Meta-Heuristic Method for Solving Bulk Oil Product Logistic in Inventory Routing Problem: Partial Comparison Optimization

Antono Adhi, Budi Santosa, Nurhadi Siswanto
Department of Industrial Engineering, Institut Teknologi Sepuluh Nopember, Indonesia
antonoadhi@gmail.com, budi_s@ie.its.ac.id, siswanto@ie.its.ac.id

Abstract

Activities in the Inventory Routing Problem (IRP) relate to the repeated delivery of a product from one facility to multiple destination sources. Logistics of bulk oil product shipments are part of the IRP. The transport process in the logistics of bulk oil products through the sea lane is very complex because it must consider the inventory level of destination ports. The optimization process is carried out to avoid stock-outs at the destination port while keeping track of the smallest freight and waiting times of the vessel. Problems in IRP include NP-Hard. The exact method used to solve it is by the meta-heuristic method. The Partial Comparison Optimization (PCO) algorithm is a new method developed to solve bulk oil logistics optimization problems. This algorithm is effective enough to get optimum bulk oil product logistic in IRP.

Keywords
IRP, Optimization, Meta-heuristic

1. Introduction

The logistics activities in the Inventory Routing Problem (IRP) will create high costs that will reduce the level of corporate competition. Therefore the selection of models in logistics must be optimized. While often the processes in IRP logistics are only done through the intuition of the user. Experienced users and have a high flying hours in managing the process in the inventory routing system are quite capable of delivering good assignment results. But it is still not enough, especially if the user does not have a high level of experiences. It is still necessary to process calculations through good methods to solve the optimization problem.

The decision in the optimization process within the IRP will be able to benefit some sides (Santos, Ochi, Simonetti, & González, 2016). In addition to minimizing costs both in warehouses and travel, the optimization process can improve the quality of service (Santos et al., 2016). The selection of the path to which the vessel will go and what products will be taken will determine the shortest route of the vessel while avoiding the stock-out warehouse.

IRP as one of the variants of Vehicle Routing Problem (VRP) is included in the NP-Hard (Kumar & Panneerselvam, 2012). To address the problem, this problem must be solved by a heuristic or meta-heuristic algorithm (Etebari & Dabiri, 2016). Several studies have used heuristic and meta-heuristic methods to solve problems in the IRP. Siswanto, Essam, & Sarker (2011) combine mixed integer linear programming and one-step greedy heuristic to complete a ship inventory routing and scheduling problem with undedicated compartments (sIRPSP-UC). Santos et al. (2016) offer an iterated local search (ILS) method with neighborhood descent variable with random neighborhood ordering (RVND) to complete the multifariate inventory routing problem (MIRP). Peres, Repolho, Martinelli, & Monteiro (2017) use the Randomized Variable Neighborhood Descent (RVND) hybrid method to complete the Inventory-Routing Problem with planned transshipment (IRPT) multi-product. Zhang, Nemhauser, Sokol, Cheon, & Keha (2018) offers the Lagrangian heuristic algorithm for obtaining flexible solutions can accommodate unplanned disruptions in maritime IRP.

IRP on bulk oil delivery is related to the continuous distribution of bulk oil from source ports or depots to a number of destination ports within a specified time horizon (Siswanto et al., 2011; Savelsbergh & Song, 2008). Assignment of bulk oil delivery is done by keeping the supply level of bulk oil at the port of destination will not be short (Siswanto et al., 2011). Ships used to bring bulk oil can deliver to any port where it is assigned. Figure 1 shows the possibility of a ship's destination before it returns to the source port for reassignment.

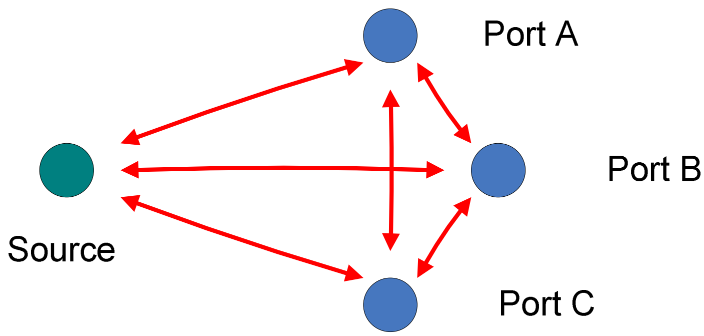

Figure 1. Possibility of ship destination

2. Partial Comparison Optimization (PCO)

PCO is discrete optimization. In this type of heuristic, results are obtained from a combination of the element. Therefore the optimum search process in PCO is based on discrete changes of possible combinations. The main parts in PCO algorithm are:

1. Random Choosing
   The selection of elements to be entered into a row of combinations is done randomly. Elements are selected one by one. This random selection will enlarge the search of the optimum point. The search shift does not need to be done as the stages in the continuous heuristic algorithm. The search pattern lies in the partial comparison stage.
2. Partial Comparison
   Positions of new elements entered in the combination sequence are attempted for each position in the sequence. The position that produces the best fitness will be selected. This process is performed as in the NEH algorithm (Nawaz, Enscore, & Ham, 1983).
3. Changing Neighborhood
   Based on researches, for a position occupied by a new element, it will change the possibility of fitness change from changing the position of neighbor next to it. Changes made by swapping the neighbor's position around it. This change can keep the optimum level, but it also gives the chance of changing the fitness level better. Consequences received is the process of changing neighborhood will prolong the processing time. But it can give the chance of the total search process optimum results faster repetition. So far, the time generated by the process of changing neighborhood is relatively faster compared than not using this stage. Changing Neighborhood can be done more than one level around the placed element.
4. Looping Process
   This process will repeat the optimized results of search results by iteration. Obtaining the optimum fitness value for each iteration is possible reached by the Random Choosing process.

3. Experiments

The experimental process is carried out by preparing the input and processing data required for oil delivery in the IRP. The required input data include port, ship, and distance data between ports. The attribute in the input data will act as a constraint during the optimization process, while the other data is initialization process. The initialized data is the condition of the ship and storage of products on the por.

3.1 Port Input Data

There are two types of ports namely source port or depot, and destination port. The source port is the port of origin of bulk oil delivery. All types of petroleum products exist in source ports while the destination port is the port to be sent oil products.

The port has some storage of bulk oil. Each storage has loading or unloading time and storage capacity level data. The unloading time will consider when the destination port storage will be empty therefore it must be recharged if it happens.

Each port has a jetty that is different in number with different ship capacity. If the jetty is being used by a ship and no other jetty is available, or the ship is not unable to enter into the available jetty due to ship load, the vessel must wait to be served until it can enter the possible jetty. The waiting time of the vessel will provide its own cost in the logistics process.

Port operating times vary. There is a full 24 hours, some are not. If the ship can not be served at that time, the ship service will resume on the following day. This can lead to shipping costs. The ship's process time at a port is different. Processing time starts from loading /unloading time, loading /unloading time, and final processing time.

3.2 Input Data Ship

The vessel is in charge of sending bulk oil from the source port to the port of destination. Any ship that has returned to the source port will be directly assigned to ship the product. The search for optimum results is when determining delivery destinations and products to be transported by ships. The purpose of the ship's delivery will give the cost consequences of the ship's trip. Selection of non optimum products can result in the cost of stock out products at the intended port.

The ship has a compartment. Each compartment has the maximum number of products that can be loaded. This type of compartment is undedicated. In this case, each compartment can be filled by any product. The determination of the product to be filled in the compartment will be determined through the optimization process.

The weight data of the vessel will determine whether a ship can be anchored in a jetty at the destination port or not. If it can not be accommodated, then the ship must wait for another ship that is using a jetty by which the ship can be anchored. And the speed data of the vessel determines how long a ship can travel from one port to another.

Expenses incurred in the vessel include travel expenses when the ship is filled and when the vessel is empty. Another cost is the cost that arises when the ship is idle.

3.3 Ship initialization data

The ship initialization data is ship position data already assigned at the time of optimization process. This data includes the date of arrival of the ship at the source port. The process begins when the ships come at the source port. For the next arrival process will follow the schedule of processing results.

3.4 Port initialization data

The port initialization data includes the storage condition data of each port. For each storage, the data required is the final condition of each product in storage and the plan for charging each product from the ship that has been assigned to fill the storage.

3.5 Process

Optimization calculation process in oil delivery is done in time windows frame. Calculations are performed within a certain time horizon. Optimization calculation process has the following steps:

1. Assignment of the ship on the nearest date
2. Optimization of the ship's destination selection
3. Optimization of product selection based on the needs of the port of destination
4. Determination of ship arrival date plan to source or depot port
5. The process is repeated to step 2 for other vessels arriving at the source port on the nearest subsequent date. The repetition is done until the time horizon finishes.

From the step stage, the process is done from the schedule of the ship that will come first. The vessel will be assigned to deliver bulk oil to the destination ports. The combination of any port to be traversed is calculated by PCO algorithm with the goal being the smallest transportation cost and demurrage. The constraint is to avoid as much as possible the stock-out of products in the destination port.

The next stage is to determine the type of product to be delivered to the ports to which the ship is destined. The purpose of the optimization is to keep considering the product stock-out.

Both the determination of the optimum ship assignment objectives, as well as the selection of the optimum product to be carried by the ship, are solved by PCO algorithm. Both the destination port and the product type are the most optimally selected combination elements. PCO is completed with the following steps:

1. Take one element that has not entered the combination sequence
2. Determine the best position of the element into a series of combinations of already formed elements
3. Repeat steps one through out all elements and specify the optimum global locale

Ship that has been assigned, based on the destination and the product carried, will be determined when the ship returns to the source port to resend. The process will be repeated again to the ship until the time horizon is exceeded

4. Result

The result of calculation of bulk petroleum transport optimization process in IRP is ship assignment. The calculated data generates assignment data for each vessel serving bulk oil transport from the source port to the destination ports as shown in fig. 2.

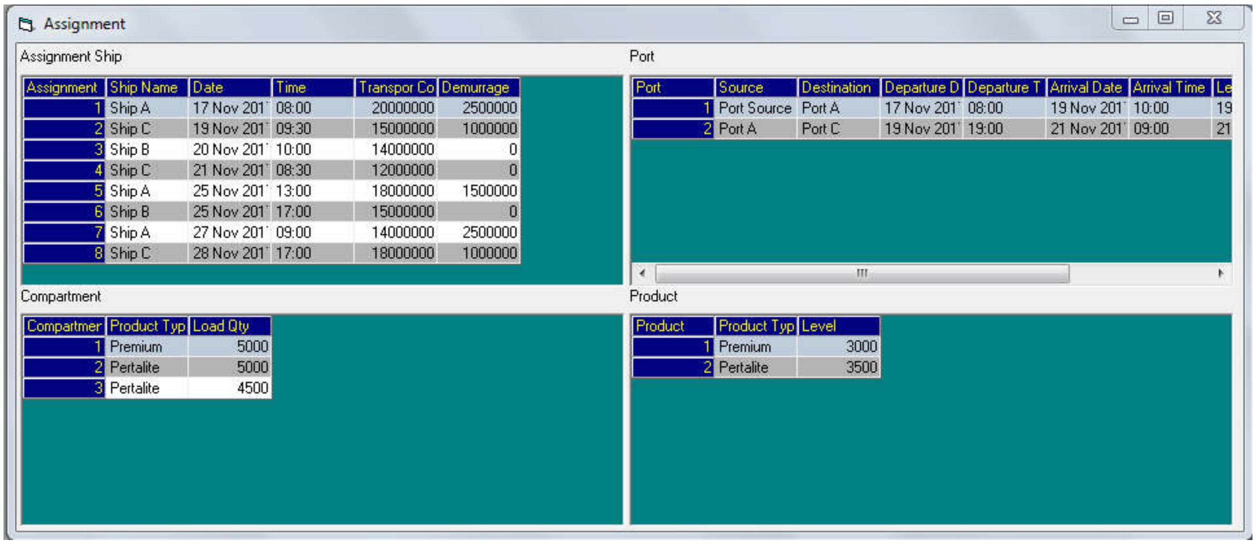

Figure 2. Ship assignment

Sistem will provide result of assignment for every ship in time horizon. The result is when the ship is assignmented to deliver oil bulk. Every data of ship will show which port will be visited by the ship for refill the storages of the port. This data also show type of product brung by ship in every compartment.

5. Conclusion

IRP is a very complex process. Optimization in IRP can only be solved by meta-heuristic method when IRP is classified as NP-Hard problem. PCO is a new meta-heuristic algorithm that is attempted to solve problems in the IRP. PCO provides good results to achieve optimization objectives within the IRP.

The result of research in oil bulk logistic give optimum result in considering inventory of every port. Every calculation of PCO algorithm will consider fitness of subject such as transportation cost and demurrage.

In further research. IRP cases can be further developed with the establishment of several source ports that are also supplied by other source ports. PCO is classified as a discrete optimization algorithm. In further research, PCO may be further developed to resolve other discrete optimization cases.

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Biographies

Antono Adhi is a student of Doctoral Program in Industrial Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. He works as a lecturer in Universitas Stikubank (UNISBANK), Semarang, Indonesia. He got his Diploma from Informatic Department Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. He got master degree from Industrial Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia and Magister Manajemen from Universitas Stikubank (UNISBANK), Semarang, Indonesia.

Budi Santosa is a professour of Industrial Engineering. He is a lecture of Doctoral Program in Industrial Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. He earned Bachelor degree from Industrial Engineering Institut Teknologi Bandung, Indonesia, Masters and Doctoral degree from University of Oklahoma, USA. His concentrations are in optimization and data mining.

Nurhadi Siswanto is a lecture of Doctoral Program in Industrial Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. He is the head of Department of Industrial Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia.