A Review into Vehicle Routing Problem in the Real – Life

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Abstract

The problem studied in the literature tend to be highly simplified compared within the issues faced by distribution managers due to such several reasons as the number of vehicles, customers, difficult real world constraints and the fact that such routes must be constructed in a relatively short period of time. In the past several years, micro computers have become more powerful and less expensive, thus enhancing their attractiveness to potential users. Not surprisingly, the market place has witnessed rapid growth in the number of vehicle routing packages that are commercially available. The paper has been focused on introducing computer programs for planning the vehicle schedules from depots. There are some interesting features in this problem, such as: different time windows for different commodities, loading restriction for different commodities, special multi trips, and an additional depot for some products. In this paper, we present some case studies, and software packages try to analyze and describe why specific algorithm should be designed for vehicle routing scheduling problem (VRSP) rather than using only commercial software packages for real world problems.

Key words: *vehicle routing and scheduling problem (VRSP), computer software packages، Algorithms*

1) INTRODUCTION

In the world of business, competition is a major concern, and all companies try to lower their costs so as they can obtain increased benefits when they satisfy their customers. For the companies, vehicle routing scheduling is an important and large problem. The costs associated with operating vehicles and crews for delivery purposes form an important part of total distribution costs. With the substantial size of current costs and the anticipated growth in future costs a small percentage savings in these expenses could result in substantial dollar savings over a number of years. The significance of detecting these potential savings has become increasingly apparent due to escalating fuel costs, higher capital costs for replacement of vehicles, growing salaries for crews, and other related factors [1] .These factors have caused a larger percentage of an organization's total operating costs to be devoted to vehicle routing and scheduling activities .The vehicle routing and scheduling problems (VRSP) have been extensively studied, especially in the last decades. The reason for their receiving so much attention is that it is simultaneously very interesting for operational research (OR) scientist and very important for the economy of the firms. Since most firms want to route and schedule their vehicles at near minimal cost, the use of vehicle routing software packages can be

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instrumental in realizing important cost saving. For the OR scientist, the VRSP is fascinating because most of its instances had resisted the many and various attempts at optimization. The VRSP and its subproblems, like the traveling salesman problem and the generalized assignment problem, play a central role in the field of combinatorial optimization. The VRSP belongs to a category of problems that is called in combinatorial optimization NP-hard, which means that the resolution time increases exponentially with the size of the problem.

In practice the VRSP is not a unique problem but a vast classes of problems each one with its own characteristics and constraints. The VRSP is conceived as a model for the real life distribution problems faced by companies.

The Problem

The Vehicle Routing Problem (VRP) is a complex combinatorial optimization problem, which can be seen as a merge of two well-known problems: the Traveling Salesperson (TSP) and the Bin Packing (BPP). It can be described as follows: given a fleet of vehicles with uniform capacity, a common depot, and several costumer demands (represented as a collection of geographical scattered points), find the set of routes with overall minimum route cost which service all the demands. All the itineraries start and end at the depot and they must be designed in such a way that each costumer is served only once and just by one vehicle (see figure 1). VRP is NP-hard and therefore difficult to solve.

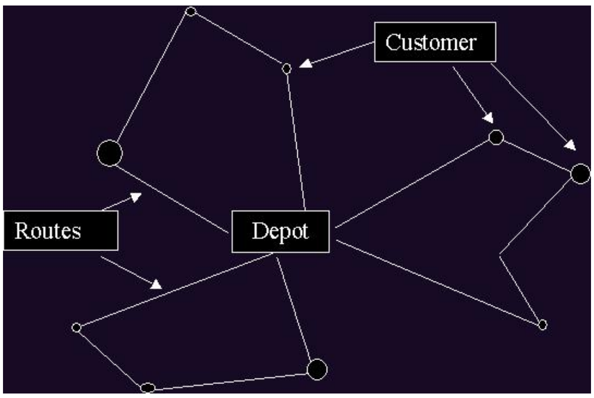

Figure 1: an example of the VRP.

2) The meaning of logistics and its importance

In this section the meaning of logistics and its importance are described. Since the VRP is a subset of logistics it is necessarily included in this description.

Logistics can be defined as studying "the problems of integrating and optimizing purchase / supply, manufacturing / processing, transport/ distribution and trading of Industrial materials [2]. In this definition it is also necessary to include the transport/ distribution of persons and / or services in order to include the problems studied throughout this paper. Some authors such as Christofides, N.Mingozzi, A [3] use distribution and logistics as synonyms. What is important is to notice that the most general logistics system includes the following functions: *"raw material and component part acquisition, transport and control; inventories management of raw materials and finished products; physical distribution management of products from factories to depots (trucking) and from depots to customers (delivery)"*.

This is a very large and complex system and so it should not be surprising to realize that in practice, logistics as a whole is still as much an art as a science.

Physical distribution, a subsystem of logistics, includes *"the series of inter related functions (principally transport, stockholding, storage, goods handling and order processing) involved in the physical transfer of finished goods from producer to consumer directly of via intermediaries [4]"*. Either vehicle routing or vehicle scheduling problems are subsystems of the physical distribution system, although in some activities these problems cannot be included in this system, because McKinnon's definition includes only the transport of goods. These are more concerned with the transport of either goods or persons or services. The importance of logistics can be seen through the costs related to it. Therefore some statistical information is presented below in order to show its importance.

Bodin et al [5] state that the distribution costs add about $400 billion per year to the cost of purchased goods in U.S.A. alone. This figure does not include other very important areas, such as garbage collection and movement of people to work and to schools.

Magee et al [6] says that over 8 percent of the Gross National Product of the USA is due to transportation. They also say that the transportation cost is the most important element of logistics costs. For some products, transportation costs can account for up to 50% of the product cost. They also assert, in the same book that logistics costs were about 9% of the sales in1984and that for many industries, logistics costs are greater that 25% of the sales.

Christoifides et al [3] said that in a developed manufacturing country the cost of logistics function is of the order of 10% of Gross National Product and contributes about 15% of the average sales price of the product. They also mentioned that the cost of supplying customers with finished goods from the depots is about 30% to 40% of the total logistics cost.

McKinnon [4] wrote that physical distribution costs account on average for approximately 8% of the net sales revenue of British and American firms. He also presented a functional desegregation of physical distribution costs which are given in the table -1.

Table 1- Physical distribution costs disaggregated

	UK (1986) (%)	US (1984 (%)
Transport	48	46
Inventory	20	22
Storage	25	22
Administration /other	7	10
Total	100	100

In Waters [7] it can be seen that distribution costs are around 20% of the product value but this varies widely with the type of product. They might range from 1-2% for expensive machinery to 60% for building materials. Besides, the distribution costs have been rising faster than general rates of inflation. Transport is the largest element in distribution costs, typically accounting for 5% of the product value.

The information above contains different types of measures and varies, for different countries and different years. Therefore, it is complementary information that allows the following common conclusions to be drawn:

- Undoubtedly in the modern economies, the logistics cost is very important and the transport cost, mainly supplying customers with finished goods, represents a large part of it.
- There is a tendency for the importance of the delivery of finished goods to increase. This can be explained by the fact that the delivery is the part of the physical distribution that involves the traveling of larger distances. Besides, it is more difficult to improve because the customers are geographically dispersed in places that are sometimes quite far apart. At the same time, the traveling related costs (principally the fuel) have increased substantially more than other costs.

These conclusions justify the attention that has been given to the vehicle routing and scheduling problems during the past decades.

3) CASE STADIES

There have been several comprehensive surveys to establish the state of the art in the resolution of practical VRSP's. Two of them can be found in Bodin et al [5] and in a book edited by Golden et al. [8]. The objective of this section is not to repeat any of them but give some new good examples that show how complex the practical VRSP's can be and how the practitioners have tackled them. Because of the computer software packages were not able to satisfy all the constraints which appear in the real world vehicle routing problems.

Vliet et al. [9]. have studied in Netherlands case of bulk sugar delivery. This study was carried out Foe Suiker Unie, farming cooperative that processes about 60 percent of the Dutch sugar beet crop. The trucks deliver full loads to each customer and can reload at anyone of the five factories but there is s a minimum and a maximum daily quantity to be shipped from each of them, although this can be taken as a soft constraint. Loading the trucks is very time consuming (about one hour per a full truck) and at each factory, trucks can only be loaded one at a time. The total number of customers is about 150 and the number of customers served per day is approximately 50.

The customer's order contains the type of sugar, the quantity, and the day and time (or time interval) for the delivery. The company owns 20 trucks of different types; each of witches has a home base where it should return at the end of the working day. Some customers can only be served by some types of trucks. If on a given day the number of vehicles is not large enough to serve all the customers additional trucks can be hired.

This problem can be classified as a multi-depot vehicle routing with time windows, but it contains also some differences: a truck delivers a full load to each customer; the trucks interact at the loading facilities because they have to be loaded sequentially.

The objective is to satisfy customer's requirements at a minimum cost. The "costs" considered are: distance traveled; driver's pay including overtime; and the cost of hired vehicles. The authors express these "costs" in terms of time.

The distance is based on a road network of the Netherlands. Therefore the distance is the shortest path between the nodes (customers, factories and truck parking facilities). The times are calculated through the distances, defining a speed for each type of vehicle and type of road (motorways, main roads, etc.).

Suiker Unie bought a package for the multi-depot vehicle routing with time windows. But the package couldn't solve thier problem completly. Therefore,they designed an algorithm just to enhance the performance of the package, customising it to the real features of company. The whole software, an interactive optimization system, has now been in used in the company since September 1991. Before that, the planning of the daily bulk delivries was made by hand. This new system produced a reduction in operating costs of about seven percent.

The next case described is a study carried out by Lysgaard [10] for a Danish company that delivers daily to approximately 500 customers, using about 100 trucks. These trucks are of different types and different capacities. The customers require to be served during a given time interval. This problem can be classified as VRSP, in which one of the peculiar difficulties is the fact that some arcs of the road network are dynamic.

The dynamic arcs result from the fact that to serve some customers that are located on islands, the vehicles have to be carried by a ferry that only makes the trip at certain hours of the day. The distances and times of travel are based on the Danish digital road network. The author emphases the time (18 months) that took him to put that road network in a form ready to be used by the algorithms.

Initially the author solved this problem using the nearest neighbour heuristic folliwing the work of Solomon [11], with some changes to take into account the different types of vehicles. The quality of the solutions given by this method was approximately the same as the computer package solution. Since the distances and times used by this algorithm do not correspond to the road network of Denmark, he decided to move to the real road network with all the characteristics referred in the previous paragraph.

The author abandoned the nearest neighbour heuristic and created a new one to take into account the real features of the road network. One of the resolution steps is to calculate the shortest path (and shortest time) between each of the customers. This is straightforward when a pair of customers is connected by land, but needs some more consideration when there are dynamic arcs between them (this is called dynamic path).

According to his assumptions and heuristic, some dynamic paths can be calculated beforehand while some others have to be calculated during the execution of the algorithm for the VRSP. His heuristic for the VRSP combines the formation of clusters of customers with an insertion type heuristic.

Another case described is a study performed by Semet et all [12] in Switzerland. The problem involves the transport of goods from one depot to 45 grocery stores. Each of these stores can require every day up to two different types of orders. Therefore the number of daily orders is of about 70 -90. An order cannot be split, but the sum of two orders may exceed the capacity of some vehicles. Each order must be delivered during a time window. The company possesses 21 trucks (not of the same type) and 7 trailers. The trailers do not have independent movement but must be drawn by a truck. The trailer and the truck constitute what they call a road train. Some customers can be visited by road trains or trucks (they call them trailer-stores), others only by trucks, and others only by some trucks (these two sets are called truck-stores).

The main peculiarity of this problem is that there are two types of routes. The classical VRP route that consists of a departure from the depot serve the customers assigned to the route and return to the depot. Another type of route, that is performed by the road trains, is the following: The road train departs from the depot, visits a trailer-store where the trailer may be uncoupled to be unloaded. Meanwhile the truck visits other customers (trailer-stores or truck-stores) and comes back to the store where the trailer was left (this is called a subtour). Then after the coupling, the road train may visit another trailer-store and another subtour may be realised,and so on.

When the authors began the study,the problem was being solved by computer package. After that, the first approach was to develop an heuristic based on Fisher et al. [13] method, with the necessary adaptations for this particular problem. This heuristic gives significantly better solutions than those obtained by computer package. However it does not take into account thetime windows.

The last case described is a study carried out by Sohrabi [14] in England. A particular distribution problem was studied in his research which is typical of that faced by companies operating supermarkets and other types of shop. The research has focused on designing an algorithm and also developing a computer programme for planning the vehicle schedules from a regionaldistribution center.

The program has been designed to deal with features and constraints which are important in practice but which are often ignored in the academic literature.

These features include:

1) Dealing with both pickup and delivery

2) Delivering different types of commodity

3) Loading constraints depending on the type of commodity

4) Pickup and delivery from a hub depot (Tamworth in his case)

5) Time window constraints, which depend on the type of commdity

6) Mutiple trips in one vehicle route

7) Service time, which includes and additional preparation time

Company attempts to solve its distribution problem by using the computer software package (PARAGON). Althogh package was a helpful tool, Company is not satisfied that it can do all The required planning. So instead of using PARAGON the programme are used.

Conclusions from These four case studies:

- There is a tendency to take into account most of the constraints, to use real data, and to use more realistic objective functions. In all cases real road network was used. None of them considers an objective function that includes all the costs. Nevertheless, the objective functionis all the cases, a little more than just the distance, as used to be the position.
- When dealing with practical cases, because they are too complex, generally heuristic methods are used, either for the master problem or for the subproblems.
- Although it is desirable to use general packages, the customisation is still unavoidable in most of the companies.Usually,is customisation is along process.

The profits of the algorithmic solution over the computer package one, measured in percentage terms are not generally very high. However, in the long run this represents a very large profit.Besides; there many other indirect benefits like the increase in the customer service level, reduction in the landing time, etc.

4) computer software packages

Once the computer programme had been written and checked, a series of experiments was carried out using the software. The first sets of experiments were designed to determine the best values of the metahuristic parameters to use. After the best values had been determined, these values were used in subsequent experiments to determine the effects of various changes in the distribution problem, which was being studied.

Since many companies are trying to solve their distribution problems, some of which are highly complex due to several constraints, there is a big market for the companies engaged in the business of developing routing software. They are keenly aware of these real constraints and are developing user friendly packages employing a blend of heuristic and optimization algorithms to assist dispatchers in routing their Fleets. In this section we focus on the computer software packages.

Golden and Assad [6] stated that in the United States, there were 15 micro based systems for VPR. They state also that commercial packages can now handle time windows, overtime, crew breaks, backhauls, pick-ups and deliveries, and mixed fleets or multiple commodities.

Willinger and Willmott [15] made an exhaustive survey of all the distribution software packages that have been produced or marketed in the Great Britain. The number of packages for transport management in what is includes the routing and scheduling was 87. However some of these do not perform routing and scheduling at all and some only do very rudimentary functions, such as calculating the shortest path between two points. The ones that really cope with routing and scheduling number about 15. Most of them are designed for microcomputers (PC) or workstations; some can take into account many constraints, while others only consider the basic problem.

Most of the packages contain, more than one logistics function. Two of them support all the seven functions in which the authors have divided logistics (stock management, fleet management, transport management, etc). However, the authors do not say if these functions are integrated by the software or not. If seems that the several functions act separately although the data can be common.

In order to give a more exact idea of the features of the software that is being sold in UK, two packages are described in more detail.

The first one described is called DiPS and is produced by a company with the same name, since 1979. According to the producer, this software is conceived either for strategic planning (depots' location), or for tactical (daily) planning (trucking operations between the factories and the depots, and delivery). The daily route planning is prepared to interface with the customers order entry system. It contains road network, postcode and gazetteer databanks. It must be executed on a PC. In fact it need two PC's interconnected: one for drawing the roads and another to make the interface with the user. The user can choose between the real distances given by the road network or the straight line distances. The speeds for each kind of road can be different but they do not vary with the type of the vehicle. Access restrictions as well as time windows are taken into account. Another feature of this software is that it is possible to plan manually.

The interface of this system is rather user- unfriendly. The algorithms for the routing and scheduling are not revealed by the company, but the impression given by reading the manual is that they are quite elementary. The experience of one of the buyers Burrton's company, that this software is not appropriate for the daily planning.

The second example is Optrak, produced by Logistics Business. The company classifies it as a decision support system, which in fact is an appropriate name, considering its features. The road network is bases on Bartholomew's 1:250000 digital maps. Each road calls may have a different speed. This software can deal with the following types of constraints: multiple time windows (up to three); different types of vehicles and products, including products that cannot be mixed, and so that have to be carried in different compartments of the vehicles; loading and unloading times; restrictions on the type of vehicles that can visit the customers the driver's hours regulations are respected; multiple driver's per vehicle (more than one shift); multiple depots; priorities for the orders;

deliveries or collections; multi-day planning fixed routes. This software runs within Microsoft Windows and the user interface is based on menus similar to those of the Windows. This interface includes the following functions: editing of the trips to make changes if desired; displaying of the trips, shortest paths and maps of more or lesser detail; execution of reports; selection, updating, and reporting of data.

The automatic planning is based on the two phase algorithm [16]. Besides, the user can establish the trips (all or only part of them) manually. A trip that is made by the computer can be changed by the user, and afterwards, the software can verify if it is feasible or not.

The package is divided into modules in order that the buyer can choose according to his needs. The whole package, that includes all the functions above, costs about £ 30.000.

Two important features that are missing in this software are the capability of a driver to make several trips per day, and the possibility of establishing by hand part of a route and then allowing the software to complete the route with other orders and/or improving it. On the other hand, the company gives no details about the quality of the solutions or the resolution time. It is known that the two-phase algorithm performs quite well with the basic VRP but it is not known what is it behavior in the presence of many other side constraints.

This section finishes with a description of two other pieces of software that are slightly different from the previous ones, because they were created by academics and they are not ready for being commercialized. Although it is the author's opinion that they have not been yet very successful, they represent and evolutionary trend in distribution software.

Duchessi et al. [17] Create software that combines a decision support system (DSS) with a knowledge base expert system (KBES).

The DSS has the following functions: enables the user to enter delivery requirements and routes, change the routes, obtain reports and view the routes on a map, generate routes automatically, and provide sensitivity analyses. The routes are generated with savings criterion, but with some modifications. The formula used is

$S_{ij} = d_{oi}+d_{oj}- \delta\ d_{ij}$

Where S_{ij} is the savings resulting from inserting the customers i and j in the same route , d_{oj} is the distance between 0 (the depot) and i , d_{oj} the distance between 0 and j, δ is a parameter , and d_{ij} is the distance between i and j . The parameter δ is inspirited in the work of Gaskell [18] and is related to the shape of the route. A similar formula to this was used by Mole and Jameson [19] but it is more generic and gives better results.

Heuristic reasoning is used to reduce the size of the routing problem through the formation of logic clusters. Their implementation enables it to handle time windows constraints.

The KBES is used to make recommendations to improve a set of routes. The whole system is very ambitious but at present the only function that it contains and performs is related to outlying stores, i.e. , store that do not comply with the constraints of the problem. This function consists of; a) identification of an outlier; b) finds another route for an outlier; c) change delivery day (recommendation); d) change delivery time (recommendation).

Potvin et al [20] developed an interactive- graphic computer system designated by ALTO that "integrates artificial intelligence (AI) and operations research (OR) techniques". This software is written in LOOPS, an object- oriented language, and is implemented on an 1108 Xerox Lisp workstation. It provides a framework called by the authors' general heuristic that allows an expert user to create specific heuristics to solve real – world problems. In this framework and algorithm is represented as a sequence of instantiated operators. The algorithms already available in ALTO (i.e., the algorithms that can be specified within the framework) are the following:

- Insertion algorithms – nearest, farthest, cheapest, quick, convex hull, greatest angle, difference x ratio;
- Nearest neighbor;
- Clarke and Wright savings, parallel and sequential;

- Clustering algorithms – sweep algorithm.

The kind of problem that can be solved is the basic VPR, but without a priori restriction on the number of vehicles, and it may have the following additional constraints:

- Maximal capacity for each vehicle;
- Maximal travel distance (or time) for each vehicle;
- A single time window at each client.

Graphics and interactive support to the user are made through the utilization of INTERLISP-D. The ALTO environment has the following features:

1. *Interactive management of transportation networks*

Transportation networks can be interactively created, edited and displayed on the ALTO screen. Partial routes are displayed each time an instantiated operator is applied.

2. *Interactive problem specification*

It is possible, via, menus, to add or remove vehicles, to redefine the set of clients, to relocate the origin and to modify values of the attributes (capacity, demand, time windows, etc.).

3. *Alternative problem solving strategies*

During the design process, any given instantiate operator to the general heuristic can be applied to the current set of routes, i.e., the solution that is being constructed. If the result appears unsatisfactory, it is then possible to restore and to redefine the operator by modifying the instantiation formulae and to apply it again.

Another interesting feature of ALTO is that the user has the possibility to work with soft constraints relative to the capacity, travel distance or time, and time windows. This is done through parameters like, for example , for the maximum travel time allowed to each vehicle T_k Travel time k $\leq$ lambda Time* T_k; where Travel time $_k$ is the effective travel time of vehicle k, and Lambda Time is a constant. So, if Lambda Time is more than one, then Travel time comes greater that T_k, what means that the initial constraint, T_k, is overtaken. This facility makes it possible to attain some goals like balancing the working time of the drivers or balancing the vehicles load, etc.

The authors have applied this software to a real problem of mail pick-up in Canada. The total time of each route is constrained and there are time windows for the pick-up. The total length of the routes that constitute the solution was reduced by 10% as compared with a solution produced by a specialized algorithm, which was already better than the produced by an expert scheduler. This algorithm takes 90 seconds to find the solution while ALTO, once correctly instantiated, takes 360 seconds. It must be said that the size of this problem, is very small –37 posts –boxes and 4 routes.

The authors are the first to recognize that more tests have to be done to assess its robustness and computing time for problems of larger dimension and with more constraints.

The idea behind the development of ALTO is very interesting, but at present the results are not so good. The main shortcoming is the fact that to create the specific heuristic from the generic one is far from simple. Only an expert user who has studied ALTO very well can do it. Besides, the user needs to know a lot about the specific algorithms for routing in order that he can do the instantiation. Another problem is the computing time, which according to the example given, is very large. This is due to the computing language in which it is implemented and to the lack that the heuristic is generic. So there are many operations that are realized that are not needed in a specific heuristic.

The three main driving forces of the distribution software evolution are:

Economic is importance of the distribution, improvements in information technologies, and improvements in algorithms for the distribution.

The high economic of the distribution was already proven in section (2).

This is the reason why so much research has been made in the field, and why it will continue.

In some areas of the information technologies the advances have been so high that they are nearly unbelievable. Bodin et al [5] stated 11 years ago : “ One may currently purchase a 64 k micro – computer with 5-10 megabytes of hard disk storage, printer terminal and all systems software for under $20,000. " Now there is no such computer for sale, but if it were, the computer itself would cost more that 100 times less. The improvements in all the areas of the information technologies communications, microprocessors, or even information storage and software- have been astonishing.

The progress on the computer side is very important for the distribution software, because it allows more and more complex algorithms to be created, that takes into account more realistic constraints and gives better solutions. Besides, if the computers are more powerful, more compatible, better intergated, and cheaper, they will be widely available in very company.

The actual trends of the VRSP computer packages are:

- To be more and more based in microcomputers (or workstations), although with easy communications with other computers to exchange information with them- to receive orders of the customers, to "know " the inventories levels, to access large geographic databases, to send the reports, etc. This also means that the tendency is towards integrated systems in order to handle the complete logistics system;
- Use road networks and to display the routes on the screen and printers;
- To be more interactive in order that the user can choose the algorithms and its parameters introduce and modify the constraints, use soft constraints which are dependent on parameters, and even create his own solutions without algorithms;
- To be more and more user- friendly through the utilization of windows on the screen, menus and comprehensive " helps",
- To incorporate many kinds of specific algorithms;
- To incorporate artificial intelligence.

This last trend is probably the "last frontier" and actually it is only at the beginning of its infancy. The objective of AI is not to substitute the techniques of OR but to complement them through:

- Suggesting to the user which are the best heuristics and / or parameters for a specific problem;
- Creating new heuristics eventually based on the existing ones and using mathematical techniques or using only an analogue human – like reasoning.
- Indicating the consequences of determined actions, this being done interactively and to answer the questions of the user.

5) CONCLUSION

A particular distribution problem has been studied in this research which is typical of that faced by companies operating factories and other types of place. The research has focused on introduce computer programmers for planning the vehicle schedules from a distribution centre.

The programs that were introduced in this paper have been designed to deal with features and constraints which are important in practice but which are often ignored in the academic literature. These features include:

1. Dealing with both pickup and delivery
2. Delivering different types of product
3. Loading constraints depending on the type of product
4. Pickup and delivery from a hub depot
5. Time window constraints, which depend on the type of product
6. Multiple trips in one vehicle route
7. Service time, which includes an additional preparation time

The programme runs quickly enough, so that it can be used on a daily basis using the most recent demand figures, instead of planners having to manually update a base schedule.

The production of the computer programme has involved the development of algorithms. The programme is designed to be user friendly so can be used by a scheduler and is very flexible in terms of being able to change time windows, demands and other inputs. The programme is not just specific to specific firms, but is general in the sense that it could be used for any distribution problem including the features listed earlier.

Further computational experiments in chapter 6 illustrate the flexibility of the computer programme and demonstrate how it can be used to address broader management issues (such as the capacity of the vehicles to be used), as well as the daily scheduling.

Considering all that has been written in this paper the following conclusions can be drawn:

i) The best software for the VRSP, and the one for which the authors advocate big savings, is that which is tailored for a specific problem. This is due to the fact that the VRSP's are very complicated and, in general, each one is different from the others at least in some important points.

ii) In general, the best saving reported, relative to the methods that that were being used are about 10-15% Frequently the greatest benefits (see for example, Rousseau [21] and Hoolan [22]do not result directly from a better solution to the VRSP but from many other related management problems, for which VRSP solutions give data:

- Strategic planning of the goods distribution;
- Planning the maintenance of the vehicles and the number to be hired;
- Planning the acquisition of vehicles;
- Control of inventories;
- Analysis (cost- benefit) of whether it is worth saving a given customer.

iii) The computer packages do not have enough generality yet to fit any specific problem. This is the principal reason why, in spite of all development, only 1-5 % of the companies use computer – based routing [7].

For these reasons we should design specific algorithm for real-world vehicle routing problem rather than using only general package.

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