On Quality of Schedule for Resource Constrained Project Scheduling Problem

Thesis Summary

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Scheduling concerns the allocation of limited resources to the competing jobs over time. This decision problem exists in lots of manufacturing and production systems as well as in most of the service industry and information-processing units. Several methods have been proposed for scheduling of jobs under different constraints for different types of objectives. The quality of the solution given by these methods is represented by its proximity to the optimal solution. These methods take values of the parameters as inputs and give schedule as output. In most of the cases, the parameters of the problem are not known and are estimated based on the domain knowledge and past experience of the manager. So there is some amount of uncertainty embedded in these estimates. The uncertainty can be at two levels:

1. At the planning level when the manager may not be very sure about the estimates of the parameter itself and

2. At the implementation level when the manager gives a deterministic estimate of the parameter, but they change while executing the schedule.

For example if the manager is risk-averse, he may provide the estimates in terms of a random number or a fuzzy number or any other measure which captures vagueness in the estimation. In the second case where the manager is very confident about his estimates and gives deterministic estimates of the parameters. But these estimates

may not hold while executing the schedule, thus making the schedule inefficient. So a schedule which is robust enough to take care of these uncertainties to some extent should be a preferred schedule.

In this thesis we propose a new and more complete perspective of quality of a schedule. Our argument, which is based on the definition of the quality given by ISO 9000 guidelines, is that the quality of the solution should not only be the measure of its closeness to the optimal solution, but should also represent its ability to take care of these inevitable perturbation in the data set. So the quality of a schedule generated by any method should also be a measure of its robustness in case of uncertainty in the execution phase and it should also be capable of taking different types of inputs.

We use the Resource Constrained Project Scheduling Problem (RCPSP) to discuss the quality of schedule as discussed above. We consider the RCPSP with renewable resource of several types, single mode activities without preemption and minimization of project completion time as the objective. We devise a priority rule for scheduling of activities at a time which takes care of the precedence and resource constraints of the problem. The priority rule considers the criticality of the activities as well as the resource utilization as the important factors for scheduling of activities. We use this priority rule for a new schedule generation scheme which schedules a set of activities at a time. This method generates a non-delay schedule.

The first measure of quality of the schedule is the measure of the proximity of the schedule to the optimal schedule. We use the proposed method to generate the schedule for the benchmark problems of PSPLIB given by Kolisch and Sprecher. The proximity of the schedule to the optimal schedule is measured by the deviation of the time taken by the proposed method to the optimal project completion time. For the cases where we do not know the optimal solution, we use the critical path based lower bound as a proxy for the optimal solution and calculate the deviation from that bound.

The second measure of quality of the schedule is the measure of its robustness. To

measure the robustness of the solution generated by this method, we do a sensitivity analysis of the schedule generated by the method. We measure the allowable change in the estimated value of the parameters such that the schedule generated with the estimated values and the changed values remains the same. Sensitivity analysis of heuristic solution is different from the sensitivity analysis of optimal solutions. Although, heuristic methods are more popular than optimal methods, the sensitivity analysis of heuristic methods has not received due attention. Sensitivity analysis of optimal solutions for any combinatorial optimization problem has been studied in detail, whereas sensitivity analysis of heuristic solution has not yet been defined properly. We discuss the property of sensitivity analysis of heuristic solution in general and then concentrate on the sensitivity analysis of the proposed heuristic. In this thesis, we consider the change in the activity duration only. In the case of variation in the duration of only one activity we derive the expression of the maximum allowable change in that parameter. In case where the duration of all the activities change from the estimated value simultaneously, we calculate a bound on the probability that the schedule would change. We find out that if we use the method proposed in this thesis, the robustness of the schedule generated by the proposed method increases with the increase in the dispersion in the activity duration.

The third measure of quality, as defined in this thesis, is to check whether the method can take care of the uncertainty at the planning phase and can work well with different types of inputs. To check this we extend the method for fuzzy and random inputs. We first use fuzzy activity duration and use the proposed method to generate schedule for problem taken from the literature. While using our method with fuzzy inputs, we propose the concept of shifting critical path, which is similar to the concept of criticality index in scheduling with random activity times. We also propose a measure to find the non-integer exponent of a fuzzy number. We also use the method with random inputs. We show that the method gives at least as good schedule as given in the literature in case of fuzzy or random inputs.