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conducted for the

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Urban and Public Transportation Bureau

and the

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ABSTRACT

This study was conducted to assist the Michigan Department of Transportation in selecting computer based software for demand activated bus systems. A literature review resulted in the selection of two software systems, QUICK-ROUTE and PARRAS, for further testing.

The demand pattern for a typical day in the operation of the Barry County Transit agency was selected for the test. The demand data and network description data were coded for each of the systems, and the routing and scheduling output were obtained.

The output of the two systems were compared based on the efficiency with which the trip demand was met. The QUICK-ROUTE system was recommended for small systems because the algorithm produced a schedule that required fewer vehicle miles and vehicle hours to meet the demand. No comparison of larger systems could be made since the software was only made available for the test runs.

INTRODUCTION

There are more than fifty cities and counties providing demand actuated or dial-a-ride services in Michigan. In addition, many social services and charitable organizations provide rides to their clients on a demand or need basis. In each case, the cost of providing this service can be reduced by determining and following an optimal routing through the network.

The determination of the optimal route can become quite complex as the number of customers increase, the number of constraints are increased (guaranteed pick up time, guaranteed delivery time, maximum time enroute, etc.), and/or the number of vehicles in the fleet increases.

There have been a number of routing algorithms developed by commercial firms to assist transit providers select the optimal route. The purpose of this task is to evaluate these commercially available packages against a common set of demand patterns and constraints.

The dial-a-ride type of service usually consists of three demand components; subscription (standing orders), advance reservations, and the same day requests. Subscription trips are highly repetitive trips such as commuting to work or paying visits to a Church on a particular day of the week. Advance reservation trips are those which are scheduled in advance (at least one day). This type of service is generally used by the elderly, handicapped and social service agencies. The third demand component is immediate request wherein a trip is requested on the same day that service is desired.

There are at least two methods used to schedule trips in a demand responsive system. In one, a standing schedule for subscription trips is prepared and advance reservation trips are scheduled on a daily basis into the time periods when vehicles are not used in subscription service. Same day trip demands are scheduled as idle time permits.

A second method is to schedule advance reservation and subscription trips in one combined routing and scheduling algorithm each day. Same day trips are then scheduled as time permits.

The advantage of the first type of scheduling is that subscription customers are always served by the same bus, at the same time, each trip. However, the route and schedule are sub-optimal.

The advantage of the second method is that the schedule and route can be optimized for the subscription and advance reservation trips, but the customer sees a different schedule and bus each trip.

Neither method provides an optimal solution for all trips, including the same day requests.

LITERATURE REVIEW

A review of computer software that deals with paratransit and dial-a-ride operation was conducted. In our initial literature search we reviewed the following paratransit software, from both the private and public sectors.

1. PARATRANSIT MANAGEMENT AND SCHEDULING - PTMS
2. QUICK-ROUTE PARATRANSIT (DSI)
3. PARATRANSIT MANAGEMENT INFORMATION AND SCHEDULING SYSTEM SOFTWARE-PARMIS
4. PARATRANSIT ADVANCED RESERVATION ROUTING AND SCHEDULING-PARRAS

5. COMSIS Routing and Scheduling System (CRSS) and Paratransit Information System (PARIS)
6. Small Transit Data management Software-SST3 Mc Trans
7. SCOOTER and DIGIMAP-MSI
8. ROUTEPLANNER - Columbia Software.

All eight of these software packages do dispatching, recording trips on a computer screen and printing out the requests in different formats. However, only the following five software packages include computer routing:

1. PARATRANSIT MANAGEMENT AND SCHEDULING - PTMS
2. QUICK-ROUTE PARATRANSIT (DSI)
3. PARATRANSIT ADVANCED RESERVATION ROUTING AND SCHEDULING - PARRAS
4. COMSIS Routing and Scheduling System (CRSS) and Paratransit Information System (PARIS)
5. SCOOTER and DIGIMAP - MSI

PARATRANSIT MANAGEMENT AND SCHEDULING - PTMS software developed by Automated Business Solutions provides automated scheduling, dispatching, billing and system management for para-transit operations but does not do automatic routing. Thus this package was not evaluated. The Routing and Scheduling System (CRSS) software developed by COMSIS meets the requirement of automatic routing and scheduling but it is considerably more expensive than the other packages and thus was not evaluated.

Based on our review of the above software packages, and also in a meeting with Mr. Chuck Richards and Salvatore Castronovo of Michigan Department of Transportation held on October 24, 1990, it was determined that the following three software packages meet the state requirements.

1. QUICK-ROUTE PARATRANSIT (DSI)

2. PARATRANSIT ADVANCED RESERVATION ROUTING AND SCHEDULING - PARRAS

3. SCOOTER and DIGIMAP - MSI

TESTING THE SOFTWARE

To test and compare these software packages against a common demand pattern over a prescribed network, letters were sent to their developers requesting them to loan Michigan State University a copy of the software to conduct the test. Alternatively, if it was not possible for them to provide a copy of the software then it was agreed that Michigan State University would provide a coded network and demand list, and ask them to run the program and report the output. A comparison would then be made of the results of the three software packages.

In response to our letters, Decision Sciences, Inc. and Paratransit Software agreed and sent a limited version of their software to permit the research team to enter trip information including addresses and coordinates.

Modeling Systems Inc., scheduled a demonstration of their program on March 10, 1991, but canceled that demonstration. They neither sent their program nor did they respond in writing. Hence only two vendors were compared.

Barry County was selected by the Michigan Department of Transportation as the test network. Mr. Joseph A. Bleam, Transportation Manager, Barry County Transit provided the trip information data together with a map of Barry County. The Tiger files for Barry County, were obtained from Mr. Gilbert E. Chesbro, Transportation Planner, Michigan Department of Transportation.

PARRAS does not use the street network for routing. Instead, it calculates travel time based on the origin and destination in (x,y) coordinates. These coordinates are obtained by placing an overlay, divided into a half mile grid over the map of the service area and converting addresses to grid coordinates.

The Quick-Route program uses the Tiger file for determining the coordinates of the addresses after the file is compressed and converted to a format suitable for use by the program. Quick-Route has a subroutine to compress the Tiger file. A copy of the Tiger file was sent to Decision Sciences Inc., to change it to the format required for the Quick-Route program. However, it was discovered later that tiger files of rural areas such as Barry county do not contain all the information required by Quick-Route. Hence, to create a data base of addresses and coordinates, street names, address ranges and end point coordinates were obtained from the map. As addresses are entered, the computer locates the street and calculates the coordinates for that location based on the assumption that addresses are linearly distributed along any given address range.

In both programs, once an address is entered, the computer retains the location in memory. Thus the coordinates of repeat trips need not be determined.

OBJECTIVE

The specific objective of this study was to compare the features of PARRAS and Quick-Route. The data base provided for Barry County included a daily trip demand of three hundred and six trips. A combination of ambulatory and wheel chair passengers was used. To standardize the test, all external variables such as number of buses with both wheel chair and ambulatory availability of buses, average urban and rural speed, passenger dwell time, etc. were kept constant for both systems.

ROUTING LOGIC

Quick-Route: The Quick-Route program attempts to minimize total vehicle miles traveled to deliver all the customers subject to the given constraints. This program looks at various combinations of trips to minimize travel distance.

PARRAS: The Parras program maximizes vehicle productivity within the service quality requirements. To satisfy this objective, PARRAS may evaluate hundreds of scheduling alternatives before it schedules one or more trips. It always looks at trips which remain to be scheduled rather than at trips which have been scheduled. Travel direction of every person in the vehicle is taken into consideration when scheduling trips so as to prevent combining trips which would irritate passengers because of directional consideration.

COMMON FEATURES

The common features for these two programs are listed below:

1. Ability to save and recall schedules.
2. Allows for multiple stops.
3. Calculates both as the crow flies and rectangular distances.
4. Can vary vehicle speed, to suit the geographical area and weather conditions.
5. Service area can be broken up into geographic regions and assigned to particular vehicles.
6. Available on a multiuser operating system and on a network and/or combination of both.
7. Fully automated batch scheduling.
8. Ability to clone (duplicate) repeat (subscription) trips.
9. Multiple client search capability.

10. Able to give addresses, building names as destinations.

11. Can vary loading/unloading times to accommodate different types of passengers.

12. Ability to block out vehicles for group trips (e.g., nursing home excursions).

13. Can print paper backup of each reservation as it is made.

14. Given appointment time at reservation, the program automatically makes a capacity check to determine probability of scheduling the trip.

15. User friendly menus.

16. Allows user to write their own custom reports.

The special features and advantages of each program are listed below.

Quick-Route

1. Can accomplish both fully automatic batch scheduling, and on-line scheduling while the caller is still on the phone.

2. Constructs street/building geo-database for the area served using the U.S. Bureau of Census Tiger Files.

3. If there is no Tiger file, once the addresses and the coordinates of the beginning and end of a street are entered, the coordinates of the intermediate addresses are generated.

4. Directions to next stop is printed on the drivers routing sheet.

5. Ability to print floppy backup of each reservation as it is made.

6. Operator can enter only appointment time for same day requests and the computer calculates the expected pick-up/drop-off time while caller is still on the phone.

7. Problem passenger warning flag.

8. Automatically remembers the last three destination addresses for each origin.

9. Automatic redundant reservation warning.

10. On line address verification.

11. Uses default values to minimize reservationist key strokes.

12. Reservationists code stored with each trip request and hence reservationists productivity can be checked.

13. Integrated agency invoicing and payment module.

Parras

1. Fully automatic scheduling of all trips or can leave subscription trip schedules intact and can then schedule advance reservation trips into slack times with fully automatic scheduling.

2. Can schedule trips even if there are insufficient number of vehicles. Excess trips will be scheduled on fictitious vehicles created by PARRAS called no vehicle.

3. Same day request trips can be scheduled with the computer assisted scheduling capabilities.

4. Service quality can be changed by changing the service control parameters.

5. Considers the travel direction of every passenger in the vehicle while scheduling, and prevents the combining of trips which would irritate passengers because of directional consideration.

6. When subscription trips are not scheduled on a daily basis, it can adjust subscription schedules to account for deletion of trips.

7. Subscription trips are retained until removed while advance reservation trips are retained for one week after they are scheduled.

EVALUATION

An absolute comparison of alternative routing and scheduling systems is not possible, since each systems logic is different, and there is no common definition of service quality. For example, in the two systems compared, PARRAS considers the direction of travel as an important measure of service while Quick-Route does not. Quick-Route attempts to minimize the route miles by combining many trips with similar origins and destinations, while PARRAS attempts to maximize the productivity of the busses in service by increasing the number of trips assigned to each bus.

Both systems are capable of producing a solution within service parameters selected by the operator - such as limits on pick-ups and delivery time. Both systems can produce an "optimal" schedule for subscription and advance reservation trips, and both can accommodate same day trip requests into their system. These same day trips are accommodated within the specified system constraints, but not necessarily in a system optimized solution.

CONCLUSION

The Quick-Route program used seven buses to schedule 306 trips, having only six trips in the seventh bus. The total vehicle miles travelled was 436.

The PARRAS program used six buses to schedule the 306 trips, having only eleven trips on the sixth bus. The total mileage driven by the buses was 609.

The Quick-Route algorithm produced a more efficient routing schedule on this test than did the PARRAS algorithm. The number of vehicle miles required to meet the demand pattern described in the test network was 436, compared to 609. Thus, the algorithm was more efficient at selecting optimal routes. However, the Quick-Route algorithm used one more bus than did PARRAS. Neither system utilized the last bus for more than one schedule during the 10 hour period. Each system could have reduced the number of busses by scheduling the few riders using the last bus into the idle time on the other busses. However, this test forced all trip requests to be serviced within the prescribed constraints.

Both algorithms are capable of producing a route and schedule matrix that satisfies the demand. The system selected for our test (Barry County) has a predominance of same day trips, and Quick-Routes ability to more easily schedule same day calls and the lower data input time requirement made it the preferred system. Thus Quick-Route was recommended for implementation in Barry County.

The results of this test should not be interpreted too broadly. It is not known whether Quick-Route will always produce a trip table with fewer bus miles or that PARRAS will always produce a trip table that uses fewer buses. It would be desirable to expand this analysis to include variations in demand density (trips/hour or trips/square mile); variations in the size of the system; variations in the mix of subscription, advance reservation and same day requests and variations in the level-of-service requirements. Unfortunately, the funding available did not provide for the purchase of the two software packages to conduct this type of detailed study.