Exact Activity Overlapping Method for Time-cost Tradeoff

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Abstract: This paper presents a computational method that identifies an exact set of optimal overlap rates between critical activities to meet job site specific needs by using rework cost-slope. The procedures to compute the exact solution are provided in peudocode algorithm. The method is coded into Exact Concurrent Construction Scheduling system that allows practitioners to make more informed decision in accordance with the site-specific condition involved in the overlapping of critical activities. Test cases verify the validity of the computational method and the usability of the system.

Keywords: Time-cost Tradeoff/Activity Overlapping/Rework Cost-slope/Optimization

I. INTRODUCTION

Various time–cost tradeoff methods that address activity overlapping have been extensively studied in the construction community. However, very few provide a mathematical method that identifies the exact global time–cost tradeoff solution by quantifying the correlation between "the degree of overlapping" and "the rework amount" (Dehghan and Ruwanpura 2011). It is certain that no existing concurrent scheduling methods offer a computation method coupled with automated software that identifies the exact global optimum overlaps between each and every activity of a large network having hundreds and thousands of activities (Lim et al. 2014).

A new mathematical method, which identifies the exact global solution (i.e. the set of optimum overlaps between all predecessor and successor activities) of a schedule network having multiple critical paths, is proposed in this paper. A project scheduler will be better equipped to identify the set of activities to be overlapped and the exact global optimum overlaps between these activities. The proposed method may facilitate time–cost tradeoff in concurrent scheduling before and during construction.

II. LITERATURE REVIEW

Recently, several researchers have begun looking more closely into activity overlapping in the context of the construction industry and studying the relationship between the rework occurrence and the schedule compression attributed to activity overlapping as follows: Khoueiry et al. (2013) present a mathematical model that identifies the rework amount resulting from the exchange of incomplete information between activities and computes the optimal overlaps that maximize profit. Dehgan et al. (2013) discuss the merge event bias which occurs when the number of predecessors and successors form a many-to-many (M:N) relationship, consider resource constraints, and introduce a time–cost tradeoff method that determines the optimum overlaps. Berthaut et al. (2014) introduce activity overlapping into resource-constrained project scheduling. Hossain et al. (2012) and use the dependency structure matrix (DSM) to predict design changes and avoid rework. Activity overlapping is hybridized with other techniques such as simulation to effectively handle the rework probability (Gerk and Qassim 2008; Hazini et al. 2013, Bogus et al. 2011; Lim et al. 2014).

However, these existing methods apply a fixed overlap to all critical activities to preserve computational resources. This study proposes a new method that identifies the exact global optimum overlaps between all construction activities. The new method complements the deficiencies of existing methods because it considers the dynamic changes of critical path(s); computes the rework amount and the rework cost; and identifies the exact global solution.

III. PROPOSED EXACT TIME-COST TRADEOFF ANALYSIS

The method developed in this research reduces PCT and/or PCC by performing activity overlapping. It determines the exact global optimum overlaps by performing time–cost tradeoff using the rework cost slope. The procedure of method is described as follows:

Step 1. Importing network information
- The method reads the network information exported from Primavera P6.

Step 2. Define activities' concurrency attributes
- The values of all activities' evolution and sensitivity are defined by the user.

Step 3. Identify the current critical activity pairs
- The method identifies critical path(s) and sub-critical path(s) by computing CPM.

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Step 4. Pairing predecessor and successor activities and extract characteristics of critical activity pair
- The values of the evolution and sensitivity parameters for the corresponding critical activity pairs are saved into matrix.

Step 5. Assigning rework probability
- Depending on the values of concurrency attributes given in matrix *Mc*, the rework probability function (P_R) is chosen.

Step 6. Compute rework-cost slope
- The rework cost slope of the activity pair is computed by dividing the successor rework cost and the successor's compressible duration.

Step 7. Identify the lowest rework-cost slope activity pair
- The method identifies an activity pair which has the minimal rework cost slope out of all the rework cost.

Step 8. Overlap activity pairs
- The method overlaps the predecessor(s) and its successor(s) of the activity which has minimal rework-cost slope by the compressible duration.

Step 9. Adjusting successor duration and cost
- The adjusted successor duration and cost in the overlapped activity pair are computed by adding rework duration and rework cost.

Step 10. Compute PCT and PCC
- The method computes the PCT and the PCC by executing CPM.

Step 11. Check the stopping rule
- The activity overlapping cycles stop as soon as all paths are critical or when all activities are overlapped to the maximum overlap limits, if not back to Step 3.

Ⅳ. CASE STUDY

Real-life plant modernization project having 134 activities is used to verify the effectiveness of the method in dealing with a large network. The PCT and PCC of the large network are 415 days and $1,511,853, respectively.

The total PCT and the total PCC may be maximally reduced to 342 days and $1,533,654.1 in the 129th activity overlapping cycle, respectively, as shown in Figure 1. The exact global minimum PCC is $1,506,963.6 at which PCT is 379.2 days was obtained at the inflection point in the 62nd activity overlapping cycle.

The computation time was only 27.07 s to obtain the complete set of analysis results on a Microsoft Windows 7 platform with an Intel(R) Core(TM) i5-3570 CPU @ 3.40 GHz driver and 4.00 RAM. This verifies that the method provides a project scheduler who needs to identify the exact global optimum overlap rates between activities expeditiously with the research methods and tools.

Ⅴ. CONCLUSION

The computational method that determines the set of exact global optimum overlap rates (or duration) between all activities of a schedule network without assigning additional resources was verified. The method considers the dynamic changes of critical path(s), handles overlapping of the activities in a merge event, analyses the PCT–PCC tradeoff using rework cost slope, and provides the mathematical formula that computes the optimal overlaps enumerative. With the method, a project scheduler may perform exact time–cost tradeoff analysis in concurrency-based scheduling by optimally overlapping activities before and during construction.

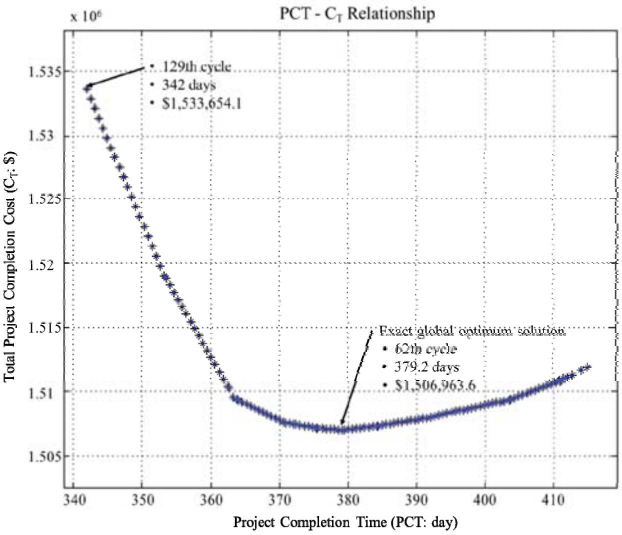

Figure 1.PCT-PCC tradeoff of Case study

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