GLOSSARY

Supply Chain Management	: physical networ between companies involved in supplying raw materials, produce goods, or deliver the finished goods to end user
Vehicle Routing Problem	: term to determine optimal route in distribution system from depot to customer
Vehicle Routing Problem Pick–Up and Delivery	: one of VRP variant that involves not only delivery but also pick-up
Genetic Algorithm	: a random search technique but directed that can find global optimal solution in complex search environment where its process is inspired by natural selection and genetics
Tabu Search	: local search procedure that moves from one solution to another until stopping criterions are satisfied
Hybrid Genetic Algorithm- Tabu Search	: algorithm that combines both Genetic Algorithm and Tabu Search

Chapter I INTRODUCTION

I.1 Research Background

Industries, specifically through production process, aims to fulfill the customers need. Beside generate products, distributing to customers also become an essential aspect. To transport and distribute, it may take up to 40 % from the logistic cost (Frazelle, 2002). Since it affects the product price, efficiency in transportation sector is needed and expected to lower the affected cost, such as production and distribution cost. Distribution is activator of the whole company's profit because it can affect supply chain cost and customer value directly. The common problem faced mostly is finding the right distribution route so effectiveness and efficiency can be achieved.

In solving problems, there are tools needed. One of the basic tool is technology, such as by using software. Beside utilizing technology, other method can be used, such as algorithm. Algorithm needs model defined before that represent the problems. By using the model, it will ease the problem–solving process. Combining model and algorithm to be calculated, technology then be used to get efficient suggestion for having the optimum fleet scheduling for a company to distribute its products into the warehouse.

CV. FAB is a trading business focused in producing drinking water. It is located in Mojokerto, Jawa Timur. Owned by local business man in Mojokerto, the products concerned as a healing media. CV. FAB has several packaging of drinking water, such as glass (240 ml), bottle (600 ml and 1500 ml), and gallon (19 L). CV. FAB distributes products to customers and agents (distributors), and each of them never order for 1 gallon, but directly numbers of gallons, for example a customer orders 10 gallons for once shipment.

CV. FAB serves customers and agents around Surabaya, Mojokerto, Sidoarjo, Pasuruan, and Gresik. To deliver the customers orders, CV. FAB has two homogenous vehicles which is pick-up. Each vehicle's capacity is same, which may carry maximum 100 gallons.

As a drinking water company, CV. FAB must take empty gallons in the customer and exchange them for filled gallon. The empty gallons will then be reprocessed so that they can be used and sent back to customer. So, CV. FAB must consider the number of gallons that must be sent and taken from customers. When distributing products, some problems may occur, such as shortage in delivering products to customers and agents. Here are data showing the shortage of every month in CV. FAB.

Table I.1 Shortage Gallons
(Source: CV. FAB)

Month	Amount of Shortage Gallon Fulfilled (Units)	Shortage (%)
January	65	6.63
February	35	3.57
March	60	6.12
April	20	2.04
May	55	5.61
June	30	3.06

It can be seen that there are customers who experience shortage in shipping have varying amounts of gallons. This is because CV. FAB does not have standard rules about shipping. Actually, CV. FAB already has a shipping route every month that can be used as a reference in shipping. However, because it has not been determined precisely, the reference is not really taken into account because CV. FAB did not know the effect obtained, like the inefficient of shipping costs.

Shortage that leads to delay delivery may be caused by some reasons, such as the gallon used by customers are not emptied yet, the production output can't be fulfilled since electricity off, and route determination is not optimized yet. Below is detail of shortage leading to delay causes every month:

Table I.2 Shortage Causes
(Source: CV. FAB)

Month	Route determination (Units)	Unemptied gallon (Units)	Production off (Units)
January	65	-	-
February	25	10	-
March	30	30	-
April	10	-	10
May	25	30	-
June	30	-	-
Total	185	70	10

Based on table above, then the percentage of causes can be summarized into graph below:

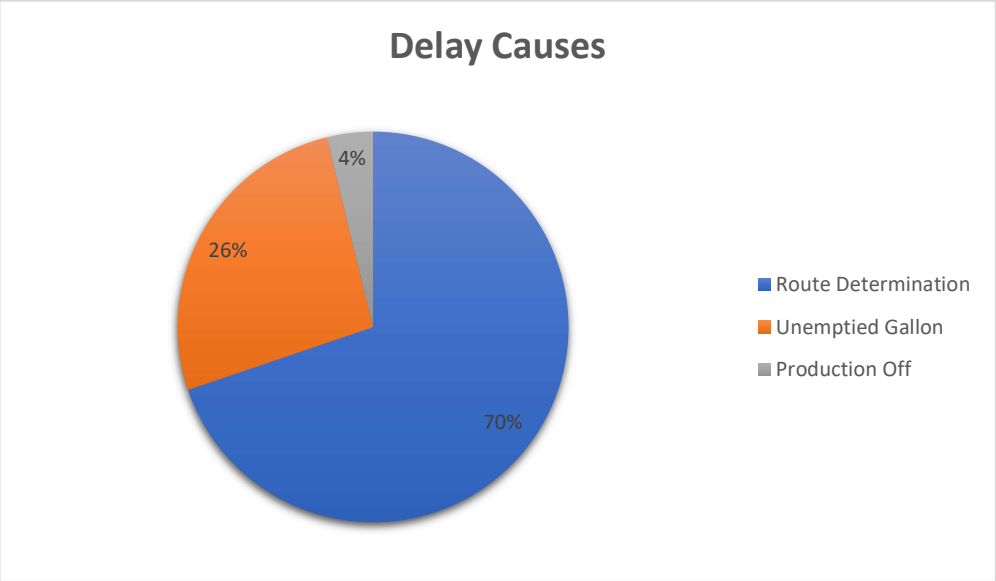

Figure I.1 Delay Causes
(Source: CV. FAB)

It can be seen above that the biggest percentage of the delay causes in delivery is route determination. The delays occur is not subject to any sanctions. Agreement between CV. FAB and customers are CV. FAB has to sent customers orders within 1 month and the shipping route is based on mutual agreement. Then it can be said

that delay happened is delay based on mutual agreement. Below is data showing delay happens to customers because of the route determination:

Table I.3 Delay Details
(Source: CV. FAB)

Customer	Amount of Gallon (Units)	Delayed (Days)
F001	50	3
F003	15	3
F015	15	5
F017	10	3
F020	25	3
F028	10	3
F004	30	7

The following is a "guidance" of CV. FAB in sending its products to customers, which every day must start from the depot and return to the depot.

Table I.4 Existing Distribution Route
(Source: CV. FAB)

Days	Existing Distribution Route	Distance (km)
1	D – F001 – F002 – F003 – F004 – F005 – F006 – D	90.434
2	D – F007 – F008 – F009 – F010 – F011 – F012 – F013 – D	48.785
3	D – F014 – F015 – F016 – F017 – F018 – F019 – F020 – F021 – F022 – D	91.028
4	D – F023 – F024 – F025 – F026 – F027 – F028 – F029 – F030 – F031 – F032 – D	55.588
5	D – F033 – F034 – D	83.495
6	D – F035 – F036 – F037 – F038 – F039 – F040 – D	103.478
7	D – F041– F042 – F043 – F044 – F045 – D	76.036
8	D – F046 – F047 – F048 – F049 – F050 – D	53.006
9	D – F051 – F052 – F053 – D	81.491
10	D – F054 – F055 – D	89.909
11	D – F056 – F057 – F058 – F059 – D	24.721
12	D – F060 – F061 – F062 – D	77.149
13	D – F063 – F064 – F065 – F066 –D	154.87
Total Distance		1029.99

Based on table above, it is known that there are 13 days CV. FAB has to run the distribution. As previously explained, even though there is already route, there are still delays in shipping because the table above is only a "reference" for shipping, which is not done by CV. FAB because it hasn't been calculated correctly.

According to the problem arised in CV. FAB, commonly can be solved by using Vehicle Routing Problem (VRP) suitable with its characteristic which is to find the optimum route. For the VRP used is VRP Pick–Up and Delivery (VRPPD) which suitable with CV. FAB characteristic which to both deliver filled gallons and pick–up the emptied ones. As the VRP chosen is because to minimize travel distance so that customers demand fulfilled.

I.2 Problem Formulation

Based on the background above, then can be defined for the problem identifications are:

1. How is the optimum distribution route to fulfill demand on distributing water gallon?
2. How is the minimum travel distance of the optimum distribution route?
3. How is the comparation between three optimization methods (metaheuristic algorithm)?

I.3 Research Objectives

The purpose of the study is to achieve the expected goal with the implementation of this research are:

1. To determine the optimum distribution route to fulfill demand on distributing water gallon
2. To determine the minimum travel distance of the optimum distribution route
3. To determine the comparation between three optimization methods (metaheuristic algorithm)

I.4 Research Limitations

The limitations for this research are:

1. Data used is historical data from January 2017 until June 2017.

2. Depot and customer location assumed as node
3. Only focus in products gallon shaped
4. Customer locations are in Surabaya, Mojokerto, Sidoarjo, Pasuruan, and Gresik
5. Each delivery doesn't exceed fleet capacity
6. Delivery planning assumed to be static, there is no additional demand when fleet is on the way
7. Delivered amount is always the same as picked-up amount
8. Traffic jam and any unexpected condition are not noticed

I.5 Research Benefits

Benefits got from the research can be defined as:

1. As a consideration for companies in the management and distribution and transportation planning. Benefits for the company is to minimize delays resulting in loss for the company.
2. As reference material or comparison in subsequent research in the related field.

I.6 Writing Systematics

This research is composed by writing systematics as follow:

Chapter I Introduction

This chapter contains of background research, problem formulation, research objective, research benefit, problem limitation, and writing systematics.

Chapter II Literature Review

This chapter contains description about theory and literature that will be used in this research. This chapter also discusses about relationship between research benefit and concept of studies.

Chapter III Research Methodology

In this chapter, the detail steps of this research in sequence order is explained. It is also include problems formulation, data analysis,

data processing, and conduct the conclusion and recommendation for the company.

Chapter IV Collecting and Processing Data

In this chapter, data that used in this research to solve the problem is shown and processed according to the method that has been stated on research methodology.

Chapter V Analysis

This chapter describes analysis of the data that has been processed and calculated on chapter IV. It is also explained about comparison between proposed improvement and current state of the company regarding the problem.

Chapter VI Conclusion and Suggestion

This chapter contain conclusion and suggestion for the company and readers for next research.

Chapter II LITERATURE REVIEW

II. 1 Supply Chain Management

II.4.1 Supply Chain

Supply chain is connected companies that add value to inputs got from the source to become end products or services demanded by customers (Lu, 2011).

II.4.2 Supply Chain Management (SCM)

According to (Hugos, 2011), supply chain management is coordination between all components in supply chain, consisting the production, inventory, warehouse, and transportation so the customer satisfaction can be fulfilled.

II. 2 Transportation and Distribution Management

II.2.1 Transportation and Distribution Management Definition

Transportation is uncertain complex area involving groups of data, models, and optimization methods that can be solved by the help of softwares (Crainic & Laporte , 1998)

II.2.2 Distribution Strategy

There are two types of delivery methods (Hugos, 2011) :

1. Direct Deliveries

Here, deliveries made from one origin location to one destination location. This method is a simple operation and delivery coordination, since it “only” chooses the shortest route between two locations. Direct deliveries scheduling needs decision about the quantity of product transported and deliveries frequency to each location.

2. Milk Run Deliveries

Unlike the direct deliveries, milk run deliveries made from single origin location to multiple destination location or from multiple origin location to single destination location. There are two techniques in milk run deliveries:

i. The Savings Matrix Technique

It is the simplest technique where can be used to assign customers to vehicles and to design routes where there are delivery–time windows at receiving locations and other constraints. The constraints are many in the

delivery schedule. The result is a good routing solution that can be used to practice.

ii. The Generalized Assignment Technique

This is a more sophisticated technique that usually gives better solution. Here, the constraints are on the vehicle capacity while delivery schedule are not.

II. 3 Vehicle Routing Problem (VRP)

Vehicle Routing Problem (VRP) was first introduced by Dantzig and Ramser in 1959 as truck dispatching problem (Toth & Vigo, Vehicle Routing: Problems, Methods, and Applications, 2014). As knowledge grows, the problem then called as Vehicle Routing Problem. VRP then defined as combinatorial optimization problem that determines optimum route by using fleet based on depots to serve customers (Toth & Vigo, Exact Solution Of The Vehicle Routing Problem, 1998). VRP can be used to define routes with the goal of meeting customer demand by minimizing transportation costs. Vehicle determination is done by looking at the limits to the capacity and the cheapest cost.

The goals of the VRP itself proposed by (Toth & Vigo, 2002) are:

1. Minimize the overall transportation costs that depends on travel distance taken overall and fixed cost related with the number of vehicles used
2. Minimize the number of vehicles used to serve all customers
3. Balancing the travel route
4. Minimize penalties related with customers served

II.3.1 Vehicle Routing Problem Classification

According (Toth & Vigo, Vehicle Routing: Problems, Methods, and Applications, 2014), there are several types of VRP nowadays:

1. Capacitated VRP (CVRP)

Capacitated VRP is included as classic VRP, which purpose is to minimize total cost by designing optimum distribution route and load brought by fleet is not exceeding its capacity. Fleet used is homogeneous and only serves one route and there is only one depot.

2. VRP with Heterogeneus Fleet of Vehicles (VRPHF)

Characteristics of this VRP is the vehicles used are more than one and has different characteristics for each vehicles. The characteristics including capacity, variable and fixed cost, velocity, and access to different customers depend on vehicles used.

3. VRP with Time Window (VRPTW)

Customers have a range of service time, such as service must be done on a range of time windows that have been set on each customers.

4. VRP Pick Up and Delivery (VRPPD)

VRP problem that allow the vehicle to perform delivery and pick-up tasks at once. This kind of VRP starts with distribution process in depot and ends with the last customer pick-up to depot.

5. VRP with Backhauls (VRPB)

Here, there are two kinds of customers which are linehaul and backhaul. Linehaul is where products are delivered at customers first, while backhaul is where products should be taken off from customers when the vehicle is empty. Customers visited by empty fleet called backhauls.

6. VRP with Multiple Depot (MDVRP)

This VRP variant has more than one depot. Each customer gets the product delivered by one vehicle from one of the depots. Each vehicle departs from a depot and ends at the different depot.

7. VRP with Multiple Product and Compartments.

This VRP variation allows the customers to order more than one product type at once. In general, this type of VRP involves vehicles with multi compartments.

8. VRP with Multiple Trip

Variations of this VRP is taken when company has limited number of vehicles and its capacity can’t handle many load, so the vehicle should be used simultaneously.

9. VRP with Split Delivery

This VRP variant allow customers to be served by more than one vehicle because demands are split, while on a standard VRP one customer is only visited by one vehicle.

10. Periodic VRP

This form of VRP covers the problem of determining the day of the customer's visit within a certain period of time periodically.

II. 4 Solution Approaches for VRP

To solve VRP, there are approaches that can be done:

II.4.1 Exact Algorithm

This algorithm will generate direct solution by trying all permutation and seek which is the cheapest. This approach is in polynom factor from O (n!), factorial from several cities, so this solution is not practical even for 20 cities.

II.4.2 Heuristic Algorithm

This algorithm generate solution fast for complex problems. One of algorithms included here is Nearest Neighbor. Heuristic algorithm then divided into metaheuristic algorithm. This one is more effective than heuristic. Processing time is longer but able to include more parameters in the process.

Below is table comparing approaches to solve VRP.

Table II.1 Approaches Comparation
(Source: Firman Faisal, 2012)

Type of Algorithm	Example	Application
Exact Algorithm	Branch and Bound, Cutting Plane	Suitable for problems involving few distribution points (less than 20 nodes)
Heuristic Algorithm	Nearest Neighbor (NN)	Suitable for problems involving multiple distribution points (tens and hundreds nodes)
Metaheuristic Algorithm	Genetic Algorithm, Tabu Search	Suitable for problems involving multiple distribution points (tens and hundreds nodes), involves many parameters and high complexity

II. 5 Genetic Algorithm (GA)

Genetic Algorithm (GA) was found by Holland. GA is a random search technique but directed that can find global optimal solution in complex search environment

where its process is inspired by natural selection and genetics (Pham & Karaboga, 2000).

There are several term used in GA:

1. Chromosome

Here, one chromosome or individu represents one solution vector. It is needed to use coding to represent one solution value by using binary.

2. Fitness

It is used to measure "fitness" value of a sought for solution.

3. Elitism

It is effort given to maintain the best individu got from one generation to the next generation so this best individu keeps showing in the next population

4. Crossover

It is done to get better combination between individuals in a population.

5. Mutation

It is used to bring out new individual that is completely different from existing individuals or it is possible to get out from local optima.

II.5.1 Genetic Algorithm Mechanism

Simple mechanism of GA is shown in flowchart below.

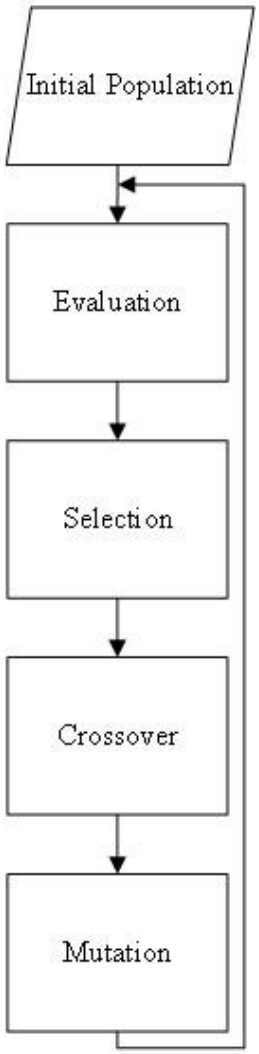

Figure II.1Genetic Algorithm Mechanism
(Source: Pham & Karaboga, 2000)

1. Initial Population

   When starting to calculate by using GA, initial solutions are needed. There are two ways to determine the initial solutions. The first is using random solutions created by random number generator. This method is used when there is no data about the existing condition or to asses algorithm performance. The second method is when there's already known datas then converges it into optimal solution in less time compared to previous method where no data is known.

2. Evaluation

It is calculation process to change chromosomes into perfect set or is the result of withdrawal of the objective function. The value of the objective function calculation will be the fitness value of each chromosome. However, for minimization problems, the fitnesss value cannot be obtained from the value of the objective function.

3. Selection

   The purpose of selection is to generate more copies of individuals that have higher fitness values than the lower ones. There are two selection procedures. The first is proportional selection or "roulette wheel". Individuals fitness values represent slots width in wheel. After a random spinning is done to select individual for next generation, individuals in large widths represent high fitness value and has higher chance to be chosen. The second procedure is ranking-based selection. Each individual produces an expected number of descendant which is based on the rank of its fitness value and not on the magnitude.

4. Crossover

   It is to create two new children from two parents that picked from selection. There are four types of crossover:

   1) One-point crossover

   Parent 1 : **1 0 0 0 1 0 0 1 1 1 1**

   Parent 2 : 0 1 1 0 1 1 0 0 0 1 1

   New String 1: **1 0 0 0 1** 0 0 1 1 1 1

   New String 2 : 0 1 1 0 1 **0 0 1 1 1 1**

   2) Two-point crossover

   Parent 1 : **1 0 0 0 1 0 0 1 1 1 1**

   Parent 2 : 0 1 1 0 1 1 0 0 0 1 1

   New String 1: **1 0 0** 0 1 1 0 **1 1 1 1**

   New String 2 : 0 1 1 **0 1 0 0** 0 0 1 1

   3) Cycle crossover

   Parent 1 : **a b c d e f g h**

   Parent 2 : 1 2 3 4 5 6 7 8

   New String 1: **a** 2 **c** 4 5 **f** 7 **h**

   New String 2: 1 **b** 3 **d e** 6 **g** 8