A literature review on Vehicle routing problems in a cross docking environment

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***Abstract* - Vehicle routing is an integral part of supply chain management (SCM) and various strategies are applied to achieve maximum efficiency. It plays an important role in deciding about all the operations involved in an SCM. In a Vehicle Routing Problem (VRP) minimisation of the total supply chain cost through effective transportation methods is a major concern and hence the problem is addressed in different ways by researchers. This paper focuses on classification of the literature on VRP with more importance on models considering cross-docking for improving the supply chain efficiency. The main objective in an SCM is to minimize the inventory carrying cost, transportation cost and timely delivery with required quality. Cross docking is a strategy that is applied in SCM for minimizing these objectives where products are delivered to a location with minimum storage facilities by inbound vehicles transferring them to outbound vehicles in minimum time. Here a survey on methods is presented that applies cross docking for vehicle routing is carried out. The survey finds that majority of the literature shows that cross docking is very helpful in increasing the performance of a supply chain.**

***keywords* - Supply chain management, Vehicle routing problem, cross docking, Evolutionary algorithm.**

I. INTRODUCTION

Logistics planning with efficient methods decide the potential of an industry to face competition and it is the most important factor to reduce the overall cost of products or services. Severe competition from multiple competitors forces companies to adopt new methods and strategies to survive. Supply chain management (SCM) is the effective co ordination and control of the movement of commodities and involves the things like routing decisions. It involves the analysis of distinctiveness of each path, number of vehicles, multi-period nature of demand, alternative routes etc. Hence for effective design of SCM, proper handling Vehicle Routing Problem (VRP) is very important. Cross-docking is one of the most attractive SCM strategies that have recently gained global acknowledgment [1]. By implementing such a consolidation strategy, companies throughout from manufacturing to retailing have given their interest on improving the efficiency of their SCM operations and try to achieve it.

Vehicle routing problems can be most often modeled with a mathematical formulation and many times as multi-objective optimization models which involves conflicting objectives and algorithms based models are possible in cases where if not able to represent as equations. Cross-docking is an SCM strategy that aims at reducing cost and time for reaching products from start delivery points to the customers. The basic cross-docking models are used to find the optimal inbound and outbound truck scheduling situations that minimizes the total time of operation [2]. The main objectives in a vehicle routing problem is the minimization of transportation cost, other material handling costs, storage cost, cost of tardiness etc. While the vehicle routing problem (VRP) tries to find out the best route for the vehicles to deliver their products from a particular source to certain destinations, the efficiency depends on different strategies associated with that and can be analyzed from the most relevant performance measures related to SCM. Here an attempt is made by reviewing the articles related to VRP problems in a cross docking environment.

II. CROSS DOCKING IN ROUTING PROBLEMS

The vehicle routing problem (VRP) Involves scheduling and logistics management activities in supply chain management and can be formulated as a combinatorial optimization model. Selection of routes for a set of transporting vehicles which is providing goods and services from a warehouse or companies to a set of destinations located at different places with minimum cost is the basic VRP problem [3]. Increasing customer satisfaction and maintaining an accurate delivery time and providing right quality product is the primary focus of industries by implementing an efficient SCM policy. Many challenges occur in SCM when we consider situations like multiple source and destinations with multiple routes. Developing models and finding the solution methodology when there is distribution from many origins to multiple destinations is the key factor in logistics management [4]. The objective of this survey is to carry out a literature review based on VRP problems with cross docking, with respect to the modelling method, solution strategies, input parameters, objective function etc. Articles published between 2011 and 2020 are chosen for review and more emphasis is made on models which uses computational methods as the solution methodology since it is more relevant in now a days. Some of the recent advancements in the area of VRP based on cross docking are narrated below with some articles.

Donto et al [5] has introduced a model to handle hybrid multi-echelon multi-item distribution networks with cross docking. Here when cross docking is used, then products are not required to be stored for long time at transitional depots. Hence, cross-dock services are applied for incoming parts based on customer necessity and immediately transport them to their destinations. They modelled the problem as a Mixed Integer Programming Model (MIPM). Madan Kumar and Rajendran (2018) proposed

Another MIPM [6] that considered alternative fuel vehicles in their design while considering fuel prices at different refilling stations

Wang and Aldaee (2019) [7] states that Cross-dock operations will get mixed results in the case of individual warehouses and in particular business operation situations. And also according to them the single-floor multitier warehouse layout results in more work related accidents and both contribute to a higher supply chain costs. Hence it is a managerial challenge for the single-floor warehouses to make a separate working area with different temperature/ humidity for shipments that require special handling, like hazardous products. But it easier to handle, and work when there is multi-floor warehouses. They presented a new mixed-integer nonlinear programming model and linearization method to find the solution. They used multi-start, genetic random key, and very-large scale neighborhood search (VLSN) for the solution finding within the critical event to solve the model. They tested the algorithm and got good results. Guemri et al 2019 [8] developed a model with a goal of assigning incoming trucks and outgoing trucks to inbound and outbound minimizing the material handling cost within a cross-docking platform while considering the capacity and assignment constraints

Damghani et al (2017) [2] proposed a new multi-period model with cross-docking and considered different products, due dates for delivery, variable capacities of trucks, and temporary storage locations in their model. The mixed-integer programming model and the evolutionary computation approach based on a genetic algorithm (GA) provided good results. The chromosomes structure, GA operators, and the constraints developed were explicitly designed for multi period problems. Molavi et al (2018) [9] developed a truck scheduling problem model that uses a two touch cross-docking centre by assigning due dates for outbound trucks as a constraint. The objective function was to minimize the total penalty cost and delivery cost for delayed shipments. The sequence of unloading shipments was considered in the model design with First In First Out for loading the shipments. A mixed integer programming formulation has been made for the new model. They concluded that due date can be adjusted between a time window or postponed to a some point based on customer's requirements or cross-dock limitations

Hence it is found from the literature survey that the articles vary in many extent based on the objectives,problem environment, methodology, different strategies etc.

III. REVIEW FINDINGS

Twenty articles were taken for a detailed review and majority from the year 2019. Table 1 shows the objectives concerned, problem strategies, type of model developed and the solution method used by various researchers. The results obtained from various articles are also is narrated in Table1. From this it is seen that the most of the researchers use mathematical models for the VRP models considering cross docking (more than 90%). Evolutionary algorithms like Genetic Algorithm (GA) are widely used as the solution methodology due to its ability to reach near optimal solutions in a reasonable time than a software package based on the time for reaching an 100% optimal solution. Also simulated annealing, particle swarm algorithm, Tabu search and other neighborhood search algorithms are used by researchers to find the solution for the mathematical model. The reason for using GA as the solution methodology for Vehicle Routing models may be due to the combinatorial nature of VRP problems.

The VRP models using cross docking strategy, apply it in various ways like Multi-floor, cross-dock door assignment, Cross-docking for perishable products, Unit-load cross-dock terminals, Cross docking systems with fixed due dates, Multi-period cross-docking etc. Regarding the objective function most of the articles consider the material handling cost, location and time to deliver as the main criteria for optimization. Quality is also seen as objective criteria for optimization in some articles. Multi criteria models are also found in the literature as in many cases as the presence of conflicting objectives will arise and one has to find a compromising solution. Cross decking in a multi echelon environment is another strategy in which some of the research articles are focusing on.

It is seen from the literature that, the cross-docking is used to control the movement of products with minimum inventory storage and most of the models as discussed in Table 1 creates good results in terms different costs and supply chain efficiency and confirm that this improvement is due to the cross docking strategy. The basic reason is because the products are directly given to the outbound for the purpose of loading into trucks so that waiting time in ware houses is minimized. Hence, overall efficiency is increased in a substantial rate

.Table 1 A comparison of literature

No	Year	Authors	Objectives	Modeling method	Problem environment	Solution Methodology	Outcome of the paper
1	2011	Dondo et al [5]	Minimize transportation cost	Mixed integer programming	Multi echelon VRP with cross docking	Computational method	A generalized model for a multi echelon VRP developed
2	2015	Ahmadizar et al [10]	Minimize purchasing, transportation and holding costs	Mathematical model	Two-level vehicle routing with cross-docking in a three-echelon supply chain	Genetic algorithm	The results shows temporary storage at cross-docks can increase the flexibility of the model
3	2016	Brim [11]	Minimize total transportation costs and the	Mathematical model	Vehicle routing problem in a cross docking setting with	Simulated annealing	Produced reasonable solutions in terms of computational time, best cost values

			fixed costs of the vehicles		heterogeneous vehicles having different capacities		and the convergence pattern on the best cost
4	2016	Goodarzi et al.. [12]	Minimize the location cost and total shipping cost	Mixed integer nonlinear programming	Location-routing problem for cross-docking networks	Biogeography-based optimization (BBO)	Performs much better than PSO in most cases in terms of total cost of the network and computational time
5	2016	Ladier and Alpan [13]	Improving the robustness of the schedules obtained	Mathematical model	Robust cross-dock scheduling with time windows	Customized algorithm	Found Minimizing the average number of trucks docked at a given door is a good way to ensure robustness in the schedule
6	2017	Damghani et al [2]	Minimizes the maximum time required for the outbound trucks to leave the shipping dock	Mixed-integer programming	Multi-period cross-docking model	Genetic Algorithm (GA)	GA provides a substantial decrease in the computational burden when compared to the branch and bound algorithm.
7	2017	Enderer et al. [1]	Minimize the total material handling and transportation costs	Mathematical model	Vehicle routing problem arising in the operation of cross-dock terminals	Column generation algorithm	Good quality solutions obtained and short computing times
8	2017	Maknoon and Laporte [14]	Find a set of minimum-cost vehicle routes to serve allrequests	Mathematical model	Vehicle routing problem with cross-dock selection	This paper presents a mathematical formulation of the problem and an adaptive large neighborhood search	Computational experiments on a set of benchmark instances demonstrate the efficiency of the proposed methodology
9	2017	Wisittipanich and Piya Hengmeechai [15]	Minimize total operational time or makespan	Mixed integer programming	Multi-door cross docking terminal	Modified particle swarm optimization	The method is capable of finding high quality solutions with fast convergence.
10	2018	Molavi et al. [9]	Minimize the total cost comprising penalty and delivery cost of delayed shipments	Mixed integer programming model	Cross docking systems with fixed due dates and shipment sorting	Hybrid genetic algorithm-reduced variable neighborhood search	Numerical results show that the due date can be adjusted between a time-window or postponed to a certain point based on customers' needs
11	2018 [16]	Nassief et al	Minimizing the total handling cost	Bilinear integer program	Cross-dock door assignment problems	Column generation algorithm	Conducted series of computational experiments to evaluate the performance of the formulations on a

							set of benchmark instances
12	2019	Luo et al [17]	Minimize sum of weighted production efficiency function and simultaneity function	Mathematical model	Synchronized production logistics scheduling in MTO plant and CD warehouse	Genetic Algorithm (GA) with local search (LS)	Model will help the decision maker to decision maker to configure the production resource and warehousing resource in different scenarios.
13	2019	Rijal et al. [18]	Minimize transportation cost, temporary storage cost and cost of tardiness	Mixed-integer programming	Unit-load cross-dock terminals with mixed service mode dock doors	Adaptive large neighborhood search algorithm	Operational costs at a cross-dock terminal reduce on average 12% compared to the best solution with a sequential approach
14	2019	Rahbari et al [19]	Optimize the earliness and tardiness penalty costs,	Bi objective model	Cross-docking for perishable products	GAMS software	Freshness of the delivered products increases by 74.14% on average
15	2019	Guemri et al.[8]	Minimize the material handling	Mathematical model	Cross-Docking Assignment Problem	Probabilistic Tabu Search	The approach outperform recent state-of-the-art approaches by reaching 45 previous best-known solutions
16	2019	Fathollahi-Fard [20]	Minimize the total operational time (makespan)	Mathematical model	Truck scheduling problem in a cross-docking system	Social Engineering Optimizer (SEO)	proposed modifications of SEO considerably outperform the state of the art algorithms
17	2019	Dulebenets [21]	Minimizing the total truck service cost.	Mixed-integer linear programming	Just-in-time truck scheduling at a cross-docking facility	Delayed Start Parallel Evolutionary Algorithm	Superiority of the proposed algorithm interms of the key algorithmic performance indicators against the other five meta-heuristic algorithms
18	2019	Baniamerian et al. [22]	Maximizes the total profit of the system	Mixed-integer linear programming	Heterogeneous vehicle routing problem with cross-docking	Hybrid meta-heuristic algorithm based on modified variable neighborhood search (MVNS) with four shaking and two neighborhood structures and a genetic algorithm (GA)	Results reveal that in the small-size test problems, the hybrid algorithm is able to find optimal solutions in an acceptable computational time
19	2019	Wang and Alidaee [7]	Minimize the total material handling cost	Mixed-integer nonlinear programming model	**MULTI-FLOOR, CROSS-DOCK DOOR ASSIGNMENT PROBLEM**	Multi start, genetic random-key, and very-large-scale neighborhood	Good solutions produced by the proposed heuristics

						search (VLSN)	
20	2020	Shahmardan and sajadeah [23]	Minimize makespan	Mixed-integer programming model	Truck scheduling in a multi-door cross-docking center with partial **UNLOADING**	Hybrid heuristic-simulated annealing	Numerical study shows that partial unloading of compound trucks has a crucial impact on makespan reduction

IV. CONCLUSION

A literature review has been carried out on SCM models which apply cross docking strategy in the truck scheduling operations. The articles selected for review ranges from the year 2011 to 2019. The factors considered for comparison are, problem environment, objective function, type of model and solution method. A comprehensive comparison is given in a tabular form based on the study. Problem environment differs in many aspects like models considering, multiple floors/doors, time windows, heterogeneous vehicles and multi-period dynamic situations, etc. Most of the methods have a mathematical model with specific objective functions and constrains so that they can be solved even by using a standard software package. Evolutionary algorithms are used as the solution method in majority of the cases and are providing good results compared to some earlier models not involving cross docking. Hence the review finds that SCM models that uses cross docking strategy perform better than other models based on different category of costs, time and certain other performance measures.

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