

Chapter 27

A Novel 3D Approach for Patient Schedule Using Multi-Agent Coordination

E. Grace Mary Kanaga
Karunya University, India

M.L. Valarmathi
Government College of Technology, India

Preethi S.H. Darius
Karunya University, India

ABSTRACT

This chapter presents a novel 3D approach for patient scheduling (3D-PS) using multi-agents. Here the 3Ds refers to the Distributed, Dynamic and Decentralized nature of the patient scheduling. As in many other scheduling problems, in the hospital domain, a major problem is the efficient allocation of resources to the patients. The resources here mean the doctor, diagnosing equipments, lab tests, et cetera. Commonly, patient scheduling is performed manually by human schedulers with no automated support. Human scheduling is not efficient, because the nature of the problem is very complex; it is inherently distributed, dynamic, and decentralized. Since agents are known to represent distributed environment well and also being capable of handling dynamism, an agent based approach is chosen. The objectives are to reduce patient waiting times, minimize the patient stay in the hospital, and to improve resource utilization in hospitals. The comparison of several agent-based approaches is also reviewed, and the auction-based approach is chosen. The complete multi-agent framework given in literature is adapted to suit the patient scheduling scenario. The patient scheduling system is implemented in the JADE platform where patients and resources are represented as agents. The chief performance metric is the weighted tardiness which has to be minimized in order to obtain an effective schedule.

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The experiment is carried out using constant number of resources and varying number of patients. The simulation results are presented and analyzed. 3D-PS produces up to 30% reduction in total weighted tardiness in a distributed environment, as compared to other traditional algorithms. A further enhancement to this approach aims to reduce the communication overhead by reducing the number of messages passed and hence resulting in a better coordination mechanism. This auction based mechanism aims to provide the basic framework for future enhancements on patient scheduling.

INTRODUCTION

The process of scheduling patients involves different resources like doctors, diagnostic units, labs etc. Each one in general belongs to different – relatively autonomous – organizational units. Each organizational unit has particular preference structures, which lead to conflicts of interests. These conflicts should be resolved in a fair manner at the same time giving more preference to the patient need. The problem of resolving different interests becomes worse by environmental influences. In today's healthcare systems, patient satisfaction is a prime factor in addition to providing quality care. Priority is assigned for the patients and hence the resulting waiting time for various patients is depending on the health condition of the patient. A plausible solution and thus the objective of this chapter is to reduce the waiting times of patients while taking into account the priority level of each patient.

A multi-agent based approach is proposed in this chapter where each patient and resource is represented by an agent. In this fast growing era of technologies the application areas of agents are so vast. In most of the cases a single agent may not be able to achieve the entire goal by itself. So in complex applications, applying Multi-Agent System (MAS) is more reasonable. In most of the cases multi-agent systems are used to address the problems that are too large for a centralized agent. MAS are systems of interacting intelligent actors, or agents, existing in some environments. As discussed by Katia & Sycara (1998) the characteristics of a MAS is that, each agent has incomplete information or capabilities for solving the

problem and, thus, has a limited view point, there is no system global control, data are decentralized and computation is asynchronous. The notions of multi-agent defined by Jiming Liu et al (2002), is presented below:

Definition: A multi-agent system is a system that contains the following elements:

1. An environment, E , a space in which the agents live.
2. A set of reactive rules, R , governing the interaction between the agents and their environment. They are the laws of the agent universe.
3. A set of agents, $A = \{a_1, a_2, \dots, a_n\}$

An altered variation of the common market based auction mechanism is used as a coordination mechanism in the scheduling process where the good to be auctioned is the timeslot, the resource agent is the auctioneer and the patients are the bidders. Integer programming with lagrangean relaxation is the optimization technique deployed to find an optimal and feasible schedule for a given time horizon.

PROBLEM DOMAIN

In order to gain an in-depth comprehension of patient scheduling problem the typical model of patients flow adapted in the health care domain is presented in the Figure 1. From this model, it can be seen that the patient care in hospitals is an iterative process and the treatment plan of patients keeps on changing with respect to time.

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