Non Linear Great Deluge Hyper Heuristic with Reinforcement Learning for Scheduling Problem

Ei Shwe Sin, University of Computer Studies, Yangon
eishwe.3l@gmail.com

Abstract

Nowadays, scheduling problems arise in almost all areas of human activity. To handle the complexity of the real world scheduling problems, many researchers have been invested over the years. Currently research is being directed to raise the level of generality. Therefore, this has led to the development of hyper heuristics system. A hyper heuristic is high level problem solving methodology that performs a search over the space generated by a set of low level heuristics. A motivating goal of hyper heuristic research is to create automated techniques that applicable to a wide range of problems with different characteristics. One of the hyper heuristic frameworks is based on a single point search containing two main stages: heuristic selection and move acceptance. By using exam timetabling problem as a test bed, this paper proposes the non linear great deluge hyper heuristic with reinforcement learning method to intend to improve the performance of hyper heuristic

1. Introduction

The University Exam Timetabling Problem (UETP) has been attracted significant research interest over the years. It can be tackled by using a wide range of exact methods, heuristics and Meta heuristics and so on. There are several hyper heuristic approaches have been proposed to solve the exam timetabling problem in the literature. It is possible to consider methodologies based on perturbation low level heuristics and those based on construction low level heuristic.

Early research works on hyper heuristic focused on the development of advanced strategies for choosing the heuristics to be applied at different points of the search. For example, Soubeiga used a choice function that incorporates principle from reinforcement learning [2]. Another mechanism based on tabu search was proposed by Burke et al. in which a tabu list is used to prevent the acceptance of low level heuristics with poor performance [4].

Likewise, researchers have proposed different acceptance criteria to drive the selection of low level heuristics within a hyper heuristic framework. For instance, Ayob and Kendall used a Monte Carlo acceptance criterion while Kendall and Mohamad used the great deluge acceptance criterion [3].

In this paper, we study a non linear great deluge acceptance criterion hyper heuristic in order to choose which low level heuristic to apply while solving exam timetabling problem instances. Section 2 describes the exam timetabling problem while Section 3 reviews previous hyper heuristic methods. In Section 4, the proposed non linear great deluge hyper heuristic method is presented. Finally, conclusions and future research is the subject of Section 5.

2. The University Exam Timetabling Problem

The university exam timetabling problem is a challenging task which represents a difficult optimization problem and finding an optimal solution is complicated and very time consuming. It is one of the most important administrative activities that take place in all academic institutions. It can be defined as assigning a set of $E=e_1, e_2, e_{3...} e_e$ into a limited number of ordered timeslots (time periods) $T=t_1, t_2, t_{3...} t_t$ and rooms of certain capacity in each timeslots $C=C_1, C_2, C_3 \ldots C_{t,}$ subject to constraints.

In a more formal way, the timetabling literature defines two types of constraints

a) Hard Constraints

These are the constraints that must be satisfied at all times. The principal hard constraints are the requirement that not a single student is enrolled for two exams scheduled in the same timeslot. Another hard constraint that needs to be obeyed is the room capacity; i.e. there must be enough spaces in a room to accommodate all students taking a given exam.

A timetable, which satisfies hard constraints, is called a feasible timetable.

b) Soft Constraints

Soft Constraints are not critical but their satisfaction is beneficial to students and/or the institution. An example of a soft constraint is the requirement to spread out exams taken by individual students so that they have sufficient revision time between the exams they have sufficient revision time between the exams they are enrolled on. Typically one cannot satisfy all soft constraints thus there is a need for a performance function measuring the degree of satisfaction of these constraints [2].

3. **Related Works**

In recent years, hyper heuristics have been increasingly used to solve a wide range of optimization problems. Fisher and Thompson are probably the first researchers to use the idea of a hyper heuristic for the job shop scheduling problem. They proposed random hyper heuristic based on probabilistic weighting to guide the selection of the heuristics.

The hyper heuristic operated at a higher level of abstraction than Meta heuristics, managing a set of low level heuristics (LLH) without knowledge of the problem domain. The most appropriate heuristic is determined and applied automatically by the technique at each step to solve a given problem. Typically, a hyper heuristic can conduct with a single point or motile point search. A single iteration of a hyper heuristic method can be decomposed in two stages, heuristic selection and movement acceptance. Some previous studies show that different combinations of heuristic selection and move acceptance as hyper heuristic components might yield different performances. According to the literature review, some researchers study on heuristic selection methods while the other emphasizes on move acceptance methods.

The performance of a hyper heuristic depends on the set of heuristics it can be choose from. Also, due to the performance changes of a number of heuristics over a search space, it is not easy to find a heuristic that always produces the best decisions. For these reasons, different learning strategies have been employed to make better selection of heuristics.

Some studies concentrate on move acceptance in hyper heuristic rather than upon heuristic selection methods, as accepting a move turns out to be an extremely important decision. The movement acceptance can be deterministic or nondeterministic. Being the non linear great deluge is proposed to use as move acceptance criteria within hyper heuristic in this paper, we would review these methods.

One of the non deterministic acceptance criteria is the great deluge algorithm, which is proposed by Dueck in 1993. It uses a threshold that decreases in time at a given rate (e.g. linearly) to determine an acceptance range for the solution qualities based on three main parameters:

1. The maximum number of iterations (or total time)
2. The number of iterations (or time) passed and
3. An expected range for the maximum fitness change between the initial and final objective value (e.g., lower bound).

In In the case of an improving move, it is accepted, while a worsening move is accepted only if the objective value of the resultant candidate solution is less than the computed threshold at a given iteration.

Bykov Y. proposed the time-predefined great deluge algorithm and Trajectory base search to exam timetabling [7].In 2006 ,Edmund K. Burke and Yuri Bykov made an extension of the great deluge algorithm (which they called “Flex-Deluge”) where the acceptance of uphill moves depends on a “flexibility” coefficient, for solving exam timetabling problem. Good results were presented and they suggested that the flex deluge method is relatively higher effective in the large-scale problems [4].

In recent, McMullan proposed an extended great deluge algorithm(EGD) for university course timetabling , which allows re-heating similar to simulated annealing, and found new best results for the 5 medium instances. Finally, for course timetabling problem, a non linear great deluge algorithm (NLGD) was proposed by Landa-Silva and Obit. That method produced new best in 4 out of 11 course timetabling problem instances of datasets [3]. Bilgin et al. (2007) also reported that a simple random-great deluge hyper heuristic was the second best after choice function-simulated annealing, considering the average performance of all hyper heuristic over a set of examination timetabling problems.

According to the literature of hyper heuristic, the great deluge and non linear great deluge algorithms are often incorporated as the move acceptance method. Recently, Ender Ozcan et. Al has proposed the great deluge based hyper heuristic with reinforcement learning for exam timetabling problem [4]. Given the success of the great deluge in hyper

heuristic, our aim here is to investigate whether non linear great deluge can be further improved in hyper heuristic or not.

4. Non Linear Great Deluge Hyper heuristic with Reinforcement Learning

Machine learning techniques, now, are vital for hyper heuristics to make the right choices during the heuristic selection process. Learning can be achieved in an offline or online manner. An online learning hyper heuristic learns through the feedback obtained during the search process while solving a given problem.

One of the machine learning techniques, reinforcement learning, is incorporated in most of the existing online hyper heuristics [4]. In this paper, it will be also incorporated with non linear great deluge to select the low level heuristics to apply at each step of the search process as shown in the figure 1.

In figure, the NLGD acceptance criterion refers to accepting improving and non-improving low level heuristics depending of the performance of the heuristic and the current water level B. Improving heuristics are always accepted while non-improving ones are accepted only if the detriment in quality is less than or equal B. The initial water level is usually set to the quality of initial solution and then decreased by a non- linear function proposed as follow:

$$B = B * (\exp^{-\delta(rnd[\min,\max])}) + \beta \qquad (1)$$

The various parameters in Eq.(1) control the speed and shape of the water level decay rate. In fact, we expect to test this proposed framework by using on the Toronto exam timetabling benchmark data sets. Therefore, the experimental results will be analyzed and reported in the next conference.

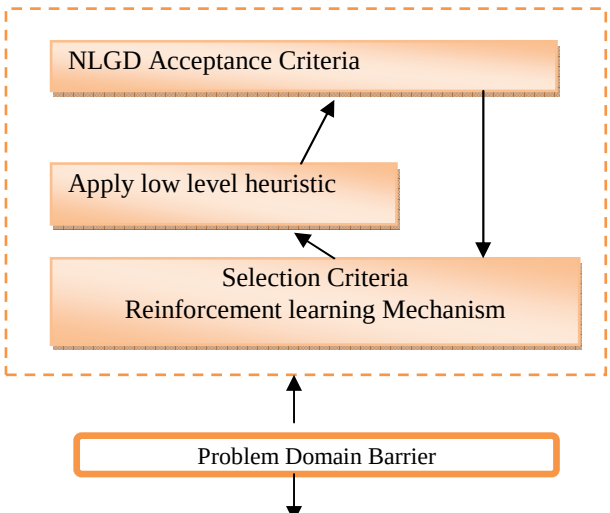

Figure 1: Non-linear Great Deluge Hyper Heuristic Approach

5. Conclusion

Hyper heuristics are starting to prove themselves as fast and effective methods for solving complex real world optimization problems. The performance of hyper heuristics is determined to a great extent by the quality of low level heuristics used. In this study, we intend to apply the proposed method to well-known instances of the university exam timetabling problem proposed by Carter et al. Within a hyper heuristic, although determining the best adaptation rate of reinforcement learning scheme seems to be a key issue, the proposed non linear great deluge hyper heuristic is expected to achieve the best performance results.

References

[1] Siti Khatijah Nor Abdul Rahim, Andrzej Bargiela, Rong Qu, *"Granular modeling of exam to slot allocation"*, School of Computer Science].

[2] E. Burke, G. Kendall, E. Soubeiga. *"A tabu-search hyperheuristic for timetabling and roistering"*, Journal of Heuristic, 9:451-470, 2003.

[3] E. Soubeiga. *"Development and application of hyper heuristic to personnel scheduling."* PhD thesis, School of Computer Science, University on Nottingham, UK, 2003.

[4] H. J. Obit, D. Landa-Silva,D. Quelhadj , M. Sevaux, *" Non-Linear Great Deluge with learning Mechanism for Solving the Course Timetabling Problem"*, MIC-2009: The VIII Met heuristic International Conference..

[5] E. Ozcan, M. Misir, G. Ochoa, E. K. Burke , *" A reinforcement learning- great deluge hyper heuristic for Examination Timetabling"* , In: Journal of Applied Met heuristic Computing, 1(1), 39-59, January-March 2010.

[6] E. K. Burke, Y. Bykov , *"Solving Exam Timetabling Problems with Flex-Deluge Algorithm"*, PATAT 2006, pp. 370-372. ISBN 80-210-3726-1.

[7] E. Burke , Y. Bykov et. Al, *" A time-perdefined local search approach to exam timetabling problems*" .