

# A Mobile Agent Approach for Ubiquitous and Personalized eHealth Information Systems

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**Abstract.** The past years have witnessed a heavy investment and research in the eHealth sector. The work of medical practitioners at all levels is becoming more information intensive as sophisticated medical equipment and computer applications are more widely used. At the same time, the demands of the patients / citizens are increasing due to the innovative medical and scientific advances. Digital technologies are becoming more important in health management aiming to reduce the cost and to deliver health care services at a distance. In addition, the Internet is increasingly used by citizens to obtain medical information, therefore it is critical that the Web-based eHealth content and services are developed efficiently, complying with the established quality criteria and being available for all in an adaptive and personalized manner delivered by multiple and ubiquitous delivery channels. In this context, the aim of this paper is to argue that in the face of the existing systems and platforms diversity and information sparsity, mobile agent technologies can provide the base for ubiquitous, transparent, secure, interoperable, and integrated eHealth information systems for the provision of adapted and personalized sustainable services to the citizens.

## 1 Introduction

During the last few years several initiatives (public and private) were undertaken addressing different applications of mobile and ubiquitous eHealth issues, ranging from doctor mobility (remote access to medical data), to patient mobility (remote monitoring of vital signals, tele-consultation, mobile medical record, wearable medical sensors) up to web based medical data access. Nevertheless, the scope of these initiatives was focused and the different approaches were designed in an ad-hoc way. As a result, it is not possible to integrate the different technological innovations and services into an integrated system. Many issues that are crucial for the deployment of an integrated ubiquitous mobile health system were not addressed, like for example social and economic aspects, changes in medical work practices and even standardization of technologies and integration with existing medical information systems. It is for these reasons that most of the technological innovations were either rejected by the market or their scope and usage remained limited. Following the improvement of the wireless transmission technologies, the primary objective of many researches today, realizing the ubiquitous mobile health problem, is to design and implement integrated ubiquitous eHealth mobile services systems and platforms emphasizing on the aforementioned issues.

The aim of this paper is to realize the common challenges and implications of the current eHealth environment. Special emphasis will be placed on the emergence of the wireless and mobile technologies and advancements in the specific area and how this affect the designing and development of ubiquitous information systems for the provision of eHealth adaptive and personalized services. Eventually, the mobile agents paradigm will be presented,

examining its characteristics, arguing that it could effectively be used for the composition of such personalized, multi-modal, and interoperable component-based eHealth information systems for sustainable services provision satisfying the growing citizens' demands.

## **2 The eHealth Sector – Current Trends and Implications**

Today's information age is accelerating at quantum speed. Advances such as the Internet and high-speed networks have propelled the never-ending quest for information. An infinite amount of information is being created and accessed by people around the globe everyday. However, healthcare today remains one of the most information intensive and least automated of all industries. Nevertheless, European Commission through its eEurope 2005 Action Plan has drawn some specific innovative guidelines and objectives for advancing the current eHealth situation. These include the creation and dissemination of electronic health cards, the set up of European-wide information networks of public health data, and the provision of online personalized health services through intelligent information systems to the citizens. Moreover, another vital consideration is the standardization of the different pertinent elements (in cooperation with the various standardization bodies like ETSI, ITU, CEN / CENELEC, ISO), defining communication and transmission protocols and interfaces that will allow the systems to work in an interoperable, coherent and cohesive way.

## **3 The Mobility Emergence – Towards the mHealth Reality**

The mHealth could be considered as a new kind of front-end access to public services with specific capabilities of delivering on demand real time information. Nowadays, as an integral part of eHealth, many governments should start offering eHealth services via a variety of service delivery channels apart from the Web. One of these mobile service delivery channels is mobile telephony. This channel becomes more relevant considering the much faster growth of mobile penetration rate compared to desktop based Internet access. The mobile phone is now pervasive and is used in every human activity, private, business and governmental. While penetration levels are likely to continue to increase, the most significant future development will be the growth of mobile broadband services, as the potential provided by third generation mobile (3G) and its enhancements, as well by other wireless technologies, including RLAN, satellite and others, is realized. The dissemination of these technologies represents a paradigm shift that will enable the emergence of new data services, combining the benefits of broadband with mobility [1].

Moreover, the needs of mobile users differ significantly from those of desktop users. Getting personalized information “*anytime, anywhere and anyhow*” is not an easy task. Such applications should be characterized by flexibility, accessibility, context-awareness, quality and security in a ubiquitous interoperable manner in order to provide the citizens with quality on demand information (services). User interfaces must now be friendlier enabling active involvement (information acquisition), giving control to the citizen and provide easier means of navigation supported by the small screens of the mobile devices and enable adaptation of hypermedia, multi-media, and multi-modal intelligent and personalized user interfaces [2]. However, mobility applications can suffer from a handful of noteworthy problems. These could be summarized into: local mobility, limited mobility, closed mobility and interrupted mobility.

To overcome these problems intelligent techniques have to be implemented to enable the development of adaptive and mobile Web-based systems [2] that will enhance the more direct and personalized eHealth services delivery. Fundamental characteristics should include openness, high connectivity speed, reliability, availability, context-awareness, broadband connection, interoperability, transparency and scalability, expandability, effectiveness, efficiency, personalization, security and privacy [3, 4].

## 4 The Web Personalization Imperative

### 4.1 User Service Requirements and Delivery

To get the right information at the right time and the right place is not so easy for the citizens. The eHealth sector working at its front or back office, it has encountered in several times and occasions the particular problem. Citizens' interaction with the services has to be improved, and a serious analysis of user requirements in the area of eHealth has to be undertaken, documented and furthermore analyzed taking into consideration its multi-application to the various delivery channels and devices in order to design effective and personalized eHealth information systems that will provide quality eHealth services. This paper presents, based on studies conducted [5, 6, 7], some of the user (citizen) requirements and arguments anticipated. They could be clearly distinguished into: (a) *General User Service Requirements* (flexibility: anyhow, anytime, anywhere; accessibility; quality; and security), and (b) *Requirements for a Friendly and Effective User Interaction* (information acquisition; system controllability; navigation; versatility; errors handling; and personalization).

### 4.2 Challenges in the Adaptive and Personalized eHealth Design

The "Mobile" generation is now extending the basis of the adaptation by adding models of context such as location, time, computing platform and bandwidth to the classic user model and exploring the use of known adaptation technologies to adapt to both an individual user and a context of their work. Now, by user needs it is implied both, the *thematic preferences* as well as the characteristics of his mobile device, the *device profile*. Therefore, adaptive personalization here is concerned with the negotiation of user requirements and device abilities. Although one-to-one service provision may be a functionality of the distant future, user segmentation is a very valuable step in the right direction. User segmentation means that the population is subdivided (ideally per service or group of related services), into more or less homogeneous, mutually exclusive subsets of users who share an interest in the service. The subdivisions are based on one or more user characteristics. These could be *demographic characteristics, socio-economic characteristics, psychographic characteristics, or individual physical and psychological characteristics*. The issue of personalization is a rather complex one with many aspects and viewpoints that need to be analyzed and resolved. Some of these issues become even more complicated once viewed from a moving user's perspective, in other words when constraints of mobile channels and devices are involved. Such issues include, but are not limited to, the following: *what content to present to the user, how to show the content to the user, how to ensure the user's privacy, or how to create a global personalization scheme* [8].

### 4.3 A Mobile Agent Approach for Web Personalization

There are a number of different approaches and architectures that have been implemented in building eHealth information systems, each one of which with different strengths and weaknesses. This paper will be focused on the intelligent mobile agent approach, since the mobility dimension is henceforth incorporated, and therefore needs as to locate the required information, on time, under any circumstances are considered vital. Agents are processes with the aim of performing tasks for their users, usually with autonomy, playing the role of personal assistants [8, 9].

Agents usually solve common problems users experience on the Web such as personal history, shortcuts, page watching and traffic lights [10]. Some of the agents' main characteristics could be distinguished according to their abilities used and according to the tasks

they execute. The former include characteristics such as *intelligence*, *social capacity* and *mobility*; while the latter classify the agents into *information filtering agents*, *information retrieval agents*, *recommendation agents*, *agents for electronic market*, and *agents for network management* [9]. Furthermore, several mobile agent platforms could be proposed in order to base the development of an efficient mobile eHealth information system. These could be broadly categorized as *Java* and *non-Java based ones*.

The main reason that the particular approach of intelligent mobile agents is proposed for a given wireless environment is that they are being identified by some specific capabilities that could enable the more efficient implementation of the adaptive and personalized eHealth information systems. These advantages of the intelligent mobile agents are focused upon: *Reduction of the network load*, *overcoming network latency*, *asynchronous and autonomous execution*, and *dynamic adaptation*.

## 5 Conclusion

In conclusion, this paper presented the current eHealth sector situation in further realization of the technological environment divergence and citizens' disorientation, due to, in the former case ad-hoc development of systems, while in the latter sparsity of information. The growing demands of the citizens for "anytime, anywhere and anyhow" information (services) delivery as well as the mobility and wireless platforms and devices emergence, intensified the imposition of the development of common standards and protocols as well as technologies that could be used for the design of interoperable, ubiquitous, secure, adaptive, personalized and transparent m- and eHealth information systems. Eventually, in the face of the mobile Health reality the mobile agents paradigm has been examined arguing that it could serve the core technology for the development of the aforementioned systems.

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