Augmented heuristic algorithm for multi-skilled resource scheduling

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ABSTRACT

Conventional project scheduling is restricted to single-skilled resource assumption where each worker is assumed to have only one skill. This, in effect, contradicts real-world practice where workers may possess multiple skills and, on several occasions, are assigned to perform tasks for which they are not specialized. Past research has shown a simple process of heuristic approach for multi-skilled resource scheduling where a project is planned under the assumption that each resource can have more than one skill and resource substitution is allowed. Nevertheless, the approach has presented resource substitution step where an activity with higher priority can claim any resource regardless of its concurrent activities' resource requirements. Furthermore, the approach is subjected to all-or-nothing resource assignment concept where an activity cannot start and resources are not needed for that activity at all unless the required resources of that activity can be completely fulfilled. This research presents an alternative heuristic approach for multi-skilled resource scheduling in an attempt to improve the resource substitution approach. Augmented resource substitution rule and resource-driven task duration are presented to increase starting opportunity of activities on earlier time. Case studies are presented to illustrate the improved result of shorter project duration.

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1. Review of resource-constrained scheduling

Conventional project scheduling assumes each resource to have only one skill. However, the assumption contradicts real-world practice where workers may possess multiple skills and, on several occasions, are assigned to perform tasks for which they are not specialized due to limited resource availability. Furthermore, several past studies have shown that the single-skilled resource scheduling has produced solutions to the inefficiencies in resource utilization, thus bringing substantial increase of the duration extension and unnecessary cost (e.g., [3,5,9,18]).

Multi-skilled resource approach, therefore, has been proposed to improve resource utilization in project scheduling. This approach assumes that each worker may possess multiple skills that allow them to participate in any activity that fits one of their skills. Past results indicate that multi-skilling can increase the productivity, quality, and continuity of work, while providing managers more flexibility in assigning tasks [3,7,20]. Field studies have also indicated that multi-skilled resource approach may benefit workers [4,15,16]. Such benefits include longer employment duration, better qualifications resulting in increased employability, and increased job satisfaction.

Although various efforts [1,2,6,8,10–13,14,17] have been proposed for solving resource-constrained scheduling, only the optimization model developed by Gomar et al. [11] and the heuristic approach

developed by Hegazy et al. [10] are capable of solving multi-skilled resource scheduling. Nevertheless, since the resource-constrained scheduling is an NP-hard problem [19], which often yields large computational time and could be trapped in "combinatorial explosion" situation, the heuristic approach seems more practical for day-to-day operation.

The existing heuristic approach developed by Hegazy et al. [10] essentially modifies the single-skilled resource allocation procedure to allow the insufficient resources to be substituted by other qualified resources. For example, assume three units shortage of R1 occurs and one R1 can be substituted by two R2 or one R1 can be substituted by three R3 (2R2 = 1R1, 3R3 = 1R1), either six R2 or nine R3 can substitute for the shortage in R1. Also, in case the free amount of either R2 or R3 is not enough to substitute for the whole shortage, a combination of R2 and R3 together, according to their availability, can be used to substitute for the shortage. When a substitution takes place, the resource pool is adjusted accordingly and the resource scheduling procedure is continued without delaying the activity, thus saving project duration.

2. Existing heuristic approach concept

2.1. Resource substitution step

Existing heuristic approach is subjected to resource substitution step where an activity with higher priority can claim any resource regardless of its concurrent activities' resource requirements. Resource substitution step will perform immediately if insufficient resource

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