A Taxonomy on Vehicle Routing Problem
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ABSTRACT: Vehicle routing problem is one of the most attractive topics in operation research, logistics, and supply chain management. VRP is used to minimizing the total cost of logistics systems. In transportation management, it is necessary to provide services from one point (depot) to various points (customers) dispersed geographically with significant economic implications. The VRP can be classified as an NP-hard problem. So, the use of exact optimization algorithms may be difficult to solve these problems in given CPU times, when the problem involves real-world data sets that are very large. The vehicle routing problem is also known as combinatorial problem. In this survey various issues of vehicle routing problem are discussed to reduce the travelling distance and minimizes the fleet size and cost.

INDEX TERMS: Vehicle Routing Problem, Optimization in VRP, Variations in VRP.

1. INTRODUCTION
Route scheduling is one of the most major real-world problems, which became an important difficulty in transportation. It has several applications like cash delivery, parcels, post, food and delivery, bus route planning, waste collection of industries, maintenance operations etc. Nowadays efficient transportation and distribution of goods is essential to the success of many companies. In an environment with increasing energy costs, efficient planning of the delivery paths allows to save resources and money. One of the most fundamental and well-studied problems in this environment is the travelling salesman problem (TSP). The aim of the TSP is to find the cheapest path through all cities, the salesman wants to visit. Each city has to be visited exactly once, the tour has to start and stop at the same location. The total tour length or costs have to be minimal. From the theoretical point of view the TSP is a combinatorial optimization problem that is very important for a huge area of applications, including logistics, production paths, semiconductor industry and many more.

The Vehicle Routing Problem (VRP) is a generalization of the TSP with more than one salesman and exactly one depot, where each vehicle has to start and end its tour. In the context of the VRP we talk about customers that are visited by the vehicles instead of cities and the salesman. In the classical VRP, each customer has to be visited only once. A large proportion of freight distribution is carried out by road vehicles. Assigning customers to the vehicles followed by routing and scheduling them, involves a set of decisions that can have a significant impact on the costs and levels of service provided.

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customers in order to fulfill customer requirements. The problem appears in a large number of practical situations concerning the distribution of goods and is known by the generic name: the vehicle routing problem. The VRP is also known as the “truck dispatching”, “vehicle scheduling” and may appear frequently in situations not related to the delivery of goods. For example, consider the collection of coins from telephone boxes or mail from mail boxes, preventive maintenance inspection tour, salesman routing etc. are all VRPs in which the ‘delivery’ operation may be a collection or/and delivery or neither, and in which the ‘vehicles’ and ‘customer requirements’ can take variety of forms, some of which may not even be of a physical nature. In view of the huge number of practical situations which give rise to VRPs, one can only hope to study the core problem which is at the basics of all vehicle routing problems. It calls this core problem as the basic VRP. GitaeKim and Yew-SoonOng[1], demonstrated that vehicle route scheduling is an important activity in supply chain management. It is nearly a kind of vehicle routing problem with time windows. An improved model of VRPTW with load balancing was built up, which aims to achieve less number of vehicles, the shortest distribution distance, load balancing and customer's time demand. The algorithm designed as a two-stage algorithm. The first Stage was used to find the vehicle route schedule by particle swarm optimization. An improved inactive coefficient was considered to enhance the search speed. The second Stage was designed for load balancing. The optimal or partial-optimal solution can be found efficiently by the proposed model for medium size vehicle routing problem. Jianlingchen and Songyanchen[2], describes the Vehicle Routing Problem (VRP) in the city, known as City VRP, has gained demand with its importance in city logistics. Similar to city logistics, City VRP mainly differs from traditional VRP in terms of the stakeholders involved, namely the carrier, administrator, resident, and shipper. Accordingly, this paper surveys the City VRP literature classified by stakeholders and summarizes the models, constraints, and solution methods for VRP in urban cities. City VRPs are also examined based on the problem of interest considered by the stakeholders and the correlating models that have been proposed in response. By this review, we identify the state of the art of City VRP, foreground the core challenging issues, and convey some potential research area in this field that have remained underexplored.N. Jozefowicz, F. Semet, et.al[3]. Routing problems, such as the travelling salesman problem and the vehicle routing problems are widely studied both because of their classic academic appeal and their numerous real-life applications. Similarly, the field of multi-objective optimization is attracting more and more attention, notably because it offers new opportunities for defining problems. This article surveys the existing research related to multi-objective optimization in routing problems. It examines routing problems in terms of their definitions, their objectives, and the multi-objective is closer to real environments in these years. Some multi-object VRPs are formulated as a single function using weight parameters determined only experientially. Pareto-based approach is good to solve such problem since the managers can make their own decisions from the Pareto optimal output.

3. MOTIVATION
The motivations for optimizing the distance in VRP are as follows:
- In nowadays industry efficient transportation and distribution of goods is essential to the success of many companies.
- In an environment with increasing energy costs, efficient planning of the delivery paths allows to save resources and money.
- One of the most fundamental and well-studied problems in this environment is the travelling salesman problem.
- A qualitative survey of trucking companies and software providers may reduce fuel consumption and CO2 emissions.
- The aim of the TSP is to find the cheapest path through all cities, the salesman wants to visit.
- The Vehicle Routing Problem (VRP) is a generalization of the TSP with more than one salesman and exactly one depot, where each vehicle has to start and end its tour.

4. OPEN PROBLEMS
Routing problems are rarely so straightforward in practice. For example, additional constraints that can have a major impact on the operation include legal requirements on driving and working times, and the fact that certain customers require delivery by particular vehicles (for loading and unloading reasons). This section introduces the problem features that can occur in practice, and some of the research into the resulting models.
- Time windows: A very common constraint concerns when a delivery can be made. The time window for a delivery is defined by a start and an end time. Depending on the problem considered, the time window may be treated as either a hard or soft constraint. A hard constraint requires that a vehicle must wait until the time window begins before making a delivery or must not arrive until the time window begins. Once the time window ends the delivery cannot be made. A soft constraint allows the delivery to be made outside of the time window at a penalty cost. This cost can either be a fixed cost or can be proportional to the earliness or lateness of the delivery.
- Backhauls: Problems that allow backhauls include customers who require an item be collected and delivered to
the depot. This is in addition to the customers expecting deliveries (also referred to as line hauls). It is common that any deliveries are made before backhauls are considered. Approaches giving exact solutions to problems of limited size have been developed. Heuristic methods have also been applied to the problem. Pick-up and delivery: In this case each item is picked up from one location and delivered to another (neither of which is the depot). Obviously, each pair (pick-up and delivery) must be assigned to the same vehicle and the pick-up must occur before the delivery. Again, there is a limit on the capacity of the vehicle at any one time. It including the dial-a-ride problem (DARP), which concerns itself with the transportation requests of bus passengers (usually the elderly or disabled). The DARP can include restrictions on the time between pick-up and delivery, which are more relevant to passenger transport. A problem that is related to both the VRP with backhauls and the VRP with pick-up and delivery is the problem with simultaneous pick-up and delivery. In this case, items are delivered to a customer from the depot and, as the delivery is made, other items are returned to the depot. d) Non-homogeneous vehicles: The vehicle fleet is often made up of different types of vehicles with different characteristics, which may be critical when determining vehicle optimizing the routing of vehicles routes. The vehicles used may have different capacities, and this may affect how they are used. In addition, some items may only be delivered by certain vehicles either due to restrictions at the customer location (the site-dependent VRP) or the nature of the item (e.g. heavy or hazardous items). e) Open VRSP: The ‘open VRSP’ introduces the idea that routes need not start or end at a depot. This may better reflect the cost structure when distribution is assigned to a third-party logistics provider and the vehicle does not need to return to the depot after the last delivery, but is allowed to go elsewhere to undertake other jobs. f) Dynamic VRSP: The ‘dynamic VRSP’ allows the rescheduling of customer requests once some new information is known. This is different from the standard approach where all information is known and fixed schedules are generated at the start of the day. This new information can be in the form of new customer requests or information regarding possible travel delays. Scheduling new customer requests is the most common dynamic feature. Although there have been technical advances in being able to modify routes according to real-time demands and traffic conditions, there are limits to the benefits that can be achieved in practice. For example, if the logistics operation is concerned with distributing specific orders from a central depot to a set of customers, then the decision about which customers can be serviced on which route must be taken initially when the vehicles are loaded and cannot be subsequently changed, even if traffic conditions change in such a way that a different allocation of orders would have produced better routes. g) Stochastic VRSP: In stochastic VRSPs, uncertainties in the demands or travel times are explicitly modelled. A stochastic demand model may be appropriate when the vehicles deliver a resource and the amount required by each customer is not known until the customer is visited. Using an estimate of the demand for each customer, an initial set of routes can be defined. However, should a customer require more of the resource than the vehicle contains, the vehicle will need to return to the depot to get more stock before it can satisfy the customer demand. Each time a delivery is made, a decision must be taken on whether to deviate from the planned route to either visit an alternative customer or return to the depot.

5. CONCLUSION

Vehicle routing problem forms an integral part of supply chain management, which plays a significant role for productivity improvement in organizations through efficient and effective delivery of goods/services to customers. This paper gives a survey on various issues of vehicle routing problem, where each issue represents different constraints like Timewindows, Pickup and Delivery etc.. From this survey it is concluded that based on different issues different objectives may be optimized.

REFERENCES


