

Multi-Agent Systems for E-Health and Telemedicine

Federico Bergenti

University of Parma, Italy

Agostino Poggi

University of Parma, Italy

Michele Tomaiuolo

University of Parma, Italy

INTRODUCTION

Health care is characterized by high degree of distributed, labor-intensive works, mobility, and information access to large set of dynamic and unstructured information, distributed over a large number of information systems. The advent of Internet and the evolution of information technologies promote the development of Internet based applications that try to facilitate the remote interaction between health-care providers and their patients and among health-care providers and to automatize the acquisition, exchange and manipulating of information distributed in a large number of (heterogeneous) information systems.

Multi-agent systems represent the most promising information technology for coping with a class of problems (i.e., remote and heterogeneous software applications integration, distributed tasks execution coordination, and remote monitoring and assistance) which are typical problems of the large part of Internet based health care applications (see, e.g., Jennings et al., 1995; Muller, 1998; Bordini et al., 2005). In particular, applications for healthcare can take outstanding advantage of the intrinsic characteristics of multi-agent systems because usually they are composed of loosely coupled (complex) systems, are realized in terms of heterogeneous components and legacy systems, manage distributed data and resources; and are accessed by remote users in (synchronous) collaboration (Moreno & Nealon, 2003; Annicchiarico et al., 2008).

The goal of this chapter is to describe the main reasons why multi-agent systems are considered one of the most interesting technologies for the development of applications for health care. It provides some guidelines intended to help identifying the kinds of applications that can truly take advantage of the features of multi-agent systems, and it presents some of the most important international projects that used multi-agent systems in the healthcare and social services domain.

BACKGROUND

Although there are several definitions of agent (see, e.g., Russell & Norvig, 2003; Wooldridge & Jennings, 1995; Genesereth & Ketchpel, 1994), all the definitions agree that an agent is essentially an autonomous software entity that should at least be designed to operate continuously in dynamic and uncertain environments, reacting to events while showing an intelligent behavior to pursue its own objectives. An agent usually provides interoperable interfaces for interacting with other agents, either concurrently or

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cooperatively, exchanging messages formulated according to some syntax, semantics and pragmatics. Since an agent behaves proactively, it requires some degree of trust by its user, and it can receive delegations from either human users or other agents in the form of required actions or desired goals, matched with permissions to access necessary resources. Additionally, an agent may also be able to perform complex reasoning at run-time and can also learn and change their behavior over time, to improve its performance. Finally, it is even able to move from one computational node to another, to follow its own user or to exploit some local resource more efficiently.

Agent-based systems are often realized by loosely coupling various agents, i.e. autonomous software entities, thus modelling a proper multi-agent system, characterized by a higher level of modularity and a richer descriptive model, if compared with a solitary agent working within its environment – either with the presence of users or not. Multi-agent systems can be also considered as abstractions capable of capturing the essence of many software systems at different levels of detail, rather than a single technology supporting the realization of distributed intelligent systems. In particular, agents and multi-agent systems are often considered the highest system level (Newel, 1982; Jennings, 2000) that we can access today and they are meant to provide a truly novel level of abstraction in the analysis, design and implementation of complex software systems (Bergenti & Huhns, 2004).

MULTI-AGENT SYSTEMS AND E-HEALTH

Sociality is one of the main distinguishing characteristic of multi-agent systems. In particular, multi-agent systems allow the delegation of goals and tasks as a mean to realize emerging social behaviors. Multi-agent systems are generally considered an appropriate abstraction for modelling complex, distributed systems, even if such a multiplicity naturally introduces the possibility of having different agents with potentially conflicting goals. Agents may decide to cooperate for mutual benefit, or they may compete to serve their own interests. Agents take advantage of their social ability to exhibit flexible coordination behaviors that make them able to both cooperate in the achievement of shared goals or to compete on the acquisition of resources and tasks. Agents have the ability of coordinating their behaviors into coherent global actions.

This characteristic fits quite well the new environment where health care and social services are being provided. In fact, significant societal changes are the mark of these years, including ageing of population, growing value attributed to personal care, preference for living at home also when needing assistance, interconnection and integration of diverse services.

Care provision is usually based either on the effort of relatives, or on hospitals and care centers. In recent years, both those approaches are being questioned and the situation is changing. In fact, the support of relatives is becoming less and less viable, as family members are frequently occupied with work. On the other side, the relocation of patients, elders and people needing social care, outside of their communities is not desirable for their own wellness; in many cases, it is not even necessary, as they preserve enough strength and capabilities to stay at home. Moreover, rooms in hospitals and care centers are in a limited number and the trend is toward their reduction, in spite of a growing number of elders. Consequently, the traditional approach to provide cares and social services in hospitals and institutional centers is being paralleled with a growing tendency to provide cares in the community, directly. In this kind of “community care” or “domiciled care”, services to assisted people are provided directly in their home or in their habitual environment, allowing them to continue to live as much independently as they

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