Optimization Payments of Client to Contactor by the use of Hybrid Genetic Algorithm

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Abstract

For increasing total Net Present Value (NPV) and performing activities with different methods this paper intends to provide a new model of optimization for specifying any payment dates of Client to contractor. The problem has been defined on an AOA network. In addition specifying the dates of payments, the presented model may provide a suitable time table of activities .First, the problem was formulated by using a nonlinear model that is strongly NP-hardness, Especially for large-sized problems,. We have used two heuristic and meta-heuristic algorithms for solving it. The applied heuristic algorithm is a complete accounting algorithm and meta-heuristic is a hybrid genetic algorithm. The results show that in great and even middle problems all results that obtained from hybrid genetic algorithm are more efficient than complete counting algorithm.
Keyword: Client & Contractor; Hybrid Genetic Algorithm; Net Present Value (NPV)

1. Introduction

According to all performed studies, Russell (1970) has studied cash flow in time tabling problems for the first time. Russell considered a promotional NPV problem without considering of resources limitations and presented a non-linear programming method for solving it. Then the case of improving NPV was considered with others and was centralized on RCPSP condition.

Generally RCPSP is a time table problem with special cases like currency workshop, manufacturing workshop and open-shop. RCPSP includes time tabling of different project activities with special goal in a way that by following up pre-requisite limitations there should not be any excess in any needs to resources out of specified capacity for each type. We may classify these resources as non-consuming (recyclable), consuming (non-recyclable) and limited resources as well.

Up to now, there are a lot of works on different projects for facing with resources limitation (RCPSP) which of course the goal of which is reducing time table of project and/or increasing the net present value. One of the first efforts in this field is to find a suitable reply for RCPSP problems for increasing the NPV and presented job by Doersch & Paterson (1977). They have presented a programming Zero & One method for solving the problem of time tabling of project and limited capital which may solve 25-15 projects completely. Smith and Aqubilano(1987) extended Doersch & Paterson(1977) model by considering any limitations of materials and capital which may solve any problems with small dimension. Paterson et. al (1999,1989) presented a programming zero & one model and a back-tracking algorithm for solving these problems with a goal of increasing the NPV and /or reducing the time table of project. Icmeli and Erenguc (1996) presented the branch & bound method and efficiency for solving RCPSP method which all numerical tests show that it is better than other algorithms.

Baroum and Patterson (1999) have presented a branch & bound algorithm for solving of increasing NPV problem as well.
Furthermore Vanhoucke et. al (2001) presented a branch & bound –first depth algorithm for solving any problems with limited recyclable resources and increasing NPV of the project.
When we face with more than one method for performing the activities we are facing with a multi-modes RCPSP which is briefly named as M-RCPSP. There are different optimization methods which have been presented to solve M-RCPSP problems and reducing the time table of project which are some developments of the branch and bound of one-mode problems. It seems that there is nothing for increasing NPV as well.

It has been proved that RCPSP includes in NP-hard problems (Kolisch.1995). It is only possible to find only one NP-complete answer for M-RCPSP and only when there are more than two non-recyclable resources (without considering other limitations (Kolisch.1995). Therefore some heuristic and meta-heuristic methods have been developed for solving of RCPSP and M-RCPSP problems.

Icmeli and Erenguc (1996) benefited from prohibited searching method for providing a primary possible answer. In their method we have primary answer through continuous repeats in which upon any movement we have betterment of an acitivity with one unit earlier / delay of time in which the most early or delay of time may not be more than an activity. Lee & Kim (1996) reported their results in benefiting from simulation of melting and gradual freezing by "Prohibited searching & genetic algorithm: on RCPSP. Their genetic algorithm was coded based upon priority amount. Mori and Tseng (1997) only considered multi-modal RCPSP with recyclable resources. They used an introduction of a direct chromosome in a way that one gene is in direct relation with an activity and includes all allocation mode, time table sequences and start/ finish times of relevant activities.

The genetic algorithm provided by Hartmann (1997) may consider both recyclable & non-recyclable resources. Ozdamar(1999) has presented a genetic algorithm with priority rules of coding for M-RCPSP and recyclable & non-recyclable resources. Goto et. al (2001) proposed an meta-heuristic algorithm including two prohibited searching steps for increasing of NPV. Their proposed algorithm provides a primary possible answer in first step by applying of primary prohibited search and generalization of proposed heuristic algorithm by Lee & Kim (1996). In second step and for betterment of primary answer, we may try not only search the possible space but also impossible one by starting from primary answer. The second step will be repeated up to finding any more possible betterment. Then the algorithm will return back to first step and a new way starts.
This algorithm will continue up to impossible new betterment possibility. Bouleimen and Lecocq (2003) presented a simulating algorithm for melting and gradual freezing for reducing the time table of project and also for RCPSP & M-RCPSP. The searching process is based upon a replacement activity and time increasing process. Then it is possible to specify all parameters after primary statistical tests on testing samples. Then for M-RCPSP we may benefit from two searching rings as replacement of activities and neighboring modes. For more information, any interested readers may refer to recent essay made by Kolisch and Hartmann (2005) which includes a comparison and integrated study of heuristic & non-heuristic methods presented for solving RCPSP problems up to now.

In this paper we have considered payment time tabling from viewpoints of contractor and Client. Dayanand and Padman (1993) formulated the problem of payment time tabling from viewpoint of contractor for the first time. They presented a programming zero & one method with proposing and testing different heuristic methods. Dayanand and Padman(1994) presented a 2-step method in which the first step includes a simulation algorithm of melting and gradual freezing and second step of activities have been specified for betterment of NPV of project.

They have stated that performing this method is meaningfully better than related heuristic methods which has been presented in prior by Dayanand and Padman(1993). Dayanand and Padman(1995) studied the problem of payment time tabling from viewpoint of Client. Dayanand and Padman(1997) considered different fixed models for analysis of payment time tabling for increasing the contractor's NPV. They have considered an immediate impose and number of fixed payments. It has specified total amount received from Client which remains fixed through the project progress period. They proposed to use these models with some modifications by both the contractor and Client. Ulusoy and Cebelli (2000) presented a double rings genetic algorithm in which external ring shows the Client and internal ring shows the contractor. In external ring we have Client who may provide a payment condition in accordance with its own benefits. Therefore we have contractor who may provide a time table for its activities and increase its NPV. These two rings may exchange their answers by discussing while reaching to a fair answer and as short as possible. The ideal reply of Client out of payment is total amount at the end of project and ideal reply of contractor is obtained through receipt of total amount of contract at the beginning of the project. One of the last works in this field belongs to Mika et. al (2005) who tried to increase contractor's NPV by the use of simulation of melting and gradual freezing and prohibited search and considering 4 types of payment from Client to contractor which are: payment of total amount of contract at the end of project, payment at completion date of activities, payment at equal time tables and payment against project progress.

In This paper the payment schedule is selected by the client under the assumption that the contractor behaves in his own best interest. The contractor protects his interests by selecting the activity schedule to maximize his own NPV and by rejecting the payment schedule if his NPV does not exceed some minimum amount. This new problem is formalized in section2. Section 3 illustrates an example to clarify and utilize the new model that we present in section2 and finally we discussed about results of implementation this method.

2. Research methodology

2.1. Defined model

The real goals of contractor and Client is to increase their financial returns (their NPV) in a way that contractor is interested to receive total budget amount within shortest possible period of time and in contrast when we have highest amount of Client's NPV with delayed payments. Therefore the presented model intends to increase total NPV of both parties by considering both parties interests as a neutral supervisor.

This problem has been specified on a vector network with considering all fixed and final aspects and assumptions that all payments would be completed at completion dates (ties). (We have an accident at the end of one or more activities). All used resources are included in recyclable resources group in which different methods would be completed by combination of resources and work performance time (different modes). In fact the time of each activity, type and used resources and their quantity would be changed based upon their selected modes for further performance.

When there is an activity with special quantity, it would be limited in relevant time schedule by the same activity. Also any mode of an activity will have a different completion costs. This is based upon the costs against consuming resources of the said activity / mode as well.

It has been assumed that related cash flow of an activity (Exit cash flow of contractor) is in compliance with starting & completion date of the said activity. But the entrance cash flow of contractor and exit cash flow of Client are based upon the completion of accidents (ties).

In addition all cash flows changed into current value with a suitable interest rate at zero time of comparisons. When the entrance of contractor (receipt from Client) is not applicable for made costs (costs of activities), (it means to find a negative cash flow), it is assumed that contractor will borrow an amount equal to this difference (which is greater than interest rate). The loan rate would be calculated based upon accidents in which the receipts are enough for any made activities costs up to the mentioned date.

There is a overhead costs /day for both contractor and Client. There is a quick action for a project. This means that by passing one unit of time out of specified date, contractor is obliged to pay a delay penalty and for advanced completion of project tan quick function date, contractor should be paid by an allowance. Also there is a date for the last completion date of project. It is naturally greater than quick function date. Any time limitations for project and /or violation of it make a total non-economic project.
If the project completes prior than quick function date, this will provide a profit for the Client out of which it is possible to pay an allowance. Similarly in case the project completes with delay and after the quick function date, Client will face with losses for which it is possible to consider a penalty.

There is a payment distribution in this way from which a percentage of total project price will be paid to contractor by the Client at occurrence date of accidents. The amount of these payments at accidents is mostly with regard to logic relations of activities and real amount of project progress, but it would be specified by the Client and/or even by contractor and based upon payment at preliminary tie (advance payment). This type of payment distribution is the entrance of model.

Upon specifying the amount of payments at occurrence date of accidents, presented algorithm may provide a time table for activities with regard to all limitations of problem. The used time table intends to provide a time schedule of activities at soonest possible time with regard to limitation of resources and all prerequisites. It is possible to specify NPV of both contractor and Client with received time table.

The real reason for benefiting for promotion time table is that since presented model is like a supervisor in considered process and also because the contractor is responsible for time tabling and performing of activities, there is no usage of presented algorithm for calculation of Contractor’s NPV out of returned time table in order to calculate nominal NPV of contractor with regard to the sequence of selected activities at worst situation. Therefore contractor has a chance to maximize his NPV by the use of returned time table. The contractor’s NPV will be obtainable out of total receipts at accidents occurrence date from which we should deduct total payments of activities, borrowing and over head costs. Of course we should consider a progress allowance and/or delay penalty when there is a different completion date than quick function date. In order to calculate equal NPV of Client it is assumed to provide total price of contract for the Client at the beginning and then deduct total payments to contractor plus overhead costs from total amount as well. Similarly when completion date of project is different from quick function date, both relevant profit & loss will be considered in this NPV. (Of course all digits changed into current net value with further performing of required calculations).

The function of presented model is a rate of contractor & Client importance. Therefore the goal is to increase net present value of both parties. But with considered limitations it could be included in reducing the time of project completion time.

2.2. Proposed model to solve the problem

Firstly we will explain all used parameters in this problem then we will propose a mathematical model for it:

A- Number of activities
N-Number of accidents
A_1- Activities which their occurrence date is after the m/accident
M-Total modes (performance modes of activities)
V-Collection of activities
D-Date of quick function
D_2-Last date of project completion ($D_2 \geq D$)
d-Time unit
R={1,2,….,k} total required resources for project completion
D(j,j) performance time of j^{th} activity in j^{th} mode.
Rr(i,j,k) – Required K recyclable resource for performing i activity in j^{th} of time unit
RrA(k,d)- Primary capacity of k at d^{th} time unit
Rcost(k) – costs of each unit of resource type k at time unit
C_1 – Cost of i^{th} activity
Totalp- Total contract price
Pay_1 – Paid amount of Client to contract at l^{th} accident
f_1 – Date of i^{th} activity completion
S_1 – Start date of i^{th} activity
t_1 – Date of i^{th} receipt
f_n – Project completion date
r- Interest rate in time unit
g- Borrowing rate in time unit
O_{cont} – Overhead costs of contractor
O_{client} – Overhead costs of Client
Rew- Progress allowance rate in time unit
Pen – Delay penalty in time unit
Pro – Profit out of any progress n time unit
Los – Loss of delay in time unit
a – Importance interval of client
b- Importance interval of contractor
α- The importance of starting time in calculation of an accident
β(r,t) is obtained out of the following formulation:
$\beta(r,t)=1/(1+r)^t$
Following formula is for calculation of Contractor's / Client's NPV:

And meaningful model of problem in a general condition is as follows:
$MaxNPV_{Total} = aNPV_{Cont} + bNPV_{Client}$
St.

Where
is equal to 1 if activity *i* is made in mode *j*, otherwise it is zero as well.

2.3. Hybrid Genetic Algorithm (HGA)

The Hybrid Genetic Algorithm (HGA) acts as globally search technique which is similar to simple genetic algorithm with only deviation of generation of initial solution. In HGA, initial feasible solution is generated with the help of some heuristics and then this initial sequence has been used along with the population according to population size for the executing the procedure of simple genetic algorithm. The proposed HGA is described as:

Step 1: Initialization and evaluation

a) The algorithm begins with generation of initial sequence with special heuristics (SH) called as one of the chromosome of population

b) Generation of (Ps-1) sequences randomly as per population size (Ps).

c) Combining of initial sequence obtained by special heuristics with randomly generated sequence to form number of sequences equal to population size (Ps).

Step2: Reproduction

The algorithm then creates a set of new populations. At each generation, the algorithm uses the individuals in the current generation to generate the next population. To generate the new population, the algorithm performs the following steps:

a) Scores each member of the current population by computing fitness.

b) Selects parents based on the fitness function.

c) Some of the individuals in the current population that have best fitness are chosen as elite and these elite individuals are utilized in the next population.

d) Production of offspring from the parents by crossover from the pair of parents or by making random changes to a single parent (mutation).

e) Replaces the current population with the children to form the next generation.

Step3: Stopping limit

Stopping condition is used to terminate the algorithm for certain numbers of generations. (Ashwani and Pankaj, 2010)

2.4.Parameter setting:

In this section, the results of the computational experiments are used to evaluate the performance of the proposed algorithm for Optimization of current value of total net profits of Client & Contractor In Payments of Client to Contactor. There are nine instances for each problem size. At this point, some information about parameter analysis would be useful. Initially, several experiments were conducted on test problems in order to determine the tendency for the values of parameters. Six test problems were used for this purpose. (Majazi, 2011).

In each step, only one of the parameters was tested. Each test was repeated four times. We considered the following values for the several parameters required by the proposed HGA:

Crossover probability (pc): four levels (0.90, 0.85, 0.80 and 0.75).

Mutation probability (pm): four levels (0.02, 0.04, 0.06 and 0.08).

Number of initial population (np): three levels (300, 200 and 100).

Number of generation (ng): one level (200).

Test results showed that these values were suitable for the problem. Later, additional tests were conducted in order to determine the best values. After completing the tests, Taguchi analysis is applied for the different values of parameters. The best values of the computational experiments for Optimization of current value of total net profits of Client & Contractor In Payments of Client to Contactor were obtained for pc = 0.85, pm = 0.06, np = 100 and ng = 200. These values were set as the default value of the Parameters.

3. A numerical example

In order to show efficiency of presented model we have a problem which has been solved by the use of mentioned method.

3.1. Example

It includes 20 activities within 2 modes. Figure 1 shows its vector display (Number of activities has been mentioned on the arcs). Table 1 shows the term of activities and manner of benefiting from resources for both conditions. Considering table 1 it is obvious that second mode includes a case with lower costs and more time. Resources limitation for 1 & 2 resources is respectively 5 &2 units. The interest rate of %18.25 per year and borrowing rate is equal to 1.8 times more than this amount (It means the assumption of interest rate of %0.5 and borrowing rate of %0.9 per time unit).

Regarding any relations between activities, payments rate has been specified on accidents as [0,05,0,05,0,05,0,05,0,05,0,1,0,55].

Since total budget is assumed as 2000 monetary unit, payment rate for first tie (as an advance payment) is 100 units (0.05 * 2000=100).

The quick function specified by the client is 75 time unit. It is assumed that any start up of project will provide a profit of 20 units per time units; therefore the employer is able to complete the project more quickly and allocate half of the mentioned amount as an allowance and/or receive a delay against one time unit of delay. The final project completion time is 82 time units. It means that project completion after this date has no more economic aspect.

The overhead cost is assumed respectively 3 & 2 for contractor and employer. The importance of contractor and client is assumed to be equal (a=b=1).

The goal is to increase total NPV of contractor and client but with regard to the structure of defined model, the maximum amount of NPV for both contractor and employer will be upon project completion at soonest possible time which may include a little of decreasing project completion time as well.

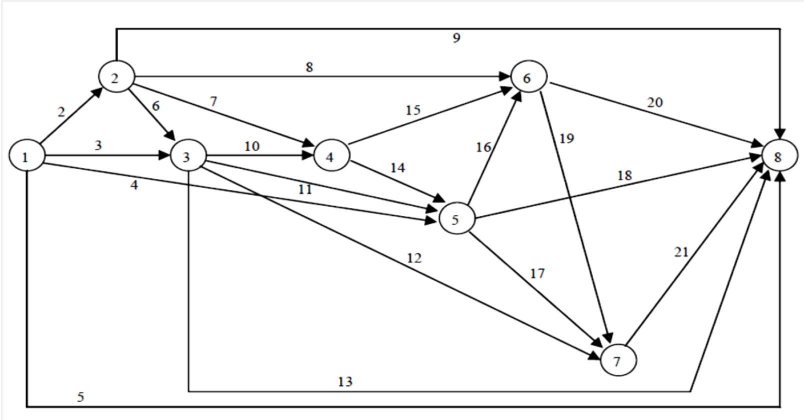

Figure 1: Vector display of problem

Table1: Activity Specifications

Activity	Mode1				Mode2			
	Time	Benefiting from resources		Relevant costs	Time	Benefiting from resources		Relevant costs
		1	2			1	2	
1	0	0	0	0				
2	3	5	2	90				
3	5	3	1	51				
4	5	3	0	36				
5	5	3	0	36				
6	1	3	1	51	2	1	1	27
7	6	5	2	90	10	2	1	39
8	6	5	2	90	10	4	2	78
9	5	3	1	51	7	1	1	27
10	4	5	2	90				
11	9	3	0	36	10	2	0	24
12	7	5	2	90	10	2	1	39
13	7	2	2	54				
14	3	3	0	36	6	1	0	12
15	3	3	0	36	6	1	0	12
16	5	3	2	66				
17	11	1	0	12				
18	5	3	2	66	7	2	1	39
19	4	0	1	15				
20	3	1	1	27				
21	15	0	1	15				
22	0	0	0	0				

4. Discussion and results

Upon solving the problem with the presented algorithm, we had total NPV of 1070 monetary unit in one of the best answers in which the share of contractor and employer are respectively 700 and 370 monetary unit. The obtained time for project performance is 68 time units and occurrence date of accidents (ties) is respectively [68, 53, 49, 38, 26, 1, 4, and 22]. For example here we have number 4 which shows that upon occurrence of accident 2, client is obliged to pay about 200 monetary unit (on date 4) to the contractor. This is equal to multiplying of payment percentage at the same accidents in total budget amount (0.1*2000=200). Figure 2 shows the sequence of time tabling of activities and manner of benefiting from mentioned resources.

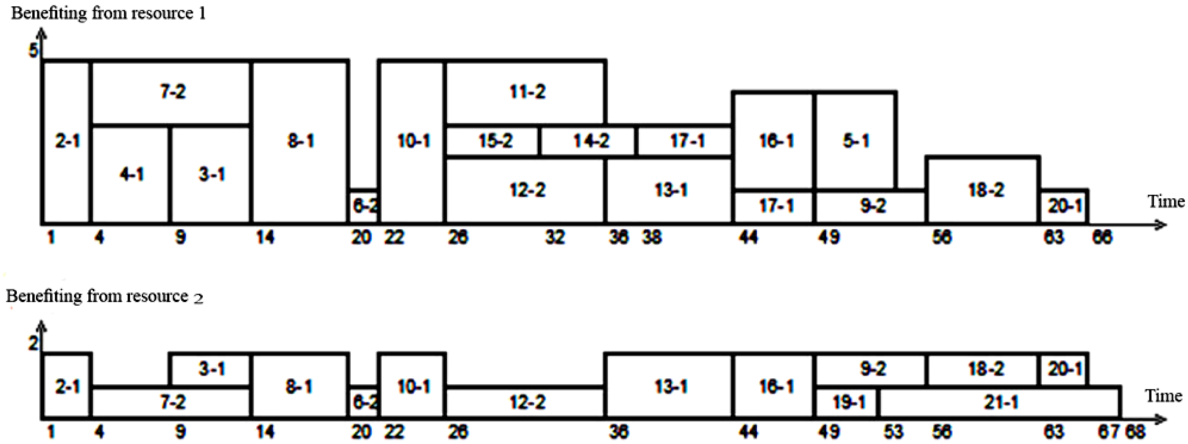

Figure 2- Benefiting from resources by different activities.

As it is obvious in figure 2, the algorithm has selected second mode in 8 cases out of 9 situation in which second mode is present with lower costs and resources and more time tables (For example activity 9-2 in figure 2 shows the selection of second mode for performing of activity 9). Then it has reduced the costs and quick function time as much as possible.

The other point is neutral attitude of model towards single parties of contract. As it is obvious the contractor receives the maximum rate of profit when all its activities may result in completion of accidents sooner than relevant time table. But since the model should consider client's profit, it is not regarded in all accidents. For example instead of specifying activity 6-2 a time table of date 14 , it has been specified on date 22 in order to make complete accidents 3 with some delay and more delays in 3rd payment by client. As a result client will find more NPV.

On the other hand, in order to calculate NPV of contractor we may have a time table on date 49 for activity 5-1 without any prerequisite need in order to calculate nominal NPV which has been reduced for contractor. While the contractor is able to increase its real NPV at the time of project performance by applying a returned time table. As it is obvious in figure 3, contractor is able to increase its NPV by performing activities 5-1, 9-2, 11-2, 15-2, 17-1, 18-2 and 20-1 and with following up any limitations of resources and making delay of prerequisites of 14,2,2,17,4,2 and 2 days.

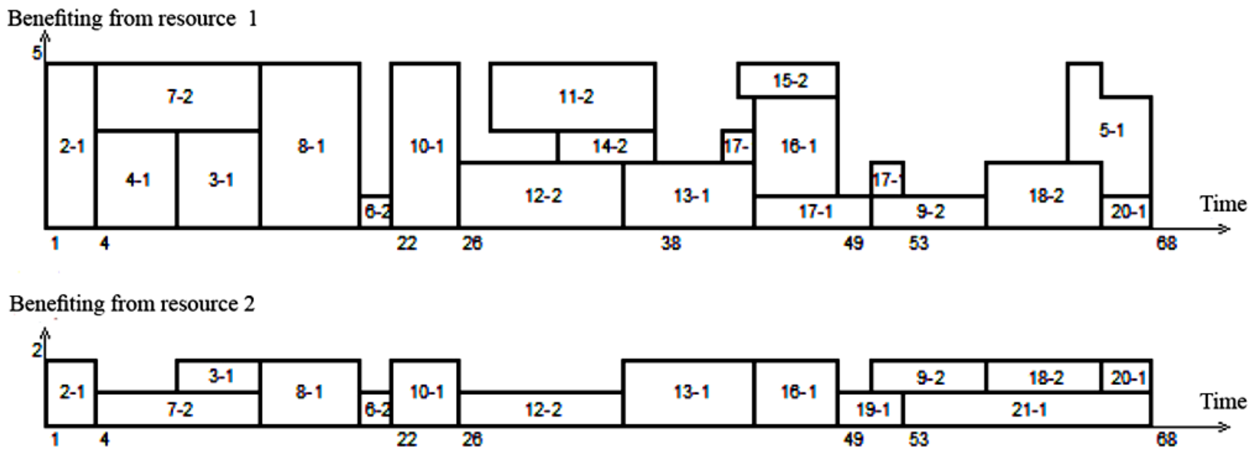

Figure 3: Benefiting from resources by different activities after return scheduling by contractor

In this section, 15 experimental issues of optimization of current value of total net profits of client and contractor in payments of client to contactor in different dimensions were done by HGA and complete accounting algorithm. We produced 15 random problems in small, medium and large sizes.
Complete accounting algorithm didn't answer for 20 hours in medium and large problem sizes, but HGA answered in a short time.
For programming the HGA and complete accounting algorithm are used MATLAB 7.5. And for running the algorithm, is used in a PC with 3.2 PIV, 2 GB RAM. Result of agreement between client and contractor by HGA and heuristic algorithm come in table 2.

Table 2: The result of agreement between client and contractor by HGA and heuristic algorithm (complete accounting algorithm)

Size	Problem Name	Best NPV of Client		Best NPV of Contractor		NPV of Client in agreement	NPV of Contractor in agreement	Parentage of improved NPV of client		Parentage of improved NPV of contractor	
		HGA	Heuristic Algorithm	HGA	Heuristic Algorithm			HGA	Heuristic Algorithm	HGA	Heuristic Algorithm
Small	Vmd1	12216	12219	10921	10956	10328	8921	84.54	84.52	81.68	81.42
	Vmd2	9785	9789	8219	8221	7852	6984	80.24	80.21	84.97	84.95
	Vmd3	13415	13415	11218	11219	10986	9841	81.89	81.89	87.72	87.71
	Vmd4	10759	10759	9784	9784	8219	7621	76.39	76.39	77.89	77.89
	Vmd5	14516	14516	11349	11349	12159	8005	83.76	83.76	70.53	70.53
Medium	Vmd6	18225	18225	15341	15341	13629	12841	74.78	74.78	83.70	83.70
	Vmd7	19268	-	16859	16859	15416	11859	80.00	-	70.34	70.34
	Vmd8	21418	-	18596	-	16523	14628	77.14	-	78.66	-
	Vmd9	15859	15859	11269	11259	11384	8416	71.78	71.78	74.68	74.74
	Vmd10	22335	-	18594	-	17119	14616	76.64	-	78.606	-
Large	Vmd11	52714	-	46216	-	38951	32169	73.89	-	69.60	-
	Vmd12	79594	-	68558	-	61128	49952	76.799	-	72.86	-
	Vmd13	94857	-	81593	-	71135	68341	74.99	-	83.75	-
	Vmd14	102418	-	93721	-	73624	69842	71.88	-	74.52	-
	Vmd15	131482	-	119886	-	98512	82159	74.92	-	68.53	-

5. Conclusion

This study provides a new optimization model for specifying payment dates of client to contractor in order to increase total NPV of client and contractor in those projects in which there are some limitations for resources and further possibilities to perform different activities in different methods. Regarding the NP-hard situation of presented model, we benefited from HGA and complete accounting algorithm. The mentioned model considers fairly both parties benefits for time tabling of activities in order to increase total NPV of client and contractor. According to numerical example in compliance with realities of contracts it was obvious that presented model may solve the problem completely neutral. Since any replacement of performance time of activities had no more effects on quality of performance in framework of time & financial limitations but had a positive effect in increasing the benefits of both parties of project (Client & Contractor). This model may increase the motivation and reduce total costs of project accordingly.
We presented an efficient hybrid genetic algorithm HGA that solves Optimization of current value of total net profits of Client & Contractor In Payments of Client to Contactor problem. First, the problem was formulated by using a nonlinear model that is strongly NP-hardness, especially for large-sized problems. We have proposed a HGA to solve the presented problems, and its performances and results have been compared with complete accounting algorithm. Complete accounting algorithm solutions have a large deviance of optimal solutions (above 30%) in large problems or they did not get optimal solutions in a reasonable

time (20 hours). But the answers obtained by proposed HGA, got optimal solution with a very little deviance in a short time. So the suggested algorithm is more efficient.

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