Chapter 5

A Multi-Agent System for Improving the Resource Allocation on Programmes in Higher Education

Constanta-Nicoleta Bodea
Academy of Economic Studies, Romania

Radu-Ioan Mogos
Academy of Economic Studies, Romania

ABSTRACT

The chapter presents UNIRA, a multi-agent system developed by the authors for a Romanian university in order to improve the resources allocation for educational programmes and courses. Different types of resources are required to deliver programmes and courses. Considering a set of resources inquires, issued by programmes and courses, UNIRA system performs a transparent negotiation process between the managers of these resources, to find the solution for the allocation problem. During the initial stage of the multi-agent system deployment, only two types of resources are considered, professors and teaching rooms. The system is now in the validation phase. After the complete validation, the system will be integrated into the university management system. The UNIRA experience is relevant not exclusively for the academic resources management, but also for a large variety of domains, including the load distribution, production planning, computer scheduling, portfolio selection, and apportionment.

INTRODUCTION

The Bucharest Academy of Economic Studies (AES) is the most prestigious institution of higher economic and public administration education in Romania (www.ase.ro). AES has 11 faculties, over 30,000 students and 1600 didactical and administrative personnel. In 2011-2012, the university delivers 182 education & training programmes, based on a public budget, coming from the Education and Research Ministry, and also based on its own resources.
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Academic staff is the most important resource of the university. Without experienced and qualified professors and trainers, the educational programmes and courses cannot be successful delivered. Other important resources are proper equipped rooms, educational software, secretarial staff and financial resources. Only a small part of the activities are performed by the departments using their own resources. Most of resources are asked from other departments of the university. The resources allocation process is a negotiation process between departments of the faculty or between faculties. The university has an Enterprise Resource Planning (ERP) system in place. The information about the resources required for the delivery the education & training programmes are organized as a database, administered by the Educational Programmes Department, part of the ERP system. Even if the university is using this system, the resource allocation process is still done outside the ERP, because it is not able to perform negotiation-like processes.

RESOURCES ALLOCATION PROBLEM AND THE SOLVING APPROACHES

The resource allocation problem (RAP) is how to allocate available resources to the clients (scheduled tasks or agents, either cooperative or self-interested) in a way which maximizes the global utility (Dolgov & Durfee, 2006). RAP is relevant in many domains, such as: sociology and marketing (for ranking different objects according to consumers’ economic social preferences), product design, architecture and construction, operations, network routing, transportation logistics, bandwidth allocation and commercial transactions, just to name a few. The real-world applications usually work in complex environments, with high dimensionality, dynamic, non-cooperative and uncertain, which make RAP even more complex and difficult.

RAP is expressed as a Constraint Satisfaction Problem (CSP). RAP can be easily mapped into a list-coloring problem in a special kind of graphs called interval graphs. In this case, RAP is called restricted coloring or feasible coloring problem. It is known that the usual graph-coloring problem in interval graphs is linear, but the list coloring is NP-complete (Choueiry & Faltings, 1994). As an optimization problem, RAP is a multi-objective and over-constrained problem. Even if the optimality is rarely needed in the real-world situations, the optimal solution is expected by the users. For solving RAP, a centralized or distributed approach could be undertaken. A Distributed Constraint Optimization Problem (DCOP) is more adequate in a large problem space. In this case, the problem is split into agents, each of them having a specific set of variables and constraints as well as local optimization criterion. The goal is to find a feasible solution with the highest ranking by all agents (Ridder, Brett, & Signori, 2012).

Developing academic class timetable is a real-world RAP. This problem involves the allocation of students, teachers and rooms, within certain restrictions (related to the regulations, proper utilization of resources, and satisfaction of people’s preferences), for executing education activities in specific time-slots. Effective timetables for academic courses delivery are crucial for the efficient utilization of university resources and for ensuring the student satisfaction. Timetable is usually developed manually, based on valid solutions applied in the previous years. This approach does not even guarantee finding an optimal solution, even a valid one. The problem complexity is increasing when multiple criteria and types of classes are considered (Silva, Burke, & Petrovic, 2004). As hard constraints, the following could be mentioned: a student or teacher should have only one class at a time; a room should be booked only for one class at a time; a class should be assigned, at least, to one teacher; a class should be scheduled in a room having