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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

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A DECISION SUPPORT SYSTEM FOR MILK TANKER SCHEDULING

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Abstract: We discuss the utility of the Decision Support System (DSS) approach in vehicle scheduling and report on the development and implementation of such a system in a practical milk tanker scheduling scenario. Using this DSS in an Irish dairy company reduced the average cost per gallon of milk collected by 36%; this represents an annual saving of US$1.3 million.

Keywords: decision support system, vehicle scheduling, milk collection, case study.

1. Introduction

The successful development and application of a Decision Support System (DSS) for vehicle scheduling is reported and the nature of milk tanker scheduling is described. The design of a DSS for milk tanker scheduling is outlined and the details of the case study are presented.

2. Vehicle Scheduling

The scheduling of a number of vehicles which visit a sequence of locations to collect or deliver a commodity or service is well known in Operations Research (OR) as the **vehicle scheduling problem (VSP)**. While the traditional OR approach to the VSP is to apply mathematical programming techniques, there has been criticism of the solutions from these models at the practical implementation level. Butler and Foulds (1989) reported deficiencies including optimizing a single, unrealistic objective function, imposing inviolate constraints, and excluding important factors which are not easily quantified. The Herlihy, Butler and Pitts (1984) study of computer packages for vehicle routing found that a "human scheduler is capable of producing routes as good, if not better, than any of the currently available VSP computer packages." The complexities involved with practical vehicle scheduling mean that an interactive computer system which the scheduler uses as a tool to assist with schedule development is more effective. This approach combines the experience of the scheduler with the quantitative power of a digital computer.

Effective procedures for the VSP must take into account the fact that servicing of all locations is only one of many considerations in the comparison of possible options. Often it is a secondary consideration of the busy planner who is under pressure to produce a satisfactory schedule. Combinations of other factors, such as: the level of customer service, equity of route duration (including driving and visiting times), rostering arrangements for drivers, efficient vehicle and driver utilization, total schedule time, company financial strategies, and political considerations are often given precedence.

Also, in practice, the majority of constraints (especially of the time or capacity variety) are indicators of desired operation, and minor violations can sometimes be tolerated. For example, a schedule with a single route over eight hours in duration, may be acceptable, even when there is a policy dictating an eight hour limit.

The majority of practical VSP's scenarios involve a multitude of considerations which are often difficult to quantify. Examples include: driver preference for certain customers, routes, and vehicles; customer access restrictions, road inclinations in snow, queuing at depots, accidents and breakdowns, geographical obstacles that complicate distance and time estimation, vehicle cleaning and maintenance, union rules, labour and traffic laws, company and customer policies, and unpredictable human behaviour.

Thus schedulers are often faced with many ill-defined objectives and constraints, the relative priorities of which may change in a markedly short space of time. These considerations reinforce the endeavour to design a scheduling system which aids, rather than attempts to replace the human scheduler. We describe such a system for the collection of milk by road tankers from farms.

3. Vehicle Scheduling Decision Support System: Design

The previous section outlined the motivation behind the development of a microcomputer-based DSS for practical vehicle scheduling problems. The kernel of the DSS is a high resolution graphics screen which enables a computer map, showing customer locations, to be displayed.

One of the keys to the design of the DSS was to first discover the behaviour, and strategies of a typical, experienced scheduler. We then devised ways in which the DSS made this person more efficient. The task faced by a vehicle scheduler is typically one of two types. The first, "local" type involves the modification of an existing schedule. This is appropriate when there is relatively little change in conditions or data. The second, "global" type involves the generation of a complete set of new routes, without reference to an existing schedule. This is appropriate in a start-up situation, or when there are significant changes in conditions or data which trigger a rationalisation of resources.

The local task often involves the clustering or re-clustering of the customers on one route or a limited number of neighbouring routes. The global task can usually be accomplished by carrying out systematically the clustering of customers' regions into which the whole area has been divided. As this is akin to carrying out the local task repeatedly, in one region after another, we deal only with the local task throughout the rest of this article.

Suppose a scheduler wishes to carry out a local task by modifying an existing schedule in order to generate the new schedule. Two key questions should be asked:

i. What are the requirements of the new schedule which differ from the previous schedule? and,

ii How should the previous schedule be modified in order to create a satisfactory new schedule?

The first question usually involves constraints governing the feasibility of any new schedule. The second question involves not only these constraints, but also the measurement of how satisfactory the new schedule is, in terms of various objectives. We now list the main-menu options of the DSS designed to aid the scheduler in the search for answers to these questions.

The Schedule List Option

In order to begin the process of new schedule generation, based on the previous schedule, the scheduler must first be able to access the previous schedule. The DSS has a listing of all the routes for any previous schedule, along with various of its summary statistics which will be used in the generation of a new schedule. Examples of such statistics are, for each route: total customer service level, excess vehicle capacity, distance travelled, and time taken.

The Parameter Comparison Option

There is a means whereby the scheduler can ascertain how the previous schedule will not meet the requirements of the forthcoming schedule. Thus a mechanism for the comparison of the parameters of the previous schedule with the new parameters is included. This requires the comparison of the parameters: customer service levels, changes in customer location, and vehicle capacity.

The Schedule Modification Option

Having pinpointed where the previous schedule is deficient, the scheduler must then devise modifications to it which produce a satisfactory new schedule. Thus in answering question (ii), the system provides for existing schedule modification by:

(a) Adding a new customer to a route,

(b) Deleting a customer from a route,

(c) Transferring a customer from one route to another,

(d) Interchanging customers between different routes, and

(e) Creating a new route.

The selection of these options is guided by the provision of the relevant statistics associated with them: vehicle capacity utilization, and route duration. There is a mechanism whereby the new schedule is recorded, by overwriting the previous schedule, which is being modified.

All relevant parameters and statistics must be automatically updated. Further, the system not only deals with options inputted by the user, but it displays an intelligence by suggesting relevant options. The system enables the scheduler to analyse the consequence of these options. Routines based on the above options enable a scheduler to behave as usual when carrying out the scheduling task, but in a more systematic and efficient manner.

The scheduler can make adjustments to the collection schedule, and display the revised routes on the colour screen or colour plotter. Summary tables of the route lengths and route durations can also be displayed or printed. The menu-driven DSS takes just a few seconds to run, being limited only by computer memory. It is programmed in FORTRAN, with the graphics routines supported by the GKS graphics system.

The analysis within the DSS involves identifying clusters of suppliers and then allocating these suppliers to a particular route. The clustering is performed by heuristics using a travelling salesperson algorithm as a sub-routine. The factors involved in forming the clusters include: milk supply, tanker capacity, vehicle access, daily/alternate day collection needs, time windows, and tanker route length and duration. This DSS was implemented in a practical situation, as described below.

4. A Case Study

Premier Tir Laighean Ltd is a dairy company based in Dublin, Ireland. A recent study of milk collection operations was conducted to enable this company to examine collection costs at two of its plants. A customized interactive DSS was built to assist the scheduler to develop the milk tanker routes, with the objectives mentioned in Section 2, including that of reducing the cost per gallon of milk collected and delivered to the processing plants. Using this DSS reduced the average cost per gallon of milk collected by 36%; this represents an annual saving of US$1.3 million for the dairy company.

At the Rathfarnham plant which collects 20 million gallons of milk from 620 suppliers, the average payload per route was increased by 50% to 3919 gallons. This was achieved by a 33% reduction in the number of both routes and drivers; with a 15% decrease in the operational tanker fleet. At the smaller Finglas plant, the average payload per route was increased by 55% to 3957 gallons. The 13 million gallons of milk from the 420 suppliers was able to be collected by 36% fewer routes with a 21% reduction in drivers; the operational fleet size was also reduced by 22%.

The successful implementation of this project depended on both the feasibility of the new routes, and acceptance of the new routes by the tanker drivers. To obtain their input and support, the drivers were involved in the design phase - sharing their local knowledge and helping to refine the proposed routes.

5. Summary

The successful development and application of a DSS for vehicle scheduling enabled the knowledge and experience of the scheduler and drivers to be captured in conjunction with a technological tool. This approach provides support for human judgement rather than attempting to replace it with an analytical tool. The interactive use of a customised DSS enables the all-important, non-quantifiable and behavioural factors, to be incorporated in the decision making.

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