Proceedings of the 5th WSEAS Int. Conf. on APPLIED INFORMATICS and COMMUNICATIONS, Malta, September 15-17, 2005 (pp357-362)

New Computing Paradigms and Health Care Management: innovation, requirements and technology

K. VOTIS[1], B. VASSILIADIS[2], J. TSAKNAKIS[1], A. STEFANI[2], K. IOANNOU[4] L. DROSSOS[3]
[1]Dept. of Computer Engineering and Informatics, University of Patras
GREECE

[2]Computer Science, Hellenic Open University
GREECE
[3] Department of Applied Informatics in Management & Economy
Technical Education Institute of Messologi
GREECE
[4]Department of Electrical and Computer Engineering, University of Patras
GREECE

Abstract: - In order to improve health care services, administrations need to deploy a variety of channels for service delivery –channels that allow users to consume their services anytime, anywhere and anyhow. This work proposes a system architecture that benefits from new computing paradigms such as wireless and mobile technology for improving benefits to the parties involved in e-health management including patients, citizens, health institutions and related governmental health units. The proposed platform is based on the concept of socio-cognitive grids and the need of transformation of the existing internetworking and web technologies into a resource pool that will be accessible by anyone, at anytime, and from everywhere in support of their needs. This platform intends to create the essential infrastructure for the provisioning of health and social services to individuals that receive residential care using Peer-to-Peer (P2P) networks over Internet, GSM and PSTN networks.

Key-Words: - GRID, P2P, Intelligent Software Agents, Web Services, Health Services, Social Care.

1 Introduction

Nowadays, users expect advanced quality of service from the public sector: they want their interactions to be convenient, and they prefer to be online rather than in line. The challenge is to innovate and in particular to: "improve public services for the benefits of citizens: to be more convenient, more joined-up, more responsive and more personalized [1]. To meet this expectation, administrations need to deploy a variety of channels for their service delivery –channels that allow users to consume their services anytime, anywhere and anyhow. New developments in IT allow the public sector to meet these challenges by adapting their front and back office: new ways of interaction through a variety of channels, restructured services that accommodate their users' needs, and re-organized business processes within and between separate administrative bodies. The eEurope Action Plan 2005 refers to these developments as follows: "Multi-platforms must enable users to benefit from new technologies and infrastructure improvements such as broadband. Moreover, alternative access platforms will facilitate e-inclusion, also for people with special needs". The number of people having access to mobile phones and mobile internet connection is increasing rapidly. The mobile access - anywhere any time – is becoming a natural part of daily life, and the governments will have to

transform their activities according to this demand of convenience and efficiency of interactions for all parties.

The forces influencing the move from e-health to m-health activities include major changes in the technological infrastructure and the advances in mobile telecommunication services. The technological changes can be broadly described under three major trends: mobile device penetration; convergence of wired Internet and wireless telecommunication networks; and the move towards 3G services and higher data transfer rates. The services include personalisation, location based services and context aware applications.

In this work we discuss how innovative technologies, and especially new computing paradigms, influence a traditional service sector such then one of Health. We propose a platform which uses a implementation strategy that involves wireless and mobile technology, service oriented computing and remote devices. The aim is to cost-effectively use new technologies for improving benefits to the parties involved in e-health: patients, citizens, health institutions and all government health units. This platform intends to create the essential infrastructure for the provisioning of health and social services to individuals that receive residential care using Peer-to-Peer (P2P) networks over the Internet, GSM and PSTN networks [2]. This will allow real time communication with medical personal, assistance in emergency, form virtual communities, communication with family members and friends over the three most common networks, retrieval of personalized information and news. It has the potential to create an open information and communication platform that integrates the care givers, hospitals, care centers, home service personnel and relatives. Furthermore, to support this care chain to plan, provide, maintain and qualify for elderly and handicapped an individualised care meeting individual needs and integrating in an efficient way this process over the care chain.

Emerging computing paradigms such as Peer-to-Peer (P2P), open Source such as JXTA, Intelligent Agents for personalization and managerial functions, Wireless Broadband Networks, MMS messaging for mobiles are some of the implementation technologies.

The rest of this paper is as follows: sections 2 and 3 describe problem identification and the innovative aspects of the proposed solution respectively. Section 4 describes the technical framework and section 5 the conclusions and future work.

2 Problem Identification

The potential of implementing mobile and wireless technology in e-health is a clear need. But the following issues need to be addressed for broad implementation of m-health services, especially in Europe:

Infrastructure development: for m-health to flourish, the information technology infrastructure must be present. This infrastructure is both physical and 'soft'. The physical infrastructure refers to the technology, equipment, and network required for implementation of m-health. No less important are soft infrastructures such as institutional arrangements and software that make transactions possible.

Privacy and Security: they are the most significant concerns patients have about m-health. The public fears that personal data and mobile phone numbers will be traced, when they are using this kind of m-health services. The governmental organizations must overcome the mistrust, and assure mobile users that people's privacy is protected and the information will not be sold to third parties.

Accessibility: the success of mobile health services will depend on largely the number of its users. But socio-economic factors such as income, education level, gender, age, handicap, language differences and regional discrepancies will affect the citizens' attitude towards mobile health. The offered services are needed to be easy accessed and by using also alternative forms such as video and voice communications, SMS and MMS messages e.t.c. in order to increase users participation and provide citizen-oriented services.

Legal issues: the European countries have not yet adopted the Law of Fair Mobile Information Practices. In some cases the current legislative does not recognize mobile documents and transactions at all.

3 Innovation

Mobile and wireless technologies provide the potential to connect patients, individuals, elderly and disabled persons that receive residential care or elderly in remote locations not only with medical centers, and hospitals but their family and friends as well. This way the patient can receive on-demand medical assistance in the case of emergency or qualified medical advice otherwise. Apart from this, the patient's relatives and friends can be notified too of the problem and can communicate with the patient. True innovation lies in the fact that doctors

located in a remote medical centre, often with insufficient means to handle numerous cases, can have on-line support and communication with a major hospital and therefore have access to distributed medical data, patients' records, ask assistance from a centre specialized in a particular health problem, etc. using personalized interfaces. The usability of mobile systems extend to many more applications: doctors can view all the patients that have a specific problem, extracting geographic and age distribution and other statistical data, while patients receive personalized information concerning the latest advances and details about their disease/disability and news of their complaint.

The main innovation of mobile platforms for e-health is the ability for heterogeneous information processing in the medical area by defining methodologies and using key technologies that unifies modern information and communication technologies and organisational approaches such as P2P networks, agents, Internet and knowledge management, multi-language and multimedia applications. The vision of such a system needs to integrate:

- Innovative methodologies that allows a user to retrieve relevant medical information from a diverse range of sources over the whole network;
- The usage of agent technologies [7] that allow the integration of these new technologies in the medical environment; solution of problems regarding communication and information management in a distributed environment; autonomous tools that needs from less user interaction and sophisticated services by means of smart medical agents with capabilities such as autonomy, mobility [8,9].
- service oriented architectures and related standards/concepts (e.g. Web Services[3], SOAP [4], WSDL [5], UDDI [6]) that will be able to provide an open system where new modules can be easily integrated.

The impetus behind such solutions is to offer a bundle of services of medical and social nature with two main objectives:

1. Provide real-time medical advice and assistance. Promote a sense of security to elderly and disabled people since their relatives and friends will instantly be notified in the case of emergency. Doctors on the move or at patient's site in remote locations can have instant access to data located to central hospitals and health centers.
2. Alleviate the sense of isolation and loneliness elderly and disabled usually feel by allowing them to form and participate in virtual groups of friends and share interests and news. The social aspect of the platform is concerned with the elimination of social exclusion that is particularly common for these people.

The services can be offered in two levels. The first level may include all the peers that have a PC terminal with Internet access and a mobile phone. These will be able to use all the provisioned services. The second includes peers where users have only a mobile phone and/or fixed telephone connection. These users can only receive notifications on their cellular phone and issue voice requests from either the GSM or PSTN network. Technically, the innovation is in the employment of Peer-to-Peer (P2P) network topology that allows the creation of small and specific groups centred upon the patient or elderly for instance. In each group peers will be, apart from the patient/elderly, his family, friends and the appointed doctor/physician. The incorporation of Intelligent Agents will allow the provision of the services briefly mentioned above while the employment of GSM and PSTN networks will make some of the services offered accessible from anywhere and will ensure that all peers will receive notification of an emergency on time. The P2P topology will allow individuals to form their own groups based on common interests, activities, etc. Of course it will be feasible to form groups with different scope: for example, doctors will be able to form their own groups that will comprise of all the patients they attend and colleagues from other hospitals and medical centres. In order to provide customized interfaces to people with special needs and specifically to account for people with vision impairment, speech recognition engines will be employed. Another innovative aspect of the proposal is the usage of wireless links combined with commercial power line equipment for the last-mile access for remote location with poor line quality that cannot reliably sustain an Internet connection using the conventional PSTN network.

4 A framework architecture

4.1 General System Architecture

This section describes the overall technical approach for the proposed system. Figure 1 presents the high level architecture of the proposed framework. The specific P2P topology can be implemented on an open source platform called JXTA, which was specifically developed to allow the development of distributed computing applications [10]. In order to provide personalized services and self-management capabilities to the implemented network, a multi-intelligent agent system (system Kernel) can be

employed [11]. It is very important to mention that the IT community has recognized that most of the efforts in the peer-to-peer arena have to confront with common problems. For that reason is promoting several P2P initiatives such as:

- P2P-WG: development of new standards
- OpenP2P: repository of information about P2P

These initiatives are sponsored by the industry but their support is limited to the development of new protocols and new standards and even more they don't support scientific investigation of the properties of these systems. That means that in order to pursue our goal we must introduce a new approach for designing P2P systems. In our opinion, techniques borrowed from complex adaptive systems and mobile intelligent agents may be more effective in dealing with the inherent complexity of P2P systems [12].

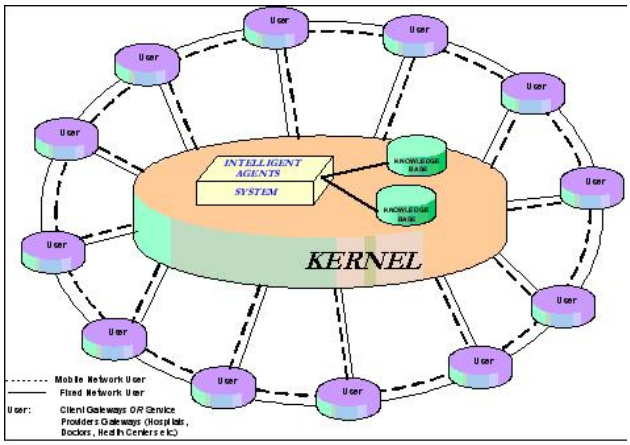

Figure 1.High level system architecture

Thus, the system consists of a dynamic network of peer nodes, and societies of adaptive agents that travel through this network, interacting with nodes and cooperating with other agents in order to solve complex problems. Each node is a peer entity sharing its computational and storage resources [13]. Nodes handle requests originated by local users, by generating one or more mobile autonomous agents that travel across the nodes network trying to satisfy the request. Autonomous agents can observe their environment and perform simple local computations leading to actions based on these observations [14]. The actions of these agents can modify the environment.

The proposed platform can support some the following group of services:

- Remote health monitoring where the patient/elderly can communicate in real time with his doctor, seek advice and receive assistance in the case of emergency.
- Automatic retrieval of information related to the users according to their existing profile such as Electronic Social Care Record (ESCR) or Electronic Health Record (HER)
- Participation in groups of interest (e.g. people with similar disease, interests, activities, etc.)
- Instant Messaging and real-time communication (audio/video) with family and friends.
- Communication between hospitals and general practitioners - The quality of clinical communication between hospitals and general practitioners has long been a contentious issue at both ends of the process.

4.2 Agent Based Architecture

In order to provide a personalized link between the user and the system, an agent based scheme is proposed. This architecture is a distributed and robust agent based platform [15]. Several kinds of agents can be used such as personal, executing and community agents (figure 2).

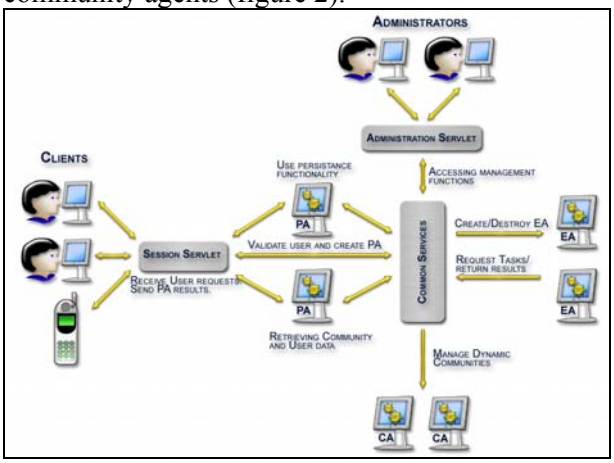

Figure 2.Agents facilitating client-system interaction

- Personal agents act as an interface between the user and the system, which can dynamically adapt to the user profile. These agents are a personification of the end-user in the system. By interacting with end user, they generate a dynamical user's profile, which will help the system to perform automatic personalised tasks, based on the user's likes and dislikes.
- Executing agents, perform specialized tasks, although the user is not connected to the system.
- Community agents, which will automatically generate virtual communities, based on the users' profiles, enhancing filtering of information (collaborative filtering), or providing tools for users, which have a similar profile, e.g., analogous interests or culture.

The Intelligent agents system component provide all the services the agents will require to work autonomously, under a robust and scalable environment [16]. Hence, these services provide tools to manage general tasks, persistence of agents, management of virtual communities, and users management, among other general features [17].

4.3 Virtual Communities Management

The Virtual Communities Management component is responsible for the management and tracking of every virtual community in the system.

Agents' lifecycle Manager. The agents' lifecycle manager performs management of Agent Factories and their agents. Agent Factories, and the created agents, are located in specific locations in an intranet. They are distributed among several computers with (maybe) different resources. For instance, an Agent Factory in charge of creating agents specialized in URL retrieval could be located in a computer with high bandwidth connection. This component acts internally as a mediator between several Agent Factories and clients, which want to have a centralized access to those factories. Externally, it offers interfaces oriented to manage agents and their factories.

Task Manager. The task manager manages the task execution in the system. It works as an intermediary in a producer/consumer scheme. Its responsibility is to receive tasks requests from PAs and send them to Executing Agents. The Task Manager is kept up to date about the status of each task.

Users Management. This component is responsible for the management of users' personal and public data. Associated with each user there is a user profile, i.e. the set of data that defines the behaviour of a user. The User's Profile data covers navigations over the web, voted web pages inside communities, confirmed meetings, and keywords in messages sent to other users. The profile is developed and managed over time by Personal Agents. It can be modified by the owners of the profile (a client), and administrators.

Persistence manager. It stores and retrieves data that could be used by agents in order to retrieve their state in case of a system crash. XML has been selected due to its wide acceptance as storing and interchange format. Actors use basic services to store or retrieve their state into XML format. There will not be any specific interface, as every entity will define its own mechanisms to translate internal state into XML.

Conversion Tool. In the proposed platform, multi-device delivery of the information will be done through the so-called Conversion Tool module. The Conversion Tool fulfils a main function: Select media that are adapted to the client device and channel for delivering. Since the same content can be received on different platforms, the content producer must be ready to optimise the way multimedia information is sent to any of them, taking into account subjects like visualization properties of the client device, bandwidth, and peripherals nature, like type of keyboard, pointing devices and so on, which will be used for navigation and browsing (figure 3). Within this component, a protocol for information exchange will be used in order to clearly set the type of visualization device, the browsing, navigation and interaction possibilities of the visualization platform, the available bandwidth, and so on, in order to dynamically adjust the type of transmission and to decide the way the information is transmitted, the kind of interaction that will be allowed during the visualization, and the amount and nature of decisions that the server should undertake given the limitations of the visualization device. Customisation for each of these devices should be assumed, easing the access to contents to the end user. Therefore the main goal of the Conversion Tool is to adapt the multimedia data to the client devices capabilities in terms of computational power and bandwidth.

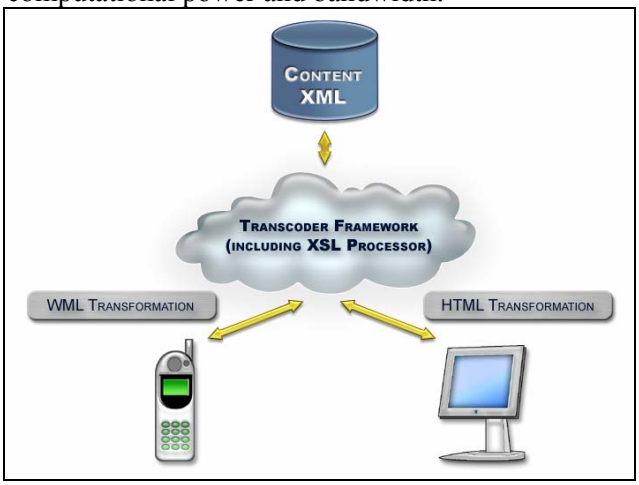

Figure 3.Multi-device delivery of information

What this actually means is that the data that will be handled is XML, which will be transformed to the appropriated format (e.g., HTML, WML, etc.) depending on the end user device trough a specific XSL template.

The end user devices will demand specific protocols and formats which the server has to comply with. More specifically:

- PDAs, will require XHTML for publishing.
- Mobile phones, GPRS or UMTS enabled will have to adapt the WAP2.0 standard, which states that XHTML Basic will be used.
- Home PCs are the most flexible devices. Hence, we will adopt XHTML and any kind of (see conversion tools for a more explicit description) content.

5 Conclusions and Future Work

Mobile health services are still in their infancy. Tools and technologies are still far from being exploitable since many technical problems need to be addressed. In mobile health services support information has to be processed rendered and projected in real time. The possibility of tens of thousands of requests from thousands of users in urban areas resulting in highly variable workloads imposes the need for great computational power. This constraint is added to other considerations that include detailed information visualization, user interaction paradigms and self-adaptation. Essential requirements for personal-health service provision include mobility, accurate positioning and fast access of distributed resources. Fundamental problems still need to be addressed. Last but not least, the scientific community has not yet reached an understanding of how these services should be delivered since an overall integrated technical and business approach is missing. We believe that the proposed system can be a first step to this direction.

Acknowledgments

This work was supported by Greek Ministry of Finance and Financial Affairs Information Society Programme (project Ο.Π.Σ.: 93255).

References:

[1] De Bruijn O. & Stathis K.: Socio-cognitive Grids: The Net as a Universal Human Resource.; In Proc. Of Tales of the Disappearing Computer, to appear, 2003.

[2] Parameswaran, M.; Susarla, A.: P2P networking: an information sharing alternative; Whinston, A.B. Computer, Volume: 34 Issue: 7 , July 2001.

[3] W3C - Web Services Activity (http://www.w3.org/2002/ws/)

[4] M. Gudgin, M. Hadley, N. Mendelsohn, J.J.Moreau, H. F. Nielsen. Simple Object Access Protocol (SOAP) 1.2. W3C, 2003, http://www.w3.org/tr/soap

[5] R.Chinnici, M. Gudgin, J.J. Moreau, J. Schlimmer, S. Weerawarana. Web Services Description Language (WSDL)2.0. W3C, 2003, http://www.w3.org/tr/wsdl

[6] K. Januszewski, E. Mooney, R. Harrah, S. Lee, J. Munter, C. von Riegen. UDDI ver, 3.0. UDDI.org, 202, http://uddi.org

[7] Intelligent Assistance from Mindscape (http://www.oser.com/csd/mi11.html)

[8] FIPA Personal Travel Assistance Specification (http://www.fipa.org/specs/fipa00080/PC00080.html)

[9] MAS for Navigation Assistance and Information (http://citeseer.nj.nec.com/correct/263037)

[10] Li Gong: JXTA: a network programming environment; IEEE Internet Computing, Volume: 5 Issue: 3, May-June 2001.

[11] Aberer, K.; Punceva, M.; Hauswirth, M.; Schmidt, R.: Improving Data Access in P2P Systems IEEE Internet Computing, Volume: 6 Issue: 1, Jan/Feb 2002.

[12] Fox, G.: Peer-to-peer networks; Computing in Science & Engineering, Volume: 3 Issue: 3, May-June 2001.

[13] Yamaguchi, S.; Maruyama, K.: Autonomous load balance system for distributed servers using active objects; 12th International Workshop on Database and Expert Systems Applications, 2001.

[14] Sudmann, N.P.; Johansen, D.: Supporting mobile agent applications using wrappers; 12th International Workshop on Database and Expert Systems Applications, 2001.

[15] Hogg, L.M.I.; Jennings, N.R.: Socially intelligent reasoning for autonomous agents; IEEE Transactions on Systems, Man and Cybernetics, Part A, Volume: 31 Issue: 5, Sept. 2001.

[16] Ferreira, E.D.; Subrahmanian, E.; Manstetten, D.: Intelligent agents in decentralized traffic control; Proceedings of the 2001 IEEE Conference on Intelligent Transportation Systems, 2001.

[17] Rui Yannian; Cui Zhiming; Liu Wenjie: Research on intelligent agent-oriented software techniques; 2001 IEEE International Conference on Systems, Man, and Cybernetics, Volume: 3, 2001.