A Review of Agent Based University Course Time Tabling Systems

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***Abstract*— In this paper, we carry out an extensive survey of various mobile agent systems that have been utilized in solving university course time tabling problem. University time tabling is an NP-hard problem which has been researched by vast amount of researchers. This is because it is a scheduling problem faced by many universities. This scheduling problem involves a number of hard (mandatory) constraints as well as soft (a lot more flexible) constraints that must be satisfied in order to generate an efficient time-table. A number of methods have been adopted in solving the university course time tabling problem such as the use of linear numberings, evolutionary algorithms, graph coloring among others. One recent technique employed involves mobile agents. Mobile agents are simply software agents which move from system to system within the network transporting both their state and code. They are not bound to the system where their execution begins. This work will involve the analysis of such systems used for university course timetabling in order to highlight their advantages and disadvantages.**

***Keywords*—Mobile Agent, University Course Time tabling, Hard Constraints and Soft Constraints.**

I. INTRODUCTION

A mobile agent is defined as a software agent that is not bound to the system where the execution is initiated. The agent is at liberty to pass through the various network hosts in the system. As soon as it is created in one execution environment, it is capable of moving with both its state and code into an alternative execution environment which is where it continues execution. When the word "state" is used, it refers to variables (values of the attributes) of the agent that it uses to decide on the next step to take as soon as it continues execution at its destination. While the term "code" refers to the class rules that the agent employs in execution. One characteristic of a mobile agent is the fact that it can move among systems in a network. This enables it to interact with other systems within the network and this is highly beneficial. Mobile agents have been found to be of great importance and so have caught the attention of researchers particularly because they enhance the creation of distributed systems [1].

[2] explain that when defining a mobile agent, two important words of interest must be addressed in the development of mobile agent systems. One of which is "autonomy" of the mobile agent. This attribute of mobile agents enable them act independently by utilizing their data and mobile logic that they include and require no assistance from humans. Mobility on the other hand, is the second key term associated with the definition of mobile agents. This attribute is essential for the movement of the agents to the location (host) where the data is physically stored. This prevents the transmission of huge quantities of data in the network. The data are locally accessed which makes only the results accessible to the user. This ensures reduced network traffic as well as improved usage of the resources in the network. Also, according to [3] any software agent that can move are called mobile agents. This implies that the agents can move from host to host. This feature of mobility has numerous advantages.

University course timetabling is a type of scheduling problem that involves the allocation of activities to slots in resources that are available while fulfilling some constraints. These activities usually take place within a specific time frame and require a number of resources in order to carry out the activity. There is also an order in which the activities are carried out which is usually based on their priority levels. Also, how and in what quantity resources are allocated to the activities are also determined based on priority. High priority constraints are termed hard constraints, which are the constraints that must be met and cannot be violated in order to ensure the generation of an efficient time table. Soft constraints on the other hand, are called preferences which reflect the desires of the users of the time table. Inability to satisfy the soft constraints will lead to a good but not so efficient time table. One way of explaining and solving this problem is through the use of constraint programming (CP).

A number of mobile agent systems have been used in university course time tabling and they will be discussed in the following section. The rest of the paper is organized into two sections. The second section includes a review of all related literature. Finally, section three concludes our survey as well as presents possible future work.

II. RELATED WORK

In this section, all related literature are reviewed as follows; [4] presented a multi agent system for university course time tabling that is based on intelligent decision making. In the system developed, the autonomous feature of agent technology is harnessed with both course agents which signify the courses to be allocated and signboard agent which carryout allocation and

negotiation of courses. The system leads to a highly intelligent and flexible timetable system. [5] carryout a study of the effect of agent technology in University timetabling. They present an open, distributed and very detailed timetable solution. [6] propose a web-based multi-agent interactive timetabling system. The system comprises of agents for both time and room allocation and resolution. The system is wholly automated and efficient. In the work of [7] titled implementation of class timetabling using multi agents, the authors develop a means of solving the course time tabling problem using multi agents that utilize hill climbing algorithms with steepest ascent. The agents attempt to create the largest number of input combinations for the timetable as well as combinations that result in the least value for the evaluation function. Their system provides an efficient time table using better heuristics. [8] design a multi-agent approach system for distributed course timetabling. They generate a timetable using multi-agents that employ graph coloring and local search heuristics. Their proposed design deals with the timetabling problem via a solution environment that is distributed. [9] in their research work titled a multi-agent system for University course timetabling present a resource negotiation, agent based system for timetabling. Their system is beneficial for efficient and flexible negotiation, providing a clear means of resolving conflicts and provide a good depiction of a number of real-life applications.

[10] in their work, a multi-agent architecture for distributed timetabling present an architecture comprising of three cooperating agents. The agents are termed; solver (which creates the solution using a number of search strategies), the negotiator (that does the negotiation) and the manager (that manages the timetable). Their proposal follows a transactional negotiation for the limited resources (space and time) and their work promises to be effective. In the work of [11] a system for distributed timetabling based on negotiation among scheduling agents is presented. They view course sharing as a relationship that exists between a supplier and a consumer. They employ methodologies in constraint satisfaction problem in solving the timetabling problem. They do this by making time allocations as values for the domain and lectures as variables . Also they have room agents that try to negotiate for the limited rooms. Mainly the architecture comprises of first, a scheduling section, then a protocol that negotiates for the generation of the university timetable, and finally a protocol for the negotiation between the scheduling and the room agents. Also, [12] introduce a way of enhancing the university timetable solution using multiple agents. In their work, the initial solution generates a not so efficient timetable using finite domain constraint programming. However, further into their work they optimized the performance of their timetable using multi-agent technology.

Furthermore, [13] proposed a mathematical model for solving the University timetabling problem using multi-agent system. Their solution is based on the JADE platform and it provides a user friendly timetabling solution. [14] study the significance of negotiating agents in timetabling. They also outline how conflicts can be resolved in timetabling through the cooperation and collaboration of agents. [15] develop a model for solving the timetabling problem through the use of cooperative agents, they present a feasible solution. [16] present a means of solving the university course timetabling problem using agent technology. They use agents to satisfy the constraints in the timetabling problem and provide a highly adaptive yet general, dynamic and modularized solution. [17] in their literature titled emergent timetabling by cooperative self organization, highlight the benefits of cooperative agents in timetabling. They highlight that based on cooperative behaviors using local rules optimal timetables can be created. They present a highly adaptive, operational and robust solution. In the work of [18], they recognize the importance of having scheduling agents while generating a timetable solution. However, they establish the need for a central agent that manages the way these scheduling agents carryout their search. This central agent works based on a number of heuristics and an efficient solution is obtained. [19] create a multi-agent system architecture for university timetabling. They take into account the various constraints and evaluate the communication process of the agents as they attempt to satisfy the constraints.

[20] in their work discuss a mobile agent based model for university course timetabling. They employ a number of agents such as course, sign board, publisher and interface agent which negotiate to arrive at a feasible timetable. They take advantage of the autonomous nature of agents to derive a highly adaptive timetable. [21] present a technique in solving distributed and dynamic constraint satisfaction problems using metaphoric bench marks based on emotional criteria. They apply their findings to the university timetabling problem using software agents. Their design is based on agents that exhibit autonomy and their research has shown some level of success. [22] also introduced a multi agent system for automated timetabling that involves resource sharing. They achieve feasible timetable solutions through the interaction of agents that employ their own algorithms. They carryout scheduling based on priority which is usually determined by some predefined requirements. The work of [23] provide a solution for university course timetabling that is highly efficient in satisfying a number of hard and soft constraints of the system. Their method is simple and makes use of agents that cooperate in order to generate an optimal timetable. All these are the related works surveyed in the subject of discourse and to the best of our knowledge contain all literature pertaining to the topic of interest.

III. CONCLUSION AND RECOMMENDATIONS

In this work, we carried out an extensive review of literature in the application of agent technology in university course time tabling. Each of the systems have been analyzed and studied. A number of the research work take advantage of the features of agents such as autonomy, cooperation/negotiation, flexibility, scalability, modularity among others. Further review work can include a comparative analysis of other application areas of mobile agent technology such as areas in network security and monitoring, other scheduling problems to mention a few.

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