Towards Multi-Agent Health Information Systems

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ABSTRACT

One of the key challenges in the healthcare sector is to adapt Health Information Systems to requirements coming from changing societies. In recent years, governments and international healthcare organizations defined a series of requirements for new generation Health Information Systems: they have to preserve past investments on legacy systems, but must also integrate new technologies, include the patient among their users, and ensure that clinical information are available at all times, even in places far from where information are physically stored. This paper proposes a multi agent-oriented architecture for Health Information Systems, which uses international standards for communication and management of clinical documents. The architecture tries to effectively model a generic healthcare organization, and aims at being easily extensible and adaptable to the particularities of specific healthcare systems. The authors present two experimental scenarios to test the proposed multi-agent health information system. In the first, they show how to model a specific use case, a radiology workflow, using agents and well-known standards; in the second one the authors demonstrate how a mobile application can use the services provided by the agents to support the medical staff in an emergency situation.

Keywords: Health Information Systems, Multi-Agent Systems, Requirements Engineering, Software Engineering

INTRODUCTION

The healthcare sector is facing large changes and many challenges in recent years. To improve the quality of health services to the citizens, it is necessary to deal with several problems.

Medical errors are one of the most important issues to deal with, because they can have dramatic consequences for the patients and for the medical institutions. There are various types of medical errors: medication errors, failures to recognize an allergy, patients misidentification, errors and delays in diagnosis, etc. Kohn, Corrigan and Donaldson (2000) pointed out that up to

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100,000 US patients die of medical errors each year; other analyses suggest that they affect up to 10% of hospitalized patients (Baker et al., 2004; Chaudhry, Olofinboba, & Krumholz, 2003). Furthermore, the incidence of medical errors is rising (Weingart, Wilson, Gibberd & Harrison, 2000).

Another major problem is related to the healthcare budget. The costs related to healthcare are rising more and more. In the US, for example, healthcare costs are constantly rising from 1960; moreover, since 1980 the spending increases in medical care for the elderly are associated with a high cost per year of life gained (Cutler, Rosen, & Vijan, 2006). This leads to a new problem for the healthcare sector, linked to the increase of the average age of the population: the number of chronic diseases and thus of emergencies related to elderly is steadily rising (Kleinberger, Becker, Ras, Holzinger & Müller, 2007).

In rural areas and developing countries, many healthcare institutions are understaffed and serve very large areas. This is due to a series of socio-economical factors: some countries do not have a proper budget to fund the healthcare sector; some developing countries fail to retain qualified medical personnel, who prefers to work in developed countries; certain geographical areas have little appeal for the medical staff (Gow, George, Mwamba, Ingombe, & Mutinta, 2013; Yeung, Craven, Wilson, Ali, & Li, 2013).

There are many other problems in the healthcare sector and, to make things worse, they are frequently linked to each other, making it difficult to solve them.

To summarize, according to Varshney (2003), the entire healthcare sector is under increasing pressure to provide better services to more people using limited financial and human resources.

Health Information Systems (HIS) are at the heart of all the challenges and changes in the healthcare sector. HIS evolved from hospital information systems (Kuhn and Giuse, 2001) and, due to their inherent complexity, have become the application field of various challenging research areas (Reichert, 2006), such as requirements engineering, artificial intelligence, distributed systems and system integration.

HIS can help to address the issues previously described. HIS are crucial to improve the coordination among medical staff and administrators, reducing the number and the incidence of medical errors (Ash, Berg & Coiera, 2004); they are essential for tracking patients’ medical histories, surgeries, medical examinations and lab test results, easing the work of physicians and medical staffs (Ludwick & Doucette, 2009). HIS generally improves the management of medical institutions and can help to reduce healthcare costs (Haux, 2006; Frisse et al., 2012).

According to Haux (2006), new HIS are urgently needed to reorganize healthcare in an aging society. Among the most important lines of development in HIS identified in the last years, it is important to cite:

- A shift towards regional, national and international HIS
- The inclusion of patients among HIS users
- The steady increase of new technologies to be included (e.g. ubiquitous computing environment and sensor-based technologies)

International boards and governments are defining requirements for the new generation HIS (Blumenthal, 2009). For example, the Italian Health Ministry, following European Union directives, issued a document defining requirements for the “Basic Infrastructure for Electronic Healthcare” (Ferronato, Lotti & Berardi, 2006):
The Benefits of Wireless Enabled Applications to Facilitate Superior Healthcare Delivery: The Case of DiaMonD
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