Design and development of the trailers optimal allocation and schedule model in the supply chain system with considering cross dock with stochastic planning

Javad Khamisabadi
Department of Industrial Management
Firoozkooh Branch
Islamic Azad University, Firoozkooh, Iran
javad_khamisabadi@yahoo.com

Mohammad Reza kabaranzad Ghadim
Associated Professor
Faculty of Management
Central Tehran Branch
Islamic Azad University, Tehran, Iran

Hasan Ali Aghajani Kasegar
Professor, Faculty of Management
Mazandaran University, Iran

Mohammad Mahdi Movahedi
Assistant professor
Faculty of Management
Firoozkooh Branch
Islamic Azad University, Firoozkooh, Iran

Abstract:

Todays, transportation and logistics engineering process are among the important issues of organizations in the competitive market. Considering the logistical structure of the logistics engineering and the more attention paid to the logistical tools and, in particular, such as the use of these tools, such as containers (pallets, containers, etc.), transportation equipment (trailer, forklift trucks, etc.), and The art of building the supply and distribution network with respect to the main warehouses, cross dock and temporary storage, is one of the most important and contemplative cases. The main goal of this paper is to present and develop a mathematical model of trailer schedule planning in possible conditions in the cross dock. In fact, the main function of this mathematical model is to minimize the total time of the logistics process from the stage of emptying the pallets from the materials producers in the cross docks and assigning the trailer to the door and finally reloading the pallets to be distributed to the production sites. . To solve this model and to analyze the outputs, mixed integer programming was used by GAMS software.

Keywords: Stochastic Schedule planning, Cross Dock, Logistics Engineering, Assign

1. Introduction

Crossdocking is a warehousing strategy that moves products through flow consolidation centers or crossdocks without putting them into storage. It is normally considered as a two-stage product flow where the first stage contains truckloads of mostly similar items from suppliers, called the inbound, and the second stage contains truckloads of mostly different items to customers, called the outbound. Products are unloaded from incoming trailers[1] and loaded onto outgoing trailers with little or no storage in between. To set up crossdocking, a big yard is required to accommodate incoming and outgoing trailers. The crossdock itself is generally a rectangular dock (Bozer & Carlo, 2008) with doors placed around its perimeter. Whenever an incoming truck arrives at the yard of a crossdock, it is assigned to a dock door (or waits in a queue on the yard until it is assigned, Boysen et al., 2010), where inbound loads are unloaded and scanned to determine their intended destinations. The loads are then sorted, moved across the dock and loaded onto outgoing trucks (or staged in load positions waiting for their outbound trailers to be assigned to dock door, Cohen & Keren, 2008). Depending on its size or shape, freight (typically palletized) is moved from inbound trailers to outbound trailers by different material handling equipment including forklifts, pallet jacks, and a conveyor belt system. In general, crossdocking helps in reducing the supply chain inventory and transportation costs, thereby improving the financial flows and profitability of the organization.

2.Integer program

The truck scheduling problem studied in this paper can be represented analytically in the context of an integer program. In the mixed integer programming (MIP) formulation, 9J9 trailers are waiting for crossdocking in a crossdock of 9M9 doors. The location of the crossdock doors is represented by their respective distances. There are in total 9P9 pallets exchanged between the trailers. For any two trailers which exchange some of their products with each other, a pallet unloaded from one of them is loaded onto the other. Accordingly, each trailer j has two sets of pallets. The first set contains those pallet IDs unloaded from the trailer[2] (denoted by U_j) and the second contains those loaded onto the trailer (denoted by L_j). The following notation is used to describe the MIP model:

- j_{Ui} - represents the unloading operation of pallet i
- j_{Mi} - represents the moving operation of pallet i
- j_{Li} - represents the loading operation of pallet i
- m_{Ui} . represents resource i required for the unloading operation. (According to the problem definition, the resource is door i and its designated worker.)
- m_{Mi} - represents resource i required for the moving operation. (According to the problem definition, the resource is forklift i designated to door i.)
- m_{Li} - represents resource i required for the loading operation. (According to the problem definition, the resource is door i and its designated worker.)

m	$door, m \in M = \{1, ..., \lvert M \rvert\}$
j	$Trailer, j \in J - \{1, ..., \lvert J \rvert\}$
p	$pallet, p \in P - \{1, ..., \lvert P \rvert\}$
U_j	set of pallets unloaded from trailer j
L_j	set of pallets loaded onto trailer j
B_p	unloading position of pullet p
l^U	time taken to unload a pullet
t^M_{pcm}	time taken to move a pallet from door m to door m'
t^L	time taken to load u pallet
T^C	Trailer change over time

Q	a big umber not less than the worst schedule length
	Decision variables
$O_{\max}$	schedule length (or make span)
u_j	assignment time of trailer j
c_j	completion time of trailer j
λ_p	time when moving of pallet p starts
μ_p	time when moving of pallet p is completed
σ_p	time when loading of pallet p is completed
$\delta_{pp'}$	1, if. for pallets p and p 'staged onto the same staging area, p is moved before p', else 0)
T_{put}	l, if for pallets p and p' loaded out the same trailer, p is loaded before p', else 0
I_{jm}	l, if trailer j is assigned to door m, else 0
V_{jj}	l, if, for trailers j and j' assigned to the same door, j precedes j', else 0
q_p	l, if pallet p is to be moved [by a forklift] before loaded onto its destination trailer, else 0
V_{jiojm}	l, if trailer j is assigned to door m and trailer j' is assigned to door m', else 0
w_{py}	l, if both pallets p and p' are to be moved [by a forklift] before loaded onto their destination trailers, else 0

With the above denotations and decision variables, the MIP formulation is as follows: Minimize $C_{\max}$
$ST.$

$$\sum_{m \in M} I_{jm} = l, j \in J$$

Constraint (3.6) determines when the moving operation of a given pallet. Constraint (3.7) ensures that a pallet is loaded only after it is moved to tis destination door. Constraint (3.8) indicates that a trailer can start its loading operations only after it completes its unloading operations Constraint (3.9) states that the loading operations of the pallets onto a given trailer are completed according to the order they arrive at the destination door Constraint (3.10) specifies that after loading its last pallet, a trailer is done and is ready to leave its assigned door. Constraint (3.11) defines the make span which is equal to the maximum completion time of the trailers.

Finally, binary variables $y_{jj'}, \delta_{pp'}, q_{p'}, w_{pp'}, \gamma_{pp'}, and\ v_{jmj'm'}$ are used as the control variables in the mathematical formulation and defined by the following constraints:

$$a_{j'} \geq c_j + \overline{T}^C - Q.(1-\nu_{jj'}), j, j' \in J, j \neq j' \quad (1)$$

$$\lambda_p \geq a_j + t^{\nu}.\beta_{\mu}, p \in U_j, j \in j' \quad (2)$$

$$\lambda_p \geq a_j, p \in L_j, j \in J \quad (3)$$

$$\lambda_{p'} \geq \lambda_p + 2\overline{t}^M_{mm'}.\nu_{jmj'm'} - Q.(1-\delta_{jq'}), p \in U_j \cap L_{j'}, p' \in P, p \neq p, j, j' \in J, m, m' \in M \quad (4)$$

$$\mu_p \geq \lambda_p + 2\overline{t}^M_{mm'}.\nu_{jmj'm'}, p \in U_j \cap L_{j'}, j, j' \in J, m, m' \in M \quad (5)$$

$$\sigma_p \geq \mu_p + \overline{t}^I, p \in P \quad (6)$$

$$\sigma_p \geq \mu_j + \max_{p' \in U}.\beta_{p'} + \overline{t}^I, p \in L_j, j \in J \quad (7)$$

$$\sigma_{p'} \geq \sigma_p + \overline{t}^I - Q.(1-\gamma_{pp'}), p, p' \in L_j, p \neq p', j \in J \quad (8)$$

$$c_j \geq \sigma_p, p \in L_j, j \in J \quad (9)$$

$$C_{\max} \geq C_j, j \in J \quad (10)$$

$$\nu_{jj'} + y_{j'j} = \sum_{m \in M} \nu_{jmj'm}, j, j' \in J, j \neq j' \quad (11)$$

$$\delta_{pp'} + \delta_{p'p} \geq \sum_{m \in M} \leq \nu_{jmj'm} + Q.(1-w_{pp'}). p \in U_j, p' \in U_j, p \neq p', j, j' \in J \quad (12)$$

$$\delta_{pp'} + \delta_{p'p} \geq \sum_{m \in M} \leq \nu_{jmj'm} - Q.(1-w_{pp'}). p \in U_j, p' \in U_j, p \neq p', j, j' \in J \quad (13)$$

$$\delta_{pp'} \leq q_{p'} \quad p, p' \in P, p \neq p' \quad (14)$$

$$\delta_{pp'} \leq q_{p'} \quad p, p' \in P, p \neq p' \quad (15)$$

$$q_p \leq \overline{t}^M_{mm'} + Q.(l - \nu_{jmj'm'}), p \in U, \cap L_j, j, j' \in J, m, m' \in M \quad (16)$$

$$q_p \leq \overline{t}^M_{mm'} + Q - Q.(l - \nu_{jmj'm'}), p \in U, \cap L_{j'}, j, j' \in J, m, m' \in M \quad (17)$$

$$w_{pp'} \leq q_{p'} \quad p, p' \in P \quad (18)$$

$$w_{pp'} \leq q_{p'} \quad p, p' \in P \quad (19)$$

$$w_{pp'} \geq q_p + q_{p'} - l, p, p' \in P \quad (20)$$

$$\gamma_{\mu p'} \geq (\mu_{p'} - \mu_p)/Q, p, p' \in L_j, p \neq p', j \in J \quad (21)$$

$$\gamma_{\mu p'} \leq 1 + (\mu_{p'} - \mu_p)/Q, p, p' \in L_j, p \neq p', j \in J \quad (22)$$

$$\nu_{jmj'm'} \leq x_{jm}, j, j' \in J, m m' \in M \quad (23)$$

$$\nu_{jmj'm'} \leq x_{j'm'}, j, j' \in J, m.m' \in M \quad (24)$$

$$\nu_{jmj'm'} \geq x_{jm} + x_{j'm'} - 1, j, j' \in J, m.m' \in M \quad (25)$$

Constraint (3.1) ensures that each trailer is assigned early to one door. Constraint (3.2) defines the timing dependencies between two different trailers that have been assigned to the same door. It slates that the assignment time of a trailer to a door is after the loading completion time of the other (which precedes the former trailer in being assigned to the same door) plus the time it takes to leave the door, that is. the trailer changeover time. Having been assigned to a door, ii trailer run start mid complete unloading pallets consecutively according to the position they have been placed at the supplier side. Constraints (3.3)-(3.5) specify the conditions required to be met before an unloaded pallet can be moved. Constraints (3.3) and (3.4) state that the movement of » pallet cannot be starlet! Unless it is unloaded and its destination trailer is assigned to an available door. Constraint (3.5) schedules the movement of the unloaded pallets staged in front or a door according to the order which itself is derided during the scheduling. Note that Constraint (3.5) implicitly emulates the situation where exactly one forklift is designated to one door for moving its singed pallets. For two pallets where the first one precedes the other in the moving order list, the bitter should wait until the corresponding forklift undo the former to its destination door and then returns to the origin door. On the value of a binary variable. Using indicator constraints, such relationships between a constraint and a variable can be directly expressed in the constraint declaration.

It is thus required to ensure that the value of Q is bigger than the maximal moving time and the maximal completion time difference between two moving operations. The value for Q can be calculated by adding all pallets' unloading and loading times together with all the possibilities for their moving times plus total trailer changeover times. The corresponding formula is described as follows:

$$Q = \left(t^{U} + t^{L} + \sum_{m \in M} \sum_{m' \in M} t^{M}_{mm'} \right) . |P| + T^{C} . |J| \tag{26}$$

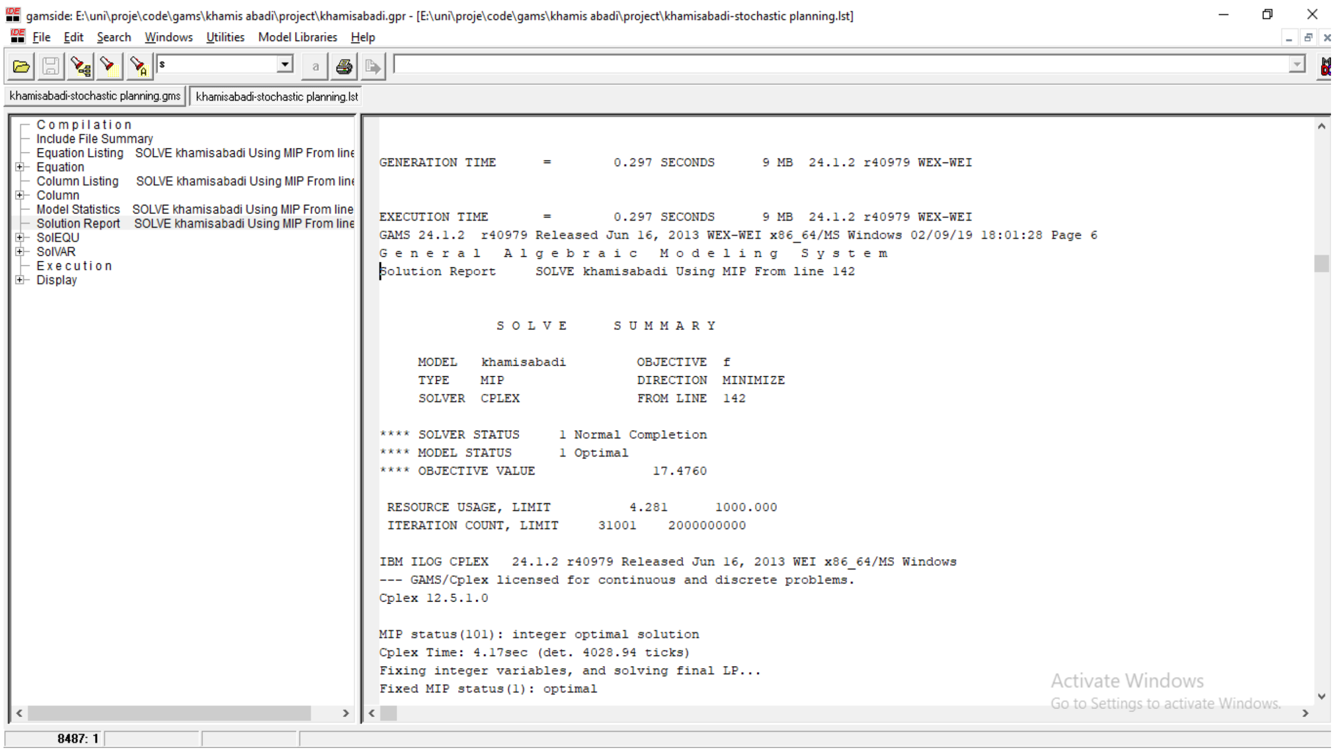
Due to the fact that the processing time in the loading and unloading stages varies in reality, in this study, these two parameters were measured and it was determined that each of the normal distribution is followed. The mean and variance of these two parameters are as follows:

Average time taken to unload a pallet = 2
Variance time taken to unload a pallet = 0.25
Average time taken to load a pallet = 2
Variance time taken to load a pallet = 0.56

In order to model, the random limit method is used which is presented in GAMES as follows:

lambda(p)=g=a(j)+(Atu*beta(p))+(1.64*beta(p)*sqrt(Vtu))
sigma(P)=g= miu(p)+Atl+(1.64*sqrt(Vtl))
sigma(p)=g=a(j)+ Atu+Atl+(1.64*sqrt(Vtu+Vtl))

After solving the model, it can be considered whether the answer is optimal or not, and the solver has managed to answer the model.



According to the above figure, the solver state is normal, which means that the solver has solved the model without problems. On the other hand, the status of the model is OPTIMAL, which means optimal solution is obtained.

---- 145 VARIABLE f.L = 17.476 define name of goal
VARIABLE Cmax.L = 17.476 schedule length (or makespan)

---- 145 VARIABLE a.L assignment time of trailer j
j3 12.000, j7 12.000
---- 145 VARIABLE c.L completion time of trailer j
j3 17.476, j4 14.275, j6 14.275, j7 17.476, j8 14.275
---- 145 VARIABLE lambda time when moving of pallet p starts

p1 2.820, p2 2.820, p3 12.000, p4 2.820, p5 2.820
p6 2.820, p7 2.820, p8 12.000, p9 2.820, p10 12.000
p11 12.000, p12 2.820, p13 12.000, p14 12.000, p15 2.820

---- 145 VARIABLE miu.L time when moving of pallet p is completed

p1 7.820, p2 7.820, p3 12.000, p4 7.820, p5 7.820
p6 7.820, p7 7.820, p8 12.000, p9 7.820, p10 12.000
p11 12.000, p12 7.820, p13 12.000, p14 12.000, p15 7.820

---- 145 VARIABLE sigma.L time when loading of pallet p is completed

p1 14.275, p2 11.047, p3 17.476, p4 11.047, p5 14.275
p6 14.275, p7 11.047, p8 17.476, p9 14.275, p10 17.476
p11 17.476, p12 11.047, p13 17.476, p14 17.476, p15 14.275

---- 145 VARIABLE delta.L 1, if, for pallets p and pp staged onto the same staging area, p is moved before p0, else 0 (ALL 0.000)

---- 145 VARIABLE gamma.L 1, if, for pallets p and pp loaded onto the same trailer, p is loaded before p0, else 0

	p1	p5	p6	p9	p15
p2			1.000	1.000	
p4					1.000
p7					1.000
p12	1.000	1.000			

---- 145 VARIABLE x.L 1, if trailer j is assigned to door m, else 0

	m1	m2	m3	m4	m5	m6
j1		1.000				
j2						1.000
j3					1.000	
j4				1.000		
j5					1.000	
j6			1.000			
j7						1.000
j8	1.000					

---- 145 VARIABLE y.L 1, if, for trailers j and jj assigned to the same door, j precedes j0, else 0

	j3	j7
j2		1.000
j5	1.000	

---- 145 VARIABLE q.L 1, if pallet p is to be moved [by a forklift] before loaded onto its destination trailer, else 0 (ALL 0.000)

---- 145 VARIABLE nou.L 1, if trailer j is assigned to door m and trailer j0 is assigned to door m0, else 0

INDEX 1 = j1

	m1	m2	m3	m4	m5	m6
m2.j1		1.000				
m2.j2						1.000
m2.j3					1.000	
m2.j4				1.000		
m2.j5					1.000	
m2.j6			1.000			
m2.j7						1.000
m2.j8	1.000					

INDEX 1 = j2

	m1	m2	m3	m4	m5	m6
m6.j1		1.000				
m6.j2						1.000

m6.j3					1.000	
m6.j4				1.000		
m6.j5					1.000	
m6.j6			1.000			
m6.j7						1.000
m6.j8	1.000					

INDEX 1 = j3

	m1	m2	m3	m4	m5	m6
m5.j1		1.000				
m5.j2						1.000
m5.j3					1.000	
m5.j4				1.000		
m5.j5					1.000	
m5.j6			1.000			
m5.j7						1.000
m5.j8	1.000					

INDEX 1 = j4

	m1	m2	m3	m4	m5	m6
m4.j1		1.000				
m4.j2						1.000
m4.j3					1.000	
m4.j4				1.000		
m4.j5					1.000	
m4.j6			1.000			
m4.j7						1.000
m4.j8	1.000					

INDEX 1 = j5

	m1	m2	m3	m4	m5	m6
m5.j1		1.000				
m5.j2						1.000
m5.j3					1.000	
m5.j4				1.000		
m5.j5					1.000	
m5.j6			1.000			
m5.j7						1.000
m5.j8	1.000					

INDEX 1 = j6

	m1	m2	m3	m4	m5	m6
m3.j1		1.000				

m3.j2						1.000
m3.j3					1.000	
m3.j4				1.000		
m3.j5					1.000	
m3.j6			1.000			
m3.j7						1.000
m3.j8	1.000					

INDEX 1 = j7

	m1	m2	m3	m4	m5	m6
m6.j1		1.000				
m6.j2						1.000
m6.j3					1.000	
m6.j4				1.000		
m6.j5					1.000	
m6.j6			1.000			
m6.j7						1.000
m6.j8	1.000					

INDEX 1 = j8

	m1	m2	m3	m4	m5	m6
m1.j1		1.000				
m1.j2						1.000
m1.j3					1.000	
m1.j4				1.000		
m1.j5					1.000	
m1.j6			1.000			
m1.j7						1.000
m1.j8	1.000					

---- 145 VARIABLE w.L 1, if both pallets p and p0 are to be moved [by a fork lift] before loaded onto their destination trailers, else 0 (ALL 0.000)

---- 145 PARAMETER QM = 756.000 a big number not less than the worst schedule length

---- 145 PARAMETER U set of pallets unloaded from trailer j

	p1	p2	p3	p4	p5	p6
j1	1.000	1.000		1.000		
j2			1.000			
j5					1.000	1.000

+	p7	p8	p9	p10	p11	p12
j1	1.000					1.000
j2			1.000	1.000		
j5		1.000			1.000	

+	p13	p14	p15
j2		1.000	1.000
j5	1.000		

---- 145 PARAMETER L set of pallets loaded onto trailer j

	p1	p2	p3	p4	p5	p6
j3			1.000			
j4	1.000				1.000	
j6				1.000		
j8		1.000				1.000

+	p7	p8	p9	p10	p11	p12
j3		1.000		1.000		
j4						1.000
j6	1.000					
j7					1.000	
j8			1.000			

+	p13	p14	p15
j6			1.000
j7	1.000	1.000	

6. CONCLUSION

This paper addressed the truck scheduling problem in a crossdocking terminal whose resources including doors, forklifts, and workers were assumed limited and non-preemptive.
An intelligent randomization function is then designed to choose the rules for ranking the clusters based on the status of the search. In other words, the selection of each ranking function is subject to a probability whose value is dynamically updated by the history of the search. This indicates that the choice of the initial cluster is adaptive (and not deterministic) to the input data. The important issue is how to define and adjust the ranking criteria of the functions such that they continually complement each other throughout the search. This can be extended to form a pool of good-quality feasible solutions of diverse attributes as the initial solutions of a neighborhood search method (such as a local search) to establish optimality.

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