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TRANSPORTATION AND LOGISTICS MANAGEMENT IN A PUMP MANUFACTURING INDUSTRY INVOLVING SUBCONTRACTORS

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ABSTRACT

In most industries today productivity improvement is a major cause for concern. This paper focuses on the logistics scenario followed by the company, involving contractors and subcontractors. In the company, more than 75% of the manufacturing processes are outsourced by the manufacturer and there is no orderly or pre-planned method to efficiently manage the logistics involved in outsourcing the required components. To help improve the current state, a Vehicle Routing Problem (VRP) was solved applying the existing constraints. The solution was obtained based on the VRP concepts. ODL Studio, an open source and free software was used to solve this rich VRP formulated. The obtained results were integrated with a map showing the optimal transportation sequence and the routes to be taken, thus instructing the driver on the sequence to be followed. With a structured mathematical approach towards the transportation problem, the total distance travelled and time taken by the vehicle was reduced. With reduction in time, there is an increase in the number of products that are being worked on at the manufacturer's facility.

Keywords: logistics, manufacturing, sub-contractors, vehicle routing problem, simulation.

1. INTRODUCTION

Productivity is the measure of efficiency of a person, machine, system etc., in converting inputs into useful outputs. "Productivity improvement" is a term that is commonly used in all industries today. There are a number of productivity improvement technologies or measures that are employed in various companies today, some of which are value engineering, operations research, job enlargement, inventory control, quality control, materials management, human factor engineering .,etc. All these techniques in general, focus on one common factor that is the betterment or the improvement of the productivity in a company. Logistics management is extremely important, especially in industries involving a lot of transportation of goods and services. The industry chosen is a leading pump manufacturing industry in India. They have a foundry, in house, wherein they cast a few major components required to manufacture a pump. The remaining components are bought from various vendors in and around the city. Since the majority of the parts that go into manufacturing the pump are outsourced, a planned logistics scenario in the company is necessary. Currently the company does not have any orderly pre-planned transportation methods. To solve this, a Vehicle Routing Problem (VRP), an extension of Travelling Salesman Problem, was used to optimize the current transportation scenario.

2. LITERATURE SURVEY

The VRP was first studied in [1]. Since then there have been many VRP studies reported in the literature. References [2], [3] apply VRP to school bus routing. Other applications include inventory and vehicle routing in the dairy food [4], transportation service at university [5], public library system [6], post service [7], and grocery delivery [8].

The most general version of the VRP is the Capacitated Vehicle Routing Problem (CVRP) which is a problem in which all customers must be satisfied, all demands are known, and all vehicles have identical, limited capacity and are based at a central depot. The objective is to minimize the vehicle fleet and the sum of travel time and the total demand of commodities for each route may not exceed the capacity of the vehicle which serves that route [9], [10]. One of the most important extensions of the CVRP is the Vehicle Routing Problem with Time Window (VRPTW) which is each customer must be served within a specific time window. The objective is to minimize the vehicle fleet and the sum of travel time and waiting time needed to supply all customers in their required hour [11], [12].

Multiple Depot Vehicle Routing Problem (MDVRP) is a problem that customer can be served from several depots. If the customers are clustered around depots, then the distribution problem should be modelled as a set of independent VRP. The Objective is to minimize the vehicle fleet and the sum of travel time and the total demand of commodities must be served from several depots [13], [14].

Vehicle Routing Problem with Backhauls (VRPB) is a VRP in which customers can demand or return some commodities. The objective is to find such a set of routes that minimized the total distance travelled [15], [16]. Literature [17] suggests that a decision support system can be developed for a dynamic VRPB.

In the present study a VRP with pick-up and delivery is the most appropriate representation of the problem. Vehicle Routing Problem with Pick-Up and Delivery (VRPPD) is a VRP in which the possibility that customers return some commodities is contemplated [18]. The objective is to minimize the vehicle fleet and the sum of travel time, with the restriction that the vehicle must

have enough capacity for transporting the commodities to be delivered and those ones picked-up at customers for returning them to the depot.

3. CURRENT LOGISTICS SCENARIO

Most of the manufacturing parts at the industry are outsourced. More than 75% of their work is sent to various sub-contractors in and around the city for completion. Currently the manufacturer takes care of the entire pick up and deliveries or Work in Progress goods from and to the sub-contractor respectively. The truck driver is just given the name and address of places to be visited at the beginning of each day. He can choose his travel path as per his convenience. As a result of this the truck runs for a large distance each day, thereby increasing costs and wasting a lot of productive time.

Currently the manufacturer owns one 'Tata 407 Pickup Truck', which is a light commercial transport vehicle. The schedule for the deliveries and pick up from various sub- contractors is made by the logistics in-charge at the beginning of every week, but a travel plan or in other words a route is not planned. The manufacturer currently has around 33 outsourcing partners that are serviced by the company owned and operated pick-up truck.

4. METHOD OF SOLVING

A. Open door logistics studio

Open Door Logistics (ODL) Studio is an open source application that allows us to manage fleets of vehicles. This software allows us to manage geographic customer data, plan routes for every trip a vehicle takes, simulate the routes, edit the routes and see the effect it has on the fleet and etc. The core of this application is a set of lines of code in Java, which again is an open source toolkit that can solve rich travelling salesman problems (TSP) and Vehicle Routing Problems (VRP). "Jspirit", the java based code is flexible and can be modified and used as need to perfectly simulate any given problem by considering all the constraints and if required defining additional constraints. ODL is also integrated with MS-Excel, making it easy to use and perform analysis that can be exported in the form of PDF, or save it in an Excel spreadsheet for further analysis.

The existing problem was modelled into the Excel file integrated with the application. The distance travelled, time taken and route map is simulated for the routes shown in the previous section. Upon analysis of the problem and considering all the alternate solutions, the observed solutions and illustrations are showed in the sections to follow. ODL Studio, powered by Open Street Map and Graph Hopper gives a fully detailed report of the directions taken and the routes chosen. Graph Hopper is one of the world's famous routing engines using open street map data and is really fast in solving and providing alternate solutions when the user modifies the routes shown in the solution. The reports obtained can be analysed and rerouted, mid-way during the trip, due to any deviations in the schedule, or if any unexpected constraints come up. Such flexibility gives the users an edge over the rest, gaining maximum efficiency.

B. Assumptions

The following assumptions have been framed and used for calculating the optimized route:

- To consider only routes which involve 5 or more stops? When less than 5 stops were considered the distance savings that the VRP gives is negligible, hence solution was found for only the trips involving more than 5 stops.
- The simulator does not account for the traffic and other miscellaneous delays that the driver has to encounter during the trip.
- Since the vehicle makes multiple trips in a day the maximum capacity is never exceeded and hence no stringent capacity constraints are given.
- An average value for loading and unloading times at the sub-contractor location is used (range of 25 - 35 minutes). Waiting times caused by delay at sub-contractors' facility is not accounted for
- The driver starts at 8:30 AM from the depot and returns back to the depot by 12:00 PM which is considered as trip 1. He is given a break of 30 minutes and resumes his work from 12:30 PM and continues till 4:30 PM which is considered as trip 2.

C. Simulation, results and discussions

In this study, the list of sub-contractors visited for 3 weeks by the vehicle, transporting goods from the depot which is the company to the various sub-contractors and vice versa was taken. The information such as the names of the sub-contractors and their locations was fed into the ODL Studio. The software using an open street map and algorithm solves the VRP modelled employing the defined constraints and the total distance travelled by the vehicle on each trip was calculated. Upon solving it gives us the optimized route for the vehicle to travel.

An example for how the routes are simulated in the software is shown in Figure-1, Figure-2, Figure-3 and Figure-4. In Figure-1, the route simulated is the actual route followed by the driver to transport components from subcontractors to the company and vice versa. This route was formed by the logistics manager in no orderly pre planned method. Figure-2 shows the solved route which is the shortest distance for the given set of stops to be made, also giving the order of stops to be followed. The above simulation shows that a distance of 8.634 km was reduced for a single trip taken on Tuesday in week-1. Figure-3 shows another instance of a different trip being simulated, this time with seven stops to be made. It is clear that the driver chose the route that was longer with no proper order. Hence it was simulated and Figure-4 shows the

results. The distance covered is reduced and the stops are made in a proper order that enable the reduction of distance. This illustrates the simulation of trip taken on Saturday (week-2) shows that a distance of 8.014 km was reduced. Similarly the optimized routes were found out using the software ODL Studio for 3 weeks and the results are tabulated in Table-1.

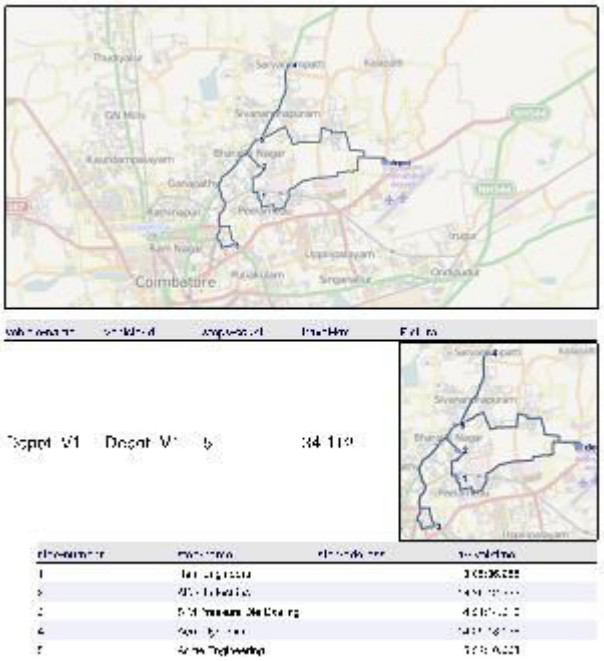

Figure-1. Simulation of week-1, Tuesday before applying VRP.

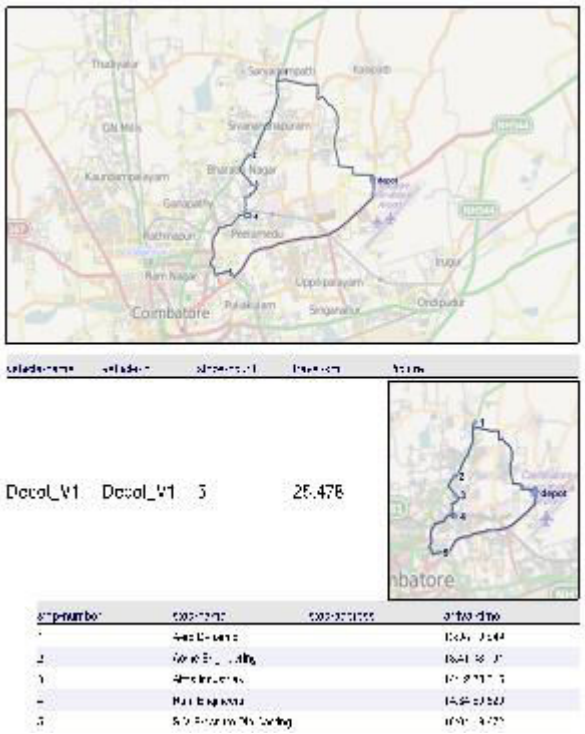

Figure-2. Simulation result of week-1, Tuesday.

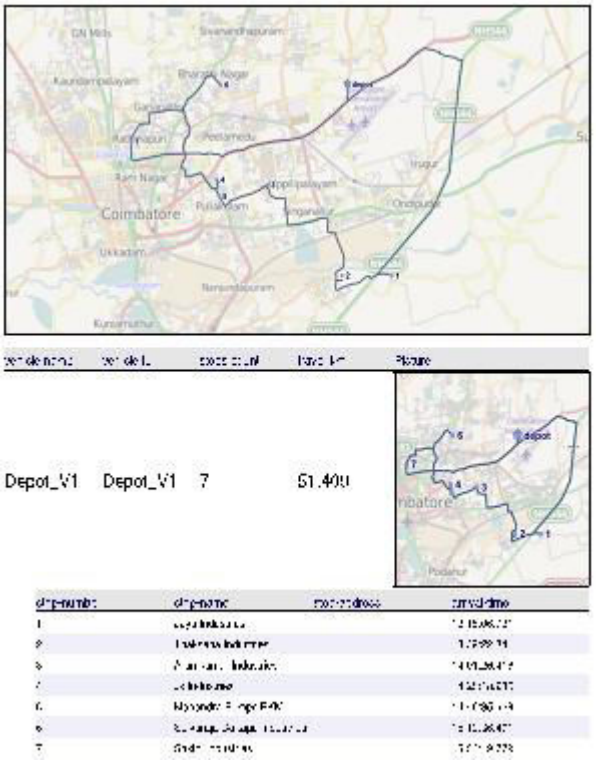

Figure-3. Simulation of week-2, Saturday before applying VRP.

Figure-4. Simulation result of week-2, Saturday.

Table-1. Tabulated results of the VRP simulation showing before and after simulation data.

Week	Day	Distance (km)		Distance saved (km)
		Before	After	
1	Monday	25.493	21.956	3.537
	Tuesday	34.112	25.478	8.634
	Friday	29.992	22.339	7.653
2	Monday	34.929	29.086	5.843
	Tuesday	30.887	25.712	5.175
	Saturday	51.409	43.395	8.014
3	Monday	37.248	31.911	5.337
	Tuesday	37.072	30.465	6.607
	Wednesday	24.846	19.198	5.648

Total Distance Saved =56.448 km

A consequence of the savings on distance will be seen by an increase in the number of final assemblies made at the manufacturer's facility. As the travel time for trucks reduce more material is taken out and also brought back in to the facility thereby, increasing productivity.

CONCLUSION

This paper shows the benefits of using a well organised and pre planned logistics management system. Using the ODL Studio for planning and organising the pick-up and delivery trips, the industry can reap maximum benefits in terms of cost incurred and time taken. With flexibility in terms of software usage to applications of constraints, any VRP can be easily solved. The solutions, if applied on large scale applications will help in reducing the consumption of resources, thus increasing productivity. Also, with the latest technological advances, the VRP can be made accurate giving details such as current location of the vehicle to the central hub, so that the trips can be planned well in advance, giving an edge for the planners to take critical operational and tactical decisions.

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