Chapter 2.19
Macroscopic Modeling of Information Flow in an Agent–Based Electronic Health Record System

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ABSTRACT

This chapter presents an architecture, or general framework, for an agent-based electronic health record system (ABEHRS) to provide health information access and retrieval among different medical services facilities. The agent system's behaviors are analyzed using the simulation approach and the mathematical modeling approach. The key concept promoted by ABEHRS is to allow patient health records to autonomously move through the computer network uniting scattered and distributed data into one consistent and complete data set or patient health record. ABEHRS is an example of multi-agent swarm system, which is composed of many simple agents and a system that is able to self-organize. The ultimate goal is that the reader should appreciate the benefits of using mobile agents and the importance of studying agent behaviors at the system level and at the individual level.

INTRODUCTION

Health information is the heart of any electronic health record (EHR) application, and the management of this growing and complex information has become a huge and complicated task for every health care organization. Moreover, much of this health information is fragmented and scattered among different medical service facilities, mainly because a patient is usually seen by many different health care providers in many different medical

service facilities. So, the patient is likely to have at least one relevant health document or record in each medical facility he/she visits. Over time, the patient's medical record becomes fragmented, inaccurate, and inconsistent. This is the complex environment in which EHR management must operate.

Fortunately, a large part of today's health information is already available in electronic form, and the primary task of the EHR system is to communicate this information electronically anywhere in the world. Based on this vision, the need to move the patient's health information among different health care facilities grows in parallel with the need to centralized health information across numerous EHR systems within the health care domain (Silverman, Andonyadis, & Morales, 1998). Therefore, in order to allow rapid and accurate access of patients' health record, the creation of a digital health information network is essential to our modern health care system.

Mobile agent technology can be an essential tool in creating this system, because of fundamental mobile agent attributes including: autonomy, mobility, independence, pro-activity, reactivity, communicability, swarm, and group intelligence. Because of these attributes, mobile agents can provide solutions to address the challenges of health information systems in the health care domain, as suggested in Nealon and Moreno (2003) and Crow and Shadbolt (2003). Later section in the chapter, we will present an architecture or general framework for ABEHRS to provide health information access and retrieval among different medical services facilities.

As shown in Lerman and Galstyan (2001), a swarm agent system (simple agents with a distributed controller) that exhibits collective behaviors has demonstrated advantages in robustness, scalability, and cost, over a traditional agent system (intelligent agents with a centralized controller) that exhibits individualized behaviors. Moreover, self-organization is one of the interesting collective behaviors that appears in a swarm system.

This concept of self-organization manifests itself in our ABEHRS, which allows the patient's health record to self-organize. In the background section, basic definitions of swarm and intelligence will be presented, and the definition of self-organization will also be presented. Later sections in the chapter will present the reasons why the swarm paradigm is chosen over the traditional paradigm and the process of self-organization used in our ABEHRS.

In order for our ABEHRS to be useful, a study of the system-level behavior must be performed. This allows a greater understanding of the system dynamics, so that if such a system was actually implemented, the dangers of unexpected system behavior could be limited. Smith, Paranjape, and Benedicenti (2001) show that the full potential of individual agents is not obtained during unexpected/unwanted agent-group behaviors (for example, oscillation of agents between hosts). Therefore, we believe that the behavior of agents in a multi-agent system must be completely understood before the completion of actually system design, so as to minimize the chances of system failure and to achieve superior system and individual agent performance. In the proceeding sections, we present a study of agent behaviors in ABEHRS using simulation and mathematical models, as well as the comparison between the simulation and numerical results.

BACKGROUND

The Electronic Health Record

As defined in Grimson, Grimson, and Hasselbring (2000) and the Web site of the Healthcare Information and Management Systems Society (http://www.himss.org), an electronic health record is an electronic version of patient's health record, which includes prescriptions, lab results, evaluations by doctors, and so forth. Since the EHR is in an electronic format, so it can be easily

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