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An overview of the time-cost trade-off problems of project planning

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Abstract

In project management there are two main operation problems like scheduling and cost optimization. These are correlated with each other and have good mathematical proved solutions for the basics. In case of applying arbitrary calendars generates such effects in scheduling which make the time -cost trade-o¤ problem unusable. The aim of this paper is to point out these effects and give an advance to find a new way to the problem.

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Keywords: Scheduling; Calendar; Time-cost trade-off

1. Introduction

For applying a network model in civil engineering practice, it must be suitable for handling two features in consideration of scheduling.

- The first one is the possibility of changing process durations depending on their start times. This is the key to apply calendar.
- The second one is using maximal constraints for activities and connections. This is useful and important in practice. In linear programming method, it is possible to give only minimal constraints. For applying maximal constraint, it must be converted by multiply the assumption with (*-1*). It effects negative process time and turning back arc which generates loops.

In case of this constraints, there is no limit to apply the solution for the models either activity on edge (AOE) or activity on node (AON). Here, notations are related to the model AOE.

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In this review there are not any restriction for any of the two generalizations. The project is modelled on a [*N;A*] digraph. Let *N* be the set of nodes, *A* be the set of arcs. Every process of the project has got a possible minimal and an acceptable maximal working time (a_{ij} and b_{ij} respectively). Both has got a necessary cost ($K(a_{ij})$ and $K(b_{ij})$). Between them the cost changes linearly, the cost intensity is

$$c_{ij} = \frac{K(a_{ij}) - K(b_{ij})}{b_{ij} - a_{ij}}$$

The matter of calendarization is that every process has a given necessary working time ($\tau_{ij}; a_{ij} \leq \tau_{ij} \leq b_{ij}$), departure time ($\mu_i$) and calendar vector ($d_{ij}$) as the work pattern.

$$d_{ij} = \begin{cases} 1, if\ \_t\_is\_a\_workday \\ 0, else \end{cases} \quad t=0,\ldots,T$$

The problem is defined in time *T* which is the maximal acceptable project duration. The calendarized process time ($\vartheta(\mu_i)$) is predictable indirectly and inconstant.

$$\tau_{ij} = \operatorname{sgn}(\tau_{ij}) \sum_{t=\mu_i}^{\min\{\mu_i+v_{ij}(\mu_i)\}} d_{ij}(t)$$

Remark

If $\tau_{ij} > 0$ and $\tau_{ij} > \sum_{t=\mu_i}^{T} d_{ij}(t)$ then $\vartheta_{ij}(\mu_i) = \infty$.

If $\tau_{ij} < 0$ and $\tau_{ij} < -\sum_{t=\mu_i}^{0} d_{ij}(t)$ then $\vartheta_{ij}(\mu_i) = -\sum_{t=\mu_i}^{0} d_{ij}(t)$.

The time-cost trade-off problem gives a scheduling to the wanted deadline with minimal cost level. The basic of it is scheduling. In this paper it is examined the possibilities in case of scheduling presented above.

2. Literature review

The first scheduling models were presented in the late of ‘50-s by Bellmann [2] and Dijkstra [6]. The problem of these works is very simplified. There is not allowed negative or changeable process durations and loops. The solutions based on linear programming. Scheduling is a longest path problem.

There are many generalization of the problem. Franck et al. [7] already showed a proper model for calendarization. Negative duration and loops are solved even in project management softwares.

The time-cost trade-off problem was presented at first in 1959 in work of Kelley and Walker [12]. They gave a solution based on linear programming on AOE network. In 1961 Fulkerson [8] and Kelly [11] gave another solution based on maximal flow algorithm. This problem can be originated to minimal cost flow algorithm which is in Ahuja [1]. In 1969 Klafszky [13] then in 1992 Hajdu and Klafszky [10] showed the acceleration of that. These solutions are based on maximal flow algorithm also.

There are many generalization of this problem also. Hajdu and Malyusz [9]deal with using benefits or outcomes on nodes. Csordas and Malyusz [3] and Csordas [4,5] shows different technics to apply technological changes is the model.

3. Researching method

There are many proved optimal solutions in literature. After studying them it must to examine if it is capable to handle the conditions.

If the known algorithm is proper only with restrictions then it must to research another way to apply the generalizations as it shown.