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RESEARCH ARTICLE

A COMPARISON STUDY OF DECISION SUPPORT SYSTEM USING CO-EVOLUTIONARY ALGORITHMS.

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Abstract

This study is proposed for a small and medium-sized steel construction company to answer their problem in choosing suppliers on a project. A steel construction company's project usually works with a same basic material for many types of item such as steel. Furthermore, the price for each item from the supplier is not based on the item type but its volumes. This study will perform a simulation of decision support system to help the company in decision making about which supplier will supply the item to gain the maximize profit. In this study, a co-evolutionary algorithm is used as the basic foundation for the application to optimize the profit by matching the right supplier for each item. The objective of doing this simulation is to proof that there is a rise in profit of the company by doing a matching the right supplier for the company. In this study will consider two kind of scenarios: (i) without considering discount (ii) with considering discount and divided into 2 cases in each scenario: First case is when the company use the same type of goods which make the price from each supplier is only based on their volumes. The second case, is when the company use different type of goods which make the price from each supplier become more variety. These scenarios are proposed see how co-evolutionary algorithms perform in making a decision when the parameters become more varieties and developed by using Java Net Beans.

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Introduction:-

Generally, the optimal solution for effective purchasing is the buyer was free to choose from a range of different sources. Mostly, all companies choose the supplier who providing the lowest price. There is a strong trend in many companies towards reducing the total numbers of suppliers as well as concentrating more on developing the relationships with the remaining ones that the company is dealing directly with. This can be achieved by forming systems of suppliers, with the right suppliers for each item in the company.

The main issue in this study is doing this simulation of decision support system to help the company to proof that there is a rise in profit of the company by doing a matching supplier with using co-evolutionary algorithm. In this study, the numerical example based on the steel-construction company (SCC) case, which in this case SCC can receive multiple project from a single company. Before doing the project, SCC will make a contract first with the

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related company. The contract is established by submitting a proposal about project timeline, budgeting, resources, etc. After the proposal is submitted and approved by the related company, SCC will start doing the project. Usually, the company will check the total cost and the duration needed to finish the project on the proposal and the proposals have the lowest cost and duration will be approved. In order to maximize the profit, SCC will choose the most expensive item from many suppliers so SCC can maximize the profit since SCC is a service company. Choosing the best supplier isn't that simple because of the variant item needed in a project and many suppliers can supply the same item with higher cost. Therefore, in this study proposes a solution by demonstrating a decision support system using co-evolutionary algorithms in matching suppliers. Decision support system is an interactive computer-based system to support user in assessing and deciding an option [6]. The applicability and efficiency of solution procedure is demonstrated through numerical example and a co-evolutionary algorithms and genetic algorithm (GA) is proposed as a solution method [7]

Background and Related Works:-

A study of coevolutionary algorithm and genetic algorithm for multiobjective optimization is performed used in the previous research by [3]. In their study, they were comparing coevolutionary algorithm (CGA) with 7 other algorithm in optimizing multiobjective function. The other algorithm is: random search (RAND), Fonseca and Fleming's multiobjective GA (FFGA), the Niched Pareto GA (NPGA), Hajela and Lin's weighted sum approach (HLGA), the Vector Evaluated GA (VEGA), the Nondominated Sorting GA (NSGA), a single-objective EA using weighted-sum aggregation (SOEA), and the Strength Pareto GA (SPEA). The used test function provide a range of difficulties for multiobjective optimization (e.g., multimodality, deception, isolated optima). In each optimization, it is desired to minimize the objective vector by finding its Pareto-optimal front. The result show that the CGA performed very well compared to the other evolutional algorithm and random search. It could be argued that the CGA qualitatively performed on par with or outperformed the other algorithms based on four of the six functions.

Based on previous research [4], genetic algorithm works well in searching and optimizing a solution. Genetic algorithm have a simple and understandable principles but it is complex to design the chromosome and implement it. These principles is rather similiar with the problem that coevolutionary algorithm had.

The study of using coevolutionary algorithm and genetic algorithm to collaborate between 2 company already performed by [1]. Their study proposed a collaboration between 2 delivery service company in 3 different region based on the terminal status and the service center location. A coevolutionary algorithm and genetic algorithm is applied in the proses and the result was satisfying. After that, they extend the study with proposes a sustainable alliance model, which deals with selecting service centers in each merging region with low demand in express delivery services by using a co-evolutionary genetic algorithm based heuristic is developed for network design, which may be implemented under a distributed decision-making scenario assumed in collaboration system by [2].

This study will develop the solution model of decision support system to matching suppliers with using co-evolutionary algorithm. The objective in this study is to maximize the profit of the company by doing a matching supplier in steel-construction company (SCC) with two kind of scenarios: without considering discount and with considering discount and also in each scenario considering for each item are made with same or different raw materials.

Problem Definition :-

The main problem in this study is how to maximize the profit by matching the right supplier for each item. This study considers a small to medium steel-construction company (SCC) in choosing supplier in a single project. Matching or choosing the right supplier become difficult as the types of item and the decision parameter increased. The more item used in a project, the more difficult it is for SCC to decide which supplier will supply the item. In this study will consider two kind of scenarios: (i) without considering discount (ii) with considering discount and based on the required problem, the problem is divided into 2 cases in each scenario:

a) Case 1

Assumptions:

There are m companies whose distribute the raw materials that needed for make items.

There are n items. All of these items are made with the same raw materials.

Labor works for each raw materials are same for each company.

Let i denoted the order of company that being used for supplying raw materials where i denote the set of possible companies. $\therefore i \in I$. Therefore, $\max\{i\} = m$.

Let j denoted the item that made from raw materials where j denote the set of possible items. $\therefore j \in J$. Therefore, $\max\{j\} = n$.

The goal of the problem is to maximize the profit whereas the profit function for the i -th company computed as follows:

$$g(i) = p(x_i + h_i) * \sum_{j=1}^n q_j \quad (1)$$

The problem become maximization problem with the statement

$$\text{Max}\{g(x_i)\} \quad (2)$$

The notations are defined as follows:

Let p be the desired profit as a fraction of the total cost.

Let x_i be the cost in Rupiah of the raw material for the i th company for each kilogram.

Let h_i be the cost in Rupiah of the labor works for the i th company for each kilogram.

Let q_j be the quantity in kilogram of raw material being used in for the j th item.

Let $g(i, j)$ be the profit function for j th item that supplied by the i th company.

b) Case 2

Assumptions:

There are m companies whose distributed the raw materials that needed for make items.

There are n items. For each item are made with different raw materials.

Labor works for each raw materials are same for each company.

Let i denoted the order of company that being used for supplying raw materials where i denote the set of possible companies. $\therefore i \in I$. Therefore, $\max\{i\} = m$.

Let j denoted the item that made from raw materials where j denote the set of possible items. $\therefore j \in J$. Therefore, $\max\{j\} = n$.

The goal of the problem is to maximize the profit whereas the profit function for the i th company of the j th item computed as follows:

$$g(i, j) = p(x_{ij} + h_i) * q_j \quad (3)$$

Since for each item we only need to find 1 company that maximizes the profit, the problem become maximization problem with statement

$$\forall_{j \in J}, \max_{i \in I} \{g(i, j)\} \quad (4)$$

The notations are defined as follows:

Let p be the desired profit as a fraction of the total cost.

Let x_{ij} be the cost in Rupiah of the raw material for the i th company of the j th item for each kilogram.

Let h_i be the cost in Rupiah of the labor works for the i th company for each kilogram.

Let q_j be the quantity in kilogram of raw material being used in for the j th item.

Let $g(i, j)$ be the profit function for j th item that supplied by the i th company.

Let i_j^* be the company that supply the j th item which makes $g(i, j)$ maximum as $i^* \in I$ and $j \in J$.

It is easier to find the maximum profit through finding the company that maximizes profit for each item (i_j^*). Therefore, the equations can be divided into several parts based on the item.

$$\begin{cases} g(i, 1) = 0.2(x_{i1} + h_i) * q_1 \\ g(i, 2) = 0.2(x_{i2} + h_i) * q_2 \\ \vdots \\ g(i, n-1) = 0.2(x_{in-1} + h_i) * q_{n-1} \\ g(i, n) = 0.2(x_{in} + h_i) * q_n \end{cases} \quad (5)$$

Research Method and Algorithm Development:-

In this study, a heuristic algorithm based on co-evolutionary algorithm and genetic algorithm is proposed. The solution procedure is implemented using a genetic algorithm (GA), which is a stochastic solution search procedure proven to be useful for solving combinatorial problems by adopting the concept of evolution [5]. In order to do this, the first step is design the suitable chromosome for each supplier. As shown in Fig1, a chromosome consists of 13 genes. Each gene represents the status of each item purchased. Each gene only has 2 type of value, "0" or "1". 0 means the item will not be purchased from the specified supplier, while 1 means the item will be purchased from the specified supplier. To evaluate the fitness values for each supplier, the co-evolutionary algorithm is performed, in which GA is also applied.

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13
1	0	1	1	1	0	0	1	0	1	1	1	0

Fig1. Chromosome design for each supplier

According to Fig 2, the chromosome is composed of three parts based on the supplier. The first one, ranging from the first gene to the thirteenth gene, denotes the type of item that will be supplied by the first supplier. The second part, ranging from the fourteenth gene to the twenty-sixth gene, indicates the type of item that will be supplied from the second supplier. The third part, ranging from the twenty-seventh gene to the thirty-ninth gene indicates the type of item that will be supplied by the third supplier.

Supplier A												Supplier B												Supplier C														
1	0	0	1	1	0	0	0	0	1	0	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0

Fig 2. Chromosome design for calculating fitness value

The procedure of the co-evolutionary algorithm can be summarized as follow steps:

1. Generate the population randomly for each supplier as shown in Fig 1.
2. Matching process for each chromosome from each supplier as shown in Fig 2.
3. Verify each chromosome as shown in Fig 5 with the following condition:
 - a. Each item can only be supplied by 1 supplier.
 - b. Each item must be supplied.
4. Calculate the fitness value for each chromosome based on the given equation (Depends on the scenarios: if considering discount then calculate the fitness function must be added the parameter which represents: If in a single supplier, SCC ordered more than 6 types of item, the SCC company will get a 2% discount).
5. Descending sort of the chromosome based on the fitness value.
6. Choose the top-ten best chromosome from each supplier and save all of them into a temporary variable.
7. A roulette wheel selection is doing to fill the other 90 chromosome which has been disposed from step 6.
8. In this study, the single-cut point crossover applied as the genetic operator based on the cross over rate. The process is shown in Fig 3. There are two processes in the crossover. First, generate a random number from 0-38 (e.g. 19) and the second is from the twentieth gene to thirty-ninth gene will be swapped with the same range of gene from the chromosome below.
9. Apply the binary mutation genetic operator. The process is shown in Fig 4. First, generate a random number from 0-38 (e.g. 5). The chosen gene value will be flipped from "0" to "1" and from "1" to "0".
10. Verify each chromosome with the same condition as step 3 describes in Fig 5.
11. Recalculate the fitness value.
12. Descending sort of the chromosome based on the fitness value to find best chromosome.
13. Repeat from step 1 through 13 until 100 generation is reached.

The genetic operators are used in the proposed GA: crossover, mutation, and selection. The single-cut point cross over method is used. The parameter values for GA are: the population size equals to 100; the maximum number of generation is 100; the mutation rate is set at 10%; the cross over rate is set 50%, Gen (2008).

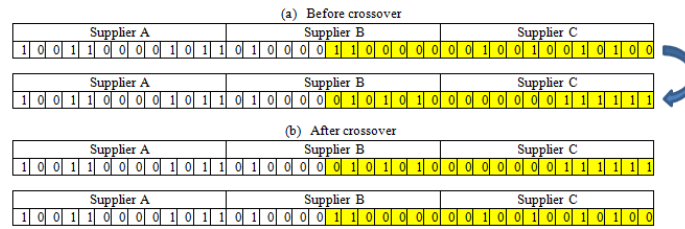


Fig 3: Crossover

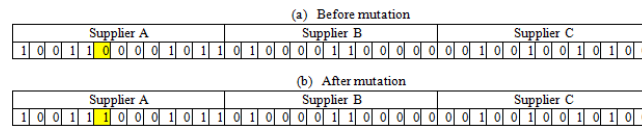


Fig 4. Mutation

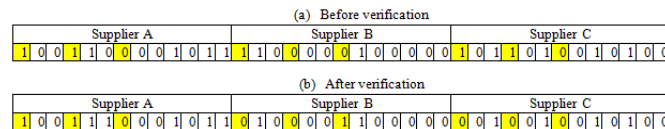


Fig 5. Verification

A Numerical Example And The Results:-

This study considers a single SCC using 13 type of item in a project with considering two kind of scenarios: without considering discount and with considering discount. There are three practicable suppliers that can supply those items with a different price for each item. For each item, only one supplier will be chosen (Supplier A, B and C).

Table1:-Price List

Item Code	QTY	Supplier A's Price/pcs	Supplier B's Price/pcs	Supplier C's Price/pcs
I1	10pcs	Rp.915.600,00	Rp.917.300,00	Rp.975.500,00
I2	10pcs	Rp.1.196.800,00	Rp.1.150.000,00	Rp.1.175.800,00
I3	5pcs	Rp.1.491.200,00	Rp.1.502.500,00	Rp.1.500.000,00
I4	10pcs	Rp.1.792.000,00	Rp.1.805.000,00	Rp.1.665.000,00
I5	50pcs	Rp.571.000,00	Rp.565.000,00	Rp.600.000,00
I6	20pcs	Rp.979.000,00	Rp.975.000,00	Rp.990.000,00
I7	30pcs	Rp.192.000,00	Rp.212.000,00	Rp.225.000,00
I8	50pcs	Rp.111.000,00	Rp.132.000,00	Rp.120.000,00
I9	32pcs	Rp.1.010.000,00	Rp.1.050.000,00	Rp.1.050.000,00
I10	22pcs	Rp.1.296.000,00	Rp.1.315.000,00	Rp.1.275.000,00
I11	13pcs	Rp.2.600.000,00	Rp.2.600.000,00	Rp.2.611.000,00
I12	9330Kg	Rp.1000,00	Rp.800,00	Rp.1100,00
I13	480pcs	Rp.4.500,00	Rp.4.800,00	Rp.4.500,00

Table 1 shows the price given by the supplier for each item. The types and quantity needed already given by the company issuing the project. The profit will be calculated based on the scenarios:

- First scenario: Multiplying the price with the quantity of each item. The result will be summed and multiplied by labor price and 20% for the profit.
- Second scenario: Multiplying the price with the quantity of each item. The result will be summed and multiplied by 5% for labor price and 20% for the profit. If in a single supplier, SCC ordered more than 6 types of item, the SCC company will get a 2% discount.

c)

The main issue in this study can be show as the comparison between the profit produced by each supplier's price list and the profit produced by co-evolutionary algorithm. Fig 6 shows the results of co-evolutionary algorithm and genetic algorithm implementation. The chromosome suggested the SCC to buy the item as shown in Table 2 for First scenario and Table 3 for Second scenario.

Supplier A												Supplier B												Supplier C											
0	1	0	0	0	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	0	0	1	0

Fig 6. Result of co-evolutionary algorithm

Table 2:-Suggested shopping list for first scenario

Item Code	Item Name	Supplier
I1	Iron Plate A36 6MMX4'X8' GRP	C
I2	Iron Plate A36 8MMX4'X8' GRP	A
I3	Iron Plate A36 10MMX4'X8' GRP	B
I4	Iron Plate A36 12MMX4'X8' GRP	B
I5	UNP Iron 150X75X6MMX6M KYF	C
I6	UNP Iron 200X75X8.5X11.5MMX6M KYF	C
I7	Angled Iron 65X65X6MMX6M STD-EQ	C
I8	Angled Iron 50X50X5MMX6M W2A	B
I9	Angled Iron 90X90X9MMX12M IBB	C
I10	Angled Iron 100X10X10MMX12M IBB	B
I11	Angled Iron 130X130X12MMX12M KS	C
I12	Zinchromate Paint	C
I13	Bolt HTB ½"	A

Table3:-Suggested shopping list for second scenario

Item Code	Item Name	Supplier
I1	Plat Besi A36 6MMX4'X8' GRP	C
I2	Plat Besi A36 8MMX4'X8' GRP	A
I3	Plat Besi A36 10MMX4'X8' GRP	C
I4	Plat Besi A36 12MMX4'X8' GRP	C
I5	UNP Besi 150X75X6MMX6M KYF	C
I6	UNP Besi 200X75X8.5X11.5MMX6M KYF	A
I7	Siku Besi 65X65X6MMX6M STD-EQ	A
I8	Siku Besi 50X50X5MMX6M W2A	A
I9	Siku Besi 90X90X9MMX12M IBB	C
I10	Siku Besi 100X10X10MMX12M IBB	A
I11	Siku Besi 130X130X12MMX12M KS	A
I12	Cat Zinchromate	C
I13	Baut HTB ½"	A

The profit gained from each supplier and co-evolutionary algorithm suggested shopping list for first and second scenario shows in Table 4 and Table 5 respectively. Based on the Table 4, the summarization of observation can be seen as follows: first, before using co-evolutionary algorithm, the maximum profit that can be gained is Rp. 47.570.380 by choosing supplier C for supplying the entire item. After using the co-evolutionary algorithm, the maximum profit that can be gained is increased by 1,49% (Rp. 48.279.000,00). Second, the company won't be needed to determine which supplier will supply each item since co-evolutionary algorithm already gave the suggested shopping list. From the Table5 can be summarize as follows: firstly, before using co-evolutionary algorithm, the maximum profit that can be gained is Rp. 49.948.899,00 by choosing supplier C for supplying all of the item. After using the co-evolutionary algorithm, the maximum profit that can be gained is increased by 12,16% (Rp. 56.020.692,00). Secondly, the company won't be needed to determine which supplier will supply each item since co-evolutionary algorithm already gave the suggested shopping list.

Based on these results we can conclude that the best matching supplier in this study is Supplier C by considering the discount or not. As we can see in Table 4 and Table 5, the profit still the highest by choosing Supplier C. This means, less time is needed to make the proposal. By doing this, not only the profit is increased, but the work duration of a project will be faster.

Table4:-Profit gained for first scenario

List	Profit
Supplier A	Rp. 46.653.640,00
Supplier B	Rp. 46.869.570,00
Supplier C	Rp. 47.570.380,00
Co-evolutionary algorithm	Rp. 48.279.000,00

Table5:-Profit gained for second scenario

List	Profit
Supplier A	Rp. 48.986.322,00
Supplier B	Rp. 49.213.049,00
Supplier C	Rp. 49.948.899,00
Co-evolutionary algorithm	Rp. 56.020.692,00

Conclusion:-

This study develops the solution model to optimize the profit by doing matching suppliers with the company with using co-evolutionary. In order to reach a more suitable supplier for a single project, there are many things need to be learned first e.g. supplier's cost, delivery time, additional charge. The proposed model considers decision support system as an interactive computer-based system to support user in assessing and deciding an option. In this study, the scope of decision parameter is limited by gaining profit from three parameters which is item types, supplier's price list and discounts. The profit gained from coevolutionary algorithm is compared with each supplier's price list which is shown in Numerical Example. For future research, the decision parameter scope can be extended to reach a more complex issue and find better solution procedure.

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