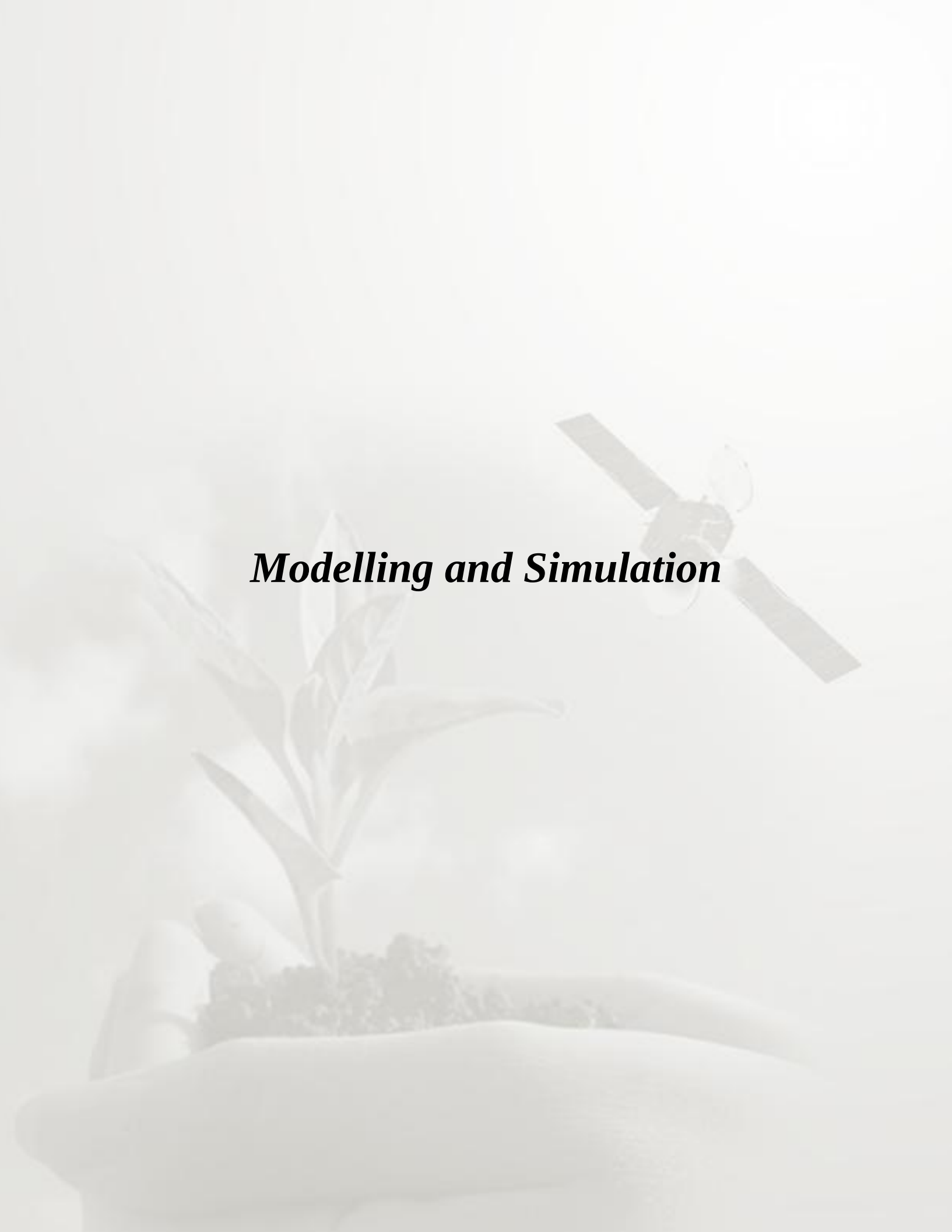

# *Modelling and Simulation*

# An UML Modeling for Optimization of Supply Chain in Palm Oil Based Bioenergy

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*Abstract* -**Shifting bioenergy use to be a commercial fuel is an important thing for this moment. The fact said that not only conventional energy (fossil based energy) will be lost in around twenty years later, but also energy demand increases significantly that insist to find energy resource alternative to solve this phenomenon. The best energy resource alternative is biomass resource such as a palm oil based biomass. Technology, management, and supply chain issues are some of many useful research areas to keep bioenergy supply and its availability as a whole. The management of supply chain issue is the one of those issues in bioenergy field research. The classic problem in supply chain management, especially bioenergy supply chain management, is an optimum supply chain path search. In this paper we use ant colony algorithm as our main research contribution. This methodology is used to optimize supply chain path search. The result of this research analysis described by using Unified Modeling Language (UML) that consisted of activity diagram, use case diagram, class diagram, state chart diagram, sequence diagram, and collaboration diagram. We prepare some solution for the problem such as electronic mapping based supply chain route analysis, optimization of supply chain path searching and the best supply chain route search.**

**Keywords: supply chain path, UML, ant colony optimization (ACO), palm oil based bioenergy**

## I. INTRODUCTION

The quest for renewable energy has intensified since the escalating price of crude petroleum in the recent years. Renewable energy has the potential to replace petroleum derived transportation fuel in the future [1]. Concerns about energy security, high oil prices, declining oil reserves, and global climate change are fuelling a shift towards bioenergy as a renewable alternative to fossil fuels [2]. Sustainability and availability of energy is important to support all activities in the world. On the other hand, sustainability is a key principle in natural resource management and involves environmental, operational and social considerations, all of which are inter-dependent [3]. That principle has been more important, because the fossil based energy will be unavailable any more in the recent years. This case made function shifting of bioenergy to be commercial function. The other reasons of bioenergy choice as potential energy that bioenergy have been recommended based on potential to (i) meet domestic energy demand and reduce fuel importation (ii) diversity rural economies and create employment (iii) reduce poverty, and (iv) provide net energy gains and positive environmental impacts[4].

Renewable energy is the energy derived from resources that are regenerative or, for all practical purposes, cannot be depleted. For this reason, renewable energy sources are fundamentally different from fossil fuels, and do not produce as many greenhouse gases and other pollutants as fossil fuel combustion. Renewable energy sources like wind, solar, geothermal, hydrogen, and biomass play an important role in the future of our energy demand [5]. One of the renewable energy biomass resources is a palm oil based biomass. Palm oil biomass is the most potential Indonesian commodity for agroindutry product, includes bioenergy.

Supply chain management is one issue of many issues in energy technology management. 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 [6]. 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 [7]. In the other word, SCM can be defined as managing the entire chain of raw material supply, manufacture, assembly, and distribution to end customers [8]. More than one company involvement in bioenergy supply area made supply chain management is the most interesting issue to be researched.

In this paper we address on how to find the best path of supply chain, in one supply chain network, among many alternative supply chain paths. We explore the potential of Unified Modeling Language (UML) to model the optimization of supply chain path searching in palm oil based bioenergy. We focus on how to optimize costing analysis in route policy for transportation on raw and product of bioenergy industry. This model consists of activity diagram, use case diagram, class diagram, state chart diagram, sequence diagram, and collaboration diagram which represent the whole complexity in this system.

We describe related works as underlying background of our work in part two. Part three provides our main contribution for supply chain route model and analysis; we also provide necessary performance evaluation to prove our approach. We close our discussion

with conclusion and recommendation to complete future works in part four.

## II. RELATED WORKS

**Unified Modeling Language (UML)**

The Unified Modeling Language (UML) is the primary modeling language used to analyze, specify, and design software systems [9]. UML consisted of many diagrams that can describe the phenomenon of system, such as: activity diagram, use case diagram, class diagram, state chart diagram, sequence diagram, and collaboration diagram.

**Ant Colony Algorithm**

Ant colony optimization is a metaheuristic in which a colony of artificial ants cooperates in finding good solutions to difficult discrete optimization problems. Cooperation is a key design component of ACO algorithms: The choice is to allocate the computational resources to a set of relatively simple agents (artificial ants) that communicate indirectly by stigmergy, that is, by indirect communication mediated by the environment. Good solutions are an emergent property of the agents' cooperative interaction [10].

An artificial ant in ACO is a stochastic constructive procedure that incrementally builds a solution by adding opportunely defined solution components to a partial solution under construction. Therefore, the ACO metaheuristic can be applied to any combinatorial optimization problem for which a constructive heuristic can be defined.

The artificial or computational intelligence concept was applied in many researches for optimizing supply chain management performance. [11] applied Fuzzy Point Estimation for optimizing solution in stationary supply chain case. [12] has worked in supply chain modeling language as information framework of supply chain management modeling. Moreover, Evolutionary algorithm approach has been applied in integrated bioenergy supply chain optimization [13].

The ant colony algorithm has been used in many researches in many fields. This algorithm was used as single method or combined to other methods. As a single method, ant colony algorithm was used in: production and maintenance scheduling optimization [14], routing design [15], determining project critical paths [16], simultaneous pickup and delivery [17], and transportation problem solving [18]. Many researchers have combined ant colony algorithm and other algorithm in their researches. The ant colony algorithm and genetic algorithm combination was used in searching research field [19]. In the other research, [20] combined ant colony algorithm and fuzzy model to classify data and to select feature. In the same year, combination of ant colony algorithm and support vector machine was used for power load forecasting [21], or in optimization for flexible job shop scheduling problem research that used combination of ant colony algorithm and knowledge based management [22]. One year before, ant colony algorithm was used in many researches too, such as: traveling sales problem simulation [23], scheduling problem [24], image segmentation [25], supermarket customer classification [26], document agglomerate clustering [27], route optimization [28], and web service composition [29]. In production system field, there are many researches that used ant colony algorithm too, such as: structured optimization in parallel production system [30], and preventive maintenance optimization in production process system [31].

## III. SUPPLY CHAIN ROUTE MODEL AND ANALYSIS

Supply chain route was defined by using distance based formula. Distance based formula (in kilometers unit size) is a mathematical formula that uses distance variable as basis of measurement as formulated as follows

$$PoP_C = D_C \times \left[\frac{\sum PoV_{C-1}}{\sum ToV_{C-1}}\right] \times Ph_C \quad \text{……..…..(1)}$$

Where:

$PoP_C$ = Performance of Current Path

$D_C$ = Current Distance, the basis of measurement

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

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

$Ph_C$ = Current Path Pheromone, depended on pheromone evaporation

There are four variables include in this measurement. Those variables used to measure the Performance of Current Path ($PoP_C$) are: Performance of Previous Node SCOR ($PoS_{C-1}$), Performance of Previous Node Financial ($PoF_{C-1}$), Performance of Previous Node Added Value ($PoAV_{C-1}$), and Performance of Previous Node Transportation Cost ($PoTC_{C-1}$) (they can be seen in equation (2)). Each variable was defined in equation (3) up to equation (7).

$$\sum PoV_{C-1} = PoS_{C-1} + PoF_{C-1} + PoAV_{C-1} + PoTC_{C-1} \quad \text{…..……..} \quad (2)$$

**Performance of SCOR**

The Performance of SCOR is a variable to explain a value of BSC – SCOR based result measurement. This variable can have value of 0.00 to 1.00.

$$PoS = \frac{Pop_L + PoS_C + PoP_C + PoD_L + PoR_E}{5} \quad \text{…..……..(3)}$$

Where:

$PoP_L$ = Performance of SCOR based Planning Perspective

$PoS_C$ = Performance of SCOR based Source Perspective

$PoP_C$ = Performance of SCOR based Process Perspective

$PoD_L$ = Performance of SCOR based Delivery Perspective

$PoR_E$ = Performance of SCOR based Return Perspective

**Performance of Financial**

Performance of financial was divided into 3 categories; low (0.50), middle (0.70) and high (1.00). The formula of this performance was explained below:

If (NPV < 0) or (IRR < 8) or (BC < 1) then
QoF = 0.5
Else If (NPV > 0) and (IRR > 8) and (BC > 1) then
QoF = 1
Else QoF = 0.7

**Performance of Added Value (PoAV)**

The formula of added value (AV) could be described below:

$$AV = \sum \frac{(Q \times P) - (Q \times C)}{(Q \times P)} \quad \text{..... (4)}$$

The performance of added value (PoAV) could be described by using rule based statement. This formulation could be three categories: low (0.50), middle (0.70) and high (1.00) that was explained below:

IF (AV > 0.3) then
PoAV = 1.00
Else IF (AV ≥ 0.5 and AV ≤ 0.3) then
PoAV = 0.70
Else PoAV = 0.05

**Performance of Cost (PoC)**

For performance of cost, the basic of measurement is added value (AV) variable. The formula can be explained in rule based formula below:

If (C > (0.3 X AV)) then
PoC = 0.5
Else if (C ≥ (0.1 X AV) and C ≤ (0.3 X AV))
than PoC = 0.7
Else PoC = 1.00

**Optimization of Supply Chain Path Searching**

Supply chain network used for optimization measurement case was described in graph in Fig 1. The cell of graph matrix in Table 1 described distance between node or element in one supply chain network.

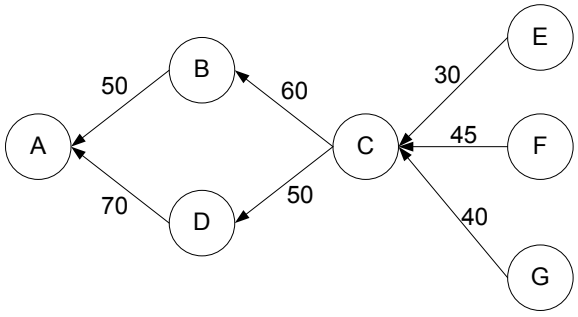


Fig 1 – Supply Chain Graph

Table 1 – Graph Matrix

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| **A** | 0.00 | 50.0 | 70.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| **B** | 0.00 | 0.00 | 0.00 | 60.0 | 0.00 | 0.00 | 0.00 |
| **C** | 0.00 | 0.00 | 0.00 | 50.0 | 0.00 | 0.00 | 0.00 |
| **D** | 0.00 | 0.00 | 0.00 | 0.00 | 30.0 | 45.0 | 40.0 |
| **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 |

The main model for optimization of supply chain could be briefly described in Fig 2. This model consisted of five main classes: class AntGraph, class Ant, class AntColony, class Ant4SC and class AntColony4SC. Class AntGraph related to ClassSupplyChainPerformance that consisted of: class SCORPerformance, class financialPerformance, costPerformance, and addedValuePerformance. This model called as distance based model could be shown by relationship between class distance and class AntGraph.

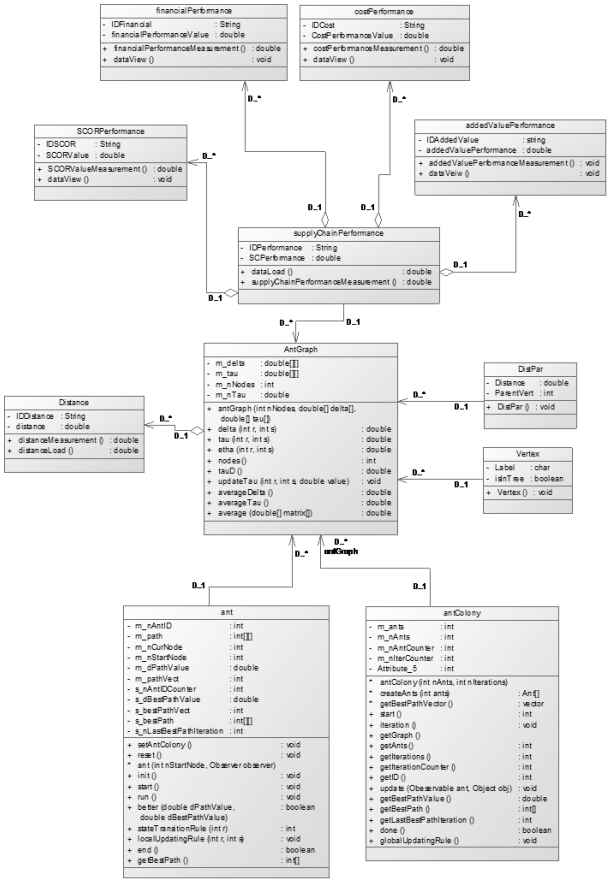


Fig 2 – Main Class Diagram

The sequence diagram of this model could be explained in Fig 3. This diagram showed relation among classes of the main model.

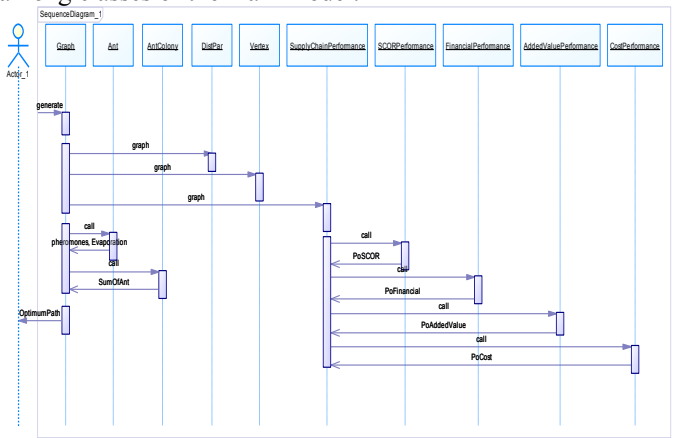


Fig 3 – Main Sequence Diagram

The performance value of each element: SCOR, financial, cost and added value, could be shown by data in Table 2.

Table 2 – Performance Value Point

| | 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 | 0.7 | 0.7 | 0.5 | 0.7 | 1.0 | 0.5 | 0.7 |
| Added Value | 0.7 | 0.7 | 0.5 | 1.0 | 0.5 | 0.5 | 0.5 |

**The Best Supply Chain Route Search (Performance Evaluation)**

The performance evaluation could be explained by using result of the model execution. Some data resulted from this execution are:

Table 3 – Execution Result

| ∑Ph. | ∑Ev. | Path | Distance | Performance Value |
|---|---|---|---|---|
| 0.82 | 0.57 | A,B,D,E | 140 | 74.02 |
| 0.95 | 0.89 | A,B,D,E | 140 | 81.24 |
| 0.98 | 0.38 | A,B,D,E | 140 | 33.03 |
| 0.53 | 0.65 | A,B,D,E | 140 | 77.88 |
| 0.23 | 0.62 | A,B,D,E | 140 | 78.75 |

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

The execution result showed that optimum path is A, B, D, E and the best performance value is 33.03, the most little one. This performance value was described in kms (kilometers) unit size.

## IV. CONCLUSION AND RECOMMENDATION

In this paper we have modeled a UML based route optimization for bioenergy based supply chain. This model has eleven connected classes which represent necessary variables that could effect to performance value of supply chain such as SCOR, financial, cost and added value; the performance evaluation result showed that model could reach the most optimum path of supply chain network.

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