HIJ © *The Journal on Information Technology in Healthcare* 2004; **2**(2): 119–133

TeleCARE Time Bank: A Virtual Community for Elderly Care Supported by Mobile Agents

Octavio Castolo, Filipa Ferrada, Luis Camarinha-Matos

New University of Lisbon/Uninova, 2829-516 Monte Caparica, Portugal.

ABSTRACT

The virtual community concept when supported by adequate information and communications technology (ICT) and organisational infrastructures, represents a very promising approach for a new philosophy in elderly care and active aging. A mobile agents-based approach to implementing services to support a Time Bank virtual community in elderly care is described and a prototype system developed in the context of the TeleCARE project is presented.

INTRODUCTION

Participation in a community is an important aspect of life for most people. In fact most humans have a natural affinity for living in communities. The structural process that is associated with community building is communication. Without communication there can be no action to organise social relations[1]. Today's fast emerging information and communication technologies have stimulated the creation of virtual communities through use of the Internet.

Virtual communities have been defined as "*social aggregations that emerge from the Net when people carry on public discussions long enough, with sufficient human feeling to form webs of personal relationships*"[2]. A virtual community is also seen as "*a community of people sharing interests, ideas, and feelings over the Internet*"[3]. Virtual communities can also be regarded as distributed online services connecting a group of people that gather to keep in touch, focused on some common interest or purpose[4].

An important application context for virtual communities is elderly care. Traditional approaches to care provision are based on support from either relatives, or elderly care centres. However, these two solutions have become increasingly insufficient for the following reasons:

Correspondence and reprint requests: Professor Luis M. Camarinha-Matos, New University of Lisbon/Uninova, 2829-516 Monte Caparica, Portugal. E-mail: cam@uninova.pt.

- Shifting the burden of responsibility onto relatives is increasingly impractical, because most family members work to maintain a good standard of living.
- Provision of sufficient care centres is costly and invariably necessitates the relocation of the elderly people, often beyond their home communities.
- Many elderly people preserve enough robustness to be in their homes, a situation that is often preferable to them, and as such better for their welfare.

Due to the rapid growth of the elderly population, finding more effective ways of providing care to the growing number of elderly people will become a major challenge.

In this context, the IST TeleCARE project was launched with the aim of designing and developing a configurable framework, based on mobile agents, that would focus on the establishment of virtual communities for elderly support[5]. The underlying principle is that an integrated elderly care system consists of a number of organisations such as care centres/day centres, healthcare institutions, social security institutions, and involves the cooperation of a number of different humans e.g. social care assistants, healthcare professionals, elderly people and their relatives. When supported by computer networks and adequate supporting tools, the collaboration among the care institutions may evolve towards operating as a long-term virtual organisation and the various people involved become part of a virtual community (VC). In this paper the TeleCARE Time Bank virtual community concept is presented and the supporting infrastructure discussed.

THE TIME BANK CONCEPT

The **Time Bank** concept provides a mechanism for collaborative community building, i.e. a way for people to come together and help each other. The idea is quite simple: people 'deposit' time they are willing to contribute to the community by giving practical help and support; in exchange they are able to 'withdraw' their time when they need something done for themselves by other community members. One key principle here is that one hour is equal for everybody. One hour of gardening is equal to an hour of legal advice or an hour of baby-sitting or any other service. Thus, time banks create reciprocal relationships between people and institutions, as well as between people. Services that can be exchanged are diverse, e.g. child care, computing, plumbing, cooking, first aid classes, tutoring, gardening, companionship, hairdressing, office help, house cleaning, translating, etc.

The bank is an organisation that takes care of registering members and implementing some bookkeeping mechanisms. Most of the existing cases run in a *quasi ad-hoc* manner, usually associated with city halls or charity organisations, and mainly resort to telephone and some complementary 'get together' meetings. These 'institutions' also require administrators or brokers that act as the driving forces (catalysts) of the community.

The Time Bank idea was conceived in the mid-80s by Edgar Cahn who set up the Time Dollar movement in the United States[6]. The following principles formulated by Cahn are the fundamental basis for the Time Bank[7]:

- **Assets:** the real wealth of our society is its people.
- **Redefining work:** to include all those things that support healthy individuals and communities and the work that is not currently valued in the market economy.
- **Reciprocity**: we need each other.
- **Social capital**: humans need social networks as much as they need roads and utility lines.

The main goals for Time Banks are[8]:

- To promote people participating actively in their daily lives.
- To offer opportunities to give and receive services.
- To act as instruments of mutual aid based on interchanges of time.

The TeleCARE Time Bank aims to apply this concept to the elderly care domain by providing adequate information communication technology (ICT) support tools to facilitate the establishment and operation of such communities. The aim is to provide elderly people with a way to feel useful in society by giving them an opportunity to share their skills and experiences with others. At the same time, it enables elderly people to fill their days and to integrate into a community to obtain better support for their own needs.

In fact, the current paradigm of aging as a 'dependent' stage of life does not match either current realities for elderly people or likely scenarios for the 21st century. Aging is less and less synonymous with dependency, because not all elderly people suffer from chronic illnesses, and even persons with chronic conditions and functional limitations retain other significant capabilities[9].

The active aging concept reflects the desire and ability of many elderly people to remain engaged in economically and socially productive activities. Active aging means more than simply encouraging paid employment among elderly people. Societies should foster socially important activities such as volunteering, household and child-care help, care-giving to the disabled elderly, and support for social service organisations, as envisaged in the Time Bank concept.

There are not many tools for supporting Time Bank activities reported in the literature. One tool described is Timekeeper[10] which provides simple administrative services for Time Banks based on Microsoft Access 97. However, it only supports administration for Time Bank members' accounts. It does not provide support for virtual communities, as the concept is understood in the literature.

THE TELECARE TIME BANK

The TeleCARE Time Bank is one of the vertical (application) services that run on top of the TeleCARE platform (Figure 1). This platform provides an infrastruc-

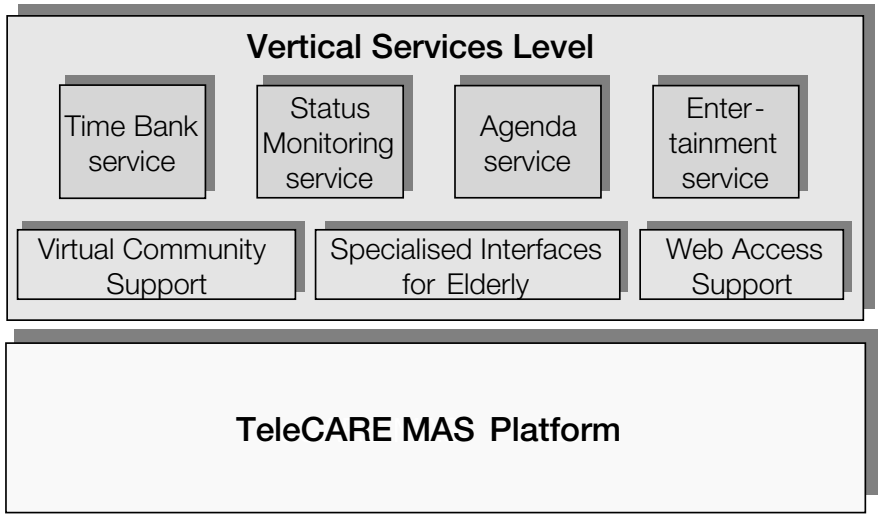

Figure 1. *The TeleCARE architecture*

ture for the implementation of distributed Internet-based systems in elderly care[11]. The infrastructure is based on multi-agent technology (mobile and stationary agents), federated information management, and safe communications (virtual private network). The TeleCARE multi-agent system (MAS) platform is installed at each site (elderly persons' homes, care centres, etc.) creating a flexible infrastructure that supports the idea of plug-and-play vertical services which can be progressively added to the system.

The TeleCARE Time Bank service supports the following macro-functionalities:

- Creating and managing the Time Bank virtual community.
- Performing the matching process between a service required by a member and the potential provider members that could accomplish it.
- Supporting the negotiation process between members.
- Providing member account management including account statements.

The Time Bank is managed by a Coordinator/Administrator who is in charge of the members' accounts, promotes active participation of members and assists in finding the best provider for a requested service. Participants in the TeleCARE Time Bank virtual community include: (*i*) elderly people, (*ii*) their relatives and (*iii*) a care centre (that performs the coordination role). A Unified Modeling Language (UML) use case diagram of the main activities of the participants in the TeleCARE Time Bank is depicted in Figure 2.

Typically, a transaction between members in a time bank includes the following main phases: service request, service performance and confirmation of a service accomplishment. In the TeleCARE Time Bank this process can be further detailed in the following steps:

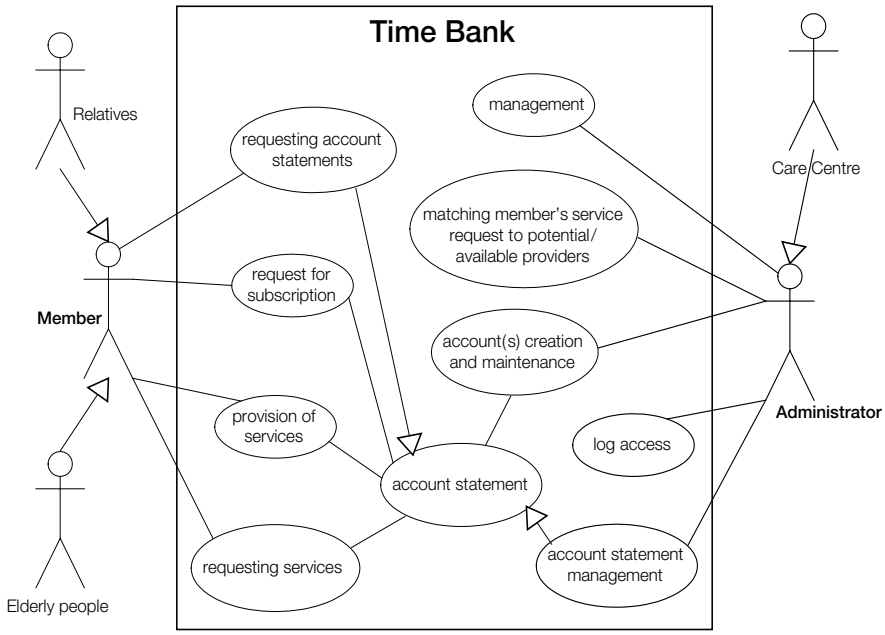

Figure 2. *Unified Modeling Language (UML) use case diagram of participants' activities of the TeleCARE Time Bank service*

A. Request a service:
   a) A member, the Requester, needs a service.
   b) The Requester contacts the Time Bank agency (Administrator) to request the service.
   c) The Administrator matches the requested service with the available potential provider member(s) and sends a list of the potential Providers to the Requester.
   d) The Requester selects one of the potential Provider(s).
   e) The Administrator contacts the selected potential Provider.
   f) The potential Provider receives the service requirement.
   g) The potential Provider confirms acceptance or refusal to provide the service.
   h) Once the Provider agrees to provide the requested service, the Administrator confirms service acceptance to the Requester.
   i) If necessary, Requester and Provider interact directly to negotiate terms and conditions for service accomplishment.

B. The service is performed.

C. Service accomplishment:
   a) The Requester issues a cheque to the Provider corresponding to the service, indicating how much time (in hours) the task took to accomplish.

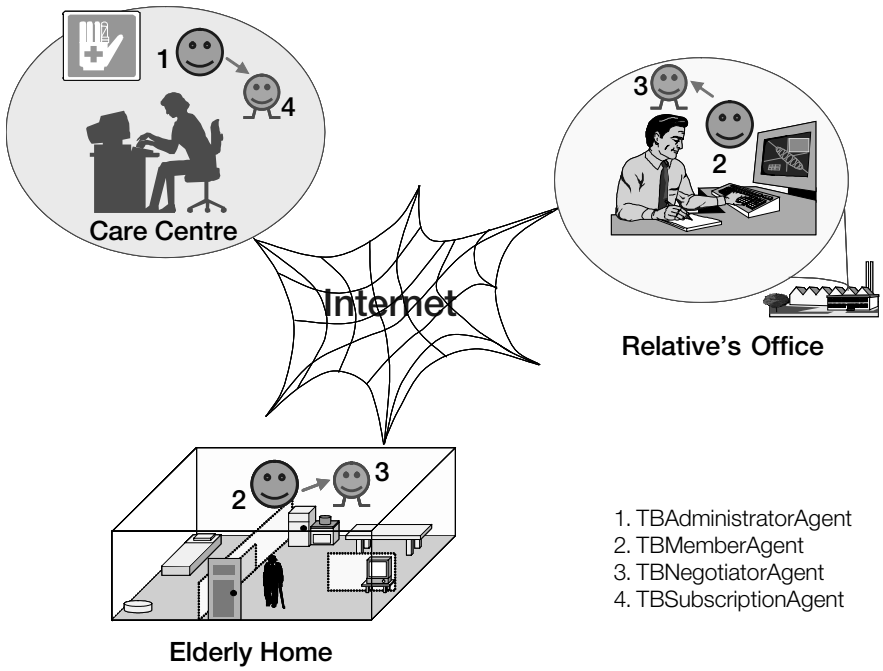

Figure 3. *The TeleCARE Time Bank MAS architecture*

b) The cheque is 'deposited' in the Time Bank agency.
c) The Administrator registers the transaction, updating the account statement of both Requester and Provider members.

In order to support this process, a number of mobile and stationary TeleCARE agents[11] are associated to Time Bank participants, as illustrated in Figure 3. These agents run in the different TeleCARE platforms installed at every site of the Time Bank participants.

The **TBAdministratorAgent** is a stationary agent located at the Care Centre and supports the following tasks:

– Time Bank creation
– Member subscription/cancellation facilities
– Creation of an agent to assist with the subscription process
– Updating members' credit account
– Issuing members' account statements
– Accepting service requests
– Matching a service request to potential providers
– Assisting with selection of adequate providers
– Issuing log files
– Interfacing with the human Time Bank administrator
– Generating the service's accomplished key/application form

The **TBMemberAgent** is a stationary agent that represents the members (elderly persons and/or their relatives) of the Time Bank. It assists members in performing the following tasks:

- Requests for member subscription
- Filling out application forms for requesting services
- Creating an agent for negotiation process
- Filling out application forms for services accomplished
- Requesting member statement accounts
- Interfacing with other human Time Bank members

The **TBNegotiatorAgent** is an agent created by the TBMemberAgent in order to execute the negotiation process whenever a member requests a service. Each time a service is requested, a TBNegotiatorAgent is created. This is a mobile agent that has the following characteristics:

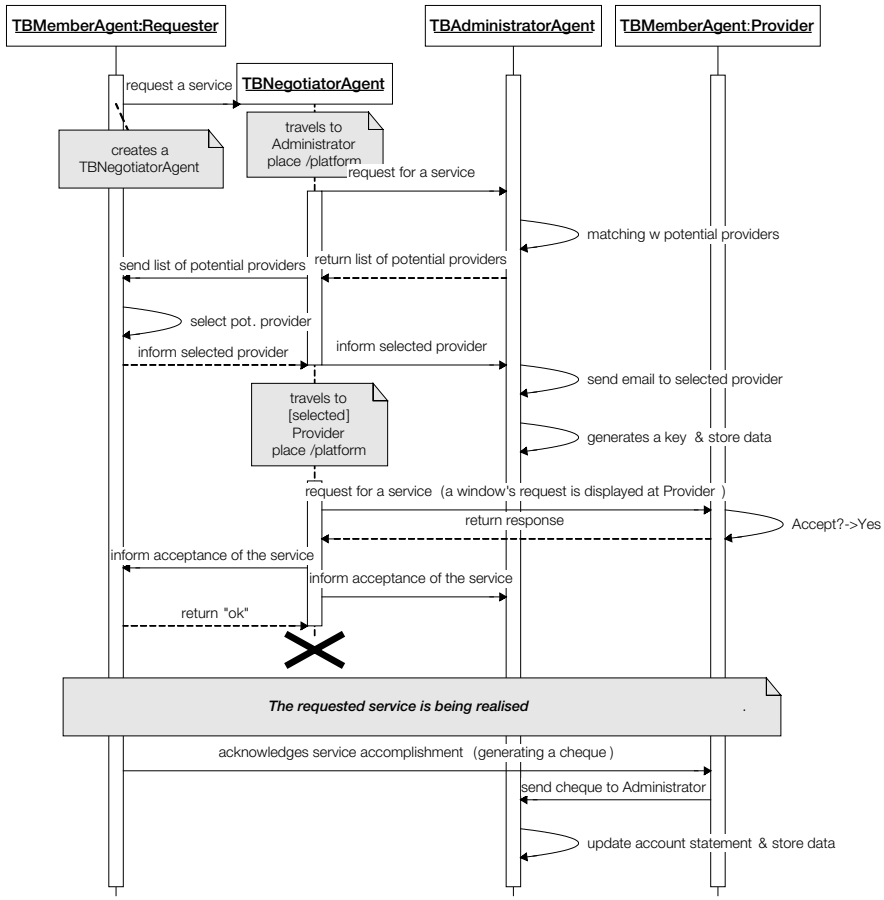

Figure 4. *A service transaction in the TeleCARE Time Bank*

– Capacity to migrate to other platforms (Administrator and potential provider Member(s) sites).
– Capacity for interaction with the agent TBAdministratorAgent at the Administrator's site, and the TBMemberAgent located at the potential providers' sites.

The **TBSubscriptionAgent** is a mobile agent created by the TBAdministratorAgent when a subscription process is solicited. It has the following features:

– Capacity to migrate to other platforms (Administrator and/or Member).
– Capacity to interact with the member who requests a subscription, when the subscription is requested from the member's location.
– Capacity to interact with the Time Bank administrator who realises the subscription of a member, when the subscription is requested from the Administrator's location.
– Fills out the application form for the Time Bank subscription.

It should be noted that a subscription can be requested remotely (from the potential member's home) or in the Care Centre.

The participants of the Time Bank interact either with the TBAdministratorAgent, in case of the Care Centre, or the TBMemberAgent, in the case of elderly people and/or their relatives, in order to realise the various tasks of the Time Bank activity. An AUML sequence diagram[12] is depicted in Figure 4 showing some of the Time Bank agents' activities in the process of requesting a service, and notification of service accomplishment.

Taxonomy of the Services

In order to facilitate the searching for a service and matching with the potential providers, a taxonomy of services is maintained (see Table 1). The initial taxonomy was defined based on information provided by GRAAL, a Portuguese nongovernmental organisation that promotes the Time Bank concept in Portugal.

The services to be offered by an operational Time Bank are specified according to the skills and needs of its members. Therefore, new categories and services can be defined (or removed) if necessary.

Time Bank Ontology

Ontologies play a key role in supporting proper interaction among the various components of this (geographically) distributed multi-agent system. The Time Bank ontologies are modelled using the Protégé[13] system and Java classes are automatically generated from these ontologies by the Dynamic Ontology-based data Structure Generator tool developed by a TeleCARE partner, the University of Amsterdam. The UML diagram of the Java classes and relations corresponding to the Administrator side ontology is shown in Figure 5.

Table 1. *The TeleCARE Time Bank services' taxonomy*

Category	Services
A. Baby-minding	A01 – Baby-sitting A02 – Taking children to school/looking after them A0*x* – …
B. Leisure	B01 – Bicycling (bicycle) B02 – Walking B0*x* – …
C. Housekeeping	C01 – Washing the car C02 – Washing dishes C0*x* – …
D. Animals and plants	D01 – Gardening D02 – Looking after animals or plants when person is away e.g. vacation D03 – Helping bathe animals (dogs, cats, etc.)
E. Bricolage (do-it-yourself)	E01 – Minor domestic repairs E02 – Carpentry E03 – Electrical repairs
F. Accompany (accompanying)	F01 – Accompanying to the doctor F02 – Talking F0*x* – Taking to Church
G. Cooking	G01 – Cooking a special meal G02 – Cooking food for freezing
H. Crafts	H01 – Seam adjustments H02 – Embroidering/embellishment H03 – Knitting
I. Lessons	I01 – Tutoring I02 – Language teaching I0*x* – …
J. Secretarial	J01 – Proofreading J02 – Word processing J0*x* – …
K. Time Bank collaboration	K01 – Supporting bureaucratic activities K02 – Helping at meetings

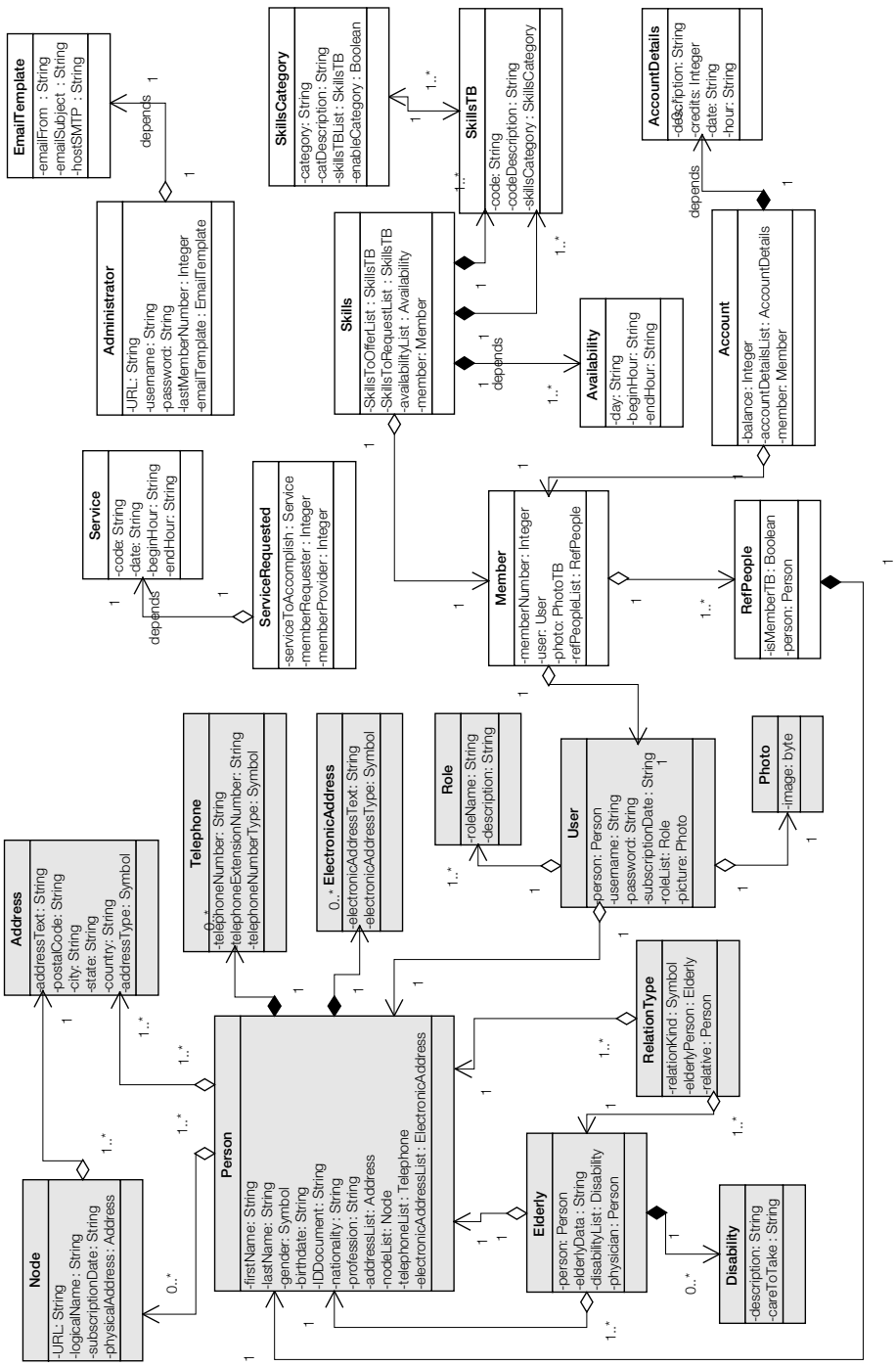

Figure 5. *The Administrator side ontology*

The left side of Figure 5 depicts the part of the ontology that is common to all vertical services running on the TeleCARE platform. The right hand side shows the Time Bank-specific structures for the Administrator side. Each member of the Time Bank (*Member*) is identified by his/her personal data that is held in the common ontology; and at Administrator ontology by his/her skills (*Skills*) and available time to realise services (*Availability*). There are also definitions of structures for member's account statement (*Account* and *AccountDetails*), services that are being realised and by whom (*ServiceRequested* and *Service*), and what services can be requested/offered (*SkillsCategory* and *SkillsTB*). The structure *Administrator* represents the Administrator entity, and the structure *EmailTemplate* is used for e-mail notifications of requested services. It is important to observe that it is mandatory for every Time Bank member to be a registered TeleCARE user. Each member must also provide the names of 1–3 people who act as referees (*RefPeople*).

In Figure 6 the Java classes and relationships corresponding to the Members' side are depicted. The heart of this ontology is the member definition at *TheMember*, *TBMember* and *PhotoM*. The structures *SkillsTBM* and *SkillsAvailable* indicate the services that can be requested. The structures *SkillM* and *AvailabilityM* contain data

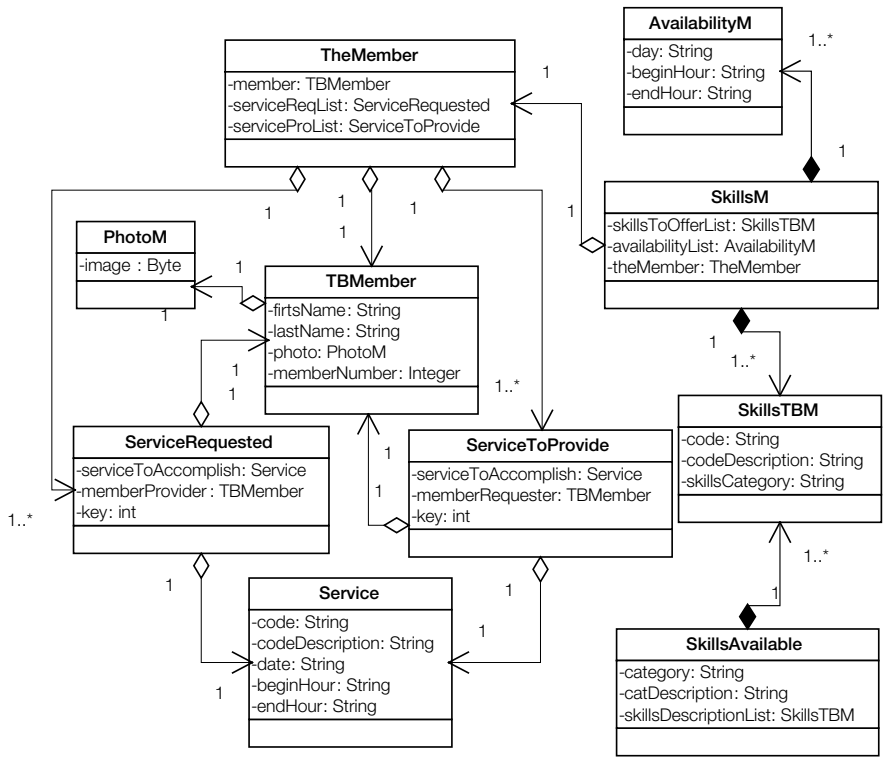

Figure 6. *The Member(s) side ontology*

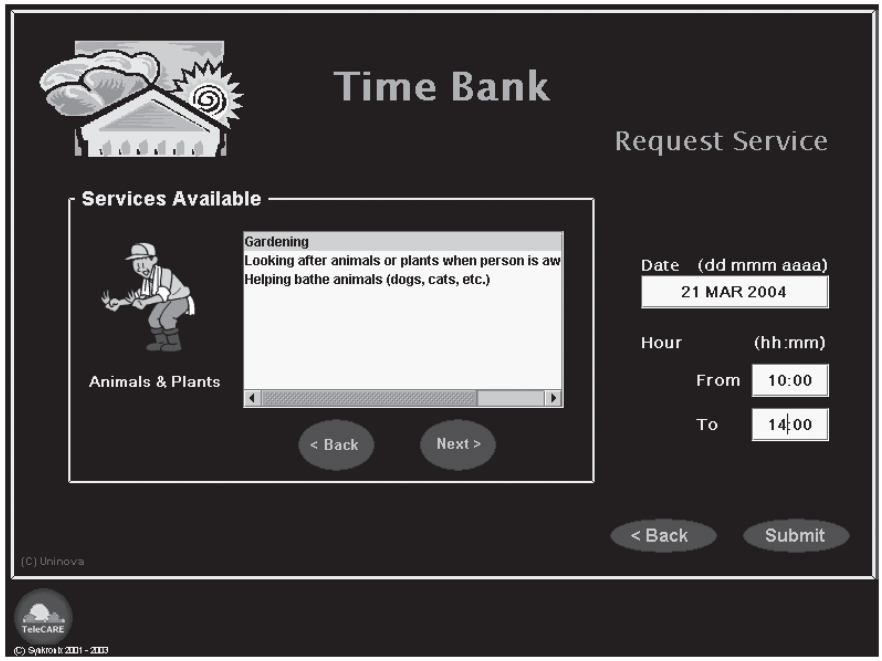

Figure 7. *Requesting a service*

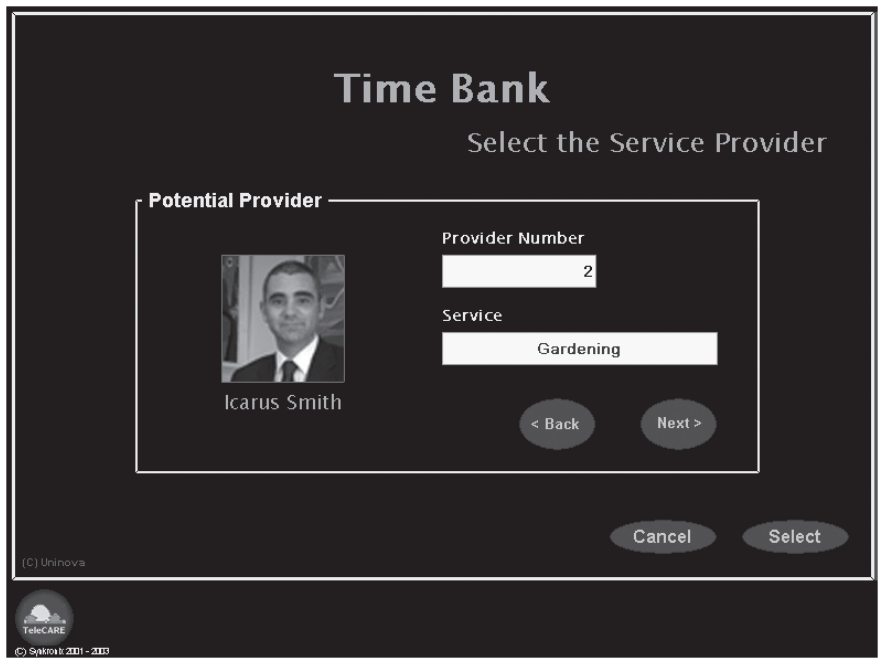

Figure 8. *Identifying a service provider*

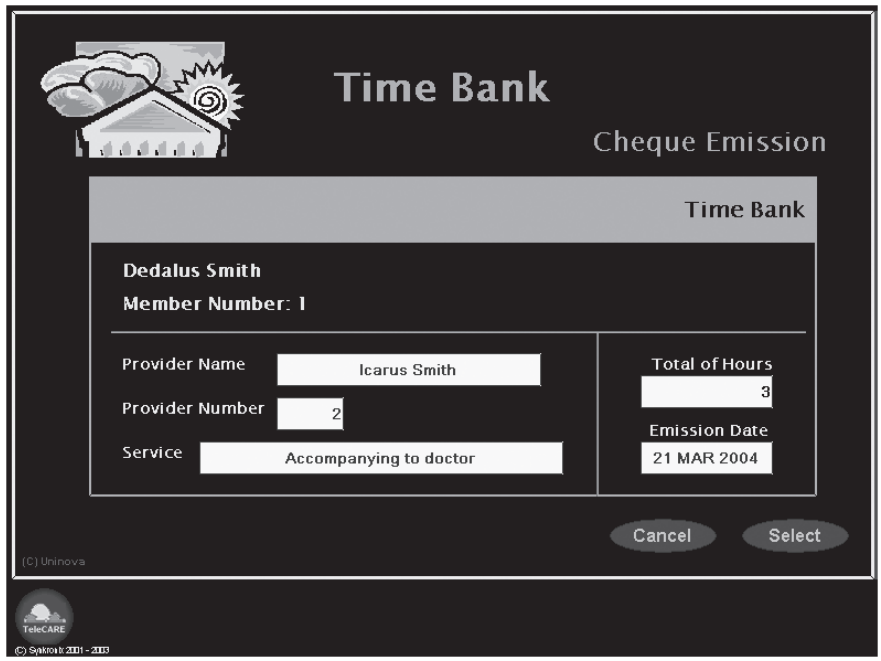

Figure 9. *Issuing a cheque after a service is accomplished*

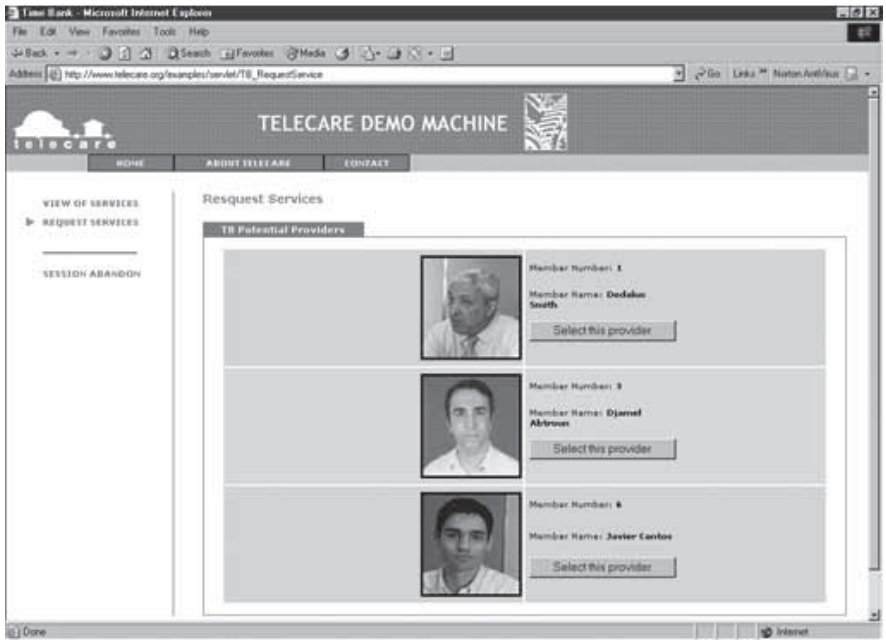

Figure 10. *Example of the Time Bank web interface: list of potential providers for a requested service*

of skills and availability time of the local member, respectively. Finally the structures *Service*, *ServiceRequested* and *ServiceToProvide* track the service accomplishment.

Implementation Aspects

The Time Bank service prototype was developed in Java, on top of the TeleCARE multi-agent platform[14] that extends AGLETS (a multi-agent software development system) and integrates a distributed/federated information management subsystem. In Figures 7, 8 and 9 some of the user interfaces of the developed system are illustrated.

The functionalities provided can be accessed both via the TeleCARE user interfaces (running in the multi-agent platform) or via a web browser. The latter need to use the component Web Access Support of the TeleCARE architecture (see Figure 1) developed by the TeleCARE partner Skill, Consejeros de Gestión. The web interface is shown in Figure 10.

For the implementation of this particular service other implementation approaches (not necessarily agent-based) could have been adopted. It was, however, felt to be preferable to take advantage of the functionalities provided by the TeleCARE platform. The goal was also to have this service integrated with other services provided to the elderly care community. Thinking in terms of future developments, the use of agents and the underlying TeleCARE platform will also facilitate the development of more intelligent matching and negotiation processes.

CONCLUSIONS

The Time Bank model seems particularly suitable to support the 'active aging' concept and represents a good example of a virtual community. It is now commonly accepted that while there is no simple solution to successfully living a long life in a healthy manner, the concepts of active aging and remaining active and engaged in society are critical components in maintaining quality of life. Actively engaged older persons are more likely to remain cognitively and physically stimulated, to nurture healthy interpersonal relationships and remain involved as contributing members of their societies. The integration of a Time Bank support service within an elderly care system thus seems a promising contribution to:

- Encourage the sense of 'being involved in/part of society' and being useful.
- Allowing elderly people to share and use their valuable experiences for the benefit of the community.
- Facilitate inter-generation interaction.

The mobile agents-based prototype system developed in the framework of the TeleCARE project illustrates a good set of functionalities to support such virtual communities. Nevertheless, it shall be noted that the actual success of field implementation of the system depends on further progress on the elderly user interfaces,

namely its integration with TV sets and other home appliances, as well as the creation of a new attitude towards elderly care by the various personnel and institutions involved in this domain.

ACKNOWLEDGEMENTS

This work was funded in part by the IST program of the European Commission. The authors thank the contribution of the TeleCARE consortium members.

REFERENCES

1 Fernback J, Thompson B. *Computer-mediated Communication and the American Collectivity: The Dimensions of Community within Cyberspace*. Albuquerque, New Mexico: International Communication Association, 1995.
2 Rheingold H. *The Virtual Community*. Boston: Addison-Wesley, 1993.
3 Whatis?com, part of the TeachTarget Network of Enterprises IT Web Site. http://whatis.techtarget.com/.
4 Afsarmanesh H, Guevara-Masís V, Hertzberger LO. Virtual community support in TeleCARE. *PRO-VE '03, 4th IFIP Working Conference on Virtual Enterprises*. Lugano, Switzerland, 2003: 211–20.
5 Camarinha-Matos LM, Afsarmanesh H. Design of a virtual community infrastructure for elderly care. *PRO-VE '02, 3rd IFIP Working Conference on Infrastructures for Virtual Enterprises*. Sesimbra, Portugal, 2002: 439–50.
6 Robinson J. The UK time bank movement. *Transnational Seminar of the Banco de Tempo*. Lisbon, Portugal, 2003.
7 Cahn E. *No More Throw-Away People: The Co-production Imperative*. Washington DC: Essential Books, 2000.
8 Méndez E. *Public Policies on Conciliation of Working and Family Life & Time Banks*. Transnational Seminar of the Banco de Tempo. Lisbon, Portugal, 2003.
9 U.S. Department of Health and Human Services. *Active Aging: A Shift in the Paradigm*. http://aspe.hhs.gov/daltcp/reports/actaging.htm.
10 Gordon K. *Timekeeper for Time Dollars*. http://www.timekeeper.org/timekeeper/.
11 Camarinha-Matos LM, Castolo O, and Rosas J. A Multi-agent based Platform for Virtual Communities in Elderly Care. *ETFA-2003, 9th IEEE International Conference on Emerging Technologies and Factory Automation*. Lisbon, Portugal, 2003.
12 Bauer B, Müller JP, and Odell J. Agent UML: a formalism for specifying multiagent interaction. In Ciancarini P, Wooldridge M (eds.), *Agent-Oriented Software Engineering*. Berlin: Springer-Verlag, 2001: 91–103.
13 Stanford Medical Informatics. *The Protégé Project*. http://protege.stanford.edu/.
14 Camarinha-Matos LM, Afsarmanesh H. A multi-agent based infrastructure to support virtual communities in elderly care. Accepted for publication in *International Journal of Networking and Virtual Organisations*, forthcoming.