A Multi-Objective Approach for the Project Allocation Problem

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ABSTRACT

In this paper, a novel system is presented for the allocation of final year projects for the Computer Science and Engineering Department at the University of Mauritius. Earlier works had concentrated only on the allocation of projects to students. The system not only performs project allocation but it also allows academics to rate projects, examiners to bid for projects they wish to examine, students to propose their own projects, students to submit project deliverables, supervisors to follow projects more closely and allows projects coordinators to have a heuristic view of the whole system. The system captures the preferences of examiners as well as students and allocates projects to them in order to maximise the number of students who gets their first choice in their preference list and to keep the load of supervisors and examiners within a reasonable range. The percentage of students who obtained their first choice is 82% on 30 projects proposed by 15 supervisors for 11 teams. The simulation results demonstrate that this new system will allow deadlines for all the different project phases to be met.

Keywords

Project Allocation, Examiner Allocation, teams, supervisors, resources, projects, examiner bidding, project rating

1. INTRODUCTION

The Computer Science and Engineering (CSE) Department of the University of Mauritius is composed of 36 academic staffs supported by 9 technical staffs. It is one of the youngest departments of the Faculty of Engineering. It is devoted towards quality teaching, research in advanced areas of computer science and consultancy work. The department is equipped with a number of laboratories, where students have facilities, in terms of hardware, software, network infrastructure and internet access to be able to carry out their practical work and assignments [1].

For every undergraduate student of the University of Mauritius, there is a final year project (FYP) which needs to be taken. The project carries nine credits and a report must be submitted for marking. Furthermore, some faculties have viva-voces while others have oral presentation.

Resource allocation is the distribution of the available resources in an economically manner. The allocation of project is like a subset of the resource allocation problem. The allocation of projects should be done fairly for both the lecturers and students [2]. The resources are the projects, students and academics. The same academics act as both supervisors and examiners but for different projects.

The project work is assigned at the beginning of Semester 1, that is, at the start of August and must be submitted by the end of March in the following year. Each student or team of two or three students is expected to spend about ten hours per week over twenty-six weeks on their projects. The final year project provides the student the opportunity to develop their problem solving, analytical skills and evaluation and programming skills. A typical project format would require the student to see how some aspect of theory, software or hardware that they are familiar with and that can be enhanced or developed into a product or a hardware/software tool.

2. BACKGROUND STUDY

The problem of project allocation crops mainly in the Computer Science and Engineering department in the University. It has a student population of about seven hundred. The CSE department consists of three undergraduate programmes which are the BSc (Hons) Information System, the BSc (Hons) Computer Science and the BSc (Hons) Computer Application. The lecturers who teach in these three programmes are the same. Each year the CSE department experiences a problem while allocating projects for the final year students. These problems are mainly due to the fact that year after year, the number of students keeps increasing and this leads to an increase in the complexity in the allocation of the projects. There are also constraints such as supervisors' workload which plays an important role in the allocation of projects. All supervisors should have more or less the same amount of projects to supervise. The lecturers need to propose a certain number of project titles for all the three programmes.

Together with the allocation of projects and supervisors, another important allocation is that of the examiners. Examiners will be the person in charge to assess the final year projects. One examiner is currently assigned for each undergraduate project. This is done in a transparent way according to their area of expertise and experience in their respective fields.

The allocation of projects is part of a degree course for most universities. However, before the allocation of projects to students is done, there is a series of steps which need to be performed. Many constraints need to be taken into consideration to achieve a fair allocation. The allocation of project causes many problems as same constraints may not be satisfied. The aim is to achieve a better system which will solve all these problems or at least reduce them significantly.In the previous years there were only two programmes in the CSE department which were the BSc (Hons) Information System and BSc (Hons) Computer Science and Engineering. During these years, the project titles proposed were for both Information System and Computer

Science and Engineering students but this was later found to be a problem since the syllabus of the programmes were different. This was unfair to many students as students from the BSc Information System's stream were working on projects involving largely on Computer Science disciplines but they were never thought such subjects. The same would be said for BSc Computer Science students who had to work on the development information systems. This created a problem, so the allocation of projects is now done separately for each programme.

The distribution of the projects is made such that each lecturer supervises a certain number of projects, whether the projects are done in groups of two or individually. Ideally, the allocation of projects should be done in one round. However, in some cases there are some students who are not allocated any projects after the first round, so a second round is performed. This can happen when students do not submit their project selection form on time, they have not yet formed a team or when students are not allocated any of the projects in the list as all of them have been allocated to other students. A third round is sometimes necessary as well.

Projects examiners also need to be assigned. In previous years, examiners were assigned one week before the final presentation of the project. This created problem like examiners found that projects given to students did not had an adequate level of complexity suitable for a final year project or that their field of expertise did not match the project they are given to examine. Also they did not have sufficient time to understand the whole project. This penalised students as they had no other opportunity to improve their work. For the current academic year (2012-2013), there has been a major change in the system. Examiners are now allocated to projects at the very beginning of the project management phase. This will help to eradicate the problem faced in the previous years. A poster presentation was also held in mid-January to allow all academics, especially project examiners, to have a look at the projects and to suggest improvements. However, as in previous years, students do not know who their examiners are. By doing so, it is expected that the whole system will now be fairer to everyone.

3. LITERATURE REVIEW

[3] presents two solutions for the project allocation problem. In the first model, every student is allocated one project at random so that each supervisor has at least one project to supervise. In the second model, students choosing the same title will form groups so that they can work on the same project. The first solution is hardly a solution as students cannot choose on which projects they wish to work. For the second one, the students who form groups may not know each other well and may have some communication difficulties in the beginning. There are also cases where more than two students select the same project. This solution does not cater for a fair distribution of project, supervision workload across supervisors.

In AssignProj [4], initially, lecturers were asked to submit up to three projects which are will be evaluated based on the level of investigation and are then modified accordingly. After this process, students are emailed these projects for them to make their selections. They will have 10 selections to make and they will be assigned to their first choice unless there is contention where they will be allocated to any random project found in their respective selections. With the new proposed solution, there are different cycles which are carried out, for the allocation of projects starting from the first choice for everyone then with the remaining student their second choice is taken into consideration. This decreases the number of unassigned projects. If there is still student unallocated to project a second is done, and the student will make choices again. This process could have been easier if the allocation instead of making different rounds were done for one student at a time that is, if the student first allocation were not done then his second to tenth choice is checked and allocation is done.

Moreover, in [5] the system matches students having preferences over projects along with the lecturers having preferences over students. Students are first matched to the best project that he could obtain. The algorithm is applied again so that the lecturers could get the best group of students to supervise. In this system, students having low academic grading can be penalised. To solve this problem, the SPA-P [5] algorithm was implemented. This handles cases where two or more lecturers would like to choose the same group of students and cases where students have not been selected by any lecturer.

In [6], before the start of semester one, each staff member (project supervisor) is requested to submit up to four project titles together with a small description. They are also expected to give any other piece of information that will help the student to understand the project well. Each project is given a unique project number and is hosted online (WebCT) for the students to access it. In the first week, students are allowed to browse through the list of projects and discuss them with the respective supervisors. However, no project will be allocated until the start of the second week. Project allocation starts in week two and the process is conducted via email. A project is allocated to a student if both parties, that is, the student and the supervisor agreed and confirmed on the same project number. The concept of first come first served is applied. With this system there is still the problem of 'popular' titles where large amount of students are attracted to a small number of projects.

In [7], supervisors have to submit a list of their proposals in a structured format to the secretarial staffs. A document with all project titles is then provided to students to make their choices. Later in the year, students are allowed to meet the supervisors and discuss about the projects. During this meeting, the supervisor elaborates on the skills required for the particular project. He can then advise the student whether he can do this project or not. However, the final decision of selecting the project remains entirely on the student. Since it is almost impractical for a supervisor to meet all the students twice, allocation is normally done on a 'first come, first served' basis even though the student may not have all the appropriate skills for the project.

A technique known as Goal Programming formulation [8] attempts to allocate a maximum number of projects taking into consideration both students and staff preferences. The model in has three hierarchical goals. The first and the most important goal is to allocate the maximum number of projects. Secondly, to maximise the total satisfaction of the students and thirdly, it minimises the dependency of Grade Point Average (GPA) for the allocation of the projects. A fuzzy algorithm was proposed in [9] to solve the project allocation problem. The students have to submit a list of eight projects in order of preference. Their Cumulative Average Point (CAP) is used to classify the students from zero to five. The algorithm uses a probabilistic approach (Pareto-Optimal

Method) to assign projects to appropriate students taking into consideration its priority, the supervisor's workload and a balanced spread of good students across supervisors. Students who do not obtain any projects are allocated a random project from the list of unallocated projects.

The Bioscience departments, within the UK Higher Education (HE) [10], conducted a survey to identify their method of allocation. It was found that 69% of the departments allocate project based on the list of preferences submitted to students. 64% allocates projects based on direct discussion of the student with academic staff, 50% uses student performance to allocate projects if there is contention, 43% ask students to indicate their own area of interest and the supervisor with whom they want to work with, 14% also ask their students to identify the fields they do not want to work in and finally, 4.3% allocate projects randomly. Another interesting study was done in [11] to compare, contrast and evaluate the different procedures that are used to allocate projects.

There is considerable work in the literature, which proposes solutions for the project allocation problem. However, none of them have created a benchmark which allows comparisons between the outputs from the different systems. Thus, in this paper, a new framework has also been proposed to allow researchers and other institutions to compare their work with each other. Table 1 shows the features of existing works.

Table 1. Comparative Analysis of existing techniques

	Student Project Selection	Lecturer Selects Student	Second Round	Student Proposed Project	How contention is resolved?
[3	Yes	No	No	No	Group students
[4	Yes	No	Yes	Yes	Assessments
[5	Yes	Yes	No	No	Not available
[6	Yes	Yes	No	No	FCFS
[7	Yes	No	No	No	FCFS
[8	No	No	No	No	GPA
[9	Yes	No	No	No	Random

4. DESIGN AND IMPLEMENTATION

The project allocation algorithm is based on the principles of the Marriage algorithm [5] which helps to allocate projects to teams. Students forms team and register themselves in order to perform project selection. Each team needs to select ten projects from their respective programme. Examiners are only allocated projects for which they have shown interest.

Firstly, all the first choices of the different teams are retrieved. The project is allocated to the team unless there is contention in which case the team with the highest CPA is allocated to he the project. Next, the second choices for all students who have not yet been allocated a project are considered. This process is repeated until all students have been allocated a project. Each project can only be allocated to only one team. Sometimes, it becomes necessary to perform a second round if ever there are some students who have not obtained any project. Examiner allocation is similar to project allocation except that a seniority list is used to resolve contention instead of CPA. The complete algorithm is shown in Fig. 1.

5. EVALUATION OF RESULTS

Using thirty projects for eleven teams and fifteen supervisors, there are 82% of first choices which are allocated to teams. Only students from the BSc (Hons) Information System programme were considered. Each team has a priority list in which the projects and project choices are saved. Number one has the highest priority while number ten has the lowest.

Table 2. Percentage of First Choice in Manual System

Course		BSc Information System	BSc Computer Science	BSc Computer Application
Manual System	**First Choice**	9	12	8
	Non-First Choice	7	15	9
	% of First Choice	**56**	**44**	**47**

Table 2 shows the percentage of students who have been allocated their first choice in each of the three programmes. This results obtained are based on a sample of students only. Nevertheless, it is seen that the percentage of students obtaining their first choice is considerably less than what was obtained in the proposed system.

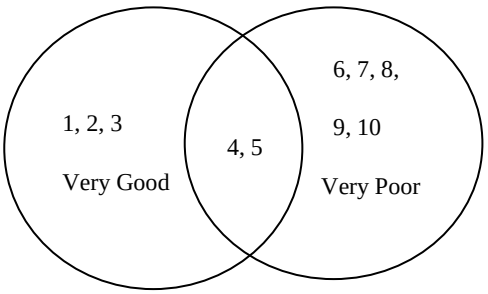

Figure 1. Satisfaction Framework

This range is based upon the level of satisfaction that a team receives after obtaining the result of the project allocation process. A performance metric which will give us an overall assessment of the efficacy of the allocation made by the system has been derived. This metric classifies the first to third project's choices as a very good allocation, the fourth to fifth choices as satisfactory and the others as very poor allocation. A ratio known as the Average Priority of Choice Allocated (APCA) is computed to assess the whole system.

The APCA is obtaining by adding the priority of each allocated project from the initial allocation list divided by the total number of projects allocated. In this simulation, nine teams got their first choices, one team got its second choice and one team got its third choice. Thus, the APCA produces a ratio of 1.27, which when compared with the classification above, implies a very good allocation.

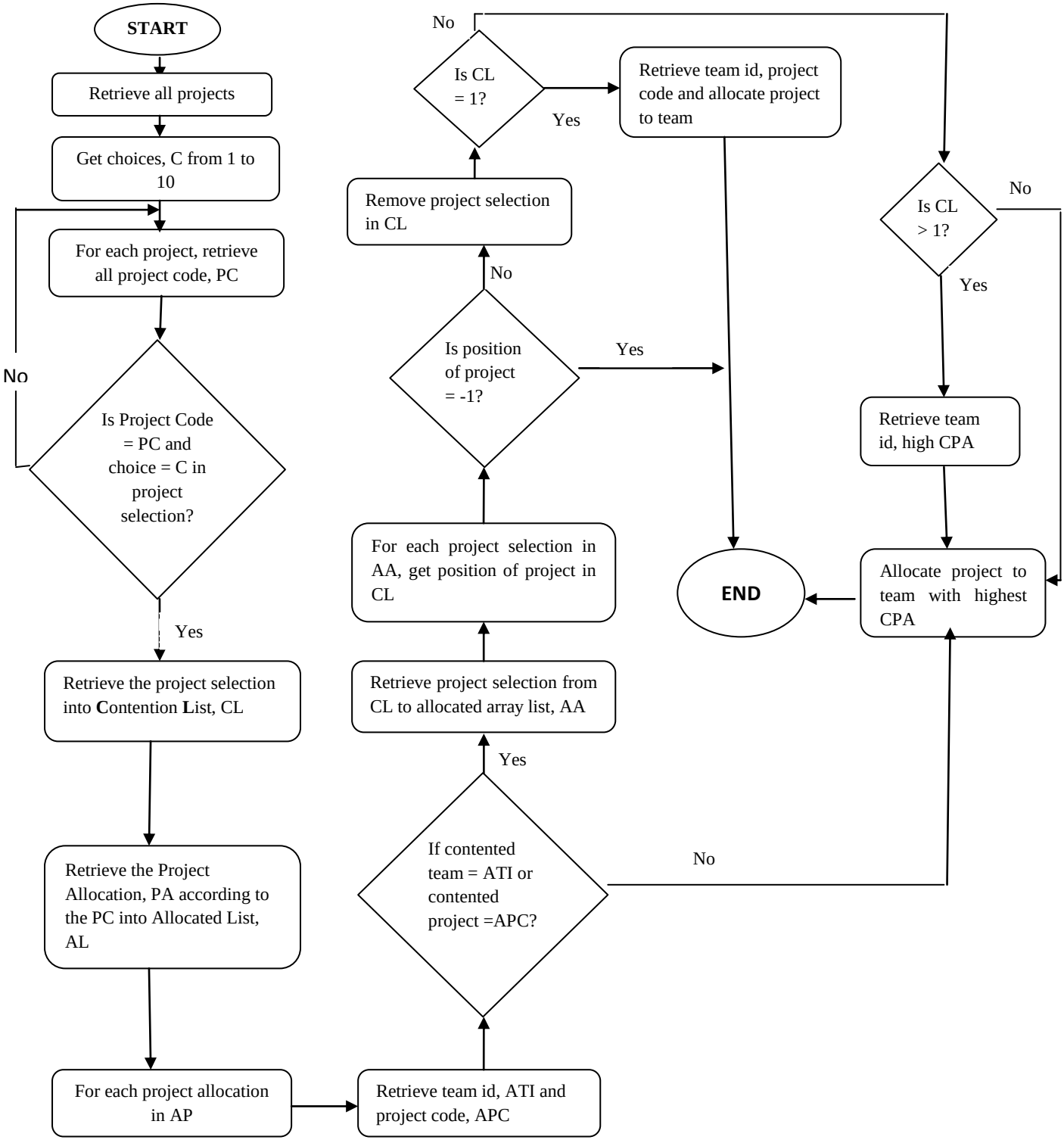

Figure 2. Allocation of Projects

6. CONCLUSION

The simulation results demonstrate that the multi-objective resource allocation algorithm is able to provide solutions to many of the problems inherent in allocation of resources. The solution not only caters for the allocation of projects to students but it also has many innovative features which have never been considered before in previous works. Indeed, the system also handles the allocation of examiners to projects based solely on their interest to supervise a project or not. A performance metric has also been devised to allow different allocation systems to be compared and hence evaluated. This metric shows that the algorithm does extremely well in allocating projects. With slight modifications, the system can also be adapted to manage assignments and mini-projects as well. In the future, different algorithms will be implemented to do the allocation and then they will be compared it with the current one.

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