Chapter 2

Principles, Theories and Literatures review

The principles, theories and literatures that related to this research are Vehicle Routing Problem (VRP), crossdocking system, Genetic Algorithm (GA), and economics costs benefit analysis. The details of them will be described below.

2.1 Vehicle Routing Problem (VRP)

"Sequenced deliveries are complicated and well-orchestrated exercises of matching the right part with the right car at the right time." Jim Brutsman, general manager of business development for VASCOR said (Terreri, 2004). VRP is one of important logistics management problems. Generally, transport management planning could be classified in 3 levels. Firstly, the top level is strategic planning such as plant/depot/warehouse location selection or design and demand forecasting. Second level is tactical planning that usually answer the question about how many vehicles do you need in your fleet, which type of vehicle. Third level is operational planning such as management of delivery/distribution and also vehicle routing problem (Indra-Payoong, 2005). VRP could be applied with many vehicle scheduling problems for example collection and delivery of goods, waste collection, street cleaning, school-bus routing, dial-a-ride systems, and transportation of people with handicap and routing of salesman.

VRP is a non-deterministic polynomial time hard (NP) problem that deals with the management of pickup and/or delivery materials activities to scheduling of pickup and/or delivery goods to each customer/supplier/depot. Generally, objective function is for maximizing profit or minimizing total transportation cost or total transportation distance (Paolucci, 2007). VRP had many categories, it was revealed in topic 2.1.1, a problem description and more detail about alternative of each category in Table 2-1.

2.1.1 Problem description

VRP can be categorized in 8 main categories (Indra-Payoong, 2005) as showed in Table 2-1 below, each one had different alternative. Some problem can be more than 1 category. For example, fleet and vehicle type problem, alternative must be number of vehicle and vehicle type. The objective is choosing appropriate number of vehicle and vehicle type to create less transportation cost or total distance. The problem of this thesis could be considered into 3 categories; fleet, vehicle type and demand location problem. This case had 3 types of vehicle each type had more than one truck, many drop points, possible routes and crossdock location selection. For previous reason can be summarized that, this research's transportation problem was within the scope of VRP.

Table 2-1: VRP category

Problem Category	Alternative
1. Fleet	- 1 vehicle - Many vehicles
2. Vehicle type	- Same type - Many types
3. Depot / Warehouse	- 1 place - Many places
4. Transport demand	- Deterministic - Stochastic
5. Demand location	- Node/point location - Arc/route location - Mixed
6. Vehicle Capacity	- Same capacity - Different capacity
7. Maximum route time	- Same route time - Different time
8. Time windows	- Single-sided - Double-sided

2.1.2 The road network

In figure 2-1, it had circle symbols known as nodes which represented customers and the rectangle symbol symbolized depot. The arrows denoted routes of origin node (arrow's tail) in the figure there was *i* to destination *j* node (arrowhead) and distance between nodes *i* to *j* was *Cij*. The current state transport network of the case study was using this road network pattern (Figure 2-1).

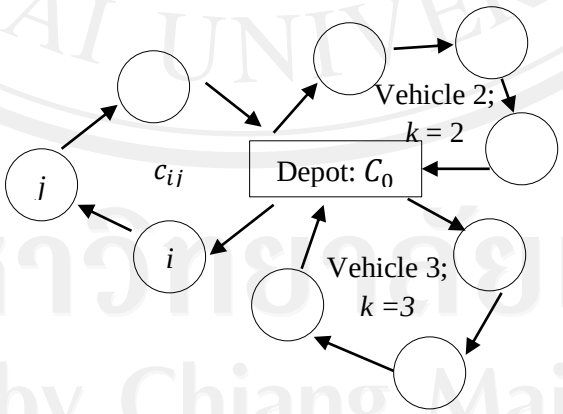

Figure 2-1: Model of VRP network

2.2 Crossdocking System

Crossdock was a famous methodology to distribute goods in a network. The crossdock was a facility that sorts and recombines inbound items from many suppliers for shipment to many customers, such as assembly plants, distributors, or retailers also known as a transshipment point (Dobrusky, 2003). Crossdock's application was being a Hub and Spoke arrangements, where goods were brought in to and then sorted for delivery to a variety of destinations. It could be consolidation arrangements, where a variety of smaller shipments are combined into one larger shipment for economy of transport, on the other hand, deconsolidation arrangements, where large shipments are broken down into smaller lots for ease of delivery.

Crossdock was dependent on continuous communication between suppliers, distribution centers (DCs), and all point of sale (POS). Influenced factors of crossdock was customer and supplier location, inventory in transit cost, complexity of loads, handling methods, logistics software integration between suppliers, trader, and transporter, and tracking system of inventory in transit.

Crossdocking was an operation in logistics of unloading goods from arriving vehicles and loading these goods into outbound vehicles that may be change vehicle type, to sort goods intended for different destinations, or to combine goods from different origins into vehicles with the same or similar destination and enable to hold the products temporary.

Advantages of crossdocking system

- Simplify the supply chain from origin to POS.
- Reduces material handling costs, operating costs, warehousing costs and the storage of inventory warehousing costs.
- Products get to the distributor and accordingly to the customer faster.
- May increase available retail sales space and temporary storage area.

Disadvantages of crossdocking system

- Potential partners don't have necessary storage-capacities or an adequate transport fleet to operate crossdocking.
- Need of adequate information technology (IT)-system.

In figure 2-2 showed the illustration of crossdocking system started from left side one truck delivered one batch of one product type. Then 3 types of product has been process by sorting, packing, breakdown and put together for each destination.

Crossdock facility design was normally designed in "I" shape, which is a lengthened rectangle. The objective in using this shape was maximization the number of inbound and outbound doors while keeping the amount of floor space inside the facility to a minimum. This shape was indeed ideal for facilities with 150 doors or less. For facilities with 150-200 doors a "T" shape is more cost effective. Finally, for facilities with 200 or more doors the cost minimizing shape will be an "X" (Bartholdi, 2004).

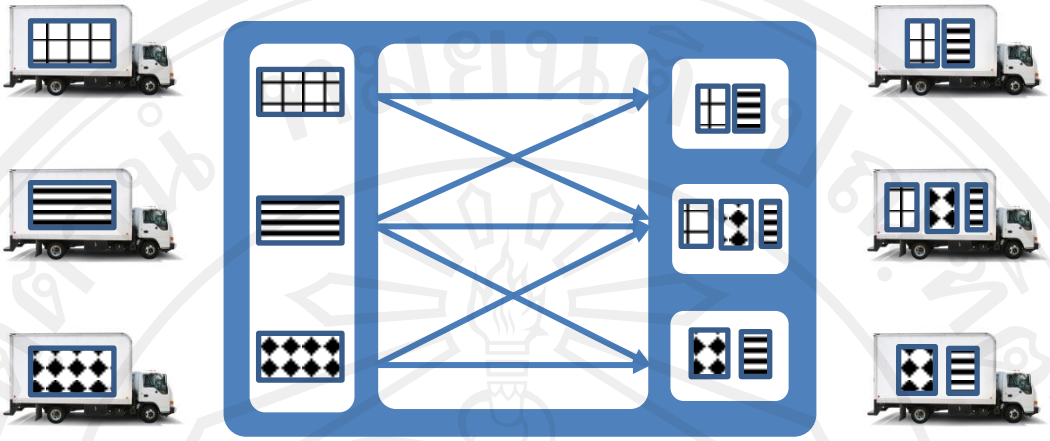

Figure 2-2: Crossdocking system
Source: http://oper3210-lean-concepts-f08.wikispaces.com/Warehouse

About the advantages of crossdocking system in previous studies that reviewed above said it can help to improve service level by reduce logistics cost, delivery to customer faster and get more temporary storage area. These rational were all the motivation to fix the issue of the case study.

2.3 Milk Runs

A delivery route that includes regular consolidates pickup and delivery of a small lot of stuffs at multiple suppliers or customers. This method lessens inventories while speeding the flow of materials between suppliers or customers. In general, milk-run logistics has been widely employed because it can reduce transportation costs due to consolidated transportation balancing, using small lot transportation, improvement of the stakeholder's production line and more precision of just-in-time (JIT) delivery by synchronization. Milk-run logistics provided consolidation of stuffs collecting needed to improve logistics procurement systems and vehicle loading rate, minimize the total distance of transportation. It can complete picking or delivery several suppliers and customers in different coordination in one travel loop, improve agility supplies and flexibility, as well as improve the quick response of the manufacturer's and system efficiency. Furthermore, it can reduce the risk of product quality. Manufacturers can rapidly notice and notify the corresponding suppliers, to minimize the impact on sales. It also changed logistics strategies, significantly reduce work in process (WIP), investment risks but increased capital flows (Kerr, 2006) (Brar & Saini, 2011).

The illustration (Figure 2-3) below can be the best description of milk run system because origin of the word "milk run" it came from a daily fresh milk delivery from some milk farm to many customers' house. Milk run transportation started by loading bottles of milk of many customers into truck by full truck load and departed from farm. Afterward, delivered 2 bottles of milk to first stop customer and also pick-

up empty bottles back too (reverse logistics) then do the same to others. When truck finished from delivery, truck will have full load of returned empty bottles. This method can solve backhaul utilization and waste of free load driving. Lastly for milk run system topic, this research will use this concept to solve VRP of the case study.

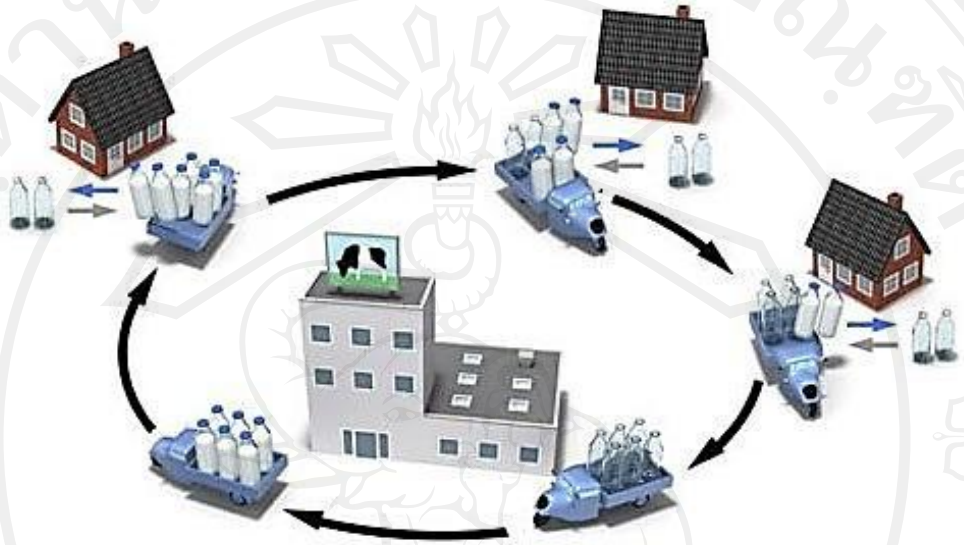

Figure 2-3: Milk run illustration
Source: http://www.pe.eng.ku.ac.th/

2.4 Genetic Algorithm (GA)

Normally, human body chromosome or any creatures always have evolution and each human never has the same chromosome this lead to the different of characteristic of each human and father-mother chromosome will combine to son - daughter chromosome gene, dominant gene or recessive gene of parents will keep or eliminate up to the method of combinations of genetic variants this is the selection of strains and all of these call the genetic algorithm of creatures, the natural evolution. “It is not the strongest of the species nor the most intelligent that survive, it is the one that is the most adaptable to change” Charles Darwin (Indra-Payoong, 2005).

GA was first invented in 1975 by John Holland, American scientist and professor of psychology and professor of electrical engineering and computer science at the University of Michigan, Ann Arbor (Wikipedia, 2012). GA was one of meta-heuristic method that simulated creature genetic mechanism by using mathematics mechanism for selecting good or bad answers, then evolution to next generation and develops the better answer that is the goal of this method (Petakhaso, 2011). Mate-heuristics was suitable for solving NP hard problem. The structure of GA was not complexity, generalization so it can be applied so simple to another problem. However, GA cannot guarantee that the answer was optimized but as good as possible answer in limitation of time to calculate. GA updates a population of solutions via genetic operators such as crossover, mutation and selection to achieve offsprings with better quality until some convergence criteria are met. At each generation, a GA was

capable of producing and maintaining a set of feasible solutions, maintaining a population of candidate solutions, and evaluating the quality of each candidate solution according to the problem-specific fitness function (Indra-Payoong, 2005). The problem of this research was VRP with 58 delivery points and 3 types of vehicle. The possible solution of VRP was *n!* (*n* = number of delivery point). This case was equal to 58! or $2.35x10^{78}$ but there were 3 types of vehicle to delivery so all possible solution was $2.35x10^{78}$ times 3, summation, $7.05x10^{78}$ possible solutions. This VRP was a NP hard problem which requisite to use meta-heuristics to solve so GA must be handled this problem. The procedure of GA will be described in a diagram below in figure 2-4.

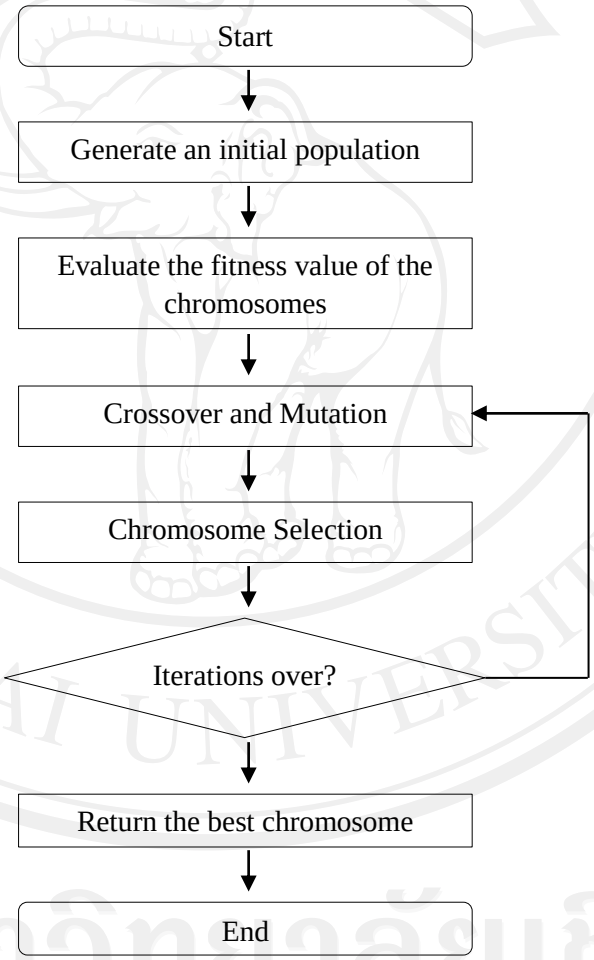

Figure 2-4: Flow chart of Genetic Algorithm

2.4.1 Generate an initial population

A representation of VRP refers to the customers were visited by the number of vehicles. A good presentation was chromosomes that contain of many routes and subset of customers that must be visited in the same order by

each vehicle that is shown in figure 2-5. GA created the initial population by using the old method of the company. In addition, the number of chromosomes in the initial population is equal to the number of customer nodes so that the population size of this case study equals to 58 chromosomes for each vehicle type.

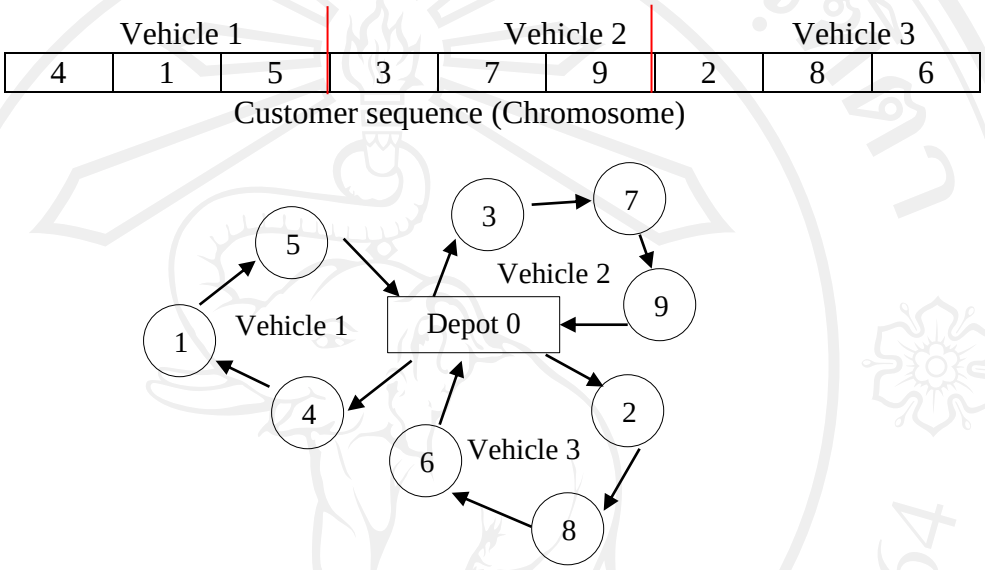

Figure 2-5: Representation of a chromosome for a 3 vehicles with 9 customers.

Figure 2-5 displayed 3 loops of milk run system by using 3 vehicles. Any route was shown in customer sequence such as vehicle number 1 started from depot to customer number 4 then 1, 5 and back to depot. These 3 routes can used just only one vehicle for all 3 loops that would be saving cost method but it always force by time window constraint.

2.4.2 Crossover and Mutation

Genetic transformation can be divided to 2 types; crossover and mutation. The illustration of both types were displayed in figure 2-6 for single point crossover and figure 2-7 to 2-9 for mutation.

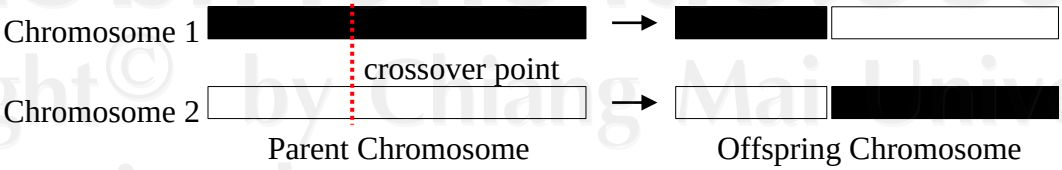

Figure 2-6: Single point crossover operation

Crossover operation was exchanging/swapping two genes or more between two chromosomes/parents to generate new offsprings. There were 4 types of crossover, first one was a simple method, single point, two-point, cut and splice, and uniform and half uniform, the complexity was increasing respectively. In figure 2-6 was illustrated single point crossover of 2 parent chromosomes which were exchange their gene between each other at crossover point. The offspring chromosomes were displayed result of crossover operation. The crossover was expected that an offspring will receive good parts of parent chromosomes (Tunjongsirigul & Pongchairerks, 2010). GA application in this research was also used single point crossover in operating.

Mutation appeared to be among the most important operation to escape local optima since it preserved the diversification in the population. The mutation step took place immediately after the crossover was performed. It switched the positions of genes in each chromosome. The switching can be occurred to every single gene in chromosomes in the same probability. The mutation had 3 types; Swap mutation (Figure 2-7), Insertion mutation (Figure 2-8) and Inversion mutation (Figure 2-9) (Ursania, Essama, Cornforthb, & Stocker, 2011).

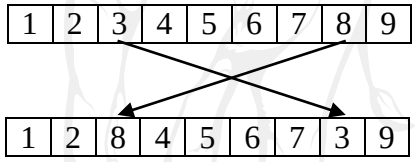

Figure 2-7: Swap mutation

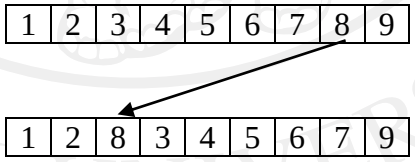

Figure 2-8: Insertion mutation

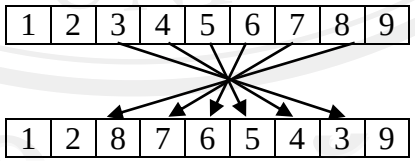

Figure 2-9: Inversion mutation

2.4.3 Chromosome Selection

GA applied the roulette wheel selection to generate the next generation offsprings by crossover and mutation. The probability of choosing an individual was directly proportional to its fitness value. Accordingly, the one with the largest fitness value became more probable to be selected as a next parent chromosome than a small fitness value chromosome (Tunjongsirigul & Pongchairerks, 2010).

The example problem below was a Travelling Salesman Problem (TSP) of 5 cities travelling (n = 5) subsequently the feasible solution is $n!$ = 5! = 120 chromosomes which are population. It was difficult to calculate all of population so it had to choose some group of chromosomes called sample population to represent all of the population. The amount of sample population called population size and this example was set population size equal to 4 chromosomes that had a gene value and fitness value as shown below in table 2-2.

Table 2-2: Fitness value and Probability of example chromosome

Chromosome	Genes	Fitness (km)	Probability
1	12345	169	0.15
2	13524	576	0.50
3	54231	54	0.05
4	31542	361	0.31
Total		1170	1.00

Table 2-3: New chromosome after selection

Old Chromosome	New Chromosome	Genes	Fitness (km)
3	1	54231	54
1	2	12345	169
4	3	31542	361
3	4	54231	54

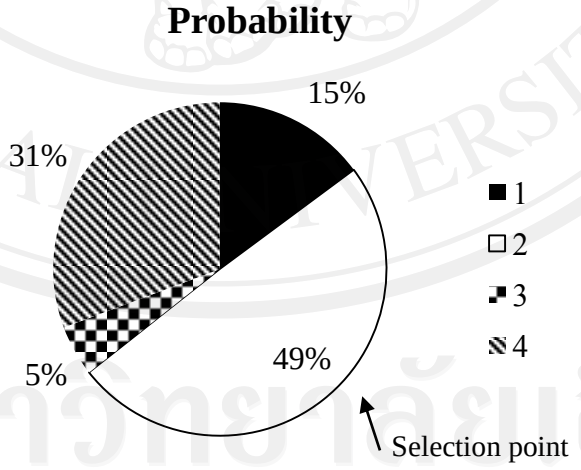

Figure 2-10: The roulette wheel of probability

The data from table 2-2 can drew the roulette wheel of probability (Figure 2-10) and then random roll the roulette wheel 4 times if any chromosome stopped at the selection point the chromosome will be the chosen chromosome and the same chromosome can be chose more than one time.

Assumed that it stopped at chromosome 3, 1, 4 and 3 (Table 2-3), these 4 chromosomes will be the next generation to do crossover and mutation again but if iterations is over these will be selected the best chromosome by the best fitness value.

2.5 Value Stream Mapping (VSM)

Value Stream is all of the activities, including those that add value and add no value, required to bring a product from concept to launch and from order to delivery (Kerr, 2006). Value Stream Mapping was one of the famous lean tools, "VSM can help the companies level production, resulting in dramatic reductions in throughput time and costs, and improved quality" said James P. Womack (Womack, 2006). The mapping of VSM displays processing line of product in a big picture that shows flow of material and production data. Proposing of VSM is for specify or identify the activities that added value to the product or non-value added/waste. The 7 wastes activities are Overproduction, Waiting, Transportation, Inappropriate Processing, Unnecessary Inventory, Unnecessary Motions and Defects then find solution to eliminate or reduce all wastes that found after the identification. VSM is simple tool created by only one of paper and pencil then can visual the whole process of product moving since was a raw material until delivered to customer. Furthermore, it was made simpler by using computer to create the mapping. The VSM is a basic tool to be a first drive of the organization to be lean organization by the next lean techniques.

2.5.1 Product-Quantity Analysis

Product-Quantity Analysis or P-Q analysis displays a Product Mix in form of Pareto Chart that can also explain Pareto theory/the 80:20 rules and separate Vital Few from Trivial Many. The Pareto chart shows the distribution of product that different in total volume by assuming the high quantity product should be the target to improve first.

2.5.2 Current State Mapping

After choosing products group to create value stream mapping, next step, drawing the current state mapping to show materials and data flows of the chosen products in big picture. Developing the map need to draw a series of icons, each representing a different step in the value stream. Map drawing steps to consisting external mapping and internal mapping. There were 3 diverse icon types those are material flow, information, and general icons. Material flow icons symbolize blocks in the manufacturing process outside sources (factories), inventories, push arrows, shipments and the others. Information boxes display key production metrics attend material flow icons. Some other material flow and general icons exist. Information lines are applied to connect material flow icons to form a complete and joint production

system. The lines represent all types of information flow. The VSM always starts with customer demand (Figure 2-11). Fill in the data boxes with the lists of customer requirements such as units per day, number of shifts, complexity breakout, and other production information. The external mapping includes the entire value stream from raw material to shipment of finished product. Therefore, the best place to start is the customer, since the customer is the only individual who can define the true value of the commodity at hand. The following step is bounding basic supplier with production process. Draw a process box on the left side of the map to represent suppliers. Regularly, select the supplier of the most vital components or the company that supplies the most components by value. Subsequently, list the production details of the operation in a data box. The final step of the external map is to connect all the icons with information flow icons. Draw the appropriate icon based on the type of information flow. In figure 2-11 has electronic information flow, which is shown with lightning bolt lines. Other types of flow make use of different types of lines. Below each information icon, draw a description box and fill in the occurrence of information flow.

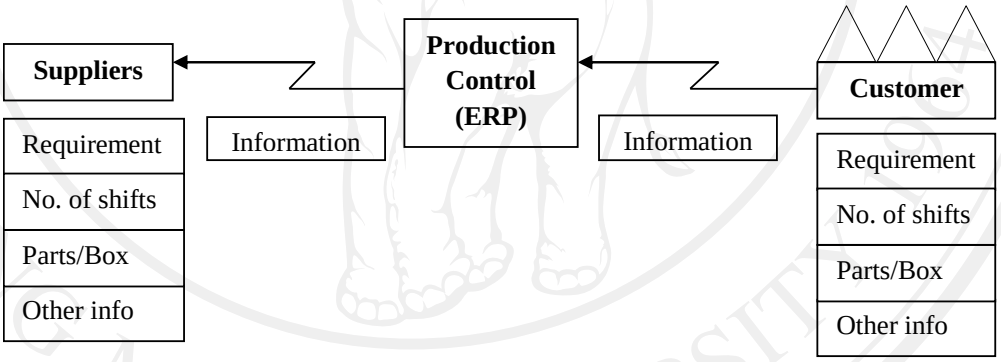

Figure 2-11: Starting of the value stream mapping

After drawing the internal process boxes, complete the circle by adding the correct material flow icon from one process to another. One illustration is a push system with WIP. This is represented by a sliced arrow (Figure 2-12) and an inventory icon. When drawing the current state, especially with inventory. Many systems are designed to have one-piece flow but in practice WIP is hidden throughout the process. Thereafter, draw a transportation from the suppliers to the first internal icon in the bottom left of the map. Repeat the step on the right side for outbound freight. For both icons, write the frequency of delivery and connect the production control system to each process icon with the suitable flow line.

The final step is to draw a time line under each process box and inventory triangle to rough draft the production lead-time. In figure 2-12 shown a lead time 9 days, a processing time about 4 days which means 70

percent of all production time is non-value added activities. The current state is now finished (Lovelle, 2001).

2.5.3 Value stream analysis: VSA

Current state mapping will be analyzed to identify that the process has value added activity or non-value added activity.

Value Added Activity (VA) is the activity that about a transformation operation of raw material or data to product that customer need or expect. The simple question is "Do customer necessary or willing to pay for the activity? " if the answer is yes the activity is value added activity in contrast it is a non-value added activity.

Non Value Added Activity (NVA) is the activity that wasting time, resource or area but not transforms to products/added value to product or not satisfies customer need. NVA must be eliminated such as waiting, rework and a pile of the work-in-process.

Necessary but Non Value Added Activity (NNVA) is the activity that wasting time, resource or area but necessary to do because it is a support activity for instance stock checking, making financial report and maintenance.

Afterward, when the analysis is done it will be conducted to process improvement by eliminate, reduce, simplify and combine the NVA or NNVA and the 7 wastes.

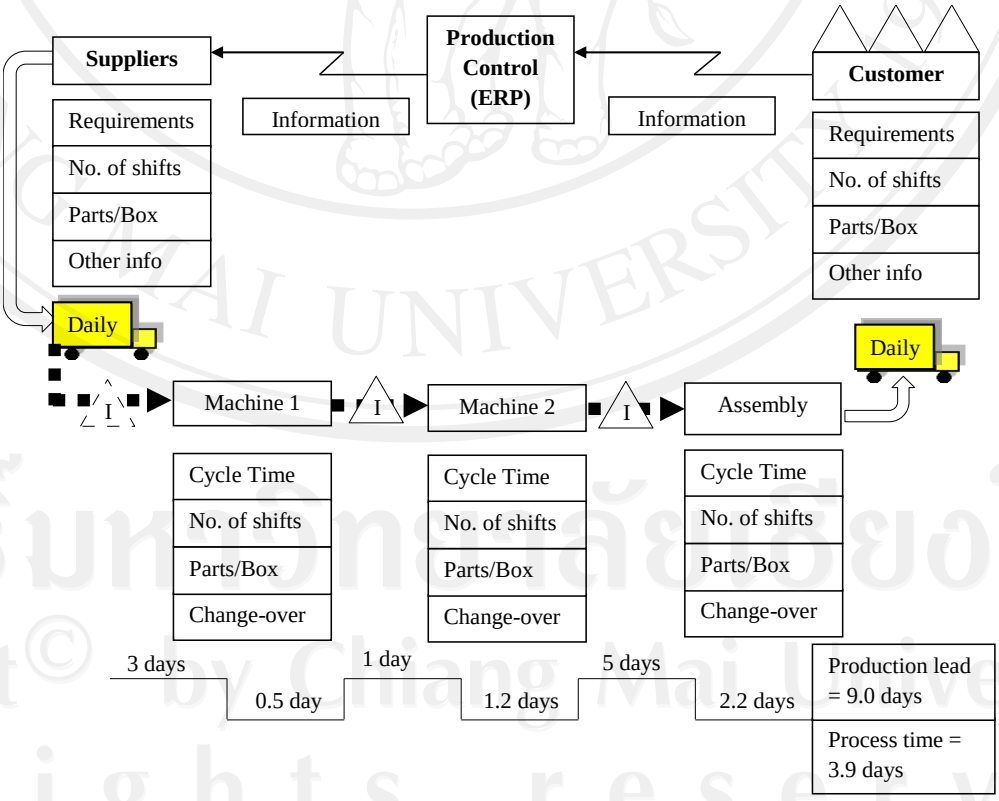

Figure 2-12: Map of the current state

2.6 9 Logistics Activities

The 9 logistics activities were used in this thesis to identify each activity of the case study. The logistics activities can be divided to 9 activities (Figure 2-13) consisting Material Management, Order Processing, Packaging, Transportation, Inventory, Warehouse, Material Handling, Customer Service and Other Logistics Activities. It did not have the most important activity in all 9 activities but it was an integration of every activities and stakeholders to make flow as smooth and flexible as possible. If every activity can perfectly collaborate between each other it will optimum logistics cost while satisfy customer service level in highest level (Khompatraporn, 2009) (Waters, 2009) (Thiengburanathum, 2010). This research focused on transportation activity because it was an activity that had highly effected to the case study. Details of 9 logistics activities analysis was in chapter 4.

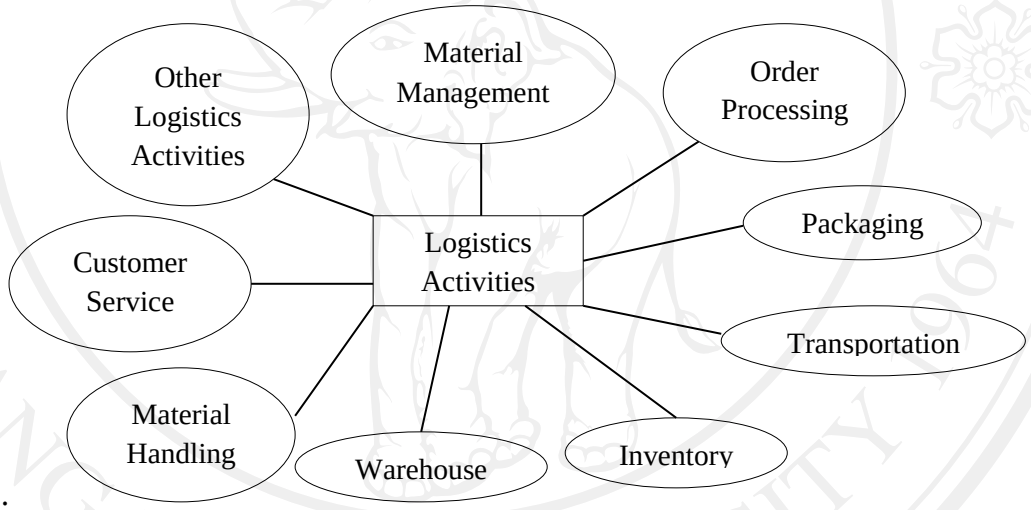

Figure 2-13: Nine Logistics Activities

2.7 Economics Costs Benefit Analysis

There were many factors that were used to be criteria to make a decision for launching any project. The most important factor was about money; cost, profit, or returned period. The famous methods that researchers or investors often use in cost benefit analysis were as follows; Break-Even Point (BEP), Internal Rate of Return (IRR) and Payback Period (PB) every method had their own advantages and definitely disadvantages also.

2.7.1 Break-Even Point: BEP

Investopedia, one of the Internet's largest sites devoted entirely to an unbiased source to learn about investing, gave 'Break-even Point' definition, "In general, the point at which gains equal losses." (Investopedia, 2012). BEP

was used to find production or sale quantity that make sales income equal to production cost both of fixed and variable cost. It can be displayed in production units or production level (Knowledge, 2009).

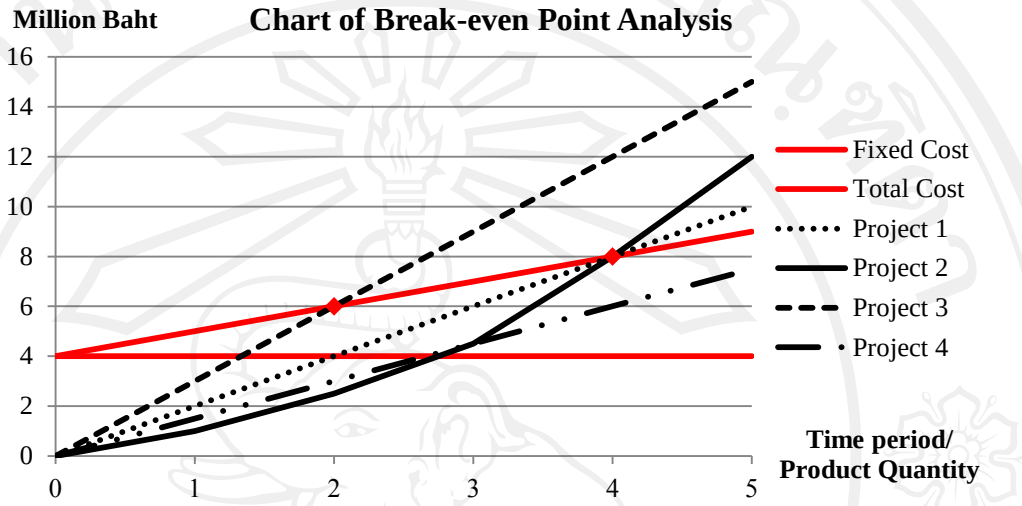

Figure 2-14: A Chart of Break-even Point Analysis.

The figure 2-14 was shown the BEP analysis chart of project 1, 2, 3 and 4 with the same total cost. The chart was displayed a fixed cost at 4 million baht and variable cost was increasing steady at 1 million baht per 1 period. The BEP of project 3 was the first red dot on the total cost line at the second period in X-axis and 6 million baht in Y-axis which mean project 3 will be able to make profit after the second period or after sale above 6 million baht. The second BEP were the second red dot at the crossing point of total cost line and incomes lines of project 1, 2 at period 4 (X-axis) and 8 million baht (Y-axis) which means project 1, 2 will gain profit after period 4 or above 8 million baht sale's. This BEP analysis can be concluded that the project 3 should be the chosen project because it is the fastest profit maker of all projects.

This chart (figure 2-14) will be showed again in chapter 4; results. This research will apply BEP chart to analyze how worth of each project solutions of the case study in the financial perspective.

The variables and parameters of BEP were exhibited below. TR stood for total revenue which is total income of the project on the other hand TC or total cost was total expenditure of the project. P stood for unit price of the product of project. X was a number of units. TFC was total fixed cost usually it was an investment of the project. VC, variable cost was expenses that change in proportion to the activity of a business.

The parameters of BEP analysis.

Total Revenue	=	TR
Total Cost	=	TC
Price	=	P
Unit(s)	=	X
Fixed Cost	=	TFC
Variable Cost	=	VC

The formula of BEP analysis.

TR	=	TC	(2.1)
P*X	=	FC + (VC*X)	(2.2)
(P*X) – (VC*X)	=	FC	(2.3)
(P – VC)*X	=	FC	(2.4)
X	=	FC / (P – VC)	(2.5)

The point of break-even was the point that total revenue equal to total cost or investment cost (Equation 2.1). Therefore, total revenue can broke down to price (P) time with unit (X) same as total cost; it can also broke down to fixed cost (FC) and unit price that came from variable cost per unit (VC) time a number of unit (X) (Equation 2.2). In equation 2.3 unit price has been move to deduct total revenue but then in equation 2.4, Xs of total cost and unit cost can be grouped together. Moved (P – VC) to divide fixed cost then it became new equation (Equation 2.5) so X is the answer of BEP; a number of products that will start the break-even (cost equal to revenue).

Benefits of BEP

1. Easy to calculate and understand.
2. The major benefit was indicated the shortest time period of project or the lowest quantity of product/service that necessary to prevent losses.
3. BEP can be used to determine product price for short term sale planning, in relation to sales and return profits in the right time.

Limitation of BEP

1. BEP was only a supply side analysis, as it tells you nothing about what sales were actually likely to be for the product at these various prices.
2. The assumption that fixed costs (FC) were constant, practical in the short term planning. The increasing in production scale was probable to cause fixed costs to rise.

3. Another assumption, average variable costs (VC) were constant per unit, at least in the range of quantities of sales.
4. BEP assumes that the quantity of goods produced was equal to the quantity of goods sold.
5. In multi-goods production, it assumed that the relative proportions of each product sold and produced were constant.

In this research used BEP in one of supporting data to help for making decision to select which project was the most appropriate solution for case study's situation.

2.7.2 Internal Rate of Return: IRR

IRR was the one of the most popular methods of evaluating potential projects. It is the interest rate or discount rate that takes a series of cash flows (positive and negative) to a Net Present Value (NPV) equal to zero, likewise, NPV of project cash flow in equivalent to out. Using IRR to obtain NPV known as the discounted cash flow method of financial analysis or the project break-even interest rate (Investopedia, 2012). It can be formulated as follows.

$$NPV_{IRR} = NPV_{in} - NPV_{out} = 0 \quad (2.6)$$

$$NPV_{out} = NPV_{in} \quad (2.7)$$

$$NPV_{out} = \sum_{n=1}^{n} \frac{Income}{(1+IRR)^n} \quad (2.8)$$

Equation 2.6 showed IRR NPV can be calculated by using income NPV minus with outflow NPV. At IRR point (in figure 2-15) NPV equal to zero, in the same way, when income NPV minus with outflow NPV at this point the result must be zero too. Afterward, income NPV minus with outflow NPV equal to zero then move any of them to the zero side, now it became new equation (Equation 2.7) income NPV equal to outflow NPV. Next equation, converted income NPV into summation formula of income and discount rate (Equation 2.8)

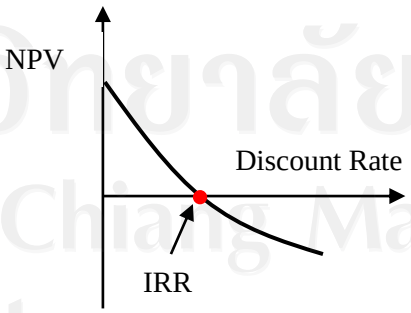

Figure 2-15: The Chart of IRR

A figure 2-15 was an illustration of Net Present Value (NPV) of cost in Y-axis and discount rate in X-axis. IRR can be calculated by drawing a graphical method. When time went by and project gained profit, the investing cost must decrease by discount rate, it will be displayed in IRR chart by the line sloped down. Once the NPV was decreasing to zero then the discount rate at that point was considered to be IRR of the project. It can also calculated by the mathematics formula. To find IRR from a set of data that showed in table 2-4 and replaced all value in the parameters in equation 2.8 that just have seen above. In this case, after equation 2.8 has been solve by finding IRR value which make NPV equal to zero, the answer (IRR) was 14% and solving steps already showed in title IRR calculation.

Table 2-4: Table of IRR calculation example data set

Year (n)	Cash Flow (NPV)
0	-4,000
1	1,200
2	1,410
3	1,875
4	1,050

IRR calculation

$$NPV_{out} = \sum_{n=1}^{n} \frac{\text{Income}}{(1+\text{IRR})^n}$$

$$NPV = 0$$

$$NPV = -4{,}000 + \frac{1{,}200}{(1+\text{IRR})^1} + \frac{1{,}410}{(1+\text{IRR})^2} + \frac{1{,}875}{(1+\text{IRR})^3} + \frac{1{,}050}{(1+\text{IRR})^4}$$

$$4{,}000 = \frac{1{,}200}{(1+\text{IRR})^1} + \frac{1{,}410}{(1+\text{IRR})^2} + \frac{1{,}875}{(1+\text{IRR})^3} + \frac{1{,}050}{(1+\text{IRR})^4}$$

$$\text{IRR} = 14\%$$

Benefit of IRR

1. Time value of money means interest and it should high because we invested money for specific time. IRR shows interest rate which investor expect from their investment. Consequently, IRR was the perfect use of time value of money theory.
2. IRR was good method of capital planning, if we set equal importance to all the cash flows not earlier or later. We just generated its relation with discount rate and want to know where NPV of cash inflow was equal to NPV of cash outflow or NPV was zero.
3. There was no base for selecting any specific rate in IRR.

4. If there was only one project to select, if we check its IRR and it was higher than its cut off rate, then it will be given maximum profitability to investors.
5. This method has no need to calculate cost of capital because without calculating cost of capital, it still can check the profitability capability of any project.

Limitation of IRR

1. It was difficult to understand because many students cannot understand why calculation discount rate in it. It became more difficult when real value of IRR will be two experimental rates because of not equalized present value of cash inflow with present value of cash outflow.
2. IRR is not good for comparing two projects (Accounting Education, 2010).

2.7.3 Payback Period: PB

The payback period (PB) is another method to evaluate an investment project. This method has shown the length of time that it took for a project to regain its initial cost out of the cash receipts that it generated. Payback period intuitively measured how long the project took to "pay for itself". The basic principle of the PB method was that the more quickly the cost of an investment can be recovered, the more desirable was the investment. The PB was usually expressed in time period such as years, months or even days. When the net annual cash inflow is the same every year, the following formula can be used to calculate the PB.

PB = Investment required / Net annual cash inflow* (2.9)

*If new equipment is replacing old equipment, this becomes incremental net annual cash inflow.

For example, a project had investment cost 1000 million baht which returned 500 million baht per year. PB calculation can be done by replacing investment cost and net annual cash inflow into equation 2.9 and solving for the answer (PB). This project would have two years payback period.

Benefit of PB

1. PB was popular because everybody can understand easily without education or professional background.
2. PB was widely used because of its ease of use.

Limitation of PB

1. PB method ignored cash generation in future periods was less valuable than the cash earned in the current period.
2. The formula was too simplistic to reflect the actual cash flow of the company and thus not so accurate.
3. The PB method focused only on the time required to pay back the initial investment and it did not track the ultimate profitability of a project at all.
4. The PB ignored any profits or losses that occurred after the payback period and measured neither profitability, nor risks.

2.8 Simple Additive Weighting (SAW)

The selection of crossdock location can be considered to be a multiple criteria decision making (MCDM) problem (Farahani, SteadieSeifi, & Asgari, 2010). Simple Additive Weighting known as SAW was the simple and widely used method. ArcGIS, the complete system for designing and managing solutions through the application of geographic knowledge was also using SAW to make preference decisions such as evaluation, prioritization and selection (Kucas, 2010).

$$V_i = \sum_{j=1}^{n} w_j r_{ij} \; ; \; \forall i = 1,2,3, \dots, m \qquad (2.10)$$

Notation

V_i = value of SAW scoring
w_i = weight score of criteria
r_i = score of alternative

Equation 2.10 was used for calculation of SAW by summation of alternative value. Each value can be calculated by scoring the alternative of each criteria then times criteria weight and summation value of each alternative. Last step, ranking all candidates by their values, the most value was the first rank and will be the chosen alternative.

Finally, SAW method will be used to prioritize or ranking candidate locations. Then, VRPs with crossdocking system were optimized by using GA and chose by the minimum total cost. The cost and benefits analysis, in this research used all 3 methods of economic cost-benefits analysis to combine their advantages and neutralize disadvantages. Comparison of VRP with and without crossdocking system by cost and benefits analysis, please find more detail in chapter 4. Later, the upcoming title is literatures review which reviewed about other researches that related to methodology of this research.

2.9 Literatures Review

Beginning the literatures review with big picture after that it must be narrowing down the problem scope. Subsequently, let started with literatures which was talked about how to study or analyze supply chain problem. From the most of preceding researches about supply chain problems that want to shorten lead time and improve operation efficiency, analyzed value stream by creating VSM. VSM was an approach of operation efficiency improvement (Millard, 2002) and it was simple tool, gave the whole process vision including flow of material and data, then concluded into mapping flow to easily identify the 7 wastes in value stream and led to wastes elimination (Thorsen, 2005) (Rother & Shook, 1999).

In Yongci Metal Machinery Factory was mainly specialized in alnico production, it provides over 1,000 types of products, which were produced in multi-type and small batches. VSM took place to visualize the current state. After creating current state VSM of the production process of a medium-sized order, problems affecting the delivery time are identified and its causes analyzed. A future state value stream map was created and an optimization scheme was correspondingly proposed, with which the production cycle of the order was expected to be shortened from 21 days to 9 days (57% reduction). VSM was proved as a useful technique to shorten delivery time and reduce production costs. (PAN, FENG, & JIANG, 2010).

Furthermore, software product customization process can also use VSM techniques. From research "Waste and Lead Time Reduction in a Software Product Customization Process with value stream maps" used VSM to identify non-value added activities of the process and the result is 3 types of waste were identified such as waiting, over processing and movement wastes these spend 38% of the total processing time (Mujtaba, Feldt, & Petersen, 2010).

These researches above were able to be confirmations how good VSM can analyze about activities and waste in the chain of vary product even if software product or machinery factory. Some company which their product was service they can still using VSM to improve their service. For the case study which was sell bakery products, it unquestionably can use VSM to study their process. The next one was a tool for study and analyze also but focusing on only logistics activities.

Currently, transportation cost is a very interesting issue in many kinds of logistics problem. One factor being emphasized was the increasing in oil price (Wannapaka, 2009). Moreover, the case study had the same current issue; investigation the problem of transportation system and finding solution for improvement. The famous reduction of transportation cost methods from many logistics consultants and research papers can be concluded in 5 main methods.

Firstly, an alternative energy, it was about changing fuel from diesel or benzene to another fuel such as bio-diesel or Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG) that is cheaper than fuel by around 60-70% but it also had higher fix cost (setup cost) and implicit cost (maintenance cost, opportunity cost).

The decision to change fuel type or not, a financial assessment must be calculated to evaluate which one was the most cost effective.

Secondly, using multimodal transportation; combining between more than 2 transportation modes, for example, deliver goods from factory by truck to the airport then using air freight to deliver to destination then using truck again for door-to-door deliver. Nevertheless, this method is hardly being used in Thailand and also in this case.

Next, distribution strategic, established the location of crossdock/ warehouse/ distribution center to distribute goods to other cities or countries. This requires an implementation of information technology system (e.g. barcode, RFID), material handling (e.g. conveyor) and stock area management, warehouse management system (WMS), etc.

The forth one was backhaul management; a maximum load utilization of vehicle to reduce waste/ non-value added activity of empty load or free load returned as in figure 2-16 the truck deliver goods from distributer to customer by full truck load, normally it will return back to depot without load (waste) but this method, management trucks are assigned to pick raw materials from nearby supplier then back to depot with a load, saving non-value cost of backhauling. The milk run transportation system was another good choice to fix backhaul issue. The success of backhaul management depends on information flow management where a group of stakeholders carry out Collaborative Planning Forecasting and Replenishment (CPFR) system.

The last one is Information Technology (IT) system that can reduce logistics cost and increase Transportation Management System (TMS) efficiency. IT system is transportation planning tool to achieve a transport business objective; fastest deliver with lowest cost. The elements of TMS are transportation manager and transportation optimizer for planning and making decision. Vehicle routing, invoice management, vehicle utilization management, fleet scheduling, and loading/ unloading, these require works that take a lot of time for planning where TMS covers all of these.

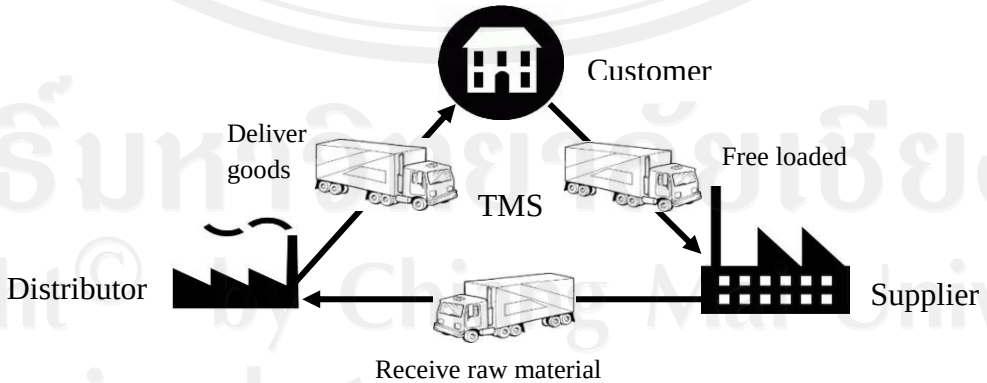

Figure 2-16: TMS for backhaul management

TMS can decrease time and increase efficiency for planning delivery plan additionally can increase TMS efficiency by using support information from Automatic Vehicle Location System (AVLS) or another real time data. About choosing TMS, the management team should be considered the main criterions; cost reduction, traveling time, and safety. Company that can effectively applied TMS to transportation of an organization, the company must also achieve the elements of 5Rs delivery and 5Rs means JIT delivery then that company would have the continuously high efficiency transportation organization. Managers must always monitor efficiency of delivery operation and service by setting Key Performance Indicators (KPIs) such as flexibility, efficiency, ability, responsiveness of delivery and the most important thing is safety (Wannapaka, 2009).

Many of the consulting companies and the previous research papers suggested utilizing TMS to reduce transportation cost. They usually said about vehicle routing management and distribution center setting for example, Gilmore said in Supply chain digest about ideas for reducing transport costs given rising fuel prices and divined an idea into 3 levels; strategic level, tactical level, operational/executional level in all levels has routing plan. Strategic plan is about information flow management of delivery, DC location selection and centralize transportation planning, tactical is optimizing of routing plan and operation is operate by following plan and evaluate how consistently the transportation plan is executed as planned (Gilmore, 2011). Another consultant in the UK suggested ways to reduce transportation cost by vehicle routing and planning, using their optimized route planning and scheduling software that can improve route planning to reduce fleet running costs. Using Geographical Centre of Gravity Analysis to analyze which is the best depot location. They guaranteed their entire plan will reduce transport cost by up to 20%, driver's hour costs, delivery lead times, increase vehicle utilization, customer service and be more responsive to customer demands (Supply Chain & Logistics Consulting Ltd, 2009).

From 5 main methods to solve transportation problem, the case study situation was appropriate for these selected methods; crossdocking system, backhaul management and TMS so the next approaching part will focus on literatures that related to find solution of these methods. Initially, the most important issue was study about TMS.

The planning of vehicle routing is one of TMS, also known Vehicle Routing Problems (VRP). The basic VRP are a classic distribution problem that has been widely studied in computer science and operation research for the past few years. Mostly of these problems are NP-hard problems that are usually solved by meta-heuristic algorithm, supplied from a single depot, delivery routes for vehicles are required, starting and finishing at the depot, so that all customer demands are satisfied and each customer is visited by just one vehicle (Baker & Ayechew, 2003). The routing problem in this case study can be considered to be a VRP (Fung, Tang, & Zhang, 2009) (Ombuki & Hanshar, 2004). Because of this case was VRP, thus, at the moment started narrowing down the TMS problem scope to focus on VRP.

An example study of real case VRP of the large chains of high-end retail stores in Thailand to manage a fleet of current trucks to deliver from a centralized DC to customers. The objective of this study is to develop a simple and effective algorithm that can help the user to manage the fleet in order to reduce the total transportation cost. The algorithm produces solutions of delivery routes and schedules of fleet that satisfy customer demands under constraints of truck capacity and delivery time window restrictions. Three performance measurements are the total distance, total travel time, and total cost (Sanjaiya, Buddhakulsomsiri, & Parthanadee, 2011). In above study was similar with current state routing method of this research's case study that had one DC but routing and scheduling without backup data or statistic.

For the reason that this research studied about distribution of bakery business hence the example of VRP of real case, bakery company will be the best example study. The research was talked about finding a route for delivering products from a single depot to the customers. The objective was minimizing the total distance and the total number of vehicles used. GA has been applied to optimize the routing in order to minimize the total corresponding distance. The proposed GA generates better solution which reduces average total distance by 6% and the number of used vehicles by 30% from the typical routing techniques (Tunjongsirigul & Pongchairerks, 2010). This above research can be one more evidences to demonstrate that VRP model can set up to improve TMS.

Some researches benchmark the VRP solving algorithms containing of GA, tabu search and simulated annealing. GA has seen more widespread application to various combinatorial optimization problems, including VRP, especially with time windows. In this example, computational results are given using a hybrid of GA with neighborhood search methods, showing that this approach is competitive with pure GA, tabu search and simulated annealing in terms of solution time and quality and hybrid GA gave the best result in the set of this example data (Baker & Ayechew, 2003).

In this research decided to use Genetic Algorithm (GA) due to the advantages of GA that is appropriate to the case study's issue. GA was extremely flexible for many kinds of problem. It can solve every multiple solutions, multi-objective functions, multi-dimensional, non-differential, non-continuous, non-parametrical problems, and optimization problems which can be described with the chromosome encoding. Furthermore, it is also easy to understand, practically does not need much knowledge of mathematics and also easily transferred to existing simulations and models. GA can be employed for a wide category of optimization problems because it is easy to modify to different problems and perform very well for large-scale optimization problems (Safaric & Rojko, 2006). From these advantages mentioned above, GA is the most appropriate with the case study problem as this problem is a large-scale optimization VRP with 25 branches and 78 retailer customers to be delivered (but overall stop was 59 stops). It is also easy to understand even setting the problem's model. Next part, it was about crossdocking system that will be able to

improve service level, handle more demand from customers which greatly increased every year.

There were some report said that crossdocking system can reduce operating cost, inventory carrying costs, transportation costs, costs associated with order fulfillment and material handling or warehousing cost. It can also increase inventory turnover rate, speed to Market Competitive; goods arrived at stores in advance of competition holding inventory, moving it, counting it, picking it and sometimes losing it, costs money. While not a solution for everyone, such as those with strict FIFO requirements, crossdocking can lead to significant benefits. It must fit in with the business, and the proper systems and processes must be in place to make it cost effective (FORTE-Industries, 2010) (KEOGH Consulting, 2010). For the case of this thesis crossdock can help by temporary hold goods before sorting and arrangement for each customer. This method can reduce arranging time and WIP at finished line of production line and also loading and waiting time for vehicles. Truck can depart earlier since no need to wait all product batches finished and no need to wait customer open time.

There were many methods of location selection, the well-known methods, using multi criteria decision making (MCDM). Finding landfill location was a site selection or location selection which was a serious problem that cannot use only a personal judgment. Basak's study was used MCDM (SAW and analytic hierarchy process: AHP) integrated with geographic information system (GIS) to prioritize and rank all candidates (Basak, Lutfi, & Vedat, 2006). Some studies used SAW with fuzzy, some studies about application and validation of MCDM tools, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Artificial Neuron Network (ANN) and SAW (Manokaran, Subhashini, Senthilvel, Murruganandham, & Ravichandran, 2011).

In this thesis will be used SAW with GIS data to select candidates. Started with choosing candidate locations and set weight or criteria then scored the alternatives of each criterion after that evaluation which alternative was the best choice. The objective was maximization utilization of resources and minimization overall cost.

The report of World Health Organization (WHO) about "The Economic Benefits of Improved Water Management and Services" used cost benefit analysis to make a decision of the project. The cost benefit analysis methods that they used are NPV and IRR (Stockholm International Water Institute, 2005).

Main objective of this research was improvement TMS of case study. From literatures review TMS problem of this case was VRP and the most appropriate method to solve this NP-hard problem was GA. Crossdocking system was another selected solution that can combine with VRP with GA. This choice has been select because it can provide higher service level and over prepared for approaching more and more customer demand. In addition, both of VRP single DC and VRP with crossdocking system objective were reduction total distance of delivery. Finally, when the solutions were created, it was the time to choose one of them. Typically,

improvement project had investment cost and each project gave different results, different income and also different cost. The evaluation of each project in financial perspective was necessary assessment that must be done to be support data before making a decision. This research used economic cost and benefits analysis; BEP, PB and IRR to evaluate the alternative solutions.