OPTIMIZATION OF MULTI-OBJECTIVE OUTBOUND LOGISTICS OPERATION

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ABSTRACT

Distribution, one of major outbound logistics functions draws attention due to high cost incurred. This study investigates the planning of a real time distribution operation achieving three objectives simultaneously. Route optimization, truck utilization and equal delivery make-span have been accompanied in order to address the problem giving financial benefits to company and satisfying the stake-holders. It is a real challenge to fulfill these three objectives concurrently; however, this research provides promising solution for the problem combining both exact and heuristics techniques. Heuristics techniques exploits to cluster the customers ensuring equal delivery make-span and Dijikstra algorithm has been modified to generate optimal route in terms of distance and delivery quantity. Algorithm was developed in C++. Results reveal that proposed route planning reduces the cost by 11.5 % included with 50% reduction of fleet size and 37% saving of travel distance.

Keywords: Outbound logistics, distribution, exact, heuristic

1. INTRODUCTION

Management of the logistics function is a crucial process for any supply chain as to function it efficiently and effectively. Under the phenomenon of globalization, deregulation, and time based competition the pressure for cost reduction and productivity improvement is ever increasing and a must for private companies as well as for the economy as a whole (Derigs, 2002). One of the most important aspects of supply chain management is maintenance of effective and efficient distribution network in order to fulfill customer requirements and expectations while achieving cost benefits. Efficient and effective logistic is all about providing the right products to the right place at the right time with the right cost (Lim, 2000).

Distribution network is an interrelated arrangement of people, storage facilities and transportation which brings products from producer to consumer. Good distribution can be used to achieve a variety of supply chain objectives ranging from low cost to high responsiveness. As a result, companies in the same industry often select very different distribution networks (Chopra, 2001).

A fast and reliable distribution network is essential for a successful company to provide goods and services to their customers right time with right quantities. Simultaneously they should highly force on distribution network optimization to sustain in highly competitive market. Complexity of the distribution networks are ever growing and in global context, therefore, many research studies have been conducted to optimize distribution network operations with efficient tools to support its decisions leading to a maximal service level at minimal costs.

According to the theoretical or mathematical programming view routing means the determination of optimum set of cycles within the graph or network. Different configurations of the underlying graphical structure, different objectives as well as different constrains have led researches to develop great varieties of optimization problems (Derigs, 2002). Optimization can be done considering single objective as well as multiple objectives. Mostly it would be cost optimization of distribution process. Moreover, the objectives may not always be limited to cost, it has extended to balancing of work load in terms of time and distance, capacity optimization can be taken into account by simply adding new objectives (Jozefowiez et al, 2008). Techniques used to solved mathematically formulated problems varies from exact algorithms to Meta-heuristics algorithms. Further many researches (Jozefowiez et al, 2008. Dharmapriya et al, 2012) accompanied hybrid of meta-heuristics in order to yield promising results in this context.

This study expands its focus into different objectives (Route optimization, truck utilization and equal delivery make-span) so as to address a current requirement of one of Sri Lankan companies. Due to the computational difficult of this problem both exact and heuristics approaches have been accompanied.

2. DATA ANALYSIS METHOD

2.1 Approaches

The proposed approach was developed integrating two main techniques such as exact algorithms and heuristics techniques at two different stages to achieve the objectives of the study.

Exact algorithm: Dijikstra algorithm was used to get the shortest path from Distribution Centre (DC) to Dealer point (DP)s. Dijikstra is the most efficient algorithm to get the shortest path for a single source problem. This algorithm itself can’t provide a solution for the whole problem which only helps to derive the shortest path from DC to DP.

Heuristic Approach**:** To schedule the distribution operation with optimal assignment and equal delivery make-span, heuristic approach has been adopted by developing new order capturing policy. This was done with the experience gained by the current order capturing policy and redesigned it to achieve objectives of the study by accommodating average distances. New order capturing policy is given in Table 2.

2.2 Methodology

Figure 1 shows the steps of the sequential procedure of the entire methodology. Initially clusters were identified with the heuristics technique and routes were derived within the cluster upon vehicle capacity, size of the order and optimal sub structure concept. The steps of the algorithm are clearly explained in the example given below.

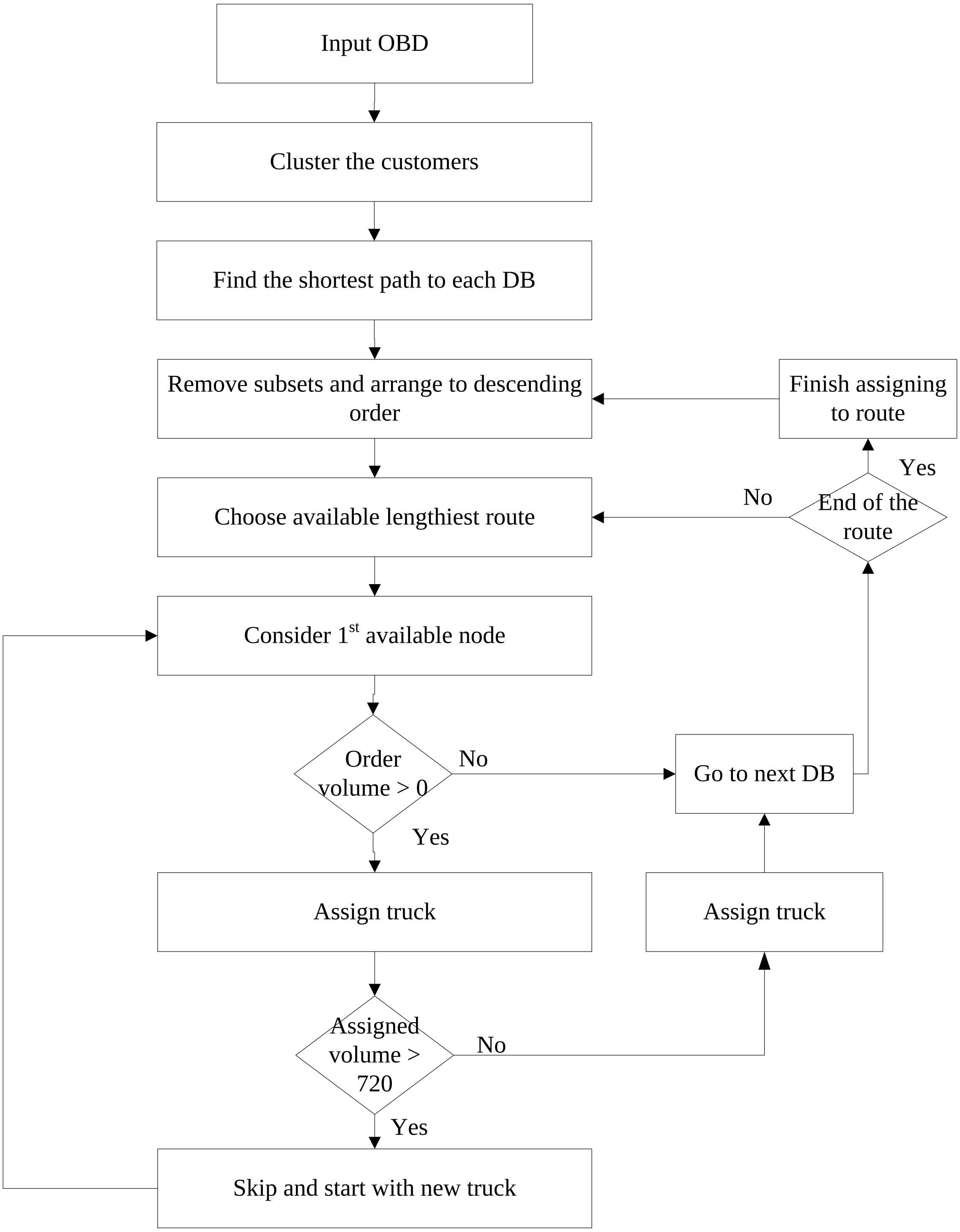

Figure 1: Flow Chart of algorithm

Example :

The steps of the proposed methodology are presented in Figure 1. Assume A,B,C,E,F,X,Y,Z,P,Q,R,S are DPs of network and O is the DC as indicated in Figure 2. Orders have been captured from all DPs except B and Y. Order placed by each DP is given in the Table 1.

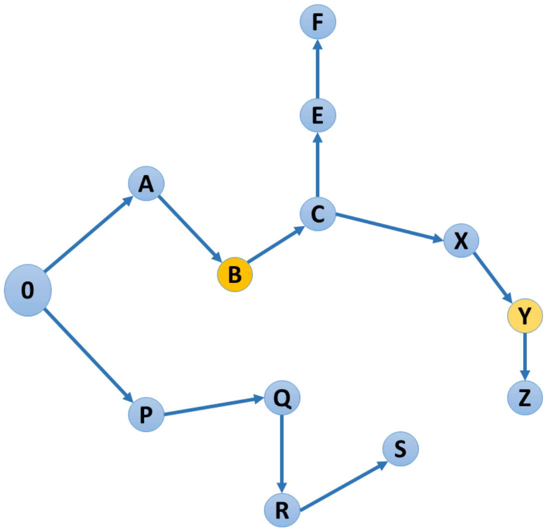

Figure 2: Example Network

Table 1: Example order volumes

A	B	C	E	F	X	Y	Z	P	Q	R	S
250	0	240	210	285	222	0	274	212	233	256	240

Step 1 : Generating the shortest path from O to each DP using Dijikstra algorithm.

[O,A], [O,A,B,C], [O,A,B,C,E], [O,A,B,C,E,F], [O,A,B,C,X], [O,A,B,C,X,Y,Z], [O,P], [O,P,Q], [O,P,Q,R], [O,P,Q,R,S]

Step 2 : Here author has used the technique called optimal substructure. If an optimum solution can be made from the solutions of its sub problems, it is called optimum substructure. Then these sub problems can be incorporated to main problem and remove these subsets and keep unique routes.

[O,A,B,C,E,F], [O,A,B,C,X,Y,Z], [O,P,Q,R,S]

Step 3: Re-arrange these routes according to the descending order.

[O,A,B,C,X,Y,Z], [O,A,B,C,E,F], [O,P,Q,R,S]

Step 4:

These routes might contain the nodes which don't have orders. That means their order quantity is zero and they should be skipped when orders are assigned to trucks.

Start from the lengthiest route and assign orders to truck until its capacity exceeded. If truck capacity exceeded then next node should be started to assign a new truck and process continues until its capacity exceeded.

Truck 1:- [A+C+X] = [250+240+222=712]

Truck 2:- [Z] =274

Truck 3:- [E+F] = [210+285=495]

Truck 4:- [P+Q+R] = [212+233+256=701]

Truck 5:- [S] =240

In this example truck 1 and 4 have been allocated to full truck loads and truck 2, 3 didn't have suitable nodes to be paired since they were at the end of each route.

3. RESULTS

This section presents a comparison between the present system and the proposed schedule of the developed system on a sample of Outbound Delivery.

Case study: Sample 1

Order capturing policy

The entire distribution network was divided into 25 zones based on Sri Lankan district division and they were again assigned to seven days of the week referring to the average travel distance to each zone. Average distance to each zone is calculated by taking the average displacement of all dealer points within the zone. For example, if Zone A consists of 3 DPs called X, Y, Z with distances of 10, 20, 30 average was calculated by [(10 + 20 +30) / 3]. Accordingly, following order capturing policy was developed considering the kilometer range as indicated in Table 2. This is the primary heuristics mechanism of getting fairly equal length for each route.

Table 2: Order capturing policy

Day	Average kilometer range	Zones
Monday	0-51	Gampaha, Kurunegala
Tuesday	52-100	Colombo ,Kandy, Matale,Puttalam ,Kegalle
Wednesday	101-150	Kaluthara, Nuwara Eliya, Ratnapura
Thursday	151-200	Anuradhapura, Galle, Polonnaruwa, Trincomalee
Friday	201-250	Badulla, Hambantota, Matara, Monaragala, Vavuniya
Saturday	251-300	Batticaloa, Kilinochchi, Mannar
Sunday	301-400	Ampara, Jaffna, Mullattivu

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Table 3 shows a sample of outbound delivery has been fed to both current system and the developed algorithm.

Table 3: Sample Outbound Delivery

Code	DP	Demand(in cases)
90	Colombo 06	231
57	Colombo 3	198
91	Moratuwa	232
58	Mount Lavinia	199
59	Piliyandala	200
61	Polgasowita	202
56	Rajagiriya	197
60	Thalawathugoda	201
89	Battaramulla	230
86	Galagedara	227
34	Galaha	223
15	Kandy	204
40	Katugastota	229
14	Kengalla	203
80	Kundasale	221
33	Peradeniya	222
13	Teldeniya	202
87	Ukuwela	228
47	Chilaw	236
48	Nainamadama	237
46	Puttalam	235

Delivery plan for above delivery sample given by the transport coordinator of current system is given in Table 4. Table 4 summarizes the details of demand points, travel distance, size of the vehicle used and related transportation cost factor. Accordingly, 16 trucks have been assigned while travelling 1292km creating the transportation cost of Rs.144, 788.

Table 4: Truck assignment under existing system

Demand points	Travelled distance(km)	capacity of fleet (CBM)	Transportation cost (Rs)
Battaramulla & Rajagiriya	68	22	8759
Colombo 3	63	16	7804
Colombo 06 & Mount Lavinia	72	22	8775
Thalawathugoda	74	16	7913
Moratuwa	79	16	8371
Piliyandala & Polgasovita	90	22	11091
Hettipola	40	16	5751
Peradeniya	89	16	8958
Kengalla & Teldeniya	110	22	12689
Chilaw & Putalam	106	22	12689
Ukuwela	104	16	7508
Katugastota & Galaha	109	22	12111
Kandy	94	16	9457
Galagedara	75	16	8500
Kundasale	102	16	9333
Nainamadama	21	16	5079
Total	**1292.5**		**144,788.00**

The same sample was fed to the developed algorithm and results are shown in Table 5 in the same format of Table 4. The proposed system has given priority to 32 CBM trucks considering their economic of scale.

Table 5: Output of Program

Truck No	Travelled distance (km)	Capacity of the fleet	Transport Cost
1	**75**	**32**	**13050**
2	**94**	**32**	**16356**
3	**106**	**32**	**18444**
4	**117**	**22**	**14508**
5	**74**	**32**	**12876**
6	**113**	**16**	**12882**
7	**112**	**32**	**19488**
8	**118**	**32**	**20532**
Total	**809**		**128,136.00**

Results were compared and presented in table 6 in terms of Total number of trucks used, travelled distance and transportation cost. According to the results presented Table 6, it is clearly shown that new algorithm has optimized the distribution network and order assignment. No of trucks have been reduced by 50% and total kilometers have been reduced by 37% compare to the existing system. Cost reduction is 11.5% and Rs.16,652 has been reduced from original value. This significance reduction of the proposed system is mainly due to the newly implemented operation policy, fully utilization of vehicle capacity and the selection of most economical vehicle.

Table 6: Comparison between existing and proposed system

Parameter	Existing system	Proposed system
No of Trucks	16	8
Total travelled distance (km)	1292.5	809
Total cost (Rs)	144,788.00	128,136.00

In addition to minimizing the transportation cost, one of the main objectives of this study is to derive routes with equal delivery makespan. Variation of the length of truck routes in the previous and the existing system is given in Figure 3 and Figure 4 respectively.

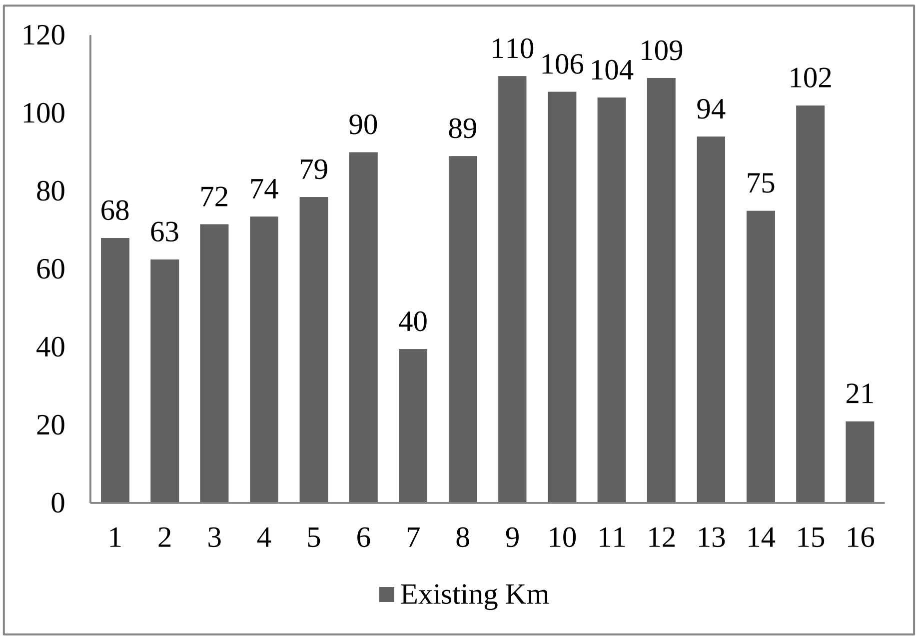

Figure 3: Distance variance of routes of the existing system

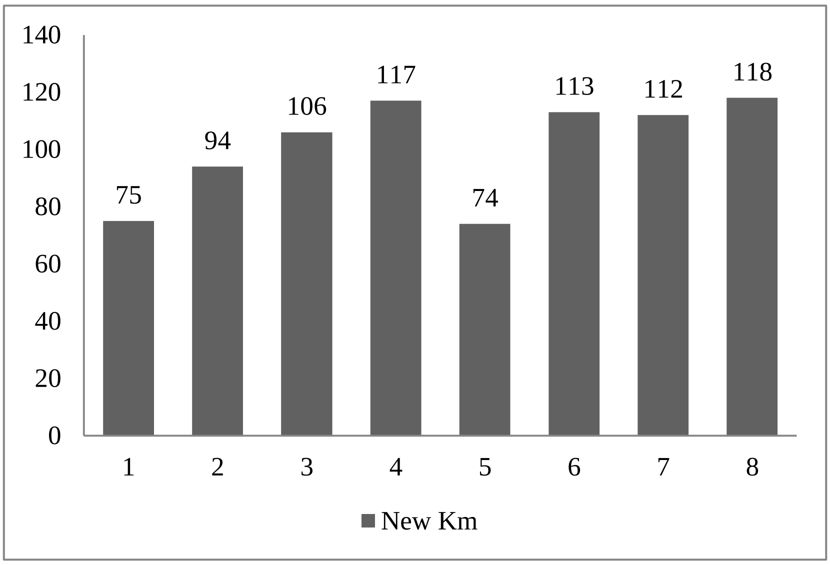

Figure 4: Travelled distance variance under new system

These results illustrate the success of proposed algorithm. Under existing situation there is a variation of 89km between lengthiest route and shortest route. But when it comes to the new system that variance has been reduced from almost 50% , which is from 89km to 44km.

4. CONCLUSION

This research has contributed to widen the boundaries of distribution optimization achieving three different objectives simultaneously. Practically, it is challenging to optimize the distribution operation with multiple objectives, however, using exact algorithms (Dijikstra) and heuristic approach objectives were achieved to a satisfactory level. Order coupling is done in the best possible way, reducing the fleet size by 50% and cost by 37%. Experience based heuristic approach ensures the total length of each route is within the acceptable km range. In addition, proposed system was able to distribute equal work load among the all transport contractors.

This research could be further developed by considering time window instead of equal delivery make span. However, distance is not the only factor affecting to same workload. Though the distances are similar there might be some routes which take more travel time than others due to traffic and road conditions. Therefore, time window would be more practicable solution to this kind of scenario.

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