SYNOPSIS

Though a large variety of Vehicle Routing Problems (VRPs) have been addressed in the literature, the Employee Pick-up Vehicle Routing Problem (EPVRP) has not been extensively investigated. Perhaps one reason is that such problems do not exist in developed countries and therefore might not have caught the attention of researchers. In India and in many developing countries, this decision problem has widespread application potential, has much national importance and needs to be investigated. The savings or improvements obtainable by improving the solution to these problems could be significant to the national economy as it has a direct effect on fuel consumption, investment and operational costs. The problem is to find an efficient solution for (a) assigning pick-up points to a vehicle or route, and (b) sequencing the pick-up points on each route subject to limitations on the vehicle capacity and on the maximum distance allowed for the route. This study was undertaken with the objective of developing implementable micro-computer based heuristic methods to solve such problems and evaluate their relative efficiencies.

A detailed literature survey on VRPs has been carried out. Various categories of VRPs, their mathematical models and the solution seeking approaches have been studied. In particular, attention is focussed on implementable algorithms which could solve large scale real-world VRPs.

The (0-1) Integer Linear Programming (ILP) formulation given by Waters (1988) was first adopted for the EPVRP. An exact solution approach using the LINDO (Linear INteractive Discrete Optimizer) computer software package

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on micro-computer was attempted on hypothetically created smaller version of EPVRP for getting optimal solution. It was observed that even very small problems with 3 to 9 pick-up points (nodes) were taking substantial computer time. A 10 nodes EPVRP required about 28 hours of computer time on a PC/AT-486 machine with 33 MHz speed and 4 MB RAM memory to produce optimal solution through LINDO, while a 11 nodes EPVRP could not be solved at all in the PC environment. These findings confirmed the computational complexities or intractability of large scale VRPs, as found in literature.

Because of the computational difficulties in solving EPVRP optimally the use of heuristic procedure(s) has become all the more relevant in this type of research. With this premise in mind five Personal Computer (PC) based heuristic algorithms were developed and evaluated for large scale EPVRPs. These heuristic methods are modifications of the classical Nearest Neighbour Rule and the Clarke and Wright Saving's Rule approaches. All the five proposed heuristic algorithms are evaluated using three performance criteria, (i) minimization of the total distance traveled by all the vehicles, (ii) number of vehicles required, and (iii) seat utilization factor. Data from a large public sector organisation in Bangalore involving the 'to and from' daily transportation of about 11,750 employees from 410 pick-up points was used to demonstrate the applicability of the heuristic methods. Other traditional route construction algorithms such as the Nearest Insertion, Cheapest Insertion and Convex-Hull were also used for comparison and evaluation purposes. The large scale application data as well as 12 standard sets of test data from the literature were used for the purpose of comparison.
All the proposed heuristic methods provided improved vehicle routings in comparison to the prevailing practice as well as the other classical route construction algorithms mentioned earlier. Vehicle routing improvements from the proposed heuristic methods in terms of total distance covered by all the vehicles across four shifts for the specific case study application ranged from 6.84% to 8.02%. In terms of the number of vehicles used for the system, the savings ranged from 5.63% to 8.92%. Simultaneously, they reflected better seat utilization of vehicle by 9.61% to 13.27%.

Further, during the development and evaluation of the algorithm, it was felt that spatial nodal demand distribution may have influence on the relative performance of the heuristic methods. Analysis of the literature revealed that so far no attempt had been made to study this aspect of the vehicle routing problem. Therefore, an experimental design was set up to examine the influence of the changes in spatial demand distributions on the relative performance of the heuristic methods while keeping the structure of the network in terms of inter-nodal distances and discrete values of pick-up point demands fixed. A hypothesis was formulated for this purpose. About 100 randomly created demand distributions as well as two extreme situations involving best case scenario and worst case scenario were used as the basic data and routes were generated using all the five heuristic methods. The results generated in the experiment were tested statistically using the 'Kendall Coefficient of Concordance'. It was observed that the relative performance of the heuristic methods is indeed influenced by changes in the spatial demand distribution.
From the results it could be concluded that (a) there is no universally best heuristic procedure for Employee Pick-up Vehicle Routing Problem, and (b) when practical considerations are important it is imperative to use a few good heuristics methods in a Decision Support System (DSS). For each specific application of the EPVRP the best among these heuristics is to be identified through evaluations.

The thesis concludes with a summary of findings and discussion of the scope for possible future work in this direction.