AI TECHNIQUES FOR LEAN DISTRIBUTION IN LOCAL CONTEXT

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Introduction

Lean Manufacturing is a systematic methodology that identifies and eliminates all types of wastes or non-value-adding activities within a manufacturing system. Moreover, lean concept is capable of balancing the customer's and manufacturer's perspective (i.e. customer desire for easy forecast change, short lead time where as manufacturer seeks for limited forecast changes and long lead time).

In Lean concept, unwanted transportation is considered as a waste, as it does not add a value to the end product. Transportation occurs at different scales in the supply chain (SC) such as transferring of raw materials to plant, movement of goods within the plant and distribution of finished goods to customer. Though the concern of minimizing unwanted transportation plays a major role in the manufacturing process, customers' concern lies on the facts such as receiving a product on time, with the required amount for a lower price. Therefore, it is vital to maintain a proper balance between the producer's and the customer's needs while trying to maintain the efficiency of the manufacturing process. Presently, various concepts are introduced to overcome the issues raised related to the supply chain. For instance, Just In Time (JIT) is a concept brought forward to minimize malfunctions in order to avoid the lateness of a single function since it will affect the whole process. Moreover, problems such as the cost of keeping an inventory, products being outdated and cost of labour can be minimized through JIT.

Since transportation is the major component of the SC of distribution operation, the study focuses on optimizing the transportation time of the distribution operations and thereby lean the SC. This is achieved by adapting Artificial Intelligent (AI) technique such as Tabu Search (TS) and Simulated Annealing (SA). Furthermore, transportation cost of the distribution process is minimized by introducing multiple depots and split delivery for heterogeneous fleet of vehicles.

Methodology

In lean implementation, Value Stream Mapping (VSM); A visual representation of every process in path from order to delivery is said to be the best tool since it gives the chance of identifying present system with drawbacks.

According to the VSM of the distribution process (Fig. 1.) activities can be categorized into (a) value-added (b) non-value- added activities and (c) non-value-added needed activity. Holding an inventory can be

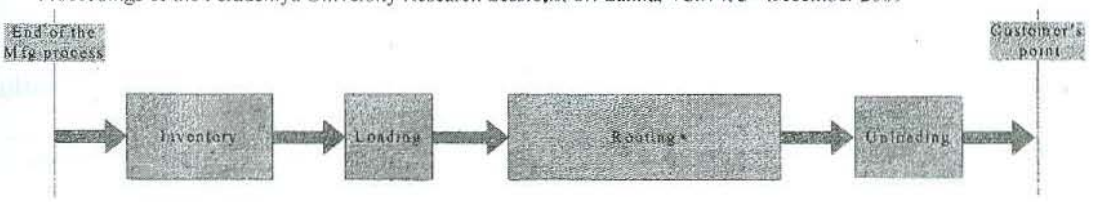

Figure 1. Distribution system

considered as non-value added whereas loading and unloading are non value added needed activities. Though the routing is value-added-needed, related cost and time is comparatively high in present distribution systems. Loading and unloading can be optimized adapting with proper packing system whereas inventory cost can be reduced by following modern concepts such as JIT. However, main objective of this research is to minimize the routing cost of a distribution network consisting of multiple warehouses, sets of dealers with defined time frame and fleet of heterogeneous vehicle. Warehouses are located in different regions where the customer is catered by most feasible warehouse. Split delivery is also allowable.

Our proposed algorithm (Fig. 2.) is divided into two stages. At the initial stage, tasks are assigned to most suitable vehicle based on the size of the first task of the sorted task list. The selection of the warehouse is based on the criterions such as distance to warehouse and availability of the warehouse. Moreover, tasks are filled to the vehicle in such a way that the vehicle is fully utilized. In the second stage it improves the initial solution using two operations of tabu search technique (Relocate and Move operator) and SA separately. Tabu Search (TS) is a meta-heuristic that guides a local space beyond the local optimality.

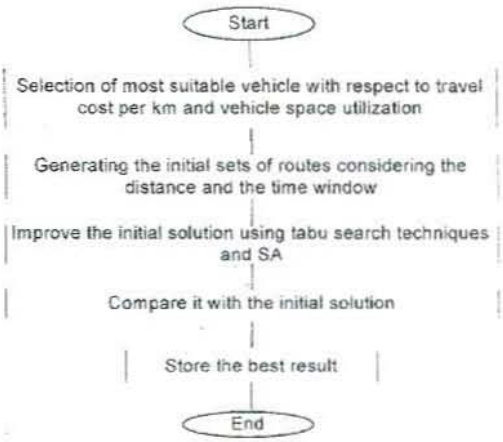

Figure.2. Basic steps of the proposed algorithm

Simulation and Results

Randomly generated data sets with different sizes are used in the case studies below. The results were based on the parameter settings presented in Table 1. In this study, we observe the variation of overall transportation cost with the number of warehouses in the distribution network (Table 2). Therefore, the significance of having multiple depots rather than a single depot has been convinced. Also we did a comparison on Multi Depot Vehicle Routing Problem (MDVRP) with heterogeneous vehicles while including and excluding the split delivery. As reported in Table 3, the splitting option is favorable in terms of number of vehicles used and the number of completed tasks. Furthermore, Table 4 gives the results obtained by optimizing the initial solution using different operators of TS technique and SA.

Table 1. Parameter setting

Parameter	Value
Fleet size 1. Container	10
2. Truck	15
3. Trails	30
Size of the distribution	
Network: 1.Customers (C)	50
2.Warehouses (WH)	7
Tabu list size	5
Starting Temperature	100
Cooling rate	0.97

Table 2. Variation of transportation cost with no. of warehouses

No. of warehouses	Transportation cost
1	600
2	495
3	500
4	370
5	345
6	335
7	320

Table 3. Comparison of including and excluding split delivery using heterogeneous fleet of vehicle.

Case No. & Size		No. of vehicles	Distance	Reject tasks
1 - 25	1	2	58	2
	2	3	62	0
2 - 35	1	4	70	2
	2	5	81	0

Table 4. Results obtained from initial stage of algorithm , TS and SA

Case		No. of vehicles	Traveled distance	Delivery
3	Initial solution	5	109	200
	TS- Operator 1	5	99	200
	Operator 2	4	100	200
	SA	4	95	200

Conclusion

In this paper, applicability of AI techniques to lean the distribution activities is studied. Meta-heuristic TS techniques and SA is proposed to solve this complex problem to get near optimal solutions within a reasonable time frame. Number of experiments revealed that the number of vehicle and total travelled distance can be reduced when split deliveries is available. Moreover, our experiments turns out that having multiple depots is beneficial since it reduces the transportation cost while meeting the customer demand in their time window with lesser number of vehicles. In future this research will be extended to test the proposed method with more operators for the local search. With TS and to develop a hybrid algorithm to improve the efficiency of the solution approach.

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