Dialog-Based Intelligent Operation Theatre Scheduler

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1 Introduction

Medical treatments planning and surgical operations scheduling are substantial elements of hospital management. Operations theatre scheduling deals with assignment of limited hospital resources (rooms, doctors, nurses, etc.) to jobs (patient treatments, surgery, etc.) over the time in order to perform tasks according to their needs and priorities, and to optimize usage of hospital resources [7]. The whole process is restricted by lots of constraints, limitations and preferences [2]. It is characterized by high complexity, which is caused by the uncertainty between the offered capacity and the true demand. As emergency cases occur the planning requirements will change. Existing industrial schedulers usually assume a predefined workflow. Furthermore, they do not take actors' preferences into account and are therefore suffer from levels of non-acceptance of their resulting schedules [2]. State of the art in this domain are the following methods: no planning, pen and paper, non-intelligent tool-based. Therefore, typically scheduling is done manually and involves specialized persons to facilitate the process. An example of an optimization that can be achieved using process automization for nurses rostering[1] is discussed in [4]. In the considered hospital one person spends 3-5 full-time working days on producing a nurses' schedule for the period of one month (only shift assignment). A use of a dialog-based semi-automated system is preferred against fully manual or fully automated systems. This is because of the inability of the later to recognize the changes in a high dynamic environment and to take the responsibility for decisions made. As it has to be possible to add new tasks in the planning process "on the fly" and to adequately plan new situations, we involve a human planner in the scheduling activity. The planner acts as a "sensor" to identify changes as they occur and integrates his knowledge as well as decision-making competence into the planning process.

The proposals for the schedules are made with the help of heuristics. Actual problem solving mechanisms of the system and their evaluation are presented

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[1] rostering and scheduling are used as synonyms here

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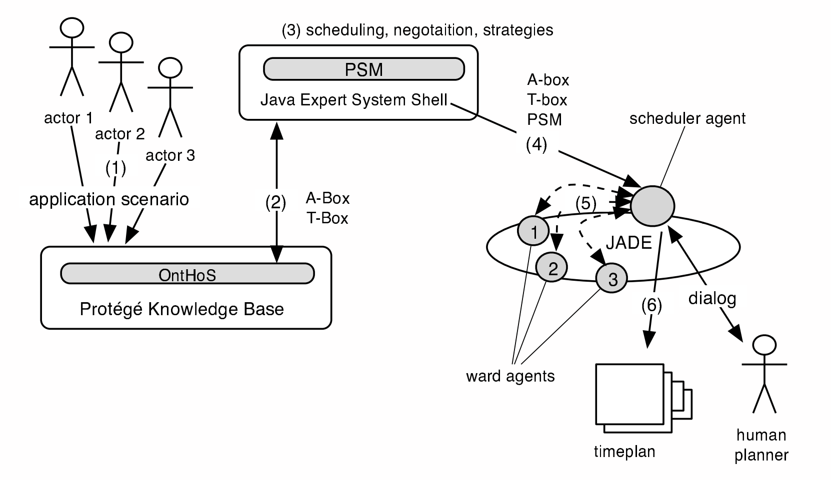

Fig. 1. System Overview

in [5]. Here we shortly describe a scheduling development framework and the constructed prototype for preference-based operation theatre scheduling [6]. Beside that, the paper covers tools used to develop the scheduling system. The framework is integrated in the framework for multi-agent systems *Agent.Hospital* [3].

2 Framework and Prototype Description

We divide the scheduling problem into four sub-problems (shift assignment, team building, job scheduling and room assignment) [6, 5]. For each of the identified subproblems a heuristic was developed that satisfies all constraints and takes into account preferences (like prefered working time, prefered collegue, etc.) of all actors (ward personnel as well as patients). The analyzed application scenario is modeled with Protégé[2]. The outcome is the task ontology [6] (see Figure 1, step 1). Ontology is an explicit specification of conceptualization. It formally defines objects in the scenario and relations among them. Domain ontology OntHoS [1] was used as a reference to develop the own task ontology. The concepts (T-Box) together with its instances (A-Box) were exported into the rule-based expert system JESS[3] as facts and rules (step 2). Rule-based expert system is used as an environment where the Problems Solving Methods (PSM) are implemented. These are scheduling heuristics and conflict solving mechanisms (step 3). It is then embedded into the multi-agent system JADE. JADE[4] is a FIPA-compliant multi agent system (MAS) that is used as a middleware. The outcome is the Jes-

[2] Protégé Home Page. http://protege.stanford.edu/ .
[3] Java Expert System Shell. http://herzberg.ca.sandia.gov/jess/ .
[4] Java Agent Development Environment, http://jade.cselt.it/ .

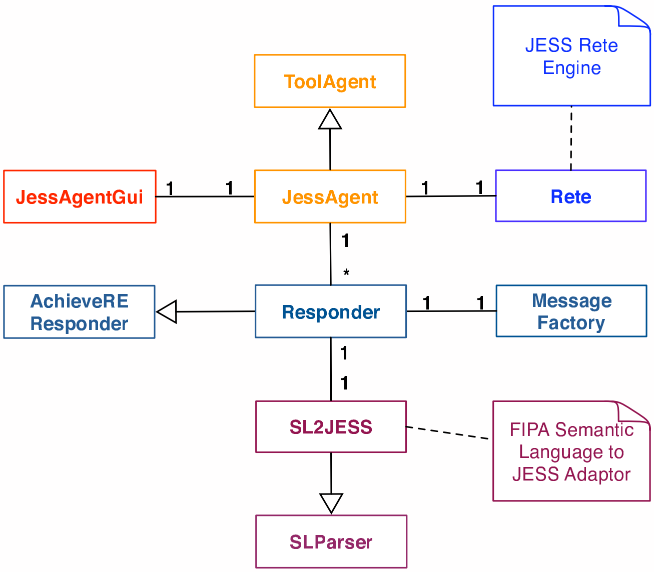

Fig. 2. Diagram of the JessAgent

sAgent[5] - a JADE-agent that has an embedded Jess engine (step 4). The ability to reason and act rationally is programmed in a rule-based expert system. Communications is facilitated by using a MAS. Further, all the agents (Scheduling Agent and Ward Agents) are started and the scheduling process initiated by the Scheduler Agent. The user interface for interaction with the planner as well as the generated subplans (based on ontological constraints) are provided by this agent. New scheduling tasks are added to the system by a wards' representatives with the help of Ward Agents (step 5).

The deployed Scheduling Agent is based on the JessAgents (see Figure 2), chosen for its suitable integration in the optimized development process. This means that the problem solving methods and the behavior of a JessAgent are written at a higher programming language, which does not require source code compilation. Task ontologies and problem solving methods are loaded at runtime as well as the new fact base, describing a possible change in the considered scenario. Inside of the JessAgent all the received messages (which are in FIPA-SL format[6]) are translated by the SL2JESS adaptor to JESS functions, evaluated in JESS and the answer is automatically generated by the MessageFactory object with respect to the used interaction protocol, speech act, content language and the agent's fact base. All the rules, facts, and functions of the agent can be accessed by the developer through the agents GUI.

[5] JessAgent Home Page. http://www-i4.informatik.rwth-aachen.de/agentcities/ .
[6] http://www.fipa.org/ .

3 Summary and Outline

This paper gives a short overview of the scheduling framework and tools, used to create a dialog-based semi-automated operation theatre scheduler. Staff timetables in medical departments are subject to lots of constraints, restrictions, and preferences. Scheduling of hospital personnel is particularly challenging because of different stuffing needs on different days and shifts, uncertainty between the offered capacity and the true demand, impossibility to predefine treatments' workflow.

We have divided the original problem into four sub-problems and provided a preference-based adaptive heuristics for each of them as described in [6, 5]. The system makes a schedule proposal and it is up to the responsible human actor either to accept, accept parts of the proposition, or to reject the schedule. The prototype was used for the comparison of different heuristic approaches. This allowed to conclude that the proposed algorithms bring a substantial improvement regarding the number of fulfilled wishes of the actors while selecting shift staff and team building, and helps to save expensive human resources that are currently used in hospitals for the manual scheduling. However, the preferences of the involved actors were randomly generated. Evaluations in a real-world setting would be of a great interest and will be made in cooperation with the university hospital.

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