

Autonomous Agents for Initiating Communication in Internet Community Chat Rooms

Mikael B. Skov

Department of Computer Science

Aalborg University

Fredrik Bajers Vej 7

DK-9220 Aalborg East, Denmark

dubois@cs.auc.dk

ABSTRACT

The Internet or the web provides interesting and promising opportunities and features for people to meet and communicate in virtual environments. Today the Internet is not only for locating and for retrieving texts and documents, virtual communities on diverse topics emerge continuously to support communication between people and serve as meeting places. Chat rooms are often used to support this kind of meeting and communication. However, filtering large amounts of information from these chat rooms is not a trivial task and moreover being present in chat rooms at all times is utopia and quite impossible.

This paper addresses a framework for a multiagent-supported community chat room. The agent framework supports users in identifying, retrieving, and filtering for them relevant and interesting information and conversations by monitoring the activity of one or more chat rooms. Users are able to communicate with their agent and delegate specific operations or tasks to the agent, e.g. monitor when certain users enter a room. Also, the solution supports that an agent is able to observe the actions of the user and recommend chat rooms or specific conversations in chat rooms based on its understanding of the user. The agent operates and makes decisions upon a number of profiles which are updated dynamically and which indicates the interests of the user. The agent is also able to communicate with other agents in order to make the most useful recommendations to its user. The framework includes an overall architecture of the involved agents and sketches for the interaction between the agents and the users.

1. Introduction

The Internet offers millions of users the opportunity to exchange electronic mail, photographs, and sound clips; to search databases for books, compact discs, scientific papers, and cars; to participate in real-time audio- and video-conferencing; and to shop for products both virtual and physical, cf. [16]). The huge conglomerate of links, hyperlinks, and virtual links is not just a technology for linking computers; it is also a medium for communication. The convergence of computer and communication technologies creates a social convergence as well. People meet in chat rooms and discussion groups to converse on everything from auto mechanics to post-modern art. In this way the Internet supports communication between people and the chat rooms and the communities serve as meeting places for all kinds of people. However, the introduction of virtual communities and chat rooms raises a number of potential problems for the Internet users, cf. [4] First, how can people be linked together with others and with communities that share similar interests? Search engines or web directories, e.g. AltaVista or Yahoo!, can partially help, but they are often inadequate for many people's purposes. Second, how can smooth communications be supported? New users in communities often face diffi-

culties in understanding what is going on in the community and they have problems in identifying interesting flows of conversations. Finally, how can the objectives or roles of communities and individuals be identified? It is often difficult to find key persons in virtual communities since virtual communities are amorphous compared to organisations like companies or schools implying a lack of organisational structures and roles in a traditional sense. Addressing or solving some or all of these issues could enhance the usefulness of Internet communities, cf. [4].

This paper presents a framework for a multiagent-supported community chat room. The agent framework addresses the three issues raised above by supporting users in identifying, retrieving, and filtering for them relevant and interesting information by monitoring the activity of one or more chat rooms. Users are able to communicate with an agent and delegate specific operations or tasks to the agent, e.g. monitor when certain users enter a room. Also, the solution supports that an agent is able to observe the actions of the user and recommend chat rooms or specific conversations in chat rooms based on its understanding of the user. The agent operates and makes decisions on a user profile which is updated dynamically and which indicates the interests of the user. The agent is also able to communicate with other agents in order to make the most useful recommendations to its user. The framework includes an overall architecture of the involved agents and sketches for the interaction between the agents and the users.

The paper is organized as follows: Chapter two presents the background of the solution with a focus on the Internet, virtual communities, and software agents. Chapter 3 presents the framework of the agent solution. Chapter 4 discusses the solution with respect to other developed agent systems for the Internet, and finally chapter 5 summarizes the work.

2. Background

Software agents or autonomous agents are being used and applied in many different contexts. Software agents have been hailed as the next major computing paradigm and that by the year 2000 software agents would be pervasive in every market [6]. In addition, Jennings and Wooldridge mention that autonomous agents are found in nearly every type of today's computer-based applications including industrial applications, commercial applications, medical applications and within entertainment [8]. On the threshold on the next millennium, software agents help people find and retrieve useful information from large and anti-transparent data sources, software agents help and guide people operate complex machines and technologies, and people interact and co-operate with autonomous agents in computer-based games, cf. [8]. On the Internet software agents are also being applied mainly to support identification, retrieval, and filtering of information, but are also used for entertainment and edutainment.

2.1 The Internet and Communities

Virtual worlds or virtual communities can be considered worlds, places, room, or spaces in which people meet and communicate with other people often sharing the same interests. Rheingold defines virtual communities as *social aggregations that emerge from the [Internet] when enough people carry on those public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace* [15]. He continues to define virtual communities as *a group of people who may or may not meet one another face to face, and who exchange words and ideas through the mediation of computer bulletin boards and networks*. Hence, a virtual community is often associ-

ated with the Internet and serves to bring people together in a non-physical environment. Valtersson makes an explicit distinction between virtual communities developed in existing organisations and virtual communities formed by people sharing the same interest [20]. The latter form of a virtual community is often built upon active attitudes to the community and on voluntarily members in contrast to the community developed in organisations. In this paper we will not use this distinction but merely focus on virtual communities as a whole.

The increasing number of virtual communities can be explained by the diffusion of the Internet. The Internet has become a technology which supports many needs and activities of people one of them being communication. People meet through virtual communities on the Internet and discuss through e.g. chat rooms and discussion groups. A virtual community or Internet community is first a social entity in which a number of people relate to one another by the use of a specific technology, cf. [16]. In this case the technology is the Internet. Opposed to the traditional society in which closeness or organizational belonging, virtual, often evokes communities or Internet communities are not a part of the real world. The discussion of virtual communities often leads to philosophical distinctions and is difficult to define. In this paper, we will rely on a definition from [16] stating that virtual communities are social communities made possible by the existence of the Internet. Chat rooms are one of the means for people to communicate and meet in Internet communities. In addition, chat rooms are becoming more serious [17]. Corporations have begun to provide chat rooms on their websites, giving the conversations a new spin and often attracting a different type of audience. Most contemporary chat rooms are simply text based where people communicate through words and sentences. No additional features of communicating are offered mainly due to problems with performance. In this paper, we will use the term virtual community as a virtual space spanned around one specific chat room.

A number of interaction problems exist when looking at virtual communities. First, it is likely that users have difficulties in locating and finding a proper virtual community addressing their current needs and purposes. In this sense, users will have to make a big effort in finding the communities and chat rooms and hence, they will probably experience many needless interactions on diverse web pages. Second, having found the right virtual community users face challenges in observing flows of conversations in various chat rooms. This in hand implies more interaction of each user and being present at all times in more chat rooms is simply impossible. With respect to interaction, virtual communities pose a number of potential problems on users, which have to be addressed and solved in order to make the communities successful and useful.

2.2 The Internet and Software Agents

Autonomous agents or software agents are widely recognised for their potential abilities to solve many of the problems associated with the Internet of retrieving and filtering information, cf. [9, 19]. Software agents have already been applied in various settings for identifying, filtering, and retrieving relevant information for Internet users, cf. [1, 9, 18, 19]. Some even argue that the introduction of autonomous agents may lead to a completely different kind of interaction with computers where you view the system as a personal assistant rather than a tool, cf. [2, 12, 13]. Application of software agents holds many promising advantages and opportunities, however the development and application of software agents is, however, still in its early years and is yet not an established field leaving plenty of room for further research and development.

Most software agents on the Internet are built to find, filter, and retrieve information for users based on user profiles. A number of different Internet agent solutions have been proposed. Thomas and Fischer introduce a framework called Basar that integrates agents into the use of world-wide-web [19]. Basar provides users to create and use agents for locating, relocating, and filtering information based on usage profiles. Lieberman presents an autonomous interface agent called Letizia that helps user in browsing the Internet [9]. Letizia observes the actions of the user and makes dynamically and real-time recommendations for web pages based on a profile of the user.

Most software agent solutions build upon active use of profiles, cf. [3]. A profile in an agent-based application is typically used to reflect basic interests and activities of users. The agent uses the information contained in the profile to operate in order to achieve its goals and intentions. The goals and intentions of a user agent are typically defined as identifying and retrieving interesting information for the user. Green, Cunningham, and Somers present an agent mediated collaborative web page-filtering system [3]. The system integrates a personal agent that updates the strength of each element with a user profile based upon feedback given on the items. Another agent-system, Letizia, compiles a profile of the user's interests by recording the URLs chosen by the user and then reads the pages. A simple key-word frequency is used to analyse the pages [9]. Finally, Basar integrates user profiles to model the preferences, interests, and tasks of a user. This is done both explicit by asking the user and implicit by observing the user, cf. [19].

The literature comprises only few articles on software agents in virtual community or in chat rooms. Hattori et. al. outline a multiagent system called CommunityOrganizer for supporting network communities [4]. CommunityOrganizer is an agent solution able to visualize potential communities around the user. Further they have identified three major issues in the support of Internet communities namely bringing people together, supporting smooth communication, and finding relationships between people.

3. FRAMEWORK: CHATAGENT

The problems identified by [4] have partially formed the design of our agent solution. On the remainder of this paper we will refer to this design solution as ChatAgent. The overall goal of ChatAgent is to enhance the usefulness of Internet community chat rooms and the three issues have been used as guidelines for the actual design and implementation process.

3.1 Setting

Multiagent systems are often complex by nature due to multitude numbers of connections between agents and the internal structure and behavior of each agent, cf. [7]. It is not a trivial task to delegate operations and behavior between more agents in a systems and even more difficult to handle at runtime. Our architecture tries to illustrate connections and communication between agents and users and outlines the roles and behavior of each agent in the community. Also, interaction design issues are presented. Interaction with software agents may require new interaction patterns different from the ones known today. This is partly a result of that you view the system as a personal assistant rather than a tool, cf. [2, 5, 12, 13]. Lieberman suggests that users at any time should be able to ignore any recommendation from the agent in order avoiding overload in the interaction [9]. Finally, the appli-

cation and use of user profiles will be described. As discussed in the previous section most software agents behave and act upon active use of user profiles.

This is also the case for the ChatAgent where user profiles are used to indicate the basic subject interests of users. The design of ChatAgent has been done in close collaboration between the author of this paper and a Danish software house specialized in developing Internet applications and search engines. The design process was carried out through 1999. The author of this paper acted as initiating designers in the project, but the design solution was created in close collaboration between the author and four people from the company. The design of ChatAgent was an attempt to test the applicability of software agents on the Internet. ChatAgent monitors user conversations and other user activities in the chat room and observes or communicates with users of the web site and based on that it makes recommendations to the user. The overall purpose of ChatAgent is to support users in bringing them together with other users that share the same interests and identifying interesting flows of discussions or conversations in Internet community chat rooms.

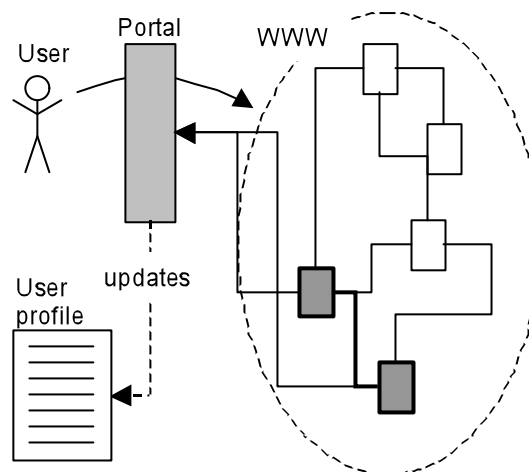


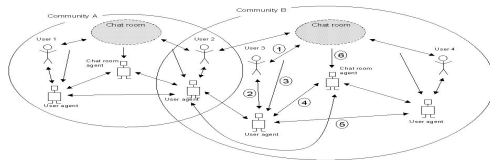
Figure 1. The surrounding web portal of ChatAgent

The agent solution is designed to be a part of larger web information system located on a portal that includes a search engine and other web facilities. The web information system provides the agent solution user profiles of users using the system. The user profile contains entries on various subjects on information about user preferences. Due to the key role of these profiles in our agent solution, we will start by outlining the semantics of the portal and these profiles. As shown in figure 1, the user interacts with and navigates web pages on the Internet (or an intranet) by the use of the portal (this is illustrated by the arrow from the user to the WWW). The portal acts like a search engine in this matter and the user can navigate to web sites identified by the search engine. Each referred web page is associated a profile defining the content of the web page. E.g. a web page containing information on the opera house in Sydney may have a corresponding profile containing entries like Sydney, Australia, opera, art, music, theater etc. Each time a user navigates to a web page, the profile of that web page affects the user's profile on the given entries. In the example with the opera house, when a user visits this web page his or her profile will be updated on entries like Sydney, Australia, opera, art, music, theater etc. Each entry in the profile is associated a value between zero and one

where zero indicates no interest in the subject and one indicates full interest in the subject. At runtime for any user, most entries would normally be zero or just above zero. The application of profiles in the agent solution is further illustrated in section 3.3.

3.2 Architecture and Interaction

We have proposed an overall architecture for the agent-based community chat room system, ChatAgent (as illustrated in figure 2). The architecture has during the design process been used to organize and design the internal and external characteristics of each agent. In addition, the architecture has been a valuable tool for visualizing the communication and interaction between user and agents at runtime. In this paper the architecture will serve as a tool for explaining the structure and behavior of the entire system.



At run-time a web portal could consist of one or more communities as illustrated in the figure by communities A and B. In each community a number of users operates and interacts using the different means made available by the portal. E.g. users can apply the integrated search engine to find web pages or they can communicate through e-mails services with other users. Each user in the community is allocated their own personal agent. Users may or may not be aware of their "affiliation" with the community and in this sense; the community is mainly a tool for organizing the agents in the system. In addition, a chat room agent is dedicated to monitor and control the activities in the chat room of each community. Figure 2 illustrates two communities. Community A consists of two users (User 1 and User 2) each associated with their own personal agent. Also, a chat room agent monitors the activities of the chat room. The user agents of the two users in the community communicate with each other and the chat room agent for retrieving information on activities in the community and the chat room. User 2 is also a part of community B. His agent is able to communicate with other user agents in this community and the chat room agent. In both communities, users are able to visit the chat room for interaction with other users of the community or just for observing the conversations taking place in the chat room. As illustrated by the figure Community B contains two other users (User 3 and User 4). The following table 1 describes the semantics of the labeled arrows in figure 2.

Figure 2. The overall architecture of ChatAgent picturing interaction and communication issues

Table 1. Communication, interaction, and observation issues in ChatAgent

#	Actors	Class
1	Users	Observation Interaction
2	User, User Agent	Interaction
3	User Agent	Observation
4	User Agent, Chat Room Agent	Communication
5	User Agents	Communication
6	Chat Room Agent	Observation

The figure consists of six different kinds of arrows with different kinds of semantics. As indicated in the table we differentiate between the kind of communication between users and agents and between agents and agents. The communication between users and agents is defined as interaction while communication is used for agent to agent. In addition, both users and agents observe the conversations and activities of the chat rooms. The six items in the table are 1) the user observes or communicates with other community members in the chat room. The user may only observe conversations in the chat room or observe which users enter and leave the room, or the user can communicate actively with other community members by addressing them individually or by addressing them all, 2) the user can communicate with her personal agent through the user interface. The agent can continuously and dynamically present recommendations to the user and the user may inform/program the agent by evaluating recommendations, 3) the agent observes the actions of the user and thereby gaining an understanding of the interests and preferences of the user. E.g. the agent could observe when the user enters and leaves the chat room, which other community members the user are chatting with, categorize conversations. In addition, the agent is able to observe the user's interaction with the portal as whole, 4) the user agent and the chat room agent can communicate. This communication may be initiated by either party, e.g. the user agent requests to know which users are currently in the chat room, 5) the user agent may also contact other user agents to gain a richer understanding of the other user, or to initiate communication between the two users, and finally 6) the chat room agent monitors the activities in the chat room. This include monitoring users enter and leave the room, the discussions taken place in the chat room.

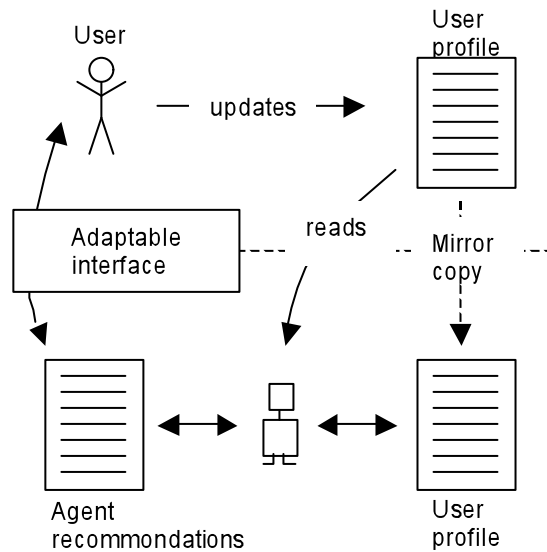


Figure 3. Illustration of the interaction between the user and the agent and the use of profiles

The users interact with their agents through a dedicated field in the portal. This is illustrated by the adaptable interface in figure 3. The user can modify the interface according to their preferences, e.g. the number of recommendations shown. Usually this field will present and list a partial selection of the recommendations from the user agent. In addition, these recommendations are normally listed in prioritized sequence where the ones the agent has assessed the highest importance are listed at the top of the list. The interaction has been designed so that users are able to ignore any recommendation made by the agent. When a user chooses to ignore a recommendation, this recommendation will eventually be removed by the agent from the list, but the ignore "action" will still be evaluated by the agent. Users are also able to discard or remove any recommendation from the agent. The agent will interpret this as no interest in the subjects contained in the recommendation. This in hand will lead to update of the user profile on the respective entries. Finally, the user is able to instruct the agent to perform a specific task, e.g. monitor when certain users enter a chat room or monitor when certain subjects are discussed in a chat room.

3.3 Profiles

Any agent solution is built upon extensive use of user profiles and hence the profiles make the agent able to adapt to user preferences, cf. [5]. In this sense, profiles serve as key elements in making a useful and successful agent solution. In this respect, ChatAgent is no exception.

The profiles in ChatAgent primarily define and describe the actions and interests of the user and hence indirectly instruct the behaviors and actions of the agent. The user agent is able to observe the user by accessing the user profile at any time, as pictured in figure 3. Thereby making the agent able to identify basic interests of the user and making the agent able to identify significant changes in the profile. The user agent is not able to delete or update any fields in the user profile, but instead the agent holds a local mirror profile of user in order to identify changes between

local profile and the user profile. The identification of significant changes is important to the agent since it indicates a shift of focus or preferences of the user and hence it may initiate actions from the agent to identify communities on these changes. The user agent will adjust to user behavior meaning that if users continuously change profile significantly, the agent will automatically increase the limit to which it operates and make recommendations.

The chat room agent holds two profiles of the chat room. Both these profiles have the same structure and content as the user profiles. The first profile is a long-term profile defining the basic interests of users who enters the chat room. Over a long period of time this profile will be stable and not subject to major changes. The other profile is a short-term profile defining the profiles of the users active in the chat room right now. This profile is more often changed and is not so stable and may at certain times be very different from the long-term profile. Both profiles are updated when users enter or leave the chat room.

The user agent can at any time request a chat room agent for the short-term or long-term profiles and then perform a match between the profiles of the chat room and the profile of the user. An algorithm performs this matchmaking where the most significant subjects in both profiles are matched. This algorithm will not be presented further in this paper mainly due to its complexity.

4. DISCUSSION

Our agent solution was designed in attempt to utilize and verify the concepts of agents on the web. As discussed earlier, the introduction of the web and virtual communities on the web has provided people with an opportunity to meet new people, communicate with them through a number of technologies, e.g. email and chat rooms. However, a number of related problems are introduced mainly due to the complexity of the web. Also, software agents have been introduced to solve a number of problems primarily related identification and retrieval of information, cf. [11]. However, a number of discussion on the agent concept has been carried out, cf. [1, 8, 9], illustrating difficulties in identifying a common widely accepted definition on the term of what constitutes an agent. We will try to discuss these relevant issues in the context of our agent solution.

Virtual communities introduce a number of potential problems related interactions as already discussed in section 2.1. Our agent solution tries to address this issue by attempting to reduce to overall interaction with web pages. Lieberman also addresses this issue for autonomous interface agents, cf. [9]. He identifies six design principles such agents. We will discuss two of these in the context of interaction.

First, *autonomous interface agents should suggest rather than act on behalf of the user*. Also, autonomous interface agents work best in environments where there decisions are not critical. The ChatAgent only make suggestions to the user and the type of suggestions and the environment must be considered no critical. The user can ignore the recommendations from the agent at any time and is still able to communicate with the chat room/other users and the rest of the web site regardless the interaction with the agent. No interaction with the agent or negative response to the recommendations of the agent will, however, influence the behavior and acting of the agent since its perception of the user changes both on positive, negative, and on no response. Ljungberg and Sørensen have coined the term interaction overload [10]. We have explicitly tried to avoid this problem in the design of ChatAgent. The control of the interaction is always with the user, the agent is not allowed to take control and force the user to interact with the agent.

Second, designers should *take advantage of the information the user gives the agent for free*. The actions taken by the user in the user interface constitute valuable information that the agent can use to infer the goals and interests of the user [9]. The ChatAgent also monitors the actions taken by the user. First, the actions related to the use of chat rooms are monitored directly and registered for later use. Second, more profiles are generated when the user interacts with the web site and these profiles are actively used by the user agent to infer the basic interests of the user.

Defining the concept of an agent has raised many discussions between researchers within the agent community. The multitude number of views of agents can partly be explained by the large number of different kinds of researchers within the field [1]. Some argue for a strict definition on the agent term while others recommend more pragmatic definitions, cf. [1, 9]. The lack of a unified definition leads often to the fact that certain software systems are referred to as agents while others totally disagree [8]. One of the more accepted definitions on the term is that an agent should be autonomous, responsive, proactive, and social [14].

Our ChatAgent can be considered a multiagent system consisting of more agents of the same type and also more than one type of agents. Both the user agent and the chat room agent can be considered autonomous. The user agent is able to act without direct interventions of humans. The user agent makes recommendations for current or past conversations in the chat room and alerts the user when certain other users enter the chat room etc. The user has only indirect control of the user agent, the user influences the user agent by the actions in the community and the actions in the chat room and by evaluating recommendations from the agent. The user is not able to alter internal states of the agent directly. The chat room agent is also autonomous. It interacts only with other agents and has no direct interaction with humans. At all times it monitors the chat room and defines the activities and conversations of the chat room. Second, the ChatAgent can also be considered responsive. When certain activities or conversations take place in the chat room the user has to be notified within a relative short period of time, e.g. when certain users enter the room. However, since no aspects of the system or the environment can be considered critical, the responsiveness aspect has not received the same attention as the other three aspects. Third, the ChatAgent can most definitely be considered proactive. It suggests or recommends various aspects of activities related to the chat room. These recommendation are not initiated by input from the user, but are continuously suggested by the user agent based on the agents understanding of the user. Fourth, the last criterion is that the agent should be social. The ChatAgent interacts with both a user and other agents in order to make the best recommendations. The agent can communicate with the chat room agent to receive information about activities in the chat room, but it is also able to contact other user agents for information. Based on the four criteria for agents, we consider the ChatAgent an agent.

5. CONCLUSION

Software agents have proven useful and powerful in many computer-based environments. At least many researchers and practitioners hold high expectations for future agent-based systems. The application of software agents seems to be very promising with respect to enhance the usefulness of the Internet by identifying, filtering, and retrieving information on the behalf of the users. A number of proposals for agent-based applications for the Internet have already been designed and evaluated, but the fully utilization of software agents on the Internet have not been explored. Agents can be especially useful in environments where changes occur

frequent and where streaming of information is provided. This is the case in chat rooms where users engage in conversations on various topics and where it is impossible to follow and understand all conversations at all times. This makes it a challenge for most users to identify and locate interesting flows of conversations.

We have tried to contribute to the research and development within agent-based systems on the Internet by our design of ChatAgent. This agent solution tries to enhance the usefulness of virtual communities and chat rooms by monitoring conversations in chat rooms and making recommendations to users.

Three potential problems or issues for virtual communities have been identified (as raised in the introduction). Our agent solution was partly designed and built to address and solve these problems. First, how can people be linked with others and with communities that share the same interests? ChatAgent able to identify chat rooms with similar profiles as the user and thereby relate and link people together. Second, how to give support for visualizing and sharing common contexts, as well as identifying the flow of conversations or discussions? The agent is able to follow and save conversations in chat rooms when the user is not present in the chat room or when the user is not fully concentrated. In addition, the definition of subjects makes the distinction between chat rooms more explicit and clear. Third and finally, how to identify the objectives and roles of communities and individuals? The user agent is able to match profiles of the user with profiles of other users in the community. As indicated in the table the first issue of bringing people together is solved by having users in the same community and by recommending them to visit chat rooms where they will find other user sharing the same interests. Matching the profiles of users does this. Second, most users are in shorter or longer time away from the Internet making it difficult or impossible to identify past and current conversations. ChatAgent addresses this by having your personal agent monitoring the activities and conversations even when you are away. Third, agents in ChatAgent can contact other agents and communicate with them in order to find other users and communities, which match the profile of the user and with profiles of chat rooms.

Still plenty of further research can be conducted within this field. One obvious and straightforward further progression would to improve the abilities and skills of the user agents and chat room's agents. Here you could focus on letting the agent have a more precise image of the user not only based on subject interests. An interesting and quite difficult extension to ChatAgent would be that users could be borrow agents from other users e.g. when entering a new community. This agent could then guide the user in this community making it easier to orientate and navigate. The idea of borrowing (or renting) an agent is quite attractive since you would be able to avoid that your agent has to "learn" everything from scratch. Another idea could that agents could learn from each other based on the profiles of their users.

Streaming of various sorts of information may increase dramatically over the years to come due to advances in network technologies. The need for agents capable of handling streaming will probably increase as well since the amount of available information will continue to grow and the use context will move from a stationary work place to a total mobile environment where users can access any kind of information and where information will be streamed continuously. The need for software agents to support people will certainly increase as well.

6. ACKNOWLEDGEMENTS

The research behind this article has been financed the Danish Research Councils' joint Multimedia Programme No. 9600869. I would like to thank people at Mind-Pass A/S, Denmark for a fruitful collaboration in particular I would like to thank Niels Jakob B. Buch and Michael Poulsen. Finally, I would like to thank Lars Qvortrup, Erik Granum, Peter Bøgh Andersen, and a number of anonymous reviewers for valuable comments to earlier versions of the paper.

7. REFERENCES

- [1] Bradshaw, J. M. Introduction. In Bradshaw, J. M. (Ed.) *Software Agents*. AAAI Press, Menlo Park, California, pp. 3 – 46, 1997
- [2] Erickson, T. Designing Agents as if People Mattered. In Bradshaw, J. M. (Ed.) *Software Agents*. AAAI Press, Menlo Park, California, pp. 79 – 96, 1997
- [3] Green, S., Cunningham, P., and Somers, F. Agent Mediated Collaborative Web Page Filtering. In proceedings of *Second International Workshop on Cooperative Information Agents*, Lecture Notes in Artificial Intelligence, Springer-Verlag, pp. 195 – 205, 1998
- [4] Hattori, F., Ohguro, T., Yokoo, M., Matsubara, S., and Yoshida, S. Socialware: Multi-agent Systems for Supporting Network Communities. In *Communications of the ACM*, March, vol. 42, no. 3, pp. 55 – 61, 1999
- [5] Huhns, M. N. and Singh, M. P. Personal Assistants. *IEEE Internet Computing*, September – October, 1998
- [6] Janca, P. C. *Pragmatic Application of Information Agents*. BIS Strategic Report, 1995
- [7] Jennings, N. R., Sycara, K., and Wooldridge, M. J. A Roadmap of Agent Research and Development. In *Autonomous Agents and Multi-Agent Systems*. Kluwer Academic Publishers, Boston, pp. 7 – 38, 1998
- [8] Jennings, N. R. and Wooldridge, M. J. Applications of Intelligent Agents. In Jennings, N.R. and Wooldridge, M.J. (Eds.) *Agent Technology - Foundations, Applications, and Markets*. Springer-Verlag, Berlin, pp. 3 – 28, 1998
- [9] Lieberman, H. Autonomous Interface Agents. In *Proceedings of the Conference on Computer-Human Interaction '97*, March, Atlanta, USA, 1997
- [10] Ljungberg, F. and Sørensen, C. Overload: From transaction to interaction. Planet Internet, (ed. K. Braa, C. Sørensen and B. Dahlbom). Studentlitteratur, Lund, Sweden, 2000
- [11] Maes, P. Agents that Reduce Work and Information Overload. *Communications of the ACM*, 37 (7), pp. 31-40, 1994
- [12] Negroponte, N. Agents: From Direct Manipulation to Delegation. In Bradshaw, J. M. (Ed.) *Software Agents*. AAAI Press, Menlo Park, California, pp. 57 – 66, 1997
- [13] Norman, D. A. How Might People Interact with Agents. In Bradshaw, J. M. (Ed.) *Software Agents*. AAAI Press, Menlo Park, California, pp. 49 – 55, 1997
- [14] Nwana, H.S. and Ndumu, D.T. A Brief Introduction to Software Agent Technology. In Jennings, N.R. and Wooldridge, M.J. (Eds.) *Agent Technology - Foundations, Applications, and Markets*. Springer-Verlag, Berlin, pp. 29 – 47, 1998
- [15] Rheingold, H. *Virtual Communities*. Secker & Warburg, London, 1993

- [16] Stolterman, E., Ågren, A., and Croon, P. O. *Virtual Communities - why and how are they studied*. Working paper, 1997
- [17] Strout, A. Finally, Cyberchat Start to Get Serious. In *Fortune International*, November, 11, pp. 122-123
- [18] Theilmann W. and Rothermel. Domain Experts for Information Retrieval in the World Wide Web. In *Proceedings of 2nd International Workshop on Cooperative Information Agents*, Paris, July 4-7, pp. 216-227, 1998
- [19] Thomas, C. G. and Fischer G. Using Agents to Improve the Usability and Usefulness of the World Wide Web. In *Proceedings of the 5th International Conference on User Modeling*, Kailua-Kona, pp. 1-12, 1996
- [20] Valtersson, M. *Virtual Communities*. Master Thesis Paper. Umeå University, Sweden, 1996