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Virtual Communities and Elderly Support

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Abstract - This paper introduces the European IST project TeleCARE that aims to design and develop a configurable framework for virtual communities focused on supporting assistance to elderly people. The main innovative aspects introduced in the design of TeleCARE project and addressed in this paper features its tele-supervision and tele-assistance, based on the integration of multi-agent and federated information management approaches, introducing the concept of *federated agency*. Federated agencies comprise both stationary and mobile intelligent agents, combined with the services that are likely to be offered by the emerging ubiquitous computing and intelligent home appliances.

Keywords: Intelligent agents, Tele-healthcare, Remote sensing, Federated information management.

1 Introduction

There is an urgent need to develop new approaches for elderly care resorting to advanced information and communication technologies. Europe's ageing population is growing rapidly, as a considerable proportion of the total while, more significantly, the proportion of the working population who will generate the means to support the elderly is shrinking. This trend may lead to a prospect of spiralling growth in social security costs unless new ways and facilities for providing care are devised.

In fact [6] during the last three decades, the number of people aged from 60 years or more has risen about 50%. Today, more than 25% of Europe's population is aged 60 years or more and this trend will continue. Within 20 years approximately a third of Europe's population will be over 60 years old, a total in excess of 100 million citizens. The percentage of people over the age of 80 is growing even more rapidly: an increase of 300% has been forecasted for the period of 1960 to 2020. Moreover, the ratio between the working and elderly population is dramatically declining. In 1995 there were almost seven adults of working age per one elderly person (aged 65 or more), by 2025 the ratio is expected to decrease to close to four. These trends present a real challenge for European social policies in the years ahead and underline the importance of developing new and more cost-effective ways of and facilities providing care and support to the elderly.

Furthermore, as a group in society, the elderly face the real threat of marginalization and exclusion from the benefits of further European integration in general and indeed, the internal market in particular, if steps are not taken to provide them with the means to exercise their freedom of choice and independence.

Development of adequate Internet-based infrastructures may provide the base to facilitate the establishment of collaborative virtual communities involving the elderly, care provision organizations, and relatives of the elderly at a low cost. A number of technological enablers of such solution can be identified, including:

- Wide dissemination of Internet access.
- Recent developments in virtual organizations and computer supported collaboration tools.
- Advanced user interfaces.
- The emergence of the so-called ubiquitous or pervasive computing.

Nevertheless, the introduction of a new technology for the elderly care sector certainly requires the analysis of its socio-economic, ethical, and organizational impacts.

In this context, the recently launched IST TeleCARE project [7] aims at design and development of a configurable framework focused on virtual communities for elderly

support. The proposed solution has to be seen as complementary to other initiatives for the integration of elderly in the society and to reduce their isolation. The TeleCARE consortium involves research organizations, technology developers, socio-economic experts, and elderly support organizations from Portugal, Spain, UK, and Netherlands.

2 Technology trends

Major home appliance manufacturers are already announcing "Internet-enabled" systems. Networking technologies are starting to invade homes, not only to carry the conventional phone conversations signals and TV signals, but also the signals from surveillance cameras, commands for controlling lights and appliances, and multimedia information through the Internet. Various emerging technologies are competing in the sector of home networking, such as the wireless communications (e.g. Bluetooth or IEEE 802.11), use of power lines for also transporting the information, or the structured wiring for the new constructions / new residential areas [5].

Advances on mobile computing based on the new UMTS system and its integration with other technologies such as GPS, biometric identification systems, smart cards, etc. are also important contributors that will be considered for the development of the TeleCARE supporting infrastructure and services.

The spread of these facilities world-wide however is a clear visible tendency of the market, and therefore facilitating the implantation of TeleCARE, when its results reach the market. There is however some uncertainty today about which one of the competing market technologies will win at the end, and when exactly the required infrastructures become generically available.

Therefore, to a great extent, the TeleCARE results will be independent of the exact winning technologies, since the system is aimed at providing a highly flexible framework. Opneness is one of the main design goals for TeleCARE.

In the area of virtual organizations a large amount of research efforts have been devoted to the establishment of infrastructures supporting the necessary enterprises cooperation. Some R&D efforts are also spent on supporting the cooperation of temporary consortia of autonomous enterprises and organizations that decide to join resources and skills, in order to achieve a common goal or better respond to a business opportunity. In particular, in the case of industrial enterprises and manufacturing in specific, the field of virtual enterprises is being addressed by a large number of international projects [1], [2]. The results of these projects are being employed towards the design and developments in TeleCARE.

3 The TeleCARE approach

3.1 General aspects

Traditional approach to care provision has either resorted to support from the relatives, or from the elderly care centres. However, these two solutions have become increasingly inappropriate for the following reasons:

(i) Shifting the burden of responsibility onto relatives is increasingly impractical, given the fact that more and more family members have to work to secure steady incomes.

(ii) Provision of enough care centers is costly and invariably necessitates the relocation of the elderly people, often beyond their home communities.

(iii) Many elderly people preserve enough robustness to be in their homes, a situation, which is often preferable to them, and as such, better for their welfare.

Therefore, the objective of this project is to leverage the potential of information society technologies, in particular by resorting to the virtual organizations paradigm and both stationary and mobile intelligent agents, to improve the quality of life, and care, for elderly people and their families. Different classes of agents are designed to perform a large number of local and remote supervision tasks and intelligent assistance, such as sensorial data collection, alarm notification, agenda assistance, leisure activities assistance, health conditions monitoring, etc. [7]. Examples of sites and functionalities to be supported at the sites include (see Fig. 1):

(i) *"Home Sites":* To guarantee the security of elderly people living at home and help them in their daily chores (e.g. in the use of home appliances), and to provide necessary

information on their daily agenda, and access to leisure activities.

(ii) *"Care Center Sites":* To provide remote care services for helping/reminding elderly people at home and monitoring their activity from specialist care centers with regard to health conditions and individual medication programmes.

(iii) *"Family Monitoring Sites"(relative's office):* To provide relatives of the elderly people with the means for monitoring their condition and offering support and assistance through a remote " window", accessible from their place of work, thereby allowing relatives to remain an integral part of the care process.

(iv) *"Leisure Sites":* To provide the means ensuring that elderly people remain active, through the provision of access to leisure activities and facilitate contact between elderly people with similar areas of interest.

(v) *"Mobile Sites":* Taking advantage of the ubiquitous computing, personal assistant agents "travelling" on devices such as mobile phones, smart cards, etc. are considered.

(vi) *"Virtual shop":* Due to the reduced mobility of elderly people, specialized electronic commerce can be expected to develop in near future, allowing for an easy way for these people to choose and buy some goods.

A cooperative virtual organization involving such diverse nodes composes the framework for virtual care communities.

Within TeleCARE project, a new infrastructure supporting seamless interactions among stationary and mobile intelligent agents, with planning the error diagnosis and recovery capabilities, able to recognize and self-adapt to a diversity of environments, and to interoperate with federated information and services management environments, is being designed and developed. Intelligent interface agents resorting to multimedia services will be of invaluable importance to the project, since elderly people may present some physical and/or cultural limitations that frustrate their interaction with automatic devices such as computers, and home appliances.

The elderly care domain constitutes a highly distributed, heterogeneous and autonomous environment including both stationary and mobile intelligent agents, that requires: advanced functionalities in terms of co-operative problem solving (for user-assistance, remote operation, status monitoring, and error recovery), and advanced facilities that are expected to be offered in near future by the emerging ubiquitous computing, intelligent home appliances, and dedicated appliances to assist elderly people.

The most important requirements for this sector, in opinion of our end users, include the

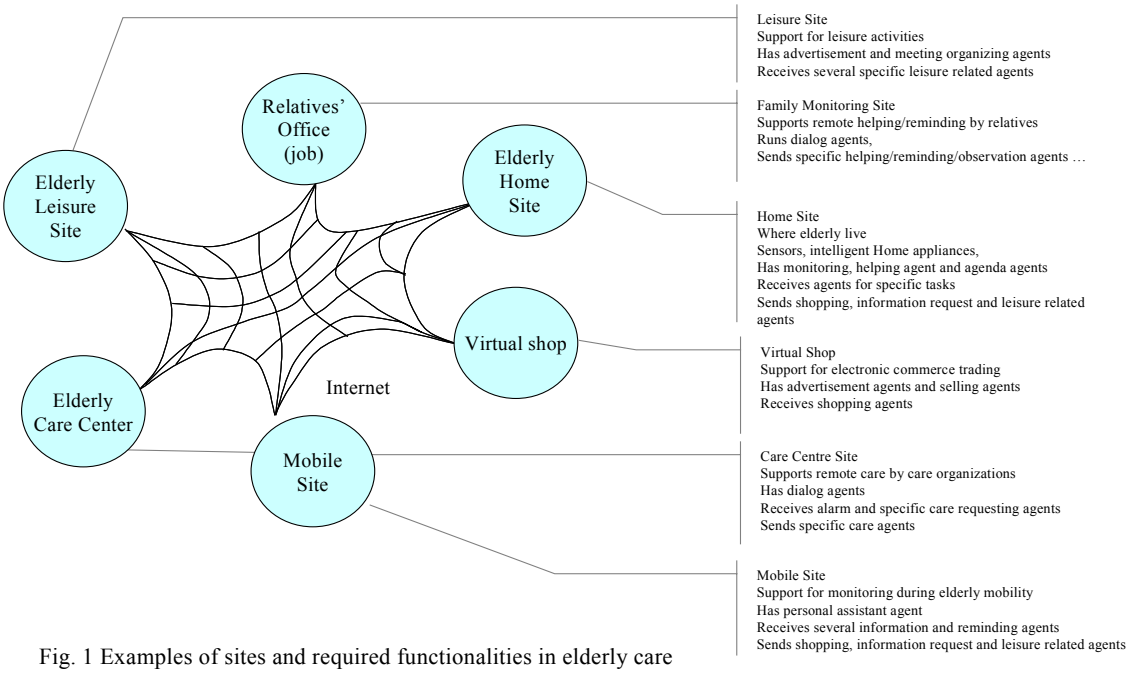

Fig. 1 Examples of sites and required functionalities in elderly care

following aspects:

– A high degree of security, privacy, and welfare considerations for the users (elderly people) is mandatory.
– An improvement of the costs, quality, and accessibility of the care services is necessary.
– The quality of life of the elderly users must be ensured by adequate support not only for professional health care, but also for their involvement on leisure and social activities.
– The privacy, ethical and socio-organizational issues must be considered when developing any such technical solutions.

3.2 Design perspectives

TeleCARE is therefore based on a distributed system built around a set of sites specialized for specific tasks. The general architecture of the sites comprise the following components:

1. **Support for mobility**. Adaptive mobile agents are used as the means to simultaneously achieve high levels of flexibility and independence on the characteristics of the network. All sites support the reception, execution, and launching of mobile agents.
2. **Stationary agents**. The sites present some specific needs that will not change over time, which are achieved by stationary agents.
3. **Coordination through tuple-spaces**. A crucial aspect in the system is inter-agent communication. In TeleCARE two types of inter-agent communications can be distinguished: i) intra-site communication where some agents executing in the same site communicate with each other, and ii) inter-site communication, where agents executing at different sites communicate with each other. Tuple-spaces (the LINDA model) are being tested for inter-site communication. Collaboration between agents with different home sites can be done if one agent is sent from one home site to the other. So a mobile agent sees two tuple spaces: the tuple-space of the site where it is executing and the tuple-space of the place where it originated.
4. **Interactive planning and simulation tools**. Building and deploying mobile agents is a crucial aspect. Since the agents have significant adaptive skills, one can imagine a library of pre-built agents that are selected and used (possibly with small adjustment) according to some application specific criteria. However, on one hand, these agents in the library have to be built, and on the other hand the user has to be confident that the chosen agent will fulfill his/her objectives. In order to achieve these objectives, a component will be developed at the sites to play the role of an interface to help the development, adjustment, deployment, simulation and monitoring of such agents.
5. **Knowledge processing capability**. In order to support the planning and error recovery mechanisms, the platforms includes rule-processing capabilities (JESS or similar).
6. **Federated database mechanisms**. To support federated / distributed database management, the platform also includes a federation layer that extends the functionalities of standard database management systems. On one hand, the usage of both emerging standards and Web tools (ODMG, XML) supporting the required interoperability criteria for TeleCARE is considered. On the other hand, innovative mechanisms and facilities will be developed to support the on line definition of both the syntax and semantics of "common meta-data" necessary to support the collaboration and information exchange / integration among heterogeneous and autonomous sites, with diverse goals and configurations. Proper settings of information visibility and access rights of different sites involved in the virtual community, also addressed through the federated information management layer.

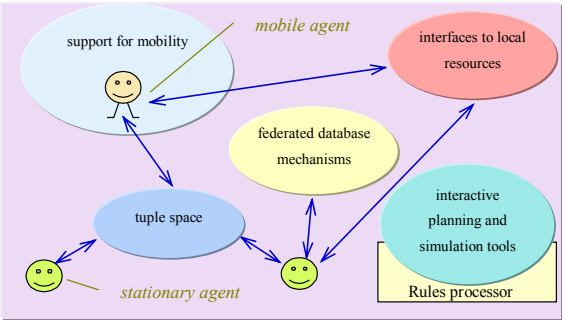

Fig. 2 General composition of the site platforms

The proposed virtual community infrastructure can benefit from the experiences and results gained earlier within the virtual enterprises area and in specific from two perspectives:

– Establishment of cooperation agreements among the various organizations and actors involved in the elderly care. Specific aspects to

be borrowed from the virtual enterprises area: definition of access rights to information / visibility rules, coordination policies, and safe communications.

– Support for the formation of virtual communities of elderly, complemented by low cost teleconferencing tools integrated with the multi-agent infrastructure.

3.3 Societal issues

Inclusion of technology in our lives is a difficult subject as there is always the potential risk of intrusion in our privacy. Therefore, in addition to the technological developments, TeleCARE project includes tasks to study and assess its social / organizational impacts, and economic issues, training needs, ethical aspects, etc.

The privacy rights of the elderly will be completely preserved by the federated information management approach in the sense that the proprietary and confidential information about elderly and the centers involved can only be accessed by authorized users and centers. Furthermore, special focus is given to the security of interactions. As such, safe communications is an important task in the project.

4 Preliminary results

A preliminary prototype focused on the adaptability of mobile agents to different environments (e.g. different home sites) was developed [3], [4]. While going through its itinerary a mobile agent has to face the heterogeneity of the environments it finds. Therefore, it is crucial that the agents have some mechanisms to cope with this heterogeneity. Also, mobile agents have to face uncertain environments that require high levels of autonomy. TeleCARE proposes the concept of adaptive mobile agents that carry high level hierarchical abstract plans enabling agents to adapt themselves to the characteristics of the local environments before execution. These high level abstract plans are annotated with monitoring and error recovery strategies that guide the agent when errors occur. The general architecture of the mobile agents is illustrated in Fig. 3.

There is an important distinction between the objectives of stationary agents and mobile agents. In fact, stationary agents will be used for those tasks that may only slightly change over the life of the site, while mobile agents will be used for those tasks that are not foreseen in advance, episodic tasks, and those tasks that have high rates of change possibilities over time. For instance, stationary agents will be used in monitoring activities which may require some sort of intelligent reasoning, agenda agents (e.g., agents to guarantee the fulfilment of a pre-defined medication program), local help agents (e.g., in a home site such an agent could use intelligent interfaces to provide help to the elderly person, when using a HIFI equipment), etc. Mobile agents will be used in activities such as specific monitoring of some health parameters motivated by some alarm condition, specific help, reminding or advice to the elderly person, and support for electronic trading.

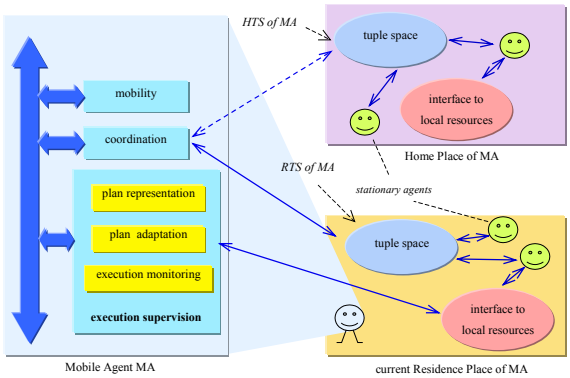

Fig. 3 General architecture of a mobile agent

An interesting concept investigated in this work is that the *data* may not be sent from one agent to the other via a high-level protocol, as in the traditional *push* strategy or via mobile carrier agents, but rather through the *pull* strategy via the access to the agent's federated information management system (FIMS) associated to each (stationary) agent [2]. The planned architecture offers both possibilities. In the case of a pull strategy, the high-level protocol is used for coordination purposes only. The message's content then becomes shorter and leaner and the agents have access to the necessary data only when needed.

Fig.4 illustrates this approach. Consider an example case where a given agent (B) processes some information and generates some results (for example r1) that is needed by another agent (A). Then B sends a message to A (represented by "1" in this Figure), communicating that certain

information (r1) is available in its local database (that can be accessed through its export schema). Please notice that the access rights for the shared data among the nodes is dynamically and bilaterally configured, according to the roles and the needs of every node and enforced through the agents' export schemas. This control message sent from B to A informs A that now this updated data item is available and can be accessed by A, through its own *import schema*. Once this message is received at A, (represented by "1"), whenever it wishes A can retrieve this updated information. Such an access goes as follows: Agent_A queries this information from its own integrated schema in FIMS-A (represented by "2") requesting r1; an automatic access will occur from FIMS_A to FIMS_B (represented by "3") using the federated mechanisms for information access – that receives and returns this authorized information from Node B (represented by "4"). This information is in turn returned to Agent_A for its internal processing (represented by "5").

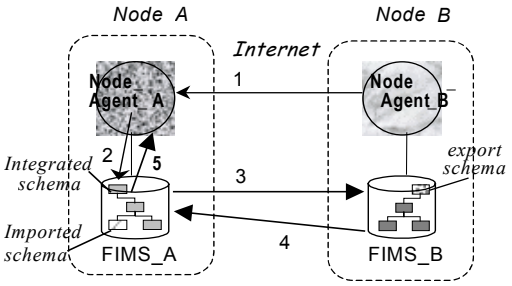

Fig. 4 Exchange of data in a *pull* strategy

The possibility of configuring, on a bilateral basis, the specific common syntax and semantics of the exchanged data, as well as the access rights to the data owned by agents for every other agent in the community, represents the important functionality addressed in TeleCARE. This functionality in turn supports the adequate levels of data integration and information exchange while preserving the autonomy required by each site in a virtual elderly community environment, which constitutes another advantage regarding the traditional MAS approaches.

Next developments are more focused on the virtual organization / virtual community facets, exploring the operating principles and needed functionality.

5 Conclusions

The convergence of a number of technologies such as multi-agent systems, federated information management, safe communications, hypermedia interfaces, rich sensorial environments, increased intelligence of home appliances, and collaborative virtual environments, represents an important enabling factor for the design and development of virtual elderly support community environments.

Although these technological factors open opportunities for new approaches to elderly care, as demonstrated by preliminary research results, this process has to be complemented by a careful analysis of the socio-economic impacts and ethical issues.

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