An Ontology-based Public Transport Query System

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Abstract

As the most important technology in the development of semantic web, ontology can help computers not only to understand each other but also to share information on the web. Therefore more and more researchers begin to realize that how important to have their domain ontology supporting for reason within the domain knowledge. In this paper, urban public transport ontology is proposed with the key concepts and relations in transportation system, and established by Protégé and Jena software, to help solving some problems existing in transportation system, such as differentiating the same station names and querying with more semantic information. Also, we adopt an improved public transport transfer query algorithm which considers both road conditions and costumer's various needs, including transfer times, walking distance, and price etc. Finally, based on the proposed ontology and the improved query algorithm, we implement a public transport query system, and also do our preliminary experimental verification with six roads, 14 stations and 5 offices. And the experimental results show that our query system has good performance.

1. Introduction

The purpose of public transport query system (PTQS) is to provide well and timely information service for travelers. Long before 1997, American researcher had designed a traveler information system – TravInfoTM, in which traveler advisory telephone service is a means to deliver the TravInfoTM information to travelers [1]. Now in our country, some public transport information querying systems have been designed, and they offer line and station information by words or electronic maps. But, the given results mostly are not concise enough to help travelers to make a prompt decision, and the results is designed to show to persons, which cannot satisfy needs of semantic web, agent appearing need more regular semantic information in the querying results. So, a good PTQS should not only help travelers to choose quickly the trip routes and the transfer lines, also help agent to implement the intelligent web service.

Here we will give a survey to the existing problems in current public transport system. First, the number of bus lines is large. There are about hundreds of lines and thousands of stations in a metropolis. Second, up and down routes of a certain line are often different. Because of having one-way streets and traffic control, the up bus route of a line is not certainly the same with the down rout of the line. Third, the same station name may appear in different places. Finally, sometimes there is a large distance between the stations of the up and down routes in the same place; some even have different station names. Then, we find that there are two kinds of problems related with precision rate of trip plan querying. One is that several buses may pass by the same place but with different station names. And the other is that same station name may appear at several different places. These two problems in the public transport are just like the synonymic and polysemantic problems happened in linguistics. Hence, it is eager for an effective knowledge presentation method to organize the domain knowledge, and at this time ontology comes.

The application of ontology in the public transport system will be significant to solve the above presented problems. And building of public transport ontology is one of our innovations in this paper. The paper is organized as followed. In the next section, we will describe the proposed ontology model that can reflect the public transport network, to solve the semantic problems existing in public transport field. In the third section, an improved transfer algorithm is presented. Then, the experimental results about the PTQS are

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shown in Section 4. Finally, conclusions are drawn in Section 5.

2. Public transport ontology model

Transport query includes public transport query, train query, and airplane query, in which public transport query is the most difficult one. So here we begin our research with the public transport query, and in the future work we will gradually establish the whole transport query system.

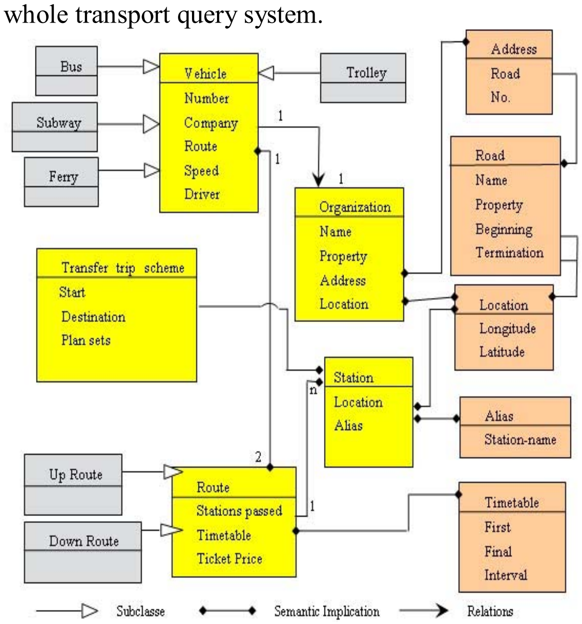

Fig. 1. Urban public transport ontology

The functions of public transport query are mainly transfer trip scheme, route query, and station query. And in the transfer trip scheme query, the start, destination, and the transfer algorithm are mainly considered. The first important one for building a complete and practical public transport system is establishing a well ontology as a base of domain-information share and communication. After a deep discussion about the real transport system, we find out there are four important concepts: vehicle, route, station and organization. As an important role of the public transport system, stations are the key marks related with actual positions. A route is composed of several bus stations with certain order. Moreover, people mainly care about the trip from one organization (or position) to another one, so the organization should also be an important concept in the query system. Also, up route and down route in the same line are separated, so concept "route" has two subclasses: up route and down route. Because the model is a preliminary one, we will extend it in our later work. In this model shown as Fig.1, we present the basic concepts and their relations, and the concepts with yellow background are the main concepts, the gray denotes the subclass. To solve the problem of the same station names, we introduce the alias to rename the station for clarity.

3. Improved algorithm of query between stations

The main functions of PTQS include transfer trip scheme query, route query, and station query. According to information about routes and stations, it is easy to implement these two queries. However, in the trip plan query according to start, destination and the traveler's priorities, a set of optional transfer trip schemes should be given with the certain order. Hence, as the kernel of transfer trip schemes query, the algorithm of query between stations draw the researches attention. Recently, there are two kinds of the algorithms focused respectively on the shortest path, and the less transfer times. And algorithms with the purpose of less transfer time are more popular, and suitable for the actual needs. That is because the less the transfer time, the less the trip fare. Travelers often long for arriving at the destination with the shortest time and the least prices.

Dijkstra's shortest path algorithm [2] has been widely used in the network path choosing, because of its stability for self-adapting network structure changing, and occupying less space of system. However, for the complexity of the public transport network, it is hard to implement Dijkstra's algorithm. Moreover, the particularity of the transfer doesn't need the Dijkstra's algorithm to find out a shortest path by which traveler may have to transfer several even ten times. Therefore, we need an effective transfer algorithm for querying between two stations. The existing algorithm [3] mainly does not consider the condition that the up and down routes are often different in the practical transport system. So the improved algorithm of querying between stations is proposed, and described in detail.

Start from user inputs (Origin, Destination and the priorities), the program searches for bus stops using a spatial radius search. The algorithm finds trips based on origin and destination pairs by bus route identification utilizing a relation matrix between route and station. The algorithm first attempts to search for no-transfer trips. If no zero transfer trips are found, it seeks for potential one-transfer trips. If one-transfer trips are unavailable, it looks for trips with two transfers, which is the maximum allowable number of transfers in our query system. Transit trip times are matched as close as possible to the user-defined departure or arrival time by accessing transit system

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schedules. Trip ranking occurs by minimizing total travel time. The total trip time is the addition of bus travel time plus layover time during transfers. The top trip itineraries are then displayed by adding the total trip time and the estimated pedestrian walking time (20 minutes per mile) from the origin and destination to their respective bus stops. Table 1 rudimentarily shows the steps of the querying algorithm including zero-transfer and one-transfer. With the same theory as the one-transfer, we can achieve the two-transfer.

Table 1. Querying Algorithm between stations

```
Input (start, destination, user-priorities)
  {
     Create the relation matrix, R, between stations and routes;
     //Each value in the matrix marks the order number of a given station in a certain route;
     for each route i do,
        {if R[start, i] <∞, then
            if R[destination, i]<∞, and R[destination, i]>R[start, i], then
                Output (route i, the direct route);// zero-transfer trip
         else for each station j, do
            if (R[j, i]) >R[start, i], then
               for each route k, do
                  if R[j, k]<R[j, Destination], then
                     Output (route i, station j, route k);// one-transfer trip
        }
  }
```

4. Experiments

Firstly, the relations between routes and stations are established with a matrix. The columns are the all fourteen station names, and the row represents six bus routes. And each value in the matrix is the order of the station in the route, if a station does not belong to a route, their corresponding value is set as ∞. With this matrix, we implement our system to do the experiment. And the Figure 2 gives the interface of the PTQS, in which have three functions: position query, route query, and change query. Also In this figure experimental result is shown. We set the start station as the Pentagonal square and the destination as People square, and get two optional paths.

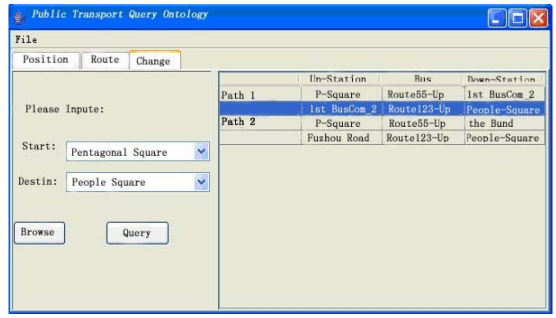

Fig. 2. Interface of the PTQS and experimental result

5. Conclusions

Urban public transport ontology is proposed with the key concepts and relations in transportation system, and established by Protégé and Jena software, to help solving some problems existing in the transportation system, such as differentiating the same station names and querying with more semantic information. Also, we adopt an improved public transport transfer algorithm which considers both road conditions and the costumer's various needs, including transfer times, walking distance, and price etc. Finally, based on the proposed ontology and the improved algorithm, we implement the PTQS, also we do our preliminary experimental verification with six roads, fourteen stations and five offices. And the experimental results show that performance of our query system is good.

In the next works, we will adopt automatic ontology learning technology to include the practical map information as more instances to enrich our ontology. Also, more rules for choosing optimal plans will be accepted. And web service function of this query system will be implemented.

6. Acknowledgement

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