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Intelligent Model for Distributing Product in Supply Chain Management

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Abstract. Distributing product is the one of many issues in supply chain management area. There are many variables that have to be involved to solve the problem, such as: type of transportation mode, optimum path, type of product, and performance of supply chain elements. By using multiple criteria decision making concept, we use four methods (fuzzy ant colony optimization, analytical hierarchy process, smoothing exponential, and fuzzy simple additive weighting) to develop generic intelligent model for distributing product in supply chain management as the aims of this paper. We produce generic model to predict future trend, choose the transportation mode, and search the optimum path in supply chain.

Keywords: fuzzy ant colony optimization, analytical hierarchy process, smoothing exponential, fuzzy simple additive weighting, generic model, supply chain.

1. Introduction

The concept of supply chain management is always be used by company to operate its business process that collaborates to other companies. A supply chain (SC) can be defined as a network of organizations, flows and processes wherein a number of various enterprises (suppliers, manufacturers, distributors and retailers) collaborate (cooperate and coordinate) along the entire value chain to acquire raw materials, to convert these raw materials into specified final products, and to deliver these final products to customers [1]. The essence of Supply Chain Management (SCM) is the coordination of production, inventory, location, and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served [2]. In the other word, SCM can be defined as managing the entire chain of raw material supply, manufacture, assembly, and distribution to end customers [3].

Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouse, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, at the right time, in order to minimize system wide costs while satisfying service level requirement [4]. On the other hand, SCM is an integrative function, with primary responsibilities for linking major business functions and business processes within and across companies, into a cohesive and high-performing business model. It drives the coordination of processes and activities across areas of marketing, sales, product design, image and information technology ([5]; [6]). Information systems are an important enabler of effective SCM, since with the advent of e-business, if there is no effective web-based information system in place, there is essentially no business. Any company, though, can benefit from the successful implementation of SCM using different information systems options, including Enterprise Resource Planning (ERP) and Decision Support Systems (DSS) that are aimed towards assisting the different functional areas in a supply chain [7]. Many researches in Supply Chain Management have been done by many researchers in the world. In 2002, [8] have researched agent based supply chain management. In year 2005, [9] researched the management of supply chain and intelligent agent application combination by using asymmetric cost function, or [10] have developed Supply Market Intelligence Network in their Supply Chain Management

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Area research. In 2006, [11] have researched in business intelligence area, they have made model of supply chain business intelligence. In the next year, 2007, [12] have researched the implementation of Artificial Intelligent in the supply chain by using Mixed Multi-Unit Combinatorial Auctions. On the other hand, [13] have researched in intelligent cold chain management by using Wireless Sensor Network (WSN).

In this paper, we address on how to find the most optimum supply chain, predict future condition of supply chain, and select the best transportation mode that can be used for distributing product. We explore combination of four methods: fuzzy ant colony optimization for searching the most optimum path of supply chain; analytical hierarchy process for arranging priority of variables that were used in the model; smoothing exponential for forecasting the future condition of supply chain; and fuzzy simple additive weighting method for selecting transportation mode; to develop generic intelligent model for distributing product. The methodology that we used in our research will be delivered in second section of this paper. The generic intelligent model that we have developed will be explained in third section (in the generic intelligent model section). The result and discussion section will be delivered in fourth section. Finally, we will describe the conclusion and suggestion in fifth section.

2. Research Methodology

In this research, we use fours methodologies. They are: fuzzy ant colony optimization, analytical hierarchy process, smoothing exponential, and fuzzy simple additive weighting. [14] said that ACO is an optimization technique inspired by observations on the behavior of biological ant colonies; it has been introduced by [15], and [16]; and developed later into a meta-heuristic for combinatorial optimization problems ([17], [18], [19]). Recently, ACO algorithms have also turned out as competitive in a discrete stochastic optimization context ([20], [21], [22], [23], [24]).

ACO algorithms are based on following ideas [25]: (1) Each path is associated with a candidate solution for a given problem; (2) When an ant follows a path, the amount of pheromone deposited on that path; and (3) When an ant has to choose between two and more paths, the path with a larger amount of pheromone has a greater probability of being chosen by the ant. Conceptually, in ant colony algorithm, two ways of food searching way, that are used by ants, are used in this method. Other principles of ACO are [26]: (1) Random direction for searching and collecting some food; (2) When one ant finds food resource, that ant traces back again the path that was used by it; (3) The ants put chemical pheromones on their path that can be evaporated; (4) In loop, the chemical pheromones will decreases, but on the other hand, it will be added; and (5) Some ants will follow the shortest path, the strongest chemical pheromone path. Fuzzy Ant Colony Optimization combines Ant Colony Optimization with Fuzzy Performance Variable.

3. The Generic Intelligent Model

Based on basic behavior of FACO model [21], we generate a generic mathematical model for supply chain performance measurement which was described in the next formula.

$$FPoP_C = D_C \times \left[\frac{\sum FPoV_{C-1}}{\sum ToV_{C-1}}\right] \times (1 - Ph_C)$$

Where:

$FPoP_C$ = Fuzzy Based Performance of Current Path

D_C = Current Distance, the basis of measurement

PoV_{C-1} = Fuzzy Performance of Previous Node Variable

ToV_{C-1} = Total of Previous Node Variable

Ph_C = Current Path Pheromone

The supply chain performance depends on the path length (in this case, distance is the basis variable for measurement), supply chain element performance and pheromone quality. The supply chain element performance could be showed in the next mathematic formula.

$$\sum FPoV_{C-1} = PoS_{C-1} + PoF_{C-1} + FPoAV_{C-1} + FPoTC_{C-1}$$

Where:

$FPoV_{C-1}$ = Fuzzy Based Performance of previous element

PoS_{C-1} = Performance of previous element's SCOR variable

PoF_{C-1} = Performance of previous element's financial variable

$FPoAV_{C-1}$ = Fuzzy Based Performance of Previous element's Added Value Variable

$FPoTC_{C-1}$ = Fuzzy Based Performance of previous element's Transportation Cost Variable

The fuzzy based supply chain element performance depends on fuzzy based performance of SCOR, financial, added-value and transportation cost variables. Two variables are defined in Triangular Fuzzy Number (TFN) format. They are Value added and Transportation Cost. The generic model is shown as aggregative variable class as shown in Fig 1. This figure represents classes, namely class AntGraph, class Ant, and class AntColony.

4. Measurement and Result

In order to justify our model, we do some measurement based on Fig 1. Data and information resource for this step is derived from field observation and computation. We verify the FACO generic model on an example for this measurement which is used for supply chain performance measurement case which was described in a tree view in Fig 2. The distance value of the tree was converted in to graph matrix in Table 1.

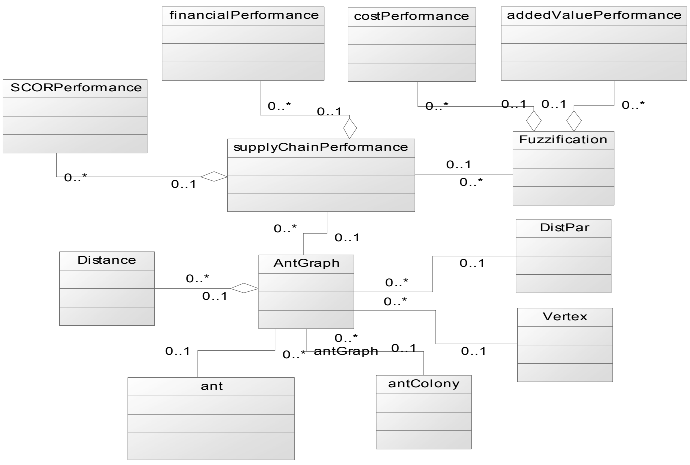

Fig. 1: Class Diagram of Model.

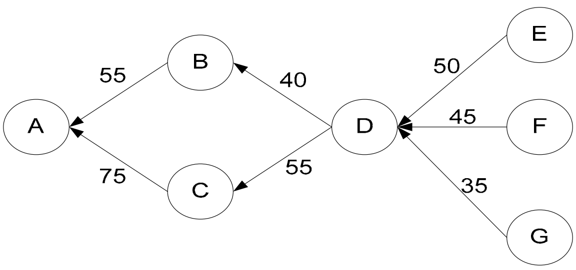

Fig. 2: Supply Chain Tree.

The performance value of each element: SCOR, financial, cost and added value, could be shown by data in Table 2. Some data resulted from this execution are in Table 3. The model produced 36.38 point of fuzzy performance value, with path A, C, D, and F.

Table 1: Graph Matrix.

	A	**B**	**C**	**D**	**E**	**F**	**G**
A	0.00	55.00	75.00	0.00	0.00	0.00	0.00
B	0.00	0.00	0.00	40.00	0.00	0.00	0.00
C	0.00	0.00	0.00	55.00	0.00	0.00	0.00
D	0.00	0.00	0.00	0.00	50.00	45.00	35.00
E	0.00	0.00	0.00	0.00	0.00	0.00	0.00

F	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 2: Performance Value.

	A	**B**	**C**	**D**	**E**	**F**	**G**
SCOR	0.7	0.7	0.5	0.5	0.5	0.5	0.7
Financial	0.5	0.7	0.7	0.7	1.0	0.5	0.7
Cost	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Added Value	0.4	0.4	0.8	1.0	0.8	0.8	0.8

Table 3: FACO Execution Result.

∑Ph.	∑Ev.	Path	Distance	Fuzzy Performance Value
0.02	0.01	A,B,D,F	140	71.42
0.05	0.08	A,C,D,F	175	66.76
0.14	0.00	A,B,D,E	145	54.09
0.08	0.01	A,B,D,G	130	36.38
0.03	0.01	A,B,D,F	140	63.67

∑Ph. = Average of Pheromones, ∑Ev. = Average of Evaporation, Sum of Ant = 2000

The measurement of Fuzzy SAW needs many decision alternatives and their criteria. The example of decision alternatives in this case is transportation mode, with three criteria. Data can be showed in Table 4. Table 4 must be normalized by using percentage base normalizing. The next process of fuzzy saw is process to get fuzzy value. The fuzzy value must be converted to grade value (Table 5).

Table 4: Example of Mode’s Criteria Value.

Mode	**Average of Time**	**Fuel Con. (L/KM)**	**Safety (%)**
Transportation Mode 1	0.54	5.00	95.00
Transportation Mode 2	0.54	5.83	95.00
Transportation Mode 3	0.50	5.00	95.00

Table 5. Grade Mode’s Criteria Value.

Mode	**Average of Time**	**Fuel Con. (L/KM)**	**Safety (%)**
Transportation Mode 1	0.60	0.60	1.00
Transportation Mode 2	0.60	0.40	1.00
Transportation Mode 3	0.60	0.60	1.00

5. Conclusion and Suggestion

The generic model has a characteristic that the model can be modified based on case. If the user wants to add some variables in to the model, this model can adopt that need. There are three main factions of this model; the first is for searching the most optimum supply chain path, by using fuzzy ant colony method. The second function of this model is for selection transportation mode. In this case, the user can add some variable that she / he want. And the last function of this model is for forecasting the future situation, like product selling or demand, path condition, or other condition. We hope the next researchers can modified or research in other method that can be applied in this main model.

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