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RESEARCH ARTICLE

Genetic Algorithm for Optimal Vendor Payment Schedule of Transportation Company

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Abstract Nowadays, businesses in any sector are under pressure to do more with less. Company cannot afford to pay more and squander opportunities to free up their company's cash, i.e. working capital. Good working capital gives greater availability to the cash trapped on your balance sheet which is beneficial to fund growth, reduce costs, enhance service levels and seize new investment opportunities. There are numerous ways to free up working capital, and one of the strategies is through account payable. Account payable are amounts due to vendor or supplier for goods or services received that have not yet been paid for. Thus, this paper focuses on the proper vendor payment schedule as one of the approaches to sustain the liquidity of business. Optimizing the vendor payment schedule could be observed through their Net Present Value (NPV). NPV is the difference between the present value of cash inflows and outflows. Therefore, our aim is to optimize the vendor payment schedule by maximizing their NPV. Genetic Algorithm (GA) is implemented in determining the optimal vendor payment schedule. Two GA parameters, which are generation number and population size, have been analyzed and optimized in order to meet the maximum NPV. The results show that the GA is efficient in maximizing the NPV of vendor payment schedule.

Keywords: Payment Scheduling Problem; Genetic Algorithm; Working Capital; Net Present Value; Cash Flow Analysis.

Introduction

Working capital is the lifeblood of every company. Working capital such as money in, money out and administration of inventory is crucial as a company needs to maintain sufficient cash flow to meet its short-term operating costs and obligations. Working capital management is considered fundamental for the financial performance of a company, as it embodies the connection between liquidity and profitability [1,2,3]. There are numerous ways to free up working capital such as accounts receivable, accounts payable, cash management and inventory [4,5].

In this paper, we are focusing on accounts payable since it is directly related to the vendor payment schedule. According to Tarun et al. [6], account payables are amount owed to vendors for goods and services delivered to a company. The sum of all outstanding amounts owed to vendors is shown as the account payable balance on the company's balance sheet. In general, the longer the company does not pay their vendor, the better for their cash flow as the money can be used for other investments. However, if the payment made is beyond the agreed time frame, the company will be penalized, and this will increase their credit. The increase or decrease in total account payables from the preceding period

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appears on the cash flow statement. Thus, the company may choose to make payments as close as their due dates as possible to improve their cash flow. In order to improve the account payable activities, it is advisable to have good vendor payment schedule.

Net cash flow refers to either the gain or loss of cash after all credits have been paid. When a business has a surplus of cash after paying all its operating costs, it is said to have a positive cash flow. On the other hand, if paying all of its obligations is more than earning, it is said to have a negative cash flow. This means the amount of cash received for that period is not sufficient to cover its obligations for that same time period. Positive and negative net cash is essential to determine the financial health of a company. Previous studies regarding cash flow in business has been discussed from the financial management perspective.

In this paper, we are focused on the transportation company as this business is tough to sustain. Many transportation companies encounter the problem of running out of cash. This is due to the company's regulation which allows customers to pay their invoice in more than 30 days, though the business needs huge daily maintenance cost. For instance, in operating a truck, the company needs to pay for fuel, repair, salary for drivers and workers, loading and unloading charge as well as toll charge. The slow payment from customers will shut down the operation of the business and cause missed vendor payments and imposed interest charge [7]. To avoid a series of problems, proper planning to optimize the utilization of resources such as cash is critical.

It is commonly seen that most of the studies on transportation problem put emphasis on vehicle routing problem and supply chain management when discussing about logistics and transportation, but they are rarely concerned about vendor payment schedule. For instance, Tamer and Maged [8] studied about integrated inventory problem to minimize the cost function in supply chain management. However, a study from Shu-Shun Liu and Kuo-Chuan Shih [9] did discuss about cash flow management for profit optimization in construction projects. The project was completed by rescheduling construction activities based on the minimum cash flow availability. This study is concerned with the construction industry which is a different business environment from the transportation industry. Ismail, M.B. et al. [10] also studied construction projects in which the cash flow model was proposed and solved by genetic algorithm. On the other hand, Mehdy et al. [11] studied a single machine scheduling in descending order of profit ratio to maximize the average and minimize the available cash.

A thorough literature review on cash flow management in transportation and logistics industry, did not reveal articles on optimizing the vendor payment schedule. However, many studies have been done on optimizing the cash flow through working capital management [3]. Sulla et al. [12] observed the movement of accounts receivable and accounts payable as one of the sources of cash inflows and outflows. Kantar, L [13] considered cash flow management in logistic company with low resource cost and working capital to gain profits.

Therefore, in this paper, we are aiming to improve the cash flow in transportation company through the vendor payment schedule. If the company could generate higher net cash flow over time, it would mean higher net present value (NPV) of those cash flows where NPV is the difference between present values of cash inflow(s) and cash outflow(s). This study is significant as having greater availability to the cash trapped on the balance sheet, gives more chances to fund growth, streamline processes, reduce costs, enhance service levels and seize new investment opportunities.

In the next section, a review of literature and contribution is presented. Next, the Research Methodology provides the mathematical model and description of proposed genetic algorithm. Subsequently, results are presented and discussed. Finally, conclusions and recommendations are mentioned in the last section.

Literature Review

Developing efficient and effective solutions in vendor payment schedule requires knowledge of theories of operation research. Operation research is a branch of mathematics that deals with the application of advanced analytical methods in order to make better decisions from the alternatives [14]. This payment schedule with the implementation of mathematics can be complicated, requiring deep thought and planning. If successful, this transformation can take businesses to new heights. The execution of vendor payment schedule drives the business to have consistent positive cash flow as the manager determines the date and amount that needs to be spent. The vendor payment schedule supports the view of embracing discipline of optimization and consistency in the business approach.

The core factor that affects the business operation certainly is financial resources which are cash inflow and outflow in the transaction. Coming into the stage of modelling, it would be ideal to have ample resources in carrying out business action plans. Unfortunately, most businesses have limited resources. Therefore, it is crucial that businesses review and realign their resources to optimize their usage. Vendor payment schedule is important to ascertain the level of financial commitment and the right technology must be identified and considered to kick-start the transformation.

The purpose of this study is to apply the theory of optimization to plan and schedule the vendor payment for a transportation company in Kluang, Johor. This study will focus on the fundamental factor that can influence the control of operation businesses. It will enable businesses to allocate enough resources in order to achieve the optimal level of usage of funds.

Project Scheduling Problem

Project scheduling problem is used in the planning and scheduling the resources within a single period. According to Klimek and Łebkowski [15], project scheduling with cash flow optimization needs the details of transactions such as starting and due dates as well as cost of the activities. According to Chaharsooghi et al. [16], the standard planning of tasks identifies competent conditions such as the least delay allowable. Such conditions tend to maximize the utilization of resources throughout the scheduled chart. Project management generally aims to maximize the allocation of resources and minimize cost incurred.

Assuming a deterministic project condition with every essential data such as project events, time durations or the different cash flows are to be known. A few types of resource constraints, considering variety of assumptions correspond to network representation either activity-on-arc or activity-on-node, cash flows form such as positive or negative cash flows as well as activity-based or event-oriented, single objective or multi objectives. In addition, there are several types of resource constraints such as capital constraint, various resource types or material considerations and time or cost trade-offs. Furthermore, many efforts emphasize on the decision of both the timing and number of payments, acknowledged as payment scheduling problem [17].

Next, the decision variables are different for every study. The objective function that has been realized in the beginning of the study is considered in formulating the model including the constraints. The resource allocation problem is aimed for the activities to be finished before the due date expires and the resources are depleted. Indeed, the change in the required resources level do not happen within the same period. Therefore, ignoring level limitation, considered due date of tasks not to be greater than the date predefined. The work of Mehdy et al. [11] stated that the cash management concentrates on the best possible use of the resource with reduced shortcoming.

Based on R.Glenn Hubbard et al. [18], real business examples are used to prove how managers formulate project schedule problem and make daily real decisions. The manager should realize the fundamental principle to the real-world situation in order to maintain the position of liquidity of the transportation company as well as ensure the company can operate smoothly.

Various practical considerations give rise to the problem concerning the operation of a project cost accounting system. The study by S.K. Sears et al. [19] is meant merely to afford some specific examples such as workers, equipment and materials. Financial control is vital to implement and maintain standard fiscal procedures in the business. The vendor payment schedule is significant to monitor the cash outflow for the daily operation in the business. Hence, the amount and timing of these cash demands are what really matter for owners and contribute to an appropriate schedule.

Cash Flow Analysis

Cash is the life blood of businesses. The financial health of the business does not look at the profit earned which is positioned in the balance sheet of the company, but it is reported in the cash flow statement. Cash flow analysis shows a big picture of the financial health of the business [20]. The primary objective of the cash flow statement is to deliver useful information about how the company obtains and spends cash, payment received and cash disbursement of a company during cash transaction and cash equivalents from the following activities:

- Cash flows from operating activities
- Cash flows from financing activities
- Cash flows from investing activities

The purpose of cash management is to improve the amount of cash on hand to the accounting. The process includes optimizing the interest gained by reserve funds not required instantly and minimizing losses resulted from delays in the transactions. The company encounters a trade-off between cash on hand for liquidity and utilizing that amount of cash for production usage. It is critical to allocate the adequate amount of cash required by the company for daily operation. Since transportation companies experience to cash flow imbalances, which suggests that it requires proper cash flow management.

According to [21], cash flow analysis provides the relevant insight on the flow of cash on hand over a specified period. The owner creates the cash flow and explains the reasons that affect the rate of cash flow. Moreover, it will drive the company to make correct decisions that can further increase the economic value of the company as well as keep the company on the right track in terms of its potential growth. Hence, proper cash flow needs to be executed. This can also ensure that the business can operate with sufficient cash. They must understand how to control the cash on hand of the company which is the liquidity that the company have access to.

This study concerns the cash flow on operating activities which is known as CFO. CFO is raised from basis operations such as net income and cash operating expenses net of taxes. Critical activities of cash flow in are summed up, in contrast, the activities of cash flow out are subtracted. In this section, the concerns are emphasized on the activities of cash flow out such as payment to suppliers. Making an efficient financial decision, comparison of cash flow that happens at various point in time is essential, but the general principle of comparison cannot be made. Thus, moving the cash flow forwards or backwards on the timeline towards a point to execute the comparisons and addition or deduction cash flow belonging stream.

According to Angelo C. [22] there are three rules to the movement of cash flow which are only the cash flow at the similar point in time can be asserted. According to the fact mentioned, the analysis to an individual time point is reduced to compare or combine cash flow. This is due to single cash payment has different values on the timeline with the various time point. The value of cash today will not be equivalent to the value in the future and money today will be less valuable in the future. Hence, this is the reason the future cash flows impose the discount rate. The second rule says that process of moving cash flow forward in time is known as compounding. The initial amount needed to be accrued with the interest following the percentage interest rate of reference. The third rule of time travel explains the principle of obtaining present value supposed to be received or paid at different points in the future.

Suitable application of the principle of time dilation enables the manager to compare or combine cash flows that happen at various time points. Regarding the analysis of the cash flows, it becomes useful to provide valuations from the perspective of present value or future value. Alexander J. [23] states that nearly all the valuation techniques are based on estimating the cash flow. Another essential fact to bear in mind, the determining value is only associated with the future expectations of cash flows.

The Discounted Cash Flow (DCF) valuation method is based on sound elementary economic theory. The discounted cash flow analysis is used to calculate the value that need to be invested in today's time in order to get the return of the investment in the future. Significantly, these future cash flows is so-called "discounted" to meet at the present value. Since DCF is based on projection of future cash flow, an assumption about the financial statement forecast is performed. DCF is evaluated as follow:

$$DCF = \sum_{n=1}^{\infty} \frac{CF_n}{(1+i)^n} \tag{1}$$

where CF denotes cash flow; i denotes discounted rate and n is the period from one to infinity. Moreover, DCF analysis is used to maximize the present value of total annual profit. The model is acquired the limited property that gradually drops over time and achieving zero as the expiration date reaches. The theoretical fact simplifies the searching process for the global solution to a local maximum in the interest of gaining useful insights [24].

Another popular cash flow analysis is known as Net Present Value (NPV) analysis. According to Joe Knight [25] net present value is defined as today's value of the cash flow at the specified rate of the task compared to the initial investment. NPV is a tool for decision making of financial analysts in determining the worthwhile tasks. This is due to the model that is functioning based on the principle of time value of money which interprets future value into today's cash flow. Nevertheless, it gives a concrete figure such that managers can perform a comparison of initial outflow of cash over today's yield.

The net present value is a vital instrument to measure the profitability of an investment, provided by the addition of all cash flows, appropriately moved in time. The internal rate of return (IRR) denotes that the rate that generates the NPV of a cash flow equal to zero. IRR of an investment is known as the discount rate that generates the net present value of expenses (negative cash flows) equivalent to the net present value of the revenue (positive cash flows). Generally, the company receives different offers in terms of payment options for an invoice. The terms may contain cash discount for settling an invoice within an agreed number of days.

The formula is applied to calculate NPV is as follow:

$$NPV = \sum_{t=1}^{N} \frac{R_t}{(1+i)^t} \tag{2}$$

where R_t denotes the net cash flow of activity, i is the interest rate at t period.

The greater the value of positive net present value, the more profit earned to the company. Considered as opposite, the negative net present value means that the investment does not advise to exercise since it will bring net loss to the company and eventually drain cash from the company.

Referring to J. Weglarz [26], the first model of cash flows initiated by A.H.Russell [27] with the aim of maximizing NPV by nonlinear function, optimal schedule for different tasks have been designed without the resource limitation. The author then developed the heuristics model using linear objective function by estimating the first term of the related to Taylor series expansion in the region of a feasible solution. The duality of the model from the problem without resources constraint have been implemented to tradeoff the early tardy cost in resource constrained problem. Then, Grinold, R.C [28] converted the unconstrained scheduling modelled by Rusell into an equivalent linear system. The study restricted the basic spanning tree in the network in the interest of obtaining optimal NPV.

The maximization of NPV is common to solve cash flow problem with the resource-constraints by using different heuristics methods. R.A. Russell [29] proposed the comparison of six heuristic methods in solving the problem. Three of the method are extension from the unconstrained problem but the solutions are not able to draw an appropriate conclusion. However, Smith-Daniels and Aquilano [30] limit the problem where the negative cash flow activities are allowed in the system along with single payment received. The solutions of the approach are improved by implementing back-shifting of activities. Finally, weighted cash flow approach was introduced by Baroum and Patterson [31] which had been solved according to weights derived for the unconstrained problem.

Genetic Algorithm (GA)

A basic feature of GA is the combination of population, generation, evaluation, selection, crossover, mutation and elitism. GA are stochastic search approach under the discipline of natural selection and genetic related to biological genetic process inspired by Charles Darwin's theory of natural evolution.

GA is mainly applied in non-convex problems that implement discontinuous functions. GA vary from conventional optimization method as obtaining an initial solution, a set of possible solutions for the search process called population is acquired.

The conceptualization of GA is under the biological genetic process. Hence, the terminology in GA is also relevant with the biological term.

- Population − A number of possible solutions of the model
- Chromosomes − The possible solutions to the specified problem.
- Generation − The chromosomes produced by successive repeated algorithm.
- Gene − One component of a chromosome.
- Allele − The value representing a gene for the specified chromosome.
- Genotype − The representation of population in the computation space.
- Phenotype − The representation of population in the original solution space.
- Decoding − The process of converting a solution from the genotype to the phenotype space
- Encoding – The transformation from the phenotype to genotype space.
- Fitness Function − The measurement of how a solution is close to the optimal solution
- Genetic Operators − The operator that alter the structure of the offspring.

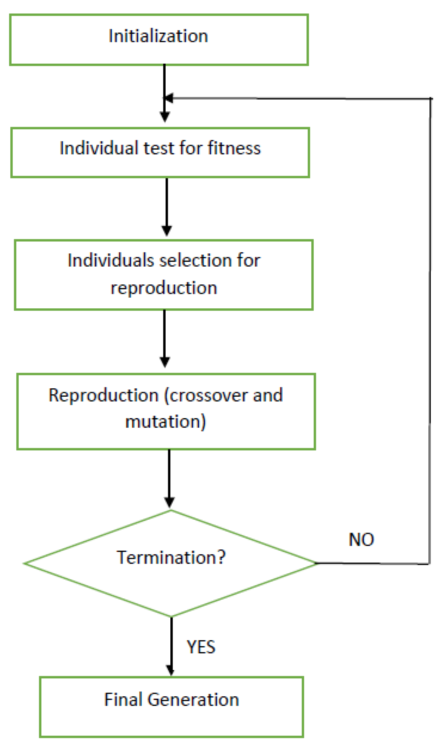

Figure 1: General GA process.

Figure 1 shows general process in GA. This algorithm emulates the process of natural selection where the fittest individuals are chosen for breeding in order to generate offspring of the next generation. GA is evolved from the bad outcomes and employ natural selection to produce better outcomes. GA begins when generating the initial solutions. After that, the individual's goodness on how well they perform at a given problem task is evaluated. GA has emphasized on the feature of population. Population size, which is usually a user customized parameter, is one of the significant factors affecting the performance of GA.

GAs have been given a lot of attention by researchers. It has been used to solve many difficult combinatorial optimization problems in optimization and search problems. One of the studies is Green Vehicle Routing and Scheduling Problem recently presented by Y.Y Xiao and A. Konak [32] that developed a hybrid heuristic solution approach, named as the GA-DP, by combining a genetic algorithm with the DP procedure. Genetic Algorithm also delivered the most optimized path with the minimum possible amount of time in Travelling Salesman Problem (TSP) studied by Senthilkumar et al. [33].

The study of [17] had given a general concept on how the genetic algorithm was applied in the project scheduling problem. He constructed a resource feasible schedule and known as serial schedule generation scheme. The genetic algorithm presented is aimed to investigate the relation between a project's net present value and its corresponding total duration or makespan, by testing the algorithm on a large and very diverse set of problem instances.

The effectiveness of GA in seeking the global optimal solution is able to generate a better-quality result for the model than others. The results verify that a nearly optimum result can be attained by GA and the optimization process can save the cost.

Research Methodology

Genetic algorithm is commonly used to solve real-life complex problems arising from different fields such as engineering, politics, economic and management. Sourabh K. [34] discussed the analysis of recent advances in genetic algorithm. There are studies in cash flow analysis and project scheduling which uses genetic algorithm to solve their optimization problem such as in [35,36,37]. Thus, this study finds the optimal vendor payment schedule using genetic algorithm.

Model Formulation

The study is proposed to construct the vendor payment schedule subject to pre-defined deadline while maximizing the sum of NPV of the negative cash flow activities. The study is illustrated by activity-on-node network $G(N,A)$ where the vendor activities are denoted as nodes N and edges of set A, the precedence relation with a time-lag at zero. The activities are numbered starting from a dummy node 0 to a dummy end node $n+1$. Each of activity i with duration d_i of 1 and its activities encompass a series of vendor invoices throughout this period.

A theoretical formulation for the vendor payment schedule considered in this study can be provided as follows:

$$\max \sum_{i=1}^{n} (I_i - C_i) e^{-\alpha(x_i)} \tag{1}$$

Subject to,

$$x_j \geq x_i + d_i + r_i \forall (i,j) \in A \tag{2}$$

$$x_{n+1} \leq \Delta \tag{3}$$

$$r_j \leq 30, \quad \forall j \in A \tag{4}$$

$$r_j \text{ as integer}, x_i \geq 0,\ i = 1,2,\ldots,n,\ j = 1,2,\ldots,n \tag{5}$$

Equation (1) maximizes the NPV of the project. A project's total NPV obtained from the difference of the revenues of vendor's activities and the respective costs that occurs at the origin point. The variable r and x indicate the invoicing date and delay in the start time of the activities respectively. Equation (2) is constrained to the precedence relations with a time-lag of zero. The renewable resource constraints are satisfied by Equation (3) and Equation (4) apply a soft pre-determined due date to the model enclosed an extra decision variable r_j allowing project delay in the starting time. The final equation identifies the decision variables. The objective function of vendor payment schedule put emphasis on that optimizes the NPV. Therefore, the model can be considered as a single-objective optimization model.

Algorithm of GA

The study is proposed to construct the vendor payment schedule subject to pre-defined deadline while maximizing the sum of NPV of the negative cash flow activities.

Pseudo-code of the algorithm is as follow:

Begin
Initialize the population, P
Generation=0
Evaluate fitness function of initial population
Generation loop
While Generation<MAX Generation do
Selection
Crossover
Mutation
Evaluate fitness value of the offspring
Reinsert offspring
Generation= Generation + 1
End

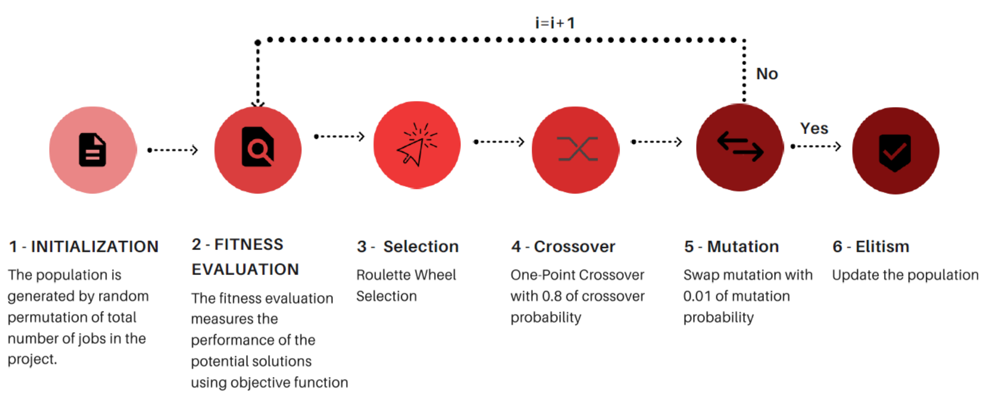

Figure 2: Optimizing the vendor payment schedule using GA

Figure 2 shows the GA process in optimizing the vendor payment schedule. Chromosome representation and the genetic operators as well as objective function must be identified. The objective function is the maximization of the NPV and it is also defined as fitness function. The advantage of using integer representation is that the efficiency can be increased as the chromosomes do not necessarily have to be converted into phenotypes before fitness evaluation. The representation also increases the precision as there is no conversion of data. The problem aimed to solve the vendor payment schedule and seek for the list of vendor activities that results in maximum NPV. The chromosome in this problem is represented by the string of vendor activities.

The process is initiated with a set of individuals known as population. Population size is defined as the number of possible solutions. Each chromosome is presented by a set of parameters known as genes.

At each iteration, the old population generates new population and the successive population is called generation. For this problem, different population size is initialized and generates different convergence rates. Small population size can converge faster but premature convergence problem occurs. Therefore, an appropriate number of populations is needed to prevent premature convergence problem. Other than that, the primary element in genetic algorithm is an appropriate generation number.

The initialization process is carried out by generating a set of population randomly. The initial population consists of specified activities which is the number of jobs to be scheduled. The potential solution is searching within possible solutions. Fitness function corresponds to the objective function of the problem which is stated in model formulation section. The fitness evaluation measures the performance of the potential solutions. The value of fitness function contributes to the development of the selection probability.

The roulette wheel selection is the method employed in this problem. This method selects individual associated with the probability of selection based on the fitness values. The method implements the concept of the Roulette wheel in casino. The probability of the selection of the individual is assigned to the proportion of the wheel. The proportion can be represented by dividing the fitness of a selection by the total fitness of all the selections. The higher the probability of selection, the higher the chance of selecting the individual to breed. This means that the individual is fitter than other individuals.

In this work, one-point crossover operator where one crossover points between 1 and maximum number of chromosomes is randomly selected using random number generator. Not all of the chromosomes will go through the crossover process. Only the selected chromosomes with the generated random number less than or equal to probability of crossover will undergo crossover process. One of the chromosomes represents father and the other selected chromosome from selection process represents mother. The two chromosomes undergo crossover at the crossover point and produce one of the offspring. However, child 2 is generated by opposing the chromosome of father and mother and undergo the crossover at the same crossover point. Two child solutions are produced. In addition, the crossover rate should be set at large probability which is in the range of 0 to 1 instead of small probability. High probability leads to more populations to experience crossover process.

The number of chromosomes that will be chosen to experience mutation process must be small. This is to monitor the searching space not to diversity. The chromosome to undergo mutation is the chromosomes with the mutation probability that is less than the predefined mutation. Then, a random number between 1 to the length of the chromosome is collected and the amount represents the genes which is needed to undergo mutation. Another random number is then generated from the similar range in previous step. The gene of the second random number is then interchanged with the gene chosen in the previous step.

The first generation is accomplished when the initial population has gone through selection, crossover, and mutation process. In order to say that one generation is completed with an updated population. The updated population is then evaluated for its fitness value. The maximum NPV value and the vendor payment schedule are obtained.

The iterative operator is repeated from evaluation to mutation until a stopping criterion is met. The result of various generation numbers will help to provide detailed analysis in the next results and discussion. The stopping criterion is set as the maximum generation number which is 100, 500, 1 000 and 10 000. Population size is set as 100, 200, 400, 800 and 1000. However, crossover probability is fixed at constant of 0.8 as well as mutation probability is given as 0.01.

Results and Discussion

This study will carry out two simulations to identify the best optimization solution in genetic algorithm. The first simulation is to identify the most suitable generation number while the second simulation is to test the best population size. Hence, the first simulation varies the generation number from 100 to 10

000 with constant population size (100, 200, 400, 800 and 1 000), crossover probability (0.8) and mutation probability (0.01). While the second simulation varies the population size from 100 to 1 000 with constant generation number (100, 500, 1 000 and 5 000), crossover probability (0.8) and mutation probability (0.01).

Implementation of GA under Constant Population Size

The stopping criterion is set as the maximum number of iterations also known as generation number. The reason for doing so is to prevent immature convergence where the algorithm will not be premature. Therefore, an optimized generation number should satisfy the stopping condition. A number of experiments have been done in this part to test the best generation number by setting the population size as constant at 100, 500, 1 000 and 10 000.

Consequently, a large number of generations allows GA to search for a more desirable solution without being trapped in a local maximum. According to the computational results of constant 100, 200, 400, 800 and 1 000 population size, the maximum NPV is attained at generation number 8 722, 986, 8 986, 5 968 and 4,359 respectively. Aside from 200 population size, the parameter of maximum generation number must be set not less than 5,000 but at least 9,000 to make sure the algorithm converges to a desirable and nearly optimum solution. A summary can be concluded to identify a range of the best generation number with respect to various population size as illustrated in Table 1.

Table 1. The Best and Minimum Number of Generations in GA

Population Size	Completion time	Maximum delay in the due date	Net Present Value	The Best Generation Number	Minimum Generation Number in GA
100	34	16	88,097.81	8,722	9,000
200	31	3	87,417.13	986	1,000
400	34	9	87,010.36	8,986	9,000
800	32	5	86,699.04	5,968	6,000
1 000	31	3	87,973.63	4,359	5,000

From Table 1, the greatest generation number is 8,986 among the five experiments. Hence, the algorithm sets the minimum generation number as 9,000. All the simulations allow to attempt a better solution with the stopping condition of the minimum generation number at 9,000 in any case of the population size. From this experiment, the best NPV is 88,097.81 with 8,986 generation number and the best expected completion time, time for delay paying allowed is 34 and 16 respectively. Even so, a good population size can enhance the efficiency of GA as the outcome might be ineffective when the population is large. In consequence, the following experiments have been carried out to detect the best population size.

The Implementation of GA under Constant Generation Number

As discussed in the prior section, the value of NPV is directly proportional to the generation number. In addition, the best solution can be attained under an adequate population size where the best solution is 88,097.81 with the peak generation number at population size of 8,722. In view of this, 4 individual computational analyses at constant generation number of 100, 500, 1 000 and 10 000 at different population size are accomplished in this section to identify the best population size by comparing the maximum value of NPV. The best population size and the computing time will be illustrated in this section.

A conclusion can be drawn that the best population number of GA is dependent on the number of generations. Then, the best population number is represented by 840, 230, 440 and 350 correspond to the generation number of 100, 500, 1 000 and 10 000. On the other side, the minimum solutions are generated at population size of 620, 860, 720 and 240 with respect to 100, 500, 1 000 and 10 000 generations. The minimum and maximum points are the decisive factor that must be considered in selecting the best population size. The results are tabulated in Table 2 and Table 3 as followed together with extra information of computing time in term of seconds.

Table 2. Summary of The Results of Maximal at Various Generation Number.

Generation Number	Completion Time	Maximum allowable of delay in the due date	The Best Population Size	Average NPV	Computing Time (seconds)
100	32	18	830	82,060.69	28
500	32	14	230	83,524.26	45
1 000	31	7	440	85,133.52	483
10 000	30	12	350	88,477.35	2497

Table 3. Summary of The Results of Minimal at Various Generation Number.

Generation Number	Completion Time	Maximum allowable of delay in the due date	The Best Population Size	Average NPV	Computing Time (seconds)
100	36	18	610	66,816.22	28
500	34	21	750	73,677.89	45
1 000	34	15	760	75,343.27	483
10 000	31	7	240	85,156.16	2497

Referring to Table 3, the high probability of obtaining a poor solution is ranged between 10 to 650 for 100 generations as the minimum result is denoted at the population size of 610. Table 3 shows that the experiment of generation 500 and 1 000 returned a minimal at population number of 750 and 760. Hence, the range of population size in generating a bad solution is increased to 700. This shows that big population size which is larger than 700 will lead the optimization to yield unsatisfactory result.

Ultimately, choosing the best population size for ten thousand times of generation is a critical decision. This is due to the population size cannot be too large or too small. Table 2 shows that the limited population number will obtain a bad output whereas the large population size will generate repeated solution. Thus, a conclusion can be outlined as the population size need to be increased when the generation number is small and for medium generation number, the population size has to be not too large as well as a moderate number of population size is considered for a large generation number.

Selecting an appropriate population size is critical as it affects the computing time needed during the generation number. Figure 3 and Figure 4 demonstrates the change of computing time from 100 population size to 1 000 population size with respect to various generation number. From Figure 1 and Figure 2, the computing time for 100, 500, 1 000 and 10 000 rises rapidly when the population number is growing. Even the computational time does not play the top priority in choosing the best population number in our research, but it always supports the decision making of investor on cost optimality beside the point of time optimality.

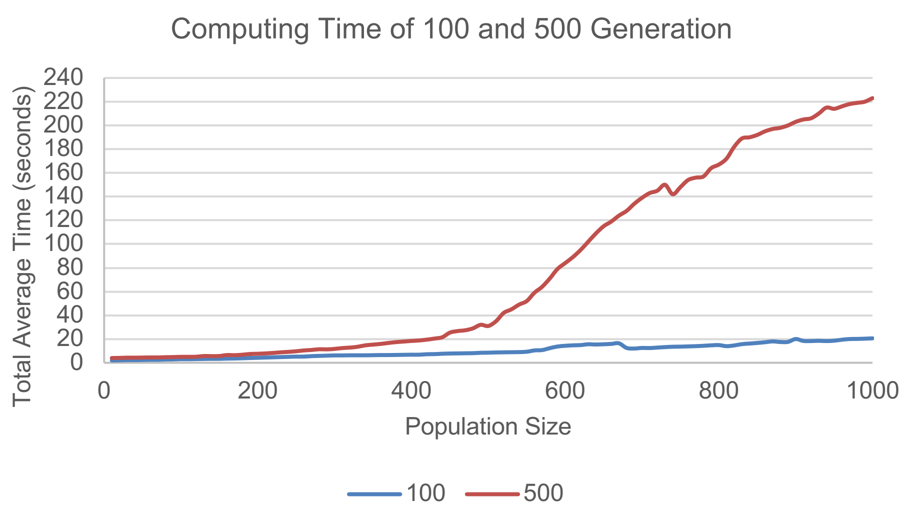

Figure 3. Comparison Result of Computing Time for 100 and 500 Generations

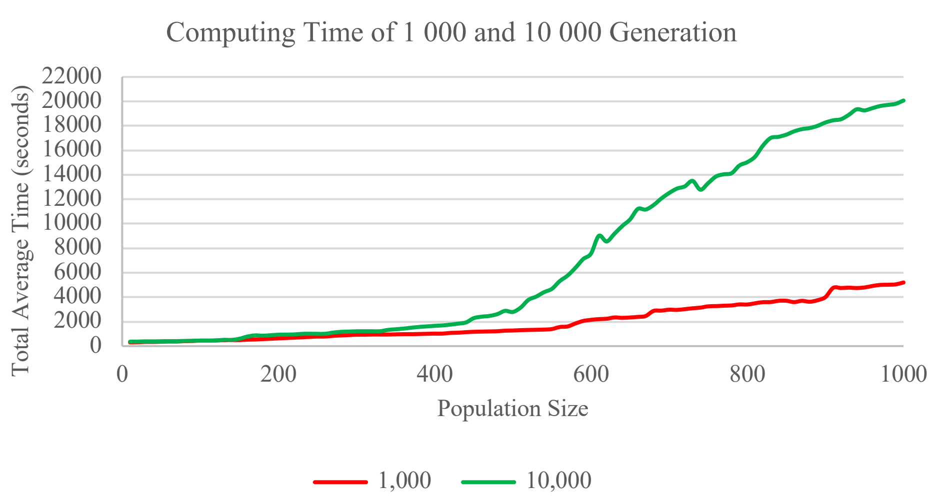

Figure 4. Comparison Result of Computing Time for 1000 and 10 000 Generations

The Best Payment Schedule

As mentioned earlier, the aim of this paper is to construct the payment schedule from all the creditors. The result obtained from prior experiments in identifying the best generation number and population size lead to determine the most appropriate number of generation and population size. Thus, the maximum NPV indicates the most desirable result. From prior simulations, the best cost solution obtained is RM 88 477.35 at population size of 350 and 10 000 of generation number.

The simulation is run with the predefined setting and obtained the best schedule from the simulation. The best schedule is then presented by an Activity-on-Node network where the node represents activity and the edge between the nodes shows precedence relationship between the activities in Figure 5. The schedule is initiated by creditor 6 and completed by creditor 16 within 30 days. The maximum usage of cash on hand is limited to RM 25,000.

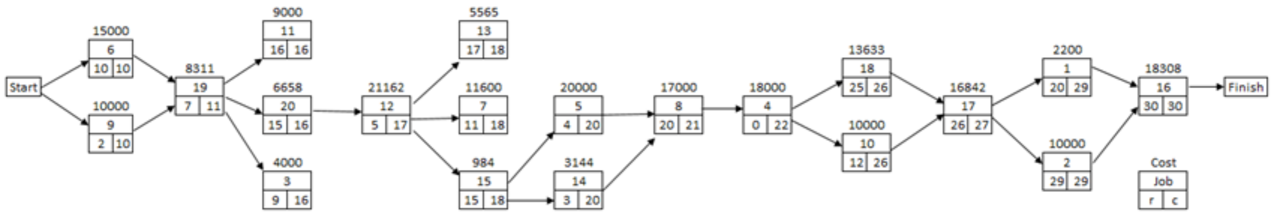

Figure 5. Project Schedule Activities Network

Conclusion

Generally speaking, this study put attention on maximizing the net present value of the vendor activities with the concept of time value of money. In this day and age, cash is king in running any kind of business to sustain day to day operations. For this reason, many studies had been done on the payment scheduling problem. This optimal cost can be attained by applying appropriate optimization method to improve the schedule of payment activities. Two computation simulations are conducted to determine the most appropriate GA parameters that is number of generation and population size by comparing the performance of the objective function. Each simulation is carried out by using Matlab 2015a on Intel Core i3 CPU, M 370 @ 2.4 GHz, 2.00 GB, Window 10, 64-bit operating system.

The experiments are analyzed that optimal solutions can be attained when the generation number is determined in the range of 900 to 9 000. Thus, the most desirable combination of population size and number of generations is 350 and 10 000 respectively which generates a near optimal solution cost of RM 88,477.35. The best sequence of the vendor payment is illustrated in the activities network and attached in the result section.

Finally, yet importantly, the implementation of GA in maximization of NPV of a vendor payment schedule contributes to the maximum solution cost of transportation and logistics. An optimal allocation of the resources to the vendor activities is considered as the primary concern of sole proprietor. Furthermore, the optimization of GA parameters delivers beneficial details to the correlation of number of generation and population size to approach study on the fitness of GA. According to this study, the outcomes presented that a crucial generation number produces the optimal solution combined with medium size of population. Alternatively, it is stated that the population size should be set at 3.5% of the generation number. From this study, the appropriate population size is 350 with 10 000 of generation number.

Recommendations

We believe this study can help practitioners and project managers to make the right decision when executing the project activities and subsequently be able to estimate the potential budget to ensure profitability. The proposed GA is problem specific where performance is dependent on different parameter combinations. Therefore, for any further extension of the problem, the algorithm should be redesigned. In this study, NPV was investigated. As defined before, NPV is the difference between cash inflows and outflows. The cash inflows come from the payments at activity's completion time. However, cash flow may occur with the progress of the work at a regular time interval. In the future, a hybrid approach of GA can be proposed and tested on different payment methods. Besides, other powerful methods such as variable neighborhood search, ant colony algorithm or particle swarm algorithm can be proposed to optimize the vendor payment schedule.

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