5 Adaptivity and Scheduling

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Abstract. The structures in health care are currently changing. Clinical management and physicians have the obligation to both ensure quality of care and to work more cost effectively. The optimization of the system respecting these contrary goals is a big challenge. New information technology and computer applications like adaptive agent based assistance agents may be one way to optimize the system. Additionally organizational changes regarding resources or processes may also enhance the system. In many cases the effects of optimization ideas are difficult to foresee. This chapter describes the possibilities of multiagent simulation for experimentation and optimization of adaptive scheduling in hospitals. It presents a specialized agent based construction kit for hospital simulation and describes the results of realized example scenarios.

5.1 Introduction

This chapter addresses the problem of coordinating and scheduling logistical issues in hospitals, in particular those pertaining to treatments and examinations. Despite the introduction of clinical information systems in recent years, the execution schedule of medical tasks is often determined by ad-hoc decisions and typically costly factors such as patient treatment duration, efficient resource loadings or balanced working hours are not optimized. Often simple waiting queues (first-in first-out) in front of functional units can be found to determine the execution sequence. If appointments are made, they are individually negotiated by telephone. Even though this is one particular solution, it is suboptimal and is likely to cause unnecessary delays and result in an uneven distribution of work amongst the functional units.

Some properties of hospital patient scheduling hamper manual or central problem solving. Firstly patient scheduling is inherently distributed. Several organizational units - traditionally autonomous and different in their nature - are involved and make their own decisions regarding appointments. The patients on the other hand are very individual, suffer from different diseases with different severities and often need immediate care.
Our patients of a clinic in particular, have individual preferences and restrictions. In fact many of the patient constraints are hard to formalize in detail and furthermore they are dynamic and subject to future change. Centralized systems can hardly represent all of the constraints and keep them up to date. Complexity is also an issue, as the processes are interdependent and patients may compete for the same resources. Compared to other scheduling domains, patient scheduling has very dynamic demands. Current schedules may become obsolete by sudden changes: durations of task execution may be unpredictable; emergencies have to be treated urgently and patients may not appear on time. A system that successfully deals with these problems has to provide the capability for efficient, dynamic rescheduling.

Considering these problem characteristics we arrive at the following conclusion: A scheduling system has to be distributed and individually configurable, and it has to perceive the changes of the environment and be able to adapt to these situations very quickly. The natural properties of agents deal very well with these circumstances: They are situated in an environment; they reason about changes in the environment, they act autonomously and interact socially with each other to solve problems. These properties can also be summarized as the adaptivity of an agent.

As we have illustrated, optimization of patient scheduling is very promising and the agent paradigm fits well for these problem properties. The projects of the priority research program SPP 1083 followed two basic approaches to provide solutions for the problem domain.

- **Introduction of agent based scheduling systems:** This approach comprises the development of an agent based scheduling assistance system. These systems can improve patient scheduling by endowing patients as well as functional units with assistance agents for appointment negotiation. (see III.4; [HeHe2004a]) The interaction between software agents is faster, cheaper and less problematic (if frequently repeated) than human interaction. The prerequisite for the application of software agents is that the system should be continually up-to-date and in close contact with their human counterparts. Then agents can perform a more exhaustive search for ‘good’ solutions than humans. Even if this could also be realized by a centralized scheduling system, an agent based solution reflects more closely the existing organization and therefore can better deal with the inherent uncertainties in the clinical environment.

- **Agent based simulation of hospital processes:** The second approach deals with the development of hospital simulations to evaluate scheduling questions. Effects on global evaluation parameters like staytime and average unit load are the result of dynamic interactions between humans