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Improve Net Present Value using cash flow weight

Vacharee Tantisuvanichkul[1] and Moray Kidd [1]

[1] School of Mechanical, Aerospace and Civil engineering
The University of Manchester

Abstract. The problem of scheduling project with resource constrained to maximise their Net Present Value (NPV) is studied in this paper. The performance of Cash Flow Weight (CFW) scheduling heuristics is evaluated. This heuristics procedure has been used to improve the NPV of the project activity. Despite their inherent simplicity, this approach performs well at improving project NPV in some certain cash flow patterns. Subsequent application of the shifting also performs well to improved activities assignment and help to increase project NPV over the initial solution obtained.

Keywords: Cash flow weight, net, present value, project scheduling, shifting procedure

1. Introduction

Project scheduling is the process where the various activities that need to be undertaken during a projects lifetime should be scheduled. It is concerned with the techniques that can be employed to manage the activities that need to be undertaken during the development of a project. It is primarily concerned with attaching a timescale and sequence to the activities to be conducted within the project. This paper will focus on *project scheduling* that is the subset of project management. Project scheduling is the process where the various activities that need to be undertaken during a projects lifetime should be scheduled.

2. Literature Review

While majority of the past research has focused on minimizing project completion time, the primary goal of undertaking any commercial project is its potential profitability. The most pragmatic project objective is, therefore, to maximize project NPV [1]. Scheduling problem can be distinguished into two categories; the unconstrained project scheduling problem, which occurs when no constraints on resource usage are imposed such that the activities are only subject to precedence constraints, and the resource-constrained project scheduling problem (RCPSP).

A.H. Russell [2] was the First to introduce the objective of maximizing the NPV of cash flows in a network. Russell deals with the unconstrained problem where both positive and negative payments occur as events in the project are completed.

Russell's objective function is to

maximize NPV = $\sum_{i=1}^{n} CF_i \exp(-\alpha T_i)$ (1)

where $\exp(\alpha Ti)$ = β, the discount factor.

CF = Cash Flow

For uniformity of expression, the criterion Eq. (1) is sometimes rewritten as:

maximize NPV = $\sum_{i=1}^{n} CF_i \beta^{-T_i}$ (2)

3. Research Methodology

The experiment was carried out to test the techniques in the set of problems. These problems consist of projects with up to 10 activities each, with at least one critical path per problem. Then the shifting procedure was used as the improvement method to enhance the NPV in each problem. The cash flow weight heuristic procedure (CFW) and the shifting improvement techniques were used in this paper. After that the results will be measured using percentage difference formula. This was done to access efficiency of each scheduling technique under different problems and cash flow patterns.

3.1. The cash flow weight heuristic procedure (CFW)

The cash flow weight (CFW) is one of the heuristic procedures. They are easy to implement, intuitively based and show significant different in performance [3]. This approach is operated by selecting a high priority activity from a list of available activities for the assignment of resource. They are formulated on the notion that higher net present value (NPV) are achieved by advancing positive cash flows as close to the start of the project as possible, while delaying negative payment as far back (to the right) as possible, while not moving any activities on the critical path and still satisfying precedence and resource constraints. This notion is called "Cash flow weighing" (CFW) whenever resource conflicts arise, the activity that is holding back a greater sum of cash inflows is scheduled first or receives higher priority in the assignment of resources.

Step 1 Determine the cash flow weight of each activity

$$CFW = W_{ij}$$

$$W_{ij} = CF_{ij} + \sum_{k \epsilon O_{ij}} CF_{ik}$$

Step 2 Add all activities without predecessors to the available lists. From the list of precedence available tasks, select the task with the highest CFW. Determine the precedence-only; early start time t of the t of the selected task. Assign the chosen task to begin at the earliest possible period, at or after its early start time, such that resource availabilities are sufficient for the duration of the task. Update resource availabilities. Add any activities to the available list that become available by virtue of their predecessors being completed.

Step 3 If no more tasks are available, stop. Otherwise go to step 2

3.2. The shifting improvement

The shifting improvement is applied to enhance the CFW scheduling techniques. It attempts to position the activities with the negative cash flows to the right (later periods), and position positive cash flow activities to the left (earlier periods) whenever precedence and resource constraints allow it.

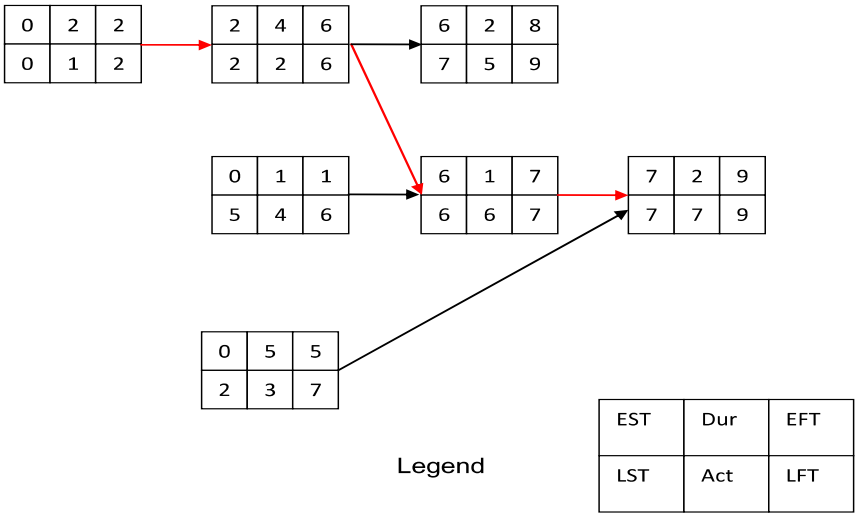
4. Discussion

Test problems for evaluating the CFW heuristics and the shifting improvement procedure were generated and the results are given.

4.1. Project data

Activity	Cash In	Cash Out	Immediate Predecessors	Duration	Resource Requirement
1	-	20	-	2	1
2	55	-	1	4	2
3	35	-	-	5	3
4	30	-	-	1	2
5	-	50	2	2	4
6	40	-	2,4	1	1
7	-	10	3,6	2	2

4.2. Network Diagram

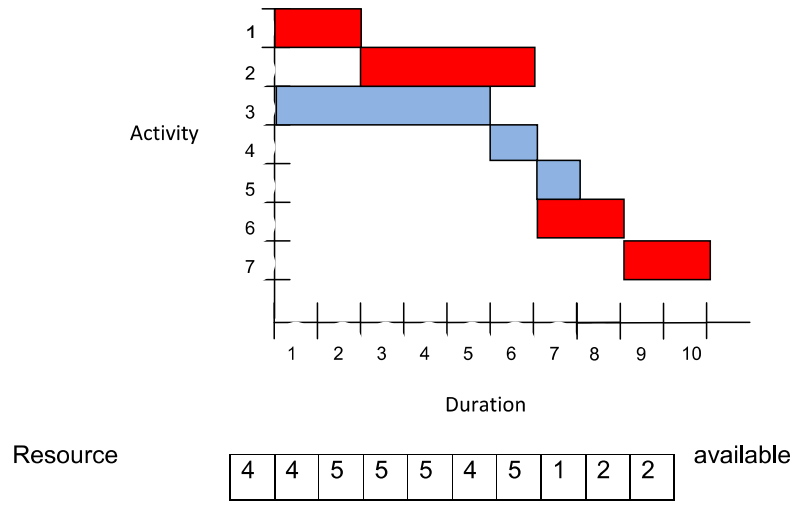


Resource availability = 5, α = 0.2, Critical path = [1]=>[2]=>[6]=>[7]

4.3. Determination of CFWs

Activity	Cash In	Cash Out	Immediate Predecessors	CFW	Duration	Resource Requirement
1	-	20	-	15	2	1
2	55	-	1	35	4	2
3	35	-	-	25	5	3
4	30	-	-	60	1	2
5	-	50	2	-50	2	4
6	40	-	2,4	30	1	1
7	-	10	3,6	-10	2	2

4.4. Schedule from the project data

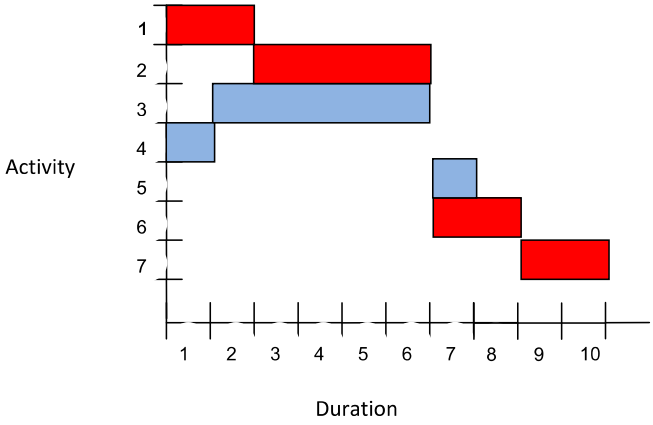


From equation (1) ; $\text{NPV} = \sum_{i=1}^{n} CF_i \exp(-\alpha T_i)$

NPV = -20 + 55exp(-2α) + 35 + (30)exp(-5α) + (-50)exp(-6α) + 40exp(-6α)

$+ (-10)\exp(-8\alpha)$ = 77.598

4.5. Schedule resulting from CFW heuristic



Resource

3	4	5	5	5	5	5	1	2	2

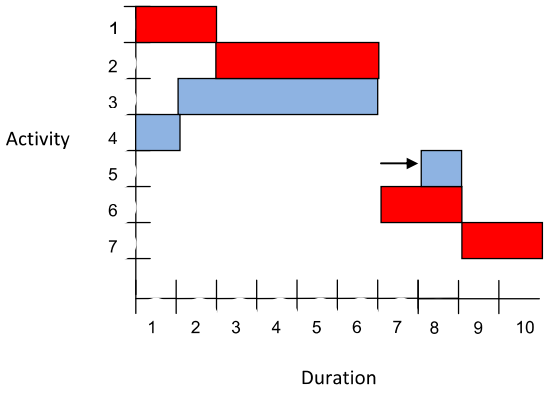
available

NPV = $-20 + 55\exp(-2\alpha) + 35\exp(-\alpha) + 30 + (-50)\exp(-6\alpha)$
$+ 40\exp(-6\alpha) + (-10)\exp(-8\alpha)$ = 79.760

NPV change = 2.162

% NPV change = 3 %

4.6. Schedule after applying the shifting improvement



Resource

3	4	5	5	5	5	1	5	2	2

available

Task 5 shifted right by one period

NPV = $-20 + 55\exp(-2\alpha) + 35\exp(-\alpha) + 30 + (-50)\exp(-7\alpha)$
$+ 40\exp(-6\alpha) + (-10)\exp(-8\alpha)$ = 80.638

NPV change = 0.878

% NPV change = 1.5 %

5. Conclusion

This paper presents CFW scheduling heuristic that are effective at maximizing NPV of resource-constrained project. These approaches are managerially significant because they are simple to compute in the context of project management and intuitively based on scheduling theory. Thus, it requires less computational effort than optimization-based approach.

The experiment seeks to improve the NPV of the resource-constrained problem by applying the shifting procedure as the improvement techniques. Thus, after initial schedule with heuristics procedure, the shifting procedure is employed in an attempt to improve upon the heuristic result obtained. It was found out that the use of the shifting procedure could be expected to improve the NPV of the project.

As the problem we used for evaluating the heuristics procedure here in this experiment had that only one resource. It should be worthwhile to experiment the heuristics under the condition of various resources available and limitation so that the impact of different levels of resource utilization could be assessed. However, it should be taking into account that each resource has a value associated with it, representing the available amount.

6. References

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