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REAL-TIME RIDESHARE MATCHING USING GIS

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ABSTRACT

Ridesharing has long been perceived as a commuting mode which requires a lot of planning and lacks the flexibility associated with other commuting alternatives such as solo-driving. An efficient rideshare matching system is essential to promote ridesharing as a more effective commuting alternative.

"Real-time" ridesharing is defined as a one-time match obtained for a trip either the same day or the evening before. It would allow travelers to review rideshare options, identify best matching riders, reserve rides in advance, register details for immediate travel requests, and help in the formation of carpools at park-and-ride lots while taking real-time demand into account. More important, a real-time matching system will make ridesharing possible for commuters who do not have a regular commute schedule in terms of departure times and destination locations.

This paper investigates ways to increase the flexibility of the rideshare matching system to provide matches not only for origin-destination and work start-time matching, but also en-route pick-up and drop-off of riders. A geographic information system (GIS) based system linked to ridesharing databases, is proposed for implementing such services. Four alternative matching scenarios considered are: driver and rider matched by their origins and destinations; driver and rider matched by rider's origin and destination and the driver's route; driver and rider matched by an overlapping portion of their routes, with the driver dropping off the rider at the end of the drivers' journey; and driver and rider matched by an overlapping portion of the two routes with the rider traveling to the driver's origin to carpool.

The model being developed may be used for three purposes: for simulation, to investigate the critical number of participants required to provide suitable matches, based on some matching criteria and a given spatial distribution of ridesharers; to investigate the effect on the critical mass of participants of varying the matching criteria; and to conduct experiments on how carpoolers select persons to share a ride with. The amount of personal information they need to have, the effect of gender, and varying time and distance inconvenience in the contexts of urgency, trip purpose, multi-person carpools for the purpose of a real-time ride, may also be investigated in the laboratory using this model.

INTRODUCTION

Ridesharing has long been perceived as a commuting mode which requires a lot of planning and lacks the flexibility associated with other commuting alternatives such as solo-driving. An efficient rideshare matching system is essential to promote ridesharing as a more effective commuting alternative.[1] Potential carpoolers are first required to provide information such as names, phone numbers, home and work locations, and work start times etc. The rideshare agency matches their information with other participants registered in the database and identifies potential carpool partners. A match list of potential carpool partners, along with their names and telephone numbers, is mailed to the participant. The individual then contacts people on the list to form a carpool.

A real-time rideshare matching system could offer many benefits. It will allow travelers to review rideshare options, identify best matching riders, reserve rides in advance, register details for immediate travel requests, and help in the formation of carpools at park-and-ride lots while taking real-time demand into account. "Real-time" ridesharing is defined as a one-time match obtained for a trip either the same day or the evening before. More importantly, a real-time matching system will make ridesharing possible for commuters who do not have a regular commute schedule in terms of departure time and destination location. Further, the most important breakthrough that Advanced Traveler Information Systems (ATIS) will bring to ridesharing is that rideshare matching information will ultimately be available in the vehicle. Therefore, the availability of a real-time rideshare matching system could significantly increase the market potential of ridesharing since the system would provide more options, and thereby increase rideshare opportunities. The results of one study suggested that a comprehensive ride matching system should include the following components:[2]

1. Means for storing information on commute patterns;
2. Means for matching commuters' information effectively so that more successful carpools will likely be formed;
3. Means for informing commuters;
4. Means for updating and validating information to ensure accuracy; and
5. Means for evaluating the system and carrying out follow-up activities.

The importance of the rideshare matching system has long been recognized. In the RIDES' 1990 survey, carpoolers were asked to think of ways RIDES could improve its service. Not surprisingly, the carpoolers wanted to see RIDES make the information more accurate and up-to-date, and provide longer match lists. When asked which people the ridesharers would call from the match list, most applicants selected those people with similar work hours or employment locations. Twelve percent of the survey respondents claimed that they did not try to call anyone on the list because they found no one matched their hours. Obviously, a well-designed rideshare matching system could play a significant role in determining the success of the program.[3]

The dissemination of rideshare information and communication among carpool partners has been done almost exclusively via mail and telephone. The efficiency and attractiveness of ridesharing are greatly reduced because of the significant amount of time (usually four to five days) required for mailing match lists and contacting carpool partners. This problem could be ameliorated by implementing a real-time rideshare matching system. In such a system, ridesharer information processing and matching procedures would be performed by computer, and matches provided to ridesharers either over the telephone, computer and modem, or information kiosks. Carpools may thus be formed within much shorter times using advanced communication facilities such as fax machines and cellular telephones instead of mailing out match lists.[2] It has been found that computerized rideshare matching systems have higher placement rates than manual ones. The more selection criteria the matching system uses, the lower the placement rate. The best placement rate was found to occur at the 500-1000 database size, which can be explained by the fact that there exist sufficient entries for good matches, and that personal service and follow-up can be provided more effectively with this number of participants.

The "critical mass" concept in the adoption of interactive communication technologies is explored by Rogers.[4] Critical mass is defined as the point when enough individuals have adopted the innovative technology to make the perceived cost-benefit of adopting the innovation change from negative to positive. At this point, a certain minimum number of individuals adopt the system, and the rate of adoption becomes self-sustaining. Three qualities of innovative communication technologies stressed here are: *interactivity* - the degree to which participants in a communication process have control over, and can exchange roles; *demassification* - the degree to which a special message can be conveyed to each individual in a large audience; and *asynchronicity* - allowing sending and receiving messages at a time convenient for the individual users, rather than requiring participants to simultaneously use the system. All these qualities will be extremely important in determining the success of the system, in addition to the critical mass of participants, since rideshare matching involves matching two or more persons with possibly different origins, destinations and timings.

Although real-time rideshare matching is not currently operational in the United States, there are plans to implement field tests of such programs in Texas, California and Washington. Computer software is being developed to help automate ride matching services to be accessed via the telephone or personal computer. The "Smart Commuter" project being carried out in Houston, Texas will test a comprehensive employer-based matching service which will include the ability to provide real-time carpool matches by providing GIS-based information and available bus transit services to employees. The California Department of Transportation is also conducting similar projects - the "Smart Traveler" project in Los Angeles and the real-time rideshare matching field operational test in Sacramento.[5]

A study conducted for the Sacramento Real-Time Rideshare Matching Field Operational Test[6] revealed six basic user needs - background screening of participants, information security, system reliability, high level of system access, matching flexibility, and a uniform compensation scheme. This paper responds to one of the user needs identified above, matching flexibility.

OBJECTIVES

This paper investigates ways in which the flexibility of the real time rideshare matching system can be increased to provide matches not only for origin-destination and work start time matching, but also en-route pick-up and drop-off of riders. A geographic information system (GIS) based system [using ARC/INFO 6.0.1], linked up with ridesharing databases, is proposed for implementing such rideshare matching services.

The proposed system will involve significant improvements over existing matching procedures, which require an exhaustive database search each time a match is to be made. Most existing matching systems also do not allow en-route matching due to their lack of geo-coding capability. The use of this prototype in testing how system attributes (e.g. database size, personal preferences, and matching criteria such as inconvenience tolerances) may affect the successful operation of a Real-Time Rideshare Matching program, is also illustrated.

METHODOLOGY

Currently, ridesharing agencies typically match potential ridesharers by origin and destination using criteria such as work start times, extra distances that drivers would be willing to tolerate in picking up and dropping off riders, and flexibility in work timings. Two methods are used for matching ridesharers - zone based matching and zip code matching. The zone based matching involves allocating each ridesharer to a traffic analysis zone, while zipcode matching requires the person to be assigned a zipcode in the database. Zipcode matching proves to be easier, since zip codes can be easily assigned using the participants' street address.

Origin-destination matching often eliminates from the ridesharing market a large number of short-distance commuters, and those who do not normally travel fixed routes or times due to their inability to secure matches with long-distance commuters. In addition, values used for the matching criteria are often arbitrarily chosen, resulting in providing unsuitable matches and disillusionment of potential carpoolers. For a real-time rideshare matching system, acceptable values must be obtained for the matching criteria, as well as the critical mass of participants necessary to ensure the generation of sufficient matches. This requires a computer model, built on existing geo-coded rideshare information, for simulation purposes.

The computer model should be flexible enough to accommodate short-distance commuters, by matching their route with at least part of the route used by long-distance commuters. Geo-coding commuters' routes allows this sort of matching to be performed. Matching criteria required for this purpose include work start times, amount of flexibility in work timings, and distances drivers are willing to go out of their way to pick up and

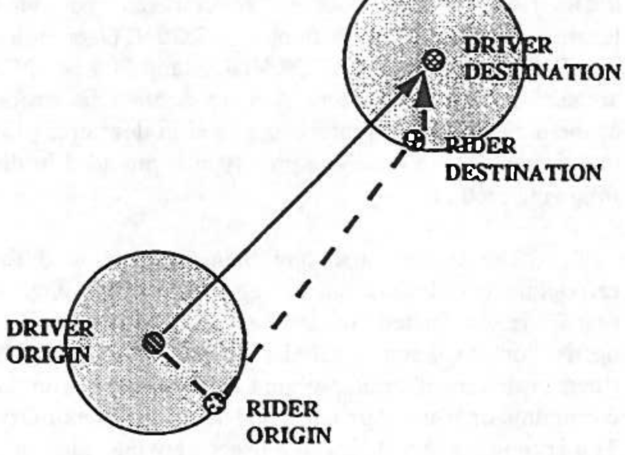

Figure 1. Matching Scenario 1

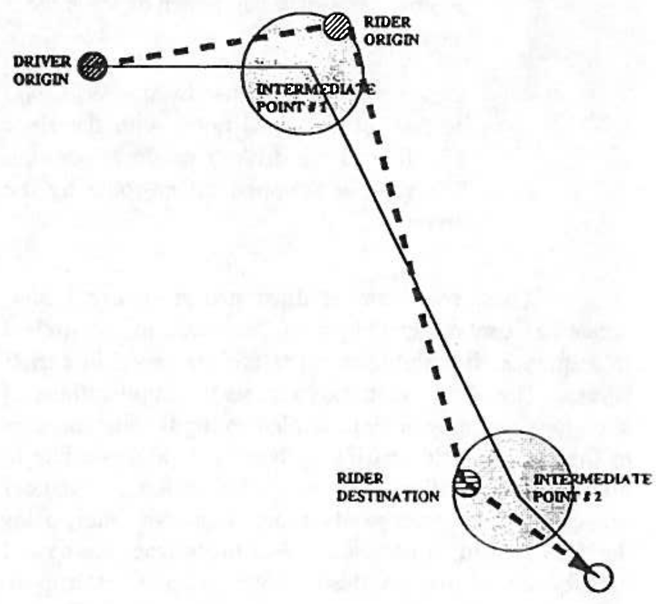

Figure 2. Matching Scenario 2

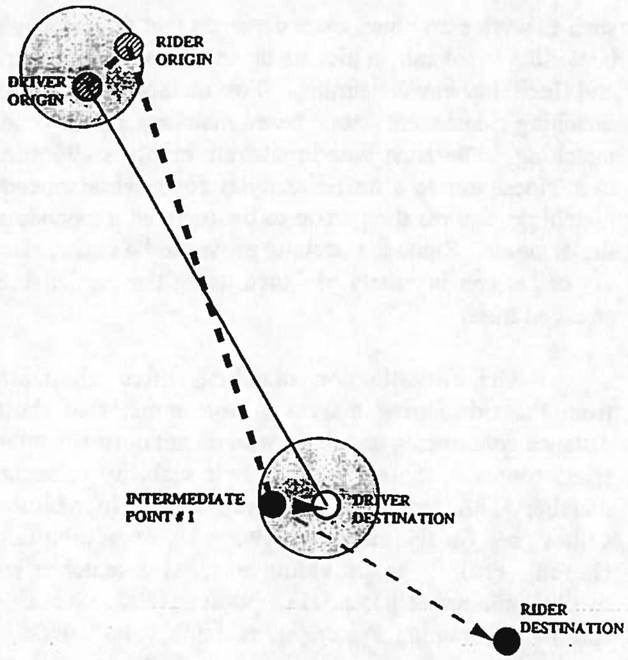

Figure 3. Matching Scenario 3

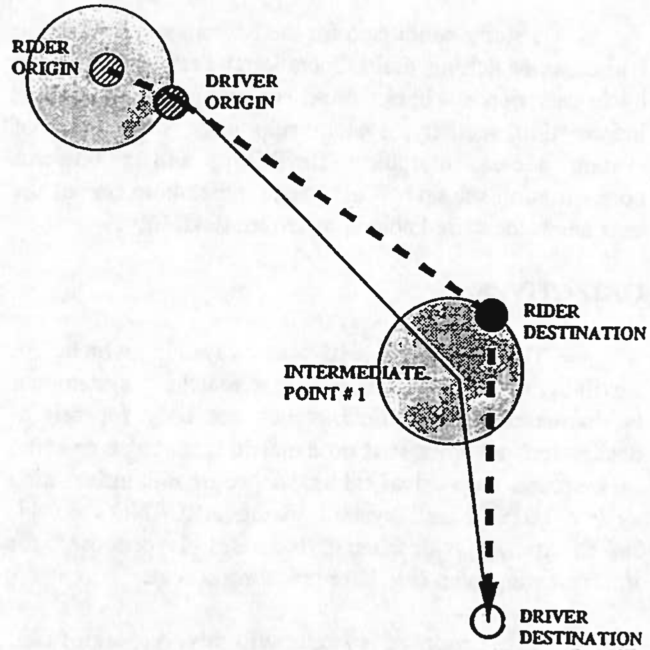

Figure 4. Matching Scenario 4

drop off riders. Four alternative scenarios are described below:

1. Driver and rider matched by their origins and destinations.

2. Driver and rider matched by rider's origin and destination with two intermediate points on the driver's route.

3. Driver and rider matched by an overlapping portion of the two routes, with the driver dropping off the rider at the end of the driver's journey, and the rider getting into another carpool, using transit or some other means.

4. Driver and rider matched by an overlapping portion of the two routes with the rider traveling to the driver's origin to carpool. The rider is dropped off en-route by the driver.

These scenarios are illustrated in Figures 1 to 4, created as a set of layers by the GIS system, to be searched in sequence, if suitable matches are not found in earlier layers. The above scenarios represent simplifications of situations that may arise in implementing flexible matches in the real-time ridesharing system. It is also possible to incorporate additional criteria like walking distances to/from pick-up or drop-off points, and wait times, using the GIS system to calculate travel times from the spatial distribution of origins, destinations and pick-up/drop-off points.

Another layer in this GIS based Real-Time Rideshare Matching System includes rideshare attribute information. This information could consist of the person's picture, personal preferences like smoking/non-smoking carpool partners, gender, and special messages, included in the database using ARC/INFO's Image Integration module. These types of information are provided by participants on a voluntary basis, together with other required data like origin and destination, work start times, routes, work time flexibility, and inconvenience tolerances of distance and time.

Image integration and network applications in transportation using ARC/INFO, are explained in.[7,8] The pre-trip planning systems provide information to select the best path depending on conditions of travel on different routes. Here, ARC/INFO is the front-end software to the user, with a database containing the street network and traffic flows. The database also contains geo-coded locations for address matching. ARC/INFO modules NETWORK, IMAGE INTEGRATION and FORMEDIT are used for this application. A more detailed discussion of the network building procedure used in developing the real-time rideshare matching prototype is provided in the following section.

The search procedure being implemented for carpool matches is done in two stages. In the first stage, a search is conducted of the geo-coded origins and destinations to match a rideshare request with possible riders or drivers of similar origin and destination, with the constraints of work start times and work time flexibility. The second stage will involve users viewing rideshare attribute information like photographs and personal preferences, to make a final match. In this stage the user is allowed to select a match according to his taste. This would be useful for conducting simulation experiments on the amount of information required, gender effects, and acceptable criteria of time and distance inconvenience.

Network Building

Network building consists of four steps which will develop a network map with all required data layers. Figure 5 shows the methodology followed in building the network. The four steps are:

- Network map
- Geo coding
- Address matching
- Network feeding

Network Map

The network layer is developed using the TIGER (Topologically Integrated Geographic Encoding and Referencing) files. TIGER/Line files are the line network product taken from the TIGER database. These files are based on a vector model and are topologically consistent. They contain both locational and attribute data, including line segments, census geographic codes, and address ranges for the left and right nodes of each segment.

Using TIGER/Line files we generate two output coverages - network link information and node information. Record types 1 and 2 of the TIGER/Line files provide network link features and attributes. Record types 4, 5 and 6 provided additional street attributes useful for geo coding applications.

After creating the network layers, we create a topology. The topology establishes the spatial relationships between different coverage feature that are required for analysis. The topology is created for lines and nodes, line topology for network links and node topology for intersections.

Geo Coding

Geo coding is a process that identifies locations on maps using addresses. Once addresses are located, the data associated with the addresses can be related to other coverage features and used for a variety of applications. With geo coding, we can get information about the best route from one address to another.

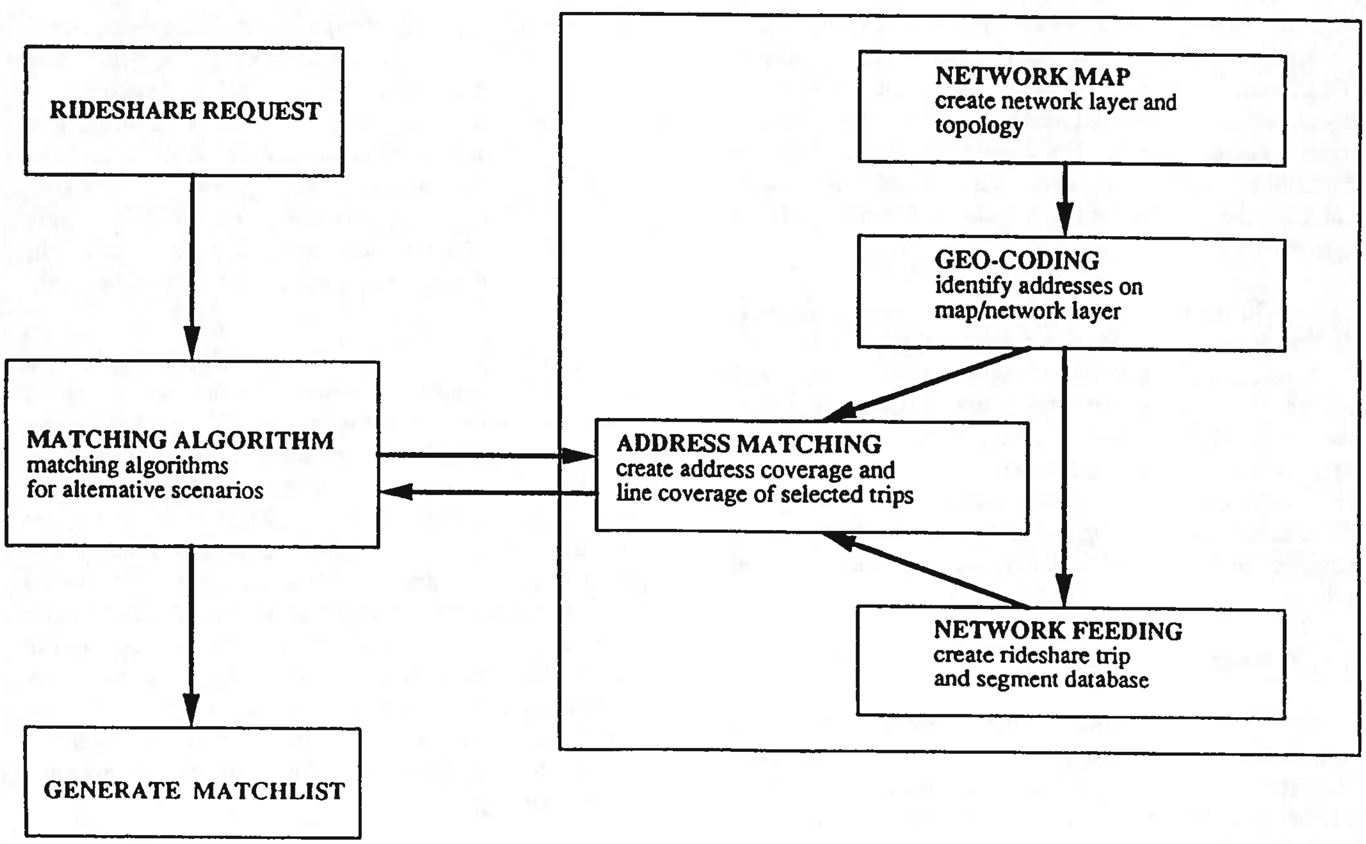

Figure 5. Network Building Methodology

Address Matching

Address matching is a process that compares two addresses to determine whether they are the same. If they are, a data relationship between the two addresses is established. This relationship permits geographic coordinates and attributes to be transferred from one address to the other. The in-built ARC/INFO facility for matching is "address match", which provides an address coverage. The address coverage will have relative geographical location co-ordinates, in this context longitude and latitude, which are highlighted on the coverage. In other words "address match" creates a line coverage of selected rideshare trips.

Network Feeding

The basic network is fed with different routes which are in the rideshare database. Each link in the network will have a series of artificial links which are parts of the carpoolers' trip. Each part is called a segment. The attribute data for each segment is stored as a data structure. This data structure is similar for all segments.

All the real network link data is stored in the "Main" class and artificial link data is stored in "Instances" of the Main class. The instances all have the same data structure, but with different values. All instances consist of data, methods and connectivity. The data may be origin, destination, mode of transportation, starting time, capacity of car, number of passengers etc. The method is designed to check the matching characteristics between rider and driver. The connectivity is a double linked list, where the front pointer will have the address of forward-link instance and the end pointer will have the before-link instance address.

In the beginning of the network feeding process, all the segments are fed with proper data. Here the database is constructed in an object-oriented fashion, and not as a relational data base like existing rideshare databases. The data can be modified and new information input into the data base at any time. Once the system finds a match for a particular trip, all the instances of that trip are eliminated. The advantage of using instances is that a new instance can be defined by inheriting data from the parent link.

User Interface

The user interface is being developed on the X windowing system using Motif windows on a DEC 5000 work station, comprising of graphical interface which takes information from the rider and makes matches using an internal database. This interface will have three windows. The main window will contain the main menu, a bar menu and an icon manager. In this window, the user will enter his/her information. The second window will display the city street network. This window will have zooming and panning features. The last window is where all matches generated will be displayed. The user interface is being programmed in Arc Micro Language (AML) of ARC/INFO. The data transfer between the matching algorithms and the GIS system are done by a pre-processor, written in C++.

USES OF THE PROTOTYPE

The GIS-based prototype being developed may be used for three purposes:

a. As a simulation model to investigate the critical number of participants required to provide suitable matches, based on some matching criteria and a given spatial distribution of ridesharers.

b. To investigate the effect on the critical mass of participants, of varying the matching criteria. Determining the time and distance inconvenience that is required for a given participant pool to successfully rideshare is part of the objective.

c. To conduct experiments on how carpoolers select persons to share a ride with them. The amount of personal information they need to have, the effect of gender, and varying time and distance inconvenience in the contexts of urgency, trip purpose, multi-person carpools etc., for the purpose of a real-time ride, may be investigated in the laboratory using the GIS-based model.

The critical mass of participants required to successfully operate a real-time rideshare matching system can be determined using the GIS-based model by randomly selecting some participants (say 1000 people) from the entire database, with the spatial distribution of their origins and destinations. Then persons may be randomly selected from these thousand people, and potential rideshare matches found for them. The process may be repeated for varying database sizes, and matches generated for, say, a 100 randomly selected people out of the database. The critical mass of carpool participants may be defined, for the above example, as the number of participants required to be in the database to be able to successfully generate matches for 90 out of 100 randomly selected participants.

Possible strategies for reaching critical mass for this system could include: shaping individual ridesharer's perceptions of the service, such that the adoption of the innovation is inevitable or very desirable; and reaching groups of people with the innovation, so that they are all likely to adopt at once. The most direct approach is to give the service free of charge to a selected group, and could be achieved by targeting ridesharers, for example.

The ultimate objectives of the Real-Time Rideshare Matching System are to increase the flexibility of the system to incorporate irregular work schedules, varying origins and destinations, and speed up the dissemination of ridesharing information. Futuristic rideshare matching systems will include in-vehicle navigation and communication technology to enable en-route notification of possible ridesharing opportunities.

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