International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.5, pp : 651-654 1 May 2014

Optimization of Transportation System Using OR (Operational Research) Approaches

M. Janani, C. Chinna muthu, A. Arun, P. Gururaj, S. Jenson Thiyagaraj
Assistant professor, Department of Mechanical Engineering, Sree Sowdambika College Of Engineering, Aruppukottai, Tamil Nadu, India
jananimanick@yahoo.com , sjt.1950.007@gmail.com

Abstract : This project aims at developing an algorithm to optimize the transportation system of our organization. Vehicle routing problem of the institution is taken as the issue which is to be solved. The data's are collected from the transportation department. According to the data, Dijkstra's algorithm is used to find the optimal path initially. Project Evaluation and Review Technique (PERT) is used to find the critical patha nad critical events present in the network. Then a heuristic approach i.e., Genetic Algorihm is used to validate the result obtained from the Dijkstra's algorithm. Path length and cost is taken as the criteria for optimising the vehicle route. Djikstra's algorithm is used to find the shortest path of the vehicle manually. Then a heuristic approach (Genetic algorithm) is undertaken to validate the result obtained.

Keywords : transportation, distribution, network, vehicle routing problem

Introduction : The vehicle routing problem (VRP) plays a central role in the optimization of distribution network. Vehicle routing problem is a well-known problem in operational research area. VRP can be formulated easily; however, it turns to be a relatively difficult problem when the number of inputs increases. Mathematical models and different solution methods have been investigated in the literature to apply them for many cases in daily life. [Alfredo Olivera, et al, 2005 and Baker.M,et al, 2002]

Most interesting real-world optimization problems are very challenging from a computational point of view. In fact, quite often, finding an optimal or even a near-optimal solution to large-scale optimization problem may require computational resources far beyond what is practically available. Heuristic local research methods, such as tabu search and simulated annealing, are often quite effective at finding near-optimal solutions with high probability says Cristian Prins, 2003.

The college bus routing problem (CBRP) seeks to plan an efficient schedule for a fleet of school buses that pick up students from various bus stops and deliver them to the college by satisfying various constraints: maximum capacity of the bus, maximum riding time of students, and time window to arrive at college. CBRP has two separate but interrelated routing issues: assigning students to their respective bus stops and routing the buses to the bus stops. CBRP is a special case of the vehicle routing problem (VRP).In a VRP, a set of n clients (the students) has to be serviced by a fleet of vehicles (the buses). Since the buses have limited capacity, the problem becomes the capacitated vehicle routing problem, which is known to be NP-hard.

There are many colleges which provide transportation routes. Sometimes these routes are not optimal; these types of routes waste time or money for those involved, necessitating an accurate college transportation model to increase efficiency. But solutions like this must also considered some factors like economic concerns, time issues, route efficacy, etc. [Belcher. J, Britt. D, et al, 2005].

In college bus transportation, the two most visible problems are routing and scheduling. In the routing problem every student is assigned to a bus stop and those particular stops are sum up to form routes. In the morning a bus follows these routes, from one to stop to another, picking up the students and carrying them to college. In the scheduling problem, particular buses are assigned to particular routes. "For example, in the morning bus A might begin at route 1, deliver the students from that route to their school, travel to the beginning of route 5, pick up the tudents along that route and take them to their college. In practice it is possible and desirable to have one bus cover several routes". [Arthur J.S, Willson.B, 1984]

College bus routing and scheduling are among the major problems because college bus transportation needs to be safe, reliable and efficient. Hence, the research question for this thesis is to answer how to transport students in most economical and convenient manner. The objective of this thesis is to create Generalized model based on college transport management system which helps in bus-stop allocation, design fastest and safest bus routes with available facility.
The model is formed for

- Sree Sowdambika College of engineering, Aruppukottai

The result from this study will be helpful to develop a college bus routing for Sree Sowdambika College Of Engg, Arupukottai. This prototype model will help the college transportation management to design shortest and fastest school bus routes and they can also allocate bus stops, which will help them in selecting the pick-up stops for the students and staff, according to their concentration in the areas.

College bus routing is a version of the travelling salesman problem, normally referred to the group of vehicle routing problems (VRP), also with or with no time window constraints. In addition to the plentiful studies that addressed the vehicle routing problem, different methods have been developed that can be used to reduce the operating cost. Two factors make college bus routing unique:

1) Efficiency (the whole cost to run a school bus)

International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.5, pp : 651-654 1 May 2014

2) Effectiveness (how well the demand for service is fulfilled)

School bus routing has two separate routing issues - assigning students to bus stops and routing the buses to the bus stops. [Spasovic.L et al., 2001]

PROPOSED METHODOLOGY

Proposed methodology has four steps. It is shown in the flow chart shown below. Data is collected from the transport department of our institution. Then they are analyzed using various techniques like Djikstra algorithm and PERT. These techniques are done manually. Then a suitable heuristic (Genetic Algorithm) is applied to validate the result proposed manually.

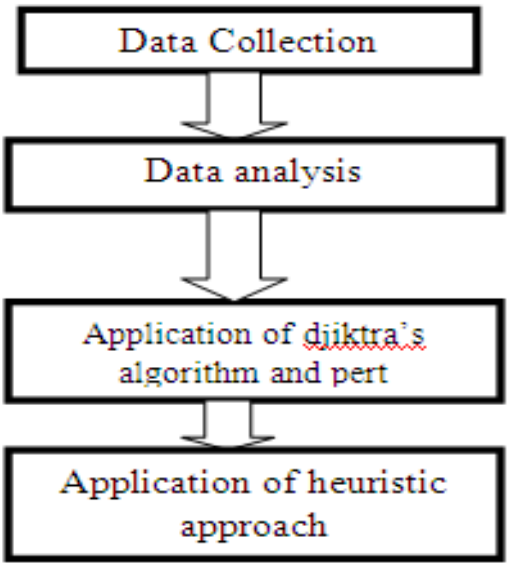

Figure 1 Proposed methodology

Data Collection

The data contains route no, boarding point, total strength, bus strength, total seat capacity, extra seat.

Data Analysis

Data's are analyzed using two methods known as Djikstra algorithm for shortest path identification and Project Evaluation and Review Technique (PERT) for Critical path identification.

DIJKSTRA'S Algorithm

Dijkstra's algorithm is called the single-source shortest path. It is also known as the single source shortest path problem. It computes length of the shortest path from the source to each of the remaining vertices in the graph.

The single source shortest path problem can be described as follows:

Let G= {V, E} be a directed weighted graph with V having the set of vertices. The special vertex s in V, where s is the source and let for any edge e in E, EdgeCost(e) be the length of edge e. All the weights in the graph should be non-negative. Before going in depth about Dijkstra's algorithm let's talk in detail about directed-weighted graph.

Directed graph can be defined as an ordered pair G: = (V,E) with V is a set, whose elements are called vertices or nodes and E is a set of ordered pairs of vertices, called directed edges, arcs, or arrows. Directed graphs are also knownas digraph.

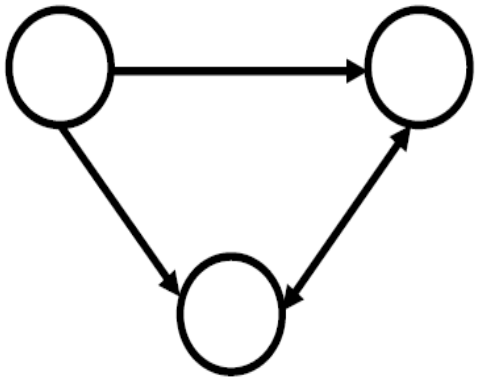

Figure 2 Directed graph

Project Evaluation And Review Technique

PERT, the Project Evaluation and Review Technique, is a network-based aid for planning and scheduling the many interrelated tasks in a large and complex project. It was developed during the design and construction of the Polaris submarine in the USA in the 1950s, which was one of the most complex tasks ever attempted at the time. Nowadays PERT techniques are routinely used in any large project such as software development, building construction, etc. Supporting software such as Microsoft Project, among others, is readily available. It may seem odd that PERT appears in a book on optimization, but it is frequently necessary to optimize time and resource constrained systems, and the basic ideas of PERT help to organize such an optimization. PERT uses a network representation to capture the precedence or parallel relationships among the tasks in the project. As an example of a precedence relationship, the frame of a house must first be constructed before the roof can go on. On the other hand, some activities can happen in parallel: the electrical system can be installed by one crew at the same time as the plumbing system is installed by a second crew.

Genetic Algorithm

Genetic algorithms are inspired by Darwin's theory about evolution. Solution to a problem solved by genetic algorithms is evolved.

Algorithm is started with a **set of solutions** (represented by **chromosomes**) called **population**. Solutions from one population are taken and used to form a new population. This is motivated by a hope, that the new population will be better than the old one. Solutions which are selected to form new solutions (**offspring**) are selected according to their fitness - the more suitable they are the more chances they have to reproduce. This is repeated until some condition (for example number of populations or improvement of the best solution) is satisfied.

Experimental Result

International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.5, pp : 651-654 1 May 2014

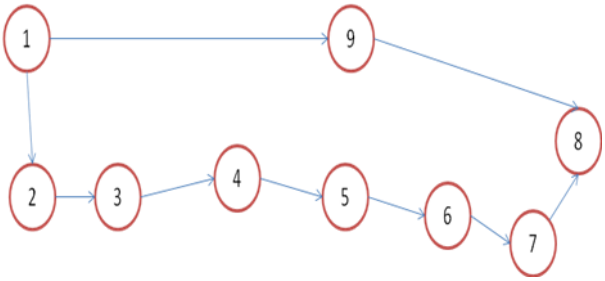

Figure 3 Network Diagram of Experimental Setup

Diagram Description

1 – Source 1-9 ----
-- 32KM

9 – Viruthunagar 9-8 ------
28KM

8 – Destination (sivakasi) 1-2 ------
4.7KM

2 – Chettikurichi 2-3 ------
7.8KM

3 – vadhuvarpatti 3-4 ------
19.8KM

4 – Naduvapatti 4-5 ------
8.7KM

5 – Sattur 5-6 ------
7.3KM

6 – Mettamalai 6-7 ------
10.9KM

7 – Parapatti 7-8 ------
1.7KM

Calculation

According To Dijkstra's Algorithm

1-2-3-4-5-6-7-8
Total Distance Is

4.7+7.8+19.8+8.7+7.3+10.9+1.7=60.9 kms

According To PERT

1-9-8

Total Distance Is 32+28=60 kms

Output of Genetic Algorithm

Genetic Output of Experimental Setup

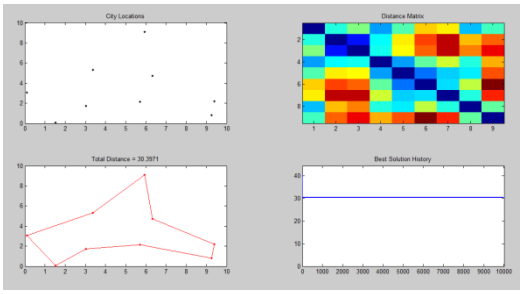

Figure 4 Genetic Output of Experimental Setup

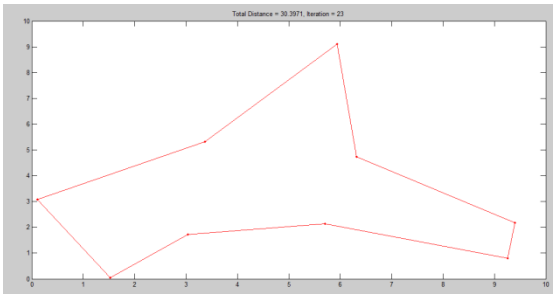

Figure 5 Genetic Output of Experimental Setup

Conclusion

The present transport system of Sree Sowdambika College of Engineering uses twelve routes using 11 buses. A single bus is used twice for reaching the depot. In the proposed model, eleven buses are covered using ten buses. Therefore, the fuel cost and maintenance cost of a bus can be saved. And also the saved bus can be used to extend the transportation system by extending to the new route or new zone or new area. A generalized model can be formed along with various constraints. Other heuristic approaches can be used and compared so as to choose the better approach. Cost analysis can be worked out so that the level of profit can be found out.

References

i. *Jorge Riera-Ledesma et al., [2011] "Solving school bus routing using the multiple vehicle traveling purchaser problem: A branch-and-cut approach"*
ii. *Dan Black et al., [2012]"The time-dependent prize-collecting arc routing problem"*
iii. *Jorge Riera-Ledesma et al., [2012] "A column generation approach for a school bus routing problem with resource constraints"*
iv. *Said Salhi et al.,[2012] "The multi-depot vehicle routing problem with heterogeneous vehicle fleet: Formulation and a variable neighborhood search implementation*
v. *G. Yazgı Tutuncu [2009] "An interactive GRAMPS algorithm for the heterogeneous fixed fleet vehiclerouting problem with and without backhauls"*
vi. *Patrick Schittekat et al., [2013] "A metaheuristic for the school bus routing problem with bus stop Selection*
vii. *Benoit Crevier et al., [2005] "The multi-depot vehicle routing problem with inter-depot routes"*
viii. *Petrica˘ C. Pop et al., [2011] "New mathematical models of the generalized vehicle routing problem and extensions*

International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.5, pp : 651-654 1 May 2014

ix. Phuong Khanh Nguyen et al., [2013] "A tabu search for Time-dependent Multi-zone Multi-trip Vehicle Routing Problem with Time Windows"

x. Y. H. Lee1, S. K. Park2, and D.-E. Chang1., [2006] "Parameter estimation using the genetic algorithm and its impact on quantitative precipitation forecast"

xi. Stephanie Forrest [1993] "Genetic Algorithms: Principles of Natural Selection Applied to Computation".

xii. Kalyanmoy Deb and Samir Agrawal., [1999] "Understanding Interactions among Genetic Algorithm Parameters"

xiii. Alden H. Wright., [1990] "Genetic Algorithms for Real Parameter Optimization".

xiv. B. S. Girish and N. Jawahar.,[2002] "A Particle Swarm Optimization algorithm for Flexible Job shop scheduling problem".

xv. Abdul Kadar Muhammad Masum, Mohammad Shahjalal, [2011] "Solving the Vehicle Routing Problem using Genetic Algorithm"

xvi. Ralf Borndo, Rfer Martin Gro¨Tschel., [2005] "Optimization of Transportation Systems"