuide users, that is, over 60%, used AgentSalon. While most of the users tried AgentSalon only two to five times, some users frequently and pleasantly used it.

In order to view how many users simultaneously accessed AgentSalon, Table 3 shows the number of users per session.† During the conference, there were 69 sessions by 123 users. Forty sessions, about 58% of the total, were by only one user. The largest number of users per session was five: this occurred 3 times. Since the access of AgentSalon by one user is not the intended usage, we can say that many sessions were conducted just to check AgentSalon's behaviour. On the other hand, we can see that there were not a few sessions by three or more users. Actually, we could observe some

†"Session" means a temporal sequence from the time of a user's access to AgentSalon when no other user is using it to the time when all users logout from it.

TABLE 4
Correlations between utilizations of various services by PalmGuide users†

	Kiosk	Record	Card	Login (1)	Login (2)	Login (3)	Login (t)	Semmap	Diary
Kiosk	1								
Record	0.2605	1							
Card	0.0926	0.2716	1						
Login (1)	−0.1853	−0.0520	−0.0014	1					
Login (2)	−0.0410	0.0868	0.0030	−0.0785	1				
Login (3)	0.0102	0.2878	−0.0249	−0.0359	−0.0821	1			
Login (t)	−0.1914	0.0493	−0.0076	**0.9388**	0.1332	0.2223	1		
Semmap	−0.1920	0.0576	−0.0039	**0.6668**	0.3514	0.1474	**0.7669**	1	
Diary	0.0502	0.1928	0.0062	−0.0733	0.3778	0.0000	0.0167	**0.4245**	1

†Kiosk: kiosk access with PalmGuide, record: visiting check, card: card exchange, login(1,2,3,t): off-site service login (before, during, after the conference, total), semmap: Semantic Map, diary: visiting diary.

"regulars" frequently gathered in front of AgentSalon and having discussions by touching Semantic Map for over 10 min. We could also observe some users exchanging their "virtual business cards" with their PalmGuides when meeting in front of AgentSalon: this implied that AgentSalon contributed towards supporting encounters among conference participants.

For a more detailed analysis, Table 4 shows the correlations between the utilizations of various service (PalmGuide functions and off-site services) by PalmGuide users. We assumed a positive correlation between two utilizations having a factor of more than 0.4, which is bold-faced in the table.

A very strong correlation appears between off-site service login before the conference and its total, which means that most logins were done before the conference. Additionally, a positive correlation exists between Semantic Map utilization and off-site service login. Therefore, we can say that such active users, who used PalmGuide at the conference site, were highly motivated by our service before the conference. A positive correlation also appears between diary browsing and Semantic Map utilization. This means that Semantic Map functioned as a portal for personal diaries and Internet resources related to the presentations and participants of the conference.

We asked onsite service users to fill out a questionnaire when they returned the PDAs. We received answers from 35 users. The questionnaire asked whether the user had used individual functions on PalmGuide, information kiosks, and AgentSalon, and if so, whether they were effective. At the same time, we also asked about off-site services for previewing the conference. The following is a summary of the results.

- All PalmGuide functions except business card exchanging were used (or noticed) by most of the PalmGuide users without the need for detailed instructions, and their effectiveness was acknowledged.
- The migration of agent characters from PalmGuide to kiosks was easily understood and used with pleasure.
- Although some authors registered links to their personal Web pages for detailed pages of their papers, most users were not aware of these. The major reason was thought to be the fact that the number of linked pages was very small.

- We employed the same Semantic Map applet for the kiosk displays and AgentSalon's background. In spite of this, the Semantic Map on AgentSalon was regarded as more effective. We believe that conference participants would prefer collaborative Web browsing with a big screen rather than single use with a kiosk terminal.

6. Related works

Recently, there have been many studies on physical interaction with real objects and/or environments augmented by computational functionality. Most of them have involved context-aware applications with ubiquitous and mobile computing technologies (Weiser, 1993; Reikimoto & Nagao, 1995; Want *et al.*, 1995; Streitz *et al.*, 1999), and have deeply inspired our project.

Specifically, Abowd *et al.* (1996) applied a variety of ubiquitous computing technologies to facilitate the automatic capture and subsequent access of multimedia information among community members. Nishibe *et al.* (1998) and Dey, Salber, Abowd and Futakawa (1999) prototyped mobile assistants for conference attendees and Abowd, Atkeson, Hong, Long, Kooper and Pinkerton (1997), Feiner, MacIntyre, Höllerer and Webster (1997) and Cheverst, Davies, Mitchell, Friday and Efstratiou (2000) prototyped guidance systems for sight/museum tourists.

Digital kiosks play an important role in open spaces, such as conference halls, museums, and town community centres, as shown in Salomon (1990) and Christian and Avery (1998). Their kiosks, however, do not provide individual users with continuous services based on user identification. On the other hand, our PalmGuide personalizes the services on information kiosks by passing on its user's accumulated contextual information.

Lamming and Flynn (1994) proposed a method for augmenting a user's external memory by using a portable PDA. Their system, called "Forget-me-not", collects a user's contextual information, and automatically indexes his/her personal activities. Their focus was on the accumulation of personal contextual information, but we are interested in exploiting accumulated personal contextual information for knowledge communications among communities.

Meme Tag, an electronic name tag that is capable of exchanging short messages while facing other tags, and Community Mirror, a big screen that visualizes the spread of messages (Borovoy, Martin, Vemuri, Resnick, Silverman & Hancock, 1998), are interesting efforts at facilitating interaction between people sharing interests at actual party locations. However, the exchanged information among users consists only of short messages, which is not enough knowledge for communities.

Our community network is similar to the social network proposed by Kautz, Selman and Shah (1997), which is a network representation of relationships between people and knowledge. There have been other related studies, such as a matchmaking agent that searches for people who share similar interests (Foner, 1997), a visualizing tool for helping community formation (Hattori, Ohguro, Yokoo, Matsubara & Yoshida, 1999) and recommender systems by collaborative filtering (e.g. Shardanand & Maes, 1995). These studies are related to ours since they aim at supporting collaborative knowledge

communications by quantifying human interests and preferences. The above systems, however, only involve a desktop computing paradigm. Therefore, users have to explicitly input their preferences and queries. Our effort in prototyping a personal guidance system embeds such systems into real-world contexts so that the systems can semiautomatically work according to the contexts of the users.

With regard to AgentSalon, there have been some works to support knowledge sharing and creation such as systems to help collaborative Web browsing (e.g. Silhouettell by Okamoto, Nakanishi, Nishimura, Ishida (1998) and Let's Browse by Liberman, Van Dyke & Vivacqua (1999)); and asynchronous knowledge sharing using alter-ego agents (Nishida, Hirata & Macda, 1998; Kubota, Nishida & Koda, 2000). However, their knowledge resources are commonly static information, such as previously prepared knowledge bases. On the other hand, AgentSalon uses personal information constantly accumulated by personal agents on PalmGuides carried by users. Such information is embedded in the real world; therefore, the information presented by AgentSalon has the potential to instantly influence the ongoing (touring) behaviours of users, and to accelerate collaborative knowledge sharing and creation among communities.

The essential jobs of AgentSalon are to detect and then to represent the shared/different parts of the personal information (e.g. interests and touring records) of several users. In terms of this, we have already proposed a method to visualize shared/different parts of several users' individual viewpoints during an online discussion (Sumi, Nishimoto & Mase, 1997). Semantic Map (running on AgentSalon) plays a similar role. However, the efforts to read the shared/different parts from the visualized information spaces and to utilize them for further discussion are fully up to the users. AgentSalon automatically reads the shared/different parts of users' knowledge/interests and represents them as *conversational stories*. Therefore, the cost of information conveyance between users is decreased, and more casual usage and understanding are encouraged.

7. Conclusion

We have shown our attempts to increase the level of awareness of shared interests and experiences among communities by presenting our ongoing project of a guidance system for exhibition tours. The characteristics of our system can be summarized as follows: personalized guidance by integrating personal mobile systems, i.e. PalmGuide, and ubiquitously located systems, i.e. information kiosks and AgentSalon; and the seamless combination of onsite services with permanent Web services.

We believe that building a context-aware personal agent not only enhances personalized guidance for individual users but also facilitates communications among them, such as community formation based on shared interests and knowledge exchanges within communities. Web-based systems have considerable potential for achieving such ubiquitous community support systems. Without connectivity with real-world contexts, however, knowledge exchange in a digitized world, even one with abundant information, will not be effective. Therefore, accumulating real-world contexts and connecting them to the digitized world, i.e. our investigation's focus, are very important issues.

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