Journal of Industrial Information Technology and Application Vol.1 No.2 (2017)
ISSN(Online) : 2586-0852

Optimization of Integrated Logistics Network Model with Location and Allocation Problems

YoungSu Yun *

Department of Business Administration, Chosun University, Gwangju, South Korea

Abstract. In this paper, an integrated logistics network model with location and allocation problem (ILN-LA) is designed. The ILN-LA which is composed forward and reverse logistics is represented by a nonlinear mixed integer programming (NMIP). The objective of the NMIP is to maximize the total profit resulting from the implementation of the ILN-LA. A hybrid genetic algorithm (HGA) approach is applied to solve the NMIP. In numerical experiment, three scales of the ILN-LA are presented and their NMIPs are solved using the HGA approach and some conventional approaches. Experimental results show that the HGA approach outperforms the others.

Keywords; Integrated logistics network model; Location and allocation; Hybrid genetic algorithm; Forward logistics; Backward logistics

1. Introduction

Recent studies have shown a growing interest on integrated logistics network (ILN) [1-5]. Wang and Hsu[2] proposed an ILN with forward and reverse logistics which is composed supplier, manufacturer, distribution center, customer recycler and landfill area. For constructing the ILN, they divided the function of distribution center into two types. First type function is to send the product to customer and the second type one is to send the returned product to recycler. Especially, in the ILN, recycler checks and then disassembles the returned product into recoverable material and unrecoverable one. The recoverable material is sent to manufacturer in forward logistics so that it is used for producing product and the unrecoverable material is sent to landfill area to be buried. Similar to Wang and Hsu[2], Amin and Zhang [3] also considered a ILN

* Corresponding author: ysyun@chosun.ac.kr
Received: 2017.4.11; Accepted: 2017.3.15; Published: 2017.9.1

with various components such as supplier, manufacturer, distribution center, retailer, disassembling center, refurbishing center and disposal center in forward and backward logistics. As an integrated concept, two types of part are used for producing product. First type part from supplier and second type one from refurbishing center are sent to manufacturer, respectively.

As shown in the previous works, most of researchers suggested various models based on the ILN. Unfortunately, however, they only used one or two integrated concepts in the ILN, which can deteriorate the efficiency of the conventional models. To overcome the weakness of the conventional works, in this paper, we consider more various integrated concepts in the ILN. That is, reuse, resell and wasted disposal concepts are used for constructing the ILN. Also we consider location and allocation problems in the ILN. For location problem, only one facility at each stage of the ILN is opened and the others are closed. The facilities opened at each stage send various numbers of part, product, and returned products to the facilities opened at the next stage for allocation problem. Therefore, the ILN proposed in this paper is called the ILN with location and allocation problem (ILN-LA).

For effectively representing the ILN-LA, a nonlinear mixed integer programming (NMIP) is suggested. The objective of the NMIP is to maximize the total profit resulting from the implementation of the ILN-LA. A hybrid genetic algorithm (HGA) approach is applied to solve the NMIP. In numerical experiment, three scales of the ILN-LA are presented and their NMIPs are solved using the HGA approach and some conventional approaches. Experimental results show that the HGA approach outperforms the others.

2. Proposed Approach

For designing the ILN-LA, we use various facilities at each stage of forward and backward logistics. For forward logistics, parts are produced from part suppliers at each area and they are then sent to product manufacturers through module manufacturers. The products produced at product manufacturers are sent to retailers through distribution centers. Retailers sell the product to customers. For backward logistics, the product returned from customers are collected at collection centers. Collection centers check and disassemble them into recoverable products, recoverable parts and unrecoverable parts. The recoverable products are resold at secondary markets after their qualities are recovered at recovery centers. The recoverable parts are sent to module manufacturers to be used for making modules. The unrecoverable parts are sent to waste disposal centers to be reclaimed or burned. Figure 1 shows the conceptual structure of the ILN-LA.

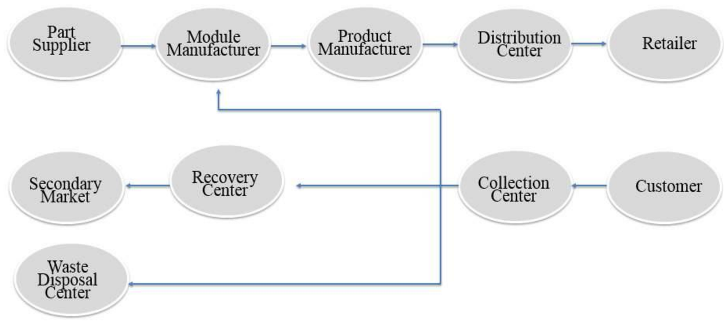

Figure 1. Conceptual structure of ILN-LA

For representing the ILN-LA, a mathematical formulation by a nonlinear mixed integer programming (NMIP) is proposed. The objective is to maximize total profit which is consisted of total revenues and total costs resulting from the implementation process of the ILN-LA. Various constraints such as opening and closing decision at each stage are taken into consideration for maximizing the total profit.

The NMIP is implemented using the HGA approach. The proposed HGA approach is a revised version of the Kanagaraj et al. [6]. The detailed implementation procedure is as follows:

Step 1: GA approach
- Step 1.1: (Representation) 0-1 bit representation scheme is used.
- Step 1.2: (Selection) elitist selection scheme in enlarged sampling space is used.
- Step 1.3: (Crossover) two-point crossover operator is used
- Step 1.4: (Mutation0 random mutation operator is used
- Step 1.5: (Fitness evaluation) fitness evaluation by objective function under satisfying all constraints is used.

Step 2: Cuckoo search approach
- Step 2.1: (Applying Levy flight) Levy flight scheme [6] is adapted to the individual which is randomly chosen from the GA population.
- Step 2.2: (Evaluation) compare the fitness value of the individual by Levy fight with that of the individual randomly chosen by the population and store the best individual among them.
- Step 2.3: (Iteration) repeat Steps 2.1 and 2.2 for all individuals of population.

Step 3: Termination condition
- If pre-determined iteration number is reached, then store current best solution and exit all steps, else go to Step 1.2.

3. Numerical Experiments

To prove the efficiency of the HGA, three scales of the ILN-LA is presented in numerical experiments. Table 1 shows the three scales.

TABLE I. THREE SCALES OF ILN-LA

Scale	Part Suppliers				Module Manufacturers	Product Manufacturers	Distribution Centers	Retailers Customers	Collection Centers	Recovery Centers	Redistribution Centers	Secondary Markets	Waste Disposal Centers
	1	2	3	4									
1	10	10	10	10	8	10	8	15	10	8	8	15	1
2	15	15	15	15	10	15	10	20	15	10	10	20	2
3	20	20	20	20	15	20	15	25	20	15	15	25	3

For various comparisons, two conventional approaches (con-GA by Gen and Cheng [7], con-HGA by Kanagaraj et al. [6]) and a benchmark approach (Lingo by Lindo [8]) are used. Each approach except for Lingo uses the following parameters. Total iteration number is 1,000, population size 50, crossover rate 0.5 mutation rate 0.3, and selection rate at cuckoo search 0.5. Total 30 trails are independently carried out to eliminate their randomness. The measures of performance are as following. Best solution and average solution mean the best value and average value resulting from each approach, respectively. Average time is the average running time of each approach. Percentage difference is the gap between the performances of each approach and that of Lingo. Table 2 shows the computation results by con-GA, con-HGA, Lingo and our approach HGA under various measures of performance.

	Scale 1				Scale 2				Scale 3			
	con-GA	con-HGA	HGA	Lingo	con-GA	con-HGA	HGA	Lingo	con-GA	con-HGA	HGA	Lingo
Best solution	390300	397800	426900	317788	394800	392700	429900	324844	381600	389400	416970	378600
Average solution	385870	389130	413780	-	386390	386460	415670	-	374810	384570	417110	-
Average Time	14	15	33	-	16.7	16.8	46.0	-	40.5	44.9	87.6	-
Percentage Difference	22.82%	25.18%	34.33%	0.00%	21.54%	20.89%	32.34%	0.00%	0.79%	2.85%	10.13%	0.00%

In the scale 1 of Table 2, our approach HGA approach shows the best result in terms of the best solution, average solution and when comparing con-GA, con-HGA and Lingo's approach. However, unfortunately, in terms of the average time, the HGA approach shows the worst performance and the con-GA the best one. In scale 2, the performance of the HGA is significantly better than those of the con-GA, con-HGA and Lingo in terms of the best solution, average solution and percentage difference. However, in terms of the average time, con-GA and con-HGA shows to be more efficient performances than the HGA. Similar results are also shown in the scale 3, that is, the HGA shows the best performances in terms of the best solution, average solution and percentage difference when compared with the con-GA, con-HGA and Lingo. However, the search speed of the HGA is about two times slower than those of the con-GA and con-HGA. By the computation results shown in Table 2, we can reach the following conclusions.

- The search scheme used in the HGA is more efficient than those of the con-HGA, though both have a hybrid search scheme using GA and Cuckoo search.
- The HGA shows to be significantly slower performance in terms of the average time than the con-GA and con-HGA, which means that search process in

the HGA is more complicated than the others, though the HGA locates better solutions than the others.

4. Conclusion

In this paper, we have proposed an integrated logistics network model with location and allocation (ILN-LA). For designing the ILN-LA, various components such as part suppliers, module manufacturers, product manufacturers, etc. in forward and backward logistics have been used. The ILN-LA has been represented by a nonlinear mixed integer programming (NMIP) in mathematical formulation. The NMIP is to maximize total profit which is consisted total revenues and total costs resulting from the implementation of the ILN-LA. The hybrid genetic algorithm (HGA) which is a revised version of the conventional HGA by Kanagaraj et al. [6] has been proposed to implement the NMIP. In numerical experiments, several scales of the ILN-LA have been presented and they have applied to compare the performance of the HGA with those of the conventional approaches (conventional GA, HGA by Kanagaraj et al. [6]). Experimental results have shown that the HGA proposed in this paper is more efficient in most of measures of performance than the other competing approaches. However, we have only considered small scales of the ILN-LA in numerical experiments. Therefore, large-sized scales of the ILN-LA will be used for proving its efficiency. An effort to reduce the search speed of the HGA will be also required since the HGA have shown significantly slower speed than the others. The efforts for improving these weakness of the ILN-LA and HGA will be left to our future work.

References

[1] P. Georgiadis and M. Besiou, M. “Sustainability in electrical and electronic equipment closed-loop supply chains: A System Dynamics approach,” Journal of Cleaner Production, vol. 16, pp. 1665-1678, 2008.

[2] H.-F. Wang and H.-W. Hsu, “A closed-loop logistic model with a spanning-tree based genetic algorithm,” Computers & Operations Research, vol. 37, pp. 376-389, 2010.

[3] S. H. Amin and G. Zhang, “An integrated model for closed-loop supply chain configuration and supplier selection: Multi-objective approach,” Expert Systems with Applications, vol. 39, pp. 6782-6791, 2012.

[4] S. H. Amin and G. Zhang, “A multi-objective facility location model for closed-loop supply chain network under uncertain demand and return,” Applied Mathematical Modelling, vol. 37, pp. 4165-4176, 2013.

[5] T. T. Chen, F. T.S. Chan and S. H. Chung, “An integrated closed-loop supply chain model with location allocation problem and product recycling decisions,” International Journal of Production Research, vol. 53, no. 10, pp. 3120–3140, 1215.

[6] G. Kanagaraj, S.G. Ponnambalam and N. Jawahar, “A Hybrid cuckoo search and genetic algorithm for reliability-redundancy allocation problems,” Computers & Industrial Engineering, vol. 66, no. 4, pp. 1115-1125, 2013.

[7] M. Gen and R. Cheng, Genetic algorithms and engineering design, John Wiley & Son, New York, 1997.

[8] Lingo, Lindo Systems (www.lindo.com), 2015.