Agents, Brokers, Traders, and Services in Cooperative Systems

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ABSTRACT

As the amount of information and communication increases dramatically new working environments must provide efficient mechanisms to maximize the benefits of these developments. In this paper a telecooperation environment based on agent technology is proposed, which can be used as an information and collaboration infrastructure for virtual enterprises and other cooperative environments. The availability of such an infrastructure is vital for cooperative processes.

Collaboration, communication and information services increase rapidly in number and complexity. Therefore mediating components between users and services are required. In the framework described in this paper it is suggested to deploy a personalized agent cluster for each user and network wide directory, broker, and trading services.

The agent cluster acts as a surrogate and digital representation of the user in the system. The cluster provides the functionality of a personal assistant that resides in the network. To achieve this each cluster consists of a variable set of personalized software agents that are aggregated according to the requirements of the user. As an example the communication agent as one part of an agent cluster is described in detail.

KEYWORDS

Telecooperation, Software Agents, Internet, Middleware, Computer Supported Cooperative Work.

1. INTRODUCTION

In the age of proliferating information and communication systems, information is becoming a vital production factor. Nearly all private and business processes rely more and more on the timely deliverance of information and data. Without intensive communication and cooperation these processes are hardly manageable. To accomplish this task an effective information, communication and collaboration environment is crucial.

As the amount of information delivered to our homes or offices is becoming larger, the time we spend on reprocessing, filtering, and structuring this information is dramatically increasing. The goal is to extract the useful and relevant information out of the available data in a cost and time effective manner.

Due to the vast amount of information available new paradigms for the interaction between the information, communication and collaboration system and the user have to be employed. The system should be proactive and trigger the interaction with the user when necessary.

The media choice is traditionally made by the sender and not by the receiving side. In ordinary group processes the person that receives information has no straightforward way of influencing the choice of media and is therefore not able to make an optimal selection of the communication media according to his needs.

Ideally all communication has a synchronous character. Delayed deliverance of messages should not be the result of the underlying transportation system but should be on purpose and adjusted to the users needs. The user wants to receive data not always as fast as possible contrarily he wants to be informed at that point in time that is best suited to help him solving his tasks (Maes 1997).

In this context synchronicity means, that messages are delivered to a user's surrogate as fast as possible. If the user is not ready to receive the information, the surrogate will hold messages back for him.
Addressing the above-mentioned problems we present in this paper a telecooperation framework utilizing software agents for personal communication and information in collaborative processes and environments. These agents residing in the network act as intelligent, personalized and synchronously accessible surrogates of a real person. The agents optimize the communication and information process both of the individual person and the overall work process. Agents being specialized for different tasks form an agent cluster to represent their user in his various communication and collaboration tasks.

2. SYSTEM ARCHITECTURE

The system architecture of the telecooperation framework comprises three layers: the agent layer, the directory, broker and trader layer, and the service layer. Before focussing on the agent layer in the following sections, we briefly describe the information exchange and coordination between the other two layers and the agent layer (figure 1). The agents offer a homogeneous user interface and support the work between different users. They can contact external service components from the service layer to use their additional specialized functionality like teleconference scheduling, workflow management or team setup. In the Internet there are already numerous sophisticated services available (e.g. the flight database START) which offer highly complex and efficient services that the lean agents are not able to implement. Nevertheless the agents shall be the gateway to such services. As the main part of functionality resides inside the service components, the agent-side complexity can be lower and less task specific.

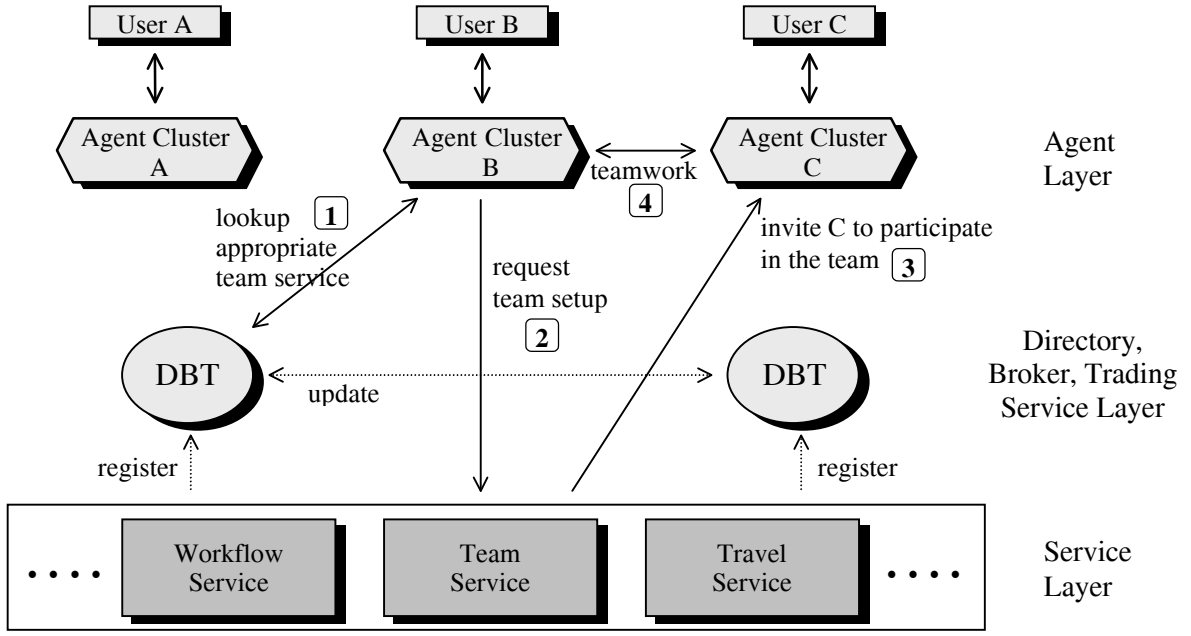

Figure 1: System Architecture

Inside the service layer all task specific knowledge is concentrated. Services such as teleconferencing, workflow management, meeting and scheduling services, electronic marketplaces or team management can be offered in the network. The service layer is designed flexible and open to integrate additional services at any time.
The directory service is used to deliver static information on service components, and location and addresses of agents, brokers and traders. The deployment of broker and trading services in a telecooperation environment as shown by Höck et al. (1997) is used here. The broker and trading functionality together with the above mentioned directory service serves as the location, negotiation

and binding foundation of the presented telecooperation environment. Figure 1 also shows, how agent clusters find desired services by using this directory, broker and trader layer. Here, a team management service is used to set up a collaboration team.

3. AGENT CLUSTER

To implement an optimal participation of each user in the cooperative process the agent paradigm is deployed. An agent cluster represents each user in the system. This surrogate acts somehow as a personal assistant for the user. In the cluster a variable set of agents is aggregated (figure 2).

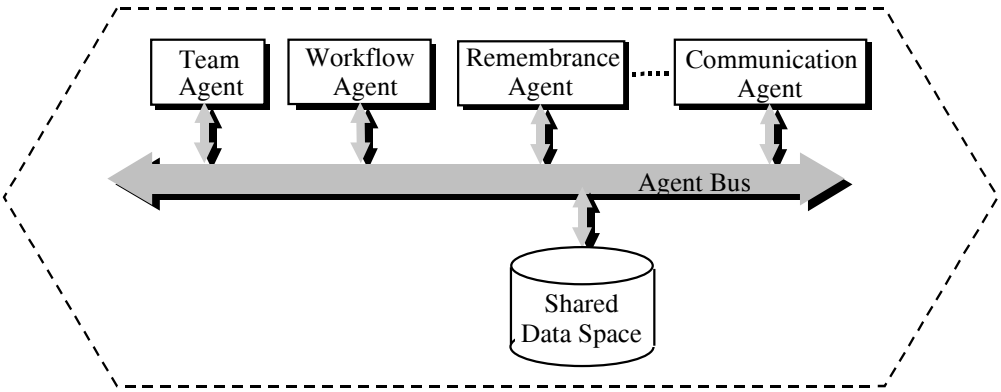

Figure 2: Agent Cluster

Each agent performs one type of tasks. E.g. the team agent (TA) is used to form dynamic groups of people working together. The workflow agent (WA) coordinates the interaction with other participants within a workflow as well as with the workflow service itself. The remembrance agent (RA) is an intelligent and proactive notebook to remind the user (Rhodes, 1996). A communication agent (CA) handles all communication on behalf of the user. Further agents may be added to the cluster.
All agents in a cluster have the following characteristics in common. These features are of major importance to gain an improved productivity by using agents.

- Personalization
  The agents of a cluster are personalized to the needs of the user. They have a certain knowledge about the preferences of their user, such as *she does not like meetings before 11am*, *he can not stand video conferences*, or *she prefers travelling by train*. A personalized agent gives users the feeling that the agent is intelligent and caring.
- Ability to learn about the user
  To improve personalization and adaptation, it is necessary that the agent can learn the likes and dislikes of the users by monitoring their behavior.
- Synchronicity
  Due to the fact that the agent cluster is always active on behalf of the user and residing within the network, synchronous communication between separate agent clusters is always possible, even if the corresponding user is not online. The sender of a message will always perceive communication in a synchronous and acknowledged manner.
- Authentication
  The user and the agent cluster authenticate themselves by employing strong authentication protocols like SKIP or SKEY (Schneier, 1996) in order to provide a trustworthy relationship. This is an important issue because the user is legally responsible for the transactions of his agent cluster, e.g. in Internet business and electronic commerce scenarios.
- Intra-cluster agent communication
  A peer-to-peer communication model is utilized inside a cluster, as there is no hierarchical relation between the agents and unrestricted communication is needed for providing high performance. Thus an agent bus is connecting the components inside the cluster (figure 2). This asynchronous

event bus is implemented using the CORBA EventChannel mechanisms (Schmidt, 1997), (Siegel, 1996).

- Inter-cluster agent communication
  Agents must have the ability to communicate with the agents in other clusters to perform communication and collaboration tasks. As a general communication protocol the knowledge query and manipulation language, KQML (Finin, 1993), is suggested for this purpose. This communication uses the same mechanisms as the intra-cluster communication and is also based on CORBA EventChannels. A dedicated cluster interface agent (CIA) handles all the intra-cluster communication as a gateway.

4. AGENT ARCHITECTURE

Using a cluster of agents the complexity of each single agent is reduced and its functionality can be kept strictly task specific. The architecture allows each user to compose his own set of agents forming an agent cluster.
One agent, very likely present in each cluster, is the communication agent. Efficient communication is a crucial aspect of distributed cooperative work. This agent handles the communication with the user and implements a front-end, e.g. within a standard web-browser, or using paging devices, or cellular phones. The following features are of major importance to the communication agent.

- Choice of media
  In the proposed architecture the freedom to choose the communication medium is given to the sender as well as to the receiver. This has the advantage that the user can always take the most appropriate way to communicate according to his situation. Media conversion will occur in order to provide the user with information according to his current working situation and also according to his physical connection and location (figure 3).

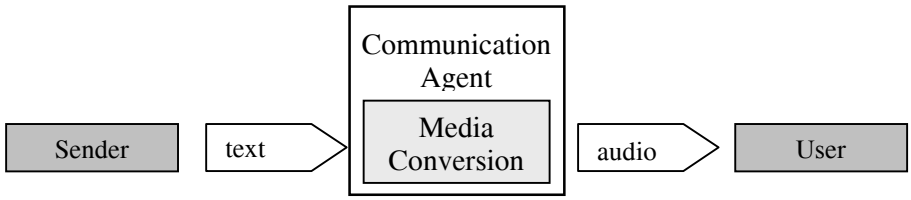

Figure 3: Media Conversion

- Active agent
  The agents are active components. The interaction between agents and user can be triggered by the agent as well as by the user. Due to the fact that the communication agent has knowledge of the whereabouts of the user (through intra-cluster communication), it can always keep the user informed about urgent and important messages, e.g. using a paging device or cellular phone. Media conversion is used to convert messages to the appropriate format.
- Freshness of messages
  To reduce the information load on the user a *best before* date is introduced into all messages. Messages can be discarded by the system after this date has expired.
- Ownership of messages
  Messages are owned either by the sender or by the receiver; they are never owned by the transport system. The system provides two general ways to send messages. In the traditional way the whole message is transmitted to the receiver who owns the message after sending. The second possibility is to send only a link to the message. In this case the message is still owned by the sender and can be modified or revoked till the receiver finally fetches the message.

5. CONCLUSION

The described system supports the work of users by adaptive system functionality through the use of a triple layered service and agent infrastructure. Agent clusters act as surrogates and digital representations of their users inside the network. They enable a sender to synchronously communicate and negotiate with the user even when that user is not online or available. A reduction of communication and information load and the perception of synchronous communication is achieved by analyzing, extracting and optimizing the data flow in accordance with the situation and environment the user is in.
Users can access different services in a uniform way by employing their personal agents to interact with other agents or services. Brokers and traders are used to locate and access services and agents in a heterogeneous environment. Due to this architecture agent-side complexity can be fairly low. Dynamic changes of services and users, such as new access protocols, changing locations, and adding of functionality are transparent.

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Résumé

Face à l'augmentation dramatique de l'information et de la communication, des nouveaux environnements de travail doivent mettre à disposition des mécanismes efficaces pour optimiser les bénéfices de ces développements. Le papier propose un environnement de télécoopération qui part du principe de la technologie des agents et qui peut être utilisé comme infrastructure d'information et de collaboration pour des entreprises virtuelles et autres environnements coopératifs. La disponibilité d'une telle infrastructure est vitale pour des processus coopératifs.
Des services de collaboration, de communication et d'information augmentent rapidement en nombre et en complexité. Pour cette raison, des éléments intermédiaires entre les utilisateurs et les services sont nécessaires. La structure qui est définie dans ce papier propose d'utiliser un groupement d'agents personnalisés pour chaque utilisateur, annuaire commun au réseau, courtier et services négociants.
Le groupement d'agents remplace l'utilisateur et fonctionne comme sa représentation digitale dans le système. Le groupement offre la fonctionnalité d'un assistant personnel qui existe dans le réseau. Pour réaliser cela, chaque groupement se compose d'un ensemble variable d'agents logiciels personnalisés qui sont réunis selon les besoins des utilisateurs. Un agent de communication faisant partie d'un groupement d'agents est décrit en détail en exemple.

Mots clés

Télécoopération, Agents logiciels, Internet, Middleware, Travail coopératif assisté par ordinateur.