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Distribution Planning of crossdocking network with different shipment ways and both soft and hard time windows

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ABSTRACT

Many distribution systems should optimize their activities to achieve higher rates of profit and customer satisfactory. Warehousing, direct shipment and crossdocking are three major physical distribution strategies where the last one has most of the benefits of two formers as well. This article deals with the freight consolidation and transportation Problem in crossdocking network considering the trade-offs among vehicles setup and transportation costs, Inventory holding costs and suppliers or/and customers time requirements. The studied distribution system includes both direct shipment and crossdocking strategies simultaneously. More over some customers are considered with less-restrictive time constraints and a related lateness penalty cost which should be minimized. The problem is formulated as an integer linear programming model and solved in various sizes using LINGO software. Experimental results demonstrate the effectiveness of the proposed model in different circumstances.

KEYWORDS: Supply Chain, Distribution Planning, Crossdock, Soft and hard time window, Integer Programming.

1 INTRODUCTION

In the distribution networks there are many strategiesfortransshipping that selecting best strategy eliminatewaste and reduce system costs .Among many strategies developed so far, cross-docking is believed to be an efficient strategy to minimize unnecessary inventory and to reduce system costs. In this article we study transportation problem in the crossdocking networks. In addition to corossdocking networks, direct shipments are also considered in which product can be shipped from manufacturer to customer either directly or through a crossdock[1]We assume that we have multiple points of supply (supplier, manufacturer or warehouse), multiple cross docks and multiple points of demand (retailers or customer). Items in one or multi-item shipment are sent or requested in a predetermined hard time window. In addition to hard time window there are soft time window which have less limitation in comparison with hard time windows. The aim of this article is trade-offs among vehicles setup ,transportation costs , Inventory holding costs and Delay penalty cost per unit product in order to minimizing the final shipping cost considering time window constraints. The problem is formulated as an integer linear programming model and solved in various sizes using LINGO software. Considering any kind of hard and soft time window and possibility of direct shipment and shipped through crossdock, checking complexity of problem solution and evaluation of solution in multiple dimension with lingo And the Similarity between the mathematical model and real condition are the main output of this article . In the second chapter, literatureof planning problem in crossdocking networks are briefly reviewed then distribution planning problem in crossdocking networks define and its mathematical model present. Computational results analysis and summary of researchalong withthe result are presented in the fourth and the last chapter respectively.

2. LITERATURE REVIEW

Bartholdi and Guemodeled the layout design of a cross dock in order to minimizing the staffing costs of material handling[2]. Vis and Roodbergerndetermined temporary storage locations for incoming unit load such that the travel distances of the forklift trucks with these unit loads[3] .

Bozer and Carloallocated vehicles to the dock to check the input and output and a solution based on simulation .They aimed at minimizing the total refrigeration transport of goods in the warehouse[4] .Mia et alin their paper in storage allocation through the door regarding the operational limits in the case have examined that the number of trucks is greater than the number of existing doors[5].

Jayaraman and Ross addressed an evaluation of new heuristics solution procedures for the location of cross-docks and distribution centers in supply chain network design[6]. Sung and songconsidered an integrated service network design problem for a given set of freight demands that was concerned with integration of

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locating cross-docking (CD)centers and allocating vehicles for the associated direct (transportation) services from origin node to a CD center or from a CD center to the destination node[7]. Gumusand bookbinder et al modeled location-distribution networks that include cross-docking facilities, to obtain the latter's impact on the supply chain[8]. Lee et al in their article considered cross-docking from an operational viewpoint in order to find the optimal vehicle routing schedule[9]. Yu and Egbelu found the best truck docking or scheduling sequence for both inbound and outbound trucks to minimize total operation time when a temporary storage buffer to hold items temporarily was located at the shipping dock[10]. Chen et alstudied a network of cross docks taking into consideration delivery and pickup time windows, warehouse capacities and inventory-handling costs[11]. Chen and Lee studied a two-machine cross-docking flow shop scheduling problem in which a job at the second machine can be processed only after the processing of some jobs at the first machine has been completed[12]. Chen and Song have examined cross dock scheduling problem on two machines structure of the schedule[13]. Larby et al studied the transshipment scheduling problem in a single receiving and a single shipping door cross dock under three scheduling policies[14]. Perez Alvarez et al studied scheduled problem which allowed a warehouse to function as a cross dock where transit storage time for cargo was minimized according to Just in Time scheduling[15]. In Boloori arabani et alstrategy products and shipments were unloaded from inbound trucks, sorted and categorized based on their characteristics, moved and loaded onto outbound trucks for delivery to demand points in a distribution network[16]. Maknoon et alformalized cross-docking process by presenting a mathematical model. They developed a sequential priority-based heuristic algorithm to deal with practical problems[17]. Vahdani and Zandiehscheduled the trucks in cross-dock systems such that minimize total operation time when a temporary storage buffer to hold items temporarily was located at the shipping dock[18].Soltani and Sajadi,scheduled truck to minimize the total flow time of the system in a cross-docking system[19]. Boyson et alhave done some simple assumptions for a basic model for the scheduling problem of vehicles on designated transit storage[20].

Waller et al developed models to predict the changes in the retailer’s system-wide inventory levels as a result of cross-docking .They also examined the impact of a number of relevant parameters on the benefit of cross-docking[21]. Yan and Tang modeled traditional distribution center storage systems through a strategy of handing over the transit storage after entering the warehouse and distribution strategy across other uses; they have investigated comparative analysis of the strategies[22]. Tang and Yancompared distribution strategies before entering the barn through after entering the transmission and distribution warehouses have done under the circumstances the possibility of transferring goods between retailers[23]. Lim et alstudied transshipment with supplier and customer time windows where flow was constrained by transportation schedules and warehouse capacities with the objective to minimize costs, including inventory costs[24]. Miao et al continue to study at Lim and colleagues examined the timing and the distribution network includes transit storage[25]. Chen et al studied network of warehouses in the proposed article .The goal is to minimize the total cost of distribution operations based on anticipated supply and demand[26]. Lee et al have created a hybrid model in his article that the scheduling problem and the problem of routing vehicles in transit to consider distribution network includes transit storage[27]. Liao et alcontinued to study Lee et al sought to determine the number of vehicles required and best of scheduling and routing of vehicles through a network consisting of a warehouse in their paper[28]. Wen et al have been raised problem of routing vehicles through a network inventory without considering the simultaneous entry of vehicles assumptions[29]. Musa et aladdressed the transportation problem of cross-docking network where the loads were transferred from origins (suppliers) to destinations (retailers) through cross-docking facilities, without storing them in a distribution center (DC)[30].

This article expand the model of transportation problem of cross-docking network that conducted by marjani et al and ma et al and present a model for implementing product distribution in crossdocking networks in which both direct shipment and shipping through crossdock are mentioned.

3. Modeling the shipment consolidation problem

The purpose of crossdocking planningproblem is finding the best physical distribution based on determined supplies and demands in multiple manufacturer, customer and crossdock networks.The intended meaning of best distribution is distribution planning that reduce holding and transshipment costs in networks as well as the total delay cost in delivering product to customer.each shipping and receiving should have done in the certain period of time .In this article in order to expand solution space and to get closer to reality, the possibility of delay is concerned for a number of shipping. Each crossdock has specific capacitythat is equal to highest level of inventory that can be kept in at that time. Possibility of direct shipping from manufacture to customer with various shipping cost is another feature of this article that assumed in order to similarity to real situation[1].

3.1.Sets:

S: Set of m supply points, indexed by i

C: Set of c crossdocks, indexed by j

D_1: Set of n_1 demand points with permitted delay indexed by k'
D_2: Set of n_2 demand points without permitted delay indexed by k''
D: set of n demand points, indexed by k where$(n = n_1 + n_2)$
T: Set of times indexed by t &t'
3.2.Parameters:
SC_{ik}=Shipping cost per unit product per unit time on route from supply point i to demand point k
SC_{ij}= Shipping cost per unit product per unit time on route from supply point i to crossdock j
SC_{jk}= Shipping cost per unit product per unit time on route from crossdock j to demand point k
FC^{IK}=Setup cost to send each truck directly from a supply point to a demand point
FC^{IJ}= Setup cost to send each truck from a supply point to a crossdock
FC^{JK}= Setup cost to send each truck from a crossdock to a demand point
$PC_{k'}$= Delay penalty cost per unit product per unit time for demand point k' with permitted delay.
TS_{ik}= Shipping time on route from supply point i to demand point k
TS_{ij}= Shipping time on route from supply point i to crossdock j
TS_{jk}= Shipping time on route from crossdock j to demand point k
H_j=Inventory holding cost per unit product per unit time in crossdock j $(j \in x)$
SS_i = Starting time defined at supply point i
ES_i = Ending time defined at supply point i
SD_k = Starting time defined at demand point k
ED_k = Ending time defined at demand point k
Sup_i = Maximum supply capacity of supply point i
Dem_k = Required demand at demand point k
T_{max} = Maximum time defining the time horizon
Cap = Capacity of each truck

3.3.Variables:
x_{ikt}=Quantity of product shipped from supply point i to demand point k at time t
y_{ijt}=Quantity of product shipped from supply point i to crossdock j at time t
z_{jkt}=Quantity of product shipped from crossdock j to demand point k at time t
v_{ikt}= number of trucks used at time t on route from supply point i to demand point k
v'_{ijt}= number of trucks used at time t on route from supply point i to crossdock j
v''_{jkt} = number of trucks used at time t on route from crossdock j to demand point k
I_{jt}= Quantity of inventory in crossdock j at time t

Cost parameter is one of the main parameters of model. Transportation costs incurred by transshipment center include fixed and variable cost. Variable costs are specified by the number of shipments and through specific shipping routes. Fixed costs include the number of vehicles used in the main model; In the main model which is continous problem, cost per unit product per unit time has been paid attention.So fixed pickup and delivery time for manufacturer and customer, affect the transportation time and the ultimate transportation cost respectively. Distance costs can always be included into time costs, whereas time costs do not always arise only from travel distance. In this study, we assume that manufacturers specify shipping time windows. Likewise, customers specify time windows in which they expect to receive shipments .This allows both manufacturers and customers to optimize their inventory flow by shipping or receiving the product exactly within scheduled times to minimize holdovers. Although customers have been allowed to delay transshipping considering delay costs at this moment penalty cost per unit product per unit time per quantity of product delayed calculated. Transshipment center costs. Additional holdover costs are incurred on a per unit basis at transshipment centers, including crossdocks when shipments are delayed. Since the key motivation for a crossdock is to achieve zero holdovers, a penalty cost per unit product held over in a crossdock is used in the objective function. This principle can be applied to any transshipment center. Shipment consolidation seeks the systematic coordination of inventory and transportation decisions at outbound warehouses. In a distribution network studied in this work that includes crossdocks as transshipment points, We assume the consolidation can take place at the manufacturer and/or at transshipment points. In the case of manufacturer, consolidation is initiated by accumulating small orders received from customers before shipment. At transshipment centers, consolidation is performed because inbound shipments are frequently broken down and/or combined before being shipped out to customers. In both cases, consolidation is done to reduce outbound transportation costs.

3-4- Model:

Min $Z = \sum_{i\in S}\sum_{k\in D}\sum_{t=T}(FC^{IK}v_{ikt} + SC_{ik}TS_{ik}x_{ikt}) + \sum_{i\in S}\sum_{j\in C}\sum_{t\in T}(FC^{IJ}v'_{ijt} + SC_{ij}TS_{ij}y_{ijt}) +$
$\sum_{j\in C}\sum_{k\in D}\sum_{t\in T}(FC^{JK}v''_{jkt} + SC_{jk}TS_{jk}z_{jkt}) + \sum_{j\in C}\sum_{t\in T}H_jI_{jt} + \sum_{j\in C}\sum_{k'\in D_1}PC_{k'}\sum_{t=0}^{T_{max}-ED_{k'}-TS_{jk'}+1}\sum_{t'=T_{max}-t}^{T_{max}} z_{jk't'}$
$+ \sum_{i\in S}\sum_{k'\in D_1}PC_{k'}\sum_{t=0}^{T_{max}-ED_{k'}-TS_{ik'}+1}\sum_{t'=T_{max}-t}^{T_{max}} x_{ik't'}$ (1)

St:

$\sum_{j\in C}\sum_{t=SS_i}^{ES_i} y_{ijt} + \sum_{k\in D}\sum_{t=SS_i}^{ES_i} x_{ikt} \le Sup_i \forall\ i \in S$ (2)

$\sum_{j\in C}\sum_{t=SD_{k'}-TS_{jk'}}^{T_{max}} z_{jk't} + \sum_{i\in S}\sum_{t=SD_{k'}-TS_{ik'}}^{T_{max}} x_{ik't} = Dem_{k'}\ \forall\ k' \in D_1$ (3)

$\sum_{j\in C}\sum_{t=SD_{k''}-TS_{jk''}}^{ED_{k''}-TS_{jk''}} z_{jk''t} + \sum_{i\in S}\sum_{t=SD_{k''}-TS_{ik''}}^{ED_{k''}-TS_{ik''}} x_{ik''t} = Dem_{k''}\ \forall\ k'' \in D_2$ (4)

$I_{jt} = I_{j,t-1} + \sum_{i\in S} x_{ij,t-TS_{ij}} - \sum_{k\in D} z_{jkt}\ \forall\ j \in C\ \&\ t \in T - \{0\}$ (5)

$I_{j0} = 0 \forall\ j \in C$ (6)

$Cap(v_{ikt} - 1) \le x_{ikt} \le Cap v_{ikt} \forall\ i \in S,\ k \in D\ \&\ t \in T$ (7)

$Cap(v'_{ijt} - 1) \le y_{ijt} \le Qv'_{ijt} \forall\ i \in S,\ j \in C\ \&\ t \in T$ (8)

$Cap(v''_{jkt} - 1) \le z_{jkt} \le Qv''_{jkt} \forall\ j \in C,\ k \in D\ \&\ t \in T$ (9)

$x_{ikt}, y_{ijt}, z_{jkt}, v_{ikt}, v'_{ijt}, v''_{jkt}, I_{jt} \ge 0\ \&\ Integer \forall\ i \in S,\ j \in C, k \in D\ \&\ t \in T$ (10)

In the objective function, the first term gives direct transportation cost from manufacturers to customers, including all truck setup cost and time cost; The second and third terms are similar to the first, and represent costs between manufacturers and cross docks and cross docks and customers, respectively. The next term represents total holding cost. The last two terms demonstrate delay penalty model that consist of delay penalty cost, quantity of product shipped and time of penalty cost for cross docks and customer, and manufacturers and customer respectively. Constraint (2) ensures the total quantity of the product shipped from manufacturers is no greater than the available supply. Similarly, constraint (3) ensure that total quantity of product receive meets demand .Constraint (4) require that, for each cross dock, the inventory at time t is equal to the inventory holdovers at time t-1 plus the total quantity received at time t minus the quantity shipped out at time t .Constraint (5) are initial and terminal conditions, respectively, of the inventory level at each cross dock .Constraint (6) assume that Quantity of inventory in cross dock at time 0 is zero. Constraint (7)-(9) ensures that the number of trucks used on any route is a minimum. Constraint (10) assumes that numbers of trucks and quantity of product variables are integer and have positive values. Definethe required variable of model in also demonstrate in term (10).

3.5.compexity

We showed that crossdocking problem is strongly N-P complete.In order to prove it ,we just need to show that in a linear function of time this problem could be convert to 3-partition problem.we know that 3-partition problem is strongly N-P complete and each problem that can be converted is N-P complete too.

3-partition problem is expressed in this way:finit set A with 3M member ,one limit and assume $s(a) \in z^*$ for $a \in A$.

If for each s(a) , relation $\frac{B}{4} < S(a) < \frac{B}{2}$ is true and also we has $\sum_{a\in A} S(a) = m$; Can we partition set A to m sets ,s_1, s_2, ..., that for each $1 \le i \le m$ have $\sum_{a\in A} S(a) = B$?

First of all it should be shown that how we setup crossdock planning problem like 3-partition problem assumption .

The assumption is that we want to write this problem for the condition that there is one product and one crossdock in network and the focous is on the planning m receipt from manufactures and 3m transshipment to customer.Also cost of direct shipment from manufactures to customer is so much that shipment never happens. Each receipt contain m units of product .The Time of receipt is assumed as constant, as a period of time $[t_i\, t_i]$;therefore each receipt accured at certain time (t_i). In addition, so as tosimplifproblem. It is assumed that there is no pair of receipt thathas the same receipt time. moreover, we can arrange a receipt as a $D_1, D_2, \ldots, D_m$sequence$(t_1 < t_2 < \cdots t_m)$.

The assumption is that period of each shipment is similar to the following format $[t_1 t_m]$. Nnumly each shipment could accur within the period of $t_1 t_m$ that is introduced previously .Now we can write one to one function from the set of demand for shipment for member as the set A.

As much as this relation $\sum_{a\in A} S(a) = mB$ is true , Each set of demands which are met by 3m shipments are equal to Mb.These 3m shipments exactly equal to m set of receipt that can be delivered from manufacturs . Therefore inorder to meet all the demands , all the receipts should be covered. Capacity constraint and holding cost in the only availabe crossdock in a network are assumed zero. This circumstance (i.e. the holsing capacity is zero) means that at any moment of time , there is no space for holding remain product in crossdock .In

addition , there is no transshipping cost .Clearly , the issues discussed above showed that crossdock planning problem in linear function of time covered 3-partition problem which is strongly N-P complete.Now we need to show that 3-partition problem has possible answer , if and only if the caused crossdock planning problem has possible answer.This assumption is possible with standard methods.
Presented model is formulated as an integer planning problem .various dimension of the problem is solved by lingo .

4-solve the model

LINGO is a comprehensive tool designed to make building and solving Linear, Nonlinear and Integer optimization models faster, easier and more efficient. LINGO software includes a powerful language for expressing optimization models, a full featured environment for building and editing problems, and a set of fast built-in solvers.As our model formulated as an integer problem so we can use lingo for solving various size of model.To run proposed algorithm we used a system with Processor AMD 2.81GH and 2.00 GB Internal storage. Problems design in a various dimension and necessary dates were used as a random variable in the interval that have been approved by experts. Presented model was programmed in lingo version 8 .result of 10 issues run in lingo were shown at below table.

Table 1: result of random issues using lingo

Time of processs (second)	Optimal object	Number of crossdock	Number of customer	Number of manufacture	Number of sample
0.3	10660	2	3	3	**1**
1.1	9741	3	4	4	**2**
3.2	14874	4	5	5	**3**
6.2	35670	3	6	5	**4**
5.8	31990	3	6	4	**5**
7.5	30400	4	6	4	**6**
11.1	92840	4	8	6	**7**
14.2	133700	5	8	8	**8**
15.1	144010	5	10	6	**9**
37.7	170040	5	10	8	**10**

We can conclude that Experimental results demonstrate the effectiveness of the proposed model in different circumstances that we can solve most of similar problems using LINGO. The fact that the larger the problem size the longer the time of processing, is the verification of being N-P complete. In large scale problems, which are similar to reality, we can use heuristic and meta-heuristic methods or we can divide shipments to use approximate results. Crossdocking is a feature that has a considerable impact on the complexityof the problem. In this article, both soft and hard time windows have been used which help expanding solution space but finding optimal objective becomes hard. As the number of customers increased with permitted delay,sufficient time to achieve optimal solution will be longer.

5 .conclusions

In the current competitive environment of global markets reducing cost and preparation time, increasing responding and better control of processes are the main purpose of supply chain that can be available by removing storing and retrieval processesbecause of using crossdocks. Crossdocking is a new strategy that has recently attracted the attention of researchers.The reviewed distribution network in this article consists of multiple crossdocks, manufactures and customers. in this network , for each shipments and receipts we define time window in which some of them were permitted to have delay .In the reviewed network ,direct transshipment and shipment through crossdocks are permitted .The main solution is finding shipment routs and time of shipping for manufactures and receipt routs and time of received for customers.The purpose of model is reducing transshipping, holding and delay cost. Distribution planning problem defined and formulated as an integer problem and solved in various size of lingo. Solving the model with lingo shown the ability of this software for distribution planning in crossdocking networks.it seems to be logical that heuristic and meta-heuristic methods for solving problem in a large scale will be considered in future .Also using various vehicle, finding optimal timing and routing for vehicle needed to be studied in future.

REFERENCES

1. Ma, H.and Miao, Z.and Lim, A. and Rodrigues, B. Crossdocking distribution networks with setup cost and time window constraint, 2011.Omega, 39, 64–72.
2. Bartholdi , J.and Gue, k , The best shape for crossdock, Transportation science ,2004.
3. Vis , I. and Roodbergen, J. Positiioning of goods in a cross-docking environment . Computer and industrial engineering,2008. 54, 677-689.

4. Bozer,Y. and Carlo,H ,optimization inbound and outbound door assidnment in a less-that-truckload crossdock:2008,40(11):1007-1018.
5.Miao , Z.and Yang, F.and Fu, K. and Xu, D. Transshipment service through crossdocks with both soft and hard time windows. Annals of operations reseach, 192, 21-47.
6. Jayaraman , V. and Ross, A. A simulated annealing methodology to distribution netwotk design and manegment .European journal of operation research,2003. 144:3, 629-645.
7. Sung , C.S. and Song , S.H. Integrated servis network design for a cross-docking supply –chain network, Journal of the operational research society,2003. 54, 1283-1295.
8. Gümüs, M. and Bookbinder , J.H. Cross-docking and its implications in location distribution systems, Journal of business logistics,2004. 25:2, 199-228.
9. Lee, Y.H.and Jung, J.W. and Lee, K.M. Vehicle routing scheduling for cross-docking in the supply chain. Computers & industrial engineering,2006. 51, 247-256.
10. Yu ,W.and Egbelu, P. Scheduling of inbound and outbound trucks in cross-docking system with temporary storage.European journal of operation research,2008.184:1, 377–396.
11. Chen , P.and Guo,Y.and Lim , A. and Rodrigues , B. Multiple crossdocks with inventory and time windows. Computers & operations research, 2006.33, 43–63.
12. Chen , C.Y. and Lee , C.H. Robust stability of homogeneuos large-scale bilinear system with time delay and uncertainties, Journal of process control,2009. 19:7, 1082-1090.
13. Chen ,F. and Song , K. Minimizing makespan in two-stage hybrid cross-docking scheduling problem, Computer and operation research, 2009.36:6, 2066-2073.
14. Larbi , R ,Scheduling transshipment operation in a multi inbound and outbound door crossdock, computer and industrial engineering , 2009.
15. Alvarez-perez and G.A., Velard, G. and Fowler, J. Cross-docking just in time scheduling: an alternative solution approach, Journal of the Operational Research Society, 2009.60:4, 554-564.
16. Boloori Arabani and A.R., Fatemi Ghomi, S.M.T. and Zandieh , M. Meta-heuristics implementation for scheduling of trucks in cross-docking system with temporary storage, Expert system with application , 2011.38:3, 1964-1979.
17. Maknoon , M.Y.and Kone, O. and Baptiste, P.A. A sequential priority-based heuristic for scheduling material handeling in a satellite crossdock, Computers & industrial engineering, 2009.72, 43-49.
18. Vahdani, B. and Zandieh, M. Scheduling trucks in cross-docking system: Rubust meta-heuristics. Computer and industrial engineering, 2010. 58:1, 12-24.
19. Soltani, R. and Sadjadi, J. Scheduling trucks in cross- docking system: Arubust meta-heuristics approach.Transportation research part E, logistics and transportation, 2010.46:5, 650-666.
20. Boysen, N. and Fliedner, M. Cross dock scheduling: Classification, literature review and research agenda, Omega,2010.38, 413–422.
21. Waller, M.and Cassady, R. and Ozment, J. Impact of cross-docking on inventory in a decentralized retail supply-chain. Transportation research part E , logistics and transportation review,2010. 42:5, 359-382.
22. Yan, H.and Tang, S.H. Pre-distribution and post-distribution cross-docking operation. Transportation research part E: logistics and transportation review,2009. 45:6, 843–859.
23. Tang ,SH. And Yan ,H , Pre-distribution vs. post distribution for crossdocking with transshipment,2010:10.1016.
24. Lim , A.and Miao , Z., Rodrigues, B. and Xu, Z. Transshipment through Crossdocks with Inventory and Time Windows, Wiley periodicals, Inc, 2005.724-733.
25. Miao, Z.and Lim, A. and Ma, H. Truck dock assignment problem with operational time constraint within cross-dock. European journal of operation research, 2009.192:1, 105-115.
26.Chen , P.and Guo,Y.and Lim , A. and Rodrigues , B. Multiple crossdocks with inventory and time windows. Computers & operations research, 2006.33, 43–63.
27.Lee, Y.H.and Jung, J.W. and Lee, K.M. Vehicle routing scheduling for cross-docking in the supply chain. Computers & industrial engineering,2006. 51, 247-256.
28. Liao, C.J.and Lin, Y. and Shi, S.C. Vehicle routing with cross-docking in the supply chain. Expert systems with applications, 2010.37, 6868–6873.
29. Wen, M.and Larsen, J., Clausen, J., Cordeau , J.F. and Laporte, G. Vehicle routing with crossdocking. Journal of the operational research society, 2009.60:12, 1708-1718.
30. Musa, R.and Arnaout, J.P. and Jung, H. Ant colony optimization algorithm to solve for the transportation problem of cross-docking network.Computers & industrial engineering,2010.59, 85–92.