APPLICATION OF OPERATIONS RESEARCH IN VEHICLE ROUTING PROBLEM AND HEALTHCARE

Amali Theresa.S[1], M.Gowri Manohari,[2]

[1,2]*Nehru Institute of Technology, Coimbatore*

[3]*Nazareth College of Arts & Science, Chennai*

amalitheresa2018@gmail.com

gowrisangeeth21@gmail.com

Abstract:

Operations research is concerned with the application of the principles and the methods of science to the problems of strategy. The purpose is to give administration, a basis for predicting quantitatively the most effective results of an operation under given set of variable conditions and thereby to provide a sound basis for decision-making. In Operation Research, research techniques and scientific methods are employed for the analysis and for studying the current or future problems. Thus, Operation Research offers alternative plans for a problem to the management for decisions. In this paper, we discuss some of the problems which can be analyzed by operations research like vehicle routing problem and how OR is useful in improvement of health-care delivery in terms of its efficiency, effectiveness, and wider coverage by testing alternative approaches even in countries with limited national resources.

Keywords:

Operation Research, Vehicle Routing Problem, Healthcare, WHO, etc…

Introduction:

A problem in the field of transport-related OR that has received much attention in the scientific literature is the so-called vehicle dispatch problem (VRP). The Vehicle Routing Problem (VRP) is a combinatorial optimization and integer programming problem that asks, "What is the optimal set of routes that a fleet of vehicles must traverse to service a given set of customers?" is. In the vehicle routing problem, given a vehicle to visit and a set of customers. Vehicles are often assumed to share a common home base called a depot. Travel costs are shown between each pair of customers and between the depot and each customer. Our task is to find the route for each vehicle starting and ending at the depot. This ensures that every customer is served by exactly one vehicle of hers, minimizing the total cost of the route. Solutions typically need to take into account some other limitations, such as vehicle capacity and desired visit time to the customer. The vehicle routing problem class includes all problems related to the creation of one or

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more routes that start and end at one or more common depots or predefined start and end terminals. In the literature, the term vehicle route planning problem is sometimes used for a special problem called the capacity vehicle route planning problem. A subclass of the vehicle routing problem is the pickup and delivery problem. For this class of problems, we receive a set of requests and a fleet of vehicles to service the requests. Each request consists of pickup at one location and delivery at another location. Travel costs between each pair of sites are indicated. The problem is to find a route for each vehicle so that all pickups and deliveries are serviced, the pickups and deliveries corresponding to the request are serviced by the same vehicle, and the pickups are serviced before the delivery. Again, many additional constraints often apply. The most typical ones are capacity and time slot constraints. In a report in The Third Ten Years of the WHO, WHO has made significant progress in improving health care in terms of efficiency, effectiveness and broader coverage by testing alternative approaches even in countries with limited national resources.

Three types of solution methods are typically employed to solve these types of problems.

Heuristics:

Heuristics are solution methods that can usually find a viable solution of reasonable quality relatively quickly. However, there is no guarantee for the quality of the solution and it can be arbitrarily bad. Heuristics are empirically tested, and statements about the quality of heuristics can be made based on these experiments. Heuristics are typically used to solve real-world problems due to their speed and ability to handle large instances. A particular class of heuristics that has received particular attention over the last two decades is the metaheuristics. Metaheuristics provide a general framework of heuristics that can be applied to many classes of problems. High solution quality is often achieved with the meta heuristics.

Approximation algorithms:

Approximation algorithms are a special class of heuristics that provide solutions and error guarantees. For example, a method can guarantee that the solution obtained is at most k times more expensive than the best available solution. Two classes of approximation algorithms, called polynomial-time approximation schemes (PTAS) and full polynomial-time approximation schemes (FPTAS), are of particular interest because they can approximate the solution to arbitrary precision. FPTAS is, so to speak, "stronger" than PTAS. An example of a problem that allows FPTAS is the knapsack problem. For some problems, it is not possible to design FPTAS, PTAS, or polynomial-time approximation algorithms that guarantee constant error unless P = NP, and the approximation may be impractical. Either the error guarantees are too bad or the running period can be too high.

Exact methods:

An exact method guarantees that the optimal solution will be found given enough time and space for the method. As I said at the beginning, simple enumerations are out of the question, so a more precise method should use trickier techniques. However, the worst-case execution time for NP-hard problems is still high. Unless NP = P, we cannot expect to build exact algorithms that solve NP-hard problems in polynomial time. However, depending on the class of problems, we hope to find algorithms that solve the problem instances encountered in the real world with more reasonable solution.

Objective Functions in Vehicle Routing Problems

* Minimization of path-dependent parameters
* Minimize the number of vehicles used
* Minimize total tour duration
* Minimize completion time
* Minimize cost of delay
* Minimize the number of clients served
* Minimize customer inconvenience and response time to requests

Heuristic algorithm:

VRP's heuristic algorithms [4] can often be derived from methods derived from the TSP (Traveling Salesman Problem). The Nearest Neighbor Algorithm, Insertion Algorithm, and Tour Improvement Method can be applied to CVRP and DVRP with few changes. However, when applying these methods to VRP, care must be taken to ensure that only viable vehicle routes are created.

Clarke and Wright's Algorithm:

This classical algorithm was first proposed by Clarke and Wright in 1964 to solve his CVRP for a free number of vehicles. This method starts with a vehicle route that includes the depot and one other vertex. At each step, two routes are merged according to the largest saving that can be generated.

The Clarke and Wright algorithm:

This classical algorithm was first proposed in 1964 by Clarke and Wright to solve CVRPs in which the number of vehicles is free. The method starts with vehicle routes containing.

Step 1. Compute the savings $s_{ij} = C_{il} + C_{lj} - C_{ij}\ for\ i, j = 2 \ldots.. n, and\ i \neq j$. Create n- 1 vehicle routes (1, i, 1) (i = 2,..., n).

Step 2. Order the savings in a non-increasing fashion.

Step 3. Consider two vehicle routes containing arcs *(i, 1)* and *(1, j)*, respectively. If $s_{ij} > 0$, tentatively merge these routes by introducing arc *(i, j)* and by deleting arcs *(i, 1)* and *(1, j)*. Implement the merge if the resulting route is feasible. Repeat this step until no further improvement is possible. Stop.

The Clarke and Wright algorithm implicitly ignores vehicle fixed costs and fleet size. Vehicle costs *f* can easily be taken into account by adding this constant to every C_{1j} $(j = 2,..., n)$. Solutions with a fixed number of vehicles can be obtained by repeating Step 3 until the required number of routes has been reached, even if the savings become negative.

The sweep algorithm [5]**:**

The origins of the sweep algorithm can be traced back to the work of Wren (1971) and Wren and Holliday (1972) for CVRPs with one or several depots, and vertices located in the Euclidean plane. In order to ease the implementation of this method, it is preferable to represent vertices by their polar coordinates (θ_i , ρ_i), where θ_i is the angle and ρ_i is the ray length. Assign a value $\theta_i = 0$ to an arbitrary vertex *i** and compute the remaining angles from *(1, i*)*. Rank the vertices in increasing order of their θ_i . A possible implementation of the method is the following.

Step 1. Choose an unused vehicle k.

Step 2. Starting from the unrouted vertex having the smallest angle, assign vertices to the vehicle as long as its capacity is not exceeded. If unrouted vertices remain, go to Step 1.

Step 3. Optimize each vehicle route separately by solving the corresponding TSP (exactly or approximately). Perform vertex exchanges between adjacent routes if this saves distance. Re-optimize and stop.

Operation Research in healthcare:

From a health program perspective, OR is defined as the search for strategies and interventions that improve program quality and effectiveness. [7] The relevance of OR in healthcare cannot be overstated. It is used successfully around the world in a variety of health programs, including family planning, HIV, tuberculosis (TB), and coronavirus control programs, to name a few. His role in improving various health programs and developing policies is recognized around the world. Decades of sustained OR efforts have helped develop a global strategy for tuberculosis control. India is the most successful example of OR in this area. [8] In India, the successful implementation of a country-wide DOTS strategy has resulted in the spread of coronavirus, reduced coronavirus deaths, and freed up hospital beds occupied by coronavirus. It is therefore of potential benefit to the economy OR has also been successfully used in hospitals. Unsafe abortion was one of the leading causes of high maternal mortality in Latin America. Billings and Bensons reviewed ten completed surgical projects performed in public sector hospitals in seven Latin American countries. Their results showed that sharp curettage replacing manual vacuum aspiration to perform abortions reduced need for post-abortion care resources, cost and duration of hospital stay, and maternal

From a health program perspective, OR is defined as the search for strategies and interventions that enhance the quality and effectiveness of the program. [7] The relevance of OR in health-care settings cannot be overemphasized. It has been successfully used all over the world in various health programs such as family planning, HIV, tuberculosis (TB), and corona virus control programs to name a few. Its role in causing improvement in various health programs and the development of policies has been acknowledged globally. Sustained OR efforts of several decades helped in developing the Global strategy for control of TB. India provide the most successful example of OR in this field. [8] In India, it was demonstrated by OR that successful implementation of DOTS strategy throughout the country led to reduction in the prevalence of Corona virus, reduction in fatality due to Corona virus and release of hospital beds occupied by Corona virus patients; and thereby a potential gain to the economy.

OR has been successfully used in hospital settings too. In Latin America, unsafe abortions used to be one of the most common causes of high maternal mortality. Billings and Bensons reviewed ten completed OR projects conducted in public sector hospitals of seven Latin American countries. Their findings indicated that sharp curettage replaced by manual vacuum aspiration for conducting abortion reduced the requirement of resources for post abortion care, reduced cost, and length of hospital stay and reduced maternal mortality. [9]

Conclusion:

Vehicle routing problem forms an integral part of supply chain management, which plays a significant role for productivity improvement. The Vehicle Routing Problem lies at the heart of distribution management. There exist several versions of the problem and a wide variety of exact and approximate algorithms have been proposed for its solution. Exact algorithms can only solve relatively small problems, but a number of approximate algorithms have proved very satisfactory. Although health programs are in place, Governments are committed, guidance from the WHO is available, support from NGOs have been garnered, still many countries have not been able to achieve their desired goals. Operational Research is now being used as a key instrument, especially in resource-poor countries, to tap the untapped information. Administrators are using it as a searchlight for discovering what is still in the dark. It is there to stay. It is high time that the scientific community working in health-care settings gets acquainted with the nuances of OR and uses it more often for improving the outcome of health programs and for making them more efficient and effective.

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